First International Workshop on Temporal Analysis of Satellite Images
Mykonos Island, Greece
May 23-25, 2012

Workshop Program & Abstract Book

Editor
Yifang Ban
Workshop Organization

Workshop Chair
Dr. Yifang Ban, Professor of Geoinformatics
Royal Institute of Technology - KTH, Stockholm, Sweden

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Kostas Perakis University of Thessaly, Greece
Rainer Reuter University of Oldenburg, Germany
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<td>Temporal Analysis Techniques II</td>
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<td>09:30 - 11:00</td>
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<td>Change Detection: Optical Data</td>
<td>Coastal Zones and Aquatic environment</td>
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1st Workshop on Temporal Analysis of Satellite Images

Wed, 23 May 2012  Welcome, Keynotes, Agriculture, Climate, & Poster Session I

Room C

08:00  Registration

09:30  Workshop Opening, Keynote Session I
      Chair: Prof. Yifang Ban
      Welcome & Workshop Overview
      Prof. Yifang Ban, Royal Institute of Technology - KTH, Sweden
      09:30 - 09:45
      EARSeL Welcome
      Dr. Rainer Reuter, EARSeL Chairman
      09:45 - 09:50
      Local Organizing Committee Welcome
      Prof. Konstantinos Perakis, University of Thessaly, Greece
      09:50 - 09:55
      Current scenario and challenges in temporal analysis of remote sensing satellite images
      Prof. Lorenzo Bruzzone, University of Trento, Italy
      10:00 - 10:30
      20 years of Earth Observation with ESA missions
      Dr. Yves-Louis Desnos, ESA ESRIN
      10:30 - 11:00

11:00  Coffee Break

11:15  Interactive Poster Session I
      General Assembly for EARSeL Members
      Room A
      11:15 - 13:15

13:15  Lunch
14:15 Agriculture
Chair: Dr. Thuy Le Toan and Dr. Kees de Bie
Sentinel-2: a new perspective for research and operational applications in the areas of agriculture and environment
Gérard L. DEDIEU, Olivier Hagolle, Valérie Demarez, Danielle DUCROT, Jean-François Dejoux, Martin Claverie, Claire Marais-Sicre, Frédéric Baup, Eric Ceschia, Benoit Duchemin
14:15 - 14:35
Land Surface Phenology retrieval and biomass production anomaly detection in semi-arid systems for food security monitoring. Methods and application to the case study of the Horn of Africa.
Michele Meroni, Michel Verstraete, Ferdinando Urbano, Felix Rembold, Francois Kayitakire
14:35 - 14:55
Estimating crop biomass and evapotranspiration using high resolution multisensor remote sensing data
Amanda Veloso, Martin Claverie, Valerie Demarez, Eric Ceschia, Benoit Duchemin
14:55 - 15:15
Generating crop masks for the EU through LUCAS data, Corine, and SPOT NDVI-imagery
Kees De Bie, Javier Gallego
15:15 - 15:35
Optimization of RapidEye time-series for annual inventory of the agriculture land at country level
Pavel K. Milenov, Kadim Tasdemir
15:35 - 15:55
Spanish Pasture Insurance System
Julia Sanz, Alfredo Romo, Cristina Moclan, José L Casanova
15:55 - 16:15
16:30 Climate I
Chairs: Prof. Massimo Menenti and Prof. Lars Eklundh
Assessing vegetation response to climate variability: Bivariate time series analysis on meteorological variables and NDVI
Pieter Hawinkel, Else Swinnen, Carolien Tote, Jos Van Orshoven
16:30 - 16:50
Analysis of Vegetation Response to Climate Variability Using Extended Time Series of Multispectral Satellite Images
Massimo Menenti, L. Jia, S. Azzali, G. Roerink, M. González-Loyarte, S. Leguizamón, W. Verhoef
16:50 - 17:10
Long term consistent global GEOV1 AVHRR biophysical products
Aleixandre Verger, Frédéric Baret, Marie Weiss, Roselyne Lacaze, Hassan Makhmara, Eric Vermote
17:10 - 17:30
Use of GEOV1 climatology based on 11 years of consistent observations: Identification of trends at the global scale
Frederic Baret, Aleixandre Verger, Marie Weiss, Hassan Makhmara, Roselyne Lacaze, Philippe Pacholczyk
17:30 - 17:50
Mapping Air Temperature By Fourier Analysis of Land Surface Temperature Time Series Observed By Terra/Modis
S.M. Alfieri, F. De Lorenzi, A. Bonfante, A. Basile, M. Menenti
17:50 - 18:10
Regression analysis of land surface temperature, air temperature and gaseous air pollutants: a combined approach of using Landsat TM imageries and ground data
Bilal Shah, Mudassar Umar, Salman Qureshi, Qihao Weng
18:10 - 18:30
Multitemporal Remote Sensing for Analysis of Relationships between Land Cover and Land Surface Temperature in Ten Megacities
Yiffang Ban, Maria Bobrinskaya
18:30 - 18:50
Characterisation of time-frequency significant events in satellite-derived Sea Surface Temperature time series from 1985 to 2009.
bertrand saulquin, grégoire Mercier, ronan fablet, odile Hembise Fanton d’Andon, Antoine Mangin
18:50 - 18:55

MODELLING NDVI TIME SERIES TO FILL GAPS OF METEOROLOGICAL DATA
Margraira González Loyarte, Massimo Menenti, Angela Magdalena Diblasi
18:55 - 19:00

Monitoring environmental change in the Andes based on low resolution time series
Carolien Tote, Else Swinnen, Katia Beringhs, Gerard Govers
19:00 - 19:05

19:30 Icebreaker
1st Workshop on Temporal Analysis of Satellite Images

Thu, 24 May 2012   Keynotes, Urban, Change Detection, Temporal Analysis Techniques & Poster Session II

Room B

08:20 Keynotes Session II
Chair: Prof. Yifang Ban
Change detection in urban areas: spatial and temporal scales
Prof. Paolo Gamba, University of Pavia, Italy
08:20 - 08:50

08:50 Urban
Chairs: Prof. Paolo Gamba
Fusion of Multitemporal Multi-Angle ENVISAT ASAR and HJ-1 Data for Object-based Urban Land Cover Classification
Alexander W Jacob, Yifang Ban
08:50 - 09:10

Urban Spatial and Temporal Changes Analysis Based on Spectral, Polarimetric, Temporal, Spatial Dimensions and Decision Level Fusion
Pei Liu, Peijun Du, Paolo Gamba
09:10 - 09:30

Urban change detection by means of multitemporal satellite imagery – the case of the Indian Mega-City Hyderabad
Maik Netzband, Christopher Kirschberg
09:30 - 09:50

Urban Mapping Using Multitemporal Very High Resolution SAR Data By A Knowledge-based SEM Algorithm
Xin Niu, Yifang Ban
09:50 - 10:10

From declassified satellite images to VHR data; temporal analysis of city growth
Karel Pavelka, Eva Matouskova
10:10 - 10:15

Multitemporal image analyses for monitoring the dynamics of urban vegetation in response to rapid urbanization in Karachi
Salman Qureshi, Mudassar Umar, Dagmar Haase
10:15 - 10:20
Nighttime imaging spectroscopy as a potential tool for urban-scale detection of aerosol pollution events
Yael Etzion Cohen, Thomas Jarmer, David M Broday, Tsafrir Kolatt, Maxim Shoshany
10:20 - 10:25

10:30 Coffee Break

10:45 Temporal Analysis Techniques I
Chairs: Prof. Lorenzo Bruzzone and Dr. Yves-Louis Desnos

Improving TIMESAT for processing temporal sequences of satellite data
Lars Eklundh, Per Jönsson
10:45 - 11:05

Hyper temporal dataset selection of multisource remote sensing images for classification improvement
Antoine Masse, Danielle Ducrot, Philippe Marthon
11:05 - 11:25

Dynamic mapping in direct receiving satellite data conditions: calibrating multitemporal data sets for automated knowledge extra
Jean François Faure, Frederique Seyler, Dominique Briand, Jean-Christophe Desconnets, Laurent Demagistri, Christelle Pierkot
11:25 - 11:45

RECONSTRUCTION OF CLOUD-FREE TIME SERIES SATELLITE OBSERVATIONS OF LAND SURFACE TEMPERATURE
Hamid Reza Ghafarian, Massimo Menenti, Jia Li, Hendrik den Ouden
11:45 - 12:05

Cloud-screening from multispectral satellite image time series
Luis Gómez-Chova, Julia Amorós-López, Emma Izquierdo-Verdiguier, Juan Carlos Jiménez-Muñoz, Gustavo Camps-Valls
12:05 - 12:25

Performance assessment of Spatio-Temporal MAP-MRF Cloud Detection from SEVIRI images
Paolo Addesso, Roberto Conte, Maurizio Longo, Rocco Restaino, Gemine Vivone
12:25 - 12:45
Towards a Tracking of Small Scale Eddies Using High-Resolution RADARSAT-2 and TerraSAR-X Imagery
Benjamin Seppke, Leonie Dreschler-Fischer, Martin Gade
12:45 - 13:05

MODIS multi-temporal data retrieval and processing toolbox
Matteo MM Mattiuzzi, Jan JV Verbesselt, Anja AK Klisch
13:05 - 13:10

Unsupervised automatic pseudo orthorectification over large SPOT image databases
dominique briand, Frédérique Seyler, Jean-François Faure, Laurent Demagistri
13:10 - 13:15

13:15 Lunch & Interactive Poster Session II

14:15 Keynote Session III
Chair: Prof. Yifang Ban
Information Retrieval from Multitemporal SAR Images: Applications to Agriculture and Forest Monitoring
Dr. Thuy Le Toan, CESBIO, France
Thuy Le Toan
14:15 - 14:45

14:45 Change Detection with Optical Data
Chair: Prof. Manfred Ehlers
Change Detection in Wadden Sea areas using RapidEye data
Sascha Klonus, Manfred Ehlers
14:45 - 15:05

Detecting changes in wetlands of the Maluti-A-Phofung Local Municipality Area , Free State Province (South Africa)
Marilyn L Sparks, Prof Cornie van Huysteen
15:05 - 15:25

A temporal analysis of Landsat imagery to study the dynamics of land-cover over Lake Kivu region
Bikash Basnet, Anthony Vodacek
15:25 - 15:45

Dynamic Changing Analysis on Land Cover of Beijing Chaobai River Basin
Anrong Dang, Haifeng Jia, Yongfu Li
15:45 - 16:05
Multitemporal Remote Sensing Data Analysis of Land Cover Changes of the Ionian Islands, Greece
Eleni Charou, Marianthi Stefouli, Sergios Petridis, Konstantinos Poirazidis, Aristotelis Martinis, Georgia Alexandridi
16:05 - 16:10

Change detection in the physical lake shoreline through spatiotemporal remote sensing data and GIS techniques
NIKOLAOS PAPANIKOLAOU, Dimitris Kaimaris, Stratos Stylianidis
16:10 - 16:15

A remote sensing investigation into decadal scale changes of Folgefonna ice cap, Southern Norway.
Benjamin A Robson
16:15 - 16:20

Multi-temporal analysis of land use/land cover dynamics using satellite images in natural coffee regions of south west Ethiopia
Mengistie Kindu, Thomas Schneider, Thomas Knoke, Demel Teketay, Degefie Tibebe
16:20 - 16:25

NDVI SPATIO-TEMPORAL CHANGES AS A PROXY FOR LAND USE QUALITY DYNAMICS: THE REGION OF ATTICA, GREECE
Sofia Bajocco, Antonella De Angelis, Luca Salvati
16:25 - 16:30

16:35 Coffee Break

16:50 Change Detection with SAR Data
Chair: Prof. Uwe Sörgel

Improving change detection using geometrical features
Paolo E Gamba, Gianni Lisini, Yifang Ban
16:50 - 17:10

Change Detection in Full and Dual Polarization SAR Data and the Complex Wishart Distribution
Allan A. Nielsen, Knut Conradsen, Henning Skriver, Morton J. Canty
17:10 - 17:30

Multitemporal SAR Data for Urban Change Detection using Markov Random Field
Osama A. R. Yousif, Yifang Ban
17:30 - 17:50
1st Workshop on Temporal Analysis of Satellite Images

Mapping of Storm Damages in Forests Using Terrasar-X Sar Image Data
Jörg Ermert, Matthias Dees, Barbara Koch
17:50 - 18:10

Analysis of multi-temporal TerraSAR-X imagery over a semi-arid region in Darfur, Western Sudan
Bernard Spies, Heiko Balzter, Peter Fisher, Sarah Brown, Alistair Lamb
18:10 - 18:15

20:00 Workshop Dinner
1st Workshop on Temporal Analysis of Satellite Images

Thu, 24 May 2012  Keynotes, Proba-V, Forest, Vegetation Stress & Drought, Poster Session II

Room A

08:30  Proba-V Special Session I
Chairmen: Matt Aitkenhead, Demetris Stathakis
Comparative Analysis of Land-Use/Land-Cover Maps for Chosen Test Areas on the Territory of Bulgaria and Romania Using Low-Resolution PROBA-V Simulated Data
Eugenia K. Roumenina, Lachezar H. Filchev, Vassil S. Vassilev, Petar K. Dimitrov, Georgi N. Jelev, Gheorghe Stancalie, Elena Savin, Denis Mihaiescu

Evaluating the Potential of the PROBA-V Sensor in Estimating Forest Cover Change Over a Range of European Biogeographical Regions: The FM@PROBA-V Project
Ioannis Manakos, Ioannis Gitas, Mathias Schardt, Chariton Kalaitzidis, E. Dragozi, H. Gallaun

08:45 - 09:00
Extracting Urban Areas on Simulated Proba-V Data Using ANFIS
Demetris Stathakis, Kostantinos Perakis, Ioannis Faraslis

Forest Mapping and Forest Cover Change Detection in the Mediterranean Region Using Coarse Resolution Data and Advanced Image Analysis Techniques
Eleni Dragozi, Ioannis Z. Gitas, Maria Tompoulidou

09:00 - 09:15
Using Data Fusion Methods to Enhance Compressed PROBA-V Imagery
Laura Poggio, Alessandro Gimona, Inge Aalders, Matt Aitkenhead

The Impacts of TER Image Compression on Classification of Synthetic PROBA-V Images
Alessandro Gimona, Laura Poggio, Inge Aalders, Matt Aitkenhead

09:30 - 09:45
Burned Area Mapping and Post-Fire Monitoring Using Time Series of Proba-V Simulated and SPOT VEGETATION Data and by Employing the BFAST Trend Analysis Method
Thomas G. Katagis, Ioannis Z. Gitas, Pericles Toukiloglou, Rudi Goossens
09:45 - 10:00
1st Workshop on Temporal Analysis of Satellite Images

Discussion - Questions
10:15 - 10:30

10:30 Coffee Break

10:45 Proba-V Keynote
Chairmen: Demetris Stathakis
Proba-V - A SPOT-VGT Successor Mission, Product Definition and Specifications
Dr. Tanja Van Achteren, Wouter Dierckx, Sindy Sterckx, Stefan Livens, Gilbert Saint
10:45 - 11:15

11:15 Proba-V Special Session II
Chair: Joost Vandenabeele
Unmixing of Proba-V and SPOT-VGT Time Series for Retrieval of Crop Specific Temporal NDVI Signatures
C. Atzberger, Y. Shimubukuro, T. Udelhoven, A. Formaggio, G. Kaiser, M. Matteuzzi, F. Vuolo, M. Harig
11:15 - 11:30

Monitoring Semiarid Agroecosystems with Products Derived from Vegetation and Future Proba-V Datasets
11:30 - 11:45

Optimal Spatial Resolution for Agriculture Applications: From Decametric to Kilometric Observations
Frédéric Baret, L. Suarez, M. Weiss
11:45 - 12:00

Monitoring of Evapotranspiration at Sub-Kilometer Scale: Downscaling MSG/SEVIRI Images Using Moderate Resolution Remote Sensing Derived Data
Nicolas Ghilain, Alirio Arboleda, Francoise Gellens-Meulenberghs
12:00 - 12:15
Burned Area Mapping in a Mediterranean Environment Using Time-Series VEGETATION and Simulated PROBA-V Imagery by Employing an Object-Based Change Detection Approach
Pericles Toukiloglou, Ioannis Z. Gitas, Giorgos Mallinis, Thomas Katagis
12:15 - 12:20
Discussion - Questions
12:20 - 12:45

13:15 Lunch & Interactive Poster Session II

14:45 Forest I

Chair: Dr. Thomas Schneider and Matthias Dees
Forest landcover dynamics analysis for carbon stocking and GHG flux assessments: multitemporal remote sensing data and methods inside the Kyoto Protocol requirements
Jean François Faure, Kenji Ose, David Réchal, Michel Petit, Laurent Durieux, Hugh Eva
14:45 - 15:05

Mapping of Storm Damages in Forests Using Rapideye
Matthias Dees, Jörg Ermert, Barbara Koch
15:05 - 15:25

Tracing structural changes of a complex forest by a multiple systems approach
Thomas Schneider, Jiaojiao Tian, Alata Elatawneh, Adelheid Rappel, Peter Reinartz
15:25 - 15:45

Tracing deciduous component in fragmented landscape of southwestern Finland with the aid of multi-temporal satellite imagery
Timo Pitkänen, Helle Skånnes, Niina Käyhkö
15:45 - 16:05

Automated monitoring of major forest cover changes based on satellite time series data.
Heinz Gallaun, Mathias Schardt, Martin Steinegger
16:05 - 16:05

Biomass Assessment in African Savanna Forest Using Multi-Temporal ALOS PALSAR Data
Stephane Mermoz, Thuy Le Toan, Ludovic Villard
16:05 - 16:25
1st Workshop on Temporal Analysis of Satellite Images

Determination of the beginning of growing season in boreal coniferous forest from MODIS time-series and comparison with modelled phenology
Kristin Boettcher, Tiina Markkanen, Mika Aurela, Olli-Pekka Mattila, Mikko Kervinen, Sari Metsämäki, Tuula Aalto, Ali Nadir Arslan, Jouni Pulliainen
16:25 - 16:30
Combining time series of aerial photography with VHR satellite imagery for modelling of woody species dispersal
Josef Brüna
16:30 - 16:35

16:35 Coffee Break

16:50 Vegetation Stress & Drought
Chairs: Prof. Rudi Goossens and Dr. Li Jia
Development of a global Agricultural Stress Index System (ASIS) based on remote sensing data
Roel Van Hoolst, Herman Eerens, Lieven Bydekerke, Oscar Rojas, Paul Racionzer, Felix Rembold, Anton Vrieling
16:50 - 17:10
A multitemporal and non-parametric approach for assessing the impacts of drought on vegetation greenness: A case study for Latin America
Hugo M S Carrão, Guadalupe Sepulcre, Stephanie Horion
17:10 - 17:30
Vegetation stress due to mining impact in Karabash using TSA of SPOT-VGT
Carolien Tote, Marc Goossens, Ben Williamson, Else Swinnen, Ils Reusen
17:30 - 17:50
Evaluation of Anomalies in Multiple Indicators for Drought Monitoring
Li Jia, Jie Zhou, Guangcheng Hu, Massimo Menenti
17:50 - 18:10
Drought monitoring in the Romanian Western Plain using TERRA-MODIS and SPOT-VEGETATION time series data
Argentina Teodora Nertan, Gheorghe Stancalie, Denis I. Mihaiescu
18:10 - 18:15

20:00 Workshop Dinner
08:20 Temporal Analysis Techniques II
Chairs: Dr. Keith Morrison and Dr. Jonathan Seaquist

EVALUATION OF HARMONIC ANALYSIS OF TIME SERIES (HANTS): IMPACT OF GAPS ON TIME SERIES RECONSTRUCTION
Jie Zhou, Li Jia, Guangcheng Hu, Massimo Menenti
08:20 - 08:40

Using SAR Interferometric Phase To Measure Soil Moisture
Keith Morrison
08:40 - 09:00

Time Series Analysis – a Tutorial in EARSeL’s SEOS Project on Science Education through Earth Observation for High Schools
Rainer Reuter
09:00 - 09:20

COMPARING PARAMETRIC AND NON-PARAMETRIC APPROACHES FOR ESTIMATING TRENDS IN MULTI-YEAR NDVI
Sadegh Jamali, Jonathan Seaquist, Lars Eklundh, Jonas Ardö
09:20 - 09:40

Assessment of radiometric normalization effects on inundation mapping of Doñana marshlands with a long time series of Landsat images
Ricardo Díaz-Delgado, David Aragones, Isabel Asencio, Javier Bustamante
09:40 - 09:40

PRELIMINARY RESULTS OF AN UNEXPECTED UPLIFT SITUATED IN A FORMER COAL MINING REGION (CAMPINE BASIN - BELGIUM) REVEALED BY RADAR INTERFEROMETRY.
Pierre-Yves Declercq, Xavier Devleeschouwer, Stéphane Brassinnes, Eric Pirard, Eric Goemaere
09:40 - 10:00

Recovery of the geometry of historical aerial photos associating self-calibration with ground control linear features
Dimitra Vassilaki, Charalambos Ioannidis, Athanassios Stamos
10:00 - 10:20
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A Bayesian approach for solar irradiance estimate using multitemporal satellite images and ground reference data
Laurent Linguet, Jamal Atif
10:20 - 10:25

Potentiality of MOD13Q1 EVI and NDVI time series for land cover classification in highly fragmentated areas: the Sangone river basin case study (Piemonte, Italy).
Enrico C Borgogno Mondino, Stefano Testa
10:25 - 10:30

Analysis of the thermal and deformative superficial fields at Ischia Island (Southern Italy) via the exploitation of long-term MODIS LST and SAR data time series
Massimo Antoninetti, Daniela Stroppiana, Pietro A. Brivio, Pietro Tizzani, Mariarosa Manzo, Lanari Riccardo
10:30 - 10:35

A Multitemporal Ts-VI (MTVI) Method for Surface Soil Moisture Assessment at Regional Scale
Roberto Carla’, Katia Fontanelli, Leonardo Santurri
10:35 - 10:40

10:40 Coffee Break

11:00 Forest II
Chair: Dr. Samantha Lavender
Multi-seasonal / multi-temporal RapidEye image analysis for forest parameter extraction using object-oriented image analysis
Alata Elatawnhe, Adelheid Rappl, Nataliia Rehush, Thomas Schneider, Thomas Knoke
11:00 - 11:20

National forest monitoring systems for REDD+
Inge Jonckheere, Danae Maniatis, Stefano Giaccio, Catherine Bodart, Przemek Żelazowski, Danilo Mollicone
11:20 - 11:40

Time course of reflectance for some forest types in Estonia
Tiit Nilson, Mait Lang, Miina Rautiainen, Jan Pisek, Urmas Peterson, Andres Kuusk, Joel Kuusk, Alo Eenmäe
11:40 - 12:00
12:10 Interactive Poster Session III

13:00 Lunch

14:00 Vegetation Dynamics
  Chair: Dr. Ioannis Manakos
  Analyzing Vegetation Dynamics by Combining Remote Sensing with Process-based Ecosystem Models
  Jonathan W Seaquist, Veiko Lehsten, Mats Lindeskog, Lars Eklundh
  14:00 - 14:20
  Dynamic Vegetation Analysis: Phenological Behaviour and Phenological Pattern
  Margarita González Loyarte, Massimo Menenti
  14:20 - 14:40
  Vegetation and land cover changes on Finnmarksvidda, Northern Norway, due to grazing pressure by reindeer
  Bernt E Johansen, Hans Tømmervik
  14:40 - 15:00
  Multi-sensor assessment of trends in attributes of vegetation dynamics and ecosystem functioning derived from NDVI time series
  Bruno Marcos, Isabel Póças, João Gonçalves, João Honrado
  15:00 - 15:05
  Spatio-Temporal Characterization Of Vegetation Cover Variability
  Roberto Carla’, Leonardo Santurri, Katia Fontanelli
  15:05 - 15:10

15:15 Coffee Break

15:30 Panel Discussion & Workshop Closing
  Chair: Yifang Ban
1st Workshop on Temporal Analysis of Satellite Images

Fri, 25 May 2012   Temporal Analysis Techniques, Hazards & Risks, Coastal Zones & Aquatic Environment, Poster Session III

11:00 Hazards and Risks
    Chair: Prof. Konstantinos Perakis
    Characterising fire hazard from temporal sequences of thermal infrared MODIS measurements
    Carmine Maffei, Silvia Alfieri, Massimo Menenti
    11:00 - 11:20

Multitemporal Trajectory-Based Change Detection for Automated Landslide Identification in Kyrgyzstan Using Satellite Remote Sensing Data
    Robert Behling, Sigrid Roessner, Karl Segl, Christian Rogass, Hans-Ulrich Wetzel, Hermann Kaufmann
    11:20 - 11:40

Flood mapping based on SAR data
    Helena Łoś
    11:40 - 12:00

REMOTE SENSING APPLICATIONS FOR FLOOD DEFENSE PLANS FOR THE HILANDAR MONASTERY
    Milutin P Stefanović, Irina L Milovanovic, Jelena Čotrić
    12:00 - 12:05

Towards monitoring post-fire vegetation cover dynamics in the Mediterranean with the use of object-based image analysis of Landsat images
    George H. Mitri, Paolo Fiorucci
    12:05 - 12:10

12:10 Interactive Poster Session III

13:00 Lunch

14:00 Coastal Zones and Aquatic Environment
    Chair: Dr. Rainer Reuter
    Monitoring of invasive aquatic plants using multitemporal RapidEye data
    Sebastian Rößler, Patrick Wolf, Thomas Schneider, Arnulf Melzer
    14:00 - 14:20

The experience of the using of the fractal and wavelet analysis for investigation of the chaotic dynamics of the ocean based on altimetry time series
    Igor Shilov
    14:20 - 14:40
Multi-temporal MERIS data to support the implementation of the Water Framework Directive
Mariano Bresciani, Daniela Stroppiana, Daniel Odermatt, Giuseppe Morabito, Marco Bartoli, Claudia Giardino
14:40 - 14:45

Multiple resolution data for the ongoing monitoring and temporal analysis of Lake Balaton (Hungary) water quality
Stephanie CJ Palmer, András Zlinszky, Vadim V. Pelevin, Igor Goncharenko, Viktor Tóth, Máté Présing, Virginia Nicolás-Perea
14:45 - 14:50

Temporal Variability of Satellite-Measured Chlorophyll a in the Northwestern Black Sea
Violeta Slabakova, Snejana Moncheva, Valentina Doncheva, Nataliya Slabakova
14:50 - 14:55

Mapping of zones with coherent dynamics of satellite derived variables for studying spring phytoplankton bloom
Anton Korosov, Lasse Pettersson
14:55 - 15:00

Temporal analysis of optical and SAR remote sensing for monitoring of intertidal salt marshes
15:00 - 15:05

Regional monitoring of Amazonia’s coastal ecosystems: landcover dynamics analysis using extensive high resolution optical data sets
Jean-François Faure, Valdenira Ferreira Santos, Maria Thereza Prost, Amilcar Mendes, Romain Goeury, Jean-François Girres
15:05 - 15:10

Monitoring Landcover changes on the coastal zone of North Lebanon using Object-Based Image Analysis of multi-temporal Landsat images
George H. Mitri, Manal Nader, Irna Van der Molen, Jon Lovett
15:10 - 15:15

15:15 Coffee Break

15:30 Panel Discussion & Workshop Closing
Chair: Yifang Ban
Sentinel-2: a new perspective for research and operational applications in the areas of agriculture and environment

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Keywords: GMES, time-series, agriculture, environment, water management

Abstract: Sentinel-2 will simultaneously offer high spatial resolution in the optical domain and a comprehensive coverage of the entire land. The mission would be particularly useful for developing regional remote sensing applications and geospatial data infrastructures. The importance of this mission will be illustrated with results obtained by CESBIO and its partners in the field of agri-environment. As part of the preparation of the Venpsy"6Ds and Sentinel-2 missions, high spatial resolution (10m) optical data (SPOT, FORMOSAT-2, Landsat) have been acquired since 2002 over an 2500 km² experimental area located in the south-west of France, with a frequency of at least one cloud free image per month. These data are used for researches on topics as diverse as the seasonal monitoring of land cover, the characterization of agricultural practices, water management issues in agriculture, the estimation of carbon fluxes, oak decline monitoring or the improvement of the yield of sunflower. Most studies are performed in the frame of partnerships with users. These various studies allow us to emphasize some conclusions which might be of interest for Sentinel-2 mission. The first general conclusion is that the availability every month of a clear image with 10 to 20 m resolution opens new a number of new possibilities for research and applications. The second is that systematic coverage over large areas is of paramount importance for actors who are often managing geographic or administrative areas larger than a single satellite scene. Third,
systematic satellite imaging from year to year leads to the building of archives that prove useful for addressing issues such as land cover and land use changes, evolution of crop rotations, forest decline and so on. All these applications are based on image time series which imply that excellent image co-registration and radiometric corrections are required. However, despite its major interest, Sentinel-2 will probably be insufficient for the most demanding applications, typically the ones which would require one cloud free image per week or decade. In addition, the acquisition of one clear image per month is not granted in cloudy regions, even when two satellites will be in orbit. This means that in some cases other satellite data will be required to complement Sentinel-2. We will summarize the different ways to solve this issue, which may involve other high resolution optical data (e.g. SPOT, LDCM), radar (e.g. Sentinel-1), and medium resolution images (e.g. Sentinel-3, Proba-V).
Land Surface Phenology retrieval and biomass production anomaly detection in semi-arid systems for food security monitoring. Methods and application to the case study of the Horn of Africa.

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Keywords: Low Resolution Earth Observation Data, Land Surface Phenology, Food Security, Horn of Africa

Abstract: The Horn of Africa (HoA: Ethiopia, Somalia, Eritrea and Djibouti) is notorious for its high risk of food insecurity, which originates from a combination of agro-climatic limitations such as aridity and decreasing soil fertility, socio-economic factors (agriculture based economies with large demographic growth rates) and high risk of conflict. In this context, agricultural monitoring and early warning is of great importance for both emergency response and longer term development projects. Various organizations, both in the USA (e.g., FEWS NET) and in Europe (e.g., JRC-MARS FoodSec) apply remote sensing (RS) techniques from space to generate frequent crop status reports that are regularly transmitted to donors and decision makers. Such reports assess two key issues: the overall production of crop and pastures during the most recently concluded growing seasons and the status of the ongoing one. In this study, we address the first issue and we outline a method to objectively assess the characteristics of concluded growing seasons on the basis of RS data only. A few key numerical indicators, derived from a statistical analysis of time series of observations from space, characterize the spatial and temporal evolution of successive growing seasons. These indicators, together with a simplified light use efficiency approach, are used to compute a proxy of the yearly gross primary production (GPP). Vegetation conditions and associated risk of food deficit are derived from a comparison of these yearly values with their long-term averages. In practice, processing proceeds in two main steps: the first one consists in characterizing the Land
Surface Phenology (LSP) by computing key indicators, such as the dates of the start (SOS) and end (EOS) of each growing season, using the Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) estimated from the SPOT-VGT instrument, for the period 1998 - 2011, at a spatial resolution of 1 km. The numerical algorithm consists in fitting a model to the yearly time series to derive key LSP parameters, and was designed to meet the following constraints: (i) it must not require any a priori information regarding the type of seasonality (mono- or bi-modal); (ii) it must be applicable to large areas experiencing significant spatial and temporal variability; and (iii) it should yield relatively robust results in the presence of a variable number of missing observations. In the second step, FAPAR values are integrated over time between the start and end of each growing season, to obtain a proxy of the yearly GPP. These values are then compared to the long-term average for the same locations, and probable causes for the deviations (especially drops in GPP) are identified, such as a delayed start or an early end of season, or a lower than usual FAPAR peak, etc. This method is exploited to document the impact of year-to-year climatic fluctuations in the HoA, which has witnessed an increasing frequency of vegetation stress periods over the last 30 years, culminating in the severe 2010-2011 drought.
Estimating crop biomass and evapotranspiration using high resolution multisensor remote sensing data

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Keywords: Crop model, Green Leaf Area Index, Biomass, Evapotranspiration, High Resolution Remote Sensing

Abstract: Crop modelling is an important tool for agricultural research and management. Crop models are able to simulate plant development, growth and yield. When combined with high resolution remote sensing data, these models provide new perspectives for crop monitoring at regional scale. In this work, we present an approach to estimate the time courses of aboveground biomass (AGB) and Evapotranspiration (ETR), for both summer (maize, sunflower and soybean) and winter crops (wheat and rapeseed) using multi-temporal high resolution satellite images from Formosat-2 and SPOT sensors.

Only high spatial resolution data can provide enough information for efficient crop monitoring applications, but until nowadays the revisit frequency was too low relative to the short period of active crop growth. New satellites, like the existing Formosat-2 and future Venuś and Sentinel-2 systems combine or will combine both the high spatial and temporal resolutions required for those applications. Nevertheless, cloud cover may still be a strong limitation and data from different sensor systems sometimes need to be combined.

A unique set of Formosat-2 and SPOT images (107 images) and in-situ measurements were taken through 2006 to 2010 over a study area located in southwest of France. Green Leaf Area Index (GLAI) is a variable that has a key role in soil-plant-atmosphere interactions and in biomass accumulation process. In this study seasonal dynamics of GLAI are estimated from multi-temporal remote sensing NDVI from Formosat-2 and SPOT data. The modelling approach is based on the FAO-56 method coupled with an agro-meteorological model based on the light-use efficiency theory of Monteith: Simple Algorithm for Yield and Evapotranspiration estimate (SAFYE, Duchemin et al., 2005). The SAFYE model is a daily time step model that simulates time series of GLAI, dry aboveground biomass, grain yield and ETR. Crop and soil model parameters were determined using both in-situ measurements and values found in the literature. Phenological parameters were calibrated based on the GLAI calculated from satellite data. The calibration process led to accurate spatial estimates of GLAI, ETR as well as of AGB over the whole image (24x24 km² window).

The results highlight the interest of using a combined approach (crop model coupled with high resolution remote sensing data) for the estimation of agronomical variables. At local scale, the model reproduced correctly the biomass production and ETR for summer crop fields (with relative RMSE of 29...
Generating crop masks for the EU through LUCAS data, Corine, and SPOT NDVI-imagery

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Keywords: SPOT NDVI, LUCAS, Corine, Crop mapping

Abstract: Recently, about a quarter of a million land cover data collected through the LUCAS project, at systematically pre-defined sample points, became available. These data paved the way, through an upscaling process, to generate reference crop-masks (maps) covering systematically the whole territory of the EU, as e.g. required for improved crop monitoring (MARS project; requiring what is where maps), setting a benchmark for future change specifications, or to support annual surveys to establish variability in crop areas planted and to subsequently generate improved annual crop area statistics. For the process of upscaling, the point data required to be correlated with a classified spatial product, generated from hypertemporal imagery that was assumed to have captured both spatial as temporal variability of actual land cover. Through the use of NDVI data of the SPOT-VGT archive, that captured differences in land cover phenology, density, and followed crop calendars at a 1km spatial resolution this feat could be accomplished. Additional use through data-mining of the most recent Corine map of the EU, which specifies where broad land use categories are practiced, though without specifying the actual crop species cultivated, proved very useful to achieve a final set of crop maps that adhere to the high producer as user accuracy requirements set by the authors. The generated temporal NDVI-profiles that link to areas where a crop is grown, the practiced cropping calendar can be deduced. Factual survey data on planting and harvesting periods remain to be integrated into the legends of the produced crop maps to make them truly comprehensive.
Optimization of RapidEye time-series for annual inventory of the agriculture land at country level

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Keywords: Common Agriculture Policy, Land cover, RapidEye, time-series, Self-Organizing Maps, object-based analysis

Abstract: In order to develop a methodology for an efficient annual state-wide inventory of the agriculture land, eligible for direct payments under EU CAP (Common Agricultural Policy), the suitability and reliability of multi-temporal remotely sensed imagery from the RapidEye constellation were evaluated to capture agriculture land cover types. The initial analysis of the classification results over several test zones within Bulgaria indicated that multi-temporal RapidEye imagery is suitable for identification of agricultural regions at relatively large-scale, and provides accurate quantification of major land cover types, necessary for the inventory of the land in good agriculture conditions in Bulgaria (Tapsall et al., 2010). Additionally, for semi-automatic data extraction and classification, an effective prototype tool based on a hybrid method (SOM+OBIA), combining pixel-based unsupervised classification (using self-organizing maps) with object based image analysis was developed (Taşdemir et al., 2012).

As a follow-up, this study aims to analyse and clarify some crucial aspects of the possible future operational deployment of this land monitoring system. If an operational system for inventory of agriculture land at national scale is to be established, the use of multi-temporal imagery as a source data would indeed be essential. However, the acquisition of several cloud-free time series in the active cultivation season may be hardly feasible, when entire state is considered. Therefore, it is essential to estimate the relevance of each acquisition made during the crop calendar, and determine the least number of required imagery providing the best performance, without a significant decrease in the classification accuracy. The recently developed SOM+OBIA approach serves as a successful tool to optimize the amount of input data needed for an acceptable level of correct classification.

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Keywords: NDVI, pasture insurance, NDVI evolution

Abstract: From 2001 a Pasture Insurance System has been established in Spain based on the temporal analysis of the pasture NDVI. The cornerstone of the system is the long NOAA image series coming from 1983. From these images, a standard NDVI evolution curve was determined for each pasture area in Spain. The NDVI values were the decadal MVC for each one of the 36 decades of the year. Each one of the points of this standard evolution curve was the average value of the 18 years from 1983 to 2001, and each one of them had its own standard deviation. The key point of the insurance system is the comparison between the current NDVI value and the standard NDVI value minus a factor $f$ multiplying the standard deviation $\sigma$: in case that the current NDVI value is lower than the NDVI value minus $f\sigma$, then the insured cattle owners are paid. From 2005 the used NDVI values are those from MODIS, and the NDVI standard curve was adapted to these new values. Some operational problems and results will be shown.
Assessing vegetation response to climate variability

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Keywords: climate variability, vegetation response, bivariate time series, NDVI, precipitation, soil moisture, temperature, evapotranspiration, SPOT-VGT, AVHRR

Abstract: A better understanding of the impact of climate variability on vegetation is required for inventorying land use-related carbon emissions. Indeed, identifying the relation between climate conditions and vegetation response is a preceding step to quantifying the relative contributions of human interventions and natural phenomena on vegetation cover and ecosystem carbon stocks. A generic approach is to combine remote sensing-derived information about the vegetation cover status with meteorological data for a corresponding period and study area.

To date, the most common approach consists of correlation analyses between NDVI time series and precipitation data. The strength and the lag of the correlation between monthly, seasonal or annual NDVI values and rainfall depths are examined and spatially related to various environmental conditions, such as soil and vegetation types.

Previous studies have attempted to adequately describe and map the forcing effect of precipitation on vegetation growth by utilizing standardized NDVI and precipitation anomalies or accumulated rainfall over variable time spans. However, off-site and lag effects may be better accounted for using a different indicator of climate variability. Therefore, confining oneself to precipitation as a proxy for climate conditions is being challenged in this research, and improvement is aimed by exploring the comparative performance of other variables for correlation analysis. At this stage, NDVI is withheld as vegetation status indicator. Soil moisture content, air temperature and potential evapotranspiration are tested along with precipitation for their correlation with the NDVI signal. Since the soil pore space can be regarded as a buffering reservoir for precipitation, a more instantaneous and site-specific correlation with vegetation growth is hypothesized for this variable. Similarly, temperature and potential evapotranspiration represent largely the atmospheric conditions affecting vegetation growth.

A regional block of countries in East and Central Africa serves as the study area, covering a range of climate zones, vegetation types and topographies, and displaying extensive land use changes. An integrated 30 year time series of 10-daily NDVI products are available from SPOT-VGT and NOAA AVHRR archives. Meteorological data series are retrieved from assimilated global datasets. Correlations are calculated as linear regression coefficients from the bivariate time series for each pixel, assuming stepwise increasing time lags. In this way, the optimal lag is assessed per pixel, and
the corresponding correlation coefficients are retained. Preliminary results will be presented, visualizing the spatial distribution of the observed sensitivity of NDVI values to variability in precipitation, soil moisture content, air temperature and potential evapotranspiration. The scale at which the utilized data describe the concerned phenomena is crucial to the interpretation of the outcome, and verification at larger scale using higher resolution NDVI and meteorological data will constitute follow-up research.
ANALYSIS OF VEGETATION RESPONSE TO CLIMATE VARIABILITY USING EXTENDED TIME SERIES OF MULTISPECTRAL SATELLITE IMAGES

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Abstract: Satellite observations of the terrestrial biosphere cover a period of time sufficiently extended to allow the calculation of reliable climatologies. The latter is particularly relevant for studies of vegetation response to climate variability. This chapter reviews studies done by the authors since the late 80-s on the use of time series analysis techniques to extract concise information from extended time series of large area multispectral satellite data. Two basic methods have been used: the Fast Fourier Transform, especially in the earlier studies, and Harmonic Analysis in more recent work. Since the first studies, work has been relying on the global radiometric data collected by AVHRR and later on MODIS, as well as it has been performed in different continents. The applications supported by published results are: a) the identification and mapping of zones characterized by a similar response of terrestrial vegetation to environmental forcing; b) the determination and characterization of terrestrial vegetation response to climate variability over any period of time covered by available time series of satellite data; c) early warning of anomalies detected during the growth of terrestrial vegetation by using indicators of photosynthetic activity such as NDVI and fAPAR. Selected parameters obtained by FFT and HANTS analyses i.e. the 1-year, 6-months and the 9-years amplitudes as well as the 6-months phase images are closely related to the distribution of vegetation types and can be applied for image classifications based on temporal dynamics of the vegetation at regional and continental level. The dependence of the NDVI Fourier spectra on climate variability in time and space has been established quantitatively. Such correlation was stronger in the spatial domain than in the temporal domain, suggesting that the Fourier spectra can be used as a measure of resilience of vegetation to interannual climate variability. The results on quasi-real-time monitoring and early warning of droughts are preliminary and much remains to be done on issues such as filtering and gapfilling of time series as well as on the accurate and timely detection of anomalies.
Long term consistent global GEOV1 AVHRR biophysical products

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Keywords: LAI, FAPAR, FCOVER, Biophysical variables, Long-term time series, Global products, Consistency, AVHRR

Abstract: Long term global terrestrial vegetation monitoring from satellite Earth Observation system is a critical issue within global climate and earth science modeling applications. A set of Essential Climate Variables was identified as being both accessible from remote sensing observations and intervening within key processes. Among those related to land surfaces, LAI (Leaf Area Index) and FAPAR (Fraction of Absorbed Photosynthetic Active Radiation) may be derived from observations in the reflective solar domain. These vegetation biophysical variables play a key role in several processes, including photosynthesis, respiration and transpiration. LAI is defined as half the total developed area of leaf elements per unit horizontal ground area. It controls the exchanges of energy, water and greenhouse gases between the land surface and the atmosphere. FAPAR is defined as the fraction of radiation absorbed by the canopy in the 400 - 700 nm spectral domain under specified illumination conditions. It is one of the main inputs in light use efficiency models. The cover fraction (FCOVER) defined as the fraction of background covered by green vegetation as seen from nadir appears also a very pertinent variable that can be used when separating the contribution of the soil from that of the canopy. The Bio-geophysical Parameters (BioPar) service within Geoland2 project (http://www.geoland2.eu) aims at developing pre-operational infrastructures for providing global land products both in near real time and off-line mode with long time series. In a first stage of the Geoland2 project, LAI, FAPAR and FCOVER variables were derived from VEGETATION data (GEOV1/VGT) for the period 1999-2010. Expanding VEGETATION archive back in time is only possible using the Advanced Very High Resolution Radiometers (AVHRR) onboard the NOAA 7-14 series satellite platforms, which is operational since July 1981. This contribution describes the Geoland2 algorithm for generating LAI, FAPAR and FCOVER products from AVHRR Long Term Data Record (LTDR). These biophysical variables are produced globally for the 1981-2000 period at 0.05° spatial resolution and 10 days temporal sampling frequency. The algorithm aims to ensure robustness of the derived long time series and consistency with the ones developed in the recent years, and particularly with GEOV1/VGT, to capitalize on the efforts accomplished and get a larger consensus from the user community. The approach is based on the capacity of neural networks to learn a particular biophysical product (GEOV1/VGT) from reflectances from another
sensor (AVHRR normalized reflectances in the red and near infrared bands). Outliers due to possible cloud contamination or residual atmospheric correction are iteratively eliminated. Prior information based on the climatology is used to get more robust estimates. A specific gap filing and smoothing procedure was applied to generate continuous and smooth time series of decadal products. Finally, quality assessment information as well as tentative quantitative uncertainties were proposed. The comparison of the resulting AVHRR LTDR estimates with actual GEOV1/VGT product demonstrates that they are very consistent, providing continuous time series of global observations of LAI, FAPAR and FCOVER for the last 30-year period, with continuation after 2011.
Use of GEOV1 climatology based on 11 years of consistent observations

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Keywords: LAI, global change trend climatology

Abstract: Vegetation plays a key role in the climate system as well as for providing vital food, fiber, fuel and fun to humans. Vegetation is reciprocally subjected to strong climate and anthropogenic pressure resulting in changes that need to be documented through few quantitative diagnostic variables. The leaf area index (LAI) and fraction of photosynthetically active radiation absorbed by the vegetation (FAPAR) have been recognized as essential climate variables (ECV) required for describing the climate system. Global and frequent remote sensing observations have started in 1981 with the AVHRR series, then relayed since the 2000’s by a new generation of sensors such as VEGETATION, MODIS and MERIS with improved spatial, spectral and radiometric performances. Estimates of LAI and FAPAR have been derived in a consistent way from these sensors at a 10 days time step and 1 km (since 1999) to 4 km (since 1981) spatial resolution. The basic principles of these products called GEOV1 are shortly presented and their performances compared successfully with other existing products and ground based measurements using the guidelines proposed by Land Product Validation group within CEOS. The global changes over the last 10 years are finally analyzed using the LAI product by accumulating the data for each dekad across the available years, and extracting a linear trend while smoothing out the confounding inter-annual variability. Results show that many areas are subjected to a significant trend corresponding either to a change (positive or negative) in vegetation amount or in a shift in the seasonality. These changes are correlated with the evolution of temperature conditions. Conclusions are drawn on the limits and possible improvements of the method used as well as on further confrontations with global vegetation models and consistent continuation of the series with the coming S3, VIIRS and PROBA-V sensors.
MAPPING AIR TEMPERATURE BY FOURIER ANALYSIS OF LAND SURFACE TEMPERATURE TIME SERIES OBSERVED BY TERRA/MODIS

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Abstract: Characterization of the spatial patterns of air temperature (Ta) is needed in a wide spectrum of environmental studies, especially when complex landscapes are investigated. In some cases the limited areal density of meteorological stations limits the use of the ordinary interpolation methods (i.e. Kriging, Multiple Linear Regression, IDW). In this work, an alternative approach for spatial interpolation of maximum near surface air temperature has been implemented employing time series of Land Surface temperature (LST) image data. The method was tested employing LST daily observations (overpass around local noon) from TERRA/MODeate-resolution IMaging Spectroradiometer (MODIS) in 2000-2006 over an area of about 200 km² in the "Telesina" valley in Southern Italy. The starting point of the procedure consists in normalizing spatial variability of LST with observations at a reference location(s). Therefore, the time series of the ratio images of LST at each pixel to LST at a reference point have been calculated. Then, in order to evaluate the interannual variability, harmonic analysis has been applied to model with a Fourier series the pixel-wise ratio images for each year. The temporal stability, i.e. limited interannual variability, of the Fourier coefficients has been verified by means of a variability index to conclude that their mean values are sufficient to characterize the annual temporal profile of the pixel-wise ratio. The second step was the identification of a linear relation between air temperature and surface temperature using near surface temperature measured at the available ground stations. A unique relation Ta vs LST has been established for the area under study. The inverse relation (LST vs Ta) has been established at the reference location. Finally, the model of the time series of normalized LST was combined with the regression coefficients to obtain Ta(x,y,t) as a function of LST(x0,y0,t). Air temperature data at the nodes of a 35 km grid for past (1961-1990), present (2000-2010) and future (2021-2050) scenarios have been provided within the project Agroscenari. The future scenario was derived from a statistical downscaling technique of global circulation models (GCM) outputs. These data were used as reference locations. The procedure was assessed against maximum air temperature measured at the four ground station available in the study area for the period 2000-2006. RMSE was calculated for daily maximum temperature, for 5 and 10 days moving average showing variations respectively in the ranges of 3.2 K - 3.9 K, 1.7 K -2.1 K and 1.5 K -2.0 K. The procedure has been also validated against the fully independent air temperature data for the period 1961–1990. Further, downscaling of future scenario maximum temperature from 35 to 1 km spatial resolution has been performed.
Regression analysis of land surface temperature, air temperature and gaseous air pollutants: a combined approach of using Landsat TM imageries and ground data

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Keywords: Urban heat island, land-use/land-cover changes, urban environment, urban modelling, NDVI

Abstract: This study assumes that besides innate environmental factors in an urban area like land-use/land-cover (LULC), transportation infrastructure and air temperature (AT), the gaseous air pollutants are also correlated with the Land Surface Temperature (LST) of an area. The relationship of the LULC with the LST has been well-established by several studies but its relationship with the AT and concentration of pollutant gases in an urban environment remain largely unexplored. This study computes the LST using Landsat TM imagery, by making use of the Landsat TM thermal band and computing Normalized Difference Vegetation Index (NDVI) by utilizing radiometrically corrected Landsat TM bands 3 and 4. Multiple regression modeling was used to reveal how the LSTs were related to the concentration of gases like Carbon monoxide (CO), Sulphur dioxide (SO2) and Ozone (O3) in addition to that with AT (data), obtained from ground observations.

The city of Lahore, Pakistan was chosen as an example of a rapidly expanding megacity of the developing world in South Asia. Lahore with its 10 million population presents a unique case for this study having a compact urban agglomeration and surrounding agricultural landscape. This city features a hot semi-arid climate having extremely hot, long and rainy summers; mild winters remain relatively dry. Thus presenting an excellent case to investigate the set objective. Results show a positive correlation of AT with LST, while a negative one with NDVI. Although not widely regarded as major greenhouse gases, the concentration of the pollutants under observation collectively show usefulness in predicting the variability in LST (R²=0.878). Individually SO2 shows positive correlation (R=0.526) while the other two gases show negative correlation (CO R=−0.394, O3 R=−0.124) with LST. The LULC and the amount of vegetation still remain the largest determining factors in the formation of the Urban Heat Island (UHI) of a city and atmospheric parameters show some relationship with the phenomenon, inclusion of more variables (e.g. Nitrogen oxides) into the equation and high density data will help in reaching more concrete conclusions.
Multitemporal Remote Sensing for Analysis of Relationships between Land Cover and Land Surface Temperature in Ten Megacities

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Abstract: In the 1950s, there are only two megacities in the world. As of 2011, there are 21 megacities globally. Urbanization causes land use and land cover change that leads to environmental degradation and altogether affects the climate. Urban climate, known as urban heat island (UHI), is characterized by its significant difference in climate variables from surrounding rural areas. The impact of UHI is not just the higher temperature, it slowly changes other meteorological indicators so that precipitation rates grow, additional showers and thunderstorms may occur as well as fogs and clouds. Additionally, UHI has a huge impact on health and well-being of the city’s citizens. The objectives of this research are to investigate the relationships between landuse and land cover (LULC) types and land surface temperature in selected megacities around the world and to analyze how the relationships change over time using multitemporal remote sensing. For each megacity, Landsat-5 TM and Landsat-7 ETM+ images from the same season with 10-year time span are collected. Pre-processing include geometric correction and radiometric normalization of the image pairs. The images are then classified to extract LULC types using a supervised classifier. Land surface temperature is then calculated using the thermal bands of Landsat 5 7 imagery. The digital numbers in the thermal images can be converted to radiance and then to temperature in Kelvin degrees. The temperature map will be multiplied (overplayed) by LULC classification in order to derive the temperature of the LULC types. The relationship between landuse and land cover types and land surface temperature in each megacity will be analyzed. Land cover change for each megacity will be performed and from-to changes will be identified. The final results will provide the possibility to analyze both the LULC types change over time and how the surface temperature change in the areas where land cover change occurred.
Characterisation of time-frequency significant events in satellite-derived Sea Surface Temperature time series from 1985 to 2009

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Keywords: sea surface temperature, trend, significant event, data mining, clustering

Abstract: We propose here to extract significant events from time-frequency representation of 2D Sea Surface Temperature (SST) anomaly time series at global scale using the AVHRR pathfinder v5.2 dataset. We first remove the climatological mean from each time-series and estimate its wavelet power spectrum using 56 scales between 0.4 and 10 years. Events are identified automatically on the significant part of the power spectrum compared to a local red noise theoretical spectrum. Each event is described using its mean and max energy value, its coordinates in scale and time and the two axes of the ellipse that encompasses the phenomena. More than one hundred thousand events are extracted from 1985 to 2009 and the SST dataset that was previously regridded at 1 degree of spatial resolution, describing the main anomalies that occured in the SST at different scales.

In a second step, a clustering method, based on an expectation maximisation algorithm, is applied to the event database to extract main features. Global maps of main features are proposed showing interesting patterns at different scales.

In a third step, we try to describe the global distribution of the low frequency main features. We show therefore a preliminary analysis of the interactions between the low frequency observed events and well known climate indexes such as the Multivariate ENSO Index (MEI), and the North Atlantic Oscillation (NAO).

Finally we argue on the interest of such data mining approach compared to the common EOF-T analysis in climate analysis.
MODELLING NDVI TIME SERIES TO FILL GAPS OF METEOROLOGICAL DATA

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Keywords: NDVI time series, fourier analysis, bioclimate, multilinear regression, phenology, Argentina

Abstract: We studied the use of a foliar phenology measure to interpolate climate statistics, in areas where meteorological observations are sparse, to produce a bioclimatic classification for a vast plain in central western Argentina. As a measure of foliar phenology, we used parameters obtained by modelling NDVI time series with a Fast Fourier Transform (FFT) applied to a 9-year time series of monthly National Oceanographic and Atmospheric Administration (NOAA) advanced very high resolution radiometer (AVHRR) NDVI global area coverage (GAC) images. The FFT decomposes the series into an average signal and to sinusoidal components (new images). The selected FFT parameters (trough amplitude contribution to total amplitude variance) were mean NDVI, amplitude and phase for a 1-year period. Climatic data were annual rainfall (P) and mean temperature (T) expressed as Potential Evapotranspiration (ETP) estimated by an empirical equation (ETP = 68.64 T). The ratio P/ETP was related to the FFT parameters through fitting a multiple linear regression model with P/ETP as predicted variable and the FFT parameters as predictive variables. The regression model, that explained 92
Monitoring environmental change in the Andes based on low resolution time series

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Keywords: NDVI, SDVI, SPI, SPOT-Vegetation, NOAA-AVHRR, MODIS, trend analysis, environmental change, Andes

Abstract: Environmental change is an important issue in the Andes region and it is unknown to what extent the ongoing processes are a consequence of human impact and/or climate change. The objectives of this research are to study vegetation dynamics in the Andes region based on time series analysis of SPOT-Vegetation, NOAA-AVHRR and MODIS derived NDVI at low spatial but high temporal resolution, and to recognize to which extent this variability can be attributed to either climatic variability or other, e.g. human induced, impacts through assimilation of satellite derived NDVI and rainfall data. Monthly rainfall estimates were available from the European Centre for Medium-Range Weather Forecasts (ECMWF) through MeteoConsult and the Monitoring Agricultural ResourceS (MARS) unit. Deviations from the ‘average’ situation were calculated for the NDVI time series using the Standardized Difference Vegetation Index (SDVI) and for the precipitation time series using the Standardized Precipitation Index (SPI). Correlation analysis between NDVI and SPI is performed in order to identify the temporal scale at which the environment is most sensitive to precipitation anomalies, the so-called ‘best lag’. Trends in SDVI and SPI are investigated using least square linear regression and non-parametric methods, taking into account the accumulated rainfall anomalies over the best lag. Hot spots of non-climate related environmental change are detected by subtraction of the precipitation induced signal. The model can be used to predict possible effects of climate change in areas with vegetation dynamics most sensible to trends in precipitation.
Fusion of Multitemporal Multi-Angle ENVISAT ASAR and HJ-1 Data for Object-based Urban Land Cover Classification

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Keywords: data fusion, image segmentation, land cover mapping, urban

Abstract: The key goal of this work is to analyze the synergy effects of multitemporal data fusion for urban land cover and land use mapping. In particular this analysis is carried out using multitemporal ENVISAT ASAR images and one Chinese HJ-1 optical image over Beijing. The SAR images were acquired in multiple incidence angles (IS2, IS4, IS6 IS7) and two look directions between May and October, 2009 while the optical image is from May 12th, 2009. The major land cover classes are high-density built-up areas, low-density built-up areas, roads, airports, forests, parks, golf courses, grass/pasture, crops, bare fields and water. To evaluate the synergy effects, land cover classifications are carried out and the quality of the classification results is assessed for comparison. Fusion of the HJ-1 data and various combinations of multitemporal multi-angle SAR data are being compared with SAR and optical data alone. From the individual processing the strengths and weaknesses of the data sources will be highlighted and from the combinations the synergy effects will be presented. The actual processing is divided into three phases, preprocessing, segmentation and object based classification. The preprocessing covers the coregistration and speckle filtering of the SAR images as well as the coregistration of the optical data to the SAR data. To remove speckle, the Enhanced Lee speckle filter is applied on all SAR data. Then image segmentation is carried out using our newly developed KTH-SEG, which is based on Edge-Aware Region Growing and Merging Algorithm. First, edges on SAR and optical data were extracted separately using a Sobel filter and a majority voting approach is used for integrating individual edge images. The edge images are then used in segmentation process to ensure that segments do not grow over edges. In the segmentation step, homogeneous objects of undetermined land cover type are created. Homogeneity is measured by a weighted combination of change of mean and change of standard deviation. The classification is then performed using a support vector machine (SVM) which is based on the LibSVM. The classification is supervised and hence training samples need to be selected. The labeled samples are then used to train a SVM based on a radial base function kernel. The trained machine is applied to predict the whole dataset. The created land cover maps are then evaluated against labeled testing sides to verify the quality of classification. The preliminary results show that fusion of ENVISAT ASAR and HJ-1 data performed much better than optical data alone or SAR data alone. The fusion of 4-date SAR data and optical data can achieve similar classification accuracy as the fusion of 8-date SAR data and optical data if multi-angle, dual look direction SAR data with suitable temporal compositions are selected. The comparison of those results shows also that both data sources have completely different characteristics in the confusion matrices. The fusion gives a much better balanced performance over all classes with less outlier.
URBAN SPATIAL AND TEMPORAL CHANGES ANALYSIS BASED ON SPECTRAL, POLARIMETRIC, TEMPORAL, SPATIAL DIMENSIONS AND DECISION LEVEL FUSION

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Keywords: land cover change, multi-temporal, Landsat TM/ETM+, CBERS, PALSAR

Abstract: In order to monitor the pattern, distribution and trend of urban land use/land cover change, it is necessary to integrate polarization, spatial, spectral and multi-temporal remotely sensed data to assess the spatial pattern and dynamics changes of urban area in spatial and temporal dimensions. In this paper, multi-temporal Landsat TM/ETM+ and CBERS optical data, dual-polarized, horizontal-horizontal (HH) and vertical-vertical (VV) PALSAR data are integrated to derive spatial information presented by eight textures variable for HH, HV, and optical bands using Grey-level Co-occurrence Matrix (GLCM) measures, including the mean, variance, homogeneity, contrast, dissimilarity, entropy, second moment, correlation, and then used to generate multi-temporal land cover maps by image classification method and decision level fusion. Finally, more than ten quantitative landscape indices including Number of Patches (NP), Patch Density (PD), Edge Density (ED), Landscape Shape Index (LSI), Mean of patch Area Distribution (AREA_MN), Mean of shape Index Distribution (SHAPE_MN), Mean of fractal Index Distribution (FRAC_MN), Mean of perimeter-Area Ratio (PARA_MN), Patch Richness (PR), Mean of contiguity Index Distribution (CONTIG_MN), Shannon’s Diversity Index (SHDI), etc. are selected to analyse and evaluate the spatial-temporal changes at the patch level, class level and landscape levels respectively. At the mean time, land use and land cover transition matrices are used to assess the dynamic changes trend of different land cover types as well. The results demonstrate the significance of combining multi-temporal optical data, SAR data and texture variables for landscape pattern acquisition. The classification accuracy increased by about 10
Urban change detection by means of multitemporal satellite imagery – the case of the Indian Mega-City Hyderabad

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Keywords: Urban Remote Sensing, Change detection

Abstract: This paper describes the temporal urban monitoring of a large Indian agglomeration by comparing satellite images. The emerging megacity of Hyderabad (India) serves as an example of a rapidly growing agglomeration on the Indian subcontinent with one of the most extremely increasing number of inhabitants during the past decades. Large slum areas exist from uncontrolled and unplanned immigration into the megacities of Asia, partly appearing even within the inner parts of the city, in which humans are living under catastrophic conditions. Additionally strong economic and industrial growth, often in direct neighborhood to populated areas, causes health problems for the adjacent residents within the respective cities. The strength of satellite remote sensing is to structure and classify such large and complex urban areas as well as evaluating their spatial development by change detection studies. Since there are hardly or only very few GIS based map bases for these large cities available in India, the satellite-based remote sensing represents a chance to structure and map such expanded urban residential areas at least approximately into different land coverage or land use classes. For this analysis ASTER (= „Advanced Spaceborne Thermal Emission and Reflection Radiometer“) data with a resolution of 15x15m per pixel was used. The area that has been covered by the data extends over the largest part of the city. In detail the following analysis steps have been conducted: i.e. Multitemporal urban Land Cover/Land Use surface and structure classification analysis, basic urban parameters: degree of imperviousness, extent and quality of green and open areas, urban structure types and brownfields/potential development areas; Examining whether a spatial correlation exists between the results of the different thematic land-use/land-cover analyses and land-cover patterns combined with a vegetation index analysis (NDVI) and Urban Structure Types (UST); and Estimation of spatial indicators for quality of life and vulnerability to natural hazards such as flooding. The scientific results are change maps of the urban agglomeration of Hyderabad between 2001 and 2009 using temporal transects of remote sensing data and applying up-to-date change detection techniques at different spatial and temporal scales. This is used for quantifying urban and peri-urban processes (land use/land cover changes of settlements, agriculture, industry, and landscape) in this urban agglomeration (growth rates, urbanization) and additionally, for predicting the development of urban fringes, rural settlements, informal settlements, urban and peri-urban agriculture. Data of macroeconomic and demographic development, instruments of urban planning, and socio-economic settings have been integrated as data were available.
Urban Mapping Using Multitemporal Very High Resolution SAR Data By A Knowledge-Based SEM Algorithm

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Keywords: Urban Mapping, VHR SAR, SEM, Knowledge-based, Pixel-based

Abstract: The objective of this research is to assess the multitemporal very high resolution single polarization SAR data for urban land cover/land-use mapping using a novel knowledge-based SEM algorithm. Three-dates RADARSAT-2 ultra-fine beam C-HH SAR data were collected over the rural-urban fringe of Greater Toronto Area in June, August and September, 2008. These data were all acquired in ascending orbit with the nominal pixel spacing about three meters. The major land cover/land-use categories in the study area include water body, forest, pasture, several types of crops, golf course, parks, industrial and commercial area, high-density residential area, low-density residential area, construction site, major road and street.

Although object-based approach represents a promising way for processing high resolution data, successful employment of such approach depends on a proper segmentation which is usually hard for the SAR data in complex urban areas. Pixel-based approach, on the other hand, requires efficient means to explore the contextual information for improvement of the classification accuracy and preventing the “pepper-salt” results. In this research, a modified Stochastic Expectation Maximization (SEM) algorithm in combination with rules has been proposed for the supervised classification. In the iteration of the SEM algorithm, the intensity distribution models of various classes were refined and pixels were classified according to the class-conditional Probability Density Function (PDF) formed by the Finite Mixture Model (FMM). In the experiments, alternative SAR intensity distribution models such as Gamma, K, G0 and Fisher were compared for the mapping effects and computing efficiency. The fitness of those models for various classes was also studied by the log-cumulants approaches. To explore the spatial contextual information, an adaptive Markov Random Field (MRF) was employed. Due to the diversity of the texture patterns of various urban land-uses, a set of rules were applied in the decision making process for the further dividing of the urban types. To make it a robust classification strategy, a safeguard criterion is proposed to prevent the well-known degenerative behavior in the SEM process especially when dealing with many classes. Moreover, through parallel computing implementation, such complicated algorithm is competent to deal with large high resolution data set in a short time. After all, the proposed contextual SEM classification algorithm which explores the spatio-temporal information with the knowledge about the urban SAR interpretation could produce the classification results with high accuracy.

To evaluate the algorithm performance, comparisons are made with the classification results from earlier studies using the same data set and multitemporal RADARSAT-2 fine-beam polarimetric SAR data. The preliminary results show that, using this algorithm, homogeneous urban maps could be obtained while the detailed shape features could be preserved. Although the overall accuracy of the single polarization data set is not as good as the one by polarimetric dataset, more details could be identified in the very high resolution results, which show the potential to improve the mapping results with other data sources.
From declassified satellite images to VHR data; temporal analysis of city growth

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Keywords: declassified images, Landsat, VHR, Erbil

Abstract: This paper deals with usage of declassified satellite images from US system Corona (and other orbital systems) for city growth documentation. New type of satellite data for non-military use was possible only after 1972 (Landsat 1, geometrical resolution 80m) but geometrical resolution of about 1m we have achieved at the end of 20th century. For temporal analysis of city growth we require extensive time frame (decades) because the growth in many cases isn’t prominent. Forty years of using civilian satellite data is in many cases not enough (it is necessary to mention that starting in the mid-eighties better data was available from Spot HRV or Landsat TM instruments); a lot of cities have rapidly changed after 2nd world war. Due to these changes the declassified satellite images from the sixties and the seventies prove to be a very good information source. During 2006-2009, GemaArt Company (in cooperation with Czech Technical University in Prague, Czech Republic) has carried out five expeditions to Erbil with the aim of basic monument documentation, archaeological investigation and finding of appropriate technology for object restoration. In Iraq, there are no photogrammetric aerial images at disposal; and as such very high-resolution (VHR) satellite images have been used. In our project (in addition to many other activities) we focused on the city of Erbil in Iraqi Kurdistan. Erbil is an ancient, originally Sumerian and Assyrian city located in the foothills of the eastern Iraqi mountains, and it is a commercial, cultural, agricultural and administrative centre of the Kurdish region. In the historic centre of Erbil, there is a worldwide known historical monument: citadel Al-Qala. The Citadel in Erbil is on UNESCO’s list of the world’s most endangered historic sites. A vast complex of buildings and narrow streets enclosed by town walls forms it. The Citadel in Erbil is one of the oldest continuously inhabited urban settlements in the world. In 1947 the city had only 40 thousand inhabitants; nowadays it has more than 1 million and the detailed development can be difficult to monitor. Many historical objects were destroyed or changed. Especially in non-developed countries, the growth of cities is very rapid and there are not precise urban plans, maps or documentation. Processing of historical and on-going satellite images can solve this problem.
Multitemporal image analyses for monitoring the dynamics of urban vegetation in response to rapid urbanization in Karachi

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Keywords: Landsat TM, change detection, urbanization, urban ecology, land use/land cover change, supervised classification

Abstract: Karachi city has experienced a tremendous population growth and urban sprawl during last few decades, resulting in increased burden on natural resources. The vegetation covers amongst these natural resources are being replaced largely by built-up land for residential and commercial purposes. The impact of urban growth has been so rampant that the agricultural areas of Karachi (e.g. Malir and Gadap) are now at the verge of desertification. Nevertheless, the urban green spaces within the metropolitan city are deteriorating putting human health and wellbeing at stake. These rapid changes are difficult to be monitored through classical field methods. A multitemporal geo-registered image analysis is an effective method for monitoring the land use/land cover (LULC) changes, including the vegetation structures. The objective of this study is to monitor the temporal changes in urban LULC to determine the possible reasons for the deterioration in vegetation covers. It was done by simplified change detection techniques (pixel by pixel) to develop the LULC maps with particular focus on built-up land and vegetation covers. A series of geometrically and atmospherically corrected Landsat TM images (i.e. for the years 1989, 1992, 1999, 2009) of Karachi city were selected for this purpose. Supervised classification technique was used for LULC classification and the nearest neighbourhood algorithm was applied. Maximum Likelihood Classification (MLC) strategy was used to maximize the probability of correct classification. Seven LULC classes namely densely built-up, sparsely built-up, water bodies, urban vegetation, agriculture, mangroves and barren land/open space can be identified by the differences in spectral wavelengths. All types of green space (parks, playgrounds, street trees) within the city were placed in the category of urban vegetation because the main objective was to monitor the net change to the green/vegetative areas. Agricultural activities are mainly located outside the metropolitan area, therefore considered as a separate landuse class of specific purpose. Nevertheless, the mangroves along the coast line were considered as a separate yet natural ecosystem. All these classes collectively served the purpose of observing the change to green structures against urbanization in general. Precise training areas were identified for each informational category. An overall accuracy from 110 reference data was 83.5
Nighttime imaging spectroscopy as a potential tool for urban-scale detection of aerosol pollution events

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Keywords: imaging spectroscopy, air pollution events, urban scale

Abstract: Spatiotemporal variations of fine ambient aerosols near the ground are important indicators for air pollution events and public health risk assessment, especially the diurnal dynamics of aerosol size resolved concentrations and composition at urban-scale resolution. Satellite remote sensing is one major approach for gathering spatiotemporal data regarding aerosol events (e.g., MODIS), however, it is limited to daytime and has limited revisit periods, and limited spatial resolution. Ground remote sensing is a promising approach for two purposes: (a) monitoring air pollution episodes at high spatiotemporal resolution, in particular, pollution by fine aerosols (suspended particles smaller than 2.5 psy"6Dm), and (b) serving as a reference methodology for validation of satellite remote sensing products. Our study objective was to develop a versatile ground remote sensing procedure for monitoring size resolved concentrations of fine aerosols along urban scale open paths. A ground hyperspectral camera that is sensitive to the visible-NIR range (400-1100nm, 180 channels) was implemented, as such spectral range corresponds to spectral signatures of urban aerosols of different size modes having diameters of 0.2-2 microns. We focused on developing a night-time remote sensing measurements which are currently unavailable. For that purpose we used emission signals from remote artificial illumination, such as street lamps, instead of using reflectance signals from land cover targets. Such procedure offers a new concept for simultaneous measurements of aerosols in multiple ambient air columns under scarce solar radiation conditions. Imaging spectroscopy was experimented with a halogen source, showing highest sensitivity to radiance attenuation by aerosols, i.e., aerosol optical thickness (AOT), in the 550-900 nm spectral range.
Radiometric calibration demonstrated linear response of the hyperspectral CCD that allows for a straightforward conversion into spectral radiance and measurements of aerosol optical thickness. Measured hyperspectral AOT signatures of controlled aerosol concentrations were found comparable to signatures obtained by forward modeling of radiation scattering by particles (Mie scattering). Specifically, it was found feasible to acquire distinctive signatures for various mixtures of aerosol modes. The hyperspectral camera response to controlled emissions of urban-like organic aerosol was demonstrated by time series acquisitions, as well as the remote sensing of none-controlled temporal aerosol events in an urban environment. Radiation response to increase in aerosol loadings over 1 km urban open path was clearly indicated in the acquired time series. The developed methodology was found suitable for remote sensing over open path lengths of up to 4 km. Such a suburban spatial resolution fits the requirements of modern environmental epidemiology studies, which are looking for methodologies to assess the variability in exposure to pollution within urban segments over time.
Improving TIMESAT for processing temporal sequences of satellite data

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Keywords: time series, NDVI, TIMESAT, phenology, seasonality

Abstract: TIMESAT is a software package for processing of time-series of satellite data. The increasing access to high-time resolution data demands new and computationally efficient methods for extracting information from these huge data bases. TIMESAT iteratively fits smooth mathematical functions (Savitzky-Golay filter, or least-squares fitted assymetric Gaussian or double logistic smooth functions) to time-series of noisy satellite data, and extracts key phenological metrics (beginning and end of the growing season, length of the season, amplitude, integrated value, asymmetry of the season etc.) for each image pixel. Specific features are upper-envelope fitting and weighting of observations in accordance with data quality labels. The package has been widely applied for data smoothing and extraction of land surface phenology during the last ten years. However, several challenges remain regarding how to best process the data and how to interpret the resulting parameters. We report on recent work concerning improvements of the TIMESAT algorithms, and work on the development of validation data for benchmark testing of satellite data products. The latter is based on a network of near-ground sensors located across several vegetation types in or in the vicinity of carbon flux towers. Our sensors measure incoming and reflected radiation in red and near-infrared channels for derivation of vegetation indices such as the NDVI. These data are useful for selection and improvement of data fitting algorithms, and for validation of current satellite products. One current development is modification of TIMESAT for handling of data with unequal time steps. This will enable full utilization of daily data from sensors like MODIS, ENVISAT, and Meteosat MSG. Tests against our field measurements will show the degree to which the quality of derived phenology metrics based on daily observations is expected to increase.
Hyper temporal dataset selection of multisource remote sensing images for classification improvement

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Keywords: hyper-temporal, classification, accuracy, commission, automatic algorithm, multisource

Abstract: As acquisition technology progresses, remote sensing data contains an ever increasing amount of information and future projects in remote sensing will give a high repeatability of acquisition. Projects like Venus (CNES) may provide data of a same area every 2 days with a resolution of 5.3 meters on 12 bands (420nm-900nm) and Sentinel-2 (ESA) with 13 bands, 10-60m resolution and 5 days frequency. With such data, process automation will appear crucial. For that purpose, we develop several algorithms to automate image processing (classification, segmentation, interpretation, etc.). In this paper, we will talk about dataset selection and more precisely temporal selection of remote sensing images in order to improve discrimination between thematic objects. A great number of tests showed that classification of a large amount of temporal images does not necessarily give the best results for every class. Thus we want to select the dataset combinations which maximize every class independently by quality indices. The novelties are automatic processes for classification improvement and their coordination: (1) search of the best dataset (for overall quality and single class quality), (2) classification of these data sets and (3) classification fusion of these datasets. New indices are introduced to evaluate and select the best temporal information. A goal of this method is to give discrimination information to users, to help them with reference study to choose the dataset which correspond to their thematic research. The interest of the presented method (selection, classification and fusion) is the possibility to reduce the date number by keeping the same quality for result. We present tests performed on Spot 4/5 (2.5/20m), Formosat-2 (8m), Landsat (30m) and Terrasar-X (3m) images. These tests have the advantage to give a wide range of resolution and data type; they validate the presented process for temporal discrimination improvement. These tests are achieved over an agricultural site located in the South-West region of France. This site is particularly well instrumented with continuous field observations (Regional Spatial Observatory or OSR), allowing accurate training and validation of land cover mapping system.
Dynamic mapping in direct receiving satellite data conditions: calibrating multitemporal data sets for automated knowledge extra

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Keywords: Dynamic mapping, satellite data flow, geometric calibration, radiometric calibration, landcover, landuse, ontologies, knowledge-driven classification

Abstract: In French Guiana a direct receiving facility called "SEAS Guyane" is operating since early 2006, bringing Envisat/Asar and Spot 5 direct receiving capacities for scientific applications. The Cartam-Sat project introduced in 2009 an original standpoint in satellite data processing praxis of ground stations such as SEAS: it aims at producing from the acquisition flow a thematic pre-knowledge flow derived from each image, useful to scientific endusers. This flow is indexed to feed a data base that can then be explored not only using satellite data criterias but also thematic criterias. This paper presents the theoretical background on which the project is built. It details the methods contemplated to operate the changes in paradigms sought by the project. It finally concentrates on the synthetic presentation of the main results obtained to this day.

The paper presents unsupervised processes and algorithms applied to satellite images and shows results of testing and quality assessments on large volumes of imagery. It concentrates on the automation of low-level and semi-elaborated processes useful to the project’s finalities: unsupervised geometric calibration, unsupervised radiometric calibration, and unsupervised ontology driven classifications for semantic calibration of informations useful to endusers.
RECONSTRUCTION OF CLOUD-FREE TIME SERIES SATELLITE OBSERVATIONS OF LAND SURFACE TEMPERATURE

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Abstract: The application of satellite observations is becoming an operational technique for managing water resources at large scales, especially by estimating evaporation (ET). Land surface temperature (LST) is the most critical land surface state variable to assess the partition of available energy between sensible and latent heat flux. In many hydrological budget calculations, daily values of evaporation are needed and in some case diurnal variation of ET is considered. Estimation of daily evaporation is usually done with instantaneous satellite observations of land surface temperature and other land surface variables and by extrapolating the instantaneous evaporation over a day, relying on the hypothesis of a constant evaporative fraction. Observations of land surface temperature (LST) from space often features missing data, positive and negative outliers, abnormal values compared to adjacent observations in time series, due to cloud coverage, malfunction of sensor, atmospheric aerosols, defective cloud masking and retrieval algorithms. Preprocessing procedures are needed to generate reasonable estimates of these gaps and outliers. Hourly LST observations by the Chinese geostationary satellite of Fengyun-2C (FY-2C) have been used in this study which covers the whole Tibetan Plateau from 2008 through 2010 with a 5ps"B45Km spatial resolution. Multi-channel Singular Spectrum Analysis (M-SSA), an advanced methodology in time series analysis, has been used to reconstruct LST time series. The results show that this methodology has the ability to fill the gaps and also remove the outliers (both positive and negative). To validate the methodology, we used LST ground measurements and created artificial gaps. The results show with 63This study shows the ability of M-SSA that uses temporal and spatio-temporal correlation to fill the gaps in LST time series reconstruction.
Cloud-screening from multispectral satellite image time series

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Keywords: satellite images, time series, cloud screening, change detection, feature extraction, kernel methods

Abstract: This paper faces the challenging problem of cloud screening in multispectral image time series acquired by space-borne sensors working in the visible and near-infrared range of the electromagnetic spectrum. Time series from such sensors are a valuable data source for studying the land-cover dynamics at an unprecedented spatial, spectral and temporal resolutions, both at regional and global scales.

However, processing and analysis of satellite image time series poses some challenges that can seriously hamper the operational use of such data. The first basic but important requirement is that all the images that form the series should be perfectly co-registered, as any spatial mismatch between images would produce erroneous results. The other factor that has a critical impact on the results is the presence of clouds in the acquired images. Clouds are one of the most important components of the Earth’s atmosphere affecting the quality of optical signals and, consequently, the quality of further derived remote sensing products.

Therefore, an automatic and accurate cloud screening is essential in order to improve the temporal consistency and the usability of the time series by considering partially cloudy images. This processing stage, which often does not receive the necessary attention, is essential for the temporal analysis of satellite images as the number of images acquired every day makes inevitable that many of them present cloud covers. It is worth noting that an accurate cloud screening providing the exact location of the clouds for all co-registered images of the series allows estimating surface properties from the time profiles of the pixels not affected by clouds.

In this context, the main objective of this paper is to provide new operational tools for masking clouds in time series from Earth observation satellites. In particular, this paper introduces a nonlinear feature extraction method based on kernels for the temporal analysis of satellite images. The proposed approach exploits the high degree of spectral, spatial, and temporal correlation beyond second-order statistics present in the time series. The method generates nonlinear features that enhance changes between acquisitions due to cloud covers compared with the smooth variation in the surface between cloud-free images.

Extracted features with the proposed method enable automatic cloud detection in multispectral time series. The effectiveness of the proposed method is successfully illustrated in a cloud screening application using a time series of Landsat TM images in 2004. Good results obtained confirm the suitability of the approach.
Performance assessment of Spatio-Temporal MAP-MRF Cloud Detection from SEVIRI images

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Keywords: Cloud Detection, Multi Target Tracking, PHD filtering, SMC methods, Maximum A posteriori Probability (MAP), Markov Random Field (MRF), SEVIRI

Abstract: Cloud detection is an important preliminary step in most earth observation procedures, such as fire, sea and urban areas satellite monitoring. In this paper we elaborate on cloud detection from sequences of remotely sensed images. This allows to improve the accuracy of cloud masks by taking into account the temporal relationship between subsequent images. In particular, the estimated positions of cloud volumes can be used for constructing an additional temporal prior term within the Maximum A posteriori Probability - Markov Random Field (MAP-MRF) approach, that, classically, takes into account only the spatial correlation among neighboring pixels. In this perspective, FInite Set Statistics Theory (FISST) has been proven to be a powerful framework for multi-target tracking of clouds, whose number changes across images due to birth, death, merging and splitting phenomena. Its computational effort can be mitigated through the Probability Hypothesis Density (PHD) approximation, that permits viable implementations based on the Sequential Monte Carlo (SMC) methods. The performance improvements achievable through this sequential Bayesian approach with respect to simpler algorithms, such as the region-matching one, are here corroborated by means of analysis performed on real images acquired by the SEVIRI sensor.
Towards a Tracking of Small Scale Eddies Using High-Resolution RADARSAT-2 and TerraSAR-X Imagery

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Keywords: Oceanography, Currents, High-resolution, SAR, Multi-Sensor

Abstract: In previous work we have already shown, that mesoscale surface currents in the Baltic Sea may be detected and measured by tracking natural surface films using SAR-images or optical images or both in conjunction (see [1]). In the frame of this effort, we will discuss the developed algorithms by means of a changing domain: from mesoscale to small-scale. Although we achieved promising results in the mesoscale domain, the extension of the approaches to the study the variability of small-scale eddies is highly challenging.

High resolution radar data provides valuable information on the position of fronts, their origin, peaking, transition and destruction. They will be used to receive statistical and other information about their variability, to observe the formation of meanders along the fronts and their departure with the formation of vortices. Therefore, computer vision algorithms will be developed or adapted to yield results in the field of small-scale high-resolution SAR imagery, based on the approaches presented in [1]. We distinguish between type, form and dynamic characteristics of the phenomena stipulated by a front and observed in its immediate proximity. Thus, jets, spiral eddies, vortical dipoles, internal waves etc. will be analyzed.

The tracking task is only one part of the project "Detection and Tracking of Small Scale Eddies Using High-Resolution RADARSAT-2 and TerraSAR-X Imagery" (DTeddie). The other task is the detection of natural surface films by means of high-resolution SAR image interpretation and complementary in-situ measurement, which will be presented in another EARSeL 2012 contribution by O. Lavrova (Russian Space Research Centre (IKI), Moscow). Inside the DTeddie project, special attention will be paid to dynamics of small-scale fronts in the Black Sea and Baltic Sea. The input of frontal instabilities in the structure formation process will be highlighted.

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MODIS multi-temporal data retrieval and processing toolbox

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Keywords: MODIS, R, open source, multi-temporal, time series

Abstract: The MODIS package is a toolbox for automatic MODIS data retrieval and processing for the programming language R, an open source language and environment for statistical computing. The package functionalities are focused for the download and processing of multi-temporal datasets from MODIS sensors. All standard MODIS grid data can be accessed and processed by the package routines. The package is still in alpha development and not all the functionalities are available for now.

One of the main capabilities is the retrieval of data from remote sources by defining simple spatial and temporal subsets. The retrieval of the data is performed or through a connection to the main MODIS ftp data pools (LP DAAC and LAADS) or through the MODIS Web service based on SOAP (Simple Object Access Protocol). Further it is possible to define user defined sources and make accessible also data within local area network.

As an example, the download of all MODIS (Terra and Aqua) NDVI 16 Days composite at 250 m data covering Austria, is performed by the command getHdf("product="MxD13Q1", extent="Austria")]. To limit the temporal coverage to the year 2005 the user has just to add begin="2005001" and end="2005365" within the function arguments. Once data is downloaded the package holds pre-processing functionalities. The main pre-processing capabilities are, mosaicking, resampling, SDS extraction and bit coded SDS decoding. These are mainly performed by using an interface to the MODIS re-projection Tool (MRT,https://lpdaac.usgs.gov/tools/modis_reprojection_tool) or to the Geospatial Data Abstraction Library (GDAL,http://www.gdal.org/).

The download and the pre-processing on user side can be performed by typing a single function and a few simple parameters. The package defaults are set to fit most of the user needs. This makes it possible to use the functionality of the package without having many skills in the programming language R. Output of the pre-processing are standard format raster files usable in any other software that handles remote sensed images.

For example the generation of a multi-temporal image stack for the year 2005 over Austria using MRT the function is: runMrt(product="MxD13Q1", extent="austria", begin="2005001", end="2005365") this function internally contains the getHdf function that handles the data acquisition. Than using internally MRT the data is re-projected, mosaicked and cropped to a bounding box containing Austria.

The main-processing part (currently not available) contains functions focused on the processing of multi-temporal data sets. Further work on the MODIS package will focus on the smoothing and filtering, trend analysis, change-detection and extraction of phenological parameters.

The package outputs are aligned with the major geospatial R packages, providing so the possibility to benefit from mostly all geospatial tools sets within R.

More details can be found under http://r-forge.r-project.org/projects/modis/
Unsupervised automatic pseudo orthorectification over large SPOT image databases

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Keywords: orthorectification, automatic registration, open source libraries, Spot image, receiving station, very large database, point detection

Abstract: Orthorectification of remote sensed images is a well known issue. However, manually performing this task over a large amount of data could be time consuming or even unthinkable in case of a very large image database. In this paper we introduce an original method for geographically calibrating images, automatically and with no user supervision. Through the SEAS-Guyane Spot image receiving station previous projects produced large scale orthorectified mosaics that we use as a target for the registration process. An elastic transformation mesh is computed using mutual information metrics between the fixed and moving image. The distance error evaluation is processed via the Scale-invariant feature transform algorithm. Open source libraries like gdal, ossim and orfeo toolbox are used to implement the processing pipeline. In this paper we first describe the methodology and the different steps of our algorithm, from the mosaic region extraction to the orthorectification error estimation. In the second part we discuss the limitation of this approach (processing time, sensitivity to changes in the images, resolution differences...) and future possible improvements.
Information Retrieval from Multitemporal SAR Images: Applications to rice crop and forest monitoring

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Abstract: In studying the Earth’s processes from space, the information we seek is very often carried by patterns of change. This is particularly true for synthetic aperture radar (SAR), for which many of the applications (e.g., hydrology, land cover mapping, monitoring of agricultural crops, forests, flood, ice sheets) rely explicitly on the use of multitemporal data. Also, information deriving from repeat pass SAR interferometry and used in advanced techniques such as PolInSAR and TomoSAR explicitly requires multitemporal data. In addition, the availability of multitemporal data can greatly improve the interpretability of single images. However, unlike the case for optical data, the issues in exploiting multitemporal SAR are not to do with missing data, atmospheric correction or varying sun conditions, but arise from the physics of microwave interactions with the surface and the impacts this has on the information content, interpretation and handling of the data. This paper takes a generic approach to the recovery of information from multitemporal SAR data in the context of vegetated land surfaces. This includes vegetation monitoring and parameter retrieval when we have temporal sequences of the backscattering coefficient, or appropriate data for and repeat pass SAR interferometry. First a survey will be given on the physical background for understanding temporal changes of the backscatter in SAR images, and for retrieval of the relevant vegetation parameters based on multitemporal data. While the backscattering coefficient and its temporal change resulting from physical properties of the medium is considered as information–bearing quantities, the speckle effect arising from the coherent nature of SAR data is regarded as a major factor perturbing the information retrieval. Multitemporal data can be used for enhancing the information content of the SAR images and can also provide tools to mitigate the speckle effects. An important property of multitemporal data is that intensity images can be linearly combined to produce unbiased output images with known, minimal equivalent number of looks. The paper will show illustrations on the approach of exploiting multitemporal SAR data for vegetation monitoring. In the first example of monitoring of wetland rice with C-band SAR data, the unique temporal backscatter sequences associated with rice growth is exploited for rice identification and the retrieval of rice parameters. This requires pattern recognition in the presence of both speckle and constraints imposed by the repeat interval of the satellite. In the second example of forest mapping at L-band, we use the multitemporal SAR data to map forest cover and its change over time, and to provide biomass mapping products with an improved spatial resolution as compared with the results using a single image. In addition, the use of multitemporal multi-baselines SAR data in polarimetric SAR interferometry and in Tomographic SAR data for the retrieval of forest height and forest biomass, designed for the future BIOMASS SAR mission will be presented.
Change Detection in Wadden Sea areas using RapidEye data

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Keywords: Change detection, Wadden Sea, Decision tree, Rapideye,

Abstract: The tidal area of the oceans is an important transition zone between terrestrial and marine ecosystems. In contrast to the non-marine surface of the earth, access to the tidal lands of the Wadden Sea is often difficult. For this reason, remote sensing offers important monitoring tools. In this study a new change detection approach is presented, adapted to the Wadden Sea and RapidEye satellite data. It is based on a decision tree and uses spectral characteristics in combination with GIS Information, neighborhood connections, textures and shape of objects. The spectral characteristics are derived from field visits and radiation spectrometer measurements. The Wadden Sea area is determined by using available GIS Information. For vegetation, the SAVI and different texture measurements are used. Mussel banks are located by neighborhoods and texture. In a first step, the image taken at date one is classified using the decision tree method. For the second image taken at date two the decision tree is extended based on the first classification. After classification of the second scene the detected change is calculated and displayed. This approach is fully automated no manual input is necessary to classify and to detect changes in the data. The method is transferable to other areas and other scenes in the Wadden Sea of lower Saxony. The results show an accuracy of over 70
Detecting changes in wetlands of the Maluti-A-Phofung Local Municipality Area, Free State Province (South Africa)

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Keywords: Remote sensing, wetland ecosystems, wetland conservation, time series, change detection, satellite imagery

Abstract: The Ramsar Convention has recognized wetlands as an essential water source and environmental benefit. In ecological, social and economic terms, wetlands are amongst the most valuable and beneficial ecosystems on Earth, offering imperative opportunities for sustainable development. In spite of these values, however, wetlands in South Africa are rapidly being exhausted or degraded as a consequence of human activities. Human activities such as overgrazing and urban development have contributed to the loss of a considerable amount of wetland areas in the Free State Province of South Africa. It is imperative to detect, document and assess changes in wetland health caused by such activities. Alterations in wetland ecosystems additionally need to be monitored over time in order to collect relevant data that will aid in the conservation and management of these sensitive systems. Remote sensing is a valuable tool in this regard as it provides data that is relatively inexpensive and time efficient. Furthermore it makes it possible to obtain land information in the form of multi-spectral and multi-temporal images due to remotely sensed data that can be acquired regularly through satellites and aircrafts, thus making it possible to detect changes in ecosystems around the world. It is for this reason that it has become important in many studies involving ecosystems of the earth, including wetlands ecosystems. When considering the unfortunate state of wetlands existing in South Africa, more specifically in the Free State Province; there are certain regions within the province that need urgent intervention. One such area is the Maluti-A-Phofung local Municipality region of the Eastern Free State. Many of the wetlands situated within this region have been severely affected by overgrazing, as well as other human activities. Such activities have altered the hydrological regime, have caused degradation and in some cases have caused wetlands to disappear. One of the reasons for such disturbances is because it is categorised as one of the highest poverty stricken regions in the Free State Province, with populations that are typically dependent on small towns and farms, and informal trading activities. The people living in these areas therefore depend on natural resources, like adjacent wetlands, for their livelihoods. This research project consequently uses GIS (Geographical Information Systems), field observation, and remote sensing, as well as, change detection methods such as image differencing, image ratioing and change vector analysis (CVA), to detect changes that have occurred over time in wetlands situated within the Maluti-A-Phofung local Municipality region. In order to obtain accurate results; the wetlands found in the “communal” and “commercial agricultural” regions of this area will be compared to the wetlands found in the “protected” areas of the Sterkfontein Dam Nature Reserve and Golden Gate Highlands National Park. The desired results will be achieved by comparing satellite images (Landsat and SPOT images), aerial photographs, as well as land cover maps of the wetlands occurring in each study area for 1994, 2001 and 2009. The images provided for 1994 and 2001 will be obtained by 30m Landsat, and the 2009 image with 10m SPOT 5.
A temporal analysis of Landsat imagery to study the dynamics of land-cover over Lake Kivu region

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Keywords: Land-cover change, Vegetation Change Tracker, Landsat, Forest disturbance, Lake Kivu

Abstract: Situated at the center and highest point of the East-African Rift valley, the Lake Kivu region is a biodiversity hotspot. A large human population around the lake is mounting pressure on the surrounding highland forests for fuel use and subsistence farming leading to loss of wildlife habitat. The high concentrations of methane and carbon dioxide gases trapped at the bottom of the lake pose a potential geohazard should the lake overturn. The potential impacts of human-induced environmental stress on the lake system and the geohazard are unknown. Our research work aims to understand those human-induced as well as natural land-cover changes over time. This is done through long term monitoring of the region by analyzing any time variations in land use and vegetation. This research will be important to evaluate hazards imposed by natural and human activities in the region and to inform the regional governments on conservation efforts.

The freely available Landsat archive at the United States Geological Survey (USGS) provides the longest running continuous data set of medium spatial resolution imagery of the Earth, spanning almost four decades. These data provide a unique opportunity to understand forest disturbance history and land cover dynamics. The Lake Kivu region extends over 91800 km² and covers Landsat WRS-2 path 173 and rows 60-62. Initial analysis of the Landsat data showed the region to be covered with clouds very frequently, affecting more than half of the data acquisitions. Some significant data gaps were also observed in the imagery collected before 2000. Fifteen to twenty scenes from the dry seasons, for each of the three Landsat rows, were selected with minimal cloud cover. These scenes spanned from 1984 to 2011 with minimum and maximum interval between scenes being one and five years, respectively. Geo-referenced surface reflectance products were obtained from LEDAPS (Landsat Ecosystem Disturbance Adaptive System) located at USGS (EROS data center). Cloud and shadow screening was necessary for the land-cover analysis and thus played critical part of this research. A temporal interpolation scheme was used to correct for data gaps caused due to cloud cover and Landsat-7 SLC-off data artifacts.

The time series of the corrected Landsat data were processed using the Vegetation Change Tracker Algorithm to map forest disturbances, water resource dynamics, and urbanization over time in the region. The images analyzed were limited to dry season months to minimize seasonal effects. Temporal changes were also compared using change detection techniques over land-cover classifications maps at some selected dates. The initial results indicate rapid deforestation at many sites near Lake Kivu after 1987 presumably due to subsistence farming by displaced people. These preliminary results will be expanded by developing methods to access data previously avoided due to larger cloud cover fractions.
Dynamic Changing Analysis on Land Cover of Beijing Chaobai River Basin

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Abstract: The land cover dynamic changing was analyzed in the paper based on the Landsat TM/ETM images from 1999 to 2005. Both the analysis method and analysis results were focused by the author because of the importance of multi-temporal images processing method for scholars and the importance of Chaobai River for Beijing citizens and officials. In order to do the analysis of land cover dynamic changing, the whole research process was divided into six steps, such as defining research goals, establishing research methods, obtaining multi-temporal images, processing multi-temporal images, classifying land cover, and analyzing dynamic changing. While the research goals are not just the land cover dynamic changing, but also the driven force of the change, the research methods are integrating of qualitative and quantitative. The multi-temporal images of TM/ETM from the year 1999, 2001, 2003, to 2005 were selected, and were processed by means of RS image processing software like ERDAS. Classifying land cover is really related to the land use and land cover classification system. According to the land use and land cover characteristics of Beijing Chaobai River Basin, the classification system was defined, which includes three level of classes, such as first level class, second level class, and third level class. While the first level class includes three classes, such as agricultural land, constructional land, and unused land, the second level class includes eight classes, and the third one includes twelve specific land use and land cover classes. According to the classification system defined above, the land cover information based on the multi-temporal images of Beijing Chaobai River Basin from the year 1999 to 2005 were obtained. Then, the dynamic changing analyzing was done by means of GIS overlay spatial analysis and temporal statistical analysis. The main results are like that from the year 1999 to the year 2005, the area of forest land which includes coniferous forest and broadleaf forest was increased steadily as the percentage changing from 27.81. It must be noticed that most of the decreased farmland and grassland were probably occupied by urban and rural construction and orchard land, because of the obvious increase of construction land from 3.57.
Multitemporal Remote Sensing Data Analysis of Land Cover
Changes of the Ionian Islands, Greece

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Keywords: MULTITEMPORAL ANALYSIS, LAND COVER CHANGES, SPECTRAL UNMIXING

Abstract: Land cover changes is of high importance for investigating the processes and patterns of landscape changes over time and the impact of these changes in sustainable development. These changes can be identified by exploiting multitemporal remote sensing images (i.e. remotely sensed images acquired on the same area at different times). Multi-temporal Landsat (MSS, TM, ETM+) acquisitions for 1984, 1990, 2000 and 2011 were downloaded from the USGS data archives for the study of land cover changes during the last 30 years in the islands of Zakynthos, Kefalonia and Lefkada in Western Greece. Training data were collected from the field and supervised classification of the Landsat Image of 2011 was carried out resulting in the Land Cover Map for this year. The 3rd level Corine nomenclature was adopted. For the historical data i.e. for the years 1984, 1990 and 2000 training sets were created based on aerial images of the corresponding dates, the Corine Land Cover of 1990 and 2000, as well as information collected from semi structured interviews to local people. Additionally, time series of the various satellite-based indicators were created such as Normalised Difference Vegetation Index (NDVI) and Tasseled Cap transformation for the six nonthermal Landsat TM bands (1-5 and 7) that computes three index values: Greenness (a vegetation index), Brightness (an index of soil brightness), and Wetness (an index of soil moisture content).

Finally a fully unconstrained Linear Spectral Unmixing algorithm was applied for the decomposition of spectrum into a set of certain endmember spectra and the corresponding abundance images are created and studied. Results demonstrate the current capabilities of satellite Earth Observation applications to support the study of land cover changes and their dynamics.
Change detection in the physical lake shoreline through spatiotemporal remote sensing data and GIS techniques

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Keywords: Natural sources, Climate change, spatiotemporal remote sensing data

Abstract: The lake Orestiada is one of the most beautiful lakes in Greece. The lake is directly connected with the tradition Kastoria, a city in North-Western Greece. It is classified as a “Monument of Natural Beauty” by the Greek Ministry of Culture and has joined the European network for environmental protection “Natura 2000”. The lake is located at an altitude of 700 meters, covers an area of more than 28 square kilometres and its depth does not exceed 10 meters. It is an important wetland which is fed with water from streams and several other natural sources. Climatic changes such as loss of snow and the simultaneous increase in heavy precipitation in the region, as well as other factors to be investigated in this study, led to the spatiotemporal changes both in the lake’s level and the surface coverage. The geometric documentation of these changes will be realised through the digital processing of spatiotemporal remote sensing data (from 1945 until to-day).
A remote sensing investigation into decadal scale changes of Folgefonna ice cap, Southern Norway

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Keywords: glaciology, remote sensing, decadal changes, Landsat, ASTER, DEMs

Abstract: Folgefonna is a maritime glacier in south-west Norway and is made up of three plateau ice-masses; Nordfonna (24.8 km² in 2011), Midtfonna (9.1 km²) and Sørfonna (156.7 km²). Folgefonna is of importance to the economy of South-West Norway, being utilised for hydro-electric power generation, water supply and tourism. Maritime glaciers are sensitive to changes in the climate, and are therefore suitable to assess recent changes in terms of climate change. Using an array of remotely sensed data several glacier parameters were investigated over time. A combination of Landsat images, mosaiced aerial-photography and historical maps were used to investigate changes in glacier area from 1860 to 2011. Multiple digital elevation models (DEMs) were used to assess the volumetric change on the glacier from 1937 until 2010, in addition to this data about the bedrock topography of Nordfonna was used to obtain an absolute ice volume. DEMs were provided by the Norwegian Water Resources and Energy Directorate (NVE) and by the NASA SRTM mission. ASTER images and topographic maps were also used to derive DEMs. The ice-covered area of Nordfonna shrank by 47
Multi-temporal analysis of land use/land cover dynamics using satellite images in natural coffee regions of south west Ethiopia

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Keywords: Remote Sensing, SPOT, Landsat, Landuse/land cover change, Ethiopia

Abstract: ABSTRACT
Land use/land cover (LULC) change has been a common phenomenon in agrarian countries like Ethiopia. Information about changes is useful for updating maps for planning and management of natural resources. This study investigated LULC changes in natural coffee regions of south west Ethiopia, Kefa zone. Satellite images of Landsat MSS (1973), Landsat TM (1987), Landsat ETM+ (2001) and Spot-5(2007) were used. Supervised classification technique with maximum likelihood classifier was used for classification of each image. Attempt was made to capture as accurate as possible six land use/land cover classes. The result shows that changes were notably differ between 1973-1987, 1987-2001 and 2001-2007. Natural forest decreased by 21.2
NDVI SPATIO-TEMPORAL CHANGES AS A PROXY FOR LAND USE QUALITY DYNAMICS: THE REGION OF ATTICA, GREECE

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Keywords: Land use quality, NDVI, K-means, Attica, Mediterranean basin

Abstract: All over the Mediterranean basin, drastic changes in land cover have taken place and are expressed by chaotic urban growth at the expense of agriculture, forests and other natural resources. These changes lead to various environmental stress processes, in particular the land degradation, as the result of green cover deterioration. Therefore there is a definite and urgent need for continuous upgrading and monitoring of changes occurring in land cover patterns. An accurate description of the spatial and temporal heterogeneity of a given region is a prerequisite of any management activity. In this view, landscape classification and mapping has recently received renewed attention, either from a theoretical viewpoint or in case-specific applications. In this concern, multi-temporal satellite images can deliver information in a timely and cost effective fashion, which cannot be obtained by conventional methods. As well, the increasing relevance of remote observations as a tool for studying and managing the earth ecosystems leads to the development of new environmental monitoring systems from space. In particular, the NDVI dynamics derived from high temporal resolution satellite images like MODIS Terra represent an effective tool for monitoring plant seasonal patterns and land cover at the local scale. This paper is a case study that focuses on detecting land cover changes by using multitemporal classification of MODIS NDVI images. The objective consists in relating the response of remotely sensed vegetation to changing land management during 2000-2009 over the region of Attica, Greece. This region, consisting of more than 110 municipalities (most of them located along the coast line) and characterized by typical Mediterranean climate, was subjected to impressive landscape changes during the most recent years. The contribution examined the potential for vegetation phenology-based land cover classification to analyze land use quality and quantify the (potential) land degradation dynamics along the elevation gradient in Attica.
Improving change detection using geometrical features

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Keywords: Urban monitoring, SAR data

Abstract: Most of the change detection algorithms developed in technical literature are based on comparison of pre- and post-event features, either per-pixel backscatter or reflectance or more complex spatial features, such as textures local spatial indexes. Change detection algorithms based on geometrical feature comparison are instead risky, as the comparison is highly dependent on the extraction results, and false positives/negatives may arise from poor performances of the extraction routines. In this work we present therefore how to use geometrical features to improve change detection using rather trivial and pixel-based techniques as well as more sophisticated results. The focus is on earthquake damage extraction using SAR, and specifically COSMO/Skymed data. The idea is that geometrical features, as well as their spatial distribution in an image, may provide additional information uncorrelated to the results of pixel-based change detection approaches just because these geometrical feature are obtained using extraction algorithms based on totally different image processing techniques than those used for change detection. It is also very relevant how this additional geometrical information is used, and since false positives are more likely than false negatives, the idea is to use geometrical features to reinforce the results where they show that no damage/no change has occurred. By this way, the proposed approach is able to reduce the false positive without including more errors in the final change map. In an alternative way to previous works by some of the authors, when the geometrical features were used to extract the pre-and post-event road networks and then to discard from change maps the potions of these networks that appear to be present in both the pre and post-event data set, in this work two other, different kind of geometrical feature information are considered. The first one is the density of geometrical features, computed as the percentage of pixels belonging to an extracted segment in a sliding window around the pixel under test. An alternative feature may be the direction (or better main direction) of the extracted geometrical feature within the same sliding window. Changes in these two quantities are likely to occur in change areas, while there is a very large likelihood that their vales is not going to change (at least significantly) in areas where no change occurred. By using sliding window estimate, the proposed approach averages the information over a set of geometrical feature extracted, thus reducing the likelihood of recognizing changes or no changes that are non-existent. Results exploiting the above mentioned COSMO/Skymed data in Haiti and L’Aquila show that the approach is valuable, and has great potential for improving change detection results obtained by more standard per-pixel approaches.
Change Detection in Full and Dual Polarization SAR Data and the Complex Wishart Distribution

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Abstract: In [2] we introduced a new test statistic for equality of two variance-covariance matrices following the complex Wishart distribution with an associated probability of observing a smaller value of the test statistic. We also demonstrated its use for change detection in both fully polari-
metric and azimuthal symmetric synthetic aperture radar (SAR) data [1]. An appendix in [2] gave
details and mentioned the possibility of application of the test statistic and the associated prob-
ability to block-structured covariance SAR data. This feature was further described in [3], which
also showed the application of the test statistic and the associated probability to edge detection
in polarimetric SAR data. At that time, i.e., in the early 2000s, not many workers had access to
polarimetric SAR data. With the advent of several spaceborne polarimetric SAR instruments:
the Japanese ALOS (a.k.a. DAICHI), http://www.jaxa.jp/projects/sat/alos/index_e.html, L-band
with single, dual and full polarization, (ALOS completed its operations in May 2011 and will be
followed by ALOS-2),
C-band with single, dual and full polarization,
the German TerraSAR-X, http://www.dlr.de/ko/en/desktopdefault.aspx/tabid-5725/9296_read-
15979, X-band with single, dual and full polarization, the Italian COSMO-SkyMed, http://www.cosmo-
skymed.it, X-band with single and dual polarization,
the European (ESA) Sentinel-1, http://esamultimedia.esa.int/docs/S1-Data_Sheet.pdf, C-band
with single and dual polarization (to be launched in 2013),
this situation has changed. For power supply reasons the instruments among the above which have
full polarization capability are mostly operated in (either single or) dual polarization modes, i.e.,
they transmit one polarization only and receive (either one or) both polarizations. We therefore
think that a revisit to the methods described and sketched in [2, 3], with emphasis on dual polar-
ization and multi-frequency SAR data, is timely and this contribution will give both theory and
case studies. Software in Matlab, ENVI/IDL and Python will be made available.

References

Multitemporal SAR Data for Urban Change Detection using Markov Random Field

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Keywords: Change Detection, Urban, Multitemporal SAR

Abstract: Multitemporal SAR images has been increasingly used in change detection in the last few years. This increased interest in the analysis of this type of imageries can be attributed to their independence of atmospheric and solar illumination conditions, and to the unique information they provide. Most of the previous change detection studies, however, only consider information contained within a pixel thus ignore the fact that it is more likely for nearby pixels to belong to the same class, even though intensity levels of neighboring pixels are known to have significant correlation. Further, changes are more likely to occur in connected regions rather than at disjoint points. Therefore, change detection algorithms that can take into account of textural and contextual information are desirable. Recently Markov Random Field (MRF) has been introduced for image classification and change detection to model interdependencies of pixels and to incorporate this in the analysis. Using MRF in image classification has a long history. However, applying MRF to change detection is still in its early stage especially when it comes to multitemporal SAR images. Most of change detection studies that use SAR images in combination with MRF focused in the detection of single type of change either positive or negative (e.g., flooded areas). Consequently, the change detection problem is addressed simply as a binary classification. In this research, our objective is to perform change detection analysis in urban areas where both positive and negative changes occurred. Three-date ENVISAT ASAR C-VV data acquired in 2009 and 3-date ERS-2 C-VV data acquired in near-anniversary dates in 1999 were selected for this study. First, the ratio operator is used to derive the change variables from the multitemporal SAR image pairs. Log normal density function is then used to model the distribution of the three classes (positive change, negative change, and no change). The contextual information was used to model the prior probabilities of the three classes and to reduce the effect of the speckle noise at the same time. Expectation maximization algorithm was used for the estimation of the unknown parameters. The change detection results will be compared with the result of a commonly used change detection method. It is expected that MRF is more effective in detecting both positive and negative changes than the commonly used method.
MAPPING OF STORM DAMAGES IN FORESTS USING TERRASAR-X SAR IMAGE DATA

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Keywords: TerraSAR-X, Synthetic aperture radar, change detection, forest, storm damage, interferometry

Abstract: This study is carried out within the framework of the EU FP7-Project EUFODOS (European Forest Downstream Services - Improved Information on Forest Structure and Damages). The objective of EUFODOS is to develop monitoring services of forest degradation. To implement services which are as much adapted as possible to the user’s needs, partnerships between forest authorities, research organisations and service providers were established. Storms cause every year massive damages to the European forests. Out of the irregular harvestings due to abiotic damages 50As most storms occur during winter, when optical satellite data is rarely available, the use of radar data for mapping storm damages has often been a topic of research (2,3,4,5,6). On the 11.09.2010, the test side of the Polish EUFODOS partner was hit by a storm with wind speeds up to 80 km/h. The test site is located in western Poland, surrounding the city Gorzów Wielkopolski. 49In this study the capability of TerraSAR-X to map storm damaged areas is examined. The advantage of TerraSAR-X data is that it can be accomplished at nearly any weather conditions all over Europe with a high optional repetition cycle. For the test site six TerraSAR-X scenes were acquired, three pre-storm ScanSar mode scenes with an azimuth resolution of 18 meters and one pre- and two post-storm Stripmap mode scenes with an azimuth resolution of 3 meters. All images are HH-polarized. The scenes were received in unprocessed SSC format (single look slant range). During processing different look numbers for the multilooking process were tested. Different filters like Gaussian Gamma, Frost, Lee and refined Lee were compared and examined. For mapping purposes the images were as first step visually interpreted and automatic change detection and differential interferometry approaches are tested. For the differential interferometry approach ScanSar-Stripmap and Stripmap-Stripmap image combinations are used. The results are validated with RapidEye scenes and field data. The results of visual interpretation show that it is possible to detect storm areas down to 0.1 hectare with TerraSAR-X Stripmap mode images when using a pre-storm ScanSar image and the developed processing routines. The interferometry and change detection studies are still ongoing.

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References (1 to 8) will be provided in the full paper version.
Analysis of multi-temporal TerraSAR-X imagery over a semi-arid region in Darfur, Western Sudan

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Keywords: Multi-temporal, TerraSAR-X, land cover change, semi-arid region, Africa

Abstract: The tropical and sub-tropical parts of the world are often covered by cloud. Since SAR sensors are generally not affected by cloud cover, the use of SAR to monitor seasonal changes and for longer time-series of land cover change over these areas is proposed. There are many factors and parameters influencing the SAR backscatter values, which include the frequency, polarisation, incidence angle and spatial resolution. These different parameters used in SAR systems all have different scattering mechanisms of surface scattering, volume scattering and dihedral scattering with features on the ground, as they interact with the geometric characteristics and water content (dielectric constant) of soils/vegetation and other land cover types. The understanding of the parameters involved is therefore paramount for the interpretation of the backscatter recorded by the SAR sensor. For this reason, when combining multi-temporal imagery, it is important to have well calibrated data, to be able to use and interpret the multi-temporal signature of the SAR backscatter values meaningfully. Multi-temporal TerraSAR-X imagery is analysed over a semi-arid region in Darfur, Western Sudan, surrounding an established town with a large Internally Displaced Person (IDP) camp. Seasonal change between the dry and wet season is observed, through widening of the river, vegetation growth and changing agricultural fields. The time-series covers data from January to August 2010. The monitoring of the seasonal variation within this one observed season can be expanded to using SAR for monitoring the long term impact of seasonal and land cover change surrounding IDP camps in semi-arid regions. All the images are HH-polarized, with images in July and August being dual-polar (HH/HV and HH/VV). The effect of the different polarisations is investigated. For validation, the TerraSAR-X data is compared to available optical imagery of the same time period. It is planned to add Radarsat-2 (C-band) and ALOS-PALSAR (L-band) images covering the same area in future work. Through this the comparison and combination of multi-frequency SAR data will be investigated. As part of GMES Initial Operations - Network for Earth Observation Research Training (GIONET), this project aims to investigate the use of multi-temporal, multi-frequency SAR for land cover change mapping, and its application to emergency response situations. Different approaches of using multi-frequency, multi-polarimetric, multi-incidence angle datasets for multi-temporal analysis are investigated and some preliminary results are presented.
Comparative Analysis of Land-Use/Land-Cover Maps for Chosen Test Areas on the Territory of Bulgaria and Romania Using Low-Resolution PROBA-V Simulated Data

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Keywords: land-use/land-cover, crops, accuracy assessment, PROBA-V
Abstract: The timely availability of land-use/land-cover maps of global and continental scale has become indispensable for a broad range of topics, such as ecosystem modelling, climate change, food security, and, ultimately, governance. Examples of recent global and regional land cover classifications are GlobCover, Africover, GLC 2000. On European scale, the importance of recent land-use/land-cover data were underscored in the CORINE Land Cover project and in the GMES programme – Geoland 2 Project. The aim of the present study is to compare and assess land-use/land-cover image classifications of low spatial resolution PROBA-V simulated data based on accuracy assessment. The PROBA-V data for the onset dates of the Tillering phenological stage were simulated by the System Performance Simulator (SPS) operated by VITO BE. The method used for land-use/land-cover classifications is the Maximum Likelihood Classification (MLC), which is carried out over two test areas, i.e. Zhiten (Bulgaria) and Fundulea (Romania) in the Tillering phenological stage. To achieve the objective of the study, six land-use/land-cover classifications using widely adopted unsupervised and supervised algorithms for the test areas in Bulgaria and Romania were carried out. For accuracy assessments of land-use/land-cover classification maps, ground-truthing data were collected simultaneously within the phenological stage on both test areas during the carried out sub-satellite experiments. The spectral and spatial separability of PROBA-V simulated data was tested using unsupervised classifications with two and four classes. In the different classification schemes, the forests and settlements were masked out. The accuracy assessments of unsupervised classifications ranged between 77.
Evaluating the Potential of the PROBA-V Sensor in Estimating Forest Cover Change Over a Range of European Biogeographical Regions: The FM@PROBA-V Project

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Keywords: PROBA-V

Abstract: The PROBA-V mission is designed to replace the VEGETATION instruments onboard the SPOT-4 and SPOT-5 satellites and ensure data continuity for the VEGETATION users until the launch of the Sentinel-3 series, as well as compliment data provision, even after the Sentinel-3 series become fully operational. In addition, the PROBA-V mission will offer data at a higher spatial resolution, while maintaining the spectral coverage and near daily global coverage of its predecessor. Amongst the various applications that the VEGETATION data have seen over the past 15 years, forest monitoring had been one of the most prominent ones. The FM@PROBA-V project, funded by Belgian Science Policy Office (BELSPO), achieved three objectives in an effort to quantify the improvements on forest monitoring brought along with the increase of the spatial resolution by the new sensor: a) it provided an estimate of European forest cover with 300, 600, and 1000 meter resolution data, b) it evaluated a number of popular classification methods on VEGETATION and MODIS 250 meter data – serving as a substitute of PROBA-V data due to the similar spatial resolution – on five test sites representing different biogeographical regions of Europe, and c) assessed the two sensors in their capacity in mapping forest cover changes caused by disastrous events, such as forest fires and wind damage. The results suggest that the increased spatial resolution will offer an opportunity for more accurate forest monitoring at global, continental, and regional scale, particularly on highly fragmented landscapes.
Extracting Urban Areas on Simulated Proba-V Data Using ANFIS

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Keywords: urban sprawl, land use, ANFIS, neuro-fuzzy, Proba-V

Abstract: Urban sprawl is gaining interest because its intensity has been strong during the recent years as well as because it greatly affects natural ecosystems. This paper is focusing on developing a method to monitor and forecast urban sprawl using medium resolution optical data. The image source is simulated Proba-V data at a spatial resolution of 300 meters. Proba-V is designed as a continuity mission to the SPOT VEGETATION series, to be launched on 2012. Its data products will be available at a resolution of 1000m (VNIR and SWIR), 600 m (SWIR) and 300m (VNIR). It provides data in four spectral bands, blue (0.44-0.48 μm), red (0.62-0.69 μm), near infrared (0.79-0.9 μm), and SW infrared (1.56-1.65 μm). The simulation, that involves a change in spatial as well as in radiometric resolution, will be based on MODIS data. Urban areas are going to be extracted from mosaics of simulated Proba-V data. For the extraction ANFIS neuro-fuzzy classifier (Stathakis et al. 2006) is going to be used to segment the data into two classes, i.e. urban and not-urban. It has been found that the combination of VNIR and SWIR as an input for urban areas extraction performs efficiently (Stathakis et al, 2011). Mosaics for 3 dates are going to be constructed covering Greece. The dates are 2000, 2005 and 2010. CORINE data will be used to train, test and validate ANFIS for the dates that it exists. For 2010 visual evaluation can be based on the nationwide aerial orthophoto mosaic that is available by the Hellenic Cadastre. Accuracy assessment will be done for each date that reference (CORINE) data exists using the accuracy matrix. For that purpose CORINE is going to be resampled to 300 meters to match Proba-V’s resolution. Urban areas extracted for the three dates are going to be compared to evaluate change detection. Changes are going to be quantified and explained in terms of driving forces. Having established the urban areas for the three dates (2000, 2005, 2010) these are going to be used as an input to a forecasting model in order to obtain an estimate of urbanization in the country for the next 15 years. The forecasting model will be based on a combination of Cellular Automata that operate with stochastic transition rules that are obtained by Markov Chains. Overall the objective is to investigate whether it is possible to monitor urban sprawl using medium resolution data and an automated method (supervised classification) instead of having to rely upon CORINE that requires considerable more effort as it is a product of manual photo-interpretation.

References
Forest Mapping and Forest Cover Change Detection in the Mediterranean Region Using Coarse Resolution Data and Advanced Image Analysis Techniques

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Keywords: PROBA-V, forest/non-forest mapping, coarse resolution data, support vector machines, artificial neural networks, maximum likelihood, object-based image analysis

Abstract: The availability of accurate and updated forest maps plays an important role in sustainable forest management and policymaking. The production of forest/non-forest maps as well as forest cover change maps, at national and continental level, can be fulfilled in a timely and cost effective manner when remote sensing and coarse resolution satellite imagery are employed. The aim of this research was to investigate the potential of using coarse resolution satellite imagery and advanced image analysis techniques for forest/non-forest as well as forest cover change mapping. The specific objectives were: to investigate the potential of Terra MODIS (250m), SPOT-VEGETATION (VEGETATION - 1000m) and PROBA-V (Landsat simulated satellite data at 300m) in forest/non-forest mapping by employing different image analysis techniques such as Maximum Likelihood (ML), Artificial Neural Networks (ANN), Support Vector Machines (SVM), and Object-based Image Analysis – Nearest Neighbourhood (OBIA-NN), to determine the advantages of PROBA-V over the two other sensors in forest/non-forest mapping, and to use the derived products from the best performing image analysis technique per sensor in order to detect changes on the forest cover. The study area which is located in central Greece was affected by large fires in the summer of 2007. Two Landsat images, one before and one after the large fires were classified into two classes, namely, ‘forest’ and ‘non-forest’. The classification process and the accuracy assessment of the resulted maps were assisted by the use of the JRC 2006 ‘Forest/Non Forest Map’ and the 2009 LUCAS data. The maps resulted from the classification of the Landsat images were then used in the classification (selection of training sites, accuracy assessment) of the coarse resolution data, i.e. MODIS, VEGETATION and PROBA-V (Landsat simulation). For the production of the ‘pre-fire Forest/Non forest’ maps from coarse resolution data four image classification techniques were employed (ML, ANN, SVM and OBIA-NN). Following the best performing classifier per sensor was chosen to be used in the classification of the post-fire coarse resolution images for the production of the ‘post-fire Forest/Non forest’ maps. Finally, a simple post-classification comparison was employed in order to detect the changes on the forest cover per sensor. SVM proved to produce the most accurate ‘pre-fire Forest/Non forest’ maps in the case of VEGETATION (overall accuracy 86.35) in relation to the forest cover change maps which resulted from the post classification comparison between the pre-fire and the post-fire ‘Forest/Non forest’ maps the highest accuracy was achieved in the case of PROBA-V (83.83). In summary, the best performing classifier in the case of ‘Forest/non-Forest’ mapping proved to be SVM while the PROBA-V sensor proved to detect more accurately the changes introduced by the fires to the forest cover. 100m, 250m and 1000 m frequent observations.
Using Data Fusion Methods to Enhance Compressed PROBA-V Imagery

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Abstract: In environmental applications, data carry a large amount of information at different resolutions. Various approaches have been used to include in models information from sources at different scales combining multi-resolution products in order to integrate the spatio-temporal variability of subpixel pattern. Often high resolution data are available only for limited areas or time periods. The aim of this study was to test data fusion methods between compressed PROBA-V images and Landsat data to obtain an image with a finer spatial resolution, while at the same time preserving the spatial structure. The methodology followed is an integration of the results obtained with a geostatistical downscaling algorithm, based on area-to-point-kriging, with a General Additive Models interpolation framework to enhance the spatio-temporal resolution of remote sensing data. The fusion aims to produce a composite product taking advantage of both sets of images to reproduce the spatial structure and pattern of the high resolution data. The information from the low resolution data serves as support in areas and periods without available high resolution data. The method was tested on synthetic data constructed to simulate the spatial pattern of real data while providing validation data. The method was implemented on images with different TER compression rates to assess the fusion capability in different situations.
The Impacts of TER Image Compression on Classification of Synthetic PROBA-V Images

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Abstract: The aim of this study was to assess the impacts of the TER image compression algorithm on the classification results of synthetic images constructed to simulate PROBA-V bands. In order to do this, synthetic image bands were generated to reduce the variability and uncertainty of real data, and to allow us to generate rapidly a large number of different images for investigating the effects of compression. The synthetic data were constructed to simulate the spatial patterns and number of land cover classes of real image data. Analysis of the synthetic band data showed that it accurately represented real imagery, in terms of structure, pixel intensity distribution and distribution of classes. The changes due to different levels of compression were analysed, in addition to comparison between the obtained classifications on compressed and synthetic images using the kappa statistic as a measure of agreement. We used Morphological Spatial pattern Analysis (MSPA) to assess the spatial pattern of misclassification error induced by compression. The results show that there are statistical differences for different compression rates on the single bands, but these differences are not evident when band ratios, i.e. NDVI, are considered. The effects on individual bands, and the relative effects between bands, also varied with compression ratio. We found that the strongest impact of compression on the synthetic images occurred at the boundaries between classes.
Burned Area Mapping and Post-Fire Monitoring Using Time Series of Proba-V Simulated and SPOT VEGETATION Data and by Employing the BFAST Trend Analysis Method

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Keywords: PROBA-V, burned area mapping, post-fire monitoring, time series, remote sensing, trend analysis

Abstract: This work aimed to investigate the potential of high-temporal and low-spatial resolution sensors such as the PROBA-V simulation (MODIS) and SPOT VEGETATION in burned area mapping and post-fire monitoring. The specific objectives were: to investigate the potential of time series Proba-V simulation data (MODIS) for mapping burned areas and monitoring post-fire vegetation recovery, to determine the advantages and disadvantages of Proba-V when compared to VEGETATION, and to perform accuracy assessment of the burned area as well as the vegetation recovery areas, by using field data and high resolution images. MODIS 250m surface reflectance composite products and VEGETATION imagery for the period 2004 - 2010 were used in this study. It should be mentioned that the MODIS dataset was used due to the similar characteristics of MODIS with the forthcoming PROBA-V sensor. The study area is located in the Peloponnese, Greece where great fires occurred during the summer of 2007. BFAST (Verbesselt et al 2010), the method employed, is a change detection approach which can be applied on time series and allows the detection and characterization of ‘Breaks For Additive Seasonal and Trend’. The method iteratively decomposes time series into trend, seasonal and noise components, without the need to select a reference period, set a threshold, or define a change trajectory. The methodology followed included the calculation of three spectral indices, namely, NDVI, GEMI, and SAVI. Then, the BFAST method was implemented on the three time series leading to the detection of sudden (fires) and trend (vegetation regrowth) changes. Validation of the results with the existing reference data revealed high overall accuracies (over 90
Proba-V, a SPOT-VGT Successor Mission, Product Definition and Specifications

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Keywords: Proba-V, global vegetation monitoring, SPOT-VGT, low resolution

Abstract: Proba-V is a new global vegetation monitoring mission, designed to ensure the continuity of SPOT-VGT 1km resolution data. SPOT-VGT has provided the world-wide remote sensing community with daily global vegetation products for more than 10 years, and is scheduled to end its services in 2013. Developed in the frame of the ESA In Orbit Demonstration (IOD) technological program, ProbaV adds a new 1/3 km resolution product to fulfill the evolving needs of the end-users. To allow continuation of time-series studies, Proba-V specifications are targeted to align closely to SPOT-VGT. With a polar orbit at 820 km altitude and a LTDN between 10:30-11:30 AM, a daily coverage is obtained for land masses at latitudes from +75° to -56° (acquisition frequency decreases for latitudes less than 35°). Spectral responses are in accordance with SPOT-VGT, differences amount to the same order of magnitude as seen between SPOT-VGT1 and SPOT-VGT2. At the time of writing, the Proba-V platform and instrument are in the phase of subsystem manufacturing and testing, and the User segment processing and image quality center implementation is near completion. Based on the characteristics of the platform/instrument and user segment, this paper will discuss the expected 1 km and 1/3 km product definitions and specifications, and how they compare to SPOT-VGT. The 1/3 km product should have the same order of magnitude SNR and MTF as SPOT VGT, while the 1km product should be much better. Geometrical accuracies are well met for the 1 km product, while the biggest challenge for the 1/3 km product lies in guaranteeing the multi-temporal accuracies due to the thermo-elastic behavior of the platform and instrument. This requires a careful in-flight calibration to monitor periodic and seasonal changes. Proba-V data delivery will be similar to SPOT VGT: 1-day and 10-day synthesis products are available in 4 bands (Blue, Red, NIR and SWIR), derived indices and quality indicators. On top of that, similarly to SPOT-VGT, unprojected P-products can be ordered by the user for both resolutions.
Unmixing of Proba-V and SPOT-VGT Time Series for Retrieval of Crop Specific Temporal NDVI Signatures

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Abstract: With daily observations at 300 m ground sampling distance (GSD), the upcoming Proba-V sensor will greatly enhance our current Earth observation capacity. However, the increased spatial resolution comes at the expense of a loss of available long term average (LTA) information. Such LTA is for example required to map vegetation anomalies using the z-score transform. Many current operational vegetation monitoring programs (e.g. JRC MARS) heavily rely on the interpretation of such vegetation anomalies. In order to provide a continuity of services, the current study examined the potential of different unmixing approaches for the (combined) use of SPOT-VGT data at 1km and future Proba-V data at 300m with the aim of detecting vegetation anomalies. For the purpose of the study two large data sets were consulted: (1) a completely artificially set of 44,000 scenes with 3 LC classes (data set 1), and (2) a set of 10 temporal NDVI images over an agricultural area in the state of Sao Paulo in Brazil with 9 LC classes (data set 2). In data set 2, the reference information at 30 m GSD was obtained from high resolution Landsat TM images from which the Proba-V and SPOT-VGT scenes were synthesized taking PSF and sensor/atmospheric noise into account. For this data set, a LC map for input into the unmixing algorithms was derived independently from the analysed time series. The LC map distinguishes 9 classes, with 4 different sugarcane sub-classes, and 2 agricultural sub-classes (plus forest, pasture, urban/water). Unmixings were done for data set 2 at administrative level with the aim to derive crop specific NDVI time profiles. For data set 1, the results demonstrate a clear superiority of the linear unmixing model (SM – simple model) compared to the model currently used by JRC-MARS (WM – weighting model) in terms of (1) endmember retrieval accuracy, (2) scaling issues between Proba-V and SPOT-VGT and (3) sensitivity to possible uncertainties in the reference LC map. For data set 2 it was demonstrated that the true endmembers (based on 30 m data) of various land cover classes can be retrieved with high accuracy within each administrative unit, and this for the two simulated sensors (Proba-V and SPOT-VGT) and the different unmixing algorithms. In all analysis, we found that the future Proba-V sensor will lead to increased accuracies compared to the current SPOT-VGT sensor. However, a clear preference of the SM model (compared to the WM model) was only found regarding the accuracy with which the true endmember signatures could be retrieved under different (sensor/atmosphere) noise levels. The important scaling issue (i.e. between 300m and 1000m data) was on the other hand better handled (in terms of linearity) by the WM algorithm, albeit this model strongly reduced the dynamics in the retrieved endmembers. For this reason, for the time being, no definitive recommendation for the most preferable algorithm can be given.
Monitoring Semiarid Agroecosystems with Products Derived from Vegetation and Future Proba-V Datasets

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Keywords: PROBA-V

Abstract: In Argentina, livestock production is moving to marginal areas. Given that 2/3 of the land surface is covered by semiarid and arid lands, these fragile regions need to develop strategies that ensure the sustainability of these agroecosystems under increased grazing pressure. In this sense, there is a great need for long-term estimates of biophysical variables to predict Primary Productivity, and so stocking capacity of rangelands. In the framework of PROBA-V preparatory program, we conducted a project aiming to examine the potential of the upcoming PROBA-V mission to provide time series analysis of biophysical surface parameters in semi-arid regions. Par-
particularly, two characteristics of the PROBA-V sensor were highlighted, i.e. its improved spatial resolution (300m) combined with the daily global coverage of the imagery. The study area was located in southern part of Argentinean Dry Chaco eco-region. As study site we selected an area located in southern part of Argentinean Dry Chaco eco-region. To evaluate the satellite based data products we gathered ground data from digital hemispherical photography, ceptometer and PASTiS57, a novel technique with the potential of continuous gap fraction and Plant Area Index (PAI) monitoring. To simulate the potential of PROBA-V daily global coverage, GeoV1 biophysical parameters produced by the GEOLAND2 program were chosen as proxy for PROBA-V future data products. It was found that the GEOv1 LAI and FAPAR products are highly consistent over time and show good agreement (resp. R2=0.77 and R2=0.87) with the MODIS15A data products. Lower correlation coefficients were found when comparing the GeoV1 LAI to ground PAI measurements (0.529 and 0.349 for resp. PASTiS and DHP). The high temporal resolution of PASTiS data corresponds to a great extend with the GeoV1 temporal LAI profile. To investigate the improvements expected for the PROBA-V derived products due to spatial resolution enhancement, PROBA-V imagery was simulated from 3 available Landsat-5 images. GeoV2, which is currently under development at INRA, was used for the creation of LAI estimates from PROBA-V simulated imagery. The increased spatial resolution of PROBA-V revealed more detailed information specifically at the end of the study period when a significant variance in biophysical parameters was detected for one of the study sites. We can conclude that PROBA-V is expected to provide temporal consistent biophysical products similar to the results found for the GeoV1 and GeoV2 algorithms with an increased spatial resolution which can allow for a more detailed monitoring and study of key variables on ecosystem functioning. As such PROBA-V can close the gap between the existing SPOT VEGETATION and upcoming Sentinel missions.
Optimal Spatial Resolution for Agriculture Applications: From Decametric to Kilometric Observations

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Keywords: PROBA-V

Abstract: Agriculture applications are targeting either intra-field variability for precision agriculture, individual field scale observations for management at the level of the farm or a group of farmers, and at the species level for production estimation at regional to national scales. Remote sensing observations offer a convenient way to monitor crops. However, it requires frequent observations at a spatial resolution suited to for the application targeted. Although the availability of frequent decametric observations would probably solve the problem, it is currently limited by technological and economical constraints. The PROBA-V mission offers an attractive alternative with its range of resolution from 100m, 250m and 1000m. The objective of this study is to evaluate the capacity of observations at several spatial resolution for agriculture applications. 18 sites have been considered, covering a large range of landscape patterns, mainly over agriculture and some mosaic between agriculture and forests over which SPOT images (20 m spatial resolution) were available. An object segmentation based on the canny edge identification algorithm was used. The edges were then closed to identify objects and the smallest objects were merged to the larger ones when their spectral response were close together. The landscape pattern is first described based on the distribution of area, complexity (perimeter/(area)1/2) and eccentricity (max_radius/min_radius). Then the number of objects, the purity (fraction covered by the largest object in a pixel) and the spectral variability (standard deviation of the simple ratio) were computed for pixel size ranging from 20m to 1000m. Results indicate that the main landscape feature is the distribution of the area of the objects, well described by the median value. The impact of the spatial resolution is the largest between 20m and 250m and then decreases for 1000m, particularly for the landscapes with small objects. Results are further discussed with regards to the relevancy of the future PROBA-V mission which will provide 100m, 250m and 1000 m frequent observations.
Monitoring of Evapotranspiration at Sub-Kilometer Scale: Downscaling MSG/SEVIRI Images Using Moderate Resolution Remote Sensing Derived Data

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Keywords: evapotranspiration, downscaling, remote sensing, water cycle, PROBA-V

Abstract: Within the water cycle, land evapotranspiration (ET) is a key component. Monitoring ET is still a challenge as no direct observation is possible, and only a combination of modeling and observations can help achieving that goal. Recently, EUMETSAT’s LSA-SAF (http://landsaf.meteo.pt) has distributed two near-real time products aiming at the monitoring of the ET, instantaneous every half-hour and cumulated daily, over the full field of view of MSG/SEVIRI (Europe, Africa and Eastern South America). ET is monitored using MSG satellite data at an unprecedented rate (every 30 minutes), however, the spatial resolution is still coarse (3 km at best). For some applications, while the LSA-SAF ET products give partly the information, higher spatial resolution is required. Therefore, combining LSA-SAF ET products with higher spatial resolution data derived from remote sensing seems an interesting way to benefit from both high time and spatial sampling resolutions. In this contribution, we present a method to downscale LSA-SAF ET at a resolution of 300 m using NDVI derived from MODIS/Terra data. Results on test sites in Europe and Africa typified by heterogeneous ET regimes are shown. The methodology is then discussed in the context of a continuous monitoring using SPOT-VGT satellite and its improved successor PROBA-V.
Burned Area Mapping in a Mediterranean Environment Using Time-Series VEGETATION and Simulated PROBA-V Imagery by Employing an Object-Based Change Detection Approach

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Keywords: burned area mapping, change detection, VEGETATION, MODIS, NDVI, PROBA-V, OBIA, object based, Mohalanobis

Abstract: The aim of this study was to evaluate the performance of an object based change detection approach in accurately mapping burned areas by employing multi-temporal, PROBA-V simulated (MODIS) and VEGETATION, image datasets. Since the PROBA-V sensor is scheduled for launch at the near future, we assess its performance in burned area mapping using MODIS imagery which presents similar spatial and spectral characteristics over the respective red and NIR bands. Such an approach, based on the use of high-temporal resolution images and the adoption of objects as the primary unit of classification, could be used for minimizing errors in the discrimination of burned surfaces from other surfaces with similar spectral characteristics (e.g. shadows, urban, water). The implemented burned area mapping approach builds upon the change detection algorithm of Bontemps et al. (2008) while its efficiency was assessed over the 2007 wildfires in the Peloponese peninsula, Greece. The ‘10-day VEGETATION’ and the ‘8-day MODIS’ products were used in the calculation of NDVI images. Following, a time series dataset was generated consisting of two ‘40-day seasonal composites’ for the year of the fire and two for the year before. Then a multi-temporal segmentation was applied, giving equal weight to the reflectance values of all four images. The spectral-temporal signature of each segment was generated and the Mahalanobis distance between its signature and the signature of the assumed unchanged reference segments was calculated. Following, a threshold was calculated for assigning an object as ‘burned’, so that the resulting burned area map would cover a pre-set percentage of the total study area. As a result, by changing the pre-set changed/burned area cover percentage, the methodology could be set to detect the ‘mostly changed’/’severely burned’ area of a study site. The accuracy of the produced maps was estimated by comparison with high resolution reference maps of the burned areas. Burned area mapping using the simulated PROBA-V images, resulted to a khat value of 0.78 and a burned area user’s accuracy of 79.48 while the lower spatial resolution of the VEGETATION sensor resulted to lower accuracy (0.72 and 74.31
Forest landcover dynamics analysis for carbon stocking and GHG flux assessments: multitemporal remote sensing data and methods inside the Kyoto Protocol requirements

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Keywords: Forest monitoring, landcover dynamics, Optical remote sensing, Kyoto protocol, French Guiana

Abstract: In French Guiana a direct receiving facility called "SEAS Guyane" is operating since early 2006, bringing Envisat/Asar and Spot 5 direct receiving capacities for scientific applications. The Kyoto I and Kyoto II programs were designed to produce information on carbon stocking and GHG flux assessments over French Guiana’s forests, in order to comply with the Kyoto Protocol requirements. This paper details the overall methodology used to meet these objectives and to produce the required informations. It then focuses on the perspectives opened by a realtime multitemporal data processing module linked to the direct receiving facility SEAS Guyane.

In 2007 and 2009 a global orthorectified multitemporal data set was produced over the French Guiana territory, known to be one of the cloudiest in the world. More than 150 Spot 2, 4 and 5 were gathered and processed for this purpose, in order to bring in more than 99.5.

In order to optimize the costly retrospective efforts needed to map forest dynamics, other methods were explored. We proposed a dynamic real time data processing module specifically adapted to a direct receiving situation such as SEAS. It was developed in IDL language and tested in an ad-hoc Envi interface. The objective was to monitor satellite acquisitions, eliminate clouds and fill uninformed pixels with refreshed acquisitions. The module computes a dynamic temporal synthetic product making possible real-time interpretations useful to forest non-forest monitoring.
MAPPING OF STORM DAMAGES IN FORESTS USING RAPIDEYE

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Keywords: storm damage mapping in forests, RapidEye, GMES

Abstract: Due to climate change, growth conditions will change and disturbances in forests will increase (1, 2). Disturbances expected to increase include droughts (3) and storm damages (4). On this background an enhanced monitoring system of forests in Europe is one of the major objectives of the European Forest Action Plan (5). With the GMES (Global Monitoring for Environment and Security) initiative EU, ESA and single European countries, such as Germany address the general challenge of environmental monitoring wherein monitoring of forests is a fundamental part. One of the national state level contributions to GMES is the German support to the development and operation of the sensor RapidEye. New possibilities for forest monitoring arise from an improved timely availability of the high to very high resolution optical satellite data as offered by RapidEye since February 2009. In the study to be presented in this paper the potential of RapidEye for fast and high detailed storm damage mapping shall be examined on the example of a storm event that took place on 11.09.2011 in western Poland in the forest district of Gorzów Wielkopolski (6). RapidEye data taken before (31. 5. 2011, 2.6.2011) and directly after the storm damages (30.09.2011, 01.10.2011, 16.10.2011) are available. The study is embedded in the EUFODOS project that aims at the development of EO based forest monitoring services that utilise GMES core service products (7) with focus on biotic and a-biotic damages (www.eufodos.info). Method development both considers recent developments of change detection (8) as well as findings from research projects that developed earth observation based applications for large scale storm damages back to the 90ies of the 20th century (9, 10) as well as the options from the EUFODOS methods tool box. The technical work is ongoing and first findings indicate that the feasibility of fast delivery of high quality mapping that meets user requirements for storm damages will be met. Collaboration with the forest administration in Poland is under establishment and has the objective to identify pathways to a future operational use of EO based mapping in case of a similar or larger event in future. Based on user feedback and considerations within the EUFODOS project on a future operationalisation of EO based storm damage suggestions will be developed and presented that address such operationalisation for RapidEye based assessments for future storm damage events. Acknowledgements The research is funded (a) by free provision of Rapid Eye data via the RapidEye Science Archive Project that is funded by Bundesministerium für Wirtschaft und Technologie, Germany, RapidEye Science Archive Proposal 460 “Monitoring von forstlichen Großschadereignissen in Rahmen des GMES Downstream projekts „European Forest Downstream Services - Improved Information on Forest Structure and Damages (EUFODOS)”” and (b) by the European Community’s Seventh Framework Programme (FP7/2007–2013) under the grand agreement no 262786 EUFODOS. References (1 to 10) will be provided in the full paper version.
Tracing structural changes of a complex forest by a multiple systems approach

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Keywords: forestry, structural changes, multisensoral, HyMap, HRSC, RapidEye, Cartosat-1, Prism,

Abstract: An investigation on the combination of information from multiple sensors is presented, dealing with the assessment of forest structure and structural changes over time in the complex Mid-European forest of the Traunsteiner Stadtwald, a communal forest in South-East Bavaria, Germany. The starting point of the investigation was a data set from 2003 combining HyMap hyperspectral data and a 0.5m grid DSM calculated from HRSC data. A canopy height model was derived with the help of the official Bavarian State Survey DTM originating from 2001 LIDAR data. During the night of 18th to 19th of January 2007 the winter storm Kyrill caused severe damages in that forest. Using satellite data from the systems RapidEye, Cartosat-1 and ALOS Prism the changes in forest structure were analysed. Of special interest was the question whether the parameter derivation accuracy from the lower resolution satellite data are sufficient to assess the damages and to update the data bases of the Traunsteiner Stadtwald forest. The validation of the results was done on behalf of the regular forest inventory data from 1999 and 2009 respectively, supported by a LIDAR data set from 2010 for height assessment of the satellite data derived surface models.
Tracing deciduous component in fragmented landscape of southwestern Finland with the aid of multi-temporal satellite imagery

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Keywords: remote sensing, Landsat, SPOT, multitemporal, multiresolution, spectral unmixing, deciduous forests, Finland

Abstract: Deciduous forests are regarded as one of the key components of regional biodiversity in the hemiboreal vegetation zone of southern and southwestern Finland. Deciduous stands occupy diverse edaphic conditions from low-lying shoreline habitats to rugged bedrock conditions and have been greatly influenced by agricultural and later by urban land uses. Today, deciduous component is spatially diverse element in the coastal zone of southwestern Finland varying from dominant stands to highly fragmented mixed forest and forest-grassland habitats. In most of the national and regional land cover mapping efforts, deciduous component is greatly underestimated as classification procedures eliminate small and fragmented elements and ignore transitional habitats. However, in practice these deciduous elements are vital pools of regional biodiversity hosting tens of threatened species such as plants, birds and invertebrates. Establishing better understanding of the deciduous component would help to locate potential diversity hot spots and pinpoint the most prominent sites for re-establishment of supportive land use and management actions for deciduous stands. Satellite images provide potentially good material to distinguish deciduous elements from the surrounding landscape matrix, but understanding and extracting deciduous component characteristics need a careful approach. This challenge relates both to spectral and temporal responses of deciduous stands in satellite imagery. Spectrally, deciduous component signatures are mixtures of photosynthetic material, branches, trunks and various reflections from background materials, in many cases also coniferous species. This mixing happens in single pixels as well as within larger entities, making the evaluation of deciduous material challenging. As deciduous trees undergo dramatic phenological changes during the approximately 200 days of the growing season, spectral signatures are temporally highly variable. While some of the keystone deciduous species, such as Pedunculate Oak (Quercus robur) is virtually leafless in mid-May, some others, such as birch (Betula pendula), are phenologically much earlier. These responses, among many others, challenge any mapping effort related to satellite imagery obtained at different stages of the growing season. Our paper explores the challenge of extracting deciduous component with the aid of multi-temporal and multi-resolution remote sensing imagery (SPOT, Landsat TM). The possibility of using several satellite images – either by fusing different sensors in order to gain better spectral discrimination against other land cover entities, or by merging frames of different dates to increase the knowledge on temporal characteristics – would provide with much stronger tool to interpret the occurrence and state of deciduous forests with higher accuracy. As deciduous component is quite rarely found as
being spectrally pure in terms of mid-resolution satellite image pixels, we also incorporate subpixel
approach into the analysis for detecting mixed deciduous stands, often undiscovered or underesti-
mated by conventional crisp classification results. By using these methods, the most valuable sites
in terms of deciduous biodiversity could be easier to detect and the rate of change could be analyzed.
Automated monitoring of major forest cover changes based on satellite time series data.

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Keywords: monitoring, forest fire, wind storm, unsupervised, time series

Abstract: For monitoring major changes of forest cover which are for example caused by forest fires or wind storms, a fully automatic approach is proposed. The approach uses satellite time series data with high temporal resolution such as from MERIS, MODIS or the forthcoming PROBA-V mission. In the present study, MODerate-resolution Imaging Spectroradiometer (MODIS) surface reflectance data in the red and near-infrared spectral region with a spatial resolution of 250m were used. In the first processing step, gap filling is performed to derive a consistent time series. From the gap-filled time series data, features are derived which are used for change detection. Areas which show significant radiometric changes are then derived by application of an unsupervised clustering approach. The method was applied in test areas in central Europe and in northern Europe. For validation of the results, random sampling has been performed for quantitative assessment of the achieved accuracies. The results demonstrate the applicability of the approach for automated large area monitoring of forest cover changes. The work has been performed in the frame of the project FM@PROBA-V, funded by the Belgian Science Policy Office (BELSPO).
Biomass Assessment In African Savanna Forest Using Multi-Temporal ALOS PALSAR Data

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Keywords: Multitemporal SAR, Savanna forest

Abstract: Reducing Emissions from Deforestation and Degradation in African Forests (REDDAF) is a collaborative project within the Seventh Framework Programme. The project aims at developing pre-operational forest monitoring services in two Congo basin countries, Cameroon and Central African Republic (CAR), which are actively involved in the Reducing Emissions from Deforestation and Degradation (REDD) policy process. In this frame, the work conducted by CESBIO is to develop and test methods to directly assess biomass using earth observation data, mainly L-band ALOS PALSAR data. The proposed processing chain is tested in Cameroon and will be further tested in CAR. The aim of this study is to improve existing biomass retrieval algorithms using multi temporal dataset in terms of product resolution and biomass change quantification. Multi temporal and multi-polarisation data filtering allows to increase the equivalent number of looks without degrading the resolution and leading to a better estimation of the indicators used for biomass retrieval. Multi-annual changes in biomass can be interpreted as due to deforestation, forest growth, or to changes in annual vegetation. The region under study is located in central Cameroon, Adamawa region, centered around Mbakaou lake near the departmental capital Tibati, encompassing the Mbam Djerem National Park. This region was chosen as it extends across a range of tropical vegetation types, from humid forests contiguous with the Congo Basin tropical forest belt in the south to savanna with narrow gallery forests in the north. A collection of 21 plots from 21 Mg.ha-1 to 225 Mg.ha-1 has been performed from mid-January to mid-February 2012 in cooperation with GAF and MESA-Consult within the REDDAF project. 38 ascending ALOS PALSAR data, including 28 FBD (at 38.75° incidence angle) and 10 PLR (at 25.75° incidence angle) scenes acquired from 2007 to 2010 (through GEO-FCT project in Cameroon), are used. Data from Tropical Rainfall Measuring Mission (TRMM) acquired from 2007 to 2010 are analysed to quantify the impacts of surface moisture condition. The inversion method is based on a model previously developed by CESBIO over tropical forests. AGB is estimated from a L-band cross-polarized gamma log-relationship. The log-relationship and the results will be updated based on the ground data which are were collected from January to March 2012. Three methods for biomass retrieval and uncertainties assessment are being investigated: the Support Vector Regression, the Bayesian inversion and the Classification And Regression Trees. Changes in biomass will be observed in more details with ALOS PALSAR temporal series from 2007 to 2010. The paper will present the results obtained on biomass and biomass change mapping, which leads to a better temporal assessment of carbon stocks and will put an emphasis on the use of multitemporal data to enhance the product quality.
Determination of the beginning of growing season in boreal coniferous forest from MODIS time-series and comparison with modelled phenology

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Keywords: vegetation phenology, MODIS, coniferous forest

Abstract: We studied the determination of the beginning of the growing season of boreal evergreen coniferous forest from Moderate Resolution Imaging Spectrometer (MODIS) time-series. The beginning of the growing season in boreal coniferous forests can typically be recognised as sudden increase of gross primary production (GPP), which can be determined at local sites from CO2 fluxes, measured with the eddy covariance method. Here, a fixed fraction of peak growing season GPP was used as a threshold value for the growing season onset (hereafter referred to as Growing Season Start Date, GSSD) at three sites in Finland. Daily time-series of Normalized Difference Vegetation Index (NDVI) and Fractional Snow Cover (FSC) from homogenous areas in vicinity of CO2 flux measurement sites were compared with in situ GSSD for the period 2001-2010. The decrease of FSC during snow melt and the spring-rise of NDVI were used as proxy indicators for GSSD and good correlation between satellite indicators and in situ GSSD was obtained (R²>0.8, RMSE<7 days). Highest site-wise correspondence with in situ dates was found for the indicator based on FSC, which was further used for the mapping of GSSD in Finland. Satellite-derived maps of GSSD from different years will be further compared with the modelled timing of the onset by the land surface model JSBACH of the Max Planck Institute (MPI), which is forced by meteorological data generated with the regional model REMO (MPI Meteorology, Hamburg). The GSSD is determined from regional GPP predictions by JSBACH and the comparison with satellite-derived GSSD provides us with means to evaluate the spatial distribution of modelled growing season onset.
Combining time series of aerial photography with VHR satellite imagery for modelling of woody species dispersal

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Keywords: Aerial images, forests, VHR

Abstract: Spreading of forests and shrubs in abandoned landscape is a common trend in many European countries. This study combines historical and recent aerial photography with very high resolution satellite imagery for monitoring changes in an abandoned landscape in an unused part of military area in Czech Republic. The former rural landscape of fields, meadows and few forests changed during last 60 years into a mosaic of shrubs, forests and few grasslands. Spreading of many different tree species across the landscape was monitored in this study without much fieldwork just by combining historical aerial images used for identification of forests spreading in general with recent World-View 2 satellite image, which was used to classify hawthorn, broad-leaved species, conifers and grasslands. Combination of these two sources was based on spatial overlay of common features. The main assumption was that the study period is short so mortality of species is negligible and there was no change in species composition since the trees create first crowns visible on aerial images. The second proved to be problematic in more recent imagery, since results show probable pathways of change from hawthorns to broadleaved species. Hawthorn is a main pioneer species in this area and knowledge of its recent extent combined with the historical development helps us to model the change more accurately. Linear mixed effects models based on presence and absence of trees in studied decades since 1952, based on orthorectified, object oriented classified imagery, provide information about long term trends and help us to unravel driving forces behind remaining grasslands. The models show faster spreading of trees and shrubs along forest edges, steep slopes and in valleys, influence of former land use is still significant. Spreading of conifers is limited to the edges of previous forest and is negligible, on the other hand broadleaved species are spreading rapidly. Fraxinus, as the most common, is spreading mainly in former villages and along field borders and its seedling can be found in the understory of other species. Knowledge about species gives us more information about pathways of secondary succession in the area. Grasslands are gradually invaded by scattered hawthorns which will prepare suitable conditions for broadleaved species at time of disintegration of the hawthorn crowns. The model can help to predict changes on a landscape scale, plan management practices in similar areas and effectively protect diversity.
Development of a global Agricultural Stress Index System (ASIS) based on remote sensing data

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Keywords: NOAA-AVHRR, METOP-AVHRR, vegetation health index, agricultural drought stress, phenology

Abstract: Drought is one of the main causes of food insecurity. In 2011, the horn of Africa has faced the worst drought in 60 years. An estimated 12.4 million people suffered from a massive food shortage. To mitigate the impact of agricultural drought, it is of high importance to dispose of timely and reliable information of the condition of food crops in all regions and countries in the world. The Global Information and Early Warning System (GIEWS) of the Food and Agricultural Organisation (FAO) is the leading source of information on food production and food security for every country in the world. In the frame of its EMSA (Environmental Monitoring System for Agriculture) FAO-GIEWS aims to develop an “agricultural stress index system” (ASIS) which should allow to assess the drought probability for agricultural areas on a global scale. The ASIS is being established in collaboration with VITO-TAP and the MARS unit of JRC.

The core of the ASIS has been developed and described by Rojas et al. (2011). This study was mainly based on the 16 km resolution weekly composite images derived from NOAA-AVHRR, provided freely by NOAA’s Center for Satellite Applications and Research (STAR). The study was limited to the African continent and it was made as a “single shot” exercise. The main challenges now consist in the extrapolation of the system to the global scale and in the near-real time application on the dekadal 1 km resolution data of METOP-AVHRR, as provided by VITO.

In the ASIS, the vegetation health index (VHI) is used as an indicator for drought probability. It is based on a linear combination of vegetation and temperature related stress indices. Data of NOAA-AVHRR and METOP-AVHRR (normalized difference vegetation index and brightness
temperature) are used to calculate the per pixel VHI on a global scale, averaged over the growing season. A phenological model, based on NDVI, is developed and employed to define the start and end of the growing season. Next, the averaged VHI over the growing season is aggregated over each administrative unit so the drought intensity can be assessed on a regional basis. The resulting data flow will provide timely and direct information on drought stress in all agricultural areas of the world.
A multitemporal and non-parametric approach for assessing the impacts of drought on vegetation greenness: A case study for Latin America

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Keywords: drought, vegetation greenness, non-parametric classification, multi-scale analysis

Abstract: Drought originates from a deficiency of precipitation that results in water shortage for natural processes (e.g. plant growth) and human activities (e.g. agriculture). Regardless of the environment, a lack of precipitation over a certain period of time and particular region may result in reduced green vegetation cover. When drought conditions end, recovery of vegetation greenness may follow, but such a recovery process may be slow and last for longer periods of time. In natural ecosystems, long-term dry conditions cause vegetation to be more prone to forest fires, while in human-induced ecosystems they reduce the fodder available for animals and the agricultural yield, thus leading to a reduction in income. The added-value of satellite imagery for monitoring vegetation vigor and phenology has been demonstrated. Indeed, the availability of remote sensing data covering wide regions over long periods of time has progressively strengthened the role of vegetation indices in environmental studies related to drought episodes. However, it is not feasible to rely solely on satellite-derived information to assess the impacts of drought duration and frequency on green vegetation cover. The problem is that relatively poor vegetation conditions may be caused by factors other than drought, e.g. unseasonable coolness or crop rotation. Thus, some additional background information on drought onset and end, derived from rainfall data as recorded in meteorological networks, is a priori demanded in this context. Indeed, the aim of remote sensing data can only be to measure the cumulative impacts of drought-related changes on vegetation cover over time. In this paper, we evaluate the relationship between the frequency and duration of meteorological droughts in Latin America and the consequent temporal changes on the characteristics of vegetation greenness for different land cover/use classes. A non-parametric and non-supervised approach, based on the Fisher-Jenks optimal classification algorithm, is used to identify meteorological droughts on the basis of cumulative distributions of monthly precipitation totals. As input data for the classifier, we use the GPCC Full Data Reanalysis precipitation time-series raster product, which ranges from 1902 to 2009 and is interpolated at the spatial resolution of 0.5º. Monthly vegetation greenness is derived at the spatial resolution of 1km on the basis of 10-daily MERIS Global Vegetation Index (MGVI) images, produced by the European Space Agency (ESA). The time-series analysis of monthly changes on green vegetation cover conditions is performed with a non-parametric method, namely the Relative Greenness (RG). The study is carried out for the period between 2002 and 2009, and we restrict our analysis to four different vegetation classes, namely forest, shrubland, grassland and rainfed croplands. ESA’s GlobCover maps of 2006 and 2009 are used as a reference to setup study cases only on geographical areas that did not undergo changes during the analysis period. The multi-scale information is integrated at the lowest spatial
resolution available and the impacts of different meteorological drought episodes are assessed for each land cover/use class. Final results report on the degree of decrease of the spatially averaged RG and its recovery as function of meteorological drought characteristics.
Vegetation stress due to mining impact in Karabash using TSA of SPOT-VGT

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Keywords: SPOT-Vegetation, SDVI, trend analysis, phenology, vegetation stress

Abstract: The town of Karabash in the Southern Russian Urals has been a centre for mining and metal production for well over 3000 years. The environmental impact of (historical) mining activities is extremely severe: Karabash and the surrounding areas are strongly affected by SO2 emissions from the ore smelter and fall-out of bioavailable metal-rich particulates (Udachin et al., 2003). A time series of 10-daily Normalized Difference Vegetation Index images from SPOT-Vegetation (April/1998–December/2011) is analyzed. In order to account for missing values and undetected clouds affecting the observations, the 10-daily time series was smoothed and monthly maximum value composites were created. To remove seasonal vegetation changes and thus facilitate the interpretation through the historical record, a Standardized Difference Vegetation Index (SDVI) was calculated for each pixel and for each record of the time series, representing the deviation from the mean in units of the standard deviation (Peters et al., 2002). Linear least squares trend analyses of SDVI depict a general tendency of increasing photosynthetic activity, with an average SDVI increase of 1.5*stdev over the last 14 years in the area at 10-50 km distance of the mining area. This confirms observations by other authors and can be related to climate change. However, with closer proximity of Karabash (< 10 km), the trend gradually decreases, reaching a steady-state situation at Karabash town. This relative impediment is strongly related to the distance to the smelter and to Pb concentrations observed in lichens (Purvis et al., 2003; Spiro et al., 2004; Williamson et al., 2004). Red-edge positions derived from 32 in-situ ASD vegetation spectra correlate with the slope of the SDVI trend over time, confirming vegetation stress hampers the
increase in photosynthetic activity which is observed at larger distances from Karabash. Further research will include the time series analysis of different phenological parameters, such as start, end and length of the vegetative season, since the increase in photosynthetic activity due to climate change is probably the result of an increase in the length of the vegetative season, while trees in the town are reported to show premature autumn colors (Purvis et al., 2003). This research is performed in the frame of the ImpactMin project (EC-FP7 no. 244166).
EVALUATION OF ANOMALIES IN MULTIPLE INDICATORS FOR DROUGHT MONITORING

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Abstract: Drought is the result of insufficient water supply from either precipitation or from surface/ground water for a certain period so that the vegetation and the soil are eventually under extreme water stress. Vegetation will respond to drought by changing spectral properties and by increasing thermal emission since the photosynthesis and transpiration activities are reduced by insufficient water supply. Anomalous vegetation development is reflected by anomalies in spectral properties described by vegetation index (VI) that can be observed by satellite sensors. At the same time anomalous thermal emission and land surface temperature can be observed. To meet the requirement of continuous monitoring of land surface conditions and of observing response to varying water availability, gap-free time series of LST and VI were generated and analyzed using a modified Fourier Transform algorithm that is capable to model time series of irregularly temporally spaced observations, as due, for instance, to clouds contamination. A weighted moving-window time-series of the vegetation index anomaly relative to the historical average was calculated both for detection and for prediction of drought events. Two new drought indicators based on satellite observations of vegetation index and land surface temperature, i.e. the Normalized Temperature Anomaly Index (NTAI) and the Normalized Vegetation Anomaly Index (NVAI), are proposed. These new drought indicators were evaluated against the widely used Kogan’s Vegetation Condition Index (VCI) and Temperature Condition Index (TCI) during summer drought events in different landscapes in China and India. The results show that the two new drought indicators NTAI and NVAI can distinguish more effectively the drought evolution stages when comparing to the TCI and VCI. The study shows that VI and LST respond consistently to climate forcing (rainfall, air temperature etc.). Long lasting rainfall anomaly led to severe drought during/after summer and LST responded as early as rainfall anomaly and lasted for a few weeks. In the present case studies, the LST anomaly once it appeared, it did not disappear, thus providing additional and useful information on the impending drought event, well in advance of the time of peak-severity. Severe drought damage on vegetation (shown by large magnitude of NVAI) occurred if rainfall and LST continuously decreased and increased respectively for a certain period. The drought impact on natural short vegetation is such that the grassland was damaged and could not recover. On the contrary, for the area where agricultural crops are the dominant vegetation cover, the vegetation condition showed recoverable behavior from a second cycle of crops. Finally, it should be noted that anomalies and trends detected with diverse measures of water availability and of the response of terrestrial vegetation do add up to a coherent picture of the developing drought event about 1-2 months in advance of the time when anomalies reached their peak values in the cases evaluated in this study.
Drought monitoring in the Romanian Western Plain using TERRA-MODIS and SPOT-VEGETATION time series data

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Abstract: Drought is a specific climate characteristic of Romania due to its excessive temperate climate with a large deviation from the normal values of climatic and hydrologic parameters. Remote sensing data with low spatial resolution and high temporal resolution provide a useful tool for the monitoring of the vegetation activity from global to regional and local scale. The multi-annual analysis of vegetation conditions commonly uses mean, maximum or time integrated values derived from seasonal profiles of remotely sensed parameters as normalized difference vegetation index (NDVI), leaf area index (LAI) and fraction of photo-synthetically active radiation (fAPAR). The LAI and fAPAR, are key inputs to parameterize and/or validate climate and ecosystem process models. Accurate estimation of biophysical parameters is important for monitoring vegetation dynamics, and this information is essentially required for the prediction of microclimate and various biophysical processes within and below canopy. NDVI is a numerical indicator that uses the visible and near-infrared bands of the electromagnetic spectrum to measure and monitor plant growth, vegetation cover, and biomass production from multispectral satellite data. The paper estimates the long-term trends in the vegetation state connected to climatic factors, based on satellite-derived MODIS LAI/fAPAR and SPOT Vegetation data series. The study presents a procedure to analyze the correlation between the dynamic vegetation parameters and the meteorological parameters. The analyze is made using TIMESAT software and includes two algorithm stages, one for smoothing and one for gap filling, which attempt to maximize the use of high quality data to replace missing or low-quality data. TIMESAT provides three different processing methods based on least-squares smoothing functions to fit the time-series data: asymmetric Gaussian, double logistic and adaptive Savitzky–Golay filtering which incorporate qualitative information on cloud contamination from ancillary datasets. The first two approaches use semi local methods and are less sensitive to the noise, giving a better description on the beginnings and endings of the vegetation seasons. The adaptive Savitzky–Golay filtering approach uses local polynomial functions in fitting and can capture subtle and rapid changes in the time series being sensitive to noise. For this study, MODIS-eight-days-LAI/fAPAR products from 2000 to 2010 (agricultural season) and Spot-Vegetation NDVI products from 2006 to 2011 (agricultural season) have been analyzed for the Western Romanian Plain. The resulting smooth curves are used to extract seasonal parameters related to the agricultural season. For each year, NDVI/LAI/fAPAR values, integrated over the agricultural season, were computed using TIMESAT software in order to evaluate the vegetation state behaviour. It allows obtaining start and end of the season, the seasonal amplitude and the seasonal length, the cumulative effect of vegetation during the season. The final results are presented as maps with spatial variation of NDVI/LAI/fAPAR values for each agricultural season, together with the deviation from the multi-annual (2000–2009) average. There are analyzed the correlations between NDVI/LAI/fAPAR values and agrometeorological parameters (mean monthly temperatures, mean monthly soil moisture and monthly precipitation sums were obtained from agrometeorological stations situated in the study area).
EVALUATION OF HARMONIC ANALYSIS OF TIME SERIES (HANTS): IMPACT OF GAPS ON TIME SERIES RECONSTRUCTION

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Keywords: time series reconstruction, harmonic analysis, NDVI, LAI/fPAR

Abstract: The time series of remotely measured biophysical parameters at land surface, such as Leaf Area Index, Fraction Photosynthetically Active Radiation (FPAR), and Vegetation Indices (e.g. NDVI), have become irreplaceable elements in numerous applications ranging from ecology to climatology and agriculture. However, because of the unavoidable effect of undetected cloud, snow or poor atmospheric conditions, the temporal continuity, consistency and reliability of these time series is less than optimal with a significant impact on subsequent applications. In recent decades, researchers have developed methods and models to reconstruct time series of irregularly spaced observations from satellite remote sensing, among which the Harmonic Analysis of Time Series (HANTS) method is used very widely. Many studies based on time series reconstructed with HANTS documented the excellent performance of this method. While some limitations of HANTS have been noticed in these applications, there is no dedicated study on systematic evaluation on the performance of the HANTS method. In this study, we will evaluate the impact of the number, size and position of gaps on the time series reconstruction of NDVI and LAI by HANTS. In the HANTS algorithm, the final time series is reconstructed from several upper envelop points of the raw data series after a number of iterations. In practice, gaps and outliers (contaminated data) will exist between the upper envelop points, and the size of maximum gap (MGS), the position of maximum gap (MGP), and the number of gaps (NG) can result in significantly distinct performance of HANTS. The present work aims to evaluate the performance of HANTS under different gap conditions expressed by the MGS, the MGP, and the NG. Firstly, a simple time series generator is designed to evaluate NDVI time series. With respect to the shape of the simulated series, four types of land-cover related time series were generated: evergreen forests (high annual average value, low seasonal variance), grasslands/scrublands (moderate annual average, single seasonal variance), double-cropping agricultural land (moderate annual average, bi-seasonal variance), barren land/desert (low annual average, low seasonal variance). About five hundred time series with random phases are generated for each one of the four land cover types. Secondly, gaps with different typical combinations of MGS, MGP and NG, which are regulated by a pre-defined combination scheme, are introduced in each simulated
series. Thirdly, for each time series, the gapped-series and the ungapped-series are reconstructed by HANTS. Lastly, the difference between the two reconstructed time series is evaluated by several indicators such as Root Mean Standard Error (RMSE) and Maximum Absolute Difference (MAD). Therefore, the performance of HANTS for different combinations of size, position and quantity of gaps in the time series can be evaluated statistically by these indicators. As a primary result, the following conclusions can be drawn: Firstly, when original time series have a large annual amplitude, MGP is the most sensitive factor in the process of reconstruction and the two terminals and the peak of the series are crucial positions. In the non-seasonal case, MGS is the most important factor as long as NG is not too large. The MGS should not be larger than 30 percent of the total samples in the time series for all seasonal or non-seasonal case; otherwise the reconstructed series is not reliable. Finally, NG does not have significant influence on the result if both MGS and MGP are under control. These conclusions can be taken as a reference to indicate the reliability of HANTS for particular cases towards the definition of a quality indicator of any time series.
Using SAR Interferometric Phase To Measure Soil Moisture

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Keywords: SAR, soil moisture, interferometry, InSAR, DInSAR

Abstract: Soil moisture is a key environmental parameter which plays a primary role in regional and global climate dynamics and has significant economic importance, whilst locally it provides help in support of hydrological and flood planning, civil engineering activities, and farming activities. Synthetic aperture radar (SAR) has the promise to remotely monitor soil moisture from spaceborne platforms over the earth’s surface using schemes which link backscatter with moisture content. Moisture estimation can be difficult because of the joint dependency of radar backscatter on both moisture and surface roughness. As a result, where a reliable site-critical measurement is required, local synoptic measurements rely on buried active probes for which a power supply must be provided, and an arrangement made for data to be collected from the field. Here, we propose the use of passive, buried retro-reflecting targets which appear directly in SAR imagery, providing time-stamped measurements of soil moisture. Conventional retro targets are not suited (e.g. trihedral), not least because of their bulky size, and their 3D structure would also likely make it impossible to interpret phase meaningfully. Further progress is only possible by utilisation of a developing, cutting-edge antenna technology, here adapted for novel exploitation. The target is a hi-gain, narrowband frequency selective surface, which confers a radar cross section approximately equivalent to that of a conventional square trihedral. Placed horizontally, this will provide the high-RCS, point-like target required for this project. The scheme works by associating phase differences between images with changes in retardation of the signal through the soil to the target, from which the soil moisture can be retrieved by model inversion. Up till now, interferometric phase has been discarded as having no relevance to moisture determination. The phase signal of the buried target shows a strongly linear relationship between soil moisture and phase change. Importantly, the behaviour of the off-normal refracted ray is very close to that of a normal incidence ray, independent of the actual incidence angle the scene is viewed at. This is a useful simplification, negating the need to consider refraction effects, which otherwise would require a priori knowledge of absolute moisture values. It also allows the use of interferometric series constructed from different viewing angles. The work will describe its application to different SAR platforms and land zones. The scheme is particularly attractive for arid regions, where lower soil moistures translate into smaller targets and higher-frequency radars – for which the TerraSAR-X satellite is particularly attractive. In more temperate zones, soil attenuation can be very large, requiring large targets. As satellites offer a slow revisit time for interferometrically coherent imagery, one aspect will be to consider maximising re-visit opportunities. For example, accepting ascending and descending modes, over a wider range of incidence angles, drops the Radarsat revisit time from 24 days to about 2 days. Because a buried target behaves as a point target, it should avoid spectral-shift decorrelation from large-baseline imagery, although with an increased fringing rate.
Time Series Analysis – a Tutorial in EARSeL’s SEOS Project on Science Education through Earth Observation for High Schools

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Keywords: SEOS, science education, e-learning

Abstract: SEOS is an initiative for using remote sensing in science education curricula in high schools funded under the 6th Framework Programme of the European Commission (EC). Eleven partners from several European countries, in cooperation with the European Space Agency (ESA) and teachers from European high schools, created e-learning tutorials for science students in high schools across Europe. Based on real examples, the tutorials use remote sensing images and data to involve students in different aspects of current environmental research and monitoring. The tutorials cover a broad range of topics, from daily weather data to long-term climatic conditions, landcover changes, marine pollution and environmental hazards, ocean currents, coral reefs and coastal water quality, natural and cultural heritage and conservation, classification and modelling, to name but a few. One of the SEOS tutorials presents the fundamental concepts of time series analysis and provides several applications using environmental data with emphasis on remote sensing. A focus is spent on plant phenology, ice in the arctic and plankton blooms. Connections between different topics are made clear, and links make it possible for teachers and students to follow their own route through the lessons according to their own interests. The tutorial uses the method of Enquiry-based Learning, which is also supported by worksheets highlighting an interesting scenario in the environment followed by questions or tasks which can be solved when studying the web-based tutorials. Advanced information on a more complex mathematical level is available through links to supplementary pages, which is particularly relevant when used in advanced physics and mathematics classes, and at university.
COMPARING PARAMETRIC AND NON-PARAMETRIC APPROACHES FOR ESTIMATING TRENDS IN MULTI-YEAR NDVI

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Keywords: Vegetation, NDVI, Trend, Non-parametric

Abstract: The aim of this study is to systematically compare parametric and non-parametric techniques for analyzing trends in annual NDVI derived from NOAA AVHRR and MODIS sensors across a range of biomes in order to examine how trend type, sample size and departure from normality assumptions affect the accuracy of the techniques in detecting long-term change. To generate annual data, the mean of a four-month long ‘green’ season was computed from NDVI for seven sites (located in Sudan, Cameroon, Spain, Italy, Sweden, and Iraq) from the GIMMS and MODIS products (MOD13C2) for the periods 1982-2006, and 2001-2010, respectively. Trends in these time series were then estimated by ordinary least-squares (parametric) and Mann-Kendall (non-parametric) methods, and compared using slope value and confidence interval measures. Preliminary results indicate that slopes and their confidence intervals obtained from sites with steep monotonic trends (gradually increasing or decreasing) compare favorably with one another for both the GIMMS and MODIS data series. Exceptions include one of the Iraq sites that exhibits an abrupt step-like increase, and sites in Italy and Sweden with weak monotonic trends, where the least-squares method outperformed the Mann-Kendall method. This study lays the groundwork for establishing a set of guidelines for more appropriately quantifying annual trends in NDVI time series.
Assessment of radiometric normalization effects on inundation mapping of Doñana marshlands with a long time series of Landsat images

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Keywords: Radiometric normalization; time series of images; Landsat; inundation mapping; Doñana

Abstract: One of the most useful applications of remote sensing is the use of long time series of satellite images to analyze spatial and temporal changes in land use and land covers. Such studies are usually aimed at finding changes in both land use and cover (qualitative) and in biophysical parameters through trend analysis (quantitative). It is therefore essential to use a coherent time series of remote sensing images consistent with each other both from the standpoint of geometric and radiometric quality. Traditionally, the manifold radiometric correction models for optical images consider at least the sensor characteristics, the illumination conditions, the topography of the swath and atmospheric conditions. Various methods, either empirical or theoretical allow to determine the reflectance values of each pixel in the scene. However, when working with a long time series of images, a normalization procedure based on pseudo-invariant areas has been proposed in order to optimize the comparison between scenes and therefore enhance the implementation of automatic mapping procedures (McGovern et al. 2002; Hall et al. 1991). Normalization assumes that the reflectance values of certain areas in the scene are relatively stable over time (traditionally urban areas, bare soil and water bodies). This paper assesses the adequacy of the radiometric normalization procedure for historical inundation mapping in Doñana marshlands. We evaluated the stability over time of the areas selected as pseudo-invariant through the various scenes of a long time series of Landsat TM and ETM + images (240 images from 1984 to 2011). Also we conducted a comparison between the classified inundation maps obtained from the normalized series (radiometric + normalization) and the ones from the radiometrically (topography + atmospheric) corrected series by using ground truth data validation. We used regression trees on band TM 5 as the best classification procedure. Results allow to identify the differences between both approaches when dealing with mapping inundated areas.

REFERENCES
PRELIMINARY RESULTS OF AN UNEXPECTED UPLIFT SITUATED IN A FORMER COAL MINING REGION (CAMPINE BASIN - BELGIUM) REVEALED BY RADAR INTERFEROMETRY

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Keywords: InSAR, coalmine, uplift, Campine, Belgium

Abstract: The Campine basin situated in the NE of Belgium is a part of a large paralic Carboniferous coal basin of NW Europe. It is located north of the Lower Palaeozoic of the London Brabant Massif. Eastwards, the South Limburg coal basin consists in the extension of the Campine basin to The Netherlands. The first coal concessions were granted in 1906 and the last coalmines (Eisden and Zolder) were closed in 1992 giving the region a particular interest for the study of the ground movement monitoring. Persistent Scatterer Interferometry (PSI) technique is applied to estimate the vertical displacement of the Campine coal basin during a timeframe of 18 years (1992–2010). Even if the area has numerous swamps, lakes and forest zones giving a poor density of reflectors, the ground motions are well highlighted. The movements have relative low amplitude with an average rate between -1.6 and +1.9 cm/year in the centre of the former coal exploitations. Both movements are related to groundwater extraction needed for the coal exploitation. Coal mining exploitation are concomitant with important groundwater pumping activities inducing a strong depression cone still active a few years after the closure of the mine as seen in the ERS results (1992-2000) in the western area. A difference of five years separates eastern (1987-1988) and western (1992) closure dates implying that the western area is subsiding while the eastern one is already starting uplifting. The explanation of the uplift seems to be related to the increasing groundwater pressure recharge in the abandoned collieries giving the possibility to heighten the area. The results issued from Envisat (Asar) processing show a new situation, the western part has an uplift trend during the period 2003-2010. From this observation, we can conclude that the recharge of the mine aquifer needs to gain a critical level before being able to raise the ground level. Ground deformations in this area are thus still visible 20 years after the end of the coal exploitation.
Recovery of the geometry of historical aerial photos associating self-calibration with ground control linear features

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Keywords: multitemporal, image orientation, ground control linear features

Abstract: Historical aerial photographs are an objective record of the evolution of Earth’s surface over the years. They are potentially useful for many applications like environmental monitoring, urban planning, settling disputes, and others. The recovery of their imaging geometry is a laborious process and usually it does not meet high standards of accuracy due to: 1) the lack of camera calibration reports and/or fuzzy fiducial marks, 2) the wide spatial changes occurred on Earth’s surface between the capture of the photos and the present situation. The former makes the recovery of the interior geometry of the camera which captured the photos ambiguous. The latter makes the recovery of the exterior geometry of the photos hard or in some cases impossible. The necessary reference points, namely Ground Control Points (GCPs) which are points with known coordinates in the 3D object space and clearly identified in the 2D image space, are rare and ambiguous, or non-existent at all. These two factors also discourage the co-registration, integration, merging and comparison of historical photos with recent geospatial and remote sensing data. This paper addresses one of the harder cases of multitemporal image analysis: the recovery of the imaging geometry of old aerial photos, captured in 1945, using 3D reference information extracted from recent orthoimages and DEMs (datasets with about 65 years time interval). Moreover the calibration report of the camera is not available; lost over the years or never documented. The photos are at a scale of approx. 1:42,000 which is generally considered as rather small scale for the identification of GCPs, such as corners of buildings. The identification of GCPs is made even harder because of the poor radiometric characteristics of the old photos, the use of reprints and the deterioration due to the aging of the film and the storage conditions. In this paper, the lack of calibration report is addressed with self-calibration methods. The difficulty to identify reliable GCPs, which are traditionally used for image orientation analysis, is addressed with the use of linear features of arbitrary geometry (Ground Control Linear Features) for reference information, instead of GCPs. Linear features such as road edges, shoreline and building outlines tend to persist over time, are more easily and reliably identified in multi-temporal datasets and provide a continuous source of information. The proposed method uses the Iterative Closest Point algorithm within a Least Squares Adjustment framework, in order to match 3D linear features of the object space to their 2D projection on the photos. The method computes the projective transformation between the 3D object space and the 2D image space. An application of the proposed method is made using real data; an old aerial photo and 3D linear features (mainly road edges) extracted from a recent orthoimage and the corresponding DEM. The evaluation of the results is made using independent Check Points. Also, a comparison with results computed by the classical point-based method is made. The results of the proposed method have better accuracy than those computed by the point-based method.
A Bayesian approach for solar irradiance estimate using multitemporal satellite images and ground reference data

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Keywords: remote sensing, solar energy, Bayesian inference, particle filter

Abstract: The knowledge of the global solar irradiance incident on the earth’s surface and its spatiotemporal distribution is of prime importance for numerous solar-based applications (Climate change assessment, solar renewable energy systems). Satellite sensors can provide an alternative to the sparse coverage of radiometric networks since they can produce database over large regions. However the computation of solar irradiance time-series (non-linear process) from multitemporal satellite images is unfortunately not straightforward. Determination of methods capable of deriving global solar irradiance at ground is still an open issue in environmental research and solar applications that we are proposing to tackle in this paper. Several mathematical models were studied, in order to estimate solar irradiance from satellite images. These different approaches have evolved toward complex models by incorporating additional observation data and both empirical and physical information. However, despite their increasing complexity recurring obstacles (e.g., the difference in spatio-temporal scale between the model and measurements; measurement errors; or errors in the representation of physical processes) still introduce a significant amount of uncertainty into the model estimates. In this paper a Bayesian filtering approach is considered to the dynamical estimation of the global solar irradiance at ground level from multitemporal satellite images. We defend the idea that an inverse approach based on sequential Monte Carlo filtering helps to relax several assumptions and constraints while keeping estimations results in accordance with those of existing methods. Among these constraints, one can note the observation model and its parameter estimation. In fact, using a stochastic observation model based on the joint distribution between ground reference data of the state variable (clearness index) and the observed satellite data avoid the use of complex physical models. In order to develop and validate the Bayesian filter a simulation study has been carried along. A set of 4454 high resolution satellite images (GOES) from the visible channel covering a 207 days period from the year 2010 has been selected. The observation function has been obtained using a learning dataset including randomly chosen satellite images and ground reference data from French national meteorological stations in French Guiana. Daily solar irradiances have been estimated using a test dataset processed by the Bayesian filter. The method has been validated by comparison with both solar irradiance estimates derived from Bayesian filter and irradiance measurements performed at ground stations. Detailed time-series analysis is presented and shows the effectiveness of the model assumed for observation data. The statistical performances (RMSE, MBE) show good agreement with existing methods. The developed method connects global and local dynamics of solar irradiance in a Bayesian framework avoiding introduction of complex radiative transference equations. This method can be used for real-time estimates and to generate solar irradiance forecast at the surface. Future works need to be pursued on a global scale and under various climate.
Potentiality of MOD13Q1 EVI and NDVI time series for land cover classification in highly fragmentatated areas: the Sangone river basin case study (Piemonte, Italy).

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Keywords: EVI, NDVI, MODIS, MOD13Q1, fragmented land cover

Abstract: In this work we compared the capability of MODIS MOD13Q1 vegetation indexes (VIs) time series (250m 16 days MVC EVI and NDVI) to identify different land cover classes over an area which is characterized by a high degree of fragmentation of the surface types. This determines an heavy presence of mixed pixels. The images belonging to the processed 10 years time-series of both the indexes range from January 2001 to December 2010 (23 images/year) and are provided together with the corresponding Pixel Reliability time-series. The study area, extending over 1936 km² west side of Turin (Piemonte, Italy) represents the Sangone river watershed. It is characterized by a highly varying topography (plane, hilly and mountainous). I.P.L.A. (institute for environment and wood-production trees) Land Cover 1:25.000 vector map shows that in the study area 48 canopy categories are present: 19 forestry-use categories covers 703 km² and are fragmented in 2762 homogeneous areas; 28 mixed-use categories (including agricultural fields) extends over 932 km² and are fragmented in 6632 homogeneous areas; urban areas occupy 301 km². Converting such vector map to the correspondent raster format having the same MOD13Q1 geometric resolution (250m) 6 land cover classes were lost. To pursue the goal of this work, we proceeded to calculate the mean VI value of the pixels belonging to the same I.P.L.A. land cover category. This was done for each of the 16 days MVC image and both EVI and NDVI images; linking together all 16 days per-category mean VI values we obtained one mean EVI and NDVI ten-years-long average temporal profile for each of the 42 I.P.L.A. land cover categories. During computation, the pixels flagged with less-than-good reliability were excluded. Considering the obtained average temporal profiles, an automatic classifier (ISODATA) was run to investigate the degree of separability of the 42 temporal profiles. Unsatisfying classification results obtained for both EVI and NDVI were attributed to the widespread presence of mixed pixels. We significantly improved the separability of temporal canopies profiles excluding not-pure pixels during the computation of the VIs per-category mean values. This was obtained by masking all MOD13Q1 images. In this way, about 93
Analysis of the thermal and deformative superficial fields at Ischia Island (Southern Italy) via the exploitation of long-term MODIS LST and SAR data time series

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Keywords: SAR, MODIS, Geothermal Atlas, Southern Italy

Abstract: In the Italian Peninsula the Apennines separate a relatively cold Po-Adriatic-Ionian “foredeep” external belt from a warmer Tyrrhenian “back-arch” internal tensional belt. The latter is characterized by high geothermal heat flow together with conspicuous recent Quaternary volcanic phenomena. In this area extending from Tuscany to Campania, the known steam and water dominated fields lie. In this geodynamic context the project "Geothermal Atlas", financed by the National Research Council (CNR) of Italy, represents a first level of geothermal data collection for Southern Italy, in order to evaluate the geothermal potential that can be used for both the production of geothermal-electric energy (medium-high enthalpy) and domestic uses (low enthalpy). Accordingly, in this work we focus on the volcanic complex of Ischia Island, located in the Gulf of Naples (Southern Italy), to characterize the island superficial thermal field. To this aim, we exploit data acquired from both satellite radar and optical sensors; in particular, we use SAR and MODIS (Moderate Resolution Imaging Spectroradiometer) data, acquired over the last ten years, to generate time series of the deformative and thermal superficial fields, respectively. For what concerns the radar data, we produce ground deformation time series at low spatial resolution scale (90 x 90 m) by benefiting from the large archive of ENVISAT SAR data acquired in the 2002-2010 time interval over descending and ascending orbits, that are inverted via the Small BAseline Subset (SBAS) technique. The achieved time series allow to follow the temporal evolution of the retrieved...
deformation pattern providing significant information for the characterization of the dynamics of the island hydrothermal system. Over the same site, time series of Land Surface Temperature (LST) extracted from the MOD11A2 product of the NASA-MODIS sensor were downloaded from the USGS Glovis web site (U.S. Geological Survey Global Visualization Viewer; http://glovis.usgs.gov/) and analysed to highlight thermal anomalies. Time series of LST covering the period 2001-2010 were used to describe the average seasonal changes of surface temperature as well as temporal anomalies with respect to the average behaviour. These anomalies are analysed together with information on the land cover/land use as provided by the UMD (University of Maryland) land cover map also derived from MODIS data. Moreover, a contextual analysis was carried out to highlight thermal anomalies within homogeneous areas (e.g. land cover classes); this type of information could be used to guide further investigations either with the use of higher spatial resolution satellite data or through field campaigns to evaluate the sources for thermal anomalies. This contribution shows the preliminary results of the analysis of time series of both radar and optical data that will be further integrated to contribute to the project "Geothermal Atlas".
A MULTITEMPORAL Ts-VI (MTVI) METHOD FOR SURFACE SOIL MOISTURE ASSESSMENT AT REGIONAL SCALE

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Keywords: surface soil moisture, multitemporal analysis, Landsat, Ts-VI, regional scale

Abstract: The relationship between land surface temperature (Ts) and satellite-derived Vegetation Index (VI) has been long investigated for the assessment of surface moisture conditions over heterogeneous large areas and several methodologies have been proposed for this purpose. Among the methods based on the Ts-VI scatterplot, the Temperature-Vegetation Dryness Index, TVDI (Sandholt et al., 2002), represents an empirical simplification of previous formulations (e.g., Water Deficit Index; Moran et al., 1994). The TVDI is closely related to surface soil moisture and conceptually and computationally straightforward. The method is only based on satellite-derived information; its complete independence from ancillary data is the most attractive advantage and can provide the potential for operational application, especially over large areas. Nevertheless, the requirement for a full range of variability in soil moisture conditions and vegetation cover in each image processed, inhibits mostly the operational estimation of TVDI. To overcome this constraint, in the present study a new multitemporal Ts-VI (MTVI) method is proposed for the evaluation of the surface soil moisture over large heterogeneous areas. A series of Landsat TM/ETM+ imagery, recently free-downloadable, has been processed in a multitemporal sequence for better characterizing the natural variability of the environment and hence determining the most suitable triangle-trapezoid edges in the Ts-NDVI space. Ts and NDVI data have been extracted from each image of the multitemporal sequence and combined in the MTVI method to obtain the spatial patterns and the temporal evolution of surface soil moisture, after removing cloud and standing water pixels. The triangle-trapezoid envelope of each acquisition date shows different positions in the multitemporal Ts-NDVI space accordingly to weather condition changes. Whereas the application of the TVDI method on the single image returns mean surface soil moisture generally in disagreement with available rainfall data, on the contrary, the results obtained applying the MTVI method herein proposed show better consistency with data from rain gauges for the whole period of the image sequence considered. These preliminary results are very promising and suggest the potential employment at operative level of the MTVI method, as an indicator of surface soil moisture evolution over large and heterogeneous areas. In order to better test the performance and the robustness of the proposed multitemporal approach, further experimentation using hydrological distributed ground model in different environmental contexts is in progress.
Multi-seasonal / multi-temporal RapidEye image analysis for forest parameter extraction using object-oriented image analysis

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Keywords: multi temporal analysis, forest, RapidEye

Abstract: Satellite remotely sensed data allow the derivation of forest parameters, which are recognized to be in great value of forest management including calamities management. Presently the fact is that in Mid-Europe these methods are still not established in operational practice. One of the main tasks of the EUS-FH (Entscheidungs-Unterstützungs-System für die Forst-Holz-Kette) project focuses on deriving time variable forest parameters such as: area of forests, forest gaps, forest damages, changes in forest boundary, coniferous/deciduous stands and tree species. The big challenge of the project is to assess whether the unique multiseasonal imaging capability of RapidEye (RE) data is able to improve the tree species identification.

Object-oriented image analysis method (using eCognition software) was used to extract forest parameters from the RE level 3A multispectral data. Examples from two of the five test areas of the EUS-FH project were chosen for demonstration, Freising and Bavarian Forest National Park. For Freising test area twenty RE images, in which two from 2009, five from 2010 and thirteen from 2011 were atmospherically corrected. For the Bavarian Forest National Park test area six images from three different seasons of the year 2011 were Top of Atmosphere (TOA) corrected.

In Freising test area all scenes were combined and indices were calculated and added to the data set to benefit the advantages of the phenological changes in our analysis. Then rule sets were developed in eCognition in order to extract the forest parameters, excluding forest damages and changes in forest since no noticeable changes have occurred. The Bavarian Forest National Park forests suffer dramatically changes due to many years of intensive bark beetles calamities and wind throw events. A semi-automated method combing change detection techniques and object oriented image analysis, was introduced to detect the changes occurred during 2011.

The results show the potential of using scenes from different vegetation periods in extracting some of these parameters. On one hand accuracies of over 95
National forest monitoring systems for REDD+

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Keywords: change detection, forest monitoring

Abstract: Reducing Emissions from Deforestation and Forest Degradation (REDD) is an effort to create a financial value for the carbon stored in forests, offering incentives for developing countries to reduce emissions from forested lands and invest in low-carbon paths to sustainable development. “REDD+” goes beyond deforestation and forest degradation, and includes the role of conservation, sustainable management of forests and enhancement of forest carbon stocks. In the framework of getting countries ready for REDD+, the UN-REDD Programme assists developing countries to prepare and implement national REDD+ strategies. For the monitoring, reporting and verification, FAO supports the countries to develop national satellite forest monitoring systems that allow for credible measurement, reporting and verification (MRV) of REDD+ activities through time. These are among the most critical elements for the successful implementation of any REDD+ mechanism. The UN-REDD Programme through a joint effort of FAO and Brazil’s National Space Agency, INPE, is supporting countries to develop cost-effective, robust and compatible national monitoring and MRV systems, providing tools, methodologies, training and knowledge sharing that help countries to strengthen their technical and institutional capacity for effective MRV systems. To develop strong nationally-owned forest monitoring systems, technical and institutional capacity building is key. The UN-REDD Programme, through FAO, has taken on intensive training together with INPE, and has provided technical help and assistance for in-country training and implementation for national satellite forest monitoring to implement change detection of forest area through time. The goal of the start-up phases for UN-REDD pilot countries in this capacity building effort is the training of technical forest people and IT persons from interested REDD+ countries, and to set-up the national satellite forest monitoring systems. The Brazilian forest monitoring system, TerraAmazon, which is used as a basis for this initiative, allows countries to adapt it to country needs and the training on the TerraAmazon system is a tool to enhance existing capacity on carbon monitoring systems. The start-up phase of the National Forest Monitoring System will allow these countries to follow all actions related to the implementation of its national REDD+ policies and measures. The monitoring system will work as a platform to obtain information on their REDD+ results and actions, related directly or indirectly to national REDD+ strategies and may also include actions unrelated to carbon assessment, such as forest law enforcement. With the technical assistance of FAO, INPE and other stakeholders, the countries will set up an autonomous operational satellite forest monitoring system. An initial version and the methodologies of the system for DRC and PNG have already been launched in Durban, South Africa during COP 17, while Paraguay and Viet Nam are actually being developed in 2012. www.un-redd.org
Time course of reflectance for some forest types in Estonia

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Keywords: Multispectral reflectance, temporal analysis, Landsat, SPOT

Abstract: While monitoring the state and productivity of forests via remote sensing all aspects of temporal changes in forest reflectance - successional, seasonal and daily courses have to be considered. Seasonal course of forest reflectance in different spectral bands is important in several aspects, primarily in relation to monitoring forest phenology. A majority of the forest productivity and carbon balance models that rely on the Monteith relation to predict the yearly net or gross primary production make use of the seasonal course of multispectral indices derived from the reflectance in specific spectral bands to represent the fraction of absorbed PAR. Moreover, the “climatological” average seasonal course of reflectance together with typical successional and daily courses can serve as a basis for building a remote sensing based forest monitoring system. To study stand-level estimates of forest productivity and carbon balance the current MODIS NPP product is too coarse. Thus, higher spatial resolution data are needed. Due to the relatively low revisit capability of most popular medium resolution scanners (Landsat TM and ETM+, SPOT) and frequent occurrence of clouds, the reconstruction of reliable seasonal courses of reflectance in different spectral bands in boreal and temperate regions is difficult in practice during a single growing season. We have to be able to include images from multiple spaceborne and airborne sensors acquired at different moments of the successional stage, season and day. One of the alternatives is to create “climatological”
mean successional, seasonal and daily curves of reflectance for several forest types in key spectral bands and for multispectral indices. It is possible to accumulate cloudless images over several years covering the whole vegetation period. A natural way to produce the time series is to calibrate the images into the units of TOC reflectance factors by making use of the absolute calibration and atmospheric correction of images. In spite of apparent success in the atmospheric correction procedures, the resulting time series is typically scattered and may need some additional smoothing. The climatological seasonal series can be used to simulate climatological estimates of forest productivity and carbon balance. A few examples of the seasonal and successional course of some forest types and of individual stands from the Järvselja region (southeast Estonia) are presented and analysed. Multiple sources of spectral data (Landsat TM, ETM+, SPOT, CHRIS PROBA images, airborne spectral data) were used. Problems of interpretation are discussed: how to cope with multi-angular data and with a combination of seasonal and daily courses and differences in spectral bands between the sensors; how large is the “natural” variability of reflectance among the stands in the same forest type and age class.
Analyzing Vegetation Dynamics by Combining Remote Sensing with Process-based Ecosystem Models

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Keywords: vegetation dynamics, remote sensing, process-based ecosystem models

Abstract: Vegetation dynamics over large spatial extents are routinely monitored using data from sensors such as the NOAA AVHRR and MODIS, typically with vegetation indices. Due to the high temporal resolution of these data, both within-season and inter-annual information about these dynamics can be extracted. These patterns can then be related to disturbance, land management, and climate variations/trends.

Combining process-based ecosystem models with high-temporal resolution remote sensing offers much potential for adding insights about the patterns and mechanisms underpinning observed vegetation dynamics at these spatial scales, but remains an underutilized avenue of research. In this study, we briefly explain the utility of such a combined approach for elucidating patterns and mechanisms of ecosystem dynamics. This includes direct comparison of remotely sensed data with ecosystem model output as well as assimilation methods. We also outline some of the roadblocks that hamper such developments, including differences in spatial support. Finally, we review some of the most promising ways forward by highlighting recent research conducted at Lund University. These include: disentangling the effects of people and climate on vegetation dynamics in the Sahel, simulating managed land in Africa, and the role of wild fires for simulating pyrogenic carbon releases as well as for determining biome distribution.

In sum, there is untapped potential for the integration of remote sensing with process-based ecosystem models for refining our understanding of vegetation dynamics, as well further contextualizing the role that terrestrial vegetation plays in the Earth system. These case studies show the benefits of such a synergy.
DYNAMIC VEGETATION ANALYSIS: PHENOLOGICAL BEHAVIOUR AND PHENOLOGICAL PATTERN

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Keywords: Foliar phenology, NOAA-AVHRR NDVI GAC images, Fourier Transform, NDVI modelling, Phenological behaviour, Phenological pattern

Abstract: A map of phenological behaviour and the main phenological patterns of the province of Mendoza, in central western Argentina, was generated through a temporal series of NOAA-AVHRR NDVI GAC images. The temporal dynamics of vegetation was described through analysis of regional foliar phenology using a series of 108 monthly NOAA-AVHRR NDVI GAC images. A Fast Fourier Transform was used to decompose the series into dynamic parameters: mean NDVI, amplitudes (maximum NDVI variability) and phases (time from start of cycle to maximum NDVI) for different time periods. Trials of classification with the bands mean NDVI, amplitude and phase for a 1-year period showed that they were more adequate for humid zones registering mainly intraannual variability; therefore amplitud for 9 and 3 year periods were incorporated as new bands because they introduce interannual variation of the arid zones without loosing quality in detection of humid areas. A classification was made based on these five bands with larger information content (inter- and intra-annual variability), achieving a map of 18 areas of phenological behaviour. Phenological behaviour is thus described by the average values of FFT parameters for each class, within the heterogeneity inherent to each class, and express the level of vegetation activity and its intra and interannual variability. This map is therefore related to ecosystems and vegetation units. The phenological pattern is a modelled monthly NDVI curve that describes the functioning of vegetation (in a particular place or pixel), month to month during an average growth cycle and allows understanding of its geographic variations; it is modelled with 11 FFT parameters, five of them are common to classification bands. The phenological pattern was modelled for 17 vegetation units in four extended ecosystems. The map contributes dynamic elements to the regional study of vegetation, generating a new zonation explained by variables that determine vegetative activity. The overall phenological pattern of vegetation of Mendoza responds to an annual cycle with localized weak bimodal patterns. The patterns of low winter-summer contrast correspond to xeric climate conditions, expressing the vegetative maximum at the end of the summer; water availability enhances this contrast, shortening the time of maximum vegetative expression.
Vegetation and land cover changes on Finnmarksvidda, Northern Norway, due to grazing pressure by reindeer

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Keywords: Vegetation changes, Landsat data, Lichen degradation

Abstract: Several regions around the word are currently undergoing rapid and wide-ranging changes in land cover. These changes are mainly associated to changes in climate conditions or changes in land use practices. In northern areas the climate changes are experienced as increased temperatures with a subsequent thawing of glaciers, snow and permafrost. In Scandinavia the land cover changes introduced by man are seen as clear-cut fields in the boreal forests and as degradation of lichen vegetation in the reindeer herding regions. Reindeer herding in northern Scandinavia is associated exclusively with the Sámi people. During the 15th century, large parts of the reindeer herds were domesticated and the Sami people became reindeer-herding nomads. This tradition has preserved until today. In Finnmark, the interior, continental parts of the county are used for herding during winter, while the summer ranges are located to the coastal areas. The continental areas are characterized by vegetation types rich in lichen – the most important reindeer forage during winter. During the past decades a severe depletion of the lichen vegetation is experienced. The dramatic increase in the reindeer population size during the 1980’s and throughout the 1990’s is regarded as one of the main explanation of the problems faced today.

In this project the degradation of the lichen vegetation on Finnmarksvidda has been described through a time-series of satellite images. Landsat TM/ETM+ images from the years 1987, 1996, 2000, 2006 and 2009 has been classified and converted into vegetation maps with special importance attached to the lichen vegetation. Different from green vegetation lichen communities are highly reflective in the visible part of the spectrum allowing an accurate and distinct detection of this vegetation by use of simple unsupervised classification methods. By comparing the thematic maps produced a dramatic depletion of the lichen cover is detected. Earlier studies based on Landsat MSS data from the years 1973 and 1980 described untouched land with lichen carpets over large areas. At that time lichen-rich vegetation covered more than one third of the area as a whole. In 1987 this amount was reduced to 19,1 percent for the winter pastures. Throughout the 1990’s the degradation of the lichen vegetation continues. In the maps from 1996 the lichen amount was estimated to 8,5 percent, while the bottom level was reached in the year 2000 with an amount of 4,9 percent. The two final steps in this time series show lichen amounts of 6,4 percent and 5,9 percent for the years 2006 and 2009. In the recorded period, vegetation types without lichen cover increased correspondingly. This project demonstrates the advantage of using remote sensing data in mapping and monitoring the reindeer winter ranges. The research fundamentals of the project are based on the ability to detect lichen-rich communities in satellite images, and to distinguish them from other community types. This distinction is mainly obtained in the visible part of the electromagnetic spectrum.
Multi-sensor assessment of trends in attributes of vegetation dynamics and ecosystem functioning derived from NDVI time series

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Keywords: trends, time series, NDVI curve metrics, vegetation dynamics, ecosystem functioning

Abstract: Vegetation Indices (VIs) derived from Earth Observation Satellite data have been widely used for vegetation monitoring due to their scalable relations with several plant biophysical parameters. Particularly, the Normalized Difference Vegetation Index (NDVI) and has been widely and satisfactorily used for monitoring changes in ecosystem structure and function, detecting long-term trends in vegetation growth and phenology, providing inputs for primary production and global circulation models, and providing a reference to model the carbon balance worldwide. Properties of NDVI time series can be summarized in several attributes of the NDVI annual curve, including attributes related with productivity and with phenology, which can provide information about the condition and functioning of vegetation and ecosystems. Such functional attributes are related with the exchanges of matter and energy and have a shorter response to environmental changes (when compared to structural attributes), thus allowing a better understanding of large-scale ecological changes associated to ecosystems function and processes. In this sense, NDVI time series datasets (e.g., from SPOT-VEGETATION and Terra-MODIS) hold considerable promise for spatially continuous characterization and monitoring of changes in vegetation dynamics and ecosystem functioning at regional scales, given their global coverage, intermediate spatial resolution (250 m to 1 km), high temporal resolution (10- to 16-day composites), availability (since 1998 and 2000, respectively), and free-of-charge status. Temporal analysis using this type of data has become increasingly popular in the last years, with particular attention being given to the detection and measurement of inter-annual trends. However, there are few studies comparing different datasets, particularly from different sensors, for these purposes. In this work, we evaluated inter-annual trends in several attributes (metrics) of the NDVI curve using time series datasets from both SPOT-VEGETATION and Terra-MODIS, for the years 2001-2010, in the northern half of mainland Portugal. First, as this data is typically very noisy, a pixel-by-pixel pre-processing procedure was employed, using filters to remove spurious values and smooth the data. The software TIMESAT was used to extract the NDVI curve metrics, for each year, from the smoothed data. Trends were then evaluated for each of these metrics using non-parametric trend tests. Finally, we evaluated the consistency between the results for trends in metrics derived from both Terra-MODIS and SPOT-VEGETATION. We found differences in both magnitude and sign of inter-annual trends of the analyzed metrics, depending on which dataset (sensor) was used, and also the processing procedures employed. We discuss the probable causes of these differences, related to different sensor characteristics (e.g., temporal resolution, spatial resolution at which the original data is acquired, sensor bandwidths). We also discuss the relevance of using data from multiple sensors in order to improve the detection and assessment of inter-annual trends in attributes of vegetation dynamics and ecosystem functioning.
SPATIO-TEMPORAL CHARACTERIZATION OF
VEGETATION COVER VARIABILITY

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Keywords: vegetation map, multitemporal satellite series, spatio-temporal characterization

Abstract: Remotely sensed data are widely used to gain information about many geophysical parameters characterizing the earth surface and the related ecosystems because of their suitable spatial and temporal coverage. Satellite-derived Vegetation Indices (VIs) are commonly used to monitoring the vegetation characteristics, and the related VIs maps are very useful in many scientific and applicative contexts. The vegetation coverage is characterized by a spatial correlation that can be found in the related VI map. Moreover, the vegetation evolves following natural changes accordingly to its phenology; therefore the VI evolution is time-correlated, providing that anthropic influence and unexpected natural phenomena such as landslides, fires, floods, etc., are excluded. The VI maps sequence should be thus characterized by a correlation both in the spatial and in the temporal domains, and therefore a local temporal correlation of spatial frequency is expected. A characterization of such correlation is very interesting, and it could be used to infer at a given time a VI map with higher spatial resolution than that acquired, or to highlight possible unexpected anomalies that could be related to natural or anthropic fast modifications of landscape and ecosystems. In this work a multitemporal series of multispectral images acquired on a large test area in the central Italy have been considered. These images have been co-registered and orthonormalized. For each image, a VI map has been created and, by means of a sliding window filtering, two maps containing the former the low spatial frequencies (VILOW ) and the latter the high spatial frequencies (VIHIGH ) have been also extracted. By this way, a multitemporal series of high and low spatial VI frequency maps are originated. To assess the possible time stability of the low and/or high VI spatial frequencies, a temporal mean and standard deviation have been evaluated for each pixel of the VIHIGH and the VILOW time series. Then, low values of temporal standard deviation, both in the low and high frequency, highlight points in which the related spatial frequency is almost time-stable; on the contrary, high temporal changes increase the standard deviation value. The results have been analyzed as regards the vegetation cover variability and the potential to synthesize sequence of VI maps at enhanced spatial resolution.
Characterising fire hazard from temporal sequences of thermal infrared MODIS measurements

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Abstract: Forest fires are a major environmental threat in large areas of the Mediterranean. There is a widespread agreement on the prominent role that fire prevention should have over remediation activities, and indeed fire managers demand for fast and reliable methodologies to forecast fire hazard. Fuel moisture and temperature are the most variable factors determining fire hazard. Traditional methods are based on meteorological measurements, vegetation maps, and on direct field sampling, but they prove ineffective when the need is for a continuous monitoring of vast areas, as requested by regional authorities in charge of forests management. This outlines a clear role for remote sensing, whereas it is proved it can be used to map fire hazard, thanks to the availability of various orbiting instruments providing global daily measurements of surface radiance at various wavelengths. The objective of the present research was to develop and test a methodology for the characterisation of fire hazard from thermal infrared measurements of MODIS sensor. At the basis of our work was the consideration that both moisture and temperature in live vegetation depend on meteorological forcing over time and on vegetation response. These factors are not independent, and can be potentially inferred by remote sensing measurements in the thermal infrared. The evolution of vegetation status into stress conditions is driven by prolonged heat and absence of rainfall, thus leading to an increase of its temperature. Water stressed vegetation is more prone to fire, and some sort of correlation is expected between observed vegetation temperature anomalies and fire events. To identify temperature anomalies, a reference temperature must be defined. By using long time series of satellite data it is possible to identify expected temporal patterns on a pixel by pixel basis. By comparing actual measurements of land surface temperature (LST) against expected values it is possible to identify stress conditions and relate them to fire hazard. The research focused on Campania, Italy (40°50’N, 14°08’E; Fig. 1), a region that extends for about 13600 km². The interest in this area is given by its position in the middle of the Mediterranean, by the diversity of the landscape and land use/land cover it embraces, and by the high anthropic pressure that leads to almost all fires being triggered by human activities. A dataset of more than 6000 fire records between 2000 and 2008 was provided by the Italian Forest Corps. Data included date and time, coordinates, duration and extent of each recorded fire event. A collection of daily Terra-MODIS LST data (MOD11A product) from 2000 to 2006 was used for this research. Removal of cloud affected pixel values and gap-filling was performed by HANTS algorithm producing continuous time series of maximum and minimum LST. Fourier analysis of the time series of LST was performed for each year, showing three main periodical components (yearly, half yearly and seasonal). These were used to construct the temporal series of reference LST against which to identify anomalies. Results show a weak correspondence between the observed inter-annual variability of amplitude and phase values of the periodical components of LST and fire events. Stronger evidence of LST hazard prediction abilities can be observed when comparing fire events against identified temperature anomalies.
Multitemporal Trajectory-Based Change Detection for Automated Landslide Identification in Kyrgyzstan Using Satellite Remote Sensing Data

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Abstract: In Southern Kyrgyzstan high landslide activity as a result of ongoing tectonic processes and high topographic relief represent one of the main natural hazards to the local population. Since human living space is scarce in this mountainous region, local authorities have a big need for objective and spatially differentiated hazard assessment. The presented research has the goal of developing an automated satellite remote sensing approach for landslide identification at a regional scale. The resulting spatio-temporal inventory contributes to an improved process understanding and thus is an important part of hazard assessment.

For the 100 km by 80 km study area at the Eastern rim of the Fergana Basin an optical satellite remote sensing database has been established consisting of about 400 georeferenced multispectral mid- and high-resolution satellite remote sensing data acquired by Landsat-(E)TM, SPOT, IRS-1C (LISS3), ASTER, RapidEye and ALOS during the last 25 years. This multi-sensor and multitemporal database represents the framework for the development of an automated approach for landslide identification during the covered time span comprising pre-processing and change detection. Pre-processing aims at the spatial and radiometric normalization required for multitemporal analysis. For this purpose an automated image-to-image co-registration method has been developed which uses a time series of USGS level 1T Landsat-(E)TM data as spatial reference. Accuracy of spatial adjustment has been assessed by manual validation and is in the range of one pixel of the original resolution of the sensors.

Multitemporal change detection analysis also requires radiometric normalization of the multi-sensor database. Since there is the goal of developing an efficient and operational approach, change detection is based on spectral indices. Indices, such as the normalized difference vegetation index (NDVI) are commonly used to reduce radiometric differences between multitemporal datasets of a multi-sensor database. In order to assess whether the remaining differences might influence the results of subsequent landslide-related change detection, a simulation study has been carried out investigating the effects of the specific imaging characteristics of the different sensors on the resulting NDVI values. For this purpose on board radiometric calibrated top of atmosphere (TOA) radiance data were simulated for each sensor and different acquisition parameters. Variability analysis of NDVI values derived from the simulated data has shown that sensor and acquisition related differences are significantly smaller than NDVI differences caused by surface changes related to landslide pro-
cesses. Thus, indices-based change detection of TOA radiance data can be used for multi-temporal landslide identification.

The change detection approach is based on the analysis of temporal trajectories of spectral indices derived from the multi-temporal data stack. First NDVI-based investigations have been carried out in order to identify typical trajectories indicating the occurrence of a landslide. In this context the high temporal resolution of the RapidEye data of 10 acquisition dates between April and September 2011 allows the identification of temporal trajectories which are typical for seasonal changes in order to discriminate them from trajectories which indicate landslide occurrence. The results of a systematic analysis of these trajectories in combination with additional thematic and topographic information will be used for spatio-temporal landslide identification at a regional scale.
Flood mapping based on SAR data

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Keywords: flood, microwave, SAR data

Abstract: Space-based services have a large potential for disaster management. They can support the organizations that deal with major natural and man-made hazards around the world. Space assets have been brought into action on many occasions, for disasters such as flooding, hurricanes, earthquakes, forest fires, volcanic eruptions and oil spills. Earth observation data are key because they provide objective and synoptic information. Moreover, they allow us to obtain information in a rapid way. Timeliness is one of the main issues in the support of relief teams and the international humanitarian organization engaged with disaster response. Most users request up-to-date information on a daily or even hourly basis (which is still not available). For hydro-meteorological events mapping Synthetic Aperture Radar (SAR) data is often requested. The most important reason for using radar imagery is the ability of the microwave to penetrate the atmosphere and independence from the sun as a source of illumination. Thanks to these characteristics SAR is an all-weather, day-night system. This paper focuses on the SAR data for mapping the extent of a flood. The strength of the radar backscatter depends on the roughness of the surface that it interacts with. The incident side-looking radar pulse is scattered away from a smooth surface such as calm water bodies. It is a case of specular reflection. The radar image values for these areas are very low due to little return of radar pulse. The radar image over that area is black or very dark. The situation is different for rough land surfaces. The radar echo is higher for them so the corresponding radar image pixels are brighter. Thanks to this, water can be well distinguished on a radar image. As a test area a part of the Danube valley in Upper Austria was studied. Two ERS2 SAR PRI scenes have been used. One image was acquired during the flood – a “crisis image” – the second – a “reference image” – was registered a year earlier. The influence of topography on the backscatter coefficient was limited by the use of a Digital Elevation Model (DEM) during the processing. After the terrain correction, there were radiometric errors on the images, especially in the region with varied terrain. The shift between DEM and the images was a source of the problem. For a control, the terrain correction was done once again with another DEM. The results of both terrain corrections were similar. It was concluded that image orbit parameters were not accurate enough or the algorithm caused the errors. A change image has been produced by dividing the backscatter values from the crisis image by the values from the reference image. The hypothesis assumed that the darkest pixels represent flooded areas. To determine pixels values corresponding with them training fields were used. Although flooded wooded areas were not distinguished (due to the wavelength used by ERS SAR) it can be said, based on this analysis, that SAR data are useful to present the range of the flood.
REMOTE SENSING APPLICATIONS FOR FLOOD DEFENSE PLANS FOR THE HILANDAR MONASTERY

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Keywords: torrential floods, erosion, sediment transport

Abstract: Hilandar is a Serbian monastery located on the north slopes of Mount Athos, which is home to 20 Eastern Orthodox monasteries and forms a self-governed monastic state. It is situated on the easternmost “leg” of the Halkidiki peninsula in northern Greece. The Mount Athos peninsula is part of the Rhodope mountain range and separates the Greek geologic complex from the Balkans. In geological terms, it consists of mainly granite and quartz. Under the influence of local climate and other factors, particularly erosion, this compound is deteriorating at the surface contact zone. Silt that is formed by the decomposition of rock mass and erosion processes reaches streams and rivers, and with every torrential event forms deposits near walls, endangering the Hilandar monastery complex. Part of the monastery walls, churches and holy sites were devastated in the great fire of 2004 when wooden structures from the chimneys caught fire. It was determined that the cause of the fire was the subsiding of the chimney structures that was in turn caused by intense torrential floods in 2003. With the use of remote sensing, satellite imagery, the land cover was determined for the purpose of hydrologic, erosion and sediment production analyses. This facilitated the design and preparation of technical documentation for flood protection of the Hilandar monastery.
Towards monitoring post-fire vegetation cover dynamics in the Mediterranean with the use of object-based image analysis of Landsat images

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**Keywords:** Forest fires, fire risk, vegetation recovery, Landsat MSS and TM, Object-Based Image Analysis

**Abstract:** Up to date information on vegetation cover is essential to assess daily fire potential danger. Even though characterized by slow dynamics vegetation cover change in time. Wildfires create deep and rapid changes in the structure of vegetation cover. In addition, cultivation and forest plantation are subject to succession dynamics in case they are abandoned. It means that in 5 to 10 years a cultivated area subject to limited fire risk can lead to shrub cover characterized by high potential fire danger. On the other hand, in some areas the effect of fire is able to modify permanently the vegetation cover changing these areas in non vegetated areas. Monitoring and assessing the impact of post-fire effects (forest regeneration and vegetation recovery) and succession dynamics in the long term is important to address fire prevention activities. Since satellite sensors are able to cover wide areas at a high frequency and are also able to provide information about non-visible spectral regions, they represent a very valuable tool for monitoring vegetation recovery and vegetation succession after fire.

The aim of this work was to develop a model for an operational monitoring of vegetation cover dynamics in fire-prone Mediterranean ecosystem with the use of multi-temporal Landsat images. The specific objectives were: 1. to map the extent of burned areas; and 2. to monitor post-fire vegetation recovery within burned areas

The work involved the development of an Object-Based Image Analysis (OBIA) model with the use of multi-temporal Landsat images covering North Lebanon. The Landsat data comprised one pre-fire MSS image (acquired on 15-9-1972), one TM image for mapping burned areas (acquired on 28-9-1986), one post-fire TM image (acquired on 19-11-2002) and another post-fire TM image (acquired on 3-12-2010). The strategy before classifying the burned area and monitoring land cover change was to create a four-level graded scale of segmentation. Thus, larger objects (regarded as super-objects) and medium-size objects at higher levels would provide information for the small objects at lower levels. After segmentation, the different levels of segmentation were classified using both spectral and contextual information (e.g. relationship to super-objects). From the moment that an object is classified as burned, for instance, local intelligence was applied and in principal everything which is done from that moment with this object and its networked environment can be done with a burned logic.

More specifically, the following classes were created at the different levels. The classes “vegetation” and “no vegetation” were classified on the 1972 image (level 4). The classes “vegetation”, “burned”, and “other” were classified on the 1986 image (level 3). The classes “recovery”, “other vegetation”, “unrecovered” and “other” were classified on the 2002 image (level 2). Finally, the classes “new recovery”, “ongoing recovery”, “other vegetation”, “unrecovered” and “other” were classified on the 2010 image (level 1). The results of the classification showed that a total of 1164 pixels were
classified as burned in 1986. When mapping vegetation recovery in 2002, it was found that a total of 1148 pixels were classified as recovered vegetation within fire affected areas. An additional area of 16 pixels was recovered by 2010.

The developed approach is flexible enough to be employed for a continuous monitoring of vegetation dynamics. In addition, Instead of processing all areas of an image with the same algorithms, a differentiated procedure would be more appropriate. This is a specific strength of the applied method. Also, it will be possible to narrow the monitoring down to a yearly basis by importing multi-temporal satellite data acquired on every year after the fire event.
Monitoring of invasive aquatic plants using multitemporal RapidEye data

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Keywords: invasive aquatic plants, RapidEye, depthinvariant indices, water constituents, semi-empirical water column correction

Abstract: Rising water temperatures due to climate change seem to favor thermopilec invasive aquatic plants. In Central Europe an increased spread of Najas marina and Elodea nuttallii can be observed. A monitoring system is required to estimate the effect of their expansion on the ecosystem. The monitoring of these spatiotemporal highly variable developments requires rapid on-demand informations which can only be achieved by spaceborne multitemporal remote sensing data. The ability of RapidEye, which offers the desired temporal and spatial resolution, is tested. Two study sites in Bavaria (Lake Starnberg and Lake Tegernsee) were visited 2011 periodically to measure in-situ reflectance of Elodea nuttallii and Najas marina with submersible RAMSES spectroradiometers. Since measurements were performed directly above the vegetation patches, as well as beneath the water surface, information about water constituents is also available. The combination of two measurements of the downwelling irradiance in different depths allows the calculation of the vertical diffuse attenuation, which is as an apparent optical property (AOP) related to inherent optical properties (IOP) like Phytoplankton, colored dissolved organic matter (cDOM) and suspended particulate matter (SPM) content. Information about the water constituents is necessary to correct for the exponential radiation loss through the water column and to achieve bottom reflectances or water column corrected derivatives. The frequent reflectance measurements (14 days interval) allow to build up a multiseasonal spectral library for both plants representing each phenological state. The in-situ derived attenuation measurements were used to calculate depth-invariant band ratios using a simple semi-empirical method based on logarithmic transformed and atmospherically corrected RapidEye data. These depth-invariant indices were also calculated for in-situ measurements. The transformed in-situ measurements were used as endmember in a subsequent linear spectral unmixing approach based on the matched filtering method. This was done to achieve sub pixel abundances of Najas marina and Elodea nuttallii.
The experience of the using of the fractal and wavelet analysis for investigation of the chaotic dynamics of the ocean based on altimetry time series

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Keywords: altimetry time series, fractal analysis, wavelet analysis, the Southern Ocean

Abstract: As the sea level is influenced by many factors affecting the different temporal and spatial scales, it can be regarded as a signal generated by a nonlinear dynamic system, where the signal itself is an observable realization of this system. The sea level can be considered as an integrated indicator of intensity of thermodynamic and dynamic processes at ocean which often shows the chaotic regime and is accompanied by sharp changes (bifurcation) of a functioning mode. Therefore, dynamics of the time series sea level is impossible to describe only by the cyclic components. The complexity of the temporal variability of the series generated by natural systems, manifested in the appearance of their new - fractal properties. Fractal properties of series of oceanographic characteristics are detected in the study of wind waves, thermal convection, sea level fluctuations. The study of the peculiarities of the chaotic dynamics and fractal properties of the fluctuation of the sea level in the Southern Ocean is based on the array of the satellite altimetry information (1992-2010 years) obtained from the Archiving, Validation and Interpretation of Satellite Oceanographic Data (AVISO) data center (http://www.aviso.oceanobs.com). The time series with week discretization based on this data are formed. The peculiarities of the fluctuation of altimetry sea level on various time scales were investigated with the using of the wavelet-analysis. The main scales of the oscillations were detected. One of the methods to identify fractal properties (determining the fractal dimension) is distinguished by the so-called R/S analysis (or analysis of Hurst), which calculation is based on the Hurst parameter. Hurst parameter is related to the fractal dimension of nonlinear dynamic systems and can be used for estimation of the possibility of the appearance of the chaotic dynamic. Calculations Hurst parameter and fractal dimension were carried out by using of the free software Fractan 4.4. Estimates of the Hurst parameter (Hu), calculated for the altimetry time series are consistent with the values obtained for various natural processes. They all lie in the range from 0.45 to 1.21 (subject to obtaining accurate estimates), demonstrating the different nature of the operation of dynamic systems from random (Hu = 0.5) to weakly deterministic (Hu = 1.25). It is established that the fractal dimension is changing in the regions of the Southern Ocean. That confirms the assumption that the dynamical system that represents the Southern Ocean has different modes of operation in different areas. The graphs of R/S statistics indicate a change in the nature of the system over time.
Multi-temporal MERIS data to support the implementation of the Water Framework Directive

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Keywords: Perialpine lakes, Chlorophyll-a, algal blooms

Abstract: The lakes of the European perialpine region constitute a large water reservoir, which is threatened by the anthropogenic pressure altering water quality. The Water Framework Directive (WFD) of the European Commission aims to protect water resources by maintaining a ‘good’ and ‘non-deteriorating’ status for all waters (surface, ground and coastal). The directive introduces a new perspective by proposing to address monitoring activities at the catchment scale rather than following national boundaries. Monitoring is a key activity to assess the status of waters and to systematically assure the maintenance of good quality conditions. Since field sampling can be very laborious and expensive over large areas, remote sensing techniques certainly constitute the most suitable source of spatially distributed and frequent data on the conditions of surface waters over Europe. Data acquired by space-borne sensors, such as MEdium Resolution Imaging Spectrometer (MERIS), can be processed to extract bio-physical parameters such as chlorophyll-a (chl-a) concentration, which is an indicator of the ecological conditions of surface waters. In this work we used a multi-temporal dataset of chl-a maps derived from over 200 MERIS images acquired between 2003 and 2009 to evaluate the ecological conditions of 12 perialpine lakes of Europe. Our results highlight the seasonal changes of chl-a concentration which is particularly pronounced in spring and autumn and for eutrophic lakes; this high variability points at the need of using multiple measurements during the year to assess the conditions of surface waters thus confirming that the integration of remotely sensed data with field measurements is necessary. Indeed, the assignment to a water quality class based on only one sample during the season, as field-based approaches
do, might lead to misleading results due to the high dynamic of surface water systems. In this work we further present the case of lake Idro where in summer 2010 an algal bloom occurred which was characterised by the presence of accessory photosynthetic pigments (e.g. phycoerythrins and carotenoids). In this specific case, chl-a concentration could not be used as a proxy of the presence of the algal bloom observed in the field thus suggesting that it could not be assumed as a general proxy of surface water quality. In order to monitor the bloom observed in lake Idro we calibrated a semi-empirical model relating field measurements of radiometric and limnological data. The algorithm was applied to over 30 MERIS images (from 2005 to 2011) to monitor the temporal dynamics of the bloom and to evaluate whether similar phenomena had occurred in the past. This analysis suggests that the integration of site-specific algorithms with more widely used indicators of water quality, such as chl-a concentration, might provide a complete set of information for surface water monitoring. As a general conclusion from a remote sensing perspective, MERIS images showed to offer suitable temporal and spatial resolution for addressing the issue of water quality monitoring at the catchment scale; satellite-derived information need, however, to be integrated with field data that are still necessary for calibration and validation activities.
Multiple resolution data for the ongoing monitoring and temporal analysis of Lake Balaton (Hungary) water quality

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Keywords: Lake Balaton, monitoring, water quality, multiple sensor fusion

Abstract: Lake Balaton is by surface area (597 km2) the largest lake in central Europe, and is of vital importance within the region due to the role it plays ecologically, as well as recreationally and economically, as the centre of a very active tourism industry. The ecosystem faces a number of synergetic pressures related to land use, tourism, and climate change, and over the past decades has periodically undergone extreme variations in water level and quality. Such events emphasize the need for adequate monitoring of related biophysical parameters. Due to the presence of the Balaton Limnological Institute (BLI), Lake Balaton has been highly studied for more than a century, particularly in terms of its various biological components and nutrient dynamics. This includes regular (1-2 times monthly) water sampling at fixed locations in the lake’s four basins, and analyses for chlorophyll-a (chl-a) and total suspended matter (TSM) concentrations. From 2011-2014 the BLI has partnered with the Marie Curie FP7 programme GIONET (GMES Initial Operations - Network for Earth Observation Research Training) to develop an ongoing remote sensing-based water quality monitoring system for Lake Balaton, while providing an Early Stage Researcher (ESR) with invaluable training and applied research opportunities.

Data available for Lake Balaton are of a variety of types and spatial, spectral, and temporal resolutions. The monitoring system to be developed by the GIONET ESR aims to make use of the existing sampling strategy, while improving upon its scope and usability through the increased spatial and temporal coverage and resolutions permitted by MODIS imagery. MODIS overpasses occur daily, and provide data at 250m and 500m spatial resolutions for the quantification of TSM and chl-a concentrations respectively. The potential of Landsat imagery to monitor Lake Balaton...
ton water quality was considered in the past (2000-2005), but discontinued due to its insufficient overpass frequency. Results were promising, however, and Landsat imagery that are available may improve possible insights through fusion with the higher temporal but lower spatial resolution MODIS images. Further groundtruthing data available for fine tuning Lake Balaton satellite water quality algorithms include punctual ship-mounted UV fluorescence lidar campaigns, using the Shirshov UFL-8 lidar, undertaken to date over three days in September 2008.

The current study investigates options to make best use of different types of data available at diverse scales and resolutions to implement a practical and sustainable water quality monitoring system sufficient for use in scientific research, by the local water authority, and in land use, tourism and development decisions alike. A subset of UFL-8 UV fluorescence lidar data were calibrated with in situ sample analyses (n = 30, R² [U+02C3] 0.9). Presented are preliminary results of MODIS algorithm development for deriving Lake Balaton chlorophyll-a and suspended solid concentrations using the full UV fluorescence lidar dataset (n = 2724 and 2778 respectively). Independent tests of the MODIS algorithms are subsequently applied to 12 scenes from different seasons and years, using associated in situ measurements (n = 60). Future goals and strategies for developing, testing, and implementing the system, and analysis of time-series data are discussed.
Temporal Variability of Satellite-Measured Chlorophyll a in the Northwestern Black Sea

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Keywords: Northwestern Black Sea, SeaWifs, AVHHR, Chlorophyll, Seasonal variations, Timing of the bloom

Abstract: Satellite-derived near surface chlorophyll-a from Sea-viewing Wide Field-of-View Sensor (SeaWiFS) from January 1998 to November 2010 have been used to study seasonal-to-interannual variability of pigment concentrations in the Northwestern Black Sea Shelf (NWS). Dynamics of both pick timing and magnitude of the bloom in the region has been evaluated with respect to the environmental factors influencing phytoplankton distribution: Photosynthetically Available Radiation (PAR, from SeaWifs) and Sea Surface Temperature (SST, from AVHHR radiometer). The analysis indicated that seasonal variability in the NW Black Sea have evident pick in late spring coinciding with the maximum of major rivers discharge. Furthermore, the analysis of interannual variation has been discussed, revealing significant decreasing trend of chlorophyll a over the thirteen year period. This study aims to improve understanding of temporal patterns of chlorophyll a concentrations, as well as the role of the environmental factors driving the phytoplankton distribution in the most productive area of the Black sea.
Mapping of zones with coherent dynamics of satellite derived variables for studying spring phytoplankton bloom

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Abstract: While analyzing series of satellite images researches face such problems as: effective visualization of 3D data; simultaneous analysis of several parameters; gap filling. One of the solutions which is used to solve these problems is division of the region of interest into several small zones and consecutive averaging of values of each parameters within each zone for each time step. But how large should be these zones in order to perform statistically meaningful averaging? If we choose to have too large zones, the averaged values will be influenced by several processes and may even have bi- or multi-modal distribution. If the zones are to small we will again end up in myriads of values which are hard to visualize and understand. And what should be the shape of the zones? We suggest a method for automatic delineation of zones with coherent dynamics of one or several variables derived from satellite data. Area and shape of the zones is fitted for each particular research purpose. The method is based on application of principal component analysis and cluster analysis of time. A Python code that realizes the suggested method of objective zoning is briefly described. Application of the method is illustrated on studies of spring phytoplankton bloom in the Nordic Seas.
Regional monitoring of Amazonia’s coastal ecosystems: landcover dynamics analysis using extensive high resolution optical data sets

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Keywords: Costal ecosystems, remote sensing, Amazonia, Mangroves, multitemporal, French Guiana

Abstract: This paper brings detailed insights on the remote sensing methods used to monitor the Amazoin’s coastal ecosystems dynamics in regional scale, caracterizing landcover dynamics over a ten year period.

In French Guiana a direct receiving facility called "SEAS Guyane" is operating since early 2006, bringing Envisat/Asar and Spot 5 direct receiving capacities for scientific applications. PROCLAM is a project that produced thematic mapping of more than 1500 km of coastal ecosystems, extending from the French Guiana/Suriname border to the Maranhao State’s Capital, Sao Luis, Brazil. Dedicated programations of the Spot 5 satellite were implemented at the facility, in order to gather more than 800 scenes; 145 were selected on various criterias for geometric rectification and coregistration, thematic interpretation and cartographic purposes.

The objective of this effort was to demonstrate the plateform’s capacity to sustain a regional scale monitoring of landcover dynamics in the Amazon’s coastal fringe. Results show spatial distribution of Amazonian coastal ecosystems in high resolution (10 m). The mangroves and associated coastal ecosystems shelter reproductive and breeding processes of numerous marine and continental life forms, and are identified as a major component of marine food chains in northern South American waters. We compared our results with previous 1997 Landsat based cartography, providing assessments of natural dynamics affecting the Amazonian shores. The project consistently documented the intensity of the natural processes impacting coastal morphology, mangrove distribution and erosive phenomenas, proving Coastal Amazonia to be one of the most changing region of the world.
Monitoring Landcover changes on the coastal zone of North Lebanon using Object-Based Image Analysis of multi-temporal Landsat images

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Keywords: Landcover change detection, Multi-temporal Landsat imagery, Object-Based Image Analysis, Coastal zone

Abstract: Landcover change is one of the most sensitive indicators for environmental change. Reliable monitoring and effective analysis techniques need to be implemented in order to estimate landcover change and its ecological impact. Remote sensing images not only provide extensive coverage of wide areas, but also provide comprehensive information about these areas. The wide area coverage and high frequency offered by satellite sensors, as well as their ability to provide information about non visible spectral regions, makes them a very valuable tool for the detection and mapping of landcover changes. Indeed, remotely sensed data can contribute to a better, cost effective, objective and time-saving method to quantify the location, aerial extent and frequency of changes in the landcover. Monitoring landcover changes in Lebanon using multi-temporal satellite images is considered an important step towards investigating environmental change over large areas with the severe lack of environmental measurements and records. Automated change detection presents a valuable tool for monitoring large areas. Until present, Lebanon lacks an operational mechanism for monitoring changes in landcover/landuse at the National level. Simultaneously, there is continuous demand for techniques such as Object-Based Image Analysis (OBIA) that allow the integration in the analysis of more than one image (possibly of different spatial resolution) and produce GIS-ready results. This work aimed to characterize landcover change during the last four decades on the coastal zone of North Lebanon using an Object-based image analysis approach. This was an initial step towards conducting a more advanced investigation for assessing the effect of repetitive armed conflicts on the Northern coastal environment. A total of five Landsat Multispectral Scanner (MSS) and Thematic Mapper (TM) covering the same geographical area of North Lebanon were employed. The satellite images were acquired on 9-9-1975 (MSS), 9-11-1984 (MSS), 5-10-2006 (TM), 6-9-2007 (TM), and 3-12-2010 (TM) successively. The methodology of work included 1)
satellite data pre-processing, 2) image segmentation and classification, and 3) post-classification comparison of the results. Pre-processing of data included geometric calibration and masking of images. OBIA included segmentation of images at different levels and classification incorporating contextual and semantic information. The concept of OBIA is that the information necessary to interpret an image is not represented in a single pixel, but in image objects. Obtained classifications from two different images in t1 and t2 were compared independently. Overall, OBIA proved to be successful in monitoring landcover change with the use of multi-temporal satellite images. The results indicated an approximate 1020 ha of lost vegetation cover during the last four decades. Also, a total seawater area of 265 ha was converted to land (existence of new jetties, marinas, sea filling, etc.). Comparison of classifications between two consecutively dated images showed that most of changes in coastal land filling happened between 1984 and 2006. Rate of negative change in vegetation cover was highest between 2006 and 2007. Field visits to 21 coastal villages where changes were recorded combined with visual interpretation of the results using multi-temporal very high spatial resolution SPOT imagery showed that recorded changes in landcover came in the form of: deforestation, land reclamation from the sea, indiscriminate construction, new road networks, and quarrying, among others. Future work includes 1) the investigation of the possible direct and indirect effect of repetitive armed conflicts on observed landcover changes, and 2) the assessment of land degradation risk as a result of changes in the landcover.