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Editors

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Introduction

This proceedings volume contains papers presented during the conference on Remote Sensing for Agriculture, Ecosystems, and Hydrology XIII. The conference was part of the 18th International Symposium on Remote Sensing sponsored by SPIE—The International Society for Optical Engineering. The symposium was held at the Clarion Congress Hotel Prague, Prague, Czech Republic, from 19th to 21th of September 2011.

The conference is dedicated to providing rapid dissemination of scientific and technical information, and attracted scientists and professionals from throughout Europe, Africa, Asia, and the Americas. Approximately 45 oral and 30 poster presentations were given, covering a broad range of topics in the field of remote sensing applications in environmental science.

The program was organized according to major themes, with 10 sessions on Agriculture: Irrigation and Energy Balance and Agriculture (2); Ecosystems: Estuarine, Coastal and Inland Waters; Vegetation and Change detection; Hydrology: Snow and Hydrology (2). The poster presentations also had good representation from the abovementioned themes. The presentations described both fundamental and applications-based research activities from modelling, to laboratory and field experiments, to operational applications. The oral program also included three invited presentations: James L. Foster of NASA Goddard Space Flight Ctr. (USA) gave a presentation on the subject "*Remote sensing of snow cover and snow water equivalent for the historic snowstorms in the Baltimore/Washington area during February 2010*" within a Snow session; Heikki K. Saari of VTT Technical Research Ctr. of Finland (Finland) gave a presentation on the subject "Unmanned aerial vehicle (UAV) operated spectral camera system for forest and agriculture applications" within General Application session; Clement Atzberger of University of Natural Resources and Life Sciences (BOKU) Wien, (Austria) gave a presentation on the subject "*Why confining to vegetation indices? Exploiting the potential of improved spectral observations*" within a Vegetation session; Short reports pointing out the state of art and perspectives in the research fields of the invited talks are reported below.

We extend our thanks to the co-editor Katja Richter of Ludwig-Maximilians-Univ. München, and Session chairs Francesco Vuolo of Univ. of Univ. für Bodenkultur Wien (Austria) and Goffredo La Loggia of Univ. degli Studi di Palermo, and to the presenters for their efforts and to the participants for their insightful questions and discussions. Special thanks are also due to the host city for the excellent venue and to all the SPIE organizational staff for their support prior to, during, and after the symposium. We look forward to an even more successful conference in 2012.

Christopher M. U. Neale
Antonino Maltese
Katja Richter

Remote sensing of snow hydrology: state of art and perspectives

Snow plays an important role in the global energy and water budgets, as a result of its high albedo and thermal and water storage properties. Snow is also the largest varying landscape feature of the Earth's surface. For example, in North America, the snow cover extent may vary from greater than 50% to less than 5% in the course of six months, and the snow water equivalent (SWE) of mid-latitude snowpacks can be reduced by as much as 100 mm in less than six days. Furthermore, snow depth and SWE, as well as snow cover extent, are important contributors to both local and remote climate. Thus, knowledge of snow extent and SWE are important for climate change studies and applications such as flood forecasting.

Melting snow contributes much of the water required for drinking, agriculture and, industry in many regions of the world. In the western U.S., upwards of 70% of the water supply is derived from snowmelt. In India, Pakistan, Afghanistan, and Nepal snow and ice melt from the Hindu Kush and Himalayan ranges are a vital resource for nearly 1 billion people. The ability to characterize snow storage more accurately at the drainage basin scale is crucial for improved management of our precious water resources. Snowmelt data are needed in hydrological models to improve flood control and irrigation. Also, SWE, snow cover, and melt onset are critically needed parameters for climate modeling and the initialization of forecasts at weather and seasonal time scales.

There is a heritage of 50 years of remotely sensed snow observations utilizing the visible wavelengths and 35 years utilizing passive microwave observations. We now have sufficient years of observation to develop robust datasets so that meaningful trends in snow cover extent can be detected and related to climate fluctuations. Additionally, we now have a much better understanding or sensor retrieval errors. This is crucial in order to correctly interpret and evaluate the observations and to successfully assimilate them into numerical models.

Despite its importance, successfully forecasting and modeling snowmelt is a challenge since the knowledge of snow physics is imperfect, even the most sophisticated models are simplifications and because errors still exist in the model forcing data. Moreover, the natural spatial and temporal variability of snow cover is characterized at space and time scales below those typically represented by models. Snow model initialization based on model spin-up will be affected by these errors. As we become more adept and comfortable in assimilating snow observation products into Land Surface Models (LSMs), the effects of model initialization error will likely be reduced with the end result being models that more accurately and reliable resemble observations.

James L. Foster
Invited Speaker
NASA-GSFC
Greenbelt, United
States of America

Exploiting the full potential of spectral observations for mapping vegetation biophysical variables: state of art and perspectives

Continuous fields of vegetation biophysical variables (e.g. LAI) are required in numerous applications (e.g. precision agriculture, irrigation management, SVAT models). Proposed methods for mapping biophysical variables range from empirical techniques mainly based on vegetation indices (VI) to physically based techniques employing radiative transfer models. Albeit numerous experiments found close relationships between VI and important biophysical variables, well known shortcomings and drawbacks remain:

Under-determined inverse problem: Even when looking only at relatively uniform agricultural crops, the measured canopy spectral reflectance (visible to SWIR) is influenced by at least by 5-10 structural and optical properties for a given illumination and observation geometry. The main structural properties affecting the canopy signature are LAI, leaf orientation (ALA) and leaf clumping. The leaf optical properties are mainly driven by the leaf chlorophyll and water content, and the leaf structure. In addition, soil optical properties are known to change with surface wetness and roughness. For this reason, attempts to define a close relation between a (2-band) VI and for example LAI, can only work well under specific conditions, where all other parameters are more or less constant. Generally, 2-band vegetation indices such as NDVI only minimize soil background influences.

Sub-optimum use of available spectral information: Most sensors record spectral data in more than two bands. Hence, the available spectral information of multi-spectral sensors and imaging spectrometers is not fully exploited when vegetation indices are used for mapping vegetation biophysical variables. Important information is ignored when using only a few (e.g. 2) wavebands for modeling LAI or other biophysical variables. If empirical techniques are to be used, it is certainly more appropriate to use full spectrum methods such as Partial Least Square (PLS) regression. Full spectrum methods are at the same time less sensitive to (Gaussian) noise as compared to VI.

Model over-specialisation: Vegetation indices can be defined and fine tuned to different environmental settings, vegetation types, and measurement conditions. This advantage, however, often leads to over-specialized models which are only valid for the specific training data base used for model calibration. For a given training data base it can be shown that the 'optimum' functional form of the VI and selected 'optimum' wavelengths are very sensitive to measurement uncertainties and calibration strategies (e.g. cross-validation, bootstrapping). Therefore, developed models can hardly be reproduced. Internal validation strategies generally yield over-optimistic performance statistics.

Lack of transferability: In most spectral regions, even relatively small spectral shifts lead to changes in the observed canopy spectral reflectance. At the same time, vegetation canopies are strong anisotropic scatterers, where the recorded signal depends on the actual sun/view geometry. Hence, empirical models developed for a given measurement geometry and sensor (e.g. with specific band widths and spectral response functions) can generally not be transferred to other sensors and measurement conditions. In practical terms this implies high sampling costs (man power) for large area mappings.

Most of the above-presented drawbacks cannot be overcome whatever mathematical transformation is applied to the data. Hence, constantly proposing new vegetation indices (e.g. functional forms and waveband combinations) is probably unproductive. Instead, research should focus on full spectrum methods and in particular physically based approaches, which provide an explicit connection between the recorded signal and the sought biophysical variables. In this way, sensor characteristics and measurement conditions are implicitly accounted for. Methods built on physical principles also better generalize across different environmental settings and are less prone to over-specialisation. The ill-posed inverse problem can be (partly) overcome by imposing constraints on the inverse problem. For example, several studies demonstrated the benefits of exploiting spatial variations in the signal (e.g. object-based inversions or patch-ensemble approaches). In addition, temporal constraints can be used to further regularize the inverse problem and to fully exploit the intrinsic dimensionality of the recorded signal.

Clement Atzberger
Invited Speaker
University of Natural
Resources and Life
Sciences (BOKU)
Wien, Austria

The Evolution of Airborne Chemical and Radiological Remote Sensing For Emergency and Natural Disaster Response

Summary of the September 19, 2011 SPIE Remote Sensing Plenary Session Presentation by Paul E. Lewis
National Geospatial-Intelligence Agency, United States of America

First responders, joint operations centers, and recovery and remediation personnel consider timely and affordable airborne chemical, radiological, imagery analysis, and related mapping products essential in the formulation of a complete understanding of an incident and its potential impact on adjacent communities, and for recovery and remediation. Airborne remote sensing provides the flexibility to produce incident specific products and conduct over-flights at the frequencies needed to provide timely and relevant information for recovery and remediation operations, optimization of resources during an event, and for the safety of emergency response personnel.

The utility of airborne chemical remote sensing became apparent to the EPA during a chemical plant explosion, which occurred in Sioux City, Iowa in December of 1994. The facility produced ammonium nitrate fertilizer, and also produced its own ammonia for use in the process. In late December an explosion occurred rupturing the main storage tank and spilling three million gallons of ammonia. This resulted in lethal vapor levels in and around the plant and created a plume of ammonia vapors estimated to be 35 miles long. Approximately 3,500 people were evacuated over a 50 square mile area. The EPA sent in vehicles with ground sampling crews dressed in Level A hazmat suits with 30 minute air packs to monitor the site. Due to heavy snow coverage on the ground and saturated soil conditions underneath the snow, all of the EPA vehicles became stuck. Ground sampling crews had to be rescued before air supplies ran out. Consequently, no monitoring of vapor levels was accomplished.

The lessons learned from responding to the chemical explosion in Sioux City, Iowa in 1994 prompted the EPA to begin evaluating the application of airborne remote sensing infrared and gamma ray spectroscopy for emergency responses involving chemical and radiological incidents. Concurrently, with the evaluation process to determine the performance and feasibility of implementing infrared and gamma ray spectroscopy in an airborne platform came the evolution of a set of core requirements for an airborne operational capability: Standoff chemical and gamma ray detection and identification with low false alarm rates; High resolution ortho-rectified day-night imagery; Airborne data collection under cloud ceilings; Rapid dispatch-wheels up in under one hour after activation; Automated data processing –real or near-real-time chemical data analysis; Direct integration of data and information to local incident commanders-local and federal joint operations centers; Data telemetry to and from the aircraft.

According to the EPA, in the United States there are approximately 123 facilities where a release of chemicals could threaten more than one million people. There are approximately 750 additional facilities where a chemical release could threaten more than a hundred thousand people.

In 2001, the EPA implemented the United States only civilian operational airborne chemical detection and identification capability called the **A**irborne **S**pectral **P**hotometric **E**nvironmental **C**ollection **T**echnology (**ASPECT**) Program. Subsequently in 2003, the EPA and NGA agreed to collaborate in a cooperative research and development program focused on evolving the capabilities of the ASPECT Program to produce near-real-time state of the art chemical, radiological and imagery mapping emergency response products.

Airborne Spectral Photometric Environmental Collection Technology (ASPECT) Program
The United States Only Airborne
24/7 Operational CIVIL Emergency Response Chemical, Radiological, & Imaging Mapping Capability

The ASPECT model of operation combines an airborne operational remote sensing suite with a research and development support team to insure that analysis and products are validated and verified scientifically and are reviewed and checked before release. The research and development support team collaboration between the EPA and NGA to evolve the capabilities of the ASPECT Program has resulted in the following significant accomplishments: Near-real-time automated onboard chemical detection and identification of 78 chemical compounds with low false alarm rates; Near-real-time information on plume direction and concentrations; Automated software producing day/night ortho-rectified imagery rapid response maps; Automated software producing gamma ray survey information maps onboard the aircraft; Data and information telemetry to and from the aircraft facilitating turn-around times and seamless integration of vital situational awareness information from the aircraft to first responders or joint operation centers in 5 to 15 minutes.

Since 2001 the ASPECT Program has provided essential information during 115 emergency, disaster, and homeland security related incidents ranging from chemical plant explosions and train derailments to fires, floods, hurricanes, and special events. The ASPECT Program played key roles in providing essential information to first responders and joint operations centers in response to the following historical events: The Shuttle Columbia break up during re-entry over Texas in February of 2003; Hurricane Katrina in August of 2005; The Deepwater Horizon Oil Spill disaster in the Gulf of Mexico from April-August 2010.

Over the past decade in over 115 responses, the ASPECT program has demonstrated the utility of having timely, cost-effective operational airborne chemical and radiological remote sensing information integrated seamlessly into to the local, state and federal emergency response and disaster recovery and remediation communities. What is needed next is the implementation of multiple aircraft strategically located throughout the United States so that ASPECT capabilities can be on the scene of a disaster or event in less than three hours.