18. Earth System Science related Earth Observation

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18.1
Imaging spectroscopy based assessment of gross primary production in heterogeneous landscapes

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Gross primary production (GPP) is an important parameter in ecology for estimating ecosystem productivity. It is the rate of carbon dioxide (CO₂) uptake by terrestrial or aquatic vegetation through the process of photosynthesis, converting atmospheric CO₂ into organic compounds. It determines provisioning of ecosystem services on which humans indispensably rely, e.g., food, fiber, bioenergy, or fisheries. Profound modifications of biological or physical processes in ecosystems due to global change drivers influence biogeochemical cycles like the carbon cycle and, thus, affects the productivity of ecosystems, the related quantity and quality of ecosystem services (ES), and consequently the climate. Accurate spatial quantification of GPP is therefore important for monitoring carbon uptake and release in particular, and the overall C-budget of ecosystems and their productivity in general (Potter et al. 2009; Reeves et al. 2005). Further, assessments of GPP enable detecting potential carbon sinks and sources over time and how they are affected by direct and indirect drivers of change, e.g., human activities or climate change. This is important, as terrestrial and marine C sinks are one of the world’s largest ecosystem services.

GPP is directly related to the light harvesting photosynthesis process. Remote sensing (RS) measuring reflected and emitted radiation from the Earth surface in various wavelengths is a useful tool to assess GPP of terrestrial and aquatic ecosystems at different scales. In particular, imaging spectroscopy (IS) allows retrieving various ecosystem parameter and processes involved in biogeochemical cycling, e.g., productivity of ecosystems and their changes. Several studies demonstrate the monitoring of productivity of terrestrial and aquatic ecosystems at small- and large-scale (Gitelson et al. 2012; Matishov et al. 2010).

Although mapping GPP for certain land surface types was successfully demonstrated, the development of accurate approaches is still needed to integrate GPP estimates and ecosystem productivity across several Earth spheres to finally provide continuous spatial representations. We consequently aim with this study to investigate spatio-temporal changes of GPP in a heterogeneous landscape in Switzerland consisting of land use gradients. We propose a continuous field approach (CF) that allows integrating GPP estimations from the biosphere and the hydrosphere.

Airborne Prism Experiment (APEX) imaging spectroscopy data was used to assess GPP at landscape level continuously over different ecosystems and a land use gradient from semi-natural ecosystems to urban areas. The suggested approach relies on two information i) abundance maps of prevailing land cover classes (i.e., forest, grassland and lakes) and ii) GPP maps of respective land use types. We conducted spectral unmixing analyses to estimate abundance maps for forest, grassland and lakes. GPP is estimated following an approach of Gitelson et al. (2006) that utilizes a close relationship between GPP on the one hand and the total chlorophyll content of vegetation in combination with the incoming photosynthetic active radiation PAR on the other hand. Both parameters are obtained from APEX data and model simulation respectively.

Resulting continuous GPP maps display heterogeneity in productivity within the landscape and highlight areas of high and low ES supply. Combined analyses of development and natural conservation plans and GPP maps allow analyzing and predicting potential future changes in ecosystem productivity, their carbon budget and their contribution to climate change. Resulting GPP maps are considered helpful for decision-makers in land use planning to investigate different scenarios in order to maintain areas of high productivity and CO₂ sequestration.

REFERENCES


18.2

Atmospheric water parameters measured by a ground-based microwave radiometer and compared with the WRF model

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The microwave radiometer TROWARA measures vertically integrated water vapour (IWV) and vertically integrated cloud liquid water (ILW) at Bern since 1994. The instrument has two microwave channels at 21.4 GHz (bandwidth 100 MHz) and at 31.5 GHz (bandwidth 200 MHz). In addition, a thermal infrared channel at $\lambda=9.5–11.5$ μm is used to estimate the cloud temperature. Thanks to the high temporal resolution (7 s) and to the almost continuous operation in any type of weather conditions (day/night, clear/overcast sky), TROWARA measurements are valuable for numerical weather prediction, nowcasting, climate research, satellite validation, and for long-term monitoring of atmospheric water (Mätzler & Morland 2009).

A new refined retrieval algorithm has been applied to TROWARA measurements for the year 2012 and the uncertainty in ILW has been significantly reduced. These high quality TROWARA data are compared with coincident data obtained from a regional climate model (RCM) simulation of summer 2012 in Switzerland performed with the Weather Research and Forecasting (WRF) model (Skamarock et al. 2008). The simulation was repeated with four different microphysical schemes. The time series of IWV and ILW (Fig. 1) and the characteristics of the statistical distributions of ILW are analysed for TROWARA and for the WRF model.

We found that the WRF model simulates very well the IWV time series measured by TROWARA with a mean bias of only 0.7 mm and with little differences between the microphysical schemes.

For what concerns ILW, the shape of the probability density function of TROWARA and of the WRF model is similar. The WRF model, however, overestimates the clear sky occurrence probability (83%) compared to TROWARA (60%). The microphysical schemes show a similar clear sky occurrence probability, while they differ more in the part of the distribution where ILW < 0.01 mm.

![Integrated water vapour](image1)

![Integrated cloud liquid water](image2)

Figure 1. Integrated water vapour (IWV, top) and integrated cloud liquid water (ILW, bottom) measured by TROWARA in June 2012 (grey points) and simulated by the WRF model with four different microphysical schemes (blue, red, yellow and green lines with their mean in black).

REFERENCES


18.3

**Imaging spectroscopy to assess the composition of ice surface materials and their impact on glacier mass balance**

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The ice-albedo feedback plays a crucial role in various glaciological processes but especially influences glacier ablation. Furthermore, glacier surface albedo is one of the most important variables in the energy balance of snow and ice and depends in a complicated way on many factors, such as cryoconite concentration, impurities due to mineral dust, soot or organic matter, grain size or ice surface morphology. Over the last two decades, several studies have focused on glacier surface albedo using automatic in-situ weather stations in combination with radiation measurement setups or satellite images [e.g. Klok et al., 2003; Paul et al., 2005; Oerlemans et al., 2009]. Due to limitations of both approaches in matching either the spatial or the temporal length scale of glacier albedo variations, strongly simplified assumptions on actual albedo values are still required. In the Swiss Alps, this is particularly critical since there are obvious changes in surface characteristics on most alpine glaciers over the last years.

In this study, we applied an approach combining observations and models to characterize glacier surfaces and focus in particular on the distribution of ice surface materials and their influence on glacier mass balance. The APEX (Airborne Prism EXperiment) image spectrometer was used to acquire spatial and spectral high resolution radiation measurements over the Glacier de la Plaine Morte, Switzerland, in summer 2013. Such high resolution data allow detailed and spatial explicit analyses of ice surfaces. For validation purposes, radiation measurements were acquired in-situ with an ASD field spectrometer in parallel to the airborne campaign. Further, data of a seasonal glacier mass balance monitoring program over the last five years, obtained using the direct glaciological method, was available. A distributed mass balance model forced by daily air temperature, precipitation and radiation, and calibrated to in-situ accumulation and ablation data, was used to calculate glacier-wide surface mass balance distribution.

We present first results obtained from APEX imaging spectroscopy data, including abundance maps of different glacier surface materials derived using the spectral angle mapper (SAM) and distributed albedo maps calculated from measured radiances. Furthermore, we present a set of experiments for analysing the suitability to implement such data products in a distributed mass balance model and for assessing the sensitivity of glacier wide mass balance computations on the assumption of bare-ice albedo. Our results will contribute to a better understanding of the spatial distribution of glacier melt, which is important to improve modelling attempts to study future glacier evolution.

Figure 1. Abundance maps of three different materials present on the glacier surface calculated by means of a spectral angle mapper analysis of a hyperspectral scene covering Glacier de la Plaine Morte: (a) bright ice, (b) wet debris and (c) clear water. (d) Spectral surface albedo ($\lambda$=0.4-2.5 μm) calculated from APEX surface radiances.
18.4 Satellite detection of volcanic CO2 release of the Kasatochi eruption, 7 August 2008

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Volcanoes are likely the largest source of carbon dioxide (CO2) from the Earth’s deep interior to the surface, but estimates of volcanic CO2 emissions as well as the ratio of eruptive versus non-eruptive CO2 releases are currently highly uncertain. Measurements from dedicated instruments aboard satellites may complement and enhance the spatially and temporally limited information from ground-based volcanic gas measurements. However, space-based detection and quantification of volcanic CO2 is challenging because of the high atmospheric CO2 background, and has to our knowledge not been reported yet. In this study, we present direct detection of CO2 in the gas plume following the eruption of Kasatochi (Aleutian Islands, USA) on 7 August 2008 from satellite measurements from the SCIAMACHY and AIRS instruments. Our strategy is to apply a threshold on coincident spaceborne sulfur dioxide (SO2) maps to distinguish between volcanic plume and background pixels. It is found that the CO2 of the plume pixels statistically exceeds those of the background pixels for the SCIAMACHY and AIRS CO2 products analyzed. In addition, significant correlations between SO2 and CO2 are found in the plume pixels as well as increasing CO2:SO2 ratios with time reflecting the relatively faster decay of SO2 in the atmosphere. We extrapolate the decay of the CO2:SO2 ratio with time to estimate the CO2:SO2 ratio at the time of the eruption to estimate the total CO2 release. We find CO2 mass emission from Kasatochi in the order of 12 and 57 Tg, respectively, although the uncertainty range is very large. In conclusion, this study demonstrates that current space-borne remote sensing instruments can detect volcanic CO2 from relatively large eruptions, that the magnitude 3-4 Kasatochi eruption in August 2008 likely released a large amount of CO2, and that global CO2 emissions from explosive volcanism are likely larger than previously thought.
Quantitative and qualitative vegetation mapping in alpine grasslands using the imaging spectrometer APEX: A tool to explain animals’ foraging sites?

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Alpine areas are characterized by their remoteness as well as their topographic variability and complexity. This variability creates large heterogeneity in soil and microclimatic conditions ultimately causing vegetation properties, such as community composition, biomass or nutrient content to vary at small spatial scales. Both the problem of accessibility of alpine areas, as well as the heterogeneity of vegetation patterns makes it unrealistic to assess vegetation properties over large areas with systematic in situ sampling. Ecologists, however, often need high resolution data to match the scale of the topic under study (Hebblewhite & Heydon 2010). Since entire food webs build upon soil and plant nutrient pools, spatially explicit information about these basic variables within a trophic system are needed to understand the organisation of communities. Remote sensing provides the only time and cost effective mean to acquire and map these environmental variables in high spatial and temporal resolution (Kerr & Ostrovsky 2003; Aplin 2005).

In our study area, the Val Trupchun in the Swiss National Park, three large ungulate species, ibex (Capra ibex), chamois (Rupicapra rupicapra) and red deer (Cervus elaphus), co-occur at high population densities. How ecologically similar species coexist in a shared environment is a classic question in resource ecology (see e.g. Hardin 1960). To investigate if and how food resources are shared among these three species we combined high resolution remote sensing with GPS data of radio-collared ungulates.

We used data from the airborne imaging spectrometer APEX (Jehle et al. 2010) and field plots to model and map grassland biomass, nitrogen and fibre content with 2 m x 2 m spatial resolution. Our 100 field reference plots covered the entire altitudinal gradient, and also all different levels of productivity and variations in plant species communities. The plant material was collected within a time window of 5 hours around the overflight. Despite the heterogeneity in our study area, our models predicted all three vegetation properties with high accuracies (biomass: $R^2 = 0.70$, RMSE = 156 g.m$^{-2}$ (fresh weight); nitrogen content: $R^2 = 0.53$, RMSE = 0.5 %; fibre content: $R^2 = 0.79$, RMSE = 2.5 %). We mapped grassland biomass, nitrogen and fibre content based on these models and analysed the foraging behaviour of the three ungulate species.

To identify core foraging areas we split the animals’ movement trajectories into behavioural phases by integrating the locations’ autocorrelation structure in time and space. The comparison of resource availability in the core feeding areas revealed marked differences between the three species. While chamois foraged in areas with low biomass and intermediate levels of plant nitrogen, red deer chose areas with high biomass and low levels of plant nitrogen (Fig. 1) and ibex areas with both high biomass and high levels of plant nitrogen. These results point towards resource partitioning between the three species and confirm that high resolution remote sensing is a useful tool to gain a better understanding of fundamental ecological processes such as animal foraging behaviour.

REFERENCES


Figure 1. Core feeding area of an individual red deer.
18.6

The potential benefits of Multi-constellation GNSS

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GNSS (Global Navigation Satellite System) has been used as an important earth observation tool, since the beginning of the US GPS (Global Positioning System). Its applications range from atmosphere, hydrosphere to lithosphere, such as ionospheric modeling, tropospheric water vapor estimation, tectonic deformation monitoring, sea level determination, GNSS seismology and so on. Besides the US GPS and Russian GLONASS (Globalnaya Navigatsionnaya Sputnikovaya Sistema), new GNSS systems like Chinese BeiDou Navigation Satellite System and Europe’s Galileo are available now. The independent but compatible multi-constellation enhances the reliability, accuracy and availability of GNSS systems. Take ionospheric modeling as an example, denser ionospheric pierce points from more GNSS satellites means better input to the ionospheric modeling. For positioning and monitoring applications, the increased number of satellites from multiple constellations provide additional redundancy and better GDOP (Geometric Dilution of Precision). Users in Swiss alpine areas, where signals are prone to multipath interference and obstruction by mountains, will especially benefit because of an abundance of satellite signals.

In this contribution, we present the visibility of Chinese BeiDou system in Switzerland and the positioning solution computed from a GPS plus BeiDou constellation. We discuss the potential benefits as well as challenges of using such a multi-constellation GNSS.

Figure 1. Left: Visible GPS and BeiDou satellites; Right: skyplot of BeiDou satellites (MGEX station: ZIM3)

REFERENCES


18.7
Towards a European surface albedo climatology
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Regional and global climate models rely on precise information of surface albedo as it is a key parameter in the Earth’s energy balance controlling the amount of reflected and absorbed radiation. Remote sensing products allow the global retrieval of surface albedo and its variability in space and time. To utilize reflectance as measured by space-borne instruments to derive surface albedo (and black-sky albedo) from satellite images, a BRDF (Bidirectional Reflectance Distribution Function) model is required. These models aim to reproduce the directional signature of the land surface reflectance by using surface reflectance values of multi-angular observations. In producing complete and physically consistent data records that are essential for studying ecosystem change, the quantification of uncertainties in satellite-derived land surface albedo products is a critical aspect. Therefore, it is mandatory, especially for the complex terrain of the European Alps, to further evaluate the potential of BRDF models in retrieving land surface properties and to generate consistent albedo datasets.

In this study, the RossThick-LiSparse-Reciprocal BRDF model is used to generate a BRDF/Albedo climate data record based on LAC data of the AVHRR. The algorithm follows the MODIS V005 standard BRDF methodology and relies on multi-day, cloud-free, atmospherically corrected surface reflectance values, and several quality flags (e.g., snow masks) to decide whether and in what manner the pixel values can be used for the retrieval process. Even though newer sensor technologies have become available, the AVHRR data record that reaches back to 1981 is of particular interest as it offers the longest and most complete record of visible satellite imagery on a daily basis. The algorithm has been adapted to AVHRR data and was successfully applied and tested using data of different NOAA and MetOp satellites for several years. Nadir BRDF-adjusted reflectance (NBAR), black-sky albedo and white-sky albedo was inter-compared to the MODIS BRDF/Albedo standard operational product MCD43A. The black-sky and white-sky albedos were combined as a function of solar geometry and atmospheric state in order to compute instantaneous actual albedo (blue-sky albedo) used for the comparison to in situ station measurements of albedo.

We thus are able to present the BRDF/Albedo data with a spatial resolution of 1.1km² based on AVHRR data over Europe. The products show a good correspondence with the MODIS BRDF products and the validation against field measurements indicates a promising sensitivity with regard to temporal changes. Based on these findings, the project aims to generate climatologically consistent albedo datasets, especially for the European Alpine region, and to show for the first time the spatial and temporal variability of albedo during the last 29 years. This dataset will serve to improve the understanding and representation of albedo in regional climate models.
P 18.1

Changes in vegetation activity and land-surface phenology in Switzerland related to climatologies

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Vegetation growth is driven and limited by a range of abiotic factors, notably by climatic controls like temperature, water availability and incident radiation (Field et al. 1986). Apart from these, anthropogenic factors and complex interactions with, for instance, the local soil or hydrology influence vegetation dynamics. The resulting changes are expressed in the intra-annual growth cycle of the vegetation, to which we refer as land-surface phenology (LSP). This pattern can be accurately observed using time series of satellite-based measurements of vegetation activity but the challenge lies in attribution of drivers to the detected changes. Only with that information can we assess the effects of current climatic variations versus other, possibly anthropogenic, effects (de Jong et al. 2013). Our goal was, for Switzerland specifically, to quantify recent changes in vegetation activity and LSP and to reveal spatial relationships with changes in growth-limiting climatologies. This analysis supports the detection of ‘hot-spots’ of change for further studies of the interactions between vegetation and a-biotic factors within the Swiss Earth Observatory Network (SEON).

Various satellite sensors provide measurements of vegetation activity. Data of NOAA satellites give the longest run, 1982-2012, but with a coarse spatial resolution of ca. 9 km (Pinzon and Tucker, 2014). More recent sensors, like MODIS, provide a spatial resolution of 0.5 km although for a shorter time span (2000-2013). We analyzed both datasets: one for a longer-term general picture and the other for a more detailed spatial analysis. Gridded datasets of climatologies were provided by MeteoSwiss (2014) and the methodology was adopted from de Jong et. al. (2013) and Garonna et al. (2014).

Preliminary results of the longer-term observations indicate increases in vegetation activity, while observations since 2000 suggest a subsequent reduction. The comparison of coarse and fine spatial resolution data reveals a large spatial heterogeneity of trend changes caused by complex topography and landscape fragmentation. Links with climatologies appeared to be not straightforward, due to the relatively short observational period of the high-resolution data and prevailing landscape heterogeneity. We present the methodological framework as it was developed for global studies, as well as the preliminary results for Switzerland, including maps of vegetation trend changes and links to climatologies.

REFERENCES

P 18.2

Remote sensing of forest ecosystems using airborne laser scanning and imaging spectroscopy

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Remote sensing offers the potential to provide spatially and temporally distributed information on key biophysical and biochemical variables of forest ecosystems. Airborne laser scanning (ALS) is especially well suited to characterize the forest structure. It allows to measure three-dimensional (3D) point clouds, which can be used for area-wide forest structural variable retrieval. Besides variables such as plant area index or canopy height, seasonal ALS data can be used to classify canopy background elements and canopy structure types (Leiterer et al. 2013, 2014).

Whereas laser scanning provides mainly geometrical information, passive optical imaging spectroscopy can be used to retrieve biochemical plant traits. However, this is challenging since atmospheric effects, canopy structure, illumination and viewing conditions have to be considered when airborne or spaceborne measurements are linked to leaf level traits. Therefore, the 3D radiative transfer model DART was parameterized using airborne, in situ and laboratory approaches to simulate imaging spectrometer data (Schneider et al. 2014). The model provides an advanced representation of the radiative regime, which is suitable to simulate most spatial and spectral features of imaging spectrometer data. The results show the potential to inversely derive biochemical plant traits from airborne and spaceborne earth observations.

REFERENCES
A European Lake Surface Water Temperature data set derived from NOAA/Metop-AVHRR (1983 – 2013)

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Lake water temperature (LWT) is an important driver of lake ecosystems and it has been identified as an indicator of climate change. Not only far back-reaching retrievals of climate information from lake sediments are of interest, but also shorter and more accurate time-series of lake water temperature are great proxies for the recent climate.

By gathering water temperature data for European lakes, one can find a patchwork of datasets with varying temporal and spatial coverage, and retrieved with various methods. Hence the available data is spatially and temporally heterogeneous and therefore not well suited for the study of climate induced change.

This project aims to compile a robust dataset of European lake surface water temperature (LSWT) with a homogeneous spatial and temporal coverage. This will be done using a consistent satellite temperature retrieval method applied on the NOAA/Metop-AVHRR data archive of the Remote Sensing Group at the University of Bern. The archive is covering Europe with a time span of more than 30 years (1983 to today).

State-of-the-art procedures to retrieve surface temperature are all based on the split-window approach. Well-known procedures to retrieve sea surface temperature (SST) are the NOAA NESDIS non-linear SST (NLSST) and the Pathfinder-SST (PFSSST) algorithms. Both methods are tailored for ocean monitoring on a global scale. But due to differences in emissivity and atmospheric conditions, the ocean-optimized methods lead to less accurate LSWT retrievals. In the work of Riffler et al. (2014) [1], a comparison of different methods with in situ measurements of Swiss lakes showed that using an optimized procedure (referred to Hulley et al. 2011 [2]) with local split-window coefficients performs better than using a approach which is globally valid.

To retrieve local split window coefficients, a method based on a fast radiative transfer (RT) model (RTTOV-11; Saunders et al. 2013) [3] is used. After simulating the AVHRR thermal infra-red channels 4 and 5 for each region, the local coefficients are derived by multi-linear regression.

To validate the retrieved LSWT dataset, in-situ measurement data for many European lakes are collected. The simulated LSWT are adapted for bulk measurements using the method of Minnett et al. (2011) [4] taking into account wind induced mixing of the uppermost water layer.

At the current state, the quality of night-time and day-time LSWT retrieval is evaluated. The accuracy of night-time-data is suspected to be lowered, due to cloud and land-contamination during retrieval. This is because geo-referencing and cloud-masking for night-time scenes are more likely to be inaccurate, as there is no information available for the visible spectrum. On the other hand night-time-data is supposed to be more robust, because of less fluctuation of the surface temperature induced by external influences, esp. solar radiation.

As a first result, the importance of these aspects are evaluated and discussed through a combined daytime/nighttime dataset. This first dataset consists in the temperature retrievals from two European lakes, one representing the mid-latitudes, and one representing the northern latitudes. This lays the foundation of further improvements for the processing of the whole available satellite data archive.

REFERENCES
Operational Snow Cover Mapping and Analysis in the Canton of Valais Based on MODIS Data

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In alpine catchments, snowmelt is a factor that can significantly accentuate flow rates during flood periods. Indeed, during a heat wave and heavy rain periods, water accumulated as snow is released and contributes directly to the increase of river flow rates. Therefore, the monitoring of snow cover over a study basin is essential to understand and prevent potential risk situations.

The methods presented in this paper are based on data from the Moderate Resolution Imaging Spectroradiometer (MODIS) carried by the Aqua and Terra satellites, from the Earth Observing System (EOS) program of the NASA. The data is automatically acquired and processed on a daily basis over a 5520 km² area representing the Upper Rhone River basin, mainly located in the Canton of Valais (Switzerland). The processing chain is operational and produces daily snow maps and related statistics. The results are available to hydro-meteorological experts and are used for decision support.

One of the main limitations of MODIS technology is the presence of clouds in the data, which cover on average 56% of the images in the Rhône basin. Indeed, MODIS detects wavelengths ranging between 0.4 and 14 µm, which cannot penetrate clouds. In order to enable a complete statistical analysis of the data, a methodology has been set up to reduce cloud obscuration in MODIS data. First, the data collected from the Aqua and Terra satellites, which pass daily at an interval of 3 hours, is combined to reduce the total number of clouded pixels by around 10%. Then, the remaining cloud areas are filled in using a time interpolation-based method (López-Burgos et al., 2013). If a pixel is obscured by clouds, the most recent value from up to 7 previous days is used instead. The remaining obscured surface is thus reduced by a further 93%. On average, the final cloud obscuration rate thus obtained is less than 1%.

After cloud obscuration processing, a daily map of snow cover and relevant statistics are calculated for the whole Rhône basin and for twenty two hydrological sub-basins. For each daily map of snow cover, statistics of replaced clouds based on previous days are presented as a pie chart (Figure 1). Statistics on snow cover are generated for both daily and monthly time steps. The snow cover is then calculated and compared to the quantiles calculated over the available 12 past years data (figure 2).

A preliminary comparison of MODIS processed data and the snow cover data (interpolated from meteorological stations) from the Institute for Snow and Avalanche Research (SLF) has been realized for the periods of Dec. 2013 to May 2014. The MODIS data usually estimates sensibly less snow cover than SLF data. During winter and depending on the region, 0 to 5% less snow cover can be observed on average. During spring time, the variation can be greater, from 0 to 10% less than SLF. Further analysis is planned for future work.

The MODIS data processing could greatly enhance our knowledge about spatial snow cover distribution and its temporal evolution throughout the year. It offers a way to assess the inter-annual variability in space and time of snow covered areas that could be linked to climate change. It provides additional information that reduces the uncertainty on the hydrological state of the basin. In addition, the snow cover data is used to validate the snow cover simulated by the hydrological model of the MINERVE system (García Hernández et al., 2013), which generates real-time hydrological forecasts for the Upper Rhone River basin. MODIS data is also useful for water resources management within the project STRADA (CREALP, Projet INTERREG III_A – STRADA, 2013-2014).

REFERENCES
Figure 1. Valais snow cover and pie chart with cloud replacement information

Figure 2. Monthly snow cover area for the Borgne basin in Valais.
P 18.5
The Three Roles of the Rapid Data Delivery System of NORS/Copernicus

K. Hocke (University of Bern) + Colleagues from NORS, NDACC, MACC

The Rapid Data Delivery System (RDDS) has been realized within the EU project NORS and NDACC. RDDS takes advantage on the infra-structure of the NDACC data center which is dedicated to the archiving of ground-based remote sensing data for the detection of long-term trends in the atmospheric composition. Complementary to NDACC, the ground-based remote sensing data of RDDS are suited for the rapid validation of satellites such as the Sentinel satellites of the Copernicus Earth Observation programme. Further, RDDS data are already taken for validation and tuning of the chemical weather forecast system MACC (EU project Monitoring of Atmospheric Composition and Climate). So, the first role of RDDS is the rapid validation of satellite data and MACC analyses. The second role of RDDS is capacity building since RDDS can serve as a testbed for new stations which may later fullfill the strict rules of NDACC data quality. In addition, the new data format GEOMS-HDF and the NORS validation server were firstly tested by RDDS, NORS and MACC, - of course with strong support from NDACC. The advantage is again that RDDS is more flexible in view of data quality, and it consists of less members and stations compared to NDACC so that new ideas can be easier discussed and tested within RDDS. The third role of RDDS could be the rapid and operational data assimilation of ground-based remote sensing data into chemical weather forecast systems. Unfortunately, the third role of RDDS is in conflict with its first role: to be an independent data source for validation of satellite data and MACC analyses.

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New perspectives from Landsat 8 and Sentinel-2: Earth Observation Products

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Earth observation facilitates a comprehensive monitoring and assessment of the status and changes in our environment. In recent years, the underlying remote sensing technologies have become more sophisticated while most data are easily accessible and freely available. This ongoing development underlines the growing importance of satellite imagery, which offers multiple opportunities to measure land-use changes (e.g. deforestation), manage natural resources (e.g. freshwater, agriculture), monitor and respond to natural disasters (e.g. fires, floods), or to predict, adapt to and mitigate climate change.

The Swiss National Point of Contact (NPOC) for satellite images aims to foster and promote the use of Earth Observation data to support Swiss authorities, research agencies, commercial providers, and end-users. It is a joint venture of the Remote Sensing Laboratories at the University of Zurich and the Federal Office of Topography (swisstopo). As part of our activities, the NPOC aims to support the use of state-of-the-art Earth Observation products by strengthening expertise and building up competences in the exploitation of satellite data. In this study, we demonstrate the use of Landsat and simulated Sentinel-2 (launch 2015) data to infer selected Essential Climate Variables (ECV) and associate remote sensing products, which provide information on the status and evolution of various terrestrial and aquatic ecosystems. The Landsat series offers a consistent data source dating back to 1972, which is suited for operational monitoring, assessing, and predicting land surface change over time. Complementary, the Sentinel-2 sensor and mission specifications hold further potential to continuously extract new surface parameters at an unprecedented spatio-temporal scale.

Spectral indices products are derived from Landsat surface reflectance data, which are generated by specialized software like LEDASP (Masek 2006) and fmask (Zhu & Woodcock 2012). This pre-processing, which generates Top of Atmosphere (TOA) Reflectance, Surface Reflectance, and Brightness Temperature data also accounts for data gaps by clouds and cloud shadows. Simulated Sentinel-2 surface reflectance data is based on airborne imaging spectroscopy acquisitions of the APEX (Airborne Prism Experiment) sensor and generated by the Sentinel-2 end-to-end simulator (Segl et al. 2012).
We illustrate the applicability of both sensors to:

i) characterize the hydrosphere by extracting surface reflectance derived spectral indices to derive chlorophyll-a concentration, total suspended solids, and secci depth transparency of Lake Geneva (Fig 1).

ii) quantify cryospheric changes by inferring information on snow cover extent, light-absorbing impurities in snow, and glacial albedo in the alpine terrain of the Findelen- and Plaine Morte Glacier (Fig 1), and

iii) to examine the biosphere and extract indices for chlorophyll absorption (MCARI2), leaf chlorophyll content (Chl), leaf carotenoid content (Car) and plant anthocyanin content (Anth) for the mixed deciduous Lägeren forest (Fig 1).

In response to natural disasters remote sensing also offers valuable information needed to manage the crises. In this context, we illustrate the use of satellite imagery to derive water extend of flooded areas and to detect active fires and burnt areas.

The selected examples of derived ECVs and associated remote sensing products across different spheres underline the unique potential of existing and upcoming satellite imagery to provide up-to-date and reliable information on the status of, and changes in, our environment. This freely available information will benefit services in land management, agriculture, forestry and hydrology as well as disaster control and humanitarian relief operations. Based on these selected examples of remote sensing products the NPOC aims to highlight the value of satellite imagery, in order to foster its use along with further scientific advice to potential earth observation data users.

Figure 1. Forests, lakes and glaciers in Switzerland draped over a hillshade image. Red rectangles indicate the location of selected study areas covering different Earth spheres and ecosystems.

REFERENCES


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**Climatic signal propagation form source to sink in a Palaeogene sediment routing system, Pyrenean foreland basin, Spain**

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Cyclicities of different types in the sedimentary record have long been documented. The ongoing debate is about the various origins that have been put forward to explain them: eustatic sea level changes, sediment supply variations or subsidence pulses. In the deep water system of the lower-middle Eocene Ainsa basin, in the southern Pyreneans (Spain), as well as in its fluvial counterparts in the Tremp-Graus basin, stratigraphic cyclicity in the form of repetitive alternations of sand and shale packages of intermediate timescales (10\(^4\) to 10\(^6\) years) has long been recognized and has typically been imputed to eustatic changes, with a modulation by active tectonics. Most of the studies have focused so far either on the deep water system or on their fluvial counterparts without a detailed effort at the correlation between both.

While eustatic variations are well known to have taken place at these periods and are thus plausible causes of the observed cyclicities, our objective is to evaluate the possible role of sediment supply variations in generating or modifying such cyclicities. This is particularly important in order to understand how sediment supply variations are tied to climate and tectonics in the source area over multi-millennial timescales and how the deep-sea sedimentary record can be used to reconstruct the Earth’s history of surface response to climate change. To address these issues a mapping and multi-proxy approach was undertaken in the Tremp-Graus and Ainsa basins. We focus on the middle Eocene Castissent formation, a major fluvial excursion and its deep marine time-equivalent; the Arro-Gerbe section. XRF geochemistry, stable isotopes and clay analyses were made on four increasingly distal cross-sections to attempt to trace environmental signals across the whole source-to-sink system. These analyses coupled with thorough physical mapping on the field and a comprehension of the volumetrical partitioning of the sediments allow us to discuss hypotheses of climatic and eustatic controls of cyclicity.

REFERENCES


