17. Earth Observation addressing key Earth System processes
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Swiss Commission for Remote Sensing, Swiss Geodetic Commission

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17.1 Observing the Bisgletscher with Ku-band differential radar interferometry

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The Bisgletscher is a steep, fast flowing glacier located above the village of Randa, on the western flank of the Mattertal, Canton of Valais. In the past, several ice falls and avalanches from the glacier caused considerable losses of human life and property.

Because an acceleration of the glacier has been related to rupture events (Faillettaz, Funk, and Vincent 2015), monitoring the glaciers velocity can be used to issue early warnings. Since 2012, an automatic camera is used to determine the glaciers velocity. However, this technique requires optical visibility; observations at night or with foggy weather are impossible. Ground based Radar interferometry (GBInSAR) offers all-weather, day and night capability and can continuously measure the line-of-sight component of the glacier velocity field (Monserrat, Crosetto, and Luzi 2014).

In summer 2014 the velocity of Bisgletscher was first measured by Ku-Band ground based differential radar interferometry (GB-DInSAR) from a fixed installation at the Domhütte. This location gives the best observation geometry under the constraints of operating a radar in an alpine environment. This campaign was successful; the estimated line of sight velocity was comparable to the reference measurements obtained with optical methods.

In this paper, we present first results of a ground-based radar measurement campaign that was held between June and September 2015. Each day, the glacier was scanned at daytime for the duration of 12 hours with an acquisition each 2:30 minutes. The dense temporal sampling reduces decorrelation between the acquisitions, minimizes phase wrapping and allows to capture the temporal evolution of the velocity. A full polarimetric ground based radar was used for this campaign; the data will be used to develop improved processing techniques that integrate the polarimetric information.

For the observation of glacier velocities, daily displacement maps were obtained by zero-baseline differential interferometry (Caduff, Strozzi, and Wiesmann 2013): subsequent images were combined into interferograms; the phase referenced to a stable scatterer in the proximity of the glacier to mitigate atmospheric phase disturbances. The interferograms were unwrapped and the residual atmospheric phase screen was corrected with a quadratic polynomial estimated in stable areas. Finally, several corrected interferograms were averaged in order to further reduce the atmospheric disturbances, which are assumed to be a zero-mean random process (Wegmüller, Strozzi, and Tosi 2000). The velocity maps measured with GB-DInSAR agree with the existing knowledge on the Bisgletscher; the measured displacement in the fastest moving parts of the glacier is approximately 2 meters per day.
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17.2

Improved land cover assessment in agriculture with optical remote sensing data

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Land cover classification in agriculture is an important task in remote sensing. On the one hand statistical data on land cover, use and management is often available on administrative units and accessible regions only (De Wit & Clevers, 2004). On the other hand, monitoring of biodiversity has gained increasing importance over the past years. Among the ten recently proposed essential biodiversity variables are land cover and vegetation phenology (Skidmore et al., 2015). These variables are equally important when monitoring diversity as well as agriculture and can be provided with high spatial and temporal resolution by remote sensing sensors.

In this study, we present first classification results using Airborne Prism Experiment (APEX) imaging spectrometer data acquired over an agricultural area in May 2013. The area is located northwest of Lyss (Swiss midlands) and is composed of 300 fields of 10 different crop types in an early stage of phenology. We identified the ten crops present in the area under study with a Random Forest classifier, which is a nonparametric method for probabilistic classification (Breiman 2001). The overall accuracy (OAA) of the crop identification is of 72% (Fig. 1a). In order to include spatial information about the crops in neighboring pixels, we further processed this result by using a Markov Random Field model with a Potts pairwise smoothing term (Schindler, 2012), thus improving the OAA by 2% (Fig. 1b).

These results show the potential of imaging spectroscopy for precise crop classification and there is still large potential for further improvement by using spatial filters such as textural, morphological or bag of visual words features (Tuia et al., 2015).

REFERENCES

17.3

High-resolution remote sensing of NO2 maps over Zurich with the Airborne Prism Experiment (APEX): new results

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Since nitrogen dioxide (NO2) concentrations have high spatial and temporal variability, high-resolution NO2 maps are an important tool for urban air pollution assessment and epidemiological studies. These maps can be obtained with airborne imaging spectrometers such as the Airborne Prism Experiment (APEX) (Schaepman et al. 2015). APEX measures back-scattered solar irradiance in the visible and near-infrared (VNIR) with a spatial resolution of a few metres.

We present an improved version of the Empa APEX NO2 retrieval (Popp et al. 2012). Our retrieval benefits from the newest APEX radiance product and better characterization of centre wavelength positions (CW) and full widths at half maximum (FWHM) of the slit function. Since the NO2 retrieval requires accurate spectral calibration, we improved CW and FWHM accuracy for the VNIR channel (385-1000 nm) by aligning solar Fraunhofer lines and fitting atmospheric absorbers (H2O and O2). The NO2 retrieval is a two-step procedure. In the first step, NO2 slant column densities (SCD) were obtained using differential optical absorption spectroscopy (DOAS) between 440 and 510 nm. This is a larger fitting window than used previously which allowed us to include more absorbers such as the oxygen dimer (O4), ozone, water vapour and liquid water to reduce cross-correlations. In addition, the first principle component of the residual spectra was fitted to include systematic instrument features not accounted for in the spectral calibration. An undersampling correction was applied to correct interpolation errors between reference and measurement spectrum. In the second step, air mass factors (AMF) were calculated to convert SCDs to vertical column densities (VCD) of NO2, the final data product. The AMFs depend on solar position, instrument viewing direction, surface reflectance and atmospheric scattering due to air molecules, aerosols and clouds.

The improved retrieval was applied to an APEX flight over Zurich in August 2013 to obtain an NO2 map with 50×50m² spatial resolution. The map shows the complex NO2 distributions in the city with increased values in densely populated areas and low values over forests and hills surrounding the city. Furthermore, local features could be identified such as major roads and NO2 emitted by a waste incinerator.

In conclusion, our revised retrieval is a significant step forward and reduces systematic and fitting errors as compared to the first version of the algorithm. Future analyses of APEX measurements already collected over Zurich and other locations will benefit from these improvements. The obtained maps will be used for further analysis such as comparison with urban-scale chemistry transport modelling.

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17.4

Lake Surface Water Temperature: Performance of split-window coefficients – a sensitivity analysis

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Lake surface water temperature (LSWT) is an important driver of lake ecosystems and it has been identified as an indicator of climate change. Available in-situ data for European LWT are heterogeneous in terms of spatio-temporal coverage and retrieval methods. Therefore they are not well suited for the study of climate induced change.

To solve that issue, a consistent satellite derived time series can serve as a baseline to standardise the available in situ data. The framework project of this study aims at compiling a homogeneous and consistent dataset of European LSWT. To ensure consistency, the same sensor type has to be used over a long period of time. The AVHRR sensor is mounted on NOAA/METOP satellites since the early 80ies, and therefore fulfills the requirements of climate relevant period as defined by the WMO.

The split-window method is the state of the art satellite temperature retrieval method. The principle is to empirically determine a relation between the surface temperature and the brightness temperatures measured at the satellite. This relationship, embodied within so called split window coefficients (SWCoefs), are then used to compute the LSWT. The precision of the method mainly depends on the quality of the SWCoefs. Therefore improving the method means that we need to understand the uncertainty sources during the SWCoefs determination process.

In general we assume that reducing the validity domain leads to more specific SWCoefs and thus to smaller errors. In the past, different split window approaches have been used, whereas the main difference amongst them lies in the way they determine the SWCoefs. For global applications (SST) the SWCoefs are determined with global validity but with limited temporal validity whereas for local studies (LSWT) the SWCoefs tend to have smaller spatial and larger temporal validity. However, there is no comparative study, quantifying and analysing the uncertainties related to the one or the other restriction of validity. Within a sensitivity analysis, the impact of the validity restricting parameters on the accuracy was quantified and compared. To improve the significance of the results, the analysis was performed on five different areas in Europe covering different climatic regions.

The results showed some interesting relationships and will help to design optimal validity parametrisations of the SWCoefs for each type of application. This will also be the basis for further improvements of the processing chain to generate the 30 years LSWT dataset of European lakes.
17.5

Satellite images: The Weissenstein anticline is younger than the Jura foldbelt

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The shape and development of the Jura foldbelt seem to be well understood, see for ex. Sommaruga (1997) or Becker (2000). Early steps in image interpretation of parts of the Jura foldbelt were undertaken by Laubscher (1981) and Berger (1994). The second named author stresses a straight N – S prolongation of the Upper Rhine graben. The present author disagrees and claims that the southern prolongation bends towards SW. This bend is best traceable along the eastern main border fault of the Rhine graben: From Lörrach via the E edges of the Laufen and Délemont basins to Gänstrubrunnen, Lyss, and Paye, possibly even Moudon. This may imply that the existence of the three lakes (Biel, Murten, Neuchâtel) is partly due to ongoing Rhine graben subsidence.

Generally all Jura folds and thrusts are convex towards NW the only exception being the Chaumont, N of Neuchâtel. In the region between Ferrette – Liestal –Bretzwil – Biel – Saigneléger we see Rhine graben faults warp through the Jura folds and thrusts. This means: Within the circumscribed area (including the Weissenstein) we observe an interference pattern between rejuvenated Paleogene thick-skinned tectonics and Neogene thin-skinned tectonics.

This statement requires amplification: The Weissenstein anticline is unusually straight, WSW – ENE from Sonceboz to Hägendorf. It is broader than the curved Jura folds and shows on satellite images soft northern and southern flanks. While the Weissenstein gives a rather roof-like impression the Jura folds show only their crests plus minor SE flanks. Based on this interpretation one should consider the Weissenstein anticline as NOT being part of the Jura foldbelt. Which of the two elements is younger? It seems that the Chasseral fold and its NE extension CROSS the Weissenstein anticline at Grenchenberg and continue from there via Gänstrubrunnen and Welschenrohr. This would mean: The Weissenstein anticline is younger than this part of the Jura foldbelt.

Bitterli (1990) reports strong indications for at least two tectonic phases in that part of the Weissenstein which he studied, between Oensingen and Wiedlisbach. He mentions the warp-through of Rhine graben tectonics and the south-vergent character required for proper section balancing. These observations support the idea of a young compressional event (post-Jura foldbelt, that means less than 5 million years ago) of thick-skin character. The Weissenstein anticline coincides with the S edge of the North Swiss Permocarboniferous trough as described by Ustaszewski and Schmid (2007). We can explain the Weissenstein as a surface expression of a reactivated basement fault or – to say it differently –as a compressed extensional form, an inversion. – There is no significant alignment of recent seismic epicentres along the Weissenstein anticline.

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17.6

Estimating vegetation parameters in an alpine catchment by means of WorldView-2 imagery

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In alpine areas vegetation parameters are decisive for several earth surface processes such as erosion, runoff generation, land sliding, and snow gliding. To account for the typical small scale heterogeneity of the alpine landscape spatially high resolved imagery such as from QuickBird was found to be promising for the mapping of land cover types and fractional vegetation cover. However, the disadvantage of this spatially high resolved imagery, in general, is the small spectral resolution that causes difficulties in separating bare soil areas from non-photosynthetic vegetation and rock. The latter is mainly caused by the lack of short wave infrared channels that are important for mineral and rock discrimination. Thus, the objective of this study is to evaluate the suitability of WorldView-2 satellite (launched in October 2009) imagery that provides both 8 spectral bands (two of it in the near infrared) and high spatial resolution (1.8 m resolution at nadir) to map vegetation parameters. First results on the performance of land use classification and spectral unmixing of pixels to apportion vegetation and bare soil abundance will be discussed for the Bedretto- and Piora Valley in Ticino.

17.7

Classification of habitat diversity in two floodplains using UAVs

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River floodplains are among the most important ecosystems with respect to biodiversity despite their very small terrestrial coverage (Postel & Carpenter, 1997). They form an environment in which the aquatic and terrestrial components of the landscape interact closely. Since 1850 to 2002, 90% of pristine floodplains have disappeared in Switzerland. Even more, since 2010 two third of all aquatic vascular plants are on the red list of threatened species. Today, more than 4'000 km along rivers must be ecologically revitalised, among the 14'000 km of swiss rivers (Federal Council, 2015).

In this context, we suggest interdisciplinary work to improve the efficiency of planned restoration works and to integrate observational and modeling approaches. Remote sensing of floodplains has demonstrated impact combining ecological and hydraulic sciences as well as hydrological modeling. However, remote sensing of floodplains is challenging because of a particular state of vegetation: while some parts are comparable to tropical forests with mixed and layered structure, other parts are comparable to temperate forests with heterogenous patches of species. Successful remote sensing techniques used in forest monitoring fail for riverine vegetation (Congalton et al., 2002). In general, observational requirements for floodplain monitoring using remote sensing are demanding in the spatial, temporal and spectral domains. Here, we propose the use of UAVs, combining high spatial resolution with flexible operating times.

Existing methods have largely been developed for landscapes not including heterogenous floodplains, in particular taking into account restoration and monitoring aspects of floodplain dynamics. One of the main challenges is to apply a method allowing to reproduce approaches used by ecologists (Mertes, 2002). In this study, two very diverse floodplains are considered: the Saane river and the Sense river (Swiss plateau). The Saane river is exposed to substantial anthropogenic influence, whereas the Sense river is without hydrologic regulation. These different habitat dynamics can be observed using classification approaches for habitats. We use supervised classification based on spectral and textural information derived from ortho-images as well as 3D structure from point clouds generated using photogrammetric approaches. A preliminary classification example using a random forest classifier is presented in figure 1. The purpose of simultaneously

using texture and structural information is to increase the precision of the classification and allow a higher number of final classes. We aggregate pixels in individual data layers to increase the dimensionality of the classifier input. This allows to include texture to the classification procedure and – as a side effect – also reduces the computation load. Further metrics based on grey-level co-occurence matrices are added to the input layers. Relative height and 3D structural information is added from the point cloud generated by photogrammetric methods from the UAV data. An independently generated digital elevation model is further used.

![Figure 1. Coarse classification using only pixel-based spectral information.](image)

Future work on floodplain classification will also make use of imaging spectrometer data (Torabzadeh et al., 2014). UAV data combined with imaging spectrometer data will allow to retrieve texture, 3D structural information as well as biochemical information, resulting in advanced habitat classification of floodplains.

REFERENCES


Mapping decadal land cover changes in the woodlands of north eastern Namibia using the Landsat satellite archive (1975-2014)

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Woodland savannahs provide essential ecosystem functions and services to communities. On the African continent, they are widely utilized and converted to intensive land uses. This study investigates the land cover changes of 108,038 km² in NE Namibia using multi-temporal, multi-sensor Landsat imagery, at decadal intervals from 1975 to 2014, with a post-classification change detection method and supervised Regression Tree classifiers. We discuss likely impacts of land tenure and reforms over the past four decades on changes in land use and land cover. These changes included losses, gains and exchanges between predominant land cover classes. Exchanges comprised logical conversions between woodland and agricultural classes, implying woodland clearing for arable farming, cropland abandonment and vegetation succession. The most dominant change was a reduction in the area of the woodland class due to the expansion of the agricultural class, specifically, small-scale cereal and pastoral production. Woodland area decreased from 90% of the study area in 1975 to 83% in 2014, while cleared land increased from 9% to 14%. We found that the main land cover changes are conversion from woodland to agricultural and urban land uses, driven by urban expansion and woodland clearing for subsistence-based agriculture and pastoralism.

Keywords: Deforestation; Tropical dry forest; Land degradation; Namibia; Remote Sensing; Landsat; Land cover change; Africa;
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Lake surface water temperatures derived from Landsat 8

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Changes in Lake Surface Water Temperature (LSWT) can have strong impacts on the quality of the lake water, the concentration of dissolved gases, on the lake biology and chemistry. In addition, Global Climate Observing System (GCOS) lists lake water temperature as an essential climate variable (ECV). Regarding those aspects, LSWT-monitoring with satellite data is very promising. It can provide continuous long-term records of observation, as well as giving information on spatial patterns of LSWT variability.

The remote sensing group at the University of Berne provided a LSWT data set based on Advanced Very High Resolution Radiometer (AVHRR) of lakes located in or near the European Alps (Riffler et al. 2015). Based on that work, the goal of this master thesis is to compile a LSWT data set from Landsat 8 data. Compared to the AVHRR-sensors on the NOAA-satellites, the Landsat 8 sensors have a higher spatial resolution in the thermal infrared spectra (100m vs 1.1km resolution). Therefore, this work will focus in a large part on the difference between the two sensors. In particular on the Landsat 8 sensor performance compared to AVHRR. The project focuses on two or three Swiss lakes (for example Lake Constance). The method used to derive the LSWT is the linear Split Window Algorithm after Hulley et al. 2011.

The poster will feature a description of the master thesis, first results and plots for the lake surface water temperature of Lake Constance and a comparison to in situ measurements and AVHRR-data. Furthermore, the poster will give information’s about the current state of the work and provide an outlook for the next steps.

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