Abstract Volume
16th Swiss Geoscience Meeting

Bern, 3oth November – 1st December 2018

20. Remote Sensing of the Spheres

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**Swiss Academy of Sciences
Akademie der Naturwissenschaften
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Académie des sciences naturelles**

20. Remote Sensing of the Spheres

Stefan Wunderle, Mathias Kneubühler, Dominik Brunner, Alain Geiger

Swiss Commission for Remote Sensing,
Swiss Geodetic Commission

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20.1
Polarimetric Analysis of Natural Terrain Observed With A Ku-Band Terrestrial Radar

Simone Baffelli [1], Othmar Frey [1,2] & Irena Hajnsek [1,3]

[1] Institut f. Umweltingenieurwiss, ETH Zurich, Stefano-Franscini-Platz 3 , CH-8093 Zürich (baffelli@ifu.baug.ethz.ch)
[2] Gamma Remote Sensing AG, Worbstrasse 225, CH-3073 Gümligen (frey@ifu.baug.ethz.ch)
[3] Microwaves and Radar Institute, German Aerospace Centre, DE-82234 Oberpfaffenhofen-Wessling

Terrestrial radar interferometers (TRI) are used to monitor changes in the natural and built environment. The sensitivity of the phase of electromagnetic waves to the location of the scatterers they interact with permits to estimate displacements using the technique of differential interferometry. The signal diversity given by polarimetric measurements permits to discriminate different scattering types within a resolution cell and enables the estimation of several environmental parameters thanks to the sensitivity of polarized microwaves to the dielectric and geometrical properties of the objects they are scattered from.

The polarimetric scattering behaviour of natural surfaces in the wavelength range between 1 m and 3 cm -especially at L and X band at 30 and 3 cm- is well characterized thanks to the availability of space- and airborne polarimetric SAR sensors. However, the polarimetric response of natural target at the shorter wavelengths -especially Ku-Band- that are often employed by terrestrial radar systems is less studied because polarimetric devices operating in this band are still relatively rare.

In this work, a polarimetric analysis of two datasets acquired using a quad-polarimetric Ku-Band (wavelength 1.7 cm) terrestrial radar is presented, aiming to characterize the polarimetric signature of natural surfaces at these frequencies. The data was acquired using KAPRI[2], a modified, polarimetric Ku-Band terrestrial radar based on the GPRI[3]. Two scenes, acquired in the Bisgletscher region, Mattertal and in the vicinity of Bern are used.

Several standard polarimetric parameters are computed, among them the Cloude-Pottier scattering entropy H[1] that serves as indicator of the scattering randomness within resolution cells.

An high entropy is observed for most terrain types, accompanied by predominantly crosspolarized backscatter. Low values of H – indicating deterministic scatterers – are only seen in correspondence of individual buildings or objects with a large radar scattering coefficient dominating in their resolution cell.

These observations suggest the presence of depolarizing scattering mechanisms, typical of natural targets, that are normally modelled as random volumes of "elementary" point-like or spheroidal scatterers with stochastic distributions of particle ellipticity and orientations[4].

The hypothesis of depolarizing scattering is compatible with the land cover types prevalent in both scenes, mostly comprising of short vegetation, forests, rough soils and ice.

Another factor contributing to the high entropy is the ratio of the resolution cell size to the wavelength: the main scattering contribution is expected to come from objects of sizes comparable to the wavelength such as grass tufts, gravel, ice crystals etc so that a large number of "elementary" scatterers per resolution cell is observed, increasing the scattering randomness and hence the entropy and the crosspolarized power.

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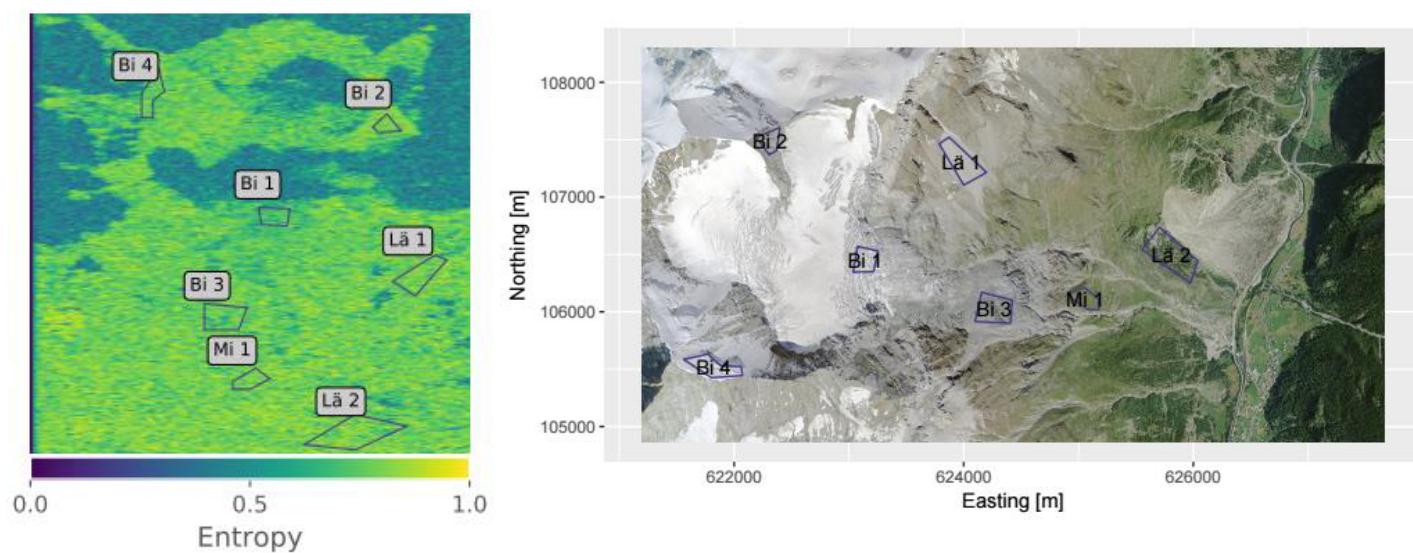
Figure 1: Example of Cloude-Pottier Entropy map in radar coordinates (x axis is azimuth angle, y axis is slant range distance) for the "Bisgletscher" dataset. To the right an orthophoto of the scene is shown, with the locations of the ROIs drawn in dark blue: they correspond to the polygons shown in the entropy map on the left. A high entropy indicates a larger scattering randomness.

20.2
Swiss Data Cube: Big Earth Observation Data for Sustainable Development

Gregory Giuliani [1,2], Bruno Chatenoux [1,2], Charlotte Poussin [1,2], Jean-Philippe Richard [1,2], Hy Dao [1,2], Karin Allenbach [1,2], Denisa Rodila [1,2], Andrea De Bono [1,2], Pascal Peduzzi [2], Michael E. Schaepman [3], David Small [3], Charlotte Steinmeier [4]

[1] Institute for Environmental Sciences, University of Geneva, Boulevard Carl-Vogt 66, CH-1205 Geneva
  (gregory.giuliani@unige.ch)
[2] UN Environment/GRID-Geneva, Chemin des Anémones 11, CH-1219 Châtelaine
[3] Remote Sensing Laboratories, Department of Geography, University of Zurich, Winterthurstrasse 190, CH-8057 Zürich
[4] Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Zürcherstrasse 111, CH-8903 Birmensdorf

Pressures on natural resources are increasing and a number of challenges need to be overcome to meet the needs of a growing population in a period of environmental variability. The key to sustainable development is achieving a balance between the exploitation of natural resources for socioeconomic development, and maintaining ecosystem services that are critical to human's wellbeing and livelihoods. Some of these environmental issues can be monitored using remotely-sensed Earth Observations (EO) data that are increasingly available from freely and openly accessible repositories. However, the full information potential of EO data has not been yet realized. They remain still underutilized mainly because of their complexity, increasing volume, and the lack of efficient processing capabilities (Giuliani, Dao, et al. 2017)»container-title»:»Remote Sensing of Environment»,»source»:»ScienceDirect»,»abstract»:»Global environmental changes are mostly induced by human activities (e.g., food and energy production, urbanization, mining activities.

Following the work done by Geoscience Australia, the Swiss Data Cube (SDC) is a new paradigm revolutionizing the way users can interact with EO data. It lowers the barrier caused by Big Data challenges (e.g., Volume, Velocity, Variety) and provides access to large spatiotemporal data in an analysis ready format. It significantly reduces the time and scientific knowledge required to access and prepare EO data having consistent and spatially aligned calibrated surface reflectance observations (Giuliani, Chatenoux, et al. 2017).

Switzerland is the second country in the world to have a national-scale Data Cube. The SDC is supported by the Federal Office for the Environment and developed, implemented and operated by the UN Environment /GRID-Geneva in partnership with the University of Geneva, the University of Zurich and the Swiss Federal Institute for Forest, Snow and Landscape Research. Currently, the SDC holds 34 years of Landsat 5,7,8 (1984-2018) and 3 years of Sentinel-2 (2015-2018) Analysis Ready Data (ARD) over Switzerland.

The SDC is aiming at delivering a unique capability to track environmental changes in unprecedented detail using EO data, enabling more effective responses to problems of national significance. This near real-time information can be readily used as an evidence base for the design, implementation, and evaluation of policies, programs, and regulation, and for developing policy advices. Indeed, the Swiss government has national and international reporting commitments and obligations as well as national environmental programs. They all need information that is synoptic, consistent, spatially-explicit, sufficiently detailed to capture anthropogenic impacts, and national in scope. For example, 44 of the 169 Sustainable Development Goals (SDGs) targets defined by the United Nations focus directly on improving the environment and human well-being. The SDC can provide the long baseline required to determine trends, define present, and inform future. It will also enable scientific institutions to facilitate research and new insights on Switzerland's environment.

We will present various examples on how the SDC can help monitoring SDG related to water. Switzerland is acknowledged as the water reservoir of Europe. While its territory represents four thousandths of the continent's total area, 6% of Europe's freshwater reserves are stored in Switzerland. In particular, snow is one of the most relevant natural water resources present in nature. It stores water in winter and releases it in spring during the melting season. Monitoring snow cover and its variability is an indicator of climate change and identification of snowmelt processes is essential for effective water-resource management.

Recently, we have developed a new algorithm using the SDC to map snow cover extension (Frau et al. 2018)"container-title":"IGARSS 2018","publisher":"IEEE","publisher-place":"Valencia, Spain","event":"International Geoscience and Remote Sensing Symposium (IGARSS. Preliminary results have shown a clear decrease of snow cover extension over the Alps in the last 30 years (Figure 1). This can be complemented by Synthetic-Aperture Radar (SAR) images that are effective and robust measures to identify melting snow (Small 2011)"page":"3081-3093","volume":"49","issue":"8","source":"IEEE Xplore","abstract":"Enabling intercomparison of synthetic aperture radar (SAR.
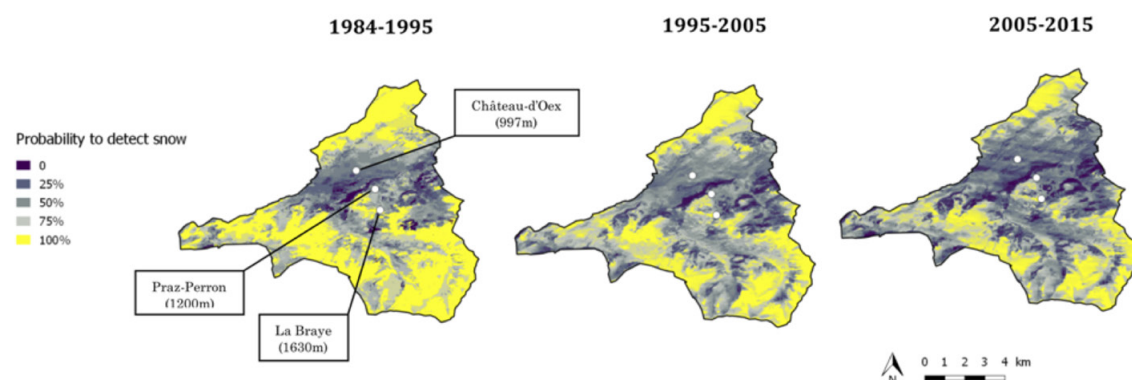
Figure 1. Snow cover evolution for the ski season (December-April) in Châteaux-d'Oex using the Snow Observations from Space (SOfS) algorithm.

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20.3
Monitoring Surface Deformation with Radar Interferometry at the Country-scale in Alpine Regions? First Results obtained With Sentinel-1 over Switzerland

Andrea Manconi [1], Francesco Casu [2], Ivana Zinno [2], Claudio De Luca [2], Michele Manunta [2], Mariarosaria Manzo [2], Manuela Bonano [3], Riccardo Lanari [2]

[1] *Department of Earth Sciences, Engineering Geology, ETH Zurich, Zurich, Switzerland (andrea.manconi@erdw.ethz.ch)*
[2] *CNR IREA, Italy*
[3] *CNR IMAA, Italy*

Studying surface deformation may help understanding processes, detecting indicators of potential failure events, and planning countermeasures. Among Earth Observation methods, spaceborne radar interferometry has demonstrated great advantages to perform these tasks. Moreover, the recent advent of the Copernicus Sentinel-1 (S1) constellation has increased our capability to observe surface deformation over wide regions with higher revisit times. Here we present the results obtained by processing images acquired from S1 constellation between October, 2015 and June, 2018. Differential interferograms were computed and combined taking advantage of the P-SBAS algorithm to obtain ground velocities and displacement time series at the country scale. We discuss the potential of such datasets in alpine countries such as Switzerland, as well the challenges for their thoughtful utilization.
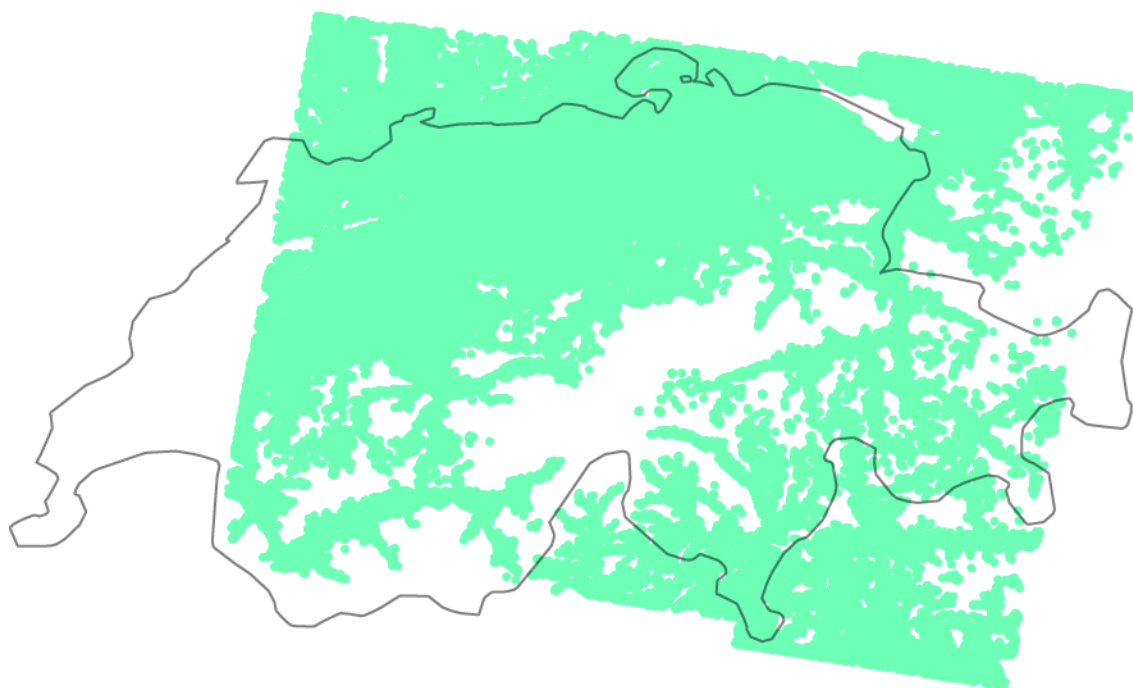

Figure 1. Coverage of surface deformation measurements obtained with the P-SBAS method applied to Sentinel-1 data, track 66, descending orbit.

20.4
Snow classification of webcam images in Switzerland

Nils Rietze [1], Céline Dizerens [1]

[1] Geographisches Institut, Remote Sensing Research Group, University of Bern, Hallerstrasse 12, CH-3000 Bern
  (nils.rietze@students.unibe.ch; celine.dizerens@giub.unibe.ch)

Snow cover is an important climate variable and can be regarded as a climate indicator. Monitoring and measuring local snow cover extent (SCE) has since been mostly achieved by observations at meteorological as point data. Accurate areal extents can be collected by using the vast public camera network, for this thesis understandably in Switzerland. Such data sets can provide a new source of small-scale areal snow cover data. Two existing and empirically tested snow classification algorithms have been applied to a sample of five Swiss webcams. The first method for classifying RGB images is based on blue band histogram analysis, while the second performs a principal component analysis (PCA) of the red and green component. Images in the morning, noon and evening are processed for further comparison of influence of shade and sunlight on the algorithms. Both algorithms performed during well-illuminated images with clear snow cover extent. The blue band classification shows significant misclassifications occurring in shaded areas and the skies. On the other hand, the PCA algorithm has fewer false classifications in the shade but shows false positives in the summer on pastures. Further comparison to a manually tagged snow cover data set, as a ground truth, shows these tendencies confirmed. Altogether, pixelwise classification of webcam images by the used algorithms is viable but needs fine-tuning in several areas. A combination of both however, would be an effective solution to start creating a large-scale SCE dataset.

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20.5
Counting the uncountable: deep semantic density estimation from Space

Andres C. Rodriguez [1] & Jan D. Wegner [1]

[1] *EcoVision Lab, Photogrammetry and Remote Sensing, ETH Zurich, Stefano-Franscini-Platz 5, CH-8093 Zurich*
(andres.rodriguez@geod.baug.ethz.ch)

We propose a new method to count objects of specific categories that are significantly smaller than the ground sampling distance of a satellite image. This task is hard due to the cluttered nature of scenes where different object categories occur. Target objects can be partially occluded, vary in appearance within the same class and look alike to different categories. Sentinel-2 satellite configuration provides since 2015 multi-spectral images of up to 10 meters ground sampling distance (GSD). For such dataset, traditional object detection with tools like Faster R-CNN (Ren et al., 2017) is infeasible due to the small size of objects with respect to the pixel size, we cast object counting as a density estimation problem.

To distinguish objects of different classes, our approach combines density estimation with semantic segmentation in an end-to-end learnable convolutional neural network (CNN) to count objects of 1/3 the size of the GSD. We compare our proposed architecture with state-of-the-art semantic segmentation methods for terrestrial images that use among other ideas atrous convolutions to prevent lowering the resolution of the learned features keeping a large receptive field (Chen et al. 2017).

Experiments on four different objects show that deep semantic density estimation can robustly count objects of various classes in cluttered scenes. For the semantic segmentation task of Olive Trees we obtained Intersection over Union of 0.86 and precision of 0.90 in our test set. See Figure 1 for a visualization. Experiments with our Tree objects (Olives, Coconuts and Palms) show the importance of infrared bands in the prediction. In contrast, Cars benefited mostly from the high spatial resolution of the RGB bands. Our Experiments also suggest that we need specific CNN architectures in remote sensing instead of blindly applying existing ones from computer vision.
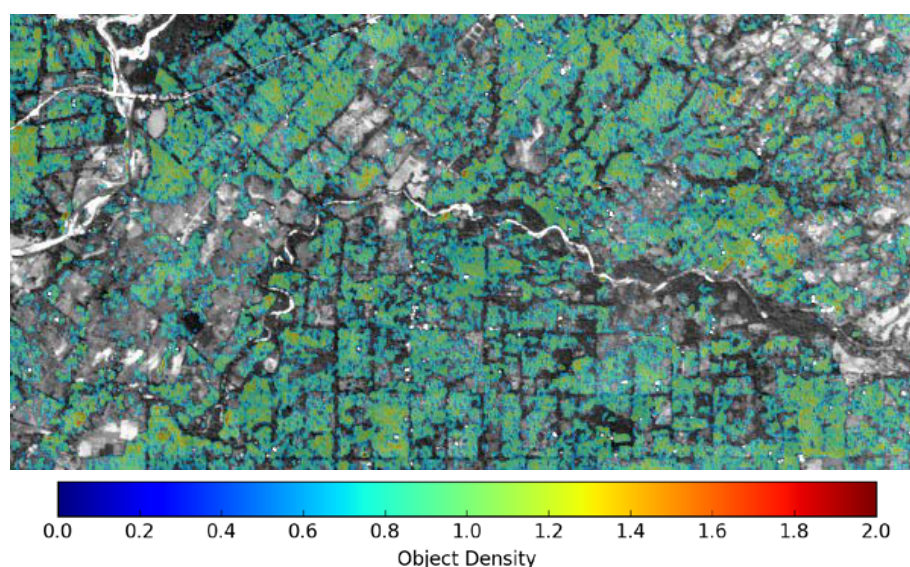

Figure 1. Predicted density estimation of coconuts overlaid to a greyscale version of the aerial image. Densities below 0.5 were trimmed for visualization.

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Ren, S., He, K., Girshick, R., Sun, J.: Faster r-cnn: Towards real-time object detection with region proposal networks. IEEE Transactions on Pattern Analysis and Machine Intelligence 39(6), 1137-1149 (June 2017)

20.6

From Space to Earth: observing land surface phenology processes using dense time-series of landsat 8, sentinel-2 and phenocams

Claudia Röösli [1], Rogier de Jong [1], Michael E. Schaepman [1]

[1] *Dept. of Geography, University of Zurich, Zurich, Switzerland*

Land surface phenology (LSP) characterises recurrent biological events in the annual profile of vegetated land surface at ecosystem scale as observed from remote sensing. LSP is a widely used indicator for terrestrial ecosystems' responses to changes of environmental conditions or for characterising species composition and biodiversity of an ecosystem.
We developed a new approach to observe LSP within the frame of a project of the European Space Agency ESA with the aim to contribute to the development of Essential Biodiversity Variables EBVs. Within the EBV-framework, biodiversity shall be observed and monitored in high-resolution and on a global scale, similar to the Essential Climate Variables ECVs. Monitoring LSP requires a dense time series of vegetation activity in the region of interest in order to study the yearly vegetation profile. This data is available from space and in high-resolution and sufficient dense time series since ESA's Sentinel-fleet has been launched. In our study we combine Landsat 8 and Sentinel-2 observations to extract LSP from the visual and near visual bands at three test sites located in temperate forest, arctic tundra and Mediterranean wetlands. We then compare the results to phenocams installed on ground to link the satellite observations to terrestrial observations. In the analysis, we focus on ecological processes and how these can be used for biodiversity assessment. This method is a crucial step for narrowing the scale gap between plant phenology and land-surface phenology and shows the potential for application at large – even global – spatial extent.
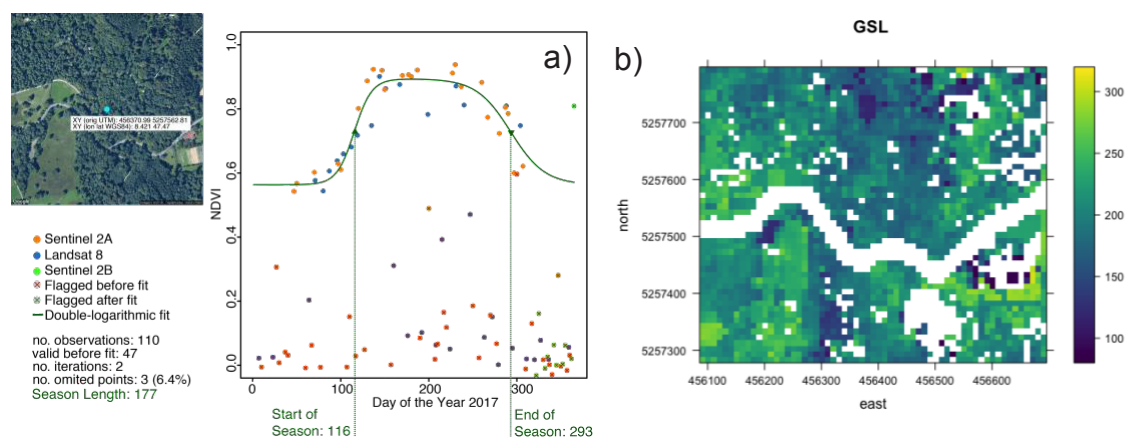

Figure 1. a) Yearly vegetation profile for one pixel extracted from Sentinel-2 and Landsat 8 images based on the Normalized Difference Vegetation Index (NDVI), fitted with a double logarithmic model. Outliers were flagged before (e.g. due to cloud cover) and after the fit (iterative fitting procedure). b) Growing Season Length (GSL=end - start of season) from the same area as shown in a). White pixels are invalid pixels due to for instance the road or a house.

20.7
Comparison of cloud base retrieval from satellites with ceilometer and observer data

Evi Rothenbühler [1], Stefan Wunderle [1,2] Céline Dizerens [1,2]

[1] Geographisches Institut, University of Bern, Hallerstrasse 12, CH-3012 Bern (evi.rothenbuehler@students.unibe.ch)
[2] Oeschger Center for Climate Change Research, University of Bern, Falkenplatz 16, CH-3012 Bern

Cloud and other weather related measurements have been done manually for many decades but their number decreases due to economic reasons. They are replaced by a network of measurement stations that collect point measurements at specific locations. For applications such as flight planning and weather forecast spatial information is needed. Satellite data provide information over large areas but in fact measure a different aspect of the atmosphere in question than the ground based instrument (e.g. observer or ceilometer). Therefore a comparison between satellite based and ground based measurements has been conducted. Data for one year at Payerne (CH) has been analysed using ceilometer and observer data (MeteoSchweiz) and Climate Satellite Application Facility (CSAF) satellite data (Deutscher Wetterdienst).

Results show that first, the two data sets measure different properties of the cloud layer. The ceilometer data gives the cloud base height (CBH) up to 7500m whereas the satellite data gives the cloud top height (CTH) (Figure 1). Second, comparing the two datasets with observer data shows restrictions related to spatial resolution (Figure 2), resulting from measuring conventions (observer), point measurements (ceilometer) and cloud detection algorithms (satellite). Third, in situations with multiple cloud layers the ceilometer measures low and middle clouds whereas the satellite data measures the topmost cloud layer. Fourth, no significant differences between day and night measurements has been found (Median height day: 2620.1m; median height night: 2363.3m). Fifth, the analysis shows that deriving information of CBH from satellite data is difficult as they measure CTH. Finding a relation to calculate CBH from CTH is difficult as many other factors of cloud properties such as cloud type, temperature profile and cloud water path play a significant role.
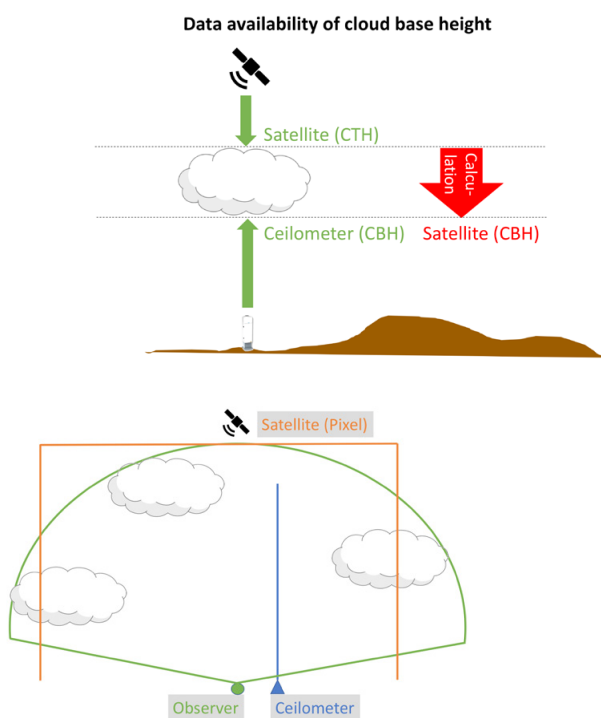Some of these findings will be presented and discussed during the talk.

Figure 1. Different properties of the cloud layer measured by ground based and satellite based instruments. Satellites reliably measure the cloud top height, ceilometers in comparison offer detailed information about cloud base heights.

Figure 2. Different spatial resolution of the three analysed datasets. Ceilometer are very point specific measurements whereas satellite and observer are more spatial.

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20.8
Tropospheric path delays derived from Global Navigation Satellite Systems data and spaceborne SAR interferometry: A case study in Swiss Alps

Karina Wilgan[1], Muhammad Adnan Siddique[2], Tazio Strozzi[1], Alain Geiger[1], Othmar Frey[2,3]

[1] *Chair of Mathematical and Physical Geodesy, Institute of Geodesy and Photogrammetry, ETH Zürich, Robert-Gnehm-Weg 15, CH-8093 Zürich (kwilgan@ethz.ch)*
[2] *Chair of Earth Observation and Remote Sensing, Institute of Environmental Engineering, ETH Zürich, Stefano-Franscini-Platz 3, CH-8093 Zürich*
[3] *Gamma Remote Sensing, Worbstrasse 225, CH-3073 Gümligen*

The Alps constitute about 60% of the Swiss total area. To assess the risk of geohazards in these areas, such as landslides and rockfall, it is important to regularly monitor land surface deformation. It has been demonstrated that both the spaceborne Synthetic Aperture Radar Interferometry (InSAR) and Global Navigation Satellite Systems (GNSS) are useful technologies for deformation monitoring. However, their use in this context requires that signal delays accumulated over the wave propagation path through the atmosphere are removed or mitigated. The troposphere is a non-dispersive medium at frequencies investigated in this study, thus, the delays estimated by one technique may be useful for mutual corrections.

For SAR images at high frequencies, such as X-band, the ionospheric effects can often be ignored, although the tropospheric delays remain relevant. The SAR interferometry is essentially exploiting the phase differences among two or more SAR images, and strives to estimate the deformation by extracting the deformation-related phases among other phase contributions (residual topography, atmosphere-induced phases). The phase information is meaningful only for those scatterers in the terrain that exhibit temporal phase coherence. These are the so-called "persistent" scatterers (PS).

However, the natural terrain in alpine regions generally limits PS behavior. It has been shown in earlier works that the atmospheric phases can be effectively isolated at PS locations [Strozzi et al. (2015), Siddique et al. (2018)]. Since interferometric phases are relative in nature, they can only be expressed as double-differenced tropospheric slant delays (dSTD), i.e. relative to the reference point as well as the reference (master) SAR acquisition. For GNSS, the tropospheric zenith delays are usually estimated along with the coordinates in the processing and can be converted into delays in slant range with an appropriate choice of the mapping function (based on the incidence angle for the SAR acquisitions).

In this study, we compare the dSTD retrieved from GNSS against the dSTD estimated with a PSI processing chain for alpine regions in Switzerland. The GNSS-based models are interpolated to PS locations using the in-house developed software package COMEDIE (Collocation of Meteorological Data for Interpretation and Estimation of Tropospheric Pathdelays). The models are calculated for 32 acquisitions of COSMO-SkyMed satellite in a period between 2008 and 2013. The acquisitions were taken from the snow-free period from June to October, always around similar time, some minutes before 6 pm. The chosen research area of around 20 km x 25 km is located in Zermatt and Matter Valley in the Swiss Alps. The GNSS-based models are calculated from 5 to 8 stations located within or close to the area of the study for the years 2008 – 2011 and from 11 stations for years 2012 – 2013.

The preliminary results show a good agreement between InSAR and GNSS estimates for some of the interferometric layers. The correlation coefficient averaged from all of the interferograms is equal to 0.64. The average bias of the residuals between InSAR and GNSS equals -6 mm with a standard deviation of 4 mm. For the period of only 2012 – 2013, with more GNSS data, the bias is reduced to -2 mm. Figure 1 shows the example of a comparison between InSAR and GNSS for one date with a good agreement between these two techniques. We are currently working on adding also the information from the low-cost L-1 only GPS stations located within the area of the study. In the next steps, the GNSS delays will be introduced as a priori models at the interferogram level and the reasons for the poor agreement between InSAR and GNSS estimates for some of the layers will be further investigated.
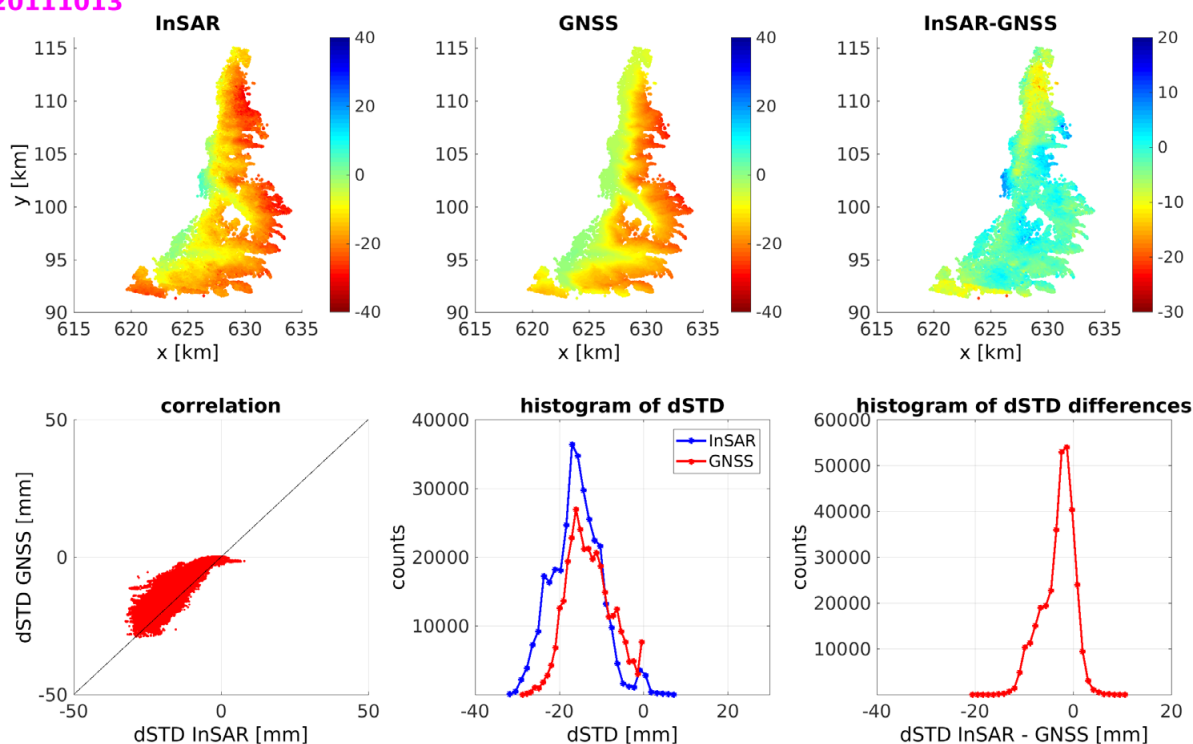
Figure 1. The comparison between dSTDs from InSAR and GNSS for one sample date (2011-10-13, 17:42:42) with a good agreement between the two techniques.

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20.9
Spatio-temporal pattern of soil degradation in Swiss alpine grasslands revealed by Object-Based Image Analysis

Lauren Zweifel [1], Katrin Meusburger [2] & Christine Alewell [1]

[1] *Environmental Geosciences, Department of Environmental Sciences, University of Basel, Switzerland*
  (lauren.zweifel@unibas.ch)
[2] *Swiss Federal Research Institute WSL, Birmensdorf, Switzerland*

Many grassland areas in the Swiss Alps are strongly affected by soil degradation due to various processes of soil erosion, intensified by the extreme prevailing topographic and climatic conditions. The changes in our climate are predicted to have a pronounced impact on the alpine regions causing not only higher temperatures but also a change in frequency and intensity of precipitation events as well as strongly altered snow dynamics (CH2011, 2011; Frei et al. 2018). In combination with changing land-use practices, an increase in soil degradation is expected (Meusburger & Alewell, 2014).

Past scientific studies mostly focus on one or two types of soil erosion processes (e.g. landslides, rill or sheet erosion). In this study we present a holistic approach to identify and map all erosion processes occurring in alpine grasslands over space and time on catchment scale (Urseren Valley, Canton of Uri). For the mapping of the degraded soil areas we apply object-based image analysis (OBIA) to orthophotos *SwissImage* taken between 2000 and 2016. The semi-automated workflow profits from the high spatial resolution of the orthophotos (0.5 - 0.25m) and takes into account spectral, spatial, contextual and textural image properties as well as accompanying information gained from digital elevation models. Additionally, the mapped areas are classified according to their predominating erosion process (landslides, sheet erosion, livestock-trails and management degradation).

The temporal analysis of the mapped sites shows an overall increase in degraded areas for all erosion types for the Urseren Valley. Since we analyse a time series consisting of several images, it becomes possible to distinguish between fast and gradually evolving processes. Spatial analysis reveals a high dynamic within the catchment, highlighting areas especially prone to newly emerging erosion, such as lower areas on south facing slopes intensely used for pasturing. An increasing amount of livestock trails can lead to larger areas affected by sheet erosion over time through trampling and grazing.

The dynamic aspect of single erosion features can be monitored and classified according to their temporal behaviour as increasing, decreasing, fluctuating and permanent degradation. The results provide an extensive understanding of the ongoing degradation processes over time as well as their spatial distribution and as such may improve our comprehension of the status and trends of alpine grassland soil degradation.

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P 20.1
Long-term measurements of middle atmospheric water vapor at the Zimmerwald observatory

Martin Lainer [1], Klemens Hocke [1], Niklaus Kämpfer [1]

[1] *Institut für Angewandte Physik und Oeschger-Zentrum für Klimaforschung, Universität Bern, Sidlerstr. 5, CH-3012 Bern*
   (klemens.hocke@iap.unibe.ch)

Atmospheric water vapor is a major field of research at the Institute of Applied Physics (IAP) at the University of Bern. Water vapor plays a key role in the earth's radiative budget and is the most important greenhouse gas in the atmosphere. In the middle atmosphere (30-80 km) water vapor is the major source of the OH (hydroxyl) radical which is involved in the destruction of the ozone layer. Mechanisms that control the long term variability of stratospheric and mesospheric water vapor are not well understood. Therefore, long-term high quality measurements of middle atmospheric water vapor are very important. With the MIAWARA radiometer more than a decade of continuous observations are achieved now.
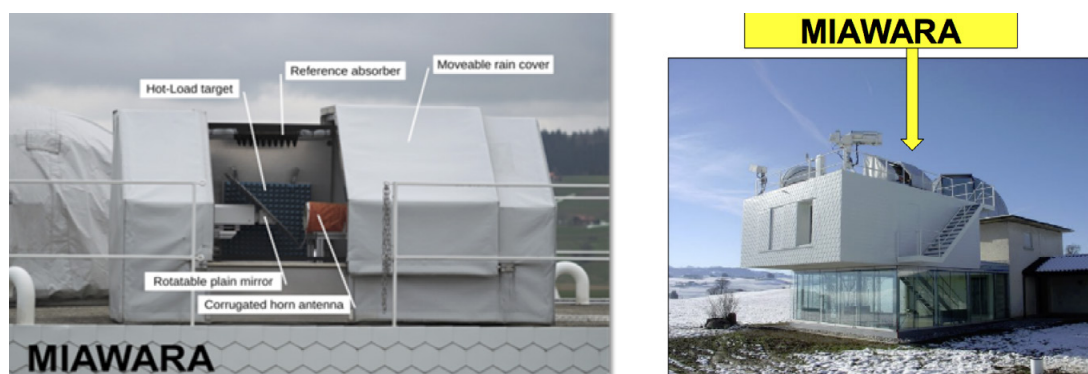

Figure 1. The observatory for water vapor at Zimmerwald and the Middle Atmospheric Water Vapor Radiometer (MIAWARA).

P 20.2

Quality check of water isotope distribution from space to ground by vertical profiling and altitude dependent in-situ records

Markus Leuenberger [1]

[1] Climate and Environmental Physics Division, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland (leuenberger@climate.unibe.ch)

There is only limited information available on water stable isotope ratios from satellites. Among which the shortwave infrared spectrometer SCIAMACHY onboard ENVISAT resulted in a total column measurement of HDO, the thermal infrared spectrometer on Aura, sensitive to mid-troposphere HDO as well as retrievals from high-resolution GOSAT shortwave infrared spectra are the most valuable ones. Yet, they experience substantial uncertainties as these techniques are relatively new and require proper comparisons. In this respect high resolution models combined with ground-based in-situ and column integrated measurements are inevitable. Until recently water vapor measurements even at the ground was rather challenging. Nowadays a couple of commercial instruments are available to perform high precision measurements. We will investigate variations of water isotopes along vertical profiles taken by the Glider-AirCore proposal. This will yield a direct comparison of the vertical distribution obtained by sophisticated models on the one hand and satellite products on the other hand. Water stable isotopes have a tremendous potential to tackle important questions of the Earth's water cycle, in this respect the new expected HDO data from the TROPOMI instrument onboard Sentinel-5 Precursor mission will be extremely interesting.

P 20.3

Glider-AirCore analyses linking ground-based and column integrated trace gas measurements with satellite retrievals

Markus Leuenberger [1] and Andreas Kräuchi [2]

[1] Climate and Environmental Physics Division, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland (leuenberger@climate.unibe.ch)
[2] Meteolabor AG, Wetzikon, Switzerland

The ESA Sentinel satellite family missions are dedicated to the needs of the Copernicus programme. The proposed Glider-AirCore proposal results – once established – in high resolution vertical profiles of trace gases and auxiliary data and is therefore naturally linked to the ESA Sentinel 5P as well as the Sentinel 4 missions focusing on column integrated trace gas retrievals and weather observation data with high spatial resolution. The Glider-AirCore consists of a robust light-weighted glider carrying a long (> 100 meters) surface coated metal tube to sample air during autonomous descending in a spiral after its lift up to stratospheric heights by a balloon. Onboard instrumentations includes GPS tracker for navigation and wind retrievals, conventional humidity, temperature, pressure sensors, pyranometer (short-waves sun radiation) and pyrgeometer (long-wave thermal radiation) both up- and downward oriented. A CRDS spectrometer will be hooked up after landing of the Glider-AirCore to determine trace gas concentrations of CO_2, CO, CH_4 and H_2O with highest precision in the sub-ppm or sub-ppb range.

P 20.4

Horizontal open-path FTS measurements for bridging the gap between high accurate point measurements and spatially averaging atmospheric models using vertical greenhouse gas retrievals from satellite (H-OP-FTS)

Markus Leuenberger [1]

[1] *Climate and Environmental Physics Division, Physics Institute and Oeschger Centre for Climate Change Research, University of Bern, Bern, Switzerland (leuenberger@climate.unibe.ch)*

ESA Sentinel satellite family has already and will increasingly contribute to our understanding of the Earth's climate focusing on the major biogeochemical cycles by measurements of greenhouse gases. Thereby, a good spatial coverage of column integrated measures will be combined with spatially high resolution state-of-the-art atmospheric models – also often used as weather prediction models. H-OP-FTS proposes to add regional-scale horizontal column retrievals over kilometer-scale in order to fill the gap between high precision in-situ measurements and rapidly growing high resolution atmospheric modelling on kilometer scale. A suggested pilot study will focus on a high altitude site which comprises a complex topography – ideally suited for high resolution model studies – and highly variable dynamic situations combined with strongly variable distributions of greenhouse gas concentrations. We anticipate that H-OP-FTS naturally complement present applications of satellite data with ground-based measurements.

P 20.5
Assessing plant traits and diversity from local to regional scales in differently managed alpine grasslands

Christian Rossi [1,2,3°], Anita C. Risch [2], Mathias Kneubühler [1], Martin Schütz [2], Rudolf M. Haller [3] and Michael E. Schaepman [1]

° Correspondence: christian.rossi@nationalpark.ch
[1] Remote Sensing Laboratories, University of Zurich, Winterthurerstrasse 190, CH-8057 Zurich, Switzerland.
[2] Research Unit Community Ecology, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Zürcherstrasse 111, 8903 Birmensdorf, Switzerland.
[3] Department of Research and Geoinformation, Swiss National Park, Chastè Planta-Wildenberg, 7530 Zernez, Switzerland.

Ecosystem functions in grasslands are essential for the survival of plant and animal species and vital in sustaining human life. Such functions are locally strongly linked to different plant traits, like leaf dry matter content or specific leaf area (SLA), and to their diversity (Díaz et al. 2007). This relationship between trait diversity, called plant functional diversity, and ecosystem functions is likely to be scale dependent and functions operate across a range of scales (Thompson et al., 2018). Generally, to transfer relationships between plant functional diversity and ecosystem functions from local to regional scales it is necessary to know the rarely studied direct relation between regional and local plant functional diversity. However, capturing the trait variations at distinct spatial scales and in differently managed grassland remains challenging, mainly because only a limited number of trait measurements are available and field measurements of plant traits are time consuming.

Modern remote sensing systems bear the potential to close this gap (Homolová et al., 2013). Satellite images provide a complete landscape picture, benefiting from the unique light reflectance properties of plant traits. Based on reflected sunlight, we quantified plant traits in grasslands of the Swiss National Park and the agricultural landscape in its surroundings (Figure 1a). For trait quantification we took advantage of a physical model that describes reflectance of the aboveground portion of plant communities. Applied to our study area, it was possible to distinguish the impact of different fertilization and grazing intensities on plant traits and functional diversity on different spatial scales (Figure 1b,c). The plant trait assessment produces evidence for the evaluation of protective and agricultural measurements. Further, due to high temporal resolution of the Sentinel-2 satellite data acquisition scheme, the proposed method is suitable for incorporation into monitoring schemes.
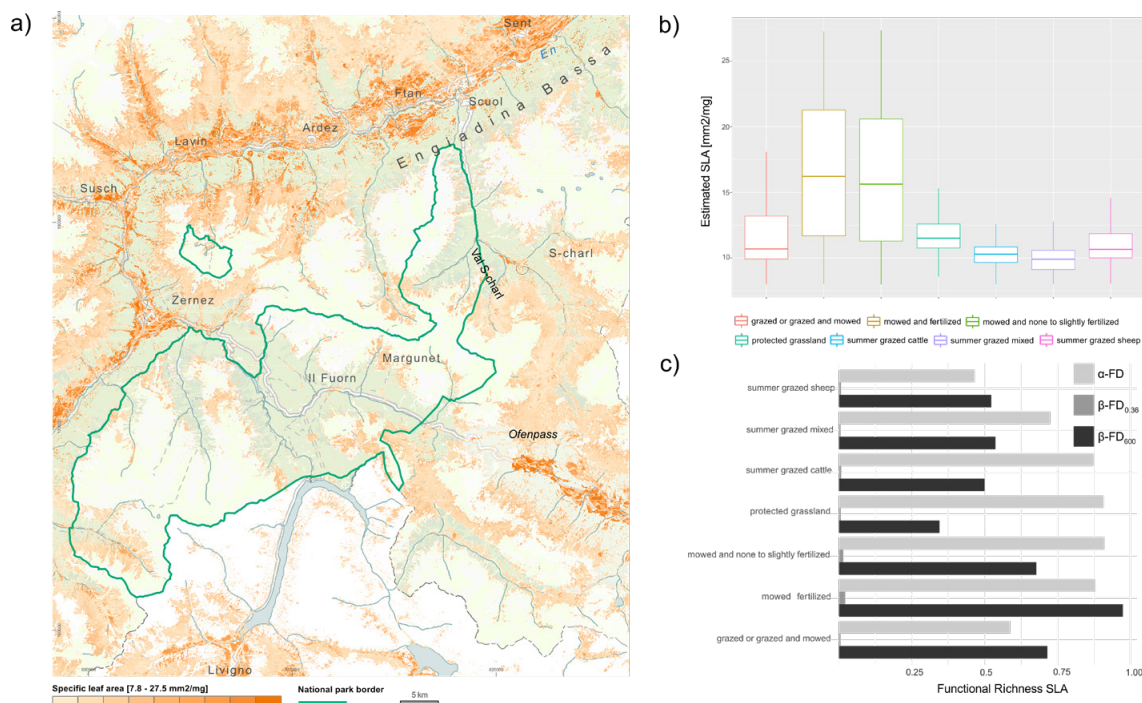

Figure 1. a) Specific leaf area (SLA) mapped for the study area through a physical model from a Sentinel-2 dataset of 06 June 2017. SLA ranges from 7.87 to 27.37 mm²/mg (12.24 ± 3.87 mm²/mg ; mean ± standard deviation);
b) Boxplots showing the differences in SLA estimated for the whole dataset among the different management practices (significant differences, Welch's ANOVA, $p < .05$); c) One aspect of SLA functional diversity (FD) in dependency of grassland management for three different spatial scales: α-FD calculated from trait measurements in reference plots (400 m²); β-FD derived from remotely sensed SLA calculated on two different scales, i.e., neighborhood (0.36 ha) β-$FD_{0.36}$ and landscape (600 ha) β-FD_{600}.

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P 20.6

Middle-atmospheric H_2O and O_3 measurements by ground-based microwave radiometry in the Arctic

Franziska Schranz [1], Brigitte Tschanz [1], Rolf Rüfenacht [1] & Niklaus Kämpfer [1]

[1] Institute of Applied Physics, University of Bern, Sidlerstrasse 5, CH-3012 Bern (franziska.schranz@iap.unibe.ch)

Water vapour and ozone profiles in the Arctic middle atmosphere have been measured with the two ground-based microwave radiometers MIAWARA-C and GROMOS-C for 3 years. The instruments have been located at the AWIPEV research base at Ny-Ålesund, Svalbard (79° N, 12° E) since September 2015 and the measurements are ongoing. We present the 3-year long and almost continuous datasets of water vapour and ozone which are characterised by a high time resolution. A thorough intercomparison of these datasets with models and with satellite, ground-based and in-situ measurements was performed. During these first three years of the measurement campaign we observed dynamical events which are typical for the Arctic middle atmosphere. The descent rate of mesospheric water vapour inside the polar vortex in fall was found to be 435 m/day on average. In early 2017 distinct increases in mesospheric water vapour of about 2 ppm were observed when the polar vortex was displaced and midlatitude air was brought to Ny-Ålesund. Two major sudden stratospheric warmings took place in March 2016 and February 2018 where stratospheric ozone enhancements of up to 4 ppm were observed. The zonal wind reversals accompanying a major SSW were captured in the GROMOS-C wind profiles which are retrieved from the ozone spectra. After the SSW in 2018 the polar vortex reestablished and the water vapour descent rate in the mesosphere was 355 m/day.