Environmental Research Station Schneefernerhaus (UFS)

Scientific Results 2009 / 2010

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Environmental Research Station Schneefernerhaus (UFS): Scientific Results 2009 / 2010
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INFRASOUND SIGNATURES FROM NATURAL HAZARDS: MODELLING AND SOURCE DISTINCTION

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Research concerning infrasound and infrasonic sources is performed at the German Remote Sensing Data Center of the German Aerospace Center (DLR-DFD) with special regard to signatures from natural hazards.

Infrasound is sub-audible sound (below human hearing, <16 Hz) and is generated by a huge variety of different sources. These include natural and artificial (man-made) signatures as e.g. severe weather and storms, active volcanoes and eruptions, meteoroids, earthquakes, tsunamis, avalanches, mountain associated waves, rocket starts, supersonic flights and explosions. Sound waves are pressure perturbations (areas of compressed and depressed air) which propagate in the atmosphere. Especially infrasound as low-frequency sound with little attenuation can travel over very long distances in the atmosphere and can be detected hundreds and thousands of kilometres afar. Infrasound is detectable in pressure and temperature fluctuations (see figures 1 and 2) and therefore also detectable in temperature time series.

The DLR-DFD operates the GRIPS-spectrometer (Ground-based Infrared P-branch Spectrometer) at the UFS to monitor the temperature of the so called 'airglow layer' in the mesopause altitude region (at ~87 km height). These measurements are amongst other things investigated with regard to infrasound signatures from different natural hazards.

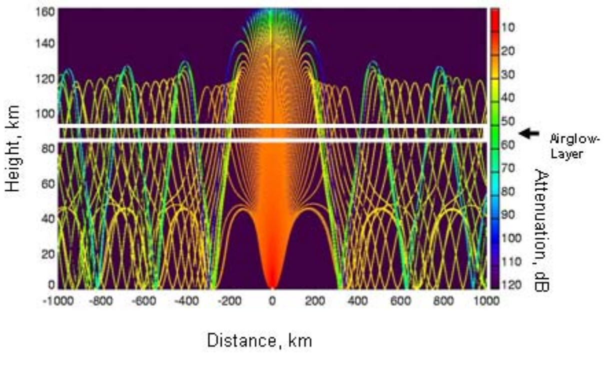

Fig.1: Infrasound propagation in the atmosphere including attenuation (in dB) for a 0.1 Hz surface source signal.

Modelling

The modelling of infrasound propagation is performed at the DLR-DFD using the numerical model HARPA/DLR. The propagation of an infrasonic signal from e.g. a surface point source into the atmosphere can be described by ray-tracing methods. This modelling is combined with the use of climatologies to describe the atmospheric background (e.g. HWM-93/ MSISE-00 for horizontal wind and temperature fields). Furthermore atmospheric attenuation and geometric spreading are implemented as weakening processes and the decreasing background air pressure is implemented as amplification process for a sound signal in the atmosphere.

Figure 1 shows a standard sound propagation pattern regarding attenuation processes in a relative pressure unit. Figure 2 shows the sound propagation pattern for temperature fluctuations also regarding the amplification process. Minor fluctuations near the ground are increased to detectable orders of magnitude within the upper atmosphere.

The strength of an infrasound induced temperature fluctuation directly depends on the source strength. While weak infrasound sources only induce signatures in the airglow layer height of some hundredth of a Kelvin, strong infrasound sources can induce signatures of some Kelvin, which are detectable with the GRIPS spectrometer.

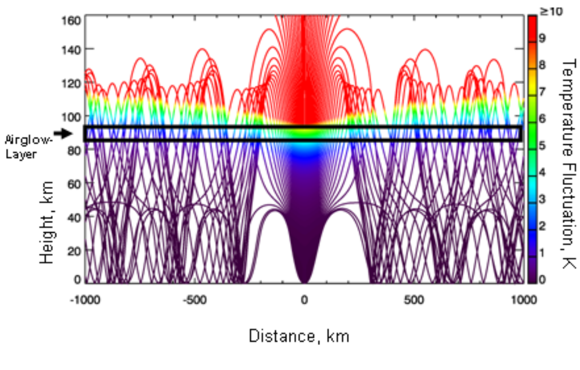

Fig.2: Infrasound propagation in the atmosphere and induced temperature fluctuations (in K) for a 100 Pa and 0.01 Hz surface source signal.

Source Distinction

Wave signatures of different infrasound sources can be distinguished by physical wave parameters as e.g. wave period, wavelength and amplitude. These parameters are measured by ground-base observations of infrasound in surface air-pressure (measurements using microbarometers) and airglow intensities (measurements using GRIPS spectrometer) as well as temperature time series derived thereof.

Figure 3 shows a distinction of different infrasound sources by their wavelength and wave period. Some infrasound sources have a very narrow period range (e.g. microbaroms: around 5 sec), others vary by some orders of magnitude and are also dependent on further source criteria. Wave period and wavelength of explosions vary for example dependent on the explosion yield: The stronger an explosion, the higher its period and wavelength.

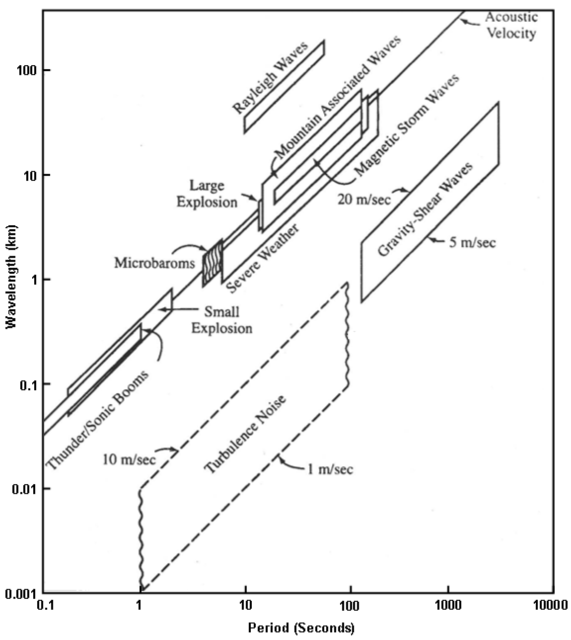

Fig.3: Wavelengths and periods for different infrasonic sources (Figure following Bedard, http://www.esrl.noaa.gov/psd/programs/infrasound/infrasonic.html).

Literature

Bittner, M., Höppner, K., Pilger C. and Schmidt, C. (2010). Mesopause temperature perturbations caused by infrasonic waves as a potential indicator for the detection of tsunamis and other geo-hazards. NHESS 10:1431-1442.

Pilger, C. and Bittner, M. (2009). Infrasound from tropospheric sources: Impact on mesopause temperature? JASTP 71:816–822.

Identification of Infrasound Sources, Example: Severe Weather and Storms

The distinction of signatures using physical (wave) parameters is a first important step to identify certain infrasound sources. Further information concerning the source is nevertheless needed for source verification.

The example of severe weather is chosen to demonstrate the further verification of source distinction using meteorological observations: If the parameters of source distinction give indications on infrasound signatures from severe weather, the tropospheric vicinity of the GRIPS field of view in 87 km height is investigated for areas of high convective available potential energy (CAPE). CAPE is an indicator of severe weather potential and may give evidence of infrasound from a meteorological source, which propagates (following propagation calculations, see 'Modelling') upwards into the field of view of the measuring instrument.

Figure 4 shows an example for a measurement night from 5th to 6th November, 2008 using the GRIPS instrument at the UFS. The temperature time series observed and the wavelet analysis performed show significant signatures in the severe weather infrasound period region between 0.5 and 5 min. The corresponding ECMWF-map shows an area with increased CAPE-potential in the vicinity of the GRIPS field of view. Infrasound from this potential severe weather source could have propagated into the GRIPS field of view and could have been detected by GRIPS.

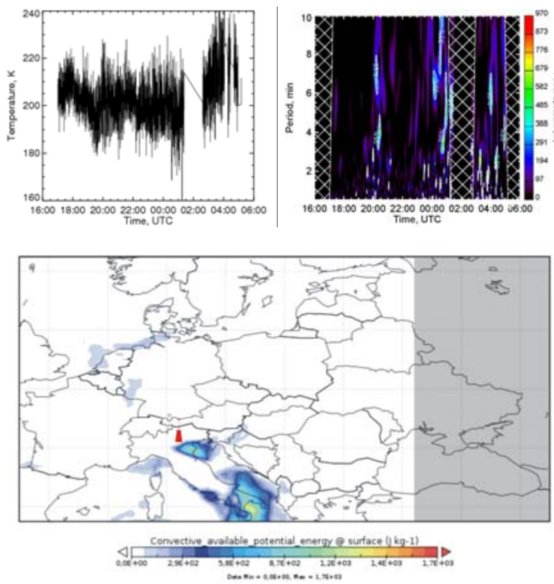

Fig.4: GRIPS nocturnal temperature time series (upper left), wavelet analysis (upper right) and ECMWF-CAPE-analysis (lower) for the night from November, 5th to 6th, 2008. The GRIPS field of view is visible in the map as a red trapeze.

THE INTERNATIONAL NETWORK NDMC FOR GLOBAL MONITORING OF THE UPPER ATMOSPHERE

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Mission Statement

The Network for the Detection of Mesopause Change (NDMC) is a global program with the initial mission to promote international cooperation among research groups investigating the mesopause region (80-100 km) with the goal of early identification of changing climate signals.
This program involves the coordinated study of atmospheric variability at all time scales, the exchange of existing know-how, and the coordinated development of improved observation, analysis techniques and modelling. The initial emphasis is on mesopause region airglow techniques utilizing the existing ground-based and satellite measurement capabilities.
Scientists investigating the mesopause region are invited to join the NDMC irrespective of their research goals and/or measurement techniques (spectrometer, lidar, radar, ground-based or satellite borne remote sensing devices). NDMC's current focus is on documenting climate change and on understanding coupling processes observable at the mesopause level. It is affiliated with the Global Atmosphere Watch (GAW)-program of the World Meteorological Organization (WMO) and with the Network for the Detection of Atmospheric Composition Change (NDACC).

Introduction

NDMC is currently composed of 49 high-quality, remote-sensing research stations for observing and understanding the physical and chemical state of the mesosphere with initial emphasis on the mesopause (see Fig.1 or at the NDMC website under http://wdc.dlr.de/ndmc).

Fig.1: Geographical distribution of the 49 measurement stations in NDMC (status as of November 2010).

NDMC network operations have officially started in 2007 based on a founding initiative of the German Remote Sensing Data Center of the German Aerospace Center (DLR-DFD). It is jointly coordinated by the DLR-DFD and the Argentinean organization CONICET and is accompanied by an international management team with representatives of the airglow community from Argentina, Australia, Germany, Norway and USA. Coordination centre is the Environmental Research Station Schneefernerhaus (UFS). The NDMC management was funded by the Bavarian State Ministry of the Environment and Public Health. The overall structure of NDMC is shown in Fig. 2.

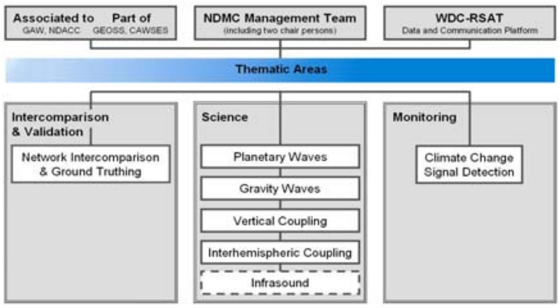

Fig.2: Overall Structure of NDMC.

NDMC is continuously evolving and plans new observing sites and facilities (e.g. in Europe or Africa) in the next years to obtain a well-balanced global coverage of its stations to adequately and reliably assess global issues. It is also planned – and partly already realized – to extend the current focus of airglow measurements to other measurement techniques such as lidar, radar, satellites or modelling. This also includes the extension to the entire mesosphere which would then close the gap to NDACC.
The World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT), operated by DLR-DFD, provides the communication and information platform for NDMC and handles all aspects of data management and web hosting.

Research Objectives

The overall question is: Is the climate of the mesopause region (80-100 km) changing, and if so, how and why?
The objectives of NDMC are:

- Identify and quantify climate changes by monitoring key parameters such as temperatures in the mesopause region, airglow brightness for the early characterization of climate signals; Identify and quantify variability at different time scales such as seasonal variations and solar cycle effects.
- Detection of solar activity effects at all time scales ("Space Weather")
- Answering other scientific questions related to atmospheric dynamics at different time scales including the description and the causes of the variability of periodic and quasi-periodic processes:
  - acoustic and gravity waves,
  - tides and planetary waves, and
  - seasonal and interannual variations. Also,
  - episodic events caused by external forcing shall be monitored.
- Validation of satellite instruments and its use for intercomparison of ground-based instruments
- Cooperation in the development of instrumentation

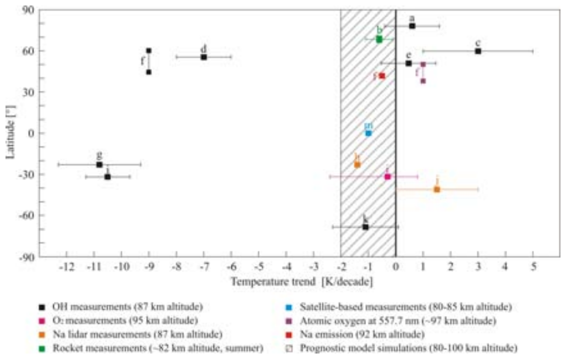

Fig.3: Temperature trends in the mesopause region (80-100 km) at different geographical latitudes as reported in the literature. Modelling studies predict a significant cooling ("cooling-to-space effect") of the middle and upper atmosphere mainly due to increases in carbon dioxide, whereby temperature time series of ground-based stations show an inhomogeneous pattern in this height region. Possible influences of the solar cycle or changes in the dynamics are ongoing research topics within NDMC.

Airglow Observations

The airglow is electromagnetic radiation emitted in the upper mesosphere in the visible and near infrared due to atomic and molecular excitations at these heights. The origin of most airglow-luminescence is a rather narrow layer of excited hydroxyl (OH) molecules peaking around about 87±4 km. The excitation is caused by the exothermic reaction of ozone (O_3) and atomic hydrogen (H). The other prominent airglow source is the layer of molecular oxygen (O_2) emitting at a peak altitude at about 95 km. The rotational temperature derived from these emissions is directly related to the kinetic temperature in these heights.

The observation of airglow features by spectroscopic methods is a widely used method for the determination of upper mesospheric parameters. DLR-DFD contributes to NDMC with its own infrared spectrometers GRIPS (Ground-based Infrared P-branch Spectrometer), which is presently one of the most advanced OH-instrument. Currently, there are such GRIPS-instruments routinely operating at UFS since October 2009 (Fig. 3) and at DLR in Oberpfaffenhofen since January 2009. The nightly temperature measurements are available in near real time at the NDMC website.

NDMC Quality Assurance
- Network Intercomparison -

NDMC has established a common NDMC database and agreed to implement a data quality assurance strategy. This implies the need for repeated intercomparison activities with comparable measurements and common standard procedures.

In principle there are three intercomparison methods: 1) Collocated simultaneous measurements of the instruments to be compared. 2) Instrument intercomparisons using mobile instruments. 3) Use of satellite-based transfer standards. A combination of the three methods promises optimal results.

For example, collocated simultaneous measurements of the different GRIPS instruments in Germany are operationally be performed (see Fig. 4).

Next steps in the network-wide intercomparison context will be to establish an operational intercomparison service for NDMC incorporating data from all NDMC stations and all suitable satellite data with defined coincidence criteria. There is consensus about the utilization of the sensor SABER on board the U.S. satellite TIMED as transfer standard.

Additionally, a mobile reference standard will be established travelling to the different NDMC stations around the globe for more frequent intercomparison audits.

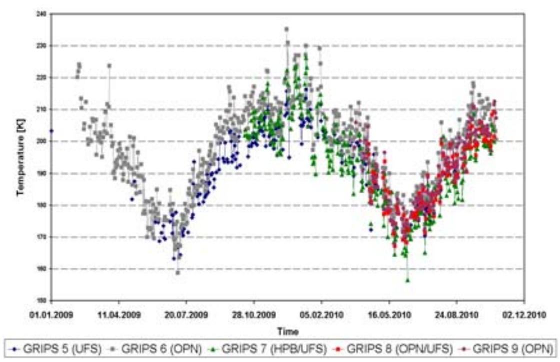

Fig.4: Collocated simultaneous measurements of the different GRIPS instruments located permanently or temporarily at the German NDMC stations Oberpfaffenhofen (OPN), Schneefernerhaus (UFS), and Hohenpeissenberg (HPB) from 01 Jan. 2009 to 20 Oct. 2010.

POP FINGERPRINTS IN ALPINE SPRING WATER

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High volume sampling of alpine spring water quality allowed the detection of POP-like organochlorine compounds in the fg/L range.
Fingerprints of Persistent Organic Pollutants (POP) confirm long range transport and also the transport of the compounds through a bedrock of about 100m.
Sampling stations close to a remaining permafrost-body near the UFS are established and will help to investigate the dynamics between percolating water and melted ancient water from the permafrost body.

Introduction
Together with emerging exploration of surface near groundwater to provide the population with drinking water it becomes more and more important to develop insight into the presence of POP in drinking water resources (WFD 2000).
Glaciers are reported to have preserved depositions in snow and ice from industrial and agricultural origin, which can be liberated after melting (Bogdal et al. 2009). At the rock-massive Zugspitze, Germany, a suitable location was identified in a tunnel which also passes a permafrost ice body and exhibits locations to sample percolated water from the above rock and possibly partly melted water from the permafrost body. This location is now under permanent observation for the coming years to characterize the water and the impact of climate change to the water quality and quantity.
Methods to elaborate concentrations of contaminants from large volumes of groundwater will help to identify tomorrow's contaminants of concern. In 1984 US-EPA has set a limit value of 0.013 ppq for 2,3,7,8-TCCD as ambient water-quality criterion (WQC) which still lacked corresponding analytical approaches (Tondeur & Hart 2009). However, the current limits of determination for drinking water in Europe are adjusted to sample volumes of about 1 L. The analytical tools are not capable to check LOD far below one tenth of the current limits which is not sufficient to achieve the abovementioned goals. Thus it became necessary to develop novel tools to meet these goals. First attempts and results about this purpose had been reported (Schramm et al. 2009).
Small and persistent molecules are most likely to enter the human pathways and are therefore of major concern to interfere with biological signal systems. Many trace pollutants with such properties (e.g toxic elements, pesticides, antibiotics, BFR, PFC, POPs etc.) being potentially present in groundwater systems for drinking water purposes are in the focus of the related investigations with relevance for impacts on humans and their resources. Many lipophilic POP are commonly not believed to penetrate through the soil column or bedrock into groundwater systems which is unfortunately a dangerous delusion and elaborated in the following as demonstrable error.
Water from a location close to a permafrost ice body at the Zugspitz-Rock-Massive was sampled during periods of weeks per sample in Sept./Oct. 2009. This activity will continue as a long-term investigation during the coming years.

Results and Discussion
The water was investigated about its origin with respect to the permafrost ice body by using isotope analysis of ^{3}H. Since ^{3}H was present in a concentration similar to actual levels, which are unfortunately also in the range of the periods before the nuclear fallout, it cannot be concluded that the water sampled was influenced by melted permafrost. However, due to the presence of the anthropogenic organochlorine POP-like compounds it must be concluded that the water received major impact of recent precipitation. In addition the $\delta^{18}O/\delta^{2}H$-values of the spring water reflect precipitated waters from autumn rather than other seasons. Since the water was sampled

Sept./Oct. 2009 it may be concluded that the passage through the bedrock performs quite fast.
The results about the hexachlorocyclohexanes are examplified in figure 1. It is obvious that the gamma-conformer is most abundant reflecting its major use in Europe in the past, but also alpha- and beta-conformers are clearly detectable. However, all hexachlorocyclohexanes are not exceeding the limit values of the German drinking water ordinance.
For the group of chlorinated and substituted benzenes a decreasing trend with decreasing water solubility has been found.

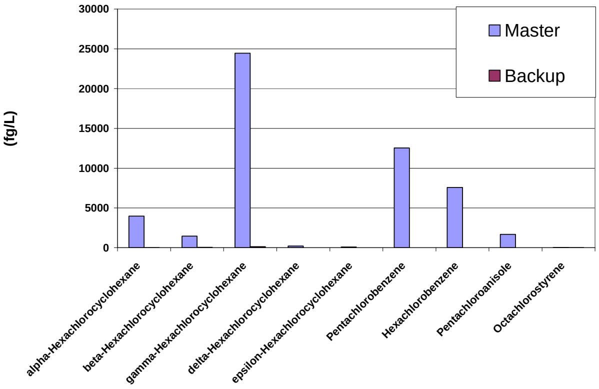

Fig.1: Fingerprint of hexachlorocyclohexanes and (substituted) chlorobenzenes in alpine spring water

References

1. Bogdal, C; Schmid, P; Zennegg, M; Ansellmetti, F S; Scheringer, M; Hungerbühler, K: ES&T, 2009, 43 , 8033
2. Schramm, K-W, Fischer, N, Henkelmann, B. *Organohalogen Compounds* 2009; 71: 724
3. Tondeur, Y, Hart, J. *TRAC* 2009; 28, 1137
4. WFD: Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000, OJL 327, 22 December 2000, pp. 1-73

DEVELOPMENT OF NOVEL VALIDATION APPROACHES: IMPACT OF ATMOSPHERIC VARIABILITY ON VALIDATION MEASUREMENTS

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Satellite-based data and products make a substantial contribution to observations of the atmosphere. Quality assurance of these data is of fundamental importance in order to interpret measurements and scientific results based on these. Since there exist deficits between the confirmed quality of satellite-based data and the corresponding user requirements development of novel validation approaches is an essential task for more accurate validation results.

To date, validation is mainly based on relatively simple comparison of satellite-based data with suitable mostly ground-based measurements. But for functional reasons satellite and comparison measurements in general do not correspond precisely in time and space (so called **mistime** and **misdistance**).

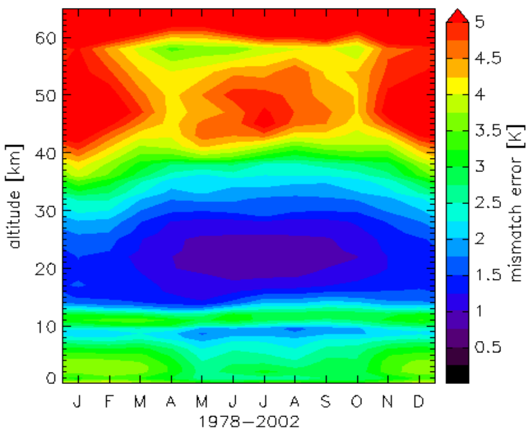

Fig.1: Mismatch error in temperature at the UFS (47.4°N, 11.0°E) for 6h mistime and 375km misdistance based on ERA-40 data. Quiet layers can be found in about 9 and 20 km altitude.

Since dynamical effects in the atmosphere lead to temporal and spatial variability of atmospheric parameters such as temperature or ozone, a non-zero mistime or misdistance can cause differences between satellite-based and validation measurements (so called mistime and misdistance errors, generally addressed as mismatch error).

These differences cannot be taken as a hint for the satellite's instrument failure. Additionally, deviations in measurement data that are caused by differing measurement geometry of the instruments have to be taken into account (misintegration error).

Analysis and quantification of the impact of natural **atmospheric variability** on validation is analysed and quantified as part of the project SatVal-A.

Generally, the mismatch error is calculated as average value of differences that occur for a specific mismatch. As data base for these studies, mainly ERA-40 (reanalysis of atmospheric variables) temperature data over a 24-year period are used, complemented through satellite as well as radiosonde measurements.

Figure 1 depicts an example of the mismatch error at the UFS (monthly mean values averaged over the years 1979 to 2002). Indicated are the variations of the mismatch error in dependance of season and height. According to the occurrence of atmospheric dynamics, for example planetary and gravity waves, the natural impact on validation measurements is in general smaller in the lower stratosphere and in the summer months but increases in higher altitudes and during winter time.

Regions, characterized y systematically lower atmospheric variability, become apparent. In these so called '**quiet layers**' comparison of measurements is much less disturbed by dynamical impact, and deviations between satellite-based and validation measurements can most probably be ascribed to instrumental or algorithmical failures. Thus, quiet layers offer the possibility of a more precise interpretation of validation results.

Another aspect of validation is the most appropriate choice of **coincidence criteria** which means the maximal mistime and misdistance between a pair of measurements. A compromise between an acceptable disturbance by natural variability and a statistical sufficient number of pairs has to be found.

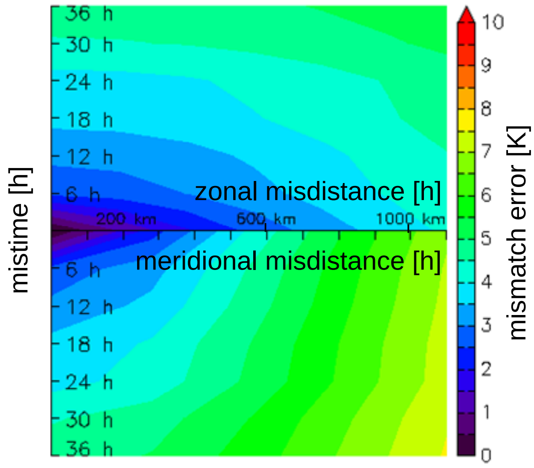

Fig.2: Mismatch error in temperature at the UFS for combinations of mistime and misdistance in zonal direction (up) and in meridional direction (down) for January averaged over 8 to 65 km height based on ERA-40 data.

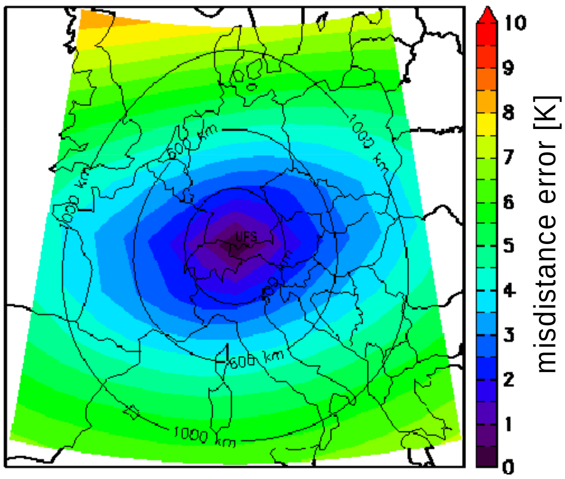

Fig.3.: Misdistance error in temperature with respect to the UFS for January averaged over 8 to 65km height based on ERA-40 data.

The general quantified mismatch error offers here a basis for decision. Figure 2 points out the increase of the mismatch error in dependence of mistime and misdistance. In this example the misdistance is distinguished in zonal and meridional direction indicating a faster increase of the mismatch error for deviations in meridional direction. This effect is pointed up in figure 3. It is shown the misdistance error referring to the UFS as mid-point. With this information the general resulting mismatch error for specified coincidence criteria is known in advance. Also the suitable relation between mistime, zonal and meridional misdistance becomes apparent.

SATVAL-A : ESTABLISHMENT OF A NATIONAL POINT OF CONTACT FOR THE COORDINATION OF VALIDATION ACTIVITIES FOR SATELLITE-BASED MEASUREMENTS IN THE ATMOSPHERE AS PART OF THE UFS

- DEVELOPMENT OF A BUSINESS MODEL -

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Atmospheric data from satellite measurements are considered an essential source of information for science, governments and industry. In contrast to data from all other measurement platforms satellite-based atmospheric data are of global coverage at homogeneous quality.
The need of assessing the quality of satellite-based data on the atmosphere (validation) as precisely as possible is of fundamental and crucial importance: it determines the benefit and the acceptance of the data and derived products (see figure 1).

Project goals

Focus of the UFS project SatVal-A is the development of a self-supporting concept for the establishment of a national point of contact on the UFS for the coordination of validation activities of satellite-based measurements in the atmosphere.

The SatVal-A project comprises several parts:

- assessment of the current and the expected data and information demand primarily by the operative user. Emphasis is being placed on GMES and GEOSS;
- analysis of available validation concepts and the identification of gaps and general deficits being present;
- development of new validation methods. The results are also to stimulate industry towards the development of novel instrumentation.

All results will be summed up in concept paper. Via service and research this point of contact shall supply the expertise for quality assurance, required for the unlimited application of products from satellite-based measurements for scientific, administrative and commercial functions.

Due to UFS' national and international network activities and the interdisciplinary of its operator consortium, it is predestined for such a national point of contact.

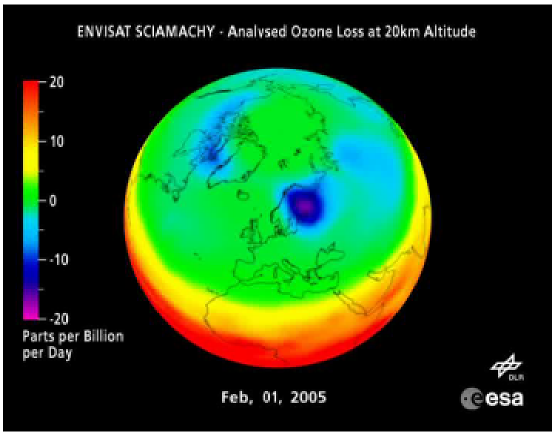

Fig.1: Ozone depletion at height of 20km

Selected results

As a base for the self-supporting concept a detailed **inventory** of all present and planned atmospheric missions (see table 1), of satellite-based atmospheric data and data products (from European projects PROMOTE, GEMS, TEMIS and ENVISOLAR, the Climate Monitoring SAF and the WDC-RSAT) and of their validation was compiled. This covers almost all European research facilities and the satellite-based observation and modelling of greenhouse gases, ozone layer and air quality, on global and on regional scale.
For validation as quality assurance of respective data and information products, quality assurance of applied models, of assimilation and retrieval methods, validation procedure and validation data was studied. Political market impacts on the business idea were analysed in-depth, including important competitors and competing technology in the field of validation

of satellite-based measurements concerning the atmosphere. European organisations, working groups and experts (like e.g. CEOS „Working Group on Calibration and Validation“) involved in validation were depicted.

Analysis of requirement and demand on current and expected data and information for the operative user with emphasis on GMES und GEOSS, are available in comprehensive surveys and investigations, e.g. final reports by GAS-Implementation Group and by ESA project CAPACITY (Composition of the Atmosphere: Progress to Applications in the user CommunITY). For PROMOTE the application area (e.g. Montreal Protocol) and needed satellite-based data products, assigned to categories stratospheric ozone loss, near-surface UV radiation and air quality, and topics climate change, greenhouse gas and aerosols, also for sectors science, administration and industry, were composed.

For an **analysis of deficits** concerning satellite-based atmospheric data there exist comprehensive studies with world-wide focus like the WMO GOS-2009 Dossier “The space-based global observing system in 2009” and European studies on the future space infrastructure, i.e. the Sentinels.

Additionally, queried user requirements matched with achieved validation results have been evaluated for PROMOTE services.
These deficits e.g. indicate potential business fields which are presented in the self-sustaining concept categorized in activities like validation support und performance, supplying tools and relevant training courses and much more.

Project SatVal-A is being carried out under the umbrella of the Betriebsgesellschaft Umweltforschungsstation Schneefernerhaus (BG UFS GmbH) in close cooperation with DLR and KIT. It is supported with funds from the German Federal Ministry for Economy and Technology by the Raumfahrt-Agentur of the German Aerospace Center under contract number 50 EE 07020.

Table 1: Section of the inventory of all present and planned atmospheric satellite missions.

Aktuelle und geplante Atmosphärenmissionen

Hauptsatelliten-betreiber, Land	Orbit	Programm	Satellit	Zielsetzung	Satelliten-start	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
EUMETSAT	geo	Meteosat 1st Gen.	METEOSAT-6	Meteorology, climatology, atmospheric dynamics. Water and energy cycles.	20.11.1993	93																									
			METEOSAT-7		03.09.1997	97																									
		Meteosat 2nd Generation	MSG-1 (METEOSAT-8)		28.08.2002																										
			MSG-2 (METEOSAT-9)		21.12.2005																										
			MSG-3 (METEOSAT-10)		31.01.2012																										
			MSG-4 (METEOSAT-11)		31.01.2014																										
		Meteosat 3rd Generation (Imaging)	MTG-I1		15.12.2016																										
			MTG-I2		15.06.2021																										29
			MTG-I3		15.01.2025																										33
			MTG-I4		15.06.2029																										29-37
	leo	EUMETSAT Polar System (EPS)	MetOp-A (MetOp-2)	Meteorology, climatology	19.10.2006																										
			MetOp-B (MetOp-1)		02.04.2012																										
			MetOp-C (MetOp-3)		02.04.2016																										
ESA	leo		ERS-2	Physical oceanography, land surface, ice and snow, atmospheric chemistry, atmospheric dynamics, water and energy cycles	21.04.1995	95																									
			ENVISAT		01.03.2002																										
		Earth Explorer Mission	SMOS	Soil moisture, ocean salinity, vegetation water content, snow cover and ice structure	02.11.2009																										
			ADM-Aeolus	Wind profiles for global 3D dynamics and transport of energy, water, aerosols and chemicals	01.11.2011																										
			EarthCARE	Clouds-aerosol-radiation interactions	01.06.2013																										
	tbd	Future M.	PREMIER	Processes linking trace gases, radiation, chemistry and climate in UT and LS	tbd																										

COSMIC RADIATION

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During the period 2009 and 2010, the two Bonner Sphere Spectrometers (BSSs) of the Institute of Radiation Protection – one located at the UFS at an altitude of 2650 m, the other on Spitsbergen at seal level at the Koldewey Station of the Alfred-Wegener-Institute (AWI) – operated continuously. The Koldewey Station is a part of the French - German Arctic Research Base AWIPEV (the AWIPEV base represents a cooperation between the German AWI and the French Polar-Institute Paul Emile Victor (IPEV)). The station is located in Ny-Ålesund, Spitsbergen, at sea level and a distance to the North Pole of about 800 km. Both BSS systems are being used to measure the spectral fluence distribution of secondary neutrons from cosmic radiation. In addition, at the UFS a number of so-called REM counters are also running, which allow continuous measurement of the dose rate due to secondary neutrons from cosmic radiation. A first analysis was performed to compare the spectral fluence distributions obtained by both BSS systems, and the dose rates deduced from the BSS spectra at the UFS and the dose rates measured by the REM counters. Some results of these analyses are summarised below, and more detailed discussions were published recently (Rühm et al. 2009a, Rühm et al. 2009b).

Comparison of BSS results obtained at the UFS and on Spitsbergen

The BSS systems installed at the UFS and at the Koldewey station are very similar. They consist of 15 proportional counters filled with ^{3}He gas and covered by polyethylene (PE) spheres of various thicknesses (diameter of the spheres: 2.5, 3, 4, 5, 5.5, 6, 7, 8, 9, 10, 11, 12 and 15 inch, respectively). Depending on thickness, incident secondary neutrons from cosmic radiation are moderated and the resulting thermal neutrons are detected through the $^{3}He(n,p)^{3}H$ reaction. As a specific feature, each spectrometer includes two additional PE spheres (9 inch in diameter) with lead shells, to increase the response to high-energy neutrons above 10 MeV. Finally, a 16th proportional counter is used in both BSS systems without any surrounding material ("bare detector"), which is mainly sensitive to thermal neutrons (Figs. 1 and 2).

The detector signals are amplified and digitised, and finally analysed in the computer. The pulse height spectra provided by the detectors are stored, and the count rates are obtained by integrating over a region of interest that was defined for each detector before installation using an Am/Be neutron calibration source. While the BSS system on the UFS stores the signals every hour, that on Spitsbergen stores them every five minutes.

Fig. 1: Bonner Sphere Spectrometer at the UFS.

Fig. 2: Note the white spheres of the Bonner Sphere Sectrometer installed in the Koldewey station in Ny Ålesund, Spitsbergen (Picture: R. Vockenroth, AWI).

Because the atmosphere acts as an effective shield against cosmic radiation, the count rates obtained by both BSS systems had to be corrected for variations in air pressure. For this, the formula given in Eq. 1 was used:

$$N_{cor} = N \cdot e^{[-\beta(p_0 - p)]} \qquad (1)$$

where N is the observed count rate at a particular pressure p, and N_{cor} is the corrected value at the reference pressure p_0. For the barometric coefficient β, a value of 0.721% per hPa was used for the measurements at the UFS (Röhrs 1995), while a value of 0.741% per hPa was used for those at the Koldewey station (Vashenyuk E, Polar Scientific Center, Apatity, Russia (2008), private communication).

The normalised count rates were then unfolded by means of the MSANDB unfolding code (Matzke 1987), a modified version of the SAND code (McElroy et al. 1967), to calculate the corresponding spectral neutron fluence distribution. The detailed response of these Bonner spheres as a function of neutron energy that is required for the unfolding procedure were calculated by means of the MCNP code below 20 MeV, and a combination of MCNPH/LAHET for energies above 20 MeV (Mares et al. 1991; Mares et al. 1998).

Because the location of the UFS is much higher compared to that of the Koldewey Station (2650 m above sea level versus seal level), the shielding of the atmosphere against cosmic radiation is much less effective at the UFS. For the period January – February 2008, the mean pressure was 999.7 hPa at the Koldevey Station and 735.8 hPa at the UFS. From Eq. 1 one would therefore expect a factor exp(-0.00721 x (735.8 - 999.7)) = 6.7 lower neutron fluence rate at the Koldewey station compared to that at the UFS. To correct for that, the mean neutron fluence distribution obtained at the Koldewey Station in January and February 2008 was multiplied by this factor, and then compared to the corresponding neutron fluence distribution measured at the UFS (Fig. 3). The figure presents the data in the lethargy representation – equal areas below the curve correspond to equal numbers of neutrons per second and cm^2, in the corresponding energy intervals. The major components of the spectrum are: a) a first peak that is due to thermal neutrons with energies between 20 and 40 meV b) a second peak at about 1-2 MeV that originates from neutrons evaporating from highly excited residual nuclei, and c) a third peak at about 100 MeV that is due to a broad minimum in the corresponding neutron-air reaction cross-sections at high energies.

It is evident from Fig. 3 that, in qualitative terms, the shape of the two neutron fluence distributions is quite similar. For a more quantitative analysis one should keep in mind, however, that local parameters such as height of snow surrounding the laboratories may also affect the distribution somewhat, particularly in the energy range below about 20 MeV. A quantitative comparison of both distributions should therefore concentrate on the high-energy part about about 20 MeV. From the mean UFS spectrum shown in Fig. 3, a total mean fluence of 3.3 x 10^{-2} n / (cm^2 s) (for a reference pressure of 735.8 hPa) is obtained for neutrons with energies above 20 MeV. This compares to 6.0 x 10^{-3} n / (cm^2 s) (for a reference pressure of 999.7 hPa) as obtained from the mean neutron spectrum for Spitsbergen, for the same period of time and energies above 20 MeV. The difference corresponds to a factor of 5.5 which is close to the factor of 6.7 discussed

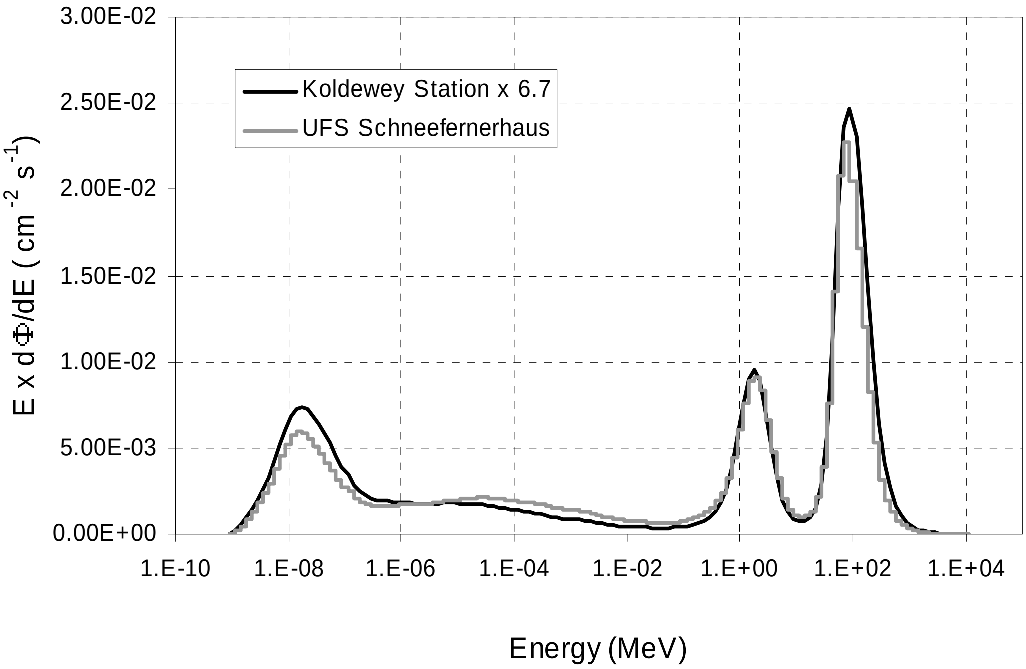

***Fig. 3:** Mean neutron fluence energy distribution as measured at the UFS and the Koldewey station in January and February 2008*

above. Note that the effect of geomagnetic shielding, which is not included in the calculation of the factor of 6.7 due to lack of reliable data, may explain part of the fact that a lower factor of 5.5 was actually observed.

Literature

Mares V, Schraube G, Schraube H (1991) Calculated neutron response of a Bonner sphere spectrometer with ^{3}He counter. Nucl Instrum Meth A307, 398-412

Mares V, Sannikov A, Schraube H (1998) The response functions of a ^{3}He-Bonner spectrometer and their experimental verification in high energy neutron fields. In Proc. Third Specialist Meeting on shielding aspects of accelerators, targets and irradiation facilities (SATIF 3), May 12-13, 1997, Sendai, Japan, OECD Nuclear Energy Agency, 237-248

Matzke M (1987) Private communication, later integrated into the Neutron Metrology File NMF-90, available from NEA Databank (http://www.nea.fr/abs/html/iaea1279.html).

McElroy WN, Berg S, Crockett T, Hawkins RG (1967) Spectra Unfolding" Vol. I-IV, Report AFWL-TR-67-41

Röhrs K (1995) The neutron monitor at Kiel (Germany) operated by the Extraterrestrial Physics Department of the Institute for Experimental and Applied Physics of the Christian-Albrechts University of Kiel.

Rühm W, Mares V, Pioch C, Weitzenegger E, Vockenroth R, Paretzke HG (2009a) Measurements of Secondary Neutrons from Cosmic Radiation with a Bonner Sphere Spectrometer at 79^{o}N. Radiat Environ Biophys, 48, 125-133

Rühm W, Mares V, Pioch C, Simmer G, Weitzenegger E (2009b) Continuous measurement of secondary neutrons from cosmic radiation at mountain altitudes and close to the North Pole-A Discussion in terms of H*(10). Radiat Prot Dosim, 136, 256-261

ANALYSIS OF VOLCANIC EMISSIONS FROM THE EYJAFJALLAJÖKULL ERUPTION AT THE SCHNEEFERNERHAUS

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A series of massive eruptions of the Eyjafjallajökull volcano at the southern coast of Iceland in April and May 2010 produced large amounts of ash, particles and sulphur dioxide (SO_2) which were then blown to Central Europe. Highly increased SO_2 and particle number concentrations were observed at the Schneefernerhaus (UFS) over several days. Measured sulphur dioxide levels were clearly above the long-term average for April and May for the period 2000 – 2007.

1st Phase: April 2010 - Synopsis

The first eruptive period was from 15 April to 25 April 2010. Within 24 hours from the beginning, large amounts of ash particles and sulphur dioxide were transported towards Middle Europe on the front side of a high pressure system between Iceland and the British Isles. The emissions reached northern Germany during the night of 15/16 April, from where north-westerly winds then carried the cloud across Germany further south as far as the alpine area. During the night of 16/17 April, the Lidar systems at Munich detected the aerosol layer at about 4-6 km above sea level. In the morning hours of 17 April, the aerosol cloud began to affect the air mass above the Schneefernerhaus (2650m), as was confirmed by the in-situ measurements taken there.

Sulphur dioxide measuremenst

Since 2000, continuous sulphur dioxide measurements have been performed at the Schneefernerhaus using a UV fluorescence analyser. Local anthropogenic sources around the Zugspitze play only a minor role, and typical mixing ratios are below 0.2 ppb. In the early morning hours of 17 April, SO_2 mixing ratios were still perfectly in line with the long-year median for April, i.e. around 0.1 ppb (solid brown line in Fig.1**).** Through the morning of 17 April, however, the concentrations rose to 3.5 ppb, which is the highest value ever measured in April at the UFS (Fig.1 shows the 99 percentile (brown dashed line) and the maximum hourly means (brown dotted line) in April for the period 2000-2007).

SO_2 concentrations reached a first maximum during the night of 17/18 April; they went down during the day to increase again on 19 April and reached a second maximum in the afternoon. From then on, the values decreased steadily, falling back to their normal level in the afternoon of 20 April. After that, they did not rise again.

Particle measurements

Since 2000, the UFS has also been taking measurements of particle number concentrations using a condensation particle counter (CPC). During the volcanic ash event of April 2010, particle number concentrations showed a behaviour which was parallel to that

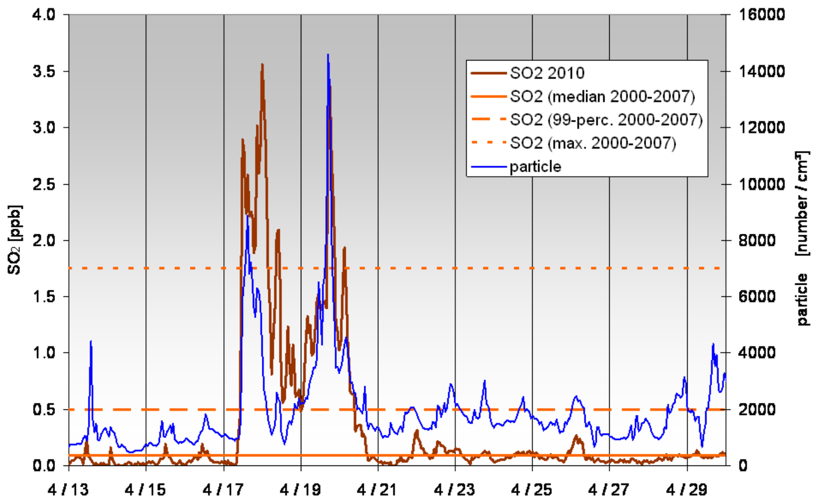

Fig.1: Time series of SO_2 mixing ratios (solid brown line) and particle number density (blue) at the Schneefernerhaus for the period 13 – 29 April 2010. The orange lines show the median (solid), the 99 percentile (dashed) and the maximum SO2 concentration (dotted) in April for the period 2000-2007.

of SO_2 values: rapid increase during the morning of 17 April, decrease during the day and on 18 April followed by a second strong increase and maximum on 19 April. From 20 April onward, the values were back at their normal level (blue line in Fig.1). The parallel measurements carried out by an optical particle counter (GRIMM-OPC) at Hohenpeissenberg produced strongly increased particle number concentrations for particles between 2 µm and 7.5 µm of diameter.

2nd Phase May 2010: Synopsis

Following a short, relatively silent period, a second series of outbreaks started on 4 May and continued until 25 May 2010. The synoptic situation during this period was highly variable, so that the conditions for a transport of emissions towards Central Europe were given on a few days only. Between 5 and 13 May, large amounts of volcanic ash were transported across the Atlantic Ocean and concentrated south and west of Iceland and partly over some West European Countries (Portugal, Azores, Spain, Ireland, and western France). The British Isles and Ireland were especially affected by ash clouds between 14 May and 16 May 2010. On 17 May, new ash and sulphur dioxide clouds were carried over Central Europe due to the north-westerly flow of air triggered between a low pressure system east of Iceland and the Azores high extending as far as the British Isles, while supported by another rapidly approaching Atlantic low pressure system. Satellite observations received from the METEOSAT/ SEVIRI instrument suggest that, in the night of 17/18 May, both the aged emissions from the heavy eruptions on 13/14 May and those from the more recent outbreaks on 15 May had reached the Benelux countries, eastern France and North-West Germany.

In the morning hours of 18 May, the cloud had arrived over the western Alpine area, Switzerland and later the Italian Po valley. On 19 May, a low pressure system over south-eastern Europe carried ash and sulphur dioxide-loaded air masses from south of the Alps on its back side back to southern Germany. Rainfall later on this day concluded this phase of enhanced SO_2 and particle concentrations.

Sulphur dioxide and particle measurements

The sulphur dioxide mixing ratios at the Schneefernerhaus increased again very rapidly during the morning hours of 18 May (Fig.2). Maximum values of about 6 ppb were reached, which was even higher than during the first episode in April (3.5 ppb). A second, but less pronounced peak followed on 19 May. The sharp increase in particle numbers registered on 18 May, however, was caused by local contamination from snow blowers (abruptly ending at 15:00 CEST) and therefore has nothing to do with the volcanic emissions. The increase in SO_2 mixing ratios at Hohenpeissenberg (40 km northerly of UFS) was less pronounced, but still well visible (Fig.2). Particle numbers at both stations, however, remained at normal level (except for the local impact of snow blowers). A possible reason for this somewhat unexpected development may be the long-range transport of air masses, during which the growth of small particles and sedimentation of large particles was favoured. The much higher level of SO_2 emissions during this second episode was also confirmed by satellite measurements (GOME-2, OMI) and airborne measurements (DLR, Falcon flights).

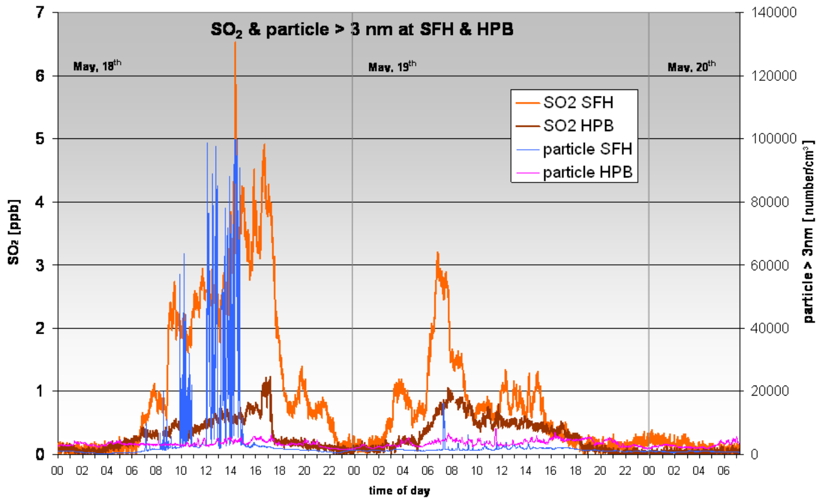

Fig.2: Sulphur dioxide mixing ratios (orange line) and particle concentrations (blue line) at the Schneefernerhaus (SFH) and at Hohenpeißenberg (HPB, brown and magenta lines) for the period 18-20 May 2010. The strong decrease of SO_2 values during the night of 18/19 April was very likely caused by local precipitation at both stations.

STUDY OF RAYLEIGH-BRILLOUIN SCATTERING IN THE ATMOSPHERE WITH LASER REMOTE SENSING FOR FUTURE SATELLITE MISSIONS

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Experiments using laser light scattering in the atmosphere were performed in winter 2009 for the preparation of future satellite missions of the European Space Agency ESA. The line shape of Rayleigh-Brillouin scattering in the atmosphere was measured with high accuracy for the first time in the atmosphere, what was achieved in the laboratory up to now. These measurements agree excellent to model simulations up to a level of 98%.

Scientists of the Institute of Atmospheric Physics of DLR performed measurements with a laser instrument – a lidar – from the environmental research station Schneefernerhaus UFS. Within the next years this lidar (light detection and ranging) will fly on a satellite of ESA within the frame of the Atmospheric Dynamics Mission ADM-Aeolus.

ADM-Aeolus mission

The ADM-Aeolus mission is planned for launch in 2013 and should contribute to the improvement of the numerical weather prediction and the knowledge of dynamic processes in the atmosphere. The mission will comprise a lidar for the first time on a European satellite.
A lidar transmits short laser pulses with high energy into the atmosphere, where they are scattered on molecules, aerosols, and cloud particles. A telescope collects the backscattered laser light, which is analysed in an optical receiver. The molecules and particles in the atmosphere move with the wind speed. The laser pulses are shifted in frequency due to the Doppler effect, because of the particle movement. This is used to determine the wind speed in the atmosphere.

Rayleigh-Brillouin scattering

The exact knowledge of the spectral distribution of the scattered light – the line shape – is needed for the determination of the wind speed for ADM-Aeolus. Also the second lidar mission of ESA with name EarthCARE is dependent on the line shape knowledge for the retrieval of aerosol properties. Thus the objective of the experiment at the UFS was to determine the line shape of the Rayleigh-Brillouin scattering with high accuracy by use of an ultra-stable frequency laser and to validate the underlying theoretical model. This model developed by the group of Tenti was validated up to now only in laboratory measurements of gases with single species and recently in air by University Amsterdam and DLR.

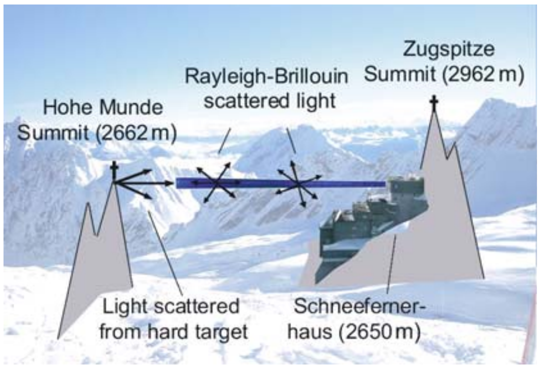

Fig.1: Rayleigh-Brillouin scattering on a horizontal laser beam path from the UFS towards south.

Laser measurement of the "fingerprint"

The scientists pointed the laser beam of the ADM-Aeolus lidar instrument horizontally into the clear and deep blue sky (Fig. 1 and 2). The blue sky is resulting from the Rayleigh scattering of sun light on air molecules. Although this effect was discovered by Lord Rayleigh already in 1871, it was not possible up to now to measure the line shape of Rayleigh scattering precisely in the atmosphere. It is known from laboratory measurements, that the spectrum is almost a Gaussian curve due to the thermal motion of the molecules. Small deviations from the Gaussian curve by a few percent are caused by scattering on density fluctuations in the atmosphere, which is called Brillouin scattering. These deviations can be regarded as the "fingerprint" of Brillouin scattering. Scientists from DLR aimed at detecting this "fingerprint" with laser measurements by sampling the line shape on more than 200 positions with a resolution of 20 femtometer (one femtometer corresponds to 10^{-15} m).

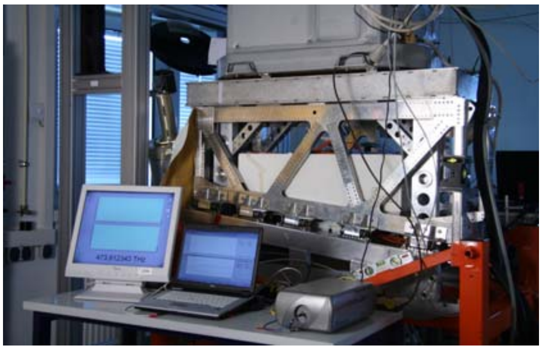

Fig. 2: ADM-Aeolus lidar from DLR at the UFS in 2009.

Measurements at UFS in winter 2009

The infrastructure and laboratories at UFS are ideally suited for this type of sophisticated laser experiments. The measurements needed to be performed in winter, because of the atmospheric conditions. During winter the atmosphere in a height of 2650 m at the UFS is above the atmospheric boundary layer. Thus the measurements are not disturbed by Mie scattering on aerosols. The laser could be pointed horizontally in order to sense air volumes of constant pressure and temperature. This allows averaging over long horizontal distances of several kilometres. In addition a variety of atmospheric parameters, like temperature, pressure or aerosol content is routinely measured at the UFS, which allows interpretation of the lidar observations.

Agreement with model better 98%

The measurements were compared to the Tenti model, which was developed in the 1970´s. The model connects macroscopic gas properties like thermal conductivity and viscosity to the movement of the single molecules. It is used to calculate the velocity distribution of molecules and therewith the spectral distribution of the scattered light. It was necessary to validate the model, because it was derived for molecular gases of single species and not for gas mixtures where the molecules act differently. Thus the main question was to assess the quality of the Tenti model for scattering in air. Therefore the gas transport coefficients within the model were adapted to the parameters of air. With this modification an agreement between observations and model of better than 98% could be achieved (Fig. 3).

The results of the experimental investigation at the UFS offer the possibility to understand the molecular transport processes better than before. Moreover the results give high confidence, that the errors in the lidar retrieval are almost negligible. Hence the results are an important contribution for the validation of future lidar missions like ADM-Aeolus and EarthCARE.

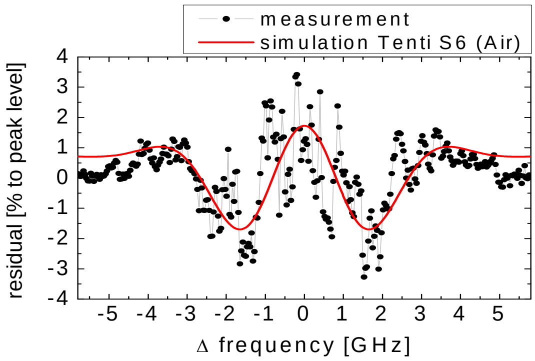

Fig.3: Fingerprint of the line shape from Brillouin scattering from Tenti model (red) and horizontal lidar observations from UFS (black).

SPECTROSCOPIC MEASUREMENTS OF ATMOSPHERIC TRACE GASES AT THE ENVIRONMENTAL RESEARCH STATION SCHNEEFERNERHAUS

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During the last decades, the scientific interest in the composition of the atmosphere increased significantly. Not only the air quality of the lower part of the atmosphere (troposphere) is of great importance for human health and ecosystems, also the ozone layer in the middle atmosphere (stratosphere) is substantial for life on earth. The environmental research station Schneefernerhaus with its location in the free troposphere, is the ideal measurement site to study the composition of both the troposphere and stratosphere. The applied measurement technique is the differential optical absorption spectroscopy (DOAS) method, a well established remote sensing technique. The set-up, which will be realized in early 2011, allows direct measurements of atmospheric trace gases that can be used for the validation of satellite-based observations.

Atmospheric trace gases

In the beginning of the 20th century, when the term „smog" was introduced, the scientific interest in the composition of the troposphere grew rapidly. With the discovery of the ozone hole at the end of the 1970s, the composition of the stratosphere gained importance as well. More recently, climate change enforced the interest in atmospheric trace gases and the related environmental processes. Also short-term events such as volcanic eruptions can affect atmospheric chemistry and can be studied using DOAS measurements.
Figure 1 shows satellite-based DOAS measurements of sulfur dioxide (SO_2) above Europe between 16 and 18 May 2010 during an eruption of the Icelandic volcano Eyjafjoll. The measurements show increased SO_2 concentrations over North-West and central Europe, including the Zugspitz area. The new DOAS instrument on the Schneefernerhaus will provide measurements of the local atmospheric SO_2 abundance that are invaluable for the validation of satellite-based measurements.

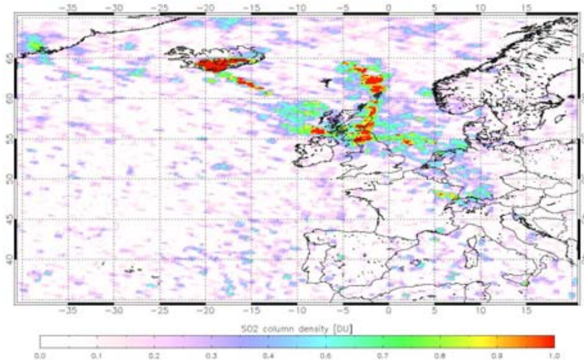

Fig.1: Satellite-based DOAS SO_2 measurements after the eruption of the Eyjafjoll on 16-18 May 2010 (from the GOME-2 instrument onboard the MetOp satellite)

Measurement Site Schneefernerhaus

With its location 2650 meters above sea level the Schneefernerhaus is based in the free troposphere. The relatively large distance to the cities Innsbruck (36 km), Augsburg (103 km) and Munich (89 km), and especially its altitude make the Schneefernerhaus the ideal location to study the free troposphere. For example, pollution events in the free troposphere can be measured. While the air at this altitude is usually clean, increased concentrations of free-tropospheric nitrogen dioxide (NO_2) can be observed: an indication for short- and long-range transport. These measurements are of great interest since there are only few instruments worldwide which measure tropospheric profiles of NO_2 and ozone.
Moreover, the visibility on the UFS is often better than in the valley allowing more measurement time and measurements of higher quality.

MAX-DOAS measurements at the Schneefernerhaus

The Multi-Axis Differential Optical Absorption Spectrometry (MAX-DOAS) instrument is based on an optical UV/VIS spectrometer that observes scattered light in two modes: (1) zenith and (2) a series of elevation angles above the horizon. MAX-DOAS instruments are capable of measuring important stratospheric trace-gases (ozone, NO_2, BrO and OClO), as well as key tropospheric trace-gases, like NO_2, ozone, SO_2, formaldehyde, HONO and aero-

sols. Zenith sky measurements are usually performed during sunset and sunrise. Zenith measurements are mainly sensitive to stratospheric absorbers, while measurements close to the horizon have a long light path through the troposphere and are sensitive to tropospheric trace gases. By combining the zenith sky and horizon viewing directions, total trace gas amounts and vertical profile information can be derived from the recorded spectra.
At the Institute of Environmental Physics (University of Heidelberg), a new generation of MAX-DOAS instruments has been developed, with a relatively simple construction (Figure 2). The measurements are fully automated and the instrument can be operated via internet. Therefore the instrument is ideal for continuous long-term measurements.

Fig. 2: MAX-DOAS instrument

MAX-DOAS instruments are used worldwide to investigate the influence of anthropogenic emissions on air quality and atmospheric composition. Moreover MAX-DOAS measurements are invaluable for the validation of satellite-based trace gas measurements from instruments like SCIAMACHY, GOME-2 and OMI.

HÖHENZUG: "Ecological analysis of the subalpine to subnival vegetation belts on the Zugspitzplatt (Wetterstein Mountains, Bavaria)"

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HöhenZug "Ecological analysis of the subalpine to subnival vegetation belts on the Zugspitzplatt (Wetterstein Mountains, Bavaria)" is part of the collaborative project "Consequences of climatic change in the Alps – analysis by altitudinal gradients (KLIMAGRAD)" and is funded by the Bavarian State Ministry of the Environment and Public Health over a period of three years since October 2009.

Topic, methods und and main objectives

The goal of the project HöhenZug is to analyse the impacts of climatic change and anthropogenic influences on the vegetation of the Zugspitzplatt.

With an extensive mapping project begun in 2009, the installation of permanent sample plots, ecological studies at preselected sites and a comparison with historical mappings and photographs a long-term monitoring of the vegetation dynamics on the Zupspitzplatt including the treeline formed by prostrate pine will be initiated.

Germanys highest research area

The research area consists of almost the whole Zugspitzplatt with about 7.5 km². Only the steep rock faces surrounding the area are excluded due to limited accessibility. The karst landscape is formed by the ladinian Wetterstein-limestone and has no superficial watercourses. The surface of the Zugspitzplatt consists of 52% rock debris, 36% bedrock and 16% of surfaces covered by vegetation.

The following vegetation zones (Fig. 1) are present (Friedmann & Korch 2010):

- the upper subalpine belt up to the krummholz-treeline (around 2100m)
- the zone of the alpine grasslands and pastures (2000 - > 2400m)
- the subnival zone and the zone of scree, rock and snowbed communities (2300-2962m).

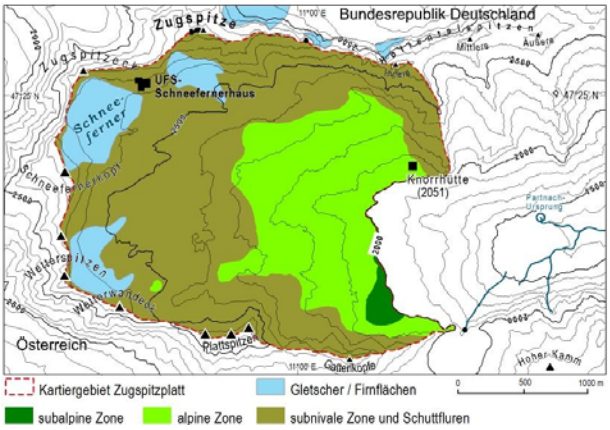

Fig.1: Vegetation zones of the Zugspitzplatt.

Characteristic plant communities

Typical plant communities of the subalpine and the lower alpine zone:

- treeline ecotone krummholz with prostrate *Pinus mugo* (Rhodothamno-Rhododendretum hirsuti)
- dwarf shrub heaths with and without *Rhododendron*
- impoverished calcareous grasslands (Seslerio-Caricetum sempervirentis).

The alpine belt is dominated by:

- closed to open *Carex firma*-meadows (Caricetum firmae)
- creeping *Salix*-communities (Salicetum retuso-reticulatae).

Characteristic for the subnival zone are:

- open calcareous scree and rock communities (e.g. Thlaspietum rotundifolii, Leontodontetum montanii)
- snowbed vegetation (e.g. Arabidetum caeruleae).

Investigations since 2009

Starting in the late summer of 2009 118 vegetation mappings following the phytosociological method of Braun-Blanquet (1964) have been completed. The mapped plots were surveyed with GPS and marked with colour to ease the re-mapping for the continuous monitoring program.

At several locations soil samples were collected for laboratory analyses of ecological variables important for plant growth.

In a thesis project the actual krummholz-limit in the lower Zugspitzplatt was surveyed and compared to historical pictures and orthofotos to reconstruct altitudinal oscillations.

Statistical and ecological analysis

The results of the vegetation mappings of 2009 were analysed statistically and compared with climate data and to previous mappings of the Zugspitzplatt by Zöttl (1950) and Credner (1995). A main aspect was the creation and analysis of a species list for each mapping and an allocation of the indicator values by Ellenberg et al. (1992).

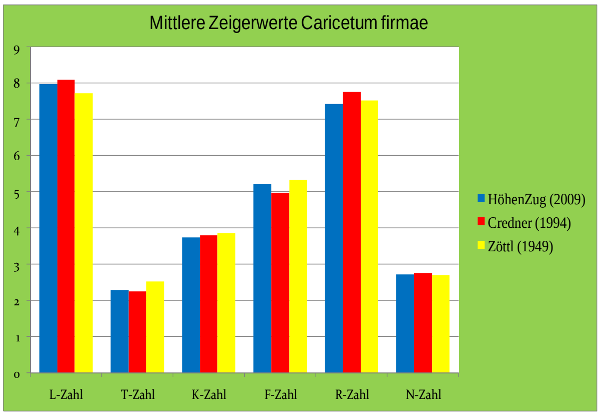

Fig. 2: Mean Ellenberg-indicator values for the Caricetum firmae.

Furthermore the mean Ellenberg-indicator values of all mappings were calculated and compared to identify changes (Fig. 2).

Anthropogenic influences

The touristic influences by hiking and skiing as well as the sheep grazing in summer has a large impact upon the vegetation of the Zugspitzplatt.

Therefore the investigated area can by subdivided into three zones of different human influence and hemerobiotic degrees:

Zone 1:
Dominance of natural dynamics, very limited anthropogenic influences (oligohemerobiotic).

Zone 2:
Areas with a dominance of natural dynamics but selective alined or pointed human influences with changing intensity and periodicity occur.

Zone 3:
Strong anthropogenic influences (grazing, tourists, building etc.) and natural dynamics (meso- to euhemerobiotic).

Future work plans

The statistical analysis of the data is going to be extended, the effects of climate change monitored and the data collected during the 2010 field season will be incorporated.

The target is to get a deeper understanding of the vegetation ecology of the Zugspitzplatt and to facilitate comparison with datasets from other alpine areas.

Also the construction of an up to date and detailed vegetation map based on the phytosociological mappings is planned.

Literatur

BRAUN-BLANQUET, J. (1964): Pflanzensoziologie. Grundzüge der Vegetationskunde. 3. Aufl., 865 S. – Springer Verlag, Wien, New York.

CREDNER, B. (1995): Vegetations- und Bodenentwicklung im Bereich des Zugspitzplatts (Wettersteingebirge). Unveröffentlichte Diplomarbeit, LMU München, 101 S., München.

ELLENBERG, H., WEBER, H. E., DÜLL, R., WIRTH, V. & W. WERNER (1992): Zeigerwerte von Pflanzen in Mitteleuropa. – Scripta Geobotanica 18, 262 S., Göttingen.

FRIEDMANN, A. & KORCH, O. (2010): Die Vegetation des Zugspitzplatts (Wettersteingebirge, Bayerische Alpen): Aktueller Zustand und Dynamik. - Ber. d. Reinh.-Tüxen-Ges. 22, S. 114-128.

ZÖTTL, H. (1950): Die Vegetationsentwicklung auf Felsschutt in der alpinen und subalpinen Stufe des Wettersteingebirges. Diss. Univ. München, 74 S.

DEVELOPMENT OF A DATA ANALYSIS CENTER FOR THE BAVARIAN ENVIRONMENTAL RESEARCH STATION "SCHNEEFERNERHAUS" (UFS) THROUGH THE ICSU/WMO WORLD DATA CENTER FOR REMOTE SENSING OF THE ATMOSPHERE (WDC-RSAT)

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Introduction

The World Data Center for Remote Sensing of the Atmosphere (WDC-RSAT; http://wdc.dlr.de) supports the Bavarian Environmental Research Station "Schneefernerhaus" (UFS) on the Zugspitze Mountain (2650 m a.s.l.) in all aspects of data management, and especially through the implementation of a Data Analysis Center for the station (UFS-DAZ).

Since 2003 the German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) hosts and operates the WDC-RSAT under the nongovernmental auspices of the International Council for Science (ICSU). In cooperation with the World Meteorological Organization (WMO), WDC-RSAT is currently being implemented as part of the WMO-GAW Strategic Plan 2008-2015 especially in the context of IGACO within the WMO program Global Atmosphere Watch (GAW). This center would concern itself with linking different GAW-relevant data sets both with each other and with models. In this context WDC-RSAT will also handle non-satellite based data which are relevant within the context of validation.

UFS-DAZ Functionalities

The UFS Data Analysis Center (UFS-DAZ) offers scientists optimal access to in-situ and satellite-based measurements, atmospheric models and user specific data analysis tools. This concept is illustrated below:

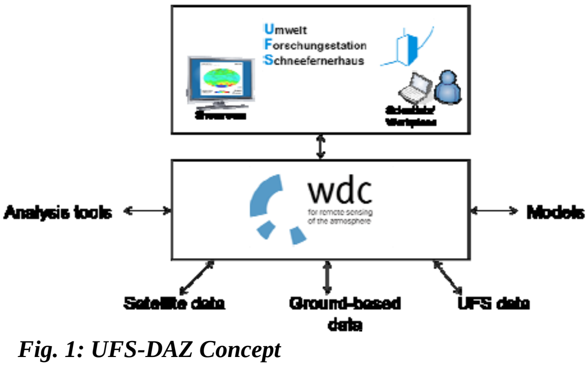

Fig. 1: UFS-DAZ Concept

The UFS data analysis center provides primarily scientists a quick, comfortable, tailored and secured access to the measurements of the station. Through the connection with the data analysis center of other stations, the observatory will additionally get access too to other ground-based measurements. Furthermore, the Data Analysis Center offers scientists comfortable access to:

- Satellite based data,
- Non-satellite based data (e.g. from ground-based networks such as NDMC etc.),
- Value added data and information (e.g. atmospheric dynamics activity or global ozone distribution),
- Services (e.g. air quality forecasts),
- Atmospheric models (e.g. trajectory models or 3D-Chemistry Transport Models),
- And user specific data analysis tools (e.g. Web Mapping Tools).

Functional presentation environment at the UFS

As an additional service, a dedicated show room will be available at the station in order to provide the scientists:

- An attractive presentation environment,
- And the access to specific information for example about the current global, continental and regional state of the atmosphere through the connection with WDC-RSAT or about the current position of relevant satellites (see fig2. below).

This information will be available in near real time and displayed in appropriated form such as graphics or computer animations.

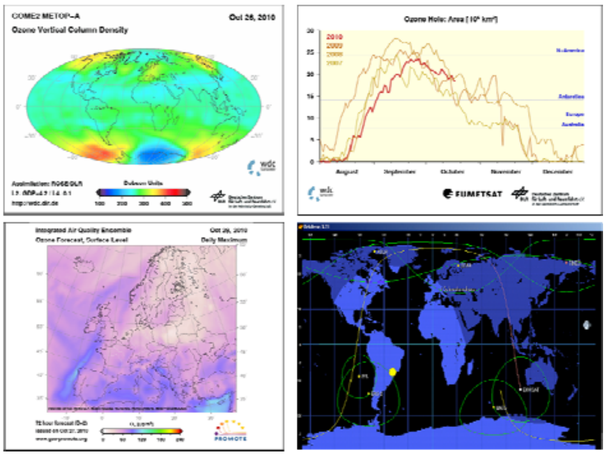

Fig.2: Examples of current satellite products / Program Orbitron to trace the position of specific satellites

From the measurement to the data analysis

The schema below (Fig3.) shows the main steps of the data flow, from the measurement at the UFS station to the data analysis and access through the UFS-DAZ at the WDC-RSAT:

① The UFS measurements are first collected at the station and temporal stored in local UFS-DAZ server.

② The UFS data are then transferred in WDC-RSAT at DLR (data synchronization).

③ The UFS data are standardized and archived at the WDC-RSAT (data management).

④ The scientists of the UFS have access through the WDC-RSAT web portal to the UFS data and also to other station data and WDC-RSAT satellite data, products and services.

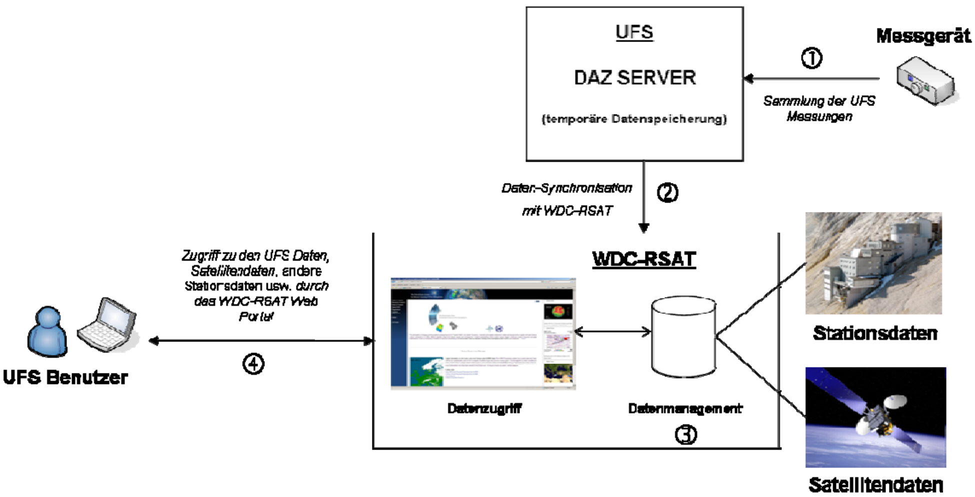

Fig. 3: Access to the data through the UFS-DAZ at the WDC-RSAT

STUDIES ON THE INHOMOGENEITY OF EXTREME-TEMPERATURE TIME SERIES DUE TO CHANGES IN MEASUREMENT TECHNIQUES

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***Introduction:* Daily extreme values of air temperature have been measured for a long time by conventional instruments: a particular mercury thermometer for daily maximum temperatures and an alcohol thermometer for daily minimum temperatures. Since the 1990s measuring sensors have been replaced by electronic instruments thereby generating sources for technical inhomogeneities in long-term data time series. And in fact, comparative studies based on data from lowland stations have indicated that considerable differences in daily extreme temperatures may occur between historical and modern measurement techniques. Such differences are still more important – in particular in context of the quantification of long-term climate change – in high-mountain domains like the European Alps being affected by recent climate change in a strongly amplified manner. Therefore, comparative measurements of daily maximum and minimum temperatures are carried out with different measuring sensors since summer 2010 at the environmental research station *Schneefernerhaus*. Inhomogeneities in long-term data time series of the high-mountain domain due to such technical reasons may thus be quantified and evaluated.**

Therefore a measurement module have been installed at the platform of the Schneefernerhaus consisting of an automatic weather station (Firma Reinhardt) and a conventional weather hut (see Fig. 1). The weather station includes electronic sensors for wind, radiation, temperature and precipitation with temperature measurements (being focussed in the present context) based on a Pt 100 thermometer. The weather hut includes the conventional mercury and alcohol thermometers (thanks to DWD staff from the weather service station Zugspitze for daily reading!); additionally, a semiconductor sensor LM 335 has been installed. The whole module is operating since the beginning of August 2010, initial evaluations indicate considerable differences in daily extreme temperatures between historical and modern measurement techniques.

Fig.1: Automatic weather station and conventional weather hut at Schneefernerhaus for comparative measurements of daily extreme temperatures

Daily maximum temperatures

Fig. 2 (above) depicts the daily differences of maximum temperatures between weather station and weather hut measurements for the period August to October 2010. As a distinct result we see a clearly dominating majority of cases with higher maximum temperatures at the automatic weather station compared to the conventional weather hut (81% of all days within the 3-month measuring period). The mean difference is around 0,8° C, the largest individual deviation even amounts to 3,5° C. For 41% of all cases the difference in maximum temperatures was greater than 1° C, for 8% of the sample this difference exceeds 2° C.

Possible influences from incoming solar radiation or from other sources will be considered in forthcoming studies. Additionally, the particular conditions leading to some few but non-negligible cases with higher maximum temperatures at the conventional weather hut compared to station measurements have to be specified.

Daily minimum temperatures

In general, they are characterized by opposite deviations (Fig. 2, below): only for around 10% of the individual days, the station measurements of minimum temperatures exceed the values from the weather hut; the 3-month mean value, however, is 0,4° C lower than that from weather hut measurements. For 22% of all days, the difference is larger than half a degree, the largest deviation amounts to 1° C.

The minimum temperatures of the weather hut reflect a more dampened daily temperature decrease with corresponding differences to the station measurements remaining generally smaller than the opposite deviations of maximum temperatures. Altogether, the station measurements produce a more extreme thermal climate throughout the day (increased daily temperature amplitudes), and this should be considered in long-term data series being affected by changes in sensor techniques. Of course, more precise statements and statistical considerations will only be possible on the basis of increased sample sizes, i.e. extended measurement time series.

Outlook

Besides the continuation of the measurement time series, earlier data will also be included within forthcoming investigations. Furthermore, comparative measurements are also intended for precipitation in the high-mountain domain based on different instruments. General aim will be the quantification and correction of technically induced inhomogeneities in long-term measurement time series being used to estimate that part of climate change which has already taken place in high-mountain domains.

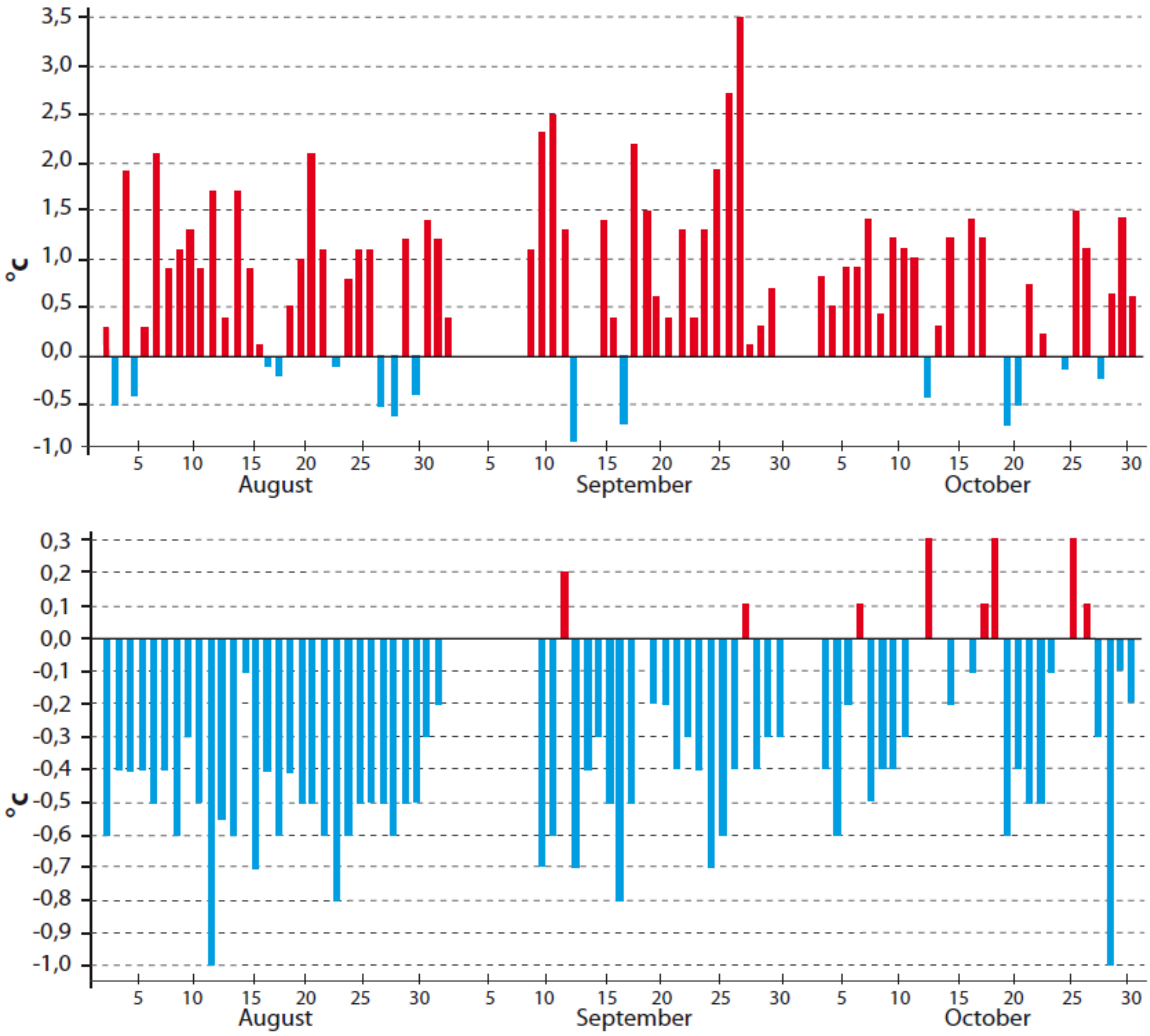

Fig. 2: Daily differences (°C) of maximum temperatures (above) and minimum temperatures (below) between automatic weather station and conventional weather hut at Schneefernerhaus during the period August to October 2010

TO THE HYDROLOGY OF THE ZUGSPITZE AREA

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In the course of the period under review some positive developments could be achieved in the hydrological field. However, the long before announced karst groundwater tracer experiment at the Zugspitzplatt could not be accomplished in 2010 in the planned manner. Nevertheless, as a whole we can look back on a positive balance for the past year. At this point it should be alluded to that the field of hydrology has not been funded by the research and developmet program (F.u.E.), because of the late accession of the University of Augsburg to the scientific consortium of the UFS Schneefernerhaus just after the beginning of the first fundation period. As a consequence all research projects were bankrolled by own financial resources. In the following the developments of the last year in detail.

Tracer experiment at the Zugspitzplatt

The long before announced groundwater tracer experiment was rescheduled for the next year due to several reasons. The realization of such an experiment, which takes from the tracer input until the final sampling more than 3 months, is a logistical challenge, especially in high mountain regions like the Zugspitz area. For the performance of such an experiment you need enough manpower with a certain technical and scientific qualification. Project planers assumed that students could be recruited for field courses and for final theses (diploma theses). However, during the past year not enough appropriate students could be found to conduct such a specific and labour-intensive experiment for a diploma thesis in a high mountain area. Furthermore, the weather conditions in the past summer with a dry and very hot period in July and several cold snaps during August were anything but favorable for undertaking said experiment. Therefore, the experiment is now rescheduled for the following summer.

Mapping of karst phenomena

Alternatively to the tracer experiment, substantial topographical surveying and mapping of karst formations and the fissure net on the Zugspitzplatt were carried out in another field course with students from the University of Augsburg (Fig. 1). The purpose of surveying and mapping is to generate a regional overview of the surface drainage network on the Zugspitzplatt. Due to intensive karst formation on the surface only short intermittent streams can be observed, most of which drain into sinkholes and dolinas after a surface flow distance of less than 100 meters, even during heavy rainfall or intensive snowmelt periods. The bedrock (Wetterstein limestone) is to some extent extremely perforated by dissolution processes so that even during intense rain effective draining of the surface water into the karstified bedrock is guaranteed.

Fig.1: Surveying and mapping of karst features and fissure nets on the Zugspitzplatt

With the projects started past summer a three-dimensional scheme of the surface subcatch-ment areas on the Zugspitzplatt shall be generated, identifying areas with the quantitatively highest drainage into the bedrock. It is anticipated to identify the most effective conduits underneath said areas because of the high amounts of water percolating into the bedrock and dissolving the limestone. The well developed karst conduits are the main reason for the rapid runoff reaction of the Partnach-Ursprung after storm precipitation or snowmelt. In addition to the field surveys an analysis of a high resolution digital terrain modell (DTM) of the Zugspitze area has to be conducted in the near future. Identifying the conduits is highly important in the field of karst hydrological modeling. Further, it is helpful for detailed modeling to get an idea of the circuit geometry.

Furthermore, several water bodies as well as snow and glacier ice have been sampled to set up a long-term tracer data collection of the stable environmental isotopes ^{18}O and ^{2}H. The intended purpose of the isotope tracer collection is the analysis of runoff production processes in the catchment of the Partnach-Ursprung. Due to isotopic fractioning as a consequence of phase transition processes during evaporation or snowmelt, for example, a different isotopic composition of rainfall, snowmelt or glacial runoff can be observed. Therefore, the isotopic composition of streamflow can be used for separation of different runoff components.

Formation of a hydrology working group

A major development for the future has been the formation of a hydrology working group for which some well-known scientists have been enlisted. So far, further to the coordinator Prof. Dr. K.-F. Wetzel (Augsburg, Karst Hydrology and Water Balance), the following scientists have joined the working group:

- Prof. K. Schulz and Dr. M. Bernhardt (LMU, Snow Hydrology)
- Dr. J. Lange and Dipl. Geogr. A. Hartmann (IHF – Institute for Hydrology Uni Freiburg, Modelling of karst processes)
- Prof. Dr. N. Goldscheider together with Dipl. Geol. U. Bellmann (TUM, Hydrogeology)
- Dr. D. Morche (University of Halle, Mass Transport)
- Prof. H. Kunstmann (KIT & University of Augsburg, Downscaling of Atmospheric Parameters)

In a first workshop in October 2010 the involved scientists set their mutual objectives and took first steps to establish a DFG-funded research group in the field of high mountain hydrology.

Proposal of third party funds

These new developments led to a postponement of the schedule and to a modification in substance compared to the initial filing of a DFG application under standard procedure (Cooperation Augsburg/Halle). The application for this purpose is intended to be filed in the first half-year of 2011. The topic will be “Processes of Runoff Formation in the Karst of the Zugspitze Area”. It will be handled in cooperation with Uni Halle (Dr. D. Morche).

Publications:

During last year publications covering hydrological topics in the Zugspitze area have been published:

Rappl, A., K.-F. Wetzel, G. Büttner & M. Scholz (2010): Tracerhydrologische Untersuchungen am Partnach-Ursprung. – Hydrologie und Wasserbewirtschaftung, 54, S. 222 – 230.

Götz, J. & L. Schrott (Hrsg.)(2010): Geomorphologischer Lehrpfad am Fuße der Zugspitze. (With contributions of K.-F. Wetzel and D. Morche) – Pfeil Verlag, 104 S., München.

Fig.2: Publication to the Geomorphology Reintal and the Zugspitze area.

Oral presentation:

Morche, D. & K.-F. Wetzel (2010): Karst hydrology and dissolved load of the upper Partnach River, Reintal/ Zugspitze. - 5th I.A.G./A.I.G. SEDIBUD Workshop, Saudarkrokur, Iceland, September 19 – 25.

OBSERVATION OF THE OH-AIRGLOW ABOVE THE ALPS USING GRIPS

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Since 2005 the German Remote Sensing Data Center (DFD) of the German Aerospace Center (DLR) operates the infrared spectrometers GRIPS (Ground-based Infrared P-branch Spectrometer) at the Environmental Research Station "Schneefernerhaus" (UFS). The instruments are applied to routine observations of the OH airglow originating from the Mesopause region at ca. 87 km height.

This atmospheric luminosity is due to an exothermic chemical reaction of ozone with atomic hydrogen producing molecular oxygen and hydroxyl (OH). The excess energy is mainly transferred to vibrational and rotational excitations of the hydroxyl. It returns to its ground state after a short time by emitting visible and infrared electromagnetic radiation. However, this short period of time is sufficient for the excited molecules to get into a local thermodynamic equilibrium with the rest of the atmosphere. Thus, the temperature in 87 km height can be obtained by ground-based measurements.
The atmosphere exhibits nearly the same mixing ratio in this height compared to the ground. Nevertheless, the density is decreased by about five orders of magnitude. Therefore this region is very sensitive to minor changes of any atmospheric parameter. Additionally, the radiative cooling into space is very efficient at this height. Since the 15µm emission of CO_2 is the main agent for this cooling, the increase of CO_2 is expected to have a large impact here. In contrast to the troposphere, however, decreasing temperatures are expected within the next decades. Therefore the continuous assessment of mesopause temperatures constitutes a major aspect in the research on climate change.

But also on shorter timescales the temperature of the mesopause region is characterized by complex dynamics. Atmospheric waves play a key role in this context. Their influence ranges from a few seconds to several weeks. One can distinguish:

- **Infrasound**: waves with periods of less than five minutes and spatial scales of a few hundred meters to a couple of kilometres; their restoring force is caused by the pressure gradient.

- **Atmospheric gravity waves**: Waves with periods longer than five minutes up to a few hours, spatial extent from a few to several hundreds of kilometres; their restoring force is the buoyancy force.

- **Planetary waves**: Waves with periods ranging from several days to a few weeks, spatial scales of several thousands of kilometres; the Coriolis force is their restoring force.

Observations and data
Due to the fact that gravity waves can be generated, when large air masses flow over mountain ridges, the UFS provides an excellent site for observations of gravity waves – right in the middle of their "birthplace".
Observations are performed with a new kind of GRIPS instrument, which was especially designed for this purpose. It was put into operation at the UFS in the year 2008 (see figure 1). The time needed to obtain a single temperature value amounts to only 15 seconds. As a consequence it can be regarded as one of the most efficient instruments in this area world-wide.

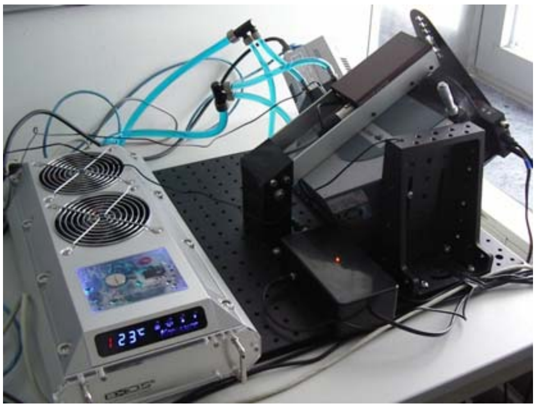

Fig.1: A new generation GRIPS instrument, the way it is operated at the "Schneefernerhaus" since 2008.

Every night up to 3500 spectra of the OH emission are obtained in the wavelength interval between 1.5µm and 1.6µm. The station provides outstanding conditions for optical observations due to its height. Single temperature values show an uncertainty of less than 10 Kelvin. So it is possible to obtain a representative nocturnal mean value for about 80% of all nights (see figure 2).

The seasonal cycle of 60 Kelvin is well pronounced, showing its warm temperature values in winter and the cold values during summer time. This effect is due to global currents in the upper atmosphere and indirectly related to the acting of gravity waves.

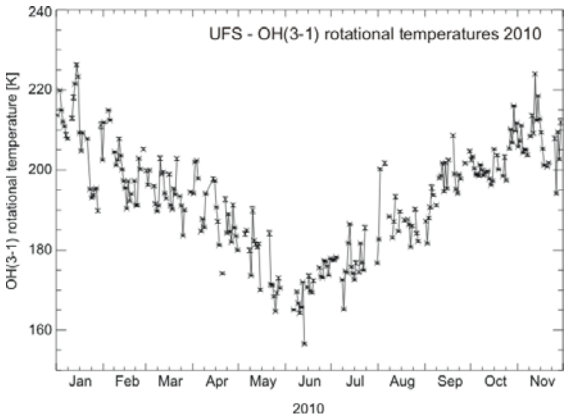

Fig.2: Seasonal cycle of OH nocturnal mean temperatures for the year 2010 obtained from the Schneefernerhaus. The scatter of the data is due to the high variability of atmospheric dynamics – mainly planetary waves.

Wave activity

The high temporal resolution temperature time series of individual nights are analyzed using spectral analyses. Usually the method of choice is the Harmonic Analysis, which has several advantages over other methods. On the one hand it unambiguously identifies the dominating oscillations and on the other hand it is insensitive to data gaps, which frequently occur in time series of optical observations of atmospheric parameters due to varying meteorological conditions.

The upper part of figure 3 shows the night from the 6th to the 7th April, 2009. The results of the Harmonic Analysis yield four dominant oscillations with periods from 1.5 hours to more than 8 hours. Amplitudes also range between 1.5 Kelvin and 8 Kelvin - meaning gravity waves can easily cause a perturbation of about five percent of the undisturbed state in the upper mesosphere. This is one more evidence for the high sensitivity of this height regime to external forcing.
The lower part in figure 3 shows the relation between periods and amplitudes of all 283 wave events, which could be identified between February 2009 and February 2010. The largest portion of the wave spectrum consists of small scale waves with periods of less than three hours. But they also exhibit smaller amplitudes, which is an evidence for smaller energy content.

A precise characterization of wave activity found in OH airglow above the Alpine region is the primary aim of this investigation. It is important, because atmospheric waves play a key role in the control mechanisms of global circulation patterns. But small scale phenomena, which are of special interest in this context, are to a large extent not understood yet and strongly influenced by local effects.

Therefore, measurements at the UFS are supported by observations performed with other GRIPS instruments located at the Meteorological Observatory Hohenpeißenberg and at the DLR-DFD in Oberpfaffenhofen.

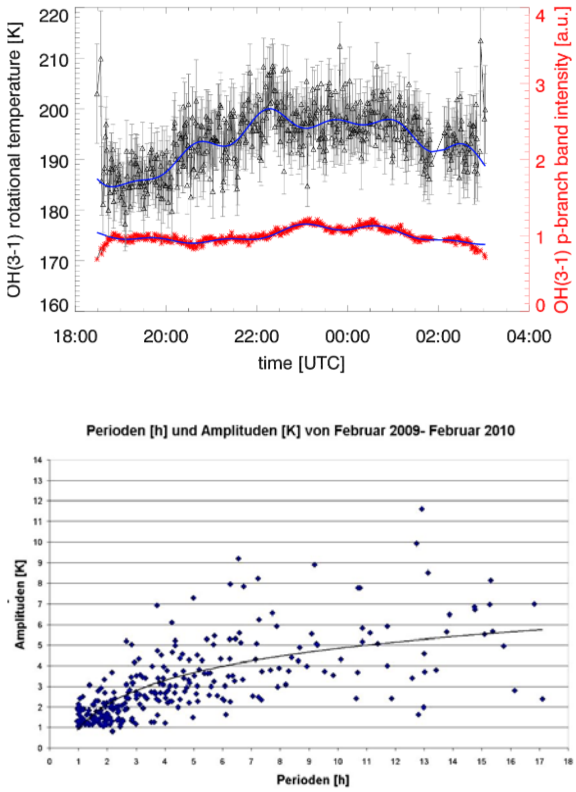

Fig.3: The upper panel shows the nocturnal evolution of OH temperatures (black) and OH intensities (red) as observed by GRIPS. Results of the Harmonic Analysis are indicated by the blue curves, which show the dominating oscillations in both parameters. These oscillations can be attributed to atmospheric gravity waves. The lower panel shows the relation between amplitudes and periods of all gravity wave events observed between February 2009 and February 2010.

OUTDOOR EXPOSURE OF PV-MODULES

UNDER EXTREME CLIMATIC CONDITIONS

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Manufacturers usually give a warranty for at least 20 years although there is still only little knowledge about the lifetime of newly developed module types. How do they cope with snow, salty ambience, desert-climate or tropical humidity? The Fraunhofer-ISE has therefore installed different outdoor exposure sites where modules have to stand extreme climates: high temperatures with high differences between day and night in the Negev desert in Israel, snow, wind and extreme UV-irradiation and frost at the Schneefernerhaus, high humidity at warm temperatures in Indonesia and high temperatures, high irradiation and high humidity salt exposure in Gran Canaria.

Besides serial modules provided by industrial partners, Fraunhofer ISE exposes experimental modules with innovative encapsulation- and back sheet-materials. UV-irradiation, solar-irradiation, ambient- and module-temperature, humidity and wind speed are measured and the data is collected at a central server. Based on this data the climatic loads at the different test sites can be calculated and used for the estimation of the service life.

Essentially the following factors are relevant for the weathering of materials and components collecting solar energy: ultraviolet irradiation, mechanical loads caused by snow

Fig. 1: Outdoor test side provided by Fraunhofer ISE at the Schneefernerhaus.

and wind, pollutants (especially salt), internal stresses due to different thermal expansion coefficients, and the permeation of water and oxygen through the polymer encapsulation.

It is difficult to combine all degradation factors realistically in accelerated lab tests in order to demonstrate their interaction during the ageing of the samples. Thus, the exposure under natural conditions is indispensable for the validation of simulation results and accelerated service life testing. Extreme climates do not only allow a faster detection of weak ponts, but also a qualification of the samples for special climatic conditions.

Results of monitoring

The sites differ remarkably in the climatic load of the modules. In the following diagram the dispersion of frequency of one main degradation factor, temperature, is illustrated. At this juncture it is particularly important that the degradation processes depend on the microclimate, that is the module-temperature.

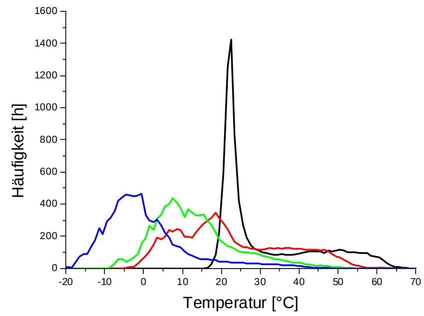

***Fig.2:** Dispersion of frequency of the average module temperature during one year at the 4 outdoor test sites: Alps (blue), city (green), desert (red) and the tropics (black).*

The ambient temperatures could be measured between -17°C and 37°C meanwhile the module-temperature reached up to 65°C (see fig. 2). The maximum temperature difference between module and ambient temperature was about 30K.

The different temperature loads can be calculated by integrating the module-temperatures T(t). They are weighted acc. to an Arrhenius relation which represents the dominating degradation process with activation energy Ep. Teff is the effective constant temperature which would lead to the same degradation in the same period as the sample

temperature T(t) which fluctuates through diurnal course and weathering.
The results are illustrated in fig. 3 for a wide spectrum of activation energies. The effective temperature is also the basis for the calculation of duration of accelerated tests under superelevated testing temperatures.
The high sample temperatures compared to the ambience derive from the natural solar irradiance which could be measured via pyranometer. In the majority of cases only the short-wavelength part of the solar spectrum is responsible for the photo-degradation. This part was measured with integral UV-A and UV-B sensors since it was expected to vary at the different test sites due to differences in climate and altitude. Most of the sensors turned out to be too inaccurate even though they have been factory calibrated in the beginning and compared under lab and real conditions. To quantify the influence of humidity, mostly the so-called 'Time of Wetness' (TOW) is taken into account which is the sum of times exceeding a relative ambient humidity of 85%. The kinetic of the then following corrosion processes is also depending of the sample's temperature.

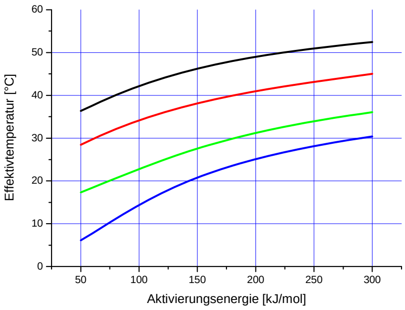

Fig.3: effective temperature dependent of the activation energy of a degradation process, calculated for 4 outdoor test sites: Alps (blue), city (green), desert (red) und the tropics (black).

Here, the differences between the Alps, desert and the tropics are particularly obvious. By integrating the loads and transformations to test temperatures of 85°C at 85% r.h. (acc. to type approval tests for PV-modules IEC61215 and IEC61646) via the effective temperature, we can see the test times, which depend on the activation energy, for 25 years of durability (shown in figure 4). Again, the strong influence of exponential dependency of temperature and activation energy can be detected. A test time of 1000 h which is designated so far can be considered as sufficient qualification even for a module exposure in the tropics for processes with activation energies over 70 kJ/mol. At the other outdoor test sites which are less strained, even processes with activation energy of 45 kJ/mol would be accelerated sufficiently. Based on the assumption that the dominating process was the diffusion of water through the polymeric encapsulation (Ethylenvinylacetat) of the modules, the module's diffusion- and permeation-coefficients for water were measured temperature dependent in order to calculate the activation energy. The activation energy was found to be 34 kJ/mol what requires test times of 3000h to 13000 h (for the tropics).

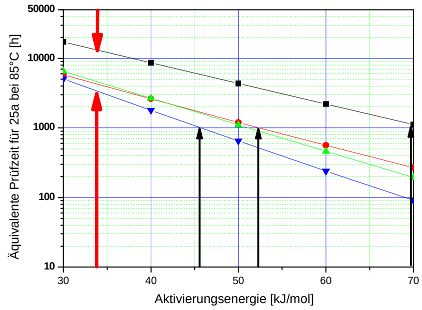

Fig.4: Test times for a damp-heat-test (85%r.F.@85°C) for lifetime as function of activation energies for degradation processes for 4 outdoor test sides in Indonesia (black), Israel (red), Köln (green) und Schneefernerhaus (blue).

Conclusion

The outdoor exposure of samples with monitoring of the ambient climate and the microclimatic loads of the samples as well as with a high temporal resolution in extreme climates enables the calculation of site specific loads and thus a rating of test sites. This is the foundation for the development of adequate accelerated durability tests which take into account the highest operational demands.
A reliable estimation of durability requires knowledge of the dominating processes as well as of their kinetics in order to calculate and predict the ongoing degradation processes.

Acknowledgement

The work was partly funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU FKz 0329978) and sponsored by different industrial partners.

PERSISTENT ORGANIC POLLUTANTS IN ALPINE SPACE

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Persistent Organic Pollutants (POPs) are chemicals of a global environmental concern. The majority of the POPs are anthropogenic compounds. These were and are still partly used as pesticides (like Aldrin, Dieldrin, Endrin, Chlordane, DDT, Mirex, Heptachlor, HCB, PeCB, HCH); additionally they have been used as industrial chemicals such as Polychlorinated Biphenyls (PCBs) in form of flame-retardants and coolants. They are also formed as products of combustion during incineration or in case of forest fires, like Polychlorinated Dibenzo-p-dioxins and Dibenzofurans (PCDD/PCDF), PAH and other compounds. The production and application of POPs have been prohibited in the member states of the EU within the frame of the POP Convention of 2004. In developing countries of Africa and Asia, however, even in the U.S. and Latin American countries, POPs are partly still produced and used. POPs are highly persistent substances with half-live periods of 10 years or longer. Attached to dust or aerosols, they can be transported over long distances in the atmosphere. Because of their physical properties, multiple deposition and re-volatilisation processes, as well as the preferential deposition in colder regions, particularly at the poles or in mountains, are possible.
Because of their lipophilic properties, they can accumulate in different ecosystems, in crops and animals, enter the human food chain and be stored in humans. The Alps act as a natural physical barrier for meteorological transport processes and as cold trap for POPs. Decreasing temperature and increasing precipitation with elevation lead to a vertical increase of deposition. Forests characterized by an extremely large effective surface, represent a significant biological sink.

Scientific programme

Within the frame of the project MONARPOP (2005-2007), a network of about 40 sites and 7 vertical profiles was installed in the alpine region. The monitoring program involved the measurement of the ambient air concentration of POPs and their altitudinal behaviour by using passive sampling (SPMD). In parallel, the contents in spruce needles and soil have been investigated.
For the first time, three higher elevated alpine sites, the UFS Schneefernerhaus (D), the Weissfluhjoch (CH) and the Observatory Hoher Sonnblick (AT), were equipped with heated precipitation samplers and a high-and low-volume air sampling devices which are particularly adapted to the extreme climatic conditions. Based on a trajectory forecast, the air samplers have been controlled via internet. By sampling on different cartridges, it is possible to gain information about the origin of air masses from pre-defined emission areas of Europe.
In the current project POPALP (2007-2011), the studies regarding to the vertical distribution of POPs in the different environmental compartments have been continued on an extended vertical transect in the National Park Berchtesgaden. At the three high-alpine mountain sites, deposition measurements and source-related investigations of ambient air concentrations have been continued.

Goals

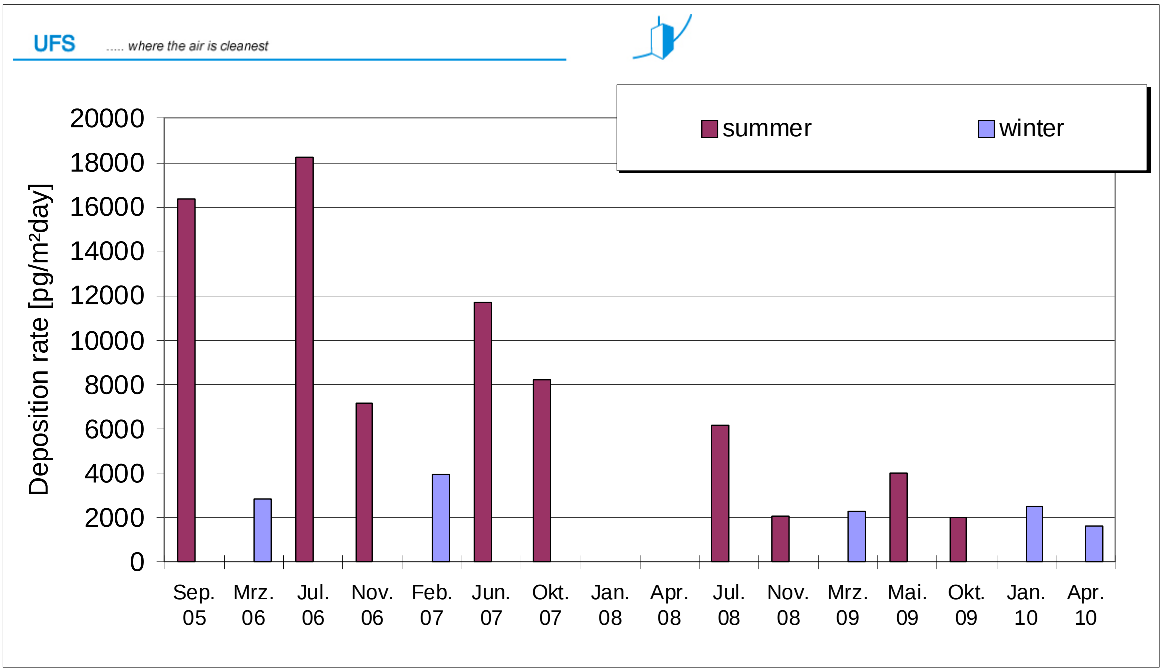
The main goal of MONARPOP was to curry out a scientific survey of the impacts by organic pollutants in different environmental compartments as soil, spruce needles and air and in relation to the precipitation in the Alpine region. The results were the basis of the implementation of Stockholm Convention in the Alpine Region by controlling the efficiency of the taken measures. The high complexity of environmental processes, as the seasonally different temperatures and precipitation amounts, the extremely variable occurrence of the different circulation types which are considered in the trajectory forecast procedure are reasons for longer observational periods and recurrent measurements. By continuing the measurements in the framework of the POPALP project, a basis should be established, which allows to detect long-term trends and control the obligations arising as a result of POP convention.

Results

The main result of MONARPOP was the finding that the concentrations of numerous organic pollutants in the air, spruce needles and the soil are higher in the Northern and Southern edges than in the Central parts of the Alps. This phenomenon can be related to the barrier effect of the Alps. Concentration measurements performed on Alpine summits for the first time provide evidence of atmospheric POP transport across the Alps. The vertical distributions of POPs along slopes showed different features for the singular pollutants: Both altitudinal concentration increases (such as in the case of pesticides) and decreases (PAHs) can be observed. Whereas some pesticides originate from regions far from the Alps, PAHs are emitted in Alpine valleys, too. The evaluations of the five-year series of deposition measurements at the UFS Schneefernerhaus show f.i. for Endosulfan, an insecticide banned by now within the EU, a negative trend during the period 2005-2010 (fig. 1).This trend is more pronounced during the summer than in winter months in which the concentrations are lower. An analogue behaviour can be observed at the two high-Alpine sites Weißfluhjoch and Sonnblick. In the case of lindane (γ-HCH), a not yet allowed insecticide in Europe, a less marked decrease is observed. On average, HCH conformers show higher concentrations during the summer than the winter periods. In the case of the deposition of most of organochlorides, higher amounts are registered at the Northern edge of the Alps (UFS) than in the Central Alps.

Because of their high toxicity, pollutants like poly-fluorinated organic compounds (PFCs), which previously did not belong to the Stockholm-list, come more and more in the focus and are considered as substances to be investigated in the future.
These compounds can enter ecosystems in alpine regions by long range transport as well as in a local scale by alpine winter sport (ski wax). They are very persistent compounds and also readily soluble in water. This could be a potential threat to the groundwater and drinking water quality in alpine catchments. The monitoring activities of deposition and ambient air concentration of the previously investigated POPs at the UFS Schneefernerhaus should be continued. Continuous measurements over longer periods are an essential base to review the effectiveness of the Stockholm Convention.

Fig. 1: Trend of the deposition rate of Endosulfan I (α) at the UFS Schneefernerhaus, 2005-2010



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FEDERAL ENVIRONMENT AGENCY, UBA

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The Federal Environment Agency, Germany, operates the platform Zugspitze of the GAW Global Station Zugspitze /Hohenpeissenberg. The participation in GAW is a long time measurement programme on quality measurements according to the state of science. The repertoire of the Federal Agency concentrates on the measurement of climate forcing gases, chemical reactive gases and ultra-fine and fine aerosols. In difference to other institutions with scientific activities at the environmental research station, varying from project to project, the GAW contribution consists of one constant measurement programme.

PAN in the lower free troposphere

Peroxyacetyl nitrate (PAN) is a reactive nitrogen species which characterizes matured anthropogenic air. PAN, a tropospheric reservoir molecule stores $CH_3C(O)O_2$ and NO_2. Besides ozone and hydrogen peroxide it is the most important compound of photochemical smog.

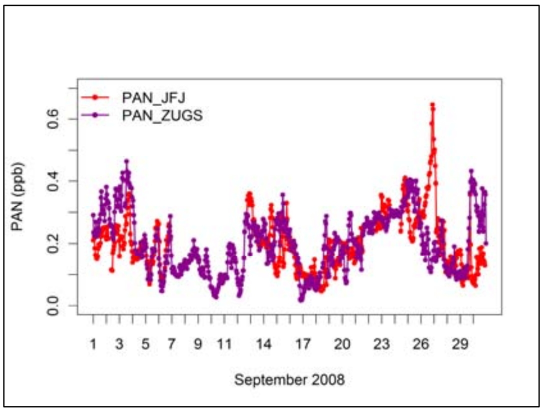

Fig.1: Comparison of 30min PAN values Sept. 2008

The atmospheric stability of PAN depends on low temperatures. By a number of photochemical volatile organic compounds (VOC) are oxidized, which produces peroxy radicals. Further reactions with nitrogen dioxide produce PAN.

On the basis of a doctorate at the ETHZ, [S. Pandey Deolal et al. 2011], PAN time series

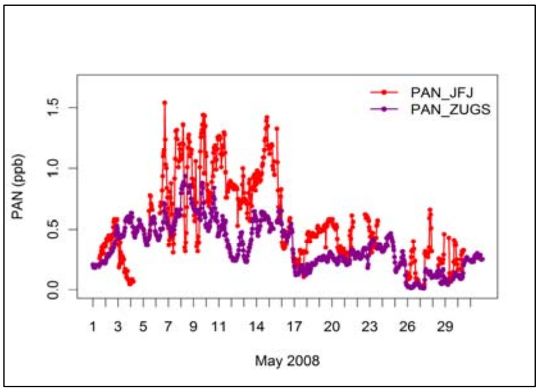

Fig.2: Comparison of 30 min PAN values May 2008

measurement data from the stations Jungfraujoch (2008) and Zugspitze (05/2004-2008) have been analyzed in a comparative investigation. Measurements of both sides show strong seasonal variation with maximum concentrations in late spring, indicating that the spring maxima of PAN are typical patterns at high mountain sites. Detailed trajectory and transport analyses showed that PAN maxima are attributable to European sources and not to intercontinental transport. As main source regions North-East Europe and the Po valley and Milan region were identified.

During spring season Zugspitze station has the tendency towards lower PAN concentrations by approximately a factor of ½ which can be deduced to a higher temperature regime and a lower PAN/NOx ratio at the Zugspitze site. In general the results of this study can be interpreted as a representative example of PAN spring maxima which can be explained with European boundary layer sources.

Source apportionment of Non Methane Hydrocarbons

Besides nitrogen oxides and solar radiation volatile organic compounds (VOC) play a crucial role in the chemistry of the lower troposphere and the formation of ozone as well as in the OH-radical budget. On the basis of a ten-year dataset (1999-2008) of canister measurements of 21 volatile C2-C8 hydrocarbons at

UFS performed by Federal Environment Agency. As contribution to the European EMEP programme whole air canister samples were taken twice weekly at noon (1999-2001) and at 02:00 h (CET; 2002-2008) to ensure the monitoring of mixing ratios associated with the European atmospheric background levels.
The canisters were analyzed offline by a gas chromatograph coupled with flame ionization detectors (GC-FID).
Preliminary Results: In order to explain the variability of predominantly anthropogenic non-methane hydrocarbons (NMHCs) at the high altitude Environmental Research Station Schneefernerhaus, receptor modeling by positive matrix factorization (PMF) of the ten year time series was performed. Approximately 17700 measurements were analyzed, missing values (~60) were replaced by the species median. Uncertainty values ranged from 15 to 80 % for the respective species depending on detection limits of the GC-FID and peak integration characteristics. Results of the factorial analysis show a seven factor solution identified by the PMF model.
Fig. 3 exhibits the different fractions of mass contributions of the seven factors to the total measured NMHC carbon mass as modeled by PMF analysis.

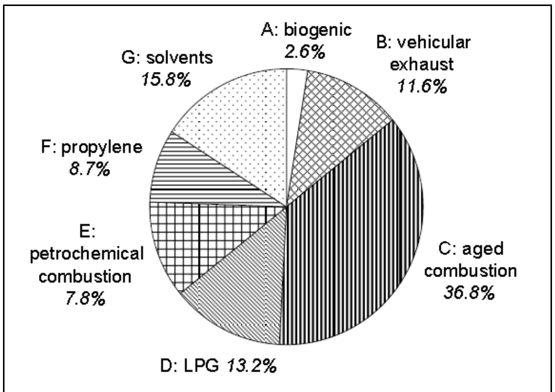

Fig. 3: Contributions to the measured NMHC mass (in ppbC) by seven identified source categories

The most abundant species were ethane (mean 2.26 ppbC), propane (1.00 ppbC), acetylene (0.73 ppbC) and toluene (0.62 ppbC). All species except isoprene which is mainly emitted by vegetation are derived from anthropogenic sources. Factor A with the smallest mass contribution is characterized as biogenic due to the only main compound isoprene that is predominantly emitted by photosynthetic processes of plants. It can only be accounted for 2.6% of the entire NMHC mass measured and shows maximal abundance within the vegetation period in summer. The 36.8% of the total NMHC mass of the most abundant factor C can be attributed to aged combustion sources. About 75% of ethane, 49% of propane, 58% of benzene, and 50% of acetylene are explained by this factor. Factor D with 13.2% of the mass is interpreted as liquefied petroleum gas (LPG) which mainly consists of propane, isobutane, and n-butane. Both factors show clear seasonal variability with summer minima and winter maxima. The seasonal differences in the mixing ratios could in parts be due to the seasonal variability of hydroxyl radical concentrations in the atmosphere and very different meteorological conditions in winter and summer that influence the atmospheric transport and vertical mixing of NMHCs. Nearby seasonal pollution from different tourist activities of the Zugspitze in summer and winter can partly explain the variation of LPG sources, since on the Zugspitze summit there is storage of LPG that varies seasonally. This investigation of source apportionments will be continued.

Participation in QA/SAC tasks

Since 2001 the GAW global station of the Federal Environment Agency supports twice per year the GAWTEC educational programme with courses about practical quality assurance and data processing at GAW stations.

Quality assurance and international intercomparisons

In 2010 the GAW measurement station of the Federal Environment Agency took part in the following intercomparisons: Worldwide NOAA/WMO intercomparison 2010 for CO2, CH4, N2O,SF6,CO,H2. CARBO EUROPE 2010 round robin for CO2, CH4, N2O,SF6,CO,H2.

Cooperation with the Bulgarian GAW Station

From December 2010 to March 2011 three scientists from the Bulgarian GAW station Beo Mousalla are invited for scientific exchange on measurement techniques, data quality assurance and statistical data processing to the Environmental Research Station Schneefernerhaus.

DZUG –DOWNSCALING PROJEKT ZUGSPITZE: FIRST STEPS TOWARDS HIGH-ACCURACY CLIMATE PROJECTIONS

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Within the framework of long-range studies for optimization of downscaling techniques a first phase consists in developing weather and circulation type classifications for detecting dependencies between large scale circulation and local temperature and precipitation changes.
A preliminary experimental study shows promising results as well as deficits. Based on result from the COST Action 733 further possibilities for systematic optimization, like variation of the spatial classification domain, are evaluated.

Introduction

The high-alpine region around the Zugspitze represents an ecosystem highly sensitive to climate variability and change. Thus this region is on the one hand suitable to serve as an indicator for climate change. Variations in climate characteristics are on the other hand a crucial factor with regard to issues of environmental protection and anthropogenic utilization of resources in this region. The investigation of potential future developments and related negative impacts thus inheres particular importance. Within a long-range project that has been initiated in order to optimize downscaling techniques it is intended to transfer climate change signals from large-scale circulation data to the regional and local scales. During an initial phase of the project quantitative relationships between circulation types and regional and local scale target variables will be established. Frequency changes of these circulation types as projected by climate models will be used in a subsequent step to estimate future climatic and environmental variations on a local scale.

Experimental classification-based short-term assessment of air temperature

In order to set up a first reference model for classification-based assessment of temperature, a short-term forecasting system for the DWD station Zugspitze has been developed. For that purpose 10 weathertypes have been determined for each month by cluster analysis of the grid section extending between 0-20°E and 42.5-52.5°N. The input variables for a first version were geopotential heights, wind components and temperature field of the 850 hPa-level as well as heights of the 300 hPa level and wind and temperature of the 500 hPa level. An alternative version solely works with the 500 hPa-geopotential heights. The types which have been determined using ERA40 data of the period 1957 to 2002, have been calibrated by the corresponding temperature values measured at the DWD station Zugspitze for the hours 00,06, 12 and 18 UTC. The median of all temperature observations for each class is used as characteristic temperature value instead of the mean, in order to avoid biasses caused by outliers.
In order to produce up-to-date model assessments, the 6-hourly GME-forecast data which are provided by the DWD via FTP twice a day, are assigned to the type centroids by determination of the minimum Euclidean distance. The calibration temperature is then used as model value. Figure 1 shows the time series which are produced by the two models in comparison to the DWD observations.

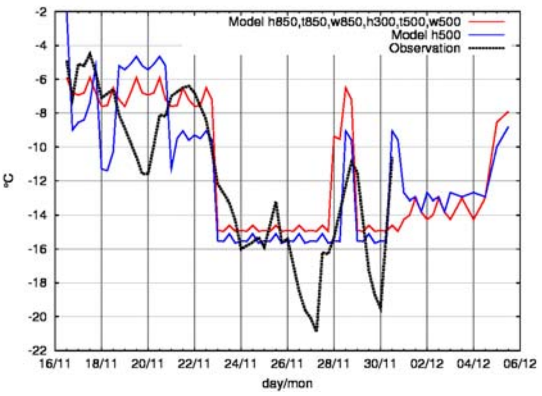

***Fig.1:** Time series for temperature values at the DWD station Zugspitze as observed and modelled by classification-based downscaling for the period 16.11.201000UTC to 06.12.2010 00UTC; red: model using multiple variable fields (see text), blue: model based on 500 hPa geopotential heights, black: observations. Spearman correlation coefficients are 0.78 and 0.75 for h500, respectively.*

Even though this example demonstrates that main parts of variance are in common between both models and observations, e.g. the cold snap on 23.11. or the sudden warming on28.11., some events cannot be reproduced like the passage of a cold air pool on the 26.11.This shows that there is potential for further improvements.

Systematic evaluation and optimization of classifications

Within the framework of the EU COST action733 „Harmonisation and Applications of Weather Types Classifications for European Regions“ comprehensive analyses on the (principal component analysis in S-mode with subsequent non-hierarchical cluster analysis), GWT (threshold-based assignment to circulation prototypes), LND (correlation analysis),

SAN (non-hierarchical cluster analysis optimized via simulated annealing and diversified randomization), TPC (principal component

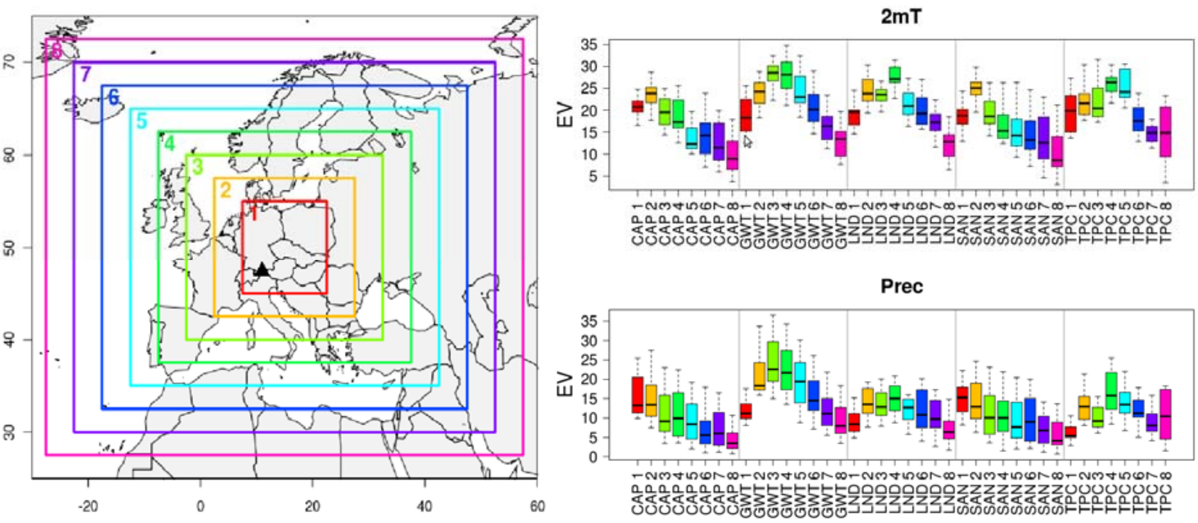

Fig. 2 (left): Varying spatial domains for the determination of circulation type classifications; the black triangle indicates the position of the Zugspitze. (right) Explained Variances (EV in %) of varying circulation type classifications for daily values of air temperature (2mT) and precipitation (Prec) for the meteorological station Zugspitze (1957-2002). EV-values are given for 5 circulation type classifications (see text) with 8 variants each (spatial domains 1-8). Each boxplot consists of 12 EV-values estimated for specific months

discriminatory power of circulation type classifications have been performed with respect to the variables used for classification (mostly sea level pressure) as well as several climatic target variables (e.g. air temperature, precipitation).

One metric for quantifying the discriminatory power of a circulation type classification for a climatic target variable is the explained variance (EV = 1 – within-type sum of squares / total sum of squares).

Results from the COST action 733 show that the discriminatory power of classifications depends not only on the underlying methodological approach (e.g. cluster or principal component analysis) but – mostly even more distinctly – on classification settings that are independent from the methodological approach (e.g. type and number of the variables used for classification).

Fig. 2 shows selected results from analyses of the influence of the size of the spatial domain used for classification on the relationship between circulation type classifications and meteorological surface variables (in terms of the explained variance) for the example of daily temperature and precipitation at the DWD station Zugspitze.Five different circulation-type classification methods, each of them representing one basic classification concept, have been applied to 8 spatial domains of varying size, respectively (left panel of Fig. 2): CAP analysis in T-mode).

All classifications only use sea level pressure from daily (12UTC) ERA40 reanalysis data for classification and comprise 18 classes (circulation types).

Subsequently the explained variance of each classification for daily values of air temperature and precipitation has been calculated separately for each calendar month (right panel of Fig. 2).

In general higher values of the explained variance can be stated for the target variable air temperature compared to the target variable precipitation. In addition – however mostly minor – differences among different classification methods appear. Most distinct variations in explained variances can be detected according to the size of the spatial domain that has been used for classification. Fig. 2 documents a clear tendency towards maximum values of EV related to spatial domains not exceeding a maximum size of 40 degrees in longitudinal direction and 30 degrees in latitudinal direction.

Based on results available from comprehensive evaluation and comparison studies, it is intended to focus forthcoming research activities on the modification and enhancement of existing circulation type classifications in order to achieve the envisaged optimization of downscaling approaches based on circulation type classifications.

IN-SITU MEASUREMENTS OF CLOUD MICROPHYSICS AND AEROSOL-CLOUD-PROCESSES

SCHLOSSER, SCHNAITER, LEISNER

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The Institute for Meteorology and Climate Research, division Atmospheric Aerosol Research, focuses on the interaction between aerosol and clouds. Aerosol particles have a key role in formation of clouds, precipitation, cloud optical properties and thus for weather, radiative forcing and climate. The processes involved are investigated at very different spatial scales which range from micrometer to several meters in laboratory experiments in Karlsruhe. In field experiments comprehensive aerosol measurements and fast single particle instruments are deployed for characterisation of aerosol, cloud and ice particles at the Zugspitze.
Clouds were sampled on the roof platform of the Environmental Research Station Schneefernerhaus (UFS) during a measurement campaign in February 2010. Some clouds showed sections consisting of supercooled water droplets quickly changing with sections consisting completely of small ice crystals. During some events mixed clouds were observed. We present first results of the concentration of sooth and bioaerosol inside and outside of the observed clouds that suggest an influence of the aerosol composition on cloud microphysical properties.

Atmospheric Aerosol Research in the Lab

The interaction of aerosol and cloud formation is being studied in the laboratory on the northern campus of the Karlsruhe Institute for Technology (KIT). Single levitated droplets can be probed on the small scale of micrometers. On a much larger scale, cloud aerosol interactions are being investigated under controlled conditions in the 85 m³ large cloud simulation chamber AIDA. This chamber allows adjusting atmospheric relevant conditions over a wide range of temperature, pressure and humidity. Different well defined materials can be added as aerosol of known size distribution and concentration, followed by adiabatic expansion. The subsequent drop in pressure and temperature equals the rise of an air packet in which the aerosol serves as condensation nuclei and ice nuclei on which water (or ice) is deposited and the formation of an artificial cloud is investigated systematically and reproducibly. The chamber also serves as a test platform for instruments that are deployed for lab and field research.

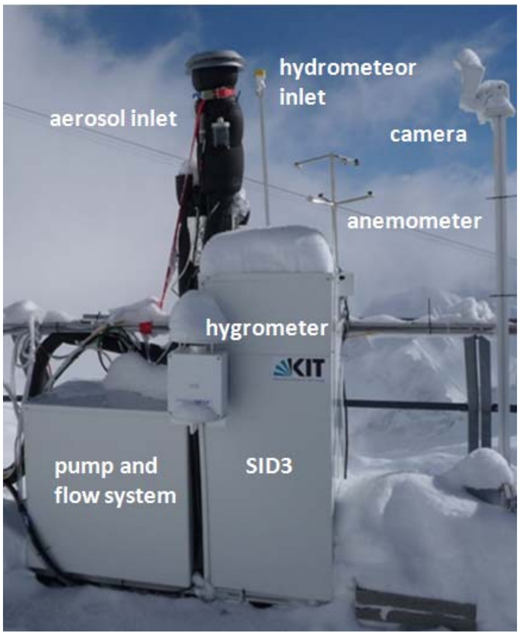

Fig.1: A mobile measurement unit to investigate aerosol cloud interactions located on the roof platform of the Schneefernerhaus (UFS). More instruments are located in the laboratory below.

Cloud Microphysics and Aerosol Processing in the Field

The mountain Zugspitze offers excellent conditions to study clouds from a ground based station. The following questions are addressed:

- What natural and anthropogenic types of aerosol can be found outside and inside of clouds and what physical and chemical properties do they have?
- Which part of the aerosol serves as ice nuclei, that have a strong influence on cloud properties, -dynamics and the formation of precipitation?
- What is the ratio of ice and water in mixed clouds. And what influence do aerosol particles have that come from different sources?
- What is the contribution of ice multiplication processes within relatively warm (> -9°C) liquid clouds?
- What is the repartition of aerosol particles with other aerosol compounds when proc-

essed by clouds. And how do the optical properties of aerosol change in the process?

Field measurements at the Schneeferner-haus (UFS)

These questions above will be addressed in the future using continuous measurements and focussed field campaigns located on the roof at the 9th floor of the Schneefernerhaus. The first field campaign took place in February 2010 (Fig.1).

The evaluation of the first SP2 measurements suggest that the observed cloud has an increased soot concentration compared to air outside of the cloud, whereas the particle fluorescence determined by WIBS shows no significant change in the bioaerosol concentration within this period. The measurements suggest that there may be an interrelationship between the ratio of ice/water and the concentration of soot in the observed clouds.

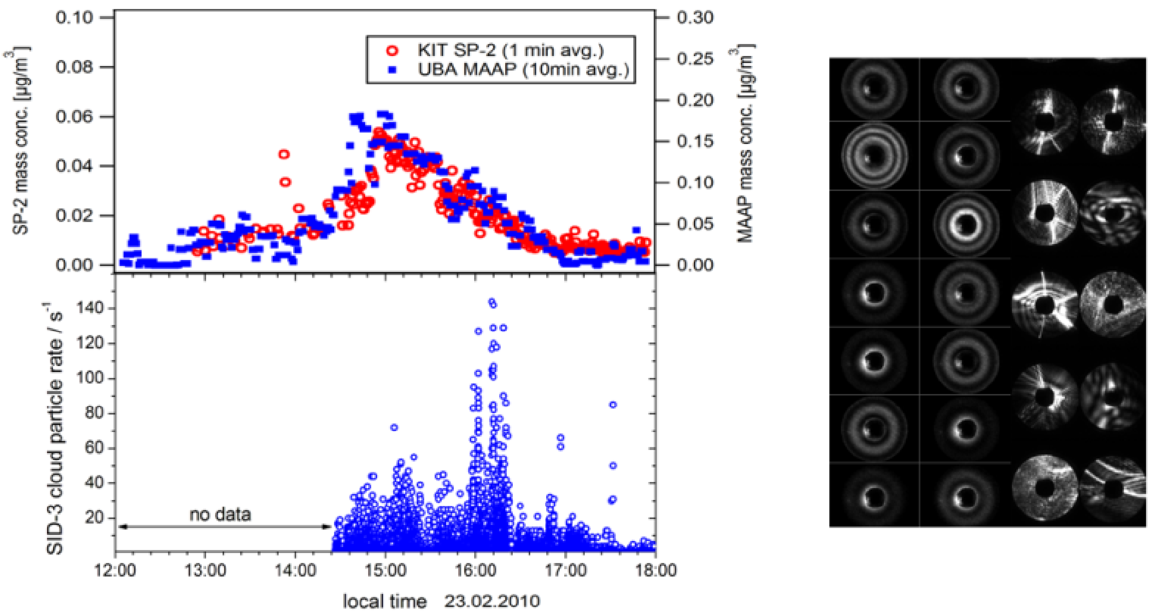

Fig. 2: upper panel left: measurements of soot and bioaerosol, lower panel: SID3 measurements in a mixed cloud. Right panel: Scattering pattern of cloud particles (SID3): supercooled water droplets (left) and ice crystals (right).

The aerosol concentration and size distribution was characterised inside and outside passing clouds. Beside particle counters and aerosol spectrometers also very specialized aerosol instrumentation was deployed. Data of an instrument of the Umweltbundesamt (Multi Angle Absorption Photometer, MAAP) was used to characterise the optical properties of the aerosol and compared with data of our Single Particle Soot Photometer (SP2). SP2 is one of the fast single particle instruments that probes the optical and chemical aerosol properties. Another fast single particle instruments is the Wide Issue Bioaerosol Sensor (WIBS) that was used to determine bioaerosol particles. The instrument SID3 (Small Ice Detector) allowed to characterise the microphysical properties of clouds (s.Fig.2).

The evaluation of the fast SID3 single particle measurements shows fast changes of cloud sections that consist of supercooled liquid water droplets with a diameter of 2.9 ± 1.3 µm that can be derived from the scattering pattern. These liquid cloud sections changed with sections with small rimed ice crystals.

Future measurements are planned to follow up the observations of the first campaign and to explore the mentioned questions in detail.

Continuous, long-term measurements will be installed and complemented by intensive field campaigns using fast single particle instruments.

Cooperation with other research groups that perform long-term aerosol measurements, and those that investigate cloud and precipitation by remote sensing, cloud dynamic and turbulence, and meteorological modelling within the UFS offer opportunities for comprehensive cloud research at the Zugspitze

BAVARIAN HEALTH INFORMATION SERVICE FOR COPD AND ASTHMA

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The LMU-DLR cooperation project "Health information service for COPD and asthma for Bavaria" aims at the provision of risk-information for patients suffering from chronic pulmonary diseases. Relevant environmental and medical data sets are analysed in order to quantify the effect of environmental factors on patients' well-being. This knowledge allows the provision of easily understandable information about health risks to the general public. Moreover this projects targets at providing warnings in case of predicted (up to three days in advance) environmental situations, which are unfavourable for the patients' health.

Introduction

Normally, weather and its variability are no primary cause of disease but may induce reactions in vulnerable parts of the body and thus promote negative health outcomes. Clinical experience shows that patients with respiratory diseases are often distressed during cold and humid weather conditions. These patients are also particularly susceptible to air pollution. Increased concentrations of particulate matter but also of ozone lead to more asthma attacks.

Medical data

Prior studies have mainly focussed on mortality or the number of hospital admissions. Both measures only account for the worst case of individual health constitution.

In order to detect weaker changes in patients' well-being we need to rely on other indicators. A major component of this study is to identify changes in the health related behaviour of the Bavarian citizens by regarding the number of visits at the GPs or phone calls to emergency centres.

This project focuses primarily on chronic pulmonary diseases, which are differentiated into asthma and chronic obstructive pulmonary disease (COPD). Obtained results (including statistical models) will be transferred to other diseases.

It utilizes several complementary daily medical data sources:

- ambulatory care visits,
- calls to medical call centres,
- emergency calls and services,
- pharmaceutical data on prescriptions.

As an example Figure 1 shows the number of ambulatory care visits due to chronic obstructive lung disease standardized on population for the Bavarian counties during 2006-2007.

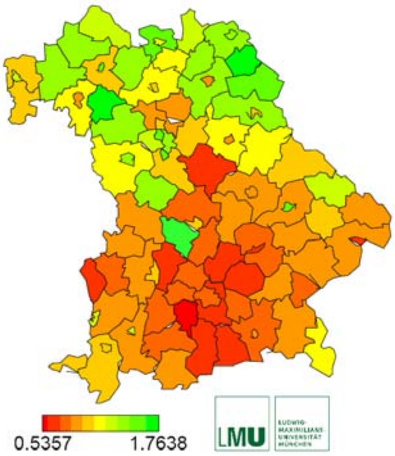

Fig.1: Number of ambulatory care visits due to chronic obstructive lung disease standardized on population for the Bavarian counties during 2006-2007

All of the above medical data sources are heavily affected by administrative patterns like holidays or weekdays.

In addition to this statistical approach, the health status of individual patients suffering from COPD is observed over the course of one year. During this clinical study the patients are obliged to perform lung function measurements and to keep a diary on their well-being on a daily basis. Moreover, several visits at Schneefernerhaus during unfavourable environmental conditions in Munich are scheduled. At Schneefernerhaus (nearly 3000m above mean sea level) in depth analyses of their lung function are performed.

Environmental data

In order to be able to understand the environmental impact on the individual's well-being it is necessary to quantify the administrative influences. This is required to determine the influence of environmental factors.

Meteorology is expected to play an important role for the well-being of the project's target group. These influences are not necessarily linear. E.g. comfort ranges for air temperature and humidity – outside of which negative influences can be seen – as derived in the framework of this study.

A crucial point for the well-being of people at risk is air pollution. Especially respiratory diseases, which are the main focus in this study, are highly influenced by atmospheric constituents. Enhanced concentrations of ozone, NO_2 and particulate matter (PM) are known to be responsible for adverse health effects. For example half of the particles smaller than 10 µm (PM_{10}) reach the lung when breathing. Particles smaller than 2.5 µm ($PM_{2.5}$) are even capable of passing the blood-brain-barrier.

Air pollutants are routinely measured using air samplers. The Bavarian air sampler network is maintained by the Landesamt für Umwelt (Bavarian Environment Agency, LfU).

These measurements inform about the air quality situation directly in the vicinity of the air sampler. They have a limited representativity when regarding air quality information at several hundred metres or even few kilometres distance. To overcome this shortcoming chemistry transport models are utilized. These models consider anthropogenic and biogenic emissions, the meteorology (temperature, wind, solar radiation) and the chemical interactions between different air constituents. In addition they allow a prediction of the expected air quality situation for the upcoming days.

Model development

Aim of the project is the prediction of tomorrow's (up to 72 hours in advance) health risk of COPD- and asthma-patients due to environmental conditions. This information needs to be provided on a high spatial resolution.

Meteorological forecasts are computed using the Weather Research and Forecast model (WRF). The interaction of meteorology, emissions (provided by the LfU) and chemical atmospheric constituents is solved by the POLYPHEMUS/DLR air quality model.

POLYPHEMUS/DLR provides state of the art high resolution forecasts of air pollution in Bavaria. Figure 2 shows a sample result for 4.10.2010.

The model chain is routinely operated at German Aerospace Center. The obtained results on air tracer concentration will be available to all scientists working at Schneefernerhaus in order to support their research fields.

Combining these data with the knowledge gained within this project will help to provide patients with health information in an easily understandable way.

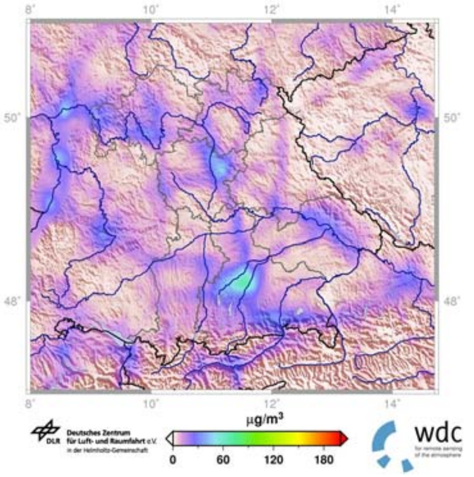

Fig.2: Air quality forecast as provided by the POLYPHEMUS/DLR air quality model

LUNG FUNCTION IN ADULTS WITH CYSTIC FIBROSIS AT ALTITUDE - IMPACT ON AIR TRAVEL

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Current guidelines for air travel state that patients with chronic respiratory diseases are required to use oxygen if their in-flight PaO2 values drop below 6.6 kPa. This recommendation may not be strictly applicable to cystic fibrosis (CF) patients who may tolerate lower PaO2 values for several hours without clinical symptoms.
We studied lung function, symptoms, blood gases and signs of pulmonary hypertension in 36 CF patients at 500m and after 7 hours at 2650m. A hypoxia inhalation test (FiO2=0.15) was performed at low altitude to predict high altitude hypoxemia.
Median PaO2 dropped from 9.8 kPa at low altitude to 7.0 kPa at high altitude. Mild exercise with 30 watts further decreased PaO2. Two thirds of all patients had PaO2 values below 6.6 kPa during exercise and were asymptomatic except for one patient. Patients were significantly less obstructed at 2650m. Low FEV1 at baseline was associated with low PaO2 at altitude.
We conclude that CF patients with baseline PaO2 values > 8 kPa safely tolerate an altitude of 2650 m under resting conditions for several hours. The risk assessment of low in-flight oxygenation should encompass the whole clinical situation of CF patients with special attention to the presence of severe airway obstruction.

Current recommendations for oxygen prescription for air travel are derived from the positive effects of oxygen supplementation on right heart function, respiratory muscle function and survival in patients with chronic hypoxemia {Crockett, 2000 1535 /id}. These effects rely however on long-term oxygen application of at least 15h/day. It is less clear what effects short episodes of hypoxemia may have especially in those subjects adapted to chronic hypoxemia. It is noteworthy that patients with CF carry virtually no cardiovascular risk and are on average younger than COPD patients.

We assessed the tolerance of adult patients with cystic fibrosis to hypoxic challenge in a laboratory setting at sea level and during actual exposure to high altitude in a mountain laboratory. This was done with the assumption that the results of an assessment performed in a mountain laboratory simulate what happens during flight. There is no doubt that patients on board an aircraft tend to remain in one position for long durations, that they may sleep and that the cabin atmosphere is dry. However, for technical and financial reasons it is not feasible to measure lung function, blood gases or echocardiography during flight in a commercial aircraft.

We chose actual exposure to high altitude on a mountain because measurements of lung function, blood gases, echocardiography and exercise testing could be performed easily. Furthermore, the stay in a mountain lab can be extended for the duration of an international flight, in our study seven hours. To improve the comparability of our data to the in-flight situation, we did not allow walking distances of more than 150 m. In addition, we encouraged our subjects to rest in a sitting position. Although the stay at a high altitude laboratory is not fully comparable to a long distance flight, the probability of underestimation of hypoxia is low due to the slightly higher altitude of the laboratory (2650 m) compared to the maximum allowed cabin pressure of 2438 m (8000 ft)

Conclusion

Our results clearly indicate that the majority of CF patients adapted to chronically impaired lung function und hypoxia may tolerate PaO2 values below 6.6 kPa (50 mmHg) for several hours without clinically relevant symptoms at rest. In fact, no patient showed any signs of cardiopulmonary decompensation when exposed to high altitude at rest.

Table 1: Baseline respiratory values (500 m above sea level) and after 1 h at 2660 m

Parameter	Baseline	1 h at 2660 m	p
FEV1 (% predicted)	66 (26 - 107)	69 (30 – 115)	< 0.001
FVC (% predicted)	85 (51 – 108)	88 (47 – 119)	0.02
FEV1 / FVC (Tiffeneau index)	65.7 (34 – 89)	68 (44 – 86)	0.001
PEF (% predicted)	72% (24-112)	88 (42 – 132)	< 0.001
MEF25 (% predicted)	19 (0 – 75)	28 (8 – 76)	< 0.001
Raw (kPa*s/l)	0.4 (0.1-1.1)	0.32 (0.16 – 1.1)	0.009
ITGV (% predicted)	117 (63 – 196)	132 (70 – 194)	< 0.001
TLC (% predicted)	105 (66 – 131)	109 (66 – 142)	0.032
Residual volume (% predicted)	152 (79-286)	188 (68 – 341)	0.14
PaO2 (kPa)	9.8 (8 – 13)	7.0 (5.3 – 10.5)	< 0.001
PaCO2 (kPa)	5.1 (4.4 – 6)	4.7 (3.7 – 6)	< 0.001
SaO2 (%)	95 (89 – 99)	90 (66 – 98)	< 0.001
Pulse rate	83 (66 – 110)	84 (66 – 118)	0.059

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IMPACT OF CLIMATE CHANGE IN THE ALPS
- OBSERVATIONS ALONG ALTITUDINAL GRADIENTS-

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The project KLIMAGRAD (funded by the Bavarian State Ministry of the Environment and Public Health) studies impacts of climate change to mountain ecosystems in Werdenfelser Land (Bavaria). Adjacent to the Environmental Research Station Schneefernerhaus, a web of climate station gradients has been set up to initiate research in the field of atmosphere-biosphere interactions. In addition to existing climate stations, four new ones have been set up in different altitudinal zones. They provide a fundamental climatic database for different investigations within the project ranging from vegetation shifts in space and time to immission of pollutants. In particular, temporal vegetation changes in different altitudes in the montane to subnival zone, as well as anthropogenic BVOCs and nitrogen deposition as additional stressors, are monitored and analysed.

In the joint research project KLIMAGRAD, the Chair of Ecoclimatology (Technische Universität München), the Institute of Ecological Chemistry (Helmholtz Zentrum München), the Chair of Physical Geography and Quantitative Methods – Group of Biogeography (Universität Augsburg), the Munich Botanical Garden and the Department of Systematic Botany (Ludwig Maximilians Universität München) are involved. In several sub-projects (Fig. 1) different aspects of climate change in the Alps are studied.

At the Botanical Garden at Schachen a new phenological observation program has been established, which provides the basis for long-term monitoring within a newly established network of arctic-alpine botanical gardens.

At observation sites along four altitudinal gradients in the area of Garmisch-Partenkirchen, phenology of vegetative and generative phases (flowering, fruiting) of tree species and their correlation with altitude, temperature and habitat parameters are analyzed.

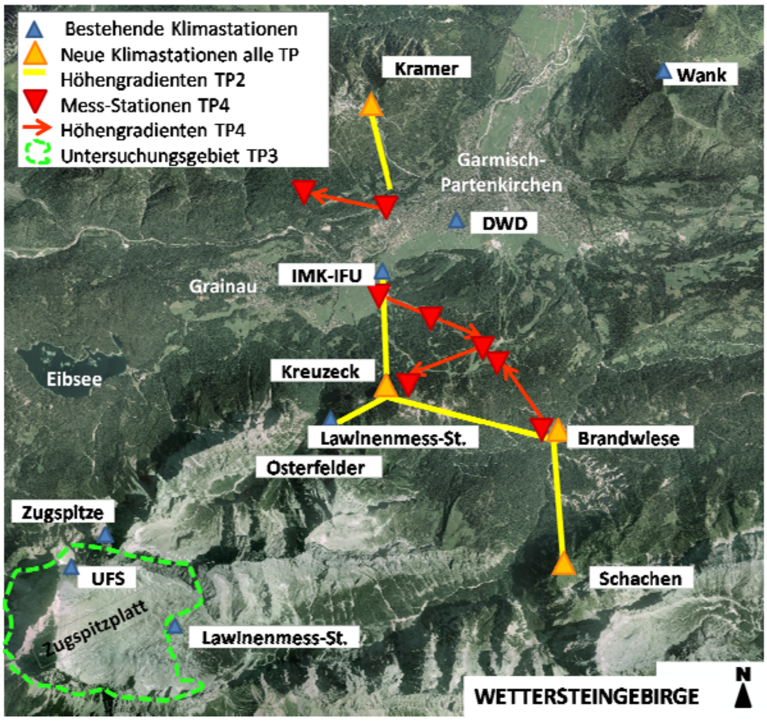


Fig.1: Overview of KLIMAGRAD research locations in the area of Garmisch- Partenkirchen

Along gradients at Kramer and Kreuzeck/ Hausberg in particular the immission of nitrogenous compounds in montane and subalpine spruce populations in northern alpine regions is investigated.

At the Zugspitzplatt the research focus is on the impacts of climate change and anthropogenic-zoogenic influences on the vegetative association of alpine species (see report on HÖHENZUG).

New meteorological stations
To provide a basic infrastructure for the research project KLIMAGRAD, we have installed and operate four new meteorological stations in different altitudinal elevations in the Garmisch-Partenkirchen area. They supply the project partners with substantial climate data from the region. After several inspections of the terrain and consultations with the Bavaria State Forest Enterprise, the project partner Alpine Botanical Garden Schachen and others, the following installation sites were chosen: Brandwiese (930 m a.s.l.) in the Reintal, Felsenkanzel at the southern slope of Kramer (1250 m a.s.l.), Kreuzalm at Kreuzeck (1600 m a.s.l.) and the Alpine Botanical Garden Schachen (1830 m a.s.l.).

From November 2009 (Schachen) and March 2010 onwards, the following meteorological parameters are available on the internet via transmission by GPRS-modem (Fig. 2):

- Global radiation
- Air temperature
- Air humidity
- Soil temperature at 5 and 25 cm depth
- Surface temperature
- Wind direction
- Wind velocity
- Precipitation

Currently the climate data are used by 17 scientists of six different institutions for their research in the Garmisch-Partenkirchen area.

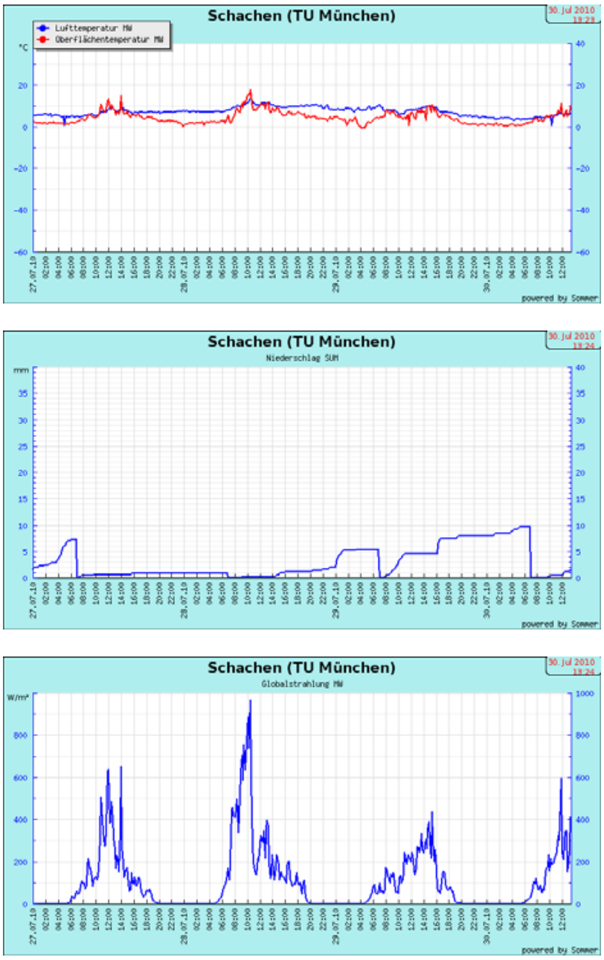
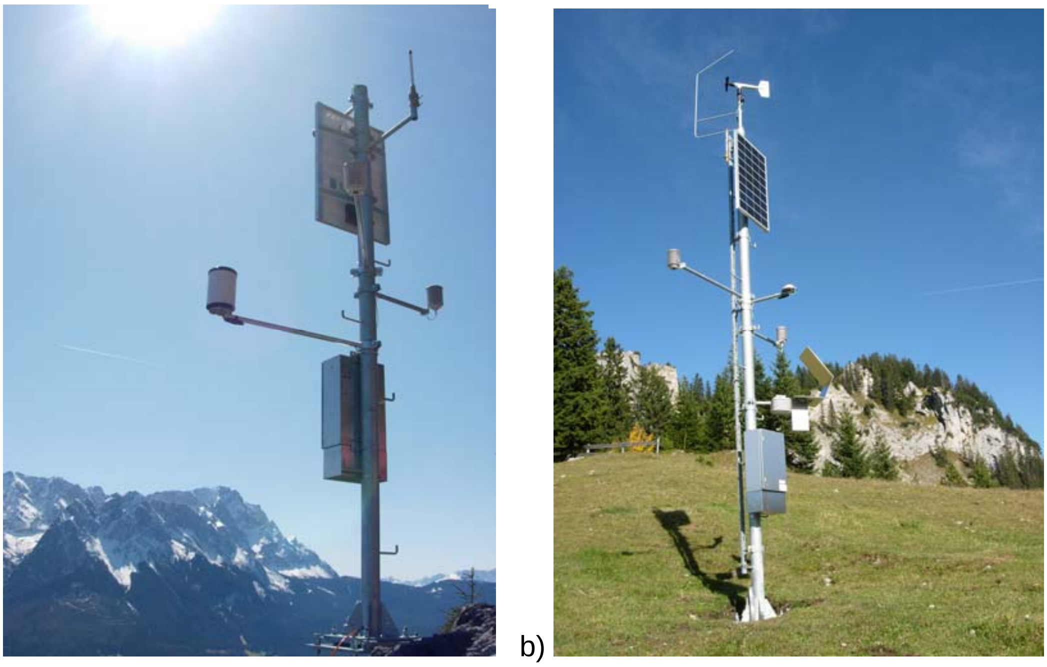


Fig.2: Examples of climate data from the meteorological station at Schachen (27.-30.06.2010)



a) b)

Fig. 3: New meteorological stations at Felsenkanzel with Zugspitze in the background (a) and at Kreuzeck (b)

A MULTI-SENSOR APPROACH TOWARDS A BETTER UNDERSTANDING OF SNOWFALL MICROPHYSICS: THE TOSCA PROJECT

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Although snow is the predominant type of precipitation in sub-polar and polar latitudes, not many reliable methods for determining micro-physical snowfall parameters exist today. Ground-based remote sensing in synergy with in-situ measurements as performed at UFS during the TOSCA campaign offers a wide potential to gather relevant information on the vertical distribution of snowfall necessary for satellite retrieval applications as well as for numerical model evaluation.

Introduction

A large part of the global precipitation falls as snow and most liquid precipitation is initiated via the ice phase. However, measuring snowfall is a highly complicated matter. The main challenges are the high spatial and temporal variability as well as the enormous complexity of snow crystal habit, density and particle size distribution (PSD). Given the enormous uncertainties in the prediction of frozen hydrometeors in numerical weather prediction and climate models, reliable monitoring of snow water content is essential. Remote sensing methods are actually the only means suited for this purpose because they can provide continuous observations with high temporal and spatial coverage. Accurate surface-based in-situ measurements of snowfall are problematic due to large errors in windy conditions, and their sparse spatial and temporal resolution. Additionally space-based remote sensing methods for deriving snowfall are not very sophisticated and suffer from large uncertainties.

Active cloud radar measurements in snow are dominated by the backscatter signal originating from ice crystals, while passive microwave measurements are either insensitive to ice scattering (below 50 GHz) or sensitive to both liquid water emission and ice particle scattering (above 90 GHz). Thus, when combining active and passive microwave measurements, the correct quantification of the super-cooled liquid water (SLW) phase is essential. This is further interesting concerning the role of SLW in snow production mechanisms such as diffusion (crystal growth via water vapour), riming (freezing of SLW on existing crystals) and aggregation (merging of two ice crystals).

Fig.1: Instruments deployed at UFS during winter 2008/2009. Top from left to right: Microwave profiler HATPRO, 90/150 GHz radiometer DPR, 36 GHz cloud radar MIRA36. Bottom from left to right: 10 m meteorological mast, 2-dimensional video disdrometer, Ceilometer, Micro-Rain-Radar, Parsivel disdrometer.

The TOSCA Project

In light of the above-mentioned scientific challenges the TOSCA (Towards an Optimal estimation based Snow Characterizing Algorithm) project, funded by the German Science Foundation (DFG), employed measurements with a unique combination of instruments (Fig. 1) at UFS. The TOSCA campaign took place in the winter season 2008/2009. The focus of the project lies in the development of improved measurement techniques for snow and SLW at temperatures below freezing throughout the atmospheric column. The main TOSCA science questions are:

- What are the combined influences of snow particle habit, PSD, mass density and SLW on passive and active microwave observations?

- Do the TOSCA observations fit to results obtained from radiative transfer models assuming common snow crystal habits and size distributions?

- Can the accuracy of remote sensing retrievals of snow water be improved if active cloud radar measurements are combined with passive microwave measurements?

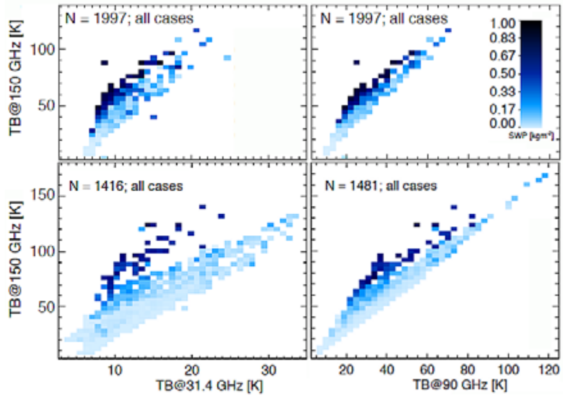

Fig. 2: Brightness temperatures scatter plots as a function of SWP for the TOSCA campaign. Top: simulations, bottom: measurements.

Microwave Signals during Snowfall

In the following we want to highlight the effect of snowfall and SLW on ground-based passive microwave measurements during snowfall events. Fig. 2 shows scatter plots for brightness temperatures (TB) as a function of snow water path (SWP). The simulations (top row) use radiative transfer simulations based on mesoscale meteorological COSMO-DE simulations. The observed TB (bottom row) are from the UFS microwave radiometers while SWP was retrieved from the cloud radar. The larger SWP values at increasingly higher 150 GHz TBs underline the higher sensitivity towards SWP with respect to 31.4 and 90 GHz. At 150 GHz the snow scattering signal is largest, whereas at 31.4 GHz the variance of the signal is almost solely caused by water vapour and liquid water variations. Note, that in contrast to the simulations, we see in the observations a rather large range of scatter in the 150-31.4 GHz plot in cases of negligible SWP. We attribute this variability mainly to the differences in temperature dependence of the emission of SLW at 31.4 and 150 GHz. At 31.4 GHz the same amount of SLW gives rise to higher TB's at colder ambient temperature than at warmer temperature, whereas this relation is opposite at 150 GHz. Apparently the temperature range in which SLW occurs in the model is much more restricted than in reality, indicating that SLW is underestimated in the model.

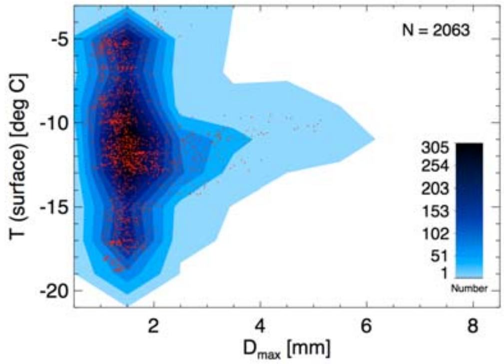

Fig.3: Surface temperature as a function of snow crystal maximum diameter. The measurements corresponding to 10 minute averages are shown as orange dots.

Snow Crystal Observations

An interesting feature was observed from the evaluation of the histogram of maximum particle size dimension D_{max} (from 2D-video disdrometer) and surface temperature (Fig. 3). D_{max} seems to be temperature independent, – except for the temperature range between -10 and -15 °C where we see a more frequent occurrence of larger snow crystals. In this temperature range the super saturation over ice with respect to liquid water reaches its maximum value so that the Wegener-Bergeron-Findeisen process, i.e. the transformation of liquid drops to ice crystals via the gas phase, may be more effective. Also, snow crystals are mostly of dendritic structure in this temperature range. Both conditions are preferable for the fast and effective growth by aggregation of snow crystals in this "secondary growth region".

Summary and Outlook

With the TOSCA data set we have collected an unprecedented combination of measurements which can provide key pieces of information needed to improve the understanding of the microphysical characteristics of mid-latitude winterly precipitation systems. Additionally we have shown the potential for deriving information on microphysical processes such as aggregation and diffusion growth.

Measurements as carried out during TOSCA are vital from the perspective of space-borne missions like EarthCARE or GPM. The instrumentation at UFS will provide a valuable contribution for the validation and development of future retrieval algorithms using active and passive microwave measurements.

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PHENOLOGICAL OBSERVATIONS AND VEGETATION SURVEYS IN THE MONTANE AND SUBALPINE ZONE IN THE WETTERSTEIN AREA AND AT SCHACHEN

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In sub-project 2 of the joint research project KLIMAGRAD, the phenological response of alpine species to climate change is investigated. The Alpine Botanical Garden Schachen has initiated a new network of arctic-alpine botanical gardens including a new phenological observation key. Also the phenological response and vitality of mountain forest trees to altitude and temperature are observed to assess possible future developments in species and habitat shifts.

1. Establishment of a long-term phenological observation program at the Alpine Botanical Garden Schachen (subalpine zone)

Botanical Gardens are an important source of long-term phenological observation series (Primack & Rushing 2009). Analysis of these series improves understanding of climate change impacts on plant life cycles (Menzel et al. 2006). Although mountain ecosystems in Europe are the habitat most threatened by climate change (Schröter et al., 2005), so far there are no long-term phenological observations in these high elevation areas. This lack of information should now be overcome by the establishment of a new phenological monitoring program within an European network of arctic-alpine botanical gardens.

Criteria of indicator species included are:

- European alpine species
- Easy vegetative reproduction
- Different life forms
- High ecological amplitude
- Clear definition of phenological attributes
- Attributes stretch over the growing season

A very important criterion to determine the phenological attributes of the new observation key is a very easy recognizability and documentation of the phenomena. Meeting these criteria the following species were selected for the observation program: *Allium senescens, Alnus viridis, Arnica montana, Dianthus alpinus, Dryas octopetala, Geum reptans, Helianthemum alpestre, Lonicera alpigena, Potentilla nitida, Rhodiola rosea, Rhododendron ferrugineum, Ribes alpinum, Salix reticulata* and *Saxifraga paniculata*.

The determination of useful phenological attributes (Fig. 1) and the composition of the observation key is the basis for the long-term project. This was achieved during a diploma thesis. At the same time for the selected indicator species, a collection of mother plants was set up. These mother plants provide vegetative reproduced clones with identical genetic information which will be supplied to the phenological gardens involved in the project.

Gardens involved so far:

- Alpengarten auf dem Schachen (D)
- Giardino Botanico Alpino "Viotte" (I)
- Jardin Botanique Alpin du Lautaret (F)
- Jardin d'Altitude du Haut Chitlet (F)
- Tromsø Arctic-Alpine Botanic Garden (N)
- Reykjavik Botanic Garden (IS)

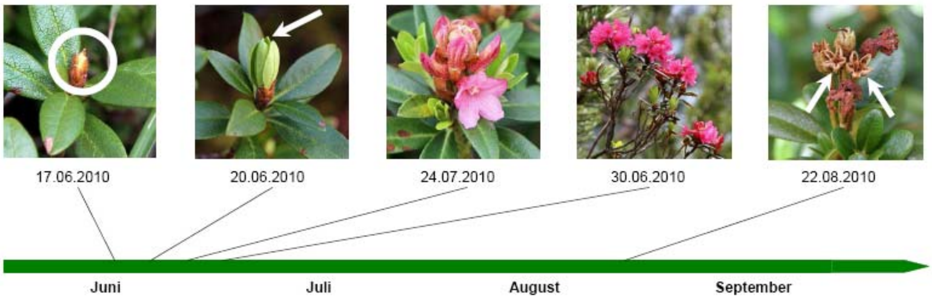

Fig.1: Phenological attributes with onset dates 2010 for Rhododendron ferrugineum

2. Phenological observation of mountain forest trees along altitudinal gradients (montane zone)

In Werdenfelser Land four observation transects along altitudinal gradients between 700 and 1800 m elevation were selected including the sites of the four new meteorological stations: Garmisch-Kramer, Garmisch-Kreuzeck, Brandwiese-Kreuzeck and Brandwiese-Schachen. With 100 m altitudinal difference between each, observation sites in the forest were chosen for phenological observation. At each site, a temperature and humidity logger HOBO Pro V2 was installed and three dominant and three young trees per species (*Abies alba*, *Acer pseudoplatanus*, *Fagus sylvatica*, *Larix decidua*, *Picea abies*, *Pinus cembra*, *Pinus mugo*, *Pinus sylvestris*) were chosen - 548 individuals in total. From April to July, weekly phenological observations were undertaken according to the BBCH code (Meier, 1997, Fig. 2).

All tree species show a clear response to altitude in their phenological development.
The slope of a regression line of the data provides the delay of onset dates of a phenological phase with altitude. These slopes reveal a high variation between species and observed phenological phase. Often, young trees show a different reaction to altitude than adult trees. Furthermore, there is obviously a difference between onset dates of north and south exposed sites. Leaf (needle) unfolding time decreases with increasing altitude.

In autumn, senescence (leaf colouring and leaf fall) were observed for the species *Acer pseudoplatanus*, *Fagus sylvatica, Larix decidua* and *Sorbus aria*. Therefore, percentages of green, coloured and fallen leaves were estimated. Here, the dependency of the onset dates of the phenophases on altitude and temperature, but also on spring phenology timing, is investigated. Röthlisberger (2010) characterizes three different possible options: (1) the vegetation period increases due to climate change, (2) autumn phenology is strongly linked to spring phenology by a constant vegetation period, (3) autumn and spring phenology respond independently to the actual environmental circumstances.

By comparison of the observed temperature responses of the phenology of mountain tree species with models of future global warming, likely trends in shifts of vegetation period, habitats and tree line can be assessed. The results also provide hints of potential vulnerable species like *Pinus cembra*, which are endangered by temperature increase because of a small sensitivity or lack of areas to retreat to.

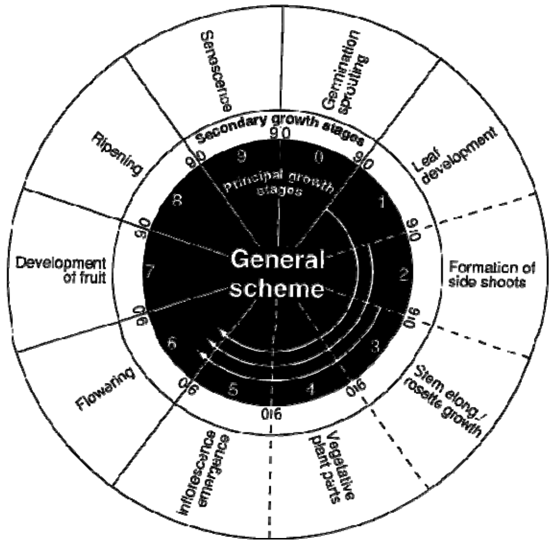

Fig.2: General scheme of the BBCH scale of phenological phases (Meier 1997)

References

Meier U (1997) BBCH-Monograph, Growth stages of plants - Entwicklungsstadien von Pflanzen - Estadios de las plantas – Développement des Plantes, Blackwell Wissenschaftsverlag, Berlin und Wien.
Menzel A (2006) Zeitliche Verschiebungen von Austrieb, Blüte, Fruchtreife und Blattverfärbung im Zuge der rezenten Klimaerwärmung. Forum für Wissen 2006, 47-53.
Primack RB, Miller-Rushing AJ (2009) The role of botanical gardens in climate change research. New Phytologist 182 / 2, 303-313.
Röthlisberger J (2010) Früher Frühling – früher Herbst? Beobachtungen und Reflexionen zur Herbstphänologie. BAUHINIA 22, 93-110.
Schröter D, Cramer W, Leemans R, Prentice IC, Araújo MB, Arnell NW, Bondeau A, Bugmann H, Carter TR, Gracia C A, de la Vega-Leinert AC, Erhard M, Ewert F, Glendining M, House JI, Kankaanpää S, Klein RJT, Lavorell S, Linder M, Metzger MJ, Meyer J, Mitchell TD, Reginster I, Rounsevell M, Sabaté S, Sitch S, Smith B, Smith J, Smith P, Sykes MT, Thonicke K, Thuiller W, Tuck G, Zaehle S, Zierl B (2005) Ecosystem service supply and vulnerability to global change in Europe. Science 310, 1333 -1337.

ALTITUDE DOES NOT INFLUENCE PLANT PHENOLOGICAL TRENDS IN THE ALPINE REGION

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We evaluated the influence of altitude on plant phenology over a large area (46 to 49°N latitude and 5 to 15°E longitude) for 1971–2000. Our attention was focused on flowering of widely distributed plants in Europe, including some important allergenic species. We calculated the dependence of phenological mean dates on altitude for different phenophases (BF -beginning of flowering, FFO - first flower opens, FF - full flowering) using linear regression. Results show a statistically significant linear dependence of mean dates on altitude. In contrast, phenological trends and temperature trends show a less strong, often non-significant, dependence on altitude.

In the past, mountain regions were regarded as healthy places for hay fever sufferers due to a low occurrence of airborne pollen compared to lowlands. Recently, however, highlands seem to have been more strongly affected by climate change than other regions. Global warming could be a major cause of biodiversity change on mountain tops. A general rearrangement of the Alpine flora could result from an elevational shift in species ranges. Phenology, the science of recurrent seasonal events, can help us understand the influence of global warming on changes in plants of the Alpine region. In the present study we used the dataset collected within the COST725 action 'Establishing a European phenological data platform for climatological applications' and the E-Obs dataset from the EU-FP6 project ENSEMBLES for monthly mean temperatures.

Results

In general, phenological onset dates depend on altitude with a very high level of significance (see Fig. 1). The value of this altitude response ranges from 0.92 ± 0.21 d $(100\ m)^{-1}$ for Norway spruce BF to 4.56 ± 0.21 d $(100\ m)^{-1}$ for common hazel BF. The value of R^2 is >0.50 for 6 out of 10 phenophases, indicating that variability of dates is well explained by altitude.
However, the analysis of altitudinal gradients of phenological trends (Fig. 2) leads to less clear results in comparison to those of phenological gradients. Values range from 0.042 ± 0.022 (small-leaved lime FFO) to –0.065 ± 0.028 d yr^{-1} $(100\ m)^{-1}$ (common alder BF); however, these regressions are statistically significant for only 3 phenophases and their relevance, indicated by R^2, is generally low ($R^2 < 0.075$). Moreover, the datasets with the largest number of stations (common hazel BF, 436; goat willow FFO, 359) have the smallest R^2 value (0.0002 and 0.0012, respectively): this finding strongly suggests the lack of dependence between phenological trends and altitude. Also, temperature trends do not show a significant dependence on altitude.

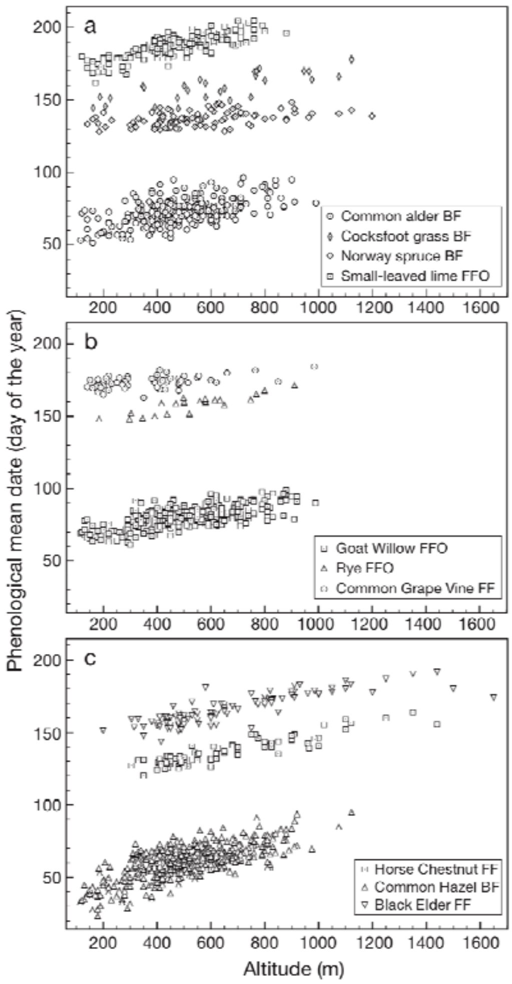

Fig.1: Phenological mean dates versus altitude, calculated in the Alpine region. Each altitudinal series is a different phenophase. Means are calculated over temporal series of more than 15 yr. BF: beginning of flowering; FFO: first flowers open; FF: full flowering

Conclusions
The temperature decrease with elevation results in a significant linear dependence of all the studied phenophases on altitude. Although climate warming is more pronounced in mountainous areas than in lowlands, there is obviously no dependence of observed temperature trends on altitude within the Alpine region. Similarly, phenological trends do not depend on altitude.

Future perspectives
Further research is needed to better understand changes of the pollination period and intensity in the Alps under climate change, including the influence of local exposition and sites (Fig. 3). We will also investigate the role of episodes of long-range pollen transport and local emissions on airborne pollen concentration monitored at three sites around the UF Schneefernerhaus (Garmisch at 720 m a.s.l., Ehrwald at 1503 m a.s.l., and Schneefernerhaus at 2650 m a.s.l.).

References
Ziello C, Estrella N, Kostova M, Koch E, Menzel A (2009) Influence of altitude on phenology of selected plant species in the Alpine region (1971–2000). Clim Res 39:227-234

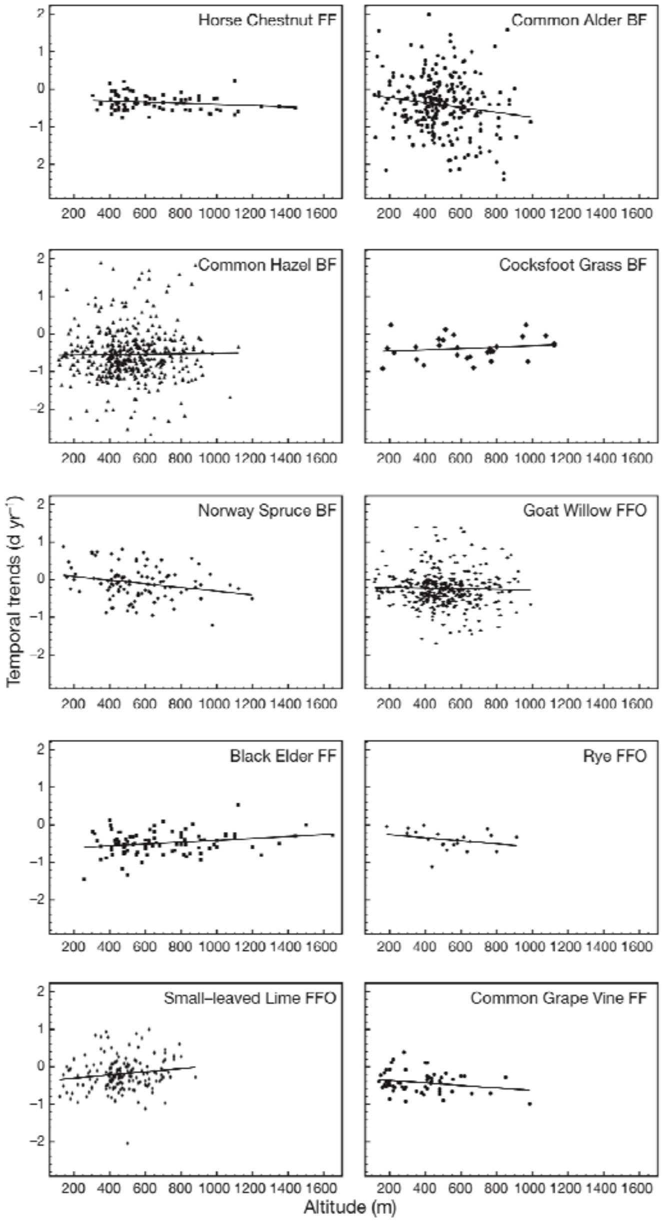

Fig.2: Temporal trends (1971–2000) of 15+ year phenological series versus altitude, together with their linear fits

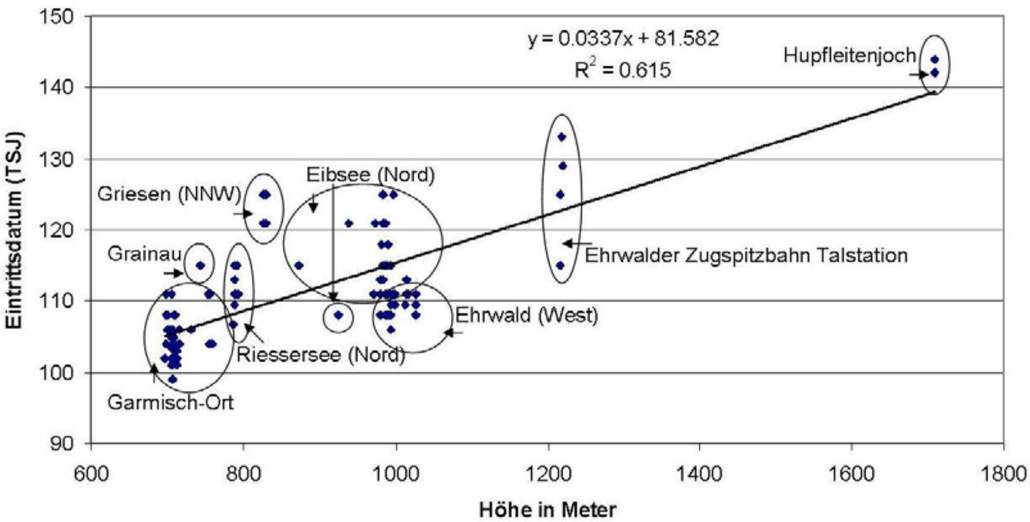

Fig.3: Dates of Birch BF in the alpine area around the city of Garmisch as a function of altitude and different exposition for the year 2009

ATMOSPHERIC NITROGEN DEPOSITION AND VOCS ALONG ALTITUDINAL GRADIENTS

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Within the scope of the project KLIMAGRAD (Impacts of climate change in the Alps – Observations along altitudinal gradients) we studied nitrogen deposition into montane and subalpine spruce stands in Werdenfelser Land in combination with the behavior of anthropogenic and biogenic VOCs. More details on the project KLIMAGRAD can be found in the overview chapter (Schuster et al., this issue). In this report the most important results so far and further objectives of the sub-project 'Deposition/Emissions' running until 2012 will be given.

Nitrogen deposition into montane and subalpine spruce stands

Nitrogen plays an essential role in plant nutrition, but it can develop quickly from a fertilizer to a stress factor. In the context of climate warming, the current nitrogen input into alpine ecosystems could be to a burden. In addition to potential sources in the valley and the prealpine region, nitrogen input is affected by meteorological parameters such as rainfall, the type of precipitation, humidity and air temperature. Topographic factors such as exposure, altitude, slope of the hill, lee situations and plant surfaces also play an important role in deposition. This means that deposition can vary greatly within small distances. This issue will be investigated in alpine spruce stands along two different exposed gradients at Kramer and the Kreuzeck/Hausberg in the Garmisch-Partenkirchen area. A total of eight points, each consisting of an open field and a forest measuring point have been established. The open field and throughfall deposition have been measured by bulk samplers, the ambient air concentration of NH_3 and NO_2 by ventilated passive samplers and air temperature and humidity by thermohygrobuttons. The aim of this study is to obtain data for the interpretation of nitrogen input into a complex terrain. A comparison of deposition in cold and warm or rainy and dry years can serve as a framework for scenarios of future climate evolution.

Ambient air concentrations of NO_2 and NH_3

First results of the measurement of ambient air concentrations are shown in Fig. 1. Due to the vicinity of emission sources, both NH_3 and NO_2 had their highest values in the Loisach Valley. While traffic and domestic heating represent the main sources of NO_2, NH_3 originates mainly from agricultural activities, e.g. from liquid-manure. As a result of the emission pattern, a contrasting annual course of the concentration of both gases can be expected. The concentrations of both gases decrease with altitude and with the distance from emission source.

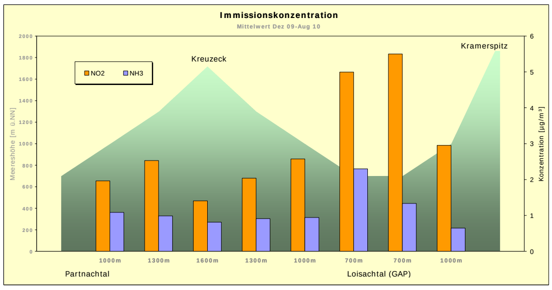

***Fig. 1:** Mean values of the ambient air concentration of nitrogen dioxide and ammonia for the period December 2009 to August 2010*

Deposition measurements

The open field deposition is determined by the concentration in precipitation (decreasing with altitude) and precipitation amount (increasing with altitude). This contrasting trend can explain the relatively homogeneous ammonium deposition at all altitudes (Fig. 2). The highest values in the Loisach Valley are caused by the vicinity to the emission sources. The deposition in forest stands is influenced by the filter effect of the stands and the increasing frequency of fog and clouds. This can explain the very high deposition at Kreuzeck at 1600 m a.s.l. A similar picture emerges for the nitrate-nitrogen input. Furthermore, single events, like the eruption of the volcano Eyjafjallajökull on Iceland and the spread of its ash cloud over Europe can be detected in the results of nitrogen input and other substances. Detailed evaluations are presently still in progress.

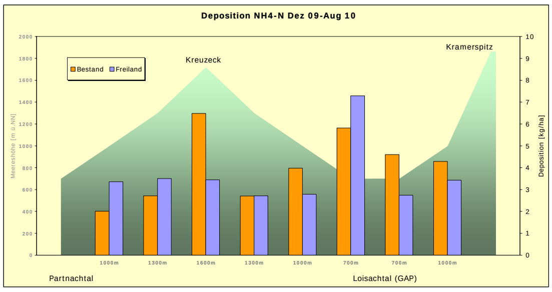

Fig. 2: Sum of ammonium-N-deposition for the period December to August 2010

Significance of volatile organic compounds (VOCs)

Tropospheric ozone, in addition to its direct negative impacts on plants (growth reduction, dieback etc.) and humans (e.g. respiratory diseases), is one of the most important greenhouse gases that has contributed largely to the anthropogenically caused radiative forcing since the beginning of industrialization. Its atmospheric background concentration is expected to increase during the 21st century. In contrast to other greenhouse gases, it is not emitted directly, but by photochemical processes of precursor compounds. Besides NO and NO_2, volatile organic compounds (VOCs) are the most important precursors that on one hand have a direct climatic effect and on the other hand contribute significantly to the anthropogenic greenhouse effect by formation of ozone and aerosols. The most important sources for VOCs in the atmosphere are fossil fuel burning from traffic and industrial processes, handling and evaporation of fuels and solvents, and emissions from plants that are linked to photosynthesis or stress defense. In particular, biogenic VOC emissions are expected to increase drastically due to increased temperature stress and thus also the fraction of biogenic precursors to the production of ozone. Improved knowledge about the composition of these VOCs will deliver important information about the contributions of emissions of biogenic and anthropogenic origin to the formation of ozone, aerosols, and other photochemically produced compounds and thus to climatic effects.

Analysis of VOCs along altitudinal gradients

During several days with different typical meteorological situations in the Zugspitze region altitudinal gradients of VOC mixing ratios will be determined. At selected sites (Fig. 3) air samples will be collected simultaneously with adsorption tube samplers. These samples will be analyzed with a GC-FID system offline. The objective is the determination of the impacts of different meteorological processes (e.g. upslope/downslope katabatic winds, vertical mixing and boundary layer development, inversions, foehn) with respect to overlaying synoptic conditions for the spatiotemporal distribution of ozone precursor compounds along the gradients. Four tentative campaigns could already be conducted along the altitudinal gradients displayed in Fig. 3 in summer 2010. The main focus of the campaigns will be set on summer 2011.

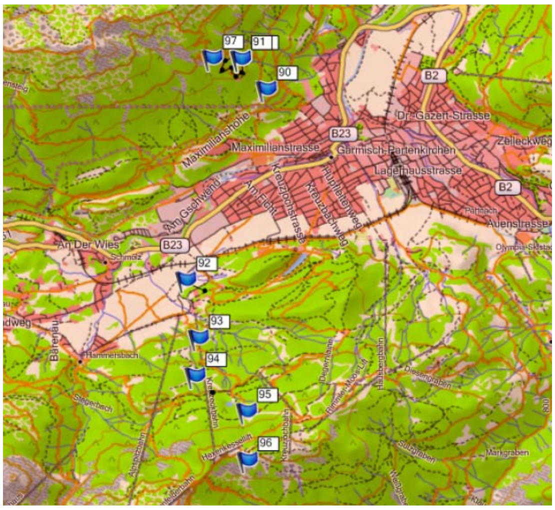

Fig. 3: Map of the sampling sites at Kreuzeck (S; 93-96), at Kramer (N; 90/91/97) and at the IMK-IFU (92).

Apportionment of VOC sources at the UFS

A first analysis of a ten year data set of the German Federal Environment Agency for the UFS Schneefernerhaus provided first results of source profiles at the high altitude station. Results of this study can be found in Ries et al. (this issue). As the project proceeds, an online GC-FID system will be installed at the UFS at the beginning of 2011 to provide quasi-continuous data of VOC mixing ratios. The measurements will only be interrupted for the analysis of the offline samples from the adsorption tubes. The objective is a quantitative apportionment of the main anthropogenic and biogenic hydrocarbon sources affecting the high mountain site UFS Schneefernerhaus.

HIGH-POWER LIDAR SOUNDING OF WATER VAPOUR AND TEMPERATURE UP TO THE STRATOSPHERE

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The primary greenhouse gas water vapour constitutes a new focus of lidar vertical sounding within the global "Network for the Detection of Atmospheric Composition Change" (NDACC), with emphasis on the climate-relevant upper troposphere and lower stratosphere. As a first step we developed a powerful differential-absorption lidar system at the Schneefernerhaus. The location of the laboratory near the edge of the moist lower-atmosphere has made possible routine measurements of water vapour in the entire free troposphere with high vertical and temporal resolution as well as errors of about 5 % up to 8 km. An extension of lidar sounding into the stratosphere is under way. Our solution is a particularly large Raman lidar system based on a 350-W XeCl laser system and a 1.5-m-diameter receiving telescope leading to a two-order-of-magnitude increase in backscatter signal with respect to existing systems. The new lidar will also provide temperature profiles up to more than 80 km.

Introduction

Due to its abundance and due to absorbing infrared radiation in a wide spectral range water vapour is the most important greenhouse gas, contributing roughly two thirds of the greenhouse effect. Thermal radiation is released to space mostly at altitudes with sufficiently low humidity (typically above 5 km). Any change in humidity at these higher altitudes has critical influence on the radiation budget of the atmosphere. During the past decade there have been considerable efforts for developing improved instrumentation for quantitative vertically resolved measurements of water vapour in the upper troposphere and lower stratosphere (UTLS), some severe deficiency remaining in the altitude range between10 and 20 km.

Lidar ("laser radar") sounding has a high potential for vertically resolved measurements in the UTLS. A challenge for lidar methods is the low signal level for large distances combined with the low concentration of UTLS water vapour. This requires the development of systems with particularly powerful lasers and large receivers for the radiation backscattered from the atmosphere.

There are two options, the differential-absorption lidar (DIAL) or Raman-lidar technique. The DIAL method offers the clear advantages of a stable, accurate calibration, a much higher sensitivity, short measurement times and full daytime capability. Because of these advantages a particularly powerful DIAL system was installed by us at the Schneefernerhaus (UFS) that, as the first ground-based system, covers the entire free troposphere above 3 km [1]. An extension of DIAL sounding into the stratosphere under average conditions requires an unrealistic laboratory altitude of about 7.5 km. Therefore, for stratospheric measurements we decided to use the Raman approach, this necessitating to install an ultraviolet laser with some of the highest power available.

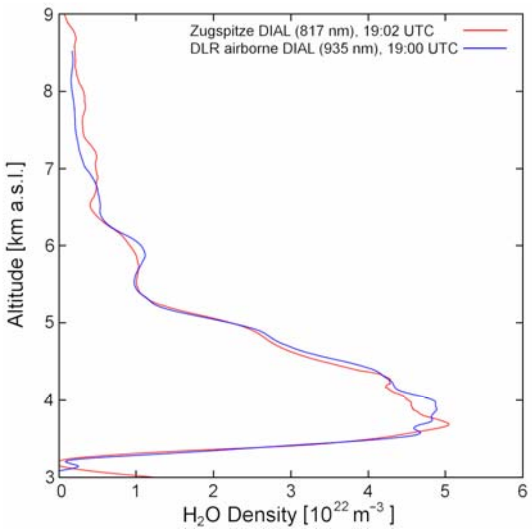

Fig.1: Comparison of the UFS DIAL and the DLR airborne DIAL on October 17, 2008 (LUAMI): The agreement is highly satisfactory below 6.3 km. The differences above this are explained by drier air during the approach of the aircraft.

Results 2009-2010 for the DIAL

After extensively testing the DIAL system routine measurements were started in 2007, with typically two measurement days per week. The results show a variability of the mean water-vapour density covering more than a factor of fourty. Particularly low densities, correspondding to 0 to 2 % relative humidity have been observed during stratospheric air intrusion events, values that are rarely recorded by standard *in-situ* instrumentation. In Fig. 1 a rather narrow intrusion layer is seen at 3.2 km. The more or less negligible humidity suggests a surprisingly low degree of mixing with tropospheric air on its long way from the arctic stratosphere to the Alps, a challenge for numerical models which overestimate free-tropospheric air-mass mixing.

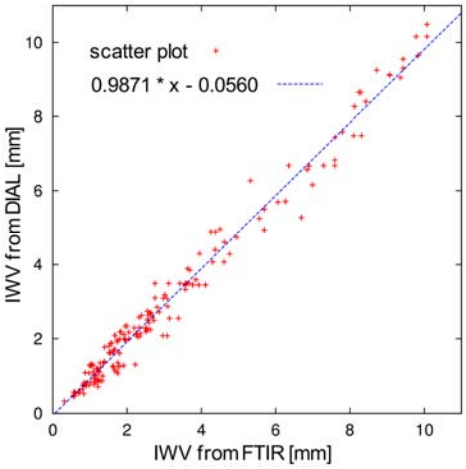

Fig.2: Comparison of vertically integrated water vapour (IWV) from the DIAL with that from the Zugspitze FTIR [2] (taken from [3])

The DIAL has demonstrated its high-quality profiling capability within the Lindenberg Upper Air Methods Intercomparison (LUAMI) campaign (Fig. 1). In a recent intercomparison of the DIAL and the high-resolution solar Fourier transform infrared (FTIR) spectrometer at the Zugspitze summit [2] a perfect correlation slope of the integrated water vapor (IWV) was found (Fig. 2), and a very high accuracy and precision, both less than 0.1 mm (3 % of the mean), could be demonstrated [3]. This proves the consistency of the molecular absorption line parameters from three different spectral regions.

Development of a High-Power Raman Lidar

Nighttime Raman backscattering, in contrast to DIAL, is a zero-background method. Consequently, by enhancing the laser power the sensitivity for H_2O can be upscaled to any level. For the Raman lidar system at UFS a 350-W XeCl laser (308 nm), normally used for industrial production, was installed. In addition, a 1.5-m-diameter receiving telescope will be used.

Fig.3: The XeCl laser (Coherent, Lambda SX) inside the staircase leading to the lidar laboratory in the top floor of UFS

The laser was successfully set up in the top floor of UFS in December 2009. For the move, parts of the staircase leading to the lidar laboratory had to be removed and the laser was pulled up with two pulleys (Fig. 3). The laser cavity is currently modified for achieving single-line operation with high spectral purity.

The primary mirror of the lidar receiver has a focal length of 5 m and the telescope, therefore, does not fit into the laboratory. A cabinet was mounted on the top of the building and covered with an astronomical dome (Fig. 4).

Fig.4: Assembly of the receiver cabinet on the top platform of UFS: Here, the astronomical dome is delivered as the last component by a big double-rotor helicopter.

Temperature measurements will be made both by rotational Raman scattering and via Rayleigh scattering. Rotational Raman scattering is insensitive to the presence of aerosol and is, thus, applied within the troposphere and the lower stratosphere. Rayleigh scattering yields substantially more backscatter signal and will be used for temperature profiling between the upper end of the aerosol layers and more than 80 km.

Although the scattering cross sections and the system parameters of a Raman lidar can be determined, the uncertainty of these values is too high for ensuring humidity errors of just a few per cent. An external calibration (e.g., with radiosondes) is required. At UFS a side-by-side calibration with the quality-assured DIAL offers a unique opportunity, avoiding questionable comparisons with remote radiosonde ascents.

Further Plans

As an experimental approach to climate research we plan to combine the water-vapour and temperature measurements with spectrally resolved measurements of the near and far infrared radiation. This effort would include a closure experiment carried out in co-operation with UFS partners and others. This would be the first study of this kind at a high-altitude observatory.

References

[1] H. Vogelmann, T. Trickl, Appl. Opt. **47** (2008), 2116-2132

[2] R. Sussmann et al., Atmos. Chem. Phys. **9** (2009), 8987-8999

[2] H. Vogelmann, R. Sussmann, T. Trickl, T. Borsdorff, Atmos. Meas. Technol. Discuss. **3** (2010), 5411-5428

INFLUENCES OF HIGH MOUNTAIN CLIMATE ON ALLERGIES AND ENVIRONMENTAL DISEASES AT THE ENVIRONMENTAL RESEARCH STATION SCHNEEFERNERHAUS

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Allergies are one of the greatest health challenges in most societies of today. Allergy problems are expected to increase with the threat of climate change.

This project is to assess the effect the high mountain climate has on allergic reactions at a height of 2600 m. The effect the high mountain climate has on selected patients and volunteer subjects is to be examined with regard to targeted parameters of the allergic reactivity as well as phenotypical characteristics of atopic diseases under standardized conditions. These studies should include in vivo and in vitro parameters. Here, examinations in particular with regard to skin function and skin condition in view of atopic eczema as well as allergic respiratory diseases are to be referred to.

In the long term, diagnostic use of certain areas of the environmental research station Schneefernerhaus for patients with allergy and environmental diseases was planned for extended and intensive allergy diagnostics, if encouraging results were gained from the preliminary examinations.

Methods

The effect the high mountain climate has on 18 patients and 11 controls was assessed with regard to targeted parameters of the allergic reaction with atopic diseases like rhinoconjunctivitis allergica (hayfever), atopic eczema and asthma under standardized conditions.

The studies on individuals were carried out with an identical approach in the lowlands (Munich) as well as the high mountain climate (Zugspitze - Schneefernerhaus) in spring (March 2009) and summer (pollen season, July 2008 and 2009). For this, groups of up to 10 individuals with 3-4 supervisors spent 5 days in the environmental research station.

Different skin test procedures were used. Furthermore, the reaction of mucous membranes on allergens was evaluated in provocation tests.

The examination of skin physiological parameters was of significant importance (fig. 1).
Furthermore, pulmonary function parameters and inflammation parameters were measured in the exhaled air.

Fig.1: Measurement of different skin physiological parameters (skin hydration, ebum, pH, TEWL, skin roughness)

The itch intensity was recorded as the main symptom of dermatological diseases under different conditions. This was done based on a specific questionnaire in connection with computer-analyzed visual analogue scales

(VAS), which make intra-individual differences in pruritic sensation objectively measurable following known and standardized stimulation.

At the same time, allergy-relevant markers of the immune response were detected in the serum.

For the evaluation, a distinction was made between main target variable (transepidermal water loss) and secondary target variables (skin findings according to SCORAD, additional skin physiological parameters, prick test, pulmonary/nose/eyes provocation test, NO measurement, blood parameters). For the statistical analysis, the Friedman test and the Wilcoxon test were used.

First of all, the main task was to prepare the conditions for carrying out the highly differentiated and not completely risk-free examinations on the study participants. For this purpose, different study groups started their work in Munich as well as Garmisch and on the Zugspitze in the environmental research station Schneefernerhaus over different periods of time.

To begin with, in March 2008 the preconditions for the clinical examinations and the technical laboratory analyses with human material had to be created in the environmental research station.

The logistics of the examination steps as well as the considerations for possible application in case of any arising health problems were thought through, planned and tested.

The above-mentioned techniques were then carried out in preliminary examinations in Munich and tested on different groups of people.

In July and August 2008 as well as in March and July 2009, based on the experience gained, larger examinations were carried out on controls and patients in the environmental research station. First of all, the examinations were carried out in Munich 3 to 7 days before the start of the stay at high altitude. This was followed by a stay of 5 days in the environmental research station with measurements at the beginning and end of the stay. The study participants stayed the night at the altitude of 2,600 m. A proportion of the test persons were examined again 4 weeks later.

Examinations on 11 controls, who had shown no previous allergic responses even in the allergy tests, were carried out during the above-mentioned periods. Equally, examinations were carried out on 18 persons with allergic rhinoconjunctivitis, asthma and/or atopic eczema, who were sensitized to grass pollen and were respectively classified in vivo and in vitro in allergy diagnostics.

Findings
The following changes in skin function parameters occurred:

Decreased skin hydration
Increased pH value
Increased scaliness
Increased transepidermal water loss

The sebum of the skin, the skin roughness, the size of wheals and erythema during prick testing as well as the score of the atopic eczema (SCORAD) did not change significantly.

The itch intensity indicated a significant decrease of the pruritic sensation at high altitude.

When examining the pulmonary function parameters, there was an improvement at high altitude. The exhalative nitric oxide (NO) values as parameters for an inflammation of the respiratory tract as well as the measured values in the rhinomanometry (nasal flow, resistance) did not change significantly.

For the serum parameters, there was a significant decrease of the eosinophil cationic protein as well as interleukin-33 at high altitude, which are both markers for inflammations in atopic diseases (fig. 2).

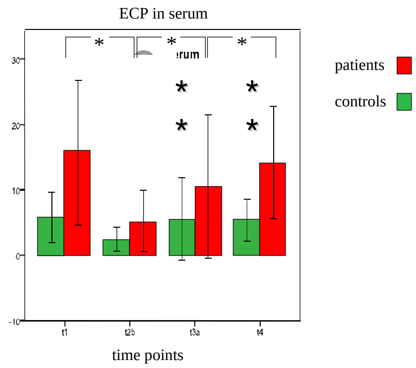

Fig.2: Eosinophil cationic protein in serum (µg/l) of patients and controls at different time points (t1 and t4 Munich, t2 und t3 UFS; * = p<0,01)

Summary
The results indicate that a stay of 5 days at the high mountain climate at a height of 2600 m exerts different effects on atopic diseases.

Asthma parameters and skin itching particularly improved. Furthermore allergologically relevant blood parameters for inflammation decreased. Sojourns lasting several weeks might be reasonable in order to find out if also the skin physiological and nasal parameters would ameliorate.

PRECIPITATION OBSERVATION IN COMPLEX ALPINE TERRAIN BY COMMERCIAL BACKHAUL LINK MICROWAVE ATTENUATION

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We explore the potential of microwave backhaul link attenuation to quantify path-integrated precipitation. The focus is on the area around Garmisch-Partenkirchen and Mount Zugspitze. First results show the performance of the new method and its potential to complement traditional methods like station or radar based measurements.

Introduction

Estimating the spatial and temporal distribution of precipitation is of crucial importance for hydrological analyses, particulary in regions with a coarse station network density or high spatial precipitation variability. A new means to accomplish this task is exploiting attenuation data from commercial back-haul links. This is a useful complementary to traditional rain gauge and radar derived estimations, since it is based on a different spatial and temporal scale.

In many regions, a mesh of point-to-point radio links is installed where meteorological instrumentation is traditionally not available, e.g. in mountainous regions or in very remote areas in developing countries.

Fig.1: A typical microwave back-haul link tower

Within the HGF-funded Virtual Institute PROCEMA (*“Regional Precipitation Obser-vation by Cellular Network Microwave Atten-uation and Application to Water Resources Man-agement”*) this new method is carried out by exploiting attenuation data from several back-haul links in the pre-alpine and alpine region of southern Germany, focusing on the area around Garmisch-Partenkirchen.

The mainfocus of its work is to develop and improve algorithms relating this attenuation rate to rainfall intensity and to develop new statistical methods to estimate spatial rainfall fields at ground level. In addtion to the analysis of data from commercial backhaul links, a custom built transmission experiment was developed and set up to allow further investigation of the physics of microwave interaction with precipitation and humidity.

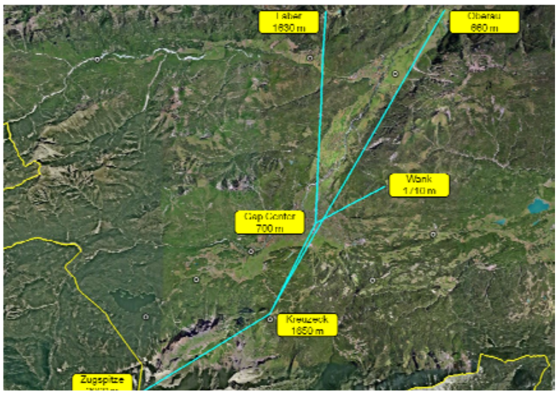

Fig. 2: The available backhaul links around Garmisch-Partenkirchen (Gap)

Measurement principle

What is a pain to engineers, who plan com-mercial backhaul links, is useful for the remote sensing of precipitation: The power transmitted on a microwave backhaul link, which are usu-ally operated at frequencies between 10 GHz and 40 GHz, is significantly influenced by precipitation. Even light rain events cause a measureable attenuation of the transmitted signal.

From the signal’s attenuation A (in dB) over a path length L_{eff} (in km) the precipitation inten-sity R (in mm/h) can be calculated by the semi empirical formula

$$A = aR^b L_{eff}$$

with the constants a and b depending on the frequency, the drop sizes distribution (DSD) and rain temperature. The above equation de-pends primarily on the frequency, so that even without knowing the other parameters, the

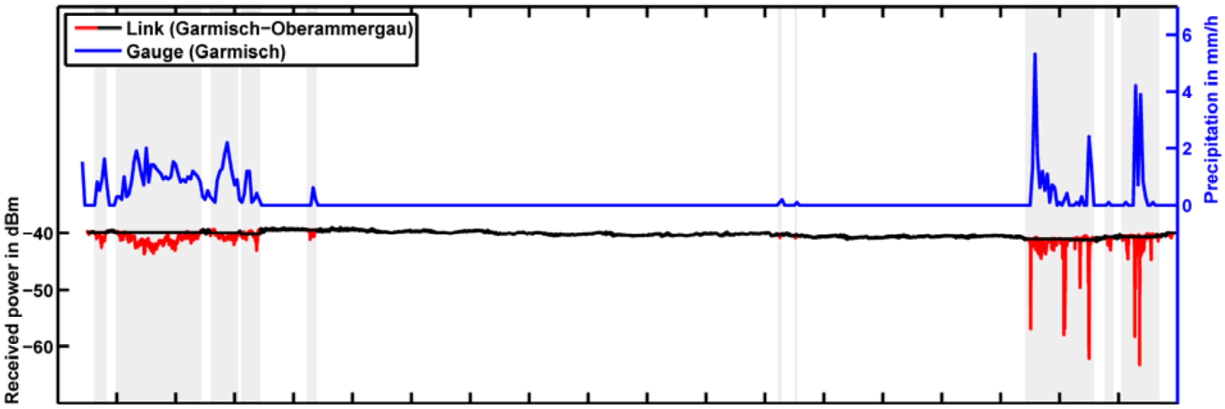

Fig. 3: "Wet/dry" estimation for the link from Garmisch to Mount Laber near Oberammergau. Gray marked are the periods detected as "wet". The black/red line is the received power of the link. During a rain event the black line represents the baseline and the red line the attenuated received power. The blue curve shows data from the DWD rain gauge in Garmisch-Partenkirchen for comparison.

derived rain intensity can be quite accurate. The value of a, and thus the sensitivity, exponentially increases with increasing frequency, whereas b is slowly decreasing from values slightly above 1 to values slightly below.
For a typical communication link with a frequency of e.g. 20 GHz, the empirically determined values of a and b would be 0.07 and 1.06, respectively. A very light rain shower with 1 mm/h intensity would thus lead to an attenuation of 0.07 dB per kilometer, which is a detectable order of magnitude with our setup.

Data acquisition
We equipped five links (shown in figure 2) on the mountains surrounding Garmisch-Partenkirchen with a specifically designed data acquisition module recording minutely averages of the received power. The modules write the data via GSM to the project server where they are stored in a database for further processing.
The links we use have a constant transmission power. That is, any decrease in the recorded signals strength is caused by attenuation of the transmitted wave. However, precipitation is not the only source of signal attenuation as other atmospheric conditions (sun radiation, humidity) also contribute to it, albeit with lower impact.
To identify the attenuation events caused by precipitation, an algorithm based on the spectral analysis of the recorded time series was developed. Going along the time series it analyses the spectrum of a short snippet of points and decides whether or not the current point (in the middle of the snippet) should be regarded as "wet" (rain) or "dry" (no rain).

Results
Figure 3 shows the results for this wet/dry estimation of a 20 day time series during summer 2010. Data is from the link leading from the center of Garmisch-Partenkirchen to Mount Laber near Oberammergau. Long term and daily fluctuation are neglected by the algorithm. Light rain events, event those on the 30th of June, are detected correctly. The baseline of the signal, which is needed to calculate the attenuation, is assumed to be constant during one rain event. It is set to the last value of the received power which was marked as "dry". For calculating the rain rate from the received power data then, only periods marked as "wet" are considered.
Figure 4 shows the hourly precipitation derived. Data is from the link leading from Kreuzeck to Oberau (blue line) during November 2010. The dotted black line represents the uncorrected signal before the wet/dry separation, indicating a further improvement of the methodology.

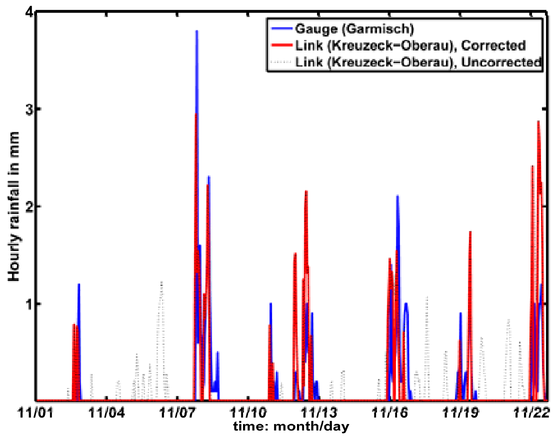

Fig. 4: Comparison of hourly rainfall data

Acknowledgement
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