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Abstract Book

Validation of SCIAMACHY limb NO_2 and BrO operational data products 2002-2012

Presenting Author: Faiza Azam

Institute of Environmental Physics (IUP), University of Bremen, Germany

SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY), aboard Envisat (2002-2012) observed the Earth's atmosphere in nadir, limb and solar/lunar occultation geometries covering UV-Visible to NIR (240-2830 nm) spectral range with a moderate spectral resolution of 0.2-1.5nm. The decadal time series (2002-2012) of SCIAMACHY's products are valuable for long term trend analysis and interpretations, as well as stratospheric ozone studies and assessments. An important prerequisite for such studies is to verify the quality of the available datasets. The ESA project SCILOV-2010 (SCIAMACHY long term validation 2010) aims at monitoring the quality of different operational data products retrieved from SCIAMACHY measurements in limb and nadir observation geometries by validations and comparisons to the correlative measurements from other satellite and ground based instruments. The limb observations from the instrument provide vertically resolved information on global scale. NO_2 and BrO play important roles in the stratospheric ozone chemistry. NO_2 controls the stratospheric ozone abundances by direct catalytic destruction or by mitigating ozone depletion through formation of reservoirs of active halogens. BrO has a large ozone depletion efficiency and contributes to ozone destruction by catalytic reactions with different radicals. Here we present the long-term comparisons of operational NO_2 and BrO (ESA/DLR V5.02) limb profiles with the corresponding scientific SCIAMACHY retrievals at the Institute of Environmental Physics (IUP) Bremen and to other satellite measurements e.g. ACE-FTS, HALOE, SAGE and OSIRIS in case of NO_2 and for BrO, with SMILES.

Validation of SCIAMACHY limb NO_2 profiles using solar occultation and limb measurements

Presenting Author: Ralf Bauer

Institute of Environmental Physics, University of Bremen

As one of the major ozone depleting species, stratospheric nitrogen dioxide (NO_2) necessitates accurate global measurements. Over the past decade, the SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) instrument onboard ENVISAT (European Environmental Satellite) has been providing global coverage of stratospheric NO_2 every 6 days. In this study, the vertical distributions of NO_2 retrieved from SCIAMACHY limb measurements of the scattered solar light are validated using NO_2 products from five different satellite instruments measuring in the solar occultation and limb geometry. The solar occultation instruments are SAGE II (Stratospheric Aerosol Gas Experiment) onboard the Earth Radiation Budget Satellite (ERBS), HALOE (Halogen Occultation Experiment) onboard the UARS (Upper Atmosphere Research Satellite), and ACE-FTS (Atmospheric Chemistry Experiment-Fourier Transform Spectrometer) onboard the SCISAT-1. By including limb NO_2 profiles from MIPAS (Michelson Interferometer for Passive Atmospheric Sounding, also onboard ENVISAT) and OSIRIS (Optical Spectrograph and InfraRed Imager System, onboard Odin), it becomes possible to perform comparisons for almost the full lifetime of SCIAMACHY.

Nitric oxide observations 2008/2009 with SCIAMACHY

Presenting Author: Stefan Bender

Institute for Meteorology and Climate Research, Karlsruhe Institute of Technology, Germany

From 07/2008 until 04/2012, SCIAMACHY performed observations in the mesosphere and lower thermosphere (50–150 km) regularly twice per month; this mesosphere-lower thermosphere (MLT) limb mode was introduced in addition to the nominal limb scans (2 km–93 km) and coordinated with the MIPAS upper atmosphere (UA) mode once every 30 days. We use the UV spectra measured by SCIAMACHY in the range 230–300 nm to retrieve the NO number densities from emissions in the gamma bands in the atmospheric region of interest.

In the winter 2008/2009, in particular in late January 2009, a sudden stratospheric warming (SSW) occurred with the consequence that in the following weeks, nitric oxide descended from the lower thermosphere around 100 km down to the stratosphere. This event was observed by a number of instruments, such as MIPAS, ACE-FTS, and OSIRIS and SMR on ODIN.

We present the results from the SCIAMACHY MLT and nominal mode for this time. Our results show the development of the NO density distribution with daily observations and a good vertical resolution in the altitude range from 70 km to 90 km when using the nominal mode limb scans and with a vertical resolution of about 5–8 km in the altitude range from 70 km to 140 km when using the MLT limb scans. Having daily data gives us the possibility to look at other winters with and without exceptional warming events and to compare and to validate our and other measurements and models.

With the SCIAMACHY observations, it is possible to distinguish for the first time between local production of NO in the upper mesosphere due to relativistic electrons from the radiation belts, and transport of auroral NO from the lower thermosphere.

Highlights of first year of data from the OMPS-limb instrument on Suomi NPP satellite

Presenting Author: Pawan K. Bhartia

NASA Goddard Space Flight Center;, Greenbelt, Maryland, USA

We will provide highlight of the data produced from the OMPS limb profiler sensor that has been flying on the Suomi NPP satellite since Oct 2011. Our focus in the past year has been on understanding the basic radiance measurements by comparing the measured radiances with radiances calculated using pressure, temperature and ozone profiles from the Aura MLS instrument. MLS data have been extensively compared with other sensors and their quality is very well understood. We have also carefully compared OMPS measured solar irradiance with reference solar spectra. These comparisons show excellent agreement giving us confidence that the OMPS limb profiler instrument is very well calibrated and that there are no significant straylight problems below about 60 km. These comparisons also suggest that the OMPS limb altitude registration (after correcting for 1.35 km fixed bias in mounting the instrument on the S/C) is quite accurate with less than +/- 200 m variation along the orbit. However, these comparisons have also revealed few issues in the L1 and L2 algorithms that we need to fix before the data can be used for scientific research. We expect to release a new version of radiance, and retrieved ozone and aerosol products on or before Oct 1, 2013.

Stratospheric aerosol activities in the framework of Aerosol_CCI

Presenting Author: Christine Bingen

Belgian Institute for Space Aeronomy

Aerosol_CCI is one of the projects initiated by ESA in the framework of the Climate Change Initiative. This ESA's response to GCOS requirements for the Essential Climate Variable "aerosols" aims at realizing the full potential of ESA Earth Observation (EO) archives, making use of datasets produced by European sensors, as well as some "Third party" missions. Retrieval algorithms developed by the main European EO teams are used in a synergetic way to better understand their strengths and limitations, and to produce improved algorithms and aerosol datasets.

This presentation focuses on the stratospheric activities of the projects, that mainly concern GOMOS but also OSIRIS datasets. The algorithm used for GOMOS aerosol retrieval is the one developed in the framework of the ESA AERGOM project. We will present an overview of the Aerosol_CCI activities, including thorough investigations and evaluation of the AERGOM dataset, the production of new data records characterized by a 3D spatial resolution, validation activities, and the most recent progresses in data merging activities.

Demonstration of 3-D trace gas retrieval with GLORIA measurements taken during the TACTS/ESMVals campaigns

Presenting Author: Jörg Blank

Forschungszentrum Jülich, Germany

The Gimballed Limb Observer for Radiance Imaging in the Atmosphere (GLORIA) is a new remote sensing instrument combining a Fourier transform infrared spectrometer with a highly flexible gimbal mount. The 2-D detector array measures spectra with a uniquely high spatial and spectral resolution. Air masses can be observed from different directions by turning the instrument's line of sight in the gimbal frame.

During summer of 2012 the instrument flew on the German HALO research plane during the TACTS and ESMVal campaigns. The large range of the aircraft allowed the inclusion of multiple closed loop flight tracts during the campaign, in which GLORIA was in dynamics mode. For the first time we were able to test the 3-D tomographic retrieval technique on GLORIA data. This mode yields 3-D trace gas fields with high horizontal resolution in every direction. This enables us to see very fine filamentary structures.

Retrievals for the Atmospheric Chemistry Experiment (ACE) Satellite Mission

Presenting Author: Chris D. Boone

Department of Chemistry, University of Waterloo, Waterloo, Ontario, Canada

The Atmospheric Chemistry Experiment (ACE) on board the SCISAT satellite has been in orbit for almost 10 years. The primary instrument is a high-resolution Fourier transform spectrometer (ACE-FTS) that collects measurements of the Eart's atmosphere using solar occultation. The most recent processing version for the ACE-FTS (version 3.0) generated information on 37 molecules, more than 20 subsidiary isotopologues, and atmospheric pressure and temperature. A new processing version is under development for the instrument (version 4.0) that will include retrievals for several new molecules (such as CHF_3, acetone, and PAN) and upgrades in the retrievals for a number of other molecules. Details of this new processing version will be described.

Stratospheric aerosol particle size information in Odin-OSIRIS limb scatter spectra

Presenting Author: Adam E. Bourassa

University of Saskatchewan, Canada

The Optical Spectrograph and InfraRed Imaging System (OSIRIS) on-board the Odin satellite has now taken over a decade of limb scatter measurements that have been used to retrieve the Version 5 stratospheric aerosol extinction product. This product is retrieved using a representative particle size distribution to calculate scattering cross sections and scattering phase functions for the forward model calculations. In this work the information content of OSIRIS measurements with respect to stratospheric aerosol is systematically examined for the purpose of retrieving particle size information along with the extinction coefficient. The benefit of using measurements at different wavelengths and scattering angles in the retrieval is studied and it is found that incorporation of the 1530 nm radiance measurement is key for a robust retrieval of particle size information. It is also found that using OSIRIS measurements at different solar geometries simultaneously provides little additional benefit. Based on these results, an improved aerosol retrieval algorithm is developed that couples the retrieval of aerosol extinction and mode radius of a log-normal particle size distribution. Comparison of these results with coincident measurements from SAGE III show agreement in retrieved extinction to within approximately 10% over the bulk of the aerosol layer, which is comparable to Version 5. The retrieved particle size, when converted to Angstrom coefficient, shows good qualitative agreement with SAGE II measurements made at somewhat shorter wavelengths.

SCIAMACHY solar occultation: Tangent height determination and trace gas profile retrieval

Presenting Author: Klaus Bramstedt

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

The spectrometer SCIAMACHY (SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY) on-board ENVISAT measured solar irradiances and Earthshine radiances from the UV to the NIR spectral region in nadir, limb and lunar/solar occultation geometry. Solar occultation measurements are performed during sunrise at northern latitudes (49N to 69N, depending on season).

Observations in limb or occultation geometry provide height resolved information about Earth's atmosphere. A critical point is always the pointing knowledge, i.e. the precise knowledge of the viewing direction and with that the observed tangent height. For SCIAMACHY solar occultation measurements, we present a method to precisely determine the viewing direction from the scans over the solar disk. This information is used to improve the pointing information of the platform.

Using an optimal estimation approach with the radiative transfer and retrieval code SCIATRAN 3.0, the measurements are used to derive vertical trace gas profiles. SCIAMACHY scans over the solar disk. Special care is necessary to select the proper measurements from the scans to get well defined transmission spectra for the retrieval.

Retrieval and variability of stratospheric aerosols from SCIAMACHY limb-scatter observations

Presenting Author: Lena A. Brinkhoff

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

Stratospheric aerosols are of scientific interest, as they primarily scatter solar radiation, and therefore increase the Earth's planetary albedo. The permanent aerosol background in the stratosphere is due to tropical injection of tropospheric air containing SO_2, COS and sulphate particles, which are precursors for stratospheric aerosols. An additional contribution is sporadically caused by an uplift of SO_2 after a strong volcanic eruption. Especially after strong volcanic eruptions, the consequential effect of stratospheric aerosols on the Earth's radiation budget is stratospheric warming and tropospheric cooling. Furthermore, they have an impact on stratospheric chemistry: Stratospheric aerosols are precursors for polar stratospheric clouds and thus support the destruction of ozone inside the polar vortex. They even lead to a halogen-driven ozone destruction outside polar vortices. On account of these properties, stratospheric aerosols belong to the so-called Essential Climate Variables.

We report on the stratospheric aerosol retrieval from SCIAMACHY limb-scatter observations. SCIAMACHY was one of ten instruments on board the Envisat spacecraft, detecting the sunlight in the wavelength range from 214 to 2386 nm with three different viewing geometries: nadir, limb and occultation. The present SCIAMACHY aerosol product (V1.1) from 2002 to 2012 will be presented, including validation with co-located SAGE II solar occultation measurements from 2002-05, i.e. for background aerosol. From the data, interesting signatures of volcanic eruptions and bushfires as well as a seasonal cycle and biennial variation in the aerosol load can be identified. However, an improvement of the data quality is planned by using multi-wavelength observations from SCIAMACHY in order to optimise the used phase function, which turned out to be a very influential factor in the retrieval.

Observation of the Upper Atmosphere: where are we and what do we need?

Presenting Author: John P. Burrows

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

The system comprising the sun the earth's atmosphere and its surface is complex. It was already recognised 40 years ago that the release of ozone depleting substances by mankind into the troposphere resulted in the destruction of stratospheric ozone. Since then the interaction between chemistry and climate has become a major focus of research. In order to attribute the different causes of changing atmospheric composition and to understand and assess the importance of these changes accurate measurements of the vertical distribution of trace atmospheric constituents and parameters are required. The different spectral regions offer different opportunities to determine atmospheric composition. This talk will review what is feasible and what we have achieved with a focus on passive remote sensing in the optical spectral range.

Retrievals of water vapour around PMCs from Odin-SMR

Presenting Author: Ole Martin Christensen

Department of Earth and Space Sciences, Chalmers University of Technology, Gothenburg, Sweden

Odin-SMR is a microwave limb sounder on board the Odin satellite, which was launched February 2001. It measures thermal emission from water vapour at 486-581 GHz and has provided global maps of water vapour [1]. One of the measured lines is the strong 557 GHz line which allows for retrieval of water vapour up to altitudes of 110km [2]. During 2010 and 2011 dedicated measurements of water vapour in the summers mesopause was made by SMR in order to study the formation of Polar Mesospheric Clouds (PMCs). To achieve the best possible spacial resolution, the measurements were performed using short scans, and tomographic retrievals of water vapour was performed. These retrievals constitutes the first tomographic retrievals from Odin-SMR. This study presents this dataset and evaluates its usefulness for the studying PMCs.

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Odin-OSIRIS a Summary of the Past Twelve Years

Presenting Author: Doug Degenstein

University of Saskatchewan, Canada

OSIRIS on Odin celebrated its twelfth birthday last February and even though it now shows some signs of aging it still continues to provide excellent quality spectrally dispersed limb-scattered sunlight radiance measurements from which climate quality data products are routinely retrieved. This talk summarize the current state of affairs for the OSIRIS Team and will highlight some of their accomplishments over the past couple of years. Particular focus will be given to the OSIRIS ozone data set and recent work done by our group to characterize and improve the current and all future versions. The goal of this ongoing work is to facilitate feedback from the characterization process into the retrieval process in order to continually improve the quality and long term stability of the data set.

ALTIUS instrument - Development of UV-Vis spectral imagers with Acousto-Optical Tunable Filters (AOTF)

Presenting Author: Emmanuel Dekemper

BIRA-IASB, Belgium

ALTIUS will be a spaceborne instrument devoted to the measurement of key atmospheric constituents based on the acquisition of spectral images of the bright limb and solar/stellar occultations in three independent spectral channels (UV-Vis-NIR, i.e. from 250 nm to 1800 nm). The instrumental concept relies on three acousto-optical tunable filters (AOTF), one in each channel. Two optical breadboards have been manufactured in order to validate this technological choice in the visible and the UV range. Laboratory tests have measured important optical and spectral properties, while field campaigns have illustrated remote sensing capabilities.

We present a summary of recent achievements obtained with these AOTF's and discuss related shortcomings and future test campaigns.

Investigation of Horizontal Inhomogeneity Effects on Aerosol Limb Retrievals using 3D Radiative Transfer Simulations

Presenting Author: Steffen Dörner,

Max Planck Institute for Chemistry, Mainz, Germany

In the past decade aerosol retrievals in limb geometry have been improved continuously. In general, these retrievals provide vertically resolved information on the aerosol distribution in the upper troposphere and the stratosphere. Passive instruments like SAGE, SCIAMACHY or OSIRIS do have a relatively rough vertical and horizontal resolution in comparison to active instruments like CALIOP, but the limb/occultation geometry with long light paths through the atmosphere strongly increases the sensitivity, enabling measurements down to very small extinction coefficients in the order of 1E-5 km^{-1}. In addition, SCIAMACHY has a good global coverage due to it's near polar sun synchronous orbit (equator crossing time 10 am on the descending node). Most limb retrievals are based upon the assumption of a horizontally homogeneous aerosol layer (1D approach). Whereas this assumption is justified under background conditions, strong horizontal gradients occur at the edge of Polar Stratospheric Clouds or highly convective tropospheric plumes (e.g. volcanic eruptions, biomass burning, tropical deep convection). In our work we show the influence of such gradients on 1D retrieval approaches and investigate the horizontal sensitivity of limb measurements along the line of sight. With the help of the 3D full spherical Monte Carlo Radiative Transfer Model McArtim the reflectance of horizontal inhomogeneous layers was simulated. By retrieving the synthetic data sets, we found that a 1D approach can lead to an underestimation of both absolute extinction and extinction altitude.

Retrieval of tropospheric ozone columns from SCIAMACHY limb-nadir matching observations

Presenting Author: Felix Ebojie

Institute of Environmental Physics (IUP), University of Bremen

Satellite observations of tropospheric ozone are of critical importance in obtaining a global and more thorough knowledge of the phenomena affecting air quality. Tropospheric ozone has a significant adverse effect on the climate. In the lower troposphere, during summer, it is a major constituent of photochemical smog and excess of it is toxic to the ecosystem, animal and man. It is known as a major oxidant, playing a great role in the production of other oxidants such as hydroxyl (OH) radicals in the middle troposphere. In the upper troposphere, ozone acts as a greenhouse gas. The retrieval of tropospheric ozone from UV/VIS/NIR satellite spectrometer such as the Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) instrument onboard the ESA satellite Envisat is difficult because only about 10% of the Total Ozone Column (TOC) is in the troposphere. In this analysis we present the retrieval of tropospheric ozone columns from SCIAMACHY limb-nadir matching observations. This technique is a residual approach that involves the subtraction of the stratospheric ozone columns derived from the limb observations from the total ozone columns derived from the nadir observations. The stratospheric ozone columns were derived by integrating the stratospheric ozone profiles from the tropopause, which was obtained from the re-analyses data of the European Centre for Medium-Range Weather Forecasts (ECMWF) in 1.50 x 1.50 x 91 levels based on both the thermal definition of tropopause using the WMO lapse-rate criterion and the potential vorticity criterion to define the dynamical tropopause. The total ozone columns were retrieved using the Weighting Function DOAS algorithm (WF-DOAS) at the spectral window of 326.6 - 334.5 nm. Also of importance in our analysis is the tropospheric ozone columns derived from the ozonesondes by integrating the tropospheric ozone profiles from the bottom to the top of the troposphere, which was determined from the ozonesondes temperature profile measurements using the WMO lapse rate criterion definition of the thermal tropopause. Our retrievals are compared with retrievals from ozonesondes and other satellites instruments, and the results obtained show good comparability with some slight deviations of about 2 - 6 DU on a global average. Some possible sources of error in our analysis will also be discussed.

Limb Imaging Aerosol Distributions from Stratospheric Balloon

Presenting Author: Brenden Elash

University of Saskatchewan, Canada

Space-based measurement of limb-scattered sunlight has been successfully used in recent years for trace gas and aerosol retrievals from the upper troposphere to the mesosphere. A distinct advantage of this technique is that the measurement is highly sensitive to thin and localized aerosol layers in the stratosphere that are very difficult to measure with other remote sensing methods. These aerosol layers include ultra-thin high altitude subvisual cirrus, which have been the subject of recent study due to their potentially important impact on the climate system through interaction with incoming sunlight and outgoing thermal radiation, and thin layers of sulphate and carbonaceous aerosol that can reach high altitude through direct injection to the stratosphere from volcanic eruptions and large scale boreal forest fires. Recent work has shown that high quality aerosol and cloud information can indeed be obtained from scattered sunlight ; however, the vertical, horizontal, and spectral range that are capable from the current generation of satellite instruments are not sufficient to understand the detailed dynamical processes and aerosol composition measurements required by weather and climate models. The work presented here entails the design and development of a new optical imager, to specifically address the required resolutions and spectral range for upper tropospheric and stratospheric aerosol measurements. A prototype version of this imager is under development and a test flight from a stratospheric balloon platform is planned from the newly developed Canadian Space Agency launch site in Timmons, Ontario, in 2014. In this work, the application of an acousto-optical tunable filter (AOTF) operating at visible and near infrared wavelength is used to allow for two-dimensional spatial imaging at rapidly tunable wavelengths providing greatly improved spatial resolution. Design and characterization of the AOTF imager will be presented, along with the proposed flight plan and customized retrieval algorithms.

Global stratospheric aerosol extinction profile retrievals from SCIAMACHY limb radiance: algorithm description and validation

Presenting Author: Florian Ernst

Institute of Environmental Physics/Remote Sensing, University of Bremen, Bremen, Germany

From 2002 – 2012, the instrument SCIAMACHY onboard the satellite Envisat measured limb-scattered radiance in the wavelength range from 214 – 2386 nm. In this work, stratospheric aerosol extinction profiles are retrieved from these observations in the visible spectral range. The retrieval algorithm is based on a colour-index approach using the normalized limb-radiance profiles at 470 nm and 750 nm wavelength. An iterative scheme in combination with the radiative transfer model SCIATRAN is employed for the retrievals using a Mie phase function to describe the angular scattering behaviour of the aerosols. This study presents a detailed description of the retrieval algorithm and a sensitivity analysis investigating the impact of the most important parameters that affect the retrieval accuracy. The aerosol extinction profiles retrieved from SCIAMACHY are compared with co-located SAGE II solar occultation measurements of stratospheric aerosol extinction during the period 2003 – 2005 at different latitudes. The global average shows a good agreement to SAGE II aerosol extinction between 15 and 25 km altitude. However, larger differences are observed at higher altitudes and different latitudes, in particular in the Northern Hemisphere.

The ALTIUS mission: a potential gap filler in atmospheric remote sounding

Presenting Author: Didier Fussen

Belgian Institute for Space Aeronomy (BIRA-IASB)

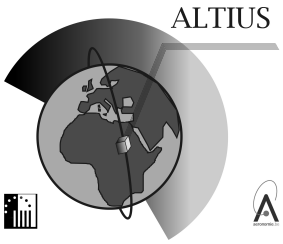
The number of available atmospheric sounders dropped dramatically in the last decade and this is particularly true for space instruments having a high vertical resolution. In the period 2005-2006, four very important and successful missions were lost or switched off: SAGE II, SAGE III, POAM and HALOE. Recently, we lost SCIAMACHY, MIPAS and GOMOS on board ENVISAT.

The ALTIUS mission was proposed to the Belgian Scientific Office in 2006 as an answer to the expected gap of atmospheric data (ozone being the first target) based on several innovative approaches. In particular, it relies on the use of a micro-satellite of the PROBA class that allows for multi-mode observations from a LEO geometry: limb scattering, solar and stellar occultations.

The ALTIUS instrument will use the hypercube measuring technique in a limb viewing geometry. Instead of a traditional "spatial x (spatial x wavelength)" construction an innovative "(spatial x spatial) x wavelength" approach will be adopted. Therefore ALTIUS will be a spectral camera with wavelength scanning. This approach should allow solving the altitude registration problem that is spoiling the traditional limb scatter technique.

The ALTIUS instrument shall be a spectral imager capable of observing the atmospheric limb in the UV (250-400 nm), VIS (400-800 nm) and NIR (800-1800 nm) domains, with a resolution better than 10 nanometers for VIS and NIR; and better than 2.5 nm for UV. For each wavelength range, a distinct Acousto-Optic Tunable Filter (AOTF) will permit to perform observations of selectable small wavelength windows.

The objectives, the status of the mission and the most recent technological developments will be presented at the conference.



Decadal O_3 and NO_2 trends from SCIAMACHY limb measurements

Presenting Author: Claus Gebhardt

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

The stratospheric halogen load is still high and a full recovery of the stratospheric ozone layer is not expected before the middle of the century. Thus, satellite observations of stratospheric ozone are of high importance now and in the future. SCIAMACHY observations in limb geometry have provided vertically resolved measurements of ozone and other atmospheric constituents for the period 2002-12. Longterm changes in their abundances are statistically described by linear changes or trends.

For limb ozone, trend profiles from SCIAMACHY are shown for the tropics and midlatitudes. The ozone trends from SCIAMACHY are compared with those from EOS MLS (since 2004) and Odin/OSIRIS (since 2001), other atmospheric limb sounders. For the tropical stratosphere, positive trends between 15-30 km and negative trends between 30-35 km, which are shown in agreement, are discussed. Using parallel trend profiles from SCIAMACHY limb NO_2, the NO_x chemistry is considered as a potential driver of the observed ozone trends. In addition, moderate positive ozone trends are seen by SCIAMACHY and the comparison instruments in the upper stratosphere.

Examining the UTLS with the GLORIA limb imager: Technique and first results from the TACTS/ESMVal campaign in 2012

Presenting Author: Tobias Guggenmoser

IEK-7, Forschungszentrum Juelich, Germany

The GLORIA instrument (Gimballed Limb Observer for Radiance Imaging of the Atmosphere) is an infrared limb sounder developed jointly by Karlsruher Institut für Technologie and Forschungszentrum Jülich. Designed for aircraft and balloon deployment, its main purpose is to enhance our understanding of UTLS chemistry and dynamics, especially concerning troposphere-stratosphere exchange processes.

To achieve this, GLORIA combines 2D imaging technology with a Fourier transform spectrometer in the thermal infrared range. Infrared radiance in the range of 770-1450 $cm^{-}1$ is modulated by the interferometer and then cast on a 128×128 pixels focal plane array. This means that each measurement records spectra for 128 distinct tangent altitudes.

GLORIA has been designed to operate in either of two modes. In chemistry mode, longer measurements are performed for a better spectral resolution, resulting in a larger number of retrievable trace gases. In dynamics mode, measurement time is shortened for better spatial sampling. Additionally, the instrument's gimballed frame and attitude control allows it to pan horizontally between dynamics mode measurements, such that the same target volume can be observed from more than one angle.

Calibration of the radiances is achieved using in-flight reference measurements of two temperature stabilized blackbodies, as well as upward-pointing deep space measurements. The calibrated spectra are then used to retrieve the mixing ratios of trace gases using the JURASSIC2 software for dynamics and KOPRAFIT for chemistry mode, respectively.

During 13 scientific flights of the TACTS/ESMVal campaign in 2012, GLORIA recorded over 60,000 profile measurements in both operational modes. Flight paths covered a latitude range from 65°S to 80°N. In this paper, we will present the current state of data processing, including first results for one-dimensional trace gas retrievals showing UTLS exchange processes. We will concentrate on 1D dynamics mode retrievals and cross-sections for these purposes.

Total inorganic stratospheric Br_y inferred from SCIAMACHY limb measurements of BrO

Presenting Author: René Hommel

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

Budgeting the total inorganic bromine (Br_y) abundance of the stratosphere is still subject to uncertainties, mainly because the contribution of natural very short lived inorganic bromine substances so far has not been measured in sufficient detail. Also observations of the major inorganic bromine compound of the stratosphere, bromine monoxide (BrO) differ to a certain degree, in particular with respect to its variability and vertical profile in the tropics.

In this work we present latest results from an assessment of Br_y in the stratosphere based on SCIAMACHY limb BrO profile measurements (Rozanov et al, 2011) and chemistry transport model (Aschmann et al., 2011) studies.

Following Kovalenko et al. (2007), the SCIAMACHY BrO volume mixing ratio (level 3 data) is scaled by the ratio of the modelled Br_y to BrO at the local time of SCIAMACHY measurements. In the zonal mean the climatological mean Br_y is low in the tropical lower stratosphere, whereas large mixing ratios are found in mid- and high latitudes during summer. This is in contrast to BrO mixing ratios, which are largest over the poles in the winter stratospheres. This contradictory behaviour has its origin in differences between the modelled and observed BrO mixing ratios. From our investigations we conclude that this may cause an underestimation of the SCIAMACHY inferred Br_y over the poles in the summer hemispheres in the order of 5 to 10 pptv (Hommel et al., 2013).

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Low Ozone over the Arctic in January 2011 - an "ozone mini-hole" condition?

Presenting Author: René Hommel

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

Remarkably large ozone losses were observed in spring 2011 over the Arctic (Manney et al., 2011; Hommel et al., 2013). Although several studies showed that this ozone loss was caused by heterogeneous processes in the presence of PSCs, so far not much attention is being given to a period showing very low ozone in the second half of January 2011. As shown in Hommel et al. (2013) for ten days GOME-2 observed total ozone as low as 200 DU commencing 21 January 2011. Height-resolved vortex-averaged ozone profiles from SCIAMACHY limb measurements show that those losses occurred below the 500 K isentropic surface ($\approx$ 22 km during this time). That is the same altitudinal range where halogens are activated and catalytic cycles effectively destroy ozone. Whether the January 2011 losses also result from a chemical decomposition or a specific meteorological situation caused the ozone low is examined in this study. It turns out that a superposition of two independently evolving synoptic-scale intrusions of tropospheric air lifted the tropopause over the Asian continent that diverged the above lying stratospheric ozone column. The induced adiabatic cooling of the stratosphere enhanced PSC formation so that subsequent chlorine activation was amplified. In turn, the January 2011 low ozone event indirectly influenced the scale of the tremendous ozone destruction later in spring. The area where low ozone was found in January 2011 covered approximately 1×10^7 km^2, which is almost a third larger than typical "ozone mini-hole" sizes and almost as large as the area covered by the Antarctic ozone hole in southern hemispheric spring.

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Initial sensor performance and product status of the Suomi-NPP OMPS Limb

Presenting Author: Glen Jaross

NASA Goddard, Greenbelt, Maryland, USA

The Ozone Mapping and Profiler Suite (OMPS), launched October, 2011 on the Suomi National Polar-orbiting Partnership (SNPP) satellite, has been collecting science data for over one and a half years. The Suite is comprised of two nadir-viewing sensors and a limb-viewing sensor. The Nadir sensors were designed as successors to the Solar Backscatter and Ultraviolet (SBUV2) and Total Ozone Mapping Spectrometer (TOMS) series of instruments, and the Nadir Mapper was patterned after the instruments. The OMPS Limb Profiler carries on the limb scatter data records of the SAGE III, OSIRIS and SCIAMACHY instruments, but has a unique imaging design that has never before been used in an operational instrument.

Initial post-launch measurements of dark currents, detector linearity, and charged particle-induced transients revealed no unexpected behavior. Internally scattered stray light had been a design concern because the 4 orders of magnitude in Earth radiance are imaged simultaneously at the focal plane. Analysis of the data confirm the adequacy of stray light mitigation in the design and in the capability of the stray light correction algorithm. However, it remains a problem at wavelengths near 1 micrometer. The sensor optics are not thermally stabilized, and this has led to an unexpected issue that affects both spectral registration and pointing knowledge. Despite initial setbacks, in-flight characterizations provide adequate corrections and we are confident the instrument is otherwise performing well.

Validation of improved SCIAMACHY ozone limb data

Presenting Author: Jia Jia

Institute of Environmental Physics, University of Bremen, Germany

SCIAMACHY aboard Envisat [Bovensmann et al., 1999] has produced a unique database of different atmospheric parameters over the past 10 years, 2002-2012. From SCIAMACHY measurements, tropospheric ozone is retrieved using the limb-nadir matching (LNM) technique. The focus of this study is validation of the improved SCIAMACHY limb profiles to be used as an input to the LNM retrieval.

Ozone limb data has been upgraded from V2.9 to V3.0 for the above mentioned purpose. Ozone sonde data from 60 World Ozone and Ultraviolet Radiation Data Centre (WOUDC) stations, ozone lidar data from 10 stations of the international Network for the Detection of Atmospheric Composition Change (NDACC) and satellite data e.g. OSIRIS are used in this study to evaluate both versions of SCIAMACHY ozone limb data. The comparisons with the new version 3.0 show improvement in the retrieved profiles for different altitude layers as well as different latitude bands. The results demonstrate an improvement of 2-20 DU in the stratospheric ozone amounts, hence adding significantly to the retrieval accuracy of tropospheric ozone.

CRISTA-NF observations of filamentary structures of different origin in the vicinity of the polar vortex

Presenting Author: Christoph Kalicinsky

Department of Physics, University of Wuppertal, Germany

The CRISTA-NF (Cryogenic Infrared Spectrometers and Telescope for the Atmosphere - New Frontiers) instrument is an airborne infrared limb sounder operated aboard the Russian research aircraft M55-Geophysica. The instrument successfully participated in a large Arctic aircraft campaign within the RECONCILE project in Kiruna (Sweden) from January to March, 2010.

We present the retrieval results derived from the measurements of one flight of the campaign, which took place in the vicinity of the polar vortex on March 2. The obtained 2-dimensional curtains of volume mixing ratios for the trace gases CFC-11, O_3, and $ClONO_2$ have an unprecedented vertical resolution of about 500 to 600m for a large part of the observed altitude range and a dense horizontal sampling along flight direction of $\approx$ 15 km. The trace gas distributions show several structures like the polar vortex and two filaments composed of air masses of different origin. By means of CFC-11-ozone-relations the air masses within one of those filaments can clearly be identified as air masses consisting to a large extent of vortex air, whereas the air masses in the other filament are of different origin.

The situation during the analysed flight is simulated by the chemistry and transport model CLaMS (Chemical Lagrangian Model of the Stratosphere). The comparison between the simulation and the measurements show the capability of CLaMS to reproduce the observations made by CRISTA-NF. Furthermore, we use a model concept, which is based on artificial (passive) tracers and capable to distinguish air masses of different origin. This concept, that is very sensitive to the initialisation date of the passive tracers, was chosen to interpret the observed structures. The distributions of the passive tracers are used to identify the origin of the observed air masses in more detail.

Overview of SMILES project in NICT and diurnal variation of HCl, ClO and $HOCl$ in upper atmosphere

Presenting Author: Yasko Kasai

National Institute of Information and Communications Technology (NICT)
Tokyo Institute of Technology, Japan

Diurnal variations of the atmospheric compositions were observed by the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) from the Exposed Module (EM) of the Japanese Experiment Module (JEM) on the International Space Station (ISS) between 12 October 2009 and 21 April 2010. The ISS has a non sun-synchronous circular orbit with an inclination angle of 51.6 to the equator, which allowed us to observe atmospheric composition at different local times. The SMILES instrument employed 4 K submillimeter-wave superconductive heterodyne receivers, and obtained spectra with unprecedented low noise, which is one order of magnitude better performance than previous microwave/sub-millimeter limb instruments in space. These unique observations gave us new products, such as the diurnal variation of short-lived radical species in the stratosphere and mesosphere. SMILES observations provided vertical abundance profiles of O_3, $H^{35}Cl$, $H^{37}Cl$, ClO, $HOCl$, HO_2, H_2O_2, BrO, HNO_3, O_3 isotopologues, CH_3CN, H_2O, as well as ice clouds, winds, and temperature from the stratosphere to the lower thermosphere. The JEM/SMILES mission is a joint project of the National Institute of Information and Communications Technology (NICT) and the Japan Aerospace Exploration Agency (JAXA). I will present the overview of current status of the SMILES project in NICT, and diurnal variation of chlorine species, HCl, ClO and $HOCl$, in the upper atmosphere.

Odin climatology of NO_x in the stratosphere

Presenting Author: Maryam Khosravi

Department of Earth and Space Sciences, Chalmers University of Technology, Gothenburg, Sweden

The Sub-Millimeter Radiometer (SMR) and the Optical Spectrograph and InfraRed Imager System (OSIRIS) instruments on board the Odin satellite measure stratospheric species since Odin's launch on February 2001. The long-term measurements of stratospheric and mesospheric species provides the possibility of climatological and trend studies. Odin observes at certain local times around sunrise and sunset because of its sun-synchronous orbit. Moreover, due to the drift of Odin's orbit at the equator, the data should be corrected before they are used for climatological studies. This correction can be applied using scaling factors taken from a photochemical model. These scaling factors can be used to scale the data from observations at a specific local solar time (or solar zenith angle) to a full diurnal cycle (24 h) . In this study, nitrogen oxide (NO) and nitrogen dioxide (NO_2) from Odin have been used to derive the climatology for these species and also for odd nitrogen (NO_x =NO +NO_2).

On the connection between stratospheric water vapour changes and widespread severe denitrification in the Arctic

Presenting Author: Farahnaz Khosrawi

Department of Meteorology, Stockholm University, Stockholm, Sweden

Water vapour is one of the most important greenhouse gases and plays a key role in the chemistry of the upper troposphere and lower stratosphere (UT/LS). Any changes in atmospheric water vapour bring important implications for the global climate. Long-term ground-based and satellite measurements indicate an increase of stratospheric water vapour abundance by an average of 1 ppmv during the last 30 years (1980-2010). Increases in stratospheric water vapour cool the stratosphere but warm the troposphere. Both the cooling of the stratosphere and the increase in water vapour enhance the potential for the formation of polar stratospheric clouds. More than a decade ago it already was suggested that a cooling of stratospheric temperatures by 1 K or an increase of 1 ppmv of stratospheric water vapor could promote denitrification, the permanent removal of nitrogen species from the stratosphere by solid polar stratospheric cloud particles. In fact, during the two recent Arctic winter 2009/2010 and 2010/2011 the strongest denitrification in the recent decade was measured by Odin/SMR. In the latter winter denitrification lead also to severe ozone depletion with similar extensions as the Antarctic "ozone hole". In this study, the correlation between observed water vapour trends and the recent temperature evolution in the Arctic together with trace gas measurements and PSC observations are considered to investigate a possible connection between the increase in stratospheric water vapour and polar stratospheric cloud formation/denitrification.

Self- and foreign water vapor continuum absorption in the 8-12 and 3-5 μm transmission windows

Presenting Author: Tatyana E. Klimeshina

V.E. Zuev Institute of Atmospheric Optics, Russian Academy of Science, Siberian Branch, Russia

Recent laboratory measurements of the water vapor continuum absorption in cases of self and nitrogen broadening in the 8-12 and 3-5 μm transmission windows (CAVIAR, NIST) provide a possibility of quantitative comparison between the measured absorption coefficients and the absorption coefficients calculated on the basis of the proposed theoretical hypotheses. There are two widely accepted approaches to the description of the physical nature of the water vapor continuum absorption: by the line wings of water vapor monomers and by water dimers. At this point it is impossible to determine unambiguously the contribution of the monomer and dimer absorption to the continuum in the intervals between the water vapor bands, and it is hard to tell which of the approaches can offer convincing arguments in the case under consideration.

In accordance with the asymptotic line wing theory, the transmission windows absorption is determined by the joint impact of the far wings of strong lines pertaining near monomer bands. In the theory, the semiclassical representation method is used to solve the total quantum problem of interaction of the absorbing and the broadening molecules. This method separates strictly the center of mass motion which is considered further as classical. The method also allows retaining the classical interaction potential in the density matrix. Then the kinetic equation for the correlation function is solved on the assumption of the large frequency detunings that also provides the asymptotic evaluation of the time integral. In the asymptotic line wing theory an expression for the absorption coefficient includes the classical and quantum intermolecular interaction potentials. Both potentials are then parametrized. The parameters are found from the comparison between the measured and calculated absorption coefficients.

The results of calculation of the spectral and temperature dependence of the continuum absorption in the 8-12 and 3-5 μm transmission windows are presented. They show the good agreement with the measured values. The absorption within the asymptotic line wing theory implies all the interactions between colliding molecular pairs apart from the formation of a new molecule and may be interpreted in principle as the absorption by metastable and "free" dimers.

The calculation of the cooling rates in the IR region due to water vapor is performed within the scope of the 33-layer radiation model and with the line shape obtained. The analysis is made on the self and nitrogen-broadening contributions as well as central and line wing parts contributions into the cooling rate as functions of height.

Satellite observations of OClO from 1995 to 2012 in comparison to ECMWF data and EMAC simulations

Presenting Author: Sven Kühl

MPI Chemie, Germany

Satellite instruments like GOME, GOME-2 and SCIAMACHY measure the spectral intensity of the sunlight, scattered back from Earths atmosphere, on an almost global and daily scale. By applying the DOAS method to the spectral measurements, the integrated concentration along the light path, the so called Slant Column Density (SCD), can be derived for a wide range of absorbers. Chlorine dioxide ($OClO$) is an important indicator for stratospheric chlorine activation, the basis for massive ozone depletion in polar spring.

Due to the daily coverage of the Polar regions, the $OClO$ measurements give a good overview of the intensity and the extension of the chlorine activation. While the observations in nadir geometry (i.e. perpendicular to Earths surface) provide a (indirect) measurement of the total column, the limb observations (i.e. tangential view) can be inverted to vertical profiles.

We investigated GOME, GOME-2 and SCIAMACHY data from 1995 to 2012, covering Arctic and Antarctic winters with very different meteorological situations (very cold and very warm winters; early and major warmings). In particular, the long lasting cold stratospheric temperatures inside the vortex for the Arctic winter 2010/11 led to large levels of chlorine activation until mid of March, also observed in the $OClO$ data.

The derived $OClO$ columns and vertical profiles are compared to ECMWF analysis data, looking at inter-hemispheric and inter-annual differences and studying the dependence of the $OClO$ enhancements on meteorological parameters like stratospheric temperatures, potential vorticity, PSC area and volume.

Also, the $OClO$ observations are compared to correlated ECHAM5/MESSy2 (EMAC) simulations, which were calculated for the exact time and place of the satellite observations. We investigate the agreement of the observed and simulated $OClO$ profiles for the dataset from 2003 to 2012 (regarding the magnitude, the altitude of the profile peak and their evolution throughout the winter).

Evaluation of ClO + $HO_2 \rightarrow HOCl$ + O_2 reaction in the atmosphere by SMILES observations

Presenting Author: Kota Kuribayashi

Tokyo Institute of Technology, Japan
National Institute of Information and Communications Technology, Japan

Diurnal variations of ClO, HO_2, and $HOCl$ were simultaneously observed by the Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) in the upper atmosphere between 12 October 2009 and 21 April 2010. It was the first observations of the diurnal variation of $HOCl$ in stratosphere and mesosphere. A major reaction to produce $HOCl$ is ClO + HO_2 $\rightarrow$ $HOCl$ + O_2 (1) in extra polar region. A model study suggested that in the mesosphere during night this is the only reaction influencing the amount of [$HOCl$] and [ClO] and there is no other competitive reaction exist to influencing this amount. It is possible to derive the rate constant k_1 of this reaction from the mesospheric observations by SMILES. Both of the rate of $HOCl$ production and the rate of ClO loss can be used to obtain an estimate of k_1. The difference between these two estimates was used as a check of a pure reaction period, where only reaction (1) occurred in Cl_y chemical system.

It turned out that data at the pressure level of 0.28 hPa (about 58 km) during night (between local time 18:30 and 04:00) in the autumn mid-latitude region (20 - 40°S, February - April 2010) were suitable for the estimation of k_1. The rate constant was obtained to be k_1(245 K) = 7:73 $\pm$ 0:26(1σ)[$\times$ 10^{-12} cm^3/ molecule s]. The k_1 obtained by SMILES is consistent with that from both laboratory experiments and ab initio calculations for similar low-pressure conditions. The 1σ precision obtained was 2-10 times better than that of laboratory measurements.

GOMOS middle atmosphere measurements from 2002-2012

Presenting Author: Erkki Kyrölä

Finnish Meteorological Institute, Finland

The GOMOS (Global Ozone Monitoring by Occultation of Stars) spectrometer on Envisat measured more than 860 000 ozone profiles during its ten years of life. These measurements cover all latitudes and extent from the troposphere up to the mesosphere. Because of the measurement method, stellar occultation, the vertical resolution is good (2-3 km), the knowledge of measurement altitude is precise and the stability of measurements is guaranteed. GOMOS measures both day and night with nearly equal number of measurements. The best data quality is obtained from the nighttime measurements and these measurements have been used to create ozone climatologies and times series. The retrieval of ozone from daytime occultations is more difficult, but ozone profiles can also be retrieved from limb scattered solar light recorded by GOMOS. The processing of this so far neglected source of data has now been accomplished. In addition to ozone, GOMOS retrieves also NO_2, NO_3, H_2O, O_2, and aerosol extinction profiles from spectrometer data. Using in an ingenious way data from its two fast photometers GOMOS is capable to determine a high-resolution temperature profiles in the lower stratosphere. Photometers have also been used to get first time global measurements of stratospheric turbulence and wave dissipation. GOMOS measurements of NO_2 and NO_3 have provided first night climatologies of these strongly diurnally varying constituents. Aerosol extinction data and photometer signals have been used to monitor polar stratospheric clouds and mesospheric noctilucent clouds. In this contribution, we provide an overview of the GOMOS mission and its scientific highlights.

Ozone time series and trend analysis from SAGE II, OSIRIS and GOMOS measurements

Presenting Author: Erkki Kyrölä

Finnish Meteorological Institute, Finland

Satellite measurements are essential for monitoring changes in the global stratospheric ozone distribution. Both the natural variation and anthropogenic change in ozone are strongly dependent on altitude. Stratospheric ozone profiles have been measured from space from 1984 to 2005 by the SAGE II solar occultation instrument. The advantage of the occultation measurement method is self-calibration, which is essential to ensuring stable time series. SAGE II measurements have been a valuable data set in investigations of trends in the vertical distribution of ozone. This time series can now be extended using OSIRIS/Odin measurements from 2001 to the present and GOMOS/Envisat measurements from 2002 to 2012.

In this work, we present combined SAGE II-OSIRIS and SAGE II-GOMOS ozone profile data sets covering 1984-2011. We show results from the inter-comparison of ozone profiles measured from 2002 to 2005 when all three instruments were operational. The combined ozone profile data sets are analyzed using time series methods. Results for the trends and natural variations in ozone are presented.

Global CFC-11 and CFC-12 measurements from MIPAS

Presenter: Gabriele P. Stiller

KIT, Germany

We present the validation, climatology and trends of global CFC-11 and CFC-12 measurements from Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) retrieved with IMK/IAA research level 2 processor. Aside comparison with all co-measuring satellite instruments, ACE-FTS and HIRDLS, the comparison with Cryosampler measurements is presented, where a very good agreement is found for both CFC-11 and CFC-12. Global altitude-resolved zonal mean distributions of CFC in the stratosphere are presented. CFC trends in the stratosphere vary with altitude and latitude: as expected, at most regions the trends are negative, but in some regions positive trends are established. Anti-corellation with age trends are observed: in most regions, the trends of age and of CFC are of opposite signs.

Comparison of MIPAS ozone with Umkehr ozone measurements

Presenting Author: Alexandra Laeng

KIT, Germany

We present the comparison of ozone content in different Umkehr layers, derived from MIPAS vertical profiles measurements, with Umkehr measurements on four stations on different latitudes. Time series from both instruments in different layers, seasonal means as function of height, as well as temporal variation of monthly means of (MIPAS - Umkehr) are analyzed. Assessment of natural variability of ozone around the stations is performed.

Metal and metal ion observations with SCIAMACHY in the mesosphere and lower thermosphere

Presenting Author: Martin Langowski

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

Meteoroids entering the earth atmosphere melt due to frictional heating at altitude of about 100 km. The meteoroids have a large metal content. This leads to the formation of sharply peaked metal layers at about 85 to 90 km and metal ion layers 5 to 10 km above the metal layers. Despite their low density the metals show strong emission signal, because of their high absorption cross sections. These Emission signals are observed with SCIAMACHY/Envisat and number densities for the metals and ions are retrieved on a 2D latitude- altitude grid. Investigations on latitudinal, altitudinal and temporal variations of the metal and metal ion layers are presented in this study. The total amount of meteoric material entering the earth atmosphere is very unknown ranging from one to several hundred tons per day and the strength of the material source needs to be characterized and its impact on atmospheric chemistry assessed.

The retrieval of the atomic oxygen profiles in the MLT region on the base of SCIAMACHY airglow observations

Presenting Author: Olexandr Lednytskyy

AG Umweltphysik, Universität Greifswald, Germany

The atomic oxygen profiles are retrieved from SCIAMACHY/Envisat observations of terrestrial airglow emissions. Demarcation of the MLT altitude layers is done with latitude lines of ten degrees step. Averaging of the measurements in a calendar month window extends the horizontal resolution of SCIAMACHY from 960 x 630 km^2 spatially distributed regions to longitudinal belts with a width of 3500 km. The airglow intensities and, therefore, production rates of atomic oxygen are localized in longitudinal belts in adjacent 3.3 km thick MLT-layers.

Under assumption of horizontal homogeneity of each layer (in the onion peeling model) and absence of absorption as well as scattering, there is a direct correspondence of the integrated limb emission rates to vertical volume emission rate profiles. The simplified emission transport problem is analysed within linear forward inversion with a regularized least squares technique. Temporal and spatial distribution of atomic oxygen is retrieved from green line airglow measurements and considered with the use of such atmospheric parameters as: concentration ratios of atomic oxygen, velocity and direction of its transportation in MLT region.

Measurement errors due to exposition of Envisat to highly energetic particles at the altitude of 800 km in the South Atlantic Anomaly are taken into account by considering geographical position of the satellite. Direct propagation of errors from the measurement to the state vector is going to be avoided with help of Monte Carlo approach to account for measurement errors and model uncertainties within inverse method quantitatively.

Variability and linear changes of stratospheric water vapour: An analysis based on UARS/HALOE and Envisat/MIPAS observations

Presenting Author: Stefan Lossow

Karlsruhe Institute of Technology, Institute for Meteorology and Climate Research, Karlsruhe, Germany

Water vapour is one of the most important trace constituents of the Earth's atmosphere. As the most important greenhouse gas in the troposphere and lower stratosphere any long-term change of its concentration in this altitude region has important implications for our climate. Here we combine observations from two satellite instruments, HALOE and MIPAS, to study in detail the variability and linear changes of stratospheric water vapour on a global scale in the period time 1991 - 2012. In the first part we focus on technical details, i.e. on our approach to combine the data sets as well as the detection of trend breaks that are characteristic for the water vapour time series. Then we discuss the distribution of annual, semi-annual and QBO variations along with the multiple linear changes that occurred. The results will be compared with model simulations.

Limb Scattering Radiative Transfer Model Development in Support of the Ozone Mapping and Profiler Suite (OMPS) Limb Profiler Mission

Presenting Author: Robert Loughman

Hampton University, USA

The Gauss-Seidel Limb Scattering (GSLS) radiative transfer (RT) model has been tested through comparison with several other limb RT models, including the Siro, MCC++, CDIPI, LIMBTRAN, and SASKTRAN. To address deficiencies in the GSLS radiance calculations revealed in earlier comparisons, several recent changes have been added that improve the accuracy and flexibility of the GSLS model, including:

1. Introduction of variable atmospheric and surface properties along the limb line of sight.
2. Improved treatment of the variation of the extinction coefficient within atmospheric layers.
3. Re-introduction of the ability to simulate vector (polarized) radiances.
4. Addition of the ability to model multiple aerosol types within the model atmosphere.

These model improvements are verified by comparison to standard radiance tables, demonstrating significant improvement in cases for which previous versions of the model performed poorly. The GSLS model is imbedded in the retrieval algorithm used to process data from the Ozone Mapping and Profiler Suite (OMPS) Limb Profiler, which was recently launched on the Suomi NPP satellite. The significance of the GSLS RT model improvements for the OMPS LP retrievals will be illustrated by several examples.

Recent results from SOFIE/AIM

Presenting Author: Martin J. McHugh

GATS, USA

SOFIE is one of two instruments aboard AIM, the first satellite mission dedicated to the study of polar mesospheric clouds (PMCs). These clouds appear near the polar mesopause for only a brief period in summer, when temperatures routinely dip below 150 K. This region of the atmosphere is largely inaccessible to in-situ measurements, and ground based observations are scarce. Prior to the launch of AIM in 2007, relatively little was known about the basic physics of these ultra-high clouds. Since then, SOFIE's solar occultation observations have contributed significantly to the understanding of PMCs and their environment. In this presentation we describe the SOFIE instrument and its measurement products and discuss several of the science contributions that have come from this experiment. These include 1) a framework describing the roles that temperature and water vapor play in the formation and evolution of PMCs, 2) inference of the physical characteristics of the cloud particles, 3) measurement of meteoric smoke particles and 4) observations and interpretations of inter-hemispheric variability. With these results in hand and more investigations underway, SOFIE and her companion instrument CIPS have established AIM's place as a key heliophysics observatory, providing an important piece of the global climate record.

The Doppler Wind and Temperature Sounder (DWTS)

Presenting Author: Martin J. McHugh

GATS, USA

We present the Doppler Wind and Temperature Sounder (DWTS), a design for a sensor to measure global winds and temperatures from cloud-top to the thermosphere. These measurements would significantly improve medium- and long-range weather forecasts and enable more advanced tracking of severe storms. The approach uses the inherent high spectral resolution from gas filter correlation radiometry to simultaneously measure the Doppler shift and linewidth of limb emission spectra from low-Earth orbit. DWTS sensors image the limb through low-pressure gas cells containing CO_2, NO and NO_2. From these measurements, very accurate vector winds and kinetic temperatures can be inferred. Profiles of temperature and wind can be measured day and night continuously from 15 to over 250 km at intervals of 10 km along-track with less than 2% uncertainty. A constellation of 6-12 DWTS instruments on small satellites would provide unprecedented observations of global atmospheric dynamics from the lower stratosphere into the middle thermosphere, predicted to greatly improve weather and storm forecasting.

CH_4 and CO_2 Profiles derived from SCIAMACHY Solar Occultation Measurements with Onion Peeling DOAS

Presenting Author: Stefan Noël

Institute of Environmental Physics/Remote Sensing, University of Bremen, Germany

Stratospheric profiles of methane (CH_4) and carbon dioxide (CO_2) have been derived from solar occultation measurements of the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY). Due to the sun-fixed orbit of ENVISAT the solar occultation measurements are restricted to the latitudinal range between about 50°N and 70°N. The retrieval is performed using a method called "Onion Peeling DOAS" (ONPD) which combines an onion peeling approach with a weighting function DOAS (Differential Optical Absorption Spectroscopy) fit.

CO_2 and CH_4 data sets covering the whole SCIAMACHY time series (August 2002 to April 2012) have been derived. By use of updated pointing information and optimisations in the data selection and retrieval approach the altitude range for reasonable CH_4 and CO_2 data could be extended to about 15 to 45 km compared to previous product versions. As measurements of the stratospheric distribution of greenhouse gases are generally sparse, the new SCIAMACHY data sets, which cover almost ten years, can provide valuable information about changes in the middle atmosphere.

In this presentation, we will describe recent improvements of the retrieval and show time series of the SCIAMACHY products. Furthermore, to assess the quality of the newly derived data sets, they will be compared with independent sources.

Variability of solar UV radiation and vitamin-D synthetic capacity of sunlight

Presenting Author: Tetiana Orlova

Institute of Physics, National Academy of Sciences of Ukraine, Kiev, Ukraine

Terrestrial solar ultraviolet (UV) radiation (280-400 nm) plays a significant role for vital functions of biosphere including humans. In proper doses UV radiation is beneficial for people because of initiation of vitamin D synthesis from its precursor 7-dehydrocholesterol in skin [1] but excessive UV doses leads to acute and chronic diseases, such as cataract, skin burn and cancer, immune system suppression, etc.

Significant variability of solar UVB radiation (280-315nm) caused by latitude, season, daily time as well as ozone layer thickness, clouds, aerosols and air pollutions, can lead to beneficial or harmful effect on human health depending on a UV dose.

Usually biological activity of solar radiation and UV index are calculated by weighting of solar UV spectrum with erythema action spectrum. But the vitamin-D-synthetic capacity of sunlight cannot be correctly estimated from these data because of significant difference between the CIE erythema and vitamin-D synthesis action spectra [2, 3].

In view of crucial role of vitamin D for human health we developed reliable algorithm for direct calculation of 7-dehydrocholesterol conversion into previtamin D upon exposure to sunlight using mathematical model which describes photoreaction of vitamin D synthesis in vitro with solar UV spectrum at the model input [4]. Good agreement between experimentally measured and numerically simulated data allows using the presented algorithm for prediction of the vitamin-D-synthetic capacity of sunlight with regard to variability of solar UV radiation [4].

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Energetic Particle Precipitation Indirect Effect: ODIN/SMR Observations Compared to Models

Presenting Author: Kristell Pérot

Department of Earth and Space Sciences, Chalmers University of Technology, Göteborg, Sweden

The Sub-Millimeter Radiometer (SMR) on board the Odin platform, launched in 2001, is a limb emission sounder measuring trace gases in the stratosphere, mesosphere, and lower thermosphere. Odin is a Swedish-led satellite project funded jointly by Sweden (SNSB), Canada (CSA), Finland (TEKES), and France (CNES), with support by the 3rd party mission programme of the European Space Agency (ESA).

Energetic Particle Precipitation (EPP) represents an important solar-terrestrial coupling mechanism because of its important implications for atmospheric chemistry. These effects can be direct (formation of NOx and HOx radicals) or indirect. Magnetospheric electron precipitation into the polar atmosphere during geomagnetic perturbations leads to nitric oxide formation in the polar mesosphere and lower thermosphere. In the winter hemisphere, generated NO_x can be transported downward into the stratosphere by the meridional circulation. This mechanism is called EPP indirect effect. SMR supplies the scientific community with rich data set for studying this effect on middle atmosphere composition.

Inter-comparisons of SMR measurements of several species with results from different models will be presented, focusing on the 2008/2009 northern hemisphere polar winter. This period is very interesting because it is characterized by peculiar dynamic conditions. A major sudden stratospheric warming (SSW) indeed occurred, followed by the reformation of a strong upper stratospheric vortex. This dynamic phenomenon was associated to a descent particularly efficient in the following weeks. This work is part of HEPPA-MMI (High Energy Particle Precipitation in the Atmosphere – Model – Measurement Intercomparison), an international working group whose goal is to get a better understanding of EPP-induced middle atmospheric changes, and to assess the ability of current models to reproduce those phenomena. Several instruments and models are involved.

The Chemical and Aerosol Sounding Satellite (CASS) mission as a solution for global climate quality atmospheric composition measurements

Presenting Author: Thomas Piekutowski

Canadian Space Agency, St. Hubert, Quebec, Canada

The Chemical and Aerosol Sounding Satellite (CASS) is a science mission concept developed by the Canadian Space Agency to provide climate quality atmospheric composition measurements from a low Earth orbit satellite platform. The measurements, by design, will trace back to the Global Climate Observing System (GCOS) Climate Monitoring Principles. CASS responds to the strongly expressed national and international need for continuation of solar occultation atmospheric composition measurements and for limb scatter measurements to provide high vertical resolution ozone profiles. Building on the strong Canadian heritage of state-of-the-art optical and infrared space instrumentation, the CASS payload is composed of the next generation Atmospheric Chemistry Experiment - Fourier Transform Spectrometer (ACE-FTS), currently on SCISAT, and the next generation of the Optical Spectrograph and InfraRed Imaging System (OSIRIS) instrument, on the Odin satellite. This presentation briefly describes the mission concept with its science objectives and requirements resulting from the Phase 0 study completed at the end of 2012.

Work developed by the CASS Mission Definition Team, led by Mission Manager Ron Wilkinson of the Canadian Space Agency, and composed by: Gaetan Perron, Louis M. Moreau and James Veilleux (ABB Inc.); Ken Smith and Andrew Bell (COM DEV Ltd.); Jennifer Michels, Jean-Francois Thibault and Don Asquin (Bristol Aerospace) and Ron Buckingham (Northeast Space Company). This work also had strong contribution of members of the User and Science Definition Team for CASS: Adam Bourassa (University of Saskatchewan); Vitali Fioletov and Chris McLinden (Environment Canada); Michaela Hegglin, Dylan Jones, Theodore Shepherd and Kimberly Strong (University of Toronto) and John McConnell and Tom McElroy (York University).

NO_2 distributions by SCIAMACHY across stratospheric transport barriers in comparison with the general circulation model EMAC

Presenting Author: Jānis Pukīte

Max Planck Institute for Chemistry, Mainz, Germany

The Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) on the ENVISAT satellite probed the atmosphere at the day side of Earth in alternating sequences of nadir and limb measurements from 2002 to April 2012.

Limb measurements performed at different tangent heights contain information about profiles of various trace gases in the stratosphere with poor horizontal resolution. The retrieval of horizontally resolved vertical profiles of stratospheric trace gases is performed by Differential Optical Absorption Spectroscopy (DOAS) followed by a tomographic inversion approach. The tomographic approach, involving either only limb or even additionally nadir measurements, minimizes errors caused by the horizontal inhomogeneity especially around transport barriers.

We study the performance of the tomographic retrieval of NO_2 profiles across the regions of stratospheric transport barriers by comparing it with modelling results from the atmospheric general circulation model EMAC. Here we concentrate on seasonal, multiannual (QBO), altitudinal and longitudinal variability of the location and strength of the tropical stratospheric transport barriers. Also a comparison with measurements performed by other satellite instruments (MLS, MIPAS) is shown.

Validation and intercomparison of SCIAMACHY V 2.5 and ESA Operational V 5.01 limb ozone profiles with concurrent sensors

Presenting Author: Nabiz Rahpoe

IUP Bremen, GERMANY

SCIAMACHY aboard ENVISAT provides global measurements of many trace gases in limb, occultation and nadir mode for nearly a decade starting in August 2002. In this paper a comprehensive validation of the SCIAMACHY V 2.5 and ESA Operational V 5.01 limb ozone profiles to other sensors e.g. MIPAS, GOMOS, SAGE II, HALOE, ACE-FTS, ODIN (OSIRIS/SMR) and MLS are presented. The validation is based on the long-term monthly mean time series as well as of collocated ozone profiles.

The Ozone Mapper Profiler Suite (OMPS) Limb Profiler. Results after one year of on-orbit operations

Presenting Author: Didier Rault

GESTAR/Morgan State University, USA/Canada

The Ozone Mapper Profiler Suite (OMPS) was launched in October 2011 on board of the Suomi NPP sun-synchronous satellite. The aim of the OMPS mission is to continue monitoring the global distribution of the Earth's middle atmosphere ozone and stratospheric aerosol. The OMPS sensor is composed of three instruments, namely the Total Column Mapper (heritage: TOMS, OMI), the Nadir Profiler (heritage: SBUV) and the Limb Profiler (heritage: SOLSE/LORE, SAGE III, OSIRIS, SCIAMACHY). The focus of the paper will be on the Limb Profiler (LP) instrument. The LP instrument measures the Earth's limb radiance, from which the ozone and aerosol vertical profiles are retrieved, nominally from the upper tropopause up to 60 km.

The paper will summarize the results obtained over the first year of on-orbit operations. The OMPS/LP has been operating continuously since February 2012, collecting limb spectra at a rate of 7000 spectra per day (160 measurements per orbit for each of the three slits and each of the 14 orbits per day) over a nominal tangent height range of 0 to 100 km and a quasi-continuous spectral range of 290 to 900 nm. Preliminary assessment of the OMPS/LP products is showing that:

1. Ozone vertical profiles are retrieved with relative accuracy of less than 5% over the 1 to 200 mbars pressure range and relative precision of less than 7% over 1 to 50 mbars, when compared with correlative measurements made by other space sensors (MLS, OSIRIS, ACE/FTS, OMPS/NP, OMPS/TC) and balloon sondes

2. Aerosol vertical profiles are retrieved with relative accuracy of less than 10% and relative precision of less than 30% over an altitude range extending from cloud top to 35 km, when compared with correlative measurements made by CALIPSO and GOMOS. Since aerosol extinctions are independently retrieved over a spectral range extending from 460 to 900 nm, one moment of the aerosol size distribution, namely the Angstrom coefficient, is also retrieved

The OMPS/LP was recently used to study and monitor the effect of the Chelyabinsk meteor on the upper atmosphere and the paper will summarize the latest findings.

Monte Carlo Radiative Transfer for Limb Scattered Sunlight Measurements

Presenter: Chris Roth

University of Saskatchewan, Canada

The SASKTRAN radiative transfer model is a spherical, successive orders, discrete ordinates model used for operational processing of the OSIRIS limb scattered sunlight measurements for retrievals of ozone, nitrogen dioxide and stratospheric aerosol extinction. Here we present results from the development of a Monte Carlo version of this model that provides the ability to test the robustness of the assumptions inherent in the operational version of the SASKTRAN model and investigate three dimensional effects, including the 3D averaging kernels for the retrievals.

Rotational Raman scattering in limb viewing geometry: modeling with SCIATRAN

Presenter: Vladimir Rozanov (or Alexey Rozanov)

Institute of Environmental Physics, University of Bremen, Germany

SCIATRAN is a comprehensive radiative transfer model allowing for simulations of the transmitted, reflected, and scattered solar radiation as well as thermal emission in the UV-Visible-NearIR spectral range. Radiative transfer calculations can be performed for the atmosphere-ocean system for any observation geometry typical for remote sensing applications.

This presentation is focused on the modeling of the rotational Raman scattering in limb viewing geometry. Affecting distribution of the solar radiance in the wavelength domain the Rotational Raman scattering is responsible for the so-called filling-in of solar Fraunhofer lines. This effect results in an incomplete canceling of the solar Fraunhofer structure than calculating the sum normalizing radiance strongly affecting DOAS-like retrievals of minor gaseous species. Besides its importance for trace gas retrieval a proper modeling of the rotational Raman scattering provides a possibility to estimate cloud parameters below the field of view of a limb instrument.

An Update on the SMILES NICT Level-2 Processing

Presenting Author: Hideo Sagawa

National Institute of Information and Communication Technology, Japan

This paper reports the current status of the NICT level-2 analyses of the JEM/SMILES data. The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) performed the atmospheric limb observations from the Japanese Experiment Module (JEM) onboard the International Space Station (ISS) between October 2009 and April 2010. The 4-K cooled superconducting receiver system of SMILES provided sensitivity of an order of magnitude higher than other satellite-borne submillimeter limb sounding instruments. Another unique characteristic of the SMILES observations is the non sun-synchronous orbit of ISS. By accumulating the data from the several ISS evolutions, diurnal variations of the atmospheric constituents can be analyzed.

The level-2 processing in the NICT employs the least squares method with a priori constraint to obtain global distributions of O_3, HCl, ClO, HO_2, $HOCl$, hnothree, BrO, and temperature at the stratosphere and mesosphere. The level-2 product version 2.1.5 has been released to the public for scientific researches. The validation studies for the major targeted species, such as O_3, HCl, and ClO, are currently under preparation for publications[$1-3$]. Because of its high sensitivity, the random errors on the SMILES measurements are kept very low, and the systematic errors due to uncertainties in the instrumental calibration and in the forward model become more important for the evaluation of SMILES product. Through the validation studies, we found that the uncertainty in the radiance calibration of the measurement spectra significantly affect the retrieved O_3 profile. The uncertainty in the SMILES antenna elevation angle, i.e., tangent heights of the limb viewing geometry, is also recognized as a critical error source for the level-2 processing. The impact of such instrumental characteristics on the level-2 processing will be discussed in the presented paper.

[1] *Sato et al. (2012), Atmos. Meas. Tech., 5, 2809-2825.*
[2] *Sagawa et al. (2013), Atmos. Meas. Tech. Discuss., 6, 613-663.*
[3] *Kasai et al. (2013), Atmos. Meas. Tech. Discuss., 6, 2643-2720.*

Twelve years of Arctic ozone depletion observed by Odin/SMR

Presenting Author: Kazutoshi Sagi

Chalmers University of Technology, Sweden

Stratospheric ozone plays an important role in the atmosphere because its absorption of solar Ultra Violet radiation directly or indirectly contributes the dynamics and chemistry. The reduction of stratospheric ozone amount in early spring over the Arctic region is of concern. Most recently, several groups reported the dramatic ozone loss of the arctic winter 2010-2011 (over 70%), which is closest to the ozone hole over the Antarctic.

Odin, The Swedish-led satellite project in collaboration with Canada, France and Finland, was launched in February 2001 and continues to produce profiles of chemical species relevant to understanding the middle and upper atmosphere.

The unstable nature of the arctic vortex due to the propagation of planetary waves from troposphere makes quantifying chemical ozone loss in the Arctic complicated. Röseval et. al., (2007) demonstrated that an assimilation technique using an advection model is effective tool for separating the dynamical and chemical changes in ozone amount. In the study to be presented, we have applied the assimilation method with a number of improvements in order to study the inter-annual variability during the last decade.

Analysis of Arctic stratospheric minor gases by combined use of JEM/SMILES and ACE-FTS

Presenter: Naoko Saitoh

Center of Environmental Remote Sensing, Chiba University, Chiba, Japan

We have analyzed the SMILES Level 2 research products (L2r) and the Atmospheric Chemistry Experiment-Fourier Transform Spectrometer (ACE-FTS) data to discuss the relationship between temperature and stratospheric minor gases related to ozone depletion and time variation of "Cl Partitioning" in the Arctic winter of 2009/2010.

Validation of SMILES level 2 version 2.4 products

Presenting Author: Takuki SANO

Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) onboard the International Space Station provided global measurements of trace gases in the middle atmosphere from 12 October 2009 to 21 April 2010. We present validation studies of the SMILES ver. 2.4 products based on coincidence statistics with satellite observations and outputs of chemistry and transport models (see the improvements in ver. 2.4 in another poster [SUZUKI et al.]). The comparisons of the stratospheric O_3 with correlative data show agreements that are generally within 10% for both daytime and nighttime. In the mesosphere, the agreements both daytime and nighttime are also good and better than 30% even at a high altitude of 73 km. The agreements of the SMILES HCl with ACE-FTS and MLS are less than 15% in the altitude range 20-44 km. In the higher altitudes, the SMILES HCl shows an almost constant value (about 3.0 ppbv) as theoretically expected, and there is in excellent agreement with SD-WACCM and MIROC3.2-CTM. The SMILES ClO also shows agreements with correlative data, and the SMILES measurements with their local time coverage also capture the diurnal variability very well. In this presentation, we will introduce the detail of the comparison results.

Overview of SMILES Mission and Scientific Outcomes

Presenting Author: Takuki SANO

Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)

A brief summary of scientific objectives, on-board operation results, 6-month atmospheric observation, and operational level 2 products of the Superconducting Submillimeter-wave Limb-Emission Sounder (SMILES) will be introduced.

As well as general pictures during the SMILES observation period (October 2009 to April 2010) such as seasonal evolutions and stratospheric sudden warming, some new features such as diurnal ozone variation in the stratosphere, validation results of ozone, ClO and HCl, and atmospheric response during annular solar exlipse in January 2010 will be also presented.

Quality assessment of water vapor satellite data records within the SPARC WAVAS-II activity

Presenting Author: Gabriele P. Stiller

KIT, IMK-ASF, Karlsruhe, Germany

The past decade has been a "golden age" for observations of middle atmospheric trace gas distributions from space since numerous satellite instruments have been in orbit. One of the most important trace species with respect to its impact on global climate and stratospheric chemistry is water vapor. The presentation will provide an overview on the currently available data base, and on climatologies derived from the satellite data sets covering the altitude range from the upper troposphere to the lower mesosphere. The current and planned efforts within the SPARC Water Vapor Assessment II (WAVAS II) to intercompare the available satellite data sets and perform a quality assessment will be presented, with some focus on the difficulties which we are facing on the way to a consistent multi-instrument long-term data set covering the last 30 years. Finally, future perspectives for the continuation of middle atmosphere water vapor observations from space will be discussed.

Observation of ClO, HO_2, $HOCl$, and BrO by ISS/JEM/SMILES

Presenting Author: Makoto Suzuki

Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)

Recent results on retrieval and validations of ClO, HO_2, $HOCl$, and BrO, their diurnal variation and discussion of chemical kinetics will be presented.

SMILES L2 v2.4 updates

Presenting Author: Makoto Suzuki

Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)

The v2.4 and future SMILES operational products and improvements on processing algorithm will be discussed.

Results of SMILES-2 Feasibility Study

Presenting Author: Makoto Suzuki

Institute of Space and Astronautical Science (ISAS), Japan Aerospace Exploration Agency (JAXA)

A plan of SMILES-2 proposal, which has 4K cooled 625-650 GHz and other bands similar to Aura/MLS will be disccussed.

A Japanese 600 kg satellite series (Sprint - Asnaro satellite-bus) using new Japanese EP-SILON solid rocket launcher can provide unique opportunity to conduct atmospheric science from 50-60 degree inclined orbit, and it can carry 50-70 kg non-Japanese instrument.

SPARC Data Initiative - Trace Gas Comparisons

Presenting Author: Susann Tegtmeier

GEOMAR Helmholtz Centre for Ocean Research Kiel, Kiel, Germany

The SPARC Data Initiative carries out a comprehensive inter-comparison of atmospheric satellite climatologies of chemical tracers and aerosols extending from the upper troposphere to the middle mesosphere. The initiative assesses the quality of the available data sets and highlights similarities and differences between them, taking account of sampling limitations and biases. The evaluations of the trace gas climatologies include zonal monthly mean comparisons investigating the latitudinal and vertical structure of the various data sets.

Additionally the seasonal cycle, time series of deseasonalized trace gas anomalies and explicit diagnostics such as quasi-biennial oscillation (QBO) for ozone and the tape recorder for water vapor are evaluated. An assessment of the range of measurements as an estimate of the systematic uncertainty in our knowledge of middle atmosphere mean state is derived for all trace gases. In this contribution we will present a selection of results for long lived key species such as ozone and water vapor, for short lived trace gases such as the nitrogen species and for aerosol.

Characterizing sampling-related uncertainties in stratospheric trace gas climatologies

Presenting Author: Matthew Toohey

Ocean Circulation and Climate Dynamics GEOMAR, Helmholtz-Zentrum für Ozeanforschung, Kiel, Germany

Stratospheric trace gas observations are often used to produce zonal mean monthly mean data sets, or climatologies. Such data products can be used as prescribed forcing for models, and are also useful for comparison with similarly averaged chemistry climate model output. In order to properly use climatologies, and interpret differences between climatologies from different instruments, it is necessary to know the uncertainty in each calculated climatological mean field. The inhomogeneous and finite temporal-spatial sampling pattern of each instrument can lead to biases and uncertainties in the climatologies. Sampling which is non-uniform in time and space leads to biases between a data set's climatology and the truth. Furthermore, the systematic sampling patterns of some instruments may mean that uncertainties in mean fields calculated through traditional methods that assume random sampling may be inappropriate. We have investigated these issues through an exercise wherein chemical fields from coupled Chemistry Climate Model simulations are sub-sampled based on the sampling patterns of the suite of limb-sounding instruments participating in the SPARC Data Initiative. Climatologies based on the sub-sampled data can be compared to those calculated with the full data set in order to assess sampling errors. The results of the study imply that the most important mechanism leading to sampling bias is the non-uniform temporal sampling of many instruments, i.e. the fact that for many instruments, monthly means are produced from measurements which span less than the full month in question. We also show that when instrumental sampling patterns are relatively uniform in terms of longitudinal sampling coverage, the oft-used standard error of the mean estimator (σ/sqrt(n)) is generally a conservative estimate of the actual uncertainty in the mean. Exceptions occur when the sampling distribution and the measured field have non-uniformity of similar zonal structure, leading to instances when σ/sqrt(n) may significantly underestimate the uncertainty in the mean.

SABER and MLS Summer Mesosphere Temperature Profiles Compared with Rayleigh Twilight Polarization Measurements

Presenting Author: Oleg S. Ugolnikov

Space Research Institute, Russian Academy of Sciences, Moscow, Russia

Non-LTE state of the mesosphere and lack of direct methods make its temperature measurements quite difficult. Remote sensing methods often lead to difference of result values. In the same time, the mesosphere temperature seems to change faster than in any other atmosphere layer, showing the possible cooling effect with the value about several degrees per decade. This effect can be related with radiative cooling by increased amount of CO2 in the mesosphere.

Global data on mesosphere temperature is provided now by TIMED/SABER and EOS Aura/MLS space experiments. These databases show the difference of temperature values, especially in high northern latitudes during the summer, the period when the fastest cooling is observed and the minimal temperatures are achieved. It makes important to compare it with results of another (ground-based) methods of temperature measurements at these latitudes, especially in the locations where no such study (microwave, lidar, etc) was done before.

In this paper SABER and MLS data are compared with Rayleigh temperature values obtained by the all-sky twilight scattered background measurements in central Russia at latitude 55°N, where the summer twilight is deep enough, but summer mesosphere cooling takes place. Polarization analysis helps to separate the aerosol and multiple scattering and gives the temperature profiles of upper mesosphere (70-85 km) with a single measurement accuracy about 5K. The method is least expensive through all mesosphere temperature measurements.

The work is done with financial support of Russian Foundation for Basic Research, grant No. 12- 05-00501-a.

Limb Trajectory Retrieval and Component Investigations of Southern Polar Stratosphere Based on High Resolution Spectroscopy of the Moon during the Total Eclipse

Presenting Author: Oleg S. Ugolnikov

Space Research Institute, Russian Academy of Sciences, Moscow, Russia

The work is devoted to the southern polar stratosphere investigations based on the high resolution spectroscopy of the Moon inside the umbra of the Earth. During the eclipse the Moon is emitted by the radiation refracted in the atmosphere of the Earth. The altitude and coordinates of the ray perigee are determined by the moon surface point position inside the umbra. The radiation transfer geometry is analogous to the space limb atmosphere measurements allowing to scan the distant atmosphere regions at several thousand kilometers from the observation point. Lunar eclipse is the only ground-based possibility to hold such study. Using the large-aperture astronomical technique and high resolution spectrographs we can hold the line-by-line analysis of the polar stratosphere components.

The work is based on the spectral measurements of the Moon near the southern umbra border during the total eclipse of December, 10, 2011. The radiation was transferred through the Antarctic stratosphere near the seasonal ozone depression, that makes the investigation especially interesting. The observations were held at 1.2-meter telescope of Kourovka observatory with fiber high resolution spectrograph (resolution about 30000). Measurements covered the spectral range from 450 to 780 nm and were calibrated by the analogous spectra of uneclipsed Moon and standard star. This allowed to hold the correct separation of local atmospheric lines above the observation point.

Observational spectra contain a lot of atmospheric lines (O_2, O_3, O_4, H_2O, NO_2). Three oxygen bands (630, 690 and 765 nm) together with O4 absorption features between 450 and 600 nm were used to retrieve the effective trajectory of the radiation transfer through the Antarctic stratosphere depending on the wavelength and estimate the influence of aerosol scattering. Other gases bands give the values of tangent column densities of these gases in the lower Antarctic stratosphere. The accuracy is especially high for ozone, since the observational range covers the majority of Chappius bands, where absorption by the tangent trajectory is very strong (up to a factor of 6). The work is done with the financial support of Russian Foundation for Basic Research, grant No.12-05-00501-a.

Improving retrieval quality for airborne limb sounders by horizontal regularisation

Presenting Author: Jörn Ungermann

Research Centre Jülich GmbH

Modern airborne infrared limb sounders are capable of measuring profiles so fast that neighbouring profiles are very similar to one another. This can be exploited by retrieving whole 2D cross-sections instead of simple 1-D profiles.

This talk presents algorithms that are able to perform such a large-scale retrieval and that efficiently produce typical diagnostic quantities. The characteristics and capabilities of the proposed method are analysed and demonstrated in a detailed case study using a series of profiles that were measured by CRISTA-NF (Cryogenic Infrared Spectrometers and Telescope for the Atmosphere-New Frontiers). It is shown that cross-section retrievals can either reduce noise-induced artefacts or produce finer vertical structures while maintaining the same image noise level. Further, it is briefly discussed how the presented methodology can also be applied to improve the retrievals for other instrument types including current satellite-borne nadir-sounders and near-future satellite-borne limb sounders.

Filamentary structure in chemical tracer distributions near the subtropical jet following a wave breaking event

Presenting Author: Jörn Ungermann

Research Centre Jülich GmbH

This talk presents a set of observations and analyses of trace gas cross-sections in the extratropical upper troposphere/lower stratosphere (UTLS). The spatially highly-resolved ($\approx$ 0.5km vertically and 12.5km horizontally) cross-sections of ozone (O_3), nitric acid (HNO_3), and peroxyacetyl nitrate (PAN), retrieved from the measurements of the CRISTA-NF infrared limb sounder flown on the Russian M55-Geophysica, revealed intricate layer structures in the region of the subtropical tropopause break. The chemical structure in this region shows an intertwined stratosphere and troposphere. The observed filaments in all discussed trace gases are of a spatial scale of less than 0.8km vertically and about 200km horizontally across the jet-stream. Backward trajectory calculations confirm that the observed filaments are the result of a breaking Rossby wave in the preceding days. An analysis of the trace gas relationships between PAN and O_3 identifies four distinct groups of air mass: polluted subtropical tropospheric air, clean tropical upper-tropospheric air, the lowermost stratospheric air, and air from the deep stratosphere. The tracer relationships further allow the identification of tropospheric, stratospheric, and the transitional air mass made of a mixture of UT and LS air. Mapping of these air mass types onto the geo-spatial location in the cross-sections reveals a highly structured extratropical transition layer (ExTL). Finally, the ratio between the measured reactive nitrogen species (HNO_3 +PAN+$ClONO_2$) and O_3 is analysed to estimate the influence of tropospheric pollution on the extratropical UTLS.

In combination, these diagnostics provide the first example of a multi-species two-dimensional picture of a chemically inhomogeneous UTLS region. Since Rossby wave breaking occurs frequently in the region of the tropopause break, these observed finescale filaments are likely ubiquitous in the region.

11-years of water vapour observations by the Odin Sub-Millimetre Radiometer and future plans

Presenting Author: Jo Urban

Chalmers University of Technology, Göteborg, Sweden

The Sub-Millimetre Radiometer (SMR) on board the Odin satellite makes limb measurements of water vapour in several 800 MHz wide spectral bands. Measurements of thermal emission in the centre of the strong water line at 557 GHz allow the retrieval of water vapour profiles in the mesosphere and lower thermosphere. The far wing of this line is also measured around 544.6 GHz providing information on water vapour in the altitude region just above the tropopause. Another line around 488.9 GHz is dedicated to observations of water vapour in the stratosphere and lower mesosphere. Additionally, several minor isotopologues of water vapour (HDO, H_2O-18, H_2O-17) are measured around 490.4 GHz and 551.7 GHz.

Regular observations by Odin/SMR started in November 2001 and the still growing data sets comprise now more than 11 years. The presentation will focus on (1) an assessment of the quality of the Odin/SMR water vapour products, (2) a presentation of some scientific high-lights related to water vapour evolution and variability, and (3) an outlook on planned reprocessing activities in order to further improve the Odin/SMR data sets.

Finally, the proposed STEAM radiometer (Stratosphere-Troposphere Exchange And Climate Monitor) will be presented. The instrument is optimised to measure water vapour in a band around 325 GHz and the STEAM measurement capabilities for water vapour will be discussed.

AERGOM: Improved aerosol extinction profiles from GOMOS measurements

Presenting Author: Filip Vanhellemont

Belgian Institute for Space Aeronomy

During its 10-year mission (2002-2012), the GOMOS instrument on ENVISAT has delivered a total of about 800,000 stellar occultation measurements, delivering a quasi-global view of the distribution and evolution of some major atmospheric trace gases and aerosols/clouds. At present, the quality of the obtained profiles is still being improved. More specifically, it has been known for some time that upper tropospheric/lower stratospheric aerosol extinction profiles suffer from rather strong retrieval-related perturbations. The purpose of the ESA-financed AERGOM project was to improve this situation, and additionally to provide microphysical quantity retrievals (particle size distributions and derived quantities). We will present an overview of the algorithm specifics, retrieval examples and validation results obtained from comparisons with satellite (SAGE II, SAGE III, POAM III) and balloon instruments.

Impact of the solar 11-year and 27-day cycles on middle atmospheric temperatures

Presenting Author: Christian v. Savigny

Ernst-Moritz-Amdt-Universität Greifswald, Germany

The sun's spectral irradiance exhibits variability at very different temporal scales, including the 11-year solar cycle as well as the 27-day differential rotational solar cycle. Solar cycle signatures have been identified in the past in several atmospheric parameters, including temperature and a few minor constituents. This talk will focus on recent results based on SCIAMACHY as well as MLS/Aura observations of mesospheric and mesopause temperatures. SCIAMACHY night-time OH* airglow measurements were used to retrieve OH*(3-1) rotational temperatures near the mesopause. A clear solar-driven 27-day signature has been identified in this temperature data set with time lags between the solar forcing and the atmospheric response being a few days at most. Remarkably, the quantitative temperature sensitivity to solar forcing at the 27-day scale agrees within uncertainties with the temperature sensitivity to solar forcing at the 11-year time scale, suggesting similar underlying physical mechanisms driving the temperature response to solar variability at these very different temporal scales. A similar effect was recently identified by our group in noctilucent cloud parameters. The temperature sensitivity is in good agreement with HAMMONIA model simulations, but the SCIAMACHY results disagree with HAMMONIA in terms of the time lag between solar forcing and the atmospheric temperature response. Apart from SCIAMACHY, MLS/Aura temperature measurements are also used to extract the solar-driven 27-day signature in middle atmospheric temperatures. The variation of temperature sensitivity with altitude and latitude may allow drawing conclusions on the physical/chemical mechanisms causing the solar-driven temperature response in the Earth's middle atmosphere.

The Atmospheric Chemistry Experiment (ACE) Satellite Mission: Overview, Mission Status and Results

Presenting Author: Kaley A. Walker

Department of Physics, University of Toronto, Toronto, Ontario, Canada
Department of Chemistry, University of Waterloo, Waterloo, Ontario, Canada

On 13 August 2013, the Canadian-led Atmospheric Chemistry Experiment (ACE) will complete its tenth year in-orbit on board the SCISAT satellite. SCISAT/ACE is uses infrared and UV-visible spectroscopy to investigate the chemistry and dynamics of the Earth's atmosphere. The primary instrument on-board, the ACE Fourier Transform Spectrometer (ACE-FTS) is a high-resolution (0.02 cm^{-1}) FTS operating between 750 and 4400 cm^{-1}. It also contains two filtered imagers (0.525 and 1.02 microns) to measure atmospheric extinction due to clouds and aerosols. The second instrument is a dual UV-visible-NIR spectrophotometer called ACE-MAESTRO (Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation) which was designed to extend the ACE wavelength coverage to the 280-1030 nm spectral region. The ACE-FTS and ACE-MAESTRO instruments have been making regular solar occultation measurements for nearly 10 years and, from these measurements, altitude profiles of over 30 different atmospheric trace gas species, temperature and pressure are obtained. The 650 km altitude, 74 degree circular orbit provides global measurement coverage with a focus on the Arctic and Antarctic regions. The primary ACE science goal is to investigate the processes that control the distribution of ozone in the stratosphere and upper troposphere with a focus on the Arctic. The secondary science goals are to explore chemistry-climate coupling, to study biomass burning emissions in free troposphere and to investigate the radiative impacts of aerosols and clouds.

This presentation will give an overview of the mission status and will provide a survey of the scientific and validation results obtained from ACE. In addition, this presentation will discuss potential missions to continue measurements of this type for atmospheric monitoring and scientific studies.

SCIAMACHY limb water vapor retrieval V3.01, 2002-2012

Presenting Author: Katja Weigel

Presenting Author's Affiliation: IUP, University of Bremen

Water vapor profiles in the upper troposphere and lower stratosphere (UTLS) are retrieved from SCIAMACHY limb measurements in the near infrared spectral range (1353-1410nm).

Here, we present the time series from 2002 to 2012 of data version 3.01 covering about 11 to 23 km altitude. This data set is the result of the DFG project SHARP (Stratospheric Change and its role for Climate Prediction) and the ESA project SPIN (ESA SPARC Initiative).

The UTLS is a region of special interest for a variety of dynamical and chemical processes and the water vapor in the UTLS plays an important role for the radiative budget of the atmosphere.

To assess the quality and long term stability of V3.01 comparisons to other satellite data, water vapor from SCIAMACHY occultation measurements and in situ measurements are presented.

UV/vis/near-IR limb measurements onboard the NASA Global Hawk in the tropical tropopause layer (TTL)

Presenting Author: Bodo Werner

Institut für Umweltphysik, Universität Heidelberg, Heidelberg, Germany

The Airborne Tropical TRopopause EXperiment (ATTREX) aims at investigating chemical and physical processes in the tropical tropopause layer (TTL) using NASA's Global Hawk (GH) UAV. Within the NASA-ATTREX project, the IUP/UCLA collaboration developed a novel 3 channel (UV/vis/near-IR) limb scanning mini-DOAS (Differential Optical Absorption Spectroscopy) spectrometer for deployments on the NASA GH. Major scientific objectives of the mini-DOAS observations are to study the photochemistry of ozone destroying radicals (e.g. NO_2, BrO, CH_2O, IO, $OClO$, $\cdots$), the budget of total inorganic bromine and iodine, as well as the abundance of particles and their optical properties in the TTL.

Primary information gained by the mini-DOAS measurements are so-called slant column densities (SCDs) of the targeted gases measured as a function of telescope elevation angles. The inversion of the SCDs into vertical concentration profiles requires forward radiative transfer (RT) modeling constrained by auxiliary parameters (atmospheric pressure, temperature, geo-location of the GH, the Sun position, et cetera) and by the changing optical state of the atmosphere due to varying amounts of aerosols and clouds. The optical state (i.e. aerosol extinction, single scattering albedo, phase function) is inferred from measured wavelength-dependent relative radiances and measured O_2-O_2 absorption bands using a non-linear Levenberg-Marquardt scheme that then determines the RT of the trace gas inversion.

The present paper reports on the measurement technique, and discusses details of the radiative transfer and the inversion algorithm. Example cases are presented and discussed along with other optical parameters simultaneously measured on the GH in order to validate our approach.

Absorbing aerosol radiative effects in the limb-scatter viewing geometry

Presenting Author: Aldona Wiacek

Department of Physics and Atmospheric Science, Dalhousie University, Halifax, Canada

We use the fully three-dimensional radiative transfer code SASKTRAN to simulate the sensitivity of limb-scatter viewing Odin/OSIRIS satellite measurements to absorbing mineral dust and carbonaceous aerosols (smoke and pure soot), as well as to non-absorbing sulfate aerosols and ice in the upper troposphere.

At long wavelengths (813 nm) the addition of all aerosols (except soot) to an air only atmosphere produced a radiance increase as compared to air only, on account of the low Rayleigh scattering in air only at 813 nm. The radiance reduction due to soot aerosol was negligible ($<$0.1%) at all heights (0-100 km).

At short wavelengths (337 nm, 377 nm, 452 nm), we found that the addition of any aerosol species to an air only atmosphere caused a decrease in single-scattered radiation due to an extinction of Rayleigh scattering in the direction of OSIRIS. The reduction was clearly related to particle size first, with absorption responsible for second-order effects only. Multiple-scattered radiation could either increase or decrease in the presence of an aerosol species, depending both on particle size and absorption.

At short wavelengths, the combined effect of single scattering decreases and multiple scattering increases led to complex total radiance signatures that generally could not unambiguously distinguish absorbing versus non-absorbing aerosols. However, we found that in the limb-scatter viewing geometry scene darkening above the aerosol layer is unambiguously due to absorption whereas scene darkening within and below the aerosol layer can simply be the result of a reduction in single-scattered radiance. Our simulations show a greater scene darkening for decreasing wavelengths, increasing surface albedo, decreasing solar zenith angle, and increasing particle number concentration, however, at 337 nm this effect did not exceed 0.2% of the total radiance due to air only for medium-sized carbonaceous aerosols.

A fortuitous, unexpected implication of our analysis is that limb-scatter retrievals of aerosol extinction are insensitive to external information about aerosol absorption.

Remote sensing of stratospheric vertical concentration profiles from TELIS measurements

Presenting Author: Jian Xu

DLR, Germany

The balloon-borne cryogenic heterodyne spectrometer TELIS (TErahertz and submillimeter LImb Sounder) has been designed to observe the vertical distribution of trace gases in the lower and middle stratosphere. The instrument was installed on a balloon gondola together with MIPAS-B (KIT-IMK) and mini-DOAS (Heidelberg University) and has participated three successful scientific flights in Kiruna, Sweden between 2009 and 2011. The broad spectral coverage of TELIS is achieved by utilizing two major frequency channels: a tunable 1.8 THz channel based on a solid state local oscillator and a hot electron bolometer as mixer, a 480-650 GHz channel with the Superconducting Integrated Receiver (SIR) technology, developed by DLR and SRON, respectively. Moreover, an extended spectral range is observed by the combination of TELIS and MIPAS-B, which can be used for cross validation of measured gas concentrations.

For estimation of vertical concentration profiles from the TELIS observations, a constrained nonlinear least squares fitting program has been developed. In this work we present the retrieval results from latest calibrated spectra during those three flights. Emphasis is placed on O_3, HCl, and CO, and error sources pertaining to the main instrumental uncertainty terms including nonlinearities in the calibration procedure, sideband ratio deviation, and pointing offset are addressed. The retrieved profiles are validated against other limb sounding instruments, e.g., SMILES, MLS, and MIPAS-B.

Strato-mesospheric HCl observed by Superconducting Submilimeter-Wave Limb-Emission Sounder (SMILES)

Presenting Author: Kengo Yokoyama

Osaka Prefecture University, Japan

We have observed vertical profiles of HCl abundance from the stratosphere to the mesosphere using the Superconducting Submilimeter-Wave Limb-Emission Sounder (SMILES) attached to the Japanese Experiment Module (JEM) on the International Space Station (ISS). The unprecedented low noise of the SMILES observation resulted 20 times better sensitivity than previous microwave/submillimeter limb instruments from space. The SMILES observation realized to measure HCl from 80 hPa (about 18 km) up to 0.001 hPa (about 95 km) for single scan. The ISS has a non sun-synchronous circular orbit and the SMILES observed day/night cycles of atmospheric compositions.

We evaluated the SMILES HCl observation by the error analysis and comparisons with Aura/MLS and ACE/FTS. The SMILES HCl product has lower abundance trend (about - 10%) in the upper stratosphere and mesosphere, which is likely due to the problems of spectrum nonlinerary and tangent height. We found the diurnal variation of HCl at 53km and 60km (around 0.5 hPa and 0.2 hPa) from the retrieved profiles and measured spectrum.