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PEKKA T. VERRONEN

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Pekka T. Verronen (ed)

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Abstract

Finnish Meteorological Institute organised the 5th International Atmospheric Limb Conference and Workshop in Helsinki, Finland on November 16th – 19th, 2009. This scientific meeting was attended by scientists from around the world. A total of 50 presentations were given, 41 of them oral and 9 posters. This report is the official abstract book of the workshop.

The conference was focused on the atmospheric observations made with limb-viewing instruments onboard Earth-orbiting satellites. The scientific program was divided into 4 sections: 1) Instruments & missions, 2) Retrieval & radiative transfer, 3) Stratosphere & troposphere, and 4) Mesosphere.

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LIMB2009-kokous: Tiivistelmät

Tiivistelmä

Ilmatieteen laitos järjesti viidennen kansainvälisen LIMB-kokouksen (”5th International Atmospheric Limb Conference and Workshop”) Helsingissä 16. - 19. marraskuuta 2009. Kokoukseen osallistui tiedemiehiä ja -naisia ympäri maailman. Kokouksen aikana kuultiin yhteensä 50 tieteellistä esitelmää, joista 41 on suullisia ja 9 julisteita. Tämä raportti sisältää em. esitysten tiivistelmät.

Kokouksen aiheena oli ilmakehän kaukokartoitus ns. ”limb-viewing”-mittalaitteilla. Tiedeohjelma oli jaettu neljään aihealueeseen: 1) Mittalaitteet ja hankkeet, 2) Mittausten prosessointi ja säteilynkuljetus, 3) Stratosfääri ja troposfääri, sekä 4) Mesosfääri.

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FINNISH METEOROLOGICAL INSTITUTE

Welcome to FMI

Dear Conference Participant:

On behalf of the Finnish Meteorological Institute, I would like to warmly welcome You to the 5th International Atmospheric Limb Conference and Workshop.

FMI is the leading space research institute in Finland. FMI participates in missions targeted to studies of atmosphere, land, snow and ice cover, and space environment. Presently FMI is involved in three atmospheric satellite instruments: GOMOS on ENVISAT, OSIRIS on Odin and OMI on EOS-AURA. FMI was a co-proposer of GOMOS in 1988. FMI serves as an ESA's GOMOS Expert Support Laboratory and FMI hosts the GOMOS Level 2 data processing facility FIN-CoPac in Sodankylä FMI is one of the data processing centres for Odin's UV-visible spectrograph OSIRIS. OMI is a joint project of the Netherlands, Finland and NASA. FMI is processing OMI VFD (very fast delivery) ozone products as well as UV-products.

The three instruments, GOMOS, OSIRIS and OMI, have produced enormous amounts of measurement data about troposphere, stratosphere and mesosphere but they have already exceeded their predicted lifetimes. In order to guarantee the continuity of data, which is essential for climate change studies, international satellite organisations and science communities have plans for new missions. In Europe ESA and EU are committed to the Sentinel-program with two missions aimed at atmospheric measurements. The Netherlands has initiated the TROPOMI mission that bridges the gap between ENVISAT, EOS-Aura and Sentinels. FMI looks for possibilities to participate in these missions and to propose new missions in the ESA's Explorer program.

In order to make optimal use of vast quantities of satellite data from ongoing and future missions, ESA and EU have created GMES program and EUMETSAT the Satellite Application Facilities (SAF) program. FMI is an active partner in these programs and, for example, the host of the Ozone SAF.

I wish you a successful conference and an enjoyable time in Finland!

Petteri Taalas
Director General
Finnish Meteorological Institute

		5th Limb conference and workshop	
		16-19.11. 2009	
		Finnish Meteorological Institute	
		Erik Palmenin aukio 1	
		Kumpula campus	
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1 Instruments & missions 1 (Monday p.m.)

The Atmospheric Chemistry Experiment (ACE): Status and latest results

Chris Boone
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Peter Bernath
Department of Chemistry, University of York, Heslington, York, YO10 5DD, UK

ACE (also known as SCISAT) is making a comprehensive set of simultaneous measurements of numerous trace gases, thin clouds, aerosols and temperature by solar occultation from a satellite in low earth orbit. A high inclination (74 degrees) low earth orbit (650 km) gives ACE coverage of tropical, mid-latitudes and polar regions. A high-resolution (0.02 cm_1) infrared Fourier Transform Spectrometer (FTS) operating from 2 to 13 microns (750–4400 cm_1) is measuring the vertical distribution of trace gases, and the meteorological variables of temperature and pressure. Aerosols and clouds are being monitored using the extinction of solar radiation at 0.525 and 1.02 microns as measured by two filtered imagers as well as by their infrared spectra.

A dual spectrograph called MAESTRO extends the wavelength coverage to the 400-1000 nm spectral region. The principal investigator for MAESTRO is T. McElroy of the Environment Canada. The FTS and imagers have been built by ABB-Bomem in Quebec City, while the satellite bus has been made by Bristol Aerospace inWinnipeg. ACE is part of the Canadian Space Agency's small satellite program, and was launched by NASA on 12 August 2003 for a nominal 2-year mission. Although in orbit now for more than 6 years, ACE performance is still excellent with no serious problems.

The first results of ACE have been presented in a special issue of Geophysics Research Letters (http://www.agu.org/journals/ss/ACECHEM1/) in 2005 and recently a special issue on ACE validation has been prepared for Atmospheric Chemistry and Physics (http://www.atmos-chem-phys.net/special_issue114.html) by K.Walker and K. Strong; more information can be found at http://www.ace.uwaterloo.ca. A mission overview and status report will be presented. Science results for a few selected topics including the detection of organic molecules such as formaldehyde and formic acid in the troposphere as well as carbon dioxide profiles in both the troposphere and mesosphere will be discussed. Challenges associated with the detection of organic molecules in the troposphere, such as line mixing and the lineshape of H_2O, will be described.

Results from the SOFIE instrument on AIM

Larry L. Gordley, Mark E. Hervig, B.T. Marshall, John C. Burton, Lance E. Deaver, Marty McHugh, Gregory J. Paxton and R.E. Thompson
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James M. Russell
Hampton University, 23 Tyler St., Hampton, VA 23668

Scott M. Bailey
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The SOFIE (Solar Occultation for Ice Experiment) instrument, launched on-board the AIM (Aeronomy of Ice in the Mesosphere) satellite on April 25, 2007, is in its third year of operation, and will enter a sixth polar summer ice season in November 2009. This simple, autonomously operating, broadband radiometer, with a solar imaging system used for pointing knowledge, achieves unprecedented pointing fidelity and broadband transmission precision. Cosmic dust detection, refraction angle based thermal sounding up through the low mesosphere and ozone and water profiles through the mesopause are augmenting a rich data set of exceptionally precise PMC extinction measurements. This paper will give an overview of SOFIE results and its approach to achieving precise occultation observations.

OSIRIS on Odin – Year Nine of a Two Year Mission

D.A. Degenstein, A.E. Bourassa, C.A. McLinden, the OSIRIS Team of Scientists, and E.J. Llewellyn

The Canadian built OSIRIS instrument has been in operation on the Odin satellite platform since the autumn of 2009. During this time OSIRIS has routinely made measurements of limb scattered sunlight and photochemical emissions over an altitude range that covers the upper troposphere up to the lower thermosphere. This paper will discuss the current state of the operational data products that include vertical profles of: ozone; nitrogen dioxide; and stratospheric sulphate aerosol extinction. Also included will be a description of the research data products such as: mesospheric OH, NO2, NO and other auroral emissions; the bromine oxide vertical profles; the cirrus and sub-visual cirrus cloud database; the volcanic aerosols; and other assorted surprises that exist within the OSIRIS measured spectra. Also presented will be a vision of where members of the OSIRIS team of scientists are heading in the near and more distant future. This is a future that looks bright with the recent award of many Canadian Space Agency sponsored Space Science Enhancement Program grants for the scientifc analysis of OSIRIS data products.

GOMOS/ENVISAT overview

E. Kyrölä and the GOMOS Team
Finnish Meteorological Institute, P.O. Box 503, 00101 Helsinki, Finland

GOMOS (Global Ozone Monitoring by Occultation of Stars) on ESA's Envisat-satellite measures transmission of light through the Earth's atmosphere in the limb direction using the stellar occultation method. From transmissions it is possible to retrieve vertical density profiles of ozone, NO_2, NO_3, H_2O, O_2, and aerosols in the stratosphere and ozone also in the MLT region. High-resolution temperature profiles in the 15-35 km altitude range can be retrieved using data from the two fast photometers. In this presentation we will show main scientific results from GOMOS during the seven years in operation. We will show climatological and time series analysis of ozone, NO_2, NO_3 from 2002-2008. Results about OClO, mesopause sodium layer, polar mesospheric clouds, gravity waves and turbulence and impact of energetic particles on polar NO_y and ozone will be highlighted. We also review the development of the GOMOS data quality during 2002-2008.

Current Status of Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES)

Masato Shiotani
Research Institute for Sustainable Humanosphere, Kyoto University, Kyoto, Japan

Masahiro Takayanagi, Takuki Sano
Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, Sagamihara, Japan

SMILES mission team

The Superconducting Submillimeter-Wave Limb-Emission Sounder (SMILES) was designed to be aboard the Japanese Experiment Module (JEM) on the International Space Station (ISS) as a collaboration project of Japan Aerospace Exploration Agency (JAXA) and National Institute of Information and Communications Technology (NICT). Mission Objectives are: i) Space demonstration of super-conductive mixer and 4-K mechanical cooler for the submillimeter limb-emission sounding in the frequency bands of 624.32 - 627.32 and 649.12 - 650.32 GHz, and ii) global observations of atmospheric minor constituents in the stratosphere (O_3, HCl, ClO, HO_2, HOCl, BrO, O_3 isotopes, HNO_3, CH_3CN, etc), contributing to the atmospheric sciences.
SMILES instrument will be launched within H-II Transfer Vehicle (HTV) by the latest version of H-II rocket (H-IIB) on September 10th from Tanegashima Space Center in Japan.

One of the most unique characteristics of the SMILES observation is its high sensitivity in detecting atmospheric limb emission of the submillimeter wave range (640GHz). The ISS has a circular orbit with an inclination angle of 51.6° and with an orbital period of 93 minutes. In order to measure high-latitude regions, the antenna beam is tilted 45° degrees left from the direction of orbital motion, enabling SMILES to observe latitudes from 38°S to 65°N (Figure 1). With its high sensitivity the SMILES observation will provide superior global data on several radical species crucial to the ozone chemistry (O_3, HCl, ClO, HOCl, BrO, HO_2 etc.) About species with larger errors such as BrO (50 - 80% in upper stratosphere), some averaging in space and/or time will reduce the error levels.

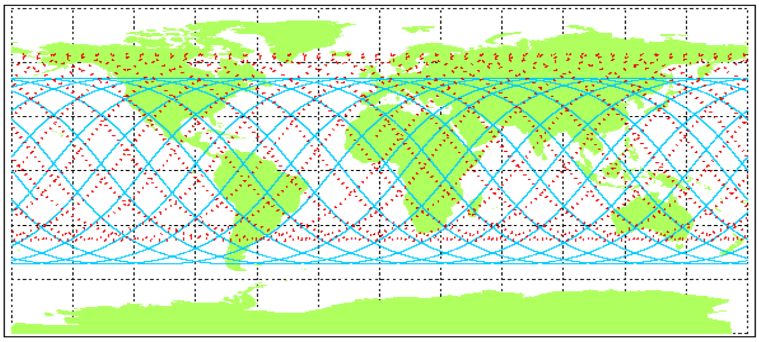

Figure 1: *SMILES Measurement positions (red) along the ISS orbit (blue)*

In this presentaiton, the up-to-date information of SMILES operation as well as the preliminary result of observation data processing.

References

Takahashi C., Ochiai S., and Suzuki M., Operational Retrieval Algorithms for JEM/SMILES Level 2 Data Processing System, JQSRT, doi:10.1016/j.jqsrt.2009.06.005, *in press.*

2 Retrieval & radiative transfer 1 (Tuesday a.m.)

2

Retrievals of the water vapor content in the upper troposphere and the lower stratosphere from SCIAMACHY limb measurements

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Stratospheric water vapor plays an important role in determining radiative and chemical properties of the middle atmosphere. Furthermore, it can be used as tracer when studying the exchange between the stratosphere and the troposphere as well as large scale circulations. The major source of the global information on the stratospheric water vapor provide satellite measurements. In the previous studies, measurements of the solar radiation transmitted through the atmosphere, measurements of the emitted radiance in the thermal infrared spectral range, or microwave techniques were used to retrieve stratospheric water vapor amounts.

This study presents a novel approach allowing the vertical distributions of the stratospheric water vapor to be retrieved from the measurements of the scattered solar radiation in the near infra red spectral range as performed by the Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY) in limb viewing geometry. We present a retrieval algorithm capable to gain the vertical distributions of the water vapor in the lower stratosphere and upper troposphere (between about 12 and 23 km) from SCIAMACHY limb measurements. The sensitivity of the retrieval algorithm is investigated. The retrieved vertical distributions of the water vapor are compared to the results of independent measurements.

Two-Dimensional performance of MIPAS observation modes in the UTLS

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The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) in its present configuration can measure the atmosphere with seven different observation modes. Two of them (denoted as UTLS-1 and UTLS-2) have been expressly designed to sound the Upper-Troposphere/Lower-Stratosphere (UTLS) region. The MIPAS "nominal" observation mode (denoted as NOM and operated for about 80% of the instrument's measuring time) also sounds the UTLS region with a vertical sampling of the atmosphere which is similar to the one of the two specific modes. The three observation modes differ in the limb scanning pattern at upper altitudes therefore, due to the different measuring time required by a single limb scan, they operate different samplings of the atmosphere in the horizontal domain.

In this communication we analyze the performance of the aforesaid observation modes when a two-dimensional (2D) tomographic approach [*Carlotti et al.* (2001)] is exploited to derive the atmospheric field of geophysical parameters in the UTLS. The 2D retrievals allow to set the horizontal separation among the target altitude profiles, therefore the horizontal resolution becomes a property that qualifies the retrieved atmospheric fields in addition to their vertical resolution and precision.
In the first stage of our analysis we have calculated 2D distributions of the Information Load (IL) [*Carlotti and Magnani* (2009)] for geophysical targets of interest in the UTLS, when they are measured with NOM, UTLS-1 and UTLS-2 observation modes. The IL maps assess the actual target-dependent atmospheric sampling of the measurements and permit to compare the performance of the considered observation modes in terms of intensity, spatial coverage and uniformity of the IL along the full orbit.
In the second stage we have carried out simulated retrievals based on the observational parameters of real orbits measured with the three observation modes. The retrieval analysis carried out on simulated observations permits to evaluate the achieved precision by comparing the retrieved value of the parameters with the reference value used to generate the simulated observations. The retrieval algorithm also provides the 2D averaging kernels that are used to evaluate both the horizontal and the vertical resolution of the retrieval products [*Rodgers* (2000)].
The overall performance of the considered observation modes will be compared in terms of *i*) *IL distribution*, *ii*) *precision*, *iii*) *spatial resolution* that they generate for the retrieval products in the 12 - 25 km altitude range.
Since MIPAS observations are invalidated by the presence of clouds in their line of sight (LOS) we will also provide statistics (based on the observation dataset of the MIPAS mission) of cloud presence in the UTLS altitude range.

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BROADBAND_CLOUDS: A tool for 2D representation of clouds in MIPAS/ENVISAT scenario.

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Clouds play a key role in the Earth's daily weather and long term climate. They represent a critical factor in regulating the Earth's atmospheric energy balance, both the earth's radiation budget and the water balance of the atmosphere. Relatively small cloud variations can alter the climate response associated with changes in anthropogenic aerosols and greenhouse gases.
Beside their importance in the Earth's radiation budget, clouds play an important role in many chemical processes within the atmosphere, acting as a surface for chemical reactions, providing a mechanism for the depletion of ozone or removal of aerosol particles through scavenging, and also altering the distribution of soluble and reactive species in the atmosphere through transport of air masses, *Tabazadeh (2002)*.

In order to understand cloud-climate feedbacks, the effects of clouds on the atmospheric radiation budgets and the correct cloudiness vertical profiles used for radiative fluxes and heating rate calculations are crucial. Until today, most of standard cloud data derived from satellite measurements and used to infer radiative fluxes and heating rates ignore cloud overlap, *Heidinger and Pavolonis (2005),* thus failing to model common situations such as semitransparent cirrus cloud overlapping lower level clouds. This can lead to wrong Cloud Top Height (CTH) estimates in case of multiple clouds layering and consequent misrepresentation in atmospheric models radiation schemes.

The Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), operating on-board ENVISAT, is a limb sounding Fourier Transform spectrometer for the measurement of high-resolution gaseous emission spectra. Studies on MIPAS data have demonstrated its measurements sensitivity to the radiation emitted from the cloud and from the atmospheric region below the cloud and scattered from the cloud particles into the instrument line of sight, *Höpfner et al. (2002) and Höpfner (2004)*. In addiction, experiments like the Stratospheric Aerosol and Gas Experiment (SAGE) have highlighted the higher detection sensitivity of limb sounders instruments to thin (subvisible) cirrus with respect to nadir viewing instruments. This capability can be considered an important feature for resolving multiple clouds layer structures and for the partitioning of clouds effects on the radiation balance between atmosphere and the Earth's surface.

The GMTR (Geo-fit Multi Target Retrieval) retrieval system, *Carlotti et al. (2006)*, is an open source code specifically designed for MIPAS measurements that adopts a 2D discretization of the atmosphere. The GMTR forward model has been used to create a self-standing Broad Band (BB) forward model (capable to simulate extended spectral regions) that has been upgraded into the BB_Clouds forward model in order to simulate cloud contamination into MIPAS spectra. Exploiting the 2D approach, the cloud is no longer represented as an infinite cloudy shell, but it is characterized by a horizontal and vertical extension (Fig. 1): the scattering and absorption cloud properties are evaluated only for the 2-dimensional discretization elements that are assumed cloudy. Tests have been performed to assess the BB_Clouds sensitivity to both horizontal and vertical cloud extension. The possibility of modelling a partially cloudy FOV does not only improve the forward model accuracy, it also opens the possibility to retrieve the CTH using highest cloudy measurement into a MIPAS limb scanning sequence.

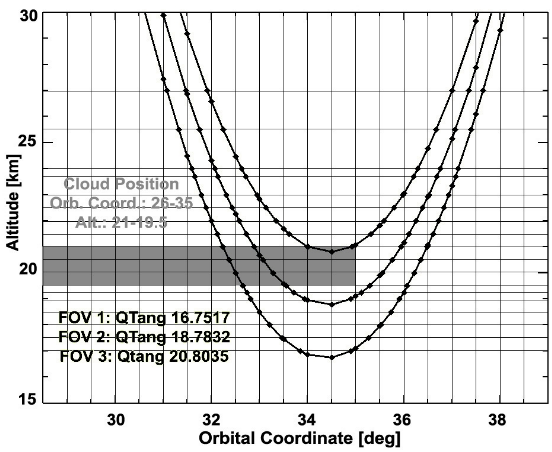

Figure 1: *Representation of cloud finite extension into BB_Clouds.*

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Operational and scientific limb retrieval for the SCIAMACHY instrument

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Due to the strict requirements regarding the computation time, the off-line processor of the SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY) instrument is forced to operate with several approximations. These approximations are incorporated in both the forward and the inversion models. Here we would like to investigate the impact of these approximations.

The main simplification which is done in the forward model concerns the treatment of the multiple scattering. At the a priori state $X_{\mathtt{a}}$ in essence we compute the signal measured by the detector $I\left(X_{\mathtt{a}}\right)$ with a radiative transfer model for a pseudo-spherical atmosphere and in the independent pixel approximation. Then, we define the correction factor for the multiple scattering effect by

$$c_{\mathtt{ms}}\left(X_{\mathtt{a}}\right)=\frac{I\left(X_{\mathtt{a}}\right)-I_{\mathtt{ss}}\left(X_{\mathtt{a}}\right)}{I\left(X_{\mathtt{a}}\right)}, \tag{1}$$

where $I_{\mathtt{ss}}\left(X_{\mathtt{a}}\right)$ is the single scattering term, and in the inversion process we use the representation

$$I\left(X\right)=I_{\mathtt{ss}}\left(X\right)\left[1+c_{\mathtt{ms}}\left(X_{\mathtt{a}}\right)\right], \tag{2}$$

where X is the actual atmospheric state. Thus, only the single scattering term accounts on the actual atmospheric state, and it is apparent that this approximation is valid if the a priori state is sufficiently close to the true atmospheric state. Note that not only the forward model but also the Jacobian are affected by the multiple scattering approximation.

The regularization method which is used in the inversion process is the Tikhonov regularization (*Tikhonov and Arsenin* 1977) with an a priori regularization parameter. This means that the regularization parameter, which should balance the residual and the constraint, is chosen in advance and is not correlated with the true measurement. The a priori selection of the regularization parameter is performed for synthetic data, and therefore the method can be problematic especially when the measurement is affected by large systematic errors.

The scientific processor developed at the German Aerospace Center is the counterpart of the off-line processor, which is not, however, limited by any time constraints. This brings the opportunity to employ more time-consuming approaches and study their impact. The processor uses the Picard iteration method to simulate the radiance field in a full spherical atmosphere and includes polarization as well as Ring effects. A large class of regularization methods as for instance, the Tikhonov regularization, the iteratively regularized Gauss-Newton method, the regularizing Levenberg-Marquardt method, the asymptotical regularization approach and the regularized total least-squares method can be used for a specific application.

Here a comparison between limb retrieval results obtained by the operational and the scientific processor for the SCIAMACHY instrument is presented.

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2D Tomography for SCIAMACHY Limb Measurements of Scattered Sunlight

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Limb measurements provided by the SCanning Imaging Absorption spectrometer for Atmospheric CHartographY (SCIAMACHY) on the ENVISAT satellite allow retrieving stratospheric profiles of various trace gases on a global scale.

We use a two step method (*Kühl et al. 2008*) for the retrieval in the UV/VIS spectral region: First, Differential Optical Absorption Spectroscopy (DOAS) is applied on the spectra, yielding slant column densities (SCDs) of the respective trace gases. Second, the SCDs are converted into vertical concentration profiles applying radiative transfer modelling.

An important point is the necessity of accounting for horizontal gradients of number densities of considered species in the retrieval algorithm. This is of special interest in Polar Regions, where photochemistry can highly vary along the long absorption paths. We investigate the influence of horizontal gradients by applying the 3-dimensional radiative transfer model McArtim by *Deutschmann, 2009*.

We introduce a tomographic method described in *Puķīte et al.* (2008) to correct for the effect of horizontal gradients by combining consecutive limb scanning sequences and utilizing the overlap in their measurement sensitivity regions. For the Arctic polar region it is found that, if the horizontal inhomogenity is not properly accounted for, typical errors of 20% for NO_2 and up to 50% for OClO around the altitude of the profile peak can arise for measurements close to the Arctic polar vortex boundary in boreal winter.

We also study the improvement for midlatitudes and tropics, if the tomographic retrieval is performed for special “limb-only” orbits on 14.12.2008. For this day the distance between the consecutive limb scanning sequences was reduced by more than 2 times compared to the normal mode (i.e. no nadir measurements were performed). The impact of the horizontal distance between consecutive limb scanning sequences on the quality of tomographic approach is investigated.

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Tomographic retrievals for high spatial resolution measurements of the PREMIER InfraRed Limb Sounder

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PREMIER is one of three candidates for ESA's 7th Earth Explorer mission that are currently undergoing feasibility studies. The main mission objective is to quantify processes controlling atmospheric composition in the upper troposphere and lower stratosphere, a region of particular importance for climate change. Satellite instrumentation will consist of the InfraRed Limb Sounder (IRLS) and the MicroWave Limb Sounder (MWLS). The IRLS will employ a FTIR spectrometer and a 2-D detector array. It can be operated in a high spatial resolution mode ('dynamics mode') for observations of small-scale structures in atmospheric temperatures and trace gas fields with unprecedented 3-D sampling (0.5 km in the vertical direction, 50 km along track, 25 km across track).

We will present a fast tomographic retrieval scheme, similar to the Geofit-method, which is designed to fully exploit the high-resolution radiance observations of the IRLS dynamics mode. The new retrieval scheme was used in an ESA study in 2008 to assess the performance of the proposed instrument and measurement mode. The presentation will cover first results of non-linear retrieval experiments for temperature, H_2O, O_3, and CFC-11.

An important result of the retrieval experiments is that the along track resolution of the retrieved data are much better than one may expect based on the broad kernel functions for the limb geometry. In fact, the horizontal and vertical resolution of the retrievals are close to the sampling grid of the IRLS dynamics mode measurements. At the same time it was found that retrieval noise does not increase significantly due to the 2-D approach. For comparison we also applied a conventional 1-D retrieval scheme, assuming a homogeneously stratified atmosphere. Based on an analysis of small- and meso-scale temperature wave perturbations (which may arise in the stratosphere due gravity waves) we find that the 2-D approach is much better capable of retrieving these structures.

The OMPS Limb Profiler Ozone and Aerosol Profile Retrieval Algorithms

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The Ozone Mapping and Profiler Suite (OMPS) Limb Profiler (LP) instrument is scheduled to fly on the NPOESS Preparatory Program (NPP) satellite, which will launch in 2011. To prepare for the imminent launch, the algorithm development team has focused its efforts on improving the retrieval software. The retrieval software has been thoroughly updated by modernizing routines to FORTRAN 90/95 standards, improving modularity and making the codes easier to understand and maintain, particularly for the radiative transfer (RT) model used to simulate the limb radiance. The modified wavelength grid used to increase the speed of the RT calculations will be described, as well as recent updates to improve the fidelity with which the OMPS LP instrument characteristics are represented. The theoretical basis for recent modifications of the ozone and aerosol retrievals will also be presented, including discussion of the importance of retrieving additional ancillary information (such as instrument attitude, cloud height and scene brightness).

On the multi-mission validation of ozone limb sounders using NDACC network data

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Since the 1970s, atmospheric composition has been measured from space by different limb viewing techniques, each one yielding specific time/latitude/altitude range, sampling and smoothing properties. Nowadays, scientific topics related to ozone and climate research and GEOSS developments require the integration of complementary data records acquired by distinct satellite missions, into a more comprehensive description of atmospheric composition and of its long-term change. A prerequisite is that individual data records to be merged together offer mutually consistent data quality. The way the atmospheric field is sampled and smoothed by the one and the other should also be compatible. But several issues make the verification of multi-mission data compatibility not straightforward. Among them are the space and time distance between individual data records (data records acquired by two missions never are perfectly collocated in time and space, and even can be distant by years), and the long-term degradation inherent to any instrument operating in the space environment (e.g., satellite-to-satellite comparisons mix long-term degradation effects of the two instruments being compared).

In this paper we explore the multi-mission data compatibility of ten limb viewing ozone profilers, from past (SAGE-II, UARS, POAM) and contemporary missions (Envisat, SCISAT, Aura). The study relies on comparisons with the long-term, pole-to-pole distributed data records available from the Network for the Detection of Atmospheric Composition Change (NDACC). Thanks to formal data protocols and QA/QC procedures, the network homogeneity of NDACC data enables their use as a standard transfer on the long term and in latitude and longitude (e.g., for network homogeneity of lidars, see Keckhut *et al.*, 2004). Here we investigate possible long-term drifts of satellite data, biases varying the altitude and the latitude, and we attempt to derive methods for the determination of the lowermost altitude above which ozone data quality is sufficient on a statistical basis.

Prior to conducting comparisons, we assess the error budget of a comparison between limb satellite and NDACC profiles. We address in particular comparison uncertainties associated with differences in smoothing and sampling of the atmospheric structures. As an illustration, mapping horizontal averaging kernels estimates calculated for Envisat MIPAS data (von Clarmann *et al.*, 2009) into atmospheric fields produced by the BASCOE 4D-var assimilation system (Errera *et al.*, 2008), we discuss the relative contribution of vertical and horizontal smoothing errors and of geographical mismatch. We also confirm the preliminary error estimates we had published in the MIPAS ozone and temperature validation papers by Cortesi *et al.* (2007) and Ridolfi *et al.* (2007).

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Non-linear inverse problems and model selection in satellite remote sensing

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Complicated and challenging non-linear inverse problems can be solved in fully Bayesian way by applying MCMC (Markov chain Monte Carlo) methodology. This technique is nowadays commonly used in various complex modeling problems in a wide range of applications. In satellite remote sensing the non-linear nature of the problem is commonly not studied much. However, thorough understanding of the posterior distribution is needed when the data is combined with other measurements or further assimilated into atmospheric models.

The adaptive variations of the MCMC are flexible and easy to implement. The MCMC technique allows also non-Gaussian measurement noise and prior information. We demonstrate the capabilities of the MCMC methodology by applying it to Envisat/GOMOS retrieval problems. As a special case we show how aerosol model selection can be included in the retrieval problem in a Bayesian way.

3 Stratosphere 1 (Tuesday p.m.)

3

Evolution of the stratospheric aerosol enhancement following the Kasatochi eruption: OSIRIS measurements

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One of the largest stratospheric injections of volcanic sulphur dioxide in many years occurred with the eruption of the Kasatochi Volcano in the Aleutian Islands of the North Pacific in August, 2008. Conversion of the volcanic sulphur dioxide into sulphate aerosol droplets during the weeks following the eruption significantly enhanced the aerosol loading of the lower stratosphere throughout the northern hemisphere. Limb scatter sunlight measurements made during this time period by the OSIRIS instrument on the Odin spacecraft are used to retrieve vertical profiles of the stratospheric aerosol extinction that reveal the evolution of the formation, transport and decay of the stratospheric aerosol cloud that forms as a result of the volcanic eruption. The maximum vertical optical depth of the stratospheric aerosol, measured by OSIRIS at 750 nm, occurs at mid- to high-latitude 30 to 40 days after the eruption and is approximately a factor of 3 beyond the background levels. Significant meridional transport in the lower stratosphere is evident in the observations, with measurable enhancement extending up to 20 km altitude and equatorward of the subtropical jet. After 6 months, the stratospheric aerosol optical depth is very near the background level measured before the eruption.

Combining recent satellite time-series for analyses of trends in stratospheric trace gases: methodology, results, future possibilites

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Recent satellite measurements by instruments on Odin (2001-), Envisat (2002-), ACE (2003-), and Aura (2004-) provide a wealth of information on the present state and evolution of the middle atmosphere. In order to derive reliable contemporary trends of trace gases such as ozone, water or related chemical species, these observations can be combined with older data sets from the 1980s and 1990s (e.g. from UARS/HALOE, 1991-2005). Various issues have to be considered when combining data from different sensors. These concern for example differences in spatio-temporal sampling characteristics, spatial resolution and sensor sensitivity, systematic biases and drifts, overlapping period, or modulation of trace gas time-series by atmospheric oscillations (semi-annual, annual, quasi-biennial, solar cycle). Besides providing results from recent analyses of trends in stratospheric key species, the presentation aims mainly to critically review and discuss methodology and uncertainties, as well as to highlight future possibilities.

A thirty-year (1979-2009) ozone data set from SAGE, OSIRIS, and SBUV observations: methodology and trend analysis

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Monitoring of stratospheric ozone remains an important endeavor for many reasons, chief among them to clearly identify the onset of stratospheric ozone recovery and understanding linkages with climate change. Such tasks require high quality, global, long-term ozone datasets. Towards that end, *McLinden et al.* (2009) recently produced a monthly, zonal-mean data set based on a combination of Satellite Aerosol and Gas Experiment (SAGE) and Solar Backscatter UltraViolet (SBUV) data. Drifts in individual SBUV instruments and inter-SBUV biases were corrected using SAGE I and SAGE II by calculating differences between coincident SAGE-SBUV measurements. This SAGE-corrected SBUV data set proved very successful but was limited by the lifetime of SAGE II.

In this work, the Optical Spectrograph and Infrared Imager System (OSIRIS), launched on the Odin satellite in 2001, is incorporated into the SAGE-corrected SBUV framework in order to extend the dataset to the present in a consistent manner. In the period of overlap between SAGE II and OSIRIS (2001-2005), differences between monthly-means are found to be small, generally 2-3%. This allows the use of OSIRIS to correct individual SBUV instruments between 2005 and 2009 with little or no bias correction. The result is a thirty-year data set suitable for trend analysis.

A summary of the methodology used to generate this new limb-corrected SBUV data set will be presented along with an initial assessment of trends and the outlook for ozone recovery.

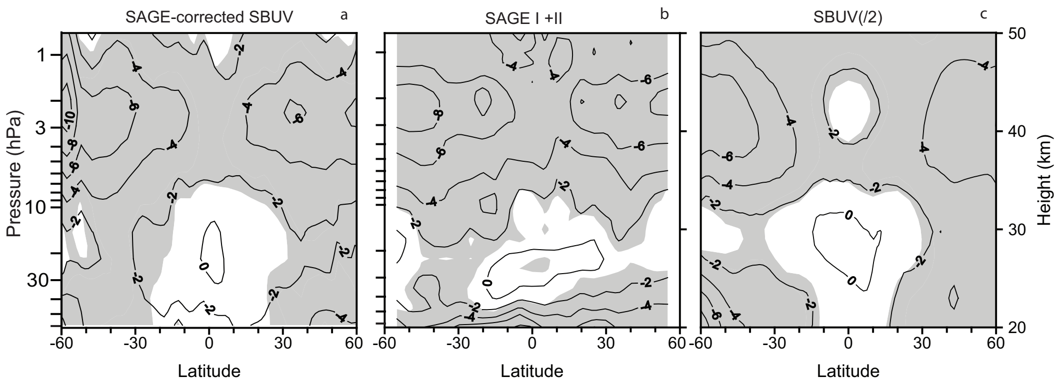

Figure 1: *Annual ozone trends (%/decade) for the period 1979-2005 derived from regression analysis for (a) SAGE-corrected SBUV, (b) SAGE I+II, and (c) merged SBUV(/2). Shadings indicate that the changes are statistically significant at the 2σ level (from McLinden et al., 2009).*

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Time series analysis of GOMOS and OSIRIS O_3 and NO_2 profiles

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The GOMOS instrument onboard the ENVISAT satellite measures O_3, NO_2, NO_3 and aerosols using the stellar occultation method. Measurements started in 2002 and have continued since with a few interruptions caused by instrumental problems. The OSIRIS instrument onboard the Odin satellite started measurements in 2001 and has worked flawlessly since. OSIRIS measures O_3, NO_2 and aerosols using the limb scattering method. In this talk we compare and analyse GOMOS and OSIRIS measurements of O_3 and NO_2. We present a time series analysis of profiles aiming to detect annual and semi-annnual variations as well as to understand how the solar cycle and the QBO affect the time evolution of the profiles.

Stratospheric profiles of NO_2, BrO and OClO: Observations by SCIAMACHY and comparisons to ECHAM5/MESSy1

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We present vertical profiles of NO_2, BrO and OClO retrieved from the SCIAMACHY limb observations of the years 2003-2008. This dataset is investigated regarding the agreement with balloon-borne validation measurements and correlated satellite observations and the relation to meteorological parameters (for long term and in case studies).
As well, the derived profiles are compared to ECHAM5/MESSy1 simulations which were calculated exactly for the time and place of the SCIAMACHY observations.
The interaction of the stratospheric trace species NO_2, BrO, OClO will be investigated for selected meteorological situations as well as for long term correlations for different seasons and latitudes, considering in particular the impact on the ozone chemistry.
We investigate the inter-hemispheric differences in the OClO profile (e.g. regarding the magnitude, the altitude of the profile peak and their evolution throughout the winter). For the Arctic, we study the inter-annual differences and investigate the dependence of chlorine activation on the respective meteorology for a given winter.

4 Retrieval & radiative transfer 2 (Wednesday a.m.)

4

ECMWF, a gravity wave resolving global model and its validation with SABER and future limb imaging instruments (PREMIER)

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The limited resolution of most global circulation models (GCMs) is not sufficient to resolve gravity waves (GWs) explicitly. ECMWF (European Centre for Medium-Range Weather Forecasts) data have now a grid resolution of 25km, so part of the mesoscale GWs can be resolved. However, most source processes are still subgrid phenomena. Therefore we validate the global GW distribution generated by ECMWF with a measured global data set. We compare real measurements from the infrared limb sounder SABER with simulated measurements of ECMWF temperatures. The simulations take into account the radiative transfer, retrieval and the separation of GWs from the background atmosphere.

Different GW sources and the modulation of the GW spectrum by the background winds can be observed in both data sets. For instance, mountain waves over the southern tip of south America and over Scandinavia are revealed as well as GWs over the polar vortex of the winter hemisphere. Also GWs from equatorial sources associated with convective systems are found. The vertical distribution of temperature amplitudes indicates that in ECMWF data the waves are strongly damped at altitudes above 50km.

With this validated data-set we simulate measurements like they will taken by an Infrared-Limb-Imager (ILI) planed by the ESA PREMIER mission. The horizontal and vertical resolution of this ILI is sufficient to measure GWs and it will be possible to calculate GW momentum flux (MF) from this data. We show first results of the GW analysis and MF calculations of these future data.

The OMPS Limb Profiler Retrieval Algorithms: Testing and Performance Analysis

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In preparation for the pending launch of the Ozone Mapping and Profiler Suite (OMPS) Limb Profiler (LP) on the NPOESS Preparatory Program (NPP) satellite, planned to fly in 2011, the OMPS LP science team has been conducting an extensive series of testing of the retrieval algorithm to qualify its performance and identify and correct for errors and biases. The primary focus of the OMPS/LP sensor is on retrieving high quality ozone profile information. To achieve OMPS/LP specified accuracy and precision requirements, the retrieval algorithm is also concerned with retrieving aerosol extinction profiles, effective scene reflectivity (or albedo), cloud top height, as well as performing accurate tangent height registration.

The retrieval algorithm is being tested with both (1) simulated data, which is generated with a forward model, and (2) proxy data, which is generated from actual measurements made by existing LS instruments, such as OSIRIS and SCIAMACHY. Both the synthetic and proxy data are convolved with OMPS spectral and spatial lineshape functions and interpolated to a 1 km grid, to simulate OMPS actual data. The first type of testing allows one a full control on the problem parameters, whereas the second one contains real world effects such as instrument effects, clouds, underlying scene inhomogeneities, along-track inhomogeneities, altitude offset, etc.

In this paper, we will present results of our ongoing work using large datasets of synthetic and proxy data. We will also discuss how we are using our testing methodology to specify the sensor error budget for each OMPS/LP product.

Retrieval of GOMOS bright limb ozone profiles

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GOMOS is a stellar occultation instrument on board the Envisat satellite. During day time occulations the limb scattered sunlight spectra is also recorded. This limb signal can be used to retrieve vertical profiles of ozone between around 20 and 60 km.

We present ozone profiles retrieved from the GOMOS limb data using the modified onion peeling inversion method. In the retrieval we use an accurate single scattering forward model and a look up table for the multiple scattering correction. The look up table is produced using the Monte Carlo radiative transfer model Siro.

The GOMOS limb signal is contaminated with stray light and we introduce a method to remove it from the signal. The GOMOS radiances are then compared with radiances from the OSIRIS instrument. The retrieved ozone profiles are compared with GOMOS time occulatations and we find a 5–10% agreement between 22–50 km altitudes in the tropics.

SASKTRAN: A spherical radiative transfer tool for the limb community.

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SASKTRAN is a spherical radiative transfer model that has been built at the University of Saskatchewan for today's multi-processor workstations. The model combines feature-rich interfaces with state-of-the-art algorithms to provide the limb community with a new tool for investigating radiative transfer problems in a spherical atmosphere. The model is broken into 3 sections, the engine, optical properties of species and climatologies of species. We present the model and show some results that demonstrate calculations involving 1, 10 or even 50 orders of scatter can be achieved in just a few seconds.

Retrieval of BrO vertical profiles from SCIAMACHY limb during Arctic spring 2008

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We present an algorithm for SCIAMACHY Limb BrO retrievals and apply it to Arctic latitudes from March 25 through April 19, 2008, corresponding with the ARCTAS spring deployment. Our retrieval process has two primary stages, (1) the calibration and fitting of trace gas slant columns from backscattered near-UV measurements registered in SCIAMACHY's channel 2, and (2) the use of a nonlinear optimal estimation (OE) procedure to invert the fitted columns into vertical profiles of number density for several species including O_3 and BrO. Resulting stratospheric BrO information is then compared to selected OMI BrO columns during the ARCTAS spring campaign to draw inference on the presence of BrO in the troposphere.

For spectral fitting, measured radiance spectra along common elevation steps in a given scan are first coadded to improve signal to noise. Of these spectra, tangent heights (TH) between 33 and 50 km are additionally coadded to generate a radiance reference spectrum (I_0) for that scan. The I_0 is fitted against a synthetic solar reference spectrum to estimate wavelength shifting and the Gaussian slit function half width that are representative of the data [*Caspar and Chance* (1997)]. These parameters are used then to generate appropriate basis functions for fitting the remaining spectra at lower THs, each spectrum being individually fitted for (1) Beer's law absorption from trace gases, (2) molecular and particle scattering (using 3rd order closure polynomials), (3) spectral undersampling [*Chance et al.* (2005)], and (4) 1st order Ring effect [*Chance and Spurr* (1997)], simultaneously in a non-linear least squares fitting routine.

Subsequent state estimation by OE [*Rodgers* (2000)] is performed in the Gauss-Newton iterative form, $\mathbf{n}_{i+1} = \mathbf{n}_i + \left(\mathbf{K}_i^T \mathbf{S}_y^{-1} \mathbf{K}_i + \mathbf{S}_a^{-1}\right)^{-1} \left[\mathbf{K}_i^T \mathbf{S}_y^{-1}\left(\mathbf{y} - \mathbf{F}(\mathbf{n}_i)\right) - \mathbf{S}_a^{-1}\left(\mathbf{n}_i - \mathbf{n}_a\right)\right]$, where $\mathbf{n}_i$ is the state vector at the ith iteration, $\mathbf{n}_a$ is the *a priori*, $\mathbf{F}$ is the forward model, $\mathbf{K}_i = \partial \mathbf{F} / \partial \mathbf{n}_i$ is the Jacobian, generated by finite differencing, and $\mathbf{S}_y$ and $\mathbf{S}_a$ are the measurement and *a priori* error covariance matrices. The fitted columns of BrO fill the measurement vector, $\mathbf{y}$, and thus $\mathbf{F}(\mathbf{n}_i)$ is a vector of modeled column amounts. These simulated columns are approximated using a two wavelength DOAS approach described by *Haley et al.* (2004) with radiance output from the *McLinden et al.* (2002; 2006) vector radiative transfer model with multiple scattering. Additionally, the forward model treats diurnal effects for several trace gases including BrO, which is especially important for limb measurements in Arctic spring due steep gradients in the solar zenith angle along the line of sight [*McLinden et al.* (2006)]. $\mathbf{S}_y$ is assumed to be diagonal, filled with column errors quantified during the spectral fitting. *a priori* information is taken from lookup tables generated by the UCI photochemical box model [*Prather* (1992); *McLinden et al.* (2000); (2006)], with corresponding errors taken as 100% of those values for BrO, to fully utilize information present in the measurements. O_3 may also be retrieved prior to BrO for a better fit to the atmospheric state, assuming 40% error in the O_3 *a priori* with a correlation length of 2 km [*Eriksson and Chen* (2002)]. Fig. 1 displays sample results for a limb scan retrieval of spectra measured over the Northwest Territories on April 18, 2008 while Envisat was crossing the terminator. Several rows of the BrO averaging kernel are plotted to the left, with inverted BrO mixing ratios in the middle panel; the O_3 retrieval is to the right and corresponds very well with concurrent ARCIONS ozonesonde data over Resolute, which can be found here (http://croc.gsfc.nasa.gov/arcions/IMAGES/resolute_20080417_pfl.jpg). Results with further optimization of the algorithm are presented at this meeting.

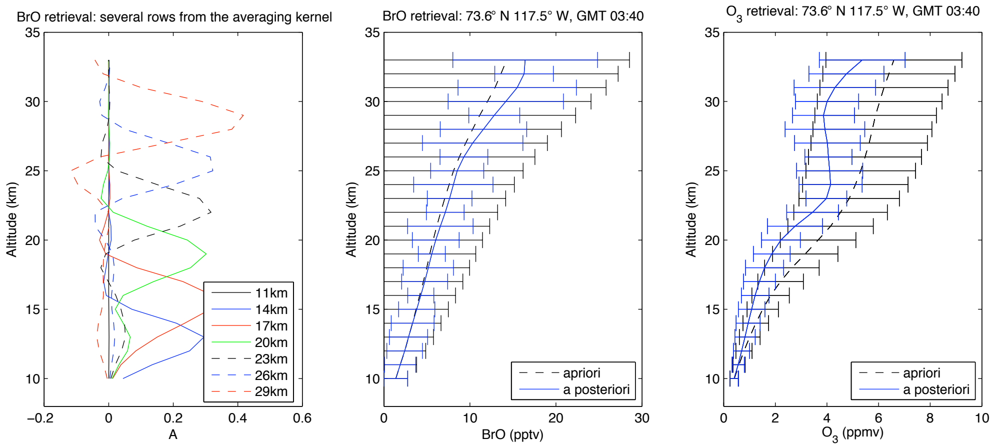

Figure 1: *This is an example retrieval before final optimization, with a state vector of trace gas concentrations defined at 1km resolution between 10 and 33km. To the left are selected rows from the averaging kernel for the BrO retrieval shown in the middle panel. To the right is the O_3 retrieval for that scan, which agrees nicely with ARCIONS data at Resolute.*

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Eight years of BrO from OSIRIS: climatology, inferred Br_y, and trends

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The OSIRIS team

The importance of the inorganic bromine family (Bry = Br + BrO + HBr + HOBr + BrONO2 + BrCl) has been recognized since the 1970s. In the lower stratosphere catalytic cycles involving bromine are important contributors to ozone destruction, particularly in the mid-latitudes. In an effort to better understand and quantify stratosphere Bry, an eight year (2001-2009) dataset of stratospheric BrO profiles measured by the OSIRIS (Optical Spectrograph and InfraRed Imager System) instrument, a UV-visible spectrometer measuring limb scattered sunlight from the Odin satellite, will be presented.

Zonal-mean radiance spectra are computed for each day and inverted to yield effective daily, zonal-mean BrO profiles from 16 to 36 km. Single profile precision and effective resolution are found to be about 30% and 3-5 km, respectively, throughout much of the retrieval range. A BrO climatology is presented and its morphology and correlation with NO_2 is consistent with our current understanding of bromine chemistry. Monthly-mean Bry maps are derived. Two methods of calculating total Bry in the stratosphere are used and suggest 21.3±4 pptv with a contribution from very short-lived substances of 5.3±4 pptv, consistent with other recent estimates. An initial estimate of the recent trend in Bry will be presented.

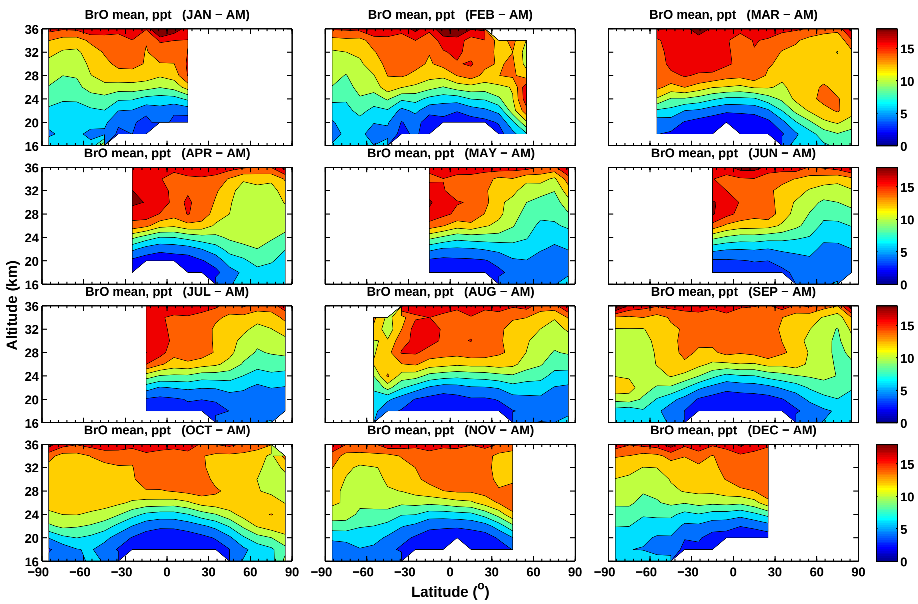

Figure 1: *OSIRIS monthly-mean descending node (AM) BrO mixing ratio (in pptv), averaged over November 2001 to December 2008 (from McLinden et al., 2009).*

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JEM/SMILES L2 data processing system on ISAS/JAXA

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SMILES mission team

SMILES (Superconducting Submillimeter-wave Limb-Emission Sounder) is planned to be launched in September, 2009 and will be on board the Japanese Experiment Module (JEM) of the International Space Station (ISS). The SMILES measures the atmospheric limb emission from stratospheric minor constituents in 640 GHz band. The SMILES carries 4 K cooled Superconductor-Insulator-Superconductor mixers to carry out high-sensitivity observations. The target species of the SMILES are O_3, ClO, HCl, HNO_3, HOCl, CH_3CN, HO_2, BrO, and O_3 isotopes (^{18}OOO, ^{17}OOO and $O^{17}OO$).

At a level 2 data processing system (DPS-L2), the vertical profiles of geophysical quantities such as composition and their errors are retrieved from the SMILES from calibrated spectra using the optimal estimation method. L2 algorithm is important to take advantage of SMILES's sensitivity data under limited computing resource. Hence, we optimaize the algorithm as follows; (1) designing accurate instrument functions such as the instrumental field of view, rejection ratio of sideband separator and spectral responses of Acousto-Optic Spectrometer which are based on the knowledge of the SMILES instrument according to the SMILES mission plan and the recent experimental results of the flight model, (2) line selection, (3) optimization of the Voigt algorithms and (4) frequency and altitude grids selection. In order to process one day L1B data, the Level 2 Processor requires about only 8 hours on 5 Linux servers with two CPU corresponding 3.16-GHz Quad-Core Intel Xeon processors.

Retrieval precision estimates of L2 operational products using current instrument function (figure 1). Most of atmospheric parameters are taken from AURA MLS v2.2 data. However, profile of CH3CN is based on UARS MLS ver. 5 data and ground-based observations, and profiles of BrO and HOCl are calculated from a CCSR/NIES chemistry-climate model simulation. The standard deviation of a priori profile is assumed to be 100% for all species. Forward model parameter errors are assumed to be negligible.

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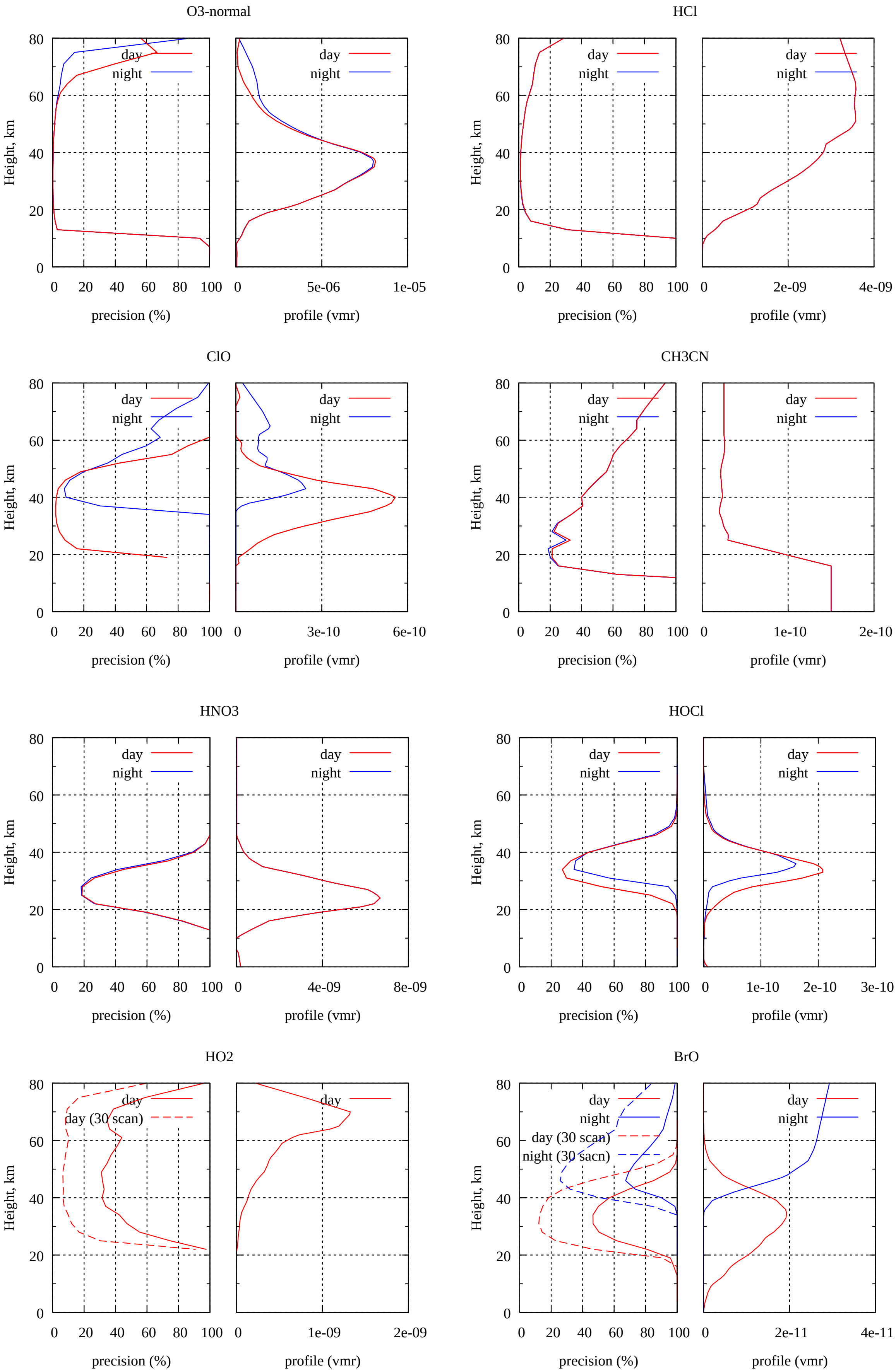

Figure 1: *Retrieval precision of L2 operational product at 3km vertical resolution for single scan (March, northern mid-latitude, clear sky case)*

ISS/JEM/SMILES operational L2 Data products by ISAS/JAXA

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SMILES Mission Team

SMILES L2 Data products will be processed by ISAS and other related institutions. This paper describe (i) current operational data system developed by JAXA, (ii) characteristics, limitations, expected performance of current L2 version, and (iii) how products and related information can be accessed. SMILES L1B data will be processed to L2 data, less than up to 7 days after observation. Processed L2 data will be accessible 24 hours to RA-PIs. Predictions for observation location-time will be available 1 year before, but ISS orbit changes frequently, thus validation activities must be careful on the latest SMILES observation plan to be update daily basis. L2 Data might be updated several times after normal observation expected to start early November 2009 (TBD).

SMILES has 3 frequency bands, and only 2 of the 3 bands are observed at the same time. The band selection will be changed up to once a day. Table 2 lists the species covered by 3 bands. Figure 2 shows expected precision in single scan. Trace species, BrO, HO2, etc will be processed by averaging.

RF Frequency (LSB)	624.32 - 626.32 GHz (bandA,bandB)
RF Frequency (USB)	649.12 - 650.32 GHz (bandC)
System Noise Temperature	Less than 700 K (SSB)
Integration Time	0.5 sec for each observation point
Input Signal Intensity	0−300 K in brightness temperature
Spectral Resolution	1.8 MHz (FWHM)
Spectral Coverage	1,200 MHz _ 2
Antenna Aperture	0.4 m (vertical) _ 0.2 m (horizontal)
E_ective Antenna Beam-width	0.096_ (HPBW, elevation)
Instrumental Height Resolution	3.5 km { 4.1 km (nominal)
Instrumental Error in Tangent Height	0.76 km (rms, bias) 0.34 km (rms, random)
Sensitivity in Brightness Temperature (for each scan)	about 0.7 K (rms) for *Tb* <20 K about 1.0 K (rms) for *Tb* >20 K
Accuracy in Brightness Temperature (for each scan)	about 1 K (rms) for *Tb* <20 K about 3% (rms) for *Tb* >20 K
Data Rate	Less than 200 kbps
Measurement Height	10 _ 60 km
Observation Latitudes	65_N - 38_S (nominal)
Mission Life	1 year
Power Consumption	about 800 W including payload bus
Payload Weight	less than 500 kg
Payload Size	0.8 m (W) _ 1 m (H) _ 1.85 m (L)

Table 1: SMILES specifications.

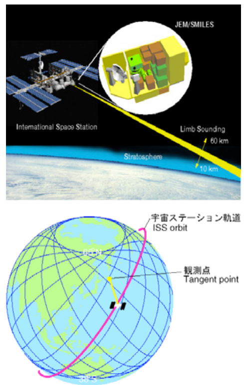

Figure 1. SMILES Observation

Target species of SMILES.

Type	Band A	Band B	Band C
Species retrieved from single-scan data	O_3 $H^{37}Cl$ ^{18}OOO HNO_3 CH_3CN HOCl $O^{17}OO$	O_3 $H^{35}Cl$ ^{18}OOO $O^{17}OO$	O_3 ClO HNO_3 ^{18}OOO ^{17}OOO
Species retrieved from multi-scan data (noisy products)	BrO	HO_2	BrO HO_2

Table 2 Target species in the 3 bands.

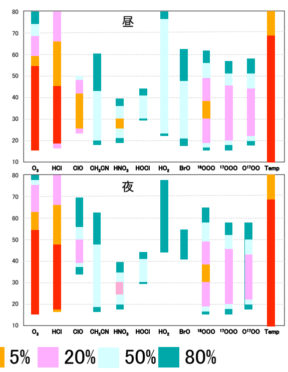

Figure 2. Single scan precision for current version.
(Upper: Day, Lower: Night)

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5 Stratosphere 2 & Troposphere (Wednesday p.m.)

5

Quantifying gravity waves and turbulence in the stratosphere using satellite measurements of stellar scintillation

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Stellar scintillations observed through the Earth atmosphere are caused by air density irregularities generated mainly by internal gravity waves (GW) and turbulence. The strength of scintillation measurements is that they cover the transition between the saturated part of the gravity wave spectrum and isotropic turbulence. This allows visualization of gravity wave breaking and of resulting turbulence. We analyzed the scintillation measurements by GOMOS fast photometers on board the Envisat satellite in order to quantify GW and turbulence activity in the stratosphere.

The analysis is based on reconstruction of GW and turbulence spectra parameters by fitting the modeled scintillation spectra to the measured ones. We use a two-component spectral model of air density irregularities: the first component corresponds to the gravity wave spectrum, while the second one describes locally isotropic turbulence resulting from GW breaking and other instabilities. The retrieval of GW and turbulence spectra parameters - structure characteristics, inner and outer scales of the GW component - is based on the maximum likelihood method.

In this presentation, we show global distributions, seasonal and interannual variations of the GW and turbulence spectra parameters retrieved from GOMOS data in 2002-2005, for altitudes 30-50 km. In addition, we show global distributions of GW potential energy per unit mass and of turbulent structure characteristic C_T^2. In our presentation, we pay special attention to gravity wave breaking. Since other measurements at such small scales are very scarce in this altitude range, the obtained global distributions provide unique and complementary information about small-scale air density irregularities in the stratosphere.

New Stratospheric ozone results from SCIAMACHY/Envisat

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SCIAMACHY, the Scanning Imaging Absorption spectroMeter for Atmospheric CHartographY on Envisat has performed observations of limb-scattered solar radiation in the UV/visible/NIR spectral ranges since summer 2002. Limb-radiance profiles in the Hartley-Huggins and Chappuis absorption bands of ozone are employed in a simultaneous retrieval to derive ozone profiles covering the altitude range from about 15 km to 70 km. For this purpose an iterative nonlinear optimal estimation retrieval is employed driving the radiative transfer model SCIATRAN. The pointing/attitude problems that affected SCIAMACHY limb observations in the past are now largely solved, and the data set has been used for a series of relevant scientific studies, including the investigation of long-term trends in stratospheric ozone and ozone recovery, the study of the 27-day solar cycle signature in middle atmospheric ozone, as well as the determination of the chemical ozone loss in polar spring in both hemispheres using the vortex averaging method. In this talk the highlights of these recent scientific applications of the SCIAMACHY limb ozone profile data set will be presented.

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Odin-SMR measurements of tropical upper tropospheric water

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Although upper tropospheric water vapour and cloud ice mass are keys in the prediction of future climate, the knowledge of these parameters in the present atmosphere is limited. This mainly as a result of that traditional sensors are not very adequate to measure these parameters. However, in the last years a series of microwave instruments (Odin-SMR, AURA-MLS, and CloudSat) capable of measuring upper tropospheric humidity and cloud ice have been launched. Odin-SMR is a passive limb-sounding radiometer operating at around 500 GHz and can measure both quantities. A new well qualified retrieval algorithm has been developed, which handle the formerly not very well controlled beam filling problem in a general way. The retrieval algorithm uses CloudSat data as a priori information on cloud structure variability on scales and dimensions not resolved by Odin-SMR measurements. Thus, the retrieval algorithm is a fruitful example on the indirect usefulness of CloudSat and upcoming EarthCARE measurements.

A detailed retrieval characterisation showed that Odin-SMR can measure profiles of upper tropospheric humidity and ice water content with a vertical resolution of $\sim$5 km with a precision of $\sim$20 % and $\sim$65 % respectively, and with a conservative estimated accuracy of $\sim$30 % and $\sim$50 % respectively. The maximum measurement response, for both humidity ($\sim$0.7) and ice water content ($\sim$1), is found between 10.5-15 km in altitude. Results of retrieved humidity and ice water content at altitude layers of high response have been successfully compared to AURA-MLS and CloudSAT respectively. Yearly mean humidity fields were shown to differ with less than 10 %. Mean values of tropical ice water content agree within 35 % and probability density functions of retrieved ice water content values compare well over the entire range of values.

As Odin-SMR measurements of upper tropospheric water now are well characterised and have been successfully compared to AURA-MLS and CloudSAT it can be considered for further studies. The diurnal cycle of upper tropospheric water is examined by combining results from Odin-SMR, AURA-MLS and CloudSat. These instruments have fixed tropical observation times at 6:00 am/pm (Odin-SMR) and 13:40 am/pm (AURA-MLS and CloudSat) and each region in the tropics is observed with approximately 6 hour intervals. The satellite measurements show that the strongest diurnal variations of cloud ice amount are found over land regions associated with strong convection, with a pronounced maximum in the afternoon. Over oceans the variations have a lower amplitude and the maximum is generally find during early morning. Obtained results can potentially be used to evaluate the diurnal cycle of convection and associated clouds in climate models, which tend to have phase errors of several hours over tropical land. The performance of ECMWF, EC-Earth, ECHAM and other climate models will be investigated.

Observation of a tropopause fold with the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere - New Frontiers

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The Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere - New Frontiers (CRISTA-NF) is a limb sounding instrument deployed onboard the high-flying research aircraft M55 Geophysica. CRISTA-NF measures in the upper troposphere, lower stratosphere (UTLS) with unprecedented sampling for an infrared limb sounding experiment. Retrieval results during the AMMA-SCOUT-O3 measurement campaign on a flight over Italy and the Mediterranean Sea on the 29th of July 2006 are presented here.

The Juelich Spectral Simulation Code (JURASSIC) is used to retrieve atmospheric constituents from infrared radiances measured between 768 and 868 cm^{-1}. Nine spectral intervals are used to retrieve the volume mixing ratios of carbon tetrachloride (CCl_4) water vapor (H_2O), ozone (O_3), nitric acid (HNO_3), and peroxyacetyl nitrate (PAN), as well as temperature, altitude, aerosol extinction, and a radiometric offset simultaneously.

The flight path crossed over the subtropical jet twice and CRISTA-NF observations indicate a tropopause fold located on the northern side of the jet. Simultaneous observations of trace gases originating either in the troposphere or in the stratosphere allow to determine the origin of air masses and detect mixing. Tracer-tracer correlation between O_3 and PAN show the presence of mixed tropospheric and lowermost stratospheric air in the vicinity of the tropopause fold.

6 Mesosphere (Wednesday p.m.)

6

Observations of Energetic Particle Precipitation Effects upon the Middle Atmosphere

Annika Seppälä
British Antarctic Survey (NERC), UK

This presentation will give an overview of what we have recently learned about the impact of Energetic Particle Precipitation (EPP) on the polar middle atmosphere, the area of the Earth's atmosphere covered by altitudes from about 20 to 120 km (stratosphere - mesosphere - lower-thermosphere). Much new information of the EPP impact on the polar middle and upper atmosphere has been gained in the recent years thanks to large data sets from atmosphere monitoring satellites becoming available. Of key role have been especially the observations made from satellite platforms such as the European Space Agency's Envisat satellite, and results from $e.g.$ the GOMOS (Global Ozone Monitoring by Occultation of Stars) instrument on board the Envisat satellite will be discussed in further detail.

The focus of this presentation will be particularly on observations of the effects of EPP on the chemical composition, such as ozone, NO_x, and HO_x of the polar middle and upper atmosphere.

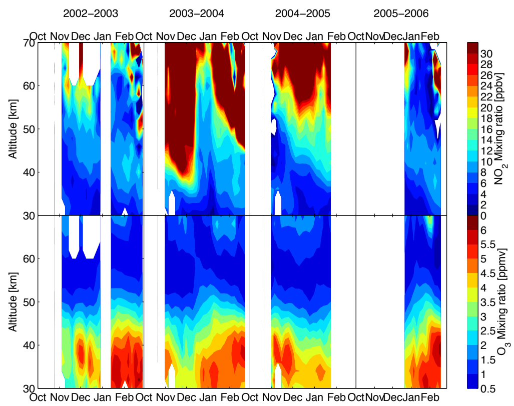

Figure 1: *GOMOS observations of Northern Hemisphere polar NO_x and O_3 showing enhancements of NO_x due to increased particle precipitation into the atmosphere and consequent ozone decreases.*

Mesospheric odd hydrogen as an indicator of energetic particle precipitation

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Energetic particle precipitation (EPP) affects the composition of the middle atmosphere. For example, solar proton events can dramatically increase the ionization rate so that large amounts of odd hydrogen ($HO_x = H + OH + HO_2$) and odd nitrogen ($NO_x = N + NO + NO_2$) are subsequently produced. Increase in HO_x and NO_x concentration leads to decrease of ozone in the mesosphere and upper stratosphere through catalytic reaction cycles.

HO_x is a good candidate for an indicator of EPP because 1) its night-time concentration can be significantly increased by moderate EPP forcing and 2) its chemical lifetime is less than 1 hour in the middle atmosphere below 80 km. Thus HO_x responds rapidly to changes, both increases and decreases, in EPP forcing. Further, atmospheric transport has a negligible effect on the HO_x distribution because of the short chemical lifetime.

MLS/Aura is the first satellite instrument capable of observing mesospheric OH and HO_2. Using MLS observations, we demonstrate how OH concentration responds to EPP. Further, it is shown that the observed changes in OH can be reproduced with reasonable success in atmospheric models, if the chemistry of positive and negative ions is taken into account (see also *Verronen et al.*, 2006 and *Verronen et al.*, 2007). Finally, we discuss the possibilities of using OH observations as a spatio-temporal proxy for the flux of EPP (see Fig. 1).

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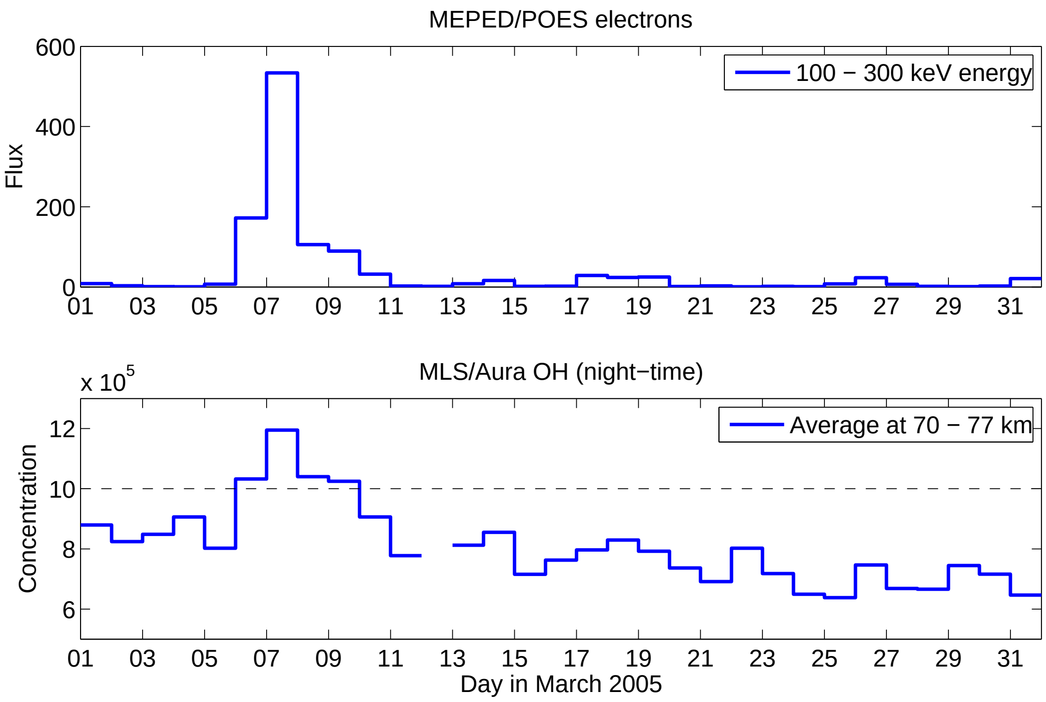

Figure 1: *Daily averages of observations made in March 2005 at magnetic latitudes 55–65° S. Upper panel: MEPED/POES electron fluxes (cm^{-2} s^{-1} ster^{-1}). Lower panel: MLS/Aura hydroxyl concentrations (cm^{-3}).*

Mesospheric Ozone from the Hartley Band

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For over 8 years the Optical Spectrograph and Infra-Red Imager System (OSIRIS) onboard the Odin satellite has observed the Earth's middle atmosphere in the wavelength region from the near UV to the IR. The Hartley Band of ozone (λ < 300 nm) gives rise to significant absorption in the limb direction up to above 80 km. By analyzing the spectral dependence of the limb Rayleigh signal in the Hartley Band, ozone densities can be retrieved in the lower mesosphere between 55 and 75 km. This complements the OSIRIS standard ozone product from longer wavelengths (up to 60 km) and new OSIRIS ozone retrievals from the O_2 Atmospheric Band (above 70 km). The retrieval method and first results will be presented.

An overview of the Odin/SMR measurements in the polar summer mesopause region

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Since 2001 measurements of the Sub-Millimetre Radiometer (SMR) aboard the Odin satellite provide information of several parameters interesting for the understanding of the mesosphere on a global scale. This instrument measures the thermal emission of several trace gases in the frequency range between 480 GHz and 580 GHz. Mesospheric water vapour information is derived from the 557 GHz emission line. Here an overview of the Odin/SMR water vapour results with focus on the summer mesopause region will be presented. In the centre of attention will be the absolute amount of water vapour in this region, inter-annual variability, long-term behaviour and inter-hemispheric differences observed in the water vapour distribution.

Solar impact on noctilucent clouds

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Noctilucent clouds (NLCs) – also known as polar mesospheric clouds (PMCs) – are a summertime high-latitude phenomenon and occur at an altitude of about 83 km. NLCs are being discussed as potential indicators of global change and long-term satellite observations with the SBUV instruments show positive long-term trends in NLC albedo and occurrence rate. However, several processes driving the variability in NLCs are only poorly understood. SCIAMACHY limb-scatter observations are used to investigate several mechanisms – related to solar impact – driving variability in NLCs and will be discussed in this contribution. First, we were able to establish for the first time a 27-day signature in NLC occurrence rate, NLC radiance and ice mass, which is anti-correlated to the 27-day signature in solar Lyman-α irradiance [*Robert et al.* (2009)]. Using Aura/MLS temperature measurements a 27-day signature in polar summer-mesopause temperature was identified, which is most likely the immediate cause of the signature in NLCs. However, the physical mechanisms driving the 27-day cycle in middle atmospheric temperature are not yet fully established.

Secondly, we established a physical mechanism that explains the strong heating of the southern polar summer mesopause during the January 2005 solar proton event (SPE), which lead to a severe depletion of NLCs over Antarctica as described earlier by *von Savigny et al. (2007)*. The physical mechanisms – based on a chain of events – involves reduced diabatic heating of the polar middle mesosphere associated with the catalytic ozone destruction by SPE-induced HO_x, which leads to a reduction in the mesospheric meridional temperature gradient. This in turn causes reduced zonal winds affecting the vertical propagation of gravity waves that drive the upper mesospheric meridional circulation. Eventually, a strong dynamic heating of the polar summer mesopause occurs due to reduced diabatic cooling. The validity of this hypothetical mechanism was verified with model simulations with the Kühlungsborn Mechanistic General Circulation Model [*Becker and von Savigny (2009*].

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Nighttime Limb Observations of the Mesosphere and the Lower Thermosphere with OSIRIS on Odin

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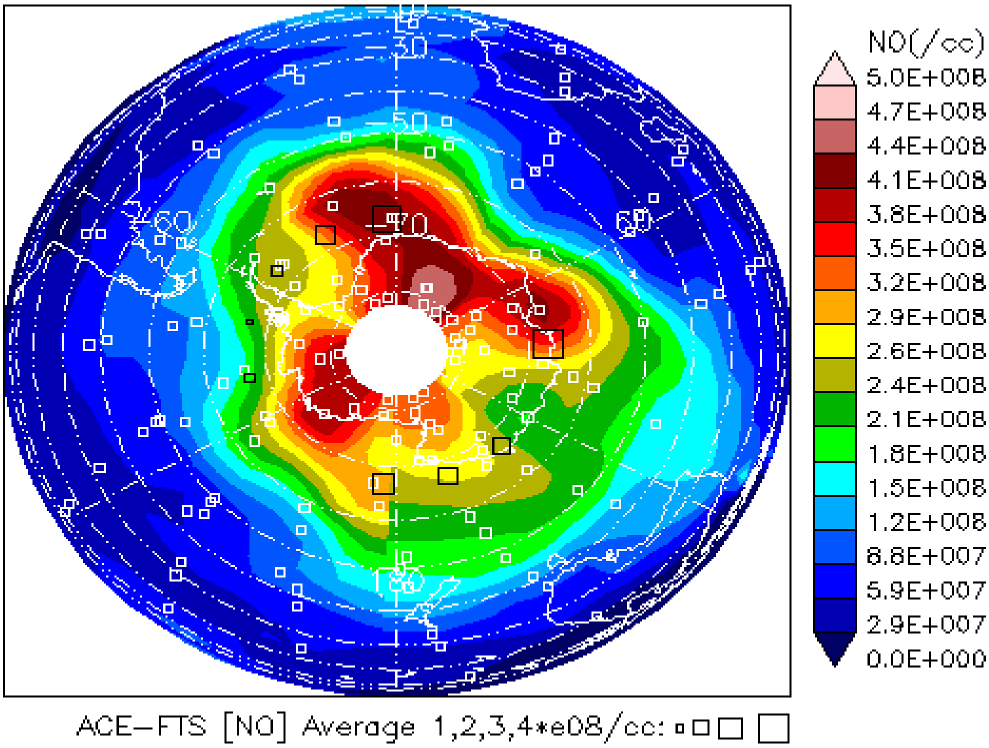
Nighttime observations of mesospheric limb from orbit provide an excellent opportunity to study the weak airglow emissions, e.g. the visible continuum which has a zenith intensity of ~10R/nm, as the natural atmospheric amplifier affords an enhanced signal. Although there is no significant albedo effect compared with daytime observations it is essential that the spectral signatures in the observations are spectrally unambiguous. Previous attempts to study the visible airglow continuum with rocket borne photometers have used filters with relatively wide bandwith filters for spectral discrimination in order to enhance the observed signal. OSIRIS observations have shown that other airglow features, e.g. the OH Meinel bands, are significant and must be properly excluded or at least corrected for in the analysis.

The primary source of the airglow continuum is the recombination reaction NO + O → NO_2^* + hν so that observations of the continuum and a knowledge of [O] allows the determination of [NO] in the nighttime atmosphere. In this paper new measurements and maps of the nighttime [NO] are presented.



Antarctic polar map of derived NO densities from OSIRIS observations of NO_2 emission for 8-9 May 2005. Densities are averages over the 80 to 100 km altitude interval. The small white squares mark the locations of OSIRIS limb profile measurements. Scaled ACE-FTS NO observations are included.

7 Posters (Wednesday coffee and lunch breaks)

7

Solar occultation images analysis using Zernike polynomials — an ALTIUS imaging spectrometer application

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The ALTIUS (Atmospheric Limb Tracker for the Investigation of the Upcoming Stratosphere) instrument is a major project of the Belgian Institute for Space Aeronomy (BIRA-IASB) in Brussels, Belgium. It has been designed to profit from the benefits of the limb scattering geometry (vertical resolution, global coverage,...), while providing better accuracy on the tangent height knowledge than classical ”knee” methods used by scanning spectrometers. The optical concept is based on 3 AOTF’s (UV-Vis-NIR) responsible for the instantaneous spectral filtering of the incoming image (complete FOV larger than 100km x 100km at tangent point), ranging from 200nm to 1800nm, with a moderate resolution of 2-6nm and a typical acquisition time of 1-10s per image.

While the primary goal of the instrument is the measurement of ozone with a good vertical resolution, the ability to record full images of the limb can lead to other applications, like solar occultations. With a pixel FOV of ~200µrad, the full high-sun image is formed of ~45x45 pixels, which is sufficient for pattern recognition using moments analysis for instance.

The Zernike polynomials form a complete othogonal set of functions over the unit circle. It is well suited for images showing circular structures. Any such image can then be decomposed into a finite set of weighted polynomials, the weighting is called the moments.
Due to atmospheric refraction, the sun shape is modified during apparent sunsets and sunrises. The sun appears more flattened which leads to a modification to its zernike moment description, as is shown in the example below:

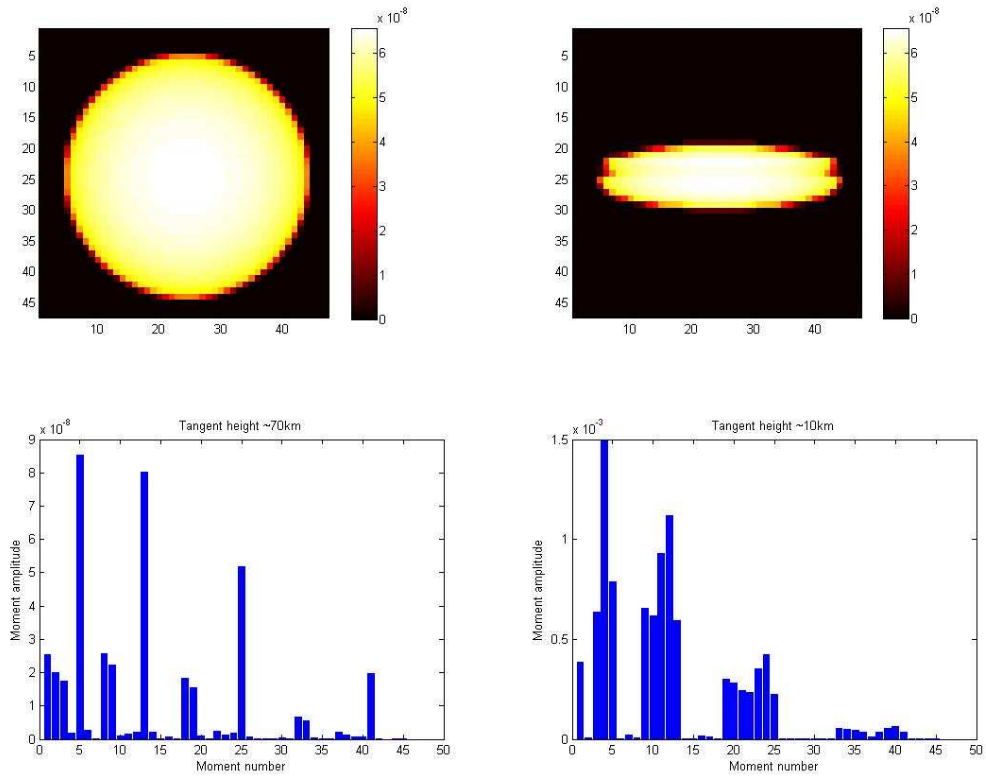

Figure 1: *Example of two Zernike moments analysis for two sun images at two different locations : left is for the sun at a tangent height of 70km, right is at 10km. One can see that the set of moments describing the two images are very different.*

A link between the pressure or the temperature profile (equivalent to the air density through the perfect gas law and the hydrostatic equation) and the Zernike moments of a given image can then be made and used to retrieve these atmospheric parameters, with the advantage that the whole sun is used and not only one or two pixels.

Some retrievals will be performed for different conditions and the feasibility of the method will be discussed.

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Retrieval of stratospheric aerosol distributions from SCIAMACHY limb measurements: first steps and methodology

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Stratospheric aerosols play an important role in atmospheric global radiation budget and trace gas retrieval, especially ozone. SAGE I-III provided a 25-year record of stratospheric aerosols by means of solar occultation technique. Since the demise of SAGE II and III in 2005/2006, no instrument with this technique provides a continuation of this data set. Goal of this work is to demonstrate that aerosol extinction profiles can be retrieved from SCIAMACHY limb scatter measurements to sustain the series. Since the eruption of Pinatubo in 1991 was the last large source of volcanic aerosols in stratosphere, we have now the opportunity to retrieve background aerosol profiles. The radiative transfer model SCIATRAN is used to derive aerosol extinction profiles and size distributions for SCIAMACHY limb data. First steps, the algorithm, sensitivity studies and first results are presented here.

Seven years of stratospheric BrO observations from SCIAMACHY

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Bromine plays an important role in stratospheric ozone depletion. One important question is whether the stratospheric bromine loading is consistent with known sources of bromine, with the ultimate goal to be able to predict how the stratospheric bromine loading will change as a result of changes in emissions and under a changing climate.

The SCIAMACHY instrument launched on board ENVISAT in March 2002 provides now almost seven years of global stratospheric bromine monoxide (BrO) measurements. The vertically resolved stratospheric concentrations of BrO are obtained from the measurement of the scattered and reflected solar radiation performed by the SCIAMACHY instrument in the limb viewing geometry. The global coverage is achieved in 6 days.

Here we will present the seven year SCIAMACHY BrO data set in comparison to multi-year time series obtained from the ground-based observations as well as to calculations from our stratospheric chemical transport model (CTM). In particular we will present trends in stratospheric BrO amount as seen by SCIAMACHY and ground-based instruments in different latitude regions and discuss the observations of BrO in the tropical lowermost stratosphere which are found to show clear signatures of deep convection with lowest BrO in actively convective regions. As a highlight of BrO observation data set we present a comparison of SCIAMACHY monthly mean BrO with day- and nighttime measurements of $BrONO_2$ performed by the MIPAS instrument.

Comparison of Ozone Profiles from the FinROSE-CTM with GOMOS data and Ozone Soundings

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E. Kyrö, R. Kivi
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Climatological ozone profiles from the chemistry-transport model FinROSE (FinROSE-ctm) have been compared to climatological profiles from the GOMOS/Envisat instrument (15-100 km) and ozone soundings (0-30 km).

Global middle atmospheric simulations have been performed with FinROSE-ctm using ERA-Interim winds and temperatures. The simulation covers years 1989-2008. The recent ECMWF reanalysis data ERA-Interim has been shown to provide a more realistic stratospheric circulation than previous reanalysis, e.g. ERA-40. This improves the ability of chemistry transport model to simulate middle atmospheric ozone and water vapor distributions.

The FinROSE-ctm is a global 3D model based on the NCAR ROSE-model. The model produces the distribution of 30 long-lived species and tracers, and 14 short-lived species. The chemistry describes around 110 gas phase reactions and 37 photodissociation processes.

GOMOS (Global Ozone Monitoring by Occultation of Stars) on the ESA Envisat-satellite measures transmission spectra of light through the Earth's limb using the stellar occultation method. During 24 h GOMOS measures 300-500 occultations leading to good global coverage. GOMOS data give global night-time profile distributions of some key constituents. For this study the GOMOS data was pre-selected to only include profiles where the solar zenith angle was larger than 107° at the tangent point. The GOMOS profiles provide a unique view to the development of the ozone layer during the polar night and are especially valuable for studying the performance of FinROSE-ctm in describing the development of the polar vortices.

Sounding the Upper Troposphere-Lower Stratosphere using a tomographic approach

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Elisa Castelli
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The Upper Ttoposphere-Lower Stratosphere (UTLS) is crucial for the atmosphere in terms of radiative forcing and climate. However, the highly interconnection of dynamics, chemistry, radiation and microphysics makes it possibly the most complex and highly variable layer of the atmosphere, preventing until today to determining in detail its behaviour and influence on the troposphere.
Satellite missions, with their global and multi-year coverage, give unprecedented possibilities in studying the physical and chemical quantities of the atmosphere, as their distribution, variability and long term trends. Among these missions, the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS), onboard ENVISAT limb sounds the upper troposphere and stratosphere since March 2002. Measurements from MIPAS, both in its original configuration (July 2002-March 2004) and in its new configuration (since January 2005) have been analyzed with the 2-D tomographic Geo-fit Multi-Target Retrieval (GMTR) system, *Carlotti et al.* (2006). The tomographic approach is needed in order to resolve the horizontal inhomogeneity of the atmosphere and aid in correctly interpreting the observed variability and change. The scan pattern of the new configuration, having a finer measurements vertical grid, especially in the UTLS region, gives the possibility to obtain a better vertical resolution in respect to the old configuration. Furthermore, dedicated UTLS mode observations have been set to achieve also an improved resolution in the horizontal domain, making it highly suitable for UTLS studies, from troposphere-stratosphere intrusion events to long term chemistry trends. In this paper we present the analysis of these measurements.

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3-D modelling of solar proton events with chemistry and transport model FinROSE

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Solar proton events (SPEs) are able to increase the amount of energetic particles that precipitate into the atmosphere. The particles affect the chemistry and composition of mesosphere and stratosphere by producing radicals such as nitric acid (HNO_3), odd nitrogen (NO_x) and odd hydrogen (HO_x). These radicals can then destroy significant amounts of the upper atmospheric ozone in catalytic reactions.

We have studied the October-November 2003 case using satellite observations measured by GOMOS and a chemistry and transport model (ctm) FinROSE. GOMOS (Global Ozone Monitoring by Occultation of Stars) on board the Envisat satellite uses stellar occultation technique and measures profiles of O_3, NO_2, NO_3, H_2O, O_2, neutral density and aerosols. GOMOS makes several hundred occultations per day and can measure in both day and night conditions (*Kyrölä et al.* (2006)). FinROSE is a global 3-D ctm reaching from troposphere to the lower mesosphere (*Damski et al* (2007)). The model dynamics are driven by realistic wind data from ECMWF. Another new feature in the modelling is the ion-chemical production of HNO_3 due to the SPEs using a parametrization.

The observations indicate that ozone abundances decrease at the same time when nitric dioxide levels are increasing inside the evolving vortex. Similar to the observations, the model reproduce the decrease of ozone and increase of nitric dioxide. Using the realistic winds, the model is also able to outline the behaviour of the polar vortex. The improved modelling of HNO_3 indicates a substantial production in the stratopause region (Fig. 1).

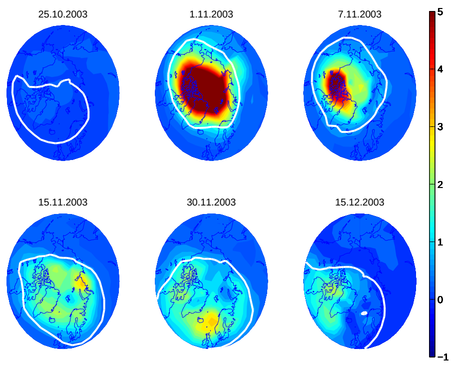

Figure 1: *FinROSE model results for HNO_3. Abundances are given in ppbv at 45 km altitude for different time points before, during and after the SPEs. The map shows latitudes $\geq$ 50 °. The model results are realistic and a large amount of HNO_3 is produced inside the evolving vortex.*

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TELIS Data Processing — Status and First Results

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TELIS (TeraHertz Limb Sounder) — a further development of the airborne THOMAS system — is a balloonborne three channel heterodyne spectrometer (DLR, SRON, RAL cooperation) that has been flown successfully together with MIPAS-B last March in Kiruna. Data processing for the DLR's $1.8\,\mathrm{THz}$ channel is based on the institute's radiative transfer and retrieval software. The current status and first results of the analysis will be presented. Topics to be discussed include forward model aspects, e.g., optimization of the line-by-line cross section computation, numerical approach for the solution of the Schwarzschild equation, and algorithmic differentiation for Jacobians, as well as inversion methodology, nb. regularization.

Excess Dark Current from the OSIRIS CCD detectors onboard Odin

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Nick Lloyd
University of Saskatchewan, Saskatoon, Saskatchewan, Canada

Like all semiconductor devices onboard spacecraft, the CCD detectors used by the imaging spectrometer OSIRIS onboard Odin are subject to radiation damage. Among other effects is an increase in the dark current (DC), which can partially be accommodated in processing, but nonetheless introduces additional noise in the signal. We present here our study of the gradual growth in excess dark current, “eDC”, by which we mean dark current values larger than expected from performance at the beginning of the mission.

The data used consist of a series of dated images, where each image consists of the average for each pixel of a large number of exposures recorded numerable time during the day when the position and attitude of the spacecraft assure that negligible external light arrives at the CCD detector (e.g., when the instrument is pointing above the atmosphere). Because dark current depends naturally on temperature, a correction is made for each measurement using a value obtained from a thermometer located close to the CCD.

The simplest way of characterizing the radiation-induced increase of dark current is, of course, to simply sum the dark current over each CCD image and to plot the results over time. When this is done, the expected increase with time is quite clear, but in addition there is a strange increase in dark current during a period which turns out to coincide with northern hemisphere summer, when Odin spends some time in shade during each orbit’s pass over the Antarctic.

Examination of individual images confirms that this is not an anomalous increase in dark current. One way of seeing this is to make a histogram of each image by forming a scale of pixel dark current values and then counting the number of pixels for each value. For early mission dates, the vast majority of pixels lie in a Poisson-like distribution, with a long, flat plateau at higher values of pixel dark current that represents pixels which have excess dark current, most likely caused by radiation, as well as other aging effects. For later mission dates, the number of pixels within the original distribution decreases, while the number at high DC values increases. When one looks at distributions for the anomalous periods, one sees that the reason for getting a higher value of dark current is because the whole distribution is shifted, although the distribution function’s shape is not different from images either preceding or following the anomalous period. In other words, if the shape of the distribution is unchanged, then a simple shift will yield a distribution that is reasonable in the context of the earlier and later images. This shift corresponds to a shift in the temperature assumed for the detector, a shift that can affect the Level 1 processing, depending on its details.

Spectral modeling at www.SpectralCalc.com

Martin McHugh, Kim Smith, Lance Deaver, Ken Beaumont, and Larry Gordley
GATS Inc, Newport News, VA 23606, USA

Calculation of molecular spectra has historically been relegated to research-grade computer codes, available only to researchers in academic or government research programs. These codes are usually tied to specific and often archaic hardware/software configurations, and are unwieldy as stand-alone applications. Simulating even simple scenarios requires configuring a host of settings, usually in unforgiving and cryptic formats. To overcome these limitations, we developed www.SpectralCalc.com, a website where molecular transmittance and emission spectra can be calculated quickly and easily. Spectral simulations are powered by the LinePak radiative transfer library. Efficient, well tested and accurate, this library is at the heart of retrieval systems in a number of major satellite remote sensing missions. The tools at www.SpectralCalc.com use the LinePak algorithms to rigorously calculate research-quality spectra in full resolution, displaying them in just seconds. Gas cell scenarios and atmospheric path geometries are easily configured with the intuitive user interface. Pressure, temperature, path length, and gas concentrations are easy to adjust. Transmittance or radiance spectra are simulated for any gas mixture in any spectral region with up to 5,000 wavenumber intervals. Calculated spectra can be saved and compared with uploaded lab spectra. High-resolution graphics and raw data are available for download. HITRAN, GEISA and other line lists can be browsed with a simple graphical interface, line parameters can be exported for local use, or upload your own line parameters. These tools can dramatically enhance remote sensing or spectroscopy research, enabling quick and reliable spectral simulations online from any internet browser anywhere.

8 Instruments & missions 2 (Thursday a.m.)

PREMIER: a proposed satellite mission to observe processes controlling atmospheric composition in the height range most important to climate

Brian Kerridge(1), Neils Bormann(2), Anu Dudhia(3), Richard Engelen(2), Patrick Eriksson(4), Herbert Fischer(5), Piers Forster(6), Daniel Gerber(1), Michaela Hegglin(11), Lars Hoffmann(7), Michael Hoepfner(5), Paul Konopka(8), Barry Latter(1), Alexandru Lupu(9), Georgina Miles(1), John McConnell(9), Donal Murtagh(4), Lory Neary(9), Johannes Orphal(5), Paul Palmer(10), Vincent-Henri Peuch(13), Jolyon Reburn(1), Martin Riese(7), Kiril Semeniuk(9), Richard Siddans(1), Joachim Urban(4), Alison Waterfall(1), Michiel van Weele(12)

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(6) University of Leeds,United Kingdom
(7) Forschungszentrum Julich, Germany
(8) Forschungszentrum Julich, United Kingdom
(9) York University, Canada
(10) University of Edinburgh,United Kingdom
(11) University of Toronto, Canada
(12) KNMI, Netherlands
(13) MeteoFrance, France

The PREMIER (PRocess Exploration through Measurements of Infrared and millimetre-wave Emitted Radiation) mission is one of three candidates for ESA's 7th Earth Explorer Core Mission (due for launch in 2016) that have recently been approved for Phase A study. The mission proposes to make detailed measurements in the mid/upper troposphere and lower stratosphere in order to quantify processes controlling atmospheric global composition in this height range of particular importance to climate. PREMIER would consist of an infrared limb imaging spectrometer which would observe 3D fields of trace gases, alongside a millimetre-wave limb sounder which would enable observations in the presence of most cirrus clouds, and also provide complementary trace gases. In addition, co-located data from EPS-MetOp would be combined with that from PREMIER, to extend the scientific impact of PREMIER down into the lower troposphere, to explore links to surface emissions and pollution. In this presentation, the PREMIER mission concept will be introduced and initial simulations of its capabilities will be described

The STEAM-R instrument – sub-mm array for atmospheric limb measurements.

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STEAM-R is the start of a new generation of sub-mm limb sounders utilising the advances in receiver and spectrometer technology to image the Earth's limb at sub-millimetre wavelengths. The availability of low power broadband spectrometers allows us to use a receiver array while still processing large bandwidth and is thus suitable for UTLS studies. STEAM-R will measure with 14 beams covering the frequencies around 312-324 GHz and 344-356 GHz. The main target species will be water vapour, ozone and CO as well as biomass burning tracers such as HCN och CH3CN.
This arrangement gives good vertical resolution combined with along track resolution consistent with the perceived performance of climate chemistry models around the time of launch.
The main scientific goals for STEAM-R are to measure the distribution of trace gases in the atmosphere that are important for climate change and that allow us to better understand the small scale processes that link atmospheric chemistry to climate change.

L2/L3 data processing in NICT for the JEM/SMILES limb sounder on International Space Station

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And the SMILES retrieval team

The super-conductive Sub-Millimeter Limb Emission Sounder (SMILES) is a high sensitive radiometer to study atmospheric dynamics and chemistry with a strong emphasis on the stratosphere. It is the result of the collaboration between the Japanese Aerospace eXploration Agency (JAXA) and the National institute of Information and Communications Technology (NICT) in Japan. Observations are planned to start from beginning of October 2009.

JEM/SMILES will operate from the Japanese Experiment Module (JEM) onboard the International Space Station. It will measure the atmospheric emission spectra in three bands at 640 GHz (wavelength = 0.5 mm) and will scan the atmosphere from below the surface up to about 90 km. It will cover latitudes from -30^{o}S to 60^{o}N.
The official products, made by JAXA, consist in stratospheric O_3 and HCl isotops, ClO, HNO_3, HO_2, CH_3CN, BrO, and HOCl.

In addition, NICT has developed a scientific processing chain to study improvements of the retrieval algorithms and to retrieve additional products such as the abundances of O_3, HCl, HO_2 and wind in the mesosphere (up to about 90 km). Retrieval of humidity and of ice water content in the upper troposphere will be studied as well, in collaboration with Odin/SMR and AURA/MLS teams.

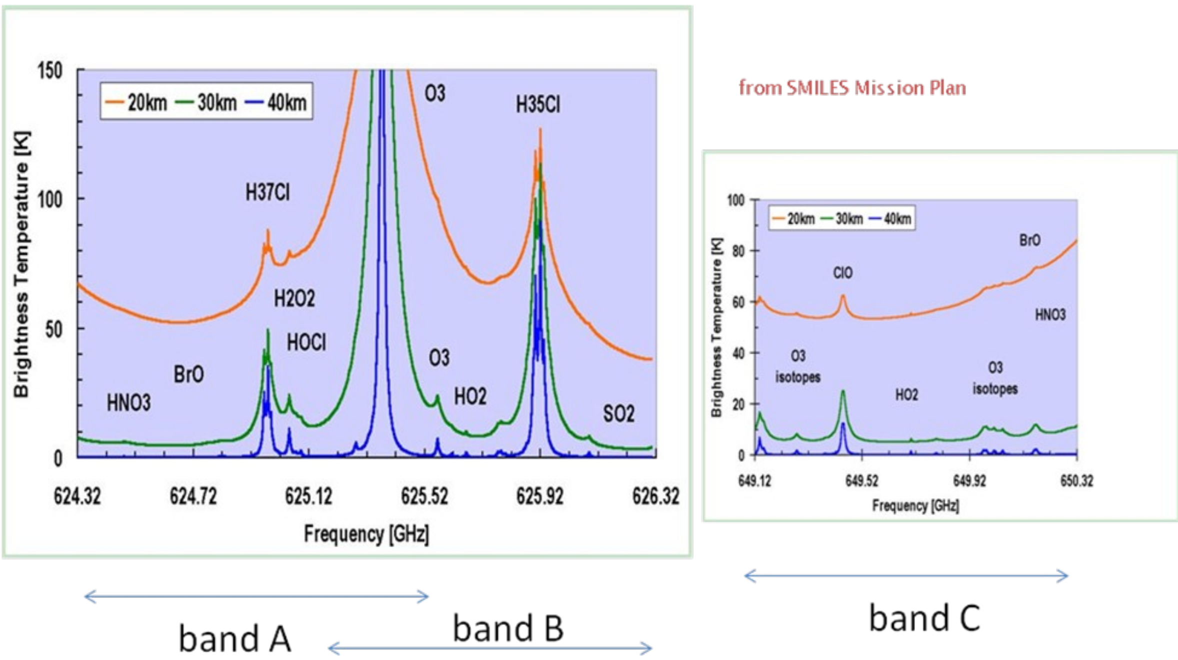

Figure 1: *Simulated JEM/SMILES spectra for bands A, B and C*
(http://smiles.tksc.jaxa.jp, http://smiles.nict.go.jp)

The upcoming OMPS/LP mission

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The Ozone Mapper and Profile Suite (OMPS) is scheduled to be launched in Spring 2011. The primary goal of the mission is to build up the Environmental Data Records (EDRs) for atmospheric ozone to allow the science community to better understand and quantify the rate of stratospheric ozone recovery. OMPS will make global measurements of the vertical, horizontal and temporal distribution of ozone in the Earth's atmosphere. OMPS 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, OSIRIS, SCIAMACHY, SAGE III).
The proposed paper will be concerned with the OMPS Limb Profiler (OMPS/LP), and more specifically will deal with the data processing and retrieval algorithms which are presently being prepared to extract ozone profile information from the sensor limb radiance measurements. The present status of the algorithm will be reviewed together with its performance when tested with synthetic and proxy data. Since the sensor uses a novel design, alternative methods are being implemented to either identify (and correct for) instrument effects or minimize the level of data preprocessing. Additionally, a detailed instrument model has been constructed to help analyze the on-orbit sensor performance as well as generate synthetic datasets for testing. The OMPS/LP data products will include: Ozone density and uncertainties, altitude uncertainties, aerosol extinction coefficients and uncertainties, one moment of the aerosol size distribution, cloud top height and effective surface albedo. A description of these data products, together with their public availability will be presented.

SPARC Data Initiative on chemical observations

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We here present a new SPARC (Stratospheric Processes And their Role in Climate) Data Initiative, launched in order to perform an international multi-instrument intercomparison of existing tracer climatologies. The need for this initiative was identified during the most recent SPARC CCMVal (Chemistry-Climate Model Validation Activity) model-measurement intercomparison project. In this comparison, a variety of available observational chemical data sets have been used and the results showed that the use of different chemical data sets can lead to considerable uncertainties in the model assessment. In order to better understand these uncertainties, we suggest a comprehensive assessment of the quality of available chemical data sets. The main objective of the initiative is to write a SPARC report on a comprehensive comparison of vertically resolved climatologies of (mainly long-lived) chemical tracers, age of air, and aerosols from all available satellite measurements. The initiative will highlight differences between the observational data sets, but not produce a new climatology. The development of the report would follow the proven SPARC approach of community involvement and peer review, and is intended to provide a guide for users of chemical data sets in order to facilitate data use for model-measurement comparisons and other data analyses. We think that the initiative is very timely, due to the wealth of available satellite observations and since there are many on-going efforts in establishing climatologies from the different satellite instruments, without which the proposed comparison would not be possible. The SPARC initiative also aims to work together with the space agencies to establish a data portal including meta data.

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