Troposat-2

The Remote Sensing of Atmospheric Constituents from Space

ACCENT-TROPOSAT-2 (AT2): An ACCENT Integration Task

AT2 Strategy Document

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Editors

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1. Introduction

1.1 Atmospheric Environmental problems

The second half of the twentieth century was marked by the realisation that air pollution was not only of local and regional importance but that it was indeed a global phenomenon, with local actions giving rise to the depletion of stratospheric ozone, the inter-continental transport of pollutants and the appearance of pollutants in hitherto pristine parts of the world.

The atmosphere, like the other components of the Earth system, is affected by the continuous increase in human population and activity, which have resulted in a variety of remarkable changes since the industrial revolution of the 19^{th} century. Among these are:

- the global decrease in stratospheric ozone and the attendant increase in surface ultraviolet radiation, emphasised by the ozone hole appearing over the Antarctic;
- the occurrence of summer smog over most cities in the world, including the developing countries, and the increased ozone background in the northern troposphere;
- the increase in greenhouse gases and aerosols in the atmosphere and associated climate change;
- acid rain and the eutrophication of surface waters and other natural ecosystems by atmospheric deposition;
- enhanced aerosol and photo-oxidant levels due to biomass burning and other agricultural activity;
- the increase in fine particles in regions of industrial development and population growth with an attendant reduction in visibility and an increase in human health effects; and
- the long range transport of air pollution to regions far from the industrial activity.

Many of these changes have socio-economic consequences through adverse effects on human and ecosystem health, on water supply and quality, and on crop growth. A variety of abatement measures have been introduced, or considered, to reduce the effects. However, continued growth in human activities, to expand economies and to alleviate poverty, will ensure that these effects continue to be important for the foreseeable future.

The physical, chemical and biological processes, which determine the composition of the atmosphere, the conditions at the Earth's surface and its climate, comprise a complex system having many non-linear interactions and much feedback. To assess accurately our current knowledge of the Earth-atmosphere system, detailed global information about the amounts and distributions of key atmospheric constituents and parameters is required.

1.2 Global Remote Sensing using satellite instrumentation

Using remote sensing instrumentation on-board orbiting satellites it is now possible to obtain global information for both the stratosphere and, thanks principally to recent European efforts, for the troposphere. In particular, passive remote sensing in the ultraviolet, visible and infrared spectral regions has provided, for the first time, information about the tropospheric column amounts of trace gases and aerosols, enabling comprehensive global views of the atmosphere to be built up.

A variety of data is now becoming available from the new generation of satellite instruments, such as ESA-ESR2/GOME and ATSR-2, NASA-TERRA/MOPITT and MODIS, NASA-AQUA/MODIS, ESA-ENVISAT/SCIAMACHY, AATSR, MIPAS and MERIS, NASA-AURA/TES and OMI, EUMETSAT-ESA-Metop/GOME-2, SEVIRI and IASI, and ADEOS/POLDER which allow the determination of two- and three- dimensional distributions and time series of trace constituents, aerosols and pollutants in the troposphere and stratosphere.

The principal research groups have already developed algorithms for retrieving tropospheric information from the complex spectroscopic data streams, and have produced the first global maps of the tropospheric distributions of NO_2, O_3, SO_2, HCHO, SO_2, BrO and aerosols.

These activities have demonstrated how such data might be used, either alone or in combination with information from other satellites or from ground stations, to determine:

- the distributions of NO_2, O_3 and SO_2 both globally, and regionally;
- regional source strengths;
- the effects of forest fires and biomass burning;
- photochemical oxidation in areas of fossil fuel combustion and biomass burning using plumes of formaldehyde as an indicator.
- the intercontinental transport and transformation of NO_2 and aerosol;
- the spatial distribution of $PM_{2.5}$ over Europe;
- the presence of BrO around the Arctic and Antarctic sea-ice in spring (which corresponds to events having nearly zero surface ozone concentrations); and
- the plumes of noxious gases resulting from volcanic eruptions.

Although it is essential that the data are fully appreciated and used by the scientific and environmental policy communities, the exploitation of satellite data has unfortunately not been the most important driver in the development of space-based instrumentation It is for this reason that the present project, AT2, has been set up. AT2 now has funds to undertake some coordination and its facilitating activities are aimed at achieving the optimal exploitation of data.

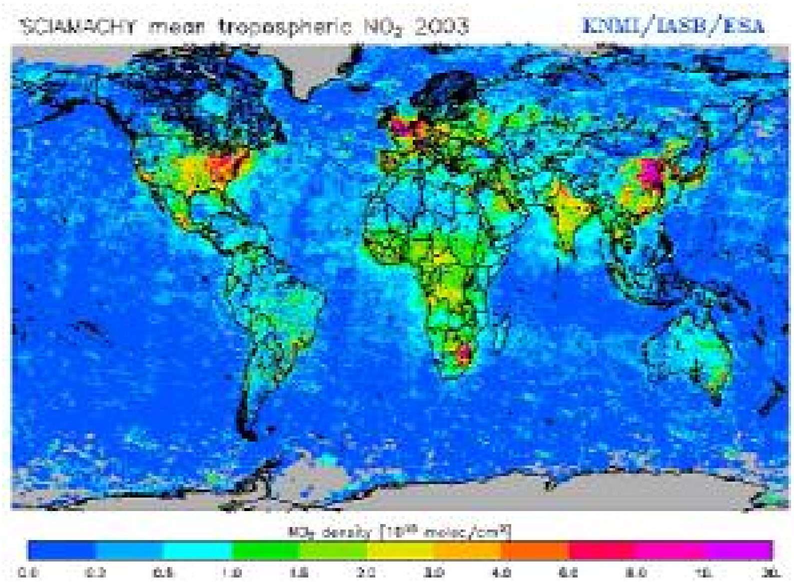

Figure 1. Global tropospheric NO_2. A yearly average of observations taken by SCIAMACHY in 2003. The industrial sources are clearly visible. [Image courtesy of H. Kelder, KNMI]

The remainder of this document details the overall aims and organisation of AT2, the detailed aims of the three task groups and the two additional activities, provides lists of the steering group, task group leaders and principal investigators and gives the proposed contributions by the principal investigators

2. ACCENT-TROPOSAT-2 (AT2)

2.1 ACCENT and AT2

ACCENT, Atmospheric Composition Change: a European network, is an EU Network of Excellence with the goal of promoting a common European strategy for research on *atmospheric composition sustainability.* ACCENT-TROPOSAT-2 (AT2) is an ACCENT integration task which addresses the need for global information about trace atmospheric constituents. AT2 will ensure that the utility of such data is fully appreciated and will facilitate the provision of data to the communities that wish and need to use them. AT2 is building upon on the efforts initiated within TROPOSAT, a subproject of EUROTRAC-2, to facilitate the generation of tropospheric data products, to encourage their use for research in the medium term, and indicate their potential use in the development of environmental policy.

The field is still in its initial phase and many scientific problems remain to be solved, particularly those associated with the retrieval of tropospheric distributions of chemically active species, and the generation of profiles of their concentrations in the atmosphere. These will be facilitated by the use of limb sounding as well as nadir observations on some instruments (SCIAMACHY for example), and the utilisation of the daily observations to generate a continuous picture of concentrations of trace species in space and time. A substantial effort is required in the near future to ensure that the potential of the data is fully realised.

2.2 Objectives of AT2

The objectives for AT2 given in the original ACCENT proposal are as follows.

- The co-ordination and optimisation of the efforts of European scientists in the retrieval of the data products for tropospheric research from the measurements by instrumentation aboard orbiting satellite platforms.
- The establishment of the remote sensing scientific team and the development of a strategy to sustain this activity within ACCENT.
- The provision of added value to the national programmes exploiting remote sensing data within the European Research Area by promotion of discussion and exchange.
- The definition of the spectroscopic data base needs and initiation of the data base
- The provision of global tropospheric data products of trace tropospheric constituents (gases, aerosol and clouds) using remote sensing from space.
- The exploitation of remote sensing data from space-based instrumentation for tropospheric research within the European Research Area.
- The provision of an interpretative interface to address the existing and developing European and international environmental policy and the role of remote sensing data from space.

The programme is ambitious but it should be possible to attain these during the proposed time scale of ACCENT.

2.3 Deliverables from AT2

The following deliverables were specified in the original ACCENT proposal.

- A web-based listing of data sets for research and policy support.
- Research Tools comprising the description of retrieval algorithms
- Documentation: Workshop reports and a Final report.
- Scientific work published in the refereed literature.
- The preparation for a meeting with a resulting peer-reviewed book to document the progress in the activities, later in the project.

2.4 Organisation of AT2

A steering committee was appointed by ACCENT from among the partners and augmented by adding those task group leaders who were not already members.

Principal investigators were invited to apply for membership of AT2 by submitting a short proposal indicating how they would contribute scientifically to AT2. Many of these were active in the former TROPOSAT project; others were new to the group.

The first AT2 workshop organised the project into three groups, with the following tasks.

1. The development and improvement of algorithms for the retrieval of tropospheric data. Task Group 1 is divided into three groups, specialising in aerosols, infra-red measurements and UV/Visible measurements.
2. The synergistic use of models and observations to improve our understanding of tropospheric chemistry and dynamics.
3. The development of validation strategies for tropospheric satellite data products using existing data.

Each task group consists of a number of principal investigators each of whom has agreed to contribute to the work of the integration task.

In addition, two further activities will be undertaken by groups of the principal investigators:

- to develop an updatable source list of tropospheric data products for use by the wider community; and
- to contribute to the outreach activities of ACCENT by developing an educational package on Remote Sensing from Space for use in Universities.

The aims of the project and its constituent parts are being pursued through regular workshops and meetings, inter-laboratory exchanges and the publication of regular reports.

The results from AT2 together with information about tropospheric satellite data available and a variety of images derived from satellite data are displayed on the AT2 web page, *troposat.iup.uni-heidelberg.de*

3. Task Group 1: Algorithm development

Thomas Wagner, University of Heidelberg, Task Group Leader

3.1 Summary of main objectives

The aim of task group 1 is to distribute information on data products and algorithms between the different groups involved and also to a wider community of data users.

During recent years a large variety of methods for the analysis of tropospheric data products from satellite sensors have been developed; it was possible to retrieve global maps of trace species (*e.g*. BrO, NO_2, HCHO, SO_2, H_2O, CO) and aerosol properties from novel instruments like, for example, GOME, ATSR, MERIS, MOPITT, SCIAMACHY, POLDER, MODIS, MISR and SeaWIFFS. Most of the retrieval methods have been developed by individual groups as scientific algorithms and are still subject to further refinement and improvement. A first very successful attempt to coordinate and encourage these activities was carried out within the framework of the EUROTRAC-2 project TROPOSAT An overview on algorithms and data products can be found at the AT2 website, *http://troposat.iup.uni-heidelberg.del*.

Since the launch of ENVISAT (and recently also AURA), improved and new sensors have become available, in particular including new instruments for aerosol properties and for absorbers in the IR spectral range. Because of these new opportunities and also due to an increased demand on high quality satellite data sets (*e.g*. for initialisation of and comparison with global CTMs), increased efforts need to be undertaken for the coordination, homogenisation and distribution of satellite algorithms for tropospheric trace gases and aerosols.

After the ending of TROPOSAT a new forum for these activities has been established within the framework of ACCENT. As a response to the increased number of sensors for IR products and aerosol properties task group 1 was subdivided into three parts:

- Trace gases derived from UV/visible sensors
- Trace gases derived from IR sensors
- Aerosol and cloud products

For all of these sub-groups specific challenges exist and special strategies have to be applied. Detailed algorithm work and exchange of specific information can best be carried within specialised sub-groups. For the specific strategies and aims of these sub-groups please refer to the particular sections below.

Besides the activities within the sub-groups, an important part of task group 1 will be the information exchange between the different sub-groups. Such information exchange is not only important because several algorithmic procedures are common between the different sub-groups, but also because algorithms for different products might depend on each other (*e.g*. tropospheric trace gas data depend on good cloud and aerosol corrections). In addition, and probably most important, such information exchange will stimulate the application and adaptation of strategies and algorithms which have been originally developed within other sub-groups. The communication and transfer of information will be ensured with different strategies.

- The activities of the different sub-groups will be reported to a general audience at regular meetings.
- Special workshops on algorithm development including all sub-groups will be held.
- The reports of sub-group workshops will be distributed.

- Research visits for scientists between different institutions will be initiated.
- Products which are available from different sub-groups (*e.g.* O_3, NO_2, H_2O and aerosol properties) will be compared.

Besides these activities, the long term aims of task group 1 also include the distribution of data products and documentation to the public. As in TROPOSAT, a list of the available data products and the respective PIs will be collected and posted on the project's web-page. The documentation distributed will include individual algorithm descriptions, validation results and reports on workshops and meetings.

3.2 Trace gases; UV/visible

Andreas Richter, University of Bremen, subgroup leader

Retrieval of tropospheric trace species from UV/visible measurements of scattered light started more than two decades ago with analysis of the TOMS data for tropospheric O_3 and SO_2. As data from the GOME instrument became available in 1995, retrieval of the tropospheric columns of NO_2, BrO, H_2O, and HCHO also became possible. Since then, several groups have developed independent retrieval algorithms that in most cases are based on the Differential Optical Absorption Spectroscopy (DOAS) method, but differ in the approaches taken for the compensation of stratospheric contributions and the correction for the variation in vertical sensitivity.

Tropospheric products derived from GOME measurements have been used in a multitude of case studies dealing, amongst others, with tropospheric bromine explosions, biomass burning, anthropogenic NO_x emissions and long range transport of pollution. They have also been compared intensively with model results and, in an iterative process, lead to substantial improvements in the quality of both model and satellite results. More recently, first attempts have been made to validate tropospheric column products, and this turned out to be a difficult task as averaging over the large ground pixel size and the intrinsic vertical integration are difficult to achieve with other measurement techniques.

After the first phase of demonstration and exploitation of tropospheric measurements from space, the second phase of satellite data use has now started with a focus on new instruments that provide better spatial resolution and coverage, improved algorithms that provide higher accuracy, and more detailed error assessments that provide more quantitative results. Also, the synergistic use of data products from different instruments (fire counts, aerosol information, different trace species) and an integrated retrieval using measurements different instruments (*e.g.* IR and UV/visible) will be investigated in the future.

Within TG1, data from four UV/visible satellites will be used : GOME-1, SCIAMACHY, OMI, and GOME-2. Several PI contributions deal with different approaches to retrieve tropospheric O_3, arguably the most difficult retrieval in particular outside the tropics. A second focus is on NO_2 retrieval with BrO, HCHO, SO_2, and H_2O also covered. Another development is the study of long-term changes in tropospheric composition, which after 8 years of GOME operation and nearly two years of SCIAMACHY measurements now is becoming possible. In view of the planned GOME-2 series on Metop, observation of tropospheric change will probably be one of the most relevant contributions of satellite based observations in the years to come.

The contributing principal investigators to the UV/visible subgroup are listed in section 9 and their individual contributions given in section 10.

3.3 Trace gases; infra-red

Johannes Orphal, LISA, Uni. Paris-XII, F; IR subgroup leader

The infrared region is useful for tropospheric remote-sensing from space because the molecular absorption bands are relatively well separated and the individual lines provide vertical information due to their pressure-dependent profiles and temperature-dependent intensities. In the mid-infrared region (MIR, about 3-15 µm), information on tropospheric traces gases can be obtained using the thermal emission of the surface and lowest atmospheric layers. It is relatively difficult to extract trace gas concentrations within the planetary boundary layer in this spectral region, however, due to the small thermal contrast, the MIR weighting functions peak in the lower troposphere, therefore making this spectral region highly complementary to the UV/visible and near-infrared (NIR, about 0.8-3.0 µm) regions. In the latter region, the photons are mainly due to surface-reflected sunlight. This, together with the fact that in the NIR atmospheric scattering is much weaker than in the UV/visible region, makes the NIR highly interesting for tropospheric observations.

Retrievals of atmospheric species from MIR Nadir spectra have been demonstrated in the past using data from the IMG instrument onboard ADEOS. Limb-spectra (*e.g.* from MIPAS onboard ENVISAT) have the intrinsic problem of clouds occurring within the line-of-sight, but provide the important advantage of very high vertical resolution in the upper troposphere. Successful NIR instruments are MOPITT (on board EOS-Aqua) and SCIAMACHY (on board ENVISAT) who have clearly demonstrated the sensitivity of the NIR region for important tropospheric species, such as CO and CH_4.

In the frame of the ACCENT-AT2 project, several PI contributions focus on the use of recent or near-future infrared satellite instruments in Nadir viewing geometry. Recent Nadir-viewing instruments comprise SCIAMACHY (covering the near-infrared region up to 2.4 microns, where absorptions of CO, CH_4, N_2O and CO_2 can be used), MOPITT (measuring CO and CH_4 in the mid- and near-infrared using a gas correlation technique), AIRS (also on board EOS-Aqua, a multi-channel spectrometer in the 3.7-15.4 micron region, capable of observing O_3, CO, and many other species), and TES (on board EOS-Aura), a high-resolution Fourier-transform spectrometer covering the entire mid-infrared region, that will provide data for the retrieval of tropospheric O_3, CO, CH_4 and other trace gases. Within the time-frame of AT2, the launch of MetOp in late 2005 will provide data from another Nadir-viewing instrument (IASI, a Fourier transform spectrometer with medium spectral resolution, covering the range of 2-14 microns). Limb-viewing instruments such as MIPAS onboard ENVISAT and ACE-FTS onboard SCISAT can provide vertical profiles below the tropopause and in the upper troposphere down to 6 km (in cloud free cases).

The main target species are tropospheric columns, and possibly a few tropospheric layers, of O_3, CO, CH_4, N_2O, H_2O and CO_2 and vertical temperature profiles, but in addition there is a much longer list of other species that will be observed and/or investigated, such as the most important CFCs and HCFs, several VOCs (like H_2CO or C_2H_6), as well as HNO_3, PAN and SO_2 (the latter mainly in volcanic regions).

The main activities of the different groups within the infrared part of TG-1 will be the development of algorithms to extract tropospheric information from satellite data, with contributions from stratospheric sensors, data assimilation including coupling of the retrieval or retrieved concentrations with chemical transport models, and high-resolution molecular spectroscopy for species where the accuracy is limited by the knowledge of the molecular parameters.

The development of combined retrievals using infrared and UV/visible data will demonstrate the capability of current and future atmospheric sounders for monitoring tropospheric trace gases.

The principal investigators contributing to the infra-red subgroup are listed in section 9 and their individual contributions are given in section 10.

3.4 Aerosol and clouds

Gerrit de Leeuw, TNO, The Hague, NL; aerosol subgroup leader

Satellite remote sensing can be a cost-effective method providing the spatial and temporal resolution to monitor the highly variable aerosol fields on regional to global scales. Until recently it was thought that the retrieval of aerosol properties from satellite data was only possible over dark surfaces, such as the ocean. However, novel satellite sensors allow for the accurate retrieval of aerosol properties over brighter surfaces, in particular over land. Satellite-based instruments that are used for retrieval of aerosol properties were not designed for this purpose. Examples are TOMS, AVHRR, OCTS, ATSR-2, and SeaWIFS. TOMS, initially developed to calculate the total ozone concentration, is especially sensitive to absorbing aerosols both over land and sea. Since 1978, a long time series of the Aerosol Index (AI) over water and over land is available from this instrument. AI is a measure of the wavelength-dependent reduction of Rayleigh scattered radiance by aerosol absorption relative to a pure Rayleigh atmosphere. AVHRR aboard NOAA satellites, designed to determine the sea surface temperature, has been used to retrieve aerosol information over the ocean since 1981. Together these two instruments provide a long time series that, even when not ideally suited for aerosol retrievals (*e.g.* the AVHRR has calibration problems, TOMS delivers only the AI, *i.e.* for absorbing aerosols), provides an excellent reference for global aerosol studies. The newer instruments include OCTS (on board ADEOS) and SeaWIFS, both primarily designed for retrieval of ocean properties, which are applied to retrieve aerosol properties over the ocean. ATSR-2 on board ERS-2 was designed to derive sea surface temperature, but it has been successfully used to retrieve aerosol properties over the ocean, and taking advantage of the dual view and the multiple wave bands, also over land. The ATSR series has been continued with AATSR on ENVISAT and is planned for the Earth Watch mission which ensures long-term data availability. POLDER was the first sensor specifically developed for aerosol retrieval over land and ocean by utilizing both polarization and multiple-angle viewing. Two instruments were launched but unfortunately they were operational only during short time periods due to platform problems. Multiple angle viewing is also used on MISR. The instrument that currently delivers most information on aerosol and cloud properties from space is MODIS, which was uniquely designed (wide spectral range, high spatial resolution, and near daily global coverage) to observe and monitor these and other Earth changes.

Within TG-1 data will be used from ATSR-2/AATSR, GOME, SCIAMACHY, MISR and OMI, and possibly from other instruments as well. Activities are underway to expand the aerosol and cloud section with PI contributions from other ACCENT participants active in these areas. Scientific questions that will be addressed are:

- what aerosol information can be retrieved from instruments that were not designed for this purpose (AOD, Ångström coefficient, speciation, modal sizes, $PM_{2.5}$, ssa, optical properties, vertical distribution), and with which accuracy?
- what are the improvements that can be expected from dedicated aerosol instruments:
  - Lidar (CALIPSO)
  - Polarization (POLDER1&2, PARASOL)

    - Multiple angle viewing (MISR, ATSR, CHRIS-PROBA) and
    - Wide spectral range, including IR: *e.g.* MODIS?
- what are the improvements from Synergistic use of different instruments (*e.g.* SYNAER)? and
- what are the improvements in the retrieval from synergistic use of satellite instruments and chemical transport models (data assimilation)?

Furthermore the question arises what the requirements are as regards the accuracy of the retrieval products for scientific users, for operational users and for policy support.

The principal investigators contributing to the aerosol subgroup are listed in section 9 and their individual contributions given in section 10.

3.5 List of achievables in the first half of the project

A number of the activities listed below cannot be completed within the first half of the project. Nevertheless, substantial progress can be expected.

- Improvement of algorithms:
    - trace gases (BrO, NO_2, HCHO, SO_2, H_2O, CO), *e.g*. better cloud and aerosol correction;
    - cloud and aerosol properties from GOME and SCIAMACHY;
    - aerosol products from AATSR, OMI, other sensors;
    - synergistic use of SCIAMACHY and AATSR for aerosol speciation;
    - demonstration of quasi-operational aerosol retrieval algorithm for ATSR-2, by application to data over Europe for the year 2000;
    - extension of aerosol algorithms to areas with complicated aerosol composition; and
    - demonstration of feasibility to deliver NRT AOD data from AATSR.
- Development of new algorithms:
    - CO, CO_2, CO, O_3 from SCIAMACHY;
    - synergistic use of AATSR and MSG-SEVIRI to provide accurate aerosol information with high resolution in both time and space ;
    - test on feasibility to derive regional $PM_{2.5}$ directly from AOD data; and
    - $PM_{2.5}$ maps based on EO data assimilated in CTM.
- Long term data sets and trends:
    - BrO, NO_2, HCHO, SO_2 from GOME
- Synergy and integration:
    - workshop on retrieval methods;
    - workshop on aerosol methods;
    - exchange of information; and
    - provide a list of products and descriptions.
- Definition of future aims:
    - define realistic long term aims;
    - long term aim for aerosol is to provide reliable, accurate and sustainable products meeting requirements of various user segments: AOD, speciation, $PM_{2.5}$, ssa, etc.; and
    - define distribution channels for products: GSE PROMOTE

3.6 Encouraging cooperation

As well as the internal communication within task group 1, the external communication with the other task groups (and also outside AT2) is of crucial importance to the success of the project. This is not only because the members of task group 1 must respond to the user needs of the tropospheric data sets derived from satellite sensors. Moreover, the data users must know not only the data product itself but also all necessary information associated with it, *e.g.* the sensitivity of the measurement under various conditions.

To ensure this information flow in both directions, several activities are foreseen.

- Besides the data products themselves necessary documentation should also be made available at the web-site.
- Reports on workshops (whole task group 1, or sub-groups) will be distributed.
- Overview presentations will be given at project meetings.
- Feedback from other task groups and projects will be distributed.

  Scientist visits at different institutions will be initiated.

3.7 Performance Indicators

The following indicators can be employed to estimate the progress of AT2 Task Group 1.

- Number of 'achievables' delivered and progress toward accomplishment of this list.
- Organisation of workshops and distribution of summary reports.
- Establishment of a data base for data products and documentation for different algorithms developed within task group 1.
- Improved use of tropospheric data products derived from satellite measurements.
- Harmonisation of similar algorithms from different groups.
- Number of scientific exchanges between different institutions.

3.8 Task Group 1 principal investigators

The contributing principal investigators to task group 1 are listed in section 9 and their individual contributions are given in section 10.

4. Task Group 2: The synergistic use of models and observations

Martin Dameris, DLR, Oberpfaffenhofen, Germany,
Task Group Leader

4.1 Summary of main objectives

Task group 2 aims to demonstrate how data products of the troposphere derived from satellite and non-satellite measurements can be evaluated and employed for scientific applications. The synergistic usage of these data together with results of different model systems is planned in order to improve the qualitative and quantitative interpretation and the understanding of dynamical, physical and chemical processes in the troposphere and stratosphere. Satellite data are increasingly suited to supply initialisation, boundary conditions, and test data for chemical-transport models (CTMs) on regional and global scales, and interactively coupled global chemistry-climate models (CCMs). In this sense, the activities of this AT2 task group includes:

- development of methods for using satellite data from the troposphere as part of model validation strategy;
- investigation of physical, dynamical, and chemical processes in the troposphere and stratosphere, especially in the upper troposphere / lower stratosphere (UTLS);
- use the combination of model results, satellite observations, ground based and airborne measurements in a synergistic way to improve our knowledge about individual tropospheric processes, such as, source attribution and impact assessment of gaseous and particulate pollutants; cloud occurrence and the hydrological cycle; and
- the use of model results to help bridge the gap between point measurements and the satellite view footprint for evaluating satellite retrievals (see example in Figure 2).

4.2 Aim of the research

Within the EUROTRAC-2 project TROPOSAT it was demonstrated that tropospheric data products derived from satellite measurements can be evaluated and employed for scientific applications. Within AT2, scientific investigations will be intensified, in particular the synergistic use of satellite and non-satellite (ground based and airborne data) together with

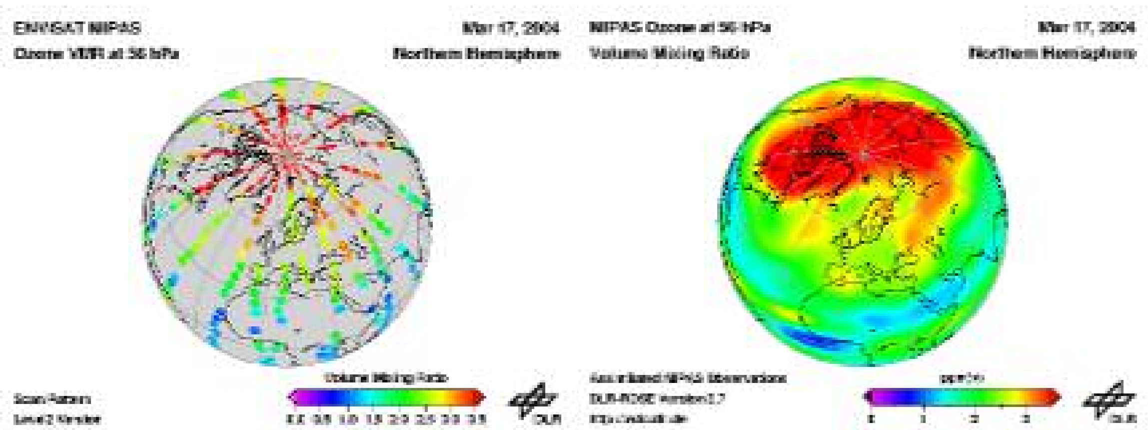

Figure 2. Example for ozone observations on a single day measured from the ENVISAT/MIPAS instrument (left) and a corresponding, assimilated ozone distribution for the respective day (right) derived with the DLR-ROSE model (Courtesy of DLR-DFD, Dr. Michael Bittner and Dr. Thilo Ebertseder).

results derived from a hierarchy of different numerical models describing atmospheric processes. Special attention will be given to data products derived from the satellite ENVISAT, in particular those from the instruments MIPAS and SCIAMACHY. ENVISAT is unique due to its combination of a wide range of multiple instruments on one platform. The synergistic use of these scientific data products will help to improve the knowledge about tropospheric and stratospheric dynamical, physical, and chemical processes and their interaction. The studies will address the following scientific points:

- evaluation of data products derived from satellite instruments (*e.g.* GOME, SCIAMACHY, MIPAS, MOPITT); synergistic use of satellite data with ground-based and airborne measurements; scientific interpretation of measurements, among others together with model results;
- characterisation of the atmosphere and its change in composition in time employing data assimilation techniques:

- investigation of long-range transport of tropospheric trace gases;
- quantification of natural and anthropogenic effects on dynamics and chemical composition of the UTLS;
- explanation of changes in the UTLS observed during recent decades;
- improvement of modelling and forecasting of tropospheric chemistry and air quality;
- evaluation of hydrological cycle and ozone budget in models.

4.3 List of achievables within the first half of the project

- Evaluation of model results employing data products derived from satellites. Key molecules include NO2 tropospheric columns, ozone, CO, and water vapour.
- Initial studies of pollution transport mechanisms observable from space.

4.4 List of achievables for the complete project

- Quality assurance of tropospheric measurements from space.
- Preparation of climatologies of GOME O_3, NO_2, BrO, *etc.* (*e.g.* tropospheric columns) for the years 1995 to 2004; statistics regarding seasonal and inter-annual variability, description of uncertainties regarding estimates derived from other methods (ground based, aircraft, balloon). It is most interesting to investigate the consistency and relationships between the various gases that are measured simultaneously.
- Provide consistent data sets (GOME plus MIPAS and SCIAMACHY data products).
- Monitoring of global and regional changes; continuation of climatologies.
- The further development of techniques to detect tropospheric composition change (the 'chemical climate') from space.
- Modelling studies to determine uncertainties of different retrieval algorithms, *e.g.* modelling of tropospheric NO_2 columns with CTMs.
- Characterisation of the 'chemical weather' of the troposphere, that is, its short-term change in chemical composition; detailed analysis of episodes; use of satellite data in chemical weather forecasting (*e.g.* assimilation of GOME/ SCIAMACHY near-real-time O_3).
- Identification and evaluation of pollution transport mechanisms observable from space;
- Inter-comparison of model results with climatologies derived from GOME data to determine general discrepancies, uncertainties and deficiencies. The investigations will focus on NO2 tropospheric columns, in particular over industrial areas (Europe, north-eastern North America), where major discrepancies are most obvious.

4.5 Encouraging cooperation

There is a need for 'cross-cutting' activities within this task group. First, the synergistic use of observations (here mainly from space) and results derived from model studies will enhance our knowledge with regards to the importance of individual physical, dynamical and chemical processes in the troposphere and stratosphere, as well as the interaction mechanisms (mutual effects) of these processes. This will be the basis for further model developments and improvements. Assessments of possible future developments of tropospheric composition and climate, which are often based on model calculations will be set on a more reliable basis.

Another cross-cutting activity of the task groups is required for inspecting the processing chain with regards to error analysis of the end products. The common effort will identify which processing steps are most critical, which scales are most difficult, which physical and chemical processes are most important, for which kind of application.

Part of the work planned within Task group 2 is a common activity with the ACCENT Modelling task, *i.e.* the use of data assimilation methods in combining observations and modelling to obtain a complete and continuous as possible picture of the atmosphere.

4.7 Performance Indicators

The following indicators can be employed to estimate the progress of AT2 Task group 2:

- improved use of tropospheric data products derived from satellite measurements;
- establishment of a joint data base available inside and outside of AT2;
- development, harmonisation and joint use of modelling tools;
- number of exchanges, joint activities and publications within task group 2; and
- a number of exchanges carried out outside AT2.

4.8 Task Group 2 principal investigators

The contributing principal investigators to task group 2 are listed in section 9 and their individual contributions given in section 10.

5. Task Group 3: Strategies for the validation of tropospheric products from satellites

Ankie Piters, KNMI, de Bilt, the Netherlands. Task Group Leader

5.1 Introduction

The tropospheric products retrieved from satellites require a thorough validation in order to assess the usefulness of these products for tropospheric research. The satellite product accuracies should be investigated by comparison with other independent observations of the same products, using ground-based, air-borne and other satellite measurements. Special attention should be paid to methods for the validation of the tropospheric part of molecules that have a substantial abundance in the stratosphere as well (*e.g.* ozone, NO_2), since the retrieval of both the satellite product and the correlative product will be influenced by this stratospheric component.

The relevant current and future atmospheric chemistry satellite missions are: ERS, ENVISAT, EOS-Aura and METOP. These missions deliver a wealth of tropospheric products, many of them generated within the framework of task group 1. Dedicated validation projects exist for every instrument onboard these satellites. However, these dedicated validation projects are typically limited in time and resources, and a lot of the validation is actually being performed by the scientists using the data in a later stage. These individual validation efforts are usually not brought together, and several independent studies often show inconsistencies or conclusions which are not comparable on data accuracy. In addition some specific tropospheric products are developed after the dedicated validation projects, or as non-official satellite products by scientific institutes rather than by the responsible space agencies. Most of these products undergo a first limited validation by the product developers themselves. This situation is not ideal, therefore this task group has the following long-term objectives.

5.2 Long-term objectives (general)

The aim of task group 3 (TG3) is to develop an international open network of collaborating validation scientists, in which the quality of the available tropospheric satellite products is thoroughly assessed. More specifically, the general long-term objectives are:

- to encourage validation of tropospheric products retrieved from current and future atmospheric chemistry satellite missions from ESA, NASA and EUMETSAT, like ERS, ENVISAT, EOS-Aura, and METOP;
- to collect validation results of tropospheric products;
- to communicate knowledge about product quality;
- to encourage interaction with retrieval groups, in particular with scientists from task group 1, in order to improve the tropospheric products more efficiently;
- to integrate the activities performed within this task group into existing large-scale validation projects, in particular those for SCIAMACHY, OMI, and GOME-2 (PI contributions: Kroon and Piters)
- to encourage activities in special regions in new EU member states;
- to encourage interaction between data providers, validators and modellers;
- to exploit the use of existing networks (*e.g.* NDSC);
- to encourage the participation in instrument intercomparison and validation campaigns; and
- to encourage mobility of instruments and scientists.

5.3 Long-term objectives (scientific)

TG3 involves scientists working individually on the validation of one or a number of tropospheric satellite products, most of them on national funding. Therefore the content of the research done in this task group very much depends on what individual scientists can do within their own national science programmes. The long-term scientific objectives, listed below, serve as a guideline for possible future nationally funded research, and more importantly for possible future cooperation projects within the task group.

The general scientific aim of TG3 is to assess the quality of tropospheric satellite products, more specifically the usability of those products in tropospheric research or monitoring of pollution or climate change. More specific long-term objectives are listed below.

1) Develop validation strategies to account for differences in retrieval methods and differences in representation of the satellite product and the correlative instrument product or model, for example differences in spatial resolution and sampling (see Figure 3), averaging kernels, and viewing geometries (PI contributions: Galle and Mellqvist)
2) Develop techniques to assess the accuracy of a product from a combination of information from different validation methods, such as comparisons to ground-based, models, and satellites (PI contributions: Gloudemans and Van der Broek)

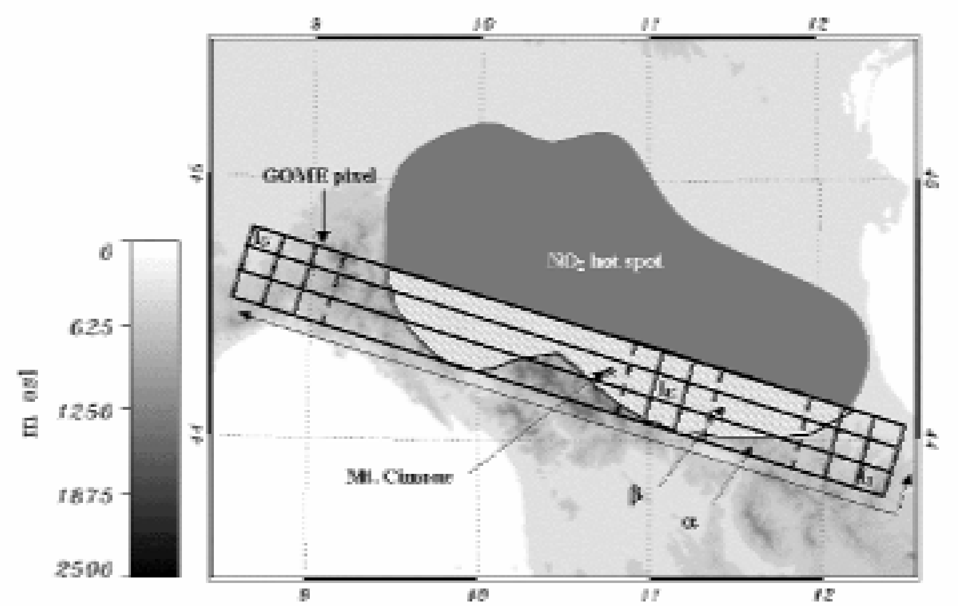

Figure 3. Illustration of the difference in representation of a satellite measurement, which is the NO_2 column over a large rectangle, and the ground measurement, which gives the NO_2 column over one specific location (picture provided by A. Petritoli, ISAC).

3) Collect, analyse, and improve correlative measurements in special areas of interest, such as megacities and volcanoes (PI contributions: Galle and Mellqvist)
4) Collect, analyse, improve, and make available correlative measurements from long-term continuous measurement stations and networks (PI contributions: Mahieu, Notholt and Sussmann)
5) Perform comparisons between tropospheric satellite products and independent correlative measurements (PI contributions: Galle/Mellqvist, Gloudemans, Van der Broek, Monks/Leigh and Petritoli)
6) Perform comparisons between tropospheric satellite products and models (PI contributions: Gloudemans and Van der Broek)
7) Assess the usability of tropospheric satellite products for specific tropospheric research areas, *e.g.* radiation budget, long-term evolution of chemical composition, air quality (PI contributions: Mahieu, Monks/Leigh, Orsolini and Petritoli)
8) Establish operational ground-truthing stations especially suited for validation of tropospheric satellite products (PI contributions: Sussmann and Ubelis)

5.4 Encouraging cooperation

- Participation in this Task group will be encouraged by inviting as many as possible colleagues in the field of validation to actively participate (which means, in first instance, to write a PI contribution). A special effort will be made in encouraging validators of cloud and aerosol products.
- The participating projects will be fully integrated in the existing large-scale validation projects for SCIAMACHY and OMI. This means that the scientists participating will have early access to data, will be informed on instrument and data issues, will be invited to validation meetings, and can participate in joint validation publications.
- A special campaign will be defined for comparison of SCIAMACHY CO total columns (from TG1) with collocated ground-based measurements, where cooperation between retrieval groups, instrument teams, and validation scientists is exploited.

- Validation scientists will be brought together at least twice a year for dedicated workshops on the validation of tropospheric products from satellites, mostly combined with other interesting workshops for validation, provided that funding is available to cover the corresponding expenses.

5.5 Specific Comparisons envisaged for the first half of the project

The new satellite measurements of tropospheric species and the algorithms used for their retrieval require an extensive validation. Various methods are envisaged to achieve this. These include intercomparisons of independent satellite measurements, comparisons of satellite measurements with ground-based measurements and/or balloon experiments, comparisons of satellite measurements with results from chemistry/transport model calculations. The products to be validated during the first 18 months are tropospheric O_3, NO_2, SO_2, CO, CH_4, and CO_2 from GOME, SCIAMACHY, MOPITT, and OMI. In addition to these products, TG3 also generates correlative measurements of (partial) columns of BrO, H_2O, N_2O, C_2H_6, HCFC-22 (+ many other FTIR species), and profiles of O_3, H_2O, T/p, and aerosol extinction.

O_3, NO_2

- Report-Assessment on O_3 observations during the European heat wave of August 2003.
- Chemiluminescence monitors in 8 separate locations in Leicester provide hourly data on boundary layer ozone and NO_2 over an area of several kilometres. The use of such a network for the validation of tropospheric measurements from GOME, OMI and SCIAMACHY will be explored.
- Data analysis from ground-based stations to retrieve NO_2 column in the PBL (by means of DOAS observations) and *in situ* concentration at representative sites.
- Validation studies at the Zugspitze (2964 m) FTIR: SCIAMACHY total columns of O_3 and NO_2.
- Training of personnel from Latvia for MAXDOAS validation.
- Planning and execution of a joint validation campaign in Latvia using existing mobile validation stations.
- General concept and design of stationary MAXDOAS validation station in Latvia.

CO, CH_4, CO_2

For these molecules only a few ground-based stations are available, most of which are at elevated locations. A detailed validation of satellite measurements of these species therefore requires not only comparisons with ground-based measurements, but also intercomparisons of independent satellite measurements and comparisons with model calculations. In addition, comparisons with measurements from a mobile solar FTIR instrument allow for good collocations in both time and space. To achieve this, the following comparisons/validation studies are proposed for the first 18 months.

- Comparisons of SCIAMACHY CO and CH_4 with several NDSC FTIR ground-stations. In particular, Harestua, Jungfraujoch, Zugspitze (2964 m) and the new Garmisch (734 m) station. The build-up and first measurements of the latter station will allow a characterization of the boundary layer and free troposphere and thereby complement measurements at the nearby Zugspitze station.
- Comparison of SCIAMACHY and MOPITT CO with mobile solar FTIR measurements from the ground at selected places: Mexico City, April 2003 and

Milan/Po Valley, Sept. 2003 and Aug. 2004. This allows for better collocation in both time and space than fixed FTIR stations.

- Intercomparison of SCIAMACHY and MOPITT CO measurements, allowing validation to be done on a global scale, instead of at selected sites.
- Comparison of SCIAMACHY CO/CH_4/CO_2 and MOPITT CO with atmospheric chemistry models, allowing validation to be done on a global scale also for species for which no additional satellite measurements yet exist.

SO_2

- Comparison between SCIAMACHY SO_2 and MAX-DOAS measurements around a few selected volcanoes (Etna: Sept. 2004, Nyirangongo, Kongo: Jan.–June, 2004).

H_2O

- Start of operation and first measurements of new Zugspitze/Schneefernerhaus (2600 m) water vapour lidar: Expected profiles up to 12 km altitude.

aerosol

- Routine measurements with the Garmisch stratospheric aerosol lidar made available for the validation of the AURA mission.
- Upgrade of Garmisch aerosol lidar with the 'high-resolution' option: thereby independent retrieval of extinction profiles. Airborne measurements of aerosol (sahara dust) above Lampedusa for satellite validation.
- Start of permanent *in-situ* measurements at the Zugspitze station of aerosol optical parameters, size distributions, scattering und backscatter coefficients, and wavelength dependent absorption.

5.6 Performance Indicators

TG3 expects to have a significant contribution, especially to the following performance indicators from the Description of Work.

1. Efficiency of the different levels of management within the NoE in running NoE activities. Integration within NoE: co-ordination and activities of scientific community at large. Establishment of action plan. Efficient solution of problems. Regularly updated activity planning.
2. A number of multilateral research activities within the subject of the NoE planned and executed by the Partners and with others outside the NoE. A number of scientific publications within the Network.
8. Establishment of joint databases available also outside the NoE, establishment of a data management procedure within the NoE. Improved use of satellite data.

The planning of co-ordinated multilateral activities, such as dedicated experimental campaigns will contribute to performance indicators 1 and 2, and the definition of a quality flag or the development of a method for a better exploitation of satellite data (for example involving the environmental services) will contribute to performance indicator 8.

5.7 Task Group 3 principal investigators

The contributing principal investigators to task group 3 are listed in section 9 and their individual contributions given in section 10.

6. E-learning

Maria Kanakidou, University of Heraklion, Crete.

AT2 set up an e-learning group at its first workshop. The members are Joern Bleck-Neuhaus (Bremen), Annette Ladstätter-Weißenmeyer (Bremen), Gerrit de Leeuw, Rob Mackenzie, Thomas Wagner and Peter Borrell.

A pilot e-learning project will focus on the understanding of the central role of NO_2 in atmospheric chemistry and the retrieval and use of NO_2 observations from space.

The e-learning course aims to introduce the student to the topic of atmospheric chemistry and spectroscopy and provide references and links for further reading. The course will continue with a step-by-step use of the satellite observations to calculate NO_2 distributions and interpret them. This itinerary will be enriched with examples and exercises that will allow the student to evaluate of his or her understanding and comprehension at each step.

The provisional outline of NO_2 module is as follows.

a. Introduction: atmospheric chemistry and physics of the troposphere and stratosphere (including examples for case studies). This part will be NO_2 oriented (chemistry/sources). At a latter stage of this effort in ACCENT, a complete introduction to atmospheric chemistry will be built - perhaps in collaboration with another ACCENT activity.

b. Remote sensing measurements to observe NO_2:

   - why satellite measurements?
   - why this species (chemical importance)?
   - introduction in spectroscopy (different wavelength regions = different instruments) and in addition the DOAS method for UV/visible spectroscopy.

c. DOAS: satellite – ground based measurements (technique), temporal and spatial resolution of the instruments.

d. Retrieval methods to obtain column amounts of the different trace gases from the measured spectra.

e. Comparison of satellite based measurements with ground based and *in-situ* air borne data for total column and tropospheric column amount of NO_2.

   i. what can we learn from? What precautions are to be taken?

   ii. Examples.

f. Comparison of satellite derived total column and tropospheric column amount NO_2 with model simulations.

   i. what can we learn from? What precautions are to be taken (references).

   ii. Examples.

It is expected that AT2 will provide the scientific material and will then seek professional help to produce the e-learning module.

7. Availability of Tropospheric Satellite Data

An aim of AT2 is the provision of global tropospheric data products of trace tropospheric constituents (gases, aerosol and clouds) using remote sensing from space. Although some data for O_3 is available from the space agencies, data for the other chemical species is difficult to produce. It generally requires an expert assessment and processing of the lower level data, produced by the satellite instrumentation, sometimes examining data pixel by pixel to retrieve the total column densities of the desired chemical species.

Thus the majority of data of interest are research products, and are made available to interested individuals on a person to person basis with a resulting co-authorship of 'producer' and 'consumer' on scientific papers produced from the work. Furthermore, the results can change as algorithms are improved and the details of the instrumentation and the necessary corrections for atmospheric conditions are better understood.

The situation is improving and it is expected that, during the life of the project, substantial steps will have been made towards implementing automatic retrieval algorithms for the more common species.

The first step to be taken in AT2 will be to list the data available on the web site, to alert the community to its existence and to invite collaboration to exploit it. This will follow on from the start made in TROPOSAT:
http://troposat.iup.uni-heidelberg.de/TROPOSAT-1/data_avail.htm.
Authors will be contacted and asked to provide the detailed information about the data to assist prospective users in choosing among what is available. It is also intended to set up a web-based questionnaire for this purpose to facilitate regular updating.

Consideration may be given later in the project to establishing a data base for data itself, although this may require too many resources to be worthwhile.

8. AT2 Web Page

A web page for AT2 has been developed from the earlier TROPOSAT page and is situated at the University of Heidelberg: *http://troposat.iup.uni-heidelberg.de/*. It is used to disseminate information about AT2 and will be used to collect and display information about the satellite data available for the troposphere; see section 7. Some AT2 pages are also available on the ACCENT web site itself, *http://www.accent-network.org/*. These are used to provide preliminary information together with notices of meetings and events. The two are connected by click-through links.

9. Organisation and Principal Investigators

9.1 Coordinator and Steering Group

Coordinator

John Burrows	A	IUP, University of Bremen, D

Deputy

Peter Borrell	C	P&PMB Consultants, Newcastle-under-Lyme, UK

Steering group

Martin Dameris	A	DLR, Oberpfaffenhofen, D
Jean Marie Flaud	A	LISA, Uni. Paris-XII, F
Maria Kanakidou	A	University of Crete, GR
Gerrit de Leeuw	A	TNO, The Hague, NL
Anki Piters	C	KNMI, de Bilt, NL
Ulrich Platt	A	IUP, University of Heidelberg, D
Thomas Wagner	C	IUP, University of Heidelberg, D

A = appointed by ACCENT; C = co-opted

9.2 Principal Investigators

Task Group 1			
Steffen Beirle	IUP, Heidelberg, D	Monitoring nitrogen oxides in the troposphere with GOME and SCIAMACHY	uv
Heinrich Bovensmann	IUP, Bremen, D	Improving tropospheric trace gas retrieval by combined UV-visible solar backscatter and thermal IR sounding of the atmosphere	ir
Michael Buchwitz	IUP, Bremen, D	Retrieval of vertical columns of carbon monoxide and long-lived greenhouse gases (methane, carbon dioxide, nitrous oxide) from SCIAMACHY/ENVISAT satellite data	ir
Cathy Clerbaux	Service d'Aeronomie, Paris VI, F	Infrared Satellite Observations for the Study of Tropospheric Composition	ir
Pierre-François Coheur	Uni-Libre Brussels, B	Tropospheric studies using infrared spectroscopic measurements from space	ir
Jim Drummond	Uni-Toronto, Canada	Measurements of Carbon Monoxide from Satellites	ir
Henk Eskes	KNMI, NL	Tropospheric Nitrogen Dioxide derived from Satellite Observations	uv
Christian Frankenberg	IUP, Heidelberg, D	SCIAMACHY near infrared retrieval of CH_4, CO_2, N_2O and CO	ir
Annemieke Gloudemans	SRON, NL	Retrieval of SCIAMACHY CO, CH_4, and CO_2	ir
Don Grainger	Uni-Oxford, UK	Aerosol, Cloud and Trace Gas Measurements in the Troposphere & Lower Stratosphere	ae

Otto Hasekamp	SRON, NL	Algorithm Development for Retrieval of Aerosol Properties from Satellite Measurements of Intensity and Polarization	ae
Lars Hoffmann	ICG-I, Jülich, D	Advanced Retrieval of Water Vapour in the Tropopause Region from Limb Observations	ir
Thomas Holzer-Popp	DLR, Oberpfaffenhofen, D	Derivation of aerosol composition from space	ae
Wolfgang von Hoyningen-Huene	IER, Uni-Bremen, D	Satellite Observation of Aerosol and Cloud Properties	ae
Anton K. Kaifel	ZSW Stuttgart, D	NNORSY Ozone Profile Retrieval Suite	uv
Johannes Keller	PSI, Villigen, CH	Retrieval of aerosol optical properties using the Multi-angle Imaging Spectro-Radiometer (MISR)	ae
Michel Kruglanski	BIRA-IASB, B	Atmospheric aerosol retrieval from thermal infrared nadir sounding	ae
Jochen Landgraf	SRON, NL	The global ozone distribution retrieved from GOME measurements and simulated with a chemical transport model: A comparison study	uv
Gerrit de Leeuw	TNO, NL	Development of EO aerosol products	ae
Diego Loyola	DLR, Oberpfaffenhofen, D	Global retrieval of cloud information combining oxygen A-band and polarization measurements of the GOME/ERS-2 and GOME-2/METOP instruments	uv
Thierry Marbach	IUP, Heidelberg, D	Identification of tropospheric emissions sources from satellite observations: Synergistic use of trace gas measurements of NO_2, HCHO, and SO_2	uv
Mathias Milz	FZK, Karlsruhe, D	Retrieval of source gases in the tropopause region and upper troposphere from MIPAS/ENVISAT measurements	ir
Walter Di Nicolantonio	CNR-ISAC, Bologna, I	Improvement of Algorithms for the Retrieval of Aerosol Optical Properties over Land	ae
Stefan Noel	IUP, Bremen, D	Retrieval of vertical columns of water vapour from SCIAMACHY/ENVISAT satellite data	uv
Johannes Orphal	LISA, Uni. Paris-XII, F	Infrared Spectroscopy for Tropospheric Remote Sensing from Space	ir
Roeland van Oss	KNMI, de Bilt, NL	Tropospheric Ozone derived from Satellites	uv
Oleg Postylyako	Inst. Atm Phys., Moscow, Russia	Linearized radiative transfer models for tropospheric investigation	uv
John J. Remedios	Uni-Leicester, UK	Infra-red sensing for the retrieval of tropospheric composition from space	ir
Philippe Ricaud	CNRS, Aerologie, Uni-Toulouse, F	Tracking pollution from space borne thermal IR sounders	ir
Andreas Richter	IUP, Bremen, D	Monitoring Changes in Tropospheric Constitution from Space	uv
Martijn Schaap	TNO, Apeldoorn,NL	Data-assimilation of AOD with LOTOS	
Michel Van Roozendael	BIRA-IASB, B	Total and tropospheric BrO retrieval from space nadir and ground-based UV/visible observations	uv
Pieter Valks	KNMI, de Bilt, NL	Retrieval of tropospheric ozone columns from UV-nadir measurements by the GOME/ERS-2, GOME-2/METOP and OMI instruments	uv
Pepijn Veefkind	DLR Oberpfaffenhofen, D	Development of algorithms for improved tropospheric data products from OMI	uv
Thomas Wagner	Uni. Heidelberg, D	Global long term data sets of the atmospheric H2O VCD and of cloud properties derived from GOME and SCIAMACHY	uv

Task Group 2		
Jean Luc Attie	CNRS, Aerologie, Uni-Toulouse, F	Assimilation of Tropospheric Species into a Chemistry Transport Model
Matthias Beekmann	LISA, Paris XII, F	Integrating Chemical Modelling and Satellite Observations for Monitoring of Tropospheric Chemistry and Air Quality
Martyn Chipperfield	Inst. for Atmospheric Science, Leeds, UK	Derivation of Tropospheric Composition from Satellites Using a 3-D CTM
Martin Dameris	DLR, Oberpfaffenhofen, D	Validation and further development of an interactively coupled climate-chemistry model for detection, attribution and prediction of changes in the UTLS
Hendrik Elbern	RIU, Cologne, D	4-Dimensional-variational assimilation of satellite data into a chemistry transport model
Thilo Erbertseder	DLR, Oberpfaffenhofen, D	Derivation of tropospheric NO_2 by synergistic use of satellite observations and a chemical-transport model
Claire Granier	Service d' Aéronomie/IPSL, F	Trends in the chemical composition of the troposphere using satellite data
Sander Houweling	SRON/IMAU, NL	Scientific Interpretation of SCIAMACHY CO, CO_2 and CH_4 Measurements
Martin Hvidberg	NERI, DK	Assimilation of RS derived Air pollution parameters and a Hemispheric Air Pollution distribution Model
Jacek W. Kaminski	York University, Toronto, Canada	Validation of GEM-Chemistry Modelling and Data Assimilation System: High Resolution Study
Maria Kanakidou	Uni-Crete, GR	Synergystic use of satellite data, ground based observations, back trajectory analysis and a global CTM results for Studies of tropospheric trace gases and aerosols over the Mediterranean
Rüdiger Lang	MPI, Mainz, D	Evaluation of the hydrological cycle in off- and online models using satellite measurements
Mark G. Lawrence	MPI, Mainz, D	Synergystic use of Satellite Data with the Global Chemistry-Transport Model MATCH-MPIC for Studies of Tropospheric Trace Gases: Long-Range Pollution Transport
Maarten van Loon	NMI, Oslo, Norway	Data assimilation applied to the EMEP model using satellite data: development and application
Mathias Milz	FZK, Karlsruhe, D	Global measurements of water vapour in the tropopause region and upper troposphere with MIPAS/ENVISAT
Franz Rohrer	FZ-Juelich, D	Correlation analysis of global tropospheric NO_2 column densities using multiple satellite measurements
Nicholas H. Savage	Uni. Cambridge, UK	Use of Satellite data to constrain ozone budgets in global tropospheric chemistry models
Herman G.J. Smit	FZ-Juelich, D	Integrated Use of Satellite and Non-Satellite Measurements to Study the Upper Tropospheric Humidity
Guido Visconti	Università degli Studi – L'Aquila, I	Synergistic Use of Satellite Data with the Global Chemistry-Transport Model GEOS-CHEM: Formaldehyde column over Europe as a proxy for biogenic emissions and CTM validation using satellite data.

Task Group 3		
Bo Galle (Mellqvist)	Chalmers Uni., Göteborg, S	Satellite Validation using Ground Based Spectroscopic Techniques
Miranda van den Broek	SRON, NL	Validation of SCIAMACHY CO, CH_4, and CO_2
Mark Kroon	KNMI, de Bilt, B	Validation of OMI data products
Emmanuel Mahieu	IAG, Liege, B	Intercomparison of Long-term Trends of Key Greenhouse Source Gases in the Troposphere, Determined In Situ and Remotely from the Ground: Validation of Related Records from Space-based Sensors
Paul Monks	Uni-Leicester, UK	Novel techniques for the retrieval of tropospheric composition from space
Justus Notholt	Bremen, D	Ground-based remote sensing observations of atmospheric trace gases, validation and complementary observations for space-borne sensors
Yvan J. Orsolini	NILU, N	Use of satellite data for atmospheric pollution and greenhouse gases monitoring
Andrea Petritoli	ISAC-CNR, Bologna, I	Validation of NO_2 tropospheric column from space in the Po valley (Italy)
Ankie Piters	KNMI, de Bilt, NL	Validation of SCIAMACHY products
Ralf Sussmann	IMK-IFU, Garmisch-Partenkirchen, D	Establishment of an integrated Ground Truthing Station for satellite data products
Arnolds Ubelis	IP, Riga, Latvia	MAXDOAS validation for GOME and SCIAMACHY
Andrea K. Weiss	Swiss Fed. Labs., Duebendorf, CH	Air pollution decision guidance employing tropospheric satellite data together with transport models and ground-based measurements

Part 2: Contributions from Principal Investigators

Contributions from Task Group 1

Monitoring Nitrogen Oxides in the Troposphere with GOME and SCIAMACHY

A contribution to ACCENT-TROPOSAT-2, Task Group 1

Steffen Beirle

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Nitrogen oxides ($NO+NO_2=NO_x$) are important ozone precursors in the troposphere. Column densities of NO_2 are detectable from satellite platforms using differential optical absorption spectroscopy (DOAS). Tropospheric column densities can be retrieved by estimating and subtracting the stratospheric fraction. From GOME observations, a time series of 8 years (1996-2003) of NO_2 column densities is available on a global scale with a spatial resolution of 320 × 40km^2. Since March 2002, SCIAMACHY provides the continuation of the GOME time series with an improved spatial resolution (60 × 30 km^2) and new viewing geometries, allowing also direct stratospheric measurements.

We performed a number of studies to identify and quantify the different sources of nitrogen oxides (traffic, industry, ship emissions, biomass burning and lightning) from the GOME data. In several cases we could also use the GOME results to estimate the lifetime of tropospheric NO_x. We want to use the specific advantages of SCIAMACHY, *i.e.* the higher spatial resolution, to continue and refine these studies to provide additional and independent estimates of source strengths of nitrogen oxides on regional and global scales. This may help to improve the absolute numbers as well as the distribution patterns of source inventories.

Time schedule

	2004	2005	2006	2007	2008	2009
NO_2 analysis from GOME and SCIAMACHY	*	*	*			
Dependence on clouds and aerosols	*	*	*	*		
Systematic studies on the source strengths of NO_x	*	*	*	*	*	*
Estimation of the lifetime of NO_x	*	*	*	*	*	*
Trends of NO_2			*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / person-years	0.4	0.4	0.4	0.4	0.4	0.4
Yearly cost (kECU)	5	5	5	5	5	5

Likely funding agencies

BMBF, EU, DFG

Co-workers

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Improving Tropospheric Trace Gas Retrieval by combined UV-VIS Solar Backscatter and Thermal IR Sounding of the Atmosphere

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Despite the progress made in sounding tropospheric trace gas distributions like CO, NO_2, SO_2 etc. from space, no single passive measurement technique alone allows us to determine profile information down to the planetary boundary layer (PBL). Retrieval of tropospheric distributions from nadir UV-VIS solar backscatter measurements has demonstrated the feasibility to determine tropospheric column concentrations of O_3, CO, NO_2, SO_2, HCHO, H_2O and CH_4 including the PBL. Retrieval of tropospheric distributions from nadir thermal IR measurements has demonstrated the feasibility to determine concentration profiles of O_3, CO, NO_2, SO_2, H_2O and CH_4 down to the free troposphere, but excluding the lowest troposphere and the PBL under most conditions due to the lack of thermal contrast. Within this project it is planned to improve the sounding of the troposphere including the lowermost troposphere down to the surface by a synergistic retrieval from a combination of solar backscattered measurements in the UV-VIS-SWIR (SCIAMACHY, OMI, GOME-2) with measurements of thermal emission in the mid infrared (MOPITT, TES, IASI). During the first 18 month of the project the retrieval environment will be set up and sensitivity studies will be performed. In the second phase of the project the methods will be applied to derive height resolved information in the troposphere from satellite data, for example by combining SCIAMACHY/OMI with TES data and/or GOME-2 with IASI data. The data will be validated to draw quantitative conclusions about the quality of the data from this new method.

Time schedule

	2004	2005	2006	2007	2008	2008
Sensitivity studies combined UV-Vis/IR retrieval and set-up of retrieval environment	*	*	*			
Application to satellite data			*	*	*	
Algorithm Improvements and Validation				*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2008
Personnel / man-years	1.0	1.0	1.0	1.0	1.0	1.0
Yearly cost (k€)	60	60	60	60	60	60

Likely funding agencies

National funding

Co-workers

Vladimir Rozanov and John P. Burrows, IUP Bremen

Retrieval of Vertical Columns of Carbon Monoxide and Long-lived Greenhouse Gases (Methane, Carbon Dioxide, Nitrous Oxide) from SCIAMACHY/ENVISAT Satellite Data

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Within the framework of the ACCENT/TROPOSAT programme it is envisaged to further improve the University of Bremen algorithm for the retrieval of total columns of important atmospheric gases from SCIAMACHY near-infrared nadir spectra (current version: WFM-DOAS v0.4), i.e., carbon monoxide (CO), methane (CH_4), carbon dioxide (CO_2), and nitrous oxide (N_2O). Starting with WFM-DOAS version 0.4 an iterative approach is foreseen based on the iteration steps: (i) Processing of a large (statistically significant) set of SCIAMACHY spectra, (ii) analysis of the accuracy and precision of this data set using independent measurements and models, and (iii) algorithm improvements. Intermediate (column) data products will be made available for ACCENT and feedbacks (especially from Task Groups 2 and 3) will be used to further improve the algorithm.

The (5-year) goal is to have a highly accurate (nearly bias free) and precise (single pixel column precision (1-sigma) close to theoretical limit: ~1% for CH_4 and CO_2, and ~10% for CO and N_2O).

The objectives for the first 18 months are:

- To process all the available SCIAMACHY Level 1 consolidated orbit files currently available for the year 2003 to generate the following data products: Vertical columns of CO, CH_4, CO_2, and N_2O, and the "dry air column averaged mixing ratios" XCH_4, XCO_2, and XN_2O (definition: Greenhouse gas column / O_2 columns × 0.2095) See Figure 1.
- To make these data products available for ACCENT
- To use feedbacks to determine the quality of the data products and if/how the algorithm needs to be improved

Time schedule

	2004	2005	2006	2007	2008
Processing SCIAMACHY data	*	*	*	*	*
Analysis of results including validation	*	*	*	*	*
Algorithm improvements	*	*	*	*	*

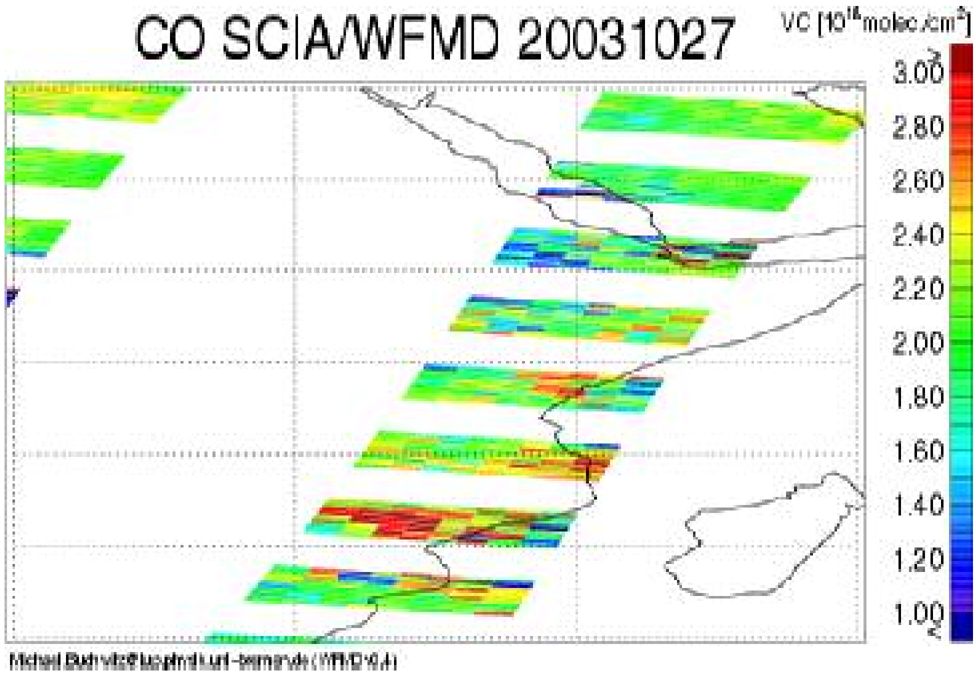

Figure 1. Enhanced concentrations of carbon monoxide (CO) due to biomass burning in eastern central Africa as retrieved by WFM-DOAS (Version 0.4) from SCIAMACHY near-infrared nadir spectra recorded on October 27, 2003 (Atmos. Chem. Phys., 4, 1954-1960, 2004).

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	1.0	1.0	1.0	1.0	1.0
Yearly cost (kECU)	60	60	60	60	60

An "ACCENT year" starts on 1st March and lasts 12 months.

Likely funding agencies

German BMBF via DLR-Bonn

Co-worker

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Infrared Satellite Observations for the Study of Tropospheric Composition

A contribution to subproject ACCENT-TROPOSAT-2 (AT2), Task Group 1

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This scientific proposal aims to use the research tools currently developed at IPSL in the framework of the preparation of the IASI/METOP mission to access the performance of current (MOPITT, AIRS, TES) and future instruments that use the thermal infrared spectral range to sound the troposphere. An illustration of the infrared satellite observation of carbon monoxide is provided in Figure 1 that illustrates the global-scale seasonal variability as measured by the MOPITT instrument [Clerbaux *et al*., *Atmos. Environ*., 2004].

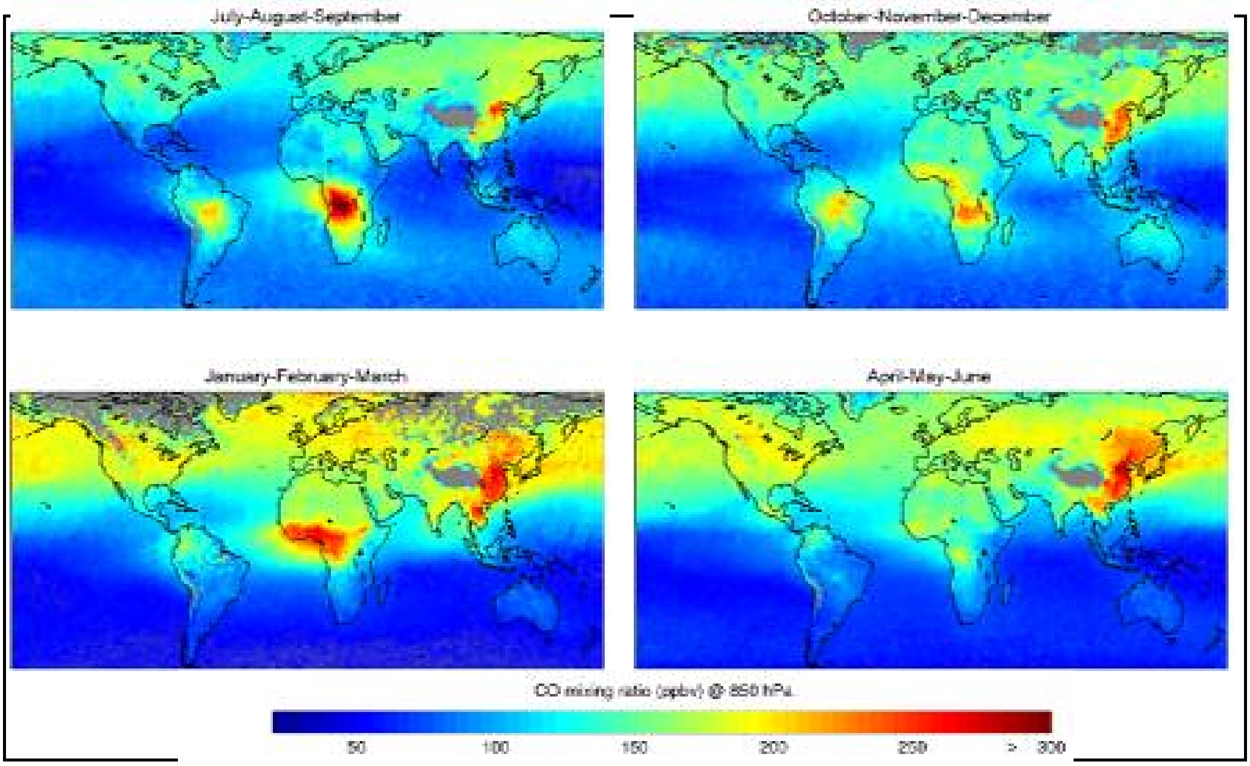

Figure 1. These composite images depict the MOPITT CO measurements at an altitude of 850 hPa. The seasonal plots show the observations (high CO values are in red) averaged over 4 years (March 2000-February 2004) of MOPITT operation. In the Northern hemisphere, most of the pollution is associated with urban activity, with persistent high values above China and elevate levels over US, Europe and Asia in spring and winter. In the tropics and Southern hemisphere, most of the CO is emitted where biomass burning occurs, such as in Africa, Central and South America (following the seasonal shift in the Inter-Tropical Convergence Zone). The CO pollution plumes emitted locally spread from regional to global scales, depending on meteorological conditions and photochemistry

The proposed work includes the development and improvement of retrieval algorithms (based on various minimization techniques) to inverse the trace gases concentrations from the radiance observations, and the characterization of retrieved products in terms of accuracy and vertical sensitivity.

The synergetic use of infrared measurement and UV/vis data (*e.g.* IASI and GOME2) to improve the vertical resolution achievable will be investigated for ozone and SO_2 (volcanic eruptions).

The potential of forthcoming instruments (to be launched on leo and geo orbits) to improve the current measurement capabilities will be evaluated using radiative transfer simulations and inversion algorithms.

Time schedule

	2004	2005	2006	2007	2008	2009
Inversion algo	***	***	***	**	*	
Synergy IASI-GOME		*	*	*	*	*
New instruments	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	2	3	3	3	2	2
Yearly cost (kEuro)	15	20	20	20	15	15

Likely funding agencies

CNRS (PNCA), CNES (TOSCA).

Co-workers

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Tropospheric Studies using Infrared Spectroscopic Measurements from Space

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The present research proposal is a contribution to the study of the Earth's tropospheric composition, of its evolution in space and time, and of its impacts on air quality and on climate. It will rely mainly on the analysis of atmospheric spectra measured by a number of space-borne infrared sounders, which will follow specific orbits and will operate in different geometries, depending on the scientific objectives they aim to achieve, and on prospective studies for future space missions.

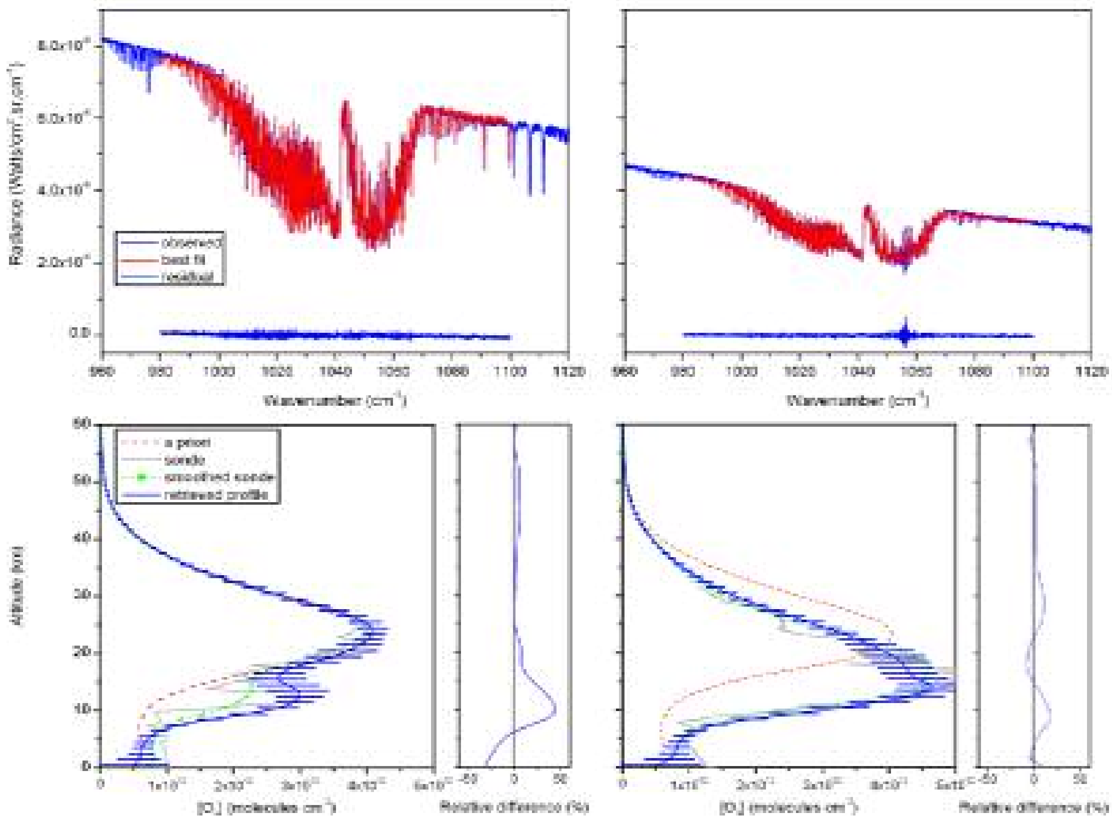

Figure 1: Ozone profile retrieval for selected IMG spectra, coincident with the Uccle (left panel) and the Ny-Alesund (right panel) observing sites. Globally, between 2 and 4 independent pieces of information can be retrieved independently from thermal IR nadir spectra, thereby providing an accurate representation of the ozone content in both the troposphere and the stratosphere. These results open promising perspectives to obtain a global view of the changing ozone vertical distributions from the operation of new generation tropospheric sounders (*e.g.* TES and IASI). Further improvements are expected from the synergetic use of IR and UV-visible instruments observing the same scene.

The foreseen tasks include:

- The retrieval of trace gas vertical profiles from nadir infrared radiance. This will include the improvement and testing of the ULB retrieval software and its application to the measurements of past (IMG), present (TES) or forthcoming (IASI) thermal infrared tropospheric sounders. The emphasis will be put on O_3 (see Figure 1), CO, HNO_3 and possibly volcanic SO_2
- The coupling of the infrared and UV/visible measurements (IMG/GOME, TES/OMI, IASI/GOME-2) to improve the accuracy and the vertical sensitivity of the ozone tropospheric measurements from space.
- The analysis of solar occultation measurements provided by ACE, to probe the upper troposphere and the lower stratosphere (UTLS).
- Prospective studies to evaluate the possibility to detect and characterize from space (leo or geo satellites), local or regional pollution events involving fast reactive species.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	***	***	***	***	**	**
Activity 2	**	**	**	*	*	*
Activity 3	*	*	*			
Activity 4	***	**	*	*		

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	3	3	3	2	2	2
Yearly cost (kEuro)	20	20	20	15	15	15

Likely funding agencies

ESA/Prodex fundings through the Belgian Science Policy

Co-workers

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Development of EO Aerosol Products

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Within the framework of the TROPOSAT programme a number of contributions are envisaged.

1. Improvement of algorithms for the retrieval of aerosol properties such as AOD, Ångström parameter and speciation from ATSR-2 and AATSR data. *In situ* data from a variety of experiments such ADRIEX and DRAGON will be used to further improve and test algorithms for a variety of different aerosol mixtures, and for validation of the results.
2. Validation of the OMI algorithm with *in situ* data from sites in Cabauw and Paramaribo and application of OMI data for scientific studies.
3. Exploration of the synergy of different sensors on the same or on different platforms for the retrieval of aerosol properties. In particular the synergy between geostationary and polar orbiting platforms (*e.g.* SEVIRI/AATSR) is promising to simultaneously achieve high spatial and high temporal resolution.
4. Assimilation of EO aerosol products in CTM and, vice versa, exploration of the use of CTM to improve the retrieval results.
5. Development of aerosol products such as maps of aerosol properties on local, regional and global scales with the appropriate spatial resolutions, time series and provision of NRT AATSR data. This activity will be undertaken in close interaction with the various user communities, including both scientific and institutional users.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	*	*	*			
Activity 2	*	*	*	*	*	
Activity 3		*	*	*	*	*
Activity 4	*	*				
Activity 5	*	*	*	*	*	*

Aims for the first 18 months

- Provision of validated AOD fields over Europe for the year 2000 from ATSR-2
- Initial global AOD data from AATSR

Long term goals

- Global AOD fields from AATSR
- Provision of validated OMI AOD data
- Assessment of the retrieval of PM values directly from satellite data and from application of data assimilation in CTM
- Synergistic use of AATSR and SG/SEVIRI to provide AOD fields with high spatial and temporal resolution

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	3.5	4.5	4.5	4.5	4.5	5
Yearly cost (kECU)	20	25	26	27	28	33

Likely funding agencies

ESA, EC; NL National Bodies

Co-workers

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Measurements of Carbon Monoxide from Satellites

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The utility of measurements of carbon monoxide has been demonstrated from a number of satellite instruments. Data are now available from a number of sensors, some of them for a number of years – *e.g.* MOPITT now has 4.5 years of data available. New instruments are being designed and these are required to continue and to improve the measurements in the future.

This project has two major foci for study:

The combination of data from several instruments to produce new results

The optimal design of new instruments using experience from current experiments

For the first point we shall initially seek to study the combination of measurements of carbon monoxide from a number of instruments: MOPITT, SCIAMACHY, TES, AIRS. These instruments have considerably different observing strategies and capabilities, so the combination of measurements is not simple, but has the potential for creating a more complete picture of the planet at any time.

The particular focus of the second part this project will be to come up with a design for a successor instrument to the Measurements Of Pollution In The Troposphere (MOPITT) instrument, to carry on the measurement sequence and to expand it. MOPITT is a monitoring instrument, designed to obtain the maximum information about the field of a very limited number of gases and it seems likely that a successor should also specialise in the same manner, perhaps to the single gas, carbon monoxide.

Schedule

Some funding is already in place and a 3-year effort is envisaged

Funding

For the first part an application for funding has been made to the Canadian Foundation for Climate and Atmospheric Science (CFCAS)

For the second part, funding is already in place from the Canadian Space Agency.

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Tropospheric Nitrogen Dioxide derived from Satellite Observations

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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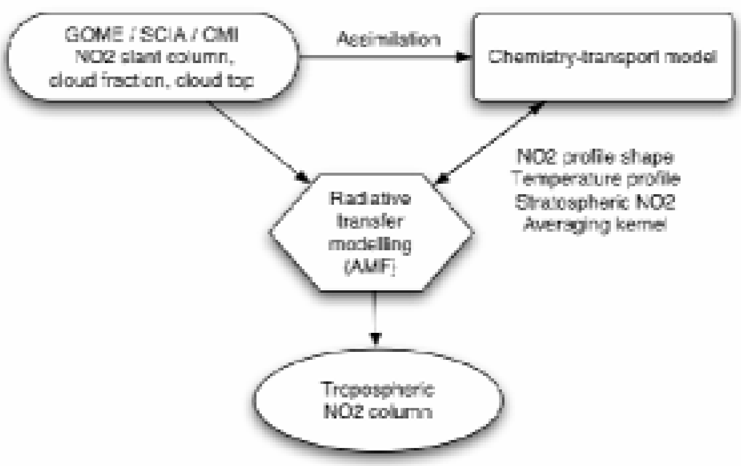
The UV-Visible spectrometers GOME and SCIAMACHY have uniquely demonstrated the capability to observe chemicals in the lower troposphere (boundary layer). In particular the key chemical component nitrogen dioxide (NO_2) can be measured with a high signal to noise ratio. The 8 years of NO_2 measurements of GOME have provided detailed information on the year-to-year and seasonal variability, as well as observations of emission events and long-range transport plumes. A disadvantage of GOME is the relatively course resolution of 320x40 km. SCIAMACHY largely improves this with a 60x40 km footprint, which allows to determine integrated NO_2 amounts originating from the major cities. Because the presence of clouds severely limits an accurate retrieval of tropospheric NO_2, in practice SCIAMACHY has a tropospheric global coverage roughly only once per month. Because of the daily global coverage OMI on EOS-AURA (launch mid 2004) will provide new information every few days with unprecedented spatial resolution.



A major challenge is the derivation of high quality quantitative tropospheric NO_2 column amounts for individual ground pixels based on the satellite data. The retrieval of tropospheric trace gas species is characterised by large uncertainties, related to clouds, the surface albedo, the trace gas profile, the stratospheric column of NO_2, and aerosols. Estimates of the retrieval uncertainties due to these aspects is non-trivial.

The retrieval of NO_2 is based on a combined retrieval, chemistry modelling and assimilation approach [Boersma and Eskes, JGR, 2004] and addresses these challenges. A chemistry-transport model, driven by realistic meteorological fields, provides best-guess profiles of NO_2, based on the latest emission inventories, atmospheric transport, photochemistry, lightning modelling and wet/dry removal processes. These model forecast fields are collocated with the satellite observations, and the radiative transfer modelling in the retrieval is performed for individual pixels based on the model trace gas profile and temperature profiles. The stratospheric NO_2 distribution is obtained from the assimilation of the NO_2 observations with the chemistry-transport model. This stratospheric distribution is employed to derive a tropospheric column by subtracting the modelled (assimilated) stratosphere from the measured column. The retrieval is coupled to cloud top height and cloud fraction retrievals derived from the GOME, SCIAMACHY or OMI data.

Retrievals of tropospheric NO_2 from GOME have been performed in collaboration with the Heidelberg group of U. Platt in the context of the European project GOA, "GOME Assimilated and Validated Ozone and NO_2 Fields for Scientific Users and for Model Validation". Results are available on the GOA web site, http://www.knmi.nl/goa/. SCIAMACHY NO_2 retrievals, performed in collaboration with the BIRA group (M. van Roozendael, I. Desmedt) are available from the TEMIS website, http://www.temis.nl/.

Time Schedule

	2004	2005	2006	2007
Tropospheric NO_2 retrieval for GOME, SCIA, OMI	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007
Personnel / man-years	1	2	2	2
Yearly cost (k€)	5	10	10	10

Reported costs are travel expenses only

Likely funding agencies

This work has been funded through the Dutch National User Support Programme (USP), the ESA DUP project TEMIS and the EU project GOA. We aim to acquire further support from USP, ESA or EU FP6.

Co-workers

Folkert Boersma, Ellen Brinksma and Ronald van der A.

SCIAMACHY Near-infrared Retrieval of CH_4, CO_2, N_2O and CO

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Methane and carbon dioxide are the most important greenhouse gases, second only to atmospheric water vapour. Especially the biogeochemical and anthropogenic sources and sinks of CO_2 and CH_4 have been widely discussed not only in the scientific community. The oxidation of methane also plays an important role in the lifetime of OH radicals. CO can be used as a tracer for anthropogenic fossil fuel emissions as well as for biomass burning. However, there are still large uncertainties in global source strengths. The near infrared channels of SCIAMACHY onboard ENVISAT enable satellite-based worldwide measurements of total columns of these species.

Since CH_4 and CO_2 are long-lived trace species, their temporal and spatial variations are rather low. Thus, the retrieval algorithm should yield precise vertical columns of the species of interest. To this end, a new iterative DOAS algorithm basing on optimal estimation was developed at Heidelberg. In combination with the new cloud retrieval algorithm, vertical columns can be inferred precisely.

In this project, we propose to develop high quality CH_4, CO_2 and CO column density data products. Especially global monthly mean maps of these species will increase our knowledge of seasonal cycles and trends of greenhouse gases. We will investigate in detail the influence of clouds and aerosols on the retrieved columns. Furthermore a special focus will be set on the optimisation of the retrieval algorithm. Especially the impact of the atmospheric temperature and pressure profiles as well as uncertainties in the spectroscopic database will be investigated. A comparison with retrieval algorithms from other institutions like IUP Bremen or SRON will also be carried out.

After having retrieved reliable mean monthly maps of the species of interest, the work will be focussed on the scientific interpretation of the results. The spatial and temporal patterns of methane and carbon dioxide columns will provide deeper insight into the processes driving their abundance in the atmosphere.

Time schedule

	2004	2005	2006	2007
Algorithm optimisation	*			
Dependence on clouds and aerosols	*	*	*	*
Creation of global mean maps	*	*	*	*
Specific case studies		*	*	*

Approximate manpower and cost

	2004	2005	2006	2007
Personnel / person-years	0.4	0.4	0.4	0.4
Yearly cost (kECU)	5	5	5	5

Likely funding agencies

BMBF, EU

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Retrieval of SCIAMACHY CO, CH_4 and CO_2

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The retrieval of the greenhouse (related) trace gases CH_4, CO, and CO_2 using measurements from the ENVISAT instrument SCIAMACHY. A well established iterative maximum likelihood method will be used and further developed to include necessary instrument calibration corrections and a refinement of the atmospheric forward modelling. The resulting total columns will be compared with those from other independent retrieval algorithms within AT2 Task Group 1. This work will be carried out in close collaboration with the AT2 Task Group 3 proposal "Validation of SCIAMACHY CO, CH_4, and CO_2".

18 months objectives

Retrieval of CH_4, CO, and CO_2 total columns from SCIAMACHY for the year 2003.

Detailed comparisons of CH_4, CO, and CO_2 total columns from independent retrieval algorithms for one month in 2003.

Time schedule

	2004	2005	2006	2007	2008	2009
All objectives	****	****	**	**	**	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	2	2	1	1	1	0.5
Yearly cost (kEuro)	130	130	65	65	65	35

Likely funding agencies

The SRON/NIVR National User Support Programme (SRON-GO), and the EU

Co-workers

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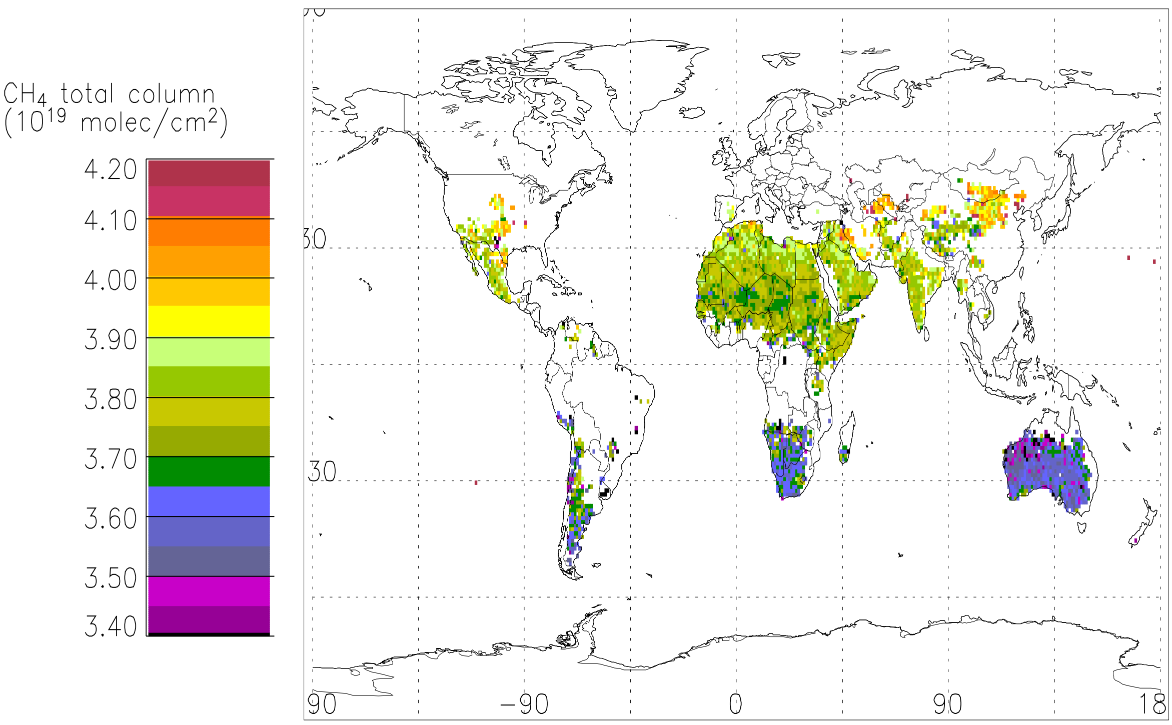

Figure 1. Monthly mean cloud-free CH_4 total columns for February 2004 from the SCIAMACHY IMLM algorithm normalised to the surface elevation (instrument related errors < 0.8 x 10^{18} molec/cm^2). [From: Straume *et al.* 2005, Advances in Space Research, Proceedings COSPAR 2004].

Aerosol, Cloud and Trace Gas Measurements in the Troposphere and Lower Stratosphere

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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This study concerns the development and application of algorithms for the retrieval of aerosol, cloud and trace gas properties from satellite measurements..

Activities

1. Global Retrieval of ATSR Cloud Parameters and Evaluation (GRAPE) was initially conceived is a project to produce a global cloud dataset using a state-of-the-art physical retrieval of the entire duration of the ATSR-2 mission (aboard ERS-2), see www.atm.ox.ac.uk/group/grape/. However we have expanded our original goal (not reflected in the website) to retrieve aerosol properties from ATSR and expanded the GRAPE algorithm to have the ability to ingest AATSR and MSG-SEVERI data (and in principle MODIS, MERIS, SEAWIFS and AVHRR). The retrievals currently provide estimates of cloud (height, optical depth, phase and particle size) and aerosol (optical depth and effective radius) properties from multichannel nadir observations. Our intension is to expand the algorithm to include ATSR's forward view. We are currently working towards producing a 10 year climatology of aerosol and cloud properties from the ATSR/2 and AATSR measurements. Additionally we are involved in validation studies (*e.g.* ADRIEX) to compare results with aircraft and ground based measurements.
2. MORSE (www.atm.ox.ac.uk/MORSE) is an algorithm developed under NERC's Earth Observation Enabling Fund to perform retrievals of atmospheric profiles from Michelson Interferometer for Passive Atmospheric Sounding

   (MIPAS) spectra. We have a number of student and post-doc projects retrieving trace gas concentrations (mostly in the stratosphere but potentially down to about 6 km). Our current target species are SF_6, NH_3, OCS, SO_2, H_2O, CH_4, CO, O_3, H_2O_2, HO_2 and isotopes HDO, H_2(18)O, CH_3D, O(18)OO and OO(18)O.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	*	*	*	*	*	*
Activity 2	*	*	*	*	*	*

Long term goal is the provision of well validated data sets of atmospheric properties.

Funding

The funding for this work comes from a number of grants (EU, ESA and NERC) and NERC studentships.

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Algorithm Development for Retrieval of Aerosol Properties from Satellite Measurements of Intensity and Polarization

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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This study concerns the development of algorithms for the retrieval of aerosol properties from satellite measurements of intensity and polarization. The retrieval will be based on an accurate linearized vector radiative transfer model in combination with an analytical inversion approach.

Activities

1. Development of a linearized radiative transfer model for the purpose of aerosol retrieval. The linearized radiative transfer model has to simulate the intensity vector at the top of the atmosphere and additionally has to provide analytical derivatives of the four Stokes parameters with respect to physical aerosol parameters, such as effective radius and refractive index. Such a radiative transfer model allows to use an analytical inversion approach.
2. Investigation of the aerosol retrieval capability of different types of satellite measurements, *e.g.* single view, multi view, intensity only, intensity and polarization. The outcome of this activity can be used for the definition of future satellite instruments capable of providing useful aerosol information.
3. Development of retrieval algorithms. This activity will be started by the development of an aerosol retrieval algorithm for measurements of the Global Ozone Monitoring Experiment-2 (GOME-2). GOME-2 will contain Polarization Measuring Devices (PMDs) that will provide measurements of intensity and polarization. This activity includes a detailed sensitivity study of the aerosol retrieval algorithm. At a later stage also other satellite instruments (*e.g.* POLDER) will be considered.
4. Application of the developed retrieval algorithm for the purpose of aerosol retrieval from GOME-2 data, and validation of the results using independent ground data.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	*	*				
Activity 2	*	*				
Activity 3	*	*	*	*	*	*
Activity 4			*	*	*	*

Aims for the first 18 months

- Development of an approach for the linearization of radiative transfer with respect to physical aerosol properties.
- Provision of an overview of the possibilities for aerosol retrieval from GOME-2.

Long term goals

- Provision of a validated aerosol retrieval algorithm for GOME-2.
- Retrieval of aerosol properties from other instruments (*e.g*. POLDER).
- Definition of specifications for a possible future satellite instrument dedicated to aerosol retrieval.

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	1	1	1	1	1
Yearly cost (kECU)	60	60	60	60	60	60

Likely funding agencies

NL National Bodies, O_3-SAF

Co-workers

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Advanced Retrieval of Water Vapour in the Tropopause Region from Limb Observations

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Accurate knowledge of water vapour distribution, variability, and long-term change is crucial for understanding and predicting climate change. Within ACCENT-TROPOSAT-2 we aim to the synergetic use of satellite and aircraft data as well as atmospheric models. Global water vapour datasets with continuous coverage in space and time are especially suited for advanced process studies and analyses of long-term changes in the tropopause region. Water vapour in the upper troposphere and lower stratosphere (UTLS) region is a research focus at ICG-I. The institute is involved in several projects, *e.g.* SPARC assessments of tropospheric and stratospheric water vapour. For the proposed subproject we envisage two activities:

1) Radiative transfer and retrieval studies for water vapour in the UTLS region: Satellite measurements (*e.g.* by the Cryogenic Infrared Spectrometers and Telescopes for the Atmosphere, CRISTA), aircraft observations (*e.g.* by the Fast *In-Situ* Hygrometer, FISH), and chemical transport models (*e.g.* the Chemical Lagrangian Model of the Stratosphere, CLaMS) will be used to construct realistic high-resolved three-dimensional distributions of water vapour and other trace species around the tropopause region. These datasets will be used for radiative transfer case studies in inhomogeneously stratified atmospheres in order to estimate the effect of large variability and strong gradients connected to small- and meso-scale structures on satellite retrieval results. Possible enhancements for current trace gas retrievals will be investigated.

2) Preparation of comprehensive water vapour distributions from ENVISAT MIPAS observations: A retrieval processor based on rapid radiative transfer algorithms and state of the art retrieval techniques has been developed at the institute. It is envisaged to derive water vapour profiles for large parts of the ENVISAT MIPAS mission. The retrieved profiles extend downwards to the upper troposphere. This region is currently not evaluated in the ESA standard product. Cloud information (*e.g.* type, top height and occurrence frequency), valuable for the detailed analysis of the derived datasets, will be available.

Time schedule

	2005	2006	2007	2008
Activity 1	**	**		
Activity 2	**	**	****	****

* = 3 man-month

Approximate manpower and cost

	2005	2006	2007	2008
Personnel / man-years	1	1	1	1
Yearly cost (kEUR)	70	70	75	75

Likely funding agencies

Personnel costs funded by Forschungszentrum Jülich. Contributions to travel expenses, publication costs, and consumables from ACCENT-TROPOSAT-2 would be desirable.

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Derivation of Aerosol Composition from Space

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Within the framework of the TROPOSAT programme a number of contributions are envisaged.

Improvement of synergetic methodology for the exploitation of a radiometer-spectrometer sensor pair (GOME/ATSR-2, SCIAMACHY/AATSR, GOME-2/AVHRR) to derive aerosol parameters from space over land and ocean. The focus is on retrieval of spectral aerosol optical thickness and estimating the type of aerosols. The latter is determined from a choice of predefined mixtures built up from a set of basic aerosol components (sulphate/nitrate, minerals, sea salt, soot). Validation of the retrieved type information using ADRIEX measurements.

Application of the synergetic aerosol retrieval to produce monthly/seasonal/annual means of optical thickness of the basic components over Europe/Africa (MSG viewing area) and globally. Demonstration of near-real time production of aerosol maps and intercomparison/validation with other satellite and ground-based aerosol observations.

Investigation of the potential to derive near-surface aerosol concentrations (PM10, PM2.5, PM1) by combining the satellite derived aerosol optical thickness and type (as an estimate of the size distribution) with a climatology of the vertical aerosol structure from a lidar network (EARLINET). Validation of PM values with ground-based *in situ* network data.

Demonstration of assimilating component-wise aerosol optical thickness into the EURAD/MADE chemistry-transport model (RIU). By relying on component-wise satellite aerosol information the level of ambiguity is lower than when assimilating total aerosol into a model with particle speciation.

Time schedule

	2004	2005	2006	2007	2008	2008
Activity 1	*	*	*			
Activity 2		*	*	*		
Activity 3			*	*	*	
Activity 4		*	*	*	*	*

Aims for the first 18 months

- Provision of validated AOD and type products over Europe/Africa (MSG area)
- Provision of 1-year climatology of component-wise AOD over Europe/Africa

Long term goals

- Global extension of AOD/type products
- Multi-annual climatology of component-wise AOD
- Evaluation of satellite-based PM products and necessary auxiliary input
- Assimilation of component-wise AOD into EURAD/MADE-CTM

Approximate manpower and cost

	2004	2005	2006	2007	2008	2008
Personnel / man-years	0.25	1.0	1.0	1.0	1.0	0.75
Yearly cost (kECU)	33	130	130	130	130	97

Likely funding agencies

DFG (0.5 PY/Y awarded 2004-2006), ESA (DUE-GlobAER), internal funds (DLR)

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Satellite Observation of Aerosol and Cloud Properties

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Aerosols are a significant part of atmospheric turbidity and air pollution. Biomass burning, industrial pollution, desert dust transports, arctic haze are events connected with strong increased aerosol impacts. Aerosol impacts are of interest in multiple ways.

They affect the climate in direct way by increasing the scattering and absorption and modification of the radiative forcing.

They affect the climate in indirect way, contributing to cloud formation and cloud modification by the aerosol-cloud interaction.

They are part of heterogeneous chemical reaction chains.

They are significant air pollutants and have feedbacks on human health, traffic and others.

All these are reasons for the investigation of the magnitude of concentration, the regional and temporal behaviour of aerosols on regional and global scales. Thus climate research and environmental control require powerful observation tool from space-borne platforms, giving accurate enough information on the aerosol status in the troposphere and the atmospheric boundary layer.

Modern multi-spectral space-borne radiometers, like SeaWiFS, MERIS, MODIS, SCIAMACHY and others provide enough spectral and radiometric information for the determination of aerosol properties from space. Methods are in development, enabling such observations over land and ocean surfaces with the required accuracies. Together with this cloud investigations can be made and can combined together. These techniques enable a new integrated kind of earth observation.

At IUP the BAER (Bremen AErosol Retrieval) for the determination of the aerosol optical thickness has been developed, [von Hoyningen-Huene *et al.*, 2003]. For the investigation of cloud properties the SACURA (Semi-Analytical CloUd Retrieval Algorithm) [Kokhanovsky *et al.* 2003] is developed. This enables the investigations of aerosol and cloud properties from satellite observations. The methods are adapted to work with data from SeaWIFS, MERIS, SCIAMACHY. Other satellite radiometers with similar data structures can be included by data interfaces. With these tools the following tasks will be undertaken:

Improvement of the retrieval methods for the space-borne determination of aerosol parameters, *e.g.* aerosol optical thickness and their spectral behaviour as preconditions for further investigations.

Application and extension of the retrieval methods to a wide range of surface and latitude conditions of the earth surface: ocean, land surfaces with different vegetation cover, desert regions, arctic regions.

Investigation of pollution events, like industrial and urban pollution, biomass burning, forest fires, desert dust transports.

Near simultaneous determination of cloud parameters from the same scenes, *e.g.* cloud optical thickness, effective radius, cloud top height and cloud phase.

Investigation of indications for aerosol-cloud interaction combining aerosol and cloud results.

Retrieval of spectral surface reflectance as by products of the aerosol retrieval.

Co workers

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NNORSY Ozone Profile Retrieval Suite (NNORSY-SUITE)

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The Neural Network Ozone Retrieval SYstem (NNORSY) was developed in recent years and was successfully applied to long term GOME-1 data for retrieval of total ozone and ozone profiles (NNORSY-GOME). It was be shown, that NNORSY-GOME is able to retrieve ozone profiles with good quality not only in the stratosphere but also in the troposphere differentiating up to 3 different ozone profile layers in the troposphere. Furthermore NNORSY-GOME is able to compensate degradation effect of the GOME instrument during training. This yield to ozone profile products independent of degradation effects which can be used for studying GOME degradation properties. NNORSY-GOME was also implemented in near-real-time (http://wdc.dlr.de/data_products/SERVICES/GOMENRT/index.html).

Within this project it is envisaged to further develop NNORSY for application to various current and upcoming satellite instruments; namely GOME-1 on ERS2, SCIAMCHY on ENVISAT, OMI on AURA, GOME-2 and IASI on MetOp.

The first 18 month of the project comprise the following tasks:

- update and improvements for NNORSY-GOME-1 with special emphasis to the troposphere.
- Reprocessing of the whole GOME-1 time range from July 1995 to end of 2003 providing long term global ozone profile data for the troposphere.
- Set up of a new ozone profile climatology for the troposphere based on a new neural network approach.
- Development of NNORSY-SCIA system enabling the combined use of limb and nadir UV/VIS/IR spectra in one retrieval step for ozone profile retrieval. This shall yield to improved ozone profile retrievals over the full height range of the stratosphere and especially for the troposphere compared to the use of nadir or limb data only. An other advantage of NNORSY is the independence of retrieval accuracy from calibration uncertainties which are still effecting SCIAMACHY Level 0 to 1 processing and ozone profile retrieval.

Next steps after the first phase of 18 months are:

- NNORSY-SCIA: Implementation NNORSY ozone profile retrieval for SCIAMACHY data in near-real-time (NRT) at DLR.
- NNORSY-OMI: Implementation of NNORSY ozone profile retrieval for OMI instrument on AURA satellite.
- NNORSY-GOME-2:´Development of NNORSY ozone profile retrieval system for GOME-2 MetOp and NRT implementation at DLR

- NNORSY-IASI: Development of NNORSY ozone profile retrieval system for ISAI IR measurements.

Time schedule

Tasks	2004	2005	2006	2007	2008	2009
NNORSY-GOME-1	*	*				
Ozone profile climatology for troposphere		*				
NNORSY- SCIA		*	**			
NNORSY- SCIA NRT			**			
NNORSY-OMI			*	**		
NNORSY-MetOp				**	**	
NNORSY-IASI				*	**	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	0.5	1.0	1.0	1.0	1.0	1.0
Yearly cost (kECU)	50	100	100	100	100	100

Likely funding agencies

German National Bodies (*e.g.* BMBF), ESA, EUMETSAT

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Retrieval of Aerosol Optical Properties using the Multi-angle Imaging Spectro-Radiometer (MISR)

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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MISR onboard NASA's satellite TERRA observes the earth from 9 different view angles and in 4 spectral bands in the visible and near-infrared spectrum. This instrument is particularly suited to retrieve the angular pattern of radiation scattered by aerosols. An operational product for aerosols over flat terrain is already available on a spatial resolution of 17.6 km.

For aerosol observations over complex terrain a new retrieval algorithm with a spatial resolution of 1 km was developed at PSI. MODTRAN 4 is currently used as atmospheric radiation transfer model. The algorithm yields realistic aerosol optical depths (AOD) over inland water bodies compared to sun-photometer data. Over land, however, the influence of the non-Lambertian behaviour of vegetation (bi-directional reflectance distribution function, BRDF) is not yet fully taken into account.

In the frame of ACCENT / TROPOSAT we will

improve the new algorithm in view of its application over land;

test the algorithm for water and for various land covers → AOD and aerosol composition over lakes, various vegetation types and urban areas;

derive PM10 data assuming pre-defined vertical aerosol profiles;

apply the algorithm to a 3 months period of the hot summer 2003. The main domain of interest is Central Europe and Northern Italy.

The improved retrieval algorithm will be validated by comparing

the retrieved AODs with AODs of the MISR operational aerosol product,

the retrieved AODs with sun-photometer AODs of AERONET and the Swiss network CHARM,

the derived PM10 data with data of the Swiss NABEL network and other monitoring stations.

In the view of synergistic use of different sensors, results of the improved MISR retrieval algorithm can be compared to various aerosol products dealt with in and outside AT-2, *e.g.* ATSR/AATSR (G..de Leeuw, TNO), SCIAMACHY (T. Holzer-Popp, DLR; W. von Hoyningen-Huene, Uni Bremen), NOAA AVHRR (S.Wunderle, Uni Bern), MISR and MODIS operational products.

Time schedule

	2004	2005	2006	2007
algorithm improvement	*	***	***	*
validation		*	***	**

Achievement after 18 months

Inclusion of appropriate BRDFs for inland water bodies and for land to match the AODs over water and over land.

Approximate manpower and cost

	2004	2005	2006	2007	total
Personnel / man-years	0.1	0.75	0.75	0.6	2.2
Yearly cost (kECU)	12	108	108	96	324

Likely funding agencies

EU 6th FP (questionable), PSI

Co-workers

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Atmospheric Aerosol Retrieval from Thermal Infrared Nadir Sounding

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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To further the exploitation of Metop/IASI, we investigate the sensitivity of the spectral radiance measurements to significant aerosol concentrations such as Sahara dust, biomass burning or fresh volcanic aerosol. We plan to develop an algorithm to retrieve aerosol features from nadir-looking high-spectral resolution spectrometers operating in the thermal infrared. The algorithm should cover aerosols located in the boundary layer and at higher altitudes in the free troposphere, either above sea or land by taking into account the land surface emissivity. The algorithm will be tested and evaluated by processing of nadir infrared spectral radiance measurements from former space instruments (*e.g.* IMG/ADEOS).

The main deliverables to ACCENT will be scientific manuscripts.

Approximate manpower and cost

	2005	2006	2007	2008	2009
Personnel/man-years	1	1	1	0	0
Yearly cost (kEuro)	80	85	90	0	0

Likely funding agencies

Belgian Science Policy via ESA PRODEX

Co-workers

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The Global Ozone Distribution retrieved from GOME Measurements and simulated with a Chemical Transport Model: A Comparison Study

A contribution to ACCENT-TROPOSAT-2, Task group 1

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This study concerns the use of ozone profiles retrieved from GOME radiance measurements to improve our understanding of transport processes in the stratosphere. Quantifying and modelling stratospheric transport is crucial for understanding and predicting the chemical evolution of both the stratosphere and the troposphere. Here 3-D chemistry transport models play a crucial role. These models are driven by meteorological 3-D model analysis of the atmospheric circulation. However, stratospheric transport is still not very well understood. For example, one important problem is the meridional transport from the equator to the poles, which is too fast in 3-D models [IPCC, 2001; WMO, 2002; Waugh, 2002]. The cause of this discrepancy is currently unknown. Due to its long chemical lifetime stratospheric ozone can be used as a dynamical tracer, which allows one to study dynamical features of the stratosphere by comparing observed ozone profiles with model simulations. In this contribution we will study stratospheric dynamics by comparing simulations from the 3-D chemistry transport model TM5 with GOME O_3 profile measurements (1996-1998). The TM5 is driven by the European Centre for Medium range Weather Forecast (ECMWF) ERA40 reanalysis of the atmospheric circulation (ERA40 = reanalysis for the period 1957-2001). The ERA40 data is a benchmark analysis of the atmosphere which is widely used within the scientific community. The GOME O_3 profile observations provide an ideal set of measurements to study stratospheric O_3 variability because of the large number of observations (typically once every 2-3 days with global coverage). Comparing GOME O_3 profiles with TM5 simulated O_3 fields using the ECMWF analyzed winds fields and the ECMWF stratospheric O_3 chemistry scheme provides clues to the (in-)ability of the TM5 model to simulate stratospheric O_3 variability.

Objectives for the first 18 month:

1. Evaluation if the quality of the GOME ozone profiles is satisfying for this study
2. Results of a first comparison between GOME, TM5 and ozone sonde measurements for a limited data set.
3. Development of statistical tools to compare the large data sets of the global ozone distribution retrieved from GOME measurements with corresponding TM5 model simulations

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	****	****	****	**	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	1	1	0.75	0.3	0.2
Yearly cost (kEuro)	65	65	65	49	20	13

Co-workers

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Global Retrieval of Cloud Information combining Oxygen A-band and Polarization Measurements of the GOME/ERS-2 and GOME-2/METOP Instruments

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Accurate cloud information is required for the trace gases retrieval, especially for the determination of tropospheric contents and aerosols.

The GOME cloud retrieval algorithms developed at DLR will be used to generate global cloud products. The first algorithm OCRA is based on data fusion techniques and determines the cloud fraction using the PMD measurements. The second algorithm ROCINN is based on neural networks techniques and determines the cloud-top height and cloud-top albedo using spectral information in the Oxygen A-band in and around 760nm

The combination of the two algorithms provides a unique set of the following accurate GOME cloud parameters:

cloud-fraction
cloud-top height
cloud-top albedo.

The activities envisaged within the framework of the AT-2 programme are in Phase 1 (eighteen months) the generation of a global GOME/ERS-2 cloud climatology covering the last 9 years. The activities for the second phase of the AT-2 programme concentrate mainly with the adaptation and validation of the OCRA&ROCINN algorithms using GOME-2/METOP data.

Time schedule

	2004	2005	2006	2007	2008
Activity 1	*	*			
Activity 2		*	**	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	0.1	0.1	0.2	0.1	0.1
Yearly cost (kECU)	11	11	22	11	11

Likely funding agency

DLR

Co-worker T. Ruppert, DLR

Identification of Tropospheric Emissions Sources from Satellite Observations: Synergistic Use of Trace Gas Measurements of NO_2, HCHO, and SO_2

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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During recent years a new generation of UV/VIS satellite instrument was put in orbit which allows us to observe global distributions of several tropospheric trace gases like NO_2, HCHO, and SO_2. Since the atmospheric lifetimes of these gases are usually small (hours to days) these maps allow to investigate the global distribution of sources and their temporal changes. This is an important forward for the knowledge of the composition and evolution of the atmosphere, and the implication on socially relevant issues, such as climate, ecosystems or human health. In particular, the influence of tropospheric emissions on the atmospheric oxidation capacity is a driving parameter for the degradation of many atmospheric compounds (*e.g.* greenhouse gases or ozone).

Here we propose to test and improve current estimates on the global distributions of sources. First we will identify and assign the different known sources to the observed tropospheric trace gas distributions. Second, from the combined investigation of the different trace species we will characterize different types of sources due to their specific mix of emissions. In a third phase we will quantify the absolute emissions of selected sources from our satellite data. From a comparison of the satellite maps with atmospheric model results we will investigate in detail the quality of current emission inventories. In particular the last aspect requires tropospheric satellite data with largely improved accuracy. Therefore much emphasis of the current project is given to the improvement of atmospheric transfer modelling and cloud correction.

Time schedule

Tasks	2004	2005	2006	2007	2008	2009
Improvements of spectral analysis algorithms for GOME and SCIAMACHY	*	*	*	*	*	*
Improved radiative transfer modelling. Correction of the effects of clouds and the vertical profile		*	*	*		
Start of the routine operation of homogenised data sets of tropospheric NO_2, HCHO, and SO_2 from GOME and SCIAMACHY	*	*	*	*	*	*
Validation of the derived data sets using existing data from ground based and aircraft observations	*	*	*			
Charcterisation of different types of sources from the spatial and temporal distribution			*	*	*	*
Correlation of the tropospheric trace gas data with results from other sensors (fire counts, lightning flash counts, *etc.*)			*	*	*	*
Case studies to determine the atmospheric lifetime trace gases			*	*	*	*
Case studies for the quantification of absolute source strengths for the different trace gases				*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / person-years	0.4	0.4	0.4	0.4	0.4	0.4
Yearly cost (kECU)	5	5	5	5	5	5

Likely funding agencies

BMBF, EU, DFG

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Retrieval of Source Gases in the Tropopause Region and Upper Troposphere from MIPAS/EVISAT Measurements

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Since March 2002 MIPAS onboard ENVISAT performs global measurements of atmospheric composition covering the mesosphere down to the upper troposphere. While ESA operational NRT Lv2 products cover the altitude range from the lower stratosphere to the mesosphere, the scientific retrieval processor operated at IMK provides trace gas and temperature profiles which extend the altitude range down to about 6 km, including the tropopause region and the upper troposphere for cloud free cases.
Currently the IMK processor provides profiles of water vapour, HNO_3, O_3, further greenhouse gases, organic compounds, and cirrus clouds in this altitude region. These species are of interest with respect to their influence on the radiative budget, their use as tracers for transport processes across the tropopause, and for studying upper tropospheric ozone chemistry and horizontal transport.

The MIPAS measurements from September 2002 until December 2003 provide a unique data set. In the framework of several projects and for monitoring purposes a large amount of these data have already been processed at IMK. In future we aim for a full exploitation of the existing data sets with the aim of a global distribution of the above mentioned species for the upper troposphere with improved data quality.

Moreover we are able to process measurements which were operated with special measurement modes designed for an optimized observation of the tropopause region and the upper troposphere, namely the so called modes S2 and S6. These data shall be analysed by making use of the improved vertical and horizontal resolution provided for the upper troposphere and tropopause region.

A 2-D retrieval approach shall be further developed and applied to obtain improved information on the horizontal distribution of the trace species while considering horizontal gradients in the retrieval.

The existing retrieval approaches will be subject to robustness tests with respect to the influence of a priori knowledge, regularization parameters, and micro-window selection. Potential needs for improved quality of the spectroscopic data used for the retrievals shall be identified.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel/man-years	1	1	1	1	1	1
Yearly cost (kECU)	60	60	60	60	60	60

Likely funding agencies

EU, national funding agencies (BMBF, DFG)

Co-worker

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Improvement of Algorithms for the Retrieval of Aerosol Optical Properties over Land

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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This study is focused on the improvement of an already existing algorithm able to retrieve aerosol optical properties, like AOD and type of aerosols, over sea surface from GOME and SCIAMACHY measurements. This algorithm will be expanded in order to be used over land. Furthermore, the potential use of EO data in air quality applications will be explored. In this framework, three main activities are singled out:

1. Retrieval of aerosol optical properties over land from SCIAMACHY measurements

Correction for weakly cloud-contaminated pixels

Evaluation of different models/measurements of surface reflectance effects in the AOD retrieval for the SCIAMACHY pixel;

Implementation of new aerosol classes to be inserted in the inversion algorithm;

Detection of different types of aerosol loadings: desert dust outbreak, biomass burning, industrial/urban pollution.

2. Study of the relationship between AOD retrieved from satellite measurements (for instance AATSR/Envisat, MODIS/Terra, Aqua) and PM content in air quality context

Height issue: the importance of aerosol, mixing, and meteorological scale heights in relating columnar to surface aerosol parameters;

Sensitivity studies on the relation between aerosol work-wavelengths for satellite sensors and particles aerodynamic diameter (PM 10, PM2.5);

Exploring the potential use of aerosol properties retrieved from satellite sensor in chemical transport models.

3. Evaluation of the added value given by geostationary observations to aerosol retrieval for air quality issue

Investigation on the possible use of a combination of SEVIRI channels to detect important aerosol transport events (i.e. desert dust, biomass burning, smokes).

Time schedule

	2005	2006	2007	2008
Activity 1	*	*		
Activity 2	*	*	*	*
Activity 3	*	*	*	*

Approximate manpower and cost

	2005	2006	2007	2008
Personnel / man-years	3	3	2	2
Yearly cost (kECU)	23	23	15	15

Likely funding agencies

ESA, Italian National Bodies (Italian Space Agency, Regione Emilia-Romagna)

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Retrieval of Vertical Columns of Water Vapour from SCIAMACHY/ENVISAT Satellite Data

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Within the framework of the ACCENT-TROPOSAT-2 programme it is envisaged to further improve the University of Bremen AMC-DOAS algorithm for the retrieval of total columns of water vapour from SCIAMACHY nadir measurements in the spectral region around 700 nm. The work will include (i) Processing of a large (statistically significant) set of SCIAMACHY spectra, (ii) analysis of the accuracy and precision of this data set using independent measurements and models, and (iii) algorithm improvements. Intermediate (column) data products will be made available for ACCENT and feedbacks will be used to further improve the algorithm.

Time schedule

2004-2005 (first 18 months of project):

Further development of the SCIAMACHY AMCDOAS H_2O data product

After 18 months (until 2009):

Processing of larger SCIAMACHY data sets for statistical analysis and validation

Algorithm improvements

First preparations for a long-term SCIAMACHY H_2O data set

Likely funding agencies

German BMBF via DLR-Bonn

Infrared Spectroscopy for Tropospheric Remote Sensing from Space

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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This contribution concentrates on the use of infrared spectroscopy for remote sensing of tropospheric trace gases from space, in particular on the relevant aspects of laboratory and theoretical work required to provide accurate reference data. Indeed the accuracy of remote sensing in the infrared region is in many cases limited by the systematic errors of the database, a situation that urgently needs to be improved, especially for instruments that are already in orbit (MIPAS) or that will be launched in the near future (TES, IASI).

The proposed project will comprise three activities:

- Intercomparison and inter-calibration of spectroscopic reference data in different spectral regions (in particular ultraviolet-visible and thermal -infrared) for tropospheric trace gases that are observed in both regions, such as O_3, NO_2, H_2CO and SO_2. This is essential for the consistency of data derived different sensors, in particular for data assimilation, and for future projects with optical instruments operating in both spectral regions (*e.g.* GeoTROPE or similar).
- Improvement of the spectroscopic database (in particular line parameters) in the mid- and near-infrared, for tropospheric species where information is already available in databases like HITRAN but systematic errors are observed in the analysis of atmospheric spectra (*e.g.* H_2O, HNO_3, …).
- Measurements and analysis of laboratory spectra of other tropospheric trace gases that can potentially be observed in infrared spectra but where spectroscopic reference data (such as line positions, line intensities, lower states energies, broadening parameters, or absorption cross-sections) are still missing or incomplete, *e.g.* H_2CO, PAN, C_2H_6, CH_3CN, HCOOH, and $(CH_3)_2CO$.

Whenever possible the new data will be used for the retrieval of atmospheric data from infrared sensors, in order to demonstrate the impact of the new spectroscopic parameters, for species where the accuracy of previously available reference data improved, and to demonstrate the feasibility of detection of new species.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	*	*	*	*		
Activity 2	*	*	*	*	*	*
Activity 3		*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	2	2	2	2	2
Yearly cost (kECU)	10	20	20	20	20	20

Likely funding agencies

CEE; Programme National “Chimie Atmosphérique” (PNCA); CNES

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Tropospheric Ozone derived from Satellites

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Ozone profile information can be derived from UV earthshine spectra measured from nadir. Retrieval algorithms have been developed for the similar satellite instruments GOME, SCIAMACHY, OMI and GOME-2. However, the amount of information on the profile in the lower stratosphere and troposphere is very limited and it is very difficult to retrieve the tropospheric column, independently from the stratospheric content, as it is very sensitive to a variety of errors.

Various methods are being developed to infer the tropospheric ozone column using:

column retrievals over clear and (high) cloud-covered scenes in the tropics,
data assimilation of retrieved ozone profiles, and
combination of limb and nadir measurements (for SCIAMACHY).

The first method, the convective-cloud-differential (CCD) method, has been successfully applied using GOME [Valks *et al*. 2002]. Monthly-mean tropospheric ozone columns for the period July 1998 to June 2003 have been produced and are available from the TEMIS website (www.temis.nl). Next step is to use SCIAMACHY and OMI, which will deliver improved estimates due to the smaller ground pixels.

Data assimilation of retrieved profiles in to a chemical transport model allows the employment of the actual profile information derived from the measurement by using the averaging kernel. The model will provide additional information about ozone concentrations in the lower stratosphere and around the tropopause, for which the nadir UV measurement is less sensitive. The result of the assimilation is an optimal tropospheric ozone column, consistent with the profile measurements and model simulations. This method has been applied to one year of GOME ozone profiles. Extension of this work to other years to SCIAMACHY and to OMI will be conducted.

The SCIAMACHY limb observations can be used to retrieve an accurate estimate of the stratospheric profile. The co-located nadir observation combined with this profile yields an accurate value for the tropospheric column. Limb retrieval is a novel development; the first profiles are currently made available (2004). A nadir-limb combined retrieval algorithm is under development. This algorithm treats the limb and nadir spectra as one measurement vector from which the full ozone profile is derived in a single retrieval.

Time Schedule

	2004	2005	2006	2007
CCD		*	*	*
Profile assimilation	*	*	*	
Limb-nadir	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007
Personnel / man-years	1	2	2	2
Yearly cost (k€)	5	10	10	10

Reported costs are travel expenses only

Likely funding agencies

This work has been funded through the Dutch National User Support Programme (USP) and the ESA DUP project TEMIS. We aim to acquire further support from USP, ESA or EU FP6**.**

Co-workers

Arjo Segers, Jeroen van Gent and Ronald van der A

Linearized Radiative Transfer Models for Tropospheric Investigation: Comparisons and Effects in Retrieval of Atmospheric Composition

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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A few linearized radiative transfer (RT) models for application in retrieval algorithms were developed recently. Linearized RT models are characterised by capability to calculate directly and efficiently weighting functions used in retrieval algorithms, but not only radiance. Their application to interpretation to operational, GOME, SCIAMACHY *et al.*, and prospective, such as GeoSCIA, satellite observations improves accuracy of retrieval of atmospheric gases, properties of aerosol and clouds due to proper calculation of multiple scattering. However, linearized models may use various approximations and algorithms for calculations, what potentially raises differences in calculated weighting functions and influences on agreement of data of different satellite experiments.

Within a framework of AT2 project the proposed study aims to better characterise, adjust and agree weighting-function calculations by different radiative models with special emphasise to tropospheric area. The study will also identify needs of the current and future satellite investigations of the troposphere in improvement of linearized RT models basing on analysis of weighting function error propagation. Thus, the study will contribute in co-ordinating research activities in RT modelling, and in evaluation of data quality of satellite measurements.

The project intends to work on the following activities.

1. Adjustment of the weighting-functions calculations by different models, and comparison for representative set of scenarios for gases and geometry of observations exploit by GOME, SCIAMACHY, GeoSCIA *et al*.
2. Investigation of weighting-functions error propagation to retrieved gas contents. To characterize the weighting-functions effects in retrieved gases quantitatively, several approaches will be studied. In particular, methods of the statistical estimation, similar to ones used in error propagation analysis for inverse problems, and comparisons of the air mass factors will be applied.
3. Development of methods for characterisation and comparison of weighting functions related with aerosol and clouds. At this stage, approaches used for weighting-function modelling of gases will be extended for scattering particles (aerosols and clouds) and validated.

Time schedule

	2004	2005	2006	2007	2008
Activity 1	*	*			
Activity 2		*	**	*	
Activity 3			**	***	**

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	0.5	2	3	3	2
Yearly cost (kEuro)	25	90	120	120	90

Likely funding agencies

TBD

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Infra-red Sensing for the Retrieval of Tropospheric Composition from Space

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The University of Leicester EOS group has been involved in infra-red remote sensing since its inception in 1993. Current work in infra-red remote sensing of the atmosphere has two main study areas: 1) characteristics of CO profiles from MOPITT; 2) retrieval of upper tropospheric composition from MIPAS, particularly the detection of organic compounds. The work in the timeframe of AT2 will focus on:

The characterisation of day to night differences in MOPITT data for CO to identify surface sources and higher altitude inter-continental transport.

The detection and retrieval characterisation of trace gases, such as organics, HNO_3, CO and O_3 from MIPAS data for the mid-to upper troposphere.

The characterisation of day to night differences in MOPITT data for CO to identify surface sources and higher altitude inter-continental transport (Activity 1).

The objectives of this work are to investigate the increased altitude sensitivity of day – night differences to differentiate the altitude region in which CO enhancements can appear. Although the vertical resolution of MOPITT is relatively low and it has limited sensitivity to the lowermost troposphere, differencing of day and night MOPITT data can have enhanced sensitivity to the surface or to the upper atmosphere. The reason lies in the differences between day and night averaging kernels for the "surface" retrieval level. The day averaging kernels for the surface tend to have stronger sensitivities to the lowermost troposphere where the surface temperature is highest, whereas the night averaging kernels for the surface tend to be more responsive to middle and upper tropospheric CO changes; high temperature surfaces tend to have strong diurnal heating. We will investigate how these differences can be used to investigate CO enhancements and variability in the troposphere. We will also include the additional information in MOPITT retrieval levels directly providing information for the upper troposphere. Already we have indications that day-night differencing can reveal low altitude industrial pollution (Houston, East Asia) and biomass burning (Africa) as well as high altitude CO transport (see Figure 1).

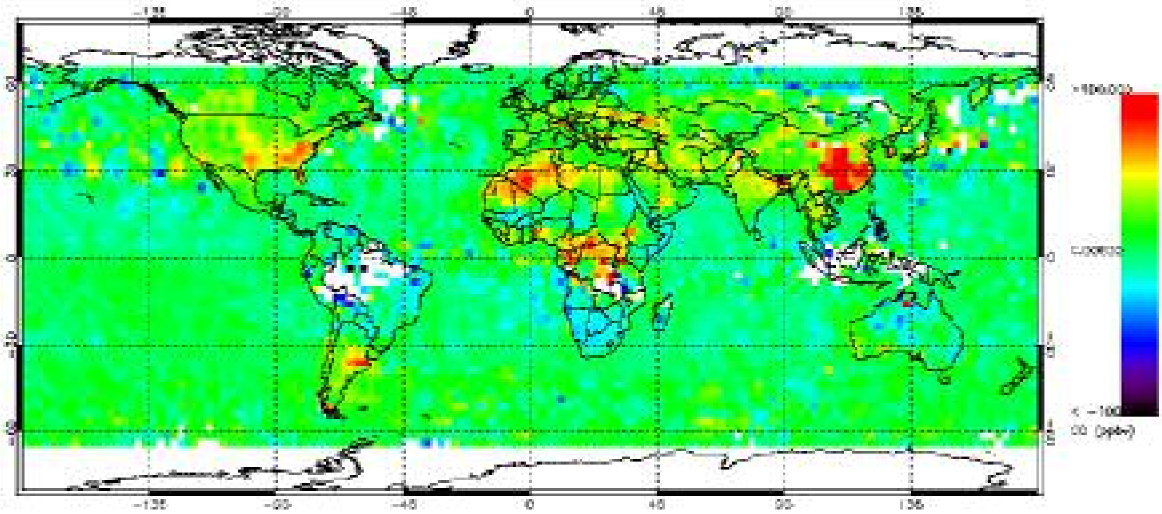

Figure 1. Monthly mean of MOPITT day-night "surface" concentrations for January 2001. Strong positive enhancements indicate high CO in the lowermost troposphere. Negative values may indicate high altitude (mid- to upper troposphere enhancements of CO).

The detection and retrieval characterisation of trace gases, such as organics, HNO_3, CO and O_3 from MIPAS data for the mid-to upper troposphere.

The MIPAS instrument is the first limb sounding emission spectrometer to routinely sound to mid-troposphere altitudes on a routine basis. The nominal scan pattern reaches down to 6 km at the bottom of its range. The MIPAS data, with its high spectral resolution of 0.025 cm^{-1} unapodised, therefore allow us an unprecedented insight into vertical variations of tropospheric composition. However, the data must first be cloud cleared and trace gas retrievals tested for residual cloud/aerosol effects. In this study, we aim to characterise MIPAS observations (detection limits, sensitivity, errors) in the upper troposphere for four groups of compounds: (a) organics, b) HNO_3, c) CO, d) O_3 (see Figure 2). Such datasets will be invaluable for modellers working in other task groups and may help to identify signatures of biomass burning and pollutant transport in the upper troposphere.

Time Schedule

	2004	2005	2006	2007	2008
Activity 1	****	***	**	*	*
Activity 2	**	****	****	**	*

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man years	1.0	1.0	1.0	0.5	0.25
Yearly Cost (kECU)	15,000	15,000	15,000	7,500	3,750

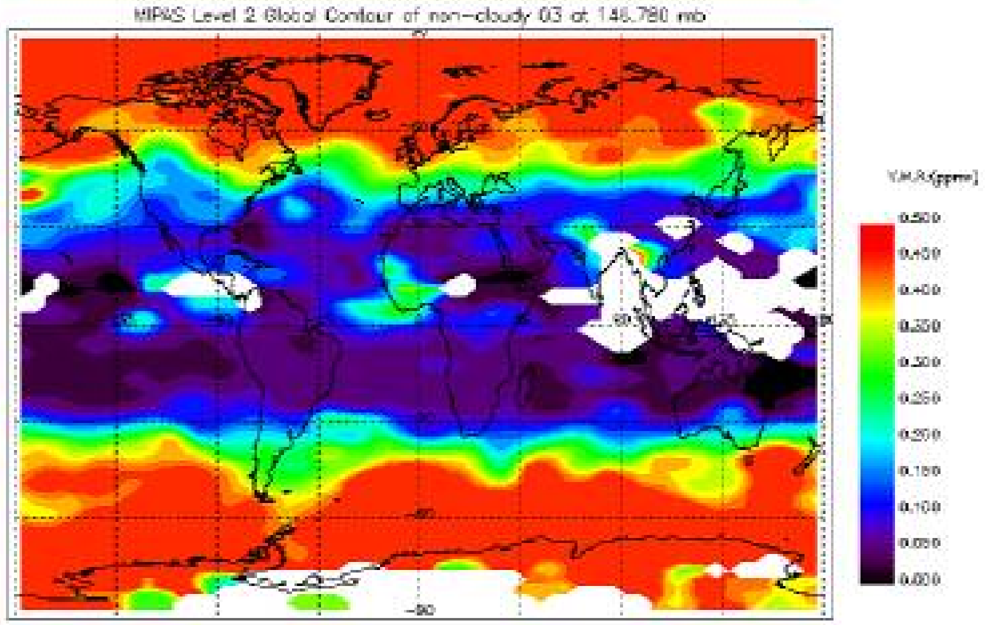

Figure 2. Global ozone at 146 mb (~13.5 km) measured by the MIPAS instrument for June to August 2003 (using operational near realtime level 2 data). White regions in the data are indicative of cloud-corrupted MIPAS data removed by the cloud detection system. Upper tropospheric concentrations over western Africa appear to reach as high as 0.35 ppmv indicating possible ozone enhancement due to biomass burning.

Likely Funding Agencies

CEC, UK national funding bodies (*e.g*. NERC, EPSRC, BNSC) and ESA

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Tracking Pollution from Space-borne Thermal IR Sounders

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The present proposal intends to investigate the potential offered by space borne thermal infrared nadir sounders to track and study pollution. Carbon monoxide (CO) will be used as a primary target as it is a good tracer of pollution and a strong thermal IR absorber. Data from past (IMG), present (MOPITT/AIRS/TES), and future (IASI) missions will be investigated. Prospective studies concerning forthcoming satellite missions and parallel assimilation of radiances will also be conducted.

The two first tasks of the proposed study will primarily rely on the radiative transfer forward and inverse model Atmosphit, developed at the Université Libre de Bruxelles (ULB). The third task will also require using the 3-D Chemistry Transport Model (CTM) MOCAGE of Meteo-France and the Projet d'Assimilation par Logiciel Multi-Methodes (PALM) developed at CERFACS.

Task 1: retrieval of CO vertical profiles from radiances measured by thermal IR nadir sounders (IMG, TES, IASI) using an Optimal Estimation Method. Characterization of the retrieved profiles in terms of precision and vertical information content.

Task 2: based on radiative transfer simulations and optimal estimation retrieval analysis, evaluation of the capabilities of a forthcoming "pollution sounder" to improve the determination of pollution parameters: primarily CO.

Task 3: direct assimilation of thermal IR radiances measured from space. The objective is to investigate the possibility to produce assimilated CO fields (level 3) from calibrated nadir radiances (level 1) through the parallel coupling of a radiative transfer model (Atmosphit) and a 3-D CTM (Mocage).

Time schedule

	2005	2006	2007	2008	2009
Task 1	*	*	*		
Task 2	*	*	*	*	
Task 3			*	*	*

Approximate manpower and cost

	2005	2006	2007	2008	2009
manpower	2	2	3	2	2
cost	15	15	20	15	15

Likely Funding Agency

French Programmes: PNCA, CNES (TOSCA)

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Monitoring Changes in Tropospheric Constitution from Space

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Starting with the GOME instrument, a series of space-borne UV/visible nadir viewing spectrometers will be operated throughout the next years. These instruments will create a data base of measurements eventually spanning several decades of atmospheric observations. The resulting data set should be a valuable tool to access changes in atmospheric constitution, and could be used for monitoring the effects of anthropogenic activities and changes in emission patterns.

The key to a combined use of measurements from different instruments is the creation of a consistent and continuous time series. This involves several points, in particular:

- correction of instrumental drifts and artefacts in the measurements of a single instrument;
- compensation for instrumental differences such as spatial resolution, sampling pattern, time of measurement, or retrieval method for different instruments; and
- long-term validation of the satellite measurements.

This project will attempt to address this issue starting with tropospheric NO_2 measurements from GOME and SCIAMACHY and extending it to OMI and GOME-2 data as they become available. Depending on the available resources, other trace species such as HCHO and SO_2 will also be included.

Tropospheric NO_2 columns will be determined using the same retrieval on all instruments, and consistency will be established by analysing time periods of overlapping measurements. A particular focus will be on monitoring long-term stability by evaluation of retrievals made in different spectral regions and for other absorbers with known distribution (O_4, O_2). Where necessary, corrections will be implemented to ensure consistent data sets. Validation will be performed using ground-based multi-axis DOAS systems. Once a consistent and consolidated data set has been created, it will be analysed for seasonal, inter-annual and long-term changes in the observed concentrations.

Time schedule

	2004	2005	2006	2007
Data Retrieval	***	***	**	**
Data Consolidation	**	***	**	*
Validation	**	**	**	*
Interpretation		*	***	***

Approximate manpower and cost

	2004	2005	2006	2007
Personnel / man-years	0.5	1	1	0.5
Yearly cost (kEuro)	15	30	30	15

Likely funding agencies

DFG, European Union

Co-workers

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Total and Tropospheric BrO retrieval from Space Nadir and Ground-based UV-Vis Observations

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Activity 1 - Total and tropospheric BrO algorithms for operational purposes.

Building on the success of the Global Ozone Monitoring Experiment (GOME) on ERS-2 (1995-), an optimized version of the same instrument (GOME-2) will be operated on three successive satellites as part of the EUMETSAT MetOp Programme (2006-2018). At the same time space nadir UV-visible observations will also be available from the OMI and SCIAMACHY instruments. The operational processor of GOME-2 will deliver three main atmospheric trace gases data products: O_3, NO_2 and BrO. Here we focus on investigating retrieval approaches adequate for BrO column processing, with possible application to historical observations of ERS-2 GOME and other nadir instruments. This activity will build upon the experience gained in the framework of TROPOSAT-1 where residual techniques based on the use of 3D-CTM model data have been explored for the retrieval of tropospheric BrO columns from GOME. This work will be continued with the aim to propose an operational algorithm for the retrieval of global total and polar tropospheric BrO columns. Tropospheric BrO columns will be derived using a residual technique accounting for the effect of clouds, surface albedo and snow-ice. Stratospheric correction strategies will be explored based on available external data sets (*e.g.* the Bremen stratospheric BrO climatology) possibly constrained by GOME-2 observations in regions of minimum tropospheric BrO content.

Activity 2 - Free-tropospheric investigation based on a cloud-slicing approach.

Several evidences have been reported from GOME, ground-based and balloon platforms suggesting the existence of sizeable amounts of BrO in the free-troposphere, possibly at the global scale. During TROPOSAT-1, attempts have been made to identify free-tropospheric BrO signatures based on a cloud slicing approach similar in concept to the one used to derive tropospheric ozone from TOMS. Results were however limited by the large size of the GOME pixels which prevented good statistics to be obtained. Owing to the improved coverage and spatial resolution of GOME-2 (and OMI), as well as the availability of improved cloud data products, we expect that the possibilities to retrieve information on free-tropospheric BrO will be greatly enhanced.

Activity 3 - Total and tropospheric BrO investigation based on the synergistic use of ground-based, satellite and balloon measurements.

UV-VIS DOAS observations of BrO can be performed from ground-based, balloon and satellite platforms. Combining the available data sets, specific air masses can be observed simultaneously (or quasi simultaneously) under a large variety of geometries, each characterized by a different sensitivity to the vertical distribution of BrO. As part of Activity 3, vertical profiling methods will be designed and applied to zenith-sky and multi-axis DOAS BrO measurements performed at Harestua (60°N) and OHP (44°N). These results will be combined with available BrO data sets from space nadir instruments (GOME, GOME-2, OMI, SCIAMACHY), as well as balloon (SAOZ BrO, LPMA-DOAS) and space Limb instruments (SCIAMACHY). The overall consistency of these data sets will be investigated with the aim to assess the accuracy of satellite retrievals (in support of Activity 1) and to contribute to improve our understanding of the atmospheric bromine partitioning.

Targets for the first eighteen months:

to provide a long term data sets of global total columns and polar tropospheric columns of BrO from GOME by the mean of an improved residual tropospheric method developed at BIRA-IASB.

to provide a new data set of global total columns of BrO from SCIAMACHY.

A preliminary tropospheric BrO product from SCIA will be studied in limited cases.

to assess the stratospheric BrO correction quality by making intercomparisons based on available stratospheric BrO data products (balloon measurements, SCIAMACHY limb profiles, CT Models: BASCOE, SLIMCAT).

to assess the quality of the GOME BrO products (total and tropospheric vertical columns) through comparisons with ground-based zenith-sky measurements over Harestua.

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel/man-years	0.3	0.6	0.6	0.45	0.45
Yearly cost (kEuro)	15	30	30	20	20

Likely funding agencies

O_3-SAF visiting scientist programme; Belgian Science Policy; ESA PRODEX

Co-workers

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Data Assimilation of AOD with LOTOS

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Within the framework of the TROPOSAT programme a number of contributions are envisaged.

1. Improvement of the Chemical Transport Model LOTOS, a 3-D Eulerian grid model covering Europe, with special emphasis on windblown dust, see salt and biogenic and anthropogenic secondary organic aerosols
2. Further development of the data-assimilation scheme: increase in computational speed and analysis of simpler schemes like optimal interpolation to arrive at operational systems
3. Provision by LOTOS of chemical consistent concentrations to improve retrieval of AOD, NO_2 and ozone.
4. Development of aerosol added value products using AOD from different satellites and instruments and ground level observations, with data-assimilation and the LOTOS-model. This activity will be undertaken in close interaction with the various user communities, including both scientific and institutional users, contributing to GMES

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	*	*	*			
Activity 2	*	*	*	*	*	
Activity 3		*	*	*	*	*
Activity 4	*	*	*	*	*	*

Aims for the first 18 months

Improved LOTOS model.

First results of aerosol fields for 2000 over Europe by using AOD data, data-assimilation and LOTOS.

Long term goals

Chemical consistent products.

Operational methods for added value products, mainly aerosol fields.

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1.5	1.5	2	2	2.5	2.5
Yearly cost (kECU)	225	225	300	300	375	375

Likely funding agencies

EC; NL National Bodies

Co-workers

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Retrieval of Tropospheric Ozone Columns from UV-nadir Measurements by GOME/ERS-2, GOME-2/METOP and OMI Instruments

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The activities envisaged within the framework of the AT-2 programme are described below. Phase 1 includes the activity for the first eighteen months of the AT-2 programme. The activities for the second phase of the AT-2 programme are listed under Phase 2.

Phase 1

Activity 1

Within the framework of TROPOSAT-1, tropical tropospheric ozone columns (TTOCs) have been successfully determined with a convective-cloud-differential (CCD) method, using ozone column and cloud measurements from GOME. The GOME-CCD method uses above-cloud and clear-sky ozone column measurements to derive a monthly-mean TTOC below 200 hPa (see TROPOSAT final report). In this activity, a TTOC data-record will be produced for the whole GOME period (1995-2003). It is expected that the ongoing improvements of the ozone column and cloud retrieval algorithms for GOME will enhance the accuracy of the TTOC. Therefore, improved GOME ozone column and cloud data, reprocessed with the latest state-of-art GOME retrieval algorithms, will be used to derive the TTOC.

Phase 2

Activity 2

The GOME-TTOC data-set will be extended, using the upcoming OMI and GOME-2 satellite instruments. The small ground pixel size of the OMI and GOME-2 instruments makes it possible to improve the spatial and temporal resolution of the tropical tropospheric ozone fields.

Activity 3

The cloud-differential method will be extended to a cloud slicing method, in which ozone column measurements are used above clouds with different cloud-top pressures. With the cloud slicing method, it is possible to retrieve ozone information for different tropospheric layers, as has been demonstrated by Ziemke *et al*. [2001], using TOMS total ozone measurements and THIR cloud top pressure data. Because of the large ground pixel of GOME, the number of cloudy and clear-sky measurements is generally too small to apply such a cloud slicing method. However, the OMI and GOME-2 satellite instruments will greatly enhance the possibilities to retrieve information about the tropospheric ozone profile with the cloud slicing method. The small ground-pixel of these instruments will allow more frequent observations between clouds, thus giving better penetration into the troposphere. In this activity, the cloud slicing method will first be applied for the (sub)-tropics, using ozone column and cloud measurements from OMI and GOME-2. In the next step, the cloud-slicing approach will be extended to the mid-latitudes, including Europe.

Time schedule

	2004	2005	2006	2007	2008
Activity 1	*	*			
Activity 2		*	*		
Activity 3		*	*	**	**

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	0.1	0.2	0.2	0.2	0.2
Yearly cost (kECU)	11	22	22	22	22

Likely funding agencies

DLR

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Development of Algorithms for Improved Tropospheric Data Products from OMI

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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The Ozone Monitoring Instrument (OMI) is a Dutch-Finnish contribution to NASA's EOS-Aura satellite now scheduled for launch in June 2004. OMI is a new instrument, with a heritage from the European satellite instruments GOME, GOMOS and SCIAMACHY. The unique capabilities of OMI for measuring important atmospheric trace gases with a small footprint of 13 × 24 km^2 and daily global coverage, in conjunction with the other Aura instruments, will make a major contribution to our understanding of stratospheric and tropospheric chemistry and climate change. OMI will provide data continuity with the TOMS instruments and will be essential to continue the 25-year ozone record of TOMS.

The following data products are foreseen for the OMI-instrument: (1) total columns of the trace gases ozone, NO_2, BrO, OClO, HCHO and SO_2; (2) ozone profile; tropospheric ozone and tropospheric NO_2 column data; (3) the spectral aerosol optical depth, including information on aerosol concentration, aerosol size distribution and aerosol type; and (4) cloud coverage and cloud height.

The following algorithm improvements are foreseen for OMI:

(1) Improved tropospheric ozone and NO_2 columns by combining total column data from OMI with limb data from MLS and/or HIRDLS

(2) Improved corrections for Raman scattering, not only for ozone, but also for NO_2 and other trace gases.

(3) Improved cloud correction methods by using scattering clouds instead of Lambertian surfaces to model clouds.

(4) Improved aerosol products by extending the TOMS aerosol algorithm to an algorithm that uses more wavelengths.

We intend to present our results during the regular AT-2 meetings and workshops. It is our expectation that joining the AT-2 network will stimulate discussions, enhance the exchange of ideas and initiate collaborations between retrieval algorithm developers that will increase the quality and sophistication of the retrieval algorithms in general.

Time schedule

	2005	2006	2007	2008	2009
Activity 1	*	*	*	*	*
Activity 2	*	*	*	*	*
Activity 3	*	*	*	*	*
Activity 3	*	*	*	*	*

Approximate manpower and cost

Subject	2005	2006	2007	2008	2009
Personnel / man-years	1	1	1	1	1
Yearly cost (kECU)	5	5	5	5	5

Reported costs are travel expenses only

Likely funding agencies

Netherlands Agency for Aerospace Programs (NIVR)

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Global Long-term Data Sets of the Atmospheric H_2O, VCD, and of Cloud Properties derived from GOME and SCIAMACHY

A contribution to ACCENT-TROPOSAT-2, Task Group 1

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Atmospheric water vapour is the most important greenhouse gas which is responsible for about 2/3 of the natural greenhouse effect, therefore changes in atmospheric water vapour in a changing climate is subject to intense debate. H_2O is also involved in many important reaction cycles of atmospheric chemistry, *e.g.* in the production of the OH radical. Thus, long time series of global H_2O data are highly required.

New UV/VIS satellite sensors like GOME or SCIAMACHY are capable of measuring the total atmospheric H_2O column (including also the surface near concentrations). In contrast to other satellite sensors they are sensitive over both land and ocean. Thus these sensors allow to investigate the global long term evolution of H_2O and possibly also to identify a trend due to climate change. Such studies can in particular focus on different regions and seasons.

Currently about 8 years of continuous GOME measurements are available. Of special interest is also the fact that there exists a one-year overlap with its successor SCIAMACHY. Therefore the data sets of both instruments can be combined.

In this project we propose to develop a sensitive and stable H_2O column density data product. We will investigate the systematic influence of clouds and aerosols on the retrieved H_2O column. Besides cloud fraction also the absorption of the oxygen monomer and dimmer (O_4) will be studied.

Using these quantities we are able to study various atmospheric aspects, in particular possible trends of atmospheric H_2O and cloud properties for different latitudes and seasons. Additional research will address spatial and temporal patterns due to El-Nino, NAO and QBO.

Time schedule

	2004	2005	2006	2007	2008
H_2O analysis from GOME and SCIAMACHY	*	*	*		
Dependence on clouds and aerosols	*	*	*	*	
Trends of H_2O and clouds			*	*	*
Specific phenomena, *e.g.* El-Nino, NAO, *etc.*			*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / person-years	0.4	0.4	0.4	0.4	0.4
Yearly cost (kECU)	5	5	5	5	5

Likely funding agencies

BMBF, EU

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Contributions from Task Group 2

Assimilation of Tropospheric Species into a Chemistry Transport Model

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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This proposal aims at assimilating chemical satellite data from present and future instruments into the MOCAGE chemistry-transport model (leaded by METEO-FRANCE). The goal is to construct assimilated fields of CO and O_3 by using data from MOPITT, GOME-2 and/or IASI in the troposphere and ODIN in the lower stratosphere.

The assimilation methods will be a Kalman filter, the 3DFGAT and 4DVAR methods via the PALM software developed by the CERFACS. The assimilation results (CO and O_3) will be compared to an independant set of aircraft data provided during MOZAIC experiment.

This study aims to test the different types of assimilation methods, with respect to different chemical schemes, applied on different species from various satellite instruments. Also it will provide a tool capable of testing various configurations for evaluating a new concept of Air quality and pollution satellite instrument.

Time schedule

	2004	2005	2006	2007	2008	2009
Assimilation of data	**	***	***	**	**	**
Comparison with aircraft data	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	3	4	4	3	3	3
Yearly cost (kEuro)	20	25	25	20	20	20

Likely funding agencies

Programme National Chimie Atmospherique (PNCA), CNES

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Integrating Chemical Modelling and Satellite Observations for Monitoring Tropospheric Chemistry and Air Quality

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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The proposed contribution of the IPSL/LISA/CNRM team aims at using existing and future satellite observations to improve our knowledge of processes constraining the chemical composition of the troposphere and to improve regional scale air quality modelling, with a focus on Europe. Theses objectives are mainly related to work in task group 2, synergistic use of models and observations. This contribution is complementary to another French contribution, by J. Orphal and C. Clerbaux aimed at developing new concepts for satellite observations of the tropospheric chemical composition. The contribution is organized within 6 activities:

- use of available and future data from instruments operating in the infrared and UV-visible in Low-Earth-Orbits (ENVISAT, GOME, MOPITT, IASI, ….) to quantify the impact of satellite observations for modelling and forecasting tropospheric chemistry and air quality (in particular in relation with the GMES project),
- development and application of methods to assimilate satellite observations for mapping various pollutants (ozone, NO_2, AODs, …) by using techniques of increasing complexity (optimal interpolation, Kalman filtering, variational methods),
- inverse modelling of emissions (NOx, CO, VOCs, particulate matter) from satellite observations using techniques of increasing complexity, from simple iterative methods to variational techniques,
- use satellite observations to improve representation of transport and chemical processes within models (horizontal and vertical pollution plume transport, photochemical ozone build-up),
- use of aerosol optical depth's available from radio-spectrometers (MODIS, MERIS) to improve the quality of particulate matter simulations both at a continental European scale and a regional scale (large agglomerations); evaluate aerosol vertical distributions and optical properties in a tropospheric chemistry transport model (CHIMERE) by systematic comparisons between lidar profiles simulated as a model output and space-borne active remote sensing observations (GLAS, CALIPSO), and
- participation in joint efforts for model / satellite comparisons within TG2.

The contribution is built on two regional and global scale models already used within the French community for long term simulations and operational air quality forecast, CHIMERE and MOCAGE (http://prevair.ineris.fr).

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1		*	*	*	*	*
Activity 2			*	*	*	*
Activity 3	*	*	*	*		
Activity 4		*	*	*	*	*
Activity 5	*	*	*	*		
Activity 6	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	3	3	3	3	3
Yearly cost (kEuro)	10	20	20	20	20	20

Likely funding agencies

CEE; Programme National Chimie Atmosphérique (PNCA), CNES

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Derivation of Tropospheric Composition from Satellites using a 3-D CTM

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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The direct observation of tropospheric composition is difficult and for many species the overlying stratosphere causes a number of complications. Different methods have been employed for the removal of the stratospheric part of total column observations, including using model results. However this is limited by the accuracy of the model.

The aim of this work is to use a detailed, tested 3-D chemical transport model (TOMCAT/SLIMCAT) to improve the *quantitative* derivation of tropospheric composition. TOMCAT/SLIMCAT will be used to simulate the stratosphere as accurately as possible. The model already gives a reasonable simulation of the stratosphere (following on-going improvements) but in this study we will further constrain the stratosphere by assimilating longer-lived species from long-term datasets such as HALOE (see Figure). In the first instance, and in collaboration with RAL, we will use GOME data (1995 onwards), and the CTM, to derive quantitative estimates of tropospheric NO_2, BrO, HCHO and SO_2 over the lifetime of the mission. We will also make use of RAL access to ATSR data to account for the occurrence of clouds. We will compare our calculations with other derivations of tropospheric species from GOME. In later work (2007 onwards) we would hope to study data from other recent missions.

18 months objectives

Set up long-term simulations of TOMCAT/SLIMCAT with chemical data assimilation. Derivation of first year of tropospheric composition from GOME using constrained CTM.

Time schedule

	2004	2005	2006	2007	2008	2009
All Objectives	**	**	***	***	***	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	1	1	1	1	1
Yearly cost (kEuro)	10	10	10	10	60	60

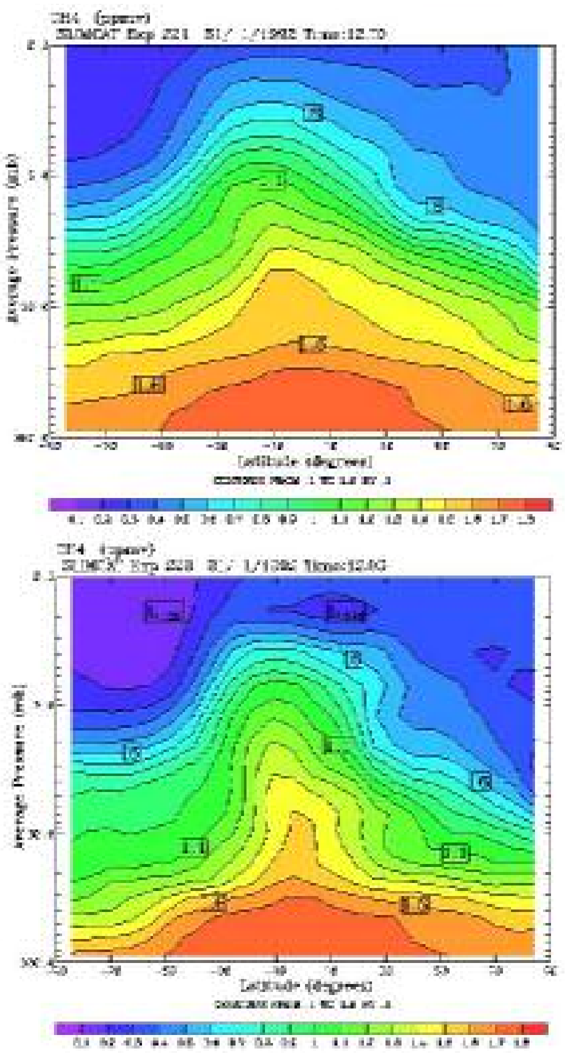

Figure 1: Zonal mean fields of CH_4 from SLIMCAT CTM. Left: without assimilation. Right: with assimilation of HALOE CH_4, which improves the model tracer gradients in the subtropics.18 months objectives

Likely funding agencies

U.K. Natural Environment Research Council (NERC) Studentship until 2007 (costs until then are for travel only). PDRA funding will be needed after that.

Co-workers

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Validation and Further Development of an Interactively Coupled Climate-Chemistry Model for Detection, Attribution and Prediction of Changes in the UTLS

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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During recent years the development of interactively coupled chemistry-climate models (CCMs) has made significant progress. Inter-comparisons of first long-term model simulations with respective data derived from observations indicated that the CCMs can realistically reproduce most relevant processes and features (*e.g.* climatological mean state of dynamical parameters and chemical compounds in the UTLS and its seasonal and inter-annual variability), but on the other hand, the different model systems do contain obvious deficiencies, for example the well known "cold-bias" in the polar lowermost stratosphere (*e.g.* Schnadt *et al.,* 2002; Austin *et al.*, 2003). Therefore, further developments of models are strongly required before reliable predictions of possible future changes of atmospheric composition and climate can be made. Within the framework of AT2 a number of contributions are envisaged, which build up on experiences made during TROPOSAT (*e.g.* Lauer *et al.*, 2002).

Within this project it is planned to employ two versions of the chemistry-climate model ECHAM5/MECCA. First, we will use ECHAM5.L41(DLR)/MECCA (E41/M) for long-term simulations (years to decades). E41/M is characterised by a high vertical resolution in the UTLS (*i.e.* 700 m near the tropopause instead of 2 km in the standard model version). This model version is mainly employed to investigate changes in climate and atmospheric composition. Second, the version E41/M(nudge) is available which uses meteorological analyses (*e.g.* ERA40); this model version can be used to investigate individual episodes (months), in particular to support the planning and analysis of measurement campaigns.

Key-questions to be answered are: (1) What are the past changes and variations in the UTLS? (2) How well can we explain past changes in terms of natural and anthropogenic effects? (3) How do changes in the UTLS composition affect climate, and vice versa? (4) Can E41/M(nudge) reproduce relevant processes and features which have been detected during measurement campaigns? (5) How do we expect the UTLS to evolve in the future, and what confidence do we have in those predictions?

Data products derived from satellite and non-satellite measurements (ground based, airborne) will be used to compare and evaluate the results of E41/M. Further development of E41/M will lead to an improved model system and a better understanding of tropospheric and stratospheric processes. The synergistic use of model data and observations is the basis for a better understanding of chemical, physical and dynamic processes and their interaction, and for reliable assessments of future atmospheric changes.

Time schedule

	2004	2005	2006	2007	2008	2009
CCM validation development simulations	**	****	****	****	****	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-months	1	2	2	2	2	1
Yearly cost (kEURO)	5	10	10	10	10	5
Consumables (kEURO)	1	2	2	2	2	1

Likely funding agencies

CEC

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Schnadt, C., M. Dameris, M. Ponater, R. Hein, V. Grewe, and B. Steil, Interaction of atmospheric chemistry and climate and its impact on stratospheric ozone, *Climate Dynamics*, **18**, 501-517, 2002.

4-Dimensional Variational Assimilation of Satellite Data into a Chemistry Transport Model

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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An increasing wealth of trace gas retrievals of the troposphere will be available for assimilation into complex chemistry transport models. Namely sensors like SCIAMACHY, GOME(-2), AATSR, and MOPITT have demonstrated that they a valuable data sources for assimilation. Species to be assimilated include O_3, NO_2, SO_2, formaldehyde and potentially various classes of aerosols.

Space time data assimilation algorithms aim to upgrade level 2 satellite retrievals, scattered in space and time to level 3 products, giving a comprehensive and continuous picture of the troposphere, commonly presented synoptically on a regular grid at the user´s disposal. In the proposed work the European scale complex University of Cologne EURAD (EURopean Air pollution Dispersion) model with its adjoint components will be taken to form a three- and four-dimensional variational data assimilation (3- and 4-D-var) system by ingesting available and envisaged tropospheric satellite data. The 4D-var EURAD assimilation system is presently the only one worldwide to also run in a multiple nesting mode, with grid resolution varying from 125 to 6 km. Further it has shown the potential not only to estimate the chemical state of the troposphere, but also provide assessments of emission strengths.

The 4-D-var method is one of the very few techniques to attain a real synergistic use of observation sets, combined from heterogeneous instrumentation. This work will build on present experiences with tropospheric NO_2 columns and artificial neuronal network based ozone profile retrievals.

The scheduled work includes combinations of satellite data with in situ observations, identifying the important boundary layer portion of the tropospheric columns. While it could be demonstrated that surface data assimilation is beneficial for the predictive skill, satellite data assimilation will be evaluated for an added performance increment of air quality forecasts. A further issue, extremely important for data assimilation algorithms, is the estimation of radii of influence associated with retrieved data, to achieve a better formulation of the background error covariance matrix.

The mature data assimilation system is also expected to fit into routine GMES service type tasks

Time schedule

	2004	2005	2006	2007	2008	2008
Activity 5	**	**	**	**	**	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2008
Personnel / man-years	0.5	1.	1	1.	1	1
Yearly cost (kECU)	30	60	60	60	60	60

Likely funding agencies

CEC; ESA, BMBF, German Science foundation

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Derivation of Tropospheric NO_2 by Synergistic Use of Satellite Observations and a Chemical Transport Model

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Tropospheric NO_2 columns can be derived by combining satellite observations and analyses of a chemical-transport model.

In the proposed method the tropospheric column is gained by subtracting the stratospheric column, obtained by CTM analyses, from NO_2 vertical column density observations from GOME and SCIAMACHY. In order to account for the daily cycle of NO_2 and the nitrogen family in general, the stratospheric analysis is derived for exactly the overpass time of the satellite-borne instrument. To avoid a bias the stratospheric analysis can be scaled to "clean" observation conditions. The tropopause is defined by thresholds of potential vorticity and temperature in the tropics. The cloudiness of the observations is considered.

Within the framework of TROPOSAT a number of contributions are envisaged.

1. The derivation of tropospheric NO_2 column densities will be applied to ESA SCIAMACHY Level 2 data and the latest version of ESA GOME Level 2 data (GDP 3.4) from 1995-2003.
2. As it was shown recently by Thomas *et al.* (2003) CTM simulations of stratospheric NO2 distributions can be combined successfully with total column densities to derive tropospheric NO_2 columns. Airborne measurements of nitrogen compounds during the SPURT campaign indicate a good coincidence with the retrieved tropospheric columns. Analyses of stratospheric nitrogen dioxide will be derived using the 3-D global chemical-transport model DLR-ROSE 3.0 to account *e.g.* for zonal stratospheric variability. The model was significantly improved recently within the AFO 200 project INVERT. The model is driven by ECMWF analyses and covers all relevant chemical and physical processes of the stratosphere.
3. Besides the use of CTM results of stratospheric NO_2, however, we also aim at assimilating ENVISAT-MIPAS observations of nitrogen compounds into the CTM DLR-ROSE 3.0. By using these observations an additional improvement of the stratospheric analysis is expected.
4. Additional to the cloud fraction of each pixel, the cloud-top height information will be exploited, too. It will be investigated to what extent the cloud-top height information allows for tropospheric column slicing. Cloud fraction will be derived by the Optical Cloud Recognition Algorithm (OCRA) and cloud-top height will be determined by ROCINN (Retrieval of Cloud Information by a Neural Network).
5. Additional application of 4-D Var analyses of GOMOS, MIPAS and SCIAMACHY for improved stratospheric analysis of NO_2

Time schedule

	2004	2005	2006	2007	2008
Activity 1	*	*	*		
Activity 2		*	*	*	
Activity 3	*	*	*	*	*
Activity 4		*	*	*	*
Activity 5				*	*

Aims for the first 18 months

- Exploitation of ESA GDP NO_2 vertical column densities (Version 3.4) from 1995-2003 and ESA SCIAMACHY NO_2 vertical column densities (Version > 5)
- Use of assimilated MIPAS observations for derivation of stratospheric NO2 column

Long term goals

- Exploitation of cloud-top heights as derived by ROCINN for tropospheric column slicing
- Validation by airborne measurements
- Use of 4-D Var analyses of GOMOS, MIPAS and SCIAMACHY for derivation of stratospheric NO_2 column

Approximate manpower and cost (travel costs only)

	2004	2005	2006	2007	2008
Personnel / man-years	1	2	2	2	2
Yearly cost (kECU)	5	10	10	10	10

Likely funding agencies

Work is currently funded by SACADA (BMBF, Germany) and EVIVA (DLR)

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Trends in the Chemical Composition of the Troposphere using Satellite Data

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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The goal of this project is to analyse satellite observations of chemical compounds and identify year-to-year variability and trends in their distributions. Observations of the tropospheric columns of nitrogen dioxide are available from the GOME instrument from 1996 to the end of 2002, followed by the SCIAMACHY instrument on board ENVISAT since August 2002. MOPITT observations of the CO vertical profile have been made available since the beginning of 2000.

We will first analyze the observations of both NO_2 and CO. Seasonal cycles will be quantified and compared for these two species. The seasonal cycles will be removed from the time series, in order to identify specific events as well as trends. Data for the largest world megacities will also be analysed and possible trends in these cities will be quantified. Finally, simulations using the MOZART-4 chemistry-transport global model will be performed over the full 1996-2004 period. The simulations results will be compared with the observations for both NO_2 and CO, with a focus on seasonal variations and long-term trends. The consistencies between observed changes in the distributions of CO and NOx and changes in emissions distributions during the observation period will be studied. This work will also use results obtained from inverse modeling studies performed at the National Center for Atmospheric Research (Boulder, USA). High-resolution simulations will also be performed for the analysis of the observations corresponding to megacities.

Time schedule

	2005	2006	2007	2008
Analysis of GOME/SCIAMACHY and MOPITT observations	*			
Identification of interannual variability patterns and trends in large continental areas	*	*		
Identification of trends in megacities		*	*	*
Modeling using a chemistry-transport model	*	*	*	*

Approximate person power and cost

	2005	2006	2007	2008
Personnel / person-years	1	1	1	1
Yearly cost (kECU)	30	30	30	30

Likely funding agencies

CNRS, EU, CNES, NCAR, NOAA

Co-workers

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Scientific Interpretation of SCIAMACHY CO, CO_2 and CH_4 Measurements

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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The following contribution to the ACCENT TROPOSAT-2 programme is envisaged.

The interpretation of SCIAMACHY measurements of the medium to long-lived atmospheric trace gases CO, CH_4, and CO_2. The aim of this project is to explore the available calibrated and validated data and to investigate the extent to which these data corroborate the existing observational evidence, or point at possible gaps in our understanding. The focus will be on regions that are not well covered by conventional monitoring efforts, pertaining to most of the tropical continents, and remote temperate and boreal zones. The measurements will be used to narrow down the uncertainties in key processes that control long-term trends in mixing ratio, and variability on seasonal and inter-annual time scales. The main emphasis will be on the estimation of surface sources and sinks, quantifying budgets on scales ranging from global to regional. These estimates will be obtained by inverse modelling, which, in most of the current applications, makes use of atmospheric transport models only. As a next step we plan to investigate the use an atmospheric transport model (TM3/5), in combination with process-based models of the land surface, such as ecosystem models (for CO_2) and wetland models (for CH_4). This approach has the promising advantage that other satellite products can be taken into account as additional constraints to the optimization procedure. Promising candidates that will be explored within this project are NDVI/LAI (photosynthetic activity), ATSR fire counts/GLOBSCAR (biomass burning), and SAR (natural wetlands). At a later stage we will also investigate potential synergies of combining the measurement of different tracers with common sources, which is the case, for example, for CO and CO_2.

This project will be in close collaboration with the proposed AT2 project 'Retrieval and Validation of SCIAMACHY CO and CH_4 Measurements'. In the first phase, before any validated SCIAMACHY measurements are available, preparatory work will be carried out including synthetic feasibility studies (activity 1). Once data are available mutual benefits are expected improving both the retrieval products and the source and sink estimates (activity 2). In a later stage the gained experience will be used to support promising new satellite missions (activity 3).

Time schedule

	2004	2005	2006	2007	2008
Activity 1	****	****	**	**	**
Activity 2		**	****	****	****
Activity 3				**	****

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	2	3	4	4	4
Yearly cost (kECU)	130	195	260	260	260

Likely funding agencies

BSIK, SRON-GO (National support programmes), and the EU.

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Improving Air Quality Modelling by Assimilation of Remotely Sensed Data

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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National Environmental Research Institute (NERI) operates an air pollution forecast model THOR. See these links respectively: www.air.dmu.dk, thor.dmu.dk

THOR is known as a reliable forecast and assessment system for describing the spatial patterns in meteorology and air pollution over Europe. A possibility to assimilate validated remote sensing data into the THOR model would undoubtedly improve the ability of the model to accurately forecast Northern Hemisphere Air Pollution. The THOR model presently forecast the atmospheric constituent: NO, NO_2, O_3, SO_2, SO_4, HCHO, CH_4, CO, Aerosols, H_2O and HNO_3. While BrO will be included later, for Hg modelling purposes.

THOR presently run a three-day forecast, every six hours. The model domain is the EMEP grid of the Northern Hemisphere. This 50 km by 50 km grid is subdivided in 3 by 3 sub-cells over Europe, providing a 16.6 km by 16.6 km model grid. The model is also used locally, in yet denser grids, to access concentrations of atmospheric constituents for input to various other models including assessments of pollution pressure on human health.

The aim of assimilating remotely sensed data into the THOR model is twofold. To improve the accuracy and reliability of the forecasts and assessments, benefiting not least persons with air ways diseases. And secondly, not but less important, to improve our understanding of the physical and chemical processes in the atmosphere.

The operational version of the THOR system includes assimilation of data from a number of ground measurement stations. Further inclusion of truly spatially distributed data from remote sensing would enable us to improve the accuracy and reliability of the system, especially in areas distant to ground measuring stations.

Specifically the THOR development team hopes to find improvements in the description of the O_3 and NO_2 concentrations by including data from GOME or SCIAMACHY, especially if data are available to support a 3-D O_3 description. In a longer perspective the preparations of ACE+ measurements of temperature and humidity are regarded as highly relevant.

Since THOR is based on, and validated against, ground station measurements it could serve AT2 with spatially distributed ground-truth values. These might be useful as validation of remote sensing data and procedures. Although the AT2 remote sensing products are already benefiting from calibration, this is commonly based on point measurements. THOR provides a complete cover (EMEP grid) data set with a number of parameters to be directly compared with remote sensing derived information. The THOR development group would be honoured to provide these data to ACCENT-AT2.

The presently proposed project supports the ACCENT objectives by providing contact to, and collaboration with an already recognised research group within atmospheric and air pollution science.

Funding

The initialisation of the projects is dependent on further funding. Potential sources are: NMR - Nordic Council of Ministers, National Research Council, Denmark and the EU Danish Environmental Protection Agency

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Validation of GEM-Chemistry Modelling and Data Assimilation System: A High Resolution Study

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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We propose to perform model validation and assimilate satellite data using GEM-chemistry modelling system developed by MAQNet and Meteorological Service of Canada.

The chemical weather model is based on the Canadian operational weather prediction model, the Global Environmental Multiscale (GEM) model (Côté *et al.* 1998). It is a global variable resolution primitive equation model using semi-implicit and semi-Lagrangian numerical techniques. The model can be run on a variable resolution regional grid with horizontal spacing ~15km. The meso-global version (~50km) will be available in 2005. Tropospheric air quality and stratospheric chemistry packages have been implanted on-line in GEM.

In terms of assimilation GEM can use both 3-D Var (operational at the Canadian Meteorological Centre since 1997) and 4-D Var. The 3-D Var system (Gauthier *et al.* 1999) can use either a non-separable and spectral representation of the error covariances, or a low-dependent representation from an ensemble perturbation method (Buehner 2004). The 3-D Var has also been modified to include an arbitrary number of chemical species in addition to the meteorological variables. At present the cross-error covariance between the chemical and meteorological variables is set to zero, but the code is designed to include the cross-error correlation whenever needed. The meteorological 4-D Var should become operational in 2005. It includes the TLM and adjoint of; 1) a simplified planetary boundary layer, 2) Kain-Fritsch moist convective parameterization, and 3) sub-gridscale orographic gravity wave drag. The 4-D Var online chemistry is currently under development at York University under the MAQNet grant.

Our unique contribution to AT2 will be in the area of high resolution model runs for selected case studies. We plan to utilize the high temporal and spatial (~50km global uniform and ~15km global variable) resolution model domains to characterize various biogenic and anthropogenic sources using data assimilation and inverse modeling techniques.

Technology developed under CFCAS grants are in public domain and will be available to EU scientists.

Funding

Canadian Foundation for Climate and Atmospheric Sciences (CFCAS)

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Synergystic Use of Satellite Data, Ground-based Observations, Back-trajectory Analysis and a Global CTM Results for Studies of Tropospheric Trace Gases and Aerosols over the Mediterranean

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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The project is a feasibility study of the synergistic use of satellite data, ground based observations over the Mediterranean, back trajectory analysis, box and global 3-D chemistry transport model results to evaluate the impact of distinct pollution sources (like urban pollution, biomass burning fires, *etc*) on oxidant and aerosol levels in the Mediterranean, the consequences on regional climate and the seasonal and inter-annual variations (since 1997).

Priority is given to the use of the European satellite products (like GOME (Global Ozone Monitoring Experiment) and SCIAMACHY (Scanning Imaging Absorption Spectrometer for Atmospheric CHartographY)). The ground based observations consist of the gas phase, aerosol data and auxiliary measurements at Finokalia monitoring station of ECPL as well as data regarding Mediterranean area and collected during EU funded projects (ADIOS, MOZAIC (aircraft data), *etc*).

Box models that have been developed by ECPL to study Boundary Layer chemistry will be applied to selected case studies to evaluate the potential of chemical built up of oxidants in the observed air masses. The global CTMs TM3/TM5 will be used to evaluate budgets of trace constituents with focus on East Mediterranean region after being evaluated against the observations.

Finally the satellite observations of aerosols and oxidants will be combined by the use of the CTM to evaluate the impact of aerosol on the oxidant levels in the area and its variability over the past 10 years by modifying the photodissociation rates of the oxidants and acting as surface for heterogeneous reactions. Selected case studies will be analysed on the basis of ground based aerosol chemical composition and oxidant observations and auxiliary data.

The short-term (18-month) objective within AT2 focuses on

- identifying the major reasons of variations of tropospheric O_3 in the East Mediterranean during spring (in 1999), and
- investigating the impact of European pollution on NO_2 and HCHO tropospheric columns in the area.

For the next year we plan to continue our study on O_3, HCHO and NO_2 analysis for the summer 2000 that was an intensive summer in terms of forest fires over Greece to define the fingerprint of these fires and their environmental impact. For this, we will examine satellite observations of NO_2, HCHO and CO in relationship to model predictions and in-situ observations.

On the longer term (5-year perspective), we will continue to exploit the combined benefits of satellite data and global chemistry-transport model capabilities as outlined above to understand and document the impact of distinct pollution sources on oxidant and aerosol levels in the Mediterranean, evaluate the potential impact of aerosols on oxidant levels and the consequences on regional climate, as well as the seasonal and inter-annual variations of these effects.

For most of these projects, we will be making increasing use of the satellite based GOME and SCIAMACHY data to analyse the tropospheric amount of the trace gases O_3 and its precursors NO_2 and HCHO as well as CO from MOPITT measurements and aerosols from MERIS.

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	0.2	0.5	1	1	0.5	0.5
Yearly cost (k€)	5	25	50	50	25	25

Likely funding agencies

Greek Ministry of Education, Greek Ministry of Development (General Secretariat of Research and Technology), European Union

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Evaluation of the Hydrological Cycle in Off- and Online Models using Satellite Measurements

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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An accurate knowledge of the 3-D water vapour (WV) field is essential for gaining an understanding of a variety of physical and chemical processes in the atmosphere and therefore one of the key parameters for the accurate modelling of climate forcing and its feedback mechanisms. WV plays an essential role in the direct and indirect effect of radiative forcing via its influence on aerosol optical properties and the formation of clouds and precipitation. In addition, the contribution of WV to the total radiative forcing budget and the various feedback processes however can still not be quantified accurately, due to its complex spectroscopic structure. Detailed parameterizations of aerosol optical properties and cloud formation in general circulation models (GCM) and chemical transport models (CTM) are currently on their way, but will significantly increase the demand for accurate knowledge of the 3-D WV distribution in the near future, as well as the demand for data for cross-comparison and model performance evaluation.

In this project a multi-sensor based 3-D water-vapour product will be developed using satellite remote sensing data from instruments situated on ESA's ERS-2 and ENVISAT and from the NASA Terra and Aqua satellite platforms. The main instruments on both platforms capable of providing water vapour (WV) over various surface types and for different parts of the atmosphere are GOME (ERS-2, Metop), SCIAMACHY, MERIS (all ENVISAT), MWR (ERS-2 and ENVISAT) and MODIS (Terra and Aqua). These instruments operate in a variety of wavelength regions from the visible part of the spectrum to the microwave region. They measure the back-scattered solar radiation or the emitted thermal radiation in either or both nadir and limb mode depending on instrument design. An optimized 3-D database will be constructed by evaluating the highest quality WV data product in 3-D space from a full information content study of the individual retrievals and by an optimized synergistic use of complementary data-sets. WV quantities will be provided in conjunction with covariance matrices to allow for an optimal assimilation of the data in numerical weather forecasts (NWP) and offline transport models as well as for sophisticated evaluation of general circulation online model output.

First 18 months project objectives (2004/2005)

Within the first year of the project, water vapour data from GOME will be used for the evaluation of model output parameters of the hydrological cycle with a special focus on the offline CTM Model of Atmospheric Transport and Chemistry (MATCH) and the GCM ECHAM 5. The evaluation results will play a key role in consequent studies of the direct and indirect effect of aerosol forcing as well as detailed studies of the role of the WV feedback in global warming. The study will define data gaps and instrument related drawbacks for model evaluations and will be used to set out a first scheme on how to combine various sensors for an optimized multi-sensor WV database product.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	Evaluation of Model output employing GOME data	Identification of data gaps and	Evaluation and testing of database			
Activity 2		Definition of a multi-sensor database scheme	Providing WV data for the modelling community			
Activity 3		Preliminary Model evaluations using MERIS, and MWR	Detailed 3D Model evaluations using MATCH and ECHAM	Model intercomparisons (in the framework of AEROCOM)		
Activity 4			Evaluating new sensors for use in database (AIRS, IASI)	Assimilation WVdata employing new high res. Sensors (MODIS, IASI, AIRS)	Studies on operational WV data assimilation in regional models	Operational assimilation of WV data in offline models

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	2	2	2	1	1
Yearly cost (kECU)	50	100	100	100	50	50

Likely funding agencies

DFG; Deutsche Forschungs Gemeinschaft, Bonn, Germany.

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Synergystic Use of Satellite Data with the Global Chemistry-Transport Model MATCH-MPIC for Studies of Tropospheric Trace Gases: Long-Range Pollution Transport

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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This project will build on the work started during the first TROPOSAT program, in which we used GOME O_3, NO_2, and CH_2O satellite data to evaluate MATCH-MPIC (Model of Atmospheric Transport and Chemistry – Max Planck Institute for Chemistry version) within the PhD thesis of von Kuhlmann (2001). We then extended our studies to various specific aspects of tropospheric NO_x, CH_2O and O_3 chemistry, in close collaboration with the Bremen group, resulting in a thesis focusing on NO_x over the southern Asian region (Kunhikrishnan, 2004), and several papers with lead authors from both sides. These studies have included modifying MATCH-MPIC to output results at 10:30 local time, corresponding to the GOME overpass, showing that the ratio of this output to the "standard" 24-hour average output typically varies between 0.4-0.9, with strong geographical and seasonal variations, and using this model output with the GOME data to analyze several aspects of the reactive nitrogen chemistry over India, including its seasonality, lifetime, and sensitivity to local surface emissions and lightning (Kunhikrishnan *et al.,* 2004a).

Our short-term (18-month) objective within AT2 focuses on using MATCH-MPIC together with satellite data to examine long-range transport of pollutants in the troposphere, particularly NO_x and CO. The first step in this work has been completed during the early months of AT2 and recently published (Kunhikrishnan *et al.,* 2003b), in which we have found in the GOME observations the existence of semi-annual plumes of NO_x originating from Africa and Indonesia which are present over the central Indian Ocean (CIO) during the monsoon transition periods (roughly May and September), with monthly mean NO_2 columns well above the GOME detection limit all the way across the CIO, which is rarely found over such extended maritime regions. We then used MATCH-MPIC, which is able to simulate the plumes, to examine its vertical structure and relationship to regional metoerology and chemistry. We plan to continue our study of pollution outflow from Asia, and to extend the focus to include transatlantic transport of pollution from North America to Europe, which will be examined in the ITOP campaign during July-August 2004. For this, we plan to examine satellite observations of NO_2 and CO in relationship to our predictions and in-situ aircraft measurements of pollution plumes; this work is intended to be done in collaboration with the AT2 project of N. Savage.

On the longer term (5-year perspective), we will continue to exploit the combined benefits of satellite data and global chemistry-transport model capabilities in various ways, which will include fully integrating satellite data into our standard evaluation dataset for new versions of the model, expanding on the work started in von Kuhlmann *et al.* (2003a,b). We will also be collaborating closely with the AT2 project of R. Lang on evaluating our simulated water vapor distribution. Finally, a major possible future step would be assimilating satellite trace gas observations into our operational chemical weather forecast system (Lawrence *et al.,* 2003); this is likely to start with CO from MOPITT and stratospheric O_3 from GOME as a boundary condition for stratosphere-troposphere exchange, and then to progress to tropospheric O_3, NO_2, and CH_2O columns once the retrieval algorithms are sufficiently advanced and rapid. For most of these projects, we will be making increasing use of the ENVISAT data, especially from SCIAMACHY.

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	0.25	0.5	0.5	0.5	0.5	0.25
Yearly cost (k€)	12.5	25	25	25	25	12.5

Likely funding agencies

German Ministry of Education and Research (BMBF), German Research Federation (DFG), European Union

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Aerosol Data Assimilation with the Unified EMEP model

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Within the framework of the ACCENT/TROPOSAT programme a number of activities are envisaged.

Ongoing improvement and development of the Unified EMEP model, with special emphasis on including all relevant aerosol sources and processes. This includes wind blown dust, see salt and biogenic and possibly also anthropogenic secondary organic aerosols.

Validation against both ground-based and satellite observations.

Development of a suited data-assimilation scheme around the EMEP model

Application and validation of the data assimilation system with emphasis on the use of satellite data.

Time schedule

	2005	2006	2007	2008
Activity 1	*	*	*	
Activity 2		*	*	
Activity 3	*	*		
Activity 4		*	*	*

Aims for the first 18 months

Improved LOTOS of the EMEP model and development of a proper data assimilation technique.

Long term goals

Development of a hemispheric and global version of the EMEP model. Routine use of satellite data.

Approximate manpower and cost

Two man-years per year, *i.e.* 333 kEUR

Likely funding agencies

EU-FP6 project GEMS; Nordic Council; EMEP

Co-workers

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The Synergistic Use of Satellite and High-Altitude Aircraft Data for the Study of Atmospheric Chemistry, Microphysics and Transport

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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The *Geophysica* aircraft is the only European research aircraft capable of reaching the lower stratosphere at all latitudes and in all seasons. It can cover, therefore, the altitude region where the error on satellite retrievals of trace constituents increases dramatically. The *Geophysica* is equipped to carry a wide range of in-situ and remote-sensing instruments. Some of the remote-sensing instruments are replicas of satellite instruments, thus offering the valuable opportunity to sense the environment using the same technology from different platforms.

The *Geophysica* will be deployed as part of the EC Integrated Program SCOUT-O3 in 2005/06, and has been deployed in several programs in 2000-2004. Future deployments are also likely, using national and European funding. Within each of the recent and upcoming deployments there exist opportunities for the synergistic use of satellite and aircraft data. We will use these opportunities for synergism to contribute to Task Group 2 of ACCENT-TROPOSAT 2. An example of the kind of work envisaged has already been published by Santacesaria *et al.* in *J. Geophys. Res.*, 2003.

We will also act within TROPOSAT as a point-of-contact with the *Geophysica* community as a whole, thus contributing to the "Access to Research Infrastructures" task of TROPOSAT.

Objectives: Months 1-18:

(i) modelling studies of water vapour transport through the tropical tropopause

(ii) comparison of model results with *in-situ* and satellite measurements of water vapour and clouds in the tropical upper troposphere, including participation in the EC TroCCiNOx 2 campaign

(iii) preparation for further aircraft campaigns in 2005-2006

Months 19-60: synergistic use of satellite and aircraft data, with models, to quantify water vapour transport and cloud processes

Approximate manpower and cost

Minimum costs of the activity will be met by existing funds. Developing the analysis, and reporting to TROPOSAT meetings, will require extra funding. Full funding of the activity would require 1 post-doctoral salary per year.

Likely funding agencies

The CEC and UK National Bodies (*e.g.* NERC).

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Global Measurements of Water Vapour in the Tropopause Region and Upper Troposphere with MIPAS/ENVISAT

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Since March 2002 MIPAS onboard ENVISAT performs measurements of atmospheric composition covering the mesosphere down to the upper troposphere. The scientific retrieval processor operated at IMK provides trace gas and temperature profiles which include the tropopause region and, for cloud free cases, the upper troposphere. Among other species water vapour in this region is of interest with respect to its influence on the radiative budget as well as for its use as tracer for transport processes across the tropopause.

At IMK a unique data set of water vapour measurements in the tropopause region exists for the time from September 2002 to November 2003. Further retrievals are foreseen to fully exploit the existing spectral data set of MIPAS measurements.

Together with modelled data these results shall be used to improve our knowledge on water vapour distribution in the UTLS and understand the role in climate change. Intrusion of air masses and water vapour into the lowermost stratosphere and the seasonal variation of transport processes will be examined on basis of single events and aiming to a climatology.

The obtained global distributions of water vapour shall be compared to GCMs (*e.g.* collaboration with DLR, Dameris). Differences and agreements between models and measurements shall be examined and understood.

Time Schedule

	2004	2005	2006	2007	2008
Activity	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel/man-years	1*	1	1	1	1
Yearly costs (kEUR)	60	60	60	60	60

Co-Workers

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Correlation Analysis of Global Tropospheric NO_2 Column Densities using Multiple Satellite Measurements

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Multiple satellite data will be used to estimate the relative contribution and geographical distribution of several NOx sources and to compare them to tropospheric NO_2 column densities measured by GOME and SCIAMACHY. Due to the short tropospheric lifetime of NOx, its global distribution strongly corresponds to the distribution of emissions, which allows a comparison of sources with tropospheric column densities.

1. As a proxy for anthropogenic emissions, we are using calibrated satellite measurements of the night-time lights of the world (Operational Linescan System (OLS), Defense Meteorological Satellite Programme, NGDC). A simultaneous examination of the different GOME tropospheric NO_2 evaluations together with the light-based and the EDGAR anthropogenic NOx source allows an estimation of the individual errors of the datasets and of the error covariance between the GOME evaluations. Emissions are transformed into column densities by using the global CTM MOZART-2. The information on the pattern errors allows us the construction of an improved anthropogenic NOx source distribution pattern with stated error estimate. These error estimations are based solely on correlation analysis of three independent data sources (GOME, OLS, EDGAR) and contain no potentially biased a priori error estimates.
2. The correlation techniques will be applied to the SCIAMACHY NO_2 tropospheric columns as soon as there is at least one year of global data available. We would like to evaluate possible improvements from the combined limb and nadir measurements.
3. Night time lights from the OLS instrument are available for the years 1992/1993 as well as for the year 2000 in order to detect anthropogenic changes. We are planning to compare these trends to shifts in the NO_2 tropospheric columns over anthropogenically influenced regions.
4. NOx emissions from biomass burning are a major source of atmospheric NO_2 but still are not well represented in global chemistry transport modelling due to their high annual and interannual variations. We will extend our analyses on novel estimations of biomass burning using satellite data from GOME, SCIAMACHY, ATSR, and MODIS. This work should also make use of other trace gases measured from satellite (CO, CH_4, formaldehyde *etc.*).

Time schedule

	2004	2005	2006	2007	2008
Activity 1	*				
Activity 2	*	*	*	*	
Activity 3		*	*		
Activity 4			*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	1	0.5	0.5	0.5	0.5
Yearly cost (kECU)	50	25	25	25	25

Likely funding agencies

Forschungszentrum Jülich

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Use of Satellite Data to constrain Ozone Budgets in Global Tropospheric Chemistry Models

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Our aim within the frame work of TROPOSAT is to develop the synergistic use of satellite and other observation for global chemistry-transport model performance quantification and development. It has already been observed that there are regional differences in correlations between global models and GOME. We plan to investigate these differences in more detail through the use of multi-annual model integrations, comparing model results to GOME, MOPITT and other satellite data and investigating model and satellite inter-annual variability. It is also intended to investigate validation of new emission inventories using satellite data (see Figure 1 below).

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	0.17	0.17	0.17	0.17	0.17
Yearly cost (kECU)	9	9.5	10	10.5	11

Likely funding agencies

UK National Bodies (*e.g.* NERC), European Union.

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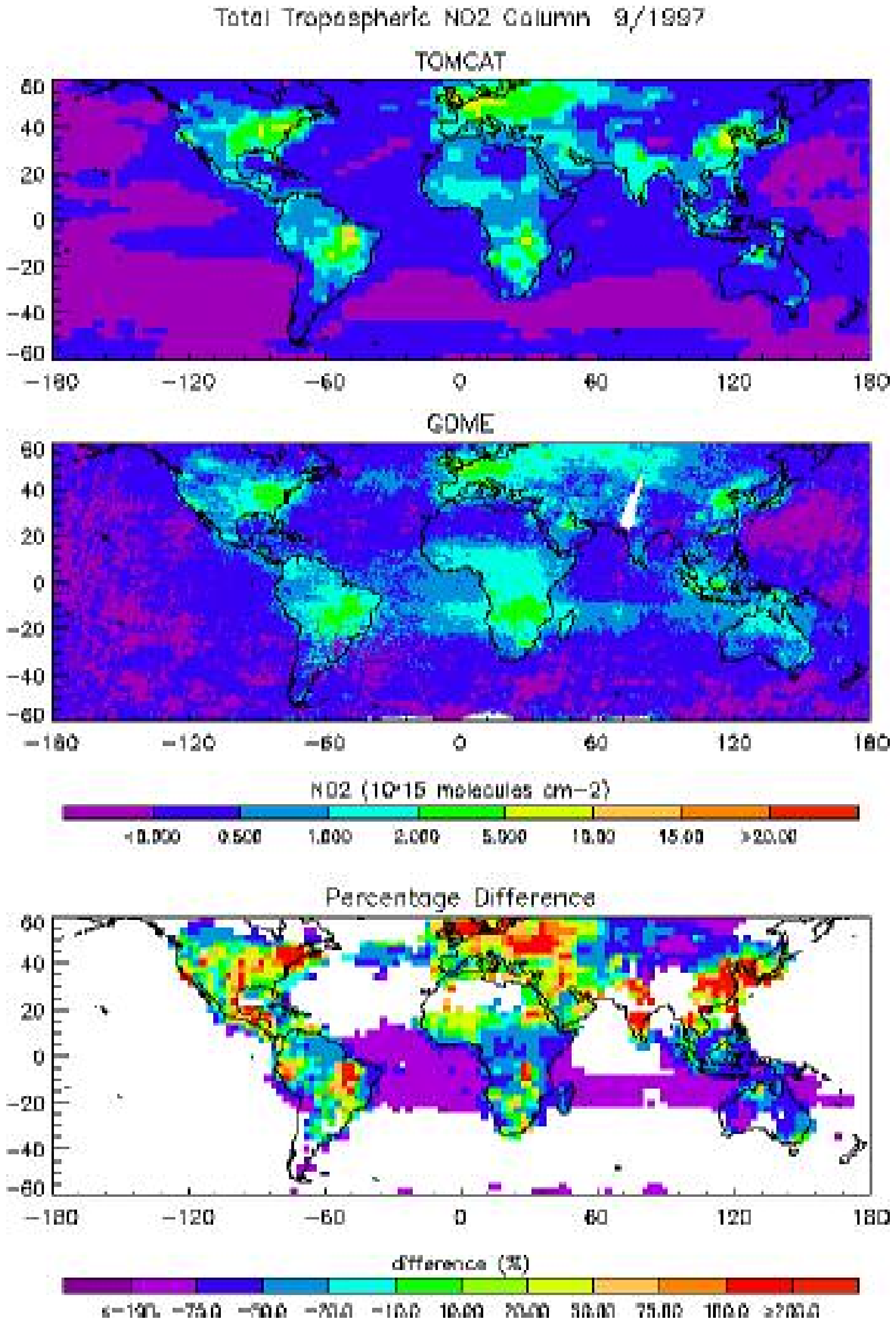

Figure 1. Monthly mean tropospheric NO_2 column and percentage difference between TOMCAT model results and GOME retrieval. Note that the model is much higher than GOME for polluted areas such as Central Europe but the model does not show the plume of NO_2 from central Africa into the Atlantic seen from the GOME data. Taken from N. H. Savage, K. S. Law, J. A. Pyle, A. Richter, H. Nuess, J. P. Burrows: Using GOME NO_2 satellite data to examine regional. *Atmos. Chem. Phys*. **4** 1895-1912, 2004

Integrated Use of Satellite and Non-Satelite Measurements to Study the Upper Tropospheric Humidity

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Through the integrated use of satellite and non-satellite (ground based, aircraft, and balloon) observations it is our intention to investigate the large scale distribution of upper tropospheric humidity (UTH) and the processes controlling it, aiming to increase the diagnostic and prognostic strength of numerical model simulations of chemistry, weather and climate of the atmosphere.

In the first phase of TROPOSAT we developed a concept to study the UTH distribution in the outflow of deep convection through the synergistic use of MOZAIC (Measurement of Ozone and Water Vapour by Airbus In Service Aircraft) UTH observations with satellite data of sea surface and cloud top temperatures. The concept had been applied successfully to the equatorial Atlantic region. It is now the intention to extend the investigations more globally. Therefore a two-step approach of assimilation of data from different platforms (satellite and non-satellite) will be followed:

1. Development and synthesis of an integrated data set of UTH observations with the best global coverage through the use of the MOZAIC passenger aircraft platform, providing accurate and quality assessed in-situ UTH measurements, to validate/calibrate water vapor channels of different satellite instruments (*e.g.* SCIAMACHY). Further, it is envisaged in how far UTH-measurements made with the new generation of radio weather sondes are of sufficient quality to use in addition.

2. Investigations of the meso and large scale variability of UTH through the synergistic use of the integrated data set of UTH observations together with synoptical observations of surface temperature and thermodynamic properties of the atmosphere (air temperature, cloud characteristics *etc*.) made by satellite platforms. The investigations will focus on the tropical regions.

Note: At the moment the research is not funded, it will be attempted in Autumn 2004 to get external funding (*e.g*. PhD student) to do the investigations.

Synergistic Use of Satellite Data with the Global Chemistry-Transport Model GEOS-CHEM: Formaldehyde column over Europe as a Proxy for Biogenic Emissions and CTM Validation using Satellite Data

A contribution to ACCENT-TROPOSAT-2, Task Group 2

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Objective 1

We intend to use data analysis from GOME to retrieve formaldehyde (HCHO) data. Formaldehyde is a very important intermediate oxidation product of VOC of anthropogenic and biogenic origin. Preliminary results suggest that the formaldehyde column over Europe is underestimated by the state-of-the-art chemistry and transport model GEOS-CHEM with respect to GOME column (Figure 1), possibly indicating biases in model VOC emissions.

The HCHO column could be also used to estimate the sources of isoprene (a major biogenic VOC) in the European continent, at least in Eastern Europe where the isoprene contribution to the HCHO column seem to be predominant from model results (Figure 2 and caption). These sources could be compared with existing inventories and with those obtained during measurement campaign.

Objective 2

We intend to develop new method to validate Chemical Transport Models and to assess their capability to reproduce natural variability. Following a technique outlined for the thermal Earth radiation we propose to compare the radiative covariance from synthetic spectra from models with covariance obtained from observed spectra. For a spectra the covariance is calculated between the different spectral channels and from that EOFs are obtained. The principal EOF components will give a quantitative estimation of the variability. Chemical fields from CTM will be used to calculate synthetic spectra and then EOF. These will be compared with real spectra obtained in the same condition. In particular we have in mind in data from SCIAMACHY.

Acknowledgement for GOME data: P. Palmer and M. Fu (Harvard University), K. Chance and T.P. Korosu (Harvard-Smithsonian Center for Astrophysics).

Time Schedule

	2004	2005	2006	2007	2008	2009
Objective 1	***	***	***	**	**	
Objective 2	***	***	**	**	**	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel/man-years	3	3	3	3	2	1
Yearly cost (kEuro)	90	90	90	90	60	30

Likely Funding Agencies

Italian Space Agency, European Community

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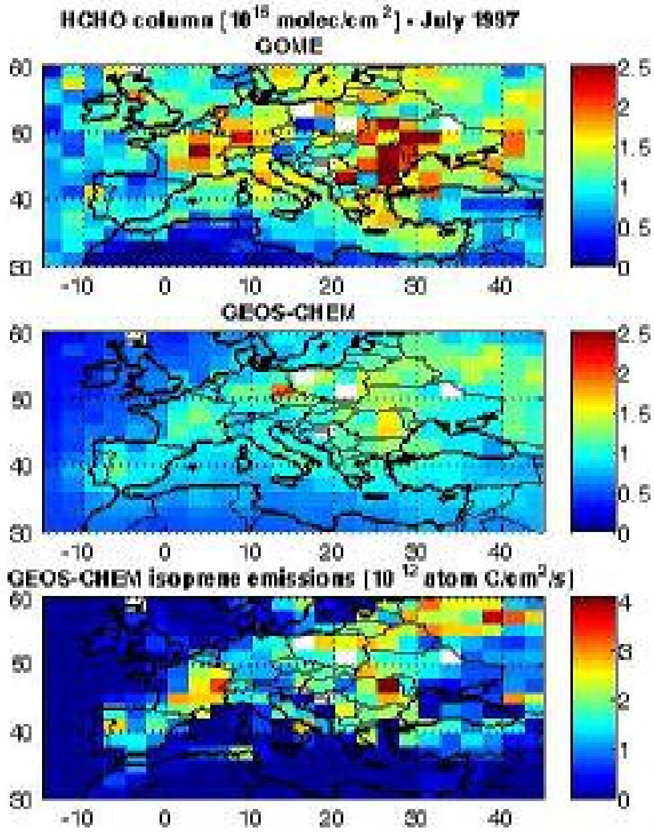


Figure 1. Upper panel: monthly mean formaldehyde column over Europe as retrieved from the GOME instrument onboard the ERS-2 satellite during July 1997. Middle panel: same as above but from model results (GEOS-CHEM). Bottom panel: monthly mean isoprene emission in the model for July 1997. Isoprene is the most important biogenic VOC and a major precursor of HCHO.

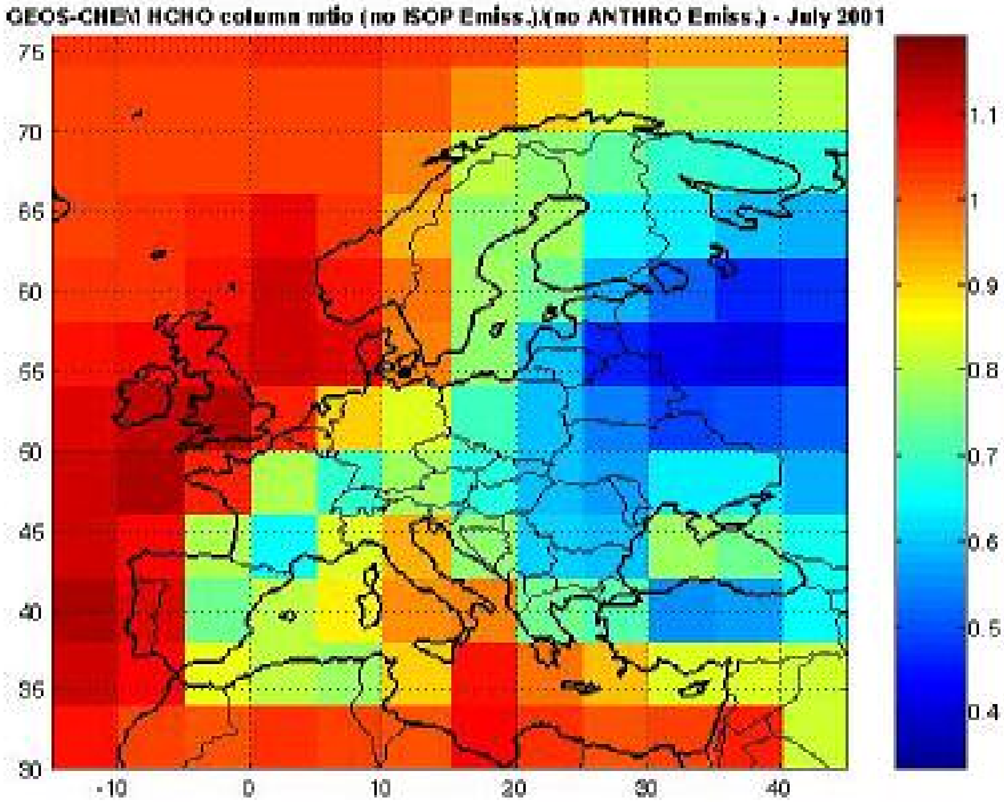
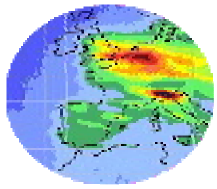


Figure 2. Formaldehyde column ratio between two model runs: the first with isoprene emissions switched off (no ISOP emission), the second with anthropogenic emissions switched off (no ANTHRO emission.). Blue colours indicate a prevalence of isoprene emissions in controlling the HCHO column, dark red a prevalence of anthropogenic emissions, yellow-orange an intermediate condition.



Contributions from Task Group 3

Validation of SCIAMACHY CO, CH_4, and CO_2

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The validation of the SCIAMACHY CH_4, CO, and CO_2 total columns by comparing them to i) atmospheric chemistry model calculations (using the TM3 and TM5 models), ii) ground-based measurements, and iii) measurements by the EOS-TERRA instrument MOPITT. The comparison of the SCIAMACHY data with atmospheric chemistry model calculations gives a first qualitative validation of the retrieved products. The emphasis in such a comparison will be the detection of concentration gradients in space and time caused by strong emissions and/or atmospheric transport. Ground-based measurements from the NDSC network will be used to locally validate the SCIAMACHY total columns. Validation using the already partly validated MOPITT measurements will be done by comparing the SCIAMACHY and MOPITT (near) simultaneous co-located observations (see Figure 1). Extended global validation of non-co-located measurements will be achieved by the use of chemistry transport models data assimilations. Techniques will be developed to combine the information from all three validation methods to give an overall accuracy of the total column products. A close collaboration with the AT2 Task Group 1 proposal “Retrieval of SCIAMACHY CO, CH_4, and CO_2 ” will be employed.

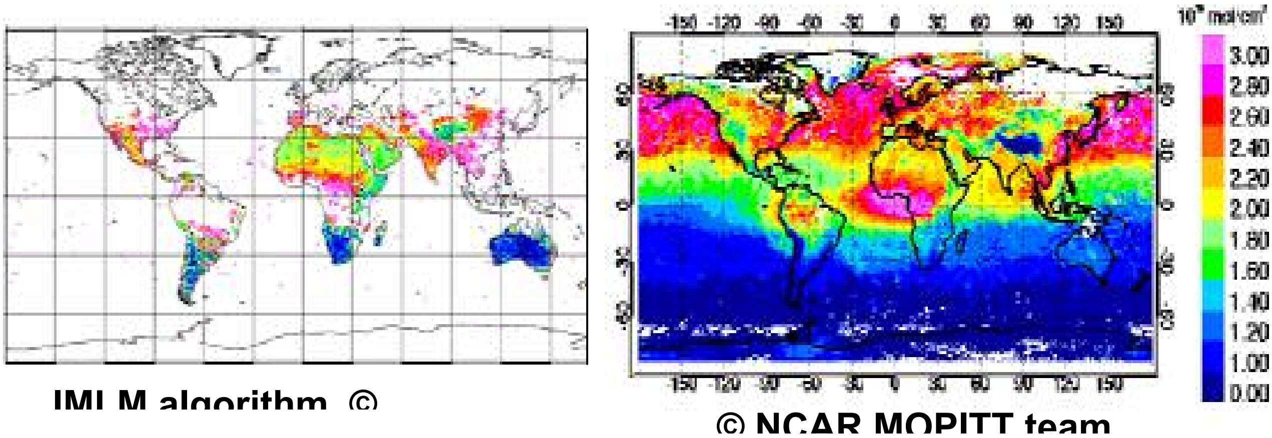

Figure 1: Global fields of monthly averaged SCIAMACHY CO retrieved with the IMLM algorithm for February 2004, compared with MOPITT CO for the same month.

18 months objectives

Comparison of SCIAMACHY CO, CH_4 and CO_2 total columns with atmospheric chemistry models and measurements from the MOPITT instrument for a couple of months in 2003/2004.

Time schedule

	2004	2005	2006	2007	2008	2009
All Objectives	**	**	***	***	***	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	1	0.75	0.75	0.75	0.5
Yearly cost (kEuro)	65	65	50	50	50	35

Likely funding agencies

NIVR Netherlands Agency for Aerospace Programmes, the SRON/NIVR National User Support Programme (SRON-GO), and the EU.

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Satellite Validation using Ground Based Spectroscopic Techniques

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The major contribution from the Optical Remote Sensing group at Chalmers is to participate in the development of validation strategies and the validation of tropospheric satellite data products using existing data.

Since 1994 the group has been operating a ground-based high resolution Fourier Transform Spectrometer for Solar spectroscopy at the site Harestua (60^{o}N, 11^{o}E) in southern Norway, as part of the global network NDSC. The work involves development of optimal strategies for comparing total columns and profiles from satellites with corresponding entities derived from ground-based FTIR spectra, hereby taking into account the different vertical resolution, averaging kernels and viewing geometries of the two techniques, and focusing on the troposphere.

In a second project a strategy for satellite and model validation will be developed based on a mobile and stationary UV-VIS/IR systems. The idea is to use direct and scattered Sunlight to derive total columns of tropospheric molecules averaged over distances comparable to the grid-size obtained from satellites and used in GCM models. In specific we will concentrate on emissions from the Megacities Mexico City and Beijing.

We are presently involved in establishing a network of MAX-DOAS instruments on actively degassing volcanoes (NOVAC, Network for Observation of Volcanic and Atmospheric Change). The main purpose of this network is monitoring of SO_2 and BrO emissions for volcanic risk assessment. However, the data will also be exploited for satellite validation, constituting our third contribution to TROPOSAT.

Approximate manpower and cost

	2004	2005	2006	2007	2008	2008
Personnel / man-years	1	1	1	1	1	1
Yearly cost (kECU)	70	70	70	70	70	70

Likely funding agencies

CEC; Swedish National Space Board, The Swedish Research Council

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Validation of OMI Data Products

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The Ozone Monitoring Instrument (OMI) is a Dutch-Finnish contribution to NASA's EOS-Aura satellite now scheduled for launch in June 2004. OMI is a new instrument, with a heritage from the European satellite instruments GOME, GOMOS and SCIAMACHY. The unique capabilities of OMI for measuring important atmospheric trace gases with a small footprint of 13×24 km^2 and daily global coverage, in conjunction with the other Aura instruments, will make a major contribution to our understanding of stratospheric and tropospheric chemistry and climate change. OMI will provide data continuity with the TOMS instruments and will be essential to continue the 25-year ozone record of TOMS.

The following data products are foreseen for the OMI-instrument: (1) total columns of the trace gases ozone, NO_2, BrO, OClO, HCHO and SO_2; (2) ozone profile; tropospheric ozone and tropospheric NO_2 column data; (3) the spectral aerosol optical depth, including information on aerosol concentration, aerosol size distribution and aerosol type; (4) cloud coverage and cloud height.

The following contributions of OMI validation to ACCENT-TROPOSAT-2 are foreseen:

1. The validation of OMI data products will greatly benefit from the upcoming "Announcement of Opportunity for Calibration and Validation of OMI Data products" that will be jointly issued this summer (2004) by ESA, NIVR and KNMI, and supported by NASA. The primary objectives of this announcement are (i) a comprehensive validation of OMI data and (ii) cross calibration and validation of OMI data with ESA data. The secondary objective is to perform early scientific investigations based on early-validated OMI data products. By presenting the OMI-AO to the AT-2 community we intend to bring OMI under the attention of the European atmospheric community and we encourage interested researchers to join us in validating OMI data products.

2. We also intend to initiate new ventures with the participants in the AT-2 network that will supplement OMI validation and early scientific investigations based on early-validated OMI data products. For example, OMI data products validation will greatly benefit from ground based and airborne measurements performed with the MAX-DOAS instruments as developed by the Universities of Heidelberg and Bremen. Ground based DOAS measurements provides day-time recording of correlative total columns of OMI products, whereas airborne DOAS measurements provides correlative tropospheric and stratospheric columns of OMI data products.

3. During the AT-2 meetings and workshops we intend to present the results of KNMI validation activities of the following OMI products; columns of ozone and NO_2, aerosols and clouds, and ozone profiles. We will also present updates on the validation results obtained for all other OMI products (i) within the OMI science team and (ii) within the OMI validation AO.

Time Schedule

	2004	2005	2006	2007	2008	2009
OMI-AO	*	*	*	*	*	*
Validation Campaigns	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	2	2	2	2	2
Yearly cost (kECU)	5	10	10	10	10	10

Reported costs are travel expenses only

Likely funding agencies

Netherlands Agency for Aerospace Programs (NIVR)

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Intercomparison of Long-term Trends of Key Greenhouse Source Gases in the Troposphere, Determined Remotely and *In Situ* from Ground Validation of Related Records from Space-based Sensors

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The long-term evolution of the chemical composition of the Earth's troposphere is a key element in understanding the climate- and the ozone layer changes, and in assessing the adherence and compliance to international Conventions (*i.e.* Vienna, Rio) and the adequacy of related Protocols (*i.e.* Montreal, Kyoto) to warrant a durable and sustainable environment for mankind.

During the five-year time span of the AT-2 program, the GIRPAS (Groupe Infra-rouge de Physique Atmosphérique et Solaire) of the University of Liège (ULg) envisages to:

1. expand the long-term solar observations performed with FTIR (Fourier-transform infra-red) spectrometers at the Jungfraujoch station (Switzerland) to retrieve total and in most cases partial (tropospheric versus stratospheric) column abundances of source gases affecting the climate and/or the stratospheric ozone layer. Key target source gases include species with large global warming- and/or ozone depletion potentials (*e.g.* CO_2, CH_4, N_2O, CFC-11, CFC-12, CCl_4, HCFC-22, SF_6), as well as others affecting the oxidizing capacity of the troposphere and the atmospheric aerosol layer, or reflecting the occurrence of forest fires (*e.g.* CO, C_2H_6, C_2H_2, OCS, HCN, HCOH, HOCOH).
2. analyse these databases to derive related temporal changes (both short- and long-term) in the tropospheric loadings and compare the latter with similar findings available from other ground-based sites, preferably within the context of both remote and in situ network-type activities (such as the NDSC, AGAGE, NOAA/CMDL,...); maintain interactions with spectroscopy groups, in order to gain guidance in the selection of the most accurate spectroscopic parameters needed in the remote sensing retrieval processes.
3. establish rationales to compare above data sets with measurements derived from observations by space-based sensors (*e.g.* MOPITT, MIPAS, SCIAMACHY, ACE, AURA, IASI,...); a particular AT-2 validation effort will deal with the study of tropospheric ozone (O_3) and formaldehyde (HCOH) in support of the AURA-OMI experiment.
4. ensure synergy with modelling activities (*e.g.* at U. of Leeds, U. of Oslo, MPIC-Mainz), in order to assess consistency between observations and predictions and to identify species-specific processes at work in the troposphere; also to perform some global assimilation of ground- and space-based ensembles of measurements, and to update predictive scenarios.

Time schedule

All above activities are expected to proceed during the full period (2004-2008) of the project.

Approximate manpower needed to support the participation to AT2

	2004	2005	2006	2007	2008
Personnel (man-year)	25	1	1	1	1
Yearly cost (kEUR)	15	60	60	65	65

Likely funding sources

Belgian Federal Science Policy Office; ESA-Prodex; EC-Research Directorate.

Some proposed activities are part of the overall research work performed by ULg-GIRPAS within the frame of national and international programs (among which are the Belgian Global Change, and the EC-SOGE and -UFTIR projects) and collaborations; related contributions to AT-2 will depend on the levels of funding received.

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Novel Techniques for the Retrieval of Tropospheric Composition from Space

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The University of Leicester EOS group has an interdisciplinary research program looking at the measurement and interpretation of data from EO systems for application to science issues in relation to tropospheric composition. In the main, the work will focus around novel techniques for the retrieval of tropospheric composition from space coupled to integration of synergistic satellite data sets for understanding tropospheric processes. These activities span a number of the AT 2 task groups. The primary contributions will centre on

The determination of the effect of changes in greenhouse gas concentrations on the Global Earth Radiation budget (Task Group 2). The objectives of this work are to investigate the role of greenhouse gases in the Earth's radiation budget using radiative transfer modelling, to asses how greenhouse gas measurements from satellite (in particular from SCIAMACHY) can improve our knowledge of the radiation budget and to compare model calculations with satellite borne measurements of the radiation budget from the GERB instrument (see Figure 1).

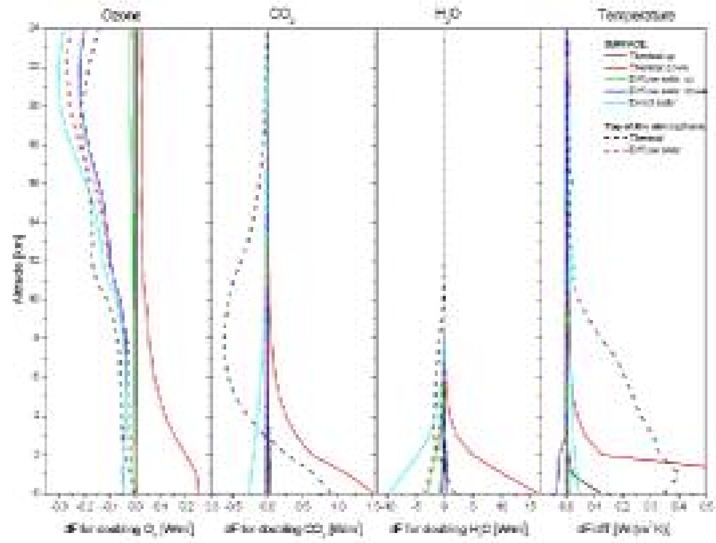

Figure 1: Modelled weighting functions for up- and down-welling solar and thermal flux at the surface (solid lines) and at the top of the atmosphere (dashed lines), illustrating the sensitivity of the radiation budget on atmospheric parameters at different altitudes.

There is growing interest in the potential to measure greenhouse gases from space. The ability to retrieve CO_2 and CO from SCIAMACHY NIR data using Weighting-Function Modified (WFM) DOAS and optimal estimation (Task Group 1) will be assessed. This technique is in early stages, but has the potential to produce novel measurements of CO_2 and CO from data in the NIR.

The development of residual methods for retrieval of tropospheric composition from spac, using synergistic measurements from multiple satellite instruments (*e.g.* GOME, TOVS, MIPAS, TOMS and SCIAMACHY), the validity of retrieving trace gas concentrations, in particular ozone, using residual methods will be assessed (Task Group 2). The MIPAS ozone profile down to 12 km will be validated against data from the SHADOZ network.

The application of Concurrent Multi-Axis DOAS (CMAX) measurements of ozone and NO_2 to satellite validation will be explored (Task Group 3). The effect of the spatial variability of stratospheric ozone and NO_2 on ground-based measurements will be investigated particularly with respect to the implications for satellite validation activities. The MAX-DOAS instrument installed in Leicester currently recording one minute time resolved dataset of tropospheric and stratospheric NO_2 and ozone will be used (see Figure 2). Comparisons with tropospheric and stratospheric satellite measurements will be part of the ongoing instrument characterisation.

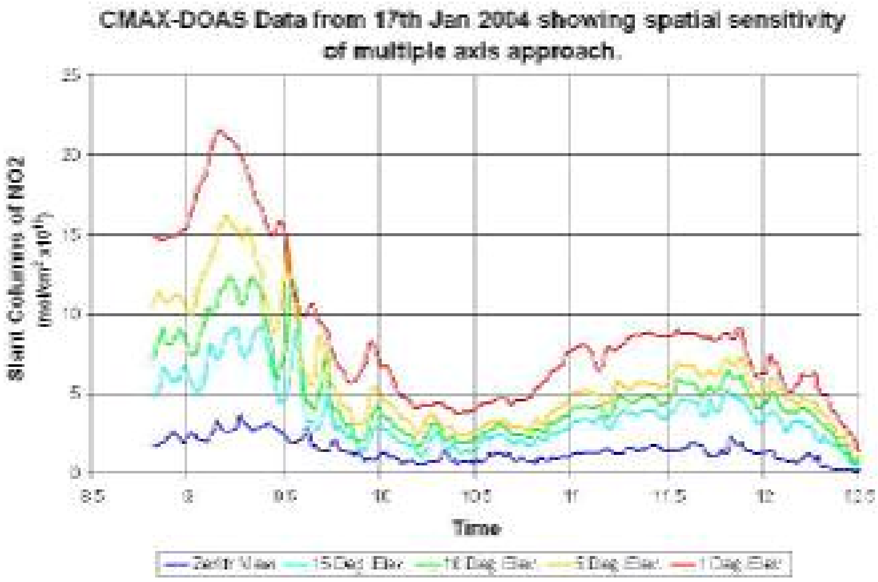

Figure 2: Slant Columns of nitrogen dioxide as measured by the Leicester CMAX-DOAS system, showing the detection of separate air masses (by resolving individual peaks), and providing an indication of dynamical motion (by the temporal shift in peaks)

Development of novel concepts for measuring the troposphere from space. As an underpinning activity within AT2, the development of new satellite observing strategies for the troposphere such as GEOSCIA for the measurement of the troposphere from geostationary orbit will be investigated. Mission concepts will be developed and tested for the measurement of high spatial and temporal resolution tropospheric composition data from space. The activities to be included in AT2 will be in addition to the developing mission concepts to develop and test the relevant science case, develop technical and scientific trade-off matrices, test prototype hardware and contribute to ESA studies (*e.g.* PROMOTE and CAPACITY) in relation to this topic.

Time Schedule

	2004	2005	2006	2007	2008
Activity 1	***	***	**	**	*
Activity 2					
Activity 3	***	***	***	*	*
Activity 4	***	**	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man years	2.0	2	1.0	0.5	0.25
Yearly Cost (kECU)	30,000	30,000	15,000	7,500	3,750

Likely Funding Agencies

CEC, UK national funding bodies (*e.g*. NERC, EPSRC, BNSC) and ESA

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Ground-based Remote Sensing Observations of Atmospheric Trace Gases, Validation and Complementary Observations for Space-borne Sensors

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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Long term observations of atmospheric trace gases on a global scale are an important part within ACCENT. The remote sensing group of the University of Bremen in cooperation with the Alfred-Wegener-Institute performs ground-based observations of atmospheric trace gases at several stations using the FTIR and microwave (MW) spectrometry. The FTIR-spectrometry allows us to measure the total column concentrations of about 20 trace gases. For a several of them the concentration profiles can be retrieved from the ground up to about 30 km with a vertical resolution of 4-8 km. The MW spectroscopy covers the stratosphere up to 60 km and complements the FTIR observations. FTIR and MW observations have been used successfully for the validation of satellite sensors. Furthermore, with their spatial and temporal resolution they increase the information content of the global satellite observations.

We propose to include the following observations within ACCENT-TROPOSAT-2.

Arctic: Ny-Ålesund, Spitsbergen (78 °N); FTIR and MW since 1992.

Arctic: Summit, Greenland (72 °N); MW since 2003.

Mid-latitudes: Bremen, Germany (53 °N). FTIR and MW since 2000.

Ship cruises on the Atlantic (typically 50 °N to 30 °S), up to now 6 cruises since 1994.

Tropics: Merida, Venecuela (8 °N) /Paramaibo, Surinam (6 °N), MW started in 2004, FTIR is planned to start at the end of 2004.

Within the frame of ACCENT-TROPOSAT-2 we suggest to perform the following activities.

1. Perform measurements at all stations and analyse the spectra in a consistent way to enable the direct comparison of the results from all stations and with observations performed by other groups. Retrieve the total columns and concentration profiles of long-lived (CFC-12, CFC-22, SF_6, CH_4, N_2O, CO_2) and shorter lived trace gases (CO, C_2H_2, C_2H_6, CH_2O, OCS, HCN, O_3).
2. Derive the seasonal or latitudinal variabilities of tropospheric trace gas concentrations at the stations.
3. Investigate the variabilities at each station with respect to, for example, nearby local emission sources (Bremen), transport of biomass burning plumes and interhemispheric differences (ship cruises, Venecuela/Surinam), or long range transport of pollutants to remote areas (Spitsbergen, Greenland).

4. Interpret the data together with existing *in-situ* data (*e.g.* AGAGE, NOAA/CMDL) and satellite data (*e.g.* SCIAMACHY, MIPAS, MOPITT, HALOE, TES, ACE) considering the specifics of each station.
5. Form a common data set that can be used by models. Make the data set available to the public.

Funding sources

EC projects, national funding, University funding. The activities will be part of existing projects (*e.g.* STAR, SOGE, UFTIR, RAMAS).

Time schedule

The activities proposed are expected to be continued on a long-term basis, covering the whole time period of ACCENT.

Co-workers

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Use of Satellite Data for Atmospheric Pollution and Greenhouse Gases Monitoring

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The NILU contribution to the TROPOSAT activities aim at validating satellite data products in order to gain understanding of atmospheric processes. In particular, we plan to use and validate the existing tropospheric ozone measurements from ENVISAT/SCHIAMACHY (*e.g* produced at U. of Bremen). Surface ozone from the EEA network, ozone sondes and column ozone measurements as well as meteorological data would be used to look at high tropospheric ozone episodes, like the one that occurred over Europe in summer 2003.

The European summer of 2003 was exceptionally warm, especially over central Europe, and characterised by persistent anticyclonic conditions. In addition, punctual heat waves associated with blocking phenomena, lead to soaring ground temperatures, particularly in the first half of August 2003. Surface ozone observations reveal extensive episodes of high ozone concentrations, that were long lasting, strongly affecting the summer mean. These exceptional meteorological conditions led to serious health problems in France and other countries.

It has been suggested that extremely warm summers may become more common in the coming decades, with important consequences on air quality in the changing climate.

We would assess the potential use of satellite data in a case study of the summer 2003, to see how such data could complement the scientific inferences derived from the limited surface ozone network.

Secondly, in the long term, beyond the first 18 months of the project, we have an interest in the development of new satellite observing strategies for monitoring greenhouse gases and atmospheric pollution. Of particular interest is the use of the geo-stationary orbit (*e.g.* GEOSCIA mission).

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	*	*	**	**	**	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	0.5	2	2	2	2	2
Yearly cost (kECU)	5	20	20	20	20	20

Likely funding agencies

CEC; Norwegian Science Foundation

Co-workers

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Validation of NO_2 Tropospheric Column from Space in the Po valley, Italy

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The target of this contribution to the TROPOSAT program is to validate the tropospheric NO_2 measurements from space in the Po valley region. The Po basin in Northern Italy is one of the main NO_2 source area in Europe. Its orography (surrounded by the Alps from north and west and by the Apennines from south) contributes to maintaining the pollutants near the source regions for several days often causing very high NO_2 concentrations. Measurements from space could be important to study the transport of NO_2 from such hot spots and to monitor regions not covered with ground instrumentation. But, of course, validation of the satellite products is required. Determination of the NO_2 tropospheric column amount from satellites (GOME and SCIAMACHY at present, but also other missions in the near future, as OMI and GOME-2) is quite a new approach and monitoring the troposphere from space is often difficult as several factors such as albedo, clouds, sensibility to the lowest atmospheric layers (where actually pollution is produced), aerosols etc. have influence on the retrieved NO_2 amount. In this scenario validation means finding a methodology to give a correct interpretation to the satellite measurements and use them, combined with ground observations, to study the tropospheric chemistry. Ground-based remote sensing measurements of NO_2 using UV-Visible spectrometers and in situ NO_2 concentrations (from regional service measurements and from remote sensing instruments) will be used to compare and integrate the satellite information. Meteorological parameters and models will be used to estimate the possible vertical distribution of pollutants within PBL. The activity can be thus summarized as follows

1. Data analysis from ground-based stations to retrieve NO_2 column in the PBL (by means of DOAS observations) and *in situ* concentration in representative sites. The PBL column, Figure 1, is obtained using simultaneous DOAS zenith sky observations in Bologna (50 m a.s.l.) and Mt. Cimone (2165 m a.s.l.).
2. Validation of the satellites tropospheric NO_2 measurements, mainly GOME and SCIAMACHY (processed by Task group 1) in the first period and also other platforms (OMI, GOME-2) in subsequent years.
3. Study of the integration of satellite measurements within the environmental regional service monitoring.

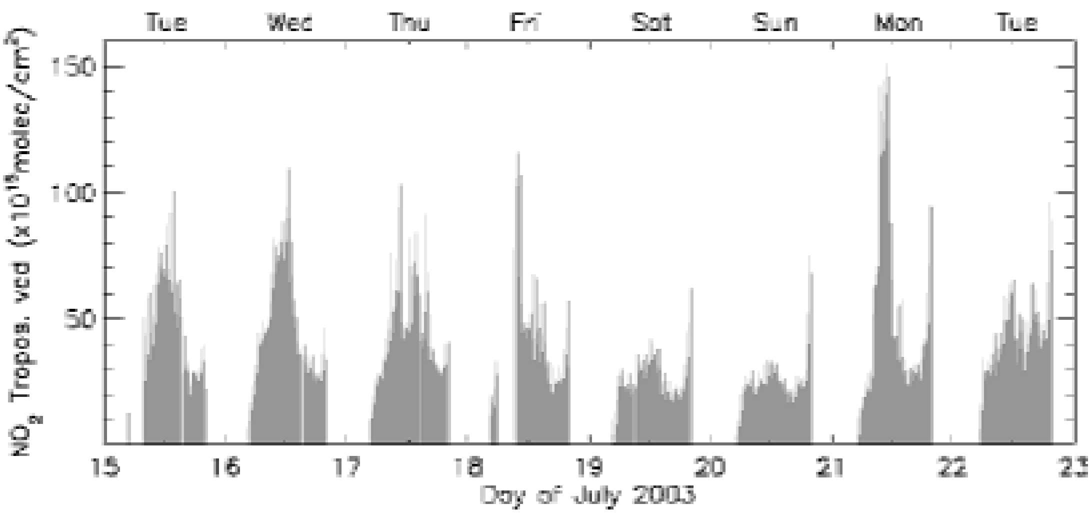

Figure 1: NO_2 column in the PBL (50-2165 m a.s.l.) observed in Bologna between 15th July 2003 and 22nd July, 2003.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	***	***	***	**	*	*
Activity 2	**	***	***	**	*	*
Activity 3		*	***	**	**	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1.2	1.2	0.5	0.5	0.5	0.5
Yearly cost (kECU)	60	60	30	30	30	30

Likely funding agencies

Italian space Agency (ASI)

Co-workers

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Validation of SCIAMACHY products

A contribution to ACCENT-TROPOSAT-2, Task Group 4

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The objective this task is to coordinate and contribute to the geophysical validation of tropospheric satellite data products from SCIAMACHY. This concerns both official ESA products as well as products derived by various scientific groups.

The coordination of validation is necessary to ensure that the quality of all products has been sufficiently assessed for its use and any data release to the scientific community is accompanied by a detailed description of the knowledge of the systematic and random errors. To this end SCIAVALIG (SCIAMACHY Validation and Interpretation Group) has set up a system with product coordinators for each SCIAMACHY product. The product coordinators are responsible for generating an overview of the error-behaviour of their products, using the inputs from the validation teams. Furthermore, a validation plan has been written that describes in detail the activities planned to ensure a proper validation of SCIAMACHY. It gives information on the organisation, coordination, communication, data-distribution and responsibilities. It provides an overview of the activities and planning in the different phases of validation. This document is written primarily as a source of information for the validation scientists.

The original schedule for the validation has been delayed leading to a still considerable validation effort at present (2004), two years after launch. The next phase is the long-term validation, which focuses on stability of the product quality and delta-validation of product updates.

The central SCIAMACHY validation website (http://www.sciamachy-validation.org/) contains information on *e.g.* time schedules, meetings and workshops, data access, validation tools and gives access to SCIAMACHY validation documents and links to other relevant web sites. A large part of the validation website is a password protected discussion site, where the validation results are posted. The web site is expanded with pages for scientific product validation.

The contribution of this activity to ACCENT-TROPOSAT is to provide a regular overview of the status of the SCIAMACHY products regarding their quality assessment and to point out product deficiencies that require solutions in the field of instrumental aspects, level 1, retrieval or data assimilation. On the other hand, AT2 will offer new and improved SCIAMACHY products affecting validation plans. The large overlap between the AT2 and SCIAVALIG communities ensure a timely and effective interaction.

Time Schedule

	2004	2005	2006	2007	2008	2009
Validation coordination	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	2	2	2	2	2
Yearly cost (kECU)	5	10	10	10	10	10

Reported costs are travel expenses only

Likely funding agencies

The Netherlands Agency for Aerospace Programs (NIVR) funds the Dutch SCIAMACHY validation effort for the period 2003-2005. Funding through EU FP6 will be attempted.

Co-workers

Piet Stammes, Renske Timmermans and Hennie Kelder.

Establishment of an Integrated Ground Truthing Station for Satellite Data Products

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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The aim of this PI contribution is to improve the capabilities for (i) validating satellite data products in the field of tropospheric atmospheric chemistry, aerosols and meteorology and for (ii) providing independent input-information for improving the trace-gas retrievals from satellite measurements by establishing and operating an "Integrated Ground Truthing Station - IGTS" at Zugspitze/Garmisch, Germany (47 °N, 11 °E) including *in-situ*, ground based remote and aircraft measurements in combination with transport modelling activities.

IGTS consists of two fully operational stations, at Zugspitze (2964 m) and Garmisch (734m) which are operated on a permanent basis, and are already equipped with a broad range of ground-based remote sounding instrumentation (*e.g.* lidar, FTIR, GPS, UV radiometry), and in-situ instrumentation. This equipment will be technically adapted and supplemented for the dedicated validation of tropospheric trace compounds (H_2O, CO, CH_4, N_2O, O_3, HCFC-22 ($CHClF_2$), C_2H_6, Aerosols). This includes the development of new ground-based instrumentation, *e.g.* a differential absorption water vapour lidar at the Zugspitze, and the set up of a new FTIR system at Garmisch which will be used to characterize the boundary layer and complement the Zugspitze FTIR. In addition, a high-spectral-resolution lidar system will be set up at Garmisch for separating the retrieval of extinction and backscatter profiles which is a pre-requisite for validating the satellite-derived extinction profiles.

Improved ground-based retrieval methods will be developed and used for obtaining tropospheric trace-gas profiles from FTIR spectroscopic measurements. The advantages of coincident ground based remote measurements at the high-altitude site Zugspitze and the nearby low-altitude site Garmisch in combination with aircraft measurements will be exploited. This allows the retrieval of vertical trace gas profiles which are representative for a large horizontal area and, at the same time, characterize the boundary layer. The latter is important, *e.g.* for detecting pollution episodes (*e.g.* strongly impacting the NO_2 columns). Furthermore, in the case of water vapour, a high-altitude site is the only means to reach by ground-based remote sensing the upper troposphere and lower stratosphere, which is a region otherwise nearly impossible to be validated.

Satellite retrievals of tropospheric trace compounds are impacted by the optical properties of aerosols, i.e. scattering and absorption of light on aerosols in the same altitude range. Therefore, one important topic in this PI contribution is to provide as an input to improved satellite retrievals the vertical profiles of aerosol size distributions and optical properties. This will be done under selected conditions with desert dust, biomass burning and industrial aerosols within the boundary layer using airborne measurements on small or ultra-light aircraft. The airborne investigations will be supported by continuous measurements with equivalent instrumentation at the Zugspitze and at the tropical GAW station at Mt. Kenya (3800 m).

Time schedule

	2004	2005	2006	2007	2008	2008
Instrumentation	*	*	*	*		
Retrievals	*	*	*	*	*	*
Comb. Instrum.					*	*
Airborne Aerosols	*	*	*	*	*	*

Approximate manpower and cost

	2004	2005	2006	2007	2008	2008
Personnel / man-years	3	3	3	3	3	3
Yearly cost (kECU)	150	150	150	150	150	150

Likely funding agencies

EC; German BMBF/DLR, Helmholtz-Society, Deutsche Forschungsgemeinschaft (DFG)

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MAXDOAS Validation for GOME and SCIAMACHY

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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This is an extension of validation network to new EU member states.

Within the framework of the TROPOSAT programme the Institute has plans to continue progress in atmosphere chemistry research in laboratory and field experiments:

1. To continue efforts to build a MAXDOAS Ground validation station for the GOME (Global Ozone Monitoring Experiment) and SCIAMACHY (Scanning Imaging Absorption spectrometer for Atmospheric CHartographY) instruments providing relevant physical infrastructure and human resources. The site of location has yet to be discussed.

   There are two options to situate such station in Riga, one in the very centre or the other outside the centre.

   Another opportunity is to place it in one of the two EMEP stations in Latvia or elsewhere, where only background or transboundary pollution affects the results. Strong cooperation with colleagues of IUP University of Bremen is expected.

2. To continue participation of our group in laboratory experiments of troposphere and stratosphere chemistry *i.e.* halogen-ozone photolysis research in IUP (Contribution with sources of atomic spectra and the capacity of our institute in modelling experiments)

Time schedule for whole project duration

	2004	2005	2006	2007	2008	2008
Activity 1		*	*	*	*	*
Activity 2	*	*	*	*	*	*

Objectives and time schedule for March 2003 to September 2005

1. Training of personal for MAXDOAS validation - (March 2004 to December 2004);
2. Planning of joint validation campaigns in Latvia using existing mobile validation stations (Chalmers University of Technology or other institutions) - (November 2004 to March 2005);
3. Validation campaign in Latvia with mobile instruments - (June 2005 to October 2005);
4. General concept and design of stationary MAXDOAS validation station in Latvia - (April 2005 to December 2005).

Approximate manpower and cost

	2004	2005	2006	2007	2008
Personnel / man-years	0.6	1.0	2	2	2
Yearly cost (kECU)	6	10	20	20	20

Likely funding agencies

Latvian Science Council, Ministry of Education and Science, University of Latvia, EU Structural funds, Other EU projects.

Co-workers

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Air Pollution Decision Guidance employing Tropospheric Satellite Data together with Transport Models and Ground-based Measurements

A contribution to ACCENT-TROPOSAT-2, Task Group 3

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Within the framework of the AT2-TROPOSAT programme, we intend to investigate the relevance of tropospheric satellite data for monitoring anthropogenic emissions relevant to air quality. The research aims on observation of sources and meteorological transport of air pollutants. Our focus is on regional scale transport of NO_2 air pollution for Switzerland.

The aims of the project are:

(1) to develop a method to include satellite data into air pollution monitoring,
(2) to assess qualitatively and quantitatively the NO_2-transport to Switzerland, and
(3) to analyse the emission areas and transport processes relevant to air quality in Switzerland

For this, we model the potential origin of the air masses observed by satellite with trajectories and Lagrangian particle dispersion models based on numerical wind fields of ECMWF and MeteoSwiss. The first three years will concentrate on point 1) and 2), the following years the focus will shift towards 2) and 3), and finally a permanent data usage is aimed for.

Time schedule

	2004	2005	2006	2007	2008	2009
Activity 1	***	***	**			
Activity 2		***	***	**		
Activity 3			**	**	**	**

Approximate manpower and cost

	2004	2005	2006	2007	2008	2009
Personnel / man-years	1	1.3	1.3	1	0.5	0.5
Yearly cost (kEURO)	70	100	100	80	40	40

Likely funding agencies

Swiss National Bodies

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