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ATMOSPHERIC COMPOSITION CHANGE
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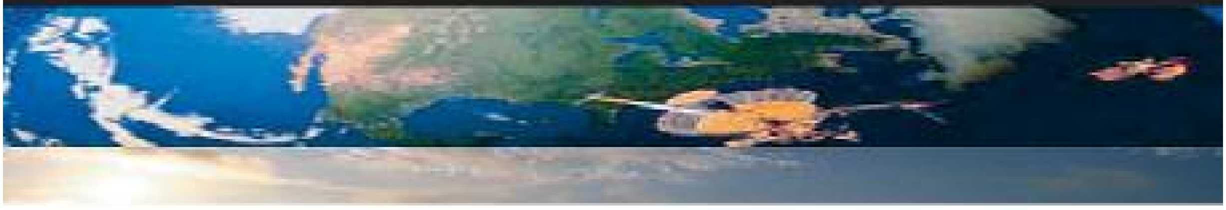

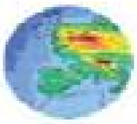

Tropospheric Sounding from Space
ACCENT-TROPOSAT-2 in 2004-5

Editors
John Burrows
Peter Borrell

6.05

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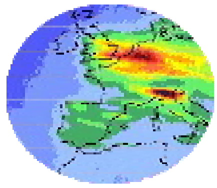

Troposat-2

The Remote Sensing of Atmospheric Constituents from Space

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

Tropospheric Sounding from Space
ACCENT-TROPOSAT-2 in 2004-5

John Burrows and Peter Borrell
Editors

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ACCENT Reports

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1.2005 Frontiers in the Transport and Transformation of Pollutants; the Report of the Barnsdale Expert Meeting, 2004, editors, Paul Monks and Peter Borrell, 2005

2.2005 The Remote Sensing of Atmospheric Constituents from Space; the AT2 Strategy Document; editors: John Burrows and Peter Borrell, 2005.

3.2005 Atmospheric Transport and Transformation at Urban and Local Scales; the Report of the Valencia Workshop, 2005; editors Nicolas Moussiopoulos and Evangelia-Anna Kalognomou, 2005

4.2005 L'ARIA (Italian version of the booklet: AIR, a short story to walk a long way) by Frank Raes, 2005

5.2005 Challenges in Training and Education (T&E), Position Paper 2005, editor: Evi Schuepbach, 2005

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Tropospheric Sounding from Space

ACCENT-TROPOSAT-2 in 2004-5

Table of Contents

Tropospheric Sounding from Space

ACCENT-TROPOSAT-2 in 2004-5

1. Summary

Using remote sensing instrumentation on-board orbiting satellites it is now possible to obtain global information for the chemical troposphere, thanks principally to recent European efforts. ACCENT-TROPOSAT-2 (AT2) is an integration task of ACCENT, the EU network of Excellence. It addresses the need for global information about trace atmospheric constituents, its aim being to facilitate the generation of tropospheric data products, to encourage their use for research and in the medium term, and indicate their potential use in the development of environmental policy.

The scientific work of AT2 is divided into three task groups:

TG1. The development and improvement of algorithms for the retrieval of tropospheric data. The task group is divided into three groups specialising in aerosols, infra-red measurements and UV/Visible measurements.

TG2. The synergistic use of models and observations to improve our understanding of tropospheric chemistry and dynamics.

TG3. The development of validation strategies for tropospheric satellite data products using existing data.

The report presents an overview of their work in the last year. Also included are accounts of the various AT2 activities, the organisation of the project, and also the E-learning group which is seeking to develop a teaching module on retrievals from satellite data of information about the distribution of trace gases and pollutants.

The larger part of the report is devoted to detailed accounts from each of the sixty or so principal investigators involved in the project. The range of scientific activity is enormous. It deals not only with the development of algorithms, methods and models, but also presents fascinating results ranging from the seasonal distributions of common pollutants such as CO, to estimates of the output of NO_2 from lightning in the upper troposphere to studies of NO_2 from shipping in the Middle East.

Altogether the report presents a picture of the vigorous activity which is required if the goals of AT2 and ACCENT are to be achieved.

2. AT2: origin, objectives, deliverables and report

2.1 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.

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.

2.2 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, which allow the determination of two- and three- dimensional distributions and time series of trace constituents, aerosols and pollutants in the troposphere and stratosphere.

Algorithms have already been developed 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 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.

An example is shown in figure 1.

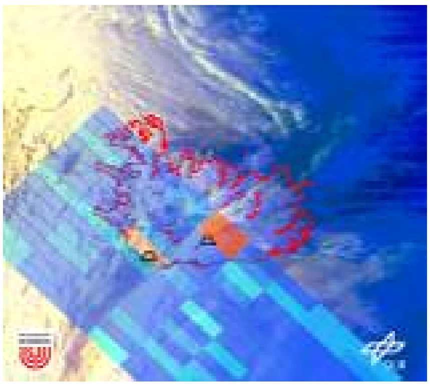


Figure 1. SCIAMACHY SO_2 total columns as observed by SCIAMACHY Increased SO_2 values are visible close to Grimsvoetn (right volcano symbol) and in the south west near Katla (left volcano symbol), on Iceland shortly after the volcano Grimsvoetn had begun to erupt. Besides large amounts of water vapour and volcanic ash, which entailed re-routing of air traffic, SO_2 was emitted. [Andreas Richter, Uni-Bremen and Thomas Holzer-Popp, DLR, Oberpfaffenhofen]

Satellite measurements of tropospheric composition offer numerous possibilities both to increase scientific understanding and for policy application. It is thus essential that possibilities the data offer are fully appreciated and used by the scientific and environmental policy communities. It is for this reason that the present project, AT2, has been set up.

2.3 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.

AT2 is the so-called "Work Package 10" (WP10) of ACCENT. The objective of WP10 (AT2) is to promote European competence and excellence in the exploitation and utilization of remote sensing data for the troposphere, using instruments mounted on space-based platforms. This field was initiated and developed by European scientists, and the tropospheric results obtained from the ESA instruments GOME and ENVISAT have demonstrated that use of satellite data has the potential to revolutionize the field of atmospheric chemistry and to provide global and regional information essential to the understanding of our environment. The principal result expected from the work in AT2 is the provision of the methodology to generate the global information required to test and improve our understanding of the Earth-atmosphere system, the impact of anthropogenic activity and the accuracy of the prediction of changing atmospheric composition and its consequences.

2.4 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.

2.5 Organisation of AT2

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.

AT2 (WP10) has been organized into three task groups that have the following objectives.

- TG1. The development and improvement of algorithms for the retrieval of tropospheric data. The task group is divided into three groups specialising in aerosols, infra-red measurements and UV/Visible measurements.
- TG2. The synergistic use of models and observations to improve our understanding of tropospheric chemistry and dynamics.
- TG3. The development of validation strategies for tropospheric satellite data products using existing data.

Some 65 principal investigators are associated with the task groups and have contributed to initial strategy document and to part 2 of this report.

In addition a web site, *troposat.iup.uni-heidelberg.de*, linked closely to the ACCENT web site, has been established to present the results of meetings and information of interest to the project and the community. The site includes an automatic form-response system developed with the objective of providing tropospheric scientific data products for atmospheric research within ACCENT AT2 web page.

Also an e-learning group has been established within WP10 with the objective of devising high-level web-based e-training in remote sensing from space.

Thus education, training and capacity building within Europe are included within WP10, in connection with the ACCENT task “Training and education”.

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

2.6 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.

2.7 ACCENT-TROPOSAT-2 in 2004-5

This report is the first annual report of the activities and progress within AT2. The following sections outline the work of the three task groups, together with short comments on the web page, data collection and e-learning activities.

Then follows an account of the external activities funded *via* AT2, and a detailed account of the activities undertaken in the project as a whole.

Contributions from all the active principal investigators follow and the report concludes with a list of publications and theses attributable to work within AT2.

3. Task Group 1

The Development and Improvement of Algorithms for the Retrieval of Tropospheric Data

Activities of Task Group 1 in the last year

Thomas Wagner, Gerrit de Leeuw, Johannes Orphal and Andreas Richter

3.1 Overview of the structure and aims of task group 1

The aim of task group 1 is to improve existing algorithms for the retrieval of tropospheric information from satellite measurements, to develop new algorithms for tropospheric data products and to support distribution and use of tropospheric satellite data. One important strategy in this direction is to facilitate information exchange on data products and algorithms between the different groups involved and to provide tropospheric satellite products also to a wider community of data users. Since the launch of ENVISAT (and recently also EOS-AURA), improved and new sensors have become available, in particular including new instruments for aerosol properties and for absorbers in the IR spectral range. 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 out within specialised sub-groups. Besides the activities within the sub-groups, an important goal of task group 1 is the information exchange between the different sub-groups.

The communication and transfer of information is ensured with different strategies.

- The activities of the different sub-groups are reported to a general audience at regular meetings.
- Special workshops on algorithm development including all sub-groups are held.
- The reports of sub-group workshops are distributed.
- Research visits for scientists between different institutions are initiated.
- Products which are available from different sub-groups (*e.g.* O_3, NO_2, H_2O and aerosol properties) are 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 the previous TROPOSAT project, a list of the available data products and the respective PIs is collected and posted on the project's web-page.

In addition to these general aims also specific goals were defined. They include the following aspects:

a. Improvement of existing 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.

b. Development of new algorithms:

* CO, CO_2, CH_4, O_3 from SCIAMACHY;
* synergistic use of AATSR and MSG-SEVIRI to provide accurate aerosol information with high resolution in both time and space;
* tropospheric trace gases from MIPAS (Limb geometry);
* tropospheric CO and O_3 from Nadir-viewing IR sensors (IMG, TES, future IASI);
* synergetic use of UV-VIS and TIR spectra (Nadir geometry) to improve the accuracy of tropospheric O_3 retrievals (*e.g.* from OMI and TES or future GOME2 and IASI);
* test of feasibility to derive regional PM2.5 directly from AOD data; and
* PM2.5 maps based on EO data assimilated in CTM.

c. Long term data sets and trends:

* BrO, NO_2, HCHO, SO_2 from GOME and SCIAMACHY.

d. 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*.;
* define distribution channels for products: GSE PROMOTE;
* play and active role in the definition phase for the ESA/EU GEMS space segment (*e.g.* ESA sentinels 4 and 5, ESA project CAPACITY);
* support future projects for monitoring of tropospheric trace gases (*e.g.* GeoTrOPE).

3.2 Activities during the last year

a. Kick-off and organization of Task Group 1

Task group 1 activities in ACCENT-TROPOSAT-2 started with the organization of the task group and the introduction of the various PI contributions. The structure and the aims of the task group were defined in the AT2 Strategy Document, which is available via the AT-2 website (http://troposat.iup.uni-heidelberg.de). Also the PI contributions were made available via the web site.

b. Strategies to encourage cooperation

From the beginning of the project, specific activities were stimulated to initiate and improve cooperation between the groups. Several specific topics were identified, for which the organization of focused workshops was recommended. So far the following workshops have been held:

* SCIAMACHY CO Retrieval Intercomparison, Utrecht, April 2005
* Radiative Transfer Modelling, Heidelberg, June 2005

Reports from these workshops are already available via the website.

These workshops were very successful and included, in addition to AT-2 members, other experts from several international institutions.

In the near future additional small workshops are planned:

* on the comparison of different water vapour retrievals;
* on trace gas retrievals in the thermal IR; and
* on the retrieval of cloud properties.

As well as the organization of workshops, information on different data products and their availability was collected and made available via the AT-2 website.

c. Progress made in the different PI contributions

For many PI contributions substantial progress was made during the last year. Especially, the quality of the analysed data products was improved and characterized by comparison with similar products from other groups and to independent validation data (*e.g.* tropospheric NO_2). In addition, new products have been developed, especially in the near and thermal IR (*e.g.* tropospheric CO), and existing algorithms were applied to new sensors.

In addition to these algorithmic improvements the activities included also the scientific use of the retrieved data. From the raw data sets, *e.g*. information on global or regional trends, or on the atmospheric lifetime was extracted. Also the global distribution of different trace gases was compared in order to characterize the respective sources. Finally accurate laboratory studies were carried out to resolve potential discrepancies between UV-VIS and IR reference spectra, in particular focusing on O_3.

A detailed overview on the progress made in the various contributions is given below:

3.3 Progress made in the sub-group on aerosols and clouds

The objectives, scientific questions and achievables of the TG1.3 subgroup on aerosols and clouds have been outlined in the ACCENT AT-2 strategy document (May 2005) as part of those for TG1. With 9 PI's (out of 35 in TG1) working on aerosols and clouds these tasks are well underway. Below we provide a brief overview on progress for each of the aerosol achievables, with reference to the individual PI reports that provide more detail.

a. Aerosols

* Improvement of algorithms:

- Aerosol properties from GOME and SCIAMACHY;

A study of the improvement of aerosol retrieval algorithms is reported by Hasekamp and Landgraf. A linearized vector radiative transfer model was developed and incorporated in a retrieval algorithm for GOME-2 (launch in 2006) to investigate the aerosol information content in the data. Both polarization and spectral information is used.

- The GOME algorithm has been further upgraded and improved and AOD over the ocean is in the same range as that retrieved from other satellites. The SCIAMACHY algorithm has been applied both over ocean and over land, providing both AOD and speciation. [Di Nicolantonio *et al.*].
- Keller reports on the use of MISR data over central Europe in a mountainous area which requires high spatial resolution.
- aerosol products from AATSR, OMI, other sensors;

Aerosol products from ATSR-2/AATSR included AOD at the available wavelengths and has been extended to Ångström coefficent and speciation. Furthermore, tools have been developed to provide the AOD on any user-requested spatial grid from 1×1 km^2 to $1^o \times 1^o$.

- Work on the OMI algorithm was focused on providing data for the initial validation, during the DANDELIONS campaign (De Leeuw *et al.*).

An algorithm has been developed for the retrieval of aerosols from the 330 nm to 500 nm wavelength range for OMI. The operational software for this algorithm has been developed, and will be integrated into the processing facility at KNMI in the summer of 2005 (Veefkind).

- For MERIS a specific version of BAER (Bremen AErosol Retroetrival) has been developed, using the capacity of the MERIS instrument with 13 channels over ocean and 7 short-wave channels over land. It enables the atmospheric correction of spectral surface reflectance over land by extrapolation of the estimates of spectral aerosol optical thickness to all MERIS channels, using Angström power law [Von Hoyningen-Huene].

• An interface program for the application of BAER to MODIS data is in development. This enables us to apply multi-instrument observation and investigation of also temporal processes with maximal 4 observation times at one day, using MERIS, MODIS (Terra), SeaWiFS and MODIS (Aqua) [Von Hoyningen-Huene].

• demonstration of quasi-operational aerosol retrieval algorithm for ATSR-2, by application to data over Europe for the year 2000;

The ATSR-2/AATSR algorithm is now quasi operational and has been applied to provide validated AOD data over Europe for the whole year of 2000, with the year 2003 underway (De Leeuw *et al*.).

• A first pass through ATSR/2 data retrieving surface reflectance, aerosol optical depth and effective radius has been completed. In addition to sub track 'level 2' data global monthly means (level 3 data) of the parameters (as well as their uncertainties) at 2.5 deg by 2.5 deg spatial resolution has been constructed. The initial 5 year GRAPE climatology is available (Grainger).

• synergistic use of SCIAMACHY and AATSR for aerosol speciation;

The synergistic use of ATSR-2/GOME and AATSR/SCIAMACHY to determine AOD and aerosol speciation is described by (Holzer-Popp *et al*.). Results on the speciation are presented.

• extension of aerosol algorithms to areas with complicated aerosol composition;

Scientific work to extend the AATSR algorithm for other areas (*e.g*. over desert, UAE[2]) and validation of identification of principal aerosol chemical components (from comparison with ADRIEX campaign data) is well underway. (De Leeuw *et al.*).

• demonstration of feasibility to deliver NRT AOD data from AATSR. Work in this area is planned for the coming year

* Development of new algorithms:

• synergistic use of AATSR and MSG-SEVIRI to provide accurate aerosol information with high resolution in both time and space ;

Work in this area has started as part of a PhD project [De Leeuw *et al.*]

• test on feasibility to derive regional PM2.5 directly from AOD data;

Work in this area is on-going in several groups as part of national projects, but has not been reported in the PI reports.

• PM2.5 maps based on EO data assimilated in CTM.

Results from 2000 have been used both for comparison with LOTOS-EUROS modeling results and for data assimilation. The first results show the importance of observations to constrain the model [Schaap *et al.*]. The provision of PM maps is planned in the next year [Schaap *et al.*].

* Long term data sets and trends:

• Work on this subject has been started using the SYNAER algorithm (Holzer-Popp); data for ATSR-2 over Europe for 2000 are available and for 2003 are underway (De Leeuw). The construction of a ten-year aerosol climatology from ATSR-2/AATSR, MERIS and MSG-SEVIRI under the ESA project Globaerosol is exploited [Grainger].

* Synergy and integration:

- workshop on aerosol methods;

Plans for a workshop on aerosol methods have been discussed during various occasions (*e.g*. WKS4 in Oberpfaffenhofen) and plans for a proposal for a workshop in 2006 are being developed.

* Definition of future aims:

- long term aim for aerosol is to provide reliable, accurate and sustainable products meeting requirements of various user segments: AOD, speciation, PM2.5, ssa, etc.;

Interaction with users takes place in GSE promote, where various service level agreements have been made in which aerosol products will be delivered to users (mainly for policy on air quality) who will provide feedback. As part of this, a brief contribution to the EMEP annual report has been written with contributions from AT-2 participants [Holzer-Popp, T., G. de Leeuw, R. Schoemaker, J. Schaug, C. Wehrli, 2005, European aerosol optical depth measurements from ground and space]. Scientific use is in national and international projects, *e.g*. ATSR-2 data have been delivered to AEROCOM for model intercomparison (http://nansen.ipsl.jussieu.fr/AEROCOM/).

- define distribution channels for products: GSE PROMOTE

Aerosol products from various AT-2 PI's are made available through the PROMOTE web site ((http://www.gse-promote.org/) or through a ling on the PROMOTE web sites to others.

b. Clouds

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

- Main contribution to this topic was the investigation of cloud interference on retrievals of aerosol optical thickness. The results have been presented at the ACCENT workshop on 5th June 2005 at DLR Oberpfaffenhofen [Von Hoyningen-Huene].

- A first pass through ATSR/2 data retrieving cloud properties (cloud top height, cloud optical thickness, cloud phase and particle effective radius) has been completed [Grainger].

- The following scientific questions formulated in the strategy documents are addressed by these efforts:

  * what aerosol information can be retrieved from instruments that were not designed for this purpose (AOD, Ångström coefficient, speciation, modal sizes, PM2.5, 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?

  * what are the improvements in the retrieval from synergistic use of satellite instruments and chemical transport models (data assimilation)?

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

3.4 Progress made in the sub-group on IR retrievals

The objectives, scientific questions and achievables of the TG1 subgroup on IR retrievals have been outlined in the ACCENT AT-2 strategy document (May 2005) as part of those for TG1. With 8 PI's (out of 35 in TG1) working IR retrievals these tasks are well underway. Below we provide a brief overview on progress for each of the IR achievables, with reference to the individual PI reports that provide more detail.

*. Development of new algorithms and improvement of algorithms

• Investigation of the day night difference of MOPITT CO observations. Due to differences in the sensitivity information on the profile can be derived

• Development of new algorithms from IMG (CH_4, O_3, CO, HNO_3). These algorithms provide limited profile information on CO and O_3 [Ricaud *et al*., Clerbaux *et al*., Coheur *et al*.].

• Validation of MOPITT CO observations using model data (MOZAIC) [Ricaud *et al.*]

• Development of new algorithms from MIPAS (CH_4, CFCs). These algorithms provide profile information for the upper troposphere and stratosphere [Stiller *et al.*]

• Validation of MIPAS CH_4, N_2O, and CFC data using balloon borne measurements [Stiller *et al.*]

*. Synergy and integration:

• Workshops on IR retrievals:

Plans for a workshop on IR retrievals have been discussed during various occasions (*e.g.* WKS4 in Oberpfaffenhofen) and plans for a proposal for a workshop in 2006 are being developed.

• Comparison of time series of CO from MOPITT and O_3 from ozone sondes for various locations; investigation of their chemical relation [Drummond *et al.*]

• Interpretation of CO data from MOPITT with respect to detailed meteorological situations [Drummond *et al.*]

• Simultaneous measurements of O_3 cross sections in different spectral ranges [Orphal *et al.*]

3.5 Progress made in the sub-group on UV/vis/NIR retrievals

The objectives, scientific questions and achievables of the TG1 subgroup on UV/vis retrievals have been outlined in the ACCENT AT-2 strategy document (May 2005) as part of those for TG1. With 17 PI's (out of 35 in TG1) working UV/vis retrievals these tasks are well underway. Below we provide a brief overview on progress for each of the UV/vis achievables, with reference to the individual PI reports that provide more detail.

* Development of new algorithms / Improvement of algorithms

• Investigation of the influence of the pixel size by comparing GOME and SCIAMACHY data of NO_2 [Richter *et al.*]

• Improvement of the precision of the GOME H_2O retrieval using O_2 absorption for the determination of the H_2O-AMF [Wagner *et al.*]

• Tropospheric ozone columns derived from GOME profile and total column observations in combination with data assimilation. [Van Oss *et al.*]

- Tropospheric ozone columns derived from Neural Network analysis of GOME observations [Kaifel *et al.*]
- Development of a CH_4 product from SCIAMACHY using CO_2 as a proxy for the probed atmospheric column [Frankenberg *et al.*]
- Development of a H_2O product from SCIAMACHY [Noël *et al.*]
- Development algorithms for CH_4, CO_2, and CO from SCIAMACHY [Buchwitz *et al.*]

* Synergy and integration:

- Investigation of the stratospheric and tropospheric partial BrO columns in satellite observations by comparison with ground based and model data [van Roozendael *et al.*]
- Comparison of CH_4, CO_2, and CO from SCIAMACHY with ground based data and model results [Buchwitz *et al.*]
- Comparison of H2O VCD from SCIAMACHY with ECMWF data [Noël *et al.*]
- Identification of NO_2 emitted from ship tracks in GOME and SCIAMACHY data [Beirle *et al.*, Richter *et al.*]
- The dependence of the H_2O VCD on surface temperature has been investigated [Wagner *et al.*]
- Tropospheric NO_2 VCDs derived from a combination of GOME/SCIAMACHY NO_2 slant columns with radiative transfer calculations, chemistry-transport model and data assimilation. [Eskes *et al.*]
- Investigation of the information content for profile retrievals of the synergistic use of UV/vis and thermal IR observations [Bovensmann *et al.*]
- Comparison of the global fields of NO_2, SO_2, and HCHO derived from satellite observations [Marbach *et al.*]
- Tropospheric O_3 from cloud slicing method applied to GOME O_3 observations
- Estimation of the lifetime of tropospheric NO_2 from GOME observations [Beirle *et al.*]
- Quantification of lightning induced NOx from the combination of GOME NO_2 data with observations from a lightning detection network [Beirle *et al.*]
- Comparison of global CH_4 distribution from SCIAMACHY with TM4 model data [Frankenberg *et al.*]

* Long term data sets and trends:

- determination of trends in water vapour from GOME data [Wagner *et al.*]
- determination of trends in the tropospheric NO_2 VCD from GOME and SCIAMACHY data [Richter *et al.*]

3.6 Aims for the next year

The individual activities as defined in the PI contributions will be continued in the next year. An important role of task group 1 will be to foster cooperation between different groups working on similar topics (e.g. trace gas or aerosol retrieval in selected spectral regions) and to suggest additional intercomparison studies, *i.e.* by exchange of information, data products, by visits of experts from different groups, and by organizing workshops on selected topics that are considered to be most important.

In the next year, the synergistic analysis of UV-VIS and IR data will be first applied to OMI and TES data from EOS-Aura. The launch of the first MetOp platform in mid-2006 will provide data from two more instruments (GOME2 and IASI) that will be used by the PIs of task group 1 for tropospheric trace gas and aerosol retrieval.

As already mentioned above, three more workshops have already been proposed by task group 1 to be held in the next year:

* on the comparison of different water vapour retrievals;
* on trace gas retrievals in the thermal IR; and
* on the retrieval of cloud properties.

These workshops, organized by PIs of Task Group 1, focusing on selected important topics, will bring together scientists from many different European countries, and are therefore an important tool to achieve the goals of task group 1 as described above.

3.7 Scientific highlights

In various PI contributions substantial progress has been achieved. The following examples can only provide an arbitrary view of the wealth of new results that have been obtained.

a CH_4 *and* CO *from nadir thermal IR looking sensors*

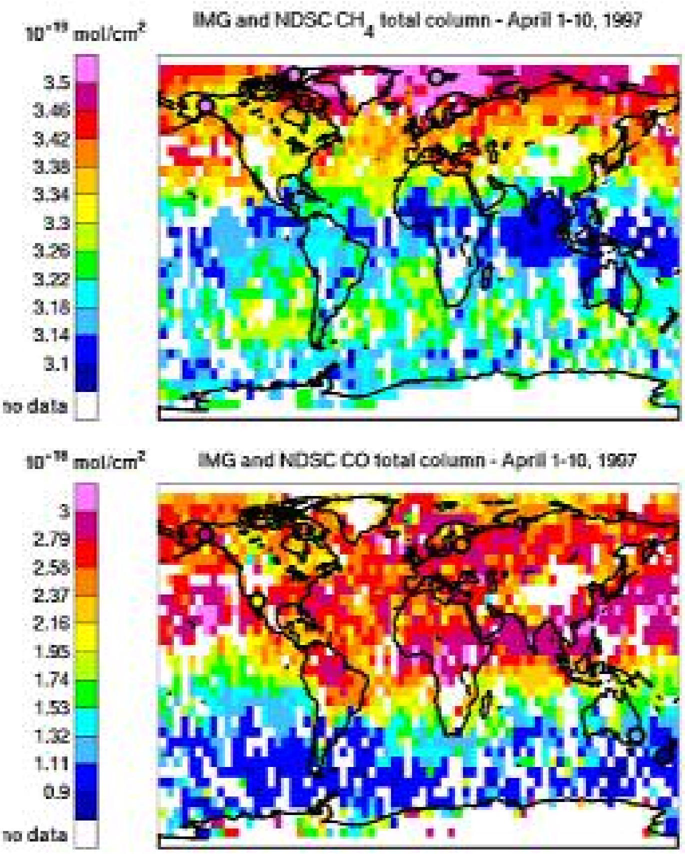


Figure 2. Global distributions of IMG CH_4 and CO total columns for the April 1st to 10th, 1997 IMG period. The data are averaged over the time period and a 5° × 5° grid. The corresponding available NDSC measurements are represented by coloured circles on each map [Cathy Clerbaux *et al.*].

b. Tropospheric O_3 *from a combination of GOME observations and data assimilation*

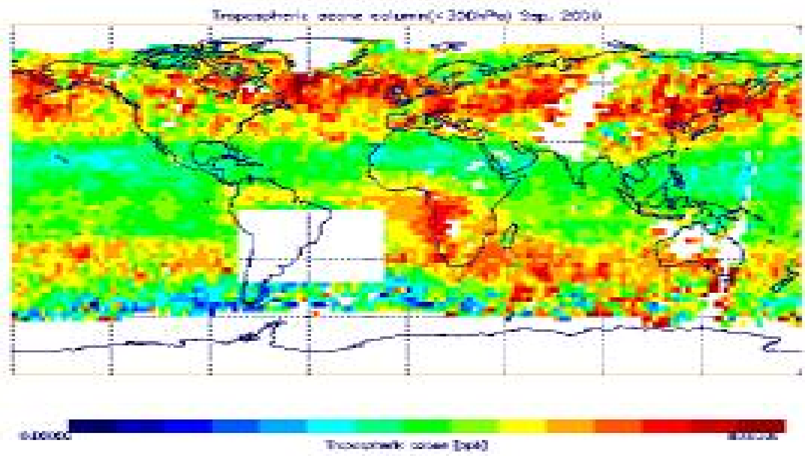


Figure 3. Tropospheric column mean ozone mixing ratios as derived from GOME measurements for September 2000. In this case the upper boundary of the vertical domain over which averaging has been performed was fixed at 300 hPa [Roeland van Oss *et al.*]

c. CH_4 *from SCIAMACHY near IR*

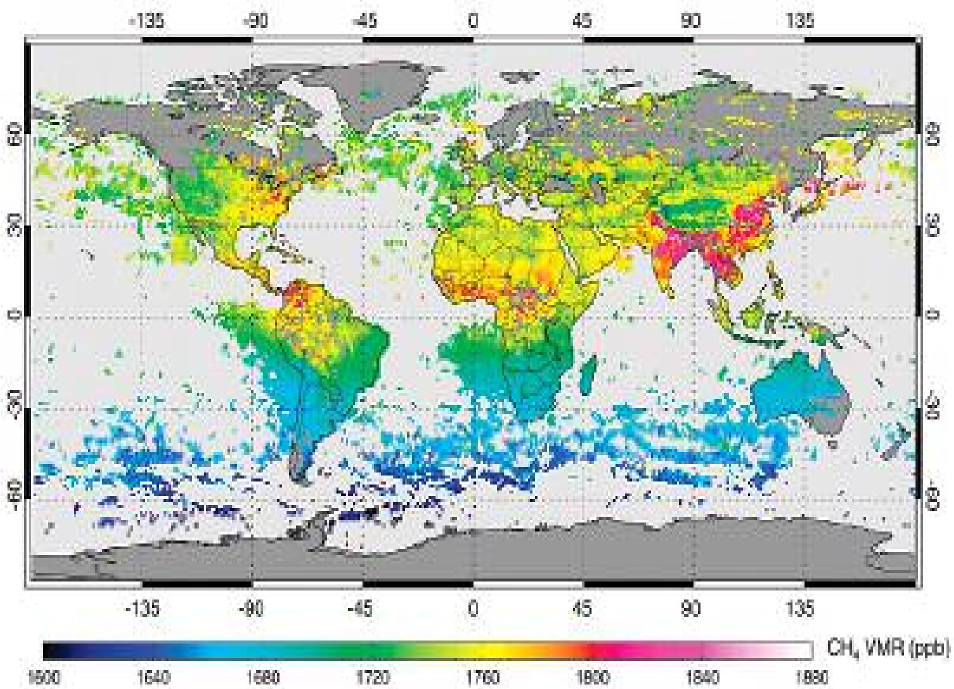


Figure 4. SCIAMACHY measurements of column-averaged methane VMR in ppb units (August to November 2003). Observations over the ocean are occasionally possible due to sun glint or clouds at low altitudes. In contrast to the thermal IR the NIR observations are sensitive to the total atmospheric column [Christian Frankenberg *et al*].

d.* *Trend of tropospheric* NO_2 *from GOME 1996-2002

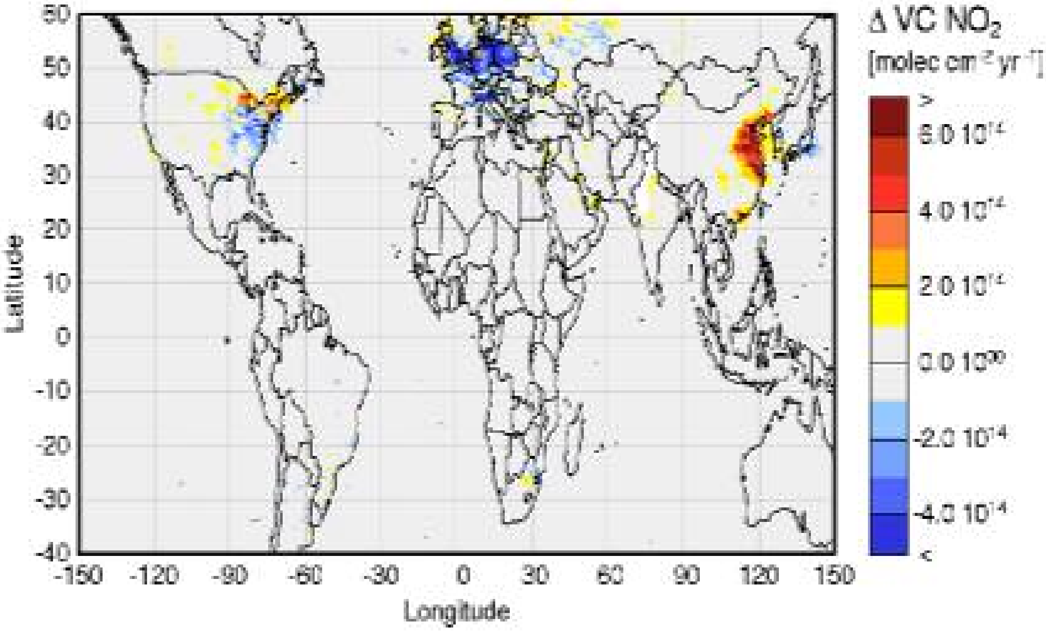
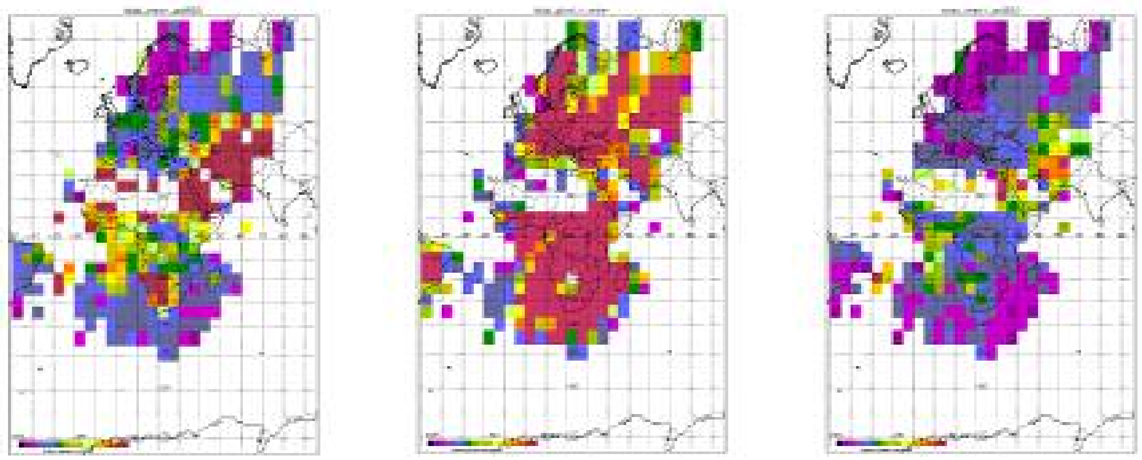


Figure 5. The gradient obtained from a linear regression of the annual averages of tropospheric GOME NO_2 columns, retrieved close to 10.30 am LT from 1996 to 2002. Reductions in NO_2 are observed over Europe and the central east coast of the United States, while large increases are evident over China [Andreas Richter *et al.*, 2005].

e. Climatology of aerosol properties from GOME

Mean AOT550 (0…1) Pixel number (0…50) Sulfate/nitrate (0…1)



Soot (0…0.4) Minerals (0…0.2) Sea salt (0…0.2)

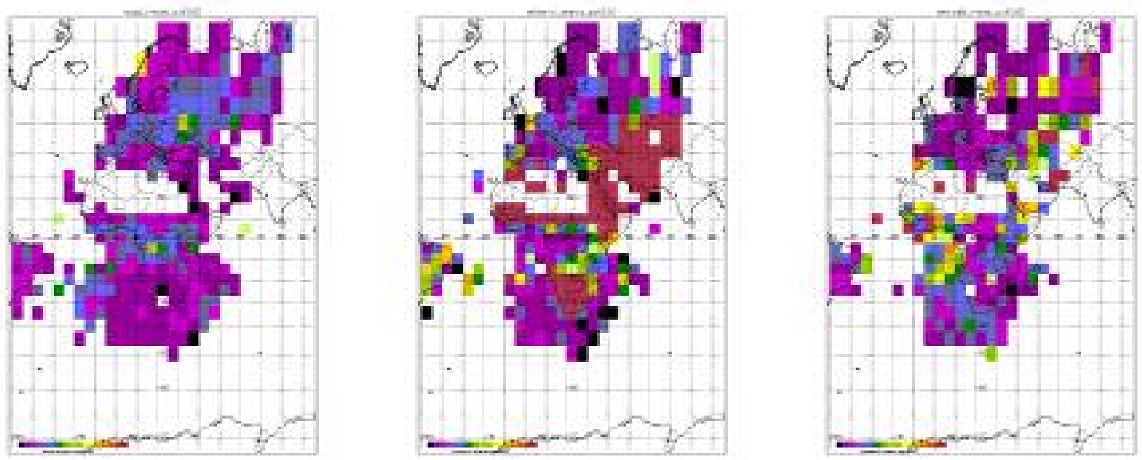


Figure 6. Preliminary aerosol climatology dataset based on observations of the period 4th July 1997 – 25th August 1998. The figure shows (from left to right) in the upper line: total aerosol optical depth (AOD), total number of pixels in a grid box (ranging from 0 to 50), sulfate/nitrate optical depth (OD); in the lower line: soot optical depth, dust optical depth, and sea salt optical depth. All optical depth values are given at 550 nm; the different range of OD values in the sub images should be noticed (total and sulfate/nitrate OD: 0 - 1.0; soot OD: 0 – 0.4, mineral and sea salt OD: 0 – 0.2); black boxes mean that no particles of this component were found at all in this box [Thomas Holzer-Popp *et al.*].

3.8 Participants

A list of Task Group 1 principal investigators and the titles of their contributions is given in section 11.3.

4. Task Group 2

The Synergistic Use of Models and Observations

Activities of Task Group 2 in the year 2005

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4.1 Introduction

The first year of AT2 TG2 was successful: The group has consolidated and clearly defined the aims and strategies for the upcoming months. During specific breakout sessions, which were held during the AT2 workshops in February (Bremen) and June (Oberpfaffenhofen), we discussed common interests and possibilities of joint collaborations. Currently, this task group host 17 active partners and associated members. The scientific activities within TG2 are not only connected with the activities of the other AT2 task groups, but there are also strong connections to the ACCENT activities "Modelling" (PI: Ivar Isaksen) and "Transport and Transformation" (PI: Paul Monks) – see below. Relationships to the EC-funded projects SCOUT-O3, GEMS, and PROMOTE have been identified.

Based on the discussions in the last year, the following overall aims of TG2 have been appointed:

- Investigation of physical, dynamical, and chemical processes in the troposphere.
- Development of methods for using satellite data from the troposphere as part of model validation strategy.
- 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.
- Use model results to help bridge the gap between point measurements and the satellite view footprint for evaluating satellite retrievals.

To get a complete overview about ongoing activities in the participating groups, a matrix (see TG2 report of the Bremen workshop) was complicated which shows all numerical models and data products which are used in TG2. Obviously, NO_2 tropospheric columns derived from GOME (ERS-2) and SCIAMACHY (ENVISAT), CO columns derived from MOPITT, HCHO (formaldehyde) columns derived from GOME, and H_2O columns and profiles derived from GOME and MIPAS (ENVISAT) are mostly employed. Additionally, data products from the ITOP campaign (summer 2004) and from the two TROCCINOX campaigns (January to March 2004 and 2005, respectively) are available for common research activities. The synergistic use of atmospheric models and airborne and ground-based measurements together with satellite observations is an important goal of AT2 TG2. TG2 agreed that the use of tropospheric satellite data can significantly support investigations with regards to campaigns. Within TG2 it was agreed to use the data of the ITOP and TROCCINOX campaigns together with data products derived from satellite instruments (esp. MIPAS, SCIAMACHY). Additionally, results of models will be used for interpretation, but also for model validation.

Based on this, two main areas of common interest have been found out which will be the basis for common activities in the next 12 months:

- Use of NO_2 tropospheric columns with models to improve our understanding of tropospheric composition.
- Use of tropospheric satellite data to help and support investigations with regards to measurement campaigns, *i.e.* ITOP and TROCCINOX.

In addition there are other important activities within TG2, for example, data assimilation with different techniques and "inverse" modelling to get more reliable information about location and strength of emissions.

4.2 Web site for tropospheric data

As a first step to inspire collaboration, a web-side on tropospheric NO_2 has been arranged to collect publications and other related information:

http://www.atm.ch.cam.ac.uk/~nick/at2_tg2/

It will be open during the project, *i.e.* relevant additions (including grey literature) can be added at anytime. Nick Savage is the scientist responsible.

4.3 Important questions

During the last breakout sessions, TG2 tried to answer some important questions related to AT2 in general and in particular with regards to TG2. Action items for the upcoming months have been assigned. With regards to the development of methods for using satellite data from the troposphere and the UTLS region as part of model strategy (here: tropospheric columns of NO_2), the following questions were discussed:

"*Where are we going now? How can we use the data products?*" It has been agreed that a unified validation strategy for models is necessary and therefore will be developed in TG2, *e.g.* use the same software to produce common statistics. First steps will be arranged within the next few months.

"*What is really missing in the employed model systems?*" Obviously, in recent scientific applications model data and observations mostly did not fit. Therefore, model output is required which matches with satellite overpasses. TG2 will consider the ongoing activities of IPCC (H. Eskes, KNMI).

"*What should be in the focus for further model developments and improvements?*" The models currently used in AT2 should simulate first the time period of GOME (1995 to 2003, or at least for parts of it) which is suitable for inter-comparison. It is planned to continue with SCIAMACHY data.

With regards to trend analyses, the following questions were discussed:

"*What are the options?*" A comparison of long-term model simulations (for past time conditions) with available observations can be performed. A wish of TG2 is a combination of GOME and SCIAMACHY data (1995 to 20xx) to get a uniform data set which is convenient for trend assessments.

"*Can models reproduce recent developments?*" A comparison of model data with observations will help to clarify it. Results can be expected within the next year.

"*Which models can be used for future estimates?*" Chemistry-climate models (CCMs) are an ideal tool to investigate long-term changes, but all other models, in particular CTMs, can also be employed for sensitivity studies to assess possible future changes. Scenario calculations and sensitivity experiments can (will) be related to IPCC (next assessment projected for 2007) and WMO activities (next ozone assessment in preparation).

During the discussions it turned out that it is still not very clear which activities are going on within AT2 which are directly related to data assimilation and “inverse” modelling, and how to get the data. TG2 realised that with regards to the troposphere, models are still in the implementation phase. Therefore, TG2 will intensify its activities with regards to this point, *e.g.* it is planned to have a *special session on data assimilation techniques and availability of data products* at one of the next AT2 workshops. Currently, six AT2 groups are strongly involved in data assimilation. Related activities are performed in the EC funded projects GEMS and PROMOTE.

4.4 Participants and activities

A list of Task Group 2 principal investigators and the titles of their contributions is given in section 11.3.

The activities of this AT2 task group can mainly be assorted in two parts: One subgroup (8) is using different kind of numerical models to diagnose and validate data derived from satellite instruments as well as airborne and ground based measurements in a synergistic way. The other part of TG2 is investigating and applying data assimilation techniques.

4.5 Scientific Highlights

There are several scientific highlights in TG2. The leader of this task group takes the opportunity to expose two of them, one from each “subgroup”.

At the Max-Planck-Institute for Chemistry in Mainz, Germany, Rüdiger Lang and colleagues prepared a multi-sensor based 3-D data field of water vapour which can be used for evaluation of global model systems. It contains information from different satellite remote sensing data. A web-side has been created (http://www.mpch-mainz.mpg.de/~saphire/gome_igam/) which provides detailed information. An example is given in Figure 7, showing the global mean distributions of water vapour columns averaged over the time period from August 1995 to August 2002 (for details see Lang et al., this report). These data products are ideally suitable for the evaluation of chemistry-climate models (CCMs) and chemical transport models (CTMs).

A 4-D-var assimilation scheme to fit data products derived from satellite instrument measurements has been developed and has made significant progress in the last year (Elbern and Strunk, this report). Data sources which were newly considered are (a) ozone profiles derived from a neural network (see TG1, Anton Kaifel), (b) tropospheric NO_2 columns, and (c) assimilated aerosol parameter sets obtained from space measurements. The plan is to develop the model system towards an operational system which can be used for future GMES activities (Global Monitoring for Environment and Security). Currently, the investigations in this AT2 project are strongly connected with the European projects PROMOTE and GEMS.

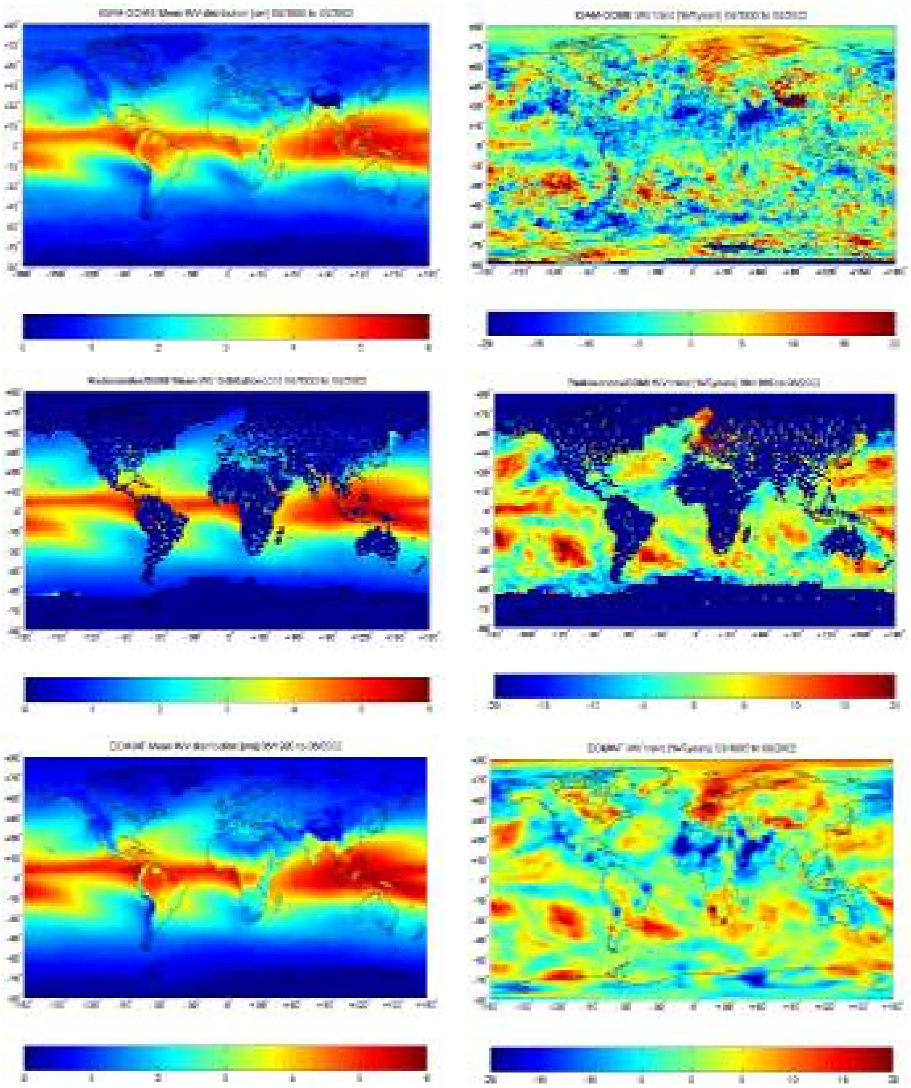

Figure 7. Global mean distribution of water vapour columns (WVC) averaged over the period between August 1995 and August 2002 (left panels). The right panel shows the WVC trend over the same period in %. The first row shows results from the GWCv1 database using GOME data only, followed by a merged product of operational radiosonde data over land (the MCOS dataset) and SSM/I over sea (second row). The third row shows corresponding results from the ERA-40 database (extracted from the annual report by Lang *et al.*, this report – see below).

In the following you will find detailed reports of the individual activities in the last project year. It is obvious that at the moment both “communities” do not really benefit from each other. Therefore, one important aim of the next project phase is to intensify the discussion between them.

5. Task Group 3

The Development of Validation Strategies for Tropospheric Satellite Data Products using Existing Data

Activity Report: March 2004 and March 2005

Ankie Piters

Royal Netherlands Meteorological Institute (KNMI), De Bilt, The Netherlands

5.1 Long-term objectives

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. 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 performed in this task group strongly depends on what individual scientists can do within their national science programmes. The general scientific aim of TG3 is to assess the quality of tropospheric satellite products and, more specifically, the usability of those products in tropospheric research or monitoring of pollution and climate change. Specific scientific objectives are to:

* develop validation strategies to account for differences in retrieval methods and differences in representation of satellite data products and the correlative instrument product or model, for example differences in spatial resolution and sampling, averaging kernels, and viewing geometries;
* develop techniques to assess the accuracy of a product from a combination of information from different validation methods, like comparisons to ground-based, models, and satellite;
* collect, analyse, and improve correlative measurements in special areas of interest, like Mega cities and volcanoes;
* collect, analyse, improve, and make available correlative measurements from long-term continuous measurement stations and networks;
* perform comparisons between tropospheric satellite products and independent correlative measurements;
* perform comparisons between tropospheric satellite products and models;
* assess the usability of tropospheric satellite products for specific tropospheric research areas, *e.g.* radiation budget, long-term evolution of chemical composition, air quality; and
* establish operational ground-truthing stations especially suited for validation of tropospheric satellite products.

5.2 Achievements

The activities of the individual groups within TG3 are described in detail in the next sections. Here, some of the highlights are listed.

Tropospheric NO_2 *from GOME and SCIAMACHY, use of averaging kernels*

Validation studies for GOME and SCIAMACHY tropospheric NO_2 (IFE, KNMI/BIRA) show that for a proper comparison between space-borne data and independently measured profile/column information, the use of averaging kernel information is essential, especially for comparisons under cloudy conditions [Schaub and Buchmann, Petritoli].

CO from MOPITT and SCIAMACHY

CO profiles from MOPITT were compared to ship-based FTIR measurements and model output. After including averaging kernel information, a reasonable agreement was found between MATCH, MOPITT and the FTIR. CO enhancements due to biomass burning are detected by MOPITT [Notholt *et al.*].

Global patterns in the three-monthly averaged CO columns from SCIAMACHY (SRON) and MOPITT are generally in good agreement. Small differences can possibly be attributed to MOPITT's lower sensitivity to the boundary layer. The differences in the monthly averaged CO values on the Northern hemisphere are less than 10 % [van den Broek *et al.*].

SCIAMACHY XCH4 versus FTIR

Validation of SCIAMACHY XCH4 (IFE) with the Zugspitze FTIR shows a major improvement between processor version WFMD v0.4 and WFMD v0.41 [Figure 8, Sussmann *et al.*].

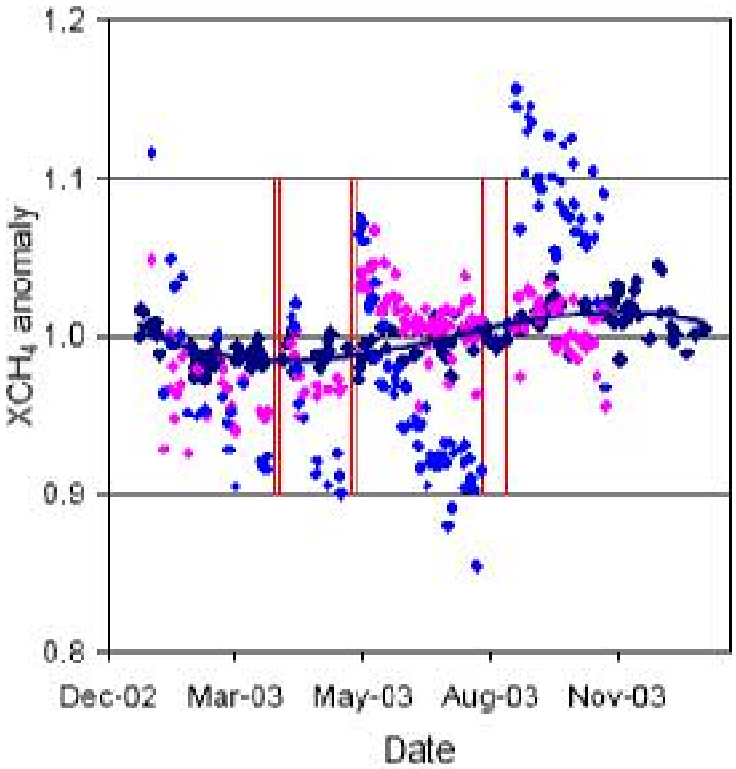

Figure 8. Anomaly of Zugspitze FTIR XCH4 daily means (dark blue points). A 3rd order polynomial fit to the FTIR data is shown as a dark blue line. Azur points: Anomaly of SCIAMACHY WFMD v0.4 XCH4; average of all data within a 2000-km radius around Zugspitze for each day. Pink points: Same as azur points but for SCIAMACHY WFMD v0.41. SCIAMACHY decontamination phases are indicated by red vertical lines. [from Sussmann *et al*, ACPD, 2005].

Mobile FTS measures* SO_2 *in polluted areas

The Chalmers mobile FTS has performed measurements of SO_2 from various sources in the Beijing area and at the Nyiragongo volcano in February and March 2004. These measurements will be used for satellite validation [Galle and Mellqvist].

First results on OMI validation

First comparisons of OMI ozone columns with those measured with 22 northern hemisphere Brewers between 1 and 16 November show an average difference of only 1.8 %, and an average standard deviation of 1.4 % [Kroon and Brinksma].

Cooperation

Initiatives were taken to enlarge cooperation in the scientific validation community, among which:

* A SCIAMACHY validation workshop was hosted by ACCENT in December 2004 [Piters]. Approximately 60 participants were present, including validation scientists, and retrieval experts.
* The DANDELIONS campaign for validation of NO_2 and aerosols from OMI and SCIAMACHY was extended with the MAXDOAS instruments from three AT2 participants [Kroon and Brinksma].

5.3 Validation strategy for tropospheric NO_2

There are 3-5 different retrieval methods for tropospheric NO_2 from GOME, SCIAMACHY, and OMI. They differ with respect to the treatment of clouds, albedo, aerosol, stratosphere component, and the NO_2 profile. Tropospheric NO_2 from satellites should be validated with representative correlative measurements. The ground-based measurements should therefore be transformed in "satellite" measurements. To do this, one would need the actual tropospheric NO2 profile and the horizontal distribution on ground pixel scale. In addition, the assumptions used in the retrieval should be verified, with respect to clouds, aerosol, stratospheric NO_2 and albedo. Validation measurements therefore ideally should be done with several independent NO_2 measuring devices (*in-situ* versus remote, column versus profile) and with additional instrumentation to measure relevant atmospheric conditions. The use of high resolution models should complete our knowledge on stratospheric and tropospheric profiles, temporal variations due to transport and (photo-)chemistry, and should aid with the conversion from point to pixel measurement.

The plans of TG3 are (1) to exploit the already planned campaign in Cabauw (NL), in May 2005, by having additional in-situ and remote NO_2 instruments available, optimising the SCIAMACHY operations for NO2 retrieval above Cabauw in that period, and measuring during SCIAMACHY overpasses, (2) to investigate the possibility to set up a small campaign in the Po-Valley in 2005 or 2006, including the RIVM NO_2 lidar, and (3) to organise a dedicated meeting on SCIAMACHY tropospheric NO_2 (end 2005 or 2006).

5.4 Validation strategy for CO from SCIAMACHY

There are 3 different retrieval algorithms developed (at IFE, Heidelberg, and SRON), which should be validated and intercompared. First validation should concentrate on the 'easy cases', where the retrieval is expected to work best. This is for situations with high albedo, no clouds, not over ocean, flat surface, high sun (low SZA), near CO sources, like fires or industrial areas, and shortly after SCIAMACHY decontamination. The current network of correlative data used for SCIAMACHY CO validation consists of a dozen FTIRs, globally distributed, but often located on an island or on a mountain, and measurements from a ship, again a difficult situation for the retrieval of SCIAMACHY CO. MOPITT is also used for the validation of SCIAMACHY CO, but MOPITT is less sensitive for boundary layer CO. The conclusion is that the current correlative measurements are not particularly suited for validation of the 'easy' cases.

The plans of TG3 are: (1) to extend the network of correlative measurements with the mobile uv-vis/ir system from Chalmers, the CMDL network (GAW stations), and with the validation networks of TES and MOPITT, (2) to try and join existing or planned campaigns, e.g. the first AMMA campaign in Western Africa (winter 05/06) with a mobile FTS, and (3) to investigate the use of models to convert in-situ (CMDL) measurements to representative measurements for comparison with SCIAMACHY CO columns. For the last point cooperation with Task Group 2 is foreseen. Furthermore, SCIAMACHY overpass information will be send to the ground stations, SCIAMACHY validation product coordinators and the already existing validation teams will be involved. A dedicated workshop on CO validation is foreseen for mid 2006.

5.5 Participants

A list of Task Group 1 principal investigators and the titles of their contributions is given in section 11.3.

6. E-learning activities

The first workshop set up a small working party under the leadership of Professor Maria Kanakidou to investigate the possibility of setting up an e-learning package to teach remote sensing. The working party is doing three things.

a. It has started to prepare a syllabus for an e-learning module on remote sensing. Initially it will concentrate on the intellectually hard topic of the retrieval of NO_2 concentrations from satellite data.

b. It commissioned a demonstration module from PerModum to demonstrate the exercise type available for testing and comprehension at a high level.

c. It held a meeting, within the second workshop to discuss the syllabus and hear a presentation of a report about practical e-learning from Richard Law.

The prototype demonstration module can be viewed at

http://www.permodum.com/moodle/login/index.php

7. Databases and Web Pages

7.1 Satellite data available

A web-based data collection page for collecting tropospheric satellite data is being developed. It was tested in early 2005 and is now live at:

http://troposat.iup.uni-heidelberg.de/AT2/Data_available/Data_available.htm.

It already incorporates some data and the resulting data base will comprise a network of producer of the tropospheric data products and a link to the site where data can be collected by users. The data from the TROPOSAT project up to 2002 has also been incorporated.

In addition three groups from Task Group 1 have collected much detailed information together on data retrieval for NO_2, CO and CH_4. This can be inspected on the link above.

7.2 Spectroscopic data of trace compounds

During the year it was found that this proposed activity would duplicate the work being done in the ACCENT support activity, Access to Laboratory Data. The development of a spectroscopic data base is being supported. The *MPI-Mainz-UV-VIS Spectral Atlas of Gaseous Molecules* can be accessed and via the web and provides spectral and line parameters for a variety of species of interest in the atmosphere.

7.3 Web Pages

In its first year of operation AT2 has established its own web page and has participated in the development of the ACCENT Web Portal.

The AT2 pages on the ACCENT web portal are to be found at:

http://www.accent-network.org/portal/integration-tasks/satellite-observations-at2.

These are self-contained providing up to date information about AT2 and its activities. They also provide copious links to AT2's more comprehensive web site at the University of Heidelberg.

The Heidelberg AT2 web site (http://troposat.iup.uni-heidelberg.de/index.html) houses the various project descriptions, the contributions from the 60 AT2 principal investigators, reports from all the meetings, as well as the list of tropospheric satellite data available to the community and a variety of striking images of the distributions of a variety of compounds in the troposphere.

The web site is currently being extended to include two new features:

a. a web-based data collection page for collecting and displaying a list of satellite data available to the community. The page is now live and can be seen at: http://troposat.iup.uni-heidelberg.de/AT2/Data_available/Data_available.htm

b. a prototype web-based e-learning module. This is currently displayed at: http://www.permodum.com/moodle/login/index.php

The site at present shows a number of test exercises in atmospheric chemistry. It will gradually be developed into an e-learning module at the master's level on remote sensing techniques.

We have been assisted in the work on the web-based data collection and the e-learning pages by Richard Law of PerModum, Ladir, Switzerland.

8. Funding of Exchanges, Visits and Meetings

The steering committee funded an external workshop and a programme of exchanges and visits, mostly by younger co-workers. The aim was to support the work of AT2 and to improve the capability of the labs and personnel involved in the field. Some 17 visits and exchanges were made during the period.

8.1 SCIAMACHY Validation Workshop

The steering committee decided to offer support to meetings of groups the activities of which serve to further the aims of AT2. The first of these was a workshop on the validation of data from the satellite instrument SCIAMACHY. It was organised by *Ankie Piters* (KNMI) and held at the University of Bremen in December 2004. Some 20 scientists attended. A report appears on the web site

8.2 Funding for visits

The following visits and exchanges were funded during the year. All those receiving funds submitted a scientific report of the work and results.

Olaf Stein	Juelich	Summer School on "Observing Systems for atmospheric composition"
S. Gerry Jennings	Galway	Student Exchange: Galway-Bremen
Maria Kanakidou	Heraklion	Student Exchange: Heraklion-Bremen
Thomas Holzer Popp	DLR	Working visit of 3 students from DLR to RIU for aerosol validation modelling
Justus Notholt	Bremen	Scientific meetings in New Zealand
Andreas Richter	Bremen	ICARRT, Orlando and Boulder, April 2004
W. v. Hoyningen-Huene	Bremen	EGU, Nice, April 2004
D. Lamsal	Bremen	EGU, Nice, April 2004
Mark Weber	Bremen	QOS, Kos, June 2004
Mark Weber and D. Lamsal	Bremen	Envisat symp, Salzburg, Oct. 2004
M.D. Dolores- Hernandez	Bremen	CEAM Valencia, Jan 2005
M.D. Dolores- Hernandez	Bremen	Amma, Paris, Feb. 2005

9. Organisational Activities during 2004-5

9.1 The AT2 Steering Committee

The AT2 project could only effectively be started after the late arrival of the contract in July 2004. However, the coordination and AT2 management team was established in March 2004. A steering group was formed and inaugurated at its meeting of the steering group, which was held on the 28th of June 2004. Members of the AT.2 steering committee include the official ACCENT steering Committee members and in addition the AT2 task group leaders, who were co-opted onto the steering committee. Two other associate members have been added since. A list of the committee is given in section 11.

Three meetings were held.: the first decided on the scientific priorities and the division of the project into task groups as well as a number of funding matters; the second, held at Schipol Airport in December planned the second workshop and allocated funds from travel and exchange. The third meeting was held in Bremen in January 2005 to review the progress of the second workshop and allocate funding.

9.2 AT2 Workshops

First AT2 workshop

The first workshop was held in Bremen in June 2004 with the aim of establishing the scientific goals of the project. The project decided to plan its scientific work with the three Task Groups, already mentioned in section 2.

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 were decided upon:

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

Some 65 people attended the workshop. A full report was published and put on the web site (http://troposat.iup.uni-heidelberg.de/index.html) which can be accessed from the ACCENT web portal.

Second AT2 Workshop

The second AT2 workshop was held in Bremen in January 2005 with the aim of fostering coordination within the task groups. Each task group held its own meetings and all the participants contributed with presentations and contributions to the discussion. Some 55 people attended the workshop. A full report was published and put on the web site (http://troposat.iup.uni-heidelberg.de/index.html) which can be accessed from the ACCENT web portal..

AT2 Strategy Document

The steering committee decided to produce a strategy document outlining the aims of the AT2 and its task groups. The coordinators, the task group leaders and all the 65 principal investigators have contributed to the document which is the process of publication. The report was published in May 2005, and is available for download on the web site.

10. Aims and deliverables for 2005-6

During the second eighteen months of AT2 (WP10), the cooperation within the task groups, initiated in the first year will be further enhanced and updated. The principal areas of work will be within the task groups, concentrating on algorithm development with inter comparisons, comparison of model results with global and regional tropospheric trace gas concentrations, and comparisons of proposed validation strategies. The work will be facilitated with workshops and the production of a detailed, scientific Annual report.

In addition, the web based data collection form will be introduced to form a web data base of tropospheric data availability. The e-learning sub-group intends to formulate the curriculum and prepare to test the high-level pilot module on remote sensing.

Deliverables for 2005-6

* Documentation: Workshop reports and the Annual Progress Reports.
* Scientific manuscripts and reports to document the progress in the activities..
* Web-based contribution to facilitate access to satellite derived data sets for research and policy support

* The preparation and possibly the provision of a pilot high-level web-based training module on the retrieval of tropospheric data from space, together with an authoring tool to enable to the module to be updated and expanded.

11. Organisation and Principal Investigators

11.1 Coordinator

John P. Burrows, University of Bremen

11.2 Steering Group

	Institution
John P. Burrows (*Coordinator*)	University of Bremen
Peter Borrell (*Deputy Coordinator*)	P&PMB Consultants
Brigitte Buchmann	EMPA, Duebendorf
Martin Dameris	DLR
Jean-Marie. Flaud	CNRS
Maria Kanikidou	University of Crete
Gerrit de Leeuw	TNO
Johannes Orphal	CNRS
Ulrich Platt	University of Heidelberg
Andreas Richter	University of Bremen
Guido Visconti	Università degli Studi – L'Aquila
Thomas Wagner	University of Heidelberg

11.3 Principal Investigators

		Title of Contribution
Task Group 1		
Steffen Beirle	IUP, Heidelberg, D	Monitoring nitrogen oxides in the troposphere with GOME and SCIAMACHY
Heinrich Bovensmann	IUP, Bremen, D	Improving tropospheric trace gas retrieval by combined UV-VIS solar backscatter and thermal IR sounding of the atmosphere
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
Cathy Clerbaux	CNRS, Service d'Aeronomie, Paris VI, F	Infrared Satellite Observations for the Study of Tropospheric Composition
Pierre-François Coheur	Uni-Libre Brussels, B	Tropospheric studies using infrared spectroscopic measurements from space
Jim Drummond	Uni-Toronto, Canada	Measurements of Carbon Monoxide from Satellites
Henk Eskes	KNMI, NL	Tropospheric Nitrogen Dioxide derived from Satellite Observations

Christian Frankenberg	IUP, Heidelberg, D	SCIAMACHY near infrared retrieval of CH_4, CO_2, N_2O and CO
Annemieke Gloudemans	SRON, NL	Retrieval of SCIAMACHY CO, CH_4, and CO_2
Don Grainger	Uni-Oxford, UK	Aerosol, Cloud and Trace Gas Measurements in the Troposphere & Lower Stratosphere
Otto Hasekamp	SRON, NL	Algorithm Development for Retrieval of Aerosol Properties from Satellite Measurements of Intensity and Polarization
Thomas Holzer-Popp	DLR, Oberpfaffenhofen D	Derivation of aerosol composition from space
Wolfgang von Hoyningen-Huene	IER, Uni-Bremen, D	Satellite Observation of Aerosol and Cloud Properties
Anton K. Kaifel	ZSW Stuttgar, D	NNORSY Ozone Profile Retrieval Suite
Johannes Keller	PSI, Villigen, CH	Retrieval of aerosol optical properties using the Multi-angle Imaging Spectro-Radiometer (MISR)
Michel Kruglanski	BIRA-IASB, B	Atmospheric aerosol retrieval from thermal infrared nadir sounding
Jochen Landgraf	SRON, NL	The global ozone distribution retrieved from GOME measurements and simulated with a chemical transport model: A comparison study
Gerrit de Leeuw	TNO, NL	Development of EO aerosol products
Diego Loyola	DLR, D	Global retrieval of cloud information combining oxygen A-band and polarization measurements of the GOME/ERS-2 and GOME-2/METOP instruments
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
Walter Di Nicolantonio	CNR-ISAC, I Bologna, I	Improvement of Algorithms for the Retrieval of Aerosol Optical Properties over Land
Stefan Noel	IUP, Bremen, D	Retrieval of vertical columns of water vapour from SCIAMACHY/ENVISAT satellite data
Johannes Orphal	LISA, Uni. Paris-XII, F	Infrared Spectroscopy for Tropospheric Remote Sensing from Space
Roeland van Oss	KNMI, de Bilt, NL	Tropospheric Ozone derived from Satellites
Oleg Postylyako	Inst. Atm Phys., Moscow, Russia	Linearized radiative transfer models for tropospheric investigation
John J. Remedios	Uni-Leicester, UK	Infra-red sensing for the retrieval of tropospheric composition from space
Philippe Ricaud	CNRS, Aerologie, Uni-Toulouse, F	Tracking pollution from space borne thermal IR sounders
Andreas Richter	IUP, Bremen, D	Monitoring Changes in Tropospheric Constitution from Space
Michel Van Roozendael	BIRA-IASB, B	Total and tropospheric BrO retrieval from space nadir and ground-based UV-Vis observations
Martijn Schaap	TNO, Apeldoorn, NL	Data-assimilation of AOD with LOTOS
Gabrielle Stiller	FZK, Karlsruhe, D	Retrieval of source gases in the tropopause region and upper troposphere from MIPAS/ENVISAT measurements

Pieter Valks	DLR Oberpfaffenhofen D	Retrieval of tropospheric ozone columns from UV-nadir measurements by the GOME/ERS-2, GOME-2/METOP and OMI instruments
Pepijn Veefkind	KNMI, de Bilt, NL	Development of algorithms for improved tropospheric data products from OMI
Thomas Wagner	Uni. Heidelberg, D	Global long term data sets of the atmospheric H_2O VCD and of cloud properties derived from GOME and SCIAMACHY
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 Atmos. 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
Sander Houweling	SRON/IMAU, B	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
Maarten van Loon	NMI, Oslo, Norway	Data assimilation applied to the EMEP model using satellite data: development and application
A. Robert MacKenzie	Uni. Lancaster, UK	The synergistic use of satellite and high-altitude aircraft data for the study of atmospheric chemistry, microphysics, and transport
Mathias Milz	FZK, Karlsruhe, D	Global measurements of water vapour in the tropopause region and upper troposphere with MIPAS/ENVISAT
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	Linearized radiative transfer models for tropospheric investigation
Miranda van den Broek	SRON, NL	Validation of SCIAMACHY CO, CH_4, and CO_2
Bart Dils	BIRA, Brussels, B	Validation of tropospheric satellite products through comparison with ground-based FTIR measurements
Mark Kroon	KNMI, de Bilt	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, Norway	Use of satellite data for atmospheric pollution and greenhouse gases monitoring
Andrea Petritoli	ISAC-CNR, Bologna, I	Validation of NO2 tropospheric column from space in the Po valley (Italy)
Ankie Piters	KNMI, de Bilt, NL	Validation of SCIAMACHY products
Daniel Schaub	EMPA, Dübendorf, CH	Air pollution decision guidance employing tropospheric satellite data together with transport models and ground-based measurements
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