Troposat-2

The Remote Sensing of Atmospheric Constituents from Space

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

Observing Tropospheric Trace Constituents from Space
ACCENT-TROPOSAT-2 in 2006-7

John Burrows and Peter Borrell
Editors

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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

6.2005 Tropospheric Sounding from Space; ACCENT-TROPOSAT-2 in 2004-5; editors: John Burrows and Peter Borrell, 2005.

7.2005 Constituents of Organic Aerosols Workshop Report, Editors Christian Dye, Cathrine Lund Myhre

1. 2006 Trace Gas and Aerosol Flux Measurement Techniques ACCENT- BIAFLUX Workshop Report, Editors David Fowler and Jennifer Muller

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8.2006 Air Quality in Eastern Europe: Review of Measurement and Modelling Practices and Needs, An ACCENT Expert Meeting, 2006 editors, Claire Granier, Paul Monks, Oksana Tarasova, Semra Tuncel and Peter Borrell.

9.2006 European on-line particle mass spectrometry, report of the Workshop held 29th-30th of November 2005 at JRC-Ispra, Italy editors, D. Mira Salama, J. Hjorth, C. Grüning, N. R. Jensen, M. Dall'Osto.

1.2007 Remote Sensing of Tropospheric Composition from Space; ACCENT-TROPOSAT2 in 2005-6; editors: John Burrows and Peter Borrell, 2007.

2.2007 Proceedings of the Workshop on Model Benchmarking and Quality Assurance, editors, Nicolas Moussiopoulos, Ivar Isaksen.

3.2007 въздухът, малка книжка за да стигнем надалеч. Bulgarian translation by Antoaneta Yotova, Ekaterina Batcharova, Tatiana Spassova, e Maria Koparova of the booklet "AIR" by Frank Raes, 2007.

4.2007 Volatile Organic Compounds in the Polluted Atmosphere, the 3rd ACCENT Barnsdale Expert Meeting, 2007. Editors, John Burrows, Tony Cox, David Fowler, Claire Granier, Ivar Isaksen, Paul Monks, Colin O'Dowd and Peter Borrell.

5.2007 ACCENT Training Workshop and Hellenic Day Hellenic Report 9-12 October 2006, Thessaloniki, Greece. Editors: N. Moussiopoulos, T. Slini, E. Schuepbach

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Observing Tropospheric Trace Constituents from Space
Table of Contents

Observing Tropospheric Trace Constituents from Space

1. AT2 in 2006-7: Summary

It is more than ten years since the launch on ERS1 of GOME, the first satellite instrument intended to probe the chemical composition of the troposphere. Since then the number of tropospheric composition satellite instruments has increased steadily. The availability of satellite data is changing the field of atmospheric chemistry. Apart from the utility of being able to make direct global observations, many field campaigns now try to link satellite retrievals into their portfolio of observations, and few global and regional modelling exercises are complete without a comparison of the results with satellite observations.

However tropospheric observations of trace substances, pollutants and particulates are still far from routine and much work is still required before tropospheric retrievals of trace substances and aerosols can become operational, and so reliably yield the desired accuracy necessary for serious scientific work.

ACCENT-TROPOSAT-2 (AT2) is an integration task of ACCENT, the EU network of Excellence. It brings together the European community of researchers in this field to address 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. Among the notable joint AT2 activities in the last fifteen months has been a follow up to the successful DANDELIONS field validation campaign for NO_2 measurements, and workshops on mid-infrared retrievals and on aerosols. The usual AT2 workshop was held with contributions from many the participating groups.

The pilot high level e-learning module for teaching the remote sensing of NO_2 from space was completed and delivered. It is now available on the ACCENT web site.

The larger part of this 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 such as the seasonal distributions of common pollutants such as CO, global and regional distributions of HNO_3 and aerosol, glyoxal emissions from anthropogenic sources, estimates of the output of NO_2 from lightning in the upper troposphere, and studies of SO_2 from volcanic eruptions.

The report presents a picture of the vigorous activity which is required if the goals of AT2 and ACCENT are to be achieved. The report also indicates the added value which such a coordination project contributes to the general research work in this diverse field.

2. AT2 origins, objectives, deliverables and report

2.1 Remote sensing of the troposphere.

It is more than ten years since the launch on ERS1 of GOME, the first satellite instrument intended to probe the chemical composition of the troposphere. Since then the number of tropospheric composition satellite instruments has been augmented with SCIAMACHY and GOME-2 launch by ESA, and by a number of instruments launched by NASA including MOPITT, MISR, MODIS, ACE, OMI, TES and IASI, results from all of which are mentioned in this report. (R. Martin and J.P. Burrows, *Satellite Observations of Tropospheric Trace Gases and aerosols, IGACtivities* Newsletter, **35**, 2007, 2 - 7.)

The availability of satellite data, as predicted in the first TROPOSAT report in 2001, is changing the field of atmospheric chemistry. Apart from the utility of being able to make direct global observations, many field campaigns now try to link satellite retrievals into their portfolio of observations and few global and regional modelling exercises are complete without a comparison of the results with satellite observations.

However tropospheric observations of trace substances, pollutants and particulates are still far from routine. The problem will always exist of attempting to observe the pollution near the ground through the overlying atmosphere, and much of the retrieval work still needs an expert hand to extract the required information from noisy data. But much progress is being made in the retrievals themselves and in the first attempts to automate them.

Thus the *raison d'être* for TROPOSAT and AT2 still exists, and the objectives are still valid and necessary: to address the need for global information about trace atmospheric constituents. The aim is 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.

2.2 Objectives

The original TROPOSAT community was subsumed by ACCENT on its formation in 2004. 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 is work package 10 of ACCENT (WP10).

The objectives for AT2 are as follows.

- The co-ordination and optimisation of the efforts of European scientists in the retrieval of 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. (*This objective has been taken over by another ACCENT activity: Access to Laboratory Data*)

- 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.

2.3 Organisation

AT2 (WP10) is 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.

TG1 has three specialist groups: UV/visible measurements, aerosol measurements, and infra red measurements, reflecting the broad divisions of the field.

Some 58 principal investigators are presently associated with the task groups of whom, 54 have contributed to this annual report.

Also an e-learning group was established within WP10 and has developed high-level web-based e-training in remote sensing from space, which is available on the ACCENT web portal. AT2 has thus contributed to the “Training and education” task of ACCENT.

The programme was ambitious but it should be possible to attain the various objectives within the proposed time scale of ACCENT.

2.4 Added value from AT2

In a coordination activity such as AT2 the question necessarily arises of whether there is any added value to the scientific work being undertaken by the participants. For AT2 the following positive points can be made.

* Satellite measurements of tropospheric trace substances, pollutants and particulates are still far from routine. The problem will always exist of attempting to observe the pollution near the ground through the overlying atmosphere and much of the retrieval work still needs an expert hand to extract the required information from noisy data. AT2 brings together, on a regular basis and in an informal way, those actively engaged in retrievals and automation, and thus facilitates their work by the exchange of ideas, methods and experience.
* The regular AT2 workshops provide the opportunity for this community to compare results and address particular topics of interest. They also provide a platform for launching cooperative activities between groups of researchers.
* The task groups provide a medium for addressing the major issues in the field: satellite retrieval, validation of satellite data and the interactive use of satellite data and models.

* AT2 produces a detailed annual report of its scientific activities which serves, not only as a tool for managing the progress of the project, but also as a handbook for researchers on current activities in the field.
* The task groups also initiate a variety of specialist workshops (atmospheric radiative transfer, retrievals for infrared data, UV/visible data, aerosols, and water vapour retrievals.
* The high level web based e-learning module would not have come into existence without ACCENT support. The meeting in Heraklion in June 2006 provided direct feedback from both teachers and students to enable the completion of the module.

2.5 AT2 in 2006-7

a. Deliverables from AT2 in 2006-7

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.

For the period 2006-7, the deliverables specified were as follows.

- Documentation: Workshop and meeting reports and a comprehensive Annual Report.
- List of published scientific papers and reports produced by AT2 principal investigators, to document the scientific progress.
- The up-dated web-based list of satellite data available.
- A pilot high-level web-based training module on the retrieval of tropospheric concentrations of NO_2 from space, together with an authoring tool to enable to the module to be updated and expanded.
- Reports from AT2 sponsored meetings.
- Reports on AT2 sponsored student exchanges *etc*.

b. The Annual Report for 2006-7

This report is the third annual report of the activities and progress within AT2. The following sections outline the scientific 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, together with 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 of algorithms for the retrieval of tropospheric data

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

3.1 Structure and aims of task group 1

The aims of task group 1 are the development and improvement of algorithms for the analysis of tropospheric data sets from satellite observations, and to distribute information on these data products and algorithms between the different groups involved. 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 links is available via the project's web-page. The documentation includes individual algorithm descriptions, validation results and overview reports on specific data products.

Task group 1 is subdivided into three sub-groups:

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

For each of these sub-groups specific challenges exist and special strategies have to be applied. For the specific activities of these sub-groups please refer to the particular sections below.

From the 33 PI contributions to task group 1, 16 are on trace gases derived from UV/visible/NIR sensors, 8 are on trace gases derived from IR sensors, and 9 are on aerosol and cloud products (see the complete list in section 9.3).

3.2 Summary of activities

During the period of reporting, very lively and manifold activities took place within task group 1. Besides substantial progress in the individual PI contributions (see highlights below, and individual reports, section 10), several coordinated efforts were carried out addressing specific scientific questions and/or improving the integration of the participating groups. Workshops on specific topics such as strategies for the analysis of a selected trace gas were held during the reporting period or are planned for the near future. Reports on these workshops are available via the AT2 web-page. Task group 1 was also actively involved in the development of an e-learning module about the DOAS analysis of satellite observations.

The progress of the individual PI contributions included the improvement of existing algorithms (*e.g.* quantitative investigation of the effects of clouds on tropospheric trace gas retrievals; retrieval of aerosol properties over bright surfaces) as well as the development of new algorithms (*e.g.* detection of ethane and SF_6 from ACE or MIPAS; and aerosol properties from thermal IR nadir sounding (IASI)). For UV/visible nadir instruments, particular efforts have been made for the quantitative merging of the results from several sensors (*e.g.* SO_2, H_2O, NO_2, HCHO from GOME, SCIAMACHY, OMI and GOME-2).

In addition to these improvements, many activities also addressed the application of the data sets to specific scientific questions. These questions include the investigation of trends, the estimation of emissions sources using inverse modelling, the determination of the aerosol layer height, or the direct relationship of satellite aerosol products to surface near aerosol concentrations.

3.3 Overviews of specific workshops

3.3.1 Tropospheric trace gas retrieval using mid-infrared spectroscopy

November 2006 (Organiser: Jean-Marie Flaud and Johannes Orphal):

The workshop provided an opportunity to exchange experience and foster collaboration between different European groups working in the field of infrared spectroscopy from space, applied to the remote-sensing of tropospheric trace gases, such as O_3, CO, SO_2, HNO_3, and several minor constituents, such as HCOOH, H_2CO, C_2H_6, *etc*., both in nadir and limb geometry (from IMG, IASI, MOPITT, MIPAS, SCIAMACHY, ACE-FTS, and TES).

As a main conclusion, one can state that infrared spectroscopy is a very promising field for atmospheric research and provides significant new results for tropospheric chemistry. There are an increasing number of satellite instruments operating in the infrared which were launched recently or are currently in preparation.

3.3.2 Determination of atmospheric aerosol properties

June 2007 (Organisers: Gerrit de Leeuw and Alexander Khokhanovski):

The aim of the workshop was to bring together experts in the area of aerosol satellite remote sensing to discuss current problems and advances with respect to quantification of local and global aerosol characteristics derived from satellite top-of-atmosphere spectral, angular, and polarisation measurements. Presentations on the various instruments in use for aerosol retrieval were invited and 63 participants from 14 countries participated with additional poster and oral presentations. The proceedings will be published as a book, now in preparation, covering the 10 most relevant presentations.

3.3.3 DANDELIONS Campaign

Task group 1 was also involved in the second DANDELIONS campaign which took place in September 2006 in Cabauw, the Netherlands. This campaign proved to be very useful for the validation of tropospheric aerosol and trace gas products derived from satellites.

3.3.4 Future TG1 workshops

- H_2O vapour retrieval workshop, Oberpfaffenhofen, November 2007, Organisers: Diego Loyola and Thomas Wagner
- NO_2 retrieval workshop, September 2007, Organiser: Ankie Piters

3.4 Progress in the different sub-groups

3.4.1 Sub-group on trace gases derived from UV/visible/near IR sensors

The objectives, scientific questions and achievables of the TG1 subgroup on UV/visible retrievals have been outlined in the ACCENT AT-2 strategy document (May 2005) as part of those for TG1. With 16 PIs (out of 33 in TG1) working on UV/visible/NIR retrievals these tasks are well underway. Below we provide a brief overview on progress for each of the UV/ visible /NIR achievables, with reference to the individual PI reports that provide more detail.

Development of new algorithms / Improvement of algorithms

* A systematic analysis of the relation between SCIAMACHY tropospheric NO_2 slant columns and cloud properties, providing both insight into the effects of clouds and a qualitative indication of the vertical NO_2 distribution (Beirle *et al.*)
* Improvements in the IR retrieval on SCIAMACHY data for CO, CH_4 and CO_2 (Buchwitz *et al.*)
* A direct retrieval for ozone profiles has been implemented which accounts for polarisation effects in the radiative transfer. The results can be directly used for an estimate of the tropospheric ozone column and will also be used as input for a data assimilation system which is expected to further improve the tropospheric data product. (de Laat *et al.*).
* Formaldehyde retrievals from GOME and SCIAMACHY have been improved by changing the spectral region used and a consistent data set from measurements of both sensors could be derived (de Smedt *et al.*).
* The tropospheric NO_2 retrieval provided on the TEMIS web pages has been extended to cover OMI data and by using forecast model fields, it can operate in NRT (Eskes *et al.*).
* The iterative maximum likelihood CO retrieval on SCIAMACHY data was extended to a third year in spite of loss of detector pixels as result of radiation damage (Gloudemans *et al.*).
* A stratospheric BrO climatology was developed based on the BASCOE 3D-CTM which will be used in the tropospheric BrO product from GOME and SCIAMACHY to improve the accuracy of the stratospheric correction (van Roozendael *et al.*).

Synergy and integration

* The newly developed consistent time series of HCHO from GOME and SCIAMACHY was compared with simulations from the IMAGES model using the recent MEGAN inventory. The good agreement over biogenic sources gives confidence to the inventory but differences remain for biomass burning regions (de Smedt *et al.*).
* SCIAMACHY NO_2 measurements have been used to validate the CHIMERE model over Europe and overall good agreement was found with some underestimation by CHIMERE in urban and suburban stations (Eskes *et al.*)
* SCIAMACHY CO retrievals have been used to study the origin of CO over Australia and it was shown that a significant part of the column originated from biomass burning in South America (Gloudemans *et al.*).
* SCIAMACHY data on NO_2 and HCHO were used to investigate the dependence of emissions during biomass burning on the type of vegetation, and systematic differences in the HCHO / NO_2 ratio were found for rain forests and grassland (Marbach *et al.*).
* GOME and SCIAMACHY BrO columns were used in combination with ground-based measurements to assess the quality of SLIMCAT total columns, and the need for additional 8 ppt of BrO from short-lived species was found (van Roozendael *et al.*).
* GOME measurements of cloud properties and O_2 absorption were used to study the link between temperature changes and cloud properties. It was found that

cloud fractions decrease with increasing temperature outside the tropical oceans while cloud height increases. Both effects indicate a positive feedback between surface temperature and cloud properties (Wagner *et al.*).

Long term data sets and trends

* Evaluation of several years of SCIAMACHY CO_2 data show excellent agreement for both seasonality and year-to-year increase when NH SCIAMACHY averages are compared to Mace Head *in-situ* observations (Buchwitz *et al.*)
* Consistent GOME and SCIAMACHY NO_2 columns have been used for trend studies and a semi-empirical source type attribution.
* The neural network based ozone climatology NNORSY has been updated to cover 8 years of GOME data and has been extended to provide a dynamical climatology taking into account location, time, and optionally also temperature profiles and ozone columns (Kaifel *et al.*).
* GOME and SCIAMACHY retrievals of H_2O have been combined to an 11 year time series. The data were explicitly adjusted for discontinuities between the measurements from the two sensors which can result from the difference in measurement time. The resulting trends are significant over many regions Noel *et al.*).
* A combined SO_2 data set from GOME, SCIAMACHY and GOME-2 data was created which shows good agreement in the overlapping time periods. The results indicate a large and continuing increase in SO_2 columns over China which could be related to both emission increases and changes in viewing conditions as result of recent changes in emission sources (Richter *et al.*).

3.4.2 Sub-group on trace gases derived from IR sensors

The activities of task group 1 concerning infrared sensors have seen a continuing and increasing effort in the last year, in particular due to the fact that a significant number of nadir and limb-viewing IR sensors are now operational on different satellite platforms and have been used for the observation of tropospheric trace gas composition:

* IMG aboard ADEOS (operational in 1996-1997) (Clerbaux *et al.)*;
* MOPITT aboard EOS-Terra (in orbit since December 1999) (Drummond);
* MIPAS aboard ENVISAT-1 (in orbit since March 2002) (Stiller *et al.*);
* AIRS aboard EOS-Aqua, (in orbit since May 2002) (Prata);
* ACE-FTS aboard SCISAT-1 (in orbit since August 2003) (Coheur *et al.*);
* TES aboard EOS-Aura (in orbit since July 2004) (Drummond);
* IASI aboard MetOp-A (in orbit since October 2006).

The fact that the infrared region allows observation of many tropospheric trace gases which are complementary to those observed in the ultraviolet-visible region, such as O_3, NO_2, CO, SO_2, CH_4, H_2CO, C_2H_6, C_2H_2, C_2H_4, PAN, HNO_3, HO_2NO_2, HCN, H_2O, HDO, NH_3 – and in many cases with significant vertical resolution – is well documented in the individual PI contributions of this year. Particular highlights are

* observations and analysis of trace gases produced in biomass burning events and from industrial pollution in the upper troposphere using MIPAS data (Stiller *et al.*),

* analysis of tropospheric CO from MOPITT and assimilation with CO from TES (Drummond),
* observation of SO_2 from volcanic emissions and in the lower-troposphere (near-surface) using AIRS data (Prata),
* measurements of C_2H_4 and H_2CO in the upper troposphere from ACE-FTS (Coheur *et al.*),
* observations of tropospheric CH_4 (partial columns between 0-10 km and 10-18 km) from IMG (Clerbaux *et al.*).

Concerning the algorithms, it is important to stress that several different scientific approaches are used to solve the inverse problem: optimal estimation, Tikhonov-Philips regularization, neural networks, and also matrix inversion techniques. It was very helpful to discuss these different techniques, the most recent results on tropospheric trace gases, and the impact of the *a-priori* information (and of the different climatologies) during an AT-2 workshop organized in Paris in November 2006, including U.S. scientists from the TES project.

Finally the synergies using data obtained from different instruments and satellite platforms are a promising route in order to obtain new data products and to improve the accuracy of the retrieved trace gas concentrations. This aspect is becoming more and more important, for example for tropospheric SO_2 (Prata) or for CO assimilation (Drummond), and will certainly provide even more interesting results in the future. Therefore, as part of the TG1 activities, a laboratory study was performed focusing on the accuracy and consistency of spectroscopic reference data in the UV-visible and infrared regions, in particular for O_3, NO_2 and H_2CO (Orphal *et al.*).

3.4.3 Sub-group on aerosol and cloud products

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

Scientific questions

1. What aerosol information can be retrieved from instruments that were not designed for this purpose (AOD, Ångström coefficient, speciation, effective size, $PM_{2.5}$, ssa, optical properties, vertical distribution), and with which accuracy?
2. 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)
   - Wide spectral range, including IR: *e.g.* MODIS
3. What are the improvements from Synergistic use of different instruments (*e.g.* SYNAER)?
4. What are the improvements in the retrieval from synergistic use of satellite instruments and chemical transport models (data assimilation)?

Question 1 is addressed by all participants who are improving their aerosol retrieval algorithms, and in particular by Holzer-Popp *et al.* with a study on the information content of SCIAMACHY, when used in combination with AATSR in the SYNAER algorithm.

Question 2 is addressed by Keller using MISR and by de Leeuw *et al.* using CALIPSO in combination with OMI

Question 3 is addressed by Holzer-Popp *et al.* who use SCIAMACHY/AATSR and by De Leeuw *et al.* using OMI/CALIPSO.

Question 4 is addressed by Timmermans *et al.*

Achievables

* Improvement of existing algorithms
  - Improvement of AATSR algorithm and application for specific studies (de Leeuw *et al.*)
  - Further development of OMI aerosol scattering algorithm (de Leeuw *et al.*)
  - Development of aerosol algorithm for thermal infrared (Kruglanski *et al.*)
  - Intercomparison between different instruments and between different algorithms for the same instrument (AATSR).
* Development of new algorithms
  - Development of algorithms to use all available information and to analyze the limitations (Hasekamp and Landgraf)
  - Development of aerosol and cloud algorithms for ATSR and SEVIRI, with emphasis on bright surfaces (Grainger and Thomas)
  - Retrieval of cloud top and cloud height from GOME (Wagner *et al.*)
  - Retrieval of aerosol properties from thermal infrared nadir sounding (Kruglanski *et al.*)
  - Work is done on future missions (Timmermans *et al.*, de Leeuw *et al.*).
  - Aerosol retrieval in the thermal infrared for application with IASI (Kruglanski *et al.*).
  - Use of geostationary satellites which potentially provide high temporal resolution (Sayer and Grainger; de Leeuw *et al.*)
* Long term data sets, trends
  - Production of long term aerosol and cloud properties data bases (Globaerosol) and validation (Sayer and Grainger)
* Synergy and integration
  - Comparison of aerosol retrieval products and assimilation of satellite data to improve $PM_{2.5}$ model results (Timmermans *et al.*)
  - SYNAER algorithm development using SCIAMACHY and AATSR (Holzer Popp *et al.*,).
  - Use of OMI/CALIPSO to improve OMI retrieval

* Applications
  - Application of satellite retrieved AOD to determine aerosol particulate matter (PM) (Timmermans *et al.*, de Leeuw *et al.*, di Nicolantonio *et al.*)
  - Application of MISR algorithm over Switzerland and northern Italy, lakes and land (Keller)
* Definition of future aims
  - Definition of requirements for new instruments (Timmermans *et al.*, de Leeuw *et al.*)

3.5 Principal Investigators and their contributions

A list of principal investigators together with their contribution titles are given in section 9.3. The individual reports from the principal investigators are given in sections 10A, 10B & 10C.

3.6 Aims for next year

The individual activities as described in the PI contributions will be continued in the next year. An important role of task group 1 will be to improve the cooperation between different groups working on similar topics (*e.g.* trace gas or aerosol retrieval in selected spectral regions, effects of clouds) 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 (see above). The outcome of the projected workshops should in particular provide detailed guidance for the improvement of the accuracy (and their assessment) of many data products.

3.7 Scientific highlights

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

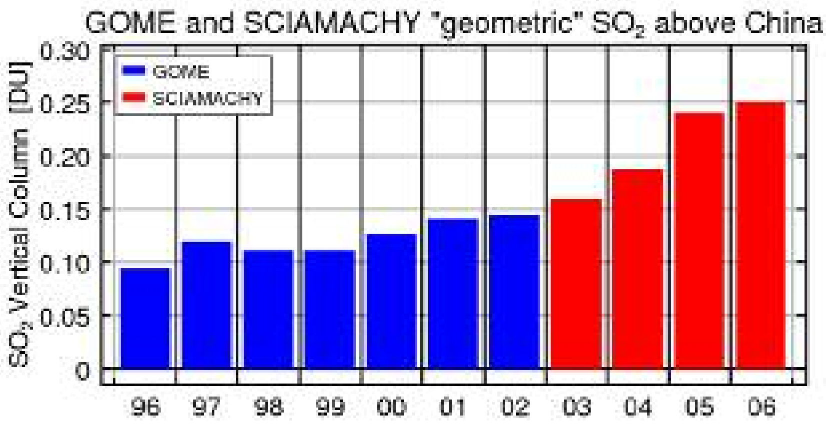


Figure 3.1. Long-term time series of GOME (blue) and SCIAMACHY (red) SO_2-columns above the industrialised part of China (20 °N, 100 °E) – (40 °N, 125 °E). As an airmass factor appropriate for volcanic eruptions was used, the absolute columns are too low over polluted areas by about a factor of two (Richter *et al.*).

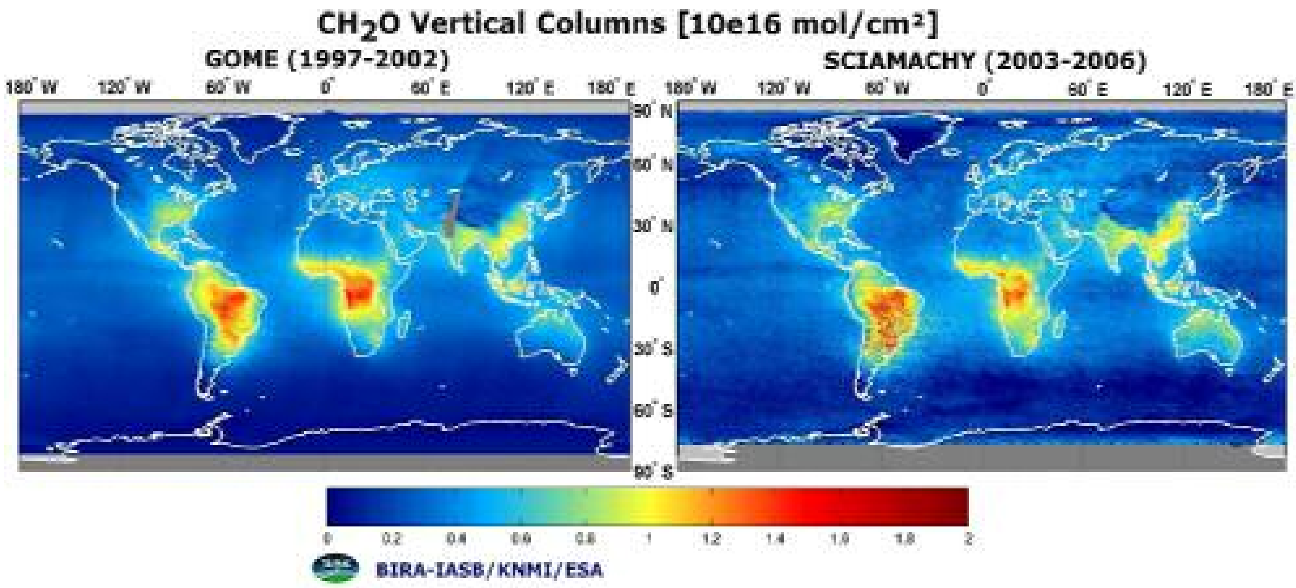


Figure 3.2. CH_2O vertical columns retrieved from GOME (1997-2002) and SCIAMACHY (2003-2006). (de Smedt *et al.*)

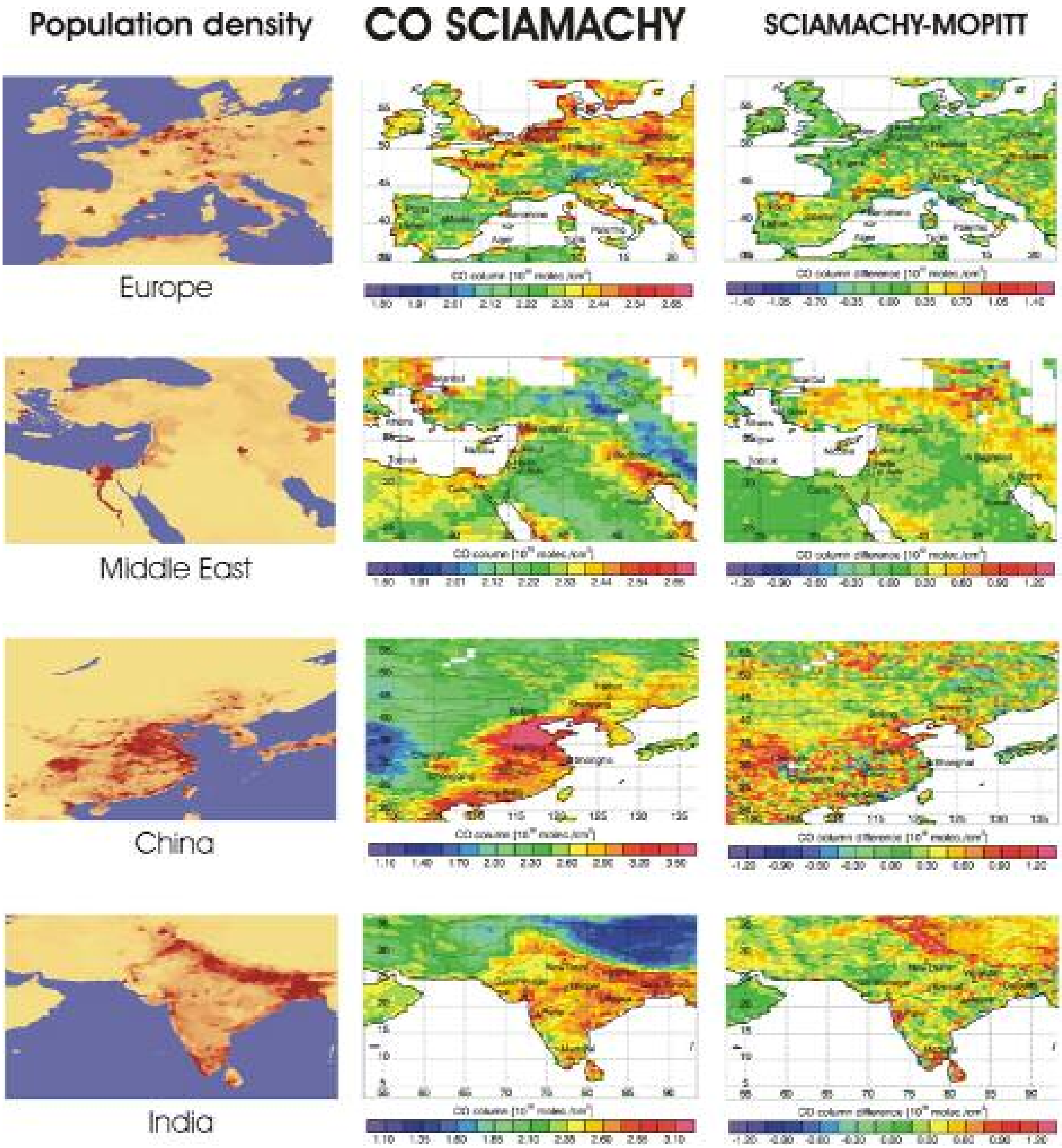


Figure 3.3. CO columns from SCIAMACHY over highly populated areas, *e.g*. cities (Buchwitz *et al.*)

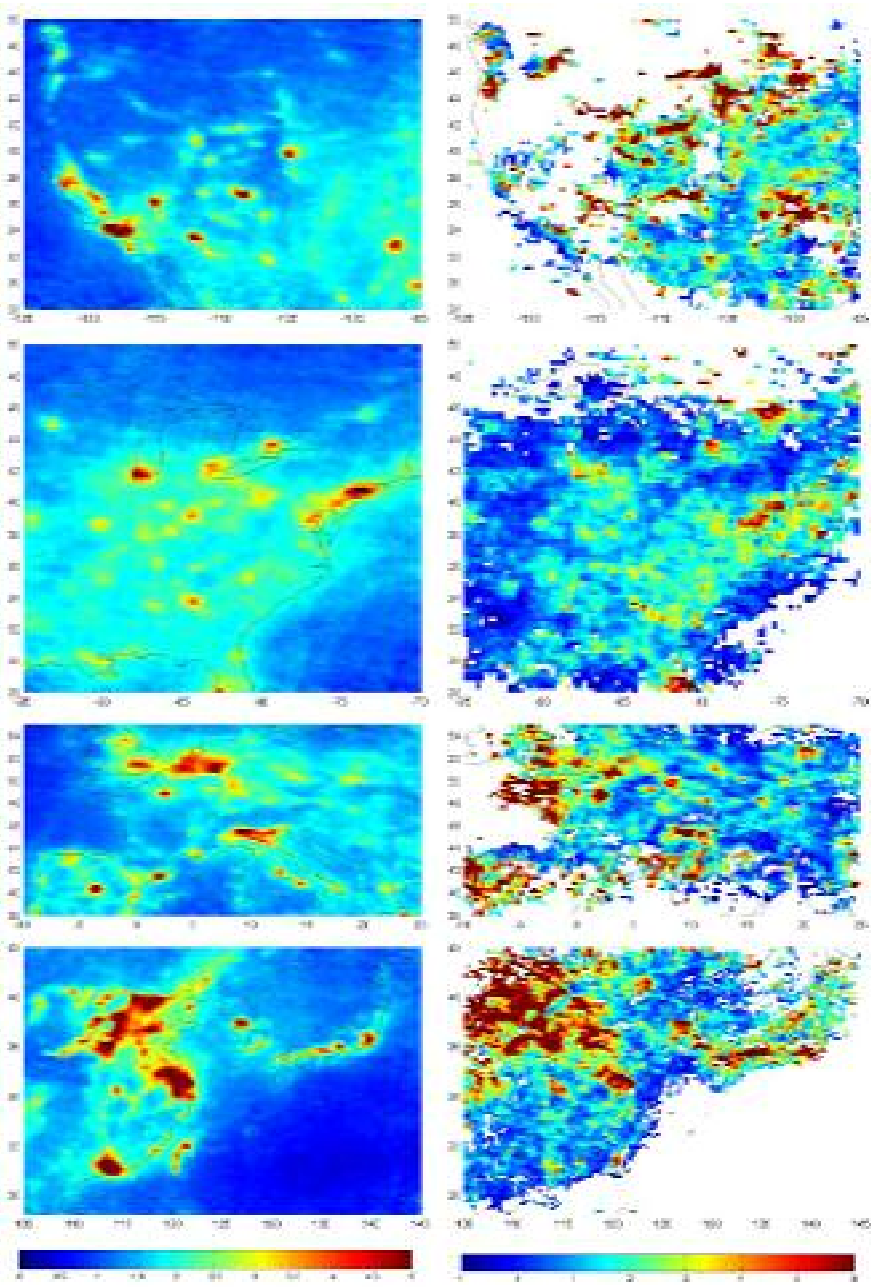
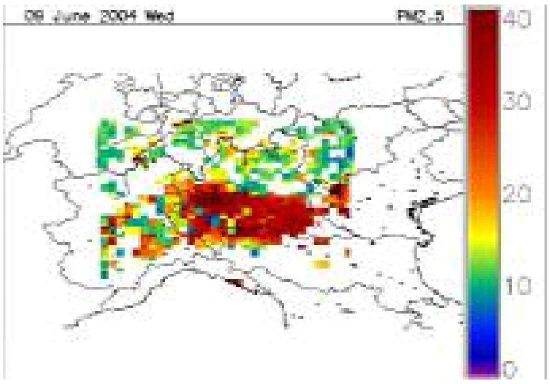


Figure 3.4. Left: Maps of mean summer NO_2 TSCD (10^{15} molec/cm^2) for different regions of the world. Right: Maps of the cloud shielding index: ratio of the tropospheric NO_2 VCD for cloud free observations compared to that of totally clouded observations. (Beirle *et al.*)



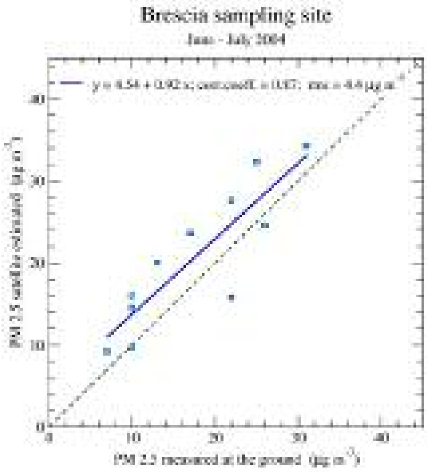
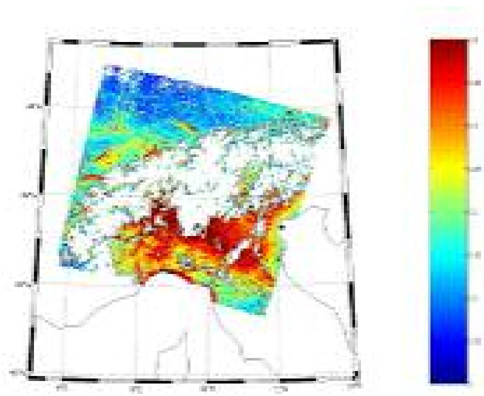
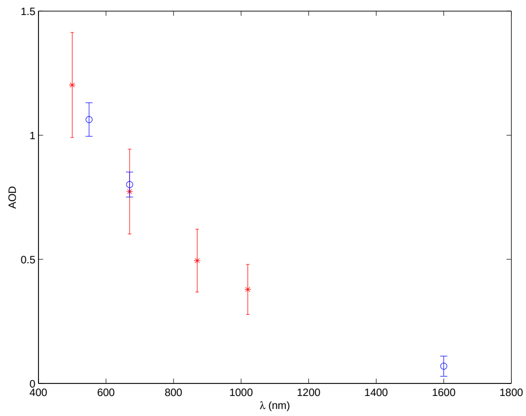


Figure 3.5a. Satellite derived $PM_{2.5}$ concentration at the ground [μg m^{-3}] for June 6th, 2004 (on the left) and for June 9th, 2004 (on the right) (di Nicolantonio *et al.*)

Figure 3.5b. Satellite-based $PM_{2.5}$ concentrations versus corresponding measurements at the Brescia ground-site for June and July 2004 (di Nicolantonio *et al.*)





a b

Figure 3.6. AOD at 670 nm over part of the Po Valley, 17th April, 2003. The Aeronet sites are marked with black stars. Ispra is the western site and Venice is the eastern. Figure b shows a comparison of AATSR retrieved AOD (blue) with collocated AEONET data for Ispra (red) for 12th June, 2003. (de Leeuw *et al.*)

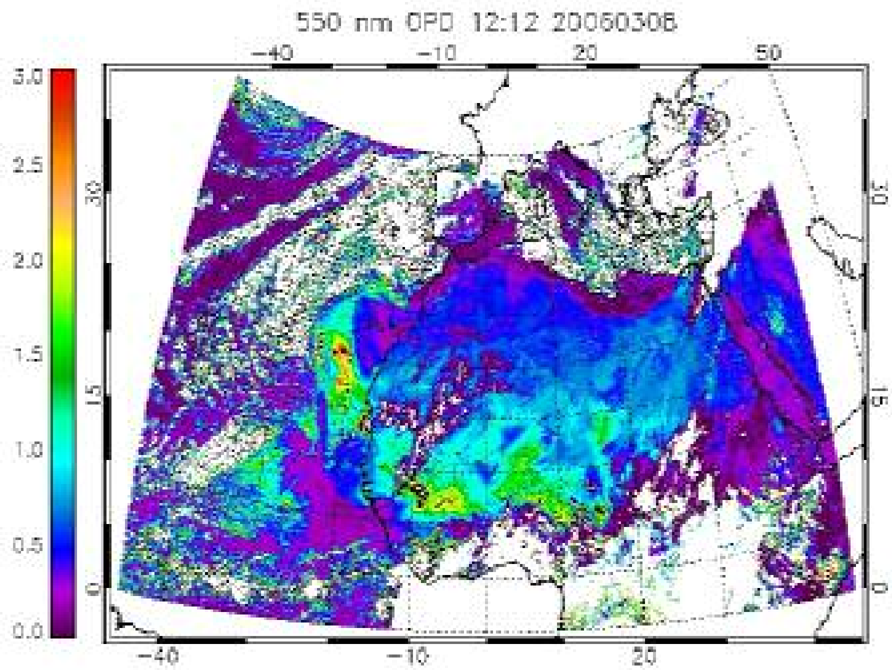


Figure 3.7. Retrieved aerosol optical depth at 550 nm using data from SEVIRI, for 12:12 pm on March 8th 2006. This retrieval makes use of refractive index measurements performed by the group. (Sayer and Grainger)

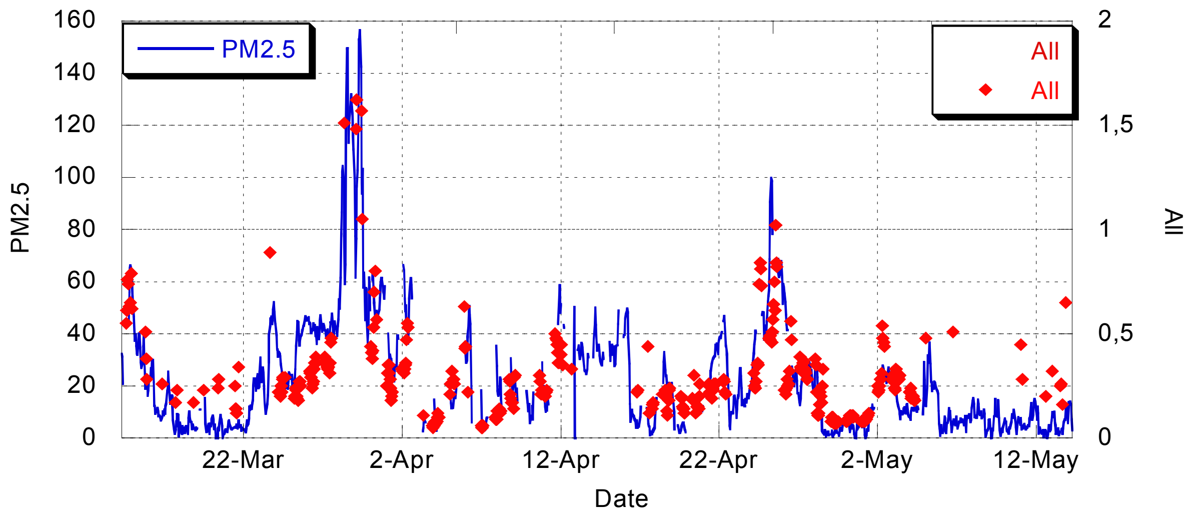


Figure 3.8. The time series of all AOD data points and $PM_{2.5}$ at Cabauw, the Netherlands (Timmermans *et al.*)

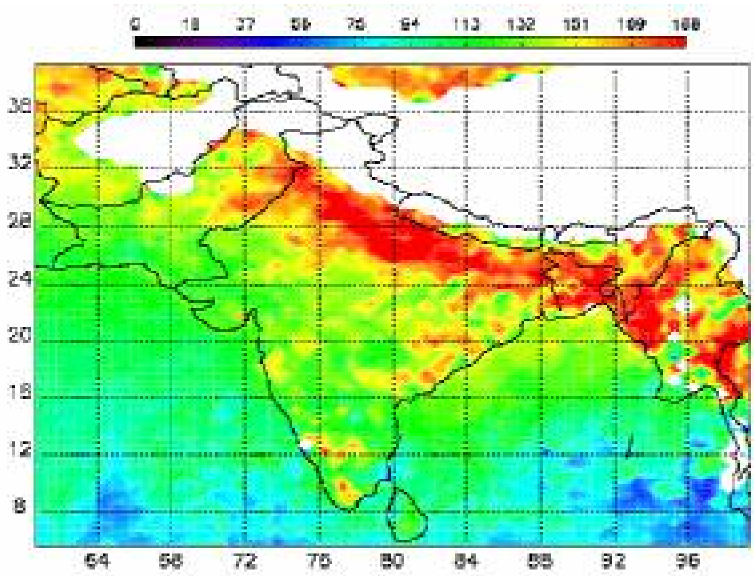


Figure 3.9. CO mixing ratios (ppbv) at 850 hPa (2000-2004) from MOPITT. Note that the band of high CO follows high population density along the Indo Gangetic basin (Drummond).

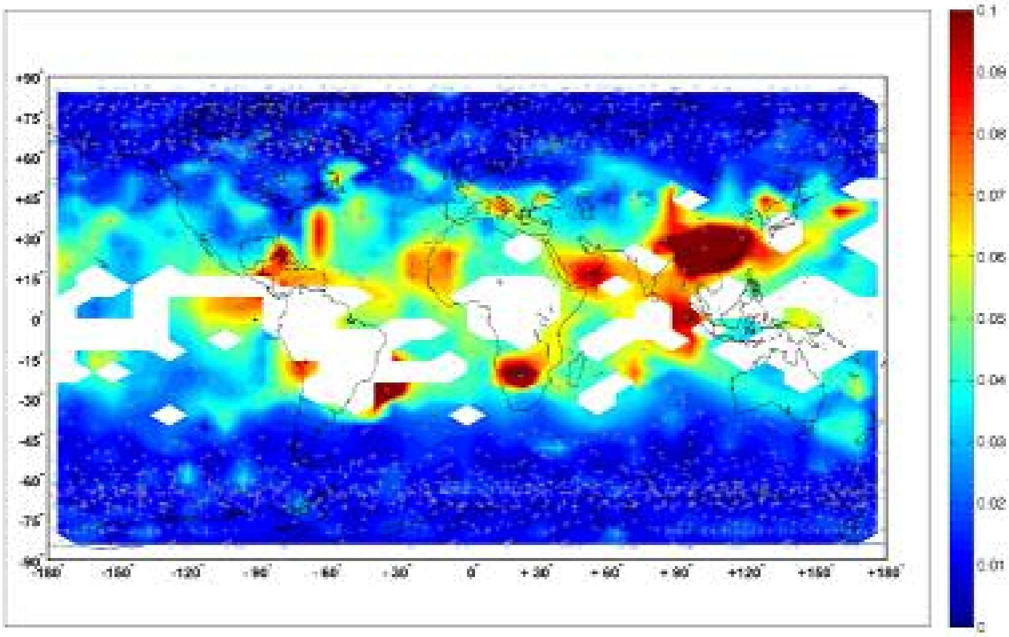


Figure 3.10. Zonal distribution of H_2CO (in ppbV) in 9.5 km altitude (2004-2005) from ACE-FTS (Coheur *et al.*)

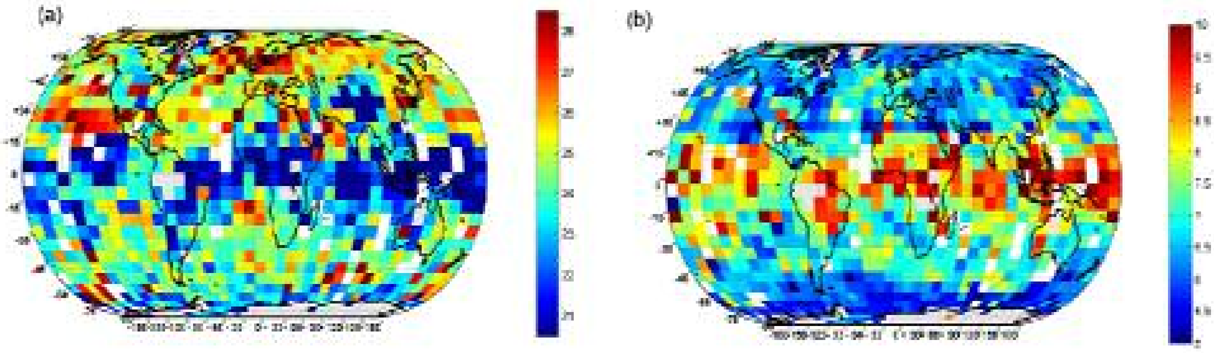


Figure 3.11. Global distributions of CH_4 (in 1018 molec/cm2) from IMG (1996-1997): (a) between the surface and 10 km, (b) between 10 and 18 km (Clerbaux *et al.*).

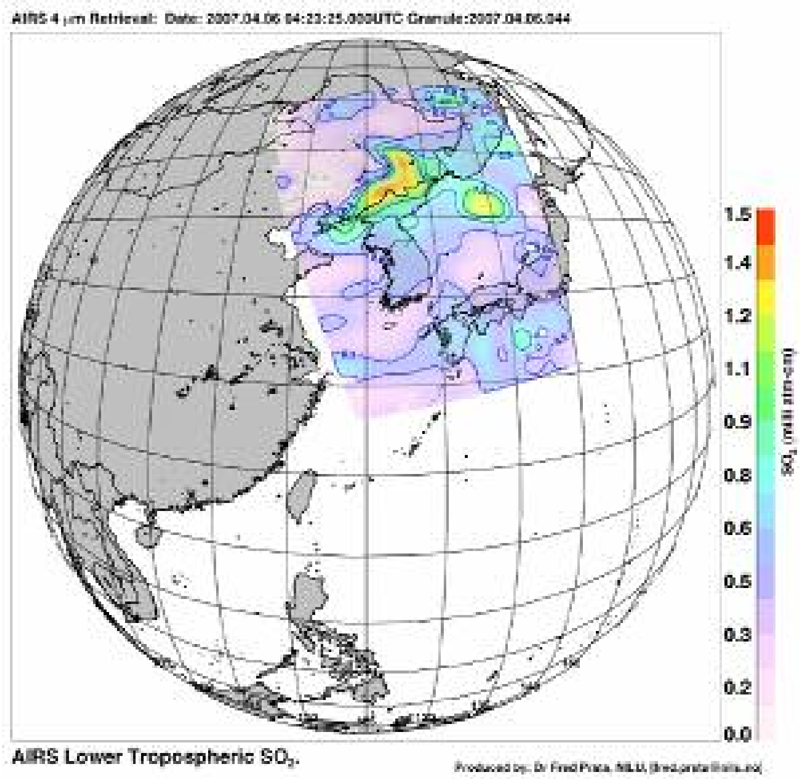


Figure 3.12. Lower tropospheric SO_2 over Asia (2007) from AIRS (Prata)

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

Martin Dameris

In the third year of AT2, a significant amount of new and scientifically interesting results have again been achieved (see individual reports). This year the task group hosts 13 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 close relations to the ACCENT-activities "*Modelling*" (PI: Ivar Isaksen) and "*Transport and Transformation*" (PI: Paul Monks). Relationships to EC-funded projects, *e.g.* SCOUT-O_3, GEMS, TROCCINOX, CAPACITY, and PROMOTE, have also been identified.

The overall aims of TG2 are listed below.

- 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, for example source attribution and impact assessment of gaseous and particulate pollutants, and their feedbacks.
- Use of model results to help bridge the gap between point measurements and the satellite view footprint for evaluating satellite retrievals.

The use of tropospheric data-products derived from satellite-instrument measurements is essential for all projects within TG2. In particular, the strength of this group is the pioneering work with so-called non-standard ('research') data products which are under development and still are not ready for common use. The identification, development and application of 'new' data products requires intensive collaboration between the three task groups of AT2. At this stage one can assess the cooperation between the task groups and overlapping activities as satisfactory, but still worthy of improvement.

In the reporting period April 2006 to June 2007, all the TG2 principal investigators delivered a report. A list of PIs and contributions is given in section 9.3; the individual annual reports appear in section 11.

4.1 Scientific highlights

In the last year, the scientific activities of TG2 were concentrated in three main areas:

1. improvement and application of data assimilation techniques including the validation of results with respective data products derived from satellite instrument measurements,
2. development and validation of numerical models to investigate individual dynamic and chemical processes of the troposphere including their feedback, and
3. development, evaluation and provision of new and extended sets of data.

Data assimilation procedures have been validated with respective observations. Assimilated data fields are used to investigate chemical as well as dynamical processes in more detail. Moreover, the further aim is to provide routine atmospheric chemistry assimilation to support operational forecasts, *e.g.* to predict air quality. Different kinds of numerical model tools are used to diagnose and assess air quality and emissions of specific regions. For that, data assimilation and 'inverse modelling' techniques together with data derived from satellite instruments are employed in a synergistic way. The evaluation of simulation results derived from Chemical Transport Models (CTMs) and Chemistry Climate Models (CCMs) with satellite data products provide the basis for the improvement of numerical modelling tools which are used to predict changes of atmospheric composition and climate.

The advantage of data assimilation is to combine data derived from different observations to get a more complete picture of the atmosphere at a certain location or period. For example, Hendrik Elbern and his group at the Rhenish Institute for Environmental Research (RIU) are using the regional CTM EURAD (EURopean Air pollution Dispersion model, Elbern and Schmidt, 2001) for their studies which focus on the European continent. They use data derived from satellite-instrument measurements (*e.g.* GOME and SCIAMACHY NO_2 tropospheric columns, GOME-NNORSY ozone profiles, MOPITT CO columns), as well as aerosol parameters (PM_{10}), which are retrieved with the new method SYNAER, in their 3/4D-var data assimilation. With their investigations Elbern *et al.* have clearly demonstrated the usefulness of assimilating AATSR/SCIAMACHY aerosol retrievals by SYNAER for atmospheric chemistry forecasting in the troposphere. Timmermans *et al.* have used satellite measurements of aerosol optical depth (AOD) to determine improved $PM_{2.5}$ fields at near surface levels. They have demonstrated that, in addition to ground based observations, satellite measurements of AOD provide a better spatial coverage and more consistent data for a larger area and therefore improve the insight into PM distributions. For their studies they have used the LOTUS-EUROS CTM. Figure 4.1 gives an impressive example: It shows the effect of assimilation of hourly ground based PM measurements and hourly satellite total AOD measurements. Assimilation of $PM_{2.5}$ at ground level lowers the RMSE with the run that simulates the 'true' state of the atmosphere (= "nature run").

There are some other outstanding examples which demonstrate the power of assimilation techniques to infer sources and sinks of chemical species (*e.g.* CH_4, NO_x) from a suitable combination of ground based and space-borne observations. For example, Beekmann *et al.* have applied for the first-time a new inverse modelling technique to assess trends of European NO_x emissions from combined tropospheric NO_2 column time series derived from the satellite instruments GOME and SCIAMACHY. A comparison of calculated decadal NO_x emissions trends (this work) and the latest version of EMEP data are given in Figure 4.2. (A detailed discussion of the obtained differences is given in the report by Beekmann *et al.*, see below.)

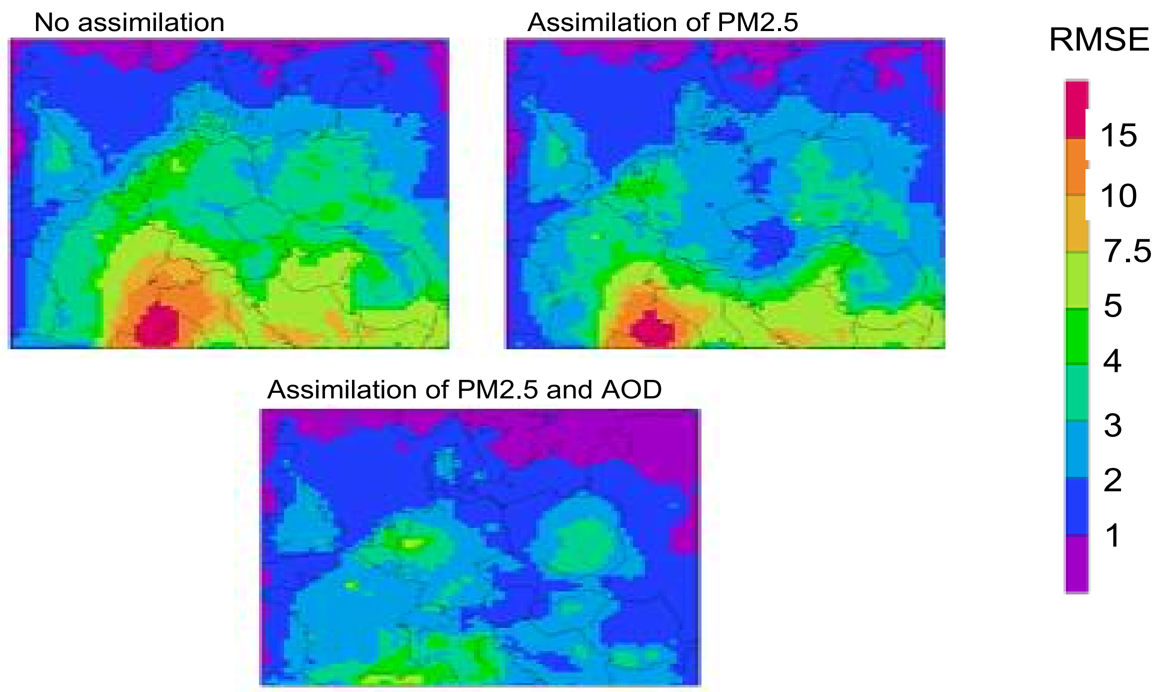


Figure 4.1. RMSE compared to the "nature run", averaged over 15th July – 14th August 2003 for 3 different model simulations: without assimilation (upper left), with assimilation of ground based $PM_{2.5}$ measurements (upper right) and with assimilation of ground based $PM_{2.5}$ measurements and hourly total AOD (bottom).

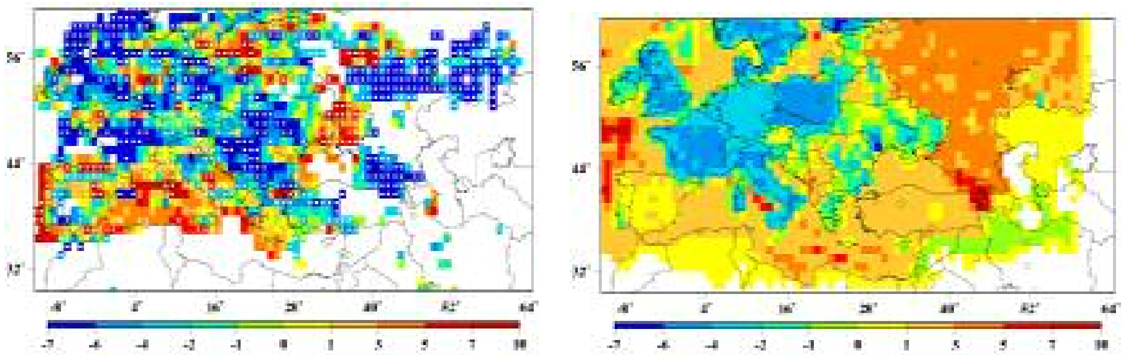


Figure 4.2. Trends in NO_x emissions (in percent per year) obtained by Beekmann *et al*. (left) and calculated using the latest EMEP data (right).

Houweling *et al*. have concentrated on the interpretation of CH_4 measurements obtained from the ENVISAT instrument SCIAMACHY. Using the 4D-var technique they have determined CH_4 sources and sinks. They have shown that the satellite data generally lead to much larger emission adjustments compared with the use of surface measurements only. As an example, Figure 4.3 shows results of an inversion including surface and SCIAMACHY measurements for the 3-month period from September to November 2003.

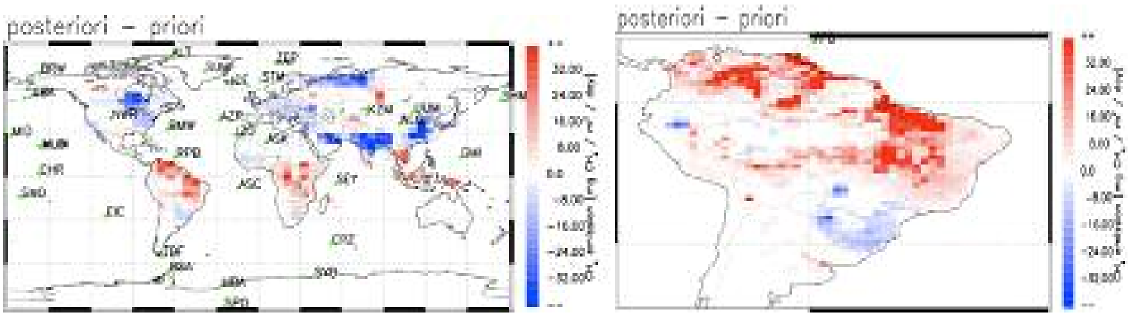


Figure 4.3. Differences of CH_4 emissions (in mg CH_4 m^{-2} day-1) obtained for posterior and prior emissions used in an inversion with SCIAMACHY data.

In section 11, progress reports of the third year of AT2-TG2 are presented together with more detailed descriptions of the achieved results.

4.2 Principal Investigators and their contributions

A list of principal investigators together with their contribution titles are given in section 9.3. The individual reports from the principal investigators are given in section 11.

5. Task Group 3: Validation strategies for tropospheric satellite data products

Ankie Piters

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 listed below.

1. Collect, analyse, improve, and make available correlative measurements from long-term continuous measurement stations and networks; establish new operational ground-truthing stations especially suited for validation of tropospheric satellite products.
2. Collect, analyse, and improve correlative measurements in special areas of interest, like Mega cities and volcanoes.
3. Perform direct comparisons between tropospheric satellite products and independent correlative measurements and models.
4. 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.
5. 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.
6. Exploit new measurement and retrieval techniques for the validation of (assumptions used in the retrieval of) tropospheric satellite products, *e.g.* horizontal/vertical/temporal distributions of aerosol, clouds, and trace gases.
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.

5.2 Cooperation

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

* A measurement campaign in Cabauw (NL) for validation of tropospheric NO_2 and aerosol from OMI and SCIAMACHY (DANDELIONS) was extended with instruments from AT2 participants, funded by AT2. This campaign was held in September 2006.

* A special session on CO validation was organised in the 5th AT2 workshop, June 2006, Heraklion. Four invited speakers reported on CO data from various satellites (MOPITT, TES, SCIAMACHY, ACE) and FTIR observations, sometimes combined with atmospheric chemistry transport models. These presentations were followed by a discussion on the need for extra analyses and/or measurements of CO, in order to increase our understanding of its atmospheric concentration.

5.3 Achievements

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

5.3.1 Tropospheric NO_2 from OMI versus in-situ

Monks et al compared two years of cloud-free OMI tropospheric NO_2 columns with the mean NO_2 measured by *in situ* monitoring stations across Leicester, representative for an urban background level. To make the measurements more comparable a geometric weighting with the OMI pixel coverage was performed to the *in situ* measurements representative for the city and a background measurement (see Figure 5.1). The correlation is good for all seasons, except winter. During the winter months, OMI retrieves much lower concentrations of NO_2 than that apparently represented by the near-surface NO_2 measurement, which may be due to the reduced sensitivity of the OMI instrument to NO_2 in the low PBL layer in this season.

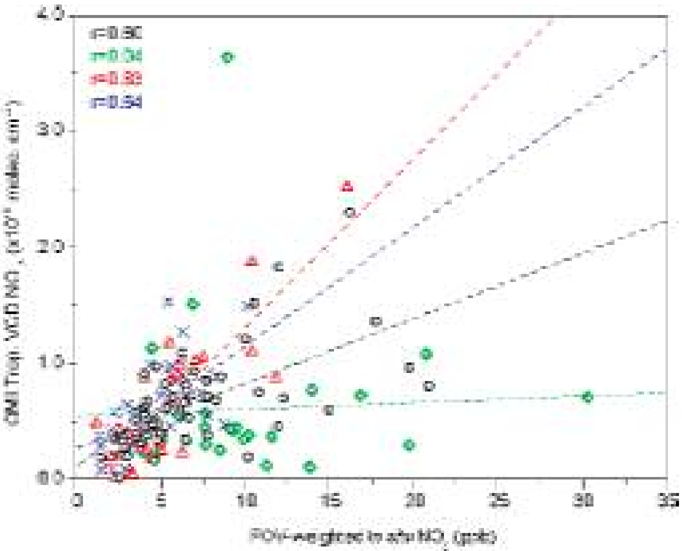


Figure 5.1. Correlation between OMI NO_2 tropospheric VCDs and the FOV-weighted mean near-surface NO_2 concentrations, for January 2005 to December 2006. The different symbols represent the seasons, autumn (black circles), winter (green diamonds), spring (red triangles) and summer (blue crosses). The dashed lines represent the linear regression for each season (from Kramer *et al,* JGR, 2007, *submitted*)

5.3.2 Improved CO *and* CH_4 *columns from SCIAMACH*

Dils *et al* showed that the new SCIAMACHY CH_4 monthly mean columns (IFE, v1.0) have significantly improved RMS scatter and correlation coefficient when compared to measurements of a quasi-global network of 11 FTIR station. The scatter of 1.4 % now almost reaches the target precision of 1 %. There is however still a substantial negative bias. The seasonality is captured rather well in the SCIAMACHY CH_4 columns, although for some stations the seasonality in the SCIAMACHY CH_4 is significantly overestimated.

Van den Broek *et al* show that SCIAMACHY CO columns (SRON) are generally in good agreement with chemical transport model calculations and that the agreement improved considerably when using biomass burning emissions based on actual satellite observations of fire counts and burned area within the chemical transport model. A statistical evaluation revealed that variations in CO columns are linearly related to the instrument-noise error, which allows improving the precision of CO columns by averaging multiple measurements either in space or time, or both.

5.3.3 First permanent Mini-DOAS installations at volcano sites

Galle and Mellqvist reported the permanent installation of 5 Scanning Dual-beam Mini-DOAS instruments in Nicaragua in November: 3 at the volcano San Cristobal and 2 at Masaya Volcano. These are the first installations within the framework of the EU project NOVAC, which is aimed at establishing a global network of stations for the quantitative measurement of volcanic gas emissions.

5.3.4 Full year of accurate ground-based **H_2CO** *columns*

Mahieu *et al* have defined and implemented a specific experimental setup at the Jungfraujoch in order to allow the retrieval of H_2CO total columns from individual FTIR observations, with good precision (~10 % for a single measurement). Measurements in this setup have now been performed for over a year. The data will be used to validate OMI H_2CO columns.

5.4 Principal Investigators and their contributions

A list of the 12 principal investigators together with their contribution titles are given in section 9.3. The individual reports from the principal investigators are given in section 12.

6. E-learning module, Database and web activities

6.1 The E-learning module

At the first AT2 workshop in 2004, it was decided to explore the possibility of constructing an e-learning course at the Master's level on remote sensing from space. The module was largely completed in 2005, but revision continued in 2006. In June 2006 a workshop was held in Heraklion to obtain live feedback on the module. It was thought to be highly successful. The module was completed in the autumn of 2006 and installed on the ACCENT web site.

http://dev1.nilu.no/moodle/at2/exerciseTutor/ExerciseModule.htm?/moodle/at2/at2-els_NO2/at2-els_NO2.htm.

It is more easily approached *via* the AT2 web page.

6.2 Satellite data available

A web-based data collection page for collecting tropospheric satellite data was developed in 2005 and can be accessed at:

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

Although a reasonable amount of data is incorporated, there are difficulties in encouraging PIs and others to enter their data and to keep it up to date.

6.3 Web pages

AT2 has its own web page,

http://troposat.iup.uni-heidelberg.de/

It houses the project descriptions, the contributions from all the AT2 principal investigators, full 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.

AT2 also has its own page on the ACCENT web portal, which is to be found at:

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

The page is self-contained, providing up to date information about AT2 and its activities. The webpage also provides copious links to AT2's more comprehensive web site at the University of Heidelberg.

7. AT2 Activities in 2006-7

AT2, the ACCENT Integration task on remote sensing from space, consists of some 58 principal investigators from 12 countries, all engaged in the extraction or utilisation of space derived data for use in the troposphere. Seventeen PIs are ACCENT associates, the remainder work at partner institutions.

The following table gives a list of AT2 activities, workshops and supported meetings during the period from June 2006 to June 2007.

5th AT2 workshop	Combining satellite observations to study atmospheric composition July 3rd and 4th 2006	Heraklion
6th Steering Group	June 2nd 2006	Heraklion
ACCENT VOC Expert Meeting	Mon Oct. 30th – Wed. Nov. 1st. Peter Borrell (*AT2 supported meeting)*	Barnsdale Hall Hotel, Rutland
Dandelions Follow Up	August to October 2006 Ellen Brinksma (*AT2 supported meeting)*	Cabauw, NL
Tropospheric trace gas retrieval using mid-infrared spectroscopy from space	November 2006 Jean-Marie Flaud (*AT2 supported meeting)*	Paris
7th Steering Group Meeting	Friday 6th December 2006	ESRIN
International Aerosol Workshop	21st – 24th April 2007. Maria Kanakidou (*AT2 supported meeting)*	Heraklion
6th AT2 Workshop.	Observing trace substances from space and integrating the results with models. Mon. 18th – Wed. 20th June 2007	IUP Bremen
8th Steering Group Meeting	Wed. 20th June 2007	IUP Bremen
Aerosol Retrieval Workshop	21st – 22nd June 2007 Gerrit de Leeuw and Alexander Kokhanovsky (*AT2 supported meeting*)	IUP, Bremen

7.1. AT2 workshops

The 5th AT2 Workshop on "Combining satellite observations to study atmospheric composition" was held in Heraklion in July 2006. There were three invited presentations together with presentation from seven PIs from task group 1, four from task group 2 and six from task group 3. A session was specifically devoted to the progress recently made with problems with CO retrievals and validation. The organiser of the workshop was *Peter Borrell.*

ftp://ftp.keele.ac.uk/pub/cha12/AT2/WP10_files/AT2_5th_wkshp_report.pdf

The AT2 E-learning workshop. The AT2 e-learning module (see below) was tested under teaching conditions at a one day workshop held in Heraklion in July 2006. The aim was introduce the module to a number of selected participants, to give them some "hands on" experience of using it and invite them to give their feedback on the details of the module. The overall impression of the module, expressed at the final plenary session, was one of admiration for approach which had been taken and the high quality of the scientific content. The organisers of the workshop were *Peter Borrell and Maria Kanakidou.*

ftp://ftp.keele.ac.uk/pub/cha12/AT2/WP10_files/2006_09_AT2_e-learning_report.pdf

The 6th AT2 Workshop on *Observing trace substances from space and integrating the results with models* was held in the Atlantic Hotel Universum, Bremen from Monday 18th to the Wednesday 20th June 2007. Some 56 people attended, the majority of whom gave presentations and participated in the discussions. There were 10 presentations in a joint session of task groups 2 & 3, and 17 from task group 1. There were also 3 presentations in a special session on the first results from IASI and GOME-2. The organiser of the workshop was *Peter Borrell.*

http://troposat.iup.uni-heidelberg.de/AT2/Reports_and_papers/2007_07_AT2_6th_wkshp_report.pdf

7.2. AT2 Supported Activities in 2006-7

AT2 provided financial support for **five** activities during 2006-7.

DANDELIONS follow-up campaign. DANDELIONS was a two-year project, with Dutch national funding, focusing on validation of OMI and SCIAMACHY NO_2 columns and OMI and AATSR aerosol data. The second campaign within the project was held in September 2006, and additional participants were invited. The organiser was *Ellen Brinksma*.

ftp://ftp.keele.ac.uk/pub/cha12/AT2/WP10_files_2007/2006_09_AT2_Dandelions2006_report.pdf

ACCENT VOC Expert Meeting. The 3rd ACCENT expert workshop was initiated to try to address the uncertainties existing in dealing with volatile organic compounds (VOC) and secondary organic aerosols (SOA). The workshop was held at the Barnsdale Hall Hotel in October 2006 under the auspices of seven ACCENT groups. The outcome of the meeting will be an ACCENT report, with recommendations and suggestions. The organiser of the meeting was *Peter Borrell.*

ftp://ftp.keele.ac.uk/pub/cha12/AT2/WP10_files_2007/AVOC_ACCENT_Report.pdf

Tropospheric trace gas retrieval using mid-infrared spectroscopy. There are currently an increasing number of infrared satellite sensors, monitoring different tropospheric species such as O_3, CO, SO_2, HNO_3, and several minor constituents such as HCOOH, H_2CO, C_2H_6, *etc*., both in Nadir and Limb geometry. The workshop was held at the "Laboratoire Interuniversitaire des Systèmes Atmosphériques" (LISA) in Créteil from Nov. 30th to Dec. 1st, 2006. The meeting showed that infrared spectroscopy is a very promising field for atmospheric research and provides significant new results for tropospheric chemistry. The organiser of this meeting was *Johannes Orphal*

ftp://ftp.keele.ac.uk/pub/cha12/AT2/WP10_files_2007/2006_10_IR_Workshop_Report_web.pdf

The ***International Aerosol and Climate Workshop*** was held at Heraklion in Crete from the 21st to the 24th April 2007. Some 80 participants attended three sessions on aerosol properties, aerosol processes and the interaction of aerosols and climate. The conference provided a forum of discussion on the latest advances and future challenges for research on the topics. Poster contributions were introduced by the discussion leaders during the sessions and were on display during the whole conference. The organiser was *Maria Kanakidou.*

AT2 Aerosol Workshop. The main scientific aim of the workshop was to compare algorithms for the retrieval of aerosol properties over land from satellite data. There were sessions on Multiple Views and Polarisation, Dual View Techniques and on Single Views. Some 60 participants attended. The organiser was *Alexander Kokhanovsky.*

http://troposat.iup.uni-heidelberg.de/AT2/Reports_and_papers/2007_07_AT2_6th_wkshp_report.pdf

7.3. Student and Scientist Exchanges and other support

No support was given in 2006-7 for exchange visits between laboratories.

8. Aims, deliverables and activities for 2007-8

The objectives, work description and deliverables, stated for the fourth ACCENT period for Work Package 10 (Remote sensing from Space) are as follows.

8.1 Objectives

* The continuation of 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 further exploitation of remote sensing data from space-based instrumentation, for tropospheric research within the European Research Area.
* The provision of added value to the national programmes exploiting remote sensing data within the European Research Area.
* Updating the web-based database to facilitate access to global tropospheric data products of trace tropospheric constituents (gases, aerosol and clouds) obtained by remote sensing from space.
* Extension of the NO_2 e-learning module to include applications
* The provision of expertise for further developing European and international environmental policy and the role of remote sensing data from space.

8.2 Description of work

During the next period (2007-8) of WP10, the cooperation within the task groups initiated in the first year, will be further encouraged and enhanced, in particular, the work 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:

* one AT2 workshop;
* the production and publication of a detailed, scientific Annual Report;
* a supported workshop on aerosols;
* supported workshops on aerosol, water vapour and NO_2 retrievals;
* a supported workshop in collaboration with ACCENT T&TP, on air quality and climate change;
* the expansion of the web based data collection of tropospheric satellite data availability;
* an extension of the NO_2 e-learning module to include applications; and
* planning for the production of a book on the "Remote Sensing of the Troposphere from Space", which will take place in the concluding phase of ACCENT.

8.3 Deliverables

* Documentation: Workshop and meeting reports and a comprehensive Annual Report.
* List of published scientific papers and reports produced by AT2 principal investigators, to document the scientific progress.
* The up-dated web-based list of satellite data available.

* Reports from AT2 sponsored meetings.
* Reports on AT2 sponsored student exchanges *etc*.
* Extension to the e-learning module to include applications

8.4 Future Activities

The following activities are planned for the next period (from August 2007).

ACCENT Symposium	23rd – 27th July 2007	Urbino
Tropospheric NO_2 workshop	10th – 12th September 2007. *Ankie Piters*	KNMI, de Bilt
Air Quality and Climate Change 4th Barnsdale Expert Meeting	5th – 7th November 2007, *Peter Borrell (AT2 supported meeting)*	Barnsdale Hall Hotel
Intercomparison of independent SCIAMACHY Carbon Dioxide (CO_2) retrievals	November 2007 *Michael Buchwitz* (*AT2 supported meeting*)	IUP, Bremen
H_2O vapour retrieval workshop	November 2007 *Diego Loyola and Thomas Wagner* (*AT2 supported meeting*)	DLR, Oberpfaffenhofen
9th Steering Group & AT2 book authors meeting	18th December 2007	MPI, Mainz
4th International DOAS workshop	March 2008 *Ulrich Platt* (*AT2 supported meeting*)	China
AT2 book – 2nd authors meeting	June 2008	tbd
7th and final AT2 Workshop	30th September – 1st October 2008	FMI, Finland

9. Organisation and Principal Investigators

9.1 Coordinator

John P. Burrows, University of Bremen

9.2 Steering Group

John P. Burrows (*Coordinator*)	University of Bremen, D
Peter Borrell (*Deputy Coordinator*)	P&PMB Consultants, UK
Brigitte Buchmann	EMPA, Duebendorf, CH
Martin Dameris	DLR, D
Jean-Marie Flaud	CNRS, F
Maria Kanikidou	University of Crete, GR
Gerrit de Leeuw	FMI, Helsinki, SF
Johannes Orphal	CNRS, F
Ulrich Platt	University of Heidelberg, D
Andreas Richter	University of Bremen, D
Thomas Wagner	University of Heidelberg, D

9.3 Principal Investigators

		Title of Contribution
Task Group 1	Leader	Thomas Wagner
UV/vis/NIR	*Leader*	*Andreas Richter*
Steffen Beirle	MPI, Mainz, D	Impact of Clouds On Tropospheric Trace Gas Retrievals
Heinrich Bovensmann unable to report for 2006-7	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 carbon monoxide and long-lived greenhouse gases (CH_4, CO_2) from SCIAMACHY/ENVISAT satellite data
Henk Eskes	KNMI, NL	Tropospheric Nitrogen Dioxide derived from Satellite Observations
Christian Frankenberg unable to report for 2006-7	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
Anton K. Kaifel	ZSW Stuttgart	New Dynamic Ozone Profile Climatology Based On NNORSY-GOME
Jos de Laat	KNMI, de Bilt, NL	Tropospheric Ozone derived from Satellite measurements
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	MPI, Mainz, D	Identification of tropospheric trace gas sources
Stefan Noel	IUP, Bremen	Retrieval of vertical columns of water vapour from SCIAMACHY/ENVISAT satellite data: Trend analysis results
Andreas Richter	IUP, Bremen, D	Monitoring Changes in Tropospheric Constitution from Space
Isabelle de Smedt	BIRA-IASB, B	Tropospheric CH_2O Observations from Satellites: Retrieval, Validation and Integration in 3D Chemical Transport Models
Michel Van Roozendael	BIRA-IASB, B	Total and tropospheric BrO retrieval from space nadir and ground-based UV-Vis observations
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
Thomas Wagner	MPI, Mainz, D	Relation of cloud cover and cloud height derived from GOME satellite observations to surface-near temperature

Infrared	*Leader*	*Johannes Orphal*
Cathy Clerbaux	CNRS, Service d'Aeronomie, Paris VI, F	Global distribution of methane retrieved from the thermal infrared IMG/ADEOS instrument
Pierre-François Coheur	Uni-Libre Brussels, B	ACE-FTS upper tropospheric measurements of ethene and formaldehyde
Jim Drummond	Dalhousie, Canada	Measurements of Carbon Monoxide from Satellites
Johannes Orphal	LISA, Uni. Paris-XII, F	Infrared Spectroscopy for Tropospheric Remote Sensing from Space
Fred Prata	NILU, Kjeller, N	Retrieval of tropospheric SO_2 from satellite infrared radiometers: AIRS, IASI and MSG-SEVIRI
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
Gabriele P. Stiller	FZK, Karlsruhe, D	Retrieval of Source Gases in the Tropopause region and Upper Troposphere from MIPAS/ENVISAT Measurements
Aerosol Group	*Leader*	*Gerrit de Leeuw*
Don Grainger	Uni-Oxford, UK	Aerosol, Cloud and Trace Gas Measurements in the Troposphere and 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	Satellite Observation of Aerosol and Cloud Properties
Johannes Keller	PSI, Villigen, CH	Retrieval of aerosol optical properties using the Multi-angle Imaging SpectroRadiometer (MISR)
Michel Kruglanski	BIRA-IASB, B	Atmospheric aerosol retrieval from thermal infrared nadir sounding
Gerrit de Leeuw	FMI, Helsinki, Finland	Development of EO aerosol products
Walter Di Nicolantonio	CNR-ISAC, Bologna, I	Satellite Observations and Meteorological Surface Characterization to Evaluate Ground-level $PM_{2.5}$ Concentrations
Renske Timmermans	TNO, Apeldoorn,NL	The use of satellite based measurements of AOD for the analysis and forecasts of $PM_{2.5}$ concentrations at ground level

Task Group 2	Leader	Martin Dameris
Jean Luc Attie	CNRS, Aerologie, Uni-Toulouse, F	Dual assimilation of MOPITT and MLS carbon monoxide in the MOCAGE 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 and Interpretation of Tropospheric Composition from Satellites Using a 3-D CTM
Martin Dameris	DLR, Oberpfaffenhofen, D	Impact of climate change on dynamics and chemistry of the UTLS: Investigations with a climate-chemistry model
Krystof Eben	Acad. Sci. of the Czech Rep	A comparison of tropospheric NO_2 columns from SCIAMACHY and OMI with model values from the mesoscale model CAMx
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 NO2 by synergistic use of satellite observations and a chemical-transport model
Célia Gouveia	IPS, Setúbal, P	Variability of Tropospheric Composition associated with Global Circulation Patterns using Satellite Data
Sander Houweling	SRON/IMAU, B	Scientific Interpretation of SCIAMACHY CO, CO_2 and CH_4 Measurements
Martin Hvidberg	NERI, DK	Assimilating remote sensing derived air quality parameters into a CTM; A study of data suitability and assimilation techniques
Jacek W. Kaminski	York University, Toronto	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
Guido Visconti	Università degli Studi – L'Aquila, Italy	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	Leader	Ankie Piters
Dominic Brunner	EMPA, Dübendorf, CH	Reconstructing fine-scale air pollution structures from coarsely resolved satellite observations
Bart Dils	BIRA, Brussels	Validation of WFM-DOAS CO and CH4 Scientific Products using Ground-based FTIR Measurements
Bo Galle (Mellqvist)	Chalmers Uni., Göteborg	Linearized radiative transfer models for tropospheric investigation
Jos de Laat	SRON, NL	Validation of SCIAMACHY CO, CH_4, and CO_2
Mark Kroon	KNMI, de Bilt	Validation of OMI data products
Emmanuel Mahieu	IAG, Liege	Optimisation of retrieval strategies using Jungfraujoch high-resolution FTIR observations for long-term trend studies and satellite validation
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
Andrea Petritoli unable to report for 2006-7	ISAC-CNR, Bologna, I	*Validation of NO_2 tropospheric column from space in the Po valley (Italy)*
Ankie Piters unable to report for 2006-7	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