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The Transport & Transformation of Pollutants

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Abstract

ACCENT (Atmospheric Composition Change: a European Network), the new European Network of Excellence was formed in 2004. One of its scientific activities is T&TP (Transport and Transformation of Pollutants). The paper offers a brief description of the necessity for ACCENT and a brief review of the recent and future activities of the T&TP sub-project.

1. Introduction

Air Pollution has a direct effect on the quality of life on earth. Its first manifestations were recognised officially in Roman times with regulations curbing the activities of certain trades. Now, with the increases in population and in agricultural and industrial activities in the nineteenth and twentieth centuries, it is all pervasive, showing itself in:

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

Many of these changes in atmospheric composition have 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 of concern for the foreseeable future.

Air pollution involves the aerial transport of pollutants between the emission source and the sites of deposition as well as the chemical transformation of the pollutants in the atmosphere. Not only are pollutants and trace substances chemically removed by atmospheric processes, they can also be transformed into secondary pollutants; an example here is surface ozone which results from the reaction of nitrogen oxides and hydrocarbons in the presence of sunlight. Thus, air pollution combines the complexity of meteorology with that of atmospheric chemistry and, while we have a reasonable overall picture of the situation, the details, on which forecasting and analysis depend, are far from clear.

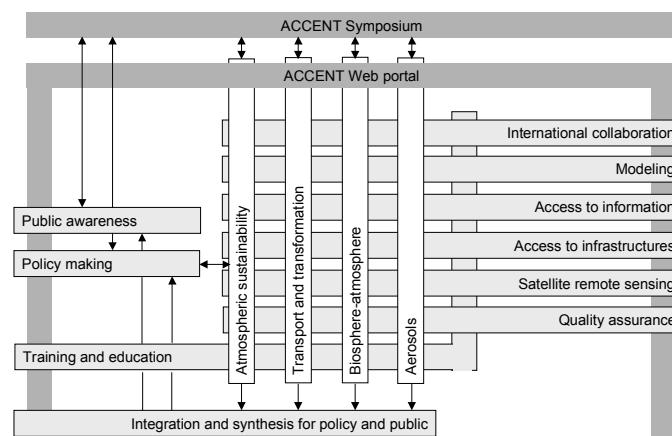
2. ACCENT

The ACCENT European Network of Excellence was set up in 2004 to provide a European scientific response to the increasing problems in the atmospheric environment. The overall goals are

- to promote a common European strategy for research on atmospheric composition change, to develop and maintain durable means of communication and collaboration within the European scientific community,
- to facilitate this research *and*
- to optimise two-way interactions with policy-makers and the general public.

ACCENT hopes to establish Europe as an international leader in atmospheric composition change research, able to steer research agendas through its involvement in major international programmes, and aims to become the authoritative voice in Europe on issues dealing with atmospheric composition change and sustainability.

The structure of ACCENT is shown in the diagram.



The ACCENT joint research programme (vertical bars) focuses on aerosols, biosphere-atmosphere interaction and transport and transformation of pollutants and it also looks for new partnership in economic and Earth System analysis.

Integration will be achieved by activities (horizontal bars) to create common facilities and activities including: a dedicated interactive web portal, models, data-bases, measurement platforms, training and education opportunities, quality assurance procedures and facilities, integrated assessment and synthesis of scientific results and an interface with the general public. The excellence and the commitment of the ACCENT Partnership guarantee an effective and durable integration of the European atmospheric composition change research and that it becomes a pillar of the European Research Area.

3 ACCENT T&TP

T&TP is one of the four components of the ACCENT jointly executed research programme. Its aim is to bring together the European community of researchers concerned with atmospheric chemistry in order to pinpoint the current problems of understanding and to foster research work aimed at resolving the principal difficulties so that the models used for analysis and forecasting on global, regional and local scales are more precise and reliable.

T&TP will fulfil the aim with a series of scoping workshops which will take place during the initial period of the program to prioritise key issues (with the aid of policy makers), define an integrated strategy for research on this topic and to plan coordinated activities to tackle nominated research topics. The goal will be to develop a series of scientific sub-foci for this activity, work on which will be pursued in the later stages.

An underlying aim will be to coordinate European research efforts in this area and so provide lasting structures for information exchange between research communities, and between the research community and those responsible for environmental policy development.

In order to fulfil the prime objective of this structuring activity there will be a range of workshops/ symposia on:

- prioritisation of key issues for development of an integrated strategy;
- planning future research activities in this area (e.g. export of European pollutants to the global atmosphere);
- development of structuring foci (such as mercury and POPs, long-range transport, atmospheric variability, chemical complexity);
- the wider context of T&TP – a multidisciplinary approach, ecosystems, health and climate; and
- how do we couple the different scales of the problem of T&TP?

The workshops will be of a variety of styles from focused small group interactive workshops to larger community undertakings. The ultimate aim of the workshop series being to arrive at lasting structures for communication and information exchange between the communities and for a set of specific recommendations for research strategies optimized to produce results to be formulated. Special attention will be paid to the role of young researchers and scientists from accession countries in such activities.

Coupled to the scoping activities, a concurrent data collection activity will be undertaken to gather meta-data on the activities of the EU member/accession countries in this science area. This activity is required in order to understand the scope of the co-ordination/exploitation required. Building structures for communication underlines the need for the actual information that is to be exchanged. Researchers in any particular country are often unaware of work being done in another country under the auspices of a national program. In order to overcome this problem, a compilation of national programmes related to T&TP that are of interest to all of the communities will be created. The T&TP national programme information service (NPIS) should act as a focus for exchange of scientific ideas and programmatic.

4. Current Activities of T&TP

T&TP has already run a number of workshops.

a. The Barnsdale Expert Meeting

The Barnsdale Expert Meeting on Frontiers in Transport and Transformation of Pollutants was the first workshop of the newly formed T&TP project, one of the four jointly executed research programmes of ACCENT. The purpose of the meeting was to review the state of understanding in four key research areas and so produce recommendations for future activities for ACCENT-T&TP.

Four principal areas were identified and working groups set up to study them.

- Chemical Complexity;
- Long Range Transport of Air Pollutants;
- Chemical Weather and
- Chemistry and Climate Interactions.

Each the four working groups identified a variety of key issues in their respective areas and made a number of recommendations for future activities within T&TP and in ACCENT, which are summarised below.

Group 1: Chemical Complexity

The group recommended the following.

- a. Formation of an expert group on the **nitrogen cycle** with the aim of writing an overview paper.
- b. Preparation of a summary of the main uncertainties in the formation of SOA (**secondary organic aerosol**) from the gas phase.
- c. Compilation a catalogue of past and upcoming campaigns (on website) to promote interactions.
- d. To “add value” to future campaigns by enabling complementary measurements for enhanced system understanding, in particular between gas phase, aerosol, nitrogen cycling, biological and deposition groups.
- e. To facilitate visits and meetings between disciplines;
- f. To encourage MCM-aerosol developments.
- g. To assimilate the knowledge from past chamber experiments and make it more accessible to scientists.

Group 2: Long Range Transport of Pollutants

The group recommended the following.

- a. Existing data that could be used to examine LRT should be collected together to create relevant database. A workshop including participants from previous EU projects (e.g. TRADEOFF) and data centres as well as end users should be the first step to formulating a strategy to achieve this. T&TP or the ACCENT Data Task might then be able to provide the resources required.
- b. A workshop would be useful to identify measurement requirement (where, what, frequency of measurements). This could be linked to IGACO. ACCENT could provide support through the Infrastructure Task.
- c. A workshop to plan an Arctic experiment which would bring together experts in Arctic research and experts in LRT.
- d. Encourage interaction with the ACCENT Aerosols Activity, which can provide much advancement in the characterisation of aerosols, the ACCENT Modelling Task which could provide improvements in modelling techniques and the ACCENT Emissions Activity which should provide improved model inputs.

Group 3: Chemical weather

The group recommended the following.

- a. Organisation of a workshop or similar meeting with discussion groups on chemical weather. It would probably be wise to choose a subset of the issues discussed within the group to focus on at such a workshop, now that this group has taken the task of defining the overall framework.
- b. Surveying the atmospheric sciences community to develop a listing of the currently operational (and “standby”) chemical weather forecast systems, subdivided into types (by scales and applications). A website with such a catalogue including links to the various operational systems would probably be of great service to the community.
- c. To link, *via* T&TP, with the chemistry-climate group to define metrics, as well as provide a mechanism for linking to the public in terms of understanding the relative value of different metrics (e.g., PM levels, visibility, etc.).

Group 4: Chemistry and Climate Interactions

The group recommended the following.

- a. A model experiment on **convection** to elucidate:
 - how changing climate will affect convection;
 - the impact of NO_x emissions from lightning
 - the impact of convection on chemistry?
- b. A workshop on the **nitrogen cycle** (see Group 1)
- c. A model experiment on **natural variability**, studying. Perhaps the El Nino/ La Nina phenomena, or the North Atlantic Oscillation. There are possible links here to the RETRO project and also AMMA.
- d. To cooperate on **emissions** with the ACCENT- emissions/GEIA group led by *Claire Granier*.
- e. **Aerosols**: To cooperate in the completion of the AEROCOM exercise in 2005 in evaluating and reducing uncertainties in the aerosol direct climate effect.
- f. To explore the area of **multiphase chemistry** with a view to it being an ACCENT topic since it appears to be of increasing interest.
- g. **Metrics**. An effort should be made to define better and more representative metrics of climate change, air pollution and hydrological cycle perturbations that will also provide regional information.

The T&TP steering group will review all these recommendations and decide with which to proceed. The recommendations will also be brought to the attention of the ACCENT community.

b. The Zeppelin Meeting

T&TP hosted a meeting in Jülich to explore the possibility of using a Zeppelin airship as a platform for instruments to study transport and chemical processes within the planetary boundary layer.



The workshop produced a proposal, the goal of which is to investigate the oxidation of anthropogenic and biogenic emissions, as well as the formation of ozone and secondary aerosols, including the chemical aging of the aerosol phase, in an innovative setup. It will be comprised of a regional pseudo-Lagrangian field experiment using a Zeppelin as a novel platform for *in-situ* sensing measurements in the planetary boundary layer. Fast detection of free radicals, volatile organic compounds and aerosols will be combined with a comprehensive chemical and meteorological characterisation in the plume downwind of a large city.

The experiment will improve our understanding of the chemical processing and the transport of pollutants from their source regions into the atmosphere. It will also strengthen the European lead role in tropospheric research by establishing the Zeppelin NT as a unique platform to explore the planetary boundary layer and its role in atmospheric chemistry and physics.

c. The Norwich Meeting on Aircraft data

Long-term systematic data bases exist for ground-based data and increasingly for satellite data. Both are available as web-based products. Unfortunately this is not the case for aircraft data even though it is much the most useful and diverse source of vertical profiles of many molecules in the troposphere. The main aim of the Norwich workshop was to define a course of action within ACCENT which will result in the assembly of a database of aircraft data suitable for defining the extent and nature of long-range transport of pollution in the atmosphere.

The main conclusion of the workshop was that a central data base for data from past and future aircraft campaigns should be set up within Europe. To this end a number of detailed recommendations were made which are currently being pursued within T&TP.

d. The Leeds meeting on the measurement of Free Radicals in the Atmosphere

Free-radicals mediate virtually all of the oxidative chemistry in the atmosphere, being responsible for the transformation of primary emissions into secondary pollutants such as NO₂, O₃ and particulates. Free-radicals control the lifetime of radiatively important gases (e.g. CH₄), the budget of O₃ in all parts of the atmosphere, and the production of acidic species. Understanding the behaviour of free-radicals in the atmosphere is of paramount importance in understanding the lifetime and hence spatial scales of pollutant transport.

This T&TP workshop brought together the world-wide community of research groups who are making free-radical measurements, together with modellers who are active in the interpretation of field data. There were *ca* 40 participants taken from the OH, HO₂, RO₂, NO₃ and halogen radical measurement community, together with modellers who are expert in the

interpretation of model-measurement comparison. The meeting had a mix of 11 keynote talks, posters from other participants and a number of parallel breakout sessions.

The outcomes of the workshop included

- An agreement on a consistent picture of field-measurements of free-radicals in the atmosphere for a variety of environments
- A better understanding of strengths and weaknesses of instruments for the measurement of atmospheric free-radicals, and an identification of future needs for instrumentation and calibration methods. Which species must be measured better and how should future field campaigns be designed?
- An identification of the major gaps in our understanding of the chemistry of free-radicals, manifested perhaps through discrepancies with modelled predictions
- A fostering of future research collaborations: new field campaigns and intercomparisons

5. Future Activities of T&TP

Among the future activities of T&TP are the following.

- a. Oslo Arctic Measurement Campaign Planning Meeting; May 2005
- b. GLOREAM/REMAPE workshop on the modelling of aerosols
- c. An Expert Meeting on the Nitrogen Cycle
- d. A Workshop on Data Assimilation in support of IGACO
- e. A Meeting on Air Quality issues in Eastern Europe.

Also a database is being set up currently to detail the various national field programmes and campaigns, and so provide a resource to bring together researchers and so maximize the scientific output from individual campaigns.

Details of all the T&TP activities can be found on the ACCENT Web Portal. (<http://www.accent-network.org/>)

6. Acknowledgements

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