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NORWEGIAN EUROTRAC PARTICIPATION 1986-1990

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1 WHAT IS EUROTRAC?

EUROTRAC is a coordinated research programme within the EUREKA initiative. The general aim is to study the transport and the chemical transformation of pollutants in the troposphere over Europe. It was approved as a EUREKA project by the Ministerial Conference in Hannover in November 1985. The next two and a half years were occupied by the definition phase in which the specific goals were decided. Subprojects concerned with specific topics within the EUROTRAC framework were established and subproject coordinators approved. EUROTRAC now comprises 14 subprojects, and a subproject on Formation of aerosols and their transformation over Europe (FATE) is about to be approved (this subproject is coordinated by Dr. Jozef Pacyna at NILU).

2 SUBPROJECTS IN EUROTRAC

A summary of the aims and objectives of the different Eurotrac subprojects is given in the following.

2.1 CLOUD STUDIES

ACE (Acidity in Cloud Experiments):

Coordinator: Tony Marsh (Leatherhead)
The aims are to determine, as a function of season:

- Bulk conversion rates for S(IV) to S(VI) and for NO_x to nitrate ion, and also the effects of organic compounds on these rates;
- The contributions from mechanisms involving peroxide, ozone and transition metal catalysts to the conversion of S(IV) to S(VI);
- Oxidant concentrations and radiation intensities throughout clouds.

GCE (Ground-based Cloud Experiments):

Coordinator: John Ogren (Stockholm)
Scientific Objectives:

- To determine the factors controlling acid-rain formation and oxidant and catalyst concentrations in cloud droplets;

- To identify the dominant European cloud types;
- To determine the importance of aerosols in cloud composition and nucleation.

2.2 FIELD MEASUREMENTS

ALPTRAC (High Alpine Aerosol and Snow Chemistry Study):

Coordinator: Hans Puxbaum (Wien)
The aims are to understand:

- The main physical and chemical processes responsible for the occurrence and accumulation of acidic and aerosol components in the high alpine region;
- The contribution of various source regions to the deposition of trace components and their geographical and seasonal trends.

TOR (Tropospheric Ozone Research):

Coordinator: Dieter Kley (Köln)
Scientific Objectives:

- To ascertain how much the mean ozone concentration over Europe is greater than that over northern mid-latitudes generally;
- To determine and to model the trends in ozone concentrations;
- To try to measure any transfer of ozone between the boundary layer and the free troposphere and between the troposphere and the stratosphere.

TOR addresses these objectives through the operation of a European network of rural research stations in which ozone and a suite of trace gas constituents of the troposphere plus meteorological parameters are measured over a number of years. Another component of TOR is a network of vertical ozone sounding stations in Europe.

The strategy that TOR follows is severalfold: In level one, the stations are set up and equipped with the necessary instrumentation. Then, the measurements will commence at each and every station. The station data will be analyzed to investigate chemical processes that determine the ozone concentration and that of other photooxidants at the respective locale of the individual station.

As the project proceeds, and the measurements of priority 1 species (O_3, NO, NO_2, NO_y, CH_4, CO, CO_2, NMHC, CFC, J_{NO2}, $J_{O(1D)}$, meteorology, priority 2 measurements are aldehydes, ketones and H_2O_2) are made at many stations, level two begins with procedures for calibration and intercalibration of instruments being

set up and executed. Data from measurements that have been made in accordance with the calibration/intercalibration protocols are called validated data. Validated data will be submitted to a central data base. The collection and storage of validated data is a prerequisite for the next level during which data will be compared among each other on the European scale.

Parallel to the experimental activities a variety of models are developed that aim at diagnostic and prognostic descriptions of the episodic and longer-term ozone distribution over Europe. TOR data will be used to test and validate these models. Finally, it is intended to conduct certain aircraft-based experiments to assist in the interpretation of station data and to obtain vertical profiles.

In the Table a list of priority 1 instrumentation at the TOR measuring sites as of December 1989, is given. CO: means continuous, OC: on occasion, w7: 7 times per week, w0.5: every second week, d8: 8 times per day,d24: 24 times per day, i.e. hourly.

TOR station #	Name of site	Principal Investigator(s)	O_3	NO	NO_2	CH_4	CO	NMHC C_2 - C_5	NMHC > C_5
1	Ny Alesund	O. Hov	CO	-	W7	W3	-	W3	OC
2	Birkenes	O. Hov	CO	-	W7	W3	-	W3	OC
3	Utö island	S. Joffre	CO	-	CO	-	-	-	-
4	Areskutan	P. Oyola	CO	CO	CO	-	CO	OC	-
5	Rörvik	A. Lindskog P. Grennfelt	CO	CO	CO	-	-	d6	-
6	Great Dun Fell	S.A. Penkett	CO	-	CO	-	-	W2	W2
7	East Anglia	S.A. Penkett	CO	-	CO	-	-	W2	W2
8	Mace Head	P. Simmonds	CO	-	-	CO	-	-	-
9	Kollumerwaard (North Holland)	R. Guicherit R. Van Aalst	CO	CO	CO	-	-	-	-
10	Brennilis	G. Toupance	CO	-	-	-	-	-	-
11	Schauinsland	A. Volz-Thomas D. Kley	CO	CO	CO	-	d24	d8	d8
12a	Garmisch-Part.	W. Seiler	CO	CO	-	-	-	W2	W2
12b	Wank	W. Seiler	CO	CO	-	-	-	W2	W2
12c	Zugspitze	W. Seiler	-	-	-	-	CO	W2	W2
13	Sonnblick	H. Puxbaum K. Radunsky	CO	-	-	-	-	-	-
14	Pic du Midi	A. Marenco							
15	K-Puszta	L. Haszpra	CO	CO	CO	-	-	W0.5	W0.5
16	RBI	L. Klasinc	CO	-	-	-	-	-	-
17	Izana	R. Schmitt	CO	-	-	-	-	-	-
18	Jungfraujoch	L. Delbouille	W5	W5	W5	W5	W5	W5	-
19	Aspvreten	P. Oyola	d24	d24	d24	-	d24	OC	-
20	Donon	G. Toupance	d24	d24	d24	-	-	-	-

Vertical soundings of ozone are done on Björnöya (Norway), Uccle (Belgium), Jülich (Germany), Haut de Provence (France) and the Hamburg LIDAR station.

Interpretation of the measurements is done using theoretical models of atmospheric chemistry and meteorology. This work is carried out by the same research groups which operate the TOR measuring sites. A data base is located at RIVM in the Netherlands.

TRACT (Transport of Pollutants over Complex Terrain):

Coordinator: Franz Fiedler (Karlsruhe)
Scientific Objectives:

- To study orographic effects on atmospheric transport and exchange processes within the boundary layer over complex terrain with special reference to turbulent dispersal, channelling and mountain induced wind systems;
- To estimate the exchange of air pollutants from the atmospheric boundary layer to the free troposphere.

2.3 BIOSPHERE/ATMOSPHERE EXCHANGE

ASE (Air-Sea Exchange):

Coordinator: Peter Liss (Norwich)
Scientific Objectives:

- To assess processes and rates of emission of trace gases in European marine environments;
- To quantify the production and removal of marine particles and aerosols, and their interaction with atmospheric gases.

BIATEX (Biosphere-Atmosphere Exchange of Pollutants):

Coordinator: Sjaak Slanina (Petten)
Scientific Objectives:

- To study the mechanisms for the uptake and production of trace constituents in relevant European ecosystems;
- To provide regional fluxes of these trace constituents on seasonal and annual scales.

2.4 LABORATORY STUDIES

HALIPP (Heterogeneous and Liquid Phase Processes):

Coordinator: Peter Warneck (Mainz)
Scientific Objectives:

- To understand the processes which generate and control oxidant and product concentrations in atmospheric droplets;
- To study the transfer of free radicals across gas/liquid interfaces;
- To estimate the contribution of aerosols to the chemistry of trace gases and radicals including the photochemical surface production of active species.

LACTOZ (Laboratory Studies of Chemistry Related to Tropospheric Ozone):

Coordinator: Karl-Heinz Becker (Wuppertal)
The aim is to provide kinetic and mechanistic data for:

- The detailed modelling of simpler organic and NO_x chemistry which influences ozone formation in the free troposphere;
- The formulation of models describing the chemistry of more complex organic and NO_x compounds occurring in the polluted boundary layer, and in air parcels transporting ozone precursors to the free troposphere.

Both HALIPP and LACTOZ are joint projects with the Commission of the European Communities' Concerted Action COST 611 (Physico-chemical behaviour of atmospheric pollutants).

2.5 MODEL DEVELOPMENT

EUMAC (European Modelling of Atmospheric Constituents):

Coordinator: Adolf Ebel (Köln)
Scientific Objectives:

- To develop a three-dimensional Eulerian gridpoint model to investigate the interaction, on a European scale, of the relationships between the sources and receptors of natural and anthropogenic trace constituents;
- To apply the model to problems of transformation and transport of trace constituents, particularly in interpreting results from other EUROTRAC subprojects.

GLOMAC (Global Modelling of Atmospheric Chemistry):

Coordinator: Henning Rodhe (Stockholm)
Scientific Objectives:

- To develop a three dimensional model of the global troposphere

for simulating the transport and transformation of trace constituents;

- To use the model to answer questions concerning the sources and sinks of tropospheric ozone and its precursors; the influence of anthropogenic processes on composition and climate; the long range transport of sulphur compounds and other acidifying substances.

2.6 INSTRUMENT DEVELOPMENT

JETDLAG (Joint European Development of Tunable Diode Laser Absorption Spectroscopy for Measurement of Atmospheric Trace Gases):

Coordinator: Franz Slemr (Garmisch-Partenkirchen)
Scientific Objectives:

- To develop new TDLAS components and techniques and TDLAS instruments for environmental measurements;
- To determine high resolution infrared spectra of compounds of environmental interest.

TESLAS (Joint European Programme for the Tropospheric Environmental Studies by Laser Sounding):

Coordinator: Jacques Pelon (Paris)
Scientific Objectives:

- To develop ultraviolet, visible and infrared lidars;
- To measure ozone in the presence of aerosols;
- To measure aerosols in the troposphere.

TOPAS (Tropospheric Optical Absorption Spectroscopy):

Coordinator: Jean-Pierre Pommereau (Paris)
Scientific Objectives:

- To develop long path measuring equipment for visible and UV spectroscopy;
- To quantify the role of oxidized nitrogen compounds in photochemical cycles;
- To test photochemical theory by the measurement of the concentrations of OH radicals and other important tropospheric species.

2.7 TO BE APPROVED

FATE (Formation of Aerosols and their Transformation over Europe):

Coordinator: Jozef Pacyna (Norway)
Scientific Objectives:
The FATE subproject will study the formation of polluted, continen- tal remote, and marine aerosol through conversions of gases and particles in the atmosphere and the transformation and removal processes of aerosol over Europe. Major emphasis is placed on examination of mechanisms which control the formation and behaviour of aerosols in the air.

Three field measurement campaigns at 8 stations representing polluted, remote continental, and marine regions in Europe are planned. The third ground-based measurement campaign will be coordinated with an aircraft campaign. In addition, some laboratory studies of gas-to-particle conversion of atmospheric compounds will be performed. Theoretical computations will be carried out to use the results from the field measurements to develop models for the transformation and removal processes of aerosols. Development of instruments and measuring techniq- ues specific to obtain the FATE goals will be performed.

3 NORWEGIAN ACTIVITY WITHIN EUROTRAC

Norwegian scientists were among the founding members of Eurotrac (Isaksen and Hov), and it was early decided to concentrate the Norwegian Eurotrac participat- ion within the Tropospheric Ozone Research (TOR) subproject. The reason was that this subproject addresses a particularly important question, which is to under- stand the mechanisms that determine the tropospheric ozone concentration over Europe. This question is linked both to acid deposition, changes in the oxidation efficiency in the troposphere, and global change. Also, the two Norwegian sites Birkenes near the south coast of Norway, and Ny Ålesund on Svalbard, are two particularly important measuring sites in the TOR network. The strong tradition in Norway for the modelling of atmospheric chemistry is also a part of the reason why the Norwegian scientific interest was particularly strong within TOR in the definition phase of EUROTRAC.

Later Norwegian scientists have joined other subprojects of Eurotrac as well (GLOMAC, EUMAC, LACTOZ and HALIPP; FATE). In the following the Norwegian contrib- ution to the EUROTRAC subprojects in 1986-1990 is summarized.

3.1 TROPOSPHERIC OZONE RESEARCH (TOR)

The objective of the research is to obtain long term, high quality measurements

at three remote Norwegian measuring sites of atmospheric trace components contributing to the chemistry of tropospheric ozone, and to carry out modelling of atmospheric physics and chemistry to support the interpretation of the measurements.

This is mainly done through the use of a trajectory model for long range transport in in the atmospheric boundary layer where chemical processes are included.

The ozone sonde measurements at Bjørnøya indicate that there is a complex vertical structure in the ozone concentration in the stratosphere. This was particularly marked during the spring of 1989 (Braathen, 1989). In January and

Measuring sites are: (1) Birkenes (South coast of Norway) 58°23'N, 8°15'E
(2) Bjørnøya (Bear Island) 74°31'N, 19°2'E
(3) Ny-Ålesund (Svalbard), 78°55'N, 4°34'E

Altitude: (1) Birkenes: 116 m a.s.l.
(2) Bjørnøya: 18 m a.s.l.
(3) Ny-Ålesund: Zeppelin Mountain 474 m a.s.l.

Species	Measured at	Frequency	Start date
Ozone, ground	1,3	Continuous	1987 (1), Sept. 1989 (3)
, sondes	2	Weekly	Oct. 1988
NO_2	1,3	Daily	EMEP (1), Sept. 1989 (3)
$HNO_3+NO_3^-$	1,3	Daily	EMEP (1), Sept. 1989 (3)
PAN	1,3	Continuous	June (1), Sept. 1989 (3)
H_2O_2	Not measured		
Hydrocarbons			
CH_4	1,3	3/week	Sept. 1989
C_2-C_5	1,3	3/week	May 1987(1), Sept.1989(3)
$>C_5$	1,3	On occasion	1989
CO	3	Continuous	1991
CFC	1,3	3/week	Sept. 1989
Precipitation			
Chemistry	1	Daily	EMEP (1)
Sum ammonium	1,3	Daily	EMEP (1), Sept. 1989 (3)
SO_2	1,3	Daily	EMEP (1), Sept. 1989 (3)
Met. data	1,2,3	Daily	
Wind (speed and direction)			
Temp.			
Pressure			
pH			

February 1989 the ozone sonde measurements at Bjørnøya were used in support of the interpretation of airborne lidar observations of ozone in the stratosphere during the Arctic Airborne Stratospheric Experiment (AASE). It was found during the first part of February 1989 that there were large regions with reduced ozone concentrations inside the polar vortex in the stratosphere (Browell et al., 1990).

During 1990 a high sensitivity continuous NO_x chemiluminescence instrument with a photolytic converter was acquired by NILU to be installed in Ny-Ålesund. It is hoped that the instrument will work as expected from the first quarter of 1991 when also a NO_y-converter built at the University of East Anglia will be installed. Also a continuous CO-analyzer has been purchased by NILU for use in Ny-Ålesund. This instrument is still also in the testing phase. An NO_2 radiometer is on order by NILU for use in Ny-Ålesund. During 1990 the analysis of C_1-C_5 hydrocarbons and chlorofluorocarbons was carried out on a routine basis at NILU on pressurized air samples. The problem of a lack of a joint TOR calibration of the hydrocarbon analysis makes a reliable comparison of hydrocarbon data from different laboratories difficult.

Two years of individual nonmethane hydrocarbon measurements at Birkenes show that there is a distinct annual cycle with a late winter maximum and a late summer minimum in the slowly reacting compounds acetylene, ethane, propane and i- and n-butane, with a concentration ratio between 2 and 4 for the average January-March values compared to July-September. Also ethene, propene and the pentanes show a similar annual cycle, but the individual scatter in the measurements in particular of propene, is large. Calculations with a photochemical trajectory model for long range transport show that the measured sum of nonmethane hydrocarbon concentrations is higher than the calculated sum when published data for European anthropogenic nonmethane hydrocarbon emissions are used.

In Figure 1 is shown the measured concentration of the nine most abundant individual nonmethane hydrocarbons in the air samples at Birkenes May 1987-September 1989. Individual measurements are shown as dots, while the full line indicates 30d running averages (Hov et al., 1990).

In Table 1 is shown the annual average for 1988 of the measured and calculated concentration of the individual nonmethane hydrocarbons and their sum, in ppbC. The five columns A-E denote the following assumptions in the model calculations: In A, calculations are carried out where photochemical reactions are taking place at the same time as there is an exchange of air between the atmospheric boundary layer and the free troposphere, in column C photochemistry is taking place while there is no exchange of air beteen the atmospheric boundary layer and the free troposphere, while in column D there is no photochemistry and no exchange with aloft air, and in column E photochemistry is occuring, there is no exchange with aloft air, and the initial concentrations are zero (i.e. only the

effect of nonmethane hydrocarbon emissions in Europe during a 96h period are accounted for) (Hov et al., 1990).

Table 1 (all numbers in ppbC)

	Measured	A	B	C	D	E
Sum NMHC	20.56	9.78	17.14	12.00	22.71	9.21
C_2H_6	4.25	4.64	5.06	5.68	6.29	2.95
C_2H_4	1.54	0.68	1.54	0.83	2.10	0.83
C_3H_8	4.62					
C_3H_6	0.56	0.28	1.15	0.32	1.57	0.32
$i\text{-}C_4H_{10}$	1.33					
C_2H_2	1.57					
$n\text{-}C_4H_{10}$	3.21	2.21	3.26	2.82	4.35	2.76
$i\text{-}C_5H_{12}$	1.94					
$n\text{-}C_5H_{12}$	1.53					

The calculated and measured sum of nonmethane hydrocarbons is seen to differ by about a factor 2 in case A in Table 1. The underestimation in the model calculation is most significant during the summer, and the underestimation is quite similar to the underestimation of NO_2 at Birkenes (see Hov et al., 1990 for further discussion). The values in column D in Table 1 represent an upper bound for what can be calculated at Birkenes with the current emission inventories of nonmethane hydrocarbons in Europe, since no chemical degradation or exchange of atmospheric boundary layer air with cleaner free tropospheric air, are assumed to take place. Still it can be seen that the calculated sum of nonmethane hydrocarbons exceeds the measured sum by only about 10%, an indication that the emissions of nonmethane hydrocarbons in Europe are underestimated at present.

In 1991 both the ground sites will run, while the ozone sonde measurements will take place with a reduced regularity. In late 1991 the frequency of sonde launches will be increased in connection with the EC/EFTA EASOE campaign (European Arctic Stratospheric Ozone Experiment). The Ny-Ålesund station will be better equipped with automatic and high quality instrumentation for NO_y, CO and J_{NO2} measurements, at the same time as projects are carried out there aimed at studying global atmospheric change (climate gases) and stratospheric ozone layer change (see Braathen et al., 1990).

A special effort will be done in 1991 in collaboration with IVL (the Rørvik station) and UEA (The Norfolk station) to interpret measurements in conjunction with model calculations for the countries surrounding the North Sea (Norway, Sweden, England).

At the University of Oslo a model of a latitude band of the global troposphere has been developed. In this model is studied the longitudinal gradients of

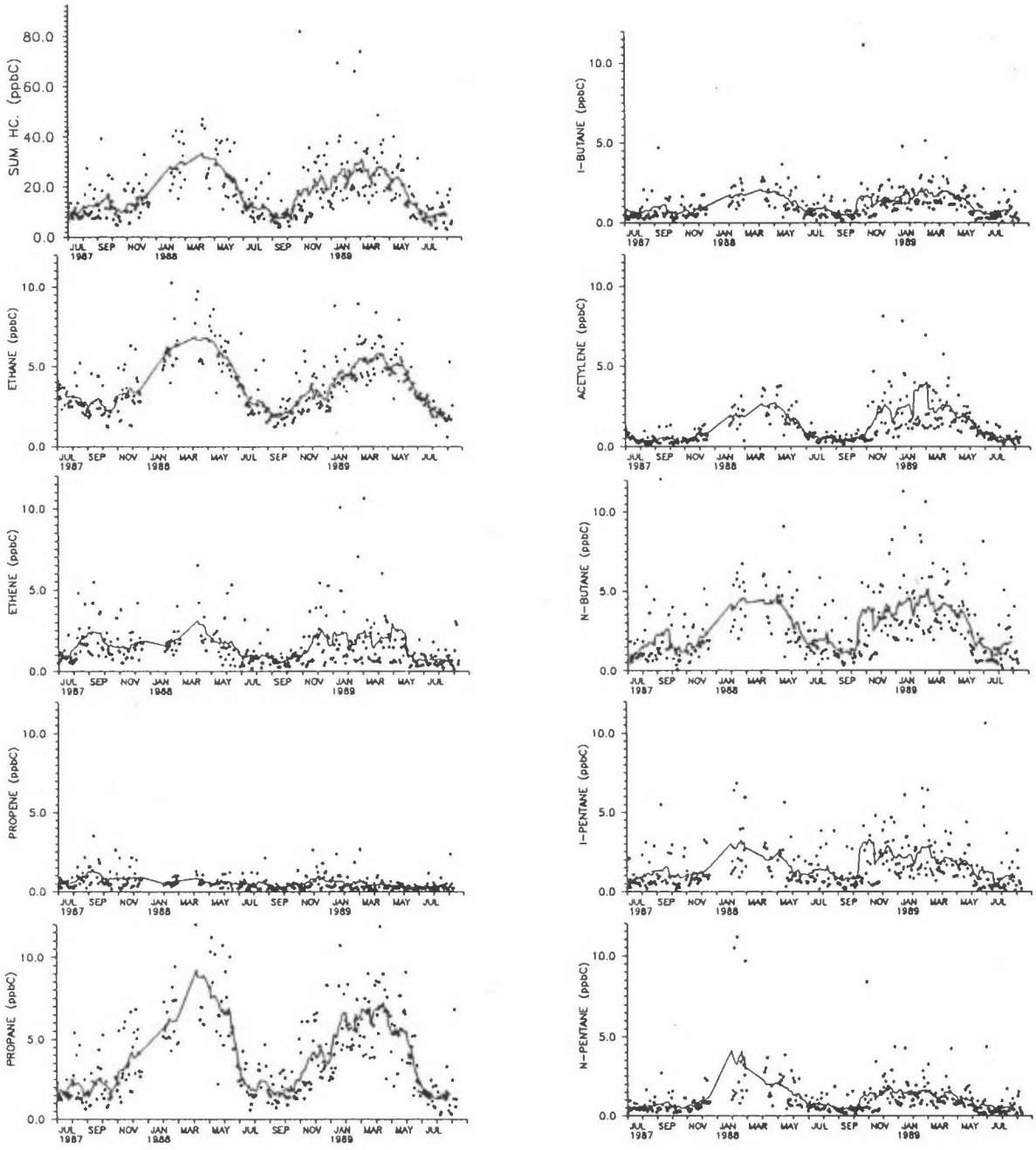

Figure 1 Measured concentration of the nine most abundant individual NMHCs in the air samples at Birkenes May 1987-September 1989. Individual measurements are shown as dots, 30d running averages as full line.

chemically active trace species over continental and oceanic regions at mid latitudes ($30^{o}N$-$60^{o}N$). Particular emphasis is given to the distribution and changes of ozone (O_3), hydrogen peroxide (H_2O_2) and hydroxyl (OH). In a situation representing spring (April) ozone was found to be photochemically formed when air masses were transported from industrialized continents to oceans where the loss processes are slow. Maximum ozone values of almost 60 ppbv were obtained in surface air over the mid Atlantic. OH and H_2O_2 were found to be anti-correlated: OH with a maximum over industrialized areas where the NO_x levels are high, and H_2O_2 with a maximum over remote unpolluted areas where the concentration exceeds 1 ppbv. Ozone was found to have increased substantially since the turn of the century as a result of man-made releases of pollutants (NO_x, hydrocarbons, CO) (Isaksen et al., 1989a).

In a different model calculation applying a meridional (pole to pole) model of the global troposphere, where complete zonal mixing is assumed in the east-west direction, it was found that there has been a substantial increase in global tropospheric ozone (≈25%) since the turn of the century. The increase is most pronounced at northern mid-latitude surface levels where ozone was estimated to have doubled. OH concentrations show a small decrease in the same time period. Nearly all future scenarios adopted, gave smaller ozone changes. From 1985 to 2100 the calculated global ozone change was in the range -5% to -25%. Global average OH changes were always less than 10% (Isaksen et al., 1989b).

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3.2 LACTOZ AND HALIPP

Claus Nielsen at the Department of Chemistry, University of Oslo is participating in the LACTOZ and HALIPP subprojects with the following research tasks:

-Infrared spectroscopic studies of the reaction between the nitrate radical, NO_3, and unsaturated, halogenated compounds (LACTOZ).
-Heterogeneous and homogeneous chemistry of ClO_y, BrO_y and NO_y compounds on polar stratospheric cloud mimics (HALIPP).

In the first research task, the aim is the following:
There is a steady increase in the anthropogenic emission of unsaturated, halogenated hydrocarbons, and it is important to obtain information of the chemical transformations of this class of compounds in the troposphere. The nighttime chemistry, i.e. the chemistry that progresses without the direct influence of sunlight, is of particular interest in Scandinavia. In the daytime the chemistry of the troposphere is dominated by the hydroxyl radical while the nighttime chemistry of the moderate to very polluted atmosphere is dominated by the nitrate radical. The goal of the research project is: (1) Characterisation of the mechanism for the NO_3-induced vapour degradation of unsaturated, halogenated hydrocarbons. (2) Determination of the rate constants for each step in the oxidative degradation. (3) Investigation of the physical properties of the reaction products.

In research task 2, the aim is the following:
The project is arranged as a cooperation between laboratories in United Kingdom, France, Germany and Norway. The aim is to obtain a quantitative understanding of the products, mechanisms and kinetics of reactions associated with the low temperature polar stratospheric cloud (PSC) surface chemistry of various chlorine/bromine species, NO_x/NO_y compounds and ozone. This information is required to clarify aspects of heterogeneous and homogeneous stratospheric chemistry, which have been shown to be important in determining observed annual depletion in ozone levels over Antarctica. The specific research objectives are: (1) Characterisation of nitric acid-ice and water-ice PSC mimics. (2) Determination of PSC surface reaction products and mechanisms. (3) Determination of sticking coefficients for ClO_y, BrO_y and NO_y on ice surfaces at different temperatures. (4) Determination of gas phase products of BrO chemistry. (5) Determination of the effects of photolysis on PSC mimics.

In the paper by Cappellani et al. (1988), the homogeneous vapour phase reactions between the nitrate radical, NO_3, and propene, 2-methylpropene, 2-butene, 2-methyl-2-butene and 2,3-dimethyl-2-butene were studied by FTIR. There were indications that the major products of the tropospheric nighttime reactions of NO_3 and the naturally emitted terpenes are carbonyl compounds and that only small amounts of dinitrates are formed.

In another paper (Hjorth et al., 1988) an experiment to determine the reaction rate coefficient for the reaction $NO_3 + NO_2 \rightarrow NO + NO_2 + O_2$ at room temperature was reported. In Hjorth et al. (1990) was reported a study of the vapour phase reaction at room temperature and ground pressure between the nitrate radical and vinylchloride by long path FTIR spectroscopy. The reaction mechanism for the NO_3 initiated degradation of vinylchloride appears to follow the pattern for unsaturated compounds: after nitrate radical addition to the compound, peroxy and oxy radicals, alcohols and carbonyl compounds are formed.

In the most recent paper by Hjorth et al. (1990), products and mechanisms for the gas phase reactions of NO_3 radicals with a series of alkenes in air have been studied. The experiments with propene, isobutene, trans- and cis-2-butene, 2-methyl-2-butene and 2,3-dimethyl-2-butene were carried out at room temperature and ground pressure in a large Teflon coated reaction chamber where NO_3 was generated by thermal dissociation of N_2O_5. Reactants and products were observed to produce nitroxy-nitroperoxy intermediates that decayed with formation of carbonyl, nitroxy-carbonyl, nitroxy-alcohol and dinitrate species. The product distribution was found to be dependent on the alkyl substitution pattern around the double bond.

3.2.1 References, LACTOZ and HALIPP related research with Norwegian participation

Cappellani, F., Hjorth, J., Lohse, C., Nielsen, C.J. Restelli, G. and Skov, H. (1988) Laboratory studies of tropospheric nighttime chemistry using FTIR. Progress in Molecular Spectroscopy, (Eds. R. Salzer, H. Kriegsmann and G. Werner), Teubner Verlag, Leipzig, 230-240.

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3.3 NORWEGIAN PARTICIPATION IN GLOMAC

The Norwegian contribution to GLOMAC comes from the Department of Geophysics at the University of Bergen and it consists of cloud, precipitation and sulphur parameterization schemes for use in a general circulation model (GCM). The experience gained from regional modelling has lead to implementation of the cloud description and an associated parameterization of wet scavenging of sulphur into a modified version of the GCM from the European Center for Medium Range Weather Forecasts in use at the University of Hamburg. Continued work on the parameterization of these processes is done by Erik Berge (dr.scient. student) in collaboration with scientists from the universities of Hamburg and Stockholm and from Max Planck Institute for Atmospheric Chemistry in Mainz.

At present, the parameterization is tested out in a 3-dimensional meso-scale weather prediction model at the University of Bergen. This meso-scale model

contains a refined description of the formation of clouds and precipitation, including a prognostic equation for the cloud water content (Sundqvist et al. 1989).

The parameterization describes the sulphur quantities explicitly both in air and clouds (Berge, 1989). It is initialized with model simulated fields of sulphur dioxide and sulphate in air, based on realistic sulphur SO_2 emission fields. The oxidation, uptake by clouds and deposition by precipitation are, as a first approach, described by simple transformation rates.

An improvement of the description of the oxidation processes is obtained by a more explicit description of the chemical processes which convert sulphur dioxide to sulphate. Oxidation by hydroxyl radicals in air, and by ozone and hydrogen peroxide in clouds is then included and tested in the meso-scale model at the University of Bergen before it is implemented into the GLOMAC model.

3.3.1 References, Norwegian GLOMAC-related papers

Berge, E. (1989) A regional numerical sulfur dispersion model using a NWP-model with explicit treatment of clouds. IBM report series, BSC 89/13.

Sundqvist, H., Berge, E. and Kristjansson, J.E. (1988) Condensation and cloud parameterization studies with a mesoscale NWP model. Mon. Wea. Rev., 117, 1641-1657.

3.4 NORWEGIAN PARTICIPATION IN EUMAC

The Norwegian scientific contribution to EUMAC is given by Jozef Pacyna at NILU who through a contract with the University of Köln has concentrated on establishing emission data for use in the EUMAC model.

The purpose of Pacyna's EUMAC contribution was to establish European emission estimates for SO_2, NO_x, VOC, NH_3, N_2O, CO, and CH_4, to relate these emissions to statistical data on the consumption of fossil fuels and the production of various industrial goods, to discuss the VOC profiles for various source categories, and to present the spatial distributions of emissions of the above constituents within the EMEP grid of 150 km x 150 km (EMEP=European Monitoring and Evaluation Programme).

In Table 2 is given a summary of the national emission figures estimated by Pacyna (1989). It is planned to continue the Norwegian work in EUMAC within the Subgroup on Emissions and Data Bases, where J.M. Pacyna is a co-chairman. This involvement will contribute to the establishment of VOC profiles for various

source categories. A method for transformation of annual emission data to daily values will also be developed.

Anthropogenic emissions of major gases in Eastern Europe in 1982 (in 10^3 t).

Country	SO_2 [1] as S	NOx as NO_2	VOC (non-methane)	NH_3 [2]	CH_4	CO	N_2O
Albania	25	28.0	32.8	21.0	0.5	121.7	7.1
Bulgaria	570	278.3	167.2	126.0	3.3	627.5	59.4
Czechoslovakia	1 575	556.9	258.7	170.0	18.7	765.9	112.1
GDR	2 500	857.1	353.6	207.0	26.0	1 020.7	250.0
Hungary	774	268.5	165.6	127.0	6.0	527.9	39.7
Poland	2 150	1 276.1	493.8	405.0	37.5	1 447.6	216.0
Romania	100	737.8	385.7	301.0	17.6	1 176.1	117.5
USSR (Europe)	6 100	7 969.0	5 822.7	1 256.0	322.5	24 009.2	1 788.3
Yugoslavia	657	440.4	290.7	198.0	9.4	929.6	91.4
Total	14 451	12 412.1	7 970.8	2 812.0	441.5	30 626.2	2 681.5

Table 2

3.4.1 References, Norwegian EUMAC papers

Pacyna, J.M. (1989) Emissions of major pollutants emitted in Eastern Europe. NILU OR 48/89.

4 EUROTRAC AND ENVIRONMENTAL POLICY QUESTIONS OF PARTIC ULAR CONCERN FOR NORWAY

Environmental problems related to atmospheric physics and chemistry and being of concern for Norway may be stated as follows:

Acid deposition. Related to SO_2, NO_x, NH_3-emissions.
Long range transport of photooxidants. Related to NO_x and VOC-emissions.
Eutrophication. Related to emissions of NO_x and NH_3 as well as other nutrients.
Ozone layer depletion. Related to emissions of CFC.
Climate change. Related to emissions and increased concentration of greenhouse gases (CO_2, CH_4, CFC, O_3, N_2O)

EUROTRAC is a scientific project, and can provide technical and scientific

information which can be relevant in policy making and decision processes. EUROTRAC is only one of several projects in Europe addressing atmospheric chemistry, however, and some of the other projects have a much tighter link to international policy making than EUROTRAC.

4.1 ACID DEPOSITION

In the decision process, the most important questions are probably: Where is the critical load exceeded in Norway, and what is the reason for this (main contributing countries/sources). The calculation and measurement of the actual deposition of S- and N-compounds are central tasks in atmospheric chemistry. Outstanding questions here which are dealt with in EUROTRAC subprojects, are e.g.
-What is the relative significance of European sources of S- and N-compounds compared to sources in the rest of the northern hemisphere? ("Background pollution") (TOR, GLOMAC, EUMAC)
-What is the influence of natural emissions of S- and N-compounds on acid deposition in different areas? (BIATEX, ASE, EUMAC, HALIPP)
-Trends in acid deposition over many years, what determines the trend? (Meteorological variability vs. changes in emissions and atmospheric transformation) (no subproject deals with this, but TOR, GLOMAC, HALIPP and LACTOZ can provide relevant information)
-What is the relationship between the aerosol size distribution, aerosol composition and acid deposition?
-Which chemical forms are the most important ones in the budget of species derived from NO_x-emissions? (TOR)

The EUROTRAC subprojects can supplement the work within EMEP. Under UN-ECE the protocols for SO_2 and NO_x emission reductions have been agreed, and the questions above are relevant in the renegotiation of these protocols. The monitoring network in EMEP is operated on a routine basis with instrumentation which can be run by all countries. The EUROTRAC subprojects which concentrate on instrument development, focus on advanced techniques not suitable for routine use (this is due both to costs and technical complexity), but advanced instruments are required as research equipment (cpr. TOR, JETDLAG, TOPAS etc.)

4.2 LONG RANGE TRANSPORT OF PHOTOOXIDANTS

In the decision process, the important questions are e.g. Where and when is the ozone concentration standard exceeded, and what is the underlying reason? Scientific questions are:
-What is the relationship between boundary layer episodic ozone maxima and the gradual free tropospheric increase? (TOR, EUMAC, GLOMAC)
-Which emissions contribute to episodic and gradual ozone increase? (TOR, EUMAC,

GLOMAC), more specifically
-Which compounds in the group of volatile organic compounds contribute to photooxidant formation, and what are the main sources for the compounds? (TOR, LACTOZ)
-What is the role of natural emissions in photooxidant formation? (BIATEX, LACTOZ, TOR)

In the UN-ECE system a VOC-protocol is now under negotiation, and the questions mentioned above are important to answer in that context. Instrumentation for the measurement of VOC and photooxidants in addition to ozone, is coming in widespread use in the TOR subproject, which will allow many countries to monitor these compounds on a routine basis.

4.3 EUTROPHICATION

This problem is perhaps more relevant for Denmark than for Norway, where nutrient deposition and runoff to coastal waters give rise to eutrophication problems. Algae blossoms in Norwegian coastal waters can also be caused by elevated nutrient deposition. Scientific questions are e.g.
-What is the main pathway for increased nutrient content of coastal waters? (atmospheric or river runoff?) (no subproject in Eurotrac addresses this, but BIATEX and HALIPP may provide relevant information)
-What are the sources for N-compounds contributing to eutrophication?

The research within EUROTRAC is relevant for international activities under the Paris-Commission and the North Sea Convention about pollutant deposition to the North Sea.

4.4 OZONE LAYER DEPLETION

Ozone layer depletion is a global pollution problem, and emissions in any one country are indistinguishable from the emissions in any other country in terms of ozone depleting effect. Policy questions here are perhaps more on how to replace current CFCs with new products with a shorter atmospheric life time and thus with a smaller ozone depleting potential (or greenhouse effect). Scientific questions are e.g.
-What are the chemical decomposition pathways for CFCs and their replacements? (Not dealt with in Eurotrac, but in other European projects like STEP)
-What are the potential consequences of chlorine accumulation in the global stratosphere in general and in the polar stratosphere in particular (not dealt with in Eurotrac but e.g. through STEP)
-What is the link between ozone depletion and global warming? (Not EUROTRAC)
-To what extent can changes in the tropospheric oxidation efficiency alter the

concentration of CFC substitutes (HCFCs)? (no subprojects, but LACTOZ and GLOMAC are relevant)

4.5 CLIMATE CHANGE

Some of the EUROTRAC subprojects can shed light on e.g. the following important questions of relevance for the build up of greenhouse gases:
-Ozone in the troposphere as a greenhouse gas (TOR)
-Relationship between pollution and changes in tropospheric oxidation efficiency (TOR, GLOMAC, LACTOZ, HALIPP)
-Relationship between changes in the cloud condensation nuclei population and albedo (BIATEX, GCE, ACE)
-Changes in emission of greenhouse gases linked to land use differences or changes in air temperature and humidity (BIATEX)

5 NORWEGIAN PARTICIPANTS IN EUROTRAC

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REFERAT

TITLE

ABSTRACT
The Norwegian scientific participation in the Eureka project EUROTRAC 1986-1990 is documented in the report. The main Norwegian activity is centered within TOR (Tropospheric Ozone Research) where measurements are carried out at Birkenes and Ny-Ålesund on Svalbard, and model calculations are done in support of the measurements to interpret atmospheric chemical change both on a European and global scale. There is also Norwegian contributions in Lactoz, Halipp, Glomac and Eumac.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C