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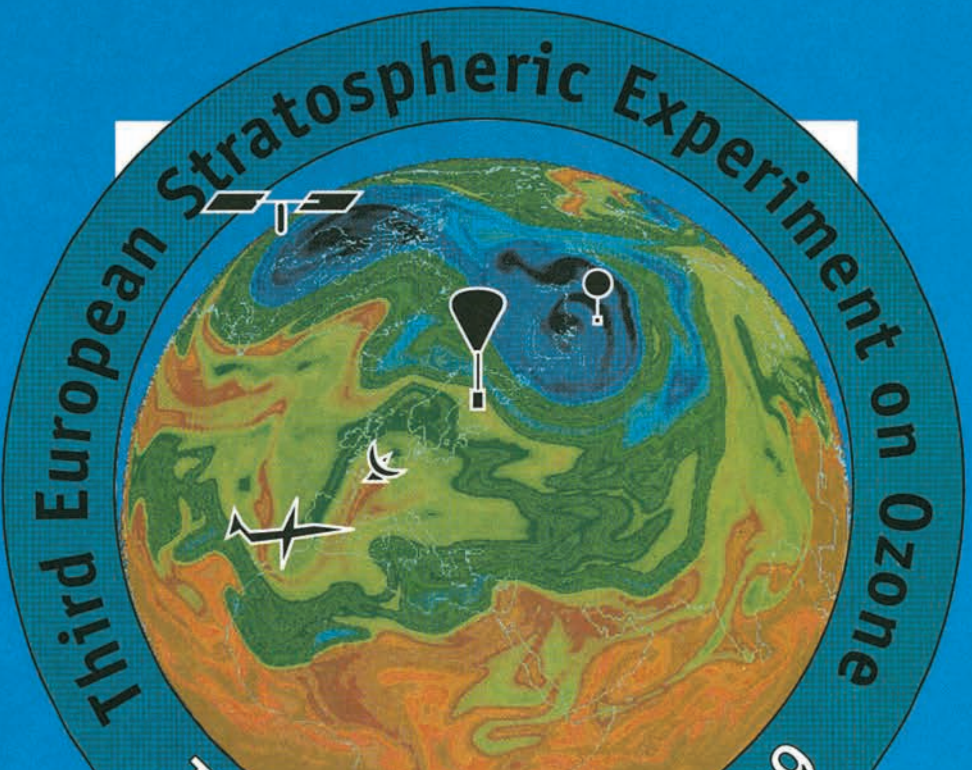

Planning Document

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THESEO PLANNING DOCUMENT

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EC Science Panel on Stratospheric Ozone Research

CONTENTS

Third European Stratospheric Experiment on Ozone (THESEO)

1. Background

This planning document for the Third European Stratospheric Experiment on Ozone (THESEO) is intended as a working document for the scientists who will be involved in making and interpreting the wide range of measurements discussed. It has been prepared by the THESEO core group and the European Ozone Research Coordinating Unit on behalf of the EC Environment and Climate programme, and it has been endorsed by the EC Science Panel on Stratospheric Ozone.

THESEO will take place during 1998 and 1999. Its outline has been developed over the last two years by European scientists at a number of meetings supported by the European Commission. The strategy, presented in the first part of the document, is well established. However, many of the fine details of the research programme will continue to be developed and refined during THESEO. As such, this planning document represents the position in January 1998; modifications, driven by the nature of scientific research, should be expected and the document, particularly the Annexes, will be updated periodically.

THESEO is the third major European campaign to study the stratospheric ozone depletion. Like the two previous campaigns, the European Arctic Stratospheric Ozone Experiment (EASOE) and the Second European Stratospheric Arctic and Mid-latitude Experiment (SESAME), it relies jointly, and heavily, on support from national funding agencies and the Environment and Climate Research Programme of DGXII of the European Commission. It is part of a wider European programme which includes laboratory-based research, instrument development, atmospheric model development and UV-B field measurements.

For THESEO, the European Commission has selected a number of projects, described in outline later, which in coordination with new and existing national programmes will form the basis of the campaign. It is not the purpose of this planning document to describe the breadth of the many national programmes, though important elements are mentioned in the text.

As in EASOE and SESAME, participation in THESEO is open to all interested scientists, from Europe and elsewhere, who have a contribution to make and are prepared to share their time and experience in a collaborative research effort to understand further the processes of stratospheric ozone loss. Analysis and interpretation of THESEO measurements will additionally involve analysis of measurements collected in previous campaigns such as EASOE and THESOE and will involve extensive use of satellite data.

2. Scientific introduction

The largest ozone depletion worldwide has been observed inside the Antarctic and Arctic vortices in their respective springs. In the Antarctic spring, effectively all the ozone is removed at altitudes between 16 and 20km, while losses of 50% have been seen at the same altitudes in the Arctic in the last three winters. The last two European field campaigns, EASOE in 1991-1992 and SESAME in 1994-1995, were mainly focused on the high latitude processes in the Northern hemisphere. Their objectives were a better understanding of the dynamical and chemical processes in and around the vortex, through specific studies of the formation of polar stratospheric clouds (PSCs), the activation of the chlorine species, and the ozone loss associated in the Arctic vortex. A great deal of progress has resulted from these and other studies, but it is still true that numerical simulations calculate smaller ozone losses than are observed, indicating that some processes are missing or poorly understood.

At mid-latitudes in the Northern hemisphere, analysis of the long-term observations has revealed a strong long-term decrease in stratospheric ozone, particularly in the lower stratosphere. This evolution cannot be explained solely by the same processes as in the Arctic vortex: there is also a discrepancy between the model calculations and observed trends (observed ozone losses greater than modelled) and a number of additional causes have been suggested. However there seems little doubt that chlorine and bromine are responsible for a significant fraction of the ozone destruction. The question 'how much?' needs to be answered before we can have faith in any predictions of the evolution of the stratospheric ozone layer resulting from the implementation of the Montreal Protocol, from the impact of aircraft emissions or from climate change.

During EASOE, scientists focussed almost exclusively on the processes occurring in the Arctic vortex. In SESAME a much greater emphasis was put on investigating the processes connecting the high to mid-latitude lower stratosphere through which Arctic ozone loss could be 'exported' to mid-latitudes. The extensive ozone loss observed in the Arctic vortex in the last three winters, the associated possibility of a long term lower stratospheric cooling and the continued decline in ozone at mid-latitudes heighten interest in the processes causing the ozone loss, especially as the predicted peak in stratospheric halogen loading has not yet occurred. THESEO is being mounted to investigate the processes occurring at mid-latitudes over Europe, together with the linkages to the relevant processes in the Arctic, the Tropics and sub-Tropics and the upper troposphere.

In the next section, the scientific objectives and the underlying issues are described in more detail, while in the following section the operational activities planned during THESEO are described with many details of the activities being presented in Annex 1. The plans for the coordination of THESEO are described in the final section.

3. Scientific objectives

The main scientific objective for THESEO is to increase our understanding of the observed ozone trends over northern mid-latitudes. These reach a peak in the late winter and early spring, but are also apparent in the early winter. Most of the trend in total ozone has occurred in the low stratosphere at altitudes below about 20km, the same region which is responsible for the annual cycle in total ozone.

Our understanding of the causes of the mid-latitude trends has improved over the past few years, but models based on the current knowledge of halogen chemistry (including the effects of changing aerosol amount) continue to calculate smaller trends in total ozone than have been observed. This discrepancy might result from incomplete knowledge of:

- chemical processes involved;
- aerosol amount (e.g., leewaves or cirrus);
- links between the mid-latitude lower stratosphere and the rest of atmosphere; and
- any long term dynamic changes;

THESEO is designed to address these outstanding issues and thereby provide a firmer basis for the prediction of the future evolution of the stratosphere. At the crux of THESEO will be the objective of understanding quantitatively the mechanisms responsible for the long term changes in ozone in polar and middle latitudes. EASOE and SESAME tackled the question of understanding the cause of short-term ozone loss. THESEO will address ozone changes occurring on longer time scales. This will involve a study of ozone loss mechanisms operating at different locations and over different timescales, and the connection between them. THESEO will take place as the peak halogen loading of the stratosphere is approached, so the effects of the chemical processes resulting from halogen loading should be more obvious.

The proposed measurement methodology is driven by the fact that the middle latitude lower stratosphere, where ozone depletion is observed, is intimately linked to the stratosphere over the Arctic and the tropics/sub-tropics, and also to the upper troposphere. THESEO will therefore address issues related to stratospheric ozone depletion in these regions and the linkages between them. Understanding these links is necessary, for example, if we are to understand how the emissions of aircraft in one part of the atmosphere will affect other parts.

Computer models of the atmosphere must play a central role in THESEO - not only in the interpretation of measurements (as in EASOE and SESAME), but also in the planning and operations. The models will be used to place the measurements in a hemispheric context; they will be tools which establish quantitatively the nature of the links between the different regions. Recent developments in research models using the analysed and forecast winds routinely calculated by the weather prediction agencies have greatly improved their utility, and it will be important to harness this improved capability.

The following three sub-sections contain background relevant to THESEO as well as specific issues within and between the Arctic vortex, the middle latitudes and the tropic/sub-tropics.

Mid-latitude lower stratosphere

The chemical processes causing ozone destruction over mid-latitudes operate on time-scales of weeks or months. They are therefore more subtle than the similar processes that occur in the Arctic vortex which take place over a few days. This fact, coupled with the greater natural dynamic variability of stratospheric ozone in mid-latitudes, makes it harder to identify changes in ozone or other constituents that can be attributed to particular chemical processes. It is possible that small changes in the basic stratospheric dynamics are also leading to longer term changes in stratospheric ozone.

Despite this recognition of the difficulties involved, it is still important to investigate how the composition of the low stratosphere varies over time. A number of individual objectives of THESEO are:

- identification and quantification of chemical ozone loss outside the Arctic vortex.
- observation over time of chemical species, including as many members of ClO_x, BrO_x, NO_x and HO_x families as possible, preferably simultaneous, in particular the study of the NO_x and NO_y budgets in the low stratosphere.
- study of the physico-chemical nature of stratospheric particles, including lee-wave and cirrus clouds.
- investigation of radiative and dynamical processes through regular measurements of tracers with a range of lifetimes (e.g., ozone, aerosols, CFCs, and methane).

Linkages

The interactions between the lower stratosphere in middle latitude and the surrounding air masses critically affect the chemical processes occurring there. The effect on middle latitude ozone of any ozone depletion in the vortex depends on how fast the ozone depleted air can move out. Similarly the speed of ozone-depleting processes depends on how quickly two chemically different air masses can mix. The Aleutian high pressure system, the counterpart to the low pressure system that is the Arctic vortex, clearly plays an important role, but it is not well defined. Similarly transport across barriers in the sub-tropics is not well enough understood. These interactions are all very complex and the use of models will be essential in studies of them.

The lowermost stratosphere is directly influenced by aircraft emissions since this is where many aircraft fly. The magnitude of this influence is not well known at the moment as it depends on the complex interactions between chemistry and dynamics. Other poorly understood phenomena which influence this region are particle formation near the tropopause, NO_x formation in lightning and fast vertical transport of NO_x and other ground level pollutants.

Specific objectives include:

- investigation of the altitude dependence of transport processes, and, e.g., evaluation of the importance of the sub-vortex region.
- determination of the interaction of the Arctic vortex with the Aleutian high to see if (and how) this interaction is important in the erosion of the vortex through the winter.
- study of occurrence of laminae at the edges of the Arctic vortex and the subtropical jet using measurements of, e.g., ozone coupled with atmospheric models with high vertical resolution.
- study of impact of these dynamic processes on shorter-lived chemical species (NO_x, HO_x, ClO_x, BrO_x, etc.)
- analysis of these measurements in the context of similar, previous measurements.

Arctic vortex

The processes occurring in the Arctic vortex have been closely studied in EASOE and SESAME and the basic sequence of events leading to ozone loss is qualitatively well understood. Low temperatures and the consequent formation of polar stratospheric clouds (PSCs) are clearly pre-requisites for the rapid ozone loss which has been observed in the Arctic vortex. However current photochemical model calculations show smaller ozone losses than those deduced empirically. This under-calculation is not straightforward, as it seems to be greater at some times in the winter than at others indicating the poor description of particular processes.

The causes of the ozone loss in the vortex are of special interest given the large ozone depletions (>50% at some altitudes) observed in 1994/95, 1995/96 and 1996/97. These three winters have each been among the coldest in the 30 years that records exist. The possibility of even larger ozone depletion in the northern hemisphere is thus real, and it is important to find out what the causes and implications of these recent dynamic changes might be.

Specific objectives include:

- determination of the physico-chemical nature of PSCs.
- better quantification of the activation and deactivation of ClO_x.
- investigation of the role of bromine in ozone destruction, particularly in the late vortex.
- empirical determination of chemical ozone loss in both total column and in the vertical distribution
- comparison of observed ozone losses with model calculations
- investigation of vortex stability through measurements of tracers, upward/downward radiation, temperature, winds, O_3, etc..

Tropics/sub-tropics

Nearly all the air entering the stratosphere from the troposphere does so in the tropics/sub-tropics and so it is the major source region for radicals and source gases. The low temperature at the tropical tropopause limits the water vapour transport to the stratosphere. Fast advection in storms is a possible mechanism for the transport of short-lived species from the troposphere to the stratosphere. The tropics/sub-tropics (and the composition of the stratosphere there) is important for the radiation balance and hence climate as these latitudes comprise half the Earth's surface.

In spite of its importance in the global atmosphere, comparatively limited measurements of the tropical/sub-tropical latitude stratosphere have been made to date. A number of scientific issues have been chosen as the aims of the research being performed within THESEO. These are:

- investigation of the factors controlling water vapour input into the stratosphere.
- study of the mechanisms of cloud formation near the tropical tropopause.
- investigation of the impact of these clouds on ozone and trace gas budgets.
- improving understanding of how tropical processes influence the global stratospheric aerosol layer.
- study of the exchange of air across the sub-tropical barrier.

4. Overview of activities

The campaign will involve a combination of measurements from the ground, from balloons (small and large balloons) and from aircraft deployed from the subtropics to the polar regions. Their ability to investigate specific short-duration phenomena will complement the satellite data and the long-term measurements such as those made in the framework of NDSC. Satellite data will be used during the campaign, both from current instruments and those to be launched in the near future. To maximise the benefits of campaign activities, numerical modelling of the atmosphere will play a central role: meteorological forecasts during the active phase will be essential for the planning of operations, and will assist the interpretation of results. One important activity of modelling will be the validation and the improvement of chemical transport models in the tropical stratosphere and the mid-latitude lowermost stratosphere.

THESEO is split into a variety of projects supported by both EC and national programmes. In this section we give a general description of activities which will take place within THESEO. In table 1 are given the full name, the acronym, and the coordinator of each EC project. Descriptions of individual projects are given in Annex 1. Timetables of balloon and aircraft activities during the campaign are given in figures 1, and maps showing the locations of ground-based stations, ozonesonde sites, aircraft campaigns and balloon launching site are given in figures 2.

Mid-latitude lower stratosphere
One main component of the THESEO campaign is to improve our knowledge of the ozone budget at mid-latitudes. This will ultimately be achieved by quantifying both the effect of transport of polar air at the end of the winter, and the local effect of the ozone destruction after heterogeneous processes on stratospheric aerosols. The latter topic needs to investigate the chemical partitioning of the main families controlling the ozone.

The main goal of HALOMAX is to characterize the partitioning of chlorine and bromine compounds from the source, reservoir and reactive families, using 3 balloon-borne payloads which will be flown in a cluster in the late spring of 1999. One payload, based on TRIPLE will consist of a whole air sampler to measure the source gases, the ClO/BrO resonance fluorescence instrument, the FISH hygrometer, an aerosol counter and actinic flux radiometer. The second payload is the LPMA FTIR spectrometer and DOAS combination which will be able to measure some of the other species (in particular the Cl reservoirs and OClO). The third payload is the AMON star-pointing spectrometer which will be able to measure the night-time abundance of OClO and NO_2. A similar cluster will fly in spring 1998 as the final part of the on-going CHELOSBA project.

A closely allied project, HIMSPEC, will also focus on the partitioning of chemical families (the nitrogen, hydrogen, chlorine, and bromine families) through aircraft and balloons measurements in the same spring 1999 time frame. The measurements of the MIPAS balloon instrument will be supplemented by those of a new Fabry-Perot spectrometer (SFINX). The SALOMON instrument (a small AMON) will fly on a second balloon and will measure NO_3 amoung others. A sub-millimeter wave radiometer measuring O_3, N_2O, HNO_3, HCl, and ClO will fly with an aerosol and ozone lidar on the DLR Falcon.

Table 1: THESEO projects selected by EC for 1998 and 1999

Airborne Platform for Earth observation: the contribution to THESEO (APE-THESEO) L. Stefanutti, IROE-CNR, Italy
Concerted Action for Scientific Strategy In the Stratosphere (CASSIS) J. Pyle, Coordinating Unit, United-Kingdom
Mid and high latitude stratospheric distribution of long and short lived HALOgen species during the MAXimum chlorine loading (HALOMAX) A. Engel, University of Frankfurt, Germany
HIgh and Middle latitude SPECiation of the nitrogen chlorine and hydrogen chemical families by airborne measurements (HIMSPEC) H. Oelhaf, FZK-IMK, Germany
A lagrangian experiment in Arctic vortex (LAGRANGIAN) J.P. Pommereau, SA/CNRS, France
MEridional TRansport of Ozone in the lower stratosphere (METRO) A. Hauchecorne, SA/CNRS, France
In-situ analysis of aerosols and gases in the polar stratosphere: a contribution to the THESEO campaign (PSC) N. Larsen, DMI, Denmark
Third European stratospheric experiment on Stratospheric Ozone Destruction by Bromine (STRATOSPHERIC BrO) M.Van Roozendael, IASB, Belgium
Stratosphere - TRoposphere Experiments by Aircraft Measurements III (STREAM-III) J. Lelieveld, IMAU,The Netherlands
THird European Stratospheric Experiment on Ozone - Ozone Loss in the Arctic and at Mid-Latitudes (THESEO-O_3 LOSS) G. Braathen, NILU, Norway
TOwards the Prediction of stratospheric Ozone (TOPOZ-2) W. Norton, University of Oxford, United-Kingdom
TRAnsport of Chemical species Across the Subtropical tropopause (TRACAS) G. Ancellet, SA/CNRS, France
Water vapour measurements from the tropics to the pole during the THESEO campaign 1998-1999 (WAVE) J. de La Noë, University of Bordeaux, France

The quantification of the role of bromine species in the ozone destruction in the lower stratosphere will be achieved by collecting a set of data of BrO total columns and profiles at mid-latitudes and high latitudes, with ground-based, balloons and satellite measurements in summer 1998, and winter 1998/1999 (STRATOSPHERIC BrO project). A small balloon payload (SAOZ, DESCARTES) measuring O_3, NO_2 and tracers will fly a number of times at mid-latitudes in both THESEO winters as part of THESEO-O_3 LOSS.

The impact of stratosphere-troposphere exchange on the chemical composition of the lowermost stratosphere at northern mid-latitudes will be studied in STREAM-III through aircraft measurements of NO, NO_y, O_3, water vapor, aerosols, sulphur species, F-11, F-12, CH_4, CO, CO_2, hydrocarbons over Canada, North-Atlantic Ocean and Western Europe in summer 1998.

O_3 loss outside the vortex will be investigated by THESEO-O_3 LOSS through ozone profiles measured by ozonesondes to calculate chemical ozone loss rates along air mass trajectories (winter 1997-1998, spring 1998, winter 1998-1999) using the Match technique. To increase the number of available measurements, greater use of ground-based lidars will be made. A large number of the ozonesondes which will be flown during THESEO will do so as a result of national programmes.

Figure 1a: THESEO current timetable for small balloons 1997/98

The detailed schedule for the 1998/99 winter will not be fixed until September 1998. The intention is to start measurements in October/November 1998 at both mid- and high latitudes so as to cover the whole winter period.

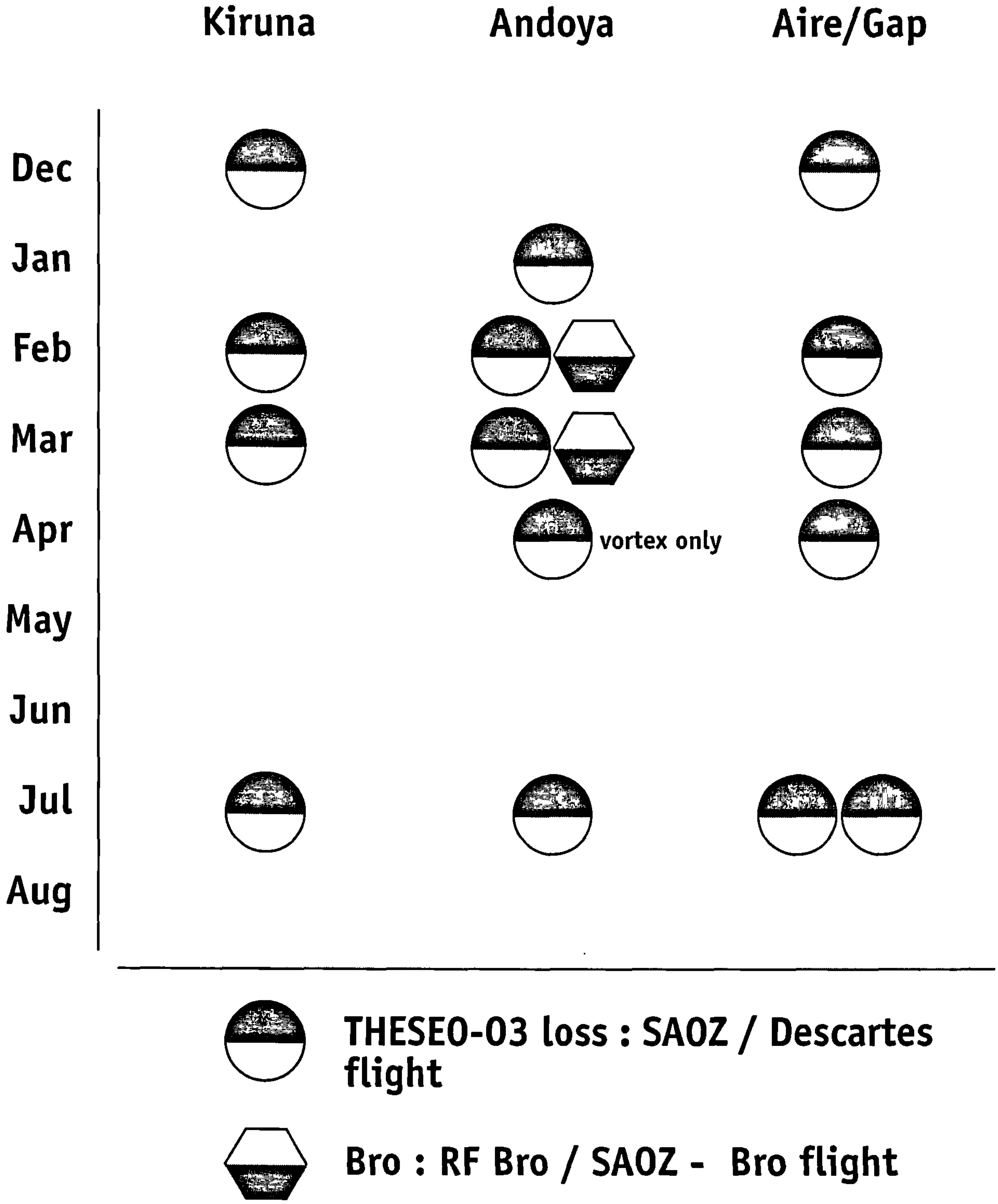


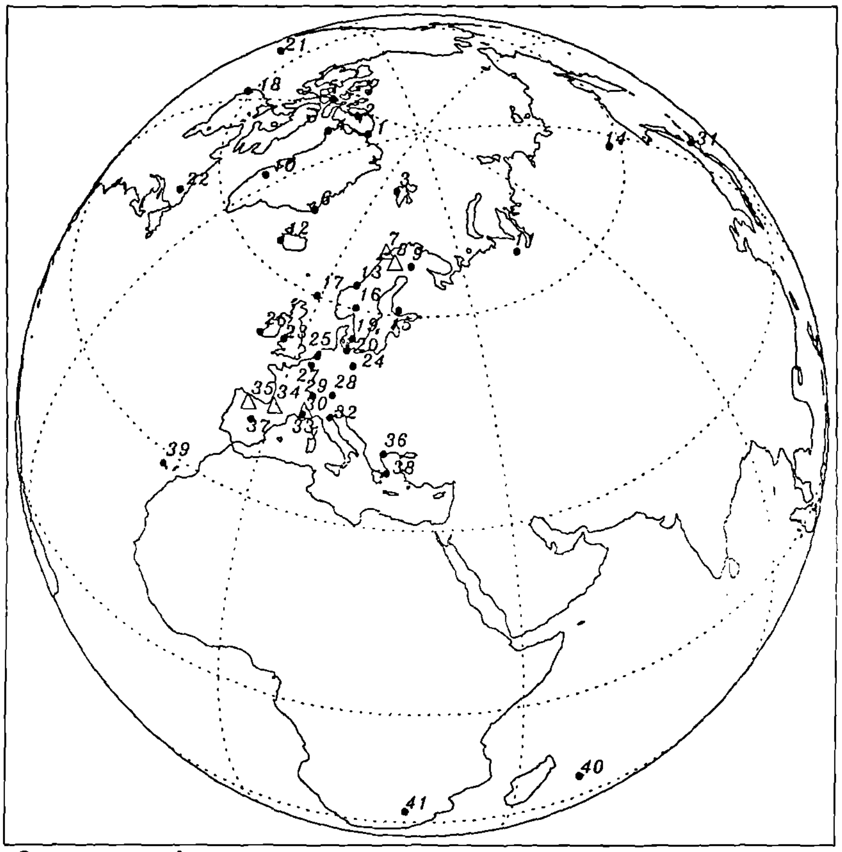
Figure 1b: THESEO current timetable for large balloons 1998/99

	Experiment	Site	Agency	Project	
Jan	Mauersberger test flight	Kiruna	SSC	PSCs	
...					
7 Mar 7 Apr	LPMA/DOAS MIPAS/SPHINX TRIPLE Lites	Leon	CNES	CHELOSBA National	
...					
Jun	SPIRALE MACSIMS	Gap	CNES	EU/National	
...					
Aug ...	LPMA/DOAS MIPAS/SFINX (?) SAKURA (?) CLO (?)	Kiruna	CNES	National Sabine	
Oct	AMON SALOMON	ASA			
...	**1999**				
15 Jan 20 Feb	2 Mauersberger + ELHYSA MIPAS/SPHINX ODIN(?) AMON TRIPLE 2 RADIBAL/BALLAD/BOCCAD LPMA/DOAS SPIRALE(?) 2 ELHYSA SDLA	Kiruna	CNES	PSC HIMSPEC HALOMAX WAVE National	13 large balloons 3 super pressure 2 Montgolfier IR
...					
late Apr	MIPAS/SPHINX SALOMON MACSIMS ELHYSA?	Leon			6 large balloons
June	TRIPLE+LPMA/DOAS ELHYSA SPIRALE	Gap or Leon in late April		HALOMAX	

Figure 1c: THESEO current timetable for aircrafts 1998/99

	Region	Aircraft	Project
late Jan mid-Feb	ARCTIC	Falcon Learjet	POLSTAR
Mar	TROPICS	Cessna	LBA/Claire STREAM
. . .			
Jul	MID-LATITUDES	Cessna	STREAM III
Oct-Nov	SUB-TROPICS (Paris-Tenerife)	Mystere	METRO
Dec	MID-LATITUDES	M55	APE-THESEO
	ARCTIC (Paris-Kiruna -Paris)	Mystere	METRO
1999			
Jan-Feb	ARCTIC	Learjet Arat	WAVE PSC
		Falcon	HIMSPEC
	ARCTIC - MID LAT	Mystere	METRO
Mar-Apr	ARCTIC - MID LAT then to the sub-tropics	Mystere	METRO
	TROPICS and SUB-TROPICS (The Indian Ocean)	Cessna M55 + Falcon	INDOEX and APE-THESEO
19-30 April	ARCTIC - MID LAT	Falcon	HIMSPEC
. . .			
Sep - Oct	ANTARCTICA	M55	APE-Antarctica

Figure 2a: distribution of ozone sondes and balloon borne instruments

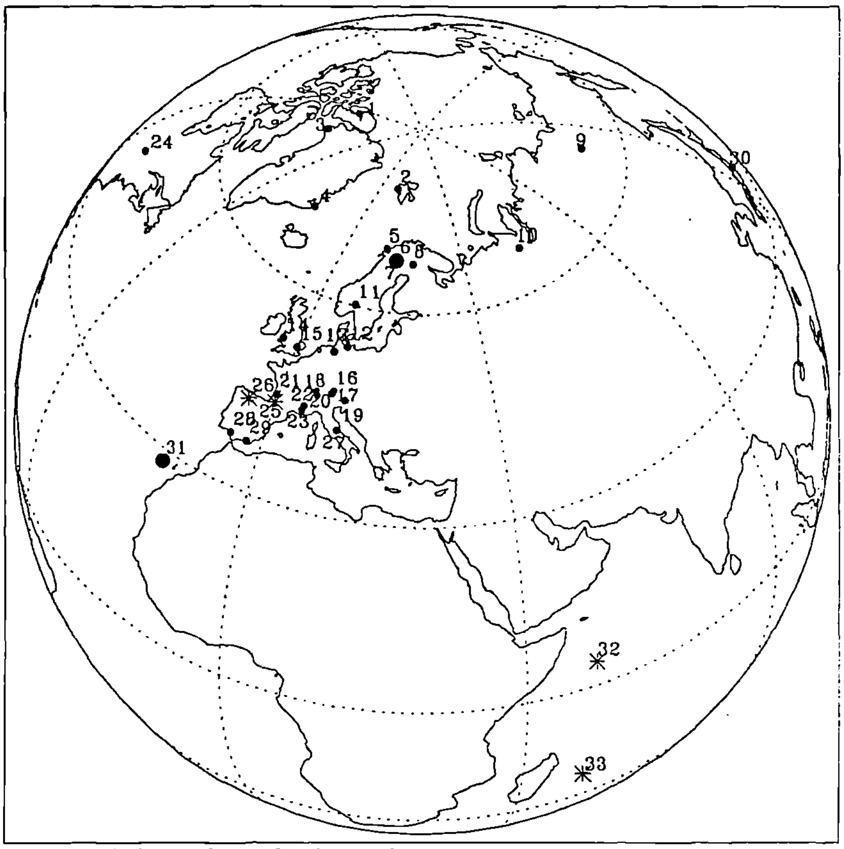


• *Ozone sondes*
△ *Ozone sondes and balloons*

	Latitude	Longitude
1. Alert, Canada	82.5°N	297.7°E
2. Eureka, Canada	80.0°N	274.6°E
3. Ny Ålesund, Spitsbergen	78.9°N	11.9°E
4. Thule, Greenland	76.5°N	68.7°W
5. Resolute, Canada	74.7°N	265.0°E
6. Scoresbysund, Greenland	70.5°N	22.0°W
7. Andoya, Norway	69.3°N	16.0°E
8. Kiruna, Sweden	67.8°N	20.4°E
9. Sodankyla, Finland	67.4°N	26.6°E
10. Søndre Stromfjord, Greenland	67.0° N	50.6° W
11. Salekhard, Russia	66.6° N	66.6° E
12. Keflavik, Iceland	64.0° N	22.6° W
13. Orland, Norway	63.4° N	9.2° E
14. Yakutsk, Russia	62.0°N	129.7°E
15. Jokioinen, Finland	60.8° N	23.5° E
16. Gardermoen, Norway	60.2°N	11.1°E
17. Lerwick, Norway	60.1° N	1.2° W
18. Churchill, Canada	58.8°N	265.9°E
19. Jægersborg, Sweden	55.8° N	12.5° E
20. Kühlungsborn, Germany	54.1°N	11.8°E
21. Edmonton, Canada	53.6°N	245.9°E

	Latitude	Longitude
22. Goose Bay, Canada	53.3°N	299.6°E
23. Aberystwyth, United Kingdom	52.7°N	4.1°W
24. Lindenberg, Germany	52.1° N	14.1° E
25. De Bilt, The Netherlands	52.1° N	5.2° E
26. Valentia Island, Ireland	51.9° N	10.3° W
27. Uccle, Belgium	50.8° N	4.4° E
28. Hohenpeissenberg, Germany	47.5° N	11.0° E
29. Payerne, Switzerland	46.8° N	6.9° E
30. Gap, France	44.5° N	6.0° E
31. Moshiri	44.4°N	142.3°E
32. San Pietro Capofiume, Italy	44.4° N	11.4° E
33. Observatoire Haute Provence, France	43.9°N	5.7°E
34. Aire-sur-l'Adour, France	43.7° N	0.25° W
35. Leon, Spain	42.6° N	5.6° W
36. Thessaloniki, Greece	40..6° N	23.0° E
37. Madrid, Spain	40.5° N	3.7° W
38. Athens, Greece	37.9° N	23.8° E
39. Izaña, Tenerife Island	28.3°N	16.5°W
40. La Reunion Island	21.0° S	55.0° E
41. Irene, South Africa	25.0° S	28.0° E

Figure 2b: distribution of ground based and aircraft borne instruments



- ● Ground based and aircraft
- ✳ Aircraft
- • Ground based

	Latitude	Longitude
1. Eureka, Canada	80.1°N	86.4°W
2. Ny Ålesund, Spitsbergen	78.9°N	11.9°E
3. Thule, Greenland	76.5°N	68.7°W
4. Scoresbysund, Greenland	70.5°N	22.0°W
5. Andoya, Norway	69.3°N	16.0°E
6. Esrange, Sweden	67.9°N	21.1°E
7. Kiruna, Sweden	67.8°N	20.4°E
8. Sodankyla, Finland	67.4°N	26.6°E
9. Zhigansk, Siberia	67.0°N	123.0°E
10. Salekhard, Russia	66.6°N	66.6°E
11. Harestua, Norway	60.2°N	10.8°E
12. Kühlungsborn, Germany	54.1°N	11.8°E
13. Bremen, Germany	53.0°N	9.0°E
14. Aberystwyth, United Kingdom	52.4°N	4.1°W
15. Cambridge, United Kingdom	52.0°N	0.0°E
16. Garmisch, Germany	47.5°N	11.1°E

	Latitude	Longitude
17. Zugspitze, Germany	47.4°N	11.0°E
18. Bern, Switzerland	47.0°N	7.5°E
19. Kanzelhoehe, Austria	46.7°N	13.9°E
20. Jungfraujoch, Switzerland	46.5°N	8.0°E
21. Observatoire de Bordeaux, France	44.8°N	0.5°W
22. Plateau de Bure, France	44.6°N	5.9°E
23. Observatoire Haute Provence, France	43.9°N	5.7°E
24. Toronto, Canada	43.8° N	280.5° E
25. Aire-sur-l'Adour, France	43.7° N	0.2° W
26. Leon, Spain	42.6° N	5.6° W
27. L'Aquila, Italy	42.4° N	13.4° E
28. Huelva, Spain	37.1°N	6.4°W
29. Calar Alto, Spain	37.0°N	3.0°W
30. Tsukuba, Japan	36.0°N	140.1° E
31. Izaña, Tenerife Island	28.3°N	16.5°W
32. Seychelles	4.5°S	55.5° E
33. La Reunion Island	21.0°S	55.0° E

Linkages

Investigations of the linkages between mid-latitude lower stratosphere and higher and lower latitudes need measurements to be made on larger scales. The main measurements sets being used within THESEO are from a network of ground-based instruments, aircraft and satellite instruments, and the results will be interpreted and extended through the use of models.

The WAVE project will investigate the behavior of the atmospheric water vapor at all latitudes, using ground-based and airborne microwave radiometer measurements from the Arctic to the Tropics during winter 1999. In addition a number of balloon-borne hygrometer flights will be made to provide higher resolution vertical profiles. The water vapour data from a number of other projects will also be included in the analysis.

The METRO project will focus on the transport of ozone depleted air from the polar vortex and the intrusion of air coming from the subtropics and their impact on the budget of ozone in the mid-latitudes lower stratosphere. Airborne and ground-based lidar measurements from the subtropics to the Arctic will provide ozone, aerosols, trace species, temperature and wind profiles.

Both these projects will be closely linked with the TRACAS project which will study the exchange of air between the upper troposphere and the lower stratosphere associated with the subtropical jet, and its possible impact on stratospheric ozone decrease, with ozone (ozonesonde and lidar) measurements and water vapor measurements by ozonesondes during the summer of 1998 and in February of 1999. Aircraft lidar measurements will be operated between the mid-latitudes and the Southern hemisphere subtropics in summer 1998. Extensive use will be made of the existing ozone and H2O data collected by the instruments on in-service A340 aircraft within MOZAIC and from satellite instruments such as SAGE and HALOE.

The use of satellite data will complement the ground-based measurements, in terms of spatial and temporal coverage (see table 2). These will be of special value in the studies of the linkages where wide area coverage is needed.

The European satellite instrument GOME, which has been operating for several years now, has a good track record in providing valuable measurements. Ozone column amounts, ozone profiles and BrO column amounts which will be used in the framework of the STRATOSPHERIC BrO, TRACAS and WAVE projects. Additionally NO_2 and OClO columns will become available. The related EC project, GODIVA, will monitor and maintain the GOME data quality and will work on improving the algorithms and operational processing of these products.

ODIN is planned to be launched in September 1998, and will routinely provide ClO, O_3, N_2O, HNO_3 and water vapour data, which will be used in the framework of HIMSPEC and WAVE projects. The ODIN instrument is to be used for both atmospheric and astronomical studies, but plans have been made for an additional extended observational period during the 1998/99 winter when stratospheric conditions are considered of particular interest. Just a few days notice is required for the ODIN instrument to be put in this special observing mode.

Full use will be made of the datasets which are available from other satellites such as the NASA UARS satellite whose data will be used to test the output from the CTMs involved in TOPOZ-2 and TRACAS projects. The other satellites launched in the near future, POAM-3 (in March 1998) and ENVISAT (in 1999) should provide very useful data for the different projects involved in THESEO.

There are close links with the satellite instruments' science teams. It is anticipated that data sharing protocols will be agreed to ensure that measurements made within the framework of THESEO can be used in the validation of the instruments and that the satellite measurements can be used in joint interpretative studies with the THESEO measurements. One related EC project in particular (COSE) involves ground-based instruments, many of them already involved in THESEO, which will be used for satellite data quality and validation studies.

Arctic vortex

In the high latitude regions, processes leading to ozone destruction during the Arctic winter will continue to be investigated. The issues being addressed are generally well defined as there is substantial experience in this area.

One important aim is to study the formation, chemical composition and physical properties of Polar Stratospheric Clouds (PSCs) in the framework of the PSC project. This will be achieved with gas and particle composition analysis and optical measurements from balloons launched in Kiruna in January 1998 (test flight) and in the main Arctic balloon period in January and February 1999, supplemented by concurrent aerosol lidar measurements from aircraft and the ground in 1999.

Several projects will focus on the study of the chemical partitioning in the Arctic stratosphere, aigain with the main activity taking place in the Jan/Feb 1999 time frame. The high-latitude part of HIMSPEC will again focus on nitrogen, chlorine and hydrogen families, on some bromine species, and on the chemical interactions between the species, with the same large balloon and aircraft payloads as at mid-latitudes. The high-latitude part of HALOMAX will particularly study the chlorine and bromine activation from large balloons, again using the same payloads as mid-latitudes. The project STRATOSPHERIC BrO will examine the role of bromine oxides in ozone destruction over the course of the winter, with an emphasis on the early and late winter.

Water vapor profiles will be measured in the lower stratosphere by balloons, aircraft, rocket and ground-based instruments operating in the WAVE project during the winter of 1999. They will provide information on partitioning of stratospheric hydrogen and dehydration linked with chemical processes on PSCs in the stratosphere.
These chemical investigations will allow us to improve our knowledge of the effect of the export of processed or ozone depleted air on the ozone budget in the middle latitudes.

The ozone loss rate and the cumulative ozone loss inside the vortex during the winters 1998 and 1999 will be investigated by ground-based instruments, by small balloon measurements and by ozonesondes from the THESEO-O_3 LOSS project, the latter using the Match technique to determine chemical ozone loss rates during the winter along air mass trajectories. Both total column loss rates and in the vertical distribution of losses will be compared with the results of photochemical model calculations.

Long-duration balloon flights using Montgolfier Infrared or superpressure balloons in the framework of the LAGRANGIAN project will provide continuous, quasi-Lagrangian measurements of water vapor, O_3, NO_2, OClO, BrO, CH_4 for periods of several weeks inside the polar vortex during the winters 1998 and 1999. These experiments will allow the collection of atmospheric data needed for integration in ozone depletion models.

These observations of chemical processes in and around the vortex during winter will be correlated with tracer measurements to infer the diabatic descent rate, mixing processes, and the monitoring of the vortex stability (and decay) at the end of the winter. Transport processes in the very low stratosphere between middle latitudes and northern polar regions will be investigated, using in-situ aircraft measurements with the POLSTAR project, as will PSC and cirrus formation.

Tropics and sub-tropics

One of the exciting new developments within THESEO is the first major European measurement activity in the tropics and sub-tropics. With the tropics comprising such large areas of the earth's surface, these THESEO activities, while substantial, should be seen in context, namely as the first real European field exercise to unravel the intricacies of the tropical stratosphere.

APE-THESEO will investigate microphysical processes in tropical cirrus, the transport of tracers across the tropical tropopause, and the transport of tracers in the tropical lower stratosphere, using the Russian M-55 Geophysica and the German Falcon aircraft measurements over the Indian Ocean in March 1999. The collaboration between APE-THESEO and INDOEX will couple these investigations to measurements of radiative forcing by aerosols and clouds and to measurements of the oxidative capacity of the tropical troposphere (including downward transport of ozone from the stratosphere, i.e. the reverse of the conventional Brewer-Dobson circulation). The Cessna Citation (also used in the STREAM-III project) will be a Dutch component of INDOEX and will be making measurements in the tropical mid-troposphere using its usual payload. A lidar will also be deployed in INDOEX on board the French Mystère.

In the tropical and subtropical regions, one of the primary interests is the possible exchange of air between the troposphere and the stratosphere, and how it is moved to middle latitudes. These issues are being studied using a mixture of measurements, principally of water and ozone, and modelling studies in a number of projects (TRACAS, METRO, WAVE, TOPOZ II). Because of the longer timescales involved, the measurements are being made in a number of periods from mid-1998 to mid-1999.

Summary of activities

The activities within THESEO are spread over wide geographic areas and over a two year time period (see the figures 1 and 2). The measurement strategy is to observe the processes involved during build up and decay of the vortex and the slow cumulative exchanges between different regions studied. A number of periods and places can be identified where the most intensive efforts will be made. In the Arctic, January/February 1999 will see a large balloon campaign coupled with deployments of several aircraft and use of ground-based and ozonesonde stations. At mid-latitudes, the main activity will be in the 1998/99 winter but will extend over the whole winter-spring period. Late spring and early summer photochemistry at mid-latitudes will be investigated with small groups of large balloon payloads, again closely linked with aircraft deployment. The main tropical/sub-tropical campaign will take place in February-March 1999 with four European aircraft deployed within APE-THESEO and INDOEX.

5. Coordination

THESEO is based on research funded by the national programmes and the European Commission. The EC has selected a number of focussed projects, with well defined objectives within THESEO. These are described in outline in Annex 1. An important objective during the planning and implementation of THESEO will be to ensure maximum effective coordination between all the projects, including new collaborations both within Europe and worldwide, which may be developed. To this end a core group has been established to work with the Coordinating Unit to advance the plans and implementation of THESEO.

Core group and the Coordinating Unit

The scientific activities will be coordinated by the core group, which consists of representatives from the EC Science on Stratospheric Ozone Panel, the individual projects and the Coordinating Unit, namely:

Georgios Amanatidis	EC/DG XII-D (European Union)
Geir Braathen	NILU (Norway)
Bram Bregman	Utrecht University (Nederlands)
Neil Harris	Coordinating Unit (United Kingdom)
Gérard Mégie	CNRS (France)
Donal Murtagh	University of Stockholm (Sweden)
Hermann Oelhaf	Forschungszentrum Karlsruhe (Germany)
Jean-Pierre Pommereau	CNRS (France)

John Pyle	Coordinating Unit (United Kingdom)
Leopoldo Stefanutti	CNR (Italy)
Hans Schlager	DLR (Germany)
Ulrich Schmidt	University of Frankfurt (Germany)
Michel Van Roozendael	IASB (Belgium)

The main tasks of the core group are the planning of the measurement timetable, the coordination of the national programmes and liaison with international programmes. The organisational core group will evolve to an operational core group during the active phase of THESEO. The duties of the operational core group will include the coordination of the measurements by different projects, e.g., the coordination of the balloon launch timetable during the intensive periods, public awareness, etc.. As such the duties will be similar to those during EASOE and SESAME. The experience of activities in recent winters is that the communication between European scientists is now excellent and that much more coordination is now done directly between individual scientists.

The Coordinating Unit will organise meetings of the core group and will work closely with them. They will facilitate the exchange of field data and scientific resources through the production of a weekly update of activities (with NILU), organisation of meetings and workshops, and through informal channels. A large Schliersee-type meeting is planned for the second half of 1999 to discuss the results of THESEO and to integrate them with the results of the rest of the European programme. The Coordinating Unit is maintaining a web page for THESEO, which includes description of projects, timetables, organisational structure and, eventually, results. It can be found on the Coordinating Unit's Web page (http://www.ozone-sec.ch.cam.ac.uk).

Other support activities

Meteorological support will be delivered by the Free University of Berlin. They will provide expert advice in the field during intensive periods, in addition to other 'added value' products such as their STRATALERT and special trajectory calculations.

Meteorological analyses and forecasts will continue to be provided routinely to the NADIR database by the ECMWF. More details on the specific products available can be found on the NILU web site (http://www.nilu.no/), together with an electronic copy of the NADIR newsletter describing the structure of the data centre. NADIR will also act as the repository for all field measurements made during THESEO as well as relevant model results. There will be free exchange of data between THESEO participants to ensure that the resources are used to their maximum. A CD-ROM containing the measurements will be printed by NILU at the end of THESEO.

The Aristotle University of Thessaloniki will produce daily ozone maps based on the ground-based WO_3OS network and data from satellites. These will be made available through their Web site (http://www.athena.auth.gr/ozonemaps/) and through the NILU data centre.

Public access to THESEO

It is important that the results of THESEO reach a wider audience than the scientists involved. This can be achieved through a variety of means. First it will be important to analyse the results in a timely manner and to disseminate the findings through scientific meetings and publications, and, where appropriate into the policy-making arena through assessments such as WMO-UNEP, IPCC. Second, contacts with the media should be maintained and press releases issued at important times such as the start of THESEO, at the end of each Arctic winter and when the scientific result warrants the additional public attention. Information of a more educational nature will also be disseminated in colour brochures and posters, and the feasibility of using the Coordinating Unit's web site as an educational resource for schools will be investigated.

ANNEX 1 :Brief description of projects

The details given in the following descriptions are those that are known as of 20/01/97. A number of activities are not finally defined as not all national contributions are decided. Their details will be included in the electronic version of this document (available at http:// www.ozone-sec.ch.cam.ac.uk) and those of the projects already described will be updated as and when the plans evolve. The descriptions are given in alphabetical order.

EC funded projects

Related EC projects

Airborne Platform for Earth observation: the contribution to THESEO (APE-THESEO):

main objectives:
to study the microphysical processes in tropical cirrus, the transport of tracers across the tropical tropopause, and the transport of tracers in the tropical and sub-tropical lower stratosphere, using aircraft measurements over the Indian Ocean in northern winter (NE monsoon). Also included are trajectory models, chemistry and transport models, and modelling studies of the microphysics of aerosols and clouds.

platforms:
Geophysica and DLR Falcon aircrafts

instruments:

instrument	*measurements*	*partner*
Geophysica payload:		
COPAS (condensation nuclei counter)	particle counter, estimation of the volatile fraction	UoM, IFA
ARIAS (FSSP-300 and MAS)	particle size distribution , particle index of refraction, large particle phase function	UoM, IFA
ABLE lidar	nadir aerosol backscatter, nadir aerosol depolarisation, nadir N_2 (H_2O possibility)	URO
MAL (lidar)	aerosol backscatter	APEMan,ON
CVI (counterflow virtual impactor) (with Lyman-alpha and HNO3 spec.)	cloud water and HNO_3 content cloud element concentration	MISU, IEQ,IROE
ECOC (chemiluminescence electrochemical ozone sensor)	ozone in-situ, at 1/30 Hz	CAO
FOZAN (in-situ ozone analyser)	ozone in-situ, at 1/2 Hz	CAO
ACH (frost point hygrometer)	tropospheric water vapor in-situ	CAO, IROE
FLASH (Lyman-alpha spec.)	stratospheric water vapor in-situ	CAO,IROE
GASCOD/A (UV-vis. spectro.)	columns of ozone, NO_2, OClO, BrO	FISBAT-CNR
HAGAR (gas chromatography)	three gases from N_2O, SF_6, CFC-11, CFC-12, H-1211, CFC-113	UoF
(the following instruments are not part of APE-THESEO contract:)		
SORAD (radiometer)	broadband flux (near 4∏ coverage)	CAO
FISH (Lyman-alpha)	stratospheric water vapor in-situ	FZJ
RAMS (radiometers)	4∏ broadband and narrowband fluxes	SIO
Cloud 2D	large particle size distribution	NCAR
DLR-Falcon payload:		
OLEX (4-wavelength lidar)	zenith aerosol backscatter, zenith aerosol depolarisation, zenith ozone cross-sections, discrimination between liquid and frozen particles	IPA

schedule:
The aircraft will be based at an Indian Ocean station. Mission flights are planned for 15-25 February 1999 to 15-25 March 1999 in-coordination with INDOEX. Approximately 40 flight hours are planned for Geophysica.

partners:
L. Stefanutti (coordinator), Consiglio Nazionale delle Ricerche (IROE-CNR)
S. Balestri, APE-Comitato di Gestione IROE-CNR (APEMan)
S. Bormann, Institut fuer Physik der Atmosphaere, Mainz (UoM)
R. MacKenzie, University Chemical Laboratories, Cambridge (UCAM-DCHEM)
G. Visconti, Dipartimento di Fisica, L'Aquila (UNIVAQ)
V. Mitev, Observatory of Neuchatel (ON)
V. Khattatov, Aviaecocentre Ltd. (AEC)
M. Volk, Institut fuer Meteorologie und Geophysik (UoF)
W. Renger, Deutsche Forschungsanstalt fur Luft und Raumfahrt (DLR-IPA)
M. Cacciani, University of Rome (URO)
J. Strom, Stockholm University, Dept. of Meteorology (MISU)
T. Peter, Max-Planck-Institut für Chemie, Mainz (MPG.ICHEM)

comment:
Geophysica test flights from Italy in late 1998 or early 1999.
APE-THESEO will be closely coordinated with INDOEX.

Concerted Action for Scientific Strategy In the Stratosphere (CASSIS):

main objectives:

a) to provide for coordination of the balanced programme of research supported by the European Commission and national agencies;
b) to work with the Core group and the project coordinators in the planning and coordination of THESEO as outline elsewhere in this planning document;
c) to provide essential meteorological and ozone data to THESEO scientists;
d) during intensive phases to provide meteorological and coordination expertise and backup in the field;
e) to maintain a data base of meteorological data and field measurements.

partners:

J.A. Pyle (coordinator) and N.R.P. Harris, University of Cambridge
G. Braathen, NILU
B. Knudsen, DMI
B. Naujokat, Freie Universitaet Berlin
C.S. Zerefos, University of Thessaloniki

Mid and high latitude stratospheric distribution of long and short lived HALOgen species during the MAXimum chlorine loading (HALOMAX):

main objectives:
to characterise the partitioning of chlorine and bromine compounds from the source, reservoir and reactive families at mid. and high latitudes; to investigate the heterogeneous activation of chlorine and bromine species in the Arctic winter stratosphere. A box model, a box trajectory model, and a 3D chemical transport model will be used for the interpretation of the data.

platforms:
balloons

instruments:

instrument	*measurements*	*partner*
payload 1		
cryogenic whole air sampler	CFCs, HCFCs, Br. compounds	Univ.Frankfurt (and Univ. of East Anglia)
in-situ ClO/BrO resonance fluorescence	ClO, BrO	FZ Julich
Ly-a fluorescence hygrometer	H_2O content	FZ Julich
aerosol counter	aerosol surface area	LMD-CNRS
filter radiometer	actinic flux	FZ Julich
payload 2:		
FTIR sun pointing spectrometer	HCl, $ClONO_2$, HF, CF_2Cl_2, HNO_3, NO_2, N_2O	LPMA
UV and vis. DOAS spectrometer	NO_2, OClO, BrO, O_3, CH_2O, IO, SO_2	Univ.Heidelberg
payload3:		
AMON (star pointing UV/vis spectro.)	OClO, NO_2	LPCE

schedule:
Three balloon launches (one per payload) are planned for winter 1998-1999 at high latitudes; payloads 1 and 2 will also be launched in spring and summer of 1999 at mid-latitudes, in collaboration with the other large balloon projects.

partners:
A. Engel (coordinator), University of Frankfurt
U. Schmidt, University of Frankfurt
W.T. Sturges, University of East Anglia, School of Environmental Sciences
K. Pfeilsticker, U. Platt, Universitat Heidelberg
F. Stroh, C. Schiller, R. Müller, D. McKenna, Fz Jülich
C. Camy-Peyret, LPMA-CNRS
J. Ovarlez, LMD-CNRS
M. Pirre, LPCE-CNRS
S. Penkett, University of East Anglia, Norwich

comment:
Another goal of the HALOMAX project is to continue several data sets on chlorine and bromine compounds for long term investigation of trends of halogen species during the predicted peak in stratospheric chlorine loading. The balloon launches will be coordinated with activities from other projects in the frame of THESEO, e.g. HIMSPEC, WAVE and Stratospheric BrO.

HIgh and Middle latitude SPECiation of the nitrogen chlorine and hydrogen chemical families by airborne measurements (HIMSPEC):

main objectives:
to study the chemistry and dynamics of ozone depletion in the lower and middle stratosphere from high northern latitudes down to subtropical latitudes, through nitrogen, chlorine and hydrogen families measurements to investigate their partitioning and their interactions. Box models, Lagrangian models, and 3D Chemical Transport Models studies will be used too.

platforms:
large and small balloons and DLR-Falcon aircraft;
satellite ODIN data will also be used.

instruments:

instruments	*measurements*	*partner*
aircraft payload:		
ASUR (sub-mm wave radiometer)	O_3, N_2O, HNO_3, ClO, HCl,...	Univ. Bremen, SRON, RAL
OLEX (lidar)	O_3, backscatter ratio & optical depths of PSCs upper tropos. and strato. aerosols, extinction coefficient	DLR-IAP
large balloon payload:		
MIPAS-B2 (FTIR limb emission spectrometer)	O_3, H_2O, N_2O, CH_4, CFCs, NO, NO_2, HNO_3, $ClONO_2$, N_2O_5,...	FZK-IMK
SFINX (Fabry-Perot spectrometer)	OH, HCl	SRON
small balloon payload:		
SALOMON (UV-vis. moon occultation spectro.)	NO_2, NO_3, O_3, ..., aerosol extinction,	LPCE

schedule:
large balloons are planned to be launched in January-February 1999 at high latitudes, and in April 1999 at mid-latitudes, in coordination with the Falcon flights and in collaboration with the other large balloon projects.

partners:
H. Oelhaf (coordinator), Forschungszentrum Karlsruhe GmbH (FZK-IMK)
H. Küllmann, K. Künzi, University of Bremen (IUP)
A. Goede, R. Hoogeveen, Space Research Organisation of the Netherlands (SRON)
B. Kerridge, Rutherford Appleton Laboratory (RAL)
V. Weiss, G. Schwaab, Deutsche Forschungsanstalt fur Luft und Raumfahrt (DLR)
M. Pirre, Laboratoire de Physique et Chimie de l'Environnement /CNRS (LPCE-CNRS)

A lagrangian experiment in Arctic vortex (LAGRANGIAN):

main objectives:
to collect the atmospheric data needed for integration in ozone depletion models, by Lagrangian measurements for periods of several weeks inside the polar vortex provided by long-duration balloons. A variety of models willbe used for the interpretation of the results.

platforms:
long-duration balloons: superpressure balloon and infrared-Montgolfier (MIR).

instruments:

instrument	*partner*
superpressure balloon payload:	
PSC detector	CNR-IFA
in-situ O3 and water vapor sensors	UCL, UCAM

instrument	*measurements*	*partner*
MIR payload: same as above plus:		
SAOZ spectrometer	O_3, NO_2, OClO, BrO	SA-CNRS
CH4 (tunable diode laser spectrometer TDLAS)	CH_4	UCAM, NPL
Lyman water vapor detector	water vapor	CAO

schedule:
The flight campaign is planned in January-March 1999 in Sweden.

partners:
J.P. Pommereau, Service d'Aéronomie/CNRS (SA-CNRS)
A. Adriani, Instituto per la fisica dell'atmosfera/CNR (CNR-IFA)
R. L. Jones, University of Cambridge, Department of Chemistry (UCAM)
B. Knudsen, Danish Meteorological Institute (DMI)
P. Woods, National Physical Laboratory (NPL)
F. Vial, Laboratoire de Météorologie Dynamique/CNRS (LMD-CNRS)
D.E. Williams, University College London (UCL)
H.K. Roscoe, British Antarctic Survey (BAS)
V. Yushkov, Central Aerological Observatory (CAO)

MEridional TRansport of Ozone in the lower stratosphere (METRO):

main objectives:
To improve our understanding of the meridional transport of O_3 taking place in the lower stratosphere and its contribution to the ozone budget at midlatitudes, through measurements and Contour Advection with Surgery numerical tools.

platform:
aircraft ARAT, balloons, ground-based instruments

instruments:
airborne lidar, ground-based lidars and radars, ozonesondes

instrument	*partner*
ground-based instruments	
O_3 lidar	SA-CNRS, UWA
aerosols lidar	SA-CNRS, UWA, IAP
T^{re} lidar	SA-CNRS, IAP
wind lidar	SA-CNRS
MST VHF radars	UWA, IAP
ozonesondes	IAP
airborne instrument	
ozone lidar	SA-CNRS

schedule:
One aircraft flight is planned in the Arctic in December 1998; two are planned in March and April 1999, covering latitudes from the Arctic to the Tropics.

partners:
A. Hauchecorne (coordinator), S. Godin, Service d'Aéronomie/CNRS
B. Legras, Laboratoire de Météorologie Dynamique/CNRS
G. Vaughan, Physics Department, University of Wales (UWA)
G.D. Carver, Department of Chemistry, University of Cambridge (UCAM)
G. Hansen, Norwegian Institute for Air Research
W. Singer, Institut fur AtmospharenPhysik an der Universitat Rostock (IAP)
C. Flesia, Groupe de Physique Appliquée, Universite de Genève

In-situ analysis of aerosols and gases in the polar stratosphere: a contribution to the THESEO campaign (PSC):

main objectives:
to obtain a complete and simultaneous characterisation of PSCs (chemical composition, physical and optical properties, and conditions of formation) through balloons and aircraft measurements. Mesoscale, microphysical and optical modelling outputs will also be used in conjunction with the measurements.

platforms:
balloons; ARAT aircraft

instruments:

instruments	*measurements*	*partner*
balloons payloads:		
aerodynamic lens	chemical composition of aerosols	MPIK
IMRMS	HNO_3 gas phase concentration	MPIK
cryogenic frost-point hygrometer	H_2O gas phase concentration	LMD
OPC, CCN (optical particle counter)	particle size distributions	UW-AS
laser backscatter sondes	aerosol backscatter	IFA-CNR, UW-PA
aircraft payload:		
lidar (Nd:Yag laser)	aerosol depolarisation	SA-CNRS, UNI-GE

schedule:
Two balloonborne payloads will be launched in January 1999 in Kiruna. The airborne lidar will be operated simultaneously with the balloonborne experiments, following the general trajectory of the balloon.

partners:
N. Larsen (coordinator), Danish Meteorological Institute (DMI), Denmark
K. Mauersberger, J. Schreiner, F. Arnold, Max-Planck-Institut für Kernphysik (MPIK)
J. Ovarlez, Laboratoire de Météorologie Dynamique du CNRS (LMD-CNRS)
A. Adriani, Inst di Fisica dell'Atmosfera-Consiglio Nazionale delle Ricerche (IFA-CNR)
C. David, Service d'Aéronomie/CNRS, (SA-CNRS)
C. Flesia, Groupe de Physique Appliquée, Université de Genève (UNI-GE)
J. M. Rosen, University of Wyoming, Dept. Physics and Astronomy (UW-PA)
T. Deshler, University of Wyoming, Dept. Atmospheric Science (UW-AS)

Third European stratospheric experiment on Stratospheric Ozone Destruction by Bromine (STRATOSPHERIC BRO):

main objectives:
to collect a set of data of BrO total column and profiles at mid- and high latitudes, to quantify the role of BrO in the ozone destruction in the lower stratosphere. Model simulations will be provided by Chemical Transport Models, Radiative-Transfer, and a box trajectory model.

platforms:
ground-based UV-vis. spectrometers, balloon payloads;
satellite data from GOME instrument, on board ERS-2 satellite will also be used.

instruments:

instrument	*measurements*	*location*	*partner*
UV-vis. spectro.	column of BrO, OClO	Ny-Alesund	UBr
		Andoya	NILU
		Kiruna	UHD, NIWA
		Harestua	IASB
		Bremen	UBr
		Cambridge	UCAM
		Haute-Provence	IASB
		Calar Alto	UCAM
		Lauder	NIWA
		Scott Base	NIWA
UV-vis. and in-situ resonance fluorescence analyser on BrO sondes			
	BrO vertical profiles	Kiruna	SA-CNRS, UCI
		Andoya	SA-CNRS, UCI
		ASA/Gap	SA-CNRS, UCI

schedule:
The ground-based UV-vis.instruments operate during the two years of the campaign (except at Calar Alto and in winter at high latitudes). Ten balloon flights are planned in the Arctic (January, February, August 1998; March 1999) and at mid-latitudes (June, July, December 1998; August 1999).

partners:
M. Van Roozendael (coordinator), Belgian Institute for Space Aeronomy (IASB)
J.P. Pommereau, Service d'Aéronomie/CNRS (SA-CNRS)
J. Burrow, IUP, University of Bremen
R. Jones, University of Cambridge
K. Pfeilsticker, IUP, University of Heidelberg
B. Arlander, Norwegian Institute for Air Research (NILU)

Stratosphere - TRoposphere Experiments by Aircraft Measurements III (STREAM-III):

main objectives:
to investigate the effects of stratosphere-troposphere exchanges on the chemical composition of the lowermost stratosphere in northern mid-latitudes; to quantify the budget of reactive nitrogen species and assess the role of aircraft exhausts. This will be achieved through aircraft measurements and 3D Chemistry Transport Models and Radiative Transfer simulations.

platforms:
Cessna Citation aircraft

instruments:

instruments	*measurements*	*partner*
ion-molecule reaction mass spectrometer	SO_2, H_2SO_4, HCN, HNO_3, $(CH_3)_2CO$	MPI-N Heidelberg
tunable diode laser spectrometer	CH_4, CO, COS/C_2H_2	MPI-A Mainz
Lyman-alpha fluoresence hygrometer	H_2O	ISC Julich
gas chromatograph (canister samples)	NMHC	IMAU Utrecht York University, Toronto
chemiluminescence (photolytic converter)	NO	MPI-B Mainz
chemiluminescence (heated gold converter)	NO_y	MPI-A Mainz
photo-optical detectors	actinic flux, J_{NO2}	IMAU Utrecht
infrared analyzer	CO_2	MPI-A Mainz
chemiluminescence	O_3	IMAU Utrecht
in situ gas chromatograph	F_{11}, F_{12}, N_2O	IMG Frankfurt
CP counters, DMA (DMPS) optical particle counter	aerosol concentration, size distribution	MISU Stockholm

schedule:
The aircraft campaign will take place during June-August 1998 above North Atlantic Ocean from Europe to Canada.

partners:
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G. Harris, Canadian Institute for Research in Atmospheric Chemistry (CIRAC)

comment:
The Cessna Citation will also be deployed in the Tropics in April 1998 (in Brazil and Surinam for LBA/Claire) and in March 1998 (as part of INDOEX).

THird European Stratospheric Experiment on Ozone - Ozone Loss in the Arctic and at Mid-Latitudes (THESEO-O_3 LOSS):

main objectives:
1. To quantify precisely the rate of chemically-induced ozone loss as a function of time both inside the Arctic vortex and at middle latitudes during the winters of 1997-98 and 1998-99. The cumulative chemical ozone loss and its geographical extent will also be determined.

2. To obtain a better agreement between measured ozone loss and ozone loss as calculated by 3D chemical transport models and thereby improve their predicitive capability. This will also help to identify and quantify the causes of ozone reduction inside and outside the polar vortex.

Platforms:
Ozonesondes, balloons, ground-based lidars and UV-Vis spectrometers from the European network.

instruments:

instrument	*measurements*	*partner*
Ozonesondes	O_3 profiles	NILU, AWI, FMI, UWA, IMWM, CAO plus approx. 30 stations in Europe, Canada and Japan
SAOZ(ground-based)	Total O_3, NO_2	NILU, CNRS, UWA plus other stations in Europe and the European Arctic
SAOZ (balloon-borne)	O_3 profiles, NO_2, OClO and BrO	SA-CNRS
DESCARTES (balloon-borne)	CFC-11, CFC-12, CFC-13	UCAM
Tunable diode laser	CH_4	UCAM, NPL

schedule:
There will be balloon campaigns during both winters 1997-98 and 1998-99. Four balloons will be launched in the Arctic and two at mid-latitudes each winter.
There will be a small ozonesonde Match campaign during the winter 1997-98 based on nationally funded sondes and a larger campaign in 1998-99 based on both nationally funded and EU funded ozonesondes.

partners:
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V. Dorokhov, Central Aerological Observatory, CAO
Z. Litynska, Institute of Meteorology and Water Management, IMWM

comment:
The ozonesondes will be launched from the network of sites (European and non-European) shown in Figure 2. A significant number of sondes are provided by national fundings. The ozonesonde launch strategy is determined at the Alfred Wegener Institute. Satellite data from GOME, POAM, TOMS and ODIN will be used to improve the hemispheric coverage of the ground-based and balloon measurements.

TOwards the Prediction of stratospheric Ozone (TOPOZ II):

main objectives:
the validation and improvement of three dimensional chemical transport models (CTMs), especially concerning the transport between mid-latitudes and tropical regions, and between the mid-latitude troposphere and stratosphere.

This project brings together a number of European modelling groups who are at the forefront of stratospheric research. Investigations of the horizontal and vertical resolution required for CTMs to model tracer transport accurately in these regions. Full use of existing, previously obtained measurements will be made. The validation of the CTMs outputs will be achieved with satellite UARS datasets and the aircraft campaigns STRAT and STREAM. Periods of particular interest during THESEO will be examined using the revised ECMWF analysis model.

partners:
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M. Chipperfield, University of Cambridge
J. Lelieveld, IMAU, Utrecht University
W. Kouker, Institut fuer Meteorologie und Klimaforcschung
I. Isaksen, Department of Geophysics, Blindern
G. Pitari, Dipartimento di Fisica, L'Aquila
G. Braathen, Norwegian Institute for Air Research

comment:
There will be close links between this project and measurement-based projects METRO, TRACAS, WAVE, STREAM-III, etc.

TRAnsport of Chemical species Across the Subtropical tropopause (TRACAS):

main objectives:
to investigate the exchange of chemical species between the lower stratosphere and the upper troposphere; to assess how the dynamical processes associated to the subtropical jet control those exchanges. This will be achieved through analysis of balloon and aircraft measurements, summer and winter campaigns in Tenerife and La Reunion, GCM simulations and Contour Advection with Surgery numerical tools.

platforms:
balloons, Mystère 20 aircraft, MOZAIC aircrafts

instruments:

instruments/datasets	*measurements*	*partner*
ozonesondes	O_3, H_2O, T^{re} profiles	INM
ozonesondes, lidar	O_3, H_2O, T^{re} profiles	SA-CNRS
airborne lidar	O_3	SA-CNRS

schedule:
The aircraft flights will take place in December 1998, between Europe and Tenerife, while balloon measurements will be performed in July/August 1998 over Tenerife and La Reunion. The winter measurements in La Reunion will be co-ordinated with measurements by ozonesondes at Irene in South Africa.

partners:
G. Ancellet (coordinator), Service d'Aéronomie/CNRS, SA-CNRS
S. Baldy, Laboratoire de Physique de l'Atmosphère/CNRS, St-Denis de La Reunion
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S. Mazorra, Fundacion Empresa Universidad de la Laguna, Santa Cruz de Tenerife

comment:
TRACAS includes a strong element of modelling the subtropical exchange processes.
In addition to the intensive campaign results, full use will be made of existing ozonesonde data, of MOZAIC in-situ aircraft measurements, of Geophysica aircraft measurements acquired in the frame of INDOEX experiment over the Indian Ocean (Austral summer 1999) and of satellite data (HALOE, SAGE and GOME).

Water vapour measurements from the tropics to the pole during the THESEO campaign 1998-1999 (Water Vapour Experiment, WAVE):

main objectives:
to improve our understanding of the behaviour of atmospheric water vapor during the winter at low, middle and high latitudes, through measurements and 3D models simulations.

platforms:
large ballons, aircraft, ground-based microwave sensors, rocket flight.

instruments:

instruments	*measurements*	*partner*
microwave sensors	water vapor profiles	UB1/OBx
frost-point hygrometer aerosol counter	H_2O, aerosols	LMD-CNRS
Lyman-alpha hygrometer/ cryogenic whole air sampler	CH_4, H_2	Fz Julich
microwave heterodyne radiometers	H_2O	UBe/IAP
hygrosonde (resonance fluorescence technique)	H_2O	MISU

schedule:

The aircraft campaign will take place in Kiruna in January and March 1999; large ballons measurements will be launched in January and February 1999 at Kiruna, and in April 1999 at mid-latitudes. The rocket flight is planned for the spring of 1999.

partners:
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comment:
Full use of satellite data will be made (ODIN, HALOE, GOME, POAM III).

Related EC project

Compilation of atmospheric Observations in support of Satellite measurements over Europe (COSE):

The COSE project is based on reliable and demonstrated ground-based intruments deployed in networks, for monitoring of atmospheric species. The global objective of COSE is to co-ordinate the ground-based observations mainly performed in Europe, in order to provide the Earth Observation community with a validated, consistent, and well-documented data set of atmospheric compounds, columns, and/or profiles that builds on past time series, and that will be archived in a data base for immediate and future exploitation.

The project is driven by several requirements, namely (i) the satellite validation product needed for GOME, ODIN, MOPITT, (ii) the THESEO campaign co-ordinated by the EC, including data that are needed to develop data assimilation, (iii) the necessary data base to collect qualified data, including those needed for upcoming ENVISAT validation and for international programmes like NDSC and SPARC.

The methodology consists of (i) an observational phase to acquire data, (ii) a so-called consolidation phase to transform the data into scientifically useful products and information and (iii) a demonstration related to the actual and upcoming satellite validation requests; all three will be running in parallel.

They will be close collaboration with THESEO in both the planning and operational phases.

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D. Maier, Institute of Applied Physics, University of Berne

comment: see figure 2b for the ground-based instruments involved in THESEO.

Related EC project

GOME Data Interpretation Validation and Application (GODIVA)

Experience with the space experiments similar to GOME (e.g. TOMS) has demonstrated the need for long-term monitoring of the performance of the instrument in-flight calibration systems and validation of the data products. Errors in the data products from space experiments arise from a variety of factors: degradation of the instrument performance, instability of retrieval algorithms, changes in knowledge or assumptions about molecular absorption cross sections and atmospheric scattering parameters. The GODIVA proposal addresses specifically the need to monitor the behaviour of GOME and its data products.

Advanced data products from GOME measurements are potentially of great importance for the European atmospheric, climate and meteorological user communities planning to use both GOME and OMI data. The second focus of this proposal aims to investigate the current status and develop further scientific algorithms suitable for later use in operational processing. The following potential GOME products have been selected for study in this project: global O_3 vertical profiles, global NO_2 columns, BrO and OClO products, polar stratospheric clouds.

In order to ensure effetcive use of the GOME data we incorporate a database facility and the EUMETSAT ozone SAF as partner in this project. The database facility already provides an established service to scientific and operational End Users. The European ozone SAF needs an operational OMI (GOME) data processing system to be ready by the year 2002. GODIVA will be an important step in achieving this objective.

In conclusion this study will provide important information about the accuracy of existing and advanced products from the remote sensing instrument GOME and its successor OMI. It will improve the effective use of these data by scientific and operational (meteorological) and users.

partners:
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ANNEX 2: Data protocol

DATA PROTOCOL

The aims of the protocol are: a) to encourage rapid dissemination of the scientific results from THESEO; b) to uphold the rights of the individual scientists; and c) to have all involved researchers treated equitably. These aims conflict at times, and it is hoped that the provisions of the protocol resolve these conflicts fairly. It is recognized that this cannot always be achieved to everyone's complete satisfaction; there are bound to be cases where individual interests clash with those of the mission. The two cases which we hope to avoid are the hoarding and poaching of data. To try to meet these aims, all Principal Investigators, in accordance with and on behalf of their co-investigators, must sign that they will abide the following conditions.

A. MEASUREMENTS

i) Preliminary data must be made available to other THESEO scientists as soon as possible, as outlined in the individual work programmes. There are 2 advantages to quick release: a) planning of the future phases of the mission can be greatly improved, and b) scientific evaluation of the data can occur in a timely manner.

ii) Any corrections/amendments to the preliminary data should be announced as soon as possible.

iii) It is the Principal Investigator's responsibility to ensure that the data used in publications are the best available at that time.

iv) This protocol does not restrict the availability of existing, long-term, "network data", such as the measurements made by the network ozonesonde and radiosonde stations. Measurements of this type that are stored at the NILU Data Centre (NADIR) will be subject to the same restrictions as other THESEO experimental data. Involvement in THESEO does not conflict with other earlier commitments. For example, ozonesonde data can be part of the THESEO database and be submitted to the World Ozone Data Centre for future publication in Ozone Data for the World. THESEO scientists should respect the rights of scientists who produce that data in the same way that the rights of other scientists are respected, as outlined in the Data Protocol.

B. MODEL STUDIES

i) Results of model studies using data acquired during THESEO must be made available to other THESEO scientists as soon as possible, as outlined in the individual proposals.

ii) Any corrections/amendments to these preliminary results should be announced as soon as possible.

iii) It is the Principal Investigator's responsibility to ensure that model results used in publications are the best available at that time.

C. GENERAL

i) All scientists involved in THESEO are to have equal and complete access to measurements and model results produced during THESEO. A registry of Principal Investigators and their co- investigators will be circulated before the operational phase of THESEO begins.

ii) If measurements/model results from other research groups within THESEO are used in a publication, joint authorship must be offered.

iii) Each Principal Investigator has the right to refuse to allow his work, whether measurement or calculation, to be used in another publication prior to his publication of that work.

iv) The responsibility for the method with which data and model results are disseminated will rest with the central data bank (the Norwegian Institute for Air Research - NILU) and the Operational THESEO Core Group. Access to the data bank is granted only after having signed this protocol.

v) Publication of results in the scientific literature is encouraged at any time during THESEO, as long as conditions ii) and iii) are met.

vii) Final versions of all data should be submitted to the NILU data centre before the end of the project period, i.e. 31 December 1999. The data files should be in the NASA Ames format.

ix) Data from ECMWF is available to all THESEO PIs who sign the separate ECMWF protocol which forbids dissemination to third parties (i.e. those who are not members of the THESEO PI's team). ECMWF must be duly acknowledged in all appropriate publications. It is also forbidden to make any commercial use of the ECMWF data.

x) During the active phases of THESEO (Jan. through Apr. 1998 and Nov. 1998 through Apr. 1999) each PI is obliged to submit a short weekly report describing activities carried out during the last week. This report should be submitted via E-mail to nadirteam@nilu.no before 12 UT every Friday. During the rest of the project period the weekly reports should be replaced by monthly reports that should be submitted on the last Friday of every month (May - Oct. 1998 and May - Dec. 1999). Stations that carry out routine measurements (such as UV-Vis spectrometers) should include daily values of the parameters they measure in the weeekly/monthly reports, unless the data have been submitted to the appropriate data directory in the NILU data base.

The undersigned agrees to the conditions of this data protocol.

Signature :
....

Date :
....

Name :
....

Address :
....

....

E-mail :
....

Please return to:
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14 Union Road
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ANNEX 3 : Addresses of principal investigators

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ANNEX 4 : Acronyms

ABLE	AirBorne Lidar Experiment
ACH	Aircraft Condensation Hygrometer
ALEX	Airborne Lidar EXperiment
APE	Airborne Platform for Earth observation
APEMan	APE Management Committee
ARAT	Avion de Recherche Atmosphérique et de Télédétection
ARIAS	Airborne Remote-sensing and In-situ Aerosol measurement System
ASA	Aire-sur-l'Adour
ASUR	Airborne Submillimeter Radiometer
AWI	Alfred Wegener Institute
BAS	British Antarctic Survey
CAO	Central Aerological Observatory
CASSIS	Concerted Action for Scientific Strategy In the Stratosphere
CHELOSBA	CHEmistry of the LOwer Stratosphere investigated with BAlloon observations
CFCs	Chlorofluorocarbons
CIRAC	Canadian Institute for Research in Atmospheric Chemistry
CNES	Centre National d'Etudes Spatiales
CNR	Consiglio Nazionale delle Ricerche
CNRS	Centre National de Recherches Scientifiques
COPAS	Condensation PArticle System
COSE	Compilation of Observations of the Stratosphere over Europe
CTM	Chemical Transport Model
CVI	Counterflow Virtual Impactor
DESCARTES	DEtermination et Séparation par Chromatographie lors de l'Analyse des Résultats des Traceurs Echantillonnés dans la Stratosphère
DLR	Deutsche Forschungsanstalt für Luft und Raumfahrt
DMI	Danish Meteorological Institute
DOAS	Differential Optical Absorption Spectroscopy
EASOE	European Arctic Stratospheric Ozone Experiment
EC	European Community
ECMWF	European Center of Meteorological Weather Forecasts
ECOC	ElectroChemical Ozone Cell
ENVISAT	European Environment Satellite
ERS-2	European Remote sensing Satellite
ESA	European Spatial Agency
EU	European Union
FISH	Fast In-situ Stratospheric Hygrometer
FLASH	FLuorescent Airborne Stratospheric Hygrometer
FMI	Finnish Meteorological Institute
FOZAN	Fast OZone Analyser
FTIR	Fourier-Transfer InfraRed
FZK	Forschungszentrum Karlsruhe
GASCOD/A	Gas Absorption Spectrometer Correlating Optical Differences/Airborne
GCM	Global Circulation Model
GOME	Global Ozone Monitoring Experiment
HAGAR	High Altitude Gas-chromatograph for Atmospheric Research
HALOE	Ozone Experiment
HALOMAX	Mid and high latitude stratospheric distribution of long and short lived HALOgen species during the MAXimum chlorine loading

HIMSPEC	Mid and high latitude stratospheric distribution of long and short lived HALOgen species during the MAXimum chlorine loading
IAP	Institute of Atmospheric Physics
IASB	Institut d'Aéronomie Spatiale de Belgique
IEQ	Institute for Quantum Electronics
IFA	Instituto di Fisica dell'Atmosfera
IMAU	Institute for Marine and Atmospheric research of Utrecht University
IMG	Institute for Meteorology and Geophysics
IMK	Institut für Meteorologie und Klimaforschung
IMRMS	Ion-Molecule-Reaction Mass Spectrometer
IMWM	Institute of Meteorology and Water Management
INDOEX	INDian Ocean Experiment
INM	Instituto National de Meteorologia
IPCC	Intergovernmental Panel on Climate Change
IROE	Instituto di riserca sulle Onde Elettromagnetiche
KNMI	Royal Netherlands Meteorological Institute
LA	Laboratoire d'Aérologie
LIDAR	LIght Detection And Ranging
LMD	Laboratoire de Météorologie Dynamique
LPMA	Laboratoire de Physique Moléculaire et Applications
LPCE	Laboratoire de Physique et Chimie de l'Environnement
MACSIMS	Measurements of Atmospheric Constituents by Selective Ion Mass Spectrometry
MAL	Microjoule Airborne Lidar
MAS	Multiwavelength Aerosol laser Scatterometer
METRO	MEridional TRansport of Ozone in the lower stratosphere
MIPAS	Michelson Interferometer for Passive Atmospheric Sounding
MIR	Infra-Red Montgolfier
MISU	Meteorology Department (Stockholm University)
MOZAIC	Measurements of OZone by Airbus In-service airCraft
MPI	Max-Planck-Institute
NDSC	Network for the Detection of Stratospheric Change
NILU	Norwegian Institute for Air Research
NIWA	National Institute of Water and Atmosphere
NPL	National Physical Laboratory
OBx	Observatoire de Bordeaux
ODIN	Outsourcing Desktop Initiative for NASA
OLEX	Ozone Lidar Experiment
ON	Observatoire de Neuchatel
OPC	Optical Particle Counter
PI	Principal Investigator
POAM	Polar Ozone
POLSTAR	POLar STratospheric AeRosol Experiment
PSC (project)	In-situ analysis of aerosols and gases in the polar stratosphere: a contribution to the THESEO campaign
PSCs	Polar Stratospheric Clouds
RADIBAL	RADIomètre BALlon
RAL	Rutherford Appleton Laboratory
SA	Service d'Aéronomie
SAGE	Stratospheric Aerosol and Gas Experiment
SALOMON	Spectroscope d'Absorption Lunaire pour l'Observation des Minoritaires Ozone et NO_x
SAOZ	Système d'Analyses par Observations Zénithales
SDLA	Spectromètre à Diode Laser Accordable
SESAME	Second European Stratospheric Arctic and Mid-latitude Experiment
SFINX	SRON's Fabry-Perot INterferometer eXperiment
SNSB	Swedish National Space Board
SPOT	Satellite Pour l'Observation de la Terre
SRON	Space Research Organisation of the Netherlands
STRAT	Stratospheric TRacers of Atmospheric Transport
STREAM	Stratosphere - TRoposphere Experiments by Aircraft Measurements

TDLAS	Tunable Diode LAser Spectrometer
TOMS	Total Ozone Monitoring Spectrometer
TOPOZ	TOwards the Prediction of stratospheric OZone
TRACAS	TRAnsport of Chemical species Across the Subtropical tropopause
UARS	Upper Atmosphere Research Satellite
UBr	University of Bremen
UBe	University of Bern
UCAM-DCHEM	University of CAMbridge, Dept. of ChEMistry
UCL	University College London
UHD	University of Heidelberg
UNEP	United Nations Environment Programme
UNI-GE	University of Geneva
UNIVAQ	UNIVersity of L'AQuila
UoF	University of Franfurt
UoM	University of Mainz
URO	University of Rome
UWA	University of Wales, Aberystwyth
UW-AS	University of Wyoming, Dept. Atmos. Sci.
UW-PA	University of Wyoming, Dept. Phys. and Astr.
WAVE	Water vapour measurements from the tropics to the pole during the THESEO campaign 1998-1999
WMO	World Meteorological Organisation
WO_3OS	World Ozone Observing System

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15

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