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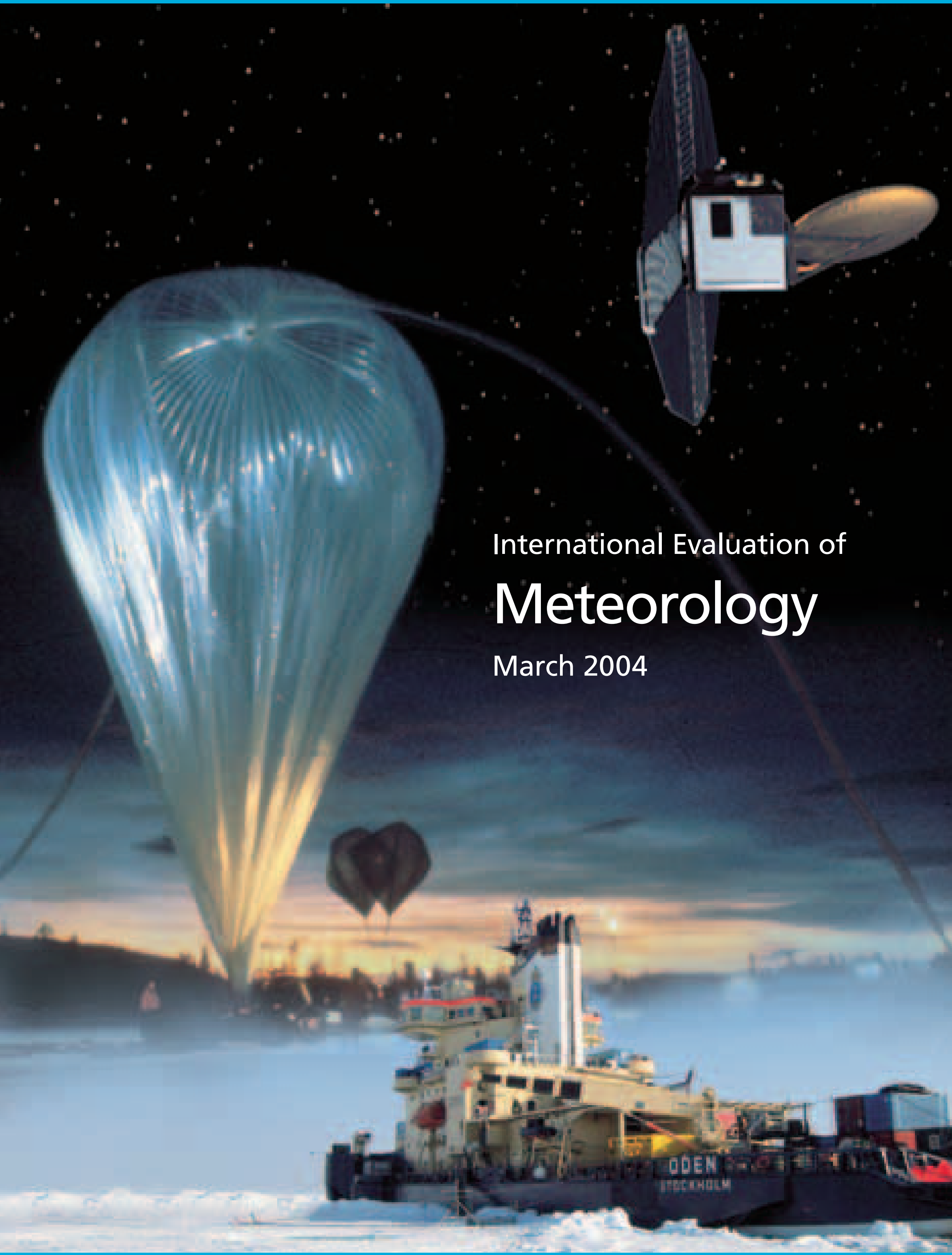

International Evaluation of

Meteorology

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To
The Swedish Research Council and
The Swedish National Space Board

A panel of international experts was appointed in March 2004 by the Scientific Council for Natural and Engineering Sciences and The Swedish National Space Board and given the task of carrying out the evaluation of Meteorology. The evaluation took place during March 15 – March 19, 2004. During these days, the grant holders under review presented their research activities to the expert panel. The panel also interviewed the grant holders during that time.

The present document reports the findings and recommendations of the expert panel, which considers its task fulfilled. In accordance with the terms of reference of the expert panel, its international members take full responsibility for this report.

March 19, 2004

Marcia Bourgin Baker

Gerald L. Geernaert

Øystein Hov

Hennie Kelder

Karin Labitzke

Chin-Hoh Moeng

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Aspects of Research in Sweden and General Recommendations

Introductory Remarks

Based on the terms of reference, and given the breadth of subjects encompassed in this review, the expert panel decided to treat the total scope as a review of atmospheric sciences, not simply meteorology. Meteorology is considered to be fully contained as the dominant part of atmospheric sciences. The panel viewed this subtle change to be positive to the evaluation, both in terms of recent productivity and future directions. Many of the panel members recognised a large number of the researchers under review. However, there was one reported conflict of interest; in that one single case, Marcia Baker excused herself from the review of Kevin Noone.

As part of the evaluation of Swedish meteorology, the panel heard presentations from 22 researchers, encompassing disciplines including upper atmospheric physics, atmospheric electricity, atmospheric dynamics, air chemistry (including aerosols), boundary layer modelling and observations, and air – sea interaction. Among the researchers being evaluated, there were nine from Stockholm University; the remaining ones were from smaller groups at Uppsala University, Lund University, Göteborg University, Chalmers University of Technology, Royal Institute of Technology, the Swedish Institute of Space Physics (IRF), and the Swedish Meteorological and Hydrological Institute (SMHI). Some of the projects under review were individual research efforts; other projects encompassed full groups. In addition, the evaluations included numerous young researchers as well as mid-career to senior scientists. This inhomogenity has to be kept in mind when analysing the results and recommendations by the evaluation. Each presenter provided supporting written documentation, through the Research Council. The panel was briefed on science progress, productivity, and the future, by all but one of the researchers. The evaluation emphasised science productivity during the previous contract period funded by the Swedish Research Council and/or the Swedish National Space Board, although consideration was also given to the science leadership of individual researchers. In most part, the panel was impressed with the quality of atmospheric sciences in Sweden and the quality of individual scientists.

Level of Research Funding and National Strategy

In stark contrast to science quality at the individual principal investigator level, the panel heard comments from an overwhelming number of the researchers being evaluated that the funding climate within the Swedish university system is under extreme stress; and that there are numerous barriers facing the future of atmospheric sciences research in Sweden. The university system appears to be facing declining governmental support, and many positions have become short-term appointments with only partial faculty support and no assurance of continuation. It became apparent that within some of the older departments there was unhealthy competition, perhaps driven by limited resources and an unbalanced institutional vision. Compounding this, neither the individual universities nor the Swedish Research Council have outlined any science strategy for atmospheric research, which can identify key areas of priority for the upcoming five to ten years. Any research policy framing basic atmospheric sciences appears to be either missing or rudderless. We note herein that the Swedish National Space Board, in fact, has a science strategy, which has combined basic and applied research in support of Swedish and ESA financed satellite missions.

Many of the researchers under review have adapted to the new stress on scientific research, others have not. Those groups, which have adapted, have made a strategic decision to diversify their portfolio by mixing basic and applied research, and in some cases also consulting. Such decisions have the benefit of stabilising the total funding base, as well as becoming more visibly responsive to socioeconomic need. Projects with a dominant monitoring character are one special ingredient of this, and the panel does not think that it is the role of the Swedish Research Council, and perhaps not even of the Swedish National Space Board, to support such projects. Other groups have maintained the traditional principle to focus only on fundamental and basic research, perhaps with the hope that a government financed rescue package will emerge at some point, in order to preserve the basic science culture of the traditional university. Upon hearing the concerns raised by the Swedish researchers; and after reflecting on their concerns, the panel feels that the evaluation of Swedish atmospheric sciences only on the project level — can only provide an incomplete picture of the state of affairs and future potential.

Atmospheric sciences research is resource demanding. This applies to both experimental and theoretical research. To ensure the largest possible impact of the science resources, it is important to agree on a generic cross-cutting basis of facilities (e.g., observational platforms, numerical models, instrumentation, and laboratory facilities) to prevent redundancies and to ensure a high return from national investments. The panel is in agreement that Sweden presently has world-class facilities (e.g., IRF facilities, Östergarnsholm field station, Esrange launch site, and Odin satellite) in place, and that these facilities need to be exploited in future planning of science in support of the atmospheric sciences.

The panel notes that much of Swedish atmospheric sciences research clusters around experimental aerosol process research in the broad sense with a bottom-up approach. In the national perspective, this bottom-up approach, when acting alone, may not provide the optimal technical underpinning for developing Swedish strategic interests, insofar as it lacks a strategic funding, which considers competition for resources and overall national science policy priorities, in general.

Recommendations

The expert panel feels that an evaluation of a national science vision, including institutional opportunities and barriers, need some serious attention. In addition, it was surprising to the panel that the universities play such a weak role in support of national policymaking for science and technology. Furthermore, the panel was given an overwhelming message from the researchers that there is very little stability in career planning in Swedish science. Given that these messages suggest that Swedish science is entering a state of potential decline, the panel therefore makes the following recommendations:

1. The expert panel recommends that the Swedish Research Council accepts responsibility to design a strategy, which includes science priorities for atmospheric and related sciences. Such a strategy should consider a priori investments in major national and international facilities, which underpin basic research. In this task, co-ordination with other, relevant funding bodies, such as the Swedish National Space Board, should be sought.
2. The expert panel recommends that future evaluations of research programmes conducted by the Swedish Research Council should focus not only on principle investigators and their individual projects, but also on the institutional commitment and strategies necessary to assure excellence and continuity of research fronts.

It seems as Sweden is lacking a clear strategy as to how the country honours its obligations to monitoring activities and to provide technical underpinning of, e.g., the Montreal Protocol. The expert panel recommends that relevant authorities clarify the national distributions of tasks.

Evaluations

Deliang Chen

Earth Sciences Centre, Göteborg University

Investigating the Varying Impact of the North Atlantic Oscillation (NAO) (1999 – 2000)

Modelling and Statistical Downscaling of Daily Climate Variables in Sweden (2003 – 2005)

Summary of the Evaluated Research

Climate change is of fundamental importance for the future planning and management. To date, General Circulation Models (GCMs) are the best available tools to estimate future global climate changes. However, their spatial resolution is too coarse to study the changing climate and its impact on the environment on regional and local scales. Various downscaling techniques have therefore been developed, in order to provide information on a finer scale. Built on recent progress on downscaling of climate change scenarios within SWECLIM, this proposed project is concerned with statistical downscaling and stochastic modelling of daily climate variables in Sweden. On the daily scale, there is increasing concern that extreme climate events, which have major impacts on society and ecosystems, may be changing in frequency and character as a result of human influences on climate. This project will define and model some of these extremes — based on long daily temperature and precipitation series in Sweden — and determine the importance of atmospheric circulation changes. A stochastic model (weather generator) will be developed for daily temperature and precipitation. Cheng will also assess the dependence of the parameters of the model on the atmospheric circulation, which provides means to create local daily climate change scenarios regarding the means and variability. At the same time, part of the uncertainty associated with the scenarios may be assessed based on the stochastic model framework.

Past Performance

Methodology

Chen's research method for statistical downscaling involves mainly detailed analyses of surface meteorological data obtained from Swedish weather stations. Based on those long records of data, he has developed a statistical model that characterises the climate variability in Sweden; and it also shows the effect of large-scale circulations in determining the Swedish regional climate. Taking advantage of those long records of observational data is highly recommended.

Position within area

Chen is in a unique position in pursuing regional climate study in Sweden. He is well connected with other international groups in Europe and in China. He has been appointed Scientific Director of the National Climate Center in China. Furthermore, Chen has served on many important committees and also contributed to book chapters on regional climate issues. Clearly, he is considered an international expert in the regional climate community.

Particular achievements

Chen has developed a statistical model that relates the regional climate in Sweden to large-scale circulation patterns and characterises the extreme precipitation events in Sweden. He has published numerous papers in internationally leading journals in this area of research.

Future

Project plans

Chen would like to combine his statistical downscaling approach with a dynamical downscaling approach using MM5 model. He also proposes to develop a stochastic model to predict Swedish weather.

Balance between resources and goal

For some time, Chen and his students have been working on a dynamical downscaling model using MM5, but this part of the research has not been supported by the Swedish Research Council. The panel feels that it is important to combine both statistical and dynamical approaches, in order to more fully understand the processes that lead to the climate variability in Sweden.

Comment on the Area

Position within Atmospheric Sciences

Chen has made an important contribution to the understanding of regional climate in Sweden. His work has better our understanding of climate variability in Sweden.

Importance and future potential of the area

Regional climate, particularly relating to extreme weather events, is an exciting meteorological research topic, which has a strong impact on national economy and ecosystems. This line of work should be greatly encouraged and perhaps enhanced.

Statistical and dynamical downscaling methods have been used separately to study regional climate for some time, but in order to further our understanding of extreme regional climate it is important to combine both approaches, as Chen has proposed to do.

General Judgement

The expert panel feels that regional climate is an important area of research within Meteorology and *strongly recommends* that Chen strengthens his collaboration with SHMI, so his research results can be put into applications. The panel regards his work as *excellent – outstanding* and *most strongly recommends* further support.

Vernon Cooray

Division for Electricity and Lightning Research,
The Ångström Laboratory, Uppsala University

Lightning Research with Special Attention to NOx Generation from Lightning Flashes

Summary of the Evaluated Research

This abstract refers to the Swedish Research Council funded research over the period of 2000 – 2006. The funding from the Council is utilised to conduct research on (a) the NOx production from electrical discharges, (b) the mechanism of electrical discharges at low pressures, (c) the production of X-rays in electrical discharges, and (d) the reduction of the breakdown voltage of discharge gaps in the presence of particles; with special attention to the initiation of lightning discharges in the cloud. During the recent years, most of the efforts have been devoted to the study of NOx production.

An assessment of the global distribution of nitrogen oxides is required for a satisfactory description of tropospheric chemistry; and in the evaluation of the global impact of increasing anthropogenic emissions of nitrogen oxides. In the mathematical models utilised for this purpose, it is necessary to have the natural as well as man-made sources of nitrogen oxides in the atmosphere as inputs. Lightning is one of the main natural sources of nitrogen oxides in the atmosphere, and it may be the dominant source of nitrogen oxides in the troposphere in equatorial and tropical South Pacific. Thus, an accurate quantification of the nitrogen oxides generated by thunderstorms is a must in further development of the chemical models of the troposphere, as well as in the evaluation of the impact of the man-made nitrogen emissions in the terrestrial atmosphere.

Past Performance

Methodology

Laboratory measurements include the quantification of NOx generated by lightning flashes through indirect methods; evaluation of the NOx generated by laboratory sparks as a function of energy; and estimation of the energy dissipated by lightning flashes, etc.

The results obtained are extrapolated globally through the global distribution of lightning flashes obtained from satellite observations.

Position within area

Vernon Cooray is full professor of Electricity (with special attention to transients and electrical discharges) at the Division for Electricity and Lightning Research, The Ångström Laboratory, Uppsala University. He has conducted experimental and theoretical research work in electromagnetic compatibility, electromagnetic wave propagation, lightning physics, lightning protection, and discharge physics.

Future

Project plans

Several studies indicate that higher emission of NOx from lightning flashes, especially the cloud flashes, than hitherto assumed is needed to explain the observation of total nitrate in the remote pacific. This calls for a thorough re-evaluation of the various assumptions that are being made in the evaluation of NOx from lightning flashes.

During this research project, all these assumptions will be put to a test; partly through the measurement of NOx emission from electrical discharges having currents and energies similar to those of lightning flashes, and partly through the study of the characteristics of lightning flashes in continental and marine thunderstorms. Moreover, a direct measurement of the NOx emitted by lightning flashes will be conducted using the triggered lightning facility of the University of Florida, Gainesville, USA. The results to be obtained in the project will provide definite answers to the questions concerning the validity of various assumptions used in quantifying the global NOx production by lightning flashes.

Balance between resources and goal

The group consists of Vernon Cooray and one to two postgraduate students, which is the lower limit to achieve the goals.

Comments on the Area

Position within Atmospheric Sciences

Cooray is internationally recognised for his research that is of very high standard. He is leading within his field, and he has authored and co-authored 115 scientific papers during the last ten years. Vernon Cooray holds a Swedish patent on a novel method of obtaining the accurate position of lightning return strokes by the time of arrival method.

Importance and future potential of the area

The research on the NOx budget is of great importance for atmospheric chemistry; furthermore, the research on lightning is of general interest and both research areas should be pursued.

General Judgement

This project is producing interesting results and publications. Vernon Cooray seems to be working mainly alone, and it is recommended that he seeks more contacts with atmospheric scientists. Overall, the expert panel judges this project as *very good* and funding is *recommended*.

Gunnar Elgered

Onsala Space Observatory, Chalmers University of Technology, Göteborg

Ground-Based GPS Meteorology

Summary of the Evaluated Research

The water vapour distribution in the atmosphere is a key observable both for weather forecasting and for climate. Observations are classically based on radiosonde measurements. However, with the help of signals used for Very-Long-Baseline Interferometry (VLBI) and from satellites for the Global Positioning System (GPS) it is possible to determine the distribution of water vapour from signals from outside the atmosphere. However, the accurate retrieval of the content needed for climate monitoring requires the development of new numerical techniques.

A further challenge is the real or near real-time estimation of the atmospheric water content for improving the weather forecasting both on regional and global scale. This is a field in strong development and of great importance for weather forecasting, and also for the prediction of extreme weather events.

Past Performance

Methodology

The VLBI and the GPS methods that both use the technique of the difference in timing of the arrival of signals as variations in the water vapour content is one major cause for this delay. Elgered estimated a Zenith Total Delay (ZTD) above each GPS site for applications in atmospheric research and weather prediction. He has developed operational software for near and true real-time applications, and studied the temporal and spatial correlations of both the ZTD and its estimation error. This knowledge is important when assimilating the ZTD. An operational system using GPS data in weather forecasting is developed in Sweden and co-ordinated with European activities.

Elgered assessed the long-term stability of GPS water vapour estimates by comparisons with microwave radiometry, radiosondes, and VLBI. Differences of the order of 0.02 mm/yr over ten years are consistent with the formal uncertainties. Ground-based GPS networks have a large potential for climate monitoring, regionally and worldwide.

Elgered used a dense network of GPS receivers and tomographic methods to estimate the 3-D structure of the wet refractivity. Due to poor geometry, additional constraints are added using models of atmospheric turbulence and microwave radiometer observations. New software to estimate the reactivity directly from the raw data was developed. Simulations indicate significant improvements when the Galileo satellites are added.

Position within area

Elgered is one of the leading scientists in his field. He is very well imbedded in the international networks. He is very keen on applying his results in climate research and weather forecasting. The number of publications in widespread reviewed journals is high. He has also been the supervisor of a number of Tekn. Lic. and Ph.D. theses.

Particular achievements

Several elements of his work should be mentioned, such as: assessing the quality of the GPS estimates of the water vapour content by contributing to several assessments; development of near real-time application; setting up an operational system for the analysis and submission of SWEPOS data to SMHI and UK Met Office; and the development and application of tomographic methods to obtain three-dimensional information on the water vapour distribution.

Future

Project plans

GPS for climate applications: Station calibration as well as validation and construction of time series. An important element is the intercomparison of trends with ERA-40 data.

Real-time data processing: Further development of real-time processing soft ware; Study of the possibility of assimilation of assimilation of the raw GPS data.

GPS tomography: Further development of direct estimation software.

Preparation for ACE+ mission: Assessments of the role of turbulence and scintillation for the accurate retrieval of the water vapour distribution.

Balance between resources and goal

The resources from the Swedish Research Council and the Swedish National Space Board are adequate and justified by the progress in Elgered's work and for the goals specified for the future.

Comments on the Area

Position within Atmospheric Sciences

The use of space data from VLBI and GPS has the potential to contribute significantly to both climate monitoring and weather forecasting.

Importance and future potential of the area

The area is in full development and the projects of Elgered are very valuable and important for the further development of the field. Furthermore, it is to be expected that these research directions remain very challenging and important in the next couple of years.

General Judgement

The field under investigation is of significant importance in different applications. The collaborations with meteorologists and climate researchers are acknowledged. Future contacts with the ECMWF are encouraged. Elgered's research programme and performances are rated *very good – excellent* by the expert panel. Support at the demanded level is *strongly recommended*.

Nils Gustafsson

Swedish Meteorological and Hydrological Institute (SMHI), Norrköping

Enhanced Assimilation of Microwave Satellite Radiances for a High Resolution Limited Area Model (HIRLAM)

Summary of the Evaluated Research

Initial data for numerical weather prediction models are needed in the form of vertical profiles of temperature, water vapour and wind. Over large areas, it is necessary to utilise satellite radiance information for this purpose. A variational data assimilation system has been developed for the High Resolution Limited Area Model (HIRLAM), which is used for numerical weather prediction at the Swedish Meteorological and Hydrological Institute (SMHI). This data assimilation system is used for assimilation of satellite radiance information into HIRLAM. The HIRLAM variational data assimilation is being further developed to optimise the utilisation of AMSU-A (Advanced Microwave Sounding Unit) and AMSU-B radiance data from operational meteorological satellites. An important step forward, during the period of the present project, has been the near-operational introduction of AMSU-A radiance data from the Northern Atlantic area. AMSU-A radiances are mainly related to temperature profiles, and they have proven to be beneficial for the quality of the HIRLAM forecasts. The assimilation of AMSU-B radiances, sensitive to moisture profiles as well as temperature profiles, has not yet progressed to an operational utilisation, but several important preparation steps have been taken within the present project.

Past Performance

Methodology

Improvement of weather forecasts has been performed by: Optimised utilisation of AMSU-A satellite radiance data for improving temperature of AMSU-B satellite; radiances data for improving moisture fields; and by applying a 4-dimensional variation data assimilation.

Position within area

Nils Gustafsson is an internationally recognised expert in the field of data assimilation for numerical weather prediction. He has significantly contributed to the development of HIRLAM variational data assimilation.

His record of publications reflects his competence. In meteorology, publications are often made in conference proceedings and technical reports. It is, however, important to find a balance with publications in widely spread peer-reviewed journals.

Particular achievements

The following achievements should be explicitly mentioned: Near operational utilisation of AMSU-A radiances; AMSU-A radiances over land and ice; quality control and assimilation of AMSU-B radiances; impact of AMSU-A and AMSU-B radiances over sea, ice, and land; improved forward modelling of AMSU-B for variational data assimilation, and 4-dimensional variational data assimilation.

Future

Project plans

Gustafsson plans a number of activities for improving the utilisation of AMSU-A and B radiance data during 2004 – 2005. Among the more long-term plans is the development of assimilation of a very high resolution (1 – 3 km), non-hydrostatic model, in collaboration with Meteo – France.

Balance between resources and goal

In the past, the balance between the resources and results has shown to be adequate. There is no demand for further support.

Comments on the Area

Position within Atmospheric Sciences

The use of satellite data to improve weather forecasting is a field of research in strong development.

Importance and future potential of the area

The satellite data are nowadays essential for the high quality of medium-range weather forecasting. Improvement of the utilisation of satellite data will further increase the accuracy of the weather forecasting on very high spatial and temporal resolution as well as on regional and global scales.

General Judgement

Nils Gustafsson has many years of experience in theoretical meteorology and has built up a very good reputation. He has significantly contributed to the use of satellite data for improving weather forecasting. His work in the field of data assimilation is highly estimated. The expert panel judges his performances as *excellent*, and future funding is *strongly recommended*.

Mattias Hallquist

Department of Chemistry, Atmospheric Science, Göteborg University

The Impact of Atmospheric Oxidation Processes on Physical and Chemical Properties of Aerosol Particles

Summary of the Evaluated Research

Adsorption of water on aerosol particle surfaces is an important factor in several key processes in the atmosphere. It influences the Earth's climate balance and changes the oxidation capacity of the atmosphere. Organics can modify the thermodynamic and chemical properties of atmospheric particles, and hence alter the role these particles play in the atmosphere. In addition, the presence of pre-existing aerosol particles and water may influence the aerosol yield of the products from degradation of organic compounds (e.g., Bonn *et al*., 2002, and Berndt *et al*., 2003).

A new experimental set-up combining an aerosol laminar flow tube and a tandem DMA system has been constructed. In the set-up the relative humidity (up to at least 85% RH) and temperature (283 – 313 K) can be controlled. The system is currently used for initial experiments using ozonolysis of monoterpenes as a source for semivolatile organic compounds and organic particles.

The future aim of the project is to characterise the effect of atmospheric aging on water uptake properties of submicron particles. In addition, it will provide more information on the water dependency on the yield of organic aerosols from the degradation process. The obtained data should be used in atmospheric aerosol mathematical models, in order to more accurately describe water uptake on particles. This may, e.g., influence the current estimates and future prediction of the impact of aerosols on atmospheric chemistry and climate due to human activities.

Past Performance

Methodology
Mattias Hallquist has used innovative experimental techniques to investigate interactions of water and aerosol particles of complex composition. These processes are important in the atmosphere and their investigation is timely.

Position within area
Hallquist and his colleagues have published a number of substantive papers in important physical chemistry and atmospheric science journals, testifying to the recognition of his work by the international community.

Particular achievements
The work done by Hallquist at Cambridge; on adsorption of water on thin films of inorganic salts, used the new technique of secondary acoustic wave analysis. Moreover, the studies at Göteborg University of secondary organic aerosol formation from atmospheric volatiles are novel and interesting.

Future

Project plans
The plan is to continue laboratory studies of the adsorption of water on aerosols and, in particular, on the impact of organics on this adsorption. While the laboratory work will focus on controlled systems, the proposal includes analysis of atmospheric aerosols collected by other groups involved in the MISTRA project.

Laboratory studies of these multiphase multicomponent processes are extremely important for atmospheric cloud models, and this group will be one of the few capable of carrying them out. In principle, these fundamental studies should provide very useful data, now lacking, for atmospheric chemistry models.

Balance between resources and goal
Hallquist requests salary support and funds for the purchase of instrumentation. These seem entirely reasonable.

Comments on the Area

Position within Atmospheric Sciences

The area is central in cloud physics. Although it is known that atmospheric aerosol particles are rich in organic material, the impacts of these organics on atmospheric processes are little understood. Hallquist's results can potentially fill an important gap in our ability to model cloud evolution.

Importance and future potential of the area

The study of aerosol – cloud interactions, and of the role of organics in mediating those interactions, represents growing fields in atmospheric sciences. The laboratory results obtained by Hallquist and his colleagues are potentially very useful in interpreting atmospheric data. The expert panel encourages Hallquist to present his results in terms of mechanisms applicable to the atmospheric context.

General Judgement

The expert panel judges Mattias Hallquist's proposal as *very good* and *recommends* increased funding.

Sheila Kirkwood

Swedish Institute of Space Physics (IRF), Kiruna

Research on the High-Latitude Middle Atmosphere: Dynamics, Trace Gases, Clouds, and Aerosol Particles

Summary of the Evaluated Research

The project involves research on middle-atmosphere dynamics, trace gases, clouds and aerosol particles. The objective is a better understanding of physical processes, which determine the behaviour of the middle atmosphere, including those with relevance for stratospheric ozone depletion and those potentially affected by or influencing climate change. A large part of the research is based on atmospheric observations made from Kiruna in Northern Sweden. The group operates MST radar, mm-wave radiometer, and lidar instruments and co-operates with scientists, mainly from other countries, to make measurements with other ground-based instruments, with balloons, and with sounding rockets. The facilities of the ESRANGE launch site in Kiruna are utilised to the highest possible limit.

Supplementary data from global databases and atmospheric satellite missions is also used. Observations are compared with physical models to study the interplay and balance between different physical factors, which can affect the region of study. Noteworthy results include: contributions to understanding stratospheric ozone depletion in the Arctic; evidence of a lack of a significant trend in noctilucent clouds (at mesopause heights) over the last 40 years; evidence that planetary waves play a significant role in the summer mesosphere; successful artificial modulation of radar scatter from mesospause heights using radar reflection heating; the first observations of atmospheric gravity waves simultaneously in both optical (noctilucent cloud) and radar measurements in the mesosphere; and evidence that aerosol particles are involved in radar scatter from the winter mesosphere.

Past Performance

Methodology

A. Middle atmosphere dynamics, clouds, and aerosol particles

The following observations are made with the group's own instruments or with international facilities: Continuous observations of radar echoes from charged aerosol particles and neutral turbulence in the mesosphere using the ESRAD mesosphere/stratosphere/troposphere radar; Campaign observations of similar echoes using the EISCAT incoherent scatter radar, combined with active modification of the aerosol layer by the heating facility; Optical observations of wave structures in mesospheric clouds; Continuous observations of the 3-D field and of the vertical structure of the upper troposphere and lower stratosphere (weather fronts, tropopause heights, and tropopause folds); and Regular observations of aerosol-particle layers by lidar.

B. Monitoring of stratospheric ozone and related atmospheric trace gases

One objective for Kirkwood's group in Kiruna is to contribute long-term observations from Kiruna to the global monitoring of the development of the stratospheric ozone layer. This in turn is to monitor the expected recovery of the ozone layer, following the banning of CFC's, and to determine whether further steps are needed to restrict the use of other chemicals.

To achieve this objective, regular observations were made with DOAS, FT-IR spectroscopy and a mm-wave spectrometer, in close co-operation with the University of Heidelberg (Germany) and the IMK in Karlsruhe (Germany). The group also participated in European ozone campaigns carried out in the Kiruna–ESRANGE area, using the balloon-borne CFC sampler DESCARTES. The result after a series of major measurement campaigns has been a rather reliable confirmation that chemical ozone depletion occurs also in the Arctic, and a quantitative agreement exists between modelled and measured depletion.

SKERRIES was a series of nine small balloon flights funded by the Swedish National Space Board between 1998 and 2001, primarily to provide measurements with DESCARTES and ozone-sounds to complement the measurements obtained with other flights. The final flight in the SKERRIES series was made in December 2001, to provide hygrometer measurements for validation of the Odin satellite.

Position within area

Sheila Kirkwood's group works in the Kiruna–ESRANGE area, where a broad facility of instruments is placed. This is a unique surrounding and an internationally well-known area, where many international campaigns are carried through. This surrounding has given Kirkwood's group the possibility to carry out research in a very remote area, yet extremely well connected in the international community. The results achieved reflect this unique surrounding, and the scientific output is very high. Kirkwood has a high international reputation and shows strong leadership potential for her group.

Particular achievements

1. There has been no significant increase in noctilucent clouds (NLC) over Norh Western Europe or Eastern Europe during the last 35 years. NLC form at about 82 km altitude, in summer at the extremely cold mesopause. There has been a widespread misconception in the atmospheric science community that there has been a substantial increase in NLC occurrence over the last 40 years, and Thomas *et al.* (Nature, 1989) predicted that the temperature should decrease and water vapour increase at the mesopause; as a result of mankind's emissions of carbon dioxide and methane. A reanalysis of the NLC sightings, which Kirkwood made, showed, however, that there is in fact no evidence for any increase of these clouds during the last 40 years.
2. The largest-scale waves in noctilucent clouds correspond to gravity waves detectable by radar. This result has been obtained by careful photo-grammetric analysis of NLC images over the same region where winds were probed directly by both VHF and MF radar. Kirdwood's group is the first to obtain such joint radar/optical observation of NCLs.
3. In a series of campaigns with the EISCAT radar and the Heating facility, the group was able to achieve (again for the first time) artificial modulation of the polar mesospheric summer echoes signal strength by modulating the temperature of the background electron gas.

Future

Project plans

Sheila Kirkwood intends to continue and expand the ongoing successful observing and modelling activities. Emphasis will be based on: Validation of ozone profiles from the Odin satellite; studies of mountain lee-waves and polar stratospheric clouds by co-ordinated lidar and radar observations from two sites simultaneously (Esrange, IRF–Kiruna); and participation in planning for STEAM.

Balance between resources and goal

To remain competitive at the international level and to be able to fully exploit the unique facilities of the Kiruna–ESRANGE region, it is important to support Kirkwood and her group. Kirkwood is clearly one of the leading scientists in her field in Sweden.

Comments on the Area

Position within Atmospheric Sciences

Kirkwood's research is centred in the Middle Atmosphere, the region between the tropopause and the mesopause (10 to 85 km). This region is recognised to be especially sensible to anthropogenic changes (ozone hole).

Importance and future potential of the area

The importance of the Middle Atmosphere for the understanding of climate and its variability has become very clear during the recent years, particularly in the context of the ozone hole problem. It is an area of research where the development of new measuring techniques (rockets, satellites, radars, etc.) and the experimental collection of data, as well as the modelling on different scales, is and will remain of greatest importance for a long time.

General Judgement

Sheila Kirkwood's research programme is considered *excellent – outstanding*, and the expert panel *most strongly recommends* that its funding be continued at the highest possible level.

Erland Källén

Department of Meteorology, Stockholm University

Variational Assimilation of Wind Profiles in the Tropics for the ESA Earth Explorer Atmospheric Dynamics Mission

Summary of the Evaluated Research

The Earth Explorer Atmospheric Dynamics Mission (ADM-Aeolus) satellite is being developed by ESA. The satellite will provide improved analyses of the global wind field in three dimensions. ADM-Aeolus will utilise the active Doppler Wind Lidars method. This is the only method that has the potential to provide the required data globally, from direct wind observations. Wind information is essential for numerical weather prediction as well as for climate studies.

Present-day atmospheric wind observations are unevenly distributed over the globe; wind profiles from radiosondes are mainly available over populated areas in the Northern Hemisphere. Remote sensing of winds from satellites has been performed using cloud tracking over tropical areas and through assimilation of humidity structures that indirectly give wind information. This wind information suffers from significant systematic errors as well as a poor vertical coverage. The large-scale dynamics in tropical areas is governed by the wind field. In mid-latitudes mesoscale dynamics, however, such as fronts and orographical phenomena are determined by the wind field (length scales less than the Rossby radius of deformation). In tropical regions, the El Nino phenomenon as well as tropical waves and large-scale monsoon systems are determined by the wind field. A further understanding of tropical dynamics is vital for developing numerical weather prediction as well as climate models.

Assimilation of the new Doppler wind lidar information in tropical regions requires the development of new assimilation methods. A new method, based on variational data assimilation and tropical wave dynamics, is proposed in this project. The first results indicate that the method is successful, and that the full, two-dimensional wind can be retrieved from unidirectional wind observations, complemented with mass field information.

Past Performance

Methodology

Erland Källén and his colleagues are using numerical model to generate idealised flow fields to investigate the background errors in variational data assimilation for the tropical region. Based on that twin experiment, they developed a new assimilation method that can be used for retrieving the complete three-dimensional wind field from unidirectional wind field observed by a satellite.

Position within area

Källén and his group are using their strong background in tropical wave dynamics to investigate problems in data assimilation technique. Their newly developed method can recover the complete wind information in the tropics, where ground-based data are rare. Their publications are too recent to reflect their impact in the field.

Particular achievements

Under support from the Swedish National Space Board, Källén and his colleagues have developed a new data assimilation technique that can retrieve the tropical wind field. The results are published in two top-ranking journals, QJRMS and Tellus.

Future

Project plans

Källén proposes to include latent heating effects to this new data assimilation technique, and to test the new scheme in the ECMWF operational model.

Balance between resources and goal

Request for continued support of a Ph.D. student and a postdoctoral student to continue this line of research is reasonable.

Comments on the Area

Position within Atmospheric Sciences

Källén is working on a main-stream meteorological problem: data assimilation for weather forecast. His data assimilation technique developed for the tropical region is unique and has a great potential for improving our weather forecast.

Importance and future potential of the area
A complete description of the 3-D wind field in the tropics is essential for weather forecast and also for climate studies. Presently, data assimilation is a very hot topic and its application to the tropical region is particularly essential, since *in situ* data in this region are rare.

Källén's group has made an important contribution in developing a retrieval technique of the wind field in the tropics based on remote satellite data. How to incorporate this technique into an operational forecast model remains a challenge.

General Judgement

The expert panel ranks Erland Källén's research in the area of data assimilation as *excellent* and *strongly recommends* future support for that line of work.

Caroline Leck

Department of Meteorology, Stockholm University

The Coupling between the Global Climate and Biogeochemical Cycles — Atmospheric Research on the Arctic–2001 Icebreaker Expedition

Summary of the Evaluated Research

Current state-of-the-art models suggest higher climate sensitivity in the Arctic than elsewhere — in climate scenarios with a business as usual emission scenario, the Arctic warms about 2.5 times more than the global average. However, the inter-model spread ranges from less warming in the Arctic than the global average to 4.5 times the global average — this figure is also larger in the Arctic than anywhere else on the globe.

The difficulties to simulate future scenarios of Arctic climate change relates to an insufficient understanding of several strong feedback mechanisms within the Arctic climate, and therefore to an inadequate descriptions of these processes in models. This is explained by sparsely distributed observations, such as long-term continuous, short-term process focused field studies, and satellite observations.

The motive and overall objective of the evaluated programme (AOE – 2001) was to identify and quantify the processes that control the evolution and properties of the atmospheric boundary layer and aerosol-cloud system relevant to radiative forcing and climate in the Arctic region.

The programme included both an experimental phase, focused on fieldwork, and a closely coupled modelling effort. The climatic sensitivity of the central Arctic Ocean; the absence of extensive data in the region; only sporadic influences of polluted air from south of the Arctic circle in summer; and the near-permanent summer cloud cover suggest it to be the most suitable area for such studies. The programme required multi-disciplinary scientific support from scientists involved in boundary layer meteorological, atmospheric chemistry and physical and marine biology. Future investigations call for the necessity of classifying the organic aerosol and to further examine the influence of soluble gases, partly soluble material and surface-active materials on water uptake, in order to form cloud droplets by aerosol particles as well as the interaction between these components and the inorganic fraction within a particle.

Past Performance

Methodology

The approach used for the Arctic research is resource intensive *in situ* measurements based on ice breaker expeditions. Several large expeditions, where the main resource (icebreaker and helicopter) was covered by Sweden, have been carried out with broad international participation and with Caroline Leck providing the leadership of the science programme of the expeditions.

Position within area

Caroline Leck is well known for her studies on the cycling, in particular of DMS between the ocean and the atmosphere.

Particular achievements

The results of the expedition in 1991 and 1996 have been published. The 1996-JGR special issue was circulated to the expert panel. This special collection of papers carried an overview of the expedition and its results by Caroline Leck and co-workers. The collection of papers is an important contribution to the understanding of physical processes in the Arctic boundary layer, including aerosol cycle processes. The Arctic Ocean 2001 programme progressed with a biogeochemical cycle approach, involving biology, chemistry, physics, and meteorology.

Future

Project plans

The future plans are made with the International Polar Year 2007/08 initiative by ICSU in mind. The plans involve another icebreaker expedition to the Arctic, in order to provide the observational basis for the exploration of a number of issues (nine listed in the proposal section, examples are: particle formation from ice leads; classification of particle mixtures, including the role and origin of the organic fraction; and boundary layer turbulence characterisation).

Balance between resources and goal

The objectives for the research programme and the means chosen to pursue them are resource demanding, not least in terms of instrumentation, hardware, and ship time. The expert panel wonders if it is possible to approach the objectives in more cost-effective ways; ahead of further full-scale Arctic expeditions. This could involve laboratory experiments and the testing of alternative and simpler hypothesis for some of the issues raised.

Comments on the Area

Position within Atmospheric Sciences

The Arctic boundary layer exploration is traditionally seen as basic, curiosity driven research with weak application implications. The climate change link is, however, important and, in particular, the fragility of the Arctic ice cover is a very sensitive feedback mechanism in global climate change.

Importance and future potential of the area

The research work is justified by the difficulties to simulate future scenarios of Arctic climate change. These difficulties are claimed to be related to an insufficient understanding of several strong feedback mechanisms within the Arctic climate, and therefore to an inadequate descriptions of these processes in GCM models. An alternative hypothesis could be that long-term variability on a much larger scale, linked to the oceanic circulation, is important for the spread in temperature change predicted by climate models for high latitudes. If this is the case, not only a better description of local heat and moisture exchange between the surface and the atmosphere within the Arctic itself is important for the improvement in predictive capability, but also the initialisation of GCM calculations and the length of the scenario calculations (beyond more than the longest timescale important for the problem).

The biogeochemical cycle approach taken is an important one, and moves the frontiers of meteorology into adjacent areas in a fruitful manner. The role of meteorological processes in biogeochemical cycling is an essential one, together with biology, chemistry, and physics. The exploitation of this potential will require considerable skills in mobilising interdisciplinary teams working across traditional divisions of work, both within and between institutions.

General Judgement

The research of Caroline Leck is *very good*, and the expert panel *recommends* future funding of her research.

Erik Lindborg

Department of Mechanics, Royal Institute of Technology, Stockholm

Non-linear Interaction and Dispersion of Scalars among Internal Gravity Waves

Summary of the Evaluated Research

It is a remarkable and until today unexplained fact that the mesoscale (wave lengths 1 – 500 km) energy wave number spectra of the stratosphere exhibit a $k^{-5/3}$-dependence, just as the spectrum of three-dimensional isotropic turbulence. Two conflicting hypotheses have been put forward to explain the observed spectra. It has either been assumed that the spectra arise as the result of an inverse energy cascade of the same type as can be observed in two-dimensional turbulence — or it has been assumed that they arise as the result of a forward energy cascade of nonlinearly interacting gravity waves. A series of previous theoretical and observational studies have given increasing evidence in favour of the forward cascade hypothesis. In this project, a similarity theory for a forward energy cascade is developed on the basis of the Boussinesq equations. A series of box simulations of these equations including system rotation is performed, showing the existence of such an energy cascade. The equations are solved in highly elongated (vertical to horizontal aspect ratio as low as 1/192) three-dimensional boxes with very high resolution (up to $768^2 \times 48$), two-dimensional forcing at small wave numbers and hyper-diffusion at large wave numbers. The strength of stratification and the rate of rotation are varied over a large parameter range including values, which are relevant to the stratosphere. A perfect stationary forward energy cascade is obtained.

Past Performance

Methodology

Lindborg combines observational data, theory, and numerical simulation to investigate the mesoscale spectra in the stratosphere. His research methodology is comprehensive and appropriate.

Position within area

Lindborg is regarded as a young talented scientist working on a fundamental research problem. His result has received a good international attention.

Particular achievements

Lindborg claims that the long-standing problem about a $k^{-5/3}$ mesoscale spectrum in the stratosphere is solved. He has published a series of papers in top-ranking international journals, e.g., JFM, Phys. Review Letter, JGR, and Phy. Fluid. These papers have stirred up heated discussions and debates in the theoretical mesoscale community.

Future

Project plans

Lindborg is proposing to include passive scalar into his numerical simulation work to investigate the dispersion property of mesoscale motions. He also wishes to work with a group of oceanographers, in order to measure the horizontal spectra of velocity and temperature in the ocean.

Balance between resources and goal

To continue his work, Lindborg requests to cover part of his own salary and a graduate student, which appears reasonable.

Comments on the Area

Position within Atmospheric Sciences

Lindborg is a junior scientist who seems to be on this way to becoming an internationally recognised scientist in the field of theoretical mesoscale meteorology.

Importance and future potential of the area

A $k^{-5/3}$ mesoscale spectrum in the velocity and temperature fields has been observed in the upper troposphere and lower stratosphere for more than a decade, but theoreticians have not yet come to an agreement as to what causes this observed spectrum. It is by itself a scientifically interesting problem.

What is (and causes) the mesoscale spectrum is an interesting fundamental research topic — and remains so even though Lindborg claims that the problem is solved. It remains a challenge to understand what consists of this flow field, how it affects large-scale circulations, and how it can be parameterised in global models.

General Judgement

As a scientist who works on a very fundamental topic, the expert panel ranks Lindborg's work as *excellent – outstanding* and *strongly recommends* further support.

Bengt Martinsson

Department of Aerosol Physics, Division of Nuclear Physics,
Lund Institute of Technology, Lund University

Quantitative and Single Particle Characterisation of the Aerosol in the Upper Troposphere and Lowermost Stratosphere from the CARIBIC Platform

Summary of the Evaluated Research

In this project (CARIBIC), more than 60 trace gases and aerosol physical and chemical characteristics are measured regularly in the upper troposphere and lower stratosphere (UT/LS). During the years 2004 – 2014, measurement flights will be undertaken once or twice per month. CARIBIC is based on a new concept utilising a commercial, intercontinental aircraft, permitting regular probing because of the comparably low costs of the measurements. The collaboration includes eight research groups from five European countries. Bengt Martinsson's group is responsible for the chemical characterisation of the aerosol, using four methods of total aerosol and single particle analysis. This research platform is the only frequent observer of the UT/LS aerosol chemical characteristics. The atmospheric constituents of this proposal, i.e., aerosol particles, cannot be characterised chemically by remote sensing. The large geographical coverage and regular probing of the UT/LS aerosol chemical composition of the CARIBIC measurement programme thus is a unique feature.

Martinsson's work in the project includes development of measurement methods, development of analytical methods, analyses, data evaluation and data interpretation. The unique data on the aerosol constituents are used to form climatologies for several regions of the world. The studies also include the residence time of particulate sulphur for various areas of the upper troposphere, the aerosol constituent's distribution and transport across the tropopause, and the sources of the aerosol in the tropopause region. The aerosol data produced in CARIBIC will also be used within collaboration with global and regional scale modellers.

Past Performance

Methodology
The elemental analyses performed by the group (PIXE and PESA) require facilities not generally available to atmospheric research, and to expertise that is not widespread in atmospheric sciences. This project, which takes advantage of the position of the group within a nuclear physics department, is therefore unusual and valuable. Moreover, they have interpreted their results in terms of atmospheric pathways. This has involved two separate approaches. In the first, they identify composition signatures to assess the roles of various anthropogenic and non-anthropogenic sources of the aerosol particles. The second approach is focused on particles of only tropospheric origin, and involves modelling of air mass trajectories from assumed particle source to collection point, in an attempt to identify the role of precipitation in modifying the upper tropospheric aerosol.

Position within area
The research group headed by Martinsson is one of a very small number capable of chemical analysis of single aerosol particles in the atmosphere. They have a long series of publications in leading aerosol and atmospheric journals.

Particular achievements
The group has elucidated the origins of Sulphur in upper tropospheric aerosol particles, finding that it has both surface and stratospheric origins. This measure of the contribution of stratospheric transport to the upper troposphere in mid-latitudes is independent of traditional gaseous tracer studies. They find, through analysis of potassium and iron contributions, that biomass burning is an important source of aerosol particles near the tropopause region.

Future

Project plans
Martinsson requests support for continued PIXE and PESA analysis of single aerosol particles collected during the CARIBIC project, and continuation of the tropospheric modelling effort.

Balance between resources and goal
The resources requested will provide support for the laboratory analyses, and appear reasonable.

Comments on the Area

Position within Atmospheric Sciences

The aerosol information to be supplied by the CARIBIC project addresses one of the major gaps (as identified, e.g., in the latest IPCC report) in our understanding of climatically relevant atmospheric properties. Therefore, the project itself is extremely important. The chemical analyses of the particles will be done only by Martinsson's group. This contribution is crucial to understanding the chemical and possibly climatic impacts of the various sources of the particles.

Importance and future potential of the area

There is minor uncertainty about the future duration of the CARIBIC project. To the extent that it will continue, the data will continue to provide important and much needed information about a little understood part of the atmospheric aerosol cycle. The expert panel feels less confident about the future potential of the trajectory modelling, unless an expanded atmospheric data base can be used to constrain the possible cloud scenarios.

General Judgement

Although the proposed work is not in itself innovative chemistry, the analyses performed by Bengt Martinsson and his group have been careful and rigorous, providing important information to modellers. The expert panel rates the work *excellent* and *recommends* future funding.

Johan Mellqvist

Department of Radio and Space Science, Chalmers University of Technology, Göteborg

Studies of Atmospheric Chemistry, Satellite Validation, and Tropospheric Emissions using Solar FTIR Spectroscopy

Summary of the Evaluated Research

The running of a monitoring station within the Network for the Detection of Stratospheric Change (NDSC) provides the backbone for many of the scientific applications of the Optical Remote Sensing group at Chalmers. The measurements and the data retrieval are however not straightforward and require considerable efforts to achieve, e.g.,

i) An important use of the ground-based solar FTIR data is for the validation of satellites, and the group is involved in validations regarding the instruments SCIAMACHY, MOPITT, and ACE-FTS.

ii) Scientific topics include the estimation of the seasonal, accumulated chemical column ozone loss and chlorine partitioning inside the polar vortex, estimation of long-term trends of ozone, chlorine, and nitrogen species in the stratosphere, but also trends of tropospheric species such as CO, methane, HCFC-22, and ethane.

iii) Another important scientific application is the comparison of measured data to results from 3-D chemical transport models. Primarily to pin-point problems in the models or parameterisation in the models, but the global coverage of the model can also be used in a qualitative manner, in order to show how representative the measured FTIR column data are.

iv) In addition to the high resolution FTIR studies in Harestua, Norway, a new mobile solar FTIR application is just being developed, by which variations of for instance CO columns in the vicinity of Mega-cities can be studied and compared to models and satellites. Also direct source emission studies can be carried out on sources such as refineries and volcanoes, leaking hydrocarbons and HCl, HF and SO_2, respectively.

Past Performance

Methodology

1) Continuation of monitoring at Haresstua station;
2) Estimation of
   a) stratospheric ozone depletion;
   b) chlorine partitioning;
   c) atmospheric dynamics using HF and COF2;
   d) comparison of stratospheric measurements with model output;
   e) trend analysis;
   f) comparison of observational data with output from tropospheric chemistry transport models;
3) Validation of Sciamachy data with Harestua observations;
4) Application of a mobile FTIR for measurement campaigns and satellite validation.

Position within area

The Harestua station is a well-recognised observatory of atmospheric composition in a very interesting region for the study of the ozone depletion. Their contribution to the validation of several satellite instruments is highly appreciated by the remote sensing community. The mobile FTIR is very well suited for the study of events and field campaigns. Mellqvist is very well imbedded in the relevant European research networks and in important international projects.

Particular achievements

The time series at Harestua are now covering eight years and are therefore of great value to study variability on seasonal and annual timescales. Dynamical information from tracers like HF has enhanced the knowledge on stratosphere – troposphere exchange. The comparison of the observations with model output has generating interesting results on model performance on the description of ozone depletion. Pioneering work on the leakage of several trace gases from the Etna volcano by their mobile column measurements should also be mentioned.

Future

Project plans

Continuation for five to ten years of NDSC monitoring activities at Harestua; New measurement site at Chili; Mobile FT/UV column measurements; Instrumentation for a network intended for the observation of volcanic gas emission and climate change.

Balance between resources and goal

The resources have been very well justified by the project results.

Comments on the Area

Position within Atmospheric Sciences

FTIRs are very important instruments for measuring the distribution of several trace gases. The NDSC network is essential for the study of trends and events.

Importance and future potential of the area

The monitoring of the atmospheric composition is essential for the study of the atmosphere and the climate, and this requires a balanced system of ground-based and satellite measurements, including a NDSC network.

An integrated approach for the observations of atmospheric composition has recently been formulated in the IGACO report for the atmospheric chemistry theme adopted by IGOS-P. FTIR observations will play an important role in this integrated system. A point of importance will be to optimising the networks, i.e., to consider the added value of Harestura compared with surrounding facilities and/or improving the synergy in the measurements programme.

General Judgement

Mellqvists contributions to the observations of the atmospheric composition are internationally very well recognised and judged *very good* by the expert panel. Monitoring of the atmosphere is important, and new resources are needed to continue. However, it is not clear that funding should be a primary task of the Swedish Research Council or the Swedish National Space Board. With respect to monitoring, the national government could consider this as a contribution to an international effort in the Montreal protocol.

Donal P. Murtagh

Department of Radio and Space Science, Chalmers University of Technology, Göteborg

Global Measurements of the Composition of the Stratosphere and the Mesosphere

Summary of the Evaluated Research

The main input of material to the middle atmosphere is in the region of the Inter-Tropical Convergence Zone (ITCZ), where large convective systems are believed to bring air into the Tropical Tropopause Layer (TTL) — from where the air then may enter the stratosphere by quasi-horizontal transport along isentropic surfaces across the tropical barrier into the mid-latitude lower stratosphere, or ascend across the tropopause in to the middle and upper stratosphere with the Brewer-Dobson circulation. Processes in the TTL lead to dehydration of the air and cause changes in the isotopic composition. The air then rises within the tropical pipe, undergoing chemical change through photolysis and photochemical processes before being transported towards the poles, and finally downward again leading to, e.g., enhanced ozone concentrations near the winter pole. Current models tend to greatly underestimate the timescale of the process. Tracer studies are needed to understand the transport and mixing of the air between the tropics and the Polar Regions. Once in the polar regions, particularly the southern hemisphere winter stratosphere, the air again becomes isolated and subject to extreme cooling, leading to the formation of stratospheric clouds and the initiation of the heterogeneous chemistry, which subsequently leads to the almost complete removal of ozone from the lower stratosphere with the return of sunlight in early spring. This project concentrates on the measurement of species relevant to our understanding of these processes, both in the stratosphere and the mesosphere. To this end, both satellite and ground-based techniques are employed. The Odin satellite is central to the project, and the project covers all aspects of the satellite; from the spectroscopic analysis of the data, from the two instruments, to the interpretation of the results.

Past Performance

Methodology

With the launch of the Odin satellite in February 2001, two unique instruments were placed in orbit. The sub-mm radiometer (SMR) is the first microwave instrument in space to utilise these wavelengths for highly sensitive measurements of strato- and mesospheric trace gases. The OSIRIS optical spectrometer is the first instrument utilising, on a regular basis, scattered sunlight from the earth's limb, in order to obtain profiles of ozone and other gases. The infrared imager in OSIRIS has demonstrated the use of tomographic techniques to obtain increased horizontal resolution in limb geometry.

Apart from the traditional inversion, neural network techniques have been applied to real Odin spectra. Neural networks offer the opportunity to speed up the inversion by factors of 10 – 100, which is considerable, since the inversion of one day worth of data can take up to twelve hours using traditional inversion methods. The results are very promising.

Position within area

Donal Murtagh started his Odin-related research at MISU. Thus, his group at Chalmers is fairly new, but developing rapidly. They are, however, already very well integrated in the international field of satellite meteorology, and their work has already received much attention.

Particular achievements

The Antarctic winter of 2002, offered a unique opportunity for exciting science. For the first time since observations have been available, the southern polar vortex experienced a major wave number two stratospheric warming near the end of September. Prior to the warming, the ozone hole had begun to form — although at a lower rate than in earlier years, due to considerable planetary wave activity.

The sub-mm radiometer (SMR) was able to make exclusive observations of chlorine monoxide, indicative of the ongoing ozone destruction process and a result of the heterogeneous chemistry on the polar stratospheric cloud particles present, due to the low temperatures.

The influx of warm air raised the temperature above the threshold for PSC formation and stopped further ClO activation. Although enhanced values of ClO can be seen within the split vortex on 25 and 26 September, deactivation is virtually complete five days later. This seems to have occurred through both the chlorine nitrate and hydrochloric acid forming reactions, model comparisons suggest about equal contributions.

Particularly important in understanding the rate of chlorine deactivation were the measurements of HNO_3 by SMR, and NO_2, by OSIRIS. This investigation, currently being prepared for publication, clearly shows synergism between the two instruments and the unique ability of SMR to measure ClO.

Future

Project plans

Although much has been achieved, the Odin data set will be greatly enhanced in value, the greater the time period it covers, simply because the atmosphere provides new experimental conditions with each season. The data set will also be enhanced by improved processing algorithms. Scientifically, many of the studies are still in an early phase and will benefit greatly from the improved accuracy of the new data version.

The stratospheric data will be exploited to assess the ozone loss during all of the Arctic and Antarctic winters from 2002. Particular attention will be paid to the degree of chlorine activation and denitrification. There is some evidence that the diurnal cycle of ClO is not well understood at the higher temperatures often present in the northern hemisphere polar vortex. Models still have problems predicting the degree of ozone loss and NOy chemistry, and it is here that the new measurements can have the greatest impact.

In response to the Swedish National Space Board call for ideas in 2001, a proposal with the title “Stratosphere Troposphere Exchange and Climate Monitor (STEAM)” was submitted. This proposal was selected as the recommended next Swedish-led satellite. The main scientific goals of STEAM are to establish the influence of upper tropospheric and lower stratospheric water vapour and ozone on the climate system.

Balance between resources and goal

To remain competitive at the international level and to be able to fully exploit the valuable data, it is important to support Donal Murtagh and his group. Murtagh is clearly one of the leading scientists in his field in Sweden.

Comments on the Area

Position within Atmospheric Sciences

Murtagh's research is centred in the Middle Atmosphere, the region between the tropopause and the mesopause (10 to 85 km). This region is recognised to be especially sensible to anthropogenic changes (i.e., ozone hole).

Importance and future potential of the area

Now that Odin data cover a number of geophysically interesting periods, they are receiving international interest. At a recent Vintersol/Solve II meeting, much interest was expressed in Odin's measurements of the early chlorine activation and potential for quantifying the denitrification. The NASA teams working on SAGE III and future instruments for ozone profiling are extremely interested in the OSIRIS measurements.

STEAM would be an excellent follow-up satellite for Sweden. It could build on the knowledge of microwave sub-mm spectroscopy gained within the Odin project. Donal Murtagh and his group will play a central role in STEAM, developing the necessary analysis software, working with partners, particularly SMHI that will begin using global climate models and sees an important role for the type of data that STEAM will provide.

General Judgement

Donal Murtagh's research programme is considered *excellent – outstanding*, and the expert panel *most strongly recommends* that its funding be continued at the highest possible level.

Douglas Nilsson

Department of Meteorology, Stockholm University

Aerosol Source Processes Parameterised for Large-Scale Models

Summary of the Evaluated Research

The man-made aerosols are the most uncertain parts of the anthropogenic climate forcing through their direct influence on backscattering of solar radiation, and indirectly as cloud condensation nuclei (CCN). In recent years, aerosol codes in the climate models have become more detailed, and it has become clear that the calculation of the aerosol and CCN populations is sensitive to how the aerosol sources are represented. Part of the large uncertainty in aerosol and CCN calculations arises from the incomplete knowledge of aerosol source processes, magnitude, and distribution.

Three main aerosol sources are studied:

1. Combination of laboratory and *in situ* flux measurements to derive parameterisations for the *primary marine aerosol source*. A new source parameterisation has been derived for the sea salt component, and a main challenge is to derive a parameterisation for the large organic component. The parameterisations are applied in process and large-scale models, and to derive a global emission database based on satellite observations.
2. The *primary urban aerosol source* is also studied with direct *in situ* flux measurements to derive emission factors and parameterise the source (in terms of traffic activity and meteorological conditions) to be used in air quality and climate models.
3. For the *secondary aerosol sources*, the focus is on how nucleation can be predicted statistically on the monthly scale from solar radiation and synoptic weather, and on how the enhancement of nucleation by processes such as atmospheric waves and turbulence, boundary layer dynamics, and tropopause exchange can be parameterised for large-scale models.

Past Performance

Methodology
Douglas Nilsson combines *in situ* process oriented flux measurements, laboratory experiments, and process modelling and has an aim to improve the process parameterisations in large scale atmospheric models. This is quite innovative in its comprehensiveness. Also his approach to research and supervision is innovative and forward looking, based on networking rather than establishing a rigid group structure.

Position within area
His position in the field is important and growing. He has a strong publication record and publishes jointly with world-leading scientists.

Particular achievements
Douglas Nilsson has carried out the first direct flux measurements of the primary marine aerosol source, and he has also carried out early measurements of the urban primary aerosol flux.

Future

Project plans
The future plans include further characterisation of the primary aerosol emissions, including the chemical and physical characterisation from marine sources, urban sources, and tropical forests, and further to characterise secondary aerosol sources.

Balance between resources and goal
The goals are ambitious and Douglas Nilsson seems unusually well suited to pursue these goals. His current funding is not insignificant, but with such high ambitions there is obviously a gap between goals and resources. His host institution may also be in the position to reconsider the allocation of internal resources, in particular to the topics where Ph.D. student scholarships are granted.

Position within Atmospheric Sciences
The connected chain from the primary through the secondary sources of aerosols, determined on an experimental/observational basis; translated into pro-

cess formulations and parameterisations for use in atmospheric chemistry and climate models, is a high priority and underexplored part of meteorology.

Importance and future potential of the area

The area is of significant importance for climate change research, for aerosol and health research (with implications for technology, e.g., related to automobile engine- and exhaust systems) and for the understanding of deposition of particles to ecosystems (cf. the nitrogen cycle). The area is also an integral part of biogeochemical cycle analysis. The potential of the area is underexplored and of great significance.

General Judgement

Douglas Nilsson is judged *excellent – outstanding*, and the expert panel *strongly recommends* increased funding.

Kevin Noone

Department of Meteorology, Stockholm University

Sources and Origins of Atmospheric Cloud Droplets — GOME Aerosol, Aerosol/Cloud Remote Sensing

Summary of the Evaluated Research

The project Sources and Origins of Atmospheric Cloud Droplets (SOACeD) is funded by the Swedish Research Council. The overall aim of the project is to learn more about the processes that determine which aerosol particles in the atmosphere form cloud droplets, how aerosol/cloud interactions influence the chemical and microphysical transformations of both clouds and the atmospheric aerosol, and ultimately how both natural processes and anthropogenic activities influence cloud properties in the atmosphere. Better understanding of these aerosol/cloud interactions will allow us to more accurately understand and predict the effects of anthropogenic aerosol pollutants on climate and on atmospheric chemistry.

The approach to achieving these goals is to develop a sampling system by which the real-time composition and origin of individual droplets in atmospheric clouds is measured as a function of cloud droplet size, and to use the system to make these measurements in background continental clouds at a mountaintop site in central Sweden.

In the Swedish National Space Board funded project "Remote sensing of aerosols and clouds", the influence of cirrus clouds on the Earth's energy budget is investigated. This is one of the least understood aspects in climate research. Cirrus clouds can either warm or cool the Earth, depending on their optical thickness at different wavelengths. Optically thin ("subvisible") cirrus clouds are suspected to have an important effect on the Earth's infrared radiative balance, but these clouds have been difficult to detect from satellites. A combination of *in situ* data, calculations of the expected radiative properties of subvisible cirrus clouds, and satellite observations (using the SeaWIFS and Envisat satellites) are used to examine whether any systematic differences in radiative properties exist between areas inside and immediately adjacent to the North Atlantic flight corridor that can be attributed to "subvisible" cirrus clouds. The aim is to assess whether commercial air traffic influences the presence or character of these clouds. A second aim of the programme is to determine aerosol optical depth over land areas, and to combine retrievals of aerosol properties from recent satellite platforms (e.g., SeaWIFS, GOME, and Envisat) with *in situ* measurements. The aims are to understand the processes controlling the distributions and properties of aerosols, the relationships between aerosol and relative humidity fields, and ultimately the climatic effect of tropospheric aerosols.

Past Performance

Methodology

The methodology uses an integrated approach to the characterisation of atmospheric composition of gases, aerosols and clouds, based on remote sensing and *in situ* analytical techniques and process-level modelling. The process understanding is put to use to address important issues, such as cloud/climate interaction.

Position within area

Kevin Noone is particularly known for analysing the evolution of marine aerosols and marine stratocumulus clouds. Lately, he has become the leader of the atmospheric physics section at MISU, and he has managed to re-establish a good programme, bringing together the capabilities to do upper/middle atmosphere research (Jörg Gumbel and Jacek Stegman), aerosol/cloud interaction (which is his own field), and aerosol sources (Douglas Nilsson).

Particular achievements

Kevin Noone shows a particular capability in fostering a good research group towards common goals and attracting new people.

Future

Project plans

The group of Kevin Noone outlines a broad research programme — to investigate processes stretching from the Earth's surface to space, combining *in situ* and laboratory measurements with satellite and ground-based observations and model investigations. The changes in the atmospheric physics group between 2000 and 2003 have lead to a broadening of the focus to include tropospheric aerosol and cloud processes. The remote sensing capability of the group, which traditionally was strong and which now is being re-established, has a core group working on the Odin satellite data. There is a wish to expand the remote sensing aspect of the group to include expertise in the area of lidar, for looking at the vertical distribution of aerosols and clouds, and to more intimately couple atmospheric remote sensing to *in situ* measurements.

Balance between resources and goal
There is an imbalance between the resources and goals in many of the areas of the programme for the group, in particular in the process modelling part. The parts of the programme with the best chances to attract reasonable resources seem to be aerosol/cloud interaction and aerosol sources.

Comments on the Area

Position within Atmospheric Sciences
The broad programme of the group covers important and still underexplored areas of meteorology; such as the formation and distribution of different clouds, and how microphysical processes affect the macroscale cloud distribution and types.

Importance and future potential of the area
The area is very important for the understanding of climate change. Due to its significance, both for climate change and as an integral part of the biogeochemical cycling of trace species, this area is expected to grow in the years to come.

General Judgement

Kevin Noone is ranked as an *excellent* researcher and an *outstanding* leader, and the expert panel *strongly recommends* future funding.

Jan Pettersson

Department of Chemistry, Atmospheric Science, Göteborg University

Microphysics and Chemistry of Atmospheric Ice Particles

Summary of the Evaluated Research

A major challenge to the atmospheric science field is to develop and validate models of the microphysics of clouds and their interactions with aerosols. A second major challenge is to develop an understanding of the chemical effects of these clouds and aerosols. It is becoming increasingly clear that many of the problems to be solved require an understanding of processes on the molecular level. The Atmospheric Science Division at Göteborg University addresses some of these questions in the present research programme. Specific goals are to

1. Characterise key heterogeneous reactions taking place on the surface of solid and liquid aerosol particles;
2. understand the mechanisms for formation of new particles in the atmosphere based on molecular principles;
3. quantify important cloud droplet processes and develop methods to account for these processes in large-scale models, and develop methods for chemical analysis of aerosol particles.

The approach taken to achieve these goals is to perform laboratory studies of ice and aerosol particles using molecular beam techniques and advanced aerosol techniques, combined with computer simulations. The results from experiments and simulations are included in models for atmospheric chemistry and cloud formation. In addition, targeted field studies are performed to complement the laboratory work.

The Atmospheric Science Division at Göteborg University was formed in 2003 and currently consists of 21 scientists and Ph.D. students. A unifying research theme is the study of aerosols, and the activities range from fundamental studies of chemical reactions on the molecular level, to applied work including field studies of atmospheric processes.

Past Performance

Methodology

This group has made contributions to a wide range of problems through both innovative laboratory studies and sophisticated molecular dynamics calculations. Jan Pettersson has an excellent record of selecting important molecular scale problems to study, and in designing and carrying out appropriate explorations of these issues.

Position within area

Although the group is relatively young, its accomplishments are considerable and its goals are ambitious. The expert panel encourage them to strengthen their collaborations with other groups involved in basic research on related issues, and to increase the visibility of the group efforts by broadening the range of journals in which they publish their findings.

Particular achievements

Pettersson's group has made interesting theoretical and experimental studies of heterogeneous chemistry, using molecular dynamics calculations to simulate HCl uptake on the surfaces of ice particles at low temperatures, a process important in the stratosphere. Their work suggests a new pathway for the uptake, which might have implications for ozone chemistry. They have used a pulsed molecular beam technique to derive kinetic parameters for heterogeneous reactions of a number of important molecular species on ice. These parameters are necessary (and, up to now, poorly known) inputs in models of atmospheric chemistry. The work on water clusters has possible implications for ion induced nucleation of aerosol particles, thought to be an important process in some regions of the upper troposphere.

Future

Project plans

Pettersson plans to continue molecular scale studies of heterogeneous chemical reactions, looking at uptake on ice, liquid, and other surfaces, and studying particle formation through interactions of water clusters. The Pettersson group has an imaginative design for measurements of interactions of gas molecules with the liquid surface. If this is successful, it will provide truly unique information of interest to scientists in many fields. Moreover, they plan to use molecular dynamics simulation techniques to simulate homogeneous freezing of supercooled water and solutions, and even to build a three wavelength LIDAR instrument to monitor aerosols up to 15 km in the atmosphere. These plans are all individually quite valid, but as a whole they are also very ambitious. Pettersson will have to carefully guard against overextending the group efforts, particularly in view of the necessity for continuation of some of their more applied projects.

Balance between resources and goal

Jan Pettersson requests salary for an assistant professor and for some instrumentation constructions. These seem very reasonable requests, given the activity of this group.

Comments on the Area

Position within Atmospheric Sciences

Pettersson has published a number of articles in top physical chemistry journals. The panel notes that in the last year, however, most of the publications of the group have been in applied combustion journals, which must reflect the group's growing reliance on other sources of funds. The work of his group perhaps deserves more recognition within the atmospheric sciences community than it has received, and the panel encourages the group to publish in journals widely read by this community.

Importance and future potential of the area

Each of the topics that this group has studied is important in its own right. The work on water clusters and on molecular interactions at the liquid – vapour and ice – vapour interfaces connects the group with a very active area of current research. While most of Pettersson's projects are in the nature of basic research, their results have important implications for the atmosphere.

The group is involved in a number of studies of topics of great current interest in the physical chemistry community. This interest is likely to grow, in view of major recent developments in the experimental and theoretical investigations of the molecular nature of water, aqueous solutions and their interfaces. The results of the laboratory experiments and simulations will be very useful in studies of atmospheric chemistry, if the results are parameterised for atmospheric models.

General Judgement

This is a dynamic group and they occupy a rather unique position in the atmospheric chemistry community. Jan Pettersson is an outstanding scientific leader, and the expert panel rates the proposed projects *excellent – outstanding*. The panel *strongly recommends* increased future funding.

Henning Rodhe

Department of Meteorology, Stockholm University

Global Impacts of Atmospheric Aerosols

Summary of the Evaluated Research

The purpose of this project is to acquire an understanding of how aerosol particles influence the energy fluxes in the atmosphere and thereby the climate. This includes the study of sources, transport, transformation, and ultimately the deposition of the particles. The primary effect on climate of this type of pollutants is to increase the reflection of sunlight to space, leading to a cooling of surface temperature. Some particles, in particular those containing elemental carbon (soot), also absorb solar energy and therefore tend to increase the temperature of the atmosphere/surface system. The work has included both naturally occurring particles, during present and past climates, and man-made pollutants. The group has shown that variations of the former type of particles have contributed substantially to the temperature difference between ice age and present climate. Surprisingly large amounts of man-made aerosols were also found to originate from South Asia and to influence air quality and climate over large portions of the Indian Ocean.

Past Performance

Methodology

The methods that Henning Rodhe and his co-workers employ, include a large model that couples climate dynamics, biogeography, biogeochemistry, and aerosol transport processes, as well as involvement in major international field programmes.

Position within area

Rodhe is an internationally well-known scientist and a leader in the area of aerosol, cloud, and climate.

Particular achievements

The global dust and glacial cycle modelling study generated a number of publications; in particular, one published in JGR 1999, by Mahowald *et al.*, has been widely cited internationally. Their observational study based on INDOEX also results in many interesting publications.

Future

Project plans

Rodhe is Dean of the Faculty of Natural Sciences at Stockholm University. Even with this heavy administrative work, he is proposing to continue his observational work by participating in the Atmospheric Brown Cloud Experiment. However, he did not mention a continuation of his modelling work.

The panel feels that his process modelling work is very important and should be utilised to train young scientists in Sweden to continue and expand that line of work, so that Sweden can remain a major contributor in the aerosol, cloud, and climate research.

Balance between resources and goal

No funding request was made.

Comments on the Area

Position within Atmospheric Sciences

There is no doubt that Henning Rodhe is a highly respected scientist in the aerosol, cloud, and climate research. His international leadership and influence will remain for a long time.

Importance and future potential of the area

Aerosol and cloud are crucial issues in climate. Our ability for better climate prediction hinges on better understanding of how aerosol and cloud affect climate.

General Judgement

Rodhe's work on global dust and the glacial cycles is highly cited and leading the field. The expert panel ranks this work as *outstanding* research. No funding request was made for the next review cycle.

Ann-Sofi Smedman

Department of Earth Sciences, Meteorology, Uppsala University

Air – Sea Interaction — A Field Experiment in the Baltic Sea

Summary of the Evaluated Research

Analysis of data from the Östergarnsholm air – sea interaction project in the Baltic Sea has led to a new understanding of the marine atmospheric boundary layer (MABL). During unstable and neutral conditions, the turbulence structure is strongly influenced by the state of the sea. For growing sea, the MABL resembles the boundary layer, BL over land, but with the roughness length represented as a function of wave age. But as soon as some waves are travelling faster than the wind, i.e., for a mature sea or mixed sea, the characteristics of the MABL start to deviate from that of the BL over land, leading to a failure of the logarithmic wind law in neutral conditions. The stability parameter z/L is then a measure of the combined effects of stability and the surface waves, thus the drag coefficient becomes a function of two separate wave parameters. As the momentum flux during unstable conditions is strongly reduced due to upward transport of momentum by the long waves, the MABL shows strong similarity with the free-convection BL over land, but the source of turbulence is located at the top of the MABL, and turbulence is brought down by pressure fluctuations as “inactive turbulence”. There are also indications that turbulent statistics of temperature in the convective MABL do not scale with height. During stable stratifications, wave influences on the MABL are less evident. Instead, strong shear related to frequently occurring low-level wind maxima has been identified as an effective barrier for turbulent transfer, through a mechanism called “shear sheltering”.

Past Performance

Methodology

Ann-Sofi Smedman has used the Östergarnsholm field measurement station as the site of nearly all data collection. The strategy for data analysis from this site has emphasised a programme to challenge the assumptions, which underpin Monin Obukhov similarity theory, i.e., as it applies to the MABL.

Position within area

Smedman operates a unique air – sea interaction experimental site, which sustains her research programme. This particular site is the only one of its kind, i.e., it contains continuous observations of MABL turbulent fluxes at numerous levels, and there is a semi-permanent wave rider buoy within the upwind flux footprint and operated by the FMI. Many of the key air – sea interaction groups worldwide collaborate closely with Smedman, and the Östergarnsholm data have been used by numerous groups to validate new concepts (e.g., groups at Risö, NCAR, and the University of Miami).

Particular achievements

Smedman and group have demonstrated that low-frequency surface wave components produce a low-frequency upward momentum flux; thus, low-frequency waves have been quantitatively related to lower than average drag coefficients, as well as deviations of the wind profile from its classical form observed over land. The close interaction between low-frequency waves and marine surface layer turbulence has also been observed, e.g., producing significantly different values of the ratios of the vertical and horizontal wind turbulence variance ratios, as is observed over land; this also implies that the use of the dissipation method for inferring surface fluxes needs to be re-evaluated.

Future

Project plans

Ann-Sofi Smedman proposes to continue her work by analysing data collected during a major international field experiment, conducted during the past two years in collaboration with the University of Miami. She also intends to analyse existing and new data, in order to explore more sophisticated relationships between surface wave spectra and boundary layer turbulence.

Balance between resources and goal

Smedman requests a continued support to maintain the Östergarnsholm experimental station with continuous data collection. This request is reasonable, insofar as the data serve both Smedman and her international partners, and it further solidifies Smedman's international reputation in this field.

Comments on the Area

Position within Atmospheric Sciences

Air – sea interactions is recognised as a critically important component of the climate system, and air – sea interaction provides the science base behind many prediction systems involved in offshore energy research and coastal zone management. Since the existing theoretical base has major limitations in coastal domains, there is tremendous opportunity for scientific growth.

Importance and future potential of the area

Air – sea interaction has its underpinnings with Monin-Obukhov similarity theory. Unfortunately, this particular theory has nearly exhausted its scientific potential, and there is a great need to revise the theory based on the interaction between surface waves and surface layer turbulence. Stably stratified flow is also of high importance. Further research is needed to form a basis behind a next generation theory, and there is a critical need that atmospheric and oceanic prediction models adopt better parameterising of surface waves and fluxes based on new understanding.

General Judgement

Ann-Sofi Smedman's research provides a valuable contribution to our understanding of air – sea interaction and micrometeorology, based in most part on the analysis of field observations. The strength of her group is on the atmospheric side of the air – sea interface. In order to prepare for the science challenge to revolutionise similarity theory for next generation models (and customers), she is encouraged to strengthen her collaborations with experts in theoretical turbulence and wave dynamics. Smedman's work is rated *excellent* by the expert panel, and continued support is *strongly recommended*.

Jacek Stegman

Department of Meteorology, Stockholm University

Studies of the Middle Atmosphere

Summary of the Evaluated Research

The atmospheric physics group has a long tradition of research in aeronomy of the upper and middle atmosphere. This programme has been originally based on the use of sounding rockets, but more recently it also includes balloon- and satellite-based instruments. Complementary ground-based studies, carried out with the help of funding from the Swedish Research Council, have been an important part of this programme. The atmospheric physics groups' research programme has always contained a very strong experimental component aiming at the development of improved measuring techniques, both remote sensing and *in situ*, for applications from ground- and space-borne platforms. Spectroscopic techniques and aerodynamics of *in situ* measurements at supersonic speeds are the group's particular competence areas. Recently, theoretical modelling has become part of the programme. International co-operation has been an essential element. The long-term goals for MISU atmospheric physics programme are

1. to establish the distributions and properties of important trace gases, aerosols, and clouds in the atmosphere,
2. to obtain a better understanding of the dynamical physical and chemical processes that determine their geographical and temporal variations, and
3. to understand the interactions between electromagnetic radiation and the aerosols, clouds, and trace gases in the atmosphere.

Water vapour, odd oxygen, and condensed particles remain in the focus of the group's programme also in the near future. Especially the fate of water; its sources and sinks, and its possible connection to global change are of great current interest.

Past Performance

Methodology

Improve the understanding of the upper and middle atmosphere by observing the atmosphere by sounding rockets, and balloon- and satellite-based instruments. Recently, modelling efforts have been started to complement the experimental approach.

Position within area

The atmospheric physics group at MISU has a strong tradition and a long history in the observations of the middle atmosphere. Jacek Stegman has contributed significantly in the last decades to the strong reputation of this group.

Particular achievements

The ODIN satellite programme is an excellent example of a very important Swedish contribution to the remote sensing from satellites of the atmospheric composition. Excellent new data are now available on the distribution of O_3, NO_2, OClO, and BrO. The Hygrosonde rocket campaign has provided the scientific world with excellent data of the wind and water vapour distributions in the mesosphere and stratosphere. These data are very interesting for the study of the dynamics of the middle atmosphere, but also for the validation of the ODIN satellite.

The Magic rocket project is a new development, with very promising facilities to the observations of mesospheric aerosol distributions. The recent development of the STEAM satellite project is a very welcome and timely contribution to the study of atmospheric chemistry and climate coupling by observing the UTLS composition.

Future

Project plans

The scientific analysis of the ODIN satellite data is the first priority in the coming years. The further development of the STEAM project; from plans to the realisation and possible launch in four to five years, is also a huge challenge.

New sounding rockets are planned for the future. MAGIC will have a first launch possibility in 2005, and the preparation as well as the evaluation and interpretation of these data are quite challenging.

Balance between resources and goal

The ambitious plans require an extensive funding, and there should be a discussion on priorities and timelines of the planned activities also in view of the available human resources.

Comments on the Area

Position within Atmospheric Sciences

The observations made by the rockets and satellite instruments are very valuable and highly estimated contributions to the better understanding of the middle atmosphere.

Importance and future potential of the area

The middle atmosphere is important both for the ozone depletion, stratosphere – troposphere exchange and climate – chemistry coupling.

Atmospheric chemistry and climate coupling is a highly important topic for the future. The interaction between the troposphere and stratosphere is important on timescales of days to seasons and years. The planned observations will contribute to a better understanding.

General Judgement

Jacek Stegman plays an important and internationally recognised role in observing the middle atmosphere, and his contributions are judged *very good* by the expert panel. Support is *recommended*. It should be noted that the group has gone trough a transition period with two former leaders leaving the group, Georg Witt, through retirement, and Donal Murtagh, by taking up a chair at Chalmers. However, the group has recently been strengthened with quite competent and promising scientists. In view of this development of human resources, a prioritisation based on the new ideas and ambitions is needed. This process should lead to a further underpinning of the support. The amount of engineering support in relation to the goals deserves serious attention. Moreover, efforts to improve the co-operation and division of tasks between other Swedish groups working in comparable fields of research are *highly recommended*.

Johan Ström

Institute of Environmental Research, Air Pollution Laboratory,
Stockholm University

Atmospheric Particles

Summary of the Evaluated Research

The objective of the proposed project is to chemically characterise the aerosol particles that serve as ice-forming particles in the tropopause region. Many details about cirrus formation and evolution are still waiting to be disclosed, details necessary to assess the impact on high clouds by anthropogenic emissions of gases and aerosols. By combining a cloud sampling device with a mass spectrometer, Ström and his colleagues intend to address the question: What type of particles forms cirrus clouds, and under what ambient conditions do these particles become activated?

A suite of four aircraft measuring campaigns is scheduled from 2004 to 2007, in order to investigate physical, chemical, and optical properties of the tropospheric polar aerosol in the Arctic and in the Antarctica (TRIACAM). The operations will include several aircraft platforms for *in situ* observations, as well as satellite and lidar instruments for remote sensing, along with ground-based measurements for long-term observations of aerosol properties. An important component of the Arctic mission is to have concurrent measurements with the CALIPSO (space-borne LIDAR). An important component of the Antarctic mission is the vertical profile of non-volatile (refractory) aerosols that may be linked to non-soluble particles found in ice cores.

Past Performance

Methodology

Johan Ström and his colleagues have collected *in situ* data on atmospheric aerosols, cloud particles and gases from aircraft measurements. They have coupled their findings with imaginative models to develop testable hypotheses regarding particulate formation and life cycles. One of the major themes running through this work is assessment of the relative contributions of various sources to aerosols found in clouds in different atmospheric regimes. Ström's work is distinguished by excellent experimental design, rigorous data analysis, and the integration of data and models.

Position within area

Ström has an excellent reputation internationally, as evidenced by his many papers published in leading journals, his participation in international scientific committees, his editorships, and his invited talks at international meetings and workshops.

Particular achievements

Ström was among the first to find and analyse the widespread occurrence of small ice particles in the upper troposphere. He is unusual in the aerosol community in his attention to the dynamic context in which his measurements are made. His work in the INCA projects led to provocative hypotheses about the differences between Southern Hemisphere and Northern Hemisphere cirrus formation mechanisms, and he has been a leader in the debate on the influence of updraft velocity in cirrus cloud formation.

Future

Project plans

Johan Ström plans to continue his work on the formation of atmospheric ice particles. He and his colleagues are planning several aircraft campaigns in polar regions, for which they will develop a new cloud probe. They will attempt to identify and distinguish heterogeneous and homogeneous nucleation of ice, and, in the case of heterogeneous nucleation, to determine the chemical composition of the ice nuclei.

Balance between resources and goal

The resources are desperately needed for salaries, and some also for instrumentation development. Without these resources, the goals of this project cannot be met.

Comments on the Area

Position within Atmospheric Sciences

One of the most important missing pieces in our understanding of atmospheric clouds is the relationship between aerosols and ice clouds in the upper troposphere. These clouds are extremely sensitive to small changes in ambient conditions, including aerosol populations, and they play important roles in radiative balance. Prediction of the formation and properties of the clouds is therefore of paramount importance. Ström's observations and his imaginative analyses of these observations have already been and will continue to be very important in these studies.

Importance and future potential of the area

Upper tropospheric ice clouds play important roles in radiative climate and in troposphere – stratosphere exchange. The quantitative modelling of these clouds, however, is very difficult, and models vary considerably in their representation of the pathways leading to cirrus formation and maintenance. The data to be collected by the Ström group are absolutely central to the effort to reduce the uncertainties in these models.

Because of the sensitivity of cirrus clouds to ambient conditions, and their modulation of radiative fluxes in the atmosphere, accurate representation of the clouds in atmospheric circulation and climate models is both a major challenge and a major goal in studies of climate change. This field will continue to be at the centre of atmospheric research for the foreseeable future.

General Judgement

The expert panel considers this project *excellent – outstanding* and *strongly recommends* increased future support.

Gunilla Svensson

Department of Meteorology, Stockholm University

The Arctic Planetary Boundary Layer and Climate

Summary of the Evaluated Research

It is well recognised by the international scientific community that increased amounts of greenhouse gases in the atmosphere lead to a warmer climate. However, to determine the degree of future warming, there are still uncertainties and disagreements between model predictions. The scientific tools that are available are climate models, which project the future climate for different emission scenarios for the future, and there are widely different ways to represent some of the key processes in the various climate models. The general picture from the climate modelling community is that the Earth will warm somewhere within the range 1 – 4.5 °C by 2100 (IPCC); the corresponding interval for the Arctic (> 60°N) shows a much greater warming, i.e., 5 – 7 °C. The predicted spread in regional warming for the Arctic is clearly large, thus suggesting that climate models handle processes important for the Arctic differently. This project is aimed at understanding why the various climate models diverge, and to improve the important parameterisations so they represent the processes in the Arctic boundary layer more accurately. A large fraction of the intermodel spread among ocean – atmosphere coupled climate models for the Arctic lies in the representation of the sea-ice and the important ice/albedo feedback. The melting/freezing depends on the heat exchange and thus to a large extent on the boundary layer parameterisations. Currently used parameterisations are based on theories that were originally developed for weakly stably stratified conditions, but not for stronger stratifications or long-lived boundary layers when the surface fluxes may be the result of other than locally surface generated turbulence. A new turbulence model, which allows for inclusion of wave effects on the turbulent surface fluxes, was developed by Gunilla Svensson and collaborators. In order to assure that the proposed work proceeds efficiently, Svenssson

is also involved in an international regional climate model intercomparison project and boundary layer parameterisation inter-comparison study.

Past Performance

Methodology

Gunilla Svensson's scientific focus is on modelling turbulence and clouds within the planetary boundary layer (with a particular focus on both Arctic leads and coastal zones), with the long-range goal to improve the accuracy of regional Arctic climate models. Svensson justified the choice of this subject (mainly the Arctic part) based on climate model intercomparisons and sensitivity studies, i.e., where the community's confidence in climate models is strongly limited by a lack of understanding of the basic physics underpinning parameterisations of key processes and mechanisms, such as cloud drizzle and surface layer turbulence. It is on this basis that Svensson selected mixing length theory and cloud physics as strategically important research subjects to pursue during the upcoming years. Svensson has available a number of high quality models, which can be used to test new ideas and parameterisations, e.g., COAMPS.

During the past three years, Svensson has focused on extending surface layer turbulence theory for stratified surface layer flow by extending the mixing length parameterisation, in order to include information on potential temperature variance. This approach implies that internal gravity wave motions in the stable surface layer can become an important source of temperature variance. Svensson explored the practical application of the improved theory by hypothesising that Arctic leads can produce gravity waves in the atmospheric surface layer, due to a convective pulse in open leads. Preliminary modelling suggests that Arctic leads may form such gravity waves, although Arctic field observations are still lacking to confirm this hypothesis.

In addition to turbulence research, Svensson has performed model studies of boundary layer aerosols, clouds, and drizzle for the Arctic environment. Drizzle was specifically studied in terms of relationships to cloud evolution and impacts on boundary layer structure.

Position within area

Gunilla Svensson is a young researcher who developed the first part of her career in air quality modelling, validation and applications. More recently, she has explored fundamental physics and chemistry involved in boundary layer evolution, most notably focusing on cloud and aerosol processes. During the past few years, she has shown interest in revising surface layer turbulence theory for stably stratified flow. She has several early and important publications in mesoscale air pollution modelling, but she has not yet published cloud physics and turbulence results. Several papers are under review. She has become active as a contributor to climate assessments.

Particular achievements

Svensson has developed a revised mixing length theory, which considers contributions from potential temperature variance. The theory is not overly sophisticated and lacks validation against field observations.

In addition, Svensson has extended the chemistry of the COAMPS model to include sea salt transport and mixing, and she has confirmed from previous studies that drizzle is an extremely important process, governing the evolution of the boundary layer structure.

Future

Project plans

Svensson proposes to continue development of boundary layer models for the Arctic, with more emphasis placed on turbulence closure and the role of wave-turbulence interactions. Special effort is planned to be placed on evaluating the importance of tropospheric as well as boundary layer gravity waves on surface fluxes, through improved mixing length parameterisation. The COAMPS model will form the model framework behind the proposed work.

Balance between resources and goal

The goal and resources appear to be well balanced.

Comments on the Area

Position within Atmospheric Sciences

Boundary layer meteorology is a critically important subject, particularly for stably stratified conditions. The interaction between cloud physics, turbulence, and internal gravity waves, for stably stratified conditions, is on a major growth curve. There are many scientific challenges.

Importance and future potential of the area

The research area is of high importance. Stable boundary layers have been difficult to model, particularly due to the lack of a theoretical framework. Developing a new and much more sophisticated surface layer theory for stably stratified flows, will rely on a new representation of wave – turbulence interaction within a highly non-linear system. The early results of Svensson are based on a simple extension of the theory. A much more rigorous and sophisticated wave – turbulence theory will be needed in the future, in order to make significant progress.

General Judgement

Svensson's research is on a high priority topic in boundary layer meteorology, and she is relatively new to the field of turbulence theory. The work has lacked a rigorous treatment of wave – turbulence interaction, and there is also lacking a coherent research strategy, which addresses which types of models need to be employed to make progress; and which types of data are needed to validate hypotheses. She would benefit from closer interaction with the physical oceanography and theoretical turbulence communities. The expert panel rates the work of Gunilla Svensson *very good*, and continued support is *recommended*.

Erik Swietlicki

Division of Nuclear Physics, Physics Department, Lund Institute of Technology, Lund University

Water-Soluble Organic Compounds in the Atmospheric Aerosol — Effects on Cloud Droplet Formation, Hygroscopic Properties, and Climate

Summary of the Evaluated Research

The Swedish Research Council funded project "Climate-related aerosol research" (2002 – 2004) is focused on the climatic importance of biomass burning aerosols resulting from deforestation in the Amazon. The project aims at determining the hygroscopic and cloud-nucleating (CCN) properties of water-soluble organic compounds (WSOC) in the atmospheric aerosol, with an emphasis on those originating from biomass burning and oxidation products of biogenic gaseous precursors.

This research is part of an EU-funded 5FP project (LBA-SMOCC, 2002 – 2004, http://dionysos.mpch-mainz.mpg.de/smocc/home.htm), with Swietlicki as principal investigator. A field campaign was carried out within this EU-project in south-western Amazonia, Brazil, during the dry biomass-burning season in Sept – Nov, 2002. The measurements of dry aerosol particle size distributions (Differential Mobility Particle Sizer) and hygroscopic properties (Hygroscopic Tandem Differential Mobility Analyzer) were used to predict the concentrations of Cloud Condensation Nuclei (CCN), and the predicted concentrations agreed very well with those measured both with regard to temporal variability and absolute concentrations. The model used requires no additional aerosol chemical information, and it is therefore capable of predicting CCN concentrations with a very high time resolution (minutes).

Within the same EU-project, measurements of the hygroscopic and cloud-nucleating (CCN) properties were also performed in the laboratory on aerosol particles, consisting of both inorganic and organic compounds and mixtures thereof. The mixtures were chosen in such a way that they are suitable as simplified model mixtures representing various types of aerosols (e.g., biomass burning influence, European continental polluted air mass influenced by biomass burning, and polluted marine). During the last year of the EU-project and the Swedish Research Council project (2004), the aerosol chemical composition measured by other partners during the field campaign, including water soluble organic species, will be used for yet another CCN closure study, based on the aerosol chemistry and the laboratory experiments.

If successful, suitable model compounds and mixtures can be used to deduce the CCN properties of water soluble organic species, thus circumventing the problems of performing detailed organic aerosol speciation, as well as the lack of thermodynamic models treating organic-inorganic mixtures. It is the intention in the EU-project that both these CCN models, describing the activation of aerosol particles into cloud droplets, will be implemented in detailed cloud microphysics model and, following suitable parameterisations, also into global climate models. They will thus form a vital and validated link for predictions of the impact of human activities on global climate.

Past Performance

Methodology

The Lund group has brought unique instrumental and analytical techniques to the atmospheric aerosol research. A recent example is the H-TDMA (Hygroscopic Tandem Differential Mobility Analyser), which is not commercially available and was designed, constructed, and calibrated in Lund. This is an important contribution to aerosol research. It measures the hygroscopic properties of aerosol particles for atmospheric as well as laboratory aerosols.

Position within area

Erik Swietlicki is an active and productive scientist with a strong name internationally. He has a particular strength in measurement technology of aerosols. Furthermore, he has important roles both in national and international aerosol research.

Particular achievements

Swietlicki has organised a broad research agenda under the heading Scientific basis for policy-making, and he is a leading figure in several important research networks. Emphasis has been on the characterisation of the hygroscopic and cloud-nucleating (CCN) properties of water-soluble including organic compounds based on observational, laboratory experimental and theoretical data.

Future

Project plans

Future plans are associated with international projects that are pending in the application phase. Included here are plans for the development and evaluation of parameterisations for the thermodynamics of atmospheric aerosols containing mixtures of inorganic and organic compounds, in particular laboratory studies of the behaviour of representative organic-containing atmospheric aerosol systems. Other plans are to carry out *in situ* observations of aerosols at a rural site, in order to characterise the evolution of the aerosols, to address Arctic aerosol formation processes, and also to study lung deposition of various aerosols.

Balance between resources and goal

The resource situation in Lund is particularly difficult and requires Swietlicki to be strongly market oriented and demand driven. A reasonable pressure to be competitive and demand driven is fine, but the Lund group seems to be beyond this limit. There are few resources available locally, even for his own research salary.

Comments on the Area

Position within Atmospheric Sciences

The area is on the boundary of traditional meteorology, and it is as such not thoroughly explored.

Importance and future potential of the area

The research topics addressed are important for several key environmental issues related to meteorology, e.g., particles and human health, climate change and deposition to ecosystems. The characterisation of the role of aerosols is a key uncertainty in the technical underpinning of these issues.

This area will attract considerable interest over the next years due to the need for a better knowledge base to improve the diagnostic and predictive capability related to the role of aerosols in climate change and in health – aerosol interaction.

General Judgement

Erik Swietlicki is a leader in his field and is rated as *excellent* in his scientific achievements related to meteorology, and as an outstanding organiser of research. The expert panel *strongly recommends* funding at an increased level.

Michael Tjernström

Department of Meteorology, Stockholm University

Hydro-Meteorological Processes – Arctic Projects

Summary of the Evaluated Research

The climate of the Arctic is poorly known and our understanding of its relationships to the global climate and to man-made climate change is therefore limited. Important local feedback processes are also incompletely understood. To a large extent, this is due to insufficient observations, relevant to both long-term climate observations and detailed process studies. As a consequence, this also leads to unreliable simulations of regional climate change. For example, although models today show a common Arctic warming enhancement relative to the rest of the planet, the exact representation ranges of Arctic temperature change show a huge range of uncertainty, i.e., model projections range from 1.5 to almost 4.5 times the global-average warming over the next 100-year period. Such a large range of uncertainty demands attention to the basic processes underpinning climate change. The models also predict a large range of future sea-ice coverage, i.e., some models predict very little future change in sea-ice coverage by 2100, while other models predict Arctic ice-free conditions during summer.

One problem in model prediction is the representation of ocean/ice/atmosphere interaction processes (driven by the coupling between the atmospheric and oceanic boundary layers), and preliminary results from ARCMIP also reveal errors in the heat budget amongst several state-of-the-art models that often is as large as the observed net energy balance itself. It is clear that important feedback processes are poorly described in currently used climate models. Because of their importance to climate predictability, the focus of this project is on the boundary-layer structure and low-level clouds, and their coupling with surface processes.

The sea-ice cover has a pronounced effect on the planetary boundary layer PBL structure, in winter by isolating the atmosphere from the relatively warm ocean, making persistent strong static stability possible, and in summer by regulating the PBL conditions by an almost infinite latent heat source caused by melting. In AOE – 2001, the summer PBL and the formation of Arctic stratus clouds were targeted. In contrast to other areas with persistent climatological stratus-cover, these clouds have a warming effect in the Arctic, but their radiative properties are distinctly different from stratus clouds observed over the open blue oceans. The interplay between aerosol production, turbulent transport, and radiation is poorly understood and constitute a major potential feedback mechanism. ARCMIP takes a broader view and aims at directly improving modelling capability, in particular for very stable conditions during winter, utilising the one-year SHEBA data.

Past Performance

Methodology

Michael Tjernström has a long history of developing mesoscale models, which can be applied to coastal and inhomogeneous environments. During the past decade, he expanded his programme to include air chemistry and aerosols, and more recently, he has further developed his modelling research with particular reference to the Arctic. Complementing his modelling interests, he has also made exemplary strides forward in leading measurement programmes, most notably as part of the field campaigns in AOE – 2001. This interest in combining modelling and measurements within his research programme has had immediate benefits in maximising scientific productivity with existing resources.

Modelling the Arctic atmosphere is a complicated task, thus requiring close collaboration among a multidisciplinary set of scientists. Tjernström has developed effective collaborations with a number of Swedish universities (e.g., Lund and Uppsala), European laboratories, and US institutions. His international network is well recognised, and it has helped secure an excellent Swedish reputation in Arctic atmospheric sciences.

Position within area

Tjernström has produced a series of excellent publications in mesoscale meteorology, using a combination of state-of-the-art models and dedicated measurements. He is presently the leading mesoscale modeller in Sweden and well recognised internationally. He has a high publication output, many in excellent journals. More recently, he must be acknowledged with a visionary approach to combine modelling and measurement programmes, as a means to increase the efficiency of scientific output.

Particular achievements

Tjernström's most recent accomplishments include advanced subgrid scale closure methods for non-hydrostatic mesoscale models, with application to coastal regions. Inclusion of aerosol and cloud physics has made this capability noteworthy in the international community. The model system has been developed with close collaborations with US scientists, most notably NRL, and a number of US and European collaborators. Some major questions documented as a consequence of model simulations and comparison to field observations include: explaining the dynamical trigger behind fog formation in the Arctic; explaining the lack of CCN in the Arctic; determining the formation mechanisms and importance of biogenic aerosols to the Arctic aerosol budget; and improving surface flux and subgrid turbulence parameterisations for use in much finer resolution in Arctic meteorological models. An emerging issue challenging Tjernström is determining the role of advection on high-resolution dynamics and chemistry. While these questions will determine Tjernström's future research strategy, they will also frame the research strategy for many international meteorological research activities dedicated to the Arctic.

Future

Project plans

Tjernström proposes to explore answers to the scientific questions outlined in the previous section, as a means to produce a science base over the next few years, in preparation for the International Polar Year (in 2007/08). In particular, this will involve investigations of the coupling between dynamics and chemistry in the Arctic boundary layer, and addressing the flux and closure physics under highly advective conditions.

Balance between resources and goal

In addition to attention given to model development, adequate resources must be dedicated to field measurements in order to support any rational science gain. In addition, the expert panel recommends that MISU provides institutional commitment and support where possible.

Position within Atmospheric Sciences

Mesoscale meteorology is an essential component of regional atmospheric and climate modelling. Tjernström has secured an important niche within the Swedish community, as the leading mesoscale modeller in the country.

Importance and future potential of the area

The combination of dynamics and chemistry in mesoscale modelling is an area of high importance. Much of the progress attained in mesoscale modelling is likely to improve the international community's ability to predict future climate conditions, both in the Arctic and in other regions.

This field is in rapid growth, with efforts to extend the understanding of the organic aerosol production, aerosol transformation, CCN production, and cloud processing. This is a challenging field, and it is essential to the development of more accurate climate predictions.

General Judgement

The work of Tjernström provides a much needed balance between modelling and observations, with tremendous growth potential. The expert panel rates his work *excellent*, and continued support is *strongly recommended*.

Sergej Zilitinkevich

Department of Earth Sciences, Uppsala University

Wave-Turbulence Meso-Scale Dynamics over Complex Terrain — Modelling, Observation, and Parametrisation

Summary of the Evaluated Research

The group has developed a new model for long-lived SBLs. These are SBLs immediately connected with the stably stratified free atmosphere, and therefore affected by internal wave interaction between the two stable layers (these SBLs differ from ordinary nocturnal SBLs, and are probably similar to the stably stratified upper mixed layers in the ocean). In these SBLs, the surface layer turbulence is essentially non-local. It is not described by the traditional theories (the Monin-Obukhov similarity theory or local turbulence closures). Instead, a new surface-layer parameterisation is recommended. On this basis, an advanced formulation for the SBL thickness (accounting for the generally non-local nature of the SBL) has been developed and validated against data.

A mesoscale numerical model is also used to study the ABL response to non-linear orographic forcing with Coriolis effect, f, over a mountain with its length comparable to the Rossby radius of deformation, LR, in the north-south direction. The orographic wave breaking occurring for Froude number $Fr<1$, affected by Coriolis force $f>0$, intensifies on the northern flank for westerly flows, as also found in other recent studies. Firstly, a cumulative effect occurs as the Coriolis force lifts the northern ABL top and generates a stronger low-level jet than on the southern side. Secondly, a differential layering appears in the turbulent kinetic energy, TKE, and specific humidity. The humidity is higher in the lowest southern ABL than in the related northern ABL and vice versa; the higher values of the TKE and humidity are in the upper northern ABL.

Past Performance

Methodology

Zilitinkevich has focused most of his recent career on extending similarity theory for stably stratified boundary layers. This has been a challenging theoretical problem, insofar as it requires dynamical coupling between internal gravity waves and highly stratified yet intermittent surface layer turbulence. For the past few years, Zilitinkevich has emphasised coupling between a layered boundary layer, i.e., where the presence of propagating gravity waves in one layer can influence the turbulence structure in another. Complementing his theoretical work, he has also used the Uppsala mesoscale model (LES) to test new concepts, particularly in environments governed by complex topography. There has been little effort to validate new theoretical concepts and more advanced models with new data; in most part, Zilitinkevich has used historical data sets to validate new concepts.

Position within area

Zilitinkevich is well known in the micrometeorology and boundary layer meteorology community. In his early career, he developed many of the concepts in surface layer theory, and he has extended the similarity paradigm throughout this career, in order to consider various degrees of inhomogeneity and the interactions between inner and outer layer coupling. Of special interest, he has extended the similarity paradigm to address coupling between internal non-linear waves and boundary layer turbulence with application to complex surface topography.

Particular achievements

Zilitinkevich has produced a sophisticated boundary layer similarity theory, which considers layers within the planetary boundary layer, and interaction between internal gravity waves and surface layer turbulence and fluxes. The theoretical developments represent a further refinement of the classical similarity paradigm, which has been applied to the atmospheric boundary layer.

Future

Project plans

Zilitinkevich has recently retired. He has no future project plans.

Balance between resources and goal
There are no requests.

Comments on the Area

Position within Atmospheric Sciences
Sergej Zilitinkevich is acknowledged as one of the fathers of classical boundary layer similarity theory, which has been applied to meteorology.

Importance and future potential of the area
Until the recent availability of the necessary computer power to address some of the past open challenges in wave – turbulence interaction, similarity theory was a very high priority in the scientific community. It has more recently declined in research importance, i.e., with the emergence of computer power to tackle many high resolution turbulence issues.

It is expected that similarity theory will make its next advances by shifting to research that focuses on high resolution three-dimensional turbulence interaction with non-linear internal and surface gravity waves (or inhomogeneously spaced surface roughness). This can proceed with less emphasis on extending the classical similarity paradigm (as has been done during recent years by Zilitinkevich), and placing more emphasis on numerical techniques applied to first principle fluid dynamics, e.g., with the use of visualisation techniques and sophisticated new validation technologies, to be applied to coupled models, e.g., where direct numerical simulation and large eddy simulations are combined.

General Judgement

Sergej Zilitinkevich did not provide the expert panel with any oral presentation. However, given the written material, which he submitted, the panel is in agreement that he has had a remarkable scientific career and must be acknowledged for his contributions. His research during the last three years of his Swedish Research Council support is rated *very good – excellent*. There was no request for further support.

Acknowledgements

On behalf of the Swedish Research Council and the Swedish National Space Board, we would hereby like to express our sincere gratitude to the international members of the expert panel. We are very much aware of the fact that the expert panel has devoted considerable time to the task of making fair assessments of the grant holders' research, their research groups, and their projects under evaluation. Our sincere thanks to the expert panel also for its efforts to thoroughly prepare for the evaluation process prior to its travel to Stockholm, as well as for the very intensive week at the Swedish Research Council. It was only through the collective expertise, the dedicated hard work, and the integrity of the panel that this evaluation of Meteorology in Sweden could be performed. We are confident that this report will aid in further development of Atmospheric Sciences research in Sweden.

We would also like to thank the scientists under review for all their hard work bringing together required research projects material, which constituted the reference base for the evaluation process, as well as for their good spirits during presentations and interviews.

Last but not least, we would like to express our thanks for all the technical and secretarial assistance provided by the Swedish Research Council staff members at all stages of the evaluation process. Our special gratitude goes to Gun Malmberg, Marie Rasck, and Sven Larsson Östergren.

Stockholm, May 17, 2004

Leif Anderson
Göteborg University
Chair

Jonas Björck
The Swedish Research Council
Secretary

Lennart Nordh
The Swedish National Space Board
Rapporteur

Maria Nilsson
The Swedish National Space Board
Rapporteur

Appendix 1
Background of the Experts

Professor Marcia Bourgin Baker

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Born in the United States, in 1938;

B.A. (Physics), Cornell University, Ithaca, New York (1959); M.S. (Physics), Stanford University, Stanford, California (1960); Ph.D. (Physics), University of Washington, Seattle, Washington (1971).

Employment History:
Research Associate, Civil Engineering and Geophysics, University of Washington (1971 – 1979); Research Assistant Professor, Civil Engineering and Geophysics, University of Washington (1976 – 1980); Associate Professor, Civil Engineering, Geophysics and Atmospheric Sciences, University of Washington (1980 – 1988); Professor, Geophysics and Atmospheric Sciences, University of Washington (1988 – present).

Special Assignments:
Royal Meteorological Society (Fellow), American Meteorological Society (Fellow), and American Geophysical Union (Member).

Dr. Gerald L. Geernaert

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Born in the United States, in 1954;

B.S., University of California, Davis (1977); Ph.D., Atmospheric Sciences, University of Washington, Seattle, Washington (1983).

Employment History:

- Director, IGPP, LANL, Los Alamos, NM, USA (2002 – present).
- Director, Atmospheric Environment Department, National Environmental Research Institute, Denmark (1994 – 2002).
- Programme Manager, Atmospheric Sciences, Office of Naval Research, Arlington, VA, USA (1990 – 1994).
- Staff Scientist (Atmospheric Sciences and Remote Sensing), Naval Research Laboratory, Washington DC (1985 – 1990).
- National Research Council Postdoc, US Naval Postgraduate School, Monterey, CA, USA (1983 – 1985).

Selected Special Assignments and Accomplishments:

- Assoc. Editor, Boundary Layer Meteorology Journal (1995 – present).
- Assoc. Editor, Environmental Sciences Library, Kluwer (1995 – present).
- Programme Manager, LANL Environmental Sciences, US Department of Energy (2002 – present).
- Member, LANL Strategy Team for R&D (2003 – 2006).
- Adjunct Professor, Scripps Institution of Oceanography (1990 – present).
- Adjunct Faculty (Geosciences Lecturer), University of Copenhagen (1999 – 2001).
- President, Danish Atmospheric Research Society (1997 – 2002); Member, Nordic Council of Ministers, Hav-og-luft gruppe (1994 – 2002).

- Member, various WHO, WMO advisory panels (1996 – present).
- Member, various AMS committees (1988 – present).
- Organiser of various international workshops and meetings.
- Publications (approx. 100 journal articles and reports; Editor of four books).

Professor Øystein Hov

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Born in Norway, in 1950;

Cand. Real. (Meteorology), University of Oslo (1975); Dr. Philos, University of Oslo (1982).

Employment History:
Research Associate, University of Oslo (1973 – 1981); Research Scientist, later Senior Scientist and Group Leader, Norwegian Institute for Air Research (NILU) (1981 – 1989), Professor of Meteorology, University of Bergen (1989 – 1996); Adjunct Director of Research at Nansen Environmental and Remote Sensing Centre in Bergen (1990 – 1996); Adjunct Professor of Meteorology, University of Bergen (1996 – 1998); Director of NILU (1996 – 2003); Head of Climate Division, Norwegian Meteorological Institute, since 2003.

Some International Assignments:
Member of the Commission for Atmospheric Chemistry, International Union of Pure and Applied Chemistry (IUPAC), since 1986; Norwegian Delegate to the Steering Committee of COST 611 "Physico-chemical Behaviour of Atmospheric pollutants", a programme of the Commission for the European Communities (1981 – 1991); Chairman of COST 611 Task Force on "Photo-oxidants — Precursor Relationships in Europe" (1985 – 1986); Chairman of COST 611 Task Force on "Acid Deposition in Europe" (1986 – 1987); Project Leader of COST 611 (1987 – 1993); Member of the EC/EFTA Task Force on Stratospheric Ozone (1988 – 2003); Chairman, Science Advisory Panel of Atmospheric

Chemistry, Commission of the European Communities (1992 – 2003); Member, Science Advisory Panel in Atmospheric Research, Commission of the European Communities, (2003 –); Member of the UK Photochemical Ozone Review Group (PORG) (1991 – 1996); Member of the steering committees of the Eurotrac projects TOR and BIATEX (1991 – 1995); Member of the Expert Group on Climate, Nordic Council of Ministers Environmental Project (1991 – 1997); Member of Luftvårdskommittén, Swedish Environmental Protection Agency, SNV, Stockholm (1992 – 1993); Member of the Board, C.N.R. Istituto Inquinamento Atmosferico, Rome (1992 – 1995); Member of the International Ozone Commission, International Association of Meteorologie and Atmospheric Physics (IUGG), (1992 – 2000); Member of SCAR Working Group on Physics and Chemistry of the Atmosphere (1992 – 1996); Member, Scientific Steering Committee of EUROTRAC 2 (1996 – 2003); Associate Editor, Journal of "Geophysical Research — Atmospheres" (1997 – 1998), Member of the Editorial Board Tellus B, (1996 –); Chairman, WMO Commission on Atmospheric Sciences' Working Group on Atmospheric Chemistry and Environmental Pollution (1998 –); Member of the Expert Advisory Group, Key Action Global Change, Climate and Biodiversity, 5th Framework Programme, EU Commission (1999 – 2002); Chairman of the Expert Group for The Ocean and the Atmosphere, Nordic Council of Ministers, (2000 –); Member of NERC (UK) Science and Innovation Strategy Board (2002 –); Member of the International Scientific Advisory Board of the Centre of Excellence in Environmental Analysis and Monitoring, Technical University of Gdansk, Poland (2002 –); Member of the Steering Committee for Nordic Centre of Excellence on Biosphere — Atmosphere Exchange of Particulate Matter (2003 –); Member of the Steering Committee for Network of Excellence on Atmospheric Composition Change (ACCENT) (6th Framework Programme for Research in the EU).

Prof. Dr. Hennie Kelder

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Born in the Netherlands, in 1944.

Special Assignments:
Member of the International Ozone Commission; Co-ordinator of KNMI contributions to several EU Environment & Climate projects, and Principle Investigator, EU projects SODA and GOA; Leader of Dutch Projects on Ozone Satellite Data Modelling: Ozone Retrieval Algorithms Developments, Chemical Data Assimilation, and Tropical research supported by the Netherlands Board for Remote Sensing, the Dutch Foundation for Space Research, and by Dutch Science Foundation; Member of the Steering Group for Eur-mets at Ozone Satellite Application Facility; Member of the Sciamachy Science Advisory Group; Chairman, Sciamachy Validation Group; Principle Investigator, Strateole/Vorcore project; Member, WMO/UNEP Ozone Research Managers Committee; Member, OMI Science Advisory Group; Leading Author, IPCC/ UNEP Report "Aviation and the Global Atmosphere"; Leading Author, EU Assessment Report on Chemistry — Climate Interaction; Thesis Supervisor of eight Ph.D. students; Member of Theses Committees at different European Universities; Member, the Steering Group for TROPOSAT; Member, WMO/ IGACO Committee; Member of the EU Vintersol Core Group; Member of the Review Board of the Institute for Atmospheric Physics of the DLR in Germany, in 1998 and 2003; Member of the Review Board of the Physics, Meteorology and Astronomy Department at the University of Graz, in 2002; Member, Executive Committee of the European Physical Society; Lecturer at schools on

Atmospheric Physics and Chemistry; Professeur Invité du CNRS, ENS, Lab Meteorologie Dynamique, Paris.

Scientific/Technological Activities and Interests:
Impact of aircraft emissions upon atmospheric composition and climate; Stratosphere — Troposphere Exchange; Remote Sensing of the atmospheric composition from satellites; Chemical Data Assimilation; Chemistry — Climate Interactions; and Tropical Dynamics.

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Born in Germany, in 1935;

Ph.D., Institute for Meteorology, Free University Berlin (1962); Senior Research Fellow, Free University Berlin (1958 – 1963); Visiting Scientist to NCAR, Boulder CO, USA (1963 – 65; 1970 – 72); Head of Stratospheric Research Group, Institute for Meteorology, FU Berlin (1965 – 2002); Professor (since 1972); Affiliate Scientist to NCAR (1988 – 2001).

Special Assignments:
Vice-Chairman of the International Steering Committee for MAP (Middle Atmosphere Programme, SCOSTEP) (1978 – 1989); WMO Rapporteur for MAP, STEP, and STRATALERT (since 1980); National Representative to SCOSTEP (1980 – present); Vice-President of IAMAS (IAMAS/ICSU) (1987 – 1995); Vice-President of the EGS (European Geophysical Society) 1989 – 1993; Dean of Faculty of Geoscience (1989 – 1997); President of the German Meteorological Society (1991 – 1995); Member of the German Advisory Council on Global Change (WBGU) (1992 – 1996); Elected to Academia Europaea (1999); Referee for several international scientific journals.

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Born in Taiwan, in 1950;

B.S., Atmospheric Physics, National Central University of Taiwan (1972);
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Ph.D., Atmospheric Sciences, University of California, Los Angeles (1979).

Employment History:
Senior Scientist, NCAR, Boulder (1995 – present); Visiting Faculty, Department of Atmospheric Science, Colorado State University (CSU), Fort Collins, CO (1994); Scientist III, NCAR, Boulder (1987 – 1995); Scientist II, NCAR, Boulder (1982 – 1987); Senior Mathematics Analyst, GSFC/NASA, Greenbelt, MD (1979 – 1982).

Special Assignments:
Member, AMS Meteorological Aspects of Air Pollution Committee (2002 – present); Editor, Journal of Terrestrial, Atmospheric and Oceanic Sciences (2002 – present); Member, GCSS Boundary Layer Cloud Working Group (1993 – present); Affiliate Faculty, Department of Atmospheric Science, CSU (1990 – present); Editor, Journal of the Atmospheric Sciences (2000 – 2003); Lecturer, ISIATA-III Summer School on Turbulence and Air Pollution Modelling, Castra Marina, Italy (2001); Chair, NCAR Geophysical Turbulence Programme (1995 – 1996); Associate Editor, Journal of the Atmospheric Sciences (1992 – 1999); Member, NCAR Climate System Modelling Advisory Committee (1992 – 1994); Member, AMS Boundary Layers and Turbulence Committee (1988 – 1992); Organiser of numerous workshops and meetings.

Appendix 2
Evaluation of Research Projects

Evaluation of Research Projects Supported by the Swedish Research Council and the Swedish National Space Board

Meteorology

1. Introduction

As from January 1, 2001, the Swedish Research Council (VR) took over the activities previously pursued by the Swedish Council for Planning and Co-ordination of Research (FRN), the Swedish Council for Research in the Humanities and Social Sciences (HSFR), the Swedish Medical Research Council (MFR), the Swedish Natural Science Research Council (NFR), and the Swedish Research Council for Engineering Sciences (TFR). There are three scientific councils within the Swedish Research Council: one for humanities and the social sciences, one for medicine, and one for the natural and engineering sciences. There is also a Committee for Educational Research. The Swedish Research Council is an agency under the auspices of the Ministry of Education and Science. The main objective of the Swedish Research Council is to support basic research of high quality in an inter-national comparison, in all fields of science.

The Swedish National Space Board (SNSB) is a central government agency under the Ministry for Industry, Employment, and Communications. The Swedish National Space Board is responsible for national and international activities relating to space and remote sensing, primarily research and development. The Swedish space programme is carried out by means of extensive international co-operation, in particular through Sweden's membership of the European Space Agency, ESA. The Swedish National Space Board functions as a research council for basic research, using instruments on space-borne platforms. Among the currently supported scientific areas financed through the Ministry of Education and Science are Atmospheric Physics and Remote Sensing/Earth Observations. The Swedish National Space Board has two scientific advisory committees, one for Space Science and one for Earth Observations.

In accordance with its Statutes, as laid down by the Government, the Swedish Research Council and the Swedish National Space Board evaluate the research, to which it has given financial support. A joint evaluation by the main funding agencies is natural, since the ground-based and space-based atmospheric and remote sensing research fields are scientifically linked and sometimes involve one and the same research group.

For each scientific field, a panel of experts is given the task of carrying out the evaluation. None of the experts are in any way involved in the projects under review. The expert panel is composed of scientists from abroad, who are able to judge the research projects in an international perspective without being influenced by considerations on a national level. The composition of the panel is based on suggestions from the grant holders who are to be evaluated. The Swedish Research Council and the Swedish National Space Board attach considerable weight to the advice given by such foreign experts and are most grateful for the positive response with which invitations to serve on the expert panel have been met.

The purpose of the evaluation is to provide the Swedish Research Council and the Swedish National Space Board with independent comments and findings regarding the scientific quality of the supported research projects, seen in an international context. The projects are thus the main elements entering into the evaluation. However, the expert panel is encouraged to comment also on structural matters. The evaluation should be forward-looking where possible, and the reports are important elements in future priority considerations.

The present document describes the evaluation and the general framework for its execution.

2. Organisation of the Work and Other Procedural Matters

The Scientific Council for Natural and Engineering Sciences appoints the Swedish rapporteur of the expert panel, as well as a research officer from the Swedish Research Council as secretary to the panel. Research officers, appointed by the Director General of the Board, will represent the Swedish National Space Board.

The international expert panel itself decides on the distribution of work among its members. The written report is produced at a stage of the process where the panel is assembled; performing interviews with the grant holders. (*Conf. points 3 and 4 below.*)

3. Collection and Distribution of Basic Documentation

Each research project or research programme supported by the Swedish Research Council or The National Space Board has a principal grant holder who is responsible for the project or the programme. These grant holders are requested by the secretariat to submit scientific reports and other documentation on which the evaluation shall be based. Points 3.1 – 3.8 below describe what is normally asked for in such a request. Of course, details may change, depending on the subject, etc.

3.1 A financial overview listing the support granted from the Swedish Research Council, including the former Swedish Natural Science Research Council (NFR), the Research Council for Engineering Sciences (TFR), and the Swedish National Space Board during the last five fiscal years, as well as support from other organisations granted in 1999, 2000, 2001, 2002, and 2003.

3.2 A list of personnel involved in the project comprising research staff, graduate students, support staff, and visiting scientists. Information on overhead costs is also included.

3.3 A summary of dissertations within the project during the last five years.

3.4 A brief description of ongoing co-operation with other research groups in formal research projects, EU-networks, etc.

3.5 A summary of the research.

3.6 A brief description concerning objectives and methods for the most recently submitted grant proposal.

3.7 A summary of the main results for the project/projects under evaluation.

3.8 Future plans.

4. Interviews

The written overviews serve as a background to the interviews. The interview starts with a short presentation by the grant holder under review, followed by a short interview and discussion between the expert panel and the grant holder. The expert panel then has a short meeting after each interview, in order to summarise and write a short report on the quality of the research performed by each grant holder.

5. Aspects to be Covered by an Evaluation

The documentation (point 3), the presentations, and the outcome of the interviews (point 4) together form the basis of the evaluation. Points 5.1 – 5.7 below list the aspects or questions, which one would like to see addressed by the panel, when reviewing individual projects. Experiences from reviews performed by the former Research Councils show great advantages with this scheme. However, each panel is free to modify the scheme when necessary.

5.1 The scientific quality of the results obtained.

5.2 The scientific value of proposed projects (including the question of possible improvements by changing the aim and direction of the project).

5.3 The merits of the methods used and proposed.

5.4 The capability of the project leader and the staff (including issues such as size and composition of the group).

5.5 The adequacy of existing and proposed research positions, facilities, and equipment.

5.6 Other considerations or viewpoints, which may be of importance for the projects or the programmes.

5.7 The question of increased, unchanged, decreased, or terminated support.

In addition, the expert panel may be addressed with particular questions by the Research Council, which has set up the panel. Such questions may relate to specific projects or to an entire field of science.

6. Report of the Expert Panel

The work of the expert panel shall result in a report to the Swedish Research Council and the Swedish National Space Board. This report should comprise a section with comments on the general scientific level in an international perspective of the research performed, including discussions of structural and organisational problems. The need for expensive equipment and other points of general relevance could also be raised here. Another section should deal with each project individually in an international perspective as outlined under point 5 above.

The expert panel should be aware of the fact that the Scientific Council for Natural and Engineering Sciences due to the present budget situation has to reject applications of excellent quality, and that many applications are funded at a suboptimal level. The same is basically true for the applications submitted to the Swedish National Space Board, but the fact that certain space projects are associated with formal commitments to external partners, sometimes influences the level of financial support.

In order to standardise the terminology used in the assessment of the individual projects, the following grades should be used:

Outstanding
Outstanding research in an international perspective; of great international interest with broad impact and with publications in internationally leading journals; the grant holder is among the leading in the whole evaluated field of research in an international perspective.

Excellent
Research at a very high international level; of international interest with impact within its field and with publications in internationally leading journals; the grant holder is among the leading in Sweden in the evaluated field of research.

Very good
Research at a very good international level with publications in internationally well-known journals; the grant holder has a good international reputation within the field and the research.

Good
Research that is of good international standard and partially published in well-known international journals. To receive the grade "Good", the research should be of sufficient quality to be eligible for funding from the Swedish Research Council.

Insufficient
Research of insufficient quality for funding from the Swedish Research Council. The grade "Insufficient" does not necessarily mean that the research is of low quality. The research could be good but not good enough to fulfil the high demands of quality maintained by the Swedish Research Council.

The Swedish Research Council appreciates a discussion on priorities of actions, both in terms of financial support and of more structural matters.

To indicate the relative importance of different recommendations, the following expressions should be used: **recommends**, **strongly recommends** or **most strongly recommends**.

7. Handling and Distribution of the Report

The report of the expert panel is presented to the Swedish Research Council and the Scientific Council for Natural and Engineering Sciences as well as to the Swedish National Space Board. It is also circulated to all grant holders concerned and, on request, to universities and any other agencies or persons who have expressed an interest in this kind of information. All reports of this kind become, by Swedish law, public documents. Not unexpectedly, an evaluation report sometimes gives rise to comments by grant holders whose work has been reviewed. If they are in a written form, they are distributed to the Members of the Scientific Council for Natural and Engineering Sciences and to those involved in the regular work in reviewing applications.

8. Honorarium

The members of the expert panel receive a small honorarium according to the regulations of the Swedish Research Council. Travel costs and other expenses are reimbursed or paid by the Swedish Research Council.

Appendix 3
Acronyms

ABL	Atmospheric Boundary Layer
ACE	Atmosphere and Climate Explorer Mission (European Space Agency)
AMSU	Advanced Microwave Sounding Unit
AOE 2001	Arctic Ocean Experiment 2001
ARCMIP	The Arctic Regional Climate Model Intercomparison
CARIBIC	Civil Aircraft for the Regular Investigation of the Atmosphere Based on an Instrument Container
CCN	Cloud Condensation Nuclei
CFC	Cloro-Fluoro Carbons
COAMPS	Coupled Ocean/Atmospheric Mesoscale Prediction Systems
DMA	Differential Mobility Analyzer
DMF	Dimethylsulphide
DNS-LES	Direct Numerical Simulation/Large Eddy Simulation
DOAS	Differential Optical Absorption Spectroscopy
ECMWF	European Centre for Medium-Range Weather Forecasts
EISACT	European Incoherent Scatter
ERA-40	Forty-year European Re-Analysis of the Global Atmosphere: Ocean wave product validation and analysis
ESA	European Space Agency
ESRAD	Esrange MST Radar
FMI	Finnish Meteorological Institute
FT/UV	Fourier Transform Spectrometry in the UV Range
FTIR	Fourier Transform Infrared
GMC	General Circulation Models
GPS	Global Positioning System
HIRLAM	High Resolution Limited Area Model

ICSU	International Council of Scientific Unions
IGACO	Integrated Global Atmospheric Chemistry Observations
IGOS	Integrated Global Observing Strategy
IMK	Das Institut für Meteorologie und Klimaforschung, Universität Karlsruhe, Germany
INCA	Interhemispheric Differences in Cirrus Properties from Anthropogenic Emissions
INDOEX	The Indian Ocean Experiment
IPCC	Intergovernmental Panel on Climate Change
IRF	Swedish Institute of Space Physics
JGR	Journal of Geophysical Research – Atmospheres
LIDAR	Light Detection and Ranging
MF	Medium Frequency
MISTRA	The Swedish Foundation for Strategic Environmental Research
MISU	Department of Meteorology, Stockholm University
NCAR	National Center for Atmospheric Research
NLC	Noctilucent Clouds
NRL	U.S. Naval Research Laboratory
PBL	Planetary Boundary Layer
PESA	Ion Electrostatic Analyzers
PIXE	Particle Induced X-ray Emission
SBL	Surface Boundary Layer
SHEBA	Surface Heat Budget of the Arctic Ocean
SMHI	Swedish Meteorological and Hydrological Institute
STEAM	Stratosphere – Troposphere Exchange And Climate Monitor
SWECLIM	Swedish Regional Climate Modelling Programme
SWEPOS	Swedish network of permanent reference stations for GPS
Tekn Lic	Tekonologie Licientiatexamen
TKE	Turbulent Kinetic Energy
UTLS	Upper Troposphere and Lower Stratosphere
VLBI	Very-Long-Baseline Interferometry
VHF	Very High Frequency
ZTD	Zenith Total Delay

Appendix 4
Programme

International Evaluation of Meteorology
March 15 – March 19, 2004

Monday March 15

The Swedish Research Council, Regeringsgatan 56, Stockholm

10.00 – 13.00	Meeting with the expert panel for initial discussions and general information on the evaluation procedure: Prof. Leif Anderson, Dr. Jonas Björck, and Dr. Lennart Nordh
13.00 – 14.00	Lunch

Interviews and Other Activities

14.00 – 15.00	Bengt Martinsson
15.00 – 16.00	Mattias Hallqvist
16.00 – 17.00	Jan Pettersson
17.00 – 18.00	Vernon Cooray
18.15	Taxi to the Wasa Museum
19.30	Dinner hosted by Jonas Björck and Lennart Nordh

Tuesday March 16

The Swedish Research Council, Regeringsgatan 56, Stockholm

Interviews and Other Activities

09.00 – 10.00	Henning Rodhe
10.00 – 11.00	Michael Tjernström
11.00 – 12.00	Donal Murtagh
12.00 – 14.00	Lunch/report writing
14.00 – 15.00	Gunnar Elgered
15.00 – 16.00	Johan Mellqvist
16.00 – 17.00	Nils Gustafsson
17.00 – 18.00	Caroline Leck
18.00 – 19.00	Erik Lindborg

Wednesday March 17

The Swedish Research Council, Regeringsgatan 56, Stockholm

Interviews and Other Activities

09.00 – 10.00	Jacek Stegman
10.00 – 11.00	Gunilla Svensson
11.00 – 12.00	Erik Swietlicki
12.00 – 14.00	Lunch/report writing
14.00 – 15.00	Deliang Chen
15.00 – 16.00	Kevin Noone
16.00 – 17.00	Sheila Kirkwood
17.00 – 18.00	Sergej Zilitinkevich (absent)
18.00 – 19.00	Erland Källén

Thursday March 18

The Swedish Research Council, Regeringsgatan 56, Stockholm

Interviews and Other Activities

09.00 – 10.00	Douglas Nilsson
10.00 – 11.00	Johan Ström
11.00 – 12.00	Ann-Sofie Smedman
12.00 – 13.00	Lunch
13.00 –	Discussion and writing of report

Friday March 19

The Swedish Research Council, Regeringsgatan 56, Stockholm

09.00 – 12.00	Short presentations of the various parts of assessments to be assembled to constitute the final evaluation report, discussion, and finalisation of report
12.00 – 13.00	Lunch
13.00 – 16.00	Finalisation of report.

Appendix 5

Support from the Swedish Research Council and the Swedish National Space Board during the period of 1999 – 2006

In addition to the research grants allocated to the main applicants, SNSB covers certain costs connected to the projects in which the research groups are involved. The following are examples of such costs during the period covered by the evaluation:

Odin satellite

The SNSB share, approximately 55%, of the development, launch, and operations of the Odin satellite has been paid directly to the Swedish Space Corporation. SNSB has spent abbout 10 MSEK/year to operate the satellite since its launch in February 2001. As Odin is a combined project for both astronomy and aeronomy, half of the operational costs can be formally assigned to each discipline.

Validation of the Odin satellite measurements

SNSB has financed or contributed to the financing of the following Odin validation projects: A validation programme led by Centre National d'Etudes Spatiales using stratospheric balloons. SNSB contribution: 1,3 MSEK. The development and launch of a sounding rocket (Hygrosond 2) from Esrange in 2001. Project cost covered by SNSB: 3,0 MSEK. Costs associated with the balloon project SKERRIES. Total cost to SNSB: 1,2 MSEK.

The Magic sounding rocket project

SNSB has decided to develop and launch the Magic experiment onboard a sounding rocket from Esrange in January 2005. Total cost to SNSB: 4,4 MSEK.

Name	NFR/TFR 1999	SNSB 1999	NFR/TFR 2000	SNSB 2000	NFR/TFR 2001	SNSB 2001	VR 2002	SNSB 2002	VR 2003	SNSB 2003	Total 1999–2003	VR 2004	SNSB 2004	VR 2005	SNSB 2005	VR 2006
Deliang Chen	197 798		197 798						473 200		868 796	473 200		473 200		
Vernon Cooray	370 899		370 899		369 900		246 238		246 238		1 604 174	540 000		472 500		
Gunnar Elgered					369 900	563 200	369 900	1 611 000	369 900	1 903 500	5 187 400		1 246 050			
Nils Gustafsson						105 000		245 900		250 000	600 900					
Mattias Hallquist							195 000		130 000		325 000	130 000				
Sheila Kirkwood	468 819		484 051		363 717	224 000	773 662		773 662	130 000	3 217 911	650 000	549 450		587 250	
Erland Källén						377 600		387 400		352 500	1 117 500		378 000			
Caroline Leck	943 513		1 234 227		1 439 401		1 469 403		1 922 635		7 009 179	799 501		607 500		
Erik Lindborg							390 000		390 000		780 000	390 000				
Bengt Martinsson	335 539								473 200		808 739	473 200		473 200		
Johan Mellqvist				247 200	450 000	256 000	450 000	334 100	450 000	442 500	2 629 800					
Donal Murtagh	296 806	4 539 900		4 474 500		179 000	260 000	1 917 500	405 600	2 421 900	14 495 206	405 600	2 018 250	405 600		
Douglas Nilsson	503 200		544 544		910 865		813 238		1 466 238		4 238 085	1 006 000		337 500		337 500
Kevin Noone						371 200	390 000	612 300	390 000	633 100	2 396 600	390 000				
Jan Pettersson	246 976		639 744		637 834		637 834		676 000		2 838 388	676 000				
Henning Rodhe	501 459		377 536								878 995					
Ann-Sofie Smedman	391 462		486 336		412 205		502 239		473 200		2 265 442	473 200		473 200		
Jacek Stegman	92 480		92 480	309 000		3 379 000		1 982 500		1 762 600	7 618 060		2 612 250			
Johan Ström	309 101		370 573		289 412		325 000		325 000		1 619 086	130 000				
Gunilla Svensson	166 899		61 798		61 614		390 000		390 000		1 070 311	390 000				
Erik Swietlicki							390 000		390 000		780 000	390 000				
Michael Tjernström	1 001 831		972 019		923 556		1 169 088		1 257 500		5 323 994	1 186 450				
Sergeij Zilitinkevich	309 101		309 101		308 177						926 379					
Total/year	**6 135 883**	**4 539 900**	**6 141 106**	**5 030 700**	**6 536 581**	**5 455 000**	**8 771 602**	**7 090 700**	**11 002 373**	**7 896 100**	**68 599 945**	**8 503 151**	**6 804 000**	**3 242 700**	**587 250**	**337 500**

The amounts in the table include overhead costs. Salaries as well as grants for equipment are included when applicable.

TFR = The Swedish Research Council for Engineering Sciences
NFR = The Swedish Natural Science Research Council
VR = The Swedish Research Council. TFR and NFR merged into VR 2001
SNSB = The Swedish National Space Board

The Swedish Research Council bears national responsibility for developing the country's basic research towards attainment of a strong international position. The Council has three main tasks: research funding, science communication, and research policy. The Swedish Research Council is a government agency under the aegis of the Ministry of Education and Science.

The Swedish National Space Board (SNSB) is a central government agency under the Ministry for Industry, Employment, and Communications. The Swedish National Space Board is responsible for national and international activities relating to space and remote sensing, primarily research and development.

In accordance with its Statutes, as laid down by the Government, the Swedish Research Council and the Swedish National Space Board evaluate the research, to which it has given financial support. A joint evaluation by the main funding agencies is natural, since the ground-based and space-based atmospheric and remote sensing research fields are scientifically linked and sometimes involve one and the same research group.

VETENSKAPSRÅDET
THE SWEDISH RESEARCH COUNCIL

RYMDSTYRELSEN
Swedish National Space Board

VETENSKAPSRÅDET
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