Evaluation of Estonian Research

- Meteorology and Hydrology -

Report to the Estonian Science Fund Council

by

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GENERAL COMMENTS ON METEOROLOGY AND HYDROLOGY

Meteorological research in Estonia relates to the following sub-areas mainly: Physical climatology, in particular studies of solar radiation; large scale climatological studies based on NOAA Nimbus-7 satellite data; theoretical studies of the equations of motion for large-scale atmospheric circulation; air electricity and atmospheric aerosol studies; studies of noctilucent clouds; development of satellite-borne telephotomerer. The quality of much of the research is very good. We were pleased to see that international contacts had been established in several cases and that international publication was attempted. The declaration of Estonia as an independent state brought about important changes for some of the groups that we met with. Thus the need to establish training for students to become professional meteorologists has led to plans for setting up courses at Tartu university, with active participation of highly skilled scientists from the Institute of Astrophysics and Atmospheric Physics in Töravere. We strongly endorse this. We foresee problems for other groups that were previously involved in close cooperation, partly with work of applied nature, with institutions in other parts of the former Soviet Union. In some cases highly qualified scientists were involved. We strongly support their attempts to reorientate their research to environmental issues, where it appears as their technique originally developed for satellite application can be used.

Hydrological research and monitoring is closely related in Estonia, where the main task is to safeguard the vulnerable ground water aquifer. In view of this we found the present organization not particularly well suited, with several groups working independently and without possibilities for efficient collaboration. Thus we strongly recommend that the groundwater monitoring activities now performed by the Geological Survey of Estonia and the modeling work at the Estonian Academy of Sciences Institute of Geology be carried out in close collaboration under suitable organizational form. We also recommend that the groups involved increase their international contacts. This is particularly important for the modeling group who would need to be more familiar with the rapid development in hydrogeolocical modeling presently going on in the western countries.

Cand. Sci. Rein Rõõm, Sirje Kevalik and Olavi Kärner
Department of Atmospheric Physics
Institute of Astrophysics and Atmospheric Physics
Estonian Academy of Sciences, Tõravere

Large-Scale Atmospheric Circulation and Cloud-Cover Climatology

Principal Activities

The work done by this group comprises two distinct project areas:

1) Cloud Cover Climatology (CCC). Researchers: S. Kevalik and O. Kärner. The aim of this project is to determine the large-scale influence of cloudiness on the Earth radiation budget components using satellite observations and is based on analysis of scanning radiometer data from the NOAA Nimbus-7 satellite, covering the time period 1978 - 1987. The work was initiated by the late Professor Olav Avaste during a visit to Boulder, USA in 1978. In particular, the aim of the study has been to investigate the trend of the energy balance of the Earth as a whole during the time period 1978 - 1987, if any. The result of the analysis so far seems to indicate no such trend so far.

2) Theoretical studies of the equations of motion for large-scale atmospheric circulation (FAD). Researcher: R. Rõõm. The aim of this project is to derive alternative formulations of the equations of motion which can be used in simplified model studies of the large scale circulation of the atmosphere. So far the work has been purely mathematical, deriving a new method for solving the equations which has the properties in common with the quasi-geostrophic approximation (QGA) that it filters out gravity waves and sound waves but is much more useful than QGA in the treatment of strongly baroclinic zones (fronts).

Evaluation

Project 1 (CCC). The work, which has been going on since 1979, has resulted in several good international publications including a book which is in the process of being published by the American company A. Depak. The group has good international contacts and have organized an international meeting to be held in Tallinn in August 1992, with invited presentations by some of the most well-known scientists in the field. In summary the group is very good by international standards.

Project 2 (FAD). This work has been going on for not more than two years and has so far resulted in Russian and Estonian publications and a manuscript submitted to Journal of Atmospheric Sciences. Although the work is still in a relatively preliminary stage the approach is interesting enough and may be very useful in future simplified studies of various properties of the large scale atmospheric flow. It is difficult at this stage to give a definitive rating of this sub-project, but it is at least 'good' on an international scale.

Recommendations

Both sub-project groups are a little vague concerning their plans for the future. It is no doubt, however, that their documented high competence should be maintained. An interesting aspect was raised during the site visit. Training of students to become professional meteorologists was previously done outside Estonia. After the declaration of independence this possibility doesn't exist any more, so such training must be started within the country. We were told that there are plans to locate this activity to Tartu University and that the scientists involved in the present project are involved in this planning. We consider it strongly recommended that such a merge between the successful research evaluated here and the professional training of meteorologists at Tartu University is being accomplished.

Professor Juhan Ross
Institute of Astrophysics and Atmospheric Physics
Estonian Academy of Sciences, Töravere

Estonian Radiation Climate and Energy Balance of the Ground Surface

Principal Activities

The work performed by this group can be divided into three sub-projects:

1) Climatological measurements of solar radiation and related basic meteorological parameters. The measurements have been going on for 40 years now and have given rise to a study of the temporal variations of radiation, temperature, cloudiness and precipitation in the area.

2) Studies of the energy balance at the Earth surface. Together with scientists from other countries within the former Eastern Bloc the group has participated in a number of field experiments at various sites in the former Soviet Union and elsewhere.

3) Studies related to the photosynthesis of forests. These studies have been carried out in cooperation with Finnish scientists. The contribution of this group is measurements of the radiation flux within the canopy, carried out with the aid of instruments developed by the group over many years.

Evaluation

The common denominator of the three sub-projects is the group's eminent expertise in the construction, calibration and use of instruments for measuring solar radiation. Thus the climatological series of measurements (sub-project 1) is of very high quality, and we were convinced that the rather large effects found in the 40 year long climatological records are indeed real, albeit the interpretation of the result is still open for discussion. The success in sub-projects 2 and 3 is also very much the result of the excellency of the radiation measurements carried out by the group. We consider the overall scientific quality of the research done by this group very good.

Recommendations

The group has listed five specific areas for their future scientific activities commented on below:

a. In connection with the inclusion of the climatological radiation station into the WMO Baseline Surface Radiation Network modernization of the station is suggested, which we strongly recommend.

b. We also strongly recommend that the analysis of the climatological records are being continued, comparisons with data from other climatological stations in northern Europe being included.The group suggests to include measurements of air pollution. In view of the rural character of the area this may be convenient from a monitoring point of view and is recommended as such, but we do not believe that it will be possible to correlate climate change in the area against air pollution data from one point.

c. and d. Energy balance measurements and photosynthesis studies. We recommend that the group continue to take part in this kind of activities and commend their intention to contribute to the international NOPEX project. We recommend that they concentrate on radiation measurements.

Ass. professor Hanno Ohvril, Juri Knyazikhin and Meelis Reinhart
Department of Geophysics, Tartu University

Atmospheric physics, marine research

Principal activities

The group is involved in various projects related to optical studies of the atmosphere and related media, such as radiation transfer in the atmosphere, in vegetation and in the surface layer of the Baltic Sea; aerosols in the atmosphere; noctilucent clouds. Of the senior scientists of this group only Dr Reinart was present. We were told that Dr Knyazikhin was away to the University of Göttingen on a Humbolt stipend to study radiation transfer in vegetation and Dr Ohvril was at the University of Grenada, Spain for studies related to atmospheric transparency.

Evaluation

The studies of noctilucent clouds (NLC) performed by this group has won high international reputation. A Ph D student, Jelena Kahre, is presently involved in a study of the microphysics of NLC formation by numerical simulation of the particle growth process. After prof Olev Avaste's untimely death in 1991 this work is expected to continue in cooperation with the Department of Meteorology of Stockholm University, with prof. Georg Witt as supervisor.

Concerning the remaining research activities the Evaluation Group had difficulties in forming a qualified opinion, because of the absence of the involved scientists. Our general impression was that the overall quality of the research is 'good' but perhaps not entirely up to date by international standards.

Recommendations

We recommend continued support for this group in spite of our impression that the research might be slightly obsolete. The reason for this is that we find it highly commendable that several members of the group, including the Ph D student Jelena Kahre, are seeking international contacts. We are confident that these scientists are able to reorientate the activities of the group according to current trends in international research.

Cand. Sci. Uno Veisman, and Kalju Eerme
Space Research Laboratory of the Institute of Astrophysics and Atmospheric Physics
Estonian Academy of Sciences, Töravere

Remote Sensing of the Atmosphere and the Earth's Surface

Principal Activities

The main task of the group in the past has been the development of a satellite-borne telephotometer for the global study of atmospheric aerosol, solving the inversion problem necessary for the evaluation of physical properties of the aerosol and also to perform scientific evaluation of the results from measurements on board the Soviet spacecrafts Salyut 4, 6 and 7. During the last few years they have also attempted at ground based applications of a similar technique to problems related to environmental issues, including measuring pollution in the surface layer of the sea.

Evaluation

No doubt, this group has developed a technique for spacecraft-borne radiometric measurements that match similar facilities in the West. Also their achievements in solving the complicated problem of the inversion of the limb-scanning profiles, i.e. the derivation of the physical properties of the aerosol from a limited set of horizontally integrated data must be considered as ~~'very good'~~

Recommendation

Naturally, this group gave the impression of despair to some degree, their main field of research being so intimately related to Soviet space research. We have the impression that this is a highly competent group, and we strongly recommend that the members concentrate their scientific effort in the future on ground based applications of their optical techniques to environmental issues, as they have already done to a certain extent.

Prof Rein Vaikmäe, Cand. Sci. Leo Vallner
Institute of Geology, Laboratory of Hydrogeology

Hydrosphere studies and Geochronology

Principles Activities

Candidate geologist Leo Vallner is leading a group of 10 persons of which 7 have scientific responsibilities for varies tasks of hydrogeological research. The main direction of research has during the latest years been hydrodynamic modelling of ground water conditions in Estonia. The purpose is to develop a general model of the major aquifers of Estonia to be used for given scientific recommendations concerning water management in Estonia.

The modelling work is based on well known physical equation for water flow in saturated media using numerical approximations of finite element type. Development of software has been made within the group in collaboration with specialists from the Institute of Cybernetics. The model coded in FORTRAN runs on a Mainframe computer. Input data and ground water observations are used for calibration of the model. These data comes in most cases from the Hydrogeological department of Geological survey of Estonia.

Evaluation

The quality of the research is fair in spite of the lack of modern PC-computers, efficient softwares and tradition of international publishing of results. The group represents an very important direction of research which is especially important for improvement of monitoring of ground water conditions and developing of an efficient protection of ground water resources in Estonia. To our knowledge this direction of research is not represented by any other group in Estonia today and it is important to use the experience of the present group when further developing hydrogeological research in Estonia.

Recommendations

The suggested plans of the group to continue the modelling work is therefore strongly recommended but the potential of the group might be better used if an better organization of hydrological research could be initiated. We recommend that a total integration of hydrological research in the area of hydrology and environmental research. This is important since both theoretical and experimental research would be improved if they are more closely connected. The modelling group should be in a position where they can influence the monitoring networks. The model need in the future better description of boundary conditions above the ground water aquifers and couplings to submodels for important pollutants like nitrogen, phosphorous, phenol and heavy metals.

To reach these objectives it is necessary to encourage the group to increase their international contacts and to publish their results in international journal.

L. A. Savitski
Estonian Hydrogeological Department
Geological Survey of Estonia
Tallinn

Studies of Regime, Underground Water Balance and Exogenous Geological Processes, Estimation and Forecasting of Geological Conditions in Estonia

Principle Activities

The Hydrological Department (staff of 12) is responsible for the compilation and evaluation of long-term monitoring of groundwater quality and underground water balances in Estonia. Water levels and in some cases water quality are recorded with various frequencies at more than 800 locations all over the country. The observation and sampling locations constitute a part of the State hydrological network of the former Sovjet Union. The pollution from various antropogenous activities can be followed but also effects of natural processes and water quality variations related to the geological conditions as well as effects of intensive exploitation of groundwater for drinking water and industrial water supply. An important activity of the Department is the processing and evaluation of data and the preparation of hydrogeological and hydrochemical maps of Estonia.

Evaluation

The existing hydrogeological network is impressive and of great value, not primarily as a basis for research but for the continuous monitoring and evaluation of changes in groundwater quality. The activities within this area should not primarily be regarded as research, but rather monitoring and environmental control. The overall quality can be regarded as fair in most parts. There was, however, not material for the evaluation group to look into the quality of the reported data, and no quality assurance procedures appear to be followed. The chemical laboratories (not at the present office) were not visited, and the resources for the determination of various pollutants (e.g. heavy metals) at trace levels are not known to the evaluation group. A general impression is that the program and general objectives are very ambitious but the technical resources inadequate.

Recommendations

Water is a limited resource in Estonia and it is essential to reduce contamination of the groundwater system. There are many activities with a potential for severe pollution of the aqueous environment which make it important to maintain an efficient organization for monitoring of water quality in surface as well as subsurface systems. A continuation of the activities within the present area is strongly recommended. It is, however, imperative that the activities in the fields of hydrogeology as well as environmental monitoring are integrated and coordinated. It appears that monitoring activities as well as hydrogeological modelling and assessment

of contamination spreading are presently taking place at several institutions, also within the Geological Survey, with little or no interactions between the groups. We also suggest that international contacts are established with similar organizations in other European countries.

E. Lippmaa, A. Pihlak, A. Sirk
Institute of Chemical Physics and Biophysics
Estonian Academy of Sciences
Tallinn

Technology Related and Natural Environmental Pollution Studies

Principal Activities

Prof. Lippmaa and his group (Group of Environmental Studies and Monitoring; staff of 11, including the senior scientists A. Pihlak, A. Sirk and E. Maremäe) are engaged in topics related to analysis of the progressing environmental pollution. Some of the most urgent pollution cases of Estonia have been selected for monitoring as well as process oriented studies. These cases include analysis of groundwater pollution in connection with mining (phosphorites) and mineral processing as well as studies of the leaching of metals etc from alum shales. The pollution resulting from shale oil production is studied as well as the contamination of surface waters from both industrial and municipal waste (particularly in Lake Peipsi). Also the occurrence of deep groundwater, with a high salinity and rich in trace elements, are studied. A major effort is devoted to studies of air pollution from the burning of oil shales (as well as from the alum shales). A mobile computerized monitoring system has been constructed with the capacity of measuring SO_2, NO_x, CO, acidity etc in air and precipitation.

Evaluation

The group has adopted a monitoring program that normally would be expected to be the reponsibility of some authority. There are, however, also projects with a character of applied as well as basic research of generally good quality, although the resources appear to be split into several in principle independent problem areas rather than being fully concentrated on one or two major objects. The mobile air monitoring system that has been developed and used in the field is a very good achievment. The publication record is very good, although the publications appear exclusively in national journals etc.

Recommendations

The use of oil shales for burning is unavoidable and an economic and practical necessity in Estonia. Also the mining of phosphorites and the problems associated with the leaching (and self-ignition) of the accompanying black alum shales are unavoidable issues of high environ-

mental relevance. A continued monitoring of air quality as well as water quality is strongly recommended, although these are task that should be the over-all responsibility of e.g. a Ministry of the Environment. The air monitoring program should be coordinated with similar international activities. A further development of the mobile system and associated analytical system is suggested rather than a development of a new network of permanent stations. It is also recommended that the group establish a collaboration with e.g. the Institute of Chemistry (problems related to oil shales and blach alum shales) as well as with the Geological Survey (utilizing the existing sampling network with recorded water quality history and coupling of air and water monitoring networks). A publication in international media of the extensive results that are produced is also advised.

V. Petersell, J. Kivisilla
Tallinn Geological Department
Geologic Survey of Estonia
Tallinn

Soil Geochemistry of Estonia

Principle Activities

The Geological Department (staff of 7) is engaged in geochemical mapping of soils as well as sea bottom sediments, particularly with respect to heavy metals. Some 15 elements are quantitatively analysed and additional elements semi-quantitatively determined in soil samples from North-East and South-East Estonia with an average of one sample per 0.8 or 3.5 km^2. Marine sediments from the Gulf of Finland as well as sediments from river mouths (number of sampling locations not clear) are analysed. The contribution of heavy metals from the precipitation is measured at 25 stations (4 times per year) all over Estonia.

Evaluation

The activities should primarily be regarding as mapping and monitoring. The quality of the measured data can not be assessed, since no publications were available and no details about sampling and analysis procedures were given. The general impression is that the quality is fair at most parts and that the program is very ambitious, although hardly anything of the extensive results have been published, and nothing at all in international media.

Recommendations

The monitoring program is of great value, both for establishing the present situation but also to evaluate the progressing pollution in certain areas as well as other chemical anomalies, possibly of natural origin. A continuation of the activities is strongly recommended. It is, however, imperative that the geochemical soil maps are published, in national as well as, in relevant parts, international journals. The geolocial surveys etc in the neighbouring countries would most likely be interested in contacts or future collaboration. A coordinated soil and water sampling as well as evaluation of monitoring data within the survey would be of value and is advised. Particularly the monitoring of precipitation in the industrialized areas should be coordinated with similar activities at various groups within the Estonian Academy of Sciences.