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INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

WORLD METEOROLOGICAL ORGANIZATION

WORLD CLIMATE RESEARCH PROGRAMME

ARCTIC CLIMATE SYSTEM STUDY (ACSYS)

SUMMARY REPORT OF THE EIGHTH SESSION OF THE WCRP ACSYS SCIENTIFIC STEERING GROUP

(Louvain-la-Neuve, Belgium, 15-19 November 1999)

October 2000

WCRP Informal Report No. 10/2000

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1. OPENING OF THE SESSION

1.1 The eighth session of the WCRP Scientific Steering Group (SSG) for the Arctic Climate System Study (ACSYS) was opened by the Chairman, Dr H. Cattle, at 09:00 on 15 November 2000 at the seminar room of the Bâtiment Sciences 17, Institut d'astronomie et de géophysique Georges Lemaître of the Université catholique de Louvain, Louvain-la-Neuve, Belgium. Dr Andre Berger, Director of the Institute d'astronomie et de géophysique Georges Lemaître, welcomed the participants in the meeting on behalf of the Institute. Appendix A contains a list of participants in the meeting.

1.2 The SSG agreed on an agenda to be followed and on the organization of their work during the session.

2. REVIEW OF RELEVANT ACTIONS TAKEN BY THE JSC-XX

The Chairman of the meeting, Dr H. Cattle, briefed the meeting on actions taken by the JSC-XX (Kiel, Germany, 15-19 March 1999) relevant to the implementation of ACSYS and the organization of WCRP research into cryosphere and climate, as detailed in WMO/TD-No. 976, 1999.

3. REVIEW OF ACTIONS FROM THE ACSYS SSG-VII SESSION

The Chairman of the meeting, Dr H. Cattle, reported on actions from the previous session of the group (see Appendix E to WCRP Informal Report No. 15/1999). The group noted satisfactory progress with actions either complete, or covered by other agenda items. It was agreed that, given that the annual report to the JSC contains many of the science items, the meeting report could be kept short, with key programmatic decisions highlighted either as bullets or in an up-front executive summary. For the future, consideration should be given to initial drafting by the IACPO, once the new Director is in place.

4. ACSYS IMPLEMENTATION PLAN AND THE ACSYS GLOSSY BROCHURE

4.1 The ACSYS SSG-VII (Tokyo, Japan, November 1998) agreed on allocation of responsibilities for updating the ACSYS Implementation Plan. The International ACSYS/CLIC Project Office (IACPO) put together the revised plan, which was reviewed by the ACSYS SSG-VIII. The meeting agreed that the plan should be relabelled "ACSYS Implementation and Achievements". The ACSYS SSG-VIII further agreed that an ACSYS Implementation and Achievements document review would be a standing agenda item of SSG meetings with an aim to providing necessary changes, if any, to the IACPO by the end of the SSG meeting. The current version of the ACSYS Implementation and Achievements document is available electronically on the ACSYS web site:

http://www.npolar.no/acsys/impplan/index.htm.

4.2 The ACSYS SSG-VII requested the IACPO to complete the preparation of an ACSYS glossy brochure, in consultation with experts as required. The IACPO reported to the ACSYS SSG-VIII on progress made in the preparation of the brochure. The SSG came to a decision that the ACSYS glossy was to be written with the help of a science writer, and that it should contain only a few pages. On behalf of the National Snow and Ice Data Centre (Boulder, CO, USA), Prof. R. Barry agreed to hire a writer on behalf of ACSYS. The target time for the completion of the brochure is summer 2000.

5. WCRP SEA-ICE RESEARCH PROJECTS

5.1 WCRP International Programme for Antarctic Buoys (IPAB)

5.1.1 Dr I. Allison, a Co-ordinator of the programme, reported that the IPAB was a consortium of nineteen agencies and institutions from twelve different countries, with interests in near-surface meteorology and oceanography in the Antarctic and the Southern Ocean. It seeks to develop and maintain an observational network of drifter buoys and other appropriate data collection systems south of 55°S, a region that includes the maximum Antarctic seasonal sea-ice extent. The programme has a strong research component and the majority of IPAB buoy deployments are made to support specific research programmes, rather than as part of operational networks and much of this research is concerned with the movement of Antarctic sea ice. Participants in the programme meet every two years. The next (third) biennial meeting of the programme Participants (Fairbanks, Alaska, USA, 26-28 June 2000) will formally review the IPAB programme. The ACSYS SSG advised that a statement on the need for continuity of the IPAB be written as an ACSYS/CLIC input to the programme review.

5.1.2 A total of 106 drifting buoys have been deployed under IPAB auspices in the Antarctic Sea-Ice Zone since 1995. Most IPAB deployments have been concentrated in the Weddell Sea and off the coast of East Antarctica, but there were new initiatives in the Ross and Bellingshausen Sea region in 1998. Most IPAB data buoys report through System Argos. Data from the IPAB programme are used operationally by meteorological agencies and in support of a wide variety of studies of the Antarctic Sea-Ice Zone, including initialisation and validation of numerical climate modelling, and for the validation of satellite remote-sensing techniques for determining sea-ice motion. The average number for 1995-1999 of drifters active in the IPAB region during a whole year is fourteen data collection systems. Detailed information on IPAB activities is available at:

http://www.antcrc.utas.edu.au/antcrc.buoys/buoys.html.

5.2 Antarctic Sea-Ice Thickness Project

5.2.1 Dr E. Fahrbach, the leader of the project, reported that presently the WCRP Antarctic Sea-Ice Thickness Project consists of six moorings with upward-looking sonars (ULS) deployed by the Alfred Wegener Institute for Polar and Marine Research (AWI, Bremerhaven, Germany) in the Weddell Sea, and two moorings deployed by the Antarctic Co-operative Research Centre (ACRC, Hobart, Tasmania, Australia) off the coast of East Antarctica. The AWI moorings will be recovered in 2001. The scheduled recovery of the ACRC moorings is sometime during 2000.

5.2.2 The AWI, the ACRC and the Norwegian Polar Institute deployed fifty-one ULS in the Antarctic Sea-Ice Zone in 1990-1999 within the framework of the project. Twelve moorings were reported lost. Thirty-one instruments were already recovered. Due to instrument failure, only seventeen out of thirty-one ULS provided good-quality measurement data. Additional information on the project activities and results obtained is available electronically at:

http://www.awi-bremerhaven.de/Research/ansitp/index.html.

5.3 International Arctic Buoy Programme (IABP)

5.3.1.1 The meeting was briefed by Dr V. Savtchenko on the current status of the IABP. The operational area of the programme includes the central Arctic Basin and its marginal seas (excluding the economic zones except where agreements of the coastal states have been obtained). As of 1 November 1999, twenty-two agencies spanning 9 countries and one international organization (WCRP) partIcipate in the implementation of the IABP. Arctic buoy data are distributed in real time on the Global Telecommunication System (GTS). Most buoys provide data on surface atmospheric pressure, air temperature, and geographic position. Some buoys also provide information on atmospheric pressure tendency, and/or wind speed and directions, and/or sea surface temperature, and/or snow and sea-ice properties, and/or subsurface oceanographic variables. As of 1 November 1999, twenty-seven data buoys were operational in the IABP observational area.

5.3.2 The ninth annual meeting of the IABP Participants was held from 2-4 June 1999 in Bremerhaven, Germany. A report of the meeting is available at the IABP web site: http://iabp.apl.washington.edu The indicated site contains also information on current status of the IABP buoy array and on buoy deployment plans.

5.3.3 The tenth session of the IABP Participants is scheduled to be organized in Fairbanks, Alaska, USA from 26-28 June 2000. A joint IPAB-III/IABP-X meeting will be held on 27 June 2000 in order to discuss common problems and share the experience gained by each programme.

5.4 Arctic Sea-Ice Thickness Project

5.4.1 Dr C. Oelke, Acting Director of the International ACSYS/CLIC Project Office (IACPO), reported on the current status of the Arctic Sea-Ice Thickness Project (ASITP) and on the ACSYS Data Centre for Sea-Ice Thickness Measurements (ADACIT) (See also Appendix 5.9 to WMO/TD No. 991, 2000). The Norwegian Polar Institute (NPI) is the ACSYS repository for ULS Arctic ice-thickness data. Dr T. Vinje (NPI Oslo, Norway) is the co-ordinator of the ASITP. Dr T. B. Loyning (NPI, Tromsø, Norway) is responsible for the assembling of an ASITP data base.

5.4.2 The NPI, the Alfred Wegener Institute for Polar and Marine Research (Bremerhaven, Germany), the Applied Physics Laboratory of the University of Washington (Seattle, WA, USA), the Scott Polar Research Institute (Cambridge, UK) and the Institute of Ocean Sciences (Sidney, B.C., Canada) participate in the implementation of the ASITP. Since the inception of the project, these institutions deployed some 100 ULS in the Arctic Ocean. As of 1 November 1999, six ULS were operational, two were lost and 89 ULS were successfully recovered. Data from 23 ULS have been put in the ULS data base. Some information on available Arctic ULS data sets can be obtained from ADACIT web page:

http://www.npolar.no/ADACIT/

5.4.3 Dr H. Melling informed the meeting that a continuous 7-year record of ice-thickness measurements in the southern Beaufort Sea obtained by Canadian scientists with bottom-mounted upward-looking sonars, was archived at the Institute of Ocean Sciences, Canada. Ice draft monitoring in Beaufort Sea is continuing through 2000 with four sites instrumented along the margin of perennial pack ice. Since the project was initiated in 1990, more than 45,000 km of survey track have been acquired. This programme is the only systematic monitoring of ice thickness within an Arctic seasonal ice zone. More studies of seasonal ice are necessary, since seasonal ice constitutes more than half of the ice cover of the Northern Hemisphere.

5.4.4 Ice draft observations using ice-profiling sonar have continued in the Fram Strait since 1987. The programme is continuing to 2000 as part of the Variability of Exchanges in the Nordic Seas (VEINS) initiative. Typically, four locations on the East Greenland continental slope near 80°N have been instrumented. The project is essential to ACSYS and CLIVAR, and its continuance has been strongly recommended by the SSG.

5.4.5 An increasing number of ice-draft data sets from nuclear submarines are being archived at the NSIDC, USA. Catalogues and data can be accessed at: http://www-nside.colorado.edu/NSIDC/CATALOG/ENTRIES/nsi-0061.html Data are available in two forms, as ice-draft profiles and as statistics derived from the profile data. As of November 1999, data from eight cruises in the years 1976, 1987, 1991-94, 1996-97 were in the archive (5 USA and 3 UK). These comprise 870 statistical ensembles, computed from over 40,000 km of survey track. All tracks lie within the central Arctic Ocean outside the EEZ's of Denmark, Canada and Russia. A recent discovery based on these data is an apparent dramatic thinning of ice in the central Arctic in the 1990's (WMO/TD No. 991, 2000).

5.4.6 Dr H. Melling underlined that the issue of the archival of sea-ice draft data was discussed at a special meeting held at the Norwegian Polar Institute on 27 June 1994 (see Appendix 3 to WMO/TD No. 991, 2000). Some recommendations were made. The issue was re-opened at the ACSYS workshop on Sea Ice Thickness Measurements and Data Analysis held in Montery, CA, USA from 7-11 April 1997. Some recommendations were also made, but a number of problems concerning the statistical treatment of data remained unresolved (see WMO/TD No. 991, 2000 for details).

5.4.7 Concern was expressed by the SSG that only a few of the measurements of ice draft by moored ice-profiling sonar were reaching the ACSYS archive. The reason is apparently the lack of accepted standard procedures both for the acquisition and for the processing of observations. Central to the issue is the important difference between the statistical characteristics of the ice cover that are derived in a distance-based analysis and those from the time-based analyses that is the only one practical if ice-motion observations were not acquired. The requirement for subjective decisions in the calibration of ice-draft data is also a concern; such decisions are required also in the calibration of data from submarines. Standards for the archival of ice-draft data from moored sonars were first proposed at the special meeting held at NPI in 1994. These were re-examined at the ACSYS Workshop on Sea Ice Thickness Measurements and Data Analysis held in Monterey (1997). Since that time, there has been no action on the issue. The SSG recommended that issues surrounding the acquisition, calibration, processing and statistical interpretation of sea-ice draft data be referred to the ACSYS Observation Products Panel for discussion and resolution. With standards in place, it should be easier to encourage the flow of new observations to the archive.

6. INTERNATIONAL ACSYS/CLIC PROJECT OFFICE (IACPO)

6.1 The meeting reviewed an annual (1998-1999) report of the Acting Director of the International ACSYS/CLIC Project Office (IACPO). The full text of the report is given in Appendix B. Following the relocation of the Norwegian Polar Institute from Oslo to Tromsø, the IACPO moved to its new location at the Polar Environmental Centre, Tromsø, Norway in January 1999. The Norwegian Polar Institute will support the IACPO until the completion of ACSYS in 2003. There are some clear indications that the Institute will be willing to support an International CLIC Project Office after the completion of ACSYS.

6.2 The Alfred Wegener Institute for Polar and Marine Research supported a position of the Deputy-Director of the IACPO until July 1999. JAMSTEC (Japan) continues providing some

financial support to the IACPO. WCRP office in Geneva provides IACPO staff with required international travel support. The SSG agreed that there was an urgent need in obtaining further resources to support the work of the IACPO. Members of the Group were tasked with identifying how this might be done through their individual national resources.

6.3 The SSG was informed by its Chairman, Dr H. Cattle, on the difficulties experienced in filling the post of D/IACPO at the Norwegian Polar Institute in Tromsø. Two suitable candidates had been found, but had subsequently withdrawn. Three additional applications for the post have been received since the SSG met. They will be interviewed in Tromsø from 18-19 February 2000 by the International Search Committee for D/IACPO.

6.4 After revising the IACPO Terms of Reference, the SSG agreed on the Terms of Reference for the office as given in Appendix C.

7. ORGANIZATION OF WCRP RESEARCH INTO CRYOSPHERE AND CLIMATE

7.1 Prof. R. Barry reported that the second session of the WCRP (JSC/ACSYS) Climate and Cryosphere (CLIC) Task Group was hosted by the Laboratoire de Glaciologie et Géophysique de l'Environnement, Grenoble, France from 10-13 August 1999. A report on the second session of the CLIC Task Group is attached as Appendix D. Following the JSC-XX advice, the CLIC Task Group reviewed and revised a draft CLIC Science and Co-ordination Plan (SCP) developed by the first session of the CLIC Task Group held in Utrecht, the Netherlands in July 1998. The meeting also addressed the strategy for co-ordination of CLIC and other relevant projects/programmes/activities. Comments made by polar science community on the draft plan developed by the Utrecht session of the CLIC Task Group were taken into account. The science questions were clarified and their focus sharpened. The IACPO put the revised version of the draft CLIC SCP on the ACSYS home pages. This version was further reviewed and revised by ACSYS SSG-VIII, which gave the necessary attention to strengthening the text of the plan and identified links with other programmes. A final draft of the CLIC Science and Co-ordination Plan is available electronically at:

ftp://npolar.no/Out/acsys/CLIC/

7.2 The meeting discussed an advisability of organizing a CLIC commitment conference in 2001, should the JSC-XXI (March 2000) decide that the CLIC project was to be launched as a separate WCRP element. Prof. R. Barry noted that, based on the success of the International CLIVAR Conference in December 1998, it would be desirable for CLIC to plan a corresponding activity. It was agreed that a schedule for this conference would be established following briefings to key national agencies in the primary countries likely to play an active role in CLIC.

8. ACSYS DATA AND INFORMATION FLOW MANAGEMENT

8.1 ACSYS OPP Activities

8.1.1 Prof. K. Steffen reported that the first session of the ACSYS Observation Products Panel (OPP) was organized in conjunction with the ACSYS combined meeting in Koblenz, Germany (see section 9.1). The panel members met for the first time to discuss and evaluate current and new techniques for providing sea-ice products for ACSYS use (particularly, in relation to model verification). The panel consists of eight members: J. Comiso (NASA/GSFC, USA), R. Kwok (NASA/JPL, USA), S. Laxon (University College London, UK), V. Smirnov (AARI, St. Petersburg, Russian Federation), K. Steffen (University of Colorado, USA), B. Ramsay/T. Carrieres (Canadian Ice Center, Canada), J. Ukita (Frontier Research Systems, Japan). The panel chairman is Prof. Steffen.

8.1.2 The OPP-I meeting reviewed remote-sensing techniques for sea-ice thickness, ice concentration and type, ice drift, surface albedo and temperature for

applications in ACSYS-relevant research, including model validation and parameterization. Most of these parameters can be readily assessed today with sufficient accuracy, and spatial and temporal resolution to be of use for model validation. Remote sensing from satellites provides reasonably accurate sea-ice extent since 1979. However, problems still exist in estimating sea-ice concentration in the summer when melt ponds are the dominant surface characteristics. Some very promising analyses of sea-ice motion from passive microwave, scatterometer, advanced very high resolution radiometer (AVHRR), and synthetic aperture radar (SAR) have been produced in the recent past. Combined analysis dating back to 1979 will soon be available. The Radarsat Geophysical Processing System is now producing estimates of sea-ice age and the thickness distribution of thin ice by combining motion fields (shear field and patterns of divergence/convergence) with simple ice growth models. No satellite sensor to date can measure sea-ice thickness directly, although the measurements of ice freeboard using radar altimetry show some promise. Sea-ice thickness remains the most important variable in need of additional data.

8.1.3 The Surface Heat Budget of the Arctic (SHEBA) project, which allowed a ship to freeze into the permanent ice pack for a year, has provided a wealth of new data that are being used for small-scale sea-ice process studies. New analyses of satellite-derived data (from 1978 to present) are providing information about interannual variability in sea-ice concentration, extent and motion. Further, homogeneous compilation of historical observations of sea-ice extent are now starting to show the long-term history of sea-ice cover. The increased level of complexity of large-scale climate models should allow significant improvements in their representation of sea- ice processes that would allow the study of the important feedback mechanisms in polar regions.

8.1.4 The panel agreed on the following agenda items to be discussed and evaluated in the future:

- evaluate user requirements of observational products obtained by *in-situ* and remote- sensing observations;
- evaluate techniques by which specified observational products are derived;
- evaluate data sets derived from the application of these techniques;
- review new techniques and products for application in ACSYS-relevant climate research;
- assess accuracy and recommend the best product for ACSYS use;
- liaise with other WCRP groups (GEWEX and CLIVAR) and external to WCRP groups.

8.1.5 The ACSYS SSG-VIII requested the OPP to consider a feasibility of an integrated ACSYS/CLIC strategy for determination of sea-ice thickness climatology combining data from a range of measurement techniques (electromagnetic observations from ships, ULS (moored and from submarines), remote-sensing measurements). The SSG encouraged the OPP to organize an intercomparison of sea-ice thickness data collected by moored ULS and those installed on submarines. The OPP was also requested to develop firm recommendations (in terms of statistics, data formats, etc.) for transfer of sea-ice thickness data by data collection centres to appropriate data archiving centres. The OPP was advised to contact organizers of a forthcoming ULS submarine data meeting and express the ACSYS interest in the sea-ice thickness data.

8.1.6 The second session of the OPP is planned for the period 4-7 October 2000 in Geneva. The ACSYS SSG-VIII agreed to move to a joint ACSYS/CLIC Panel on Observation Products.

8.1.7 Prof. R. Barry reported on concerns voiced at a GLIMS workshop in Zürich,Switzerland in August 1999 on pricing and access to SAR data for polar and cryospheric research. On behalf of the workshop, Prof. Barry presented a draft letter documenting these concerns. He requested this be considered for submission on behalf of the community to the WCRP from the ACSYS SSG Chairman. The matter was discussed in a subgroup (H. Cattle, R. Barry, B. Goodison, I. Allison) and B. Goodison undertook to prepare a revised letter suitable for relaying to various national space agencies.

8.2 ARDB Assembly

8.2.1 The ACSYS SSG-VIII was informed by Dr W. Froehlich, a representative of the Global Run-off Data Centre (GRDC, Koblenz, Germany), that the Arctic Run-off Data Base (ARDB) was updated in 1999 by data sets received from Canada, USA and Scandinavian countries. Information about the ARDB is available at the ADIS web site.

8.2.2 The ACSYS SSG-VIII recommended that a Pan-Arctic river run-off data base be utilized by the GRDC to provide monthly river run-off data, to the ARDB in particular to provide data on Arctic river flow over the last decade. Detailed information on the data base of Pan-Arctic River discharge (R-ArcticNet) is available at the following web site:

http://www.r-arcticnet.sr.unh.edu/main.html

8.2-3 The SSG further recommended that an inventory of Russian river run-off stations with locations and dates of closure be compiled and procedures to get data from regional Russian offices to be set up. The SSG finally recommended that a letter be sent from WMO to Russian authorities requesting release of the full set of Russian river run-off data to present day to the GRDC under provision of the Resolution 25 (WMO Cg-XIII).

8.3 APDA Assembly

8.3.1 The seventh session of the ACSYS SSG directed that a review of status and directions of the Arctic Precipitation Data Archive (APDA) be conducted Dr. B. Goodison reported that an ACSYS workshop on status and directions for the APDA was held in Offenbach, Germany from 30 March to 1 April 1999. The report on the workshop is published as the issue No. 14/1999 of the WCRP Informal Report Series. The workshop recommended that:

(i) a better focus of APDA as being a distinct activity within the Global Precipitation Climatology Centre (GPCC) be developed;
(ii) a monthly precipitation climatology for the ACSYS hydrological region be developed;
(iii) the focus of APDA be on development of the highest possible quality station/gauge-only products, as it is unlikely that satellite data will prove very useful within the ACSYS region in the near future, given the confines of current sensors and retrieval algorithms;
(iv) a strategy statement for the development of APDA until the end of ACSYS in 2003 be developed by GPCC staff, listing expected activities and priorities, possible sources of funding and how APDA could support the proposed WCRP CLIC project;
(v) the APDA adopt the data access policy recommended for the ARDB, i.e. that the data are freely and openly available for non-commercial scientific purposes.

8.3.2 The ACSYS SSG-VIII was informed by Dr T. Fuchs, a representative of theGPCC, that necessary steps were being taken towards the implementation of the

Offenbach (1999) workshop recommendations. The SSG agreed that the APDA (as well as the ARDB) should be continued beyond ACSYS into CLIC, depending on CLIC requirements to be defined.

8.4 ACSYS DMIP activities

8.4.1 On behalf of Dr W. Grabs, the chairman of the ACSYS Data Management and Information Panel (DMIP), Dr Froehlich reported that the second session of the ACSYS DMIP was held in conjunction with the ACSYS combined meeting in Koblenz, Germany (see section 9.1). The DMIP-II agreed on allocation of responsibilities and a deadline for the preparation of an outline of the ACSYS Data and Information Management Plan. The meeting further agreed on an extension and modifications of the ACSYS web site in order to improve the visibility of the ACSYS Data and Information Service (ADIS). Information on Arctic hydrological, and modelling data sets already assembled or being assembled, meteorological, sea-ice, glaciological, oceanographic, radiation, remote-sensing is available at the ACSYS ADIS web site:

http://www.npolar.no/oelke/adis.html.

The DMIP reiterated its position that the ACSYS DMIP should facilitate assembling and archiving of ACSYS data sets in designated data centres. DMIP and IACPO should establish a feedback with users and providers of Arctic ACSYS-related data and information. The meeting recommended that a centralized and well co-ordinated access to high quality cryospheric data sets be established. The distributed data sets should be accessible through a single-shop facility which could be an extended ADIS system. The DMIP-II noted, however, that an extension of services to CLIC was beyond IACPO's present resource capacity.

8.4.2 The ACSYS SSG-VIII recommended that DMIP consider and advise on identification and publication as necessary of data collected during the ACSYS period itself (1994-2003 inclusive). The SSG requested DMIP to define criteria for archiving of model data. The SSG agreed to move to a joint ACSYS/CLIC Data Management and Information Panel.

In reviewing developments in ACSYS/CLIC data management, the group recognised the limitations set by the size of the available resource. In discussion, the group identified the need to keep watch on developments with respect to Antarctic metadata, SCAR effort on which was, it was understood, under threat, but which was relevant in a WCRP context to CLIC. Prof. R. Barry agreed to keep the group informed on this issue.

8.4.3 Under this agenda item, the ACSYS SSG-VIII discussed the contents/ purpose of the ACSYS web site. The group agreed the need for continued development of the ACSYS Home Pages which were intended to provide information at a variety of levels on ACSYS and CLIC. Top level pages should provide effective summaries of the purpose and objectives of these projects with appropriate links to more detailed information as well as other Web Sites. The intended audience could be wide, including the general public curious about polar science, politicians and administrators and working scientists. It was agreed that the ACSYS glossy (see section 4.2 for details) once complete, should form a useful base on which to further build the Web Site.

8.5 Activities of the ACSYS Panel on Polar Products from Re-analyses

8.5.1 The meeting was briefed by Dr M. Serreze, the chairman of the ACSYS Panel on Polar Products from Re-analyses, on main results of Second International Conference on Re-analyses which was held from 23-27 August 1999 at Wokefield Park, Reading, UK. The conference included a Polar Applications Session, chaired by Dr Serreze. The session highlighted the use of re-analysis data in a wide variety

of polar applications, including assessments of hydrologic budgets, use as driving fields for sea-ice and regional atmospheric models, diagnosing air-sea interactions and understanding high-latitude climate variability. Trends such as those associated with the North Atlantic Oscillation, the Arctic Oscillation and ENSO were also highlighted. The provision of accurate representations of the vapour flux convergence over northern high latitudes is a major re-analysis success. It is also apparent that re-analyses are deficient in a number of respects that have hampered their use in some applications. This is particularly true for surface flux fields such as evaporation, radiation and precipitation. Problems are particularly severe in the data-sparse southern high latitudes.

8.5.2 Immediately following the Polar Applications Session, Dr. Serreze chaired an informal wrap-up. In attendance were most of the speakers at the session, along with representatives from the NCEP and ECMWF modelling teams. The purpose was to review the identified deficiencies in the present round of re-analyses that bear on the polar regions and how these are being addressed. The ACSYS Panel has itself been very active in advising and helping ECMWF with improved sea-ice data sets and with the numerical representation of sea ice for ERA-40.

8.5.1 The ACSYS SSG-VIII agreed to move a joint ACSYS/CLIC Panel on Polar Products from Re-analyses. The SSG requested the Panel to explore opportunities for ACSYS advice to the next NCEP re-analysis. The Panel was recommended to advise to re-analysis centres about GAME-Siberia data sets of soil moisture time series.

8.6 ACSYS historical data sets

8.6.1 Dr Oelke, Acting Director of the IACPO, presented a summary on ACSYS CD ROMs/historical data sets/data bases being assembled or already assembled, as detailed at::

http://www.npolar.no/oelke/adis_datasets.html

8.7. ACSYS/CLIC Panels

8.7.1 As already noted, the group agreed in principle to recommend to the JSC that there be a move to joint ACSYS/CLIC Panels for data management, observational products and polar products for re-analysis. Setting the data management strategy for CLIC was seen as the most urgent at this time, and the DMIP were asked to explicitly consider this issue at their next meeting. It was also agreed that there was a potential need for the ARDB and APDA to be continued beyond the ACSYS timeframe and into CLIC, depending on CLIC requirements, to be defined.

8.7.2 The group agreed that changes would be needed in the ToR of the DMIP, OPP, Panel on Polar Products from Re-analysis, and in the main provisions of APDA and ARDB to reflect the tasking under CLIC as well as ACSYS. Dr Cattle agreed to do this in consultation with Panel Chairs in the first instance and to report to and agree revised ToRs with the SSG via e-mail, once the JSC had decided whether to proceed with CLIC itself.

9. ACSYS MODELLING ACTIVITIES AND RELATED ISSUES

9.1 A combined ACSYS meeting in support of Sea-Ice/Ocean Modelling

9.1.1 An ACSYS meeting on data and data management in support of sea-ice/ ocean modelling activities was held in Koblenz, Germany from 28 June-1 July 1999 The meeting was organized as a combined meeting of the second session of the ACSYS Numerical Experimentation Group (NEG-II), the second session of the

ACSYS Data Management and Information Panel (DMIP-II), and the first session of the ACSYS Observation Products Panel (OPP-I). Professor P. Lemke, a member of the ACSYS SSG, chaired the combined meeting, general objectives of which were:

1. To review the potential of the current data base to support ACSYS modelling activities.
2. To discuss modelling strategies for optimal use of available observations, and
3. To discuss strategies for future observations in support of model validation and optimisation.

9.1.2 The format of the combined meeting envisaged plenary sessions and sessions of the enhanced ACSYS group/panels. During the plenary sessions, directions for co-operation between ACSYS observational, modelling and data management experts in meeting the ACSYS goal and objectives were discussed and agreed. Specific activities and future plans of the ACSYS NEG, DMIP and OPP were discussed in detail at their separate meetings held simultaneously on 28-30 June 1999. Each separate meeting was organized and chaired by an appropriate chairman of the ACSYS group/panel. Results of the separate meetings of the ACSYS NEG-II, DMIP-II and OPP-I are reported in sections 9.3, 8.4 and 8.1 accordingly.

9.1.3 The combined ACSYS meeting recommended that (see WCRP Informal Report No.6, 2000 for details):

(i) the WCRP International Programme for Antarctic Buoys be continued as the data collected by the IPAB were not available from any other sources;
(ii) all available sea-ice thickness measurement data be optimally interpolated to provide gridded annual and seasonal mean climatological sea-ice thickness fields for both hemispheres, taking into account that the fields are extremely valuable for sea-ice model evaluation and other climate research applications; this remains to be scoped;
(iii) efforts be continued to develop a reliable gauge correction procedure for solid precipitation measurements in high latitudes; it will be initiated by ACSYS/CLIC in co-operation with GAME-Siberia;
(iv) data sets on run-off from the Greenland and Antarctic ice sheets/shelves be assembled by applying a modelling approach based on simple degree-day methods, high resolution digital elevation models and ECMWF climate parameters;
(v) data sets on iceberg calving from the Greenland and Antarctic ice sheets/shelves be developed utilizing ship-born data assembled by the Norwegian Polar Institute and available ice-margin data from satellites;
(vi) the next combined meeting of the ACSYS NEG, DMIP and OPP be organized in 2001.

9.2 The first session of the ACSYS NEG

Prof. P. Lemke briefed the meeting on the main results of the first session of the ACSYS Numerical Experimentation Group (Appendix E).

9.3 The second session of the ACSYS NEG

9.3.1 Dr G. Flato reported that the second session of the ACSYS NEG was held in conjunction with the ACSYS combined meeting in Koblenz, Germany (see section 9.1). Prof. P. Lemke stepped down as the chairman of the NEG. Dr G. Flato from the Canadian Centre for Climate Modelling and Analysis was nominated to serve as the chairman of the NEG. The meeting summarized modelling data requirements and, based on both the utility and availability of various data, recommended that special efforts be devoted to improve climatological sea-ice thickness estimates, snow water equivalent data, and estimates of heat/salt/mass fluxes through the

straits connecting the Arctic Ocean with the global ocean.

9.3.2 The NEG-II agreed to co-ordinate one-dimensional sea-ice model studies using the SHEBA atmospheric and oceanic data as forcing for an annual cycle. The ACSYS NEG would promote one-dimensional atmosphere-sea-ice-ocean column model experiments, using the SHEBA data set. The focus would be on coupled processes and feedback, boundary layers and radiative transfer. This will be done in collaboration with the GEWEX Cloud System Study (GCSS) Working Group on Polar Clouds. The meeting also recommended that an Arctic regional climate model (RCM) intercomparison study be organized. The goal will be to quantify and understand differences in simulated Arctic climate from one model to the next, to investigate the role of model resolution and boundary location/orientation, and to improve the parameterization of processes important in simulating Arctic regional climate.

9.3.3 The third session of the ACSYS NEG will be held in the International Arctic Research Centre of the University of Alaska Fairbanks, Fairbanks, Alaska, USA, from 11-15 September 2000. The session will be organized as a combined meeting with an Arctic Climate Model Intercomparison Project Workshop.

9.4 ASPeCT CD-ROM

An application received by WCRP from SCAR ASPeCT for financial support towards publication of sea-ice data on CD ROM was reviewed by a sub-group of the meeting and subsequently agreed by plenary. The activity was seen to be of direct relevance not only to ACSYS/CLIC but also to WCRP more widely. It was agreed, therefore, to recommend to WCRP that though they should not pay towards the cost of data preparation, it would be appropriate for some contribution to be made from ACSYS/CLIC funds towards the cost of publication.

9.5 Hydrology Models Intercomparison

9.5.1 Prof. D. Lettemaier reported that the GEWEX/ACSYS Workshop on Cold Regions Hydrological Modelling (Quebec City, Canada, 25-27 August 1998) recommended that an intercomparison of hydrological models be planned with the objective of identifying the capabilities of models to simulate high-latitude water and energy cycles. It was suggested that a small working group be formed jointly by ACSYS and GEWEX to develop a science plan for the intercomparison (WCRP Informal Report No. 13, 1999). The suggested meeting took place in Koblenz, Germany from 27-29 March 1999. The meeting examined:

1. The feasibility and desirability of study areas for the proposed intercomparison, and
2. The structure of the intercomparison and participating models.

9.5.2 The meeting developed a strategy and an Experiment Plan for the intercomparison which will take place in a phased approach and will be modelled after the WCRP/GEWEX Project for Intercomparison of Land-surface Parameterization Schemes (PILPS) 2c experiment (see WCRP Informal Report No. 12, 1999 for details). Dr D. Lettenmaier at the University of Washington has agreed to co-ordinate Phase 1, which will utilize data from the Torne River Basin in Sweden. Phases 2 and 3, planning for which will depend on the outcome of Phase 1, would tentatively utilize data from the GEWEX Continental-Scale Experiments in the Mackenzie River Basin (MAGS) and the Lena River Basin (GAME-Siberia). The ACSYS SSG-VIII reviewed and approved the Experiment Plan.

9.6 ACSYS/CLIC NEG

In anticipation of launching a CLIC project as an element of the WCRP, the ACSYS SSG-VIII discusses the expanding role the ACSYS NEG might be expected to fulfil. The

SSG agreed to recommend a move to an ACSYS/CLIC NEG. The following Terms of Reference of the ACSYS/CLIC Numerical Experimentation Group were agreed:

TERMS OF REFERENCE OF THE ACSYS/CLIC NEG

General terms of reference:

1. In liaison with other NEGs within the WCRP:

   - to address cryospheric modelling issues of the coupled system (atmosphere, sea ice, ocean, ice sheets, ice shelves, ice caps, glaciers, and land hydrology including snow cover, frozen ground, permafrost, and lake and river ice) relevant to ACSYS/CLIC;
   - to promote the investigation and improvement of the parameterisation of specific cryospheric processes in climate models;
   - to distribute the improved parameterisations.

2. To advise the ACSYS/CLIC SSG on data requirements for model development, validation and optimisation, and on archiving model output, and

3. To develop, review and update as appropriate the ACSYS and CLIC implementation plans on a regular basis.

Specific terms of reference are:

4. To create temporary task groups where required to:

   - promote the improvement and evaluation of models of individual components of the cryosphere;
   - investigate coupling processes and techniques in models whose representations of cryospheric components are interactively connected in part or in combination, and
   - advise the ACSYS/CLIC SSG on the use of data assimilation techniques applied to individual components and coupled models.

10. ACSYS/CLIC/CLIVAR AND ACSYS/CLIC/GEWEX LINKS

10.1 ACSYS/CLIC/CLIVAR co-operation

10.1.1 Dr D. Martinson briefed the meeting on actions taken by the eighth session of the CLIVAR SSG (10-14 May 1999, Southampton, UK) in the areas relevant to ACSYS and CLIC. The CLIVAR SSG-VIII saw a need to develop an effective means to deal with CLIC/CLIVAR overlap/interaction on a wide range of issues. It was suggested that this could be in the form of a common member of SSGs and working groups/panels.

10.1.2 The CLIVAR SSG-VIII updated its philosophy of co-operation between CLIVAR, ACSYS and CLIC, reiterating that a number of cryosphere related issues overlapped in the science plans of these projects. CLIC would work to ensure that all issues are addressed (minimizing overlap and optimizing co-operation) regardless of which project took the lead. No cryosphere issue would be removed from one project and relocated to another (e.g., cryosphere issues that are presented in CLIVAR will not be removed from CLIVAR and "taken over" by ACSYS or CLIC). Issues in any Science Plan are directly relevant to that project and therefore must be addressed. CLIVAR will concentrate on those issues of direct relevance to global climate.

10.1.3 CLIVAR will be organizing a workshop in Perth, Australia from 17-20 November

2000 to discuss Southern Ocean issues and plans for addressing them by interested parties. This mainly involves the D5 Principal Research Area (PRA) of CLIVAR. Since this is one of the PRAs containing PRA material of direct interest to CLIC and ACSYS, then CLIVAR SSG has suggested that appropriate representatives are present in the workshop to help facilitate the optimal means of addressing the cryospheric issues of that PRA. The ACSYS SSG VIII agreed to help facilitate this.

10.2 GEWEX Working Group on Polar Clouds activities

10.2.1 Following a request made by the ACSYS SSG-VII, Dr Flato (on behalf of Prof. J. Curry) reported on GEWEX Working Group on Polar Clouds activities relevant to ACSYS. The Polar Clouds and Radiation Programme initiated by ACSYS has evolved into a GEWEX project called the GEWEX Cloud System Study (GCSS) Working Group on Polar Clouds. This project was initiated in December 1998, with J. Curry as chair. The GCSS Working Group on Polar Clouds aims to improve the understanding and model parameterization of cloud, radiative, and boundary layer processes in the polar regions. The overall methodology is to conduct careful intercomparisons between models and observational case studies. The primary working group activities focus on a wide range of modelling activities, although data analysis and integration and field studies play an integral role in the working group activities.

10.2.2 Of central interest to the GCSS modelling effort are Cloud Resolving Models (CRMs) and Single Column Models (SCMs). General Circulation Models (GCMS) and process models (e.g. radiative transfer models) are also important to the GCSS modelling activities. Over almost 100 people are registered participants in this group, including modelers, field observation and remote-sensing scientists, and programme managers. Scientists from Canada, Spain, the Netherlands, the United Kingdom, Russia, and Germany are participating, in addition to a large number from the USA.

10.2.3 Data obtained from the recent SHEBA, FIRE, and ARM field programmes are providing the initial focus for working group activities. A web page has been developed:

http://paos.colorado.edu/~curryja/wg5/over.html

which contains projects and case studies (including direct data links), a list of publications, and a participants list. Project activities are managed mainly on the web page. A newsletter is sent to participants approximately every other month. Initial projects that are being assembled include:

1. preparation of several case studies for an intercomparison of radiative transfer models;
2. assembly of several case studies against which to evaluate microphysical models, and
3. assembly of a year-long dataset with which to force and evaluate single-column models.

10.2.4 The GCSS Working Group on Polar Clouds is collaborating with the ACSYS NEG on the following two projects:

1. intercomparison of single-column models of the coupled atmosphere-ice-ocean system, and
2. participation in the intercomparison of Arctic regional models for the SHEBA year.

10.3 Summary on GHP-V results and CEOP-I planning

10.3.1 A report on the fifth GEWEX Hydrometeorology Panel meeting (13-17

September1999, Hamburg, Germany) and plans for the Coordinated Enhanced Observing Period (CEOP) were presented by Dr R. Lawford. In addition to CEOP, GHP highlights of relevance to ACSYS include the water and energy budget studies being undertaken by each of the five Continental Scale Experiments, the implementation of a data and management working group, progress on a joint GEWEX/ACSYS hydrologic model intercomparison and an upcoming soil moisture workshop. In addition, GHP members discussed the newly funded ISLSCP-II data base development initiative and the formation of a water resources working group. Ongoing GEWEX projects of relevance to both GHP and ACSYS include Project for the Intercomparison of Land Process Schemes (PILPS) , Model Parameter Estimation Experiment (MOPEX), GCSS, GPCP, GRDC, GEWEX Water Vapor Project (GVaP) and new land surface initiatives. Each of the cold region/season CSEs have specific studies that relate to ACSYS. MAGS, which lies in the Arctic drainage basin, has made considerable progress in understanding hydrometeorological processes within the Mackenzie River Basin through studies of the 1994/95 low flow water year and through its intensive observation period (CAGES) in 1998/99. GAME-Siberia has obtained new data sets from its intensive observations in the Lena River Basin. BALTEX which includes many cold region processes has undertaken runs with high resolution mesoscale models to simulate cold season processes and is developing data systems relying on GPS. BALTEX is preparing for intensive observational periods in summer 2000, spring 2001 and winter 2002. GCIP has been incorporating seasonal ground frost and heterogeneous snow cover into its land surface and coupled models as part of its winter season research. In addition, GCIP's efforts in developing a land data assimilation system hold promise of providing a missing component for initializing climate prediction models.

10.3.2 The GEWEX CEOP is directed at "studying the influence of continental hydro- climate processes on the predictability of global atmospheric circulation patterns and changes in water resources on time scales up to seasonal." The initiative is aimed at understanding how land areas respond to the large scale climate system, how land-atmosphere surface interactions feed back onto regional and larger scale climate systems and how these processes operate over diurnal and annual cycles. The initiative will involve an observational initiative during 2001 that will take advantage of new satellites coming on-line during that period as well as the continuation of the Continental Scale Experiments (CSEs) through this period. Data set development efforts will include those obtained from reference sites in each CSE, coupled model transferability studies between CSEs, satellite remote sensing validation studies and the initiation of an extensive study of land-ocean-atmosphere interactions in the Asian/Australian Monsoon Region.

10.3.3 In addition to the extensive briefings provided on other GEWEX activities, Dr. R. Lawford summarized several new initiatives within GEWEX including the GEWEX Water Vapor Project (GVaP) and new land surface initiatives within the GEWEX Modeling and Prediction Panel (GMPP). Based on this presentation, a number of ACSYS/ GEWEX links were identified pertaining to:

- acquisition of validation data sets from the ACSYS region for GEWEX data products;
- inclusion of ACSYS water and energy budget studies in the GEWEX WEBS initiative;
- co-ordination issues between CLIC and GEWEX relative to areas of common interest/concern;
- more electronic links between GEWEX and ACSYS home pages;
- a possible GEWEX/ ACSYS workshop on solid precipitation;
- opportunities for ACSYS use of GEWEX infrastructure within the Arctic Ocean drainage basin.

10.4 GAME-Siberia activities

Prof. T. Ohata briefed the meeting on activities undertaken by the GAME-Siberia (Appendix F).

10.5 Strengthening links between ACSYS/CLIC and GEWEX and CLIVAR

10.5.1 Dr Cattle reported on a visit made by IACPO staff and himself to the International CLIVAR Project Office (ICPO). It was agreed that the links established by that visit should be developed further. In particular, the DMIP should consider the CLIVAR Data Task Team (DTT) report and its implications for ACSYS/CLIC. As identified by Dr Martinson, the region of the Nordic Seas forms a particular area of joint scientific interest and the need to explore the possibility of an ACSYS link to the CLIVAR North Atlantic Panel was identified. Dr Cattle agreed to take this up with the ICPO in the first instance.

10.5.2 The group agreed that a similar visit of IACPO staff to the International GEWEX Project Office was desirable, particularly once the new D/IACPO is in place. In consideration of particular areas of potential joint ACSYS/CLIC/GEWEX interaction identified by Dr Lawford (see section 10.3), the group agreed:

- to provide input as appropriate to ISLSCP parameter requirements once received;
- to explore the possibility of ACSYS promotion of ground truth for GEWEX water vapour satellite remote-sensing data sets with the US ARM CART site at Barrow, Alaska;
- to scope a possible ACSYS contribution to study of the water and energy budget for the Arctic Basin as a component of WEBS, based on re-analysis and other data;
- to make a presentation on CLIC to the GEWEX SSG at its next meeting in Honolulu in January 2000 (to be made by Dr Goodison).

10.5.3 The group also identified NASA's Cold Processes Mission as being of particular relevance to ACSYS/CLIC, as well as to both GEWEX and CLIVAR. The group wished to bring the relevance of this mission to all three WCRP projects to the attention of both NASA and the JSC.

11. STATUS AND FUTURE PLANS FOR ACSYS OBSERVATIONAL COMPONENTS

11.1 The ACSYS Arctic Ocean Circulation Programme

11.1.1 Dr P. Jones informed the meeting that in the framework of the Barrow Strait Flow-Through Study, a CTD survey of channels in the Barrow Strait-Lancaster Sound was carried out in 1999. A finite element model to simulate barotropic flow in response to a 10 cm elevation difference between the Beaufort Sea relative to Baffin Bay is under development.

11.1.2 Dr E. Fahrbach reported that transient tracer measurements suggested that in spite of the absence of open-ocean deep convection in the Greenland Sea and suspension-driven slope convection off Spitsbergen, deep-water renewal did occur. A follow-up programme will start in 2000 to investigate the hypothesis that the roughness of the Greenland continental slope is able to generate downslope flow perpendicular to the East Greenland Current.

11.1.3 Dr M. Serreze informed the meeting that the US National Science Foundation (NSF) Arctic System Science (ARCSS) programme was developing a new initiative known as the Study of Environmental Arctic Change (SEARCH). This initiative is intended to promote an understanding of the complex of environmental change

observed in northern high latitudes over the past several decades. This includes general warming, shifts in atmospheric circulation seen in a tendency towards positive modes of the Arctic Oscillation and North Atlantic Oscillation, increased areal extent and warming of Atlantic-derived waters in the Arctic Ocean, reductions in sea-ice extent and terrestrial snow cover, permafrost warming and alterations in terrestrial ecosystems. SEARCH will include both diagnostic studies and monitoring programmes. A related NSF effort known as Shelf-Basin Interactions (SBI) will take a systems-oriented approach to understanding shelf-basin exchange in the Arctic. SBI is envisioned to be a major contributor to SEARCH. SEARCH recognizes the need for international collaboration and is seeking to link with and contribute to efforts under ACSYS and CLIC.

11.2 The ACSYS Sea-Ice Programme

11.2.1 Dr H. Melling reported that in 1997, the US National Ice Centre released a release is expected in March 2000. The Canadian Ice Service has completed the transfer of their ice-chart archive from hard-copy media to ArcInfo format on CD-ROM. Chart series are available for the Canadian East Coast and Hudson Bay, the eastern Canadian Arctic and the western North American Arctic for the years 1968-1997. The CD-ROM will be released in March 2000. Additional contributions to the Global Digital Sea-Ice Data Bank were received from Russia, USA, Finland and Sweden in 1999. The principal Arctic data sets in this archive will be presented in the SIGRID and EASE-GRID formats in the Joint Russian-American Atlas of Arctic Sea Ice on CD-ROM in June 2000. The Radarsat Geophysical Processing System at the Alaska SAR Facility is now quasi-operational, providing a weekly snapshot of Arctic ice at a resolution of 200 m. Derived products from the imagery are under evaluation.

11.2.2 The first trial of the British Autosub AUV with upward-looking sonar will be conducted in December 2000 from the RRS *James Clark Ross* in the Antarctic. The AUV will run under floes to profile thickness in the marginal ice zone.

11.2.3 Ice draft monitoring in the Beaufort Sea is continuing through 2000 with four sites instrumented along the margin of the perennial pack ice. The development and decay of ice-thickness distributions in seasonal ice is being studied in a Eulerian framework using data from sonars moored in the Beaufort Sea. An important gap in our present understanding of the thickness distribution of pack ice involves the thermal evolution of ridged ice through consolidation and melt. There are no studies that follow this evolution in a Lagrangian framework.

11.2.4 The Radarsat Geophysical Processing System at the Alaska SAR facility uses consecutive snapshots of Arctic ice by Radarsat ScanSAR to measure ice-cover deformation, and compute the area of new ice. By modelling the continuing growth of new ice in leads, a thickness distribution for new ice can be determined.

11.2.5 Weekly measurements of ice thickness and on-ice snow depth at 195 sites on fast ice across Canada are available via the Internet at:

http://www.cis.ec.gc.ca/cia/icesnow.html

Some of the Arctic stations date back to the late 1940s.

10.1.1 Canadian scientists are evaluating a technique to measure the transport of sea ice through the Canadian Arctic Archipelago, combining ice profiling and Doppler sonars for accurate point measurements with Radarsat to guide extrapolation of the point measurements across the complex system of interconnecting channels of the Canadian Arctic. Instruments to measure currents have been in place in Smith, Lancaster and Jones Sounds since 1997. The array will be augmented with ice-profiling sonar in 2000.

11.3 The ACSYS Arctic Atmosphere Programme

11.3.1 Dr M. Serreze provided a summary on ACSYS Arctic Atmosphere Programme studies. The ACSYS SSG-VIII reviewed on-going efforts under the ACSYS Arctic Atmosphere Programme and noted:

a. the growth of interest in Arctic atmospheric processes stemming from recognition of links between the Arctic Oscillation, observed warming over northern high latitudes and changes in other environmental variables; increasing interest in the applications of re-analysis data to study Arctic processes, and in particular, the atmospheric hydrologic budget via analysis of the vapor flux convergence;
b. advances in our understanding of polar processes from the success of the SHEBA field effort;
c. activities relevant to ACSYS on polar clouds and radiation, carried out under the GEWEX Cloud System Study Working Group on Polar Clouds.

The group also noted a number of activities related to atmospheric re-analyses, reported under Section 8.5.

11.4 The ACSYS Hydrological Programme

11.4.1 The ACSYS SSG-VIII discussed a proposal made by Prof. V. Vuglinsky to establish an Arctic regional component (ARCTIC-HYCOS) of the World Hydrological Cycle Observing System (WHYCOS). The main purpose of the ARCTIC-HYCOS will be the monitoring of a fresh water in-flow to the Arctic Ocean. The group agreed that there may be advantage in an ARCTIC-HYCOS and recommended that the Hydrology and Water Resources Department of WMO be approached by Prof. V. Vuglinsky and requested to advise on a feasibility of the ARCTIC-HYCOS initiative.

11.4.2 Other relevant activities are reported under Sections 8.2; 8.3 and 9.5.

11.5 Research interest and planned activities/achieved results of institutional and international programmes and initiatives relevant to ACSYS

11.5.1 *Surface Heat Budget of the Arctic Ocean (SHEBA)*

On behalf of Prof. J. Curry, Dr H. Cattle informed the meeting that since the completion of the SHEBA field experiment in October 1999, investigators have been preparing their data sets. Preliminary data can be accessed via the SHEBA home page: http://sheba.apl.washington.edu/. The data remain proprietary until October 2000, but can be utilized with permission of the principal investigator for a particular data set. Several working groups have been formed to facilitate co-ordinated use of the SHEBA data set to meet modelling and remote-sensing objectives. Special issues in the Journal of Geophysical Research are planned for the FIRE Arctic Clouds Experiment (papers due December 1999) and for SHEBA (papers due February 2000). The next SHEBA workshop is scheduled for April 2000 in Boulder, Colorado, USA. The third and final phase of SHEBA funding commences in April 2000, which focuses on data analysis and modelling. SHEBA data are a focal point for GCSS Working Group on Polar Clouds modelling activities. SHEBA investigators are also very interested in co-ordinating with the ACSYS NEG on using SHEBA data to design a testbed for evaluating the thermodynamic component of sea-ice models.

11.5.2 *The programme for Arctic Regional Climate Assessment (PARCA)*

Prof. K. Steffen presented a summary on PARCA research (Appendix G).

11.5.3 *Some Norwegian and Nordic studies relevant to ACSYS*

Prof. T. McClimans briefed the meeting on some ACSYS-relevant Norwegian and Nordic programmes (Appendix H).

11.5.4 *Russian ACSYS-related activities*

A summary on ACSYS-related activities in the Russian Federation was presented by Prof. G. Alekseev (Appendix I).

11.5.5 *Frontier Observational Research System for Global Change*

Prof. T. Ohata reported that a research body for observation under the Frontier Research System for Global Change, has been established in August 1999 to implement measurement of long-term variation of the climate system and to prepare data sets for modelling of various components of the climate system for 10-20 year time period. Research related to ACSYS/CLIC are the Water Cycle and programmes of the International Agricultural Research Centre (IARC). Land-surface processes (including surface water/heat exchange and run-off characteristics in the northern part of the continents, mainly Siberia) and the Arctic Ocean will be studied. Inclusion of observation of cryospheric components being considered. It is hoped that this system can contribute to the study and assembling of data sets of the essential components in the climate system.

11.5.6 *SCAR programme on Global Change and the Antarctic (GLOCHANT)*

The meeting was briefed by Dr I. Allison on current status and future plans of the SCAR GLOCHANT programme (Appendix J).

11.5.7 *Cryospheric System to Monitor Global Change in Canada (CRYSYS)*

11.5.7.1 Dr. B. Goodison provided an update of the Canadian CRYSYS initiative on variability and change in the cryospheric system in Canada. The updated objectives of the project are to develop capabilities for improved satellite-based measurement, monitoring and understanding of cryospheric variables over a range of spatial and temporal scales; to contribute to development and validation of local, regional and global models of climate -cryospheric processes and dynamics, and to improve understanding of the role of the cryosphere in the climate system; and, to assemble, maintain and analyze key historical, operational and research cryospheric data sets for climate monitoring, model development and validation, and change analysis. Significant advances or new thrusts include the following:

- the cryosphere is a distinct part of the Earth and Environment component of the new Canadian Space Plan;
- the team is in the process of initiating a Canadian Cryospheric Information Network, a means of accessing Canadian snow and ice data, including agency archive data, through a single entry point;
- implementing, as part of its web site, a section on the “State of the Canadian Cryosphere”;
- initiating discussions on possible contributions to a Canadian CLIC initiative and sources of funding of university research;
- participated in, and leading the preparation of the cryosphere component of the Canadian GCOS Plan. Canada recognizes the cryosphere and hydrosphere as separate entities within GCOS to allow their distinctive needs to be properly assessed.

11.5.7.2 A summary of the projects within the three components of

cryospheric measurement and monitoring, modelling and variability was also provided. Details are available on the CRYSYS web site at::

http://www.tor.ec.gc.ca/crysys/.

It was noted that although the CRYSYS team originally started as an EOS IDS team, it has grown such that it is able to bring together much of the Canadian cryospheric community to address cryosphere-climate issues of concern in Canada. Within the Canadian Climate Change Action Fund the team had two research proposals accepted for completion over the next two years: definition of a core Canadian Cryospheric Network of *in-situ* and remotely- sensed data for monitoring the Canadian cryosphere in support of GCOS; and, state of the Arctic cryosphere during the extreme warm summer of 1998: documenting cryospheric variability in the Canadian Arctic for assessing the significance of recent warming.

12. ACSYS/CLIC MEETINGS IN 2000-2001

12.1 Following review, the group agreed to hold the following meetings in 2000:

- DMIP-II, Boulder, Colorado, USA, 30 May-2June 2000;
- OPP-II, Geneva, Switzerland, 4-7 October 2000;
- ACSYS NEG-III, Fairbanks, Alaska, USA, 11-15 September 2000.

12.2 The group also agreed to proceed with the long-anticipated Workshop on Measurements and Models of the Arctic Ocean System, to be held at Lamont-Doherty Earth Observatory, Palisades, New York, USA during 2000. Drs Fahrbach, Flato, Jones, McClimans and Melling agreed to help with further scoping the workshop as needed.

12.3 Potential meetings for 2001 included a joint ACSYS/CLIC/GEWEX Workshop on Solid Precipitation (a follow-on from the 1995 ACSYS solid precipitation climatology project workshop held in Reston, VA, USA), to be scoped by Drs Lawford, Barry and Lettenmaier, and a CLIC Commitment Conference. The next meeting of the SSG should also begin consideration of a final ACSYS Conference, to be held possibly in 2002/03.

13. JSC-XX QUERIES

13.1 The JSC-XX requested each WCRP project group to:

i. detail current and foreseen linkages with IGBP projects and means of enabling them (overall report to be given to JSC-XXI);
ii. improve links between GEWEX and other components of WCRP to discuss overall requirements/use of satellite-derived data sets; and
iii. consider how advantage can be taken of CEOP and contributions that could be made.

13.2 Responding to the request (i) above, the ACSYS SSG-VIII noted that the key link with IGBP was through IGBP PAGES, aspects of which were seen as directly relevant to CLIC, which will need to take action to ensure this is fully explored.

13.2.1 Responding to the requests (ii) and (iii) above, the SSG noted that these were felt to be covered by the meeting under agenda items 10.5 and 10.3 respectively.

14. ACSYS/CLIC SSG

14.1 It was noted that the terms of four members of the SSG will expire on 31 December 1999 and of eight other members on 31 December 2000. Assuming JSC approval of CLIC, the group agreed on the need to establish a joint ACSYS/CLIC SSG to provide scientific

guidance on the implementation of ACSYS until 31 December 2003 and the organization of CLIC activities from 2000 onwards. The group considered a number of potential candidates for SSG membership.

14.2 Appendix K contains the suggested Terms of Reference for the ACSYS/CLIC SSG.

15. SUMMARY OF THE MEETING AND ACTIONS TAKEN

15.1 Dr Cattle summarised the outcome of the meeting via an action list which was agreed by the meeting (Appendix L). The meeting, which he felt had been a very productive one, had been assisted by the considerable hospitality and help offered by the meeting hosts and he expressed his gratitude for the very considerable assistance given.

15.2 The group gracefully accepted the kind invitation from Prof. P. Lemke to host the next session of the SSG in Kiel, Germany, from 23 to 27 October 2000.

References

WCRP Informal Report No. 12, 1999: Report on the hydrology models intercomparison planning meeting (Koblenz, Germany, 27-29 March 1999).

WCRP Informal Report No. 13, 1999: Report of the GEWEX/ACSYS workshop on cold regions hydrological modelling (Quebec City, Canada, 25-27 August 1998).

WCRP Informal Report No. 14, 1999: Report of the ACSYS workshop on status and directions for the Arctic Precipitation Data Archive (Offenbach, Germany, 30 March-1 April 1999).

WCRP Informal Report No. 15, 1999: Summary report of the seventh session of the WCRP ACSYS Scientific Steering Group (Tokyo, Japan, 2-6 November 1998).

WCRP Informal Report No. 6, 2000: Summary report of an ACSYS meeting on Data and
Data Management in Support of Sea-Ice/Ocean Modelling (Koblenz, Germany, 28 June-1 July 1999).

WMO/TD No. 976, 1999: Annual review of the World Climate Research Programme and Report of the twentieth session of the Joint Scientific Committee (Kiel, Germany, 15-19 March 1999).

WMO/TD No. 991, 2000: Joint report of the fourth session of the ACSYS Sea Ice/Ocean Modelling (SIOM) Panel and the ACSYS workshop on Sea Ice Thickness Measurements and Data Analysis (Monterey, CA, USA, 7-11 April 1997). Eds. P. Lemke and R. Colony.

Appendices

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Annual Report of the International ACSYS/CLIC Project Office (IACPO) (November 1998 to November 1999)

(by Christoph Oelke, Acting Director)

The International ACSYS/CLIC Project Office (IACPO) was initially established to support the ACSYS Scientific Steering Group (SSG) in implementing the Arctic Climate System Study (ACSYS). This support includes service to the ACSYS research community and to ACSYS observation, modelling and data management activities. In particular, the IACPO promulgates and represents ACSYS in the international community, organizes workshops and conferences, identifies and establishes new data sets, and initiates small projects. This short report summarizes activities for the period November 1998 through November 1999 and gives an outlook to anticipated activities for 2000.

From 1 January 1999 the Project Office took on the responsibility for the anticipated new WCRP project Climate and Cryosphere (CLIC) and modified its name to the International ACSYS/CLIC Project Office. The newly established CLIC Task Group is responsible to the Joint Scientific Committee (JSC) for WCRP through the ACSYS SSG for the development of a Science and Coordination Plan for CLIC. The IACPO is active in planning the CLIC project and in informing the broader scientific community to ensure the widest possible participation of all interested nations. CLIC is anticipated to be launched as a separate component of WCRP after the next meeting of the JSC for WCRP in March 2000. ACSYS will remain a distinctive project until the end of its lifetime at the end of 2003.

As acting director of IACPO, I participated in both ACSYS SSG meetings within the 1998/1999 time period, and took part in the 20th session of the JSC for WCRP (which emphasizes the connections and necessary co-ordination between the various WCRP projects. I also attended the 2nd CLIC Task Group meeting to work on the draft of the Science and Co-ordination Plan and gain perspective on the extended responsibility of IACPO for the additional subdisciplines of glaciology and cryospheric components, i.e., glaciers, ice sheets and ice caps, snow cover, perennially and seasonally frozen ground, lake, river and sea ice worldwide addressed by CLIC. The worldwide geographical coverage of cryospheric problems will likely involve further nations in mid-latitudes, the tropics and the southern hemisphere in CLIC.

During the past year both changes in personnel and geographical location of the IACPO took place. Roger Colony, director from 1995 through 1998, left the Project Office to take a position at the new International Arctic Research Center (IARC) in Fairbanks/Alaska. The effort of WCRP and the Norwegian Polar Institute (NPI) to find a new director for IACPO has been unsuccessful so far. In the meantime I have served as acting director of IACPO, assisted by our office co-ordinator Tordis Villinger. IACPO was managed in consultation with the ACSYS SSG chairman Howard Cattle, the JPS of WCRP, the ACSYS SSG members, and the sub-panel chairmen.

Following the relocation of the Norwegian Polar Institute from Oslo to Tromsø the IACPO moved to its new location at the Polar Environmental Centre in January. The IACPO occupies 3 offices in the 6th floor of the building, and holds additional storage space at 2 different locations. The facilities at the Norwegian Polar Institute are excellent.

IACPO is active in supporting activities in the Russian shelf seas: Within the ocean part of the Norwegian program Transport and Fate of Contaminants in Northern Seas, IACPO co-ordinates the creation of an oceanographic data base for the White, Barents and Kara Seas (BarKode). Two workshops in Tromsø and Helsinki were held in 1999. The unique hydrographic data set covers the 100-year time period 1898-1998 and is the most complete one for this area. It will be released by IACPO on CD-ROM in co-operation with scientists from Russia by the end of 1999. The report, data and figures will also be available from our web site:

http://www.npolar.no/oelke/barkode/barkode.html

A Portfolio on the Circulation of the Arctic Ocean, a set of almost 100 figures illustrating the motion of the ocean, has been assembled by IACPO. The purpose of this project is to make available a high-quality set of figures which may be used by a number of communities. As we solicit the figures (both published and unpublished) we hope to summarize present understanding and recent research. This portfolio lives on the Internet (address below) with easy access and updates as new and better figures become available.

http://www.npolar.no/oelke/portfolio.html

IACPO worked with Torgny Vinje on historical sea-ice data from the past 350 years. Originally a project of the Norwegian Polar Institute, this data set will now be supplemented with German and Danish observations for the years 1750 to 1880 supplied by a German PhD student. The first set of CD-ROMs containing historical sea-ice data from Norwegian sealers will be completed in early 2000 as a joint ACSYS-NPI project. As a next step a joint research proposal together with scientists from Europe and North America is planned.

Supporting activities of the IACPO include:

- Updating the Initial Implementation Plan (IIP) for ACSYS. The new Implementation Plan (IP) is accessible from IACPO's web site under:
  http://www.npolar.no/acsys/impplan/index.htm

- ACSYS Data Management and Information Panel (DMIP): IACPO assists the DMIP in data search and data management questions. I attended their 2nd meeting which was held in combination with two other ACSYS panel meetings. IACPO is responsible for the new ACSYS Data and Information Service (ADIS) and created, maintains and develops the ADIS web site at:
  http://www.npolar.no/oelke/adis.html

IACPO sent out questionnaires to data holders, analyzed and published their responses, and supplies meta data for ACSYS- and ACSYS-related data sets. An ACSYS data users network is in the planning stage. It can be helpful in the startup phase of new projects and will foster communication and co-ordination among ACSYS scientists.

The ACSYS web page acts as an important source of information for the ACSYS community. This site is currently under complete reconstruction:

http://www.npolar.no/acsys

- The IACPO continued to issue its printed newsletter, ACSYS *Arctic Forecast*.

- The following reports were partly or completely prepared by the IACPO and are available in printed or in digital form (from the ACSYS home page):

  - IAPO Informal Report No. 1, Nov. 1998: Status and directions for the Arctic Runoff Database.

  - IAPO Informal Report No. 2, Dec. 1998: Joint ACSYS/EMaPS workshop on the co-ordination of physical oceanography in the Nordic Seas.

  - IACPO Informal Report No. 3 (WMO/TD No. 949), July 1999: Workshop on sea-ice charts of the Arctic.

  - IACPO Informal Report No. 4, Aug. 1999: Conference on the Arctic Buoy Programme.

  - IACPO Informal Report No. 5, Dec. 1999: Barents and Kara Seas Oceanographic Data Base (BarKode).

Work on the report on the 4th ACSYS sea ice/ocean modelling workshop, and the CLIC Science and Co-ordination Plan is in progress.

Howard Cattle, Tordis Villinger and I visited the CLIVAR/WOCE Project Offices in Southampton. The following points were discussed: Which cryospheric aspects are covered by CLIVAR/WOCE; which will be covered by ACSYS/CLIC conference. The idea is to strengthen the ties between the different projects of WCRP and to improve co-ordination. There are clear common interests in the Southern Ocean and the Nordic Seas, for Arctic hydrology and atmosphere-land surface interactions. The idea of a CLIC conference at an early stage and CLIVAR's experience with such a conference were also discussed, together with ideas on publications, newsletter, databases, bibliography and the web pages. A printed WOCE-style Arctic/Nordic Seas Hydrographic Atlas would lead to real global coverage of the planned WOCE atlases. It is in the planning stage and strongly depends on available funding for data analysis and printing. In a next step we plan a similar visit to the International GEWEX Project Office.

In the first half of 2000, a workshop on Measurements and Models of Arctic Ocean Circulation is planned to be held at Lamont-Daherty Earth Observatory (LDEO) in New York. LDEO, IARC and WCRP are co-sponsors, and the IACPO is involved in the planning phase. The electronic portfolio assembled by IACPO (see above) will serve as an introduction to this workshop.

The ACSYS glossy brochure was worked on extensively in 1998, but its completion was unfortunately put on hold when the previous D/IACPO resigned. The brochure, which is nearing completion, will be an important PR instrument to inform both scientists and the general public about ACSYS' goals and achievements.

Financial and personnel situation: The Norwegian Polar Institute will support the IACPO until ACSYS ends in 2003. I detect their interest in keeping and supporting an International CLIC Project Office in Norway after that time. The Alfred Wegener Institute stopped supporting IACPO through July 1999, and NPI now pays all salaries until my term expires in July 2000. Managing an international project office and supporting four ACSYS sub-panels and working groups (in 2 of which IACPO has ex-officio membership) with only one scientist and a co-ordinator is not easy. There is a need to obtain funding to obtain positions for one scientist and one scientist/data manager in addition to the position of the director. With expanded responsibilities for CLIC, additional staff for the IACPO appears to be an immediate need.

Travelling from Tromsø is both more time-consuming and more expensive than from Oslo, and the IACPO travel budget needs further strengthening. At the moment IACPO's international travel is partly financed by JAMSTEC and by the Joint Climate Research Fund of WCRP, whereas NPI supports domestic journeys within Norway.

Appendix C

Terms of Reference for the International ACSYS/CLIC Project Office (IACPO)

1. The International ACSYS/CLIC Project Office (IACPO) is established to support the ACSYS/CLIC Scientific Steering Group (SSG) in implementing the Arctic Climate System Study (ACSYS), the international co-ordination of ACSYS observation, modelling and data management activities, and planning and implementing the WCRP's Climate and Cryosphere (CLIC) project.

2. The IACPO operates as a component of the WMO/IOC/ICSU Joint Planning Staff for WCRP. The Director of IACPO (D/IACPO) is responsible to the Director of the World Climate Research Programme (D/WCRP).

3. The IACPO initiates international correspondence and carries out international liaisons at the working level, as required for the development and implementation of ACSYS observational and data management systems, ACSYS modelling, planning and implementation of the CLIC project, ensuring the widest possible participation of all interested nations in ACSYS and CLIC.

4. The specific tasks of the IACPO include:

(i) Co-ordinate national commitments of resources and logistical support as required to achieve the goals of the ACSYS Implementation and CLIC Science and Co-ordination Plans.
(ii) Implement the data management plans for ACSYS, and the ACSYS Data and Information Service, promoting the timely flow of ACSYS scientific data.
(iii) Support the development and implementation of the data management plan for CLIC, and the preparation of a CLIC Implementation Plan.
(iv) Develop and maintain linked ACSYS and CLIC Home Pages on the World Wide Web.
(v) Ensure the timely flow of operational and other relevant information to the ACSYS/CLIC Scientific Steering Group, national agencies, appropriate international bodies, as well as ACSYS and CLIC participants and the climate science community.
(vi) Support the preparation and distribution of the working documents required for the implementation of ACSYS and CLIC and inform the broad scientific community of the activities of these projects.
(vii) Assist in planning and organising ACSYS/CLIC meetings, workshops and conferences as required.
(viii) Other organizational duties as may be required during the course of ACSYS and CLIC.

5. The Director of the IACPO will attend the sessions of the ACSYS/CLIC SSG, and may also participate in other national and international meetings relevant to ACSYS and CLIC.

6. The IACPO is located at the Norwegian Polar Institute in Tromsø, Norway. It may be constituted by staff seconded by participating countries.

7. The Director of the IACPO will seek additional funding to support the Office, including supplementing the support for the international travel required for discharging the responsibilities of the Office which is provided by the Joint Climate Research Fund (under the responsibility of D/WCRP).

8. Annual reports on IACPO activities will be submitted to the Chairman of the ACSYS/CLIC SSG, the Director of the Norwegian Polar Institute, D/WCRP and to the agencies that have seconded personnel to the office or made monetary contributions to its operations.

Condensed report on the second session of the WCRP (JSC/ACSYS) Climate and Cryosphere (CLIC) Task Group (Grenoble, France, 10-13 August 1999)

1. Organization of the meeting

1.1 The second session of the WCRP (JSC/ACSYS) Climate and Cryosphere.

1.2 (CLIC) Task Group was hosted by the Laboratoire de Glaciologie et Géophysique de l'Environnement (LGGE), Grenoble, France from 10-13 August 1999. The list of participants in the meeting is attached as Annex 1.

1.3 The session was chaired by Prof. R. Barry, a co-chair of the CLIC Task Group.

1.4 Following a welcome by the Director of the LGGE, Dr D. Raynaud, and remarks by the Director of WCRP, Prof. H. Grassl, on behalf of the WCRP and the JSC, the participants were informed by Dr H. Cattle, the chairman of the ACSYS SSG, that the goals of the session were:

(i) to review and revise, as necessary, a draft CLIC Science and Co-ordination Plan developed by the first session of the CLIC Task Group held in Utrecht, the Netherlands from 8-11 July 1998; and

(ii) to address the strategy for co-ordination of CLIC and other relevant projects/programmes/activities.

2. Results of the meeting

2.1 The meeting worked in plenary and in small groups to review and revise the draft plan. Comments made by polar science community on the draft plan developed by the Utrecht meeting were taken into account. The science questions were clarified and their focus sharpened. A parallel procedure was followed for the related science strategies. The structure of the draft plan was revised (see Annex 2 for details) to reflect these changes.

2.2 Potential options for co-ordination of CLIC activities with those of the other WCRP projects, and relevant programmes of SCAR, SCOR, IASC, ICSU and the IGBP were discussed. Cross-cutting issues relating to observations, remote sensing, data management and modelling for CLIC, as well as economic and societal implications of changes in the cryosphere as results of global changes were also discussed. Finally, the meeting discussed some organizational issues relating to the International ACSYS/CLIC Project Office (IACPO), and a feasibility of establishing a joint ACSYS/CLIC Scientific Steering Group (if the JSC-XXI approves launching the CLIC project as a separate WCRP element). The chairman of the meeting, Prof. R. Barry, was requested to report to the ACSYS SSG-VIII (Louvain-la-Neuve, Belgium, 15-19 November 1999) on conclusions of the meeting regarding the discussed topics.

2.3 The Acting Director of the IACPO, Dr Ch. Oelke, was requested by the meeting to prepare and present to the ACSYS SSG-VIII a list of relevant polar and cryospheric organizations and projects, including their sponsors and status, as well as a list of acronyms to be included as an Appendix into the revised draft CLIC Science and Co-ordination Plan. The IACPO was requested to put the revised version of the draft CLIC Science and Co-ordination Plan on the ACSYS home pages in September 1999. The final draft is to be presented to the next session of the ACSYS SSG for their final review and comments.

Appendix D
Annex 1

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Appendix D
Annex 2

Suggested structure of the CLIC Science and Co-ordination Plan

1. EXECUTIVE SUMMARY

2. BACKGROUND

3. THE CRYOSPHERE AND CLIMATE: AN OVERVIEW

3.1 Definition of the cryosphere and its components
- 3.1.1 Snow
- 3.1.2 Sea Ice
- 3.1.3 Freshwater Ice
- 3.1.4 Frozen Ground and Permafrost
- 3.1.5 Glaciers, Ice Caps and Ice Sheets

3.2 The role of the cryosphere in climate

3.3 Impact of changes in the cryosphere on climate

4. KEY SCIENTIFIC QUESTIONS OF THE CRYOSPHERE AND CLIMATE

5. ATMOSPHERE-SNOW-LAND INTERACTIONS

5.1 Cryosphere-atmosphere interactions on a global scale

5.2 Key scientific questions

- 5.2.1 How Does Climate System Interact with the Terrestrial Cryosphere?
- 5.2.2 Where are the Key Land Crysopheric Processes and what is their Role in the Hydrological Cycle?
- 5.2.3 What is the Precipitation in Cold Regions?
- 5.2.4 Frozen Ground/Permafrost and Surface and Atmospheric Exchanges

5.3 Science strategy
- 5.3.1 Modelling
- 5.3.2 Observations/Monitoring
- 5.3.3 Validation/Verification

6. ATMOSPHERE-LAND ICE-SEA LEVEL INTERACTIONS

6.1 Key scientific questions
- 6.1.1 Observed Sea-Level Change over the Last Hundred Years
- 6.1.2 Present State of Balance of Glaciers, Ice Caps and Ice Sheet
- 6.1.3 Internal Variability in Ice Sheet - Ice Shelf Systems
- 6.1.4 Sensitivity of Land Ice Volume to Future Climate Change

6.2 Science strategy

7. ATMOSPHERE-SEA ICE-OCEAN INTERACTIONS

7.1 Key scientific questions

7.1.1 Sea Ice Characteristics and Variability
7.1.2 Interactive Processes in the Sea Ice Zone
7.1.3 Modelling the Response of Sea Ice to Climate Change

7.2 Science strategy

8. CRYOSPHERE-CLIMATE INTERACTIONS ON A GLOBAL SCALE

8.1 Cryosphere-atmosphere interactions on a global scale

8.1.1 Representation of Cryospheric Processes in Climate Models
8.1.2 Cryospheric Impacts on Broad-scale Atmospheric Circulation
8.1.3 Atmospheric Influences on Large-scale Cryospheric Change
8.1.4 Atmosphere – Cryosphere Feedback

8.2 Science strategy

8.3 Crysophere-ocean interactions on a global scale

8.3.1 Thermohaline Circulation
8.3.2 Large Scale Circulation
8.3.3 Efficiency of Carbon Uptake and Exchange

8.4 Science strategy

9. CRYOSPHERIC INDICATORS OF CLIMATE CHANGE

9.1 Monitoring cryospheric indicators of current change

9.1.1 Sea Ice
9.1.2 Snow Cover
9.1.3 Lake Freeze-Up/Break-Up
9.1.4 Permafrost/Active Layer Thickness

9.2 Records from the recent past

9.2.1 Mass Balance of Glaciers, Ice Caps and Ice Sheets

9.3 Records from the past (multi-decadal and longer scales)

9.3.1 Glacier Extent
9.3.2 Ice Sheet Extent
9.3.3 Borehole Temperatures
9.3.4 Ice Cores

9.4 Records from the last climatic cycles

Appendix E

An abridged report on the first session of the ACSYS Numerical Experimentation Group (by Prof. P. Lemke)

1. The first session of the ACSYS NEG was held at the Institut für Meereskunde, Kiel, Germany from 16-19 November 1998. The main tasks for the meeting were to discuss the current state of the Sea-Ice Model Intercomparison Project (SIMIP), to investigate the relevant data sets and data requirements, to discuss the current state of sea-ice/ocean modelling, regional atmospheric modelling, modelling the hydrological cycle in atmospheric general circulation models, and the representation of sea ice in global coupled climate models.

2. Four models were compared during the first phase of SIMIP: a viscous-plastic model with an elliptical yield curve and replacement closure, a cavitating fluid model, a compressible Newtonian fluid model, and a free-drift model with stoppage. All models were optimised by minimising an error function through tuning of the dynamic model parameters. From the application of different error functions it was found that the speed distribution difference represented the most adequate error function for the optimisation of dynamic model parameters. The viscous-plastic model achieves the best fit to the speed distribution. Therefore, SIMIP has identified the viscous-plastic rheology as the best representation of large-scale sea-ice dynamics within the tested hierarchy of models. More details and references are listed on the SIMIP home page:

http://www.ifm.uni-kiel.de/me/research/Projekte/SIMIP/simip.html

3. Modelling of the coupled Arctic Ocean – Sea Ice system requires not only a proper treatment of the different model components but also adequate coupling of the two components as well as more detailed prescription of the atmospheric states to be used for model forcing. The ice-ocean coupling requires proper communication between the two models which must ensure conservation of properties in the coupled system. At the same time evolution of prognostic fields in each model component should be independent of the coupling approach. The complexity of tasks involved in the development of a coupled ice-ocean system combined with rather large computational requirements have resulted in a rather limited number of research efforts aimed at modelling of the coupled Arctic Ocean – Sea Ice system. Four such studies have been presented during the ACSYS NEG-1. The discussions focussed on the following questions to be addressed by coupled sea ice – ocean models of the Arctic Ocean:

- What are the exports of fresh water (liquid and solid) from the Arctic Ocean into the North Atlantic and what is their interannual variability?
- How sensitive are the results answering the above two questions to different sea ice dynamics and thermodynamics and representation of the ocean physics?

4. Three presentations on the high resolution regional Arctic modelling efforts with advanced state-of-the-art dynamical atmosphere regional climate models (RCMs) were made at the session. Due to a better representation of topographical and land/sea, as well as sea/sea-ice contrasts, these models tend to give a more realistic simulation of near surface climate parameters. It was demonstrated that interannual variability of large-scale atmospheric parameters can be captured realistically by these models. Based on the three presentations the following general questions were discussed:

- Are there natural limitations to the accuracy we can achieve?
- Are there specific RCM flow problems for the Arctic?
- Is there a need for an AMIP-type project with an Arctic focus for RCMs?

It was concluded that more research is required on:

- Cloud-radiation interaction, and
- Surface - PBL - cloud interaction.

The research should be carried out through sensitivity studies (such as that of PILPS) on permafrost

5. During the Atmospheric Model Intercomparison Project (AMIP) the quality of representation of the hydrological cycle in different AGCMs especially in the Arctic was investigated by comparing models results to observations and reanalysis products. The AMIP models reveal a significant model-to-model scatter and the total fresh water input into the Arctic Ocean is generally oversimulated. The simulated precipitation and evaporation are highly correlated across the models. The specification of soil moisture seems to be important in this regard. Improvements of certain parameterisations including the hydrological discharge model in the new ECHAM-4 GCM are encouraging since they produce a better simulation of the river discharge into the Arctic Ocean. However, without controlled experiments establishing the dependence of the hydrological cycle on model parameterisations an understanding of the model improvement will not be possible.

6. Most sea-ice models used in present GCMs are of striking simplicity. Of the 19 CGCMs participating in the Coupled Model Intercomparison Project (CMIP-I) only 4 account for a sea ice rheology other than free drift, 10 include only ice thermodynamics, and 2 treat the sea ice as a diagnostic variable. Thus, 12 out of 19 CGCMs totally neglect the well known negative feedback mechanism between sea-ice dynamics and thermodynamics. In regions where the thermodynamics reduces the ice thickness, the ice gets weaker and the dynamics (under favourable conditions, i.e. convergence) can readily increase the ice thickness (by importing ice into the region). In regions where the dynamics reduces the ice cover (divergence), the thermodynamics (under favourable conditions, i.e. cooling) can easily increase the sea ice thickness. These interactions produce a negative, i.e. stabilizing feedback. This mechanism is a potential candidate for reducing the presumably overestimated sensitivity of CGCMs in global warming scenarios. An improvement of the sea-ice representation in CGCMs is urgently required.

7. The future focus of the ACSYS NEG will be the sea ice – ocean coupling and the regional modelling of the Arctic atmosphere including the coupling to the sea ice – ocean interface. Since most of the coupled sea ice – ocean and atmospheric regional models are still under development and improvement it was decided to postpone the discussion about co-ordinated model experiments until the next session.

Summary on GAME-Siberia activities (by Prof. T. Ohata)

The research activities of GAME-Siberia continued in 1999. During the 1996-1999, the following results have been obtained:

1. Full year observations of the land-surface heat/water exchange in local sites at flat taiga. The seasonal cycles of heat/water fluxes were clarified. Influence of the snow cover seemed to be low during snow covered season; evaporation rose clearly in relation to blooming of the trees. Evaporation amount during this few years seem to be lower than the result of past studies.

2. Full year patch scale and drainage scale observations at tundra area facing Arctic Ocean. Unexpected high precipitation amount occurred in August in 1997 and 1999. Thaw depth has rather high variability within small area, which may regulate subsurface flow. Surface heat fluxes depend upon wind system in this region.

3. Application of stable isotope to the water exchange in the land-surface system. This method is very fruitful for tracking the movement of water and speculating large scale water movement.

4. Development and evaluation of the drainage scale model of the water circulation in permafrost zones. Existing model can simulate the runoff fairly well for winter but not yet for the annual cycle.

5. Development of atmosphere-vegetation-ground system model in permafrost zones. One dimensional models were tested to taiga condition and seem to be applicable with slight tuning.

6. Information on vegetation conditions, snow cover characteristics and soil moisture from satellite data.

7. Past hydrometeorological data set and satellite data were collected and archived.

8. Long-term automatic observation system was established. Tower and mast observation systems are perfectly functioning under severe cold condition.

9. Large scale water budget analysis was implemented. Analysis of atmospheric water budget based on objective analysis shows that strong convergence year seem to be proceeded by high evaporation year.

10. Large scale hydrological model was developed. Two models have been tested to the Lena River Basin. Both have limited applicability yet.

In year 2000, an Intensive Observation Period is scheduled from April to June. The overall objectives of this is to study the seasonal evolution of spatial water/energy dynamics in the forested area predominating in Siberia. The following new measurements will be undertaken in the year 2000:

1. The water/heat exchange study will be extended to different surfaces such as sparse forest, younger larch forest and grassland.

2. Aircraft will be used to measure the spatial distribution of sensible and vapor fluxes, and related surface parameters.

3. A one-dimensional heat/water exchange model and a meso-scale atmospheric model will be tested against the spatial data to check their performance and applicability.

4. Processes related to land water storage(lake) in the region will be examined.

Following questions are to be answered:

a. What are the response characteristics of the various Siberian land surface to seasonal variation in atmospheric forcing? How does the influence of snow cover, permafrost and vegetation differ? What is the seasonal variation of integrated fluxes in the area?

b. Can existing atmosphere and land surface models simulate Siberian condition? Target study area is 100x50km, north of the Yakutsk connecting the Spasskaya Pad area and the Tungulu area(alas area) during April to June 2000. Main observation systems to be employed are: 3 forest towers, 2-3 masts on grass-land, periodic aircraft measurement of mean meteorological values, isotopes and CO_2. Enhanced radiosonde observations will be made at 5 sites in vicinity of Yakutsk.

The Programme for Arctic Regional Climate Assessment (PARCA) (by Prof. K. Steffen)

The PARCA programme is a NASA project that was formally initiated in 1995 by combining into one coordinated program various investigations associated with efforts, started in 1991, to assess whether airborne laser altimetry could be applied to measure ice-sheet thickness changes. It has the prime goal of measuring and understanding the mass balance of the Greenland ice sheet, with a view to assessing its present and possible future impact on sea level. Toward that end, the main components of the programme are as follows:

- Airborne laser-altimetry surveys along precise repeat tracks across all major ice drainage basins, in order to measure changes in ice-surface elevation.
- Ice thickness measurements along the same flight lines.
- Shallow ice cores at many locations to infer snow-accumulation rates and their interannual variability, recent climate history, and atmospheric chemistry.
- Estimating snow-accumulation rates by climate-model analysis of column water vapor obtained from radiosondes, satellite atmospheric sounding observations, and European Center for Medium-Range Weather Forecasting (ECMWF) model data.
- Surface-based measurements of ice motion at 30-km intervals approximately along the 2000-m contour completely around the ice sheet, in order to calculate total ice discharge for comparison with total snow accumulation, and thus to infer the mass balance of most of the ice sheet.
- Local measurements of ice thickness changes in shallow drill holes.
- Investigations of individual glaciers and ice streams responsible for much of the outflow from the ice sheet.
- Monitoring of surface characteristics of the ice sheet using satellite radar altimetry, Synthetic Aperture Radar (SAR), passive-microwave, scatterometer and visible and infrared data.
- Investigations of surface energy balance and factors affecting snow accumulation and surface ablation.
- Continuous monitoring of crustal motion using global positioning system (GPS) receivers at coastal sites.

1999 has been a milestone year for PARCA, with the airborne laser-altimeter and radar-sounding re-survey of the northern part of the ice sheet, and completion of many complementary field activities, with emphasis on ice coring. Some programme components listed above are largely complete, and the emphasis now becomes analysis of the data, with new measurements focused on addressing important problems revealed by the analysis. The contributions in this report contain summaries of the 1999 field, modeling, and data-analysis activities.

The network of Automatic Weather Stations on the ice sheet is now almost complete, and is routinely providing measurements of meteorological conditions, including accumulation rate, in near real time to many scientists studying a broad spectrum of research problems. These data will also be important to the interpretation of GLAS data.

Ice thickness has been successfully measured along all the aircraft flight lines, with results available within a few months of acquisition to any interested investigator. They are important to most PARCA investigations and are extensively used also by non-PARCA scientists. Over the coming year, the entire data set will be used, together with the laser topography measurements, to produce an improved map of the bedrock beneath the ice sheet. Radar sounding is also used to map internal layers in the ice sheet, indicative of past dynamics and basal conditions, and high-resolution radars have been used to map near-surface layers to infer snow-accumulation rates. Further development of this approach is directed towards an airborne shallow-depth sounder capable of tracking the depths of volcanic layers between ice-core sites, and thus inferring spatial and temporal variability of snow-accumulation rates over large regions.

Significant progress is being made towards understanding microwave signatures of the ice sheet. These are strongly affected by conditions beneath the surface, and contain information on depth-hoar and ice-layer intensity, snow temperatures and wetness, and accumulation rate. As a result of PARCA investigations, we now have a better physical understanding of how these processes affect the microwave signatures, with the prospect of more reliable techniques for extracting information from them.

The main result from our mass-balance investigations is that most of the coastal regions of the ice sheet are changing quite rapidly – predominantly thinning – but we don't know why. Further inland, patterns of thickening/thinning can to some extent be explained by inter-annual variability of snow accumulation, and near-coastal changes are expected to be sensitive to temporal variability in surface-ablation rates. However, observed thinning on many outlet glaciers exceeds 1 m/yr with values as high as 10 m/yr. Although coastal summer temperatures have increased recently, particularly along the east coast, the increase cannot explain these very high thinning rates, suggesting that discharge velocities must also have increased. Based on these observations, the PARCA scientists recommended a focused study of the coastal regions, with emphasis on surface ablation and its sensitivity to summer warming and possible albedo feedbacks, and on the dynamics of those glaciers that are observed to be changing rapidly.

The approach adopted by PARCA – a focused, yet interdisciplinary, effort strongly guided by clearly-stated goals and objectives, comprising an appropriate mix of in situ and remote sensing data acquisition, interpretation, and modeling - can be applied to the ice sheet in Antarctica.. This will require interagency and international collaboration, which runs the risk of diluting the focus and weakening the guidance, but the key importance of GLAS and SAR data to this effort offers NASA the opportunity to provide the strong leadership needed to make such a programme succeed.

Appendix H

Some Norwegian and Nordic studies relevant to ACSYS
(by Prof. T. McClimans)

There are several national and regional programmes related to ACSYS that are not included in lists of international co-operations. This presentation is an attempt to present some of these newer projects/programmes as information to the ACSYS SSG.

ACSYS-Relevant Norwegian Programmes:

The major research programme in progress under the auspices of the Norwegian Research Council is RegClim (Regional Climate Change with Global Heating) Web site:

http://www.nilu.no/regclim/

Emphasis is being placed on the studies of heat fluxes at the Polar Front and the MIZ (marginal ice zone). The programme is developing a coupled global atmosphere, ocean and ice model that, regionally, is better than the Hadley Centre model. This programme will be part of the Norwegian CLIVAR effort.

The Department of the Environment supports a programme entitled "The Transport and Effects Programme" Web site:

http://www.npolar.no/transeff/

This programme has fostered the IACPO's data base "BarKode", a laboratory transport benchmark and several numerical models of the circulation in the Barents and Kara seas.

ACSYS-Relevant Nordic Programme:

The Nordic Arctic Research Programme (NARP) is financed by the Nordic Council of Ministers. The funds are primarily earmarked for Nordic network activities (co-ordination, fellowships, meeting and workshops) and it focuses on both the scientific questions in climate variability and consequences. There are 15 projects in the category of land, sea and air, 8 projects on biological diversity and 8 projects on living conditions.

ACSYS-related projects include:

- Long-term variations in atmospheric circulation and climate in arctic [Nor. Met. Inst.]
- Nordic network on permafrost engineering [Nor. Geotech. Inst.]
- Study of Atlantic Water inflow to the Nordic seas using motionally-induced voltages in a TransAtlantic cable [U. Stockholm]
- Monitoring the flow of Atlantic Water through the Norwegian and Barents seas using coastal water level data [SINTEF]
- Interannual to decadal climate changes in the Atlantic Arctic [NERSC]
- Climate variability and effects of Arctic water distribution in the northern seas [IMR]
- Sources of aerosols in the Arctic and their effect on climate [U. Lund]

More details of NARP are found on Web site: http://www.thule.oulu/fi/narp/

European Fifth Framework Research Programme:

There are two ACSYS-related projects from the first round of the European Fifth Framework Research Programme with Norwegean involvement:

- ERA-40 – Data base for ERA-40 reanalysis [ECMWF]
- MAIA – Monitoring the Atlantic inflow toward the Arctic [SINTEF]
  Web sites for these projects will be available soon.

In addition to the above, there is an informal (not funded by EU) collaboration (ARCICE) to observe the transport routes of SF6 discharged during the ESOP project. There are also plans to extend the VEINS programme as part of the Fifth Framework Programme.

Many of the above programmes are aimed at the understanding of effects of climate variability and human-inflicted change, to support decision making for regulations and ameliorating measures within the Nordic countries. Many of these are coordinated through the AMAP and IASC organizations.

Further, a northern European initiative for education related to the consequences of climate variability (IRISEN) has a core of Nordic participation.

Appendix I

A summary of Russian ACSYS-related activities (by Prof. G. Alekseev)

The Arctic and Antarctic Research Institute jointly with GEOMAR (Germany) and with participation of specialists from the other Russian and German institutes carried out two expeditions to the Laptev Sea in the framework of the Russian-German "Laptev Sea System" Project. The first expedition was undertaken in the zone of landfast ice and drifting ice north of the Lena River delta during the period April 16 to May 7, 1999. The oceanographic CTD observations were performed at 24 stations located on landfast ice (15), in the polynya (2) and on drifting ice (2). Data on the distribution of salinity, temperature, nutrients, etc., were obtained at the time of ice generation in the polynya shedding light on the features of development of winter convective processes and water dynamics on the Arctic shelf. The second expedition was conducted from August 22 to September 8, 1999 on board the Russian vessel "Yakov Smirnitsky". Observations at 31 oceanographic stations were made and two bottom self-contained stations for measurements of water temperature, salinity, oxygen concentrations and current speed that operated for one year were recovered.

In September 1999, the Pacific Oceanographic Institute (Vladivostok) with participation of the Institute of Marine Science (Fairbanks, the USA) carried out an expedition on the study of water hydrology and bio-chemistry in the coastal areas of the Laptev and the East-Siberian Seas onboard the Russian vessel "Dunai" that performed observations at 46 hydrological stations including observations of the levels of nutrients. Anomalous high pCO2 in the near-bottom layer were recorded.

The Shirshov Institute of Oceanography (Moscow) continued its activities connected with the acoustic thermometry of the Arctic Basin using a Russian-American self-contained system. The emitting device for this system was set up in 1998 from board the R/V "Akademik Fedorov". A control measurement made in late August 1999 in the Barents Sea area confirmed the efficiency of the system over this period. Preliminary processing of the signals that were received for a week in the Beaufort Sea in spring 1999 suggests further spreading of anomalous warm Atlantic water to the American and Eurasian sub-basins and continuing relative warming along the Franz-Victoria trough-Beaufort Sea route.

The AARI continues preparation for issuing the "Meteorological Atlas of the Arctic" on CD-ROM in 2000 jointly with the USA scientists in the framework of activities of the Environmental Working Group. The Atlas will contain mean monthly meteorological data of 95 Arctic stations over 1951-1990, data of meteorological observations at synoptic times onboard the Ice Patrol vessels (1952-1982), data of measurements of the atmospheric characteristics by the drifting automated radio-meteorological stations (DARMS), data of meteorological observations at synoptic times at all drifting stations and daily precipitation sums from measurements at 65 stations (1940-1990).

A CD-ROM with the Arctic atmosphere sounding data at the North Pole drifting stations from 1951 to 1991 was prepared. It contains a total of 33840 soundings.

The Global Digital Sea Ice Data Bank in AARI was supplemented with seven new digital data sets submitted by its participants. They include a set of 10-day ice charts for the Arctic in the SIGRID format for 1950-1952, 1953-1966 and 1991-1992; a set of weekly ice charts for the Arctic and the Antarctic in the SIGRID format for 1972/1973-1994 from the US National Snow and Ice Data Center; a set of ice charts with 3-4 day interval in the SIGRID format for the North-European Basin prepared by FIMR (Finland) and SMHI (Sweden).

Information on the ice data resources in the Global Data Bank can be obtained via Internet at the addresses:

http://www.aari.nw.ru/gdsidb_2html
http://www.dmi.dk/pub/gdsidb_mirror/content.html
http://www-nsidc.colorado.edu

The following Arctic Ocean circulation models were evolved:

- At the Arctic and Antarctic Research Institute:
  - coupled Arctic Ocean and North Atlantic circulation model (Semenov G.A.).
  - coupled Arctic Ocean and ice circulation model (Polyakov S.V.)

- At St. Petersburg branch of the Shirshov Oceanographic Institute of the Russian Academy of Science:
  - coupled ocean and ice circulation model (Neyelov I.A., Ryabchenko V.A.)

- At Institute of Numerical Mathematics of the Russian Academy of Science:
  - Arctic Ocean circulation model (N.G. Yakovlev),
  - Global ocean circulation model (V.B. Zalesny).

The Main Geophysical Observatory performs the numerical experiments with a global climatic model of coupled atmosphere/ocean circulation with a special stress on the role of sea ice and other polar processes, as well as permafrost (V.A. Meleshko, V.M. Katsov, S.P. Malevsky).

Research in the Antarctic

From May 10 to June 9, 1999, the oceanographic observations were carried out in the Cosmonauts Sea including a transect of 9 stations, 6 stations in Prydz Bay and 1 multi-day station of 27 soundings to the bottom (770 m).

Plans for 2000

In the Arctic: . It is planned to undertake a complex scientific expedition “Arctic-2000” onboard the R/V “Akademik Fedorov”. The expedition route), its aims and goals and organization are described in a special booklet and are presented at the AARI site in Internet

www.aari.nw.ru/pages/vivanov/ARKTIKA2000.html

In the Antarctic: It is planned to carry out oceanographic observations in the eastern Cosmonauts Sea in the area of interaction of cyclonic gyres where a local deep water upwelling can develop resulting in polynyas at the ice-covered sea surface. Observations will be performed at four transects of 40 stations.

SCAR Programme on Global Change and the Antarctic (GLOCHANT) (by Dr I. Allison)

The GLOCHANT programme is an initiative of the Scientific Committee on Antarctic Research (SCAR) concerned with global change and the Antarctic. SCAR established a Group of Specialists on Global Change and the Antarctic (GoS/GLOCHANT) at XXII SCAR (Bariloche, Argentina, 1992). Initially GLOCHANT focused on developing a broad scientific agenda for Antarctic global change research, and with establishing links and integrating Antarctic science within the broader global research framework, including with the World Climate Research Programme (WCRP) and with the International Geosphere-Biosphere Programme (IGBP). During the last 5 years GLOCHANT has evolved into a recognised international science programme with a programme office and full-time staff. GLOCHANT initiatives are now included in IGBP core project such as PAGES, JGOFS and GLOBEC, and linked with WCRP programmes.

The GLOCHANT programme has evolved to concentrate on four themes:

1. Antarctic and Southern Ocean sea ice, climate and ecosystem.
2. Antarctic climate and environmental history.
3. Antarctic ice-sheet mass balance and its contribution to global sea-level, and;
4. Impacts of physical and biological changes on Antarctic terrestrial and aquatic ecosystems.

There are three active international initiatives now addressing themes 1 and 2 under the GLOCHANT umbrella.

Theme 1: Antarctic Sea-ice Processes and Climate (ASPeCt)

ASPeCt aims to develop a broadscale climatology of the pack-ice zone of the Southern Ocean from internationally cooperative cruises, historic observations during this century of sea ice characteristics, remotely sensed data, and process studies. ASPeCt contributes to the aims of WCRP projects, including the Antarctic Ice Thickness Research Programme (AnITRP) and the International Antarctic Buoy Programme (IPAB).

ASPeCt has a significant level of scientist participation from countries with major Antarctic research programmes and infrastructure. A Science and Implementation Plan for ASPeCt has recently been prepared by the Scientific Steering Committee and is available at:
http://www.antcrc.utas.edu.au/aspect/plan/plancont.html

Theme 2: **International Trans-Antarctic Scientific Expedition (ITASE)**

The ITASE programme deals with the high-resolution climate and environmental history of Antarctica over the last 200-500 years, and with the role of Antarctic climate in global circulation and natural variability. ITASE field plans include retrieval and analysis of shallow to medium depth ice cores collected at 100-200 km intervals across the ice sheet. The major output of ITASE will be data on snow accumulation variability and proxy climate time-series which can be used to extend the short duration instrumental climate and ice sheet mass balance records. The ITASE Science and

Implementation Plan, “200 Years of Past Antarctic Climate and Environmental Change” was published jointly by GLOCHANT and IGBP PAGES in 1997. It is available at:

http://www.antcrc.utas.edu.au/scar/itase/toc.html

Theme 2: Late Quaternary Sedimentary Record of the Antarctic Ice Margin Evolution (ANTIME)

ANTIME is geosciences programme focused on the broad climate, environmental and ice sheet history over the last glacial cycle (130,000 years), and in detail over the last 10,000 years. It was established in liaison with the SCAR Working Groups on Geology and Geophysics, in 1996. The programme has developed around the study of circum-Antarctic onshore and offshore sediments. Three sub-working groups on the coastal zone record, the continental shelf record and on glacial, sedimentological and oceanographic processes were established following a workshop held in Hobart in 1997, and over 100 scientists are now involved with ANTIME. There are good links between ANTIME and the SCAR ANTOSTRAT programme of the Working Groups on Geology and Geophysics which is concerned with Antarctic paleoenvironments of the last 130 Myr. The integration of both the younger age Quaternary geological research with the older Cenozoic research coordinates paleoenvironmental studies within SCAR.

Less progress has been made to date in developing project initiatives addressing themes 3 and 4. In particular, the state of the Antarctic ice sheet mass balance remains one of the most significant unanswered questions in Antarctic global change research. Despite national and multinational research activity on ice sheet mass balance, particularly in the remote sensing sector, there remains a gap in synthesising the results of the field glaciology, remote sensing and modelling communities. A priority for GLOCHANT in the immediate future will be to convene a forum to assess the certainties and uncertainties in determining mass balance by field, remote sensing and modelling techniques, and to better examine methods of combining the three approaches.

Appendix K

Terms of Reference of the WCRP ACSYS/CLIC Scientific Steering Group

1. Formulate and guide the ACSYS observational and modelling programmes for determining Arctic climate processes and realistic representation of the Arctic region in global climate models.

2. Formulate and guide the CLIC observational and modelling programmes for determining the role of the cryosphere in global climate and realistic representation of the cryosphere in global climate models.

3. Formulate in particular the implementation plan for CLIC.

4. Stimulate exchange and analysis of data relevant to ACSYS and CLIC projects, and the dissemination of scientific results.

5. Use the advice of experts and expert groups as necessary in order to assist with the development and implementation of the ACSYS and CLIC projects.

6. Establish scientific liaison and logistic co-operation with other WCRP projects, with IGBP and with other appropriate programmes/organizations/groups and activities relevant to ACSYS and CLIC.

7. Advise the JSC on progress achieved in the implementation of the ACSYS and CLIC projects and advances in the understanding of polar and cryosphere processes.

Appendix L

List of main actions taken by the ACSYS SSG-VIII

Agenda item	Actions
3	Production of a SSG report: Keep short and produce in as timely a fashion as possible, noting that JSC reports contain many of the science issues. Key programmatic decisions to be highlighted. Consider initial drafting at IACPO. **Action: H. Cattle/V. Savtchenko/C. Oelke to discuss**
4	ACSYS Implementation Plan to be relabelled 'ACSYS Implementation and Achievements' **Action: T. Villinger** ACSYS Implementation and Achievements document review to be standing agenda item at SSG meetings with aim to provide changes to IACPO by the end of the SSG meeting. **Action: G. Flato (modelling), P. Jones (ocean), H Melling (sea ice), M. Serreze (atmosphere), V. Vuglinsky (hydrology), C. Oelke (DMIP) and group members** ACSYS glossy to be written with help of a science writer; target length is a few pages; the chairs of the above-mentioned groups should draft 1 page for input to a science writer, and identify candidate figures and photographs. **Action: Group leaders as above, H. Cattle, T. Villinger (review), I. Allison (review); R. Barry to arrange for a science writer**
5.1	Statement on the importance of continuance of the IPAB to be written for ACSYS/CLIC input to the programme review. **Action: I. Allison, E. Fahrbach, V. Savtchenko, K. Steffen; H. Cattle.** Metadata on IPAB to go to IACPO and NSIDC. **Action: I. Allison, C. Oelke**
5.3	Encourage continued efforts under IABP programme and, though recognising EEZ sensitivities, consideration of extension of buoy network to marginal seas (e.g. Chukchi Sea, Baffin Bay, Sea of Othotsk, etc.) **Action: V. Savtchenko to report to IABP-X** Recognising that its main rationale for implementation is for operations, emphasize the importance of the IABP network for both operations and climate, and so its relevance to GCOS. **Action: V. Savtchenko to report to IABP-X**

Agenda Item	Actions
5.4	Need to consider feasibility of an integrated ACSYS/CLIC strategy for determination of ice thickness climatology combining data from a range of measurement techniques (electromagnetic measurements from ships; ULS (moored and from submarines); remote-sensing techniques). **Action: OPP** Encourage intercomparisons of sea-ice thickness data from submarines and buoy ULS. **Action: OPP** Write to organizer of a forthcoming Submarine ULS Data Meeting to express ACSYS interest. **Action: H. Cattle/K. Steffen** Develop firm recommendations for transfer of moored ice thickness data to data centres in terms of statistics, data format, etc. **Action: OPP/R. Barry/DMIP**
6	Consider resources for IACPO. **Action: All** Revisit names of those who applied for D/IACPO; write to those definitely not to be invited for interviews. **Action: Search Committee/JPS**
7	The meeting agreed that a CLIC commitments meeting is essential, though the precise timing needed to be worked out and appropriate groundwork laid. **Action: I. Allison, R. Barry, H. Cattle**
8.2	The Pan-Arctic river run-off data base should be utilised by GRDC to provide monthly river run-off data to the ARDB (in particular, to provide data on Arctic river flow over the last decade). Route is via NSIDC when released to them. **Action: R. Barry, GRDC** An inventory of Russian river run-off stations with locations and dates of closure be compiled and procedures to get data from regional offices to be set down. **Action: V. Vuglinsky in consultation with R. Barry** A letter should be sent from WMO to Russian authorities requesting release of full Russian river run-off data to present day to GRDC under new provisions agreed at WMO Congress-XIII for release of hydrological data (WMO Congress XIII Resolution 25). **Action: V. Savtchenko**

Agenda Item	Actions
8.3	To help identify funding for continued support of APDA, including development for CLIC activities. **Action: H. Cattle in consultation with B. Goodison and GPCC.**
8.4	All attendees are asked to view IACPO ADIS pages and input appropriate information to help build them. **Action: All** Alleged lack of response from some World Data Centres to be investigated and if a common issue, raised with JSC. **Action: H. Cattle to discuss with C. Oelke** IACPO to take note of SSG comments on ADIS, particularly in respect of Questionnaire issues and need for proactive approach via examination of other Web Sites. **Action: C Oelke**
8.5	Explore opportunities for ACSYS advice to next NCEP Re-analysis. **Action: M. Serreze**
8.6	Statement on co-operative use of Russian Hydrographic and Chemical data bases to be provided for ACSYS Web Pages **Action: G. Alekseev**
8.7	Keep watch on developments with respect to Antarctic metadata, SCAR effort on which may disappear, but which is relevant in a WCRP context to CLIC. **Action: R. Barry to keep watch and advise on action to H. Cattle as the situation develops** DMIP to consider and advise on identification and publication as necessary of data collected during the ACSYS period itself (1994-2003 inclusive). **Action: DMIP** DMIP to broaden to considerations of full terms of reference and to move to DMIP for ACSYS/CLIC. **Action: DMIP** Agreed in principle to move to joint ACSYS/CLIC Panels for DMIP, OPP and Polar Products for Re-analysis. Only DMIP is urgent; others to evolve with time. ToRs to be re-visited off line. **Action: H. Cattle in consultation with Panel Chairs and SSG**

Agenda Item	Actions
8.7 (Cont'd)	APDA and ARDB to be continued beyond ACSYS into CLIC, depending on CLIC requirements to be defined. **Action: ACSYS/CLIC SSG**
9.3	Criteria for archiving of model data are needed. **Action: R. Barry/DMIP to explore in consultation with others as appropriate** Agreed to move to ACSYS/CLIC NEG; ToR agreed. Suggestions for membership to be passed to G. Flato. **Action: G. Flato to take forward/all to provide suggestions**
10.5	DMIP to consider CLIVAR DTT report and implications for ACSYS/CLIC. **Action: H. Cattle to obtain copy and pass to DMIP** Explore possibility of ACSYS link to CLIVAR North Atlantic Panel. **Action: H. Cattle, D. Martinson** Develop issues arising from IACPO visit to ICPO. **Action: H. Cattle to take up with J. Gould** Recommend advising re-analysis centres of GAME-Siberia data sets of soil moisture time series. **Action: T. Ohata in consultation with M. Serreze as needed** List of parameters for ISLSCP parameters to be sent to R. Barry and H. Cattle for consideration of ACSYS input (CIRES/NSIDC already providing some). **Action: R. Lawford** Inform NASA of relevance of Cold land processses mission to CLIC (also relevant to GEWEX and CLIVAR). **Action: R. Barry, H. Cattle, R. Lawford** Contact ARM CART site at Barrow concerning ground truth for GEWEX water vapour satellite remote-sensing data sets. **Action: H. Cattle in consultation with R. Lawford**
11.1.3	Consider ARCSS, Arctic Climate Change (SEARCH) initiative and SBI and if appropriate write to express interest and ask that relevant areas be seen as supporting projects to ACSYS/CLIC. **Action: H. Cattle in consultation with others as needed**

Agenda Item	Actions
11.4	Approach the Hydrology and Water Resources Department of WMO to advise on the feasibility of an ARCTIC World Hydrological Cycle Observing System (WHYCOS) initiative. **Action: V. Vuglinsky**
12	The following meetings were agreed: NEG-III: Fairbanks, AK, USA, 11-15 September 2000 OPP-II: Geneva, 4-7 October 2000 Workshops on Measurements and Models of the Arctic Ocean System, Palisades, NY, USA Consider: Joint ACSYS/CLIC/GEWEX Workshop on Solid Precipitation in 2001 **Action: R. Lawford, R. Barry to consider** CLIC Commitment Conference in 2001 ACSYS Conference in 2002/03