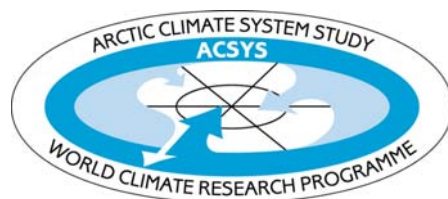


WORLD CLIMATE RESEARCH PROGRAMME



REPORT OF THE ACSYS FINAL SCIENCE CONFERENCE

“Progress in Understanding the Arctic Climate System:
The ACSYS Decade and Beyond”
(St. Petersburg, Russia, 11-14 November 2003)



WCRP-120
WMO/TD No. 1249
September 2004

The World Climate Programme launched by the World Meteorological Organization (WMO) includes four components:

- The World Climate Data and Monitoring Programme
- The World Climate Applications and Services Programme
- The World Climate Impact Assessment and Response Strategies Programme
- The World Climate Research Programme

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International
Council for
Science

World
Meteorological
Organization

International
Oceanographic
Commission

THE WORLD CLIMATE RESEARCH PROGRAMME

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Foreword

As the World Climate Research Programme's (WCRP) Arctic Climate System Study (ACSYS) drew to a close, nearly 250 scientists attended the project's final conference at the Arctic and Antarctic Research Institute (AARI) of the Russian Federal Service for Hydrometeorology and Monitoring of the Environment (Roshydromet) in St Petersburg from 11-14 November 2003. This CD is the proceedings of that conference. It is part of a pair of CDs that mark the end of the ACSYS project by recording all its activities throughout the decade (reports, newsletters, and other publications), and by demonstrating the state of scientific knowledge on the Arctic climate system as presented at the conference.

This 'Proceedings' CD presents the brief formal report of the conference, including the programme and the list of participants. Also included is an electronic version of the 'Book of Abstracts', which was given to participants at the conference. In addition, as many as possible of the conference presentations – both oral and poster – were collected and are available on the CD for viewing and printing. Unfortunately, the large volume of material made it impossible to store high quality versions of all figures and posters. If higher quality versions are sought, the first approach should be to the author of the presentation, and if that fails, the International Project Office for ACSYS (now the CliC International Project Office (CIPO)) may be contacted at clic@npolar.no.

In addition to oral and poster presentations, the CD contains 'Extended Abstracts' of material presented at the conference. Due to the large number of submissions, these have not been refereed, and were subject to only a minimal amount of editing limited to the use of English language. The primary responsibility for content lies with the authors. That said, the lively discussions that took place at the conference provided an opportunity for authors to place their results in context and to take the views of other scientists into account when preparing their extended abstracts. The result is that there is a large amount of very good science in these abstracts (and the proceedings in general) and we hope that we have provided a useful service in bringing all these items together in one electronic publication.

The pair of CDs is provided free of charge to all conference participants and to other interested parties in the Arctic climate research and policy community. The content of both CDs is also accessible through the ACSYS web site at <http://acsys.npolar.no>, which will be maintained as a service under the WCRP's *Climate and Cryosphere (CliC)* project. This new project addresses the links between climate and the cryosphere globally, and will continue to focus attention on the Arctic as a vitally important part of the global climate system.

Chad Dick
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Progress in Understanding the Arctic Climate System

Introduction

The Arctic region is where numerical climate models generally predict the largest warming under the influence of increased greenhouse gas concentrations. It is also the area where discrepancies between predictions are greatest. Arctic processes seem crucial for maintaining the oceanic meridional overturning circulation (MOC), and some models suggest that global warming might freshen the Arctic Ocean and peripheral seas to the extent that this circulation collapses. If that happens, parts of the North Atlantic region might cool rather than warm over the next 100 years.

So, what are the global consequences of natural or human-induced changes in the Arctic climate system? Is the Arctic climate system really as sensitive to enhanced greenhouse gas concentrations as climate models suggest?

For the past 10 years, the World Climate Research Programme (WCRP) Arctic Climate System Study (ACSYS) worked to answer these questions through the development and coordination of national and international research activities on Arctic climate.

ACSYS consisted of five related programs. Four covered the main elements of the Arctic climate system: sea ice, ocean circulation, the atmosphere, and the hydrological cycle. The fifth program, numerical modelling, was aimed at simulating these components and their interactions to improve understanding of the Arctic influence on, and response to, changing climate.

When the decade-long project drew to a close at the end of 2003, nearly 250 scientists met to assess progress in understanding the Arctic climate system. The *Final ACSYS Science Conference* was held in St. Petersburg, Russia, at the Arctic and Antarctic Research Institute of the Russian Federal Service for Hydrometeorology and Monitoring of the Environment (Roshydromet) from 11-14 November 2003.

Meeting Summary

Aims and Themes

The conference aim was to summarize improvements in knowledge of the Arctic climate system during the ACSYS decade, drawing together advances in understanding of each of the elements of the Arctic climate system, and more particularly, of the interactions among them. The conference also sought to examine future research challenges for the Arctic climate system. To do this, it brought together observational scientists and modelers to provide a common forum for presenting results.

The conference was divided into four sessions addressing the following:

- 1) *The state of the Arctic climate system*: Improvements in knowledge of the Arctic climate system and its variability through historical data, ongoing measurements, and process studies.
- 2) *Observing the Arctic climate system*: Improvements in our ability to measure and observe aspects of the Arctic climate system and its processes across a range of spatial and temporal scales.
- 3) *Process studies and modelling*: Improvements in representation of atmospheric, cryospheric, oceanic, and terrestrial processes in models, including assimilation of observations into models.

- 4) *Interactions with the global climate system*: Improvements in understanding of the Arctic's role in the global climate system, its response to large-scale climate variations, and the processes involved.

Each session included keynote lectures and selected presentations from submitted abstracts.

In a final session, the chairmen of the four ACSYS panels made presentations on numerical modelling, observation products, data management and information, and polar products from re-analysis. This was followed by a panel discussion examining the question: What are the important gaps in our knowledge and what opportunities and initiatives exist to fill them?

More than 160 posters, displayed throughout the four-day meeting, complemented about 40 oral presentations.

Scientific Highlights

Talks and posters provided many scientific highlights, both in the presentation of new results and in synthesizing improved knowledge during the ACSYS decade.

In concert with the global trend, the Arctic experienced very strong warming during the last three decades. However, examining the entire last century period, variations in Arctic climate do not simply match global variations, suggesting a more complex relationship to global climate. This relationship remains the focus of ongoing study and debate.

No convincing evidence of significant slowdown of the Atlantic MOC has yet been found, but some evidence suggests that recent freshening of the sub-Arctic seas might not be a localized Atlantic event, but rather the strong local expression of a change in the global water cycle. Freshening has been observed in high latitudes of both the Atlantic and Pacific Oceans, while low latitude oceans seem to become more saline.

Satellite passive microwave data reveal that the Arctic sea ice extent has decreased approximately by $0.30 \times 10^6 \text{ km}^2$ (that is, 2.5%) per decade since 1972. All months have negative trends, with September, the month of minimum ice extent, showing the largest decrease. The lowest levels were reached in September 2002 and 2003.

Arctic sea ice is reported to have thinned substantially over the last 20-40 years in most of the deep-water areas, especially during summertime. However, sea ice exhibits a pronounced interannual variability in thickness, making it difficult to interpret the spatially and temporally sparse record. This variability is reasonably well captured by current high-resolution sea ice-ocean models forced by the re-analysis of atmospheric data, but much work remains to fully understand the Arctic sea-ice mass balance and its influence on atmospheric and oceanic circulations. Recently launched, or impending, satellite systems offer the prospect of more comprehensive estimates of future ice thickness variability and change.

In 2002, the Greenland Ice Sheet experienced the most extensive melt since satellite observations began in 1980. A model study suggests that, by the end of this century, the greenhouse gas-induced increase in freshwater flux from this ice sheet might be sufficient to induce an abrupt weakening of the Atlantic MOC, with subsequent cooling over eastern Greenland and the northern North Atlantic.

River runoff into the Arctic Ocean has increased significantly during recent decades, and the length of the river ice season has diminished noticeably.

Proxy data point to a northward movement of the Arctic tree line since the late 1950s, particularly in northwestern Canada and eastern and coastal Siberia, while satellite-derived vegetation indices indicate a coincident "greening" of Alaska.

Taken together, these changes seem to indicate warming in the Arctic region during the last decades of the 20th century that perhaps was induced by increased greenhouse gas concentrations in the atmosphere. However, during the last decade, a picture also emerged of a climate system that is highly variable over a number of time scales – making it difficult to draw conclusions about the causes of climate changes within the Arctic system.

Gaps in Knowledge and Opportunities to Fill Them

Despite considerable progress in understanding during the ACSYS decade, there are still many gaps, but there are also many opportunities to address them. The conference discussion covered the areas of processes, observations, data, modelling, and, ultimately, prediction and predictability. Some highlights include:

The Arctic climate feedback mechanisms remain relatively poorly known particularly for the negative feedbacks. The associated spatial and temporal scales are connected with the feedback "carriers"; for example, sea ice, snow, clouds, etc., giving a complex range of possible climate cycles. Important issues are the extent and fidelity of model representation of these feedbacks.

The existing Arctic observing systems were generally established to help guide weather forecasting and water resource management rather than to monitor climate and environmental changes. Although satellite observing systems have made remarkable advances, many aspects of the Arctic climate system remain inaccessible to space-borne instruments. Hence there is still a strong need for coordinated and dedicated international efforts to improve the Arctic climate observing system, using both in-situ and remote-sensing techniques. Current examples include developing under-ice technology to supplement the 'Argo' float ocean observations, and the long-term support ice camps such as the North Pole Environmental Observatory. The Earth Observation Summit (31 July 2003, Washington, DC, USA) and subsequent formation of the Group on Earth Observations provide opportunities to start the development of enhanced observing systems.

The ACSYS project provided a valuable legacy of data sets vital to the study of Arctic climate and processes. The challenge is to foster future international collaboration, using tools such as the World Wide Web to facilitate data sharing through international archives and networks.

Despite improvements in the ability of climate models to reproduce many features of the observed climate and its variability, numerous uncertainties remain. Simple models may be used to provide fundamental insight into climate processes, but these must be utilized with caution to avoid misleading oversimplifications. The use of objective analysis of observations, data assimilation in models and reanalysis efforts have been very successful in improving the data sets for atmospheric climate research, and this should now be pursued more vigorously for both the ocean and the cryosphere. In addition, models should be used to assist in the development and deployment of observing systems or design of field campaigns.

Arctic climate predictability is still not well characterized and should be given elevated importance as part of the developing WCRP Coordinated Observations and Prediction of the Earth System initiative.

WCRP has established a new core project to address the ongoing issues that concerned ACSYS. The Climate and Cryosphere (CliC) project will study the climate system in all cryospheric regions (i.e., where "water exists on the Earth's surface in solid form"). This includes the Arctic, Antarctic, and other cold regions worldwide. As CliC develops, one of its major challenges is to ensure good

communication among the international cryospheric science community. We must learn to share our data and to apply understanding from one region to the problems of another, and to balance this with investigations that continue to improve our knowledge of the unique Arctic environment

Acknowledgments

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Appendices

Appendix 1 - Agenda

Final Programme		
ACSYS Final Science Conference - The ACSYS Decade and Beyond		
St. Petersburg, Russia, 11-14 November 2003		
Day 1 - Tuesday, 11 November 2003		
08:00-09:00	Registration	
09:00-09:20	Welcome, introduction and local arrangements	Frolov (Rus), Fichfet (Bel), Priamikov (Rus)
	Introduction	Chair: Timokhov (Rus)
09:20-09:40	The Origins of ACSYS	Savtchenko (WCRP, Ret.)
09:40-10:15	ACSYS, the Cryosphere, and the WCRP	Lemke (Ger)
Session 1	Theme: The State of the Arctic Climate System	
10:15-10:50	A decade of change in our perspectives on Arctic sea Ice	Rothrock (USA)
		Chair: Colony (USA)
11:20-11:40	Historical variability of sea ice in the Nordic Seas	Divine (Nor)
11:40-12:15	The Arctic Ocean in the 1990s - advective challenges and internal response	Rudels (Fin)
12:15-12:35	Multi-year and seasonal variability of the Arctic Ocean freshwater budget	Timokhov (Rus)
		Chair: Oelke (USA)
14:00-14:20	Arctic Ocean salinity anomalies in response to AO-like atmospheric forcing	Houssais (Fra)
14:20-14:55	Hydrology and water resources within the Arctic Ocean Drainage Area	Shiklomanov (Rus)
14:55-15:15	On the factors controlling the surface and air temperatures over the Arctic sea ice in winter	Pirazzini (Fin)
15:15-15:35	Detecting Arctic climate change using Köppen climate classification	Wang (USA)
16:05-17:30	Poster introductions	Chair: Steffen (USA)
17:30-18:30	Poster session	
18:30-20:00	Buffet plus poster session continued	
20:00	Close	

Appendix 1 - Agenda

Day 2 - Wednesday, 12 November 2003		
Session 2	Theme: Observing the Arctic Climate System	Chair: Wilson (Can)
09:00-09:35	Historical, Seasonal and Regional Arctic Temperature Change	Overland (USA)
09:35-09:55	Observations, simulations and scale interactions of the stable boundary layer over polar ice sheets	Heinemann (Ger)
09:55-10:30	The Arctic hydrological cycle	Rudolf (Ger)
		Chair: Ananicheva (Rus)
11:00-11:20	Snow pack variability from satellite passive microwave data	Grippa (Fra)
11:20-11:55	Arctic Ocean observations and their outcomes over the ACSYS-Decade	Takizawa (Jap)
11:55-12:30	Formation and circulation of waters in the Arctic Ocean evaluated by chemical tracers	Anderson (Swe)
		Chair: Dethloff (Ger)
14:00-14:20	The East-Siberian sea hydrography as an indication of atmospheric circulation over the Arctic Ocean	Dmitrenko (USA)
14:20-14:40	Distribution and pathways of Atlantic Water in the Greenland Sea	Walczowski (Pol)
14:40-15:15	The thickness of Arctic pack ice - advances and challenges	Melling (Can)
15:15-15:35	Refinement of the Seawinds/QuikScat sea ice edge	Haarpaintner (Nor)
		Chair: Anisimov (Rus)
17:00-17:35	Remote sensing observations of the Arctic climate system	Drinkwater (Neth)
17:35-17:55	Arctic Ocean sea ice cover from small-scale sea ice motion: Dispelled notions and new paradigms	Kwok (USA)
Session 1 contd.	Theme: The State of the Arctic Climate System	
17:55-18:30	Arctic Climate Change - observed and modelled temperature and sea-ice variability	Johannessen (Nor)
18:30	Close	

Appendix 1 - Agenda

Day 3 - Thursday, 13 November 2003		
Session 3	Theme: Process studies and modelling	Chair: Quadfasel (Ger)
09:00-09:35	Ocean Convection in Arctic Shelf Polynyas	Schauer (Ger)
09:35-09:55	The Arctic inversion over sea ice and its representation in operational weather models	Bruemmer (Ger)
09:55-10:30	Modeling the Arctic climate with global coupled models	Bitz (USA)
		Chair: Bamber (UK)
11:00-11:35	High resolution modeling of the Arctic Ocean: A decade of progress	Maslowski (USA)
11:35-12:10	Data assimilation in coupled ice-ocean modelling	Lisæter (Nor)
12:10-12:30	Characteristics of snowmelt runoff in the Mogot experiment watershed, in the southern mountainous taiga of eastern Siberia	Suzuki (Jap)
		Chair: Khromova (Rus)
14:00-14:20	Application of the Canadian land surface scheme to modelling the Mackenzie river basin	Verseghy (Can)
14:20-14:40	Effects of surface heterogeneity on the atmosphere over polar oceans	Vihma (Fin)
14:40-15:00	Recent advances in our understanding of polar lows	Turner (UK)
Session 4	Theme: Interactions with the Global Climate System	
15:00-15:35	Arctic climate variability	Alekseev (Rus)
		Chair: Isaksson (Nor)
17:00-17:35	Processes of Arctic-global ocean interactions	McClimans (Nor)
17:35-17:55	The Iceland-Faroe inflow of Atlantic water to the Nordic Seas and Arctic Ocean	Østerhus (Nor)
17:55-18:30	Observational evidence for Arctic/global ocean interactions at large space-time scales	Dickson (UK)
18:30	Close	

Appendix 1 - Agenda

Day 4 - Friday, 14 November 2003		
Session 4 contd.	Theme: Interactions with the Global Climate System	Chair: Boscolo (Spa)
09:00-09:20	ENSO signature in North European time series of ice conditions detected by singular spectrum analysis and wavelet transformed	Grinsted (Fin)
09:20-09:40	Multi-decadal variability in a long integration with the MPI-OM1 ocean model	Schmith (Den)
09:40-10:00	Evaluation of snow cover and permafrost in Northern Eurasia for some climate change scenarios	Shmakin (Rus)
10:00-10:	Arctic climate in the 21st century	Cattle (UK)
Session 5	ACSYS legacy	Chair: Fichfet (Bel)
11:05-11:30	Improvements in Numerical Modelling During the ACSYS Decade	Flato (Can)
11:30-11:55	Improvements in Satellite and In-Situ Observations During the ACSYS Decade	Steffen (USA)
11:55-12:20	Data Management and Information Support for the Arctic Climate Systems Study	Moore (USA)
12:20-12:45	ACSYS Polar Products from Reanalysis	Serreze (USA)
Session 5 contd.	Gaps in knowledge, opportunities and initiatives	Chair: Goodison (Can)
14:00-16:00	Panel discussion	Members: Colony (USA) Gascard (Fra) Groisman (USA) Laxon (UK) Mauer (Ger) Ohmura (Swi) Yakovlev (Rus)
16:00	Closing remarks	
	Fichfet (Bel), Frolov (Rus)	

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