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Challenges in Arctic-Alpine Environmental Research

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Comprehensive international scientific research over the recent years shows that the global climate processes and variability are changing and that the changes are real and fast. Arctic and alpine regions play a crucial role and are considered "early warning sites" for processes related to increased average temperatures and precipitation, reduction in sea ice, and melting glaciers, and they are thus valuable for monitoring and evaluating these environmental changes. These processes also have a significant potential for large and positive feedbacks on the global scale. The environmental impacts from these natural and anthropogenically forced changes, as well as the increased level of UV-radiation and pollution from long-range transported contaminants, introduce new stress factors for marine, terrestrial, and freshwater ecosystems. The large natural variation in most of the physical parameters governing these extreme environments is also a key factor in structuring the biodiversity and biotic productivity. Thus, the effect of the stress factors on the biological processes can be critical for population structures and community interactions. Socioeconomic effects of these changes are also considered significant and are directly interlinked to expected changes in environmental living conditions and indirect changes in bioproduction, which form the basis for the complex marine and terrestrial food webs.

It is a scientific challenge to provide a fruitful platform for interdisciplinary scientific knowledge exchange and a balanced and multidisciplinary presentation of the environmental changes in these areas. In this context, the international conference entitled *"The Arctic-Alpine Ecosystems and People in a Changing Environment,"* held at the Polar Environmental Center in Tromsø, Norway (24 February-1 March 2003), was conceived to address this broad interdisciplinary field of environmental change research. The conference focused on complex environmental research issues connected with climate change and ecosystem response, long-range transport of pollutants as well as ozone/UV-radiation, and biological effects in aquatic and terrestrial environments. The overall goal of the conference was the identification of major future challenges in arctic-alpine environmental research along the main transport routes from middle latitude regions in the remote and pristine arctic and alpine regions. Altogether 120 oral and 60 poster presentations were accepted for the conference in Tromsø.

In cooperation with *Arctic, Antarctic, and Alpine Research*, this special issue contains 12 selected papers invited for publication after presentation at the conference, constituting a multidisciplinary cross-section of the papers presented in the fields of climate change, UV-radiation, long-range transport of pollutants, and socioeconomic implications of environmental change. A complementary set of marine-related papers from the conference are published in a similar special issue of *Polar Research*, vol. 23, no. 1, 2004.

The first two papers of this special issue present challenges related to the long-range transport of pollutants, with emphasis on pathways, environmental fate, and levels. Berg et al. reviews temporal trends for selected atmospheric contaminants like heavy metals and persistent organic compounds, monitored since the early 1990s at the Zeppelin atmospheric research station in Ny-Ålesund, Svalbard. The authors demonstrate that most of the organochlorine compounds show significant decreasing trends in correspondence with national and international governmental regulations. However, most of the heavy metals analyzed did not show significant decreasing temporal trends over the monitoring period. These atmospherically derived findings are not directly supported by the paper of Poikalainen et al., who on the basis of surveys of 10 heavy metals in mosses and the atmospheric deposition of Hg, Cd, and Pb beyond the Arctic Circle to northern Finland, found a significant decrease in Cd and Pb concentrations during the period 1985–2000 and a slight decrease in Hg. This continuous decrease in environmental levels is consistent with the decreases in heavy metal emissions throughout Europe.

The effects of climate variability on terrestrial arctic and alpine ecosystems are covered by six contributed papers. With elevated temperatures, the vast stores of soil carbon in the arctic tundra may release CO_2, inducing positive feedback and amplify temperature increase. In an experimental study by Marchand et al., the effects of temperature increase on carbon balance in a high-arctic tundra were evaluated. Small changes in the carbon balance were found, although the turnover increased due to a combination of direct and indirect temperature effects. Belowground respiration was also studied by E. J. Cooper. Root respiration rates, thermal sensitivity, and thermal acclimation for various arctic/alpine *Ranunculus* species were compared, as were high-

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arctic and subarctic ecotypes of *Ranunculus pygmaeus* and subarctic/lowland ecotypes of *Ranunculus acris*. The highest potential for acclimation of root respiration to increased temperatures was measured in a Svalbard ecotype of *Ranunculus pygmaeus* from a site of poorly vegetated soil. Cooper suggests that arctic plants with high acclimation potential can survive in widely fluctuating or warmer soils, whereas those which show limited acclimation have distribution limited to colder and thermally stable soils.

The structure of the forest line in northeast European Russia is the main focus in the paper by Virtanen et al. GIS-based landscape-level analyses were conducted, and logistic regression models developed showed that the forest line location to be explained by ambient summer temperature and permafrost, and to a lesser extent by yearly minimum temperatures and soil moisture. Compared to elsewhere in the Arctic, a higher temperature isoline was found, which they suggested is mainly a result of local spruce ecotypes that are unable to grow on permafrost terrain. Correspondingly, their models even suggest that predicted increase in future temperature potentially would allow forest spread after some decades almost to the shore of the Arctic sea. Results also indicate that other factors like permafrost conditions and their changes will also affect to this response bringing more uncertainty to forest-line change predictions. The change in forest distribution was also evaluated in the paper by Tømmervik et al., although with a different approach. By the use of remote-sensing techniques and ground survey, significant changes in the cover of various vegetation classes during the last 40 yr were revealed. A steep decline in lichen-dominated areas, with a corresponding increase in birch forest, appears to be a result of intensive reindeer grazing as well as increased precipitation favoring other species to expand.

In a paper by Kohler and Aanes, the impact of winter climate was assessed for an isolated herd of reindeer in Svalbard. In a retrospective analysis of past winter conditions, 80% of the variance in the population's growth rate was explained by the modeled mean winter ground-ice thickness. Even when other variables like modeled mean winter snowpack thickness and previous years' population sizes were added, the significant contribution by ground-ice thickness remained relatively unchanged. Concerning aquatic environments, vertical distribution data of freshwater phytoplankton biomass and the integrated phytoplankton biomass of two high-mountain Mexican lakes, 4200 m a.s.l., is presented in the paper by Alcocer et al. They conclude that the phytoplankton biomass in these lakes is low and similar to that of temperate high-mountain lakes, being controlled by the combined effect of nutrient input and zooplankton grazing pressure.

This special issue also includes three selected papers dealing with the problem of UV-radiation and its biological effects on terrestrial ecosystems like vegetation in Greenland as well as subarctic freshwater zooplankton. Jean Verdebout presents a satellite-derived UV-climatology for Europe, prepared to support UV-impact studies on ecosystems and human health. The paper use realistic parameterizations of cloud and aerosols, surface albedo, and elevation necessary to create maps of surface dose-rates and daily UV-doses, giving geographical distribution and year-to-year variability in surface UV radiation. Bredahl et al. investigates the effects of ambient UV radiation on gas exchange and chlorophyll fluorescence of arctic vegetation, using traditional methods of reducing the UVB-doses with Mylar and Lexan films. They indicate that the observed short-term effects could result in long-term negative effects on growth and survival for the investigated species. In the freshwater environment, Zellmer et al. investigates five subarctic ponds with different DOC-contents and consequently different natural UV-protection and light climates. They find a negative correlation of lipid content (eicosapentaenoic acid) and seasonally variable DOC-concentration of different *Daphnia* species, as well as interesting results concerning UV-tolerance and parameters related to survival and metabolism.

A number of papers addressing the socioeconomic and integrated effects of environmental change were presented at the conference, related to the development of tourism, technological stress and impact factors on the environment, effects of climate and UV-radiation variability on living conditions and health issues, etc. The paper by Førland et al., included in this special issue, presents issues concerning the effects of variations in temperature and its effect on climatic parameters which in turn affect living conditions in the Nordic Arctic. They demonstrate, on the basis of observational series and downscaled scenarios of air temperature, that climatic indices like growing season, heating season, and freezing season show substantial variations during the 20th century, with a forecasted continued increase in vegetation growing season and decrease in energy consumption (heating season).

On the basis of this ambitious multidisciplinary approach and the contemporary and complex scientific, social and political issues related to environmental challenges in arctic and alpine regions, a comprehensive set of review papers, based on the keynote talks and other presentations at the conference, is put together in a book project entitled "Arctic-Alpine Ecosystems and People in a Changing Environment" published by Springer-Verlag in 2005.

Acknowledgments

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- Norwegian Polar Institute, Polar Environmental Center, Tromsø (Host)

- Norwegian Institute for Nature Research, Polar Environmental Center, Tromsø
- Norwegian Institute of Air Research, Polar Environmental Center, Tromsø
- Institute of Marine Research, Tromsø

The scientific program committee consisted of:

- Dr. Jon Børre Ørbæk (Chairman), Norwegian Polar Institute Svalbard, Program Manager of ENVINET and the Ny-Ålesund Large Scale Facility
- Associate Professor Else Nøst Hegseth, Norwegian College of Fishery Science, University of Tromsø, Representing the Arctic Seas Ecosystems Consortium
- Mr. Jochen Peters (for Associate Prof. Alf Håkon Hoel), Dept. of Political Sciences, University of Tromsø, Representing the Scientific Steering Committee of NARP
- Dr. Stig Falk-Petersen, Norwegian Polar Institute, Polar Environmental Center, Tromsø
- Dr. Roland Kallenborn, Norwegian Inst. for Air Research, Polar Environmental Center, Tromsø
- Dr. Ingunn Tombre, Norwegian Inst. for Nature Research, Polar Environmental Centre, Tromsø

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