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Polar weather and its research and forecast challenges

In May 2008, the Little Alaska Weather Symposium organized by B.D. Day, N. Mölders, D. Morton, G.B. Newby, E. Stevens, and M. Stuefer and sponsored by the Alaska Region NOAA, University of Alaska Fairbanks' Arctic Region Supercomputing Center, College of Natural Science and Mathematics, Geophysical Institute and International Arctic Research Center took place at the University of Alaska Fairbanks. K. Friedrich, J. Cassano, G.A. Grell, and M.D. Shulski presented the keynotes. In the following paragraphs, we present high-level summaries of the presentations, findings, discussion topics, and points of agreement among participants.

The symposium gathered about 50 scientists to discuss the challenges of research, data collection, weather forecasting and model development in Polar Regions. Symposium participants reflected that challenges differ for the Arctic versus Antarctic. Antarctica is an unpopulated continent with international agreements, research stations and well-funded and well-maintained observational networks. The Arctic encompasses an ocean surrounded by land populated by various nations, which makes data exchange and coordinated field campaigns difficult.

In the Arctic, costs for logistics to install, maintain and power a site are the same or even lower than in Antarctica, but research projects often lack continuity of sufficient funding for these tasks. Sites are often not suitable for the intended scientific purpose, and compromised by logistics. The few remote sites only run from mid-spring to mid-fall because the long dark nights prohibit using solar energy to power them, while low temperatures make batteries useless. Non-equally distributed networks, however, may bias regional averages and climatology. Automatic monitoring sites generally provide data of lower quality when only maintained once or twice a year. In harsh polar conditions, instruments get ice-coated frequently and/or become useless, which also compromises data quality. For the Arctic, model development and evaluation relies on only few temporally limited field experiments, while in the Antarctic experimental work takes place year-round. This observational situation aggravates the development and improvement of models for Arctic weather forecasts where forecast accuracy may be critical for equipment and/or safety. A further challenge for Polar Region weather forecasts is the high variability of climatology and unknown forcing from volcanic eruptions that may release water vapor, radiative heat and aerosols to the atmosphere.

Given the paucity of data, using data from all available sources, despite their different quality, is an urgent need for model initialization, development and evaluation. In Polar Regions, the accuracy of surface wind forecasts depends heavily on the correct initialization of low-level sounding profile and the profile itself. Over water, synthetic aperture radar surface wind retrievals can be used to provide 2-D surface wind speeds for initialization that may lead to improved forecasts for marine customers. Simulations with assimilation of the Tropospheric Airborne Meteorological Data Reporting (TAMDAR) data improve short-range forecast skill, despite that data is only available along the flight routes of PenAir with 46 flights per day to and from southern Alaska airports. The TAMDAR instrument provides data on humidity, pressure, temperature, winds aloft, icing, and turbulence and transmits them in real-time to a ground-based network operations center, along with the corresponding location, time, and altitude from built-in GPS. The Real-Time Four Dimensional Data Assimilation and forecasting (RTFDDA) system continuously collects and ingests diverse synoptic and asynoptic weather observations from conventional and non-conventional platforms to provide accurate spun-up nowcasts and short-term forecasts for Alaska. A version of this system (E-RTFDDA) can generate ensemble analyses and probabilistic forecasts. Both RTFDDA and E-RTFDDA can be easily adapted to support other weather-sensitive applications in different polar areas.

The few radar measurements available in Polar Regions should not only be used to support short-term forecasts, but also for studies of kinematic and thermodynamic processes in mountains relevant to cloud formation, mountain-induced enhancement of precipitation, and outbreak of severe weather within thunderstorms. Other potential usages are improved quantitative precipitation estimation for flood forecasts, fire management, wind and precipitation information for the onset and duration of orographic precipitation, data assimilation and evaluation of numerical weather prediction models.

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The high stability and free convective conditions that occur frequently in Polar Regions were at the center of interest with respect to their climatology and model performance and improvement. Currently, results from modern parameterizations of atmospheric fluxes differ more than 100 W/m^2.

Capturing inversions and free convection is not only of interest from a meteorological prediction point of view, but also for air quality studies. The frequent Arctic wildfires require smoke forecasts. In Polar Regions, chemistry transport modeling is challenging due to the lack of chemical measurements and emission inventories. The later is less difficult for Antarctica where anthropogenic emissions only occur at the research stations, but a challenge in the Arctic where anthropogenic emissions occur in cities, along the sparse road system and shipping lanes. The unique light conditions yield chemical processes dominated by daytime chemistry during the long white nights of summer and nighttime chemistry during the dark days of winter.

Nicole Mölders
University Alaska Fairbanks, Geophysical Institute,
P.O. Box 757320, Fairbanks, AK 99775-7320, USA
University Alaska Fairbanks,
College of Natural Science and Mathematics,
Department of Atmospheric Sciences,
903 Koyukuk Drive, Fairbanks, AK 99775, USA
Corresponding author.
E-mail address: molders@gi.alaska.edu.

Gregory B. Newby
University Alaska Fairbanks,
Arctic Region Supercomputing Center,
909 Koyukuk Dr., Fairbanks, Alaska 99775, USA

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