PREFACE

Antarctica is one of the most remote and inhospitable parts of our planet. Yet marked signatures of climate variability/change are being seen ever more clearly, from the five decades of strong warming along the west side of the Antarctic Peninsula (Vaughan et al. 2001) to the pronounced impact of El Niño–Southern Oscillation in the Ross Sea sector during the 1990s (Bromwich et al. 2000). The Antarctic ozone hole has underscored the impact of human activity on the global atmosphere since its discovery in 1985 (Farman et al. 1985). In addition to its scientific importance, tourist visits to Antarctica during the austral summer by ship and air continue to increase steadily. These developments call for much better weather forecasting for year-round operations.

Recent efforts to enhance Antarctic weather forecasting particularly include the international First Regional Observing Study of the Troposphere (FROST) project that ran from 1993 to 1999 with the goal of determining how well operational analyses and forecasts were performing poleward of 50°S (see the special issue of *Weather and Forecasting* dedicated to the project: December 1999, vol. 14, no. 6). Over the Southern Ocean the global products considered, such as from the European Centre for Medium-Range Weather Forecasts (ECMWF) and the National Centers for Environmental Prediction (NCEP), showed encouraging skill. However, significant differences in the numerical analyses, and therefore forecasts, were present over Antarctica. This was followed by the *International Antarctic Weather Forecasting Handbook* (Turner and Pendlebury 2000), which collates forecast experience and site knowledge for a large number of Antarctic locations along with specific forecast guidelines.

Two events combined to stimulate the next advance. A version of the widely used fifth-generation Pennsylvania State University–National Center for Atmospheric Research (NCAR) Mesoscale Model (MM5) that was optimized for polar conditions was developed by the Polar Meteorology Group at the Byrd Polar Research Center (available online at http://www-bprc.mps.ohio-state.edu/PolarMet/pmm5.html and as options in the standard release of MM5 version 3.5). It was found to perform surprisingly well over Greenland (Cassano et al. 2001; Bromwich et al. 2001), and good performance over Antarctica was thus suspected. A medical emergency at the South Pole in October 1999 led to the realization that Polar MM5 might provide useful guidance for the evacuation, but events moved too quickly for this to be implemented. The Polar Meteorology Group brought an experimental forecast version of Polar MM5 online in January 2000 and demonstrated the potential of tailored Antarctic numerical weather prediction. Soon after, discussions with the Office of Polar Programs of the National Science Foundation (NSF), which is responsible for U.S. operations in Antarctica, led to the organization of the Antarctic Weather Forecasting Workshop (http://www-bprc.mps.ohio-state.edu/WFWS/index.html) to plan advancements in the forecasting support particularly for the extensive aircraft operations at McMurdo station on Ross Island. The manuscripts in this special section largely grew out of presentations to this international workshop.

Simmonds et al. review the characteristics of the intense belt of cyclonic activity that surrounds Antarctica and whose effects represent key forecast questions to be addressed each day. Carrasco et al. follow with a review of mesoscale cyclone activity based on satellite and automatic weather station observations and show that some of these events can be severe and therefore a major forecast concern. In particular they demonstrate that perhaps the most active cyclogenesis area in the Southern Hemisphere resides just north of Ross Island, with major impacts on McMurdo station operations. Heinemann and Klein model representative mesoscale cyclogenesis events and capture the characteristics, but not the full intensity. They confirm that near the coast these features result from the interaction between katabatic winds from Antarctica and the synoptic-scale circulation. Parish and Cassano challenge the idea that Antarctic surface winds are primarily generated by gravitational drainage of radiatively cooled near-surface air (i.e., are katabatic winds) and argue that the terrain modifies the synoptic-scale flow to mimic the drainage pattern long associated with katabatic winds. Clarification of the relative contributions and the mechanisms by which this modification occurs are key issues for forecasting the behavior of Antarctic surface winds and their interaction with synoptic and mesoscale cyclones.

Pendlebury et al. provide an update (since FROST) on the performance of global forecast models in Antarctic latitudes and continue to find that the ECMWF forecast products do slightly better overall. Limitations of global forecast products include their limited spatial resolution and model physics not generally optimized for Antarctic conditions, suggesting that limited-area models tailored for the Antarctic might prove to be very useful forecast tools. Murphy performs an empirical study on the use of precursors for forecasting major synoptic-scale cyclones along the coast of East Antarctica and finds modest skill. Lazzara et al. provide an overview of satellite data that are primary tools used to infer current and near-term weather conditions in this otherwise data-sparse area. Exploitation of the vast amount of satellite observations is a key challenge for Antarctic numerical weather prediction.

A primary recommendation to NSF arising from the Antarctic Weather Forecasting Workshop was to establish a mesoscale prediction capability targeted to the needs of the U.S. weather forecasters at McMurdo station on Ross Island. This led to the development of the Antarctic Mesoscale Prediction System (AMPS) by the Mesoscale and Microscale Meteorology Division of NCAR in conjunction with the Polar Meteorology Group (http://www.mmm.ucar.edu/rt/mm5/amps/). AMPS, which employs Polar MM5, has been providing numerical weather prediction in support of the U.S. Antarctic Program since October 2000. Guo et al. perform a formal evaluation of the performance of Polar MM5 in the Antarctic and find many encouraging aspects. They also identify aspects of the model physics and numerics that need improvement. Bromwich et al. evaluate the forecast performance of AMPS during a case of mesoscale cyclogenesis that took place to the north of Ross Island in January 2001, the first field season. Although AMPS forecasts possessed many skillful aspects, performance was hampered by the limited accuracy of the initial conditions derived from the NCEP Aviation Model. This underscores the need to refine the model initial conditions by making optimal use of all available surface and satellite-based local observations. Seefeldt et al. perform high-resolution simulations around Ross Island and illustrate the benefit of 3-km spatial resolution to resolve the atmospheric motions in this region of mountainous terrain and frequent low-level stability. A 3.3-km simulation was added to AMPS in January 2002. Notable successes of AMPS in rescue situations include another medical evacuation from the South Pole in April 2001 (two months after the typical closing of the station to aircraft operations) and the evacuation of the crew from a ship trapped in sea ice in July 2002. In general, AMPS has made Antarctic operations safer, more reliable, and more economical, but much more can be done.

The papers presented in this special issue provide a contemporary status report on many aspects that the international Ross Island Meteorology Experiment (RIME; see http://www-bprc.mps.ohio-state.edu/RIME-01/RIME.html) is designed to address. The Antarctic Weather Forecasting Workshop recommended that the RIME field program was needed to test and refine the physical parameterizations used in forecast and global climate models so that they accurately reflect the unique environment of Antarctica, to investigate the important physical processes, and to study the atmospheric interactions between the Ross Sea region and lower latitudes. One outcome of RIME will be greatly improved numerical weather prediction for Antarctica.

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