P1.19 ANTARCTIC REGIONAL INTERACTIONS METEOROLOGY EXPERIMENT (RIME)

David H. Bromwich

Polar Meteorology Group, Byrd Polar Research Center, The Ohio State University,
Columbus, Ohio

1. INTRODUCTION

The *Antarctic Regional Interactions Meteorology Experiment* (RIME) is a basic and applied research program to explore in detail the local and regional atmospheric processes over Antarctica and their interactions with lower latitudes via the Ross Sea sector. RIME will consist of both observational and modeling components; fundamental goals include the study of physical processes in the lower atmosphere over the Ross Sea sector during episodes of extratropical cyclone forcing and simulation of such processes by atmospheric numerical forecast models. The RIME field phase will run from the austral summer of 2006-2007 through the spring of 2008, a period that overlaps with the International Polar Year (IPY, 2007-2008). Details of the scientific objectives can be found in the *RIME Detailed Science Plan* that can be found at:

http://polarmet.mps.ohio-state.edu/RIME.

RIME will incorporate three field seasons, the austral summer periods of 2006-2007 and 2007-2008 and the austral springtime period of 2008. Field activities will use the home base at McMurdo Station with associated field activities at other sites over the Ross Ice Shelf. Five measurement strategies have been identified; the resulting data analyses will be used with state-of-the-art numerical modeling of the Antarctic environment.

Selection of the Ross Sea region of Antarctica is based on the emerging view that this region is critical in the transport of mass, heat and momentum between the Antarctic continent and middle latitudes of the Southern Hemisphere on a variety of scales. The Ross Ice Shelf is logistically accessible by the U.S. Antarctic Program, which can support the logistical needs of a large, multi-component field program such as RIME. An additional benefit for conducting RIME out of McMurdo will be the expected impact that model improvements and new data products will have on weather forecasting in support of operations in the vicinity of the Ross Sea.

Two scales of atmospheric processes, *regional* and *local*, will be considered during RIME. These two scales shape the experimental design of the program. The interaction of Antarctic processes with the meteorology of the subpolar latitudes of the Southern Hemisphere requires a *regional-scale* examination. The scope of RIME on this scale will encompass an area from the South Pole to approximately 65°S and from approximately 135°W to 135°E. The topics to be addressed on this scale include the (i) circumpolar vortex about Antarctica, (ii) topographically-induced mesoscale circulations, (iii) moist processes and cyclonic events and (iv) mesoscale cyclones. Although it is through this regional scale that Antarctica communicates with the rest of the Southern Hemisphere, smaller scale processes such as the interaction of various mesoscale flows from the Ross Ice Shelf Airstream (RAS); boundary layer transformations caused by cloud-radiation interactions, surface-air interactions and strong wind shear in the stably-stratified flow modulate the transport processes that take place along the western edge of the Ross Ice Shelf. Recognizing the importance of such interactions, a *local-scale* study will also be conducted during RIME. Extensive instrumentation will be deployed on the Ross Ice Shelf to study these local and regional scale processes.

Here a brief overview of the RIME implementation plan is given. The full document can be found on the website referenced above. It is recognized that plans for RIME can not be rigid owing to changes in proposal funding issues, deployment and other logistical considerations and other external factors. It is the intent of the RIME Scientific Steering Committee that the plan will be updated as needed, and so must be viewed as a "living" plan.

2. RESEARCH COMPONENTS OF RIME

The RIME Detailed Science Plan lays seven science topics that are integral to the polar direct circulation over Antarctica (Fig. 1). All are elements of the Overarching Hypothesis. At the smallest scales, boundary layer structure and transformation along with local moist atmospheric processes generate the cold boundary layer air flows over Antarctica and are factors most poorly represented by numerical models. At somewhat larger scales are the mesoscale cyclones and terrain-induced circulations that act on the boundary layer processes to form the RAS. At synoptic scales oceanic cyclones advect warm, moist air southward and steer the cold, dry air of the RAS northward. Over time these large cyclones modulate the circumpolar vortex, which in turn affects hemispheric-scale climate variability, namely the Antarctic Oscillation and the El Niño-Southern Oscillation (ENSO). The Antarctic Oscillation is recognized as the leading mode of Antarctic circulation variability, and interacts with the tropical forcing from El Niño/La Niña events. A more detailed summary of each science topic is given below:

1. Boundary layer structure and transformation:
Much of the previous research into the Antarctic near surface atmospheric state has focused on regions of katabatic flow, with limited observations of the vertical structure of the boundary layer. RIME provides an opportunity to study the near surface atmospheric state of the Antarctic in a region of much greater complexity than previous studies, and offers the opportunity for improved observations of the vertical structure of the lower atmosphere. Key areas for boundary layer and surface process studies in RIME include:

- Detailed description of the vertical boundary layer structure (depth, mean and turbulent profiles of winds, temperature, and moisture, turbulence sources and sinks)
- The role of small scale gravity waves on heat, moisture, and momentum transport
- Improved observations of the time evolution of snow and ice surface properties including albedo, thermal properties, and the susceptibility of the surface to the onset of blowing snow

2. Local moist atmospheric processes:
Moist atmospheric processes are important from both an operational weather forecasting perspective and a basic science perspective. For operational weather forecasting, moist processes are responsible for adverse weather conditions associated with fog and precipitation, which can often be difficult to predict accurately. In terms of basic science, little is known about moist processes in the Antarctic. This lack of knowledge is reflected by the fact that even accurate cloud climatologies for the Antarctic are not currently available. This limits our ability to accurately represent these key processes in numerical weather prediction and climate models

3. Mesoscale cyclones:
Mesoscale cyclones are thought to contribute significantly to the precipitation falling on Antarctic coastal areas and can be associated with blizzard conditions. In the vicinity of the Bellingshausen Sea they may also play an important role in modulating the midtropospheric circulation. Mesoscale cyclones form with great frequency in the vicinity of Ross Island. They present a major forecasting challenge for McMurdo Station operations during the open water season when advection of moist air from the Ross Sea can lead to abundant precipitation and/or fog formation. The focus of this study will be on the region to the north of Ross Island in the western Ross Sea. It is certain that katabatic outflow from the elevated East Antarctic interior, that issues through the glacier valleys near Terra Nova Bay, plays a key role in cyclone formation. Resulting cyclones are most intense in the lower atmosphere, are typically of horizontal scales of 300 km or so, and are classified as "mesoscale" cyclones.

4. Terrain-induced circulations:
The meteorology of the Ross Sea sector is profoundly influenced by the local and regional topography of the Antarctic ice sheet and adjacent Transantarctic Mountains. Low-level katabatic winds transport cold air over the continent toward the coast. The presence of the ice sheet serves as a formidable barrier to the southward movement of air. Local terrain features such as glacier valleys, points, and bluffs further constrain motion. To understand atmospheric motions in the lower atmosphere, topographic influences must be considered.

5. Moist-processes and cyclonic events:
It has long been known that cyclonic disturbances are the primary means by which the atmosphere transports heat, momentum and moisture between the middle latitudes and the poles. The Southern Ocean is notorious for the frequent and often intense cyclonic storms. Farther south, the Ross Sea sector is among the most active cyclonic regions about the periphery of Antarctica. A variety of regional scale atmospheric processes will be examined as part of RIME. In particular, the evolution of moist process associated with cyclone activity will serve as a major theme. Such a study has practical implications to the U.S. Antarctic Program activities, since moist processes such as fog, low clouds and precipitation events impact

logistics. Such events also are of importance in understanding the linkage between Antarctica and middle latitude atmospheric processes.

6. Circumpolar Vortex:
The time-averaged midtropospheric circulation in the Southern Hemisphere is characterized by zonal flow around a cyclone typically centered just to the northeast of the Ross Ice Shelf. This center of the circumpolar vortex usually tilts with height to reside near the South Pole at 100 hPa. The midtropospheric cyclone center does move around causing weekly variability in the weather at Ross Island and is associated with the ENSO variability on the multiannual time scale. A field study in the Siple Coast part of West Antarctica during spring found large, persistent vertical wind shear associated with the circumpolar vortex and large spatial variations in height of the shear zone caused by the Antarctic terrain. Symptomatic of the limited understanding of this profoundly important circulation system is the important disagreement between global atmospheric analyses for this part of Antarctica. There is little knowledge of the detailed vortex structure and the causes of its variability, primarily because of limited observations.

7. Hemispheric interactions:
Studies to better resolve the linkages between the Ross Sea region and Southern Hemisphere midlatitudes are required. Observations suggest that the linkage between high and middle latitudes is not necessarily symmetric, and the asymmetric component of the Antarctic Oscillation should be a part of the RIME climate analysis. An anticorrelation of the time-mean surface pressure field appears to be particularly high between the Ross Sea sector and the New Zealand/Australia sector. Thus, a better understanding of the timescales on which this seesaw occurs is needed. In addition, the atmospheric processes providing the linkages should be addressed.

The following investigation approaches are proposed to address the RIME science topics and are described in detail in the RIME Implementation Plan posted on the RIME website:

- Regional surface-based array
- RIME Supersite
- Aircraft studies
- Modeling
- Remote sensing
- Climate studies.

The integrated nature of these approaches is demonstrated in Table 1; at least several are necessary to address each science topic.

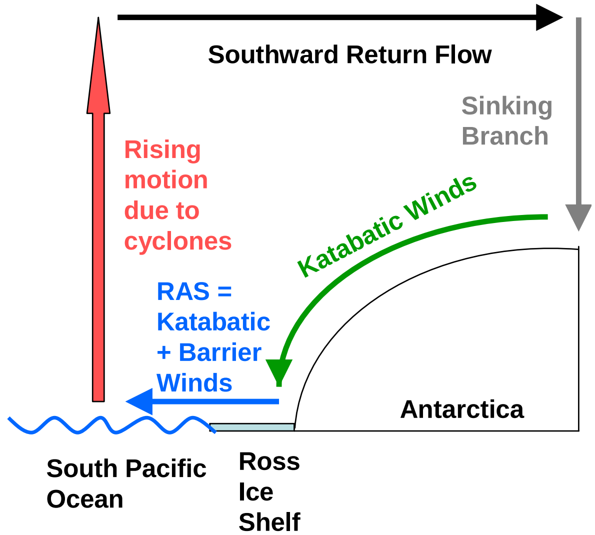

Fig. 1. Schematic of the polar direct circulation over Antarctica emphasizing the Ross Sea sector.

3. ORGANIZATIONAL CONSIDERATIONS

Discussions were held at the recent RIME Implementation Plan Workshop to create an organizational framework. These include a steering committee and project office to enhance communication and coordinate efforts among scientists participating in RIME. A timeline was also constructed and is shown in Table 2. Dates and activities are subject to change.

Table 1. Relationship between RIME investigation approaches and science topics.

			Investigation Approaches					
			Regional Surface-Based Array	RIME Supersite	Aircraft Studies	Modeling	Satellite Remote Sensing	Climate Studies
	Small scale	Boundary Layer Structure and Transformation	x	x	x	x		
		Local Moist Atmospheric Processes	x	x	x	x	x	
		Mesoscale Cyclones	x	x	x	x	x	
		Terrain-Induced Circulations	x	x	x	x		x
		Moist-Processes and Cyclonic Events	x		x	x	x	x
		Circumpolar Vortex	x		x	x	x	x
Science Topics	Large scale	Hemispheric Interactions			x	x	x	x

4. PROGRAMS ASSOCIATED WITH RIME

It is envisioned that Antarctic RIME scientists will interact with the following groups:

- ANTCI (Antarctic Tropospheric Chemistry Investigation; http://acd.ucar.edu/~mauldin/ANTCI_Web/ANTCI_Home.htm) – Coordinate flight and field activities.
- CLIVAR (International Research Programme on Climate Variability and Predictability; http://www.clivar.org/) – Integrate an Antarctic perspective into CLIVAR studies.
- ITASE (International Transantarctic Science Expedition; http://www.ume.maine.edu/itase/) – Coordinate field activities, exchange ice core and model results.
- IPY (International Polar Year; http://www.ipy.org/) – Coordinate field activities to coincide with this historic event and take advantage of the interdisciplinary activities that are planned.
- SCAR (Scientific Committee on Antarctic Research; http://www.scar.org/) – Integrate research into the broader goals of SCAR.
- WAIS (West Antarctic Ice Sheet Initiative; http://igloo.gsfc.nasa.gov/wais/) – Draw on WAIS results and extend them to the Ross Sea region.
- BAS (British Antarctic Survey; http://www.antarctica.ac.uk/) – Collaborative exchanges with BAS are planned. For example, the BAS Twin Otter has been scheduled for participation in RIME during November 2007.
- PNRA (Italian National Research Program in Antarctica; http://www.pnra.it/) – Observational collaborations are planned. For example, PNRA has expressed interest in participating in intensive radiosonde launching campaigns during the RIME field phases.

5. ACKNOWLEDGMENTS

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Table 2. Proposed timeline of RIME activities.