P3.28 ANTARCTIC METEOROLOGY: SATELLITES AND WEATHER FORECASTING

Matthew A. Lazzara*, Linda M. Keller, Charles R. Stearns, Jonathan E. Thom, and George A. Weidner
University of Wisconsin, Madison, Wisconsin

1. INTRODUCTION

Applications of satellite imagery during the early days of the polar orbiting weather satellites (Television Infrared Observing Satellite (TIROS) and Nimbus) were few for the Antarctic. The high altitude and coarse resolution made it difficult to resolve many surface features. With the advent of the Environmental Science Services Administration (*ESSA-1*) satellite, operational products for the Antarctic were processed from the digitized video data. Streten (1968) and Troup and Streten (1972) used the archived imagery to study the large-scale circulation and to compare the cloud vortices with conventional observations of positions. This began the evolution of using satellite data and imagery for Antarctic forecasting.

2. SCIENCE AND FORECASTING

In January 1980, the United States Antarctic Program (USAP) installed a high resolution picture transmission (HRPT) system to receive the National Oceanic and Atmospheric Administration (*NOAA-6*) and *TIROS-N* series of satellites (Wiesnet et al. 1980). Science was able to utilize the output for a variety of applications. The new system was primarily used for operational weather forecasting, especially in support of aviation operations (Wiesnet et al. 1980 and Foster 1982). HRPT data are now received at most of the manned Antarctic stations.

2.1 Mesoscale Features

With the availability of science quality polar orbiting imagery, mesoscale features that affect operations could be investigated. Mesoscale vortices, with their small size and intense winds, were especially troublesome not only for aviation but also oceanographic vessels and research projects. Satellite imagery allowed investigators to pinpoint favored regions of development as well as synoptic conditions that enhanced the possibility of their occurrence. In addition, katabatic winds also caused problems at many of the manned stations. Satellite infrared imagery allowed detection of the characteristic thermal signature of the adiabatically warmed air (e.g., Bromwich 1989; Bromwich et al. 1992). Today all Antarctic weather forecasting benefits from this work and include katabatic wind and polar low effects in the forecasts.

2.2 Composite Imagery

Bristor et al. (1966) were among the first to generate a full resolution polar stereographic mosaic of a section of the Southern Hemisphere using *ESSA-1* weather satellite data (Wiesnet et al. 1980). In addition, one of the first research uses was the development of an Antarctic mosaic for a joint NOAA and United States Geological Survey (USGS) program funded by the National Science Foundation (NSF) (Wiesnet et al. 1980). In late 1992, with support from NSF, the University of Wisconsin began routine generation of composite satellite images over the Southern Ocean and Antarctic continent (Stearns et al. 1999). These composites combined the available geostationary and polar orbiting satellite imagery which were remapped into a polar stereographic projection. This product is useful to researchers for the depiction of the atmospheric circulation from a hemispheric view. It is even more popular with forecasters who are able to determine long-wave patterns and monitor regions up stream and beyond the area covered by typical HRPT and other polar orbiting satellites local/regional view.

2.3 Forecasting Research and Procedures

In 1994 and 1995, the First Regional Observing Study of the Troposphere (FROST) project, organized by the Physics and Chemistry of the Atmosphere Group of the Scientific Committee on Antarctic Research (SCAR), took place. The main objective was to focus on "the meteorology of the Antarctic, determine the strengths and weaknesses of operational analyses and forecasts ... and to assess the value of new forms of satellite data that are becoming available" (Turner et al. 1996). In a study of Southern Hemisphere analyses during this time (Turner et al. 1999), reanalyzed surface charts were created using data from satellite sources. The satellite data was important and in some cases critical in improving most of the analyses.

The outcome of Project FROST led to the development of the International Antarctic Weather Forecasting Handbook (Turner and Pendlebury 2000). Previously, few manuals existed that were widely available that documented Antarctic weather forecasting procedures (e.g., the Naval Support Force Antarctica (NSFA) Forecaster's Handbook). The new handbook

* *Corresponding author address:* Matthew A. Lazzara, Univ. of Wisconsin, Space Science and Engineering Center, 1225 W. Dayton St., Madison, WI 53706; email: mattl@ssec.wisc.edu.

has a comprehensive examination of the climatology and topography of each station along with specific guidelines for forecasting. In a substantial section on satellite data, each of the instruments or sensors is discussed along with ways to use them singly or in combination as forecasting tools. The process of deriving vertical profiles of temperature and water vapor (TOVS and Advanced TOVS (ATOVS)) is explained in detail. The problems encountered when processing retrievals near and over Antarctica are discussed. Several studies are cited which have developed techniques to compensate for the peculiar properties in the atmosphere over Antarctica.

2.4 New Generation of Satellite Sensors

Over the years, satellites have grown dramatically in number and ability. The latest set of satellites launched contains improved sensor capabilities. *NOAA-16* carries the ATOVS while the DMSP satellite uses the special sensor for microwave imaging and sounding (SSMIS). The National Aeronautics and Space Administration (NASA) has launched its Earth Observing System (EOS) *Terra* satellite, and the EOS *Aqua* will be launched in late 2001. Both *Terra* and *Aqua* transmit data at X-Band (18 Ghz) with much higher data rates than NOAA or DMSP satellites, and both carry the Moderate Resolution Imaging Spectroradiometer (MODIS) sensor with 36 channels and increased spatial resolution (Bernstein 2000). MODIS offers the multispectral capability to retrieve a large number of atmospheric properties that are useful for forecasting and numerical modeling simulations (Bromwich and Cassano 2000). *Aqua* and the Japanese Advanced Earth Observation Satellite (*ADEOS-2*) will carry the Advanced Microwave Scanning Radiometer (AMSR) that greatly improves upon the capabilities of SSM/I for detecting cloud liquid water and precipitation rate over the ocean. The challenge for both the Antarctic forecaster and researcher will be in developing means to exploit these data for better forecasts.

3. SUMMARY

Antarctic weather forecasting has evolved since the advent of the weather satellite. Advances in detection and monitoring of mesoscale features; generation and use of composite imagery; improved forecasting procedures and scientific research; and continuous updating of weather satellite sensors has brought Antarctic weather forecasting into the modern age. New satellite technologies are planned, so the potential for improved Antarctic weather forecasts is promising.

ACKNOWLEDGMENTS. This work was supported by the NSF-OPP, Ocean and Climate Program Grant OPP-9908842.

4. REFERENCES

Bernstein, R.L., 2000: Availability and visualization of satellite data in the Antarctic. Preprints, Antarctic Forecasting Workshop, BPRC Miscellaneous Series M-419, Byrd Polar Research Center, The Ohio State University, Columbus, OH, 24-25.

Bristor, C.L., W.M. Callicott, and R.E. Bradford, 1966: Operational processing of satellite cloud pictures by computer. *Mon. Wea. Rev.*, **94**, 515-527.

Bromwich, D.H., 1989: Satellite analyses of Antarctic katabatic wind behavior. *Bull. Amer. Meteor. Soc*., **70**, 738-749.

________, and J.J. Cassano, Eds., 2000: Recommendations to the National Science Foundation from the Antarctic Weather Forecasting Workshop, BPRC Miscellaneous Series M-420, Byrd Polar Research Center, The Ohio State University, Columbus, OH, 48 pp.

________, J.F. Carrasco, and C.R. Stearns, 1992: Satellite observations of katabatic wind propagation for great distances across the Ross Ice Shelf. *Mon. Wea. Rev*., **120**, 1940-1949.

Foster, M.S., 1982: Aviation forecasting for the U.S. Antarctic program. *Antarctic J. of the U.S.*, **17**, 265-266.

Stearns, C.R., B. Sinkula, R. Holmes, M.A. Lazzara, and J.T. Young, 1999: Six years of composite infrared images south of Forty South at three hourly intervals. IUGG99 Conference, Birmingham, UK, p. B119.

Streten, N.A., 1968: Some aspects of high latitude Southern Hemisphere summer circulation as viewed by ESSA 3. *J. Appl. Meteor*., **7**, 324-332.

Troup, A.J., and N.A. Streten, 1972: Satellite-observed Southern Hemisphere cloud vortices in relation to conventional observations. *J. Appl. Meteor*., **11**, 909-917.

Turner, J., and S. Pendlebury, Eds., 2000: The International Antarctic Weather Forecasting Handbook, Vol. 1.1, 691 pp. [Available via FTP from the BAS Web site where details are available at http://www.nerc-bas.ac.uk/public/icd/jtu/ftpinst.html.]

________, and Coauthors, 1996: The Antarctic First Regional Observing Study of the Troposphere (FROST) project. *Bull. Amer. Meteor. Soc*., **77**, 2007-2032.

________, S. Leonard, G.J. Marshall, M. Pook, L. Cowled, R. Jardine, S. Pendlebury, and N. Adams, 1999: An Assessment of Operational Antarctic Analyses based on data from the FROST Project. *Wea. Forecasting*, **14**, 817-834.

Wiesnet, D.R., C.P. Berg, and G.C. Rosenberger, 1980: High-resolution picture transmission satellite receiver at McMurdo Station aids Antarctic mosaic project. *Antarctic J. of the U. S.*, **15**, 190-193.