AMPS Operational Utility

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1. Introduction

Since the inception of the Antarctic Mesoscale Prediction System (AMPS) a unique combination of research and numerical modeling development has provided a robust experimental model for the Antarctic. This model has been evaluated in the operational field at McMurdo Station. Operational forecasters have viewed the output twice daily, finding great value in the strengths identifying weaknesses in various situations. Although it is an experimental model, the fine resolution and increased prognosis reliability has made this the model of choice for the U.S. Antarctic Program weather operations personnel.

Weaknesses have been discovered in the placement of moisture, and temperatures within the inversion layer. Strengths have been found in wind patterns, coastal thickness values, elevated inversions, and projections of low level moisture when initial validation correlates.

The operational stem of this partnership is one of direct contribution for direct benefit. The information technology era has provided the capability to collect and distribute information that in previous years was only available to a select few. Technology has also assisted in providing Automatic Weather Station (AWS) data and optical instrumentation, aiding weather observations taken from inexperienced field observers. Operations benefit from this joint alliance to increase accuracy in a highly volatile location where forecasting accuracy balances between mission success and the safety of life.

2. Environmental Concerns

The location of Ross Island does not provide an easy environment to conduct air operations. From the beginning of Antarctic aviation a suitable alternative to the McMurdo area was explored. The Metcalf and Eddy engineering team from Boston, MA presented a potential hardened runway plan at Marble Point in May 1958. This area presented not only a large area to build a hardened runway but better weather to conduct aviation operations (Metcalf and Eddy, 1958).

Three contrasting boundary layer environments with unique surface conditions are joined in the McMurdo region. The Plateau offers an elevated area with prevailing winds to support and maintain an arid environment. Inflections from this region will typically provide dry katabatic winds and produce fair weather at McMurdo.

The Ross Sea provides a huge moisture source with a warm surface creating instability. Moisture can be derived from this region even during the dark of winter with sublimation driven by relatively thin and warm sea ice, polynas, and leads. A major change in McMurdo area weather can be noticed when the Ross Sea opens and the availability of moisture maximizes. Other changes in the local weather can occur, produced by the location of open water in relation to McMurdo. When strong southerly winds are driven through the McMurdo Sound, a reciprocating northerly flow will typically produce snow and reduced cloud bases driven by the newly opened water. Strong winds to the east of Ross Island force ice packs into the McMurdo Sound and decrease instability and available moisture in the area providing an improved condition over the norm.

The third unique environment within the area is the Ross Ice Shelf. This region is a dynamic modification of the two previously mentioned air masses placed over the coldest surface provided. If left standing, the potential temperature will be reduced to the lowest value in comparison. When intrusions from the Ross Sea progress over this cold surface, the natural surface based inversion is enhanced and moisture is typically condensed and trapped at low levels.

It is for these reasons that a thorough knowledge of the area, geographic effects, and an advanced understanding of atmospheric dynamics are required to successfully forecast weather conditions.

3. Forecasting Tools

Interpreting satellite information has been the backbone of short-term weather forecasting. This process is used worldwide, but higher levels of dependency have been placed on this tool where there is limited support from computer generated numerical models. Numerical modeling faces many of the same challenges as the forecaster in resolving the unique terrain features and convergence of multiple variables. At the May 2000 Antarctic Weather Forecasting Workshop, many of these physics and modeling obstacles
were outlined. Regardless, an initial effort was made to develop a numerical tool that best reflects the polar environment - AMPS.

4. AMPS Strengths

AMPS has provided a robust year of operations for the United States Antarctic Program. During this year of utilizing the tool in a secondary operational role, it has provided valuable insight into features that assist in the forecast development process.

The primary strength is the projection of wind patterns around Ross Island. The wind direction and velocity fields are used frequently with a high degree of confidence in most situations. Wind depictions above 1,000 ft (300 m) are most accurate; below 1,000 ft the direction is generally fair and the velocity bias will vary depending on the situation. Generally the bias is high in conditions that promote southerly winds to 25 kts (13 m/s), and low in situations where observed winds are greater than 30 kts (15 m/s).

Situations where low clouds or fog has formed in close proximity and under light wind regimes are most difficult to forecast due to variability in wind directions based on local observed weather and satellite imagery. AMPS has offered precision in this area, indicating weak shifts in wind that may advect low level moisture or dry air into the region when fog or low clouds exist. In the example provided, a photo indicates fog to the south of McMurdo (Fig. 1). In Fig. 2, the AMPS 16-h forecast indicates fog to the south of McMurdo. (over Williams Field), which retreated as the wind shifted from the north as indicated.

![Fig. 1. View of fog bank extending from the Windless Bight. View is to the south.](image1)

This same run shows the accuracy of moisture values. This element is both a strength and weakness of the system. When the moisture is properly located in the analysis the accuracy of the wind directions assist in advection. Development and dissipation of moisture is generally represented well.

The resulting wind shift from the north as projected on the on the 22hr forecast drives a layer of elevated moisture from Lewis Bay which further develops in the McMurdo Sound and is photographed showing the low cloud cover moving over the station (Figs. 3 and 4).

![Fig. 2. AMPS 16hr forecast.](image2)

![Fig. 3. AMPS 1K RH 22hr forecast](image3)
5. AMPS Weaknesses

Although AMPS has provided a valued tool there are areas of improvement that are needed. Accurate representation is not depicted for the immense terrain that is offered in the area. Hut Point Peninsula is absent on the 10-km scale. This obstacle provides a major adjustment to wind directions and produces converging winds causing acceleration in the area of the active airfields that is not represented because of the absence of this feature. As depicted in figure 5 (Seefelt, 1996), a developed runway crosswind was captured as a result of deflected super katabatic wind flows. This feature would not be detected without the depiction of Hut Point Peninsula causing the redirection.

The second element of concern is the representation of surface temperatures. The modeled temperature patterns over a 24-hour period will not have a similar cycle when compared to the daily observations. This weakness was observed repeatedly throughout the season. A main contributor to this error could be unveiled by the performance of the surface temperatures over this last month (August 2001). With the majority of the Ross Sea covered with ice, a more consistent surface is now offered to the environment. The actual may now be more closely related to the model's representation. Surface temperatures over this period fall within a few degrees and frequently mirror the general trend (figure 6).

The temperature errors extend upward though the surface based inversion. AMPS frequently produces a weaker inversion that breaks easier with surface temperature fluctuations. It should be stated that elevated inversions are regularly captured at or near the observed level.

6. Summary

The MM5 product has provided the first real forecasting tool since the introduction of the Automated Weather Sensors and the High Resolution Picture Transmission satellite receiver. It produces many tools to extend forecasting and the forecaster's confidence beyond observations and satellite interpretation.

If surface based temperatures can be more accurately depicted and forecasted, increased accuracy can be readily obtained in the forecasting of fog. This element is highly dependent on the cooling temperature trends.

Greater confidence and accuracy in mid-range forecasting will assist in optimizing mission scheduling and accomplishment. Increased conventional and non-conventional data sets will
be required to increase the accuracy of initial parameters. Polar physics modifications are being studied and implemented. The addition of this joint effort to improve weather forecasting capabilities leads to the inference of an accurate polar environment and refinement of the global depiction.

The combination of improved observational tools, computers and numerical models has led to substantial improvements in the accuracy of forecasts (Polger et al., 1994). It is the priority of Aviation Technical Services personnel to follow this same path and overcome the limitations that Antarctica presents.

References

