Meteorology Satellite Requirements For Operations Conducted by The United States Antarctic Program

Antarctic Program Office
SPAWAR System Center, Charleston

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1. Introduction

During the annual Antarctic Operations Engineering Conference conducted in April 2002, National Science Foundation requested that the Antarctic Program Office of Space and Naval Warfare Systems Center (SPAWARSYSCEN), Charleston provide the National Oceanographic and Atmospheric Administration (NOAA) the United States Antarctic Program (USAP) customer requirements detailing the usage of NOAA controlled satellite systems. In completing this task

2. Description of Operations

The United States Antarctic Program (USAP) provides year around operational meteorology services for an Area of Responsibility (AOR) that includes the Antarctic continent and the Southern Ocean south of 60°S. In this environment personnel safety is threatened by extreme weather and requires specific attention. Satellite derived information is vital to operations and personnel safety. Area, surface land traverse, ship, and aviation forecasting services are provided from the forecasting center located at McMurdo Station, Antarctica. Primary operations are conducted during the austral summer from late August until the end of February. During the austral winter months of March through mid-August, meteorology services provide support for personnel safety issues, for land traverses, and for occasional aviation forecasts provided for emergency situations (e.g. Dr. Shemenki's rescue, April 2001).

In this remote region, covering an area larger than North America, USAP is responsible for the development of weather forecasting products throughout areas south of 60°S and the flight corridor from Christchurch, New Zealand to McMurdo Station. To assist with this effort, the USAP meteorologists rely exclusively on National Oceanographic and Atmospheric Administration (NOAA), Defense Meteorological Satellite Program (DMSP), and the SeaStar (SeaWiFs) polar orbiting L-band satellite data as well as Geostationary Meteorological Satellite (GMS).

3. Satellite Usage

Satellite images have been the backbone of forecasting. Dynamic mesoscale systems can easily fit between areas of reports and synoptic scale features can be easily misrepresented. Global models do not provide a reasonable representation of polar weather. Weather radar networking is non-existent and is not logistically feasible.

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Mesoscale models are improving but also require satellite data to be factored into and to validate the model's output. In this area of sparse reports, satellite data becomes the only viable real-time information tool.

University of Wisconsin provides a composite loop of the southern hemisphere. These images are constructed using High Resolution Picture Transmission (HRPT), Global Area Coverage (GAC), and Geostationary satellite images (figure 1). The data is available to the forecasters and used operationally to provide validation to long wave patterns and storm tracks. In addition, the nine-year historical record allows patterns to be studied for climatic purposes.

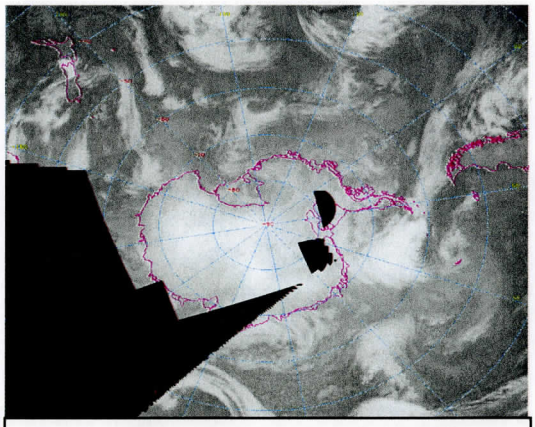

Figure 1 – U/Wisconsin Composite Image of the Southern Hemisphere

GMS provides coverage of the northern portion of the flight corridor from Christchurch, New Zealand to McMurdo Station. This information is used to conduct and monitor intercontinental flight paths.

Satellites provide not only valuable images, but also relay Automated Weather Sensor (AWS) reports from the unmanned stations established on continent. This communications link is conducted via Argos Data Collection System (DCS) available on designated NOAA satellites. Nearly sixty AWS stations are located in various parts of the continent and assist in providing required surface data that fill in broad gaps from the scant number of manned reports. Real-time data retrieval would not be available without the use of this system. This information is the only real-time data in many areas of the AOR to produce a course surface analysis for both operations and computer modeling efforts (figure 2).

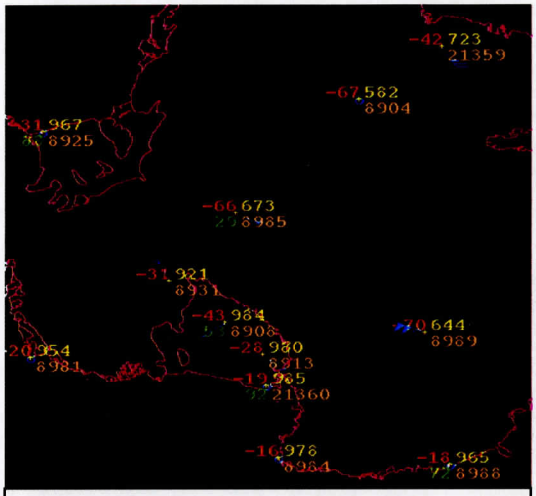

Figure 2 – Sampling of Argos DCS relayed U/Wisconsin AWS reports from U/Wisconsin

4. Operational Requirements

<u>High Resolution Picture Transmission (HRPT) Images</u>

Current use of NOAA satellites includes the capture of all available NOAA HRPT images. These images are captured at the ground station in McMurdo Station using a SeaSpace TeraScan system. Data from channels 1-5 are used on location to provide AOR forecasts for aviation, ships, land traverses, and site/station locations.

USAP operations require the continuous broadcast of L-Band images. Current coverage is gapped between the hours of 2200 to 0300(UTC). Excessive coverage is observed for the hours of 0800 to 1900(UTC) when NOAA and DMSP images are combined. Satellites merging near the poles produce an overlap from the orbital clusters with similar sun synchronous times. Images are dropped from the schedule when pass conflicts cannot be avoided.

During the hours of 0400 to 0700 (UTC) and again from 2000-2200 (UTC), ample coverage is provided. Images from late morning DMSP or NOAA-16 provide this coverage with no conflicts.

The hours from 2200 to 0300 (UTC) are frequently void in the area of McMurdo Station to the Ross Ice Shelf. The launching of NOAA-16 combined with the prospective orbit of NOAA-17 and the late morning DMSP satellites provide the narrowest gap in this period but the gap still remains.

For operations to benefit from the satellite periods, USAP requires the late morning orbits to be pushed as late in the day as possible, and the evening orbits as early as possible. This will continue to narrow the 22-03(UTC) gap. Any additional effort to stray unused assets or fill this void in any manner would be highly encouraged and needed for the described operational uses.

Global Area Coverage (GAC), Local Area Coverage (LAC) and Automatic Picture Transmission (APT) Data

Additional image information used includes the processed GAC data to provide area coverage away from the McMurdo ground station. This utility assists in seeing regions out of the swath area but still within the AOR and requiring forecasting services.

LAC data coverage for the Antarctic region could assist in supporting finer resolution products for the University of Wisconsin and National Ice Center. Products from these agencies provide operational support.

APT images have been used as a backup to the HRPT system. This backup could be replaced by more frequent LAC data over the region.

Geostationary Services

GMS provides the USAP images to support flights to and from New Zealand, when functioning to full capacity. Images and vapor winds have been a valuable tool in flight forecasting and flight following efforts. With the reduced image due to gradual system failure, these services have been hindered (figure 3). Replacement by the GOES-9 is highly encouraged to reestablish these support services.

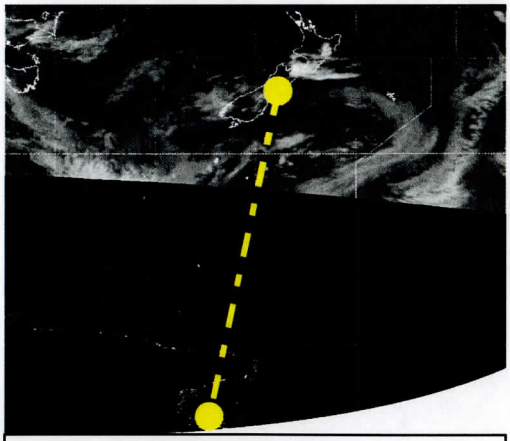

Figure 3 – GMS image with the USAP intercontinental flight path depicted in yellow. This reduced area coverage increases USAP operations dependency on orbital systems.

Other Services

Argos DCS will continue to be the means to communicate with AWS sites. This provision of surface data is vital to operations. The data is also gapped during the same periods as the images. Any effort to fill this lack or orbital passes during the periods of 2200 to 0300 (UTC) would greatly enhance operational ability and safety concerns.

Water vapor winds have been derived from the use of X-Band passes using the Terra satellite. This system offers an enhancement to our data sparse region to contribute non-traditional information for Numerical Weather Predictions to ingest and to validate model output at various levels. Prior to this new initiative, this luxury has been afforded to all areas of the globe except the Polar Regions where they are needed most. The projected lack of a water vapor sensor on future NPOESS systems would eliminate this function.

The deployment of a polar sitting satellite as presented by Pat Mulligan of NOAA, could fill most of USAP concerns in both image and communications. Deployment of a polar sitting satellite equipped with a medium to high-resolution sensor for imaging, and a communications package could:

- Replace the need to fill in the orbital gap.
- Eliminate the need for Argos DCS transmission.
- Reduce the required number of orbital satellites.
- Replace the need for GAC and LAC data.
- Capture dynamic development using rapid scanning techniques.

In keeping with the projected deployment concept of a limited number NPOESS systems, a polar sitting satellite with a meteorology imaging and a communications package could fill all the voids that would be created by the phasing out of the L-Band constellation. Current X-Band post processing will improve with time but the large data downloads and file sizes will be hard to manage for real-time use, sharing information, and the construction of composites. The concept of GAC/LAC data will be either eliminated with L-band systems or force NOAA into a greater effort to process X-band global data in a timely manner. Faced with these potential limiting factors a polar sitting satellite would become a necessity for USAP operations.

5. Summary

The USAP is responsible for conducting operations over a vast area in the southern polar region. With limited weather resources, satellite data becomes a main focal point for weather predictions. The harsh environment threatens personnel safety of USAP participants and distinguished visitors. Accuracy of weather predictions and severe weather warnings are highly dependent on continuous satellite data. Efforts to expand the capability to a 24-hrs service void of extensive gaps would assist the meteorology effort and improve the safety of USAP personnel.

NOAA Satellite Ground Station Customer Questionnaire has been completed and submitted posting summaries of the above USAP concerns. This process will be maintained

annually, as recommended in the posting.

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