Using Hyperspectral Sounders to Detect Cold Air Aloft over Alaska

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Introduction

Air temperatures -65C and colder at cruising elevations used by jet aircraft can be hazardous to aviation, as jet fuel will gel at these temperatures. Outbreaks of such "cold air aloft" can occur over the Arctic Ocean and Alaska. The National Weather Service's Center Weather Service Unit (CWSU) in Anchorage, Alaska provides weather support to air traffic controllers directing traffic over the Arctic Ocean and Alaska.

While numerical weather prediction models help meteorologists forecast the occurrence and movement of cold air aloft, to date National Weather Service (NWS) meteorologists have had no access to an observational dataset revealing the actual presence of cold air aloft in real time in regions not sampled by conventional radiosondes. Hyperspectral sounders, such as the Cross-track Infrared Sounder (CrIS) aboard the Suomi National Polar-orbiting Partnership (S-NPP) satellite, are well-suited for observing cold air aloft over Alaska and the Arctic Ocean due to the sensitivity of these instruments and the comparatively high number of passes satellites in polar orbits make per day over the high latitudes. The high elevation of the cold air in question, occurring 30 or 40 thousand feet above sea level, is advantageous because satellite-borne hyperspectral sounders perform well at higher elevations in contrast to their occasionally-degraded performance in detecting phenomena in the planetary boundary layer.

The Geographic Information Network of Alaska (GINA), as part of the High Latitude Proving Ground, receives CrIS data from the SNPP satellite via direct broadcast, uses the Community Satellite Processing Package to generate products from the data, and then delivers the products to the National Weather Service in Alaska, all with the goal of providing meteorologists a vital observational dataset while minimizing latency.

A Case Study: The Event of February 24-25, 2014

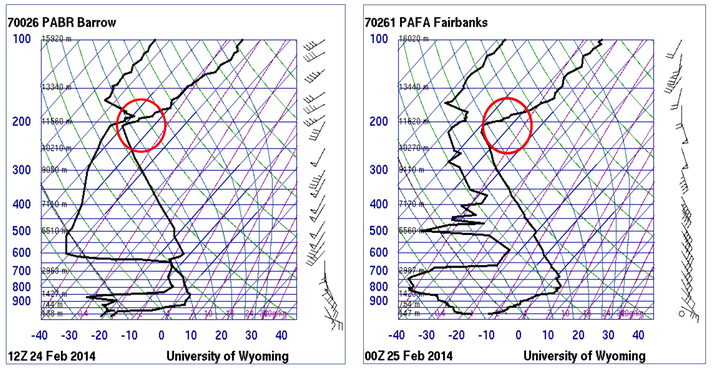

Figure 1: NOAA/NWS radiosonde data from Barrow and Fairbanks, Alaska 12Z February 24, 2014 and 00Z February 25, 2014, respectively. Regions circled in red indicate air temperatures between -60C and -70C.

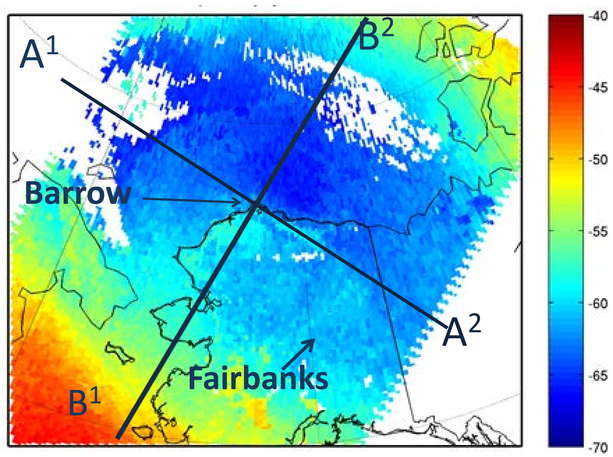

Figure 2: Temperature data at the 200mb pressure level as detected by the CrIS instrument at 1334Z February 24, 2014. Temperatures are shown in degrees C, per the color bar to the right of the image.

A high-elevation cold air event occurred over Alaska and the nearby waters of the Arctic Ocean in late February, 2014. The upper air profiles from Barrow and Fairbanks (fig. 1) show a layer of air with temperatures ranging from -60C to -70C extending in elevation from 250mb up to between 150mb and 100mb at 12Z February 24 and 00Z February 25.

As an observational dataset, radiosondes offer the strength of depicting the magnitude and vertical extent of the layer of cold air with a high degree of accuracy and detail. However, radiosondes suffer the shortcomings of being point-based in space with wide gaps between sounding locations (and no soundings at all over the vast Arctic Ocean), and also of being available only once every twelve hours. Satellite-borne hyperspectral sounders detect the cold air aloft with reasonable accuracy and have the great advantage of sampling a wide horizontal swath of the atmosphere as opposed to sampling fixed, isolated points. Also, at high-latitude locations such as Alaska and the Arctic Ocean, the temporal frequency of observation by sounders on polar orbiting satellites is much higher than just twice a day.

One challenge for product developers is how to depict the large amount of three-dimensional temperature information provided by hyperspectral sounders onto a two-dimensional screen in a timely and intuitive manner for use by NWS forecasters. Cross sections are one approach. Figure 2 shows temperatures retrieved from CrIS measurements at 1334Z, February 24, 2014 on one horizontal plane, in this case the 200mb pressure surface. These temperatures were retrieved from CrIS radiance measurements using the University of Wisconsin's hyperspectral retrieval algorithm, which is part of the Community Satellite Processing Package (CSPP) used at GINA. This figure also shows the locations of Barrow and Fairbanks, as well as the locations of two additional vertical cross sections, A^1-A^2 and B^1-B^2 shown in figure 3. Cross sections A^1-A^2 and B^1-B^2 intersect each other at Barrow. Figures 2 and 3 show that hyperspectral sounder data, while still having some gaps in coverage, is much more complete in space than the radiosonde data, especially at the higher elevations where these cold air events occur.

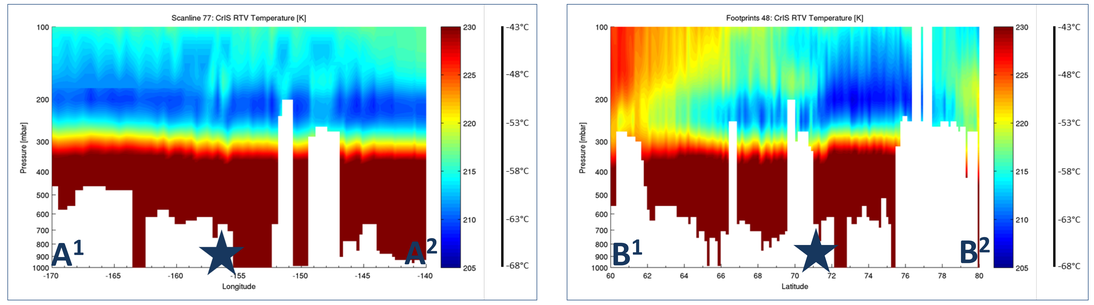

Figure 3: CrIS temperature data in vertical cross-sectional planes A^1-A^2 and B^1-B^2 as depicted in Figure 2. These two cross sections intersect at Barrow, Alaska, noted here by the blue star. Colors correspond to degrees K, with a Celsius scale bar also provided to the right of each cross section.

Future Work

Future work will likely involve the inclusion of additional cooperative institutes such as the Cooperative Institute for Research in the Atmosphere (CIRA) and NASA's Short-term Prediction Research and Transition Center (SPoRT). Progress can be made in the delivery of products intended for use by NWS forecasters in the Advanced Weather Interactive Processing System (AWIPS) and on the Internet.

Additional instruments such as the Atmospheric Infrared Sounder (AIRS) on the Aqua satellite can be used, and efforts to include CrIS and AIRS in the data assimilation process of local Weather Research and Forecasting (WRF) numerical modeling over Alaska can be expanded.

Resulting products may prove helpful beyond the NWS by users such as the U.S. Department of Defense, commercial air carriers, and the U.S. Antarctic Program.

Data Cited and Acknowledgement

Skew-T plots of NOAA/NWS radiosonde data from University of Wyoming internet site http://weather.uwyo.edu/upperair/sounding.html

Background image is a true color image over Alaska from the Visible Infrared Imaging Radiometer Suite (VIIRS) aboard the S-NPP satellite received at GINA via direct broadcast, 2252Z Feb 26, 2014 and archived by GINA online at http://feeder.gina.alaska.edu

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