NCAR Input for CLIMODE R/V Knorr cruise KN188-2

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The National Center for Atmospheric Research (NCAR) operated a balloon borne radiosonde sounding system and a wind profiler for CLIMODE. The wind profiler is a 915 MHz clear-air radar and measures wind and atmospheric reflectivity in a column above the radar. The radar also includes a Radio Acoustic Sounding System (RASS) to measure virtual temperature aloft. The radiosondes were typically launched at three to six hourly intervals, whereas the wind profiler operated continuously. These instruments are components of an ISS (Integrated Sounding System) in NCAR's Earth Observing Laboratory (EOL). The ISS measurements for CLIMODE are available on the web at http://www.eol.ucar.edu/rtf/projects/climode/

Radiosonde sounding system

NCAR operated a GAUS (GPS Advanced Upper-air Sounding) system launching 100 balloon borne radiosondes. Approximately 80% of the soundings reached 100 mb (about 16 km), and about half of those went above 50 mb (approx. 20 km).

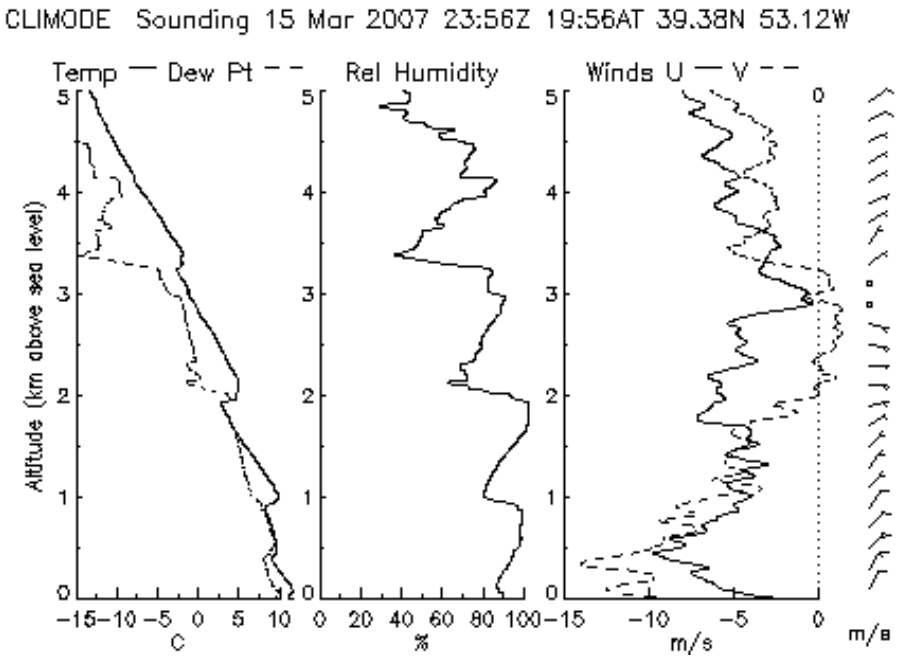

Figure 1: Profiles of temperature (and dew point temperature), relative humidity, and wind (eastward U, and northward V) as functions of altitude for a radiosonde sounding launched at 2356 UTC on March 15. The wind barbs at the far right show the direction the wind has come from (here mainly east or northeasterly).

An interesting feature of many of the soundings was the multiple layers. An example is shown in figure 1. The bump at 1 km in the temperature and humidity profiles is the characteristic temperature inversion at the top of the boundary layer. Notice there are other unexpected inversions in the temperature profile. These represent layers of air warmed or cooled elsewhere, probably by blowing over warm or cold pools of water to the east and north. Similar features were observed in many of the soundings, and these

will provide valuable clues about the exchange and transport of heat in the atmosphere around the Gulf Stream.

Wind Profiler

The wind profiler worked very well for this cruise. During the first cruise there was a problem with sea spray in some of the cables, disabling the stabilized platform that keeps the antenna steady. Repairs were carried out in Bermuda and the platform operated normally during the second cruise. There was also a problem with the radar's coherent integrator cards that degraded the performance of RASS during the first cruise. These cards were replaced in Bermuda and so RASS operated normally during the second cruise.

There have been preliminary performance and accuracy checks of the wind profiler measurements as compared with the radiosondes. The wind measurements agreed with the radiosonde wind measurements to within about 2 m/s (standard deviation), which is a reasonable agreement given that the radiosondes and ship drift some distance apart during the observations. Wind measurements were available up to an altitude of 1500 meters at least half of the time, and when there was precipitation present, measurements extended through the precip, sometimes to 5 km. The wind profiler doesn't provide the depth of coverage of the radiosondes, however does provide the continuous coverage of the boundary layer that would be prohibitively expensive with radiosondes.

An example of the measurements made by the wind profiler is shown in figure 2. The upper panel shows SNR (Signal to Noise Ratio) which indicates the reflectivity of the atmosphere over 48 hours from 0 UTC on March 15. Reflectivity is a complicated function of humidity, temperature, and turbulence. Here we can use it to trace the evolution of layers in the atmosphere. For example, the sounding in the figure above was made at about 0 UTC on the 16th (approximately where the Day 075 line is on the plot). Some of the inversions in the sounding figure correspond to the layers in the SNR plot. The lower panel shows the winds measured by the profiler; on the 15th the winds were mainly northeasterly, turning to northerlies on the 16th. The wind profiler provides a means of tracking the inversion layers and the winds between soundings.

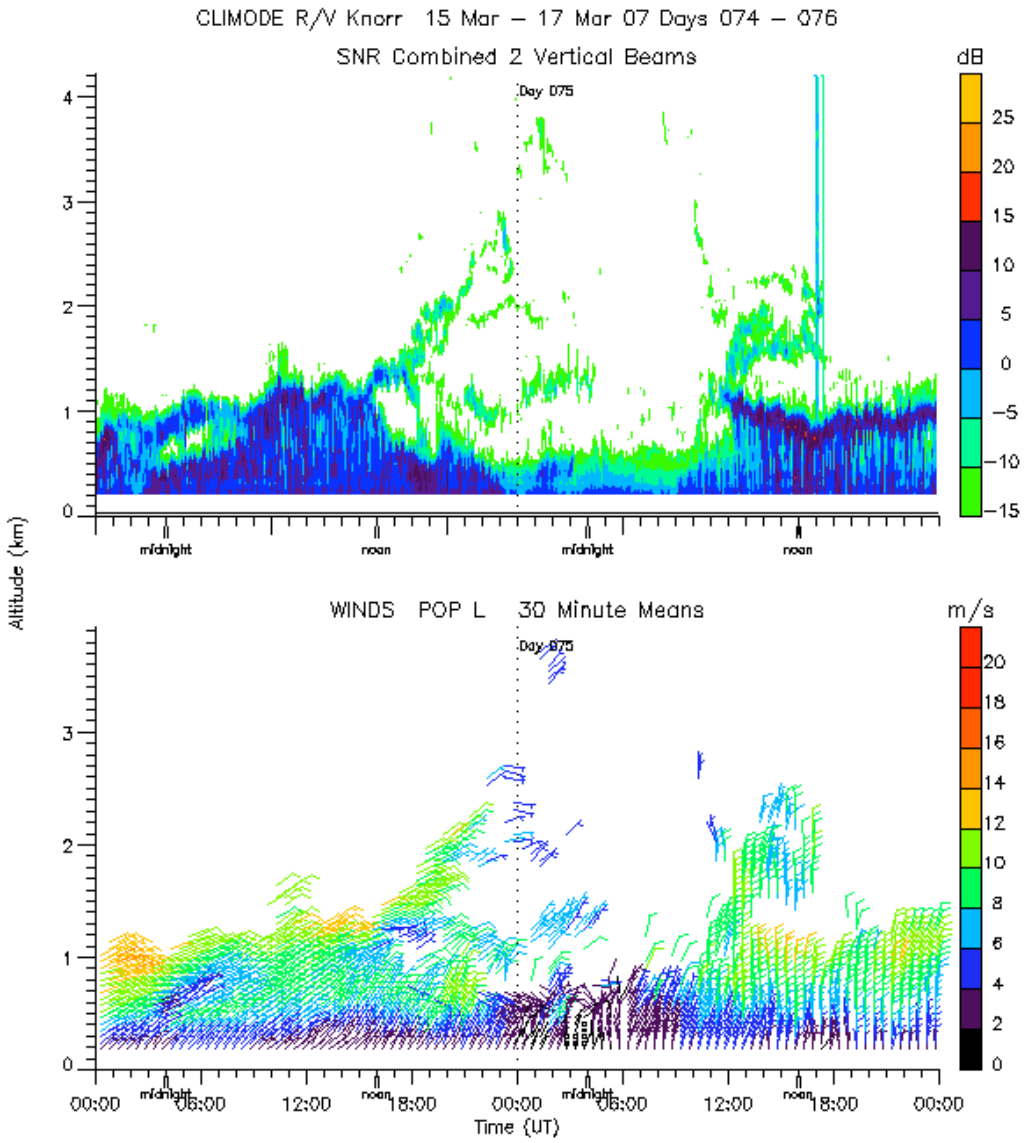

Figure 2. . Wind profiler observations from 0 UTC on March 15 to 0 UTC March 17. The upper panel shows SNR (Signal to Noise Ratio) and the lower panel shows wind barbs (30 minute averages, color coded by speed) as functions of altitude. The barbs indicate the direction the wind is from.

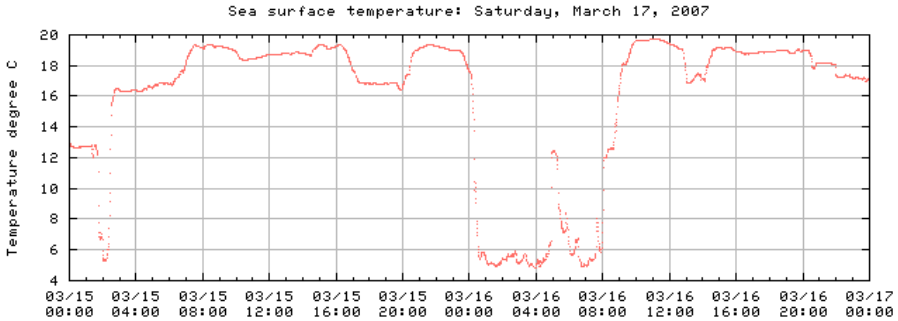

Figure 3. Imet sea surface temperature for the same period as figure 2.

The imet sea surface temperature for the same time period is plotted in figure 3. Notice how the temperature drops substantially between about 0 UT and 8 UT on the 16th. This period was during the third Sea Soar observation period as we sailed out of the Gulf Stream, and then turned back into the Gulf Stream. During the transit over the cooler seas the reflectivity of the atmosphere (SNR in figure 2) dropped considerably as surface driven convection was suppressed. The reflectivity recovered when we returned to warmer waters around 8 UT.

RASS

The Radio Acoustic Sounding System (RASS) measures virtual temperature aloft by emitting a loud tone; the wind profiler radar can detect the sound wave as it travels vertically and uses the relationship between the speed of sound and virtual temperature to measure temperature.

The RASS virtual temperature measurements were compared to the radiosonde observations and agreed to within about 1C. RASS measured up to 500 m around half of the time, and occasionally over 1000 m (for example when there was a tail wind advecting the acoustic signal along with the ship).

An example of RASS virtual temperature measurements is given in figure 4. This example is for the same time period as figures 2 and 3. Notice that when the sea surface temperature drops (0 UTC on March 16) the temperature measured by RASS also drops. As expected the air temperature recovers as the sea surface temperature warms; using RASS we can see that this recovery extends at least 500 meters up into the atmosphere.

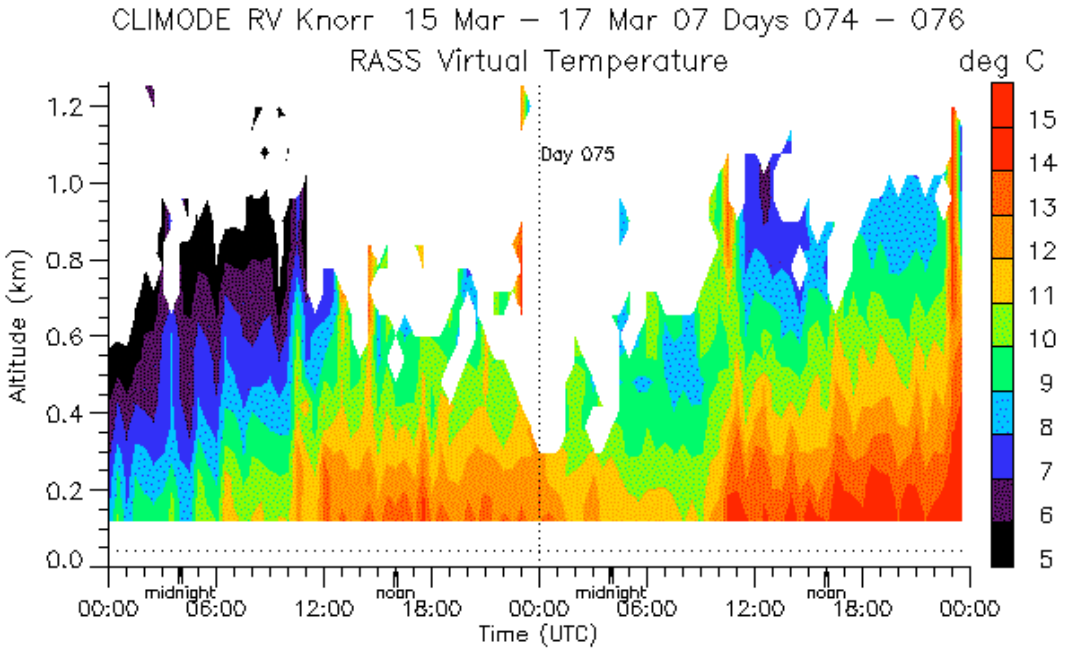

Figure 4. Wind profiler RASS virtual temperature for the same time period as figures 2 and 3.