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Continuous Water Vapor Profiles for the Fixed Atmospheric Radiation Measurement Sites

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1. Background

The Atmospheric Radiation Measurement (ARM) Program defined a specific metric for the first quarter of Fiscal Year 2006 to complete a continuous time series of the vertical profile of water vapor for selected 30-day periods from each of the fixed ARM sites. In order to accomplish this metric, a new technique devised to incorporate radiosonde data, microwave radiometer data and analysis information from numerical weather forecast models has been developed. The product of this analysis, referred to as the merged sounding value-added product, includes vertical profiles of atmospheric water vapor concentration and several other important thermodynamic state variables at 1-minute time intervals and 266 vertical levels.

2. Scientific Relevance

Atmospheric water vapor plays a critical role in the earth's energy cycle through direct interactions with electromagnetic radiation, energy transfers through changes in phase and impacts through the hydrological cycle. Through these interactions water vapor provides a dominant feedback on the climate system, and we must be able to define the role of water vapor in redistributing energy throughout the atmospheric columns if we are to predict future climate states. In order to perform accurate calculations of the transfer of electromagnetic radiation through the atmosphere, information on the vertical profiles of water vapor concentration and temperature are needed. While these quantities are measured by balloon-borne radiosondes (at 4- to 24-hour intervals) and some specialized remote sensing instruments (e.g., profiling microwave radiometers), the need for continuous estimates of these vertical profiles required the development of new techniques that combine observations from several different platforms.

3. Results

The merged sounding value-added product uses a combination of observations from several different platforms, output from computer model simulations of atmospheric conditions, and a sophisticated scaling/interpolation/smoothing scheme in order to define profiles of the atmospheric thermodynamic state at 1-minute time intervals. The vertical profile of atmospheric state variables from the periodic balloon-borne radiosonde observations are used as a starting point for the algorithm. The time lag of upper air observations compared to the surface is taken into account as these measurements are distributed over the time-height domain. Surface-based meteorology observations are also used as a boundary condition at the surface. In order to fill the remaining locations in the time-height domain, we use output from computer model simulations from the European Centre for Medium-Range Weather Forecasting. These observations and model output are then interpolated over the merged sounding grid giving an initial estimate of the atmospheric thermodynamic state at 1-minute time intervals and a total of 266 altitude levels, which vary such that greater detail (20 meters) is captured near the surface with the resolution becoming coarser (200 meters) as the maximum altitude—20 kilometers above mean sea level—is attained. The thermodynamic fields are then smoothed in the horizontal dimension, in order to avoid anomalously large gradients, with a greater weighting towards observations compared to model output. Finally, the vertically integrated water vapor amount measured by the microwave radiometer is used to scale the vertical profile of water vapor at each 1-minute interval.

The output of the merged sounding value-added product includes 17 variables including vertical profiles of the temperature, water vapor content, barometric pressure, and horizontal winds. Figures 1-3 show examples of the time-height cross sections of relative humidity for a representative day at each of the fixed ARM sites. Note that in each case there is important horizontal and vertical structure that must be quantified accurately in order to properly model the energy transfers within the atmosphere. Here, we provide output for three primary field research sites of the ARM Program for three different time periods of interest, specific to each site. They represent the state of the atmosphere at (1) the Southern Great Plains for March 2000, (2) the North Slope of Alaska for 01 March through 15 April 2004 and (3) the Tropical Western Pacific at Darwin, Australia, for January 2005.

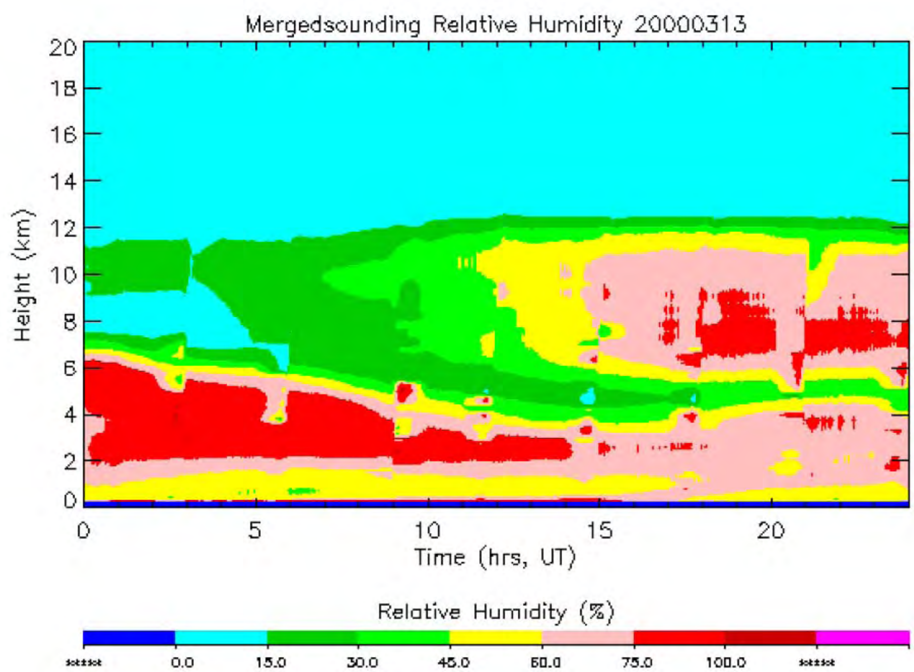

Figure 1. Relative humidity for the Southern Great Plains site on March 13, 2000.

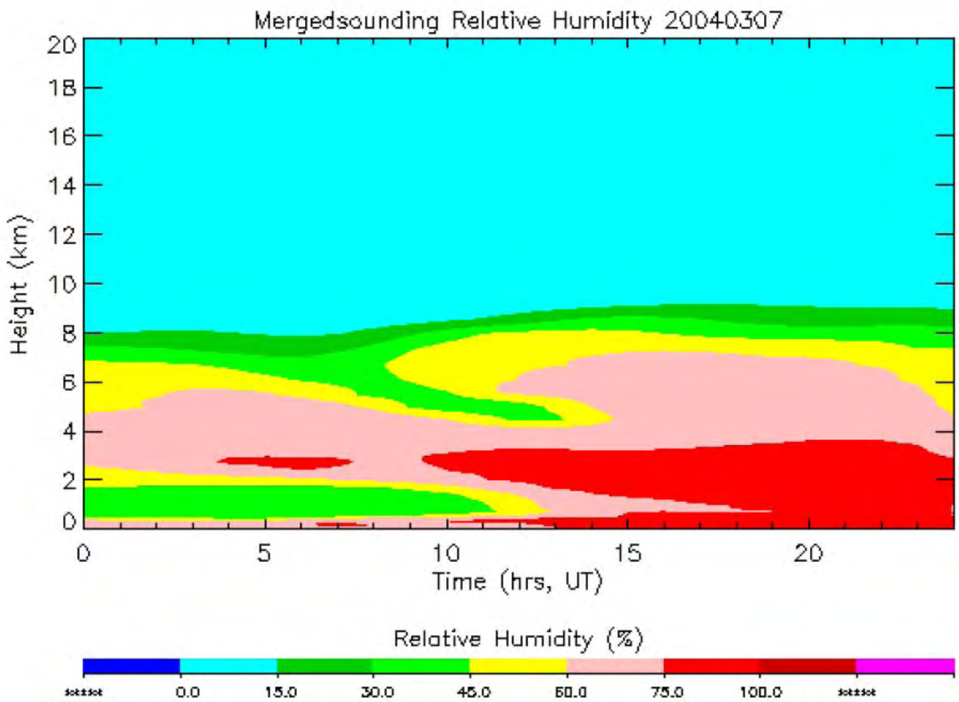

Figure 2. Relative humidity for the North Slope of Alaska site on March 7, 2004.

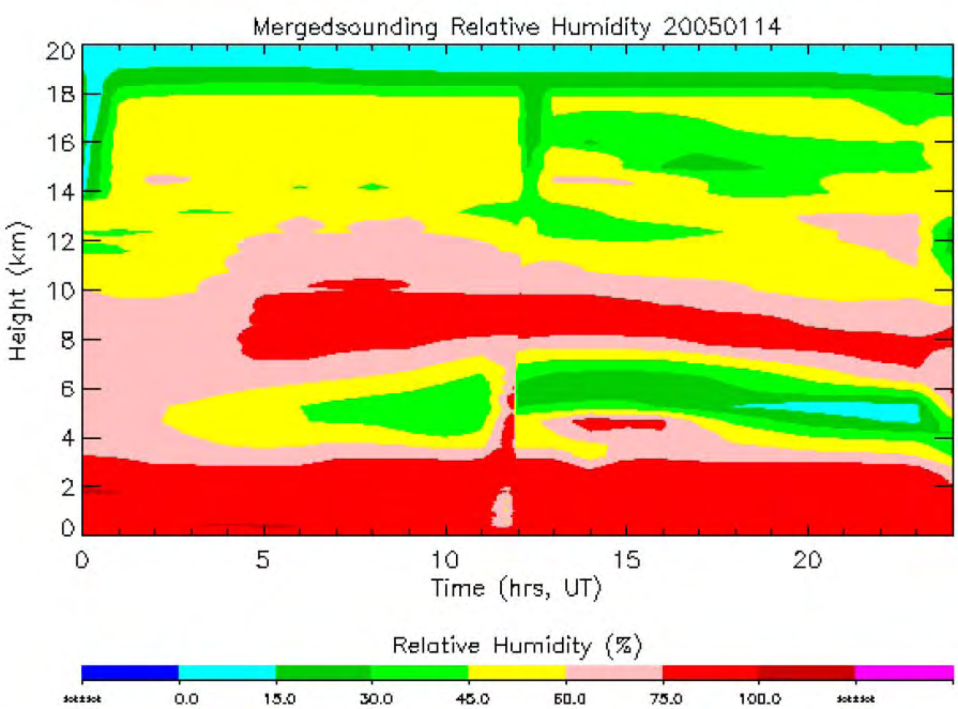

Figure 3. Relative humidity for the Tropical Western Pacific Darwin site on January 14, 2005.

The above files and the rest of the data sets may be retrieved from the Data Archive at http://www.archive.arm.gov/merged-sounding/.

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