Progress Report for SENH grant NAG5-13744

Advancing Solid Earth Science through Improved Atmosphere Modeling

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We proposed to investigate and develop better models for the effect of the hydrostatic and water vapor components of the neutral atmosphere on delay for VLBI and GPS by using a Numerical Weather Model to better simulate realistic atmosphere conditions. By using a raytrace calculation through the model atmosphere at the times of actual VLBI observations, the potential improvement in geodetic results can be evaluated. Also, by calculating the actual variation of delays with elevation and azimuth, the errors in current mapping function models can be assessed.

The VLBI data to be initially analyzed are the fifteen days of the CONT02 sessions of 2002 October which included eight stations. There are three segments to the research. 1) The PSU/NCAR fifth generation mesoscale numerical weather model (MM5) will be used to provide the state of the atmosphere with highest horizontal resolution of 3 km. 2) A three-dimensional raytrace program will be developed to determine the delays through the model atmosphere at the times and in the directions of the VLBI observations for each of the sites. 3) The VLBI data will be analyzed using both standard models for the atmosphere mapping functions and the mapping functions derived from the NWM raytracing.

To date the MM5 program has been installed on a 20-node Beowolf cluster here at the Haystack Observatory. An initialization data set has been obtained and preliminary timing tests have been run to determine the optimum number of nodes to utilize. This work is being done by Mark Leidner of Atmosphere and Environmental Research, Inc (sub-contract). Figure 1 shows the distribution of water vapor mixing ratio from the surface to a height of 13 kilometers (just above the tropopause) along a cut from southwest to northeast passing through the Westford VLBI site. This result was produced on the Haystack Beowolf cluster with the MM5 software.

Initial work on the design of the raytrace program has included consideration of 1) the reference frame in relation to the network of output data provided by MM5 and 2) the overall structure of the program.

The accuracy of the numerical weather model parameters for calculating mapping functions (the dependence of delay on elevation angle) has been evaluated by comparison of raytraces using vertical profiles of temperature and water vapor obtained from radiosondes with profiles of the same quantities from the ECMWF numerical weather model interpolated to the location of the radiosonde launches. The results agree at a level that is smaller than the uncertainties needed for the analysis of VLBI and GPS geodetic data.

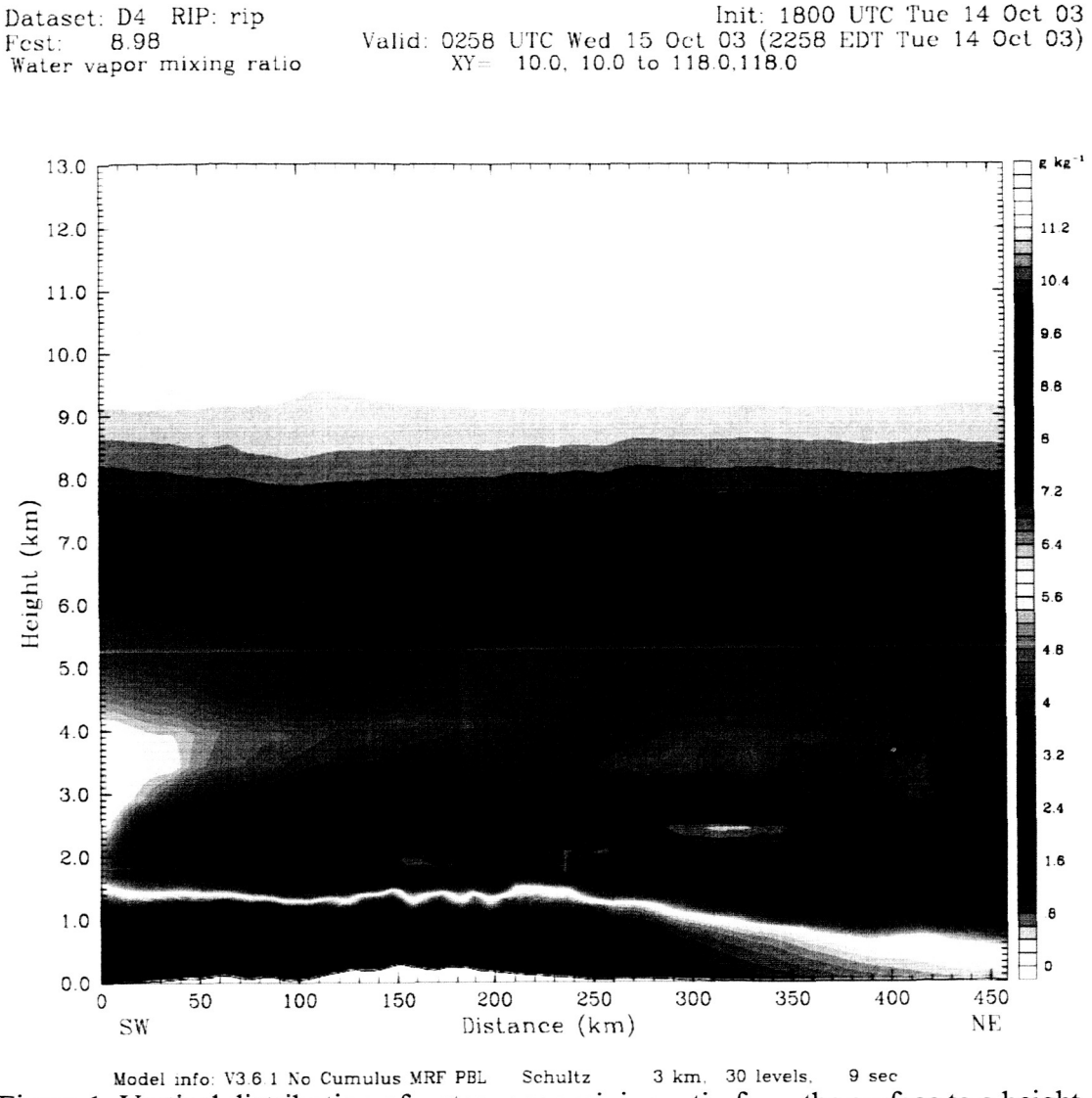

Figure 1. Vertical distribution of water vapor mixing ratio from the surface to a height of 13 kilometers (just above the tropopause) along a cut from southwest to northeast passing through the Westford VLBI site produced using MM5 on the Haystack Observatory Beowolf cluster.