Abstract

The International H₂O Project 2002 (IHP-2002) was a field experiment located in the United States Southern Great Plains (SGP). The primary objective was to improve warm season rainfall prediction through the collection of precise observations of the water cycle and their assimilation into numerical weather models. ARM participated in this experiment through the launch of additional radarsondes at the central and extended facilities as well as making the normal ARM data products available to IHOP researchers. As part of a large assortment of observing systems, more than 40 Global Positioning System (GPS) stations were operating in the SGP region during IHP-2002. A map of station locations, color-coded by operating agency, is shown below. We present an analysis of the evolution of the water vapor field during a storm on June 12, 2002. Spatial and temporal changes in vertically integrated precipitable water vapor (PW), latent water vapor (SW), and tomography solutions of the moisture field show it’s complex behavior during, and after, the passage of the storm. The observations collected with this system are able to observe the rapid convergence of water vapor during the initial stages of convection and track the movement of moisture from the boundary to the free troposphere.

Regional Conditions

The figures below illustrate the regional conditions between 1200 and 1400 UTC, June 12, 2002. A storm had developed in south-central Kansas. Increased total column water vapor amounts (top panels) are located just ahead of the leading edge of precipitation (middle panels). Surface observations (bottom panels) show the convergence of low level winds in conjunction with the storm. The storm moved south and east through the densest portion of the GPS network. Rain gauges measured almost 30 mm of precipitation from the storm.

Surface Observations, Tomography Profiles, and Total Column Water Vapor

Tomography Comparisons to Raman Lidar

The two figures below plot the vertical profiles of water vapor density as a function of time and height above the ARM SGP central facility on May 26, 2002. The figure on the left is the profile as measured by the CARF Raman Lidar. This profile has been averaged so that it has a vertical resolution of one kilometer. The profile obtained through the tomographic estimate from the GPS SW observations (right panel). The GPS tomography solution utilizes radiosonde observations to help initialize and constrain the vertical distribution of water vapor. Radiosonde launches occur at 3-hour intervals. The initial tomography solution uses both the radiosonde profile and GPS SW observations. The tomography field is updated with a new estimate every 15 minutes, using the previous estimate as the a priori profile. It can be seen from this comparison that the GPS tomography shows strong similarity to the Raman Lidar profile—both techniques capture the moist layer between 2-3 km with it merging into the boundary layer between 8 and 10 UTC.

Summary

The figures shown above capture the organization and movement of the squall line as it passes through the network of GPS stations. The top row of panels shows the surface met observations collocated with the GPS stations. The second row of figures shows the vertical profile of water vapor extracted from the tomography estimate. Each figure in this second row represents the vertical profile of water vapor density in the 28 km x 28 km horizontal grid above an individual GPS station. The vertical resolution of the solution is 1 km. The third row of figures is the variation of the water vapor profile with respect to the average profile for that station. The fourth row is a plot of PW (red diamonds) and vertically scaled SW (blue diamonds) at each station. The tomography solution is obtained through a combination of SW observations obtained from the GPS network and radiosonde launches at the ARM SGP central facility.

There are a few significant features to point out in the figures above. Within the tomography solution there is coherent vertical structure throughout the network. This can be seen in the second and third rows of figures. The increase in water vapor prior to squall line passage is clear in both the tomography estimate and the PW and SW observations. It can also be seen that there is significant moisture within the boundary layer before convection occurs, but during and after the storm the moisture is elevated to above the boundary layer. After the squall line has passed, the boundary layer has experienced significant drying and the moist layer has now been lifted to above the boundary layer. These findings are consistent with the current understanding and modeling of a mid-latitude squall line.

The results from the GPS tomography network shown here indicate that it can provide a unique view of the atmosphere. While it does not have the vertical resolution of a radiosonde or Raman Lidar, it does provide both time and spatial sampling advantages that cannot be matched by either system. All the weather capabilities of GPS also make it a valuable research tool for investigations of moisture structure in the presence of clouds and precipitation.

References


Related URLs

SuomiNET and LORAN-GST Realtime PW Results: http://www.coms.giss.nasa.gov/gps/project/realtime/ HPF GPS Results: https://www.coms.giss.nasa.gov/index.html
Single-Frequency GPS Network: http://www.coms.giss.nasa.gov/pszapq
SuomiNET PW Results (XMM Emotional Data Center): http://www.arm.gov/docs/xds/static/suomigps.html