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Technical Attachment

Record Atmospheric Water Vapor Measured

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(Ed. Note: See a late-breaking addendum at the end of the author's text.)

Water vapor is one of the most important constituents of the free atmosphere since it is the principle mechanism by which moisture and latent heat are transported and cause "weather." Water vapor is also a greenhouse gas that plays a critical role in the global climate system. This role is not restricted to absorbing and radiating energy from the sun, but includes the effect it has on the formation of clouds and aerosols and the chemistry of the lower atmosphere. Despite its importance to atmospheric processes over a wide range of spatial and temporal scales, water vapor is one of the least understood and poorly described components of the Earth's atmosphere.

In response to the need for improved upper-air moisture observations, the Forecast Systems Laboratory has been using GPS - the Global Positioning System - to make integrated (total atmospheric column) precipitable water vapor measurements since November 1994. Precipitable water (PW) is defined as the height of a column of liquid water that would form if all of the water vapor in that column were to completely condense. In general, the amount of precipitation in a given storm is highly correlated with the precipitable water vapor in the air masses involved in those storms. Note, however, that the amount of precipitation that falls during a rainstorm can often *exceed* the precipitable water amount because moisture-laden air continues to flow into a storm, condense, and fall as rain throughout the storm lifetime.

The maximum precipitable water vapor in the atmosphere ever measured using GPS remote sensing techniques was observed as tropical storm Frances passed over Tallahassee, Florida on September 6, 2004. The observed value, 7.57 cm or approximately 2.98 in, represents the average amount of PW in the atmosphere between 1900 and 1930 UTC. The top figure on the accompanying page reflects this measurement, and also illustrates the close correlation between GPS-derived PW observations and those derived from RAOB sounds at the same location. As can be seen in the bottom figure, the *maximum* PW observation closely coincided with the 30-minute average pressure and temperature *minimum* values of 982.3 mb and 23.9 C, respectively, that were measured in the storm between 1930 and 2000 UTC.

The data used to make this and other continuous GPS measurements in Florida are provided to FSL by the Florida Department of Transportation GPS Permanent Reference Network. More information on the FDOT GPS Permanent Reference Network can be found at

http://web.flgps.dot.state.fl.us/. For more information on GPS Meteorology within the National Oceanic and Atmospheric Administration, please see our web site at http://gpsmet.noaa.gov, or contact the author at Seth.I.Gutman@noaa.gov.

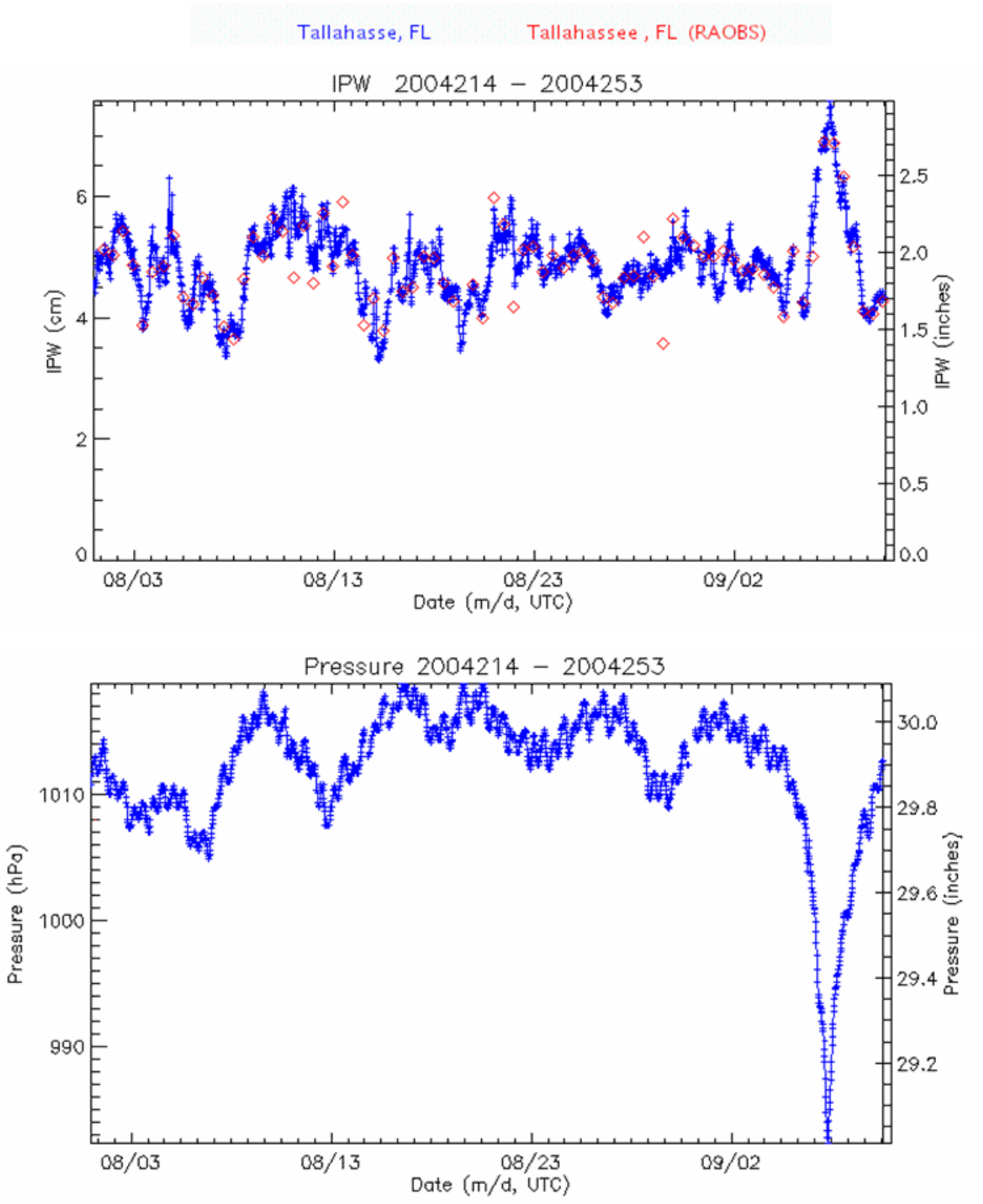
Late-breaking update to the above provide by the author:

This describes the meteorological events associated with the landfall of hurricane Ivan around 2 AM CDT (0700 UTC) on September 16, 2004. Landfall occurred about 31 km (19 mi) east of the USCG DGPS site at Mobile Point. Ivan was a strong Category 3 hurricane at the time, with winds exceeding 58 m/s (130 mph).

Contact with MOB1 (the USCG GPS receiver at Mobile Point) was lost at 0758 UTC; data from the GSOS stopped shortly thereafter. The minimum pressure reported by the NDBC GSOS unit installed at the site was 948.4 mb between 0645 and 0655 UTC. The maximum quantity of precipitable water vapor retrieved from the GPS signal delays by FSL was 80.4 mm (~3.16") between 0630 and 0700 UTC.

The GPS and GSOS equipment at Mobile Point appears to have successfully collected data through the passage of the eye wall and into the eye. This has resulted in two notable events: the first known ground-based observation of upper-air moisture from within the eye of a hurricane, and the highest recorded level of precipitable water vapor in the atmosphere using GPS meteorological techniques.

There is presently no communication with the site, so the status of the equipment is unknown. My sincere thanks to USCG, NDBC, and NGS for their assistance in making this achievement possible.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