A Blended Total Water Vapor Product for the Analysis and Forecast of Weather Hazards

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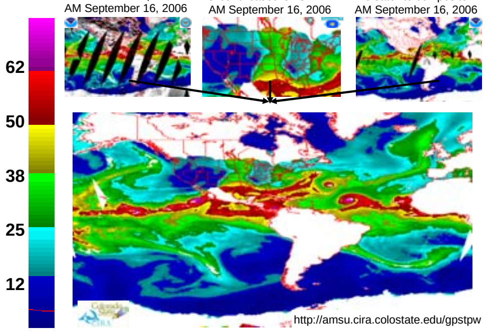
Introduction

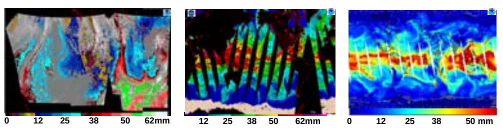
For over 25 years meteorologists within NOAA's Satellite and Information Service's (NESDIS) Satellite Services Division (SSD) have provided highly detailed satellite analyses and developed applications to support NOAA/National Weather Service (NWS) Weather Forecast Offices (WFOs), River Forecast Centers (RFCs) and National Centers for Environmental Prediction for storms that are currently or expected to produce heavy precipitation/severe weather resulting in loss of life and property to the nation. Since the early 1990's, NESDIS has acquired additional remote sensing imagery tools and worked closely with governmental and academic researchers, to stay on the cutting edge of improved applications and satellite analysis of weather hazards to further improve support to NOAA's NWS offices from Guam to Puerto Rico (Ferraro, et.al, 1998). The Satellite Services Division (SSD) is also a test-bed for improving current and future satellite data, including the imagery/products from the new sensors aboard National Polar-orbiting Environmental Satellite System (NPOESS) Preparatory Project (NPP)/ NPOESS and applications so that forecasters can improve their ability to analyze severe weather, recognize computer model deficiencies and respond faster to potential threats with longer forecast warning lead times. This poster presents current operational and future blended satellite derived Total Precipitable Water (TPW) products; examples and applications of these future blended TPW products for a number of high impact severe weather and heavy precipitation cases during the past 2 years.

Operational/Experimental Satellite Derived TPW Imagery

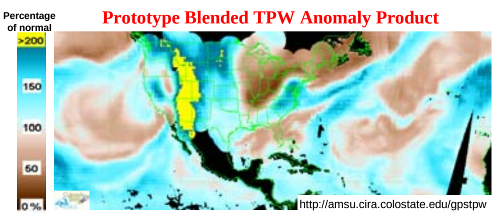


CIRA/Colorado State University Experimental Blended TPW Product from 2 SSMIs, 3 AMSUs and Ground-based GPS MET - AM September 16, 2006

Possible Additional Data Sources for an Operational Blended TPW Product



Prototype Blended TPW Anomaly Product



CIRA/Colorado State University Prototype Blended TPW Anomaly Product from 2 DMSP SSM/Is, 3 NOAA AMSUs and Ground-based GPS-MET AM October 6, 2006

Paper URL:
ftp://gp16.ssd.nesdis.noaa.gov/pub/Publications/4th_NPOESS_Symposium_extended_abstract_Jan_2008.doc

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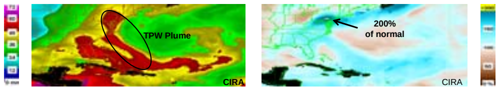
Operational Examples of the Use of Future TPW Products

Heavy Precipitation/Flood Cases - Long Fetch TPW Plumes affecting United States

Since most of the precipitable water in the atmosphere exists from the surface to 3km (Kusselson, 1993), TPW has been useful for locating concentrations of high low level moisture (sometimes referred to as the TPW plume or atmospheric river). This TPW plume is one of the most recognizable satellite signatures of potential heavy rainfall and subsequent flooding. During June and November 2006, the experimental blended TPW product was used operationally to help forecasters on the East and West Coast, respectively, of the United States identify conditions that could result in heavy precipitation and subsequent flooding.

East Coast



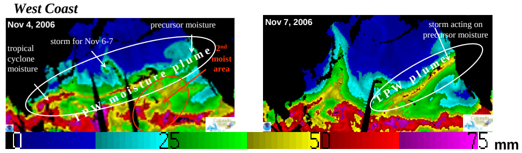
Experimental Blended TPW product for the morning of June 25, 2006 — Prototype Blended TPW Anomaly product for the morning of June 25, 2006

Record Rainfall Results

Observed rainfall at the lead author's home in Montgomery County, MD (Washington, D.C. suburbs) was:

217 mm for the 24h through AM on June 26
296 mm for the 48h through AM on June 27
323 mm for the 84h through AM on June 28

West Coast

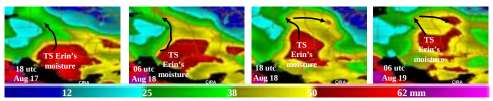


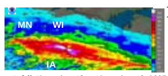
Record Rainfall Results

- Widespread major flooding
- Rain amounts of 254 to 965 mm in the Cascades and Olympics
- 100 to 254 mm in the lowlands
- Nearly every river exceeded flood stage;
- 12 rivers reached all-time record flood crests levels

Heavy Precipitation/Flood Case - Predecessor Rain Event (PRE) affecting Mid-West

A Predecessor Rain Event or "PRE" is a heavy rain event that can form unexpectedly well in advance of a landfalling and/or near-coastal tracking tropical cyclone (Cote, et.al, 2007). Below is a series of Blended TPW images between 18 utc August 17 and 06 utc August 19 showing the low level moisture from Tropical Storm Erin that could have helped produced the PRE and record rainfall results in the upper Midwest.

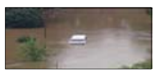




rainfall 12 utc Aug 18 to 12 utc Aug 19, 2007

Record Rainfall Results

24hr rainfall record for Minnesota: 384 mm (15.11") ending 12 utc August 19 near Hokah, Houston County, MN



References

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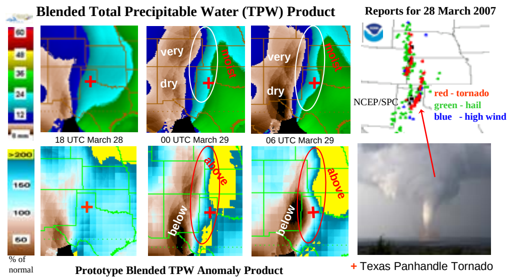
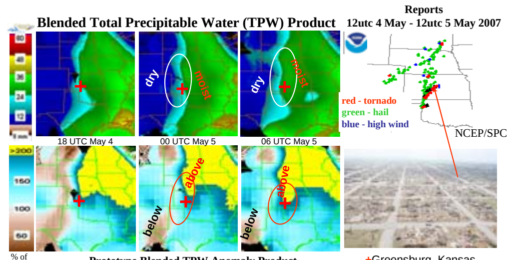
Severe Weather Case Examples - Western Plains of the United States

Satellite observations, when used with conventional observational data and numerical model output have helped forecasters key-in on areas of potential severe weather (Lashley, 2003). Moisture is a key ingredient for the generation of severe weather. It can also be used to compliment the other key parameters that forecasters can use to predict severe weather. The experimental blended TPW and anomaly products (below) serve to show one of those key parameters, total atmospheric moisture. Overland, the product mostly utilizes the ground-based GPS MET network over the CONUS. The main advantages of using GPS MET in lieu of GOES sounder is the ability to derive TPW information in cloud covered areas. Satellite analysts in NOAA/NESDIS have developed subjective satellite signatures that can be used, in conjunction with other parameters, to help locate favorable areas of severe storm development and intensification. Examples of the use of the blended TPW and anomaly products for severe weather case is seen below with the March 28th and May 4th (Enhanced Fujita (EF) 5 Greensburg, Kansas) cases.



Development of severe storms is helped by moisture interacting with dry air (Konop, 2006). Above and below, the experimental blended TPW (top panels) and prototype blended TPW anomaly (bottom panels) products could have been used for the severe weather events that occurred on March 28 and May 4 in the western Plains. For both cases the top panels of blended TPW showed the trends in total moisture leading up to and extending through the events. The moisture gradient (white oval) signature seemed to be a good first guess of potential severe weather. A sharpening and/or persistence of that gradient can increase the likelihood, number and/or intensity of storms. In addition, the TPW anomaly product (bottom panels of each case) showed that the gradient (**red** oval) between the below and above normal TPW could have also served as a good proxy for the severe weather that occurred in each case. To the right of each case are the actual results showing the location and type of severe weather reports. The location of the Texas panhandle (March 28 above) and Greensburg, Kansas (May 4 below) tornadoes can be found in the imagery with a **red** cross (+). The results for each case should be compared with the blended TPW and prototype anomaly products to see if the imagery could have been successfully used in forecasting the events.



Summary and Future

When used with other meteorological parameters, blended remote sensing derived Total Precipitable Water (TPW) products are tools that are already helping meteorologists understand the contributions of low level moisture for the development of weather hazards. These products continue to evolve and develop with the help of a unique collaboration between researchers and forecasters in the governmental and private sector communities. Future improvements to the products include microwave retrievals overland, more frequent updates, the addition of more satellites, including the NPP and NPOESS Advanced Technology Microwave Sounder in 2009 and 2013, respectively. By the time the TPW products are operational in the next decade, applications will be further improved so that forecasters will use the imagery more efficiently with other data sets. This should contribute to improved forecasts and lead times for hazardous weather events, thus enhancing NOAA's mission of protecting lives and property.