Using JPSS Retrievals to Implement a Multisensor, Synoptic, Layered Water Vapor Product for Forecasters

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Cooperative Institute for Research in the Atmosphere, Colorado State University

All products currently produced at CIRA every three hours and distributed to NHC, SAB, WPC, OPC and SPC. Satellite inputs currently are S-NPP, NOAA-18, NOAA-19, Metop-A/B, and DMSP F18 MiRS Retrievals

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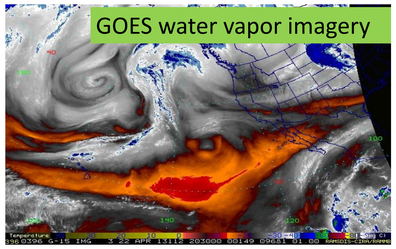
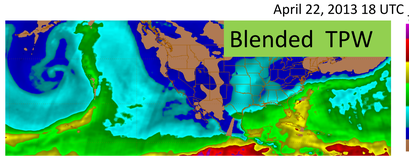
View near-realtime animations at http://cat.cira.colostate.edu/sport/layered/blended/lpw.htm

What Do Forecasters Currently Use Operationally to Analyze Water Vapor?

Analyzing the distribution of water vapor from observations is a key component of the forecast cycle. Both integrated (total precipitable water - TPW) and vertically resolved fields are necessary, depending on the particular forecast challenge. Typically, National Weather Service (NWS) forecasters rely on a few standard tools for this task. There are currently no observing systems within the NWS region of responsibility that provide hourly, vertically resolved, land and ocean, clear and cloudy sky moisture soundings for weather forecasting. A 4-D water vapor product can be applied to many forecasting problems. It can be used to assess the depth of an atmospheric river to determine how much moisture will make it over coastal mountains such as the Cascades. A hostile or favorable mid-level moisture environment around a tropical wave can be used to help predict whether genesis is likely. Upper level moisture above 500 mb can be useful to predict whether cirrus clouds will form or persist and impact high or low temperature forecasts. A new layered precipitable water vapor (LPW) product supported by the JPSS Proving Ground is assisting forecasters in this process.



April 22, 2013 18 UTC

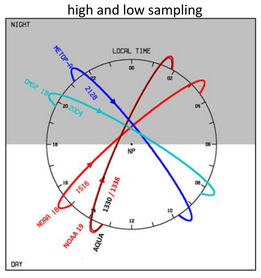


Blended, layered water vapor products fill a void in observations

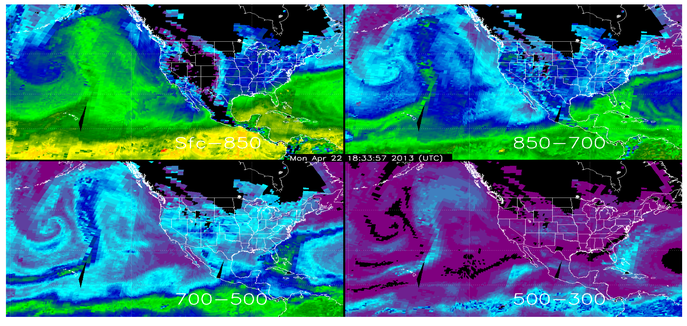
Moisture Product	Spatial Resolution and Coverage	Temporal Resolution	Strengths	Limitations
Radiosondes	~ 500 km over CONUS land, none over ocean	12 hours	Trusted High vertical resolution	Spatial and temporal coverage
GOES Water vapor channel (6.7 μm) imagery	4 km, near-hemispheric coverage	15 minutes or less	Very high spatial and temporal resolution Animations show flow	Upper level moisture only No vapor signal in high clouds Variable sensing depth
GOES Sounder retrievals	20 km, CONUS, Hawaii, Puerto Rico and adjacent waters only	1 hour	High spatial and temporal resolution Limited vertical structure	Clear sky only Forecast model dependence
Blended TPW	16 km, near global	1-3 hours (varies based on time of day)	Retrievals in clouds Near-global coverage Multiple types of inputs including very accurate GPS TPW	No profile information No retrievals in heavy precipitation

How is the Blended LPW Product Created?

Local equator crossing times, periods of high and low sampling



- **NOAA operational Microwave Integrated Retrieval System (MiRS) retrievals from six spaccrafted received at CIRA. Typical latency 2-3 hours.**
- **Four layers of precipitable water created (surface-850, 850-700, 700-500 , 500-300 mb)**
- **Satellites overlaid every three hours in a revolving composite to create animations**
- **Product routed via NASA SPoRT (thank you) to NOAA National Centers (NHC, SAB, WPC, OPC, SPC)**

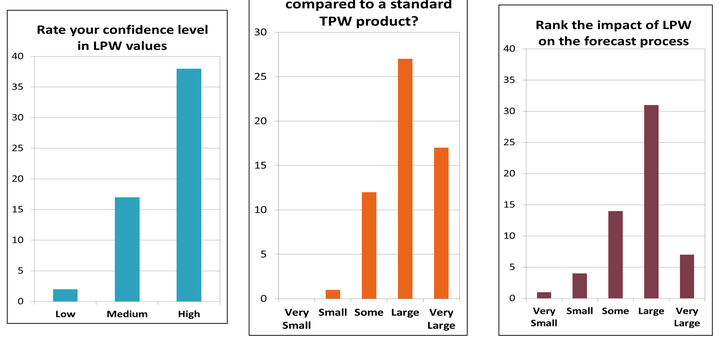


How Do Forecasters Currently Use the Experimental LPW Product?

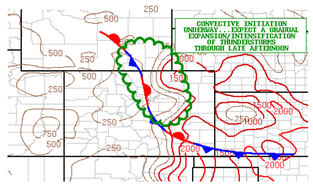
Forecasters at National Centers (NHC, WPC and SAB) and a few SPoRT-partner WFO's (e.g. NWS Tucson) are routinely using the blended CIRA LPW product in their forecast process,

- **For 28 days in July 2016, in the NHC Atlantic Tropical Weather Discussion (TWDAT), CIRA LPW mentioned 45 times (out of 110 discussions). Widely used to assess the environment around tropical waves. Passive microwave retrievals perform around clouds, unlike GOES water vapor imagery or the Saharan Air Layer product.**
- **NOAA Weather Prediction Center Mesoscale Precipitation Discussions evaluate the LPW to analyze the moisture flow into heavy rain scenarios. Fusing of low-mid and high-level moisture, often with a tropical connection, is a precursor to excessive rainfall or snowfall.**

SPoRT-led NWS forecaster survey of Alaska and Puerto Rico NWS offices during 2013 demonstration of Layered Precipitable Water



LeRoy et al. 2016, J. Operational Meteorology



RAP32 ML CAPE (lowest 90MB) j/kg 160630/1900f000
WPC MPD #0399

MESOSCALE PRECIPITATION DISCUSSION 0399
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
358 PM EDT THU JUN 30 2016

AREAS AFFECTED...SOUTHEAST WY...CENTRAL AND NORTHERN CO...EXTREME WESTERN NEB

CONCERNING...HEAVY RAINFALL...FLASH FLOODING POSSIBLE ,
...
THE CIRA LPW PRODUCT SHOWS A FAIR AMOUNT OF MOISTURE ALREADY FOCUSED IN THE 700MB/300MB LAYER. THIS COUPLED WITH THE BOUNDARY LAYER MOISTURE FLUX IN VICINITY OF THE FRONT SHOULD HELP LEAD TO EFFICIENT RAINFALL PRODUCERS

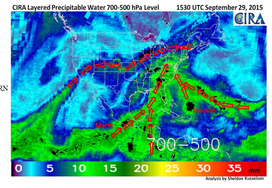
Tropical Weather Discussion
NWS National Hurricane Center Miami FL
616 AM EDT SUN JUL 10 2016

...TROPICAL WAVES... A tropical wave is in the central Atlantic with axis near 32W, moving west at 15 knots within the last 24 hours. The wave is embedded in **a mainly low moist environment from surface to 850 mb as indicated by CIRA LPW imagery.** Meteosat imagery show Saharan dry air and dust in the wave environment that along with strong deep layer wind shear in the region limit the convection to scattered showers from 04N-08N between 30W and 35W. A tropical wave is in the west Atlantic with axis near 60W, moving west at 20 knots within the last 24 hours. **The wave is embedded in a moderate moist environment from surface to 850 mb as indicated by CIRA LPW imagery.** A diffluent environment aloft ahead of the wave supports scattered showers across the Windward Islands and adjacent waters. A tropical wave is in the central Caribbean with axis near 75W, moving west at 15 knots within the last 24 hours. **CIRA LPW imagery show the wave is embedded in shallow moisture whereas water vapor imagery show strong subsidence aloft.** Passing showers are across Hispaniola and adjacent waters.

MESOSCALE PRECIPITATION DISCUSSION 0530
NWS WEATHER PREDICTION CENTER COLLEGE PARK MD
1016 AM EDT TUE SEP 29 2015

CONCERNING...HEAVY RAINFALL...FLASH FLOODING LIKELY

SUMMARY...A TROPICAL AIRMASS WITH NEAR RECORD PRECIPITABLE WATER WILL RESULT IN A CONTINUED FLOOD AND FLASH FLOOD THREAT INTO THIS AFTERNOON.
...
FORCING FROM THE SHORTWAVE IN GA AND A GENERALLY DIVERGENT PATTERN ALOFT IS HELPING FORCE ASCENT ON THE LARGE SCALE...WITH 20-30 KTS OF LOW LEVEL UPSLOPE FLOW ADDING IN LIFT. LAYERED PRECIPITABLE WATER PRODUCTS SHOW AN IMPRESSIVE COMBINATION OF FACTORS CONTRIBUTING TO THE NEAR RECORD PRECIPITABLE WATER VALUES ACROSS THIS REGION. A CONNECTION TO THE PACIFIC AND TROPICAL STORM MARTY CAN BE SEEN IN THE MID/UPPER LEVELS...WITH A DEEP LAYER CONNECTION TO THE GULF OF MEXICO AND ALSO TROPICAL STORM JOAQUIN IN THE ATLANTIC. THIS IS ALL RESULTING IN A VERY EFFICIENT ATMOSPHERE FOR HEAVY RAIN RATES, THE ONE THING LACKING IS INSTABILITY...BUT AT LEAST SOME DOES EXIST ACROSS THE AREA AS NOTED BY SOME LIGHTNING AND COLDER CLOUD TOPS....



Five streams of moisture fuel flooding in SC at the time of Hurricane Joaquin

What Research is in Progress Under JPSS PGRR?

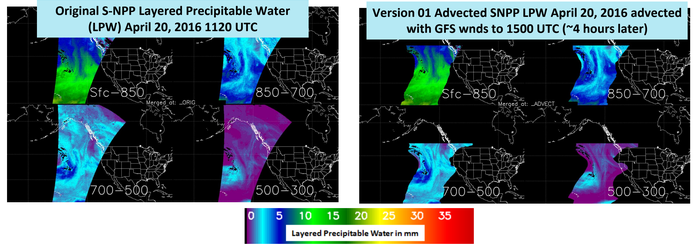
CIRA has just begun the second year of a 4-year effort to improve the blended TPW and distribute it to national centers for evaluation. Forecasters continue to advocate for the blended LPW product to become operational at NESDIS, similar to the path for blended TPW.

We participate in the JPSS PGRR Hydology Initiative under Ralph Ferraro. Michael Folmer is our point of contact for National Centers.

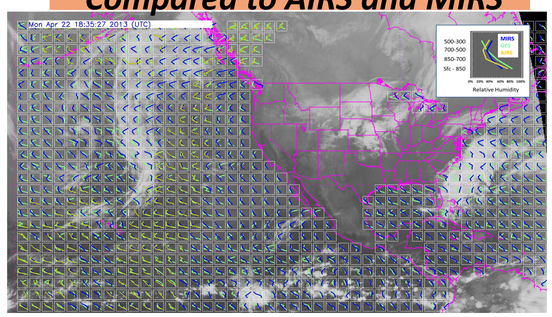
Work in progress this year includes:

- **Ingest MiRS V11 soundings for all satellites when they become operational. Currently, only S-NPP is running V11 MiRS, others are using V7.**
- **Develop "advective blending" where the LPW fields are moved along with model (GFS) winds to a selected time. This will facilitate comparison with forecast models, as time will be the same.**
- **Update the compositing routine to weight the advected fields.**
- **Gather feedback from forecasters to assess the value of changes and to guide development**
- **Develop a VISIT training module.**
- **Explore uses of other fields such as blended relative humidity.**

First Demonstration of Advective Blending



GFS Forecast RH Soundings Compared to AIRS and MIRS



MIRS (blue) and AIRS (yellow) four layer RH profile overlaid on 00 UTC initialized GFS forecast (green)

More details:

Forsythe, J. M., S. Q. Kidder, K. K. Fuell, A. LeRoy, G. J. Jedlovec, and A. S. Jones, 2015: A multisensor, blended, layered water vapor product for weather analysis and forecasting. J. Operational Meteor., 3, 41- 58.

LeRoy, A., K. K. Fuell, A. L. Molthan, G. J. Jedlovec, J. M. Forsythe, S. Q. Kidder, and A. S. Jones, 2016: The operational use and assessment of a layered precipitable water product for weather forecasting. J. Operational Meteor., 4, 22-33.