Multisatellite Water Vapor and Rain Rates

Presented by John Forsythe

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30-year passive microwave record of Total Precipitable Water (TPW) over ocean shows global TPW increasing at about 1.5% / decade

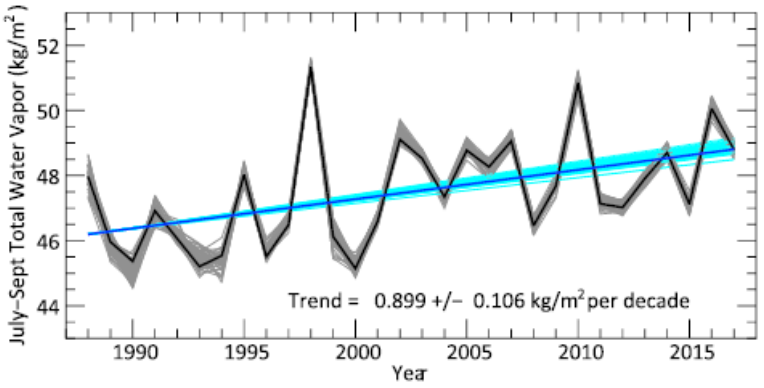
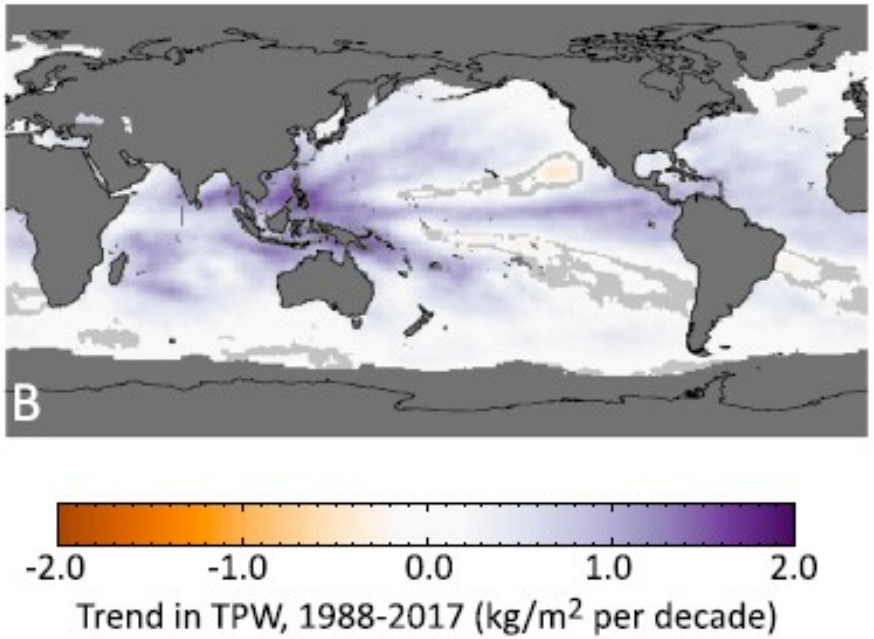


Figure 11. Time series of summertime (JJA) total precipitable water over the Gulf of Mexico. The black and dark blue lines show the baseline time series and linear fit. The lighter gray and blue lines show the results for each of the 50 error ensemble members. The ensemble members each have had a small additive adjustment applied so that the linear fits have the same value in 1988 as the baseline fit. This was done so that the differences in trends are easier to see.



Gulf of Mexico Summertime:
6% increase in TPW since 1988

Multisensor Blended Hydrometeorological Products are a tool used in the forecast process to evaluate the initial atmospheric state

Mears et al, 2018, Earth and Space Sciences

Input Needs for the Blended Product Algorithm

- Blended Product Name: **Total Precipitable Water and TPW Anomaly**

Required Satellite and Ancillary Input Data Products

	Data Product Name (Inputs)	Input Data Type (Satellite/Model Forecasts/*In-situ*)	Temporal/ Spatial Resolution, Format	Source(s)
1	**Blended TPW**	MiRS V11 retrievals from S-NPP, N-18,N-19, Metop-A/B, DMSP F-17/18, GPM AMSR-2 TPW. GOES-15 Sounder GPS surface over CONUS	Swath format – netCDF.	ATMS - NDE MiRS NDE GAASP SFOV NOAAPort
2	**Blended TPW Anomaly**	Blended TPW Product and NVAP heritage **(1988-1999)** weekly means	HDFEOS – same as blended TPW	Blended TPW Processing

Input Needs for the Blended Rain Rate Algorithm

- Blended Product Name: **Blended Rain Rate**

Required Satellite and Ancillary Input Data Products

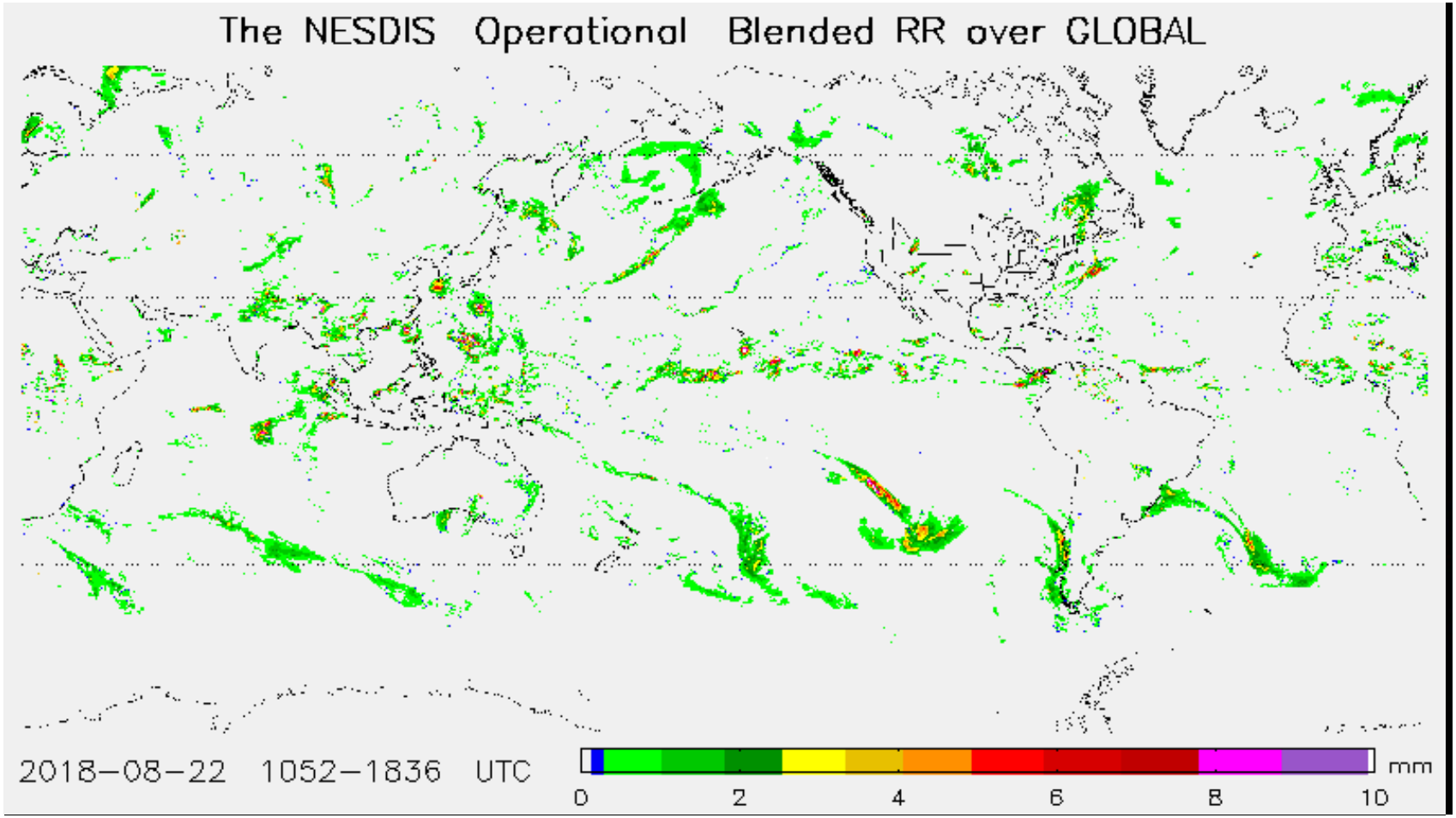
	Data Product Name (Inputs)	Input Data Type (Satellite/Model Forecasts/*In-situ*)	Temporal/ Spatial Resolution, Format	Source(s)
1	**Blended Rain Rate**	MiRS V11 retrievals from S-NPP, N-18,N-19, Metop-A/B, DMSP F-17/18, GPM AMSR-2 TPW.	Swath format – netCDF.	ATMS - NDE MiRS NDE GAASP

Outputs

	Blended Data Product Name (Outputs)	Output Data Type (Satellite; Model Forecasts; In-situ)	Spatial, Temporal Resolution, Format	Source(s)
1	**Blended TPW**	Satellite-derived, no model	Hourly / 16 km near-global Mercator projection / HDFEOS / netCDF / McIDAS / AWIPS-2	OSPO
2	**Blended TPW Anomaly**	Satellite-derived, no model	Same	OSPO
3	**Blended Rain Rate**	Satellite-derived, no model	Same	OSPO

Product	Operational?	Inputs	Details
Blended TPW and TPW anomaly	**Yes**	• **Microwave retrievals from 9 spacecraft.** • **~ 500 surface GPS stations each hour.** • **GOES-15 Sounder TPW**	**Hourly** **16 km near-global** **Non-advected*** ***(MIMIC TPW is advected)**
Blended Rain Rate	**Yes**	**Microwave retrievals from 9 spacecraft.**	**Hourly** **16 km near-global** **Non-advected**
Advected Layered Precipitable Water	**No*** ***Distributed in near-realtime to WPC, NHC, and ~ 20 WFO's. SPSRB ?**	**MiRS retrievals from 7 polar orbiters (NOAA-20 to be added soon).** **GFS model winds, 6 hourly 0.5°**	**3-hourly (currently-exploring hourly)** **4 layers (sfc-850, 850-700, 700-500, 500-300 mb)** **16 km N. Hemisphere grid**

NESDIS Operational Blended TPW, TPW anomaly and Rain Rate



https://www.ospo.noaa.gov/Products/bRR/Product_Animation.html

https://www.ospo.noaa.gov/Products/bTPW/

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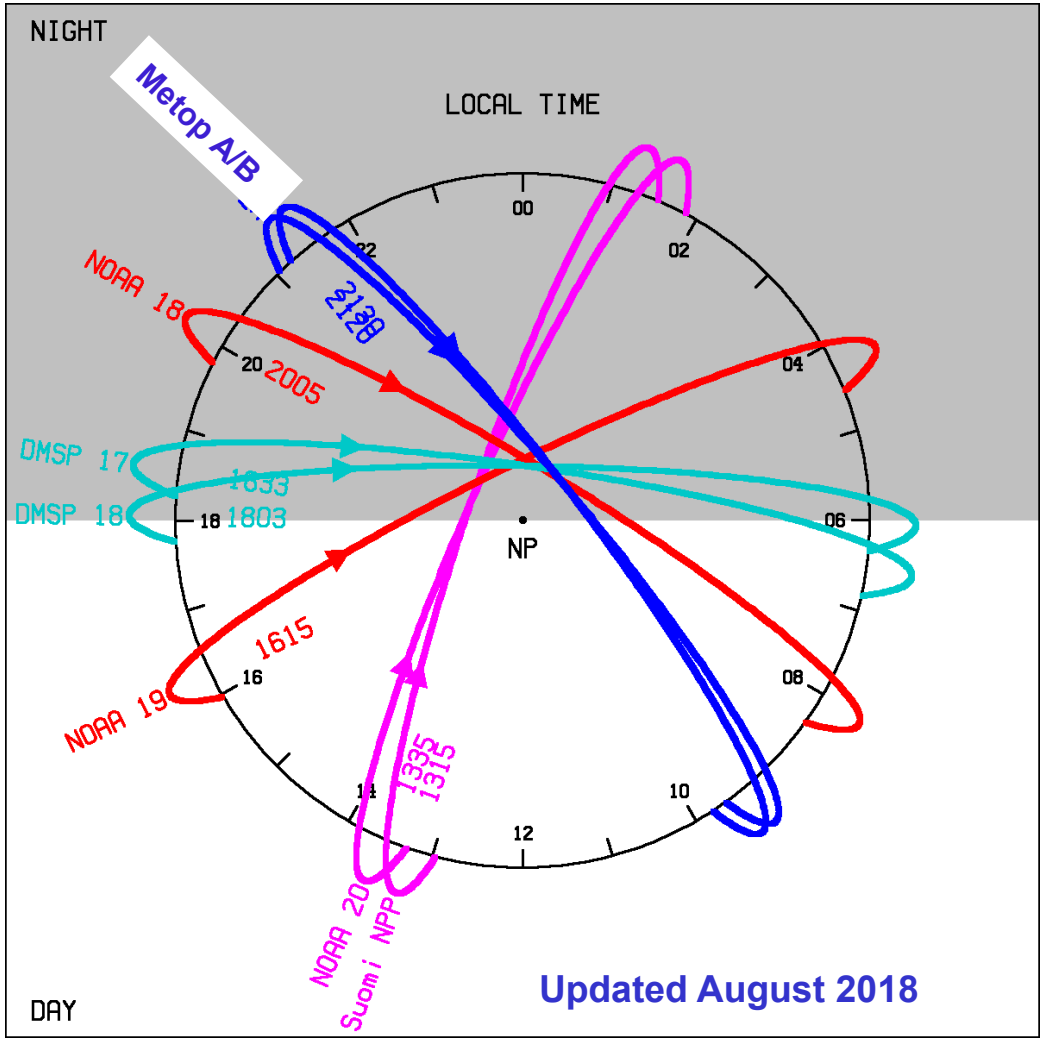
“Clock Diagram” shows local time of sunsynchronous polar orbiting spacecraft

Current configuration for Layer Precipitable Water: 7 satellites:

S-NPP, NOAA-18/19, Metop-A/B, DMSP F17/18

→ **Periods of high sampling and no sampling make animations for forecasters challenging** – advected products smooth this out

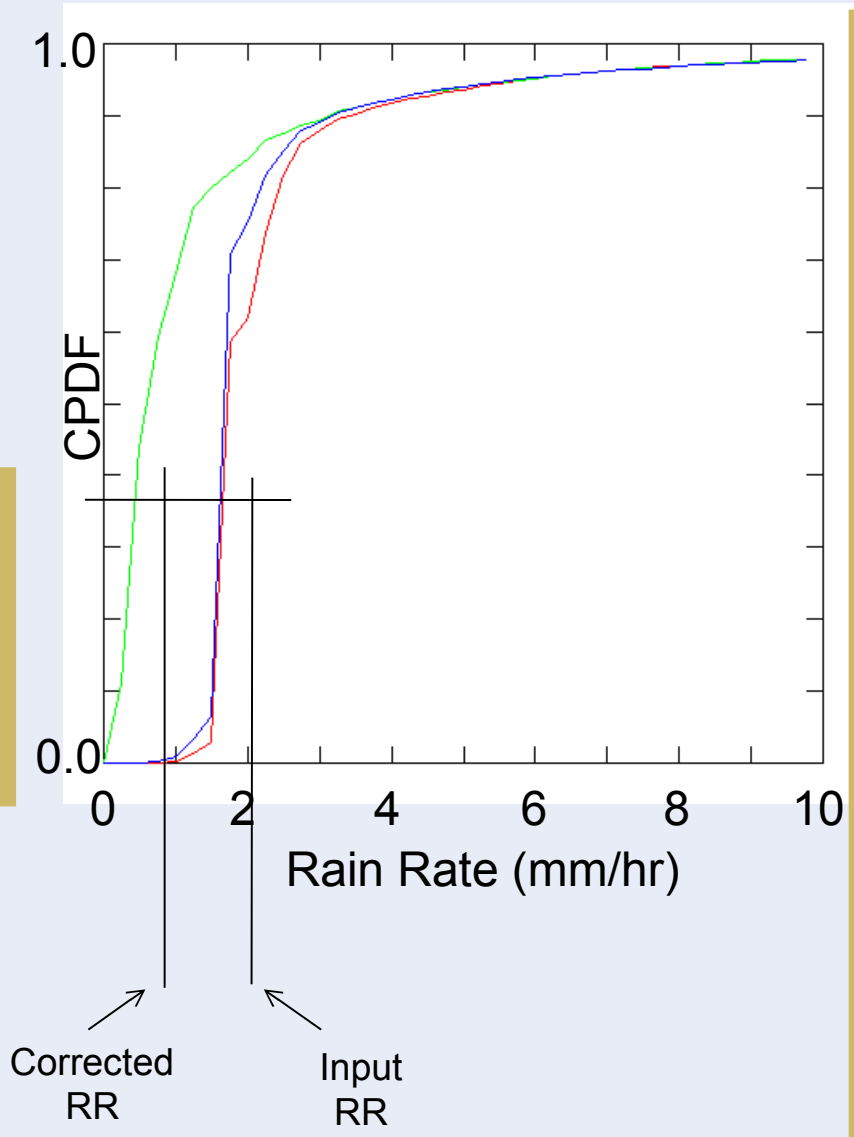
→ All of these spacecraft measure microwave radiation around the 183 GHz water vapor absorption line.



Older satellites play a valuable role in extending temporal sampling – orbital drift can be an asset

Histogram Adjustment Schematic

Interpolate Cumulative PDFs to correct RR (or TPW)



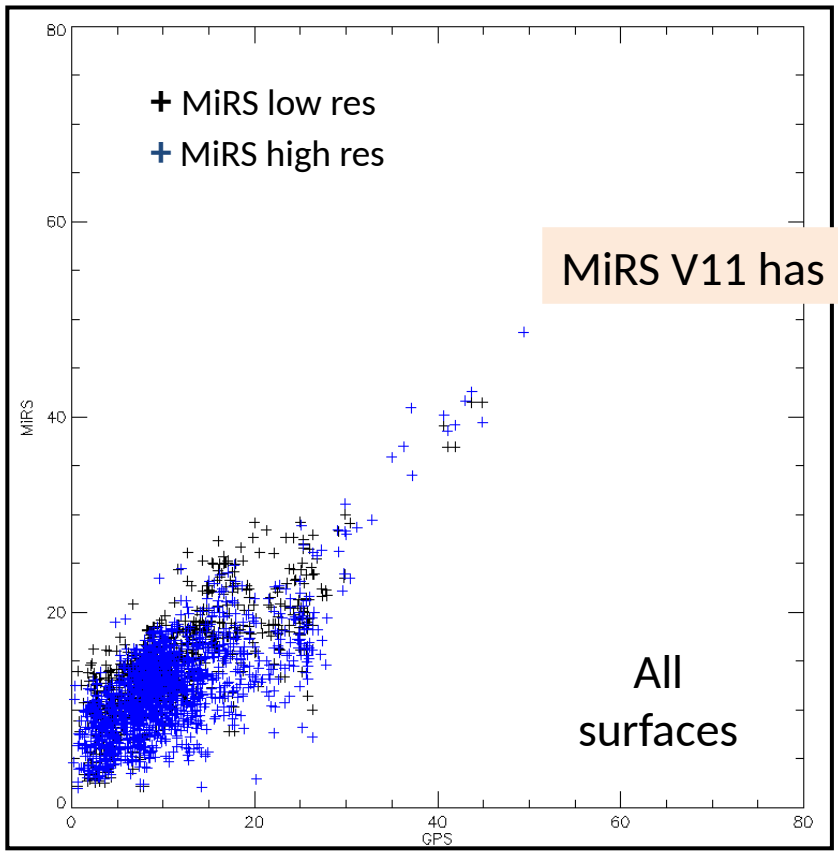
In effect, histogram adjustment uses the global ocean (or global land) as a vicarious calibration source.

5 day averages use (Pentad).

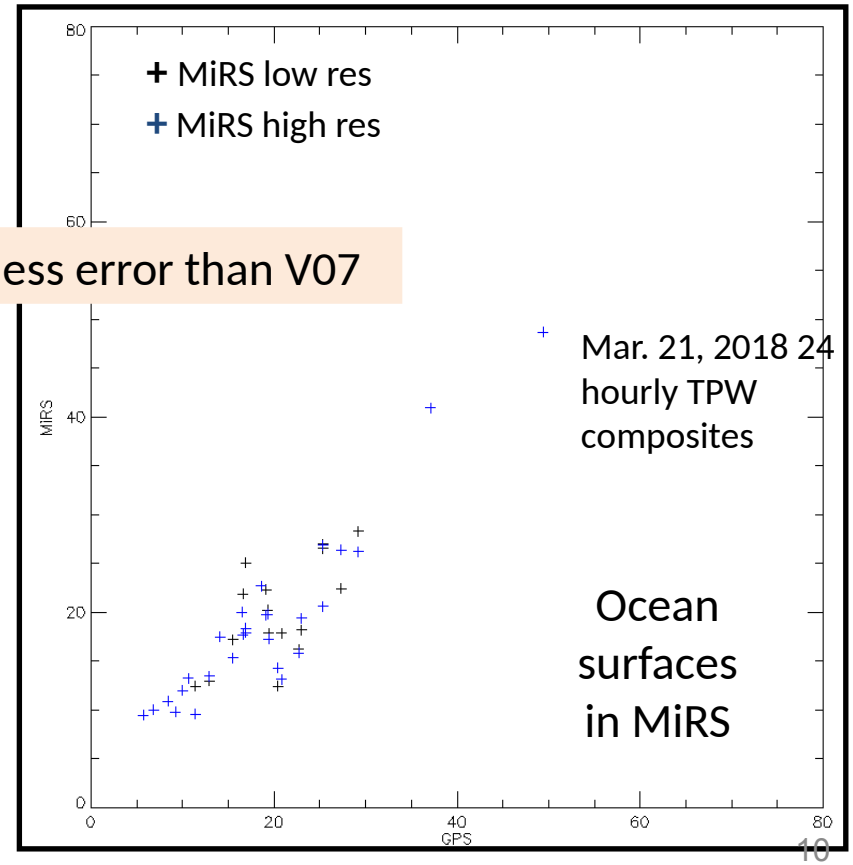
Needed more in the past (MSPPS / MiRS) versus now (all MiRS V 11 except AMSR-2).

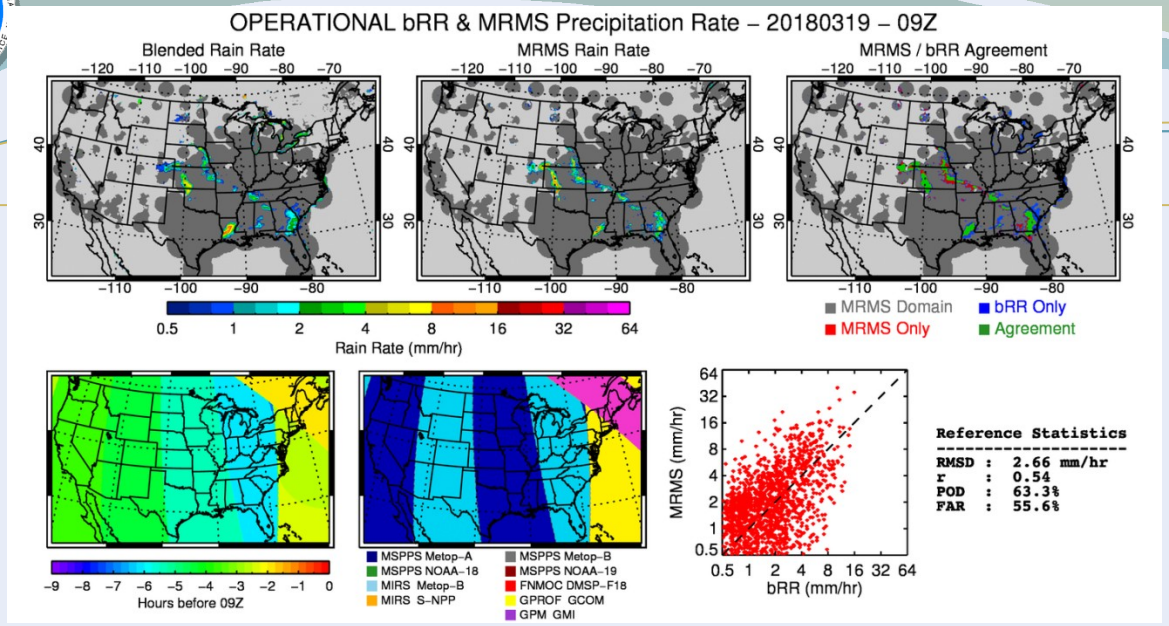
Surface GPS TPW is a Core Validation Source

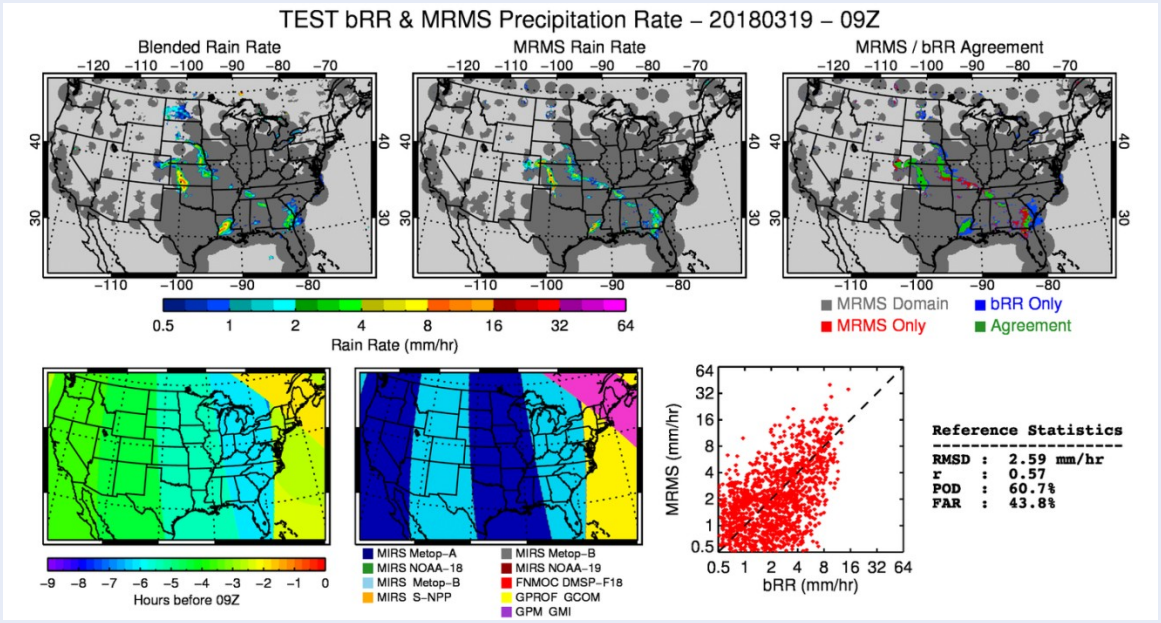
Sample	N	RMS V07 (mm)	RMS V11 (mm)	BIAS V07 (mm)	BIAS V11 (mm)
All Surfaces	1508	5.1	4.8	2.8	1.7
Ocean in MiRS	28	3.7	3.3	0.9	0.0
Land > 10 mm	976	5.4	5.2	3.3	2.4



MiRS V11 has less error than V07







NRT comparison of blended rain rate to MRMS

(The Blended Rain Rate validation work and images credited to Ralph Ferraro and Patrick Meyers)

DPEAS – The Foundation of these Blended Products

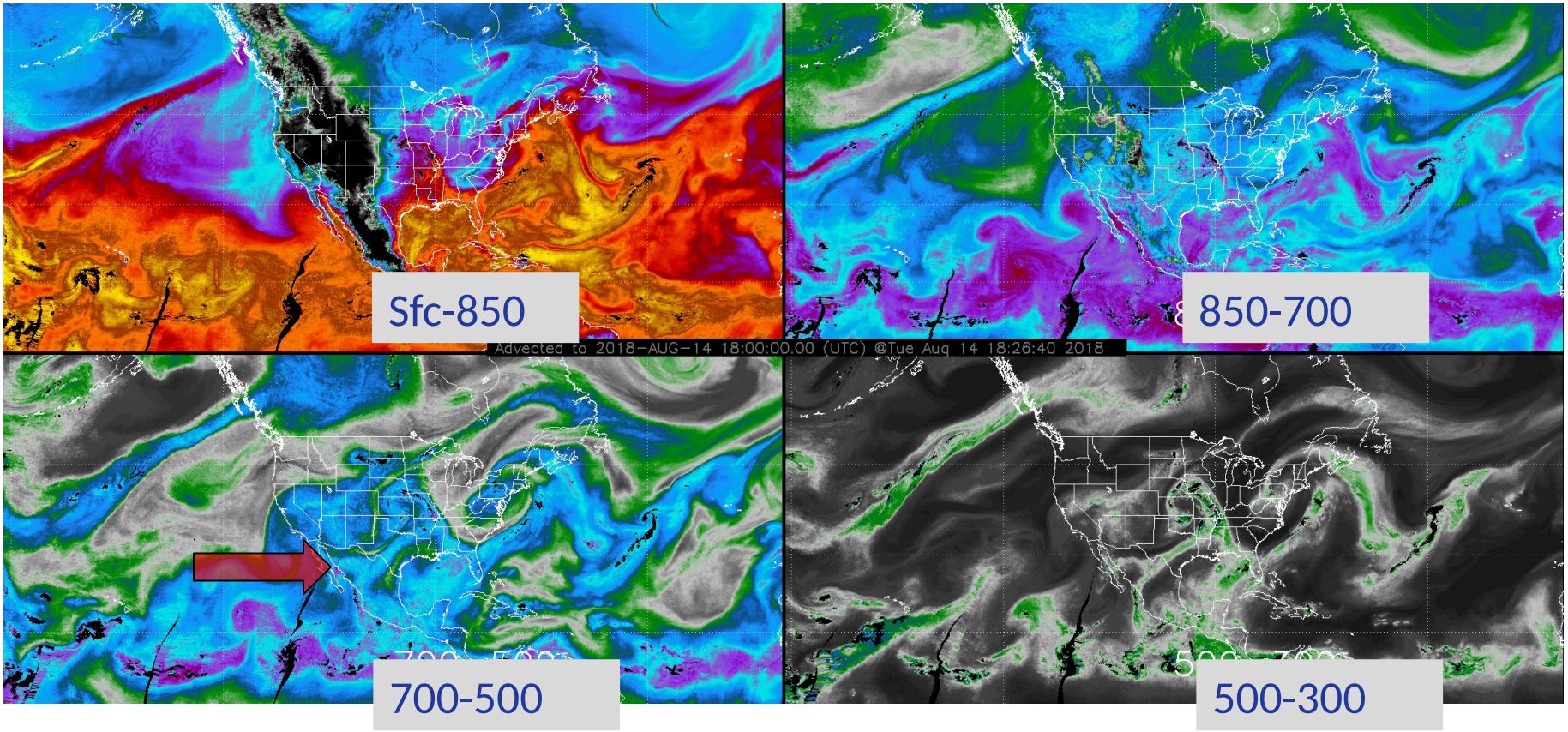
- Data Processing and Error Analysis System *(Jones and Vonder Haar JTECH 2002)*
- Developed at CIRA, runs at OSPO (AIX system) to produce blended products
- Also CIRA's R&D system for other products (e.g. Layer Precipitable Water) => Facilitates R2O.
- Current JPSS PGRR Project with CIMSS to implement MIMIC advection approach in DPEAS (Python integration)
- Native set of ingest decoders, remapping, compositing, output in HDFEOS, netCDF, McIDAS, AWIPS-2…
- Uses Fortran 90 as a scripting language (ease of programming)
- Work in progress at OSPO to port to Linux

Example DPEAS Scripting – Use of Intrinsic Composite and Remap Functions

```
call filename(swath_file, '*.HDF', swath_dir(j))
call get_files (swath_file, file, n, DURATION = INTERVAL, CONTEXT = hdf_context(j))
do i = 1, n
    call read_hdfeos (file (i))
    call time
    call apply_tpw_correction2 (file (i), TPW_CORRECTION_DIR_ASCII, &
     ocean_ref_sat(j), ocean_corr_type(j), land_ref_sat(j), land_corr_type(j), &
     TPW_CORRECTION_DIR_HDFEOS, correction_file)
    call time
    call deallocate_hdfeos (file (i))
    call filename (remap_file, correction_file, DIR_SPEC = REMAP_DIR_TPW, SUFFIX_SPEC = '_REMAP')
    call time
    call remap (correction_file, PROJECTION_SAB_GME16, remap_file)
    call time
    call deallocate_hdfeos (correction_file)
    call write_hdfeos (remap_file)
    call deallocate_hdfeos (remap_file)
enddo
```

```
! composite
   call filename (search, '*.HDF', DIR_SPEC = REMAP_DIR_TPW)
   call get_files (search, file, n, DURATION = INTERVAL)
   call filename (composite_file, 'BLENDED_TPW', DIR_SPEC = COMPOSITE_DIR_TPW, &
                  file_type_spec = '.HDF')
   do i = 1, n
       call read_hdfeos (file (i), ONLY='Sat_Number,Time,TPW')
       call composite (file (i), composite_file, 'OVERLAY', START = 'NOW', CONTROL = 2709)
       call deallocate_hdfeos (file (i))
   enddo
   deallocate (file)
   call write_hdfeos (composite_file)
```

Layer Precipitable Water (LPW), like MIMIC, uses model winds to advect water vapor – more forecaster friendly



WPC and OSPO had initial discussion in April 2018 about initiating SPSRB process

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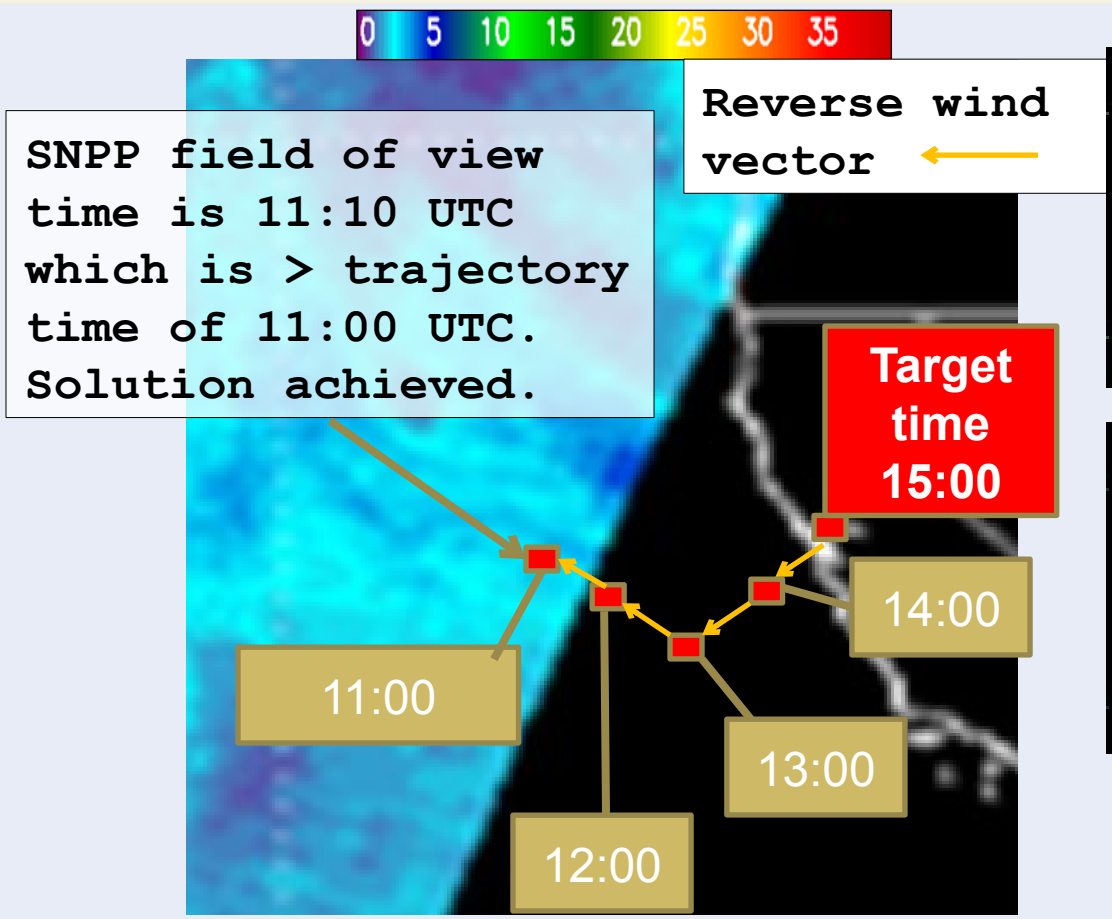
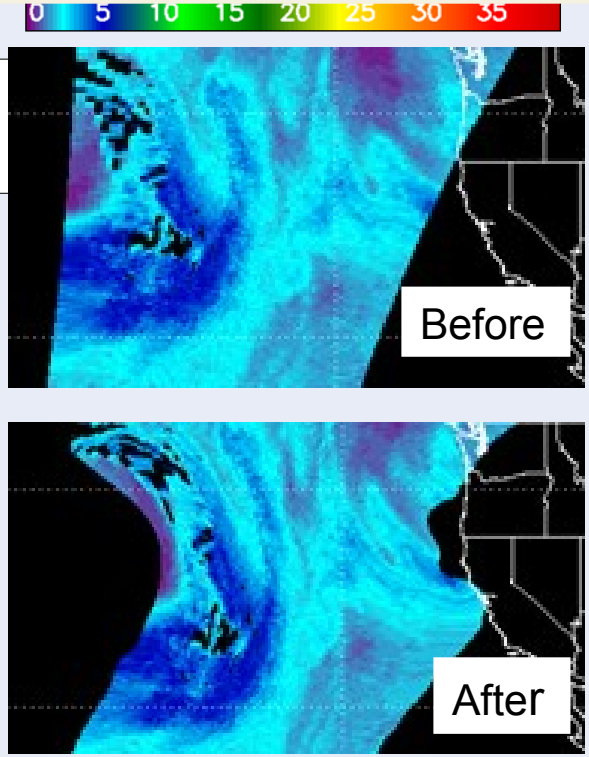
Schematic of how the back-trajectory method works for advection

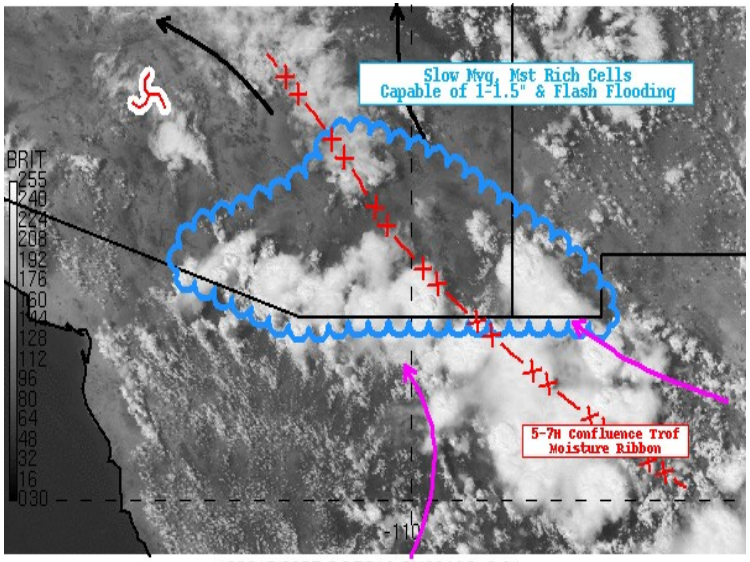




S-NPP 700-500 LPW April 20, 2016 advected to 1500 UTC (~4 hour advection)

Winds are from the GFS 3 hour forecast

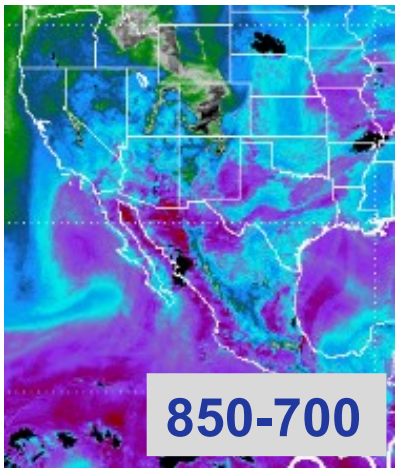
Example CIRA LPW Usage at WPC for Tracking Tropical Moisture

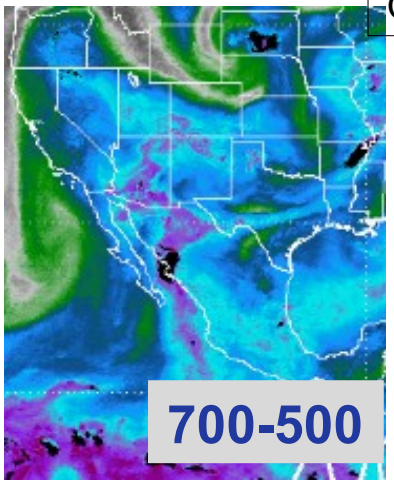


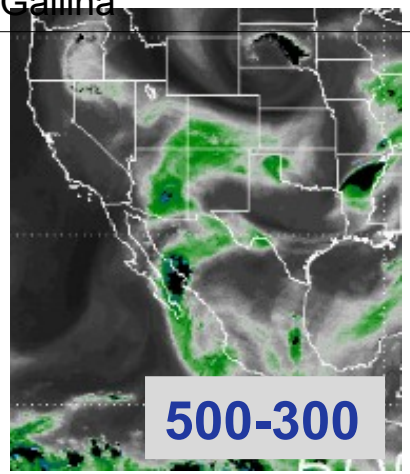
180815/2057 GOES16 CH02 VIS_0.64
WPC MPD #0669

Mesoscale Precipitation Discussion 0669
NWS Weather Prediction Center College Park MD
459 PM EDT Wed Aug 15 2018
Areas affected...Ext Southeast AZ...Ext. Southwest NM...
Concerning...Heavy rainfall...Flash flooding possible

SUMMARY...Slow moving, heavy rainfall producing convection in confluent 7H band. DISCUSSION...GOES-16 Visible depicts the eroding cloud shield of last evening's MCV that is moving lifting from Pima to Maricopa county. **CIRA LPW 7-5H loop depicts deepest/rich moisture of .4 to .6"** PWATs along the eastern band of the exiting MCV toward Northern Chihuahua. …
Gallina







Layer Precipitable Water (mm)

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As of August 21, 2018 in the NHC Atlantic Tropical Weather Discussion (TWDAT), **CIRA LPW mentioned 72 times in August 2018**.

- Widely used to assess the environment around tropical waves.
- Passive microwave retrievals perform in clouds, complements GOES-R water vapor imagery and the Saharan Air Layer product.

AXNT20 KNHC 051741
TWDAT

Tropical Weather Discussion
NWS National Hurricane Center Miami FL
141 PM EDT Sun Aug 5 2018
...
A tropical wave is in the E Atlc with axis extending from 08N-19N along 35W, moving W at 15-20 kt. The wave continues to be affected by intrusion of Saharan dry air and dust as indicated by GOES-16 RGB and water vapor imagery as well as **CIRA LPW imagery.** Isolated moderate convection is from 07N-10N between 30W-36W.

A tropical wave is in the central Atlc with axis extending from 06N-20N along 54W, moving W at 15-20 kt. The wave is in a low deep layer wind shear environment, and **CIRA LPW imagery** shows abundant low level moisture associated with it. However, some dry air intrusion is noted in the NW wave environment shown both in **CIRA LPW** and water vapor imagery at the lower levels…

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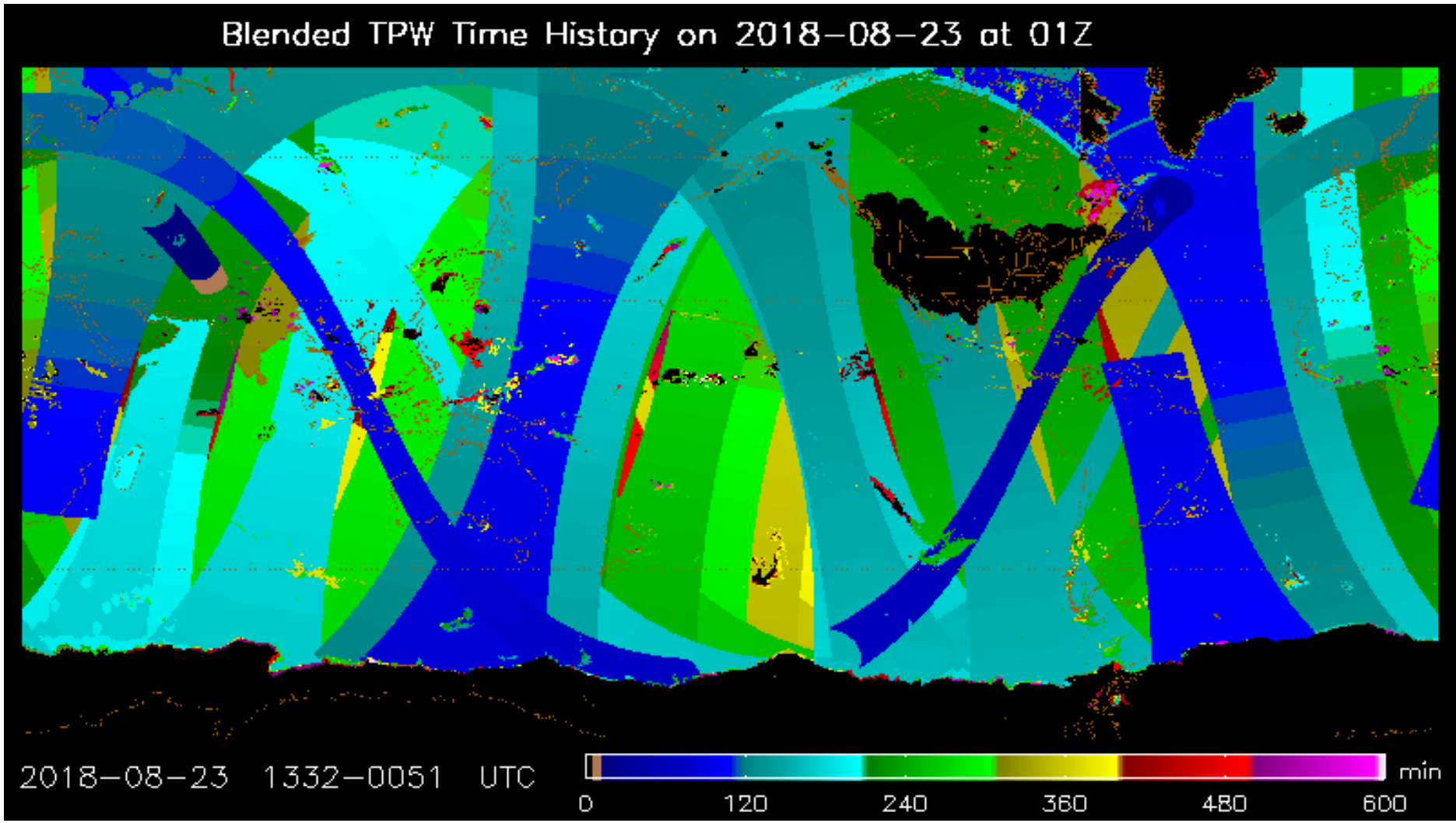
Identified Issues/Risks/Mitigations

Identified Risk/Issues	Action/Mitigation
Latency of MiRS retrievals	Tracking metrics http://cat.cira.colostate.edu/poes_status/ https://www.ospo.noaa.gov/Products/bTPW/time_history.html
Precipitation Flagging	"Tiger Team" formed to look at cases. MiRS V11 has yielded less artifacts. Rain rate masking script implemented and ready if needed.
How / whether to present metadata (e.g. time, satellite id) to users	Demonstrate / evaluate products on AWIPS-2 system

Realtime Time Latency Mapping

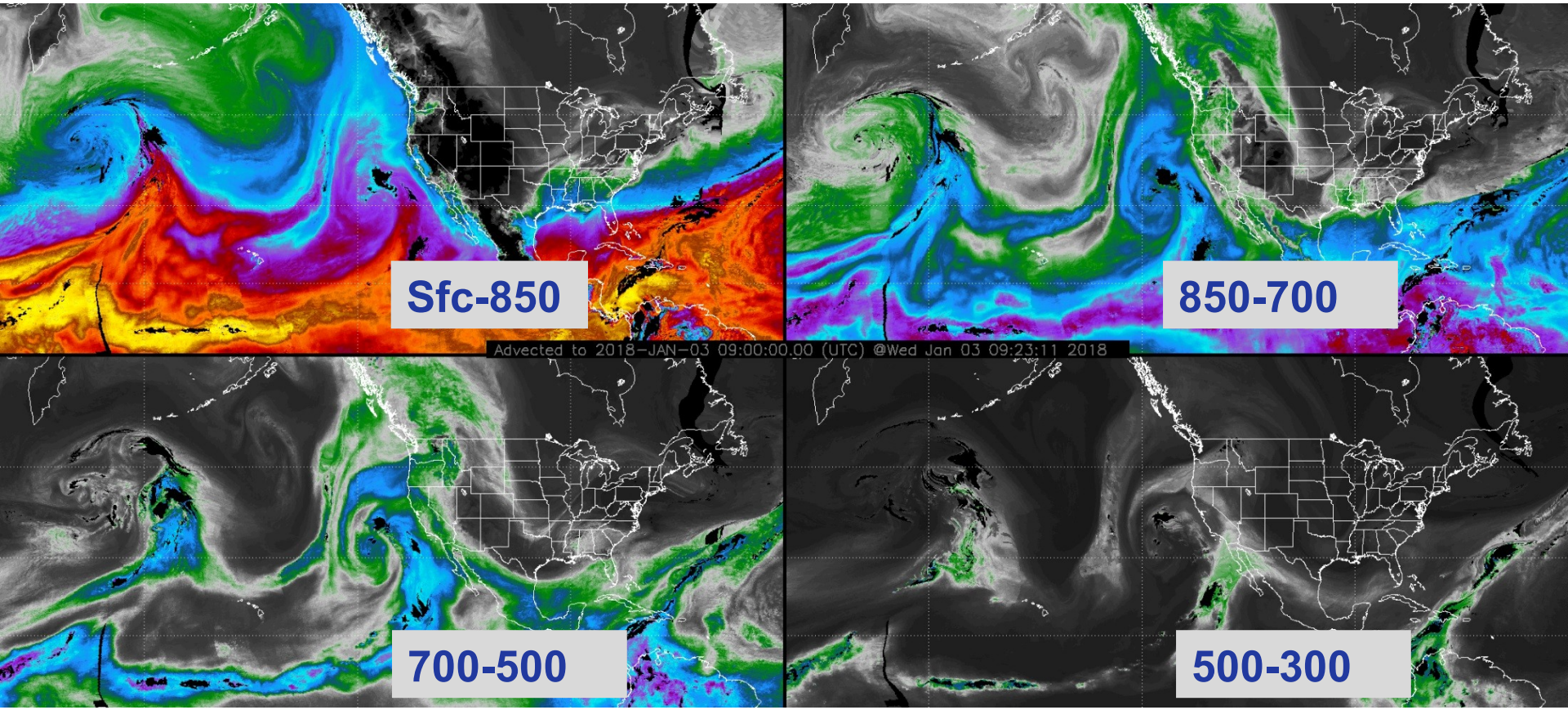


Closing Thought – Importance of Comparison to Models

Example of current NOAA Hydrometeorology Testbed project where LPW is compared to model LPW for forecasters.

CIRA Advected LPW

Layer Precipitable Water (mm)



09 UTC January 3, 2018 CIRA LPW

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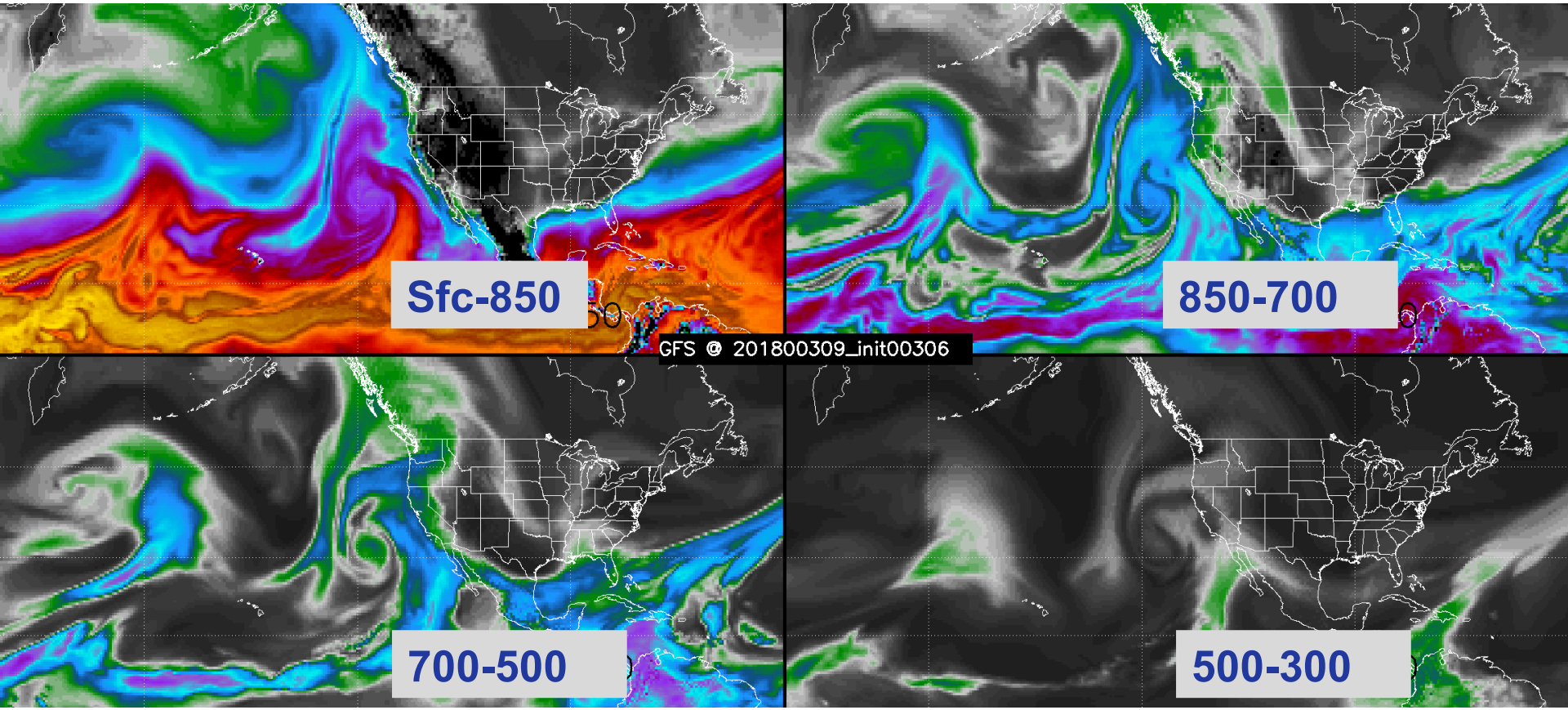
GFS LPW Derived from RH profile



09 UTC January 3, 2018 3 hour forecast from 06 UTC GFS

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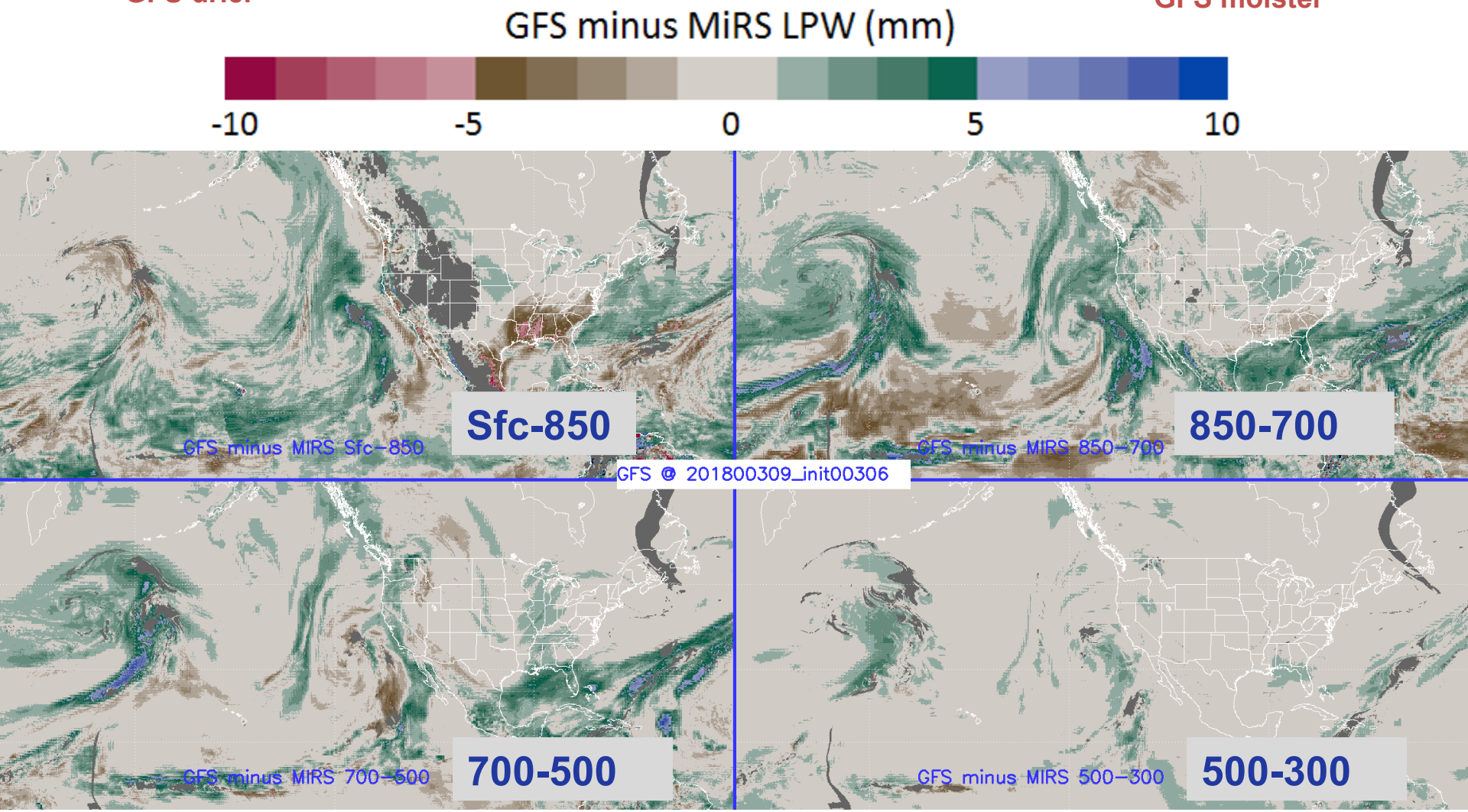
GFS drier

GFS moister



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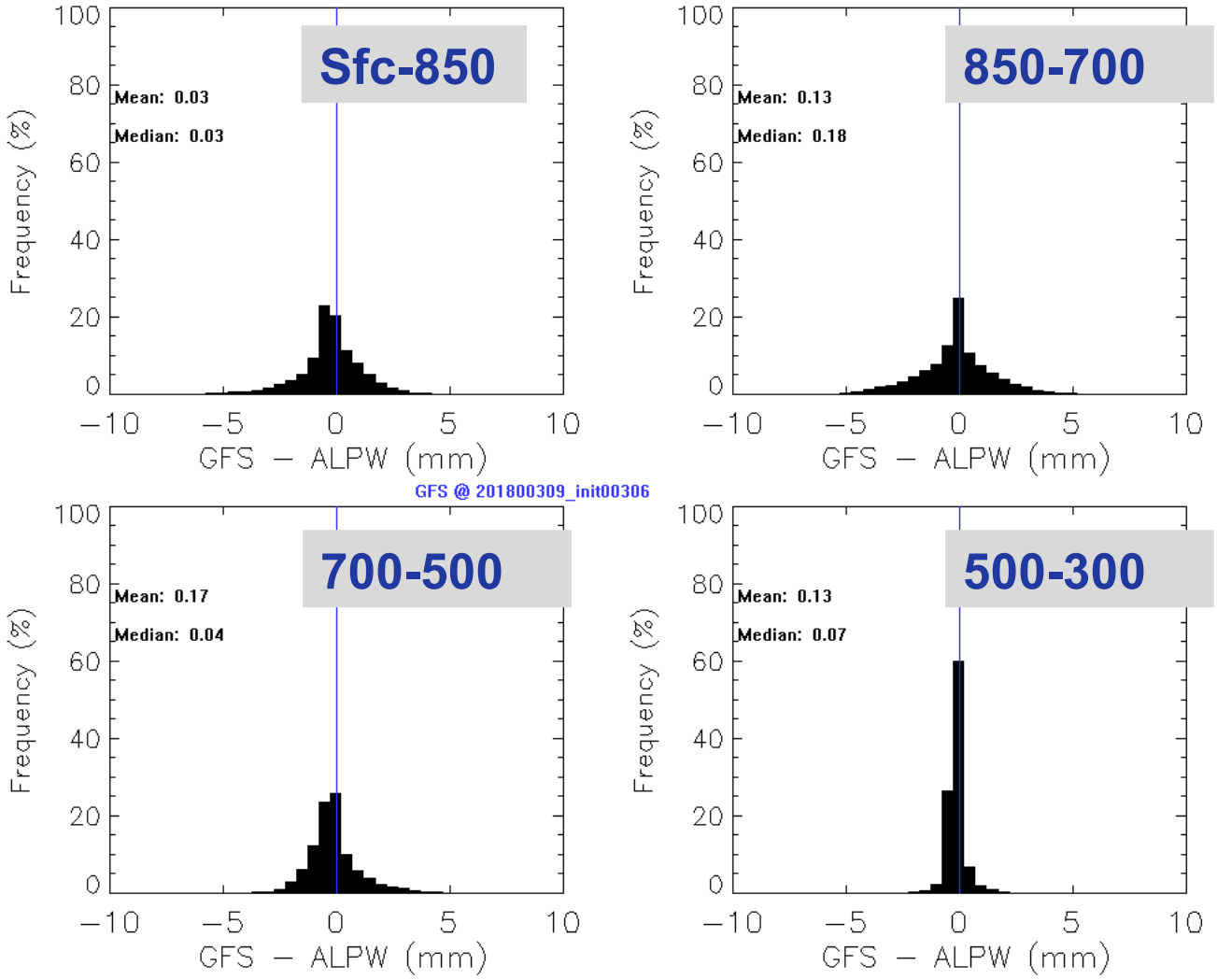

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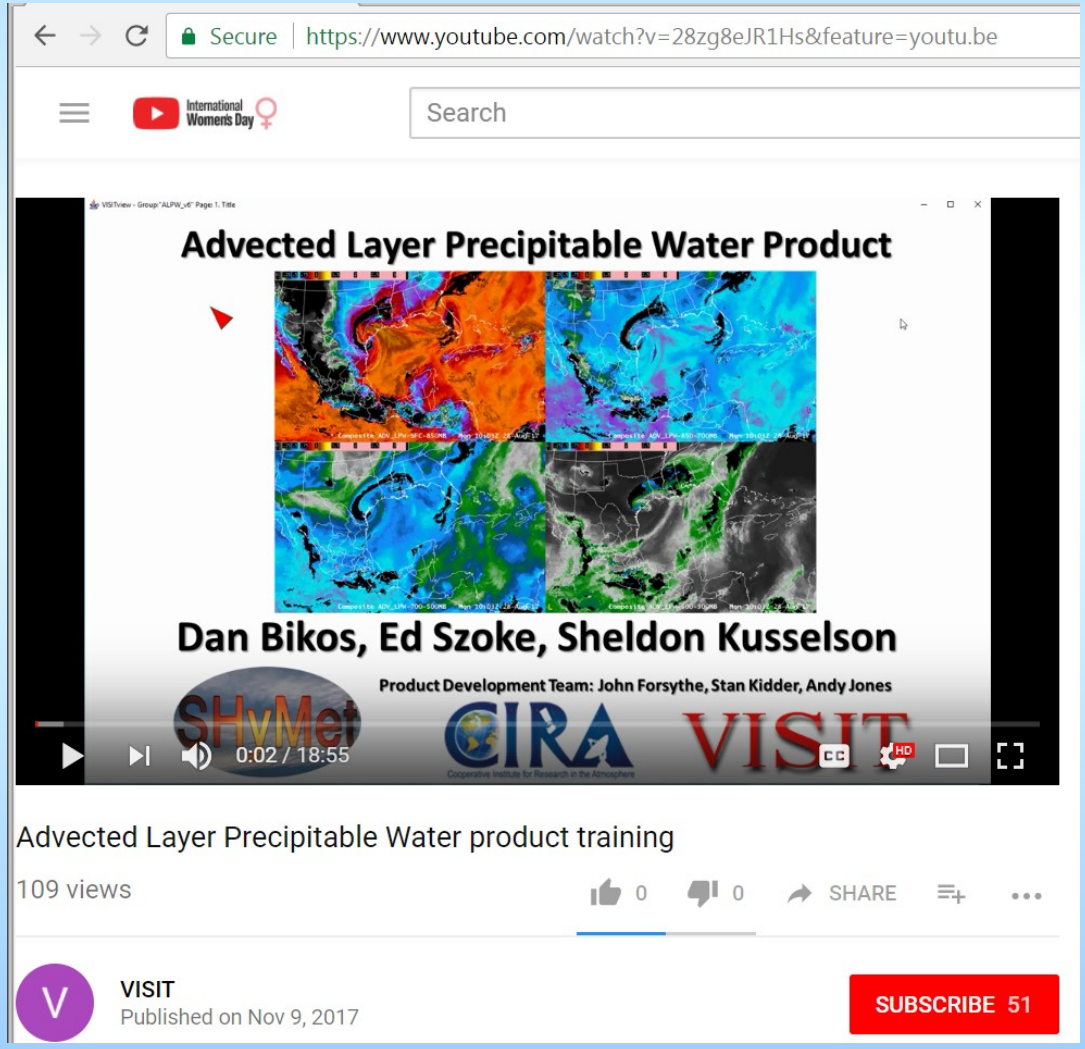
ALPW VISIT Training Session Available in Commerce Learning Center. 12 WFO's teletrained by CIRA to date.

http://rammb.cira.colostate.edu/training/visit/training_sessions/advected_layer_precipitable_water_product/

NWS WFO's which are receiving ALPW in AWIPS format via CIRA:

Portland, OR
Portland, ME
Binghamton, NY
Pueblo, CO
Boulder, CO
Burlington, VT
Indianapolis, IN
Jackson, KY
Buffalo, NY
Blacksburg, VA
Sterling, VA
Monterey, CA
San Joaquin Valley, CA
Gray, ME
Amarillo, TX
Aberdeen, SD



Future Algorithm Improvements

- Advected TPW (merger of MIMIC and operational blended TPW just began in 2018 JPSS PGRR project)
- GOES-R Risk Reduction project underway to learn how to include the enhanced temporal / spatial sampling of GOES-R into blended TPW
- Future Validation Plans
  - WPC Flash Flood and Intense Rainfall Experiment (FFaIR) participation in 2018, next version blended TPW in 2019.
  - Near-realtime radiosonde comparison being implemented at CIRA
  - OCO-2 provides a high quality (daytime, clear sky) satellite TPW retrieval for independent comparison

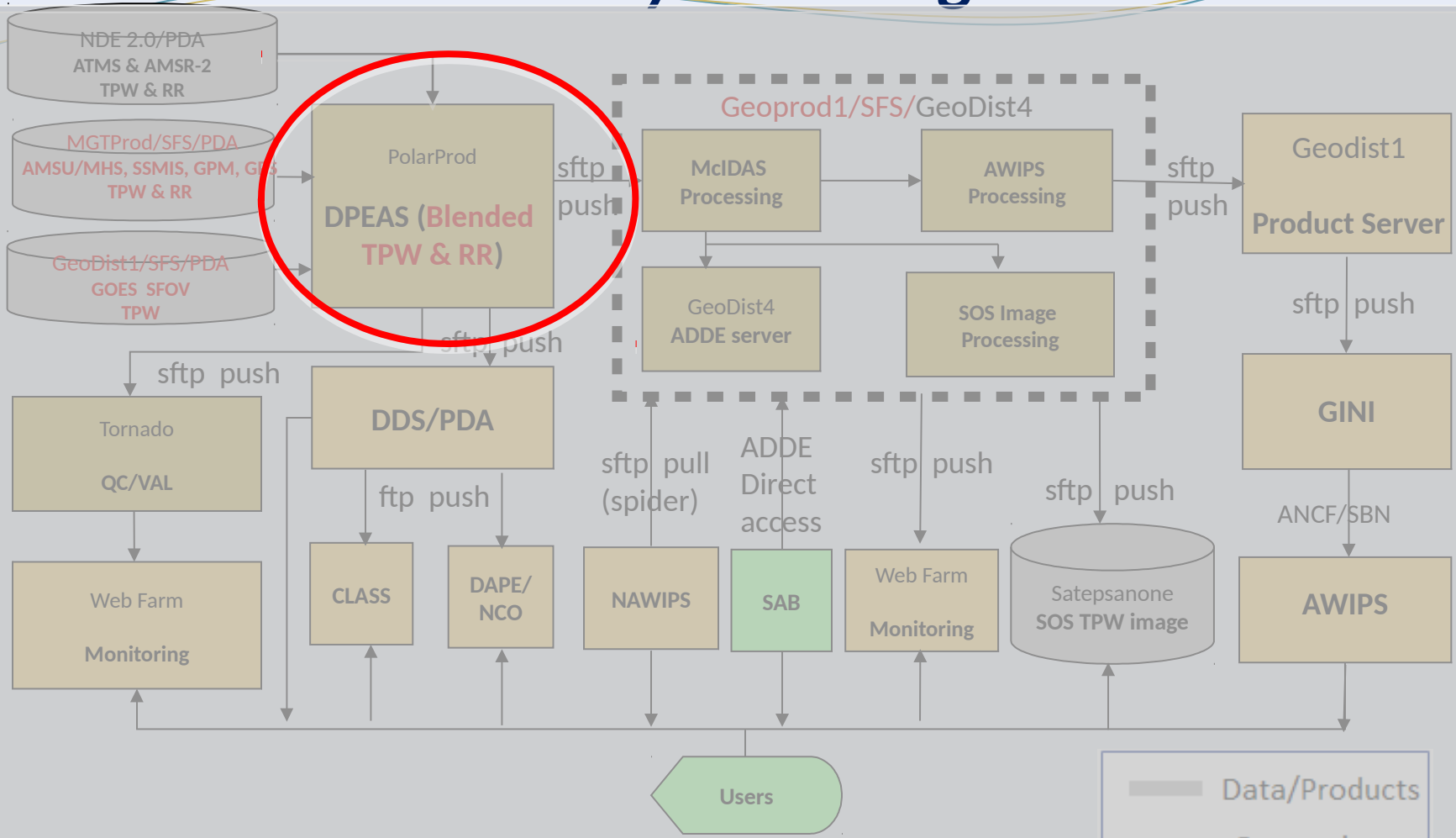
Summary and Path Forward

- CIRA developed blended TPW, TPW anomaly and Rain Rate operational since 2009
- TPW (operational) and LPW (non-operational) are used routinely by forecasters, blended rain rate not as widely used.
- MiRS V11 inputs the primary driver, transitioned to operations for blended TPW in May 2018

- DPEAS processing system hosts these products, work in progress to integrate MIMIC TPW.
- Awareness of how blended products compare to models is important
- Continue to update forecaster training (e.g. VISIT program) as products evolve

Backup Slides

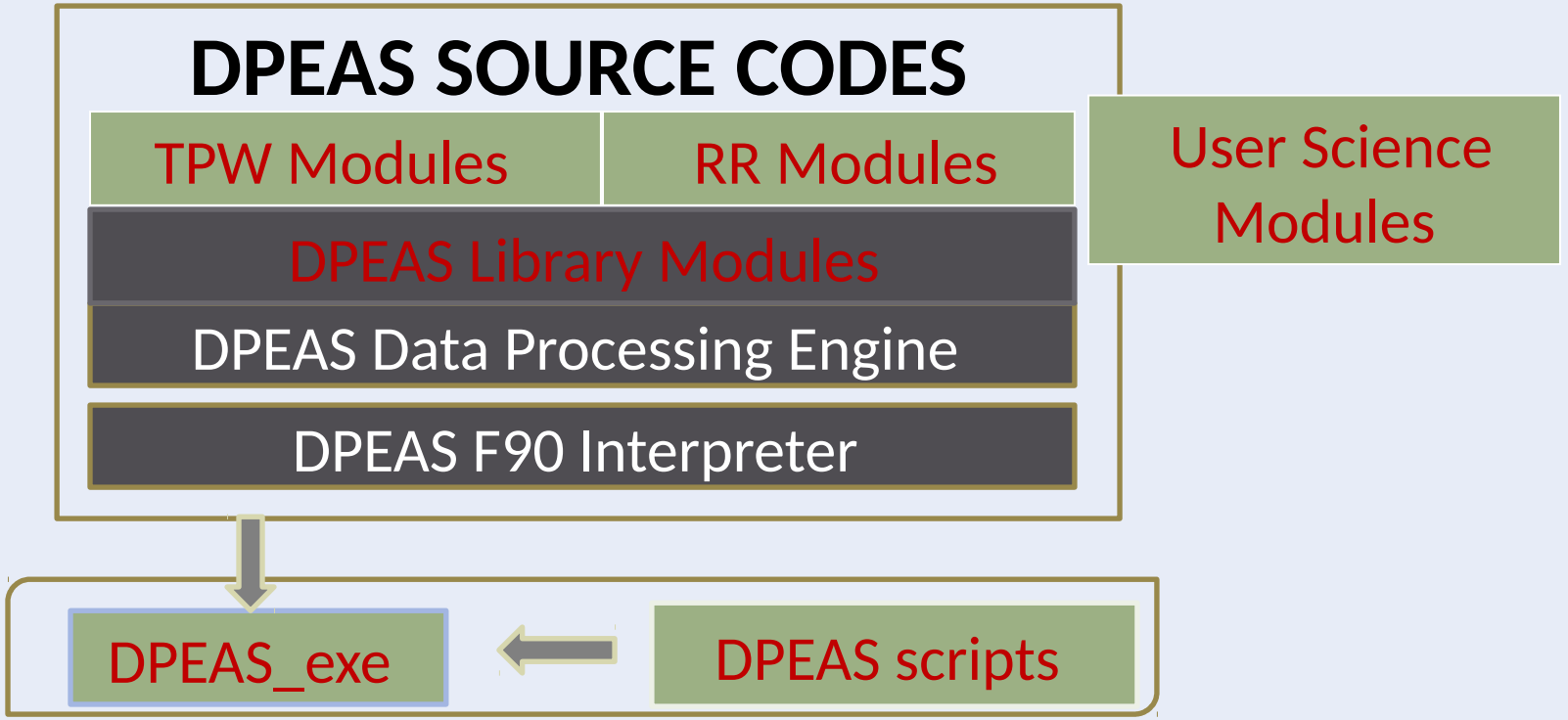
The Enhanced Blended-Hydro *Products System Diagram*



Input Data Includes: AMSU TPW & RR from ~~MSPPS and~~ MiRS high res(v11), SSMIS TPW from MiRS high res(v11), SSMIS RR from ~~FNMOC~~ MiRS high res, GOES TPW from SFOV, and GPS from NWS/NCO (MADIS), ATMS TPW and RR from MiRS (v11) at NDE; AMSR-2 TPW and RR from GAASP at NDE; GPM/GMI TPW and RR from MIRS at ESPC.

- See May 7, 2018 ORR Briefing for MiRS V11 blended TPW (slides attached)

DPEAS System Structure and Environment



Currently run on AIX in OSPO, project beginning to port to Linux

Project Stakeholders - Customers and Users

- **NWS AWIPS –** Weather Forecast Offices
- **NWS NAWIPS –** National AWIPS
- **NESDIS/SAB** – Satellite Analysis Branch
- **NWS HPC –** Hydrometeorological Prediction Center
- **NWS WR –** Western Region
- **NWS SPC –** Storm Prediction Center
- **NWS NHC –** National Hurricane Center
- **NWS TPC –** Tropical Prediction Center
- **FNMOC** – Fleet Numerical Meteorology and Oceanography Center
- **AWFA** – Air Force Weather Agency
- **GDS SOS –** Science on Sphere
- **DoD/NRL –** Naval Research Laboratory
- **NOAA OAR** – Office of Oceanic and Atmospheric Research
- **Worldwinds** – TV broadcasts
- **NESDIS STAR** - Center for Satellite Application and Research
- **Public Users -** through ftp and Internet, especially for the Web-based Animation Tools

Project Stakeholders – O&M

- **OSPO ESPC**
  - Run the Blended-Hydro products processing system (DPEAS)
  - Tailoring the products to meet users' requirements (McIDAS and AWIPS)
  - Distribute the products to users
  - Perform routine product quality monitoring and maintenance

- **OSPO Products Area Lead – Limin Zhao**
- **OSPO QA Lead – Zhaohui Cheng**
- **ESPC O&M Team**
  - Vicky Lin
  - Stephen Quinn
  - Clay Davenport
- **CIRA Science Maintenance Team**
  - Stan Kidder
  - John Forsythe
  - Andy Jones

Project Stakeholders – Development Team

- **STAR/CIRA**
  - Stan Kidder
  - John Forsythe
  - Andy Jones
  - Ralph Ferraro
- **OSPO**
  - Limin Zhao
  - Vicky Lin
  - Stephen Quinn
  - Clay Davenport

Blended-Hydro Requirements – Basic Requirement 1.0

- **Basic Requirement 1.0**: *The project shall generate operational blended TPW and RR products from POES , Metop, DMSP, S-NPP/JPSS, GCOM-W1, GPM, GOES and Met-GPS for users. (product, functional)*
  - **Derived Requirement 1.1**: The *Blended-Hydro products shall be tailored to meet various users' need.*
    - **Derived Requirement 1.1.1:** *For AWIPS users, the bTPW and bRR products shall be generated over four AWIPS specific regions in AWIPS format* (system, functional).
      - **Derived Requirement 1.1.1.1**: *The project shall write bTPW and bRR for AWIPS into McIDAS format so the tailoring tool can be used to convert it into AWIPS format.*
      - **Derived Requirement 1.1.1.2:** The product shall with be generated with the proper AWIPS headers
    - **Derived Requirement 1.1.2**: For SAB and NAWIPS users, *the bTPW and bRR products shall be generated over global in McIDAS format.*
    - **Derived Requirement 1.1.3**: For archive users, *the bTPW and bRR products shall be generated over global in HDF-EOS format.*
    - **Derived Requirement 1.1.4**: For SOS users, *the bTPW and bRR products shall be generated over global in GIF format.*

Blended-Hydro Requirements – Basic Requirement 1.0

- **Derived Requirement 1.2**: *The products shall have geographical coverage from 70°S to 70°N.*
- **Derived Requirement 1.3**: *The products shall have horizontal resolution of 16 km.*
- **Derived Requirement 1.4**: *The products shall have mapping uncertainty of 16 km.*
- **Derived Requirement 1.5**: *The blended TPW products shall have measurement range of 0 ~ 75 mm/h.*
- ***Derived Requirement 1.6***: *The blended rainfall products shall have measurement range of 0 ~ 50 mm/h.*
- **Derived Requirement 1.7**:*T he blended rainfall products shall have measurement accuracy of greater of 2 mm/h or 30%*
- **Derived Requirement 1.8**: The blended rainfall products shall have measurement accuracy of greater of 3 mm or 10%
- **Derived Requirement 1.9**: *The product shall be generated and made available within three hours of observation.*

Blended-Hydro Requirements – Basic Requirement 2.0

Basic Requirement 2.0: *Integrated Product Team (IPT) shall develop a product system to generate the unified products from multi-satellites/sensors.*

- **Derived Requirement 2.1**: *The processing system shall be a stand-alone system.*
  - **Derived Requirement 2.1.1**: *The processing system shall be written in C, C++, and/or Fortran90/95/2000 programming languages*

Blended-Hydro Requirements – Basic Requirement 2.0

- **Derived Requirement 2.1.2**: *The processing system shall have capability to ingest required satellite and other data resources.*
  - **Derived Requirement 2.1.2.1**: *The processing system shall be able to ingest GPS TPW data from NOAAPort.*
  - **Derived Requirement 2.1.2.2**: *The processing system shall be able to ingest TPW and RR data from NOAA POES satellites.*
  - **Derived Requirement 2.1.2.3**: *The processing system shall be able to ingest EUMETSAT Metop TPW and RR satellites.*
  - **Derived Requirement 2.1.2.4**: *The processing system shall be able to ingest TPW and RR data from DMSP satellites.*
  - **Derived Requirement 2.1.2.5**: *The processing system shall be able to ingest TPW from GOES-W/E satellites.*
  - **Derived Requirement 2.1.2.6**: *The processing system shall be able to ingest TPW and RR from S-NPP/JPSS satellites.*
  - **Derived Requirement 2.1.2.7**: *The processing system shall be able to ingest TPW and RR from JAXA GCOM-W1 satellite.*
  - **Derived Requirement 2.1.2.8**: *The processing system shall be able to ingest TPW and RR from NASA GPM satellite.*

Blended-Hydro Requirements – Basic Requirement 2.0

- **Derived Requirement 2.1.3**: *The processing system shall have capability to generate required products from various data resources.*
- **Derived Requirement 2.1.4**: *The processing system shall have capability to distribute the products to users.*

Derived Requirement 2.2: *IPT shall verify that the products in the output files are generated correctly and documented.*

Blended-Hydro Requirements – Basic Requirement 3.0

Basic Requirement 3.0: *The Blended-Hydro output files shall be archived* (product, functional)

- **Derived Requirement 3.1**: *The bTPW and bRR shall generate for CLASS with an associated metadata file for each product file. This file shall be an FGDC-RSE compliant file in xml format.* (product, quality)
- **Derived Requirement 3.2**: *The bTPW and bRR IPT shall create a Data Submission Agreement (DSA) with CLASS. The DSA shall include all information regarding the archival of product files.* (product, quality)

Blended-Hydro Requirements

Basic Requirement 4.0: *The Blended Hydro Products system shall have QC monitoring capability.*

Basic Requirement 4.0

- **Derived Requirement 4.1**: *The Product files shall include overall quality control flags.*
- **Derived Requirement 4.2**: *The system shall be capable of monitoring input data latency and overall quality.*
- **Derived Requirement 4.3**: *The system shall be capable of monitoring product latency.*
- **Derived Requirement 4.4**: *The system shall be capable of monitoring product generation and distribution status to ensure that the data/products are available for and successfully transfer to the user community.*
- **Derived Requirement 4.5**: *The system shall be capable of monitoring product quality.*
  - **Derived Requirement 4.5.1**: *The data shall be able to push data to the ESPC web servers.*
  - **Derived Requirement 4.5.2**: The system *shall have a web interface for displaying the products images, processing and distribution status and timeliness.*

Blended-Hydro Requirements – Basic Requirement 5.0

Basic Requirement 5.0: *The Blended-Hydro Products system shall comply with OSPO Code Review Security check.*

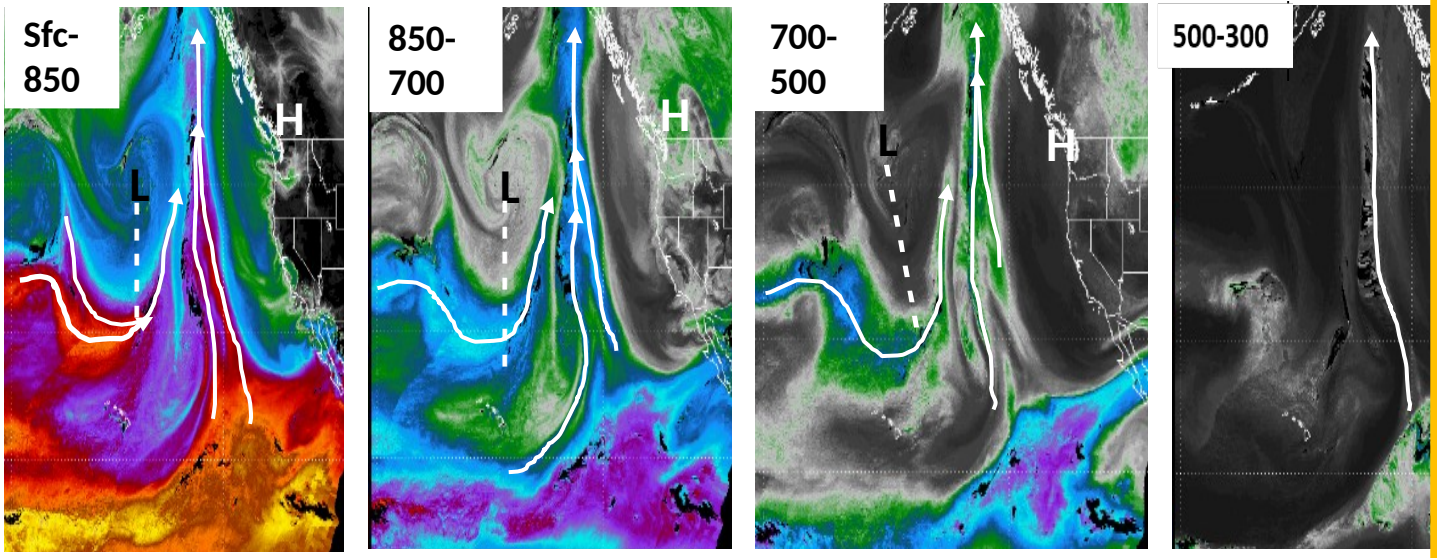
Blended-Hydro Requirements – Basic Requirement 6.0

Basic Requirement 6.0: *The IPT shall deliver a Blended-Hydro Products system document package to OSPO.*

- **Derived Requirement 6.1**:*The document package shall include an Algorithm Theoretical Basis Document (ATBD).*
- **Derived Requirement 6.2**:*The document package shall include a System Maintenance Manual (SMM).*
- **Derived Requirement 6.3**:*The document package shall include an External User Manual (EUM).*
- **Derived Requirement 6.4**:*The document package shall include an Internal User Manual (IUM).*
- **Derived Requirement 6.5**:*The document package shall include an Operations Procedure (OP).*

"Atmospheric Rivers" of High Concentrated Moisture into Alaska at 4 Layers for Incredible Excessive Valdez Snowfall – 6 December 2017

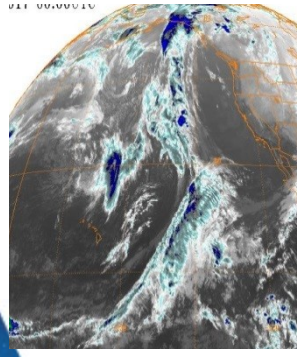
CIRA Advected Layered Precipitable Water (ALPW) for 00 UTC 7 December 2017



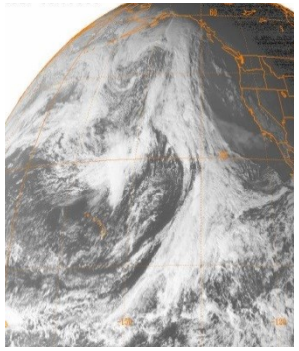
Thompson Pass
(just outside Valdez, AK)
Snow
1.7" in 10 minutes
5" in 30 minutes
10" in one hour
15" in 1.5 hours
40" in 12 hours

Avg Wind flow at layer

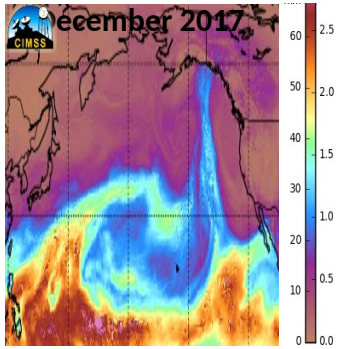
Layer Precipitable Water (mm)



GOES-15 IR



GOES-15 VIS



CIMSS MIMIC TPW2.0

Snowplows clearing Richardson Highway near Thompson Pass, Ak. (Alaska Dept of Transp & Pub Facilities)

http://www.kvoa.com/story/37040816/7-feet-of-snow-over-3-days-buries-alaska-town

Analysis Prepared by Sheldon Kusselson

Cooperative Institute for Research in the Atmosphere

Importance/Benefits/Users

(Provide this information in your back-up slides)

- Product Importance/Benefits/Users
- PGRR/PGI Activities

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations

Product Evaluation/Validation/Tools

- Product Evaluation/Validation
  - Data sets used for validation (in-situ, correlative data sets);
  - Validation results
  - Evaluation and visualization tools
    - ✓ Identify whether these tools are available for users
- Defined Quality Flags
  - Variable, description, value, verification
    - (discuss quality flags, but provide details as backup slides)

Implementation Status

(Provide this information in your back-up slides)

- Discuss current status of implementation including the availability in AWIPS or alternatives.
- Algorithm version/LUTs
- Processing environment and resources required for implementation or porting.
- Future plans on implementations including AWIPS or alternatives

{Product Name} Technical Approach

1. Blended Product Algorithm Description
2. Technical Approach (as applicable to your product)
   - Methods of Bracketing (gather all inputs in the desired area during the desired time)
   - Quality Control Methods (to filter data as needed)
   - Calibration (handle biases)
   - Geo-location Tests (to ensure locations are correct/consistent)
   - Gap Handling (how missed data or data gaps are accounted)
   - Handling Duplicates

Input Product(s) Requirements

Identify satellite and ancillary data Inputs
(use additional slides as needed)

Input Data	Resolution	Source
e.g. GFS – T(p), q(p)	0.5 x 0.5 deg; 31 levels	NCEP
e.g. Annual Surface Type	1 km Global	JPSS-VIIRS
e.g. SST	5 km Global	ACSPO

Output Product(s) Specifications

- Blended Product Name: **{SST}**
- Output Data Type(s): {S-NPP/NOAA-20/GOES-16}
- If your blended product algorithm produces more than one output product, use additional slides as required.

Output Product(s) Attributes	Threshold	Observed/validated
Latency		
Geographic coverage		
Vertical Coverage		
Vertical Cell Size		
Horizontal Cell Size		
Mapping Uncertainty		
Measurement Range		
Measurement Accuracy		
Measurement Precision		
Measurement Uncertainty		

Quality Flags

- Defined Quality Flag(s)
  - Variable, description, value, verification

Quality Flag	Description	Value
MiRS	MiRS TPW quality flag good required	0

Implementation Status

- Discuss current status of implementation including the availability in AWIPS or alternatives.
- Algorithm version/LUTs
- Processing environment and resources required for implementation or porting.
- Future plans on implementations including AWIPS or alternatives

Importance/Benefits/Users

- Product Importance/Benefits/Users
- PGRR/PGI Activities

Name	Organization	Application	User Feedback - User readiness dates for ingest of data and bringing data to operations

Documentation/website links

- Provide website links for documentation, down-load instructions, etc.

https://www.ospo.noaa.gov/Products/bTPW/index.html

http://cat.cira.colostate.edu

{Product Name} Blended Product Team

Algorithm Team Members

Name	Organization	Major Task