

MIMIC-TPW and lessons learned from a lifelike verification of MiRS

Tony Wimmers

With contributions from Chris Velden, Jordan Gerth and Scott Bachmeier

Cooperative Institute for Meteorological Satellite Studies

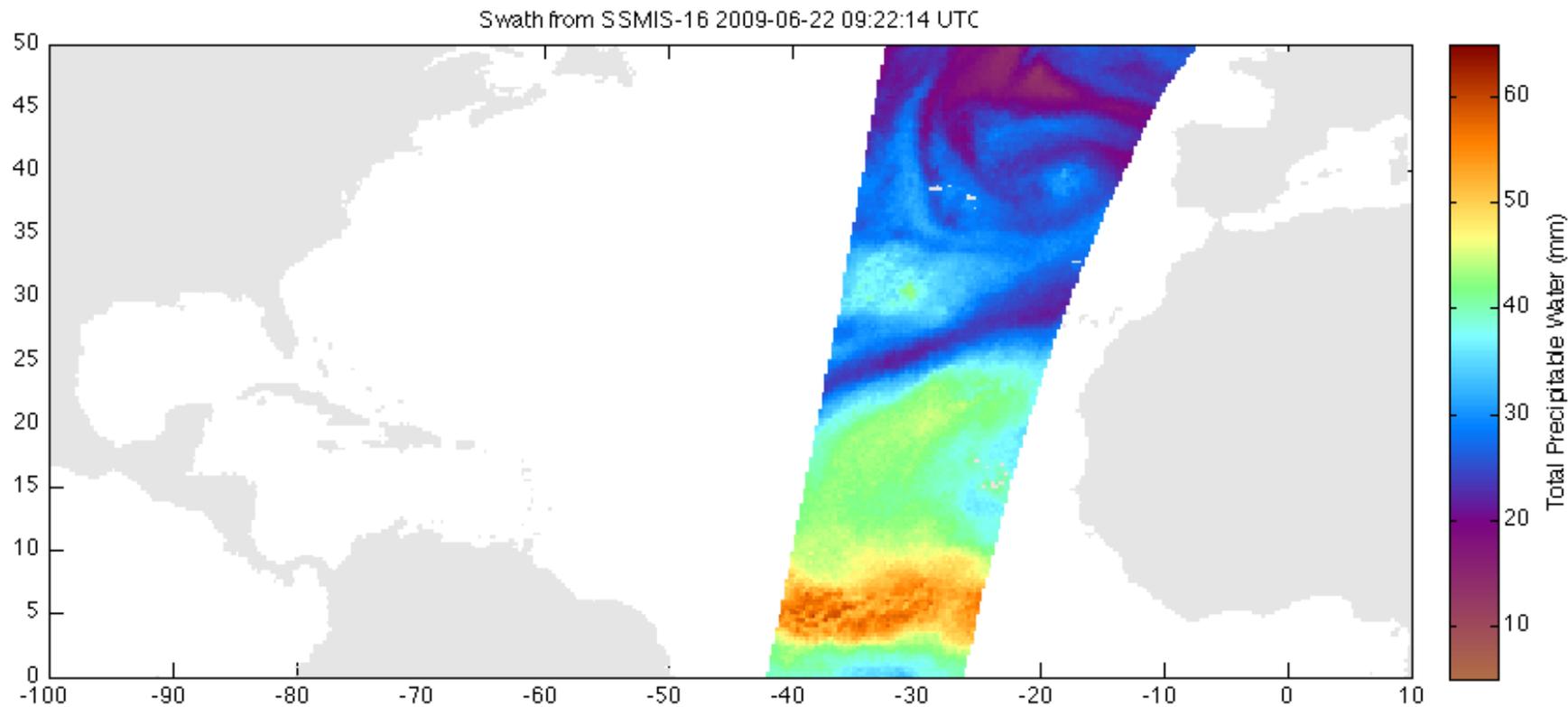
University of Wisconsin - Madison



R&D supported by JPSS Risk Reduction, and the Naval Research Lab and Office of Naval Research

Data advected from 09:22 UTC

2009 / 06 / 22

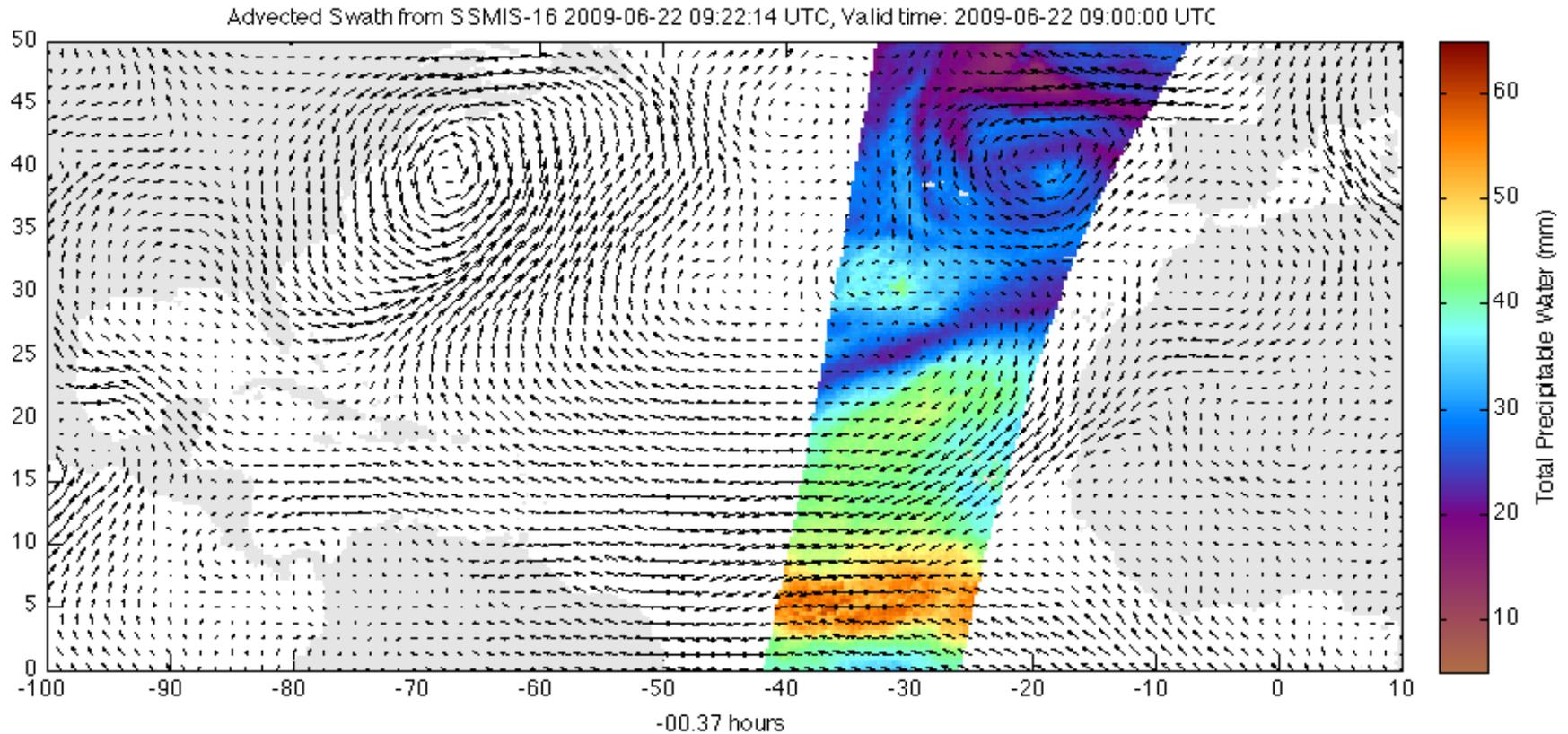


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Data advected from 09:22 UTC

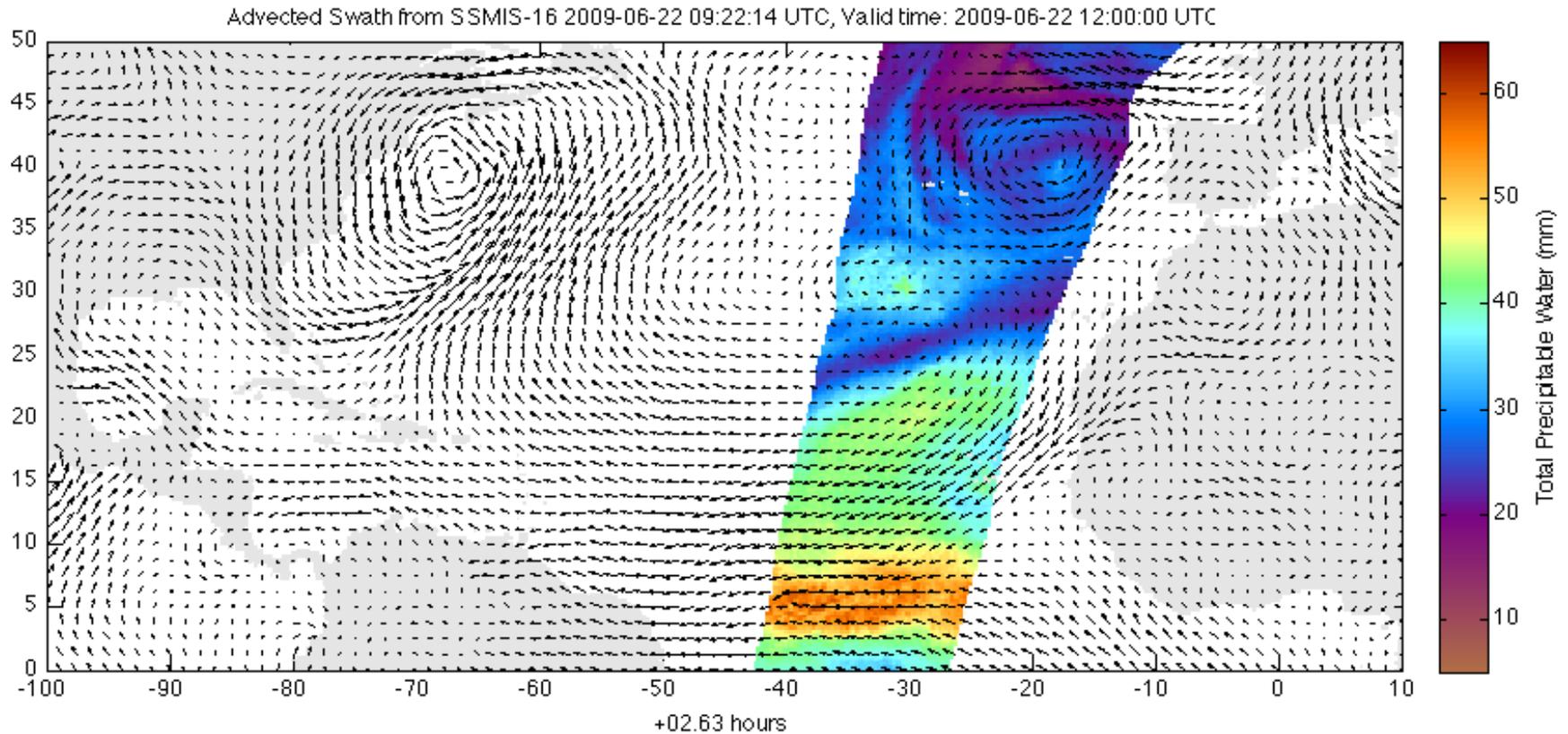
2009 / 06 / 22



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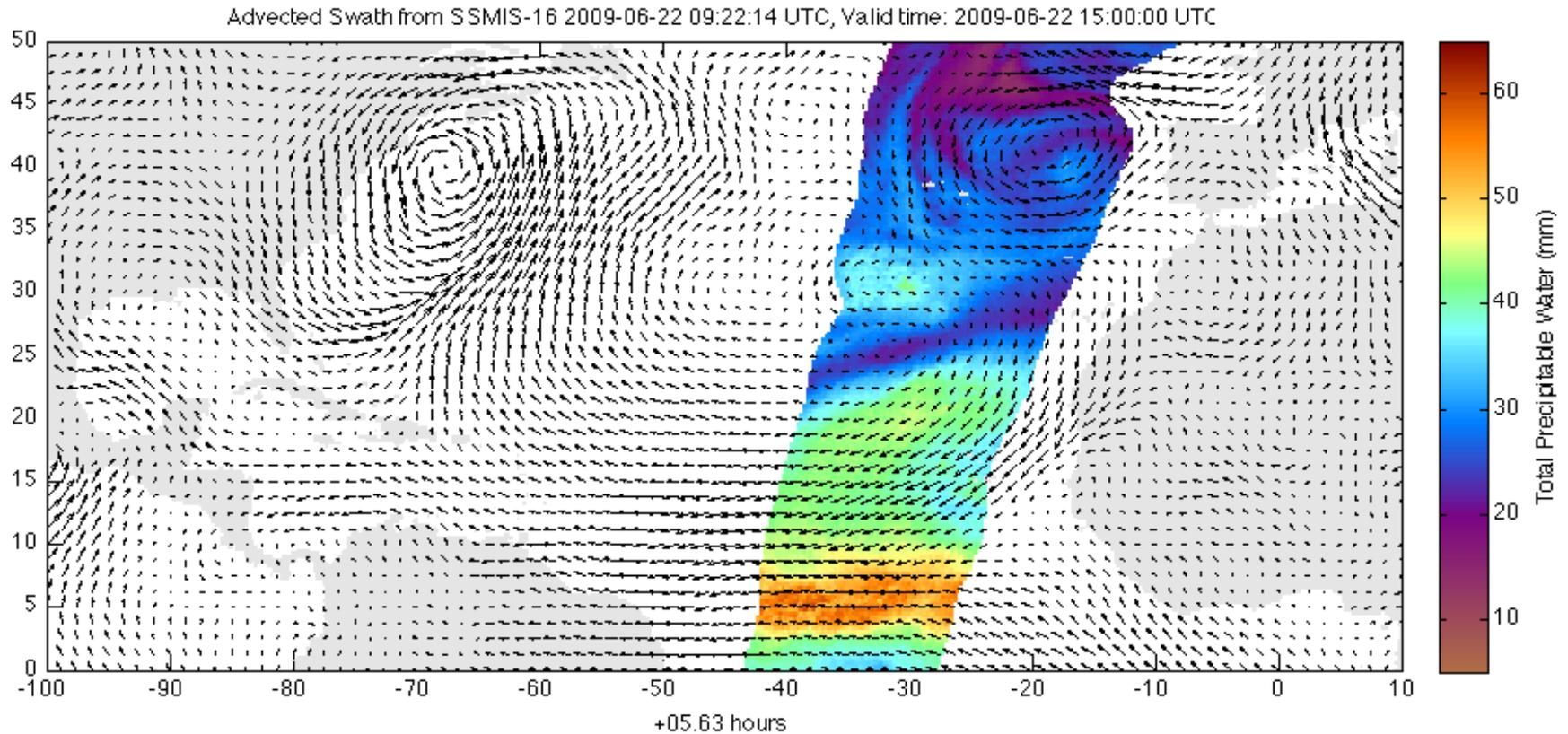
2009 / 06 / 22



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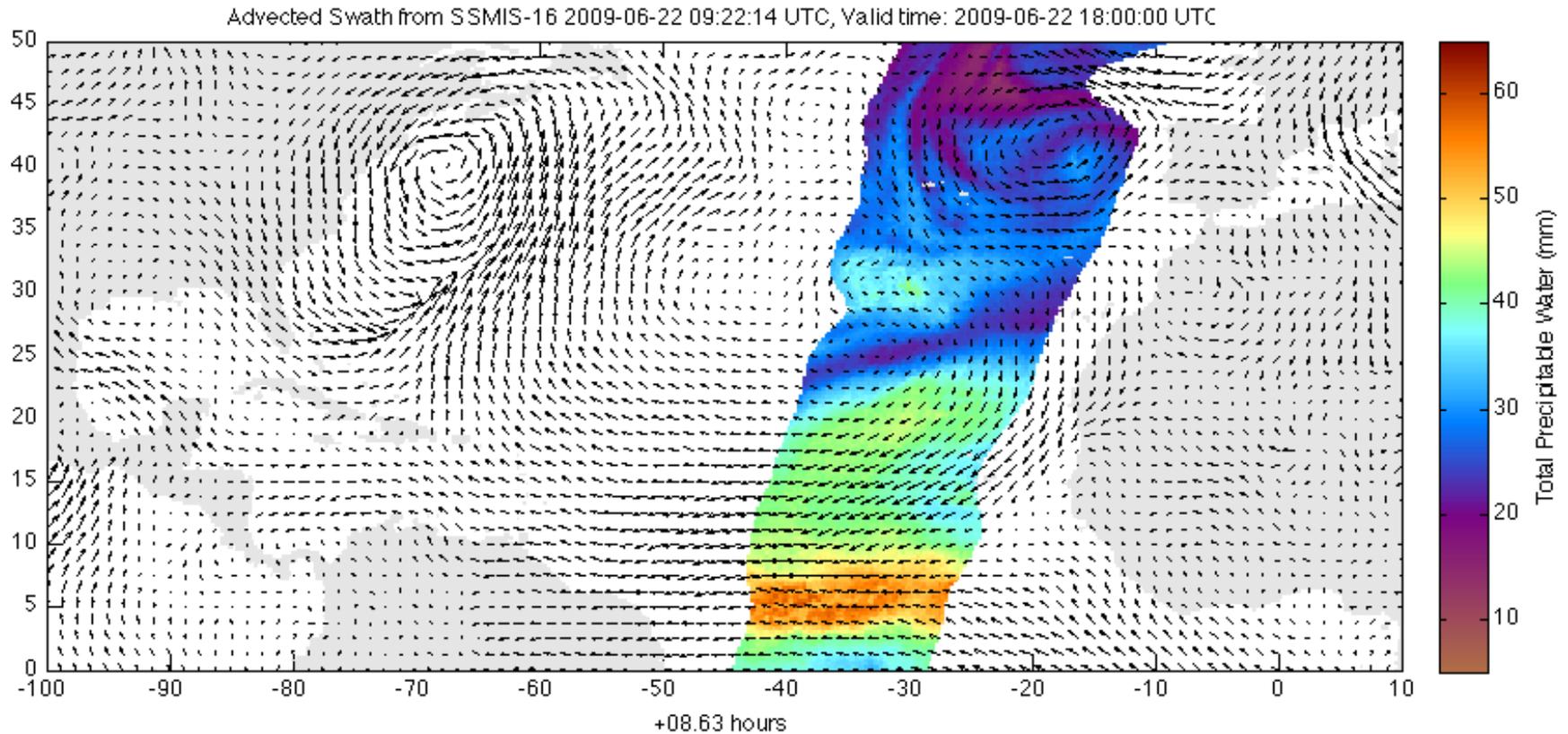
2009 / 06 / 22



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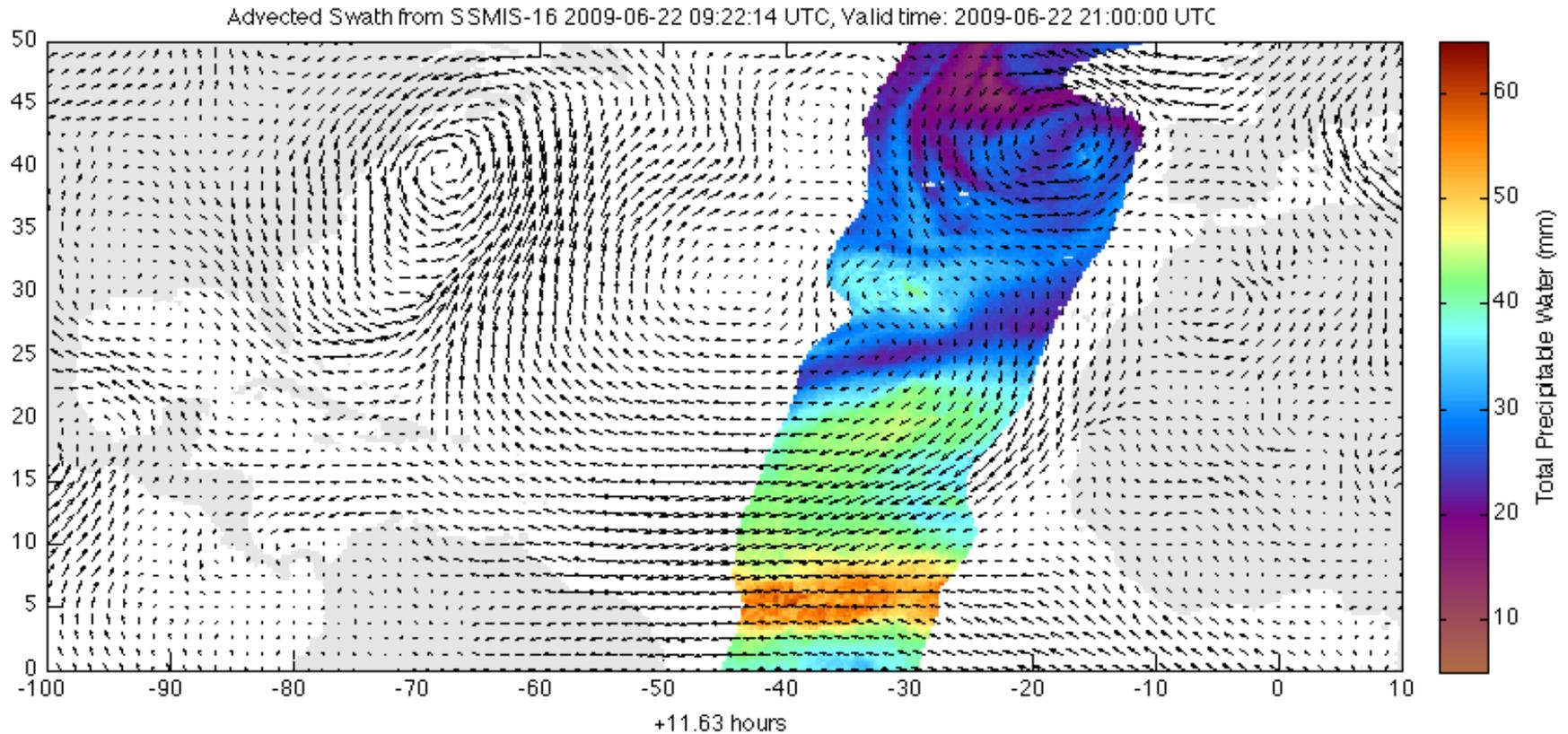
2009 / 06 / 22



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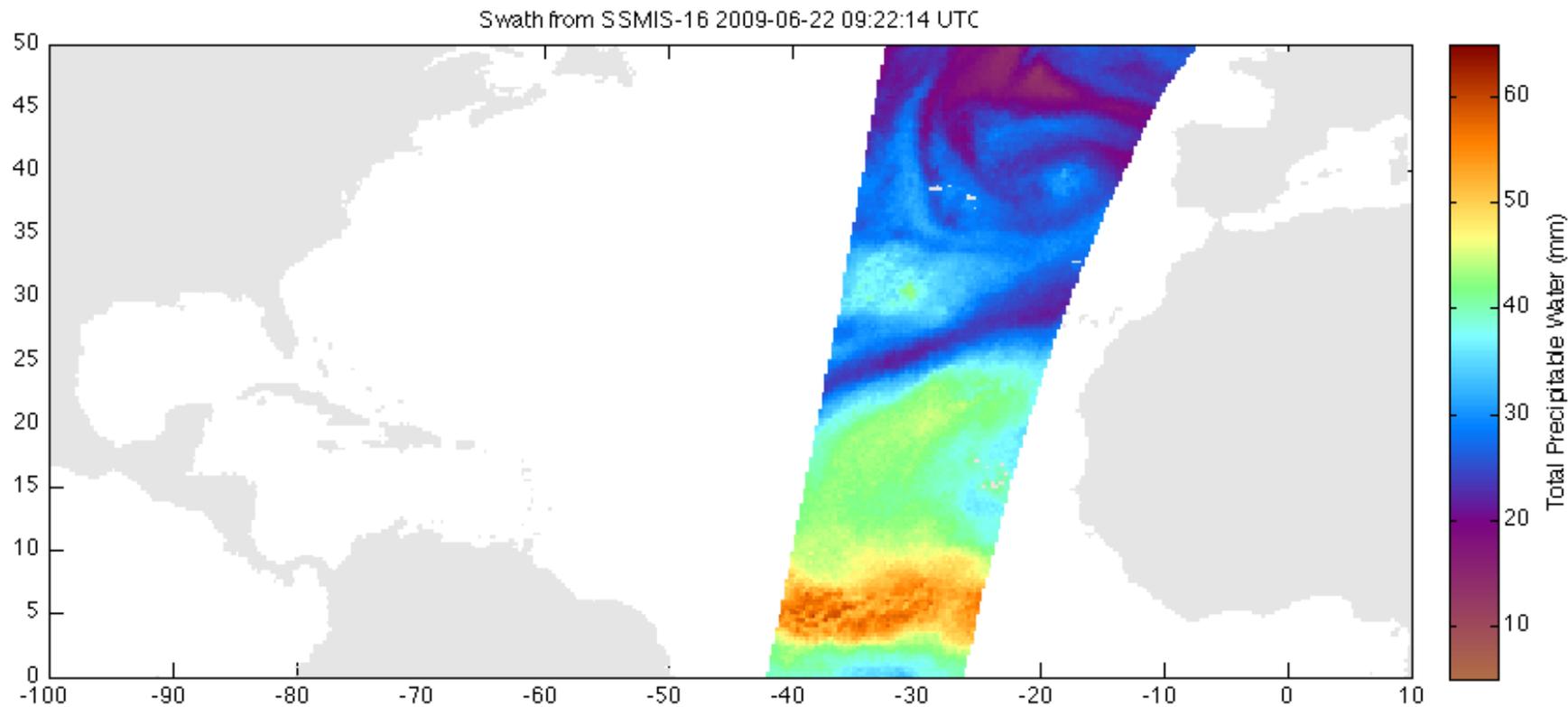
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2009 / 06 / 22

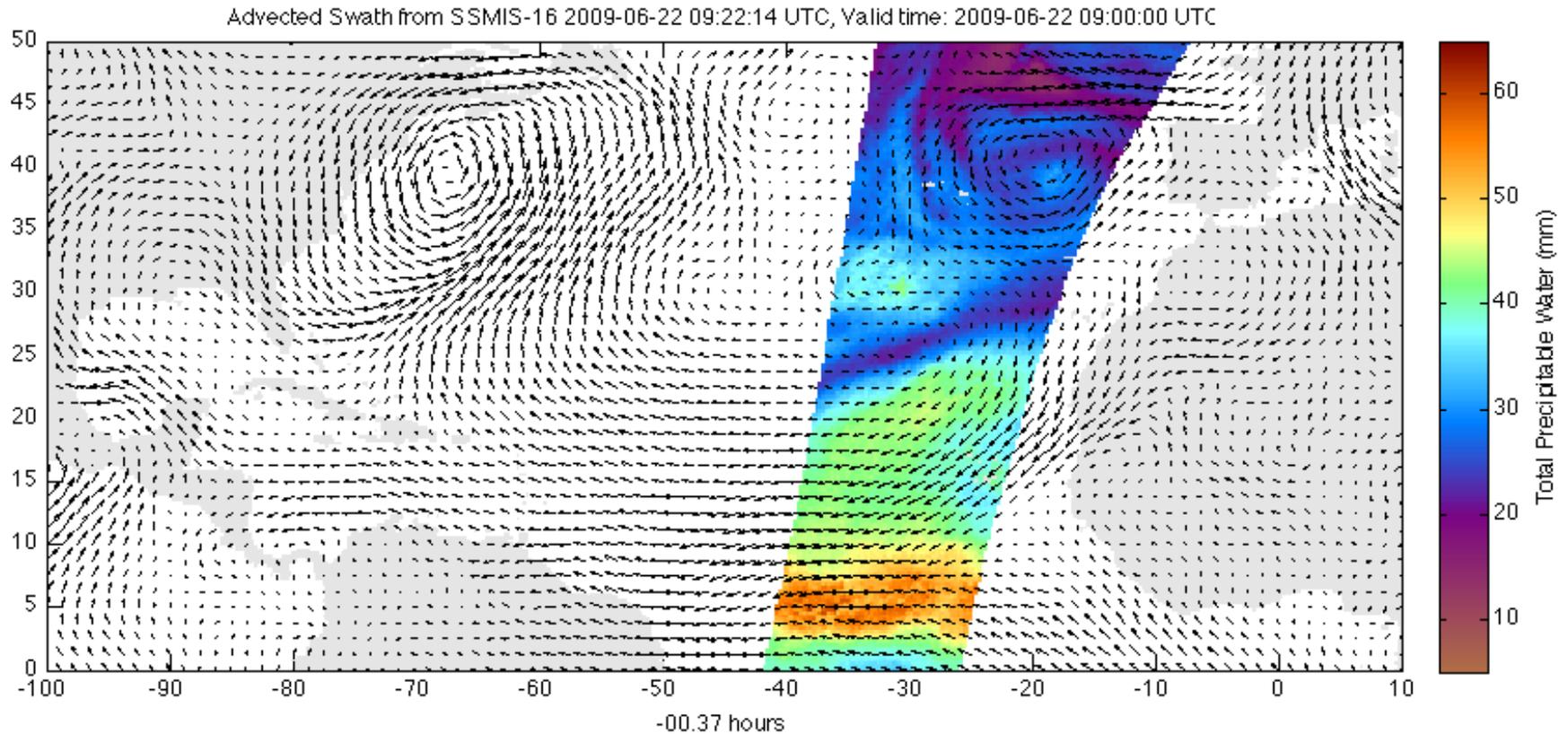


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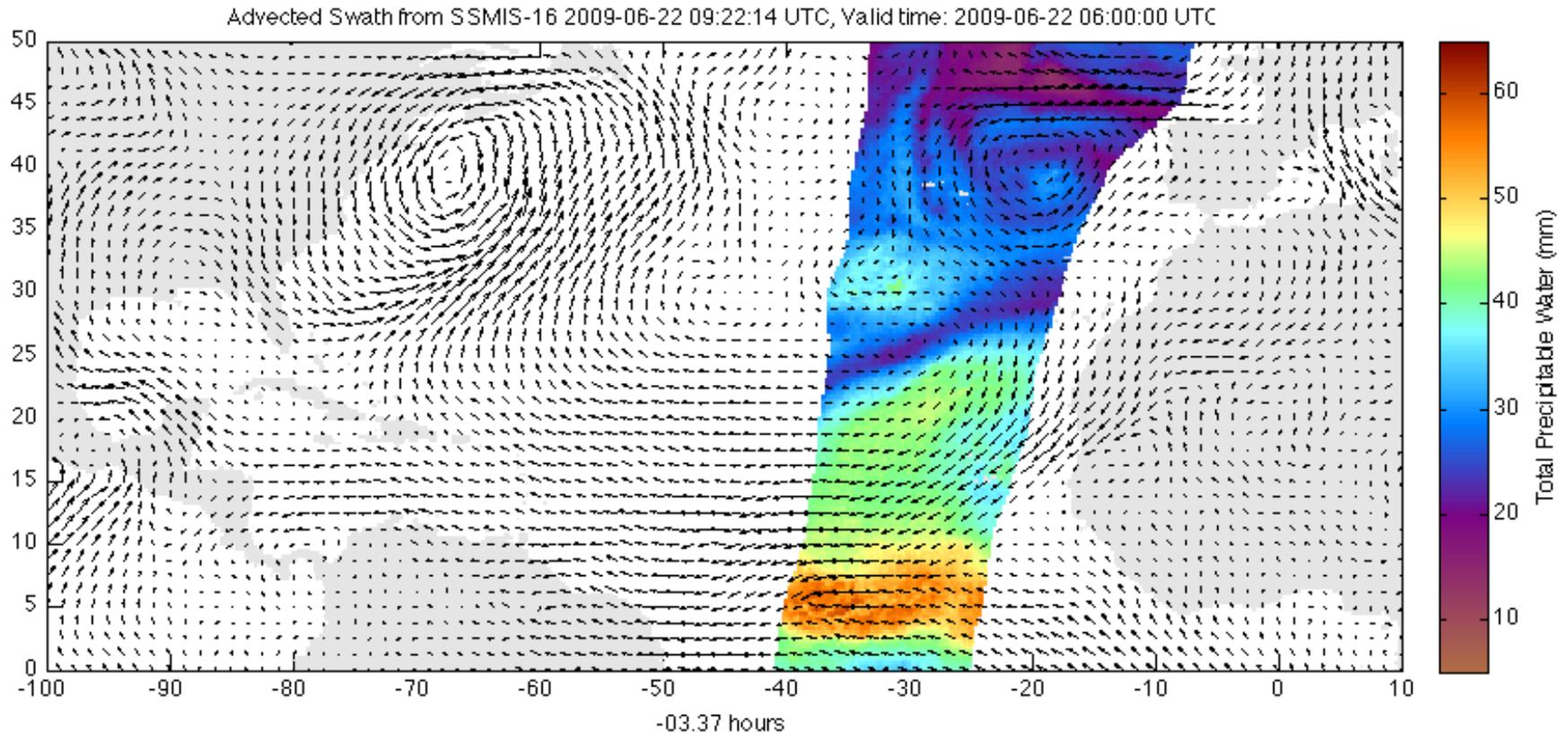
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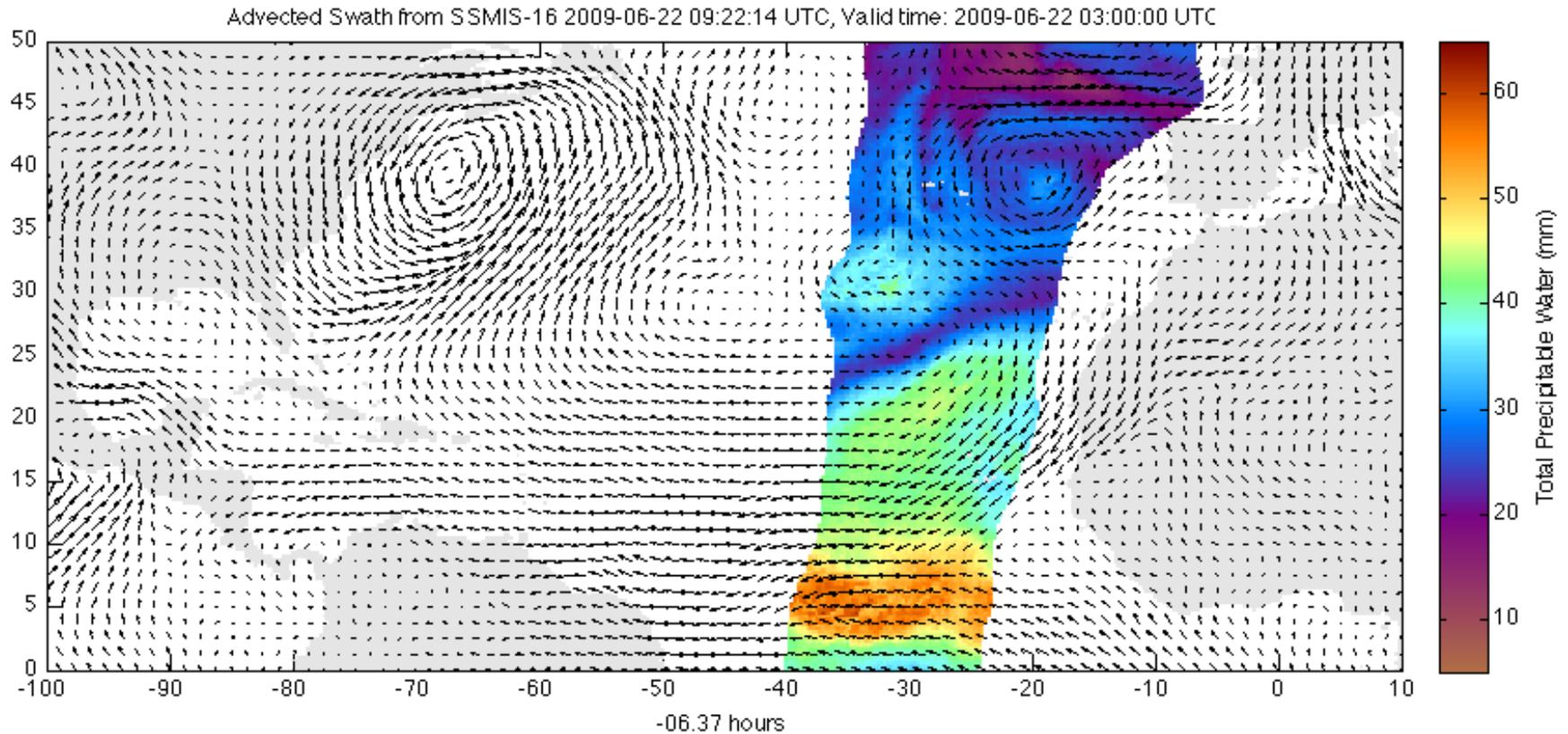
2009 / 06 / 22



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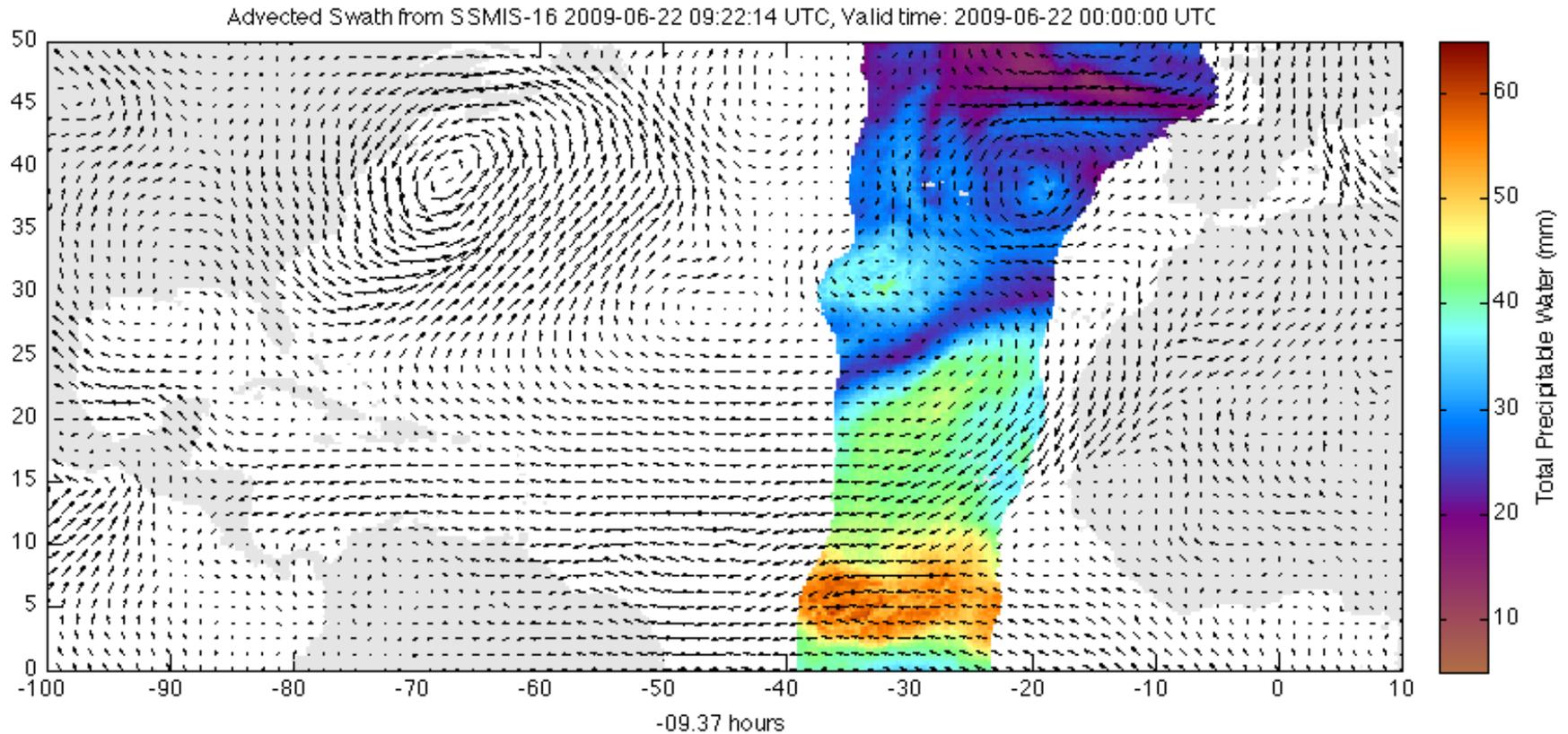
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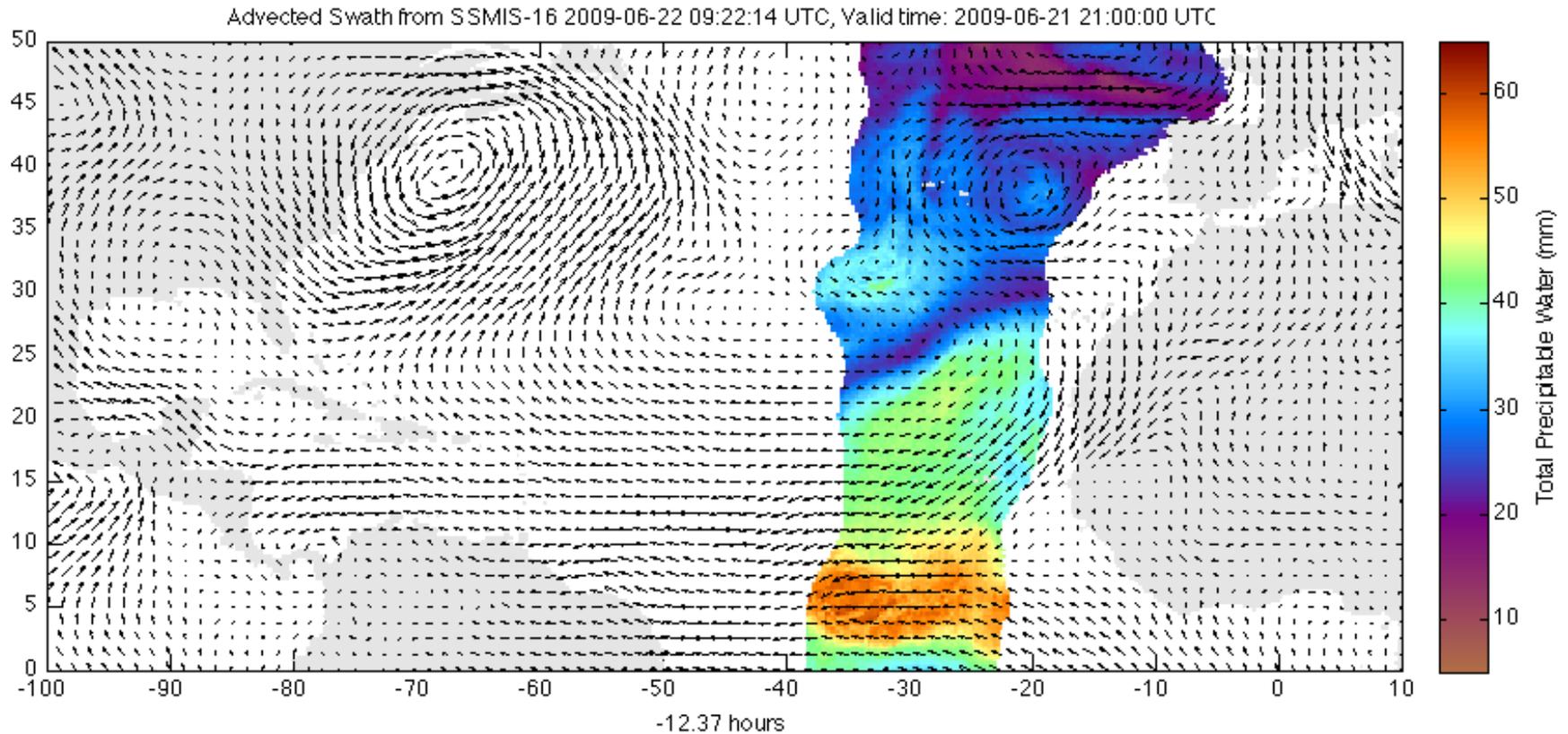
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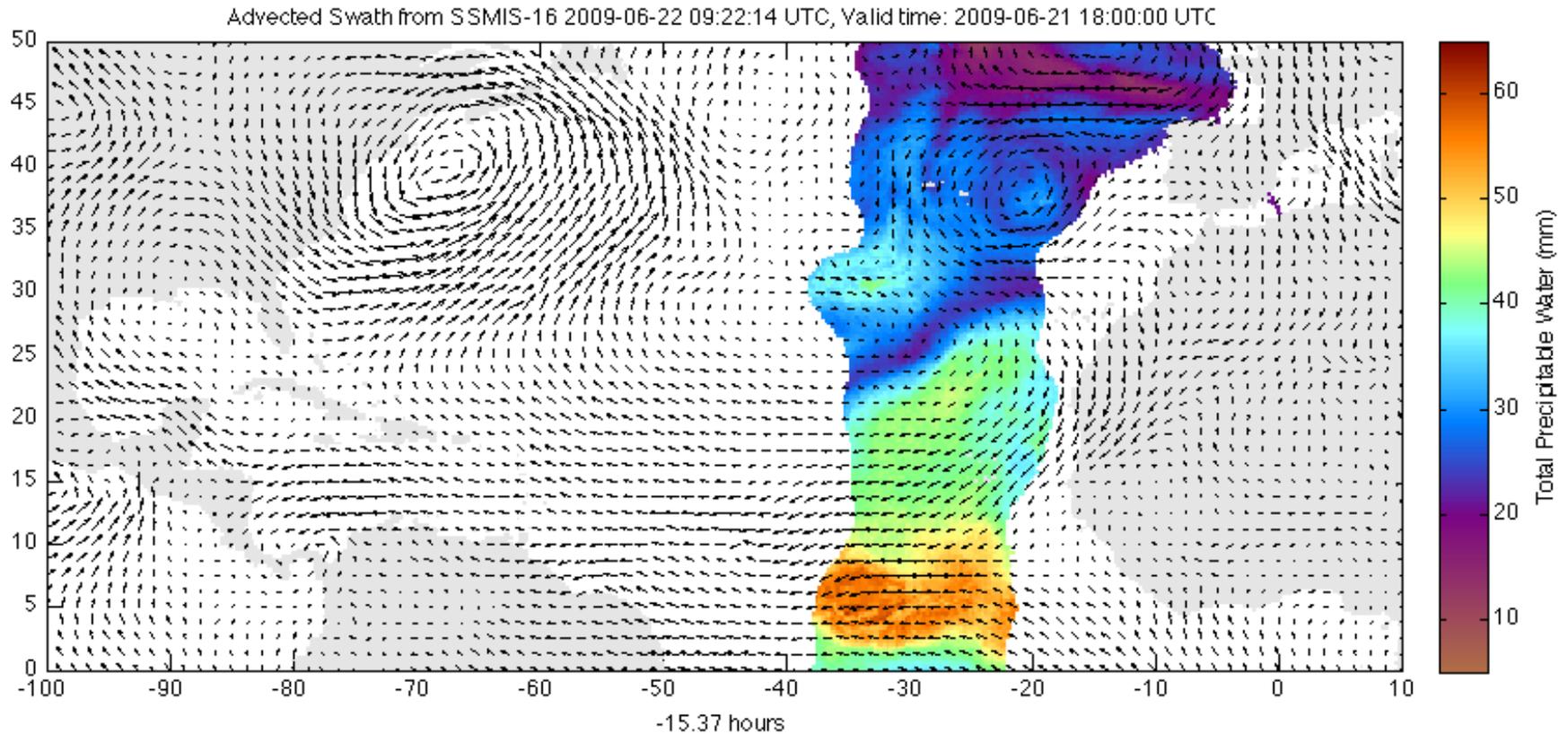
2009 / 06 / 22



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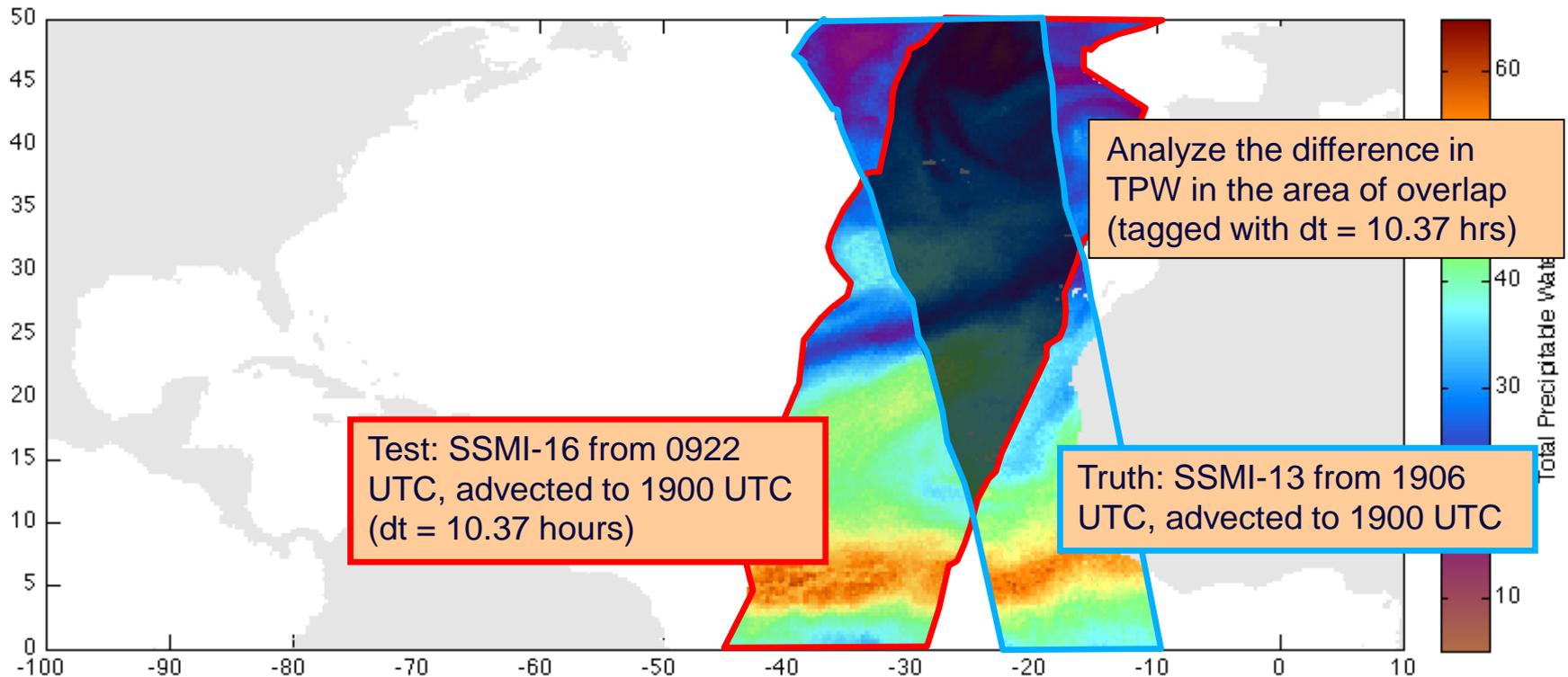
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2009 / 06 / 22



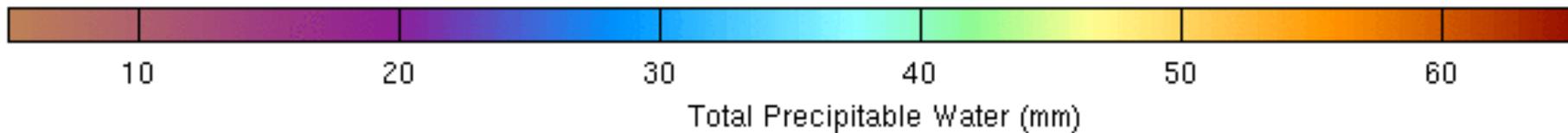
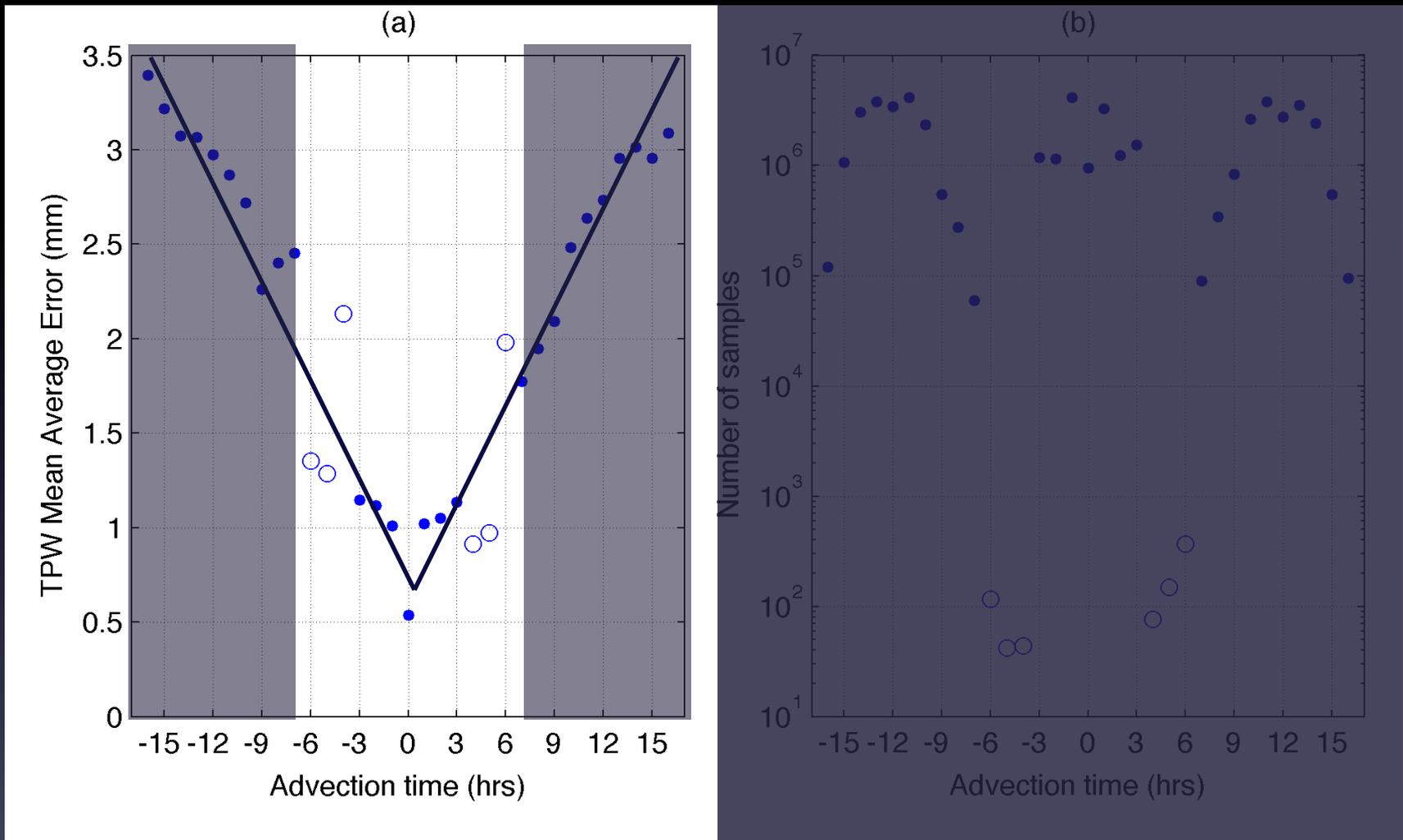
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Validation

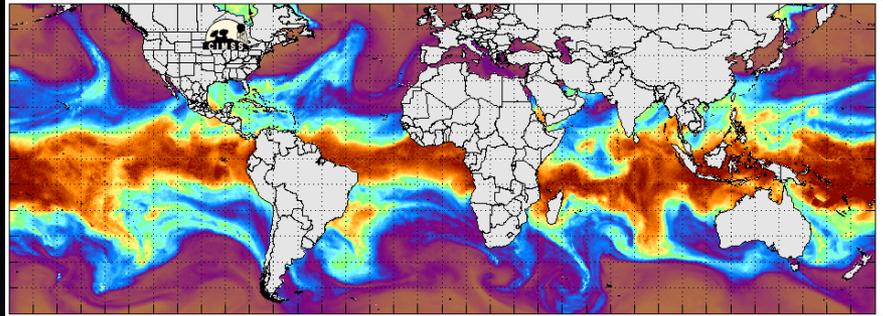


Valid 2009/06/22 1900 UTC

Error statistics binned by advection time



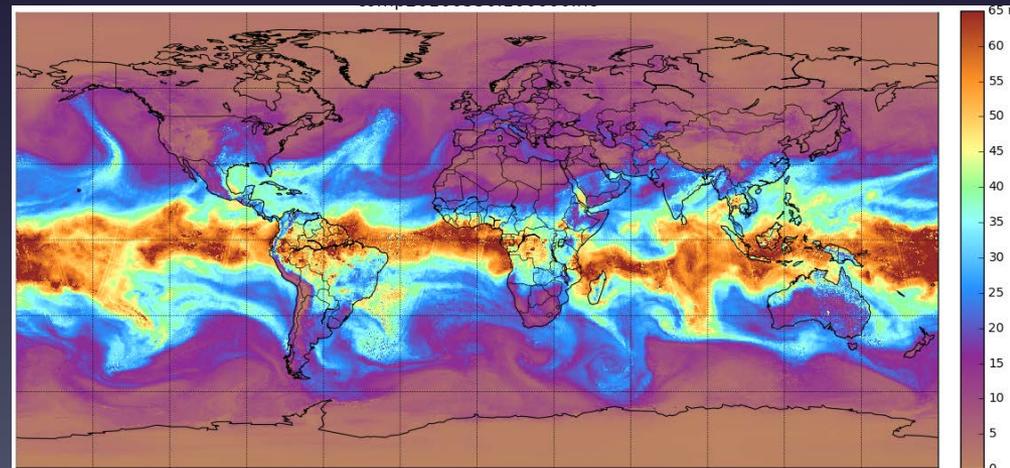
MIMIC-TPW: Background



Version 1: 2008-present

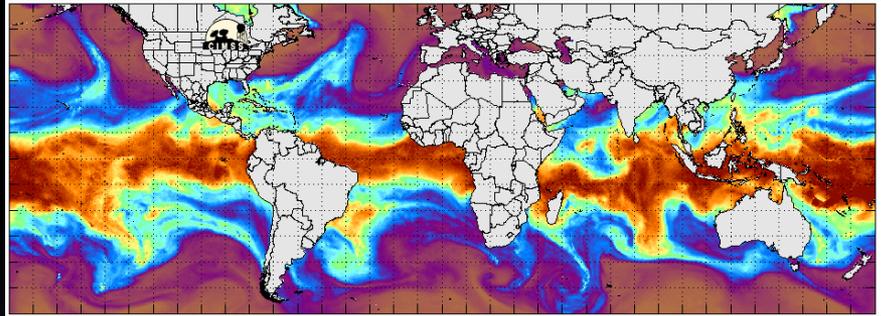
- 2004: CMORPH demonstrates morphed advection on MW precip
- 2007: CIMSS supported by the Office of Naval Research to create real-time morphological composites of TPW from SSMI/S, AMSR sensors (4 conical scanners)
 - Retrieval only over liquid water (not a problem for the Navy!)
- ~2014: DoD indicates end of DMSP (SSMIS) program

- 2015: CIMSS supported by JPSS RR program to switch over to ATMS and AMSU-B/MHS, and improve the algorithm
 - Now uses the MIRS retrieval, which is valid over water, ice and land.
- 2016: Version 2 product goes online

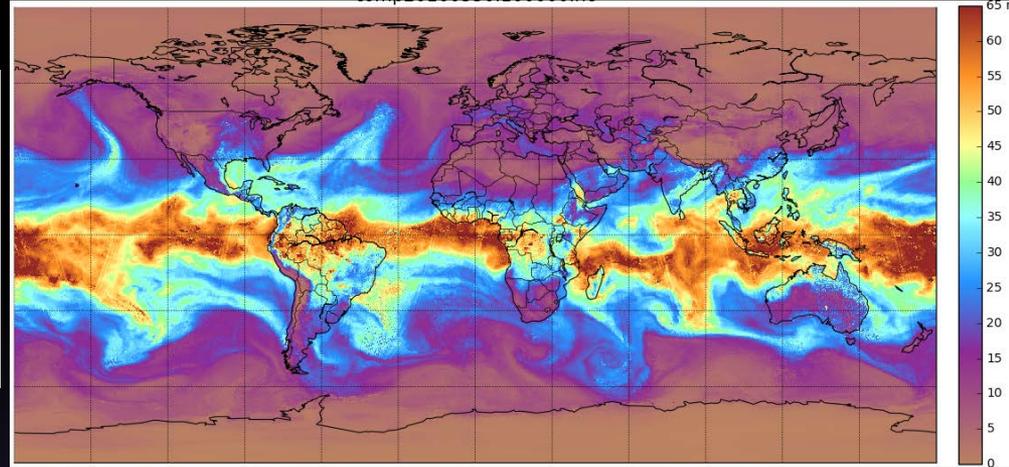


Version 2: 2016-present

Benefits of using MIRS



Version 1: No MIRS

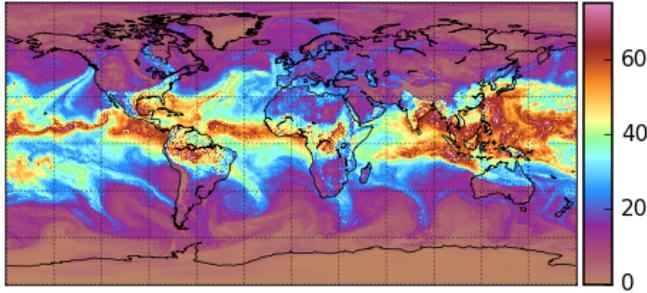


Version 2: Uses MIRS

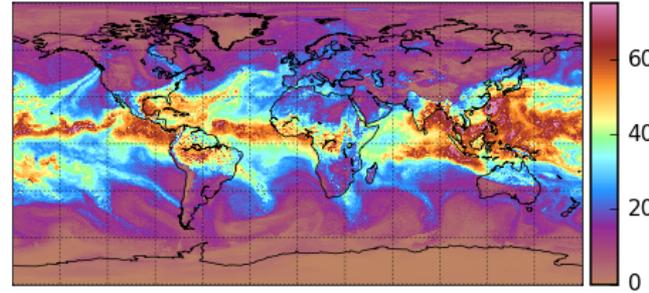
- *Full global coverage* (versus over-water only)
- *Continuity*: We can be sure that this will continue after the DMSP program is over
- *Accuracy*: MIRS is well-validated and actively maintained
- *Big surprise benefit*: Morphed data also works well over land

2016-09-27 0000 UTC

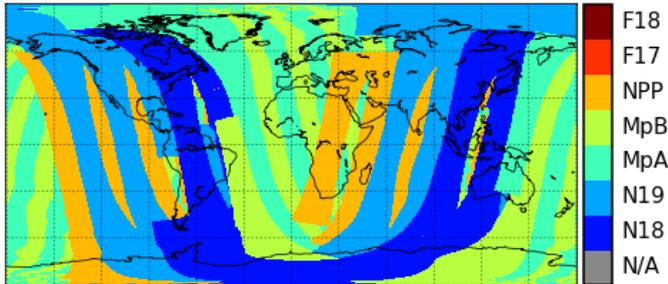
TPW, mm (prior)



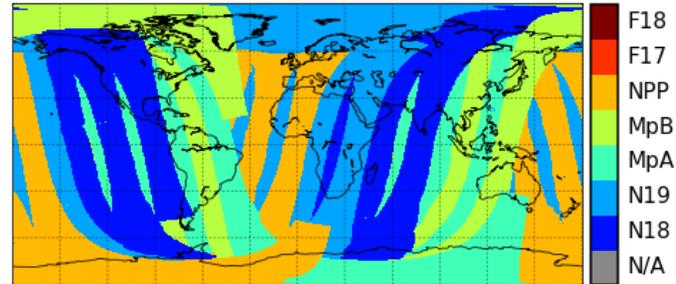
TPW, mm (subsequent)



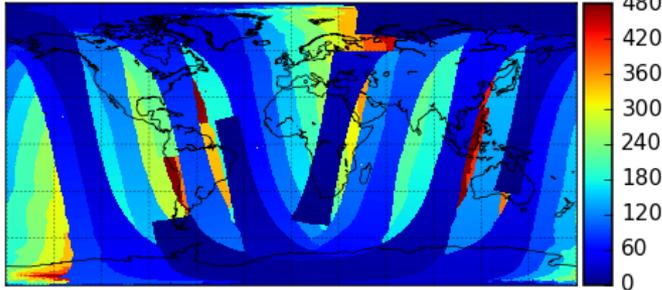
Satellite source (prior)



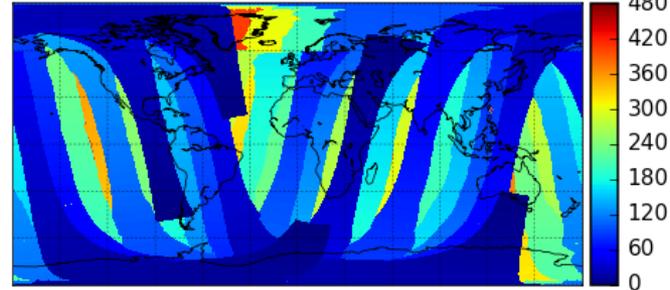
Satellite source (subsequent)



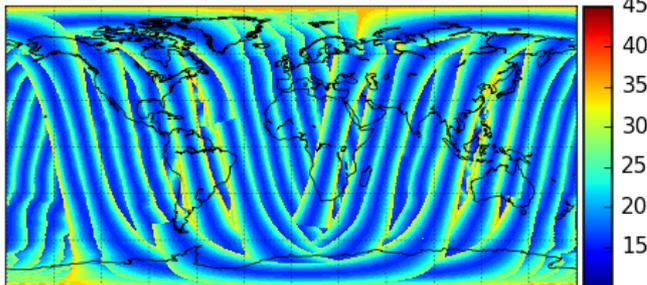
Time away from composite, minutes (prior)



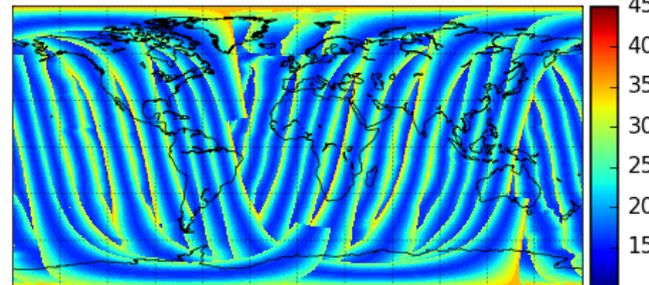
Time away from composite, minutes (subsequent)



Footprint size, km (prior)

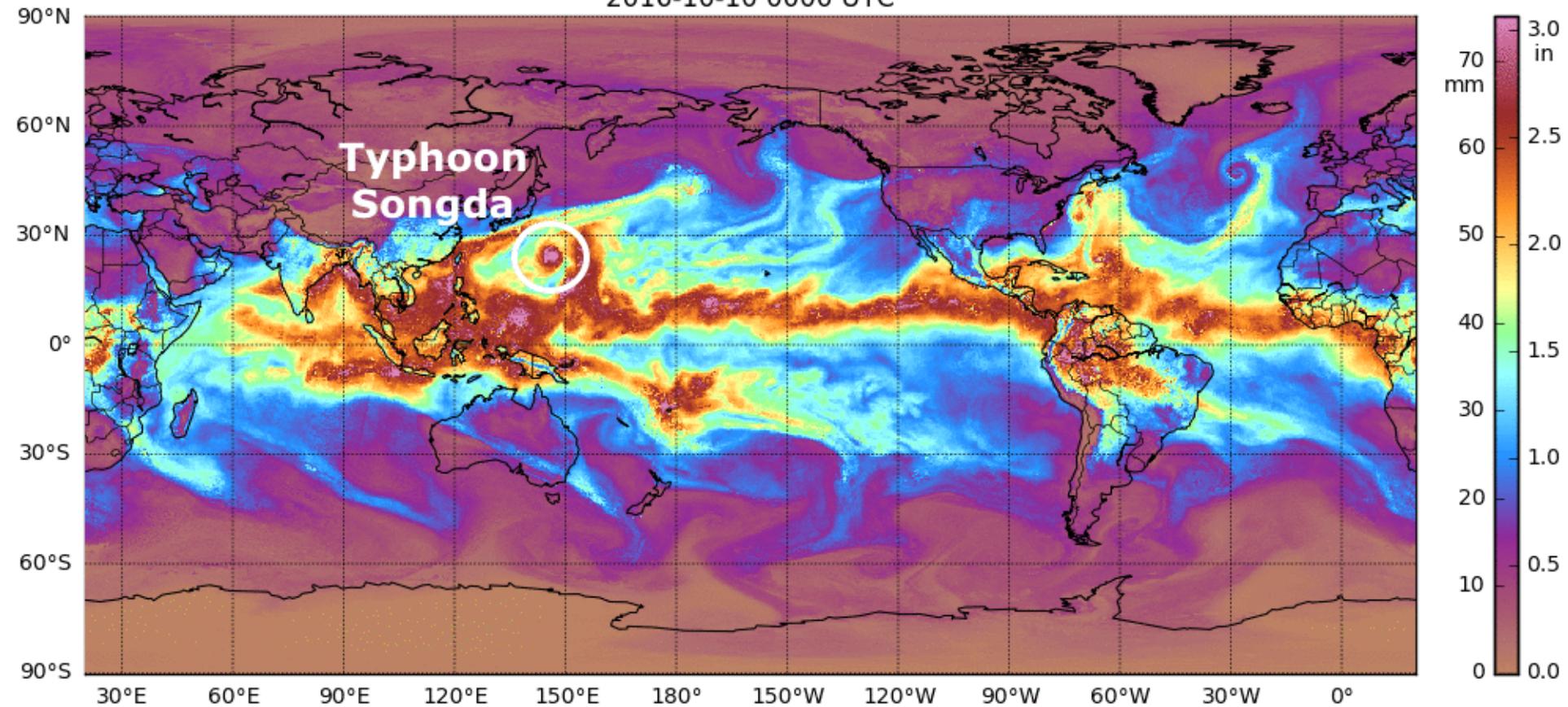


Footprint size, km (subsequent)



MIMIC-TPW: Examples

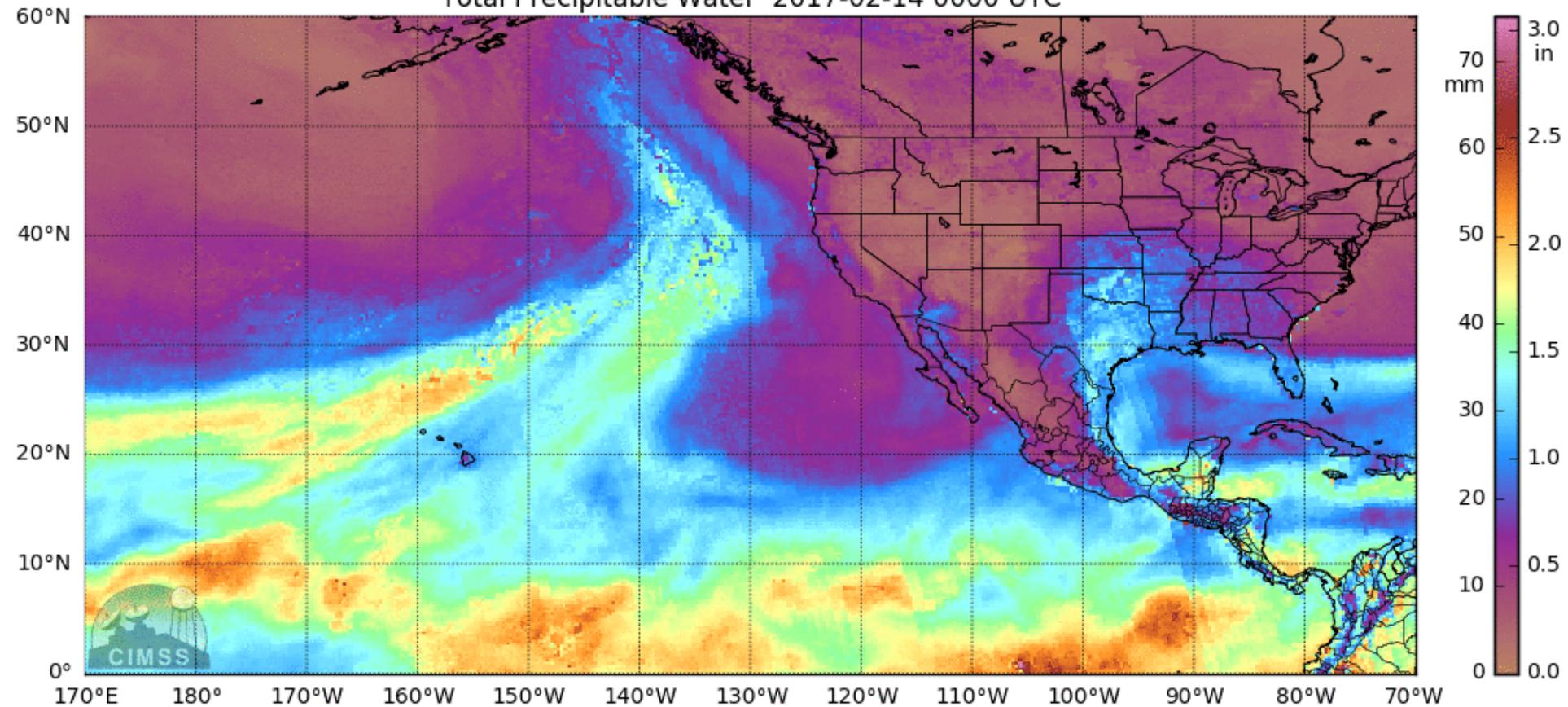
2016-10-10 0000 UTC



- Oct 2016: Remnants of Typhoon Songda hit U.S. west coast

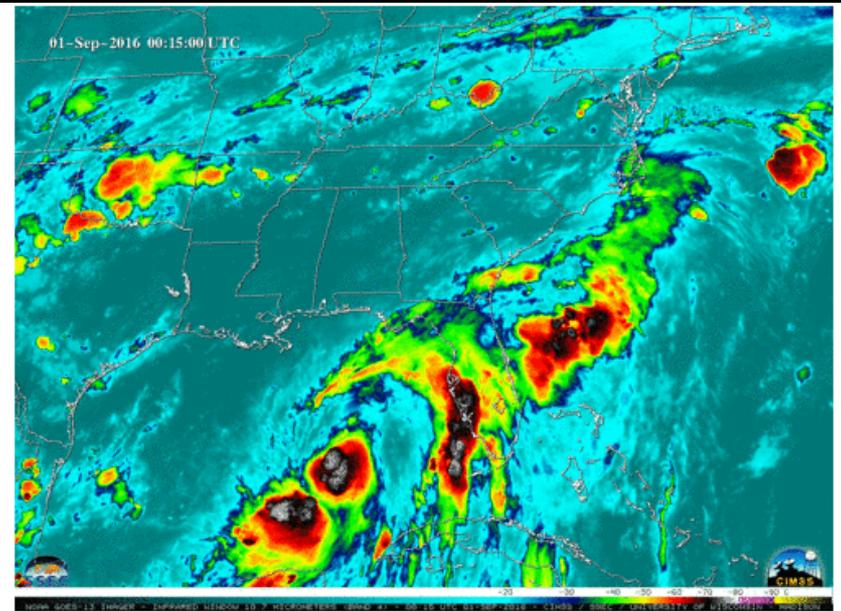
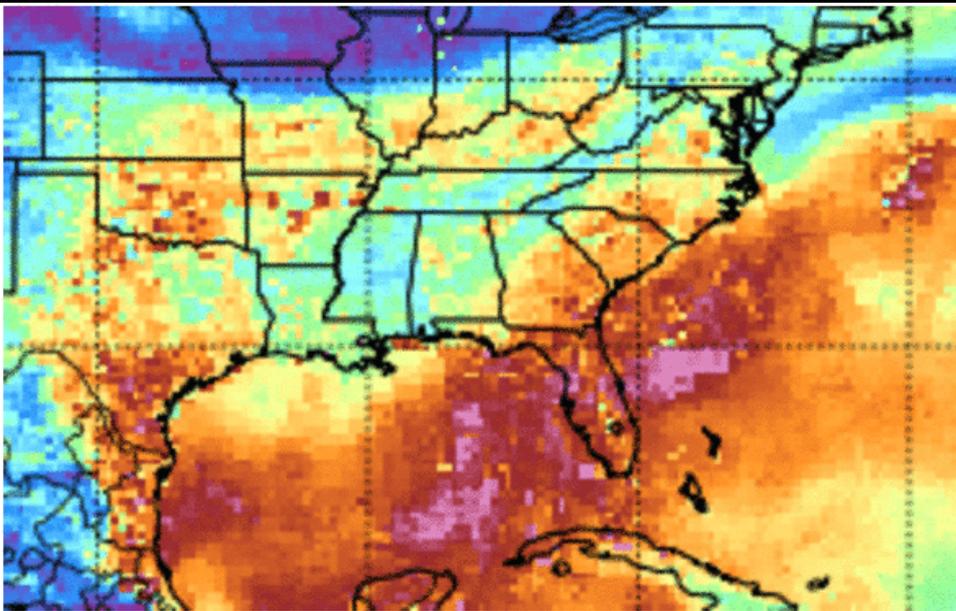
MIMIC-TPW: Examples

Total Precipitable Water 2017-02-14 0000 UTC



- Feb 2017: Atmospheric rivers cause flooding in California, Pacific northwest

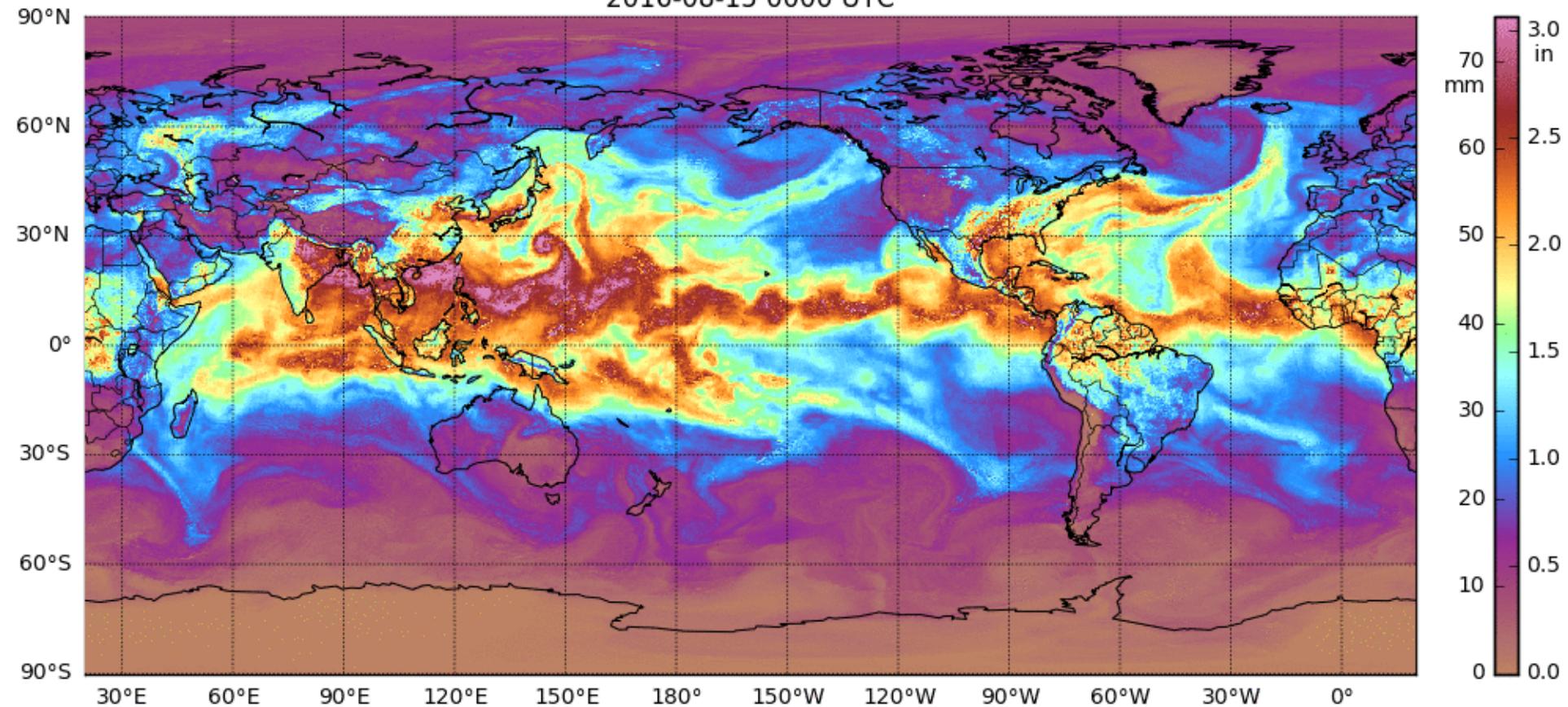
MIMIC-TPW: Examples



- Landfall of TS Hermine (2016)

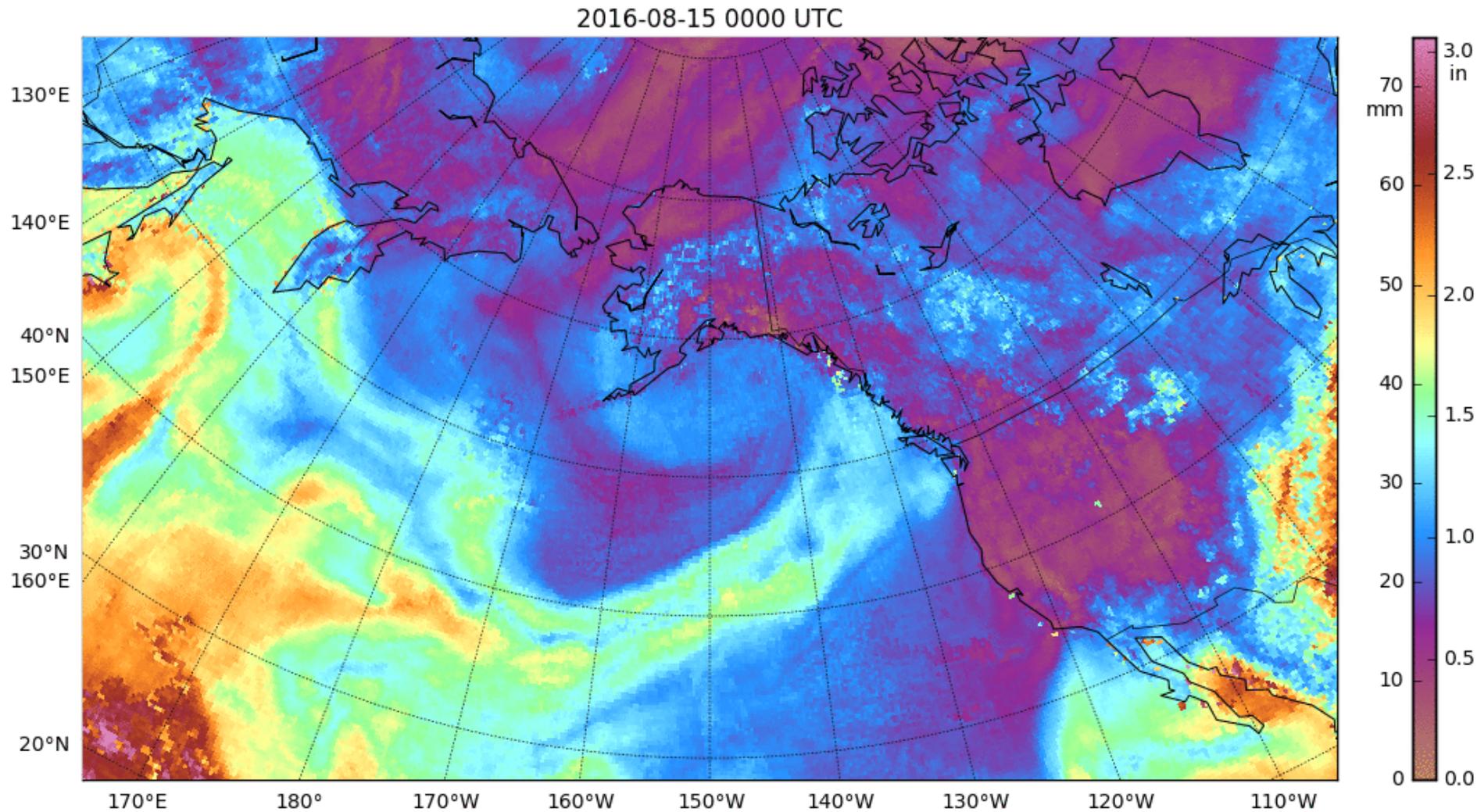
MIMIC-TPW: Examples

2016-08-15 0000 UTC



- Tropical wave development

MIMIC-TPW: Examples



- Tropical moisture hitting Alaska

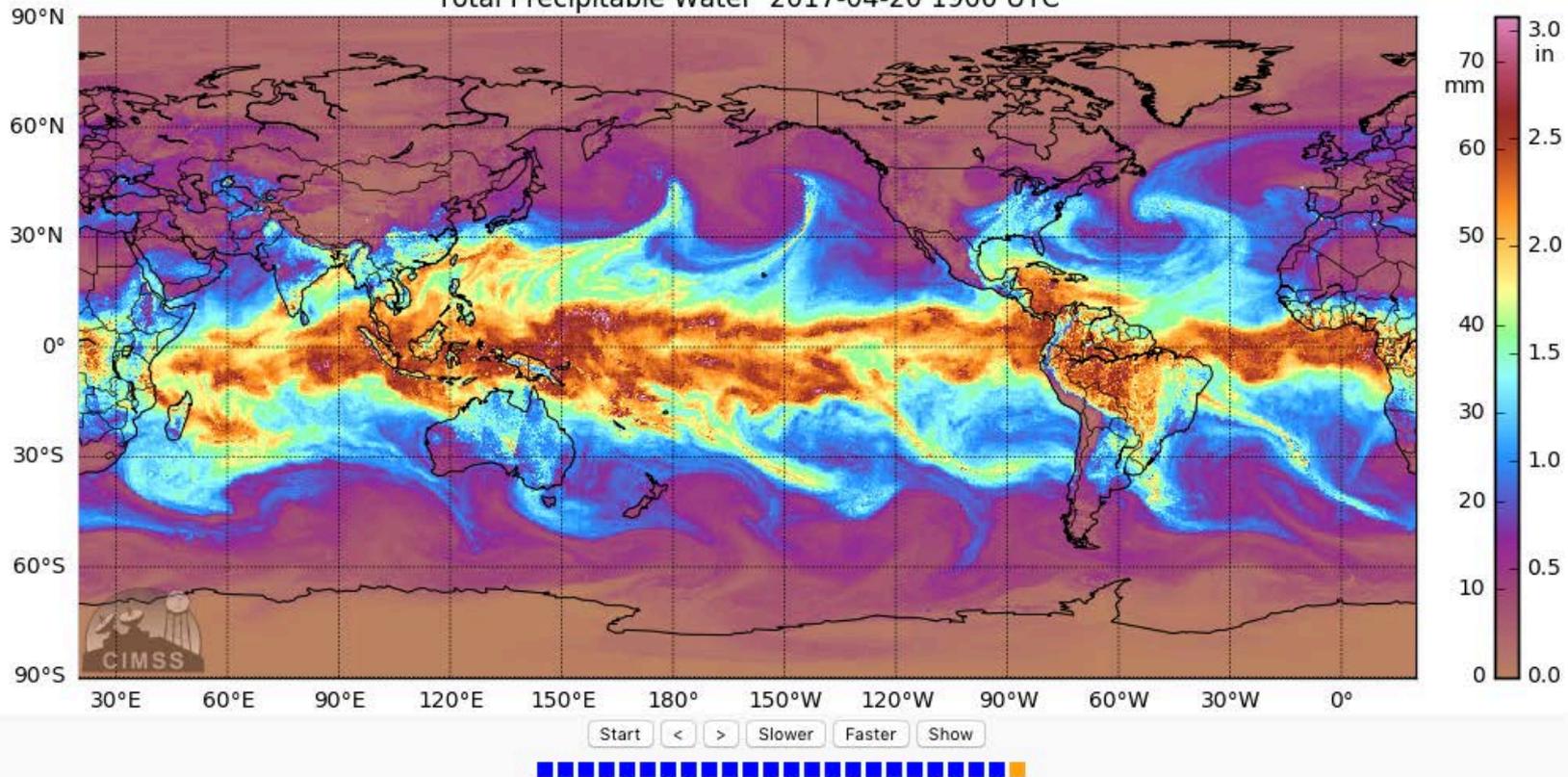
MIMIC-TPW₂: Website

[Real-time](#) [Archive](#) [About](#) [News](#) [Credits](#) [MIMIC-TPW "1"](#)

Real-time Product View

Color Scale ▾ Domain ▾ Timespan ▾ Animation ▾ Page loaded on 2017-Apr-20 20:18:12 UTC

Total Precipitable Water 2017-04-20 1900 UTC

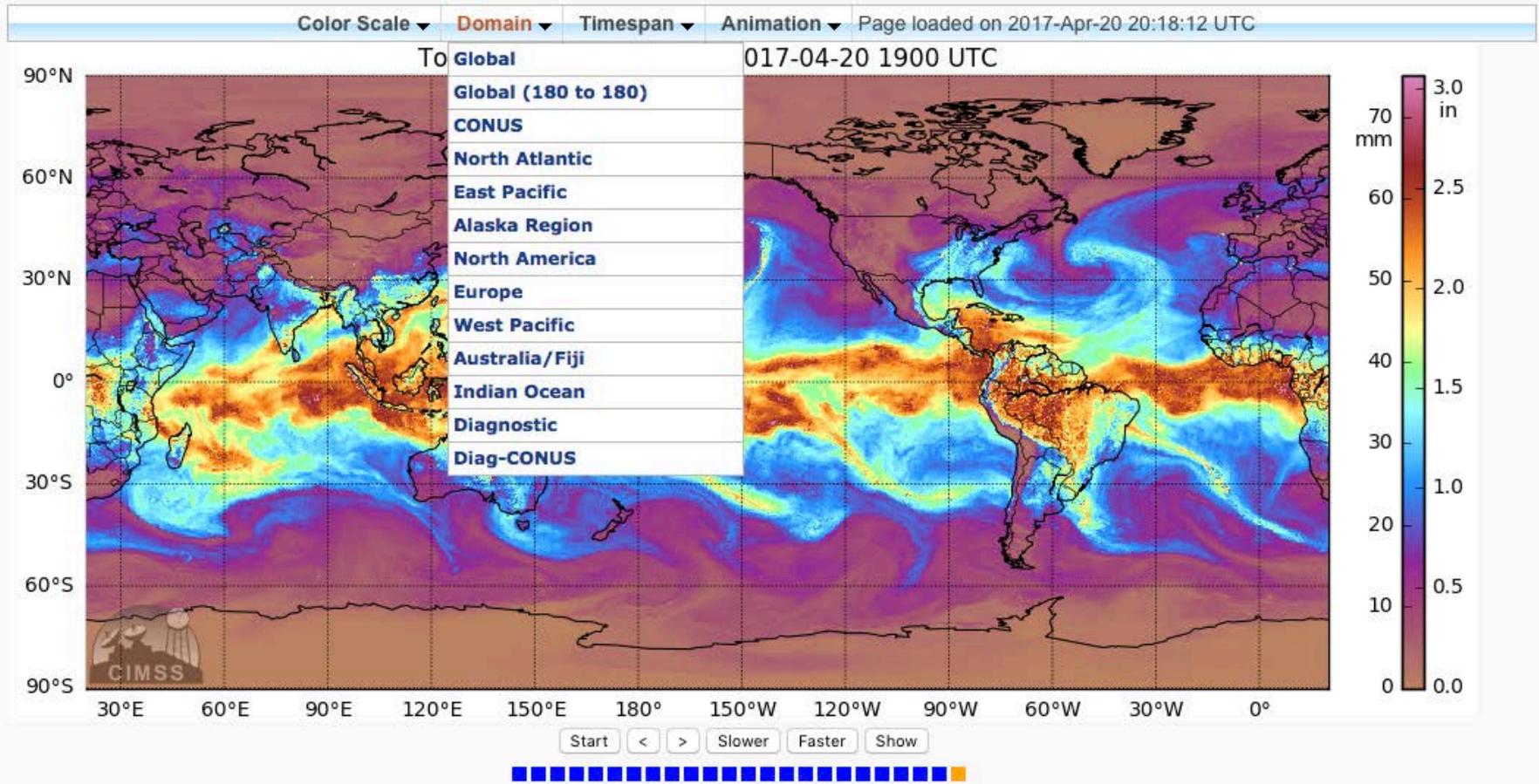


What's
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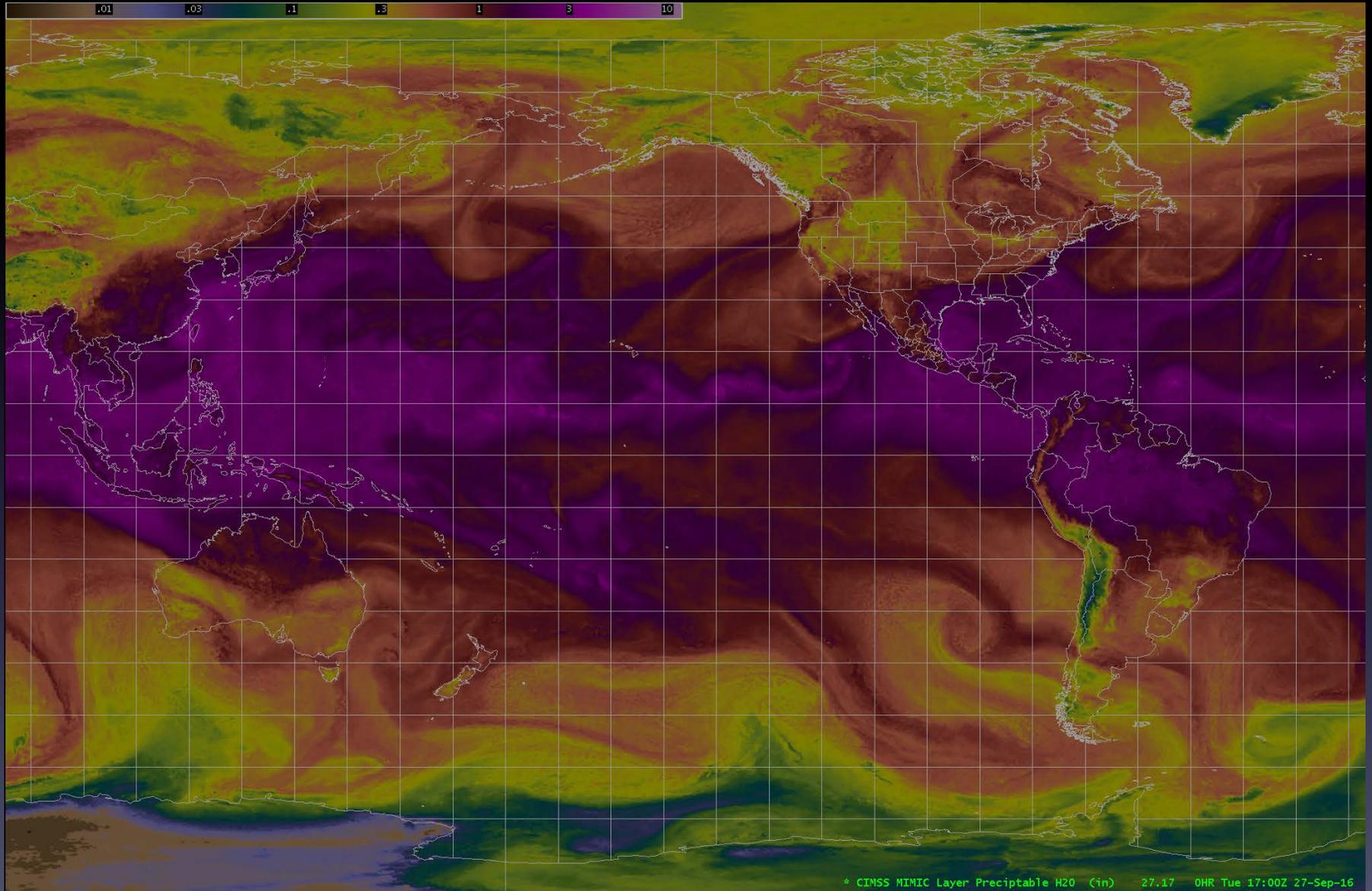
MIMIC-TPW₂: Website

Real-time Archive About News Credits MIMIC-TPW "1"

Real-time Product View

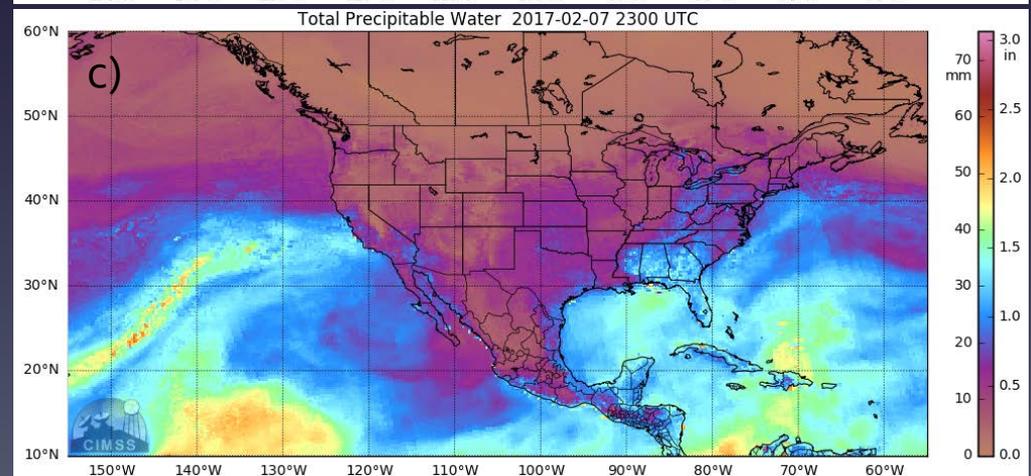
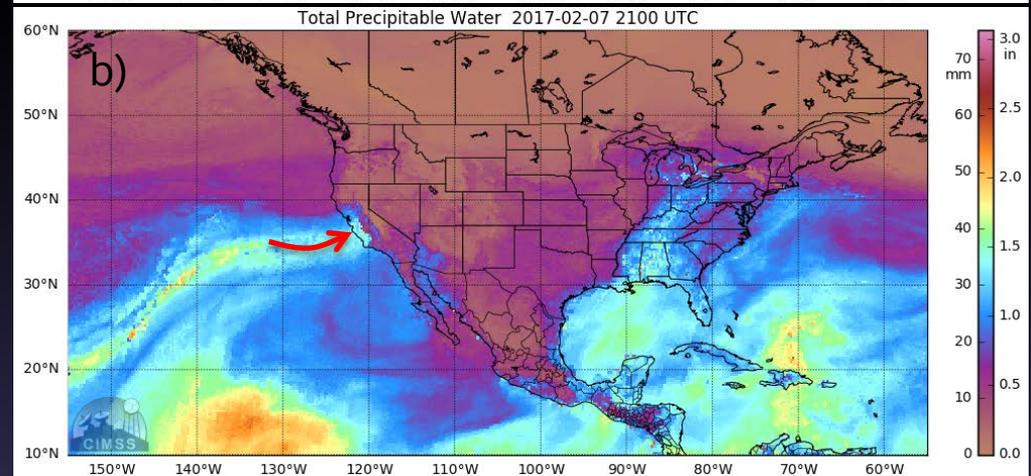
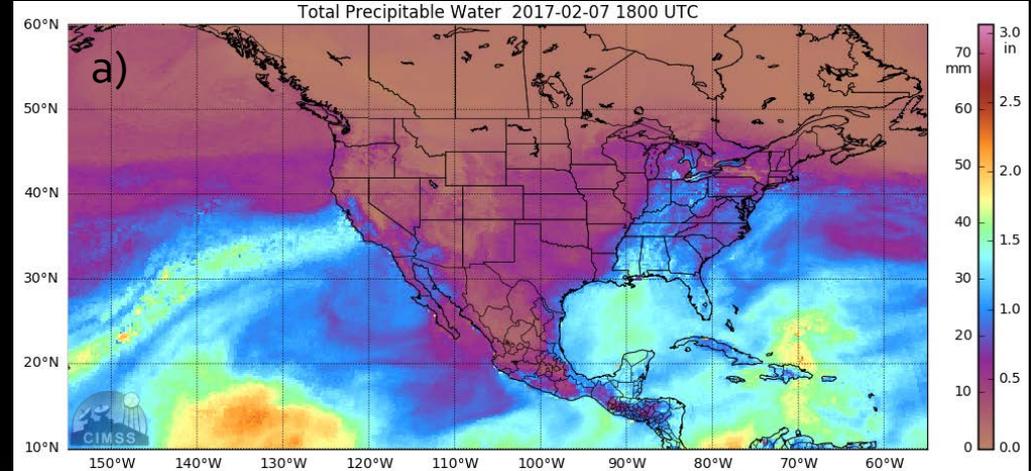


MIMIC-TPW₂: AWIPS



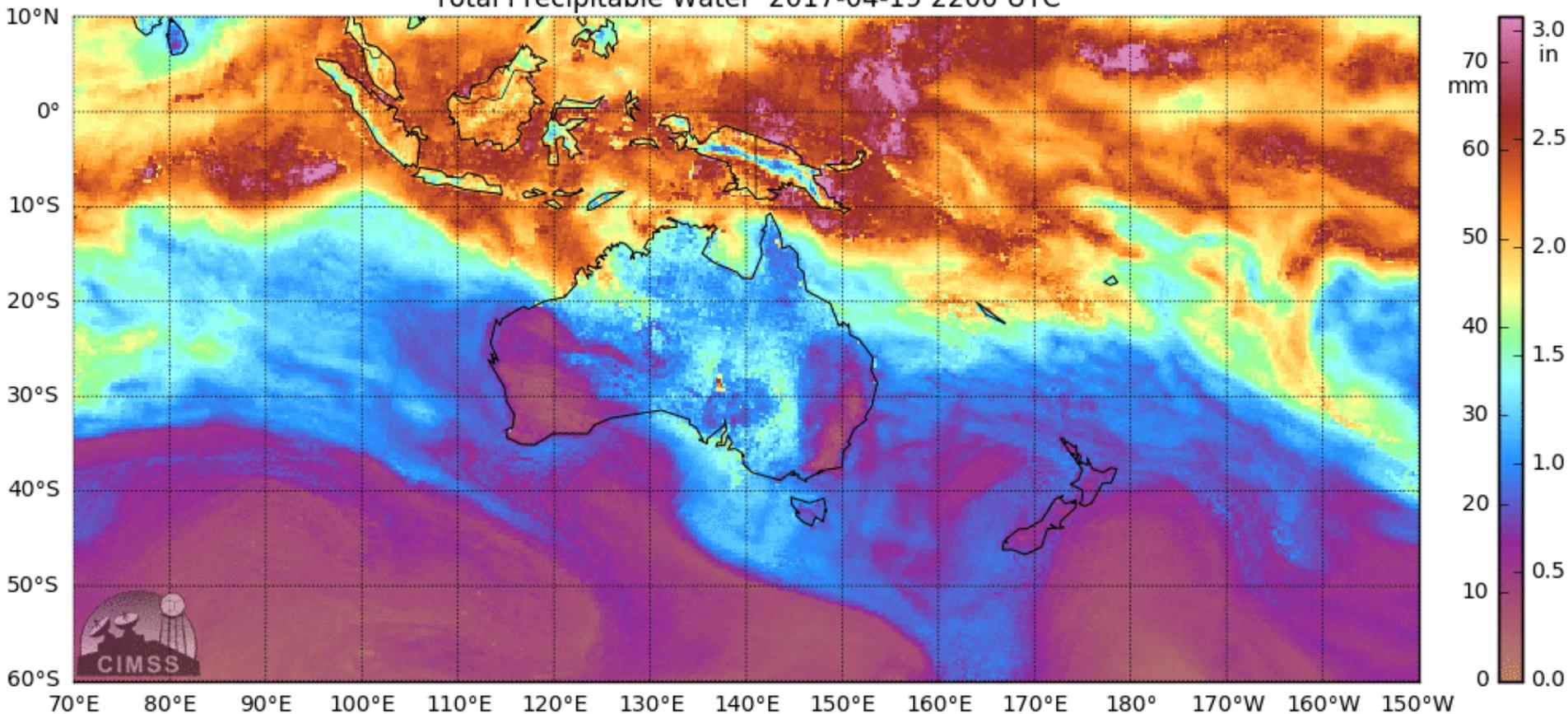
Remaining issue: Advection over land and across coasts

- Simple one-level advection causes moisture to be depicted crossing the coastal boundaries even when it should not (due to trapping from an inversion or other discrepancies).



Remaining issue: Adjusting for AMSU-B

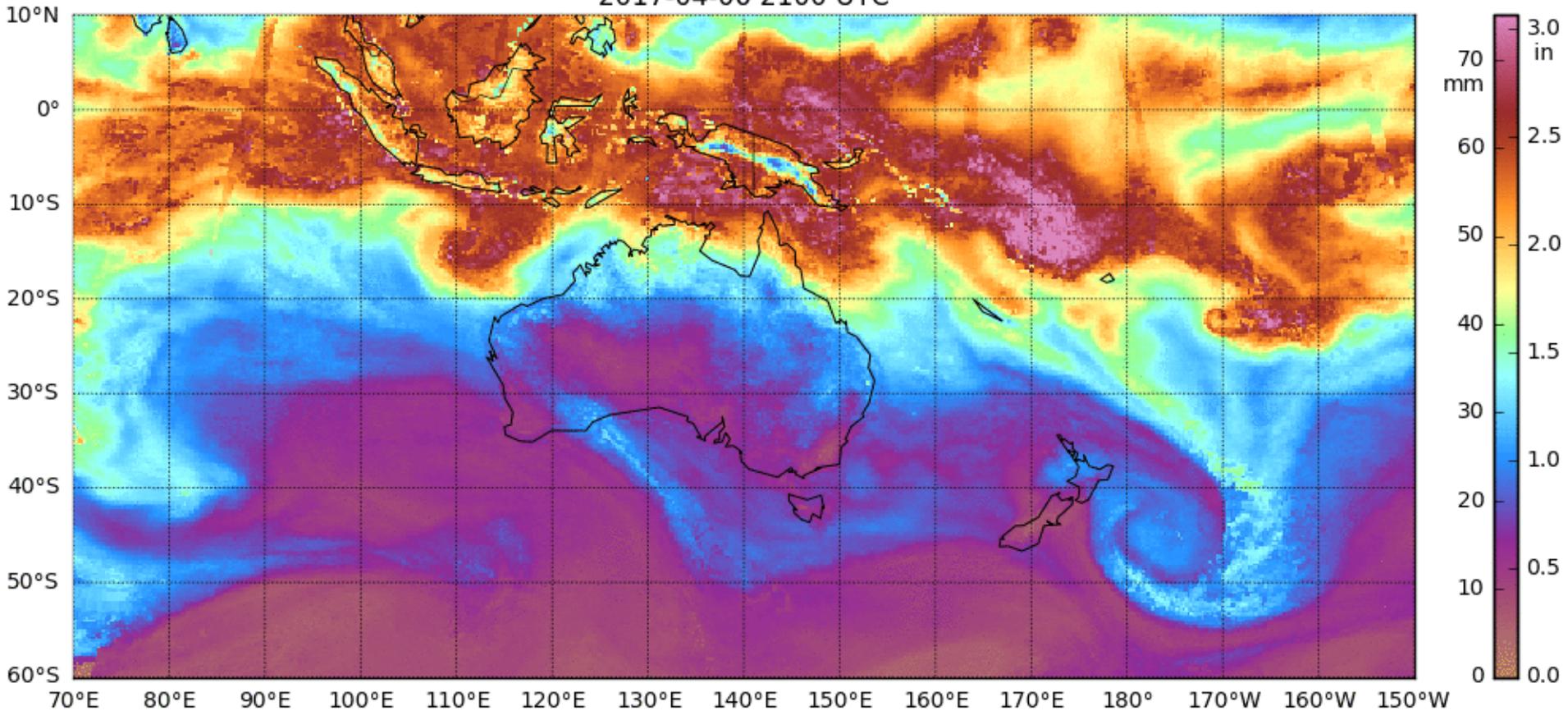
Total Precipitable Water 2017-04-19 2200 UTC



- MIMIC-TPW₂ from all sensors

Remaining issue: Adjusting for AMSU-B

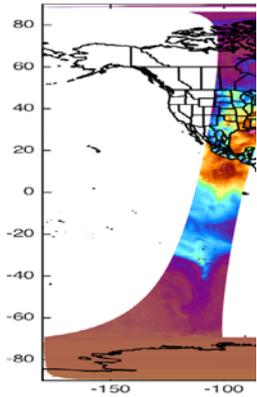
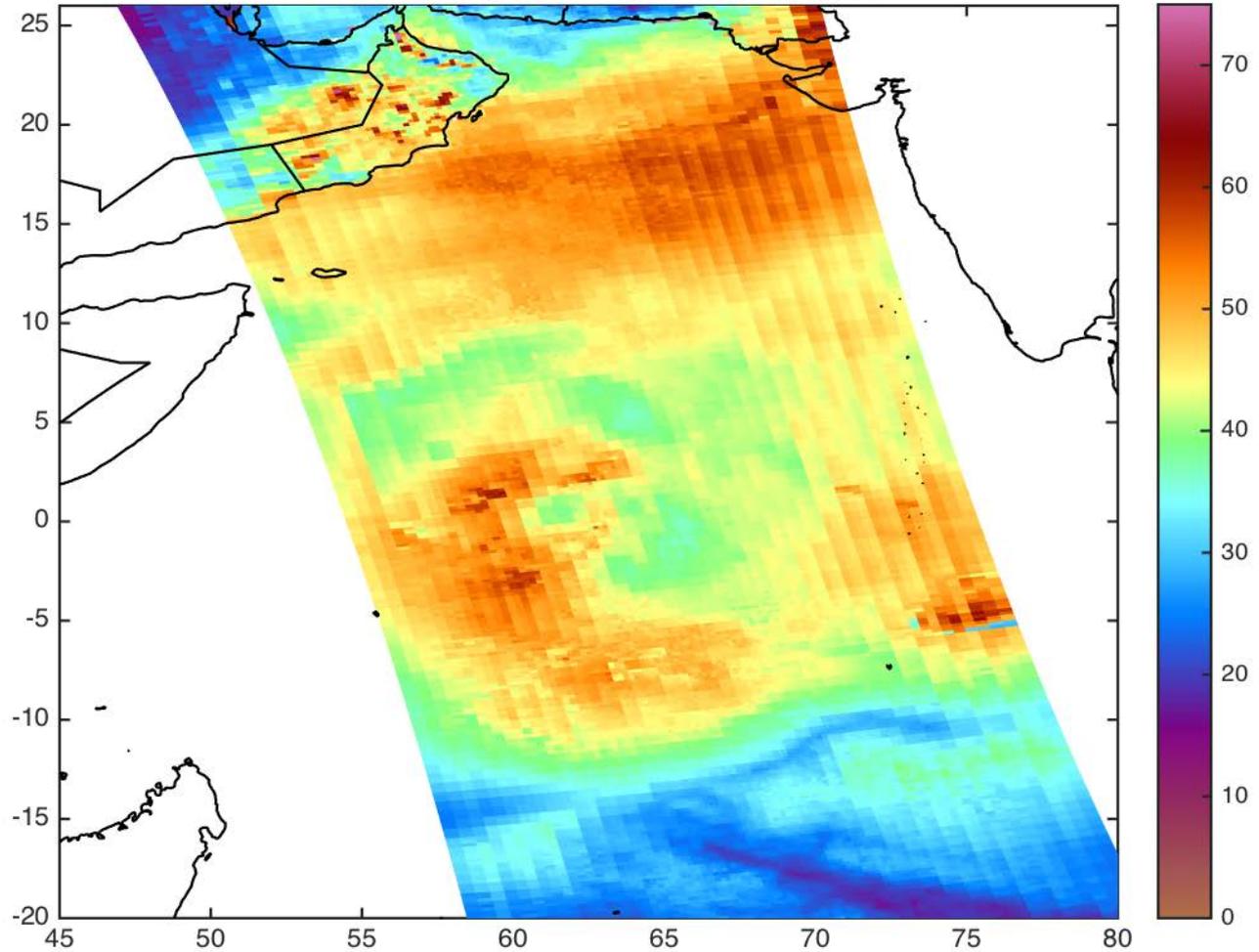
2017-04-06 2100 UTC



- MIMIC-TPW from Suomi ATMS only

Nearly solved issue: MIRS striping

MIRSV11 TPW, NOAA-19, 2016-08-10 09:09



- Original MIRS v11.2 TPW

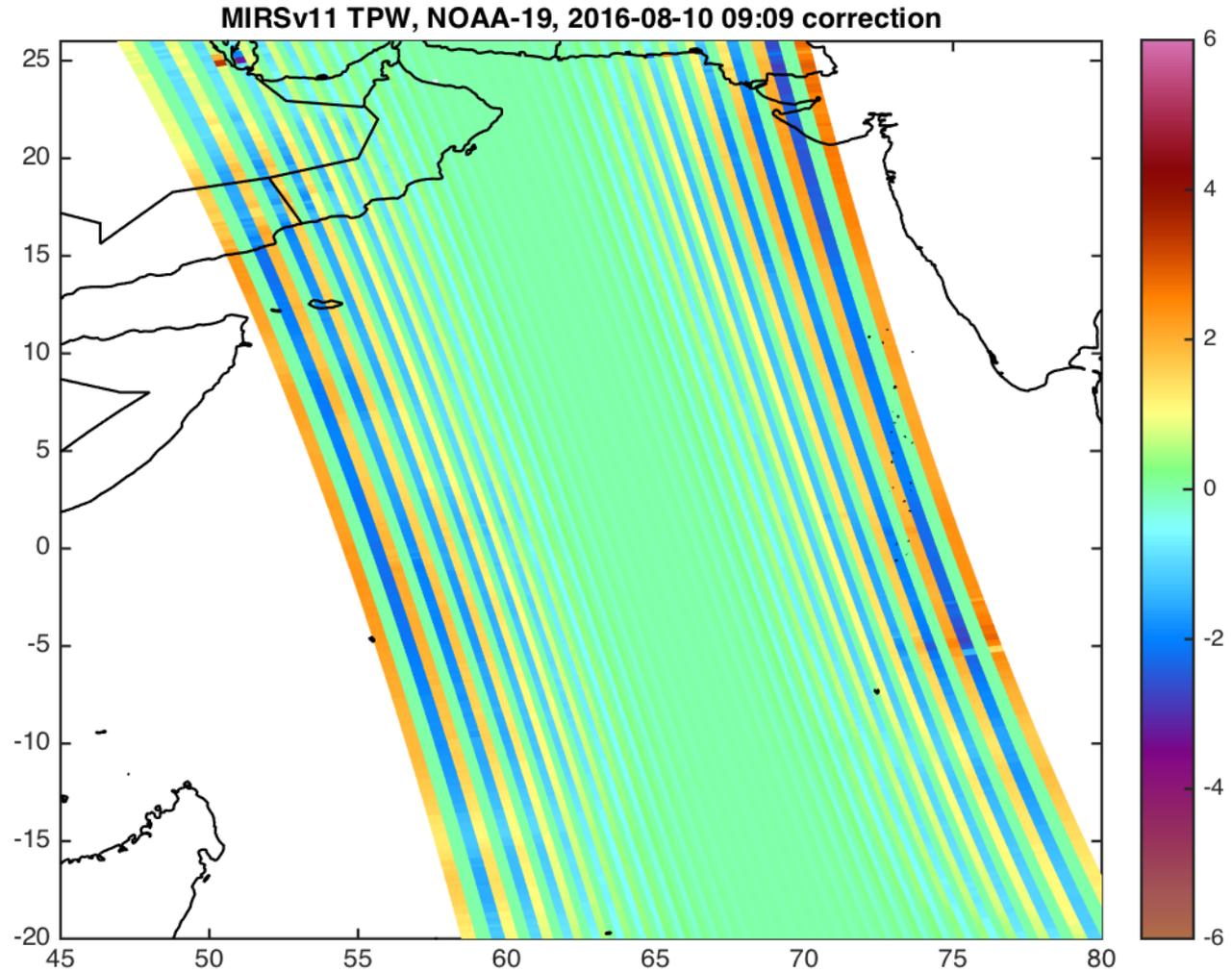
Nearly solved issue: MIRS striping

θ_{i-1} θ_i θ_{i+1}



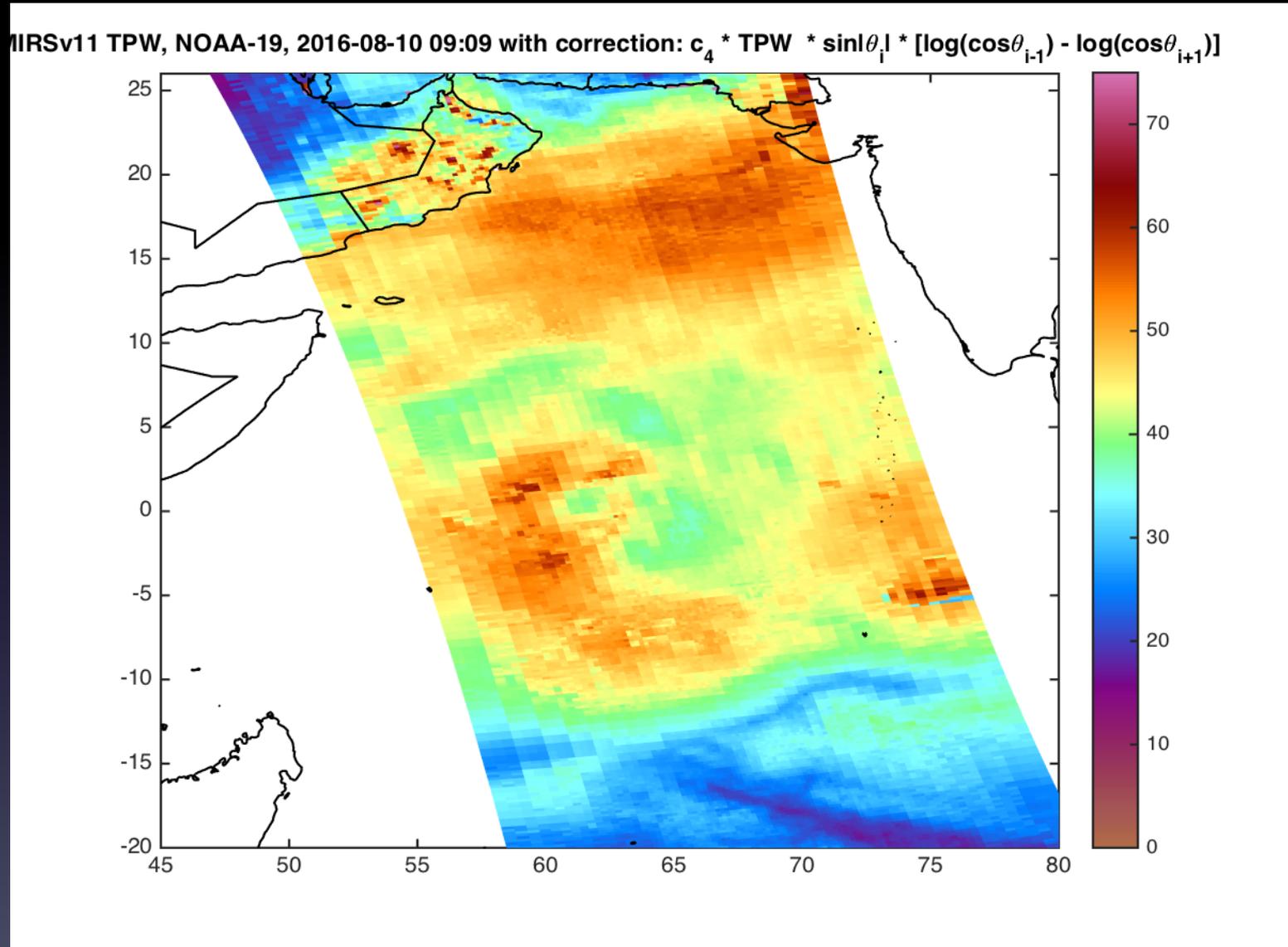
(MHS)

(AMSU-B)



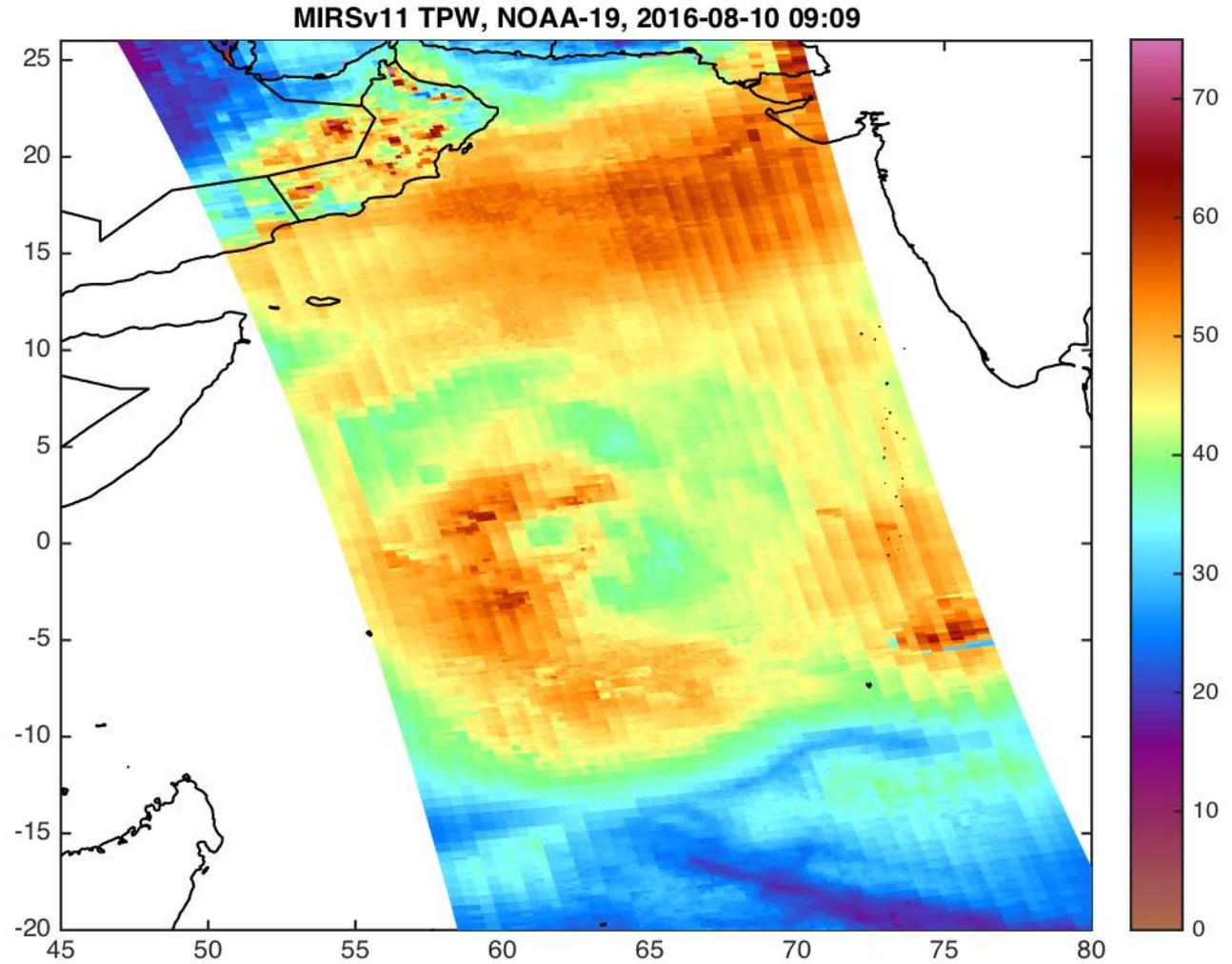
- Correction: $c * TPW * \sin |\theta_i| * [\log (\cos \theta_{i-1}) - \log (\cos \theta_{i+1})]$

Nearly solved issue: MIRS striping



- TPW with correction

Nearly solved issue: MIRS striping



- TPW without correction

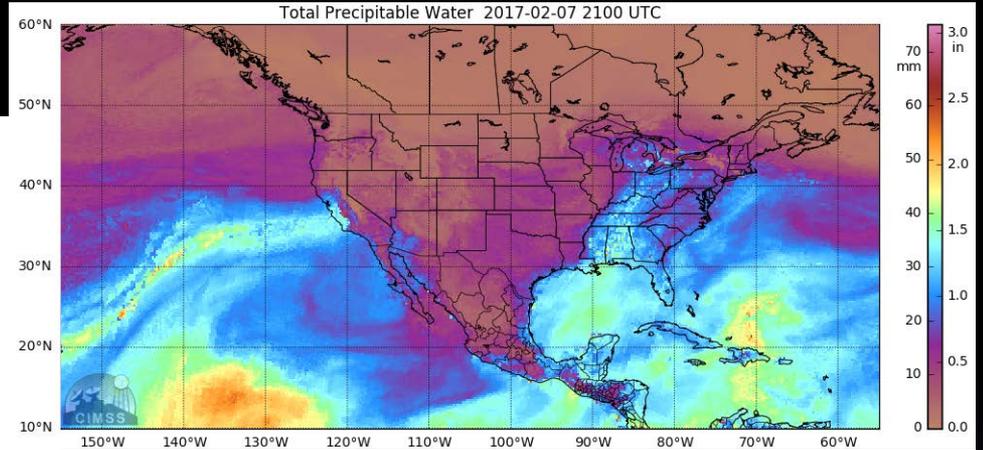
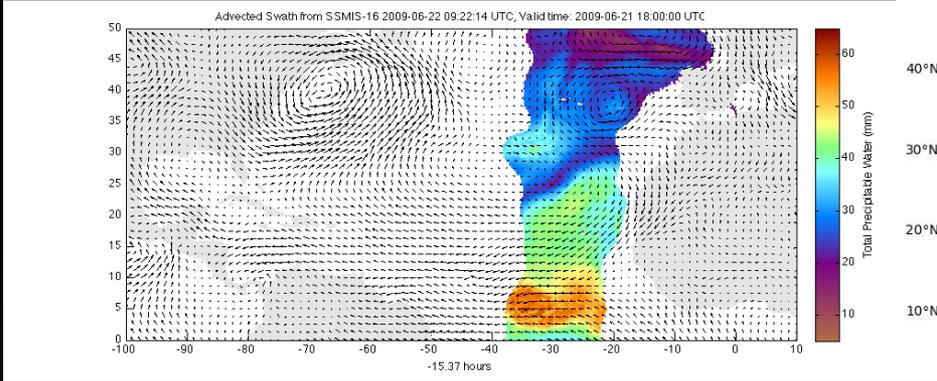
Final Remarks

General benefits of morphological compositing of MIRS retrievals

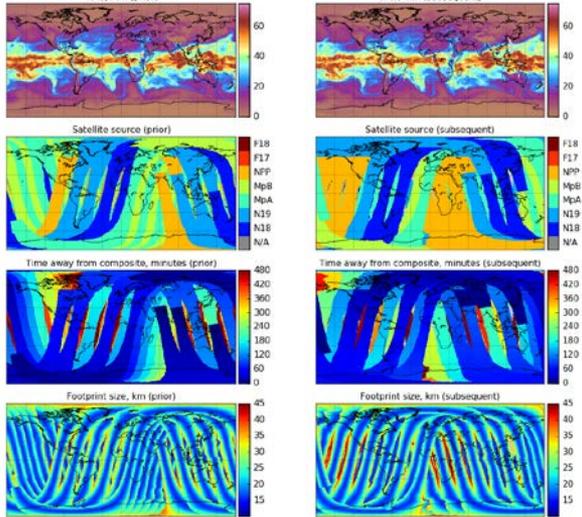
- Use polar orbiters like geo
- Increase the temporal resolution of satellite products
 - Regular time-stepping
 - Better matching with in-situ data
 - Improve satellite temporal interpolation
 - **Natural, fluid motion matches with users' intuition**

Lessons Learned

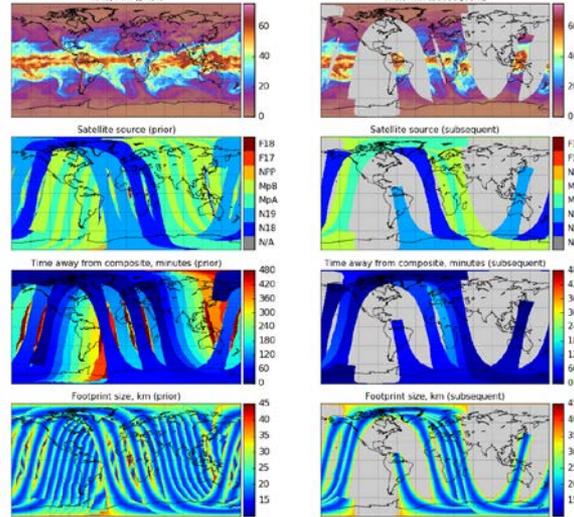
- Morphological compositing is successful where the tracer lifetime exceeds the sampling rate. Integrated Water Vapor is nearly ideal for this.
- Accuracy:
 - 1-2mm error (negligible)
 - Also accurate in more subjective ways, such as temporal continuity
- The biggest obstacles for general use are the new requirements for incorporation into AWIPS



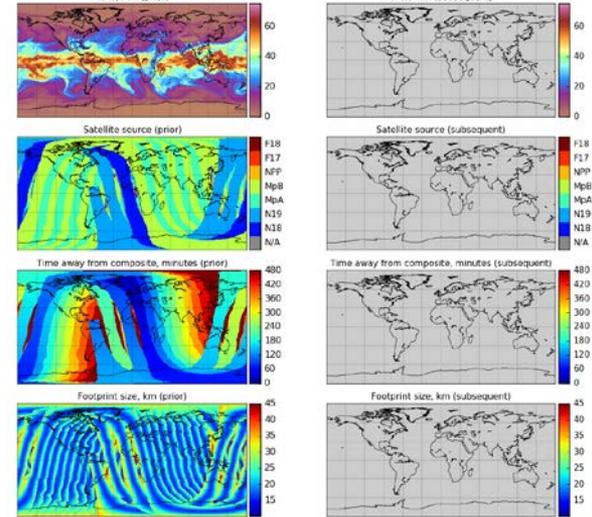
2017-04-13 0900 UTC



2017-04-13 1800 UTC



2017-04-13 2100 UTC

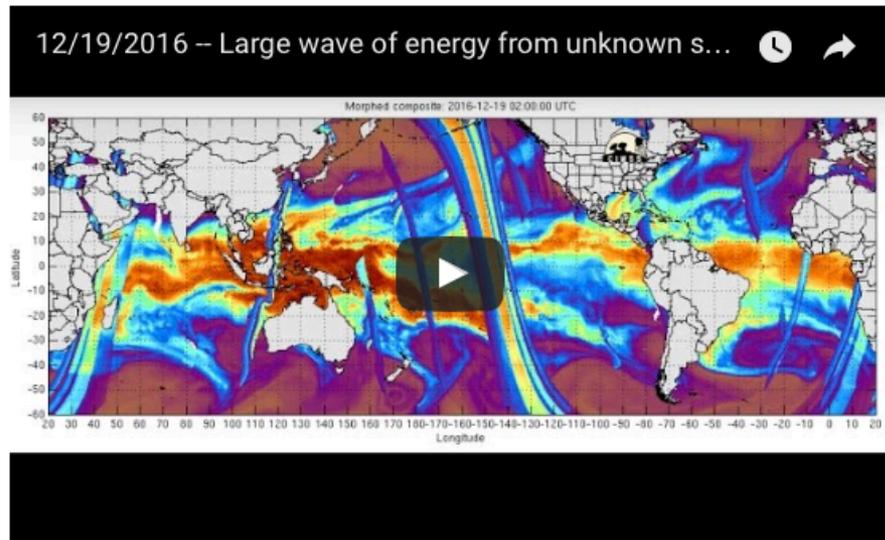


Extras

Required adapt

Dutchsinse 12-19-16... "Large wave of energy from unknown source hitting Earth now – Possible effects?"

Posted on [2016/12/22](#)



<https://youtu.be/fCyLWFZoAIE>

[Kp update: I've downloaded the gif from 12-19-16 that Dutchsinse talks about. [Click here](#) to view or download.]

This has been flying around and a few have contacted about it, but finally I had chance to view it... and I've never heard Dutchsinse so astounded by something. Anyway, to me it definitely indicates something major (huge) going on energetically.

Published on Dec 18, 2016 (December 18th into 19th, 2016)

Update : 457pm Dec 19, 2016 – MIMIC has issued a statement via twitter saying this is a mistake, an error in their system... hmm..

A large wave of energy impacting the entire planet has UNINTENTIONALLY been detected by the MIMIC TPW microwave background imagery. Currently ONGOING as of 12/19/2016 at 1:20am US central time)

But some people may never understand how to read it...

Points to argue over

- We can do better than standard composites of polar orbiter data
- Imagery is much more popular if it fits into the viewer's intuition
- The weather community's software and forecasting systems are poor at accommodating polar-orbiter products that fit with intuition
- Error has more than one dimension

MIMIC-TPW₂: Upgrades

Software:

- Version 1:
 - Matlab code (requires license, not supported in NOAA operations.)
 - Runs on a desktop server
- Version 2:
 - Python code, using standard libraries (portable, supported)
 - Runs on a cluster system at CIMSS (can live forever)
 - Outputs netCDF data, .png images and anim'd gifs
 - 10x faster

Questions

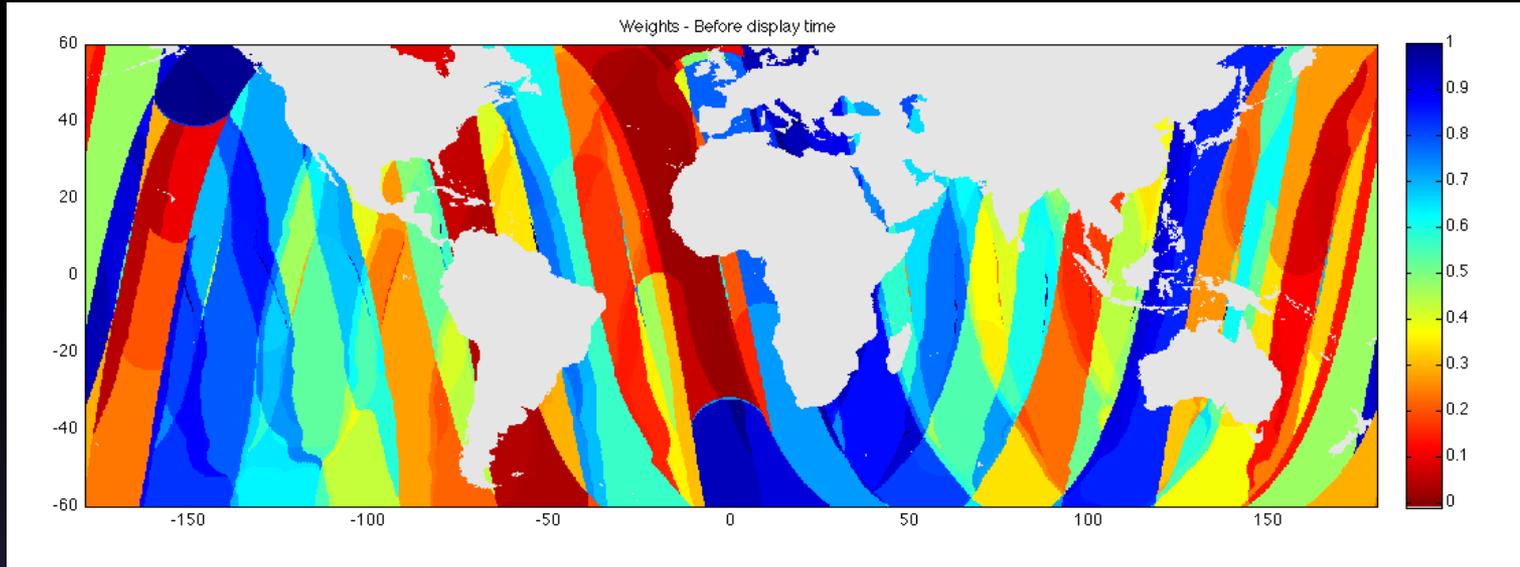
1. Is morphing just about making pretty pictures?
 - No, it really does correct our bad habits of how we look at satellite imagery.
2. Is this just a stopgap until we have better satellites and models?
 - No, because there will always be temporal and spatial scales to exploit.
3. Is this actually science?
 - Not sure!

Required adaptations (esp. from NOAA)

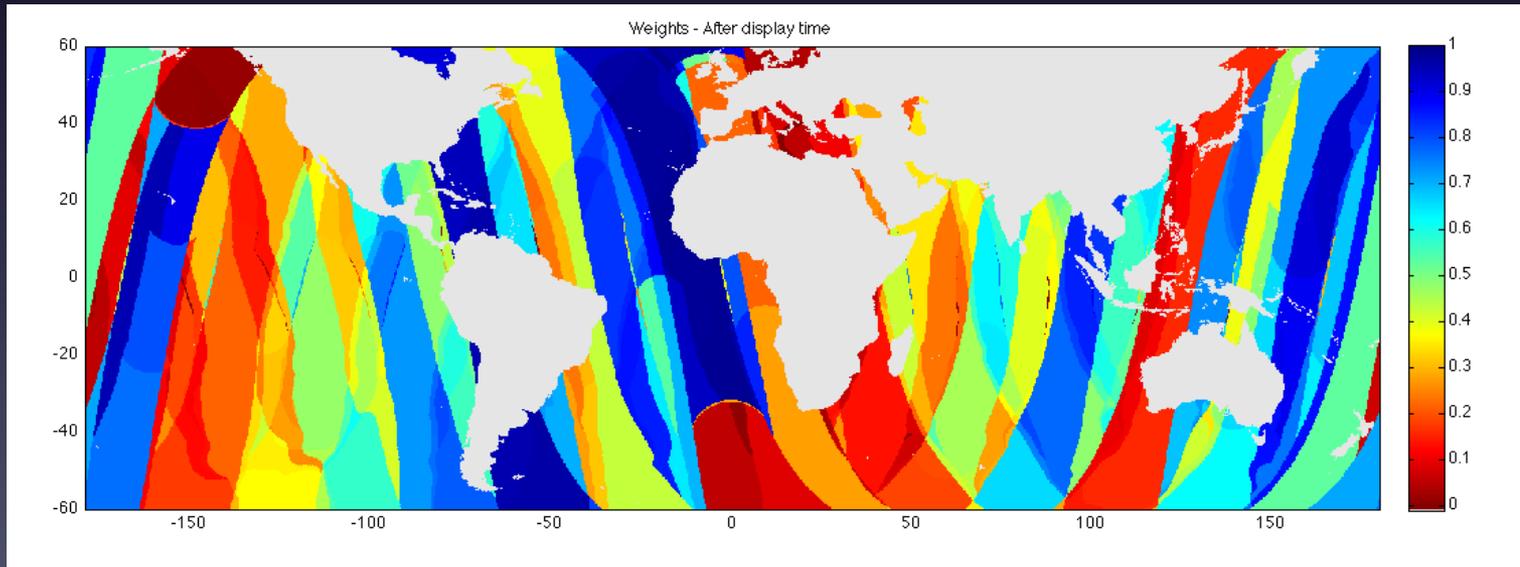
- * We need a new file updating system on AWIPS2 that allows overwriting image sets
 - Do not just keep the first image you find!
- We need increased user awareness of the particulars of morphed compositing
 - 1) Understanding the difference between displacement error and other forms of error
 - 2) Recognizing new kinds of artifacts in morphed composites
 - 3) Using the diagnostic images to immediately recognize (1) and (2)

Compute prior/subsequent weights proportional to dt:
 $w(\text{prior}) = dt(\text{subsequent}) / [dt(\text{prior}) + dt(\text{subsequent})]$

w(prior)



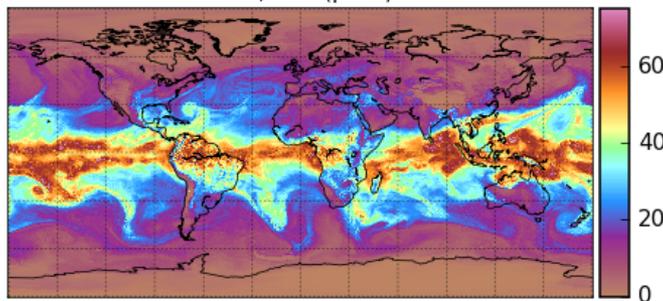
w(subseq.)



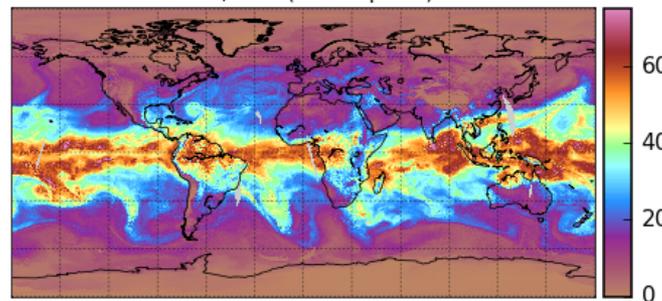
Valid time: 2009/06/22 1800 UTC

2017-04-13 0900 UTC

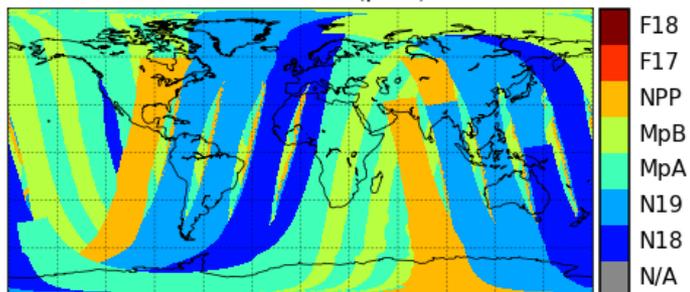
TPW, mm (prior)



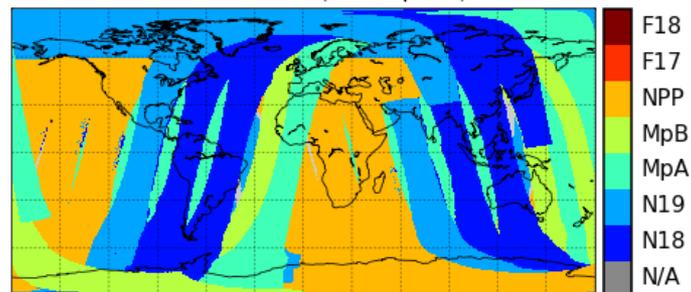
TPW, mm (subsequent)



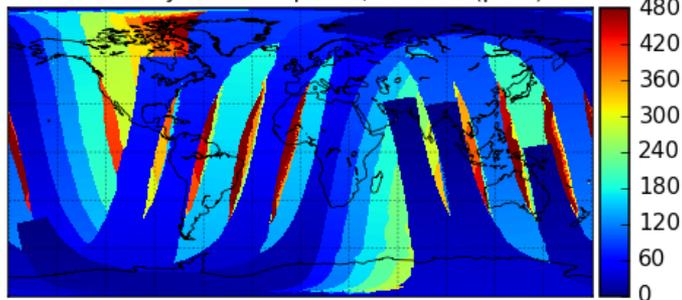
Satellite source (prior)



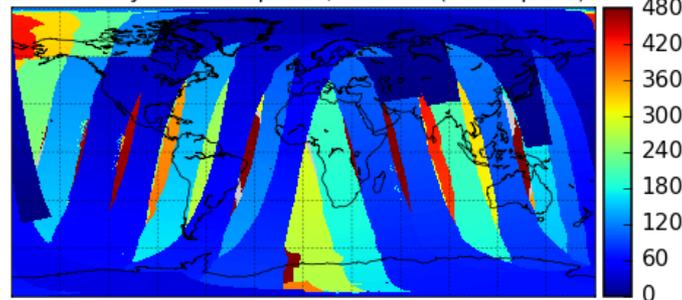
Satellite source (subsequent)



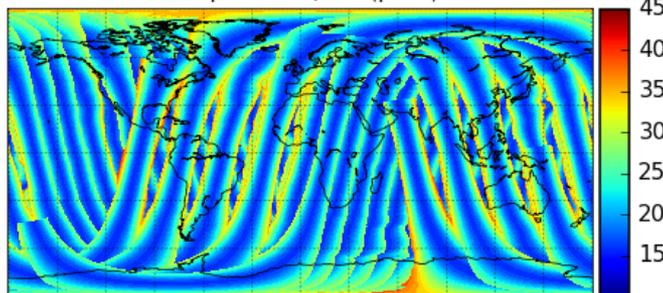
Time away from composite, minutes (prior)



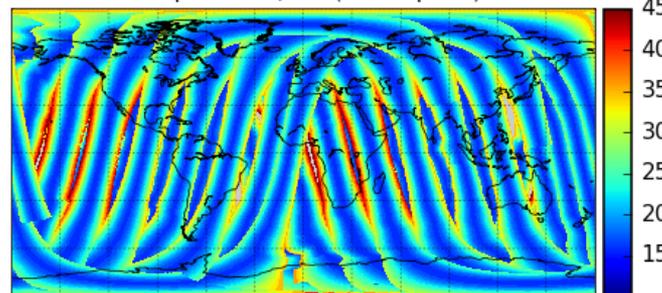
Time away from composite, minutes (subsequent)



Footprint size, km (prior)

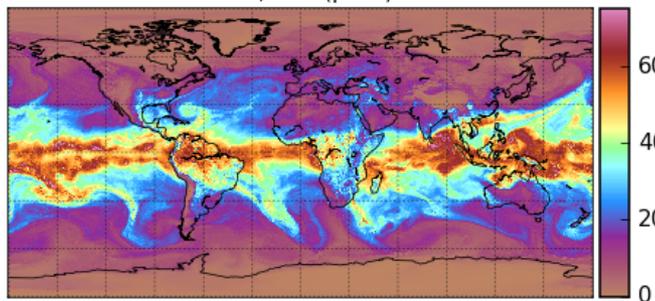


Footprint size, km (subsequent)

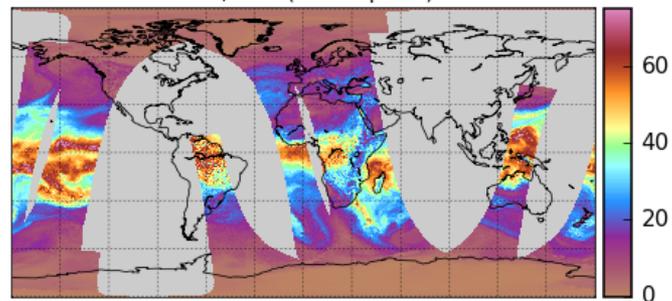


2017-04-13 1800 UTC

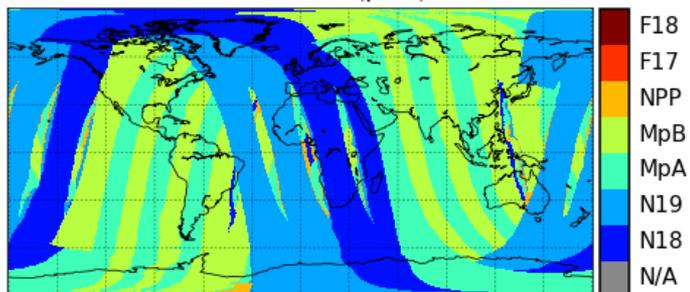
TPW, mm (prior)



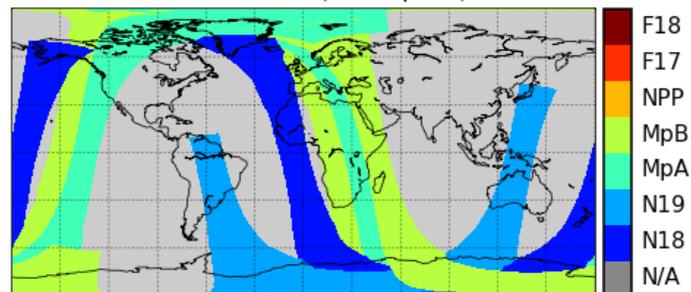
TPW, mm (subsequent)



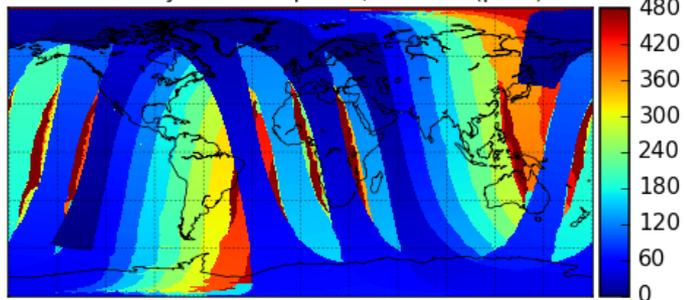
Satellite source (prior)



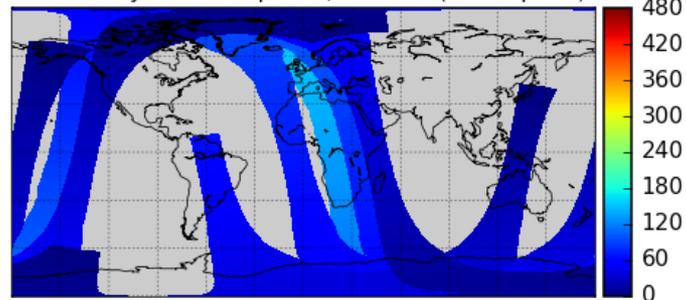
Satellite source (subsequent)



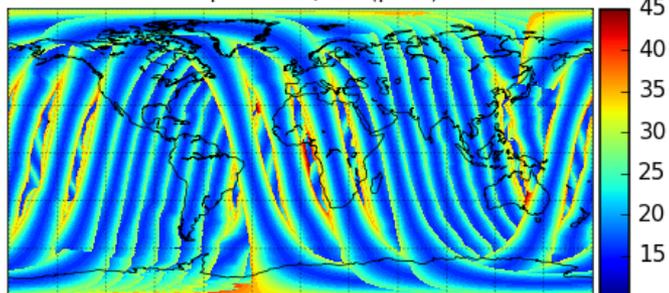
Time away from composite, minutes (prior)



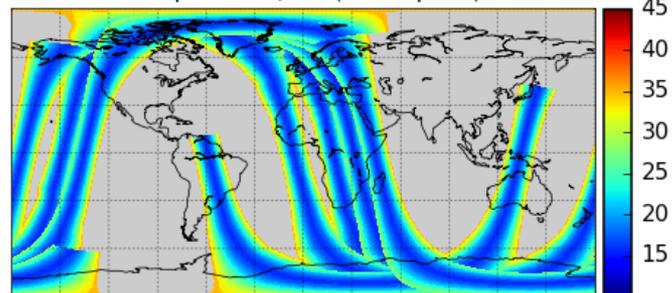
Time away from composite, minutes (subsequent)



Footprint size, km (prior)

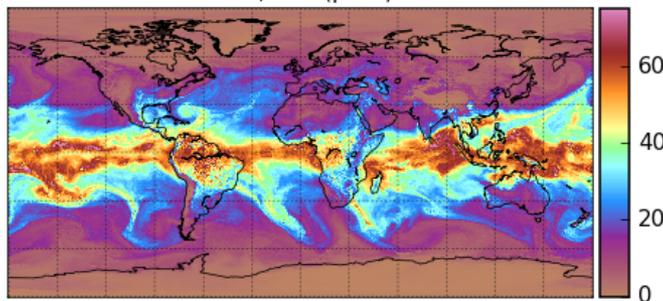


Footprint size, km (subsequent)

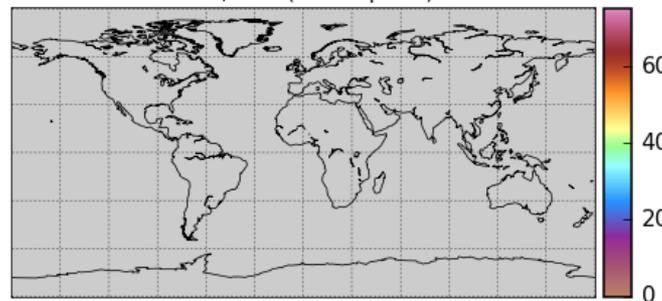


2017-04-13 2100 UTC

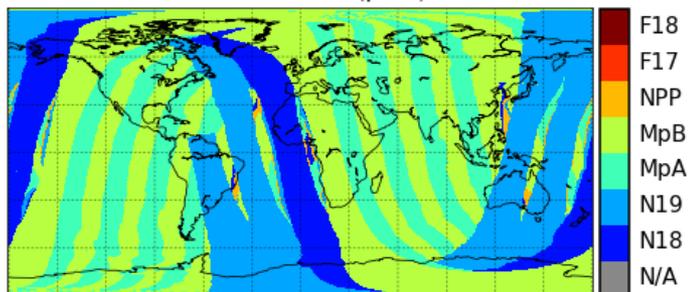
TPW, mm (prior)



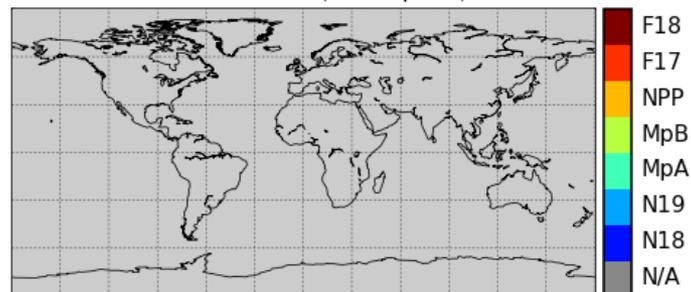
TPW, mm (subsequent)



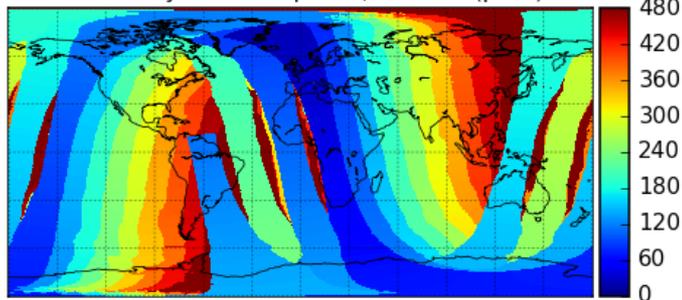
Satellite source (prior)



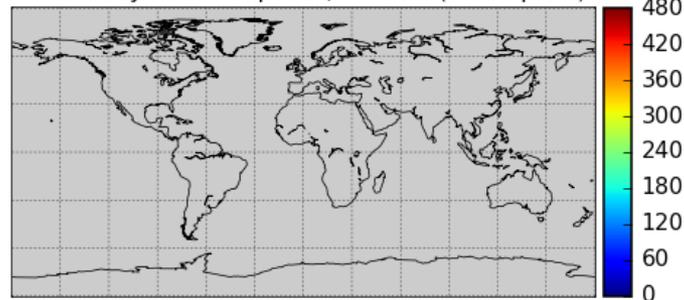
Satellite source (subsequent)



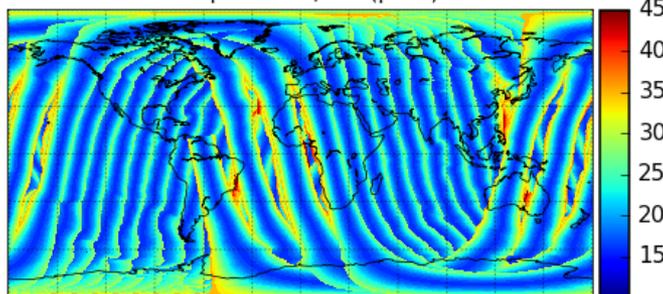
Time away from composite, minutes (prior)



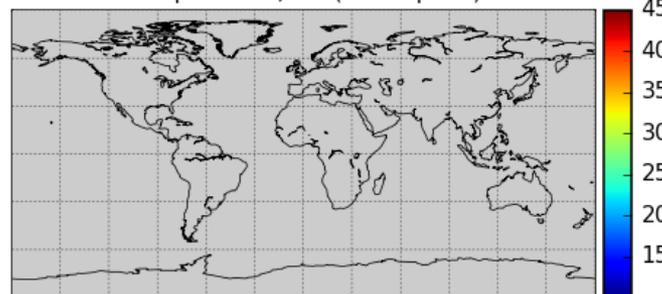
Time away from composite, minutes (subsequent)



Footprint size, km (prior)



Footprint size, km (subsequent)

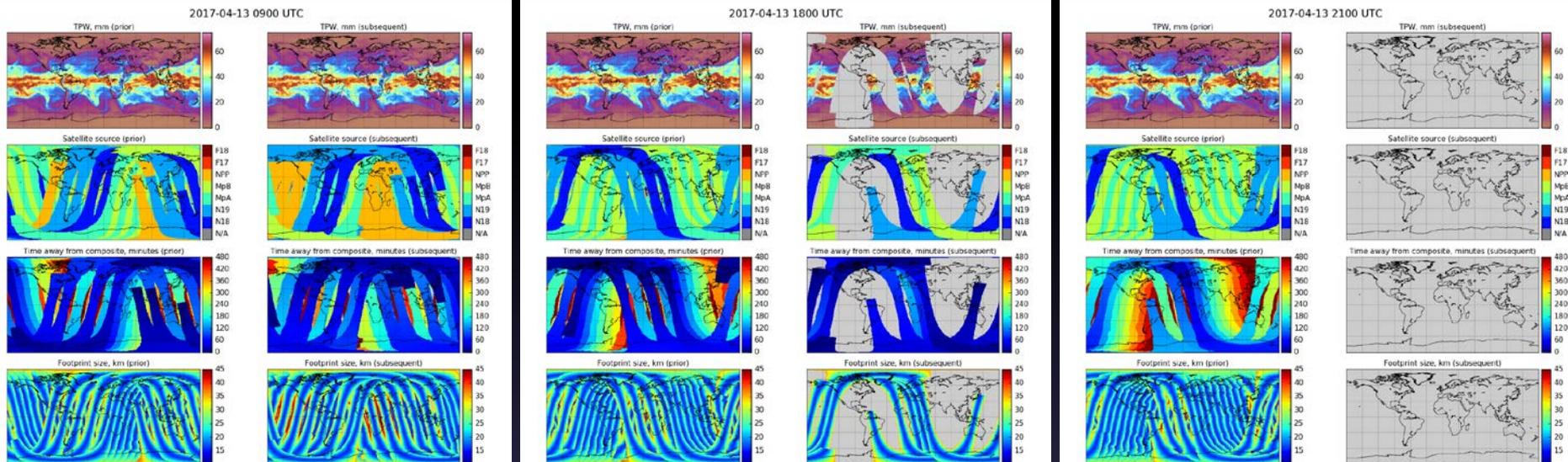


Product updating

“Archive-ready”

Near real time

Real time



- A product that begins at “real time” is gradually overwritten by more data over the next 12 hours.
- A single product may be revised 20-40 times until it is “finished” and archive-ready. Every revision is necessary to maintain a fluid transition.
- Therefore, you can’t simply make an animation of the first images that were created in real-time, like with other satellite images. You have to “refresh” the last 12 hours of data every time. Is your AWIPS station set up to do this?

Remaining issue: Advection over land and across coasts

- Simple one-level advection causes moisture to be depicted crossing the coastal boundaries even when it should not (due to trapping from an inversion or other discrepancies).
- In this example, moisture is improperly advected to central California in (b), through the same process that correctly captures the advection of moisture-laden air from the Gulf in the eastern U.S.

