Connecting Satellite-Based Precipitation Estimates to Users

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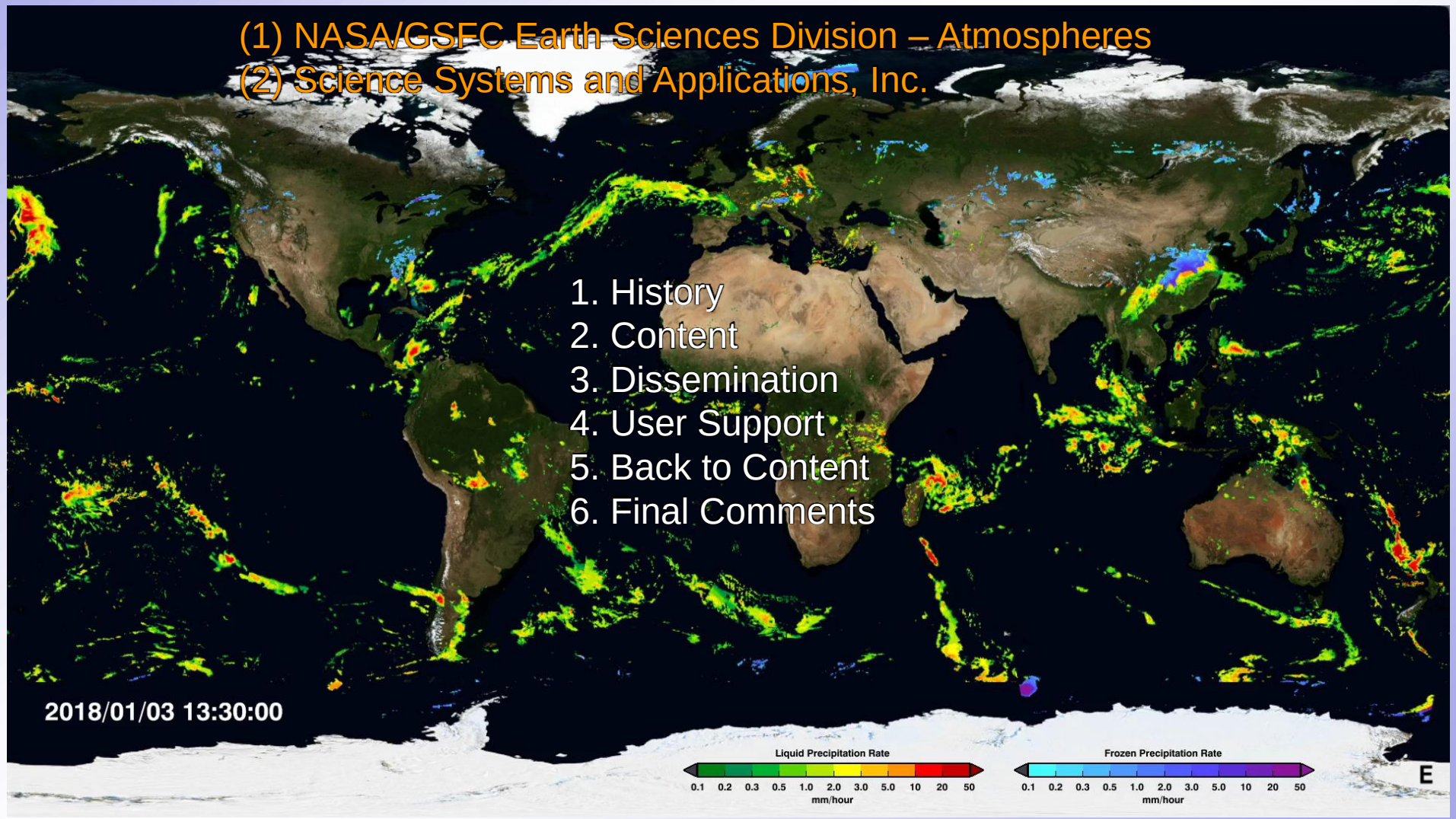
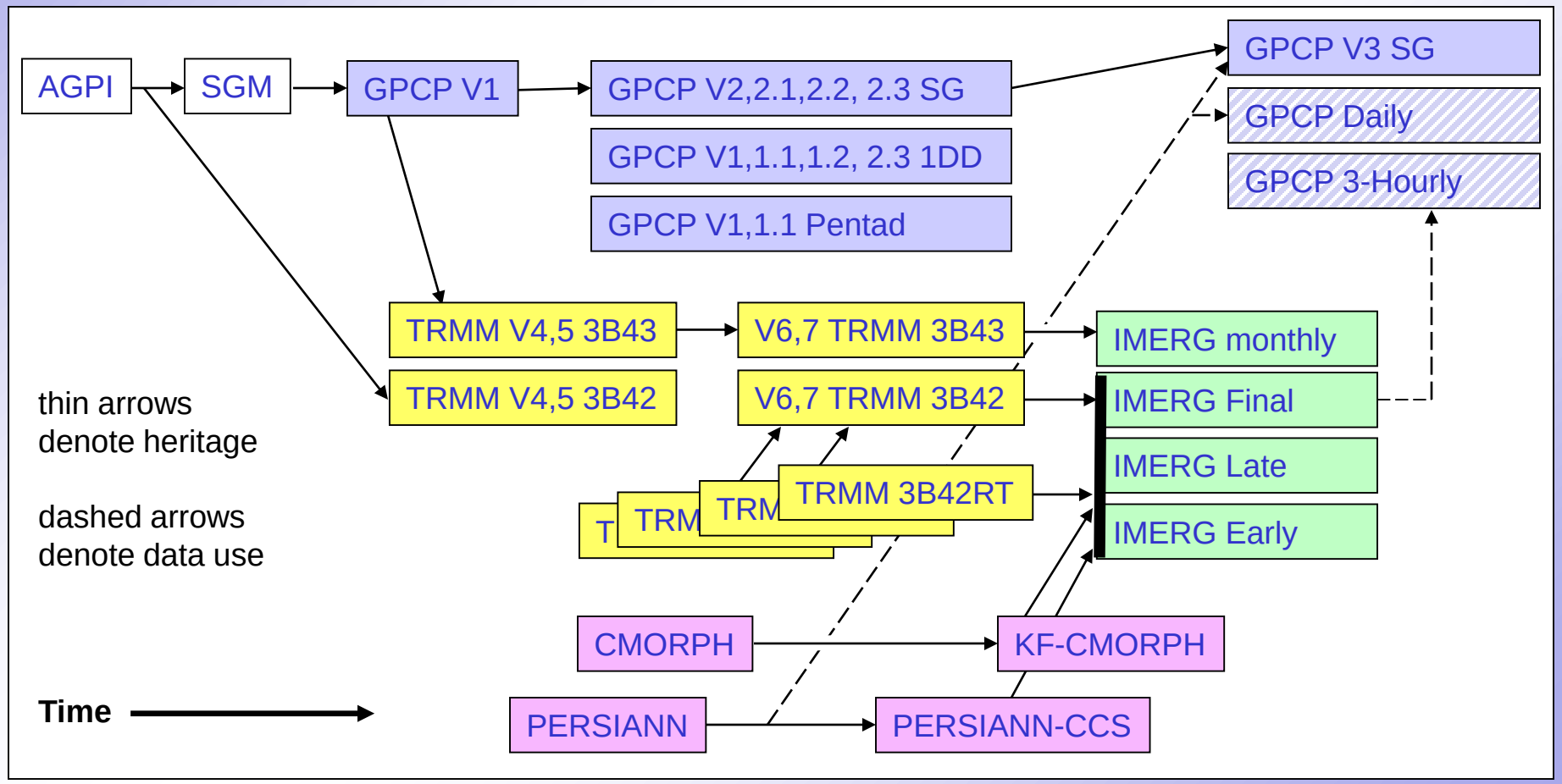


1. HISTORY

Merged Precipitation Group has had a major role in

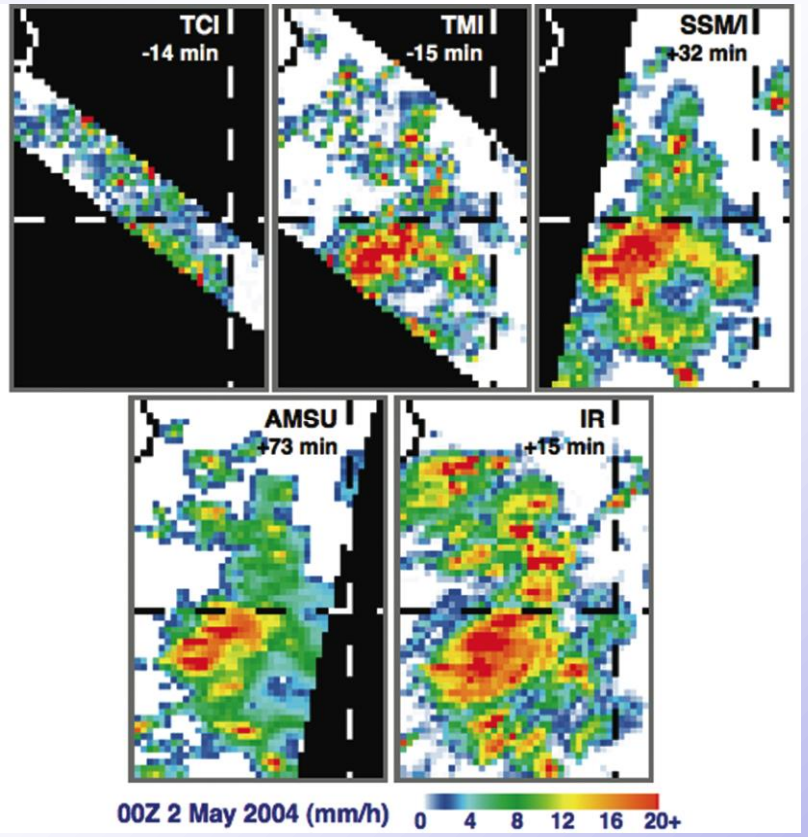
- Global Precipitation Climatology Project (GPCP) – 1995
- TRMM Multi-satellite Precipitation Analysis (TMPA) – 2002
- Integrated Multi-satellitE Precipitation Retrievals for GPM (IMERG) – 2014



2. CONTENT

Multi-satellite datasets merge retrievals/analyses of precipitation from individual satellites (and gauges)

- this puts a premium on consistent and accurate retrievals
- intercalibrations are required to improve consistency
- still, different sensors "see" precipitation differently
  - nearly coincident views by 5 sensors southeast of Sri Lanka
  - offset times from 00Z given below the sensor name
- data gaps in the combination process are filled by various interpolations
  - necessarily smoother than in reality
  - need to control effect on fractional coverage



2. CONTENT – IMERG Example

The original GPCP dataset included "all" intermediate fields

- assumed that precip experts would want to see these – not true

The original TMPA fell back to just precip and random error

- discovered we needed some fields for diagnosis and development
- some users needed them, too
- re-introduced fields with actual need

IMERG has continued this trend

- introduce ancillary fields at user request
  - Probability of Liquid Phase Precip
    - diagnostic, using model data
  - Quality Index
    - new, work in progress

IMERG Data Fields

	Half-hourly data file (Early, Late, Final)
1	[multi-sat.] precipitationCal
2	[multi-sat.] precipitationUncal
3	[multi-sat. precip] randomError
4	[PMW] HQprecipitation
5	[PMW] HQprecipSource [identifier]
6	[PMW] HQobservationTime
7	IRprecipitation
8	IRkalmanFilterWeight
9	[phase] probabilityLiquidPrecipitation
10	precipitationQualityIndex
	Monthly data file (Final)
1	[sat.-gauge] precipitation
2	[sat.-gauge precip] randomError
3	GaugeRelativeWeighting
4	probabilityLiquidPrecipitation [phase]
5	precipitationQualityIndex

3. DISSEMINATION (1/2)

Format

- originally in flat binary, sometimes encoded
- innovation: add an extra row loaded with metadata
- standards have evolved
  - HDF flavors, NetCDF flavors, tending toward interoperability
  - still a work in progress, particularly in dealing with libraries for different versions
- data centers are adding web services, format converters, subsetting by parameter and location, value-added products (shape file averages, accumulations)

Time/space interval driven by data availability

- GPCP V1 was 2.5° /monthly, then introduced 1° /daily (for a shorter period)
- TMPA V4 was 1° /monthly and 1° /daily, then went to 0.25° /monthly and 0.25° /3-hourly
- IMERG is 0.1° /monthly and 0.1° /half-hourly

Errors are higher for finer-scale estimates

3. DISSEMINATION (2/2)

Multiple runs accommodate different user requirements for latency and accuracy

- TMPA backed into handing out near-real-time (~8 hours old) by user request
  - tapped into a strong demand for current data
  - lesson learned: users need a long, consistently processed record for each dataset to support calibration of applications

    - the entire record of all variants has to be upgraded in a version shift

    - "real time" ≠ "disposable" … this is a paradigm shift for archive operators
- IMERG has 3 "Runs" to support a wider variety of use cases
  - "Early" – 4 hr (flash flooding)
  - "Late" – 12 hr (crop forecasting)
  - "Final" – 3 months (research)
  - waiting longer includes more input data – presumably more accuracy
  - lesson learned: users get confused when confronted with multiple products

    - this is also true across data providers

    - data providers have to do a better job at "suitability for use" information

4. USER SUPPORT

User support was originally

- algorithm papers
- e-mail with developers
- text README files
- technical documents

Modern support includes

- mailing list(s)
- web site
  - documents
  - data access hot link(s)
  - Frequently Asked Questions
  - Ask-A-Question hot link
  - Recipes
- social media presence
  - facebook
  - twitter
  - ResearchGate
  - LinkedIn

4. USER SUPPORT – PMM Example (1/2)

PMM summarized all data access at Goddard on a single set of pages

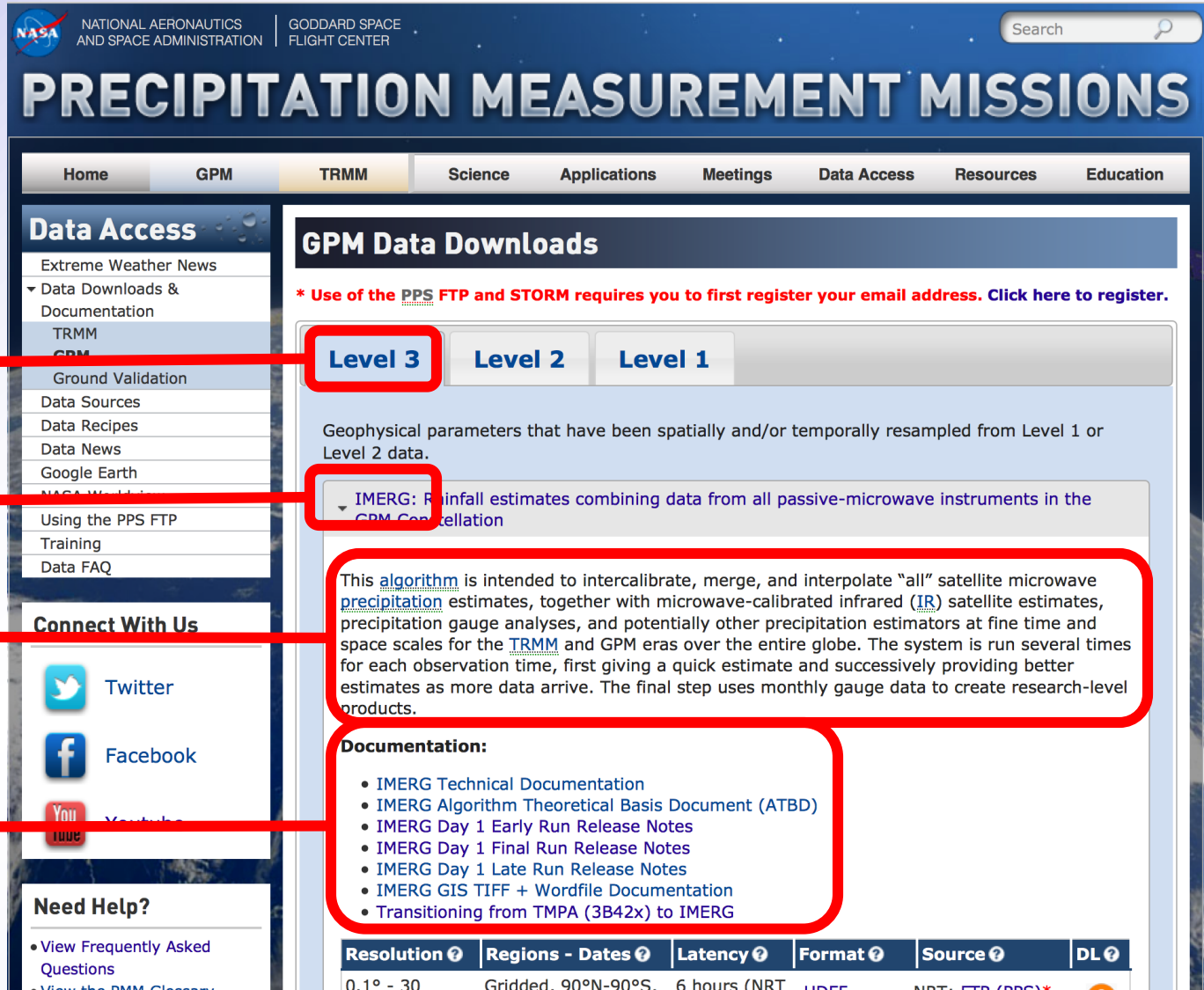
- https://pmm.nasa.gov/data-access

Gridded Data

Opens to IMERG by default

Short description

Hot links to documentation



4. USER SUPPORT – PMM Example (2/2)

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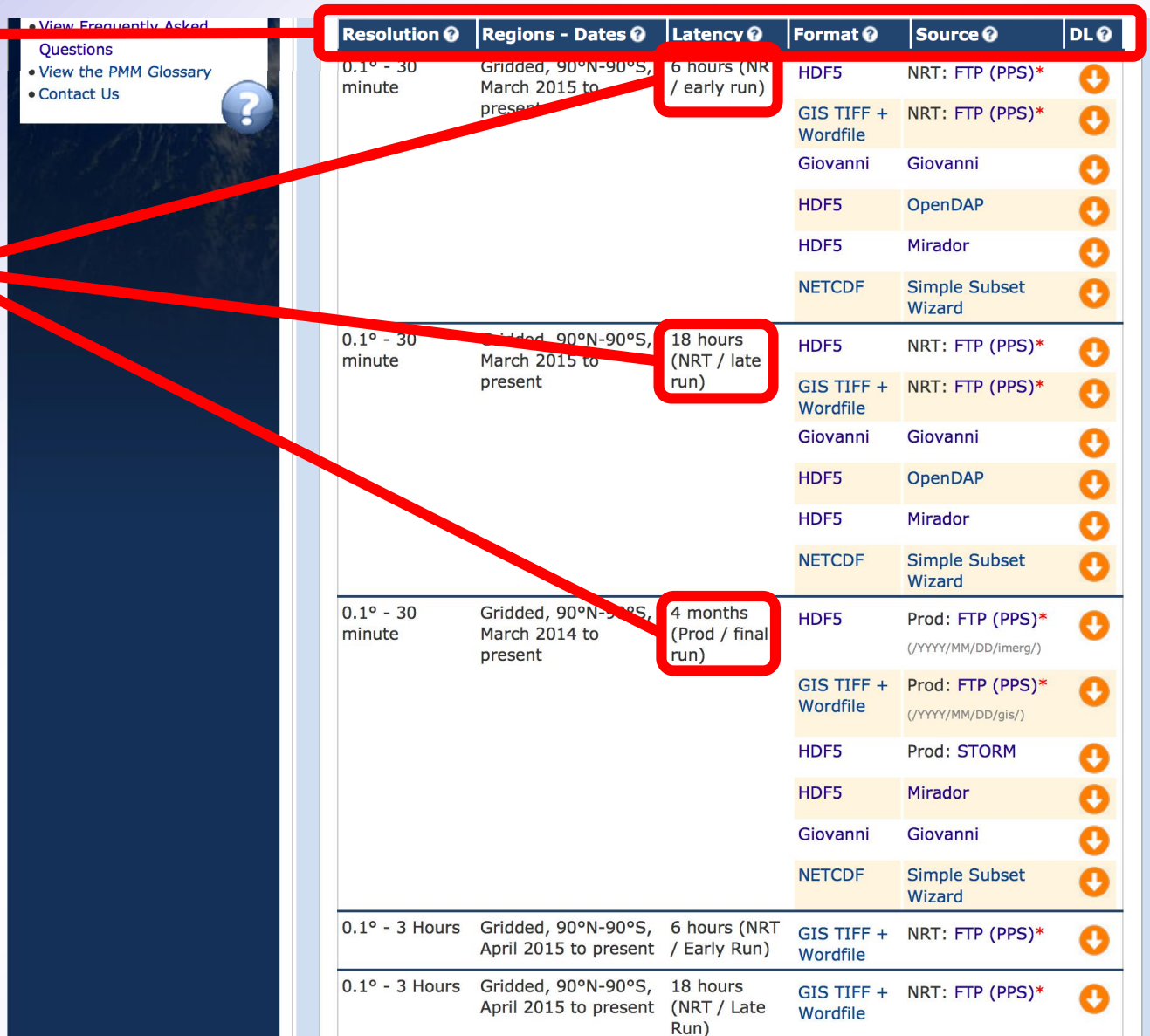
Access details

3 runs
2 NRT,
1 post-RT



4. USER SUPPORT – PMM Example (3/3)

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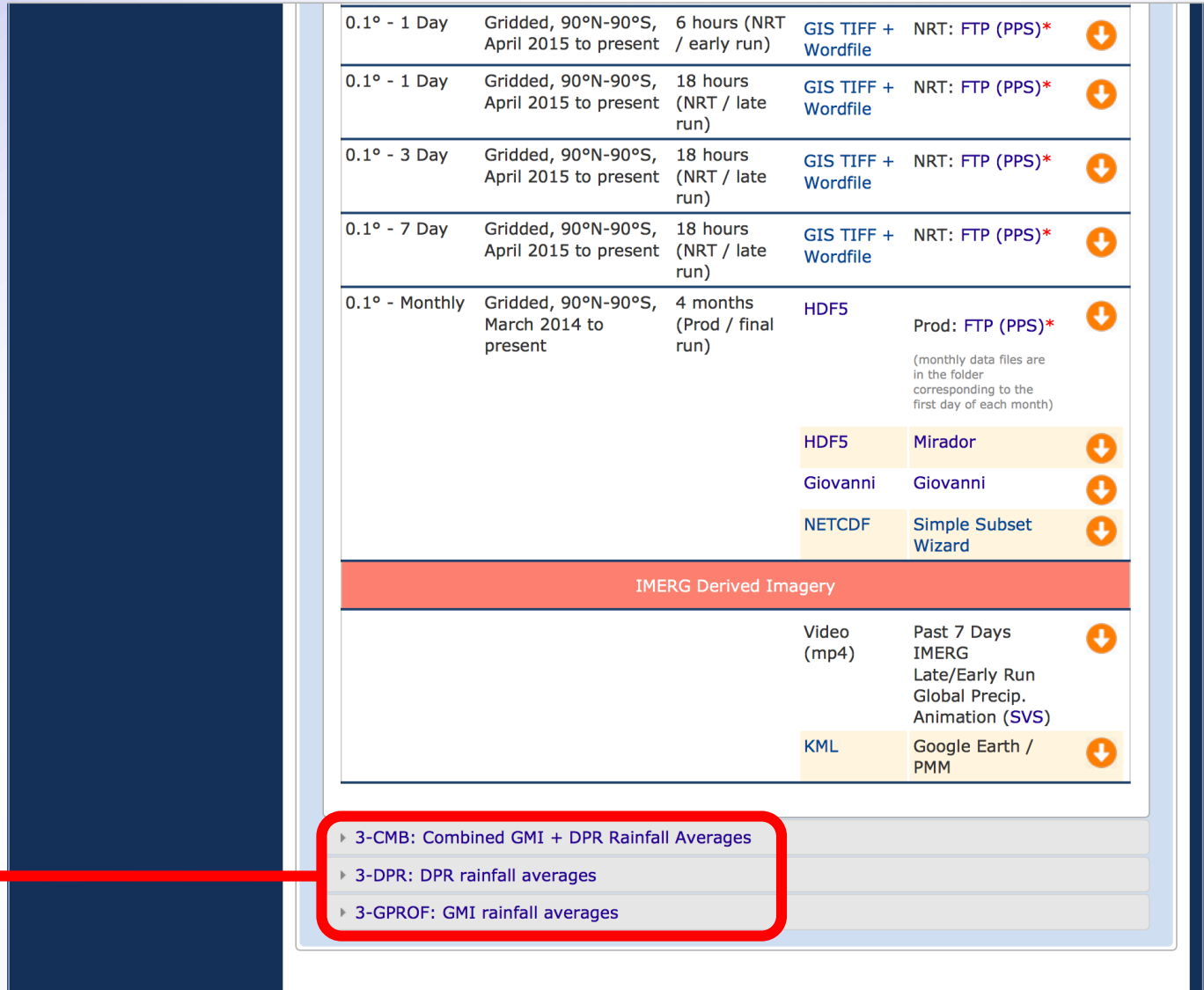


0.1° - 1 Day	Gridded, 90°N-90°S, April 2015 to present	6 hours (NRT / early run)	GIS TIFF + Wordfile	NRT: FTP (PPS)*
0.1° - 1 Day	Gridded, 90°N-90°S, April 2015 to present	18 hours (NRT / late run)	GIS TIFF + Wordfile	NRT: FTP (PPS)*
0.1° - 3 Day	Gridded, 90°N-90°S, April 2015 to present	18 hours (NRT / late run)	GIS TIFF + Wordfile	NRT: FTP (PPS)*
0.1° - 7 Day	Gridded, 90°N-90°S, April 2015 to present	18 hours (NRT / late run)	GIS TIFF + Wordfile	NRT: FTP (PPS)*
0.1° - Monthly	Gridded, 90°N-90°S, March 2014 to present	4 months (Prod / final run)	HDF5	Prod: FTP (PPS)* (monthly data files are in the folder corresponding to the first day of each month)
			HDF5	Mirador
			Giovanni	Giovanni
			NETCDF	Simple Subset Wizard
IMERG Derived Imagery				
			Video (mp4)	Past 7 Days IMERG Late/Early Run Global Precip. Animation (SVS)
			KML	Google Earth / PMM

- 3-CMB: Combined GMI + DPR Rainfall Averages
- 3-DPR: DPR rainfall averages
- 3-GPROF: GMI rainfall averages

other Level 3 datasets

4. USER SUPPORT – But Wait, There's More

GPCP and TMPA reformatted to the Obs4MIPS archive

- CMIP5 standard for model work

Custom product releases to NOAA

- Short-term Prediction Research and Transition (SPoRT) Center

Training Activities

- Applied Remote Sensing Training (ARSET)
- PMM application workshops

Secondary archives outside of Goddard

- typically without coordination with developers

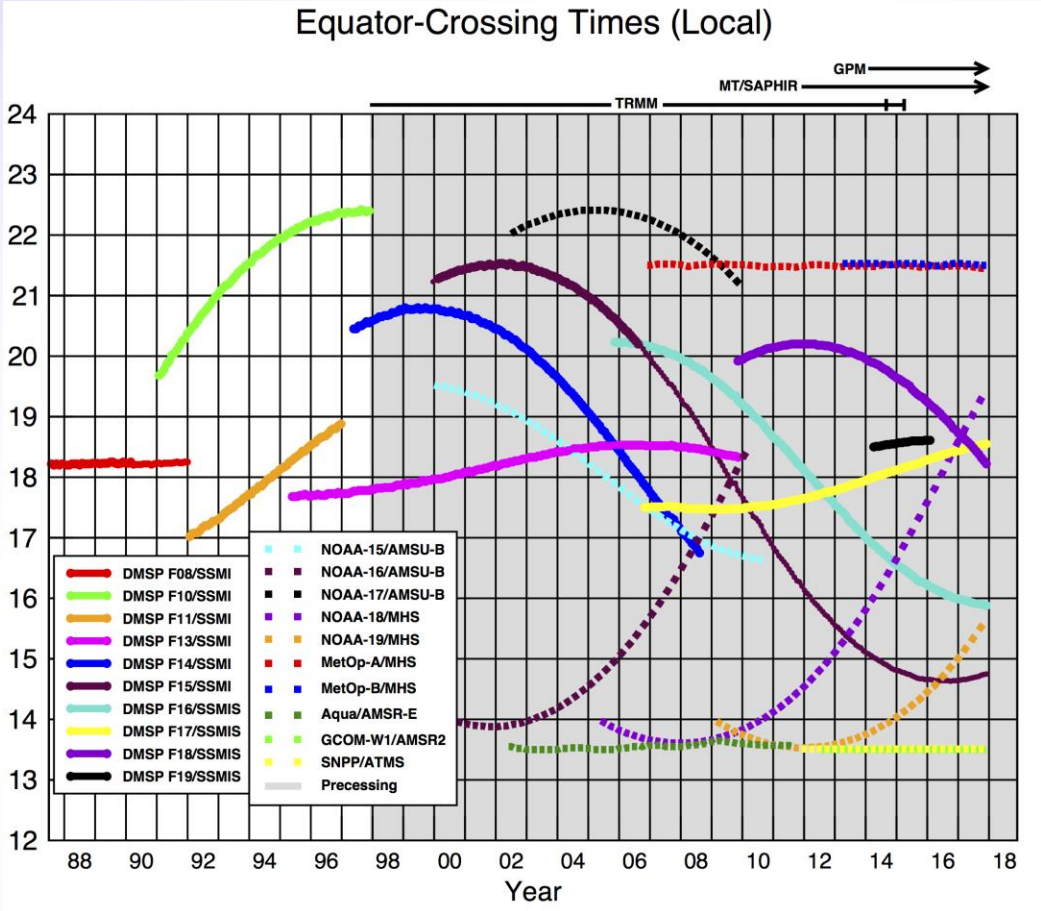
5. BACK TO "CONTENT"

Multi-satellite precip datasets have advanced over the last 20 years due to

- improved retrievals from individual satellites
- continued advancement in combination approaches
- increased numbers of microwave sensors
- improved sensors

The launch manifests for the next generation of satellites are sparse

- the user community expects the existing (or better) products in the future
- this requires a steady supply of high-quality satellite observations



Ascending passes (F08 descending); satellites depicted above graph precess throughout the day.
Image by Eric Nelkin (SSAI), 14 December 2017, NASA/Goddard Space Flight Center, Greenbelt, MD.

6. FINAL COMMENTS

All of this work has taken sustained commitment of resources

Going into the future the challenges are

- how do we maintain/augment the observational base (including surface gauges)?
- how do we squeeze additional information out of space-based sensors?
- what are sustainable models for supporting the enormous community of non-expert users?

The climate community has a stake in this discussion

- "extremes" are inherently fine-scale, so the climatology of extremes requires a long record of fine-scale estimates
- even precipitation averages tend to be dominated by a few large events, which are usually fine-scale

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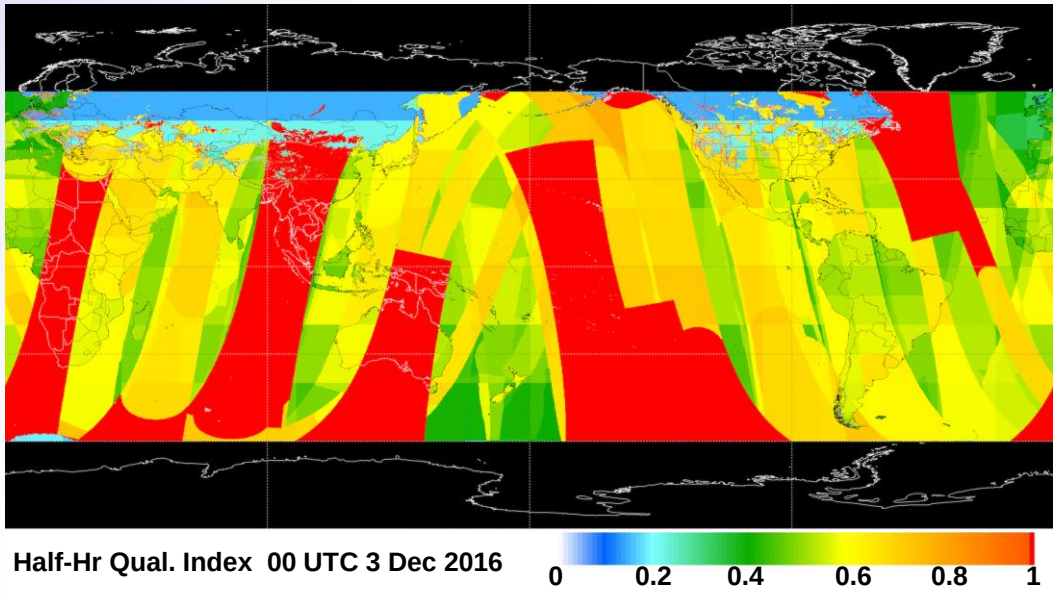
IMERG on the Hyperwall 4 p.m.

extra slides

4. VERSION 05 IMERG – Quality Index (QI)

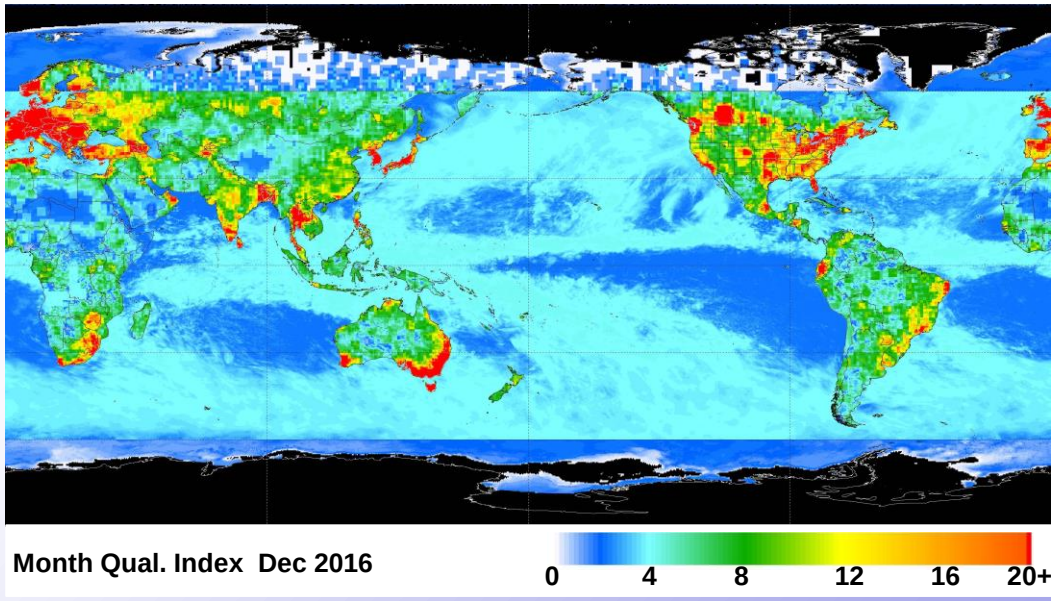
Half-hourly QI

- approx. Kalman Filter correlation
  - time to nearest PMWs
  - IR at time (when used)
  - set to 1 when a PMW is used
- thin strips due to inter-swath gaps
- blocks due to regional variations
- low values at high lat. due to using IR with PMW masked out over snow



Monthly QI

- Equivalent Gauge (Huffman et al. 1997) in gauges / 2.5° x2.5°
- invert random error equation
- largely tames the non-linearity due to rain amount
- some residual issues at high values



D.Bolvin (SSAI; GSFC)

2. CONTENT – IMERG Example

Multiple runs accommodate different user requirements for latency and accuracy

- "Early" – 4 hr (flash flooding)
- "Late" – 14 hr (crop forecasting)
- "Final" – 3 months (research)

Time intervals are half-hourly and monthly (Final only)

0.1° global CED grid

- merged PMW precip 90° N-S
- morphed precip 60° N-S for now
- probability of liquid precip 90° N-S

User-oriented services by archive sites

- interactive analysis (Giovanni)
- alternate formats (TIFF files, …)
- value-added products

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