Moving IMERG Through the Versions

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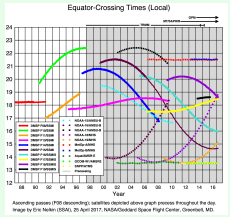
THE CURRENT GPM MICROWAVE CONSTELLATION

The original goal was 3-hourly observations, globally
- Original basis was sampling the diurnal cycle
- But also, morphed microwave loses skill outside ±90 minuntes

The current IMERG constellation includes:
- 5 polar-orbit passive microwave imagers
  - 3 SSMIS, AMSR-2, GMI
- 5 (4?) polar-orbit passive microwave sounders
  - 4 (3?) MHS, ATMS

The future is "interesting"
- Legacy satellites are allowed to drift
  - apparently 06/18 (00/12) UTC is a stable (unstable) point
  - exact coverage is a complicated function of time
  - duplicate orbits aren't very useful for getting 3-hourly observations
- GPM fuel will last >10 years, so likely not the limiting factor
- Future launch manifests are sparse



IMERG DESIGN PHILOSPHY

IMERG is a unified U.S. algorithm that takes advantage of the strengths of the partner algorithms

- Kalman Filter CMORPH – CPC/NOAA
  - Lagrangian time interpolation
  - Kalman statistical weighintg
- PERSIANN with Cloud Classification System – U.C.-Irvine
  - Infrared-based precipitation
- TMPA – GSFC NASA
  - Satellite intercalibration
  - Gauge combination
- All three partners have received PMM support
- Precipitation Processing System (PPS, GSFC/NASA)
  - Computes/assembles input data sets
  - Generates IMERG products
  - Archives IMERG products
- IMERG is a single integrated code system appropriate for near-real and post-real time
- "The devil is in the details"

The Japanese merged-satellite counterpart is GSMaP

IMERG DATASET CHARACTERISTICS

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

	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

VERSION 4 IMERG UPGRADES

Use new Version 04 precip from sensors using GPROF2014v2 algorithm

Reduce Final Run latency from 3.5 to 2.5 months
- change how ancillary data are handled

Shift from static to dynamic calibration of PERSIANN-CCS by PMW precip

Extend PMW gridders to 90°N-S

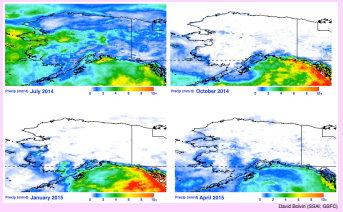
Reduce blockiness
- turn off volume adjustment in gauge analysis
- screen off-shore gauge influence
- spatially average 2BCMB-GMI calibrations

Correct bug that placed morphed values one gridbox south of actual location
- found thanks to a user's question

Adjust 2BCMB to the zonal-mean GPCP (land and ocean, except low-latitude ocean)

Calibrate all microwave sensors to 2BCMB

MERGED MICROWAVE IN V04 AT HIGH LATITUDES



Warm-season estimates appear useful at high latitudes

Input precip estimates are still deficient in snow/ice-covered surface regions
- still screening out PMW estimates in snow/ice areas and use PMW-calibrated PERSIANN-CCS estimates

ADJUSTING GPM CORE PRODUCTS TO GPCP

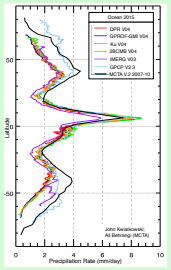
GPM Core products are low in the extratropical oceans

Ocean-only zonals for 2015

V04 GPM products are similar, by design
- V03 IMERG somewhat similar
  - Day 1 (pre-launch calibration)

GPCP is higher in the extratropics
- new Version 2.3 of community standard
- Behrangi Multi-satellite CloudSat, TRMM, Aqua (MCTA) product confirms GPM bias
  - includes CloudSat rain, snow, mixed
  - higher than GPCP in mid-latitudes
  - roughly agrees at high latitudes

Adjust IMERG V04 to GPCP at higher latitudes with seasonal "climatology"
- provides reasonable IMERG bias in V04
- low biases in GPM products addressed in V05, but still low, still require GPCP



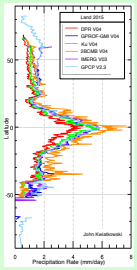
GPM Core product biases vary by latitude over land

Land-only zonals for 2015

V04 GPM products tend to show more spread

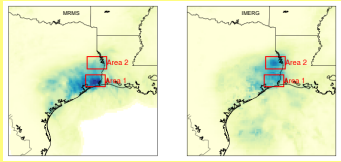
GPCP is higher in the extratropics
- V03 IMERG similar (both use GPCC gauge analysis)
- MCTA n/a over land

Adjust IMERG to GPCP for V04 at all latitudes with a seasonal "climatology"
- first cut at the adjustment to gauges that the final calibration in IMERG enforces
- biases in GPM products addressed in V05, but still low, still require GPCP



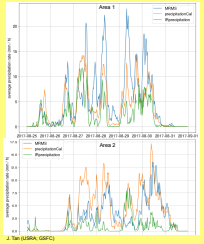
VALIDATION – HURRICANE HARVEY

Harvey loitered over southeast Texas for a week, 25-31 August 2017
- Multi-Radar Multi-Sensor (MRMS) considered the best estimate
  - some questions about the details of the gauge calibration of the radar estimate
  - over land
- Late Run IMERG V04 under(over)-estimated in Area 1(2)



The differences between MRMS (blue) and IMERG (orange) tend to be of the same sign as the event-average difference
- less true in Area 2
- some jumpiness in IMERG is due to overpasses by different sensors
- opposite-sign differences occurred at the same time in the two areas
- PMW-calibrated IR (green) is mostly less than MRMS in both areas

This presumably tells us about the meteorology
- "juicy", liquid-process tropical convection in Area 1
- drier, more continental convection in Area 2
- deviations from global calibration are regionally correlated

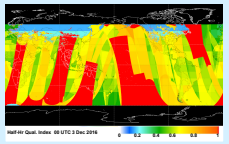


QUALITY INDEX – NEW IN V05

Half-hourly QI
- approx. Kalman Filter correlation
  - time to nearest PMWs
  - IR at time (when used)
  - set to 1 when a PMW is used

$$QI_{hh} = tanh\left(\sqrt{\sum arctanh^2(r_i)}\right)$$

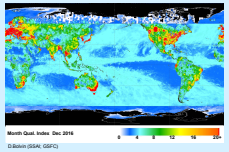
  - where r is correlation, and the i's are for forward propagation, backward propagation, and IR
- thin strips due to inter-swath gaps
- blocks due to regional variations
- low values at high lat. due to using IR with PMW masked out over snow



Monthly QI
- Equivalent Gauge (Huffman et al. 1997) in gauges / 2.5°x2.5°

$$QI_{mo} = (S + r) * H * (1 + 10 * r^2)/e^2$$

  - where r is precip rate, e is random error, and H and S are source-specific error constants
- invert random error equation
- largely tames the non-linearity due to rain amount
- some residual issues at high values



SCHEDULE AND FINAL REMARKS

Early Spring 2017: Version 04, first-generation GPM-based IMERG archive, March 2014–present

Fall 2017: Version 05 IMERG, March 2014–present
- DPR calibration change
- "minor", but important upgrades to other algorithms
- IMERG Quality Index
- still no morphing outside 60°N-S

Spring 2018: TRMM V.8/GPM V.05 TRMM/GPM-based IMERG archive, 1998–present

Late Spring 2018: Legacy TMPA products retired

~2 years later: Version 06