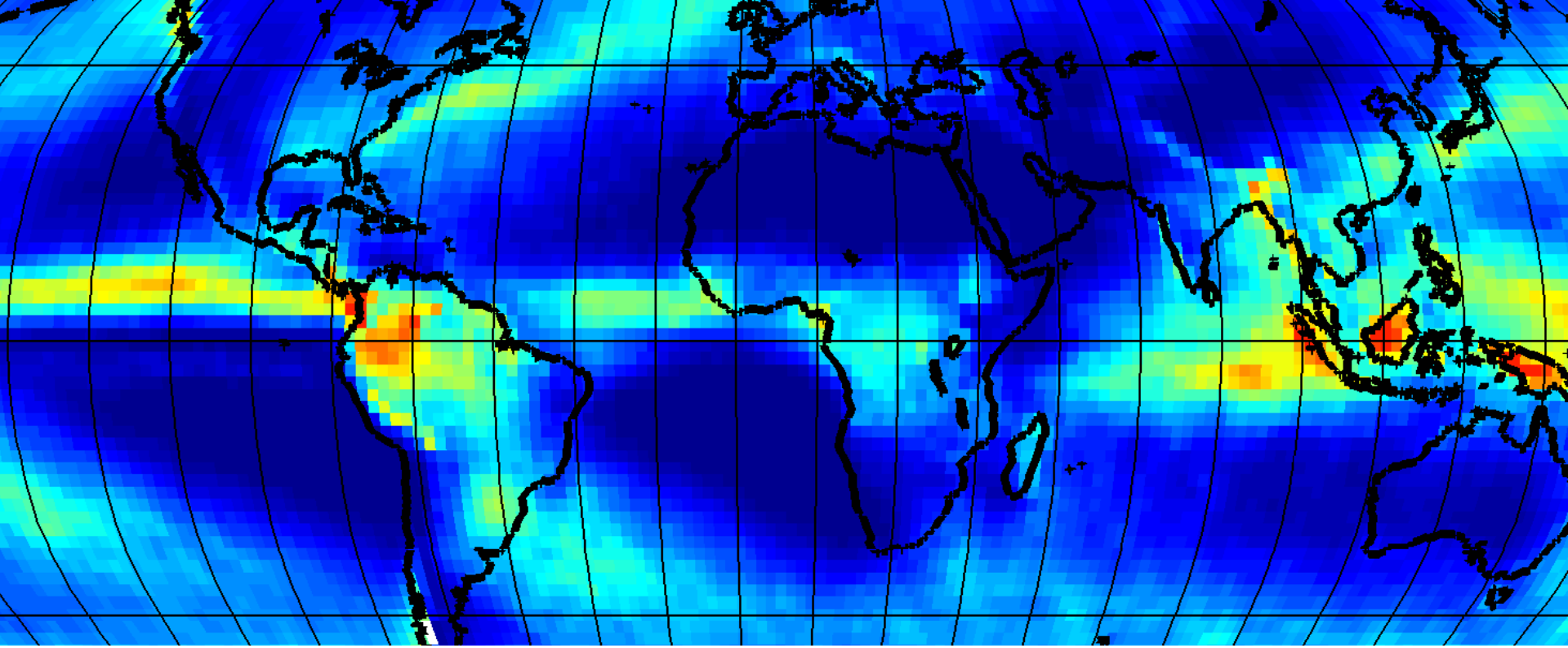


Precipitation Studies using the Global Precipitation Measurement Mission

Daniel Watters
Supervisor: Alessandro Battaglia
Earth Observation Science Group, University of Leicester

NERC SCIENCE OF THE ENVIRONMENT

CENTA

UNIVERSITY OF LEICESTER

Content

- Motivation
  - Precipitation
  - Global Precipitation Measurement (GPM) Mission
  - GPM Core Satellite
- Capabilities of GPM
  - GPM Core Satellite – Tropical Storm Event
  - GPM Constellation – Summertime Diurnal Cycle of Precipitation
- Opportunities with GPM
  - Precipitation Microphysics
- Conclusions and Future Work

Motivation – Precipitation

Water Cycle

- Important component due to impact on civilisation (Schouppe and Ghazi, 2007)
  - Flooding
  - Water Availability

Energy Budget

- Annual global mean equivalence – Precipitation and latent heat flux (Kiehl and Trenberth, 1997)

Motivation – Global Precipitation Measurement (GPM) Mission

Mission

- Goal - Improving understanding of the Earth's water cycle and energy budget (NASA)

GPM Satellite Constellation

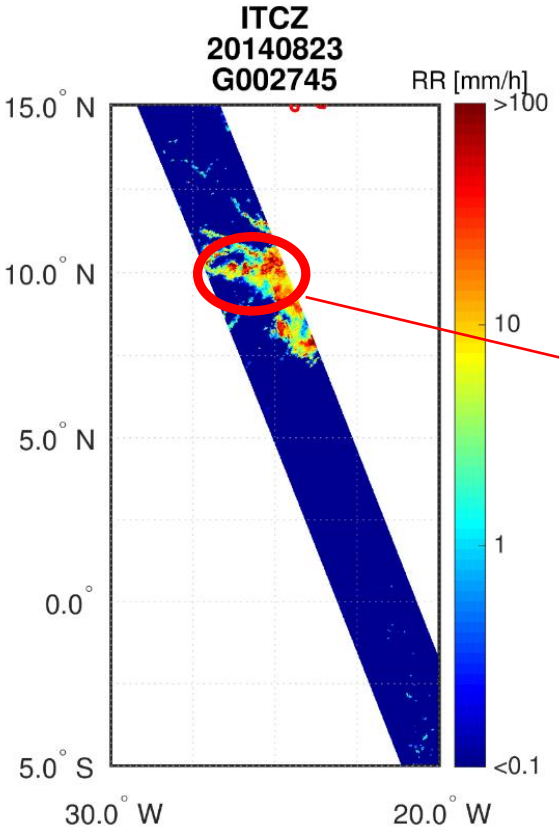
- Each satellite has a microwave radiometer
- GPM Core Observatory is the reference satellite for the constellation (Hou et al., 2014)

GPM Core Observatory

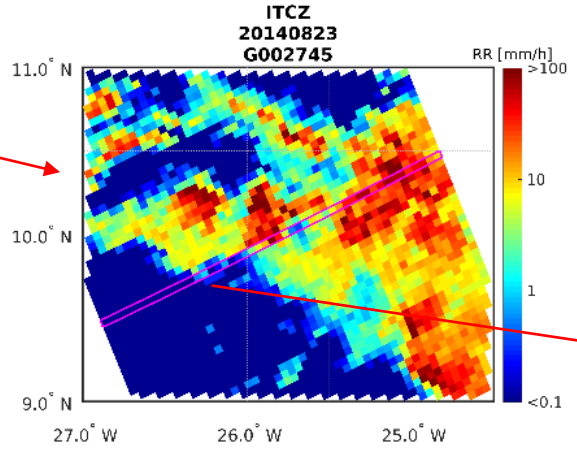
- Launched – February 2014 (Hou et al., 2014)
- Radar
  - Dual-frequency (Ku-band - 13.6 GHz, Ka-band - 35.5 GHz)
  - Threshold: 0.2 mm/h
- Microwave Radiometer
  - 13 frequency channels (10 – 183 GHz)

Capabilities of GPM

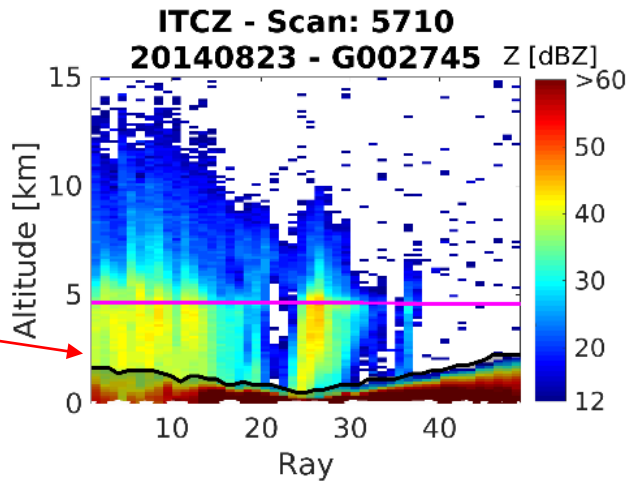
GPM Core Satellite – Tropical Storm Event



Horizontal view of precipitation field



Vertical view of a scan of the field



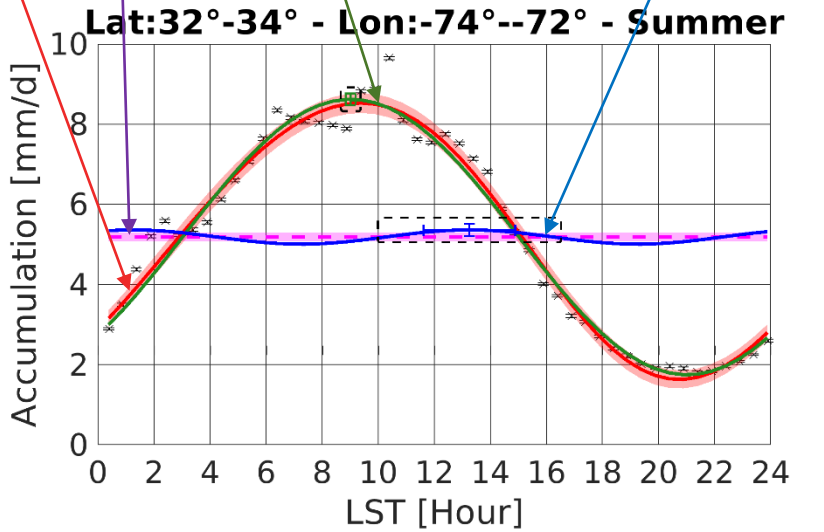
UNIVERSITY OF LEICESTER

Capabilities of GPM

GPM Constellation – Summertime Diurnal Cycle of Precipitation

- IMERG product (Huffman et al., 2018)
  - 0.1˚× 0.1˚, half-hour resolution
  - Derived from GPM microwave constellation and infrared sensors
- Period: June 2014 – May 2018
- Fit harmonic function to IMERG estimates at 2˚× 2˚ across the globe

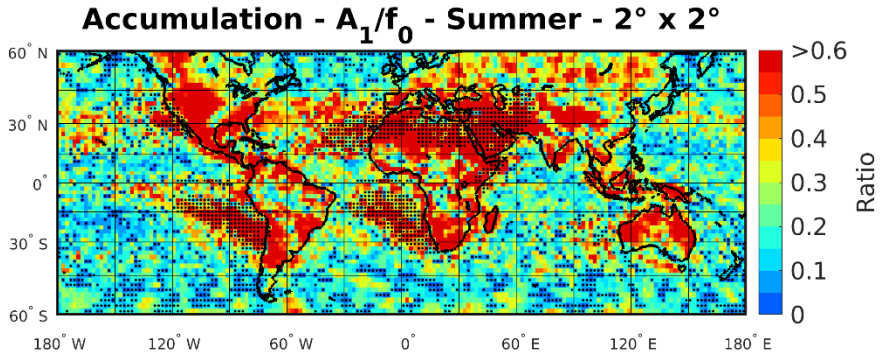
$$F(t) = f_0 + A_1\cos\frac{2\pi(t-T_1)}{24} + A_2\cos\frac{2\pi(t-T_2)}{12}$$

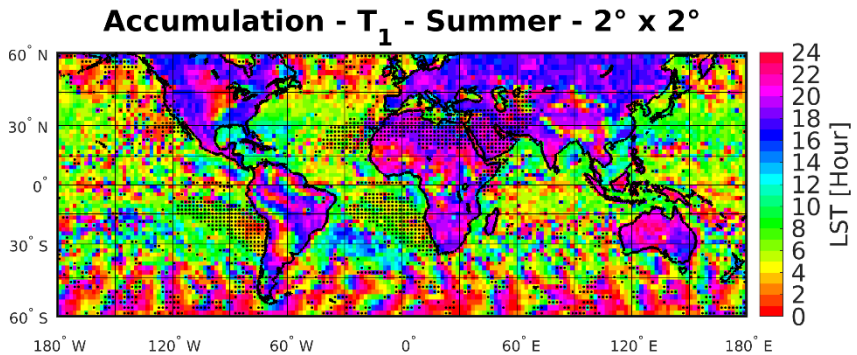


Note: LST = Local Solar Time

Examples of GPM's capabilities

GPM Constellation – Summertime Diurnal Cycle of Precipitation





Note: LST = Local Solar Time

- Land
  - Amplitudes > 25%
  - Peak - late afternoon and evening (~16-22 LST)
- Ocean
  - Amplitudes < 25%
  - Peaks
    - Open waters – Morning (~0-10 LST)
    - Coastal waters – Late morning and afternoon (~8-15 LST)

Watters & Battaglia (2019) – The Summertime Diurnal Cycle of Precipitation Derived from IMERG – MDPI Remote Sensing

Opportunities with GPM - Precipitation Microphysics

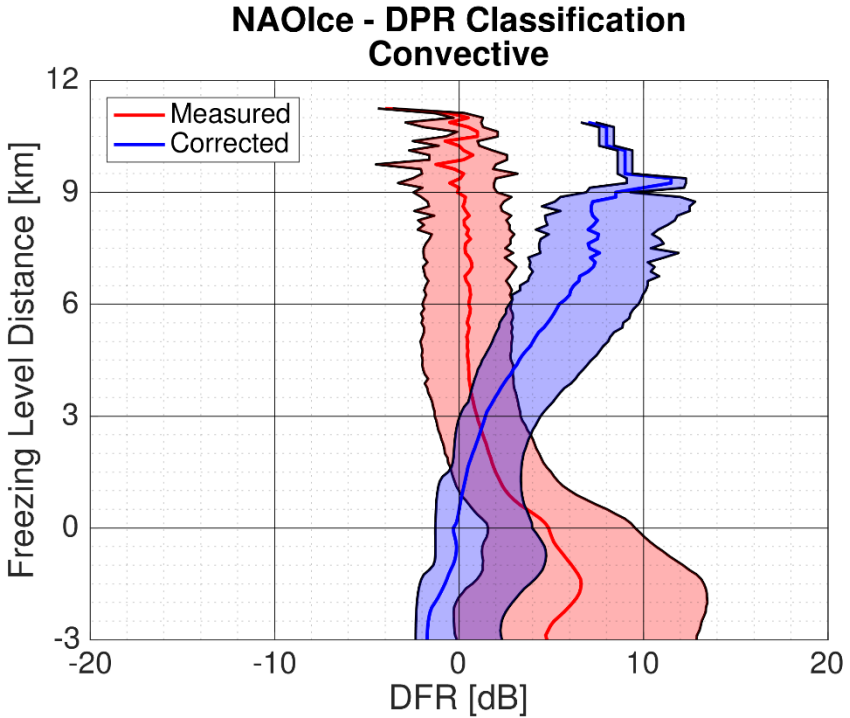
- Dual-frequency ratio (DFR) is related to the mass-weighted mean raindrop diameter (Matrosov et al., 2006)
  - Difference between observations at two frequencies (Ku- and Ka-band) in logarithmic units [dBZ]
  - Measured in 3D by the GPM radar

Opportunities with GPM – Precipitation Microphysics

- Region: Section of North Atlantic Ocean
- Period: April 2014 – December 2017
- Convective-stratiform ratio = 0.12
- Rainy profiles = 24,433,458

Stratiform	Convective	Other
82.2%	9.6%	8.2%

Non-Shallow	Shallow Isolated	Shallow Non-Isolated
89.6%	2.8%	7.6%



UNIVERSITY OF LEICESTER

Conclusions and Future Work

- GPM offers opportunity to improve knowledge of precipitation and its representation within models
  - Microphysics
  - Diurnal cycle
  - Latent heat

- Future work
  - Investigate precipitation over the Southern Oceans
  - Investigate microphysics trends for different regions / precipitation classifications

References

- Schouppe, M. and Ghazi, A., 2007. European Commission Research for Global Climate Change Studies: Towards Improved Water Observations and Forecasting Capability. In *Measuring Precipitation From Space* (pp. 3-6). Springer, Dordrecht.
- Kiehl, J.T. and Trenberth, K.E., 1997. Earth's annual global mean energy budget. *Bulletin of the American Meteorological Society*, *78*(2), pp.197-208.
- NASA. Global Precipitation Measurement, Available at: https://www.nasa.gov/mission_pages/GPM/main/index.html, Accessed 20 June 2019.
- Hou, A.Y., Kakar, R.K., Neeck, S., Azarbarzin, A.A., Kummerow, C.D., Kojima, M., Oki, R., Nakamura, K. and Iguchi, T., 2014. The global precipitation measurement mission. *Bulletin of the American Meteorological Society*, *95*(5), pp.701-722.
- Huffman, G.J., Bolvin, D.T., Braithwaite, D., Hsu, K., Joyce, R., Kidd, C., Nelkin, E.J., Sorooshian, S., Tan, J., Xie, P., 2018. NASA Global Precipitation Measurement (GPM) Integrated Multi-satellitE Retrievals for GPM (IMERG). Algorithm Theoretical Basis Document, Version 5.2. Available at: https://pmm.nasa.gov/sites/default/files/document_files/IMERG_ATBD_V5.2_0.pdf, Accessed 18 June 2019.
- Watters, D. and Battaglia, A., 2019. The Summertime Diurnal Cycle of Precipitation Derived from IMERG. *Remote Sensing*, *11*(15), p.1781.
- Matrosov, S.Y., Heymsfield, A.J. and Wang, Z., 2005. Dual-frequency radar ratio of nonspherical atmospheric hydrometeors. *Geophysical research letters*, *32*(13).