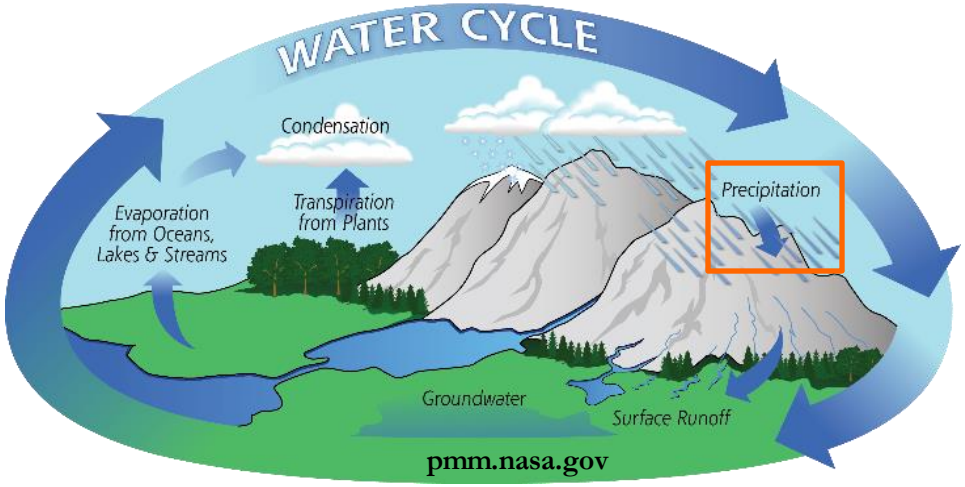
Rainfall estimation from satellite

Rômulo A. Jucá Oliveira
Marielle Gosset

20/09/2022

Rainfall estimation from satellite

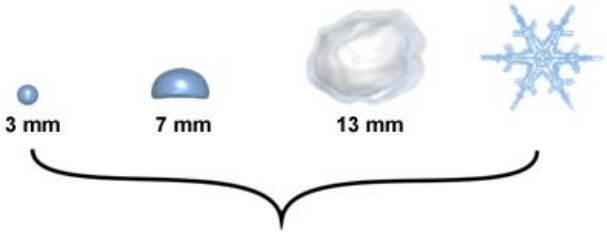


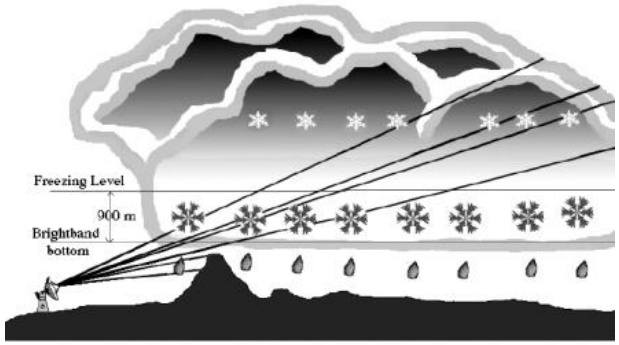
- Estimating rainfall with satellite : how
  - Satellite Rainfall estimation principles
  - Current products, quality, applications
- Some perspectives

Large variabilities

Spatial-temporal /vertical / intensity

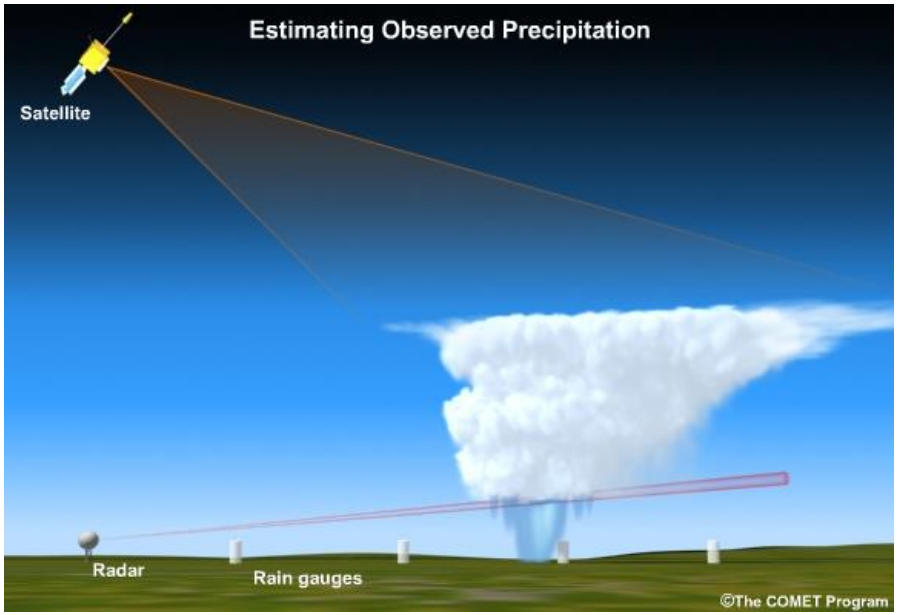
❖ Microphysical Scale





- Detailed Characterization of Precipitation

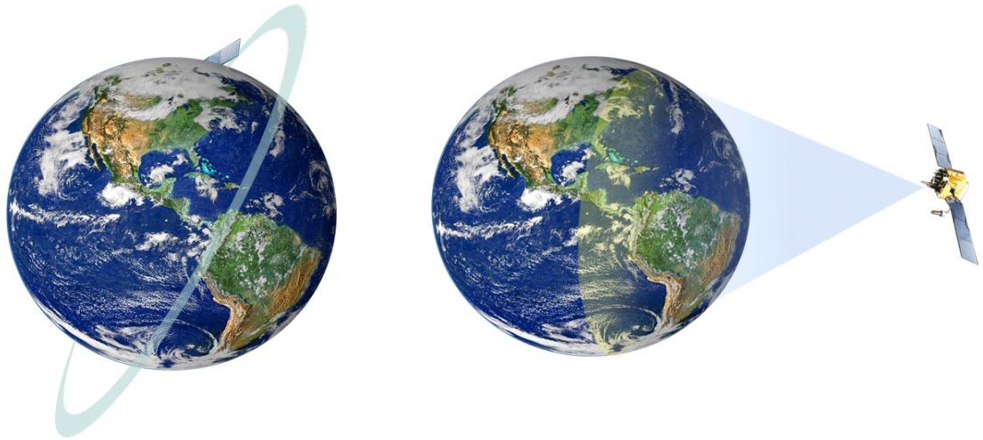
➔ Remote sensing instruments



Complex
Multi-scale (time and space) – Intermittent
Difficult to observe and quantify

❑ The Remote Sensing of Precipitation

➔ Satellites



➔ Orbits:
- → Geostationary
- → Polar
- → Low-Earth Orbit (LEO)

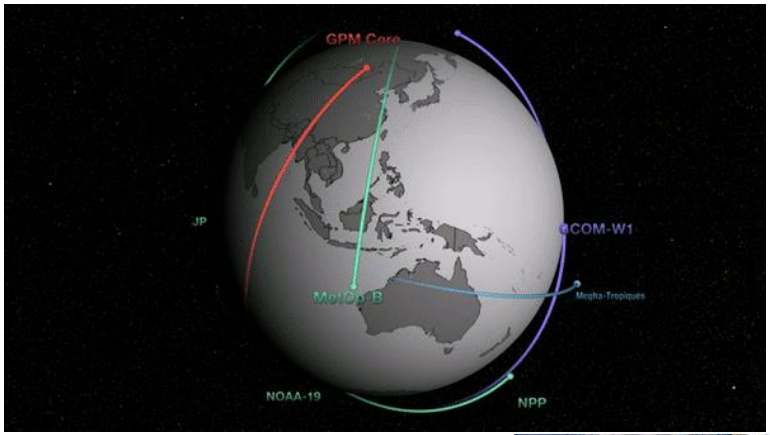
➔ Resolutions:
- → Spatial
- → Temporal
- → Spectral
- → Radiometric

❑ The Remote Sensing of Precipitation

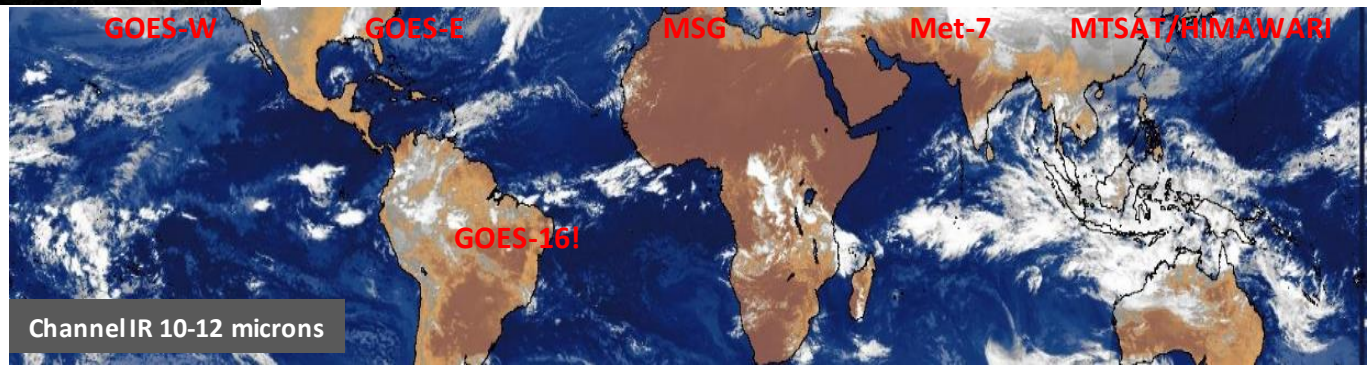
➔ Satellites

➔ Orbits:
- → Geostationary
- → Polar
- → Low-Earth Orbit (LEO)

➔ Resolutions:
- → Spatial
- → Temporal
- → Spectral
- → Radiometric

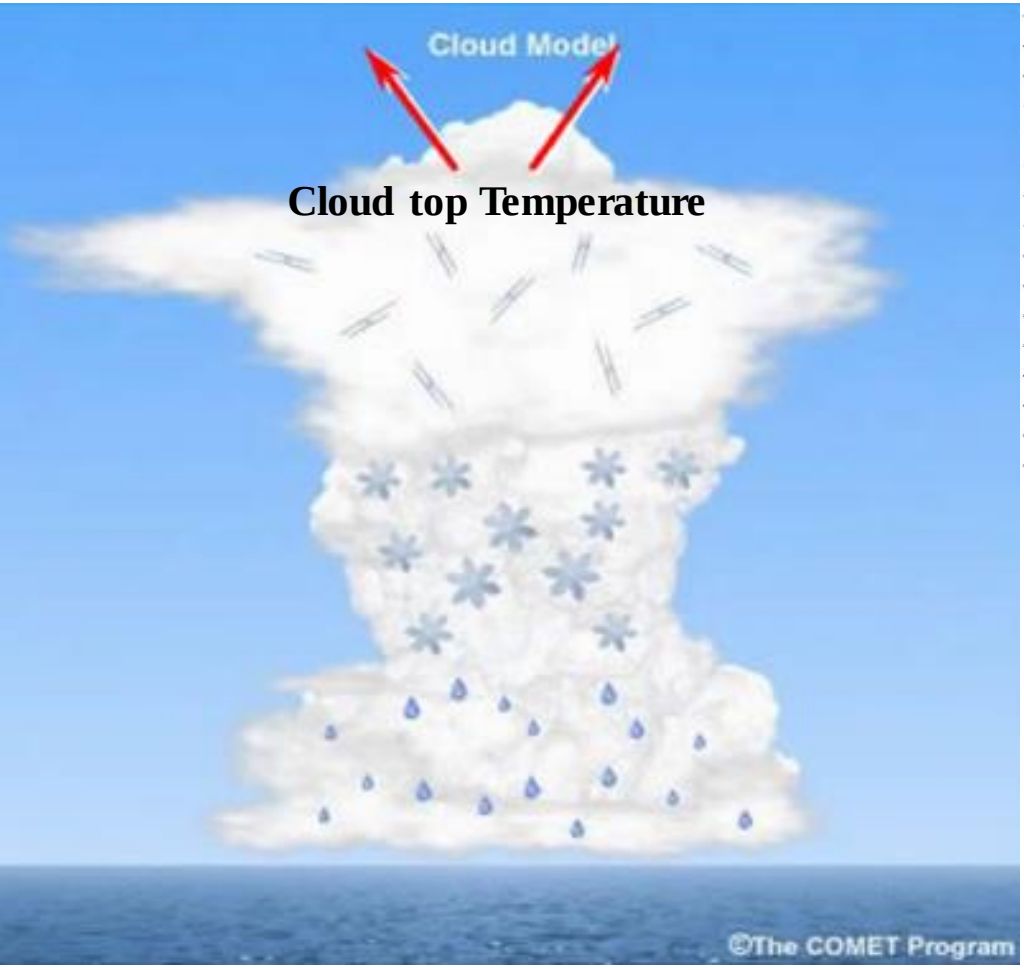


The current global coverage

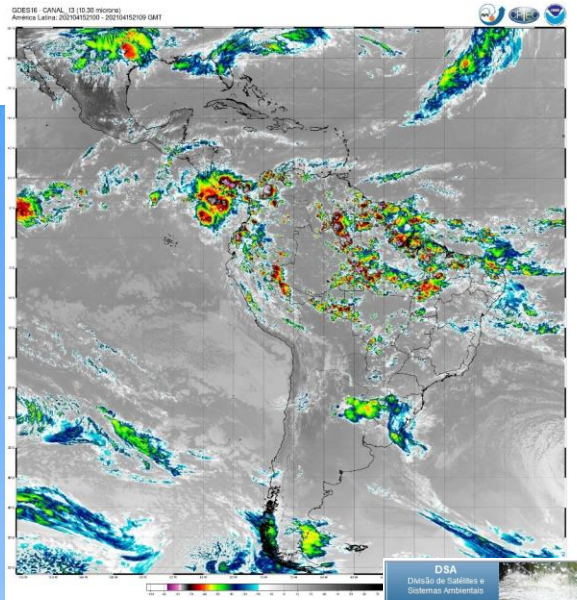


❑ Rainfall estimation from satellite – The initial methods

Infrared (IR)

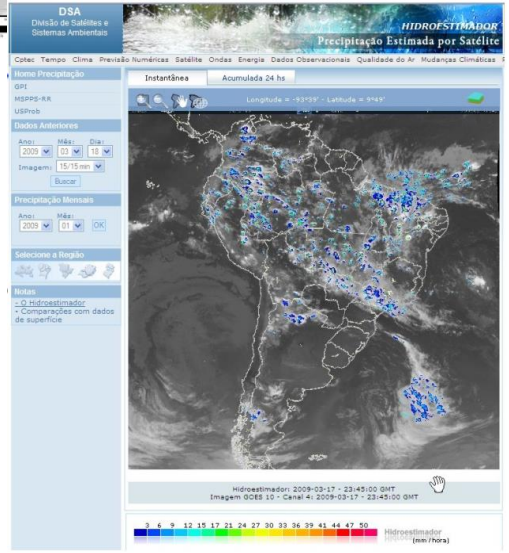


GOES-16 (10.3µ)
Brightness Temperature (K)



Example:

Hidroestimator
(CPTEC/INPE)



Also eumetsat
products

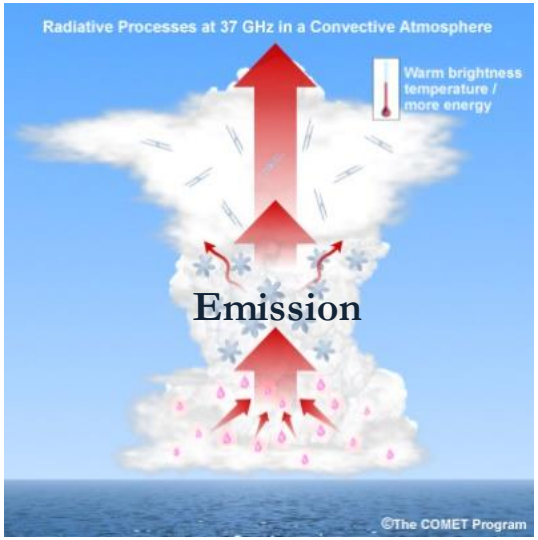
❑ Rainfall estimation from satellite – The addition of microwaves

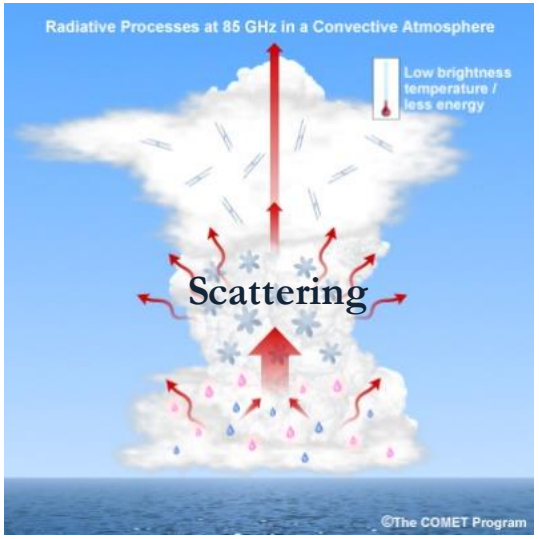
Microwave (MW)

Low Frequencies
< 60 GHz

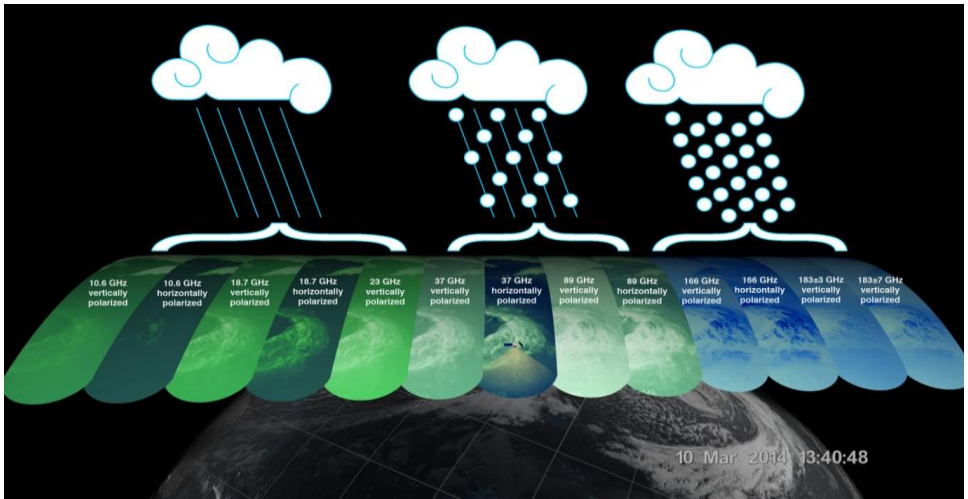
Passive

High Frequencies
>60 GHz





GPM GMI:

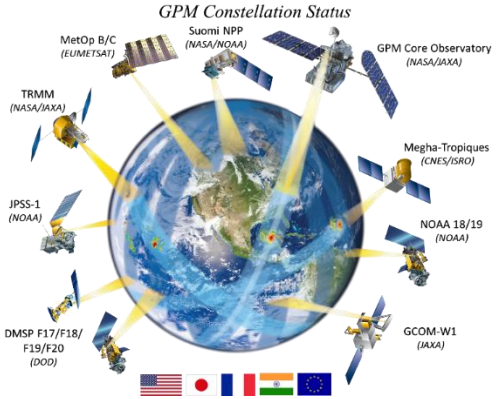


❑ Rainfall estimation from satellite – Instant rain rate (overpass/snapshot)

➢ Level-2

The GPM Constellation

Precipitation characterization



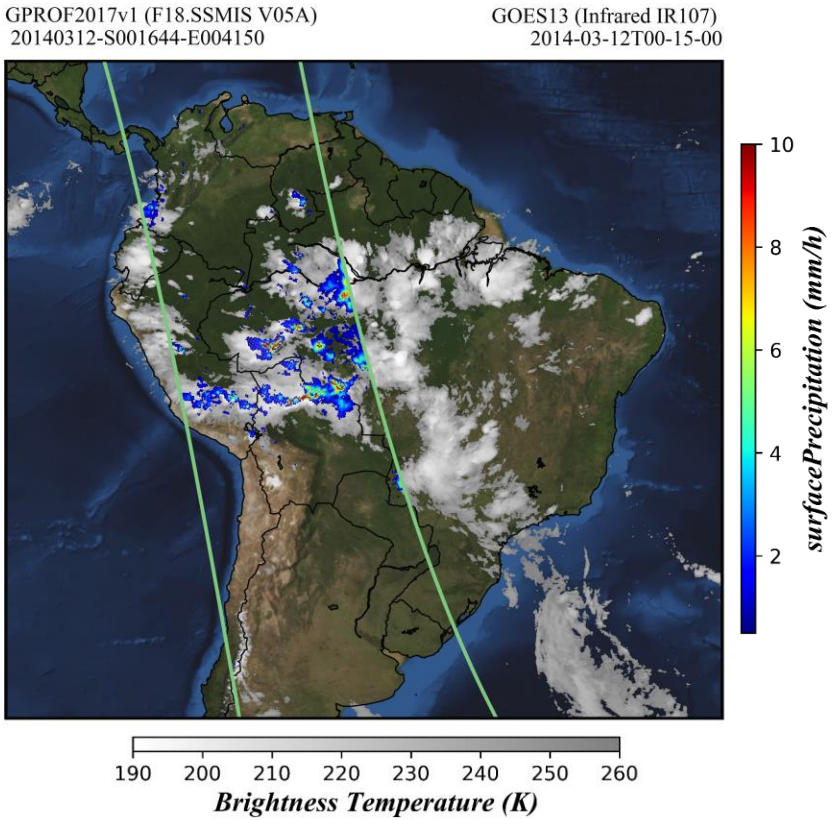
The GPM L2 PMW rainfall estimation algorithms:

- ✓ **Goddard Profiling algorithm (GPROF)**
- ✓ **Precipitation Retrieval and Profiling Scheme (PRPS)**

Algorithm	GPROF					PRPS
Type	Imagers (*Conical scan*)			Sounders (*Cross-track scan*)		
Sensor	SSMIS	AMSRE2	GMI	MHS	ATMS	SAPHIR
Satellite	DMSP-F16, F17, F18	GCOMW1	GPM	NOAA18, 19, METOP-A, B	NPP	MEGHA-TROPIQUES
Channels	19.35-183.31 GHz	6.7-89.0 GHz	10.7-183.31 GHz	89.0-183.31 GHz	23.0-183.31 GHz	183.31 GHz (x6)
Retrieval resolution (km)	45 x 74 (19.35 GHz)	14 x 22 (18.7 GHz)	10.9 x 18.1 (18.7 GHz)	17.1 x 21.6 (at nadir)	16.5 x 16.2 (at nadir)	10 x 10 (at nadir)

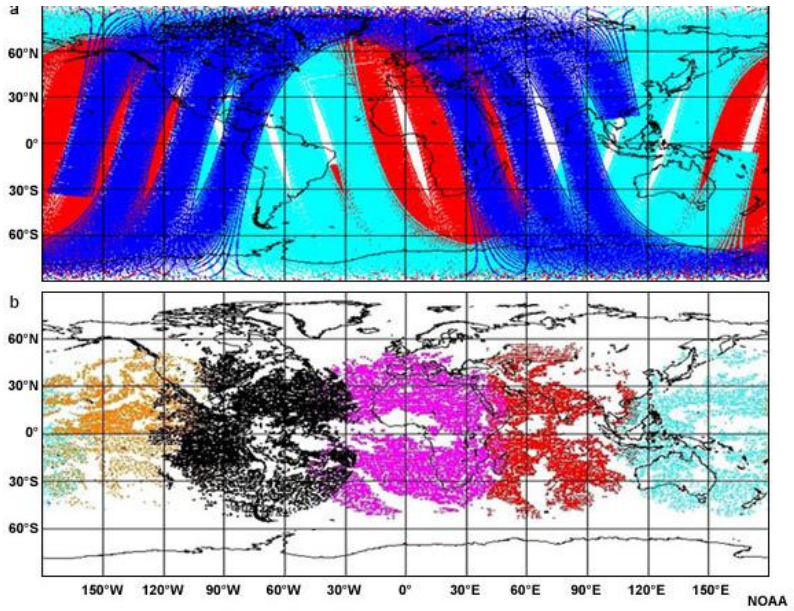
Adapted from Kidd, 2019

Instantaneous observations / Retrievals



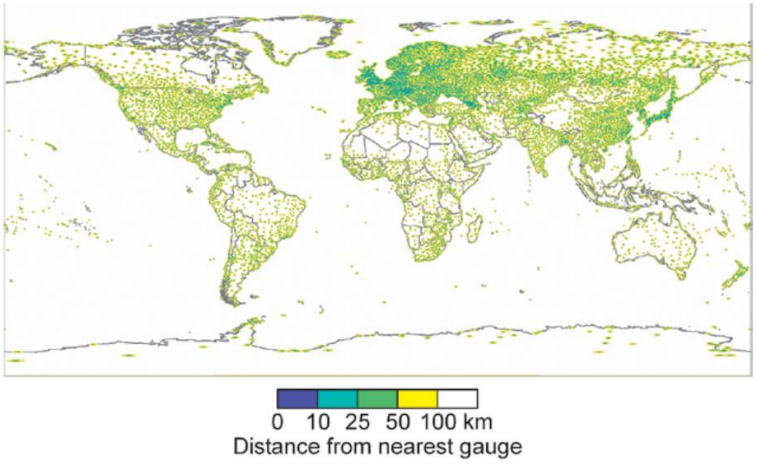
❑ Rainfall estimation from satellite – gridded / regular time step

Level 3-4 - A variety of products based on satellite available ! !



MW+IR Combination

e.g.,:
CMORPH.RAW, IMERG.Early/Late, TAPEER, TMPA RT, GSMaP, PERSIANN, GIRAFE

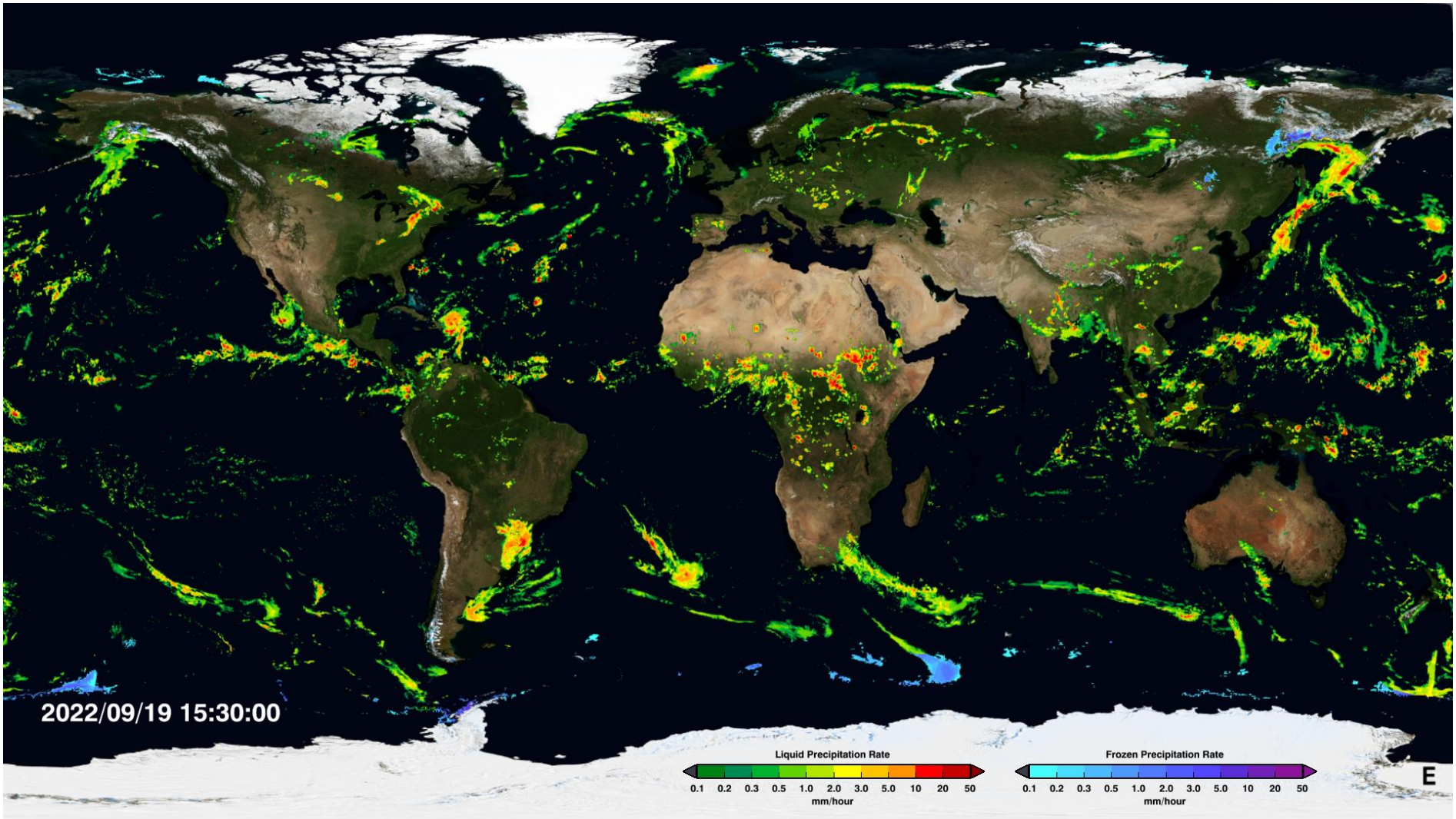


Combination MW+IR
+
Rain-gauges

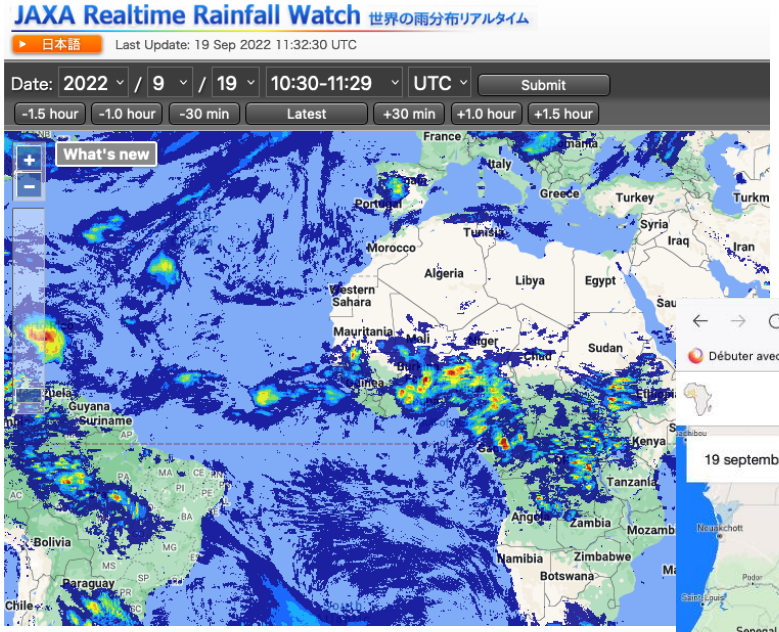
e.g.,:
CMORPH.CRT, IMERG.Final, MSWEP, TMPA V7, GSMap.Gauge.

SATE OF THE ART & CURRENT WORK

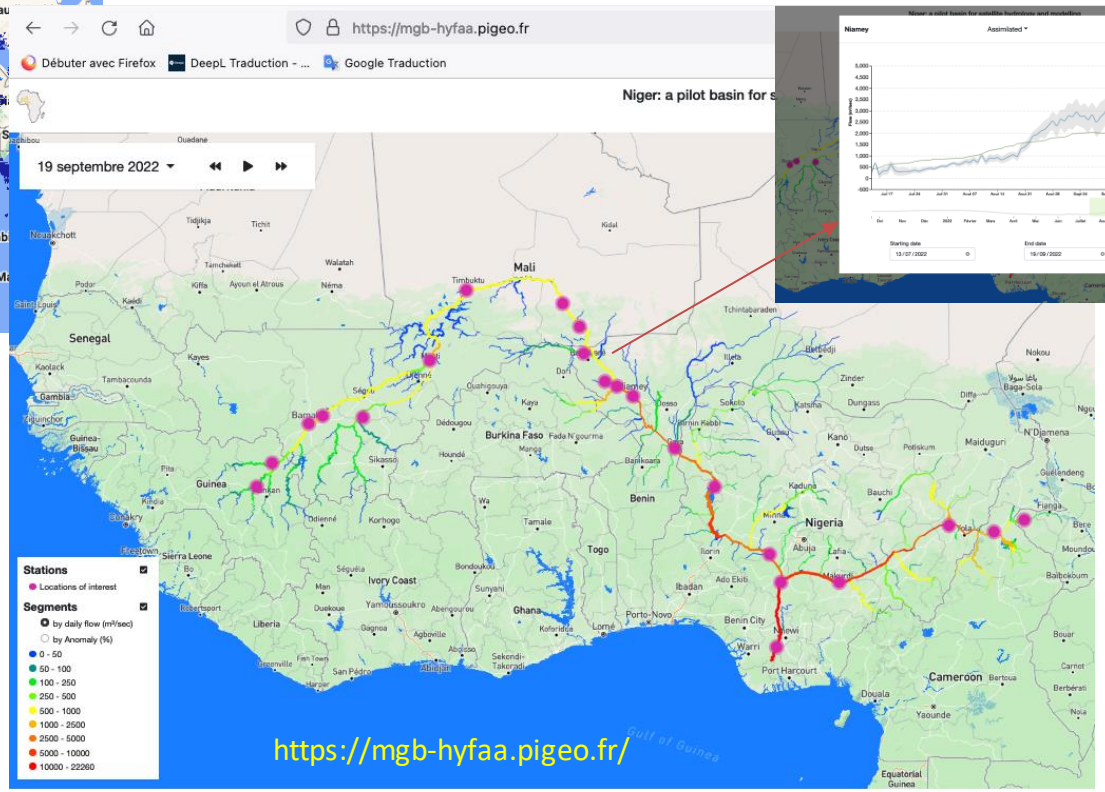
IMERG 10 km/30 minutes

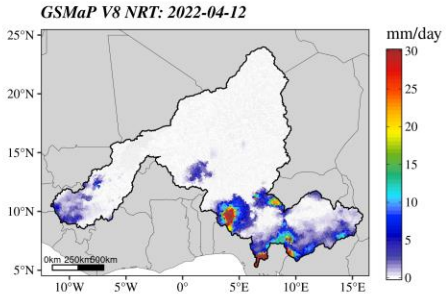


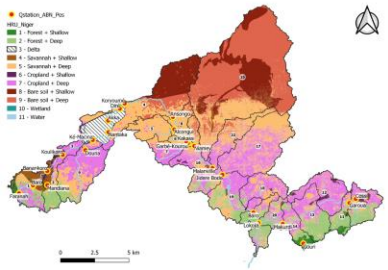
HYDROLOGICAL PREDICTION – FLOOD WARNING

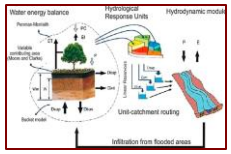


MGB HYFAA NIGER :
Real time demonstrator based on GSMAP_now product + MGB hydro model









Model Hydro MGB Niger : Fleischman et al., 2018. Modelling two-way coupling of hydrologic and hydrodynamic processes in large semi-arid wetlands

With Niger Basin Authority

ANALYSIS OF EXTREME EVENTS - ANOMALIES

Pakistan
2022 monsoon

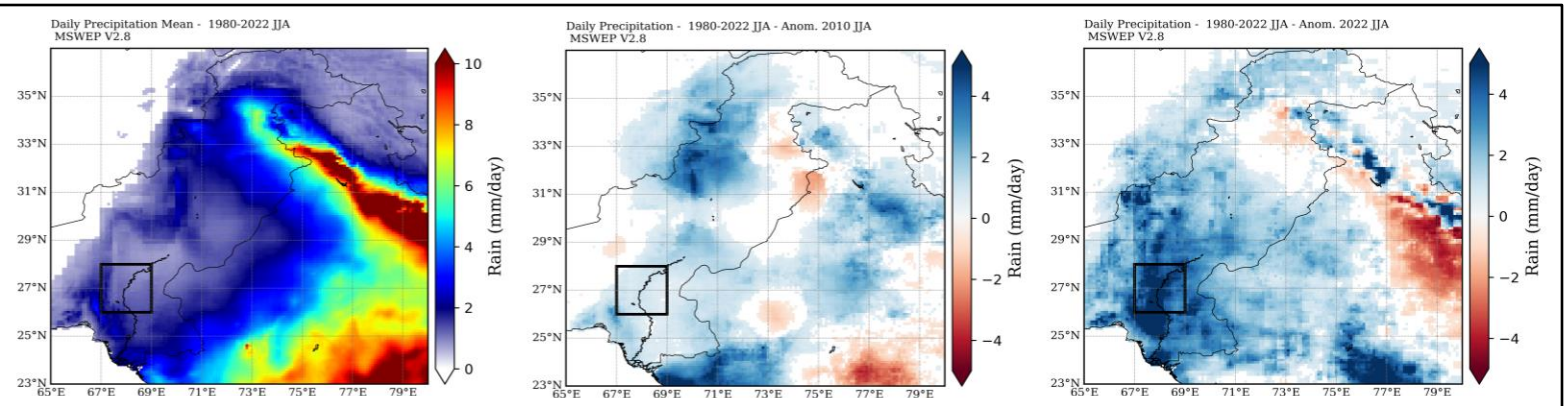
doi: https://doi.org/10.1038/d41586-022-02813-6

➔ 43 years Precipitation analysis over Pakistan (JJA monsoon season)

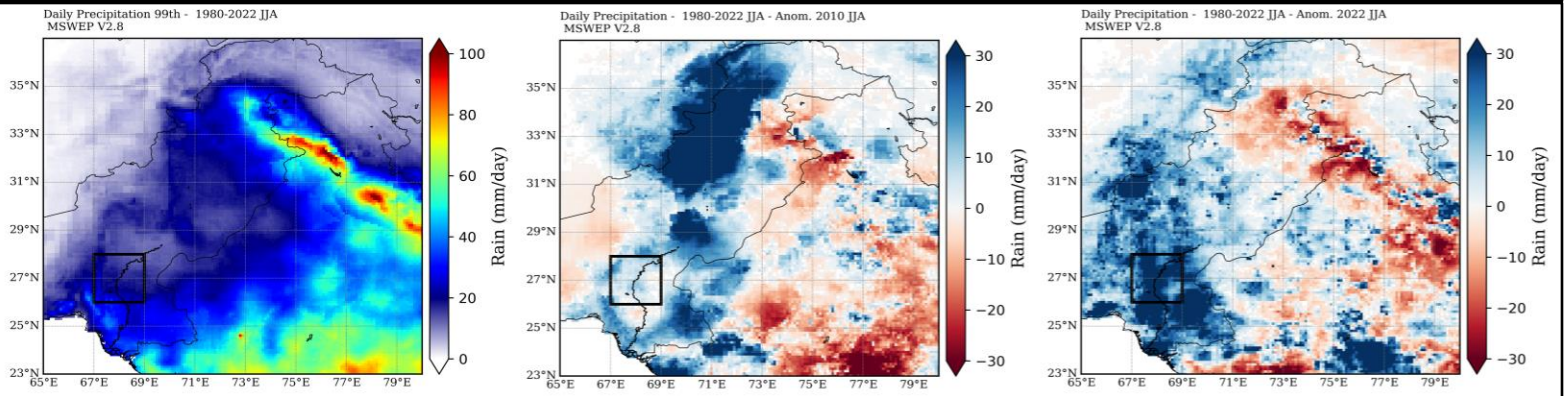
Climatology **Anomaly**

1980-2022 **2010** **2022**

Precipitation Mean



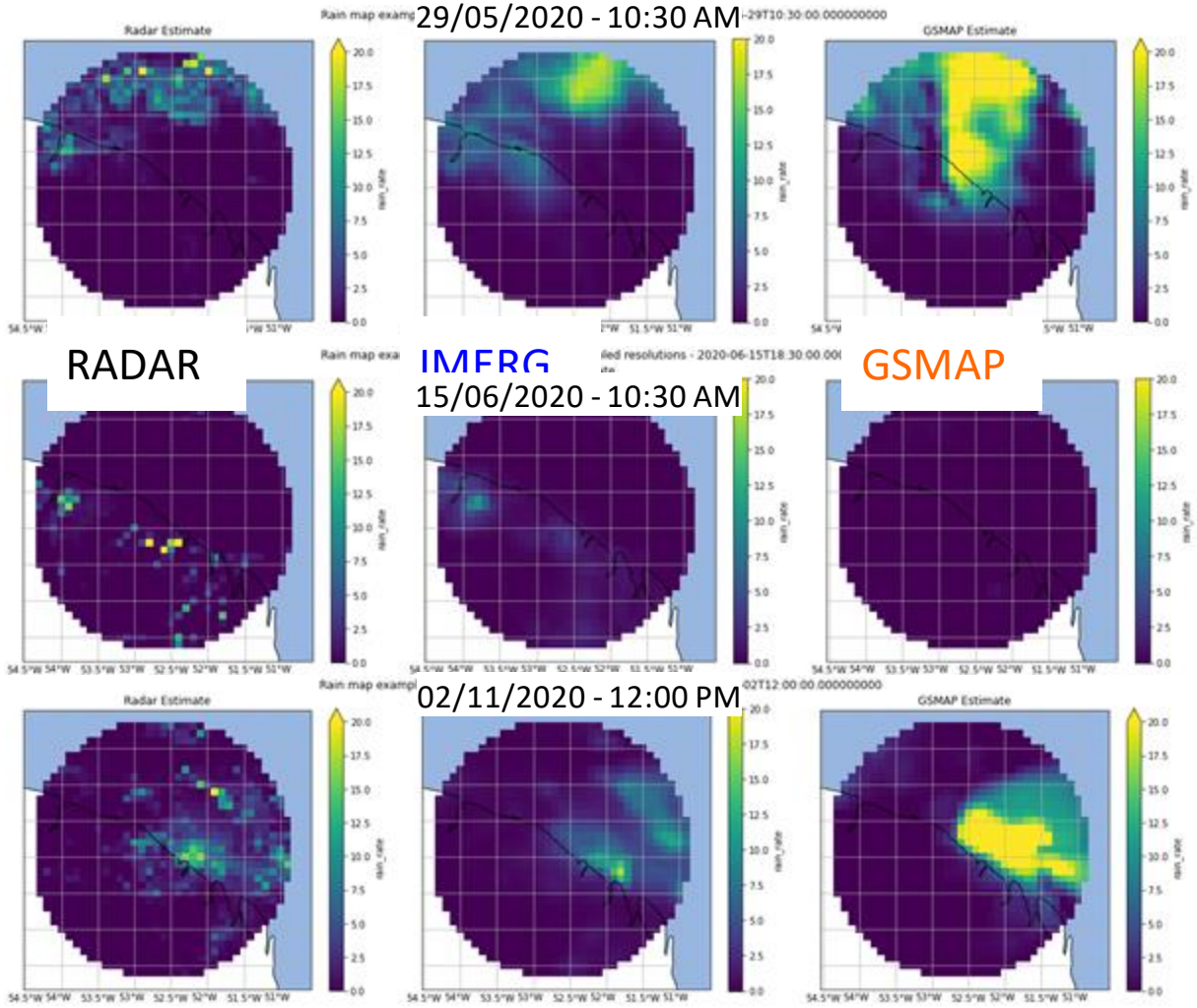
Precipitation 99th (Extremes)



MSWEP V2.8 0.1°/daily precipitation product

QUANTITATIVE ASSESSMENT / VALIDATION ?

Lack of high resolution (kilometric / sub-hourly) and quality checked rain Maps for validation
Especially in the Tropics



Zambrana, Gosset et al. IPWG 2022
Assessment of high resolution products against weather radar in French Guyana

Analysis:

- Coherent to the naked eye
- Satellite estimates are smoother
- Spotty, high intensity rain very difficult to see with satellite
- Differences among algorithms (GSMAP / IMERG same input data …)

❖ Take home messages

❑ **Rainfall Estimation from Satellite – Significative Evolution since the early days**

- Initial estimates (70's-80's) based on IR Only ; Much more information relevant to rainfall/hydrometeors with microwave (passive and active) since the 90's - TRMM and GPM (with MT for Tropics) in particular in the 21st century.
- Algorithms greatly improved thanks to better understanding of the microphysics – Combination with models (Bayesian approach ; assimilation etc..)

❑ **Current limitations**

- Products still uncertain at their highest resolution – Ok at 50 km/3h (cf Guillotau et al.)
- Real time / Mountainous regions / coastal areas (warm rain) still need improvement
- Assessing the uncertainties in the Tropics still difficult because of lack of GV / QPE at the required resolution.

❑ **Perspectives**

- Improve/enhance input information : newspace / constellations of small MW satellite and Active MW sensors ; new sensors in Geostationary (lightning) ; Analyse dynamics.
- Progress in high-resolution numerical Weather model /microphysics ->assimilation/merging
- New algorithms based on IA
- Merge with new source of information (telecommunication networks / Citizen observations)

Online resources :

http://ipwg.isac.cnr.it

Thank you
Merci - Obrigado

romulo.oliveira@hydro-matters.fr
Marielle.Gosset@ird.fr

20/Sept/2022