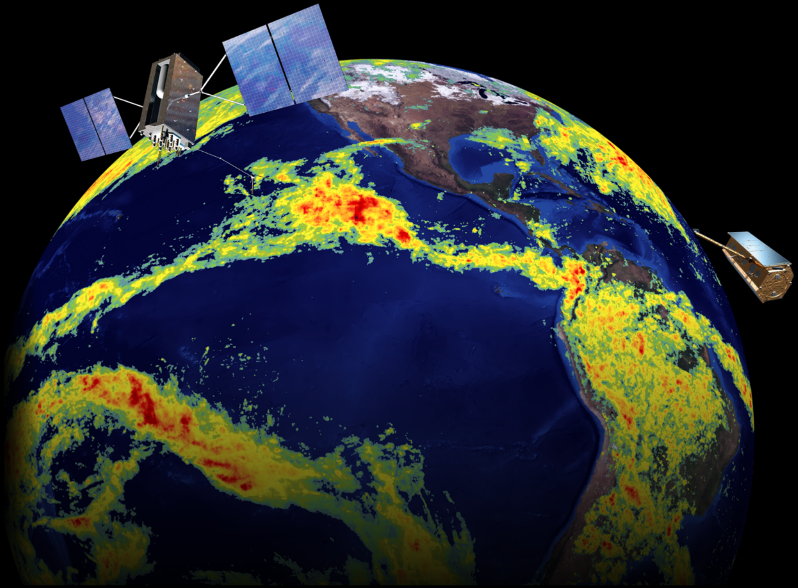
Calibration and Validation of the Polarimetric ROHP - PAZ experiment and potential scientific applications



Ramon Padullés[1*], F. Joe Turk[1], Chi O. Ao[1], M. de la Torre[1], Kuo-Nung Wang[1], Byron Iijima[1], Estel Cardellach[2]

[1] Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA
* NASA Postdoctoral Program (NPP) fellow, USRA
[2] Institut de Ciències de l'Espai, ICE, CSIC, IEEC, Barcelona

Jet Propulsion Laboratory
California Institute of Technology

Outline

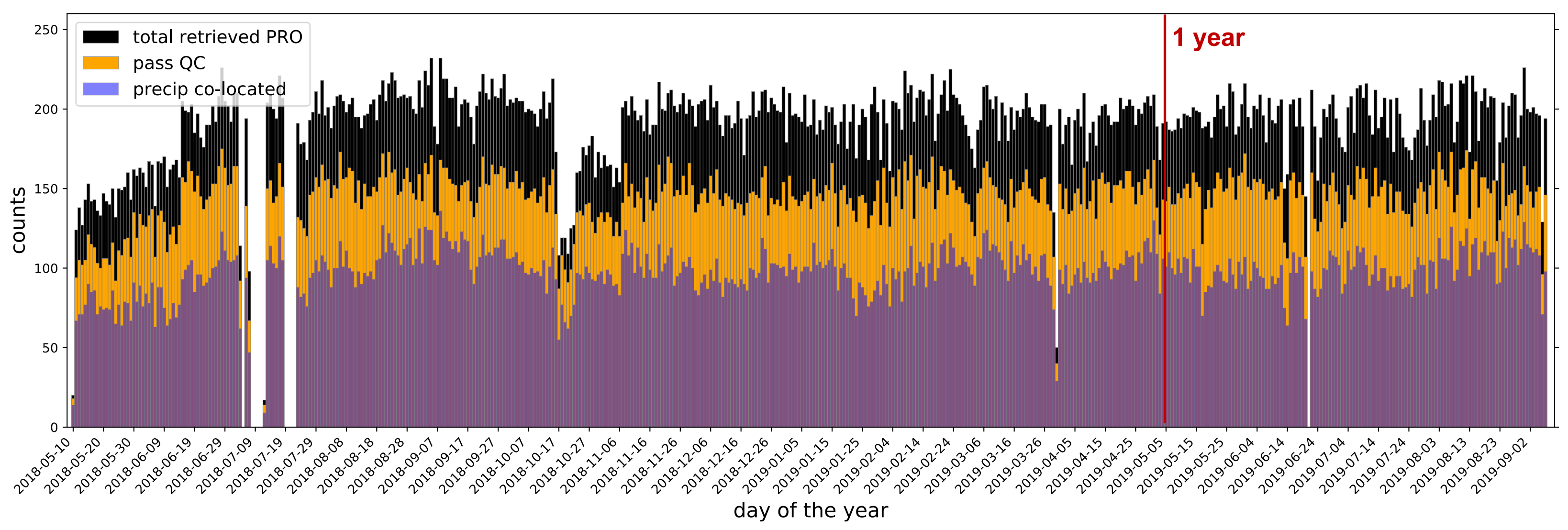
1. Calibration of the ROHP PAZ experiment data

2. Validation with GPM products

3. Vertical structure of precipitation

Status processing at JPL

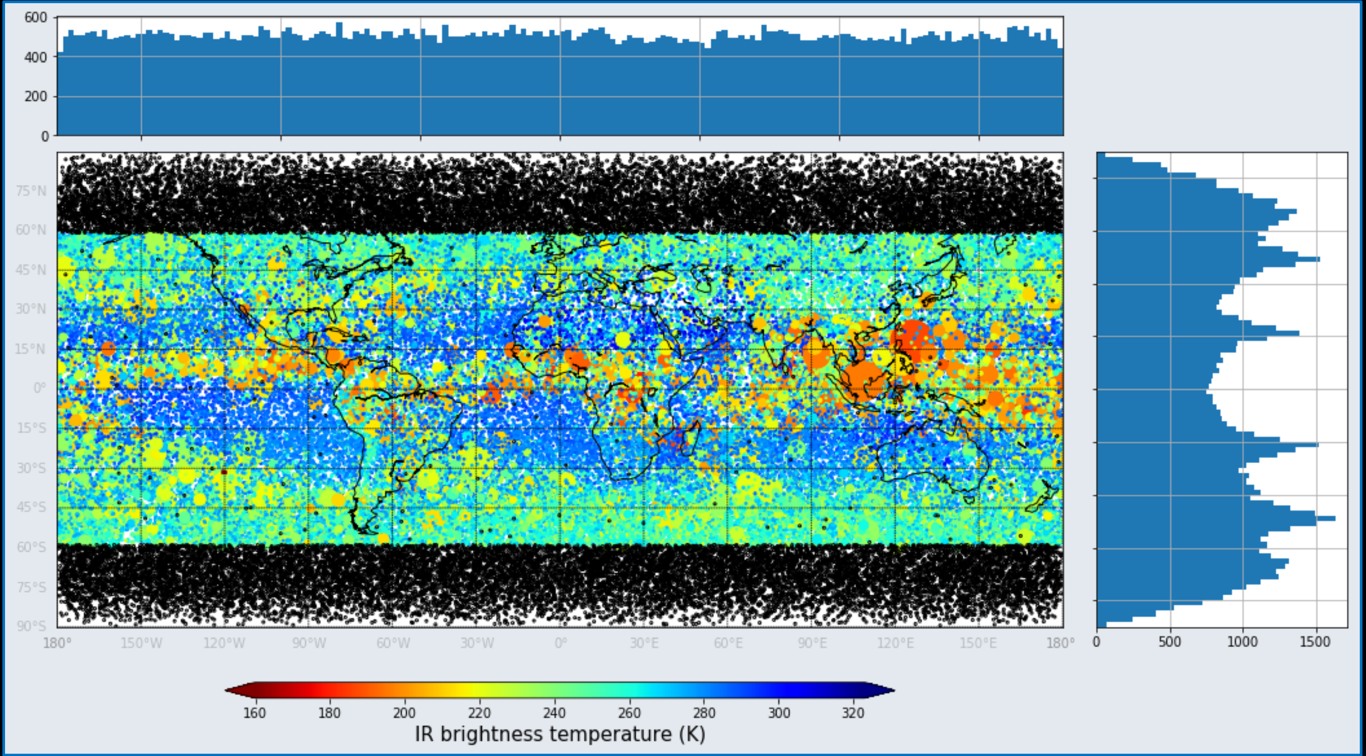
Total number of processed Polarimetric ROs [up to 2019 – 09 – 07]



Total number of processed profiles: 90,864
Total gone through QC: 71,302
Precipitation information (surface): 49,315

Status processing at JPL

Total number of processed Polarimetric ROs [up to 2019 – 09 – 07]



Calibration of ROHP PAZ data

Calibration strategy

- A metallic structure was introduced to adapt the satellite to the launch vehicle. Partially blocks the antenna & introduces multipath

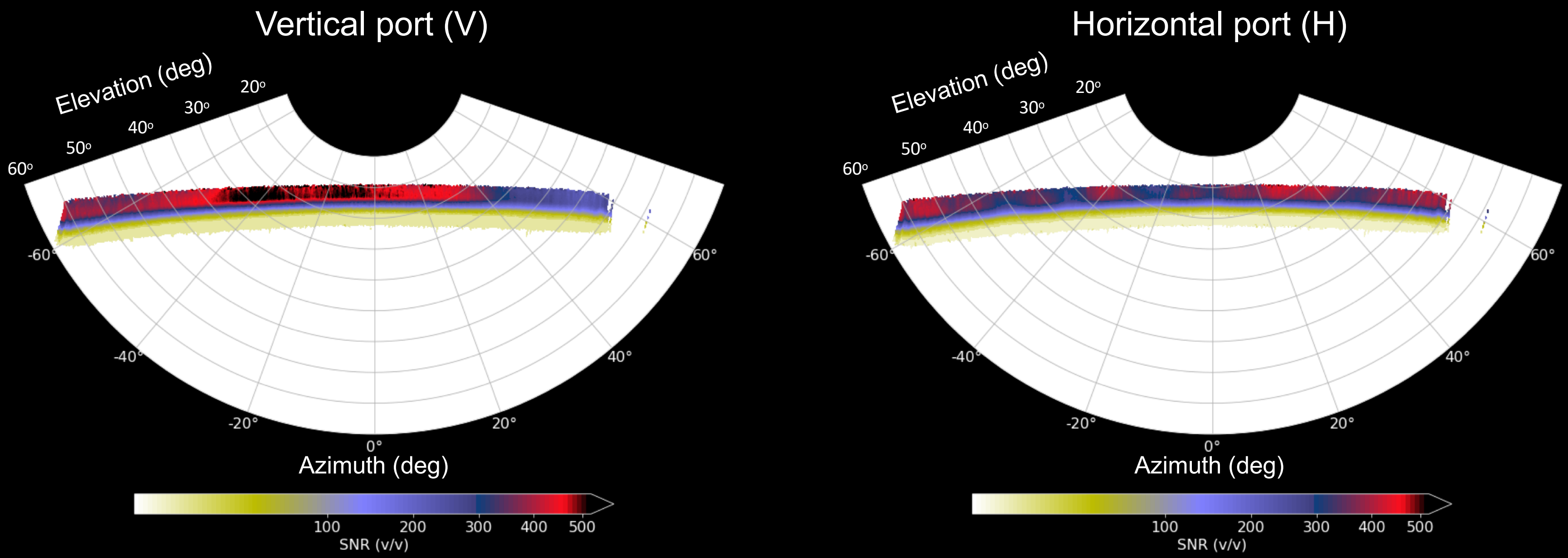
- On-orbit calibration required: accumulation of free of rain observations to build an antenna pattern

- Precipitation information (**surface** rain rate and brightness temperature) from the GPM (Global Precipitation Mission) IMERG products: global +-60deg latitude, every 30 min, high spatial resolution, products from MW and IR precip retrievals

Padullés et. al, 2019, doi.org/10.5194/amt-2019-237, *in review*

Calibration of ROHP PAZ data

Signal to Noise pattern



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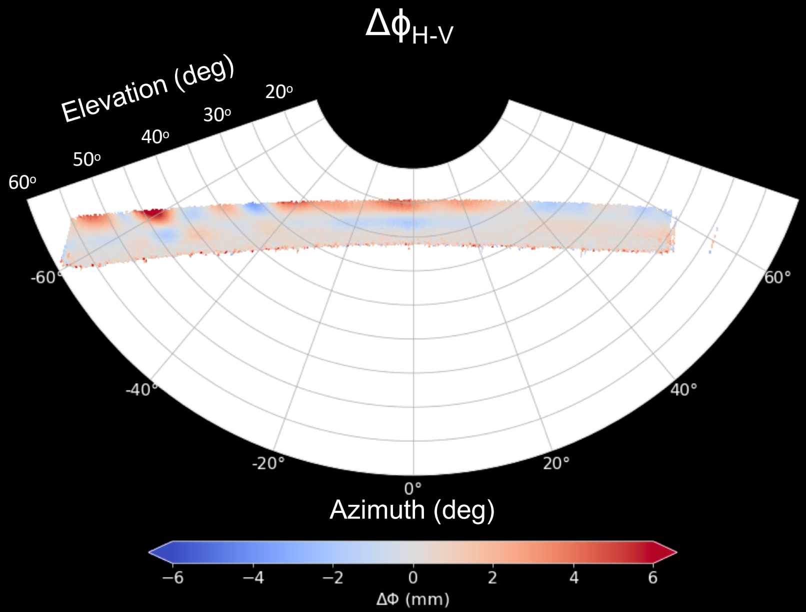
Calibration of ROHP PAZ data

Differential phase shift pattern



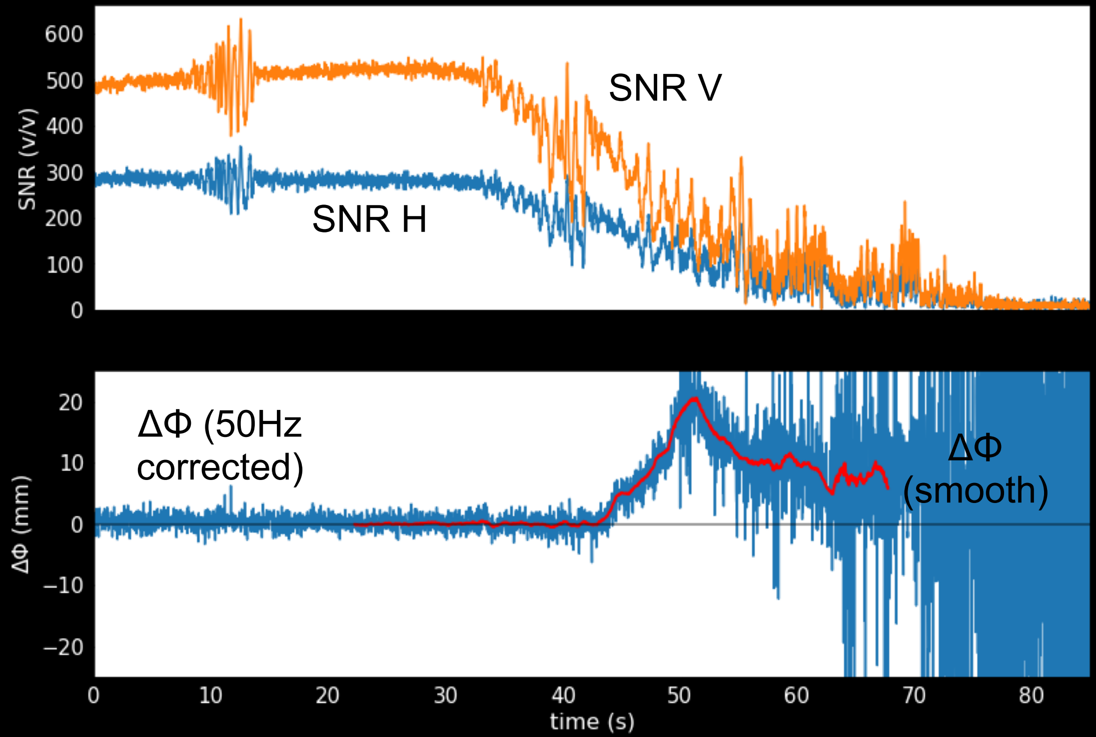
Antenna pattern created using observations with no rain

The rest of the data is corrected using this antenna pattern

Padullés et. al, 2019, doi.org/10.5194/amt-2019-237, *in review*

Calibration of ROHP PAZ data

Using the antenna pattern to correct the measurements



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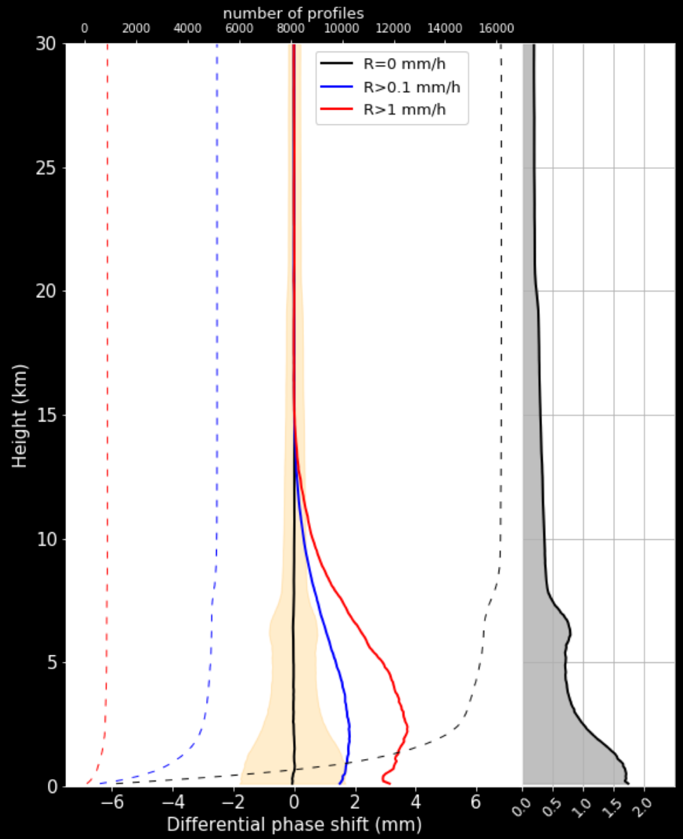
Calibration of ROHP PAZ data

Calibrated differential phase shift

- Calibration using on orbit antenna patterns offer good results:
  - No biases
  - Standard deviation comparable to previous sensitivity studies
  - Data within precipitation regions exhibit a large positive signature well above $\sigma_{\text{no rain}}$
- The stronger the rain, the larger the signature
- Bump around 7-8 km: closed loop -> open loop transition? [under investigation]



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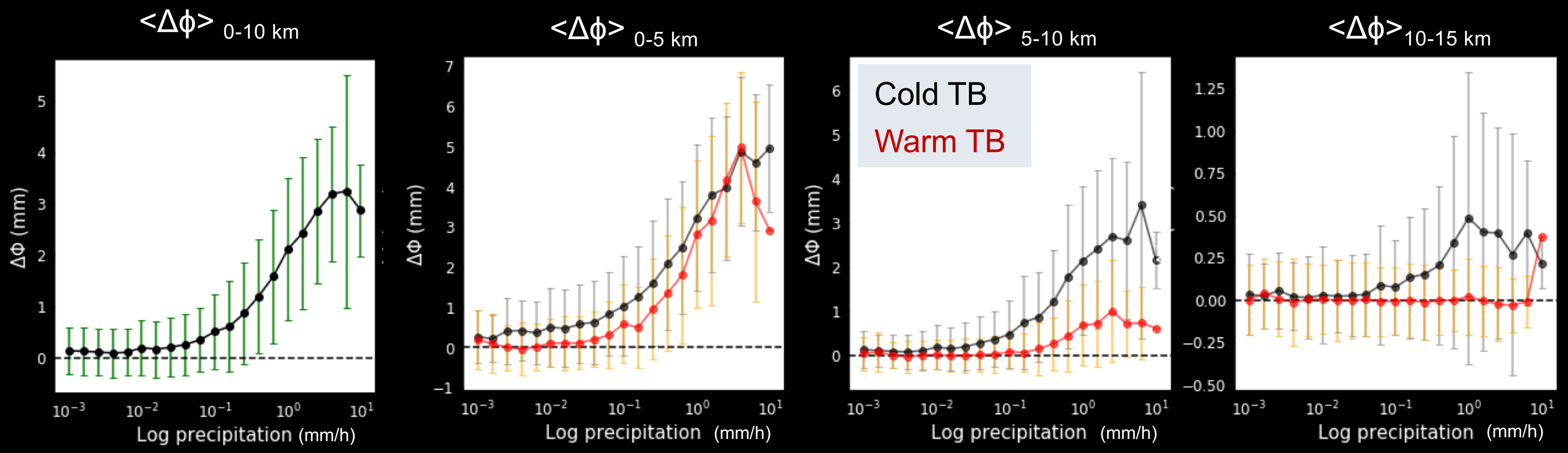
Validation with GPM products

Validation of ROHP PAZ data

Sensitivity to precipitation intensity

Each observation is linked to a measure of Δϕ

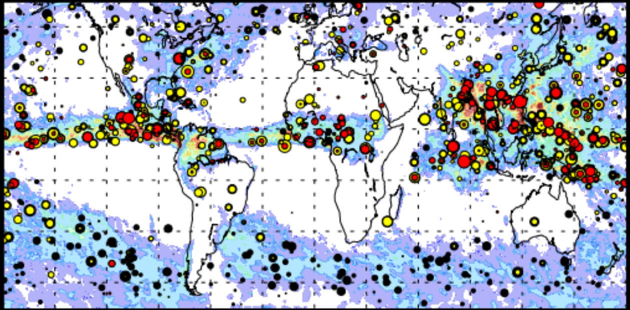
- <Δϕ> 0-10 km
- <Δϕ> 0-5 km
- <Δϕ> 10-15 km
- <Δϕ> 5-10 km



Validation of ROHP PAZ data

Vertical structure of Δϕ: geographical distribution of the top percentile

Jun Jul Aug

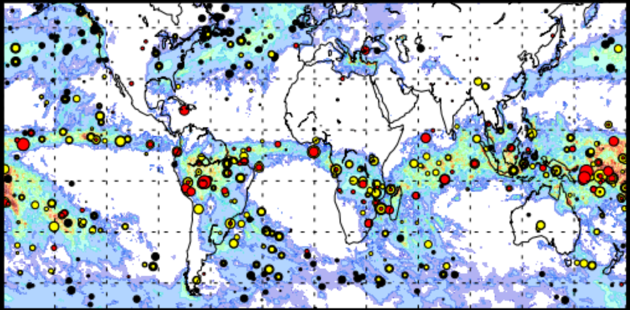


<Δϕ> 0-5 km

<Δϕ> 5-10 km

<Δϕ> 10-15 km

Dec Jan Feb



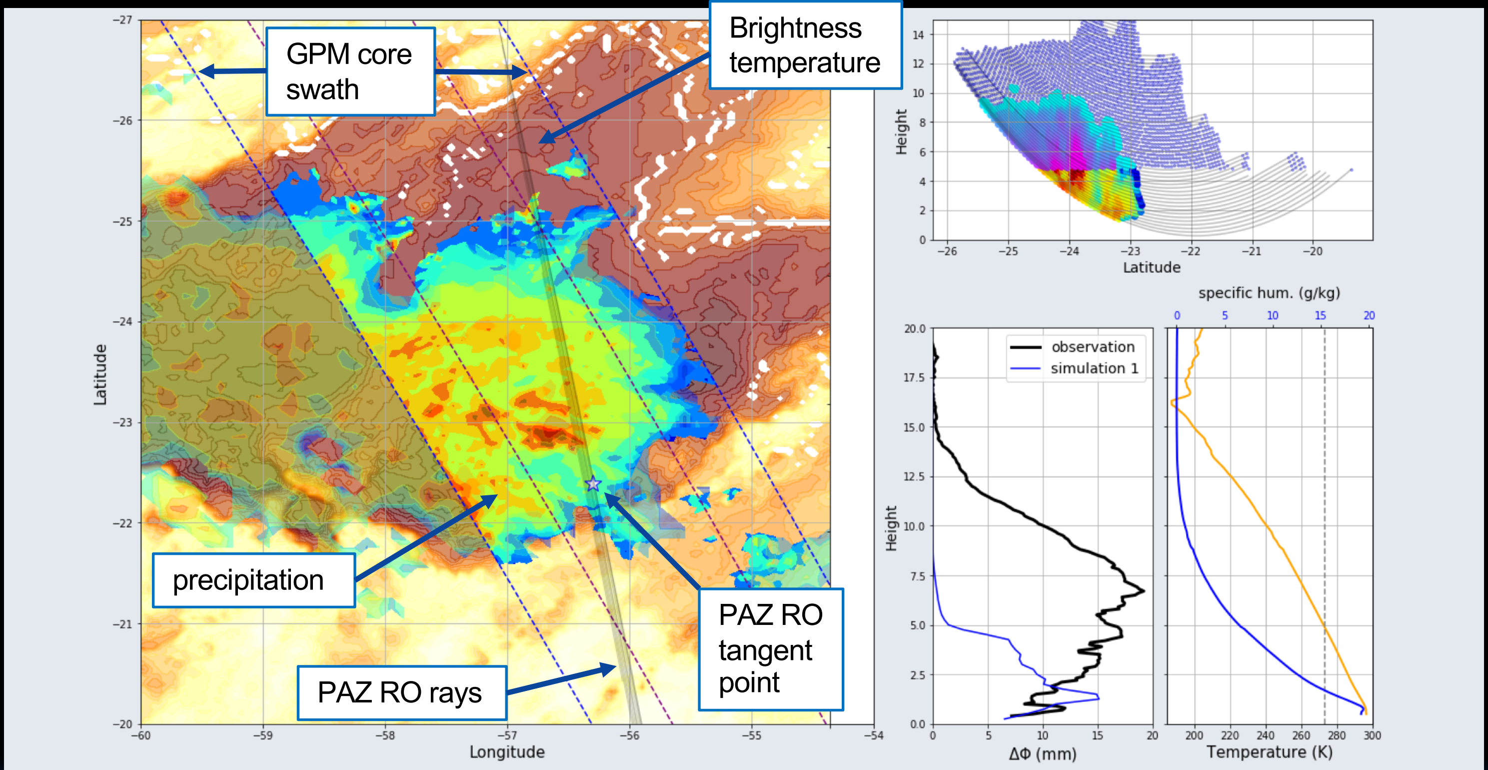
Background: accumulated precipitation from GPM for the same months

- Agreement of <Δϕ> with precipitation climatologies
- Agreement with vertical structures:
  - Sensitivity above 10 km only in deep convective regions
- Strong precipitiation in the lower layers not restricted to tropics

Investigation of the vertical structure

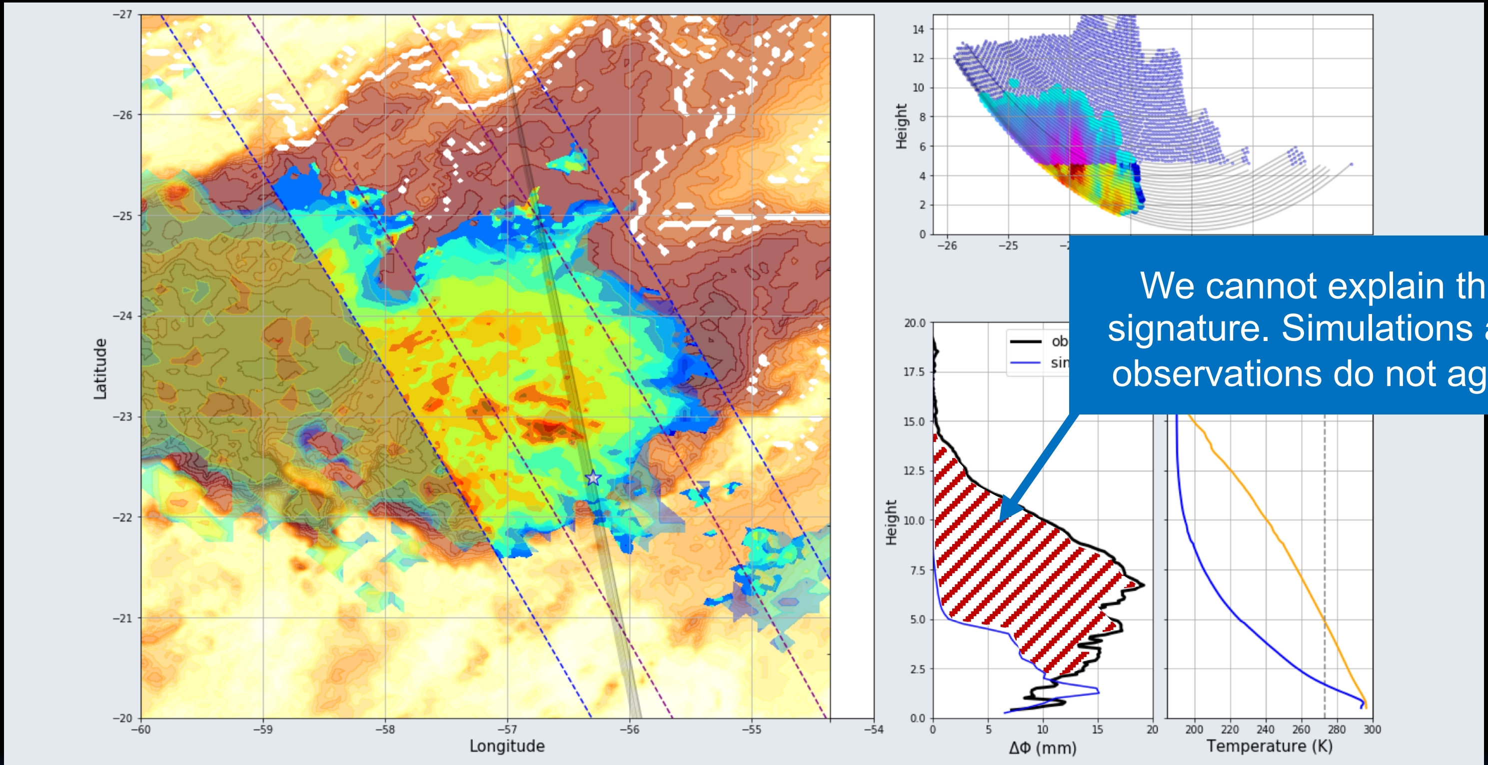
Validation of ROHP PAZ data

Colocations with GPM core radar



Validation of ROHP PAZ data

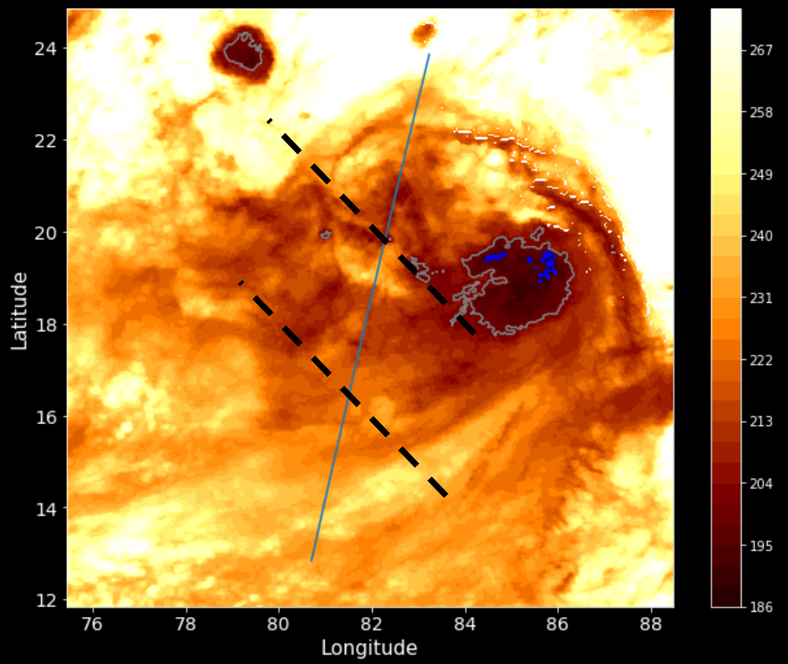
Colocations with GPM core radar

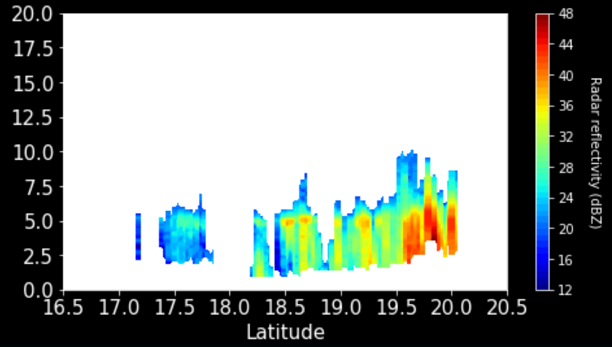


We cannot explain this signature. Simulations and observations do not agree

Validation of ROHP PAZ data

Vertical structure of precipitation: colocations between TRMM and CLOUDSAT

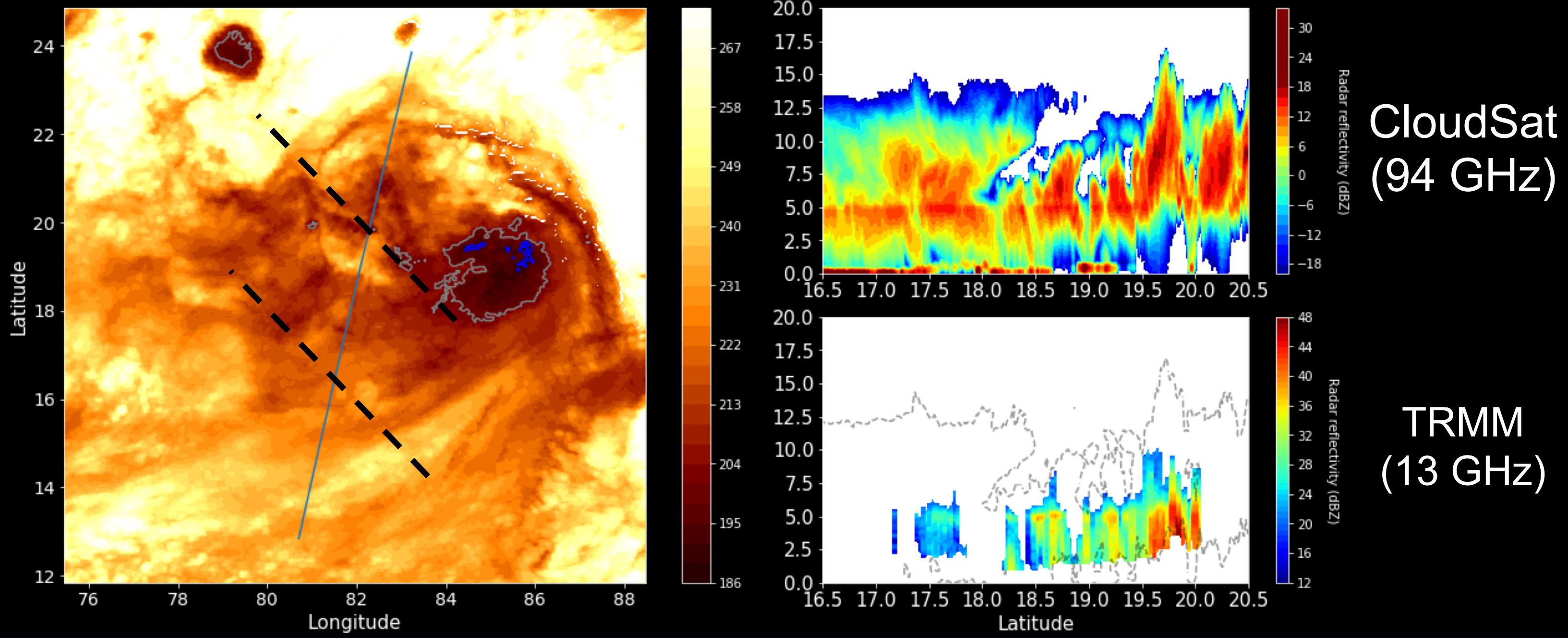




TRMM
(13 GHz)

Validation of ROHP PAZ data

Vertical structure of precipitation: colocations between TRMM and CLOUDSAT



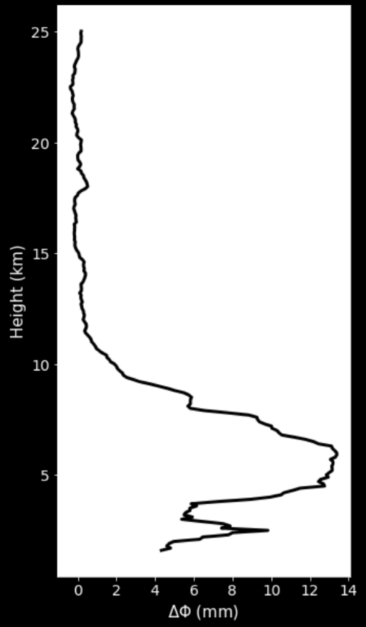
Validation of ROHP PAZ data

Vertical structure of precipitation: colocations between TRMM and CLOUDSAT

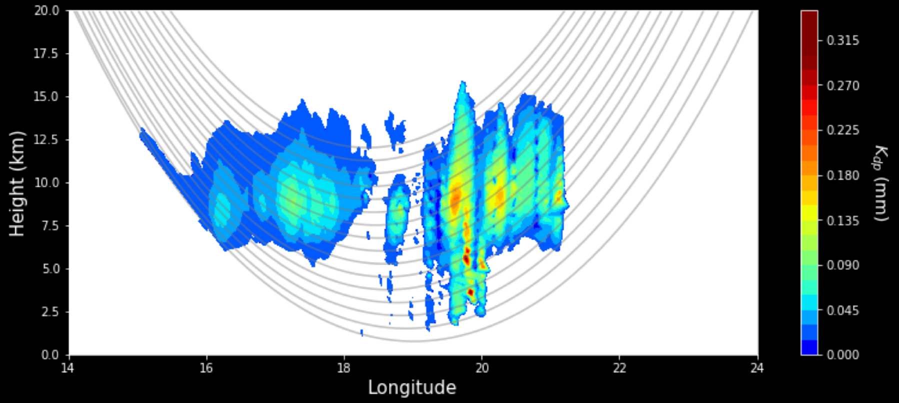
Pseudo-colocations: we look for the most similar PAZ profile based on:

- Temperature profile
- Specific humidity profile
- Brightness temperature
- Column water vapor

PAZ profile



TRMM – CoudSat retrievals are used to simulate the Kdp using forward scattering techniques



Validation of ROHP PAZ data

Vertical structure of precipitation: colocations between TRMM and CLOUDSAT

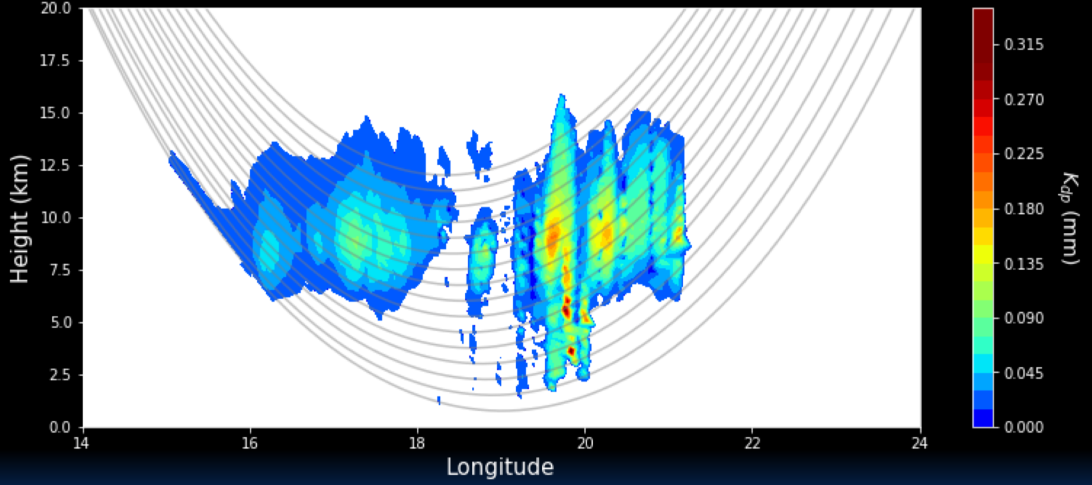
- Drop Size Distribution *N(D)* from TRMM and Csat retrievals
- Temperature profile from ECMWF
- Water drops: T-Matrix method
- Ice particles simulations: forward scattering simulations using Discrete Dipole Approximation method

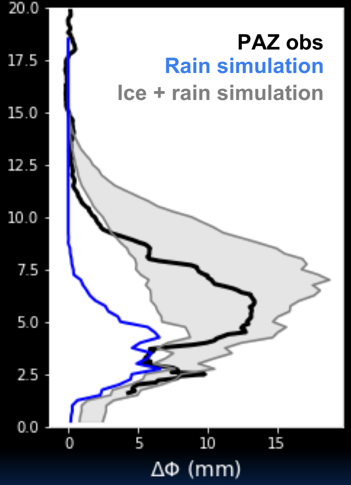
- Orientation of ice particles?
  - Two different vertical profiles of % of oriented particles

From top of cloud to freezing level

- 0 -> 25 %
- 0 -> 75 %

Gray shade





Validation of ROHP PAZ data

Vertical structu ... UDSAT

- Drop Size Distri ... ticles?
- Temperature pr ... ertical profiles
- Water drops: T- ... d particles
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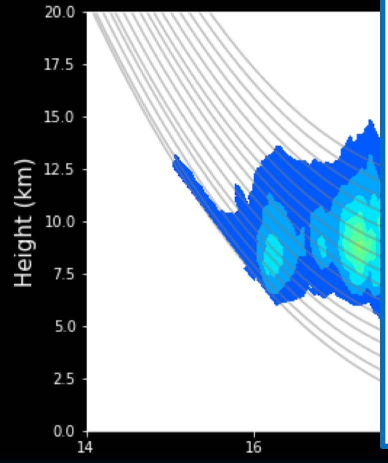
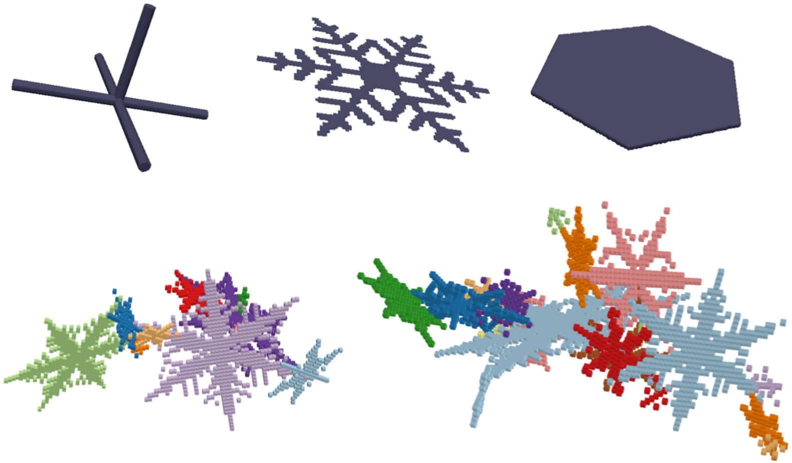


Examples of realistic ice particles used in the simulations



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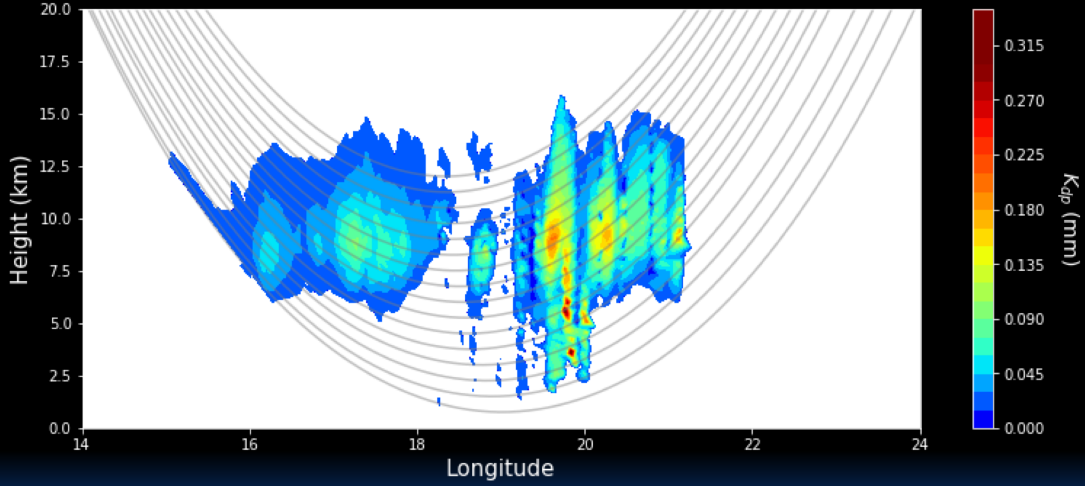
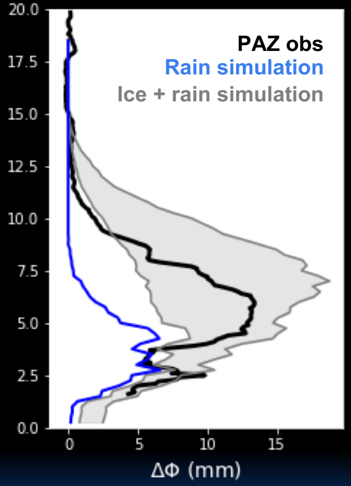
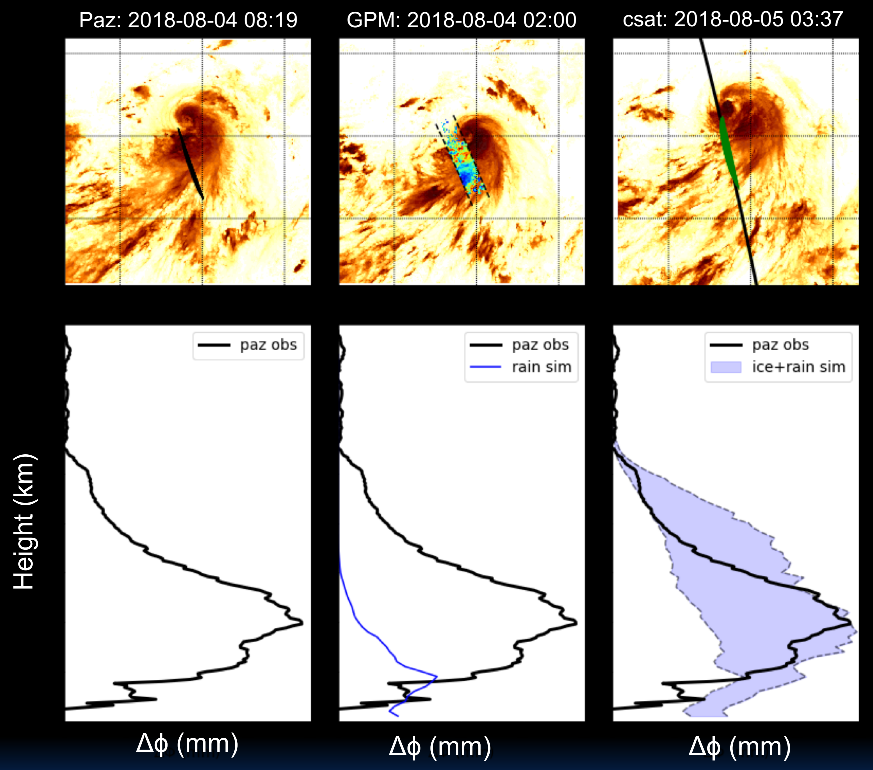




Validation of ROHP PAZ data

Vertical structure of precipitation: Observations at different times



- Observation of the same event, although with significant time difference
- Simulations including ice can explain the observed signal (with caution), at least qualitatively
- Demonstration that ice particles are inducing a significant contribution to <Δϕ>

Conclusions

- PAZ has been in orbit for more than one year already. It has provided more than 90,000 polarimetric RO
- On-orbit calibration has been proven useful to correct for biases and artifacts in $\Delta\phi$
- The dispersion in $\Delta\phi$ agrees with previous sensitivity studies
- $\Delta\phi$ shows sensitivity to precipitation intensity and agrees well with rain climatologies
- The vertical structure of $\Delta\phi$ correlates with deep convective events, showing the ability to sense whole vertical precipitating structures
- Realistic simulations of ice particles show that $\Delta\phi$ is also sensitive to ice

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