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

Ramon Padullés*¹, F. Joe Turk¹, Chi O. Ao¹, M. de la Torre¹, Kuo-Nung Wang¹, Byron Iijima¹, Estel Cardellach²

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

© 2019 All rights reserved
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

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

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

Padullés et. al, 2019, doi.org/10.5194/amt-2019-237, in review
Validation with GPM products
Validation of ROHP PAZ data

Sensitivity to precipitation intensity

Each observation is linked to a measure of $\Delta \phi$

$<\Delta \phi>$ 0-10 km

$<\Delta \phi>$ 0-5 km

$<\Delta \phi>$ 10-15 km

$<\Delta \phi>$ 5-10 km

Cold TB

Warm TB
Validation of ROHP PAZ data

Vertical structure of $\Delta \phi$: geographical distribution of the top percentile

During Jun Jul Aug

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

Background: accumulated precipitation from GPM for the same months
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
Validation of ROHP PAZ data

Vertical structure of precipitation: colocations between TRMM and CLOUDSAT

CloudSat (94 GHz)
TRMM (13 GHz)
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

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

Examples of realistic ice particles used in the simulations

Gray shade
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 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 $\langle \Delta \phi \rangle$
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