The ROHP-PAZ research dataset and applications

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(1) Abstract

Polarimetric Radio Occultations (PRO) represent an augmentation of the standard Radio Occultation (RO) technique that **provides precipitation and clouds vertical information along with the standard thermodynamic products**. A combined dataset that contains both the PRO observable and the corresponding RO standard retrievals produced at UCAR has been developed with the aim to foster the use of these unique observations and to fully exploit the scientific implication of having information about vertical cloud structures with intrinsically collocated thermodynamic state of the atmosphere. Following UCAR file name convention, we have called these new comprehensive files **resPrf (doi:10.20350/digitalCSIC/16137)**.

One of the strengths of the dataset is that it also contains the **simulated ray-trajectories** for the PRO observation, and **co-located information with global satellite-based precipitation products**, such as merged rain rate retrievals or passive microwave (PMW) observations. These co-locations are used for further validation of the PRO observations and they are also provided within the resPrf profiles for additional use.

(2) Dataset description

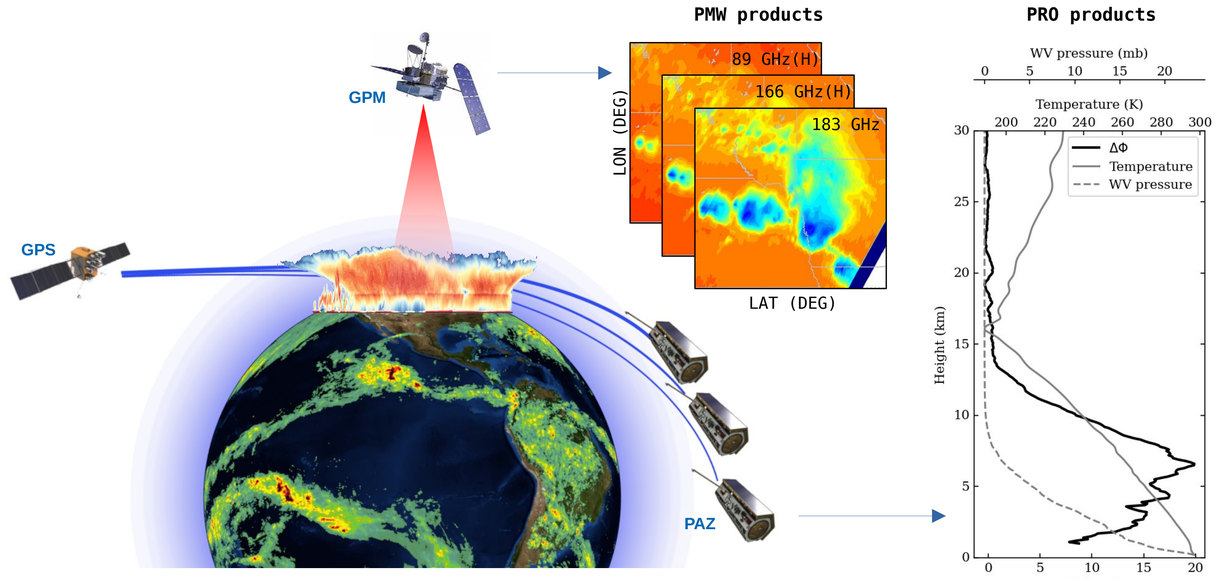

Figure 1. Sketch with the PRO geometry and the coincidence with PMW, and the corresponding products.

The resPrf dataset is freely available at **https://paz.ice.csic.es** and contains these main products:

- **Vertical profiles of Δϕ** along with the UCAR's wetPf2 **standard RO retrievals** (Refractivity, temperature, pressure and water vapor pressure).
- **Simulated ray trajectories coordinates (lat, lon, hei)** that account for GPS and LEO position, and bending.
- GPM IMERG surface rain rates, and Infrared (IR) Brightness Temperatures (Tb) interpolated into the lat-lon projection of the ray trajectories.
- GPM constellation PMW radiometers Tb interpolated into the lat-lon projection of the ray trajectories.

These provide a complete dataset that allows for scientific applications and validation, with the proper **context** of the precipitation condition in the surroundings of each PRO event.

The provided ray trajectories coordinates facilitate interpolation with other products such as NWP model outputs for testing and development of 2D Forward Operators.

(3) Assessment of the standard RO products

PRO observables at H and V can be combined and the RHCP – equivalent retrievals can be obtained.

Comparisons with other RO missions show that the resulting retrievals are of equivalent quality as the standard RO retrievals.

This also depends on the antenna configuration that each mission implements. For example, Spire has shown an improvement with the H, V combination with respect to the standard RHCP configuration.

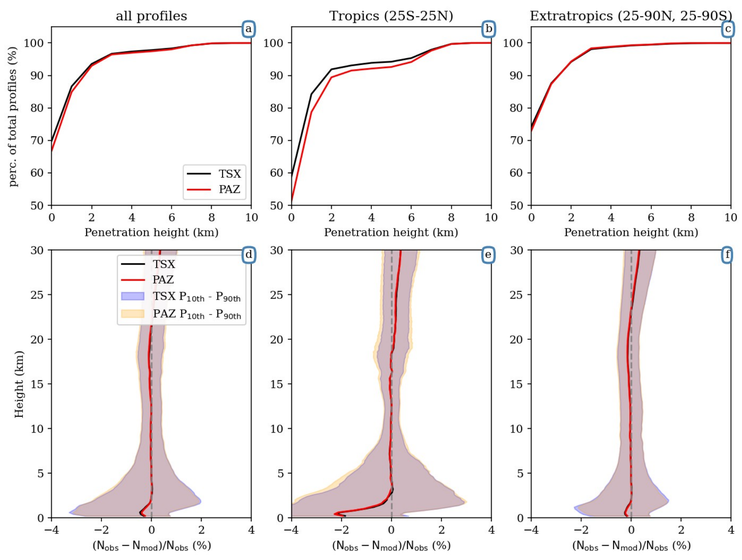

Figure 3. (Top) penetration depth and (bottom) fractional difference with respect to ECMWF of refractivity obtained from PAZ combining the H and V observables, compared with refractivity retrievals from TerraSar-X (TSX) during the same time period.

(4) PRO Horizontal resolution

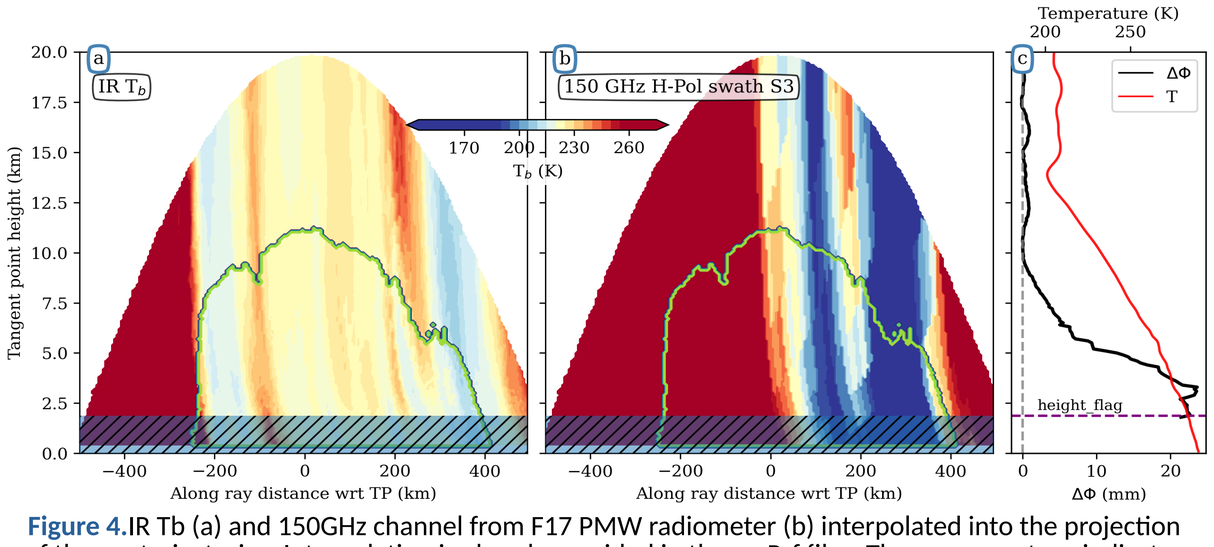

Figure 4. IR Tb (a) and 150GHz channel from F17 PMW radiometer (b) interpolated into the projection of the ray trajectories. Interpolation is already provided in the resPrf files. The green contour indicates where the rays are inside cloud according to the IR Tb matched with the temperature profile (c) retrieved by PAZ.

The along-ray horizontal resolution of PRO is coarse, since anything along the ray can contribute equally to Δϕ. However, clouds and precipitation are expected below ~15-18 km. The height of the cloud top determines the horizontal resolution if no other information is available.

The horizontal resolution of a ray with a tangent point at 5km, assuming a cloud top height of 14 km is ~700km.

Having the high frequency Tb from the radiometer observations (e.g. >90GHz) and the IR Tb interpolated into the ray trajectories provides information on **which portions of the rays are actually inside clouds, and therefore the horizontal resolution can be further constrained**.

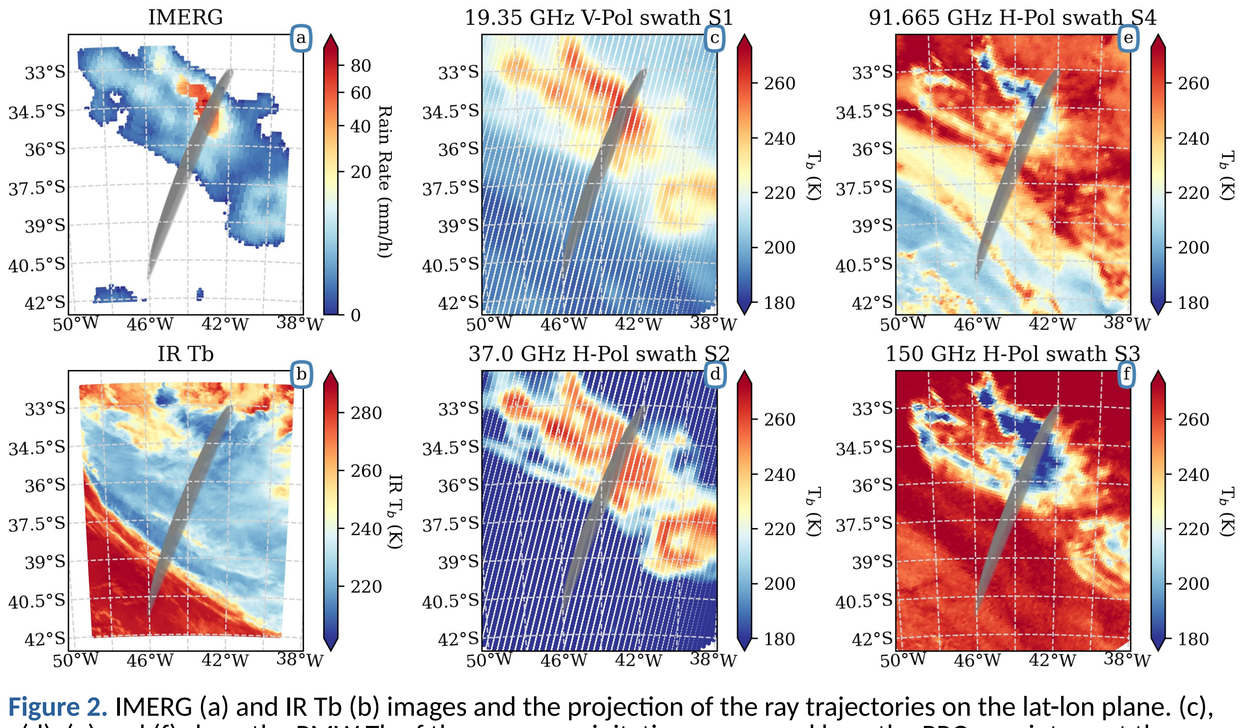

Figure 2. IMERG (a) and IR Tb (b) images and the projection of the ray trajectories on the lat-lon plane. (c), (d), (e) and (f) show the PMW Tb of the same precipitation scene, and how the PRO rays intersect them.

(5) Cloud top height (CTH) determination from Δϕ

PRO observable Δϕ is sensitive to horizontally oriented frozen hydrometeors that form convective clouds. If a majority of the hydrometeors forming these clouds are oriented, the top of the signal (TOS) of Δϕ(*h*) must relate to the actual CTH.

The TOS is defined as the height where Δϕ(*h*) exceeds a threshold:

$$\text{thresh} = m_{\Delta\Phi} + 3 \times SD_{\Delta\Phi}$$

It correlates well with the IR Tb inferred CTH, with a small bias attributed to the fact that PRO uses L-band (much lower frequency than IR).

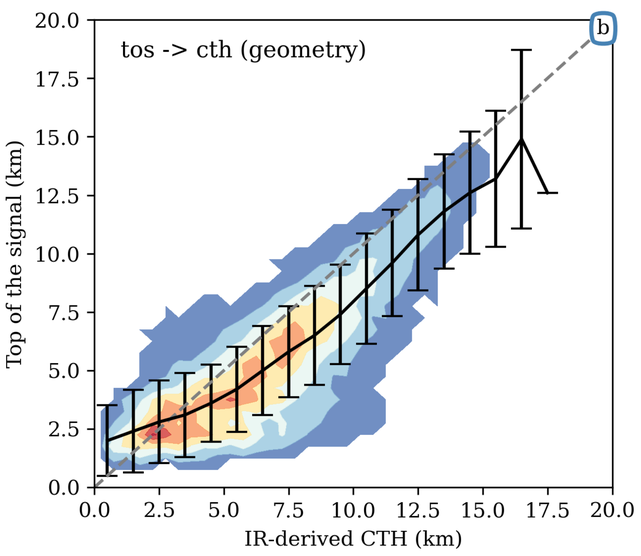

Figure 5. CTH derived from Δϕ (y-axis) compared to CTH derived from IR Tb matched with T (x-axis).

References

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Funding: RYC2021-033309-I, PID2021-1264436OB-C22, and CEX2020-001058-M from MCIN/AEI (10.13039/501100011033), and EUMETSAT ROM SAF CDOP4. The work by authors KNW, FJT, COA and MTJ was carried out at the Jet Propulsion Laboratory, California Institute of Technology under a contract with NASA