New precipitation and cloud ice observations with polarimetric GNSS RO aboard the PAZ satellite

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1- GNSS POLARIMETRIC RADIO OCCULTATIONS (PRO):

Left: sketch of a ‘standard’ GNSS Radio Occultation (RO), where a circularly polarized antenna receives signals in occulting geometry, the receiver measures the additional Doppler effects induced by the vertical gradients in the refractive index of the atmosphere to finally generate vertical profiles of thermodynamic variables (T, p, q).

Right: The only modification in the GNSS PRO is the replacement of the circular antenna by a dual-polarized one: horizontally + vertically polarized. The hypothesis of the experiment is that hydrometeors, especially big rain droplets associated to heavy rain, will increase the phase delay of the horizontal propagation w.r.t. the vertical one.

2- THE ROHP-PAZ EXPERIMENT:

This new measurement concept is being proved aboard the satellite PAZ Low Earth Orbiter: the Radio Occultation and Heavy Precipitation experiment aboard PAZ (ROHP-PAZ) https://paz.ice.csic.es

Successful launch on February 22, 2018, by SpaceX (Falcon9) into a polar orbit (97.4⁰) at ~514 km altitude, sun-synchronous dusk/dawn.

3- FIRST POLARIMETRIC RESULTS (I): Strategy

- Published in GRL Jan’19 [https://doi.org/10.1029/2018GL080412].
- Co-located with IMERG 2D rain products + successful QC: 14,297 with 4,338 rainy cases.
- IMERG provides 2D rain rate combined from different sources, in 30 minute interval, but ~14% detection failures.
- Co-location by averaging wide areas of IMERG rain around the GNSS-PRO central point.

4- FIRST POLARIMETRIC RESULTS (II): Sensing rain

Rain-free: Rain

Rain: Data from May 2, 2018, to May 29, 2018, with 14,297 cases of rain and 4,338 rainy days. Signal, <NWP?...>

Vertical structures consistent with the cloud, not directly linked to the water vapor, and with high sensitivity to frozen particles (cloud ice, mixed phase)

5- FROZEN PARTICLES?

- No cirrus cloud ice detected (layer too thin?).
- Dual pol signals above the freezing layer are analyzed in terms of its average signal, ΔΔpol freezing level, and the maximum altitude at which ΔΔpol is found (Hmax).
- Strong ΔΔpol signals above the freezing layer found in convective systems:

Potential use of PAZ data for validation of microphysic schemes?

- Murphy et al., 2015 Simulations of GNSS polarimetric RO aboard an aircraft, during an Atmospheric River event captured during the CalWater 2015 field campaign.
- Two numerical experiments were run using a mesoscale model (WRF) configured with two different microphysical parameterizations: WRF Double Moment 6-class (WDM6), and... Potential use of PAZ data for validation of microphysic schemes?

6- CONCLUSIONS:

- PAZ carries a polarimetric RO payload, to prove the GNSS-PRO concept.
- New measurement concept: thermodynamics + heavy rain.
- Polarimetric phase shift linked to precipitation, larger signals for more intense rain.
- Vertical features in polarimetric phase shift consistent with storms at reaching different altitudes.
- Strong signals induced by frozen particles above the freezing layer.
- Use of other derived-observables (top height, signal above freezing level, ...) potential for convection products?
- Use of PAZ ΔΔpol and PAZ RO moisture profiles → Direct use of PAZ data for better understanding of deep convection systems?
- Use of PAZ ΔΔpol to validate or improve micro-physics schemes in NWP?

DATA PUBLICLY AVAILABLE