Evaluation of tropospheric specific humidity from GPS radio occultations using ERA-Interim, MERRA, and AIRS satellite data sets

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Objectives

1. Create a data record of specific humidity using GPS-ROs

2. What new physical information can we infer from it?

3. How can GPS-RO improve climate studies?
Global coverage

All-weather capability

Vertical resolution
~ 0.1 km in troposphere

Horizontal resolution
varies with altitude:
~ 100-200 km in troposphere

Water vapor feedback
[Vergados et al. 2016]

Hurricane humidity
[Vergados et al. 2013]

Tropospheric humidity retrievals
[Ho et al. 2007; Collard and Healy,2003; Vergados et al. 2014; 2017 (in review)]
## Components of Software

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### Set Up
- 01/2007–12/2015
- 40°S–40°N
- Tropical Zones:
  - a. ITCZ
  - b. Trade Winds
  - c. Subtropics

### Analysis
- Interquartile ranges
- Mean climatologies
- Difference & Std. Dev.
- Monthly variabilities

### Statistics

### Retrieve
- Monthly zonal means
- 9–year long time series
- Interannual anomalies
- 700 – 400 hPa

### ERA-Interim
European Center for Medium-Range Weather Forecasts
Re-Analysis Interim

### Aqua/AIRS
Atmospheric Infrared Sounder

### MERRA
Modern-Era Retrospective Analysis for Research and Applications
Results (1/5) (± 15°)

Monthly zonal mean variability

- **Pressure level: 700 hPa**
- **Pressure level: 600 hPa**
- **Pressure level: 500 hPa**
- **Pressure level: 400 hPa**

Inter-annual anomaly variability

- **Pressure level: 700 hPa**
- **Pressure level: 600 hPa**
- **Pressure level: 500 hPa**
- **Pressure level: 400 hPa**

**Data Sources**
- JPL-RO
- UCAR-RO
- MERRA
- ERA-Interim
- AIRS
Results (2/5) (± 15°)

**Interquartile range statistical analysis (15S - 15N, 01/2007 - 12/2015)**

- Pressure level: 700 hPa
- Pressure level: 600 hPa
- Pressure level: 500 hPa
- Pressure level: 400 hPa

**Interquartile range statistical analysis, Specific humidity anomalies (15S - 15N, 01/2007 - 12/2015)**

- JPL
- UCAR
- MERRA
- ERA-Interim
- AIRS
Results (3/5) (± 15–30°)

Interquartile range statistical analysis (15NS - 30NS, 01/2007 - 12/2015)

Interquartile range statistical analysis, Specific humidity anomalies (15NS - 30NS, 01/2007 - 12/2015)

Pressure level: 700 hPa
Pressure level: 600 hPa
Pressure level: 500 hPa
Pressure level: 400 hPa

JPL
UCAR
MERRA
ERA-Interim
AIRS

Trade winds – Calm atmosphere

09/26/2017
UT Specific Humidity

COSMIC – IROWG/6 Workshop, 2017
Results (4/5) (± 30–40°)

Interquartile range statistical analysis (30NS - 40NS, 01/2007 - 12/2015)

Interquartile range statistical analysis, Specific humidity anomalies (30NS - 40NS, 01/2007 - 12/2015)

JPL  UCAR  MERRA  ERA-Interim  AIRS
Fraction variations in the water vapor pressure, due to refractivity variations:

\[
\delta N \equiv (N' - N) = a \cdot \frac{P}{T} + b \cdot \frac{(e + \delta e)}{T^2} - a \cdot \frac{P}{T} - b \cdot \frac{e}{T^2} = \frac{b}{T^2} \cdot \delta e \quad \Leftrightarrow \quad \frac{\delta N}{\delta e} = \frac{b}{T^2}
\]

**Example:** Inter-tropical Convergence Zone (ITCZ) at 700 hPa

We quantify that the mean refractivity difference of 1.365 N (the difference between JPL and UCAR) translates to 0.29 g/kg difference in specific humidity.

**Example:** Inter-tropical Convergence Zone (ITCZ) at 500 hPa

We quantify that the mean refractivity difference of 0.678 N (the difference between JPL and UCAR) translates to 0.12 g/kg difference in specific humidity.

Besides the small refractivity difference (~0.5%) between JPL and UCAR, other factors, such as differences in the retrieval techniques and temperature, could lead to humidity discrepancies.
Conclusions

1. All data sets, within their error uncertainty, agree on the amount of specific humidity.

2. Small discrepancies exist among the data sets mean values, which are function of geographic region and pressure level.

3. The variability captured in the inter-annual anomalies of all data sets is the same and the refractivity differences between JPL and UCAR are similar with a sub-percentage difference.

4. The observed difference between the JPL and UCAR specific humidity statistics can be partly explained due to small refractivity differences between the two and partly due to different processing strategies [requires investigation].