Probing a hurricane’s eye with the GPS radio occultation technique

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1. Study Tropical Cyclone (TC) activity

2. Compare our results with ECMWF

3. Can GPS RO provide an insight in a hurricane’s core?
The recipe for Tropical Cyclone formation is:

- Late summer over the oceans
- Sea surface temperature $> 26 \, ^{\circ}C$
- Eye; eye-wall; spiral rain brands

The Global Positioning System radio occultation:

1. Insensitive to clouds and precipitation
2. High vertical resolution: 100 – 200 m (in troposphere)
3. Global coverage
Mendelsohn et al., [2012] describes in great detail future projections of tropical cyclones in society

Economic impact:

**Forecast of baseline damage**
The present annual global damage from tropical cyclones is US$26 billion (which is equal to 0.04% of the gross world product (GWP))\(^3\).

Example: New Orleans – Hurricane Katrina
## COMPONENTS OF SOFTWARE (double collocations)

<table>
<thead>
<tr>
<th>DATA</th>
<th>COMBINATIONS</th>
<th>RETRIEVALS</th>
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<tr>
<td><strong>Data</strong>&lt;br&gt;- JTWC&lt;br&gt;- COSMIC&lt;br&gt;- ECMWF</td>
<td><strong>Combine</strong>&lt;br&gt;- GPSRO+ECMWF</td>
<td><strong>Water vapor</strong>&lt;br&gt;- $P_w = \frac{1}{b} (NT^2 - aPT)$</td>
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<tr>
<td><strong>Collocations</strong>&lt;br&gt;- $\leq \pm 600$ km&lt;br&gt;- $\leq \pm 3$ hr&lt;br&gt;- Extract GPSRO to ECMWF pressure levels</td>
<td><strong>Use</strong>&lt;br&gt;- Forward refractivity operator&lt;br&gt;- GPSRO: Refractivity&lt;br&gt;- ECMWF Temperature</td>
<td><strong>Retrieve</strong>&lt;br&gt;- Derive water vapor profiles&lt;br&gt;- Compare profiles with reference (ECMWF)</td>
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Results (1)

Figure 1: The tropical cyclone locations from the Joint Typhoon Warning Center (JTWC) between 2002 and 2010 (top) and the distribution of their collocated GPSRO events as function of distance from the storms’ center up to 600 km (bottom).

GPS RO events: ~700

51 Tropical Cyclone events in North Atlantic
GPS data seem to capture the general characteristics of Tropical cyclones

ECMWF moister (drier) than GPS below (above) 4 km
1. Gradual decrease in RH from tropical depression to tropical storm to Category-I hurricane
2. Increase in RH at transition from Cat.-I to Cat.-II hurricane
3. Almost steady state after that

Relative Humidity appears more homogeneous than water vapor pressure.
1. GPSRO captures the morphology of Tropical Cyclones

2. GPSRO sees the same features as AIRS Tropical Cyclone studies

3. GPSRO can (potentially) be used to probe the inner core (eye) of Tropical Cyclones

In progress research:

- Focusing in the inner core (0 – 100 km) and outer core (100 – 200 km)
- Comparisons between these two regions

Future research plans:

- Focus on the eyewall and investigate the moistening of the upper troposphere through “water vapor injection”
Thank you!