GNSS Instrument System for Multistatic and Occultation Sensing (GISMOS): Working towards moisture profiling of the large scale environment

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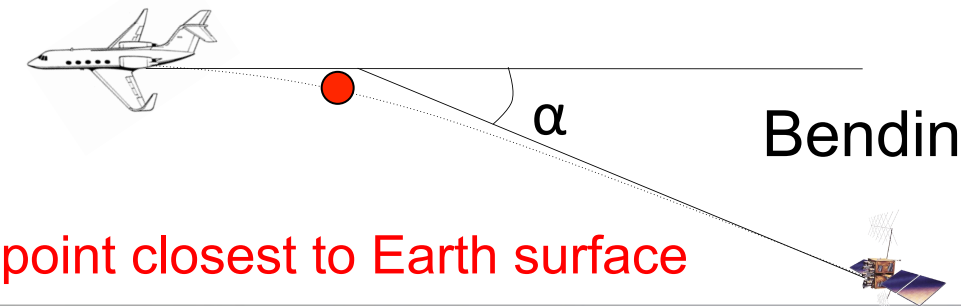
Objectives of field campaign

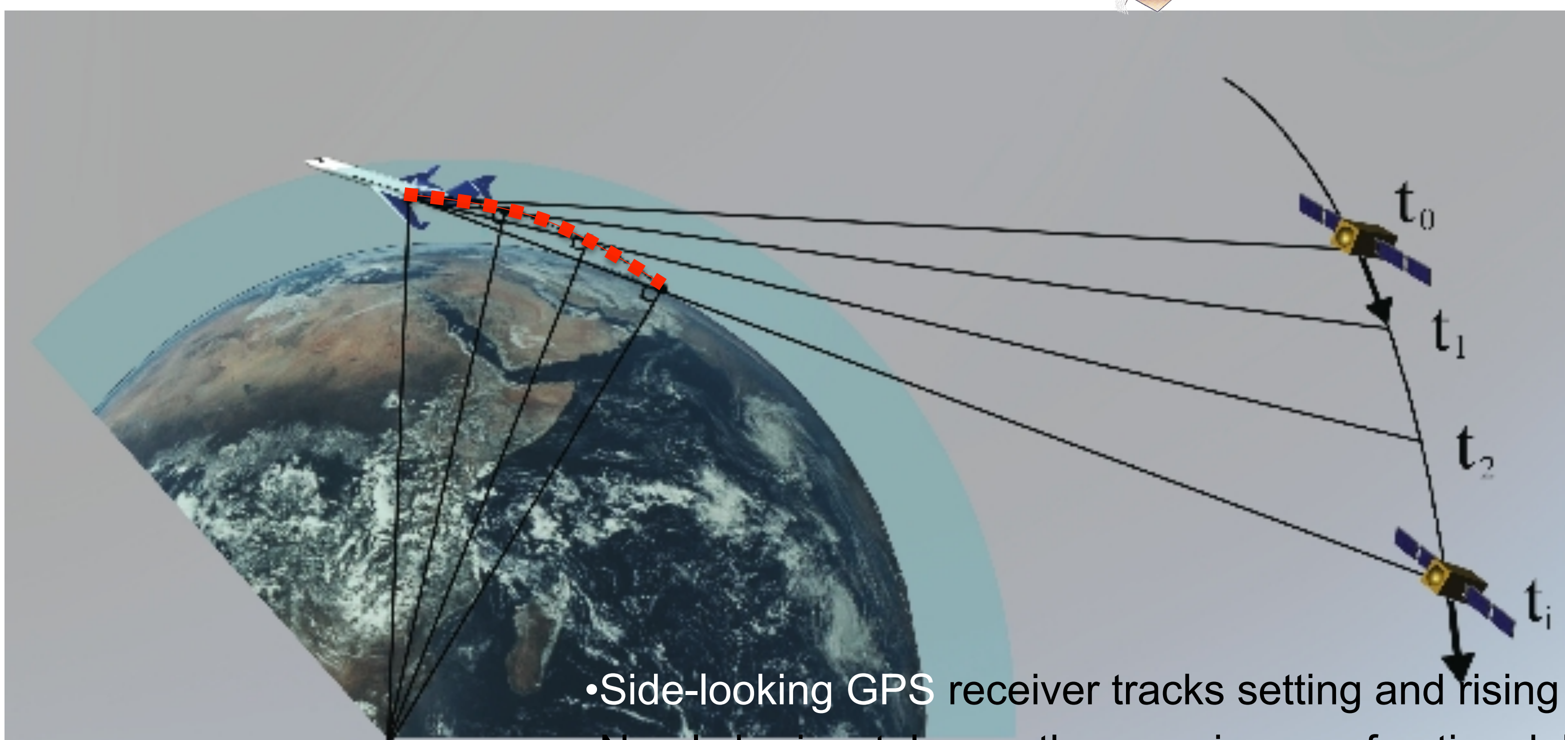
- Test the impact of airborne radio occultation in tropical cyclone assimilation for improving intensity forecasts.
- Investigate moistening with time in the 4km-8km levels
- Systems of most interest are those where the model forecasts give very different estimates of what the evolution of the intensity would be.
- Use occultations to determine the large-scale environment and compare them with radiosonde and dropsonde profiles to examine where moisture is increasing locally relative to the location of convective activity

Radio occultation refractive bending angle



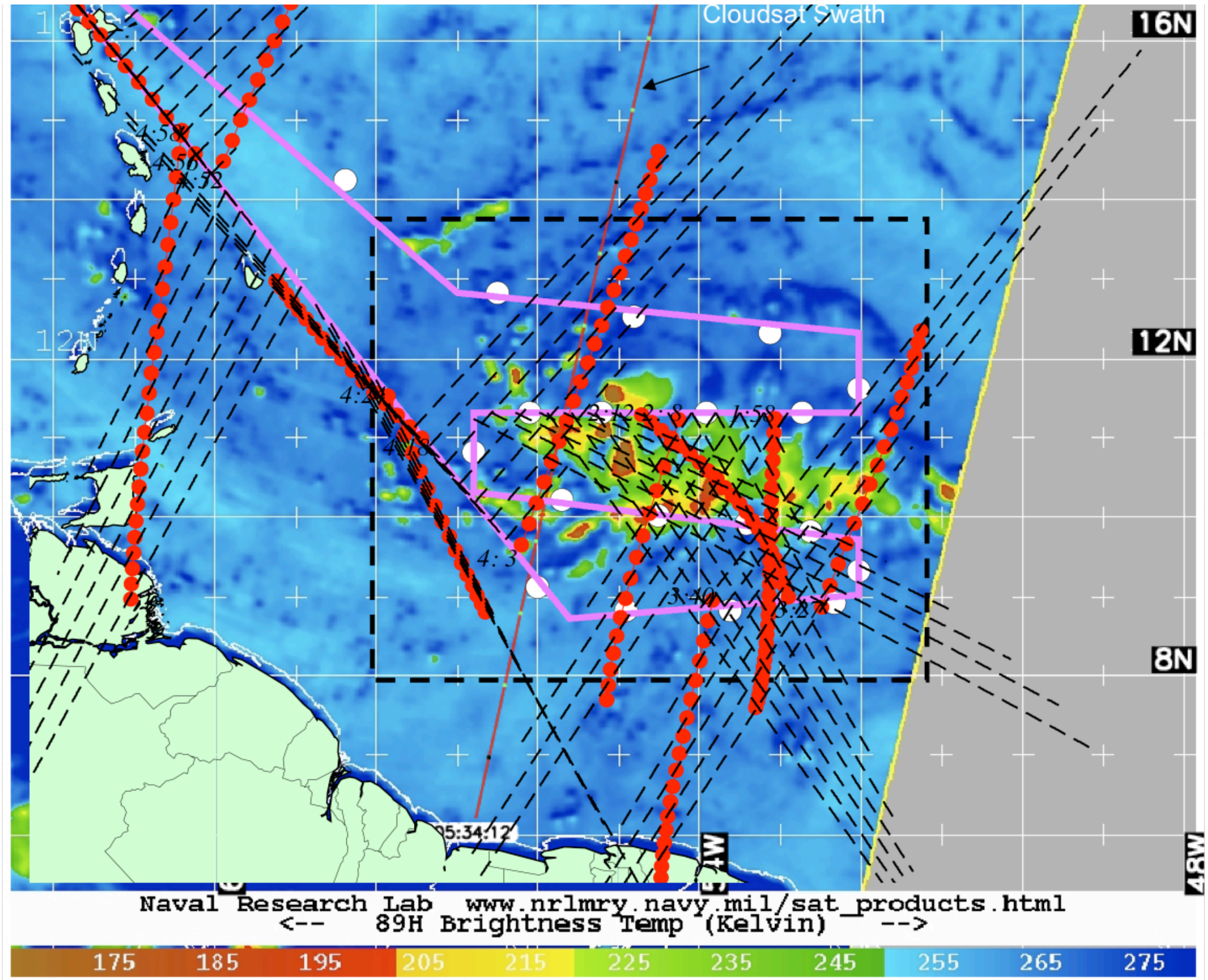
Bending angle

Tangent point – point closest to Earth surface

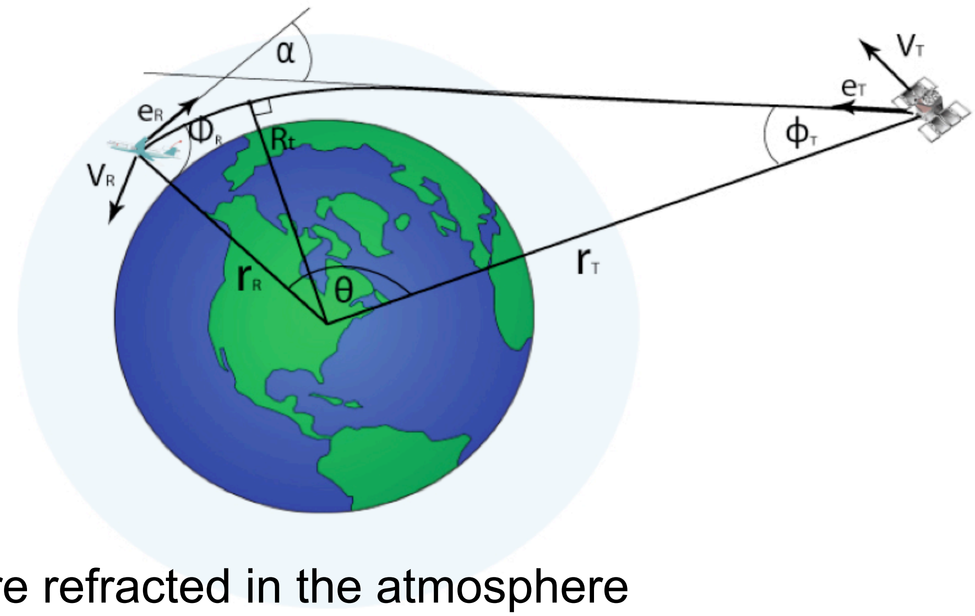


- Side-looking GPS receiver tracks setting and rising satellites
- Nearly horizontal raypaths experience refractive delay
- Atmospheric humidity profile is derived from refractive delay

Observation geometry for pre-depression convective systems



GPS radio occultation theory



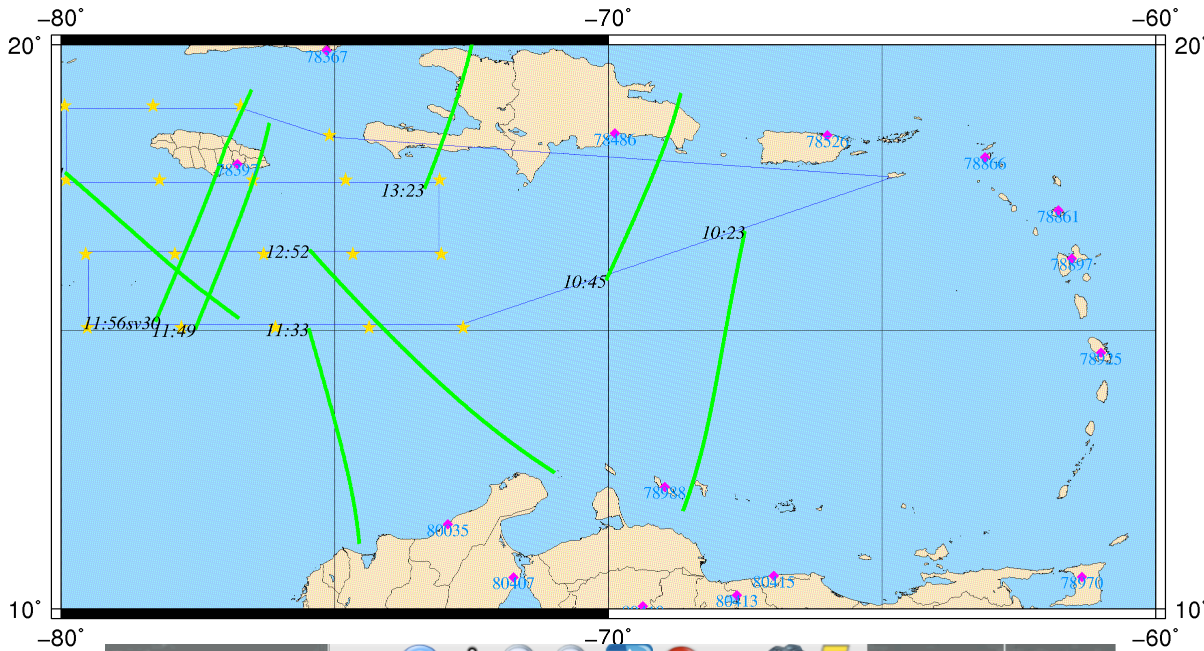
- GPS signals are refracted in the atmosphere
- Measure the difference between the observed distance and the straight line
- Refraction causes a Doppler shift in the carrier frequency
- The bending angle is an integral of the refractive index, which depends on P,T, and e

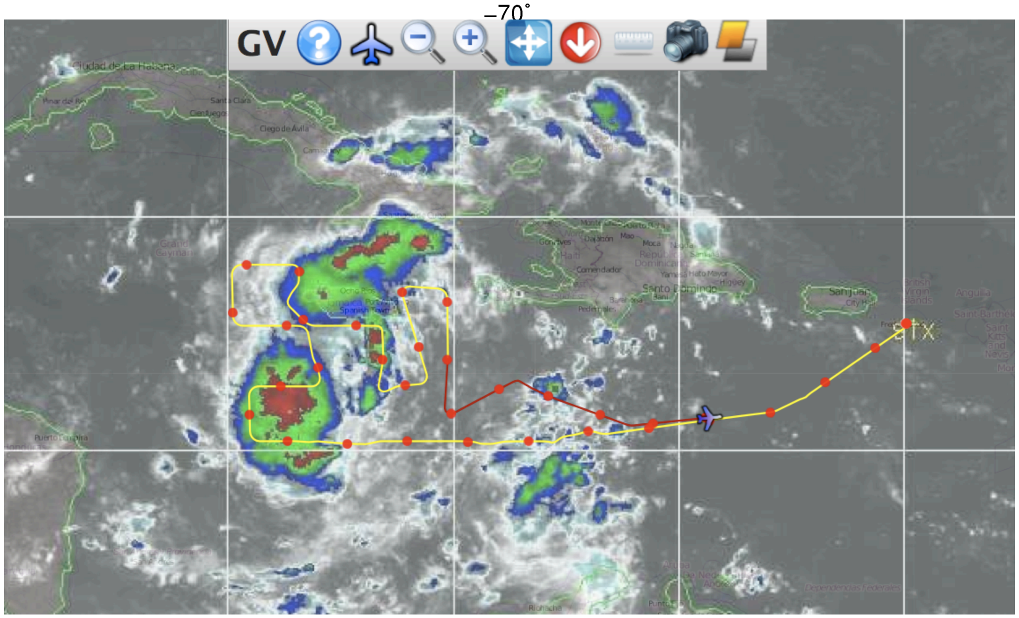
$$N = (n-1)\cdot 10^6 = k_1 \frac{P_d}{T} + k_2 \frac{e}{T} + k_3 \frac{e}{T^2}$$

0.50 % N ~ 1 K Temperature error
0.25 % N ~ 5% RH error at 7 km
Less accurate just below aircraft flight level

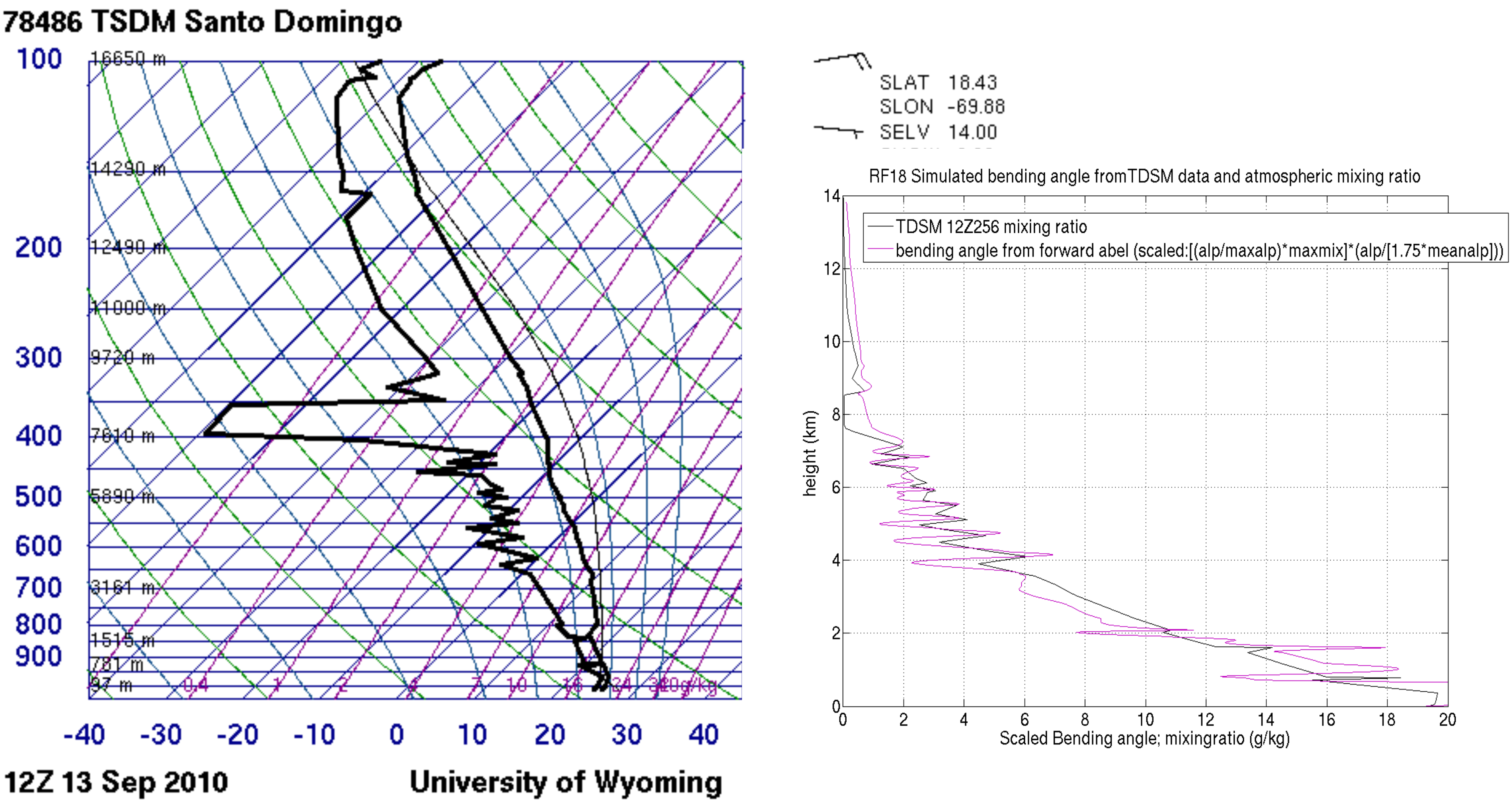
Xie et al., 2008, TGARSS

RF18 September 13, 2011



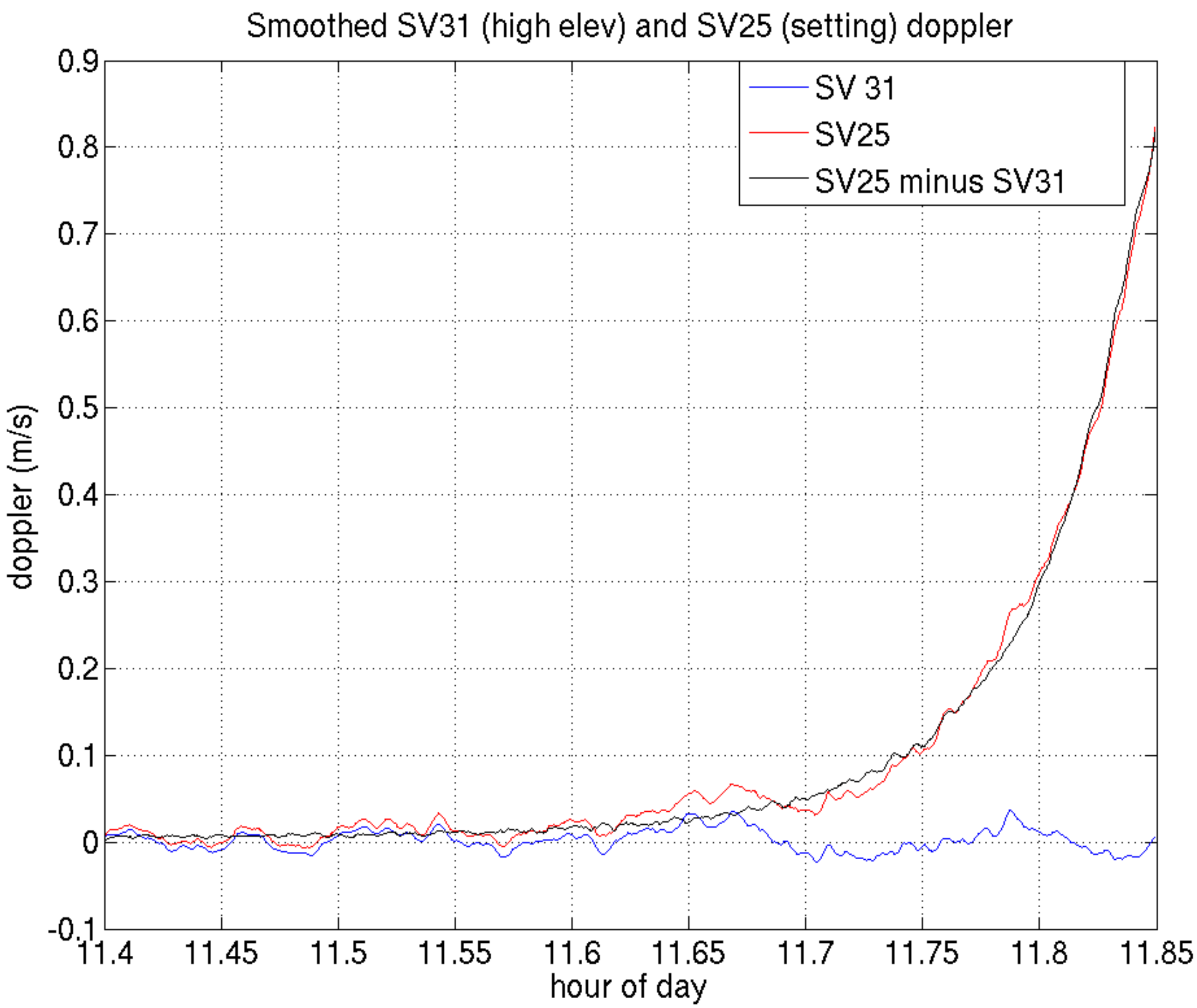


Vertical sensitivity

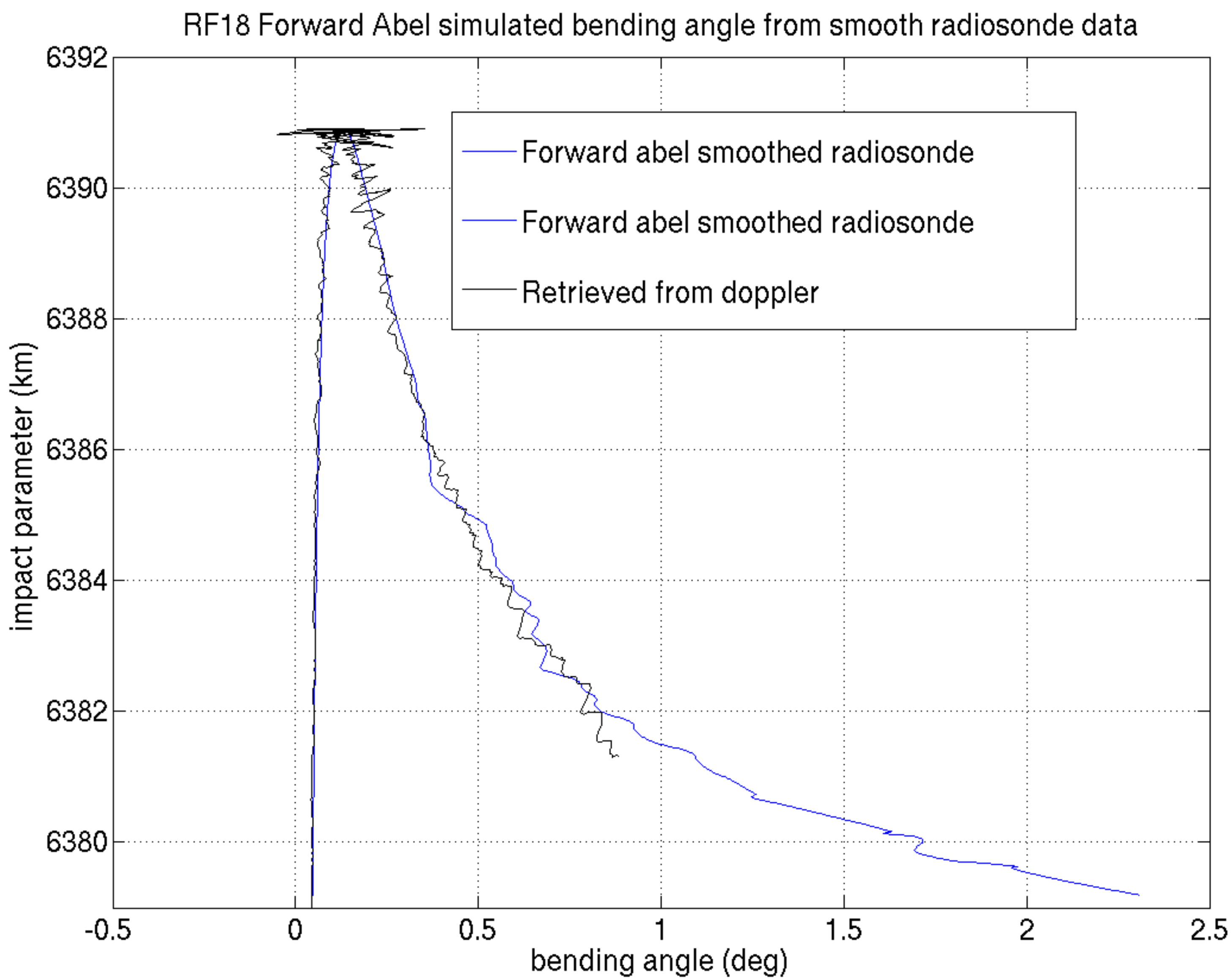


Bending angle is very sensitive to vertical structure
TSDM radiosonde profile at 12Z on 13 Sep 2010 and simulated bending angle profile.

Excess Doppler



Bending Angle



Retrieved refractivity

RO: more moisture at 8km,
less moisture at 5-7 km
much less moisture at 3-4 km

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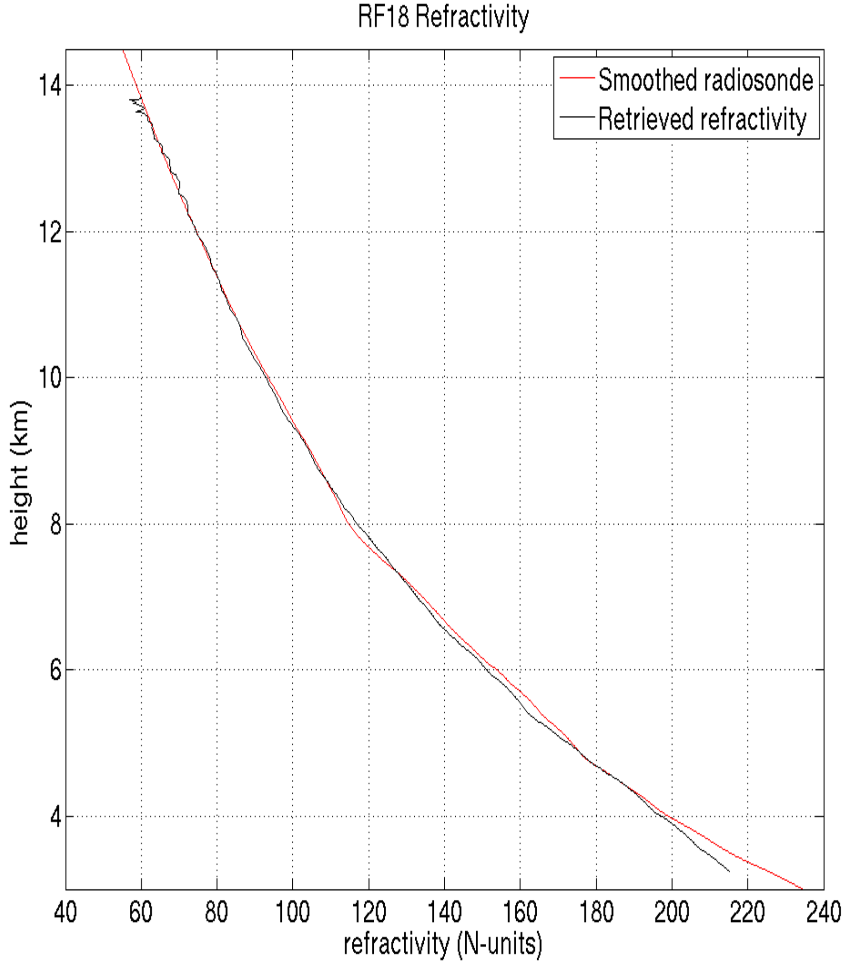
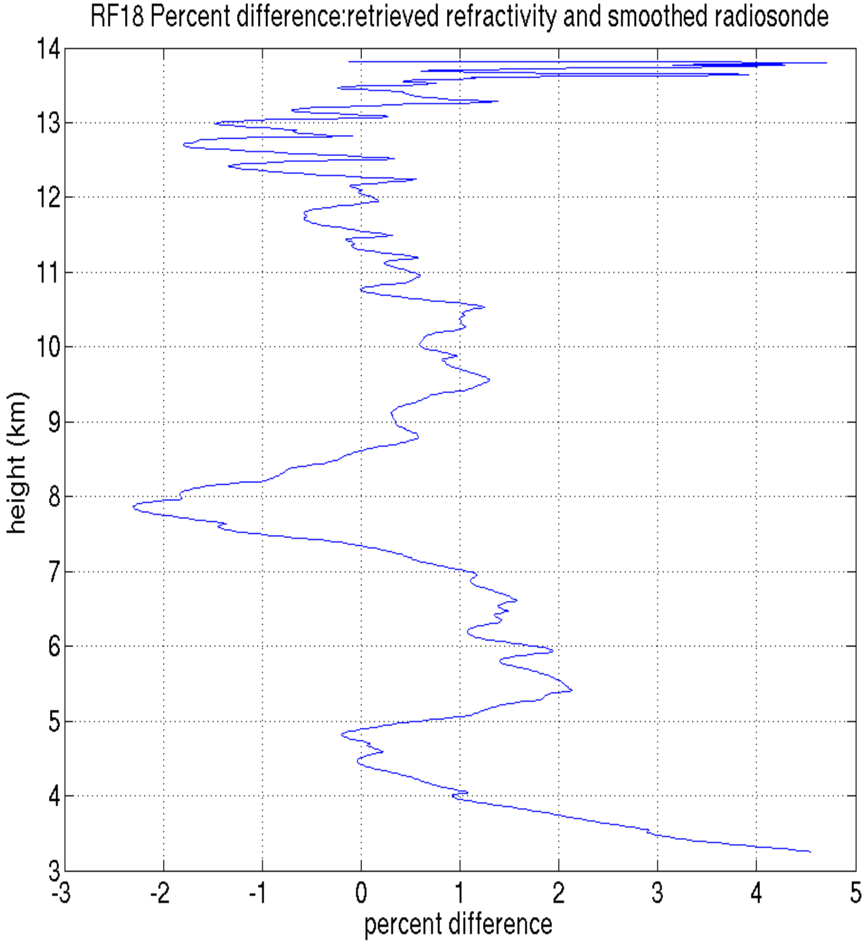
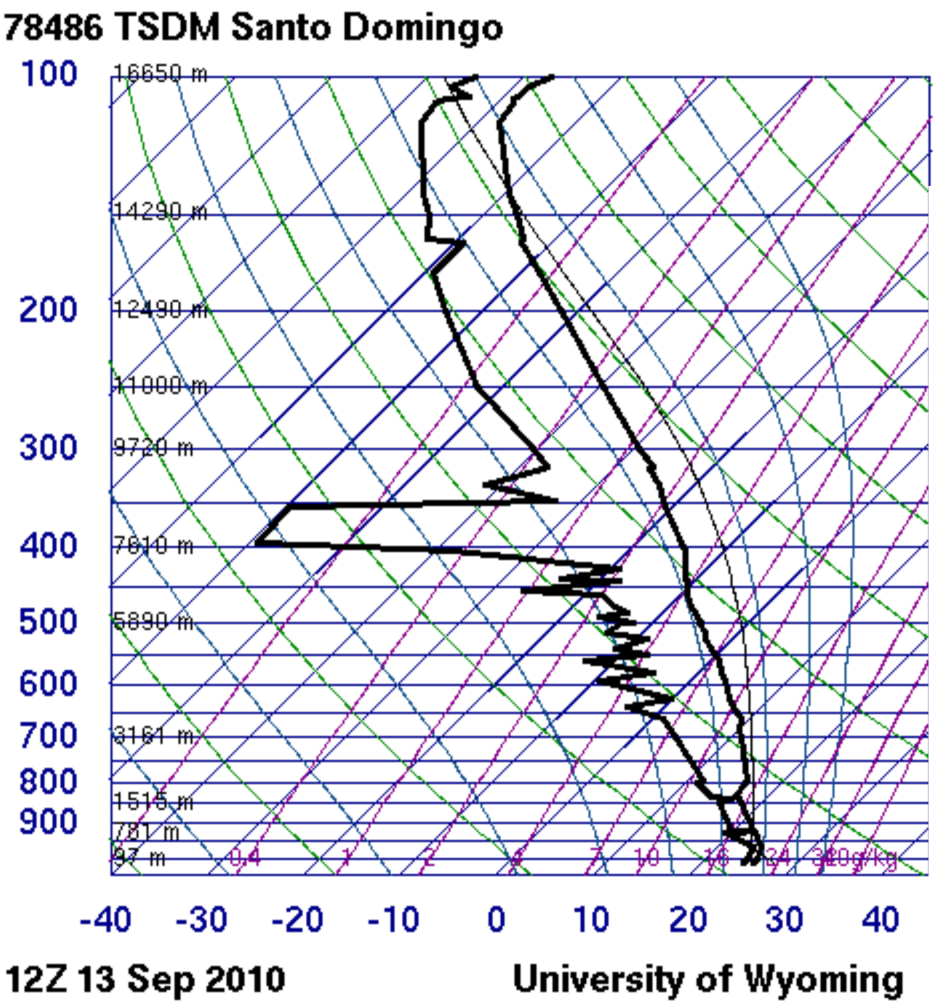
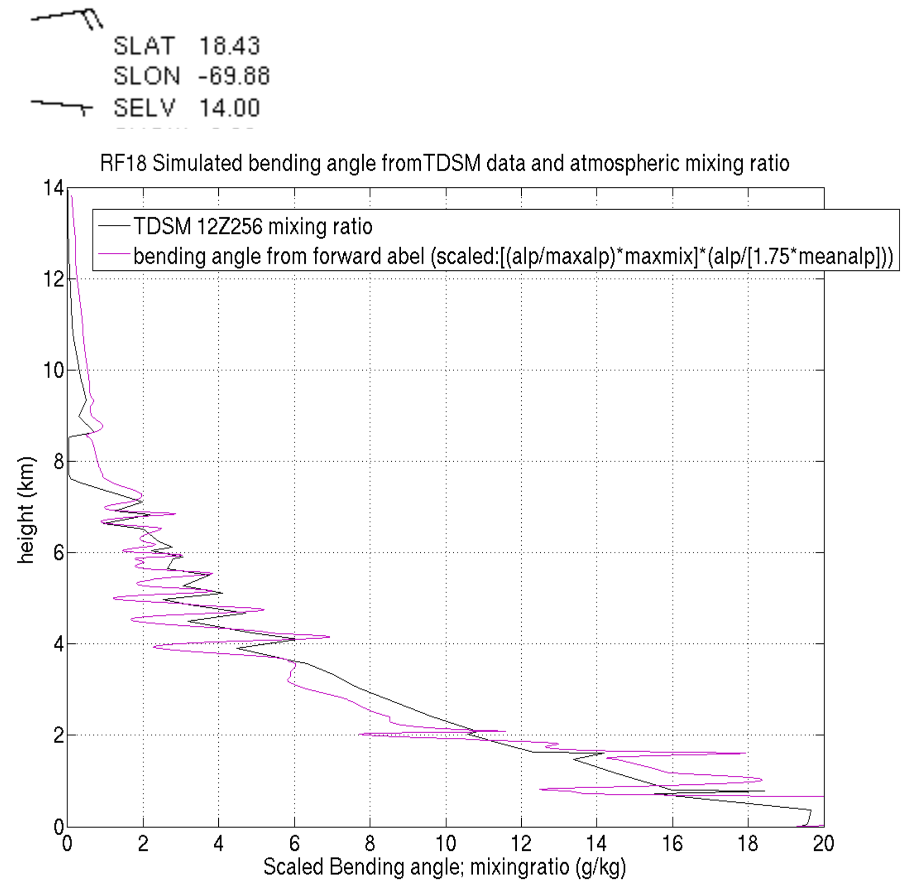




Vertical sensitivity

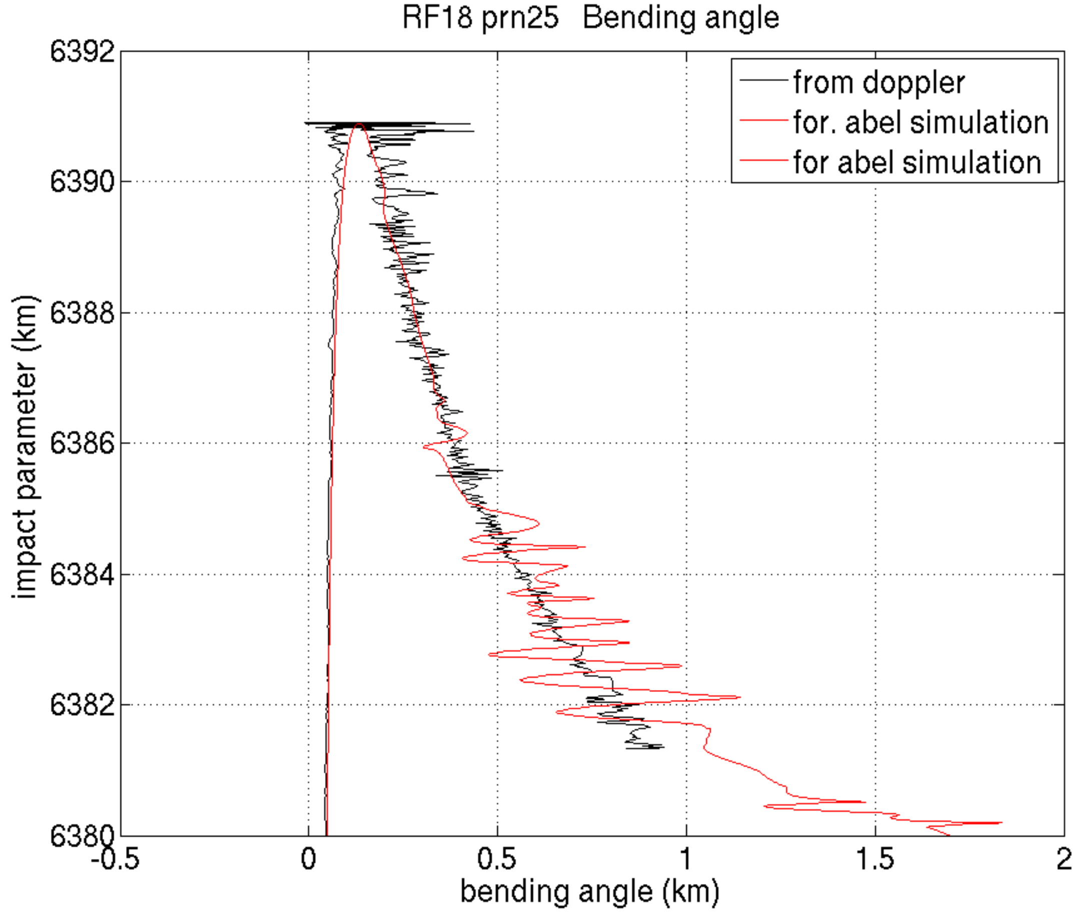




Bending angle is very sensitive to vertical structure
TSDM radiosonde profile at 12Z on 13 Sep 2010 and simulated bending angle profile.

Higher resolution bending angle

Next steps: looking at higher temporal sampling in RO data and open loop tracking data will produce higher resolution bending angle results

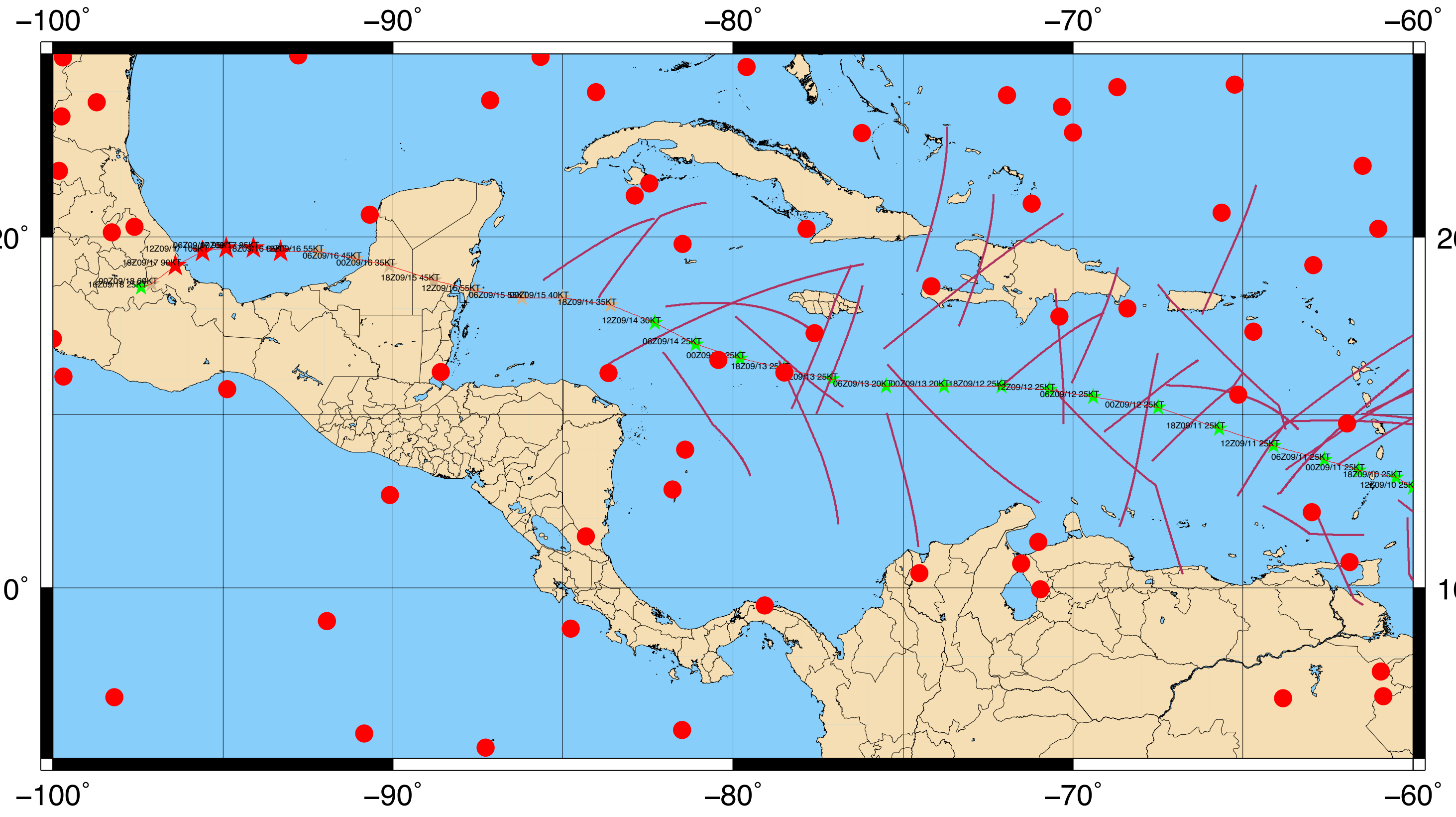


Sampling of Hurricane Karl

RF14 to RF19 sampled Karl environment

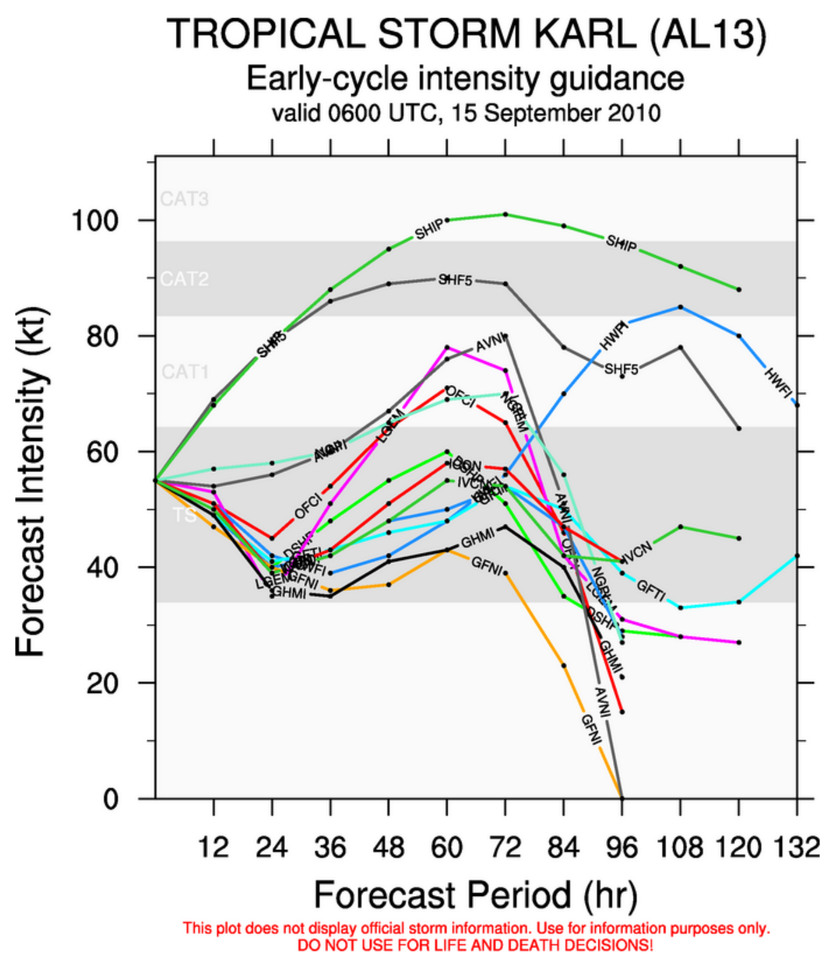
6 flights from September 10 to September 14

Red dots indicate COSMIC profiles over same period



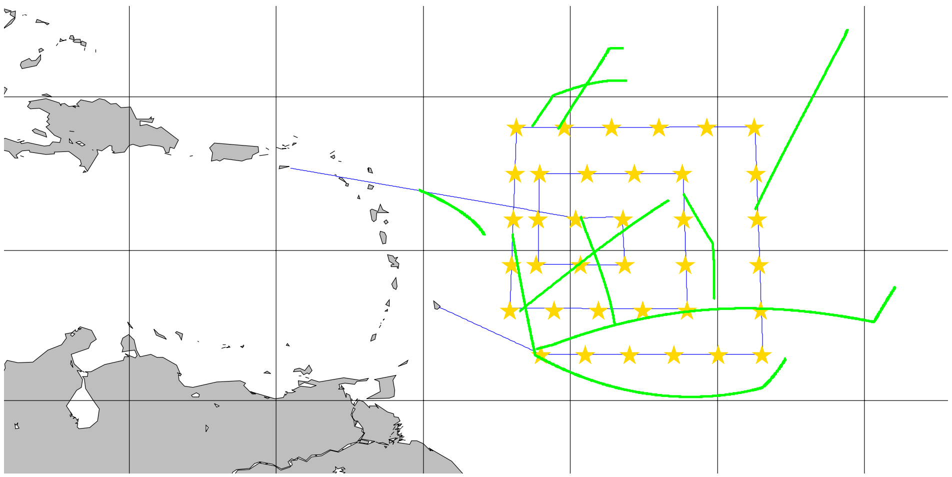
Future work - assimilation

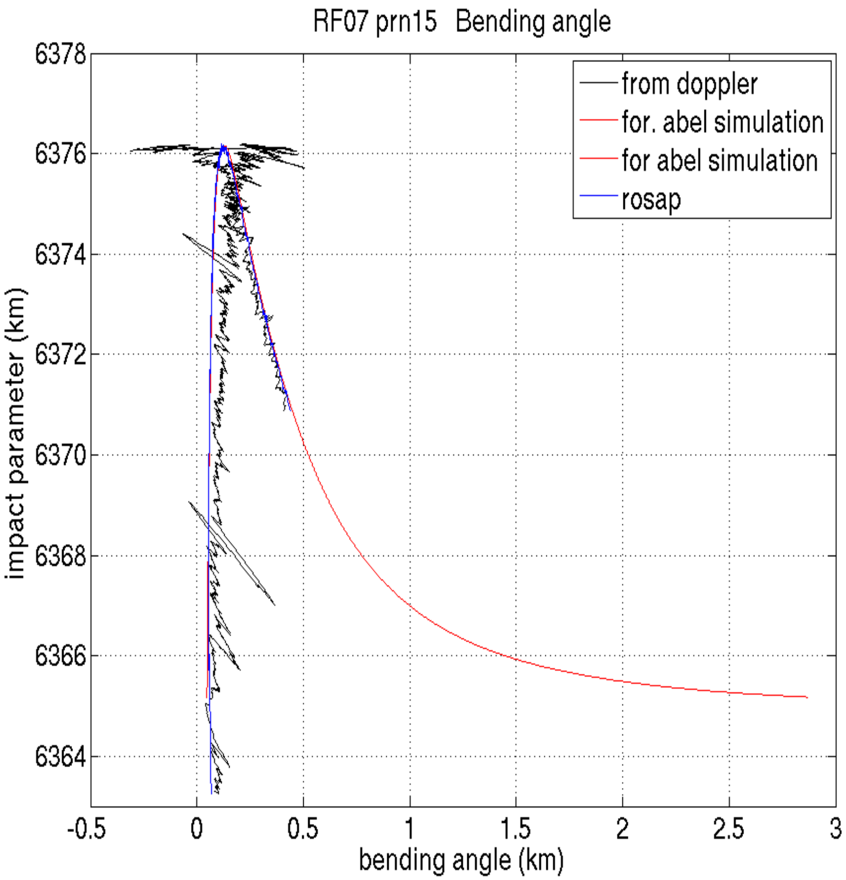
- Would like to see whether assimilated radio occultation data reduces some of the uncertainty in the evolution of Karl as a tropical storm



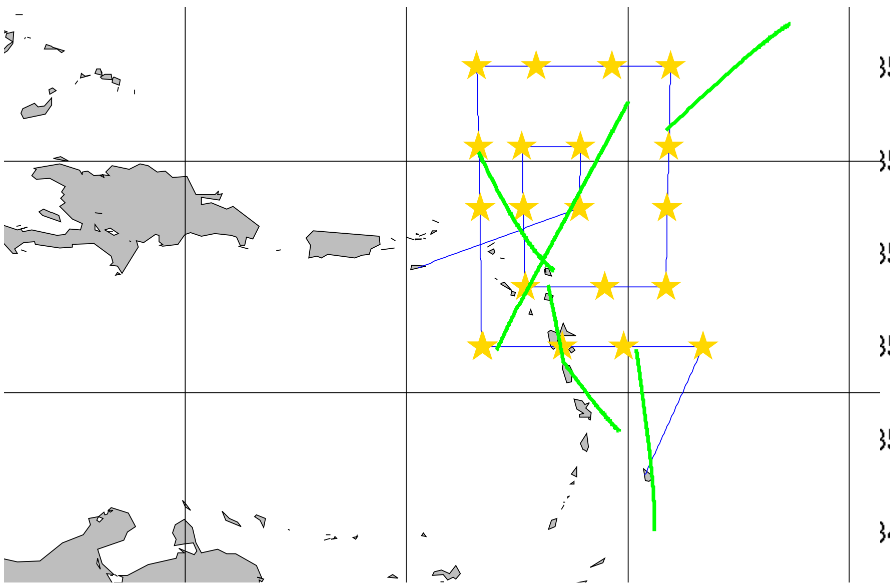
NHC, http://euler.atmos.colostate.edu/~vigh/guidance/

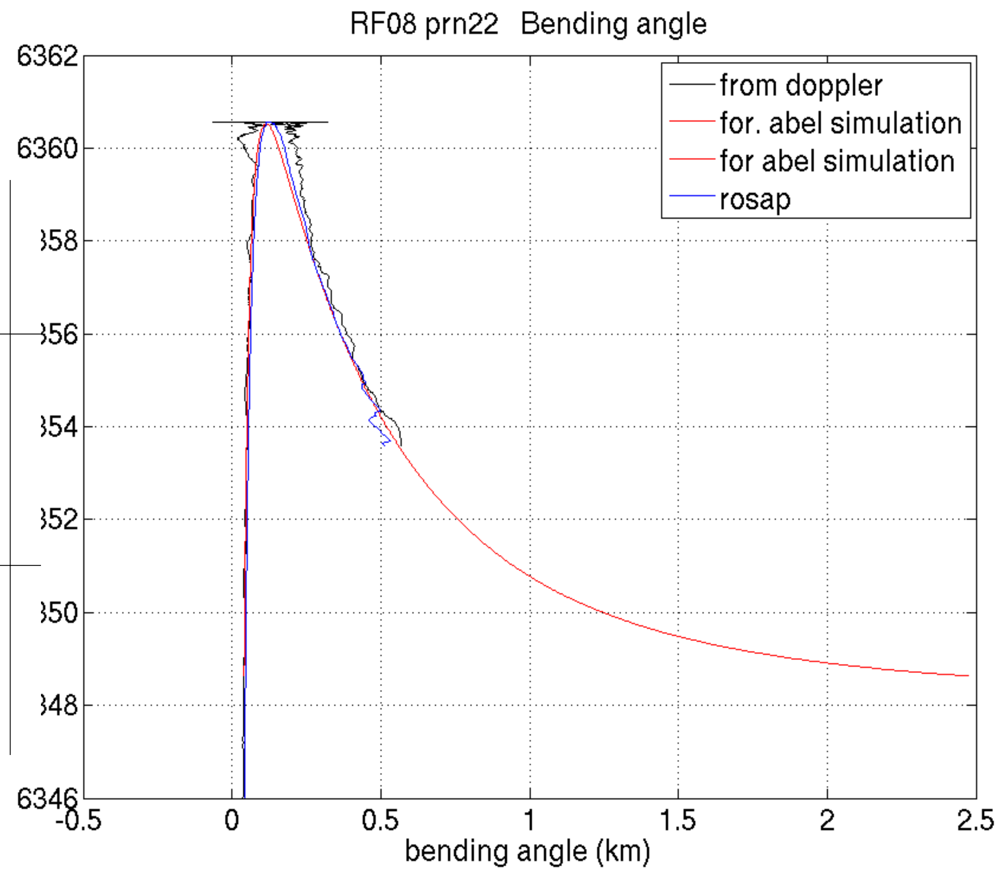
2010/08/31 RF07
2nd mission to Fiona



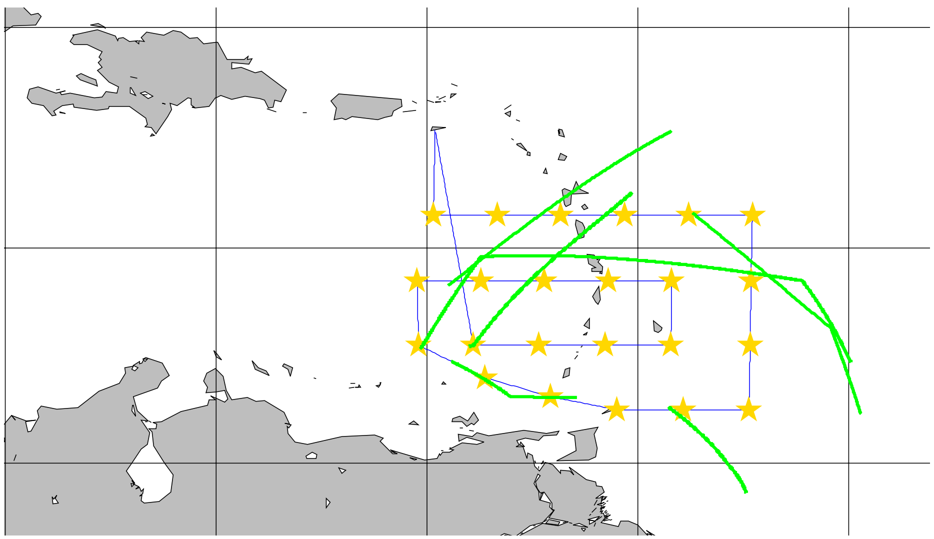


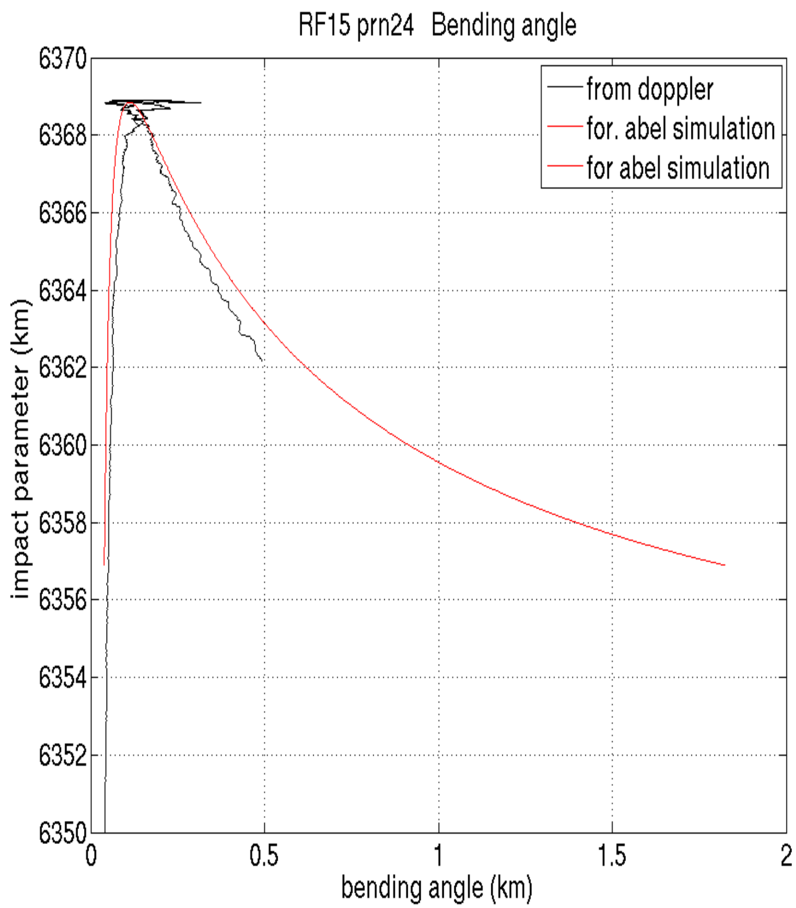
2010/09/01 RF08
3rd mission to Fiona



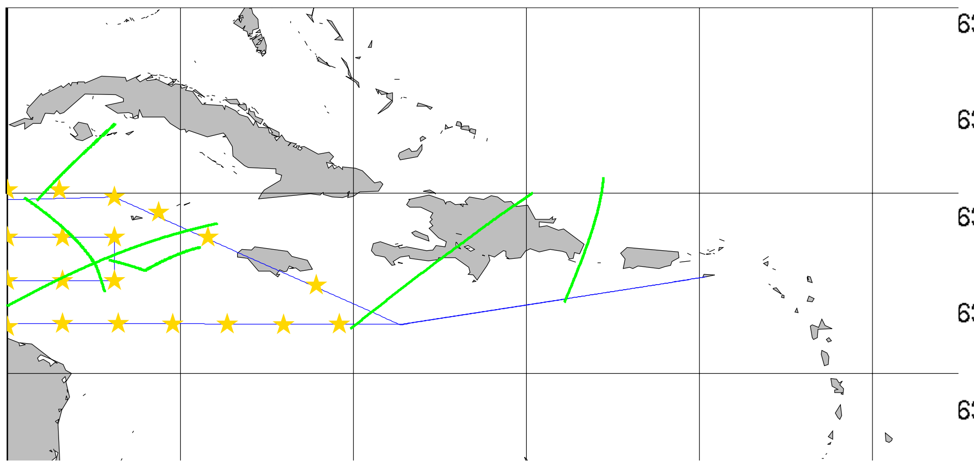


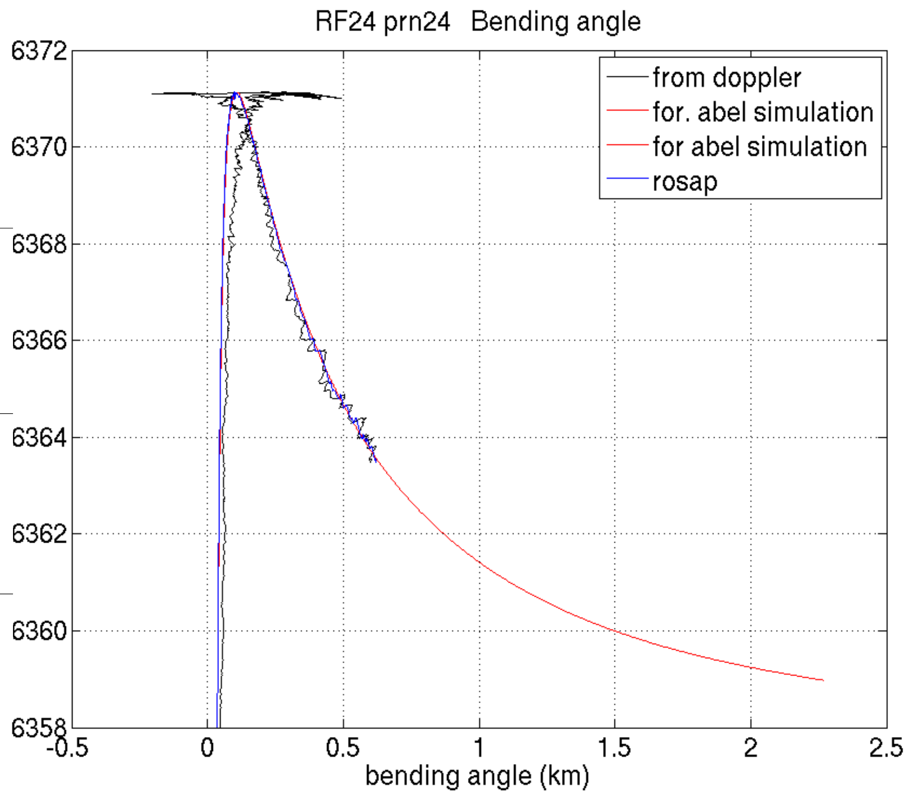
2010/09/10 RF15
2nd mission into PGI44 (Karl)



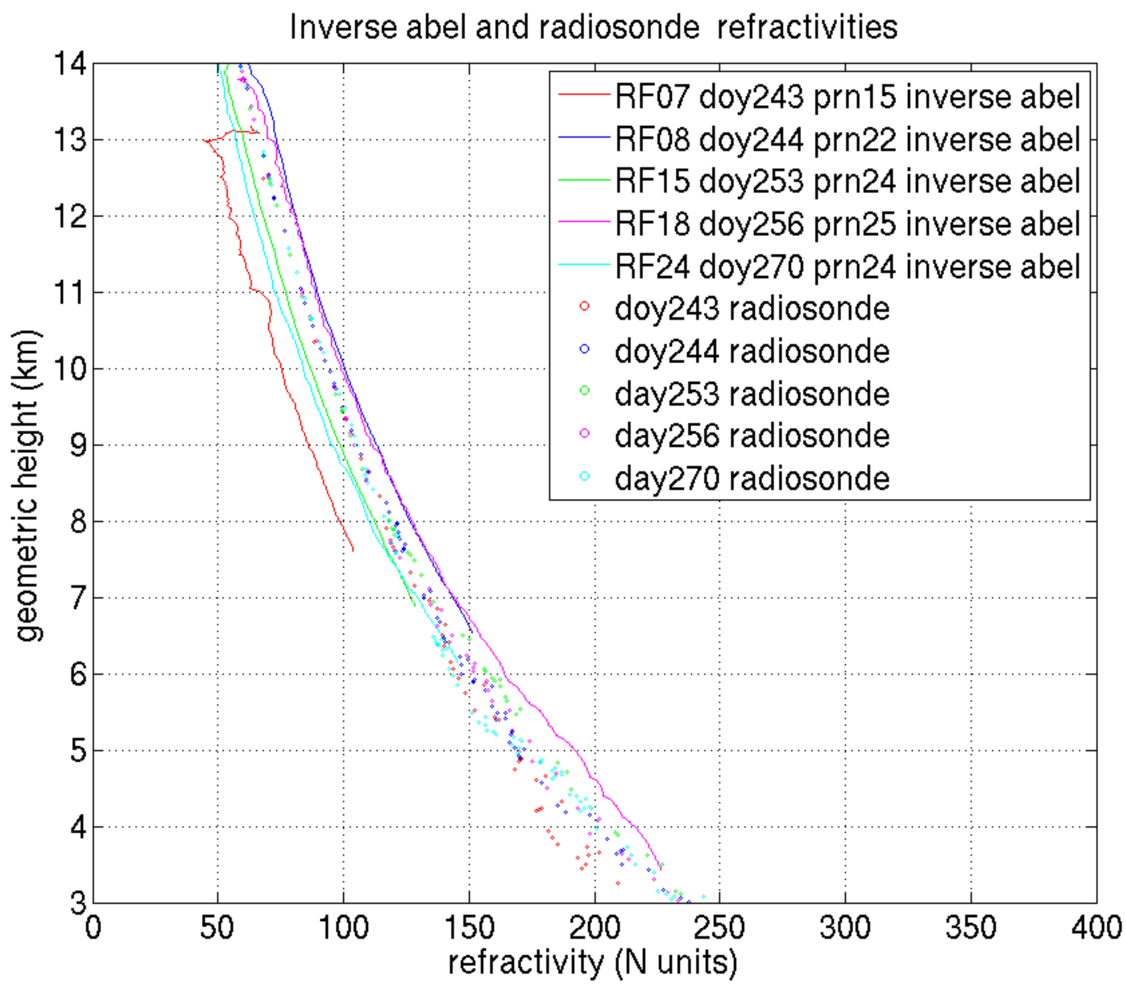


2010/09/27 RF24
1st mission into PGI50 (Nicole)





Refractivity comparisons with radiosondes – 5 flights



Research Plans

- Collected an extensive dataset:
  - 28 research flights, ~12 occultations per flight
- Demonstrated in first comparisons that RO profiles agree within 2% with refractivity of radiosonde profiles
- We are processing excess phase and bending angle retrievals for a larger dataset – so far we have seen a significant refractivity bias that seems to depend on the orientation of the source-receiver velocities relative to the occultation plane
- We are processing the 10MHz recorded GPS signal using new signal processing techniques to optimize RO technique in moist troposphere (open loop tracking) to extend the profiles lower
- Future plans include assimilation into high resolution WRF models (Shu-Hua Chen, UC Davis)

Acknowledgements

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