Monitoring Changes of Tropical Extreme Rainfall Events Using Differential Absorption Barometric Radar (DiBAR)

introduction, measurement approach: O_2 absorption, technology development, space application, summary

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Water and Energy cycles in the Tropics
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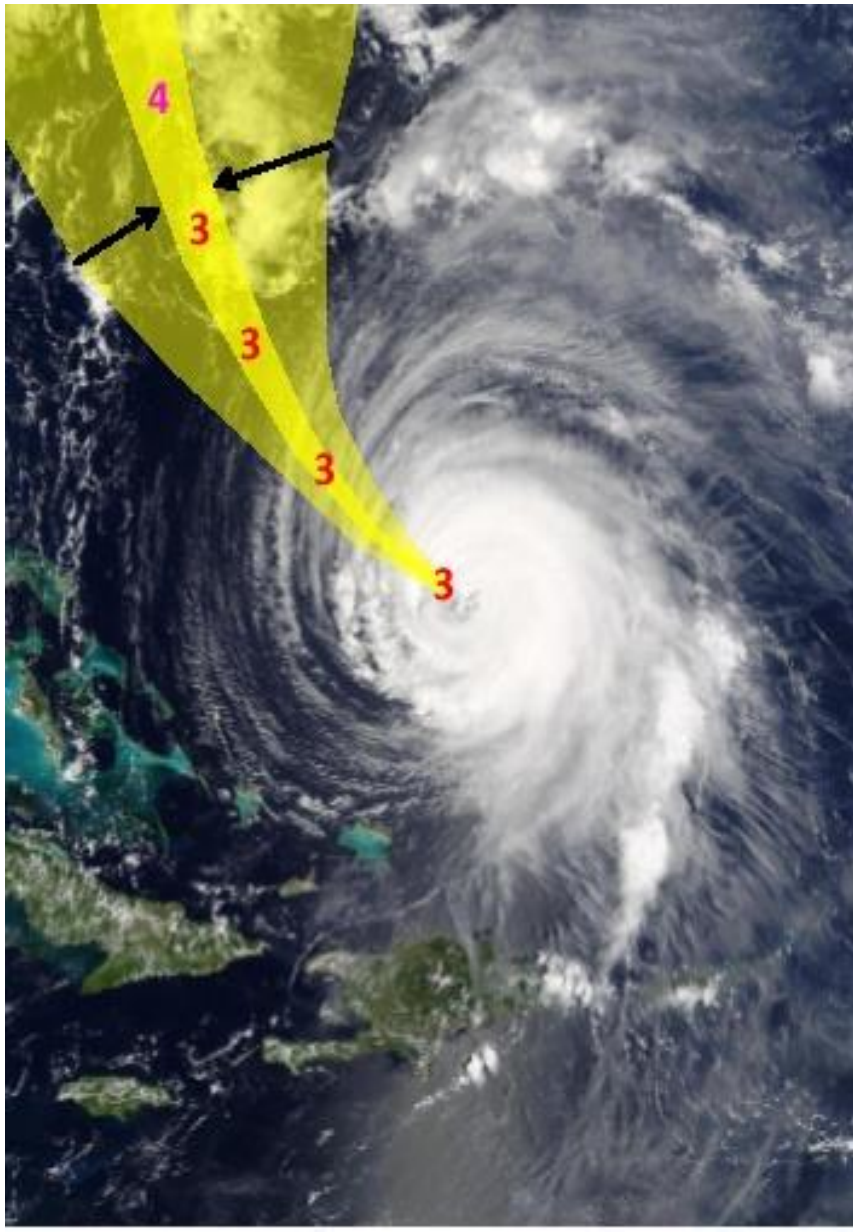
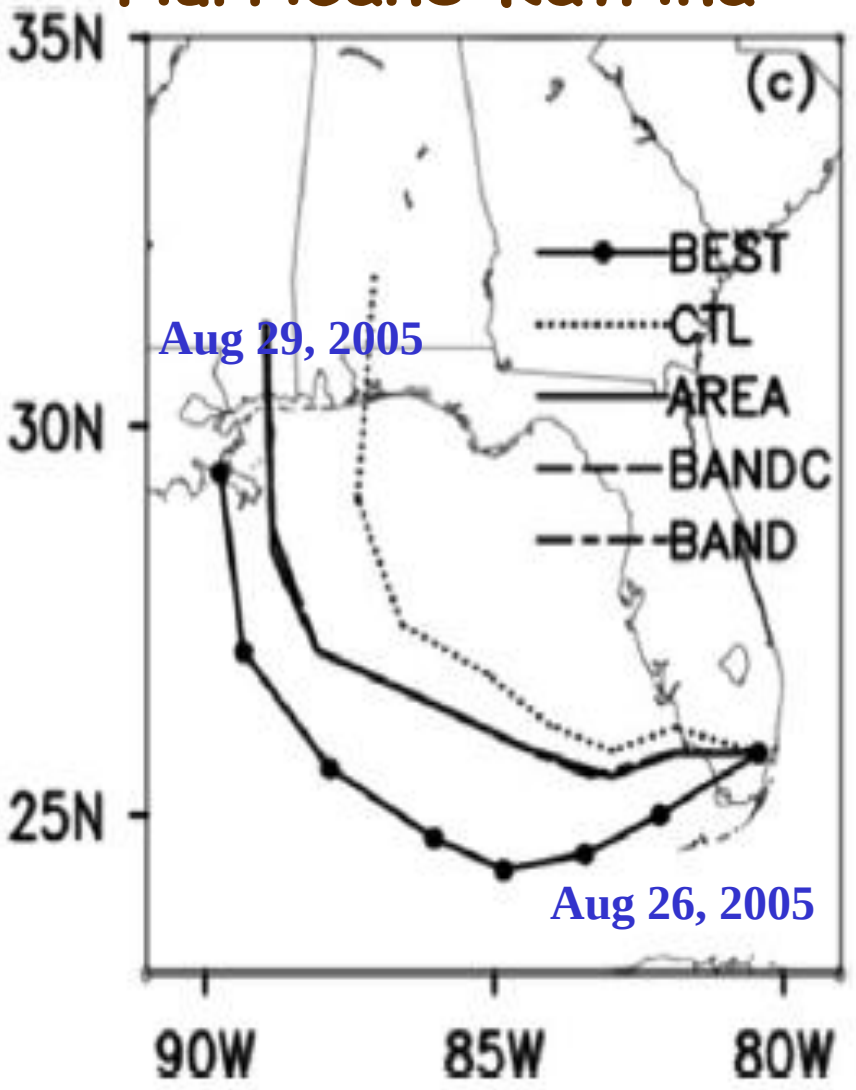
Objectives and Progresses

- Develop satellite capability of Surface Level Pressure (SLP) observations, especially over oceans
- Global SLP measurements will:
  - greatly improve hurricane forecasts (intensification & track predictions)
  - advance severe weather forecasts
  - directly measure the fundamental variable of meteorological dynamics
- Current: develop Proof-of-Concept (PoC) system, demonstrate the Differential absorption BArometric Radar (DiBAR) technology using PoC system for SLP measurements
- Existing capability: limited obs from buoy & dropsonde over oceans



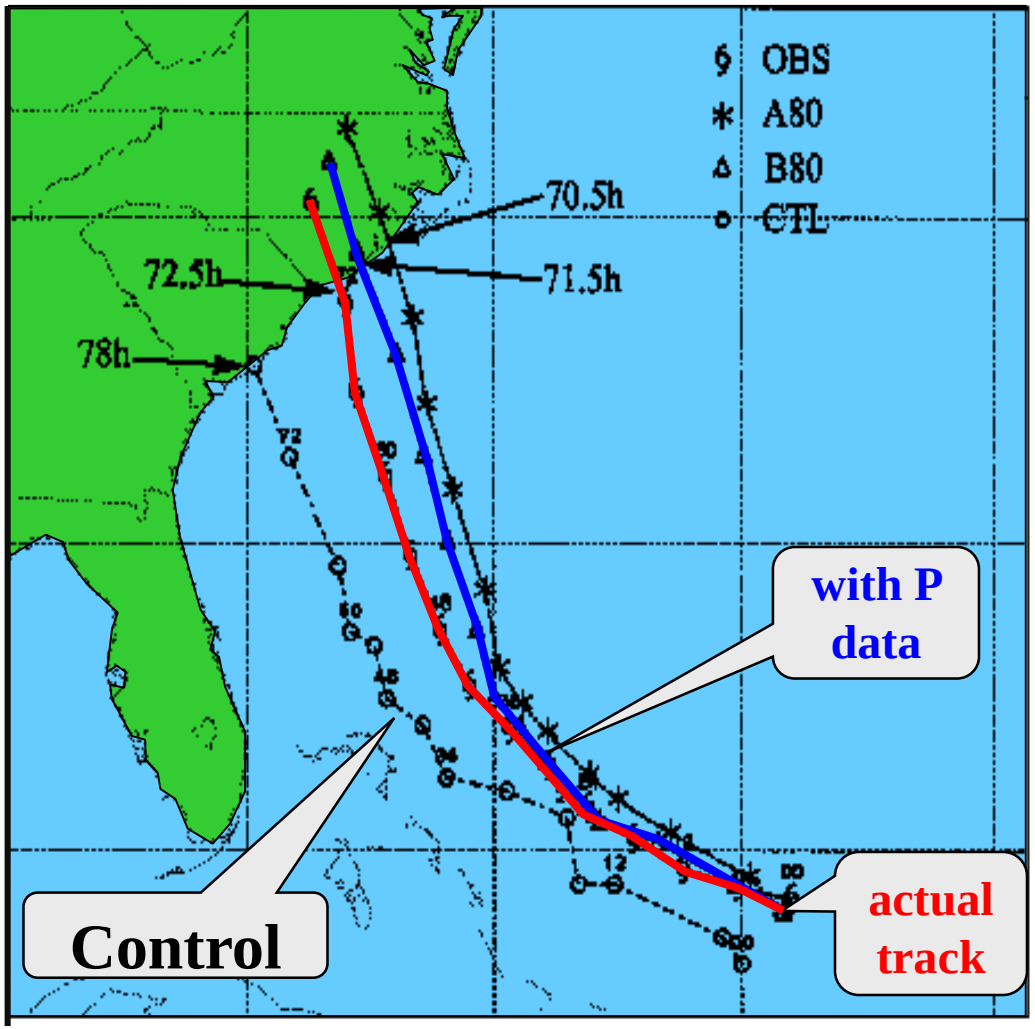
Benefits of sea surface barometry

Hurricane Katrina



Min et al., 2014

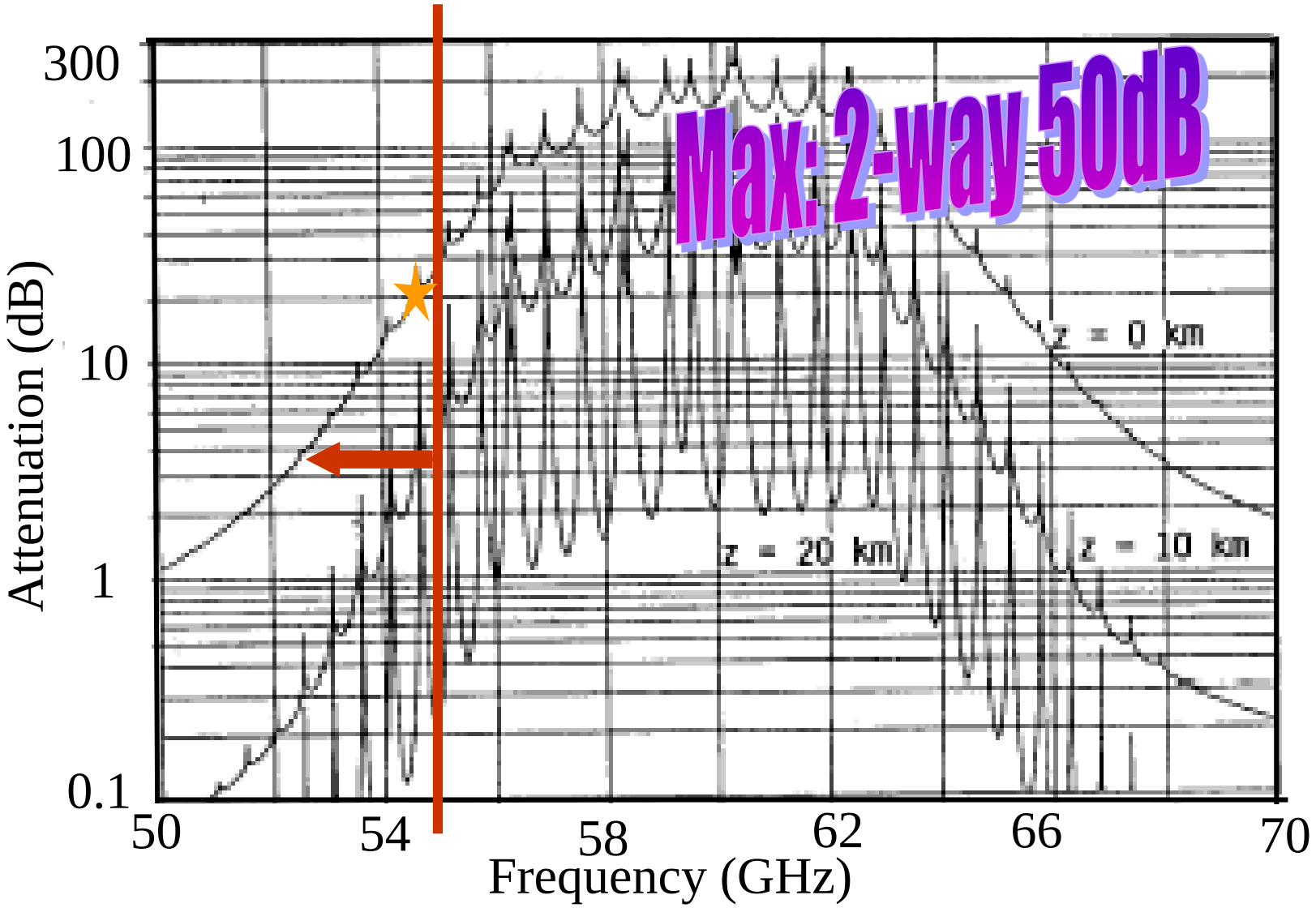
Fran'97



Lawrence et al., 2012

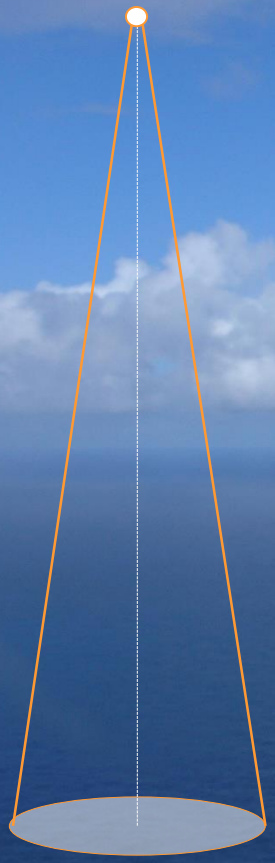
350 km landfall error reduced to < 100 km

Atmospheric attenuation

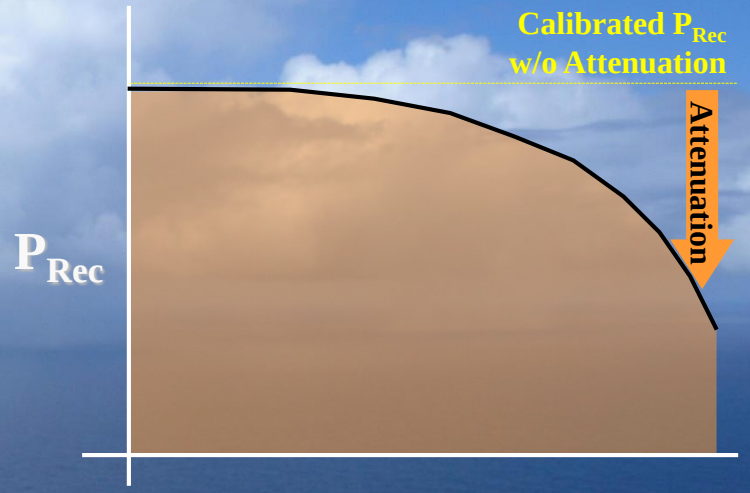


Measurement Concept

Aircraft/Spacecraft-Based Q-Band (50-56GHz) Radar

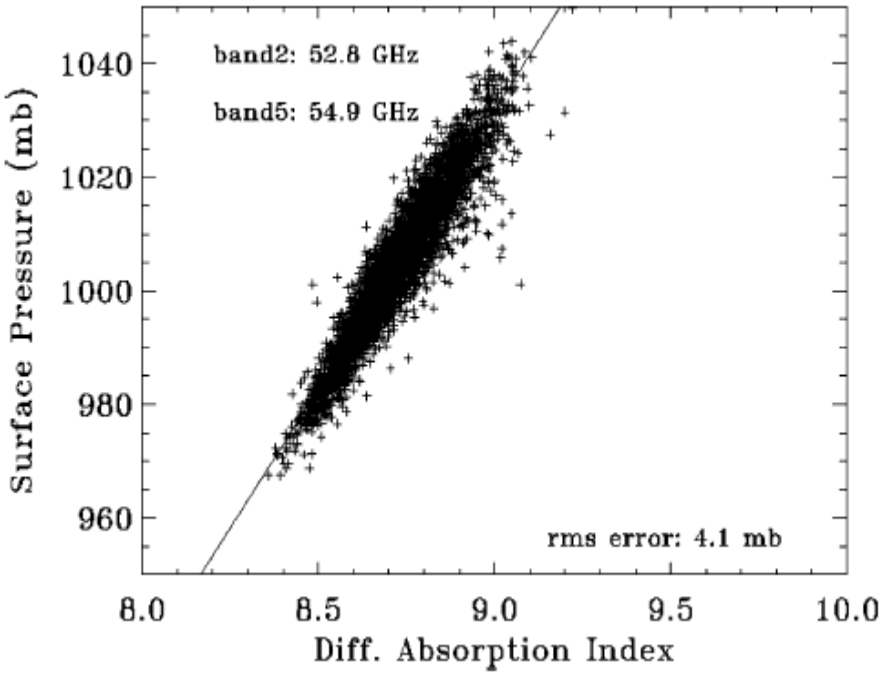


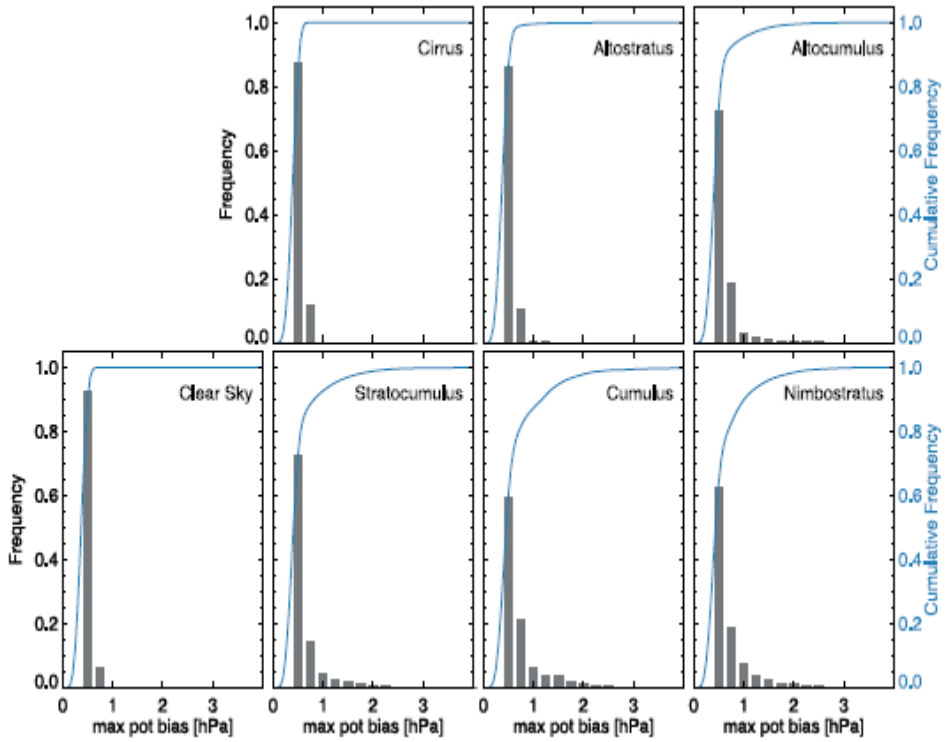
Oxygen in the atmosphere attenuates the transmitted signal – less at lower freq. and more at higher freq.



The amount of attenuation is directly related to barometric pressure and altitude.

Radar Simulated Results

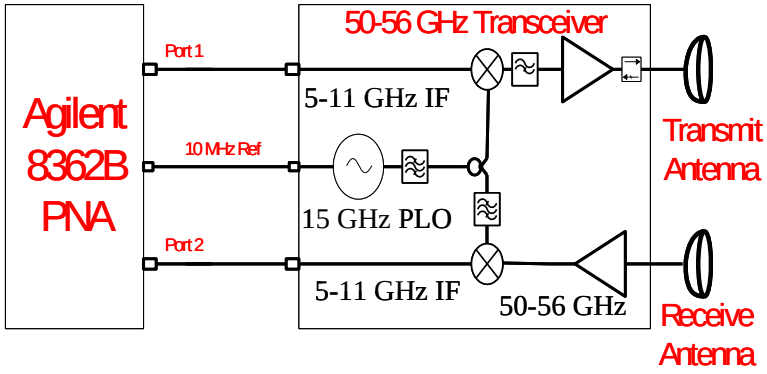


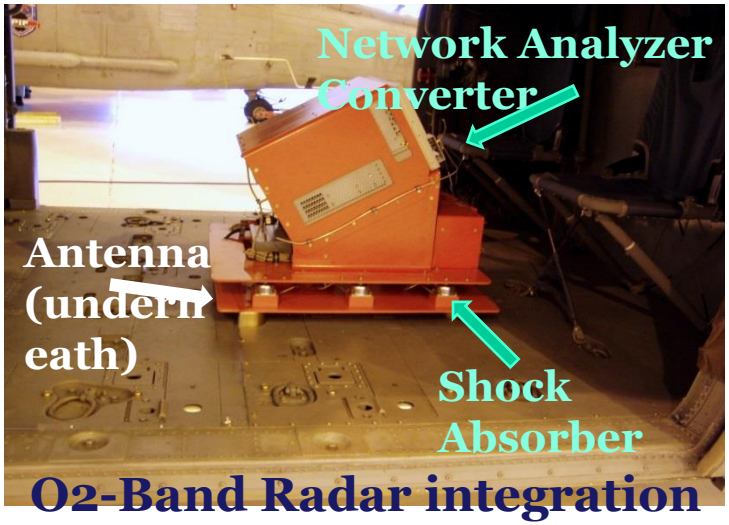


Lin and Hu, 2005

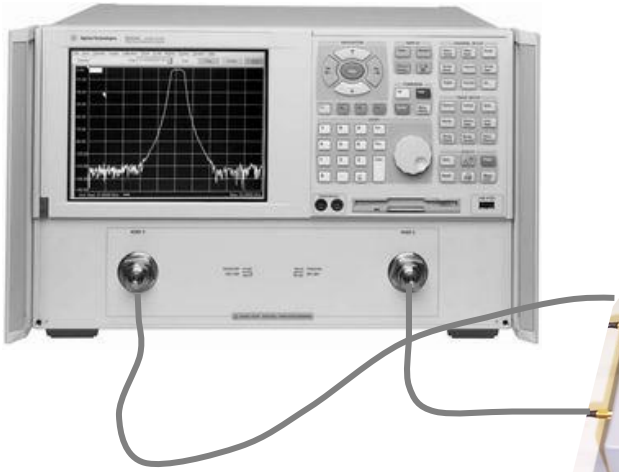
Millan et al., 2014

PoC Instrument Development

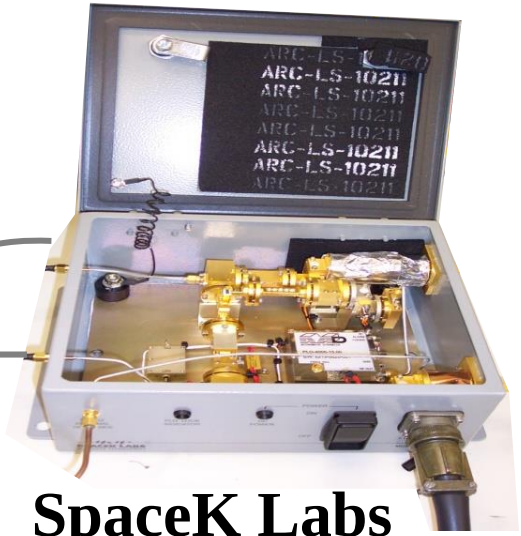




O2-Band Radar integration



Agilent 8362B Network Analyzer



SpaceK Labs 45GHz Up/Down Converter

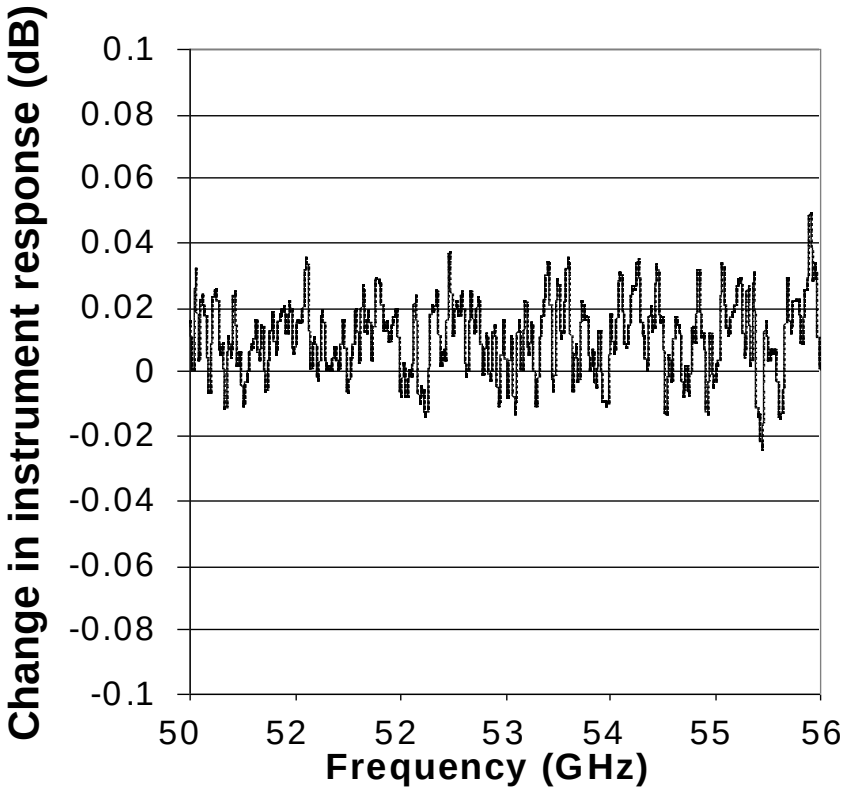
Quinstar 24" Cassegrain Antennas

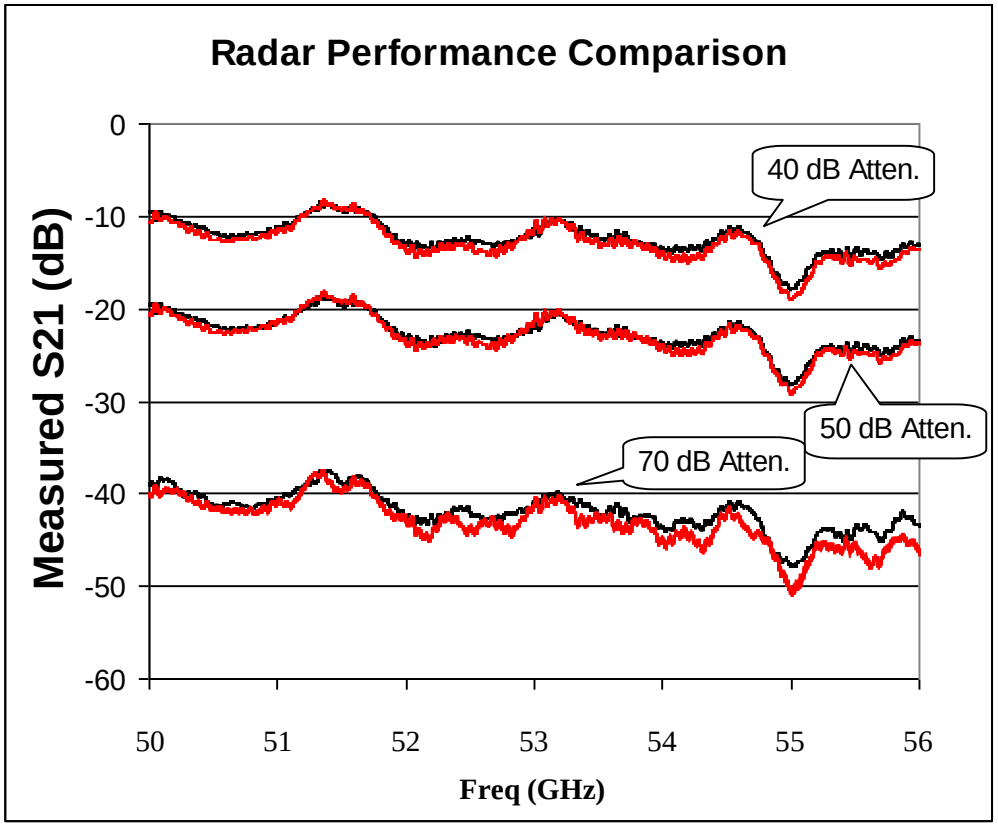
simplified to a small horn during flights

Stability (short- and long-term)

- Characterization of the end-to-end spectral response and linearity
- Repeatability suggests calibrations will be stable both short and long terms.
- Flight tests will use measurements at low altitudes to verify spectral calibration.

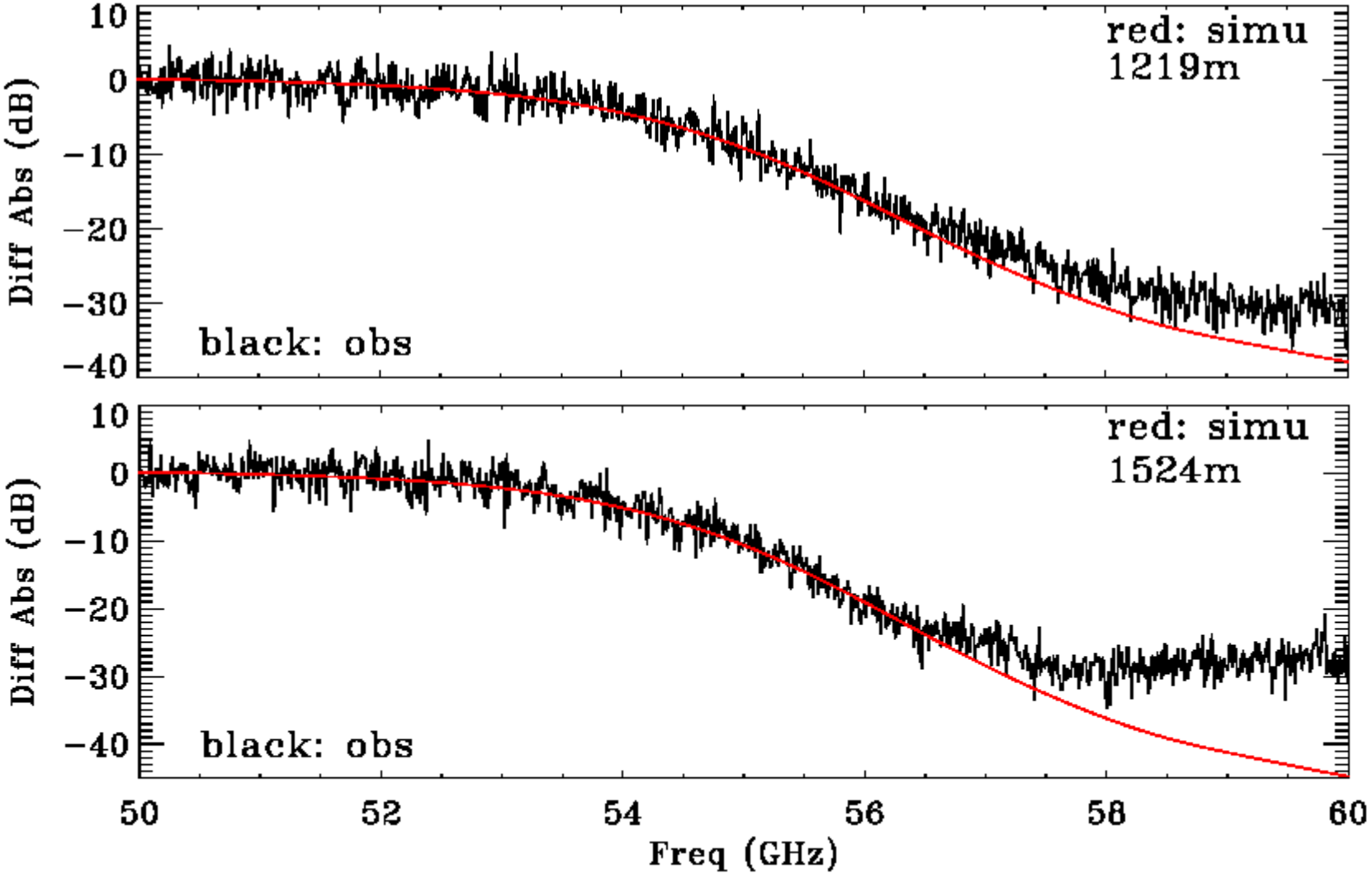
repeating tests in 30 minutes and 6 months





Besides lab tests,
tests in open fields and over bridges were also conducted.

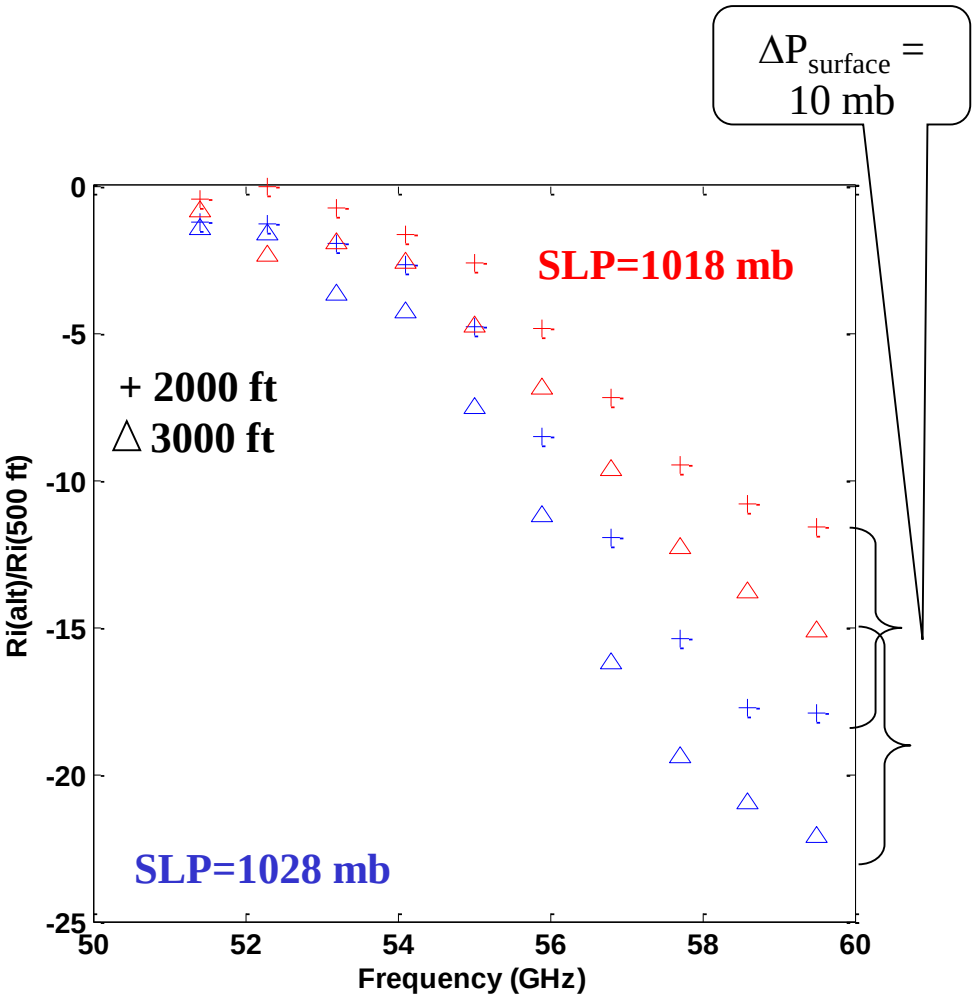
Flight Test: Spectral Scanning



DiBAR Flight Test

Flight Test Results

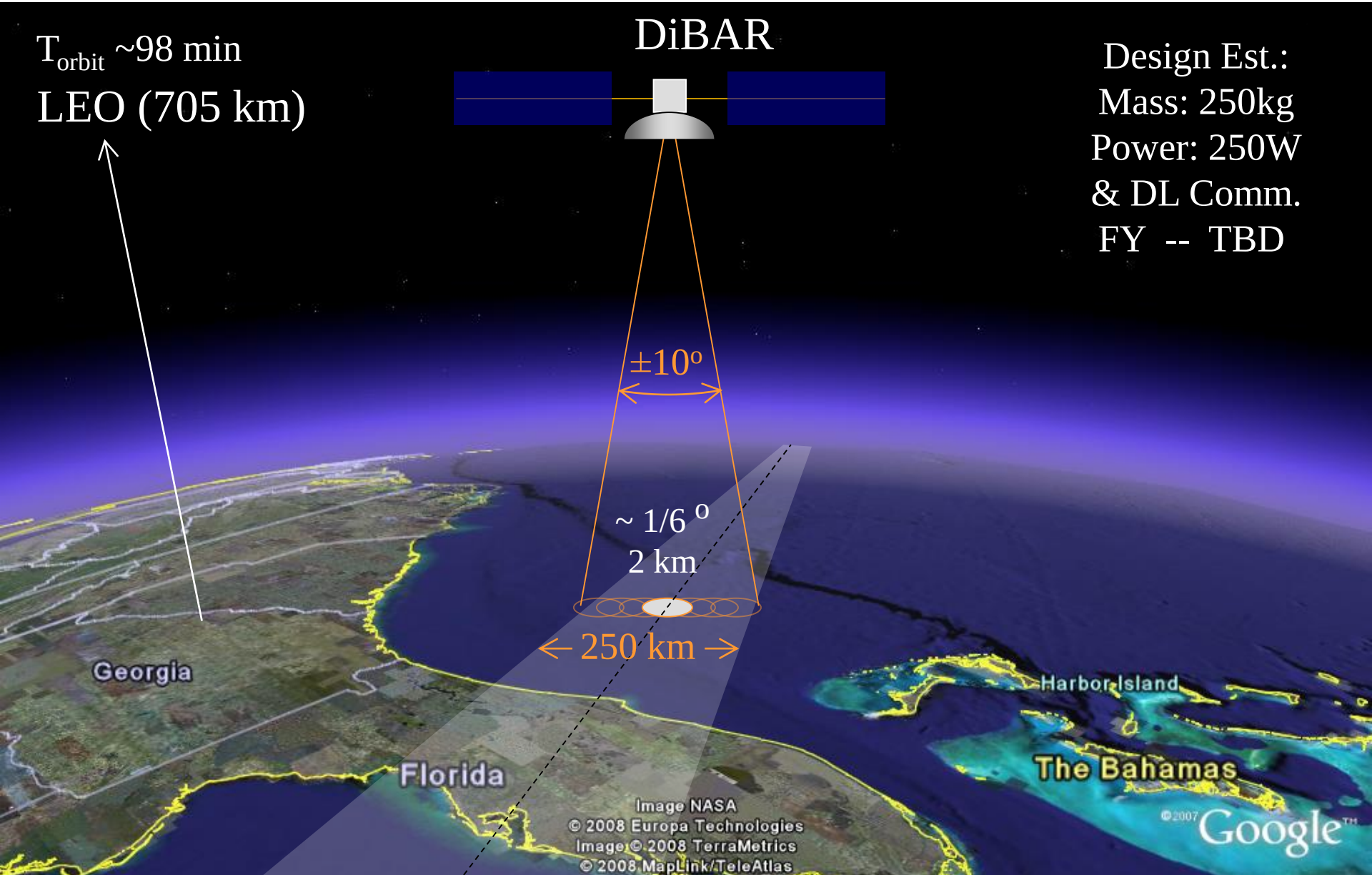
- Differential absorption was measured for 1000 – 6000 ft.
- Results are consistent with O_2 absorption model
- Sensitivity to surface barometric pressure has been demonstrated



+ Ri(2000)/Ri(500)
△Ri(3000)/ Ri(500)
P_s=1018 mb

+ Ri(2000)/Ri(500)
△Ri(3000)/ Ri(500)
P_s=1028 mb

Satellite Concept



Summary

The SLP measurement approach will dramatically extend the current, limited-point barometric measurements for tropical storm observations when spaceborne instruments are available.

- The differential O_2 absorption approach will provide the first remote sensing barometric data over tropics!
- The accuracy of instantaneous sea surface air pressure measurements from O_2-band sensors could be as high as ~4 mb.
- DiBAR technology will lead significant improvements in predictions of hurricane intensities and tracks and provide great benefits for the public.
- Operational capability of DiBAR approach potentially enables the monitoring of changes in the extreme precipitation events such as tropical storms over tropics, and has both weather and climate applications.