Remote Sensing Global Surface Air Pressure using Differential Absorption BArometric Radar (DiBAR)

Bing Lin[1], Steven Harrah[1], Wes Lawrence[2], Yongxiang Hu[1], and Qilong Min[3]

[1]NASA Langley Research Center, Hampton, VA
[2]Old Dominion University, Norfolk, VA
[3]State University of New York, Albany, NY

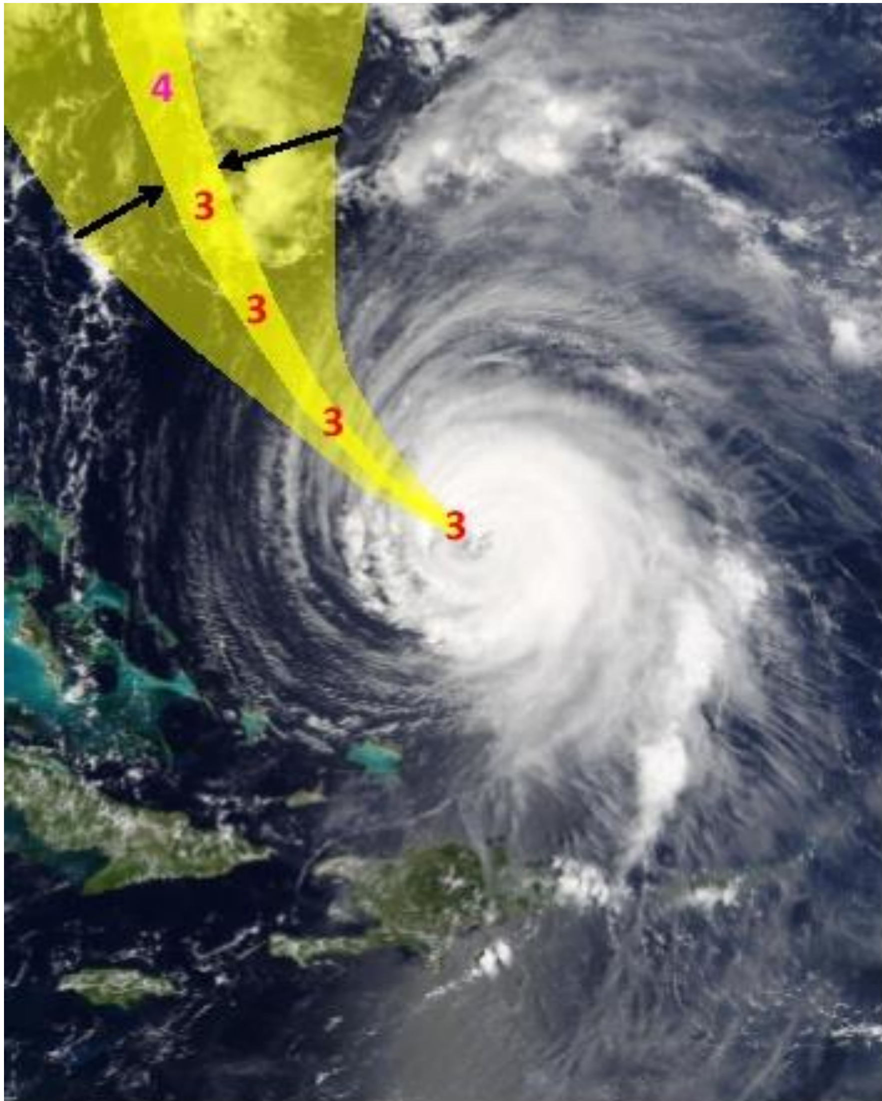
International Radiation Symposium 2016
16-22 April 2016, Auckland, New Zealand

Objectives
(Dynamic fields, hurricanes)

- **Develop satellite capability of Surface Level Pressure (SLP) observations, especially over oceans**
- **Global SLP measurements will:**

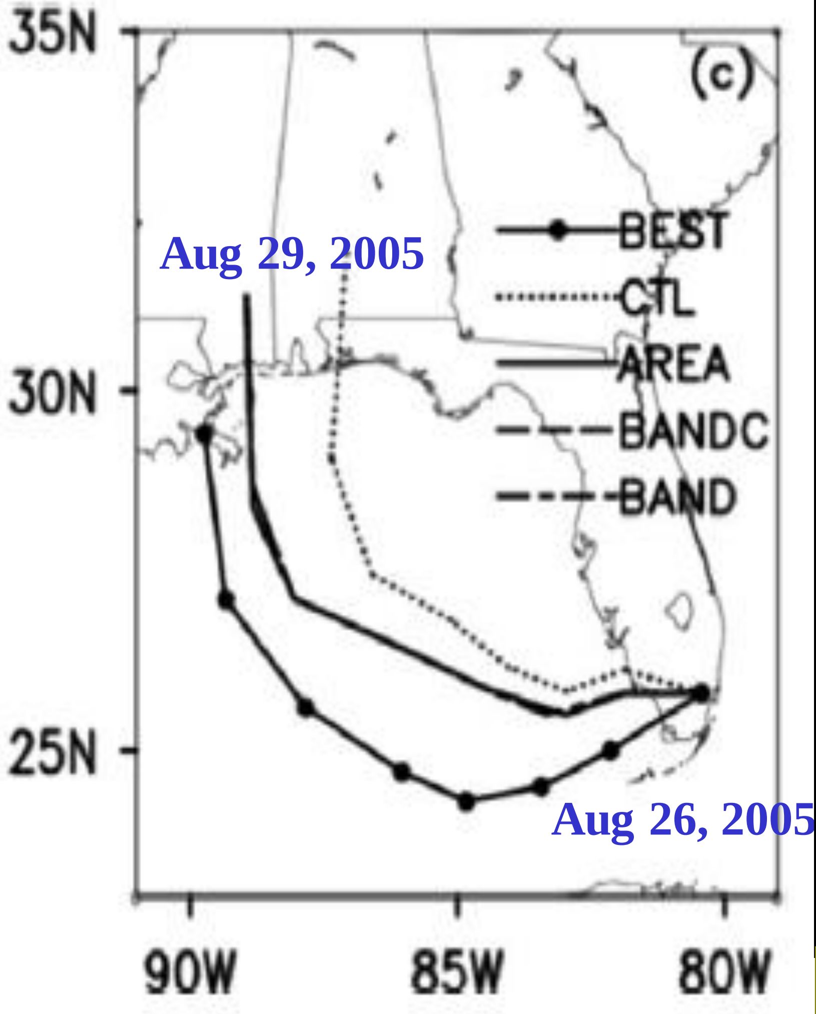
- greatly improve hurricane forecasts (intensification & track predictions)
- advance severe weather forecasts
- directly measure the fundamental variable of meteorological dynamics

- **Current: develop Proof-of-Concept (PoC) system, demonstrate the Differential absorption BArometric Radar (DiBAR) technology using PoC system for SLP measurements**



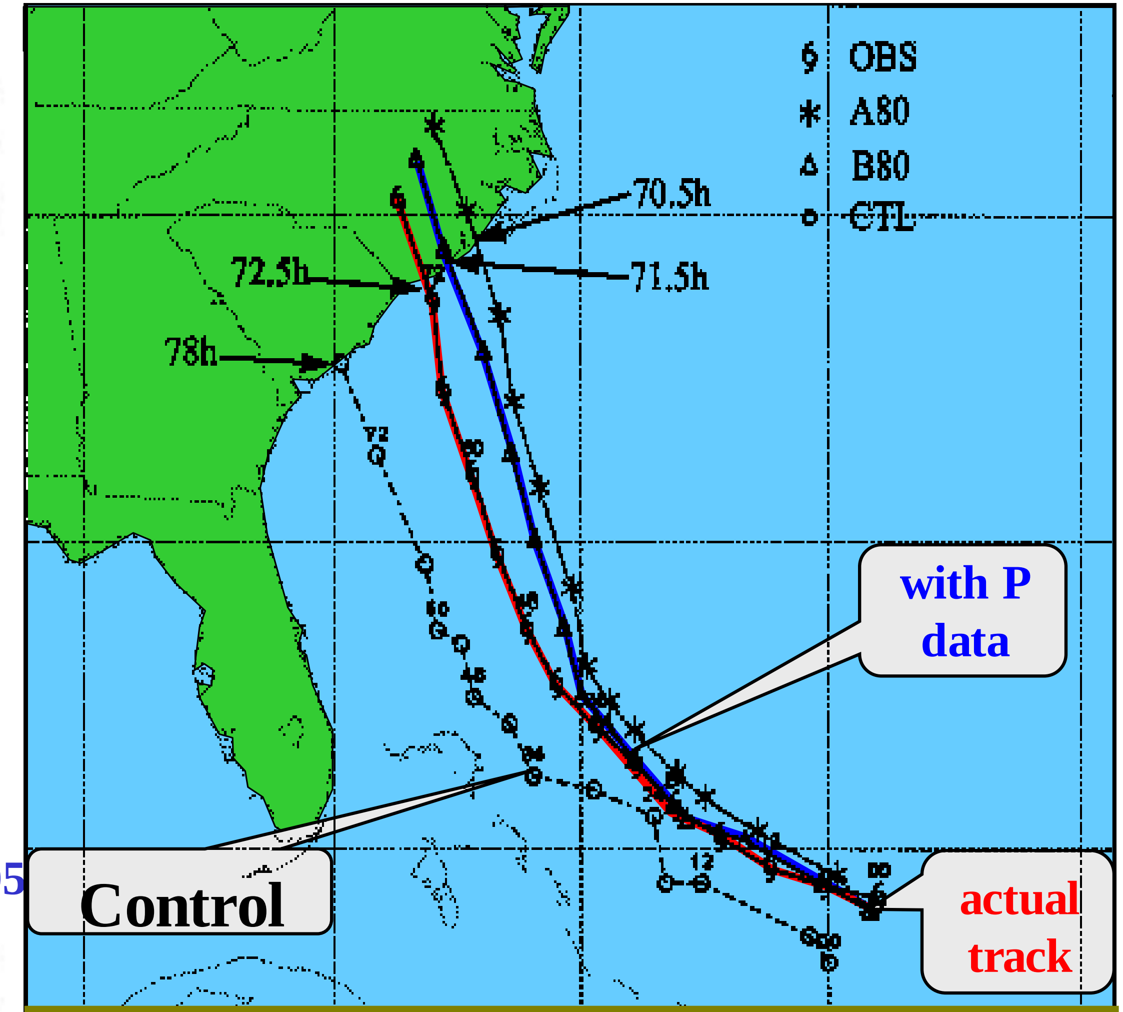
Benefits of sea surface barometry

Hurricane Katrina



Min et al., 2014

Fran'97



350 km landfall error reduced to < 100 km

Current Capability

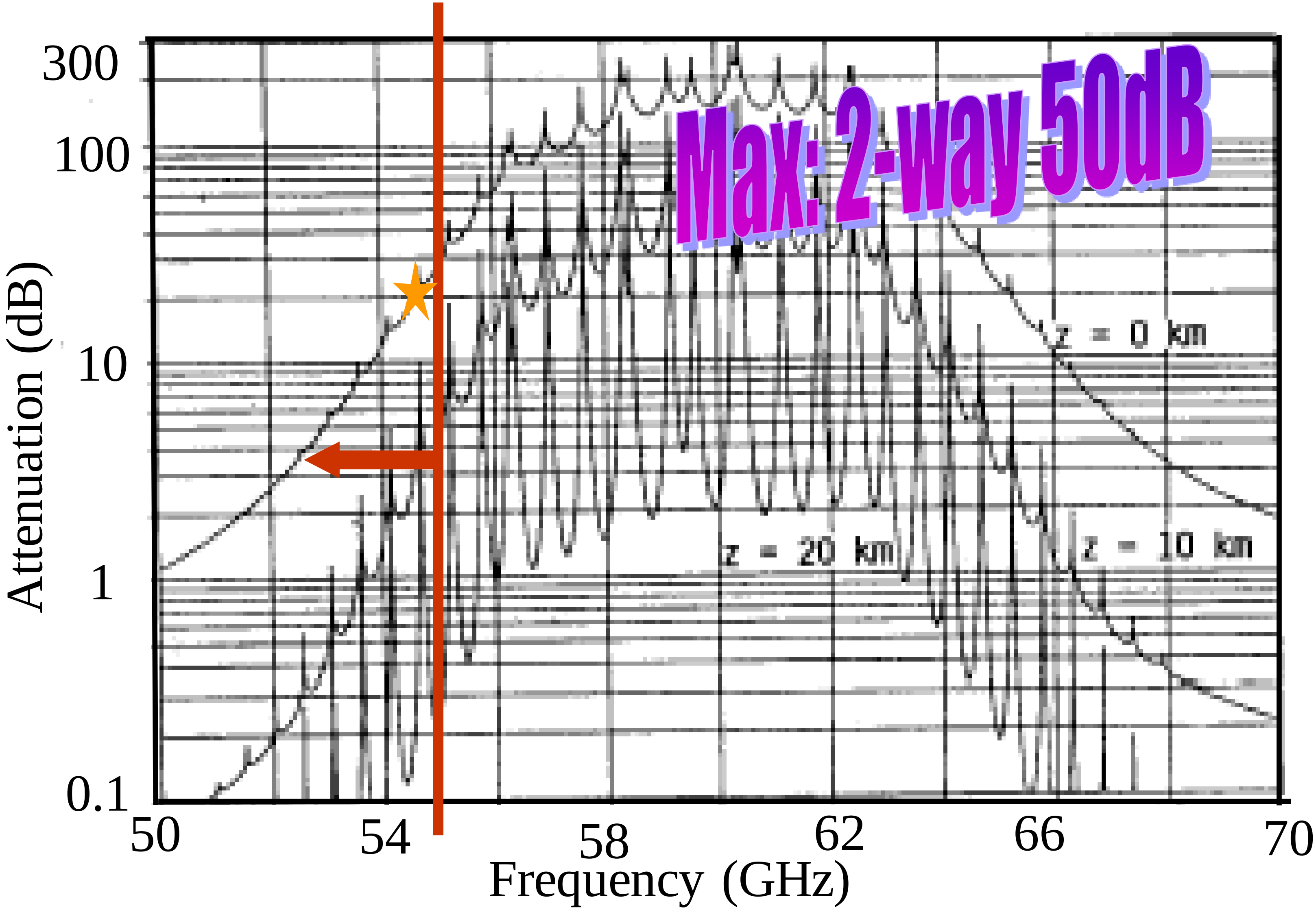
In-Situ Sea Surface Air Pressure Measurements for Weather Forecasts and Atmospheric Dynamics

Existing techniques: in-situ

- Spatial coverage: very limited
- Costs: high
- Buoy: uncertain in hurricanes
- Uncertainty: ~1 mb

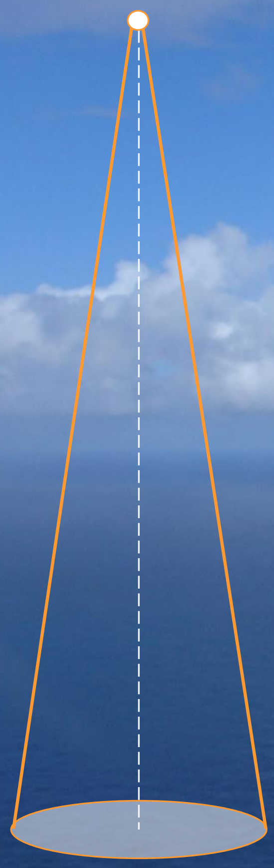
No remote sensing technique is available.

Atmospheric attenuation

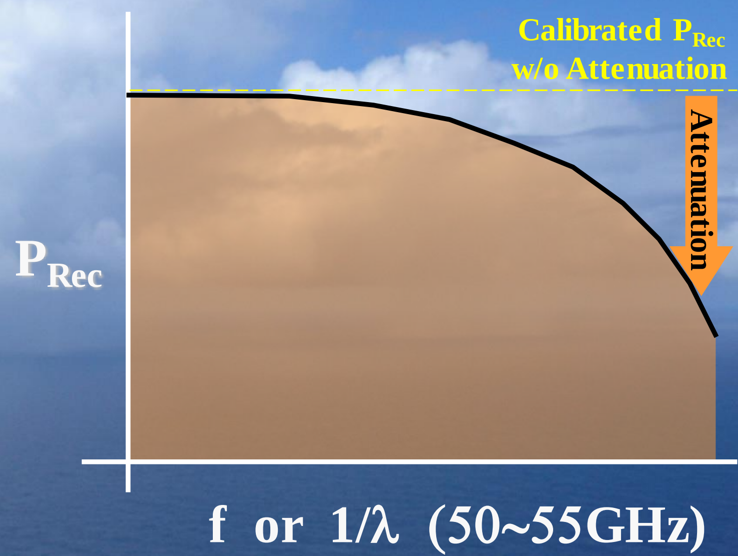


Measurement Concept

Aircraft/Spacecraft-Based Q-Band (50-55GHz) Radar

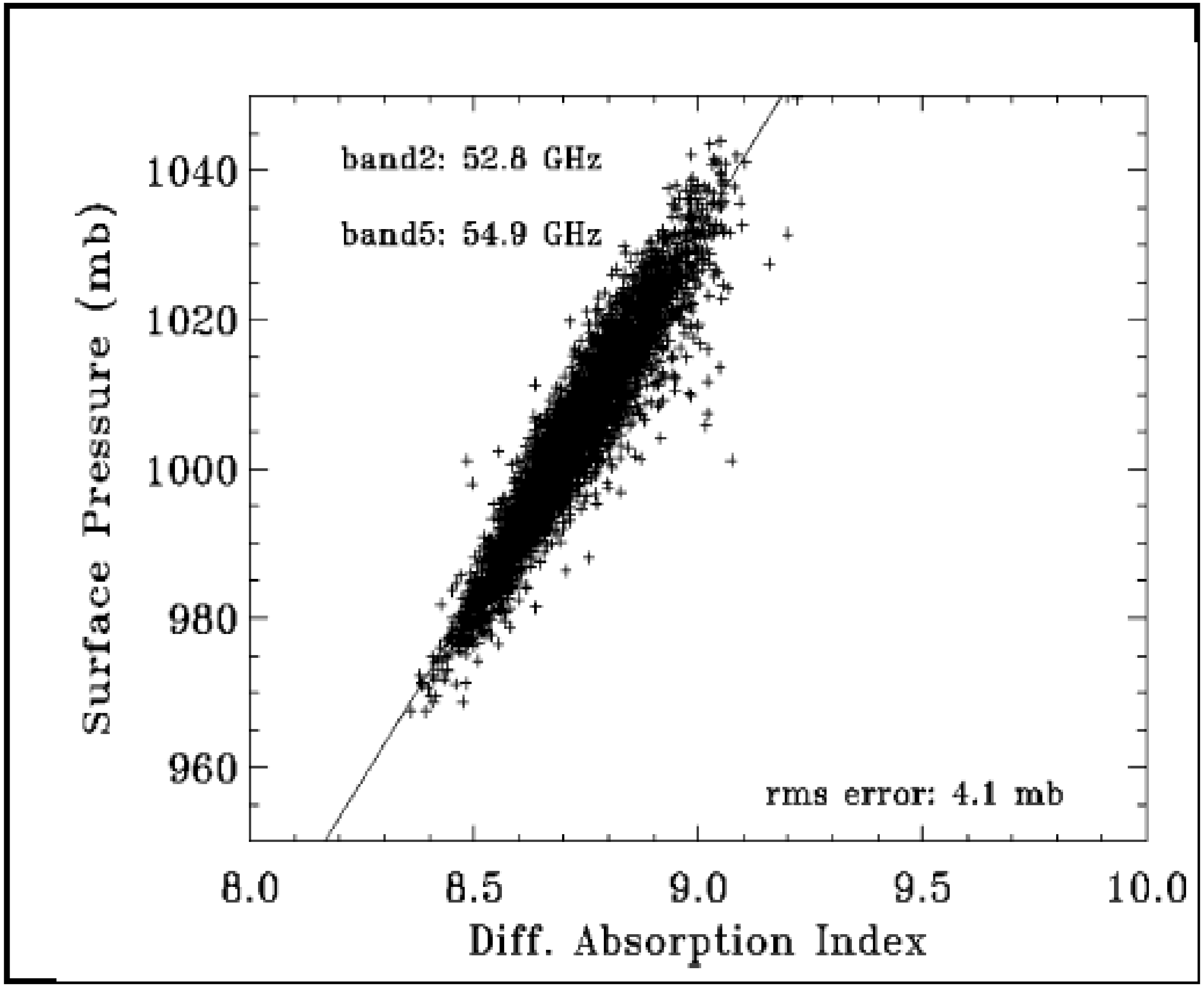


Oxygen in the atmosphere attenuates the transmitted signal – less at lower freq. and more at higher freq.



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

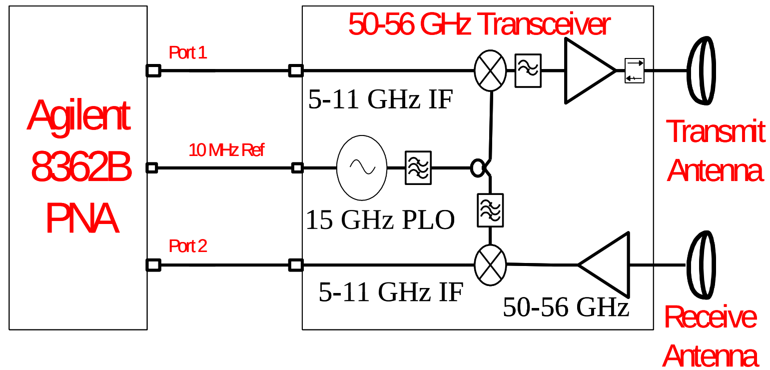
Simulated barometry results



Lin and Hu, 2005

Global weather conditions

PoC Instrument developed



Agilent 8362B Network Analyzer

SpaceK Labs 45GHz Up/Down Converter

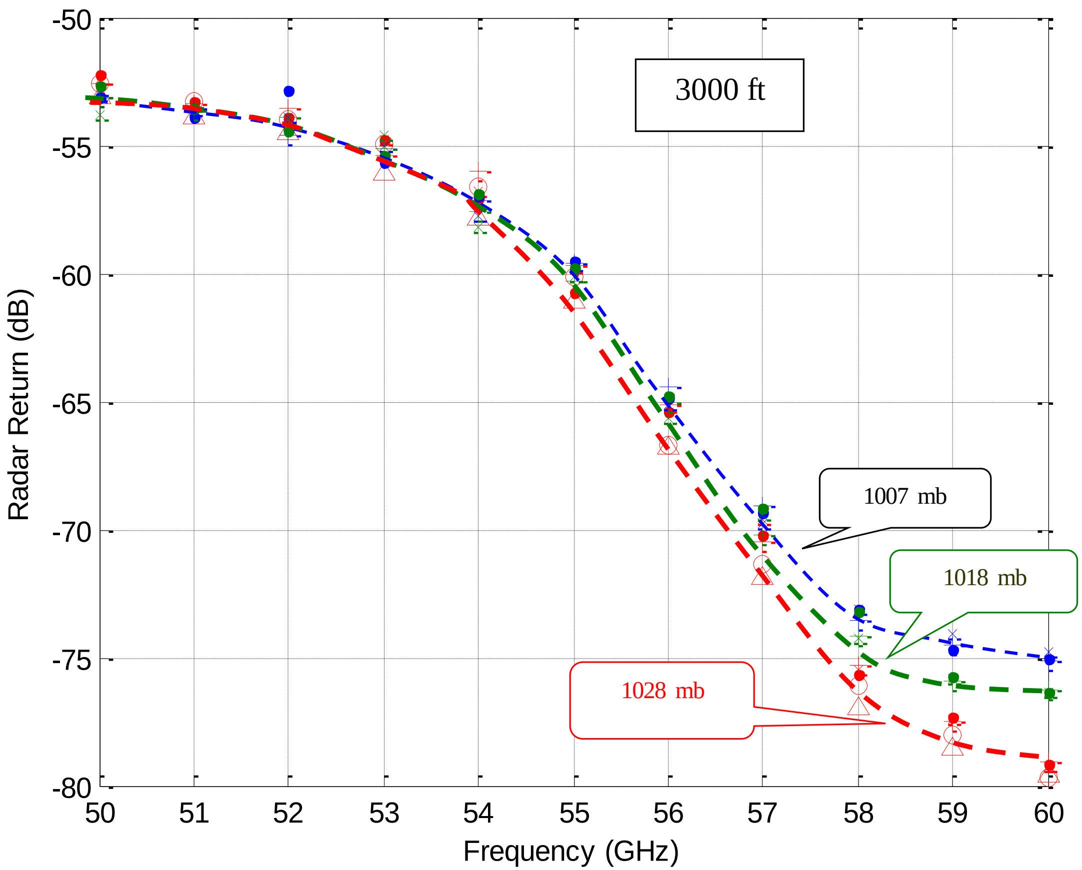
Quinstar 24" Cassegrain Antennas

Thursday, November 13, 2008   10:30 am EST

DiBAR flight results

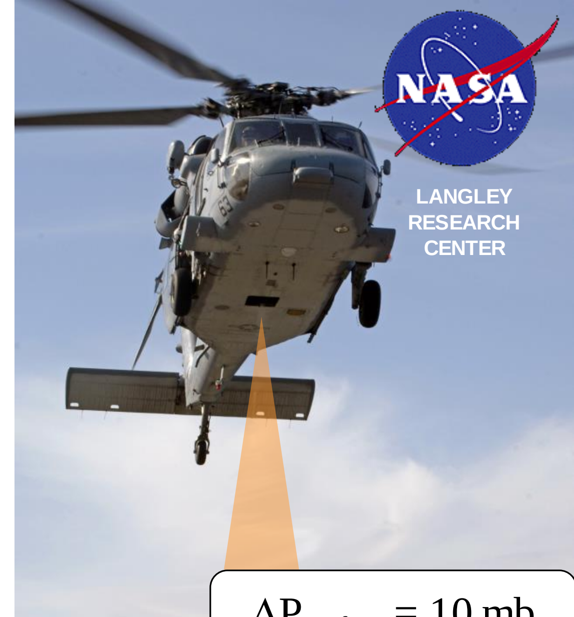
The measured differential loss validated the predicted frequency dependence and was clearly correlated with surface level pressure.

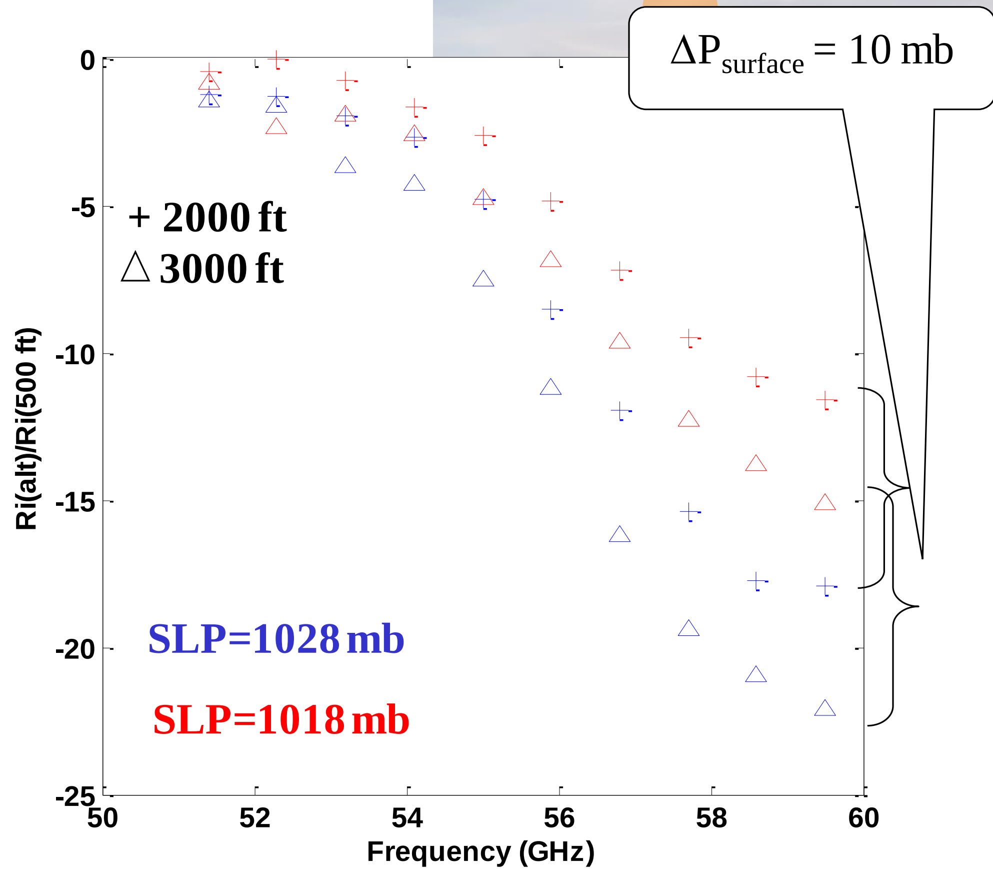
- **Increased O_2 absorption loss vs. frequency evident for all flight measurements.**
- **Differential absorption, or Ri, shows correlated with increasing SLP for the flight campaign data.**



DiBAR Flight Test

- Differential absorption was measured for 0 – 2 km altitudes.
- Results are consistent with O_2 absorption model.
- Sensitivity to surface barometric pressure demonstrated.

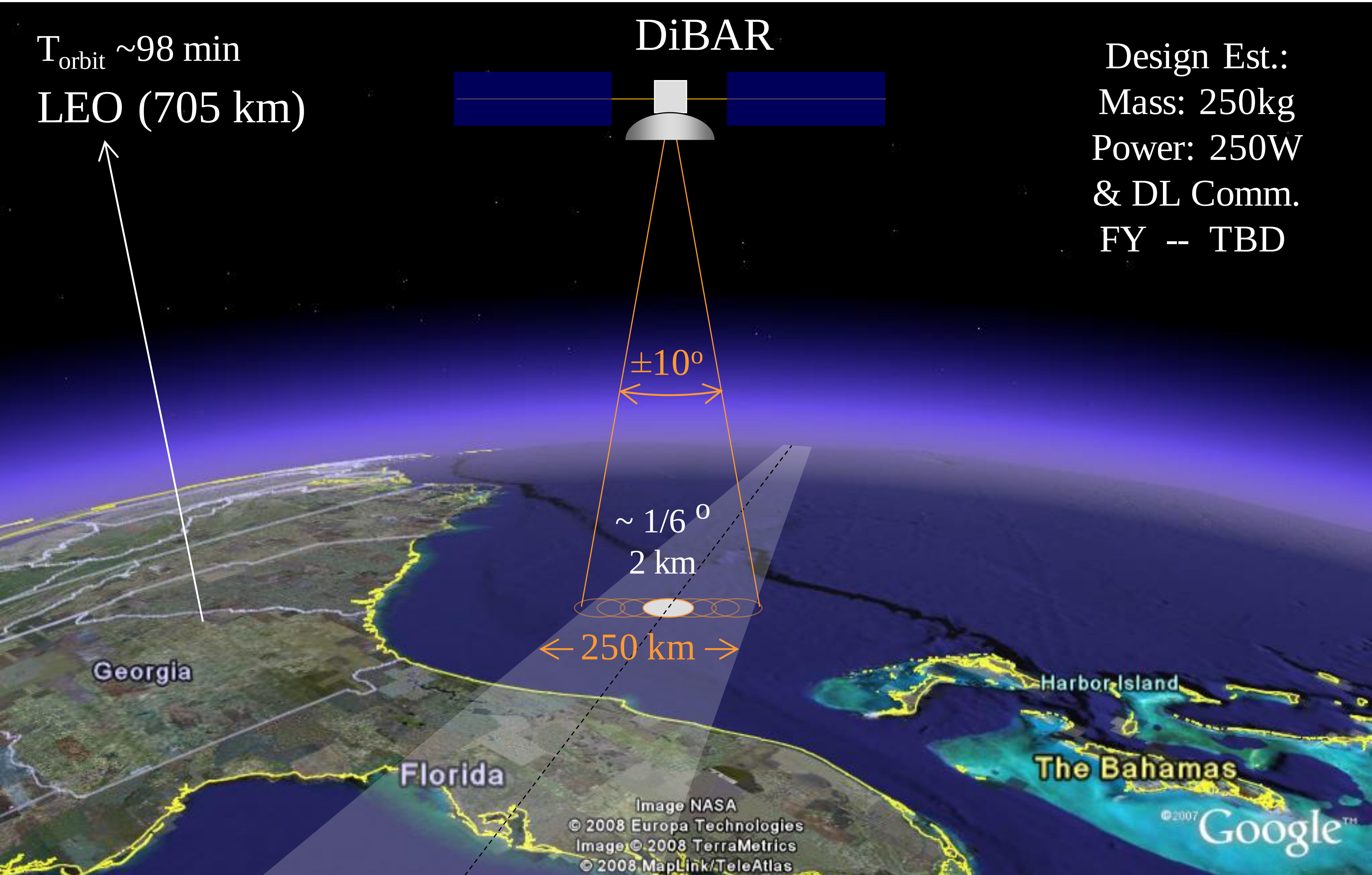




+ Ri(2000)/Ri(500)
△Ri(3000)/ Ri(500)
} P_s=1018 mb

+ 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 to global observations for tropical storm forecasts when spaceborne instruments are available.

- The differential O_2 absorption approach will provide the first remote sensing barometric data over the globe!
- 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 storm and precipitation events such as tropical storms, and has both weather and climate applications.