Current and future PBL Sounding of Temperature and Water Vapor

By

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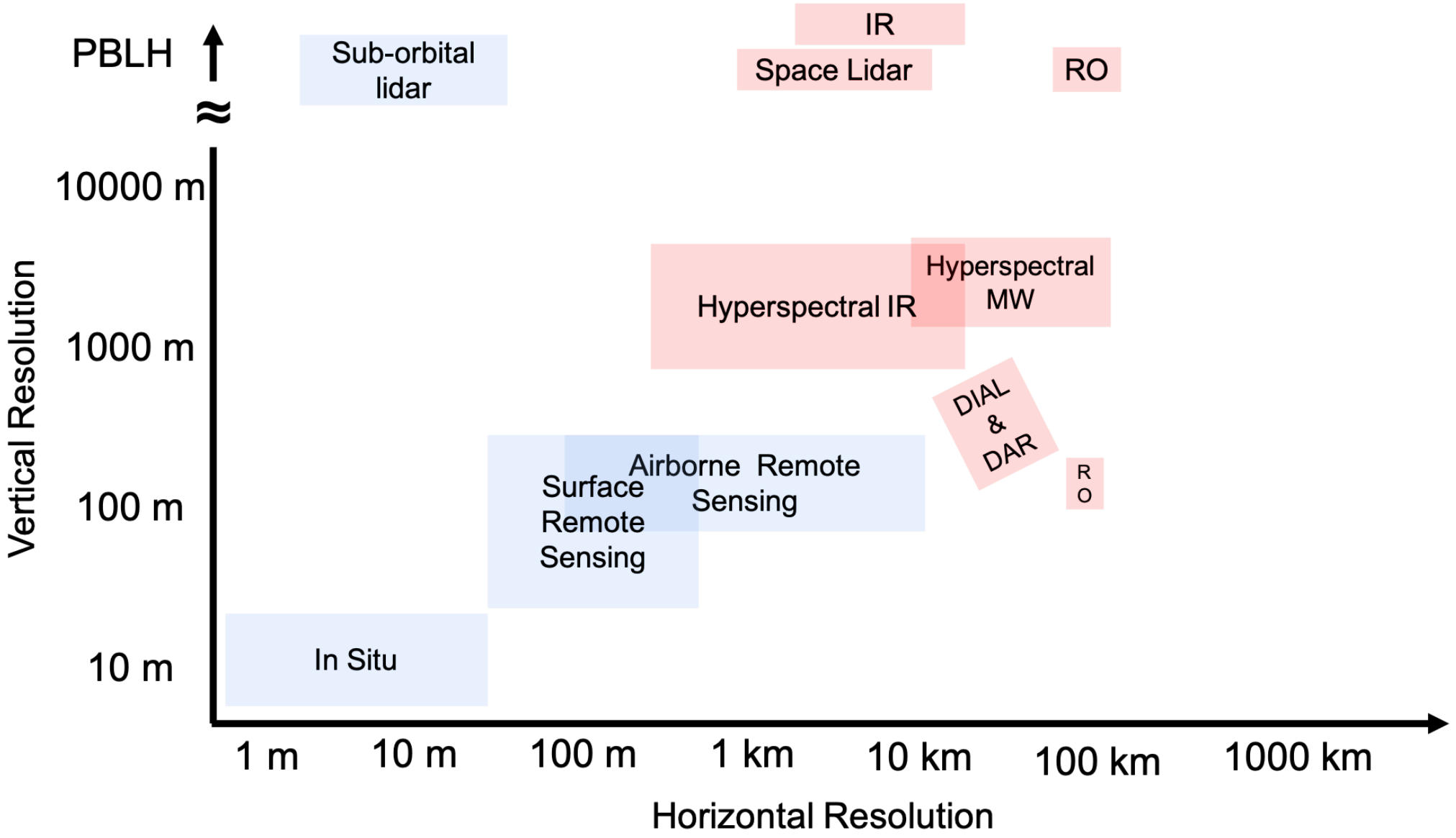
NASA PBL Incubation Study Team Report

- The next slides all come from a report by scientists at various institutions given to NASA to accomplish the goals laid out in the decadal survey for PBL science
- It can be found at the following link
- https://science.nasa.gov/science-pink/s3fs-public/atoms/files/NASAPBLIncubationFinalReport.pdf

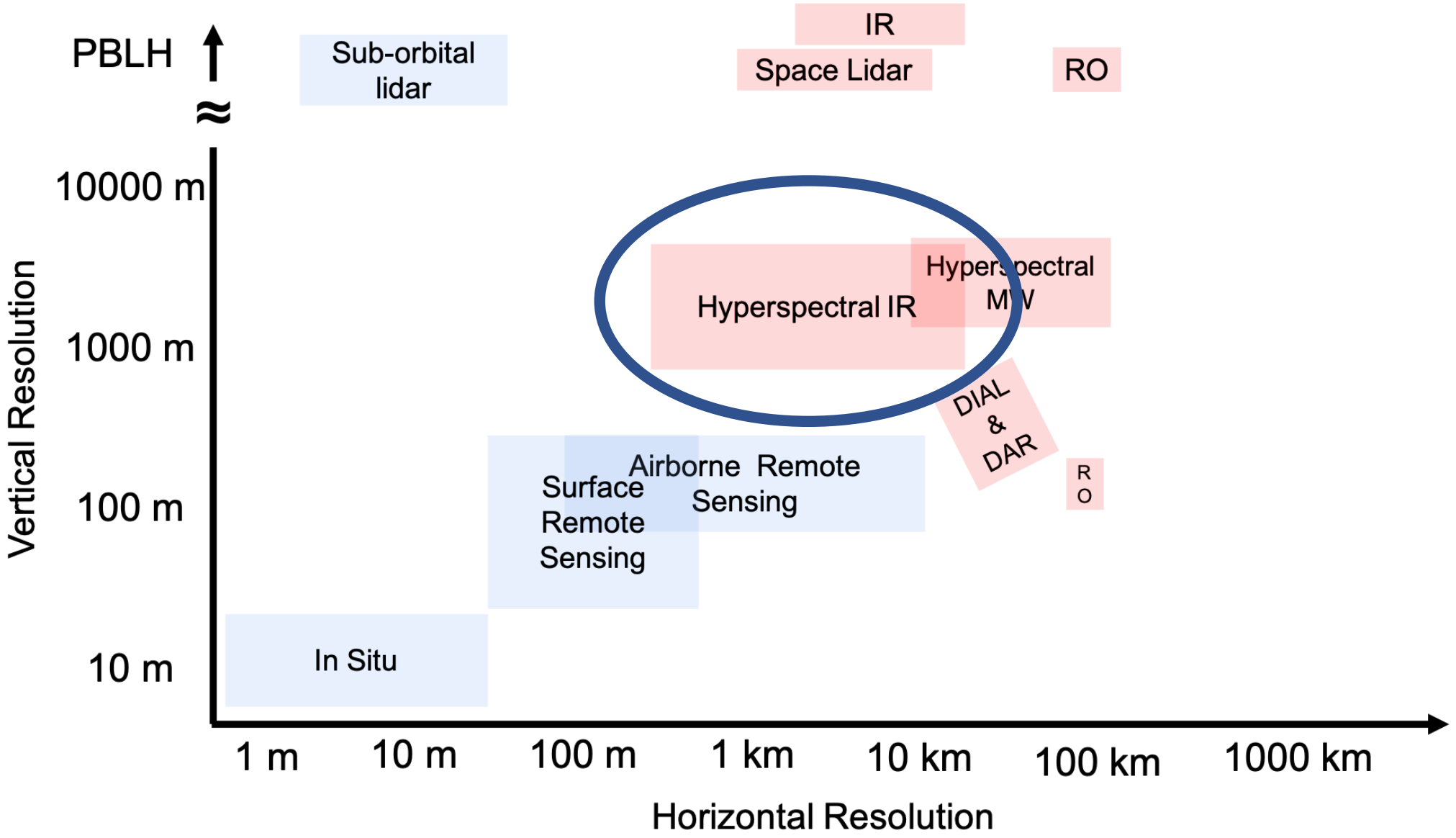
Current Space Observed Program of Record

Instrument Type	Current Platforms	Physical Parameters	Resolution and Accuracy	Applications and Liability
Hyperspectral IR	AIRS, CrIS, IASI, IRAS/HIRAS	T,q profiles	T: 1km(v) 14km(h) 1K(a) Q:1-2km(v) 14km(h) 10%(a)	Clear Sky, optically thin clouds Limited Vertical Resolution and clouds
Microwave	AMSU, MHS, ATMS	T,q profiles	T: 2-4km(v) 40km(h) 1-2K(a) Q:2-4km(v) 40km(h) 10-20%(a)	Limited Vertical Resolution
GNSS-RO	GRAS, IGOR, KOMPSAT	T,q profiles,PBLH	T: .2-.5km(v) 100km(h) 1-2K(a) Q:.2-.5km(v) 100km(h) 0.5-1g/kg(a)	T&Q not fully decoupled Limited horizontal res Bias and depth issues

Estimated Future observations by 2026



Estimated Future observations by 2026

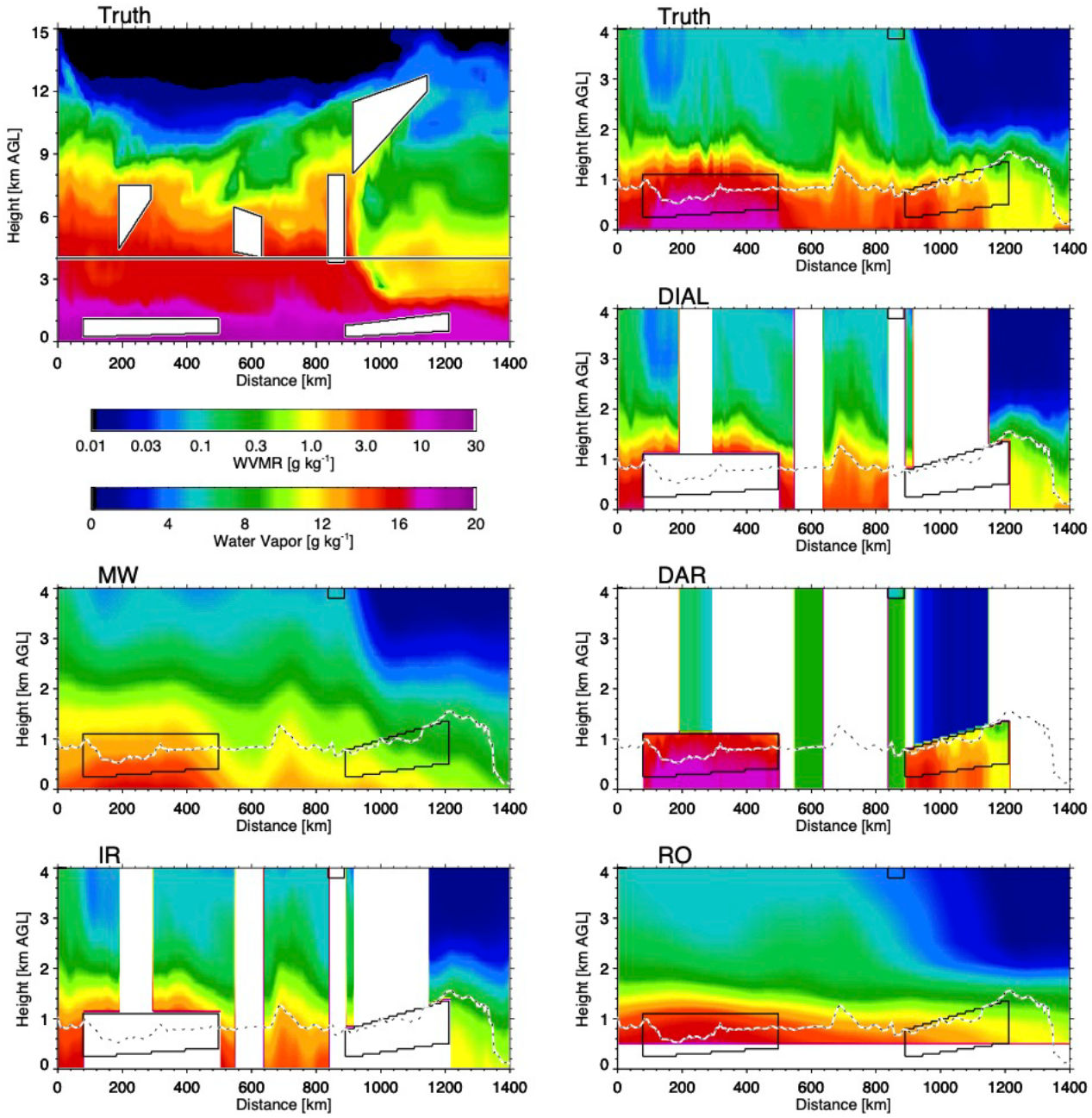


- Simulation of NOAA HRRR for truth and simulated retrievals of various instruments

Two new technologies

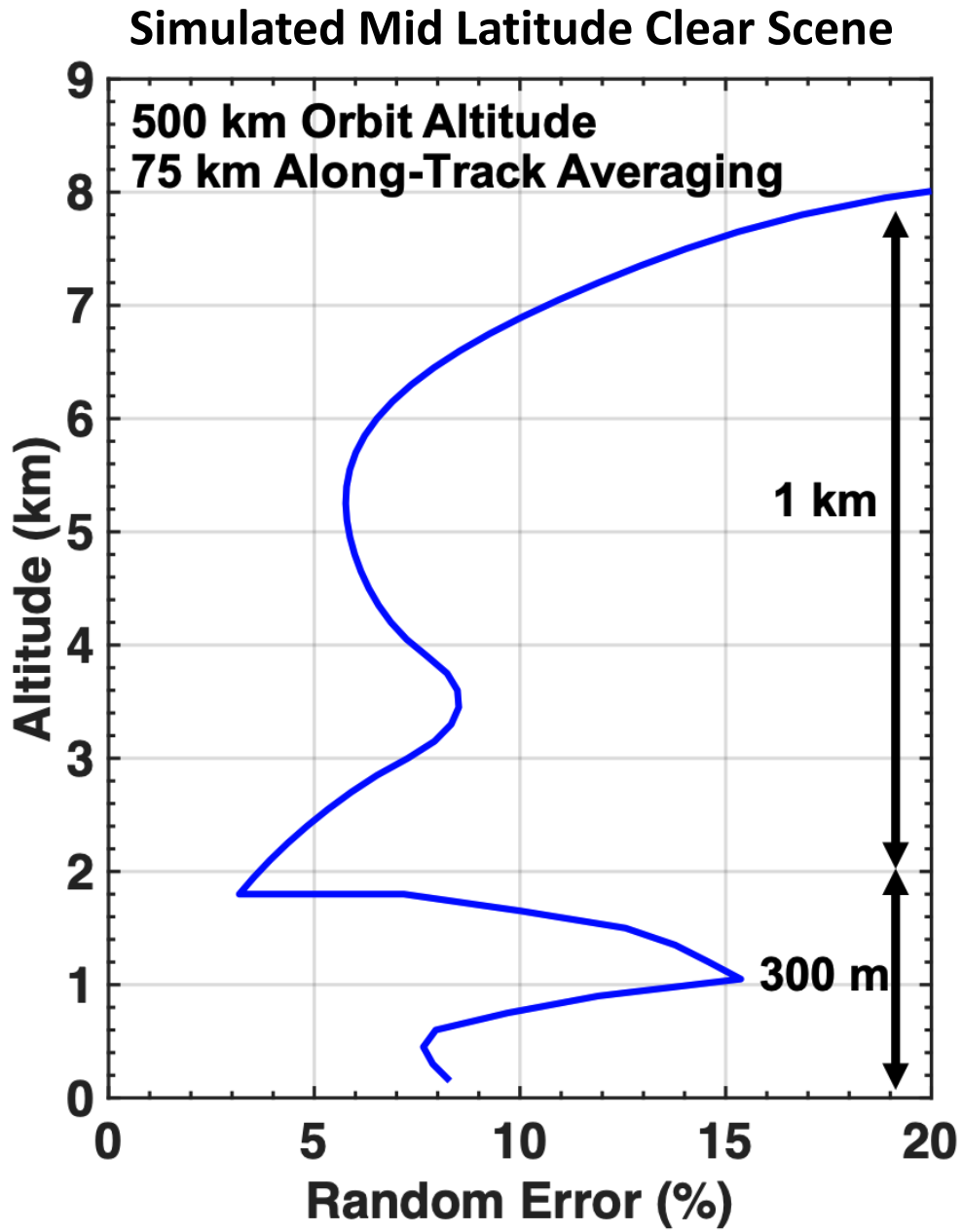
DIAL: Differential Absorption LIDAR

DAR: Differential Absorption Radar



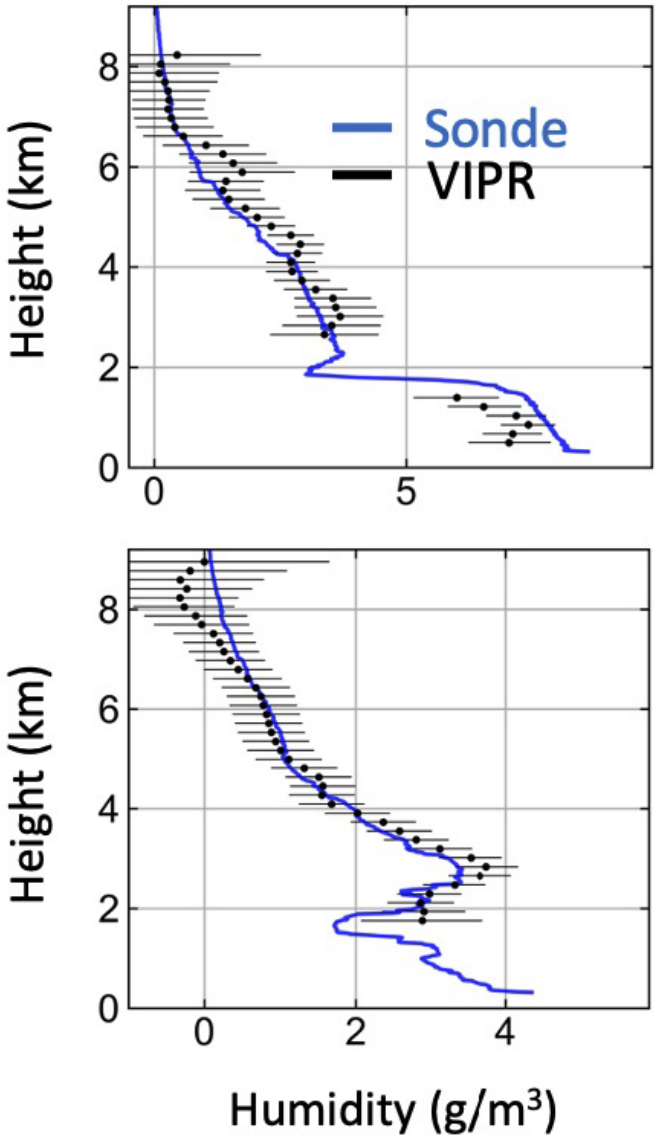
DIfferential **A**bsoprtion **L**IDAR

- Able to directly measure profiles of water vapor in clear and broken sky scenes with high accuracy and vertical resolution (200 - 300 m).
- Clouds attenuate the lidar signal and you are unable to get water vapor profiles below clouds



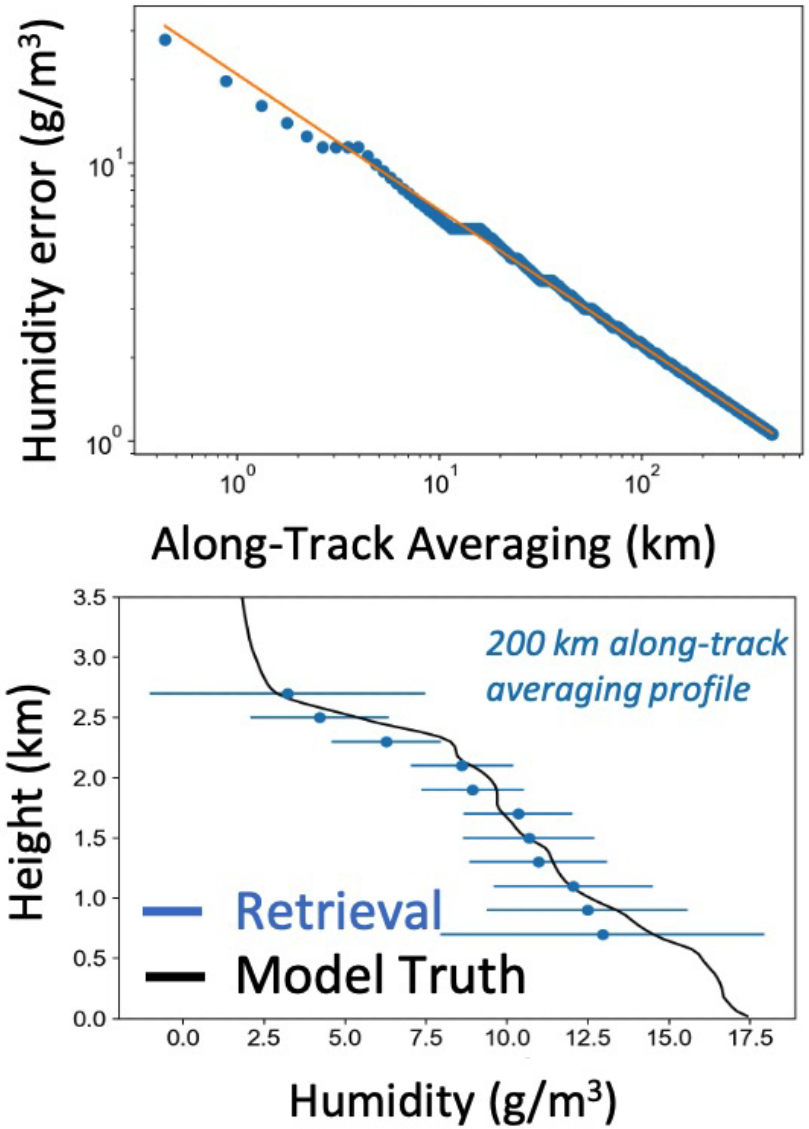
DIfferential **A**bsoprtion **R**adar

VIPR Validation

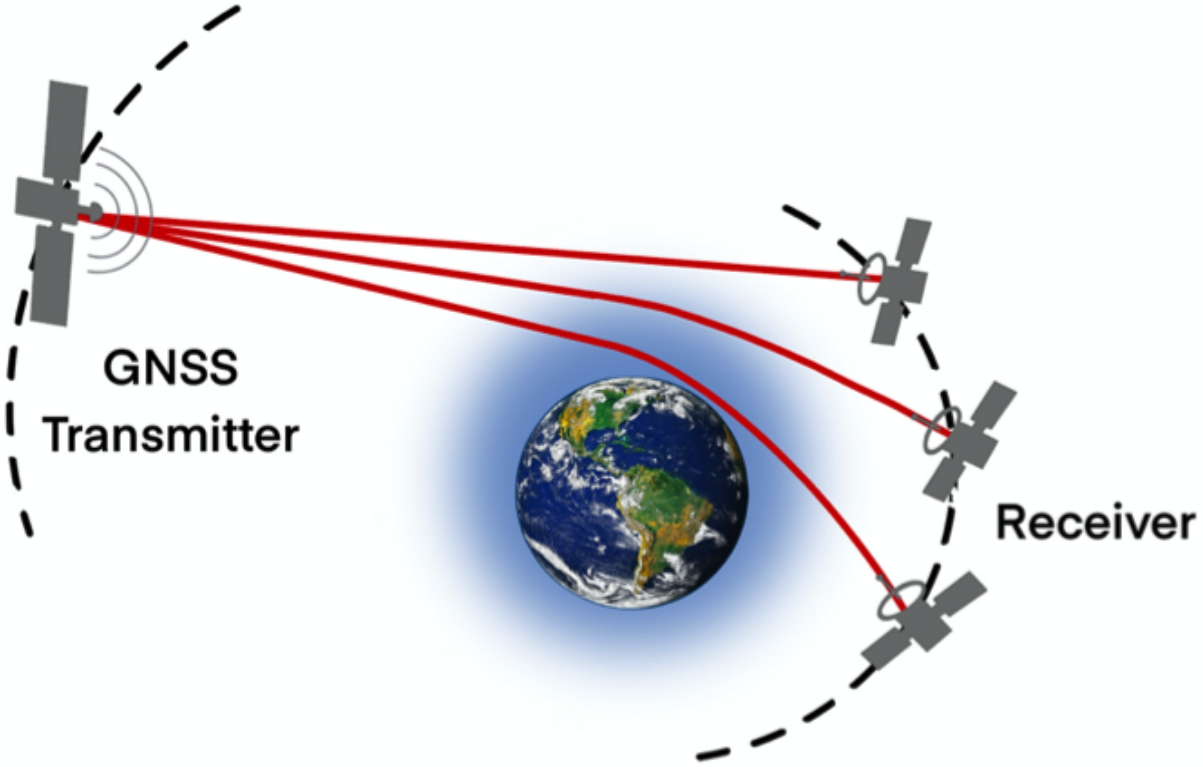


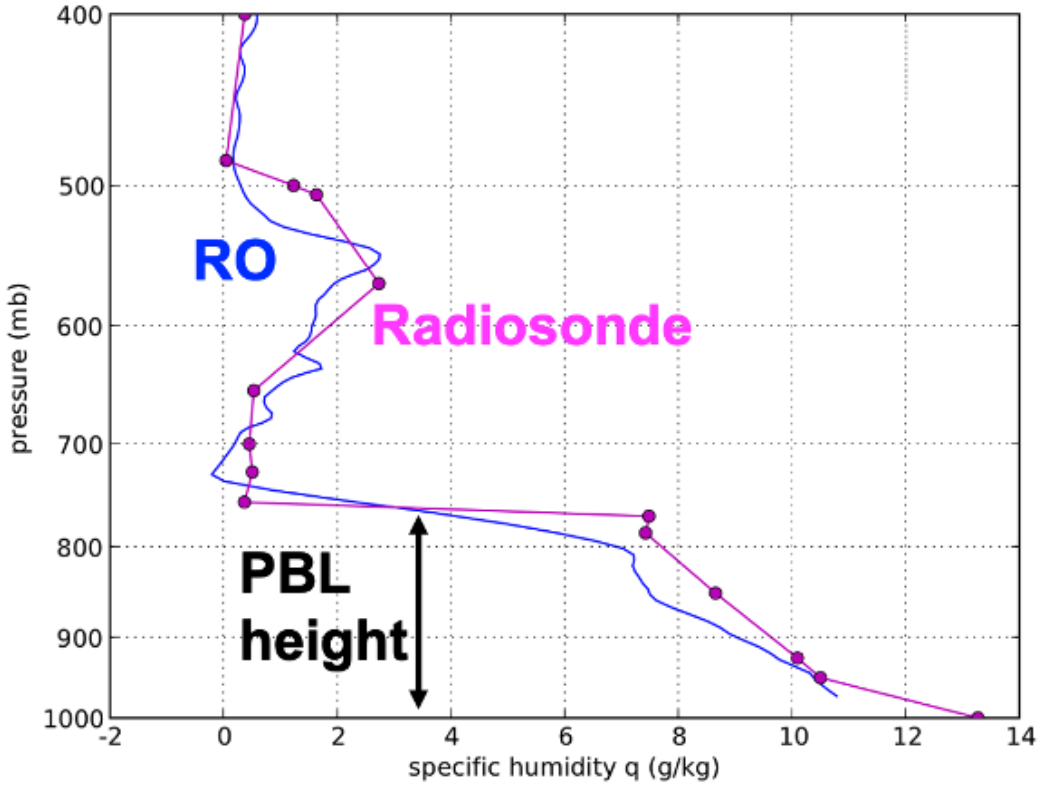
- Able to directly measure profiles of water vapor in clouds with a vertical resolution (200 - 300 m), with 1.5 gm^3 precision
- Can get temperature from liquid clouds
- Single line of sight curtain like DIAL
- VIPR is an instrument flown on an airplane

Orbital simulation of Marine Cumulus



Global **N**avigation **S**atellite **S**ystem **R**adio **O**ccultation

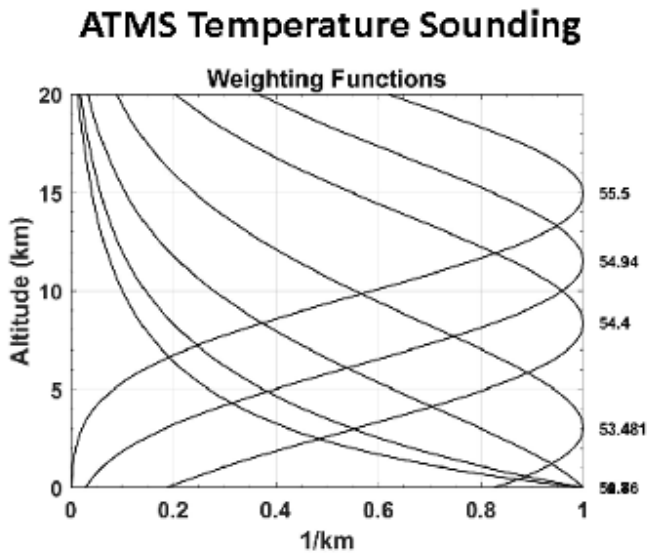


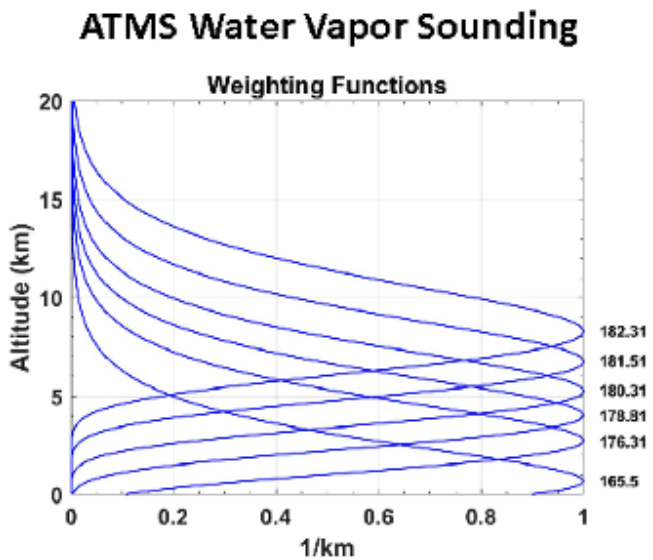


- High rertical resolution (~100 m)
- Low horizontal resolution (100km)
- Issues with penetration at low latitudes

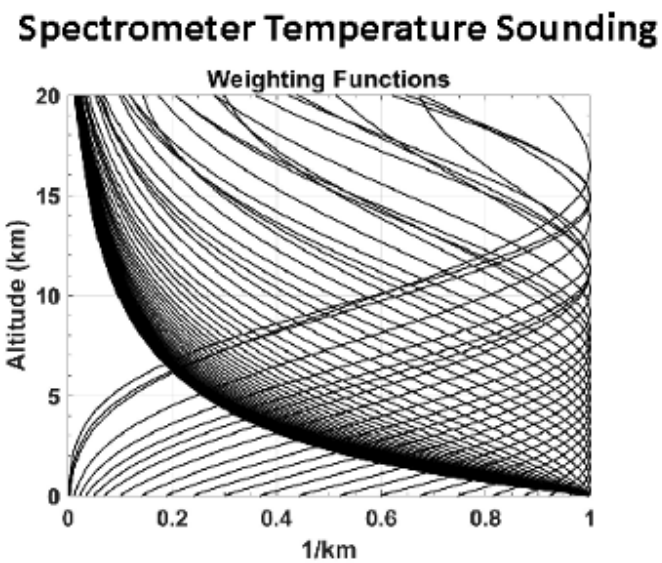
- Hyperspectral MW estimates up to 1.5 DOFs in the PBL which is similar to current Hyperspectral IR instruments
- Works in all sky except for heavy precipitation.
- Vertical resolution is limited by physics
- Ill posed problem like hyperspectral IR

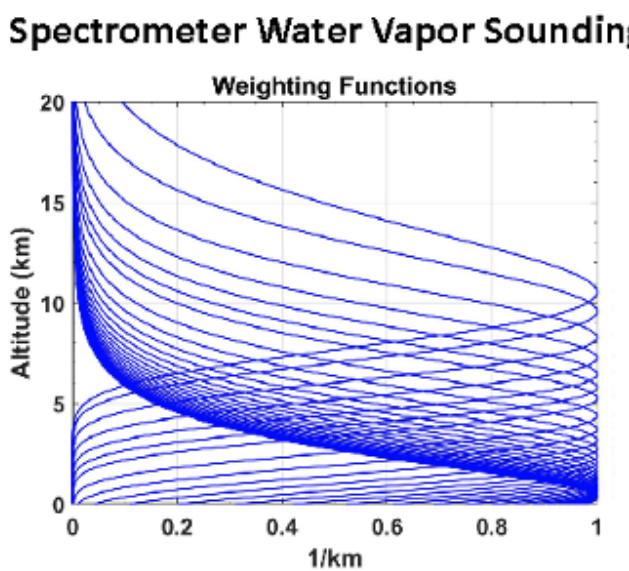
Current MW





Hyperspectral MW



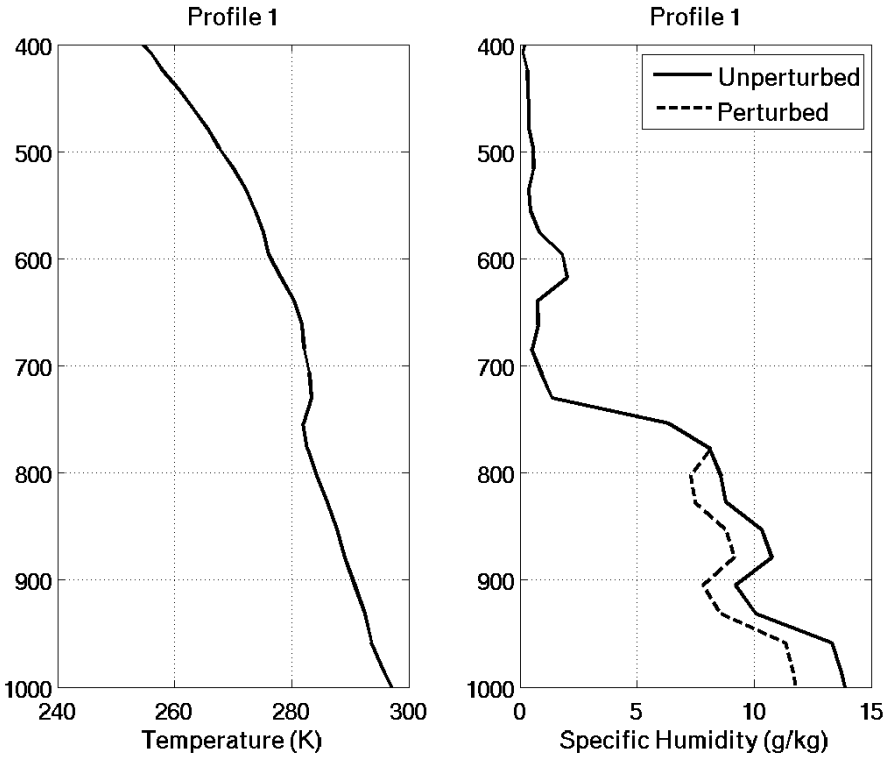


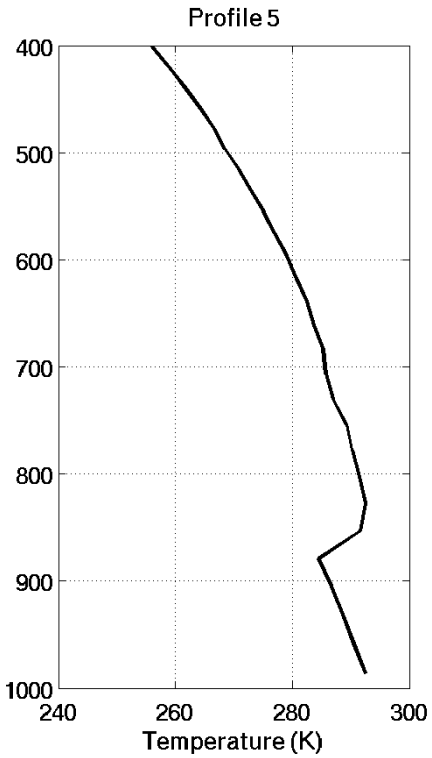
Pushing the vertical resolution of IR Sounders

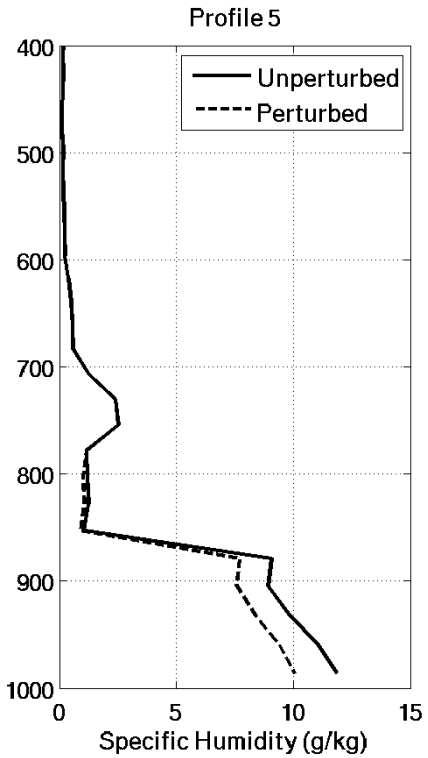
- The PBL study team asserted that IR vertical resolution is nominally 1km in the PBL
- Increasing the spectral resolution can yield higher vertical resolution though, up to 500 meters for ideal circumstances
- The vertical resolution is a function of instrument noise, spectral resolution, and thermal gradient
- Once you start resolving individual spectral lines you don’t gain any significant information by going to higher spectral resolution
- Same physical limitations applies to hyperspectral MW

MAGIC Profiles

- Information content analysis was performed for two profiles out of the magic dataset
- Profile 5 has a strong capping inversion while Profile 1 is more adiabatic



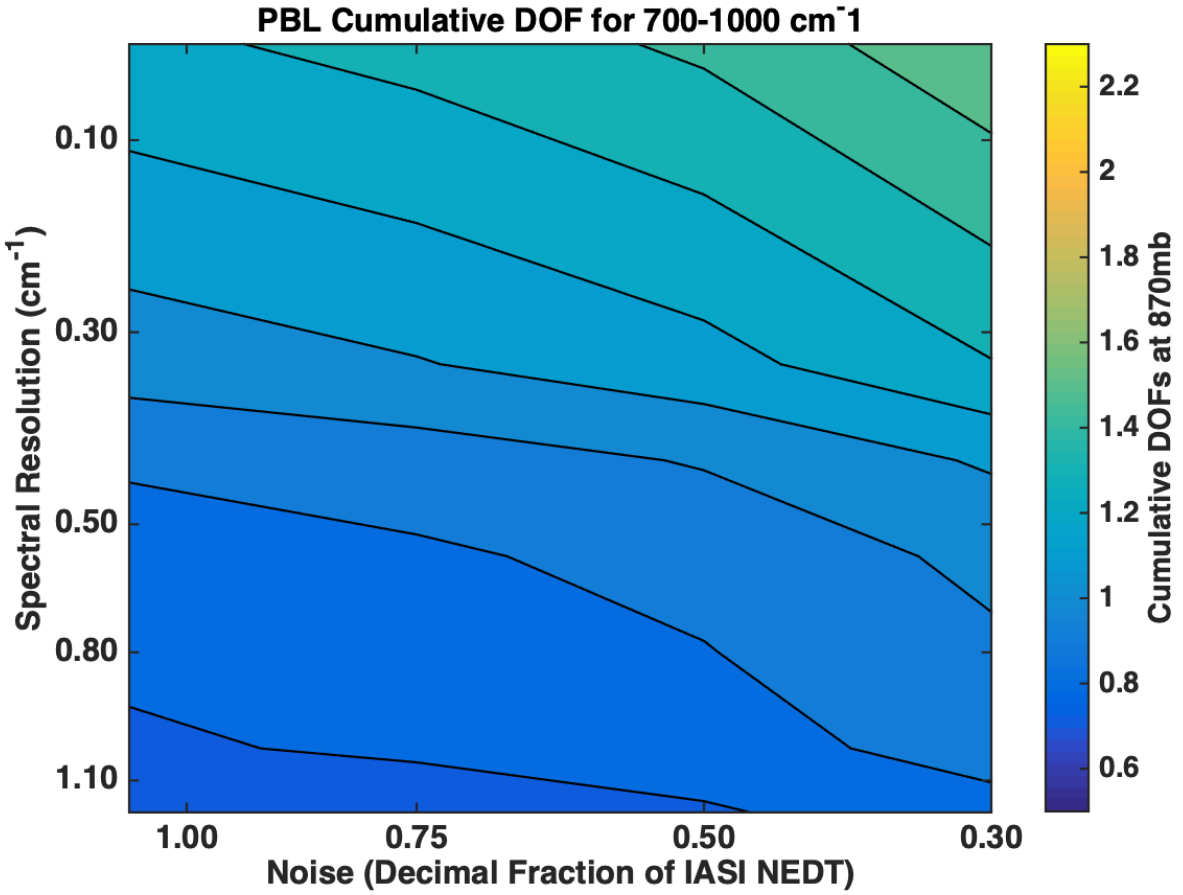


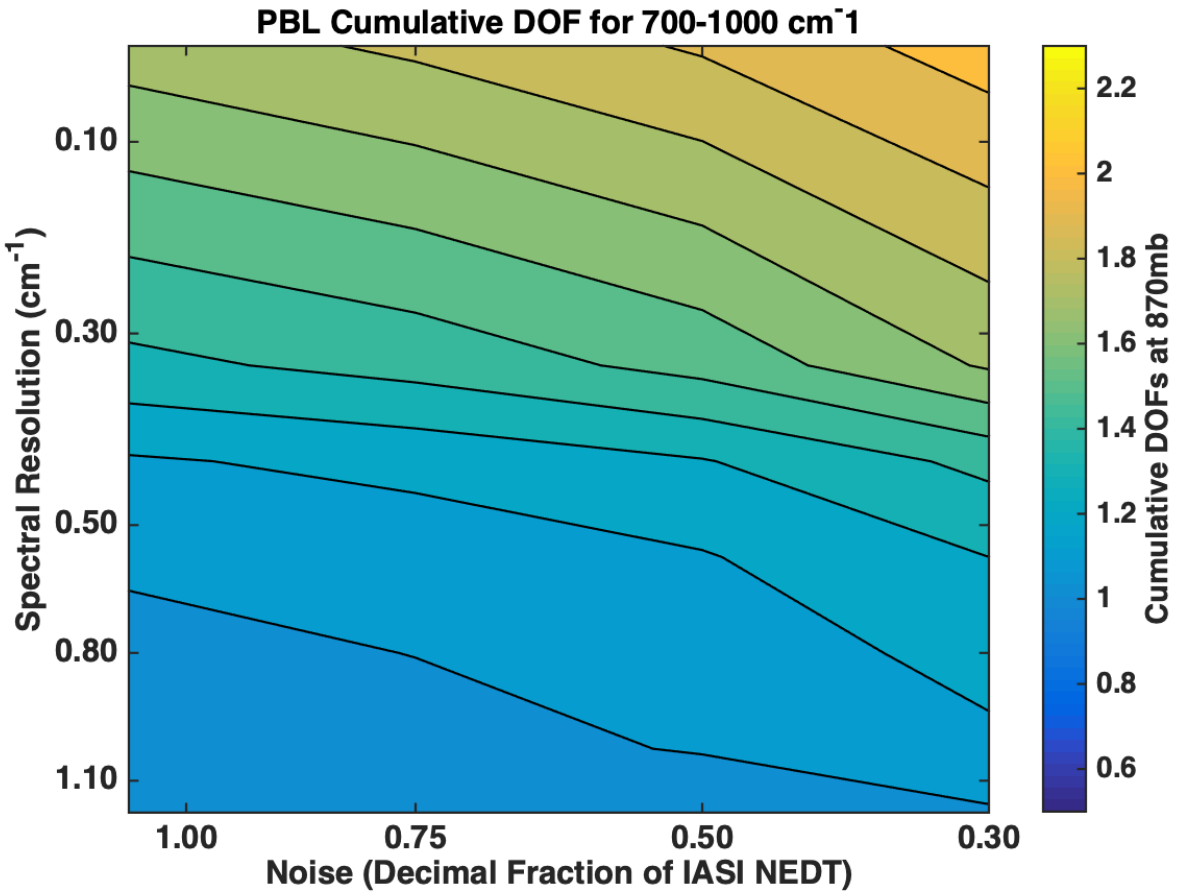


Magic Summary

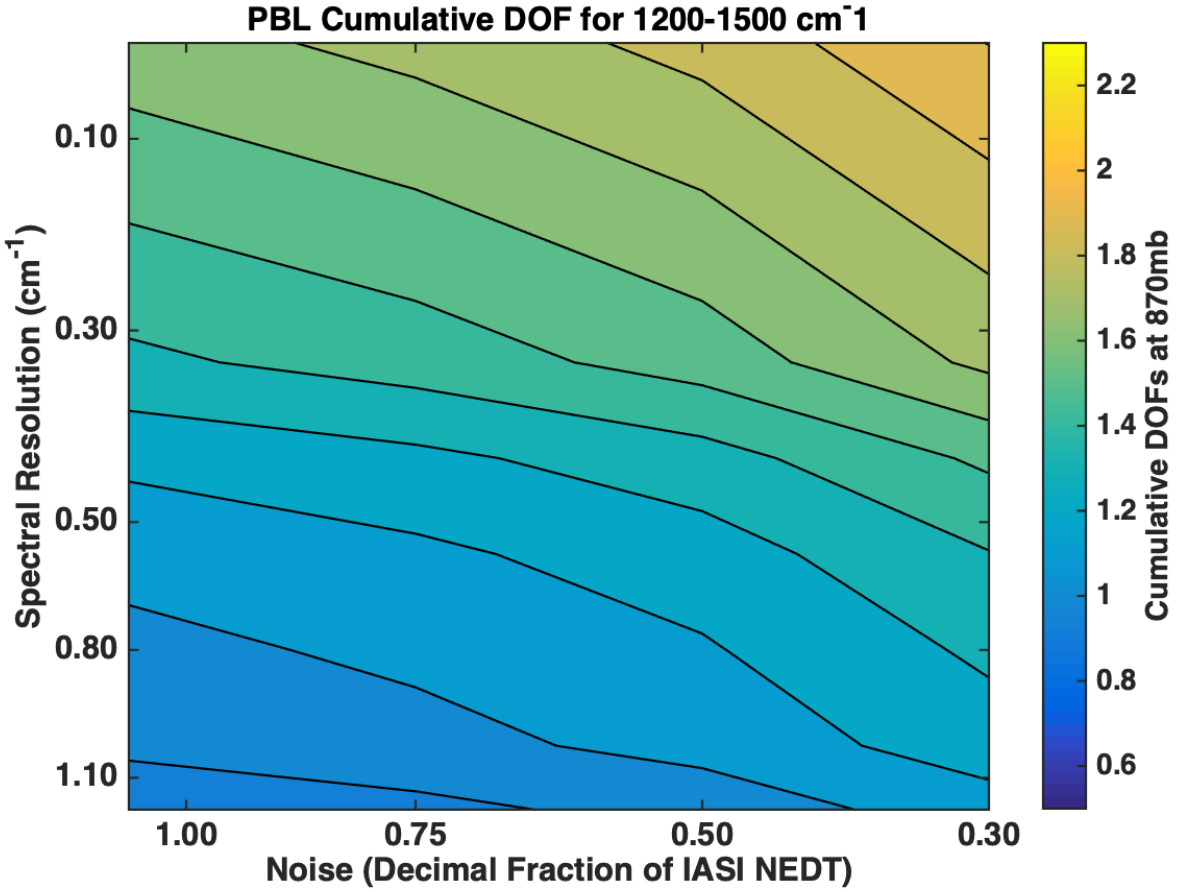
PBL	IASI Prof 1 (top = 750 hPa)	IASI Prof 5 (top = 850 hPa	AIRS Prof 1 (top = 750 hPa	AIRS Prof 5 (top = 850 hPa
H2O DOF	2.9-3.4	1.5-2.5	2.4-2.8	1.3-1.5
Temp DOF	4	3	3.3	2.5
H2O Error (%)	10-35	15 -25	11-35	15-25
Temp Error (K)	0.8-2	0.7-1.1	0.8-2.2	1-1.3

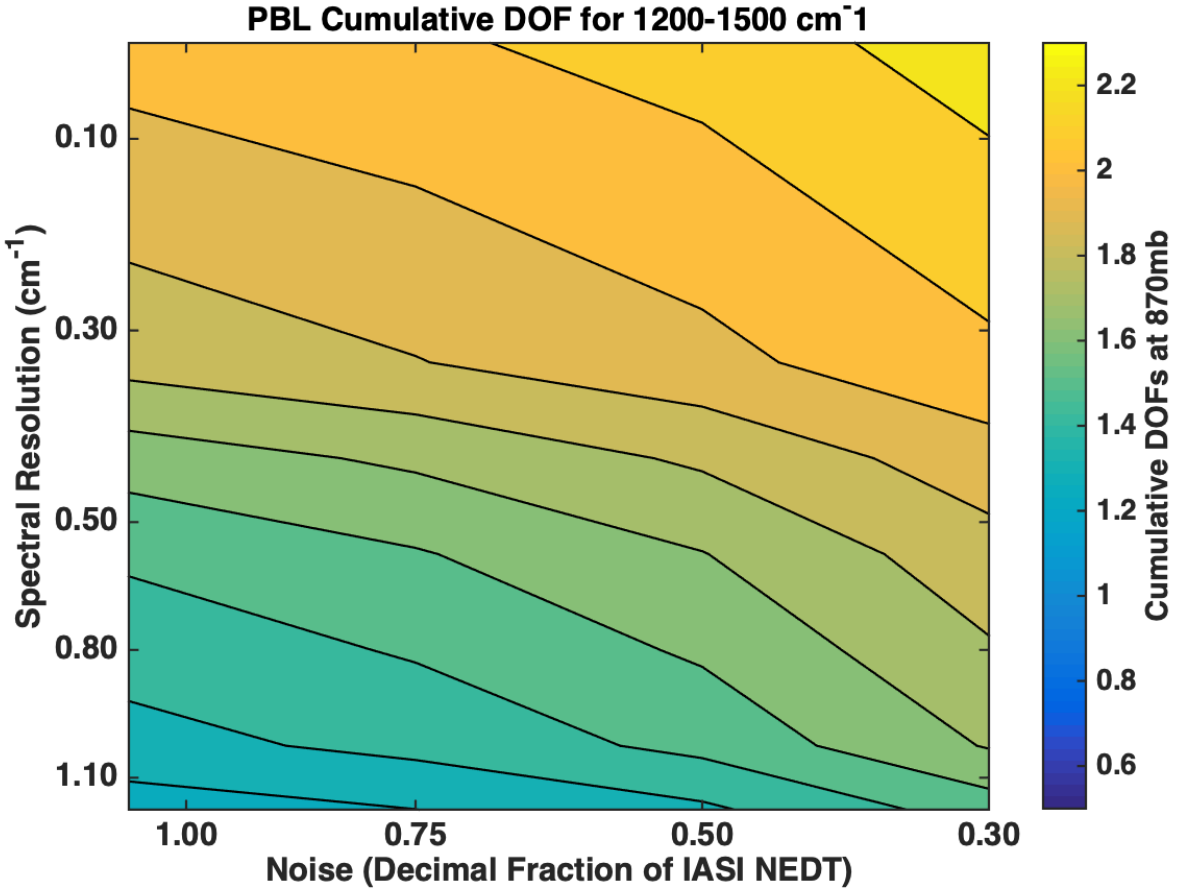
Profile 1 vs Profile 5 (LW)



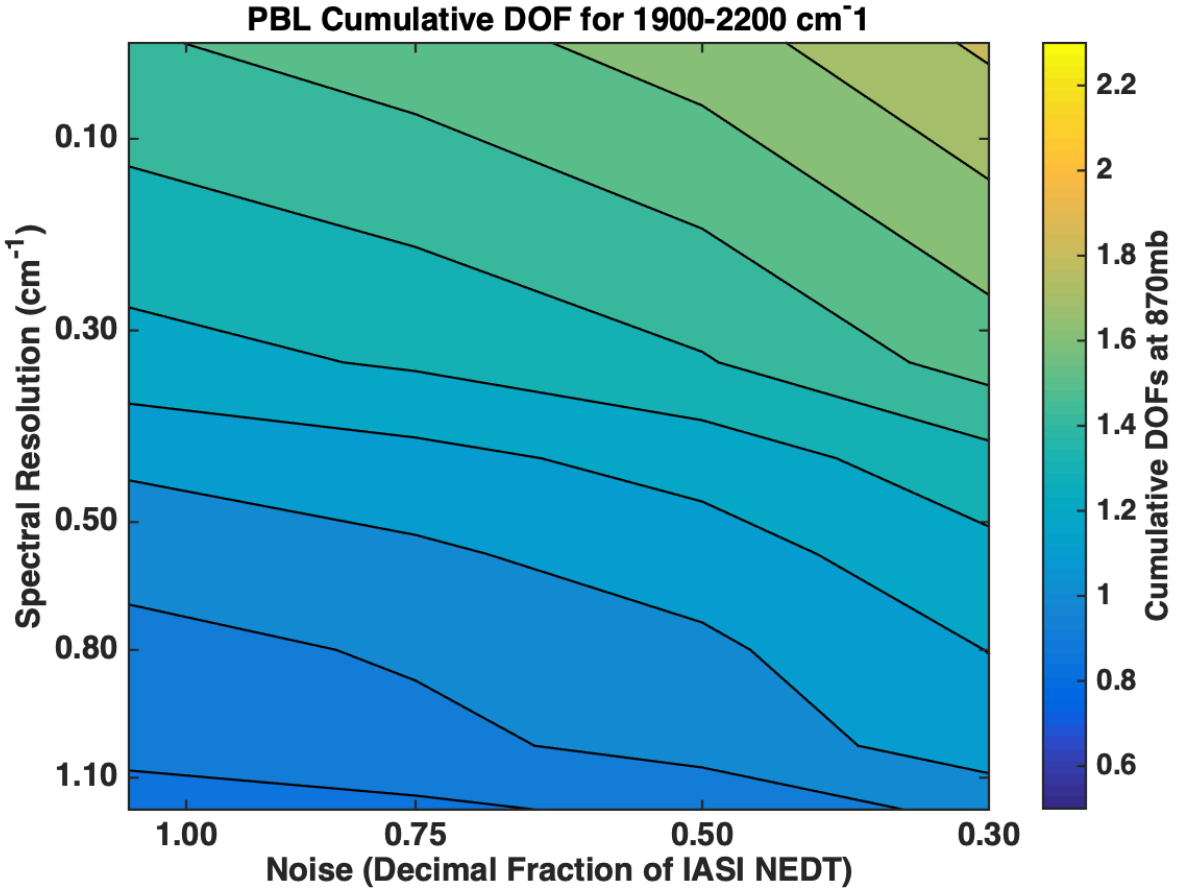


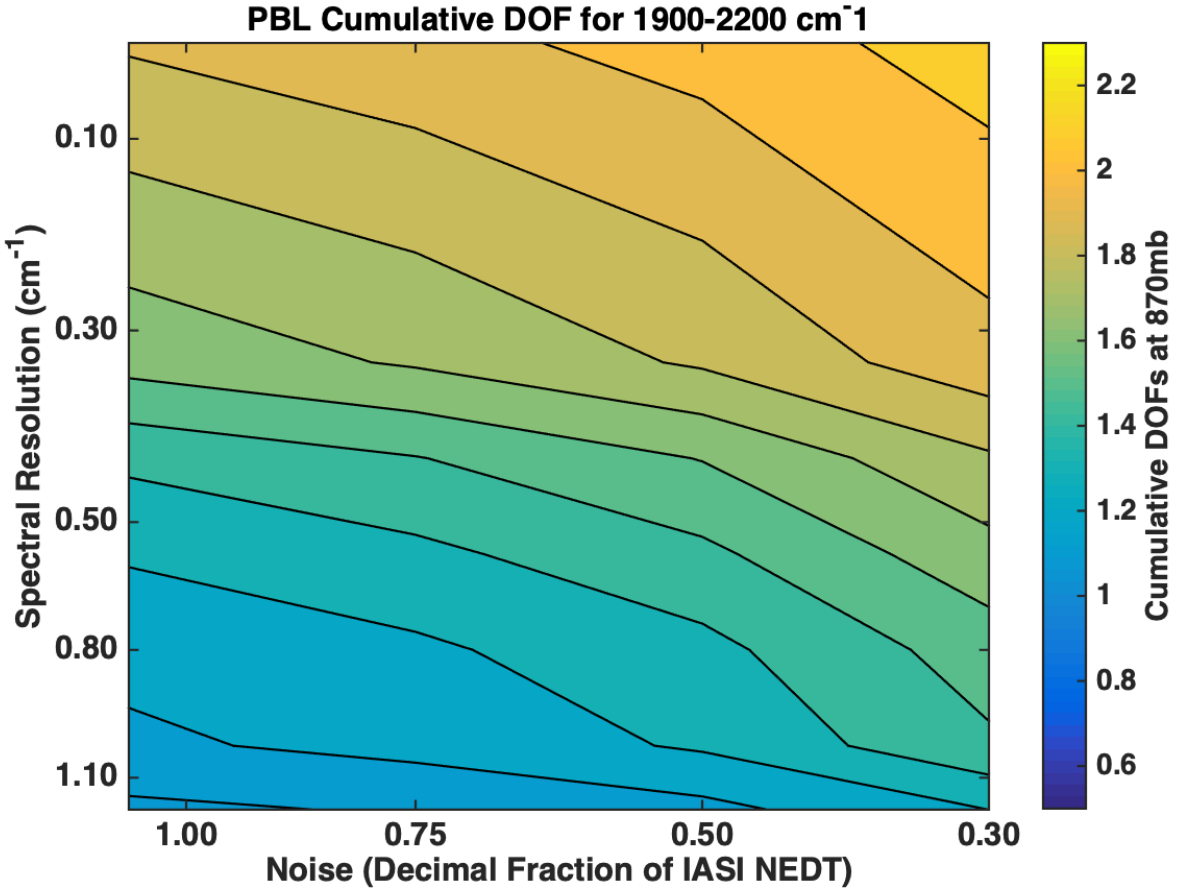
Profile 1 vs Profile 5 (MW)

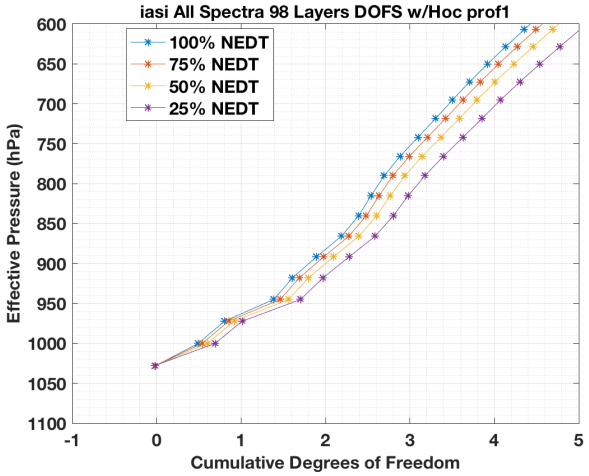


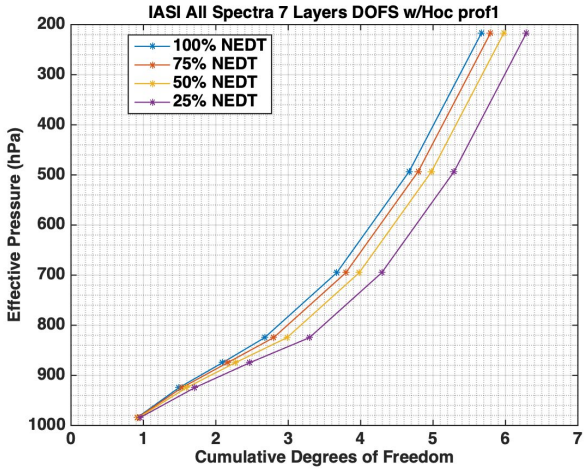


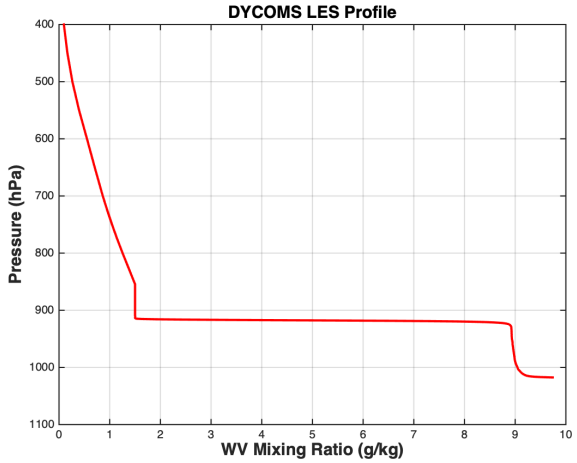
Profile 1 vs Profile 5(SW)

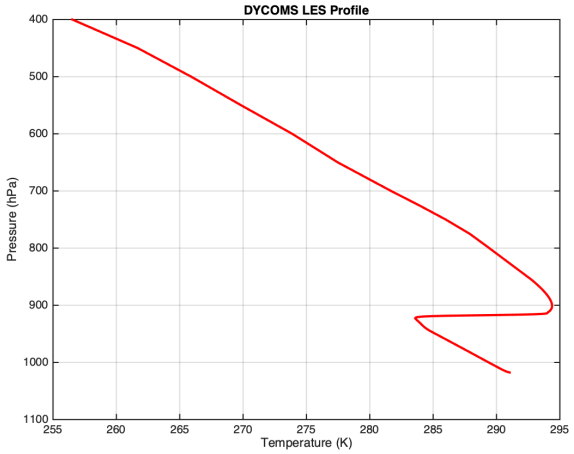










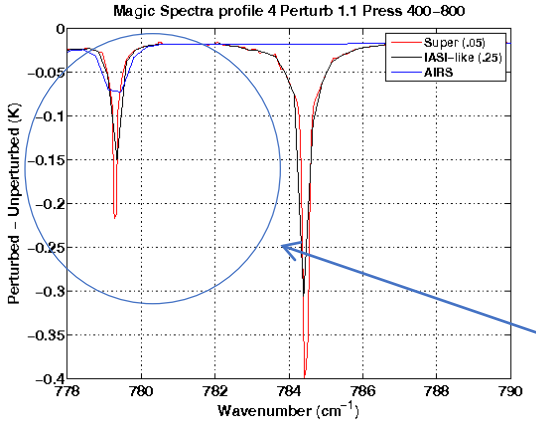


DYCOMS

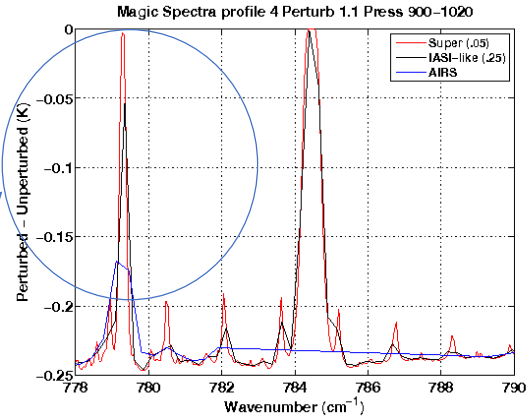
- non-precipitating marine nocturnal stratocumulus over ocean

400-800 10 Percent Increase

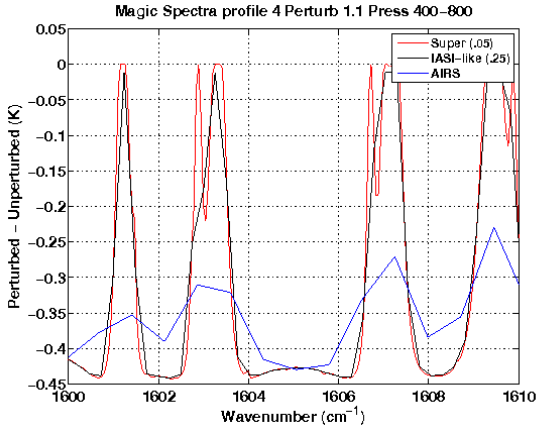
Surface-900 10 Percent Increase



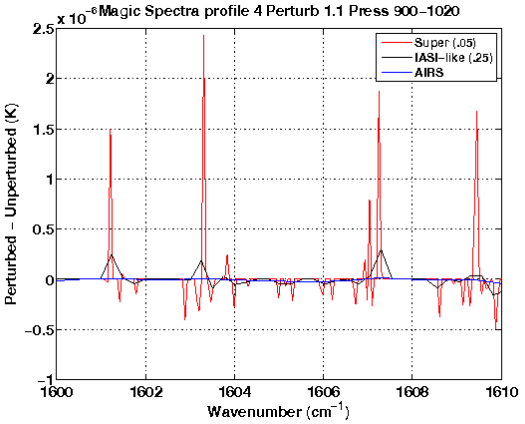
- AIRS insensitivity to mid-tropospheric perturbation is due to spectral resolution

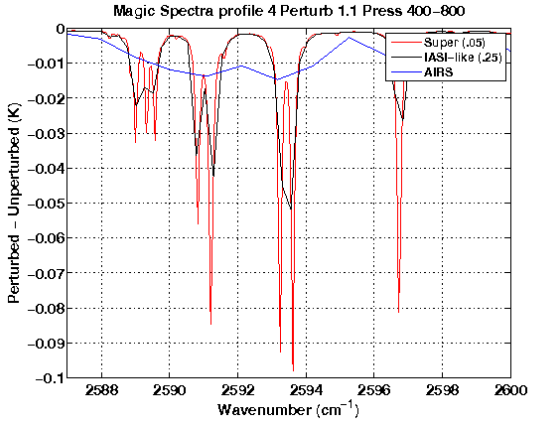


- LW has unique signal when spectral resolution is higher than AIRS



- To measure something you need signal and the signal needs to be unique





- Perturbation signal is larger in SW for PBL change, but is not unique
- IASI is almost .1K while AIRS is .05K.
- At IASI Resolution you can resolve online vs off line differences