Validation of Satellite Atmospheric Soundings
The GRASP Campaign

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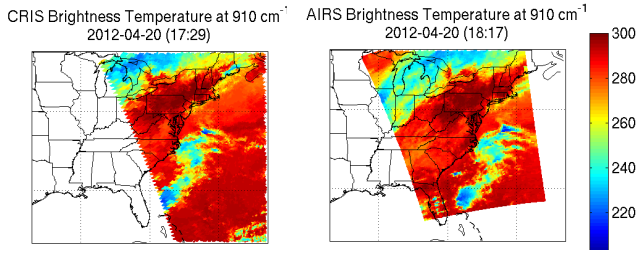
[1] Hampton University, [2] University of Wisconsin – Madison,

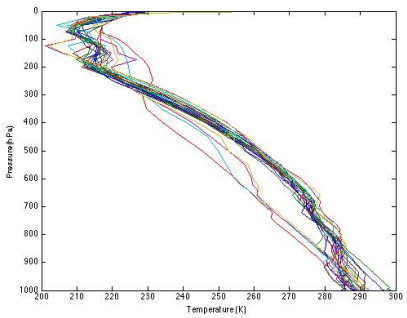
[3] National Security Technologies, [4] LR Technologies, [5] NASA Langley Research Center

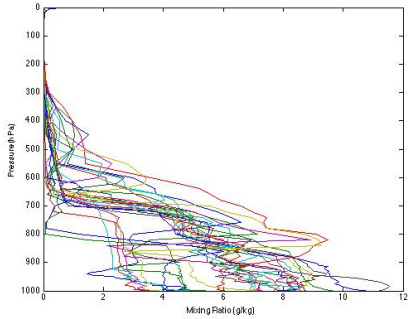
Satellites

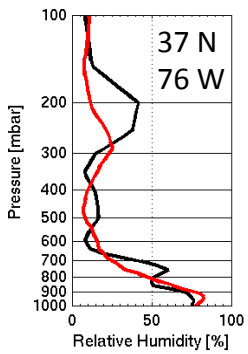


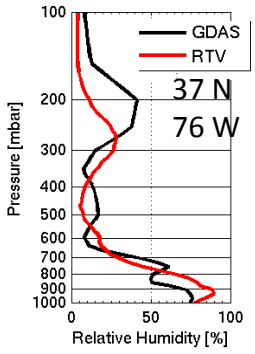
CrIS-17:30 **AIRS-18:17 UT**

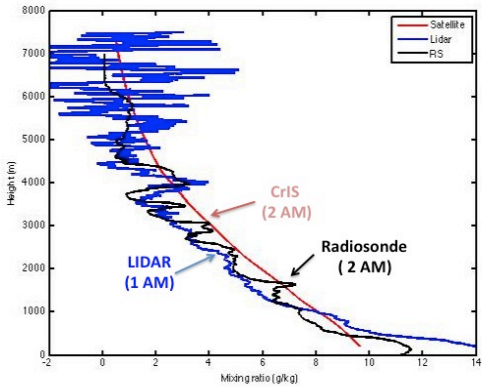
Radiosondes

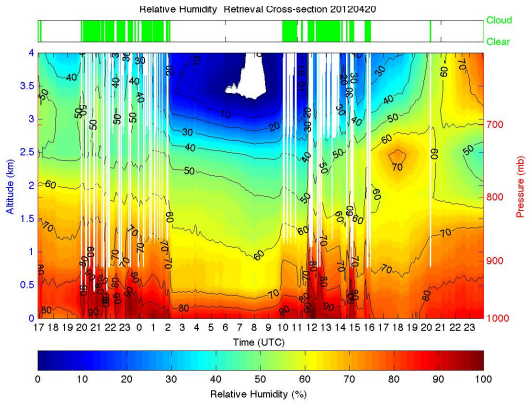










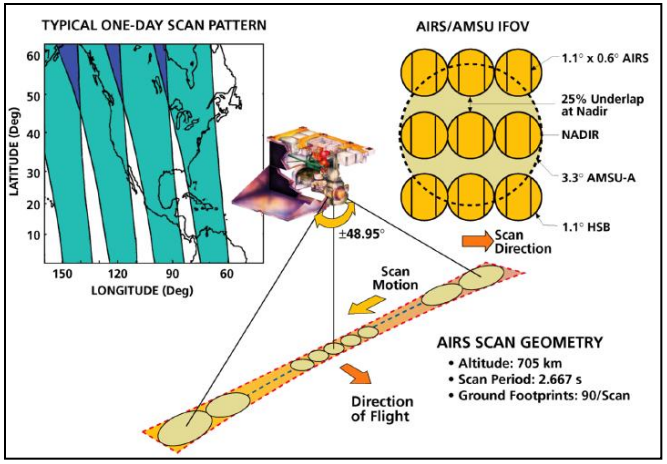


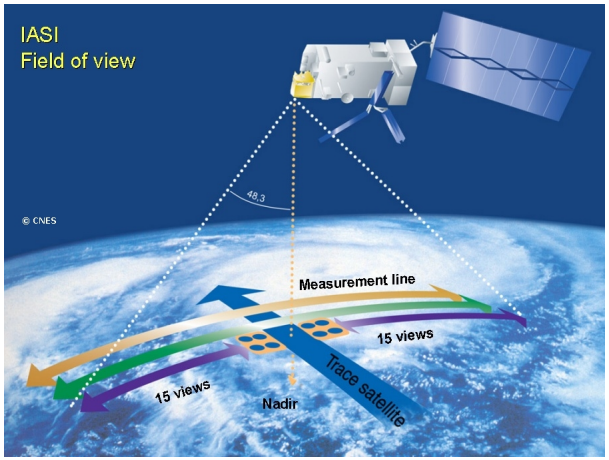
Models

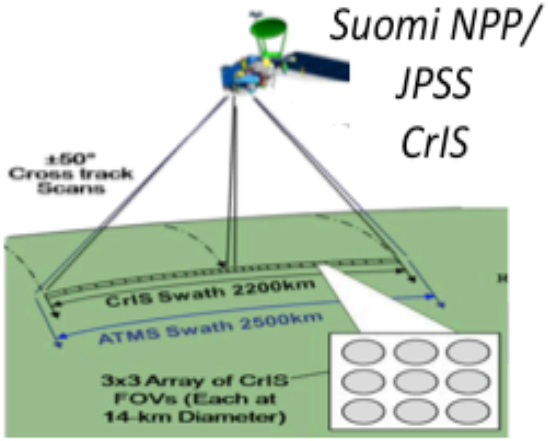
Raman Lidar

Ground based FTS

Satellite Ultraspectral Sounders







- Grating Spectrometer with resolution of 0.5 –2 cm^{-1} (resolving power of ~1200)
- Spectral range: 650 – 2700, cm^{-1} PV and PC HdCdTe focal plane mechanically cooled to 60K
- Focal plane has 4756 detectors, 2378 channels
- 310 K Blackbody and space view provides radiometric calibration
- NEDT ranges from .05K to 0.5K

AIRS (2002)

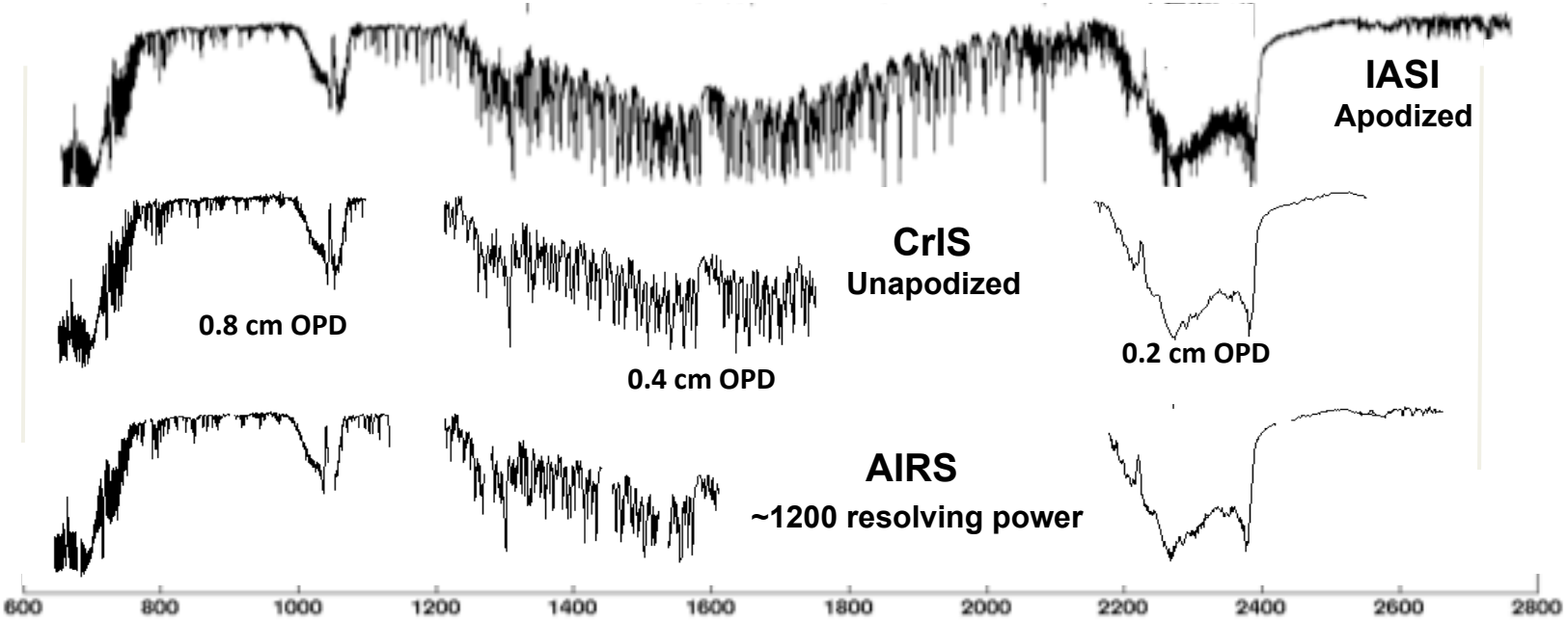
- Michelson Interferometer with resolution of 0.25 cm^{-1} (resolving power of 2400-12000)
- Spectral range:660 – 2700 cm^{-1} PV and PC HdCdTe focal planes radiatively cooled to 90K
- Focal plane 12 detectors, 8461 spectral channels
- 310 K Blackbody and space view provides radiometric calibration
- NEDT: 0.1 – 0.75 K

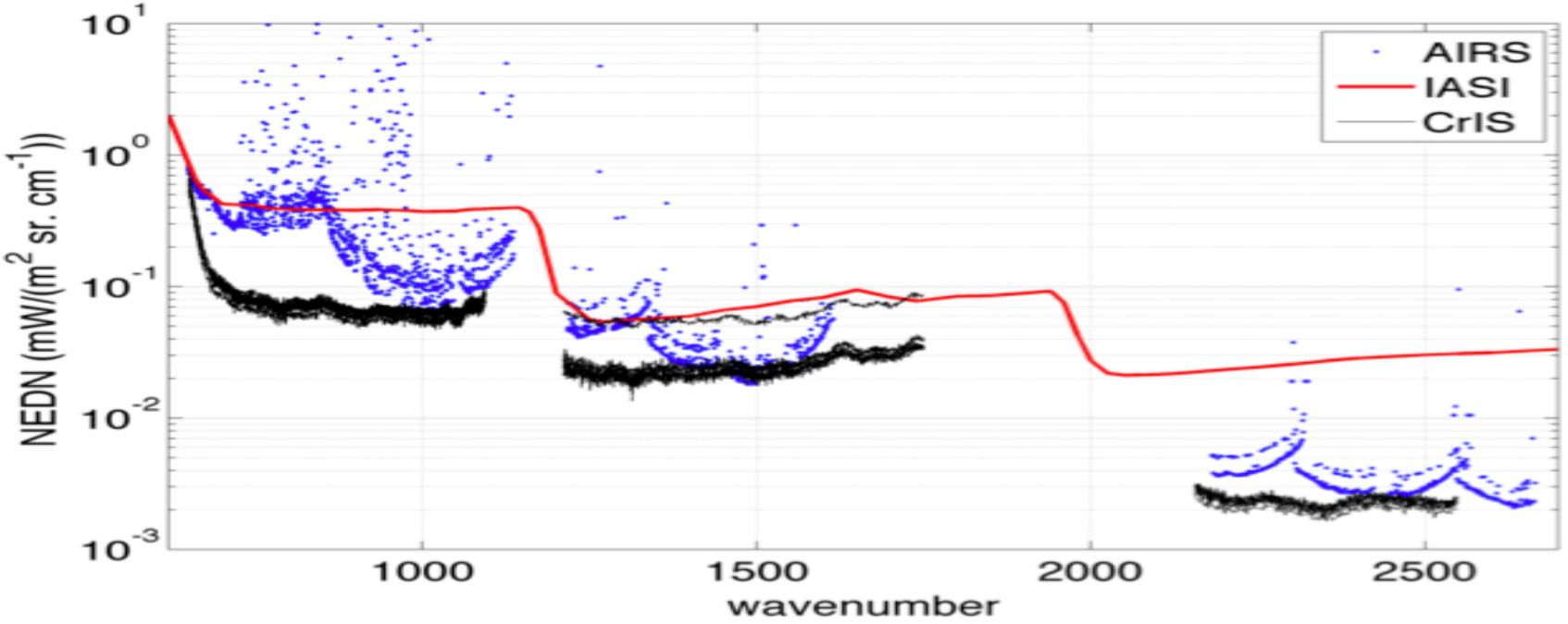
IASI (2006)

- Michelson Interferometer with resolution of 0.25 cm^{-1} (resolving power of 2400-12000)
- Spectral range:660 – 2700 cm^{-1} PV HdCdTe focal planes passively cooled to 85K
- Focal plane 27 detectors, 1305 spectral channels
- 310 K Blackbody and space view provides radiometric calibration
- NEDT: 0.05 – 0.5 K

CrIS (2011)

Spectral Coverage, Resolution, and Noise





Dual-Regression Retrieval Method[1]

Global Clear Soundings

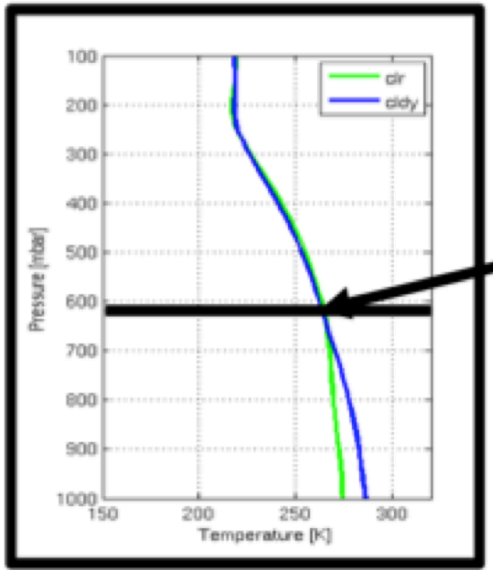
Global Cloudy Soundings

Radiances (calculated with clear FM)

Radiances (calculated with cloudy FM) 8 cloud height classes (100-900 hPa)

Clear trained EOF regression results

Cloud trained EOF regression results



Cloud Top Altitude

level where T(cloudy)>T(clear) for $p>p_{cld}$

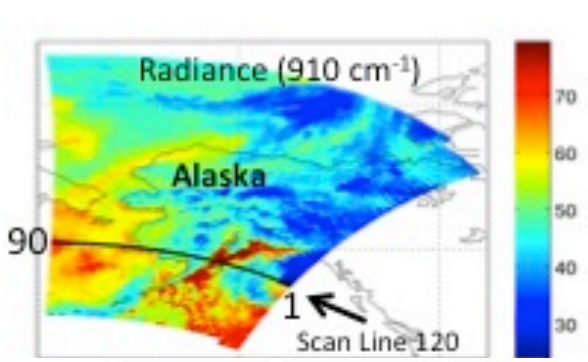
Final Profile

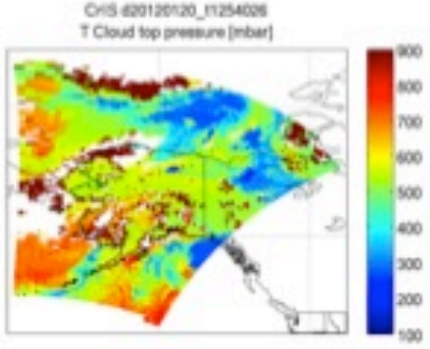
•clear-trained above,

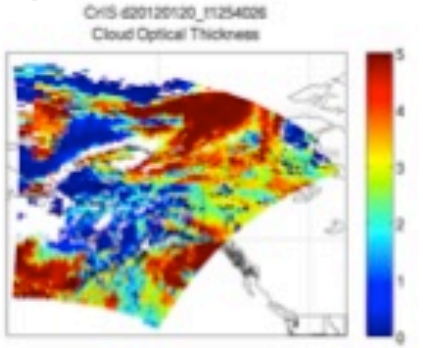
•cloud-trained below cloud level

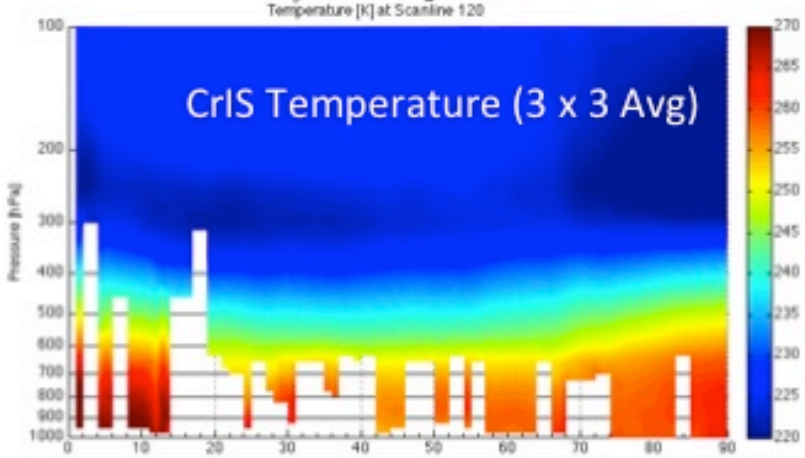
[1]Smith, W. L., E. Weisz, S. Kirev, D. K. Zhou, Z. Li, and E. E. Borbas, 2012: Dual-Regression Retrieval Algorithm for Real-Time Processing of Satellite Ultraspectral Radiances. *J. Appl. Meteor. Clim. http://dx.doi.org/10.1175/JAMC-D-11-0173.1.*

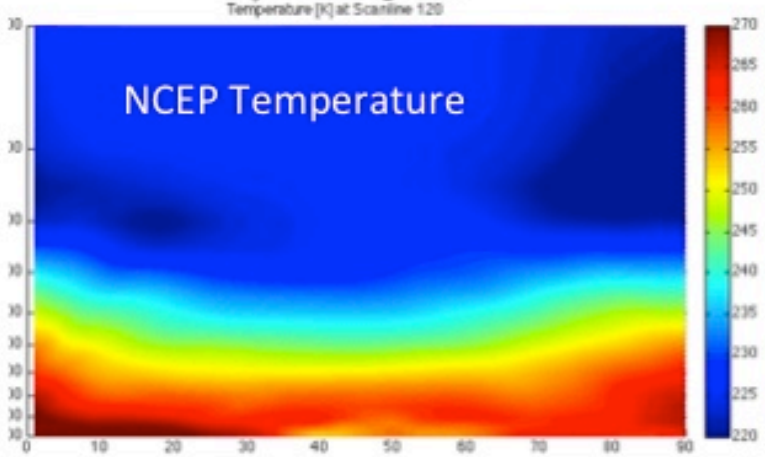
First CrIS Results Produced with the DR Retrieval Algorithm (Feb 1, 2012)

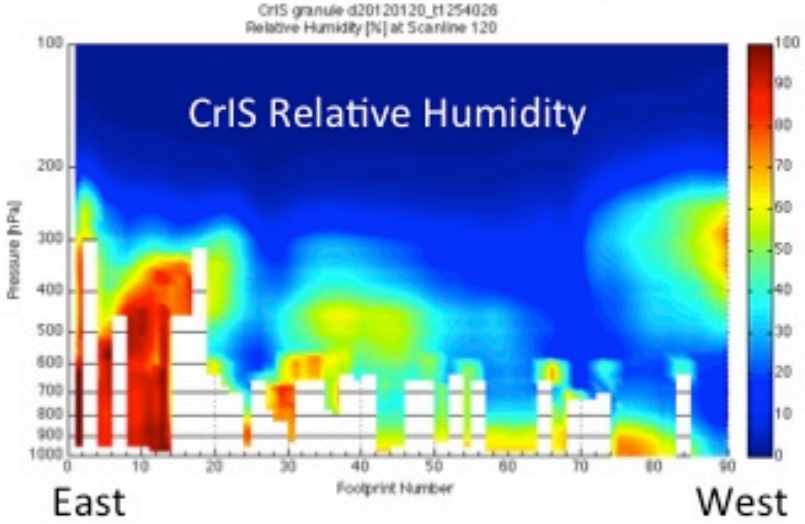


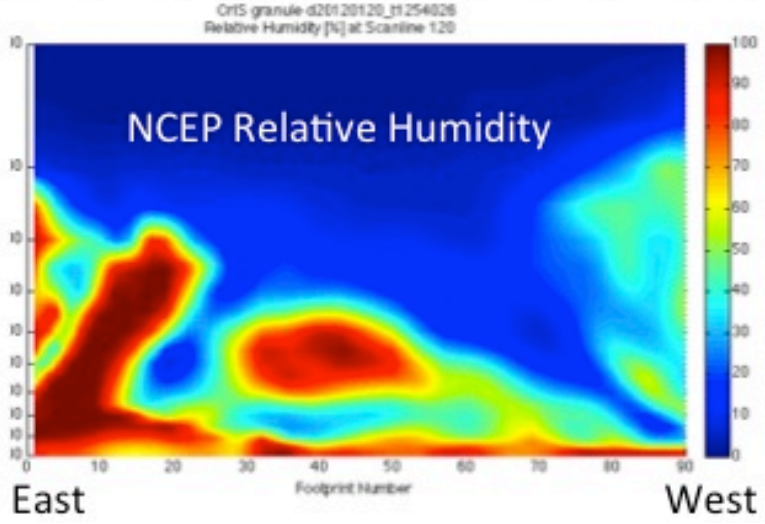








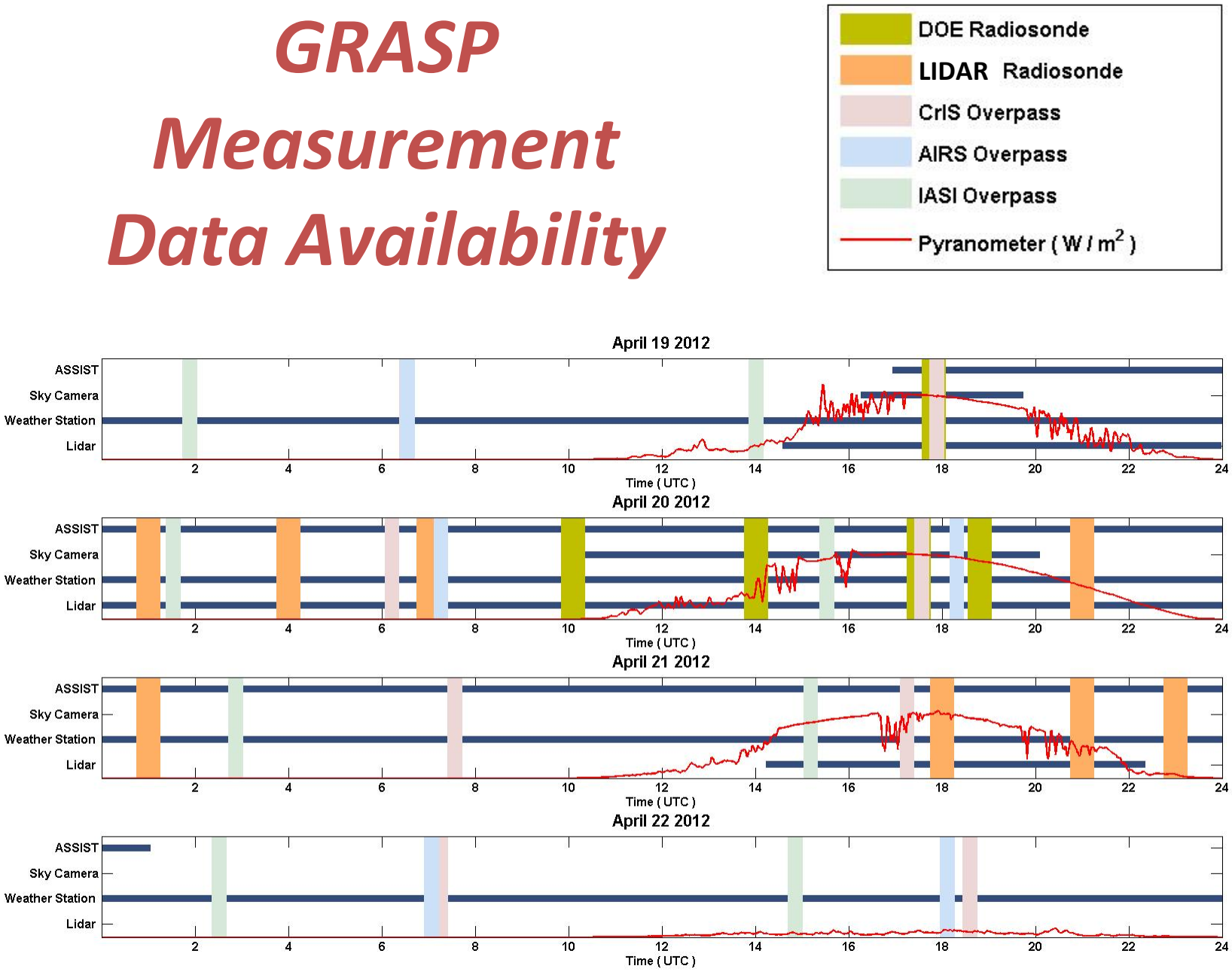




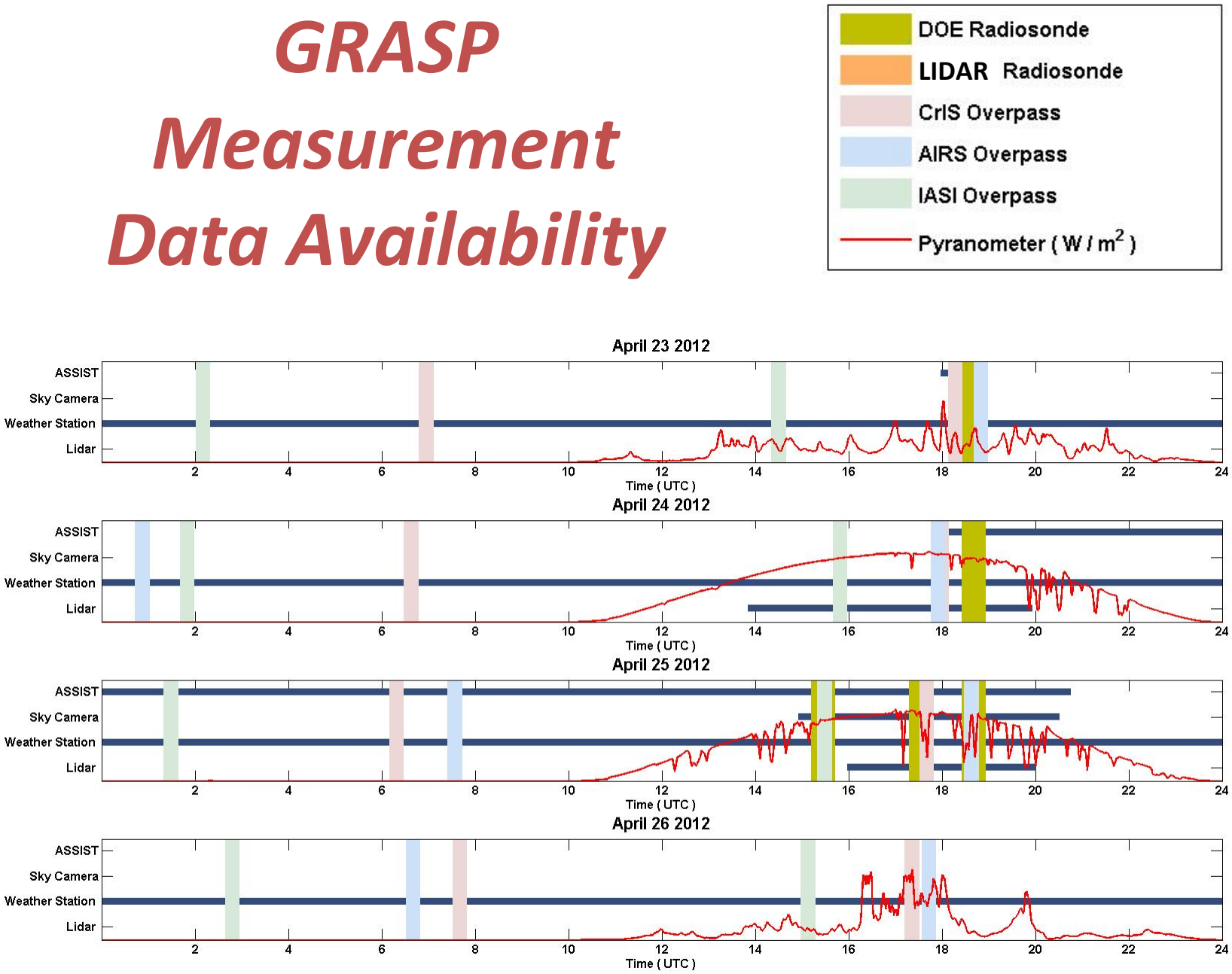
Ground Remote Atmospheric Sounding Project (GRASP) Validation Campaign (16 – 30 April, 2012)

- ***Profile retrievals*** *from all Metop IASI, Aqua AIRS, Suomi NPP CrIS data for orbital tracks within 1000-km of Hampton University(HU), Hampton VA, were processed for validation*
- ***Radiosondes*** *were launched from HU at satellite overpass times*
- *Quasi continuous* ***upward looking FTS*** *measurements were made for determining PBL temperature, moisture, and trace gas structure*
- ***Raman LIDAR*** *measurements were made for deriving cloud, aerosol, and free troposphere temperature and water vapor profiles*
- *Continuous measurements of* ***surface meteorological and radiative flux parameters*** *(P, T, Q, V, LW Flux, SW Flux) were obtained*
- ***All-sky camera*** *operated for identifying cloudiness during radiation and meteorological measurements*

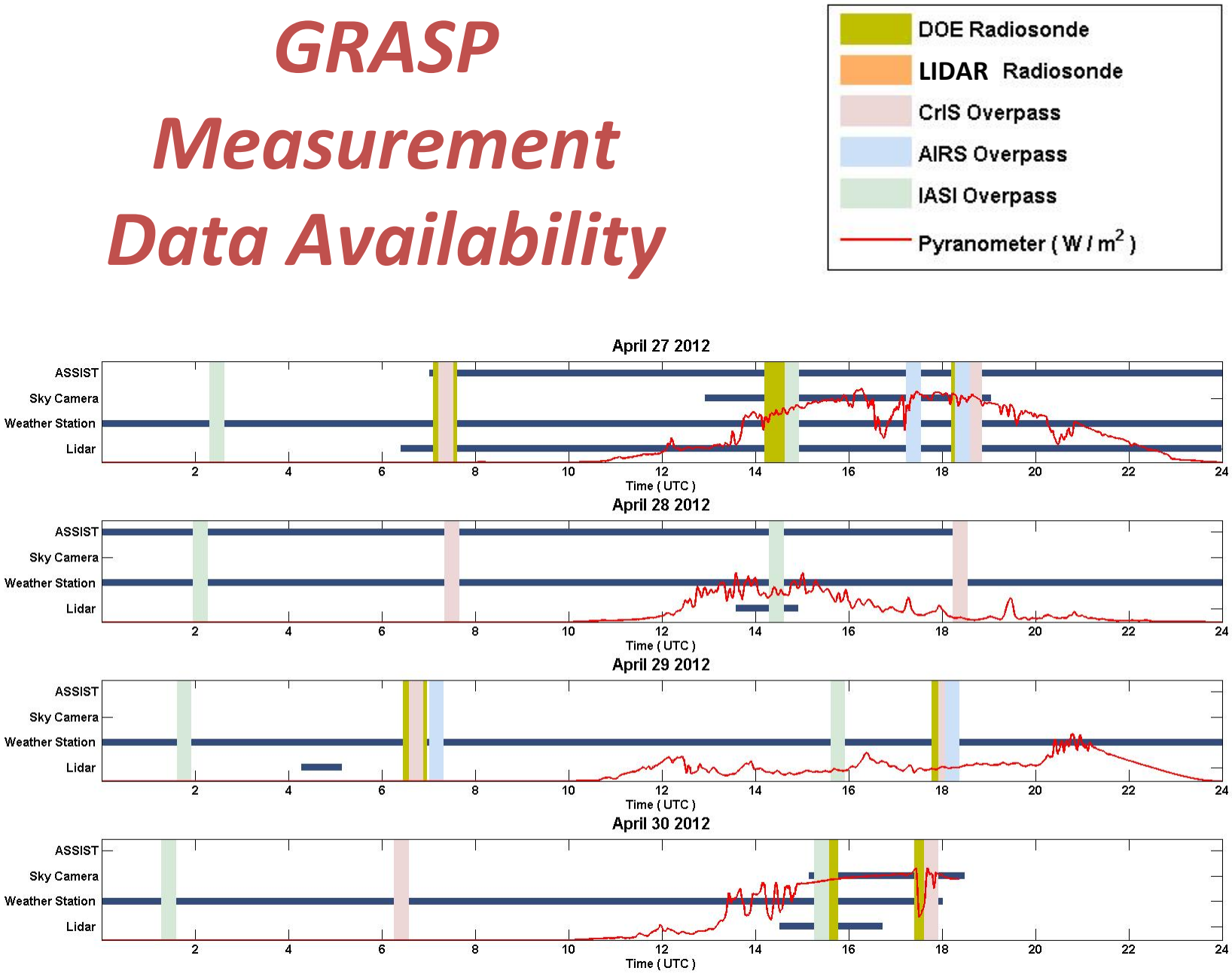
GRASP Measurement Data Availability



GRASP Measurement Data Availability

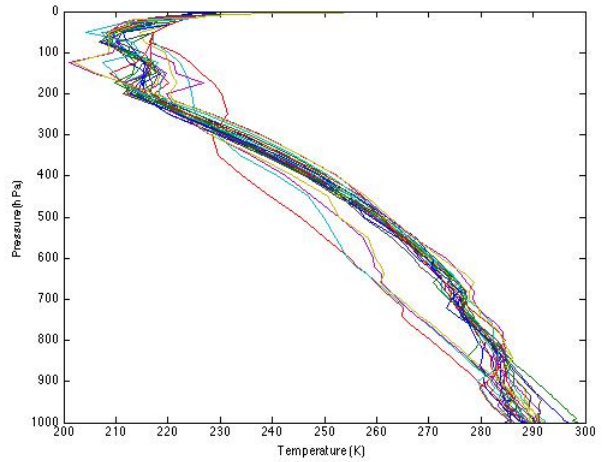


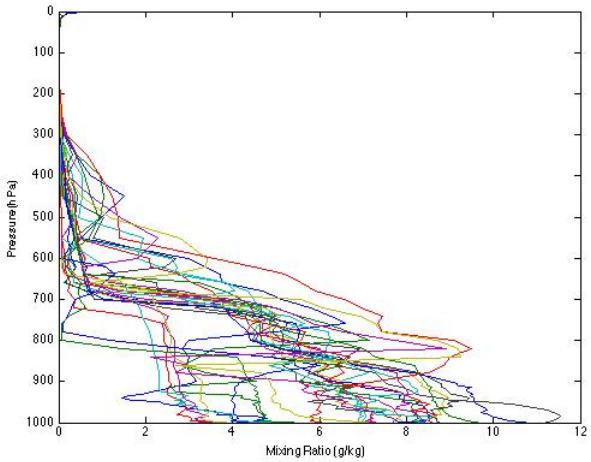
GRASP Measurement Data Availability

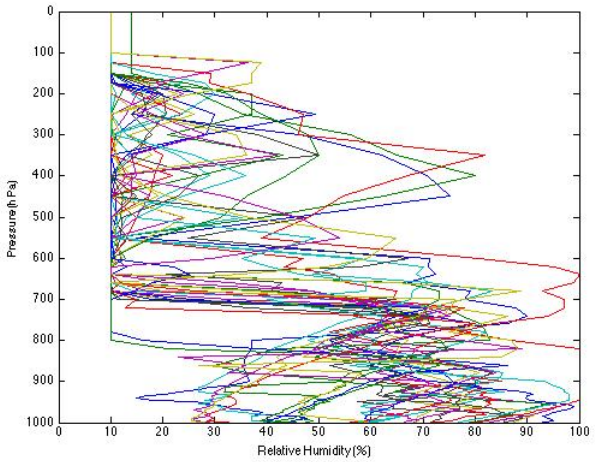


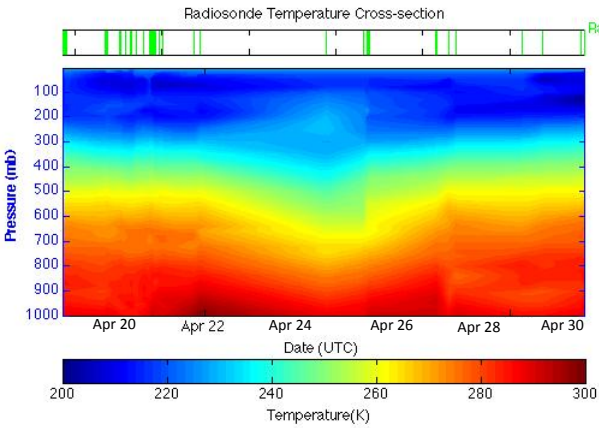
GRASP Radiosonde Observations (27)

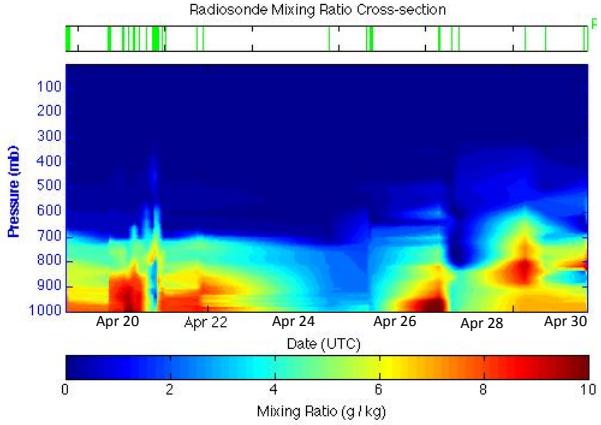
April 19 – April 30, 2012

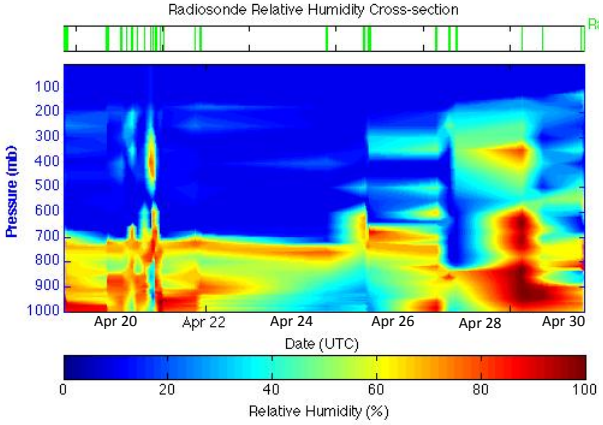








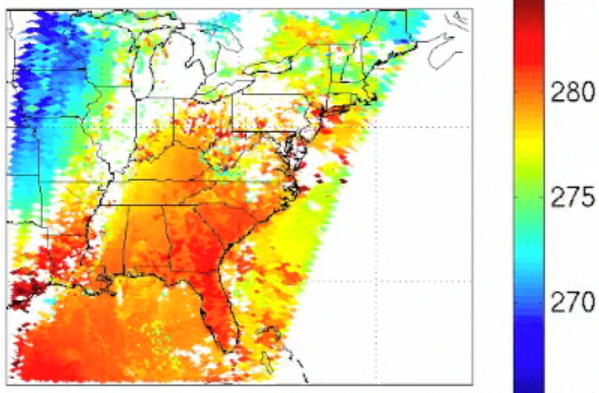


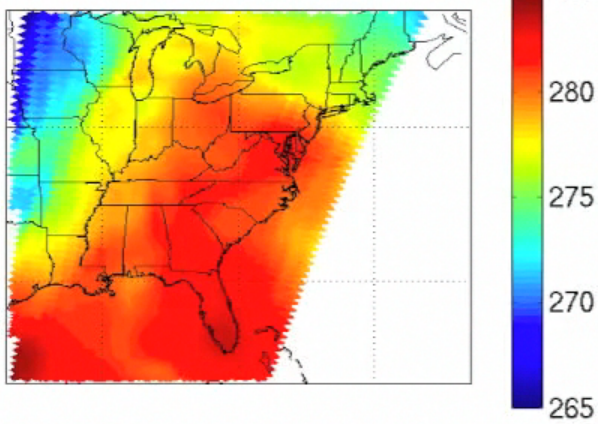


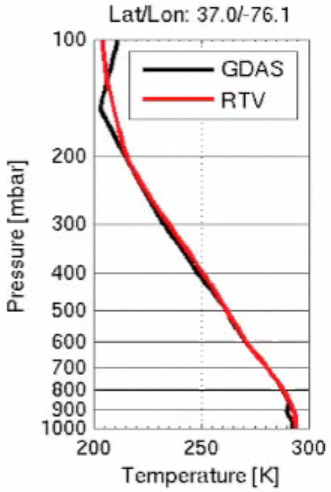
GRASP Validation Campaign April 2012

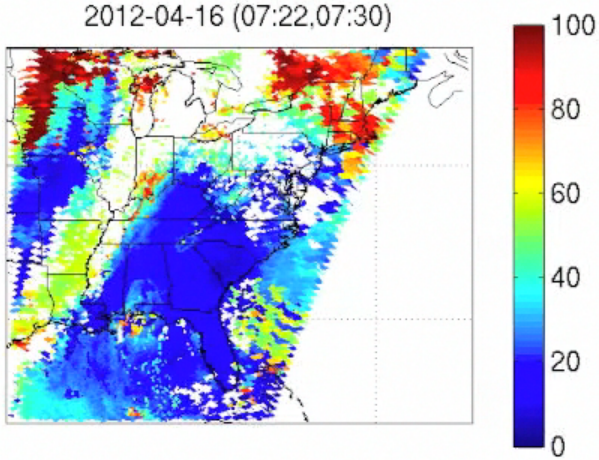
AIRS, CrIS, IASI Retrievals

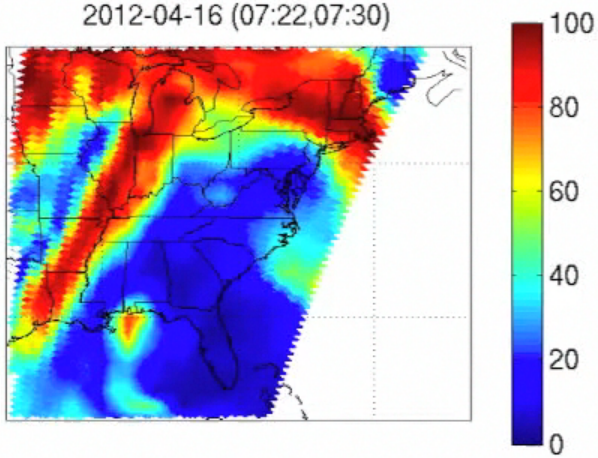
16-22 April, 2012

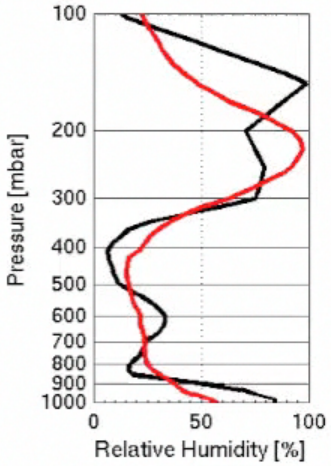

CRIS Temperature [K] at 707 hPa
2012-04-16 (07:22,07:30)
285
280
275
270
265


GDAS Temperature [K] at 706.6 hPa
2012-04-16 (07:22,07:30)
285
280
275
270
265

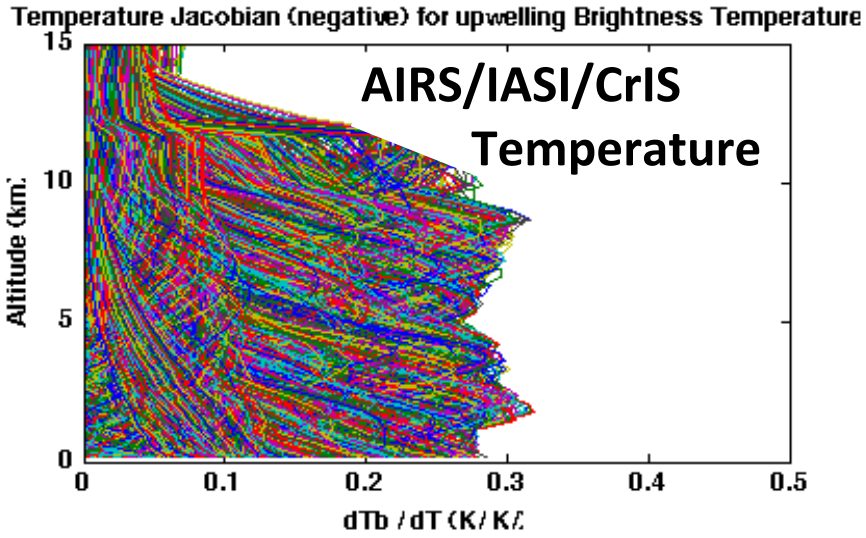

Lat/Lon: 37.0/-76.1
GDAS
RTV
Pressure [mbar]
100
200
300
400
500
600
700
800
900
1000
200
250
300
Temperature [K]

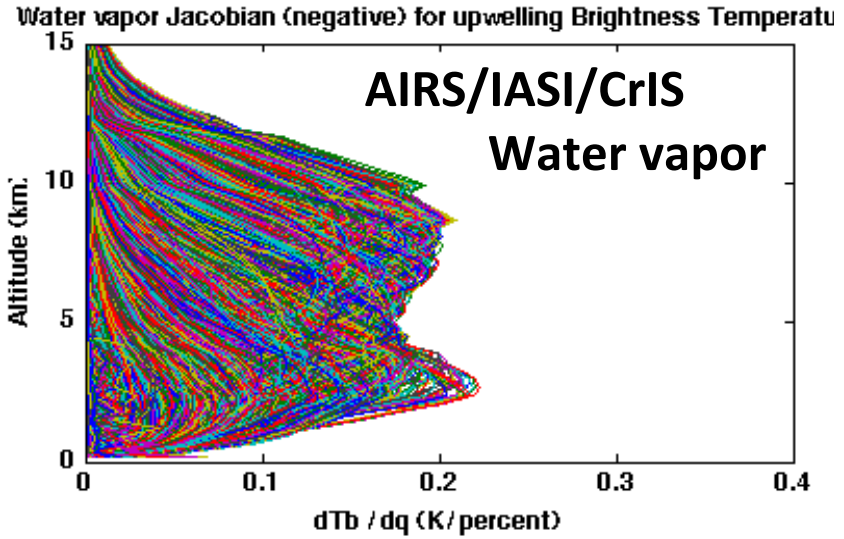

CRIS Relative Humidity [%] at 707 hPa
2012-04-16 (07:22,07:30)
100
80
60
40
20
0

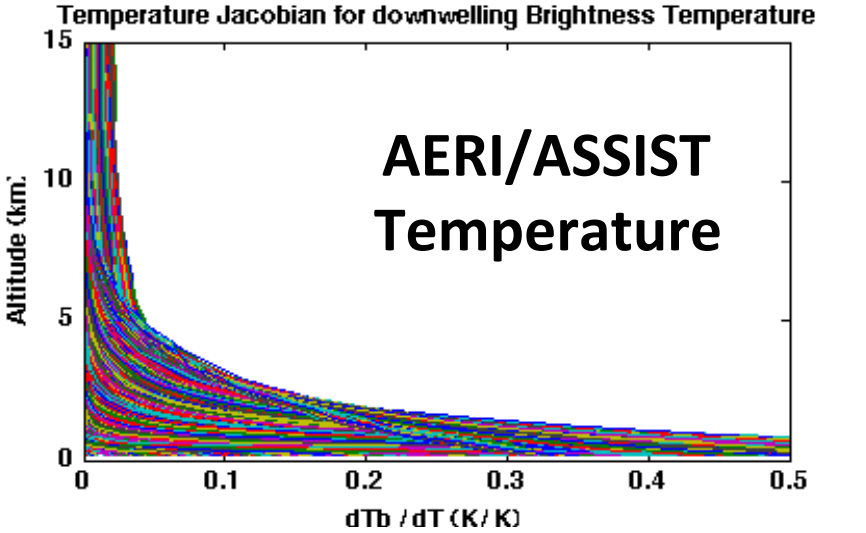

GDAS Relative Humidity [%] at 707 hPa
2012-04-16 (07:22,07:30)
100
80
60
40
20
0

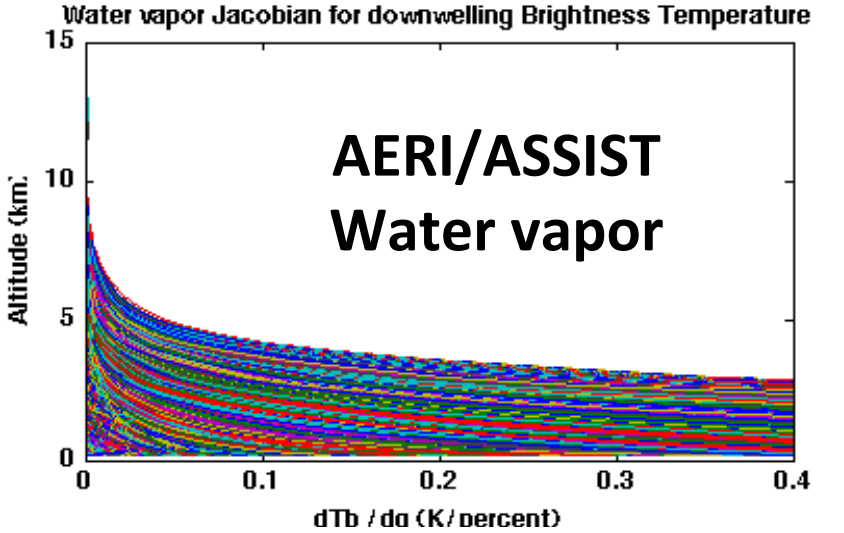

Pressure [mbar]
100
200
300
400
500
600
700
800
900
1000
0
50
100
Relative Humidity [%]

Satellite Vs Ground-based Profile Sensitivity









Satellite Information Content is High in the Free-atmosphere
Ground-based Information Content is High in the Low Atmosphere

Physical Regression (PR) Retrieval Methodology

$$Q_{ret} = q_o + (r_m - r_o)C$$

$$C = (R'^T R' + \lambda E^T E)^{-1} R'^T Q'$$

q = atmospheric profiles (temperature, water vapor, etc.)

C = statistical covariance about the initial profile q_o

r_o = radiance calculated from the initial profile q_o

Q & R = climatological ensemble of profiles & radiance spectra

( )' = deviation from the initial conditions q_o and r_o

$E^T E$ = statistical covariance of spectral radiance noise

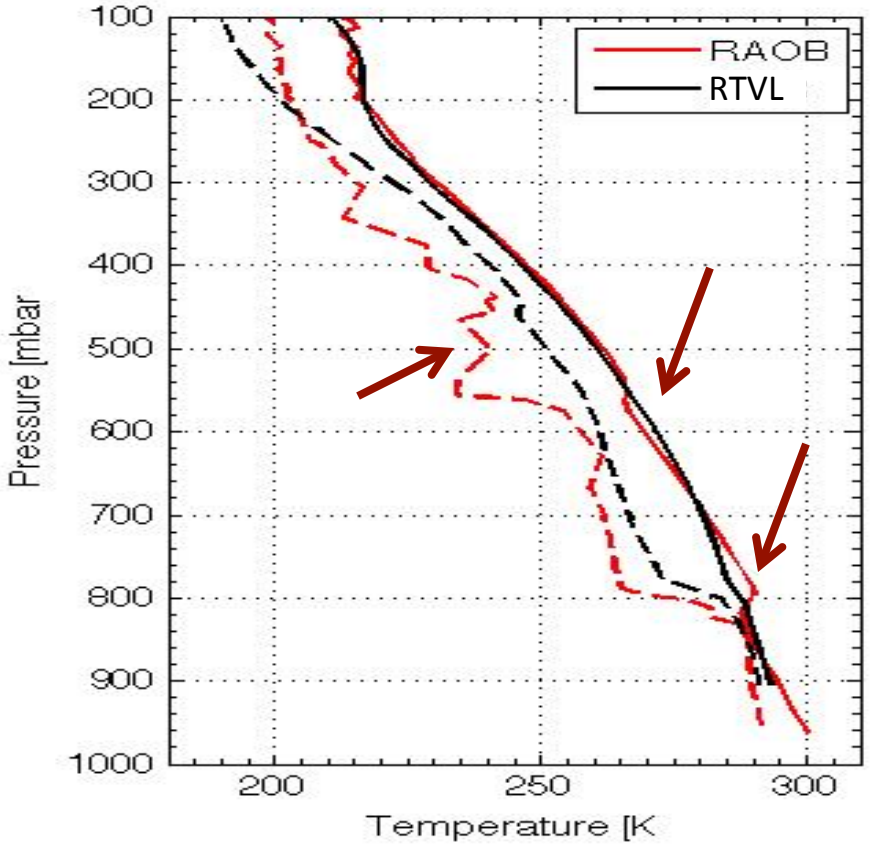
λ = scaler determined as that value which minimizes the RMS difference between the retrieval calculated radiance spectrum and observed radiance spectrum

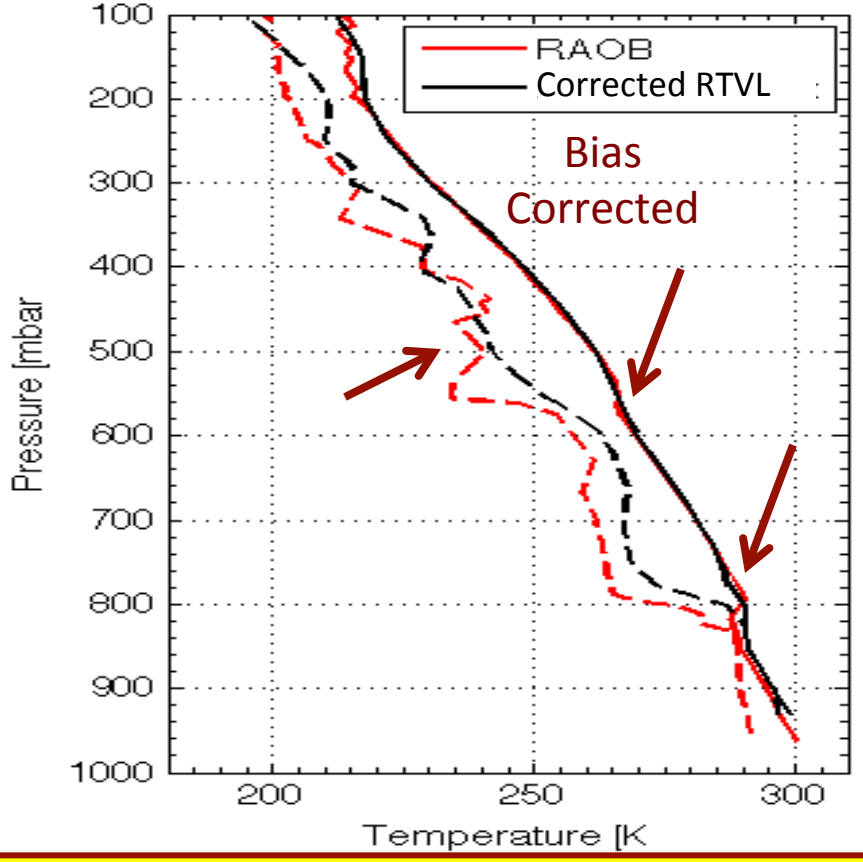
BIAS Corrections Using Forecast Model Profile

Problem: PR method uses a statistical training data set. Imperfect skill due to lack of vertical resolution in radiances leads to local bias in PR retrievals.

Solution: Calculate radiances from forecast model profile (FP) and perform PR retrieval using model radiances.

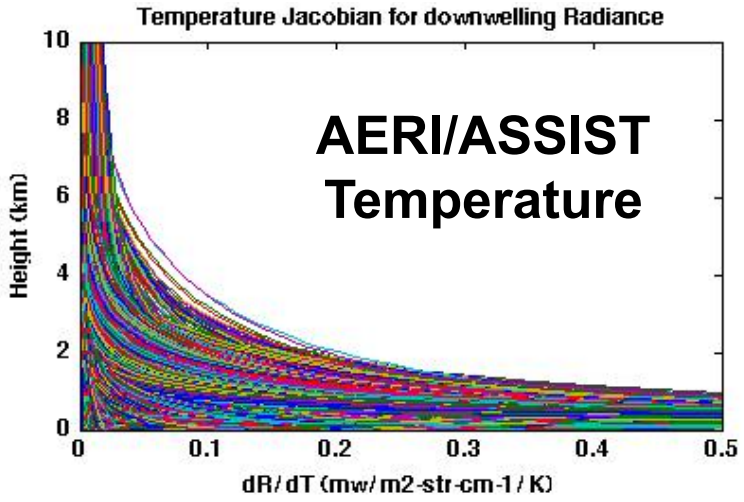
Statistical bias correction = FP – FP radiance retrieved FP

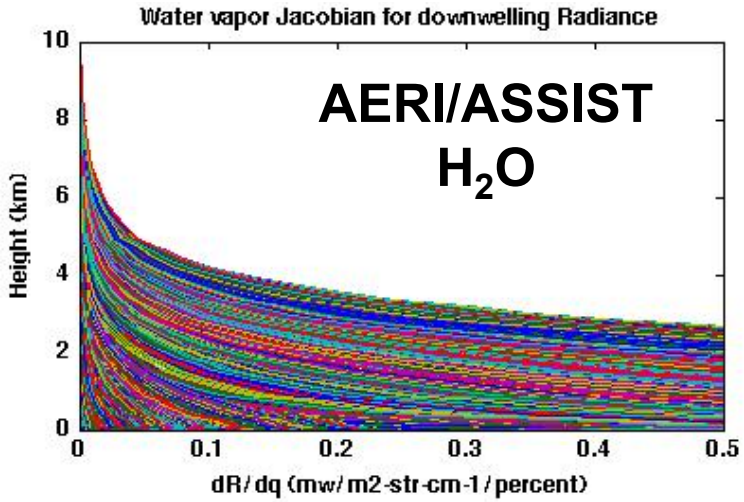


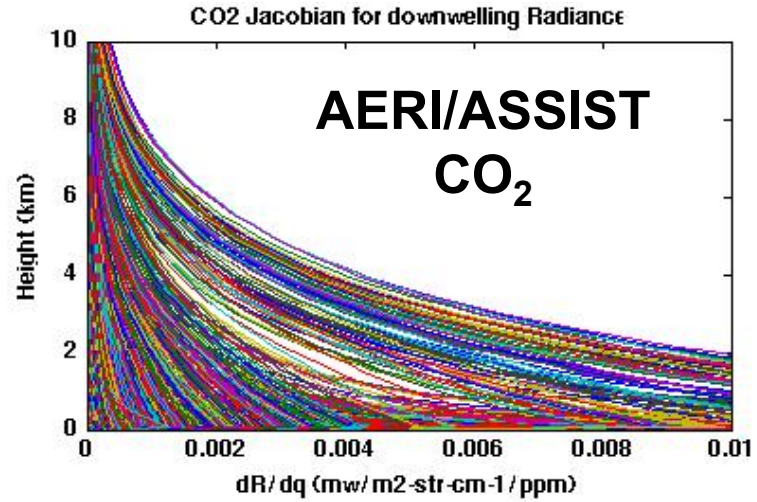


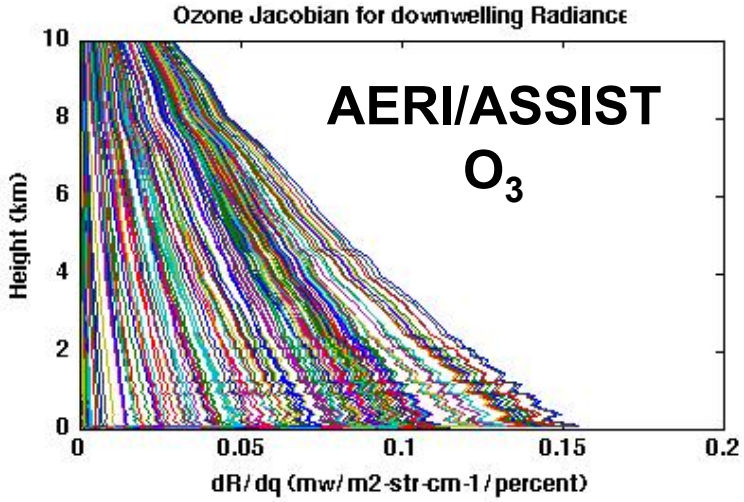
Bias Correction removes statistical bias with respect to the model FP

Ground-based Profile Sensitivity





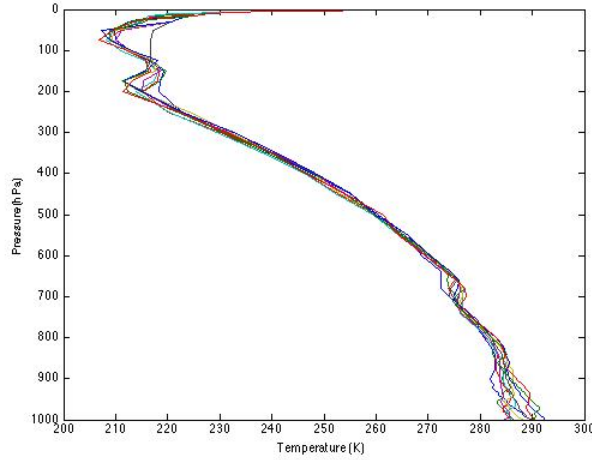


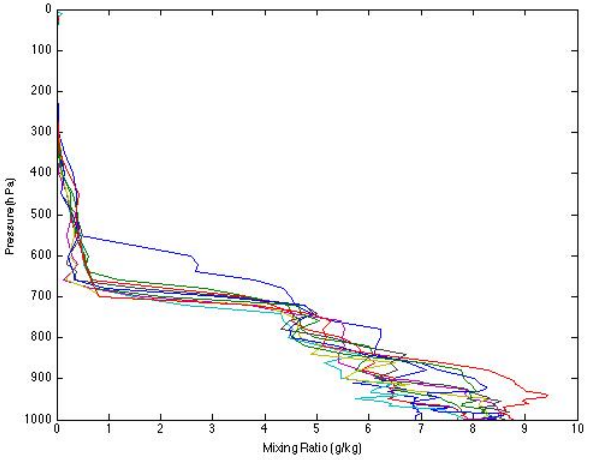


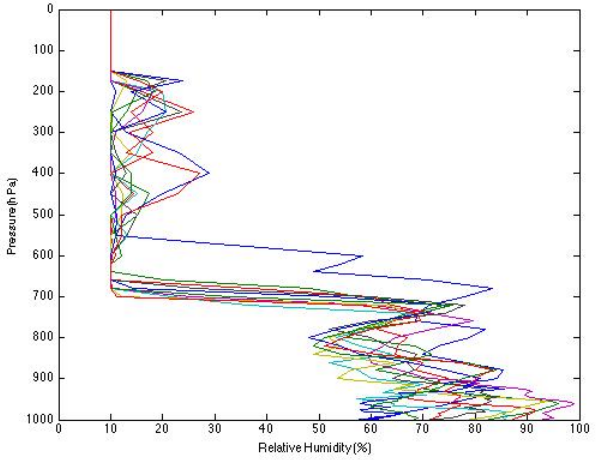
AERI/ ASSIST measurements are very sensitive to temperature, water vapor, and GHG variations in the lower atmosphere (i.e., 0 – 4-km)

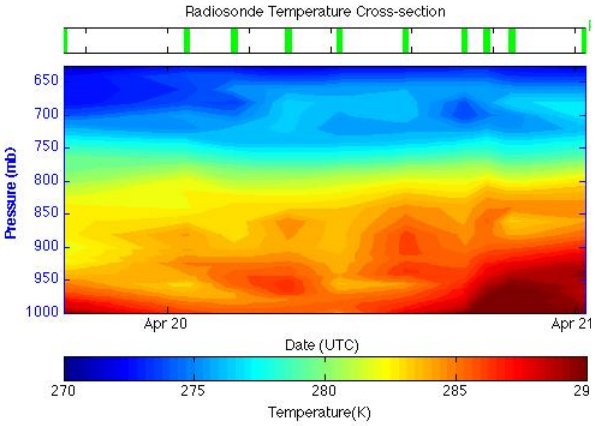
GRASP "Golden Day" April 20, 2012

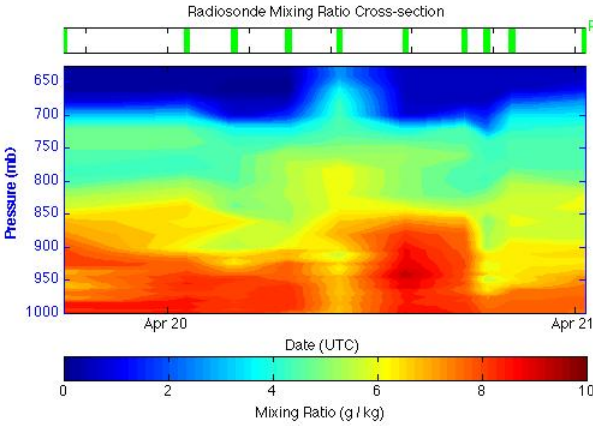
Radiosonde Observations (10): 19 (17 Z)- 21 (00Z) April 2012)

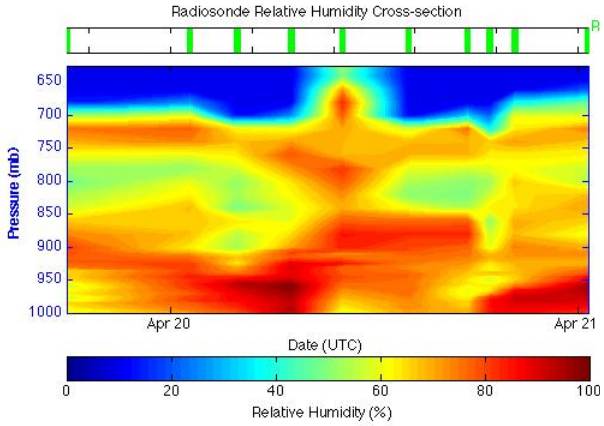




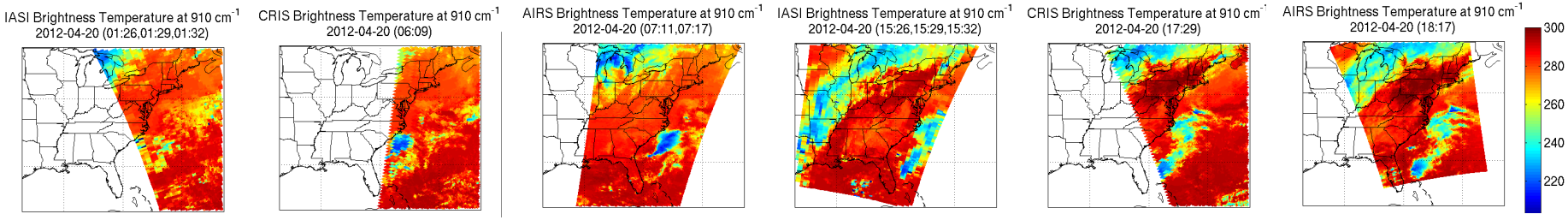




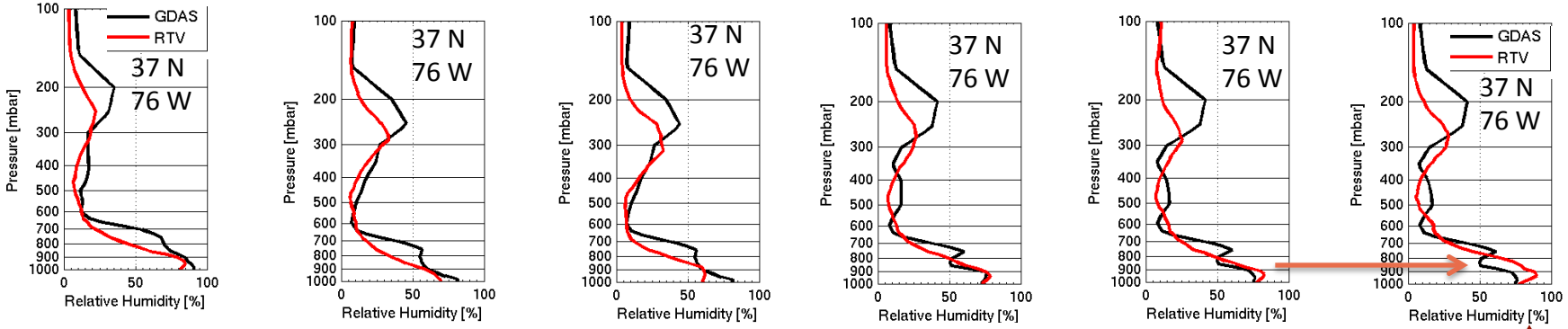


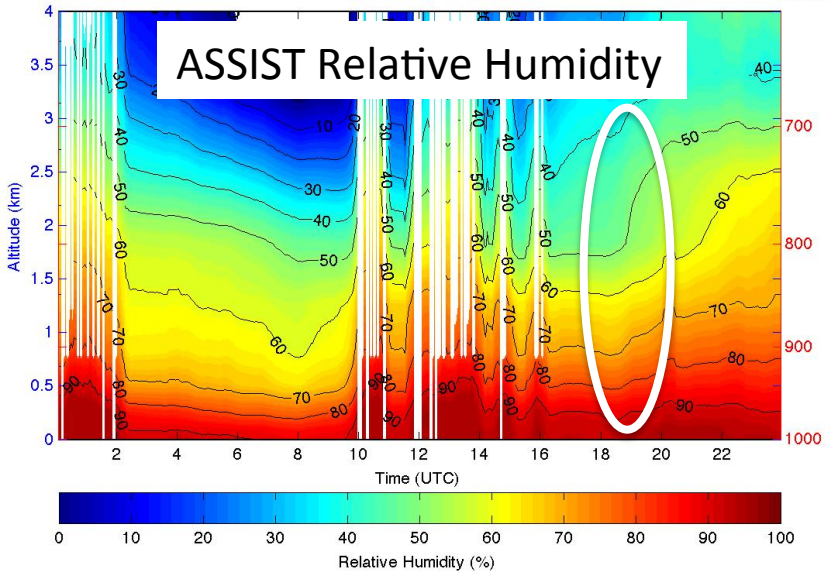


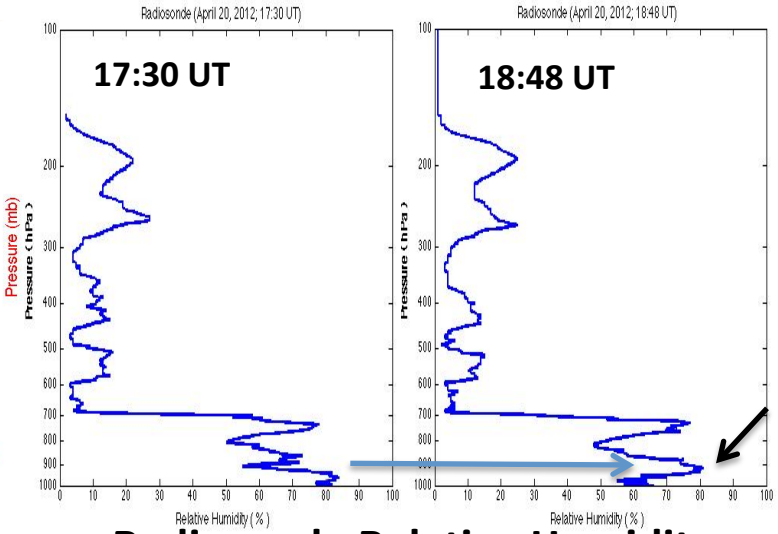
GRASP Validation Campaign (April 20, 2012)



IASI-01:30 UT | **CrIS-06:10** | **AIRS-07:11** | **IASI-15:30** | **CrIS-17:30** | **AIRS-18:17 UT**



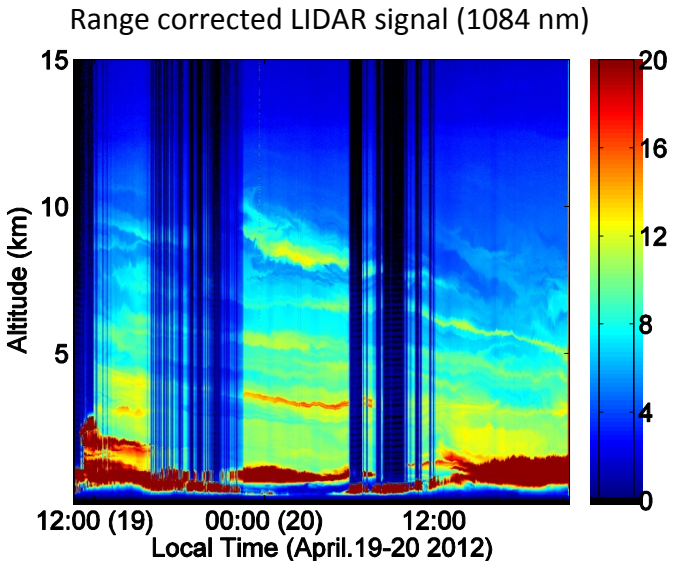


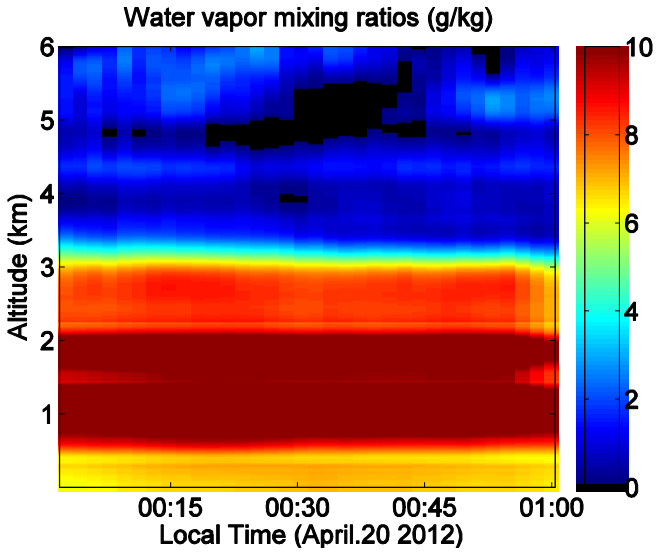


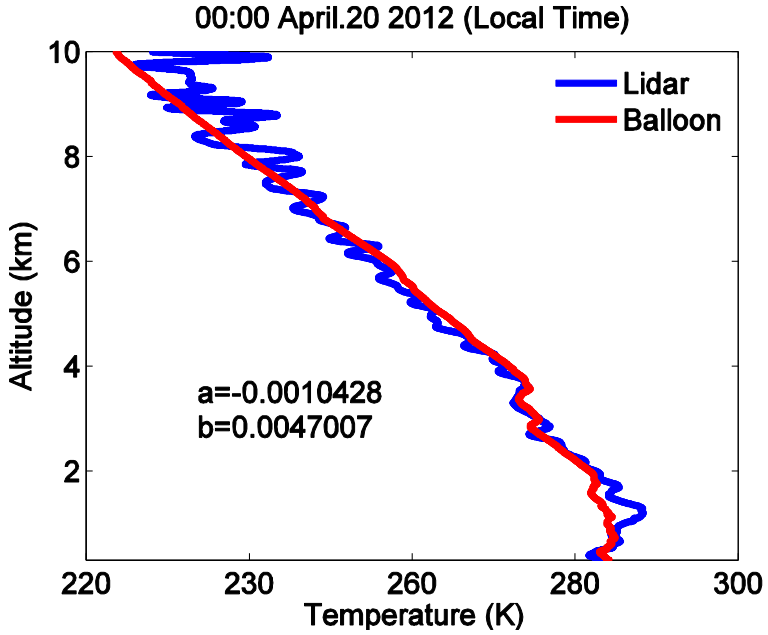
Radiosonde Relative Humidity

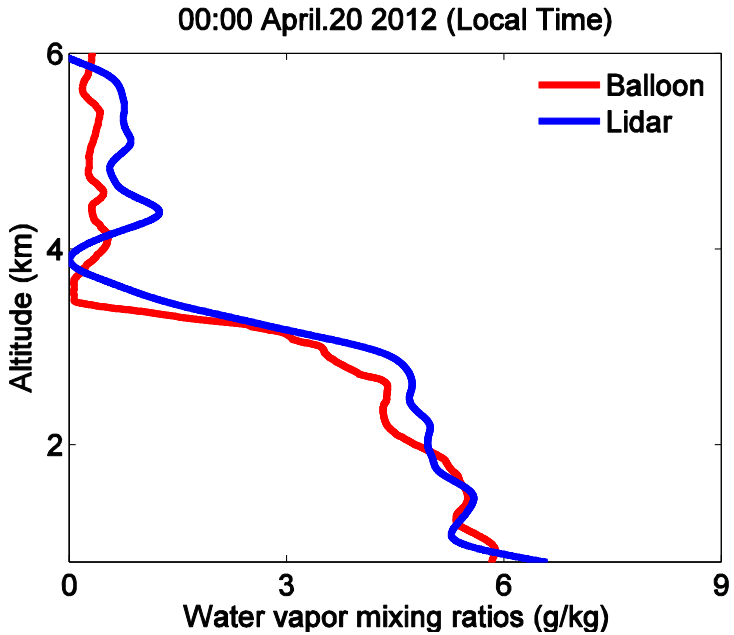
AIRS-CrIS Moisture Change Verified by Raob & ASSIST

GRASP April 20, 2012: Raman Lidar





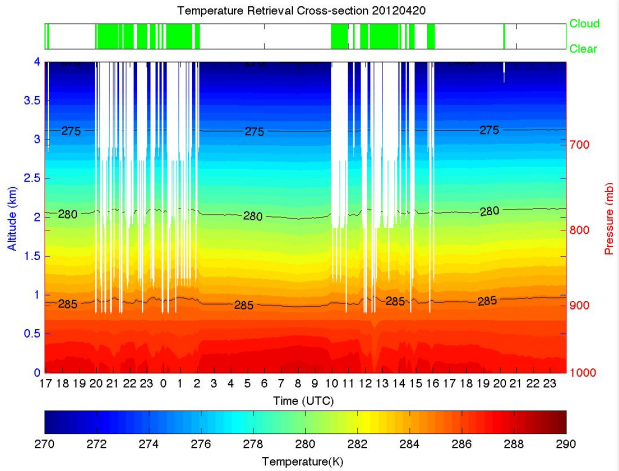




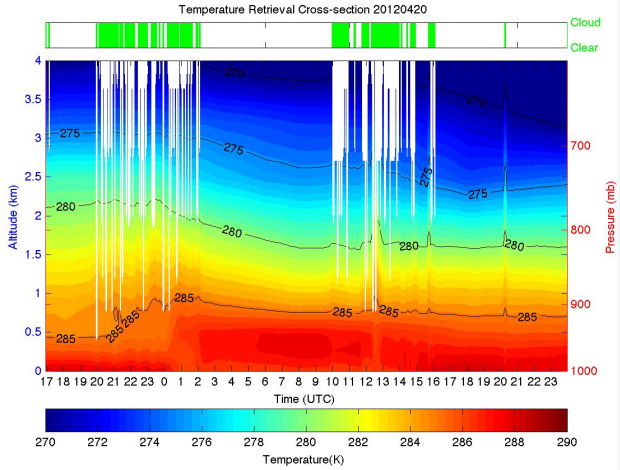
ASSIST Profile Results

April 19 17 UTC – April 21, 00 UTC

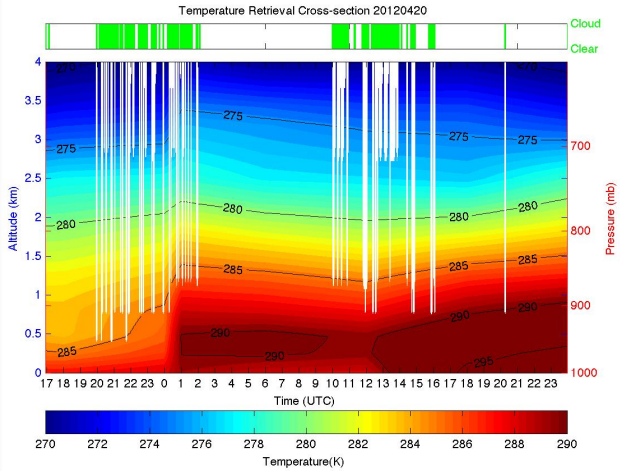
Temperature (0 – 4 km)



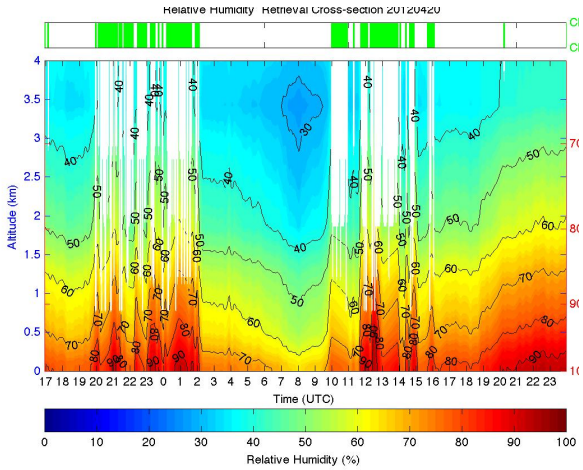
ASSIST - only

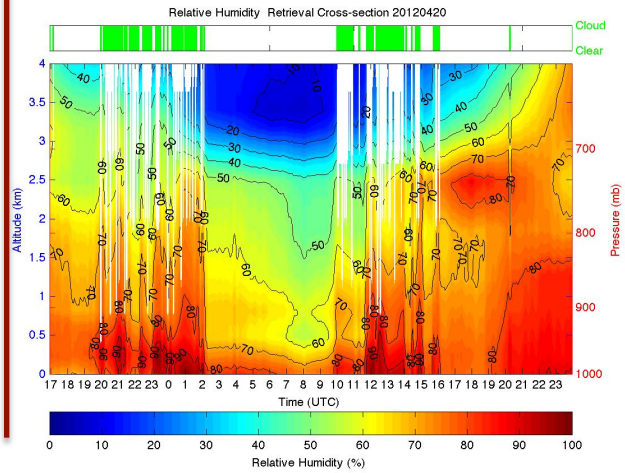


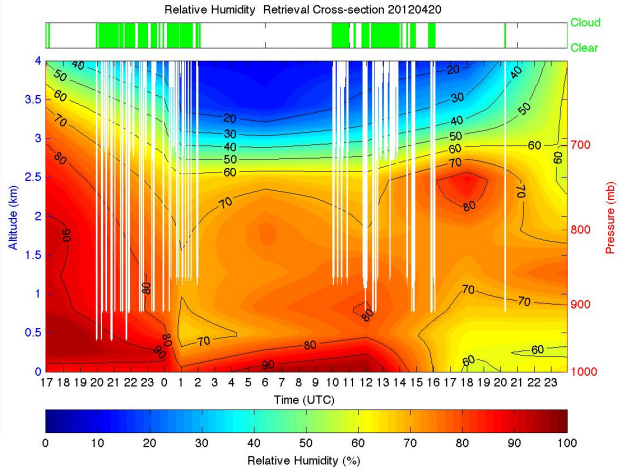
ASSIST w RAQMS



RAQMS





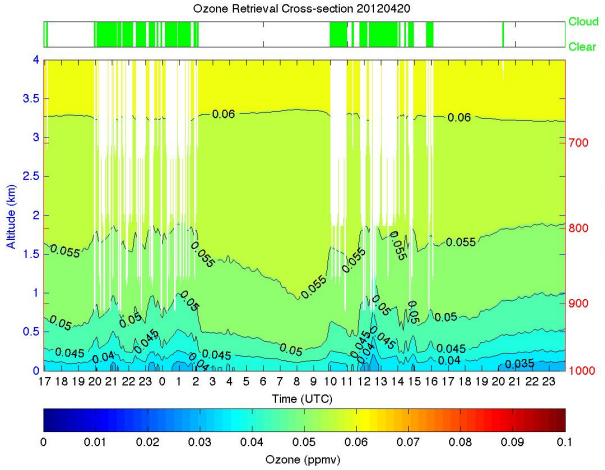


Relative Humidity (0 – 4 km)

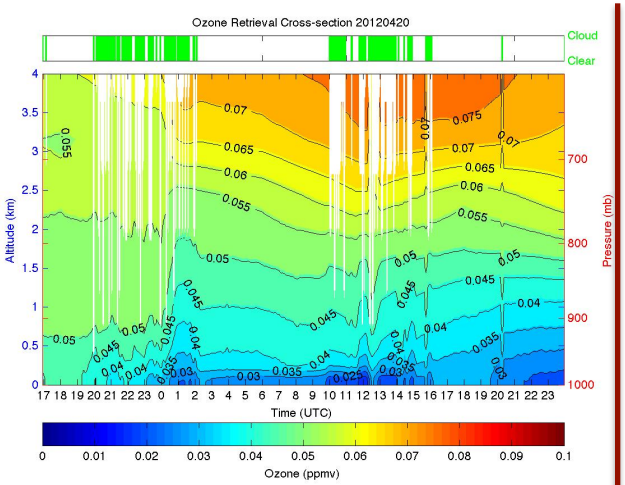
ASSIST Profile Results

April 19 17 UTC – April 21, 00 UTC

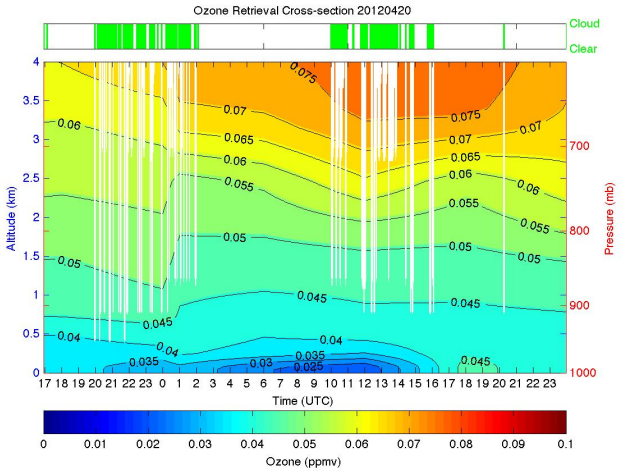
Ozone (0 – 4 km)



ASSIST - only



ASSIST w RAQMS



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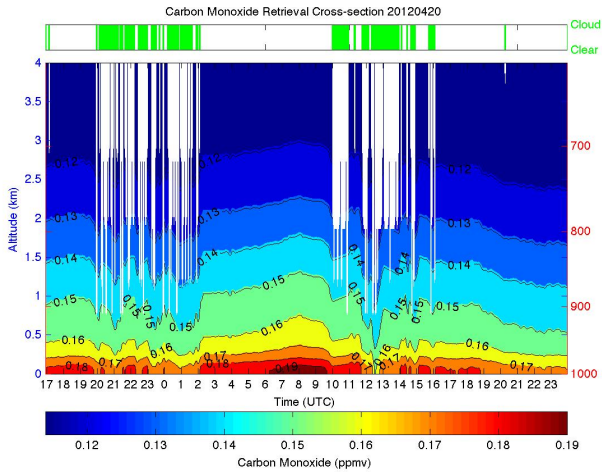
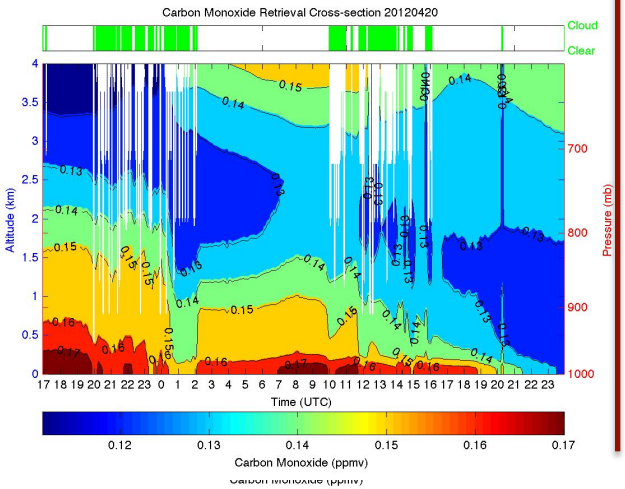
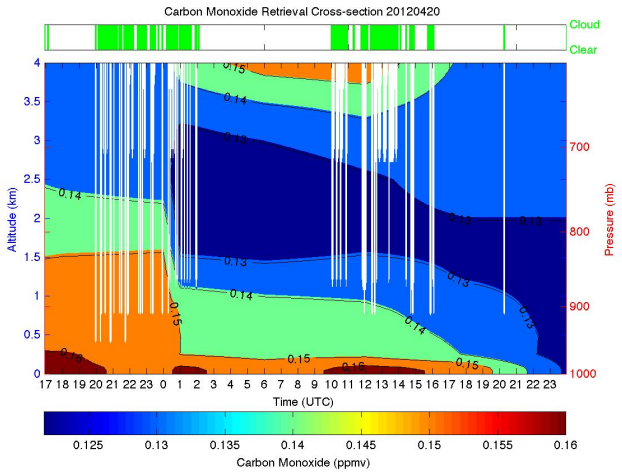




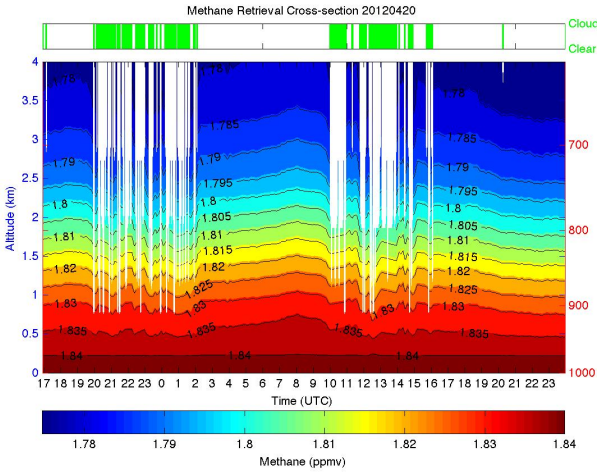


Carbon Monoxide(0 – 4 km)

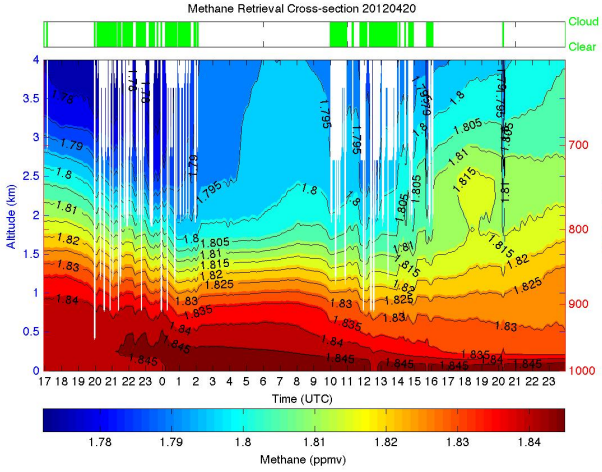
ASSIST Profile Results

April 19 17 UTC – April 21, 00 UTC

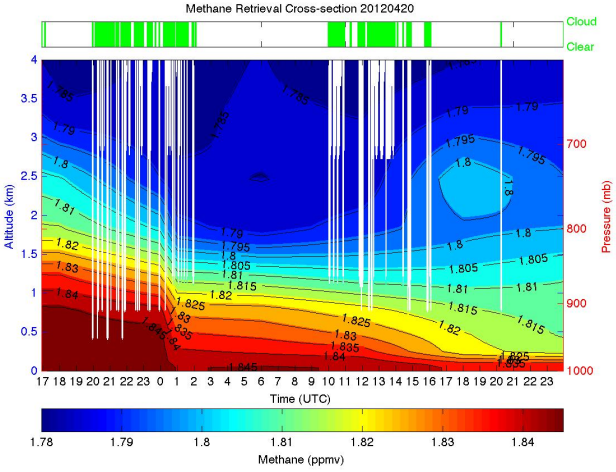
Methane (0 – 4 km)



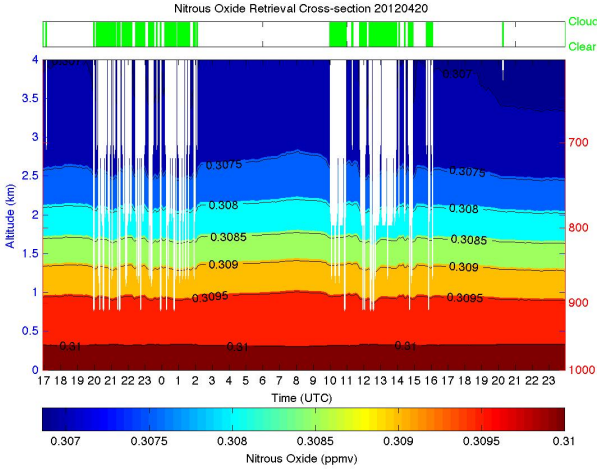
ASSIST - only

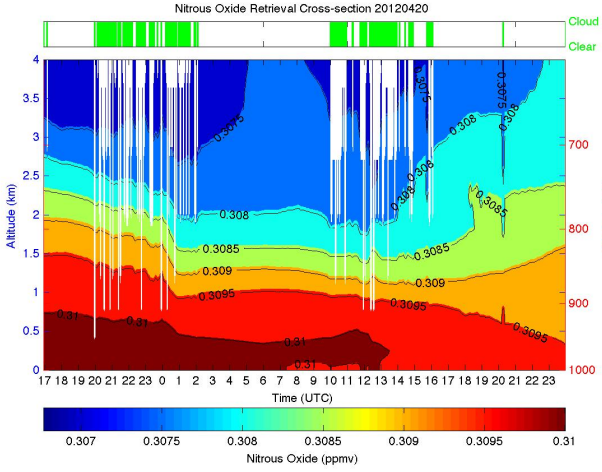


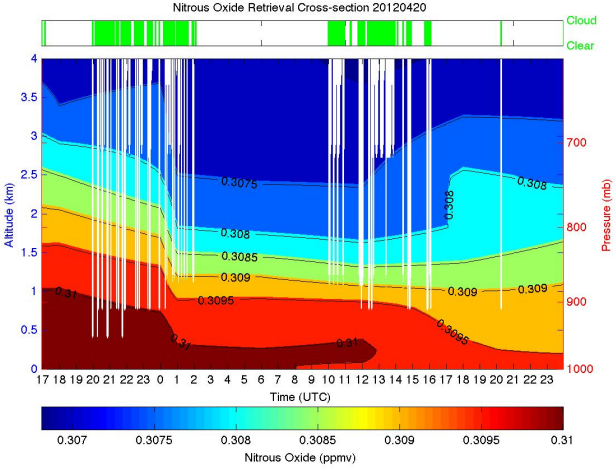
ASSIST w RAQMS



RAQMS



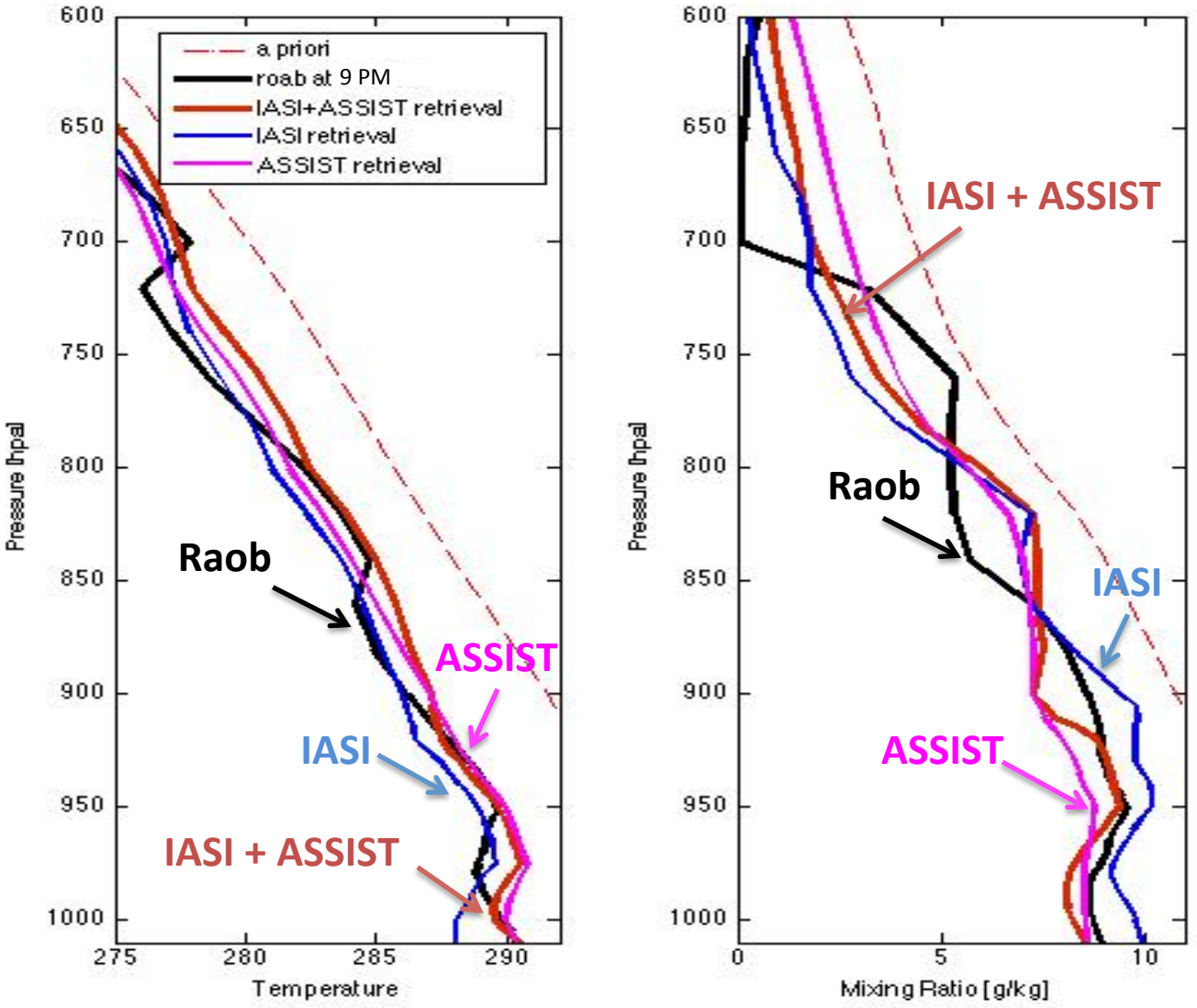




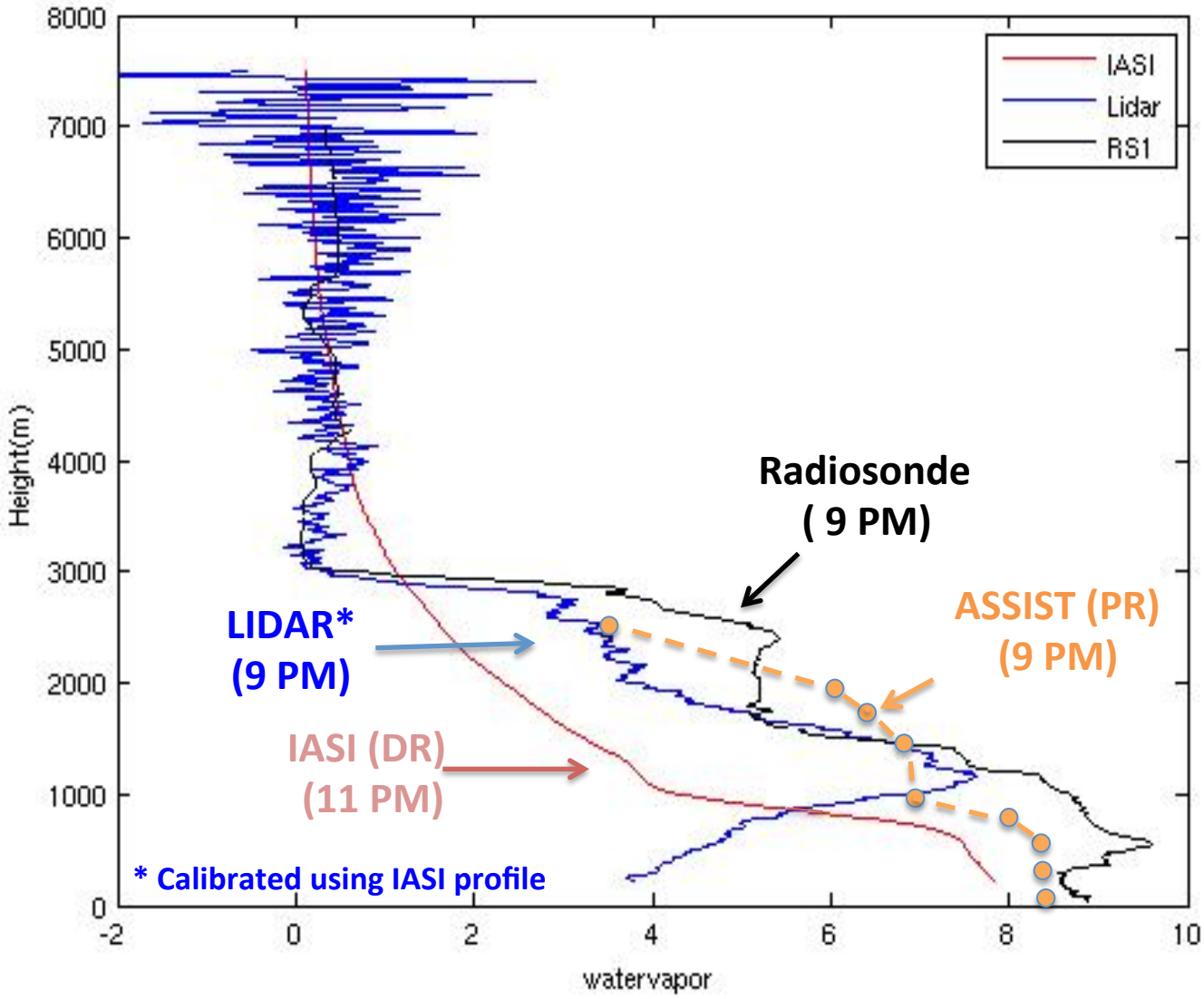
Nitrous Oxide(0 – 4 km)

ASSIST + Satellite (April 20, 2012)

Physical Regression (PR) Retrieval for IASI (11 PM) and ASSIST (9 PM) on 20120420



Raman Lidar (April 20, 2012)



Summary

- A unique in-situ and remote sensing data set has been collected during the HU/UW Ground-based Remote Atmospheric Sounding Project (GRASP) satellite ultraspectral sounding validation campaign
- It is shown that ground based FTS and Raman Lidar data can be used to validate satellite tropospheric soundings with an accuracy close to that provided by radiosonde observations
- The GRASP satellite and ground based data set is to be made available to the research community for remote sensing algorithm development and validation.

Thank you for listening

We greatly appreciate our GRASP campaign sponsors: DOE, NASA, NOAA, US Army