

Testing average then retrieve approach with PCRTM with CALIPSO/CloduSat clouds

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Objective of this work

- Test temperature and water vapor retrievals with a finer vertical resolution
 - 15 layers (16 layer boundaries): 0.005, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 850, 900, 950, 1000, 1100 hPa
- Evaluate retrieval results quantitatively
 - Nadir view sampling error vs. retrieval error
- Test retrievals with AIRS data (16 day mean nadir view spectral radiances)

Spectral radiance computation

- CCCM (CALIPSO, CloudSat, and MODIS derived cloud fields)
- MERRA (T and Q)
- Nadir view spectral radiance
- Sampling is the same as nadir view AIRS spectral radiance
- PCRTM

Main Elements

- PCRTM over AIRS channels, thermal IR only
 - 2378 channels (649-1613 / 2181-2665 cm^{-1})
- Calipso, CldSat, Ceres, Modis (C3M)
 - near nadir FOVs
 - cloud properties: fraction,tau,height, phase,Re/De
- GMAO Merra assimilation
 - (0.66 deg x 0.50 deg x 72 levels)
 - Temperature , Humidity , Ozone:profiles
 - Skin Temperature
- IASI surface emissivities for 18 lgbp types at PCRTM
493 monochromatic wavenumbers

Additional Details

- Up to 4 (Clear, Low, Mid , High) cloud columns per FOV fractionally weighted to total-sky FOV.
- Jacobians for each sub-Fov scale cloud column:
 - Temperature and Humidity 15 levels
 - Cloud : Fraction , Pressure, Cloud Tau , Particle Size
- Computation for a nadir view angle made for slightly (< 15deg) off-nadir FOV atmosphere properties from C3M.
- Gridding to 2.5x2.0 deg grid, individually averaged for ascending and descending over 16 day period to match gridded AIRS nadir radiance product (X.Huang)
 - Gridded AIRS from nadir Fov locations, slight spatial mismatch
 - Two 16 day periods : Jul 12-Jul27 and Jul28-Aug12 2006

Retrieval simulation

$$\mathbf{a} = (\mathbf{S}^T \mathbf{S} + \lambda \mathbf{H})^{-1} \mathbf{S}^T \overline{\Delta \mathbf{I}},$$

$\Delta \mathbf{I}$: Difference of 16 days mean nadir view radiances

$\mathbf{S}$: 10 degree zonal mean kernels

Skin temperature, 15 layers of T and Q,

3 cloud types (high, mid, and low) of top height, optical thickness, particle size, and cloud fraction

Retrieve 43 variables for 10 degree by 10 degree regions and average for zonal means

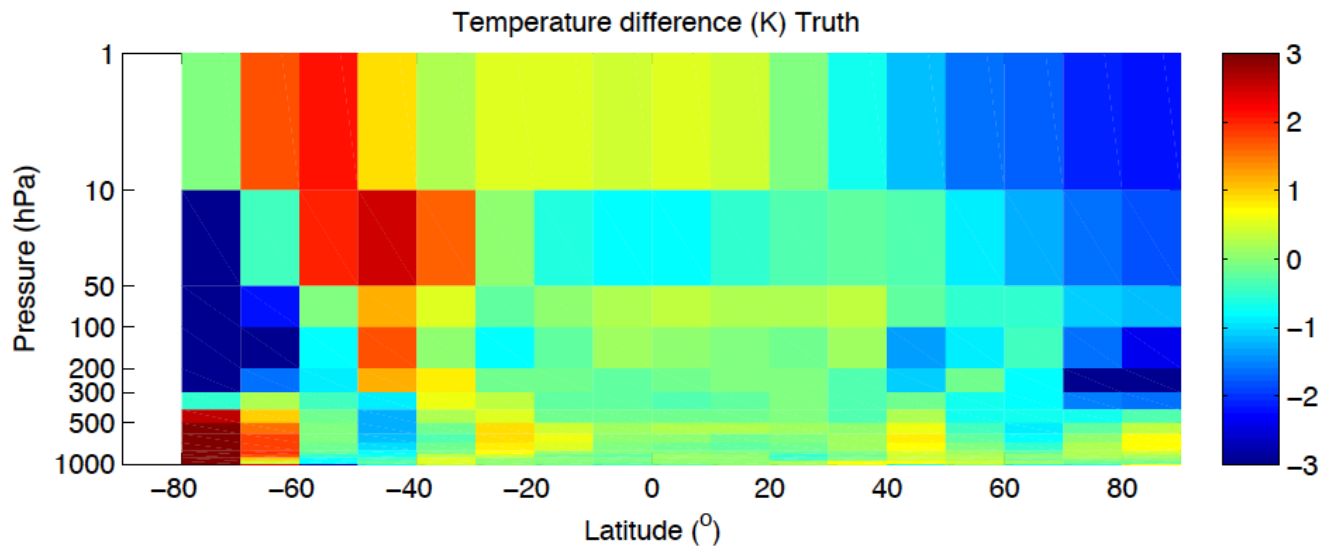
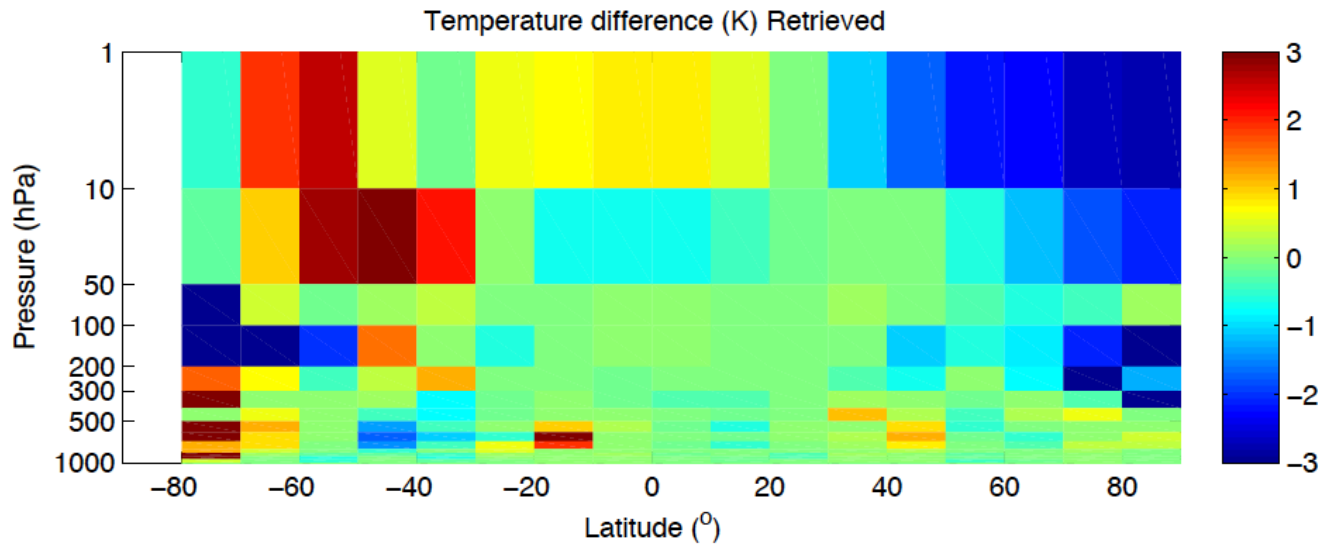
T and Q layer boundary pressure

0.005, 10, 50, 100, 200, 300, 400, 500, 600, 700, 800, 850, 900, 950, 1000, 1100

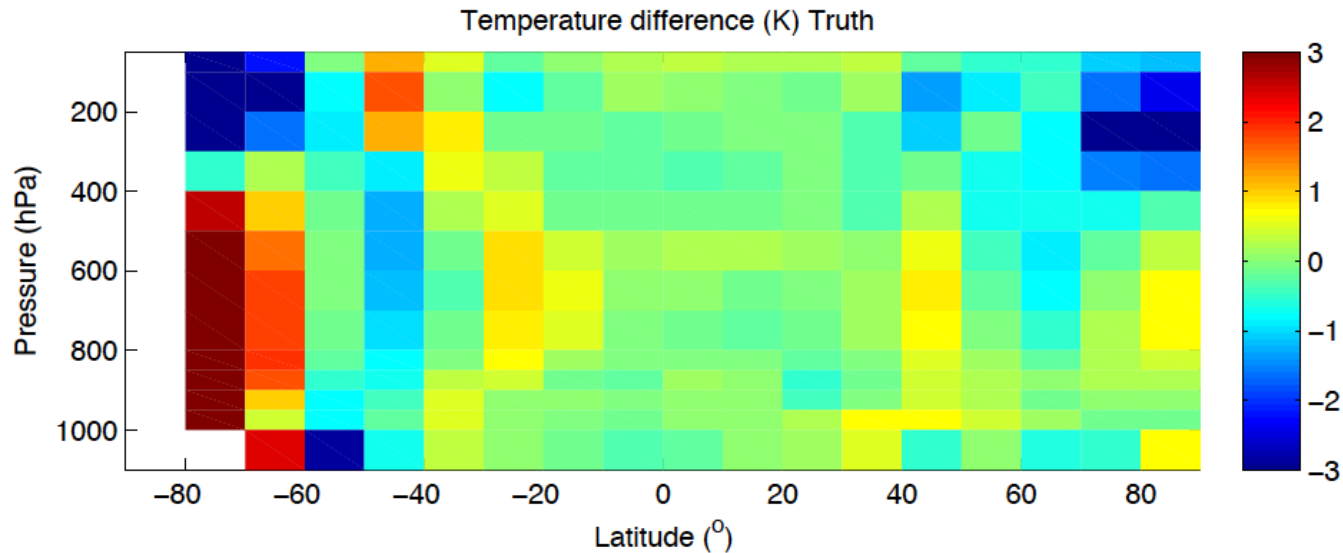
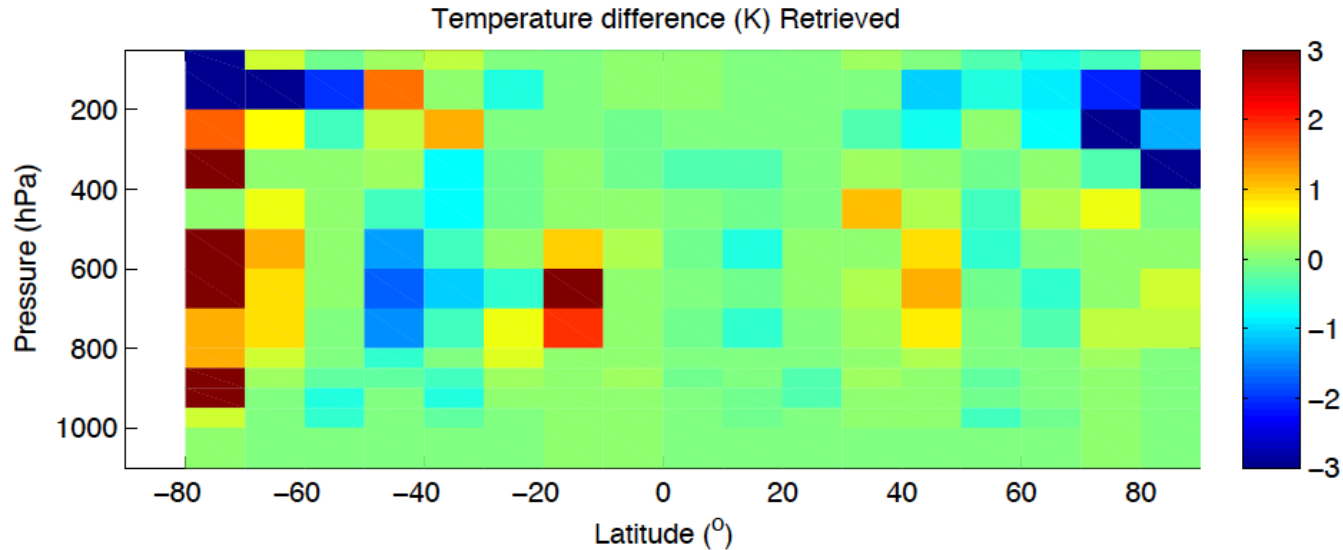
Retrieval

- Retrieving T, Q and cloud property differences between two 16 day periods (descending (nighttime) and ascending (daytime) orbits separately).
 - Period 1: 20060712 to 20060727
 - Period 2: 20060728 to 20060812

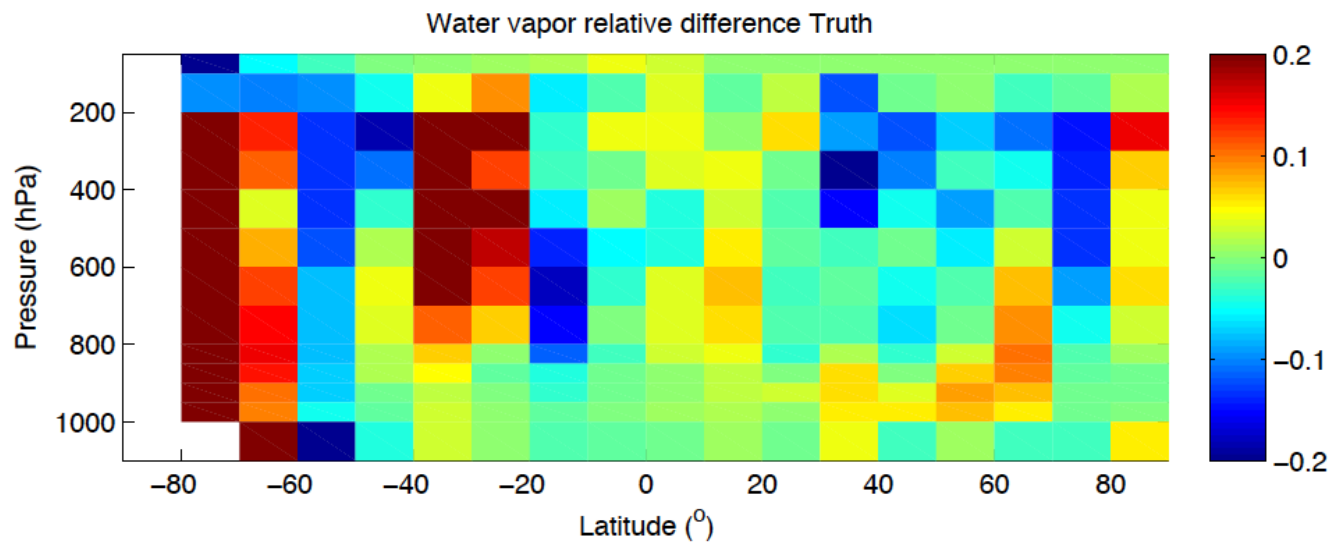
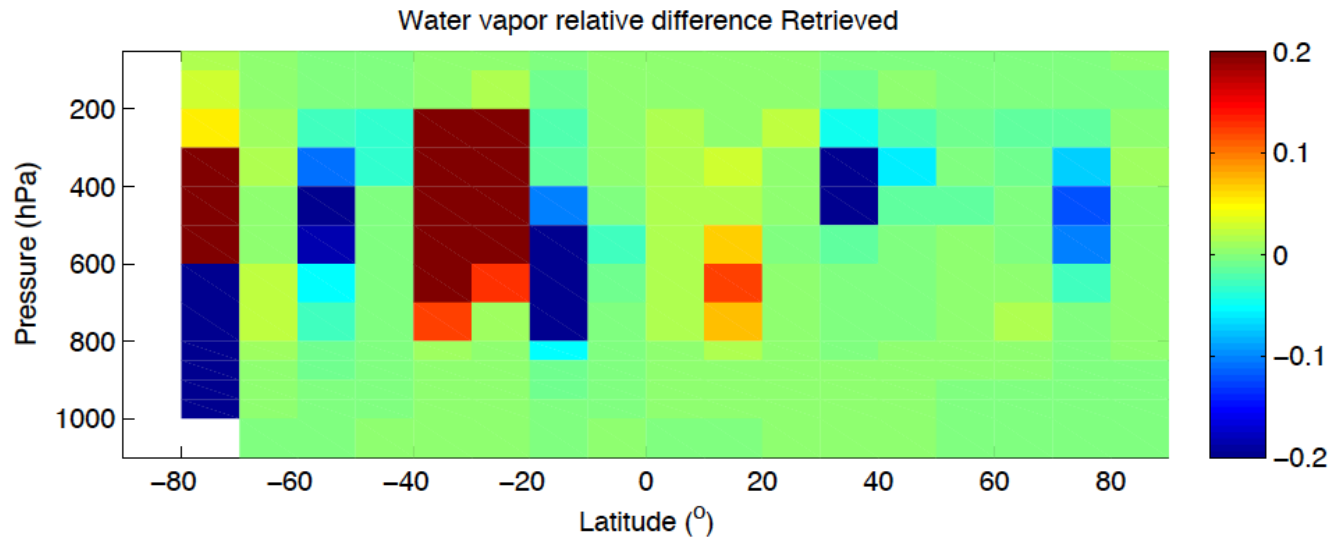
Clear-sky (clouds are taken out)



Clear-sky, tropospheric temperature

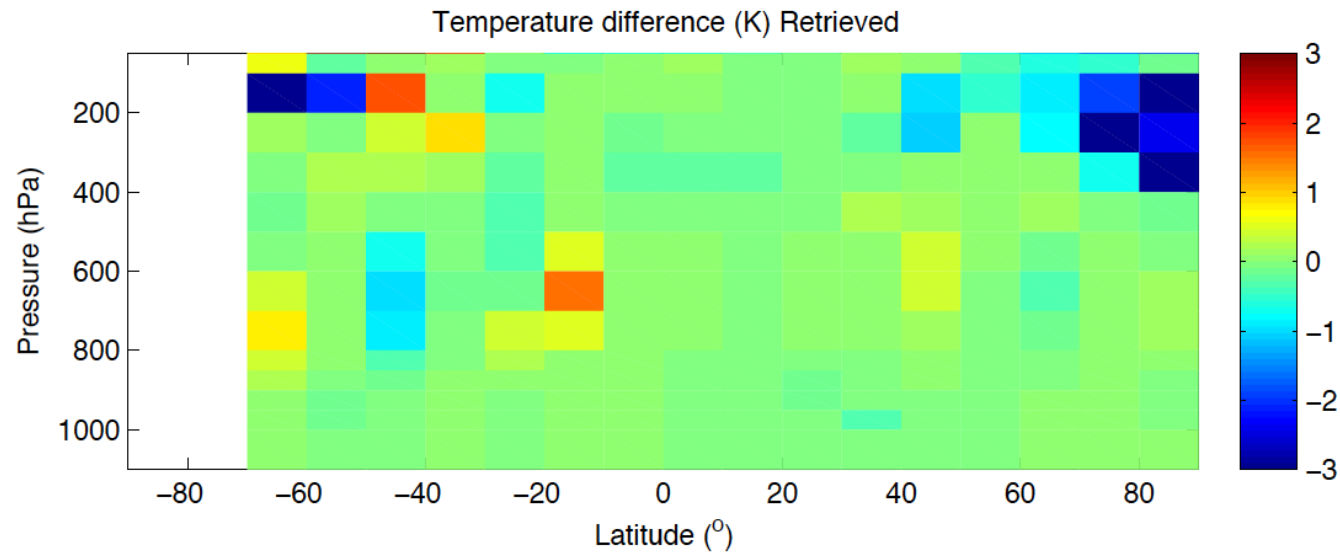


Clear-sky, water vapor

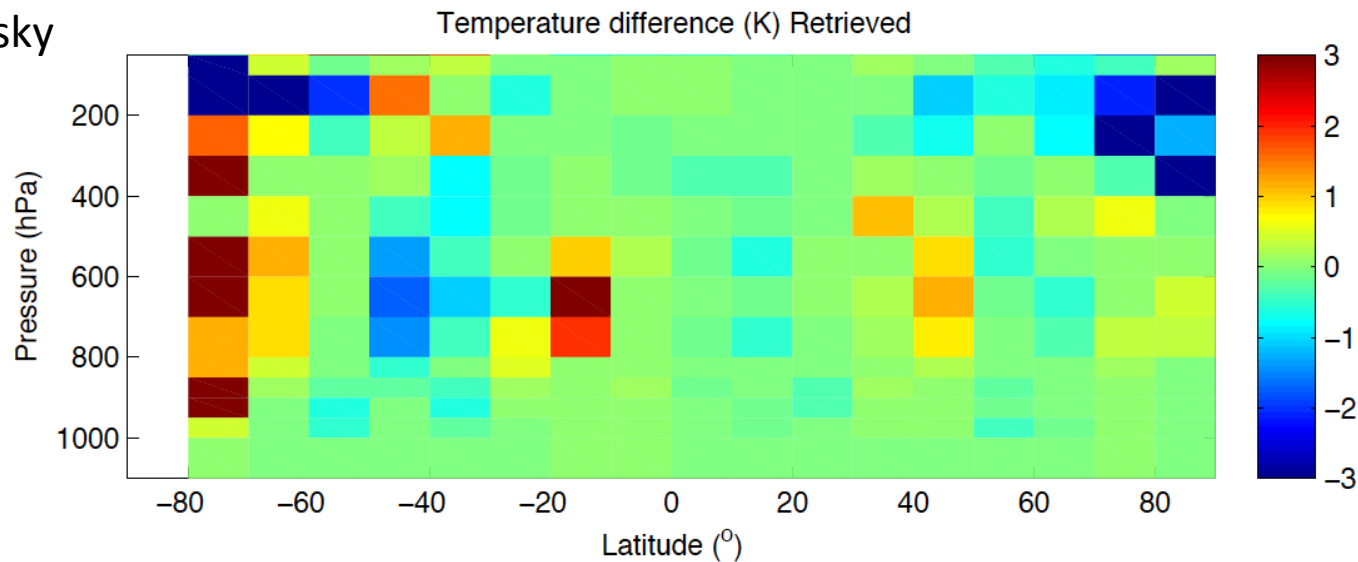


Clear-sky vs. All-sky, temperature

All-sky

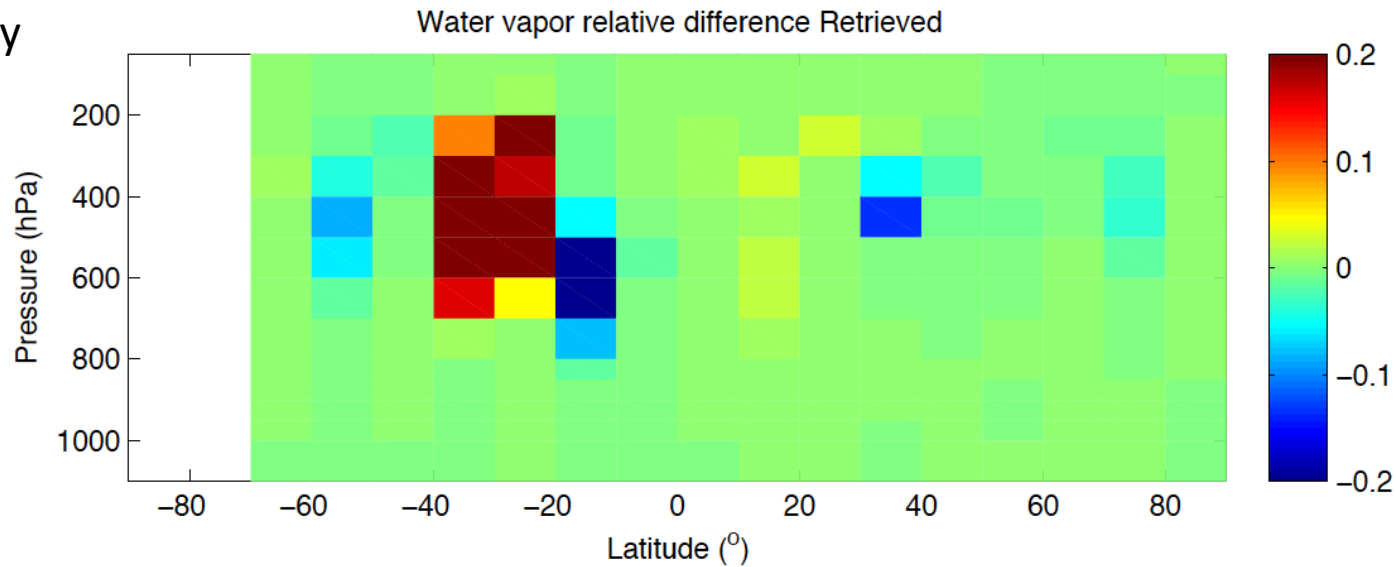


Clear-sky

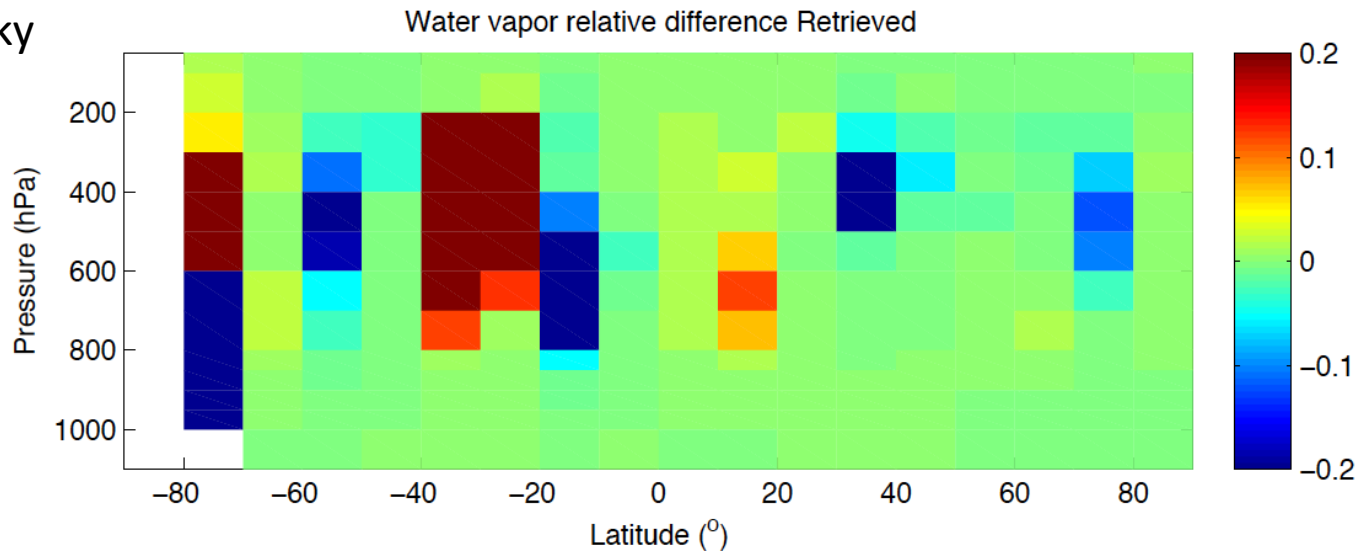


Clear-sky vs. All-sky, water vapor

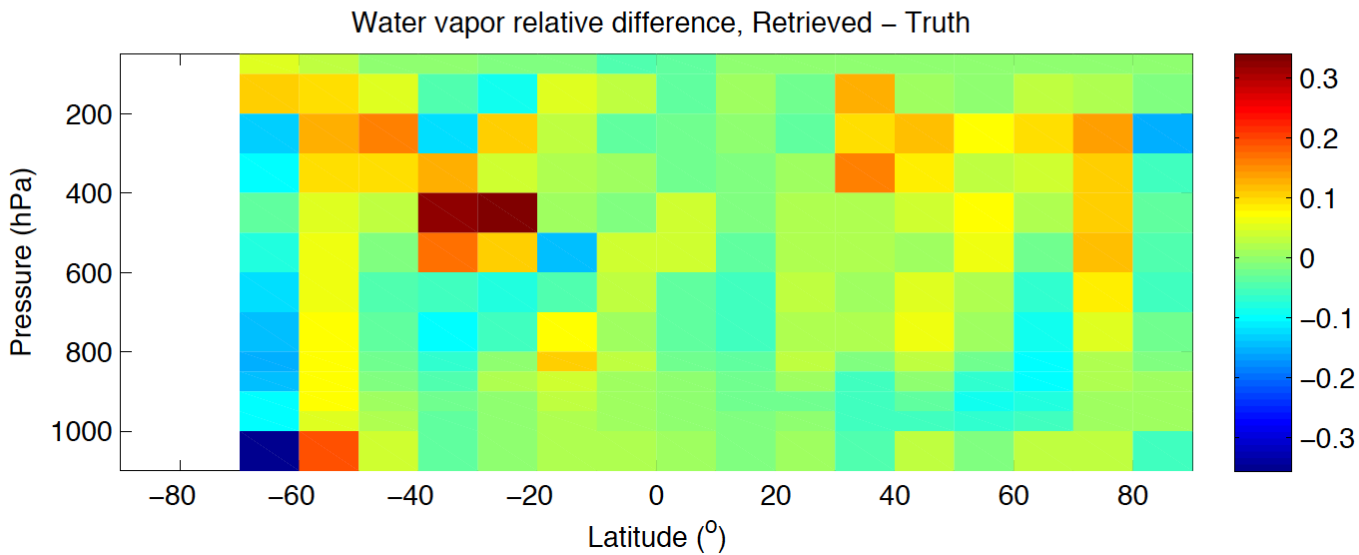
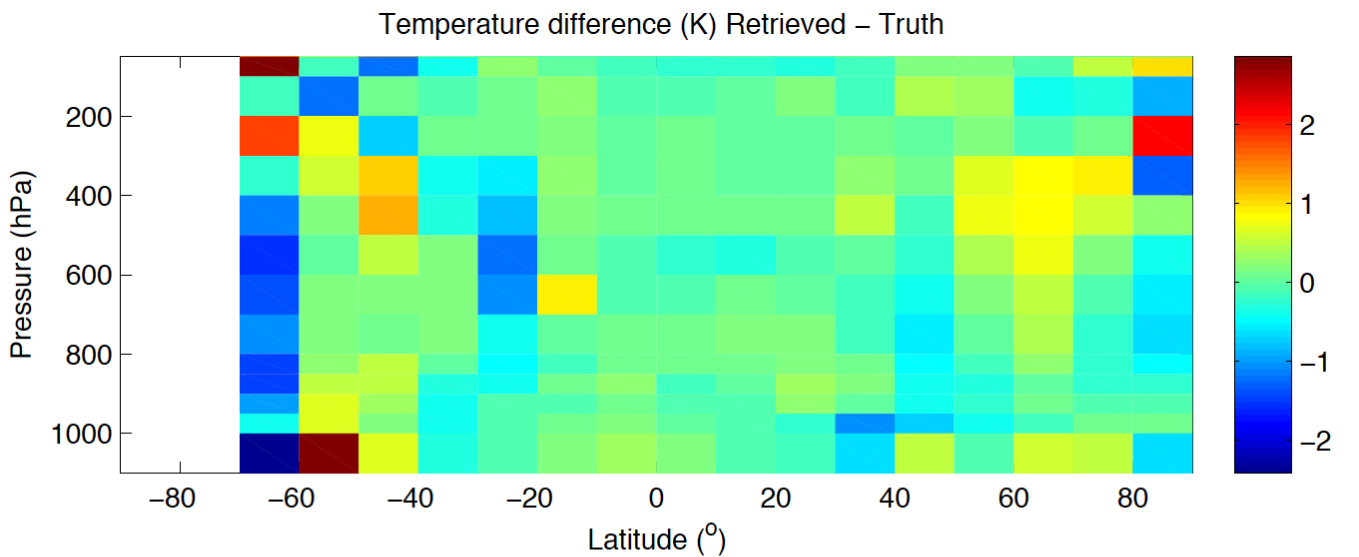
All-sky



Clear-sky



Retrieved - Truth

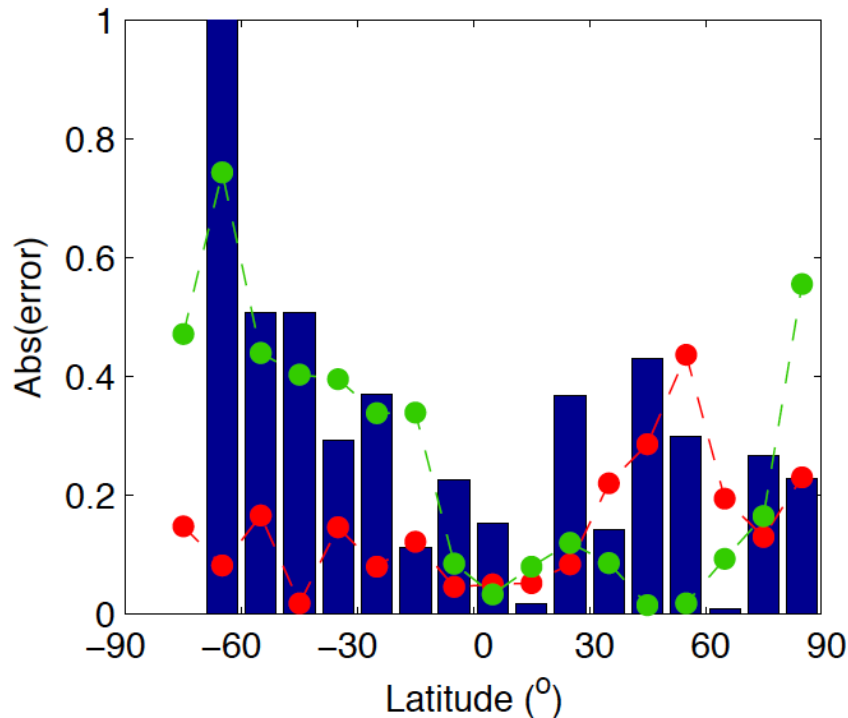


Retrieval evaluation

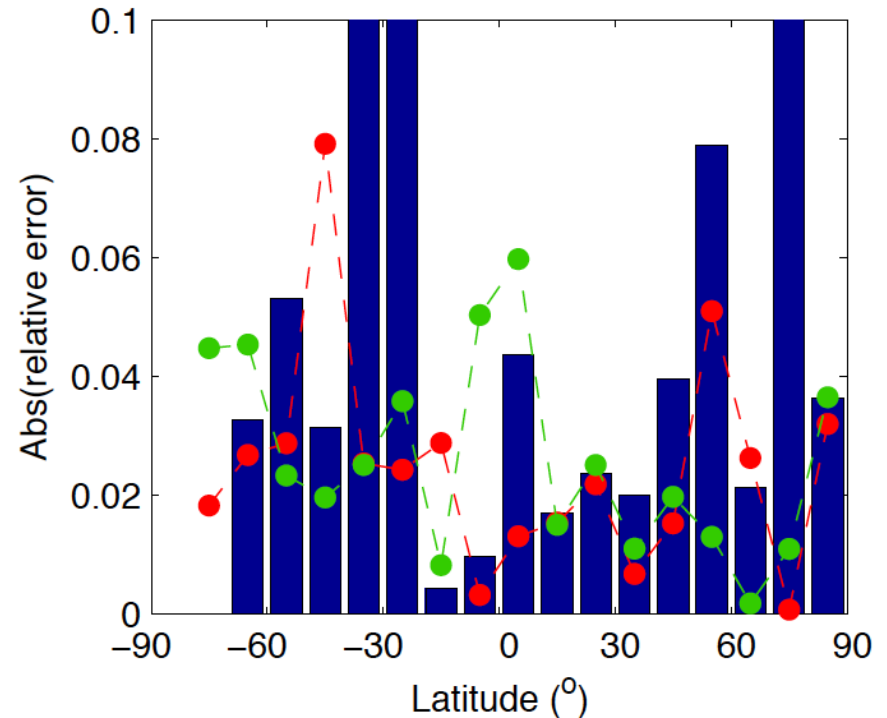
- Retrieved ΔT and ΔQ are evaluated by comparing the retrieval errors and nadir view sampling error
- Nadir view sampling error is determined by comparing with zonal means computed with all grids.

Retrieval evaluation

850 hPa – 900 hPa Temperature
(nighttime)



400 hPa – 500 hPa Water vapor amount
(Nighttime)



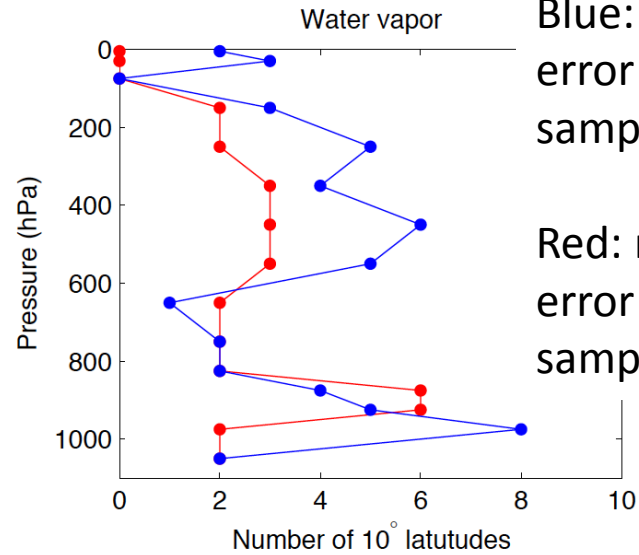
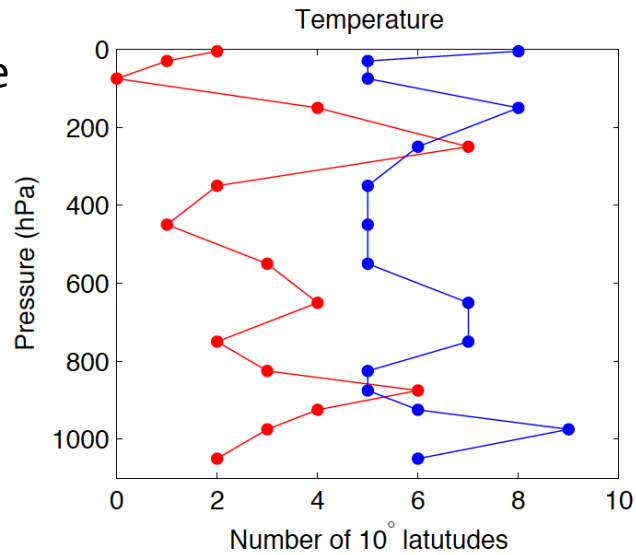
Blue bar: Absolute value of error

Red circle: Absolute value of nadir view sample error (zonal mean period 1 – period 2)

Green circle: Absolute value of nadir view sample error (zonal mean T and Q)

Retrieval evaluation

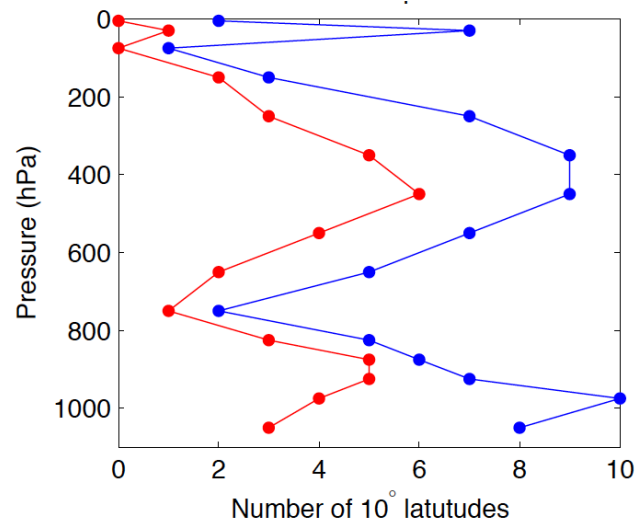
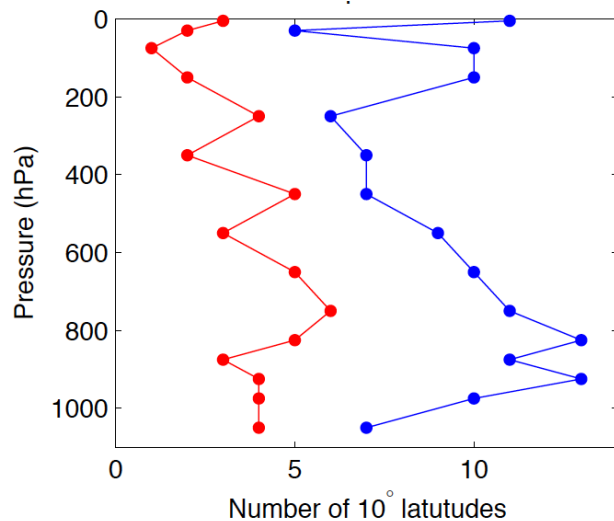
Nighttime



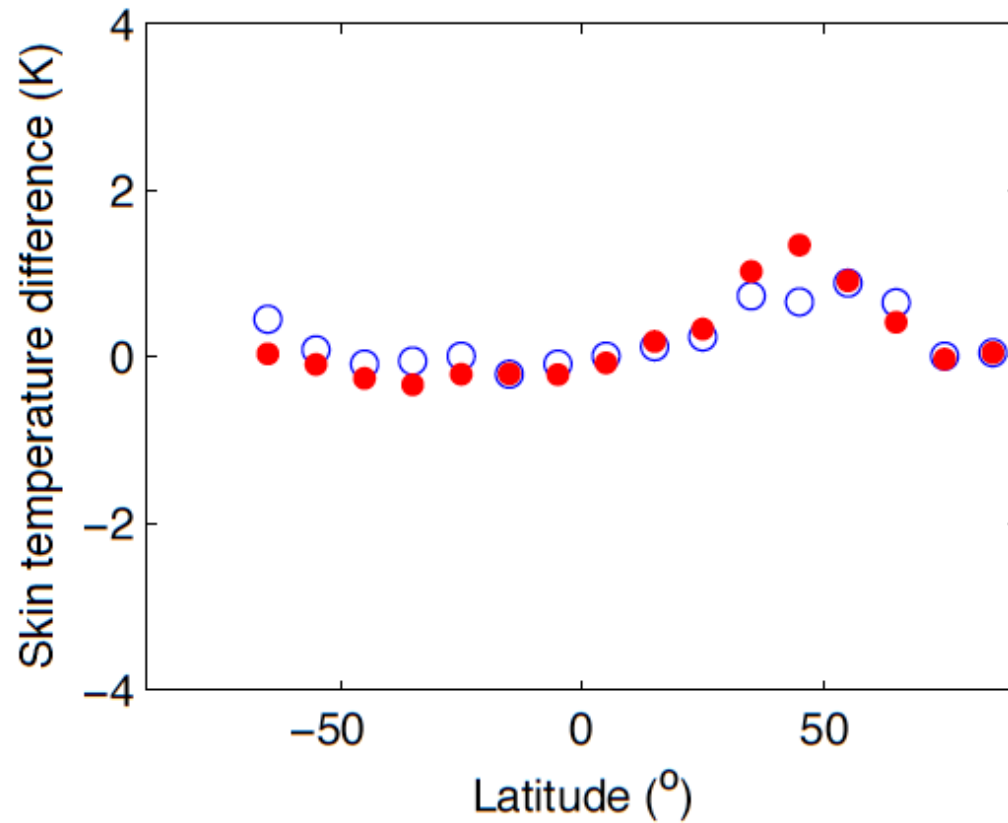
Blue: Retrieval error < T and Q sampling error

Red: retrieval error < ΔT and ΔQ sampling error

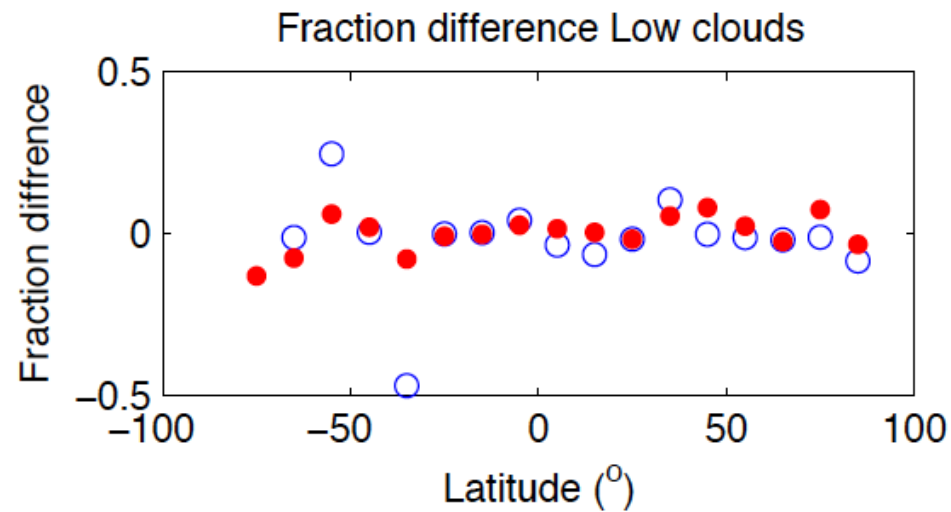
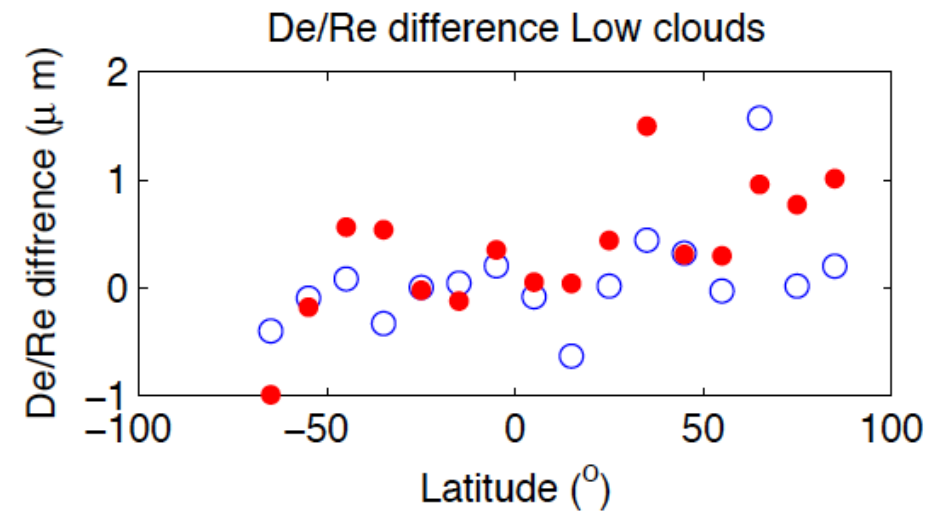
Daytime



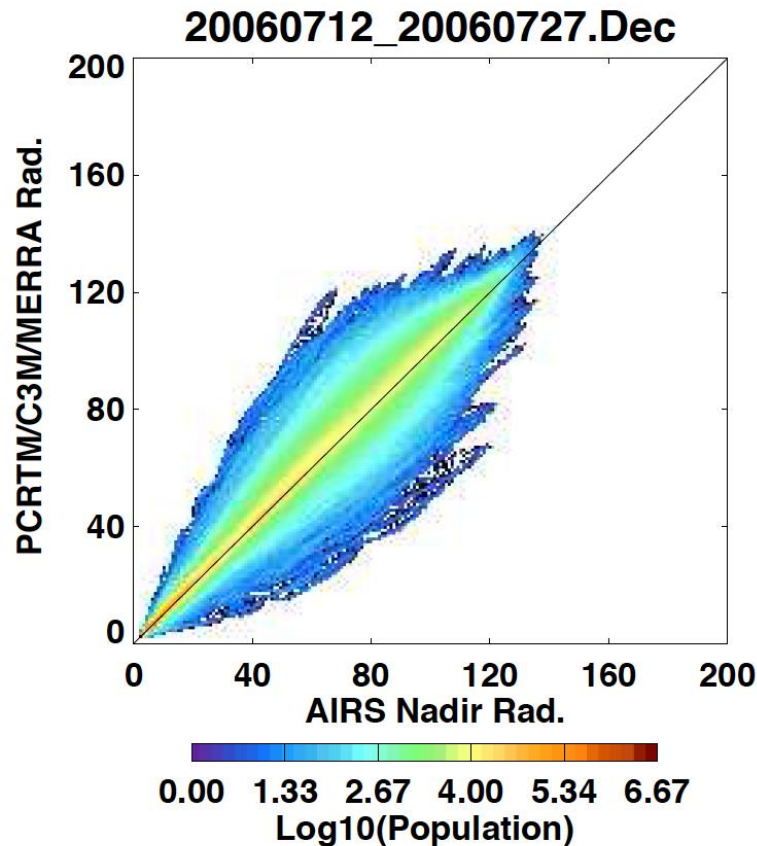
Skin temperature



Cloud properties

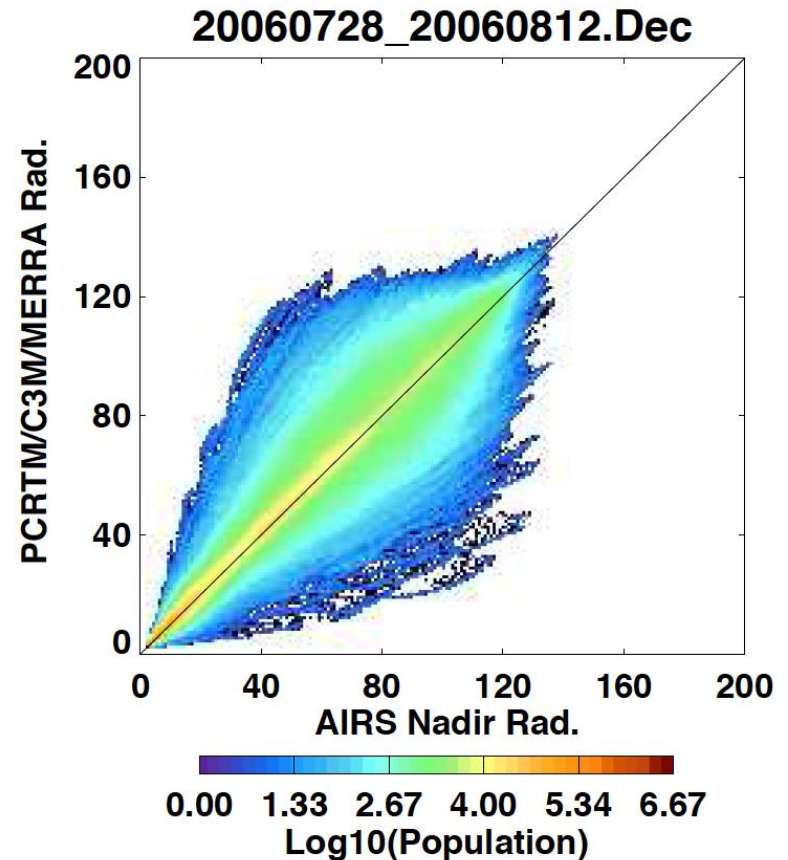


Modeled vs. Observed (AIRS) radiances



N= 22168893.

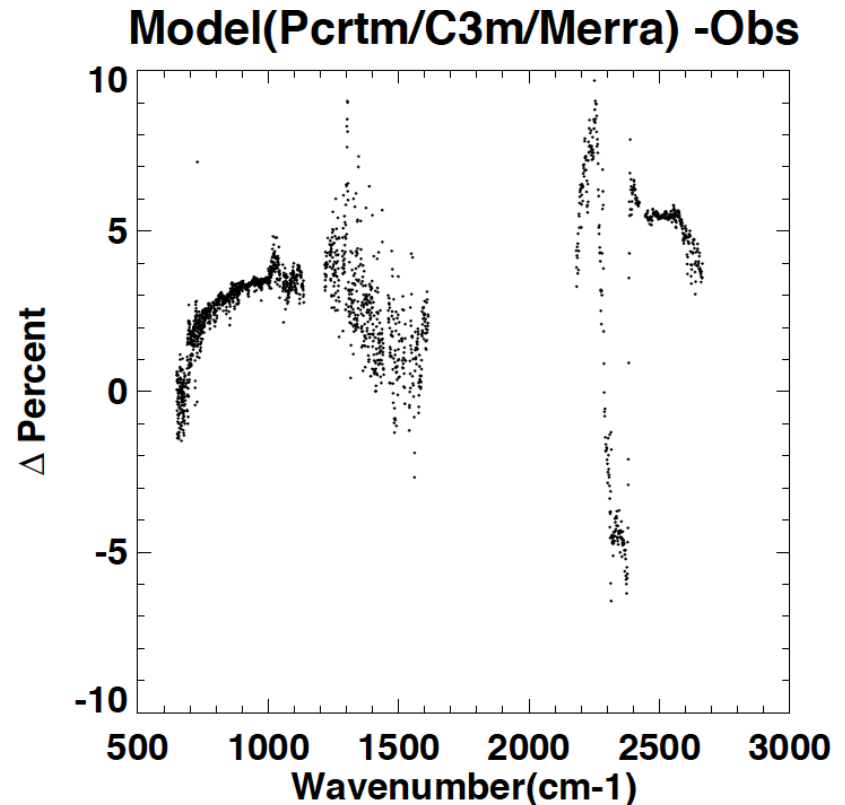
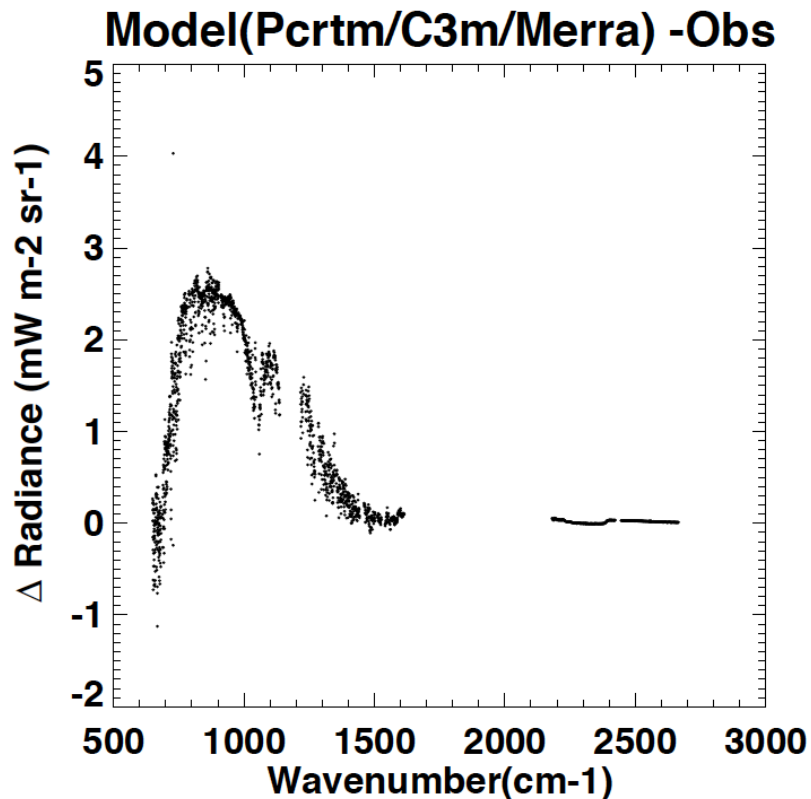
	Mean (StdDev)
AIRS Nadir Rad.	36.35(34.38)
PCRTM/C3M/MERRA Rad.	37.31(35.21)
Y-X	0.959(4.63)
RMS(	4.72).....



N= 22175136.

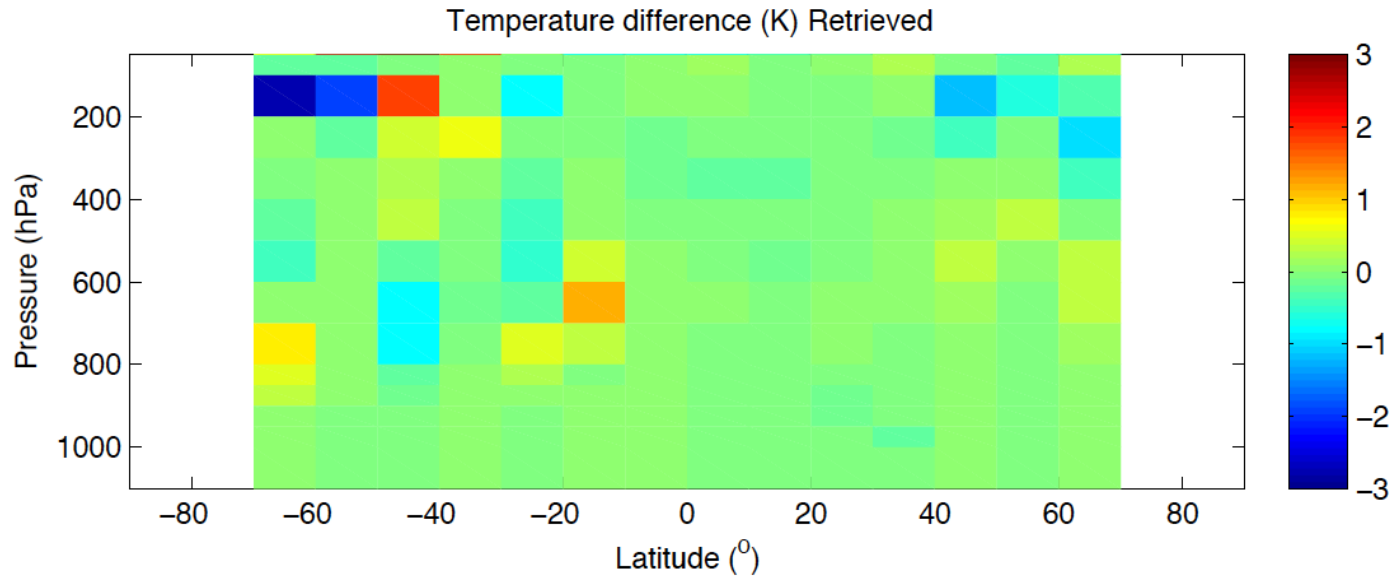
	Mean (StdDev)
AIRS Nadir Rad.	36.36(34.38)
PCRTM/C3M/MERRA Rad.	37.29(35.06)
Y-X	0.929(7.48)
RMS(	7.54).....

Global mean spectral radiance difference

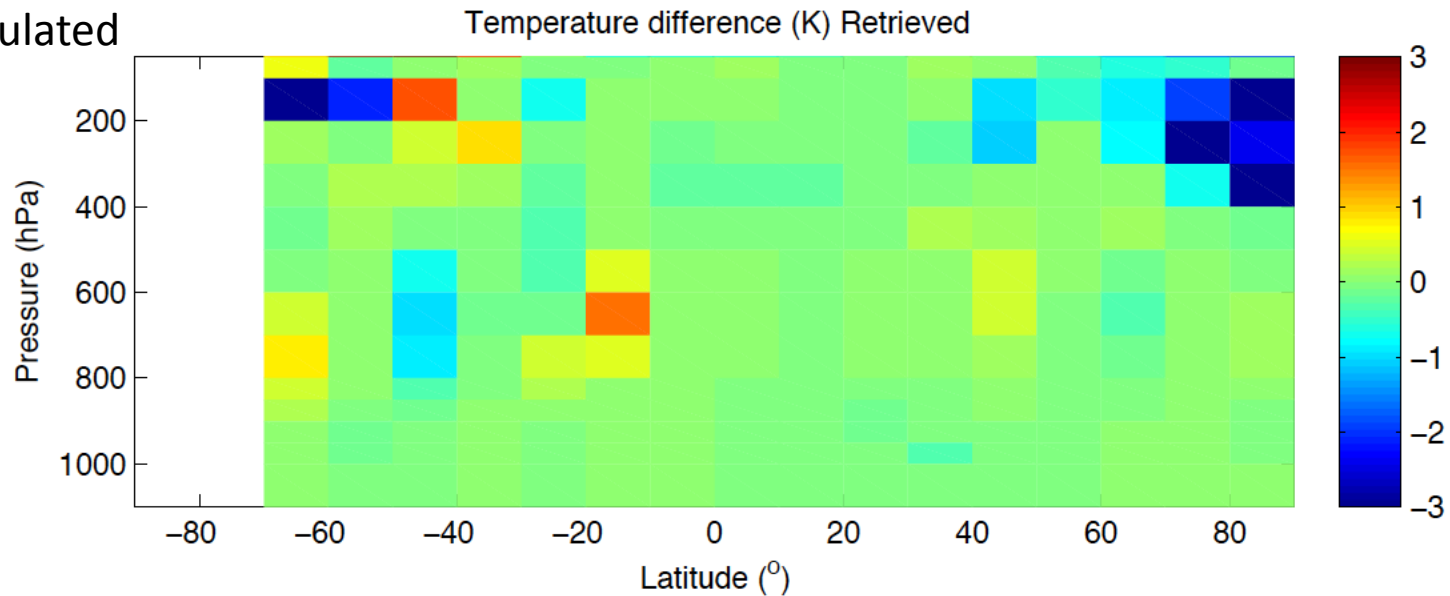


Retrieval with AIRS nadir view radiances: T

AIRS

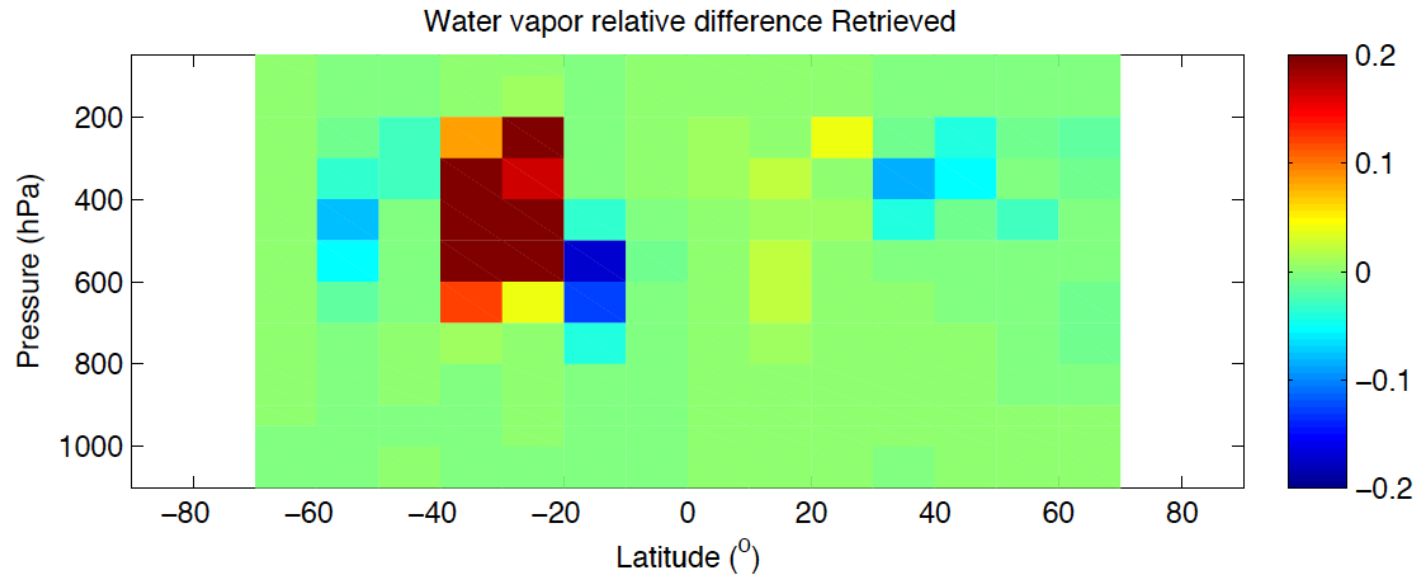


Simulated

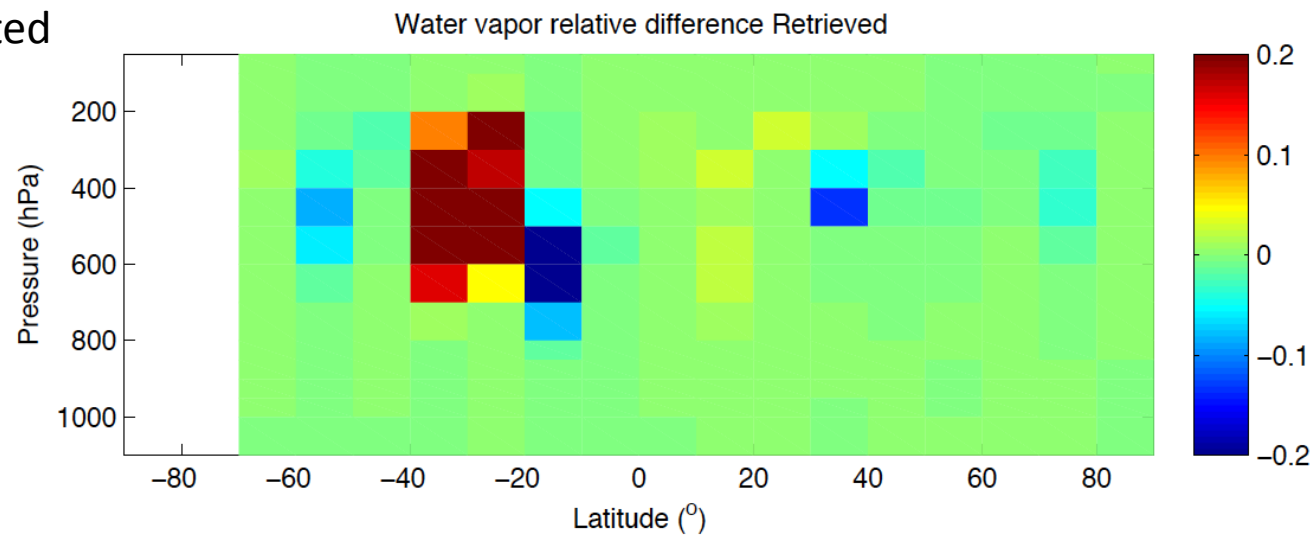


Retrieval with AIRS nadir view radiances: Q

AIRS

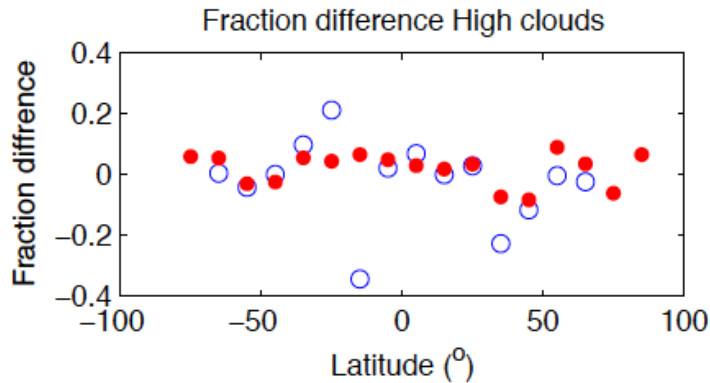


Simulated

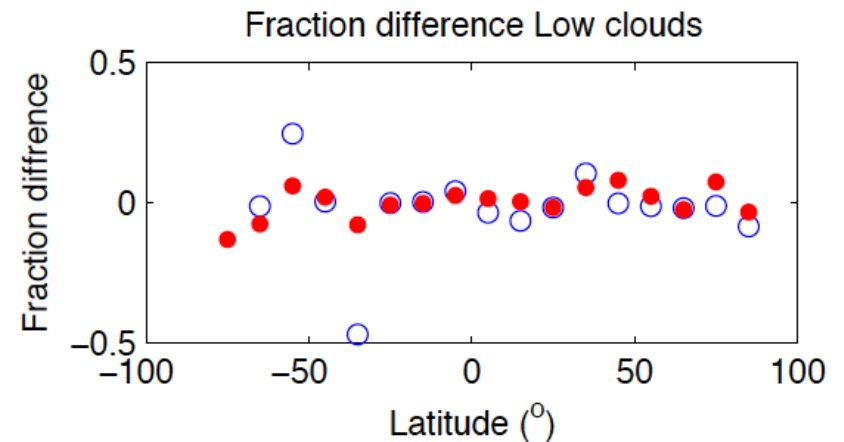
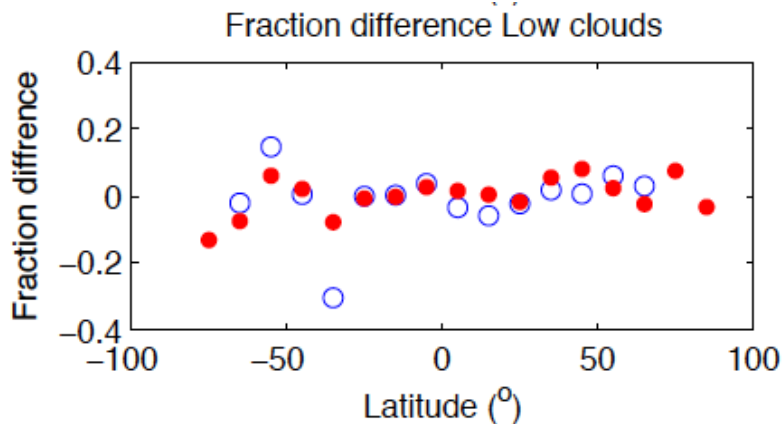
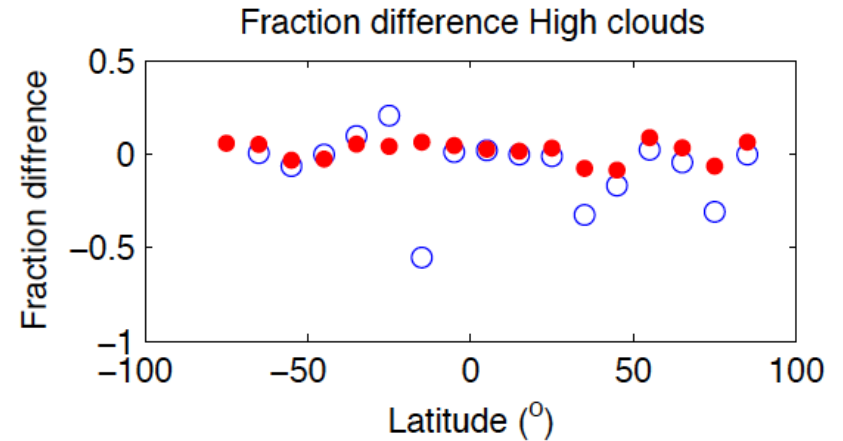


Low-level cloud fraction

AIRS



Simulated



Summary

- Retrieval of ΔT and ΔQ , with a high vertical resolution is demonstrated using two sets of 16 day 10° mean nadir view all-sky spectral radiance over ocean using the average-then-retrieve approach.
- 20 to 30% of zonal mean temperature and humidity change retrieval error is smaller than nadir view sampling error.
- Average-then-retrieve approach is also demonstrated with two sets of AIRS 16 day 10° zonal mean spectral radiances. Even though modeled spectral radiances are different from observed spectral radiances up to $\sim 20\%$ depending on wavenumbers, ΔT and ΔQ can be derived.
- Retrieval needs to be improved especially changes in cloud properties and humidity at 800 to 700 hPa levels.