MERRA-2/AIRS/MODIS Temperature/Humidity Comparisons

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Outline

- Clear Sky OLR and Surface LW Down sensitivity to temperature and humidity
- Skin temperature comparison
  - AIRS vs. MERRA2
- Surface air temperature comparison
- Upper tropospheric humidity comparison

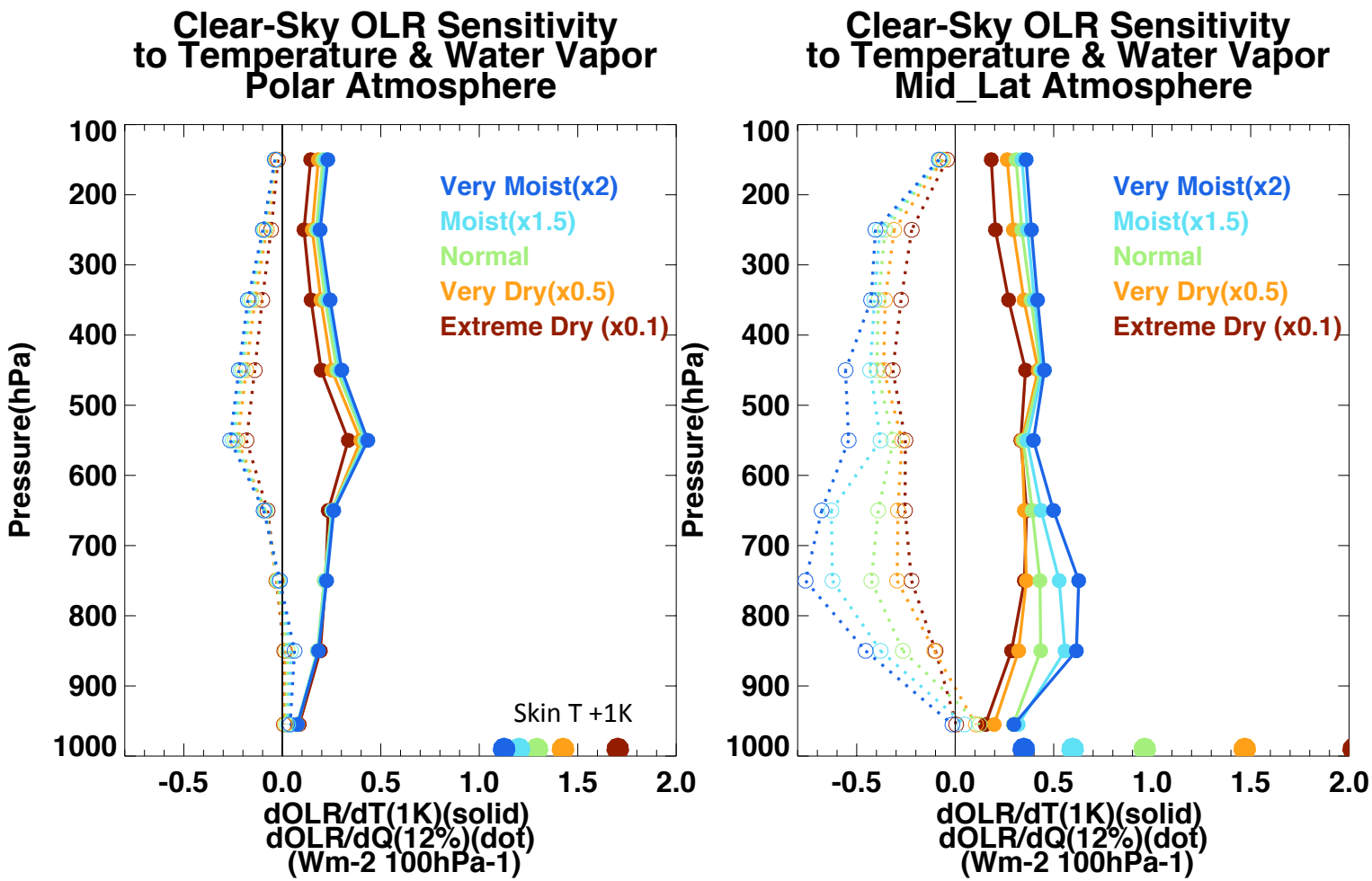
Clear Sky TOA and SFC Longwave Sensitivity to Water Vapor and Temperature Perturbations.

Clear Sky Outgoing Longwave Sensitivity

Fu-Liou code for a wide range of temperature and water vapor conditions.

For a 100hPa thick layer : ΔT 1.0 K -or- ΔQ -12% = 0.4 Wm^{-2} ΔClear Sky OLR

ΔT 2.5 K -or- ΔQ -30% = 1.0 Wm^{-2}

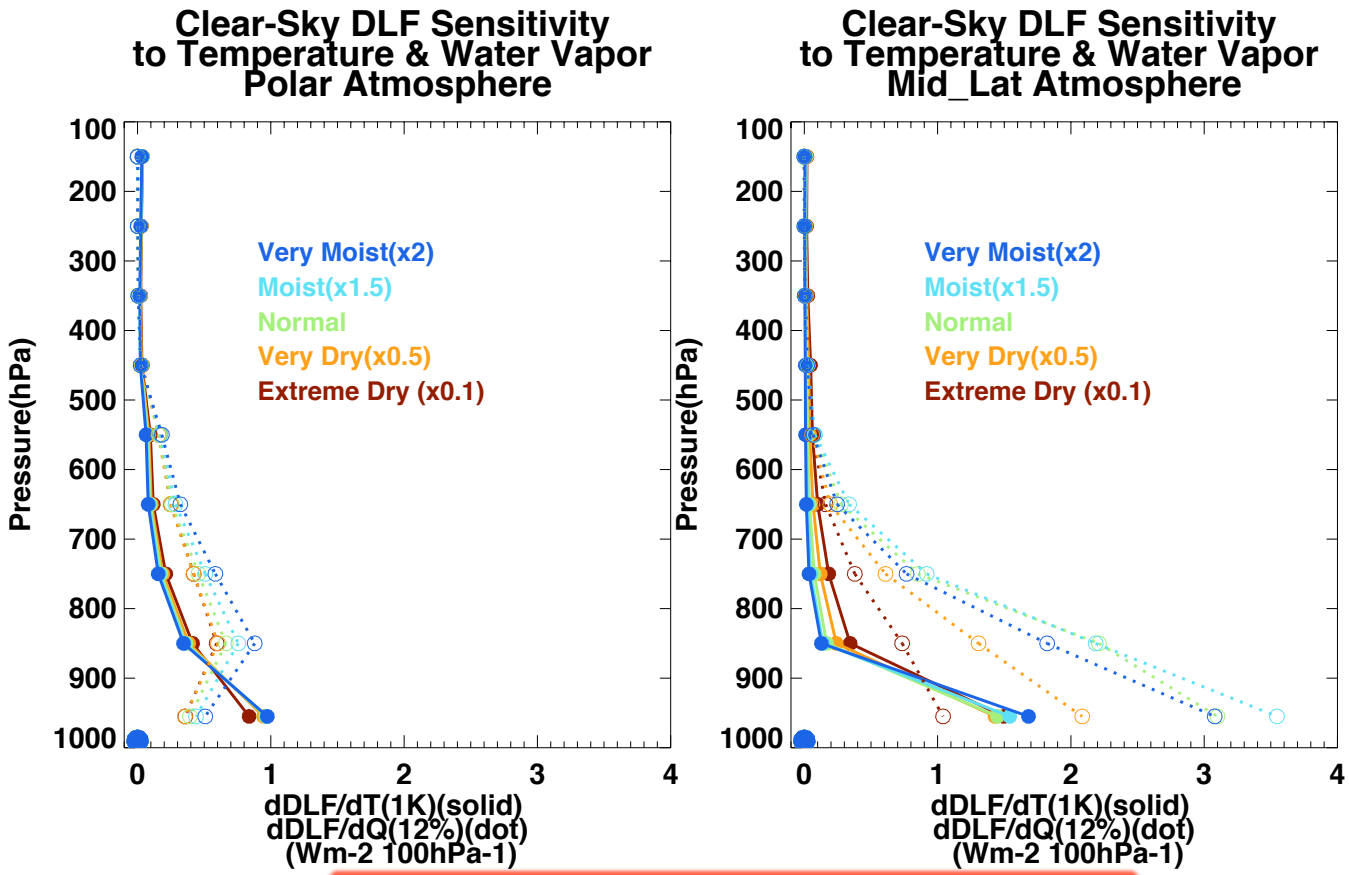


Clear Sky Surface Downward Longwave Sensitivity

Fu-Liou code for a wide range of temperature and water vapor conditions.

Clear DLF is most sensitive to lower troposphere T & Q , near surface has largest sensitivity.

Later we adopt Dilley & O'Brien parameterization of Clear DLF sensitivity which uses surface air temperature and total precipitable water differences.

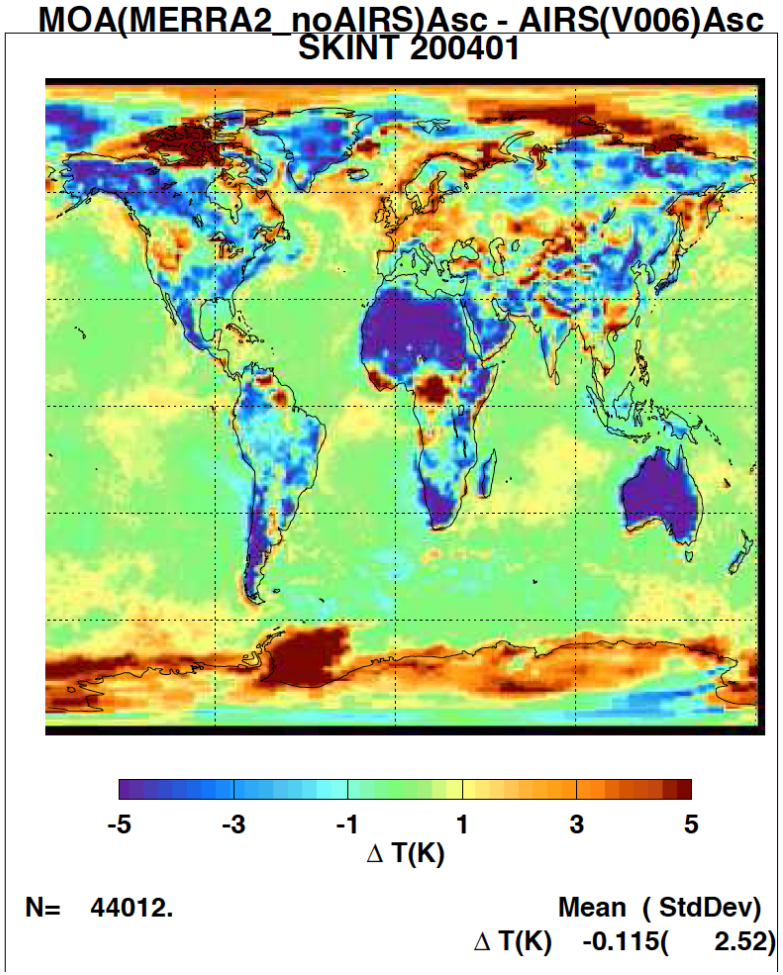


$$\Delta \mathrm{DLR} = 6\beta\left(\frac{T}{T_*}\right)^5\frac{\Delta T}{T_*} + \frac{1}{2}\gamma\left(\frac{w}{w_*}\right)^{-1/2}\frac{\Delta w}{w_*}. \qquad (2)$$

Method

- Selected month January and July 2004.
- Compare temperature, water vapor mixing ratio, and skin temperature
- Both MERRA2 with and without AIRS are compared with AIRS-retrieved values (AIRSX3STM.006 TQ joint)
- MERRA2 native temporal and spatial resolutions are converted to those used as inputs to CERES products (MOA) (6 hourly T and Q profiles, 1 hourly skin T).
- Select an hour box that has AIRS overpass [ascending (daytime) and descending (nighttime) separately]. [75-80NS use a 2 hr window, 80-85NS use a 3 hr window, and 85-90NS include all hours].

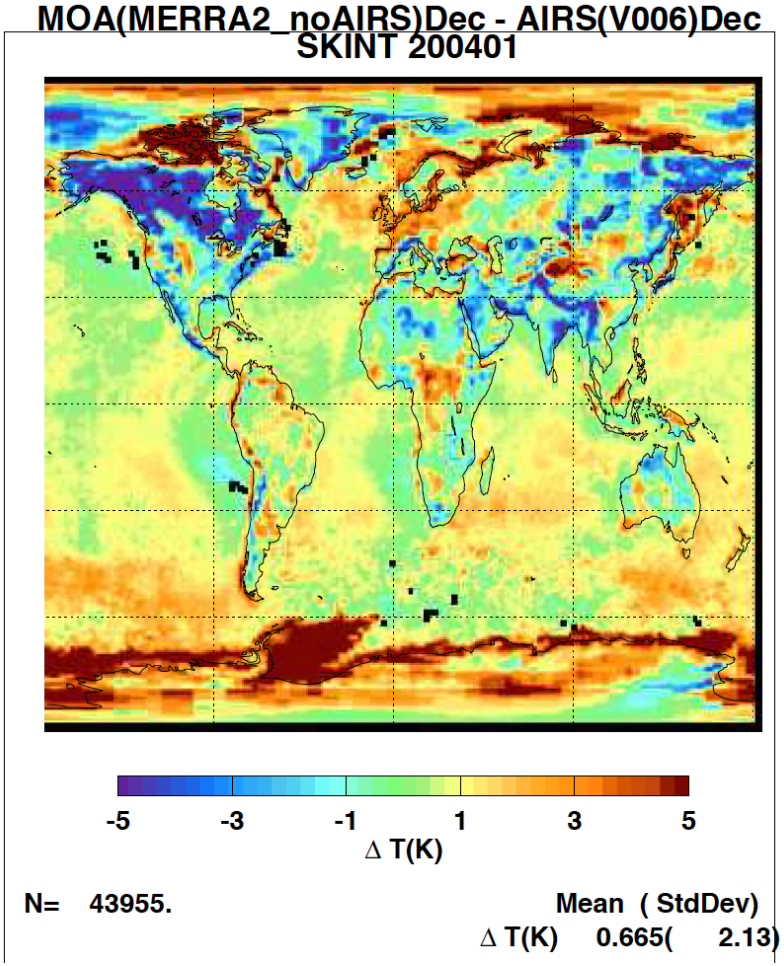
Skin temperature, daytime



Clear-sky sampling?

MERRA significantly underestimate skin temperature over the northern part of N. America, Greenland, Southern S. America, Africa (except central part), and Australia. MERRA agree with AIRS over ocean, except at high latitudes, where it tends to be too warm (Note that AIRS clear-sky sampling might contribute to the difference).

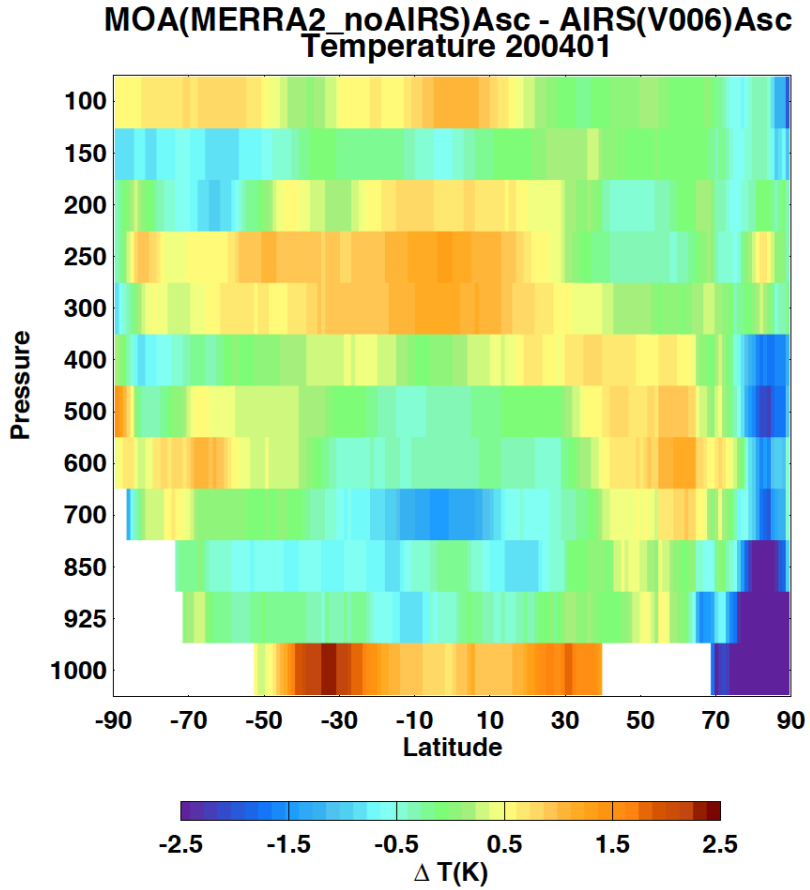
Skin temperature, nighttime



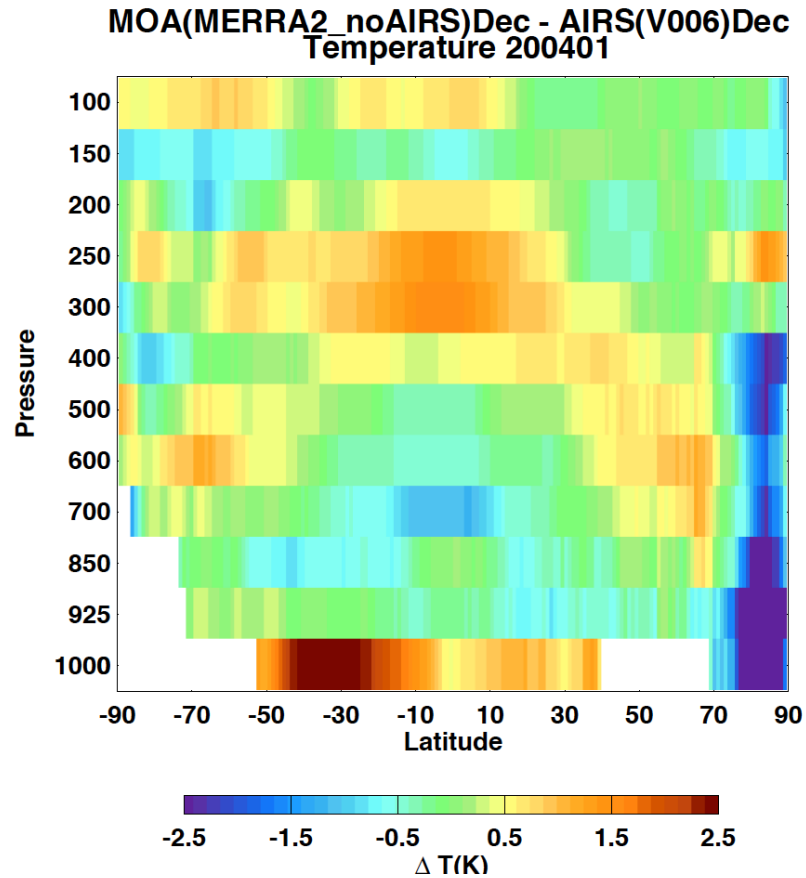
MERRA is generally closer to AIRS over land compared to the ascending node except over Northern part of N. America, where the negative bias is worse. Over ocean, MERRA overestimates skin temperature by 1-3 K.

Temperature

Daytime

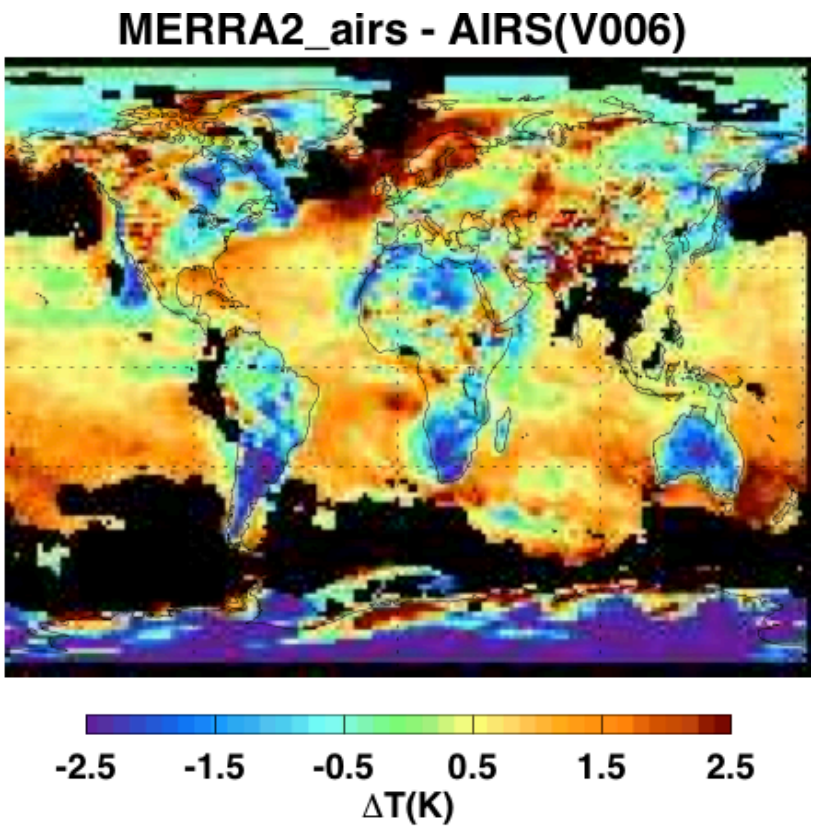


Nighttime



- MERRA upper troposphere is generally warmer compared to AIRS except in a layer near 150 hPa and above 300 hPa in the northern mid- and high-latitudes.
- MERRA near surface temperatures are too warm in the tropics and too cold for 70-90N. This might be due to AIRS sampling which is predominately clear-sky.

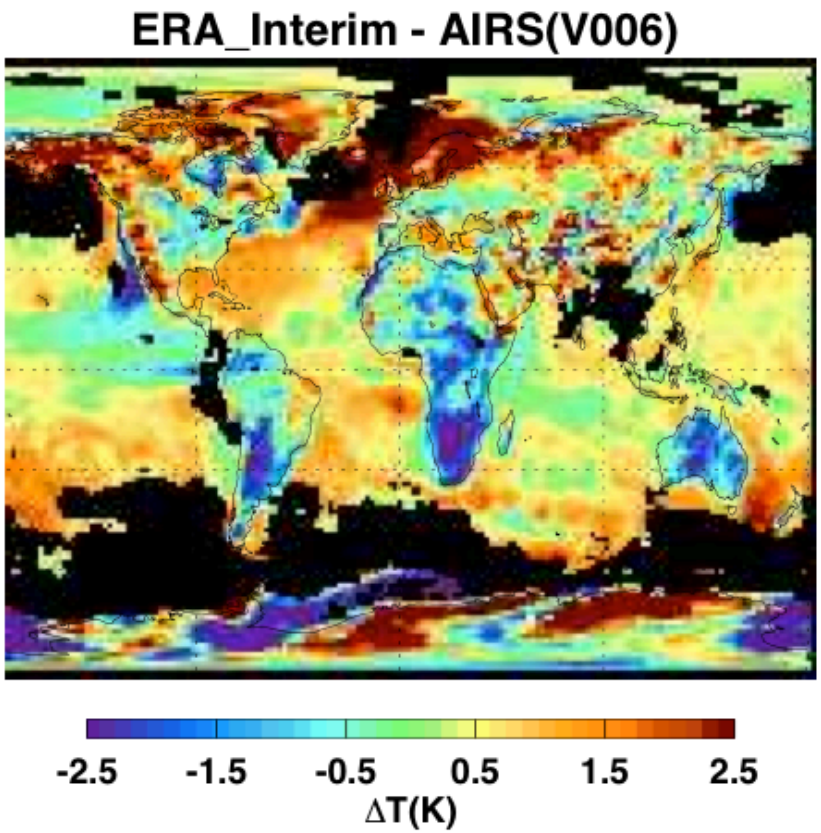
Surface air temperature



N= 37569.

Mean (StdDev)

ΔT(K) 0.450 (1.61)



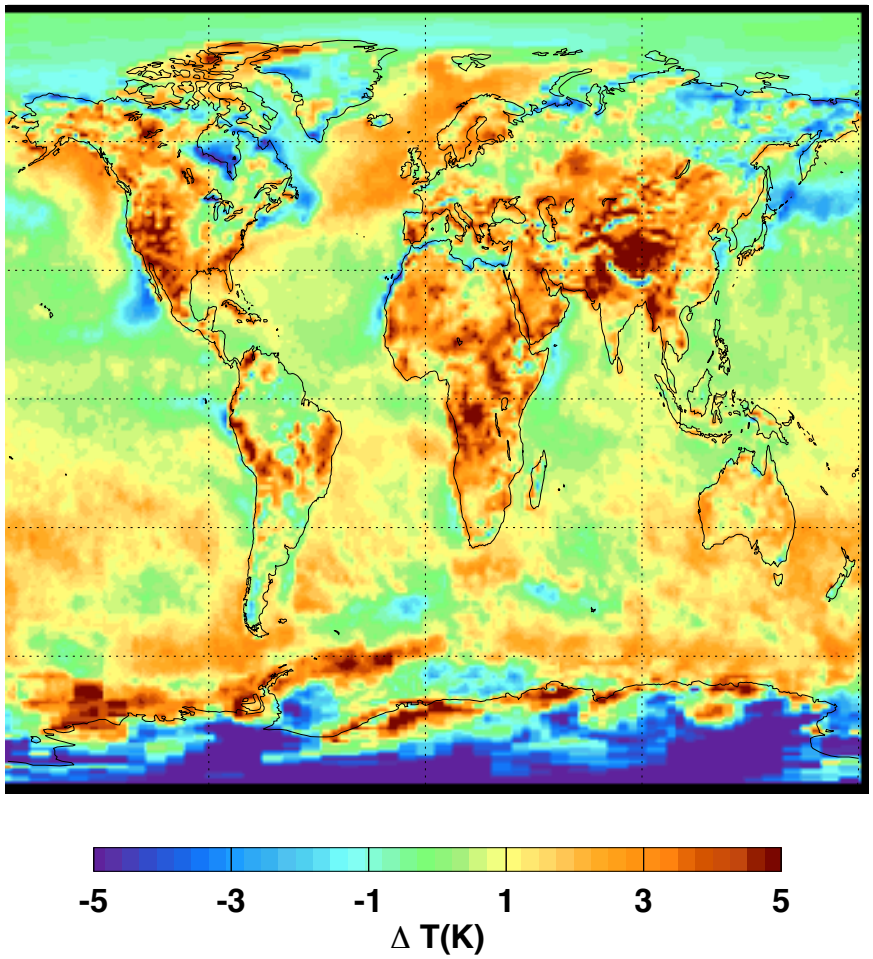
N= 37569.

Mean (StdDev)

ΔT(K) 0.376 (1.44)

Cloud fraction < 90%

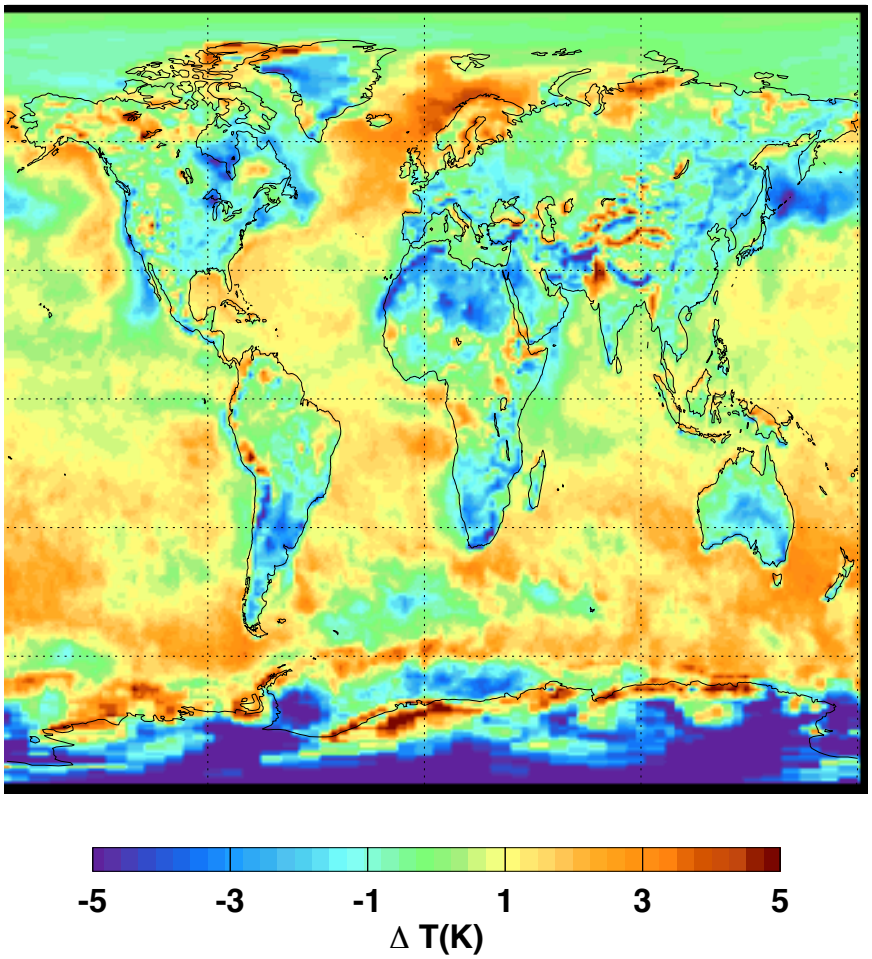
ASCENDING Orbit "DAY"
MERRA2_Airs – AIRX3STM
Surface Air Temperature



N= 44012.

Mean (StdDev)
Δ T(K) 0.952(1.78)

DESCENDING Orbit "NIGHT"
MERRA2_Airs – AIRX3STM
Surface Air Temperature

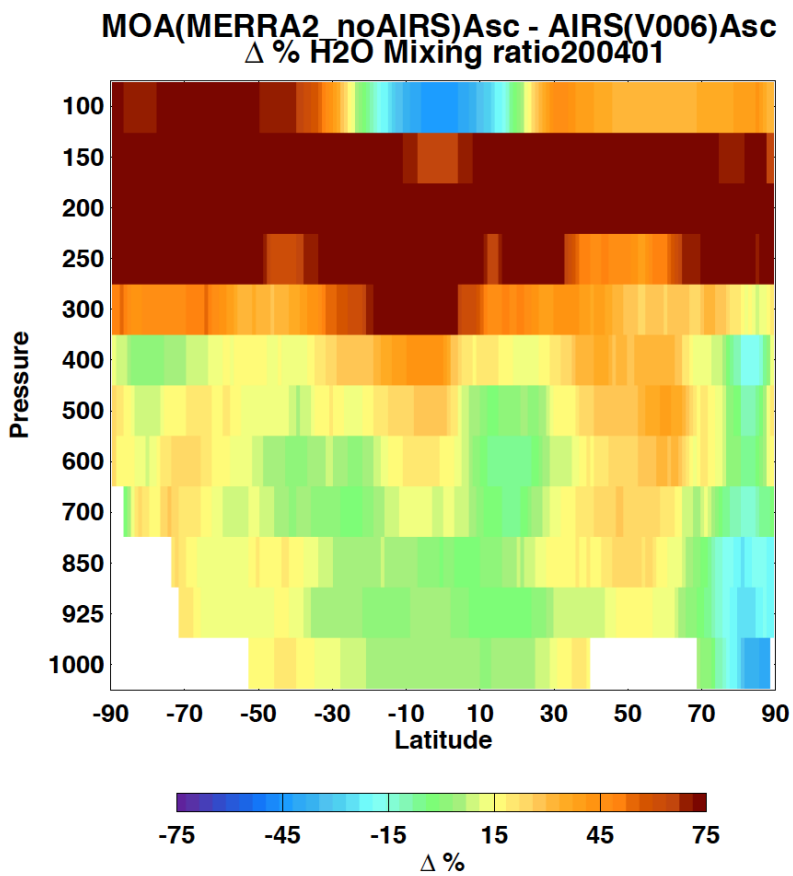


N= 44012.

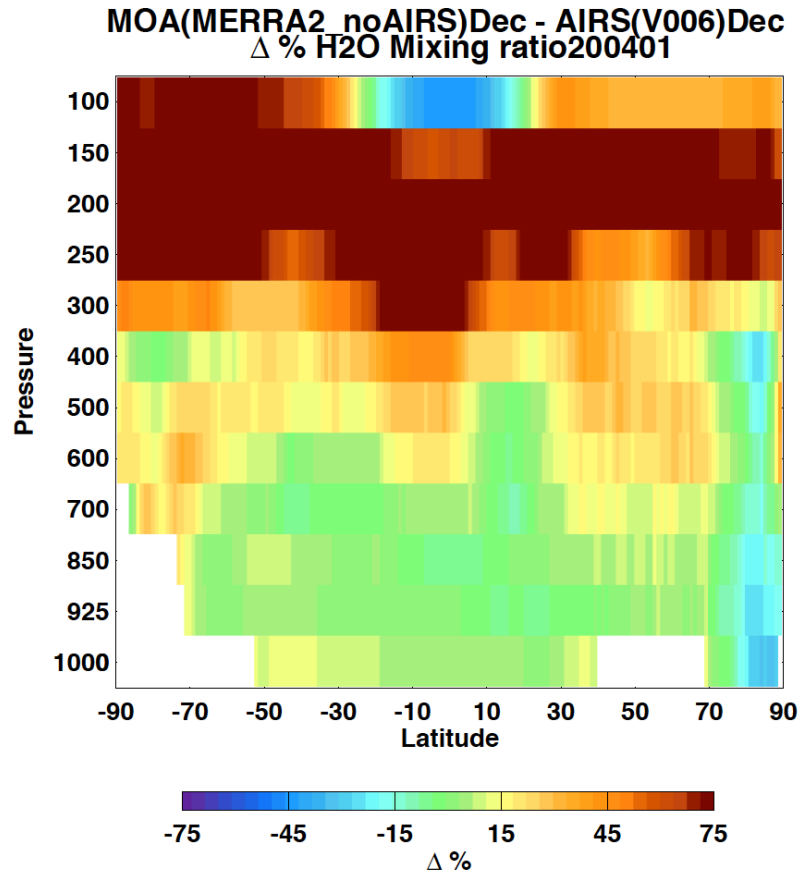
Mean (StdDev)
Δ T(K) 0.420(1.71)

H2O mixing ratio

Daytime

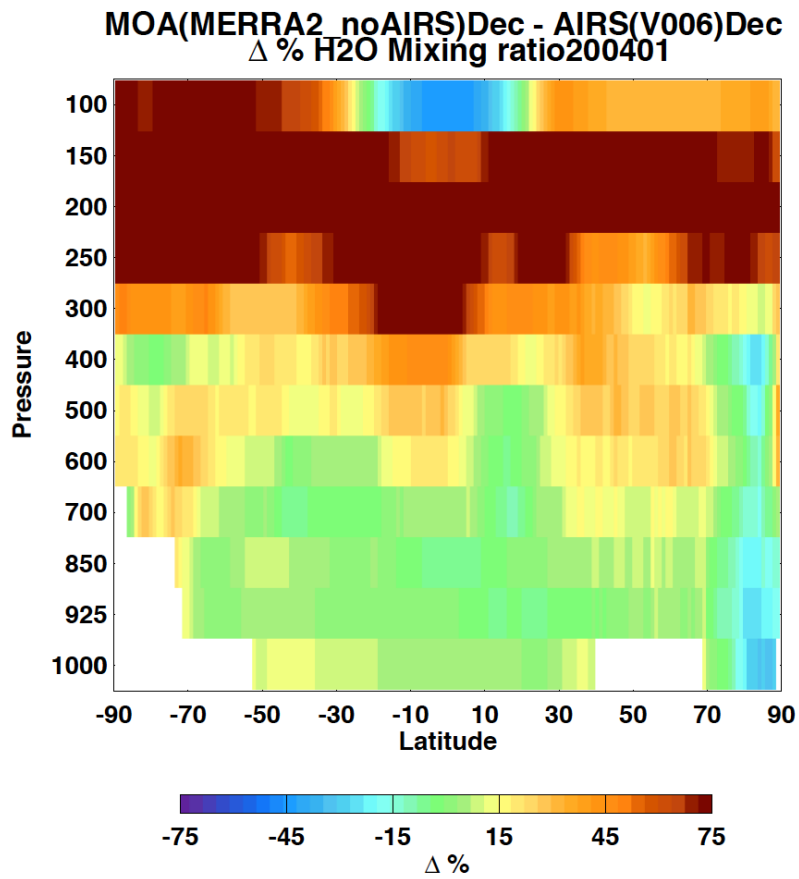


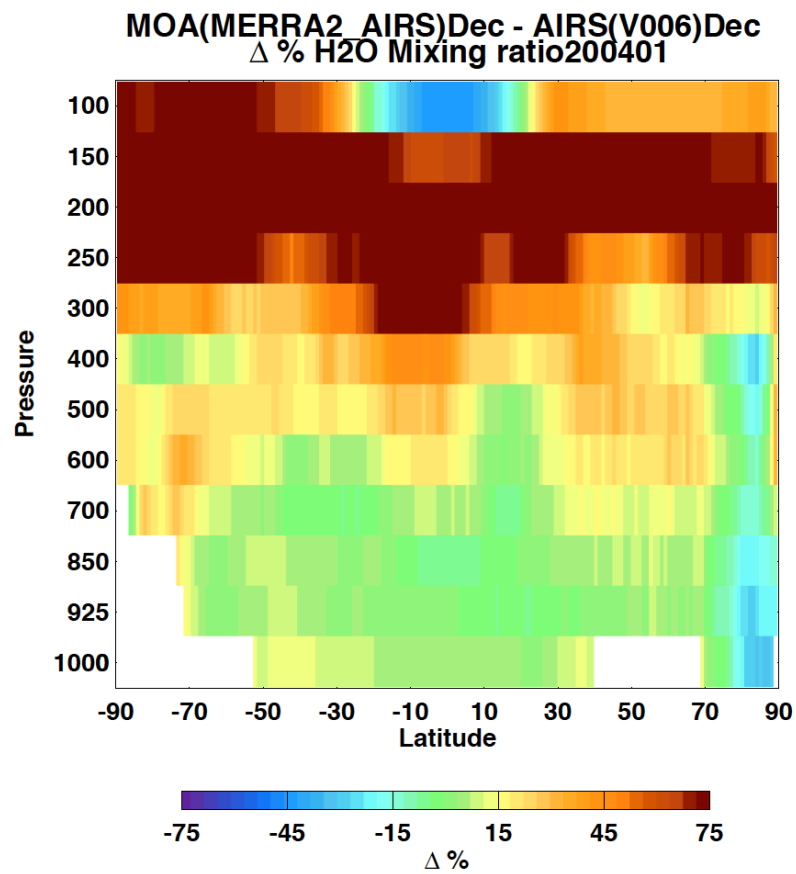
Nighttime

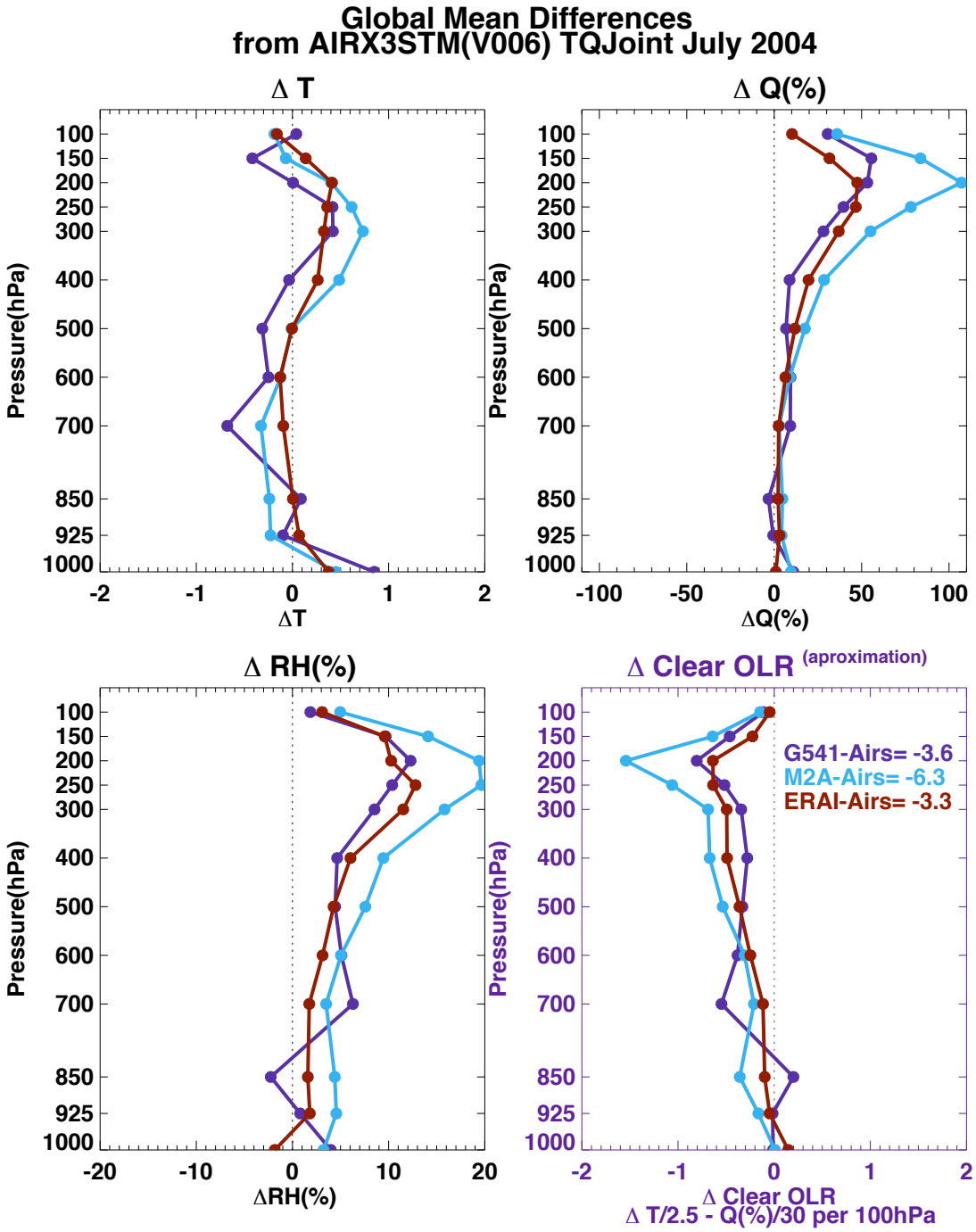


- MERRA upper atmosphere is much more moist compared to AIRS.

H2O mixing ratio, nighttime






Global Mean Differences
from AIRX3STM(V006) TQJoint July 2004
Δ T
Δ Q(%)
Δ RH(%)
Δ Clear OLR (aproximation)
Pressure(hPa)
100
150
200
250
300
400
500
600
700
850
925
1000
-2
-1
0
1
2
ΔT
-100
-50
0
50
100
ΔQ(%)
-20
-10
0
10
20
ΔRH(%)
G541-Airs= -3.6
M2A-Airs= -6.3
ERAI-Airs= -3.3
Δ Clear OLR
Δ T/2.5 - Q(%)/30 per 100hPa

Summary

- MERRA2 daytime skin temperature over land is generally colder (up to 5 K) than AIRS daytime skin temperature.
- MERRA2 upper troposphere (1 to 1.5 K) and boundary layer (up to 2.5K) temperature is warmer than AIRS over tropics and mid-latitude. MERRA2 troposphere temperature over the Arctic is colder (2 to 2.5 K in January) than AIRS.
- MERRA upper troposphere water vapor mixing ratio is larger (> 75%) than AIRS mixing ratio.
- These differences are larger than the AIRS target accuracy of temperature (1 K accuracy in 1-km layers) and water vapor (15% accuracy in 2 km layers) (Marshall et al. 2006 BAMS).