Inter-comparison and Assessment of AIRS Version-5 and Version-6 Temperature, Water Vapor, Surface Emissivity, and Cloud Products

Joel Susskind, John Blaisdell, Lena Iredell, Gyula Molnar

NASA GSFC Sounder Research Team (SRT)

AIRS Sounder Science Team Meeting
Greenbelt, MD

November 15, 2012

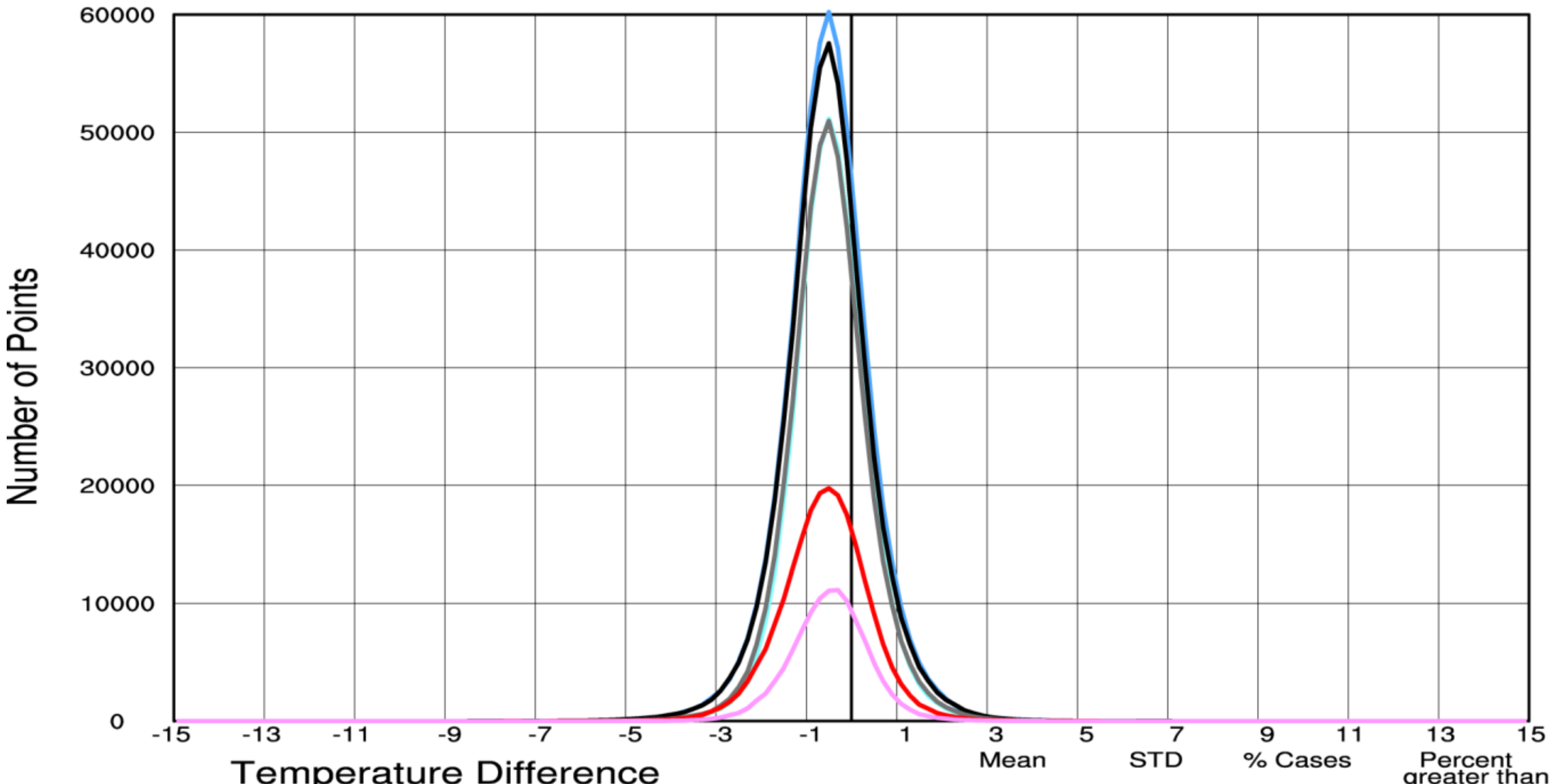
Comparisons of V6.07, V6.07 AO, and V5.0

Two types of evaluation

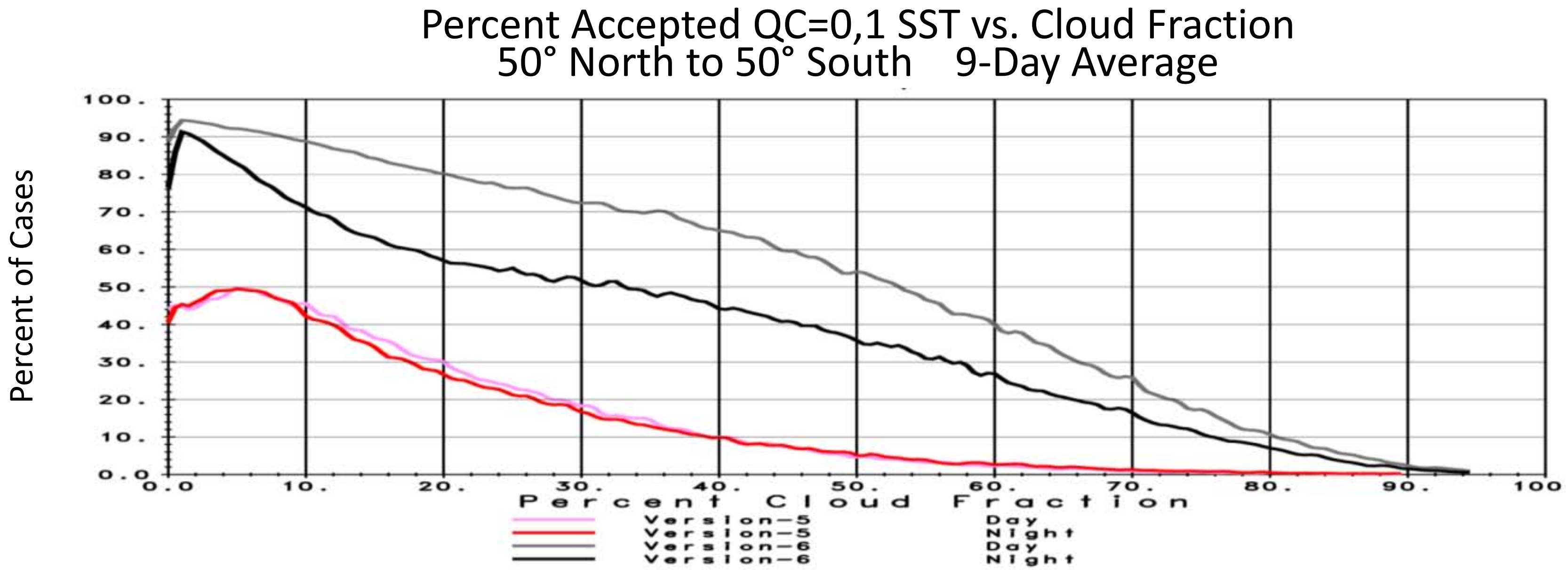
- 9 focus days, September 6, 2002 through September 14, 2012, validated against ECMWF truth
  - Evaluated T_s*, surface spectral emissivity ε_ν *, T(p)**, q(p)**
    - Mean* and trends** of yields, RMS differences, and biases

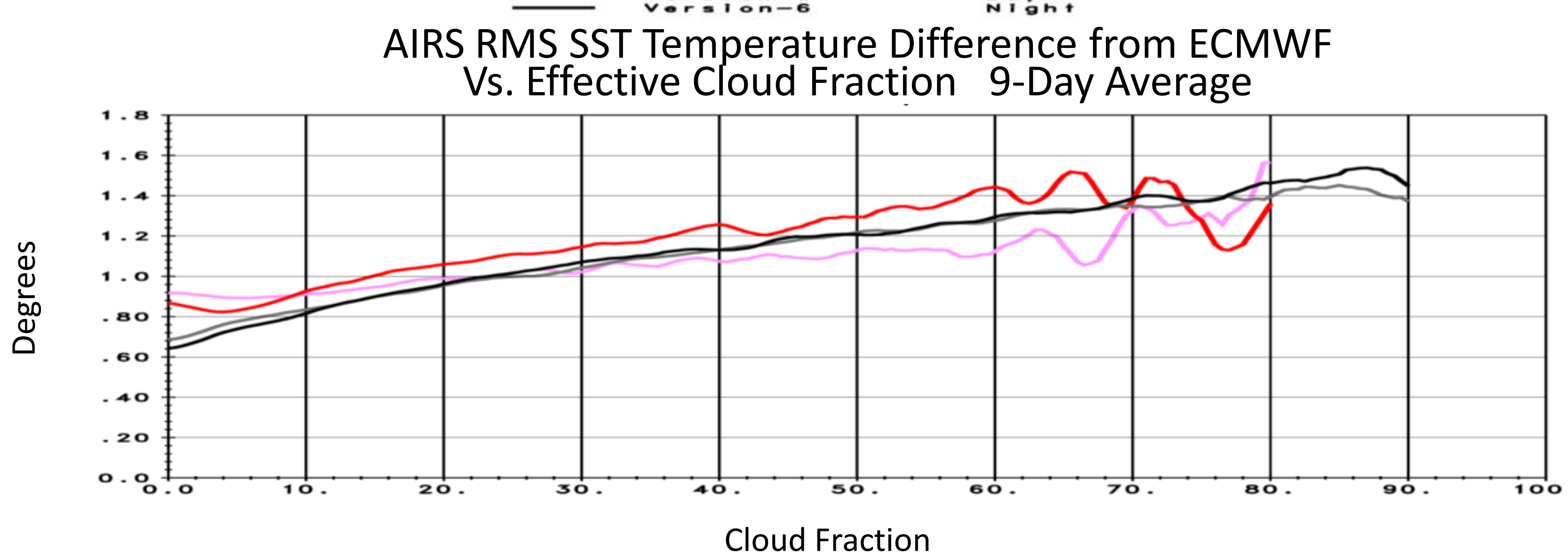
- 12 monthly means for 4 different months in 3 different years
  - January, April, July, October 2003, 2007, 2011
  - Evaluated biases as well as trends of V6.07 T_{500}, q_{500}, W_{TOT}, $\alpha\varepsilon$, OLR and OLR_{CLR} compared to V.5

Surface Skin Temperature Difference
9-Day Average Daytime and Nighttime combined
50 N to 50 S Non-Frozen Ocean



		Mean	STD	% Cases	Percent greater than |3| from mean
Version-6.07	QC=0,1	-0.32	0.95	53.39	1.40
Version-6.07	QC=0	-0.27	0.84	41.59	0.60
Version-6.07 Airs Only	QC=0,1	-0.34	0.95	50.18	1.49
Version-6.07 Airs Only	QC=0	-0.30	0.87	41.54	0.76
Version-5	QC=0,1	-0.58	0.63	20.19	1.25
Version-5	QC=0	-0.49	0.56	10.20	0.50

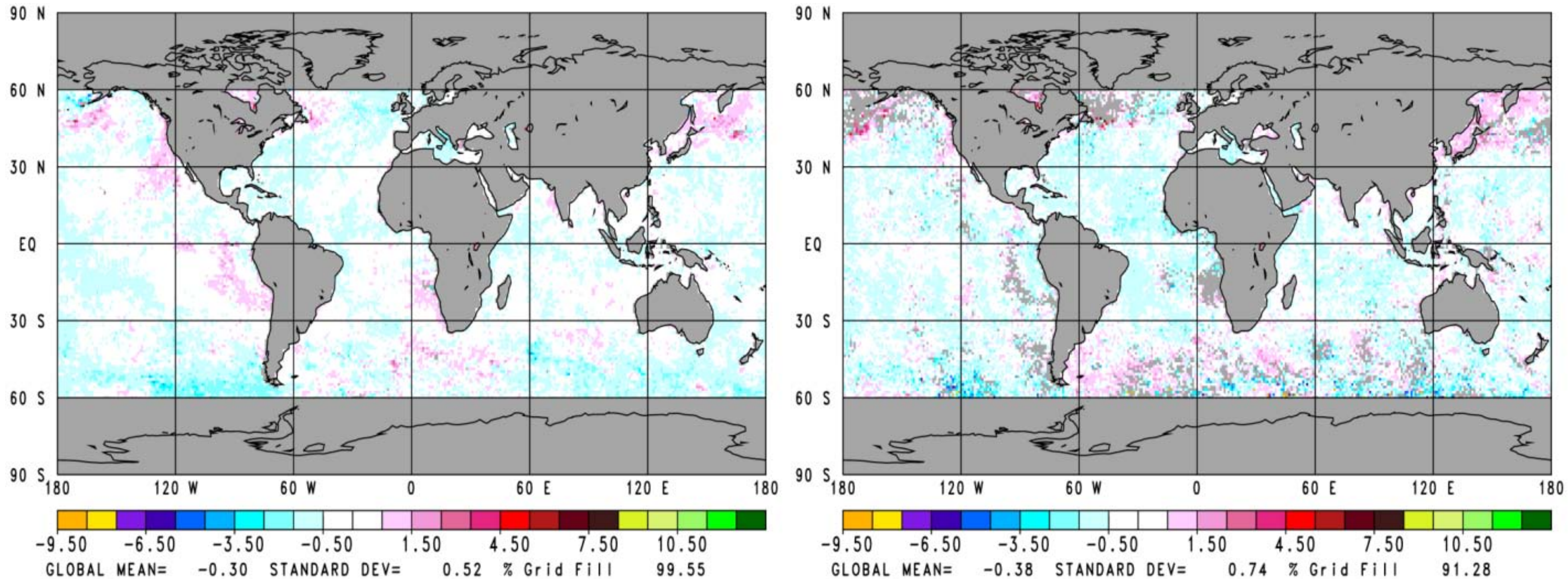




Version-6 accepts many more cases than Version-5, especially at moderate to high cloud fraction
RMS errors of both Version-5 and Version-6 SST grow slowly with increasing cloud fraction

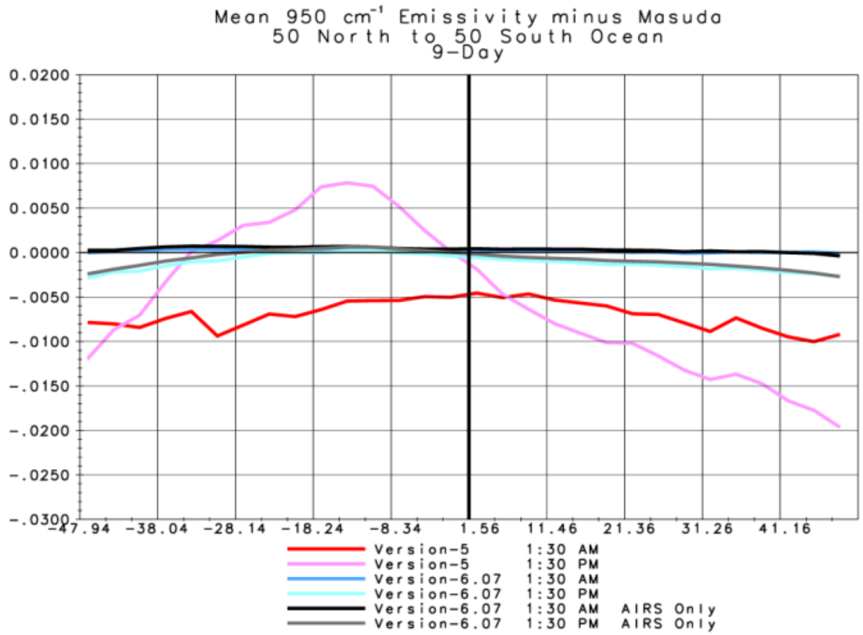
9-Day Surface Skin Temperature (K) Non-Frozen Ocean
Retrieved minus ECMWF AM/PM Average

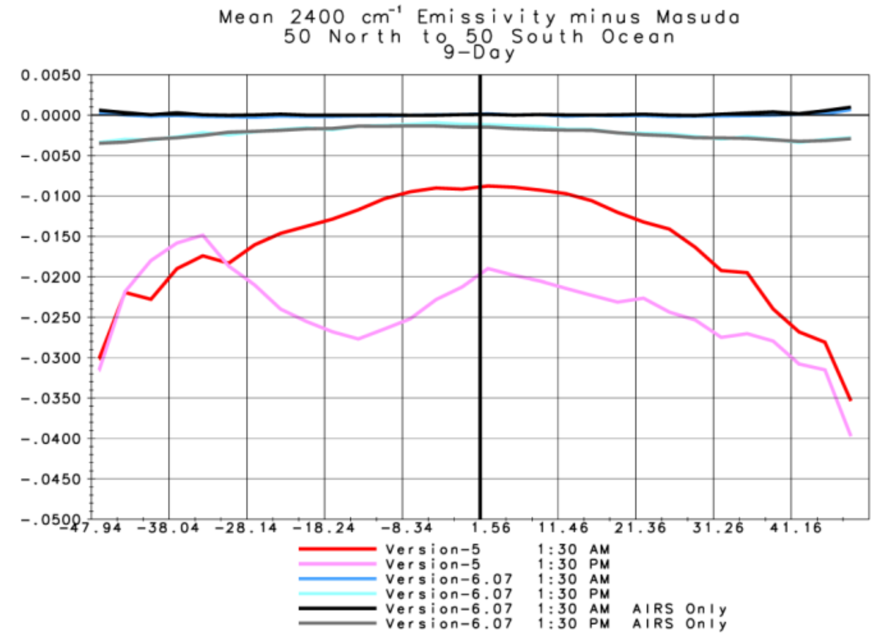
Version-6.07 Version-5

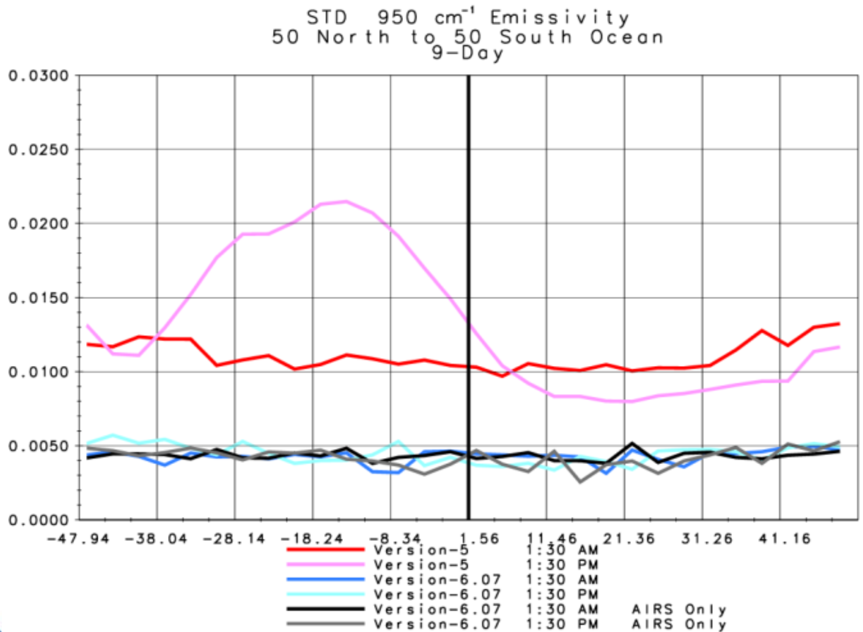


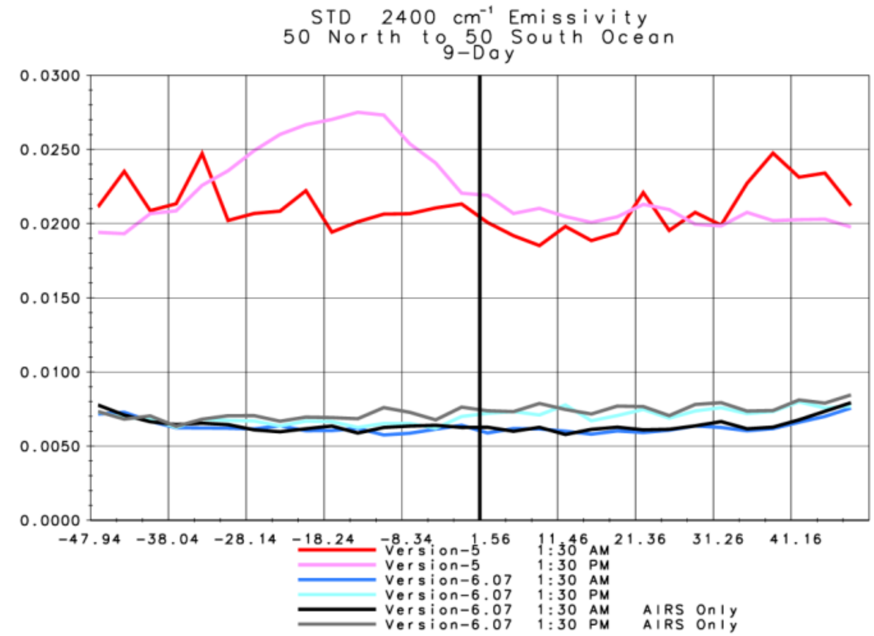
Version-6 Level-3 SST product has much better accuracy and spatial coverage than Version-5

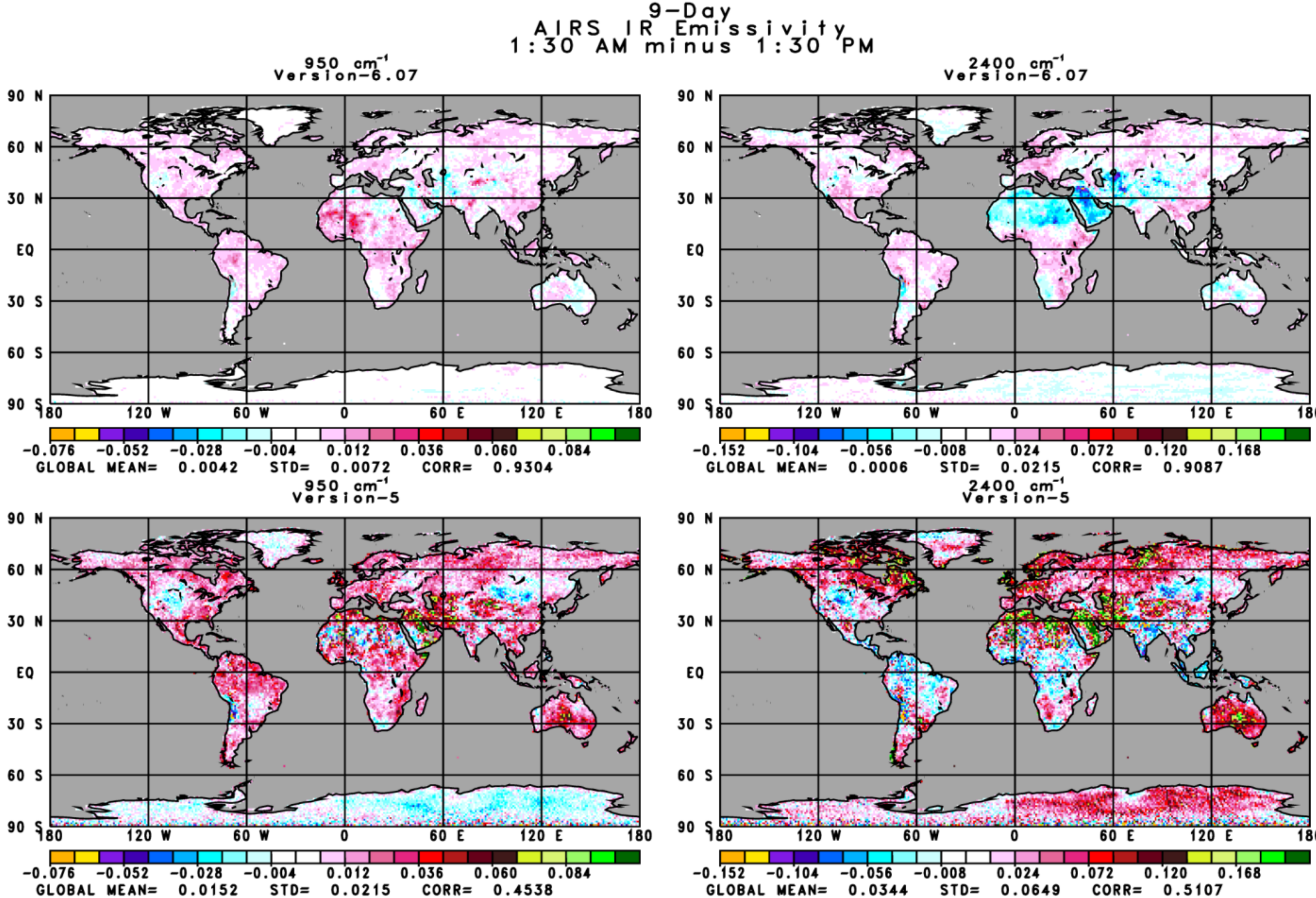
Ocean Surface Emissivity vs. Zenith Angle









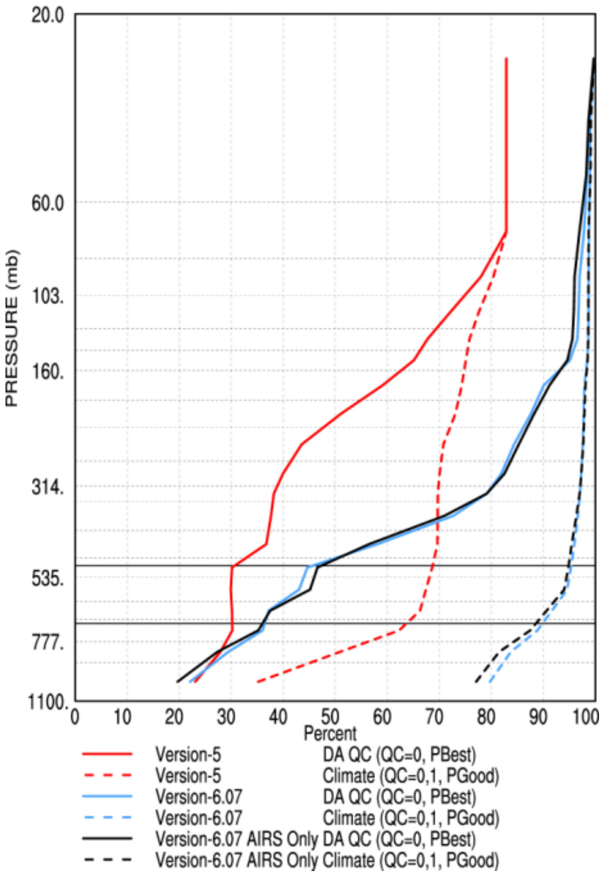


Day/night differences of land surface emissivity are much smaller in Version-6 compared to Version-5

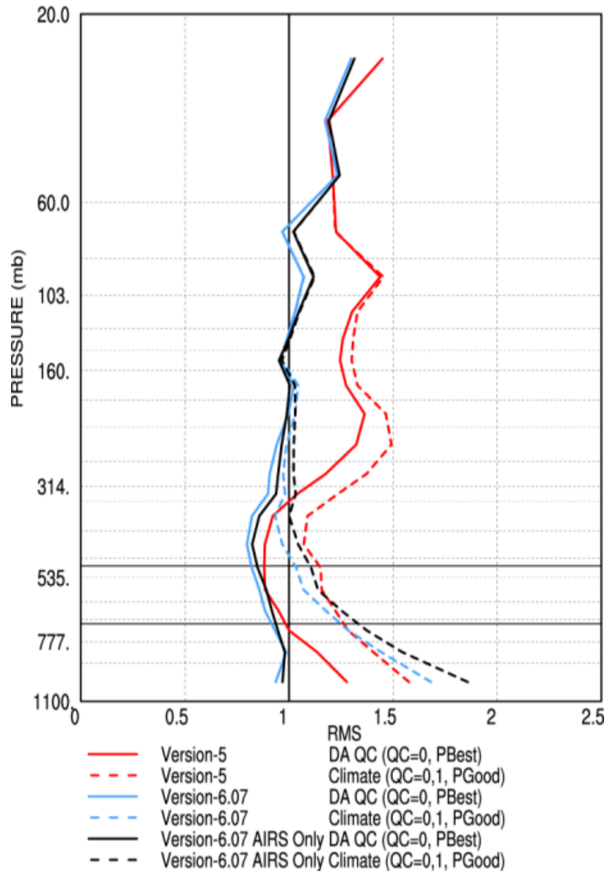
Global Temperature 9-Day

Statistics use their own QC

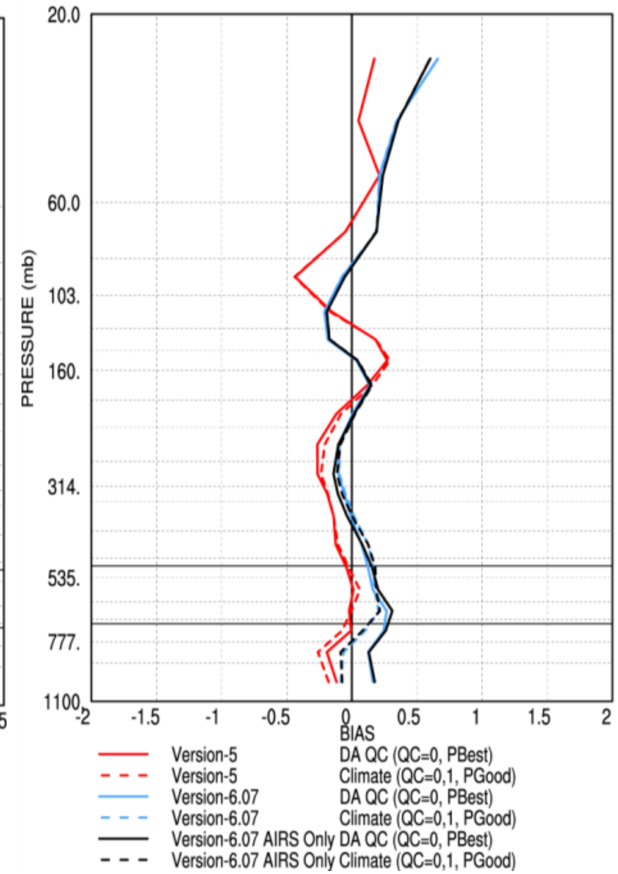
Percent of All Cases Accepted



Layer Mean RMS (°K) Differences from ECMWF

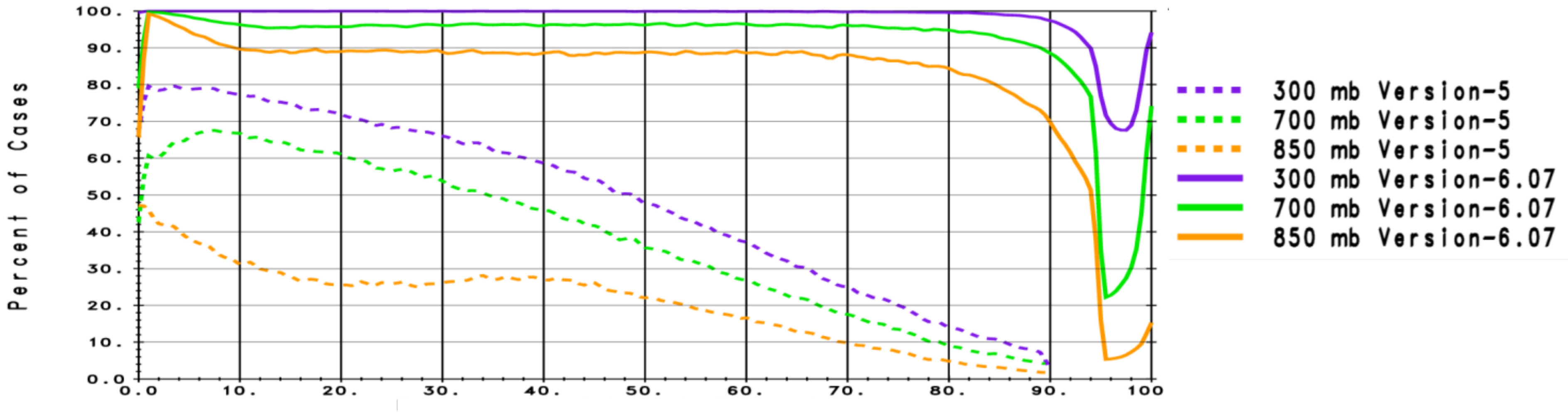


Layer Mean BIAS (°K) Differences from ECMWF

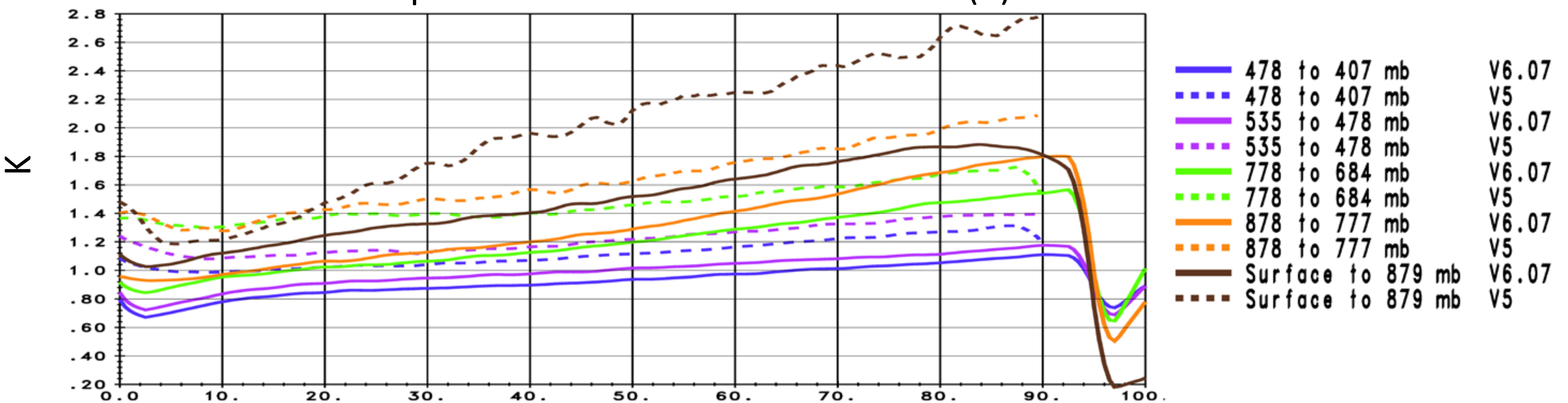


Version-6 T(p) retrievals with Data Assimilation QC have RMS errors ≤1K throughout troposphere
Version-6 T(p) retrievals with Climate QC have much greater yield than Version-5 with small biases
Differences between V6.07 and V6.07 AO are small

QC=0,1 9-Day Average % Accepted vs. Cloud Fraction

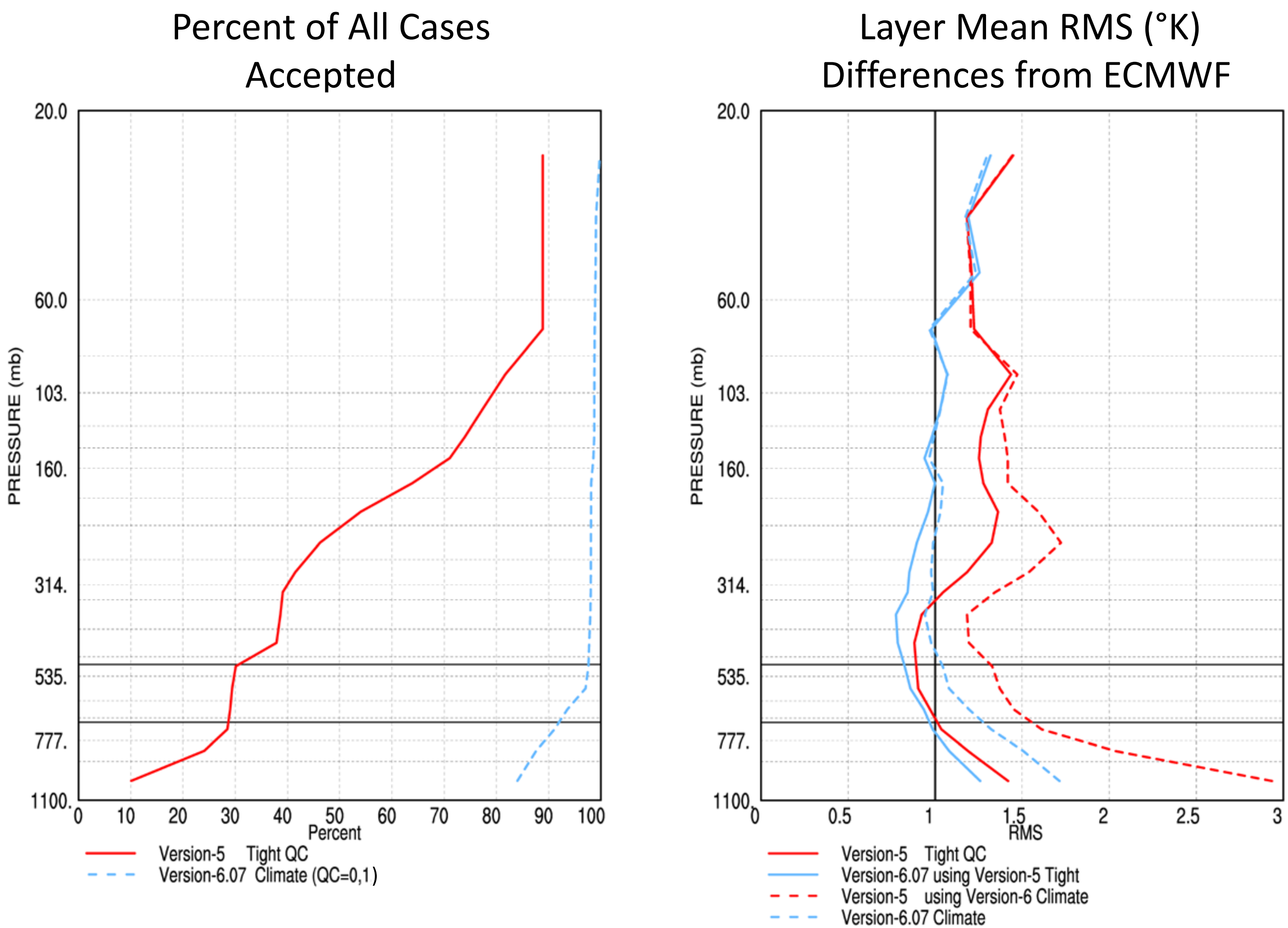


RMS Temperature Difference from ECMWF (K)



Version-6 errors are smaller than Version-5, and Version-6 yields are higher than Version-5, especially at larger cloud fractions

Global Temperature 9-Day
Two Common Ensembles



9-Day Mean Statistics Tropospheric Temperature Metric (TTM) and Boundary Layer Metric (BLM)

Cases in Common Using the Version-5 Tight Ensemble

	Global		Land ±50˚		Ocean ±50˚		Poleward of 50˚N		Poleward of 50˚S	
	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM
Version-5	1.14	1.54	1.22	1.78	1.06	1.21	1.18	1.74	1.43	2.01
Version-6.07	0.94	1.35	0.94	1.49	0.86	1.00	0.98	1.54	1.28	1.95

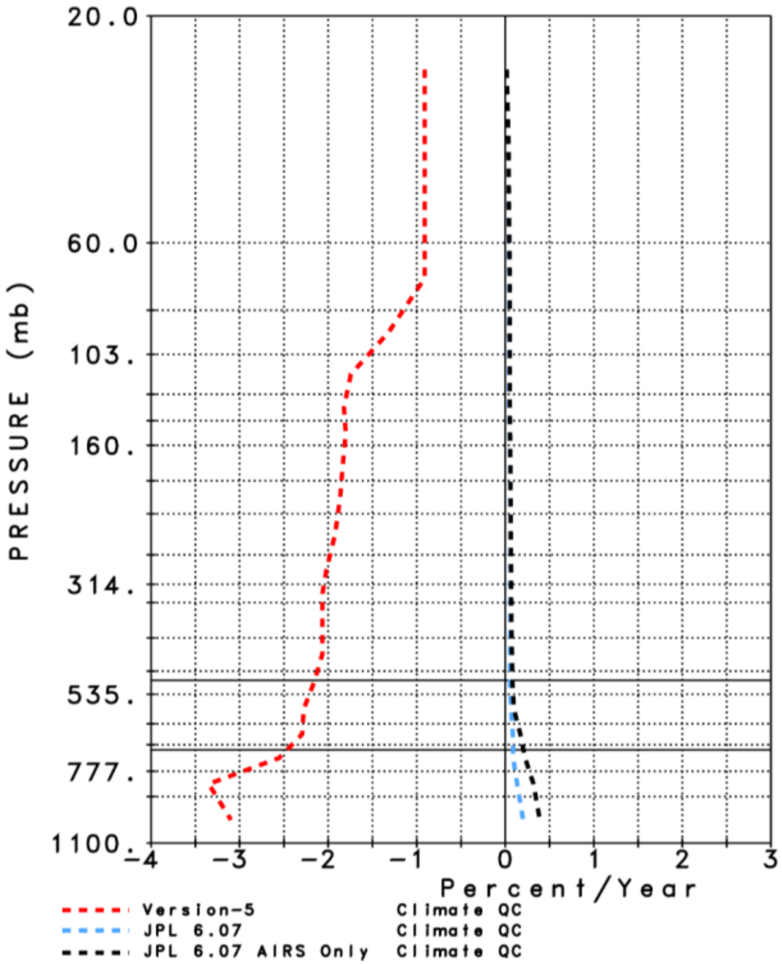
Cases in Common Using the Version-6.07 Climate Ensemble

	Global		Land ±50˚		Ocean ±50˚		Poleward of 50˚N		Poleward of 50˚S	
	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM	TTM	BLM
Version-5	1.56	2.84	1.75	2.92	1.43	2.70	1.51	2.95	1.70	2.96
Version-6.07	1.11	1.69	1.05	1.72	1.02	1.35	1.11	1.92	1.33	2.09

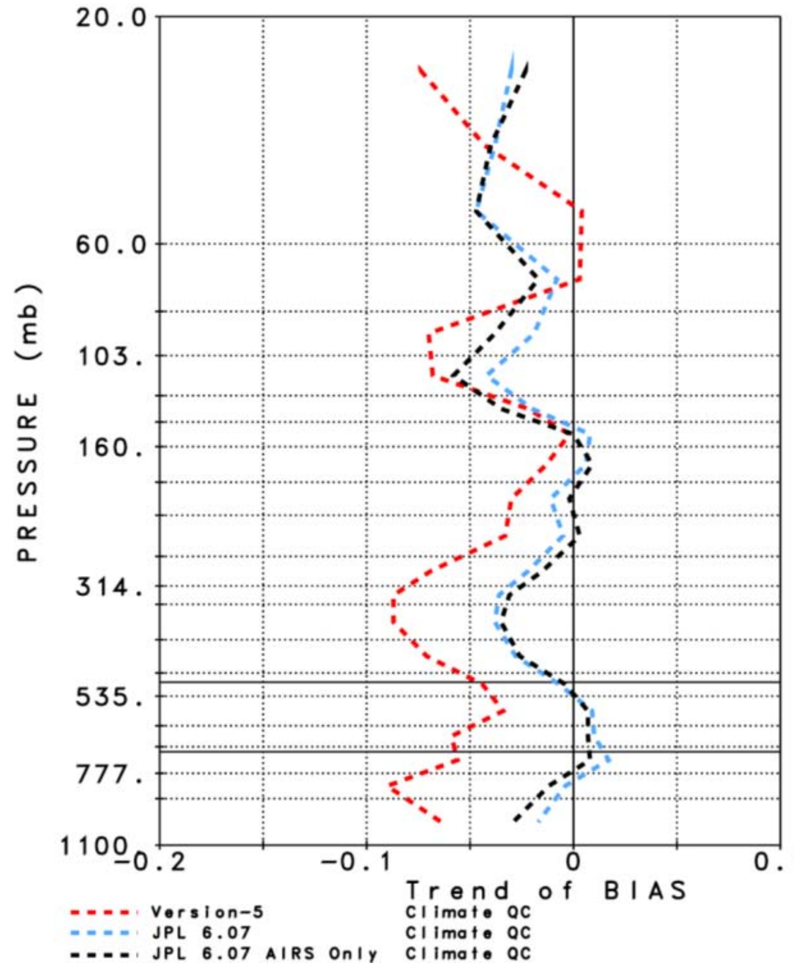
TTM is the average T(p) RMS difference from ECMWF over all 1 km layers from surface to 100 mb
BLM is the average T(p) RMS difference from ECMWF over the lowest 6 0.25 km layers
All Version-6 metrics are much better than Version-5, especially for the difficult climate ensemble

Global Temperature Trends 9-Day

Percent of All Cases
Accepted



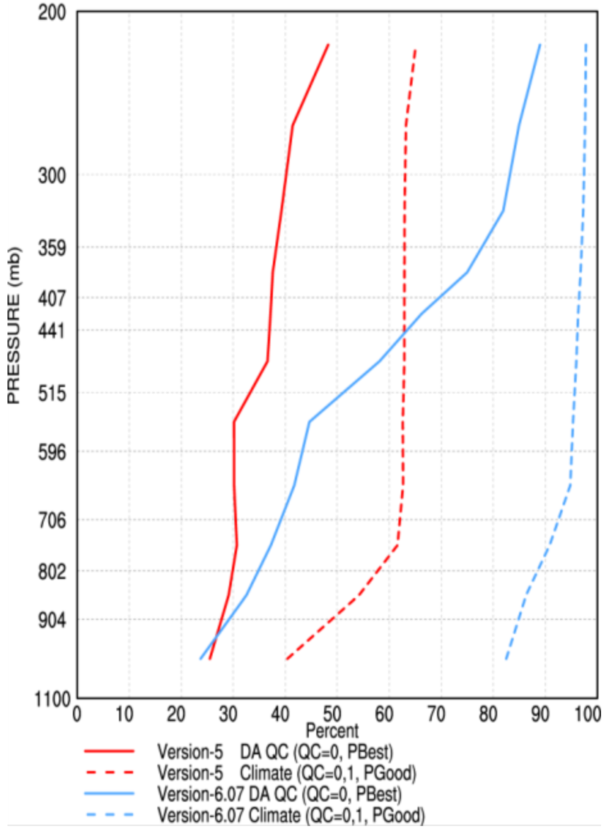
Layer Mean BIAS (°K)
Differences from ECMWF



Version-5 had significant negative yield and tropospheric T(p) bias trends
These are significantly improved on in Version-6 and Version-6 AO

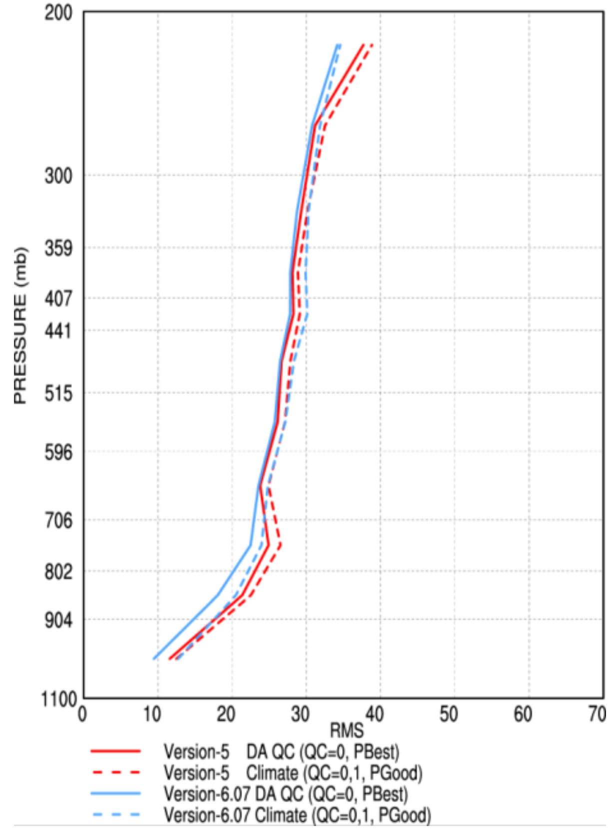
Global Water Vapor 9-Day
Statistics use their own QC

Percent Yield



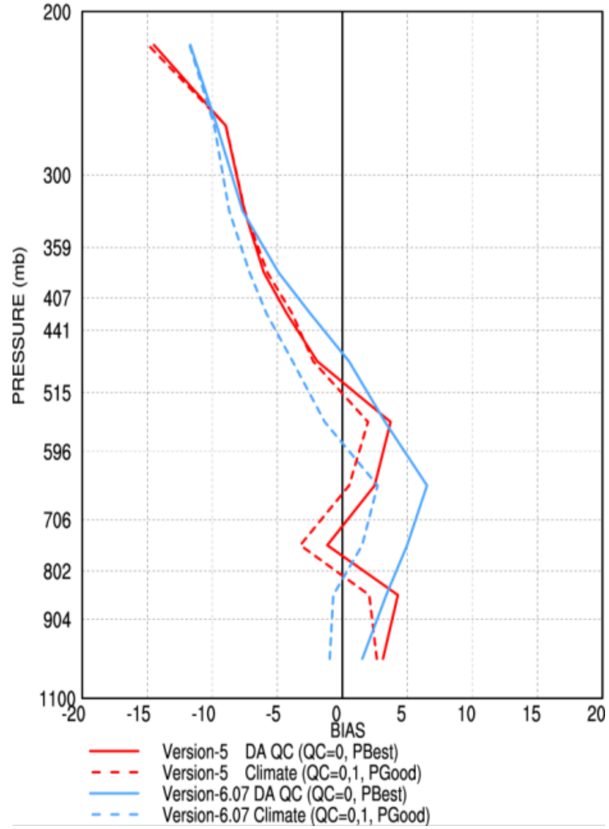
1 Km Layer Mean Precipitable Water

RMS % Differences from ECMWF



1 Km Layer Mean Precipitable Water

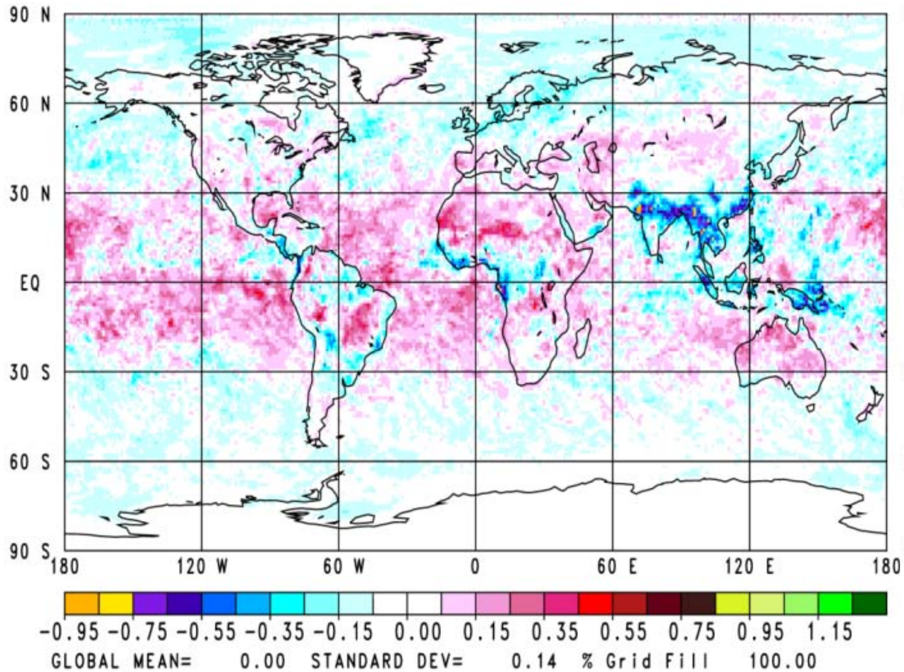
BIAS % Differences from ECMWF

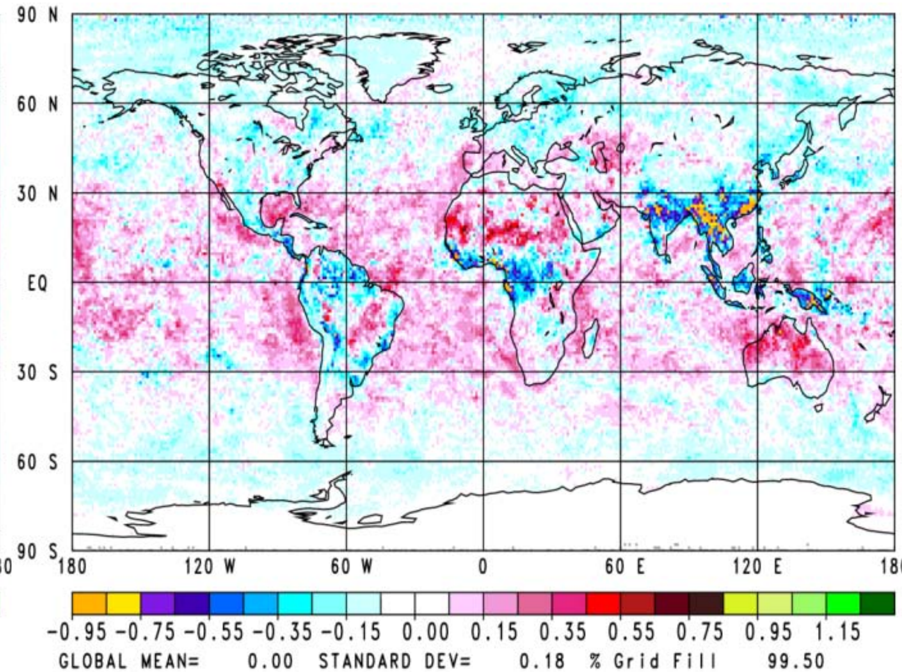


Version-6 has higher yield than Version-5 and performs better in the lower troposphere

9-Day Surface Total Precipitable Water (cm)
Retrieved minus ECMWF AM/PM Average

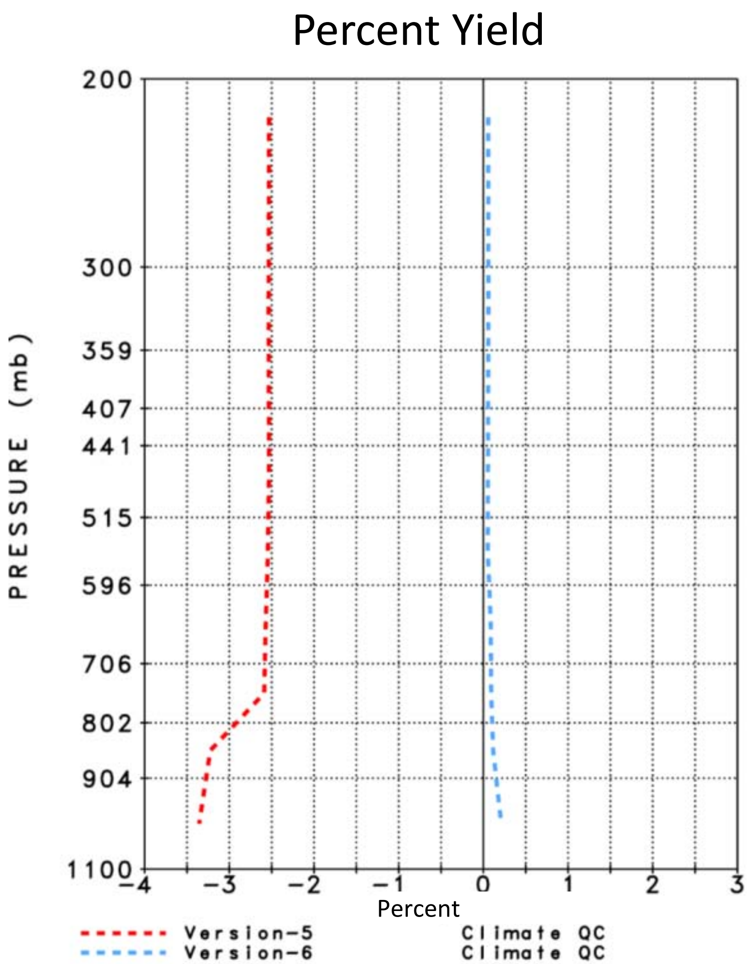
Version-6.07 Version-5

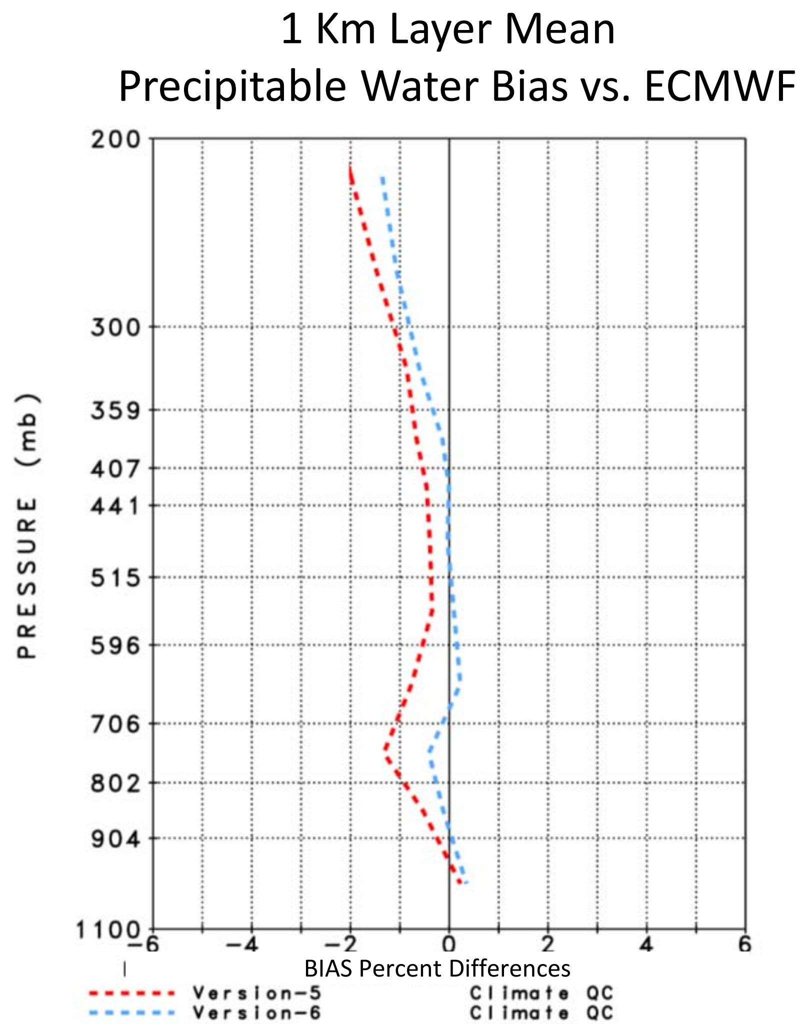




Version-6 Level-3 total precipitable water is more accurate than Version-5

Global Water Vapor Trends (%/yr) 9-Day
Statistics use their own Climate QC





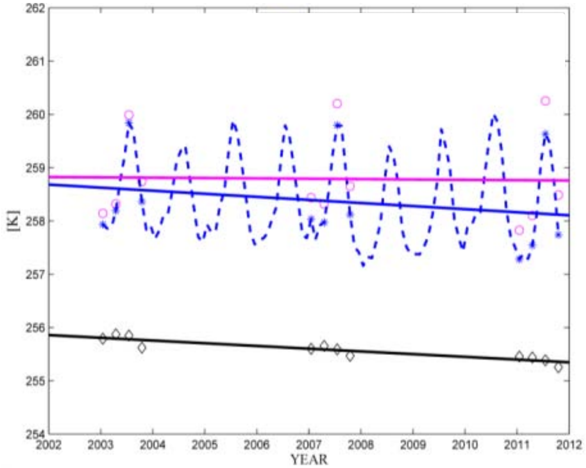
Negative yield and tropospheric water vapor trends are improved in Version-6 compared to Version-5

Assessment of Differences in Version-6.07 and Version-5 Trends

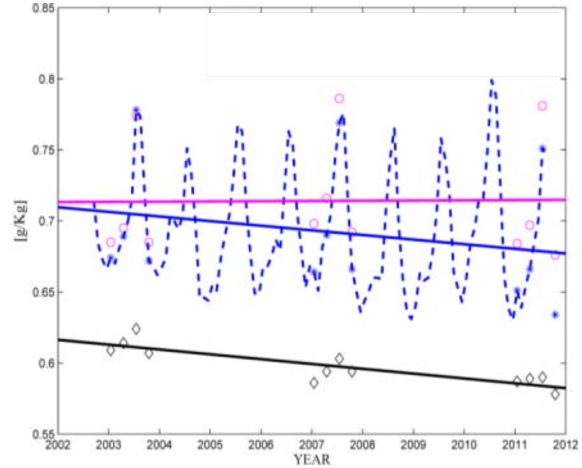
- Version-5 Level-3 products are known to have some spurious trends
- We have compared global mean Level-3 Version-5 and Version-6.07 products to see how much Level-3 trends might improve in Version-6
- The following plots show monthly mean global mean time series of select Version-5 products and Version-6.07 products for the 12 months January, April, July, and October 2003, 2007, and 2011 which have been run
- We also show the "trendline" of Version-5 and Version-6.07 products defined as the linear least squares fit of the time series passing through the 12 months sampled by Version-6
- What is most important is the difference between Version-6 and Version-5 trendline slopes
- These results are shown for:
  - T_{500}, q_{500}, W_{TOT}, $\alpha\varepsilon$, OLR, and OLR_{CLR}

Global Time Series January 2003 through October 2011

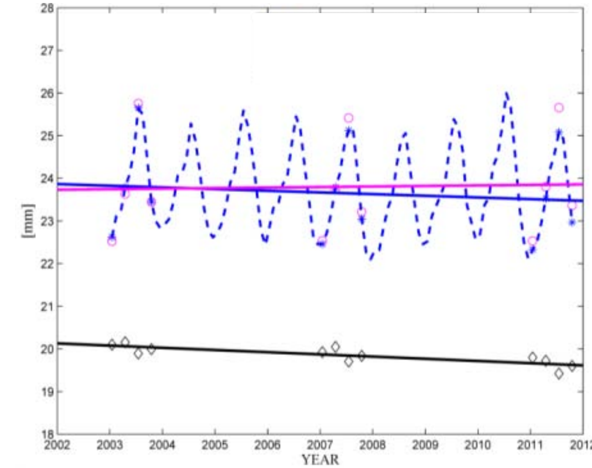
500 mb Temperature (K/yr)



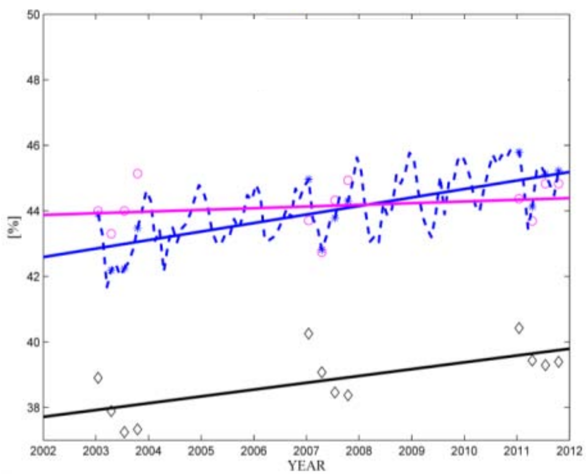
500 mb Water Vapor Mixing Ratio (g/kg)



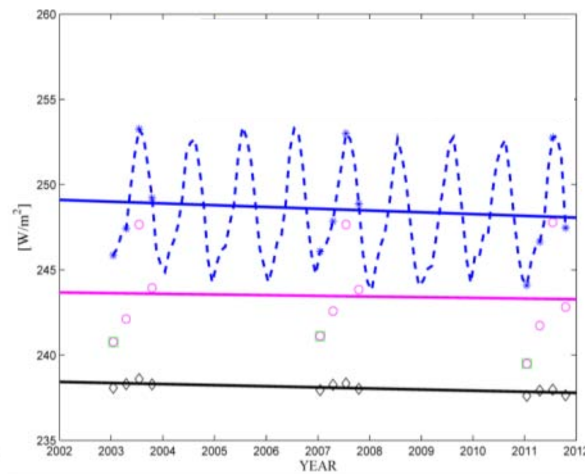
Total Precipitable Water (mm)



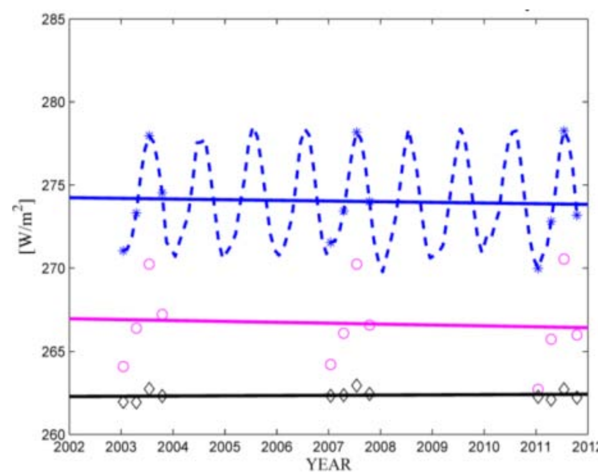
Effective Cloud Fraction (%)



OLR (W/m^2)



Clear Sky OLR (W/m^2)



AIRS V5 January 2003 through October 2011

AIRS V6.07 12 Months

AIRS V5 12 Months

AIRS V5 minus AIRS V6.07

V5 trendline

V6.07 trendline

V5-V6.07 trendline

Trendline slopes of Global Mean Time Series January 2003 through October 2011						
	OLR $W/m^2/yr$	Clear Sky OLR $W/m^2/yr$	Cloud Fraction %/yr	500 mb Temp K/yr	W_{TOT} mm/yr	q_{500} g/kg/yr
✳ AIRS V5	-0.104	-0.040	0.260	-0.058	-0.039	-0.00325
○ AIRS V6.07	-0.038	-0.054	0.049	-0.006	0.012	0.00001
◇ AIRS V5 minus AIRS V6.07	-0.066	0.014	0.211	-0.052	-0.050	-0.00326

V6.07 trendline slopes are closer to zero than those of V5

Comparison Summary

Version-6 is significantly improved with regard to Version-5 in every way with regard to T_s, ε_ν, T(p), q(p), αε

OLR, OLR_{CLR} both agree better with CERES (not shown today)

Version-6 AO is roughly comparable to Version-5

Version-6 gets my blessing for release

Congratulations to the entire AIRS Science Team and supporting cast!

Short Term SRT Plans for Version-7

- Implement Neural-Net start-up option at SRT
  - John expects to complete this by the end of November
  - This is critical for optimal development and testing of further improvements
- Improve water vapor retrieval using Neural-Net start-up:
  - channels, functions, damping parameters
- Improve temperature profile retrieval by using tropospheric 15 μm CO_2 channels that do not see clouds.
  - Theory says that 15 μm CO_2 channels that see clouds should not be used in T(p) retrieval. Version-6 assures this by using only stratospheric sounding CO_2 channels in T(p) retrieval
  - Many tropospheric 15 μm do not see clouds depending on the scene and can (should) be used in T(p) retrieval for that case

Longer term SRT Plans for Version-7

- Implement 1 (cross track) x 3 (along track) FOV retrieval system
  - This triples the spatial resolution and density of the AIRS soundings
  - Approach was previously attempted for Version-6 before Neural-Net implementation, but dropped because 1x3 soundings had degraded in harder cloud cases
  - New Version-6 Neural-Net start-up allows for much better soundings under cloudier cases
- Perform cloud spectral emissivity retrievals
  - Important for OLR calculation and radiance computation closure
- Attempt to include absorption by dust in the retrieval process
  - This should improve retrievals in dusty scenes rather than (hopefully) rejecting them as done now
- Any other ideas that come up by us or other team members