Evaluation of JPL Version-5.9.12 Temperature Profiles, Ocean Skin Temperature, Surface Emissivity, and Cloud Cleared Radiances

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Outline

- Modifications to JPL 5.9.12 compared to V5.9.1 (July 28, 2011 Net Meeting)
- Some results showing that V5.9.12 O, with original water vapor sounding channels, is preferable to V5.9.12 N with Antonia Gambacorta's new water vapor channels

  More comparisons are shown in back-up material
- Comparison of V5.9.12, V5.9.12 AO, V5.9.1, and V5.0

  More comparisons of V5.9.12 with V5.9.12 AO are shown in back-up material
- Accuracy and yield of channel by channel Quality Controlled clear-column radiances $\hat{R}_i$
- Plans for Version-7

Changes Since Version 5.9.1 (July 2011)

Updates to neural net first guess (Manning and Milstein)

- Improved interpolation near surface
- Better handling of sea ice

Modification to emissivity first guess and retrieval (Manning, Hulley, Blaisdell)

Changes to RTA for large solar zenith angles (Maddy)

Changes to cloud parameter retrievals (Manning, Blaisdell, Susskind)

- Neural net T_{skin} is used over ocean when retrieval is thought to be bad

Updated channel lists to remove channels bad by 2010 (Manning, Blaisdell)

Error estimates (Susskind, Iredell)

- Separate error coefficients are generated for polar cases
- New coefficients generated consistent with V5.9.12, V5.9.12 AO

Comparison of Results Obtained Using V5.9.12 O and V5.9.12 N

Version-5.9.12 O and V5.9.12 N are otherwise identical in every way except for use of a new set of water vapor sounding channels in V5.9.12 N as suggested by Antonia Gambacorta and co-workers

Use of new channels in current system improves some products but significantly degrades the accuracy of the water vapor profiles, especially for harder (cloudier) cases

In the absence of time for further optimization, we recommend use of the old channel set in Version-6. Further optimization should be done in Version-7

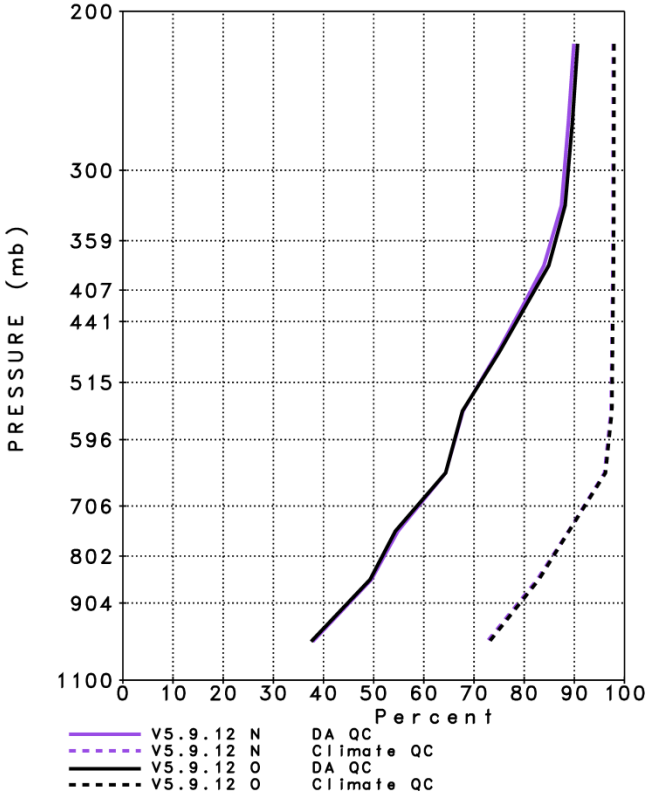
The next two charts show results related to water vapor profiles

Other comparisons are shown in the back-up material

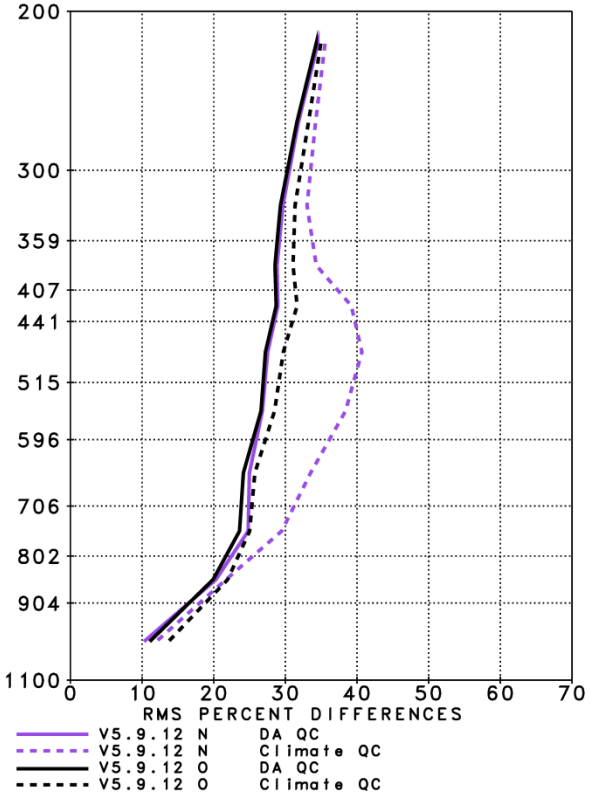
All further comparisons are V5.9.12 O, called V5.9.12

Global 1 Km Layer Precipitable Water 7-Day

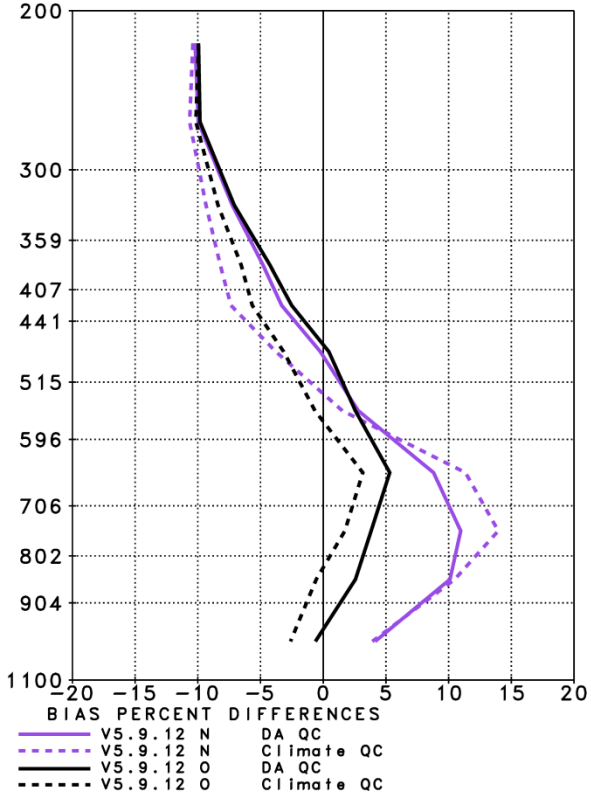
Percent Yield



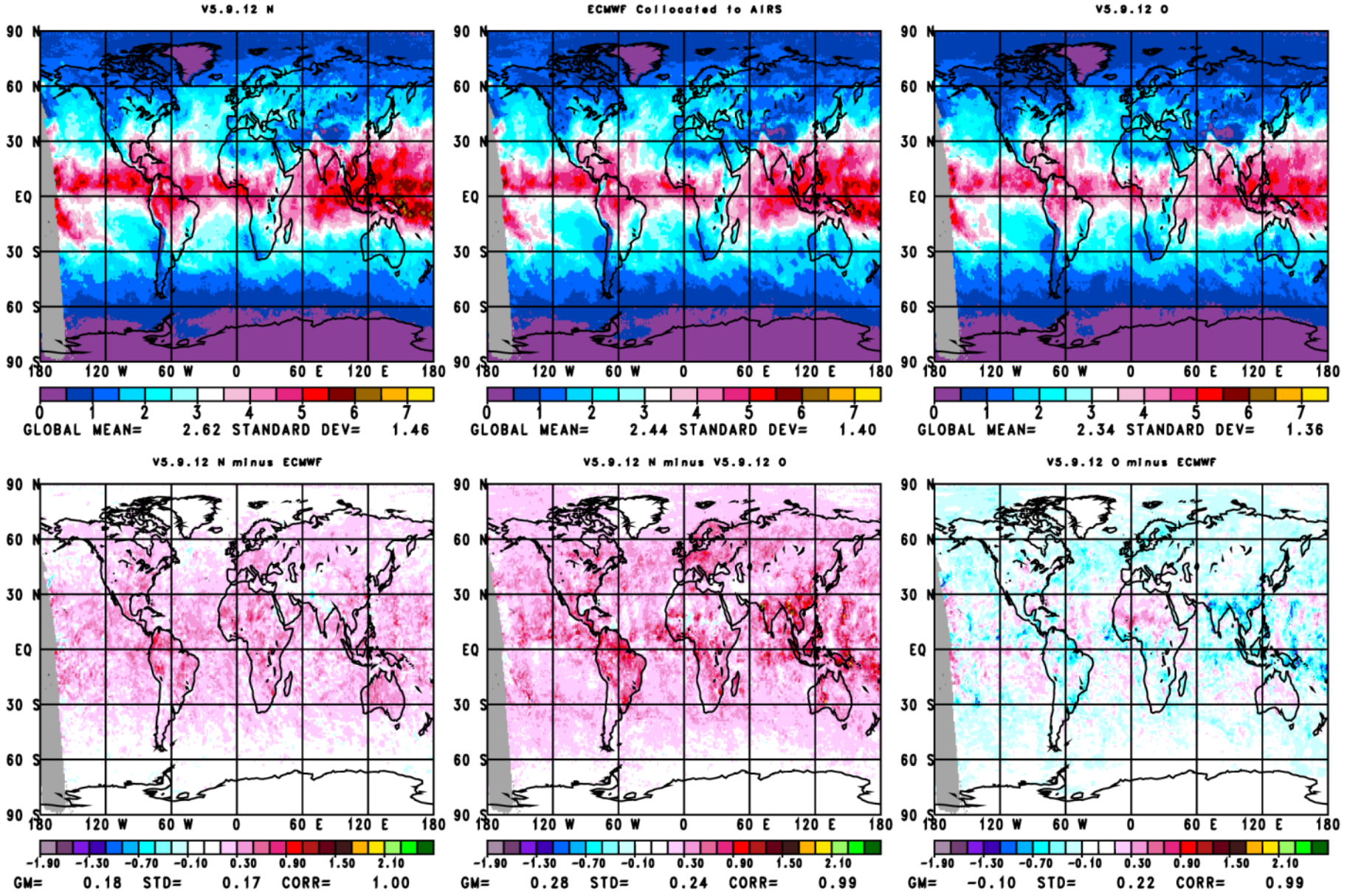
% Difference from ECMWF RMS

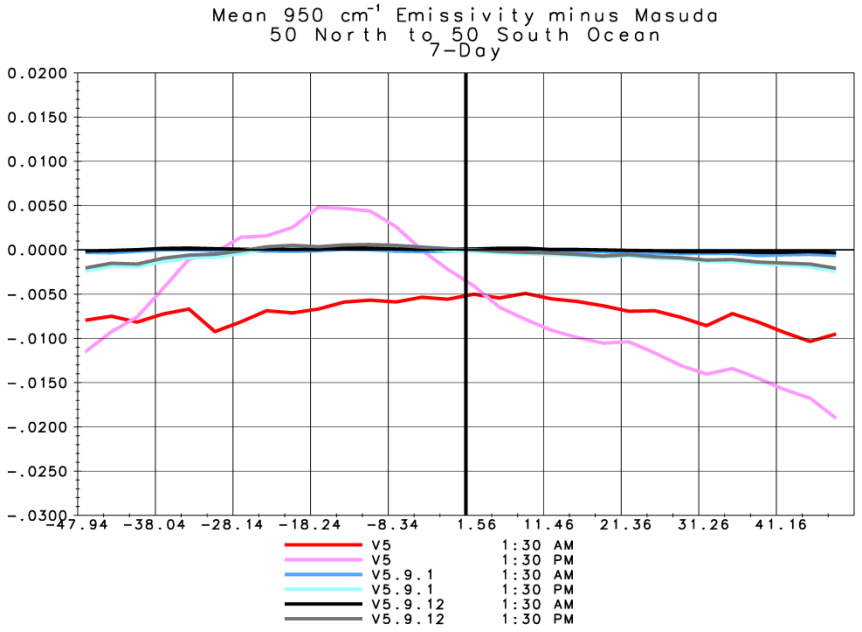


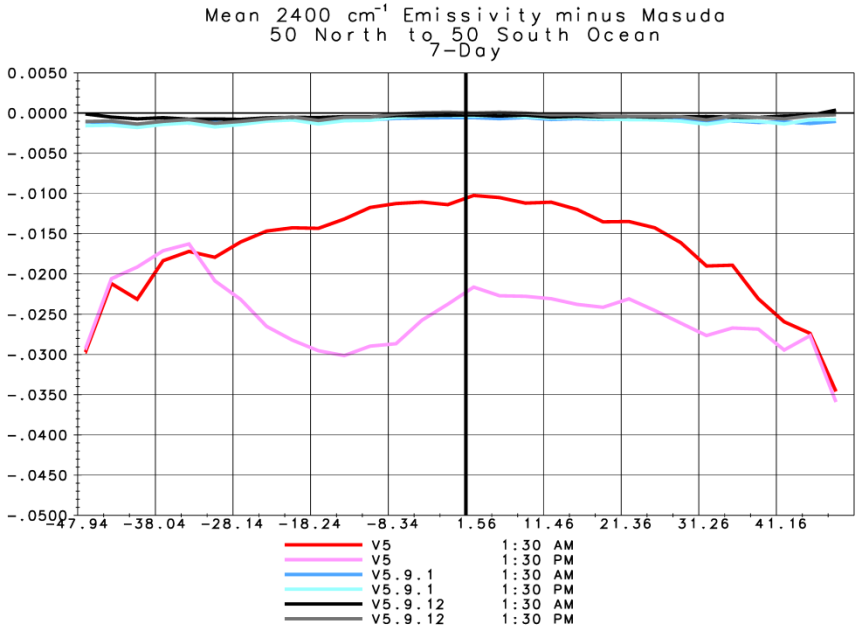
% Difference from ECMWF BIAS

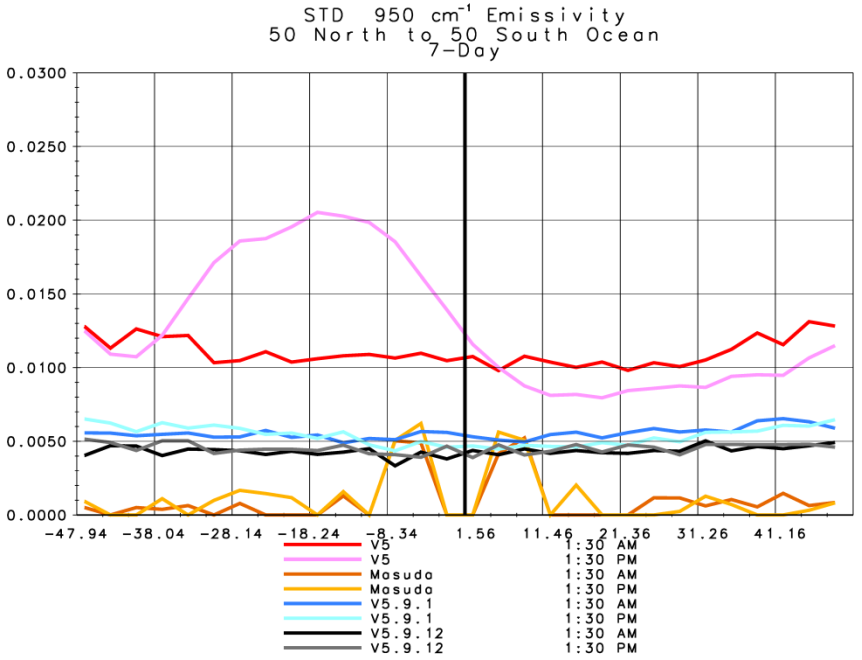


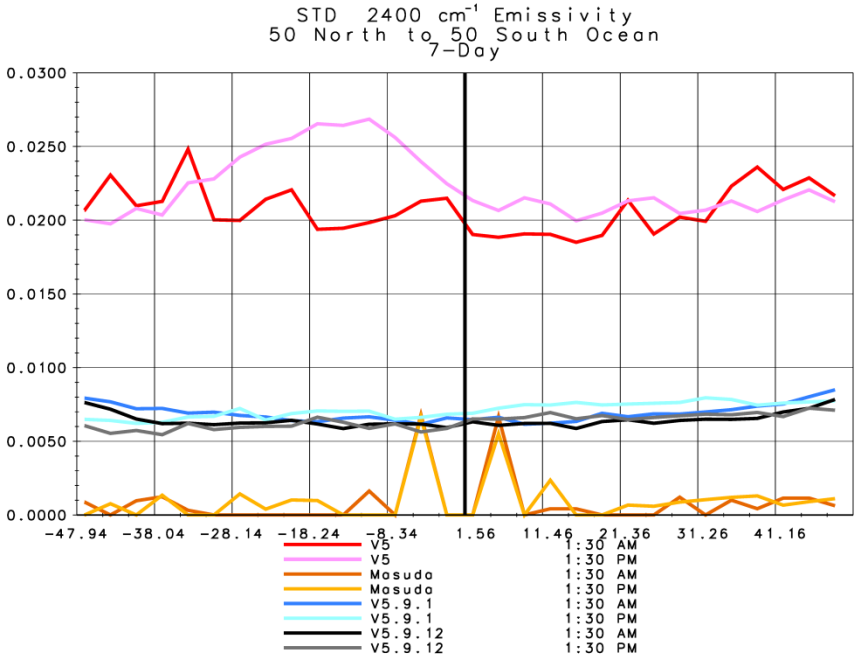
7-Day
Total Precipitable Water (cm) 7-Days 1:30 PM
New Water Channels vs Old Water Channels

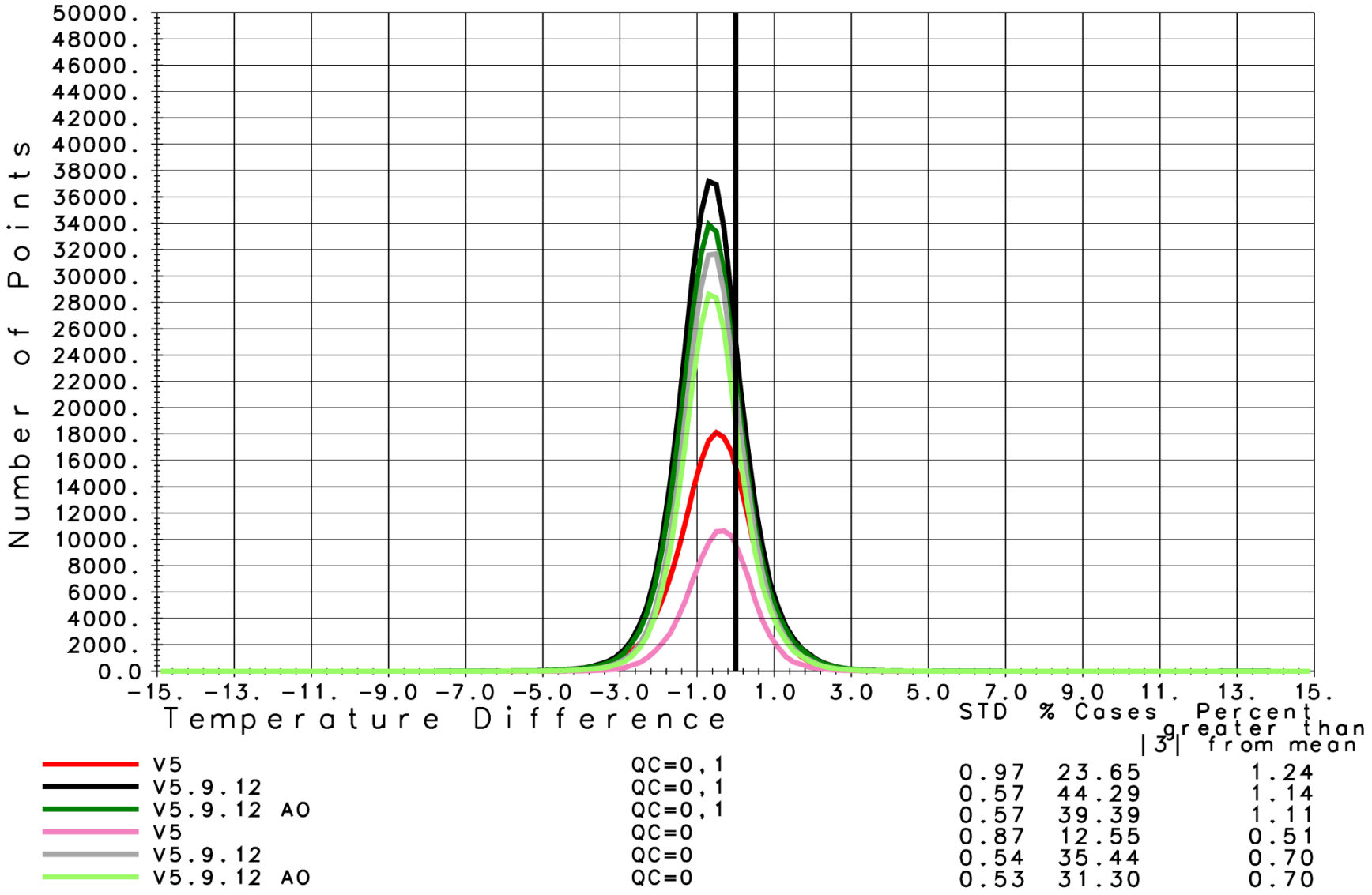



Mean 950 cm-1 Emissivity minus Masuda
50 North to 50 South Ocean
7-Day
0.0200
0.0150
0.0100
0.0050
0.0000
-.0050
-.0100
-.0150
-.0200
-.0250
-.0300
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
V5 1:30 AM
V5 1:30 PM
V5.9.1 1:30 AM
V5.9.1 1:30 PM
V5.9.12 1:30 AM
V5.9.12 1:30 PM


Mean 2400 cm-1 Emissivity minus Masuda
50 North to 50 South Ocean
7-Day
0.0050
0.0000
-.0050
-.0100
-.0150
-.0200
-.0250
-.0300
-.0350
-.0400
-.0450
-.0500
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
V5 1:30 AM
V5 1:30 PM
V5.9.1 1:30 AM
V5.9.1 1:30 PM
V5.9.12 1:30 AM
V5.9.12 1:30 PM

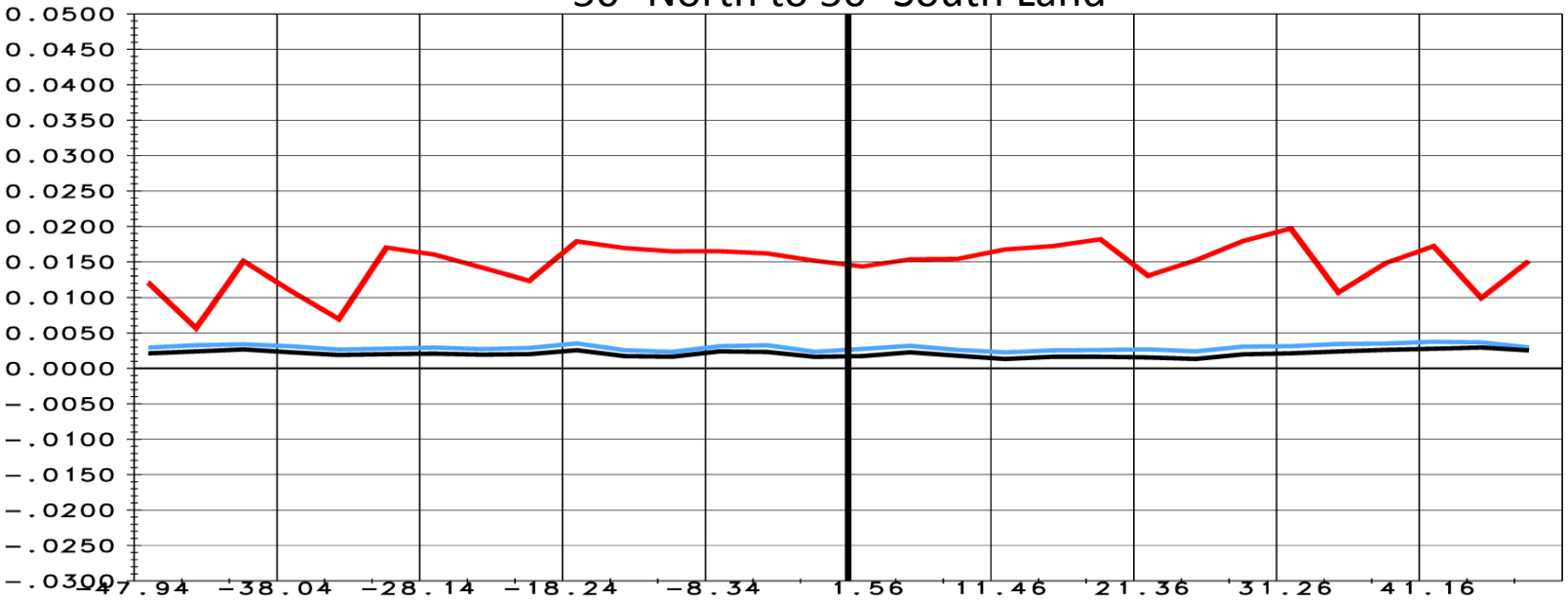

STD 950 cm-1 Emissivity
50 North to 50 South Ocean
7-Day
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
V5 1:30 AM
V5 1:30 PM
Masuda 1:30 AM
Masuda 1:30 PM
V5.9.1 1:30 AM
V5.9.1 1:30 PM
V5.9.12 1:30 AM
V5.9.12 1:30 PM


STD 2400 cm-1 Emissivity
50 North to 50 South Ocean
7-Day
0.0300
0.0250
0.0200
0.0150
0.0100
0.0050
0.0000
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
V5 1:30 AM
V5 1:30 PM
Masuda 1:30 AM
Masuda 1:30 PM
V5.9.1 1:30 AM
V5.9.1 1:30 PM
V5.9.12 1:30 AM
V5.9.12 1:30 PM

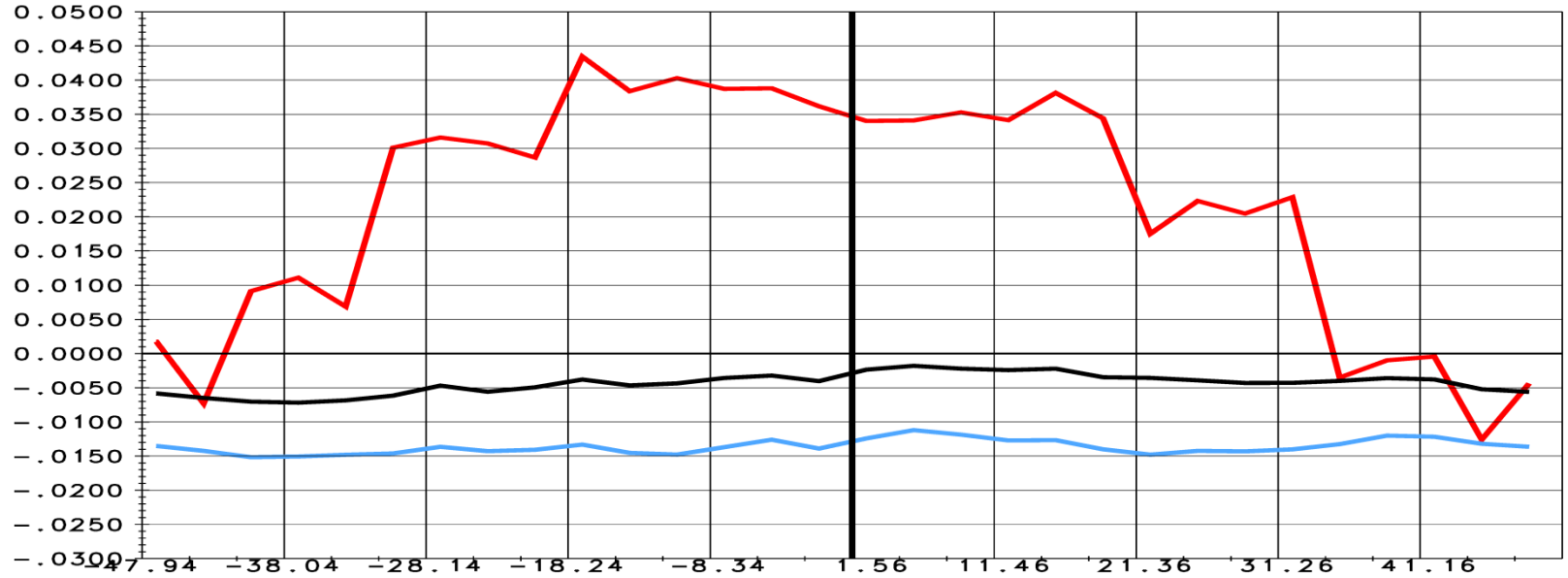

Surface Skin Temperature Difference
7-Day Daytime and Nighttime combined
50 N to 50 S Non-Frozen Ocean
Number of Points
50000.
48000.
46000.
44000.
42000.
40000.
38000.
36000.
34000.
32000.
30000.
28000.
26000.
24000.
22000.
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
V5 QC=0,1 0.97 23.65 1.24
V5.9.12 QC=0,1 0.57 44.29 1.14
V5.9.12 AO QC=0,1 0.57 39.39 1.11
V5 QC=0 0.87 12.55 0.51
V5.9.12 QC=0 0.54 35.44 0.70
V5.9.12 AO QC=0 0.53 31.30 0.70
STD
% Cases
Percent greater than |3| from mean

Mean AM minus PM Emissivity 7-Day Average
50° North to 50° South Land

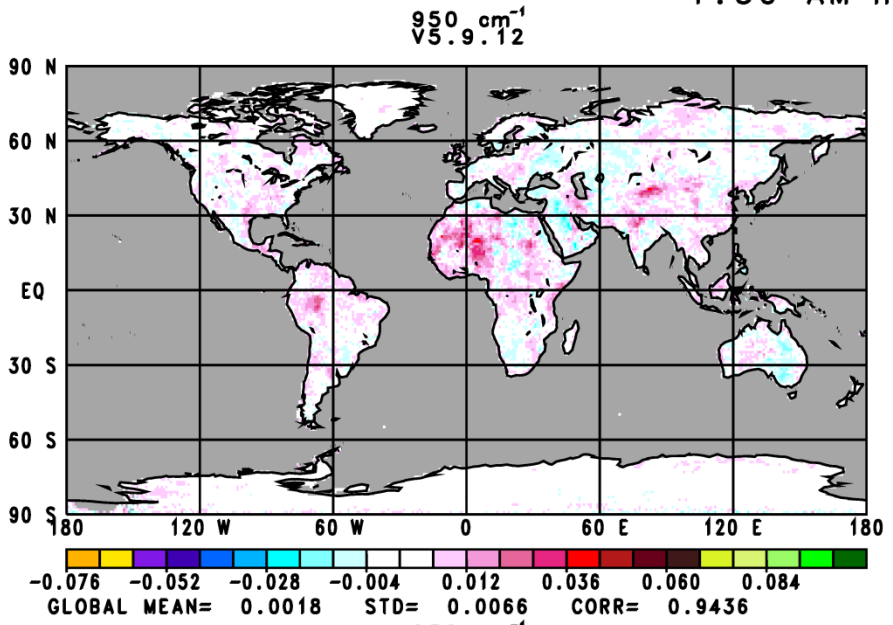
950 cm^{-1}

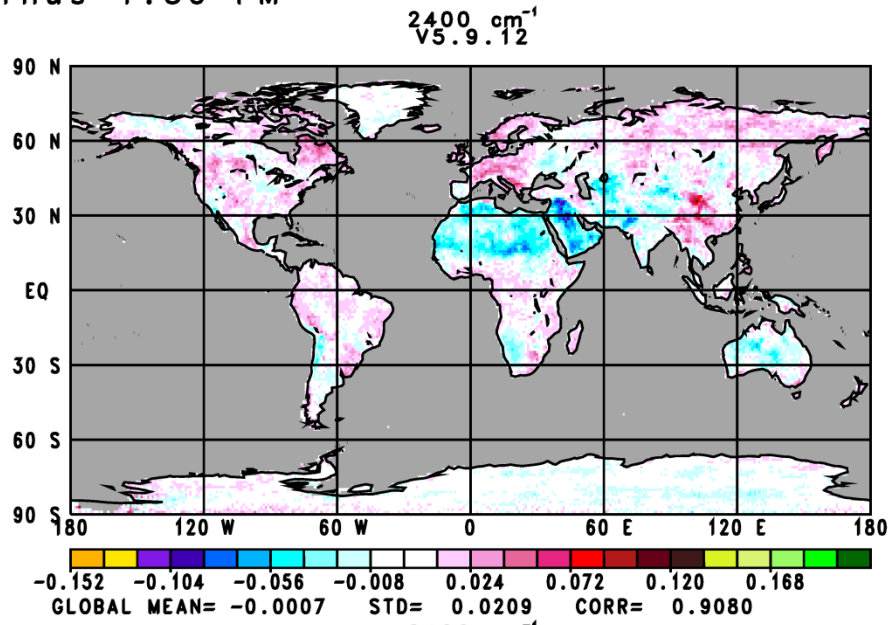


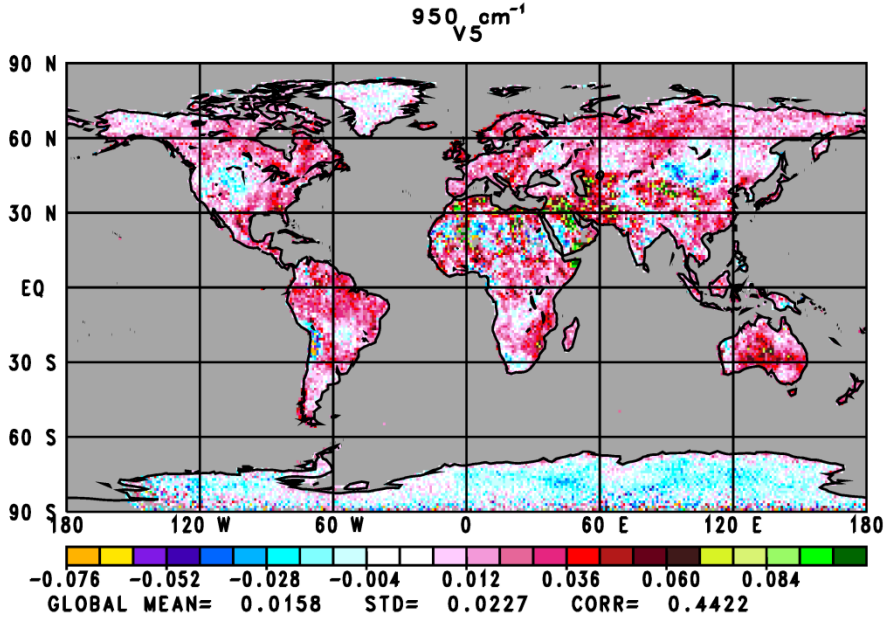
2400 cm^{-1}

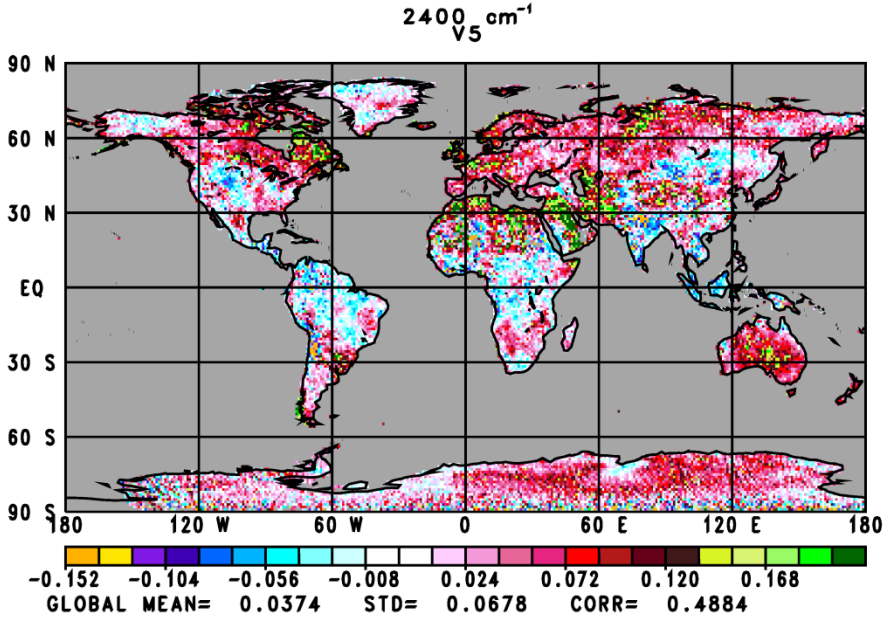


7-Day
AIRS IR Emissivity
1:30 AM minus 1:30 PM



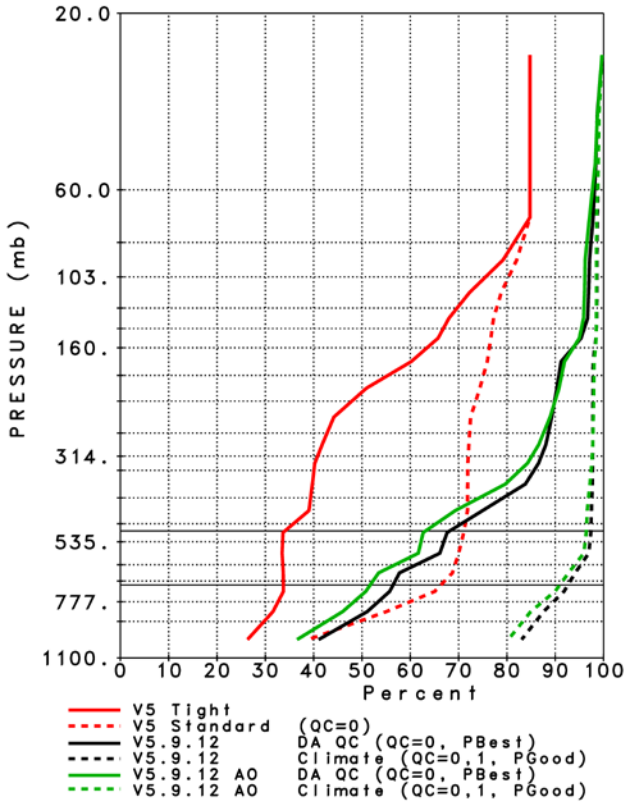




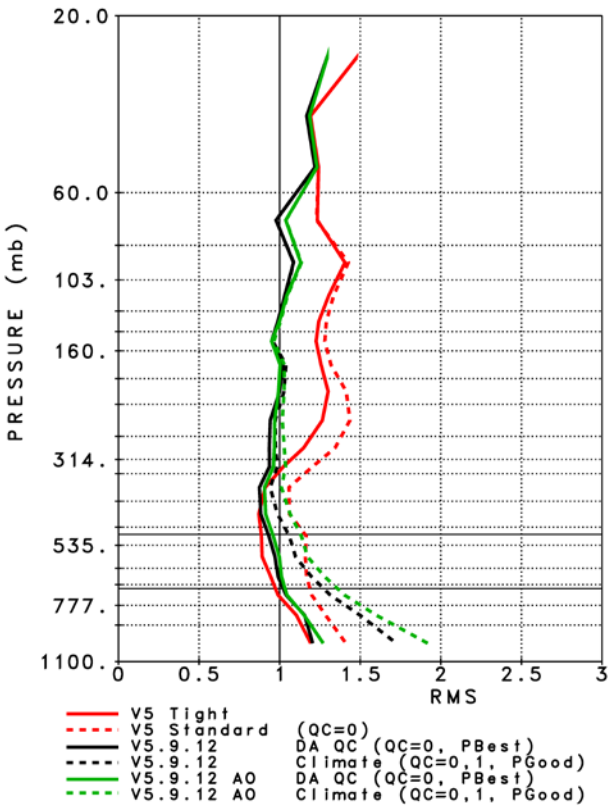


Global Temperature 7-Day
Statistics use their own QC

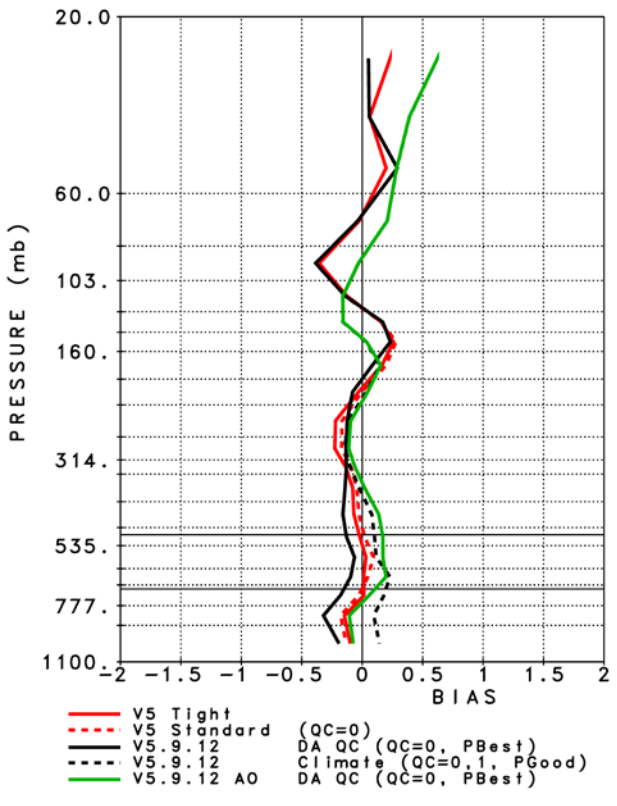
Percent of All Cases Accepted



Layer Mean RMS (°K) Differences from ECMWF

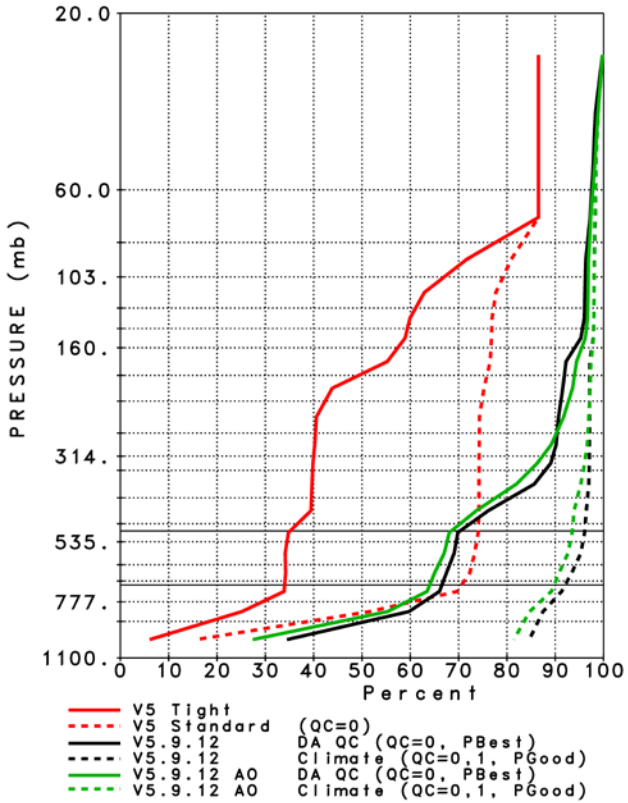


Layer Mean BIAS (°K) Differences from ECMWF

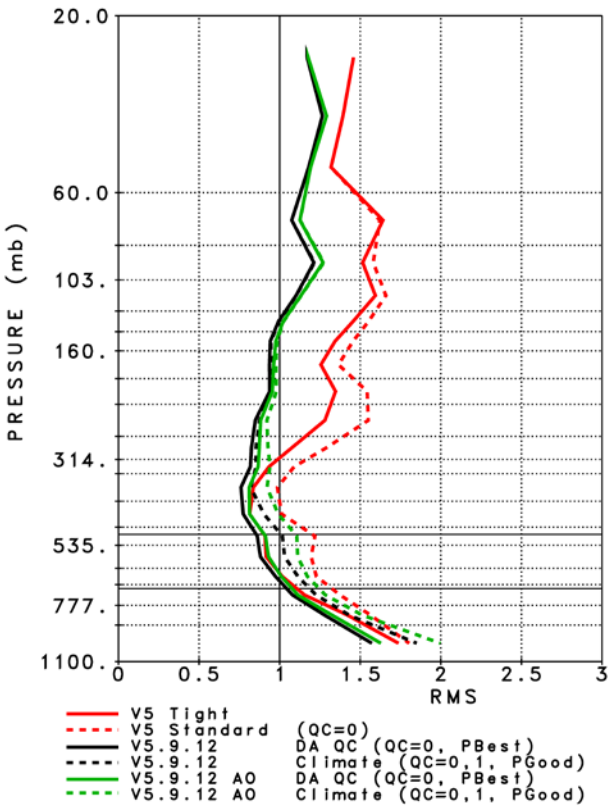


50° North to 50° South Land Temperature 7-Day
Statistics use their own QC

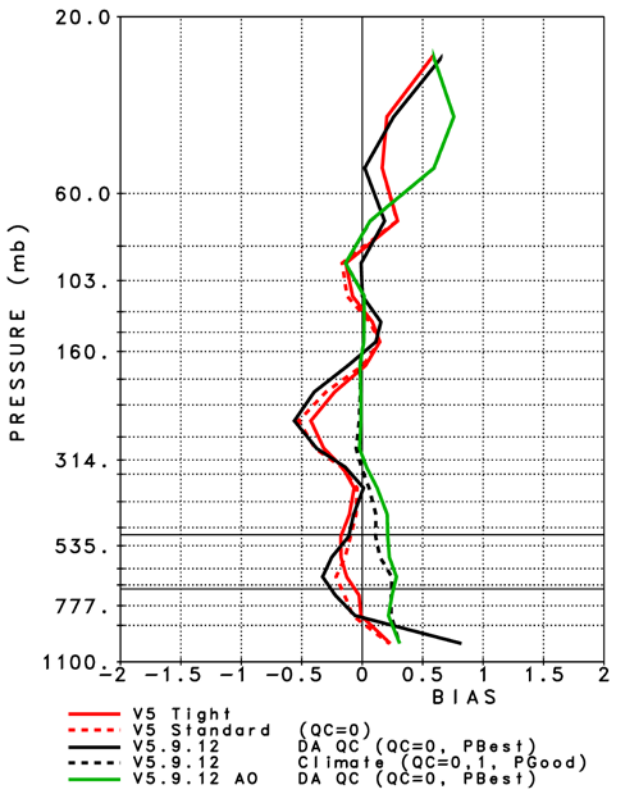
Percent of All Cases Accepted



Layer Mean RMS (°K) Differences from ECMWF

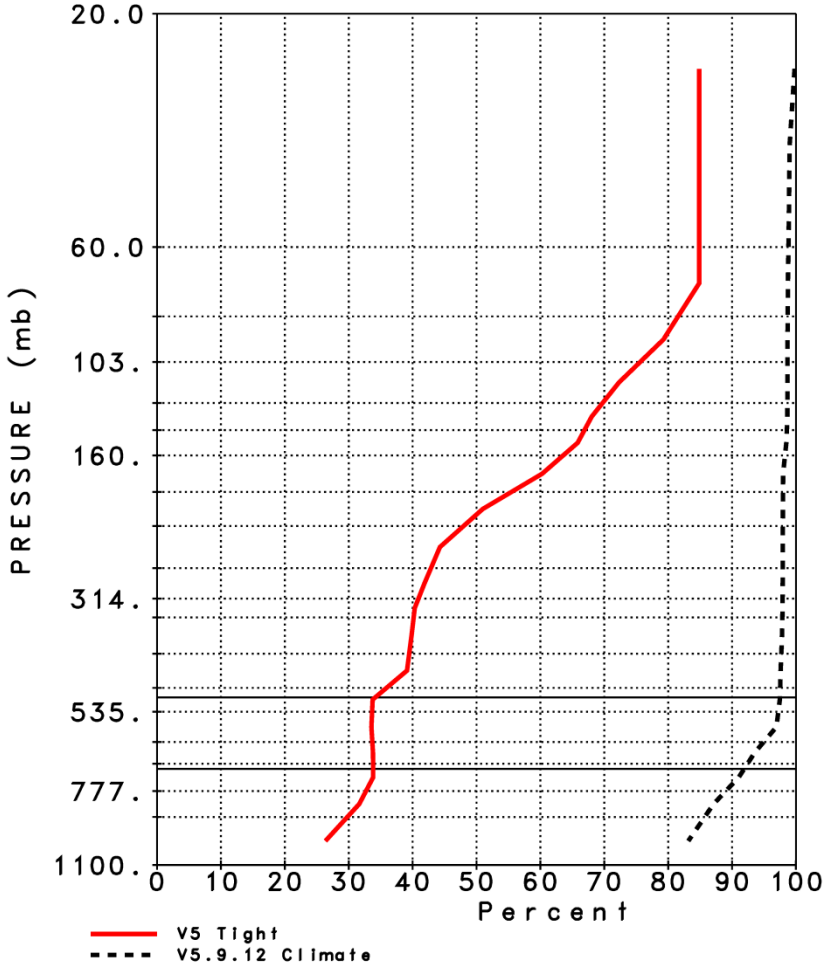


Layer Mean BIAS (°K) Differences from ECMWF

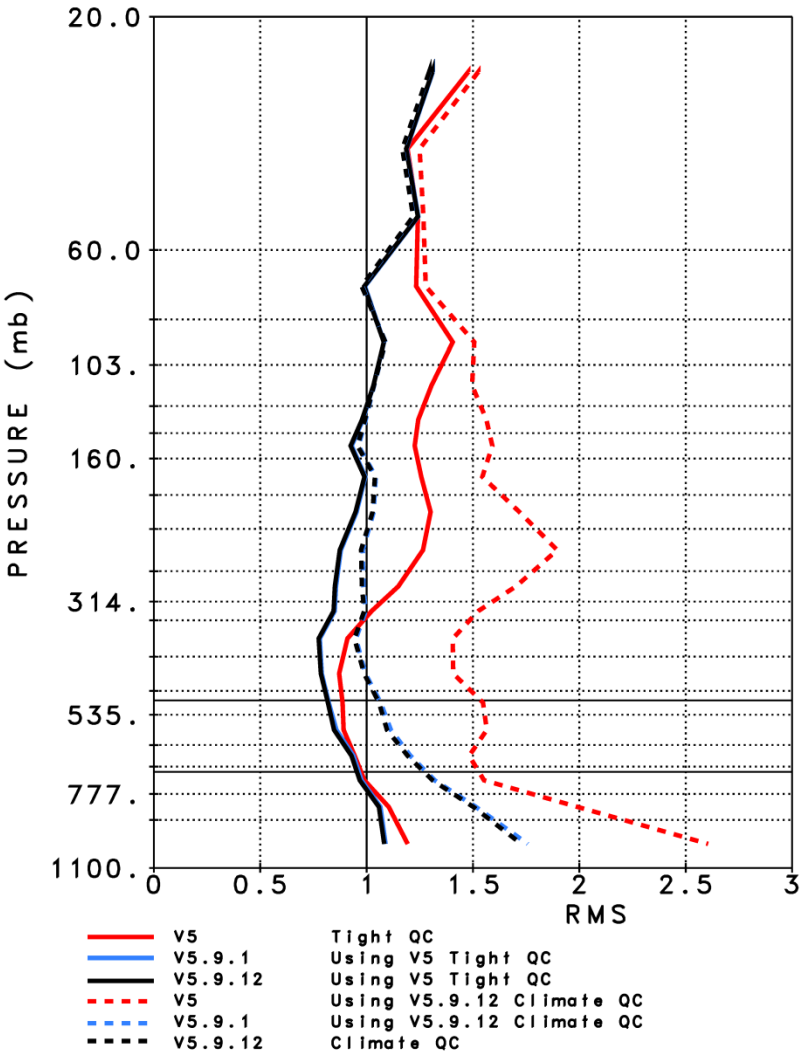


Global
Temperature Statistics for two Identical Ensembles 7-Day

Percent of All Cases Accepted

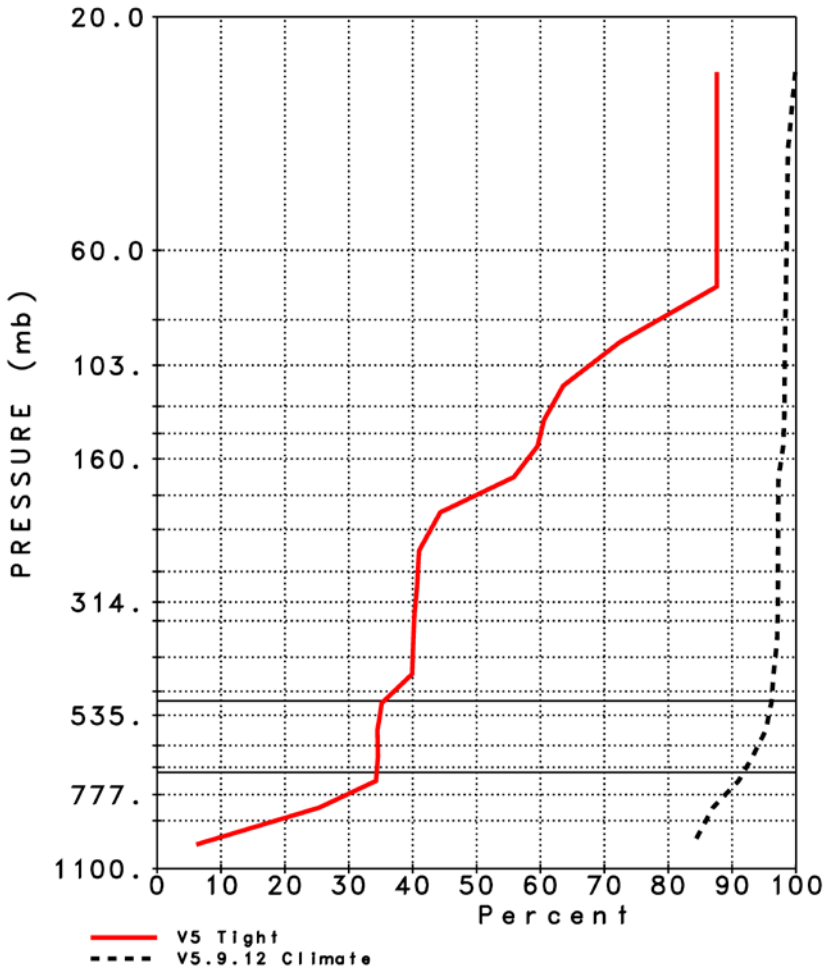


Layer Mean RMS (°K) Differences from ECMWF

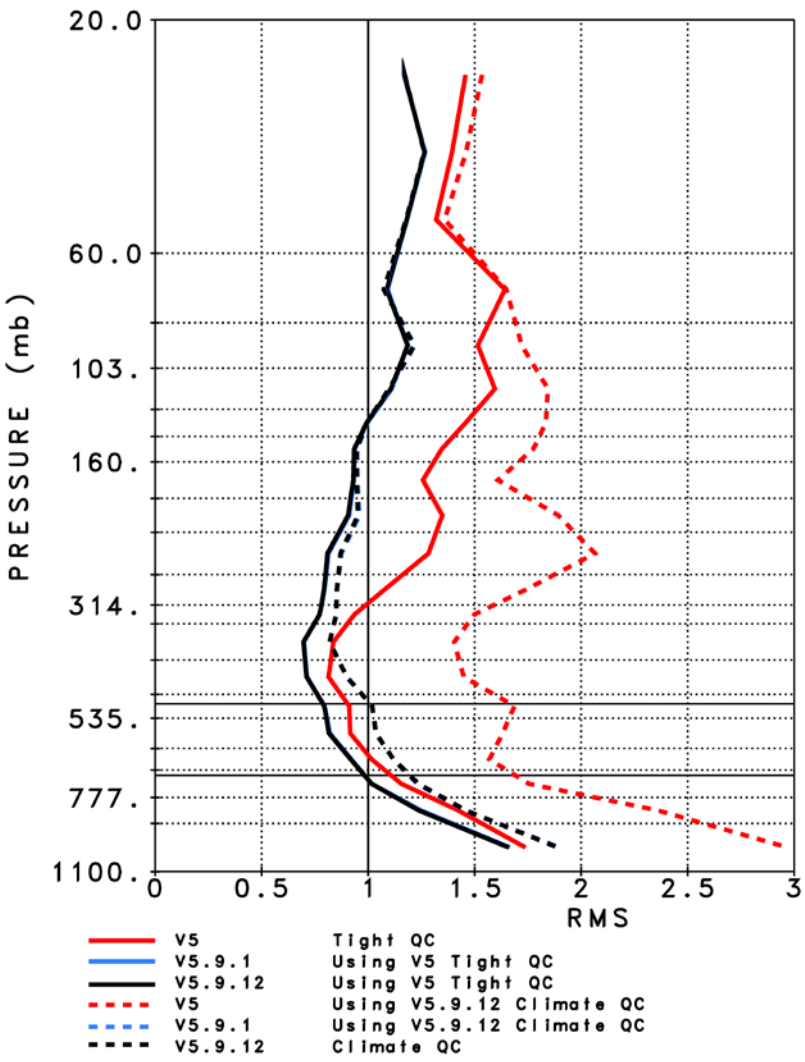


50° North to 50° South Land
Temperature Statistics for two Identical Ensembles 7-Day

Percent of All Cases Accepted

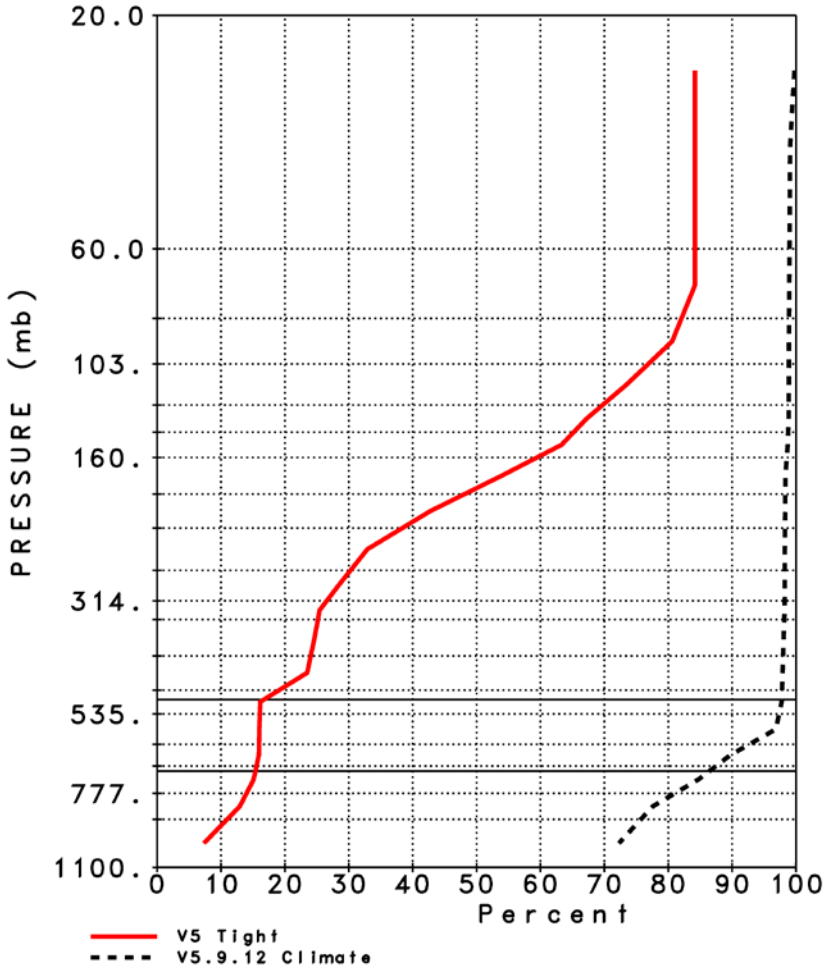


Layer Mean RMS (°K) Differences from ECMWF

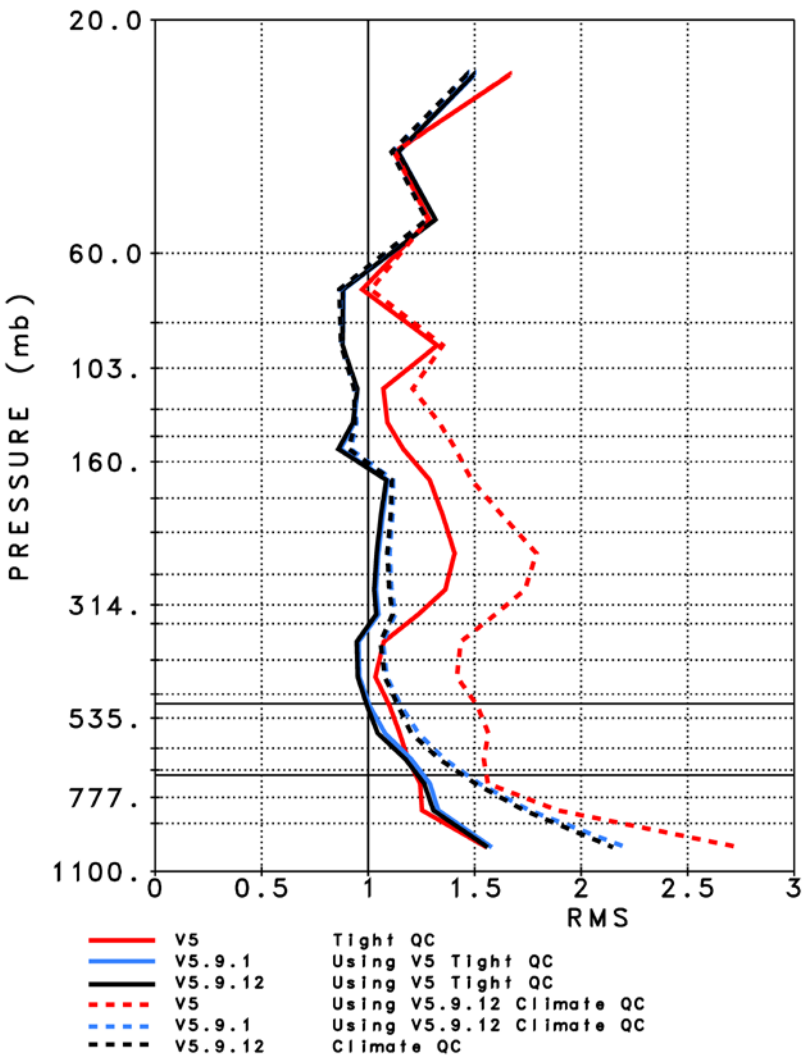


Poleward of 50°
Temperature Statistics for two Identical Ensembles 7-Day

Percent of All Cases Accepted



Layer Mean RMS (°K) Differences from ECMWF



7-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	1.10	1.29	1.19	1.71	1.04	1.13	1.14	1.50	1.31	1.76
V5.9.1	0.92	1.17	0.95	1.50	0.86	0.99	0.98	1.53	1.21	1.72
V5.9.12	0.92	1.16	0.94	1.49	0.86	0.98	0.96	1.47	1.20	1.69
V5.9.12 AO	0.94	1.30	0.98	1.63	0.88	1.13	0.98	1.64	1.22	1.82

Cases in Common Using the 5.9.12 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	1.66	2.53	1.82	2.75	1.64	2.43	1.52	2.35	1.71	2.70
V5.9.1	1.12	1.88	1.06	1.92	1.03	1.44	1.14	2.24	1.33	2.33
V5.9.12	1.11	1.85	1.06	1.90	1.02	1.40	1.12	2.15	1.32	2.28
V5.9.12 AO	1.18	2.10	1.14	2.10	1.08	1.64	1.18	2.45	1.43	2.63

Comparison Summary

JPL Version-5.9.12 is significantly improved compared to Version-5 with regard to temperature profiles, ocean skin temperature, and surface emissivities

- T(p) is slightly improved compared to Version-5.9.1
- Land surface emissivity is somewhat improved compared to Version-5.9.1 especially in the shortwave

Version-5.9.12 AO performs only slightly poorer than Version-5.9.12

Comparisons of some Level 3 spatial plots are shown in back-up material

Agreement of all fields shown in backup is very good

Version-5.9.12 retrieval system is ready for use in Version-6

Some work still needed for error estimates and QC for clear column radiances

Clear Column Radiance Error Estimates $\partial \hat{R}_i$

$\hat{R}_i = \bar{R}_i + \sum_{k=1,9} n_k (R_{i,k} - \bar{R}_i)$ channel$_i$, *FOV* $_k$

$\hat{R}_i$ has two sources of error: instrument noise $NE\Delta N_i$ and error due to cloud clearing CCE_i

The instrument noise $NE\Delta N_i$ is amplified by taking a linear combination of $R_{i,k}$ to get $\hat{R}_i$

Instrument noise contribution is given by *A* times $NE\Delta N_i$ where *A* is the noise amplification factor

A increases with η_k and is typically greater than 1

Special case: channel$_i$ does not see clouds in this scene $A_{i,clear} = 1/3$

We parameterize the cloud clearing error for a given channel and sounding as

$CCE_i = \sum_{j=1}^{6} B_{i,j} \partial T_j$ where ∂T_j is the error estimate for T_j

B_{ij} are error estimate coefficients

$\partial \hat{R}_i$ is expressed as $\partial \hat{R}_i = \left[(A_i NE\Delta N_i)^2 + CCE_i^2 \right]^{1/2}$

$\partial \hat{\Theta}_i$ is the equivalent error estimate in brightness temperature units

Need for $\partial \hat{R}_i$ and Error Flags

1) $\hat{R}_i$ is a derived product and therefore requires an uncertainty and an error flag
2) Operational agencies currently assimilate AIRS R_i for channels unaffected by clouds
   - Primarily stratospheric channels in 15μm CO_2 band
   - The spatial coverage is very poor for tropospheric sounding channels
   - Assimilating Quality Controlled values of $\hat{R}_i$ is potentially a much better approach with better spatial coverage
   - To do this optimally, $\partial \hat{R}_i$ and QC flags must be taken into account.

QC Flags

Current QC approach at SRT

QC = 0 if $\partial\hat{\Theta}_i$ < 0.8 K QC=0 Is suitable for Data Assimilation

QC = 1 if 0.8 K < $\partial\hat{\Theta}_i$ < 2.5 K

QC = 2 otherwise

We generated coefficients $B_{i,k}$ based on Version-5.49 at SRT – two regression system

There are 6 sets of $B_{i,k}$: non-frozen ocean; land; and sea ice/snow covered land; with separate coefficients for day and night

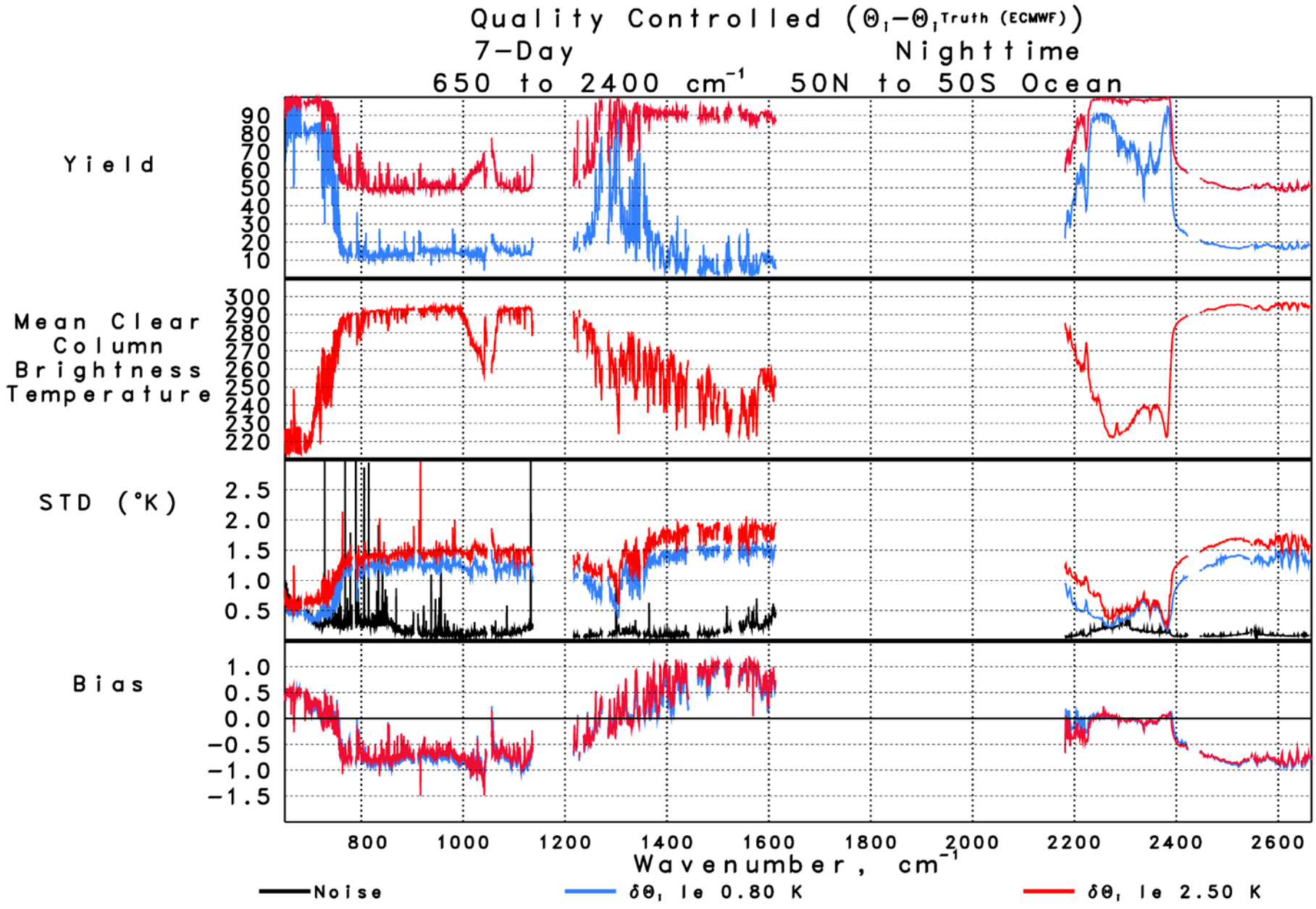
John Blaisdell implemented the code to generate $\partial\hat{R}_i$ and QC flags at JPL using Version-5.49 values of $B_{i,k}$

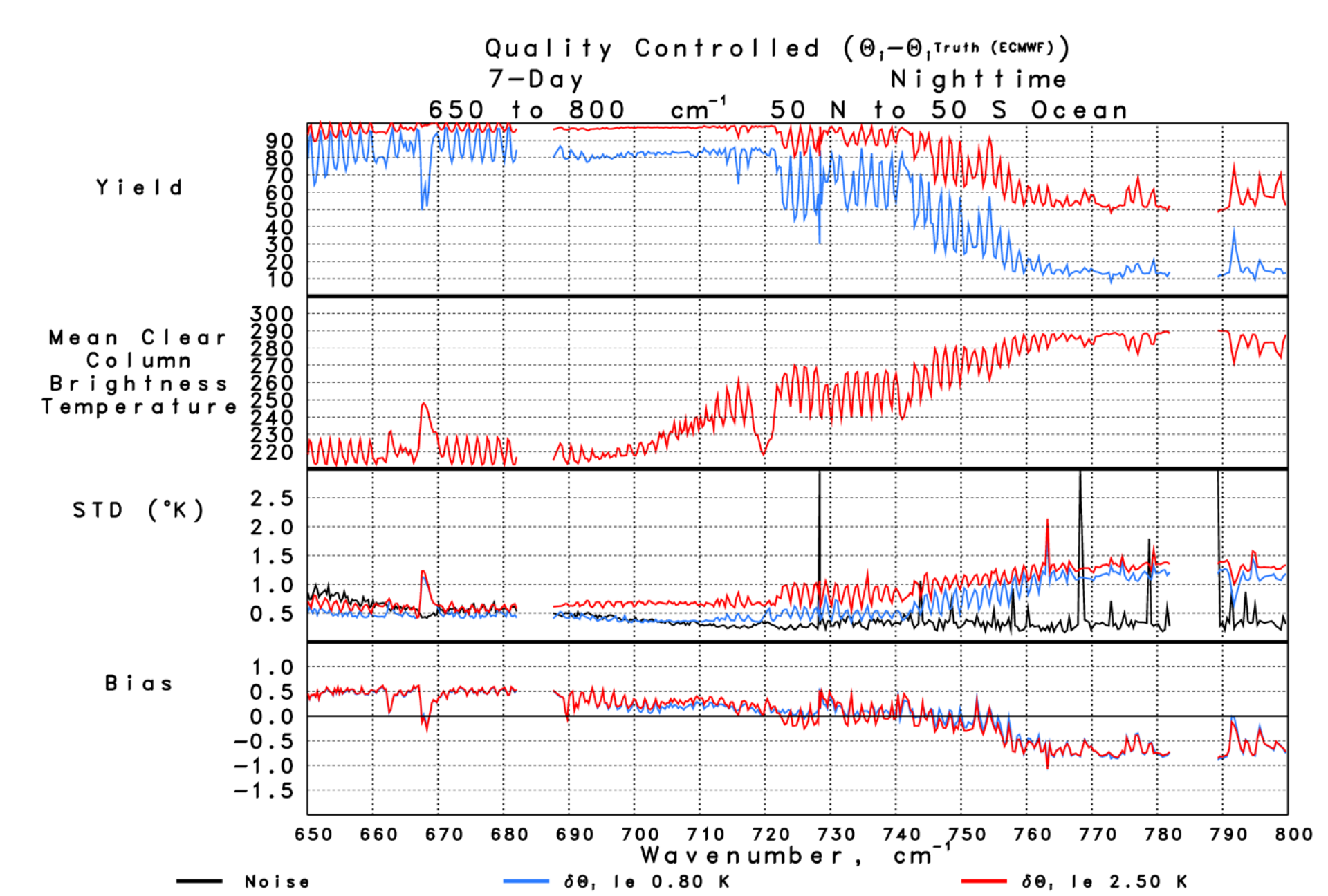
The code is not yet working correctly at JPL

This should not affect any other results of the system

Next set of results shows QC controlled Version-5.49 $\hat{R}_i$

Statistics should be even better using Neural-Net because cloud clearing is better with Neural-Net


Quality Controlled ($\Theta_i - \Theta_{i\,Truth\ (ECMWF)}$)
7-Day Nighttime
650 to 2400 cm^{-1} 50N to 50S Ocean
Yield
Mean Clear Column Brightness Temperature
STD (°K)
Bias
Wavenumber, cm^{-1}
Noise
$\delta\Theta_i$ le 0.80 K
$\delta\Theta_i$ le 2.50 K


Quality Controlled (Θi−Θi Truth (ECMWF))
7−Day
Nighttime
650 to 800 cm−1 50 N to 50 S Ocean
Yield
Mean Clear Column Brightness Temperature
STD (°K)
Bias
Wavenumber, cm−1
Noise
δΘi le 0.80 K
δΘi le 2.50 K

SRT Plans for Completion of Version-6

Necessary Research

Implement code to generate $\partial \hat{R}_i$ and QC flags correctly at JPL

Generate $B_{i,j}$ coefficients and optimize QC threshold for $\hat{R}_i$ based on results run at JPL

Desirable Research

Optimize Version-6 Climate QC thresholds for all parameters based on 1 month runs done at JPL

Fix any possible glitches in the processing system found in JPL Version-6 testing

Short Term SRT Plans for Version-7

Implement Neural-Net start-up option at SRT

- 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
- Many tropospheric 15 μm do not see clouds depending on the scene

Longer term SRT Plans for Version-7

Implement 1 (cross track) x 3 (along track) FOV retrieval system

- This triples the spatial resolution of the AIRS soundings
- Approach was attempted for Version-6, but dropped because soundings degraded in harder cloud cases
- Version-6 Neural-Net start-up allows for much better sounding at cloudier cases

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

Back-up Material
New Water Vapor Channels

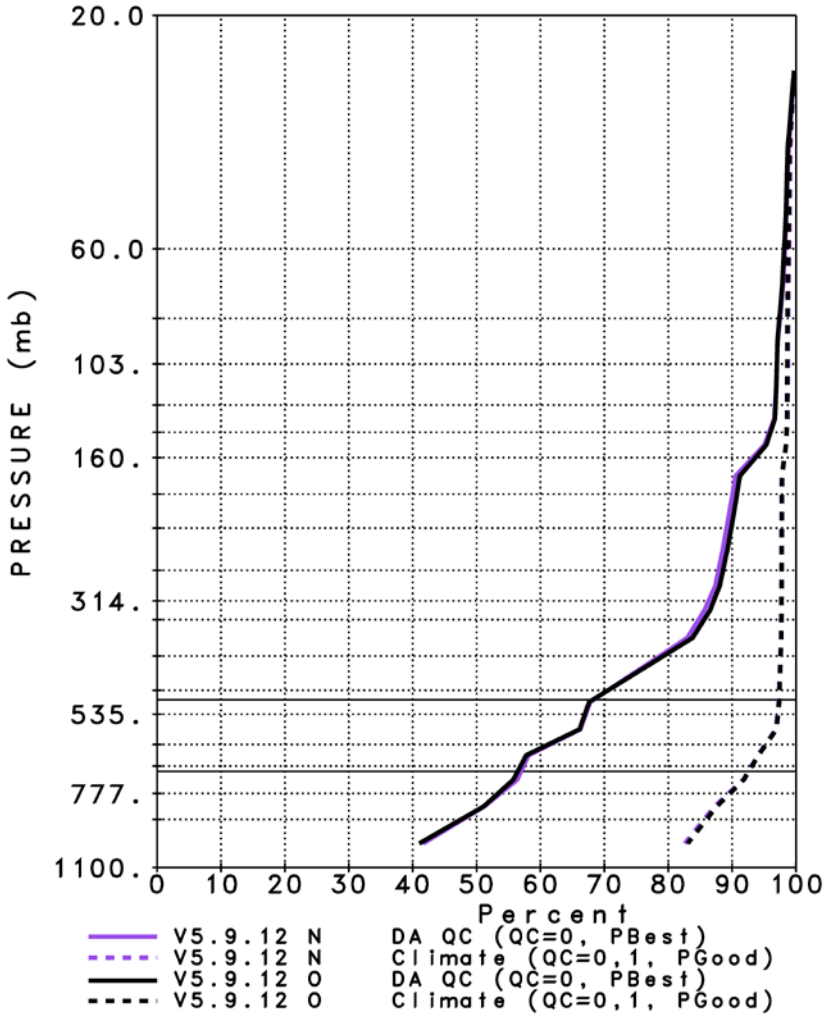
- T(p) results using new and old water vapor channels are comparable

- SST is degraded somewhat using new water vapor channels

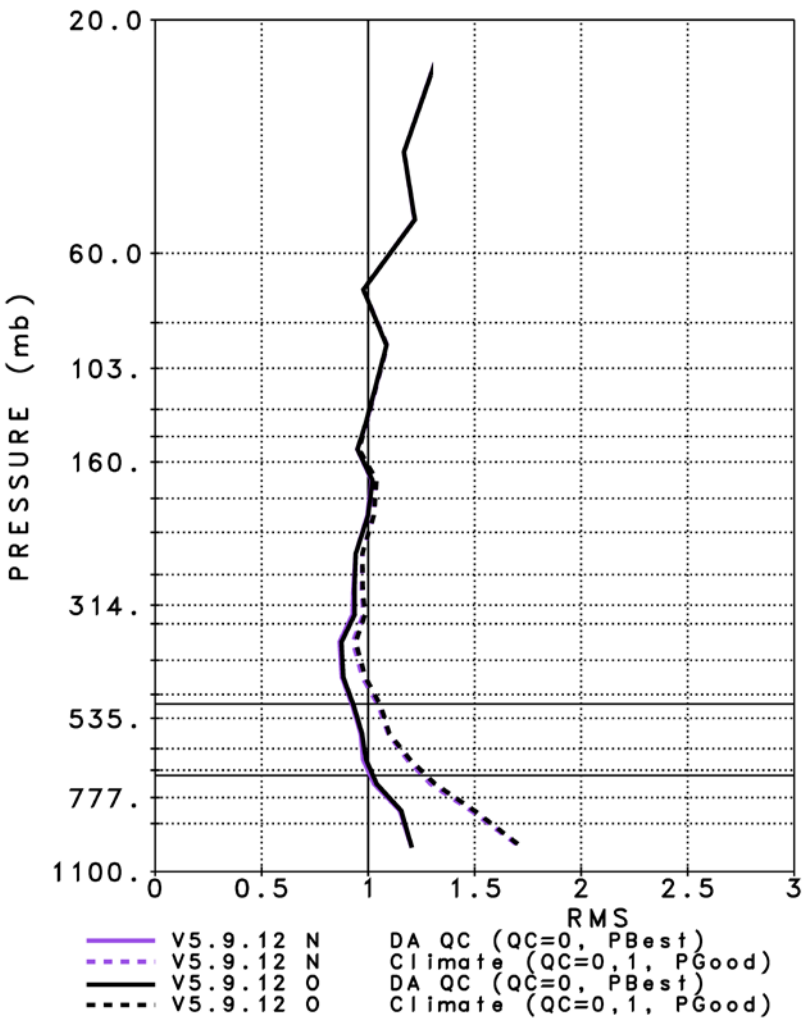
- Day/night differences of total methane are smaller (better?) over Northern Hemisphere land using new water vapor channels

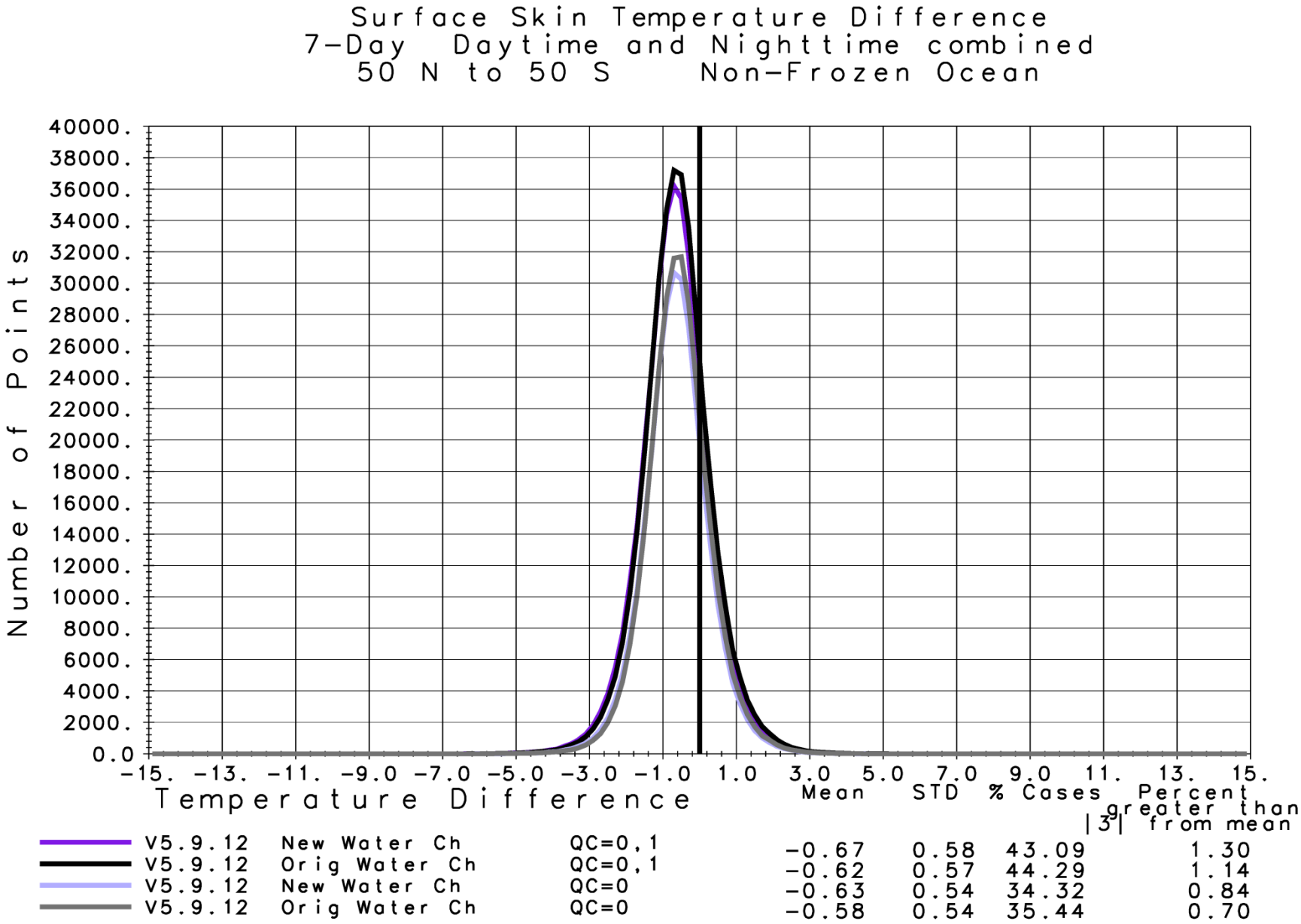
Global Temperature Old and New Water Channels 7-Day

Percent of All Cases Accepted

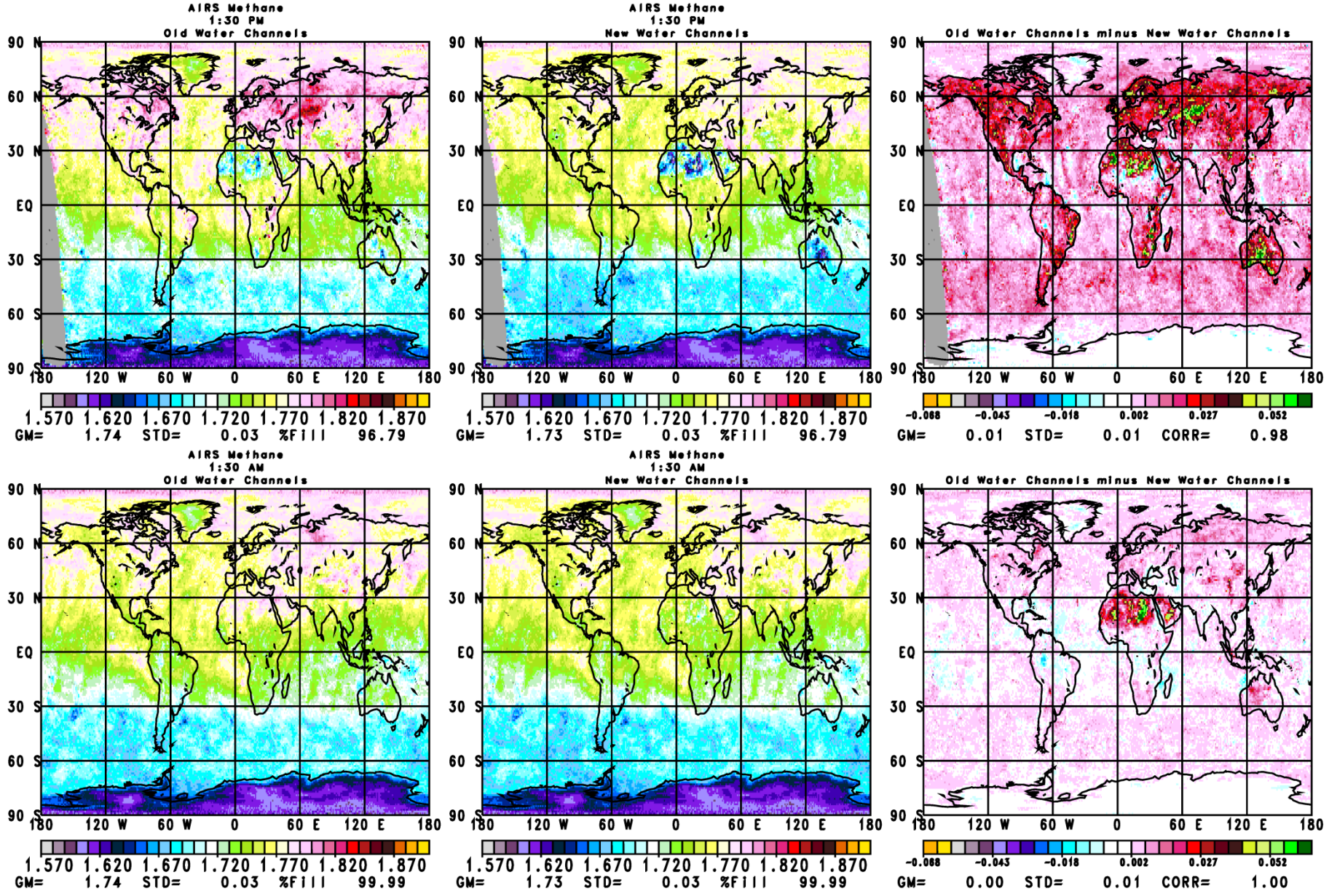


Layer Mean RMS (°K) Differences from ECMWF




Surface Skin Temperature Difference
7-Day Daytime and Nighttime combined
50 N to 50 S Non-Frozen Ocean
Number of Points
40000.
38000.
36000.
34000.
32000.
30000.
28000.
26000.
24000.
22000.
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent
greater than
|3| from mean
V5.9.12 New Water Ch QC=0,1 -0.67 0.58 43.09 1.30
V5.9.12 Orig Water Ch QC=0,1 -0.62 0.57 44.29 1.14
V5.9.12 New Water Ch QC=0 -0.63 0.54 34.32 0.84
V5.9.12 Orig Water Ch QC=0 -0.58 0.54 35.44 0.70

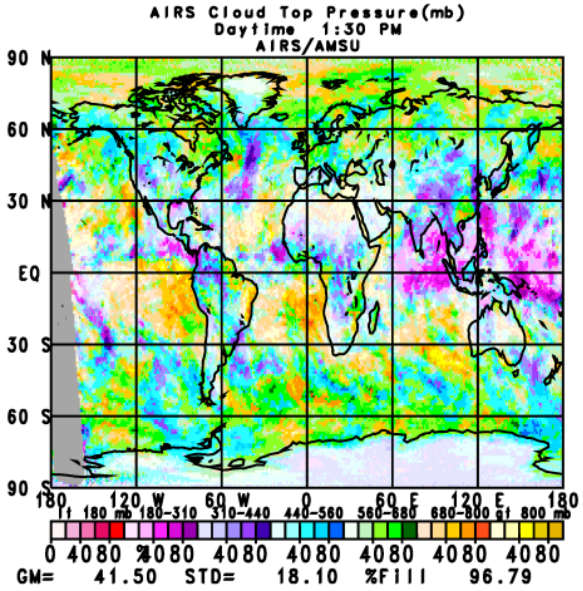
Trace Gases Methane 7-Days
V5.9.12
Old Water Channels vs New Water Channels

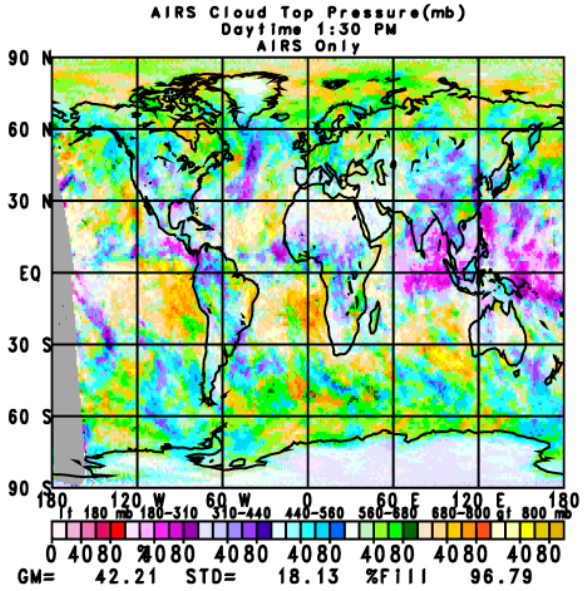


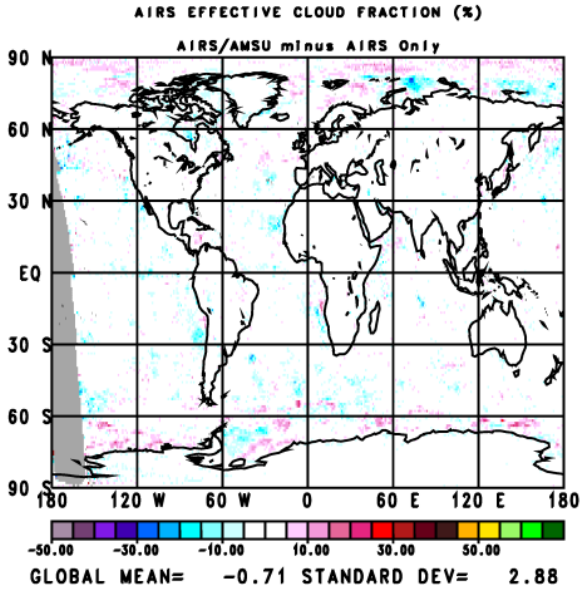
Back-up Material

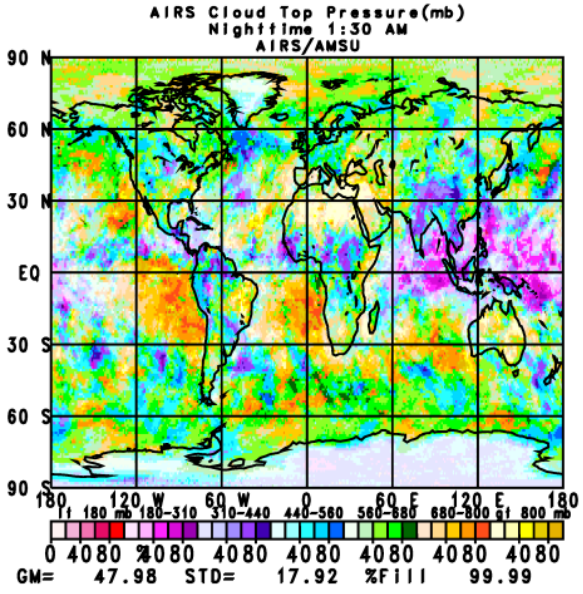
- Comparison of 7-day mean V5.9.12 Level 3 products with V5.9.12 AO
- All results are extremely close with each other
- V5.9.12 AO total precipitable water is slightly poorer over ocean as a result of loss of AMSU-A2 23.8 GHz and 31.4 GHz channels

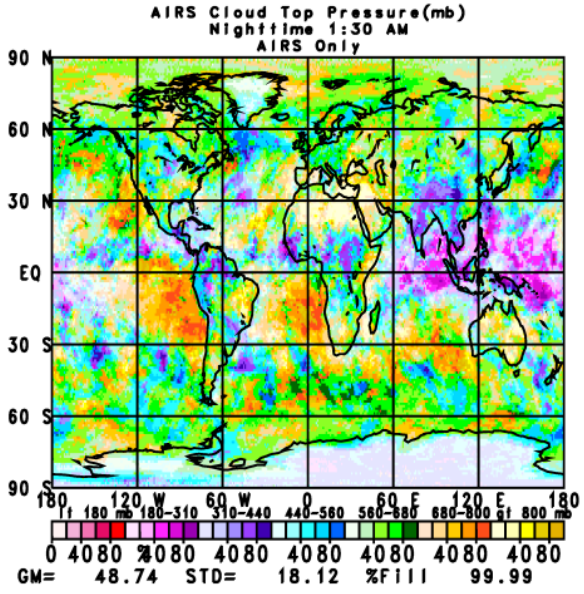
Cloud Parameters 7-Days
V5.9.12 Old Water Channels
AIRS/AMSU vs AIRS Only

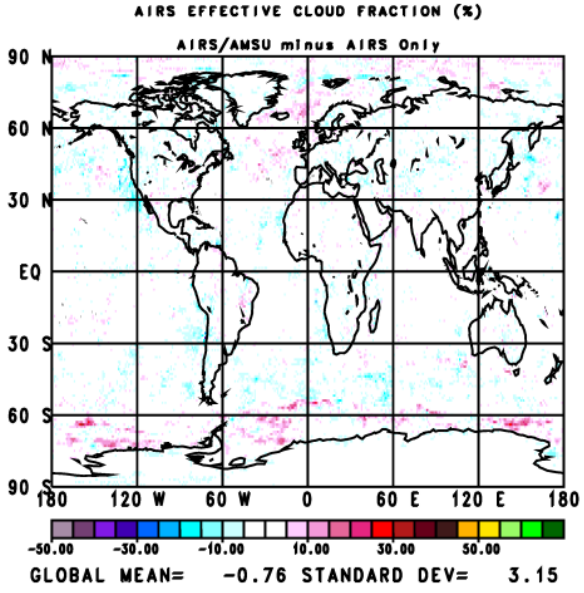




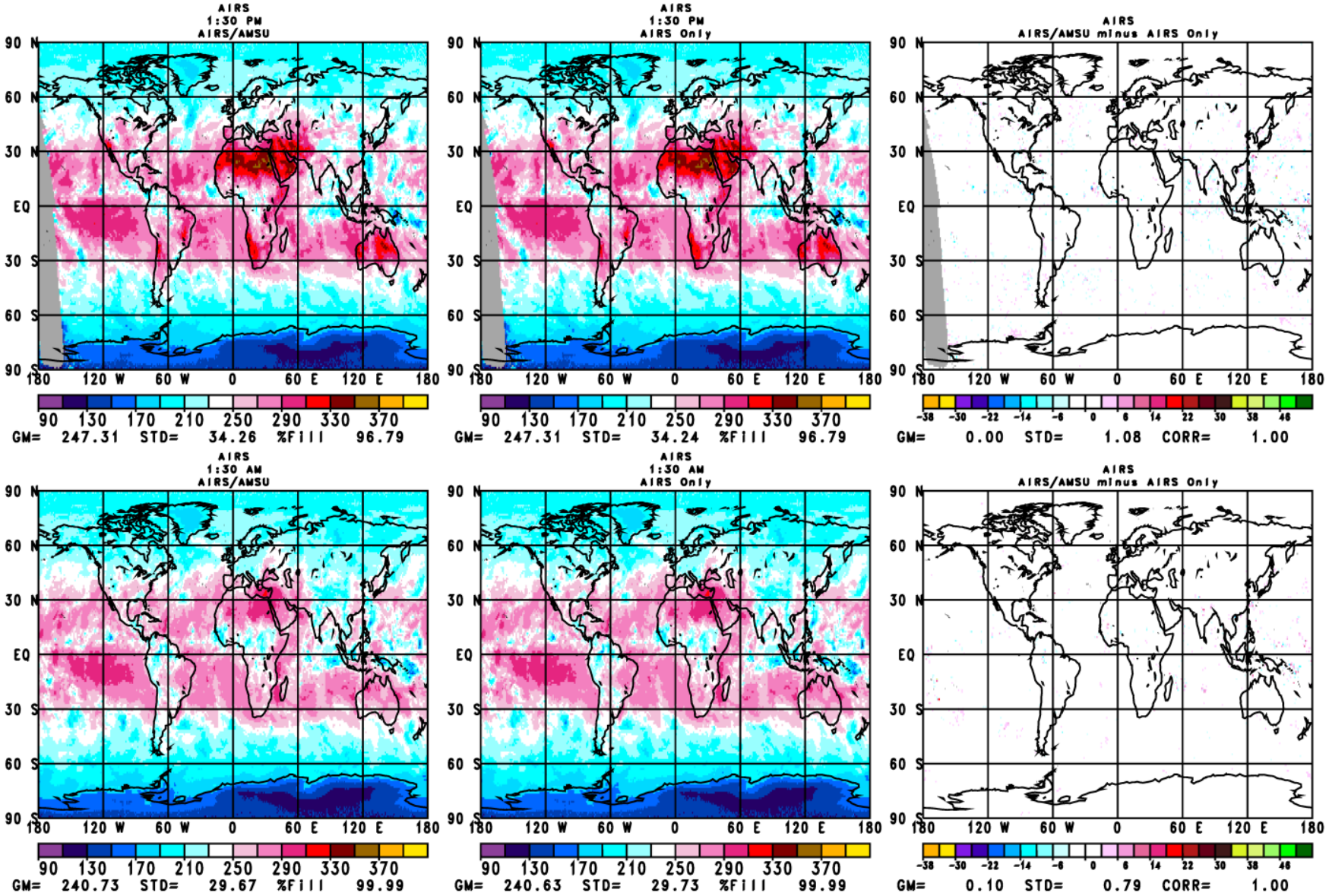




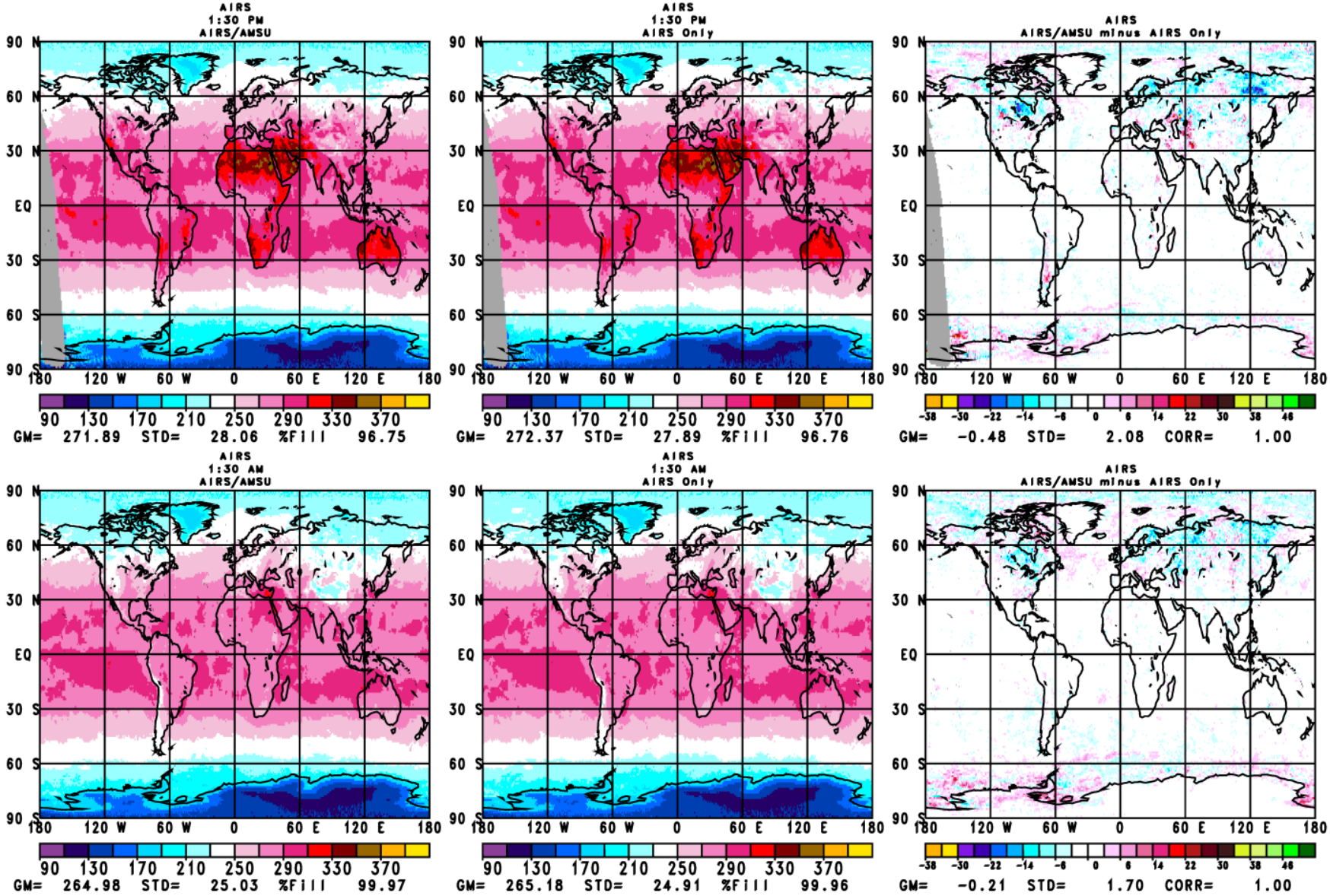




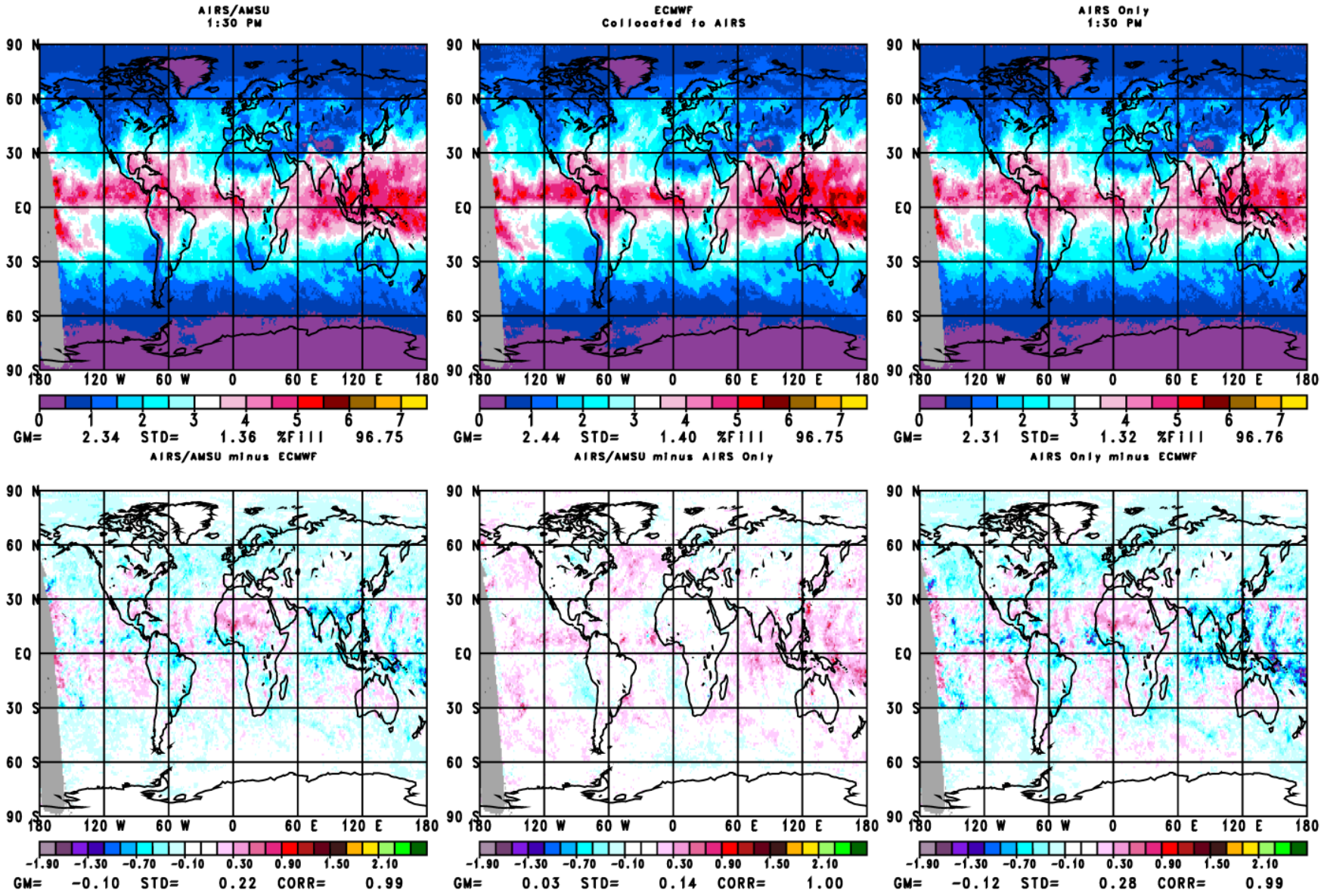
Outgoing Longwave Radiation (Watts/m²) 7-Days
V5.9.12 Old Water Channels
AIRS/AMSU vs AIRS Only



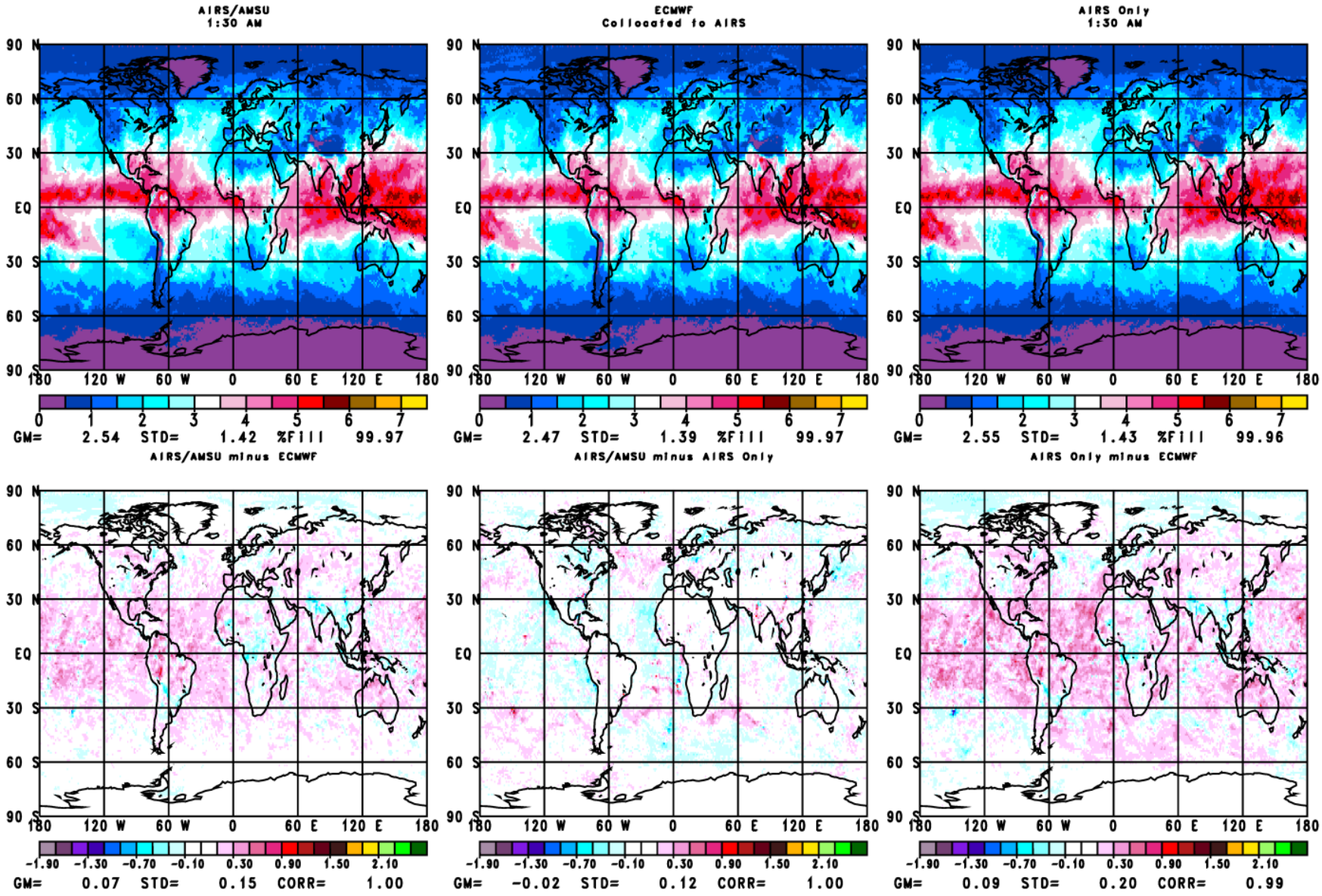
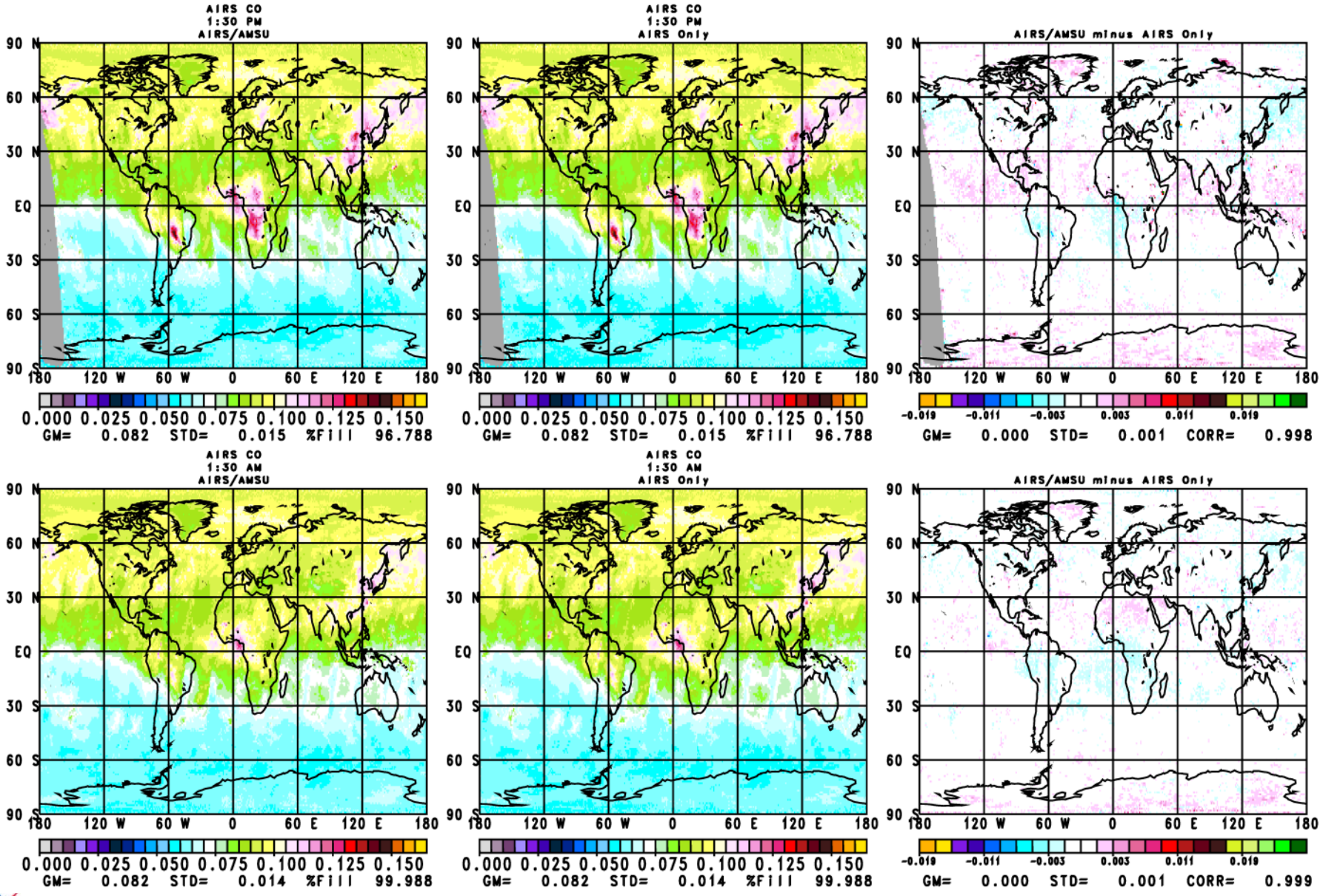
Clear Sky OLR (Watts/m²) 7-Days
V5.9.12 Old Water Channels
AIRS/AMSU vs AIRS Only



Total Precipitable Water (cm) 7-Days
V5.9.12 Old Water Channels
AIRS/AMSU vs AIRS Only



Total Precipitable Water (cm) 7-Days
V5.9.12 Old Water Channels
AIRS/AMSU vs AIRS Only



Trace Gases CO 7-Days
V5.9.12 Old Water Channels
AIRS/AMSU vs AIRS Only