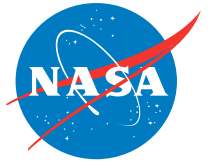


SRT STATUS AND PLANS FOR VERSION 6

Joel Susskind, John Blaisdell, Thomas Hearty, Lena Iredell, and Gyula Molnar

NASA GSFC Sounder Research Team (SRT)

AIRS Science Team Meeting

October 17, 2008

Greenbelt, Maryland

Priorities for Version 6 - As Shown in July 31 Net-Meeting

Immediate priorities

- Improved determination of surface skin temperature and spectral emissivity -- John Blaisdell

  Version 5.18, shown July 31, being implemented at JPL
  Current version called Version 5.20

- High spatial resolution retrievals -- Thomas Hearty
- Improved OLR RTA -- Gyula Molnar

Important for Version 6 - how much gets done depends on cutoff date

- Improved T(p), q(p) retrievals - especially over land
- Improved retrieval of cloud parameters
- More robust use of AMSU channels in case of future channel failures
- Improved QC
- Improved generation of level 3 products - especially for AIRS Only system

Important for Version 7 - probably not in time for Version 6

- Incorporation and testing of neural-net initialization
- Incorporation of dust into RTA - dust indicator will be part of Version 6, possibly used in error estimates

Modifications to July 31 viewgraph

Status of Implementation of Version 5.18 at JPL

There are five packages needed to go from Version 5.0 to Version 5.18

1. Change spectral hinge points to universal set of 39 in all steps
2. Change form of emissivity and reflectivity perturbation to multiplicative instead of additive
3. Add longwave emissivity retrieval step
4. Initialization of surface reflectivity
5. Namelist changes (channels, functions, damping)

Steps 1 and 2 are completely implemented and tested at JPL

Complete implementation and testing of all steps at JPL anticipated by October 30

Liens on Version 5.18

SST

Nighttime bias of SST versus ECMWF did not meet goals

Ocean Spectral Emissivity

Longwave

No longwave liens vs. Version 6 metrics

Shortwave

Spectral emissivity at nadir differed from Masuda by more than Version 6 metric

was greater than Version 6 metric

$\mathrm{MAX}\left|\varepsilon_{\mathrm{Day}}(\Theta) - \varepsilon_{\mathrm{Night}}(\Theta)\right|$ was greater than Version 6 metric

$\mathrm{MAX}\left|\varepsilon_{\mathrm{Day}}(\Theta) - \varepsilon_{\mathrm{Day}}(-\Theta)\right|$

Temperature Profile

Large data gaps existed in QC'd 1:30 PM 300 mb temperature (and land surface temperature) over desert during summer

% Accepted cases over land near surface was very low

Version 5.20 addresses all liens on version 5.18

Improved Spatial Coverage in T(p) Retrievals Over Land

Level 3 products beneath 300 mb, including land surface parameters, are generated if $p_{best} \geq 300$ mb

Over hot land (1:30 PM summer deserts), p_{best} was < 300 mb - data gaps occurred in level-3

This was a result of two problems

1) 4 longwave channels sensitive to the surface were included in second pass T(p) retrieval
   Very poor T(p) retrievals resulted over hot land - retrievals should be rejected by QC

   These 4 channels were removed - T(p) retrievals were now good but still rejected by QC

2) T(p) QC methodology to determine p_{best} was conceptually flawed

   300 mb error estimates $\delta T(p)$ were small but p_{best} was set at 100 mb

   100 mb T(p) error estimates $\delta T(p)$ were large, as was 100 mb temperature errors

   - bad tropopause temp

   Old methodology sets p_{best} equal to the top of a layer in which $\delta T(p) >$ threshold for 3/4 km

Improved Spatial Coverage in T(p) Retrievals Over Land (continued)

Concept was based on the thought that problems are due to clouds - get worse as you get closer to the surface (3/4 km should be a good test)

Improved methodology allows for a tropopause error

p_{best} set equal to top of a 2 km layer with $\delta T(p) >$ threshold

Hot land data gaps disappeared with change of p_{best} methodology

Now we could tighten land $\delta T(p)$ mid-tropospheric temperature thresholds to get better QC and loosen surface temperature thresholds to improve yield near surface

Poor tropopause temperatures over hot tropical land were improved somewhat by adding 15 μm lower stratospheric sounding channels - 4.2 μm channels have low signal at cold tropopause

Changes Affecting Surface Skin Parameters

- T_{surf} and $\varepsilon_{SW}(\nu)$ are updated in T(p) retrieval step

  Removing 4 temp 2 channels and adding 15 μm channels in T(p) retrieval affected T_s and $\varepsilon_{SW}(\nu)$

  Both made T_s warmer

- In addition, longwave window cloud clearing channels extending to 1228 cm^{-1} were added in the cloud clearing and cloud retrieval steps

  Addition of cloud clearing channels also made T_s warmer

- In Version 5.18, damping in surface parameter retrieval was decreased from Version 5.0

  This lessened the negative bias in ocean T_s versus ECMWF

  This also allowed shortwave emissivity to differ more from first guess (Masuda)

- In Version 5.20, damping could be increased in T_s retrieval because retrievals became warmer

  Improved SST accuracy and improved shortwave ocean spectral emissivity

Changes from Version 5.18 to Version 5.20 – all namelist

- Deleted 4 temp 2 retrieval channels: 1238.11 cm^{-1}, 1239.16 cm^{-1}, 1251.36 cm^{-1}, 1285.48 cm^{-1}

- Added 12 stratospheric sounding 15 μm channels between lines 662.02 cm^{-1} - 699.38 cm^{-1}

- Added 11 longwave window cloud clearing and cloud retrieval channels 773.28 cm^{-1} - 1227.70 cm^{-1}

  These channels will also be used to determine cloud spectral emissivity

  Currently no window channels are used over land for cloud clearing or cloud retrieval

  This will be re-evaluated in future experiments

- Damping was decreased both day and night in surface parameter retrieval step

- A modification was made in the definition of % yield in T(p) retrieval over elevated terrain

  Up to Version 5.18, %(p) is number with good T(p) divided by the number of retrievals

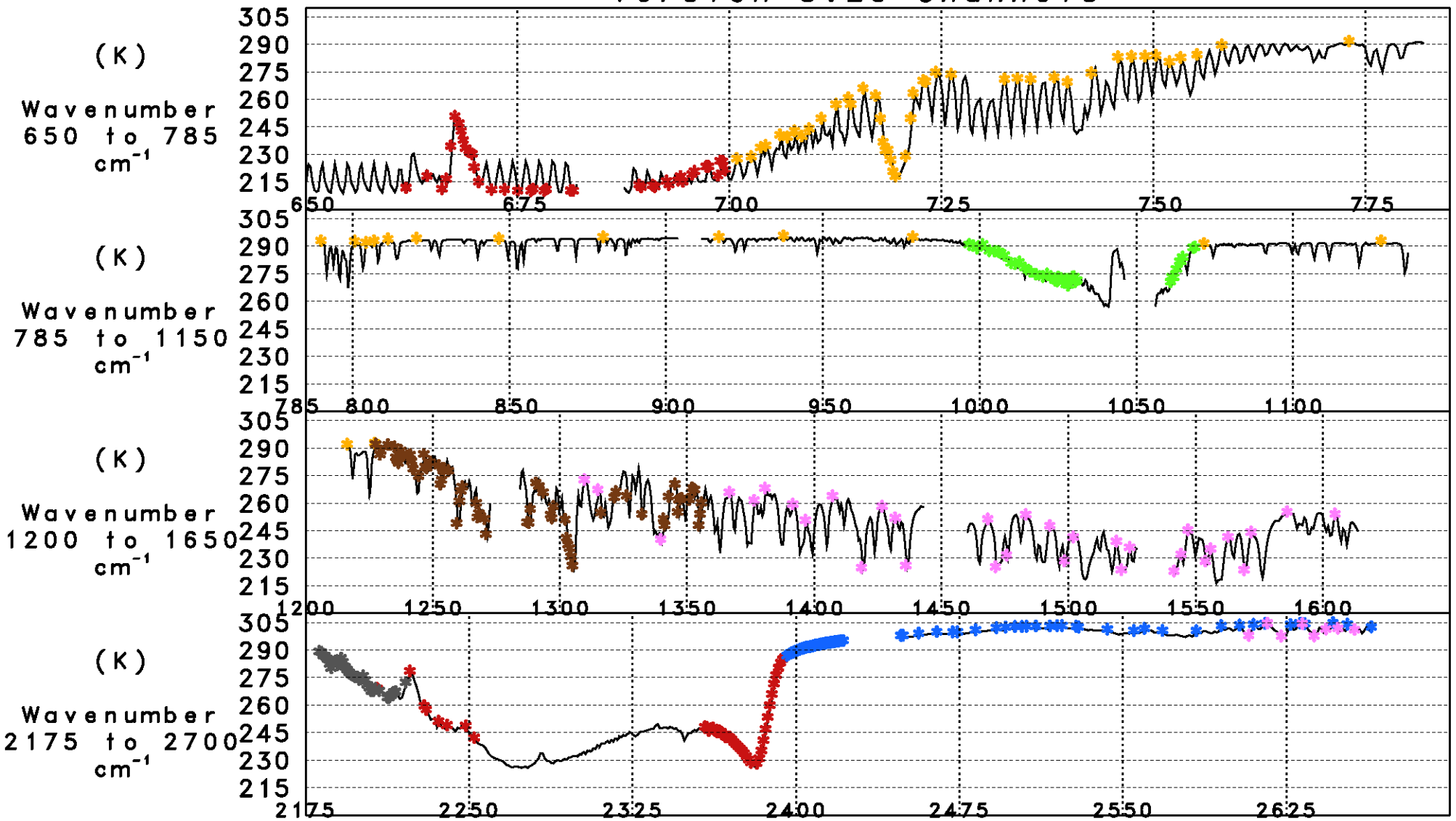
  In 5.20 %(p) is number with good T(p) divided by the number of cases having $p_{surf} \geq p$

  This does not affect RMS errors - only % yield

- New diagnostic - spatial plot showing layer mean results for lowest 1 km (4 layers)

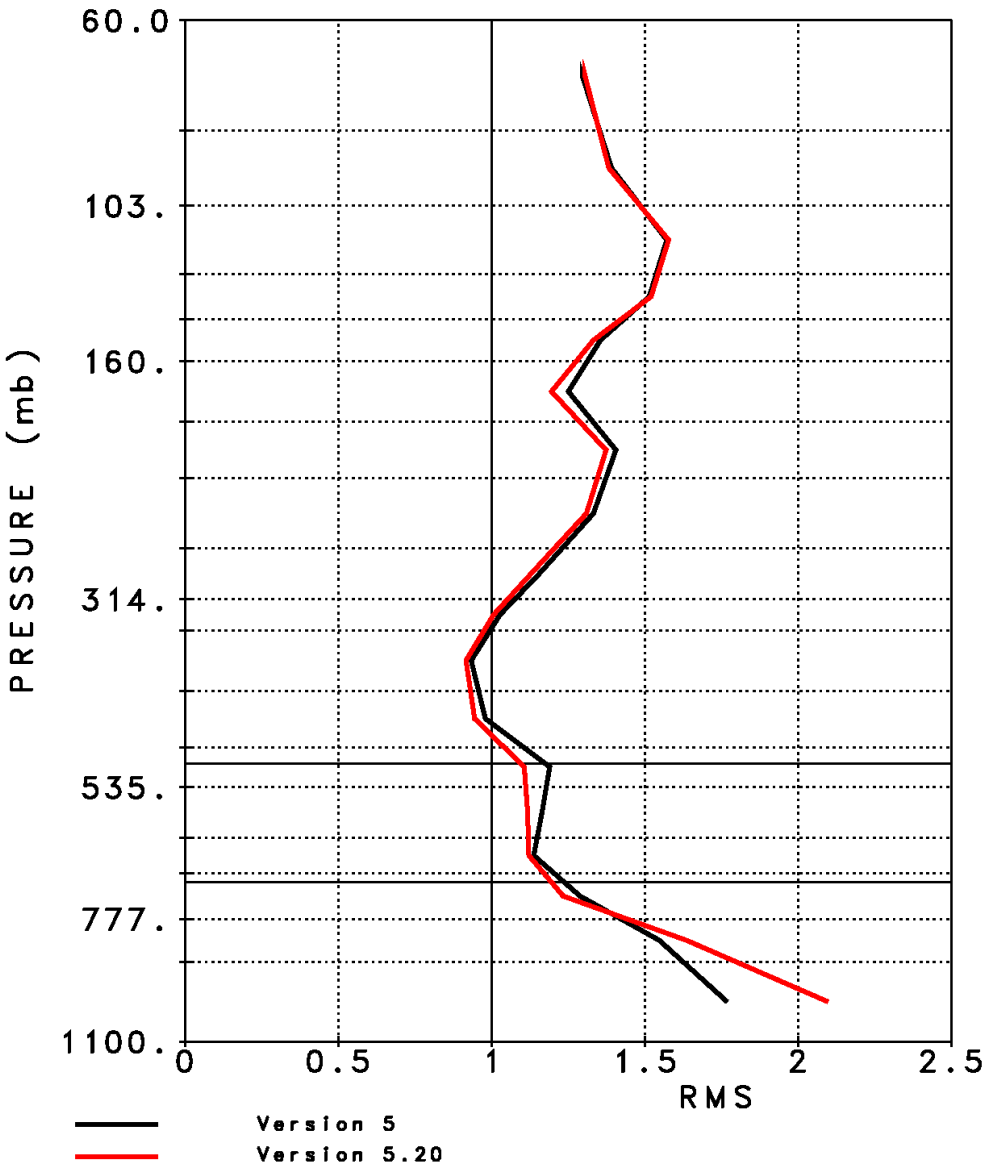
  Plot of results at 1000 mb masks performance over most land with elevated terrain

Sample AIRS Cloud Free Brightness Temperature Version-5.20 Channels

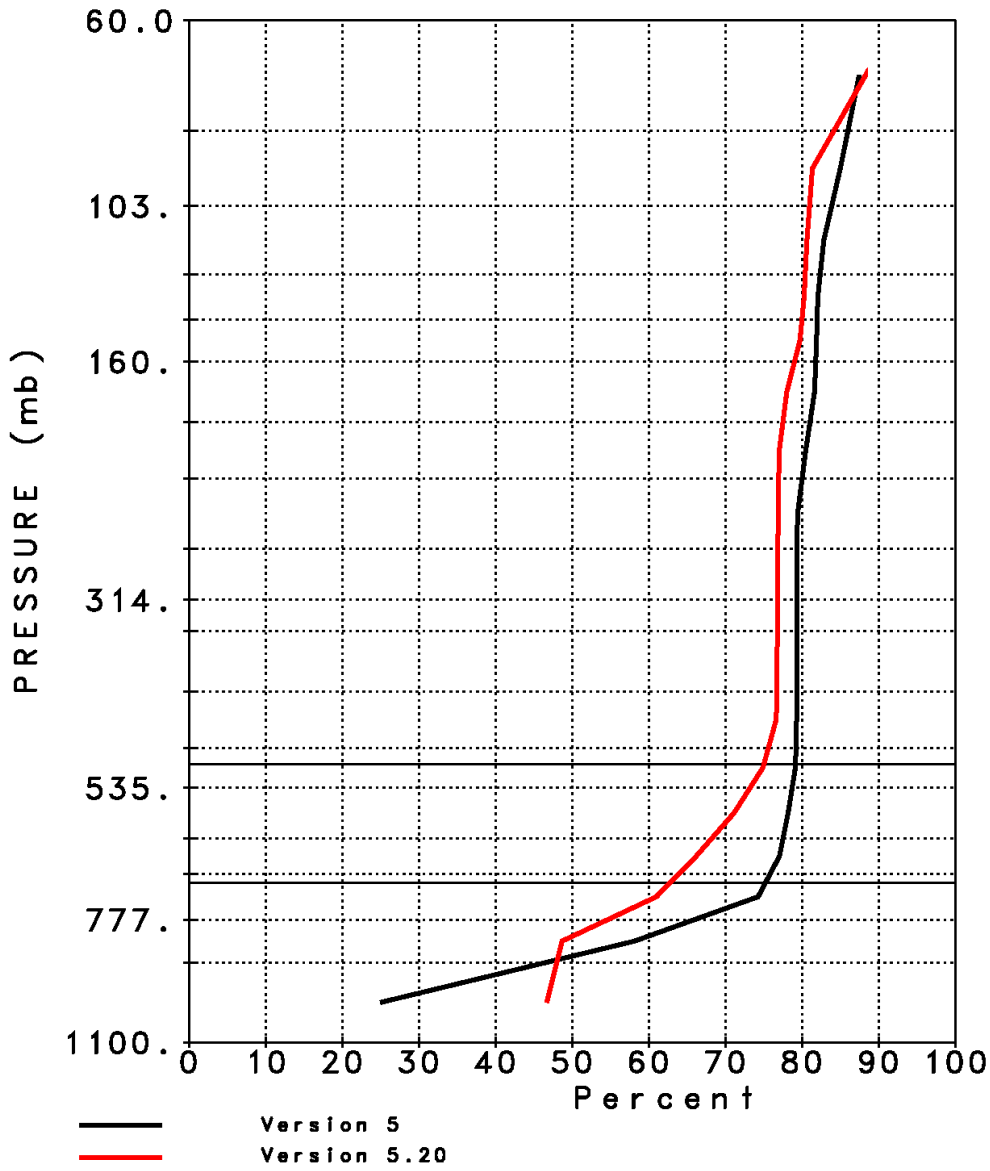


*Temperature Profile *Surface Skin *Cloud Clearing
*Water Vapor *Ozone *CO
*CH_4

LAYER MEAN RMS TEMPERATURE (°C)
Differences from ECMWF
Sep 6, 2002, January 25, 2003, and Sep 29, 2004
50N to 50S Non-Ocean

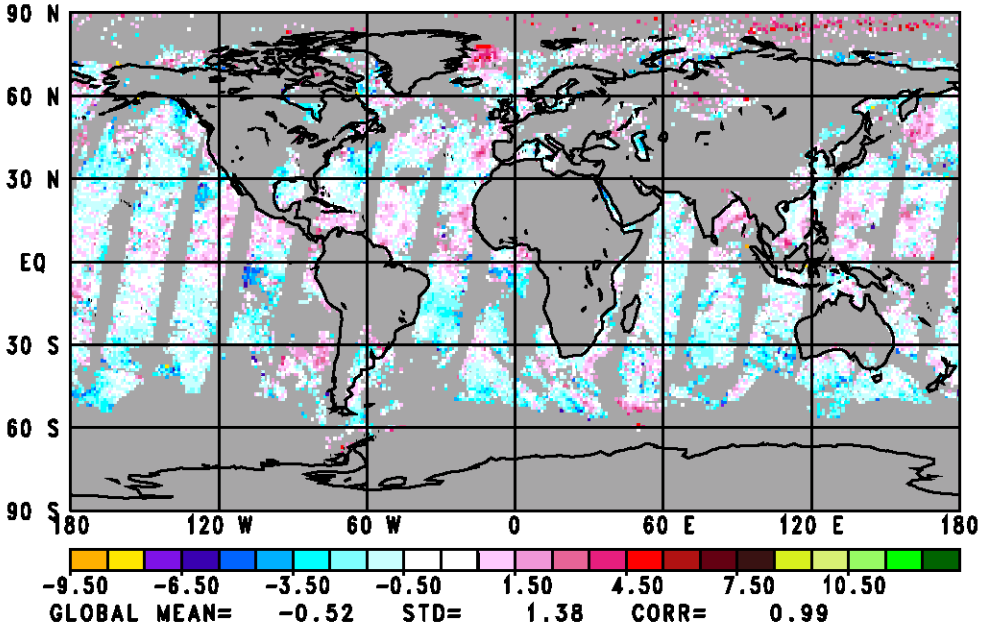


Percent of All Cases Included
Differences from ECMWF
Sep 6, 2002, January 25, 2003, and Sep 29, 2004
50N to 50S Non-Ocean

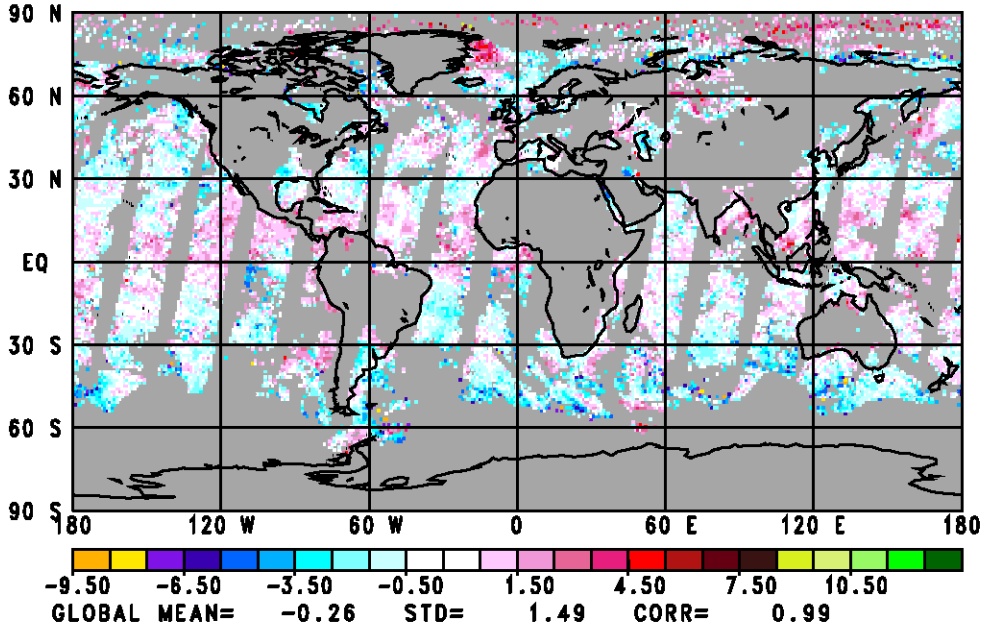


September 29, 2004 1:30 AM
Difference from ECMWF

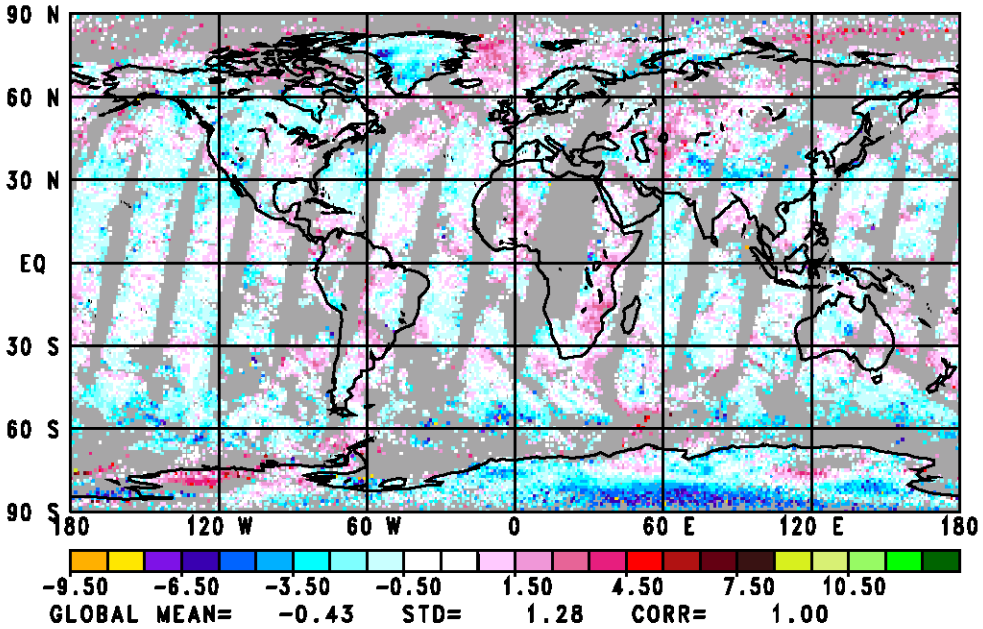
1000 mb
Version 5.0



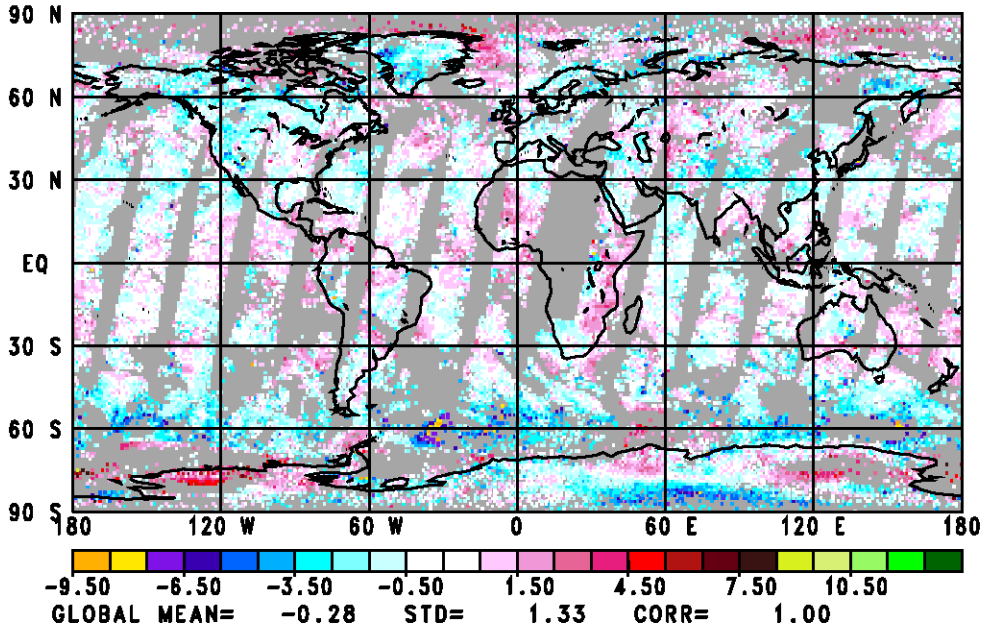
1000 mb
Version 5.20



Boundary Layer
Version 5.0

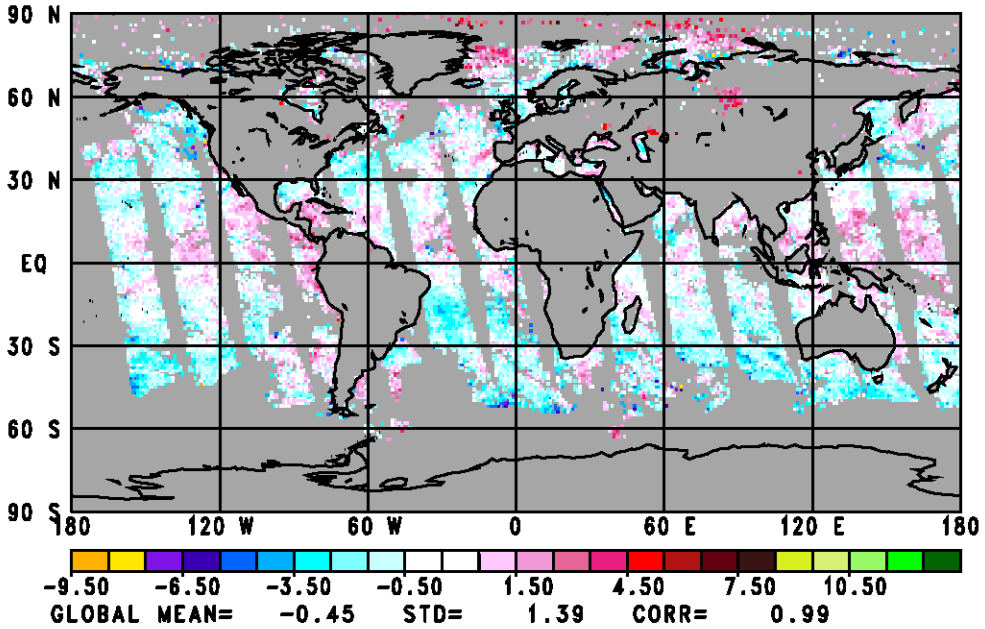


Boundary Layer
Version 5.20

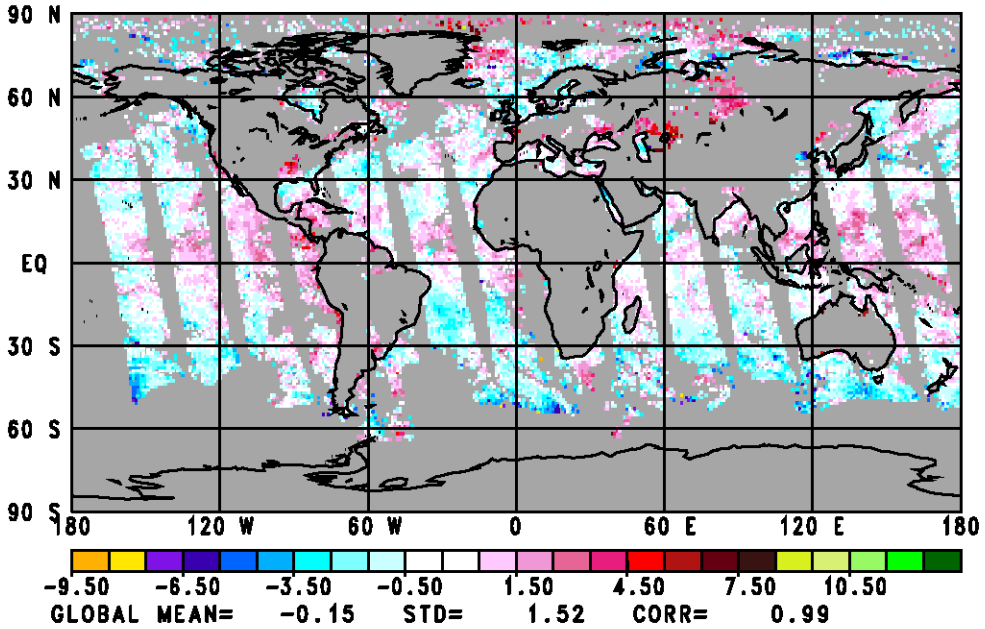


September 29, 2004 1:30 PM
Difference from ECMWF

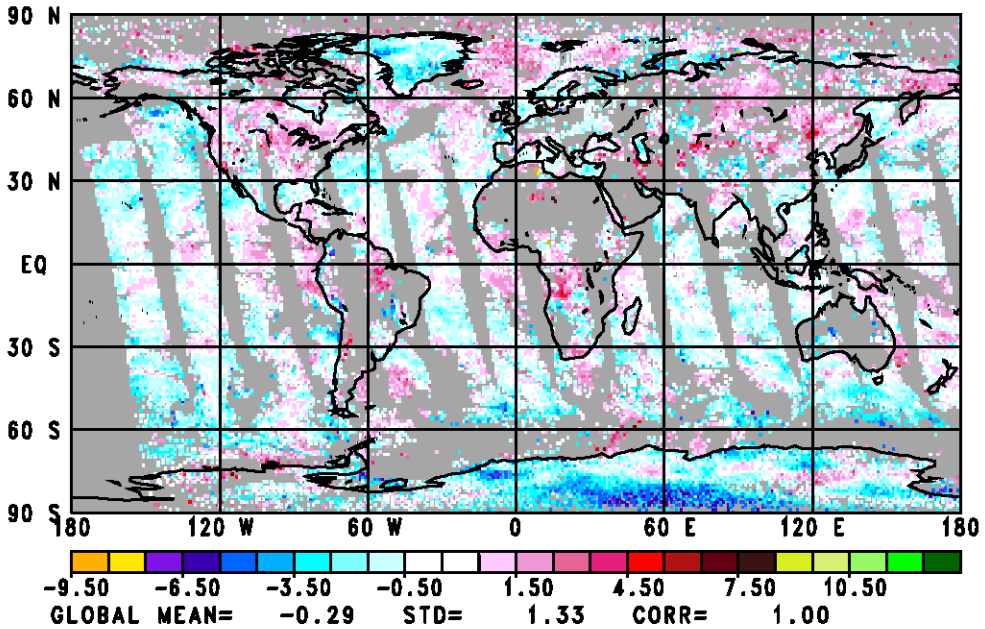
1000 mb
Version 5.0



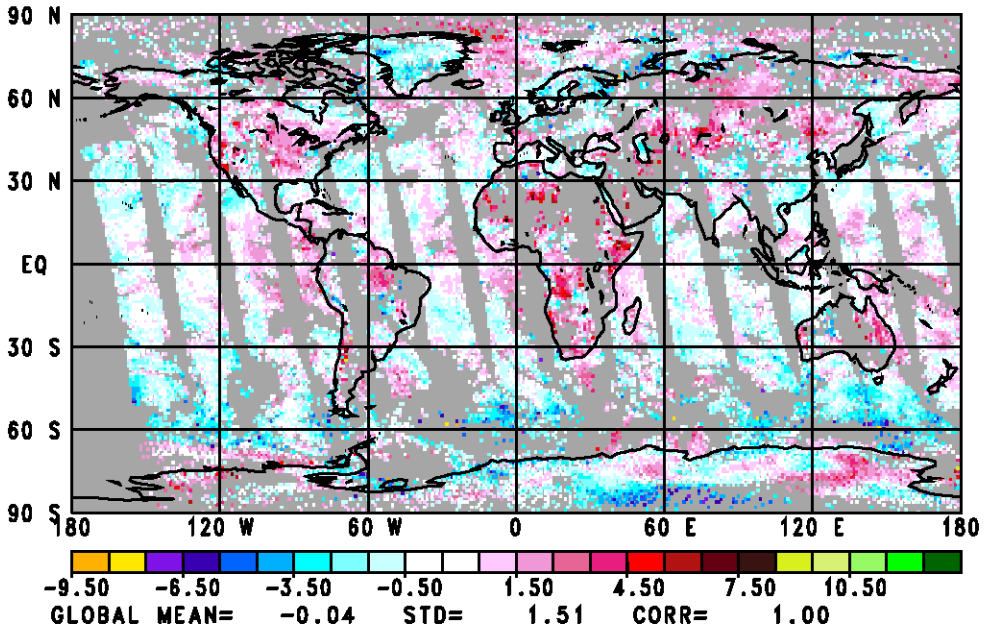
1000 mb
Version 5.20

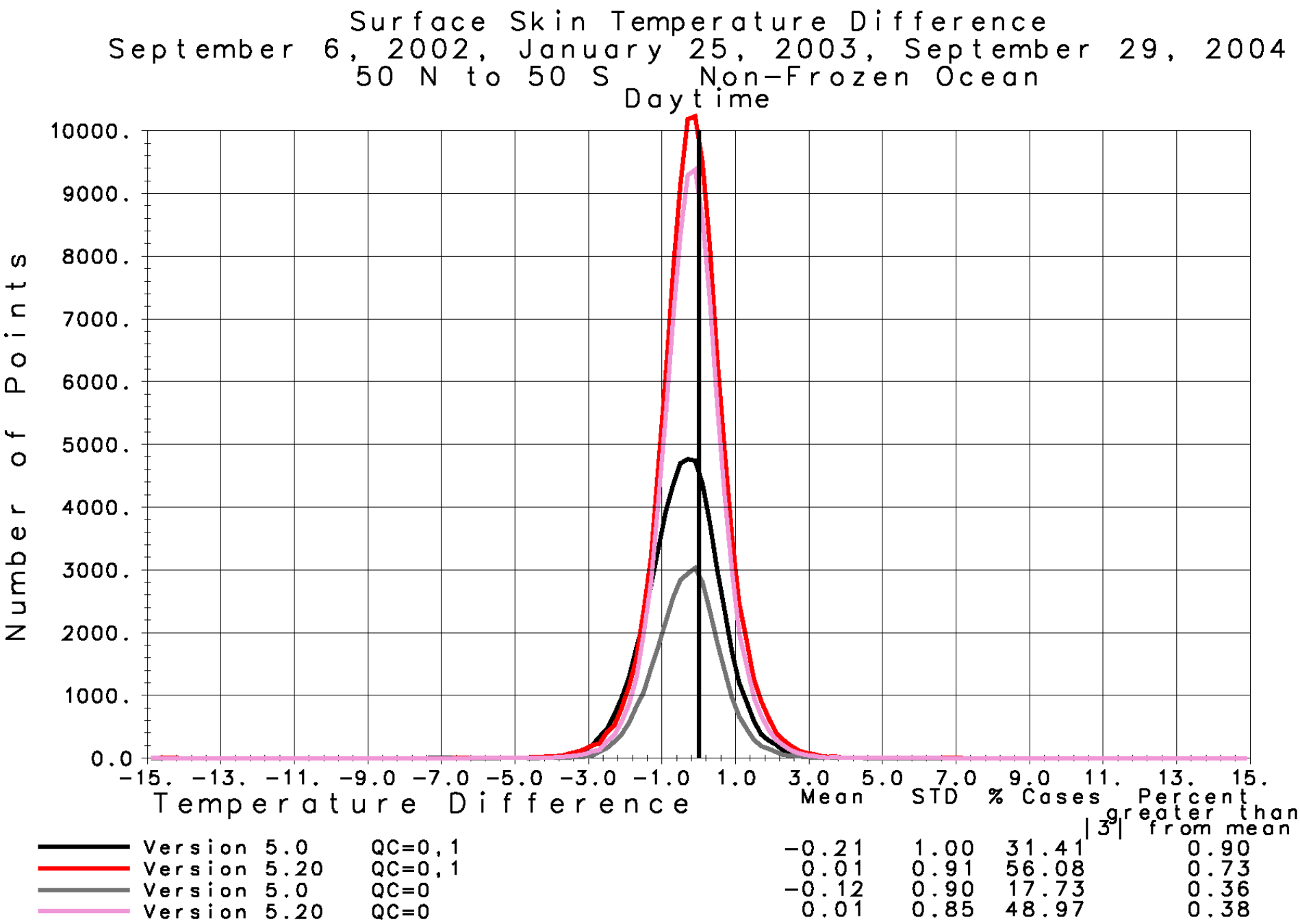


Boundary Layer
Version 5.0



Boundary Layer
Version 5.20

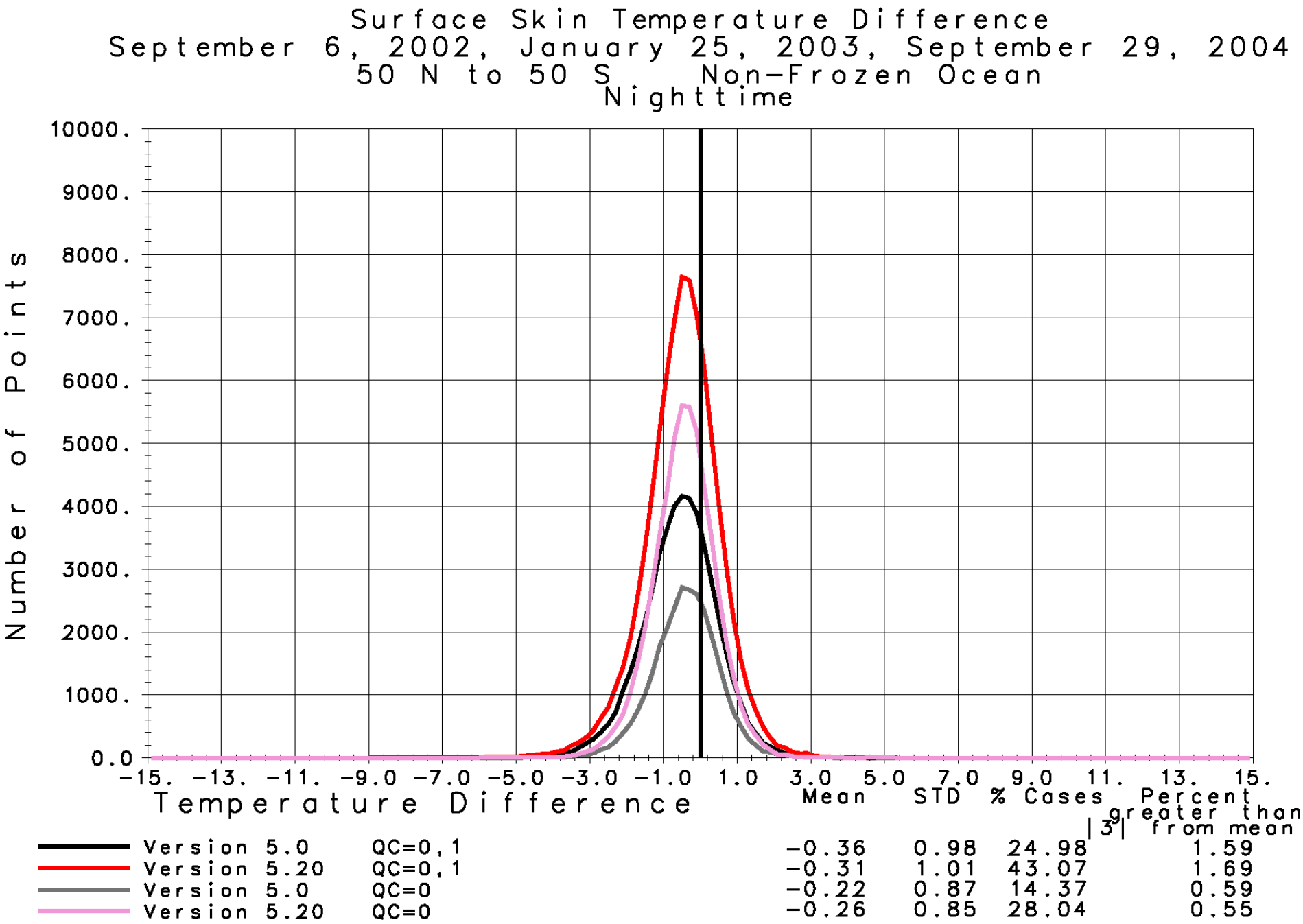



Surface Skin Temperature Difference
September 6, 2002, January 25, 2003, September 29, 2004
50 N to 50 S Non-Frozen Ocean
Daytime
Number of Points
10000.
9000.
8000.
7000.
6000.
5000.
4000.
3000.
2000.
1000.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent greater than |3| from mean
Version 5.0 QC=0,1 -0.21 1.00 31.41 0.90
Version 5.20 QC=0,1 0.01 0.91 56.08 0.73
Version 5.0 QC=0 -0.12 0.90 17.73 0.36
Version 5.20 QC=0 0.01 0.85 48.97 0.38

Metrics for Improved Daytime Ocean Skin Temperature

		% Accepted	% Outliers	Bias (K) vs. ECMWF
Version 5	QC = 0	18%	0.36%	-0.12
Version 5	QC = 0, 1	31%	0.90%	-0.21
Version 5.20	QC = 0	49%	0.38%	0.01
Version 5.20	QC = 0, 1	56%	0.73%	0.01
Version 6 Goal	QC = 0	30%	0.50%	-0.15
Version 6 Goal	QC = 0, 1	50%	1.00%	-0.20

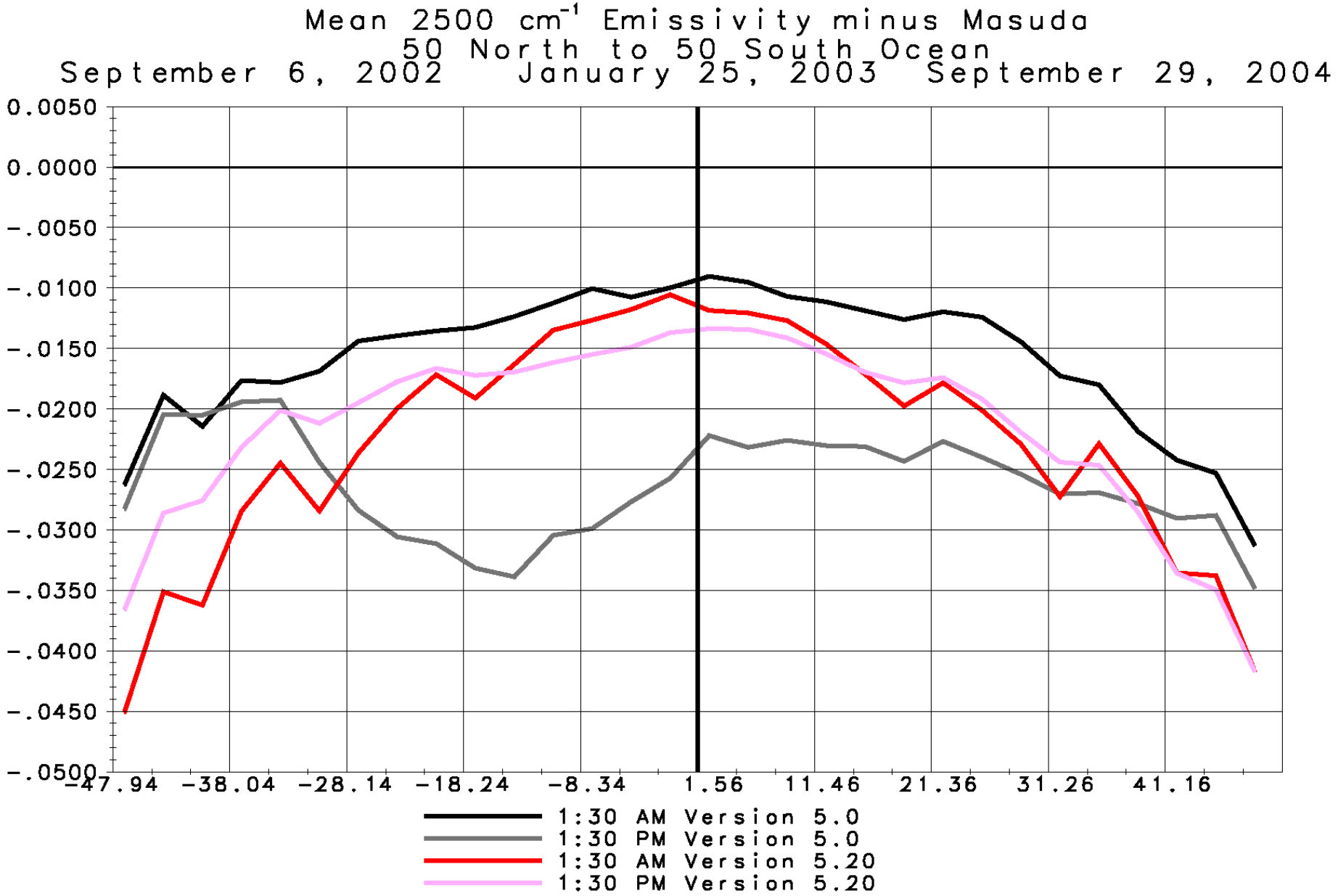
Version 5.20 performance exceeds all goals with higher yield

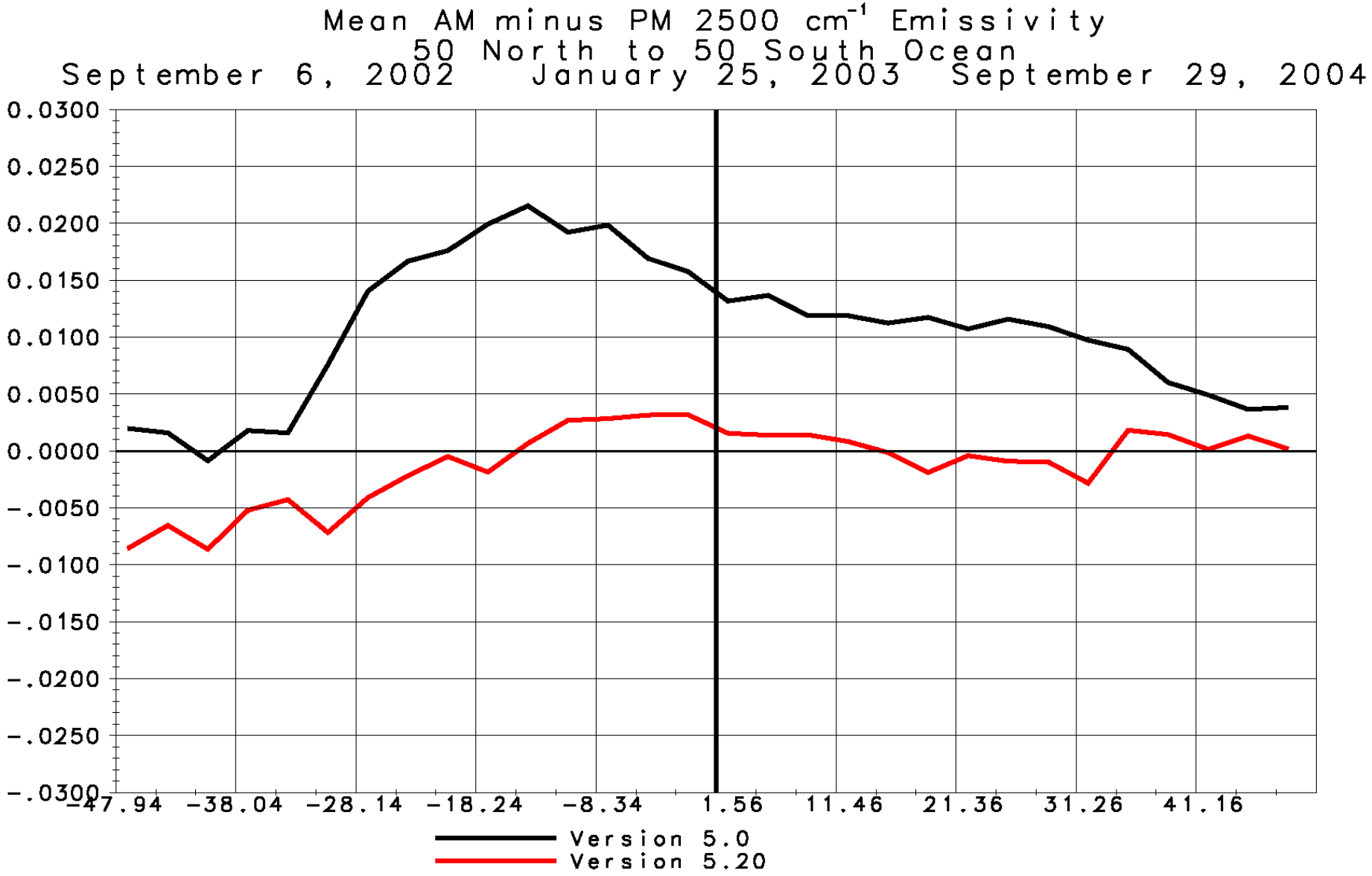

Surface Skin Temperature Difference
September 6, 2002, January 25, 2003, September 29, 2004
50 N to 50 S Non-Frozen Ocean
Nighttime
Number of Points
10000.
9000.
8000.
7000.
6000.
5000.
4000.
3000.
2000.
1000.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent greater than |3| from mean
Version 5.0 QC=0,1 -0.36 0.98 24.98 1.59
Version 5.20 QC=0,1 -0.31 1.01 43.07 1.69
Version 5.0 QC=0 -0.22 0.87 14.37 0.59
Version 5.20 QC=0 -0.26 0.85 28.04 0.55

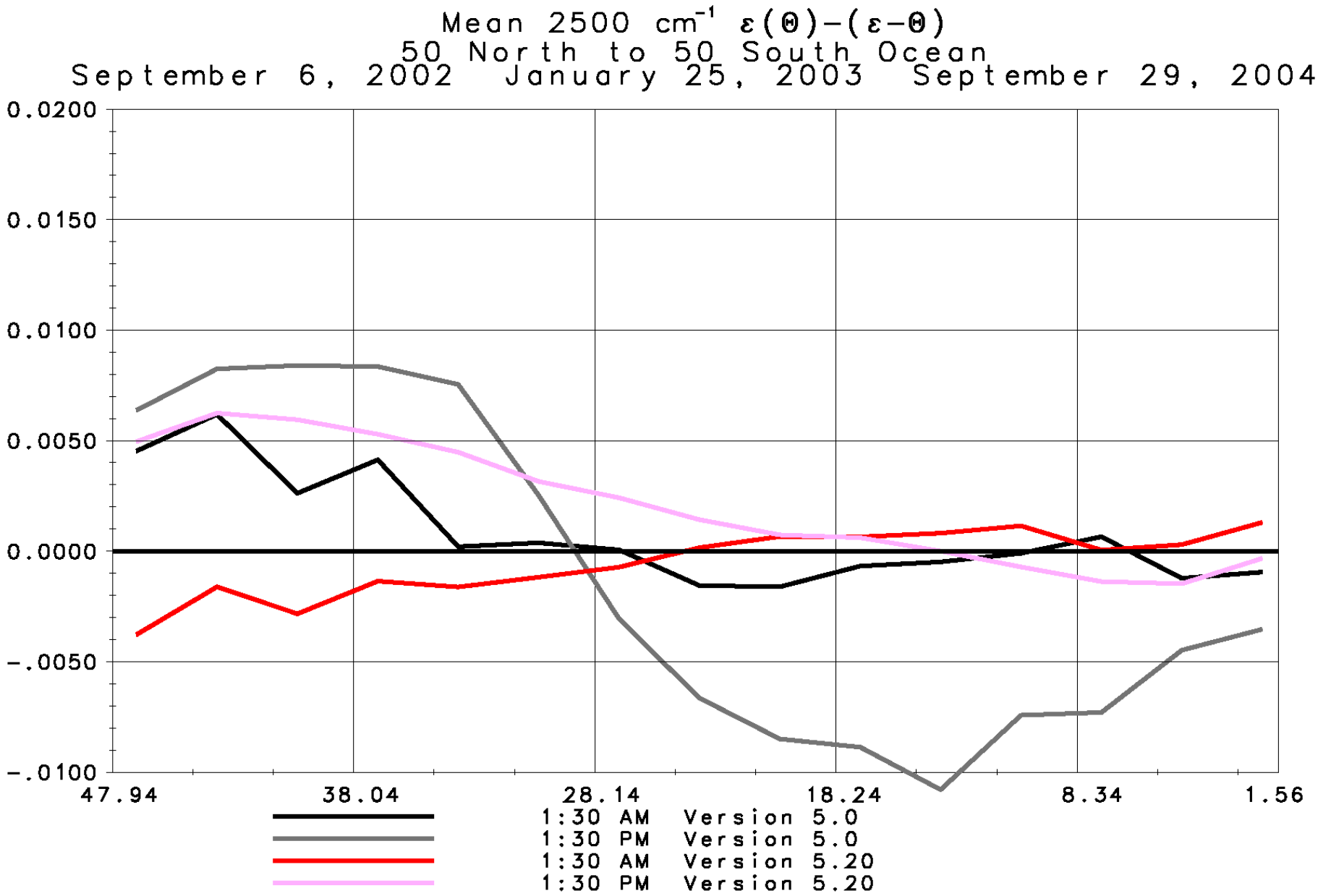
Metrics for Improved Nighttime Ocean Skin Temperature

		% Accepted	% Outliers	Bias (K) vs. ECMWF
Version 5	QC = 0	14%	0.59%	-.22
Version 5	QC = 0, 1	25%	1.59%	-.36
Version 5.20	QC = 0	28%	0.55%	-.26
Version 5.20	QC = 0, 1	43%	1.69%	-.31
Version 6 Goal	QC = 0	25%	1.00%	-.25
Version 6 Goal	QC = 0, 1	40%	2.00%	-.30

Version 5.20 performance exceeds goals for outliers with higher yield
Version 5.20 performance essentially meets goals for biases


Mean 2500 cm-1 Emissivity minus Masuda
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
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
1:30 AM Version 5.0
1:30 PM Version 5.0
1:30 AM Version 5.20
1:30 PM Version 5.20


Mean AM minus PM 2500 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
0.0300
0.0250
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
Version 5.0
Version 5.20


Mean 2500 cm^{-1} ε(Θ)−(ε−Θ)
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
0.0200
0.0150
0.0100
0.0050
0.0000
−.0050
−.0100
47.94
38.04
28.14
18.24
8.34
1.56
1:30 AM Version 5.0
1:30 PM Version 5.0
1:30 AM Version 5.20
1:30 PM Version 5.20

Metrics for Improved Ocean Spectral Emissivity

950 cm^{-1}	$\varepsilon_N(0)-\varepsilon_{MAS}0$	$\varepsilon_D(0)-\varepsilon_{MAS}0$	MAX $\lvert\varepsilon_N(\Theta)-\varepsilon_D(\Theta)\rvert$	MAX $\lvert\varepsilon_D(\Theta)-\varepsilon_D(-\Theta)\rvert$
Version 5	-.007	- .006	.009	.015
Version 5.20	-.001	- .001	.001	.001
Version 6 Goal	-.002	- .002	.006	.010
2500 cm^{-1}	$\varepsilon_N(0)-\varepsilon_{MAS}0$	$\varepsilon_D(0)-\varepsilon_{MAS}0$	MAX $\lvert\varepsilon_N(\Theta)-\varepsilon_D(\Theta)\rvert$	MAX $\lvert\varepsilon_D(\Theta)-\varepsilon_D(-\Theta)\rvert$
Version 5	-.010	- .023	.022	.011
Version 5.20	-.012	-.014	.008	.006
Version 6 Goal	-.005	-0.10	.008	.006

Version 5.20 performance exceeds all emissivity metrics at 950 cm^{-1}
Version 5.20 performance meets most all metrics at 2500 cm^{-1}
Version 5.20 emissivity difference from Masuda at nadir does not meet Version 6 goals

Improved OLR RTA

Version 5 OLR RTA is more than 20 years old – used with TOVS data

RTA coefficients were generated by me - was state of art at that time

Limitations of Version 5 OLR RTA

- Version 5 OLR is biased about 8 Wm^{-2} too high compared to CERES
- Version 5 OLR RTA does not allow for variable CO_2 concentrations

We have incorporated the AER OLR RTA into the Version 6 processing system

AER OLR RTA is used to compute OLR in conjunction with Version 5 AIRS products

- Major difference is in the OLR parameterization of H_2O absorption
- Use of AER OLR RTA removes the 8 Wm^{-2} ORL bias compared to CERES
- AER OLR RTA allows for variable CO_2 as well as other trace gas concentrations

An accurate OLR product computed using AIRS products enhances the value of the other AIRS products

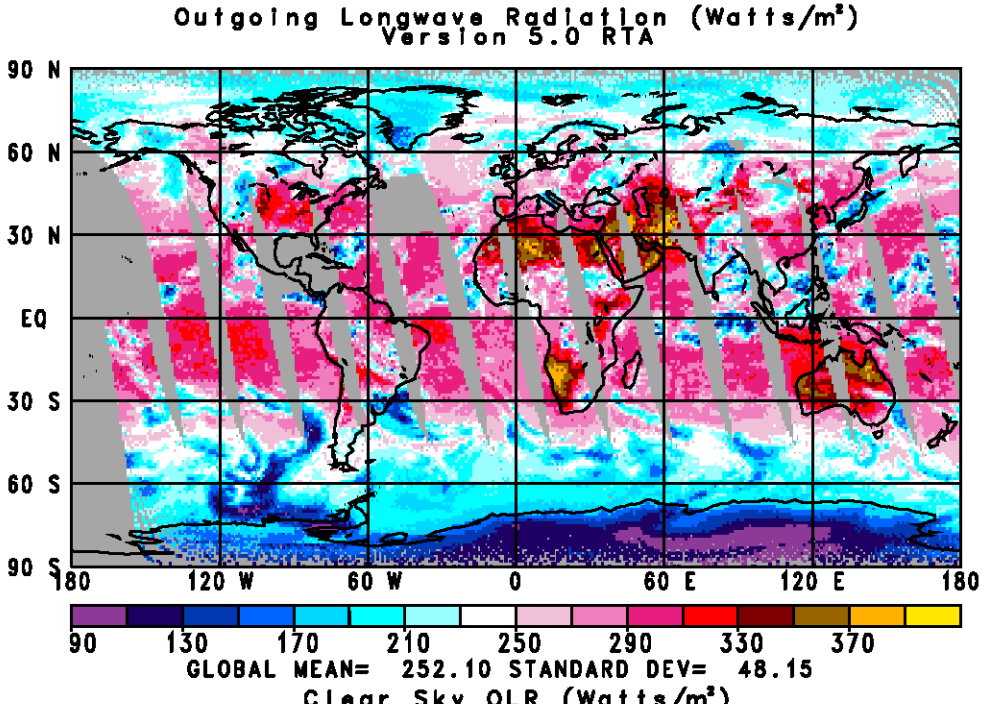
Use of AER OLR code increases level 2 processing time by 26% (called twice)

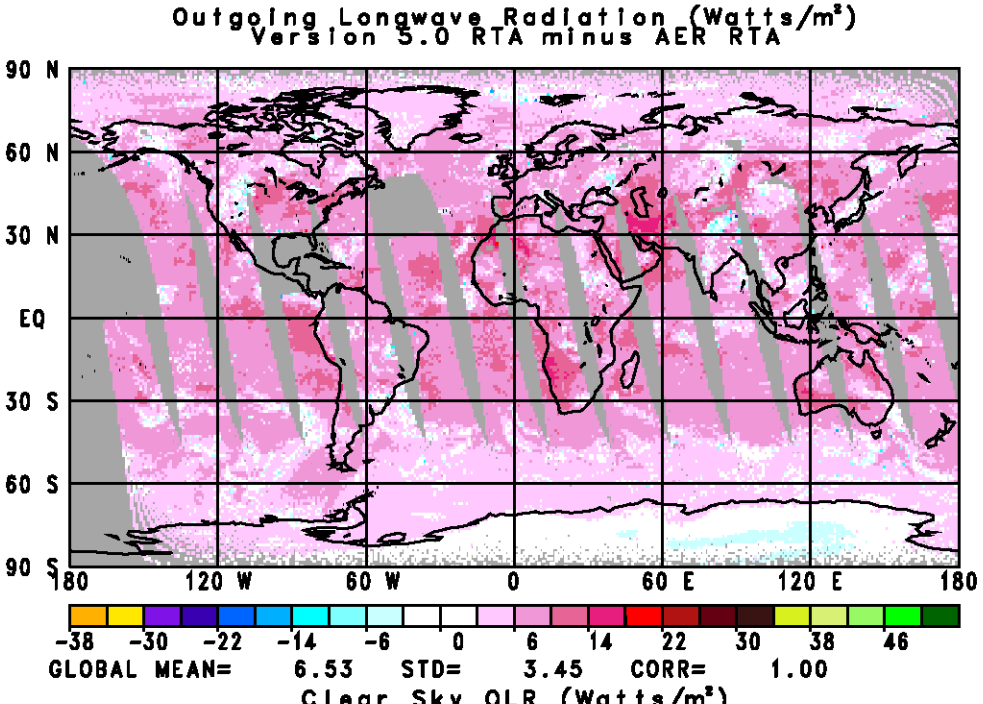
Can be reduced to 13% by some changes in infra-structure – only 1 call needed

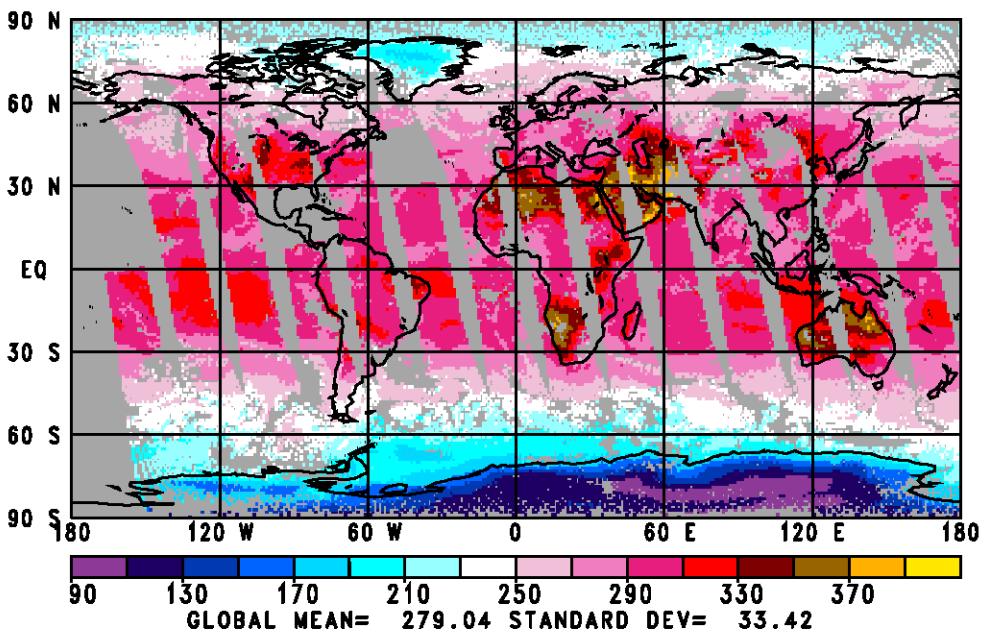
Possible Concern

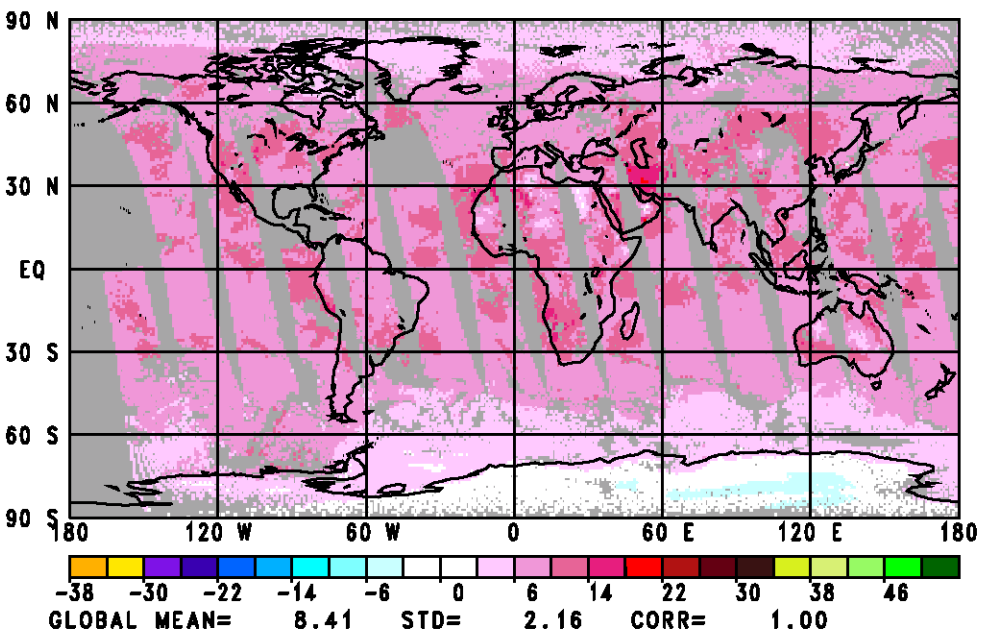
AER OLR code is similar in size to rest of level 2 code

September 6, 2002 1:30 PM









High Spatial Resolution Retrievals

High spatial resolution retrievals were run using Version 5.20 – 5.20HR

One retrieval is performed for a 1 (cross track) x 3 (along track) array of AIRS spots

Three retrievals performed for each 3 x 3 AIRS golfball

Level 2 processing takes 3 times as long

Everything is the same as 3 x 3 retrieval but no local zenith angle correction is applied

Solve for up to 2 values of η per 1 x 3 retrieval (up to 4 values solved for in 3 x 3 retrieval)

QC applied separately to each 1 x 3 retrieval

All retrievals are written out (3 times as much level 2 data)

Version 5.20HR SST's have a smaller standard deviation of errors and % outliers than Version 5.20 compared to ECMWF

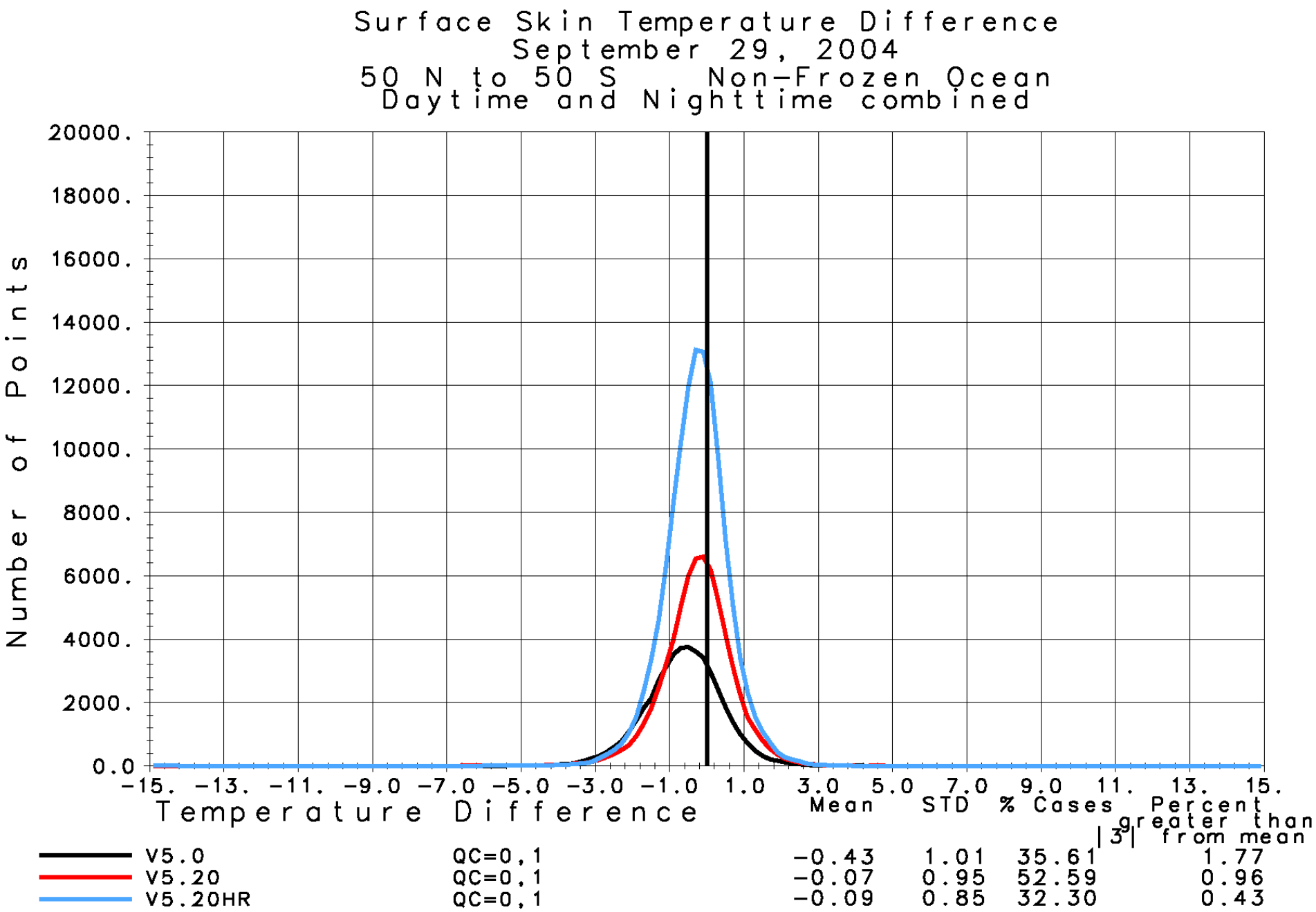
% yield is misleading because there are 3 times as many cases to try in Version 5.20HR

Many more high quality retrievals are performed compared to outliers in Version 5.20HR

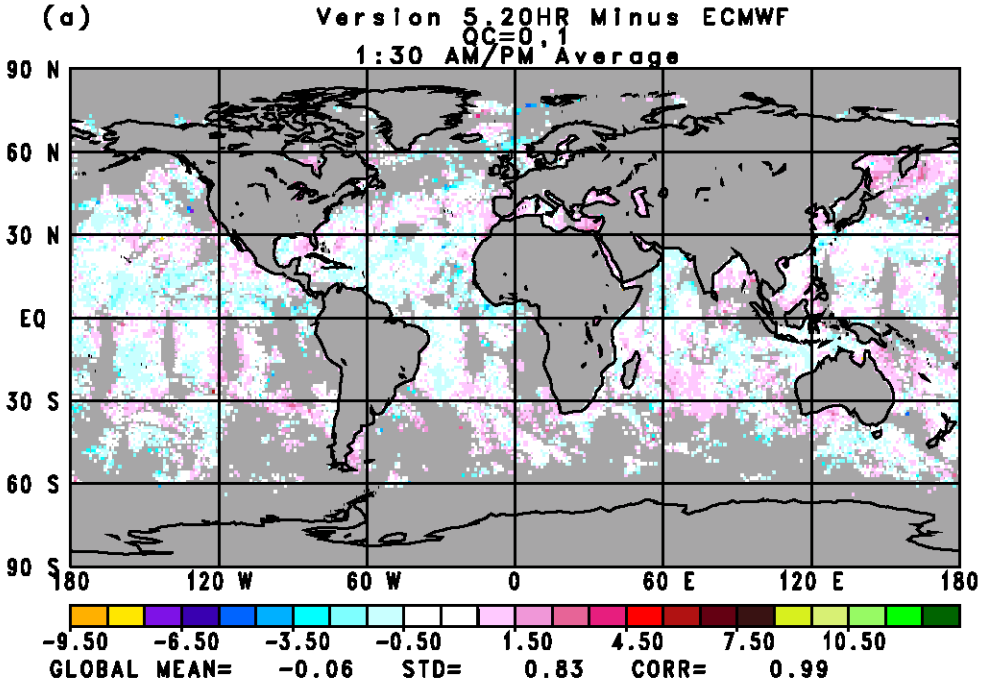
More research is needed to assess improvement of T(p), especially over land

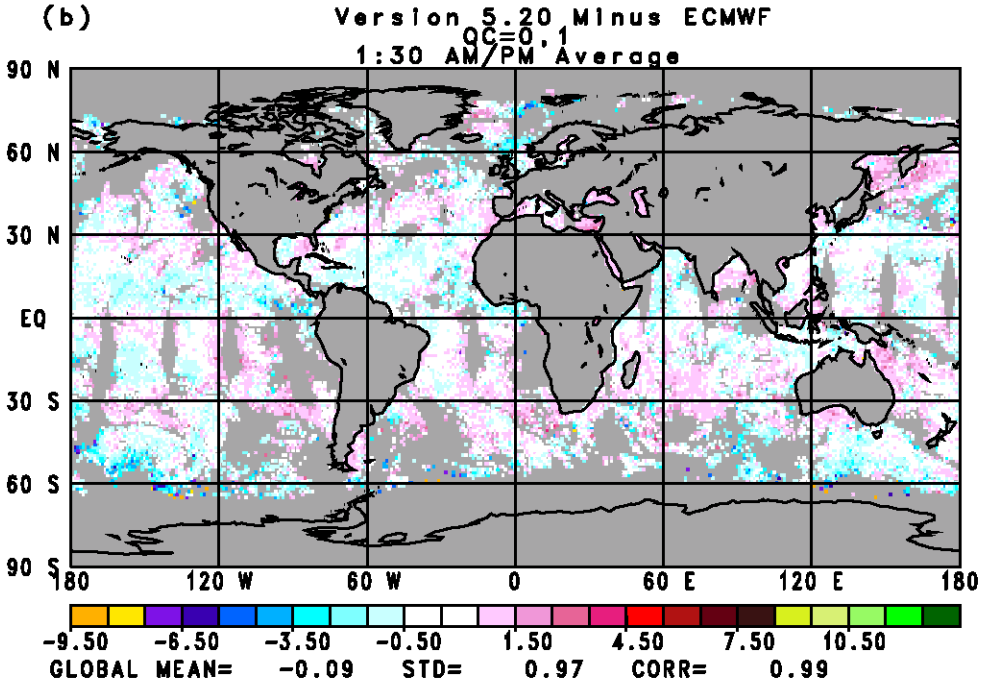
Do these improvements justify the extra processing time and data output?

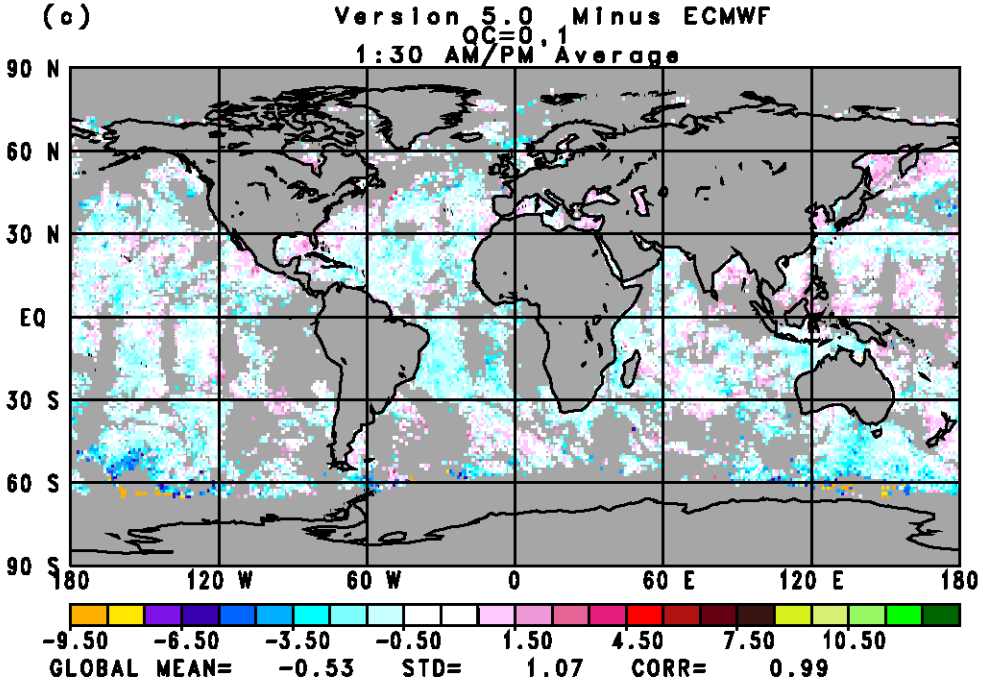
We will study this further and give a final recommendation in a November Net-Meeting

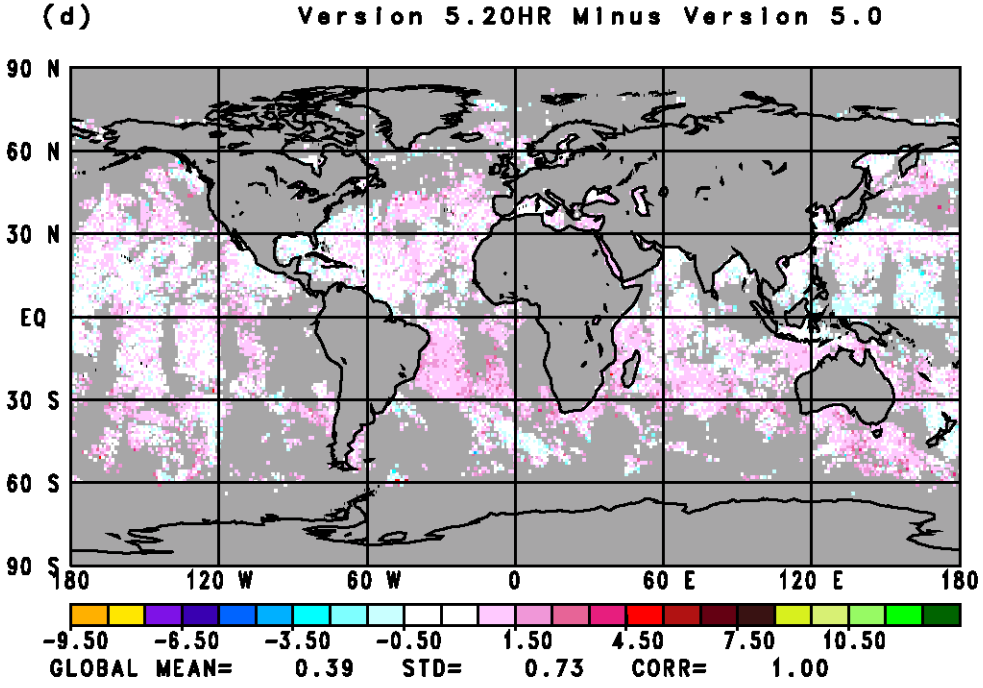

Surface Skin Temperature Difference
September 29, 2004
50 N to 50 S Non-Frozen Ocean
Daytime and Nighttime combined
Number of Points
20000.
18000.
16000.
14000.
12000.
10000.
8000.
6000.
4000.
2000.
0.0
-15. -13. -11. -9.0 -7.0 -5.0 -3.0 -1.0 1.0 3.0 5.0 7.0 9.0 11. 13. 15.
Temperature Difference
Mean STD % Cases Percent greater than |3| from mean
V5.0 QC=0,1 -0.43 1.01 35.61 1.77
V5.20 QC=0,1 -0.07 0.95 52.59 0.96
V5.20HR QC=0,1 -0.09 0.85 32.30 0.43

Surface Skin Temperature (K)
September 29, 2004









Improved QC and Level 3 Products

QC Flags

Products are assigned QC flags 0, 1, and 2

0 means best quality - use for data assimilation and generation of Level 3

1 means good quality - use for generation of Level 3

2 means don't use

Data assimilation tests with Version 5 showed QC=0 is too loose

Examination of Level 3 products shows QC=1 needs more study

QC=1 recipe for Version 5 AO is particularly poor - needs more study

Level 3 Products

Related to QC=1 flags above

For temperature profiles right now, QC is set to zero at some levels, 2 at others

Probably better to use or reject entire profile for level 3 products

Other issues

- Currently average all level 2 products falling into a given 1° x 1° grid box to generate Level 3

Weighting level 2 products into different 1° x 1° grids according to distance might be better

- Resolve the question about whether to include or exclude coasts in Level 3 gridding

New QC Flags - Suggested by Evan Manning

Evan pointed out that current QC flags are confusing to most users

Version 5 QC flag structure was designed to be identical to Version 4

- Three T(p) QC flags - analogous to Stratosphere, Mid-Troposphere, Lower Troposphere
- One Constituent QC flag for each constituent
- One clear column radiance flag for all channels
- Etc.

Currently all Standard Products have a value and error estimate

Evan suggested all Standard Products should have their own QC flag as well

- In this context, we can point out that 100 mb temperature is poor but 300 mb is good

We do not plan to eliminate the words p_{best} or p_{good}

Channel clear column radiances should each have their own flag as well

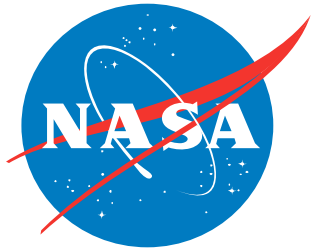
Improvements in q(p) and Clouds

Water Vapor Profile Retrieval - not looked at for a long time

- Re-examine use of channels, functions (more vertical functions is probably better), damping
- Assess the utility of a second pass q(p) retrieval
  - We now have better surface emissivity over land in second pass

Cloud Parameter Retrieval

- Improve stability of cloud parameter retrievals - retrieves $\alpha\varepsilon, p_c$
  - Sometimes get spurious clouds near surface and tropopause
- Determine cloud spectral emissivity ratio $\alpha\varepsilon_\nu / \alpha\varepsilon_{850\,cm^{-1}}$ for upper level clouds
- Understand and correct source of (possibly) spurious Version 5 cloud fraction trend $\approx$ 0.2% per year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