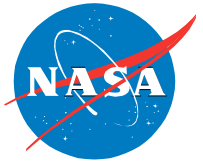


STATUS AND PLANS FOR VERSION 6

Joel Susskind

GSFC Sounder Research Team

AIRS Science Team Meeting

Greenbelt, MD

October 2007

Current Overall Status

Roses 2006 AIRS climate proposal is funded

- Funding level TBD

Still awaiting notification about Upgrade and Maintenance proposal

Fricky Keita became ill in May 2007 - returned to Senegal

- This slowed down progress
- Thomas Hearty joined us September 17 to replace Fricky

Basic plans for new development are unchanged from June 20, 2007 NET meeting

- In addition, we will implement and test improvements made by other groups

Results shown represent current status - as of 10/01/07

Areas of Planned Improvement - As Shown June 20, 2007

- Surface temperature and spectral emissivity
- Temperature-moisture-ozone profiles, especially over land

  Examine continued need for regression state
- Error estimates and quality flags (Fricky)
- High spatial resolution retrievals (Fricky)
- Cloud parameter retrievals
- OLR calculation
- Precipitation estimate

Significant progress in current baseline

Indirect progress in current baseline

No progress in current baseline

Steps in Version 5 Level 2 and Current Status System

MIT AMSU Retrieval

Cloudy regression gives X^{CR}

AMSU Retrieval using X^{CR} gives $X^{microwave} = X^0$ (now solve for T(p), ε_ν only - not T_s)

Determine $\hat{R}_i^0, \alpha^0, P_c{}^0$ using X^0

Determine X^{reg} from $\hat{R}_i^0$

AMSU retrieval using X^{reg} gives X^1 (now solve for T(p), ε_ν only - not T_s)

Determine $\hat{R}_i{}^1$ using X^1

Physical retrieval using $\hat{R}_i{}^1$ and X^1 gives X^{PHYS}

AMSU retrieval using X^{PHYS} gives X^{test}

$\hat{R}_i{}^2$ determined from X^{PHYS}

Physical retrieval using $\hat{R}_i{}^2$ gives X^{final}

Select X^0 or X^{final}

Clouds, OLR determined from X^0 or X^{final}

Generate error estimates δX

Do QC

Steps Modified in Current Status System

Changes Made to Steps in the Physical Retrieval

First Pass

Initialize $\rho(\nu)$ - new step

Solve for surface parameters - $T_s, \varepsilon_{SW}(\nu), \rho_{SW}(\nu)$

Solve for T(p)

Solve for q(p)

Solve for $\varepsilon_{LW}(\nu)$ – new step

Solve for $O_3(p)$

Second Pass

Initialize ρ_ν - new step

Solve for surface parameters - $T_s, \varepsilon_{SW}(\nu), \rho_{SW}(\nu)$

Solve for T(p)

Solve for $\varepsilon_{LW}(\nu)$ – new step

Steps Modified in Current Status

Initialization for Spectral Bi-directional Reflectance $\rho^{o}(\nu)$

In Version 5, $\rho^{o}(\nu)$ is generated from the regression step emissivities $\varepsilon^{o}(\nu)$

$$\rho^{o}(\nu) = \left(1 - \varepsilon^{o}(\nu)\right)/\pi$$

Used as part of initial state for surface parameter retrieval

$\rho^{o}(\nu)$ is often very poor

Very large values ($\approx$ 10K) of $\left(\hat{\Theta}_i - \Theta_i{}^{o}\right)$ exist for short wave window channels

An incorrect value of ρ^{o} shows up as a large slope in $\left(\hat{\Theta}_i - \Theta_i{}^{o}\right)$

In current status system we modify ρ^{o} immediately after regression step

$$\rho(\nu)^{o'} = \rho(\nu)^{o}\left[1 + f\left[\left(\hat{\Theta}_{2647} - \Theta^{o}_{2647}\right) - \left(\hat{\Theta}_{2448} - \Theta^{o}_{2448}\right)\right]\right]$$

Use $\rho^{o'}$ as initial state for surface parameter retrieval

Changes in Surface Parameter Retrieval Step

Change form of emissivity and reflectivity perturbation equation

Version 5

$$\varepsilon(\nu)' = \varepsilon(\nu)^0 + \sum A_i F_i(\nu)$$

$$\rho' = \rho(\nu)^0 + \sum B_i G_i(\nu)$$

$F_i(\nu)$ and $G_i(\nu)$ are trapezoid emissivity and reflectivity perturbation functions

Current Status System

$$\left(1 - \varepsilon(\nu)'\right) = \left(1 - \varepsilon(\nu)^0\right)\left[1 + \sum A_i F_i(\nu)\right]$$

$$\rho(\nu)' = \rho(\nu)^0\left[1 + \sum B_i G_i(\nu)\right]$$

$F_i(\nu)$ and $G_i(\nu)$ are trapezoid emissivity and reflectivity perturbation functions

Benefits of new form

$\varepsilon(\nu)' < 1$ as long as $\varepsilon(\nu)^0 < 1$ and each $A_i > -1$

We set $A_i = -.99$ if A_i found to be < -1

$\rho(\nu)' \geq 0$ for analogous reason

Changes in $\varepsilon(\nu)$ are small if $\varepsilon(\nu)^0$ is close to 1.0 - Stabilizes ocean emissivities

Changes to Surface Parameter Retrieval Channel Set and $F_i(\nu)$

Version 5 - solves for $T_s, \varepsilon_{LW}(\nu), \varepsilon_{SW}(\nu), \rho_{SW}(\nu)$

15 channels between 758 cm^{-1} and 1228 cm^{-1}

10 channels between 2456 cm^{-1} and 2658 cm^{-1}

3 LW $F_i(\nu)$, 1 SW $F_i(\nu)$, 1 SW $G_i(\nu)$

Current status - solves for $T_s, \varepsilon_{SW}(\nu), \rho_{SW}(\nu)$

57 channels between 2395 cm^{-1} and 2660 cm^{-1}

All channels on weak line centers removed

2 SW $F_i(\nu)$, 2 SW $G_i(\nu)$

$F_i(\nu), G_i(\nu)$ functions were rebalanced and damping parameter changed

Using only shortwave channels to solve for T_s lessens sensitivity to cloud clearing errors

$\varepsilon_{LW}(\nu)$ is solved for in a new step after T(p), q(p) are solved for

ε_{LW} step - keeps T_s, T(p), q(p) as fixed

70 channels between 758 cm^{-1} and 1234 cm^{-1}

All channels on weak line centers removed

3 LW $F_i(\nu)$

This step is very stable - may allow for more functions $F_i(\nu)$

Results with Current Status System

Current status system has been tested on September 6, 2002, January 25, 2003, and September 29, 2004

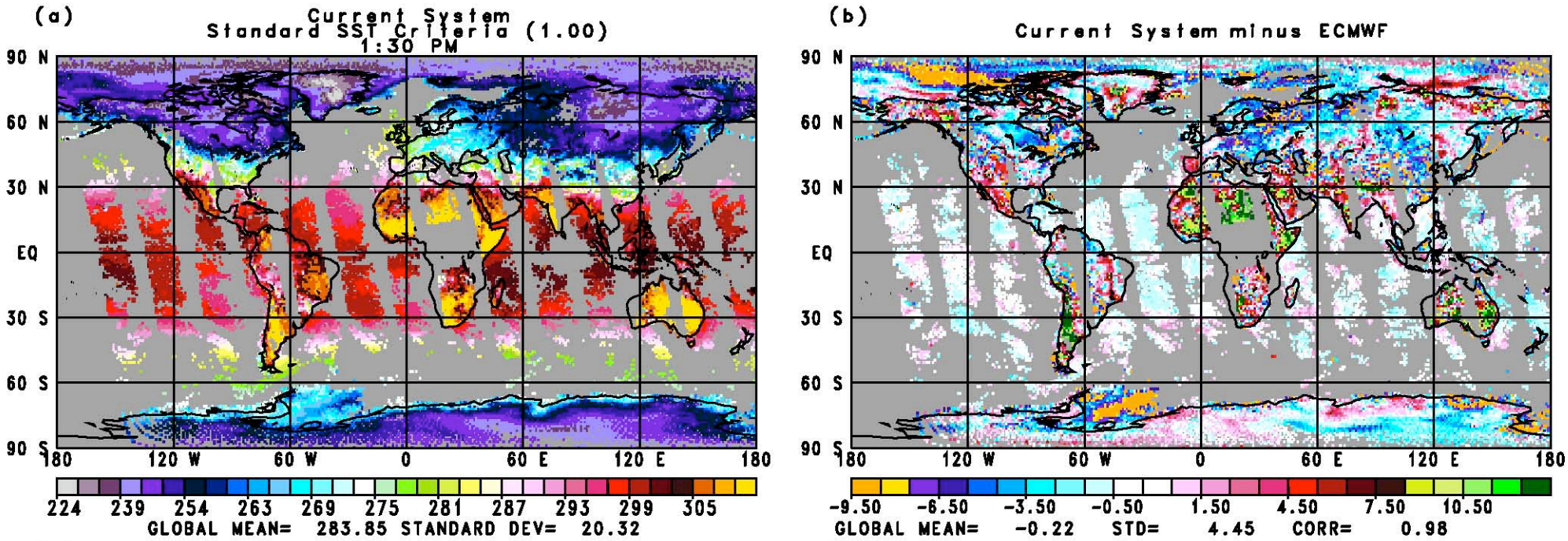
Single day fields are shown for January 25, 2003

Statistical plots represent averages over all three days

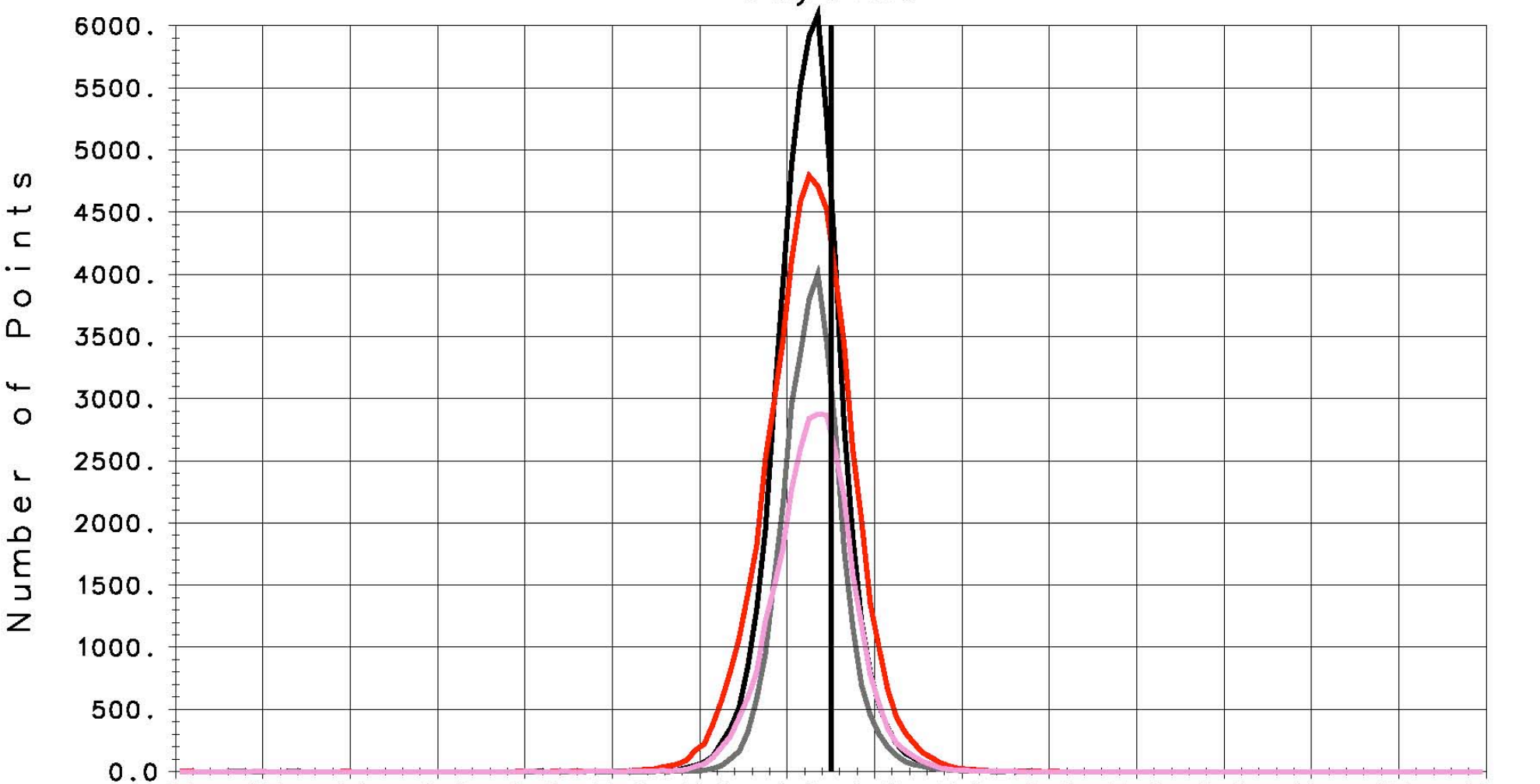
Error estimate coefficients are from an earlier version of the retrieval system

- Results should improve somewhat with up to date error estimates
- Loss of a computer is causing temporary technical difficulties

Surface Skin Temperature (K)
January 25, 2003



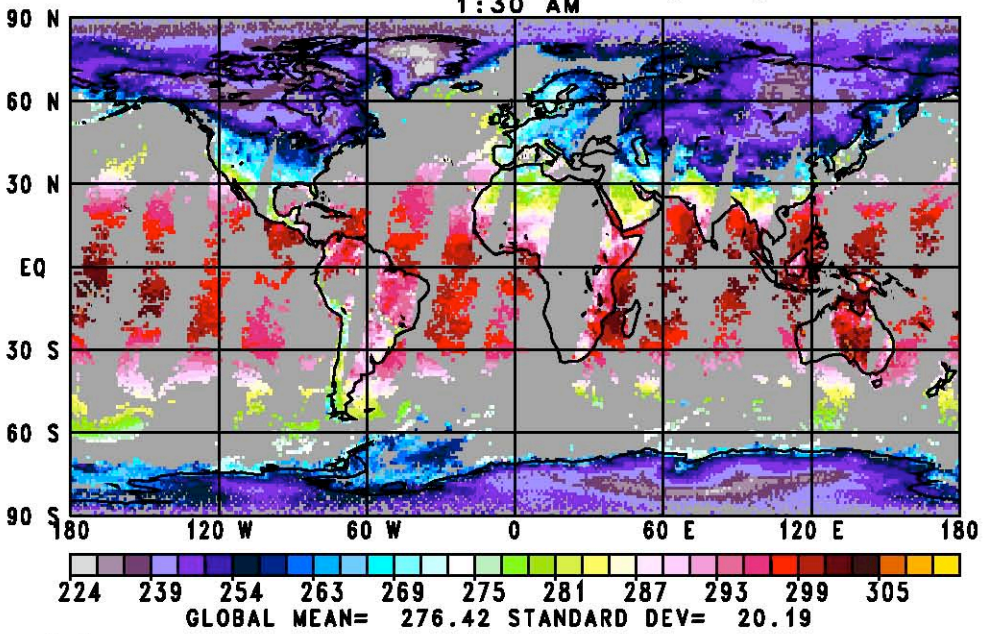
Surface Skin Temperature Difference
September 6, 2002, January 25, 2003, September 29, 2004
50 N to 50 S Non-Frozen Ocean
Daytime



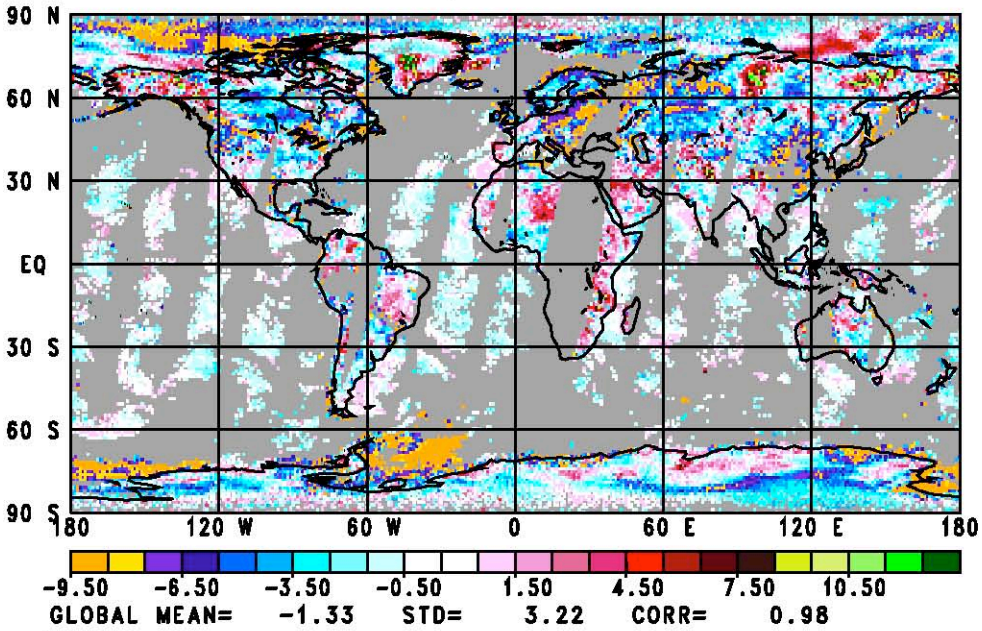
		Mean	STD	% Cases	Percent greater than |3| from mean
Current System	1.0 cutoff	−0.29	0.76	29.40	0.28
v5.0 Baseline	1.0 cutoff	−0.31	0.98	30.83	0.96
Current System	0.8 cutoff	−0.22	0.70	17.51	0.09
v5.0 Baseline	0.8 cutoff	−0.20	0.90	17.09	0.40

Surface Skin Temperature (K)
January 25, 2003

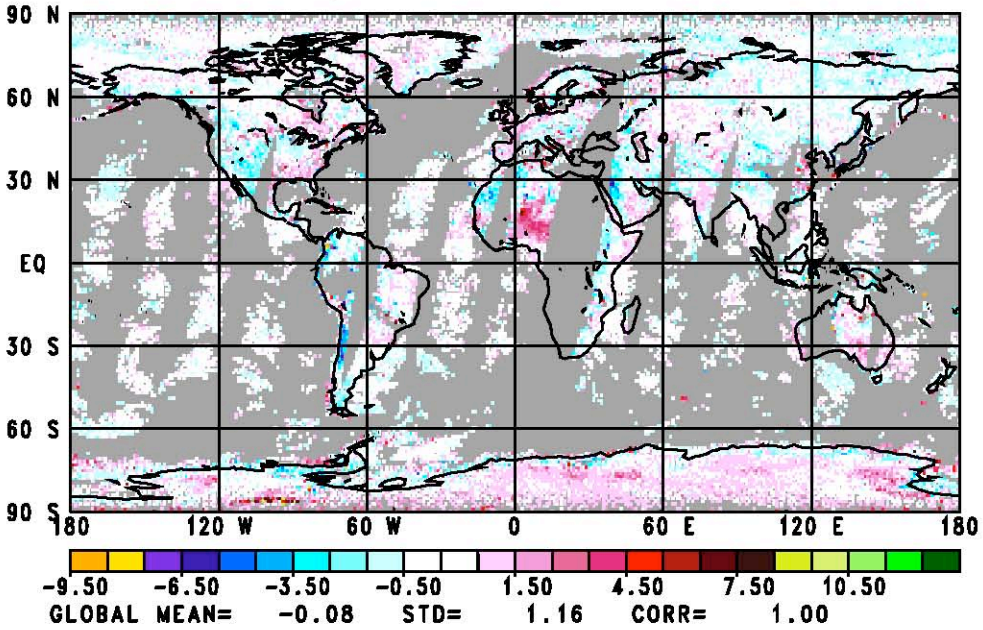
(a)



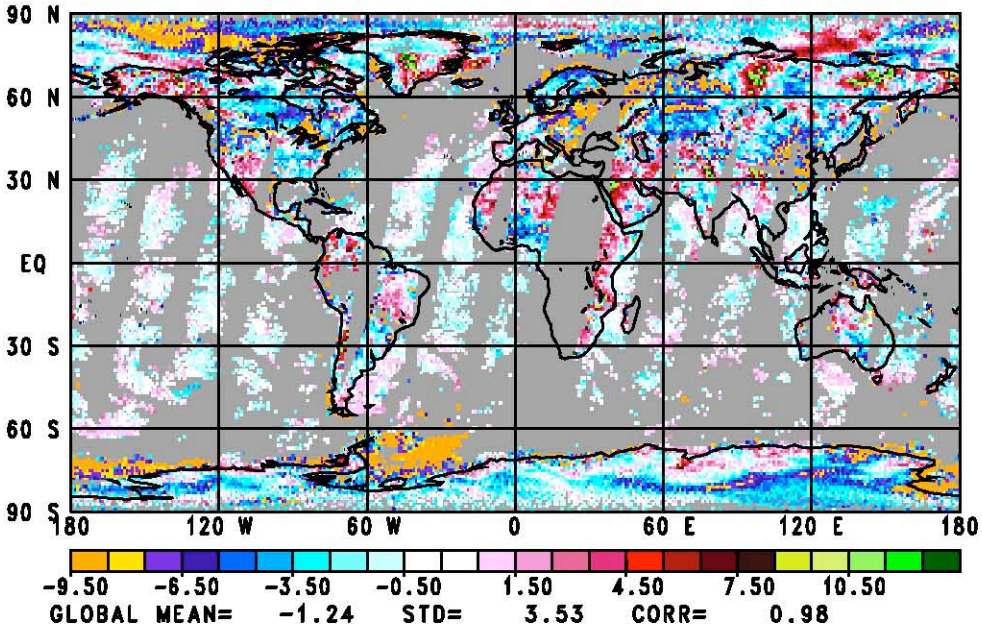
(b)



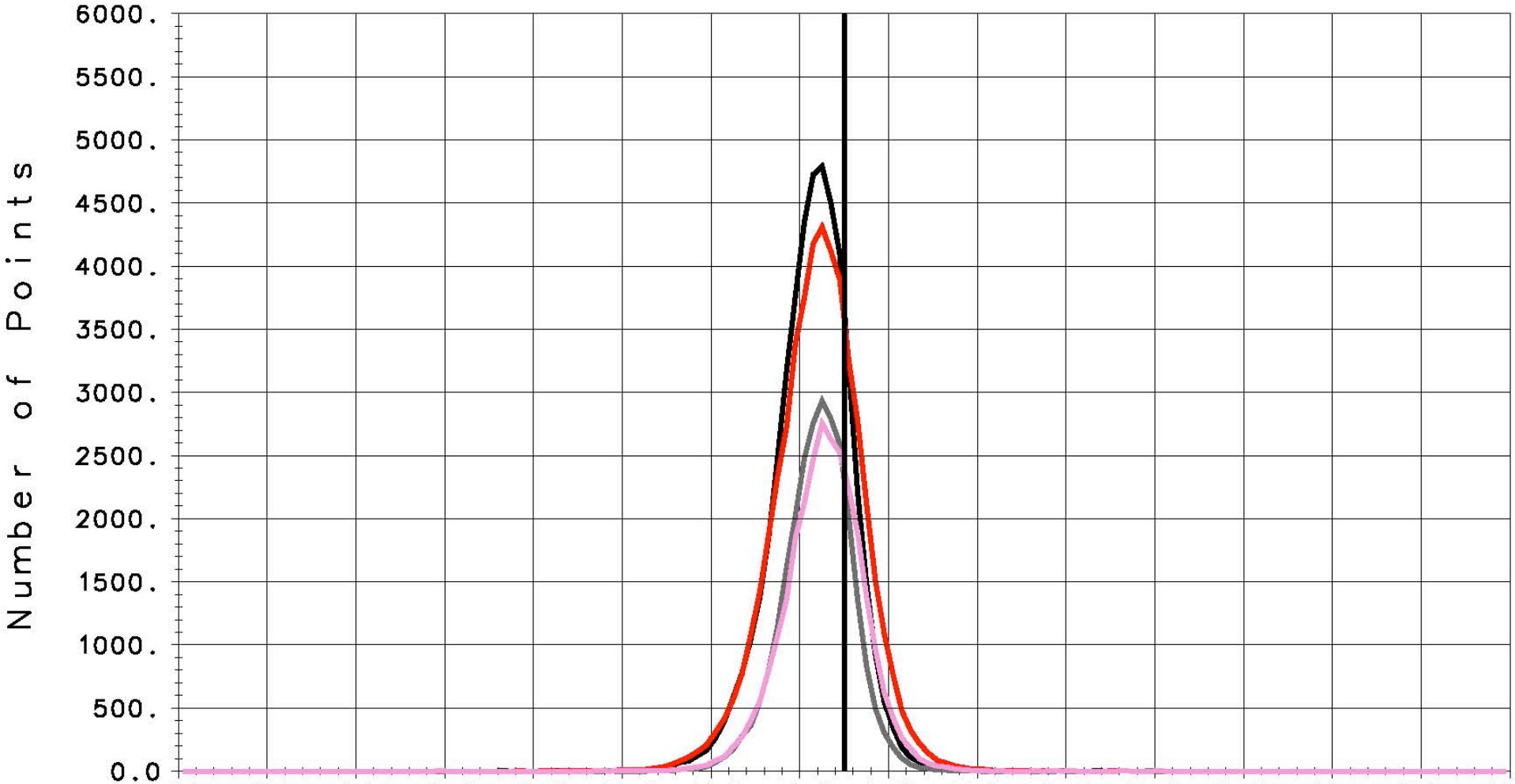
(c)



(d)



Surface Skin Temperature Difference
September 6, 2002, January 25, 2003, September 29, 2004
50 N to 50 S Non-Frozen Ocean
Nighttime



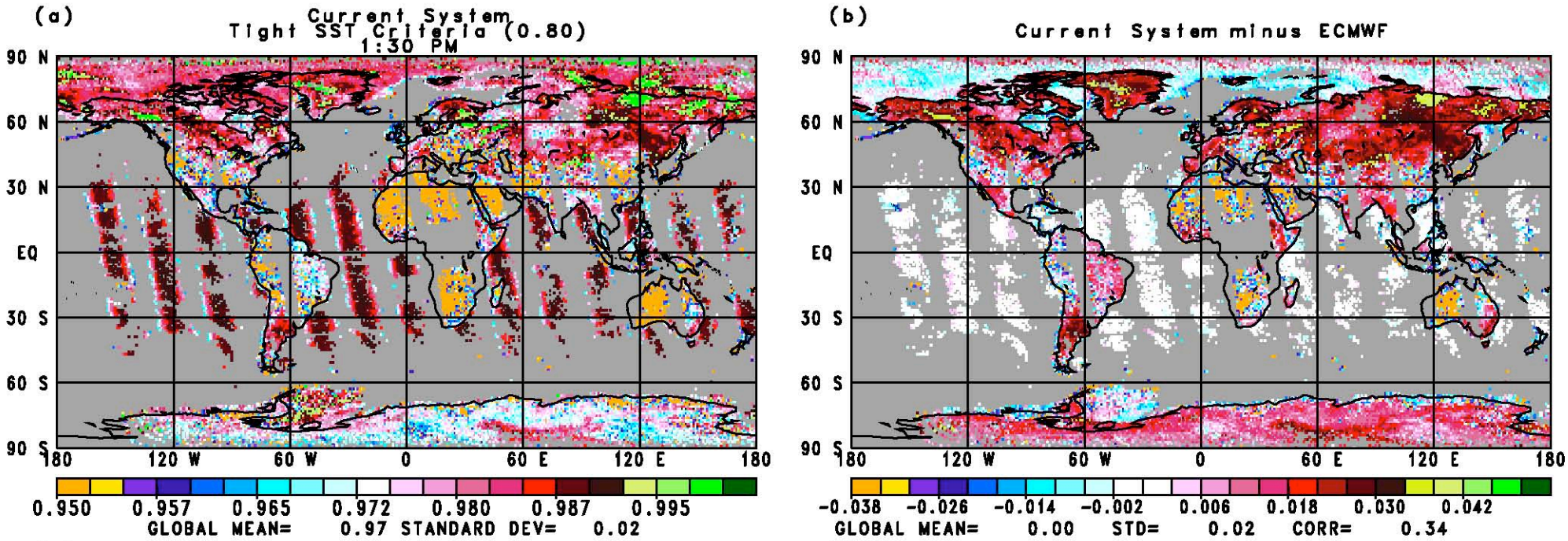
		Mean	STD	% Cases |3| from mean	Percent greater than
Current System	1.0 cutoff	−0.52	0.82	24.59	1.19
v5.0 Baseline	1.0 cutoff	−0.41	0.96	25.04	1.58
Current System	0.8 cutoff	−0.40	0.73	13.45	0.40
v5.0 Baseline	0.8 cutoff	−0.26	0.86	14.15	0.56

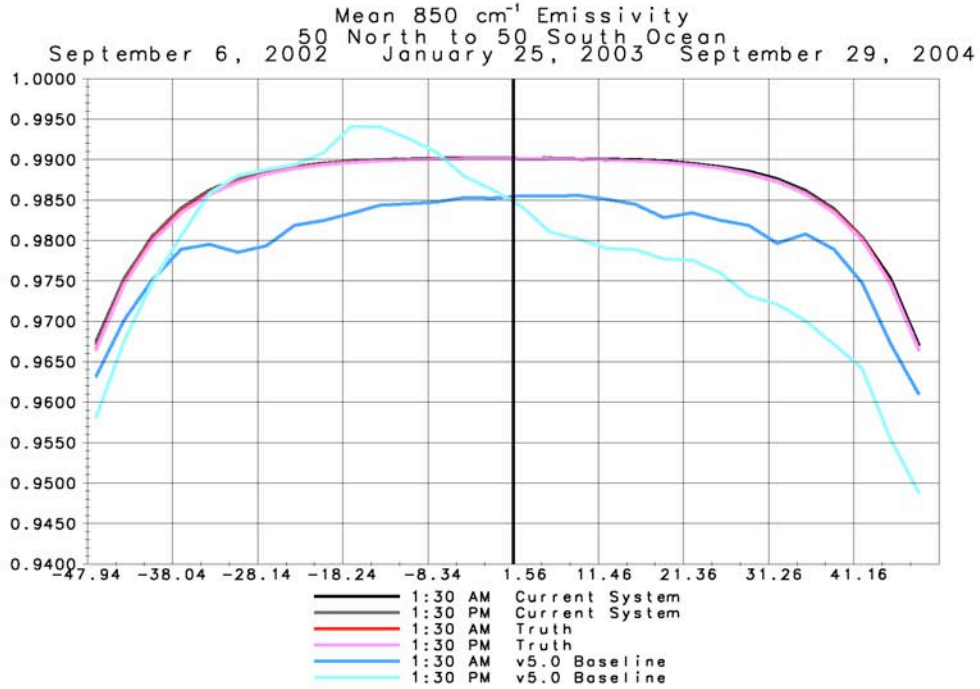
June 2007 Metrics for Improved Ocean Surface Skin Temperature

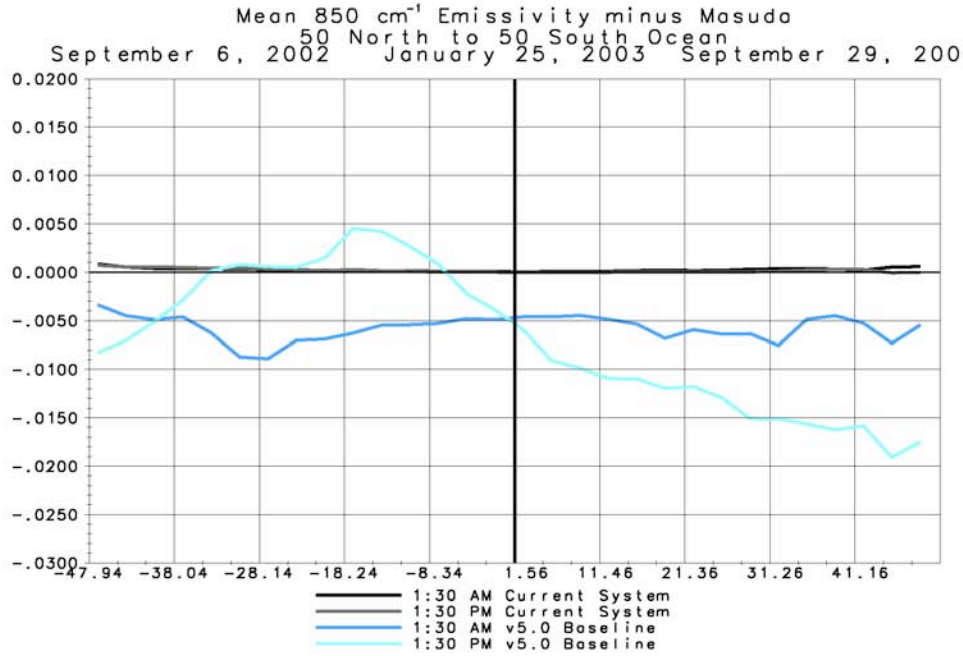
		Day			Night		
		% Accepted	Bias (K)	% Outliers	% Accepted	Bias (K)	% Outliers
Version 5	QC=0 (0.8K)	17%	-.20	0.40%	14%	-.26	0.56%
	QC=0,1 (1.0K)	31%	-.31	0.96%	25%	-.41	1.58%
Version 6 Goal	QC=0	30%	-.15	0.50%	25%	-.25	1.00%
	QC=0.1	50%	-.20	1.00%	40%	-.30	2.00%
Current Status	0.8K Cutoff	17.5%	-.22	0.09%	13.5%	-.40	0.40%
	1.0K Cutoff	29.4%	-.29	0.28%	24.6%	-.52	1.19%
		30.2%	-.35	0.34%	24.9%	-.55	1.37%
		41.1%	-.41	0.96%	30.5%	-.59	1.96%

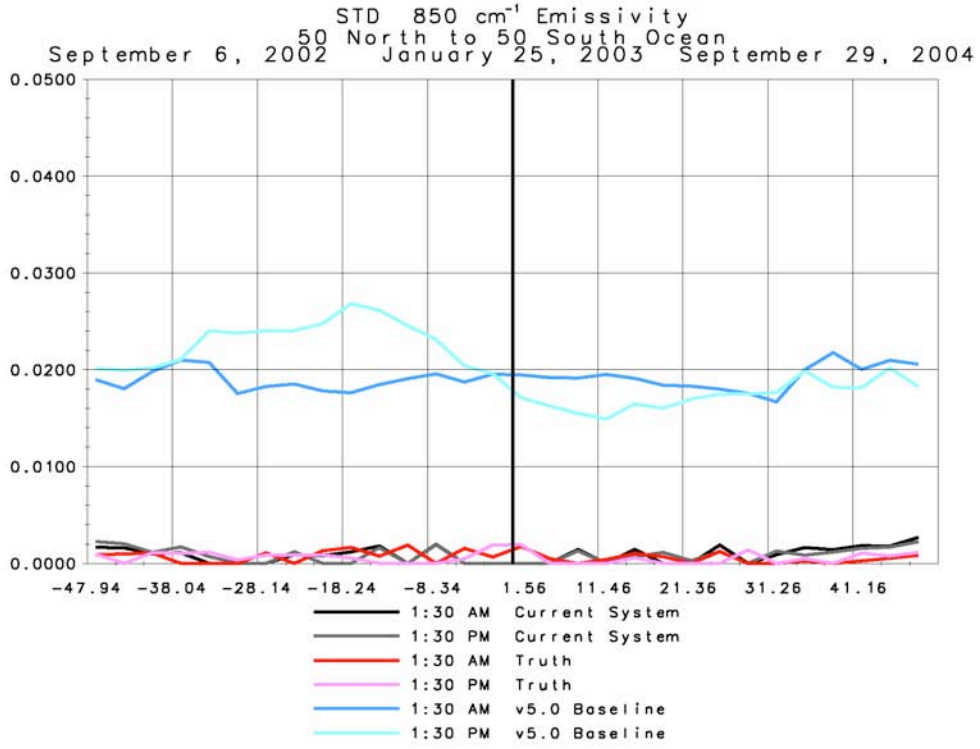
Updated error estimate coefficients and high resolution retrievals will each improve accuracy vs. yield

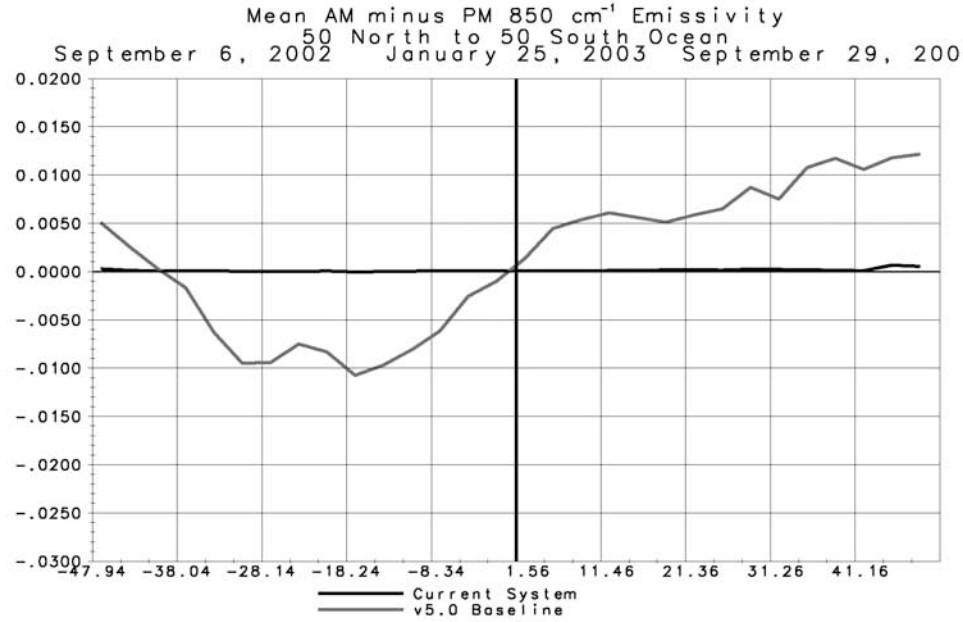
AIRS IR EMISSIVITY 850 cm^{-1}
January 25, 2003

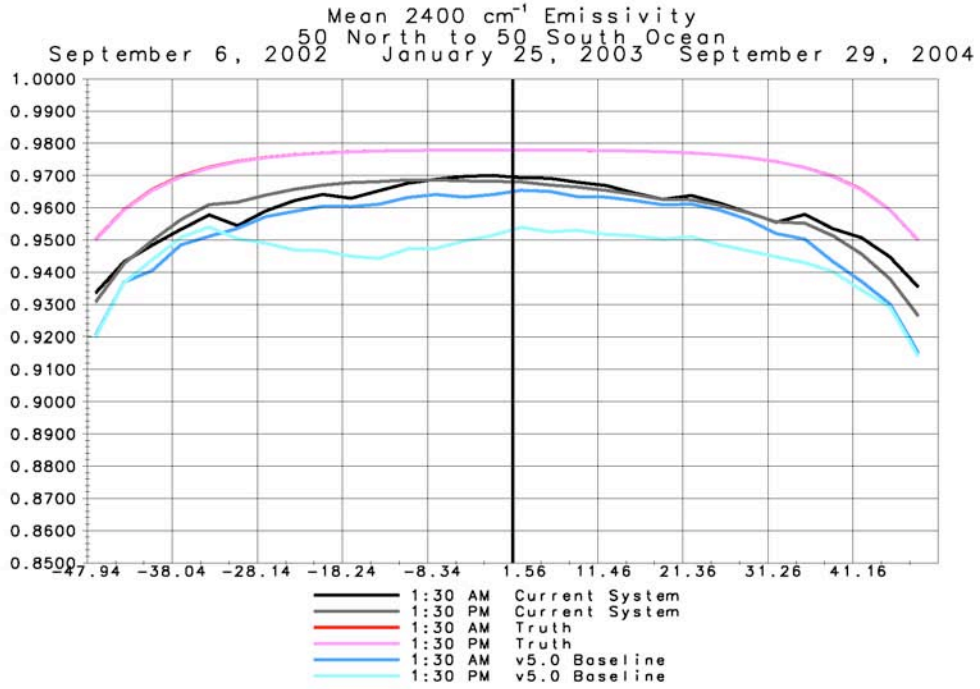


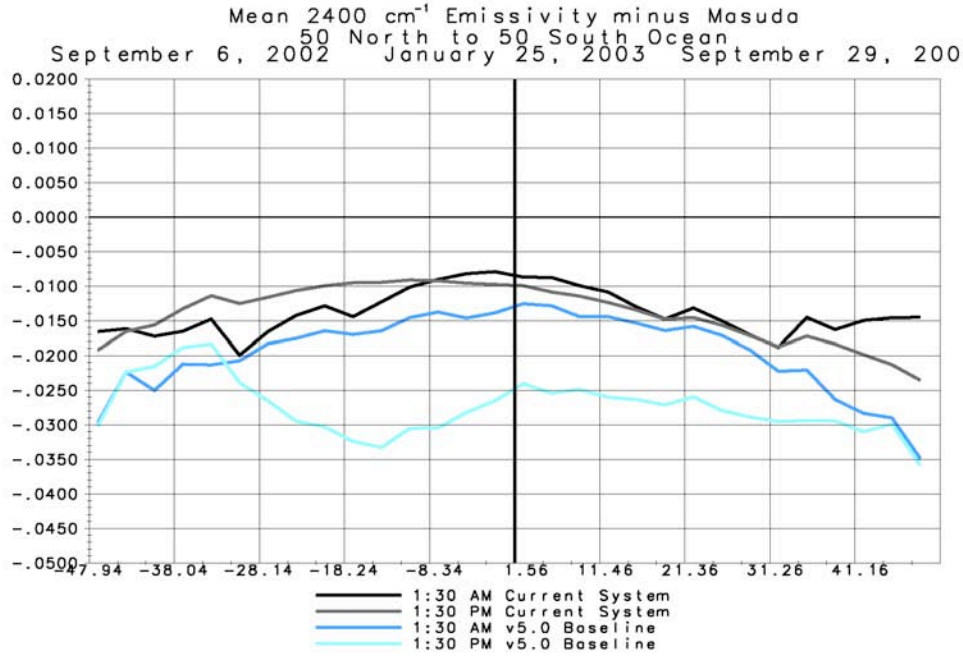

Mean 850 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
1.0000
0.9950
0.9900
0.9850
0.9800
0.9750
0.9700
0.9650
0.9600
0.9550
0.9500
0.9450
0.9400
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM Truth
1:30 PM Truth
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline

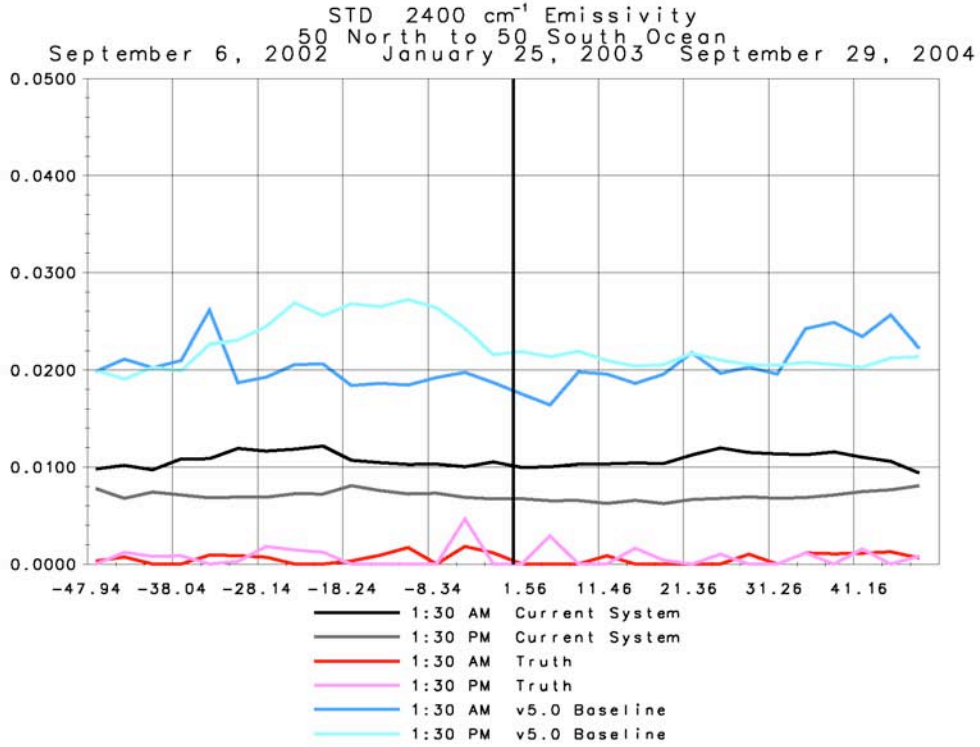

Mean 850 cm-1 Emissivity minus Masuda
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 200
0.0200
0.0150
0.0100
0.0050
0.0000
-.0050
-.0100
-.0150
-.0200
-.0250
-.0300
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline

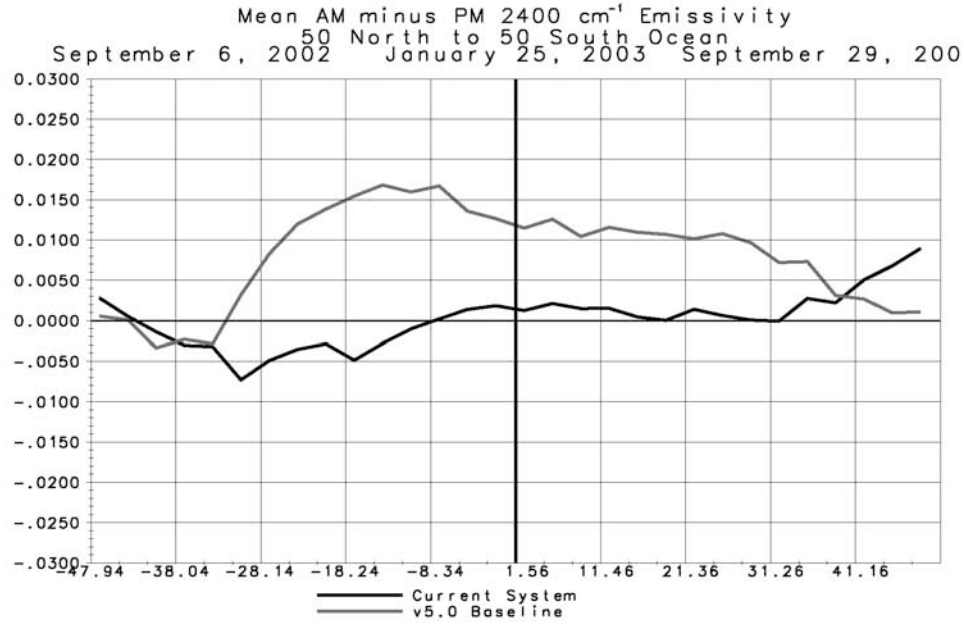

STD 850 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM Truth
1:30 PM Truth
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline


Mean AM minus PM 850 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 200
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
Current System
v5.0 Baseline


Mean 2400 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
1.0000
0.9900
0.9800
0.9700
0.9600
0.9500
0.9400
0.9300
0.9200
0.9100
0.9000
0.8900
0.8800
0.8700
0.8600
0.8500
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM Truth
1:30 PM Truth
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline


Mean 2400 cm-1 Emissivity minus Masuda
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 200
0.0200
0.0150
0.0100
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 Current System
1:30 PM Current System
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline


STD 2400 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 2004
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM Truth
1:30 PM Truth
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline


Mean AM minus PM 2400 cm-1 Emissivity
50 North to 50 South Ocean
September 6, 2002 January 25, 2003 September 29, 200
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
Current System
v5.0 Baseline

June 2007 Metrics for Improved Ocean Spectral Emissivity

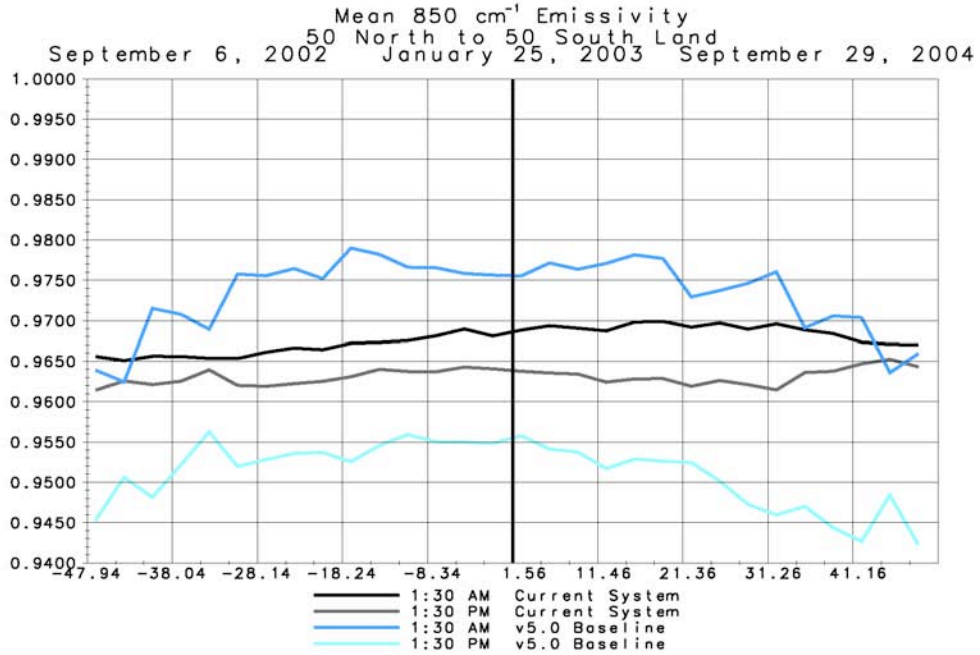
850 cm^{-1}

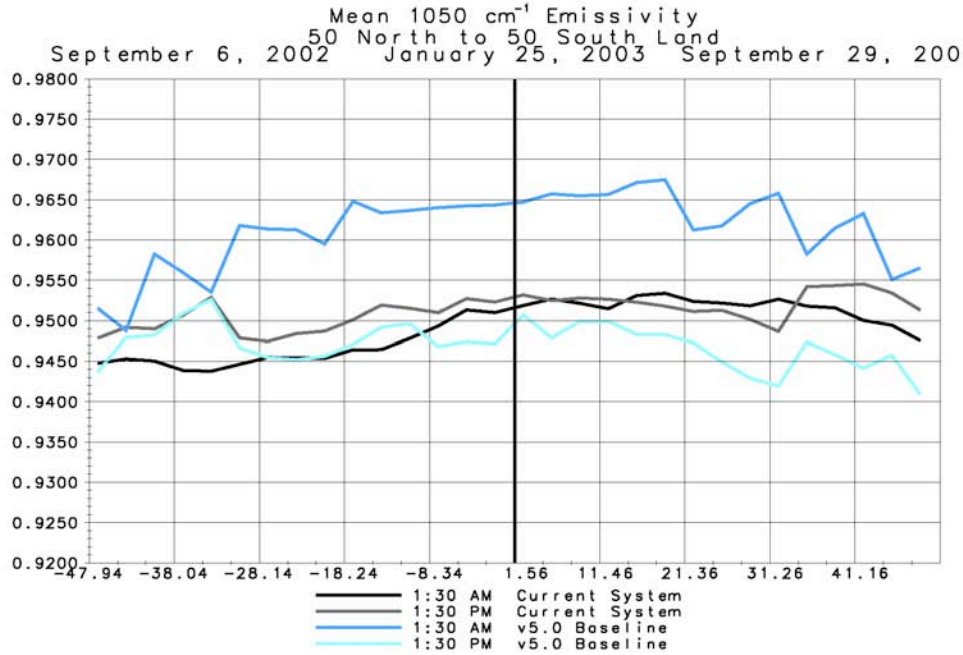
		$\varepsilon_N(0) - \varepsilon_{MAS}(0)$	$\varepsilon_D(0) - \varepsilon_{MAS}(0)$	$MAX\left\|\varepsilon_N(\Theta) - \varepsilon_D(\Theta)\right\|$	$MAX\left\|\varepsilon_D(\Theta) - \varepsilon_D(-\Theta)\right\|$
Version 5	QC=0	-.005	-.005	.012	.017
Version 6 Goal	QC=0	-.002	-.002	.006	.010
Current Status	QC=0	.000	.000	.001	.001

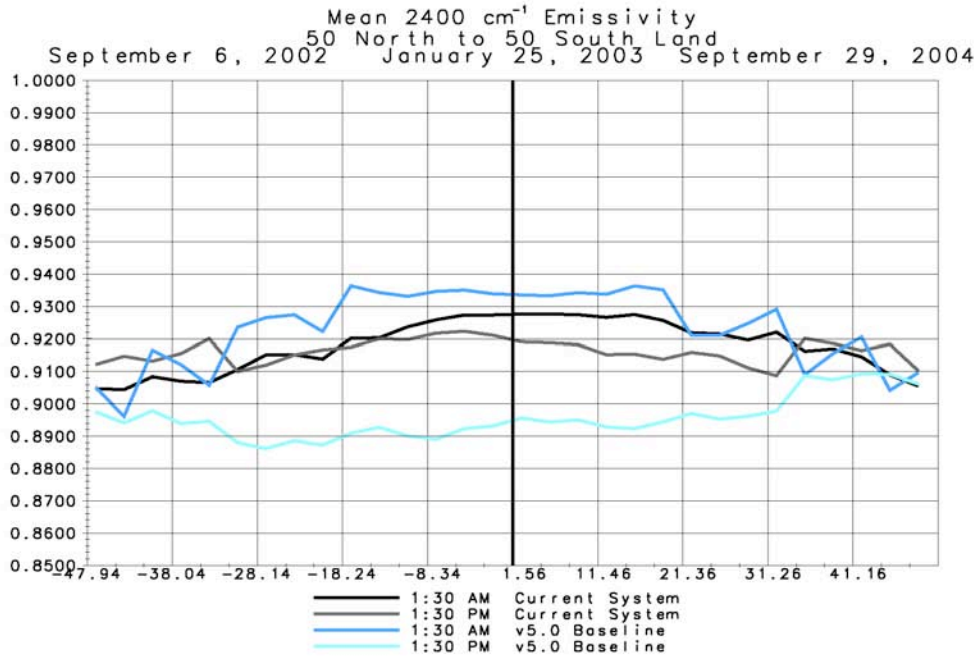
2400 cm^{-1}

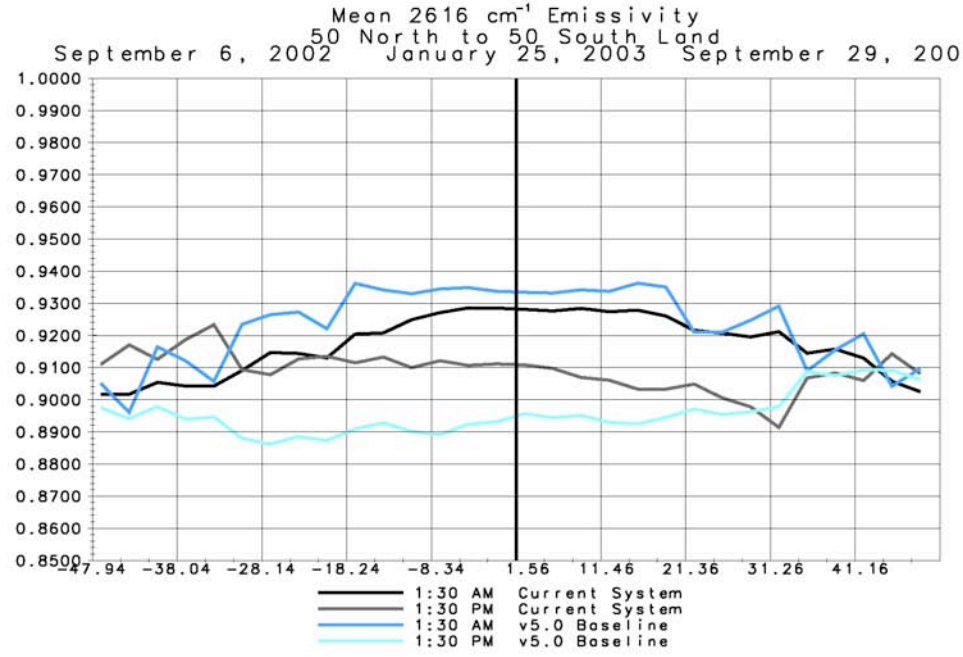
		$\varepsilon_N(0) - \varepsilon_{MAS}(0)$	$\varepsilon_D(0) - \varepsilon_{MAS}(0)$	$MAX\left\|\varepsilon_N(\Theta) - \varepsilon_D(\Theta)\right\|$	$MAX\left\|\varepsilon_D(\Theta) - \varepsilon_D(-\Theta)\right\|$
Version 5	QC=0	-.012	-.025	.017	.012
Version 6 Goal	QC=0	-.005	-.010	.008	.006
Current Status	QC=0	-.008	-.010	.008	.006

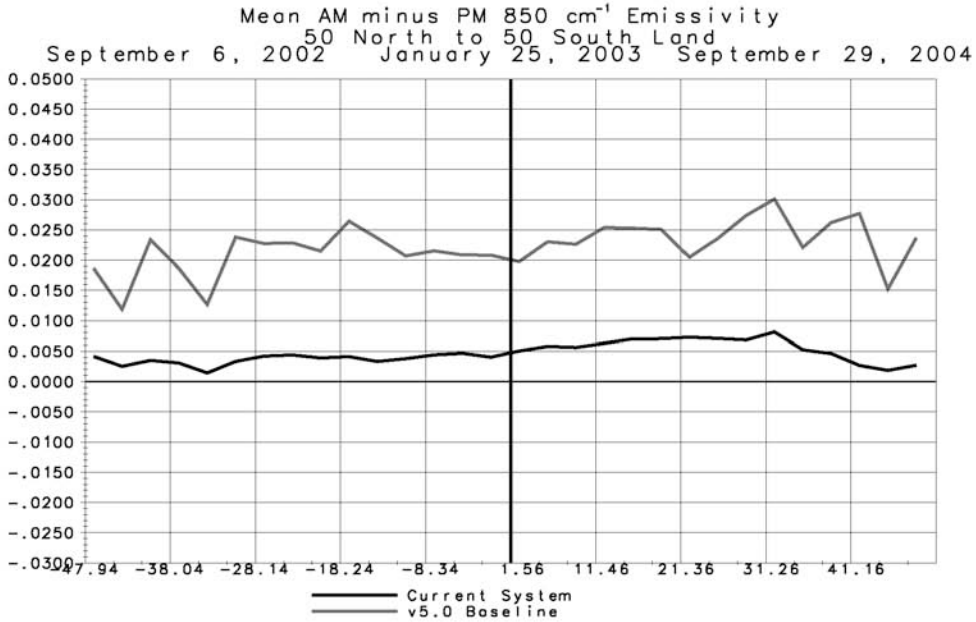
N=Night D=Day MAS=Masuda

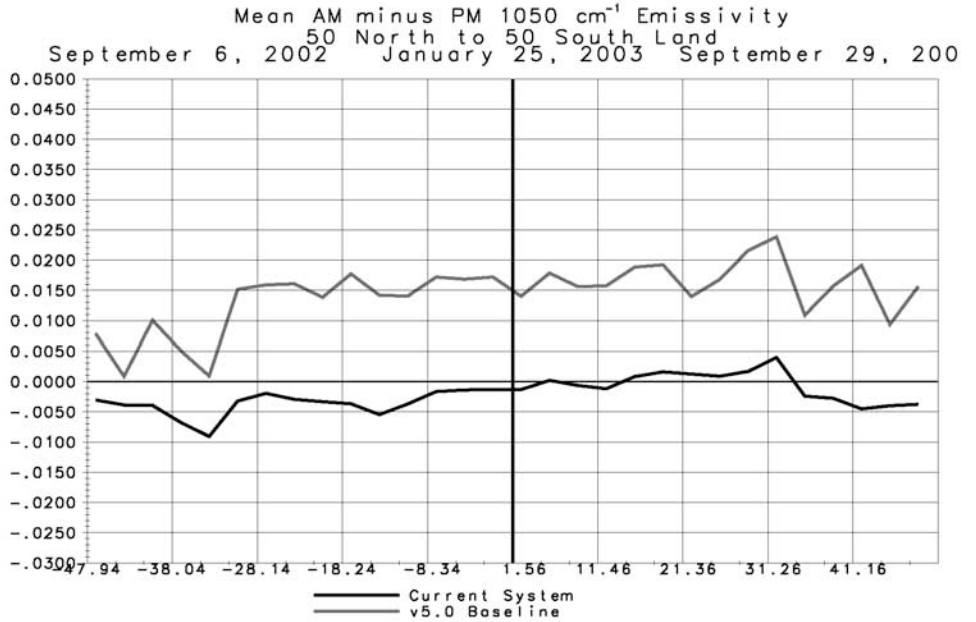

Mean 850 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 2004
1.0000
0.9950
0.9900
0.9850
0.9800
0.9750
0.9700
0.9650
0.9600
0.9550
0.9500
0.9450
0.9400
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline

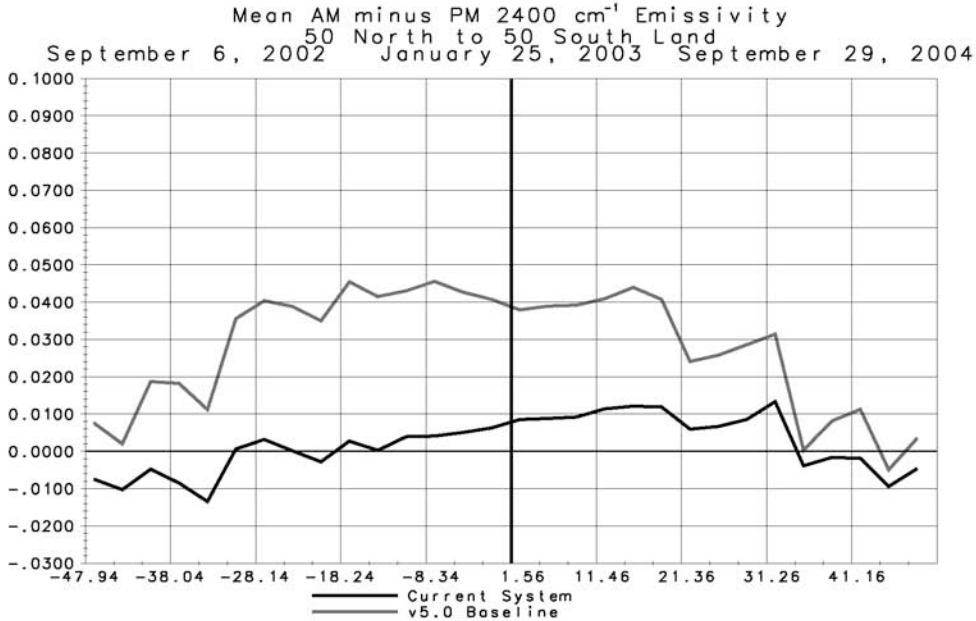

Mean 1050 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 200
0.9800
0.9750
0.9700
0.9650
0.9600
0.9550
0.9500
0.9450
0.9400
0.9350
0.9300
0.9250
0.9200
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline

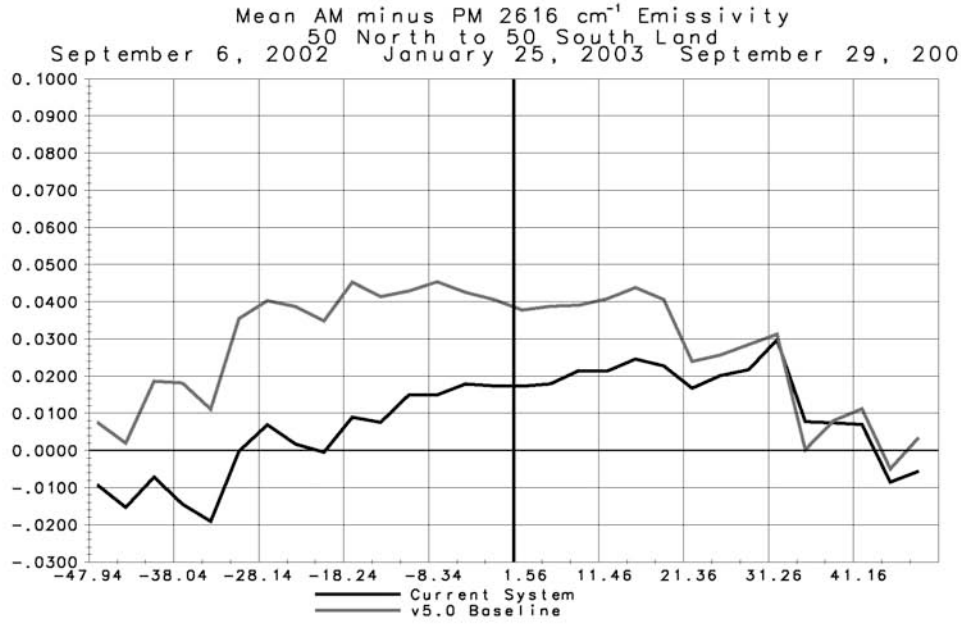

Mean 2400 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 2004
1.0000
0.9900
0.9800
0.9700
0.9600
0.9500
0.9400
0.9300
0.9200
0.9100
0.9000
0.8900
0.8800
0.8700
0.8600
0.8500
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline


Mean 2616 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 200
1.0000
0.9900
0.9800
0.9700
0.9600
0.9500
0.9400
0.9300
0.9200
0.9100
0.9000
0.8900
0.8800
0.8700
0.8600
0.8500
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
1:30 AM Current System
1:30 PM Current System
1:30 AM v5.0 Baseline
1:30 PM v5.0 Baseline


Mean AM minus PM 850 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 2004
0.0500
0.0450
0.0400
0.0350
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
Current System
v5.0 Baseline


Mean AM minus PM 1050 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 200
0.0500
0.0450
0.0400
0.0350
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
Current System
v5.0 Baseline


Mean AM minus PM 2400 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 2004
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
-.0100
-.0200
-.0300
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
Current System
v5.0 Baseline


Mean AM minus PM 2616 cm-1 Emissivity
50 North to 50 South Land
September 6, 2002 January 25, 2003 September 29, 200
0.1000
0.0900
0.0800
0.0700
0.0600
0.0500
0.0400
0.0300
0.0200
0.0100
0.0000
-.0100
-.0200
-.0300
-47.94 -38.04 -28.14 -18.24 -8.34 1.56 11.46 21.36 31.26 41.16
Current System
v5.0 Baseline

Indirect Indications of Improvement

Retrievals of other geophysical parameters are sensitive to T_s, $\varepsilon(\nu)$

Small improvements are found in total O_3 and boundary layer T(p)

Total O_3

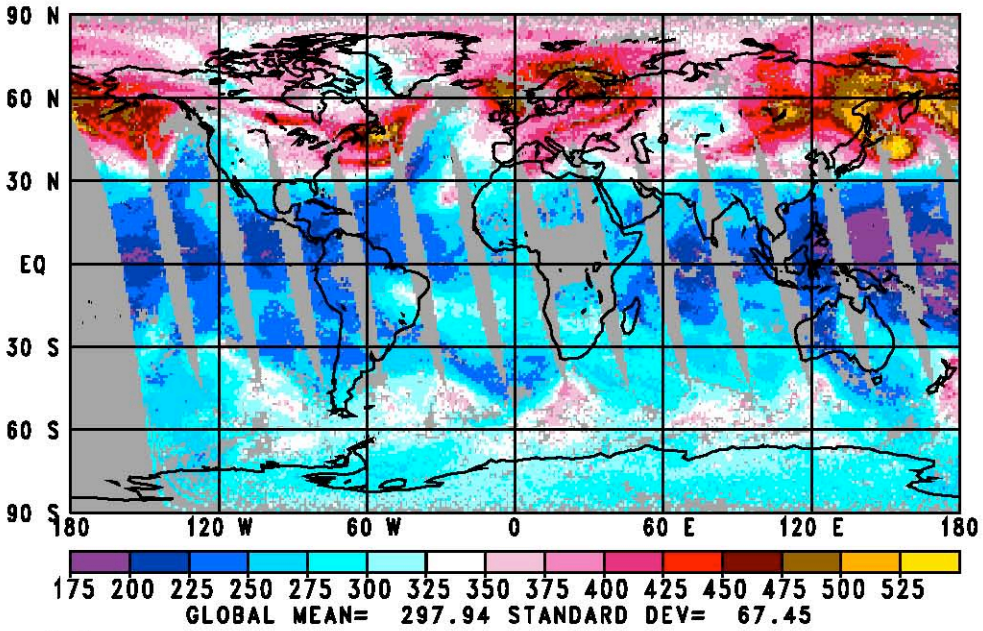
- Total O_3 increases slightly over ocean
- Has larger changes over land - positive and negative
- All changes improve agreement with TOMS

T(p)

- Boundary layer temperature improved over land in both RMS and bias sense

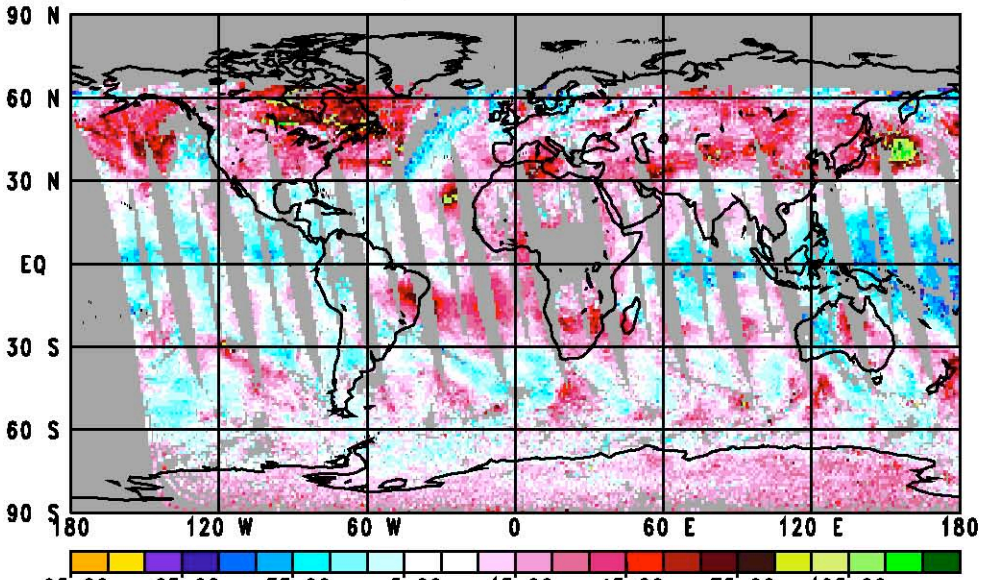
OZONE (DU)
January 25, 2003

(a) Current System
1:30 PM



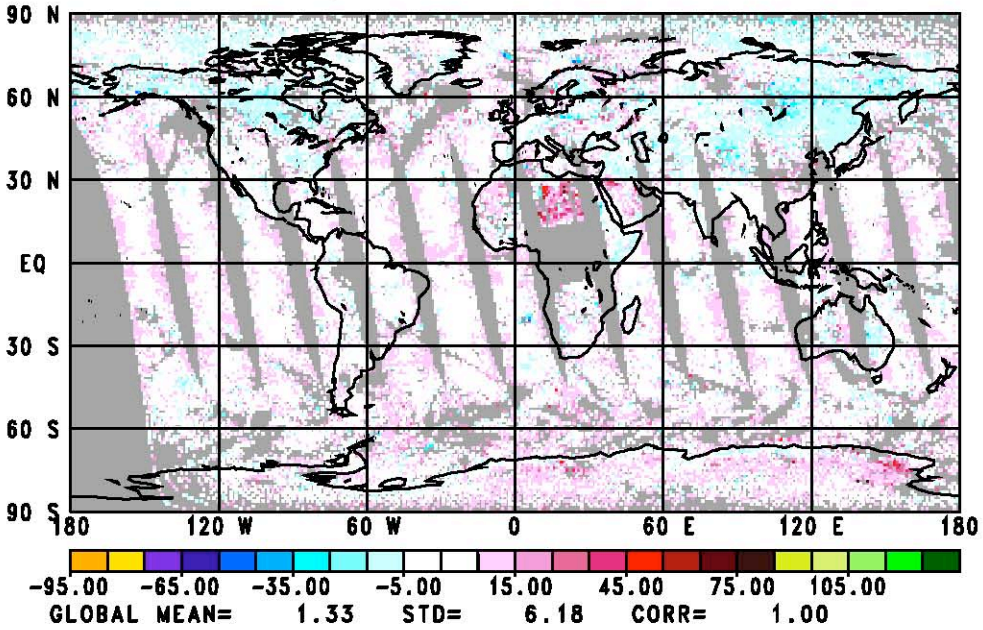
GLOBAL MEAN= 297.94 STANDARD DEV= 67.45

(b) Current System minus TOMS Ozone



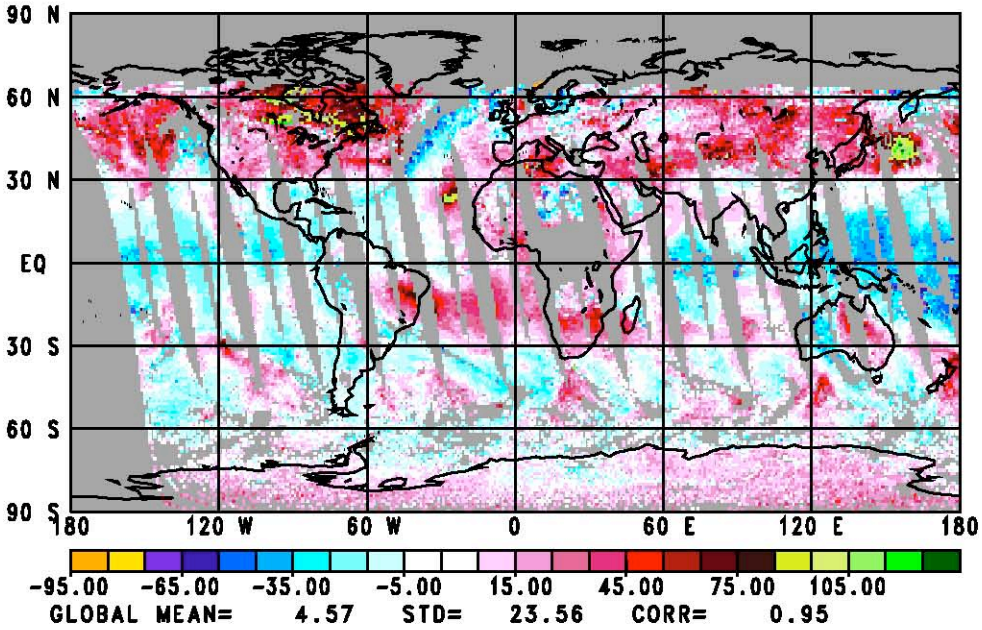
GLOBAL MEAN= 6.47 STD= 23.23 CORR= 0.94

(c) Current System minus Version-5 Baseline

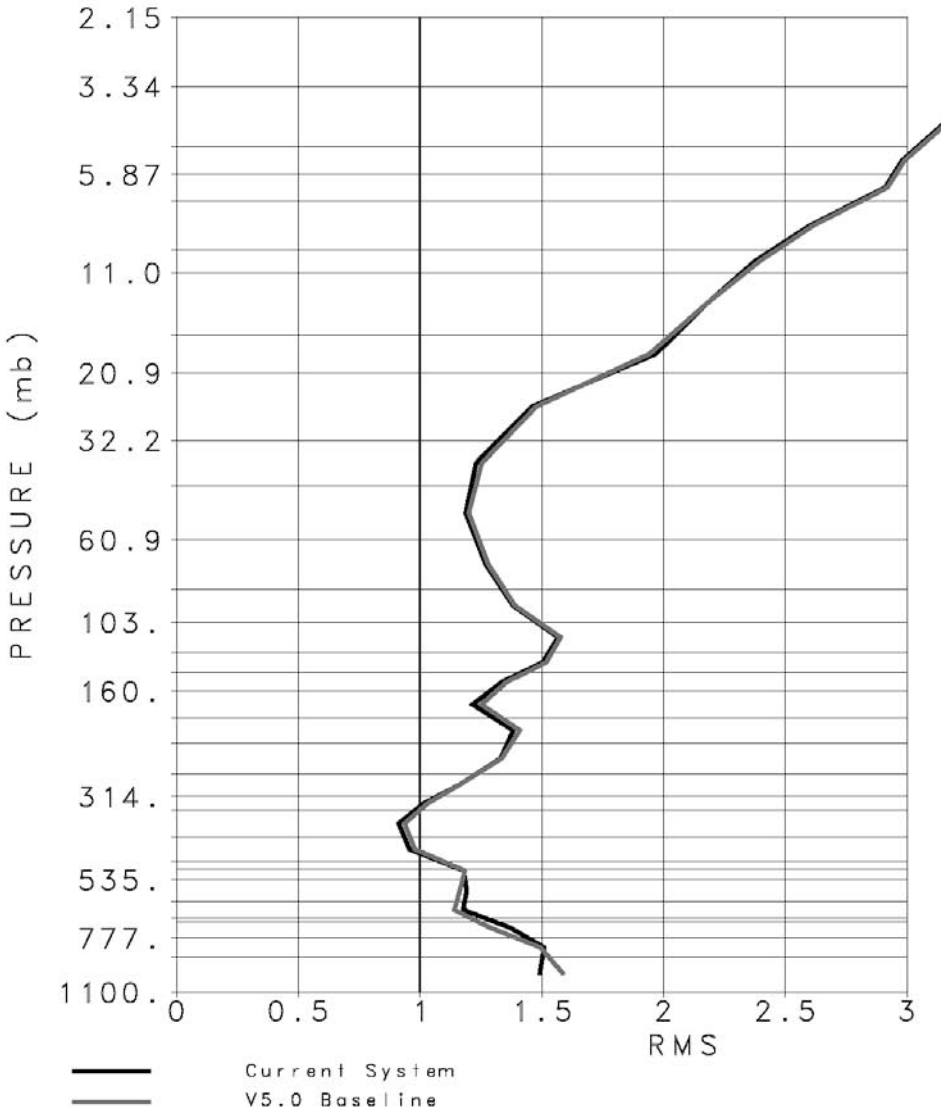


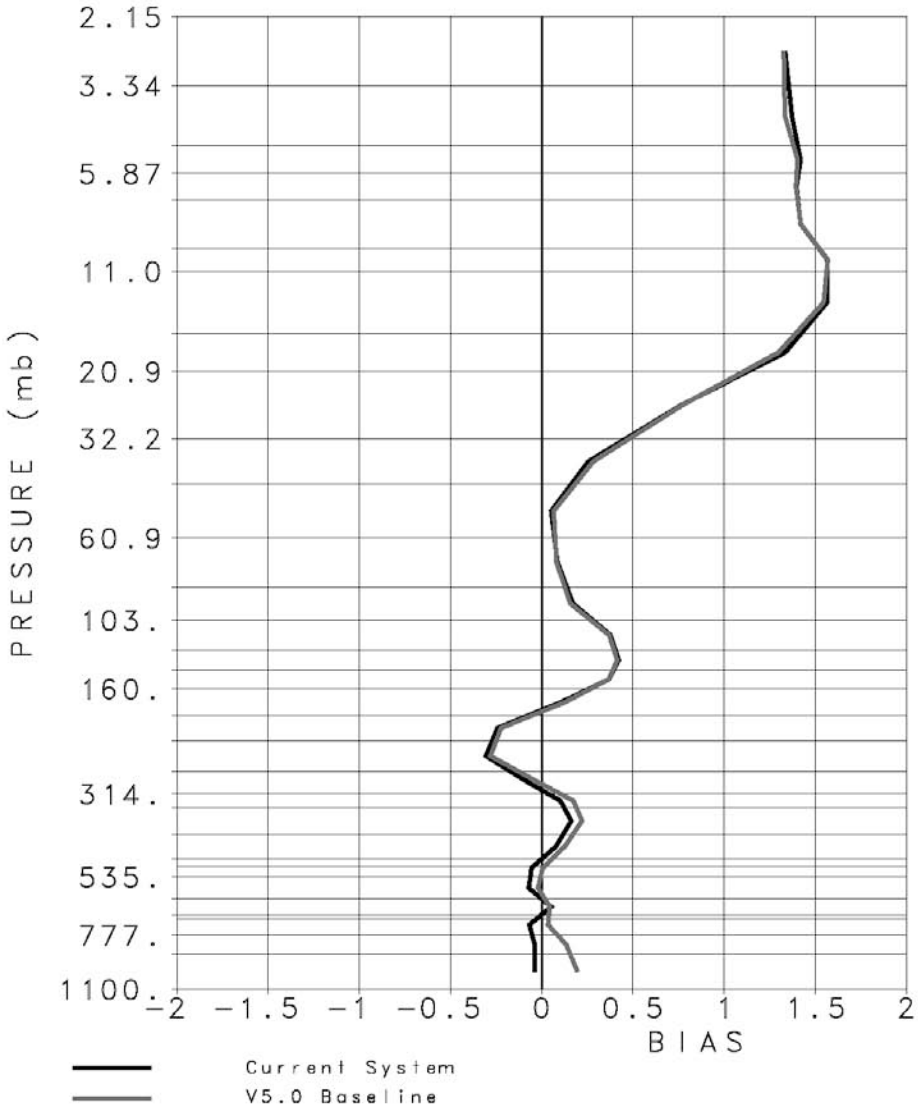
GLOBAL MEAN= 1.33 STD= 6.18 CORR= 1.00

(d) Version-5 Baseline minus TOMS Ozone



GLOBAL MEAN= 4.57 STD= 23.56 CORR= 0.95


LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM ECMWF
Sep 6, 2002, January 25, 2003, and Sep 29
50N to 50S Non-Ocean
PRESSURE (mb)
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100.
0
0.5
1
1.5
2
2.5
3
RMS
Current System
V5.0 Baseline


LAYER MEAN BIAS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM ECMWF
Sep 6, 2002, January 25, 2003, and Sep 29, 20
50N to 50S Non-Ocean
PRESSURE (mb)
2.15
3.34
5.87
11.0
20.9
32.2
60.9
103.
160.
314.
535.
777.
1100.
−2
−1.5
−1
−0.5
0
0.5
1
1.5
2
BIAS
Current System
V5.0 Baseline

Plans to Improve T(p) Retrievals

We will try each of two major new thrusts:

I) a) Update $\varepsilon_{SW}(\nu)$ and $\rho_{SW}(\nu)$ as part of T(p) retrieval, keeping T_s fixed

or potentially better yet

b) Solve for T_s, $\varepsilon_{SW}(\nu)$, $\rho_{SW}(\nu)$, T(p)in a single retrieval step

We will try a) first, and then see if b) is better

It must not degrade SST's

II) Include brightness temperature differences on and off weak CO_2 lines ℓ $\left(d\Theta_\ell\right)$ in window regions as single pieces of information

$d\Theta_\ell$ is very sensitive to boundary layer temperature

$\left(d\hat{\Theta}_\ell - d\Theta_\ell^{comp}\right)$ is less sensitive to cloud clearing and q(p) errors

Cloud clearing and moisture errors can be ignored in noise covariance matrix

If II) is successful, we will try to include weak H_2O lines in window regions in q(p) retrieval

Tentative Near Term Schedule

Surface parameter retrieval

Conduct further optimization studies - channels, functions, damping parameters

Generate new error estimate coefficients

Deliver to JPL by November 2

Temperature profile retrieval

I) Solve for $\varepsilon_{SW}(\nu)$ and $\rho_{SW}(\nu)$ (and T_s?) as part of the T(p) retrieval

Generate new error estimate coefficients

Assess results

Show results in NET-meeting (end of November?)

Deliver to JPL by December 7 if worthwhile

II) Implement and test approach of using weak line depths $d\Theta_\ell$ in T(p) retrieval

Generate new error estimate coefficients

Show results in NET-meeting (end of December?)

Deliver to JPL by January 15 if worthwhile

Near Team Schedule Continued

High spatial resolution retrievals

Perform retrieval every 1 (cross track) x 3 (along track) AIRS FOV's

Attempt 3 retrievals every AMSU FOR

Should improve accuracy as a function of % yield - especially over land

% yield defined as fraction of cases with at least one accepted retrieval per AMSU FOR

We will start this immediately after AIRS Science Team meeting

Present results in (mid-January?) NET meeting

Improve OLR calculation

Version 5 OLR RTA does not allow for variable CO_2 and also causes biases between AIRS and CERES OLR

Both need to be corrected if AIRS will produce a meaningful OLR climate record

Currently implementing and testing AER OLR RTA at GSFC with Version 5 retrievals

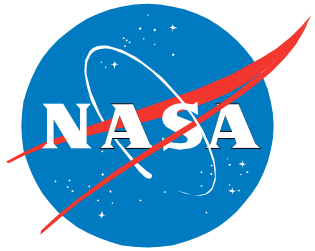
Clear sky AER OLR RTA tested at Wisconsin with Version 4 retrievals by Dave Tobin and co-worke

Allows for variable CO_2 concentrations

Removes bias between AIRS and CERES OLR

This is an intermediate measure undertaken to demonstrate improved agreement with CERES on a monthly mean basis

We are awaiting Larrabee Strow's new OLR RTA to use in Version 6


NASA