STATUS OF VERSION-6 at SRT

Joel Susskind, John Blaisdell[1], Lena Iredell[1]

NASA GSFC Sounder Research Team

AIRS Science Team Meeting

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1. SAIC

Current System at SRT – Version-5.29 (V5.29)

V5.29 is similar to what is now running at JPL.

V5.29 is essentially complete – could become Version-6 except

1. V5.29 uses the old cloudy regression containing AMSU-4 and AMSU-5.
   - This **must** be replaced with something that does not use AMSU-4,-5
2. V5.29 uses the old cloud cleared regression
   - This causes a significant negative yield trend
   - This is alleviated by not using regression T(p), q(p) guess

We need new cloudy regression and new cloud cleared regression for Version-6

Hopefully negative trend issue will go away

Neural network could replace both regressions, possibly improve results

Another option is to use the current AIRS Only cloudy regression

This requires nothing new

Changes in Current JPL System Since October 2009 Team Meeting (V5.24)

Removed CO_2 noise covariance term from retrieval (NOAA recommendation)

- Reduces spurious T(p) trends

Changes in second pass temperature profile retrieval channels

- Removed N_2O sensitive channels (Eric Maddy's suggestion)
- Added three shortwave water lines

Improve surface classification in AIRS-Only retrieval

- Used AVN forecast T_s for ice determination
- Coastline definitions made consistent with MIT algorithm

Removed cloud artifact at 300 mb (identified by Van Dang)

Differences of V5.29 from Current JPL System

Subsequent Research

- New approach for thresholds for T(p) QC flags
- New thresholds for other QC flags

Features at JPL not yet incorporated at SRT

- Modifications to Phil's tuning
- Use of Evan's new climatology start up
  - Primarily influences water vapor above 100 mb

Version-5 Temperature Profile Quality Control

Used for Stratosphere Good cases only

Temperature profile error estimates $\delta T(p)$ are used to determine pressure p_{best}, down to which Qual_Temp = 0

p_{best} is the pressure down to which $\delta T(p) \leq \Delta T(p)$ where $\Delta T(p)$ is an acceptance threshold

Version-5 $\Delta T(p)$ thresholds were one "size fits all"

Same Standard thresholds were used for weather (data assimilation) and climate purposes

Data assimilation needs highest accuracy with good spatial coverage

Climate needs best spatial coverage with good (unbiased) accuracy

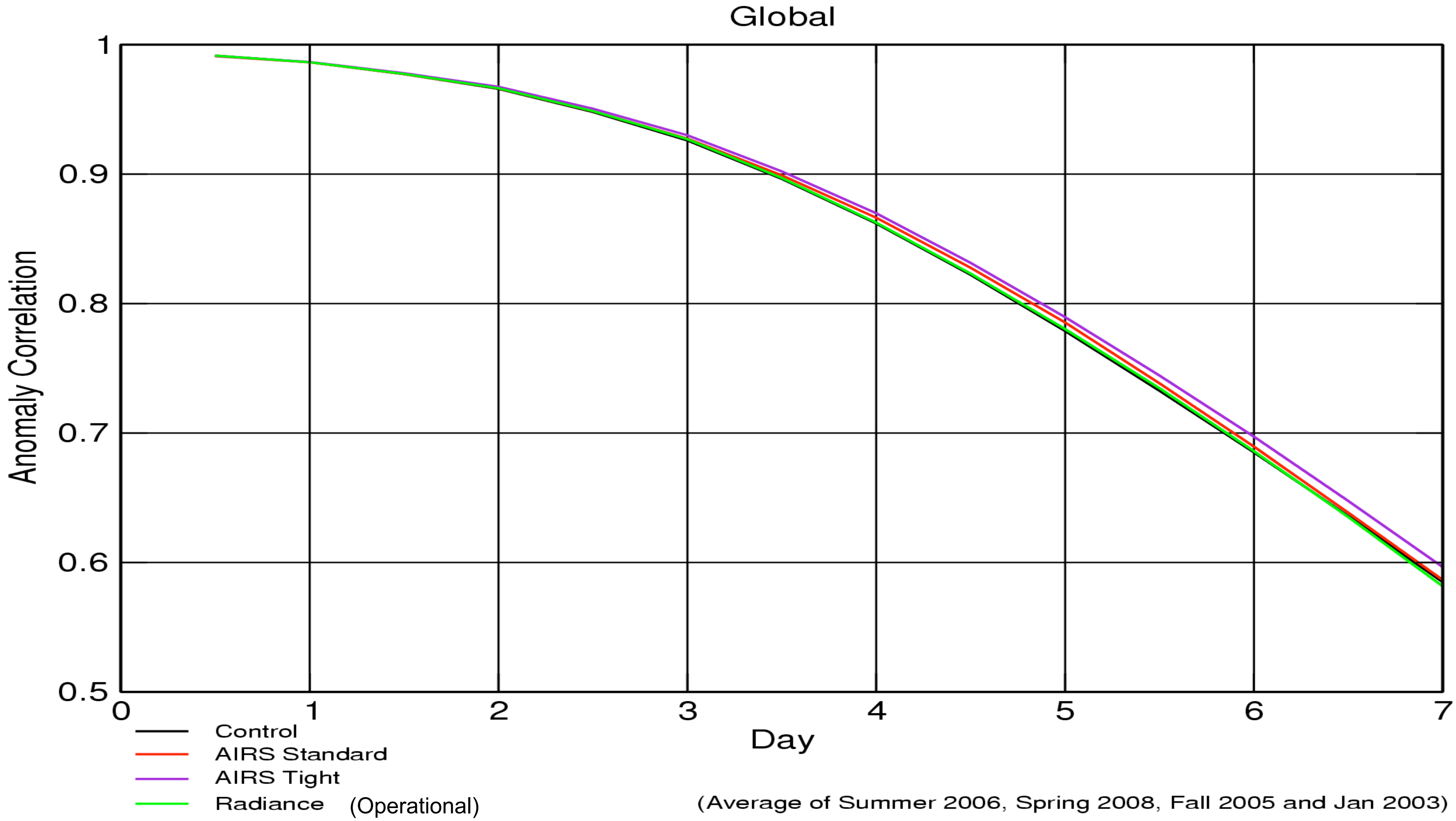
p_{good} represents the pressure down to which soundings are included in Level-3

Data assimilation experiments showed Standard Version-5 $\Delta T(p)$ was looser than optimal

Tight Version-5 $\Delta T(p)$ performed better

Average anomaly correlation coefficients for four experiments using GEOS-5

500 mb Geopotential Heights



An anomaly correlation of 1.0 represents a perfect forecast

An anomaly correlation of 0.6 is the lower bound of a useful forecast

AIRS Tight improves 7-day forecast skill by about 4 hours

Approach to Generate Level-3 Temperature Products

Version-5

Cases in which Stratosphere is “no good” are not included in Level-3 product at any level

Cases in which Stratosphere is good are included down to p_{best} (say 500 mb)

Over land - cases are also included in Level-3 down to p_{surf} if $p_{best} \geq 300$mb: i.e. $p_{good} = p_{surf}$

Otherwise cases are excluded from Level-3 for $p > p_{best}$: i.e., $p_{good} = p_{best}$

Over ocean - cases are excluded from Level-3 for $p > p_{best}$: i.e., $p_{good} = p_{best}$

p_{best} could be p_{surf} over ocean

Modified Approach to Generate Level-3 Temperature Products

George is concerned that Version-5 Level-3 products at different pressure levels contain different ensembles of cases

Proposed Version-6 Approach to generate multiple Level-3 temperature data sets

Version-6 Level-3 products will use all cases down to p_{good} as before

Version-6 Level-3A products will use a common ensemble at all levels
Criterion TBD

Improved Version-6 Approach to Obtain p_{good}

p_{good} was obtained in an ad-hoc manner in Version-5

In Version-6, p_{good} will be determined by error estimate thresholds as is p_{best}

We define two sets of thresholds $\Delta_A T(p)$ and $\Delta_C T(p)$ to replace $\Delta T(p)$

Used for data assimilation and climate purposes respectively

Essentially no retrievals are "left behind"

p_{best} is defined as before but using $\Delta T_A(p)$

$\Delta_A T(p)$ is tighter than current $\Delta T(p)$

p_{good} is defined analogously to p_{best} but using $\Delta T_C(p)$

$\Delta_C T(p)$ is looser than current $\Delta T(p)$

As done now

Level-2 soundings will be flagged as 0 down to p_{best}

Level-2 soundings will be flagged as 1 between p_{best} and p_{good}

Level-2 soundings will be flagged as 2 for $p > p_{good}$

Assessment of Results

We ran retrievals for 6 days for V5.0, V5.29, and V5.29AO

9/6/2002, 1/25/2003, 9/29/2004, 8/5/2005, 2/24/2007, 8/10/2007

Assessments are done based on differences from ECMWF for 6 days

All experiments have their own error estimate coefficients EE

We look at 1) yields, 2) RMS differences from ECMWF, and 3) bias

We compare 6-day means and temporal trends of 1) through 3)

Merit Criteria

1) Best temperature profile RMS and bias difference from ECMWF with highest yield
   - We now are significantly improving forecast skill by assimilating T(p)
   - We do not want to lose this

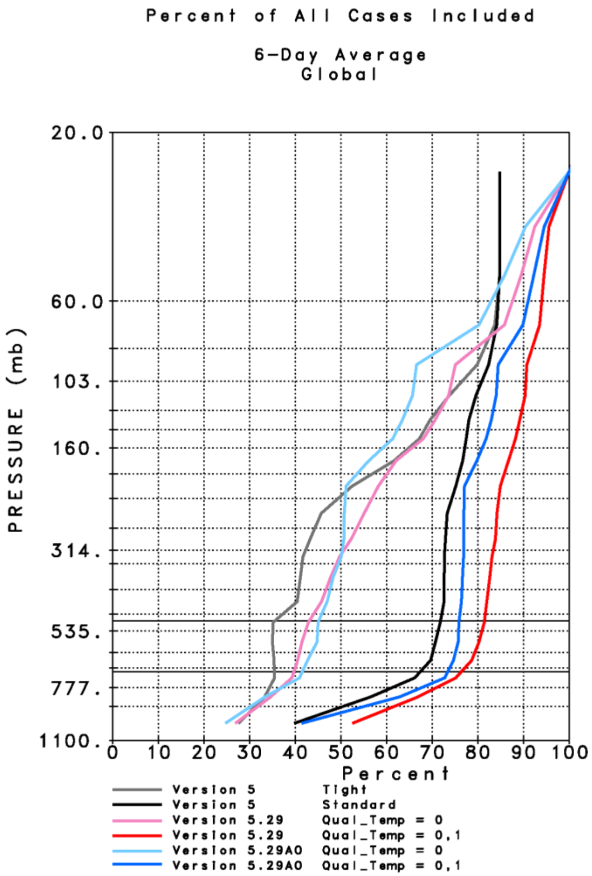
2) Smallest trends in (T(p) – ECMWF)

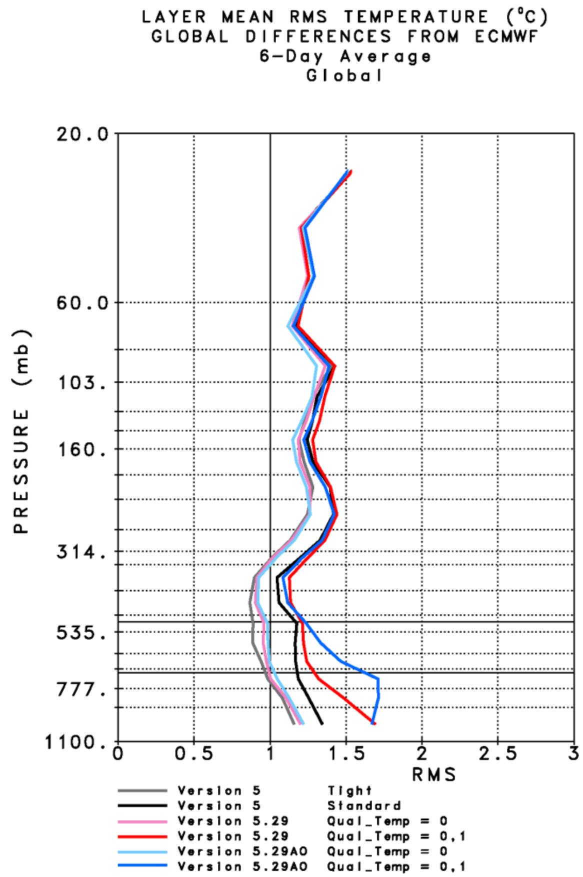
3) Smallest (negative) trends in yield, especially for climate product
   - Is the system stable over time?

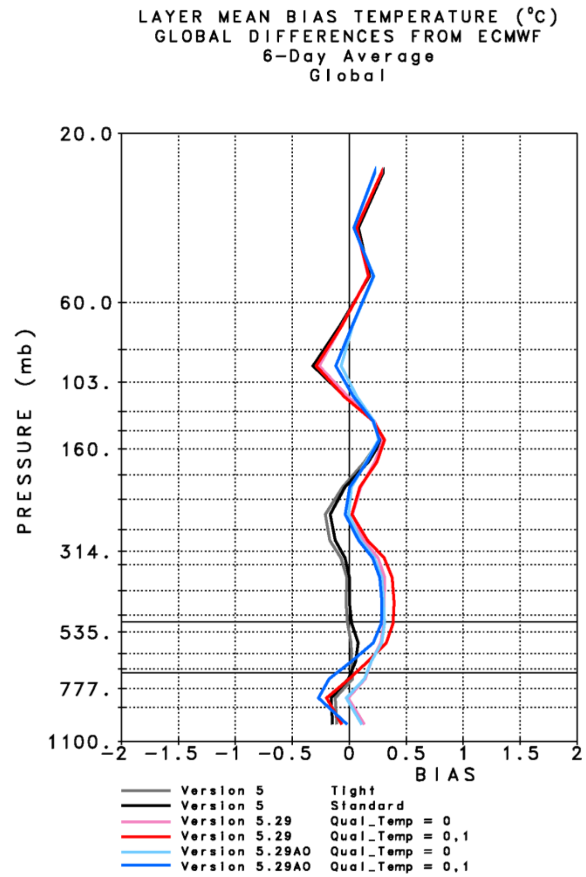
4) Best SST product in terms of lowest RMS differences and % outliers with high yield

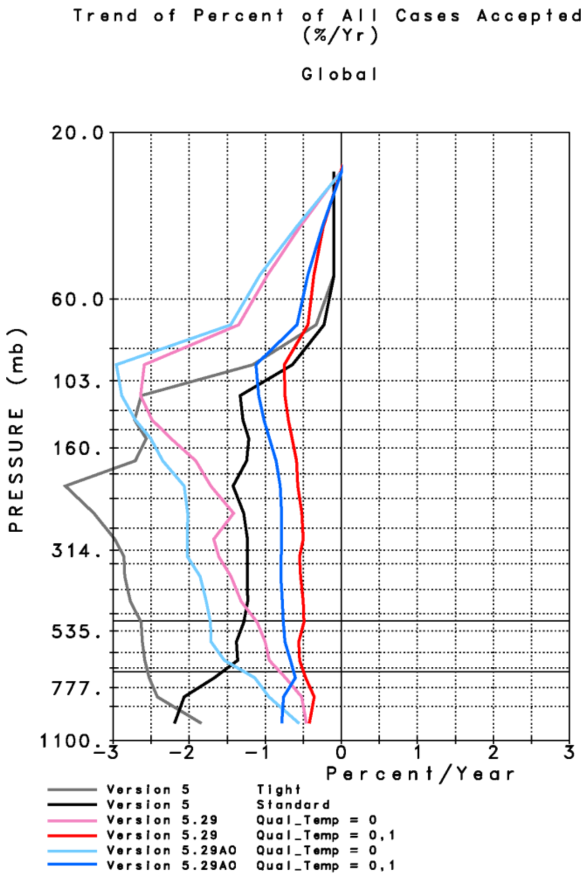
5) Smallest difference of ocean spectral emissivity from Masuda

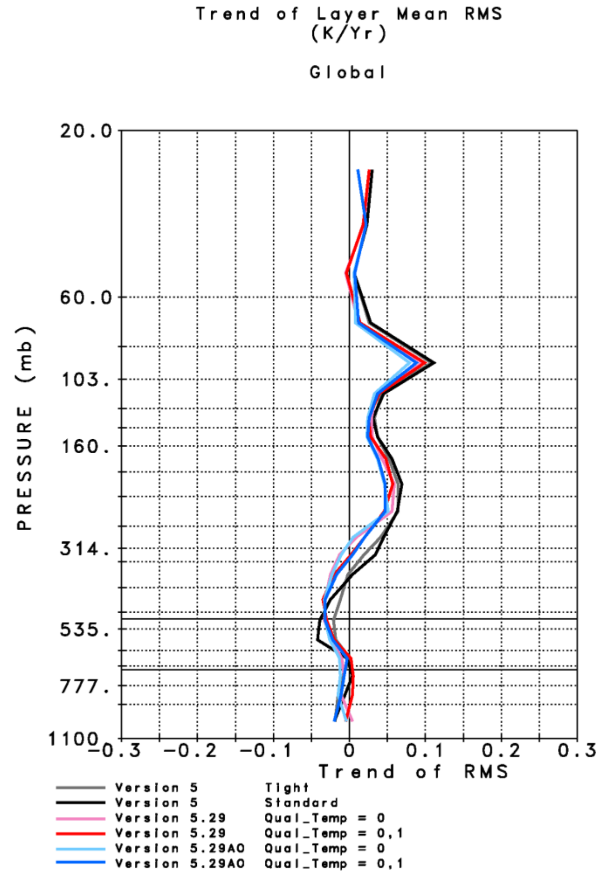
6) Smallest day/night differences in spectral emissivity

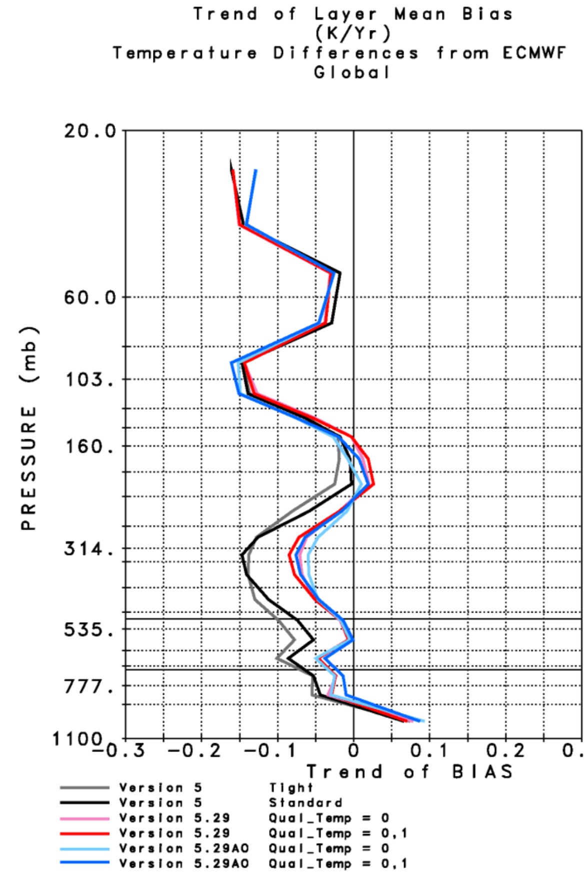

Percent of All Cases Included
6-Day Average
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100.
0 10 20 30 40 50 60 70 80 90 100
Percent
Version 5 Tight
Version 5 Standard
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29AO Qual_Temp = 0
Version 5.29AO Qual_Temp = 0,1


LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM ECMWF
6-Day Average
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100.
0 0.5 1 1.5 2 2.5 3
RMS
Version 5 Tight
Version 5 Standard
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29AO Qual_Temp = 0
Version 5.29AO Qual_Temp = 0,1


LAYER MEAN BIAS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM ECMWF
6-Day Average
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100.
-2 -1.5 -1 -0.5 0 0.5 1 1.5 2
BIAS
Version 5 Tight
Version 5 Standard
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29AO Qual_Temp = 0
Version 5.29AO Qual_Temp = 0,1


Trend of Percent of All Cases Accepted
(%/Yr)
Global
20.0
60.0
103.
160.
314.
535.
777.
1100
PRESSURE (mb)
-3
-2
-1
0
1
2
3
Percent/Year
Version 5 Tight
Version 5 Standard
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29AO Qual_Temp = 0
Version 5.29AO Qual_Temp = 0,1


Trend of Layer Mean RMS
(K/Yr)
Global
20.0
60.0
103.
160.
314.
535.
777.
1100
PRESSURE (mb)
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
Trend of RMS
Version 5 Tight
Version 5 Standard
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29AO Qual_Temp = 0
Version 5.29AO Qual_Temp = 0,1


Trend of Layer Mean Bias
(K/Yr)
Temperature Differences from ECMWF
Global
20.0
60.0
103.
160.
314.
535.
777.
1100
PRESSURE (mb)
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
Trend of BIAS
Version 5 Tight
Version 5 Standard
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29AO Qual_Temp = 0
Version 5.29AO Qual_Temp = 0,1

Comparison of V5.29, V5.29AO with Version-5 Temperature Profiles

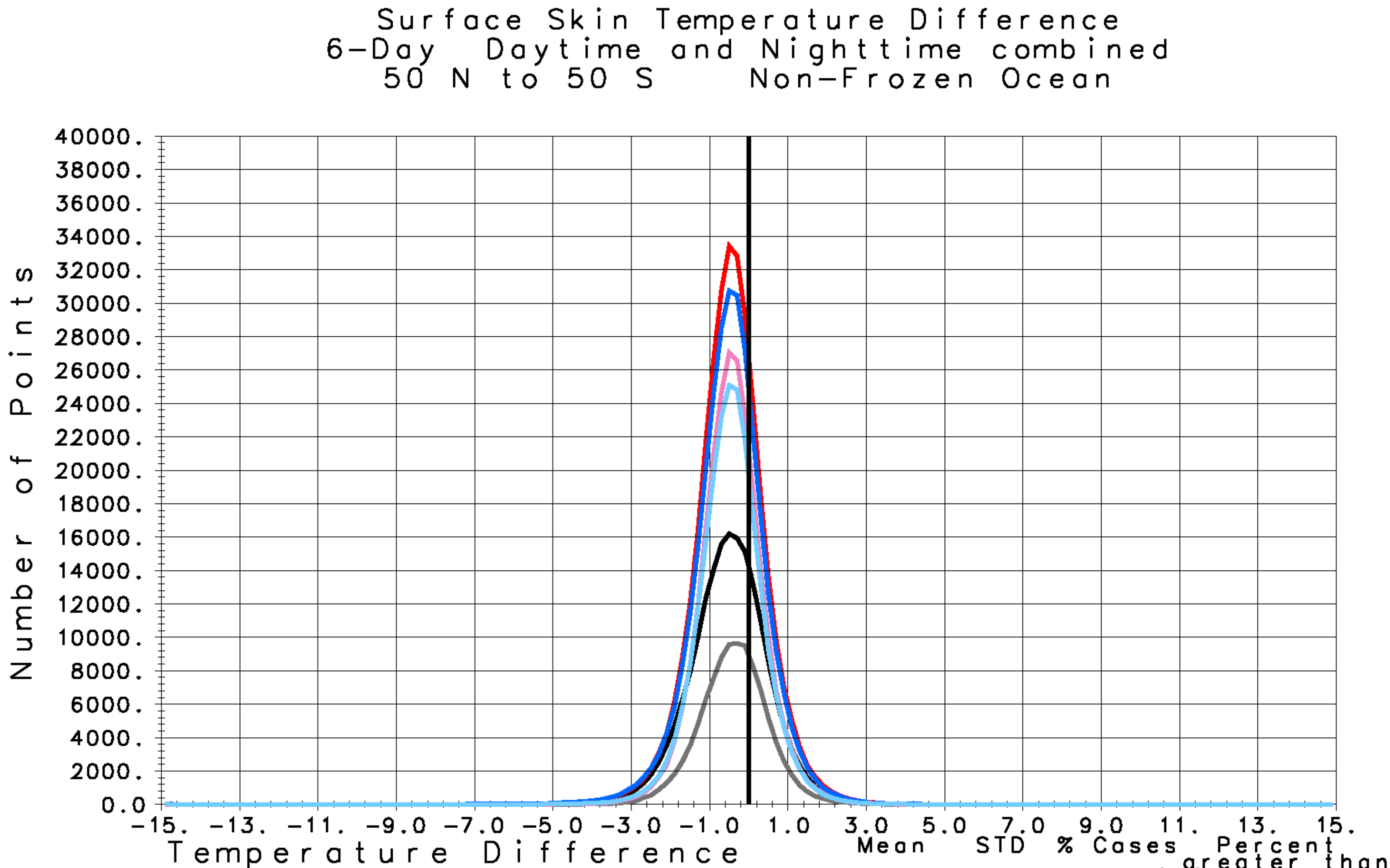
Temperature profile mean statistics

No retrievals are left behind

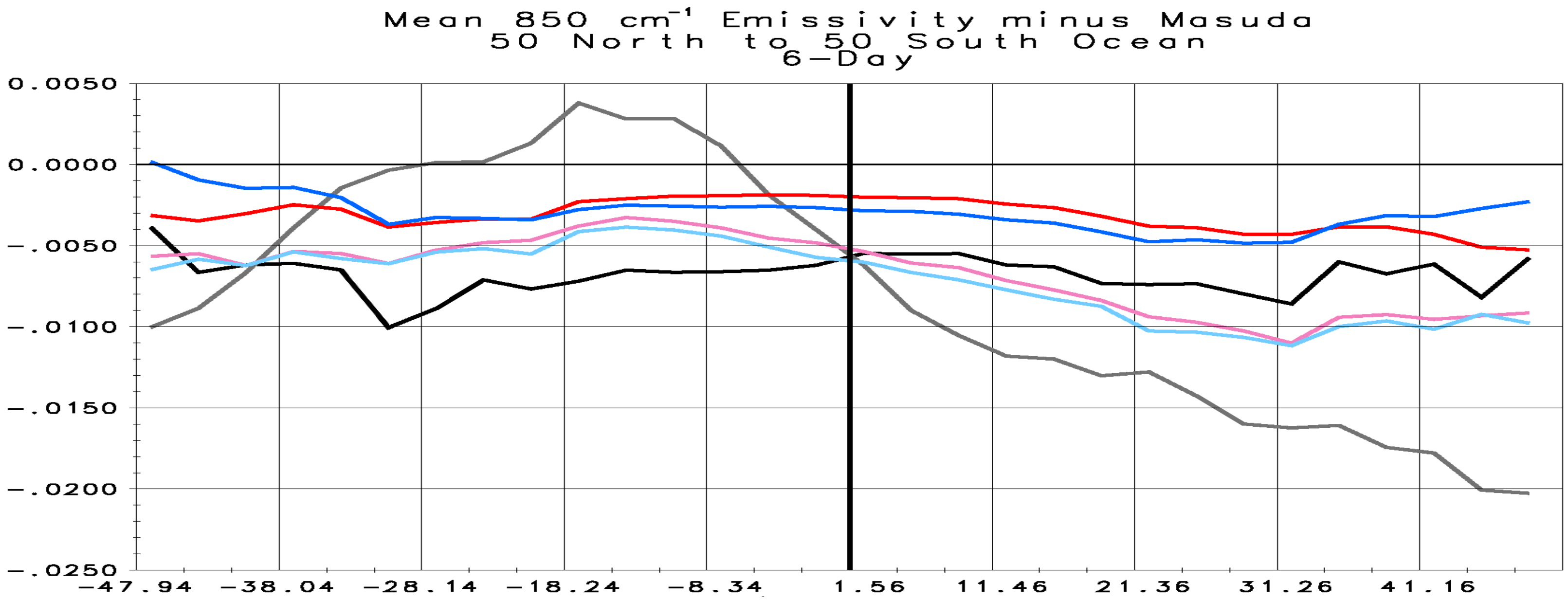
- V5.29 Qual_Temp = 0 retrievals are comparable to Version-5 Tight QC in yield, RMS
- V5.29 Qual_Temp – 0, 1 retrievals have higher yield than Version-5 Standard QC – comparable bias
- V5.29 AO is comparable to V5.29 for Data Assimilation
- V5.29 AO is somewhat poorer than V5.29 for Climate

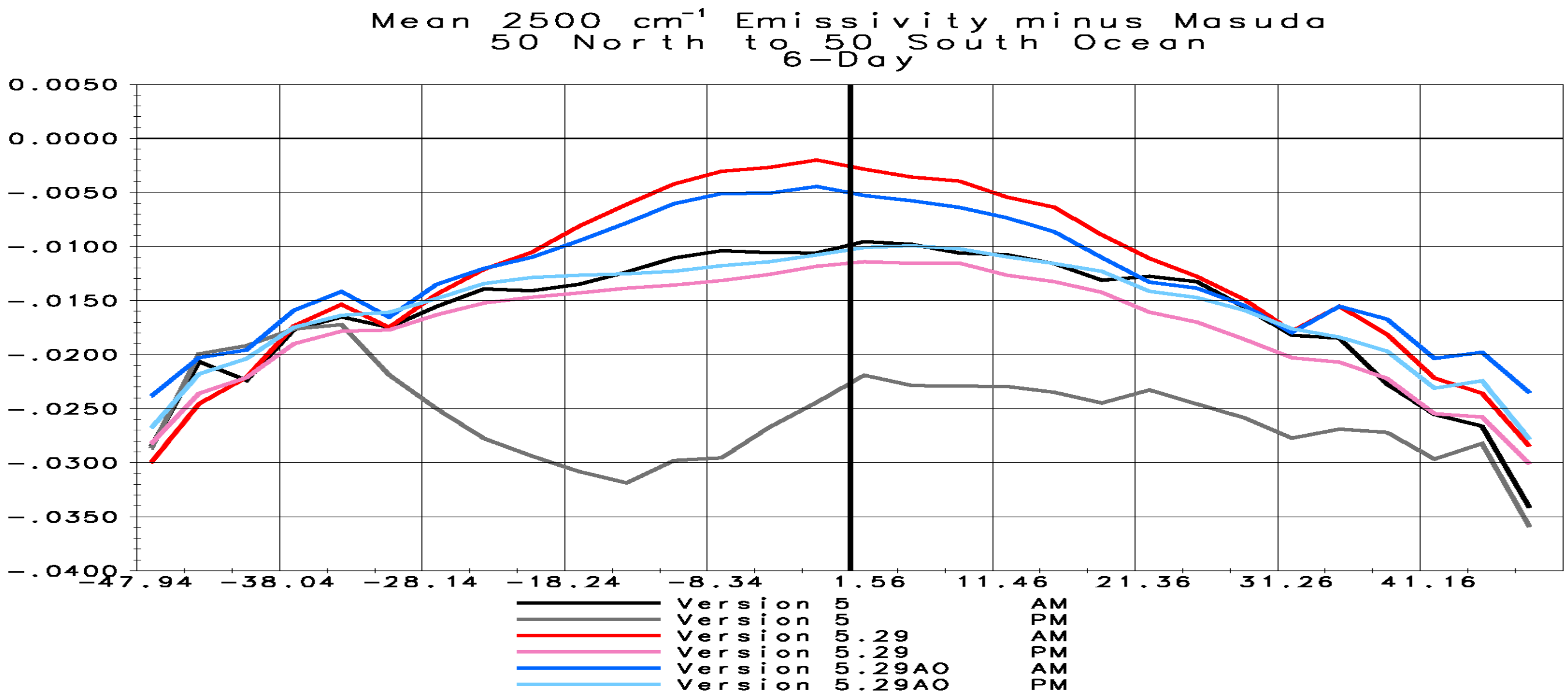
Temperature profile trends

- V5.29 has a much smaller spurious negative T(p) trend than V5.0
- V5.29 has a smaller negative yield trend than Version-5 – but still too large
  - The negative yield trends are less for Climate than Data Assimilation
- V5.29AO yield trends are slightly poorer than V5.29, T(p) trends better



Version	QC	Mean	STD	% Cases	Percent greater than |3| from mean
Version 5	QC=0,1	-0.31	0.98	26.00	1.21
Version 5.29	QC=0,1	-0.28	0.91	43.38	1.04
Version 5.29A0	QC=0,1	-0.30	0.97	40.59	1.36
Version 5	QC=0	-0.20	0.87	14.02	0.49
Version 5.29	QC=0	-0.25	0.81	32.34	0.50
Version 5.29A0	QC=0	-0.28	0.87	30.78	0.67





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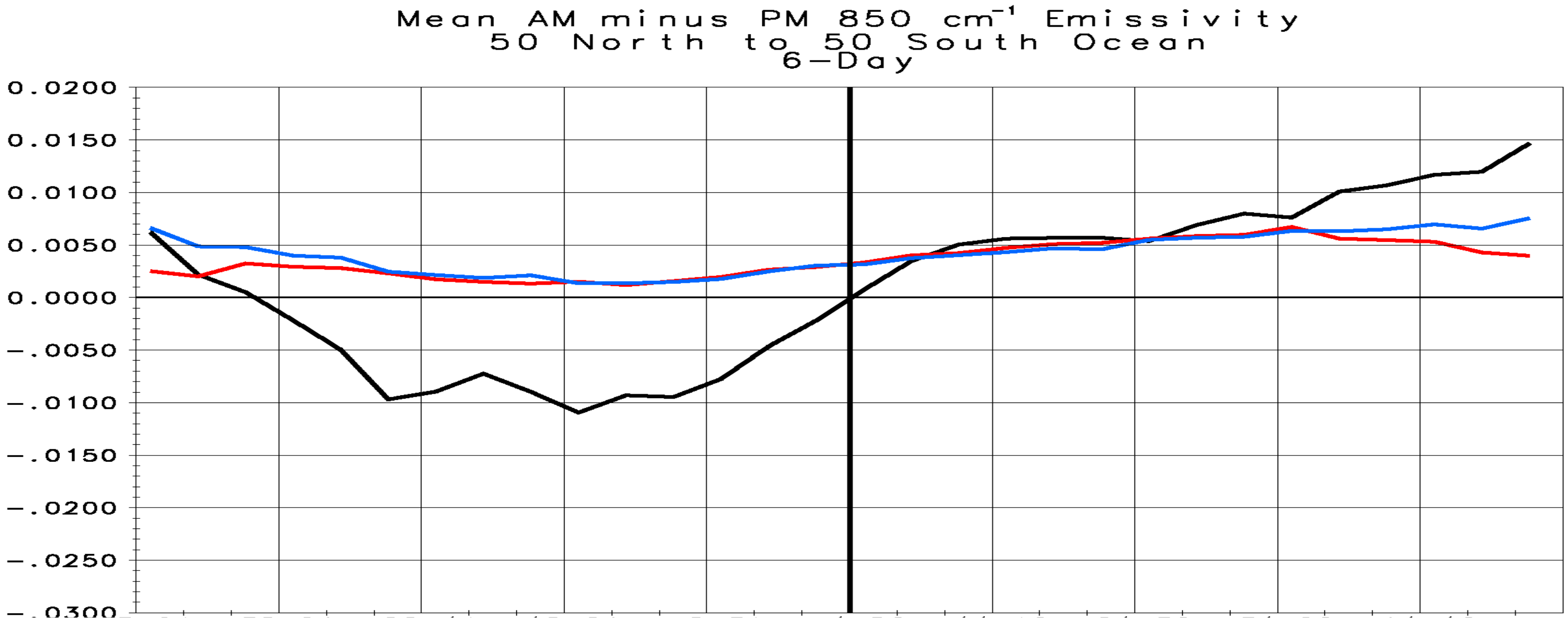
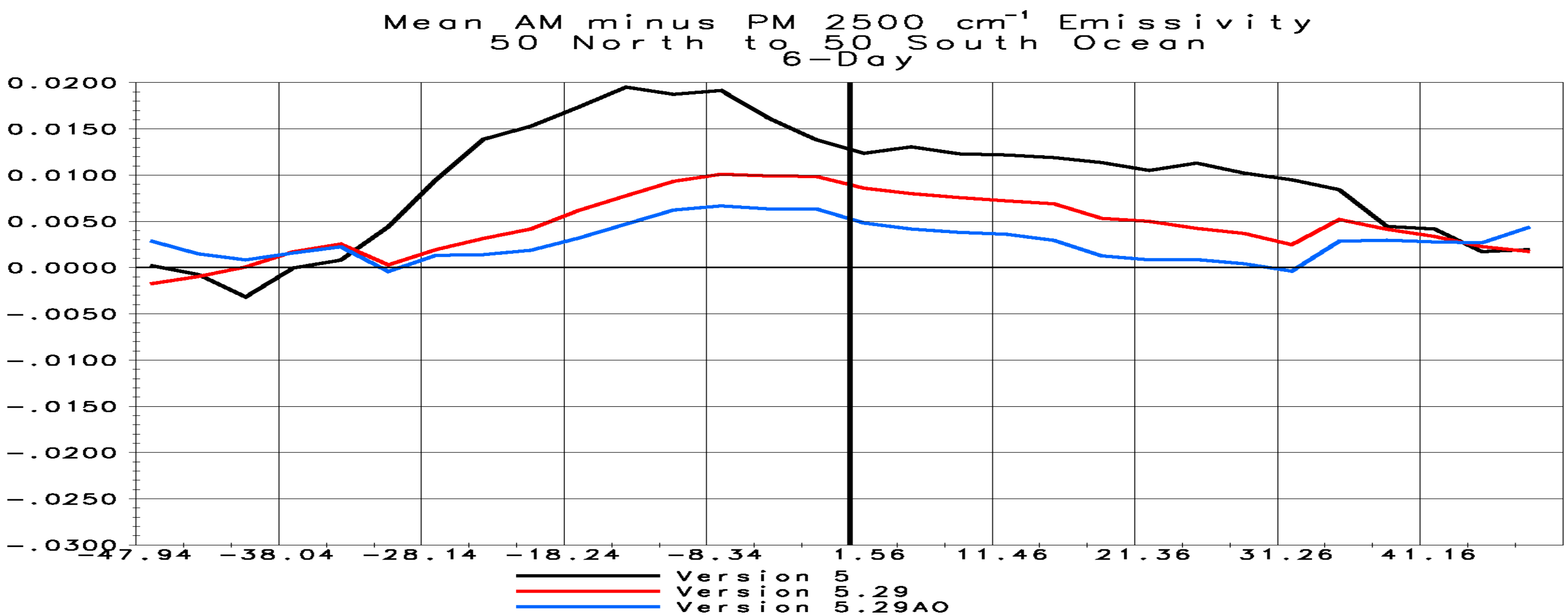
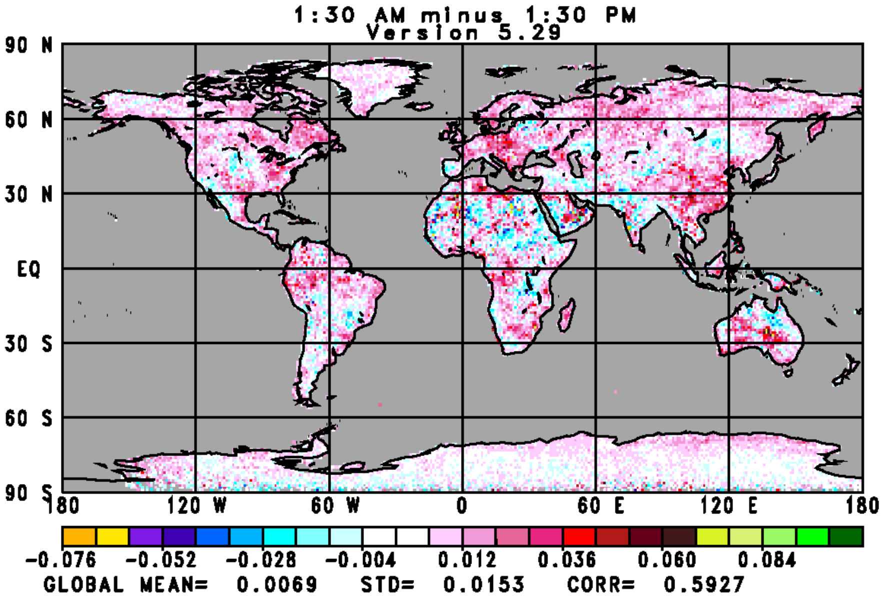
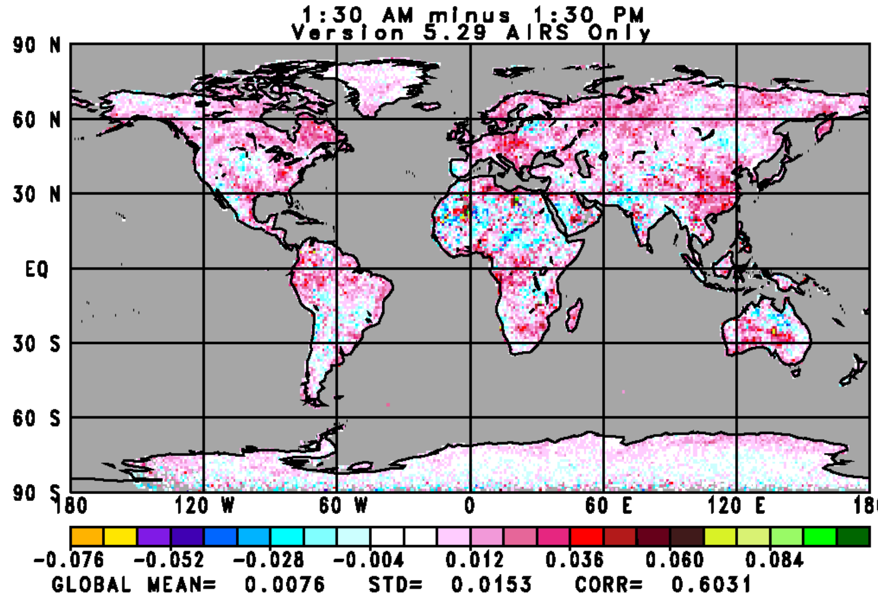
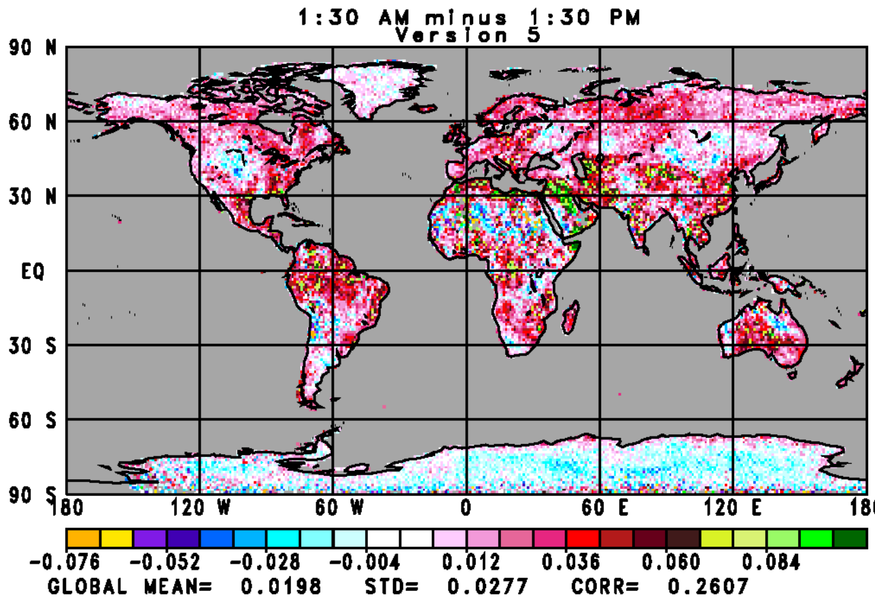

Mean AM minus PM 850 cm⁻¹ Emissivity
50 North to 50 South Ocean
6-Day
0.0200
0.0150
0.0100
0.0050
0.0000
-.0050
-.0100
-.0150
-.0200
-.0250
-.0300


Mean AM minus PM 2500 cm⁻¹ Emissivity
50 North to 50 South Ocean
6-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
Version 5
Version 5.29
Version 5.29AO

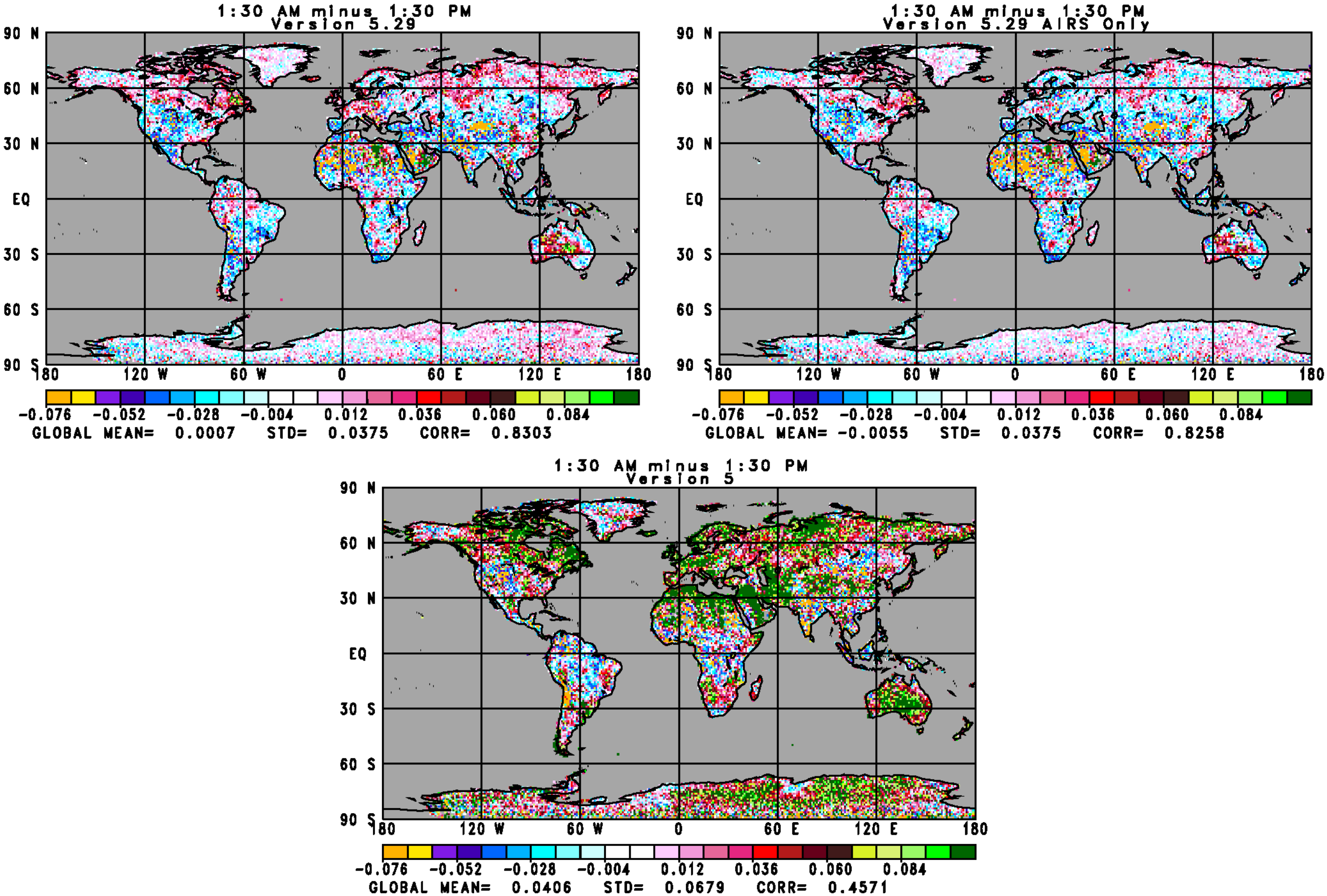
6-Day
AIRS IR Emissivity 850 cm^{-1}







6-Day
AIRS IR Emissivity 2500 cm^{-1}



Comparison of V5.29, V5.29AO with Version-5 Surface Skin Parameters

Surface Skin Temperature

Quality controlled V5.29 SST's are much better than V5.0

- Better accuracy with much higher yield
- V5.29AO SST's are slightly poorer than V5.29

Surface Spectral Emissivities

V5.29 Ocean surface spectral emissivities are much better than V5.0

- Day/night differences are much smaller – no sun-glint effect
- Angular emissivities are much more symmetric
- Emissivities are closer to Masuda, especially at 2500 cm^{-1}

V5.29 Day/night land surface emissivity differences are much smaller than Version-5

V5.29AO Ocean and Land surface emissivities are of comparable quality to V5.29

Version-5.29 NoCCReg (No Cloud Cleared Regression)

Version-5.29 NoCCReg is just like Version-5.29 with 2 exceptions

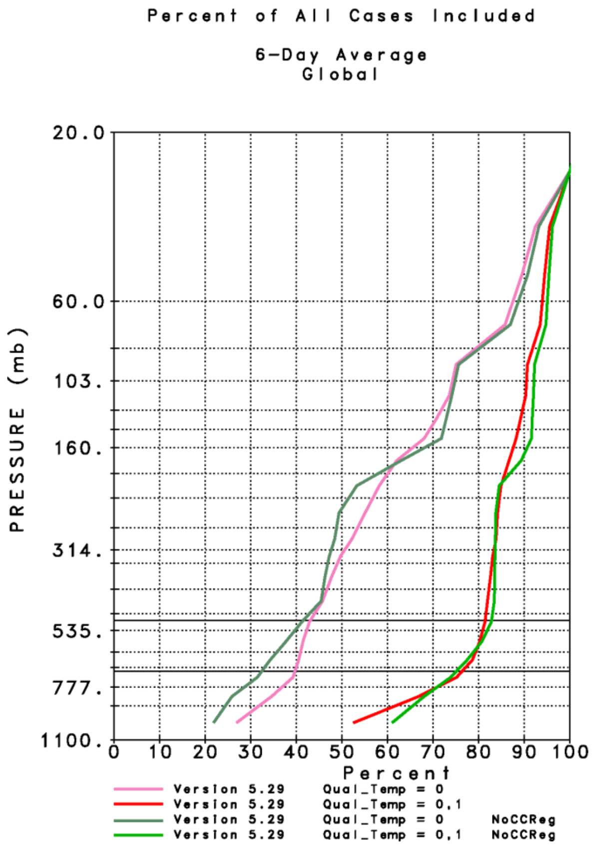
- The cloudy cleared regression step is run, but not used as first guess for T(p), q(p) – as done now for O_3(p)
  - Cloudy regression followed by microwave retrieval is first guess for T(p), q(p)

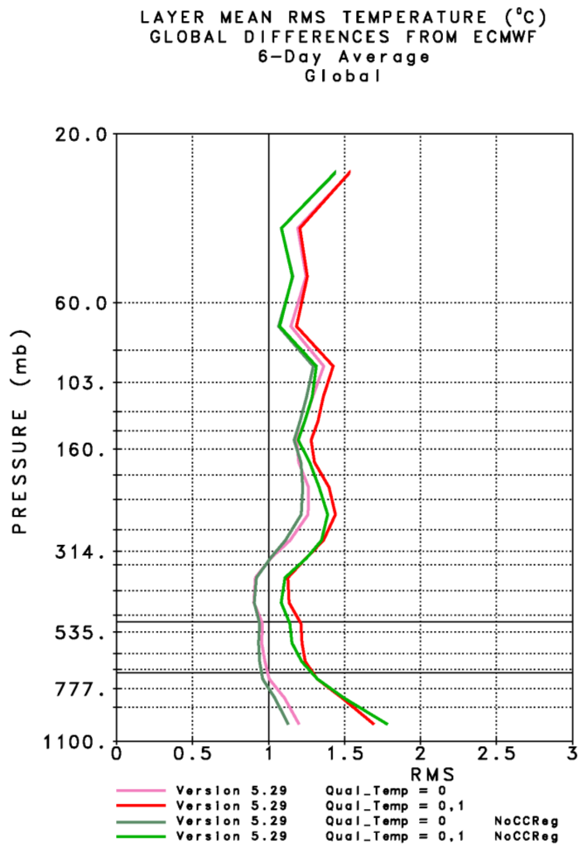
  The cloud cleared regression is still used as a first guess for surface skin temperature and emissivity – results were better this way

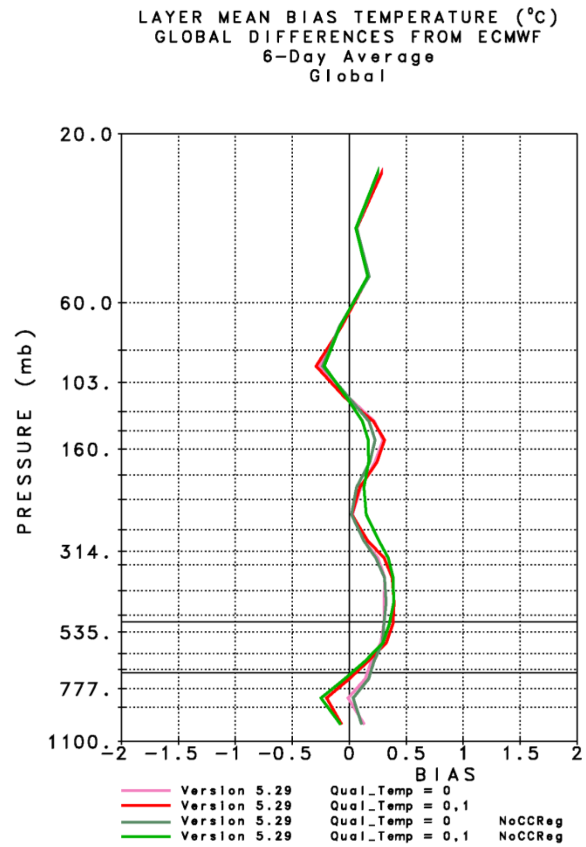
- NOAA score is not included as a predictor for error estimates

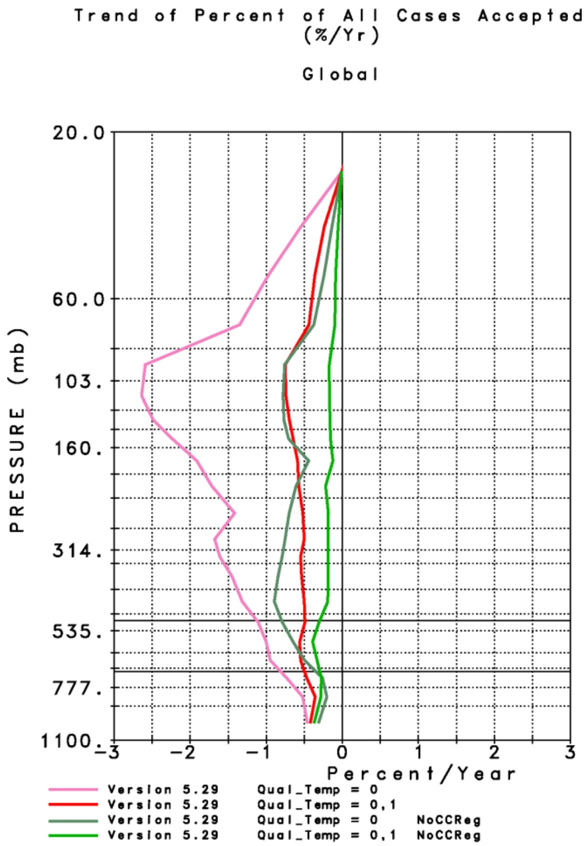
This experiment was run to see if skipping the cloud cleared regression would help trends.

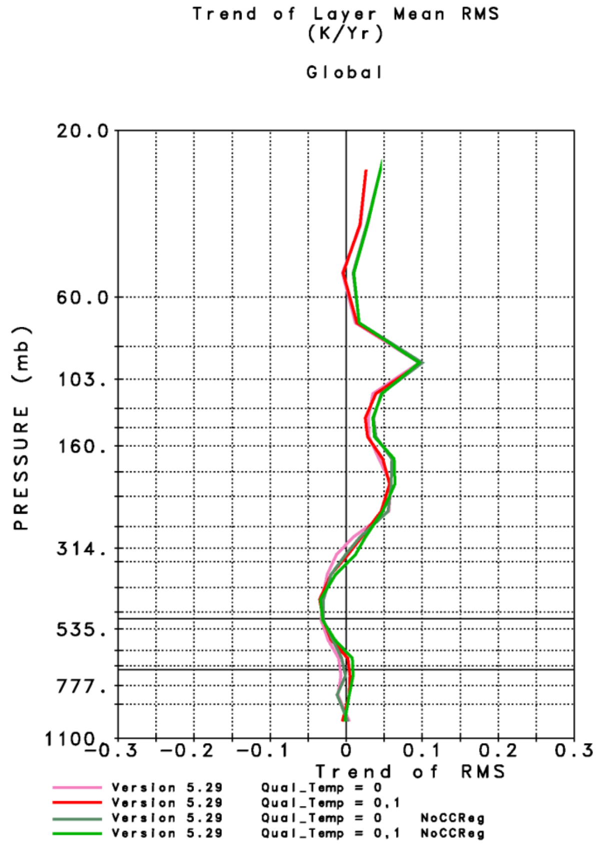
Results shown for AIRS/AMSU system only
AIRS Only is similar

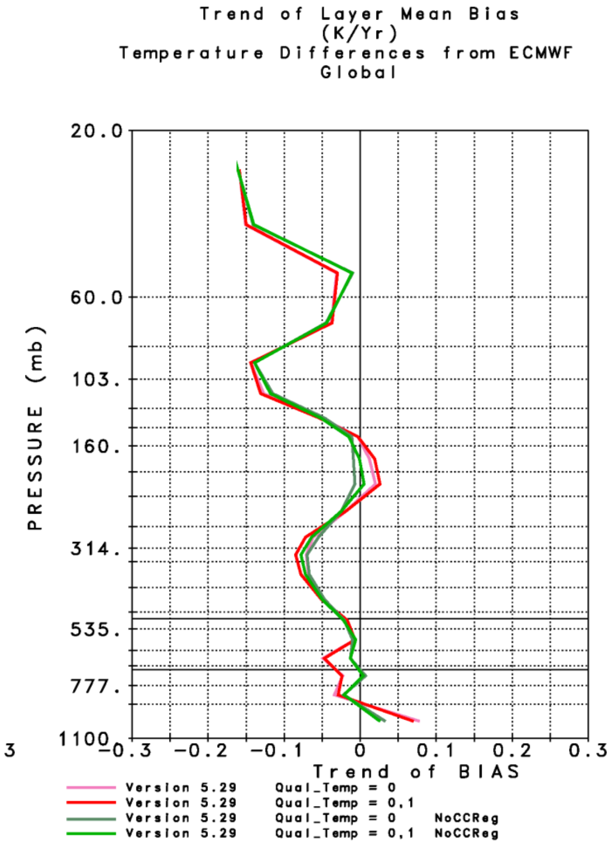

Percent of All Cases Included
6-Day Average
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100.
0 10 20 30 40 50 60 70 80 90 100
Percent
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 NoCCReg
Version 5.29 Qual_Temp = 0,1 NoCCReg

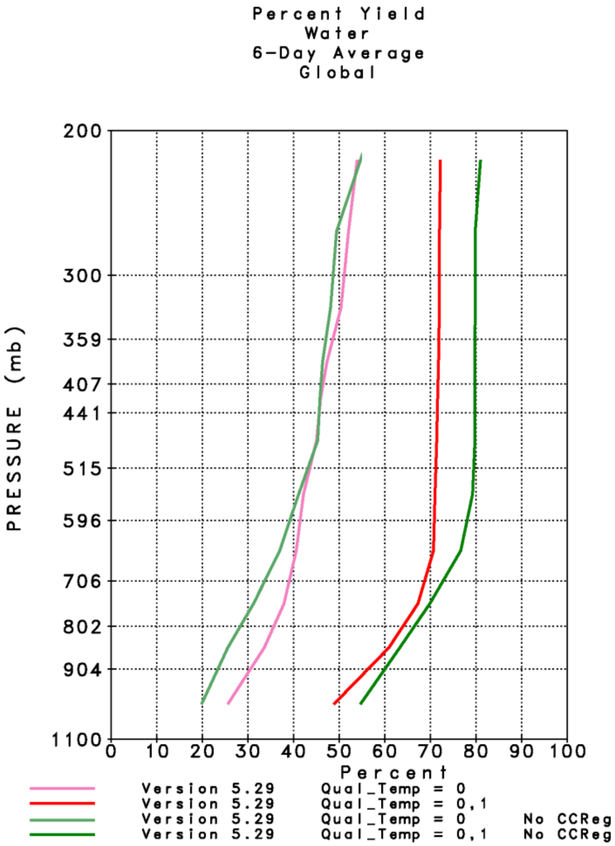

LAYER MEAN RMS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM ECMWF
6-Day Average
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100.
0 0.5 1 1.5 2 2.5 3
RMS
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 NoCCReg
Version 5.29 Qual_Temp = 0,1 NoCCReg

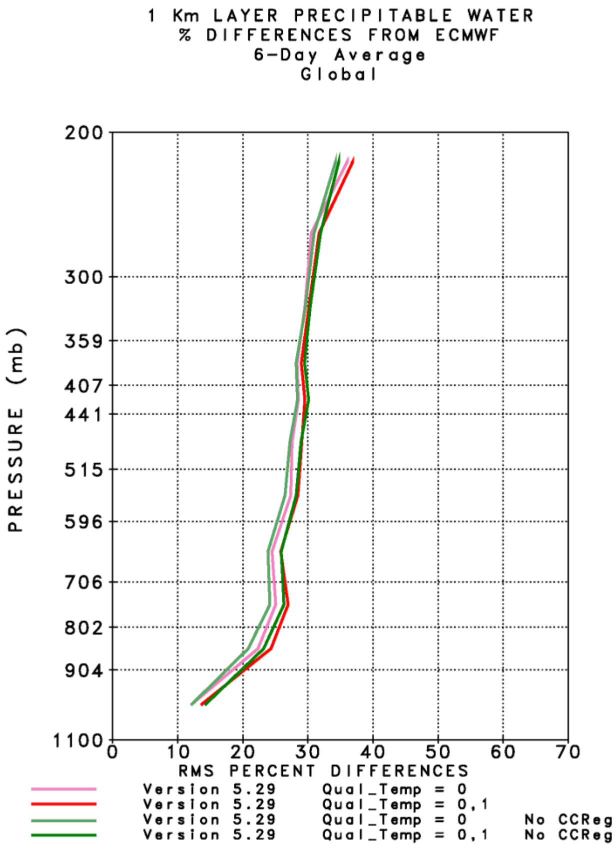

LAYER MEAN BIAS TEMPERATURE (°C)
GLOBAL DIFFERENCES FROM ECMWF
6-Day Average
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100.
−2 −1.5 −1 −0.5 0 0.5 1 1.5 2
BIAS
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 NoCCReg
Version 5.29 Qual_Temp = 0,1 NoCCReg

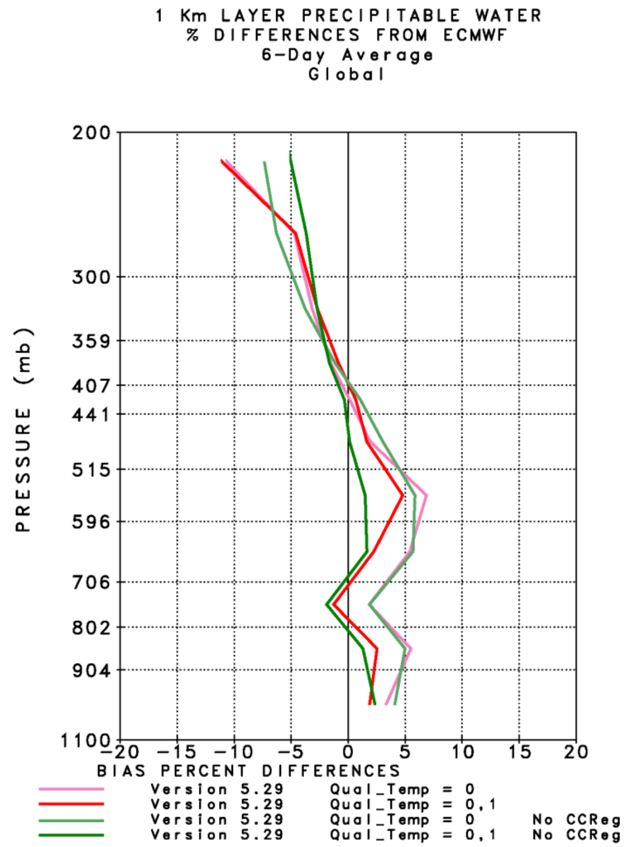

Trend of Percent of All Cases Accepted
(%/Yr)
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100
-3 -2 -1 0 1 2 3
Percent/Year
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 NoCCReg
Version 5.29 Qual_Temp = 0,1 NoCCReg

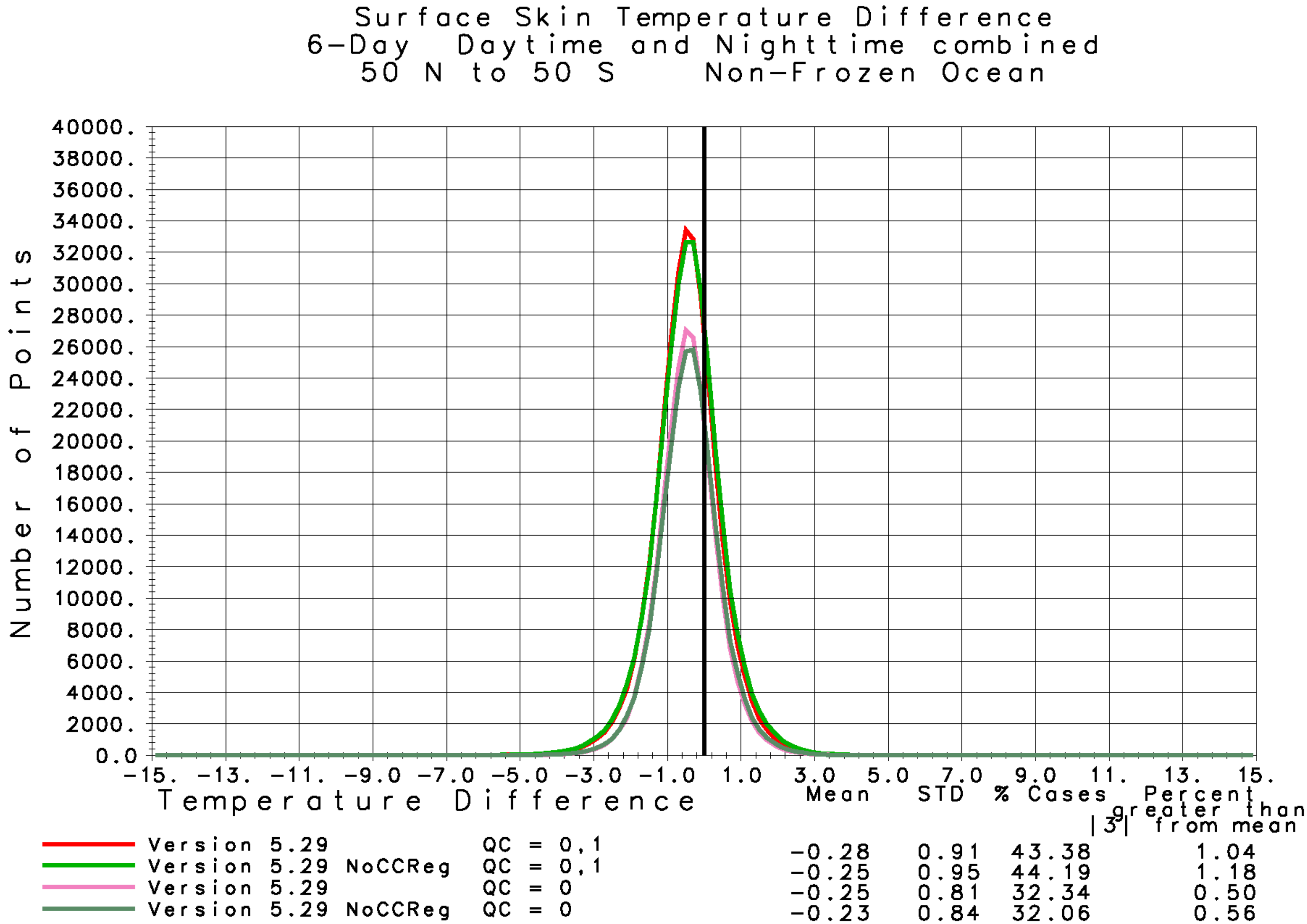

Trend of Layer Mean RMS
(K/Yr)
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100
-0.3 -0.2 -0.1 0 0.1 0.2 0.3
Trend of RMS
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 NoCCReg
Version 5.29 Qual_Temp = 0,1 NoCCReg


Trend of Layer Mean Bias
(K/Yr)
Temperature Differences from ECMWF
Global
PRESSURE (mb)
20.0
60.0
103.
160.
314.
535.
777.
1100
-0.3 -0.2 -0.1 0 0.1 0.2 0.3
Trend of BIAS
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 NoCCReg
Version 5.29 Qual_Temp = 0,1 NoCCReg


Percent Yield
Water
6-Day Average
Global
PRESSURE (mb)
200
300
359
407
441
515
596
706
802
904
1100
0 10 20 30 40 50 60 70 80 90 100
Percent
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 No CCReg
Version 5.29 Qual_Temp = 0,1 No CCReg


1 Km LAYER PRECIPITABLE WATER
% DIFFERENCES FROM ECMWF
6-Day Average
Global
PRESSURE (mb)
200
300
359
407
441
515
596
706
802
904
1100
0 10 20 30 40 50 60 70
RMS PERCENT DIFFERENCES
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 No CCReg
Version 5.29 Qual_Temp = 0,1 No CCReg


1 Km LAYER PRECIPITABLE WATER
% DIFFERENCES FROM ECMWF
6-Day Average
Global
PRESSURE (mb)
200
300
359
407
441
515
596
706
802
904
1100
−20 −15 −10 −5 0 5 10 15 20
BIAS PERCENT DIFFERENCES
Version 5.29 Qual_Temp = 0
Version 5.29 Qual_Temp = 0,1
Version 5.29 Qual_Temp = 0 No CCReg
Version 5.29 Qual_Temp = 0,1 No CCReg


Surface Skin Temperature Difference
6-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
Version 5.29 QC = 0,1 -0.28 0.91 43.38 1.04
Version 5.29 NoCCReg QC = 0,1 -0.25 0.95 44.19 1.18
Version 5.29 QC = 0 -0.25 0.81 32.34 0.50
Version 5.29 NoCCReg QC = 0 -0.23 0.84 32.06 0.56

Comparison of V5.29, with V5.29 NoCCReg

Temperature Profiles

RMS errors of V5.29 NoCCRreg are somewhat improved above 300 mb compared to V5.29

Negative yield trends of V5.29 NoCCReg are significantly smaller throughout atmosphere than V5.29

Sea Surface Temperatures

RMS V5.29 NCCR SST's are comparable to those of V5.29

Humidity Profiles

RMS and bias errors of V5.29 NoCCReg are improved slightly compared to V5.29.

Other Version-5.29 Quality Flags

Constituent Good test requires Qual_H_2O=0

Current Constituent Good Test

Qual_H_2O=0 if $\delta W_{tot} \le 0.35 W_{tot}$

q(p) profile plots shown used Qual_Temp=0,1 plus Qual_H_2O=0

Qual_Cloud_OLR is always 0 as long as retrieval does not fail
cloud parameters never use a fallback state

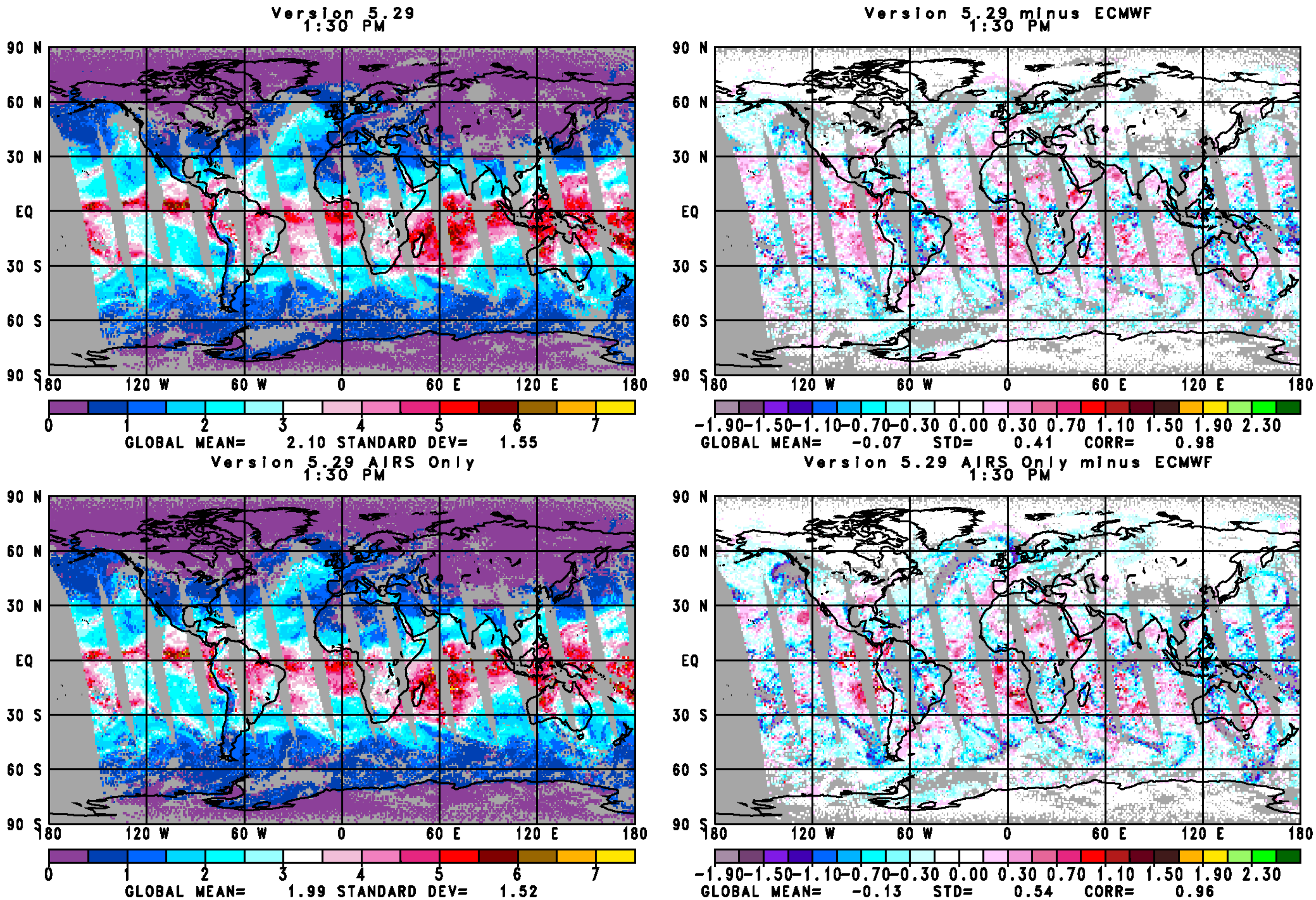
Qual_clrolr is 0 if Qual_H_20=0, otherwise Qual_clrolr=2

Qual_O_3, CO,… is 0 if Qual_H_2O=0 and other tests are passed
otherwise Qual_O_3 ,… =2

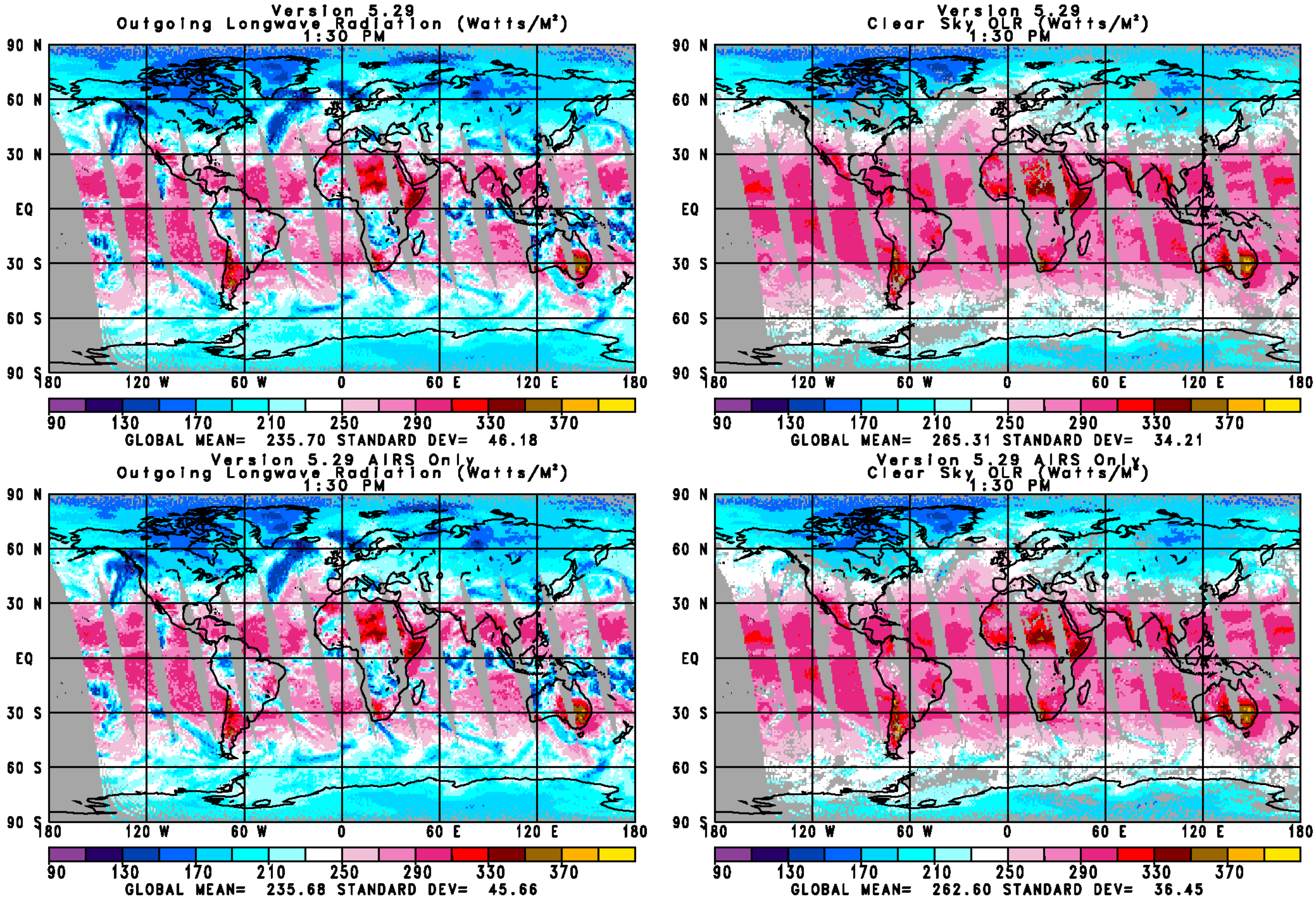
Some sample fields are shown for January 25, 2003

Constituent Good Test requires refinement, especially for AIRS Only

Total Precipititable Water (cm)
January 25, 2003



Outgoing Longwave Radiation (Watts/M²)
January 25, 2003



Clear Column Radiances CCR

Clear column radiances currently have a single flag Qual_CC_Rad

Qual_CC_Rad is in a separate product file with the cloud cleared radiances $\hat{R}_i$ for all channels

File contains $\hat{R}_i$ for all channels i as as well as uncertainty $\delta\hat{R}_i$

$\hat{R}_i$ and $\delta\hat{R}_i$ are in radiance units

In version 5.29 Qual_CC_Rad will be set equal to Qual_Cloud_OLR

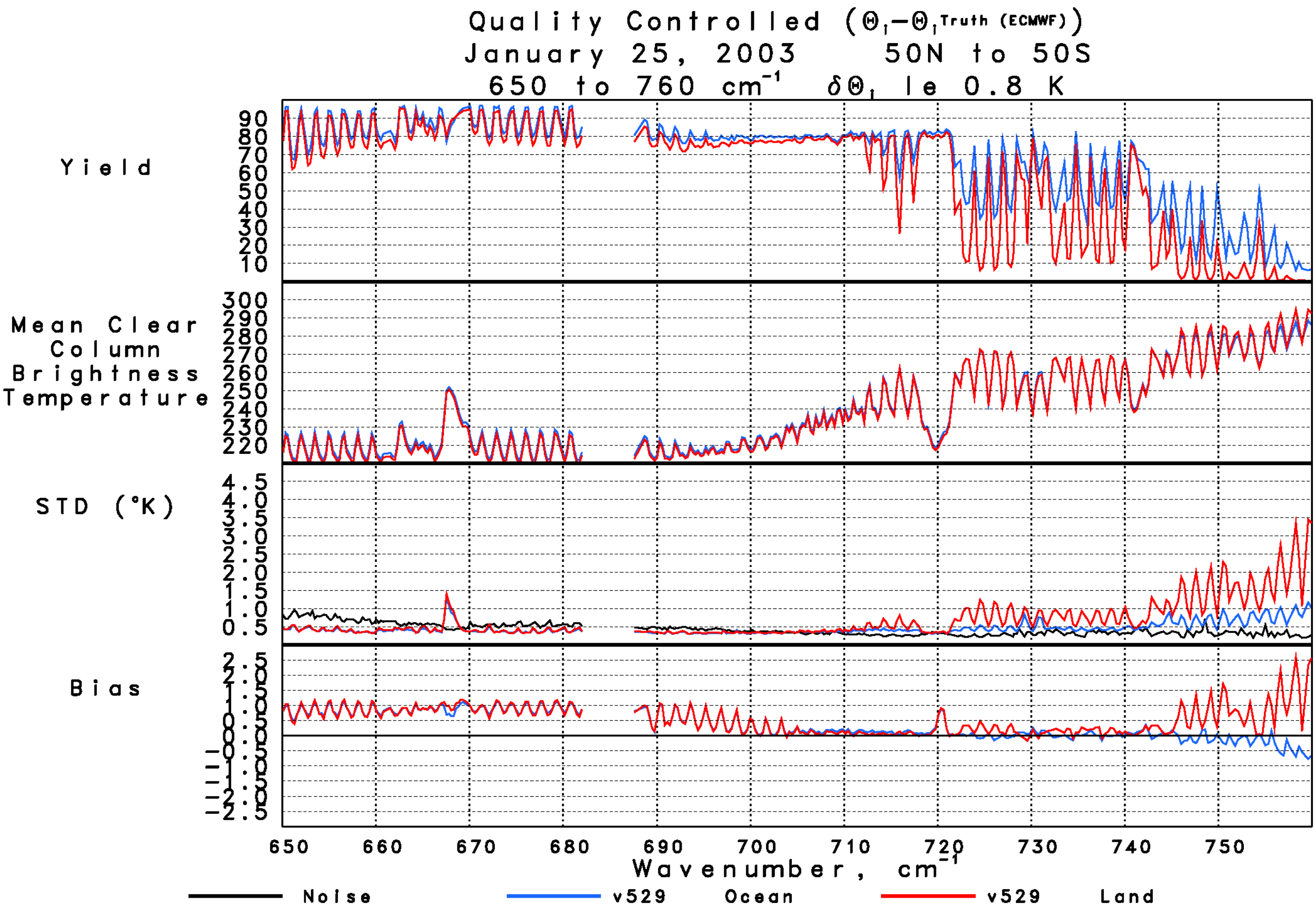
Quality Controlled clear column radiances can be used for data assimilation purposes

We recommend a channel-by-channel quality control according to

Qual_CC_Rad$_i$=0 if $\delta\Theta_i < 0.8$K where $\delta\Theta_i = \left(\frac{dB}{dT}\right)^{-1}_{\hat{\Theta}_i} \delta\hat{R}_i$

This is a channel by channel flag

We plan to start data assimilation experiments with QC'd $\hat{R}_i$ soon



Susskind, Blaisdell, and Iredell

Summary

Version 5.29 is improved considerably compared to Version 5.

Version 5.29 AO performs slightly poorer than Version 5.29 but is very good.

I do not recommend going exclusively to Version 5.29AO at this time.

Given the current set of regression coefficients, Version 5.29 NoCCReg performs best

I recommend this approach if we get nothing new.

Version 5.29 is essentially ready to become operational with one caveat.

There are no other significant liens on the system.

Requirement for Version-6

We must have a cloudy regression or other start-up state that does not use AMSU-4, 5

We could use current AIRS Only start-up state in absence of anything new. Better yet:

1) A new cloudy regression and cloud cleared regression from NOAA using new pristine channel set

2) A neural network start-up to replace both regressions

We will test 1) and/or 2) as soon as we get it

We estimate about 1 month to optimize and evaluate new start-up

Error estimate coefficients, QC thresholds, etc.

Further Desires for Version-6

Research to be done at SRT

A 9 spot cloud retrieval algorithm – 9α's, $9p_c$'s, 9 OLR's

John is working on it now – not more than 1 month

Re-examine Version-5 use of larger ad-hoc Level 3 SST thresholds from 40S to 60S

Current SST yield if considerably higher than Version-5

Research to be done elsewhere

Incorporation of latitude and seasonal dependent CO climatology first guess

Recommendation for new products

Spectral components of OLR

A level-3 surface emissivity product for select window channels only

Further recommendation

JPL should include coastal cases in Level-3 product as we do

Spectral OLR

OLR is computed as a sum of 16 spectral OLR components Fi

$$F = \sum_{i=1}^{16} F_i \qquad F_{CLR} = \sum_{i=1}^{16} F_{i,CLR}$$

We currently write out F and F_{CLR} in Level 2 and Level 3 products

I strongly recommend we also write out F_i and $F_{i,CLR}$ for all components

Trends of F_i and $F_{i,CLR}$ would be useful in explaining trends of F, F_{CLR}

NASA