



USING HYPERSPECTRAL INFRARED RADIANCE GLOBAL DATA SETS TO VALIDATE WEATHER AND CLIMATE ANALYSES



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NOAA/NESDIS

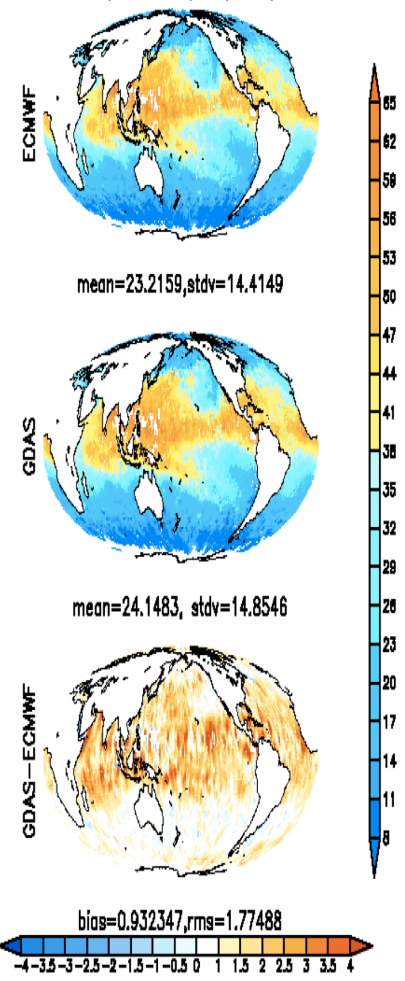


Motivation

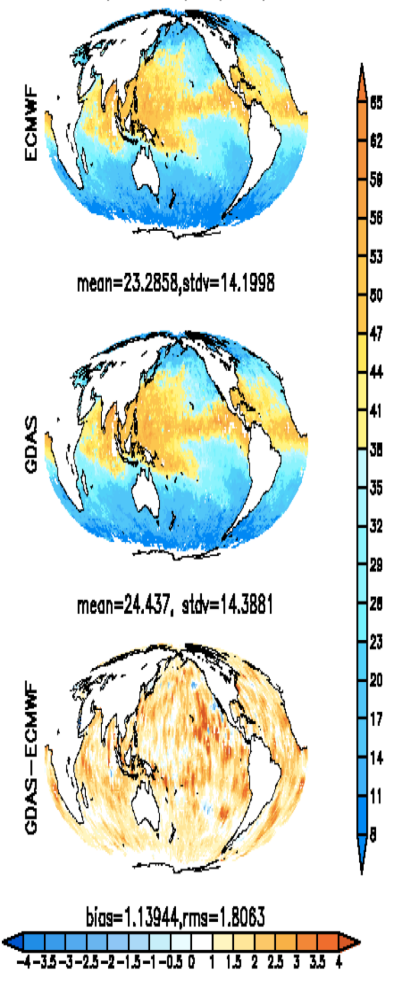
- Many studies comparing AIRS, IASI and aircraft interferometer have demonstrated the accuracy and stability of AIRS and IASI.
- Finally we have a very precise, accurate reference dataset to validate other datasets, such as radiosondes, model analyses, reanalyses, etc.
- Unlike GPS RO, the thermal infrared radiances are influenced by key essential climate variables:
 - CO₂, CH₄, O₃, CO, Clouds, Aerosols, Temperature, Moisture.
- CLARREO mission is design to meet this objective, with onboard SI traceability.
- Climate Reanalyses are gaining recognition for providing climate trends but each are different, why??

NCEP Water Vapor is consistently higher than ECMWF Wx Analysis

Total Precip Water (mm), Sept. 2003

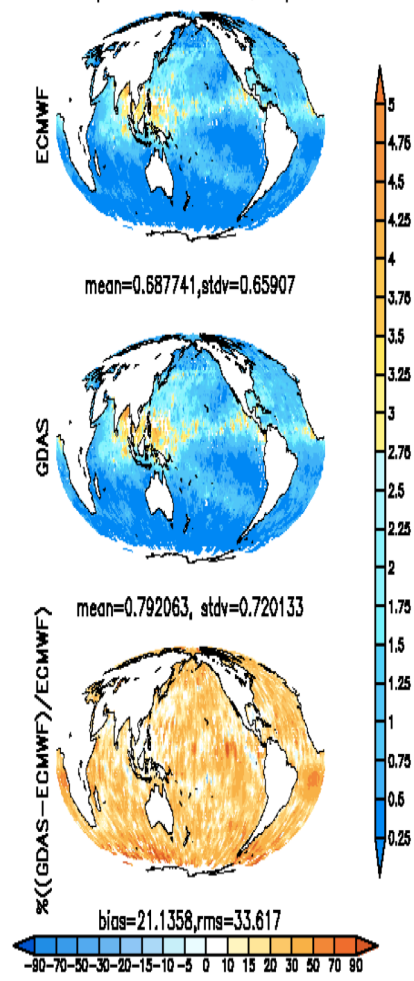


Total Precip Water (mm), Sept. 2004

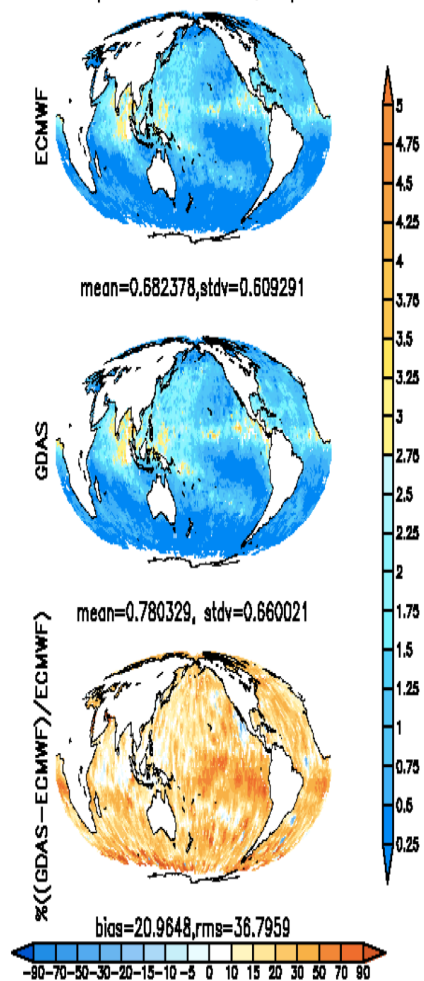


TPW

Water Vapor above 500mb, Sept. 2003



Water Vapor above 500mb, Sept. 2004

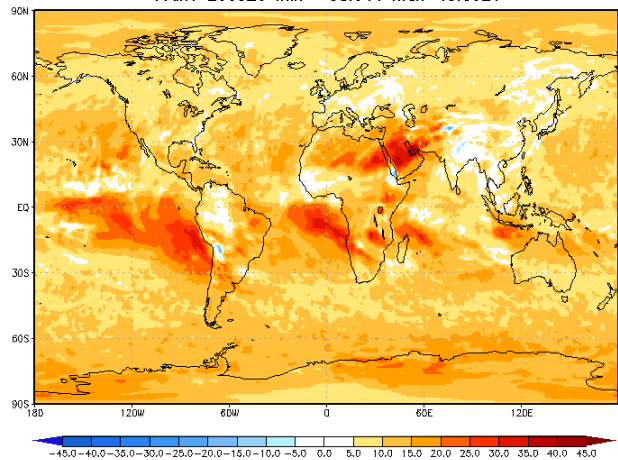


Integrated Water Vapor above 500 mb

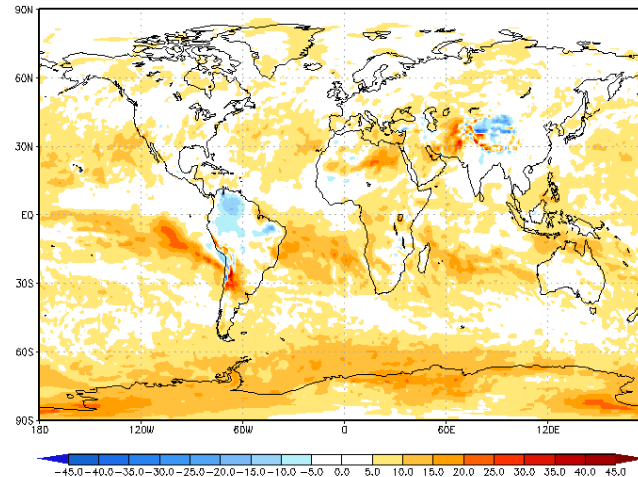


ERA Interim Reanalysis - ECMWF Weather Analysis – September 2004

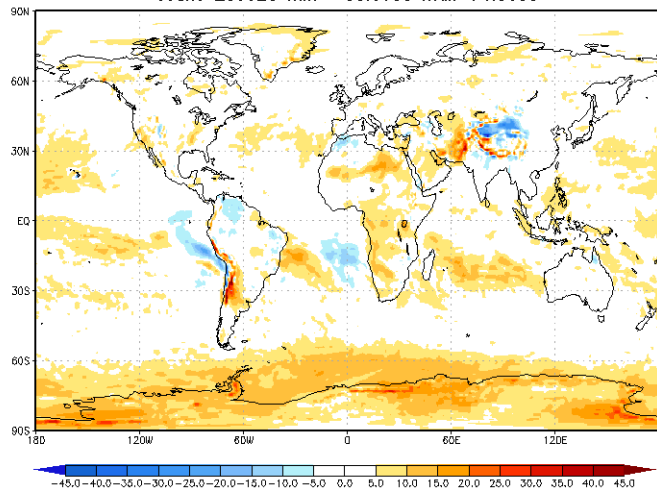
Total Precipitable Water Diff (%): ERAIM-ECMWF, Above 500 MB, Sep2004
bias=11.3523 rms=12.2848
count=259920 min=-38.944 max=43.8521



Total Precipitable Water Diff (%): ERAIM-ECMWF, Above 700 MB, Sep2004
bias=6.04922 rms=7.64281
count=259920 min=-80.9105 max=69.7934



Total Precipitable Water Diff (%): ERAIM-ECMWF, Above 800 MB, Sep2004
bias=4.02537 rms=6.42975
count=259920 min=-88.6155 max=74.3653



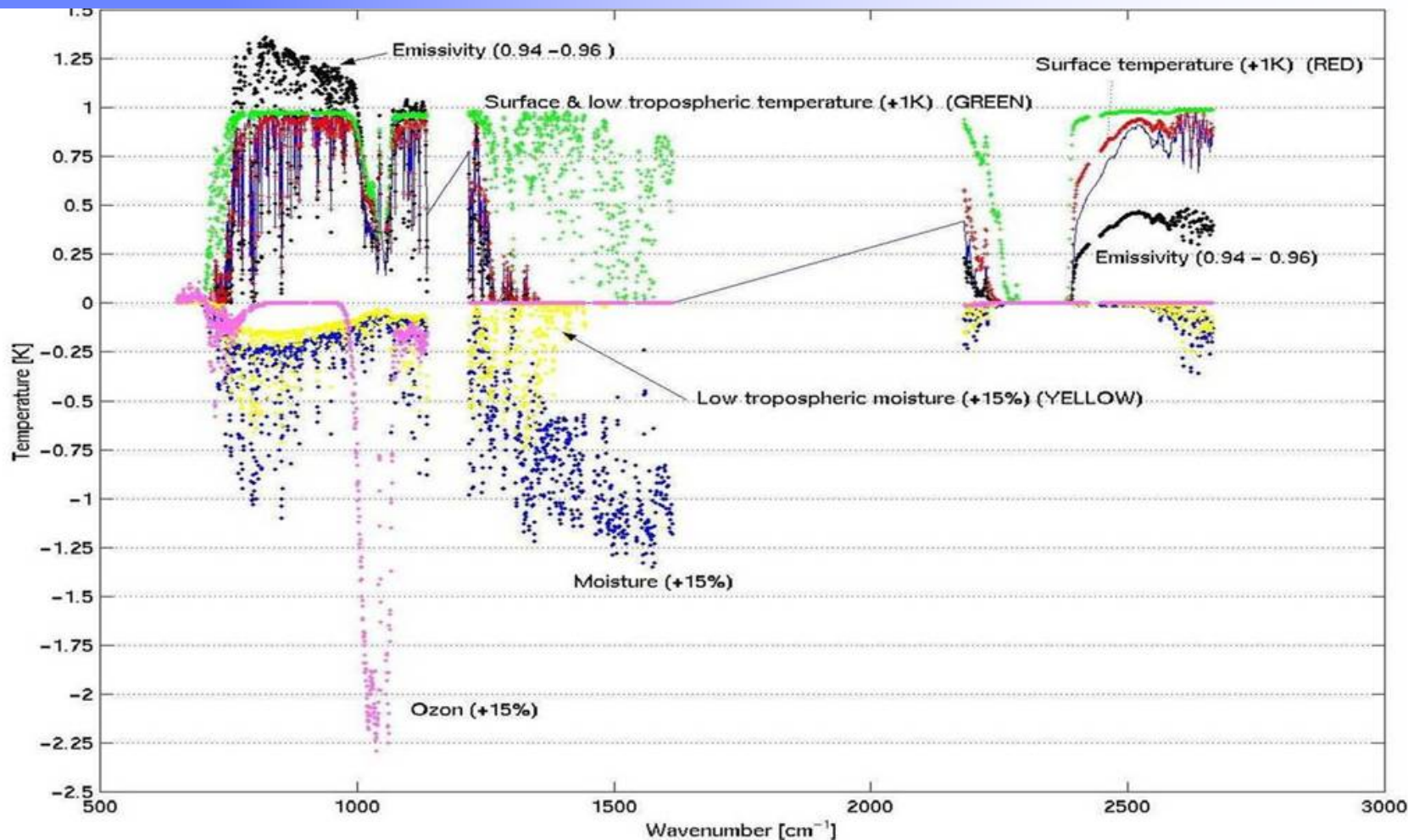


AIRS Spectrally Resolved InfraRed (SRIR) Climate Data Record (CDR)

- Purpose: To describe a new spectrally resolved infrared dataset from AIRS demonstrate its utility to:
 - Validate weather analyses and climate reanalyses to test the realism of the model-derived atmospheric states with very high certainty.
 - Assess changes in model-derived fields due to assimilation of new data or an operational change in processing



AIRS Sensitivity to Atmospheric Change





Approach

- We limb adjust AIRS observations and then average into daily and monthly grids for both ascending and descending orbits. (Spectrally Resolved InfraRed (SRIR) Climate Data Record: 2003 – 2007)
- We create gridded datasets of ECMWF and NCEP analyses and compute brightness temperatures using SARTA (Strow).
- Compute differences between observations and calculate, and make an assessment of which model is more accurate.

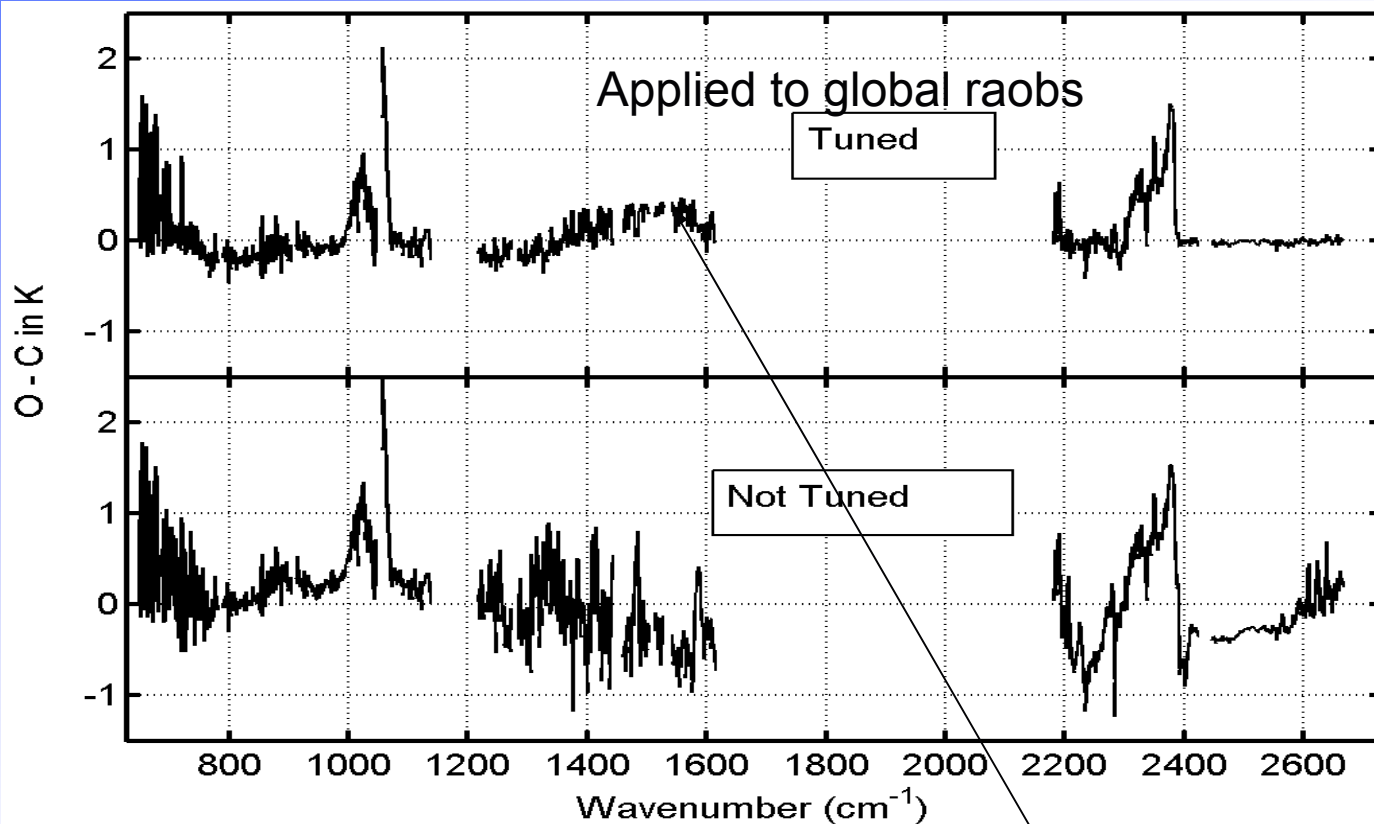


Limiting factors

- How good is the limb adjustment?
- How good is the radiative transfer model (SARTA)?
 - AIRS is climate quality
 - Spectroscopy is not (quote from Strow)
 - ◆ Hence the RTA must be tuned against high quality insitu observations



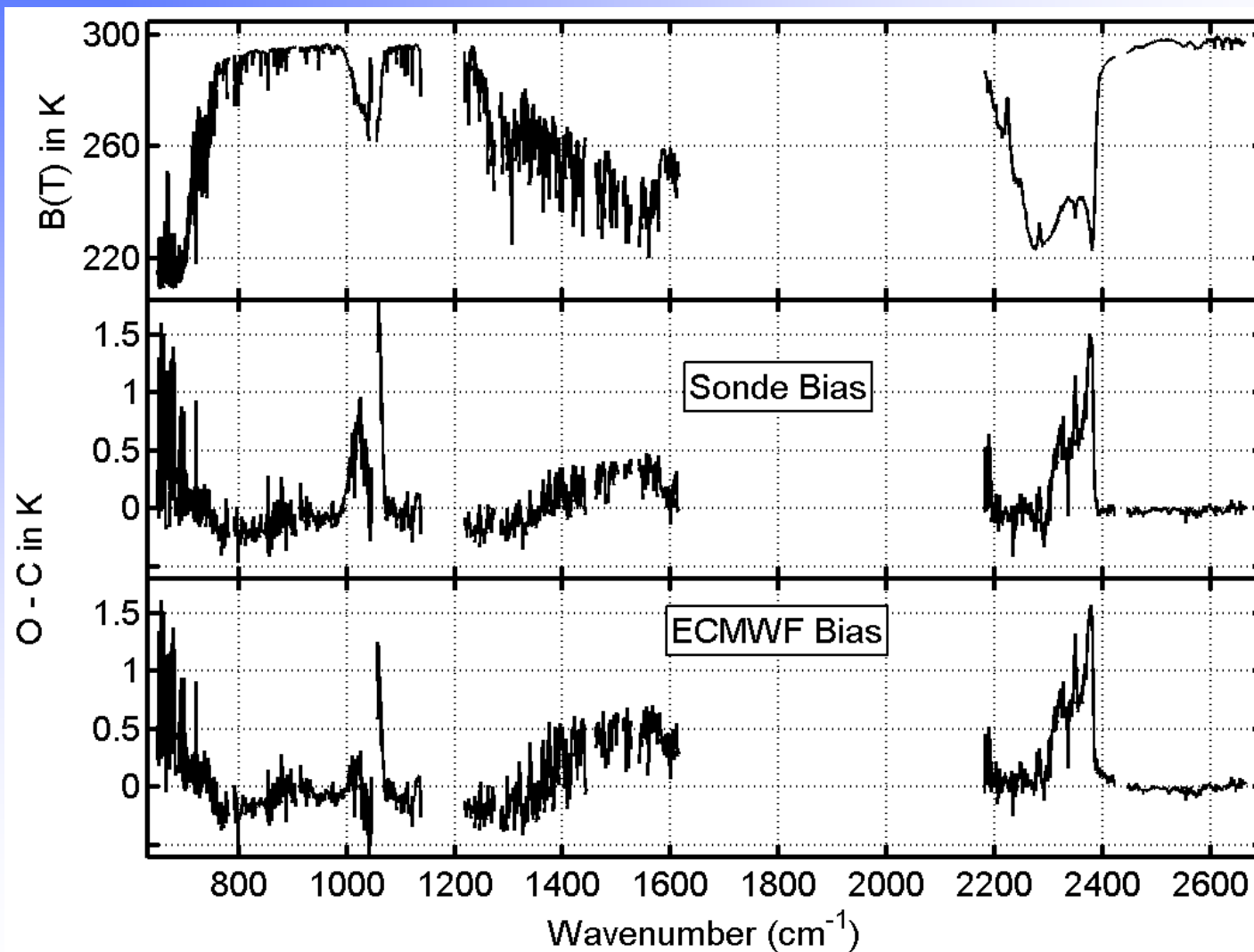
SARTA is tuned using GRUAN-like radiosondes



Uncertainty of the SARTA is less than 0.5 K



SARTA BIAS with global radiosonde





Steps to derive the SRIR climatology



Steps

- Gridded radiances are converted to Principal Component Scores (PCS) and stored into gridded daily datasets (0.5 long x 2.0 lat).
- PCS are limb adjusted and stored in angle adjusted gridded daily datasets
- Angle adjusted PCS are converted to brightness temperatures and stored in gridded daily datasets.
- Each gridbox for each dataset has a clear flag.
- Compute monthly clear and all-sky gridded datasets of limb adjusted brightness temperatures.



AIRS Limb Adjustment Methodology:

Step 1) Limb adjust the off-nadir PCS to the nadir PCS.

Use regression to predict the limb adjusted PCS from the first six PCS and the PCS to be limb adjusted

$$\text{Limb-adj PCS}(n, \text{angle}) = \sum_{i=1}^6 C(i, \text{angle}) * \text{PCS}(i, \text{angle}) + C(n, \text{angle}) * \text{PCS}(n, \text{angle})$$

The regression coefficients are generated from six months of data. Averaged PCS as a function of scan angle (90 per scan line) over two degree latitude bands for ocean and non ocean cases.

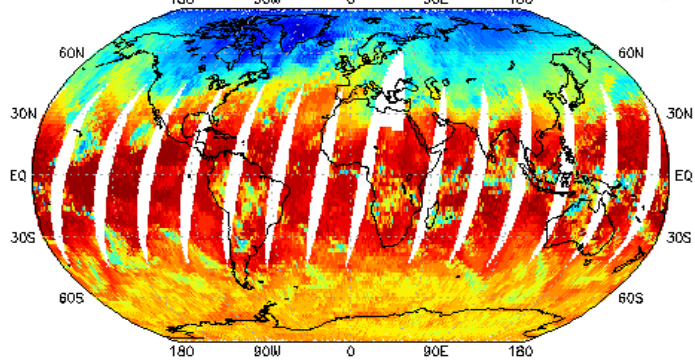
Step 2) Reconstruct the limb adjusted radiance from the limb-adjusted PCS.

Step 3) Convert the limb adjusted radiances to limb adjusted brightness temperatures

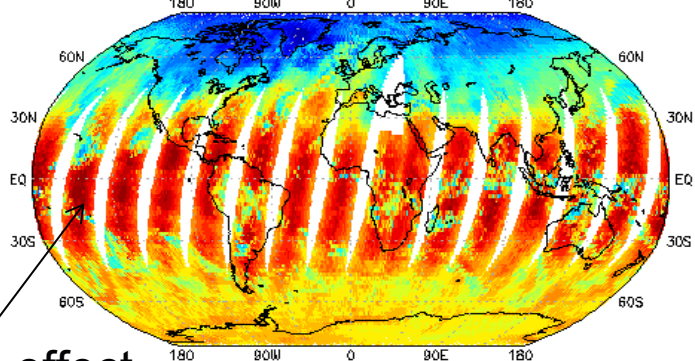


Example of AIRS limb adjusted data

Lim. Corr, January 1st, 2005, [1055.97cm⁻¹]

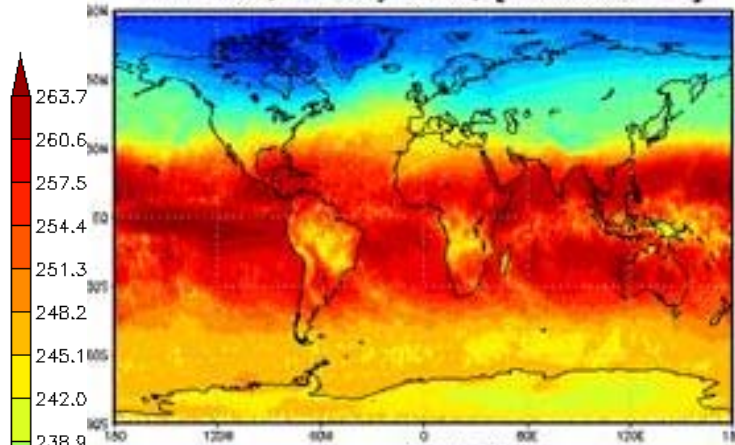


AIRS Obs.



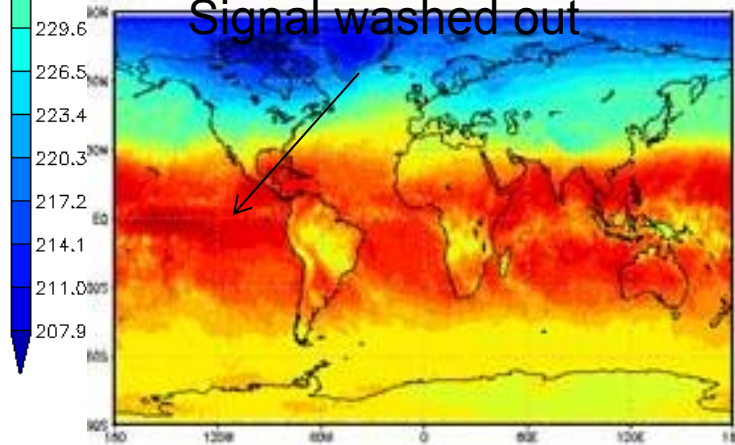
Limb effect

Lim. Corr, January 2005, [1055.97cm⁻¹]



AIRS Obs.

Signal washed out



Limb corrected (upper left) and original observed (lower left) AIRS radiance; monthly averaged limb corrected (upper right) and original (lower right) AIRS radiance

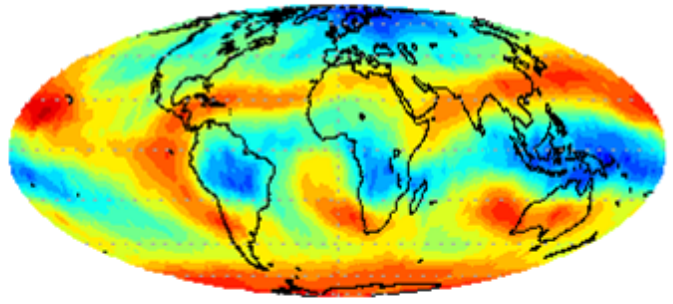
Must limb adjust the data to create meaningful global datasets



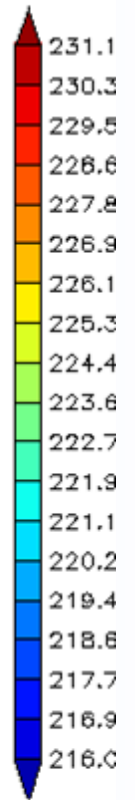
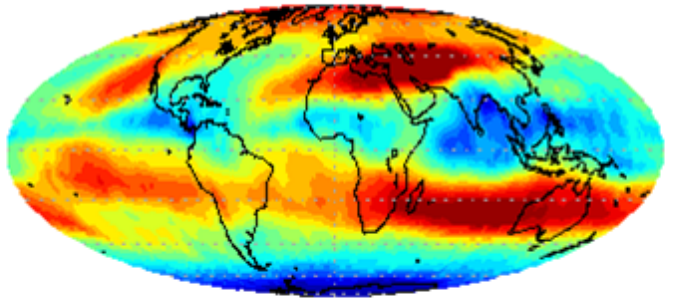
1520.87cm⁻¹

2006 Mid – upper tropospheric water vapor channel

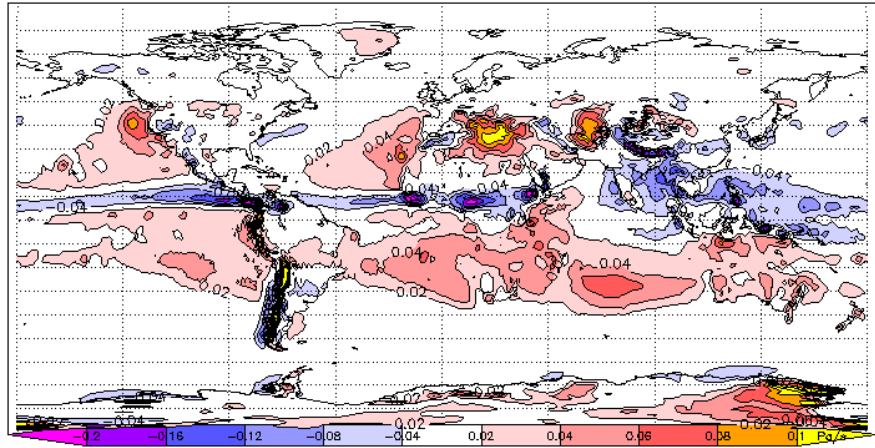
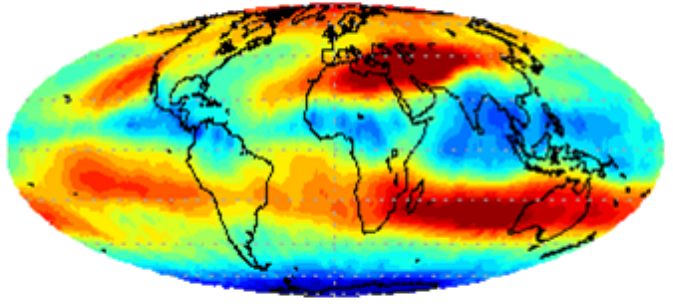
Jan Ascending



Jul Ascending



Jul Descending



ERA40 July 1979-2001 mean

Warmer brightness temperatures correspond to dryer air and matches areas of descending air from ERA40



Clear Flag

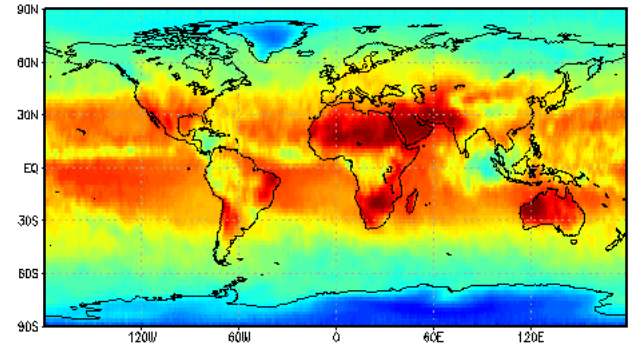
- Clear test is described in detail in [*Goldberg et al.*, 2003].
- Predict clear AIRS (2390 cm^{-1}) from AMSU
- Compare predicted AIRS (2390 cm^{-1}) with actual AIRS.
- Predict surface temperature from AIRS and compare with NCEP forecast surface temperature.
- Compute variability of AIRS (2390 cm^{-1}) for 3x3 array of AIRS footprints within the AMSU footprint.



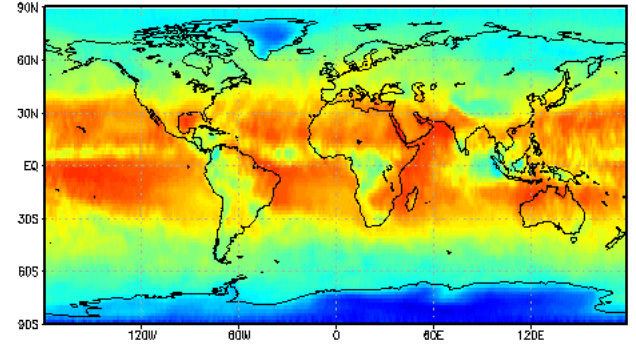
All Sky

Monthly Average Limb Adjusted BT, All Sky, Oct 2005, 1001.38cm-1

Ascending: mean=267.007 std=18.127
count=64386 min=209.532 max=316.106



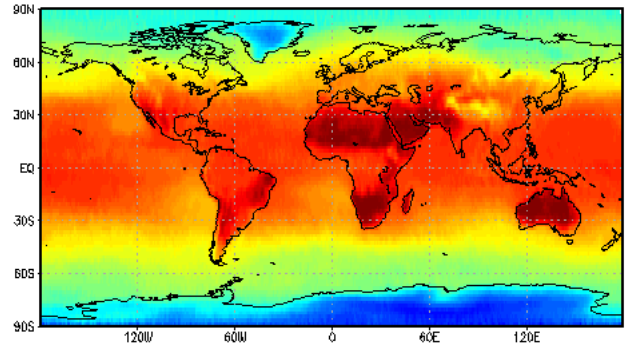
Descending: mean=263.883 std=16.8159
count=64422 min=198.485 max=297.527



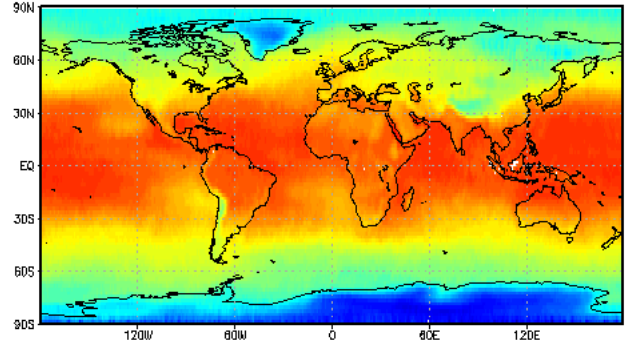
Clear Sky

Monthly Average Limb Adjusted BT, Clear Sky, Oct 2005, 1001.38cm-1

Ascending: mean=274.198 std=19.1584
count=64011 min=209.532 max=317.288



Descending: mean=270.57 std=18.0633
count=63972 min=198.314 max=297.494



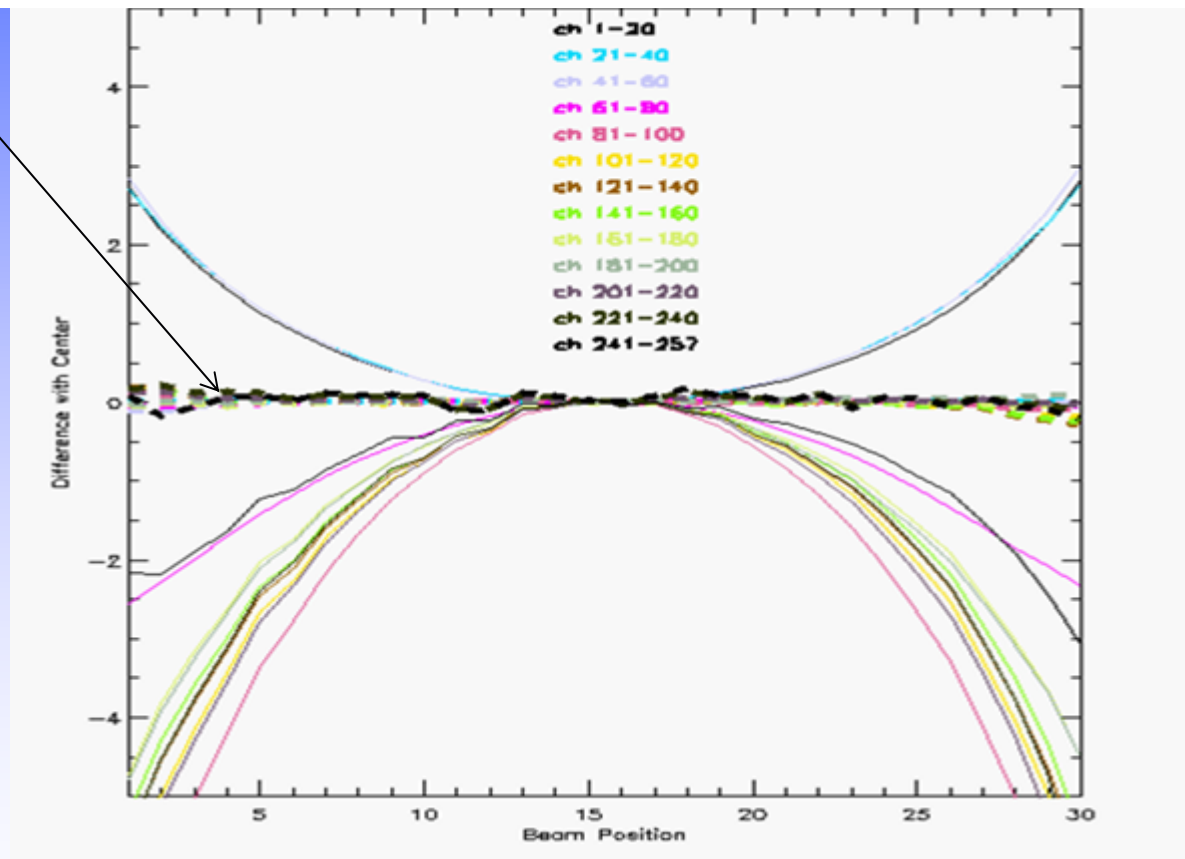


Validation of the SRIR climatology



Validation of Limb Adjustment

Limb adjustment successfully removes the large scanline dependency



Deviations of averaged original (colored curves) for groups of channels and limb adjusted (heavy dashed curve) brightness temperatures from nadir as a function of beam position

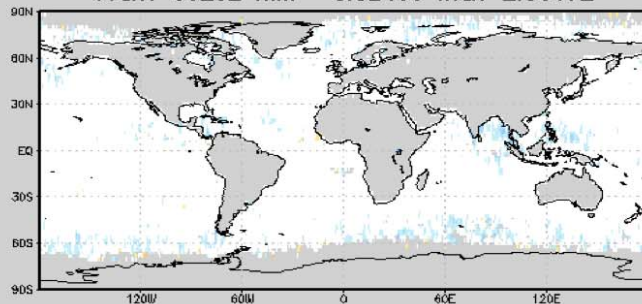


SRIR validation by comparing measured vs simulated brightness temperatures against ECMWF with and without limb adjustment

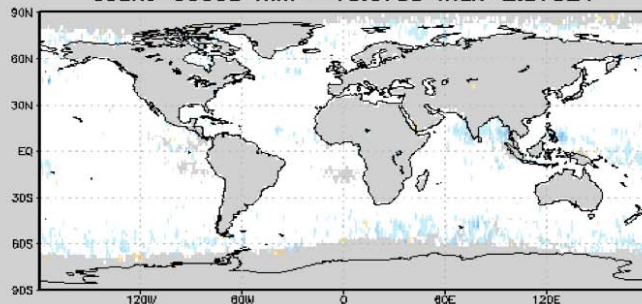
Original - EC(sim, f(angle))

Observation - ECMWF, 723.029cm⁻¹, Clear Sky, No Score, Sep, 2004

Ascending: bias=-0.15108 rms=0.456039
count=35252 min=-8.52405 max=2.38672



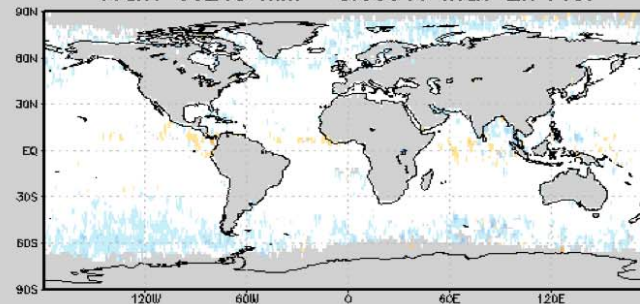
Descending: bias=-0.166967 rms=0.486816
count=33603 min=-10.3709 max=2.37924



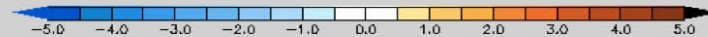
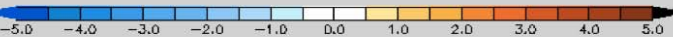
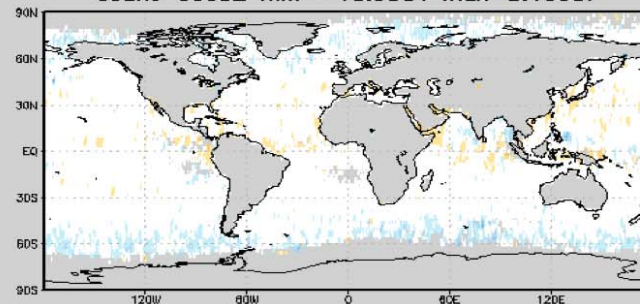
Limb adjusted - EC(sim, f(nadir))

Limb Adjusted BT, 7 PCs - ECMWF (NAD), 723.029cm⁻¹, Clear Sky, No Score, Sep, 2004

Ascending: bias=-0.190429 rms=0.556302
count=35245 min=-8.60046 max=2.74487



Descending: bias=-0.0413993 rms=0.565617
count=33592 min=-10.9084 max=3.48587



Bias and standard deviation nearly the same, channel peaks near 700 mb

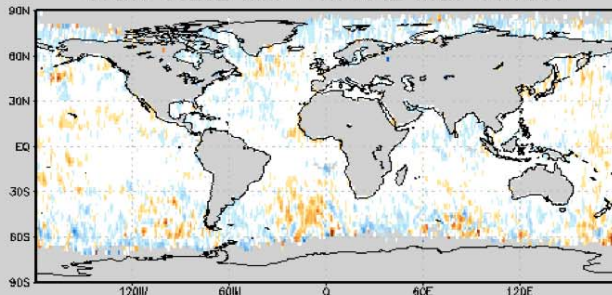


SRIR validation by comparing measured vs simulated brightness temperatures against ECMWF with and without limb adjustment

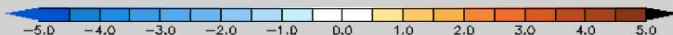
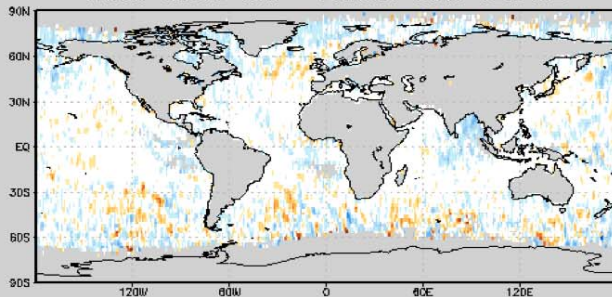
Original - EC(sim, f(angle))

Observation - ECMWF, 1598.49cm-1, Clear Sky, No Score, Sep, 2004

Ascending: bias=-0.0661891 rms=1.11611
count=35252 min=-9.79042 max=16.7093



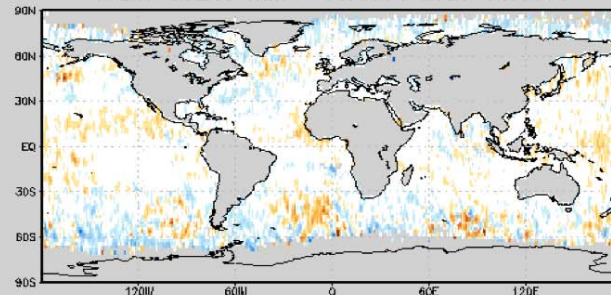
Descending: bias=-0.116707 rms=1.19503
count=33603 min=-11.6857 max=13.0458



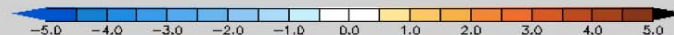
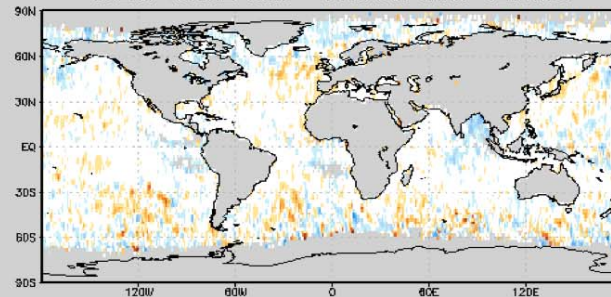
Limb adjusted - EC(sim, f(nadir))

Limb Adjusted BT, 7 PCs - ECMWF (NAD), 1598.49cm-1, Clear Sky, No Score, Sep, 2004

Ascending: bias=-0.00965988 rms=1.12849
count=35245 min=-10.0071 max=16.4171



Descending: bias=0.0265201 rms=1.18533
count=33592 min=-11.5689 max=13.0889

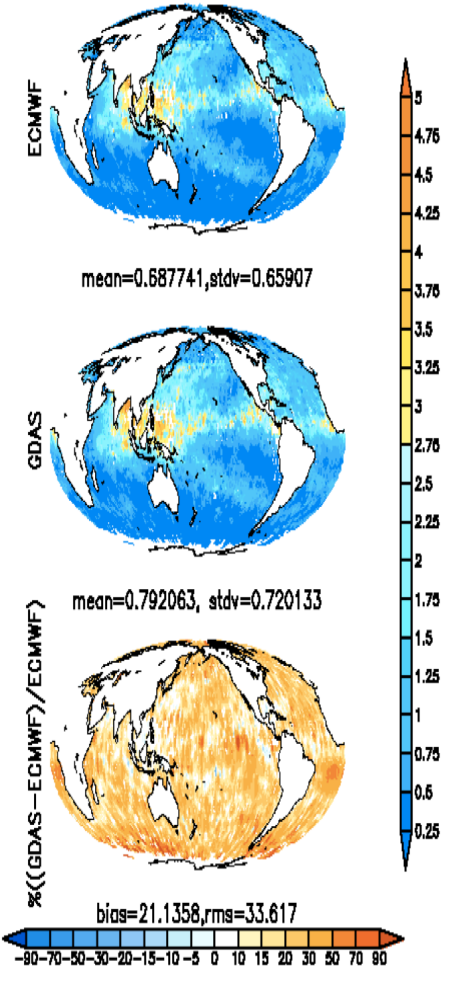


Bias and standard deviation nearly the same, water vapor channel peaking near 500 mb (for mean profile)

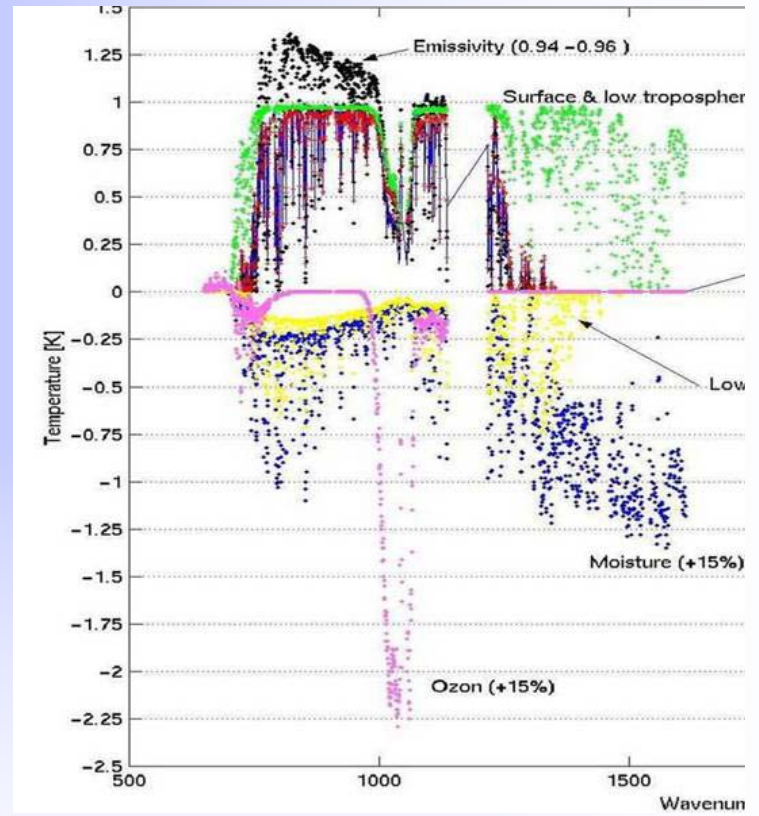
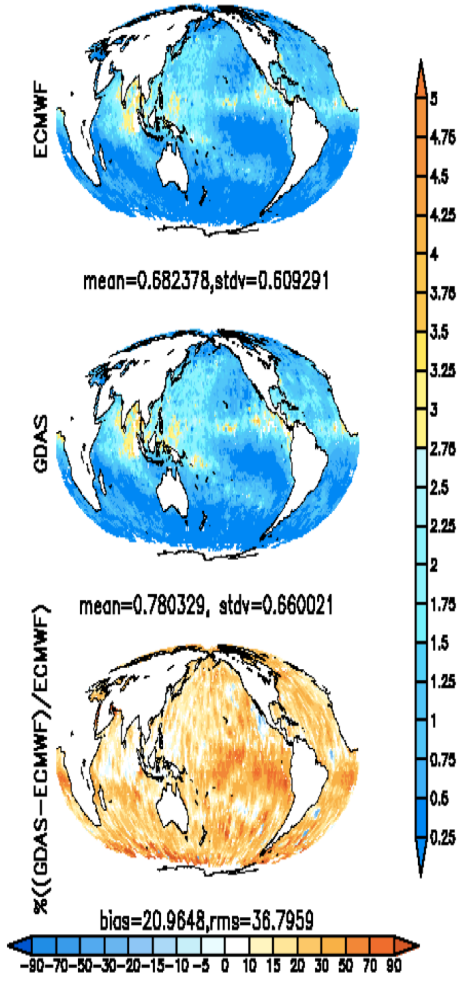


Validation of model fields using AIRS clear-sky SRIR climatology

Water Vapor above 500mb, Sept. 2003



Water Vapor above 500mb, Sept. 2004



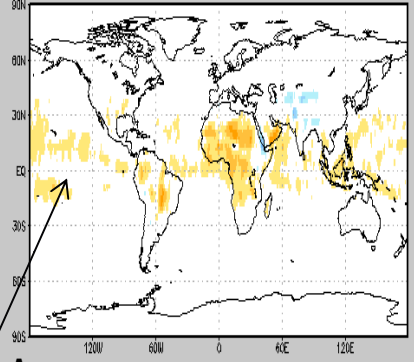
20% ~ 1.6 K



ECMWF minus GDAS simulated brightness temperatures for A: 801.09 cm⁻¹ (850 mb), B: 723.029 cm⁻¹ (700 mb), and C: 704.436 cm⁻¹ (350 mb)

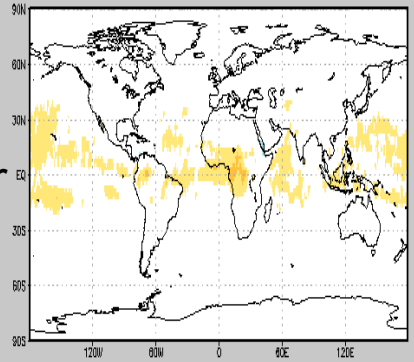
ECMWF (NAD) - GDAS (NAD), 801.099cm⁻¹, All Sky, Sep, 2004

Ascending: bias=0.152822 rms=0.345362 count=64722 min=-3.0799 max=2.88982



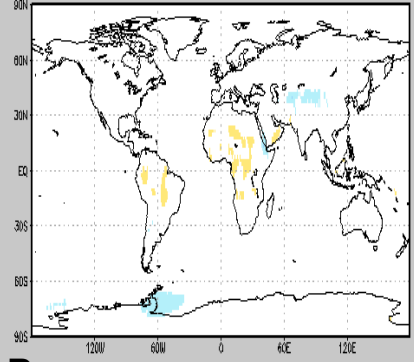
A

Descending: bias=0.149493 rms=0.300216 count=64655 min=-2.77622 max=2.00234



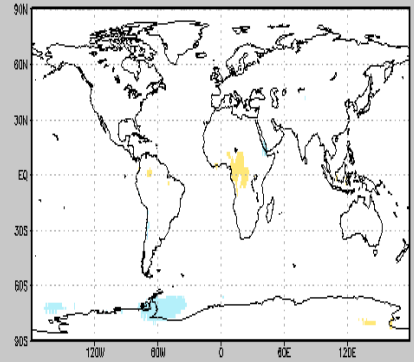
ECMWF (NAD) - GDAS (NAD), 723.029cm⁻¹, All Sky, Sep, 2004

Ascending: bias=0.0034263 rms=0.22101 count=64722 min=-2.0102 max=1.36794



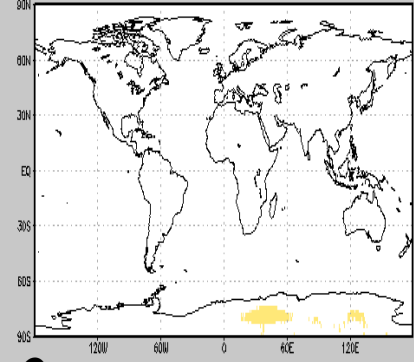
B

Descending: bias=-0.00183653 rms=0.218622 count=64655 min=-2.08679 max=1.38104



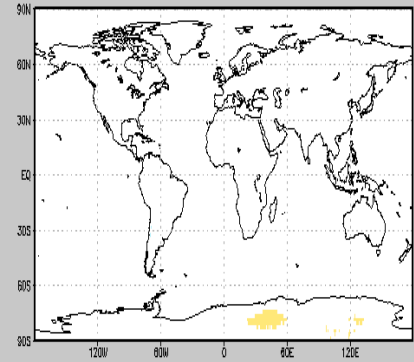
ECMWF (NAD) - GDAS (NAD), 704.436cm⁻¹, All Sky, Sep, 2004

Ascending: bias=-0.12814 rms=0.219024 count=64722 min=-1.16527 max=1.39995



C

Descending: bias=-0.136878 rms=0.224389 count=64655 min=-0.947857 max=1.26265



Water vapor sensitivity

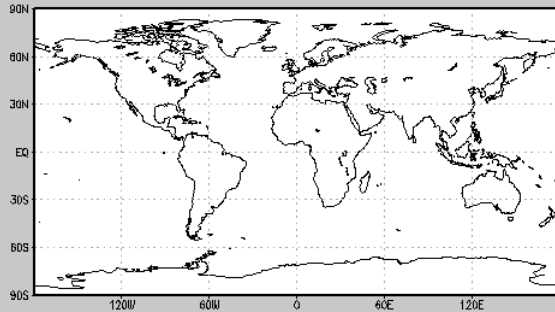
Temperature channel differences are very small



ECMWF minus GDAS simulated brightness temperatures for C: 666.766 cm^{-1} (40 mb), and D: 667.018 cm^{-1} (25 mb)

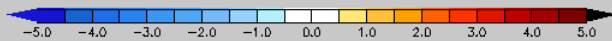
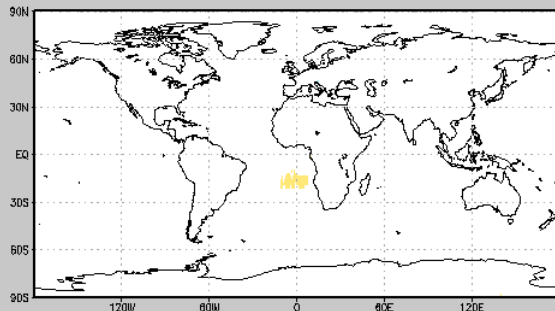
ECMWF (NAD) - GDAS (NAD), 666.766 cm^{-1} , All Sky, Sep, 2004

Ascending: bias=0.0177204 rms=0.117121
count=64722 min=-1.57379 max=2.52542



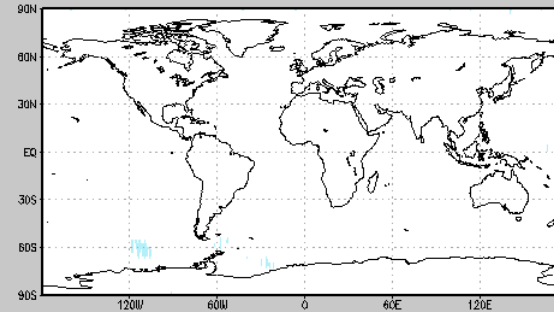
C

Descending: bias=0.0362061 rms=0.149237
count=64655 min=-1.44522 max=3.10333



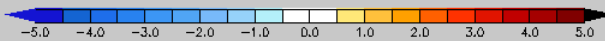
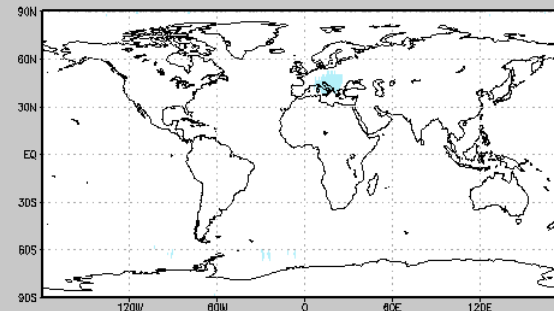
ECMWF (NAD) - GDAS (NAD), 667.018 cm^{-1} , All Sky, Sep, 2004

Ascending: bias=-0.22552 rms=0.26192
count=64722 min=-1.75775 max=2.05731



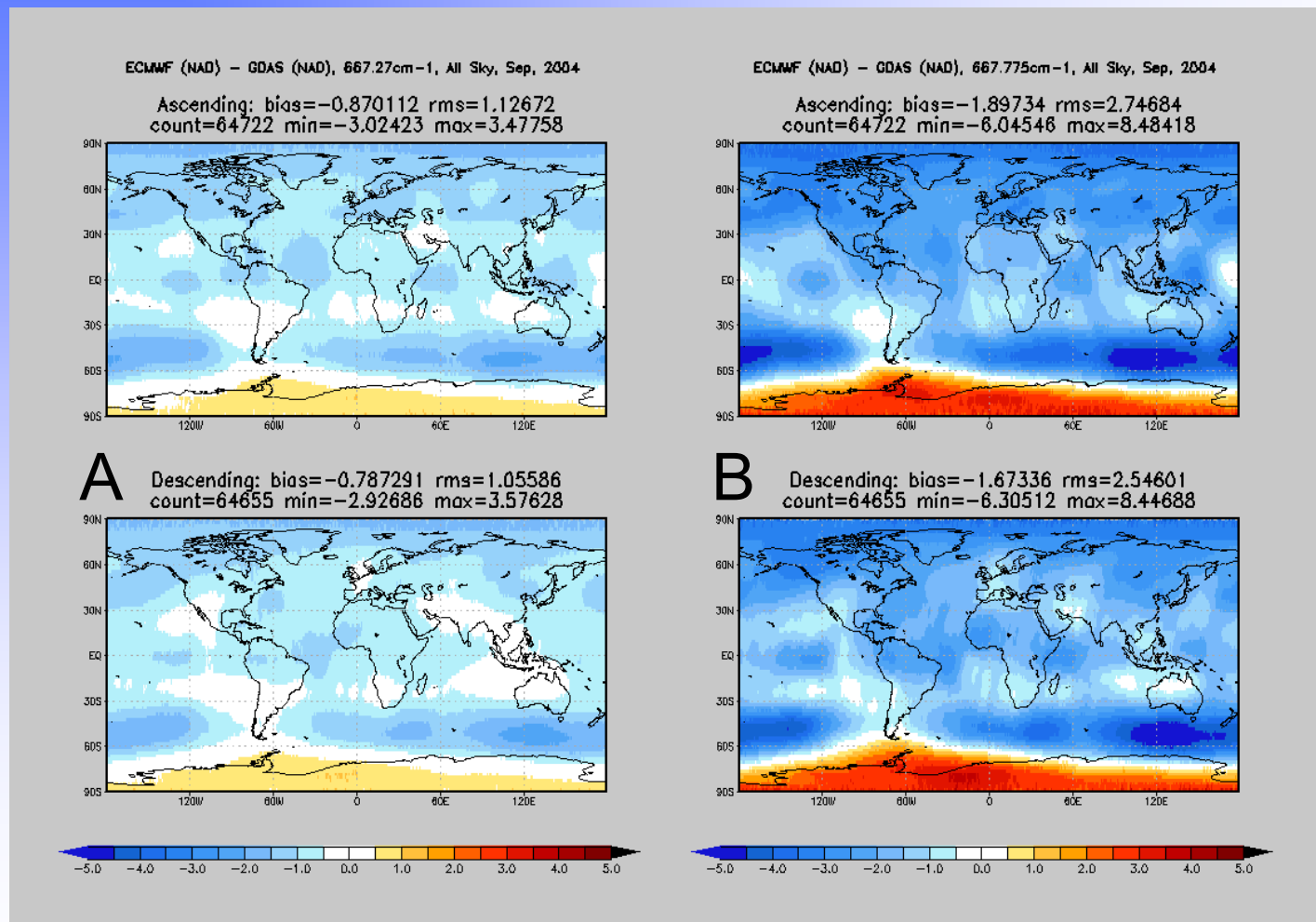
D

Descending: bias=-0.209098 rms=0.256626
count=64655 min=-1.99518 max=1.34569





ECMWF minus GDAS simulated brightness temperatures for A: 667.27 cm⁻¹ (15 mb) and B: 667.775 cm⁻¹ (1.5 mb)



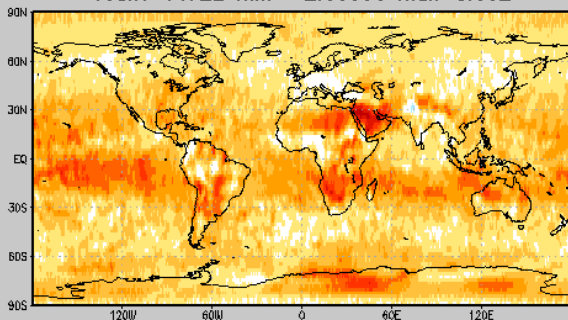
Finally we see large differences at 15 and 1.5 mb



ECMWF minus GDAS simulated brightness temperatures for A: 1519.07 cm⁻¹ (315 mb) and B: 1598.45 cm⁻¹ (490 mb)

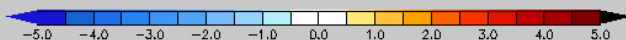
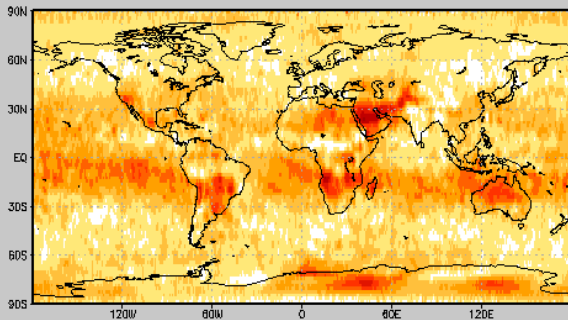
ECMWF (NAD) - GDAS (NAD), 1519.07cm⁻¹, All Sky, Sep, 2004

Ascending: bias=1.2539 rms=1.43501
count=64722 min=-2.85356 max=5.502



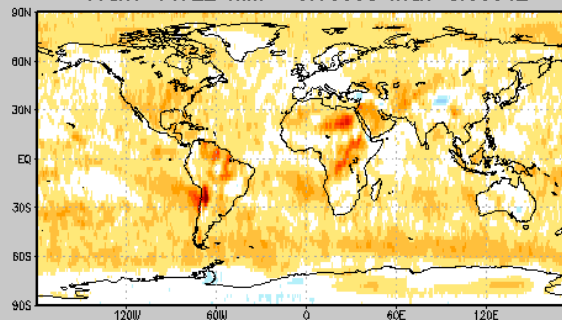
A

Descending: bias=1.20973 rms=1.39601
count=64655 min=-3.51067 max=5.75882



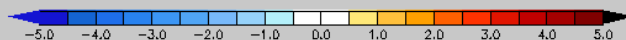
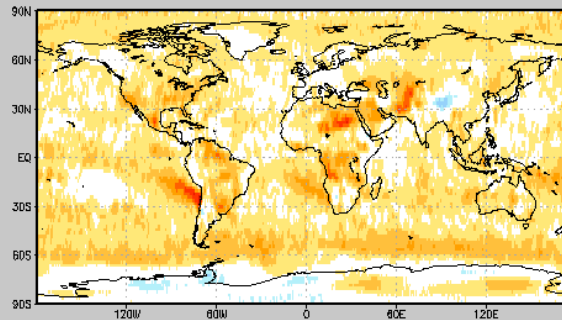
ECMWF (NAD) - GDAS (NAD), 1598.49cm⁻¹, All Sky, Sep, 2004

Ascending: bias=0.76404 rms=0.968526
count=64722 min=-3.15038 max=8.00342



B

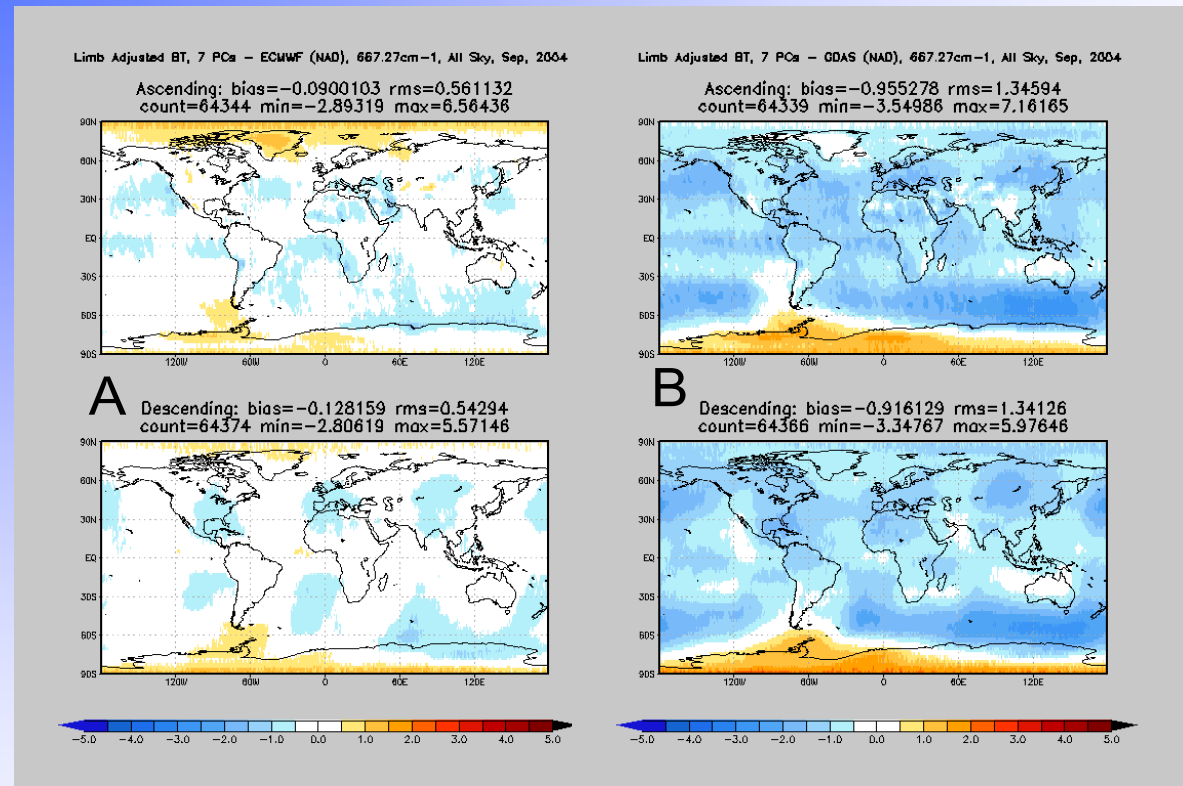
Descending: bias=0.743487 rms=0.949117
count=64655 min=-3.0182 max=4.69273



And large differences in water vapor



ECMWF more accurate at ~15 mb



Difference between limb adjusted AIRS
and simulated ECMWF brightness
temperatures (A) and with NCEP (B) for
667.27 cm⁻¹ (15 mb)

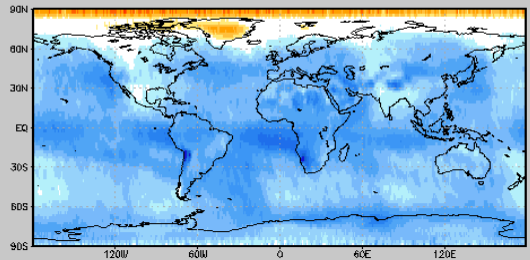
ECMWF agrees with the AIRS SRIR Climate Data Record ,
The difference with ECMWF is nearly zero



ECMWF more accurate at ~ 1.5 mb

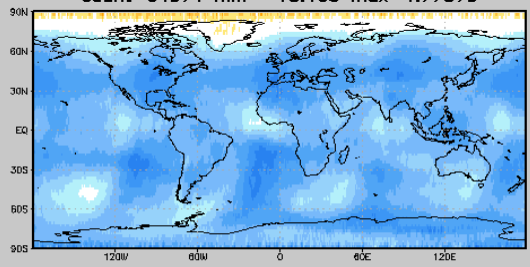
Limb Adjusted BT, 7 PCs - ECMWF (NAD), 667.775cm⁻¹, All Sky, Sep, 2004

Ascending: bias=-1.66927 rms=1.99811
count=64344 min=-8.47488 max=4.86778



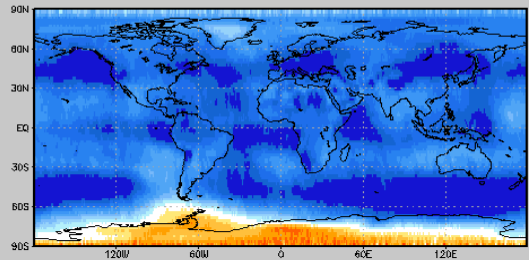
A

Descending: bias=-1.83739 rms=2.0548
count=64374 min=-10.463 max=4.77075



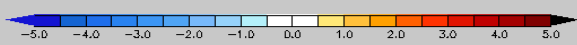
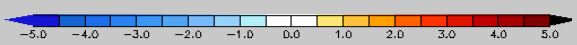
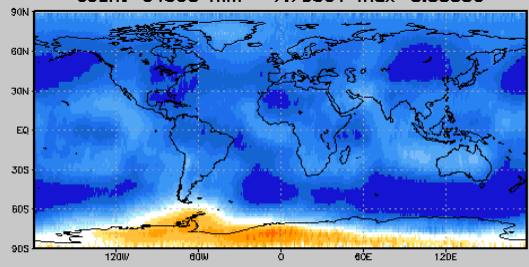
Limb Adjusted BT, 7 PCs - GDAS (NAD), 667.775cm⁻¹, All Sky, Sep, 2004

Ascending: bias=-3.56201 rms=4.06716
count=64339 min=-7.96894 max=7.25009



B

Descending: bias=-3.51311 rms=3.96571
count=64366 min=-7.76561 max=6.00906



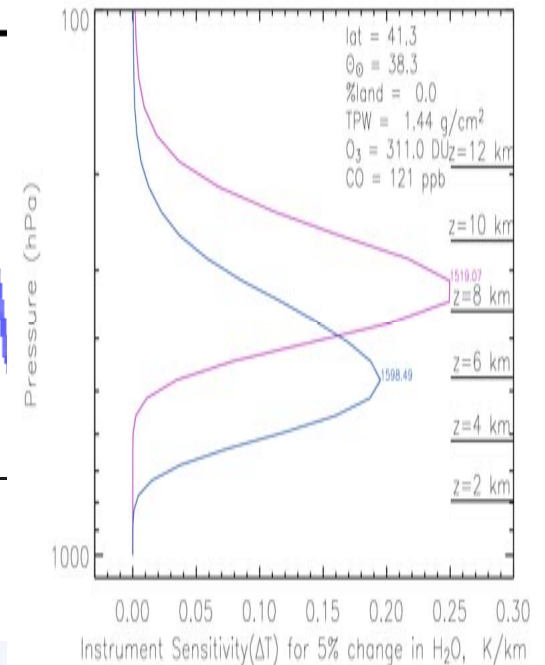
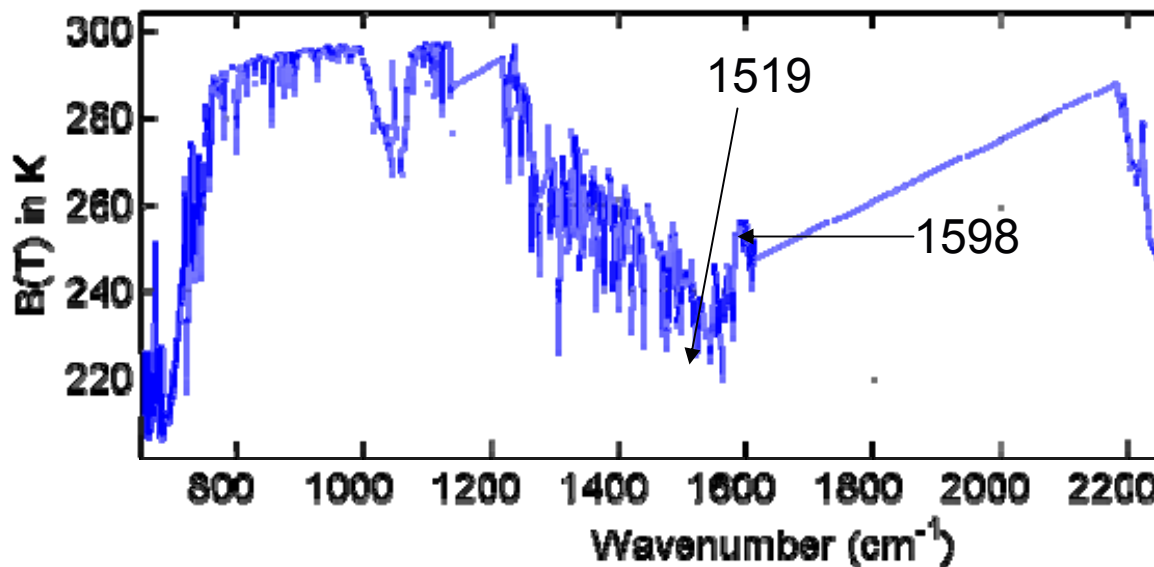
Difference between limb adjusted AIRS
and simulated ECMWF brightness
temperatures (A) and with NCEP (B) for
667.775 cm⁻¹ (1.5 mb)

ECMWF agrees better with the AIRS SRIR Climate Data Record ,
Both model analysis need to improve



Which water vapor field more accurate?

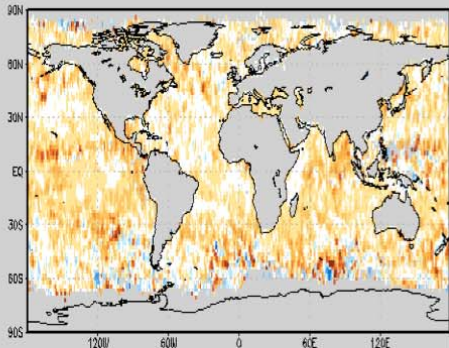
We selected an upper tropospheric water vapor channel (1519 cm^{-1})
and a mid tropospheric water vapor channel (1598 cm^{-1})



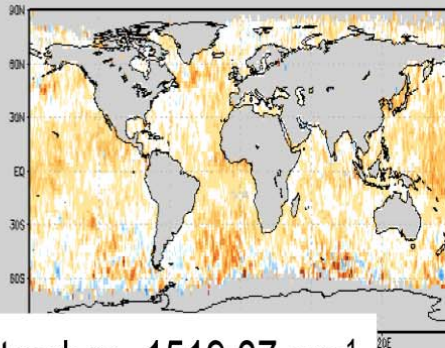


Observed AIRS minus ECMWF Simulated AIRS for Upper Trop. Water Vapor

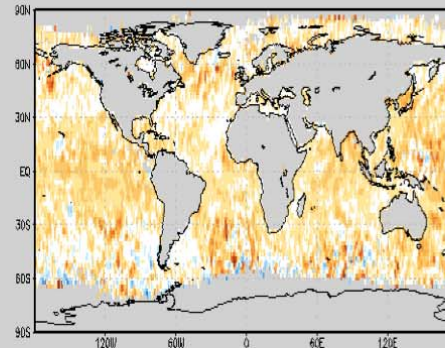
Ascending: bias=0.739526 rms=1.64274
count=33296 min=-16.2292 max=20.2521



Ascending: bias=0.611965 rms=1.39402
count=35245 min=-10.596 max=16.6671

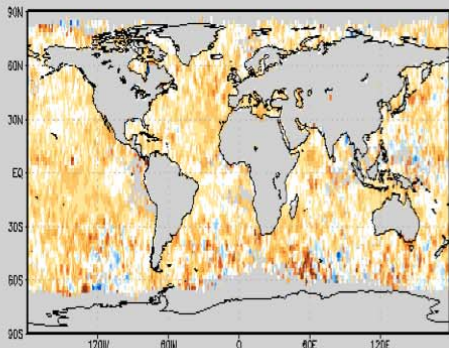


Ascending: bias=0.713495 rms=1.42539
count=34461 min=-14.687 max=15.7027

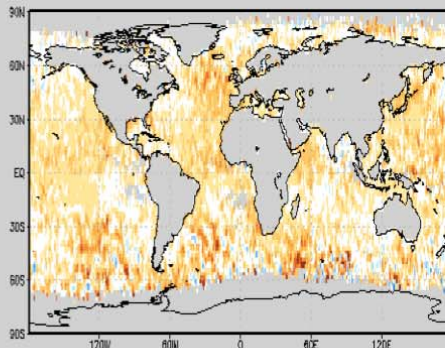


September, 1519.07 cm⁻¹

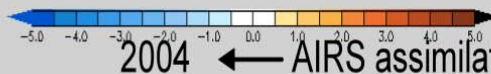
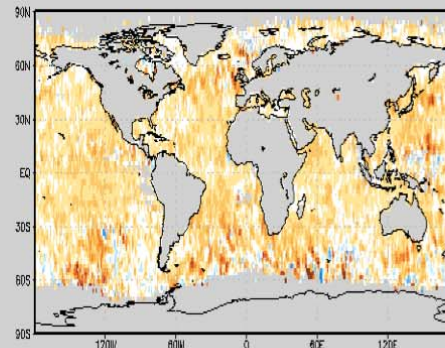
Descending: bias=0.806916 rms=1.68002
count=31107 min=-20.7551 max=17.8908



Descending: bias=0.734266 rms=1.32481
count=33592 min=-12.8482 max=16.5283



Descending: bias=0.816108 rms=1.53891
count=32612 min=-10.2056 max=19.5798



2003

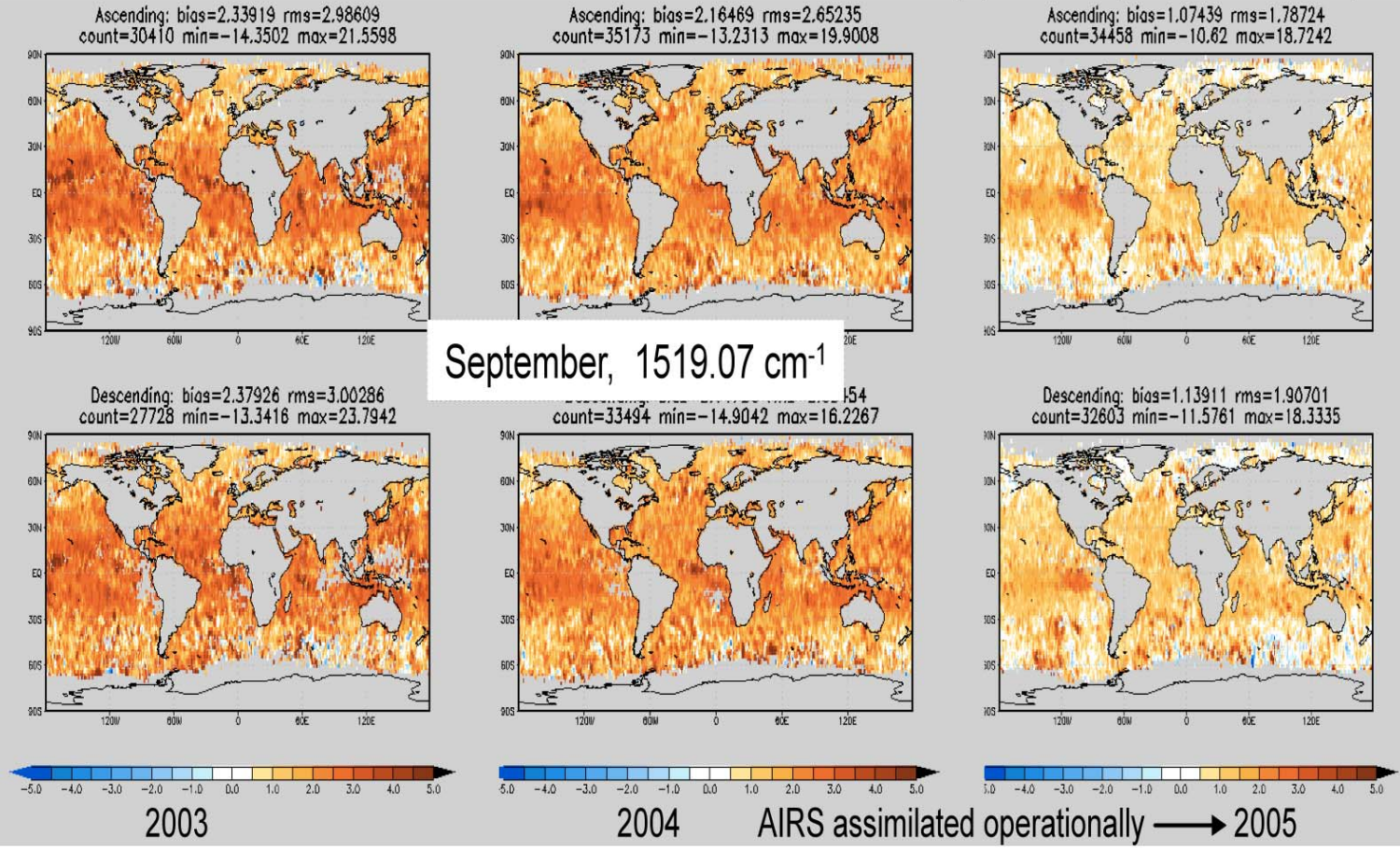
2004

← AIRS assimilated operationally → 2005

ECMWF bias is about 0.7 K, and seems to be consistent for 2003 – 2005

Note 2004 ECMWF assimilated AIRS

Observed AIRS minus NCEP Simulated AIRS for Upper Trop. Water Vapor

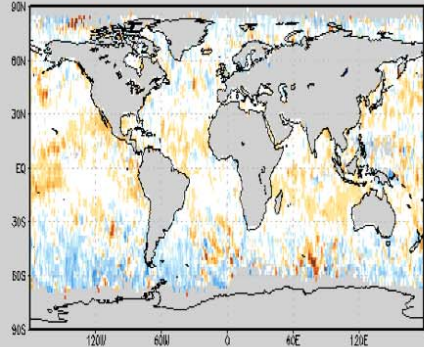


NCEP bias is 3 times larger but reduces by half after AIRS is assimilated.

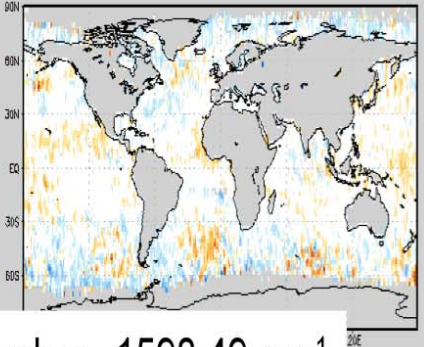


Observed AIRS minus ECMWF Simulated AIRS for Mid. Trop. Water Vapor

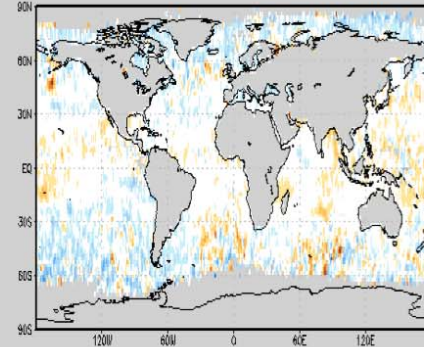
Ascending: bias=0.0775871 rms=1.36024
count=33296 min=-11.4684 max=15.5337



Ascending: bias=-0.00965988 rms=1.12849
count=35245 min=-10.0071 max=16.4171

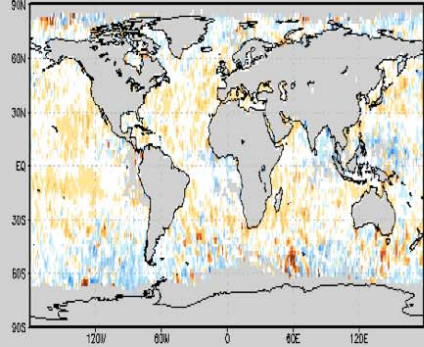


Ascending: bias=-0.0989282 rms=1.14666
count=34461 min=-12.2345 max=14.0103

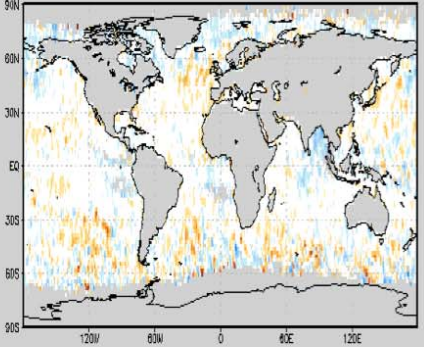


September, 1598.49 cm⁻¹

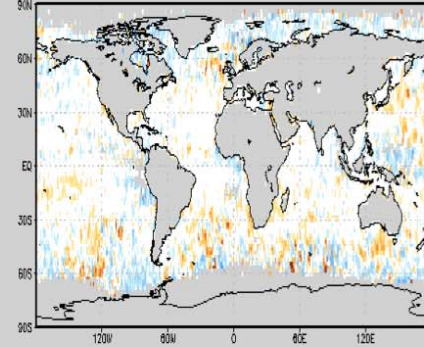
Descending: bias=0.134889 rms=1.37997
count=31107 min=-11.1455 max=12.9063



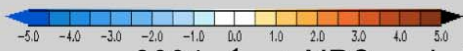
Descending: bias=0.0262021 rms=1.18533
count=33592 min=-11.5689 max=13.0889



Descending: bias=-0.0133827 rms=1.19657
count=32612 min=-9.85138 max=13.8735



2003



2004

← AIRS assimilated operationally →



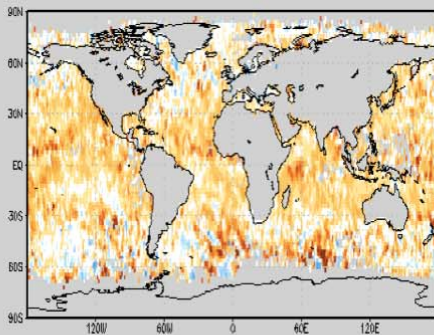
2005

ECMWF bias is nearly zero !!!

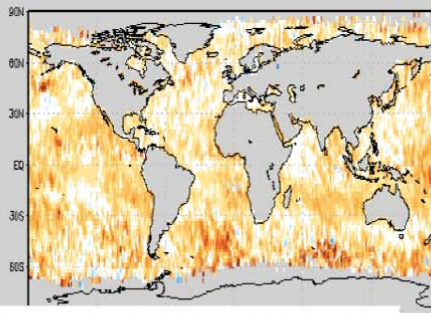


Observed AIRS minus NCEP Simulated AIRS for Mid. Trop. Water Vap or

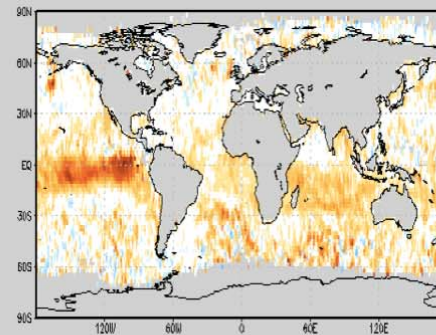
Ascending: bias=0.878548 rms=1.809
count=30410 min=-12.9485 max=18.2543



Ascending: bias=0.89881 rms=1.57801
count=35173 min=-8.46484 max=16.6099

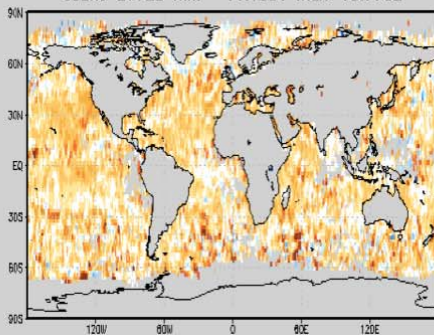


Ascending: bias=0.572103 rms=1.41223
count=34458 min=-9.91933 max=14.0816

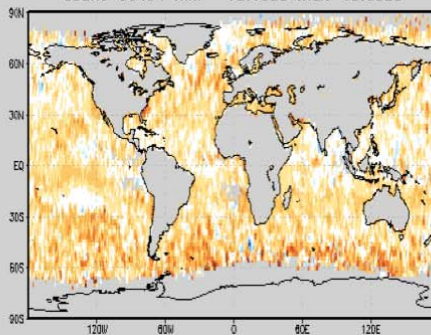


September, 1598.49 cm⁻¹

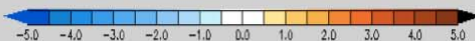
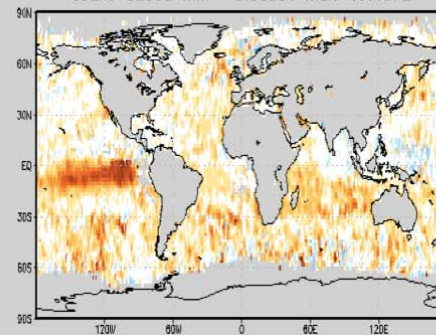
Descending: bias=0.935697 rms=1.8164
count=27728 min=-11.1691 max=16.7782



Descending: bias=0.628501 rms=1.5489
count=32603 min=-8.68994 max=17.4972



Descending: bias=0.628501 rms=1.5489
count=32603 min=-8.68994 max=17.4972

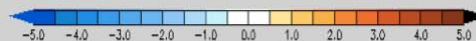


2003



2004

AIRS assimilated operationally → 2005



NCEP bias is relatively much larger, reduces after AIRS is assimilated, but large bias over equatorial eastern Pacific



ECMWF water vapor fields are more accurate

- But
- Operational change in ECMWF in Sept. 2006 caused an increase in the bias.
- NCEP above 500 mb TPW in 2003 and 2004 was 20% higher, then in 2005 just 11% higher because NCEP assimilated AIRS, and in 2006 the difference is close to 0% because of a change in the ECMWF water vapor field.



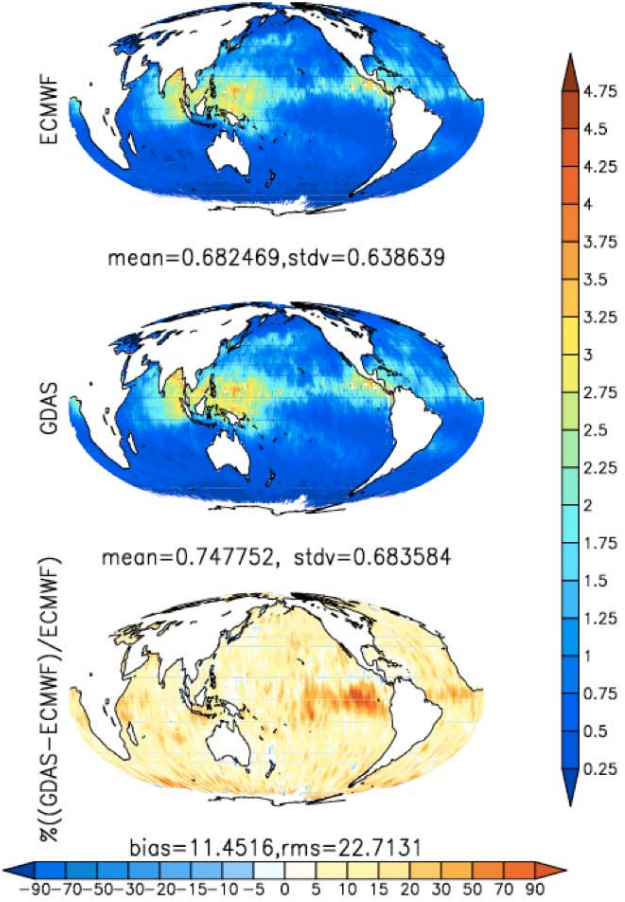
Sept. 2006 Changes

- 12 September 2006 Introduction of Cycle 31r1. This version includes the following changes:
- Revisions to the cloud scheme, including treatment of ice supersaturation and new numerics
- Implicit computation of convective transports
- Introduction of turbulent orographic form drag scheme and revision to sub-grid scale orographic drag scheme
- Gust fix for orography and stochastic physics
- Reduction of ocean surface relative humidity from 100% to 98% (due to salinity effects)
- Revised assimilation of rain-affected radiances
- Variational bias correction of satellite radiances
- Thinning of low level AMDAR data (mainly affects Japanese AMDAR network)

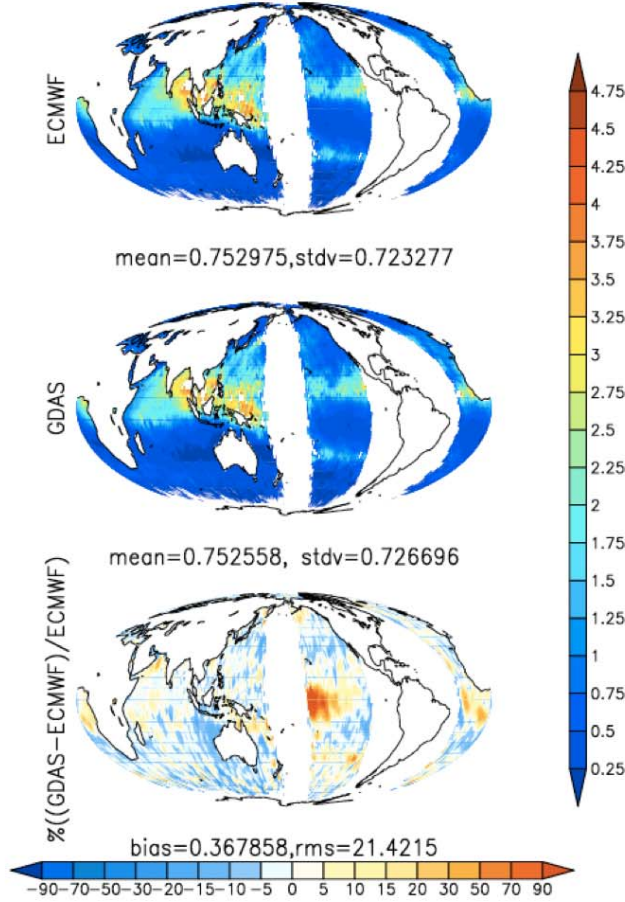


Note ECMWF TPW above 500 mb in 2006 is now similar with NCEP

Water Vapor above 500mb, Sept. 2005



Water Vapor above 500mb, Sept. 2006





Upper Tropospheric Water Vapor Channel - 2006

ECMWF

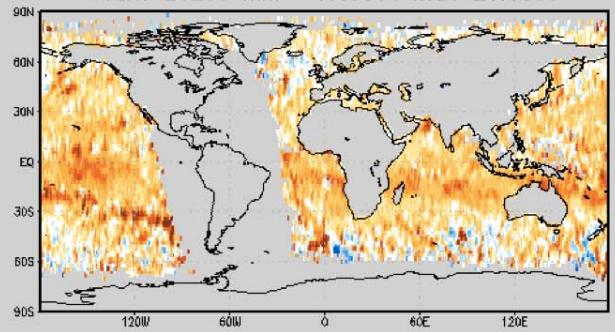
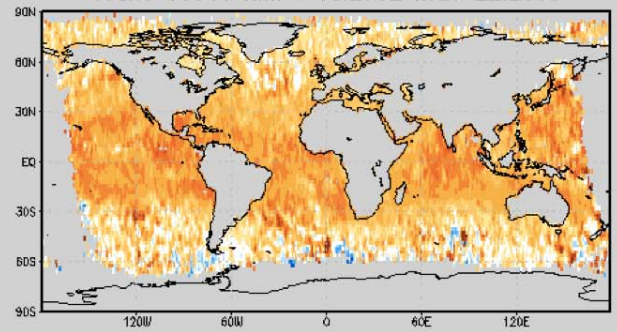
NCEP

Limb Adjusted BT, 7 PCs - ECMWF (NAD), 1519.07cm-1, Clear Sky, No Score, Sep, 2006

Limb Adjusted BT, 7 PCs - GDAS (NAD), 1519.07cm-1, Clear Sky, No Score, Sep, 2006

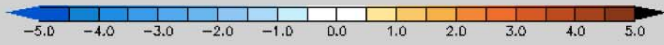
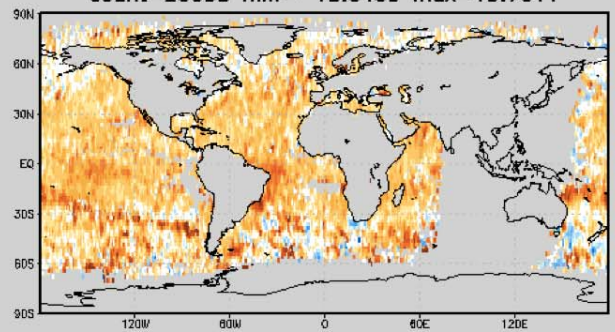
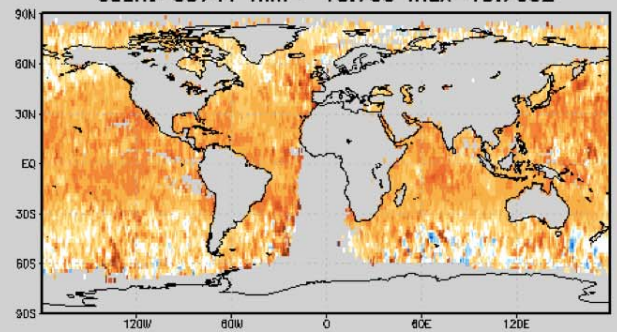
Ascending: bias=1.545 rms=2.09211
count=30344 min=-13.2702 max=22.2539

Ascending: bias=1.1298 rms=2.11822
count=25209 min=-17.3364 max=21.5035



Descending: bias=1.61995 rms=2.165
count=30741 min=-10.733 max=19.7652

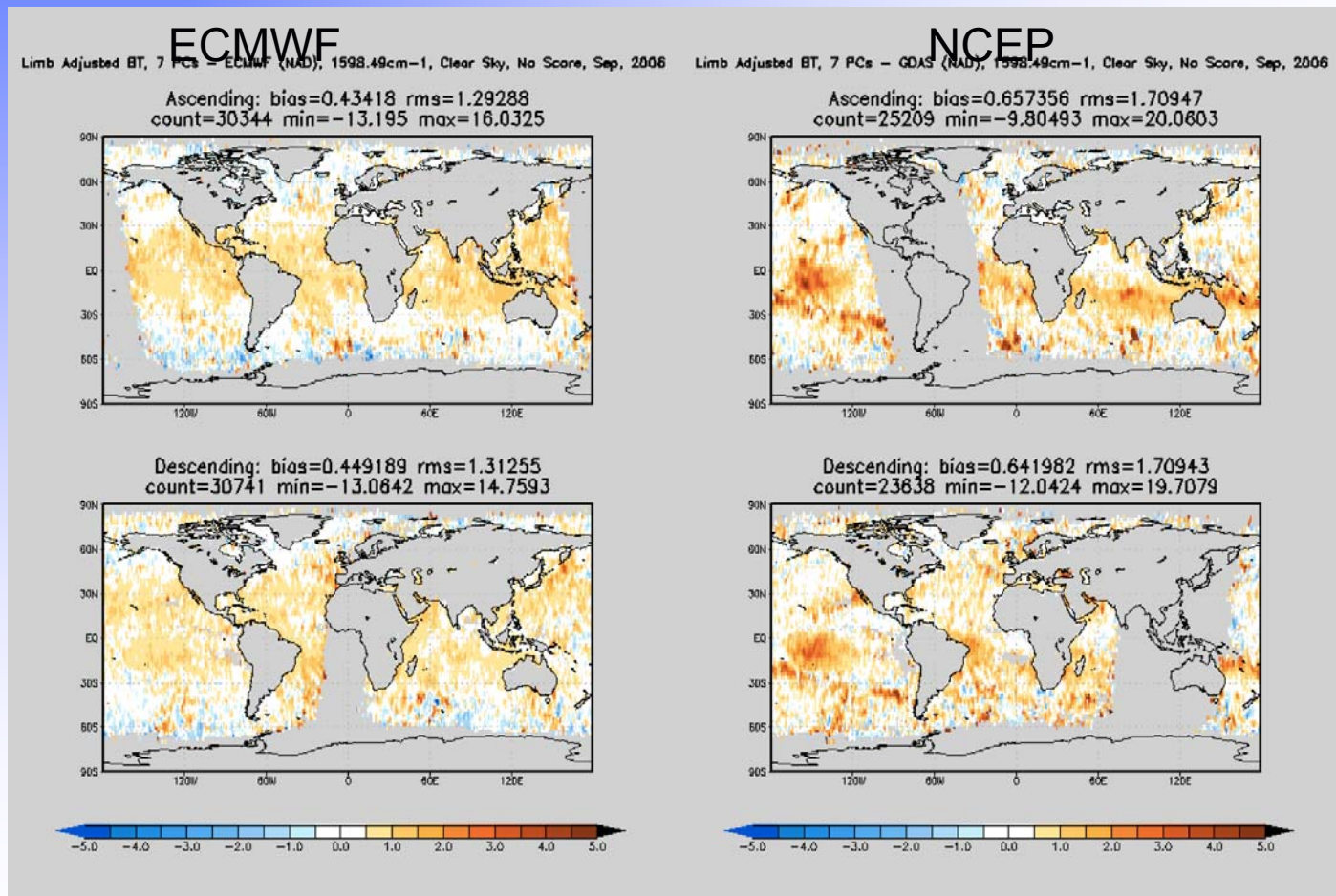
Descending: bias=1.19426 rms=2.17833
count=23638 min=-13.5455 max=19.7611



ECMWF bias is now larger than NCEP!!! (increased by ~0.8 K)



Mid Tropospheric Water Vapor Channel - 2006



ECMWF bias is nearing NCEP

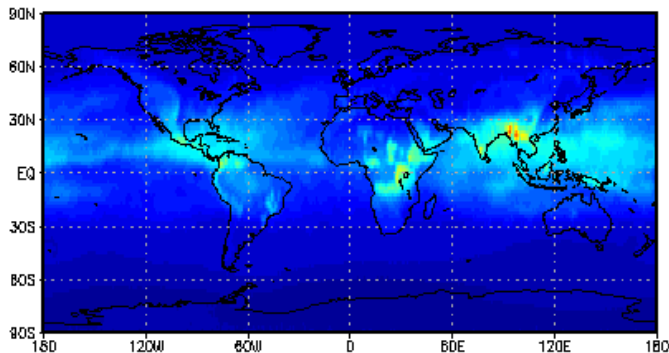


So what is the cause??

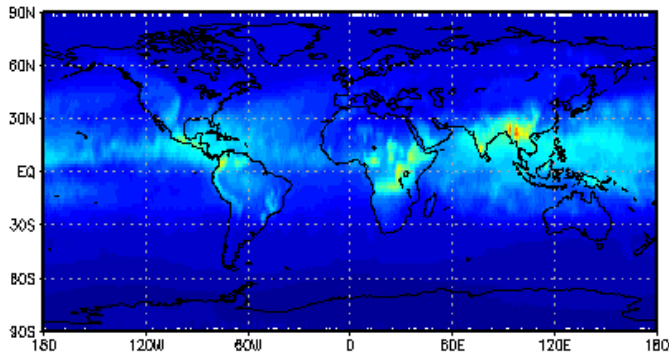
We found the water vapor (TPW) above 200 mb is nearly twice as large
(this is consistent for 2006, 2007, 2008)

Precip Water (above 200MB), ECMWF, Sep, 2005

Ascending: mean=0.00689914 std=0.00409231
count=64812 min=0.00229686 max=0.0422541



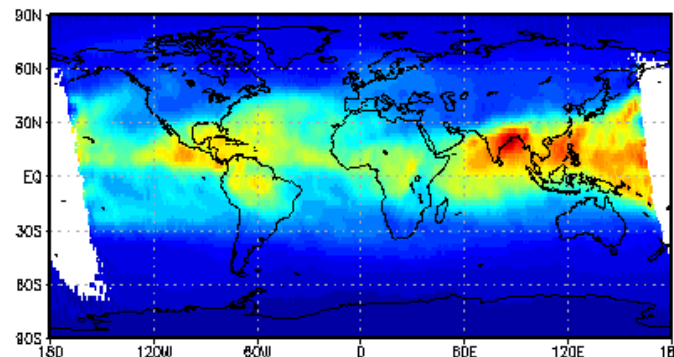
Descending: mean=0.00698395 std=0.00414626
count=63308 min=0.00215838 max=0.0384316



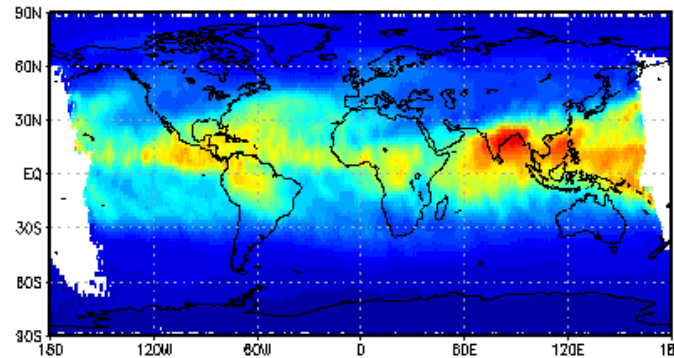
0.002 0.006 0.009 0.013 0.018 0.020 0.024 0.027 0.031 0.034 0.036 0.041

Precip Water (above 200MB), ECMWF, Sep, 2006

Ascending: mean=0.0103912 std=0.00666976
count=60533 min=0.00268439 max=0.0367425



Descending: mean=0.010538 std=0.0067149
count=58623 min=0.00261917 max=0.0359632



0.003 0.006 0.009 0.012 0.015 0.018 0.021 0.024 0.027 0.030 0.033 0.036

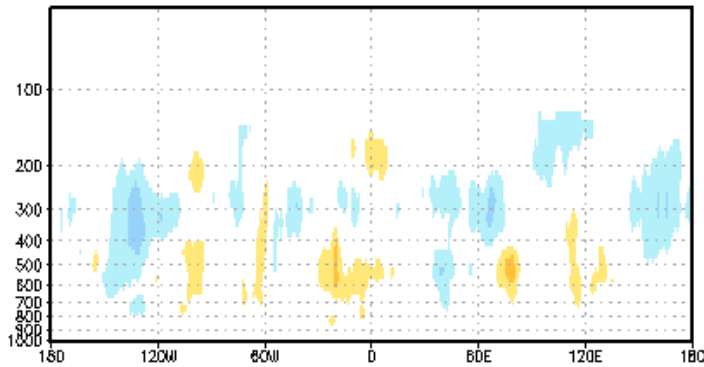


Compare Annual Difference (%) of ECMWF using 2005 as Base Year

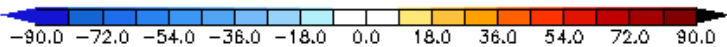
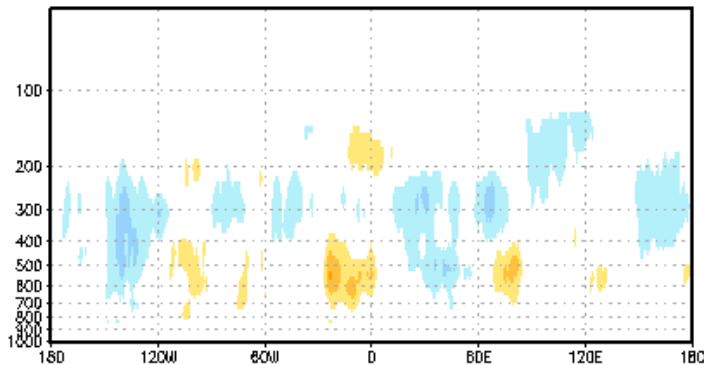
Very small year to year differences (2003 – 2005, 2004 – 2005)

Water Vapor Cross-Section, ECMWF, (2003–2005)/2005 (%)

Ascending: mean=-1.69638 std=6.69409
count=46208 min=-30.6876 max=27.7328



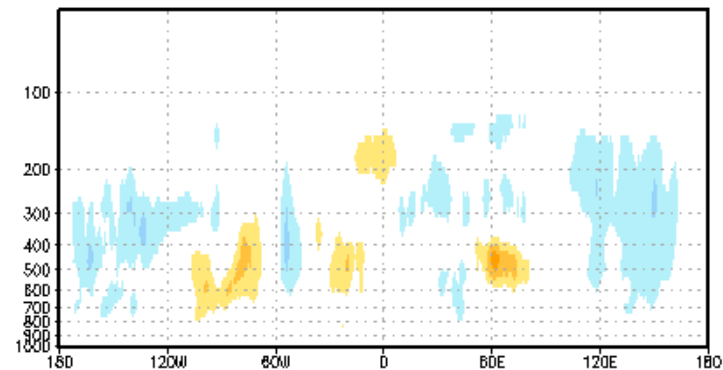
Descending: mean=-1.81166 std=7.04918
count=46208 min=-25.4245 max=33.1656



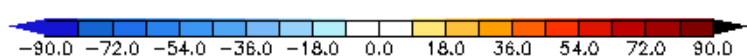
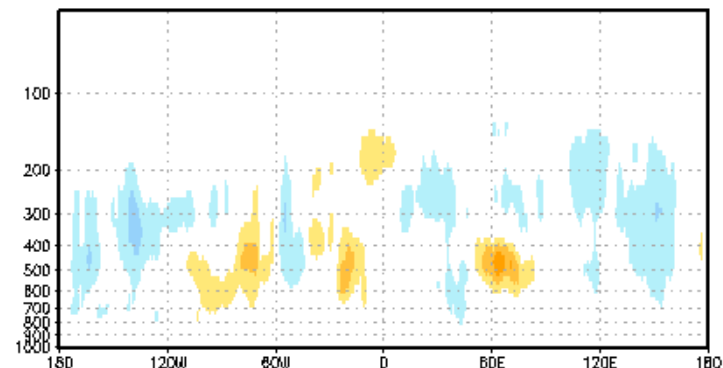
2003

Water Vapor Cross-Section, ECMWF, (2004–2005)/2005 (%)

Ascending: mean=-1.92665 std=7.30636
count=46208 min=-25.3074 max=38.101



Descending: mean=-1.47719 std=7.45873
count=46208 min=-25.0952 max=41.1136



2004

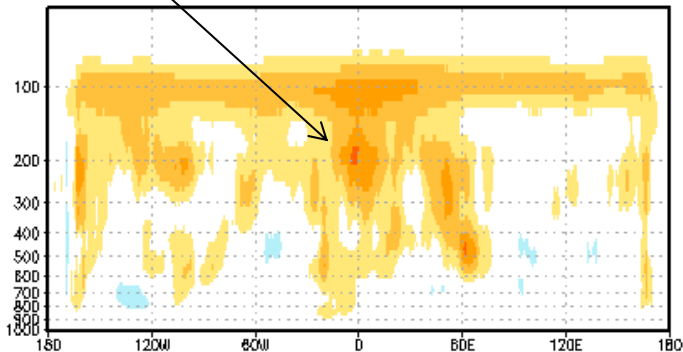


Compare Annual Difference (%) of ECMWF using 2005 as Base Year

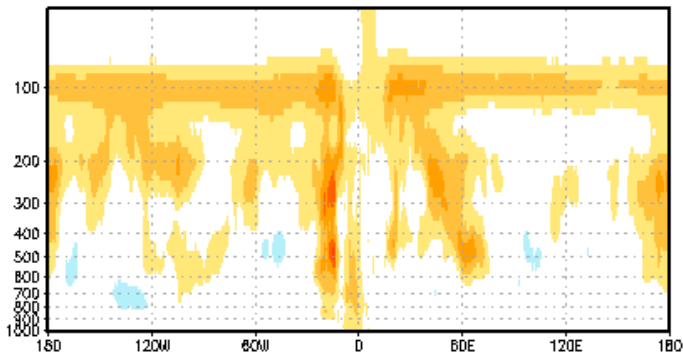
More water from previous years, difference with 2005 is now much larger

Water Vapor Cross-Section, ECMWF, (2006-2005)/2005 (%)

Ascending: mean=7.06542 std=10.6581
count=46208 min=-23.9533 max=44.2831



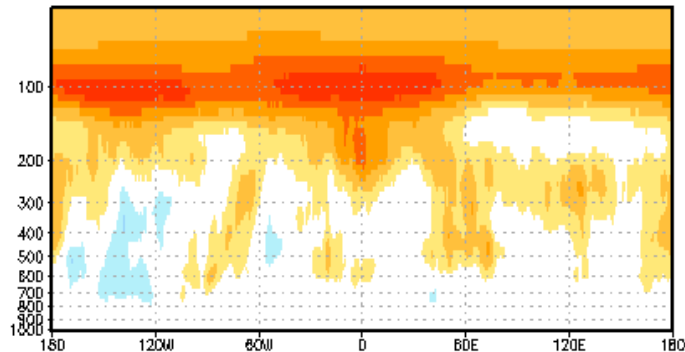
Descending: mean=7.1877 std=10.6747
count=46208 min=-20.3207 max=55.8853



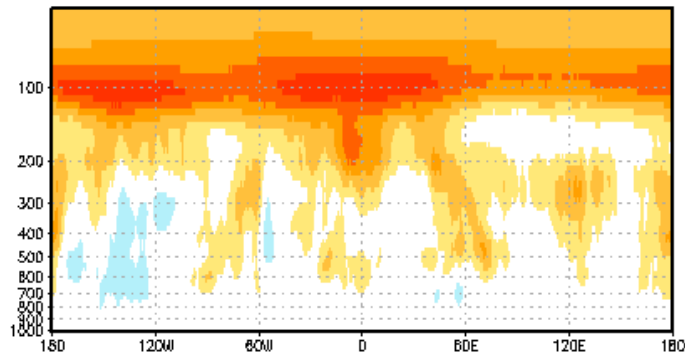
2006

Water Vapor Cross-Section, ECMWF, (2007-2005)/2005 (%)

Ascending: mean=12.7902 std=16.0639
count=46208 min=-21.4512 max=59.8314



Descending: mean=12.5862 std=16.1389
count=46208 min=-19.6088 max=58.9336



2007

(2008 ~ 2007)

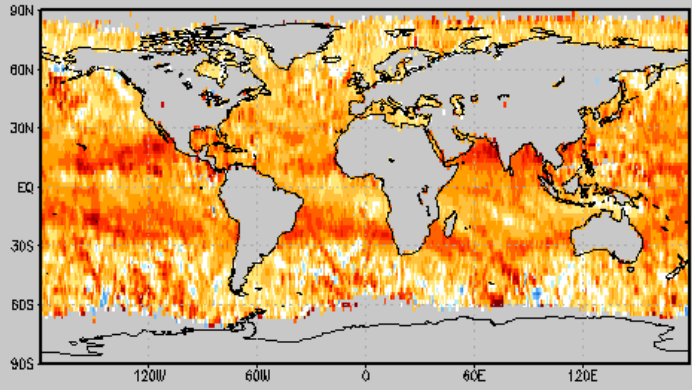


September 2008 AIRS – EC bias remains consistent with 2006

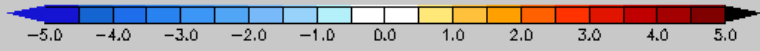
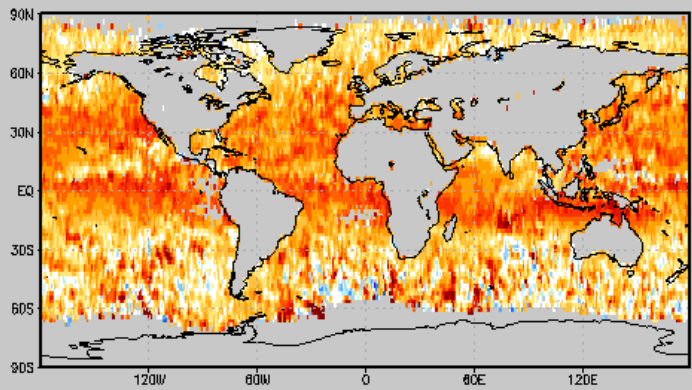
Upper trop water vapor

Limb Adjusted BT, 7 PCs – ECMWF (NAD), 1519.07cm⁻¹, Clear Sky, SST Only, Sep, 2008

Ascending: bias=1.58327 rms=2.21479
count=38422 min=-17.2329 max=19.0339



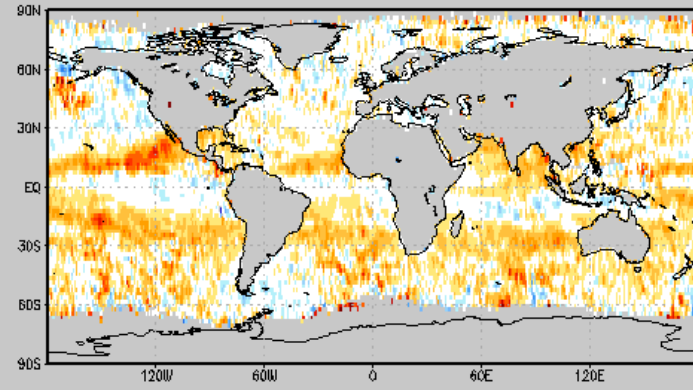
Descending: bias=1.58977 rms=2.39864
count=34417 min=-17.9672 max=20.3508



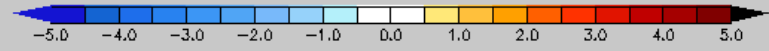
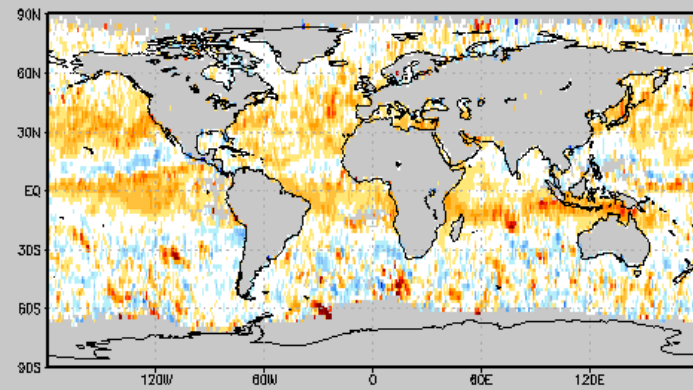
mid trop water vapor channel

Limb Adjusted BT, 7 PCs – ECMWF (NAD), 1598.49cm⁻¹, Clear Sky, SST Only, Sep, 2008

Ascending: bias=0.512161 rms=1.51725
count=38422 min=-13.0998 max=13.3609



Descending: bias=0.407457 rms=1.64683
count=34417 min=-14.3076 max=16.5478





How about Reanalyses??



New Generation of Reanalyzes

	MERRA	ERA Interim	JRA-25	CFSR
Producer	NASA	ECMWF	JMA	NCEP
Time Period	1979-now	1989-now	1979-now	1979 to 2009
Data Assimilation	Incremental Analysis Updates (IAU)	4D-Var	3D-Var	3D-Var
Vertical Resolution	42	37	23	64
Model Top (hPa)	0.1	1.0	0.4	0.26
Horizontal Resolution	0.66*0.5	1.5*1.5	1.25*1.25	0.5*0.5
Data Format	HDF	netCDF	GRIB	?

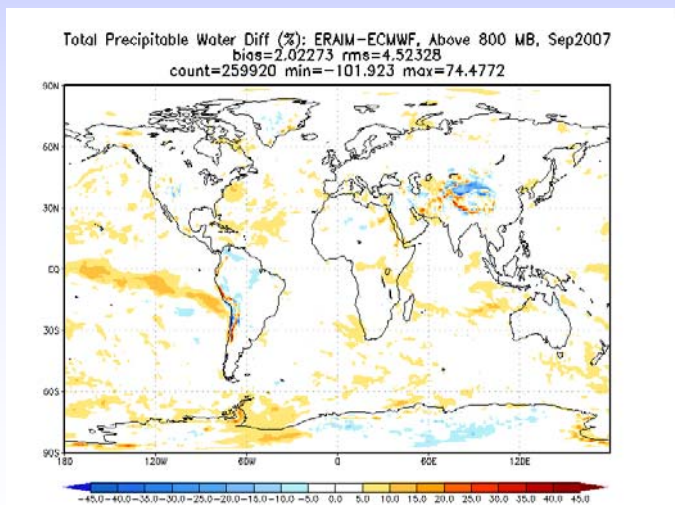
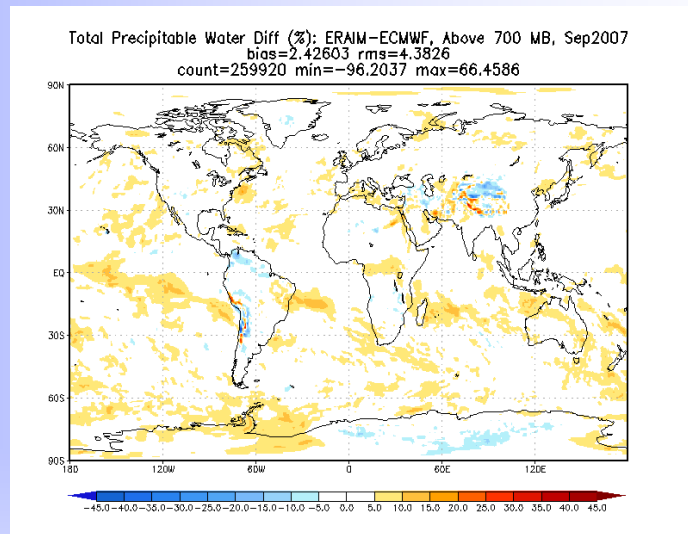
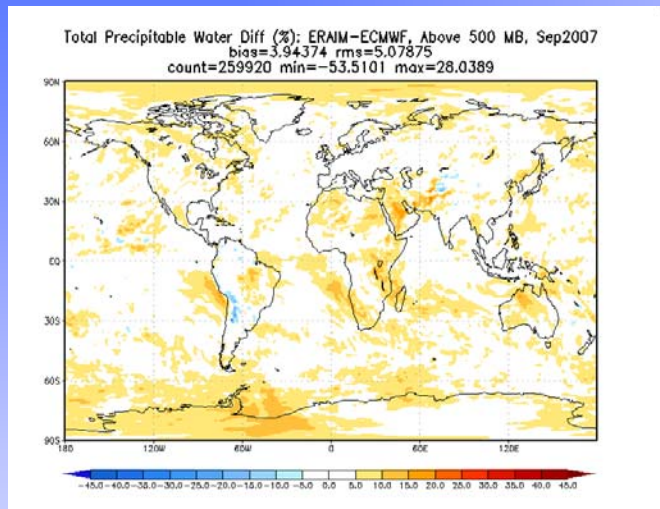


Conservative Error Budget for Water Vapor Channels

- RTA ~ 0.5 K $\sim 5\%$
- Interpolation to RTA levels $\sim 5\%$
- RMSE $\sim 7\%$
- Cannot determine which water vapor field is more accurate if differences are within 7%



ERA Interim Reanalysis - ECMWF Weather Analysis Sept. 2007

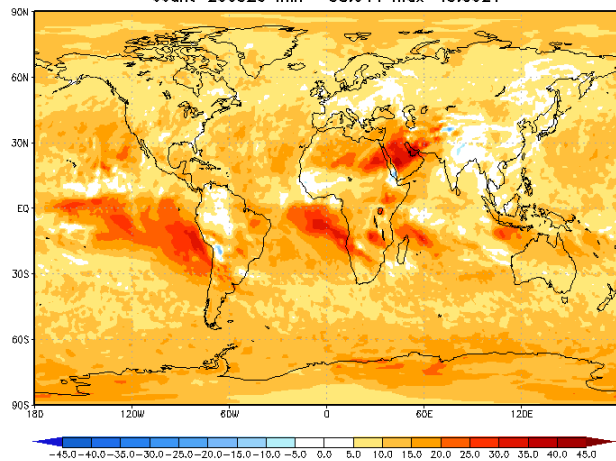


ECMWF 2003 – 2005 can be used to validate reanalyses

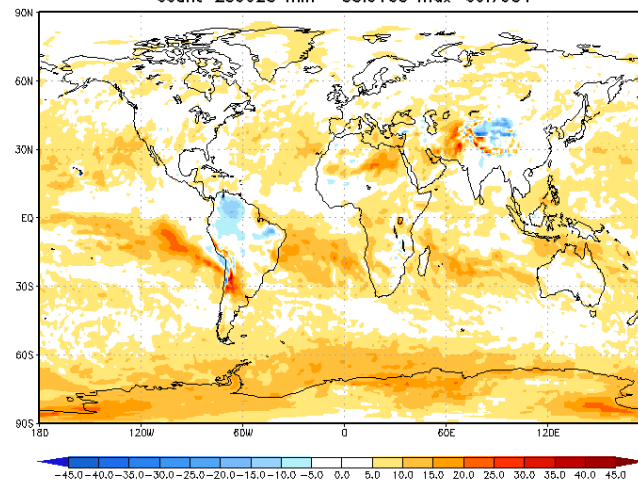


ERA Interim Reanalysis - ECMWF Weather Analysis Sept. 2004

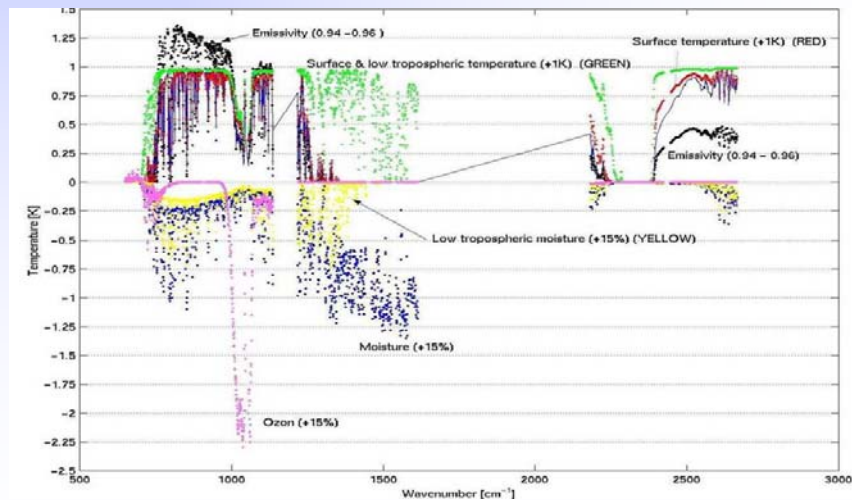
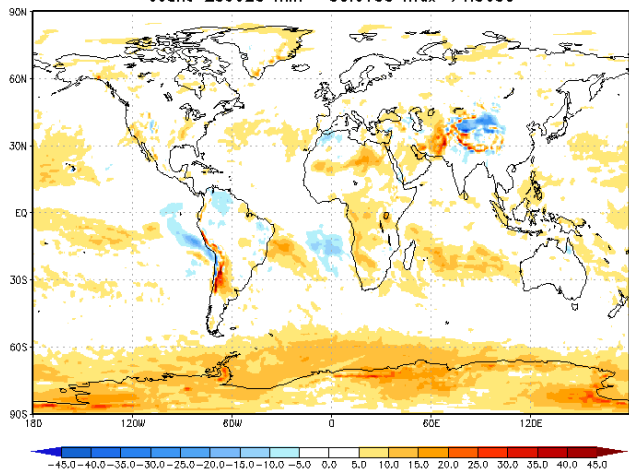
Total Precipitable Water Diff (%): ERAIM-ECMWF, Above 500 MB, Sep2004
bias=11.3523 rms=12.2848
count=259920 min=-38.944 max=43.8521



Total Precipitable Water Diff (%): ERAIM-ECMWF, Above 700 MB, Sep2004
bias=6.04922 rms=7.64281
count=259920 min=-80.9105 max=69.7934



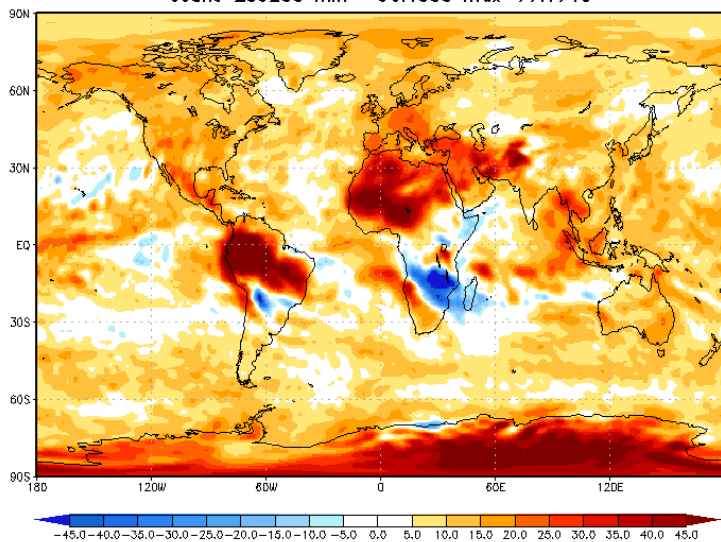
Total Precipitable Water Diff (%): ERAIM-ECMWF, Above 800 MB, Sep2004
bias=4.02537 rms=6.42975
count=259920 min=-88.6155 max=74.3653





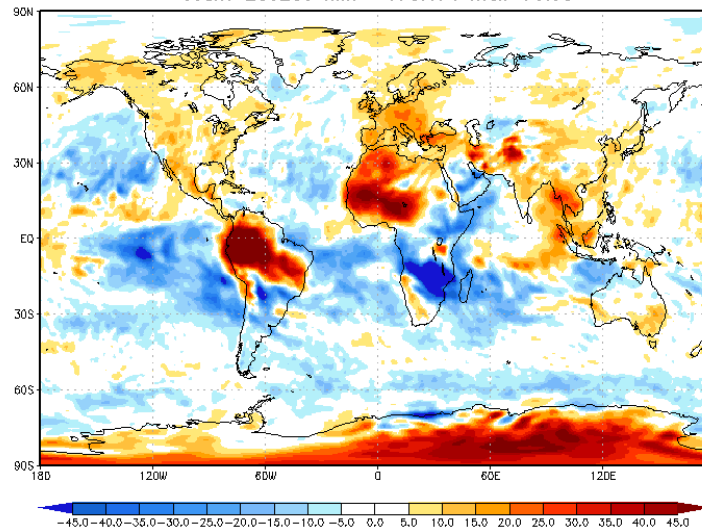
JRA25 vs ECMWF and ERA Interim (above 500 mb)

Total Precipitable Water Diff (%): ERAIM-JRA25, Above 500 MB, Sep2004
bias=12.7534 rms=17.3312
count=259200 min=-96.4588 max=77.1743



ERAIM - JRA25

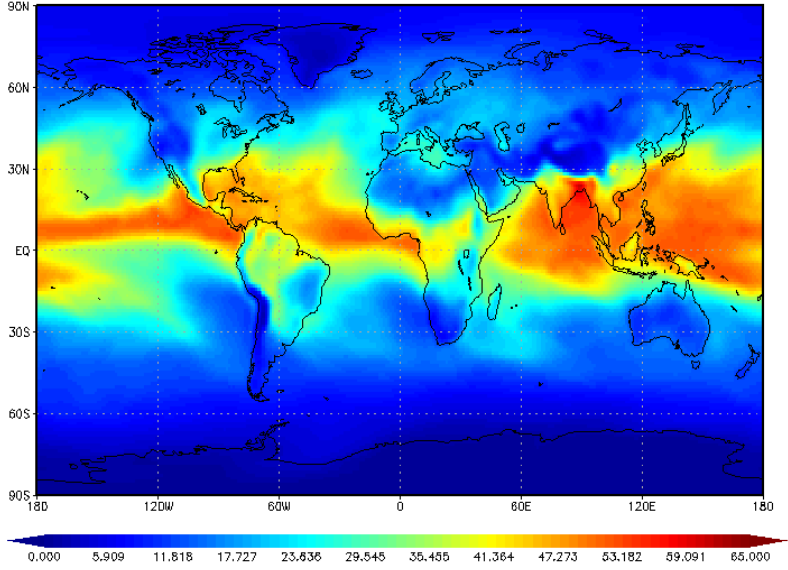
Total Precipitable Water Diff (%): ECMWF-JRA25, Above 500 MB, Sep2004
bias=1.33145 rms=14.3672
count=259200 min=-178.474 max=75.98



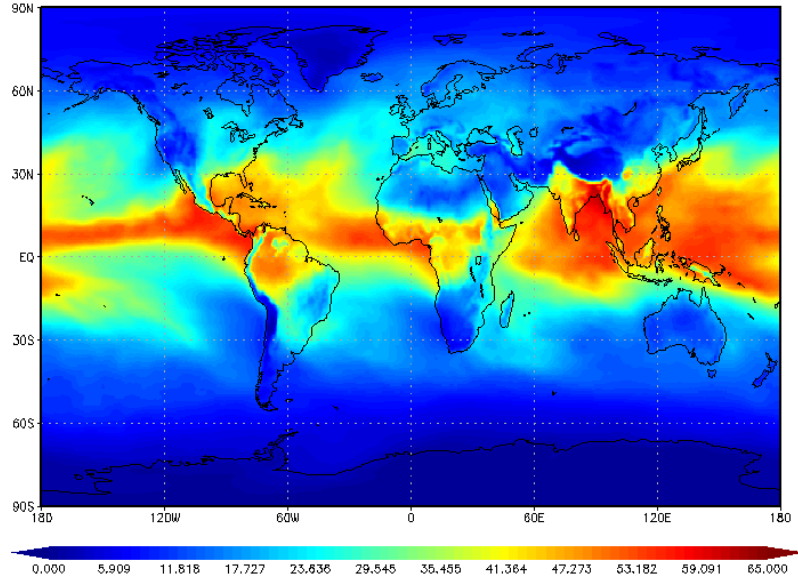
ECMWF - JRA25



Total Precipitable Water, Truth, Sep2004
mean=18.9514 std=14.985
count=51360 min=0.0477415 max=62.8299

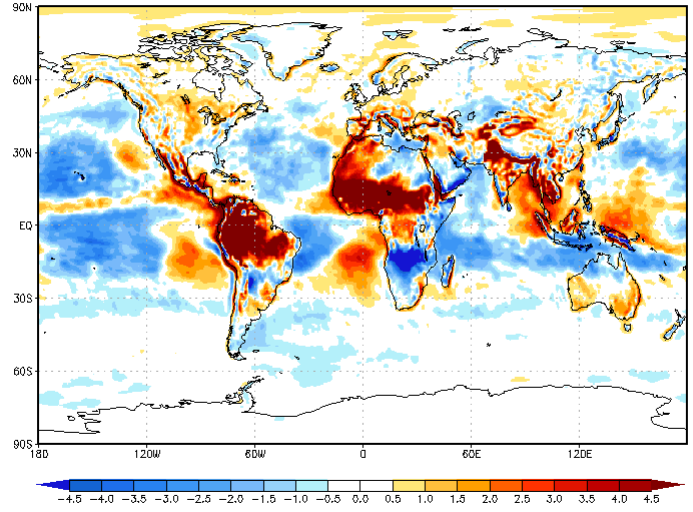


Total Precipitable Water, Truth, Sep2004
mean=18.9764 std=15.1504
count=260281 min=0.112127 max=63.6754



TPW Comparison of ECMWF vs JRA25

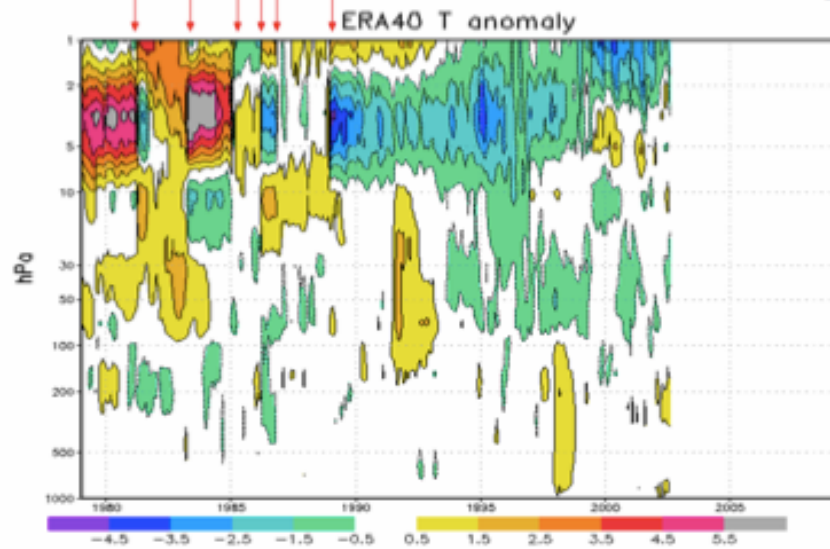
Total Precipitable Water Diff: ECMWF-JRA25, Sep2004
bias=0.120866 rms=1.91553
count=259200 min=-21.2793 max=25.8876



ERA40 / CFSR / MERRA

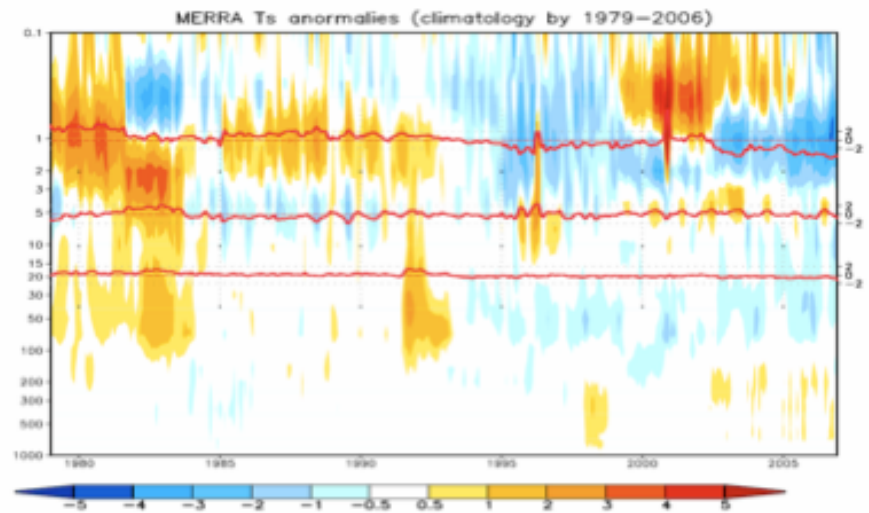
Changes in satellite data used

ERA-40



No apparent changes in satellite data used, BUT Big inter-stream jumps!

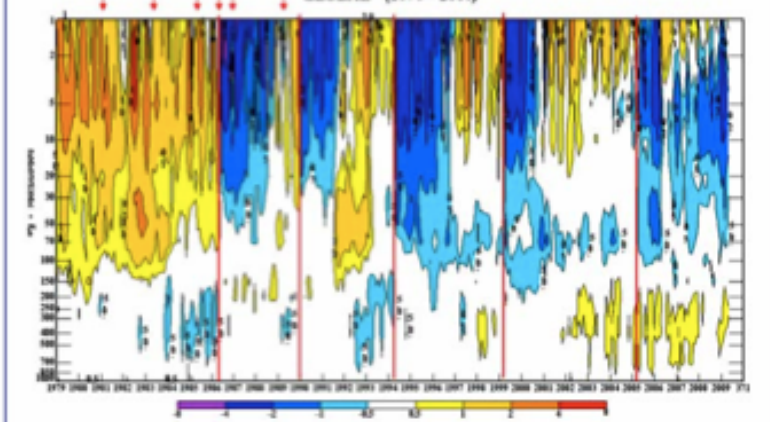
MERRA



NO big jumps between satellites and streams in MERRA

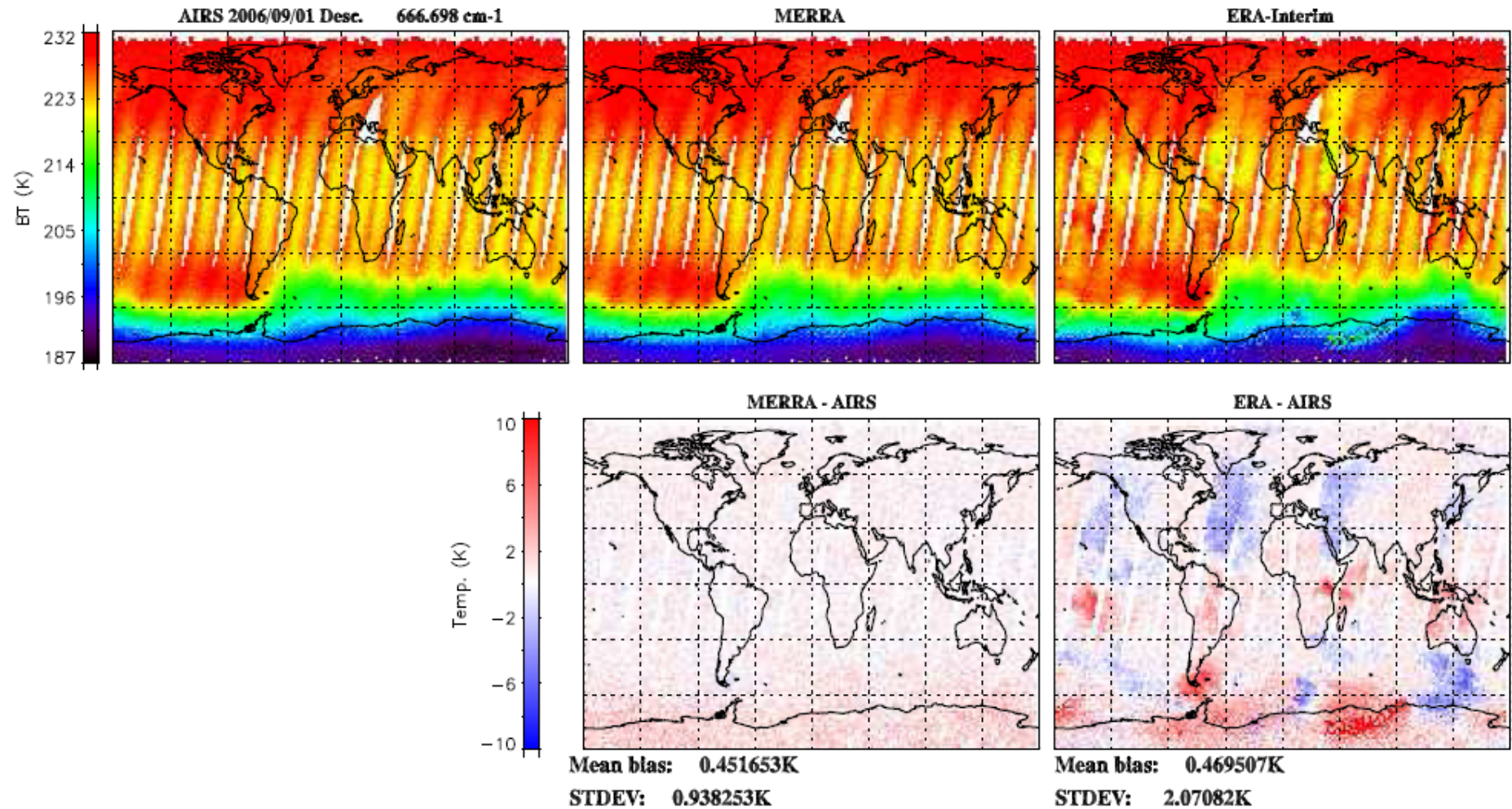
Monthly CFSR Temperature Anomalies GLOBAL (1979 - 2009)

CFSR





Stratospheric temperature: 666.7 cm-1 channel (1.5 hPa)





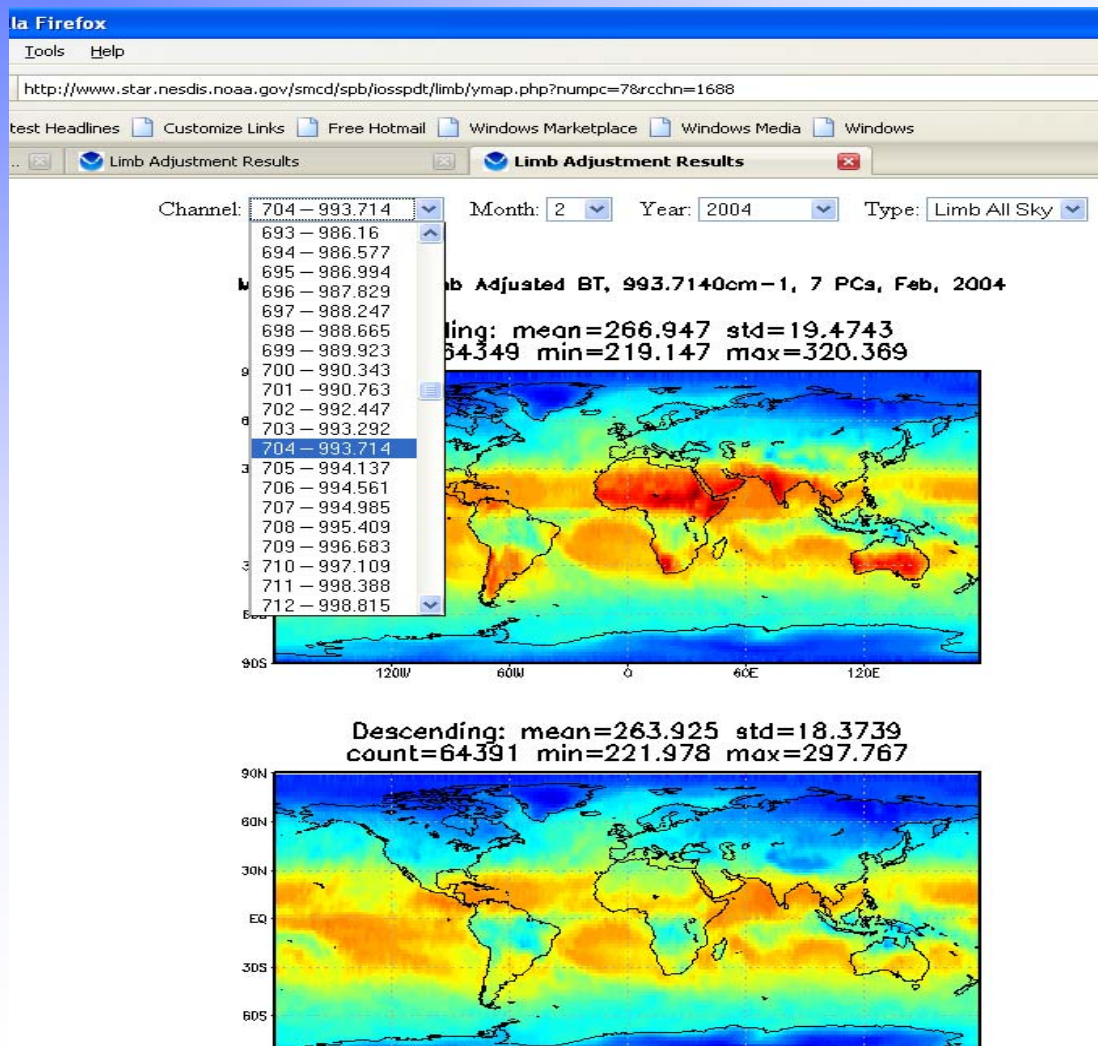
Summary

- Developed a SRIR radiance CDR
- The CDR consists of monthly brightness temperatures for all AIRS channels
 - Ascending (day), clear sky
 - Ascending, all sky
 - Descending (night), clear sky
 - Descending, all sky datasets
- Will extend into the future, and also use IASI and CrIS



Summary

Datasets have been generated for 5 years data from January 2003:





Summary

- Demonstrated two very important applications:
 - Determine the accuracy of model analyses (ECMWF is more accurate 2003-2005, the so-called “Golden Years”)
 - Demonstrate the use of the SRIR to monitor the accuracy of models as a function of time (Observed a degradation of ECMWF vs AIRS bias after ECWFM operational changes in September 2006)



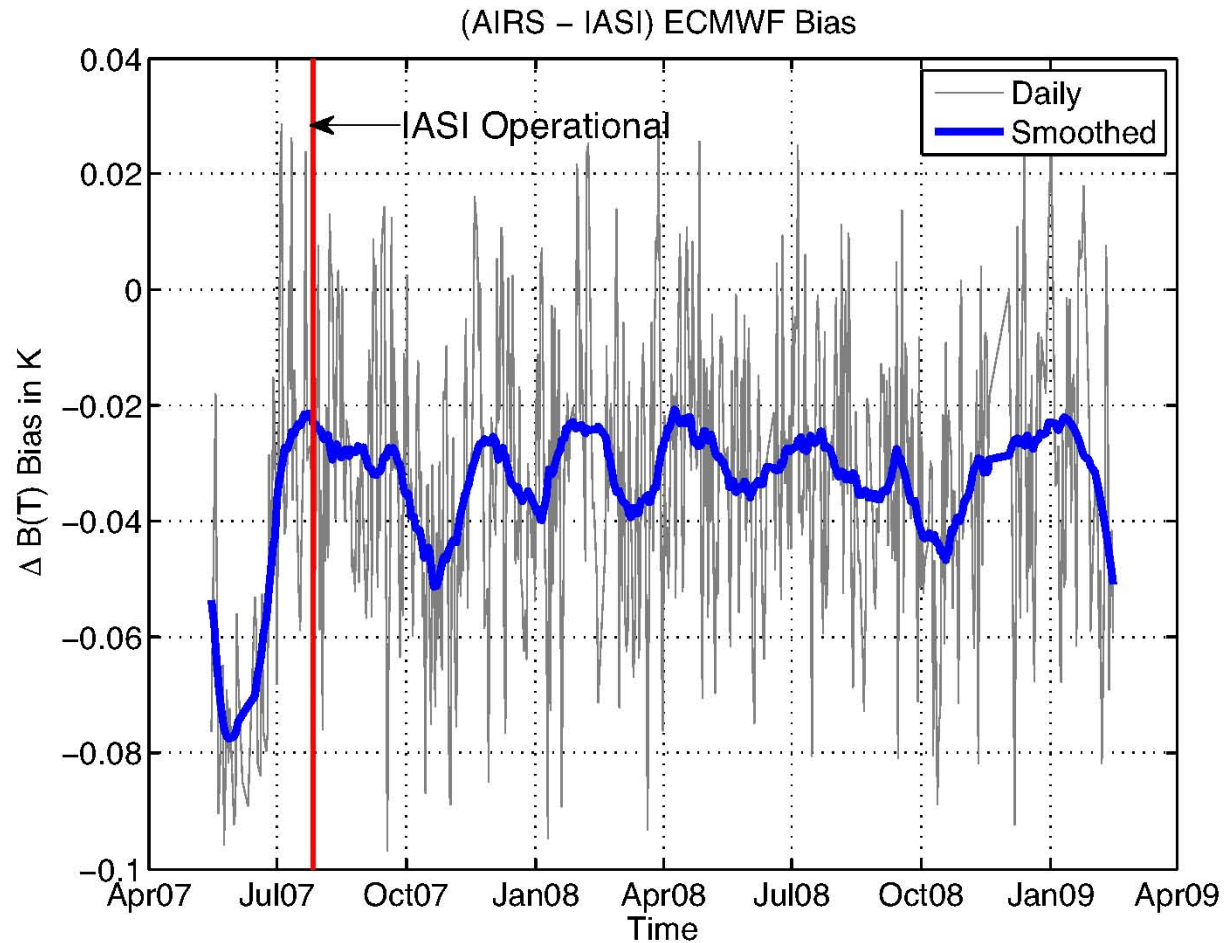
Backup

AIRS versus IASI Stability

-0.0019K/year \pm 0.008K/year (corrected for lag-1 correlation of 0.45)

IASI/AIRS

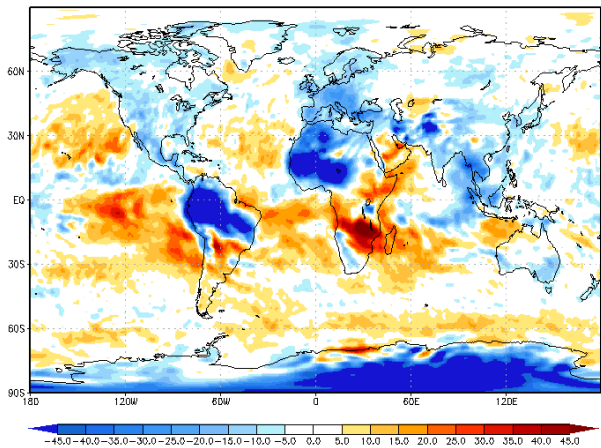
L. Strow
UMBC



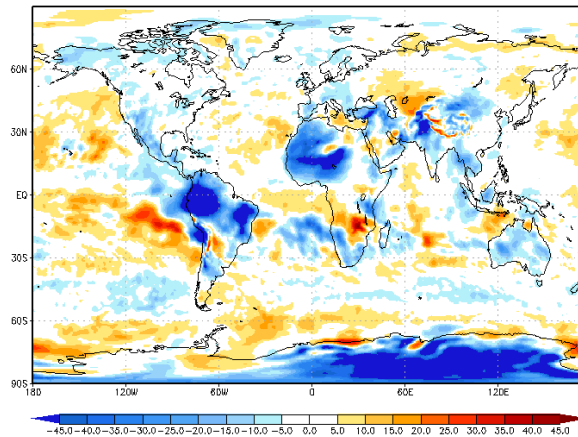


JRA 25 Reanalysis - ECMWF Weather Analysis Sept. 2007

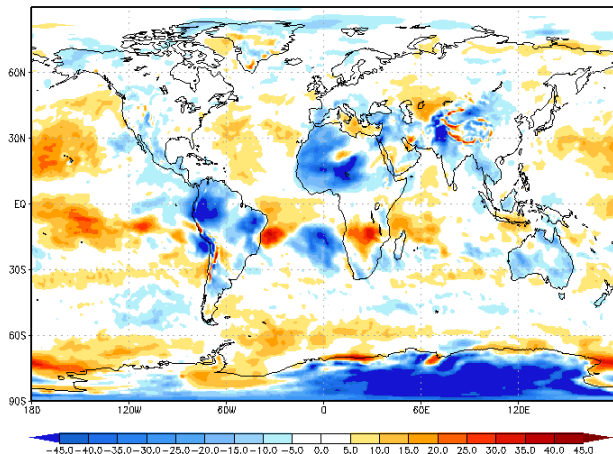
Total Precipitable Water Diff (%): JRA25-ECMWF, Above 500 MB, Sep2004
bias=-4.05271 rms=21.1384
count=259200 min=-316.32 max=64.09



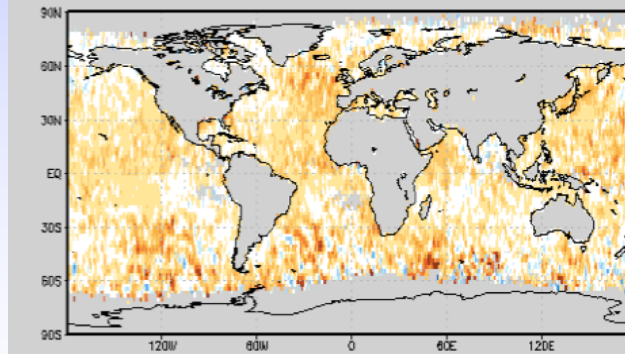
Total Precipitable Water Diff (%): JRA25-ECMWF, Above 700 MB, Sep2004
bias=-3.63526 rms=17.2116
count=259200 min=-157.347 max=61.1574



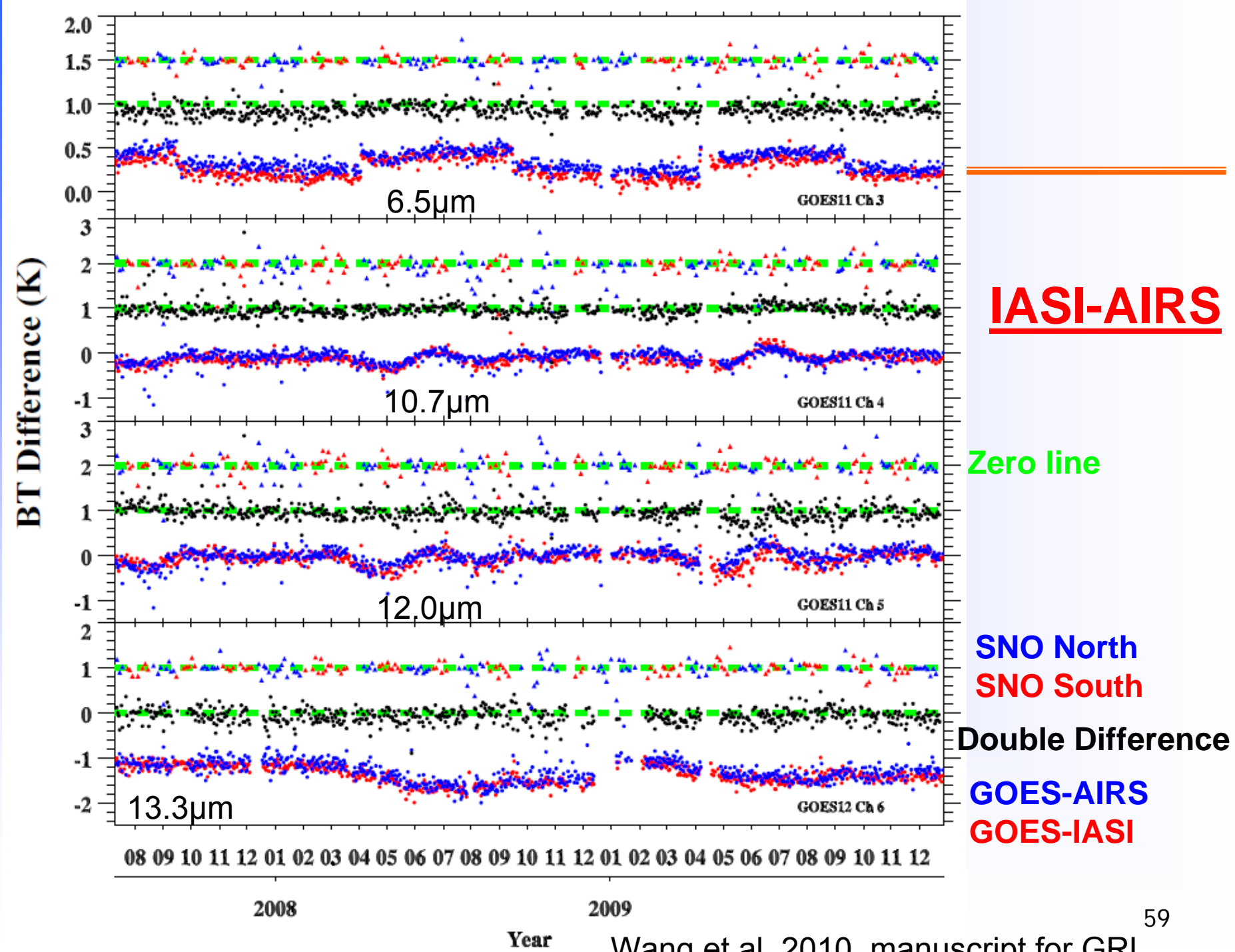
Total Precipitable Water Diff (%): JRA25-ECMWF, Above 800 MB, Sep2004
bias=-2.76522 rms=16.0491
count=259200 min=-175.896 max=65.6222



Descending: bias=0.737436 rms=1.52481
count=33592 min=-12.8482 max=16.5283



2004 ← AIRS assimilate





Statistical results

		<u>GOES-11 Ch3</u>	<u>GOES-11 Ch4</u>	<u>GOES-11 Ch5</u>	<u>GOES-12 Ch6</u>
Central Wavelength (μm)		6.7	10.7	12.0	13.3
Double Differ ences	Sample number	694	688	691	626
	Mean (K)	-0.0707	-0.0262	-0.041	-0.0751
	95% confidence level (K)	0.0052	0.0116	0.0135	0.0124
SNOs	Sample number	228 *	228	228	228
	Mean (K)	-0.011	-0.0624	-0.010	-0.0124
	95% confidence level (K)	0.0091	0.0300	0.0295	0.0211