

Enhanced use of radiance data in NCEP data assimilation systems

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NOAA/NWS/NCEP/EMC



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Changes in use of radiance data

- Updates to radiative transfer
 - Updated Microwave and IR LBL calculations
 - Separate water vapor continuum
 - VanDelst's surface emissivity (later talk)
- Modifications to data selection and quality control
 - Equal area data selection based on:
 - Likelihood of passing QC
 - Center of box
 - Smallest time difference
 - IR QC based on estimating cloud top and percentage from $_T_b$



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Changes in use of radiance data

- Changes to data assimilation and forecast systems – Implementation by end of year
 - Improved time interpolation – allows use of more frequent output fields – time interpolates surface fields
 - Allows use of guess solution – early analysis can be used for GFS
 - Satellite data monitoring file upgrade
 - <http://wwwt.emc.ncep.noaa.gov/gmb/gdas/radiance/prx/index.html> (parallel)
 - <http://wwwt.emc.ncep.noaa.gov/gmb/gdas/radiance/prq/index.html> (AIRS)
 - Streamline code, simplified data handling, and a few bug fixes



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Radiance usage

- IR instruments
 - GOES-10/12 sounder
 - HIRS/2 NOAA-14
 - HIRS/3 NOAA-16/17
 - AIRS
 - GOES imager
 - AVHRR
- Microwave instruments
 - MSU NOAA-14
 - AMSU-A NOAA-15/16/17, EOS
 - AMSU-B NOAA-15/16/17
 - SSM/IS



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New data types/usages

- AIRS data
- GOES imager data
- SSM/I data
- SST analysis



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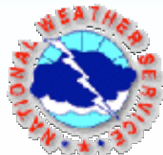


AIRS data

- 254 out of 281 channels used
 - 73-86 removed (Channels peak too high)
 - 1937-2109 removed (non-LTE)
 - 2357 removed (Large obs-background diff.)
- Shortwave channels down weighted (wavenumber > 2000) or removed (wavenumber > 2400) during day



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Parallel testing

- Testing of system and data impact underway
- System updated as problems uncovered
- Recent changes
 - Removal of channel 2357 – large differences
 - Thinning to 225km vs. 150km – AIRS penalty too large – slow convergence
 - Increase observational error .2 K – AIRS penalty too large – slow convergence



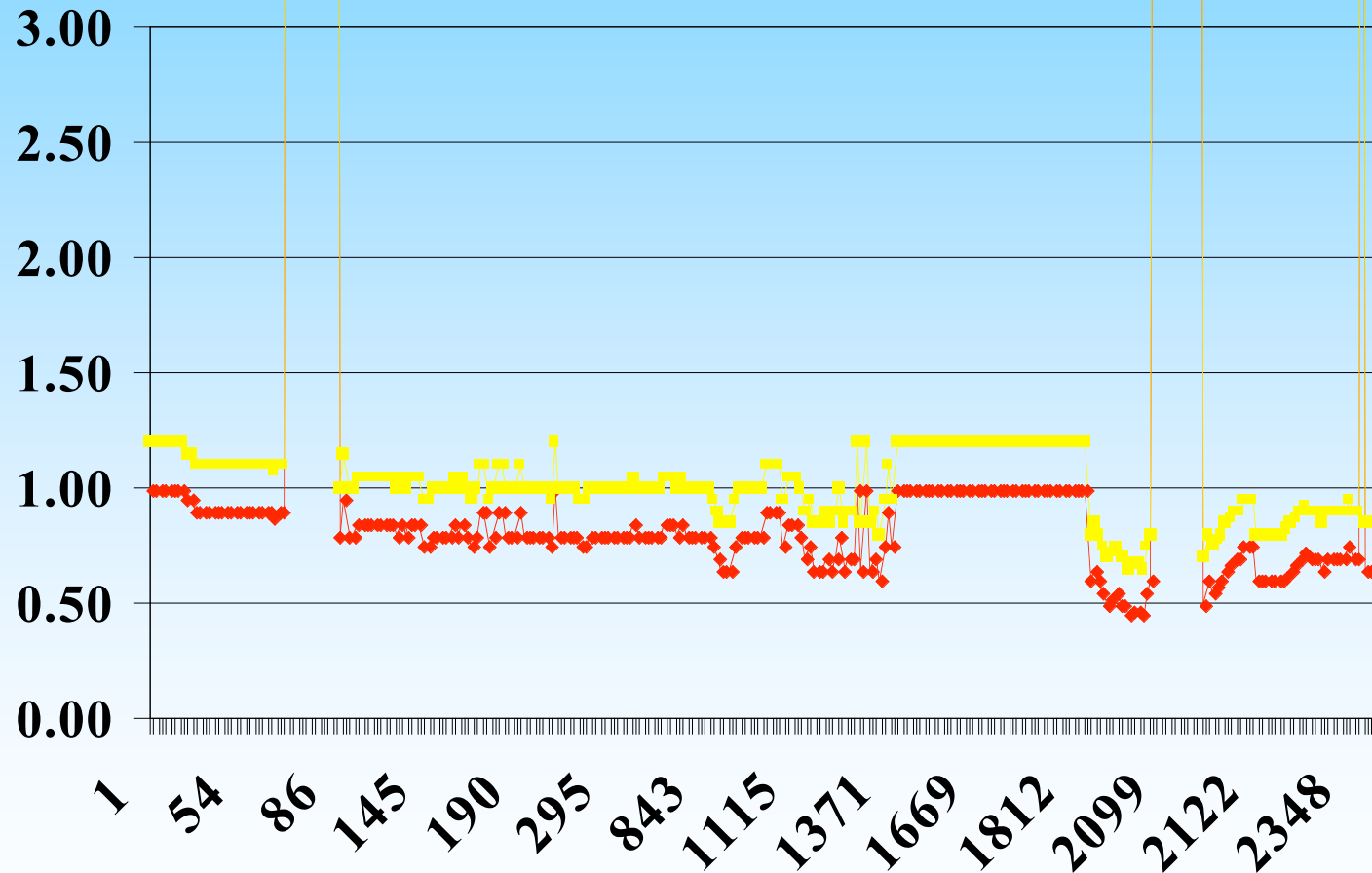
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AIRS observational errors



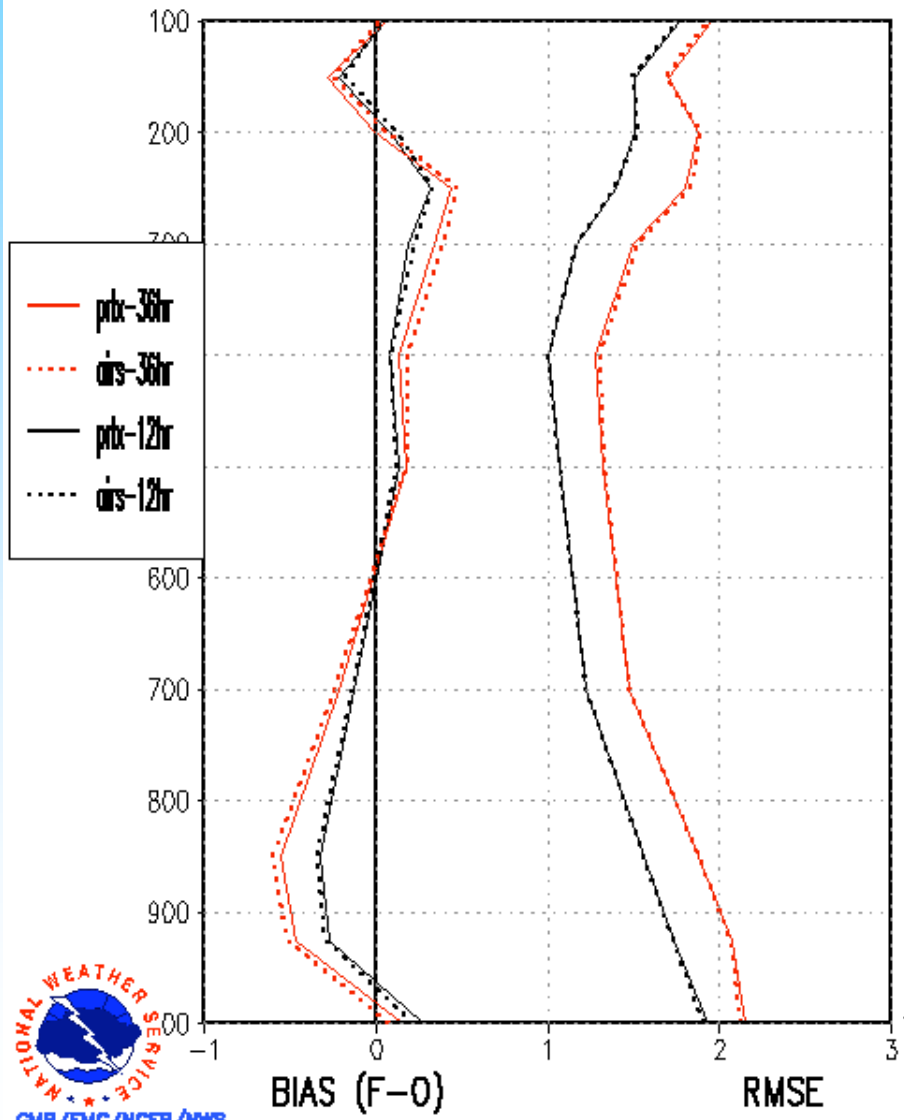
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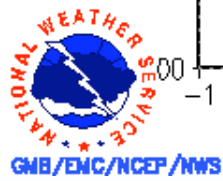
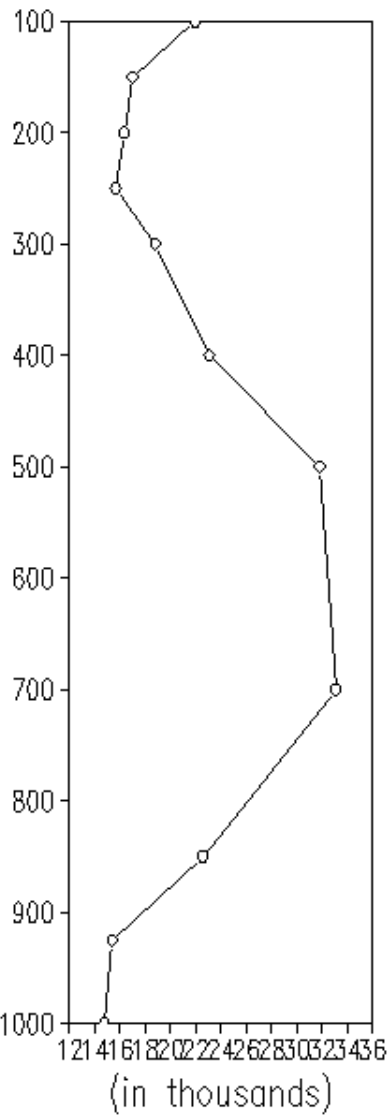
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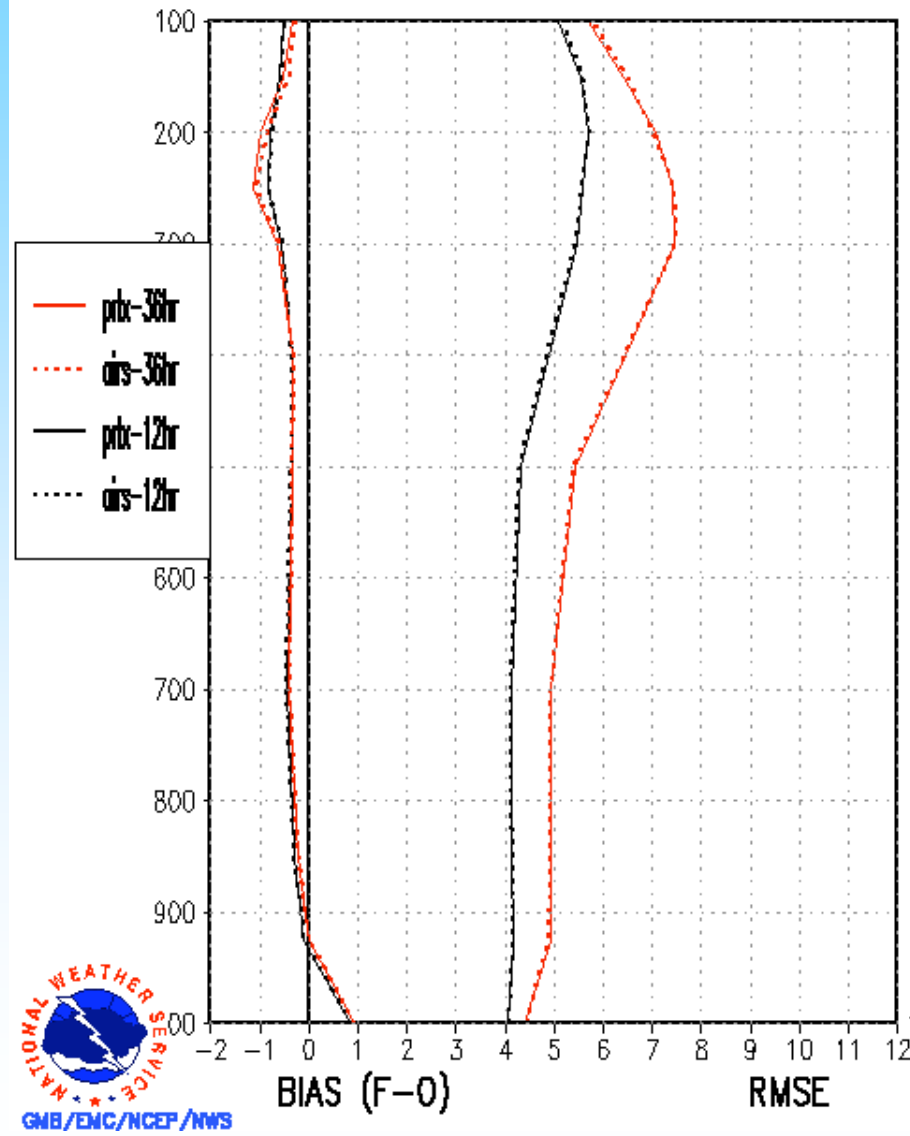
Global Temp Fits to RAOBS 12z05oct2003 - 12z23oct2003



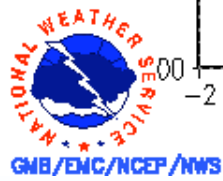
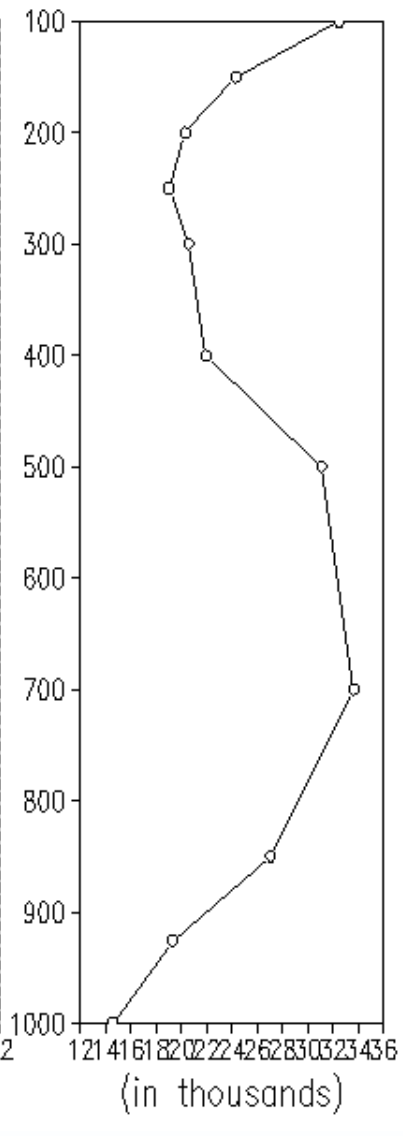
Global Data Counts



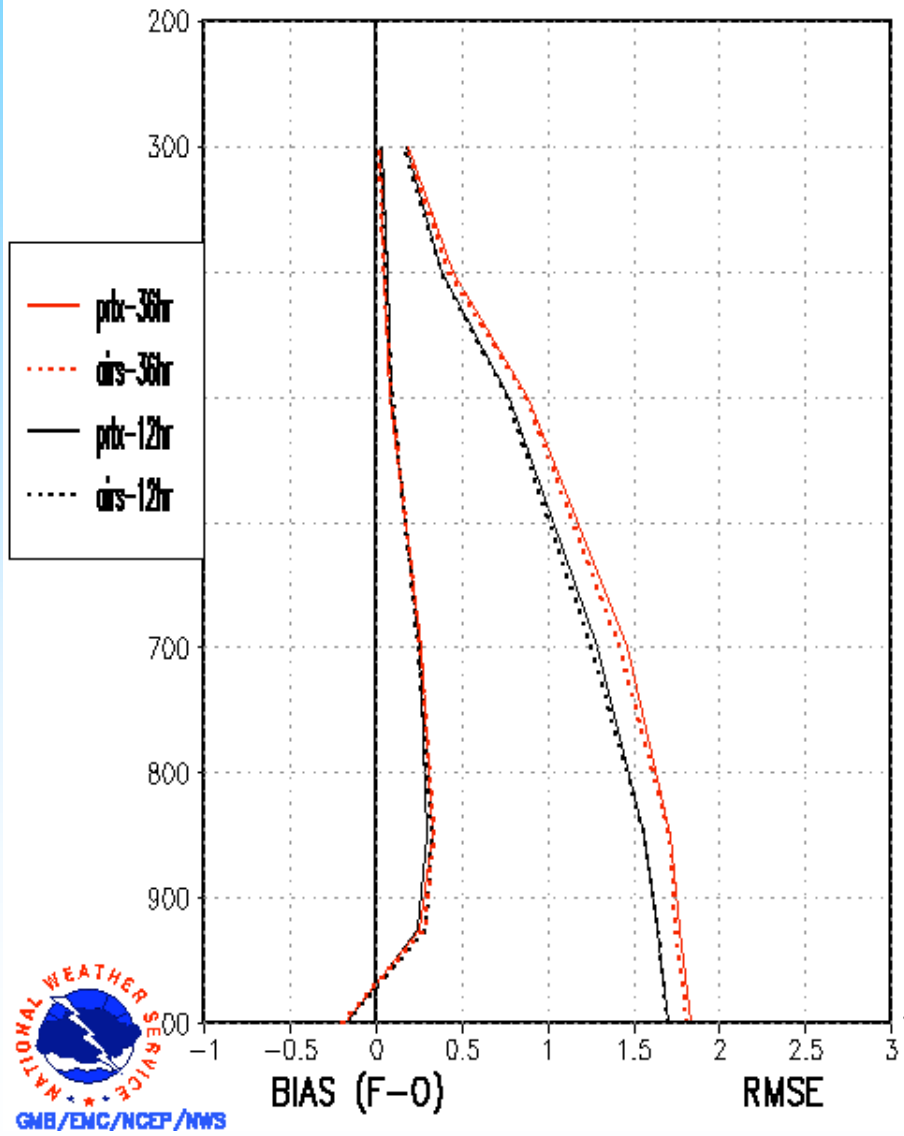
Global Vector Wind Fits to RAOBS 12z05oct2003 - 12z23oct2003



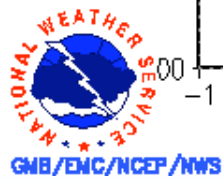
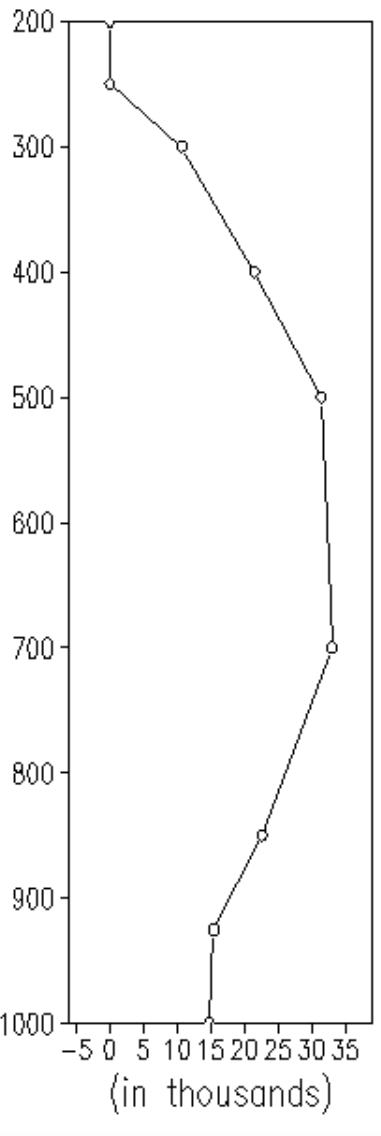
Global Data Counts



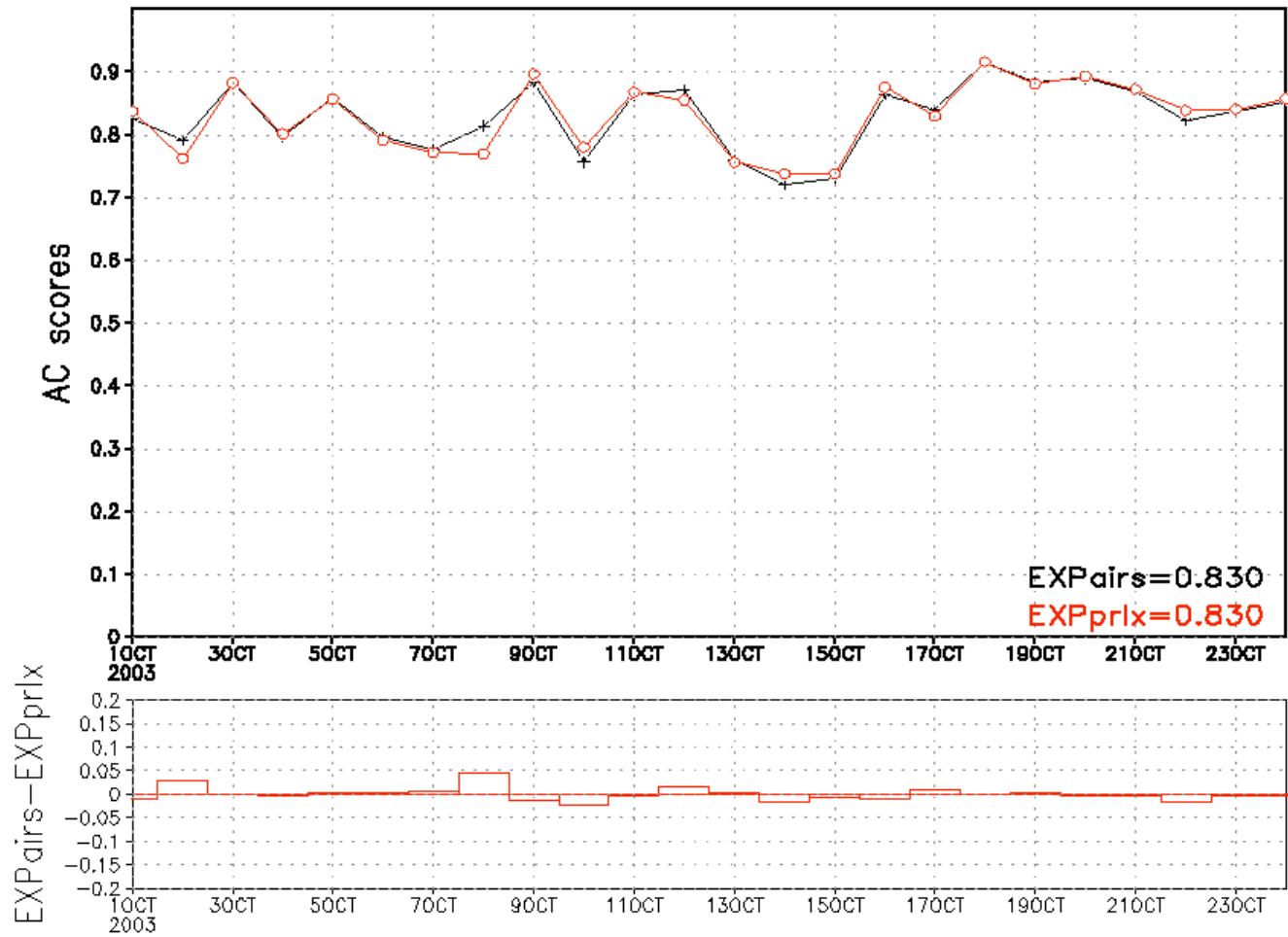
Global Moisture Fits to RAOBS 12z05oct2003 - 12z23oct2003



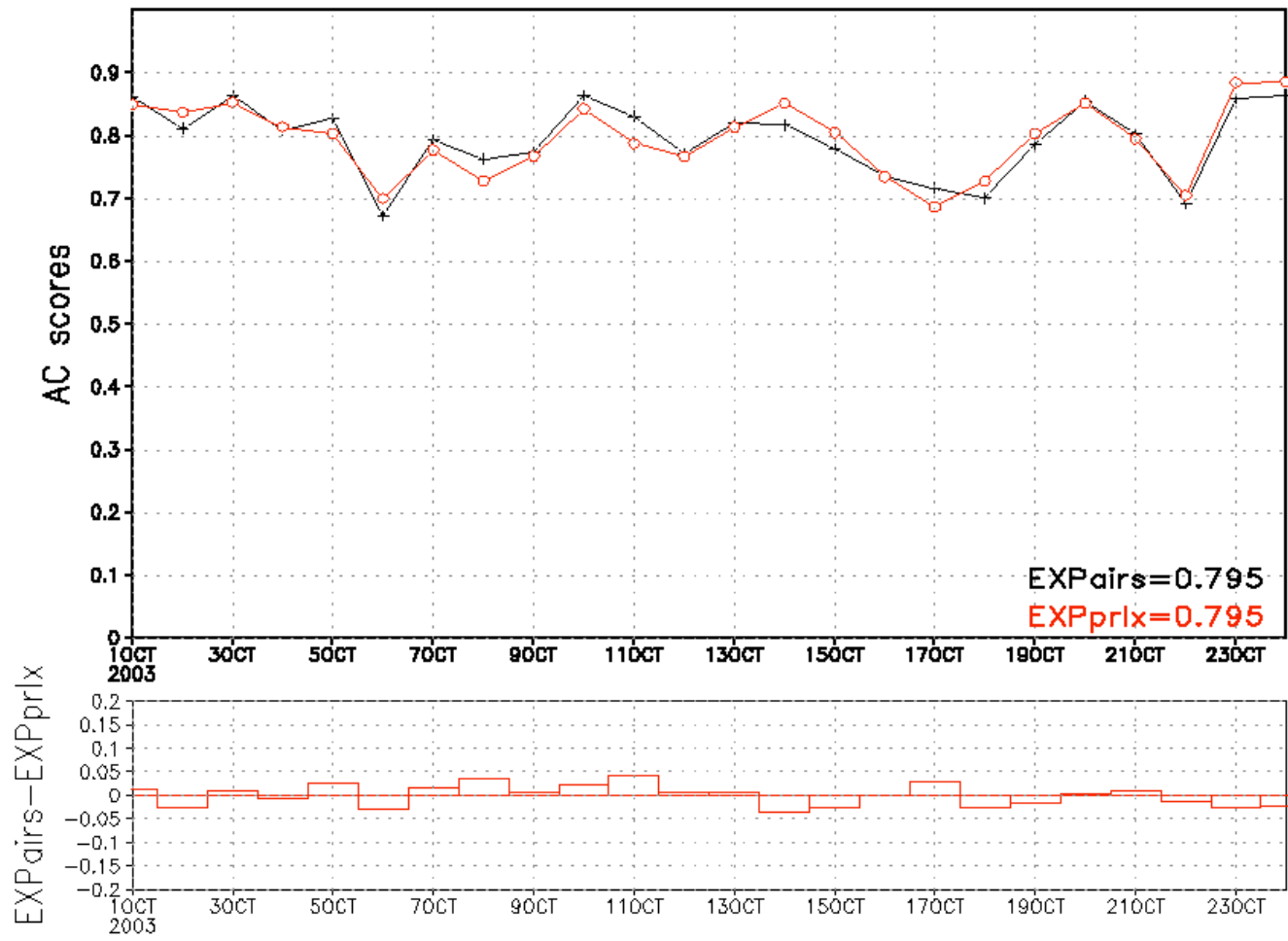
Global Data Counts



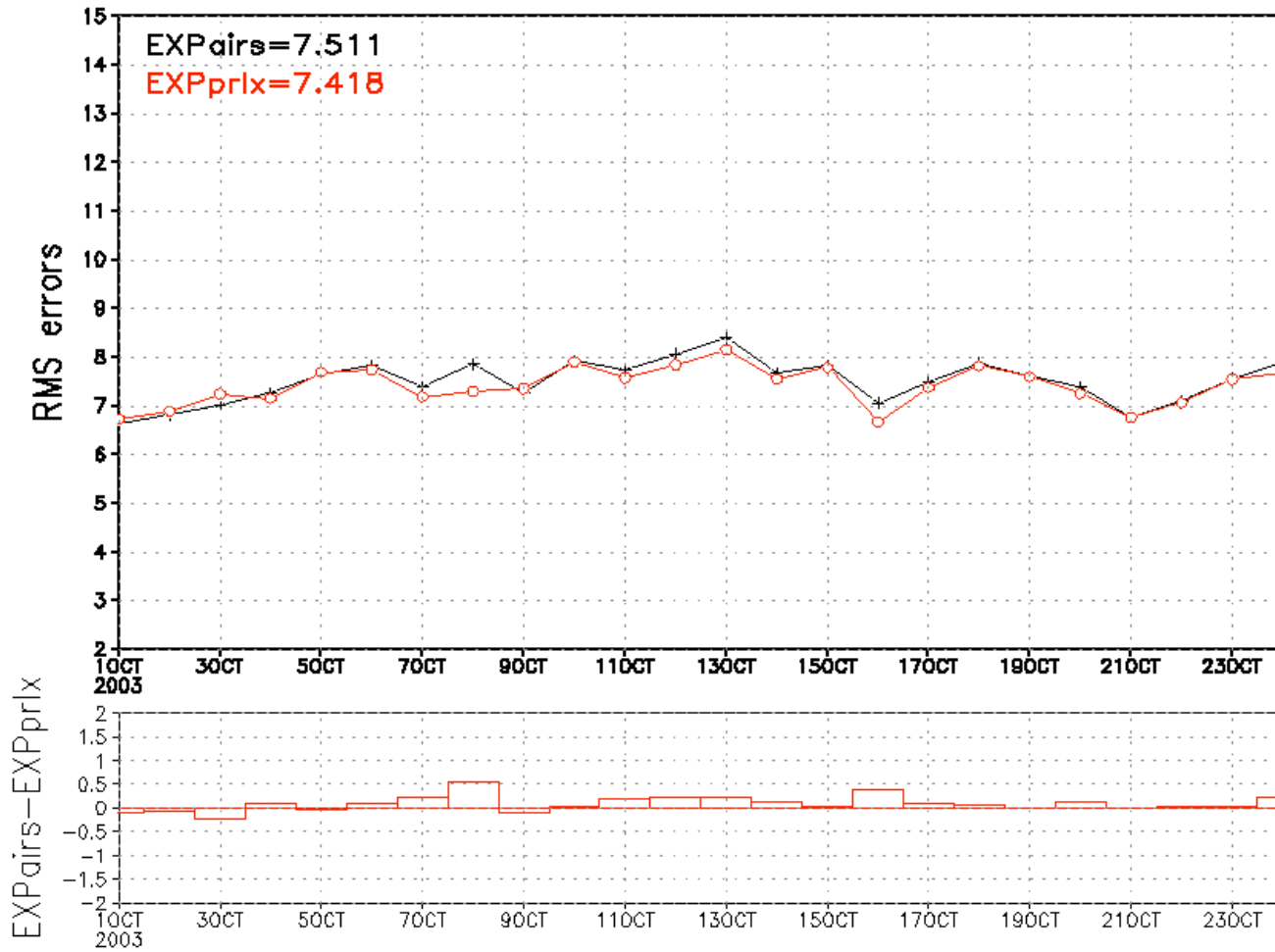
NH 500 mb Geopotential Height at day 5 for 00Z01OCT2003 – 00Z24OCT2003



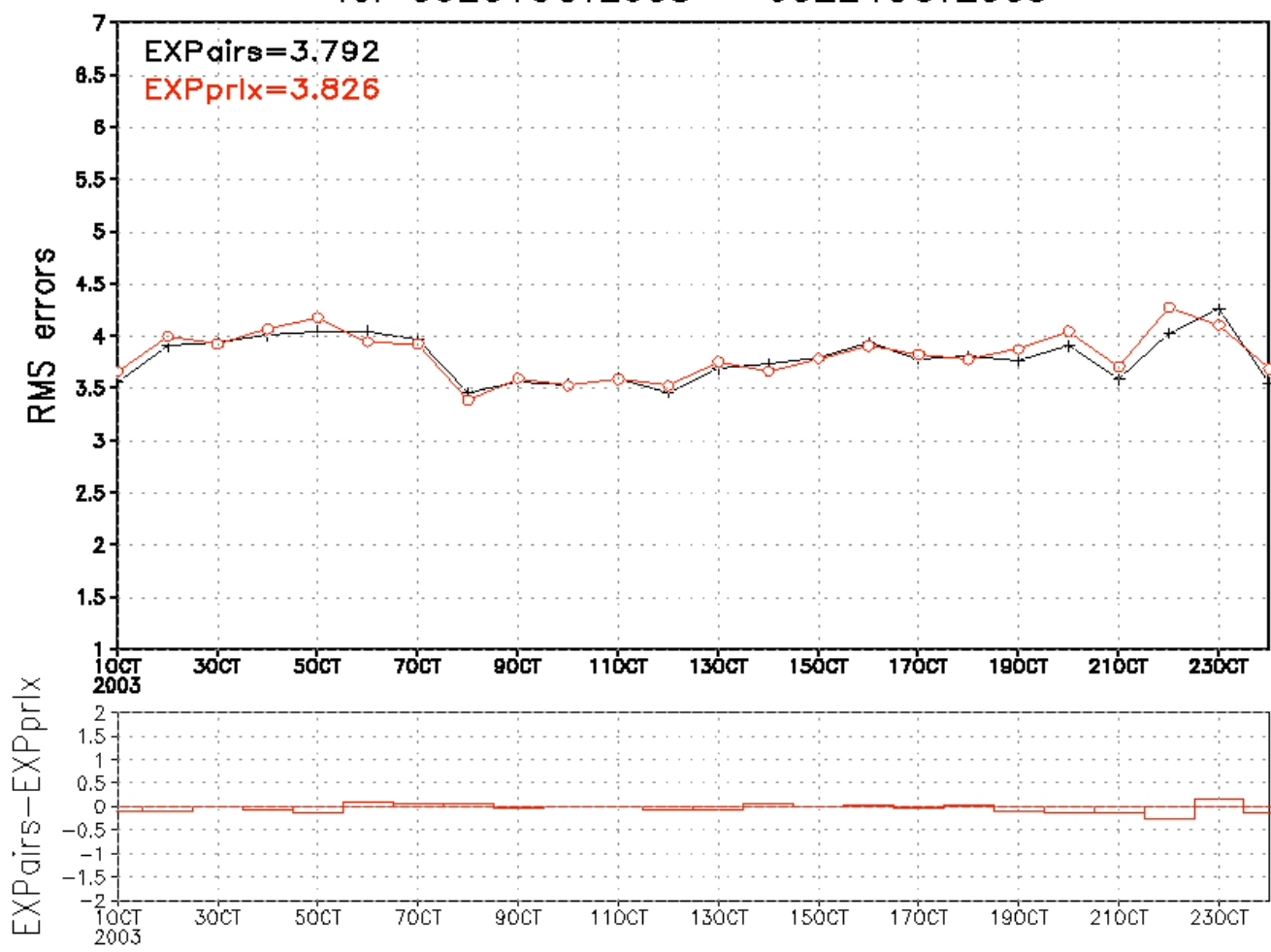
SH 500 mb Geopotential Height at day 5 for 00Z01OCT2003 – 00Z24OCT2003



TROPICAL 200 mb Vector at day 3
for 00Z01OCT2003 - 00Z24OCT2003



TROPICAL 850 mb Vector at day 3 for 00Z01OCT2003 – 00Z24OCT2003



AIRS Comments

- AIRS data used when radiances clear (above and between clouds) – 38 % of thinned data used
- To date – little impact of AIRS data
- Impact studies continuing



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GOES imager data

- Using NESDIS box average data
- Data Quality Control
 - Greater than 25% clear sky fraction for GOES-12, 10% for GOES-10
 - Bright Temperature Standard Deviation (BTSD from box averaging) less than 1.5K and background departure less than 3 times error
 - Not using 6z for GOES 12 because of midnight effect
- Thinning the data (110km, 20000 → 4000)
- Observational error varies depending on BTSD



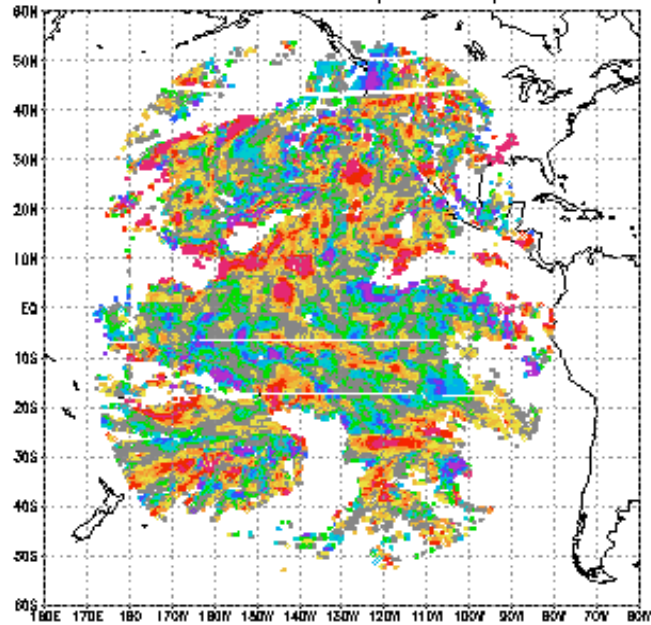
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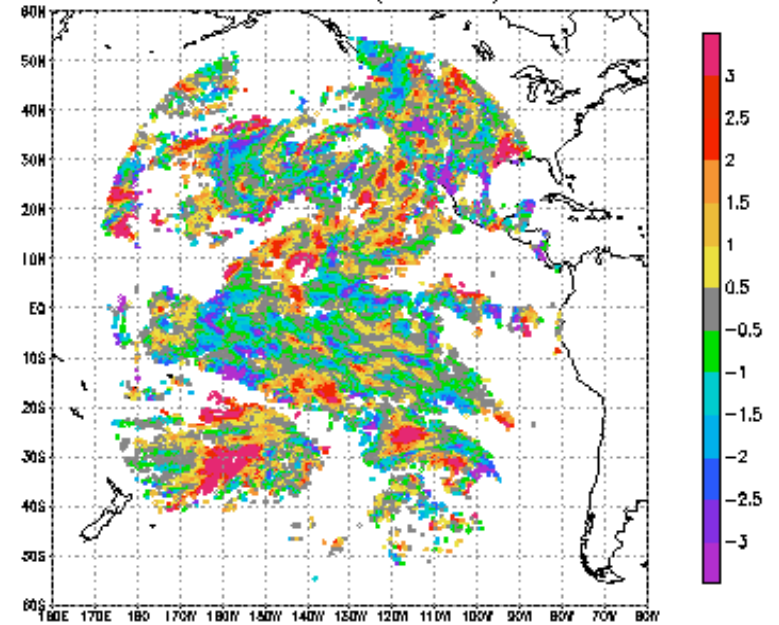
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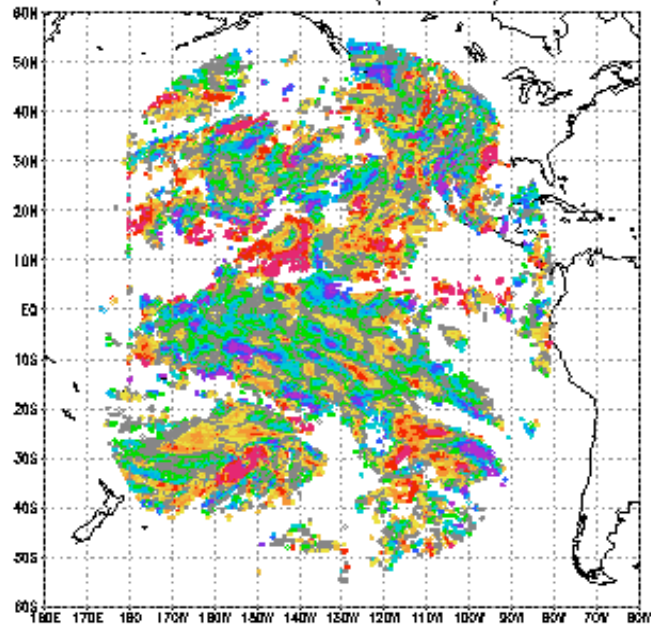
Background departures(K) for channel 3
at 2003081700(GOES010)



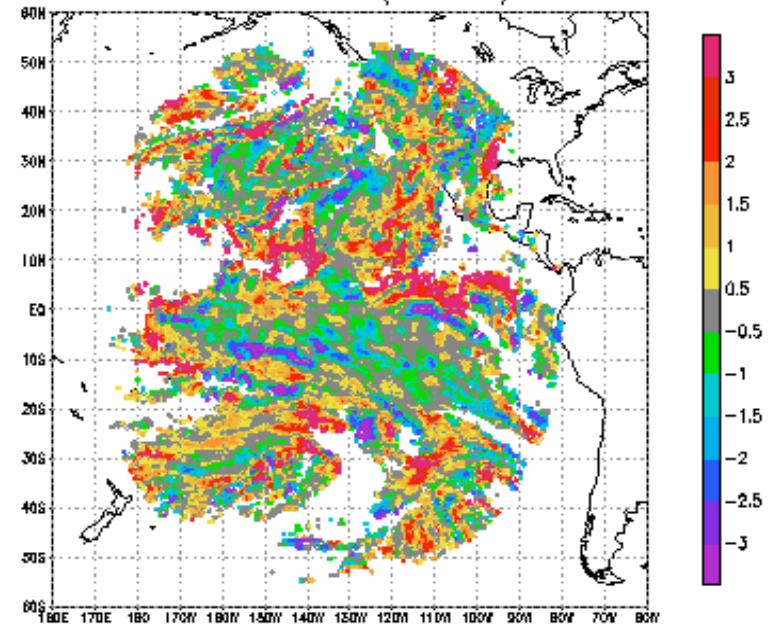
Background departures(K) for channel 3
at 200308176(GOES010)



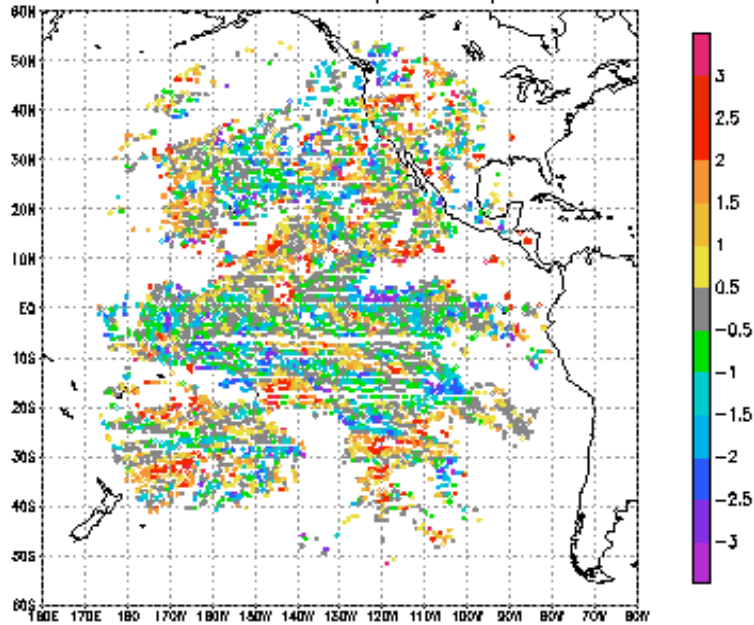
Background departures(K) for channel 3
at 2003081712(GOES010)



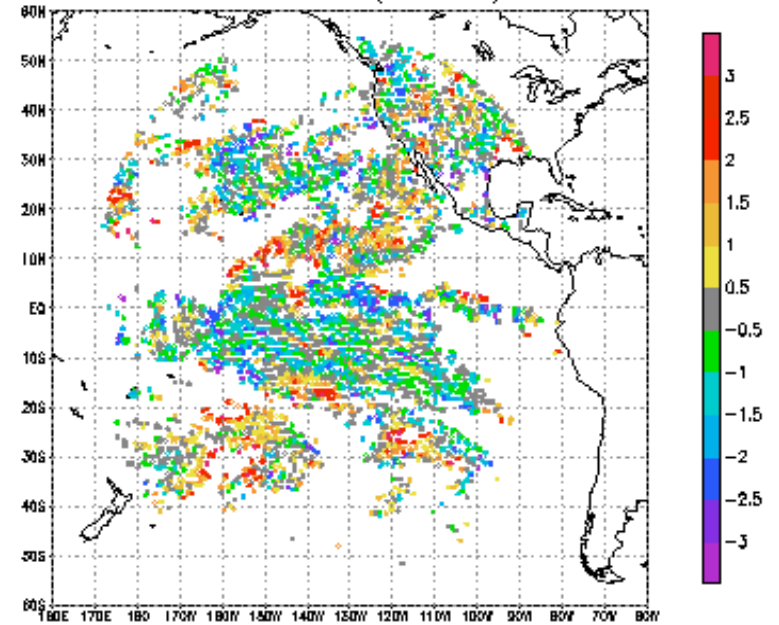
Background departures(K) for channel 3
at 2003081718(GOES010)



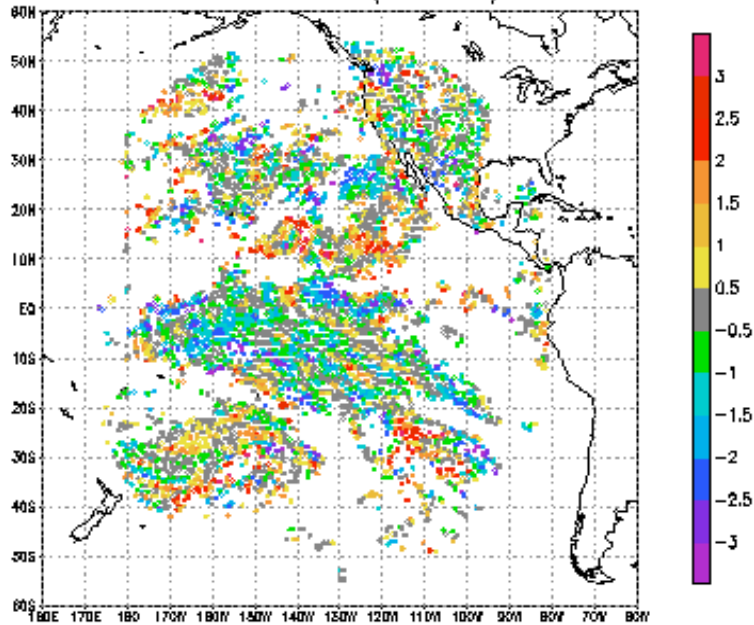
Background departures(K) after QC for channel 3
at 2003081700(GOES010)



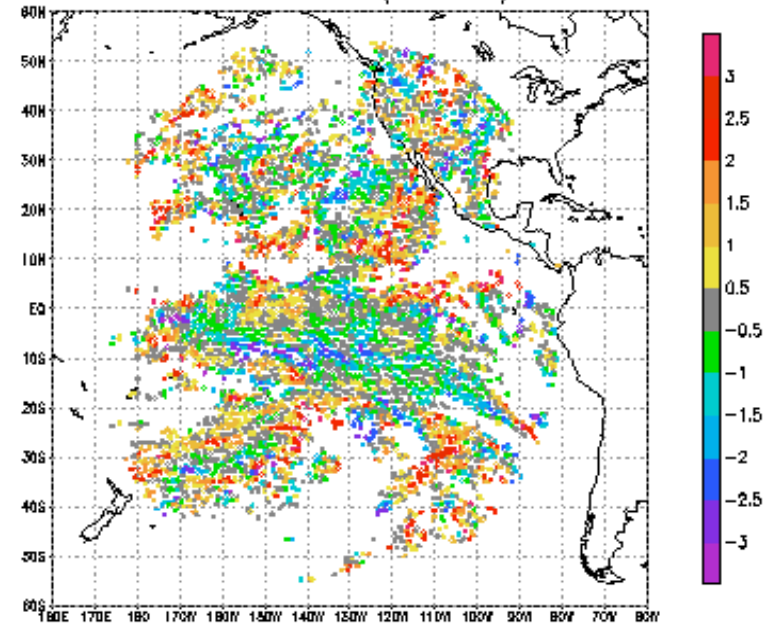
Background departures(K) after QC for channel 3
at 200308176(GOES010)



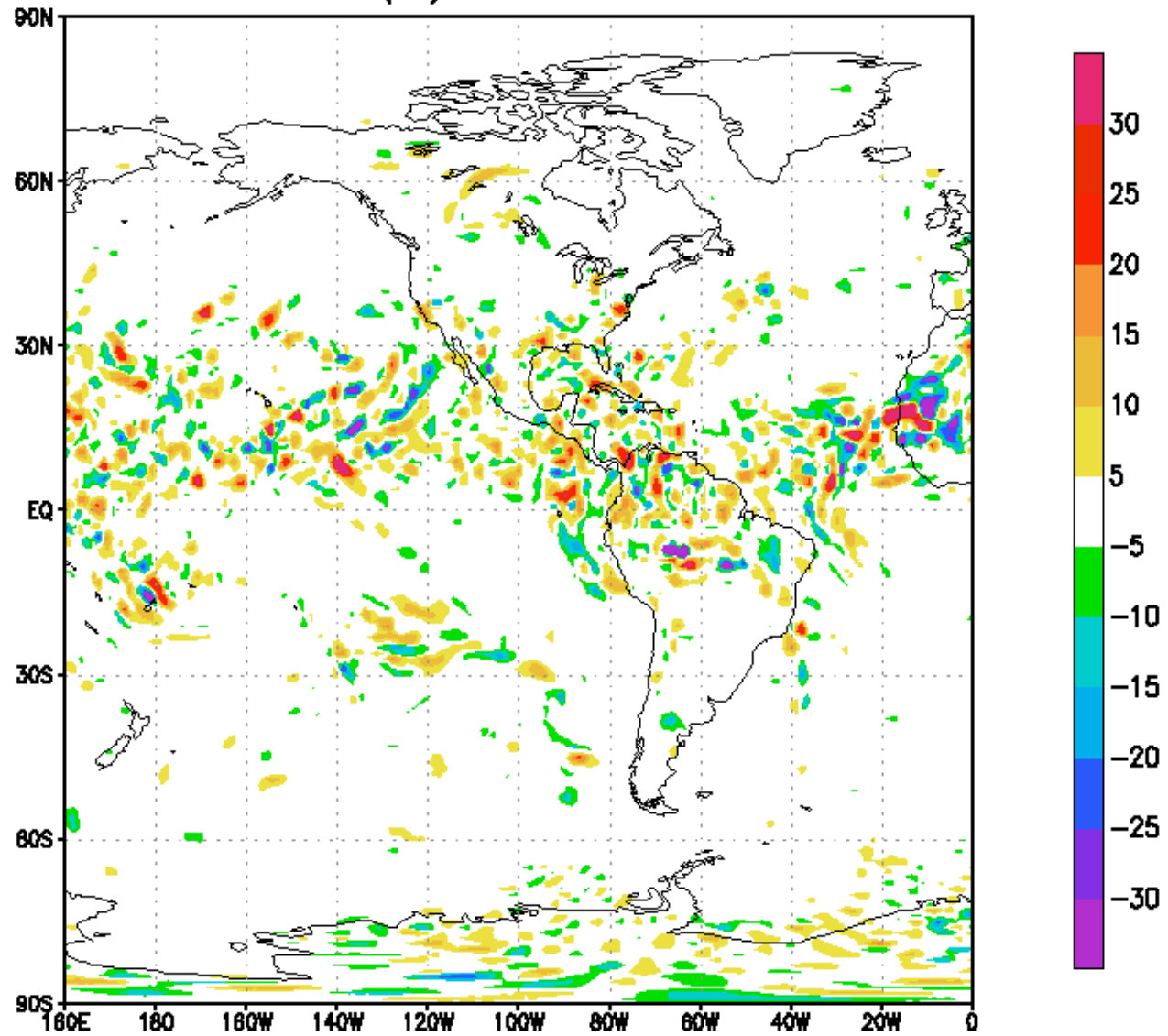
Background departures(K) after QC for channel 3
at 2003081712(GOES010)



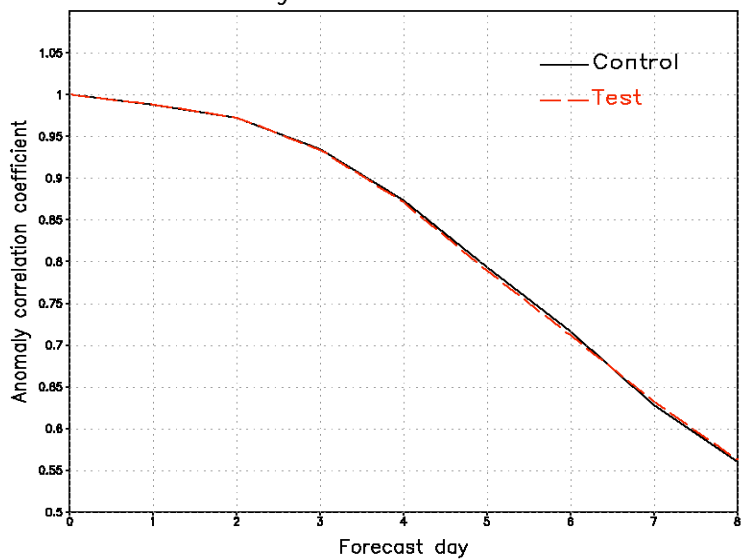
Background departures(K) after QC for channel 3
at 2003081718(GOES010)



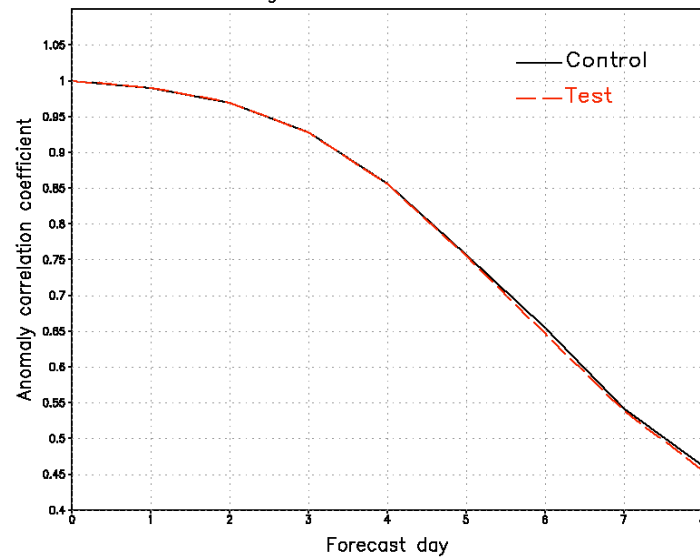
Anal dif: RH(%) 300mb 2003081700



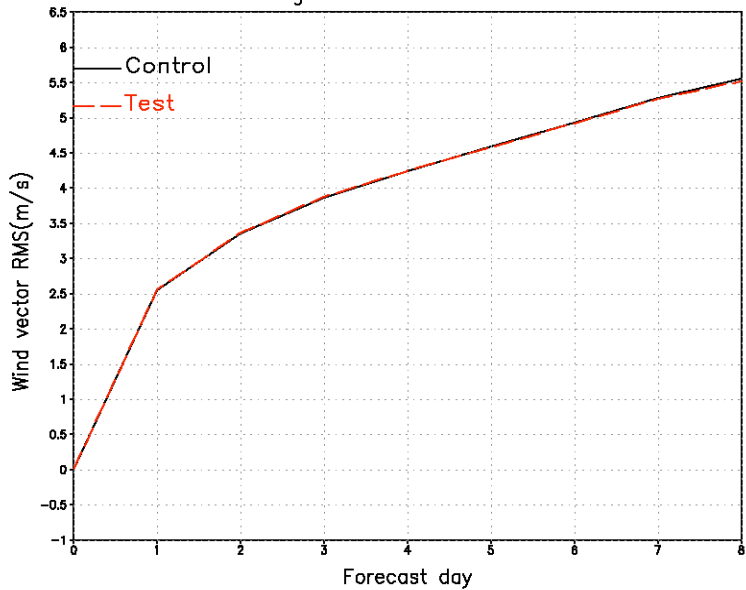
NH 500mb Anomaly correlation score
averaged over 20030712-0819



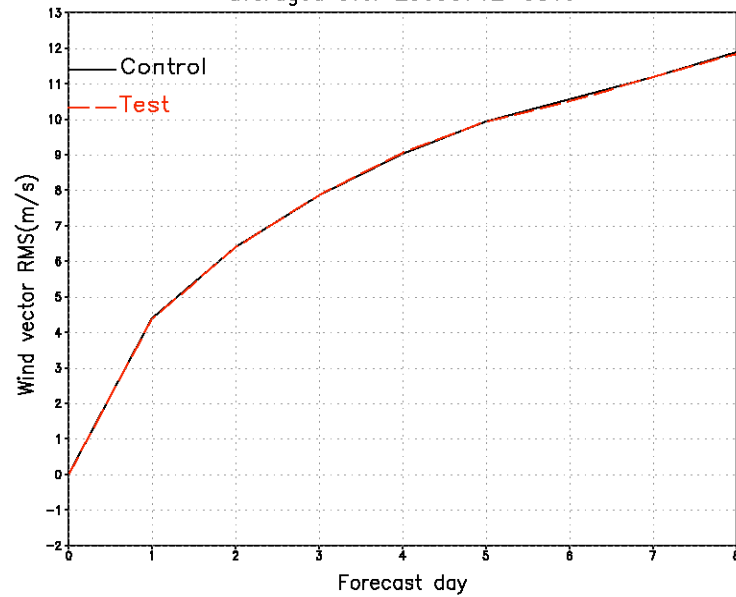
SH 500mb Anomaly correlation score
averaged over 20030712-0819



Tropical 850mb Wind vector RMS
averaged over 20030712-0819



Tropical 200mb Wind vector RMS
averaged over 20030712-0819

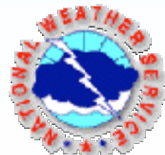


SSM/I Data

- Developed quality control and bias correction for SSM/I data
- Examining impact of direct use of SSM/I data on analysis system (primarily moisture)
- Eventual extension to use of data over land and ice
- Preparation for SSM/IS and CMIS data



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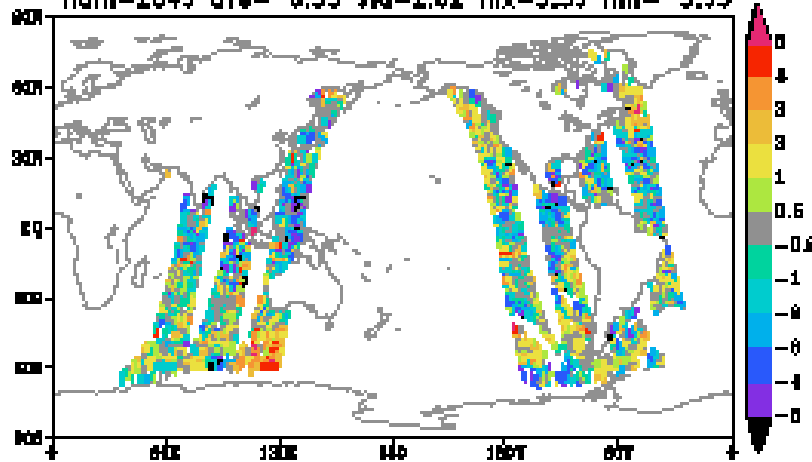


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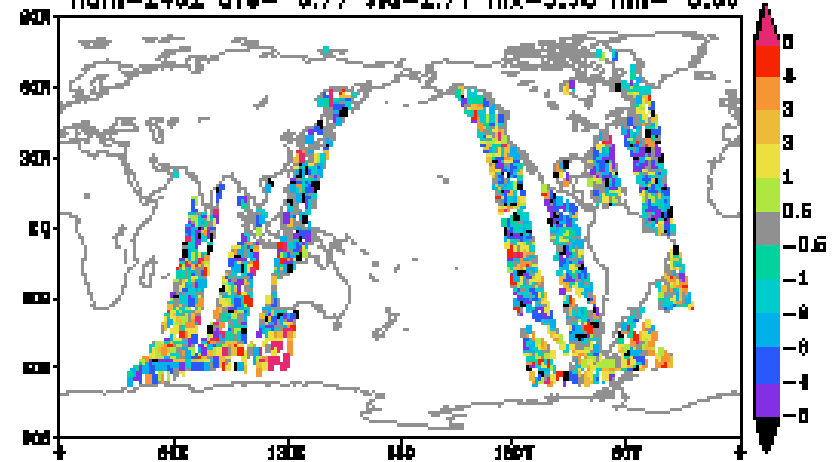


Used DMSP13 SSM/I 00Z01JUL2003

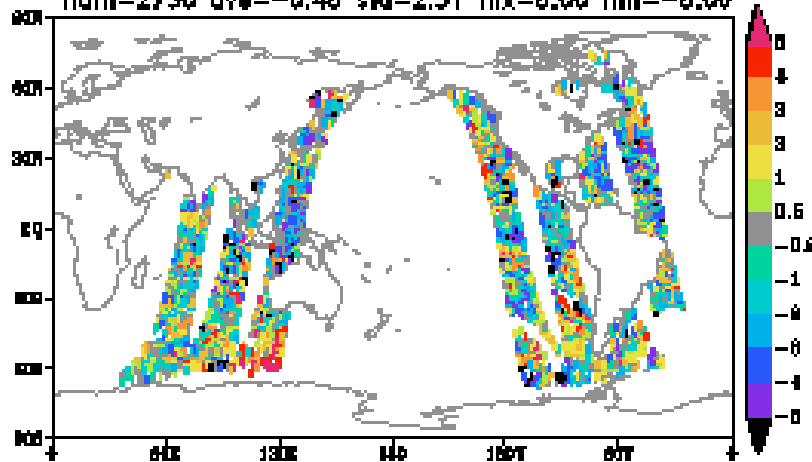
TBB BG-OBS (wBC) SSM/I 19V
num=2849 ave=-0.39 std=2.02 mx=5.59 mn=-5.95



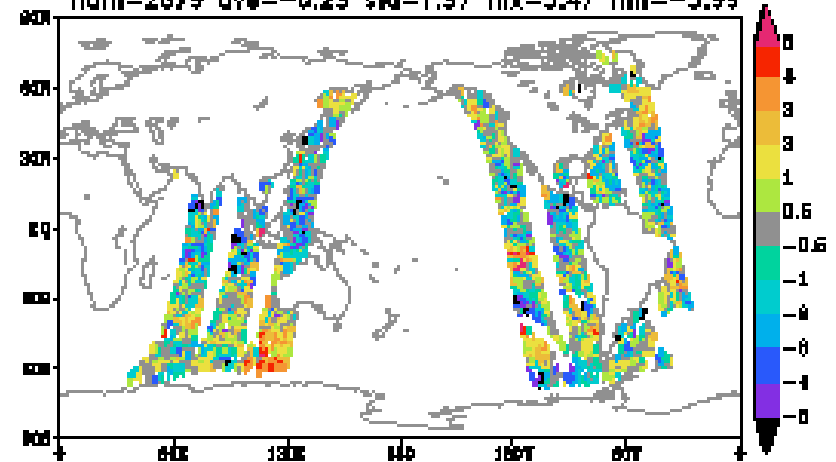
TBB BG-OBS (wBC) SSM/I 19H
num=2402 ave=-0.77 std=2.71 mx=5.98 mn=-6.00

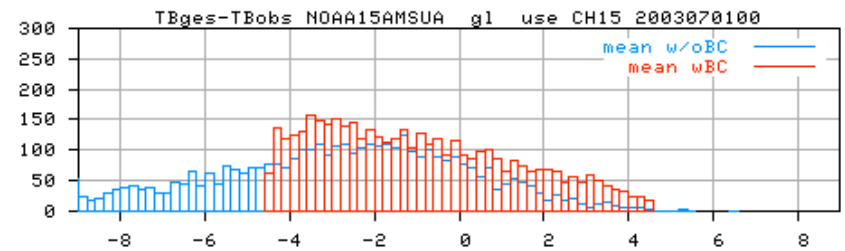
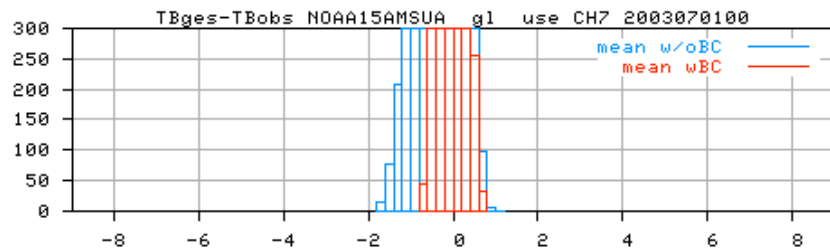
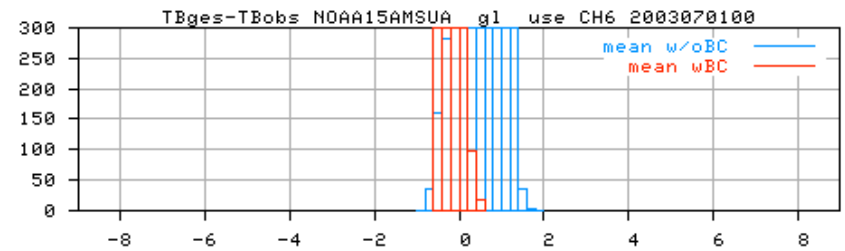
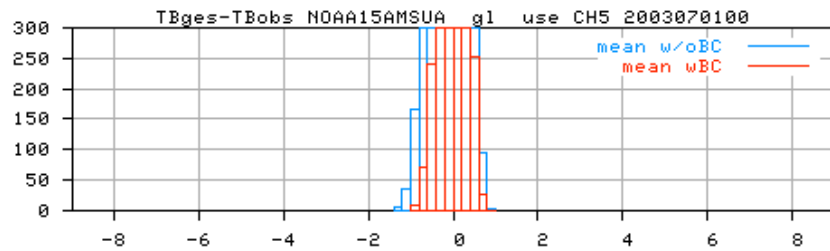
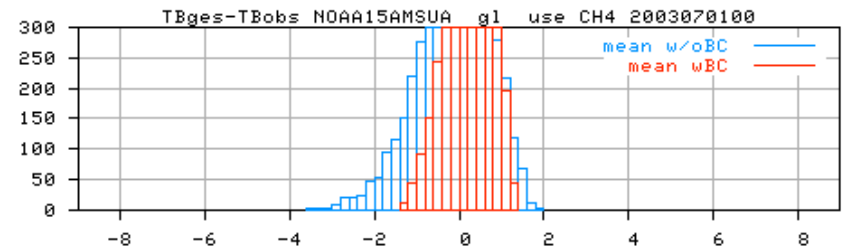
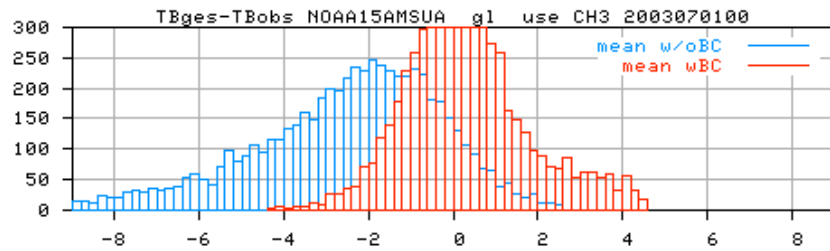
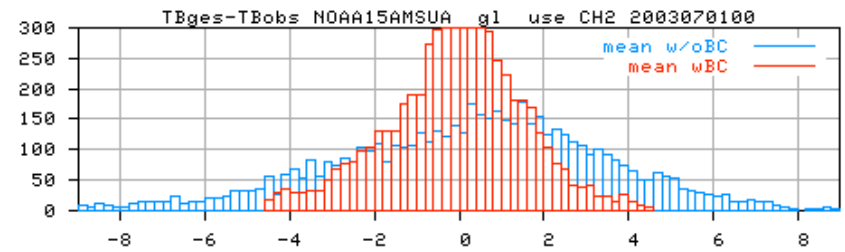
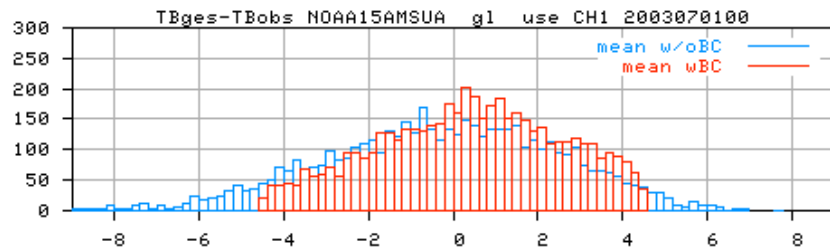


TBB BG-OBS (wBC) SSM/I 22V
num=2730 ave=-0.48 std=2.51 mx=6.00 mn=-6.00



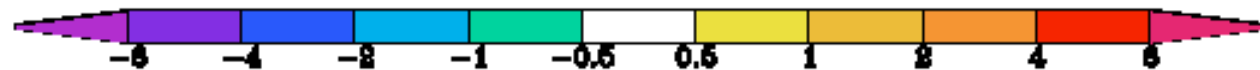
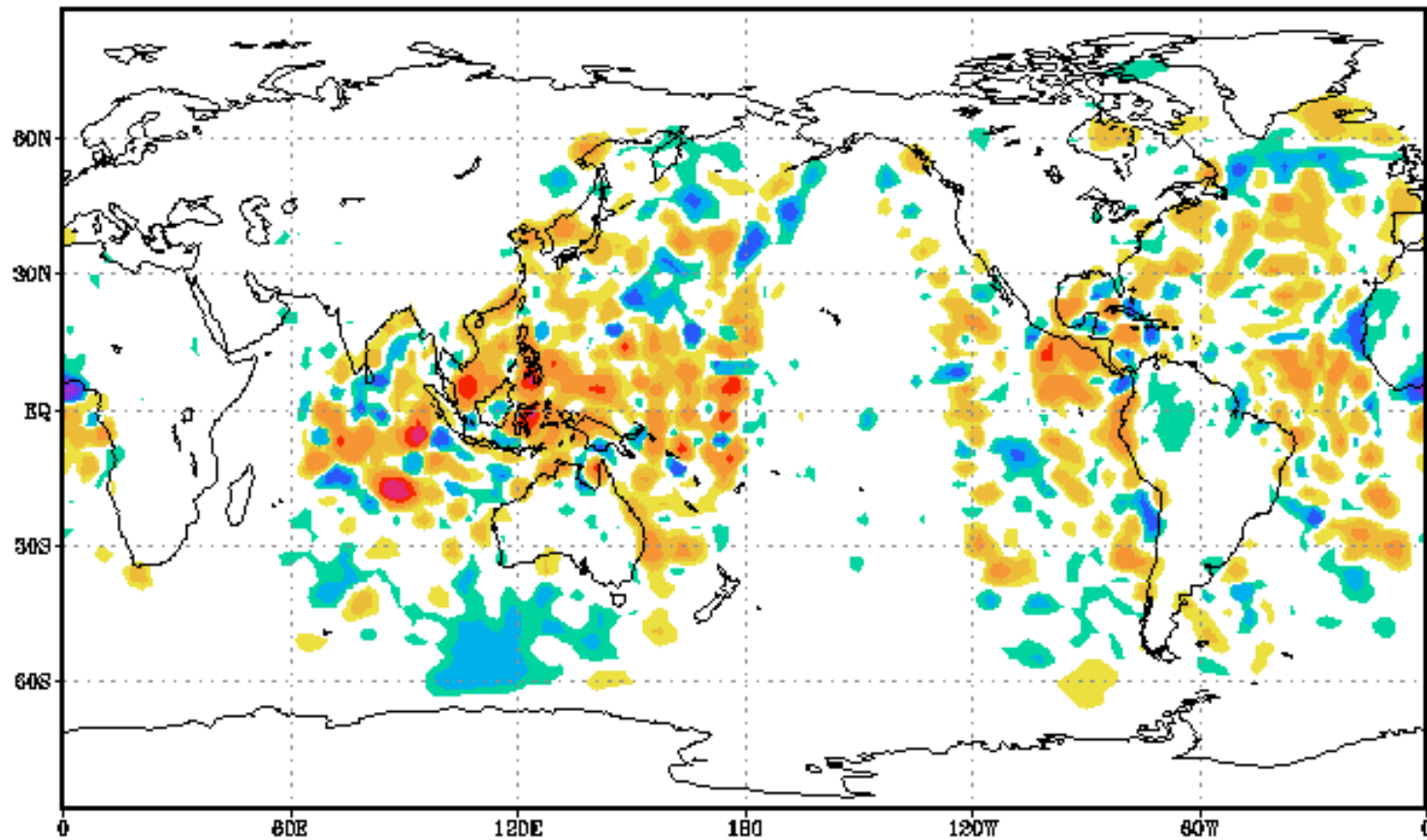
TBB BG-OBS (wBC) SSM/I 37V
num=2879 ave=-0.29 std=1.97 mx=5.47 mn=-5.99





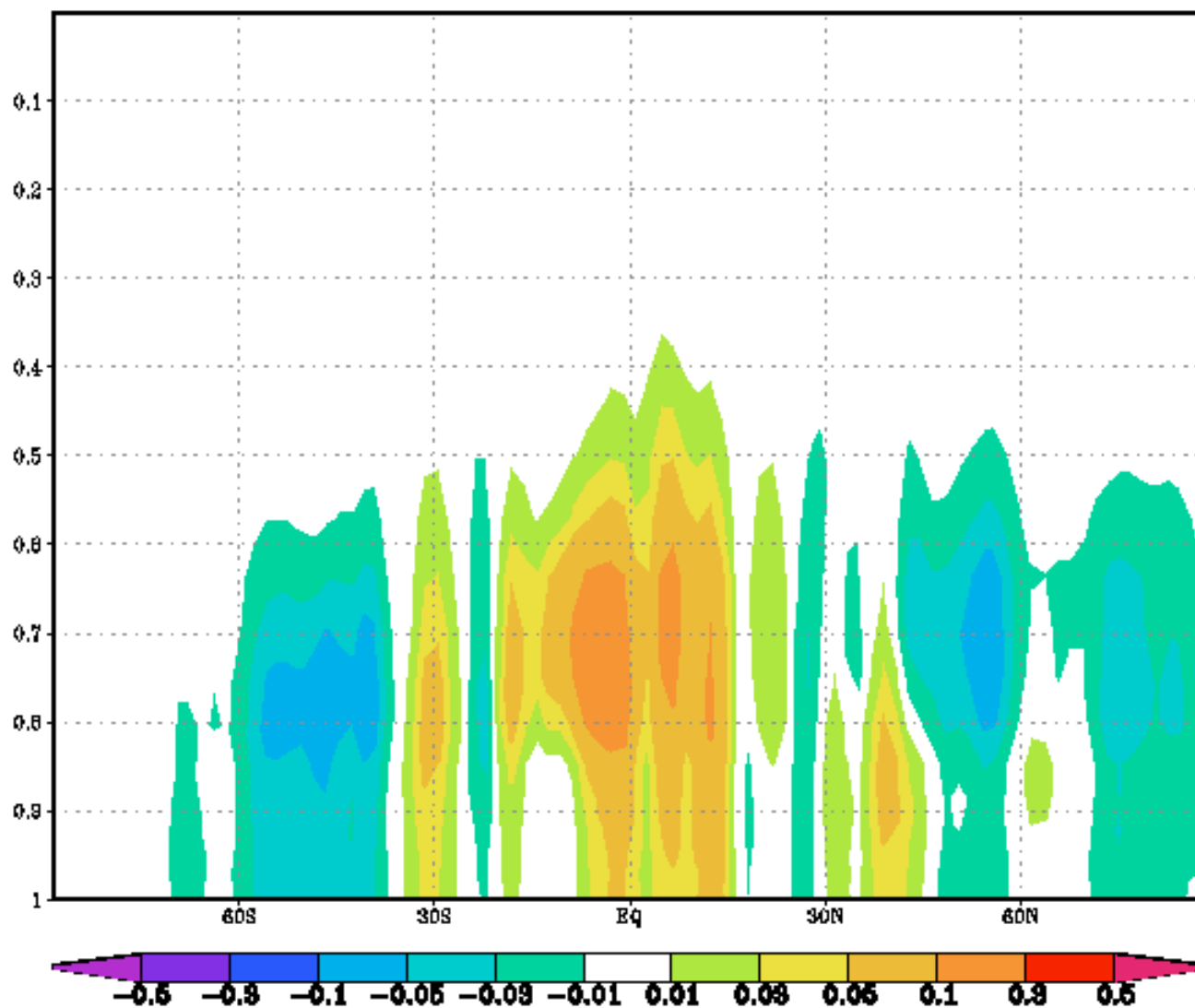
Test-Cntl : Init TPW [mm] (ft00) 00Z01JUL2003

ave=0.008 std=0.732 mx=8.600 mn=-6.900



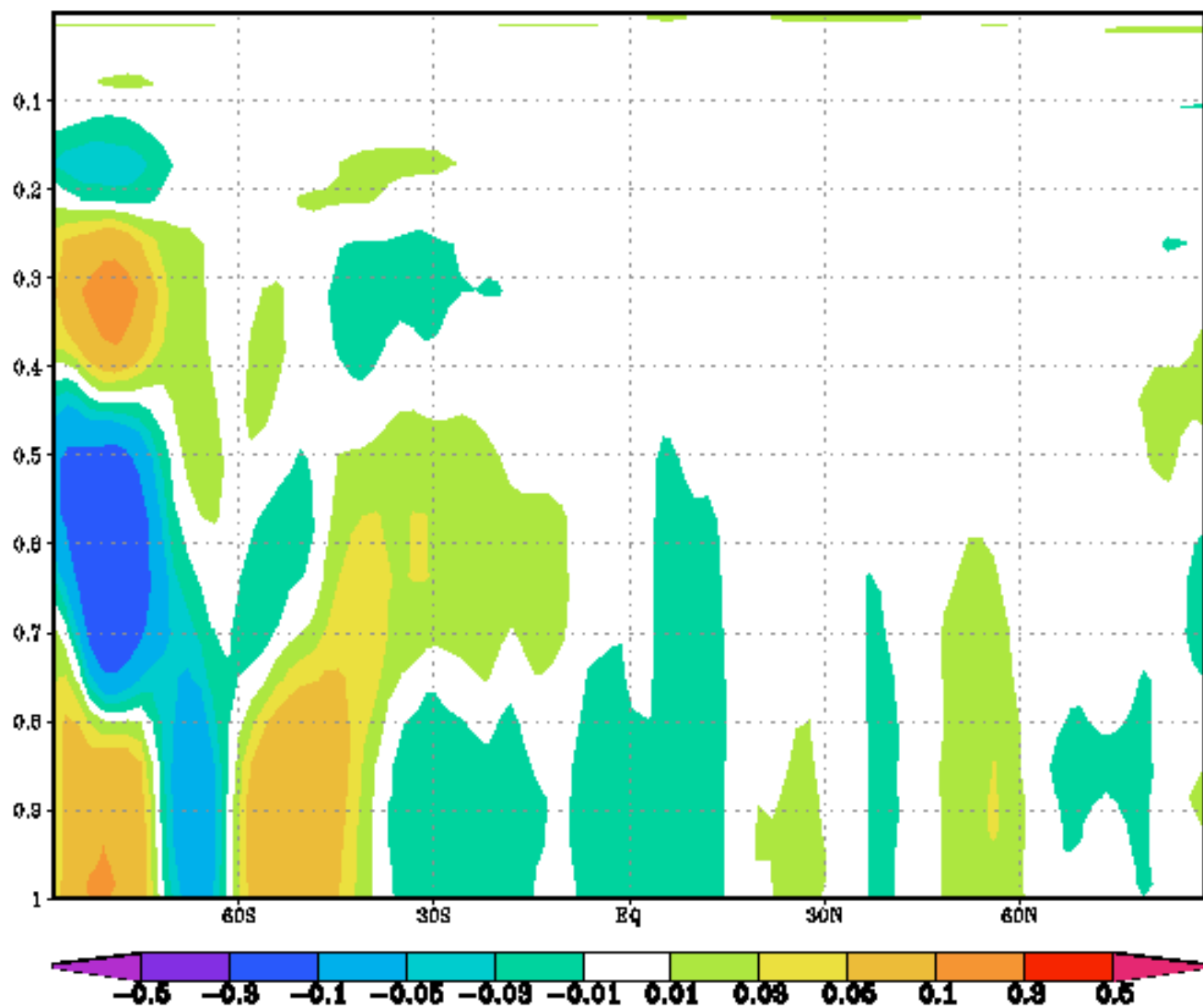
Test-Cntl : Anal Q [g/kg] 00Z01JUL2003

ave=-0.010 std=0.115 mx=0.688 mn=-1.698



Test-Cntl : Anal T [K] 00Z01JUL2003

ave=0.004 std=0.049 mx=0.362 mn=-0.283



SST analysis using radiances

- Physical retrievals as first step in development
 - Community radiative transfer code
 - NCEP's GDAS atmosphere
 - NCEP's SST analysis from previous day
 - U.S. Navy Brightness Temperatures
- Solve for $d(T_s)$, $d(T_a)$, $d(Q_a)$ and assume $d(T_a)$ and $d(Q_a)$ do not vary with height
- Minimize:

$$J = \sum_i \frac{1}{\sigma_{b,i}^2} [T_{b,i}^o - (T_{b,i}^f + dT_{b,i})]^2 + \frac{1}{\sigma_{T_s}^2} (dT_s)^2 + \frac{1}{\sigma_{T_a}^2} (dT_a)^2 + \frac{1}{\sigma_{Q_a}^2} (dQ_a)^2$$



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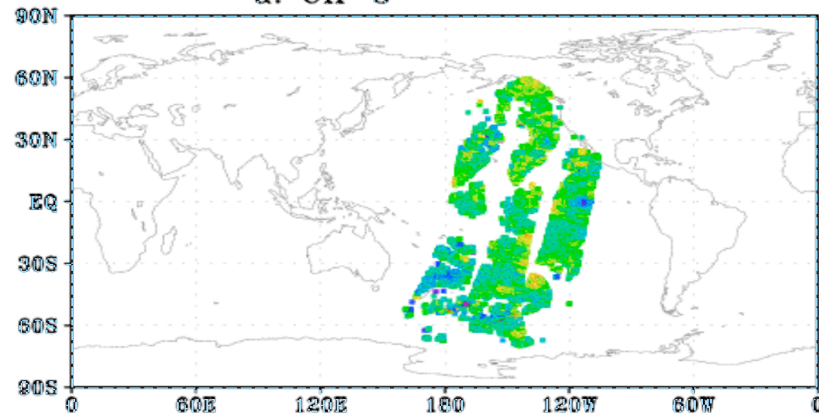


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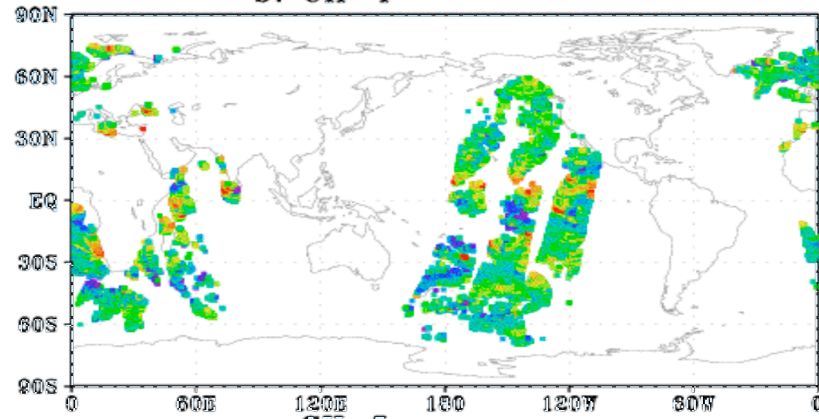


Tb (Observed - Simulated), 04/12/2003, 12Z

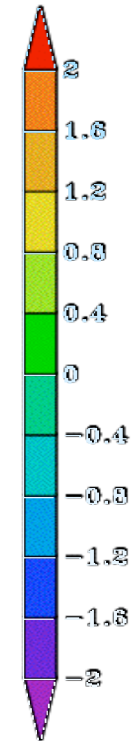
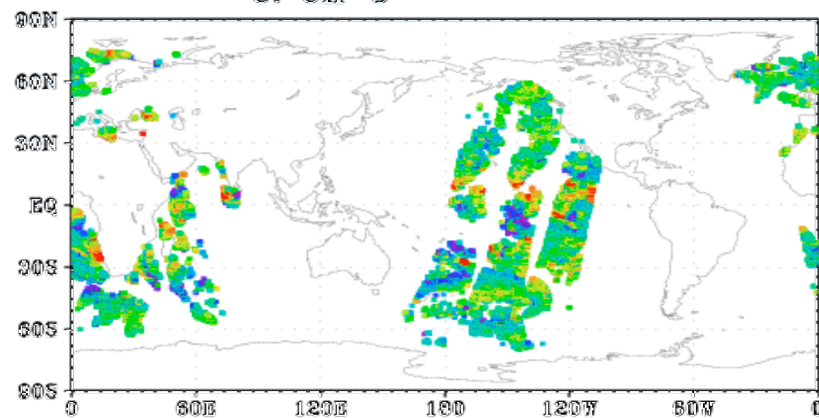
a. CH-3



b. CH-4

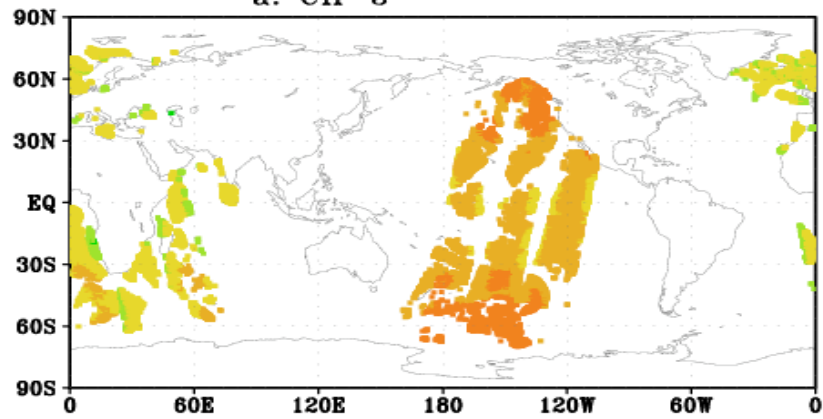


c. CH-5

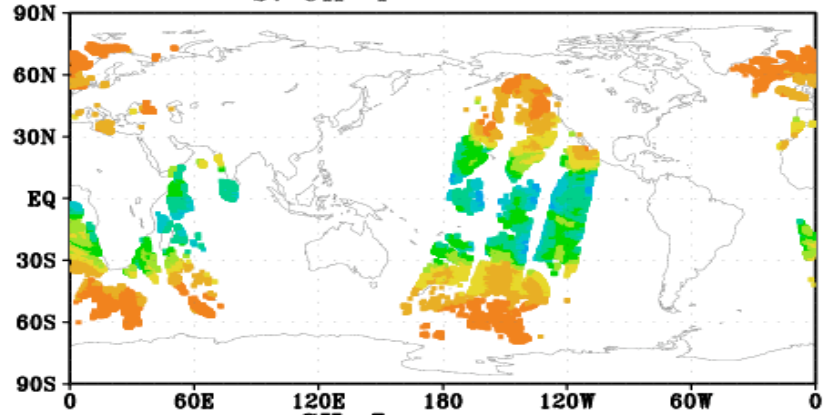


$d(T_b)/d(T_s)$, 04/12/2003, 12Z

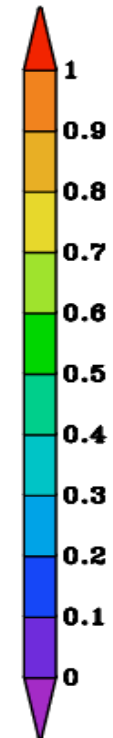
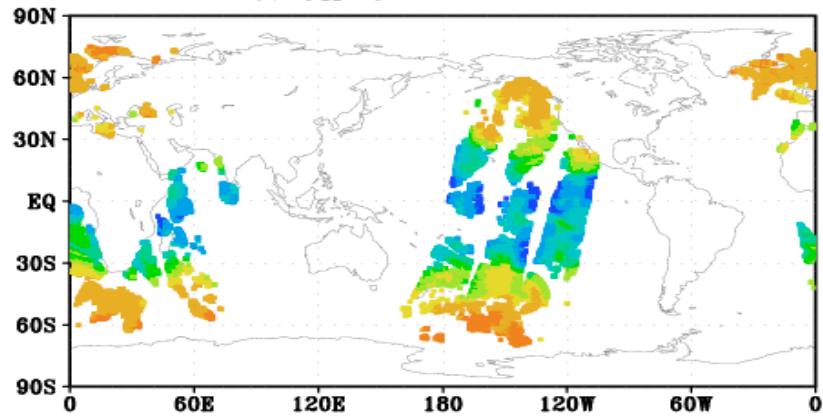
a. CH-3



b. CH-4

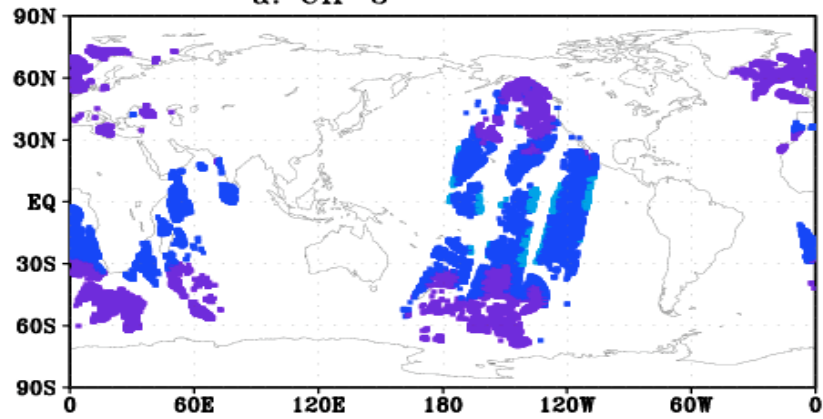


c. CH-5

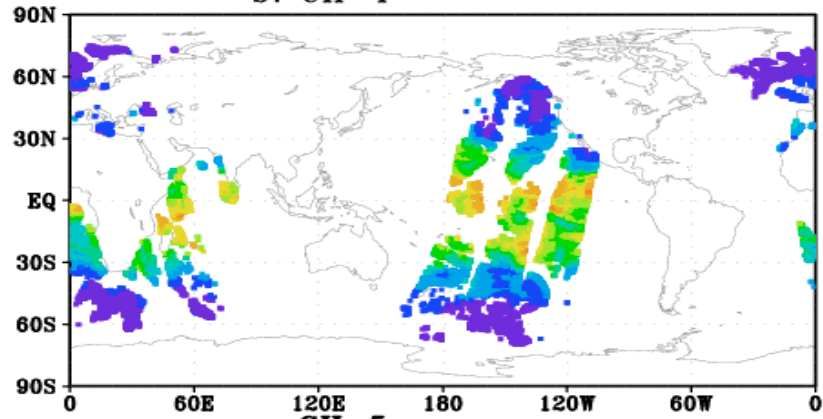


$d(T_b)/d(T_a)$, 04/12/2003, 12Z

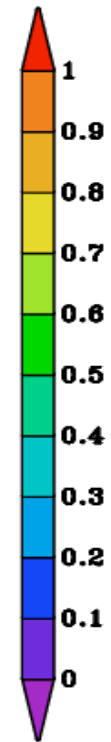
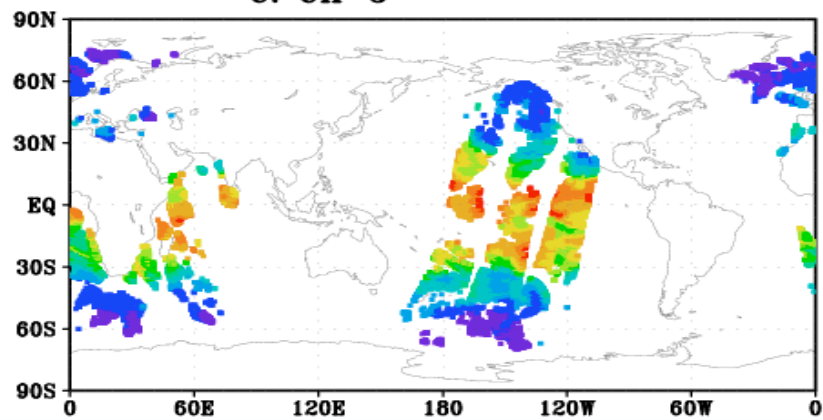
a. CH-3



b. CH-4

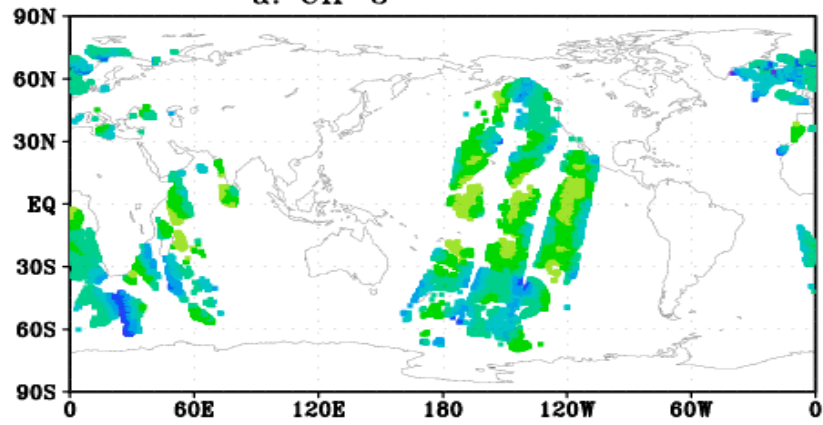


c. CH-5

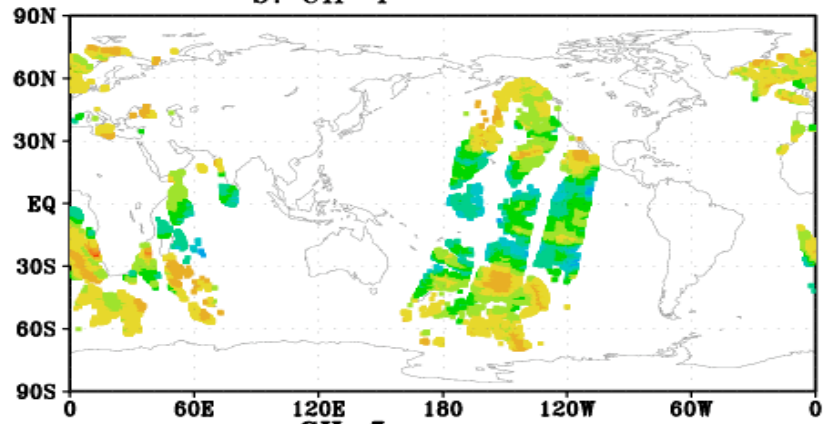


$d(Tb)/d(Qa)$, 04/12/2003, 12Z

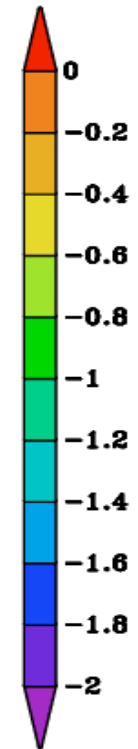
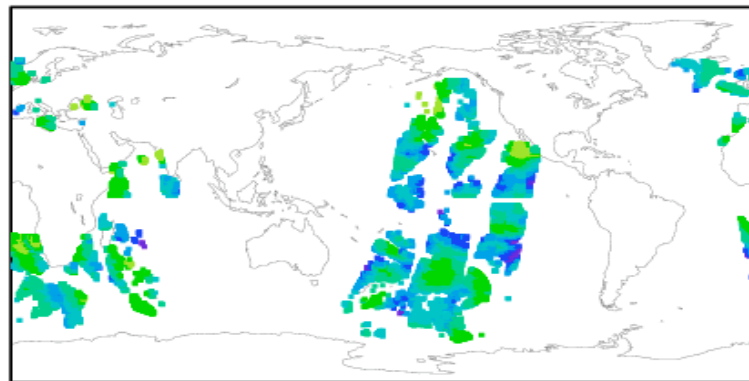
a. CH-3



b. CH-4



c. CH-5

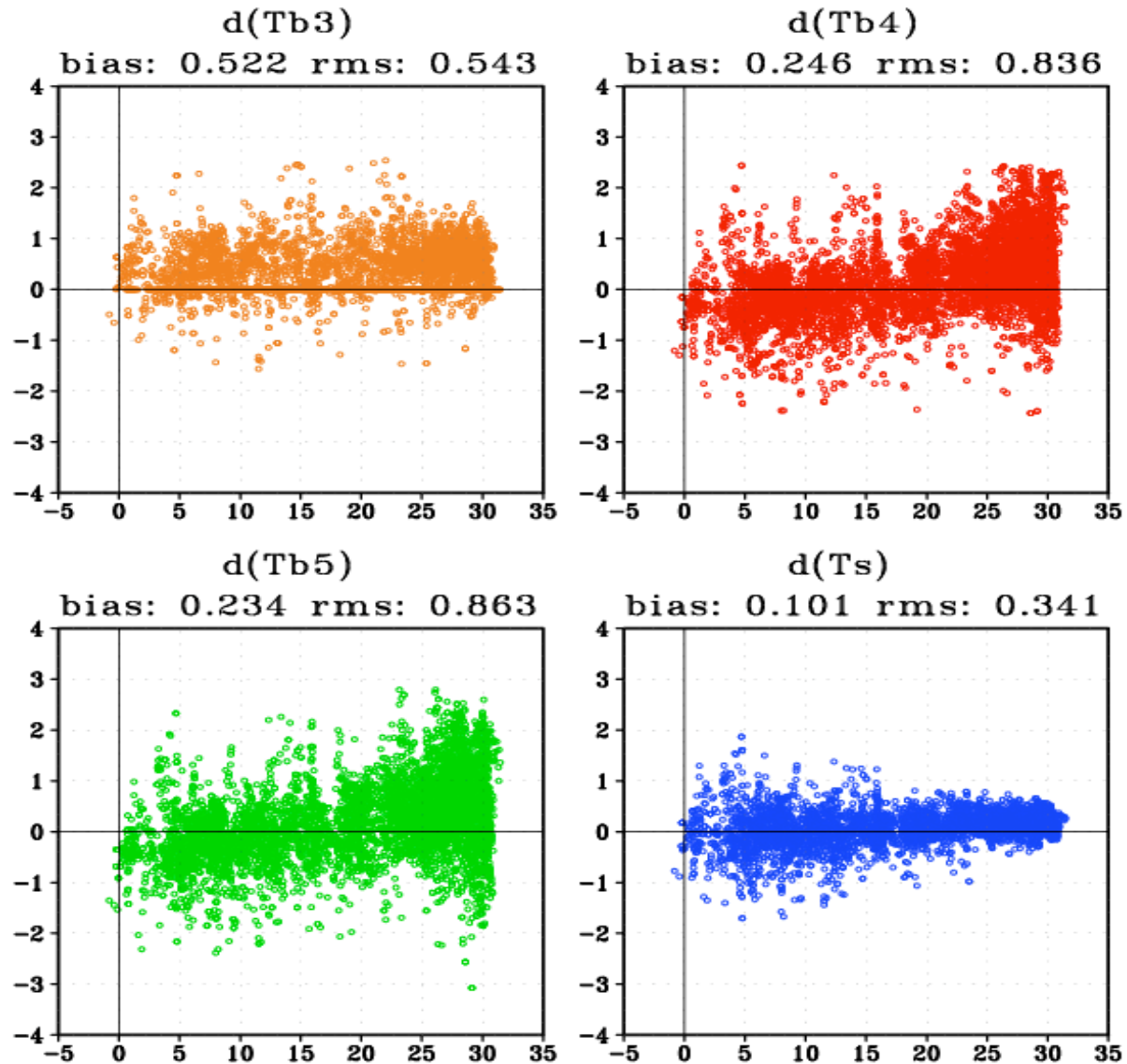


Scatter to SST, Exp_b00

04/12/2003 - 04/15/2003

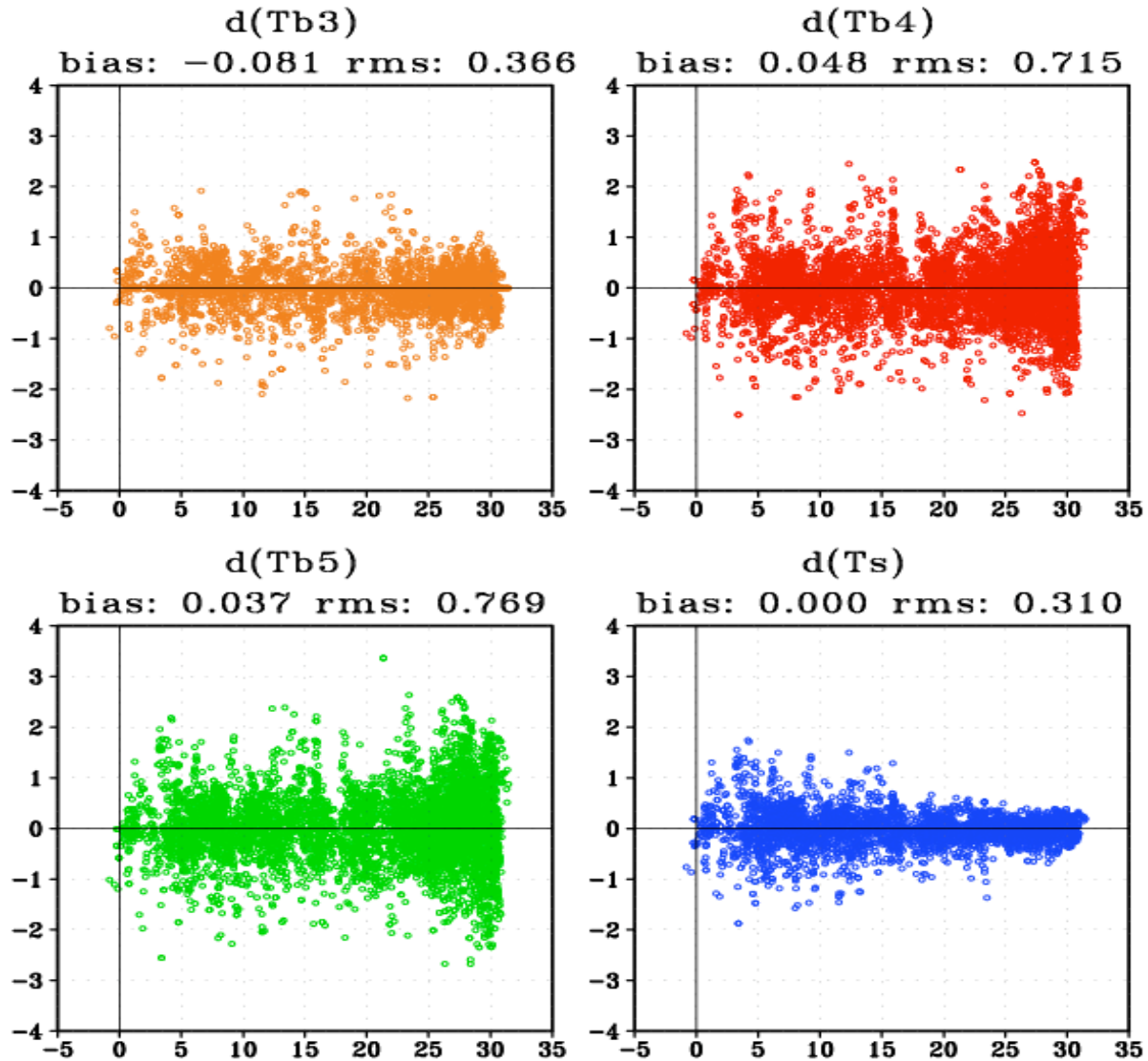
Observation Number: 5373

No Bias Correction

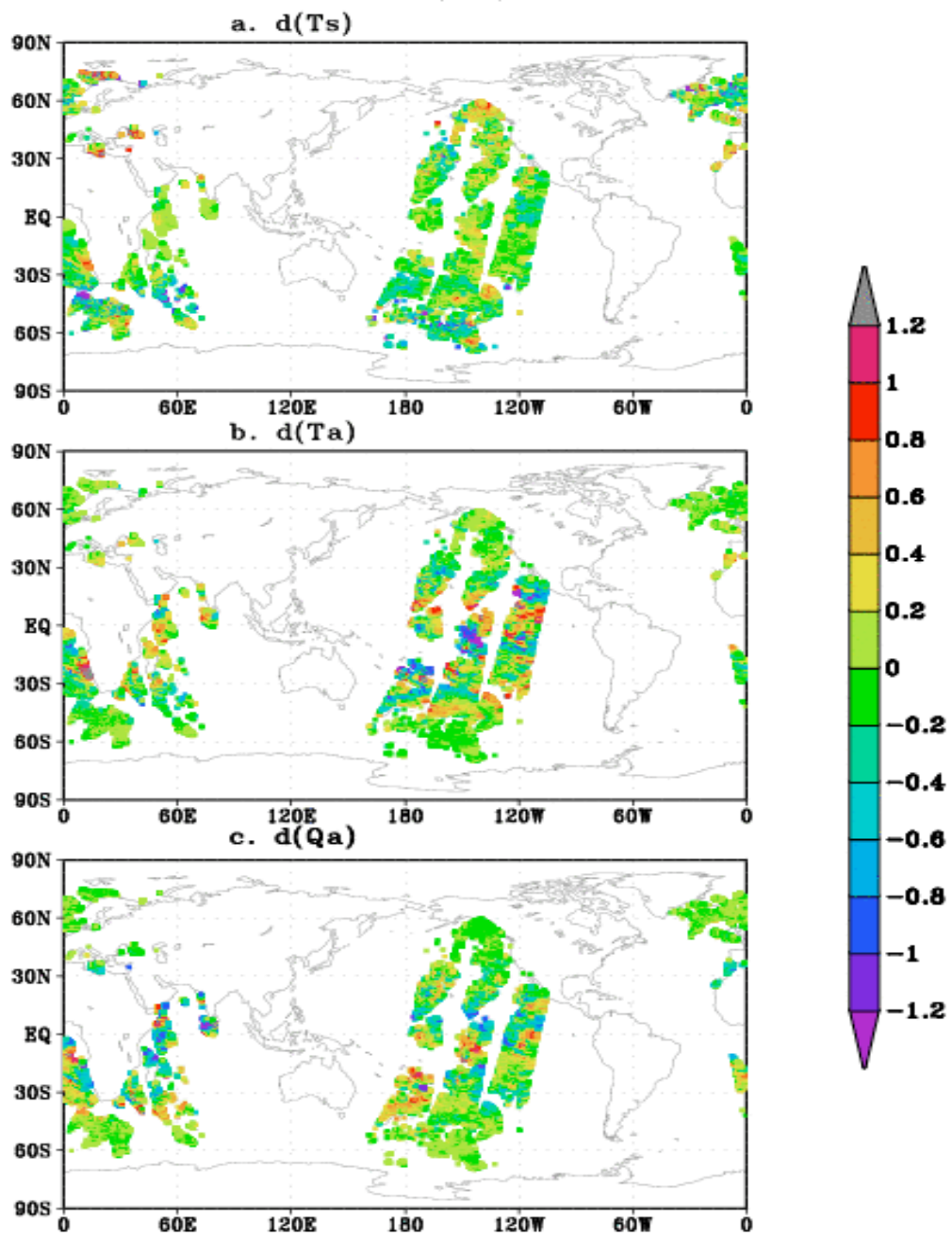


Scatter to SST, Exp_b02
04/12/2003 - 04/15/2003
Observation Number: 5378

Bias Corrected

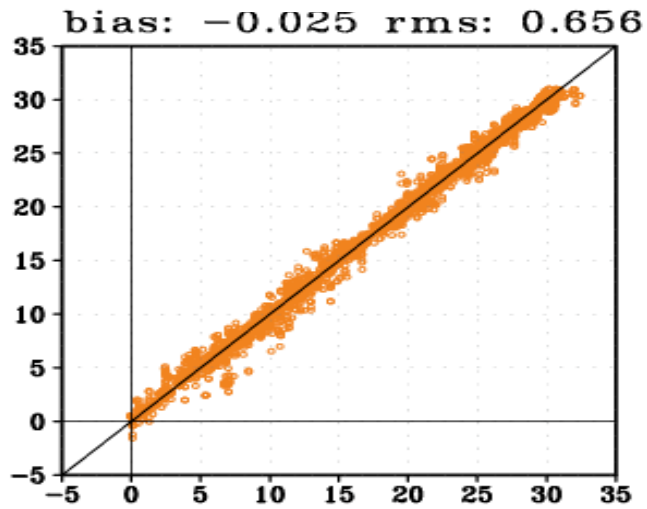


Increments solutions, 04/12/2003, 12Z

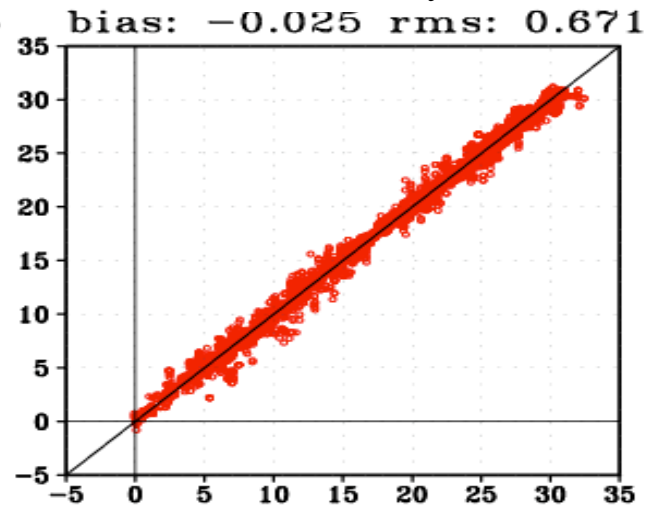


Scatter to Buoy data, Exp_b02
04/12/2003 - 04/15/2003
Observation Number: 5378

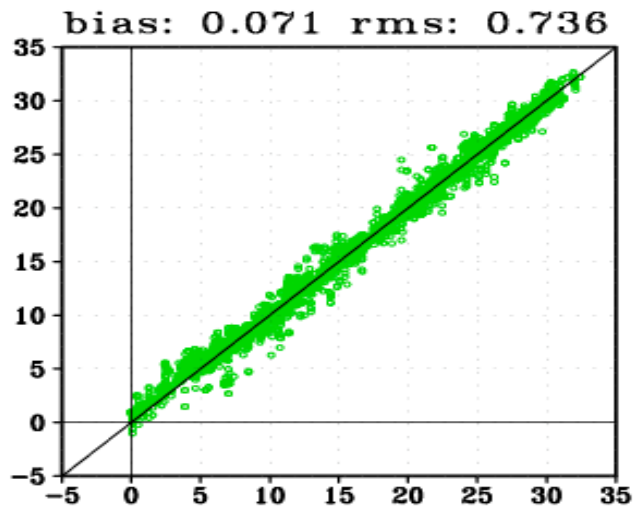
NCEP Retrieval



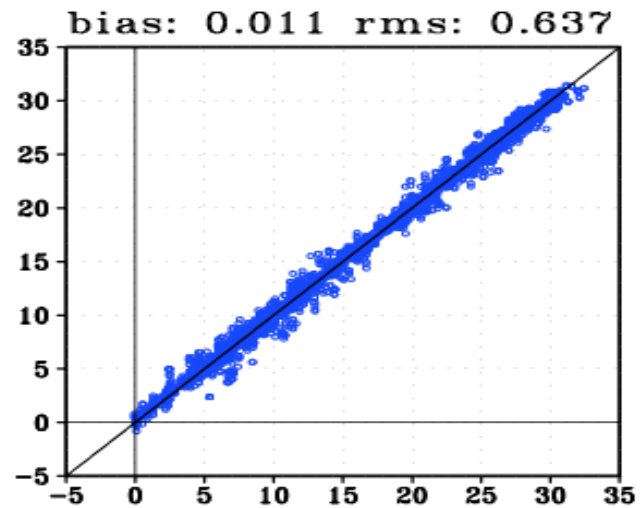
NCEP T-1 Analysis



Navy Retrieval



Current NCEP analysis



Future SST development

- Include additional satellites and instruments
- Supply retrievals to SST analysis and cycle
- Use raw AVHRR level-1c data (GAC)
- Incorporate radiances directly in SST analysis
- Develop SST predictive capability to enhance guess – discriminate between skin temperature and bulk SST



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Final Comments

- Use of radiances in NWP has reached a level of maturity with new instruments being added routinely over ocean in non-cloud/precipitation situations
- Improvements to RT, models and assimilation techniques continue to extend/improve use of data
- Extension of direct radiance techniques to other data/applications (e.g., imager/SST) is ongoing



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