Assimilation of IASI data

N. America Perspective

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Contributions from

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Outline

- Environment Canada
  - Assimilation of IASI radiances at CMC
- US Navy Research Laboratory
  - Hyperspectral Radiance Assimilation in NAVDAS_AR
- NOAA/NWS/NCEP
  - Hyperspectral Water Vapor Radiance Assimilation

Environment Canada Environnement Canada

Canada

Assimilation of IASI radiances at CMC

Sylvain Heilliette, Louis Garand
Environment Canada
May 6, 2009

Model Setup

4D-var assimilation made with:

- Global GEM model "GEM-Meso"
- Grid 800x600
- 58 vertical levels with model top at 10 hPa

4D-var tests soon to start with:

- New version of the model "GEM-Meso-Strato" with a 0.1 hPa top and 80 levels. This will allow to assimilate more channels.

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IASI Dataset Characteristics

- Level 1.c BUFR files: 616 IASI channels and AVHRR cluster radiance analysis received from NOAA/NESDIS
- Warmest Field Of View (U3 files)
- Typically 81000 observations (i.e spectra) for a 6 h time windows. After thinning, about 4000 observations are typically assimilated.
- 128 channels (43 temperature channels, 66 water vapor channels and 19 surface channels) selected for assimilation in GEM-Meso
- 22 extra channels (all in the 15 μm band) will be tested in GEM-Meso-Strato

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IASI QUALITY CONTROL (QC)

- IASI quality control very similar to the now operational AIRS quality control. Details on additional slides.
- Use is made of the AVHRR cluster radiance analysis to improve cloud detection and characterization

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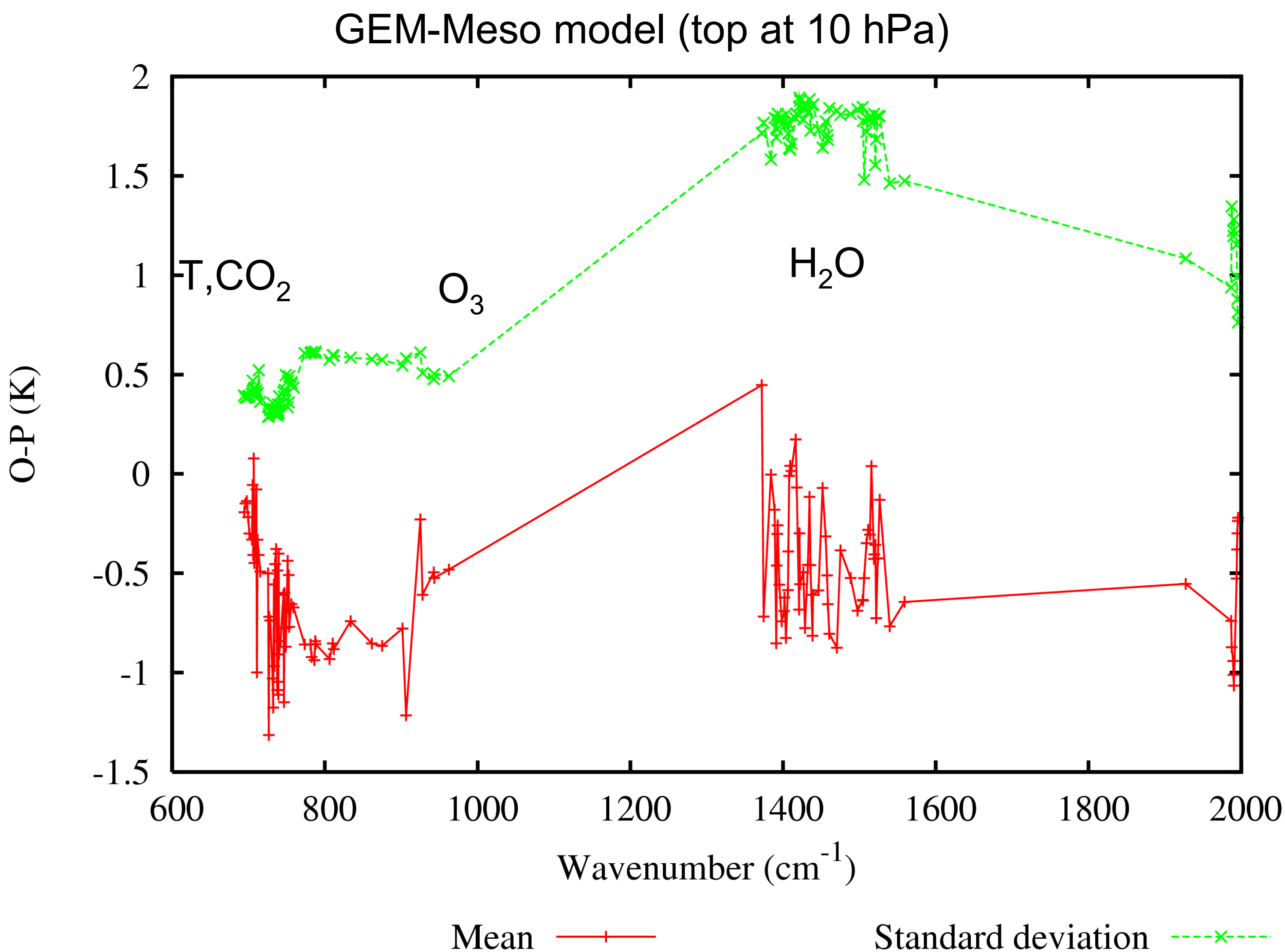
O-P statistics for the selected channels



Assimilation Experiments Setup

- 4Dvar assimilation
- From 11/20/2008 to 12/17/2008
- Dynamical bias correction
- **Control experiment** assimilation of:
  - Conventional data (radiosondes, etc…)
  - Quickscat winds
  - AMSU-A and AMSU-B microwave radiances from NOAAxx and AQUA platforms
  - SSM-I microwave radiances from DMSP-xx platforms
  - GOES infrared radiances
  - AIRS infrared radiances (87 channels)
  - GPS radio-occultation (refractivity profiles)
- **Test experiment**: all the above plus the assimilation of the 128 IASI selected channels

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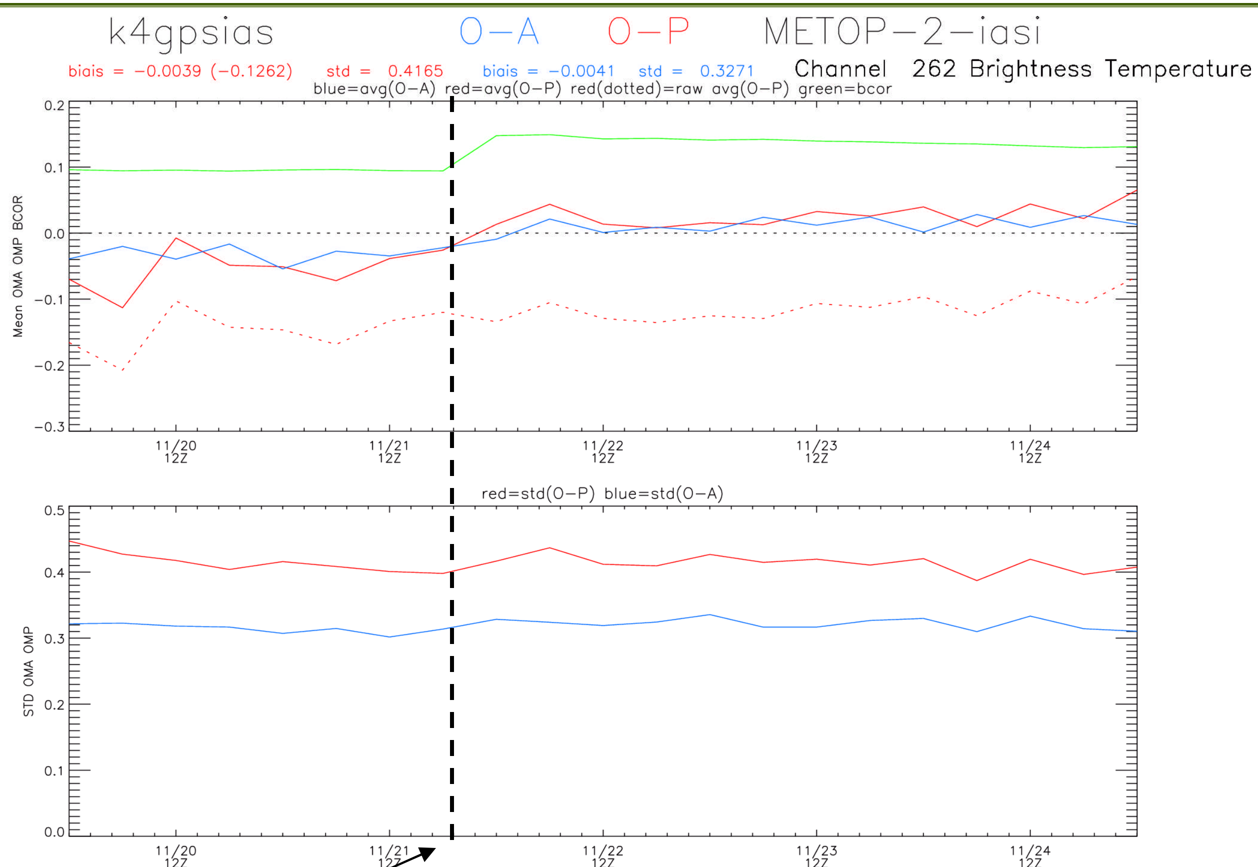
Assimilation Monitoring

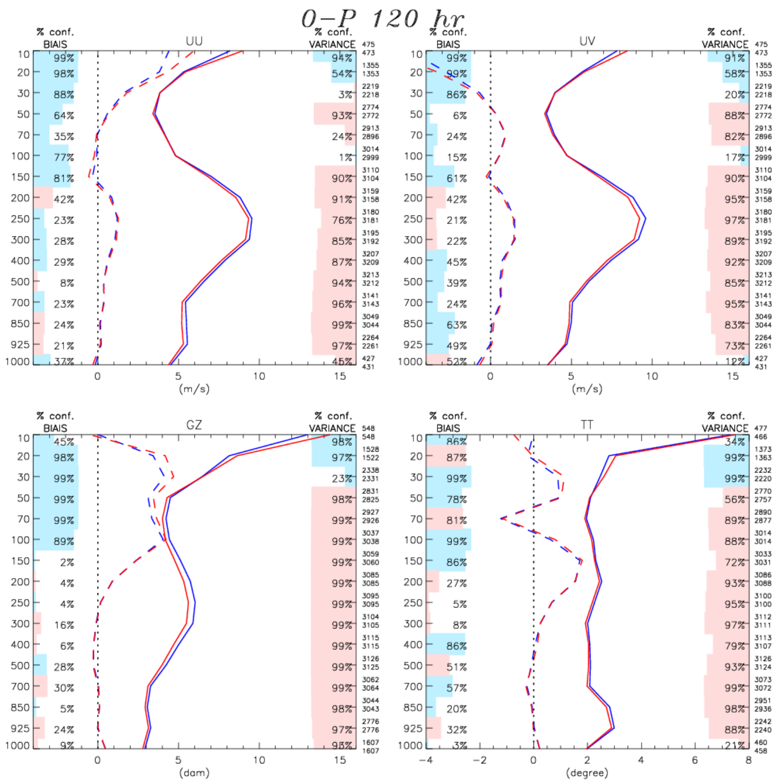


Activation of the dynamic bias correction

Results of 4Dvar assimilation 1/2

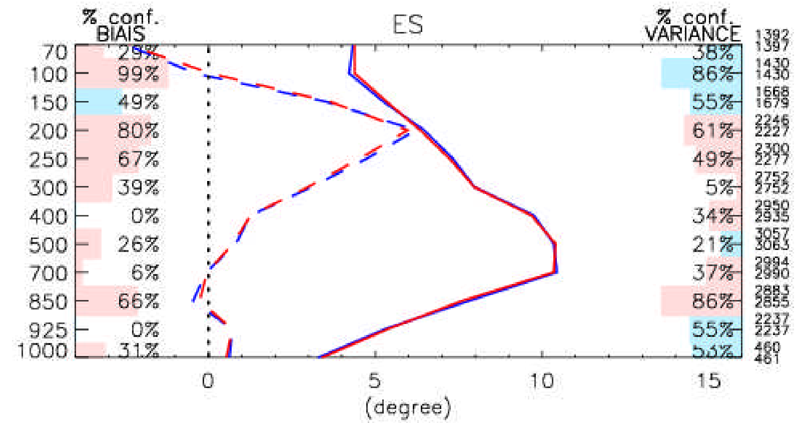
- Validation of forecasts against radiosondes: Southern hemisphere 120h

Wind



Geopotential height Temperature

Dew point depression



56 cases

Legend:

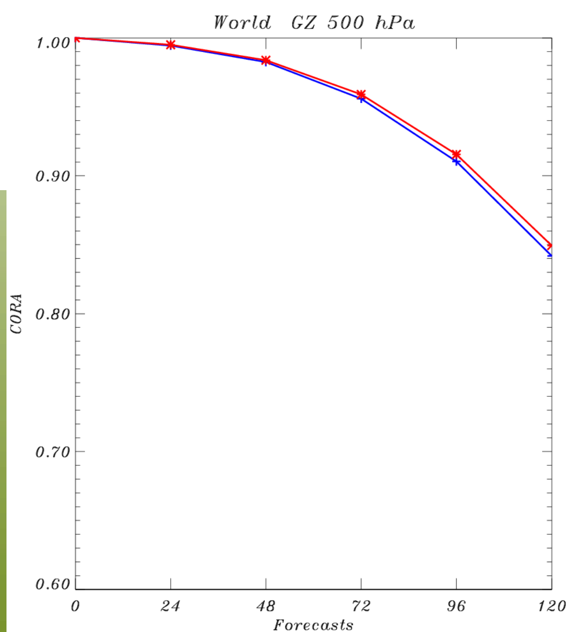
Control is better

Test is better

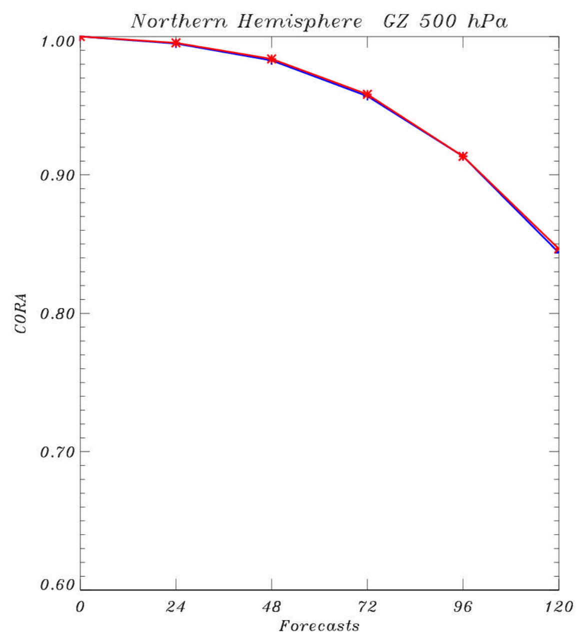
Results of 4dvar Assimilation Exp. 2/2

- Validation against analysis: Anomaly Correlation Coefficient for geopotential height at 500 hPa

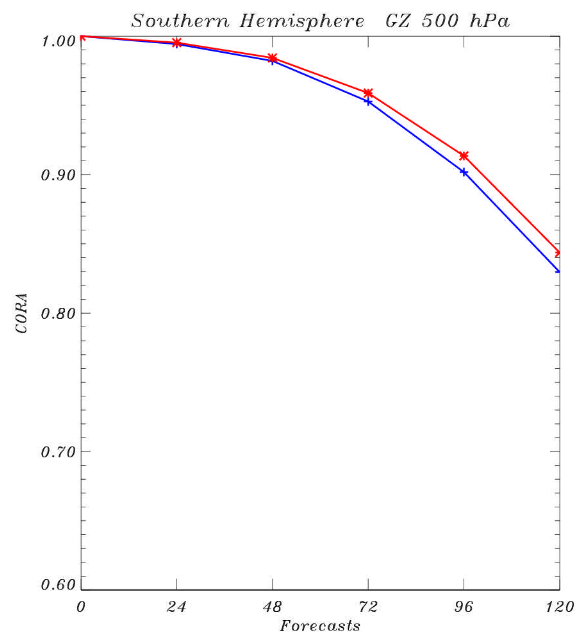
WORLD



NORTHERN H.



SOUTHERN H.



Conclusions, Perspectives

- Results of these first 4Dvar assimilation very encouraging, notably in Southern Hemisphere, this on top of all operational data. Impact similar to that obtained from AIRS.
- Improved quality control using sub-pixel AVHRR information.
- Experiments in GEM-strato with 22 more channels started.This could improve the noted GZ bias at high levels.
- Operational implementation expected in October 2009 (as part of a bigger package including IASI, AMSU-A and MHS from METOP-2, SSMI-S from DSM14, Georad, humidity from aircrafts)
- Ongoing research on the assimilation of cloud-affected radiances (in the case of IASI use of sub-pixel information should help). Cloud parameters part of control vector (height, fraction, optical thickness).
- Incorporation of revised AIRS/IASI quality control should improve cloud parameter retrievals. CO2-slicing details under revision.
- Higher resolution inner loop + thinning reduced from 250 km to 150 km should also impact positively on radiance assimilation. Tests now under way.

Hyperspectral Radiance Assimilation at the U.S. Naval Research Laboratory

Ben Ruston

Naval Research Laboratory

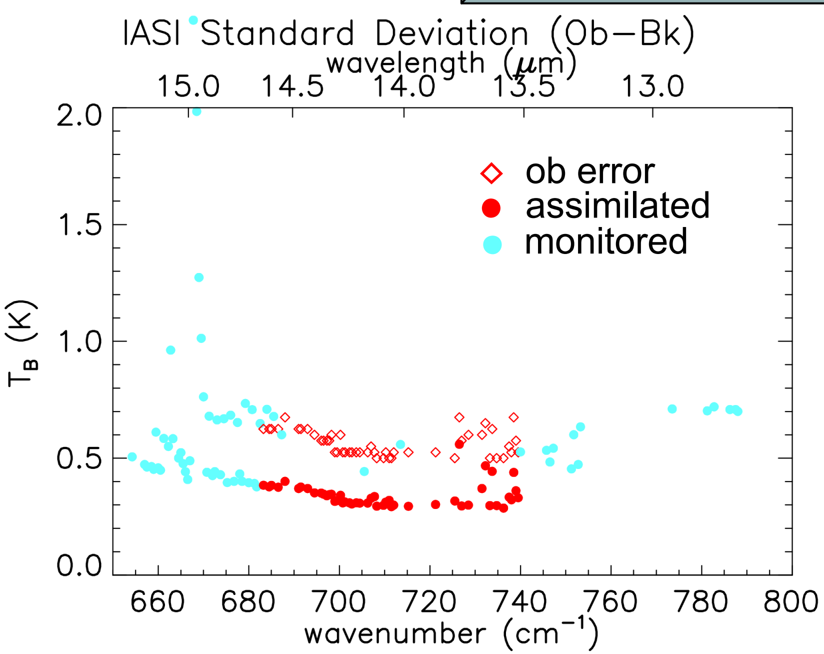
IASI and AIRS observations in NAVDAS_AR for April 2009

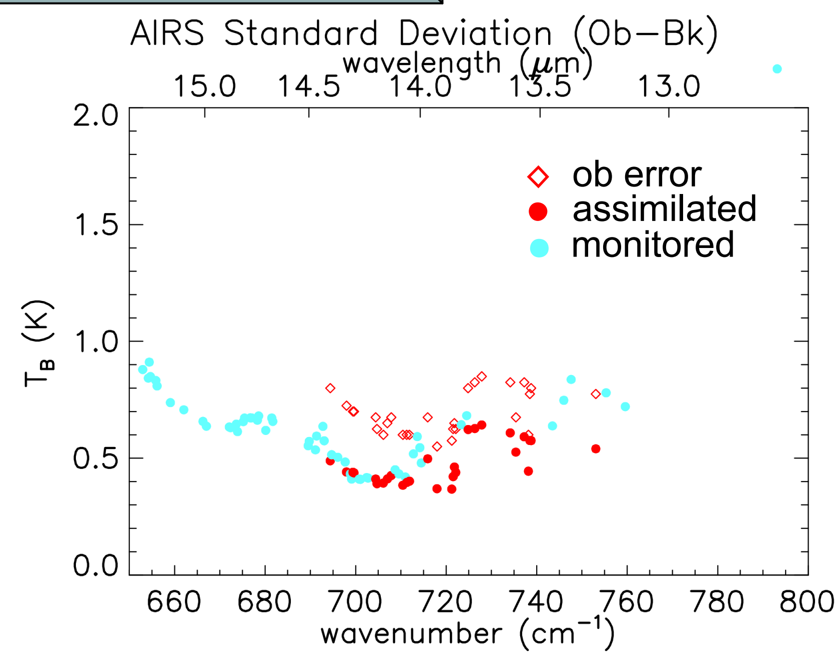
IASI running in NRL ‘alpha’ since August 2008

AIRS running in NRL ‘alpha’ September 2008

IASI/AIRS running in FNMOC ‘beta’ since March 2009

15-day RMS ending Apr28, 00UTC



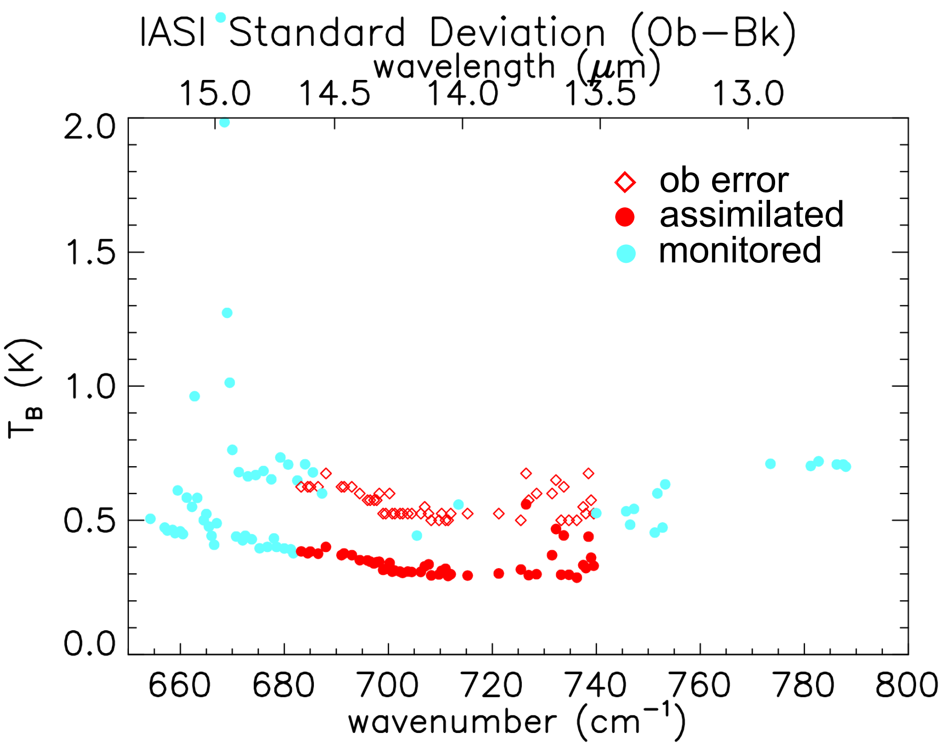


IASI and AIRS observations in NAVDAS_AR for April 2009

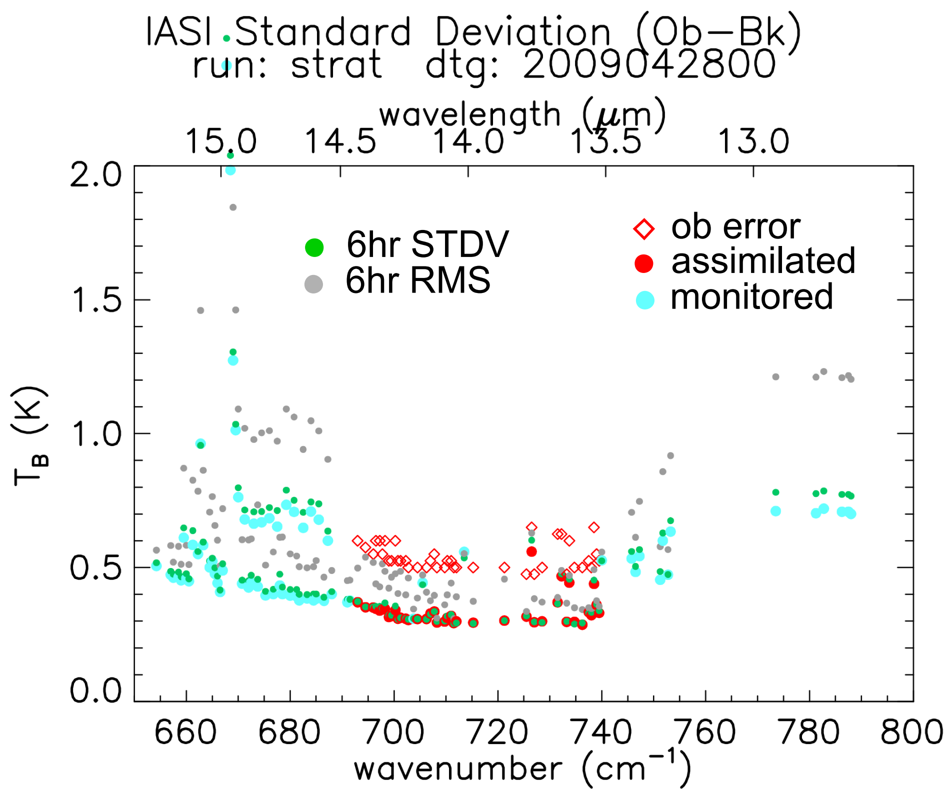
Un-bias corrected (ob-bk) RMS about 0.1-0.2 K higher

than (ob-bk) STDV for assimilated channels

15-day STDV ending Apr28, 00UTC



15-day STDV ending Apr28, 00UTC and 6-hr watch stats



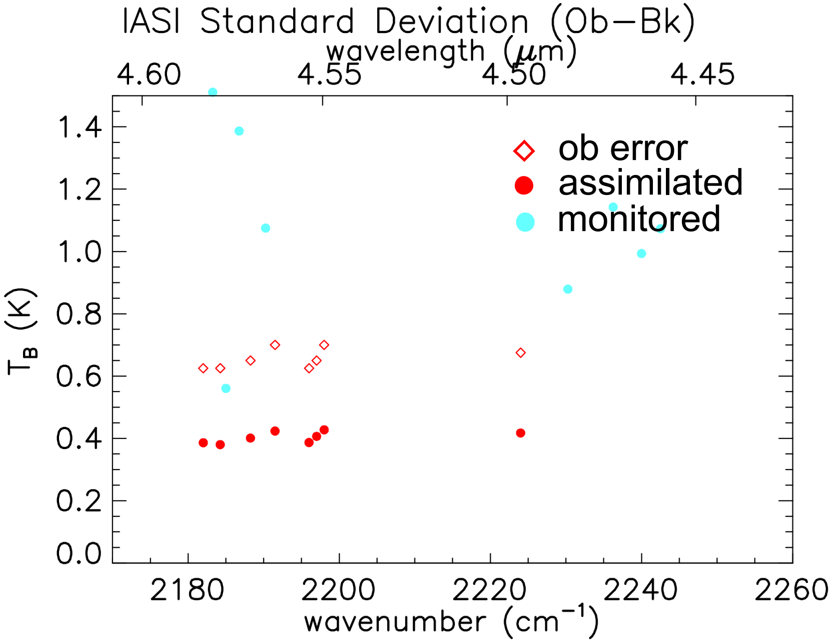
IASI and AIRS observations in NAVDAS_AR for April 2009

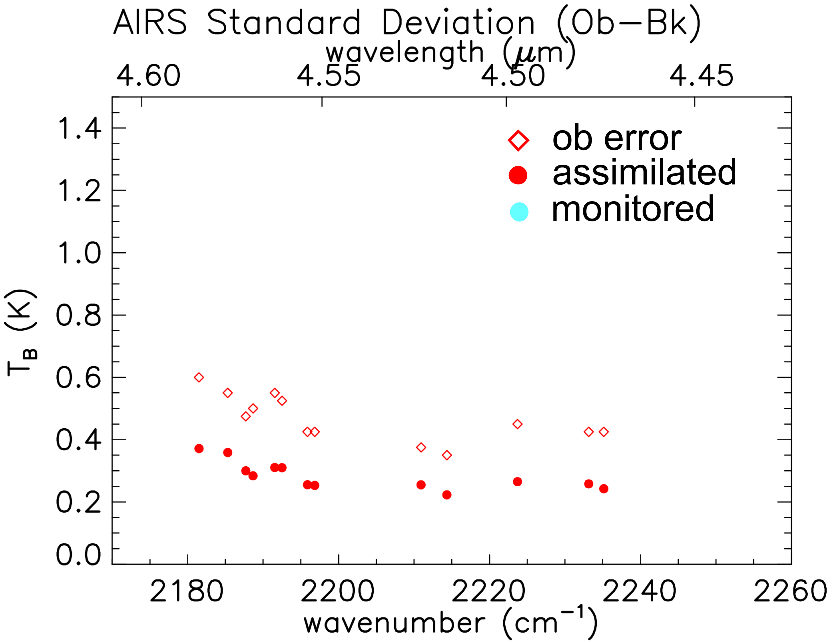
AIRS originally used two shortwave channels (ch1923, ch2113)

by Nov2008: AIRS using 7; channels IASI using 8 channels

April 2009: AIRS now testing 13 channels

15-day RMS ending Apr28, 00UTC



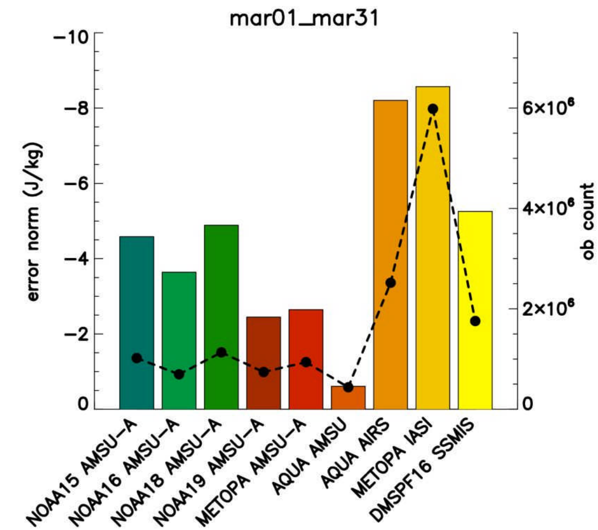


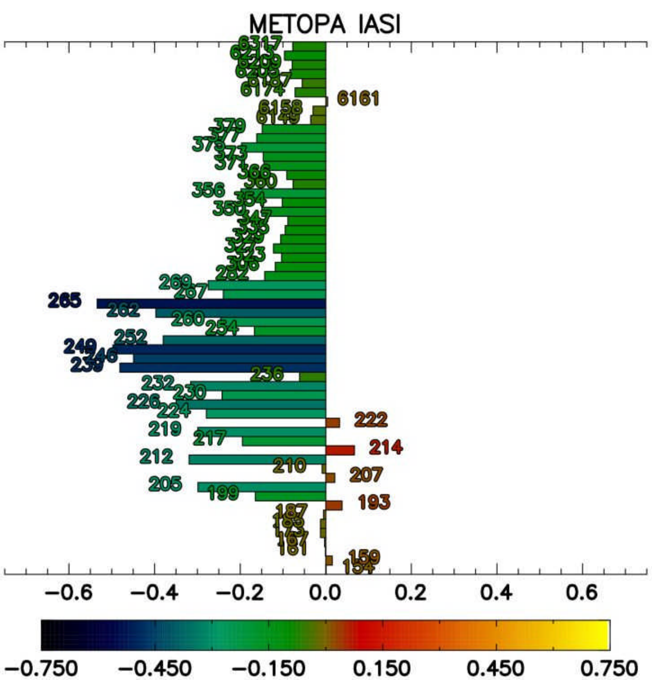
IASI/AIRS observation sensitivities for NAVDAS_AR March 2009

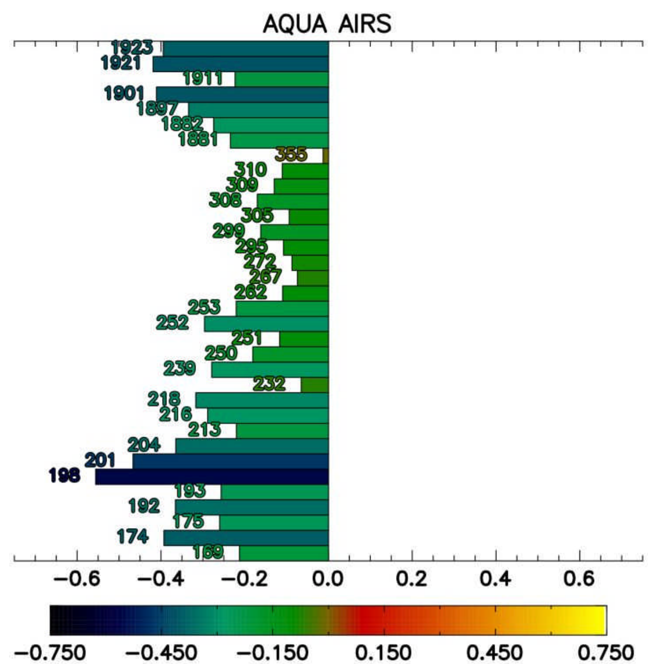
IASI largest volume of data into system

IASI has much smaller, but still positive impacts from the near infrared channels

Complex channel interactions; observation sensitivity has been a powerful tool discriminating impacts of additional channels







IASI/AIRS future plans

- Aid FNMOC in the NAVDAS_AR transition {reports, committees, meetings}
- Squeak out a few more LW channels for AIRS/IASI
- Another detailed re-evaluation of the cloud screening now that the model top is at 0.04 hPa
- Use some high peaking channels over land
- Set up real-time monitoring page write automatic scripts, get permissions to distribute to public

Even further in the future:

- examine humidity channels
- examine ozone channels
- examine cloudy radiances
- examine principle component assimilation

Hyperspectral Water Vapor Radiance Assimilation

James Jung
Cooperative Institute for Meteorological Satellite Studies

Work in Progress

Outline

- IASI Status at NCEP
  - Experiment design
  - Results
- Tropospheric Water Vapor Assimilation
  - Problems
  - New approach
  - Results
- Stratospheric Water Vapor Assimilation
  - Channel selection
  - Results
- Items yet to be resolved

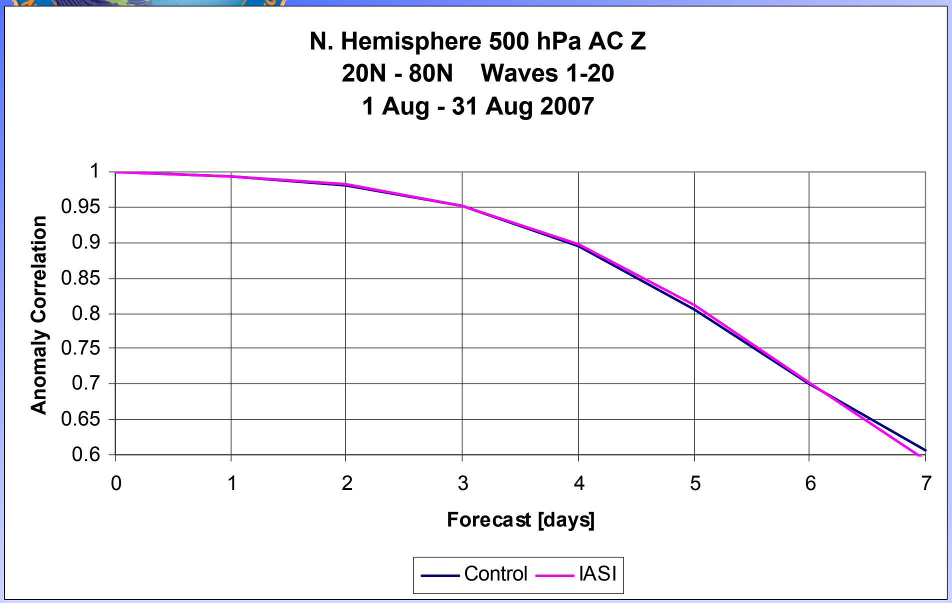
IASI status at NCEP

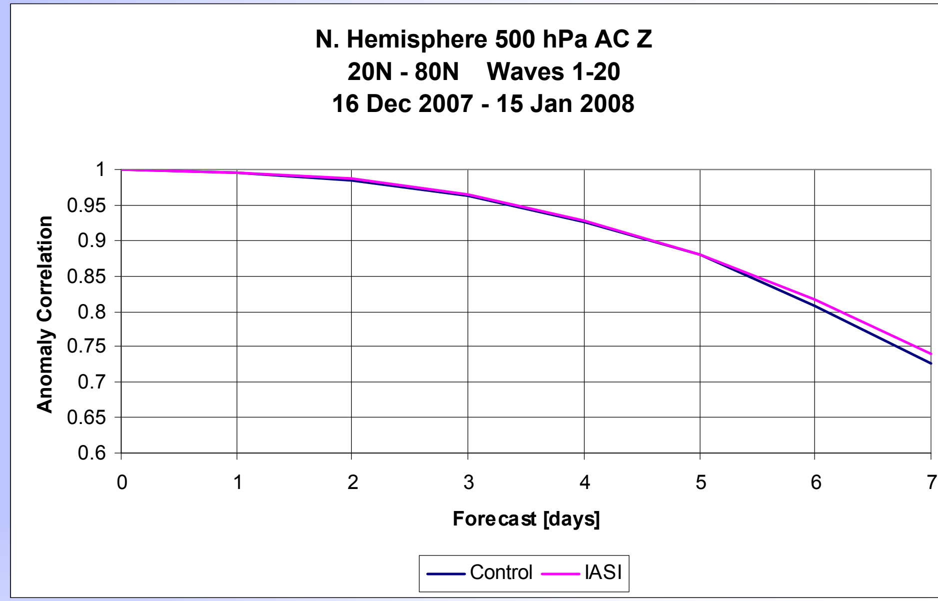
- 616 channel subset
  - Processed and available through NESDIS
  - Minor BUFR modifications
- EUMETSAT channel selection used
  - 165 channels longwave only
- Thinned to 180 Km
  - Similar to all Infrared radiances
- All operational data used

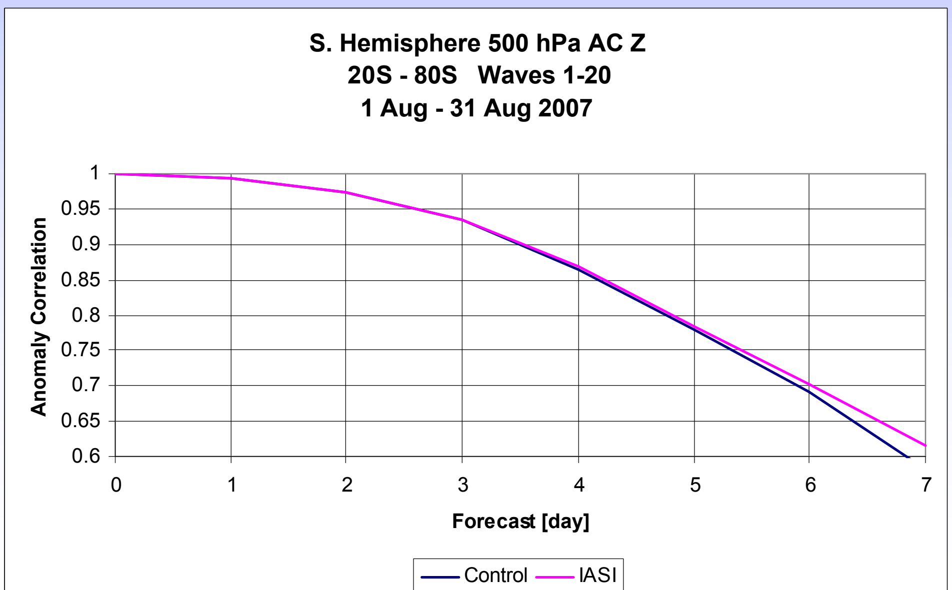
IASI status at NCEP cont'd

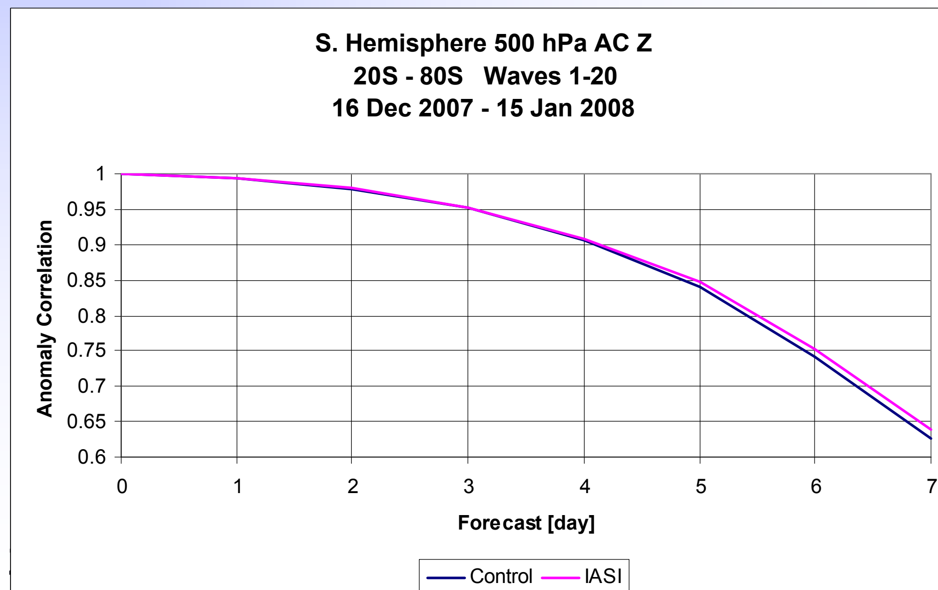
- Two season verification (JCSDA)
  - One month spinup
  - One month verification
- NCEP parallel testing
- Transitioned to NCEP Operations in February 2009

Anomaly Correlations









CIMSS

Tropospheric Water Vapor Assimilation

Assimilating water vapor channels

Problems

- Increase penalty
- Decrease convergence
- Unstable moisture field
  - Supersaturation
  - Negative moisture
  - Precipitation spin down

Attempts to fix them

- Down-weight obs
- Tighter cloud checks/QC
- Increased number of inner and/or outer loops
- Black list specific channels

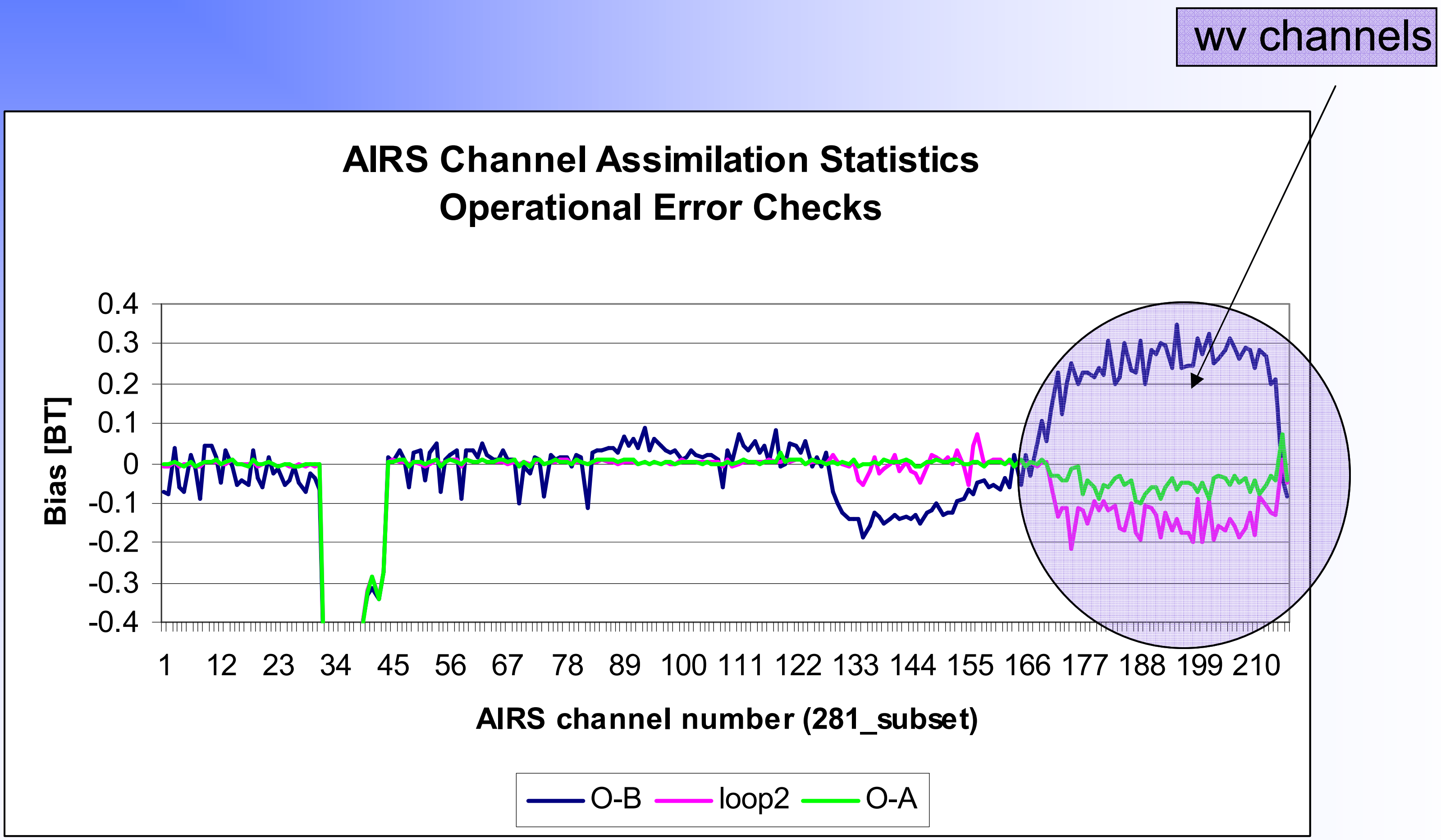
Background

- NCEP Global Spectral Model
- T382L64
- Gridpoint Statistical Interpolation (GSI)
  - Pseudo RH used for moisture assimilation
- February 2009 update

- All Operational conventional and Satellite data
- IR data thinned to 180 Km
- 165 longwave IASI
  - 35 water vapor
- 121 total AIRS
  - 27 water vapor

1– 31 January 2008

Operational AIRS Bias



* Not all AIRS channels are used

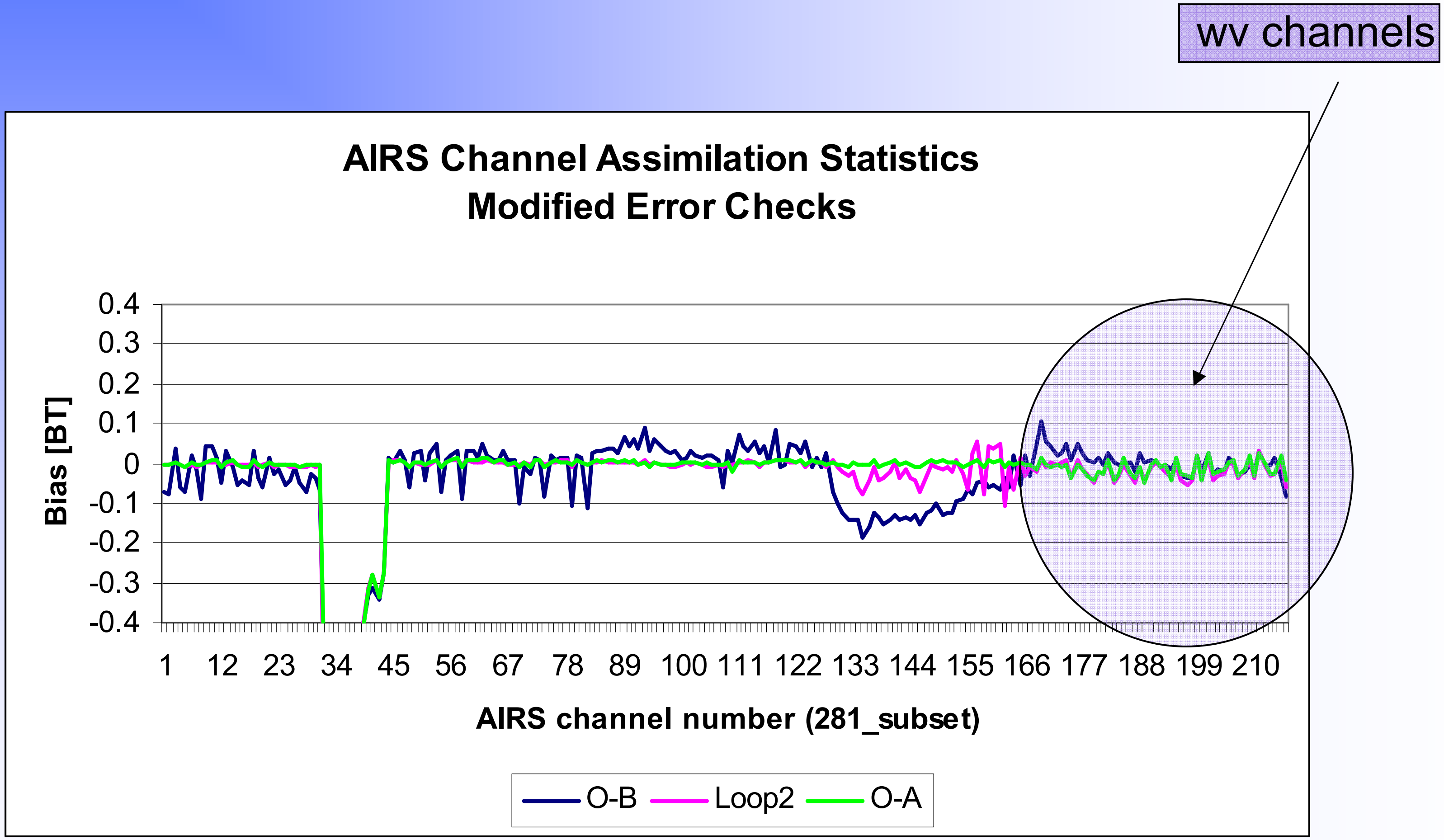
New Approach

- Use the gross error check to limit the response
  - Adjusted gross error check 4.5 -> 0.9 [K]
  - Adjusted assimilation weights closer to the noise equivalent delta temperature (nedt).
- Used for both AIRS and IASI

Effects

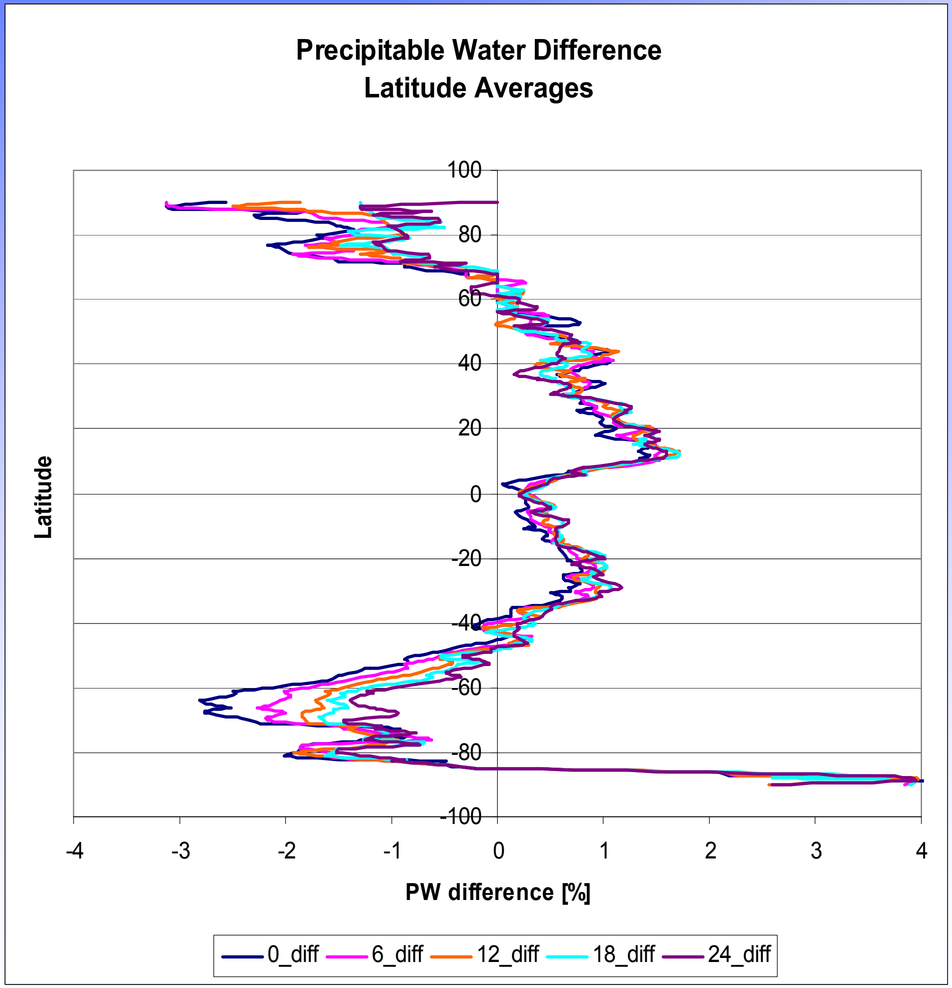
- Less observations per channel used wrt using 4.5K
  - ~70% reduction initially
  - ~20% reduction in final analysis
- Most observations pass QC on second outer loop
  - Better temperature profile (?)
- Water vapor channels now have similar characteristics to temperature channels
  - Convergence improved
  - Penalty improved
- Smaller initial changes to the moisture field, greater changes over time
  - Each assimilation cycle changes are about an order of magnitude less than the model values
- Most changes occurring in the mid- and upper Troposphere

New AIRS Bias



* Not all AIRS channels are used

Precipitable Water Changes



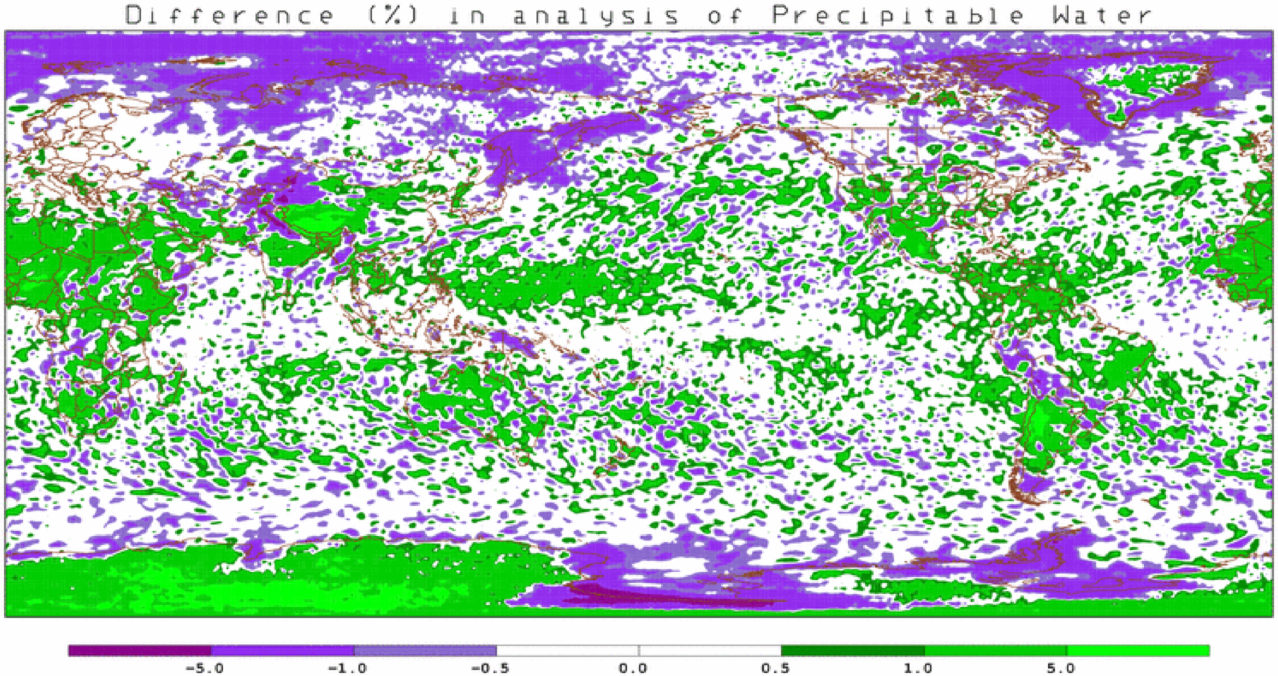
Relatively small changes in moisure

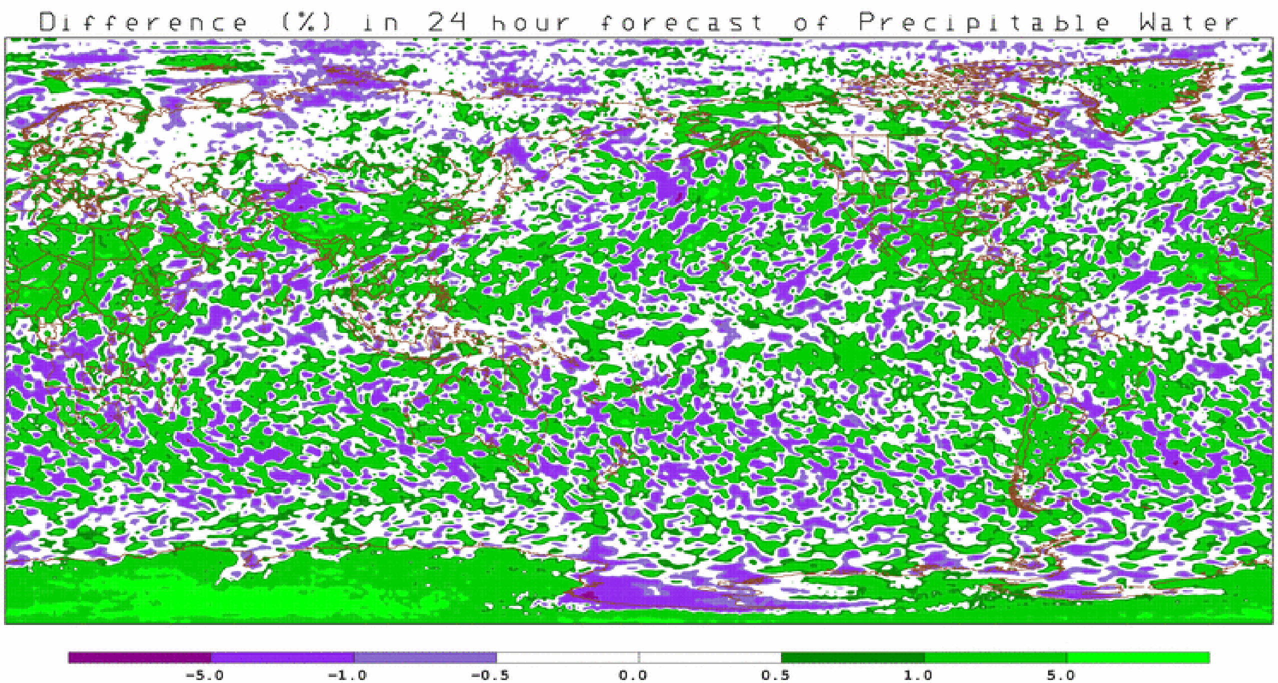
More moisture in the tropics

Dryer at high latitudes

Moisture retained in tropics

Moisture “returns” at higher latitudes



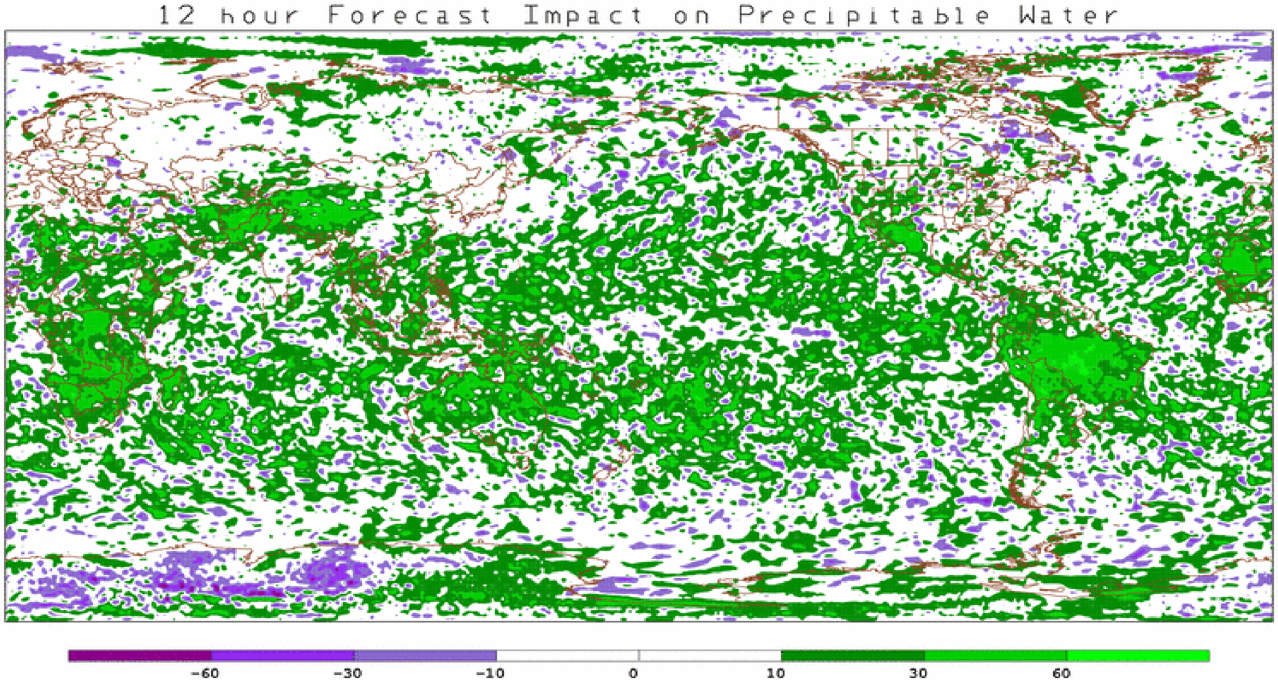


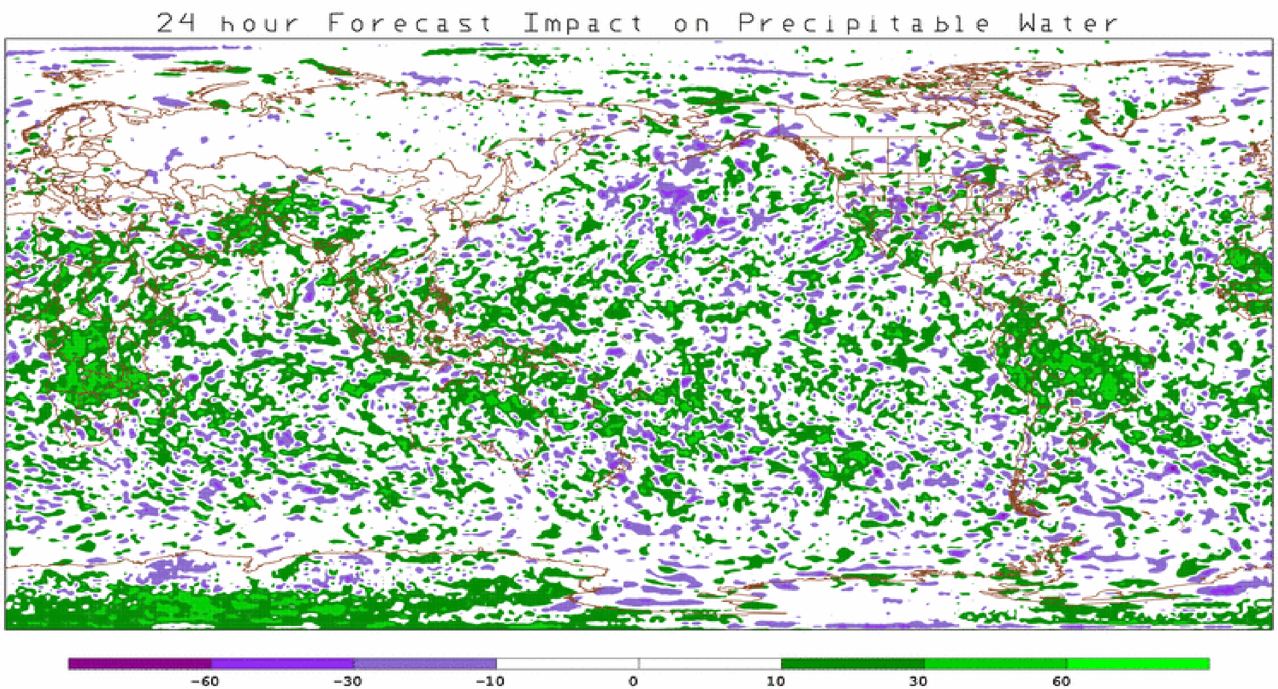
Monthly average changes in precipitable water between the control and experiment.

Forecasts in the Polar regions trend toward the control but tropics remain wetter than the control.

Precipitable water differences are in percent [%]

CIMSS





Forecast Impact (Pseudo RMS) on precipitable water.

Forecast Impact decays rapidly with time and becomes mostly neutral by 24 hours.

Units are percent [%]

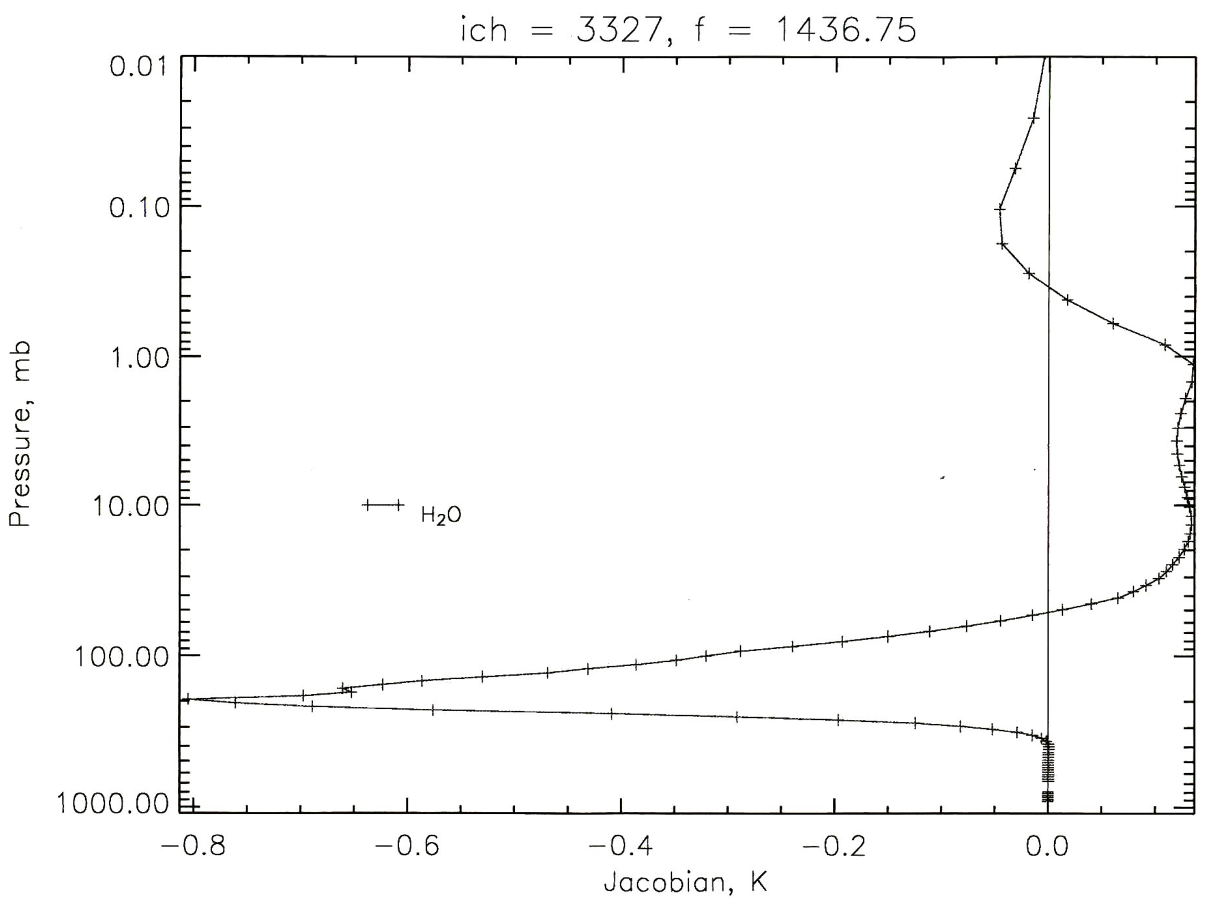
Stratosphere Water Vapor Assimilation

Experiment

- Assimilate on-line (absorption) water vapor channels
  - 68 water vapor IASI channels
    - 35 off-line
    - 33 on-line*
  - 38 water vapor AIRS channels
    - 27 off-line
    - 11 on-line

* IASI has better spectral bandwidth channels to accomplish this than AIRS

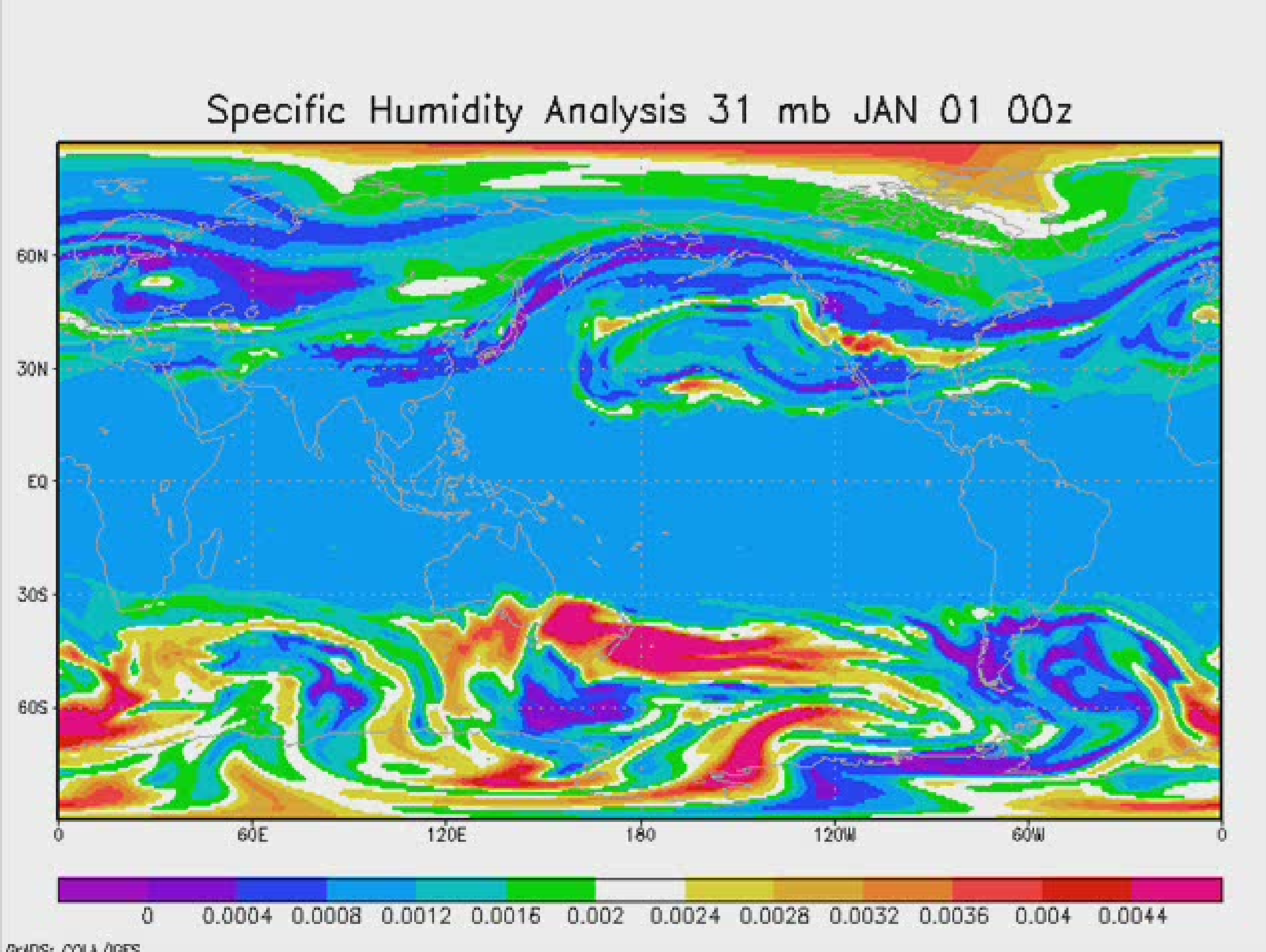
IASI Jacobian for on-line water vapor channel 3327



From Chris Barnet

Items to note:

- Background Error
  - Modified to allow small changes per cycle
- Negative Moisture
  - -q values set to 10^{-6} [Kg/Kg] (Stratosphere)
- GPS-RO
  - Develops fields that are similar
- Verification (?)

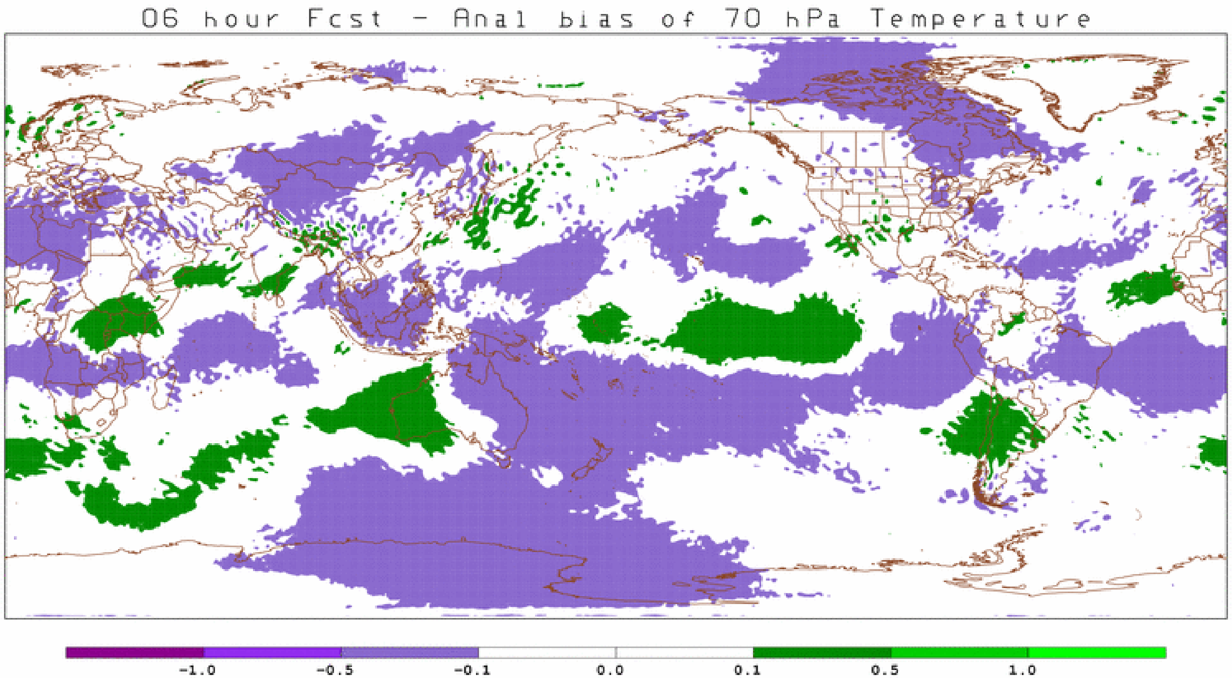

Specific Humidity Analysis 31 mb JAN 01 00z
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
0
0.0004
0.0008
0.0012
0.0016
0.002
0.0024
0.0028
0.0032
0.0036
0.004
0.0044
GrADS: COLA/IGES

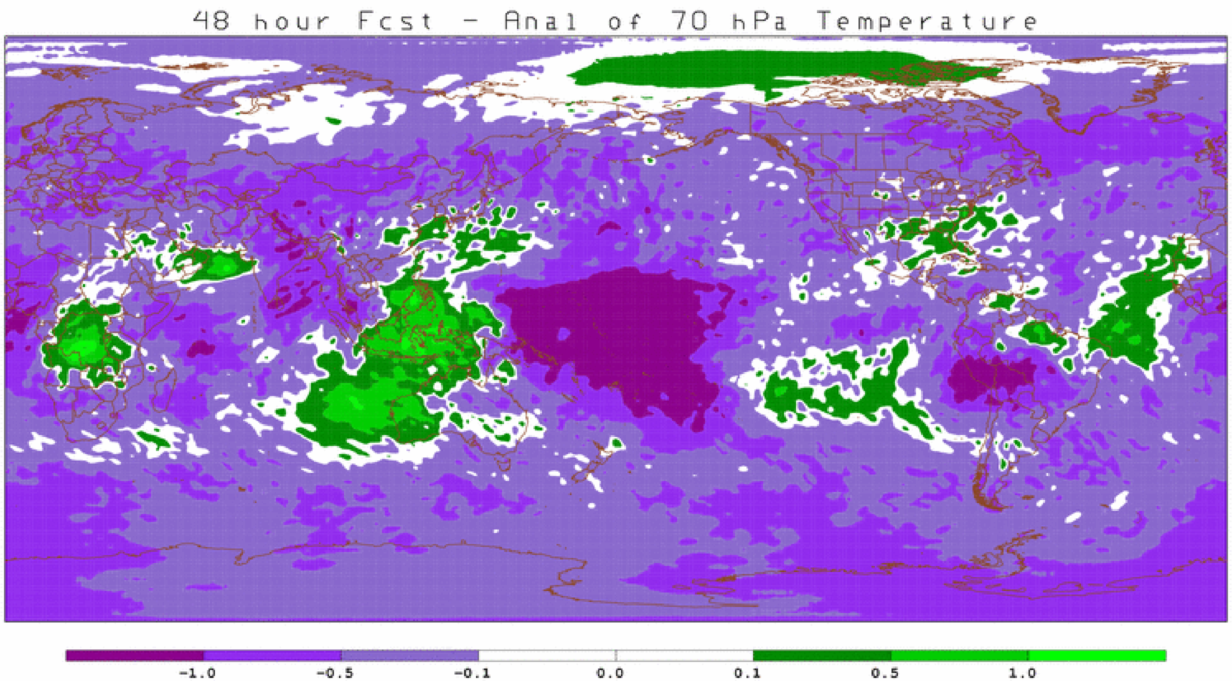
CIMSS

Problems

- Cold temperature bias from 100 hPa to the top of the model and increases with forecast time
- Geopotential height bias above 100 hPa also increases with forecast time

Both are enhanced by assimilating Stratospheric Moisture

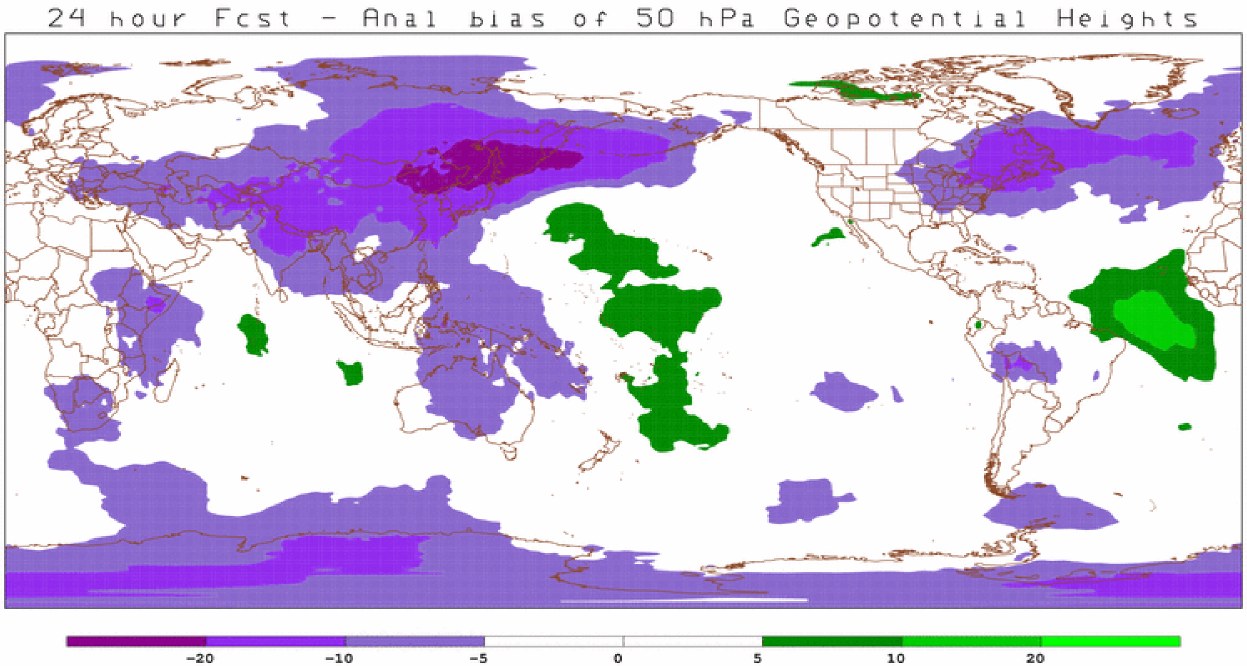


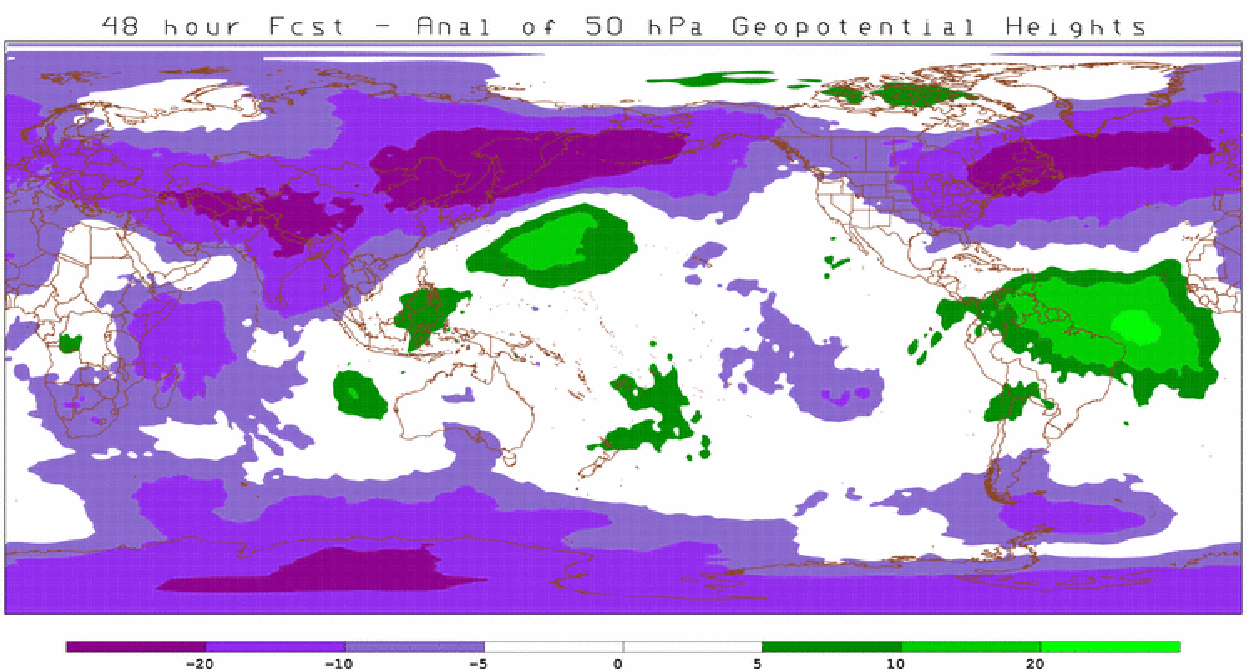


Bias = monthly average of Forecast minus its own Analysis

Forecasts become colder with time.

Units of Temperature [K]





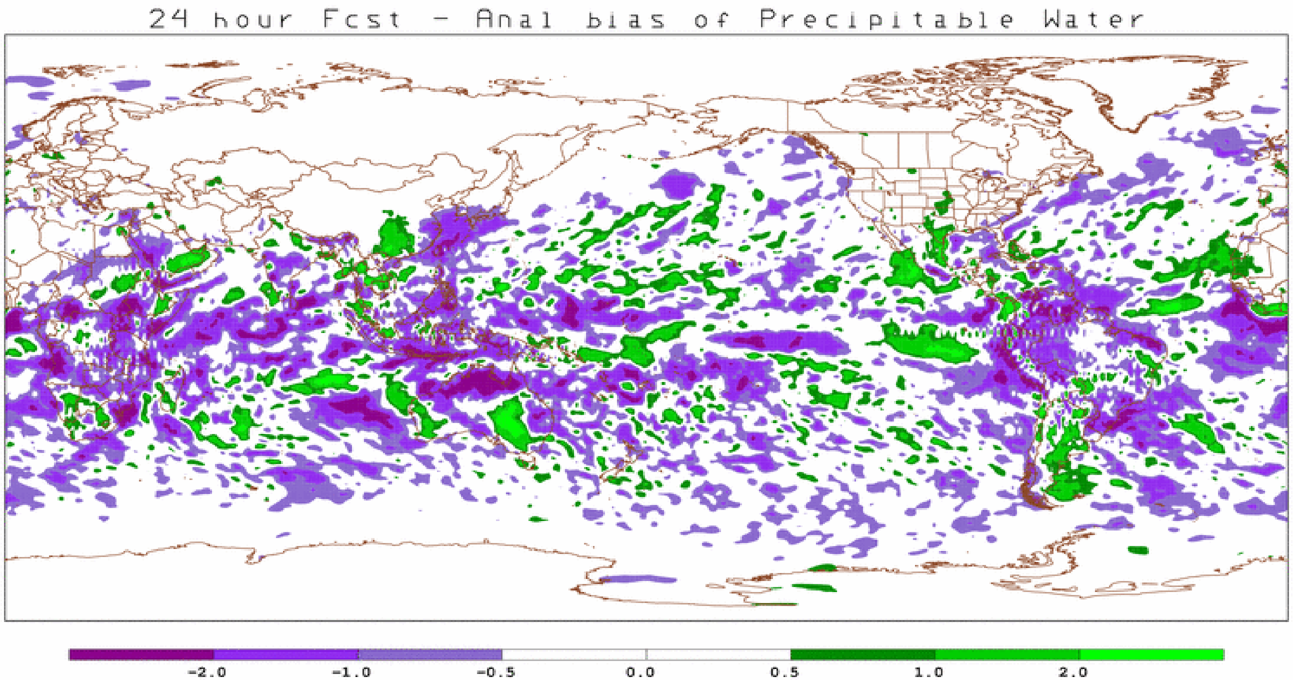
Bias = monthly average of Forecast minus its own Analysis

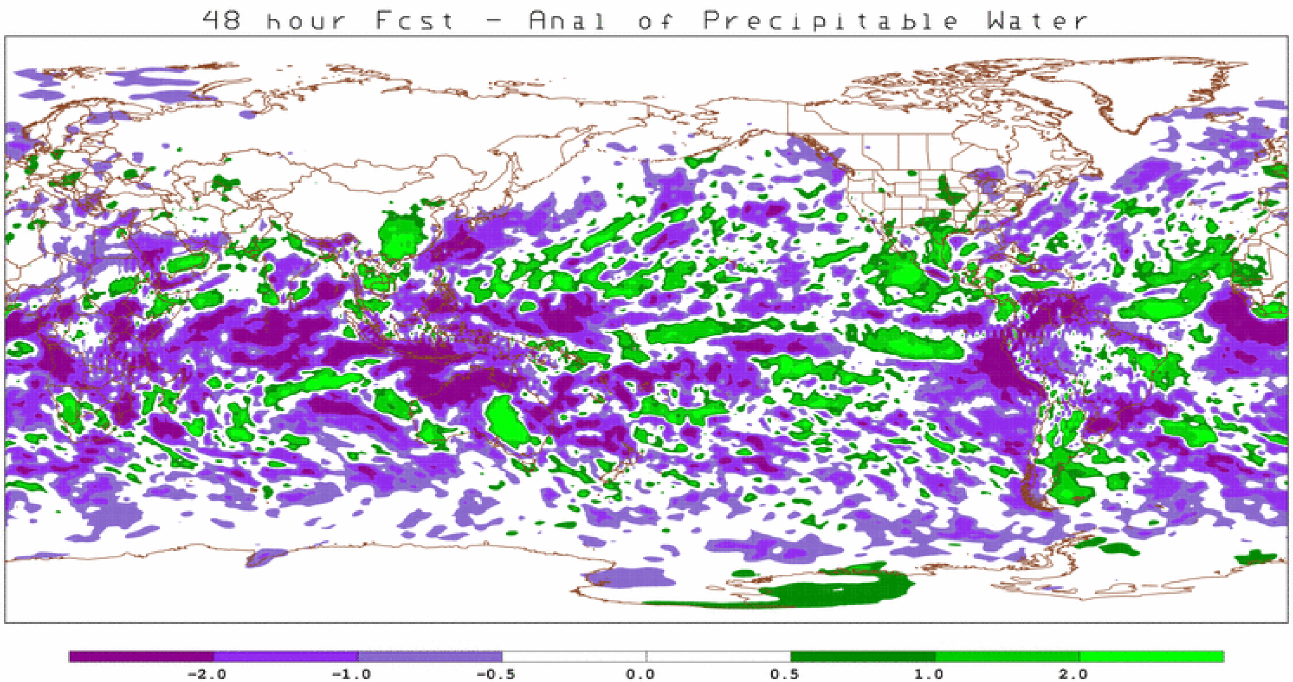
Heights also decrease with forecast time.

Units of geopotential heights [m]

Work in Progress

- New background error for moisture (RH)
  – Stratosphere
- Height/Temperature bias
  – Tropopause
  – Stratosphere
- Channel selection
  – Sensitivity to Stratosphere moisture
  – # required to maintain a stable stratospheric moisture field
- Greater Impact near the surface
  – Surface emissivity
  – Background error



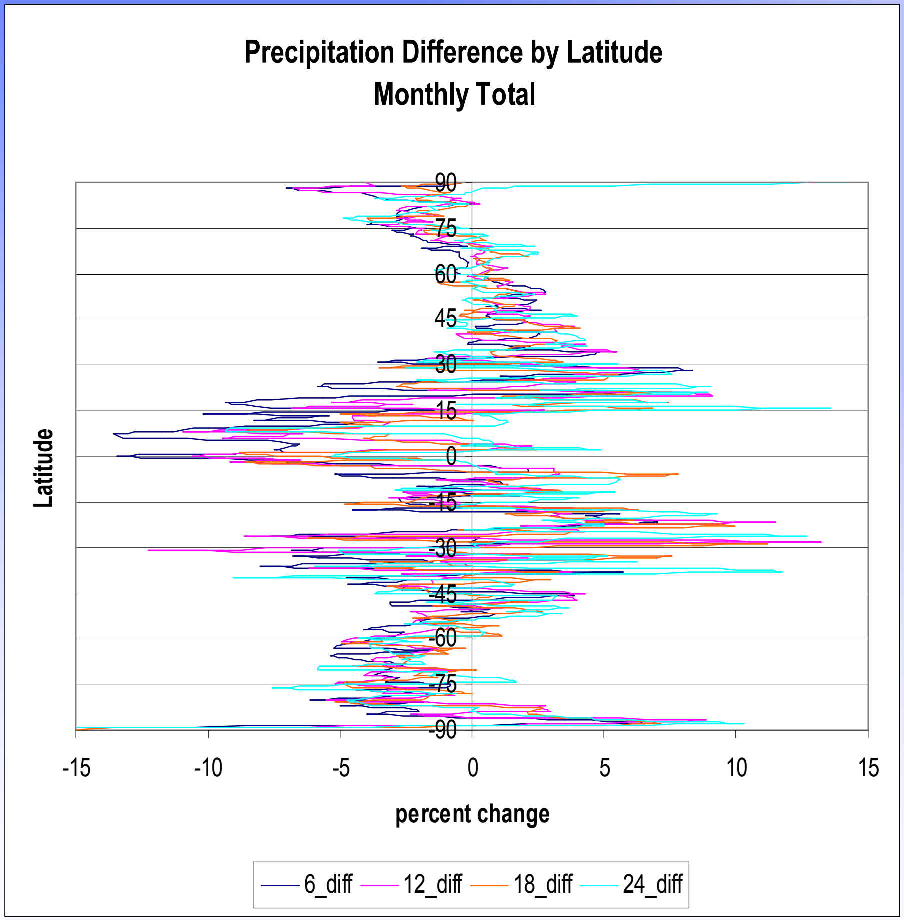


Bias = monthly average of Forecast minus its own Analysis

Forecasts become dryer with time.

Monthly average in Precipitable water [mm]

Monthly Average of 6 Hour Precipitation Changes



- 6 hour changes in total precipitation have large fluctuations
- Generally more precip. in the ITCZ region, less in "dry season"
- Rainfall changes do not show a geographic dependence (not shown)
- Threat scores over US show no significant changes