Use of Current Hyperspectral Sounders, an NWP User Perspective

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for

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Workshop on Hyperspectral Sensor Greenhouse Gas and Atmospheric Soundings from Environmental Satellites

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Current Use of Hyperspectral Sounders

- Almost all operational NWP centers assimilate radiances in their global and regional models
  - Ozone retrievals are the main exception because some NWP centers are not ready to assimilate UV radiances, limb sounders, etc.
- Channel usage:
  - Spatial and spectral thinning
    - Spatial thinning is model dependent
    - ~200 channels from each sensor (AIRS and IASI)
  - Most centers use clear and above cloud
  - Longwave: CO_2 region dominates the selection
  - Water Vapor: with reduced weights, troposphere
  - Shortwave: mostly at night

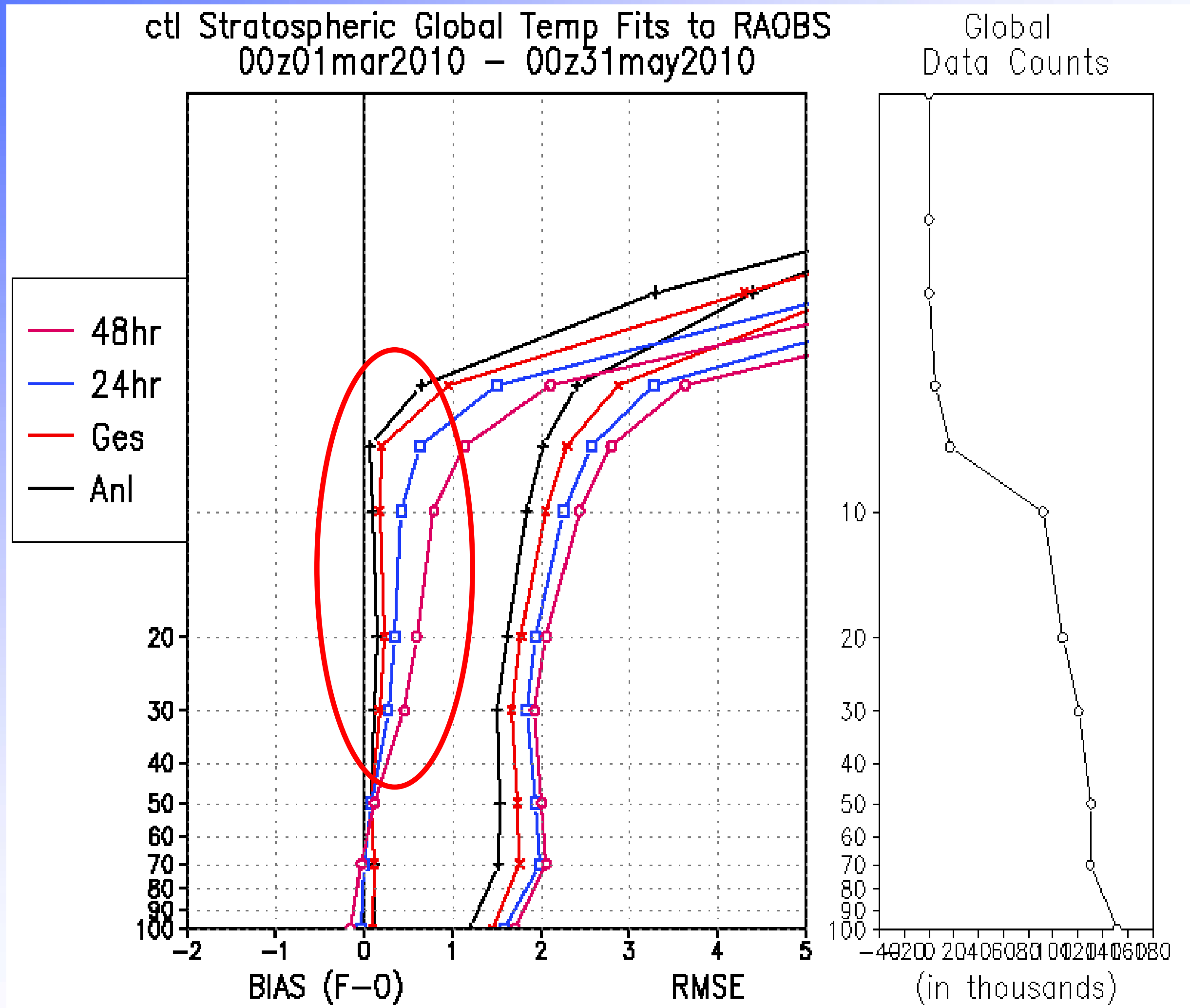
Current Use of Hyperspectral Sounders

- Channel usage cont'd:
  - Trace Gas and non-LTE regions are mostly avoided
  - Surface sensing channels are given reduced weights or avoided depending on surface type (knowledge of surface emissivity)
- Radiative Transfer Model (CRTM specific)
  - Trace gas concentrations are a fixed profile derived from climatology except CO_2, O_3 and H_2O
    - CO_2 is currently set to 390 ppmv with a stratospheric reduction of 10%
    - O_3 and H_2O are from model fields
  - Working toward using actual values when available.

Current Use of Hyperspectral Sounders

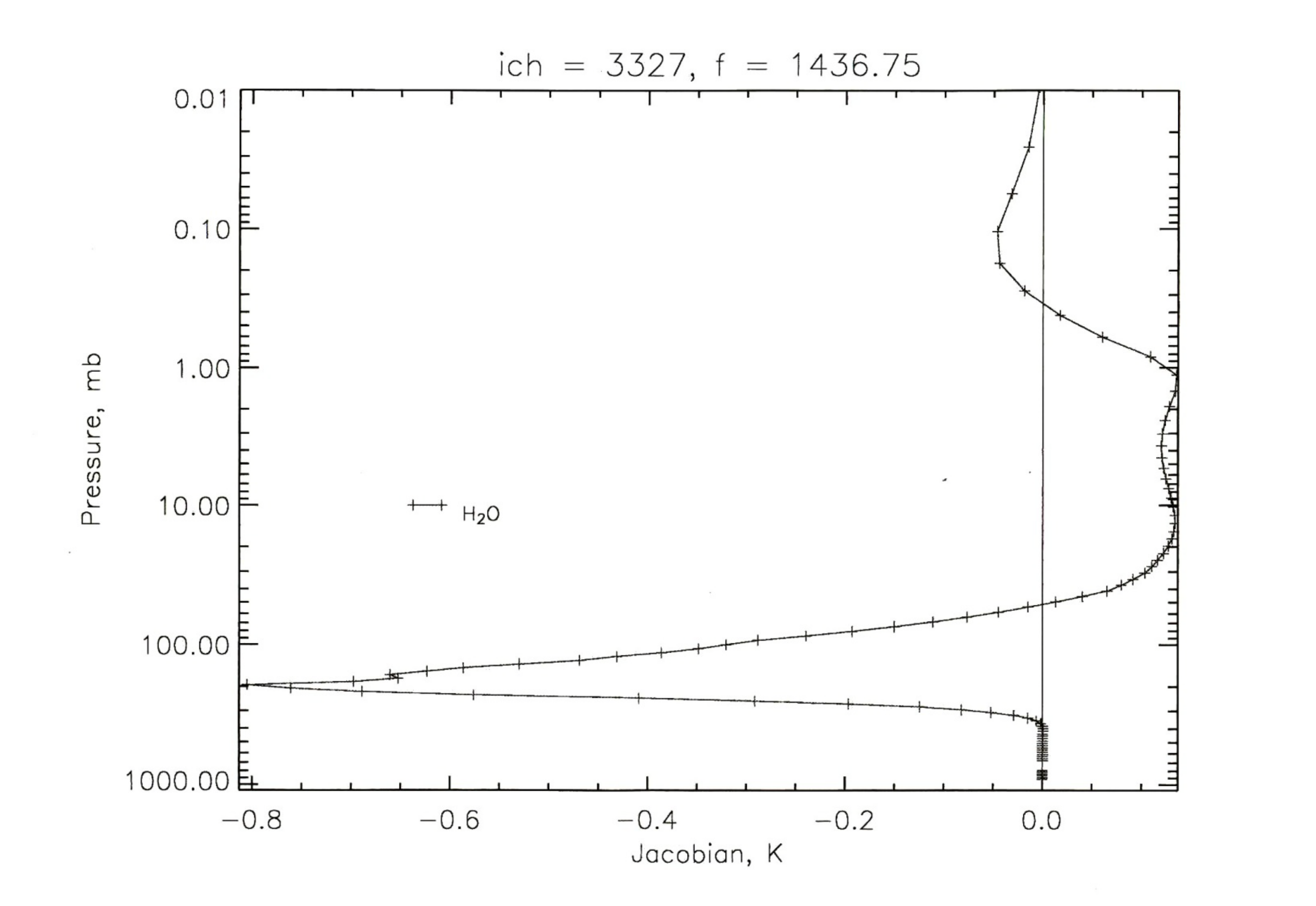
- Forecast Model Radiation Scheme
  - Is sensitive to some greenhouse gas concentrations
  - Derives Incoming solar and outgoing longwave radiation for the model heating and cooling.
  - The current NCEP global model uses fixed climatology concentrations for all but 3 gases
    - CO_2 is a global annual mean that is vertically fixed and changes with time
    - O_3 and H_2O are model fields
  - More fields for trace gases could be added but are computationally expensive

Example of H_2O impact on the NCEP/GFS radiation budget



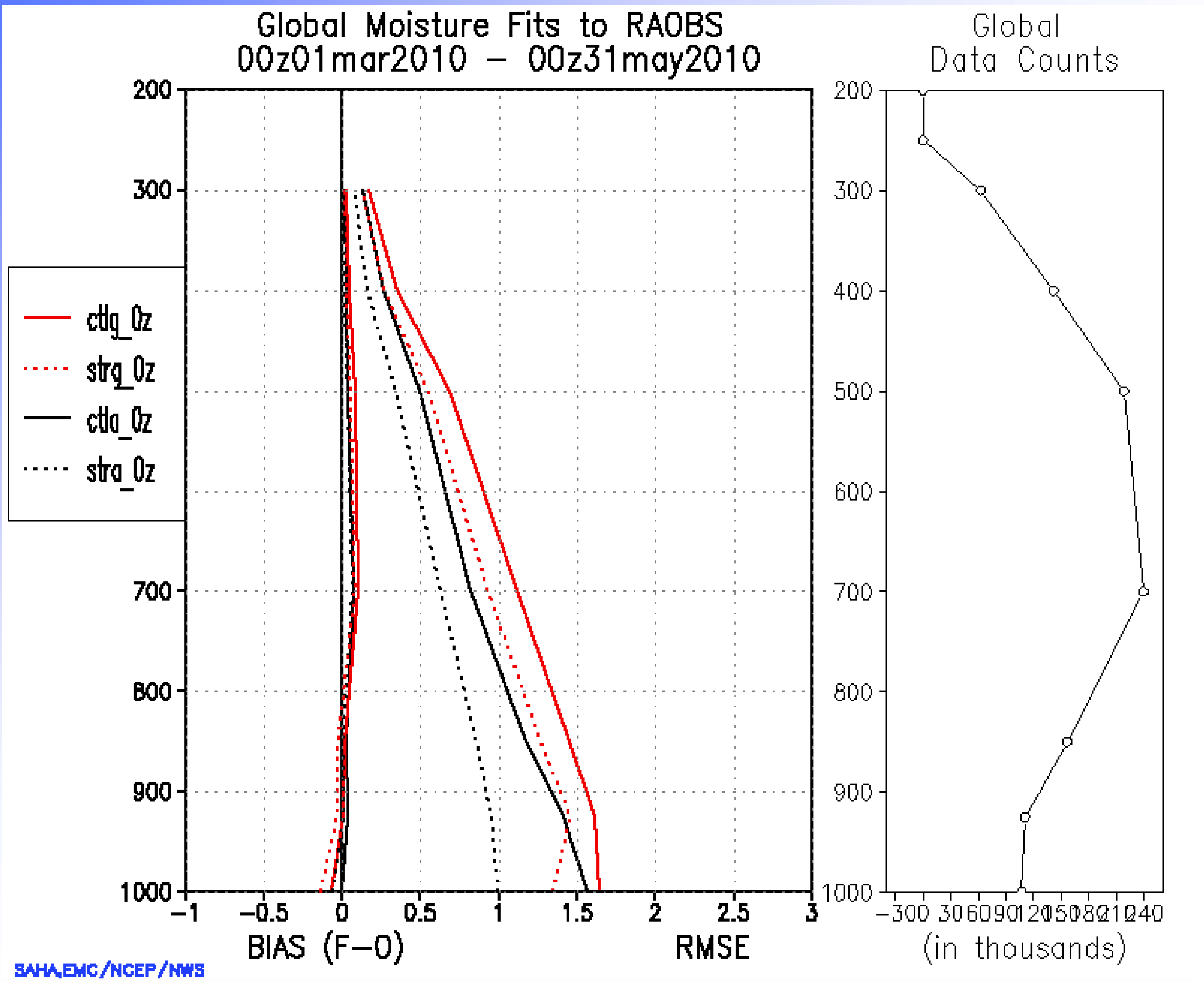
Stratospheric temperature drift due to incorrect concentration of H_2O

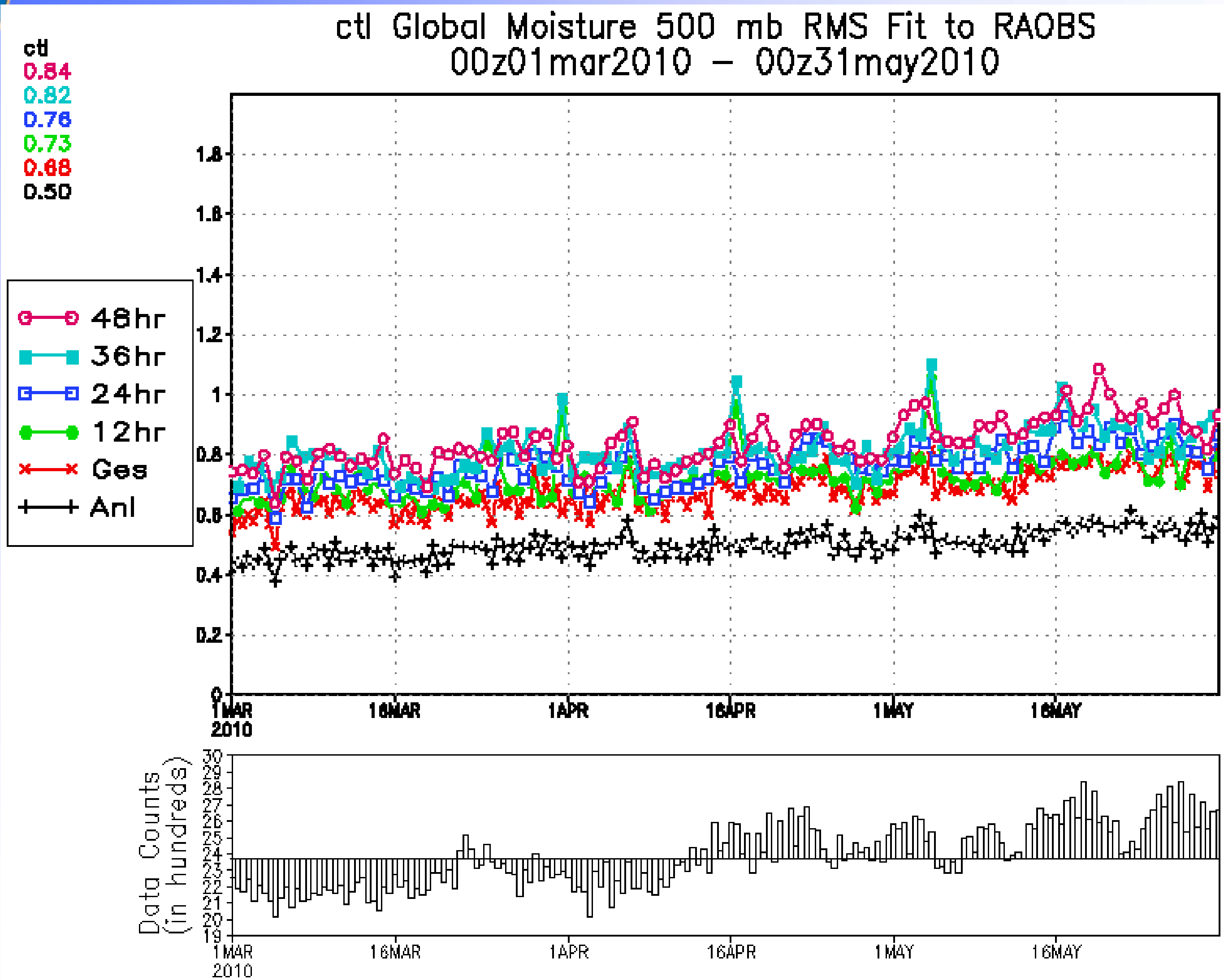
IASI Jacobian for on-line water vapor channel 3327



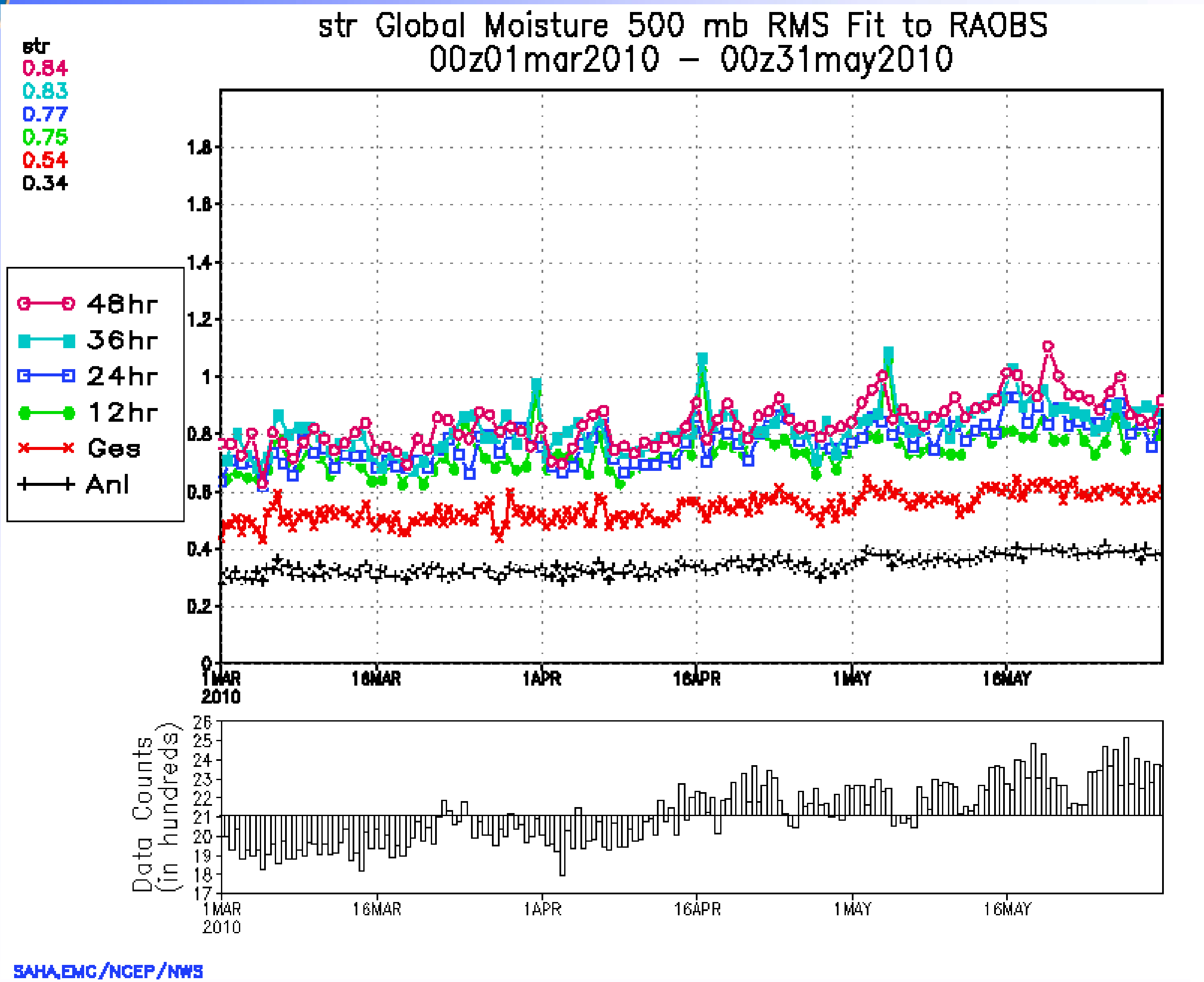
From Chris Barnet

Hyperspectral radiance improvements to the NCEP/GFS moisture field





SAHA,EMC/NCEP/NWS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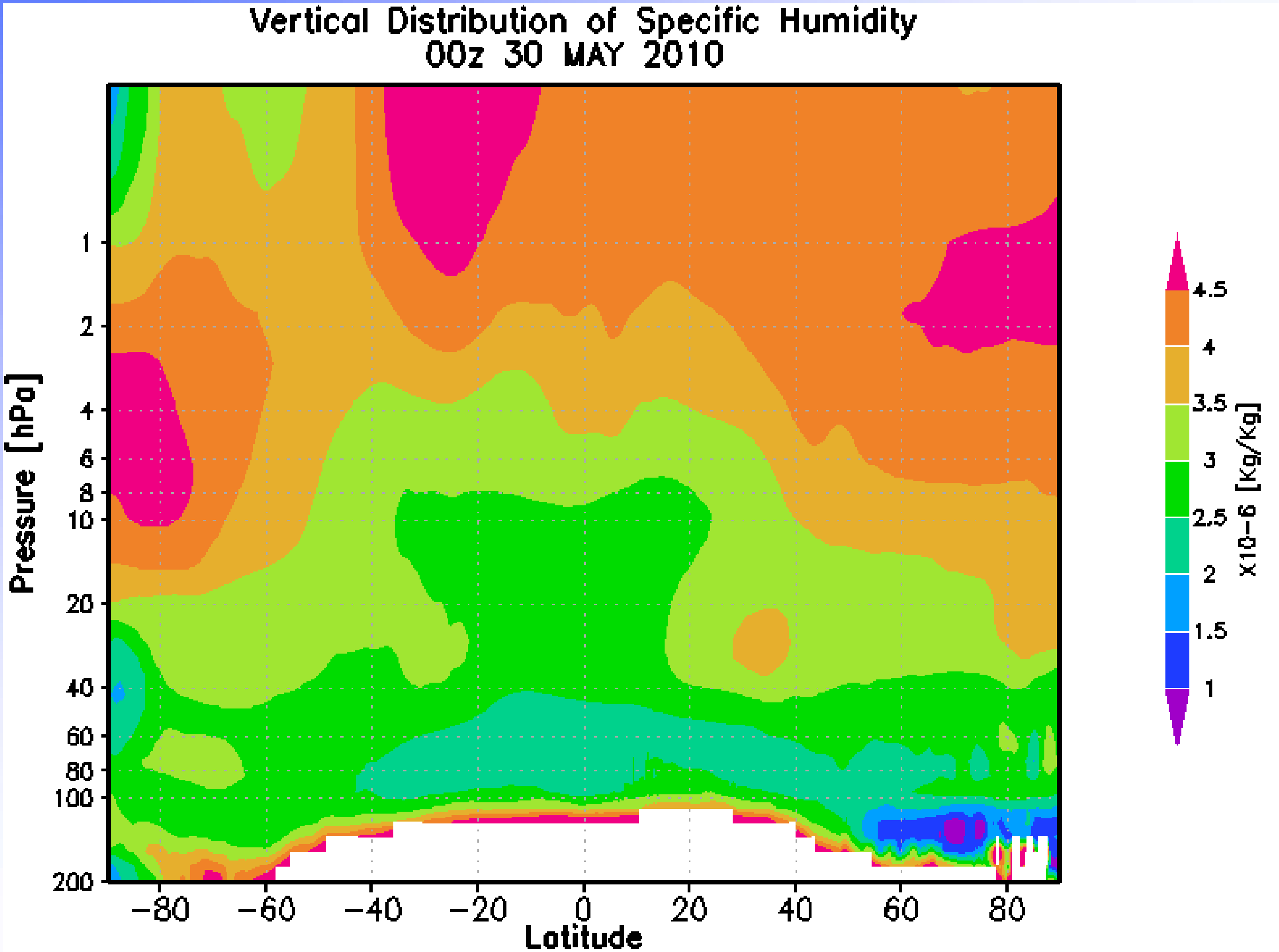
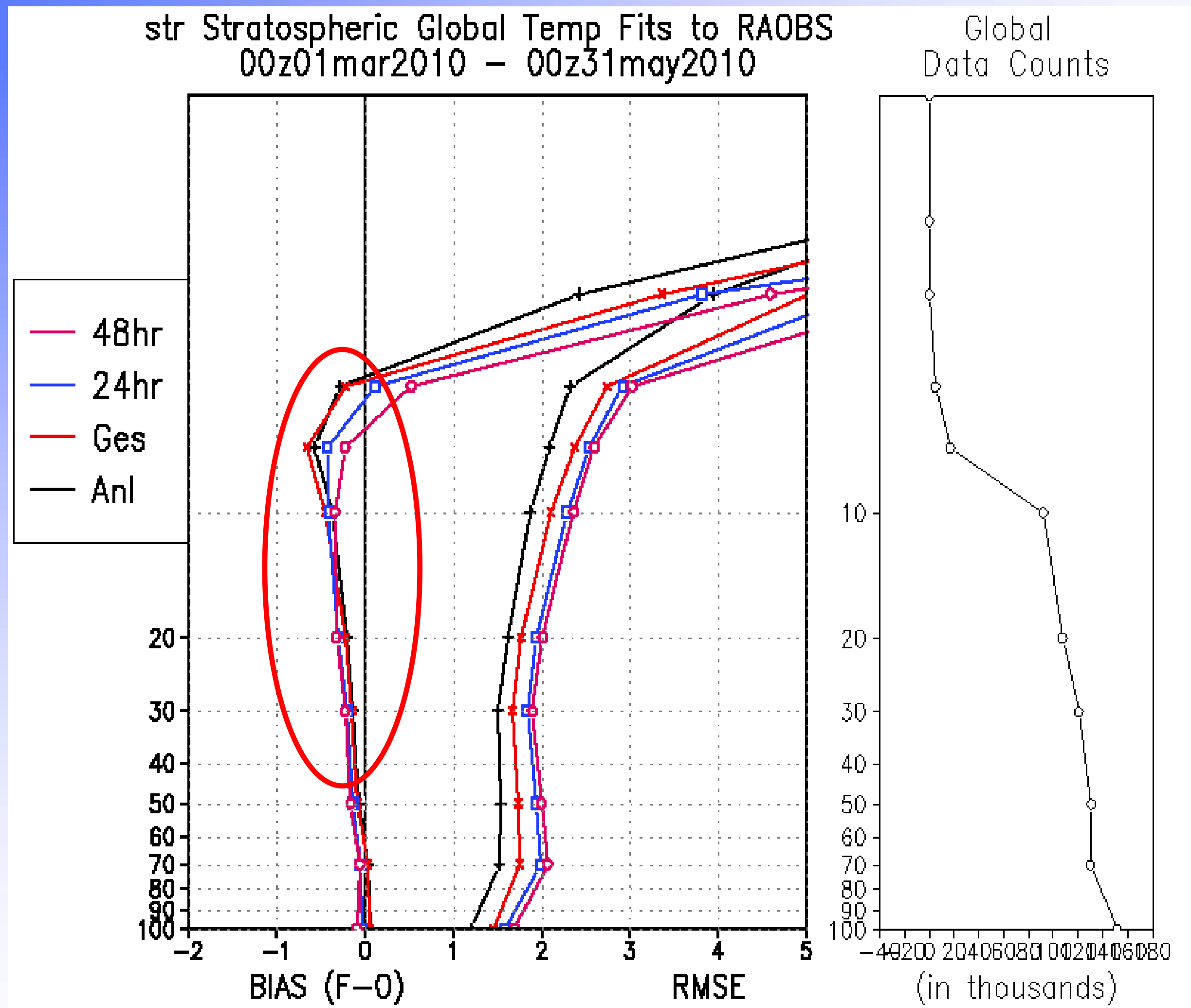
Data Counts (in hundreds)
SAHA,EMC/NCEP/NWS

Vertical cross section of stratospheric H_2O estimated from AIRS, IASI, and GPS-RO



Example of H_2O on the NCEP/GFS radiation budget



Stratospheric temperature stability due to a reasonable concentration of H_2O

What are the Deficiencies?

- Spectral Resolution
  - Improved spectral resolution in regions of interest for specific trace gases would improve our estimates used by the radiative transfer model, assimilation system, model radiation scheme and ultimately the forecast.
  - The differences between AIRS and IASI for deriving stratospheric H_2O are considerable due to:
    - Channel selection
    - Spectral response functions
- Instrument Calibration
  - Instrument calibration drift.
  - Differences between published and actual spectral response functions.
  - Little information on instrument/detector anomalies.

What are the Deficiencies?

- Detector Differences
  - Detector differences between the 4 IASI FOVs are noticeable by some NWP centers. ECMWF only uses information from one detector.
- Instrument Noise
  - AIRS longwave channels have limited impact in the stratosphere.
  - IASI shortwave channels presently have limited use by NWP centers.
- Spatial Resolution
  - More clear FOVs.
  - More cloud information.
- Temporal Resolution
  - Data latency.
  - To properly assimilate mesoscale features, mesoscale spatial and temporal observations are needed.
  - Could be more regional.

What improved information is needed by the user?

- Reduction in instrument noise in critical sounding regions
  – As the data assimilation system improves, the instrument accuracy and precision must also improve.
- Long term instrument stability
- Improved detector consistency
  – Differences between detectors must be reduced.
  – Knowledge of radiometric biases and drift.
- Information on satellite/instrument health
  – Satellite/instrument health should be a part of the data stream so users can setup accept/reject criteria inside the assimilation system.
- Improved spatial and temporal resolution
  – More clear FOVs and potentially more cloud information.
  – Temporal resolution needs to keep pace with spatial resolution.

Questions ?

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