Assimilation of AIRS Data at NRL

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Data Use

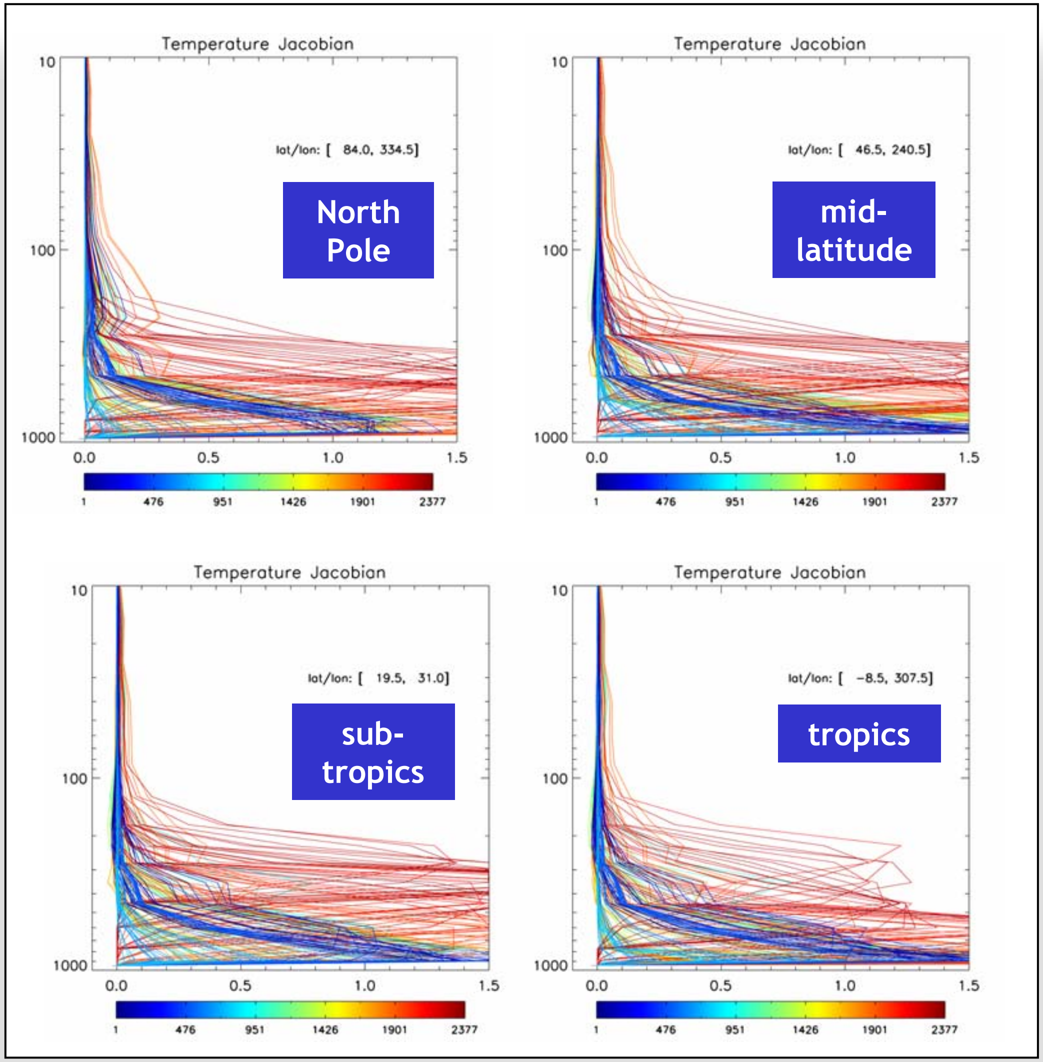
- AIRS-324 channel subset, U1 and U2 alternate golfballs
- Co-located with AMSU/A sensor, simultaneous assimilation
- Thinned to approximately 300km resolution
- Channels with sensitivity above model top (4mb) rejected
- Ozone sensitive channels rejected
- Near-infrared channel rejected in daytime
- Approximately 4million observations per 6 hour watch before thinning and quality control

Channel Selection

Examine Jacobians for T and O_3

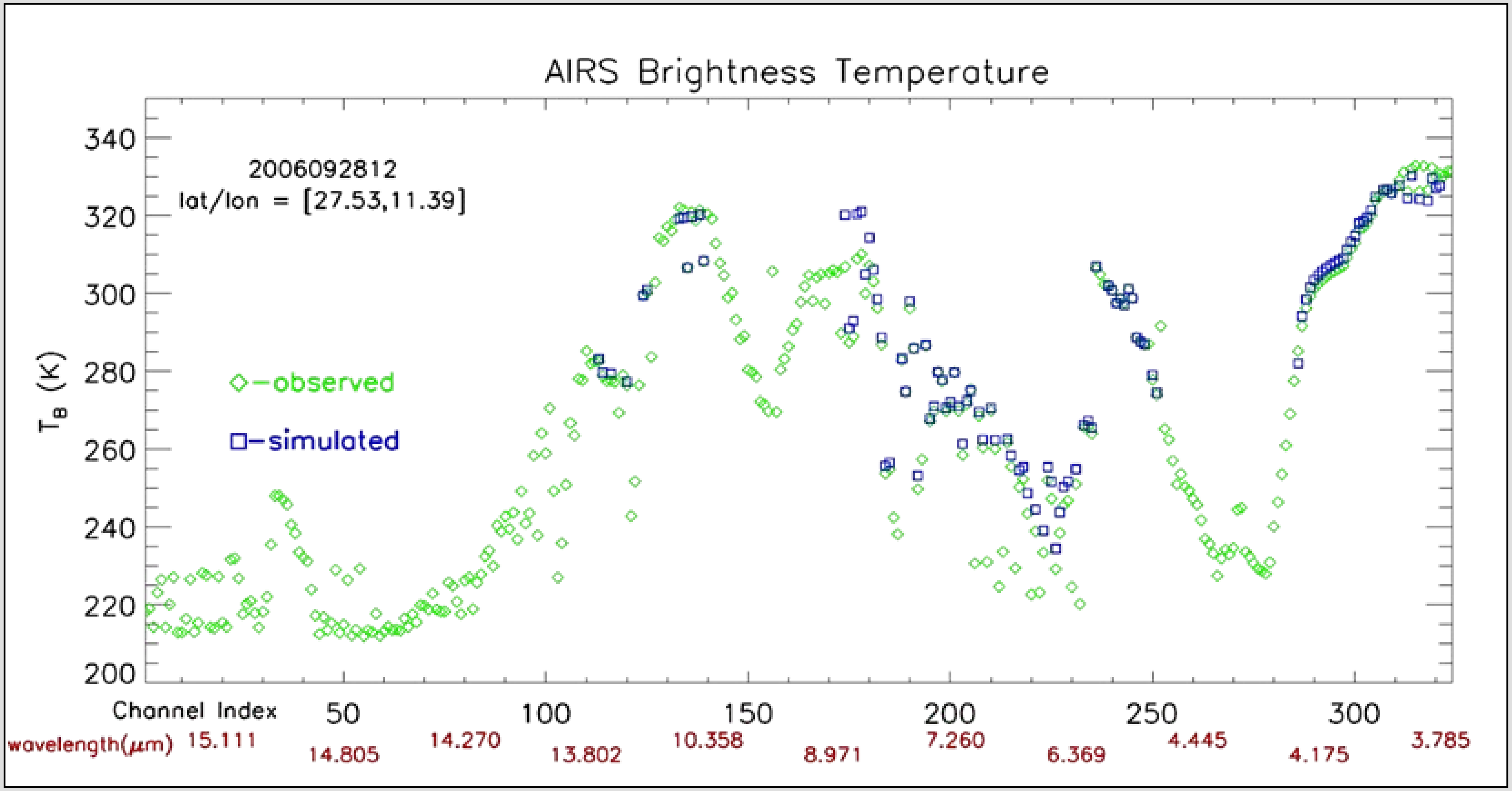
screen channels with temperature sensitivity above model top:
J(ch)/dln(p) > 0.1
at p ≤ 4hPa

or ozone sensitivity:
J(ch)/dln(p) > 0.1



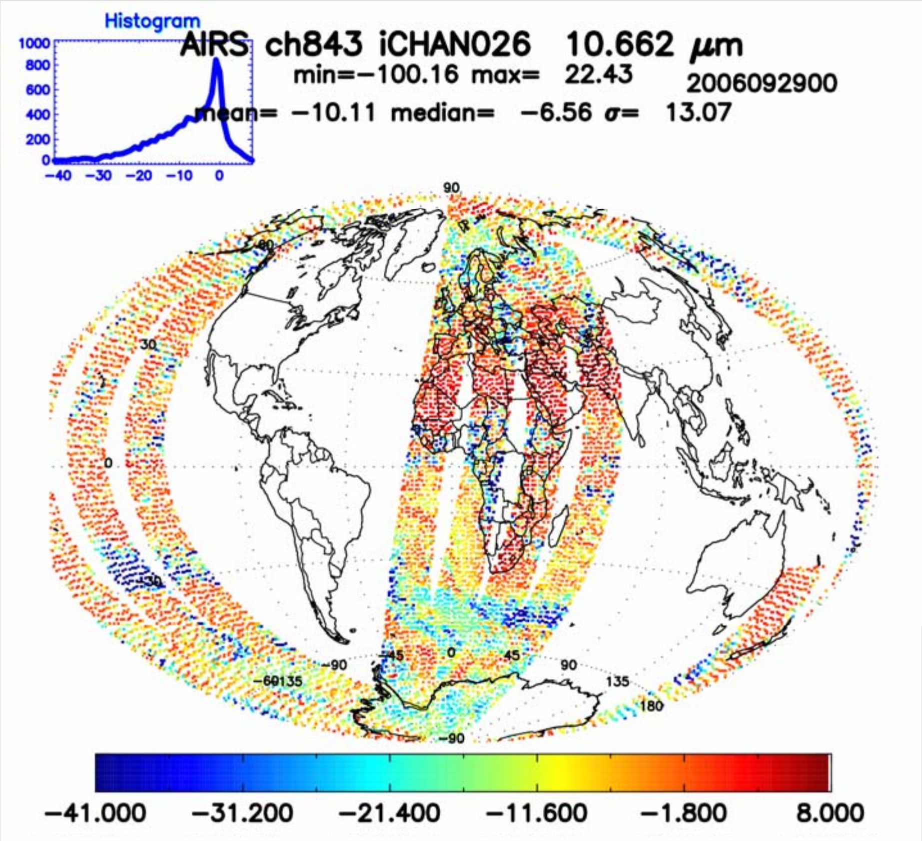
Channel Selection

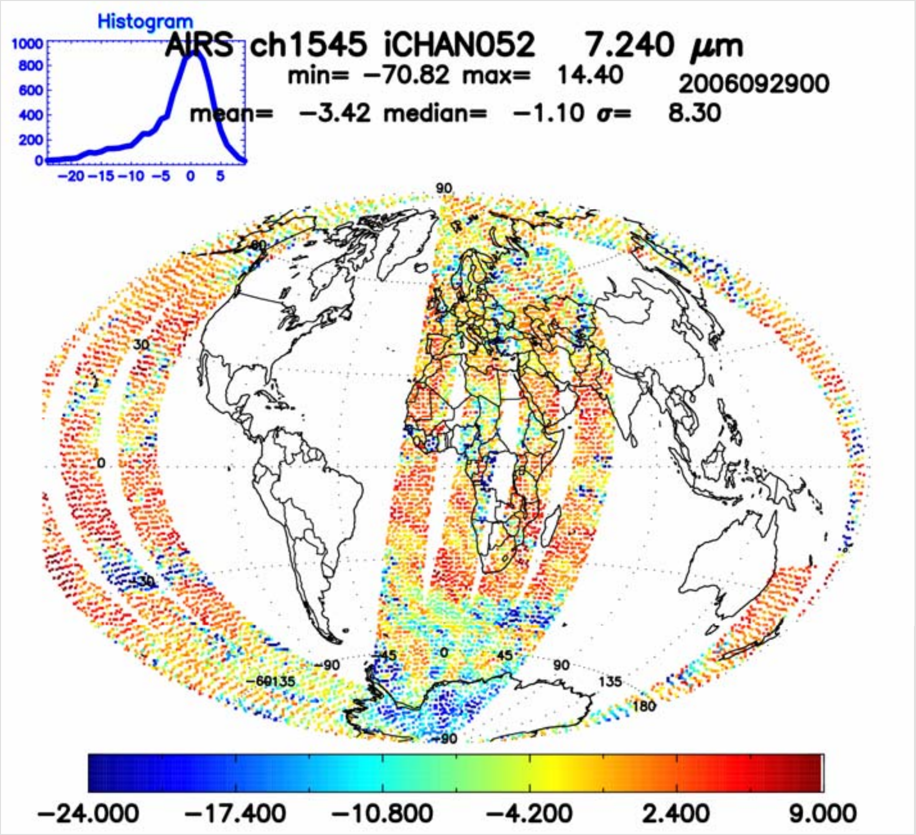
106 AIRS channels chosen



Data Thinning

thinned to ~300km resolution





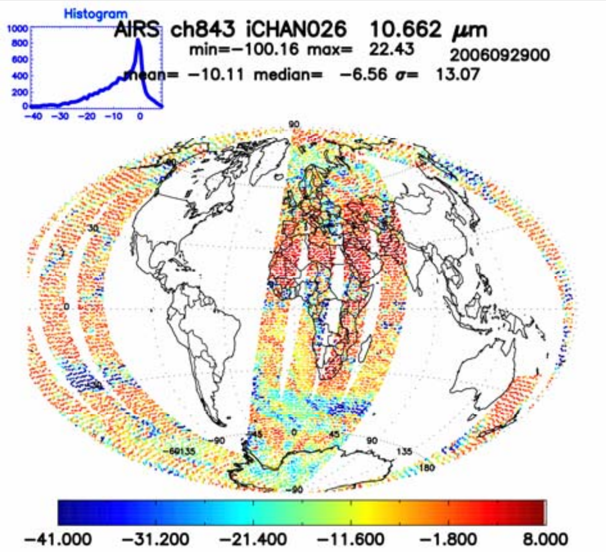
Quality Control

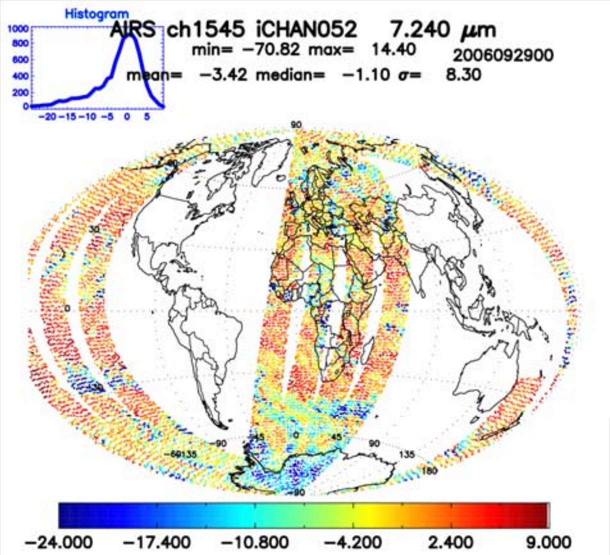
Radiances modeled using JCSDA-CRTM

- Histograms of observed minus simulated (ob-background)

not implemented

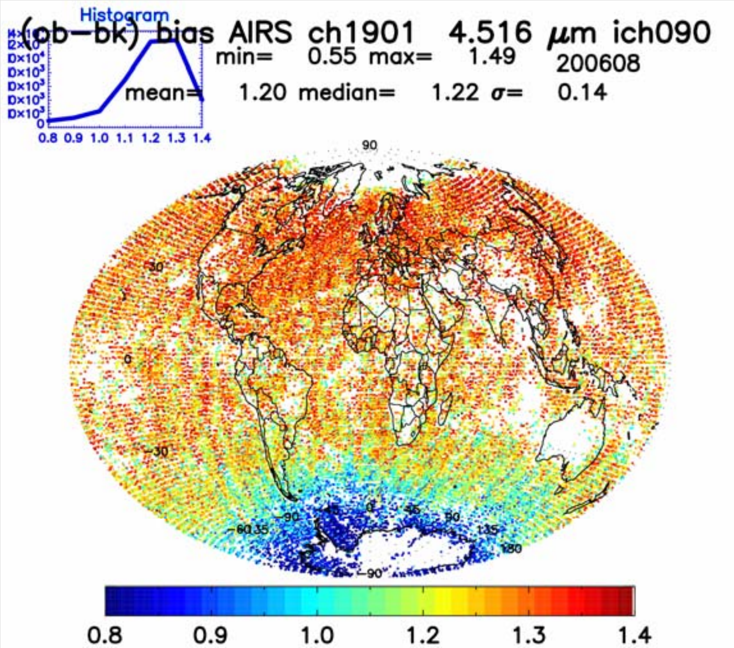
- Slope change in (ob-background) vs. channel rank
- Gross check on 2 window and 2 water vapor channels
- Individual checks for each channel based on ob error

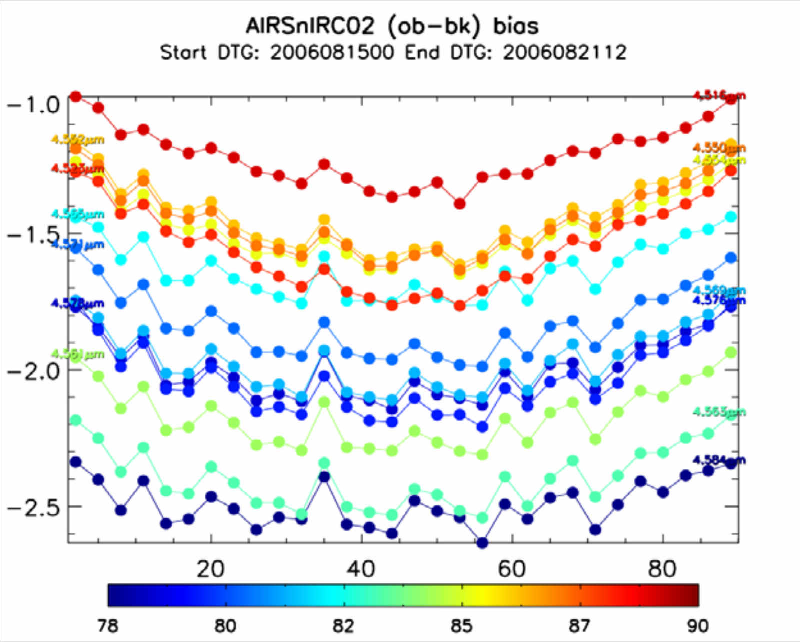




Bias Correction

- Correction updated dynamically 2-week sliding bin *(dynamic updating not implemented still tuning and running by hand)*
    - Global scan bias
    - Airmass correction (850mb - 200mb, 200mb - 50mb)

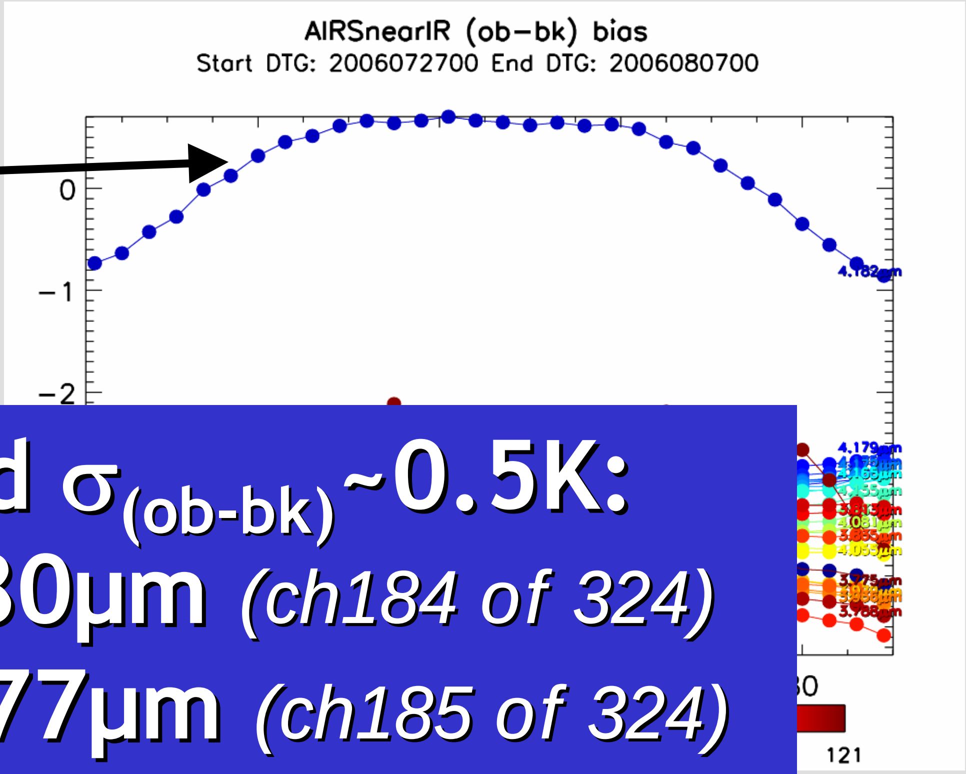




Bias Correction

Anomalies

scan bias:
ch2112 - 4.182 µm
(ch286 of 324)



ch2

(

really good $\sigma_{(ob-bk)}$~0.5K:
ch1400 7.680µm *(ch184 of 324)*
ch1401 7.677µm *(ch185 of 324)*
~1302 cm^{-1} ECMWF blacklisted due to N_20

Assimilation Strategy

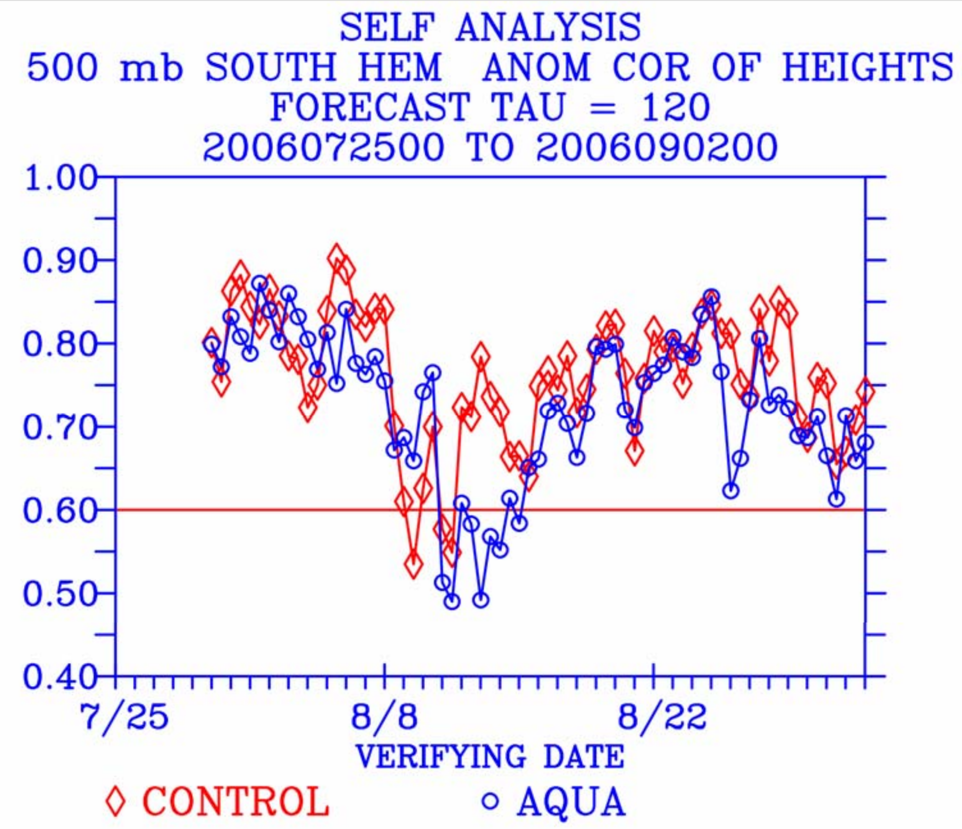
- NRL Atmospheric Variational Data Assimilation System (NAVDAS)
  - Backgrounds from NOGAPS forecast model
  - Radiances modeled using JCSDA-CRTM
  - NAVDAS assimilate radiances and their Jacobians to produce new analysis
  - NOGAPS forecast

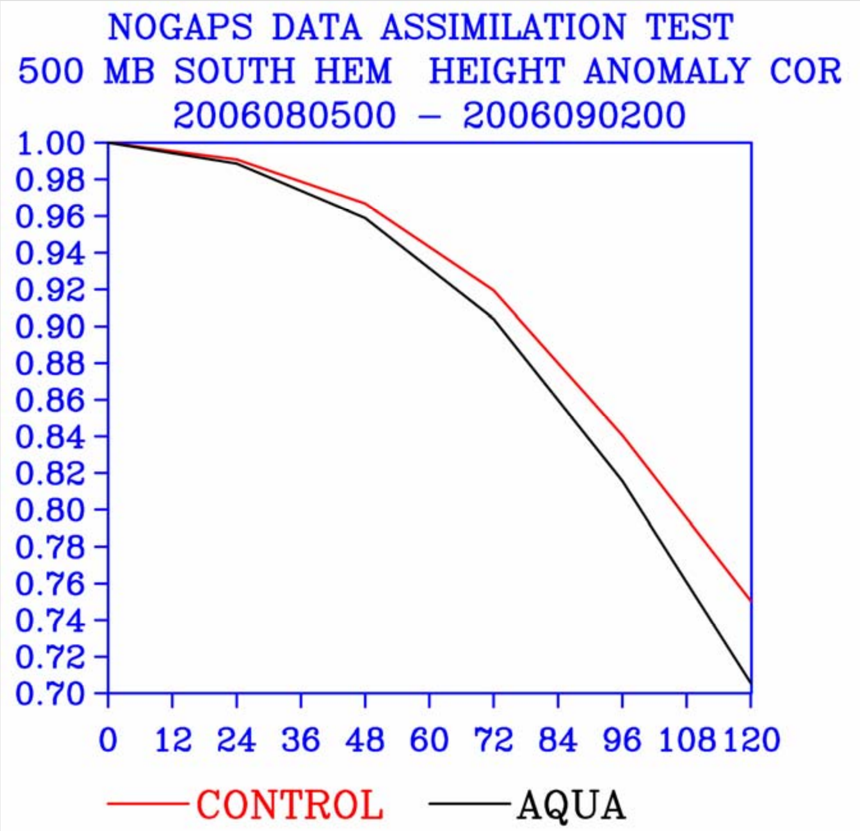
results pending

  - Sensitivity to particular radiances assessed with adjoints of the data assimilation system and forecast model

Forecast Impacts

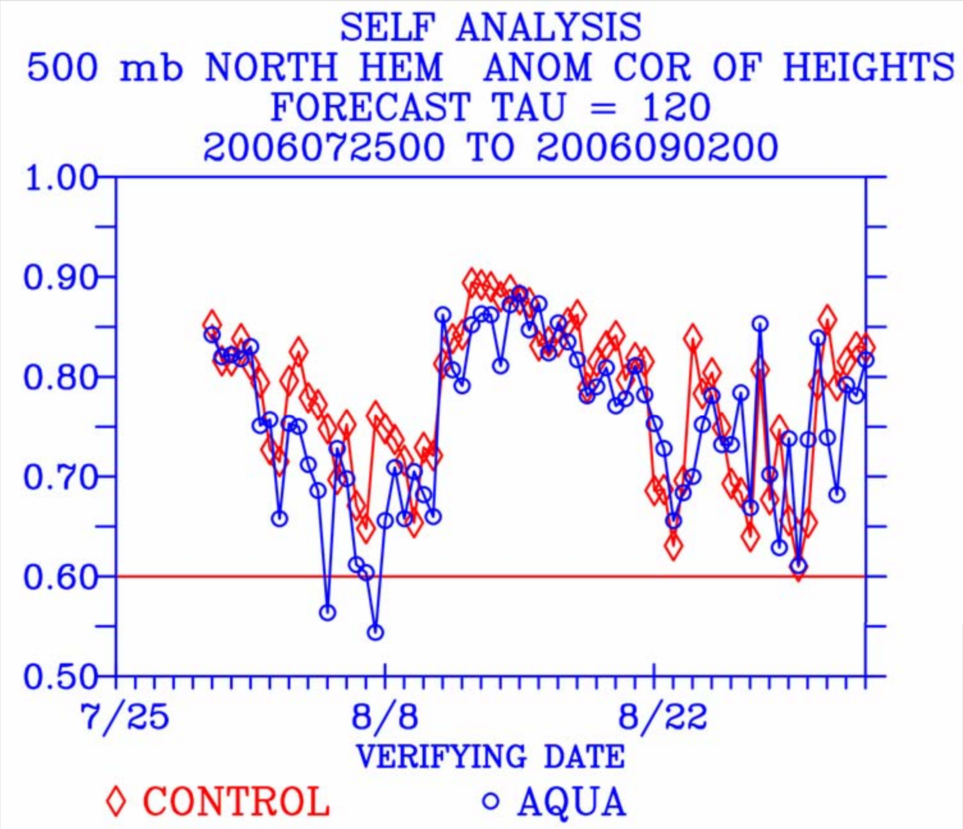
Southern Hemisphere

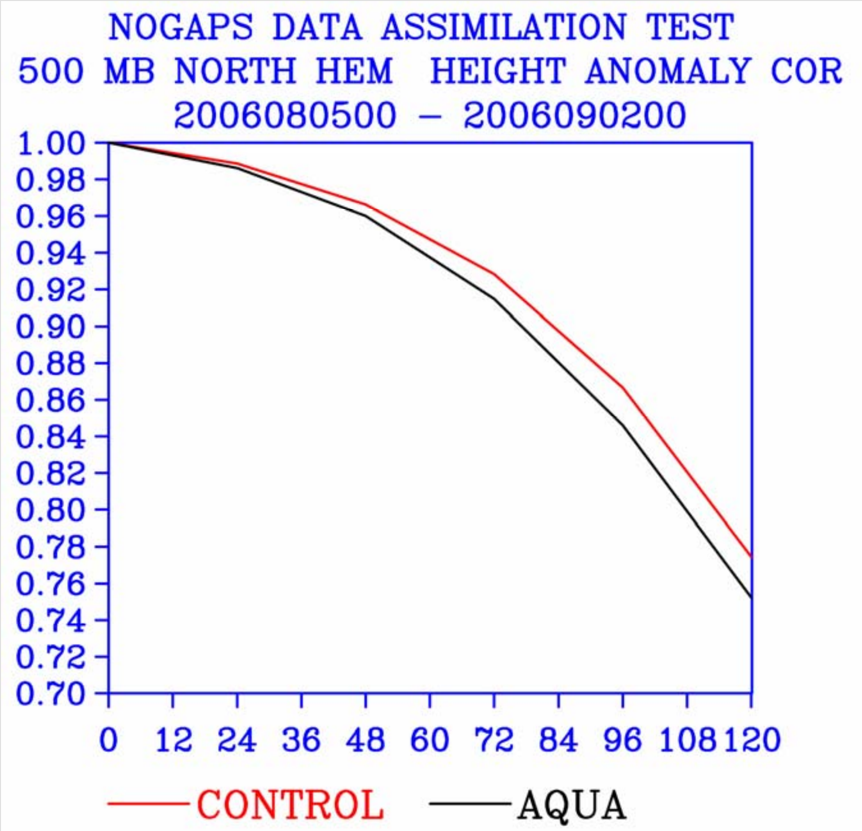




Forecast Impacts

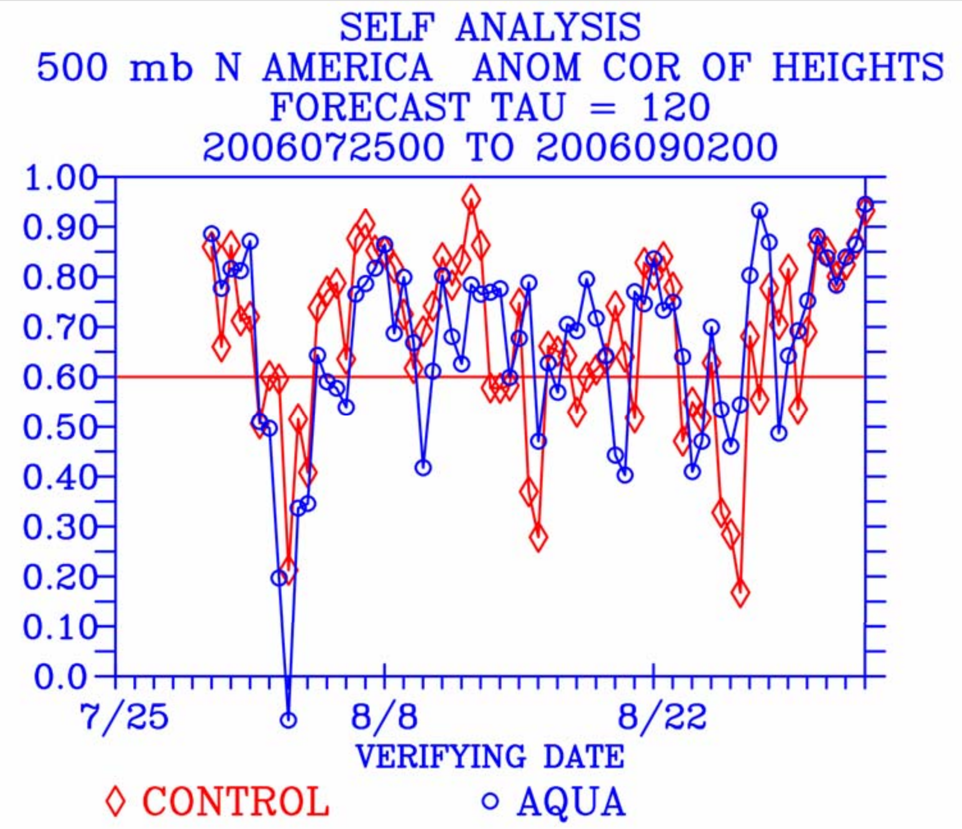
Northern Hemisphere

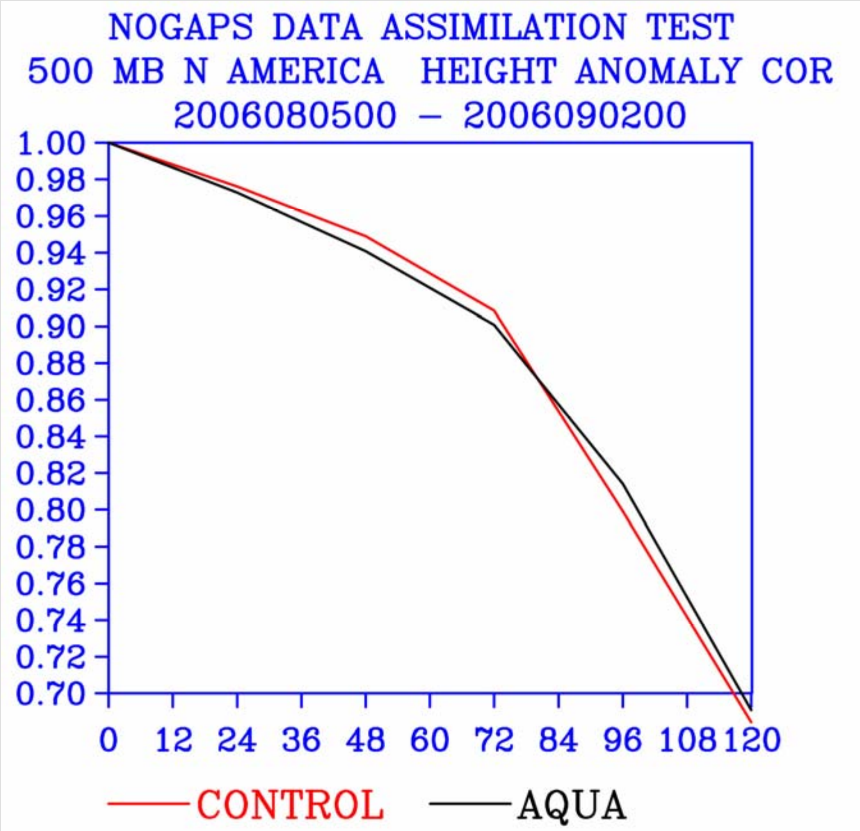




Forecast Impacts

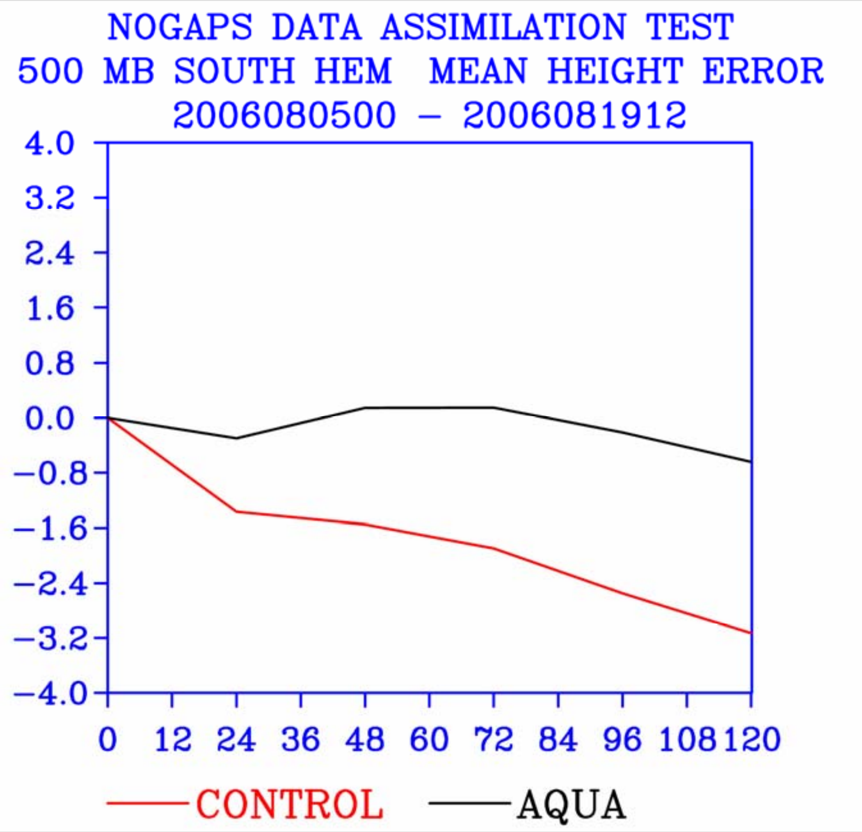
N. America

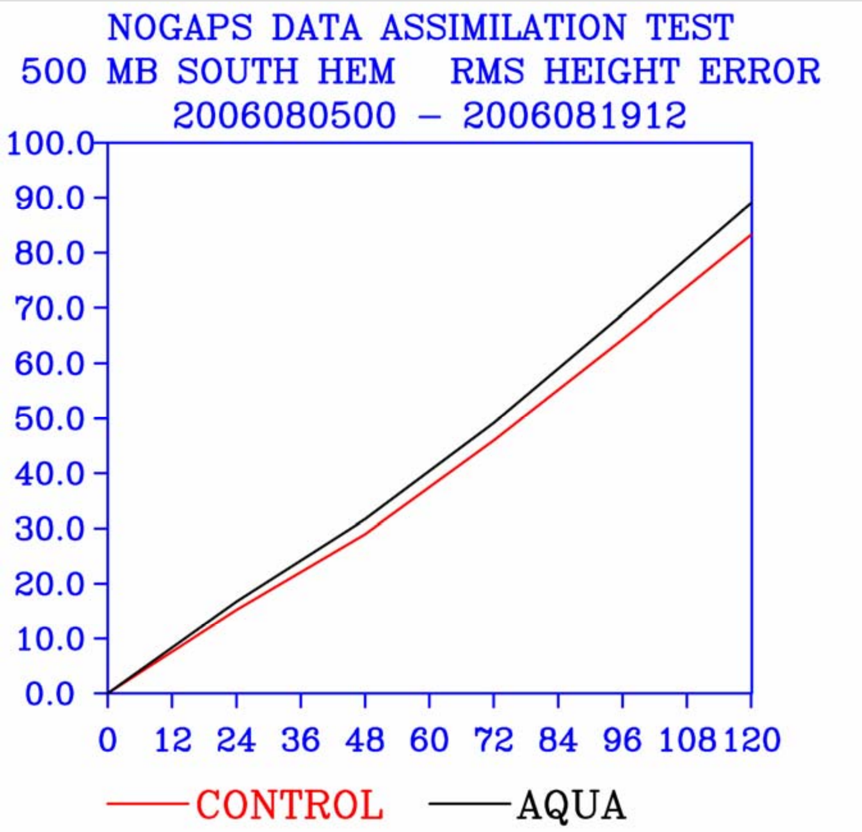




Forecast Impacts

Southern Hemisphere





Adjoint Sensitivities

- Sensitivity to radiances assessed with adjoints of NAVDAS & NOGAPS
- Energy-weighted forecast error norm (moist TE-norm)

C = matrix of energy-weighting coefficients

f = NOGAPS forecast

t = verifying NAVDAS / NOGAPS analysis

x = NOGAPS state vector (u, v, θ, q, p_t)

$$e_f = \left\langle \left(\mathbf{x}_f - \mathbf{x}_t\right)^T, \mathbf{C}\left(\mathbf{x}_f - \mathbf{x}_t\right) \right\rangle$$

e_f has units of J kg^{-1}

$\langle \, , \, \rangle$ = scalar inner product

Langland and Baker (Tellus, 2004), slide courtesy of Rolf Langland

Ob Impact Calculation (1)

NAVDAS analysis and background

FNMOC ops

$$\mathbf{x}_a \,(00\text{UTC}), \quad \mathbf{x}_b \,(6h \text{ fcst from } 18\text{UTC})$$

NOGAPS forecasts & error norms

T239L30, full physics

$$\begin{cases} \mathbf{x}_{24} = M(\mathbf{x}_a) \\ \mathbf{x}_{30} = M(\mathbf{x}_b) \end{cases}$$

Forecast errors

NOGAPS adjoint

T239L30, includes large-scale precip

$$\begin{cases} \partial e_{24} / \partial \mathbf{x}_a = \mathbf{L}^T \left[C\left(\mathbf{x}_{24} - \mathbf{x}_t \right) \right] \\ \partial e_{30} / \partial \mathbf{x}_b = \mathbf{L}^T \left[C\left(\mathbf{x}_{30} - \mathbf{x}_t \right) \right] \end{cases}$$

Sensitivity gradients in model grid-point space

Langland and Baker (Tellus, 2004), slide courtesy of Rolf Langland

Ob Impact Calculation (2)

Sensitivity gradient in observation space

NAVDAS adjoint

0.5 deg, current to ops version of NAVDAS

$$\frac{\partial\left(e_{24}-e_{30}\right)}{\partial\left(\mathbf{y}-\mathbf{Hx}_{\mathrm{b}}\right)}=\mathbf{K}^{T}\left[\frac{\partial e_{24}}{\partial \mathbf{x}_{\mathrm{a}}}+\frac{\partial e_{30}}{\partial \mathbf{x}_{\mathrm{b}}}\right]$$

Observation Impact

(J kg^{-1})

$$\delta e_{24}^{30}=\left\langle\left(\mathbf{y}-\mathbf{Hx}_{\mathrm{b}}\right),\frac{\partial\left(e_{24}-e_{30}\right)}{\partial\left(\mathbf{y}-\mathbf{Hx}_{\mathrm{b}}\right)}\right\rangle$$

Innovations assimilated for Xa

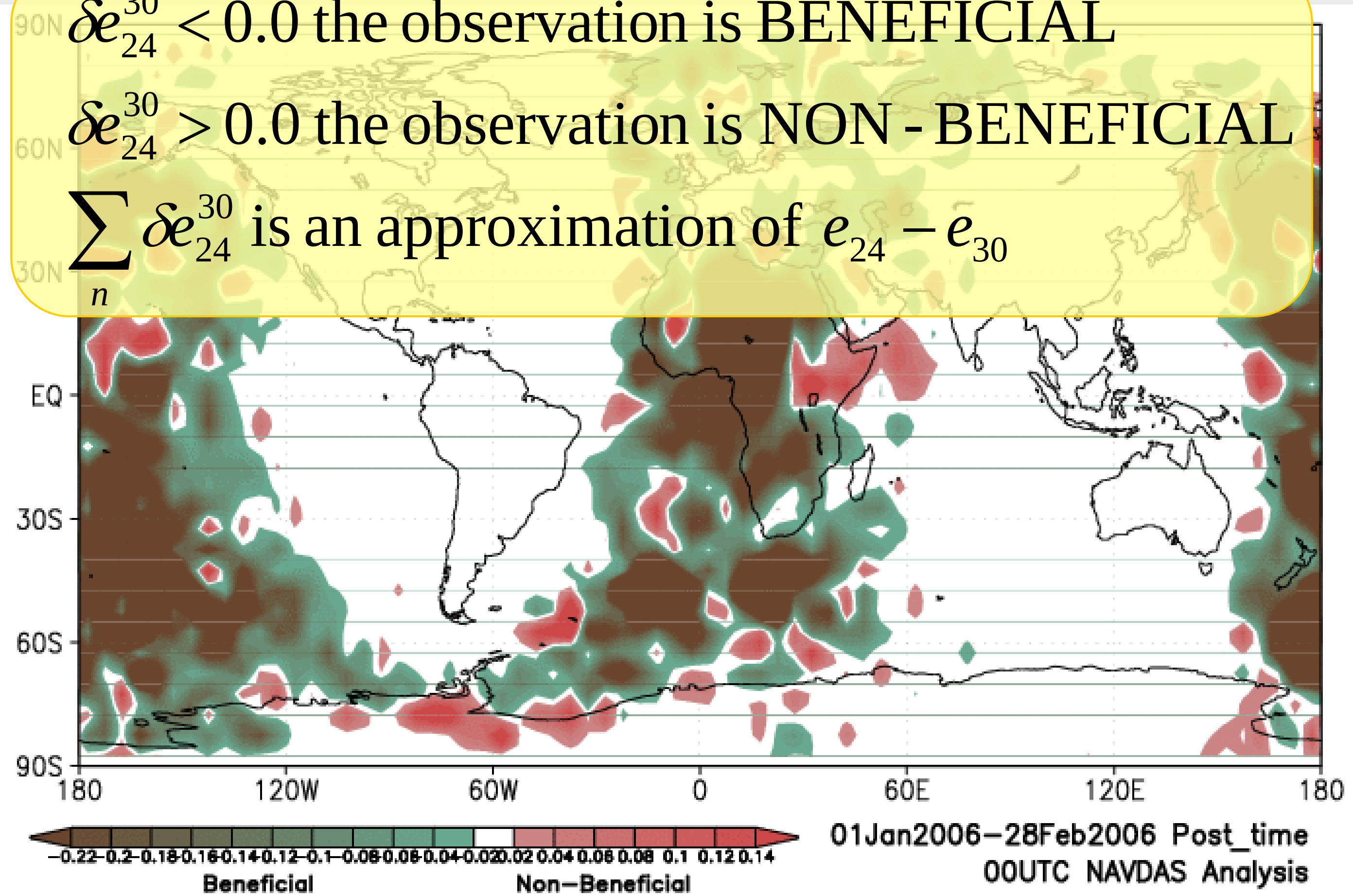
Langland and Baker (Tellus, 2004), slide courtesy of Rolf Langland

Observation Impact

$$\delta e_{24}^{30} < 0.0 \text{ the observation is BENEFICIAL}$$

$$\delta e_{24}^{30} > 0.0 \text{ the observation is NON-BENEFICIAL}$$

$$\sum_{n} \delta e_{24}^{30} \text{ is an approximation of } e_{24} - e_{30}$$



10^{-1} J kg^{-1}

AMSU-A NOAA-18: Ch 6 (peak near 350mb)

Future Plans

- Include surface sensitive radiances
- Implement BRDF for use of daytime near-IR (~4µm)
- Extend methodology for use of AMSU-A/IASI
- Add ozone assimilation, and turn on ozone sensitive channel
- Begin testing with NAVDAS-AR (Accelerated Representer) the NRL next generation 4DVAR
    - ob-error correlation?
- Test use with NOGAPS-ALPHA*
- Implement with ATMS/CrIS

*Advanced-Level Physics and High Altitude