# Observation Impact and Satellite Channel Selection

## JCSDA Project

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# 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, $p_t$)

$$e_f = \left\langle \left(\mathbf{x}_\mathrm{f} - \mathbf{x}_\mathrm{t}\right)^T, \mathbf{C}\left(\mathbf{x}_\mathrm{f} - \mathbf{x}_\mathrm{t}\right) \right\rangle$$

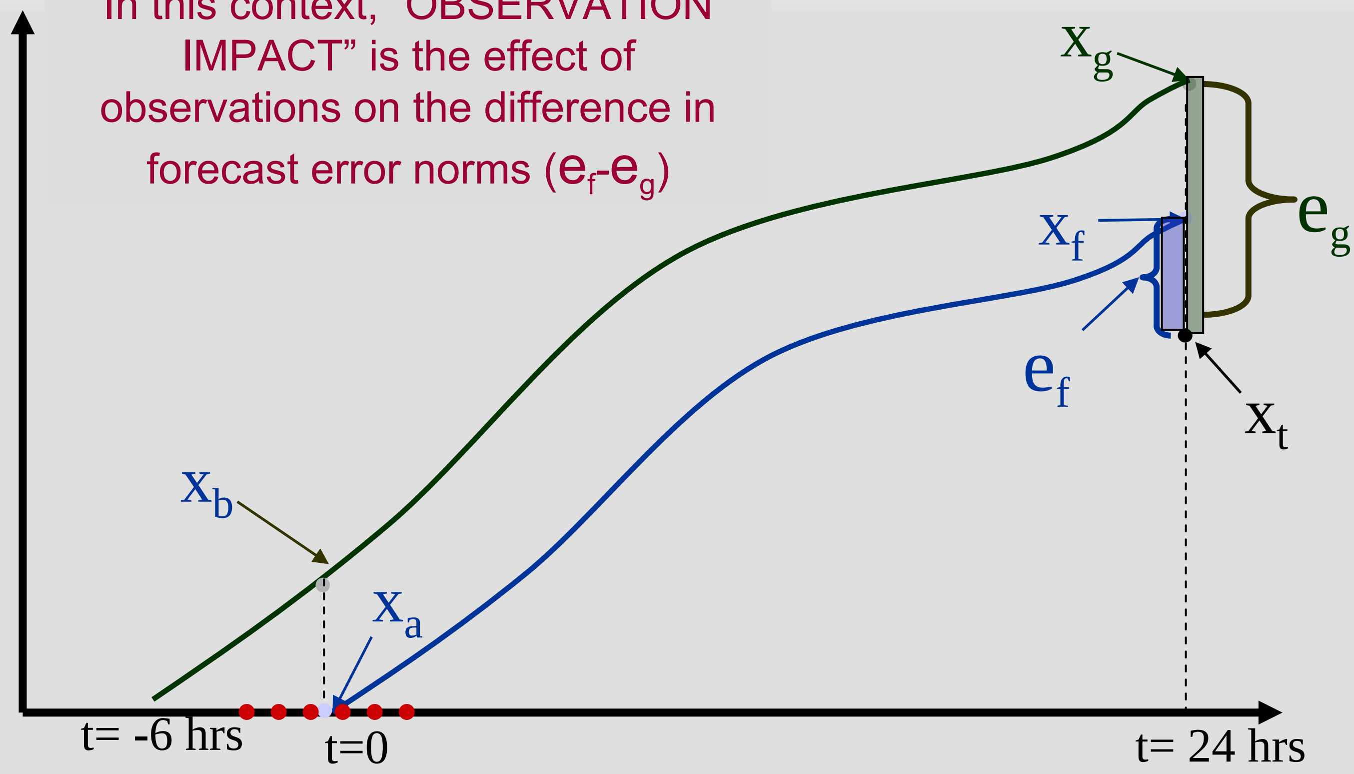
$e_f$ has units of J $\mathrm{kg}^{-1}$

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

# Observation Impact Concept

Observations move the forecast from the **background trajectory** to the **trajectory starting from the new analysis**

In this context, "OBSERVATION IMPACT" is the effect of observations on the difference in forecast error norms ($e_f$-$e_g$)




**6 hr assimilation window**

*Langland and Baker (Tellus, 2004)*

# Observation Impact Equation

$$\delta e_f^g = \left\langle (\mathbf{y} - \mathbf{H}\mathbf{x}_\mathrm{b}), \mathbf{K}^\mathrm{T} \left\{ \frac{\partial e_f}{\partial \mathbf{x}_\mathrm{a}} + \frac{\partial e_g}{\partial \mathbf{x}_\mathrm{b}} \right\} \right\rangle$$

- We use a moist total energy forecast error norm, *f*=24h, *g*=30hr
- Forecasts are made with NOGAPS-NAVDAS.
- Adjoint versions of NOGAPS-NAVDAS are used to calculate observation impact
- The impact of observation subsets (e.g., separate channels, or separate satellites can be easily quantified)

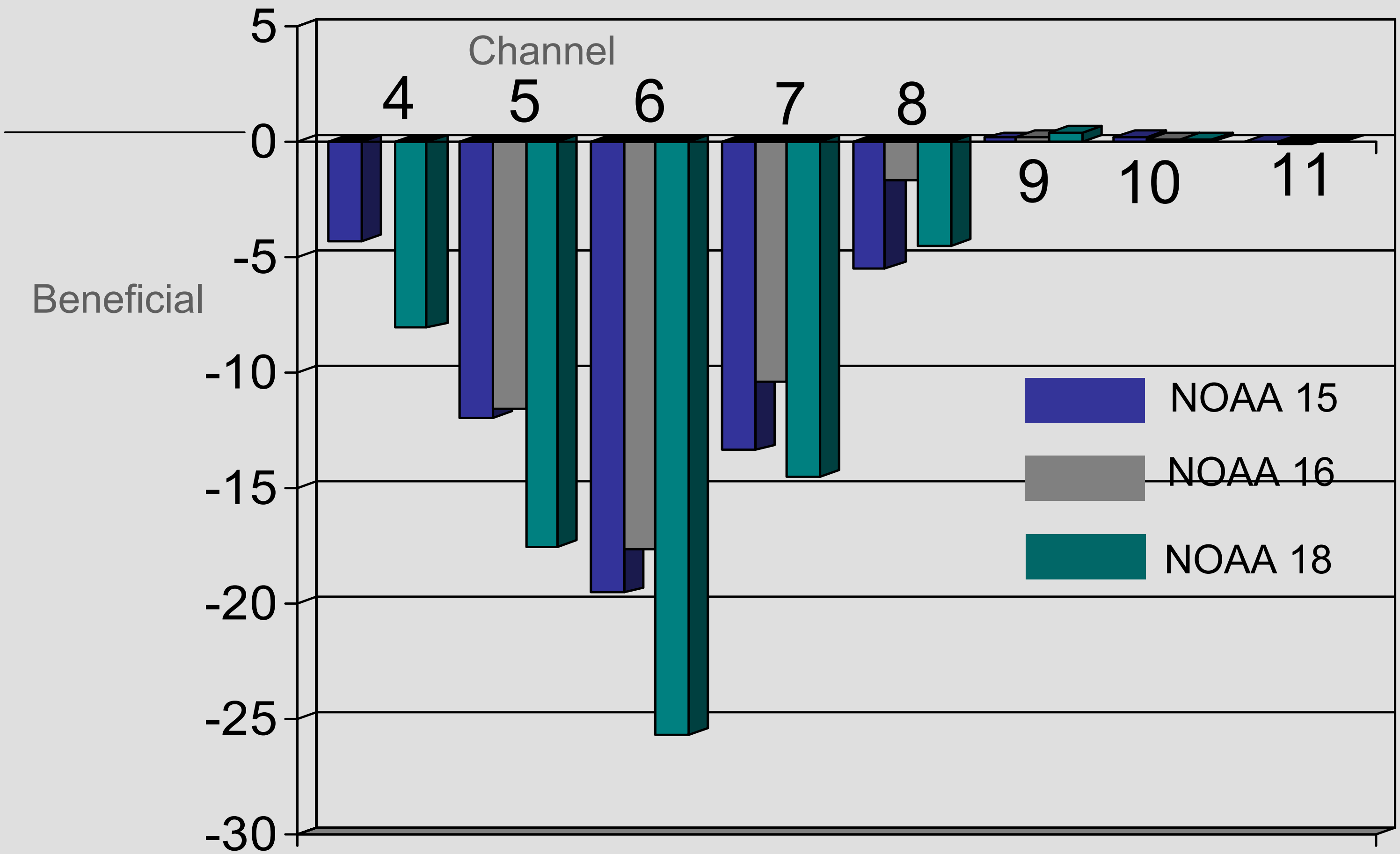
$$\delta e_f^g < 0.0 \text{ the observation is BENEFICIAL}$$

$$\delta e_f^g > 0.0 \text{ the observation is NON-BENEFICIAL}$$

# Impact for AMSU-A channels - NAVDAS-NOGAPS

**1 – 31 Jan 2007, 00,06,12,18 UTC**

Units of impact = J $kg^{-1}$




**Ch. peak near**

**11: 20mb**

**10: 50mb**

**9: 90mb**

**8: 150mb**

**7: 250mb**

**6: 350mb**

**5: 600mb**

**4: surface**

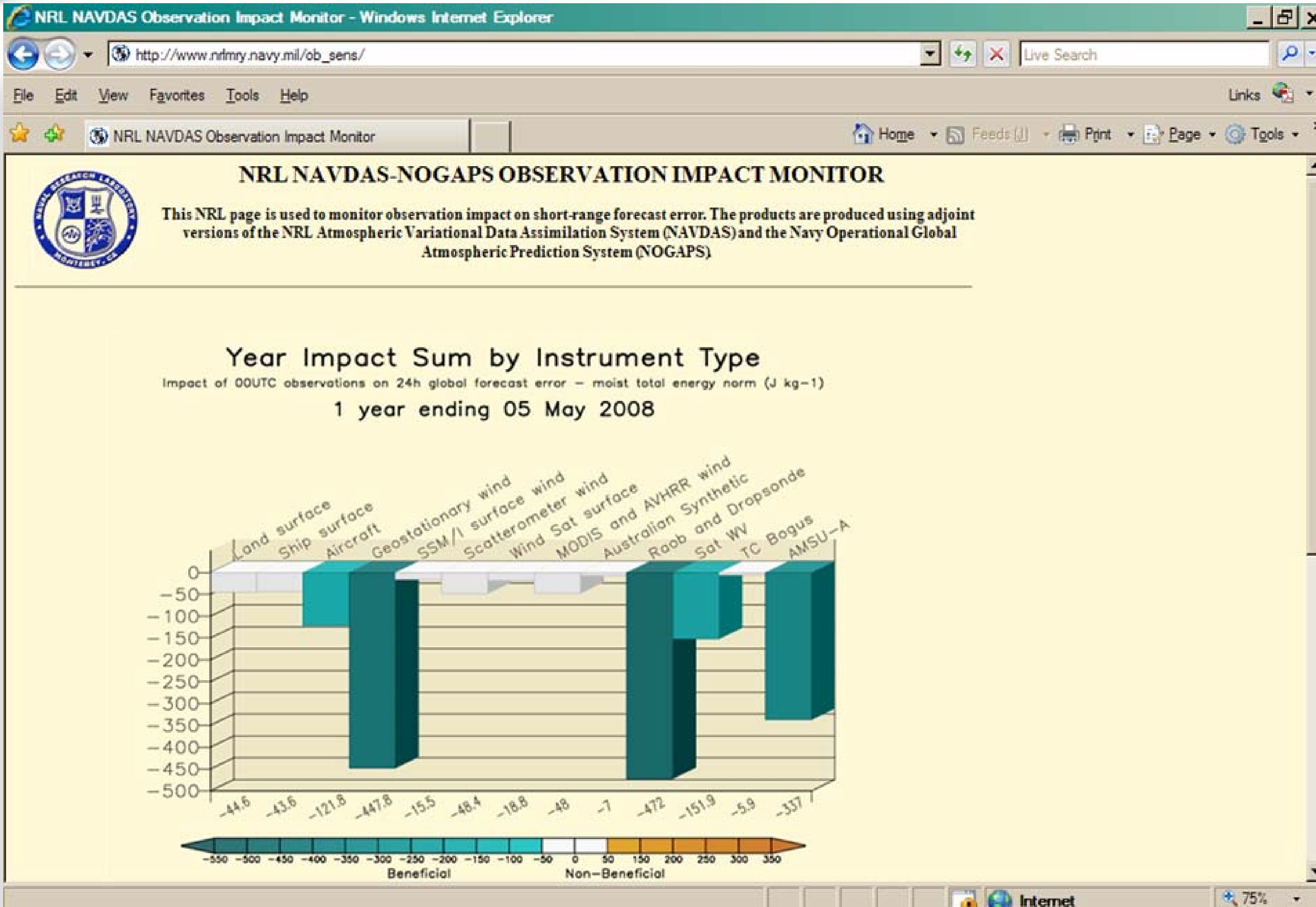
# Why do some "good data" have non-beneficial impact ?

- Observation and background error statistics for data assimilation cannot be precisely specified
- This implies a statistical distribution of beneficial and non-beneficial observation impacts
- Assimilating the global set of observations improves the analysis and forecast, even though 40-50% of observation data are non-beneficial in any selected assimilation

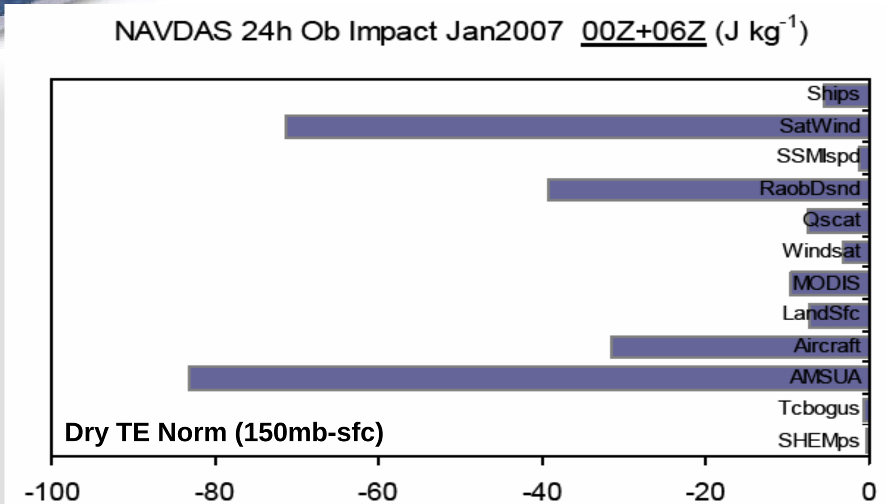
Information about the impact of individual observations and subsets of observations can be used to improve the data assimilation and observation selection procedures

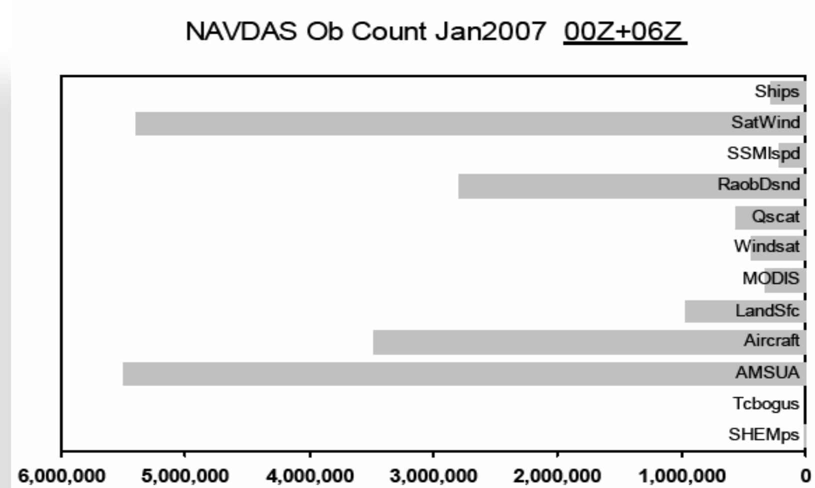
# On-line Observation Impact monitor

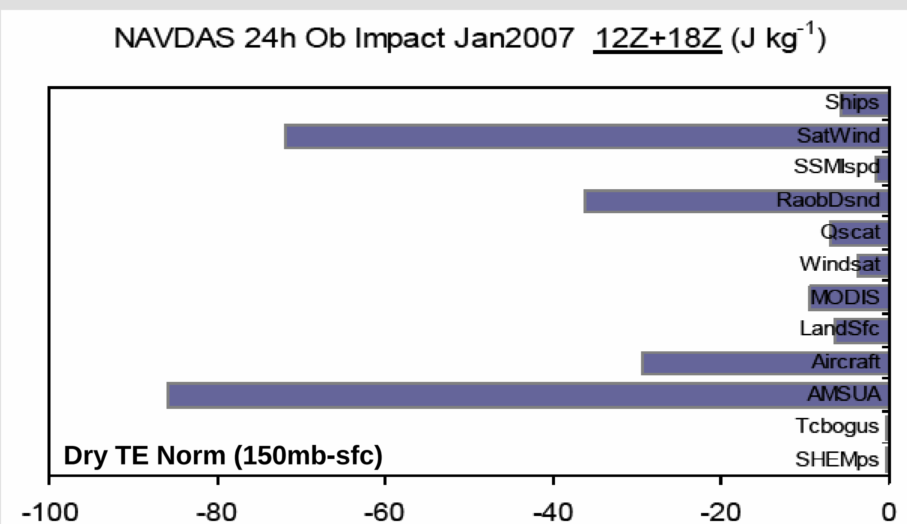
**www.nrlmry.navy.mil/ob_sens/**

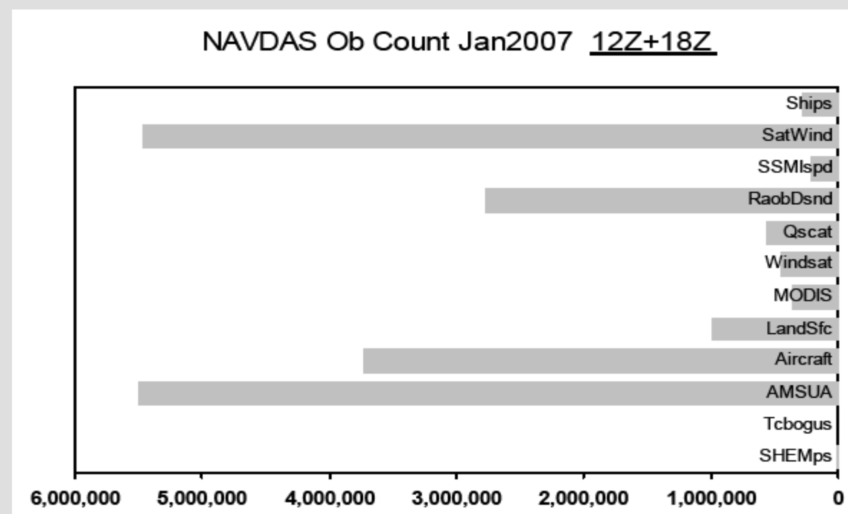


# Total impact by instrument type – Jan2007

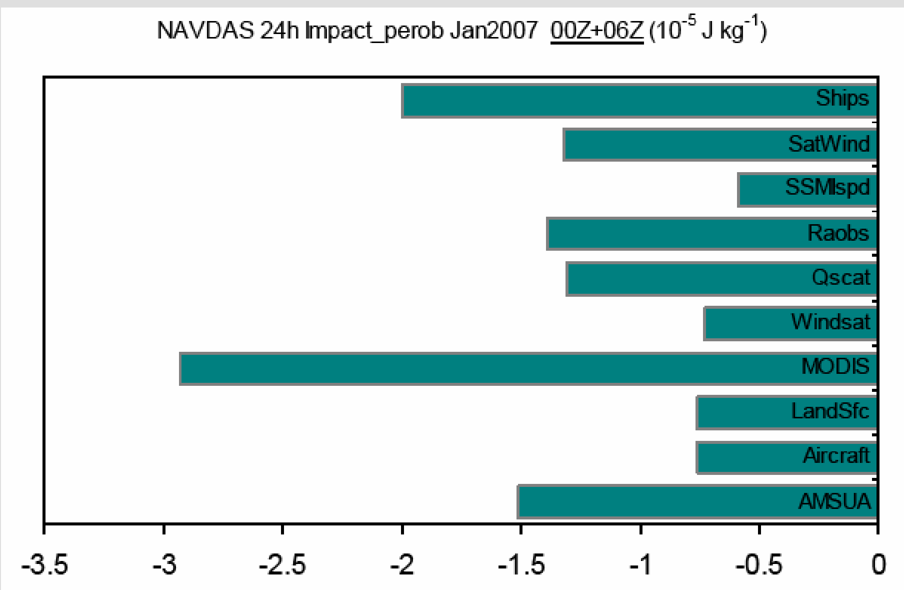


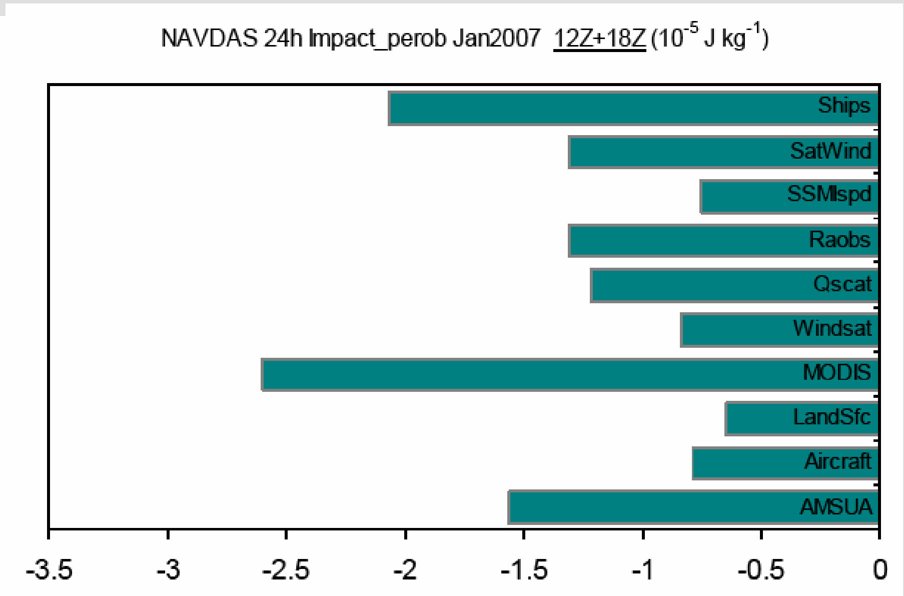



# Impacts per-observation by instrument type

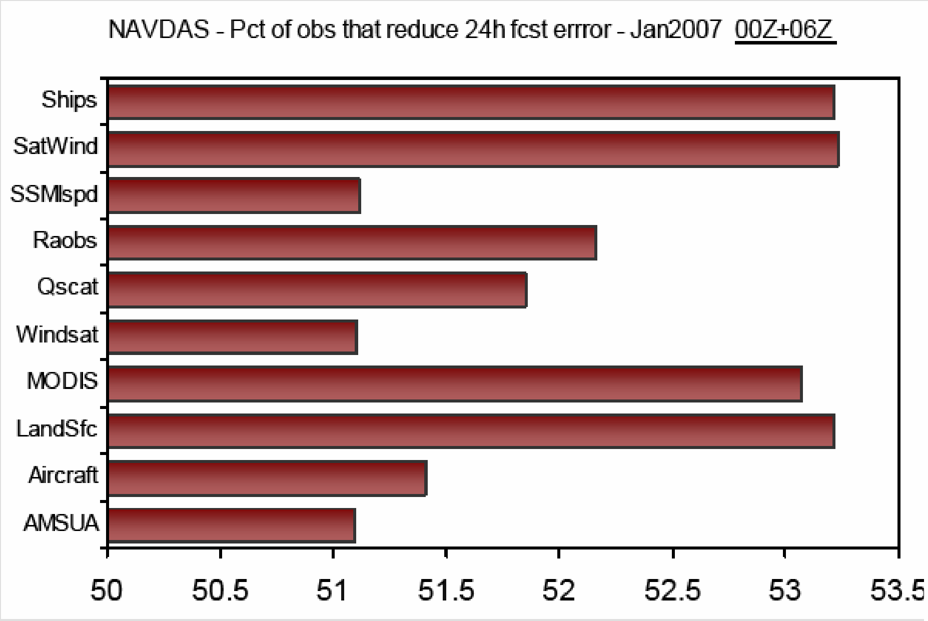


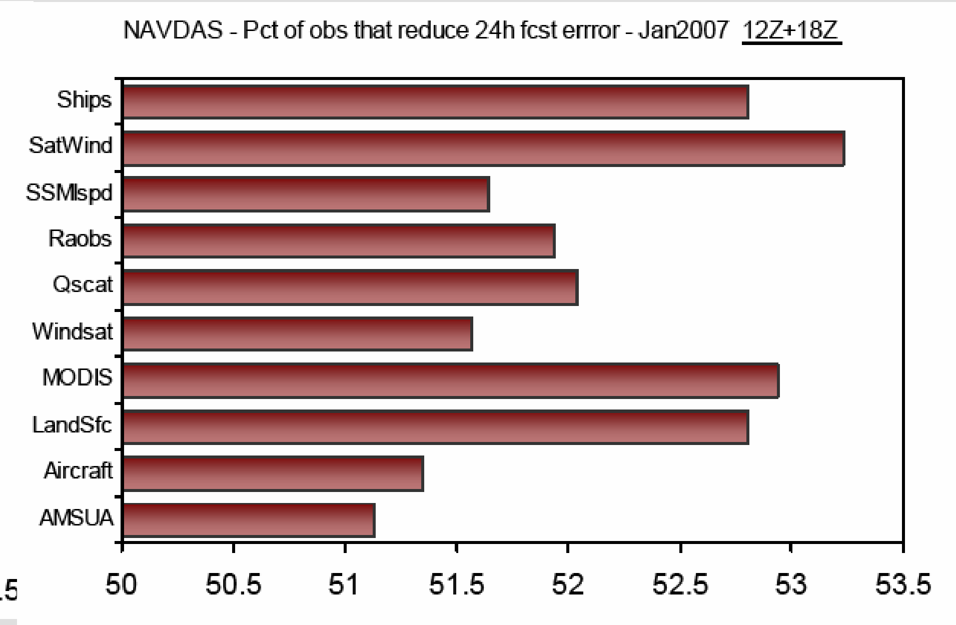

$10e^{-5}$ J $kg^{-1}$




$10e^{-5}$ J $kg^{-1}$

# Percent of observations that produce forecast error reduction ($e_{24} - e_{30} < 0$)



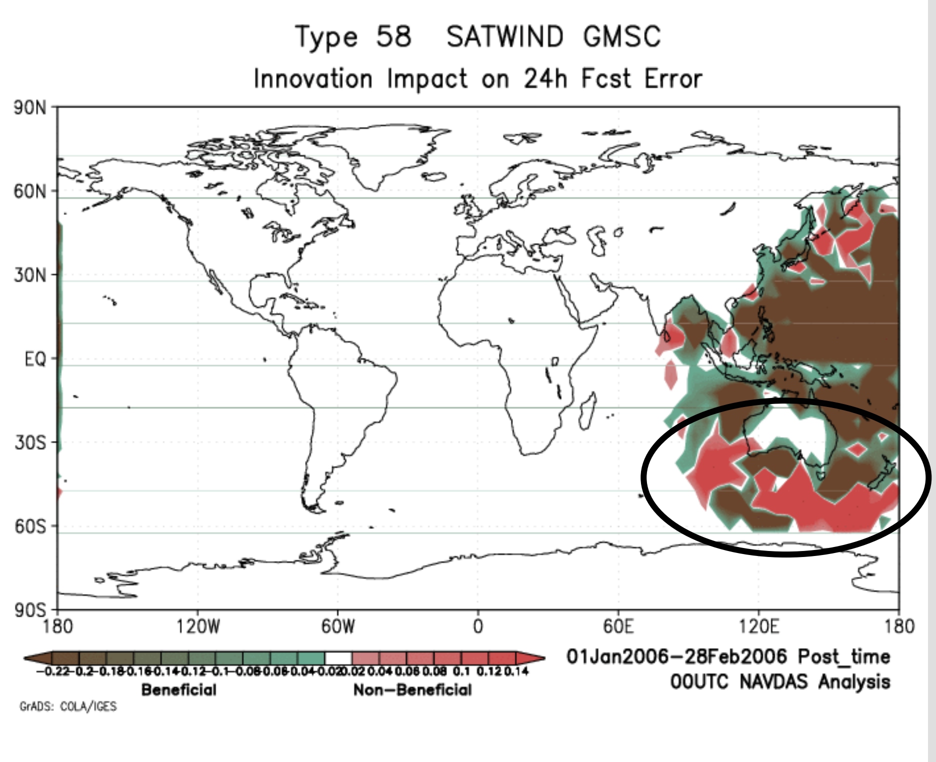



# Example: SATWIND data processing problem identified

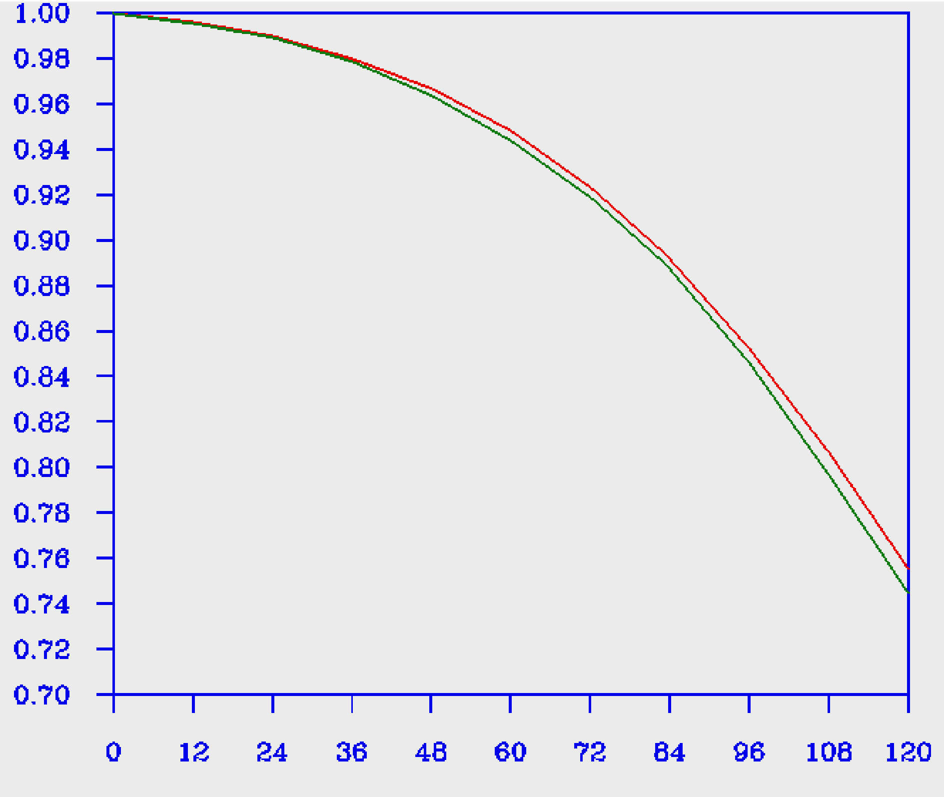
**Date**: Jan-Feb 2006

**Issue**: Large innovations and non-beneficial impact from satwinds at edge of coverage area

**Action Taken**: Ob data removed if > 39° from satellite sub-point – gave 3-hr improvement in SHEM NOGAPS forecast skill



# Restricting SSEC MTSAT Winds
# 500 mb Height Anomaly Correlation

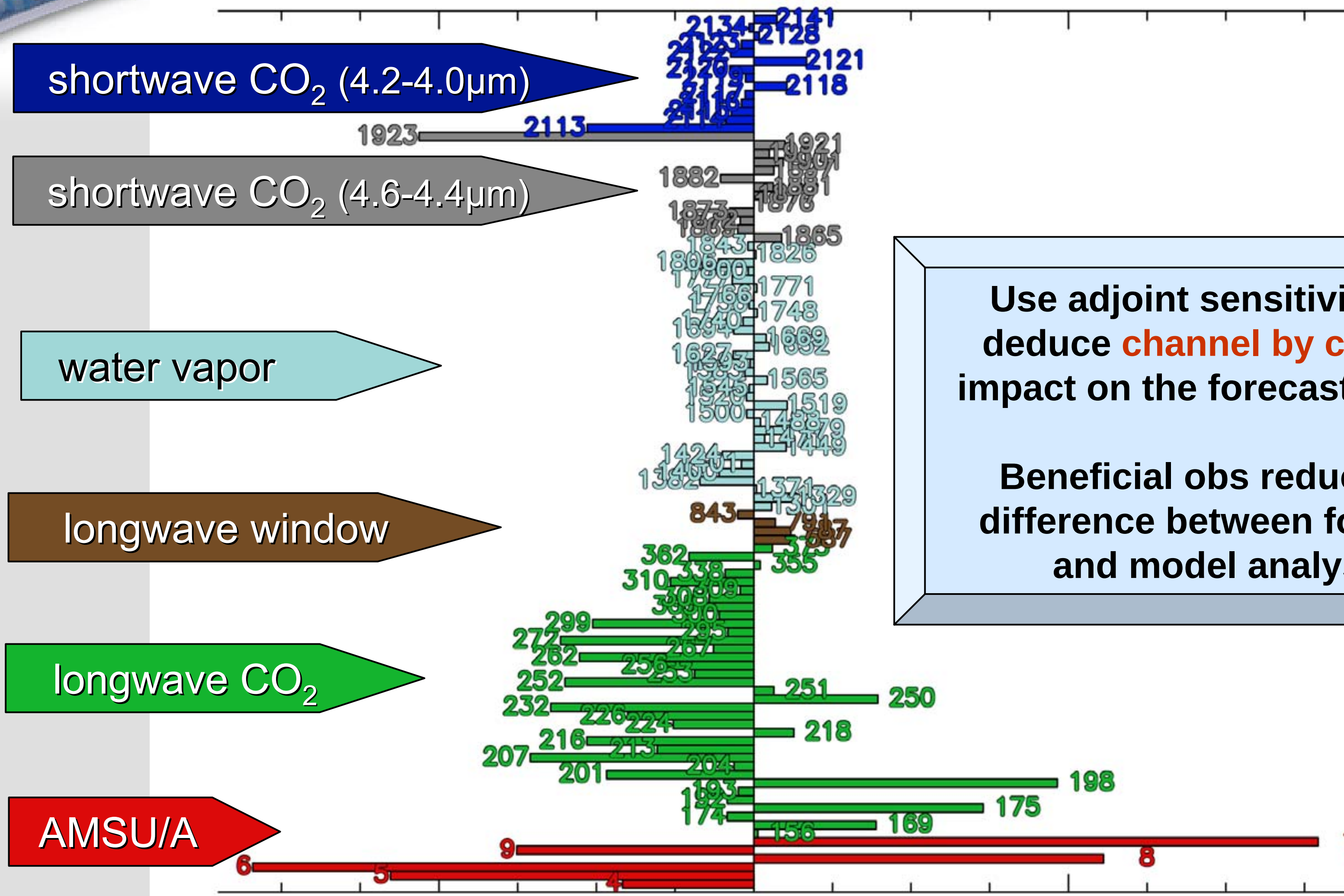



Southern Hemisphere

**Restricted Winds** **Control**

**February 16 – March 27, 2006**

# AIRS and AMSU Observation Impact
# Aug 17-31, 2006




**Use adjoint sensitivities to deduce channel by channel impact on the forecast system**

**Beneficial obs reduce the difference between forecast and model analysis**

Beneficial **reduction ← error → increase** Non-beneficial

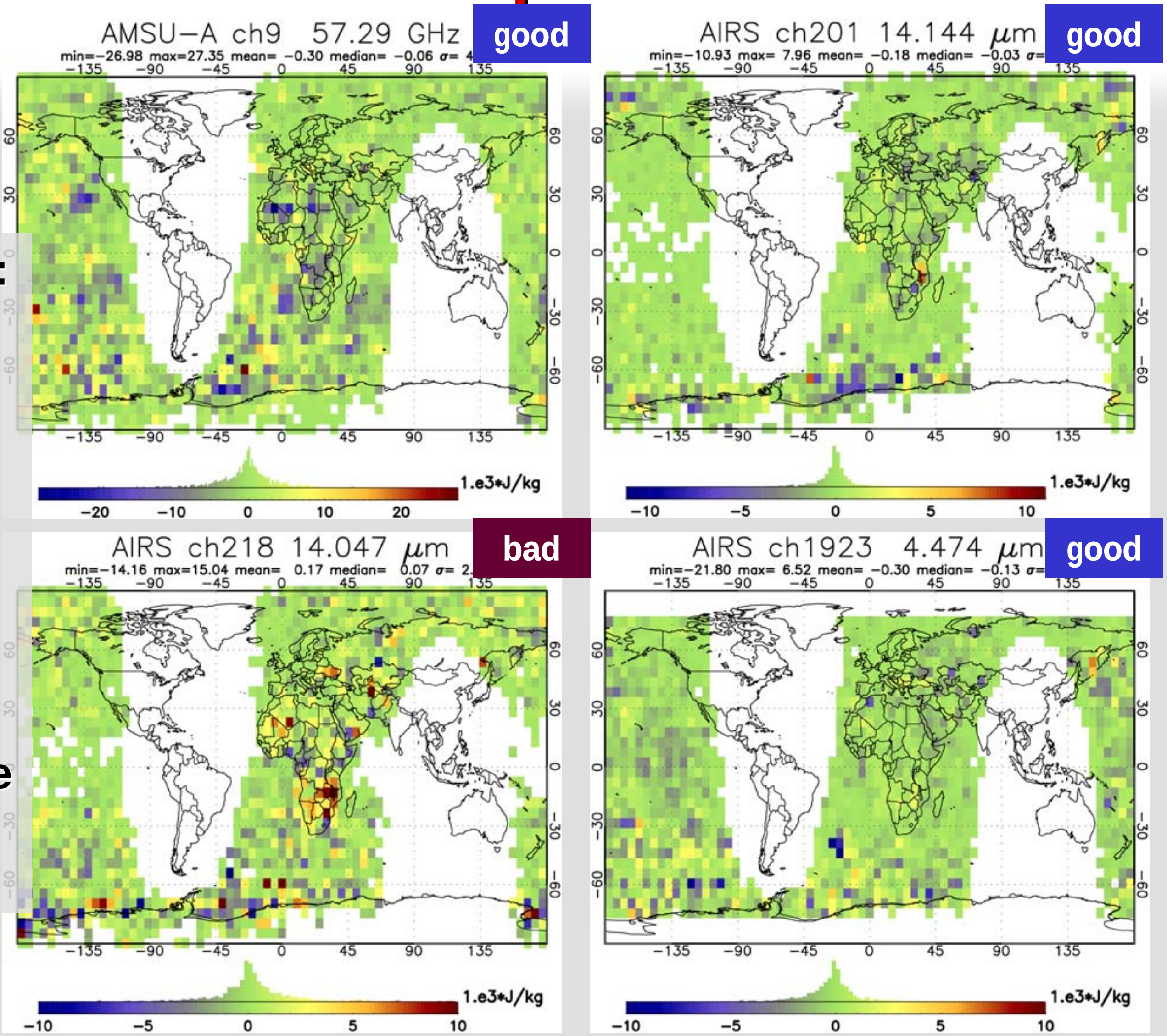
# Observation Impact

**Ob sensitivity summary:**

**Aug 15-26, 2006**

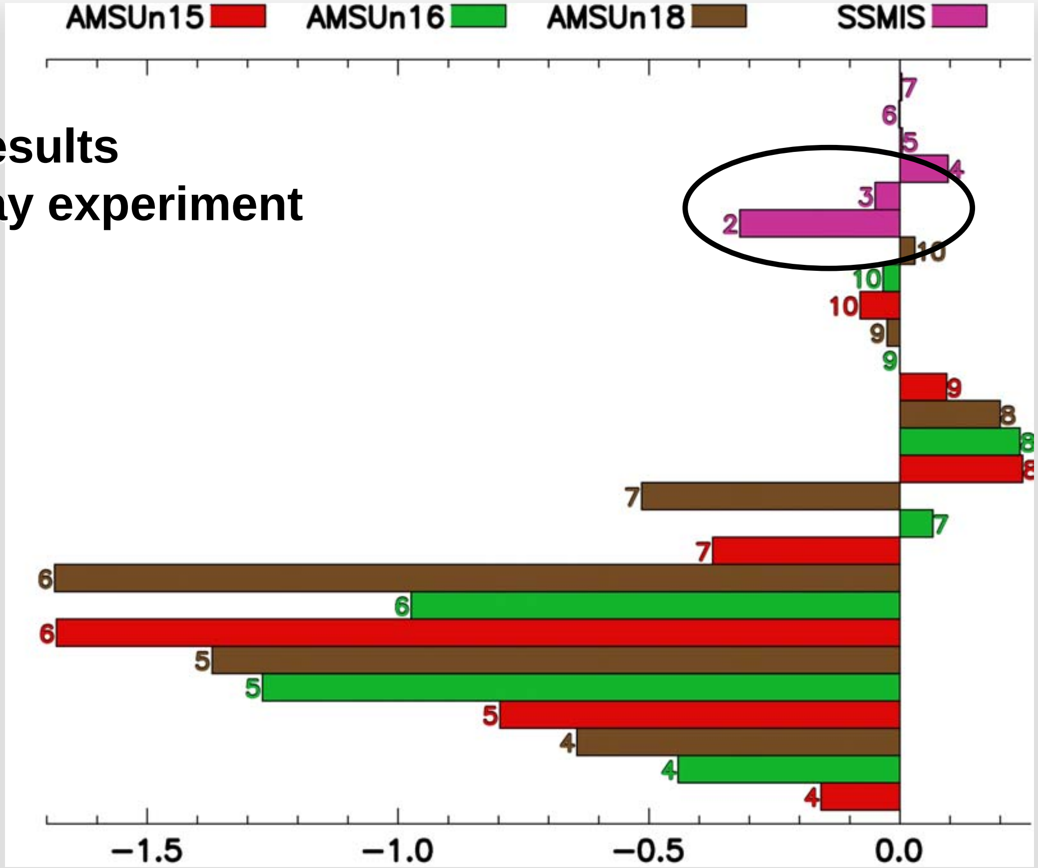
**spatial distribution shows strong impacts are generally outliers**

**beneficial channels have slightly positively skewed distributions**



# Observation Impact

Preliminary results
based on 5 day experiment




$1E^{-3}$ J $kg^{-1}$

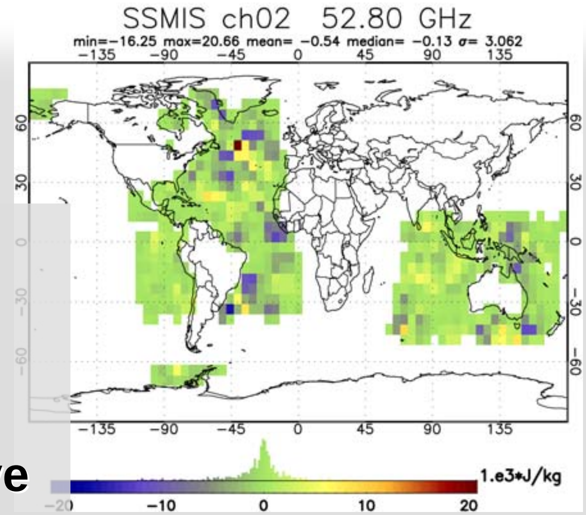
(Reduction in forecast error using moist static energy norm)

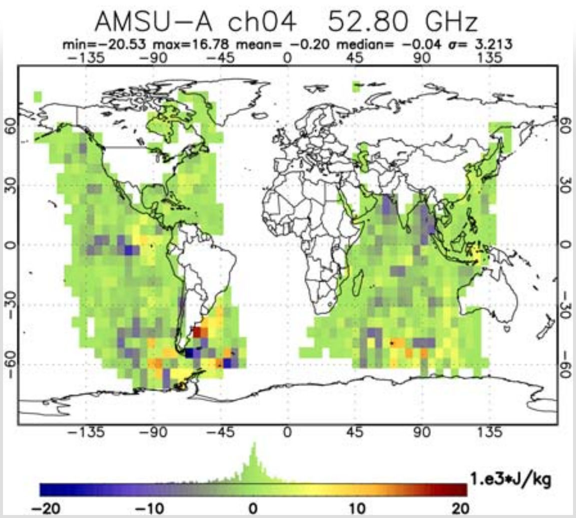
# Observation Impact

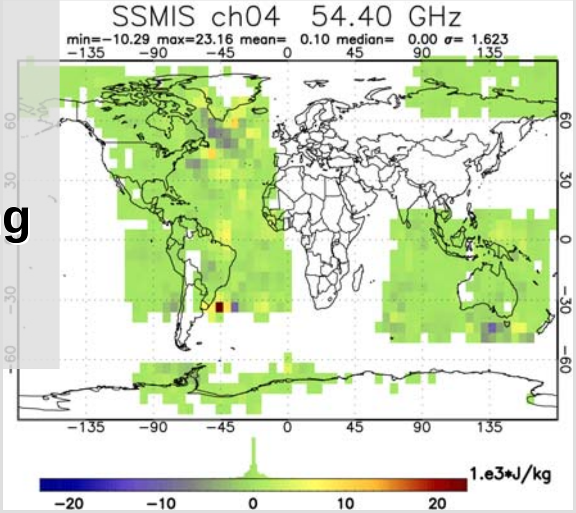
SSMIS provides "gap filling"

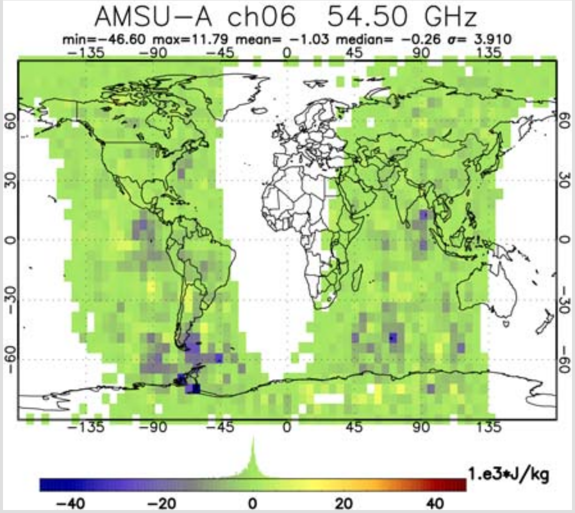
SSMIS and AMSU have similar forecast error reductions

Preprocessor mitigating most problems with SSMIS data stream



# Summary

- **Ob sensitivities proven useful in refining channel list**
  - early CRTM release (2005), low model top cause AIRS channels around 14μm to have negative impact
- **Ob sensitivities valuable real-time diagnostic**
  - monitoring of ob sensitivities of satellite wind vectors identified problem with GMS feature-track winds
- **Ob sensitivities potential for targeted thinning**
  - spatial variation of observation sensitivities are being explored for unlocking intelligent methods for selective ob thinning

## Summary

- IASI data undergoing trial assimilation in NAVDAS-AR
- IASI capable version of CRTM performing reliably
- Observation sensitivities will be used to 'refine' channel list
- Principle component assimilation offers possibility to utilize "full spectrum" at little extra computational costs

## Future Work

- Test NASA 1D-Var principle component retrievals against channel subset, and PC assimilation
- Collocation with Met-Op AMSU simultaneous emissivity retrieval