Impact of Satellite Atmospheric Motion Vectors in the GMAO GEOS-5 Global Data Assimilation System

…update of results presented at the *5th WMO Workshop on the Impact of Various Observing Systems on NWP,* Sedona, AZ, May 2012

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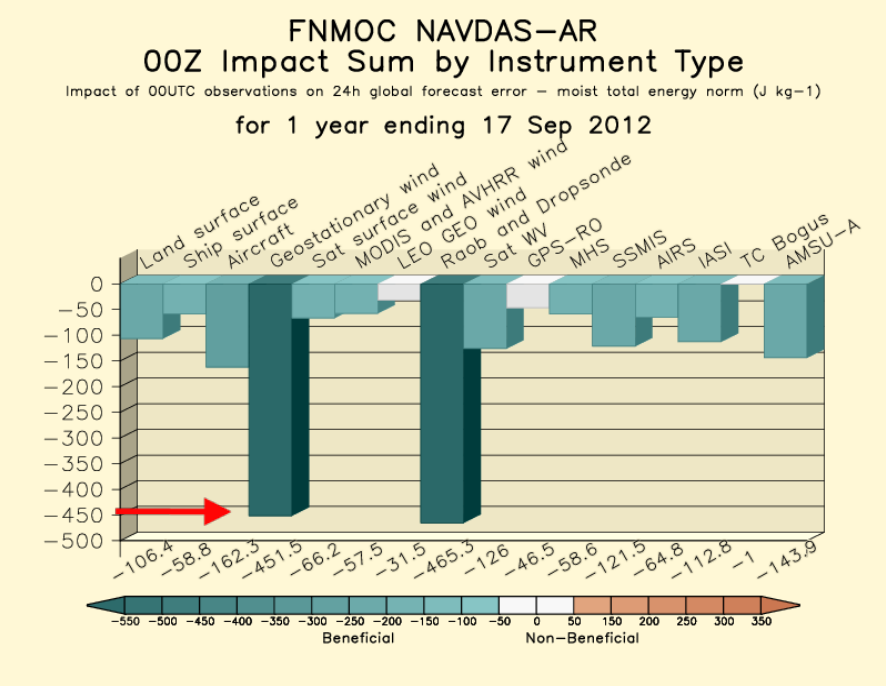
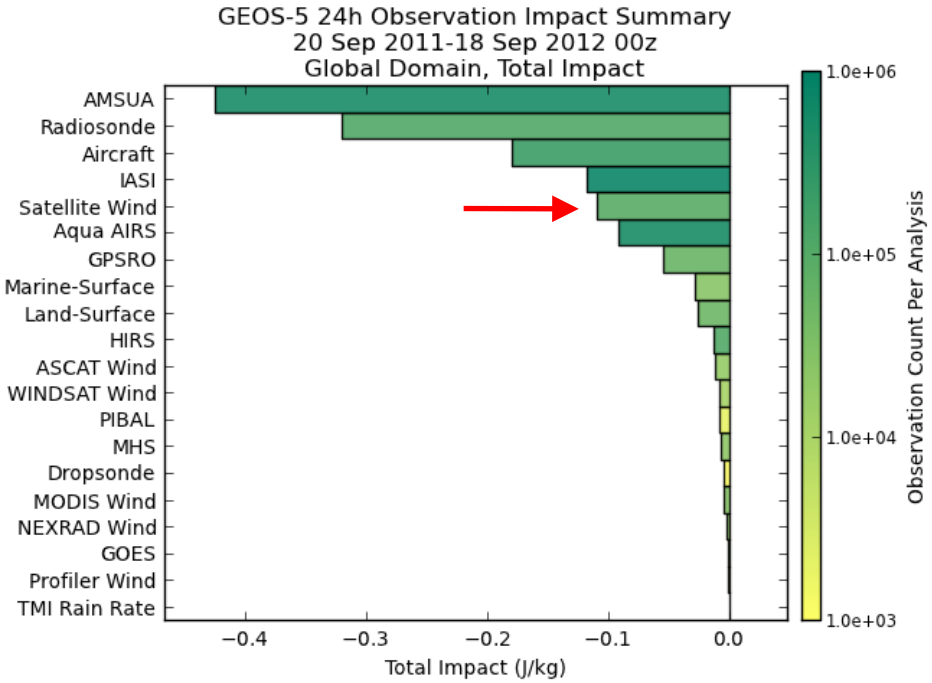
with special thanks to Pat Pauley, Nancy Baker
Naval Research Laboratory, USA

FNMOC and GMAO Observation Impact Monitoring

Current Operations



http://www.nrlmry.navy.mil/obsens/fnmoc/obsens_main_od.html



http://gmao.gsfc.nasa.gov/products/forecasts/systems/fp/obs_impact/

→ Much larger relative impact of AMVs in Navy system

Why does FNMOC get such large impact from satellite winds?

- Use of more satellite winds from more sources?
- More effective treatment of satellite winds …superobing?
- Assimilation of fewer satellite radiances?
- All of the above?

Notable observing system differences:

Observation Counts per 6h (K)

	Satwind	AMSU-A	Hyps IR	All Obs
GMAO	90	**520**	**1220**	2500
FNMOC	**350**	350	800	2200

Approximate average values for the year ending 15 May 2012

GMAO: 1.5x Radiances

FNMOC: 4x Winds

A simple first experiment:

Assimilate NRL/FNMOC-prepared satellite winds in the GMAO forecast system…

GEOS-5 AMV Impact Experiments

GEOS-5 Forecast System (reduced resolution)

- GEOS-5 AGCM + GSI analysis (~½° L72)
- 6-h assimilation cycle, 3DVar
- 5-day forecasts, adjoint-based 24h obs impacts at 00z (dry energy norm, sfc-150 hPa)

Experiments for two periods: **Aug-Sep 2010** and **Dec-Jan 2011**

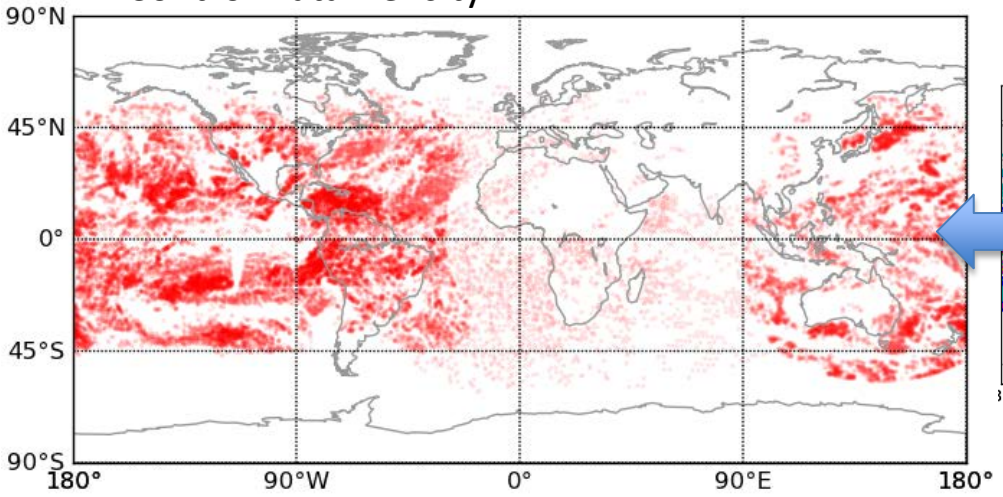
- **Control** – GMAO/NCEP operational data set
- *(full monty)* **NRLAMV** – substitute all NRL Geo, MODIS, LeoGeo winds
- *(super obs)* **NGMAO** – NRL Geo types/sources matching GMAO control
- *(# radiances)* **NLoRAD** – NRLAMV but with thinned radiances
- *(super obs, data redundancy)* **NGMAO2** – NGMAO but allow multiple sources

NRL obs error & QC used in all substitution experiments, no other retuning

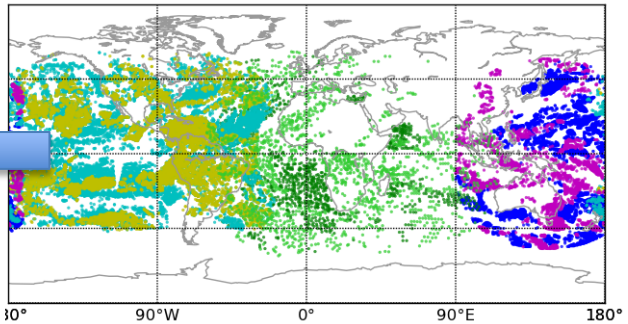
Geo Wind Data Coverage and Density

10 Jan 2011 00z

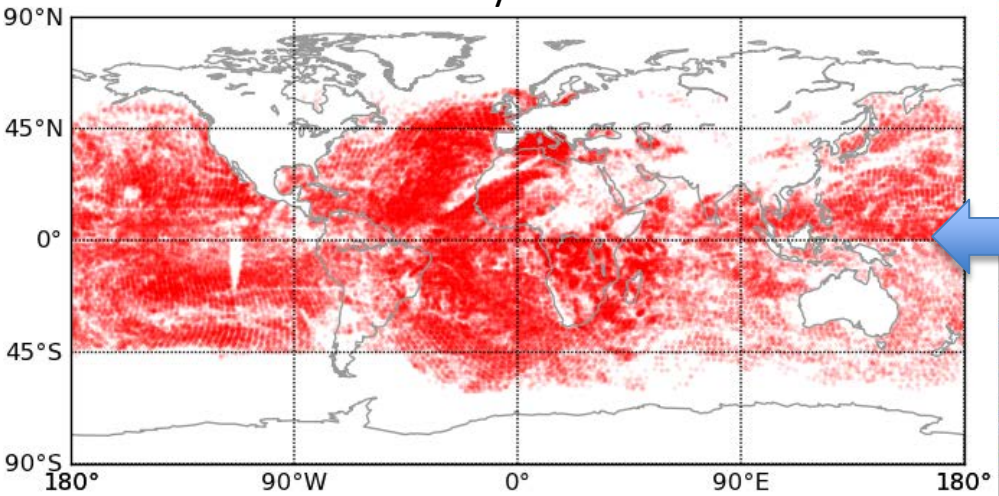
Control Data Density



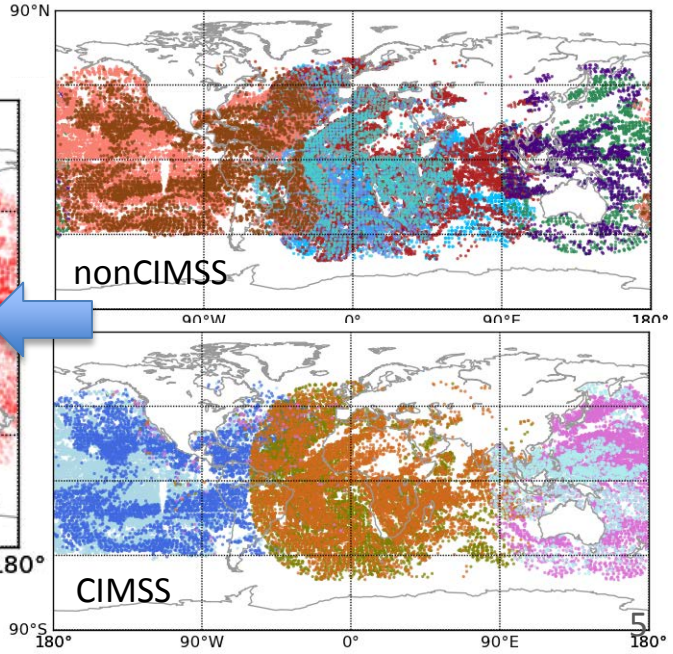
Control Data Coverage



NRLAMV Data Density

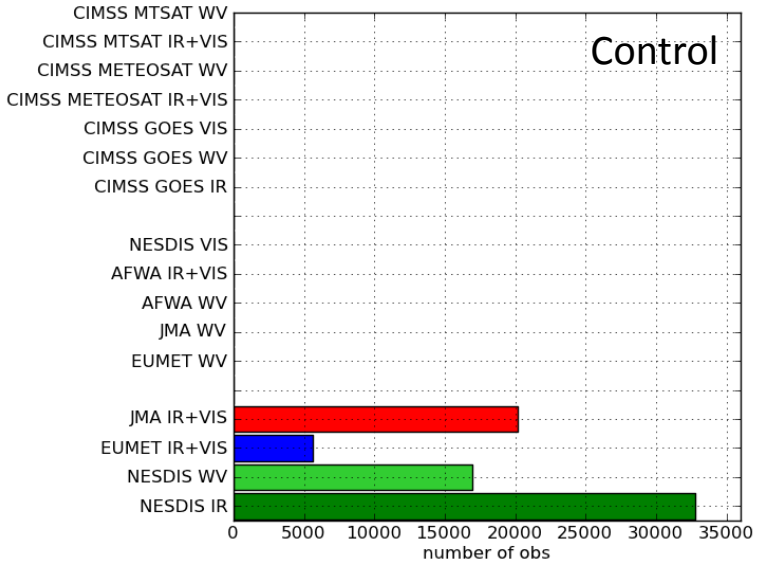


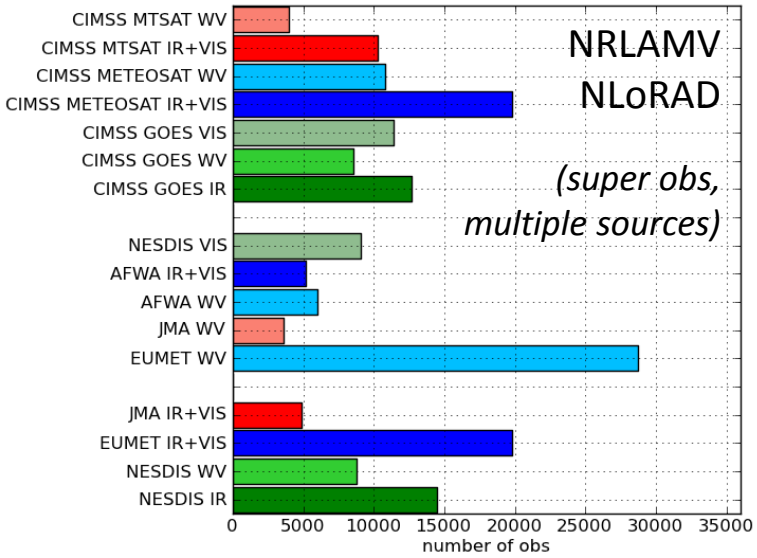
NRLAMV Data Coverage

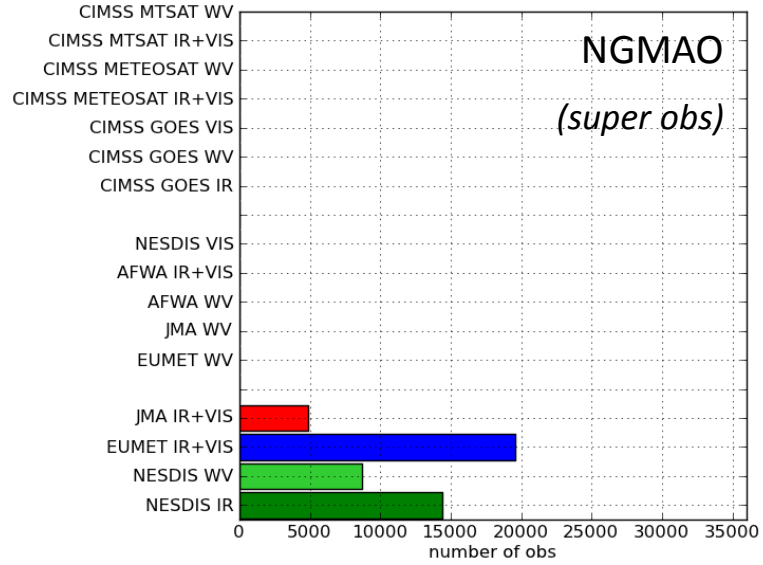


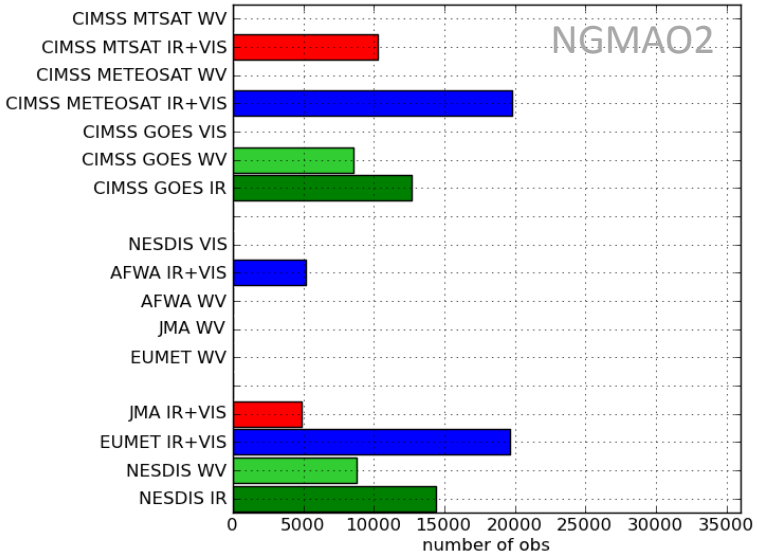
Geo Wind Experimental Configurations

Dec–Jan 2011





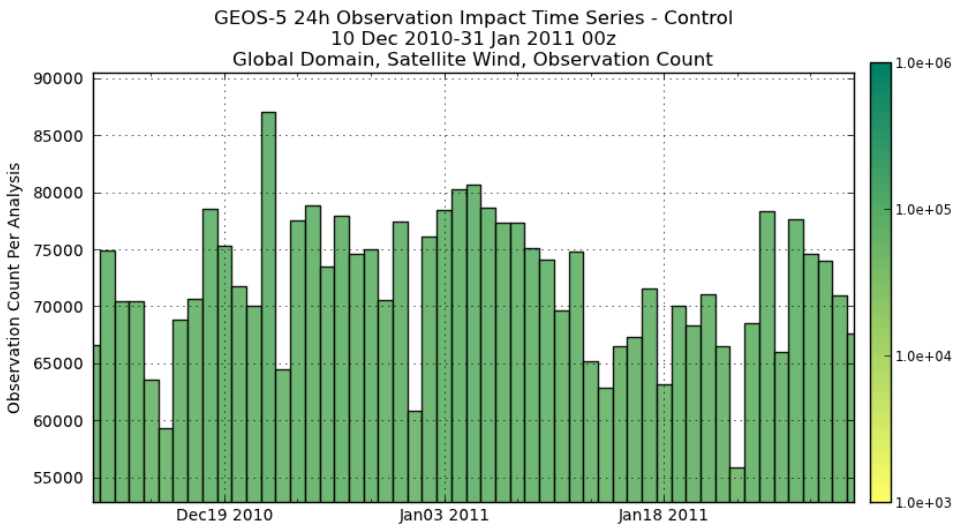




Geo Wind Observation Counts (used) – Global

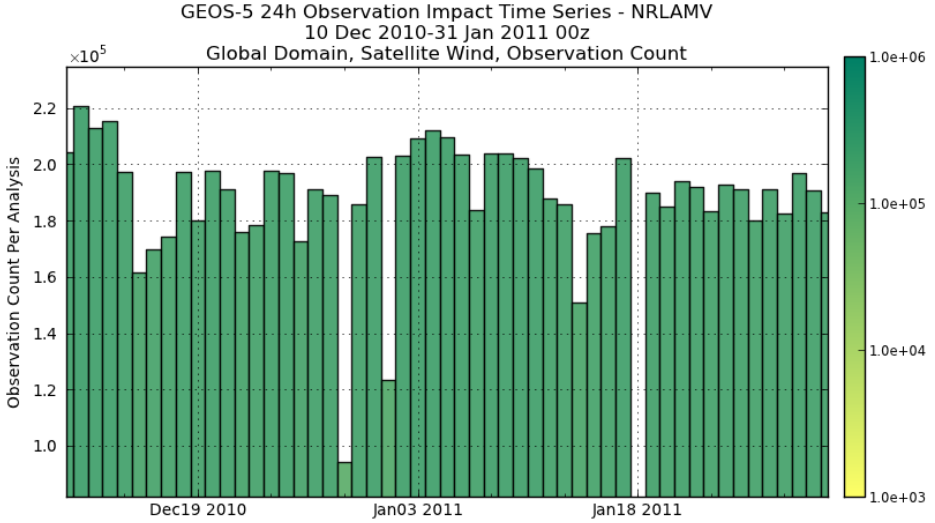
10 Dec 2010 – 31 Jan 2011 00z

Control



65-80K obs/anal

NRLAMV

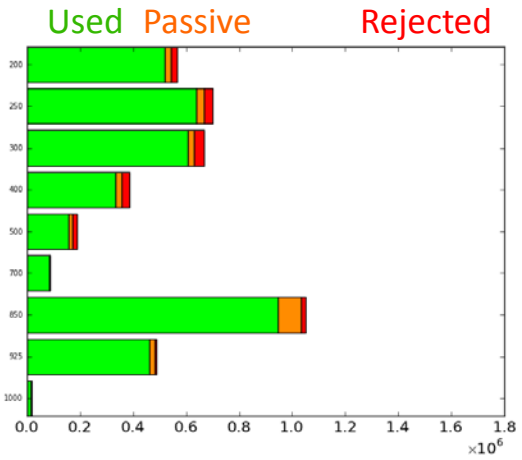
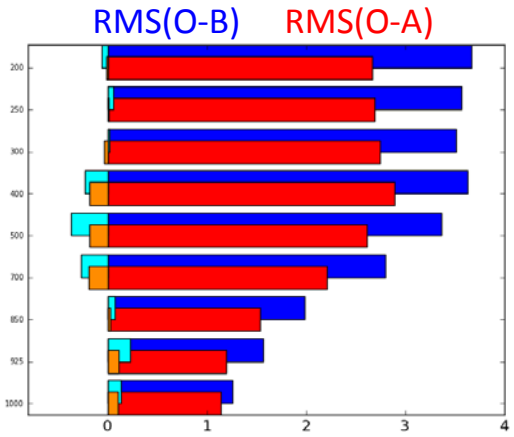
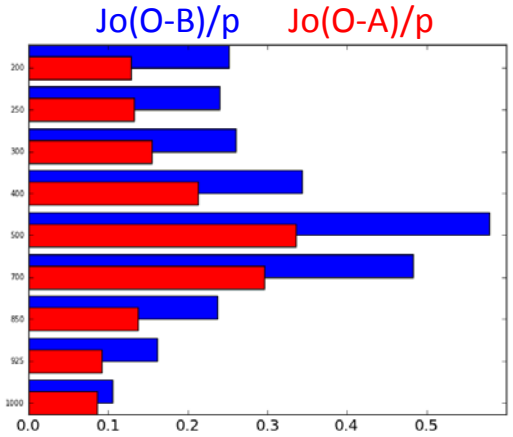
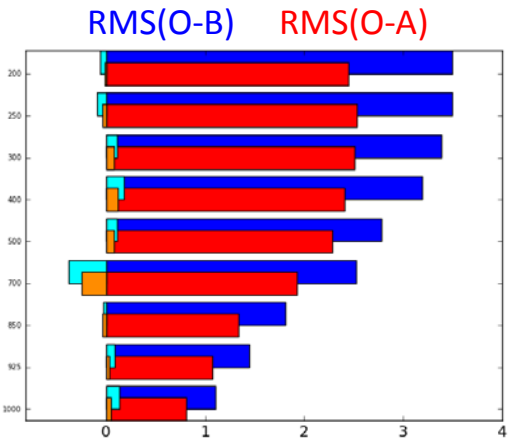
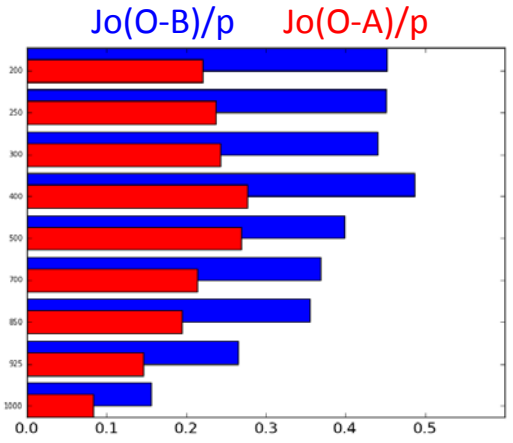


160-200K obs/anal

(No satwinds received on 18 Jan)

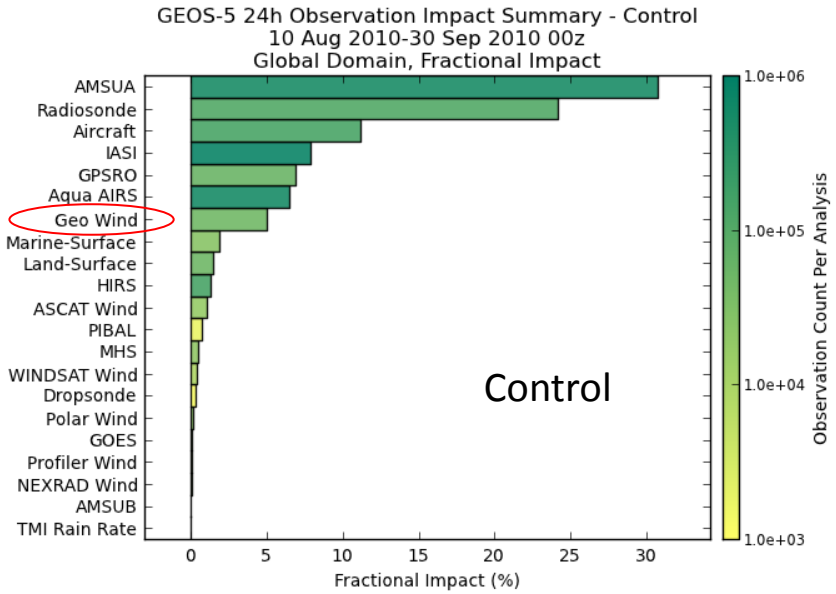
Data Assimilation Statistics for Satellite Winds

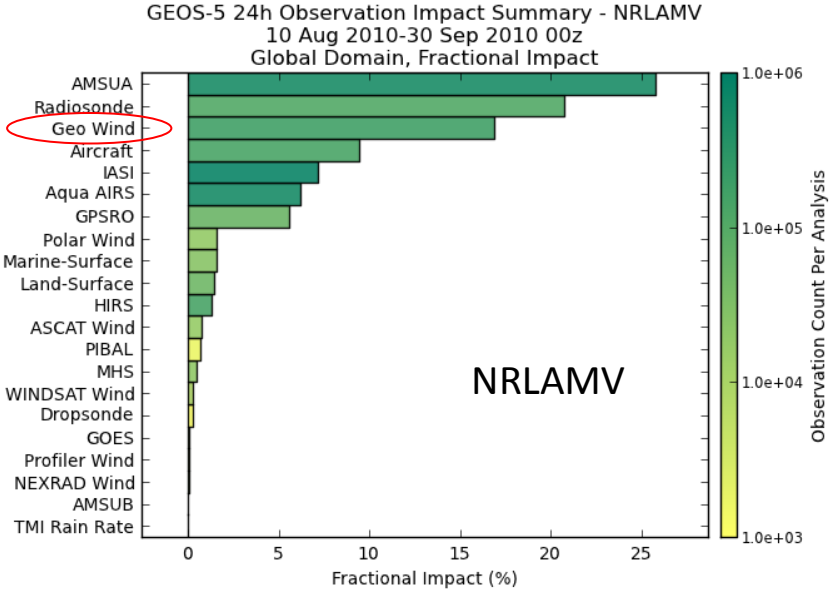
10 Dec 2010 – 31 Jan 2011 00z

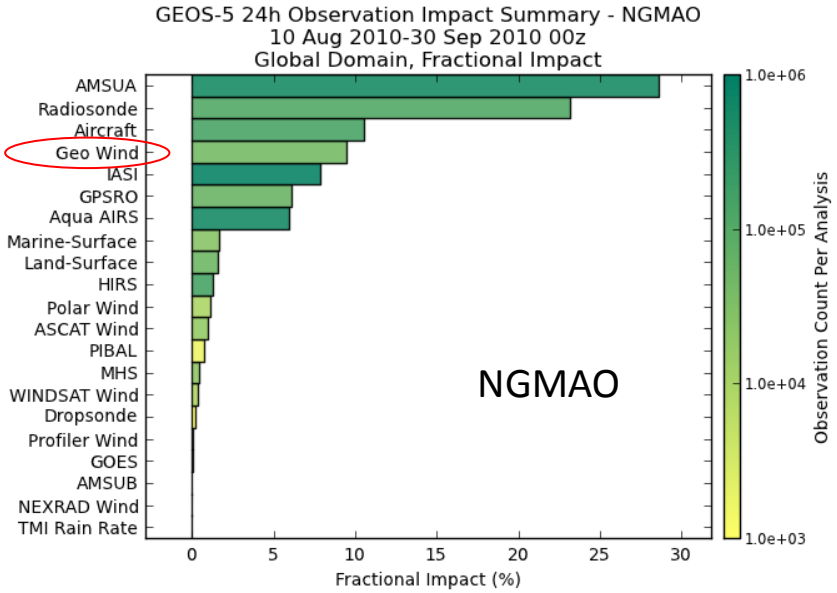
	Data Counts	Departures	Normalized Cost
Control			
NRLAMV			

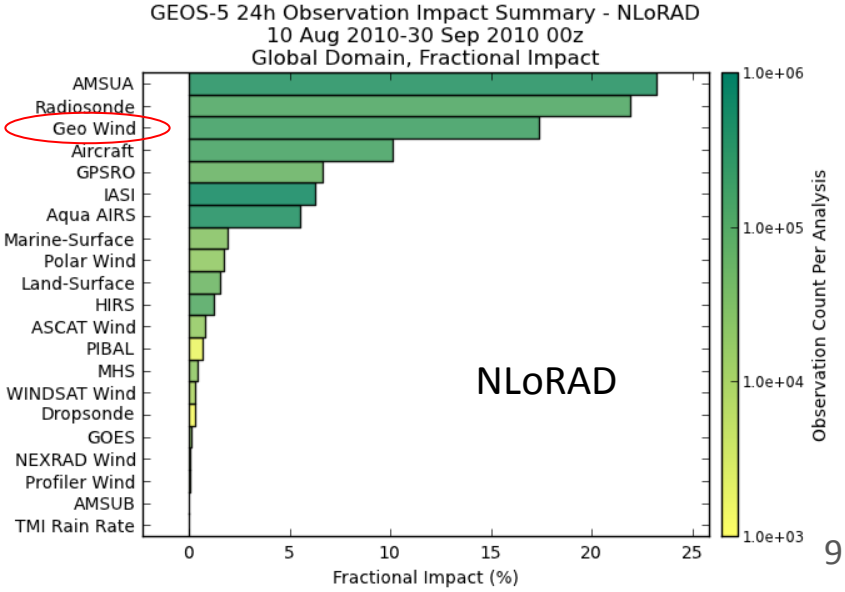
Observation Impact – Global

Aug – Sep 2010



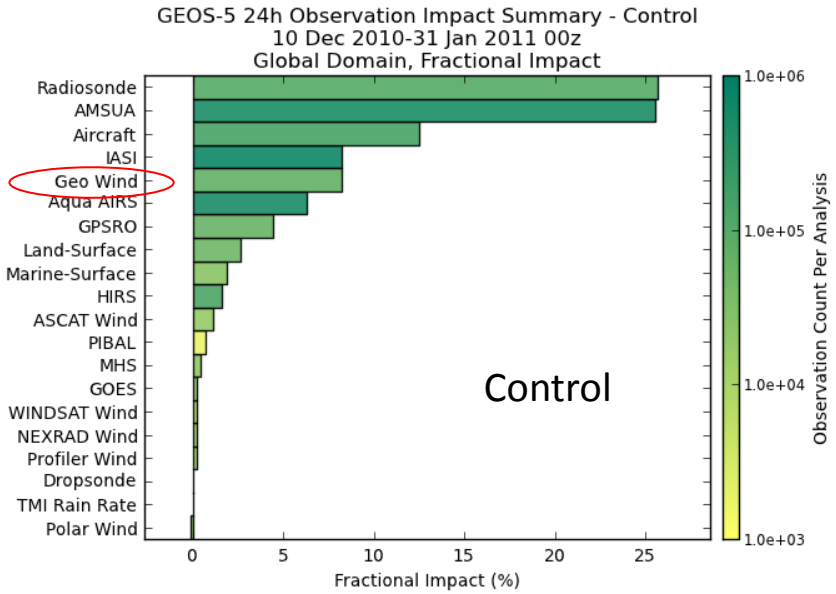


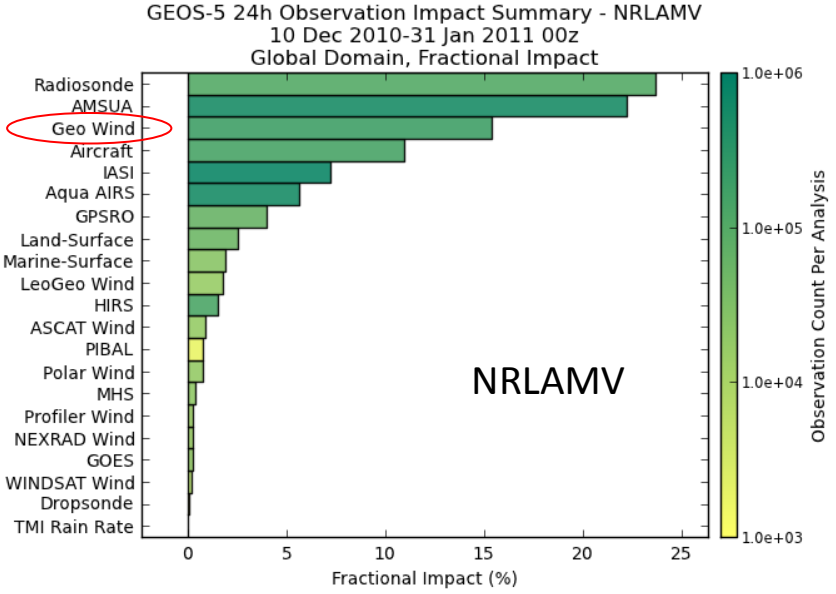


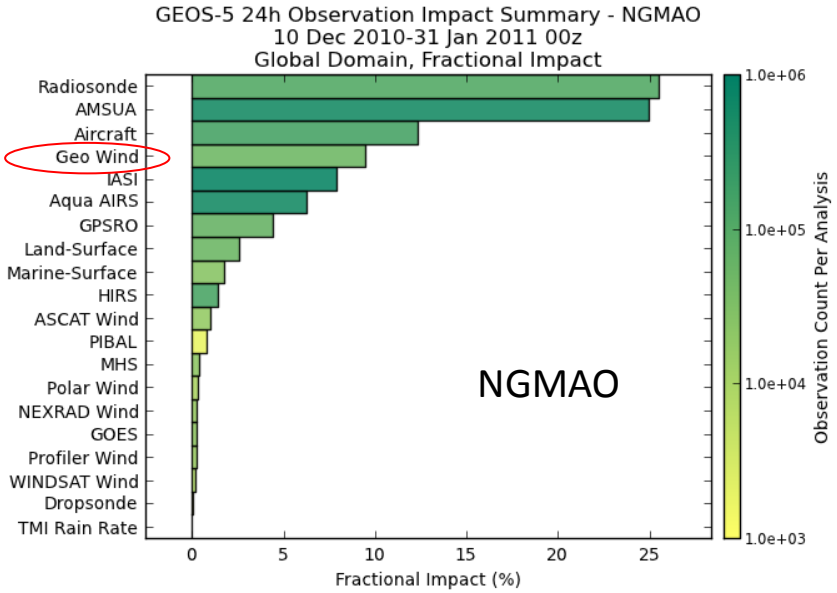


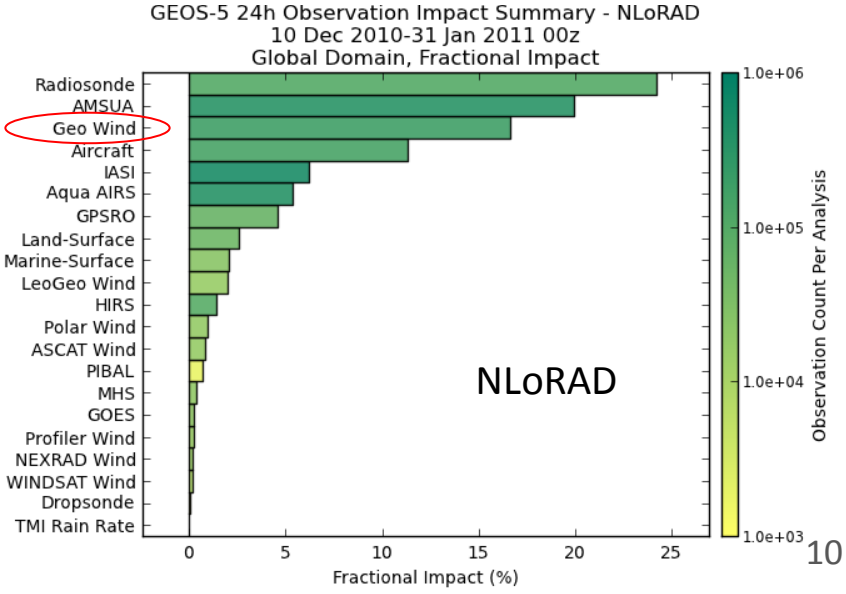
Observation Impact – Global

Dec – Jan 2011





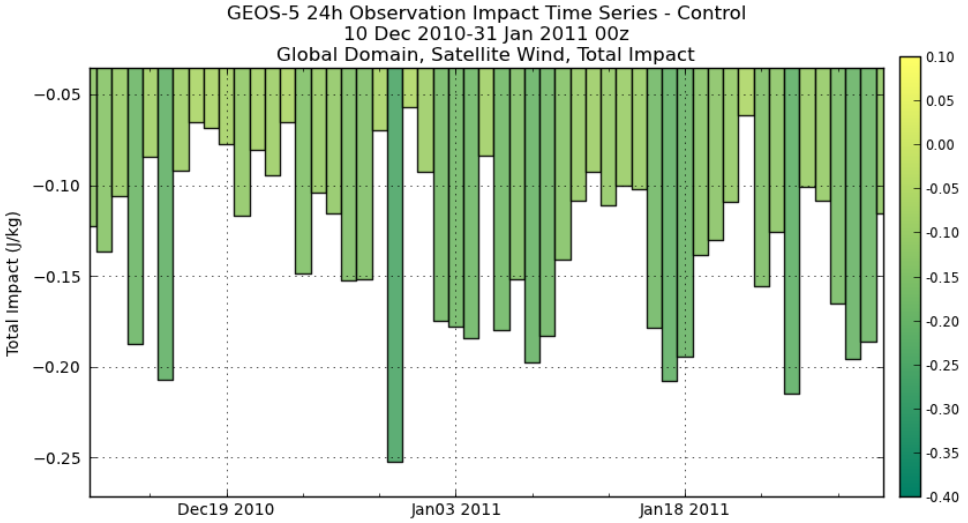




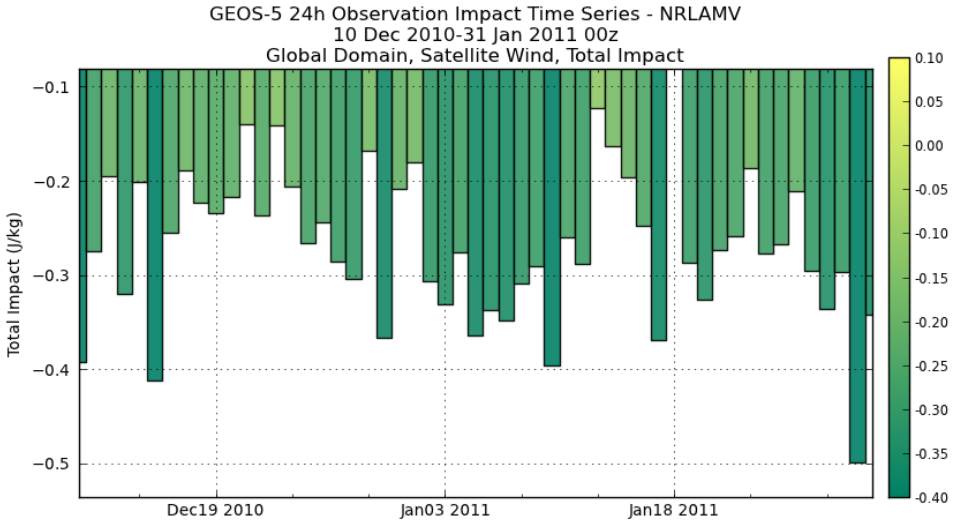
Time Series of Satellite Wind Total Impact – Global

10 Dec 2010 – 31 Jan 2011 00z

- Total impact of NLR satwinds is roughly 2x that of control satwinds
- Dates with large satwind impact tend to coincide in both experiments



Control



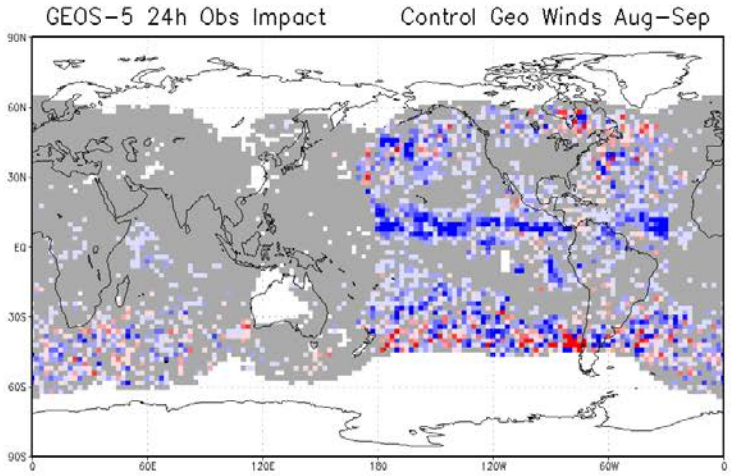
NRLAMV

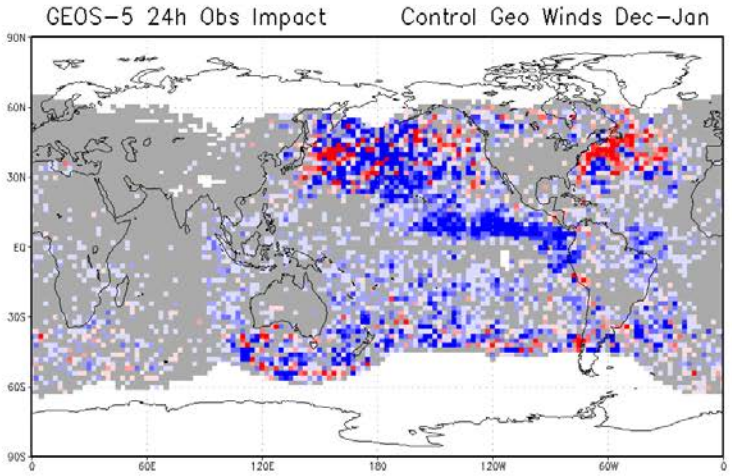
Gridded Vertically Summed Impact of Geo Winds

Aug–Sep 2010

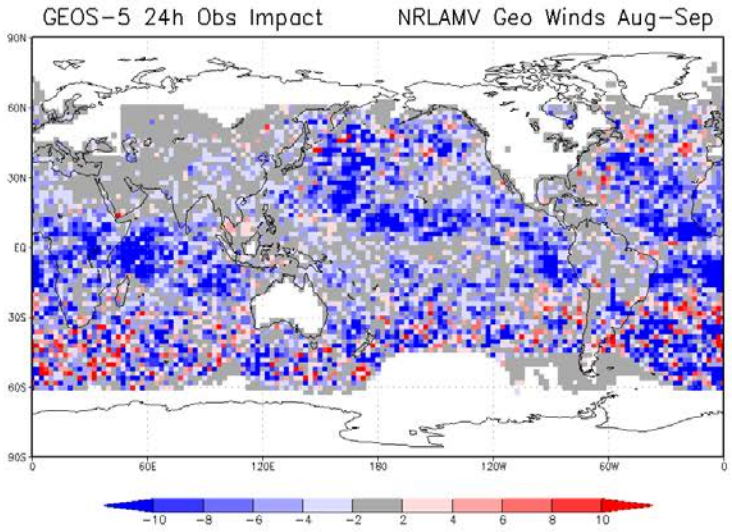
Dec–Jan 2011

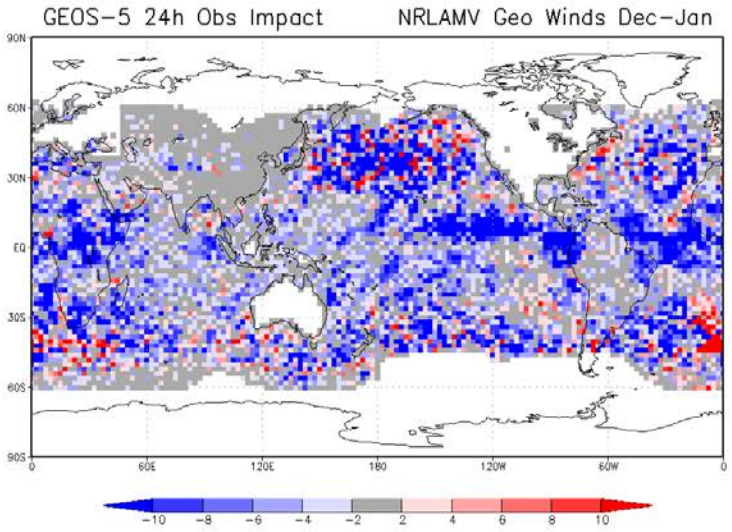
Control





NRLAMV

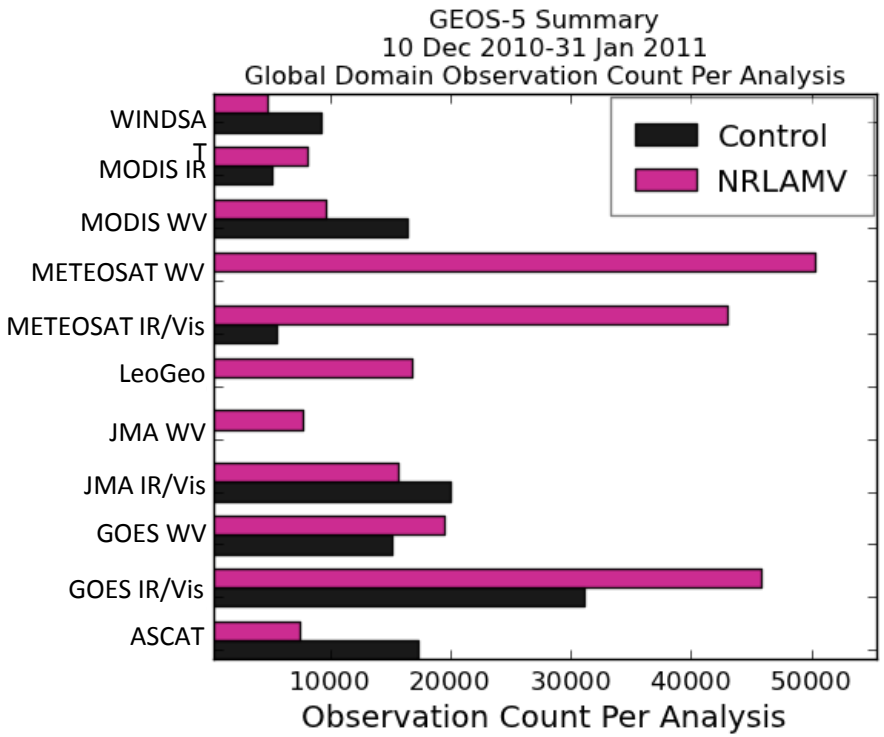




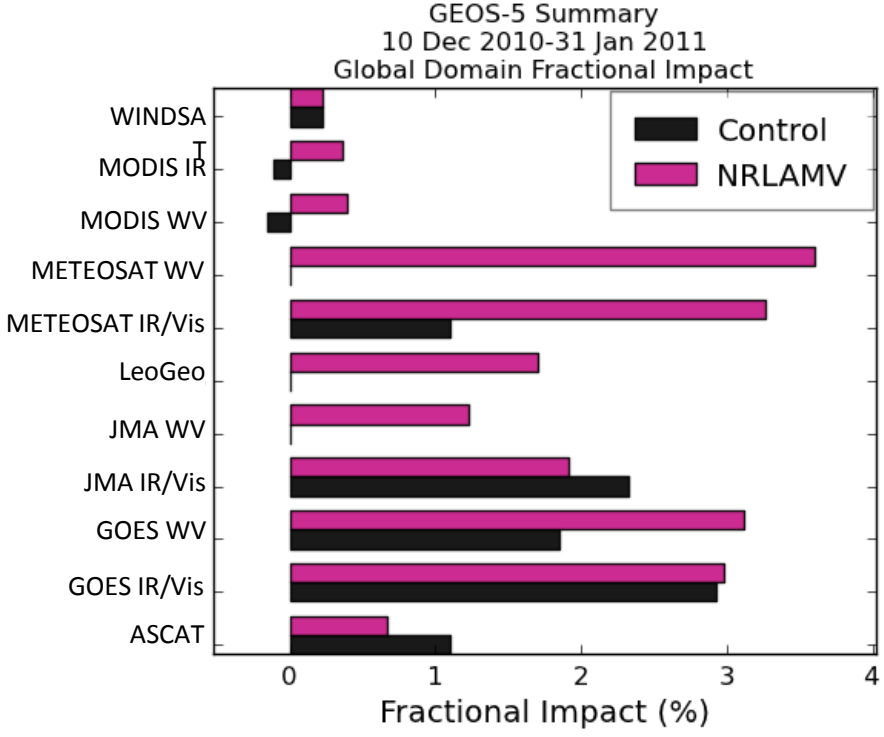
Relative Impacts of Selected AMV Types

Dec – Jan 2011

Global Data Count

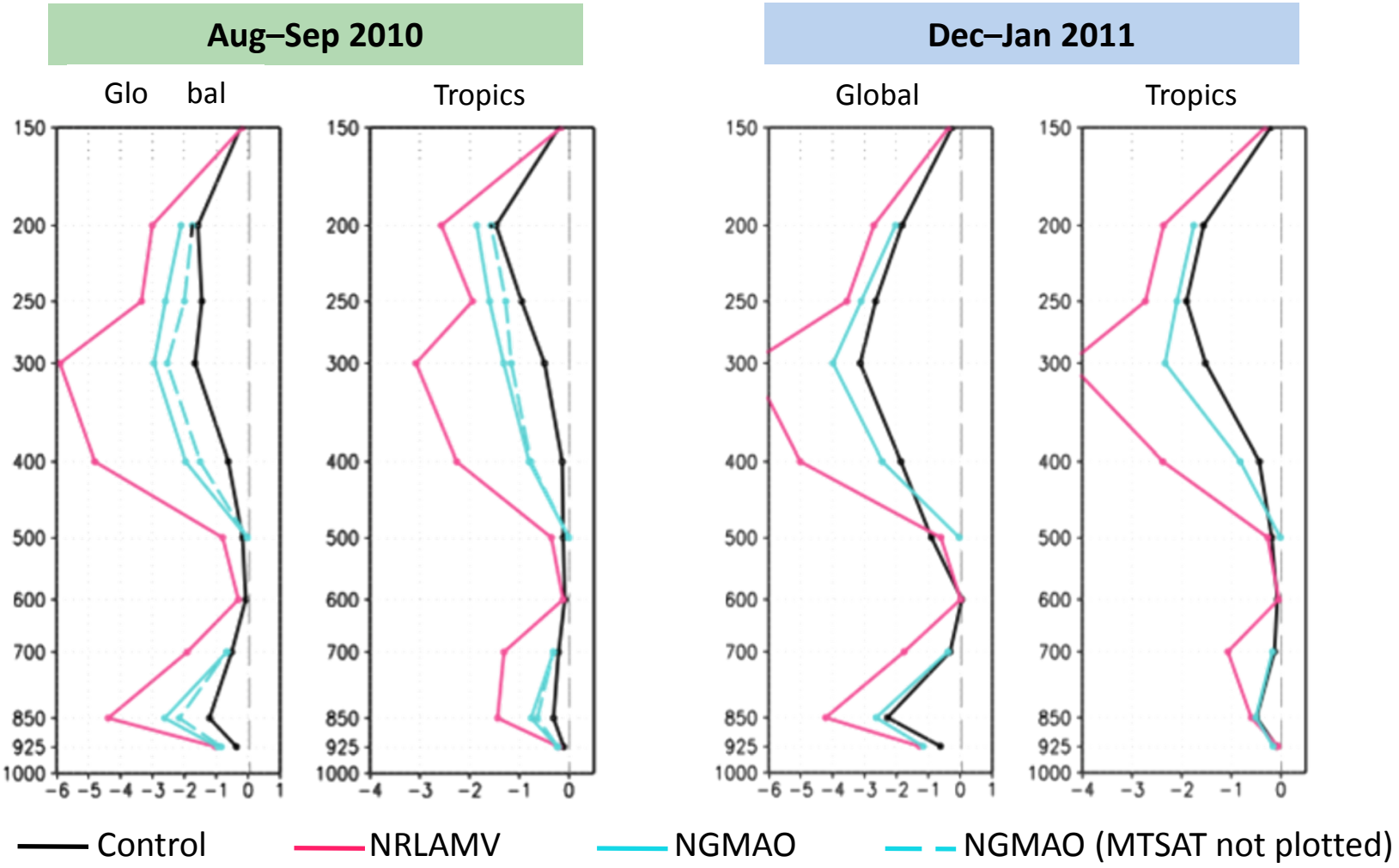


Global Total Impact



- Relative impacts of most AMV types correlate well with data counts
- Beneficial impact of MODIS winds in NRLAMV (versus non-beneficial impact in control) requires other explanation….superobs?

Vertical Profiles of Geo Wind Impact



- NGMAO > Control suggests beneficial impact of super-obs

Gridded Vertically Summed Impact of Geo Winds

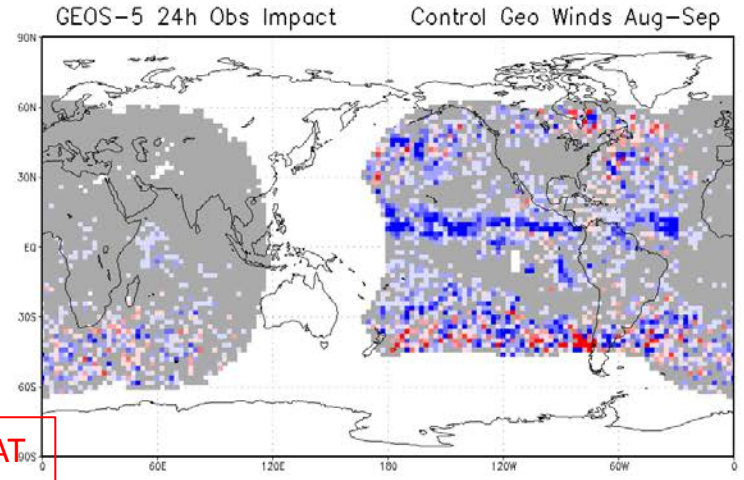
Aug–Sep 2010

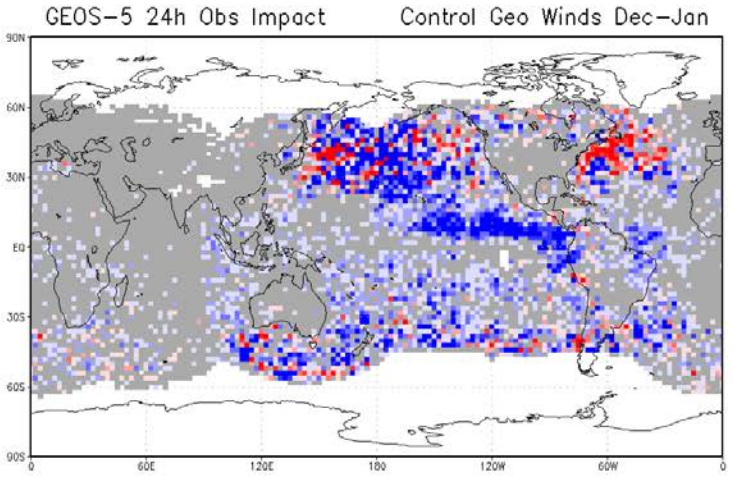
Dec–Jan 2011

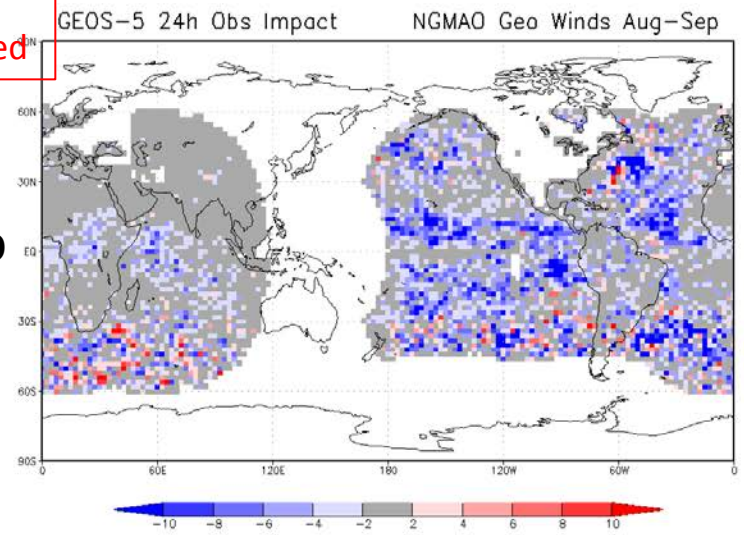
Control

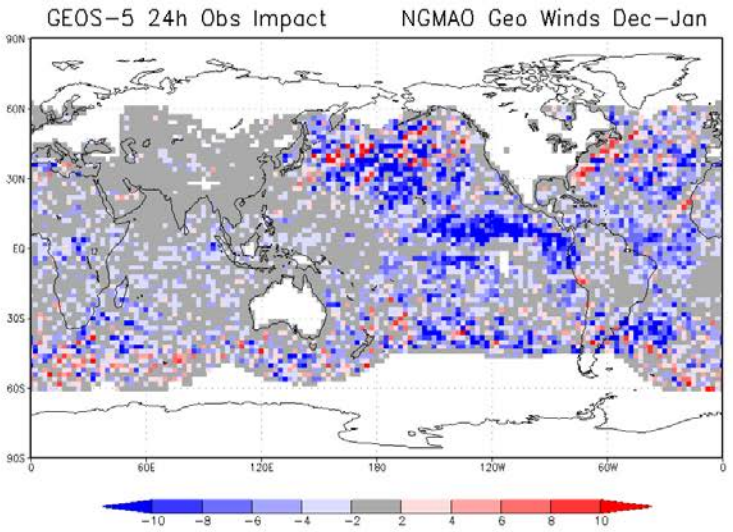
NGMAO

MTSAT not plotted





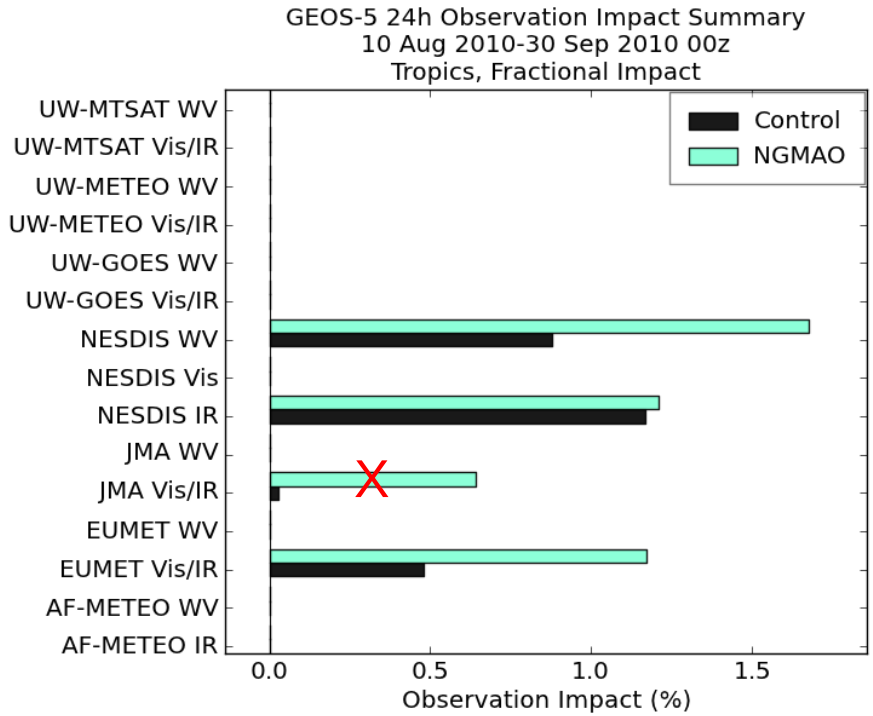




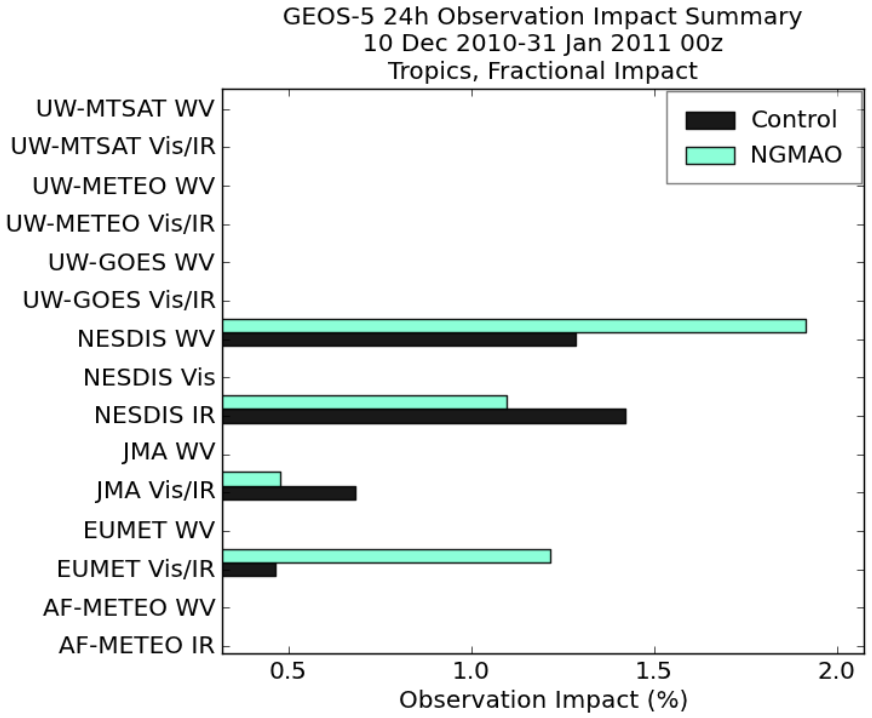
Relative Impacts of Geo Wind Types

Tropics

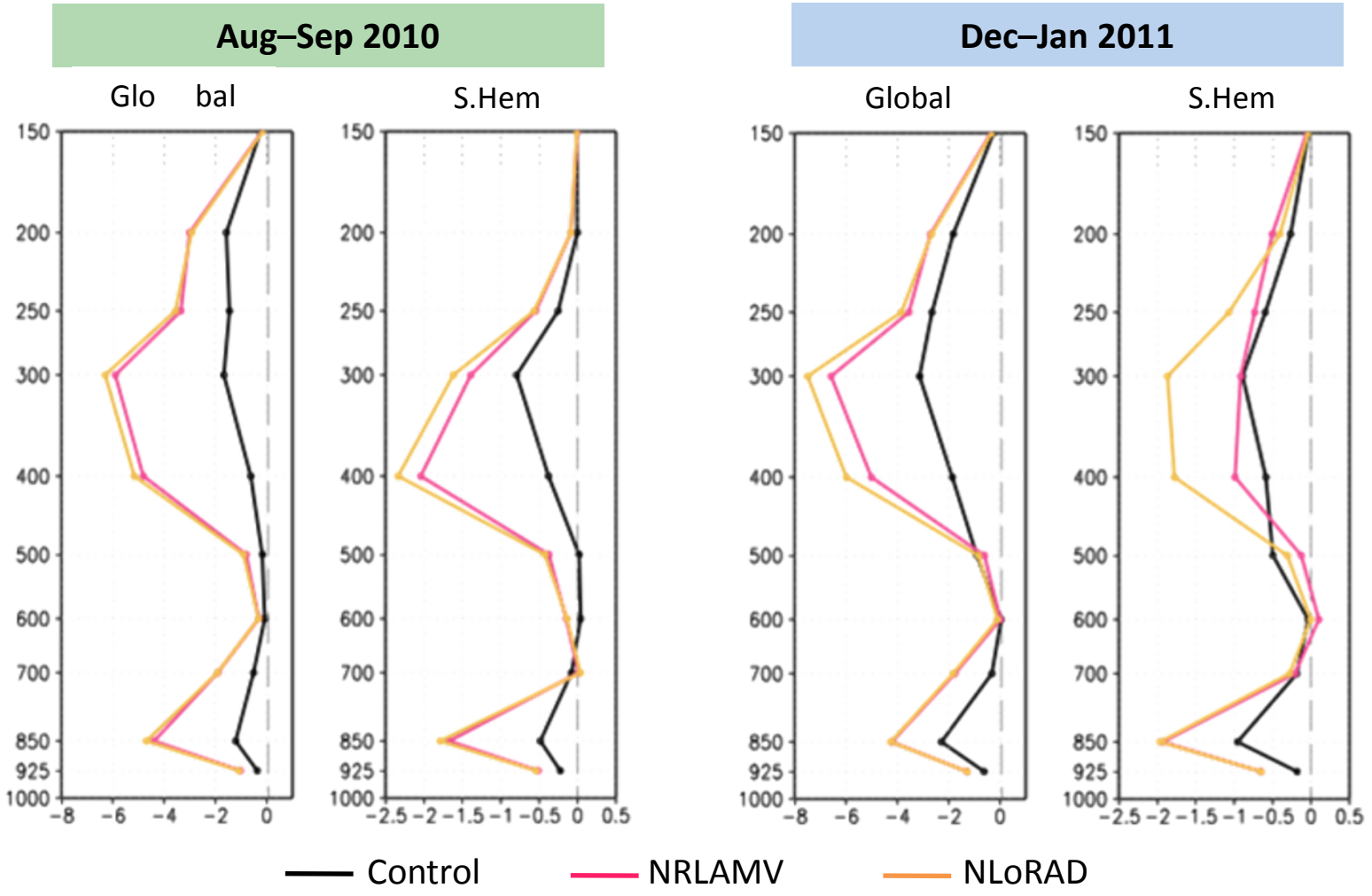
Aug–Sep 2010



Dec–Jan 2011



Vertical Profiles of Geo Wind Impact

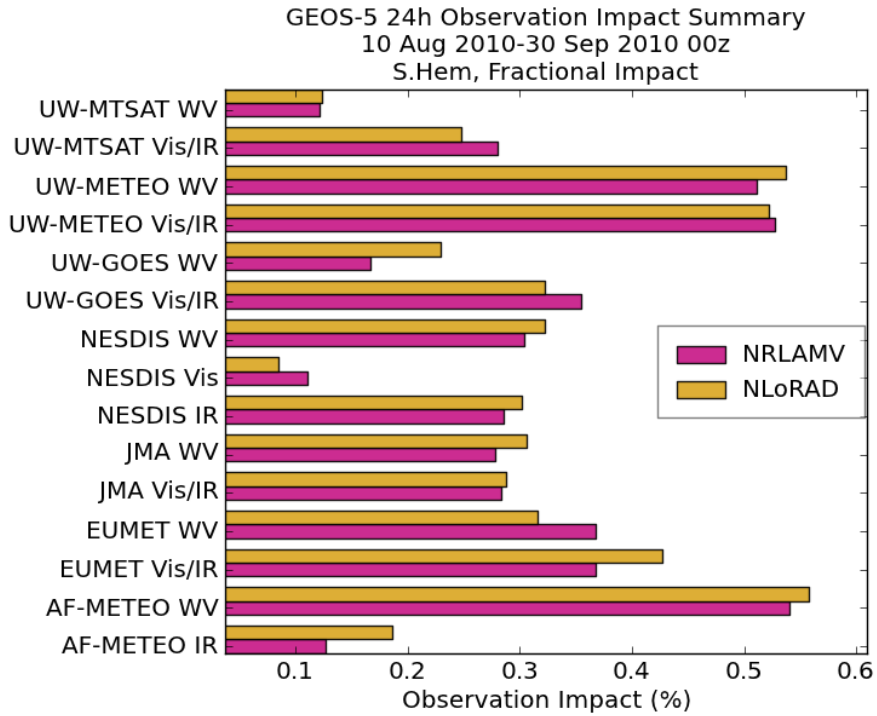


- Evidence of larger AMV impact when fewer radiances assimilated, but mostly in S.Hem during summer

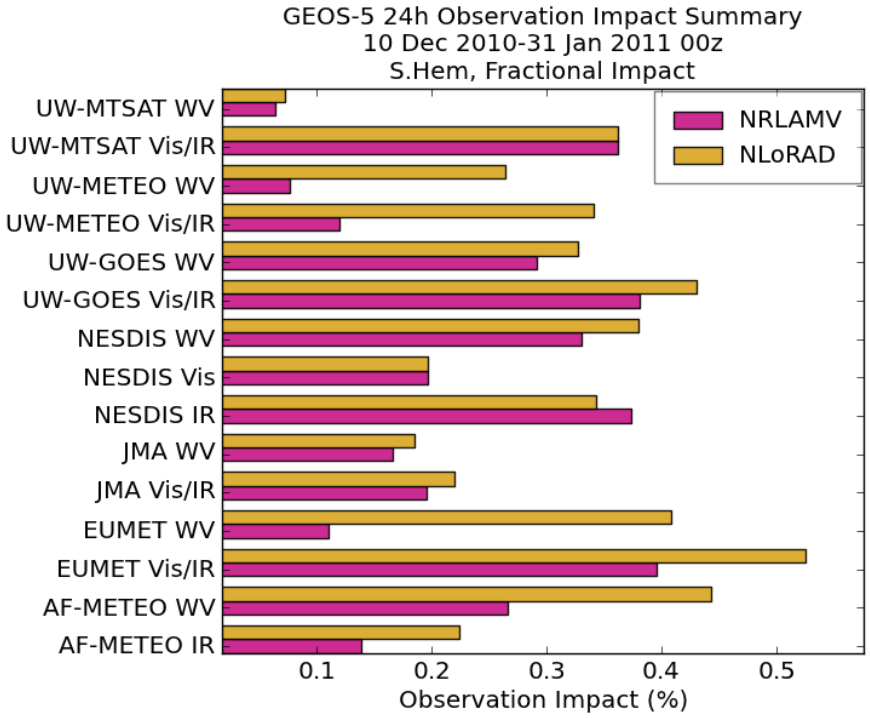
Relative Impacts of Geo Wind Types

Southern Hemisphere

Aug–Sep 2010



Dec–Jan 2011



Conclusions

- NRL AMVs were crudely but successfully assimilated into the GMAO GEOS-5 data assimilation system

- Compared to the control run with GMAO (NCEP) AMVs, the assimilation of NRL AMVs provides substantially increased beneficial impact (ADJ), and also appears to improve forecast skill overall (OSE)

- The greater volume of the NRL AMVs (from multiple sources) appears to be the primary reason for their larger impact

- Use of super-obs and reduction in radiance data increase AMV impacts but these effects are secondary and vary by season and location

- In general, robustness of the current observing system reduces the dominance/impact of any one data type (also see 5th WMO Workshop on Obs Impact Impact on NWP). Subtleties of DAS response to observing system changes argue for continued use of both OSE and ADJ techniques where possible