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

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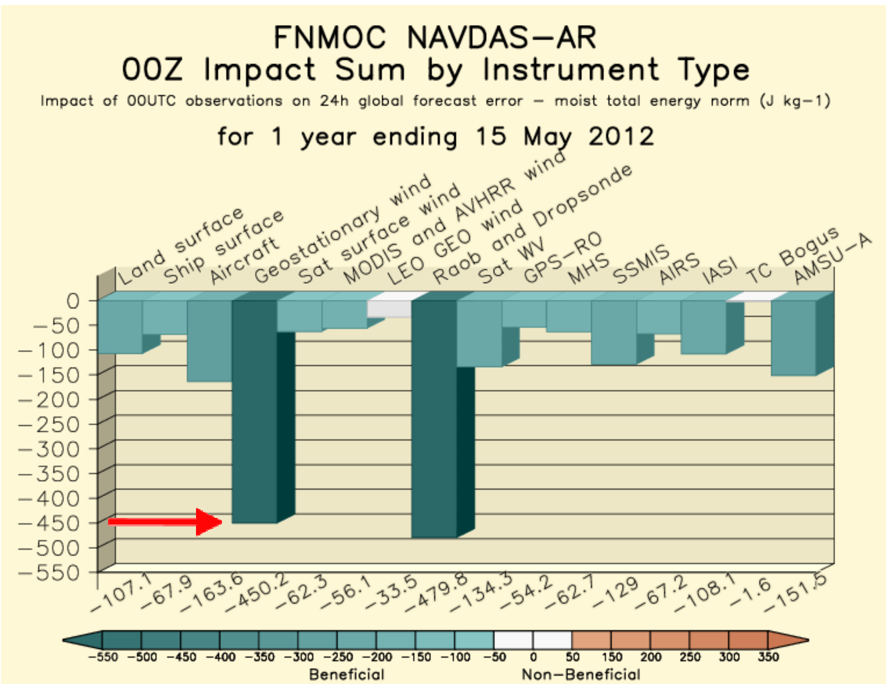
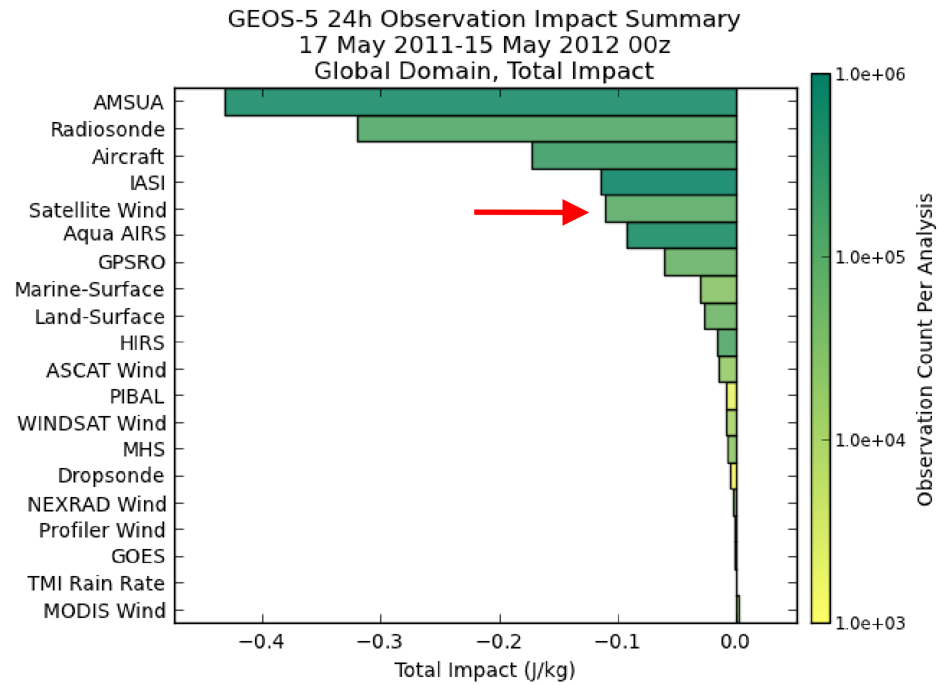
FNMOC and GMAO Observation Impact Monitoring

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	AllObs
GMAO	90	**520**	**1220**	2500
FNMOC	**350**	350	800	2200

Approximate average values for the year ending 15 May 2012

A simple first experiment:

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

GEOS-5 Observing System 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 **Winter (Dec-Jan 2010/11),** Summer (Aug-Sep 2010)

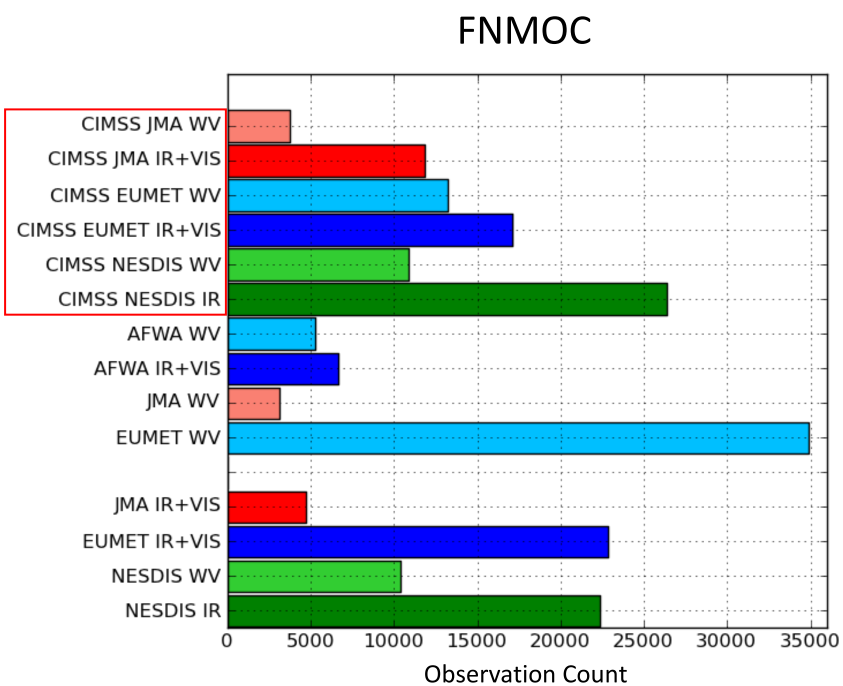
•**Control** – GMAO/NCEP operational data set

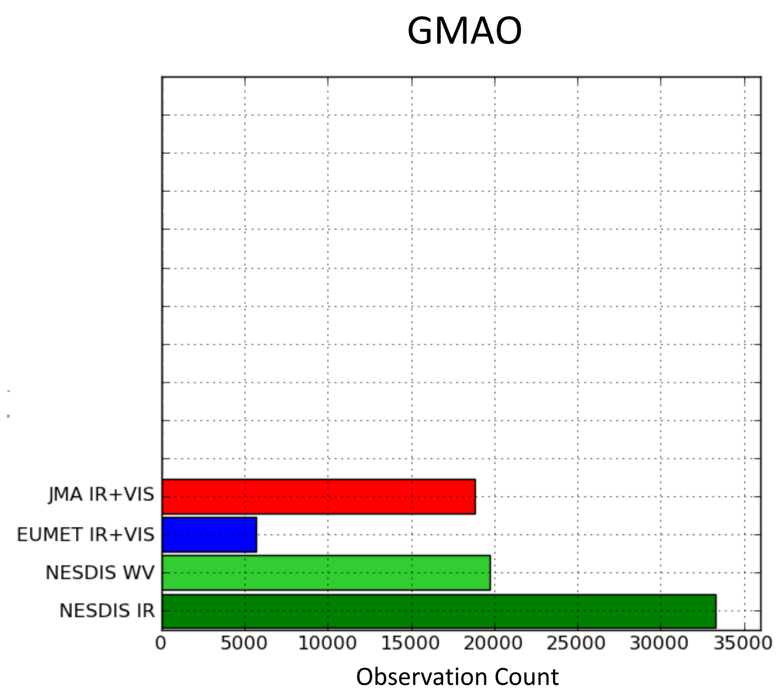
•**NRLAMV** – substitute NRL Geo, MODIS, LeoGeo winds (NRL obs error & QC, no other retuning)

•**NoAMV** – withhold all geo winds
•**NoRAOB** – withhold all radiosonde
•**NoACRFT** – withhold all aircraft
•**NoGPS** – withhold all GPSRO
•**NoAMSUA** – withhold all AMSU-A (5)
•**NoHYPS** – withhold all AIRS and IASI

Sources of Satellite Wind Observations

10 Jan 2011 00z





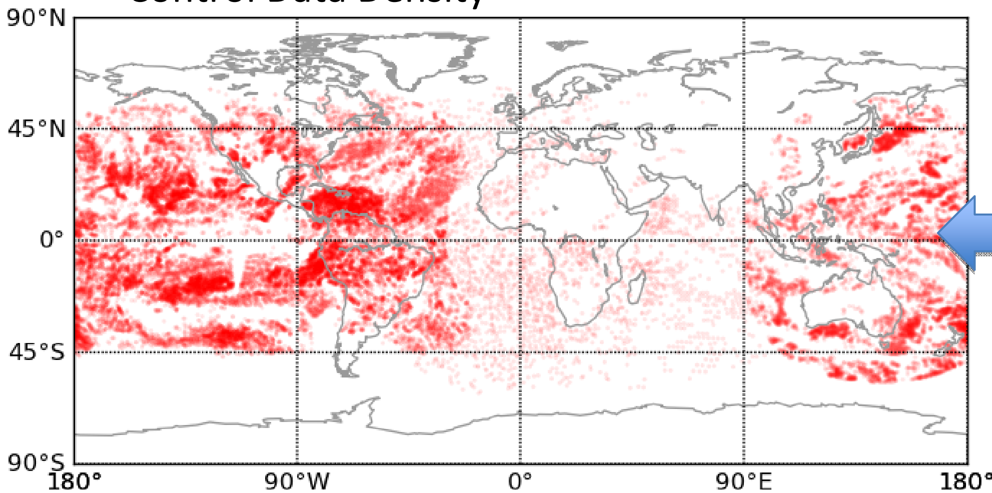
- FNMOC assimilates far more WV winds, and Vis, IR and WV winds from additional sources…most notably U.Wisc/CIMSS

- FNMOC uses superobs; GMAO uses observation thinning

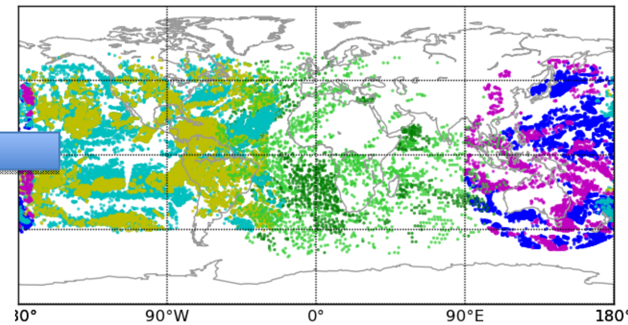
Satellite Wind Data Coverage and Density

10 Jan 2011 00z

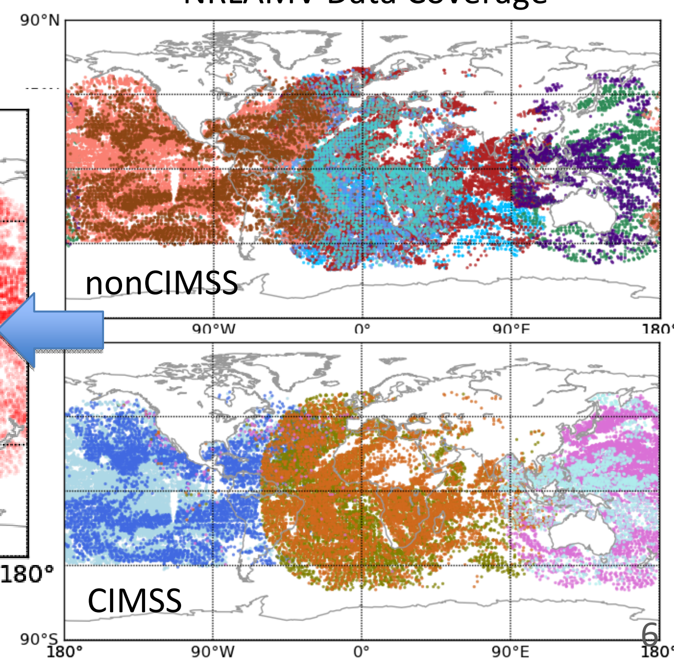
Control Data Density



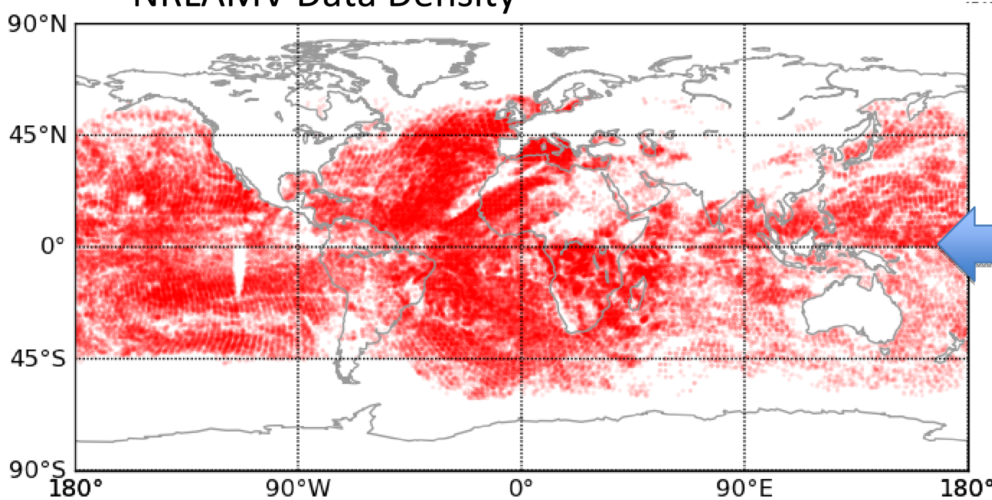
Control Data Coverage



NRLAMV Data Coverage



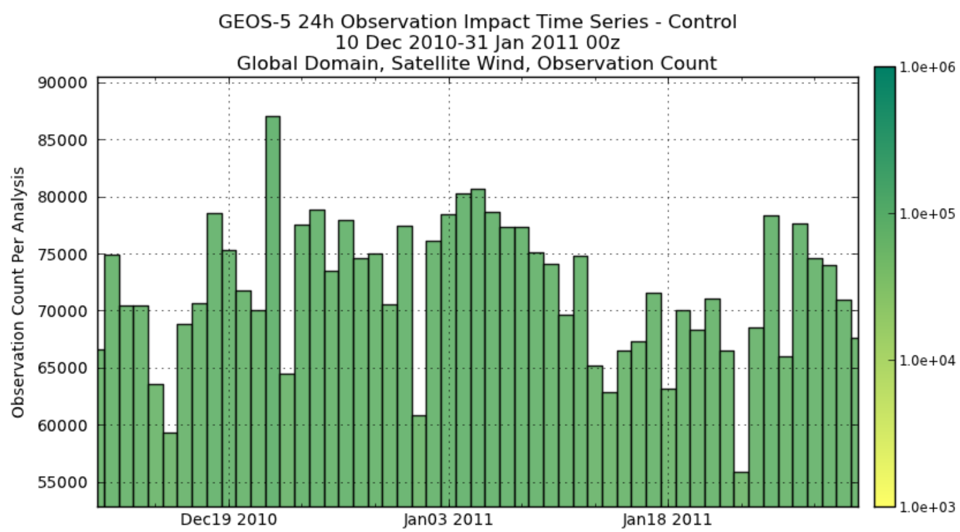
NRLAMV Data Density



OSE Satellite Wind Observation Counts (used) – Global

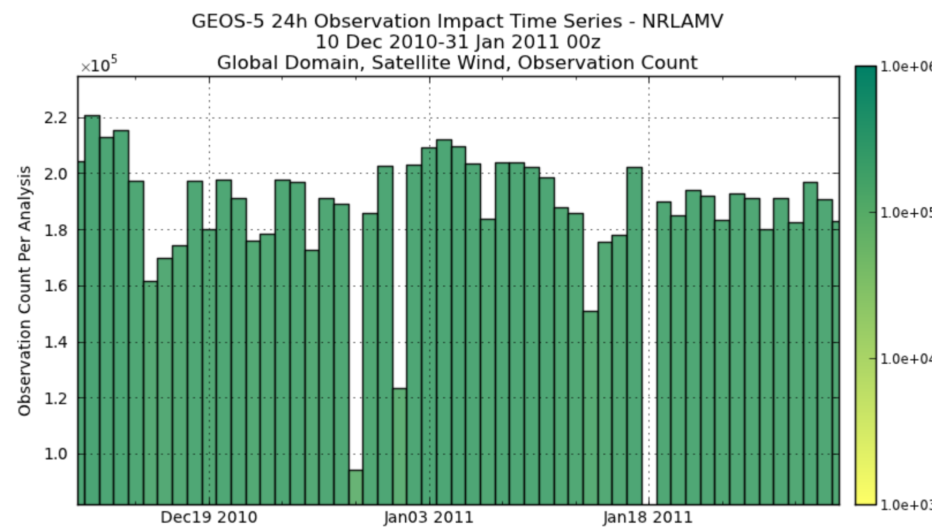
10 Dec 2010 – 31 Jan 2011 00z

Control



65-80K obs/anal

NRLAMV



160-200K obs/anal

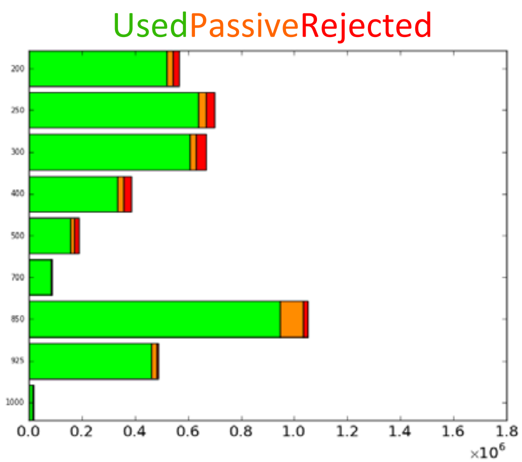
(No satwinds received on 18 Jan)

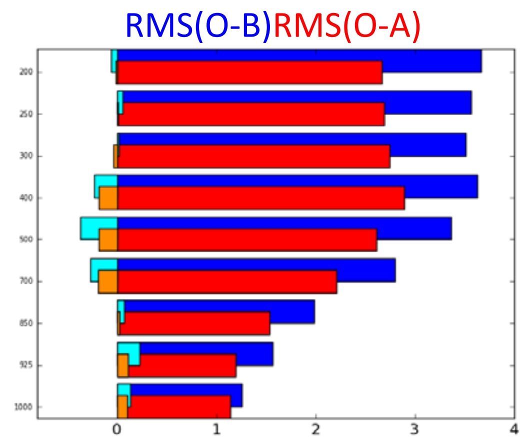
Data Assimilation Statistics for Satellite Winds

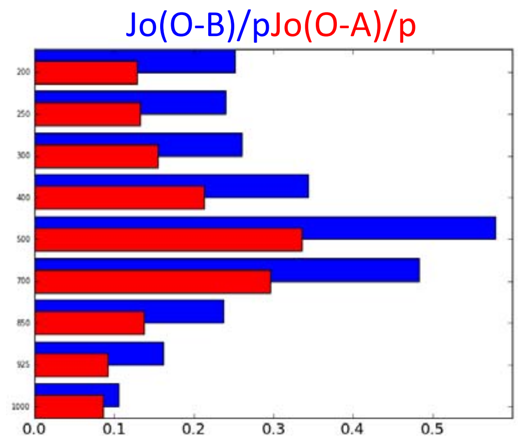
10 Dec 2010 – 31 Jan 2011 00z

Data Counts | Departures | Normalized Cost

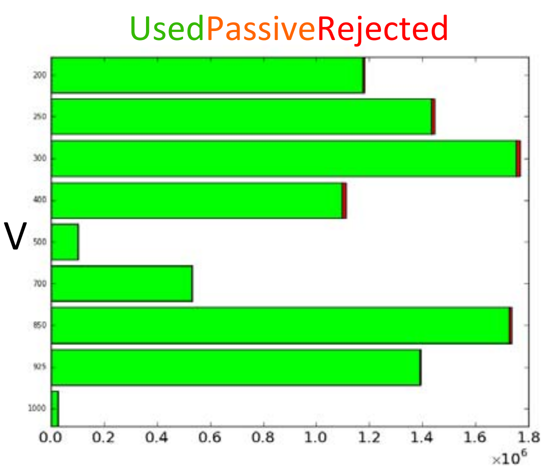
Control

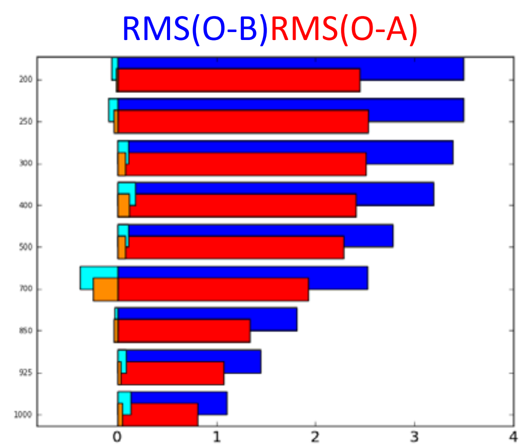


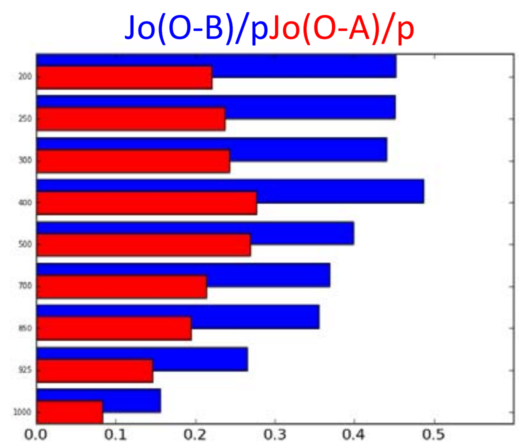




NRLAMV



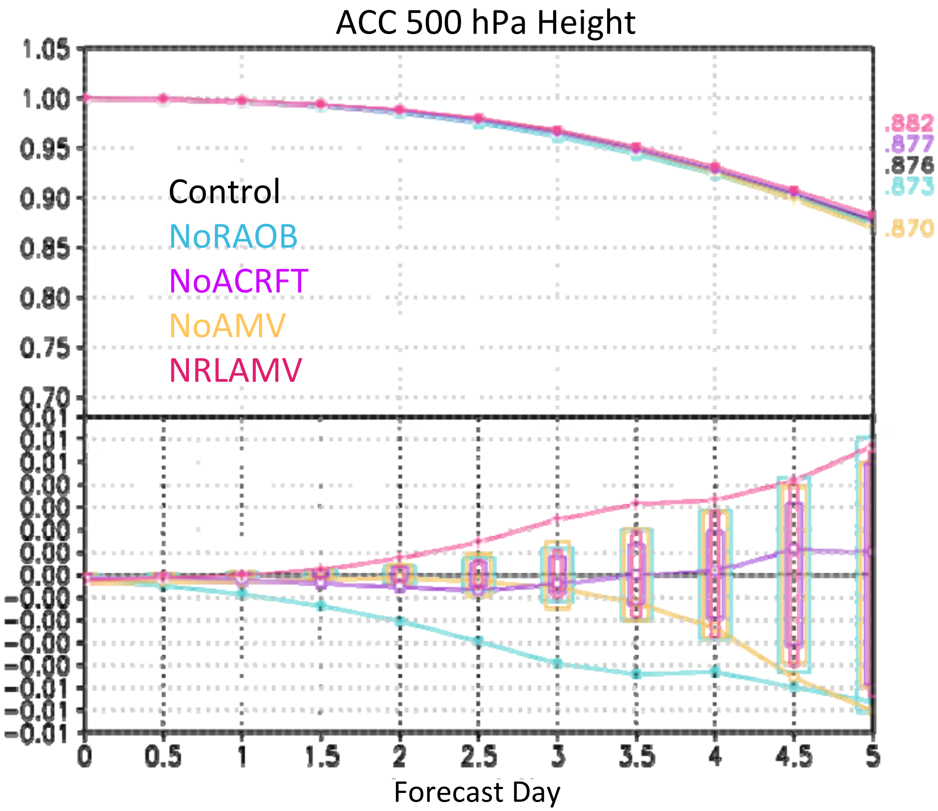


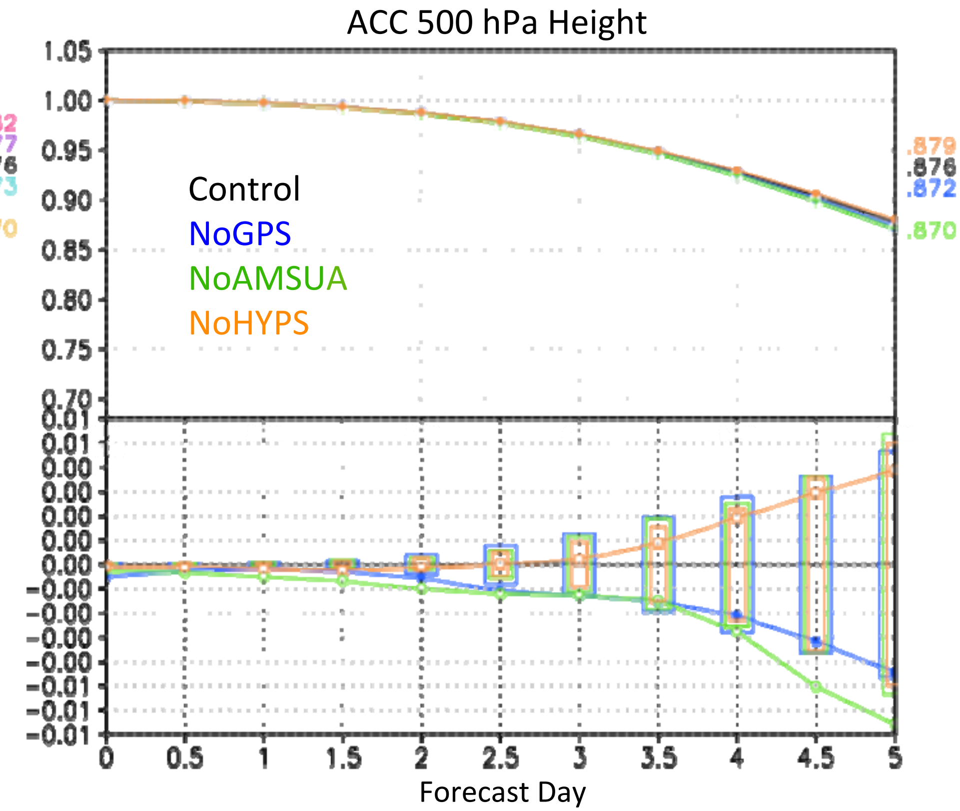


GEOS-5 OSE Forecast Skill and Significance

10 Dec 2010 – 31 Jan 2011 00z

Northern Hemisphere



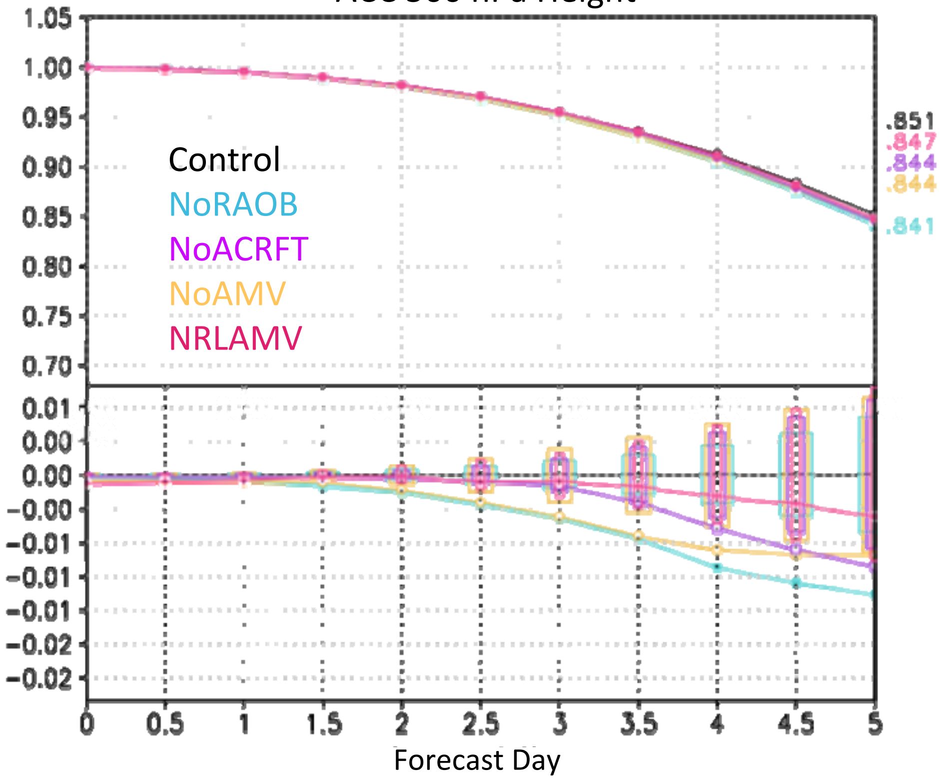


GEOS-5 OSE Forecast Skill and Significance

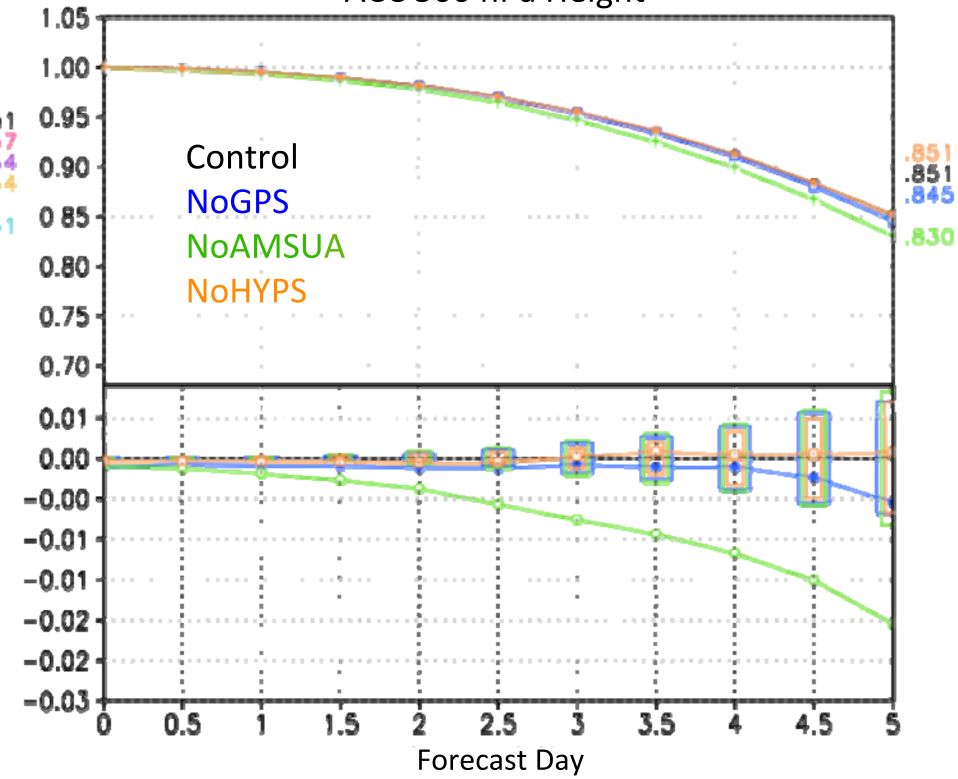
10 Dec 2010 – 31 Jan 2011 00z

Southern Hemisphere

ACC 500 hPa Height



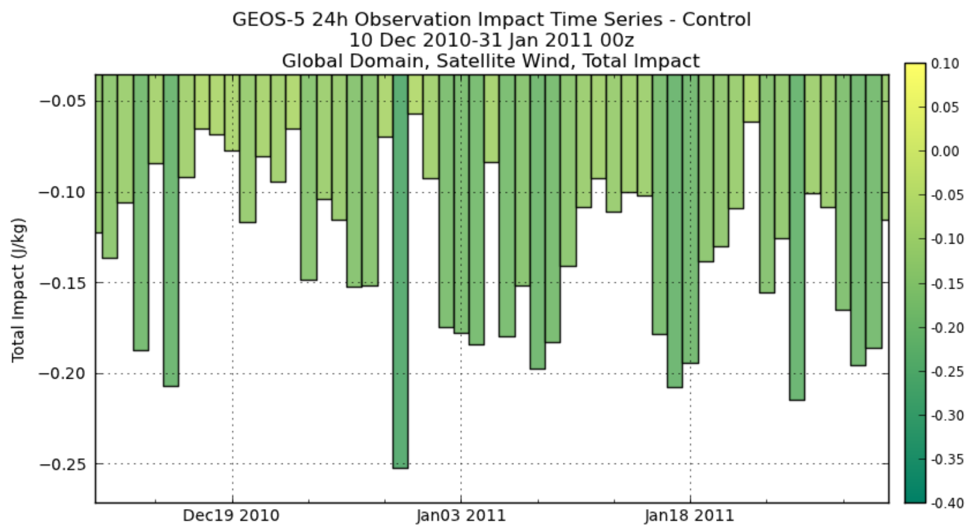
ACC 500 hPa Height



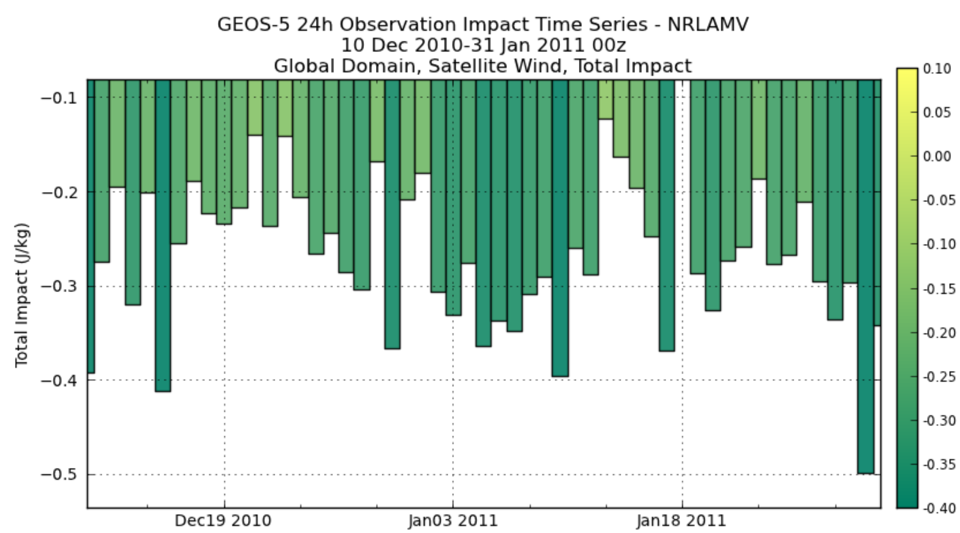
Time Series of Satellite Wind Total Impact – Global

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

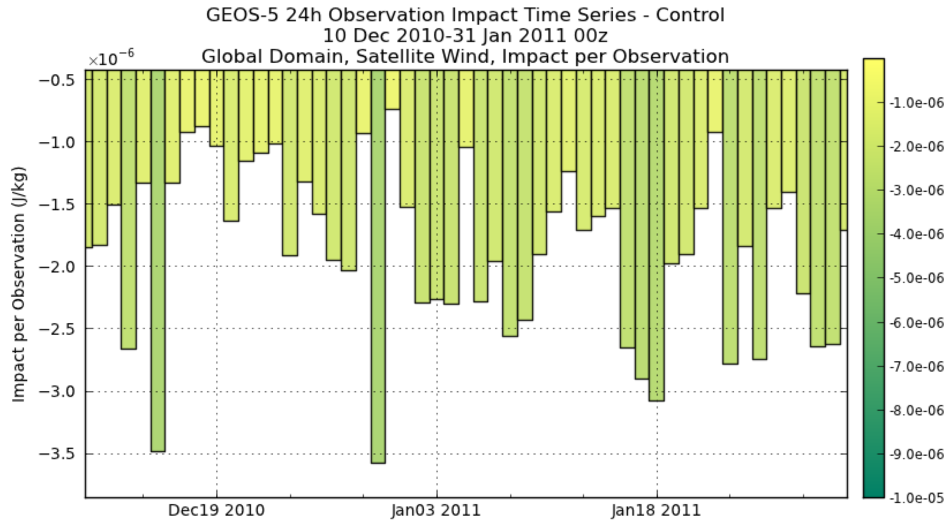


NRLAMV

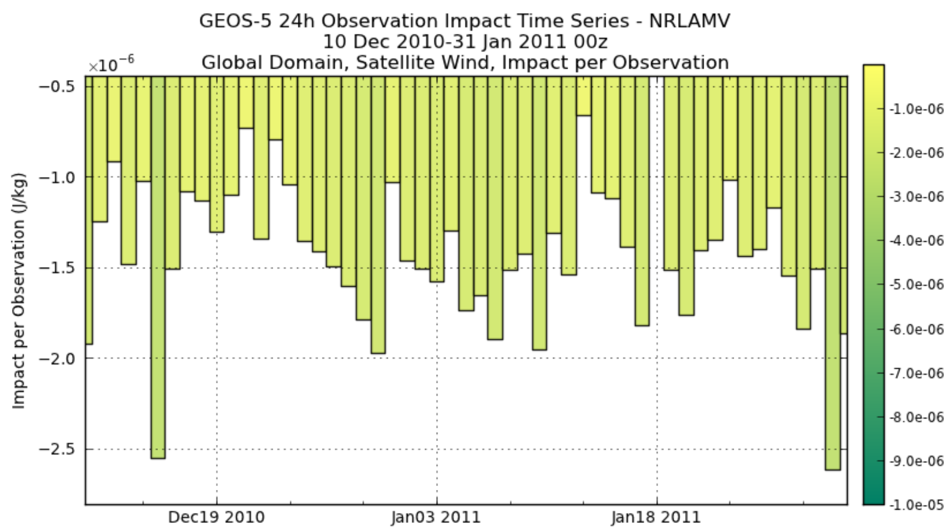
Time Series of Satellite Wind Impact Per Observation – Global

10 Dec 2010 – 31 Jan 2011 00z

- Impact per observation comparable in both experi-ments, though slightly larger in the control



Control

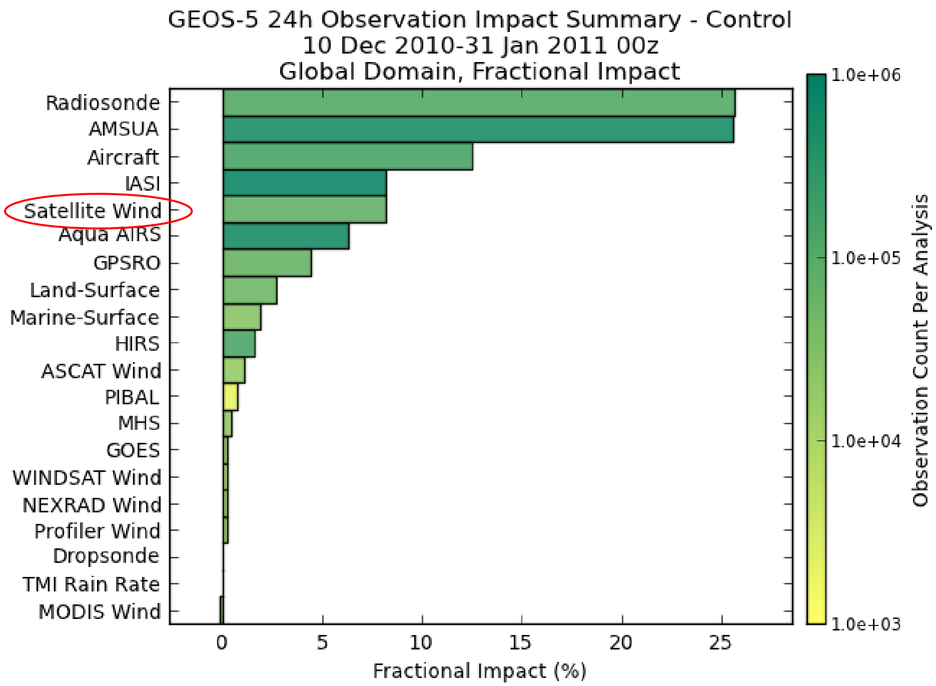


NRLAMV

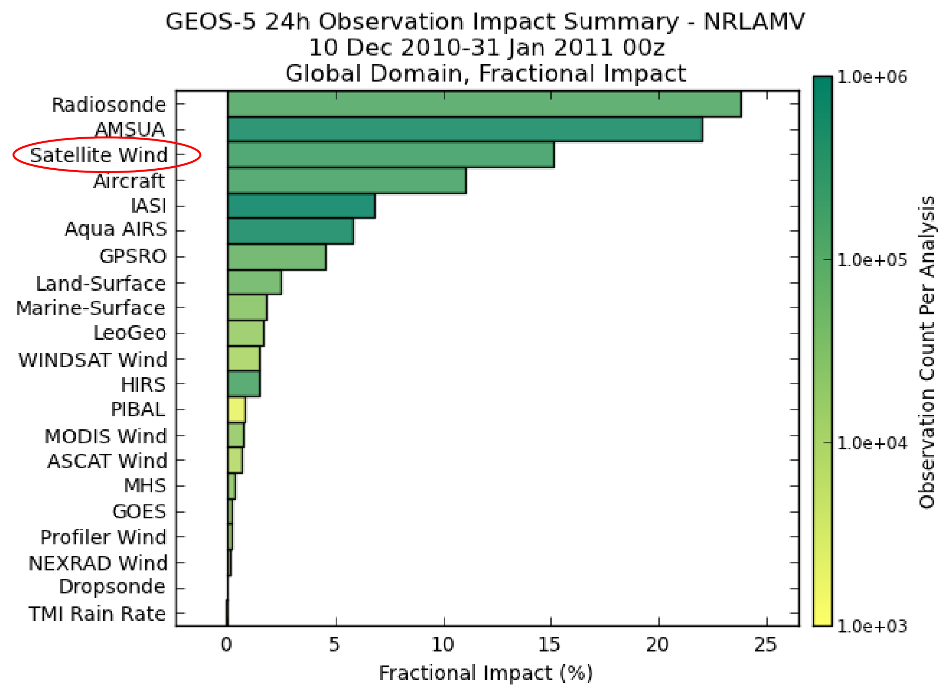
Summary of Total Observation Impact – Global

10 Dec 2010 – 31 Jan 2011 00z

Control



NRLAMV



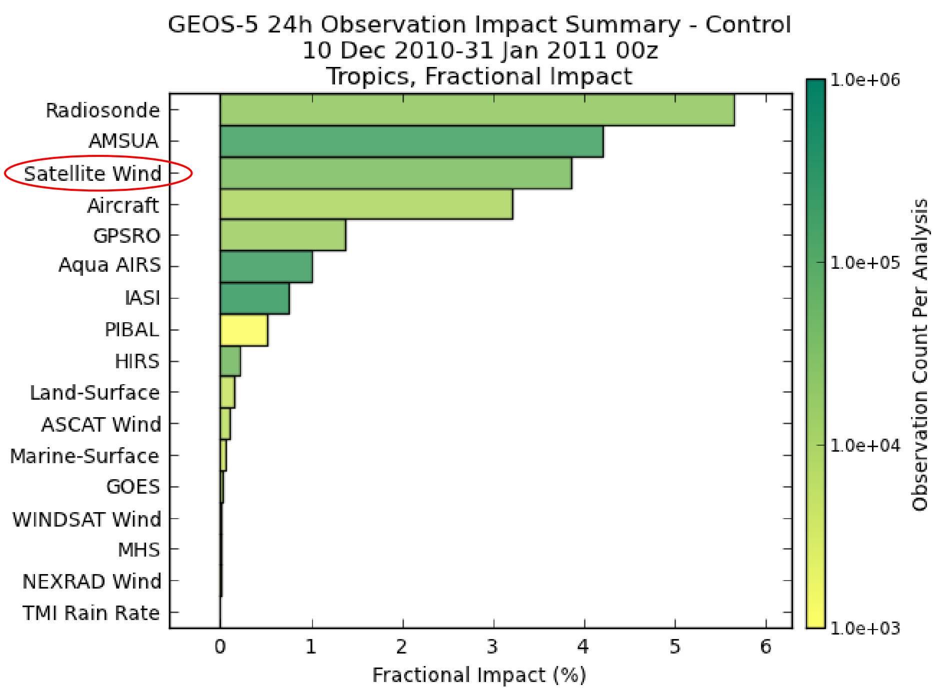
- NRL satwinds (in all locations) have roughly *double* the total impact of GMAO satwinds

… "inconsistency" with OSE result?

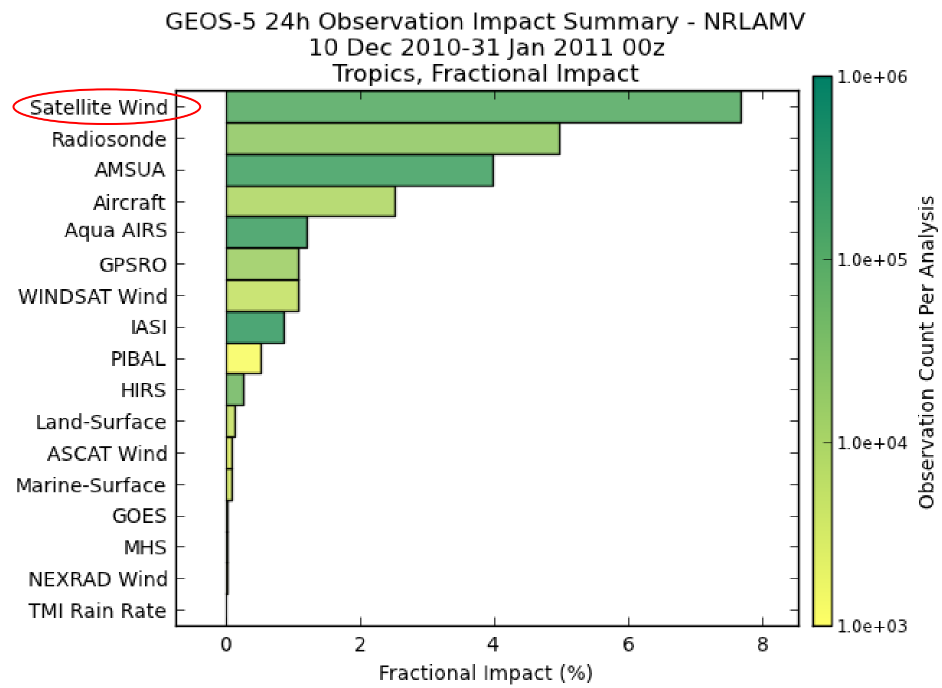
Summary of Total Observation Impact – Tropics

10 Dec 2010 – 31 Jan 2011 00z

Control



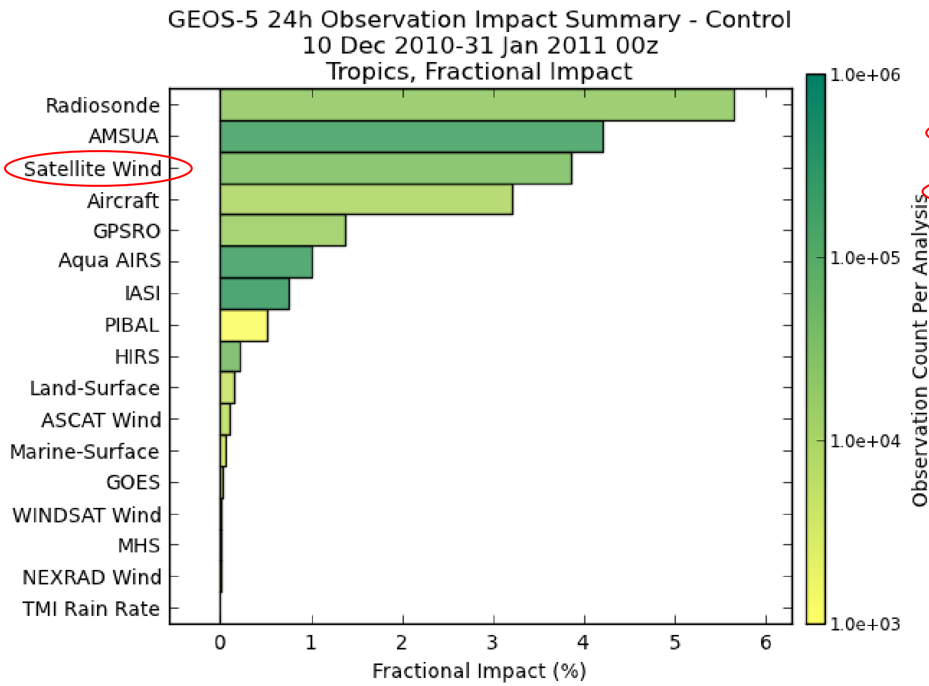
NRLAMV



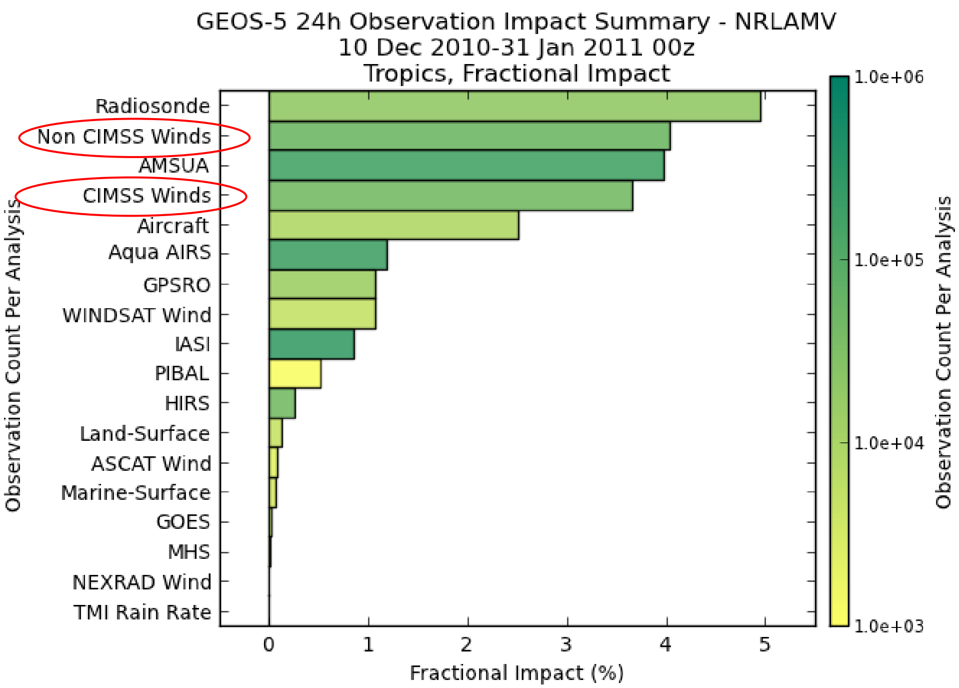
Summary of Total Observation Impact – Tropics

10 Dec 2010 – 31 Jan 2011 00z

Control



NRLAMV

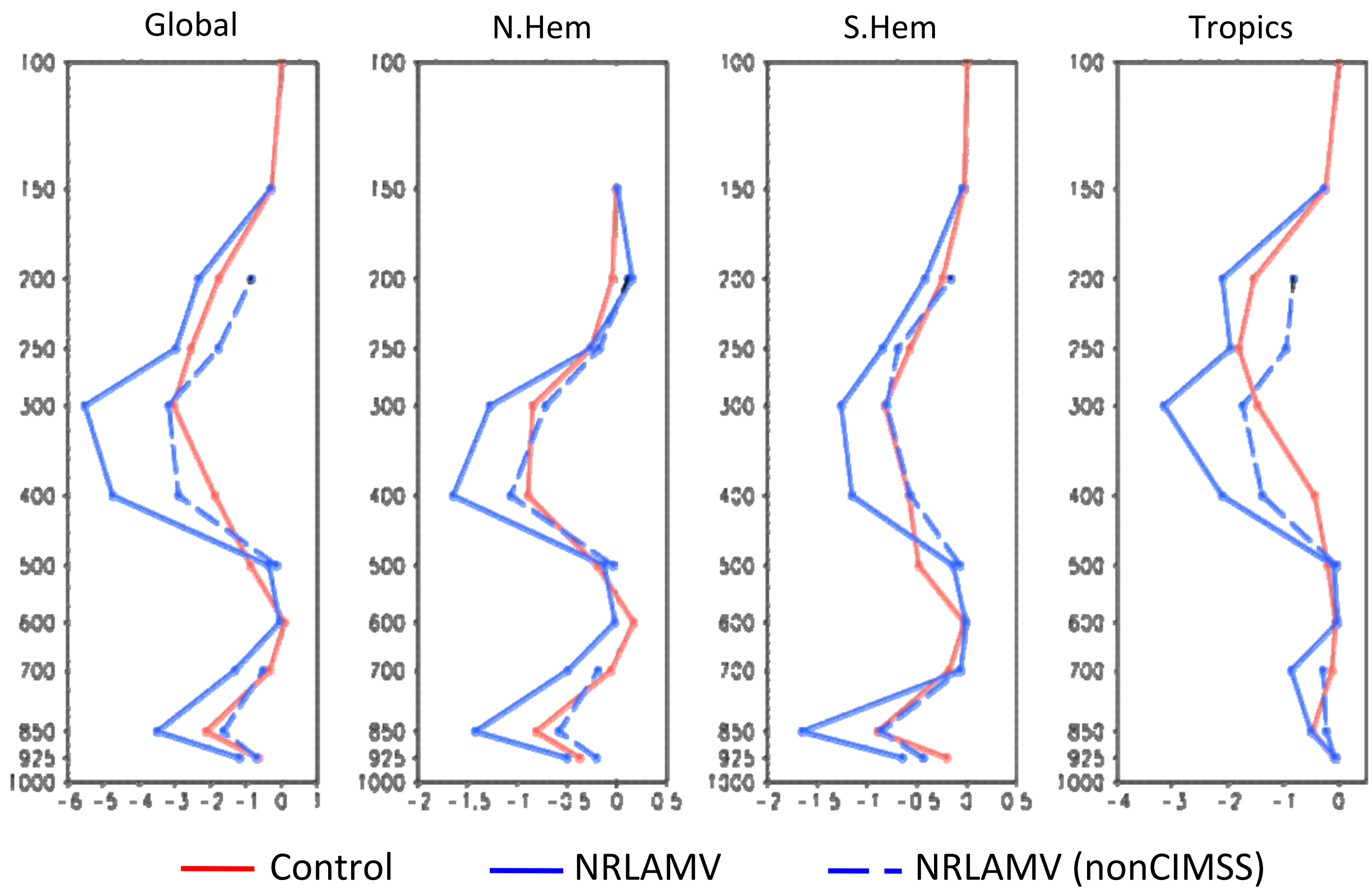


- Contributions from CIMSS and non-CIMSS winds are comparable to each other, and to that from GMAO control winds

…NRLAMV data volume drives the larger impact

Area-Averaged Vertical Profiles of Satellite Wind Impact

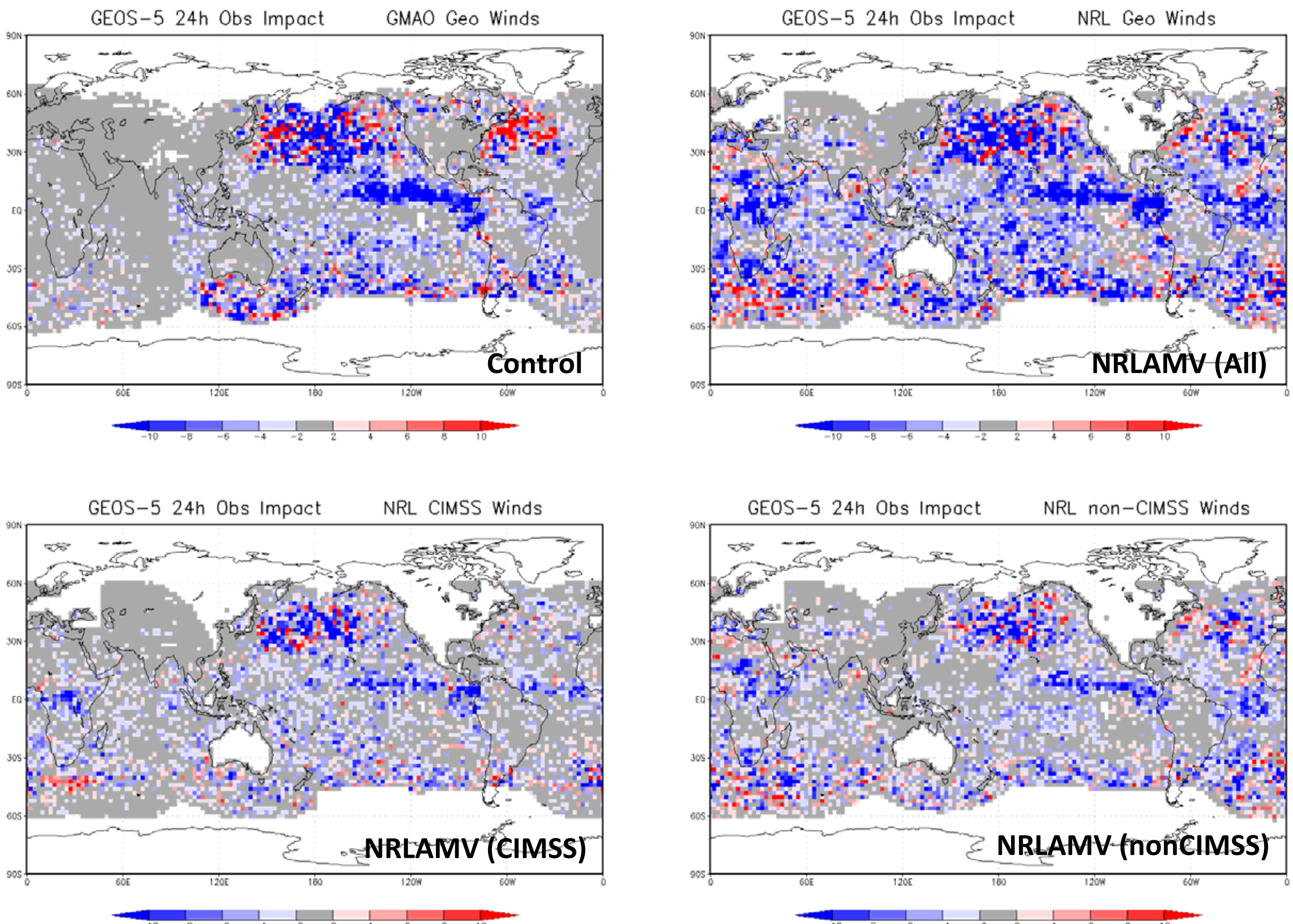
10 Dec 2010 – 31 Jan 2011 00z



• Discounting contribution from CIMSS winds, impacts of NRL and GMAO satwinds have virtually identical magnitude and vertical distribution

Gridded Vertically Summed Impact of Satellite Winds

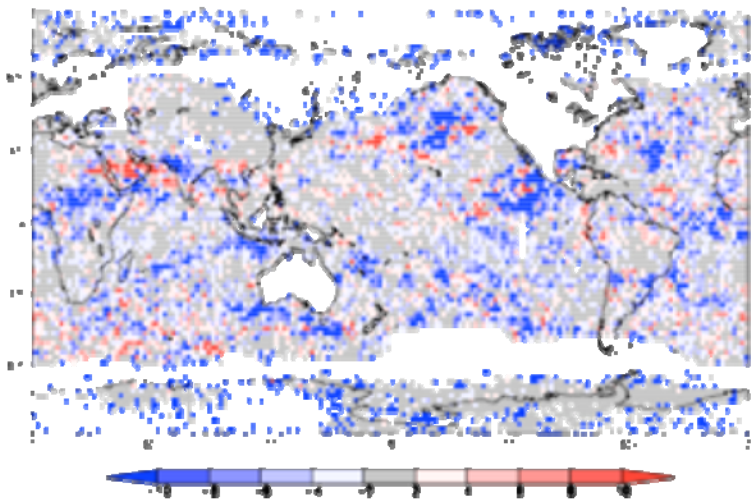
10 Dec 2010 – 31 Jan 2011 00z



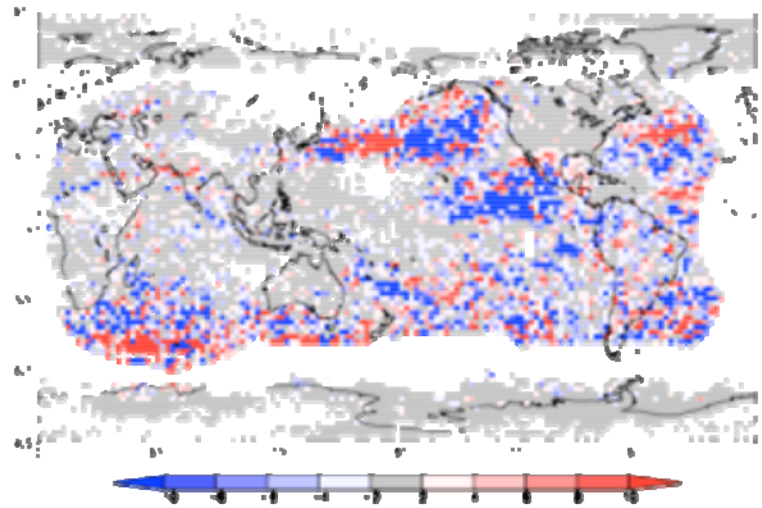
A Previous Intercomparison Study…

January 2007

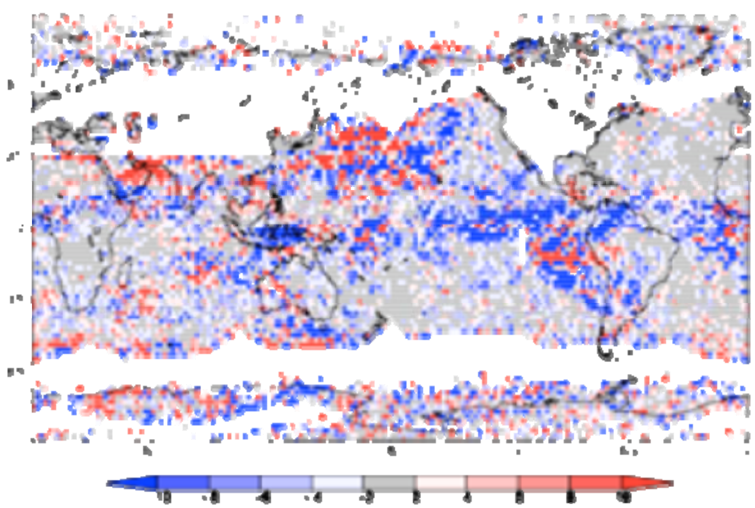
NRL NOGAPS



GMAO GEOS-5



EC GDPS



Satwind impacts 700-300 hPa

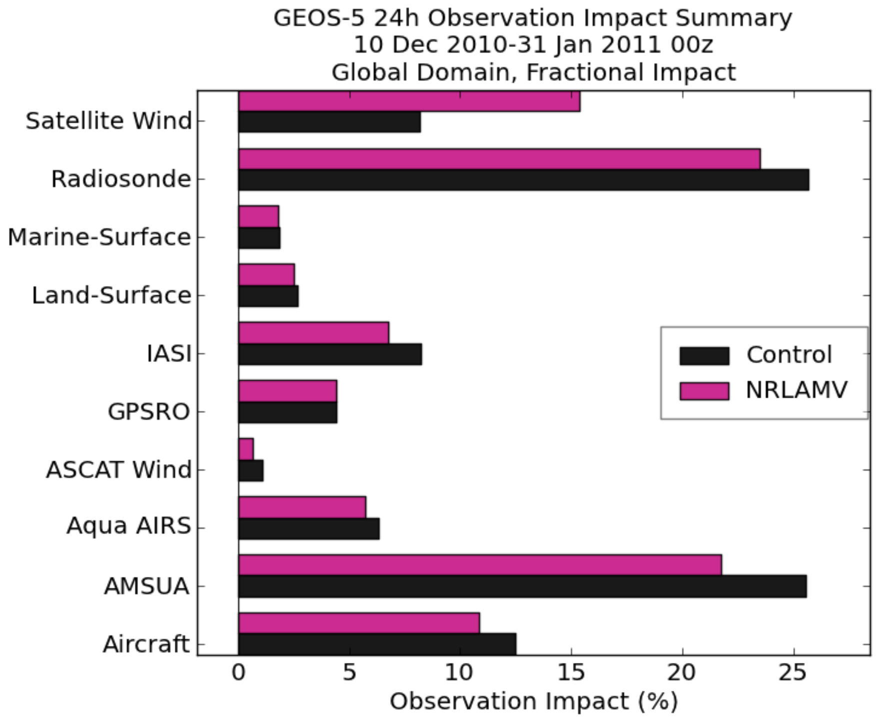
…more uniformly beneficial impact ofsatwindsin NOGAPS compared with Canadian and GMO systems

Gelaro et al. 2010

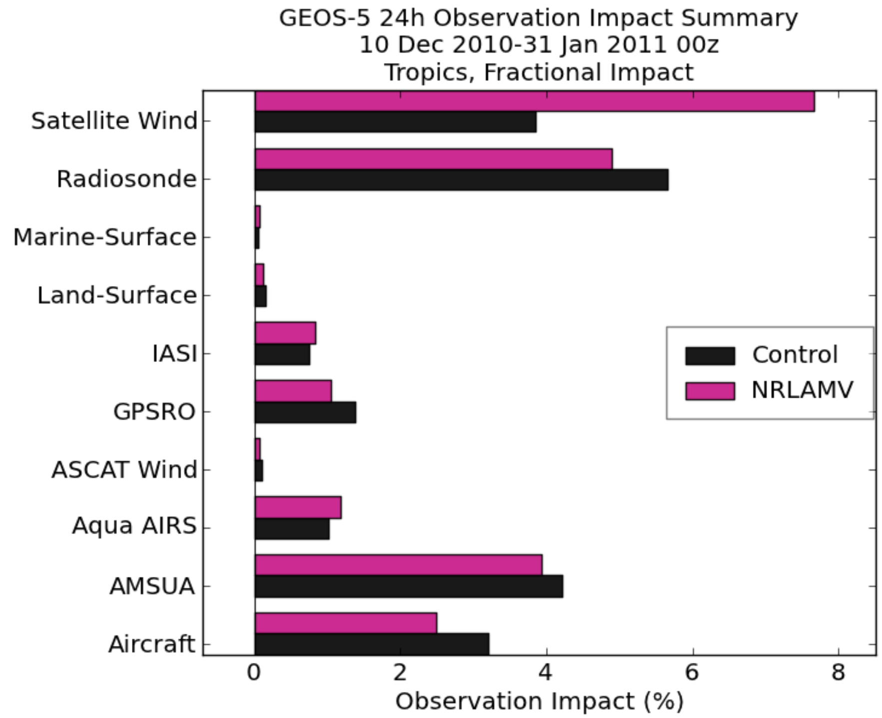
Relative Impacts of Selected Observing Systems

10 Dec 2010 – 31 Jan 2011 00z

Global Obs



Tropical Obs

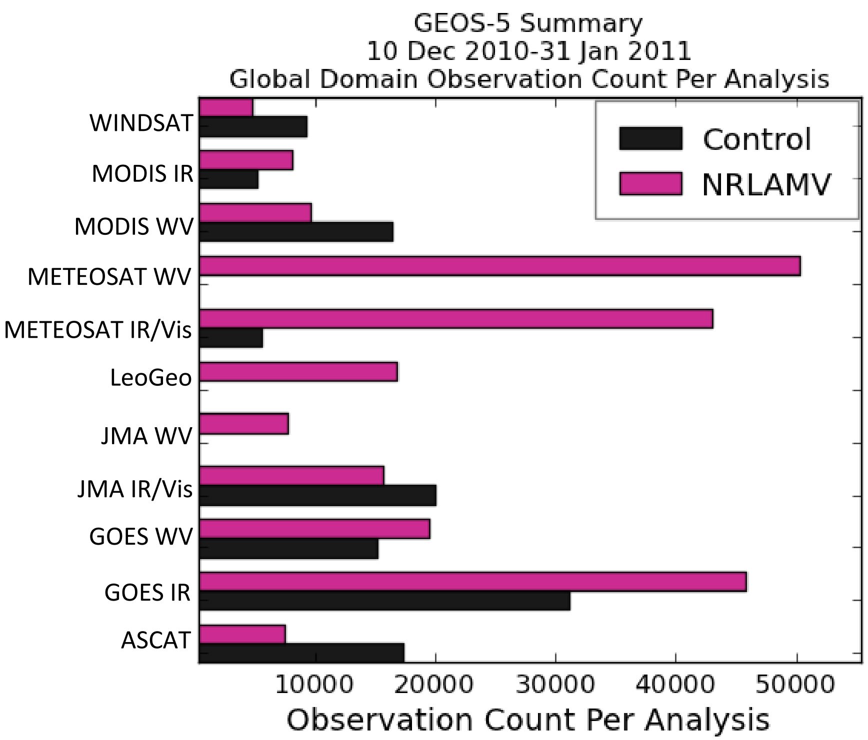


- NRL satwinds have *double* the fractional impact of GMAO satwinds, and slightly reduce the fractional impacts of several other observing systems (e.g. aircraft)

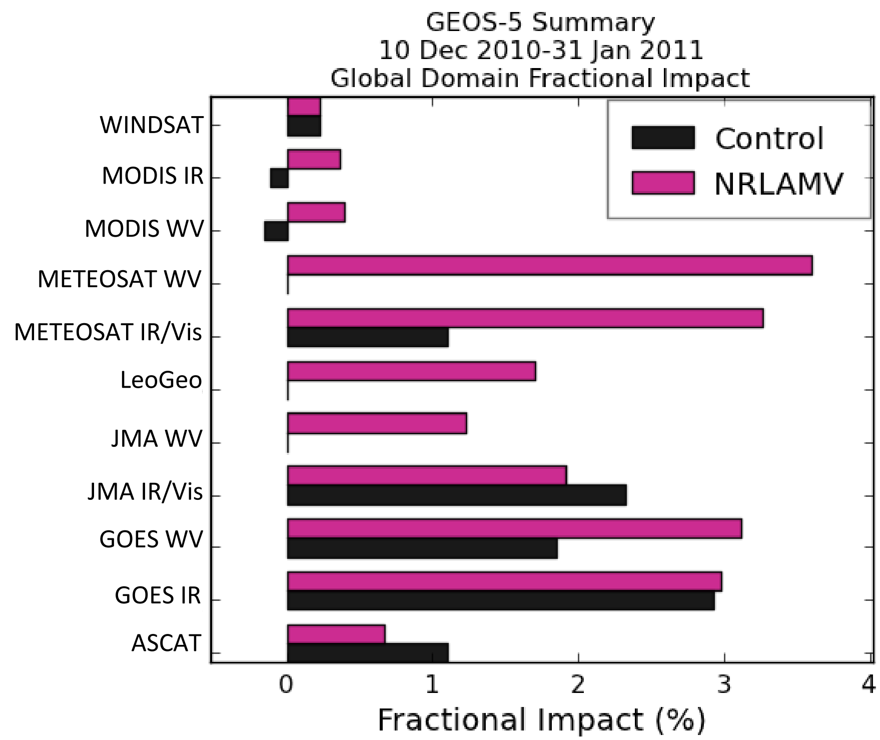
Relative Impacts of Selected AMV Types

10 Dec 2010 – 31 Jan 2011 00z

Global Data Count



Total Impact

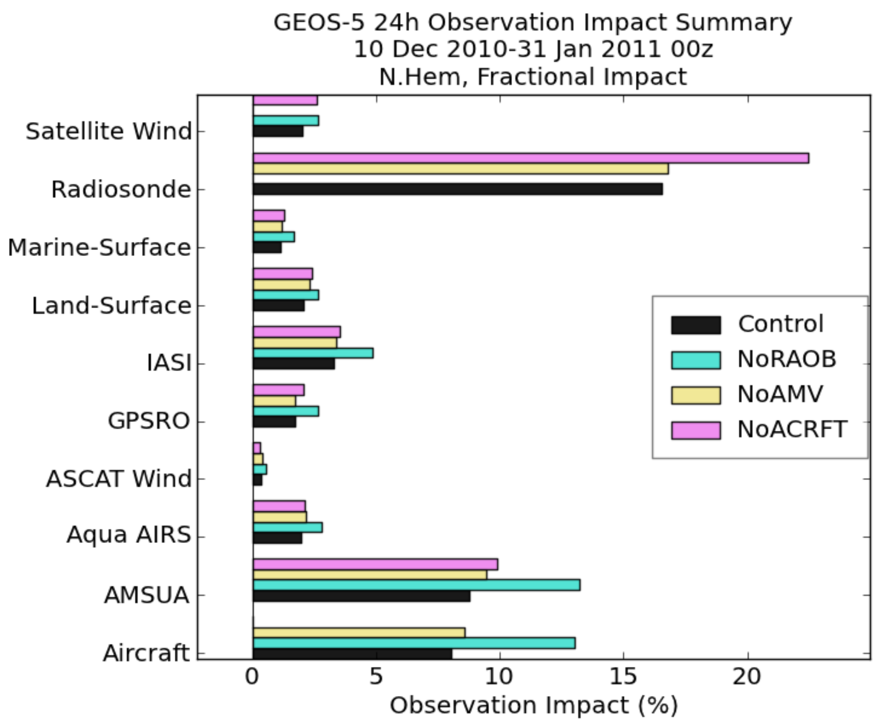


- Relative impacts of most AMV types correlate well with data counts
- Beneficial impact of MODIS winds in NRLAMV (versus non-beneficial impact in control) requires other explanation….superobs?

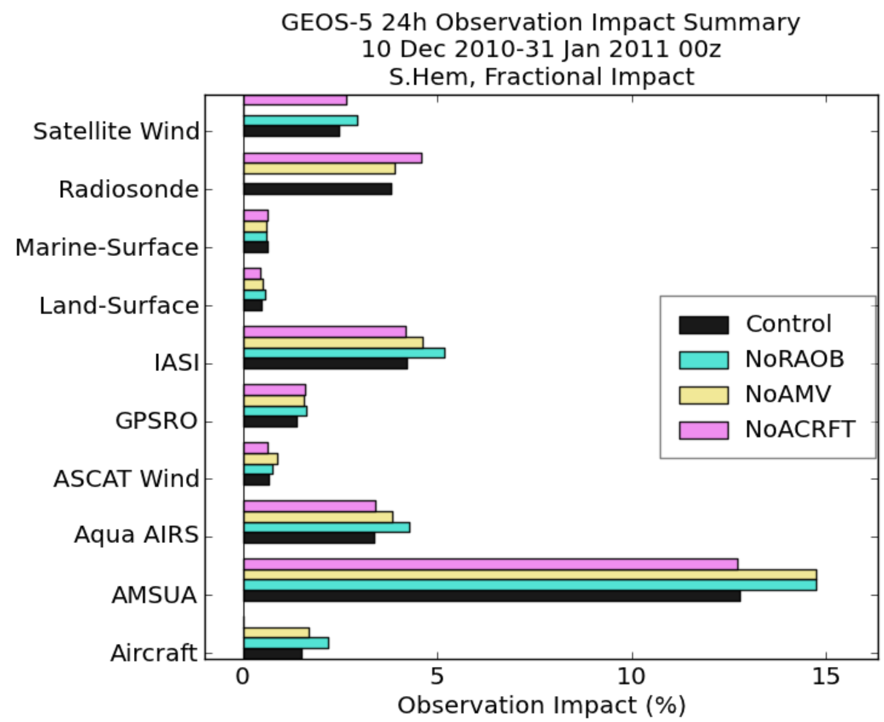
Relative Impacts of Selected Observing Systems - Conventional

10 Dec 2010 – 31 Jan 2011 00z

N.HemObs



S.HemObs

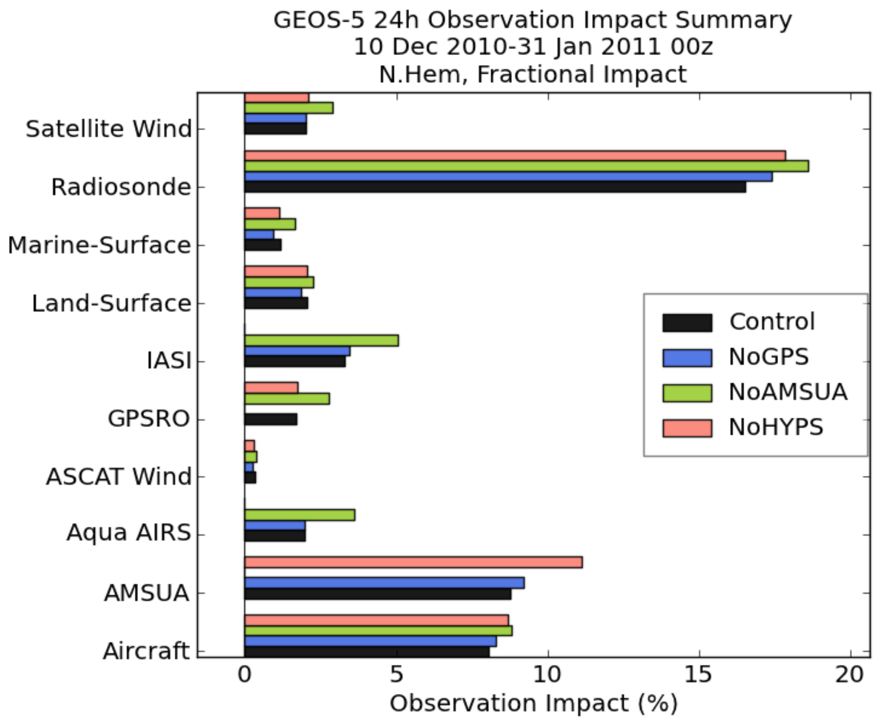


- Compensating effects of removing conventional observing systems are largest in the NH
- Removal of raobs increases fractional impact of aircraft and AMSU-A (>60%); removal of aircraft increases fractional impact of raobs (>30%)

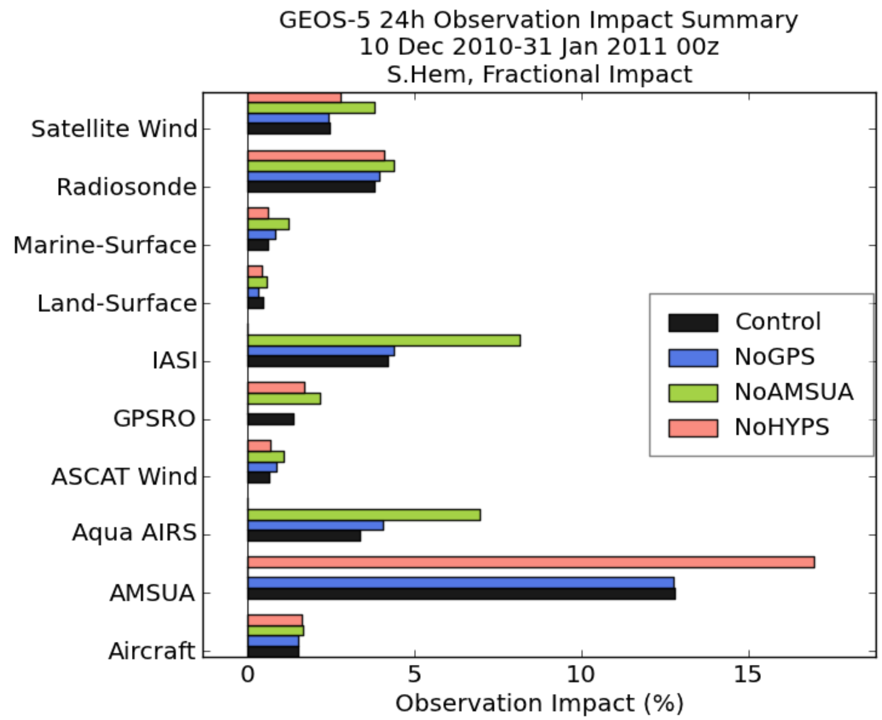
Relative Impacts of Selected Observing Systems - Satellite

10 Dec 2010 – 31 Jan 2011 00z

N.HemObs



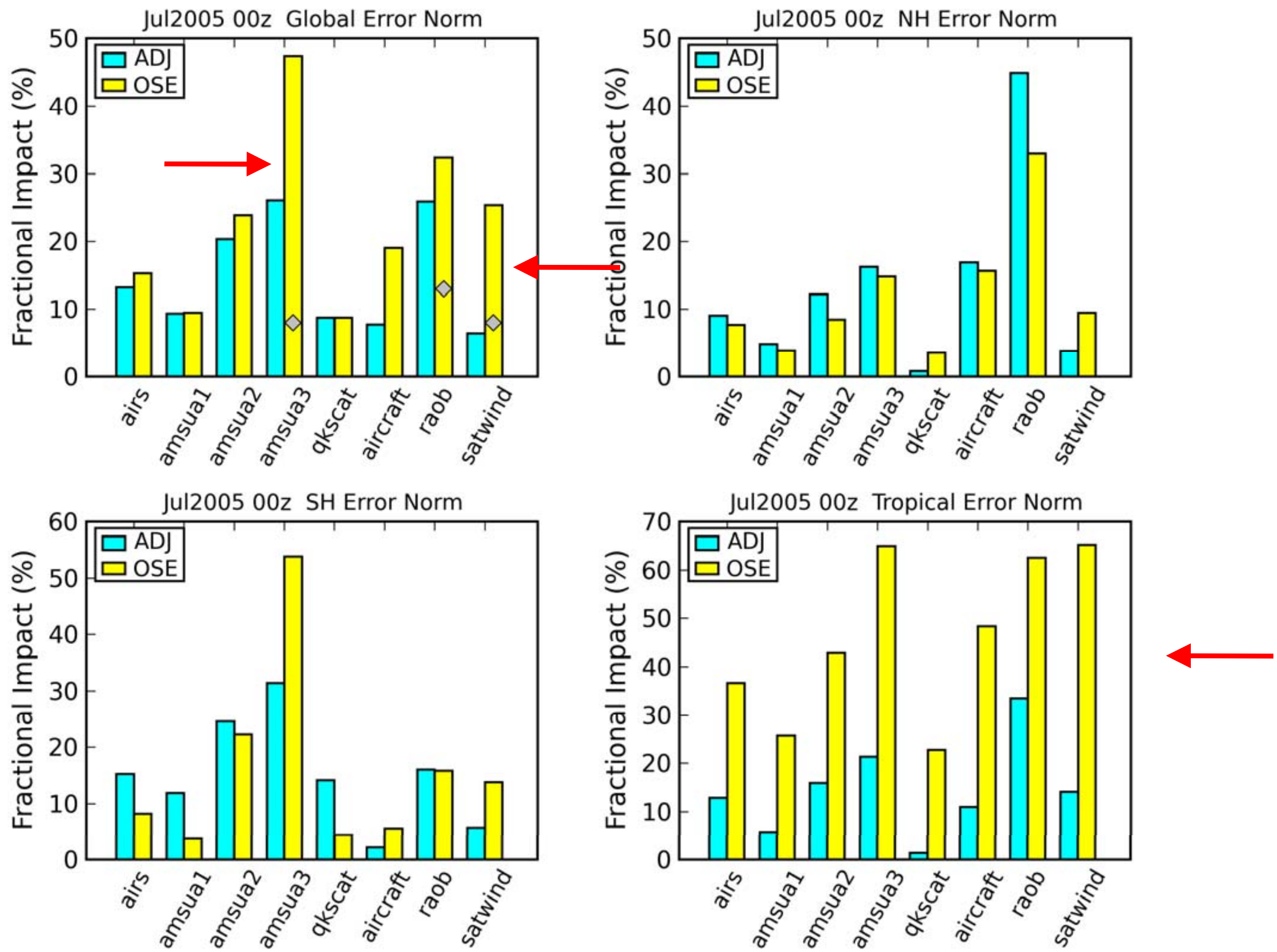
S.HemObs



- Compensating effects of removing satellite radiances are largest in the SH
- Removal of AMSU-A doubles the fractional impact of hyperspectral IR; removal of hyperspectral IR increases the fractional impact of AMSU-A (>35%)

A Previous Comparison of OSE- and ADJ-Based Obs Impacts

July 2005



…generally consistent, but not in all cases. *(Gelaro and Zhu 2009)*

Conclusions

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

- Comparedtothe 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)

- All results indicate that the greater volume (versus superobing) of the NRL AMVs is primarily responsible for their larger impact, but there is evidence that superobing is also beneficial

- Observation mix plays a significant role in modulating the impact of any one data type: the smaller impact of the NRL AMVs in the GMAO system (compared with their impact in the NRL system) is likely due to the larger number of satellite radiances in the GMAO system

- Additional experiments might include assimilating NRL AMVs while reducing the number of radiances

- Richness of (not inconsistency between) OSE and ADJ results argues for the continued use of both approaches where possible