

JCSDA

GMAO Data Assimilation Overview

Michele Rienecker

Ron Gelaro, Ricardo Todling, Emily Liu, Steven Pawson, Ron Errico, Will McCarty

Christian Keppenne & Guillaume Vernieres

Rolf Reichle

Global Modeling and Assimilation Office (GMAO)

NASA/Goddard Space Flight Center



JCSDA 7th Workshop on Satellite Data Assimilation

May 12-13, 2009

A few highlights....

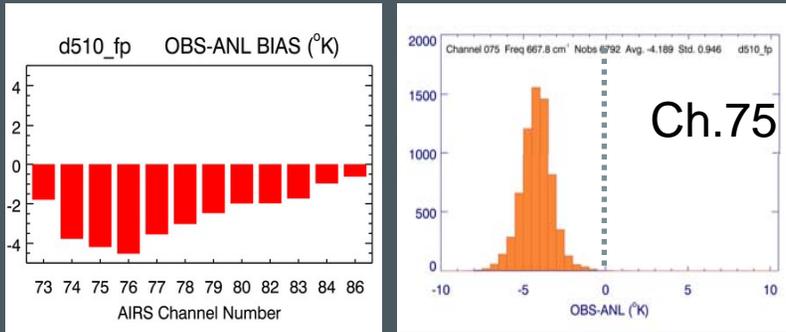
- Atmospheric Data Assimilation
 - AIRS
 - MLS Temperature assimilation
 - Observing System Impact with Adjoint Tools
 - Progress on OSSE infrastructure
 - Preparing for ADM and 3DWinds

 - System update – 4DDA system - Observing system impacts
with Adjoint
tools

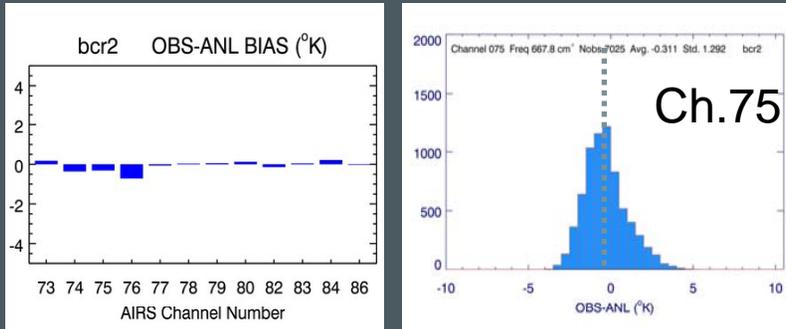
- Land and Ocean data assimilation

Impacts of Variational Bias Correction on GEOS-5 Temperature Analysis and Assimilation of AIRS 15 μm CO₂ Channels

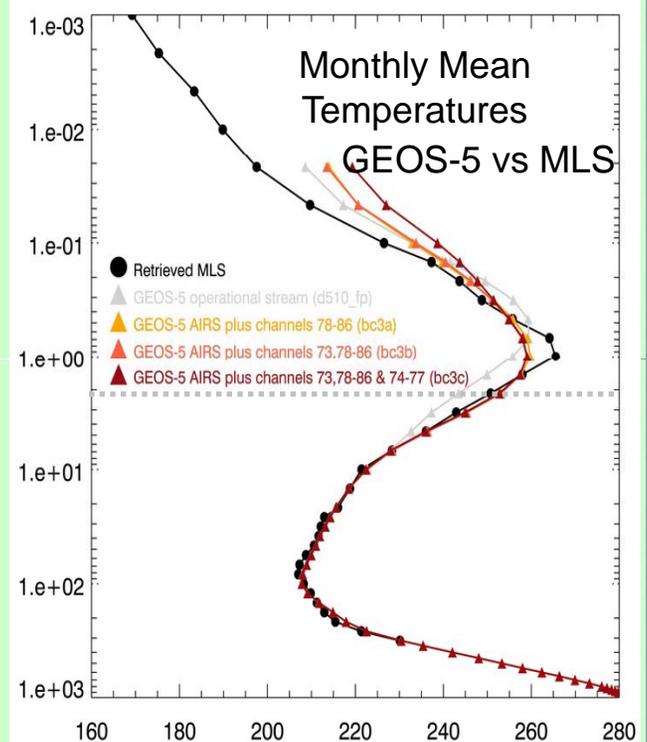
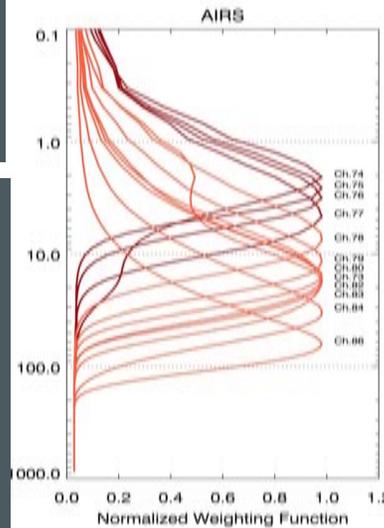
...see poster by Emily Liu



VarBC ON



VarBC OFF



- Good agreement with MLS up to 2 hPa
- Negative impact from AIRS channels in the mesosphere due to spurious temperature Jacobians from CRTM near the model top

GEOS-5 temperature analyses show significantly better fit to AIRS **passive** channels 73-86 in 15 μm CO₂ absorption band

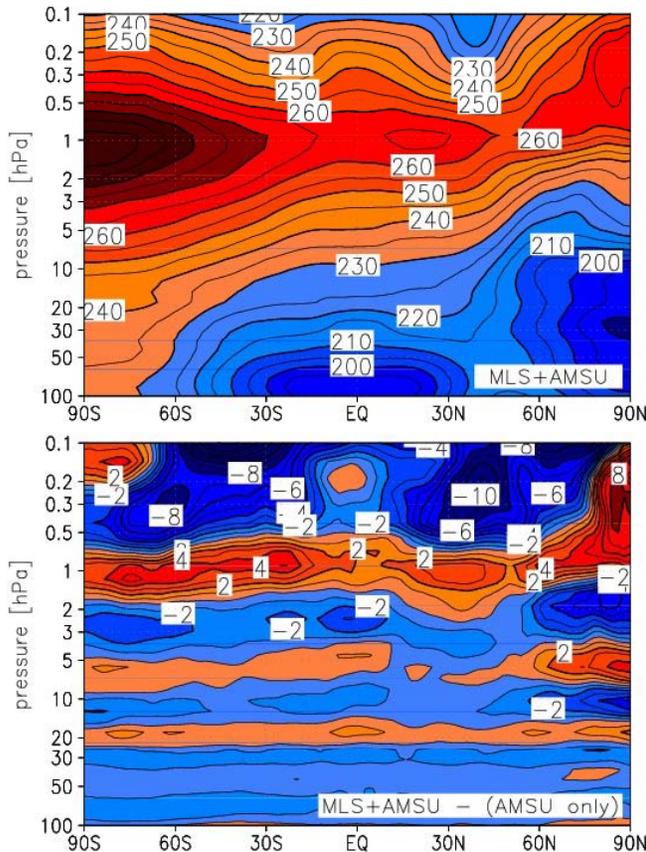


Assimilation of MLS Temperature

Impact on other data

Observed minus analyzed (O-A) of brightness temperatures: N-15 AMSU-A Ch 14 (assimilated) and AIRS Ch 74 (passive). Both channels peak in the upper stratosphere.

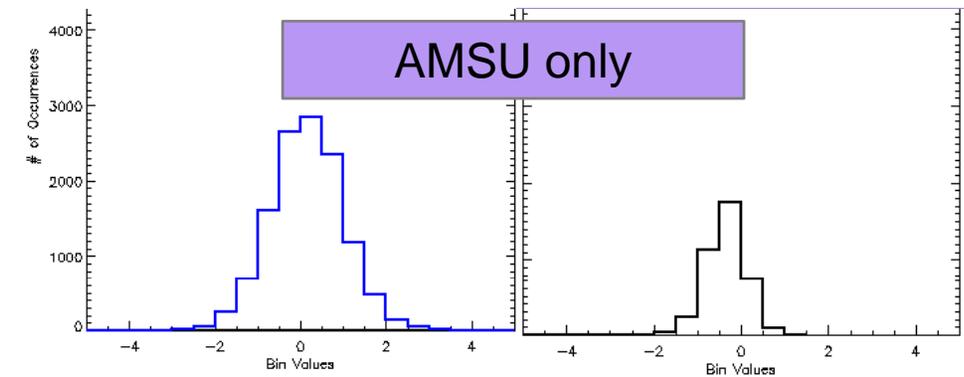
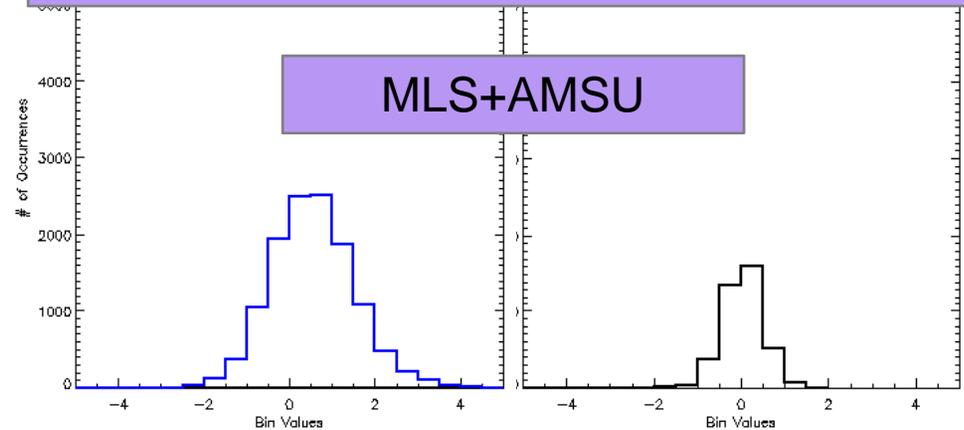
The zonal-mean temperature, Jan 1 2005
AMSU only c.f. MLS+AMSU



Stratospheric layering may be an MLS issue

From comparison with lidar and HALOE data:
Assimilating MLS temperatures leads to improved structure esp. stratopause and lower mesosphere

Pawson, Sienkiewicz, et al.



MLS temperature results in a slight degradation - a positive bias and a wider pdf.

MLS temperature removes a slight negative brightness temperature bias.

Comparison of Data Impact in Navy and NASA GEOS-5 Forecast Systems using Adjoint Methods

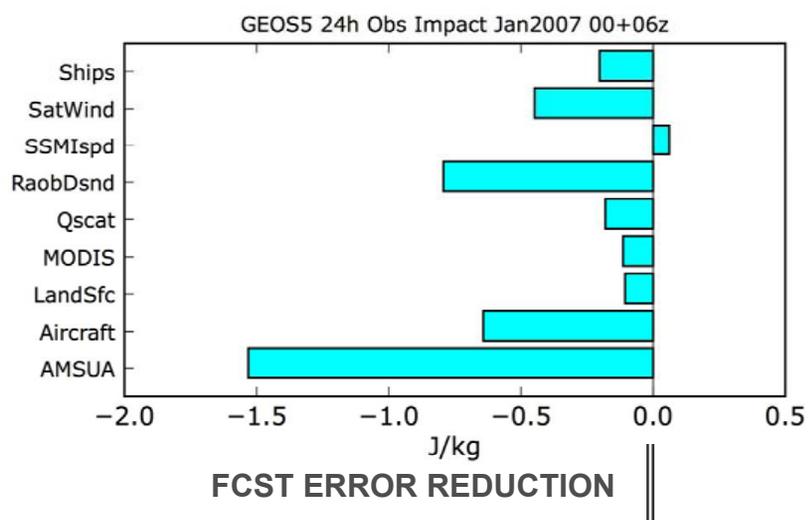
...see talk by Langland, Baker & Gelaro in session 2a

- NOGAPS and GEOS-5 comparison completed for baseline set of observations
- Largest impacts provided by AMSU-A and Raobs (GEOS-5) and AMSU-A and Satwinds (NOGAPS)
- Differences between GEOS-5 and NOGAPS in impacts of selected AMSU-A channels
- Problem areas with AMSU-A noted
- Final study to include ECMWF and Canadian global model results ?

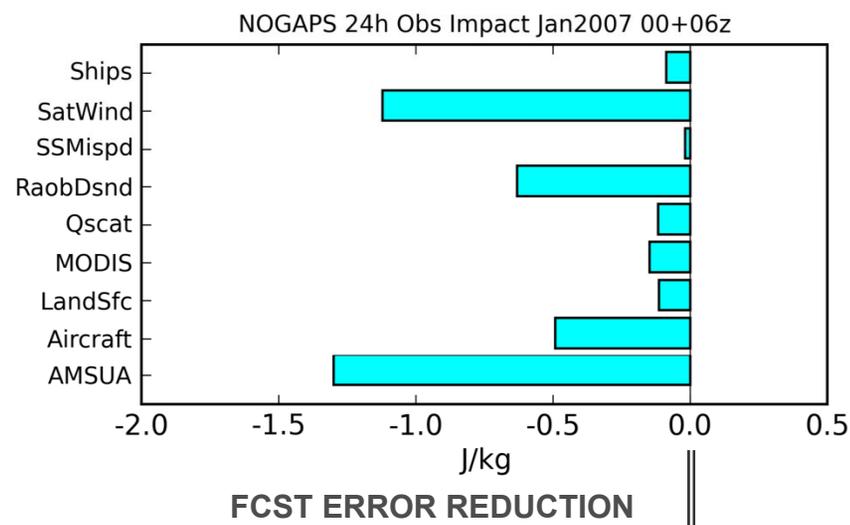
Total Observation Impacts for Jan 2007

Global Domain 00+06 UTC Assimilations

GEOS-5



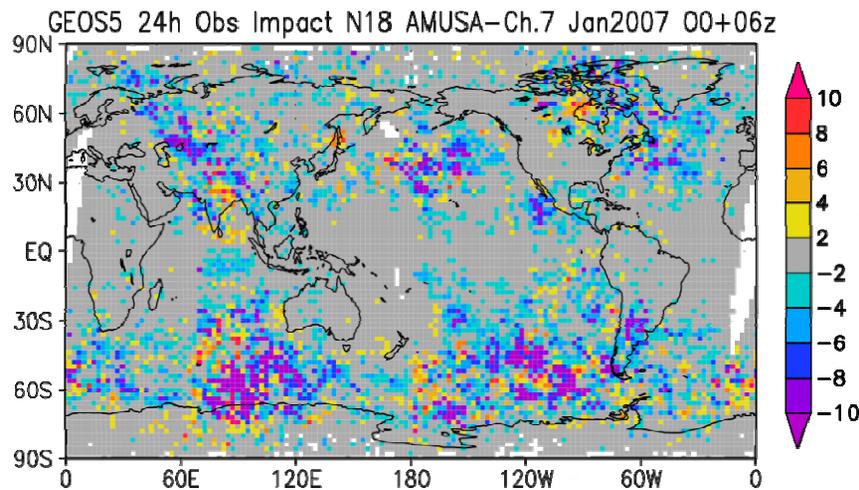
NOGAPS



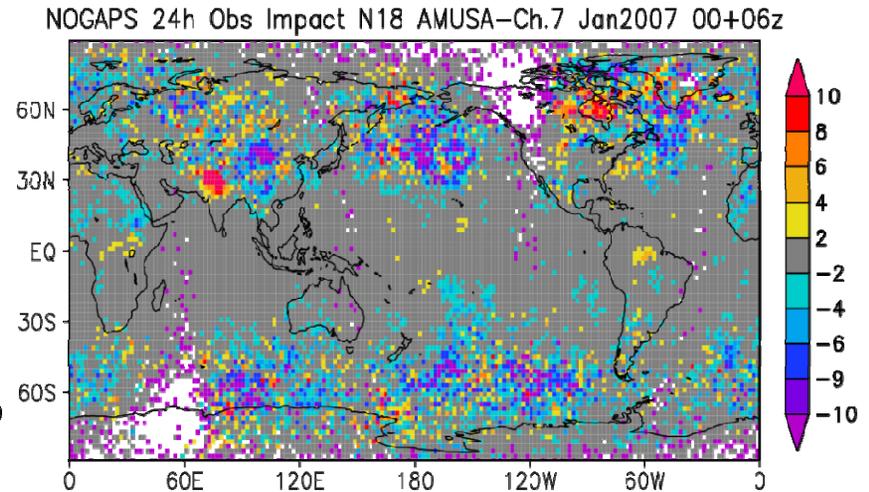
Larger impact of satellite winds (AMVs) in NOGAPS; for this one observation type, more data are used in NOGAPS

Observation Impacts: NOAA-18 AMSU-A Ch.7 Global Domain 00+06 UTC Assimilations

GEOS-5



NOGAPS

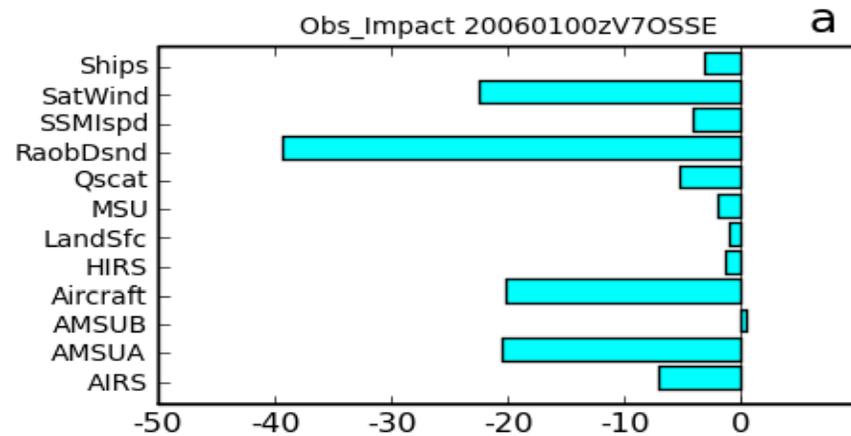


Regions of beneficial and non-beneficial impacts generally agree in both systems...the latter may provide focal points for improving the use of satellite observations

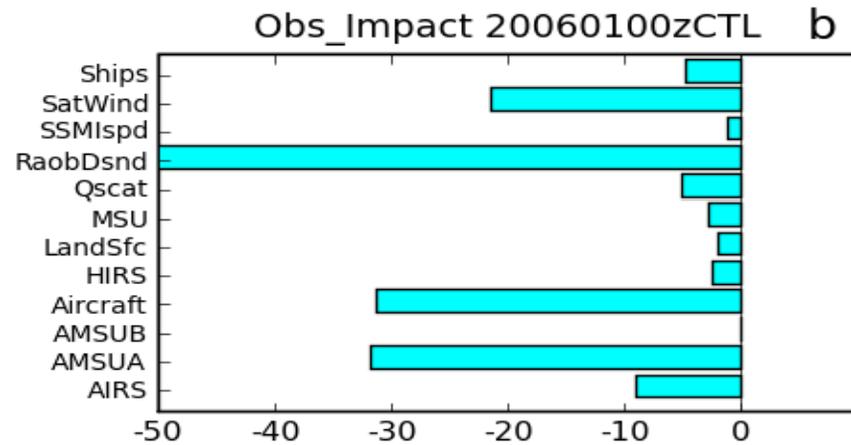
OSSE Calibration - Validation

Adjoint-derived estimates of observation impacts
on 24-hour forecast error energy

OSSE DAS

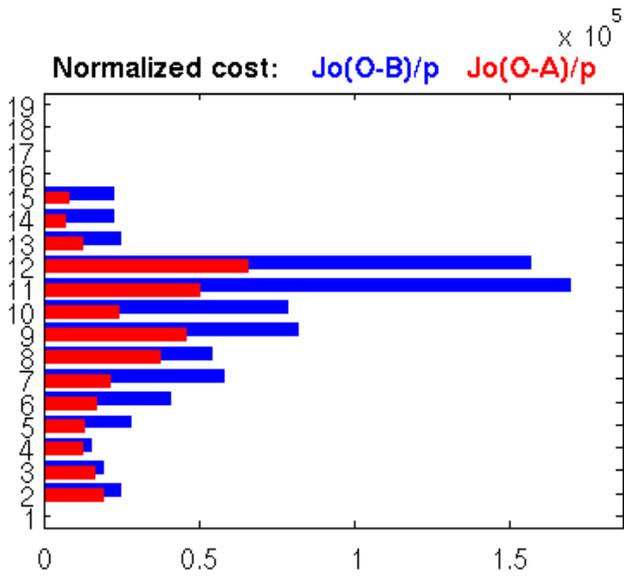
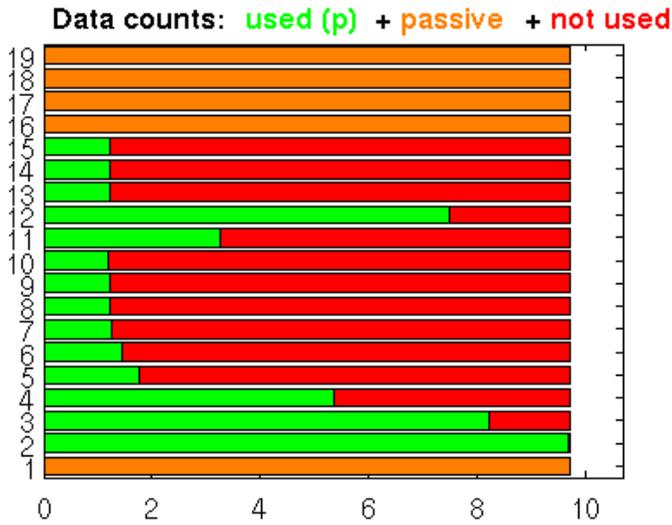


Reference DAS

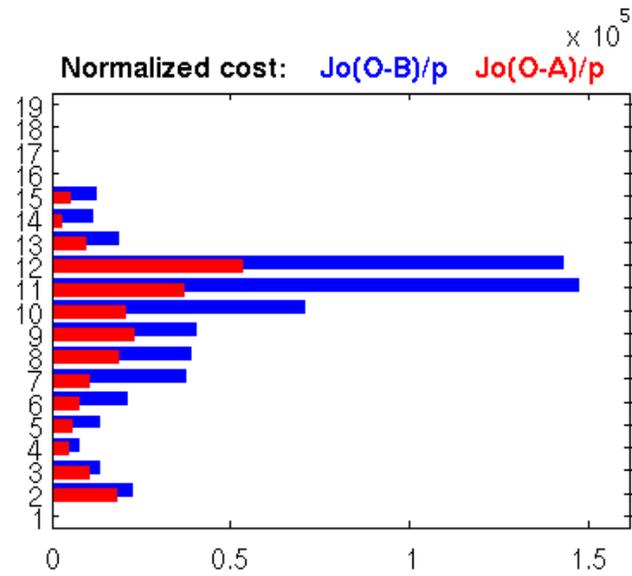
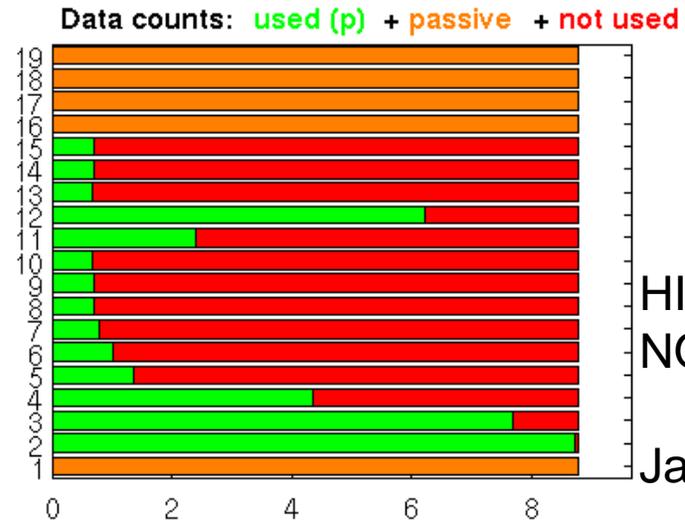


OSSE Validation

OSSE DAS



Reference DAS

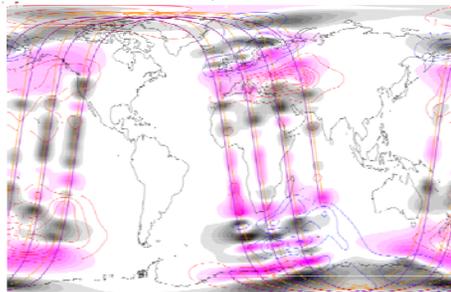


HIRS-3
NOAA-17
Jan 2006

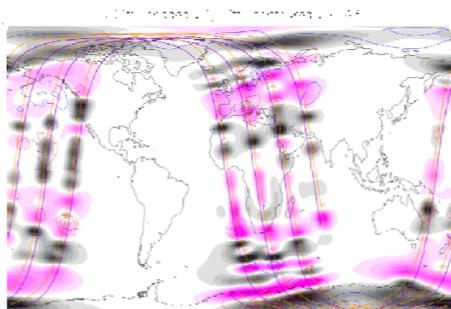
The Development and Simulation of Doppler Wind Lidar Measurements and Assimilation Methodologies in Preparation for ADM-Aeolus and 3D-Winds

Assimilation increments: 200 hPa u , T_v

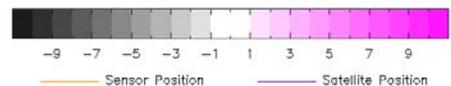
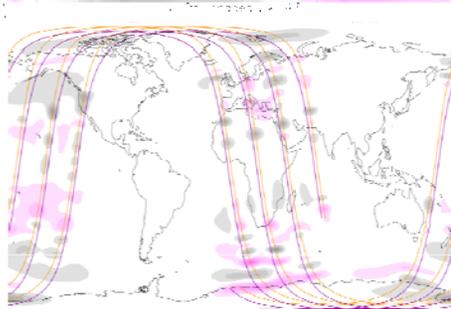
LOS - BKG



CNTRL + LOS
- CNTRL



Δ



...see poster by Will McCarty

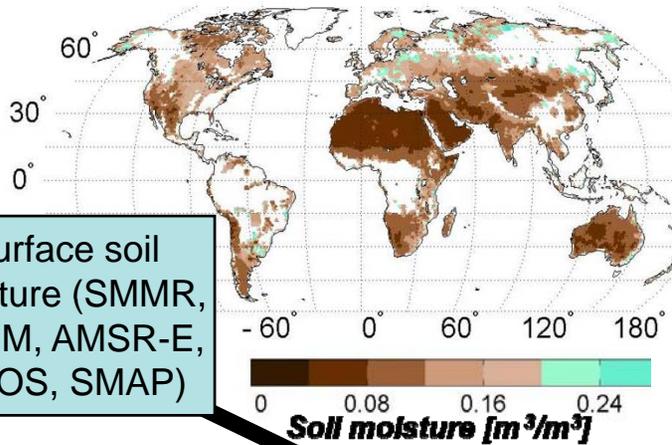
- Developed base infrastructure to simulate individual LOS measurements from the ECMWF Nature Run
- 1st step: ADM-like orbit, no addition of error, crude assessment of cloud structure
- Updated GSI to ingest and assimilate these Level-2 measurements
- Test case underestimates LOS wind error

Summary of 4DVar Progress at GMAO

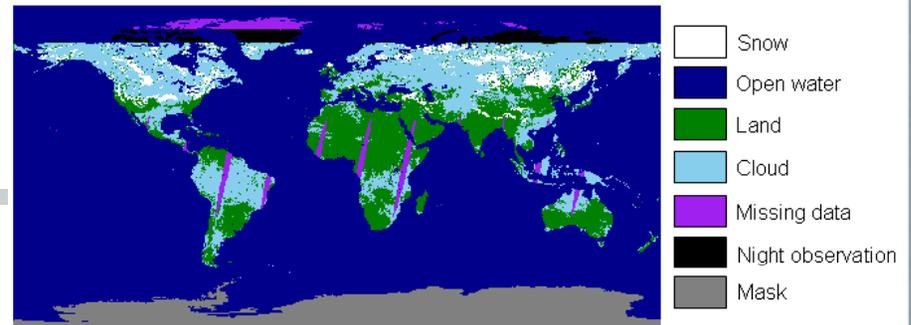
- Prototype NASA GEOS DAS 4DVAR now available
- Encouraging preliminary results with prototype 6-hr and 12-hr cycle 4DVAR
- Various adjoint-based diagnostic tools now available in GEOS DAS: forecast sensitivities, singular vectors, analysis sensitivity, and observations impact.
- **Folded into latest code merge with NCEP**
- Next steps:
 - Address computational efficiency of TLM/ADM
 - Develop adjoint of physics modules
 - Bring prototype 4DVAR to Operational-readiness status
 - Work on weak constraint 4DVAR formulation

*The implementations done thus far benefited greatly from the
original infrastructure of EMC-GMAO GSI
and
from 1-year visit by Yannick Trémolet from ECMWF*

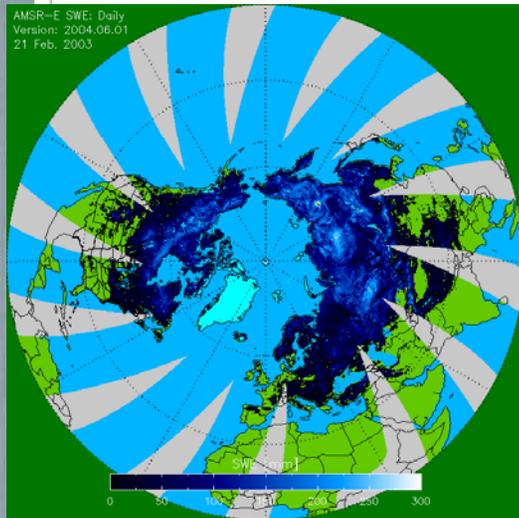
GMAO Land data assimilation



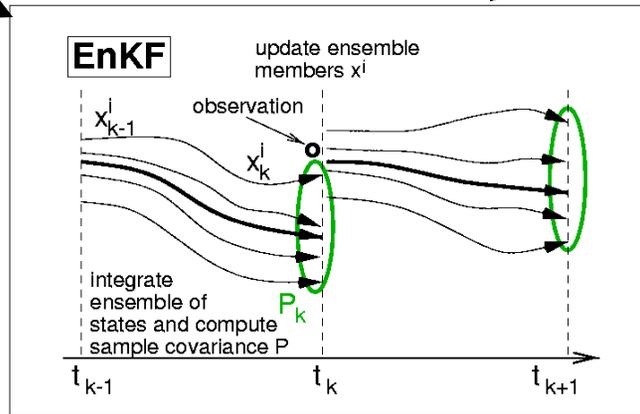
Surface soil moisture (SMMR, TRMM, AMSR-E, SMOS, SMAP)



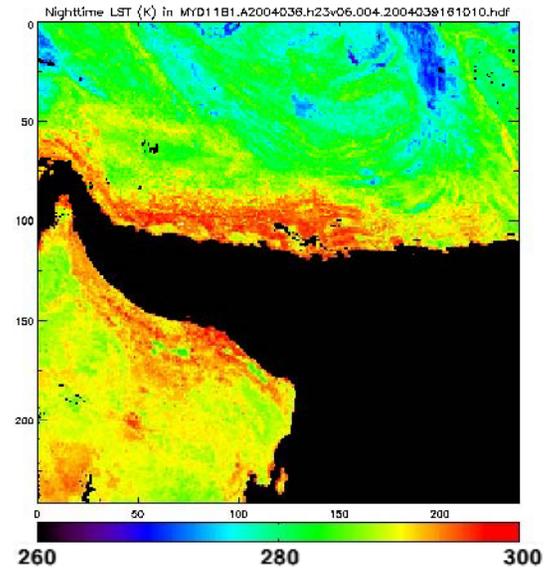
Snow cover fraction (MODIS)



Snow water equivalent (SWE) and snow cover (AMSR-E, SSM/I; MODIS)



Ensemble-based land data assimilation system

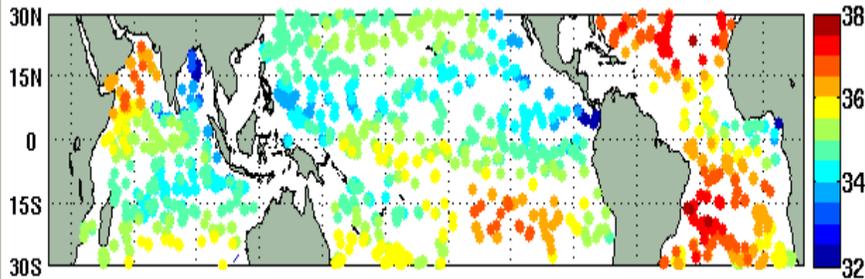


Land surface temperature (MODIS, AVHRR, GOES, ... "ISCCP")

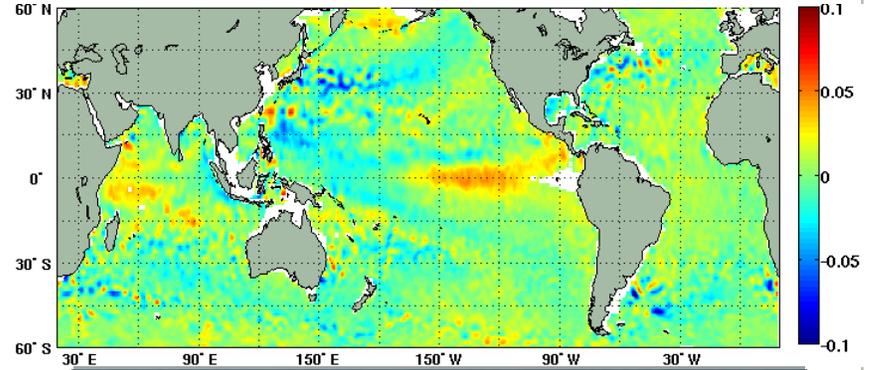
Land surface data products (incl. root zone soil moisture, evaporation)

Reichle

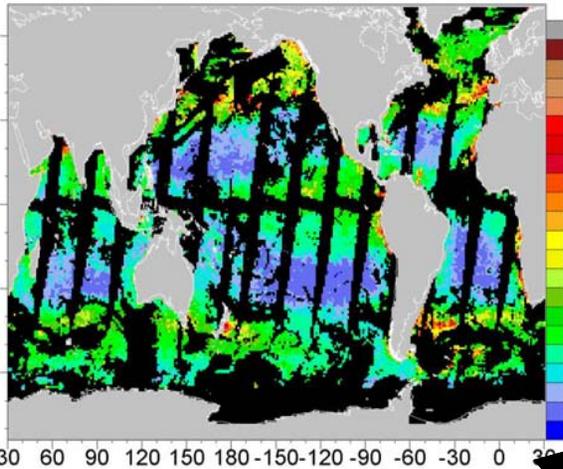
Ocean data assimilation in the GMAO



Temperature and salinity profiles from Argo floats

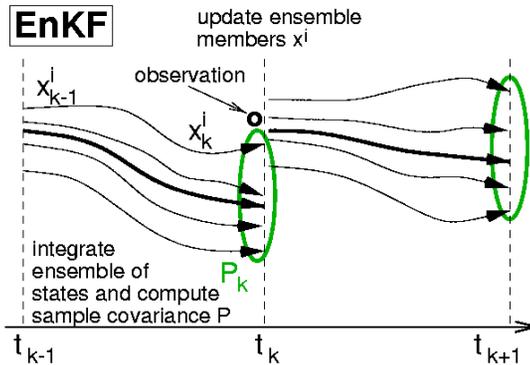


Sea Level anomalies (TOPEX/JASON)



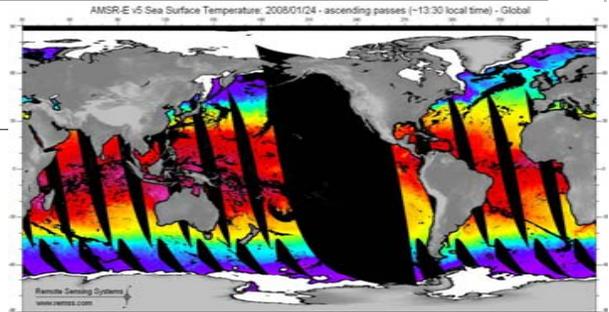
Surface chlorophyll (CZCS, SeaWiFS, MODIS)

EnKF

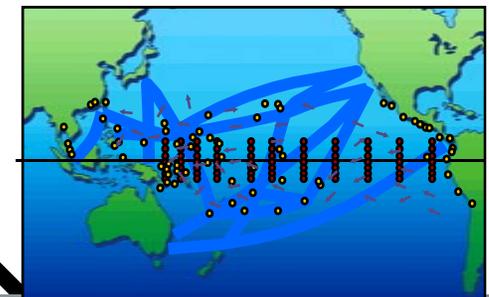


Ensemble-based ocean data assimilation system

Ocean state estimates for climate analysis and for short-term climate forecasts



SST (AMSR-E; MODIS)



In situ temperature profiles (TAO/PIRATA moorings, XBTs)

Summary

- GMAO's JCSDA efforts are focused towards improving the use of AIRS, MLS and OMI data, preparing for ADM and NPP/OMPS
- Data assimilation adjoint - efficient tool for observation impact studies
 - Complements traditional OSEs
 - Comparisons of impacts - clarify deficiencies in data quality vs. assimilation methodology (GMAO and NRL)
 - Is being applied to OSSEs to validate calibration
- 4DVar development maturing - important to extract information from satellite data
- Aerosol and carbon species included with real-time operational system
- Emerging JCSDA collaborations on ocean data assimilation - Jason-1, OSTM, Aquarius
- Preparing for SMAP L4 product