JCSDA
GMAO Data Assimilation Overview

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JCSDA 8th Workshop on Satellite Data Assimilation
May 4-5, 2010

A few highlights….

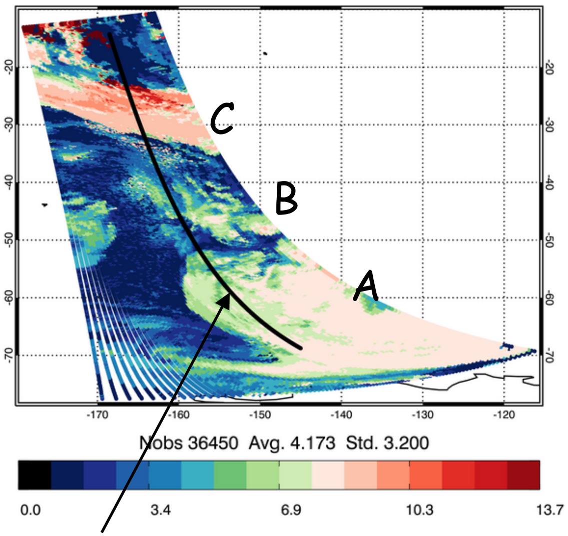
- Atmospheric Data Assimilation
  - AIRS: cloud detection algorithm compared with CloudSat and CALIPSO
  - Preparing for ADM and 3DWinds
  - Ozone Assimilation & Preparing for OMPS
  - Observing System Impact with Adjoint Tools
  - System update – 4DDA system - Observing system impacts with Adjoint tools

- Ocean data assimilation – tests with MOM4 and using altimetry
- Land data assimilation – surface temperature for NOAH and CLSM

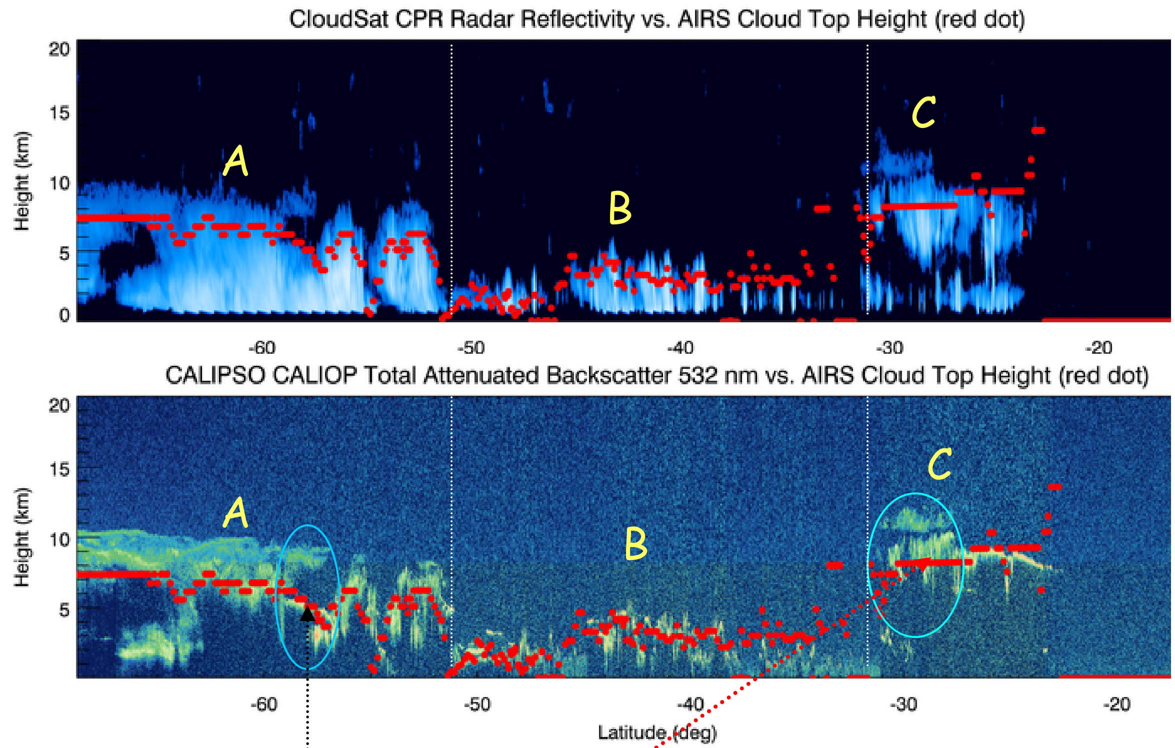
GEOS-5/GSI estimate of cloud top height from AIRS compared with CloudSat and CALIPSO

Emily Liu

GSI retrieved cloud top height (CTH) from AIRS



CloudSat/CALIPSO track

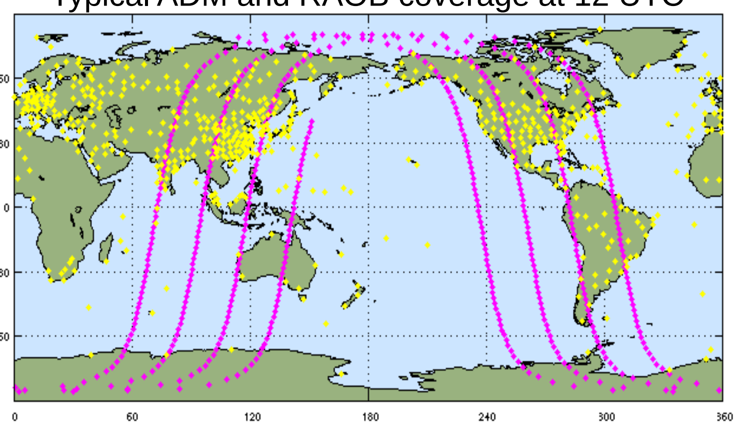


- Due to large differences in footprint size between AIRS and CPR/CALIOP, the CTH validation is done only in regions A and C where the clouds are more uniform.
- In general, GSI retrieved CTHs from AIRS are underestimated for optically thick clouds.
- Difficulties in retrieving CTH in multi-layer cloud region.
- Next: Include MODIS cloud products for further validation.

Utilizing Simulated Observations in Preparation for the Assimilation of ADM-Aeolus Measurements

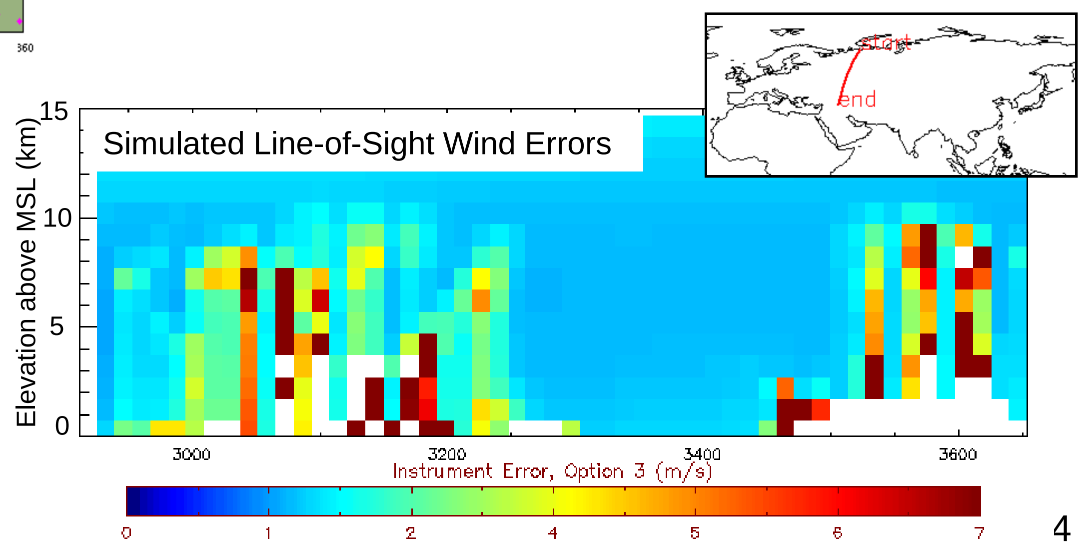
Will McCarty (talk at 3:45)

ADM-Aeolus: ESA-launched Doppler wind lidar to measure winds globally
Launch: late-2011



- Generate simulated ADM-Aeolus observations within Joint OSSE framework
  - KNMI-developed instrument simulation software (LIPAS)
  - Full observing system simulated in-house (R. Errico and R. Yang)

- Refine GSI and GEOS-5 DAS to accommodate new measurements
- Analysis of initial cycling studies under way



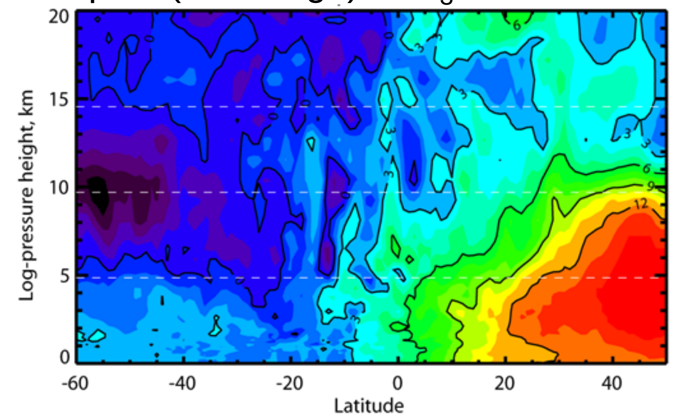
Ozone Assimilation

Steven Pawson (talk at 4:45)

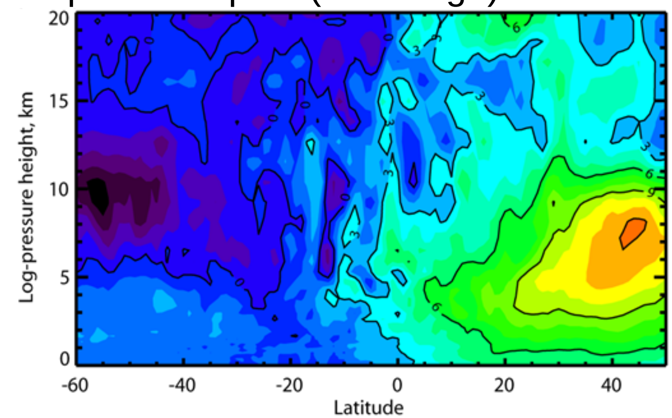
Activities in GEOS-5/GSI include:

- Assimilation of SBUV, OMI and MLS ozone observations
- Improvements to system:
  - ➢ observation operator for OMI (+TOMS/GOME/etc.) kernels
  - ➢ Background error covariance models (beginning)
- Investigations of ozone structure in the UTLS and the troposphere
- Impacts of assimilating MLS profiles on AIRS radiances
- OSSEs for NPP-OMPS:
  - ➢ MLS+OMI system is baseline
  - ➢ Generation, retrieval and assimilation of limb profiler observations

Impact (% change) of O_3 from OMI data



Expected impact (% change) with kernels



Present system omits the decrease in sensitivity to low tropospheric ozone in OMI – this is being built into H operator, with expected reduction in impact of OMI ozone in middle troposphere. Results for Jan 2006.

Comparison of Data Impacts in Navy, NASA and ECanada Forecast Systems using Adjoint Tools

Ron Gelaro, Rolf Langland, Simon Pellerin, Ricardo Todling

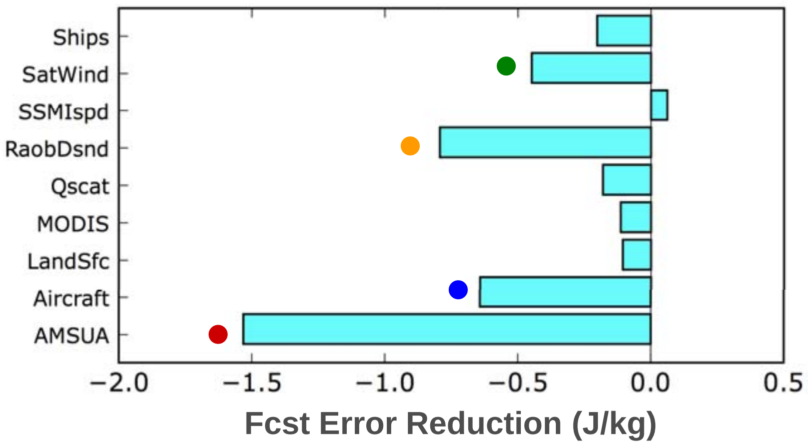
(part of the THORPEX Observation Impact Inter-Comparison Project)

- Comparison experiments for NASA, Navy and EC systems completed for baseline set of observations
- Overall quantitative results similar between systems, but details of impact differ (spatial distribution, impact per-ob)
- Largest overall impact provided by AMSU-A in all systems, but raobs, satwinds and aircraft data also have large impact
- Only a small majority (50-55%) of assimilated observations improve the forecast
- Common problem areas with AMSU-A noted…influence of surface properties a possible cause
- Future study to include more recent observation types and possibly other forecast systems

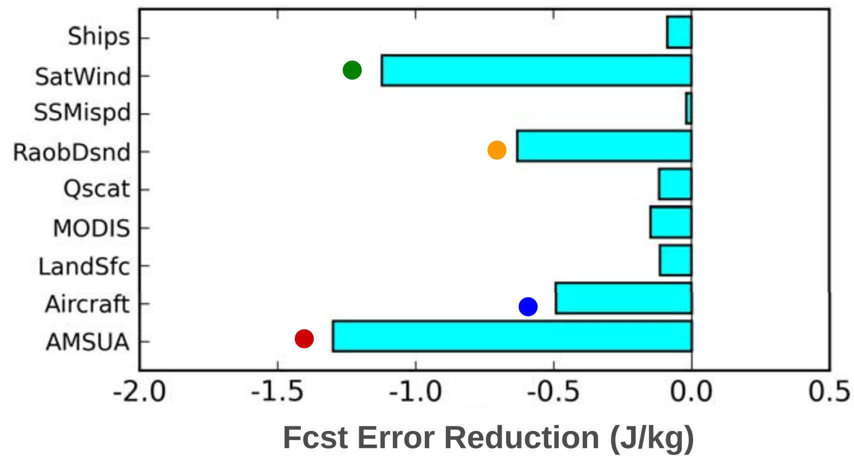
Daily average 24-h observation impacts

Global domain: 00+06 UTC assimilations Jan 2007

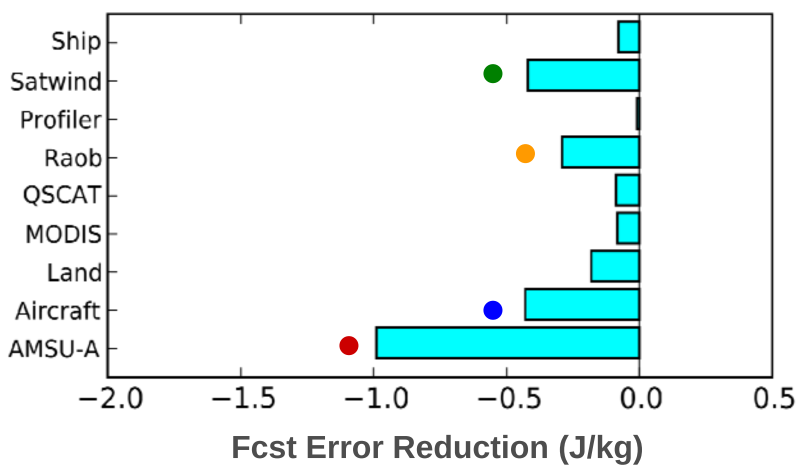
NASA GEOS-5



Navy NOGAPS



EC GDPS



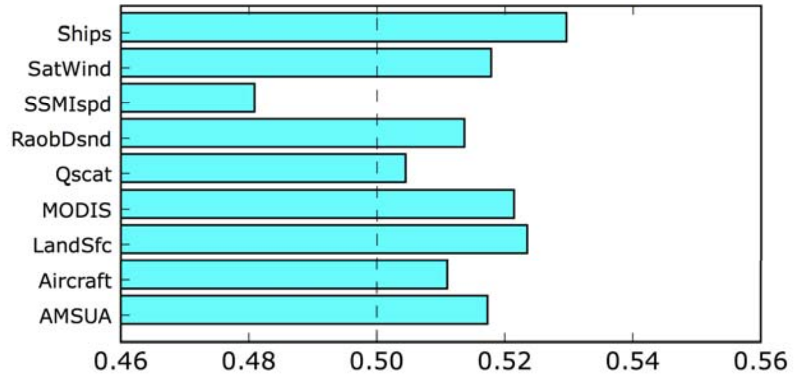
All obs types, except SSMI speeds in GEOS-5, are beneficial

- AMSU-A, •Raob, •Satwind and •Aircraft have largest impact in all systems

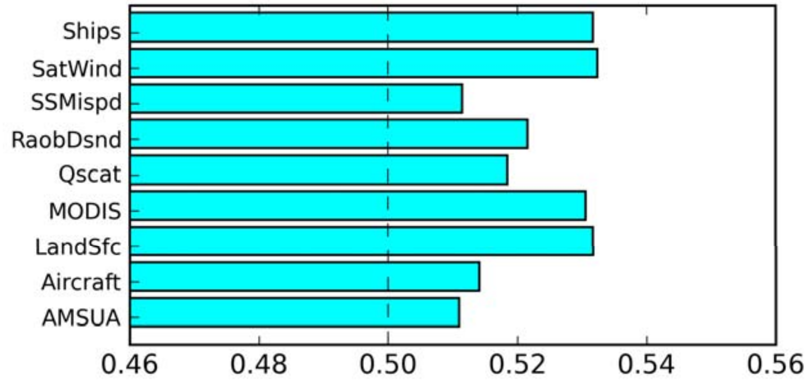
Fraction of obs that reduce 24-h forecast error

Global domain: 00+06 UTC assimilations Jan 2007

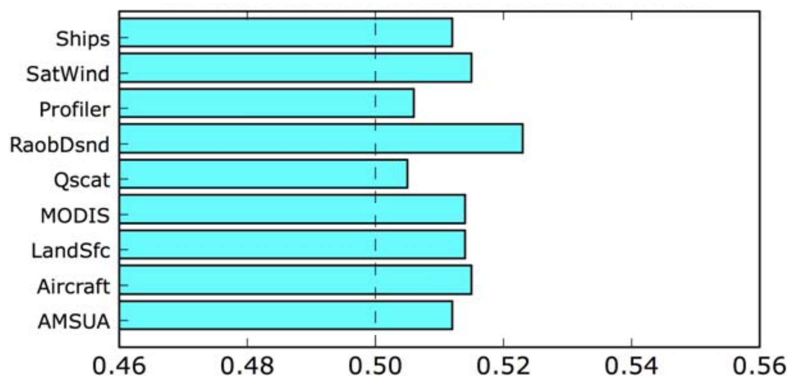
NASA GEOS-5



Navy NOGAPS



EC GDPS



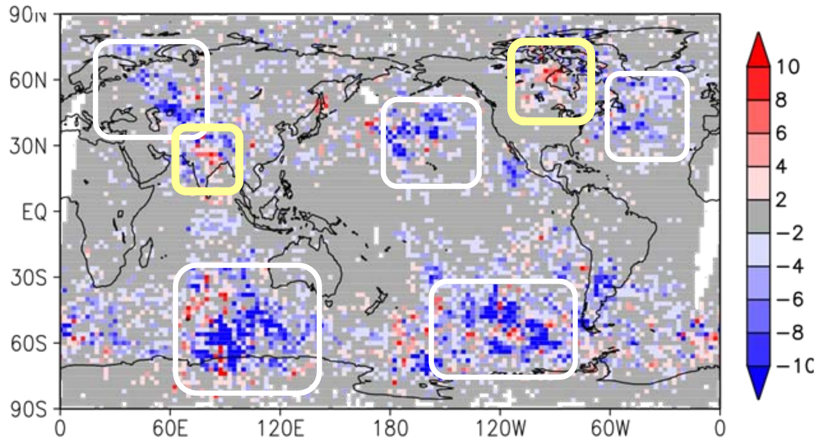
All observation types (except SSMI speeds in GEOS-5) are in the range of **50-54% beneficial**

Observation impacts: NOAA-18 AMSU-A channel 7

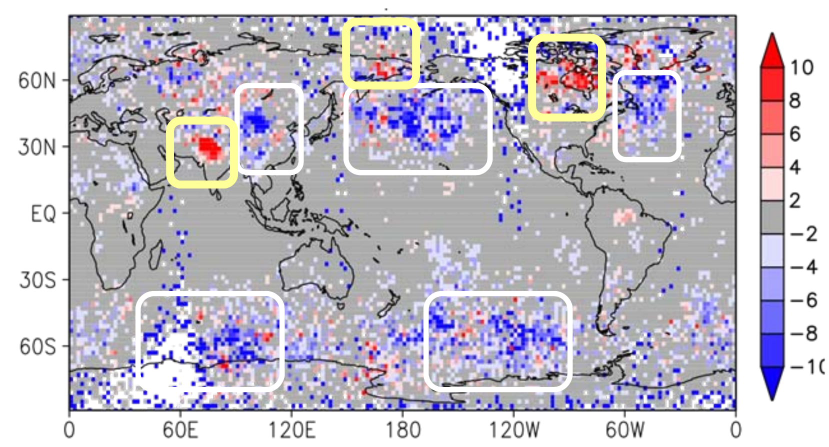
Global domain: 00+06 UTC assimilations Jan 2007

Impacts binned by observation location (2°×2°)

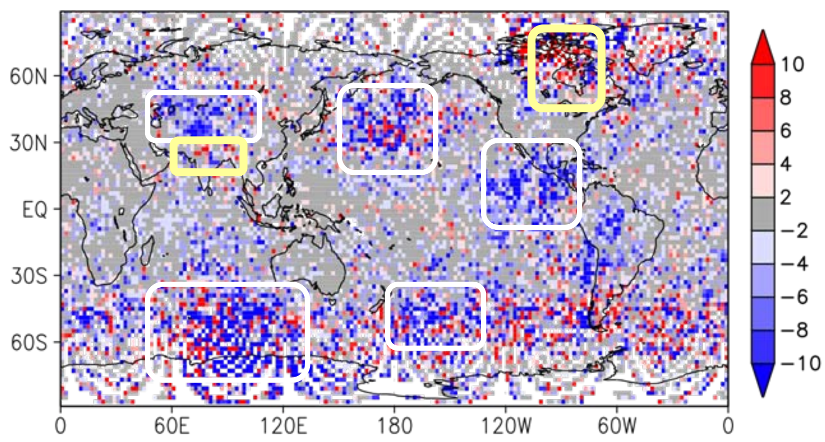
NASA GEOS-5



Navy NOGAPS



EC GDPS



Observations that produce large forecast error reductions

Observations that produce forecast error <u>increases</u> …poor use of radiance data over snow and ice surfaces?

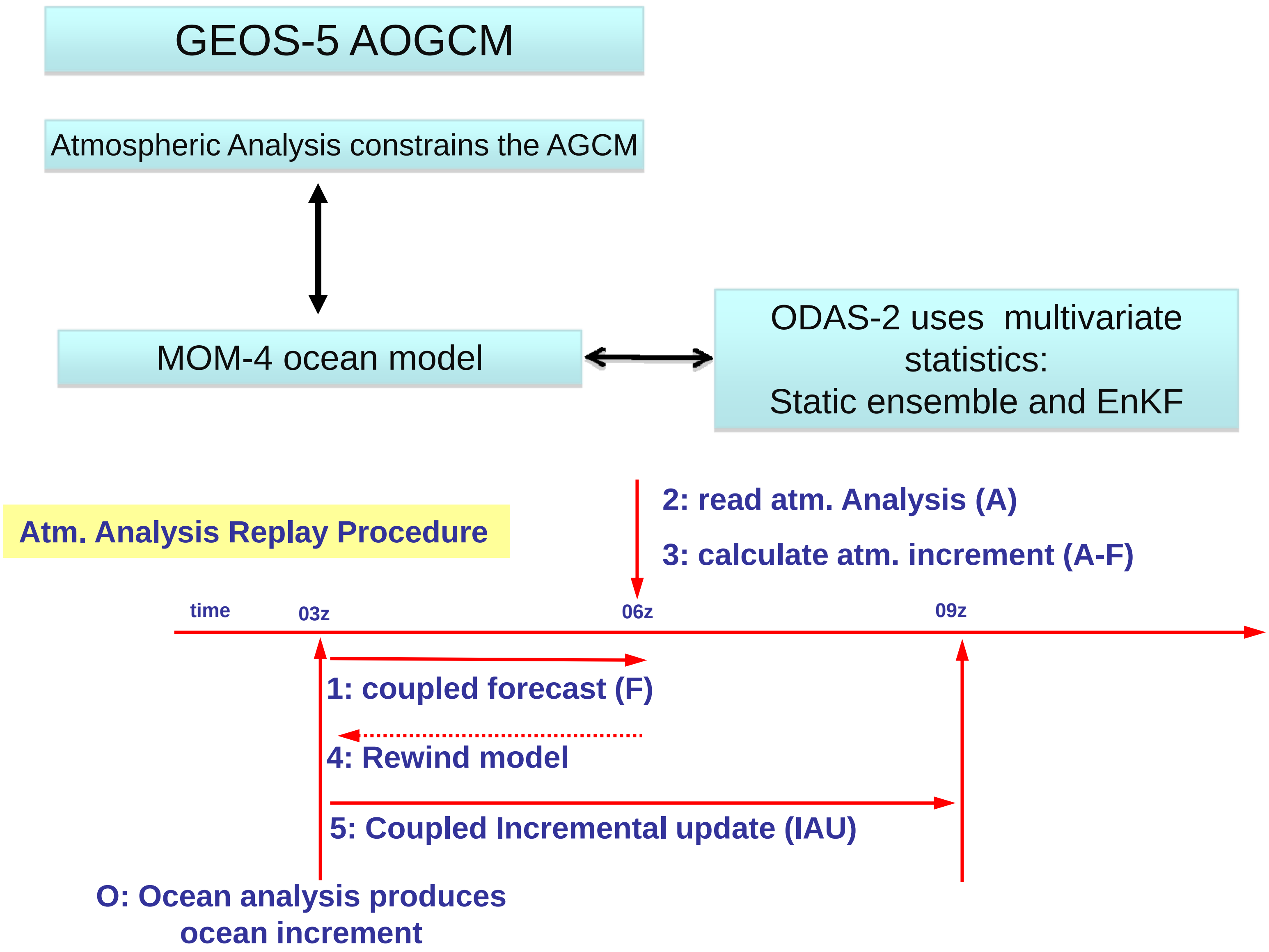
Summary of 4DVar Progress at GMAO

Ricardo Todling

- **GMAO/NCEP effort:**
  - 4DVAR option has been a part of official GSI release since mid-2009. Its full exercise requires the availability of TL and AD models:
    - Prototype TL/AD available for the GEOS-5 AGCM with minimal physics
    - A perturbation model is being developed at NCEP; this will be general enough to work with any nonlinear model (just as GSI currently handles its background states)
  - Developments underway:
    - Working to extend 3DVAR hybrid ensemble capability to work within context of GSI's 4DVAR option.
    - Working to develop multi-resolution outer/inner loop capability

- **GMAO specifics**:
  - Observer allows calculation of observation-minus-guess residuals as the guess becomes available
  - Testing with a 1-degree/2-degree 6- and 12-hr 4DVAR
  - Developments underway:
    - Observer to run in multi-resolution configuration
    - TL and AD models of cubed-sphere GEOS-5 dynamical core
    - Prototype system (model) error covariance to be used in weak constraint formulation (following ECMWF's approach)
    - Investigating feasibility of obtaining analysis errors from Lanczos-based 4DVar

Ocean data assimilation in the GMAO



ODAS-2 EnKF Analysis validation

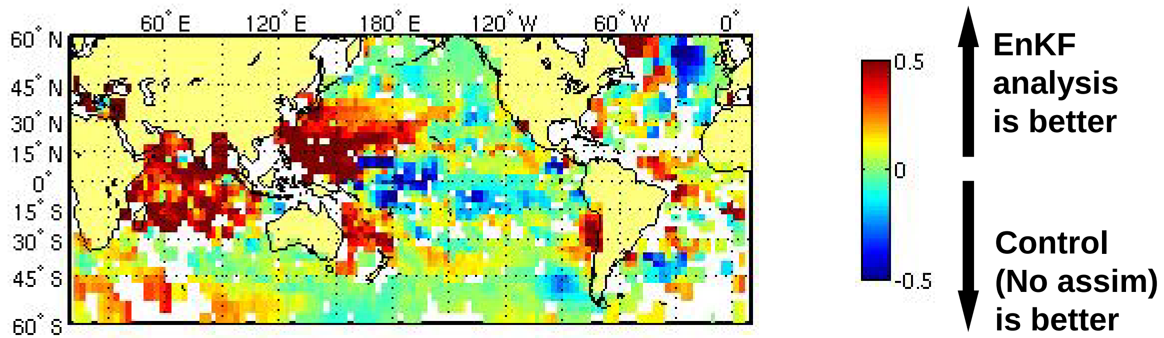
Assimilation of Argo temperature profiles

Validation is against passive Argo salinity profiles

Christian Keppenne

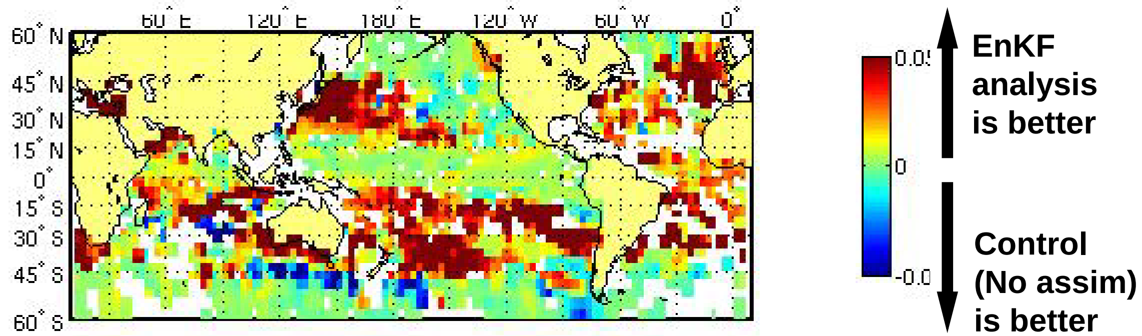
Control RMS OMF – HPENKF RMS OMF

z < 200 m



Control RMS OMF – ENKF RMS

z > 200 m



EnKF: EnKF with 16 streams and 11 lags within each stream - a 176 member ensemble

HPEnKF: hybrid particle-EnKF filter with 16 streams and 11 lags

Control: mean of 16-member control ensemble without data assimilation

Impact of Altimetry assimilation in GMAO ODAS-2

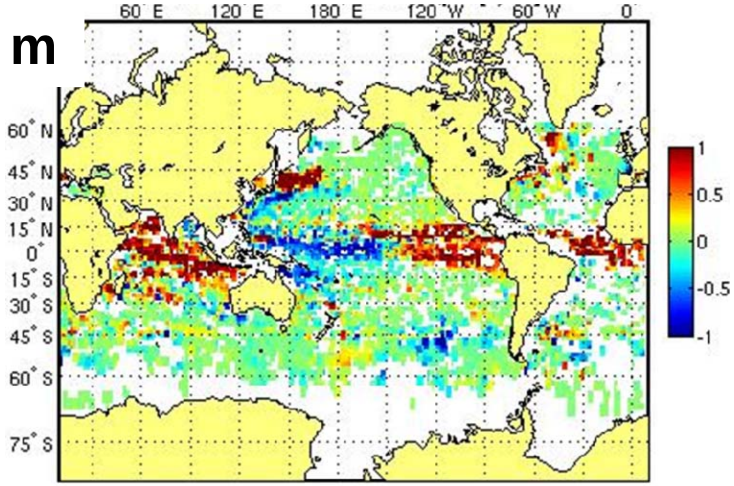
Comparison against passive Argo Temperature and Salinity

Guillaume Vernieres & Christian Keppenne

0-300 m

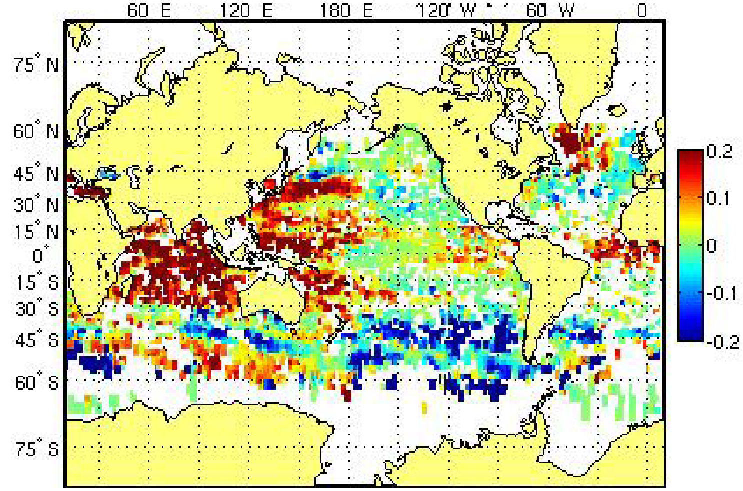
Temperature

$rms(T_{obs}-T_{control}) - rms(T_{obs}-T_{sla\_assim})$



Salinity

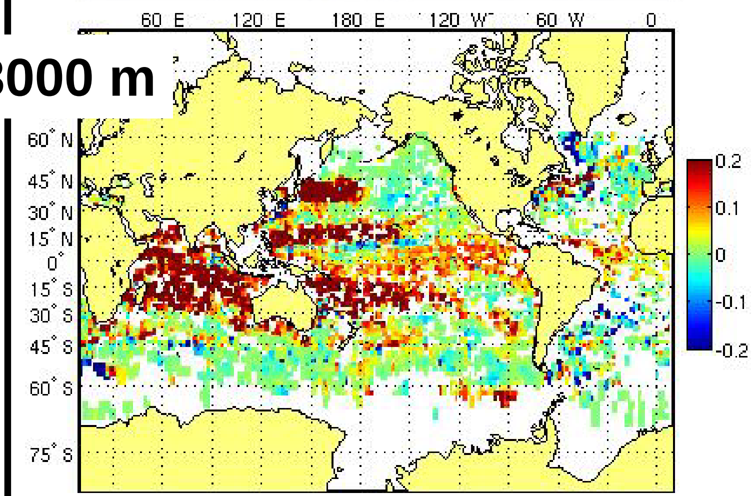
$rms(S_{obs}-S_{control}) - rms(S_{obs}-S_{sla\_assim})$

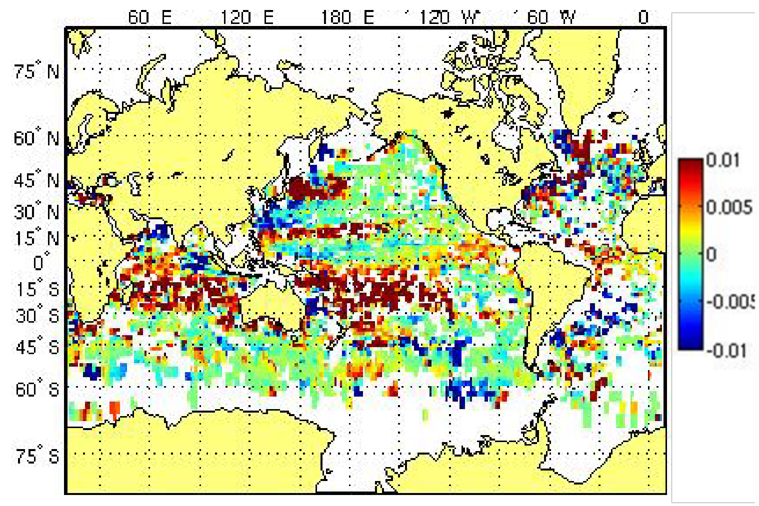


SLA analysis is better

Control (No assim) is better

300-3000 m





SLA analysis is better

Control (No assim) is better

Land surface temperature (LST) assimilation

R. Reichle (GMAO/610.), **S. Kumar** (SAIC/614.3), **S. Mahanama** (GEST/610.1),**R. Koster** (GMAO/610.1), **Q. Liu** (SAIC/610.1)

LST retrievals from the International Satellite Cloud Climatology Project (ISCCP) are assimilated into the Noah and Catchment (CLSM) land surface models using an ensemble-based land data assimilation system.

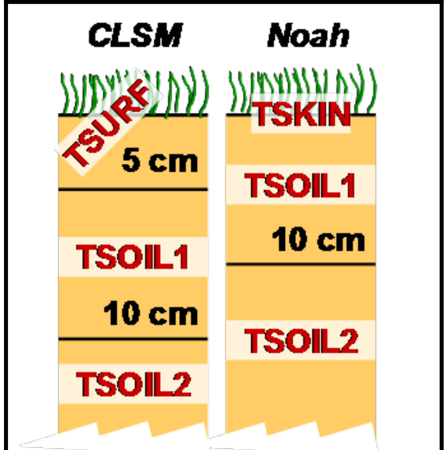
Performance is measured against 27 months of *in situ* data from the Coordinated Energy and Water Cycle Observations Project at 48 locations around the world.

LST estimates from model runs without data assimilation are comparable to each other and superior to ISCCP retrievals.

Assimilation of ISCCP observations provides modest, yet statistically significant RMSE improvements (up to 0.7 K).

The impact on flux estimates is small (not shown).

Fig 1: Assimilate LST retrievals into off-line land models



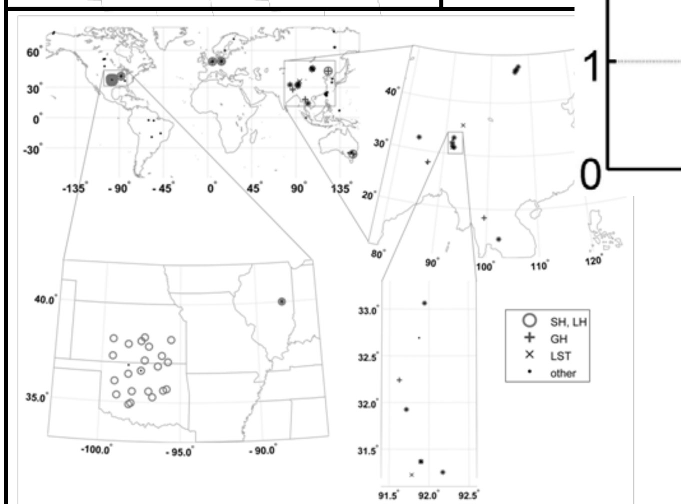
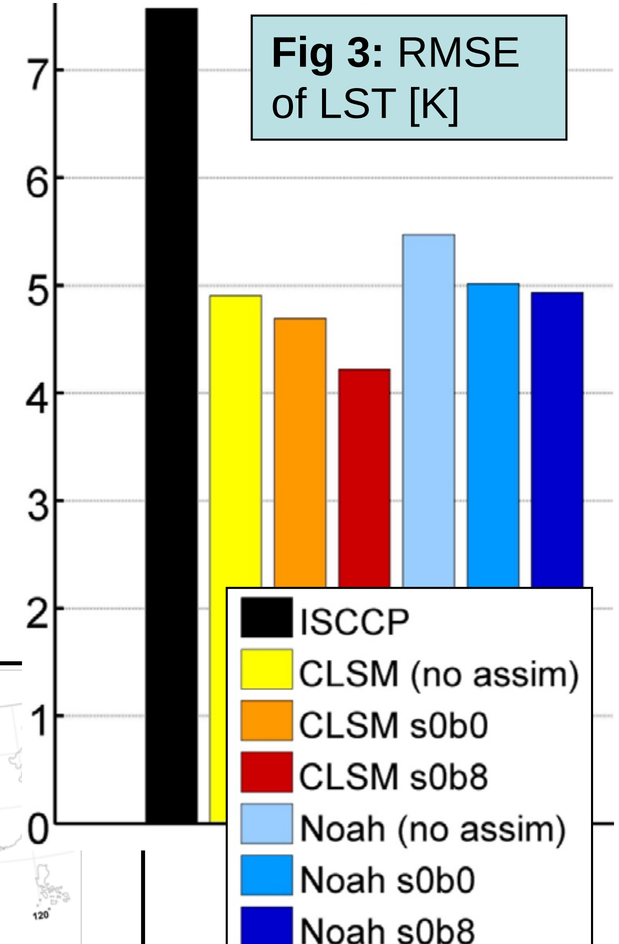


Fig 2: Validate against in situ obs

Fig 3: RMSE of LST [K]



Assimilation:
s0: without a priori scaling
b0, b8: Without and with dynamic bias correction

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
  - Provides a more detailed view of how each observation is included and its impact on short-range forecasts
  - Comparisons of impacts – a THORPEX collaboration (GMAO, NRL & EC)
- 4DVar development maturing
- Ocean data assimilation - Jason-1, SMOS, Aquarius
- Land Data Assimilation – surface temperature assimilation & preparing for SMAP L4 product