Validation of the GMAO OSSE Framework

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Outline:

1. OSSE framework
2. Assimilation metrics
3. Forecast metrics
4. Summary
5. (Some applications)

Applications of OSSEs

1. Estimate effects of **proposed instruments** (and their competing designs) on analysis skill by exploiting simulated environment.

2. Evaluate present and **proposed techniques** for data assimilation by exploiting known truth.

Validation of OSSEs

A variety of statistics that can be computed in both real assimilation and OSSE contexts are evaluated and compared.

All these statistics measure difference or errors and therefore generally depend on explicit or implicit modeling, instrument, and representativeness errors and on chaotic effects of model dynamics and physics.

ECMWF Nature Run

Free-running "forecast" from 2006 model
T511L91 reduced linear Gaussian grid (approx 35km)
SST and sea ice cover is real analysis for that period

Assimilation System

NCEP/GMAO GSI (3DVAR), GEOS-5 (GMAO) model
Resolution 0.5x0.625 degree grid, 72 levels
Evaluation for July 2005 after spin-up in June
All observation having significant impacts operationally in 2005

Simulation of Observations

1. All observations created using bilinear interpolation horizontally, log-linear interpolation vertically, linear interpolation in time
2. Radiance observations created using CRTM version 1.2
3. Clouds and precipitation are treated as elevated black bodies
4. No use of NR snow coverage
5. Locations for all “conventional” observations given by corresponding real ones, except no drift for RAOBS
6. SATWNDS not associated with trackable features in NR

Simulation of Explicit Observation Errors

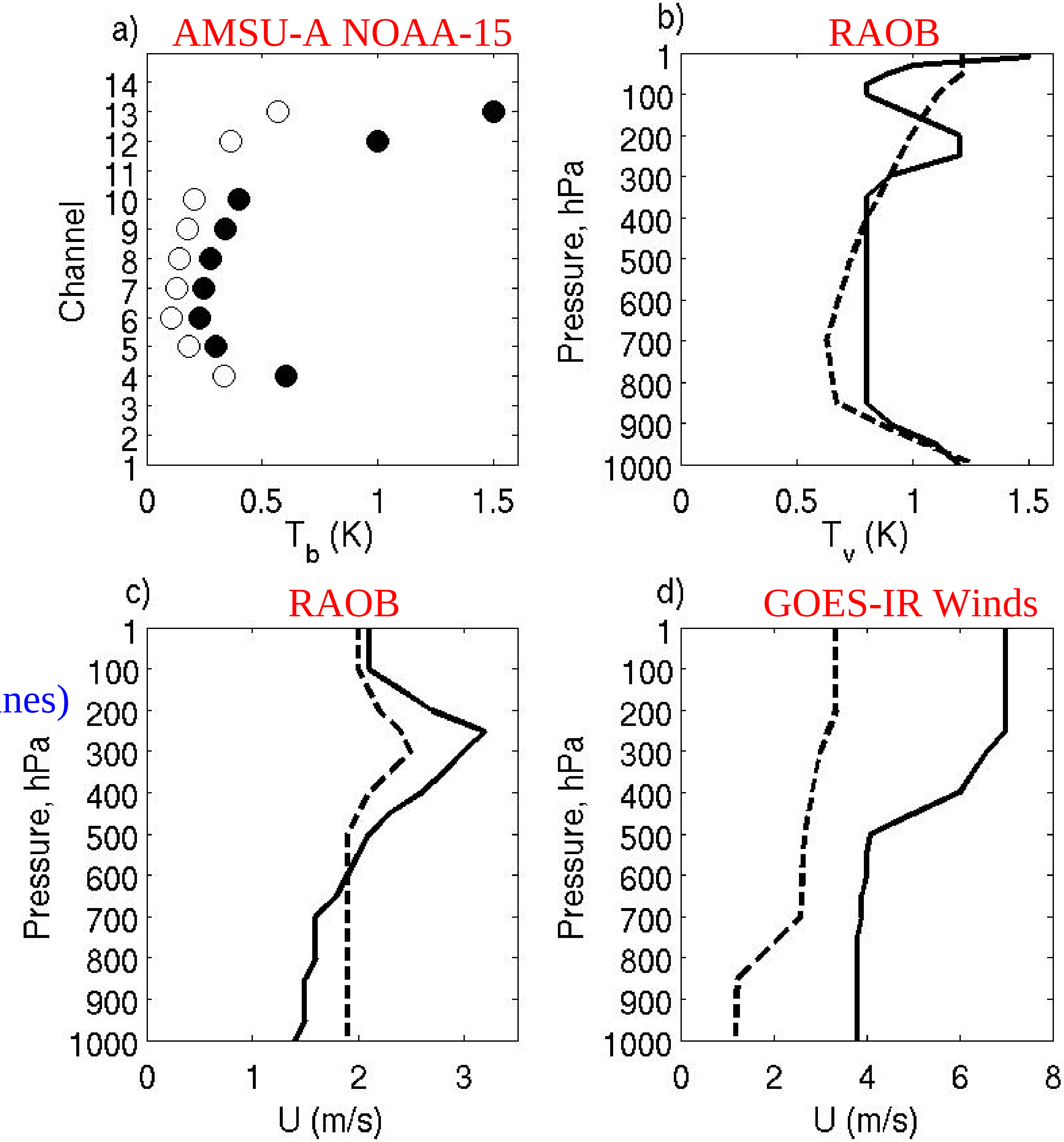
1. Some representativeness error implicitly present
2. Gaussian noise added to all observations
3. AIRS errors correlated between channels
4. Observational errors for SATWND and non-AIRS radiances horizontally correlated (using isotropic, Gaussian shapes)
5. Conventional soundings and SATWND observational errors vertically correlated (Gaussian shaped in log-p coordinate)
6. Tuning parameters are error standard deviations, fractions of variances for correlated components, vertical and horizontal length scales

Standard deviations of Observation errors

In GSI error tables
(solid circles or lines)

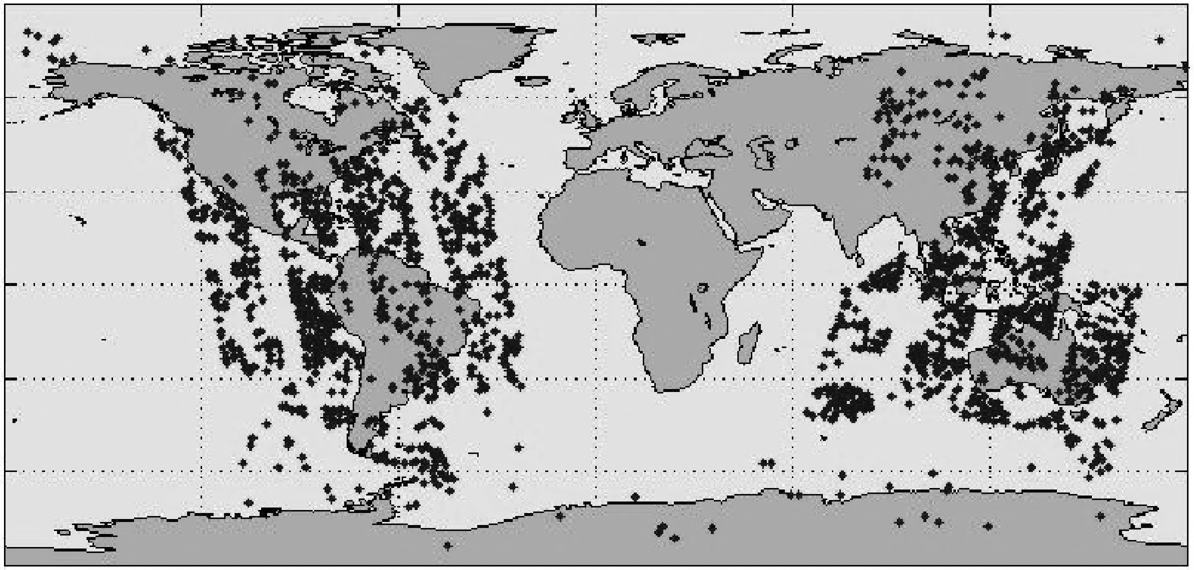
vs.

For adding obs. errors
(open circles or dashed lines)

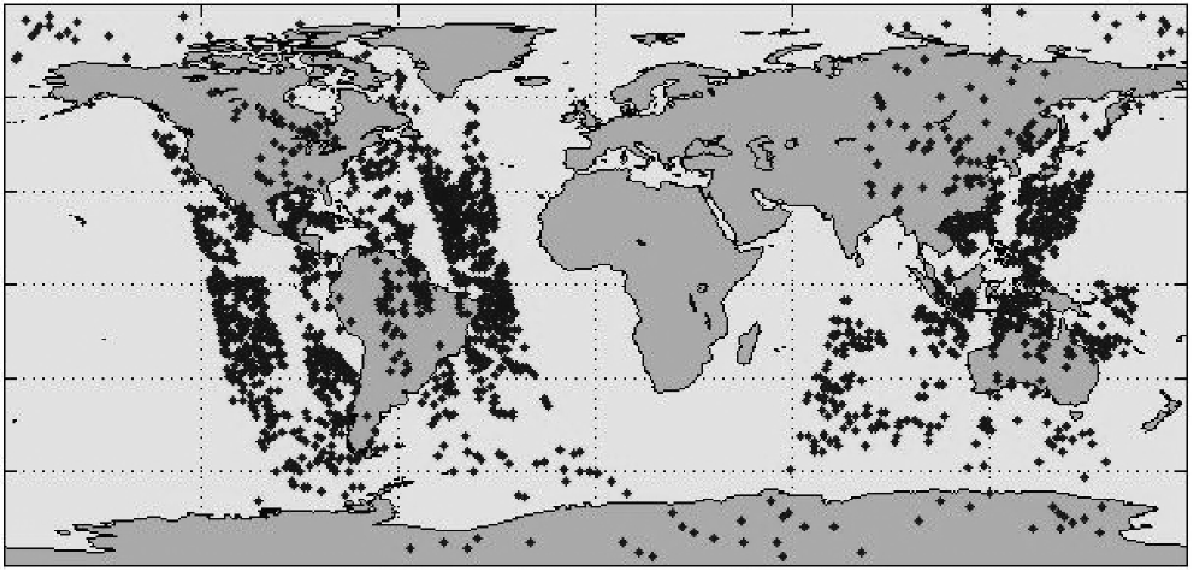


Locations of QC-accepted observations for AIRS channel 295 at 18 UTC 12 July

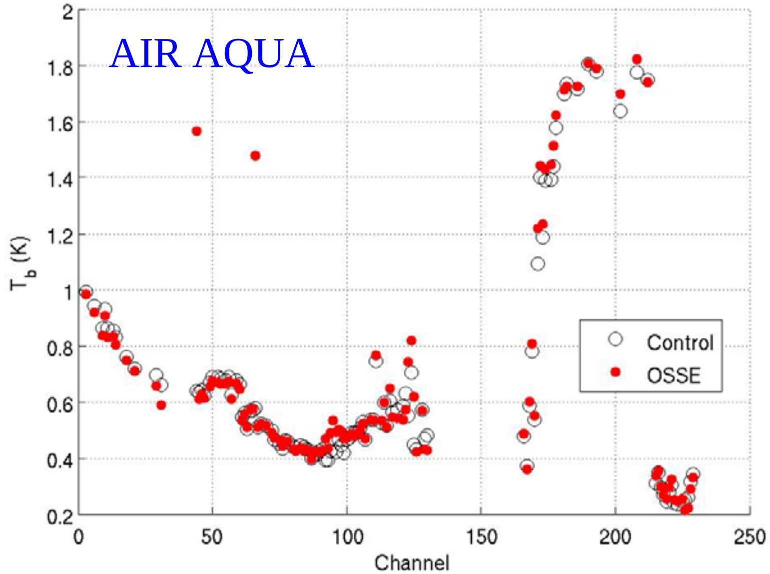
Simulated

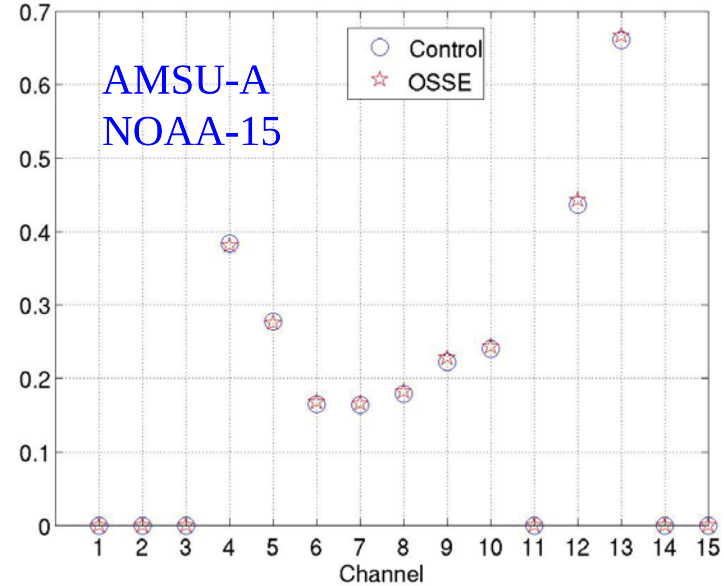


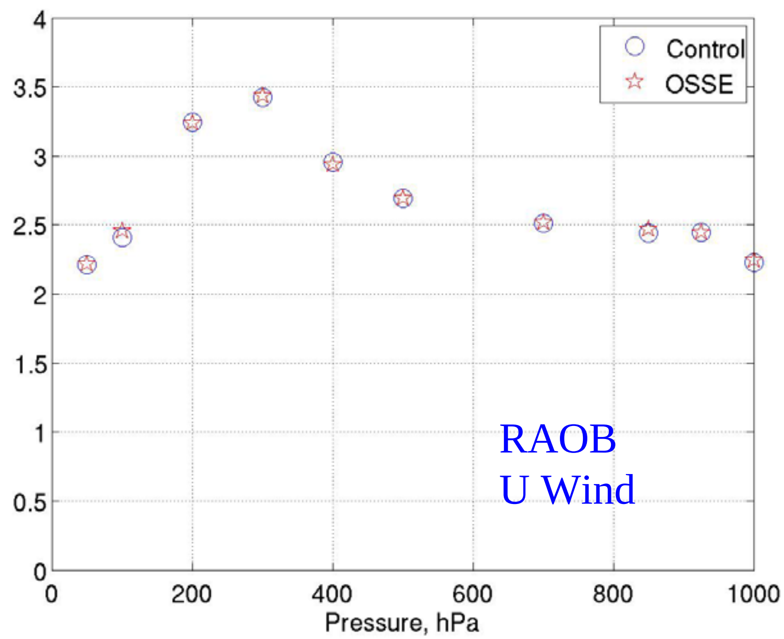
Real

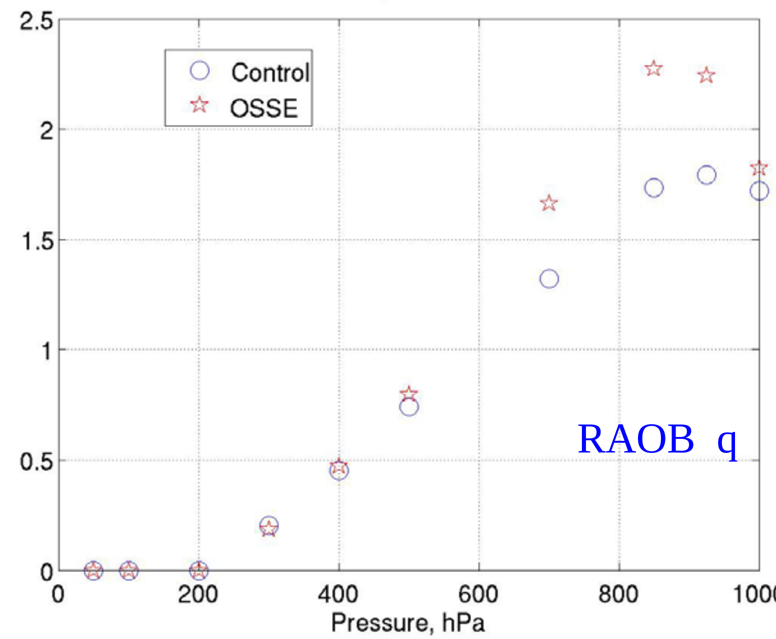


Standard deviations of QC-accepted O-F values (Real vs. OSSE)



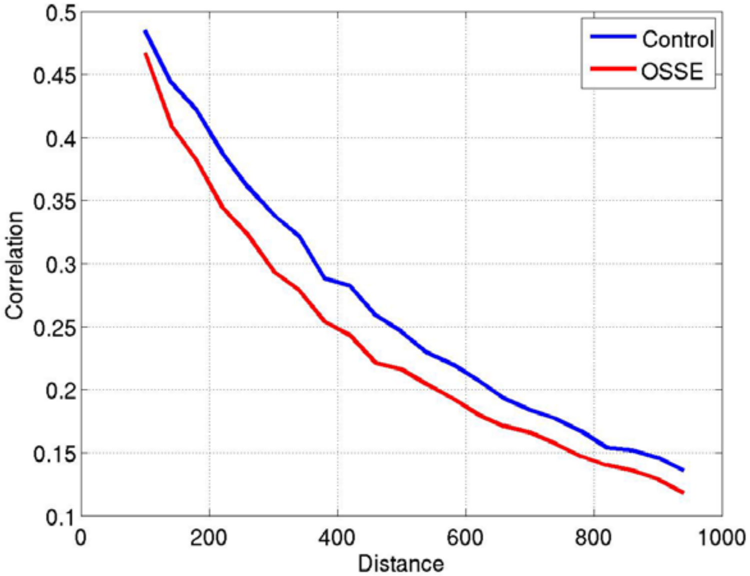




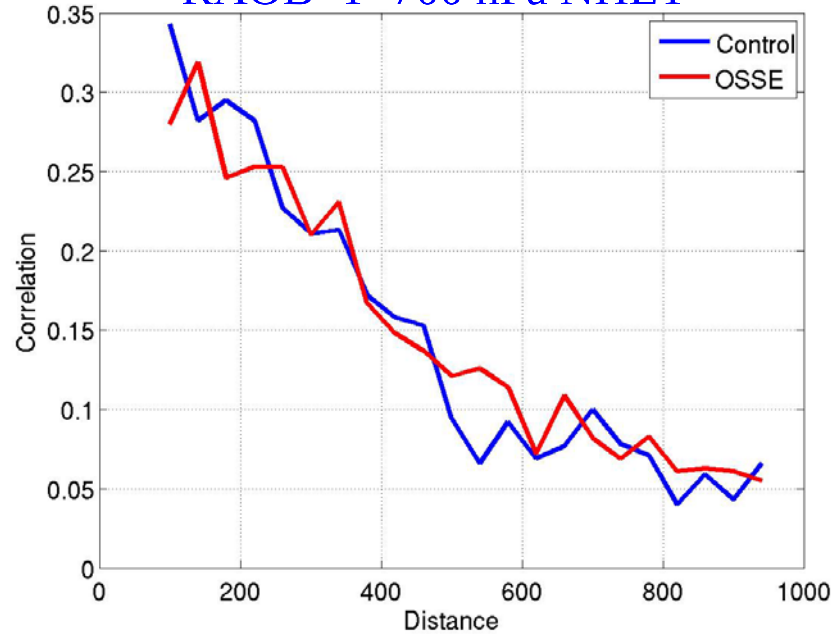


Horizontal correlations of O-F

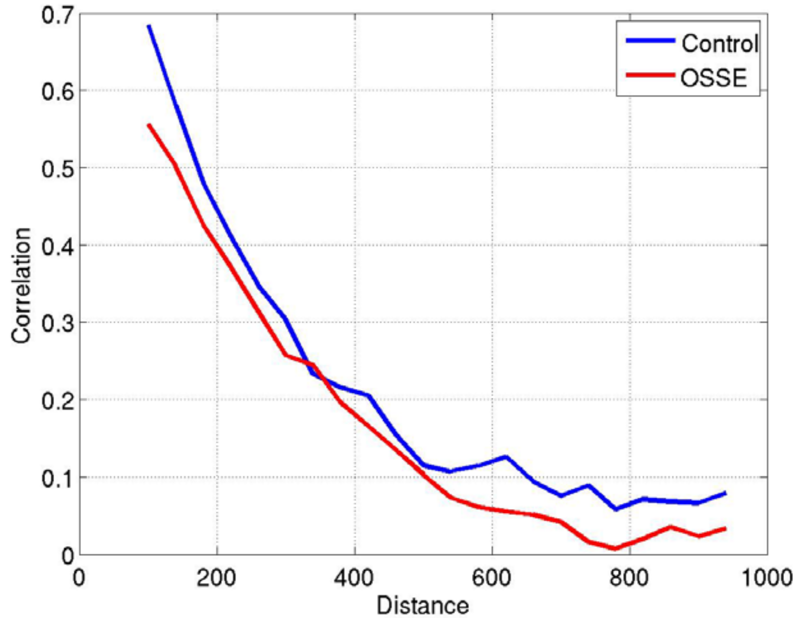
AMSU-A NOAA-15 Chan 6 GLOB



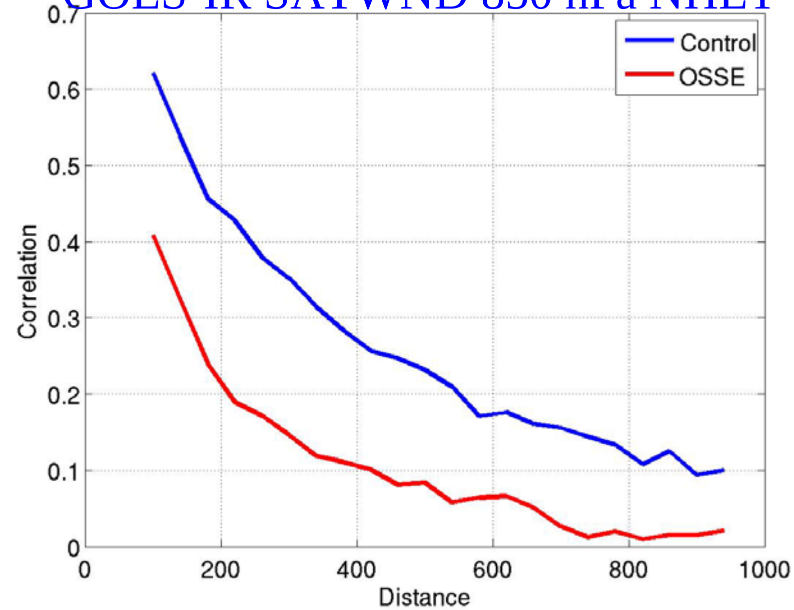
RAOB T 700 hPa NHET



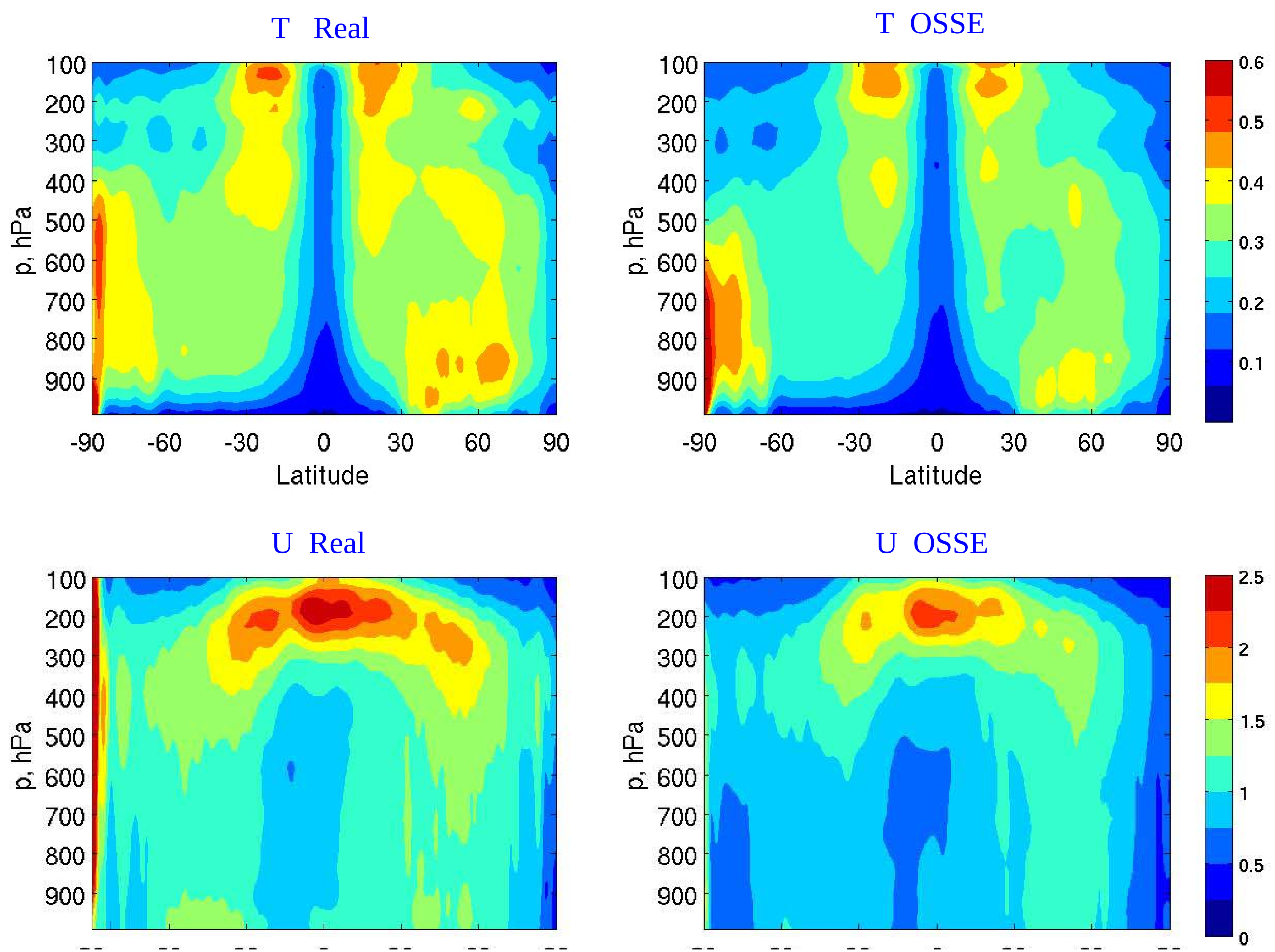
GOES-IR SATWND 300 hPa NHET



GOES-IR SATWND 850 hPa NHET



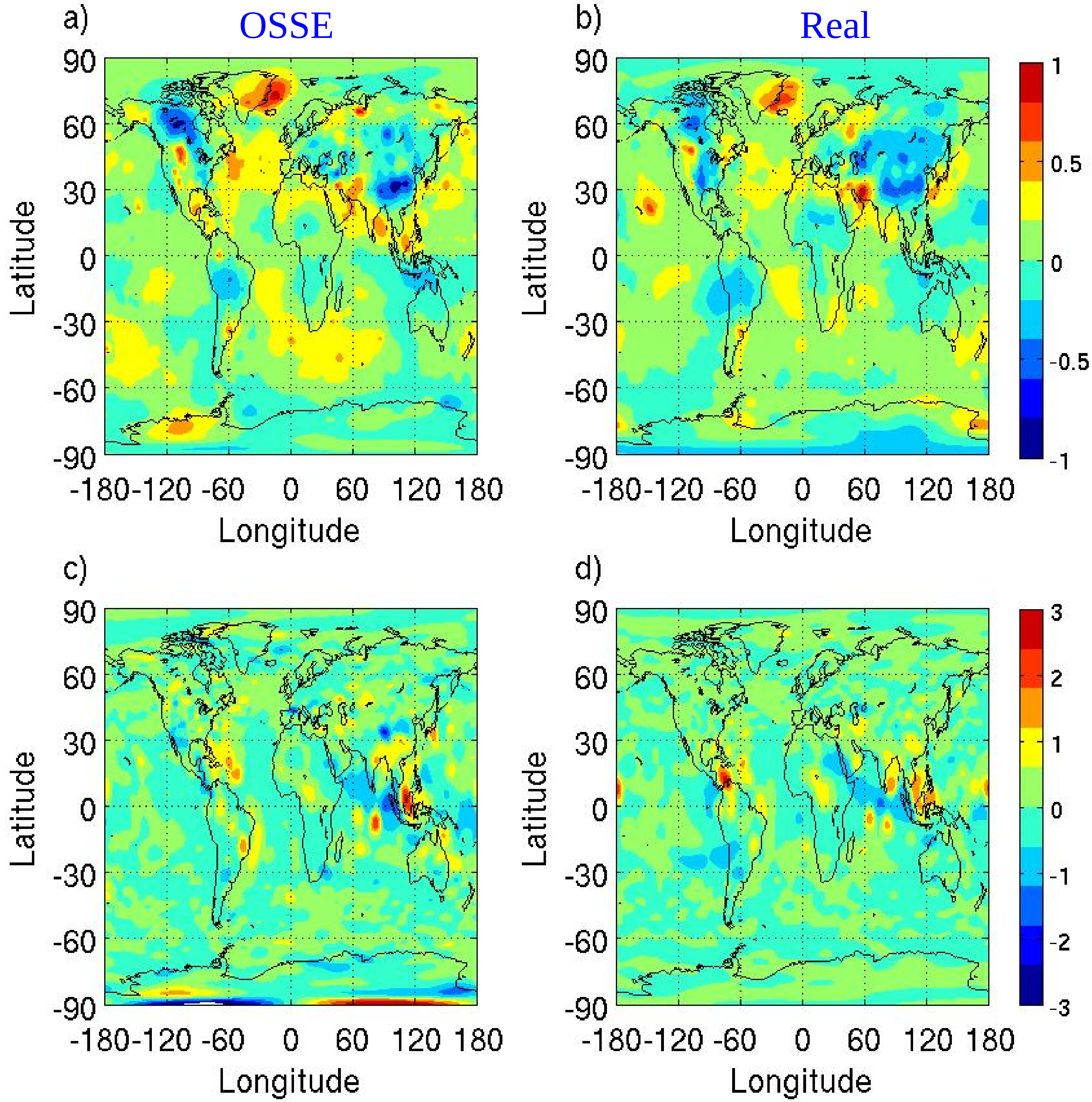
Square roots of zonal means of temporal variances of analysis increments



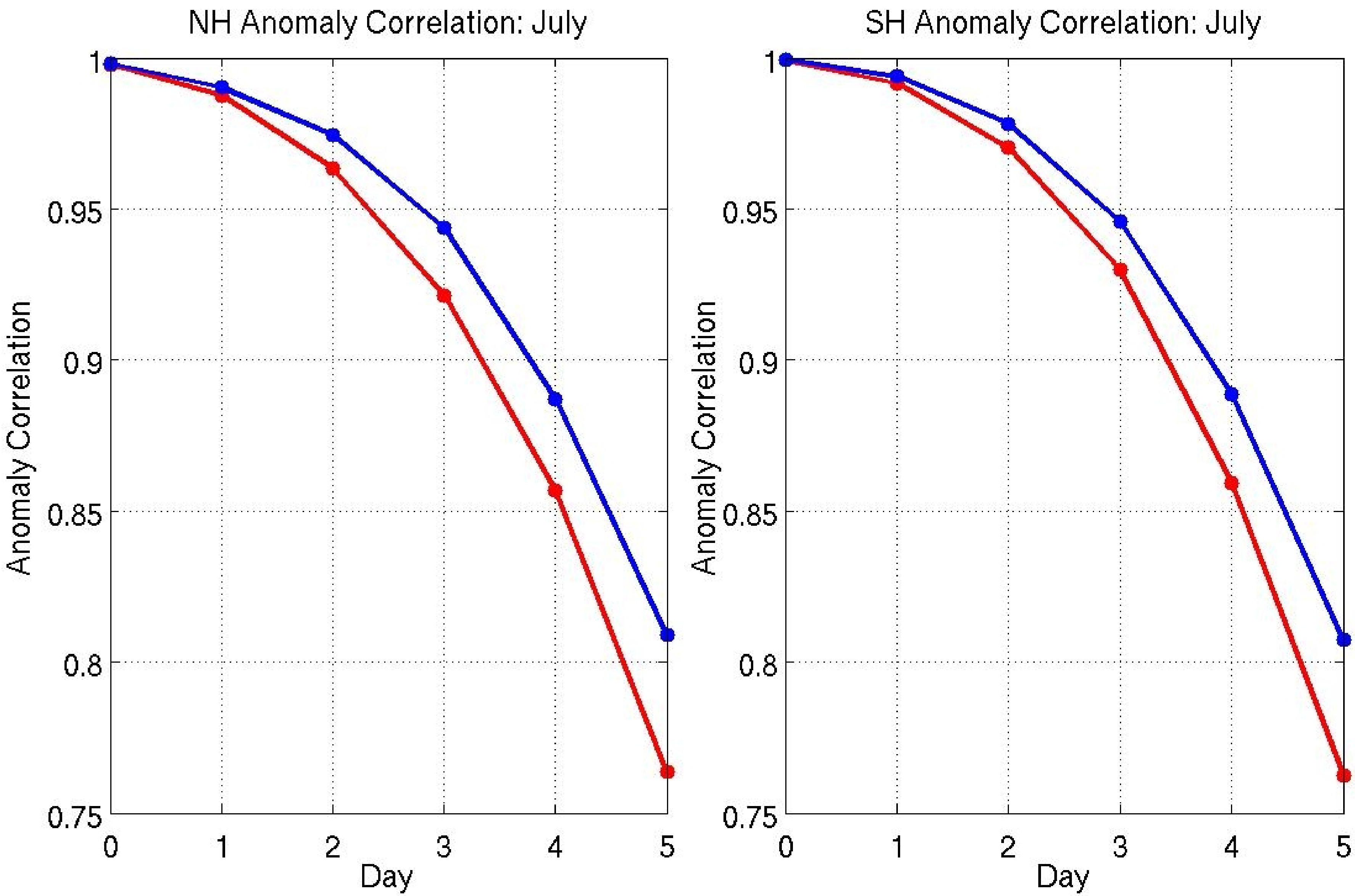
T 850 hPa

Time mean
Analysis increments

U 500 hPa

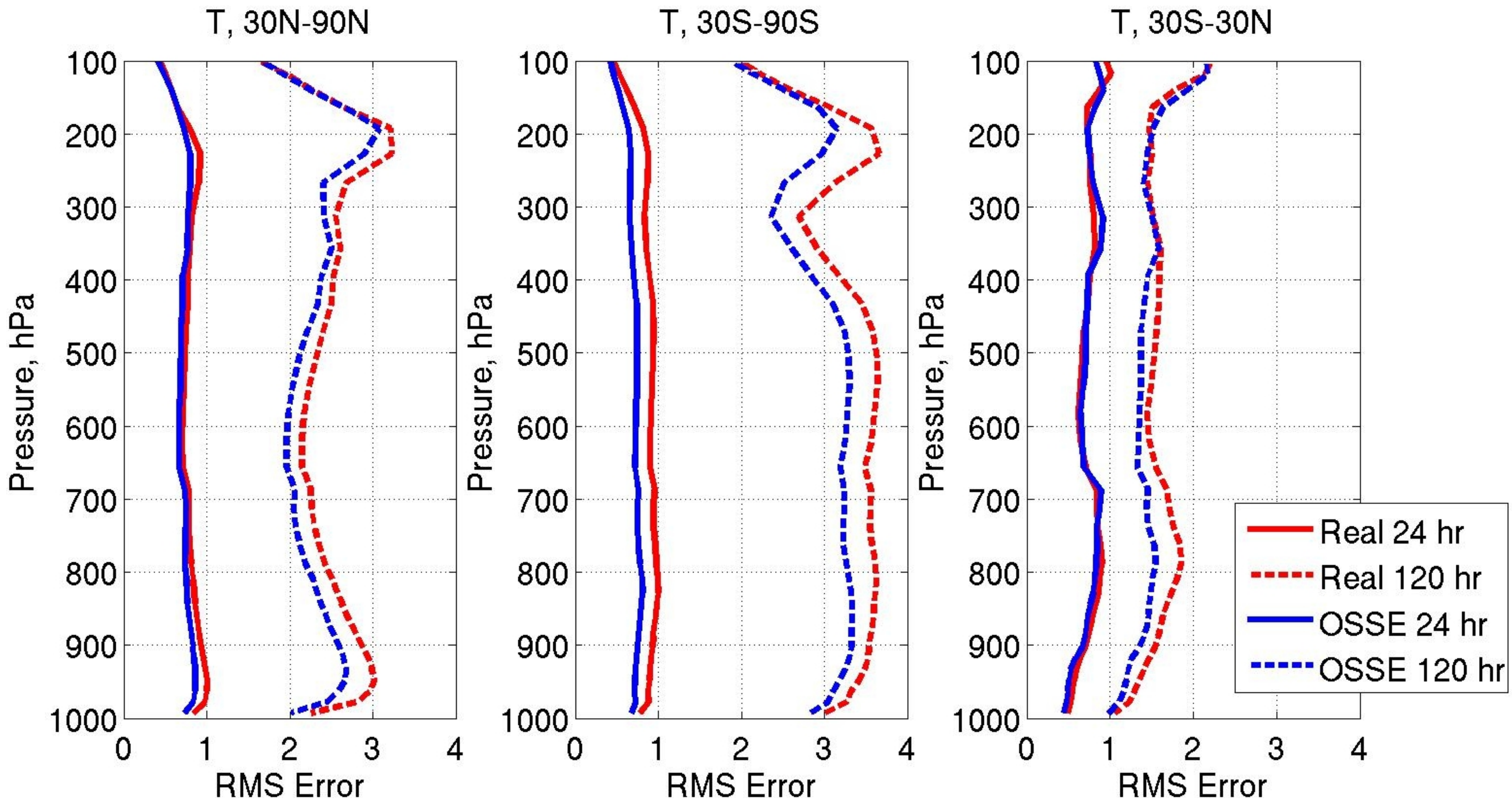


OSSE vs Real Data: Forecasts



Real Control
OSSE Control

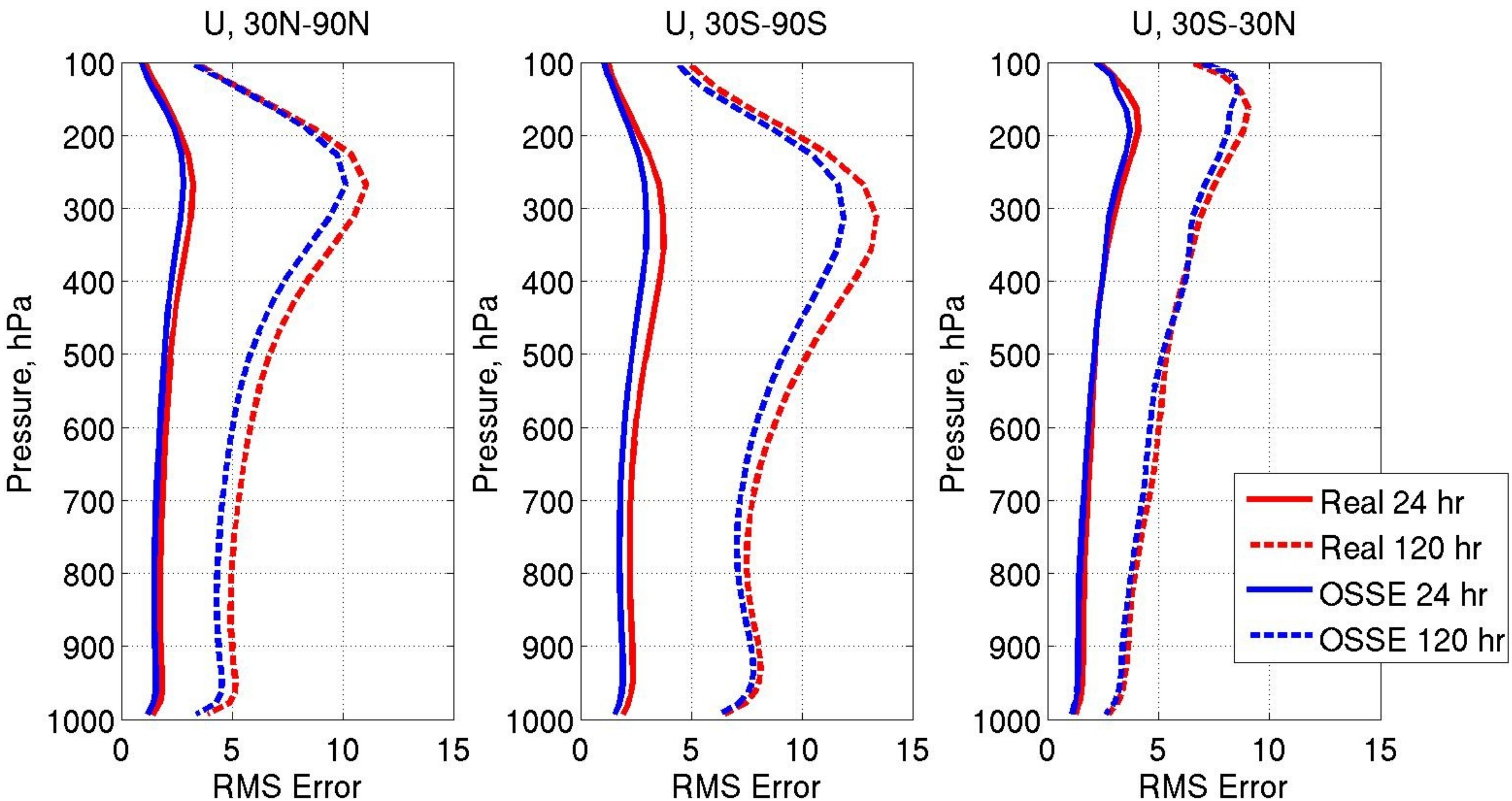
T RMS error: July



Solid lines: 24 hour RMS error vs analysis
Dashed lines: 120 hr forecast RMS error vs analysis

Real Control
OSSE Control

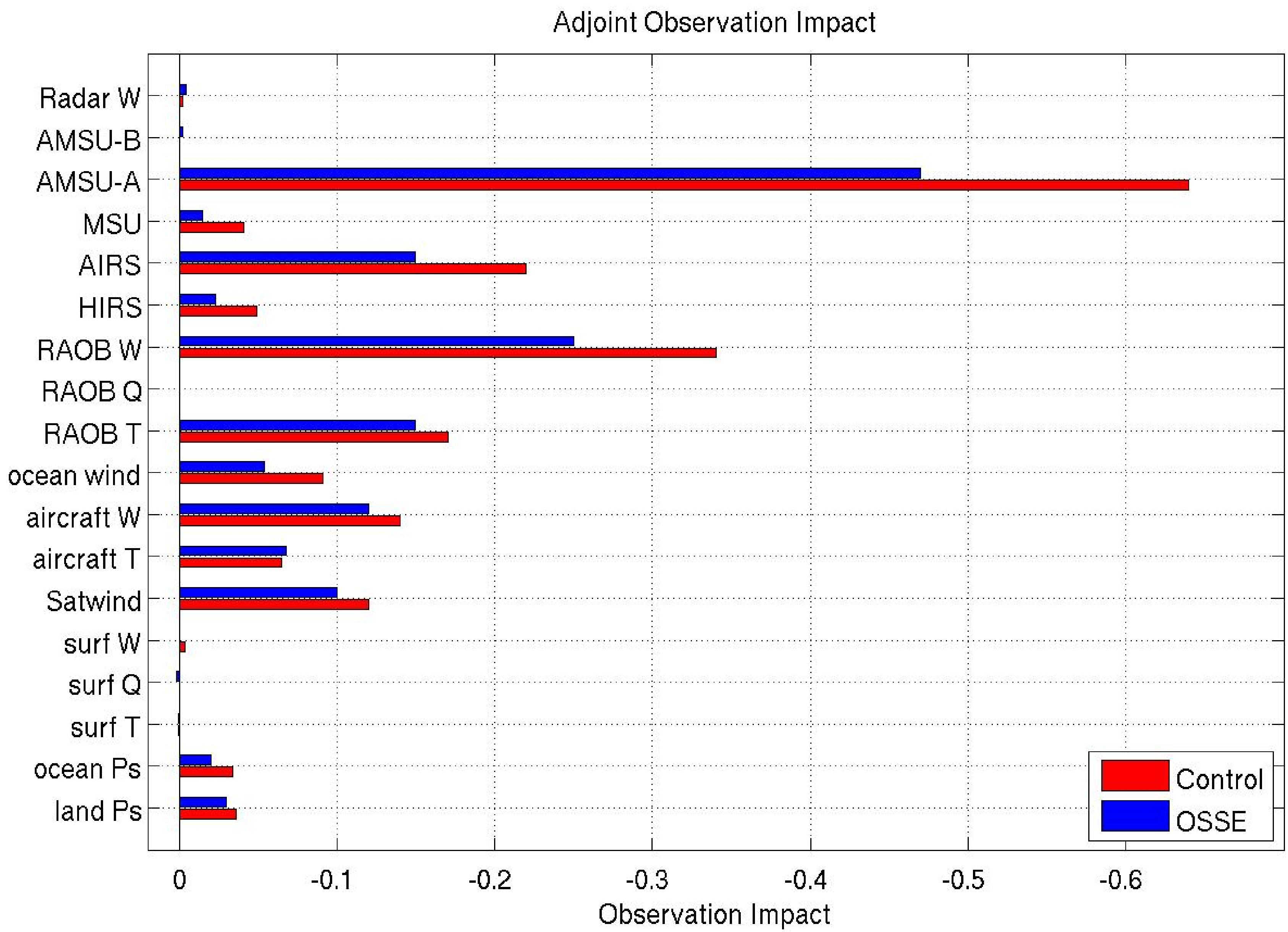
U-Wind RMS error: July



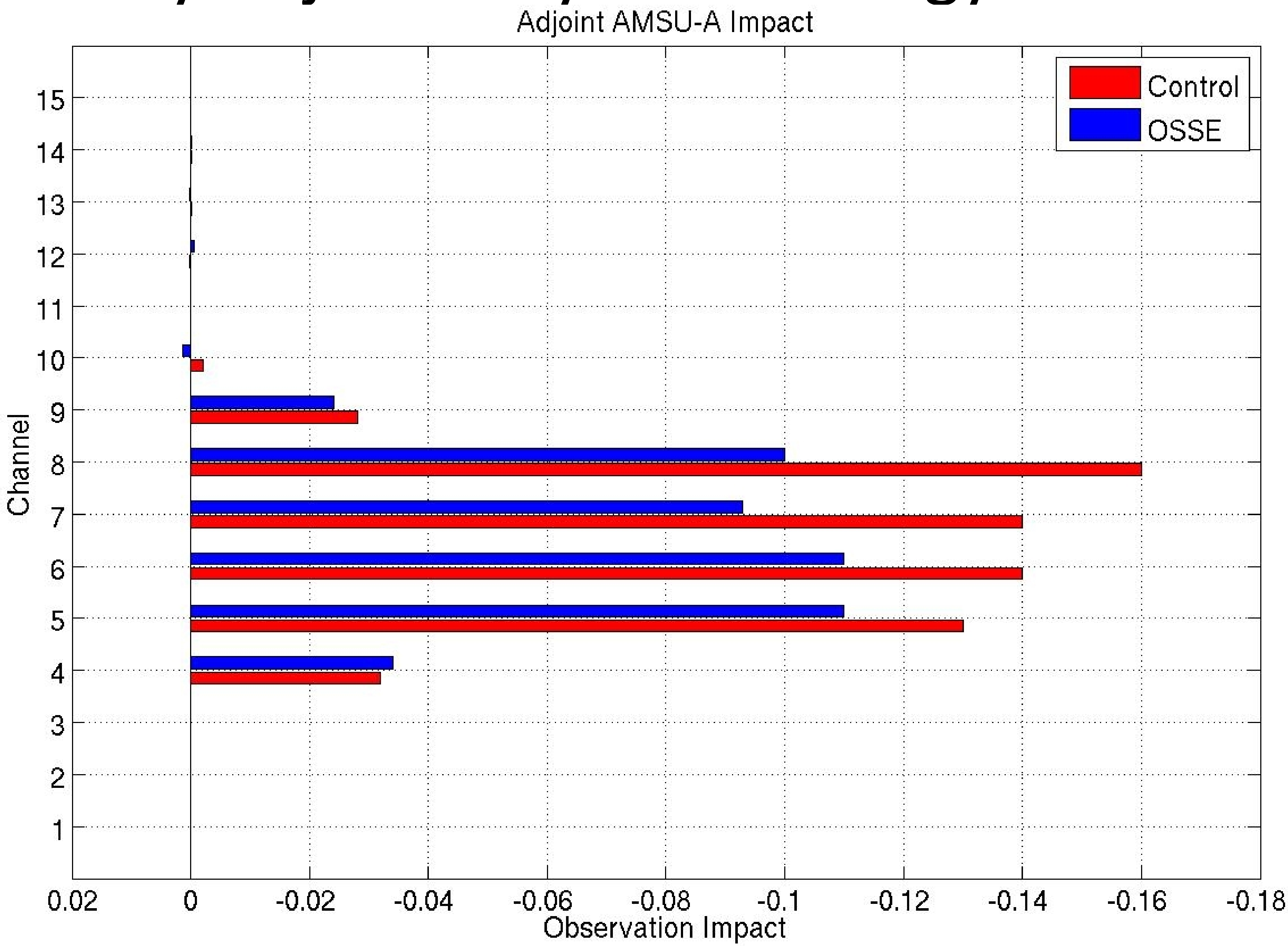
Solid lines: 24 hour RMS error vs analysis
Dashed lines: 120 hr forecast RMS error vs analysis

Real Control
OSSE Control

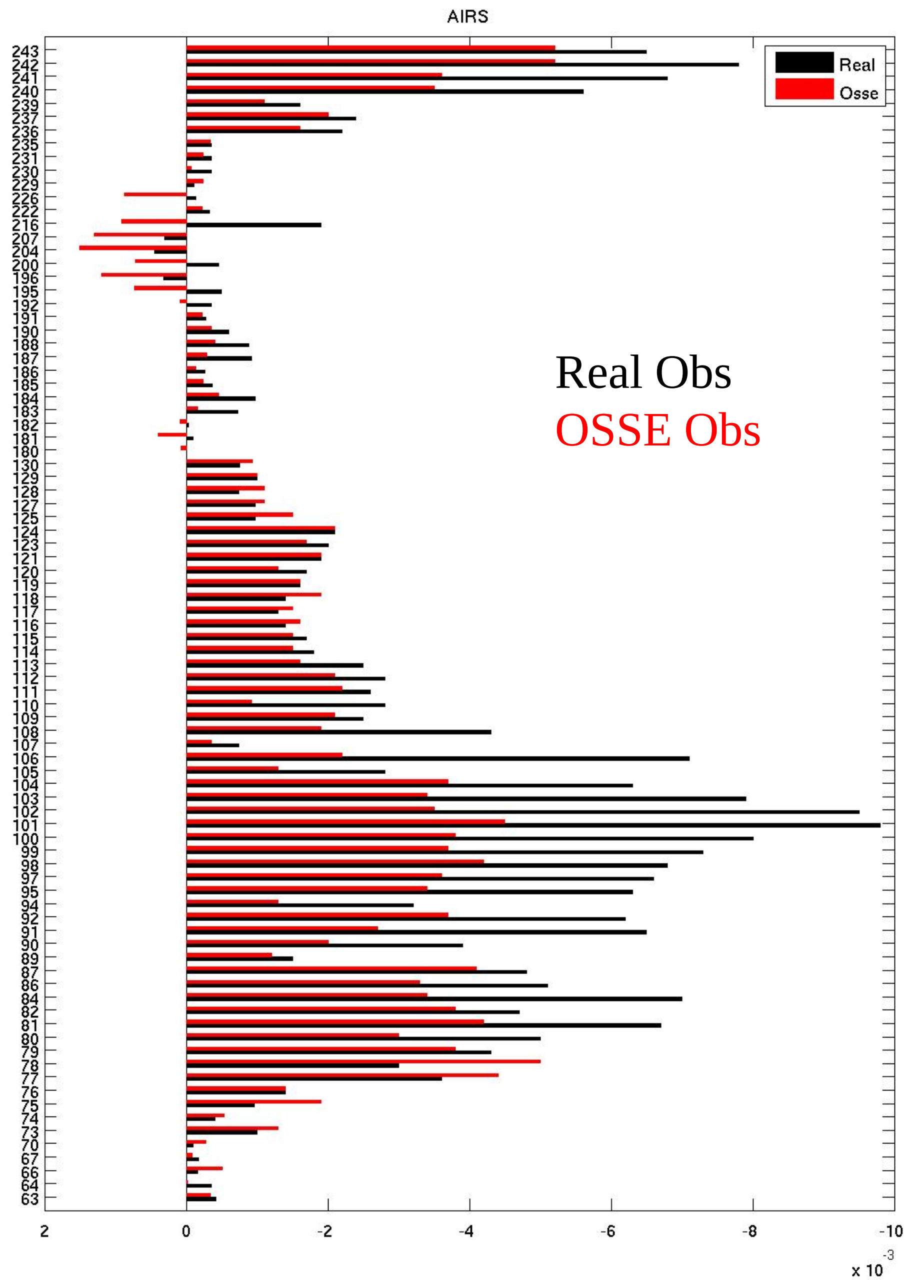
July Adjoint: dry error energy norm



July Adjoint: dry error energy norm



Airs Channel Impacts (24 Hr E-Norm



Summary

1. Fairly easy to match O-F covariances
2. Harder to match analysis increment statistics
3. Hardest to match forecast error metrics
4. Present OSSE framework validates reasonably well, but …
5. Some correctable deficiencies
6. Some puzzles

Continuing Development

1. New SATWND observation location determination based on NR
2. Improve specification of land surface parameters for CRTM
3. Additional observations (IASI and GPSRO)
4. Inclusion of RAOB drift
5. More complete tuning of observation errors
6. Estimation of model error in OSSE framework
7. Use of other NR data sets
8. Demonstration of OSSE applications
9. Further examination of NMC method for estimating **B**
10. Examination of dependence of results on error simulation

Application:
Characterization of analysis error
(as an example of the kinds of calculations that can be performed)

Fractional reduction of zonal means of temporal variances of analysis errors compared with background errors

$$\frac{\overline{e_b^2} - \overline{e_a^2}}{\overline{e_b^2}}$$

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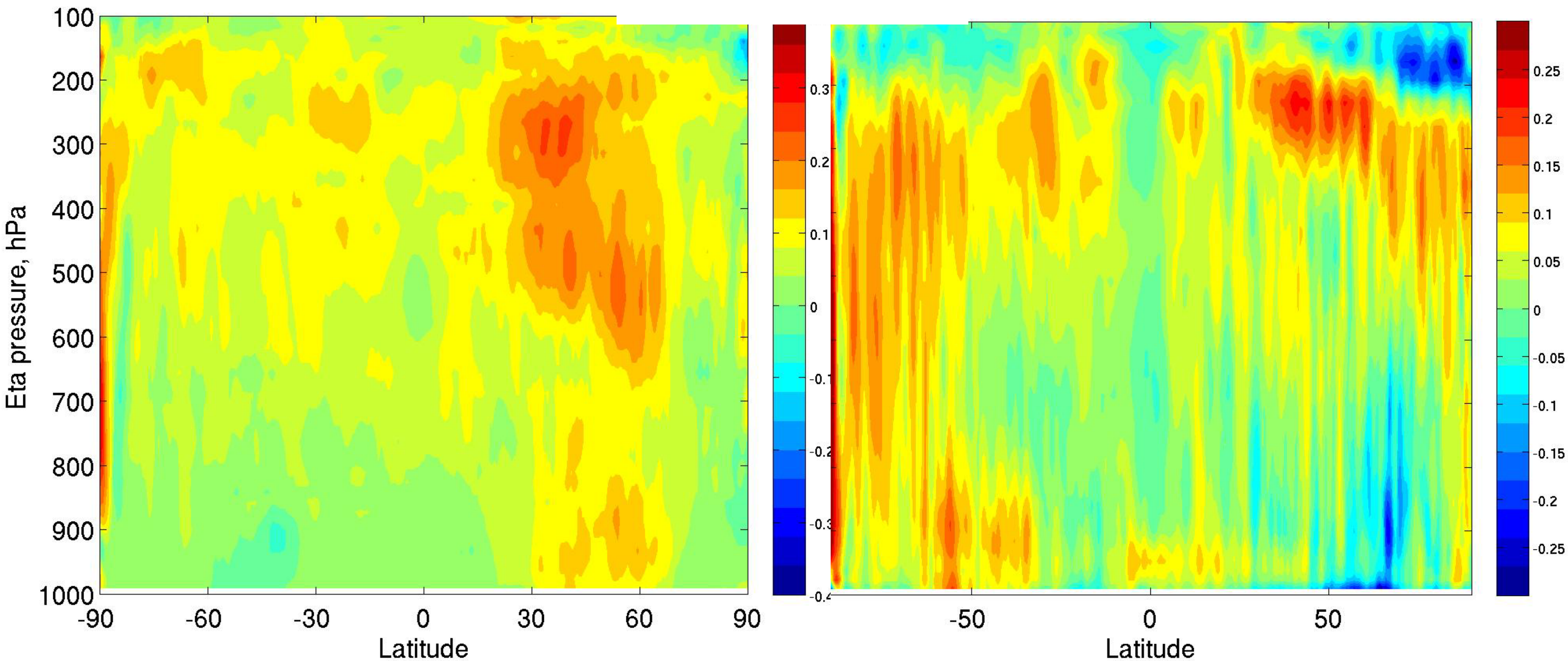
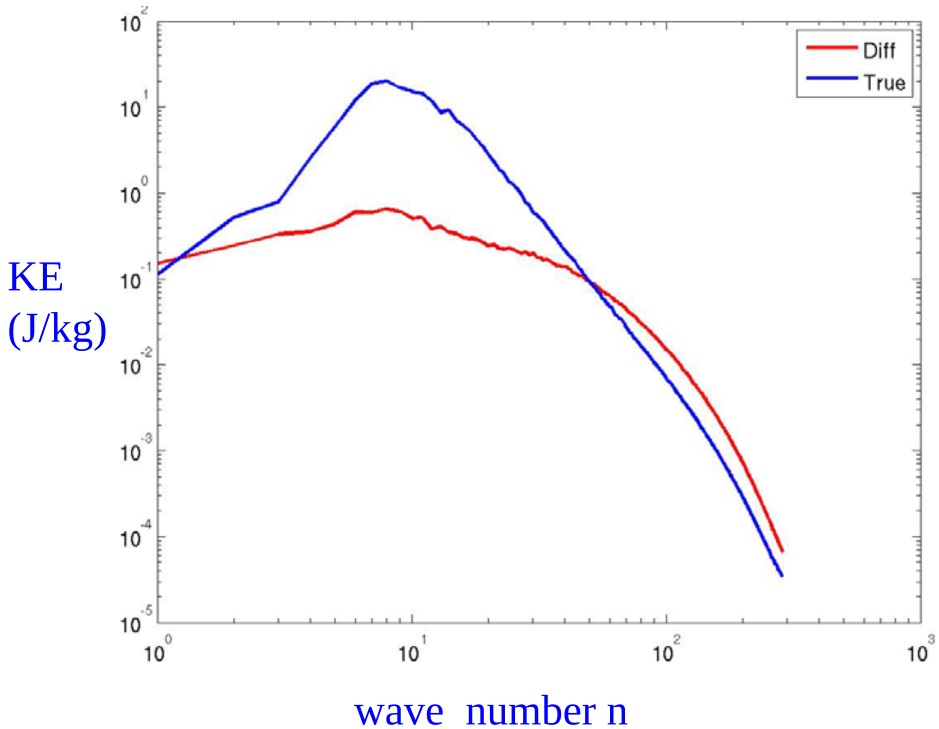
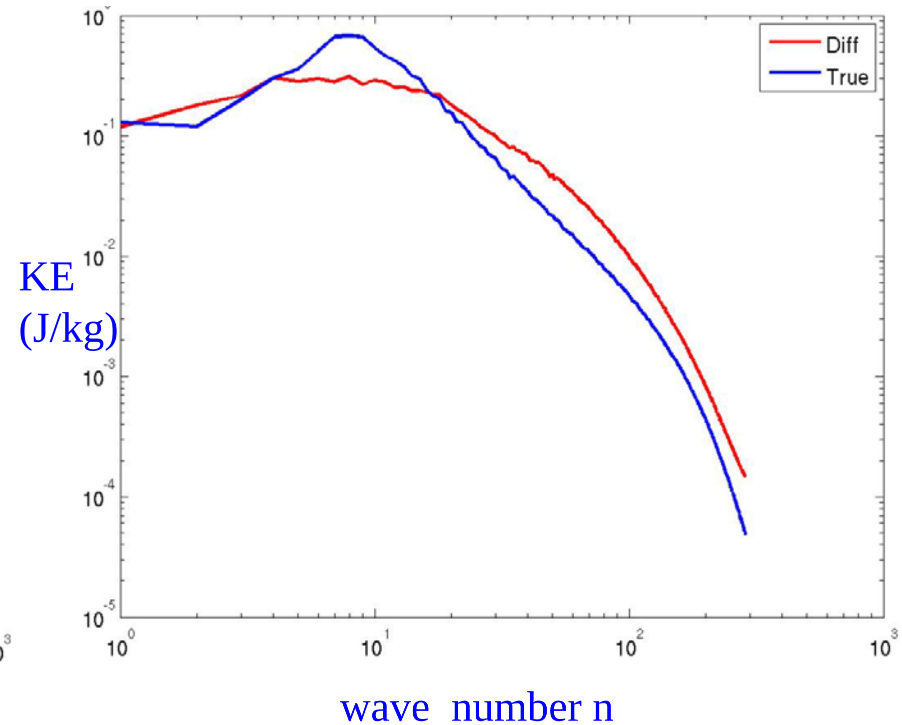


Horizontal spectra of analysis and analysis error
(Spectra of time-mean fields subtracted)

Rotational Wind 200 hPa



Divergent Wind 200 hPa



Horizontal correlation length scales for v wind
(Explicit bkg error vs. NMC method estimate)