The GMAO OSSE for Weather Analysis and Prediction Using the High-Resolution GEOS-5 Nature Run

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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.

Almost all OSSE validation and application metrics are concerned with how analysis accuracy or forecast skill are affected by the observations.

Therefore, OSSEs are about simulating observation errors and other system errors, not simply about simulating observations themselves.

$$O - F = y^o - H(x^b)$$
$$= e^o - e^b$$

Uncommon Aspects of the GMAO OSSE Framework:

Sondes are advected by NR winds.
Radiances are (crudely) affected by clouds or precip.
AMVs are only where NR clouds can be distinguished.
GPSRO obs are produced using ROPP software.
Observation errors are correlated vertically, horizontally, and/or between channels.
Tuning of observation errors is mostly automated.
Validation includes obs impact estimates produced using GSI and model adjoints.
56K lines of software are extensively documented both internally and externally (140 pages).

Model for explicitly simulated observation errors

Schematically:

$$\epsilon(\lambda, \theta, z) = \epsilon_f \left[\sqrt{\nu(z)}\ \gamma(z) + \sqrt{1 - \nu(z)}\ \alpha(\lambda, \theta, z) \right]$$

$$\alpha(\lambda, \theta, z) = \sum_i s_i(\lambda, \theta)\ \phi_i(z)$$

ϵ_f is a scaling factor (generally 1)

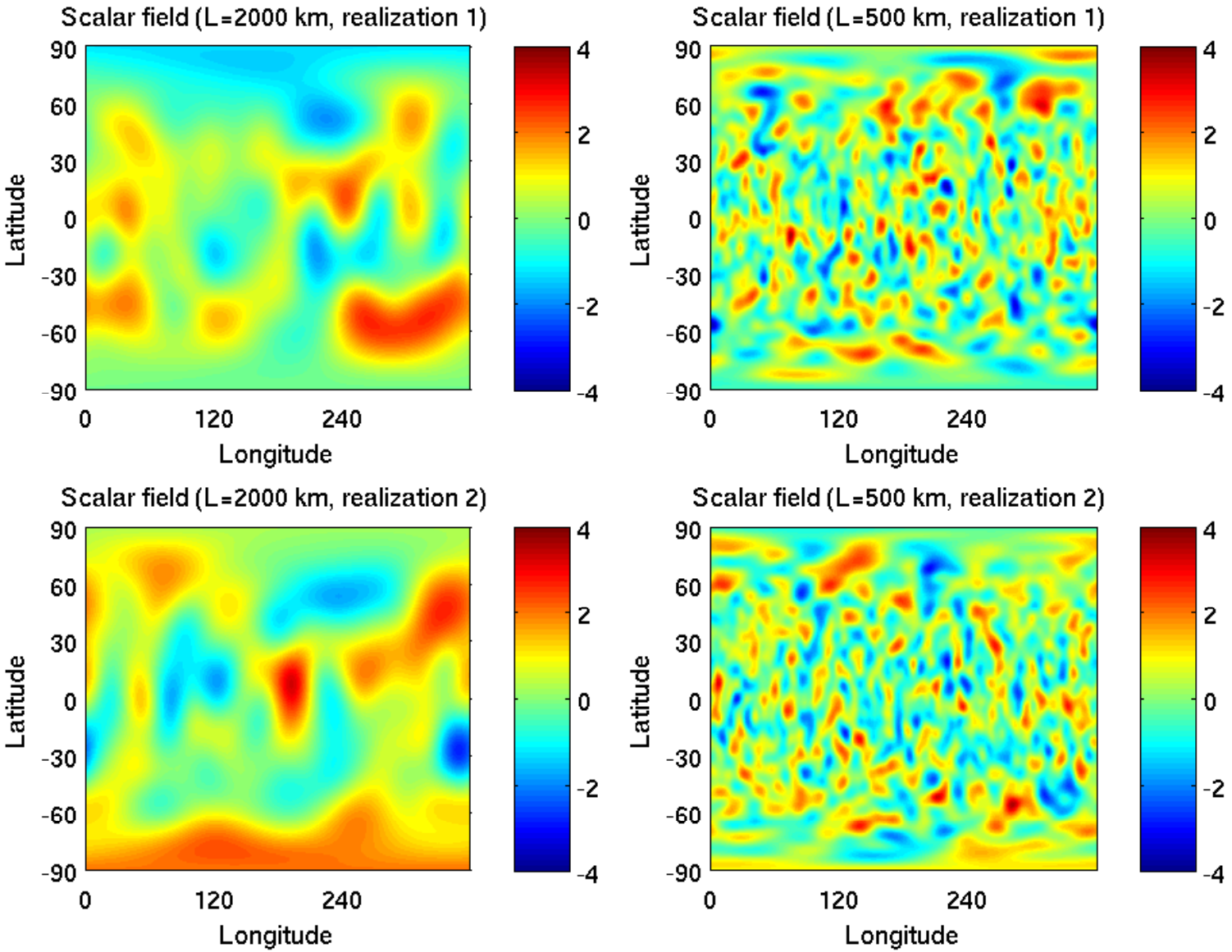
ν is the the fraction of total variance ascribed to an uncorrelated part of the error

γ is a random number from a N(0,V) distribution.

s_i are a set of random, homogeneous, isotropic, horizontally correlated, global, scalar or vector fields

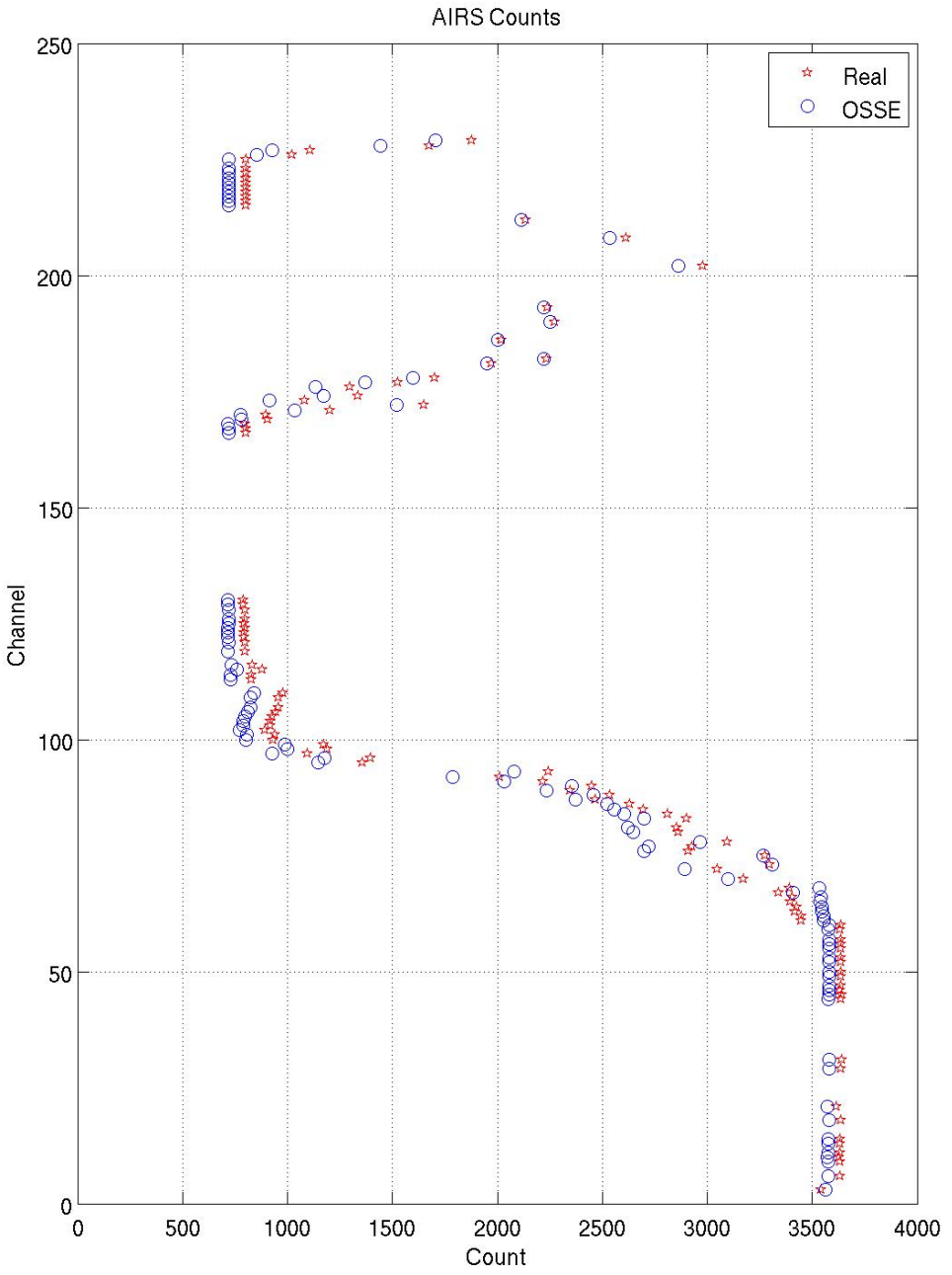
ϕ_i are PCs of a vertical or channel error covariance

Examples of random scalar fields



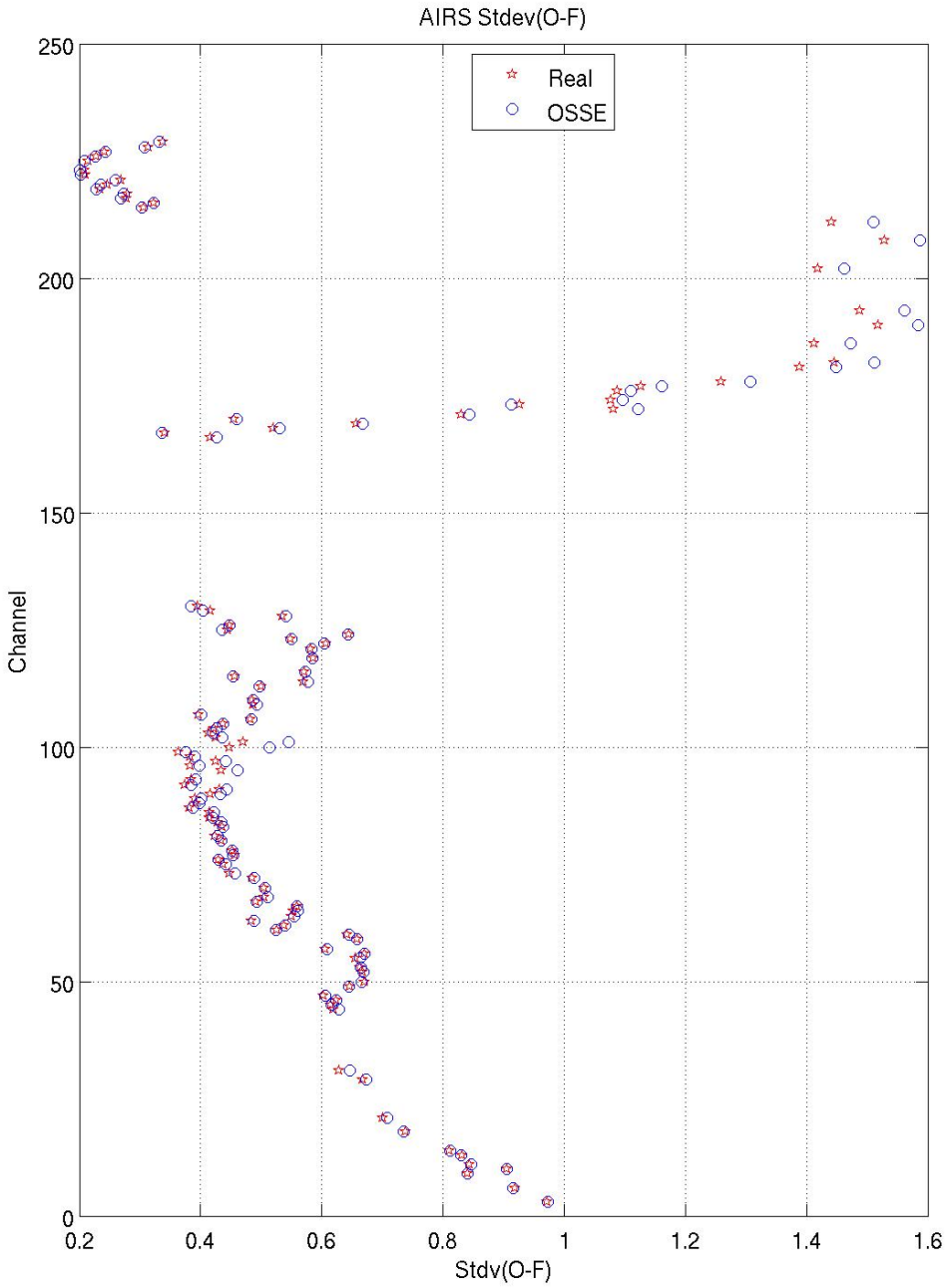
Mean counts per
6-hour assimilation window
for QC-accepted
AIRS channels

REAL stars OSSE circles



Standard Deviations of T_B O-F for QC-accepted AIRS channels

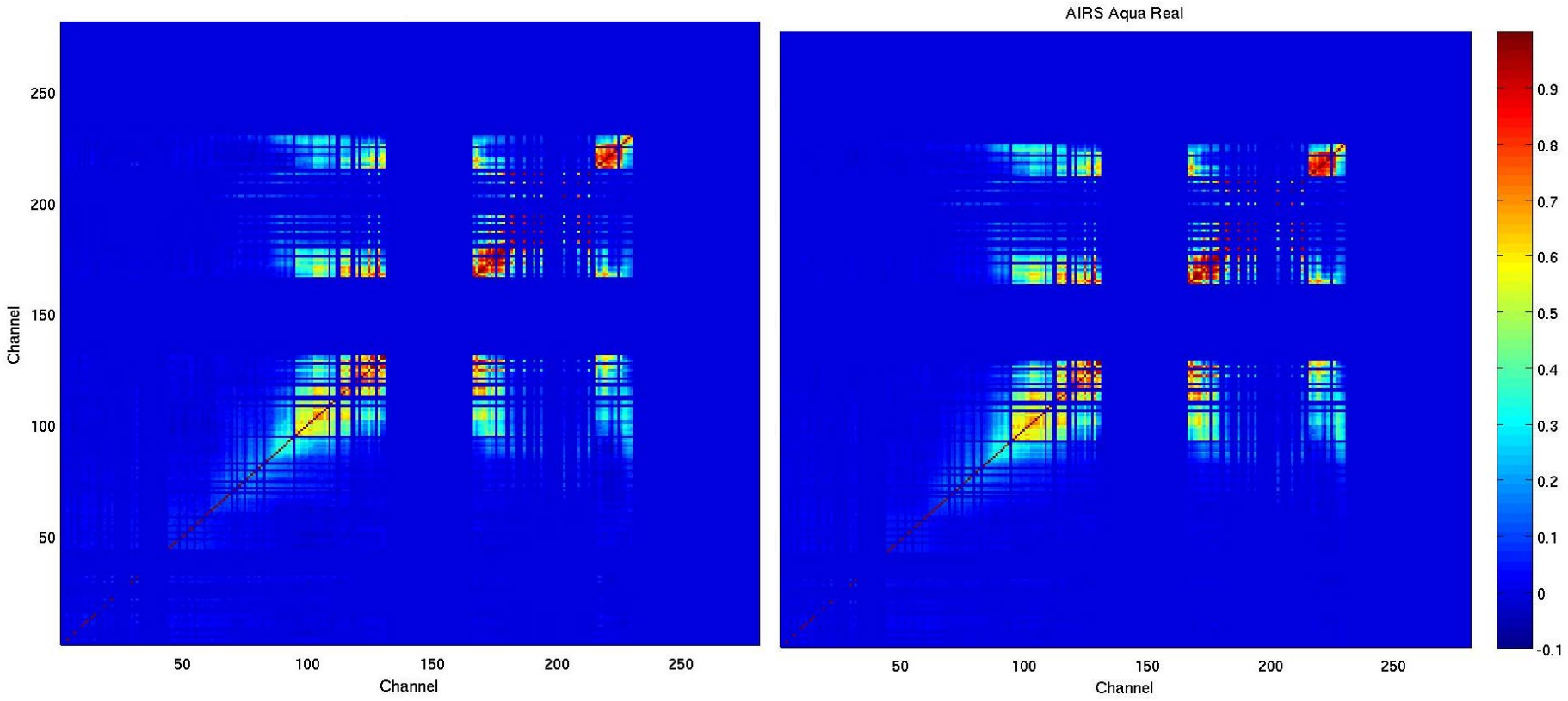
REAL stars OSSE circles

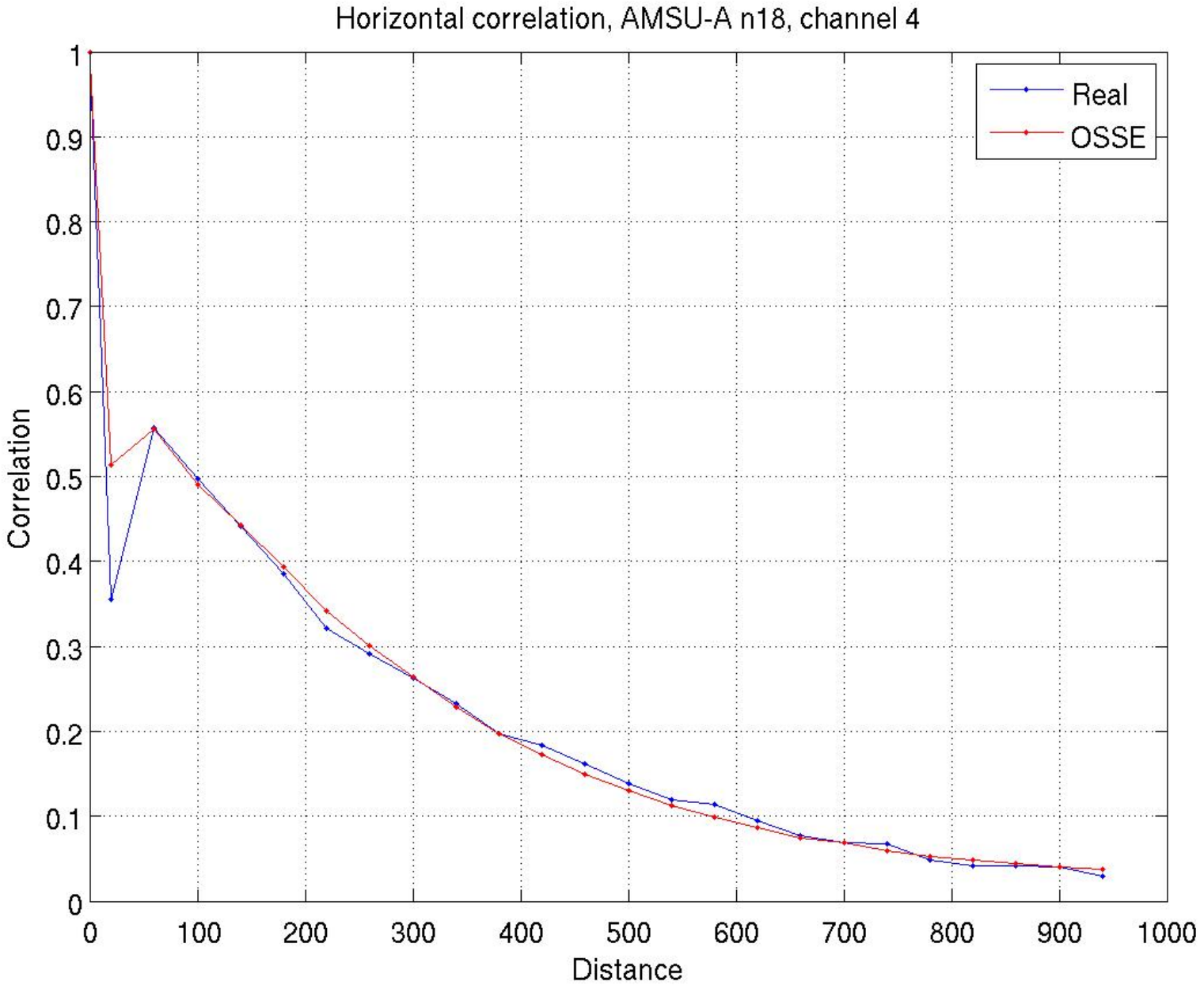


Inter-channel correlation of O-F for AIRS

OSSE

Real



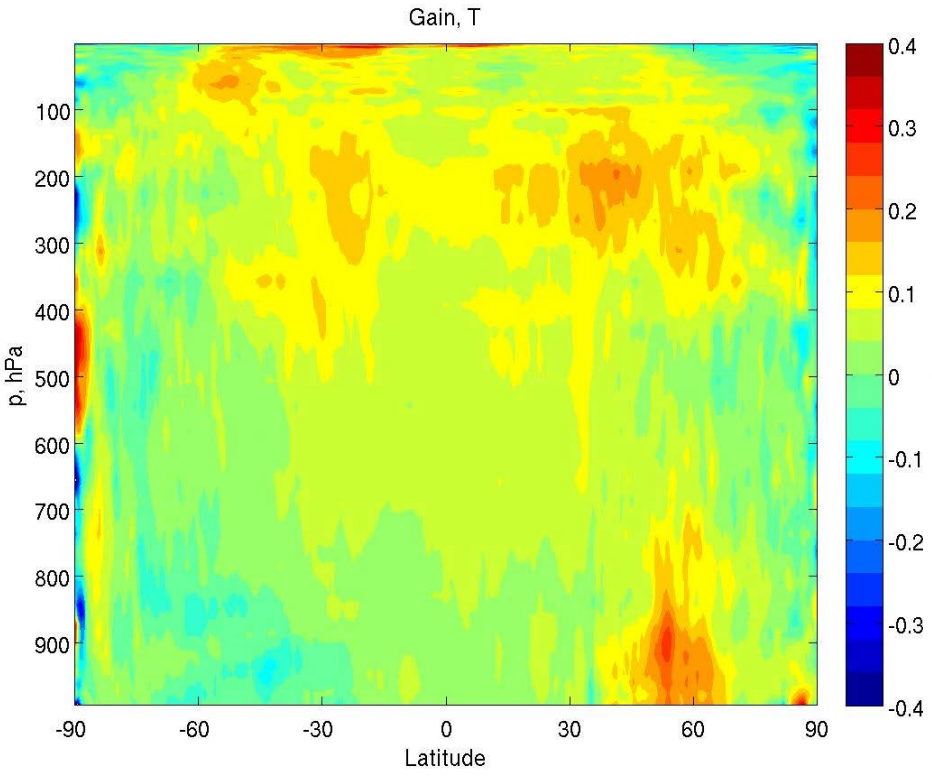

Horizontal correlation, AMSU-A n18, channel 4
Real
OSSE
Correlation
Distance
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
100
200
300
400
500
600
700
800
900
1000

“Kalman Gain”

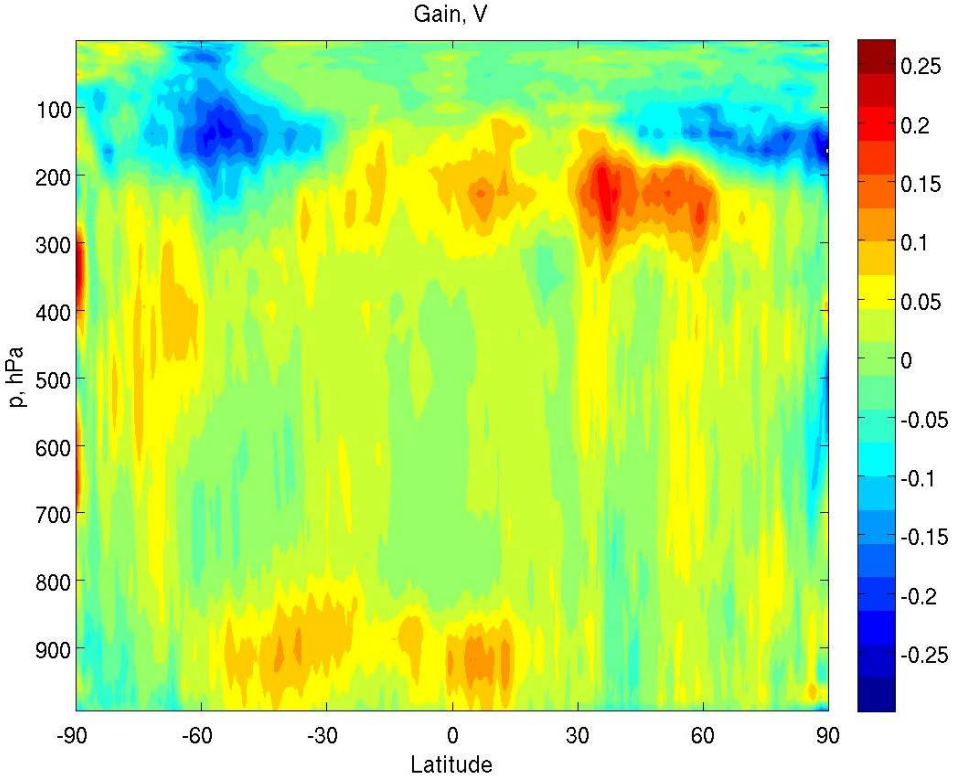
K= (Var(bkg error) – Var(ana error)) / Var(bkg error)

Var = zonal mean of temporal variance of indicated error field

T



V



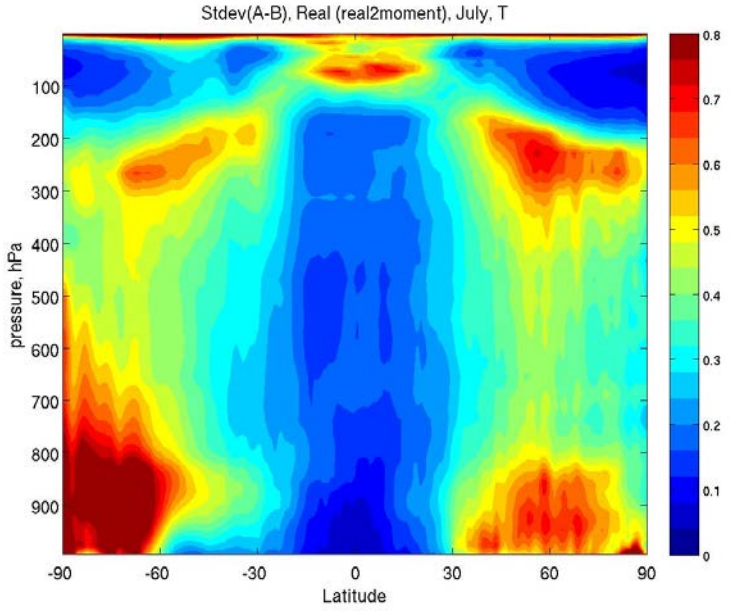
Standard deviations of zonal-mean temporal variances of Ana-Bkg

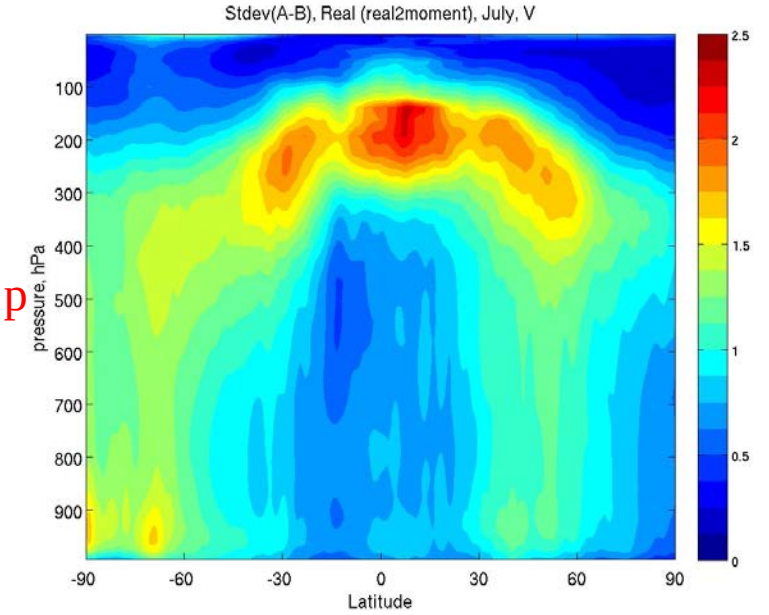
T

V

p

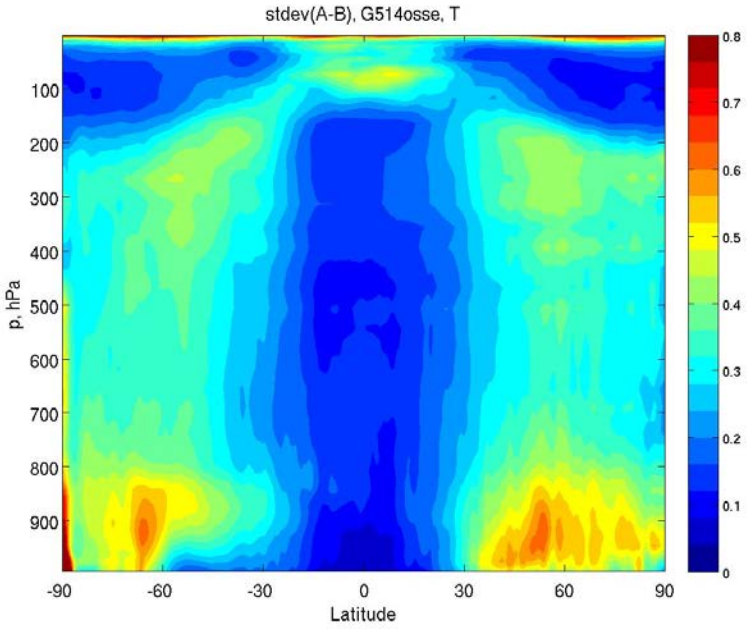
Real

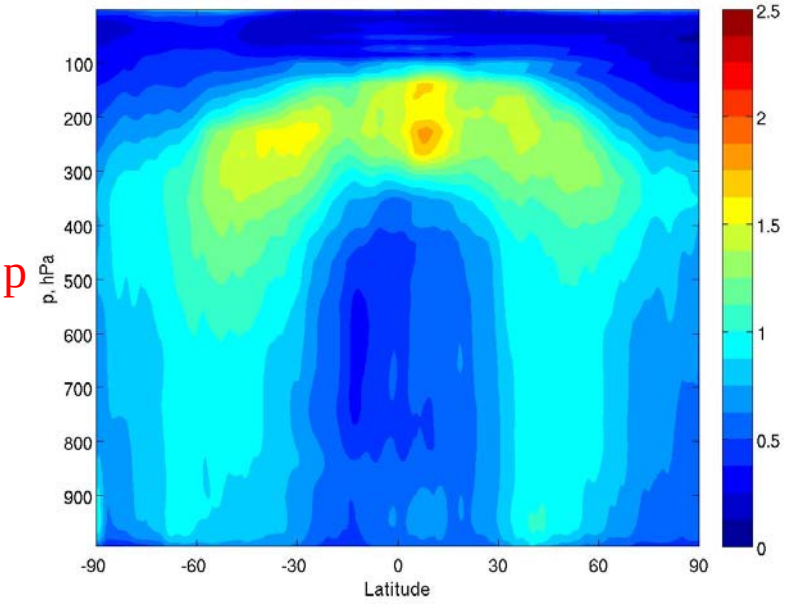




p

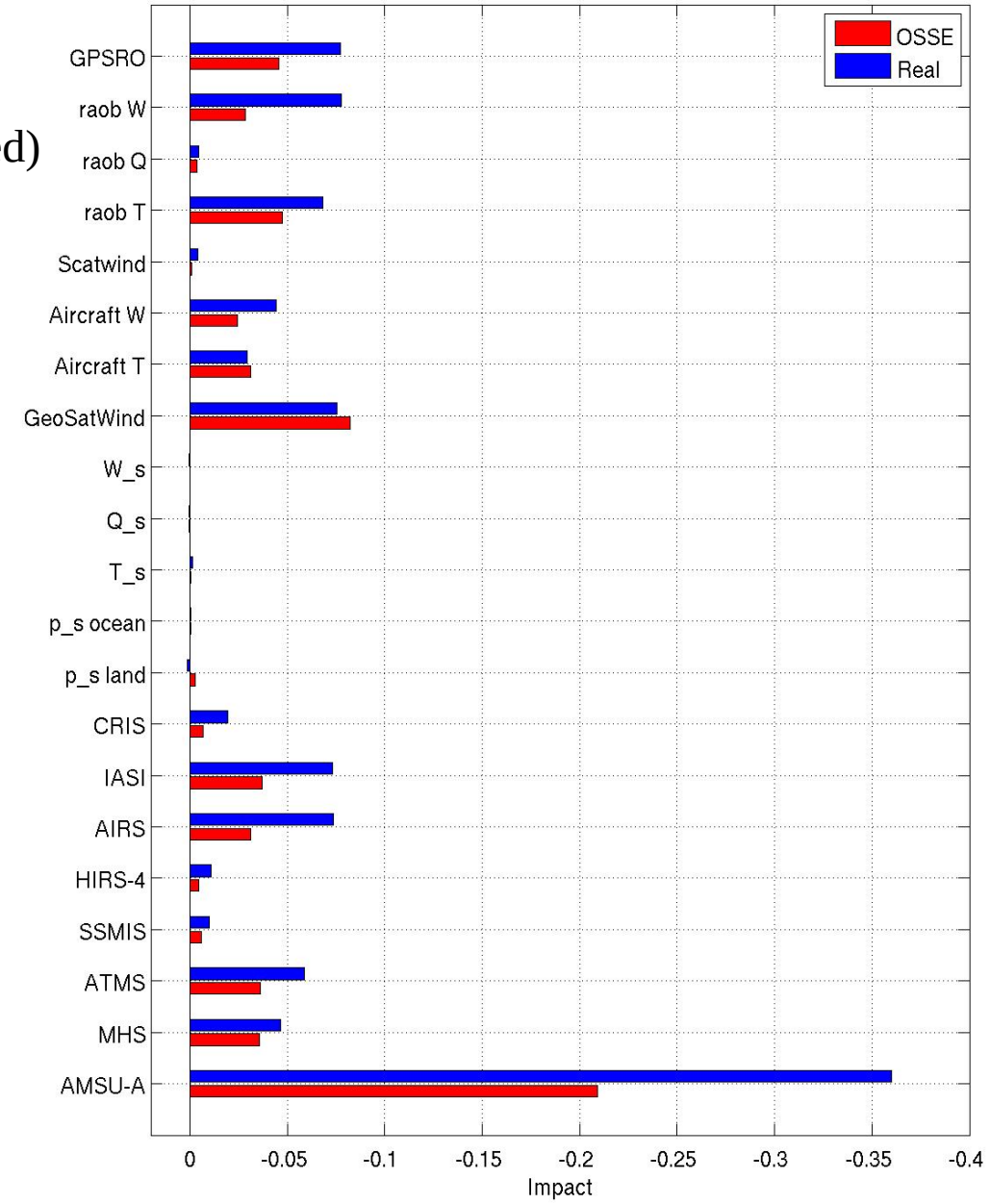
OSSE





Obs Impacts (adjoint-derived)
24-hour forecast error
Moist energy norm

OSSE vs. Real



Summary

1. New GMAO OSSE for Weather Analysis Software Package
   Includes:
   - Use of PREPBUFR, GPSRO, AMV, AIRS, IASI, CRIS, AMSUA, MHS, ATMS, SSMIS, and generic radiances
   - Simulation of correlated observation errors
   - Software for quasi-automated tuning of obs error parameters
   - Technical note for external documentation

   Anticipated availability September 2017

2. Simulated observations for selected periods of GEOS-5 NR:
   - Bufr files of simulated obs with no explicit errors added
   - Bufr files of simulated obs with added explicit simulated errors

   Anticipated availability September 2017