Observing System Simulation Experiments as tools for investigating the behavior of data assimilation systems

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What is an OSSE?

An OSSE is a modeling experiment used to evaluate the impact of new observing systems on operational forecasts when actual observational data is not available.

- A long free model run is used as the “truth” - the Nature Run
- The Nature Run fields are used to back out “synthetic observations” from all current and new observing systems.
- Suitable errors are added to the synthetic observations
- The synthetic observations are assimilated into a different operational model
- Forecasts are made with the second model and compared with the Nature Run to quantify improvements due to the new observing system

Utility of the “Truth”

The availability of a complete true state of the atmosphere allows the explicit calculation of some quantities not possible in the real world:

- analysis error
- short-term forecast error
- efficacy of the data assimilation system

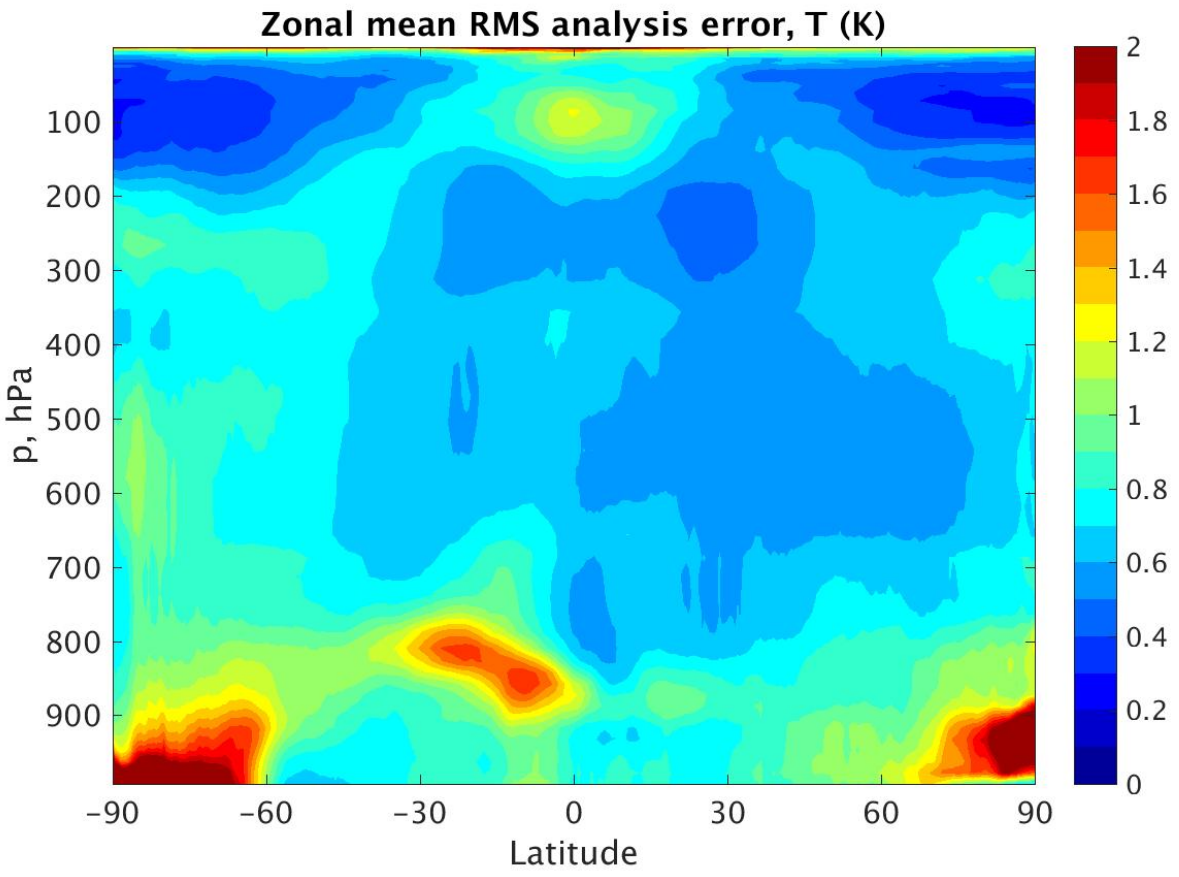
One caveat: specific findings are applicable within the OSSE, but extensive validation is needed before extrapolating results to the real world.

GMAO OSSE Framework

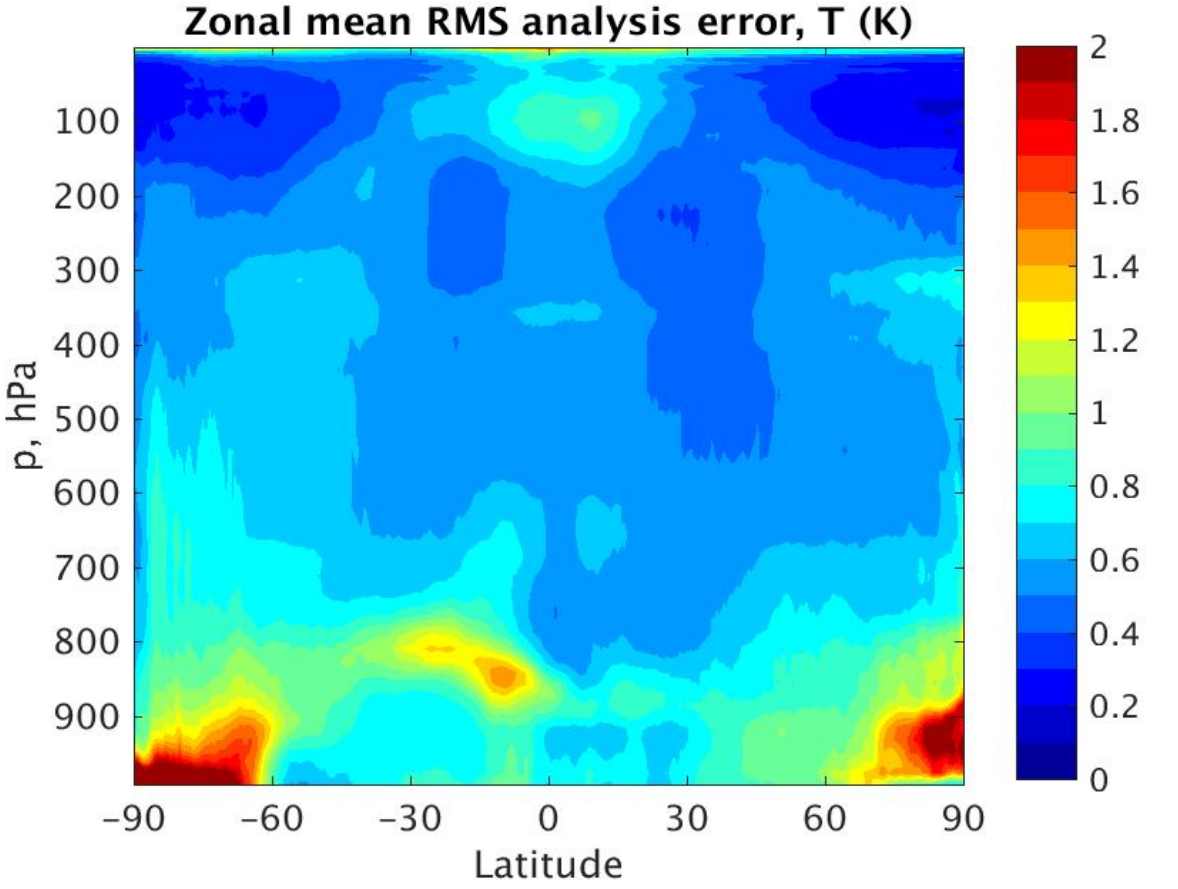
- **Nature Run**
  - ❖ 2 years free forecast of the GEOS-5 model (G5NR)
  - ❖ 7 km horizontal resolution, 72L
  - ❖ 30 min output, 13 aerosols
- **Synthetic observations**
  - ❖ Generated from G5NR output fields
  - ❖ Include G5NR cloud effects
  - ❖ Conventional, GPSRO, AIRS, IASI, CRIS, AMSUA, MHS, ATMS, SSMIS, HIRS4
- **Correlated and uncorrelated observation errors**
  - ❖Calibrated and validated to match statistics of real data
- **Experimental model**:
  - ❖GEOS-5 v. 5.17, 25 km horizontal resolution, 72L
  - ❖3DVar and 4DEnVar GSI available
- **FSOI:**
  - ❖ adjoint tool with moist physics option, total wet energy norm (TWE)

Analysis Error (T)

3D Var

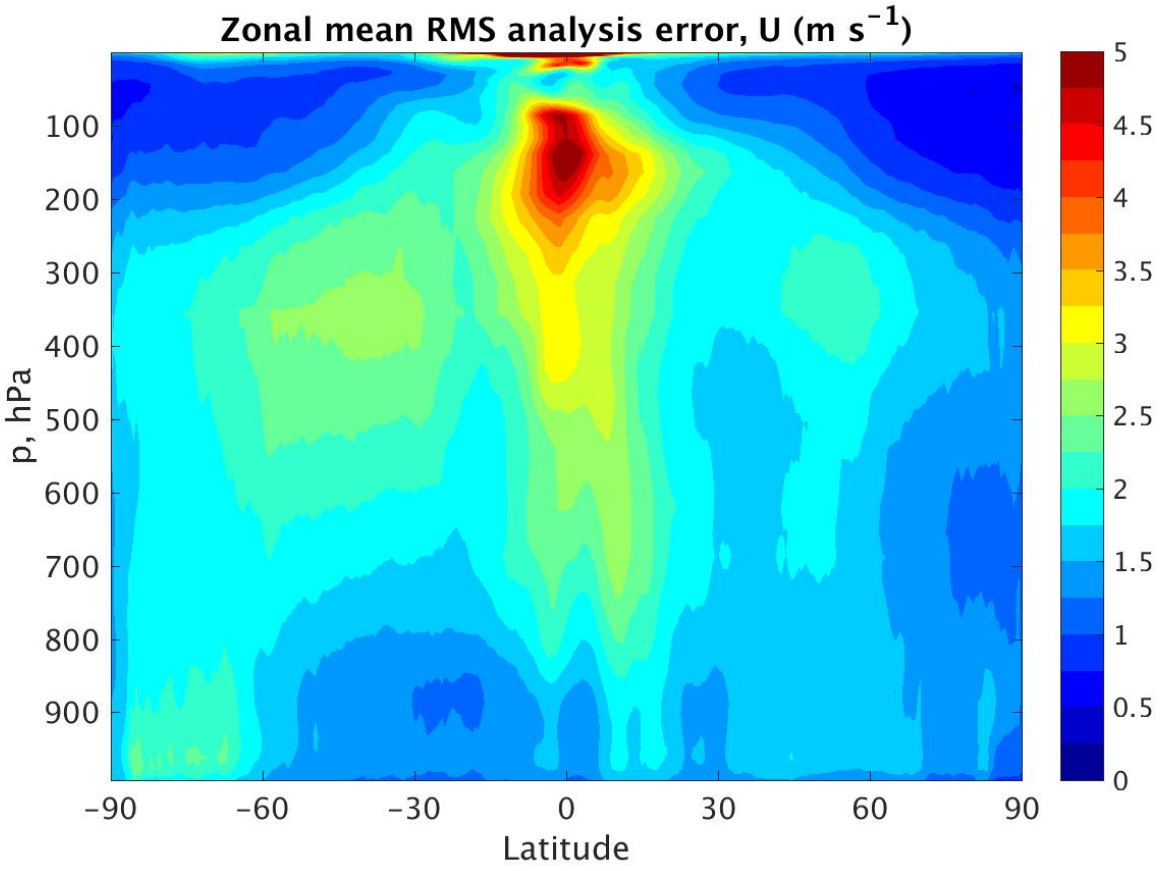


4D EnVar

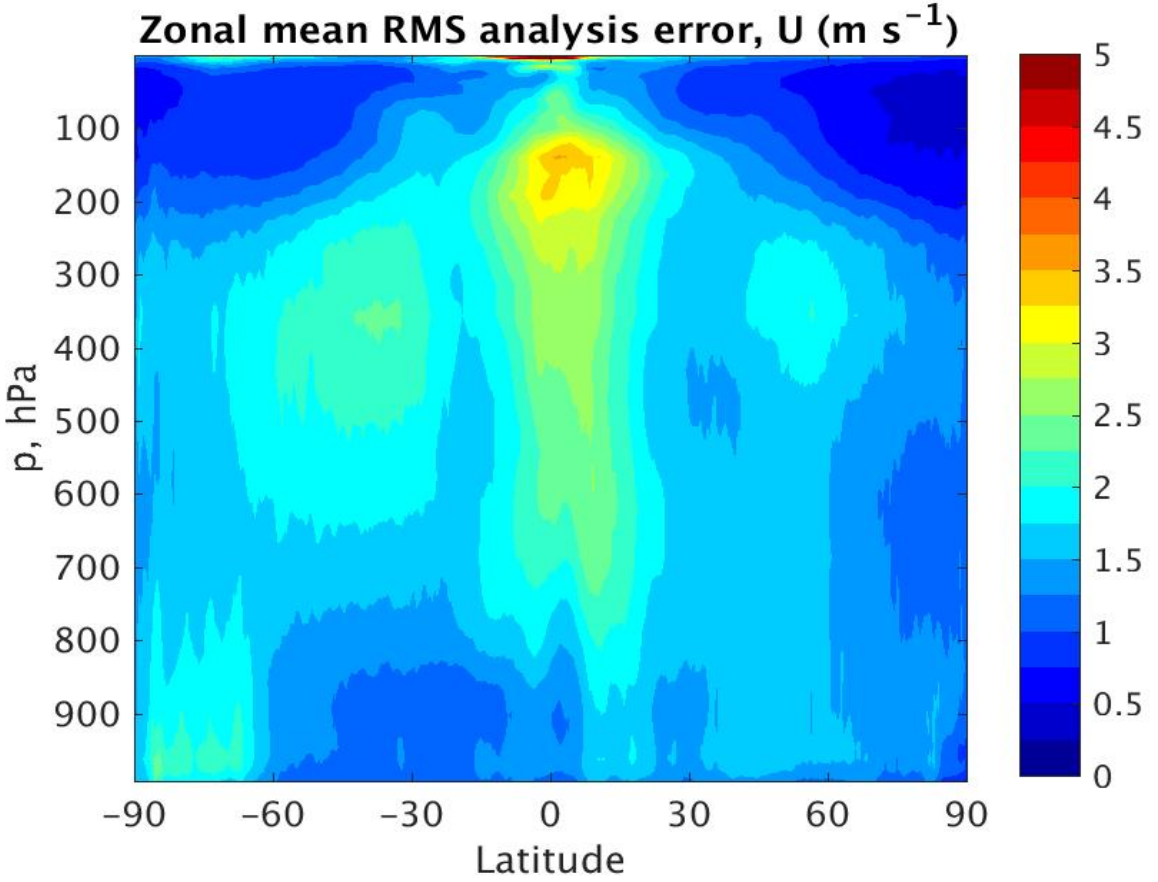


Analysis Error (U)

3D Var

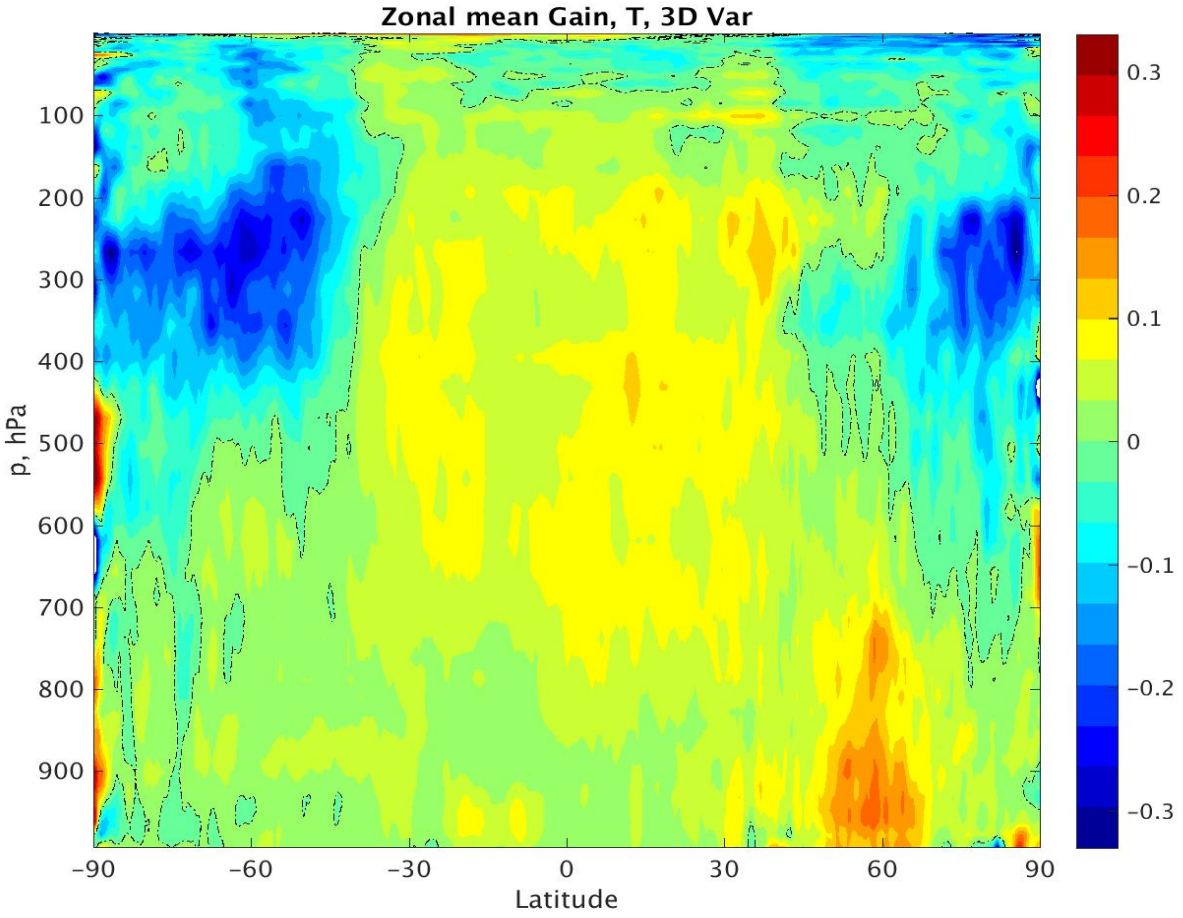


4D EnVar

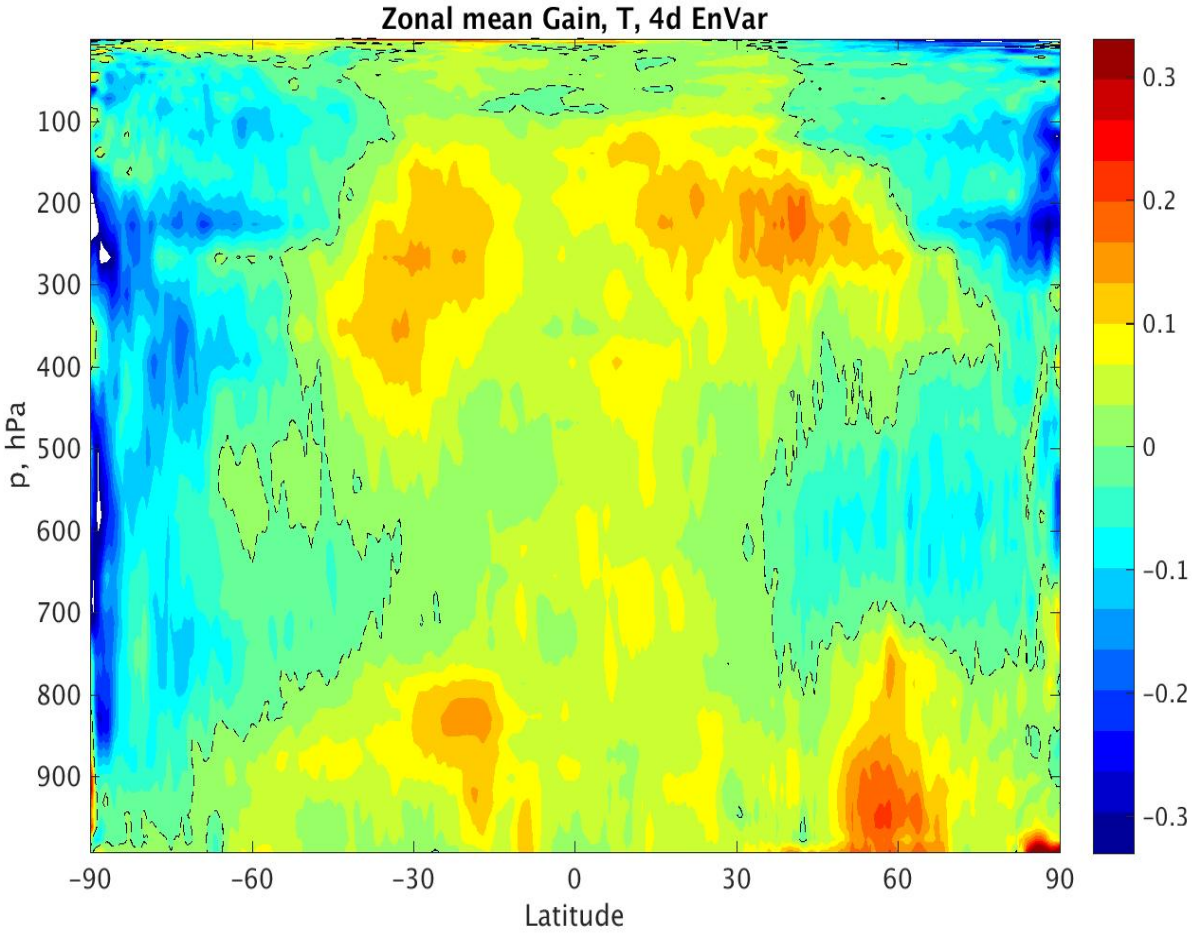


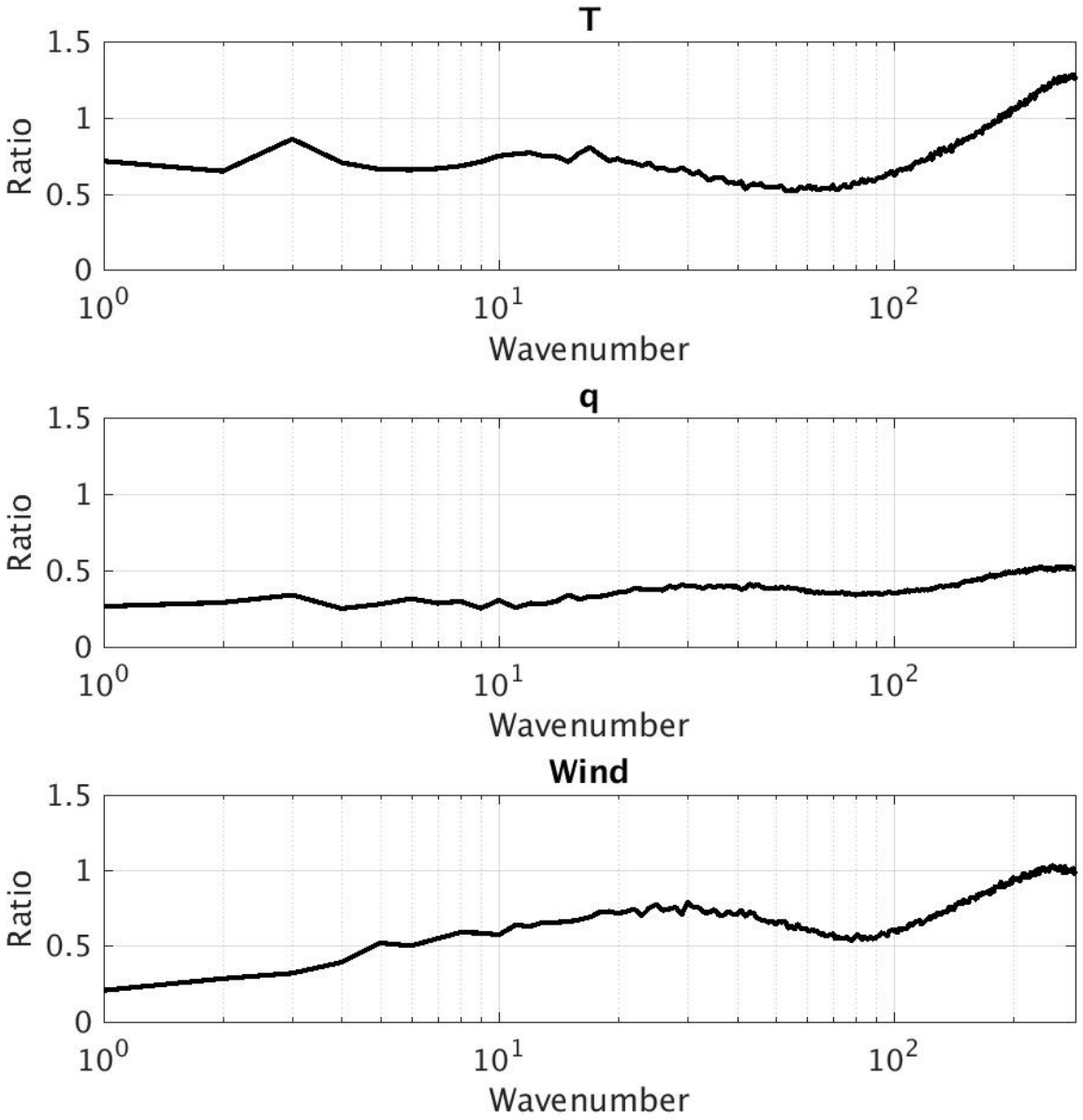
“Gain” or Beneficial Impact of DAS

3D Var



4D EnVar



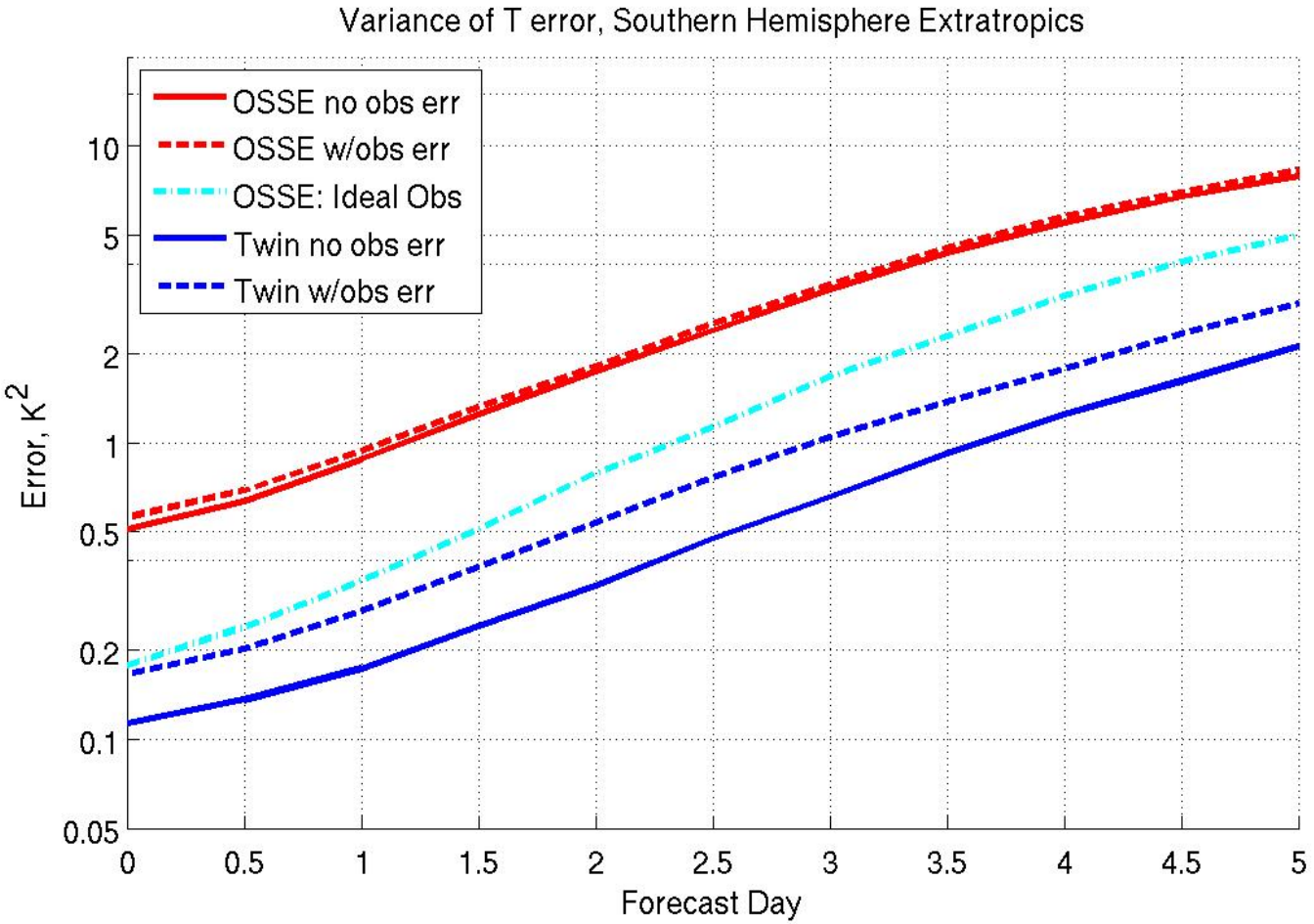


Forecast Error

Error for short term forecasts can be calculated without uncertainties from self-analysis verification or the need for a special verification observation set.

OSSE experiments have shown that using self-analysis verification can underestimate the 24-hour forecast error by more than 70%, especially for fields such as humidity that have substantial model biases.

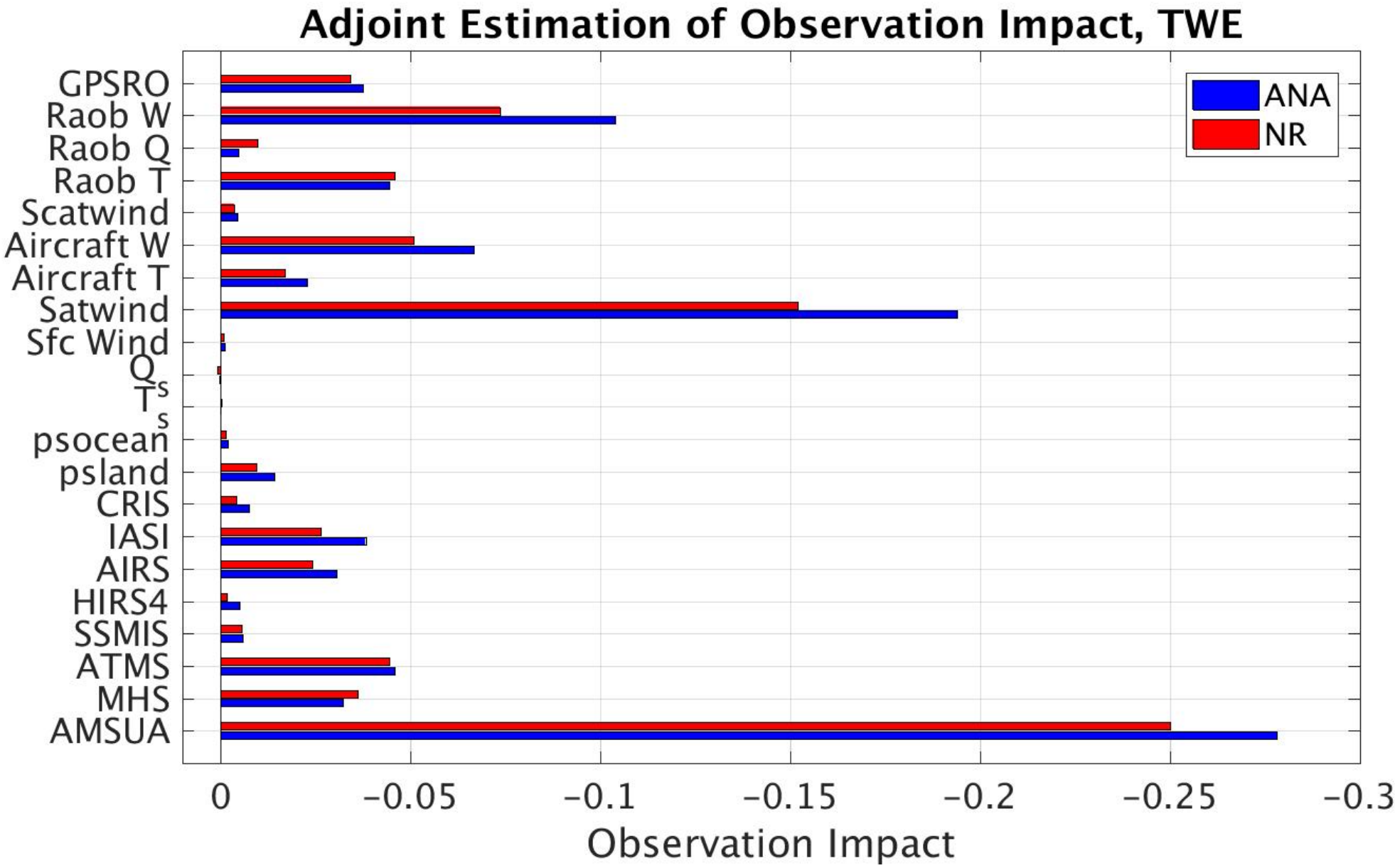
Model Error



OSSEs used in an identical twin framework have no model error and can be used for idealized studies of DAS and model behavior.

Comparing perfect model behavior with the imperfect model system can be used to characterize model error in the OSSE framework.

Since Nature Runs are generally too similar to the experimental model, greater model error is expected in the real world.


Adjoint Estimation of Observation Impact, TWE
GPSRO
Raob W
Raob Q
Raob T
Scatwind
Aircraft W
Aircraft T
Satwind
Sfc Wind
Q
T
s
s
psocean
psland
CRIS
IASI
AIRS
HIRS4
SSMIS
ATMS
MHS
AMSUA
ANA
NR
0
−0.05
−0.1
−0.15
−0.2
−0.25
−0.3
Observation Impact

Takeaways

- Results are trustworthy only if the OSSE is fully validated
- The availability of the “truth” allows investigations of the behavior and characteristics of data assimilation systems not possible in the real world
- OSSEs can be used to compare and evaluate different metrics used with real data to evaluate data assimilation systems