Design and Validation of Observing System Simulation Experiments At the GMAO

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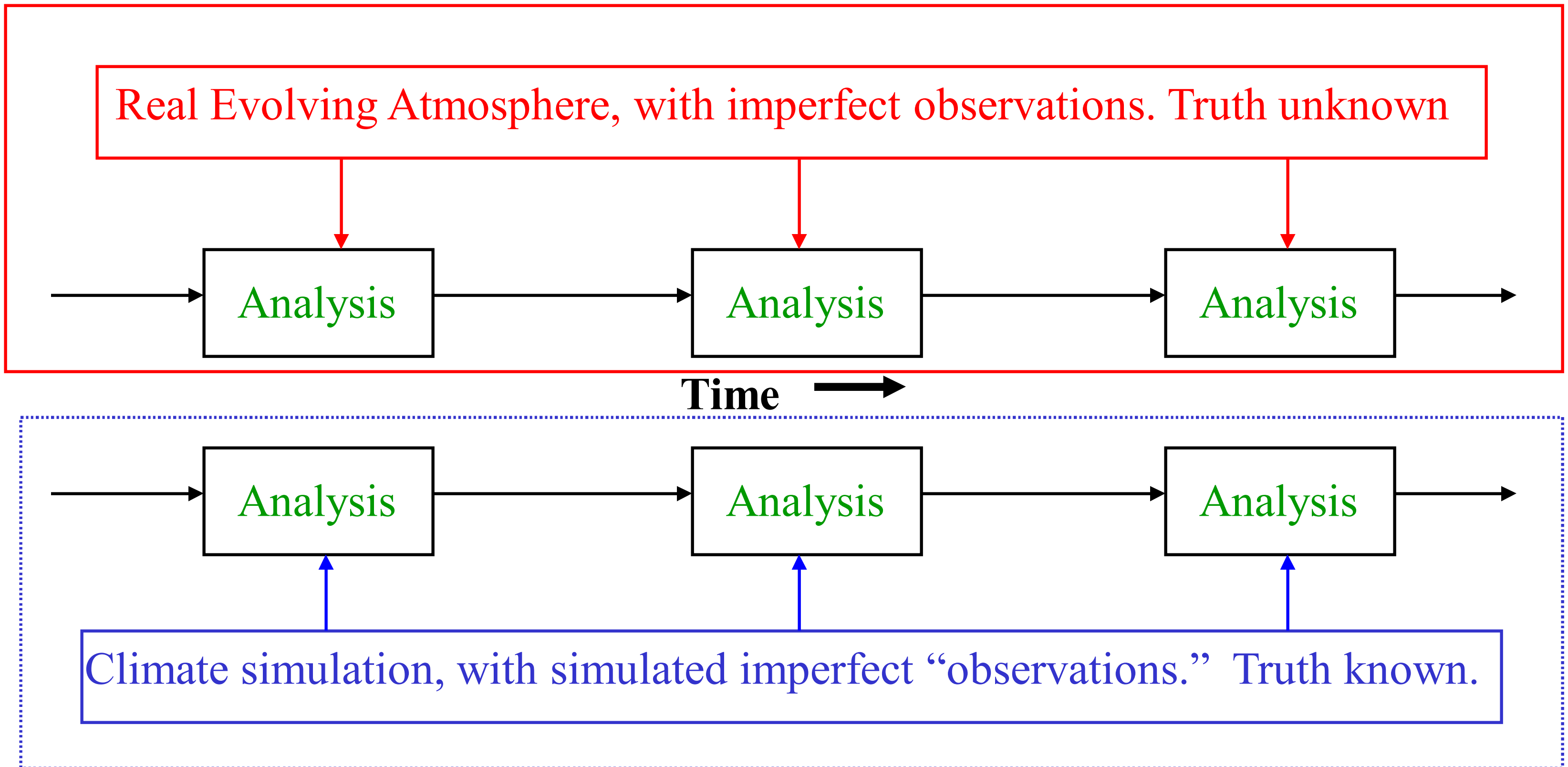
The GMAO in General

Format

1. Part tutorial
2. Part introduction for next talk
3. Part update on GMAO OSSE development
4. Includes results from latest experiments

Data Assimilation of Real Data



Observing System Simulation Experiment

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.

ECMWF Nature Run

1. 13-month “forecast” starting 10 May 2005
2. Use analyzed SST as lower boundary condition
3. Operational model from 2006
4. T511L91 reduced linear Gaussian grid (approx 40 km)
5. 3 hourly output

NCEP/GMAO Data Assimilation System

1. NCEP/GMAO GSI 3DVAR every 6 hours
2. GMAO GEOS-5 forecast model with FV dynamical core
3. Resolution in current experiments: 0.5x0.625 degree grid, 72 levels
4. Baseline obs. set includes: usual “conventional” obs., SATWINDS, HIRS2, HIRS3, AMSUA, AMSUB, AIRS, MSU

Simulation of Observations and their Errors

Innovation for DAS of real observations:

$$\mathbf{d} = \mathbf{y} - H(\mathbf{x}_b)$$

Innovation for DAS of observations in OSSE:

$$\mathbf{d} = [H_z(\mathbf{z}) + \mathbf{e}] - H(\mathbf{x}_b)$$

The OSSE Validation Problem

1. As with any simulation, it is a useful only if it validates well against reality with regard to relevant aspects.

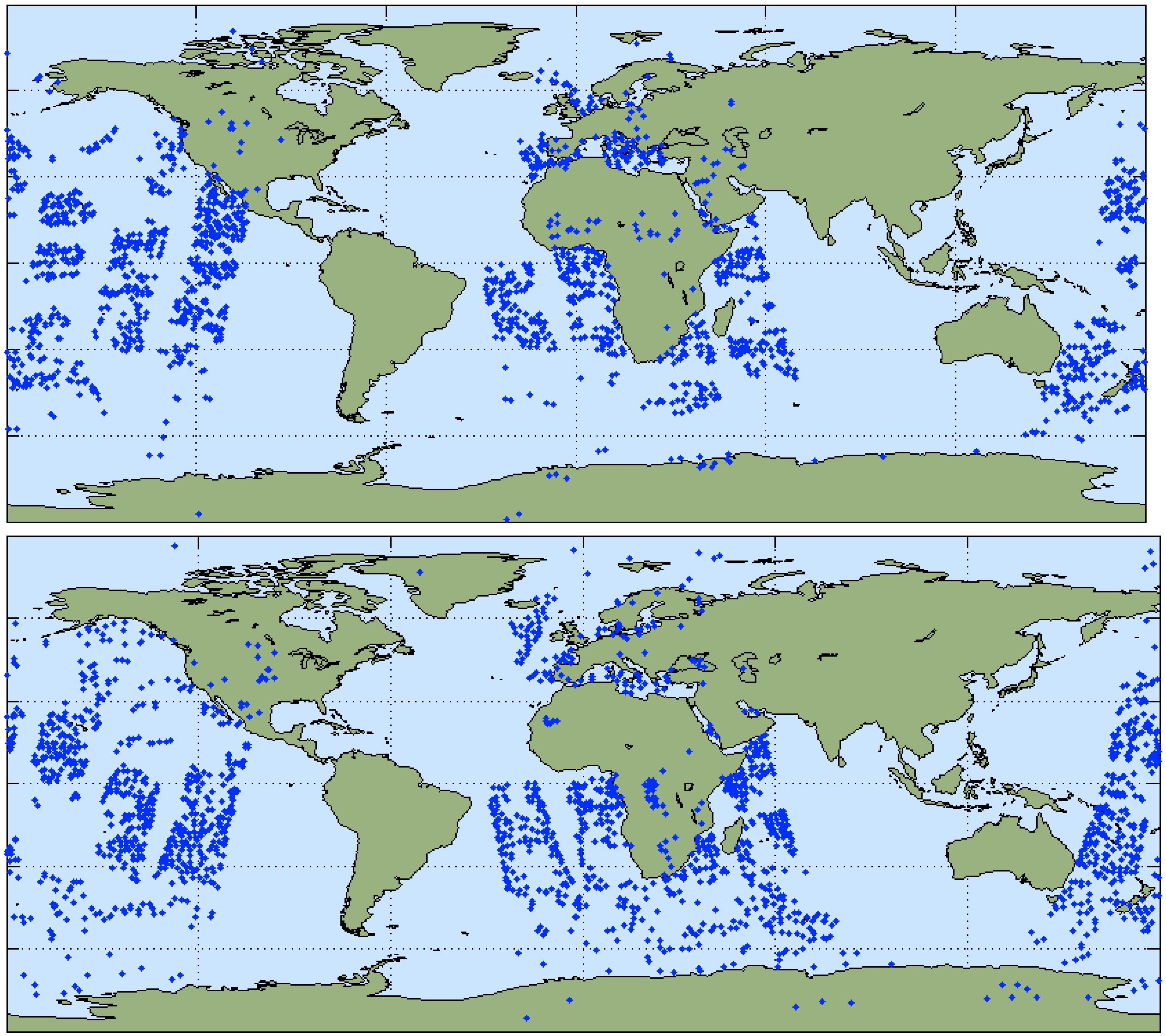
2. With regard to the complex behavior of data assimilation systems, it is necessary to examine a variety of metrics.

3. Most DAS metrics concern either increments or estimated errors produced by the analysis and subsequent forecast systems.

4. These metrics are functions of the background errors, instrument errors, forward observation operator errors , assimilating model formulation errors, and chaotic dynamics; e.g., A=A(B, E, F, Q, M)

5. The OSSE development problem is to adequately model the input errors, particularly those that can be introduced explicitly.

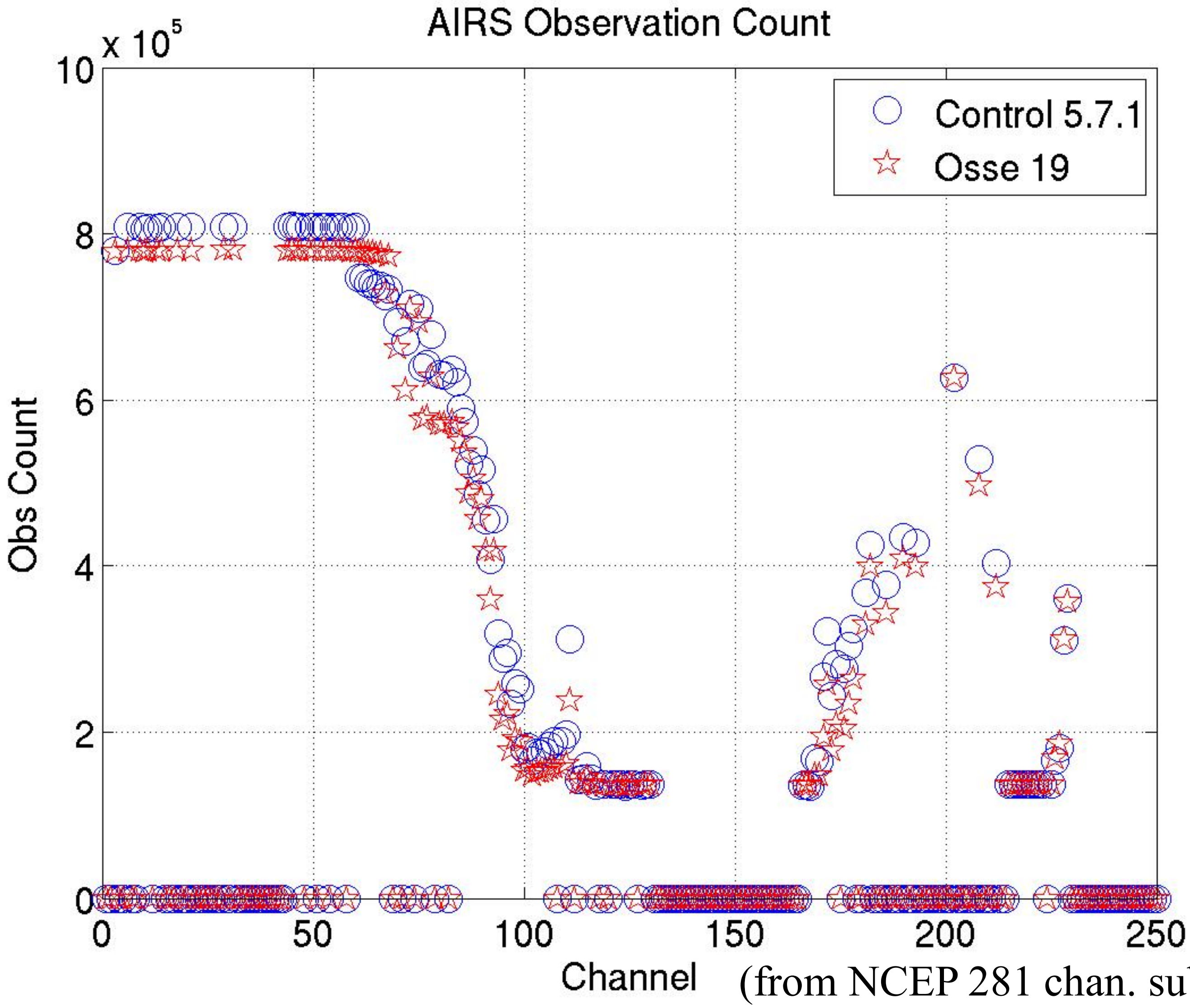
Quality-Accepted Observations for AIRS chan 295 for 12 Jan. 2006 12Z



OSSE
(1503 obs)

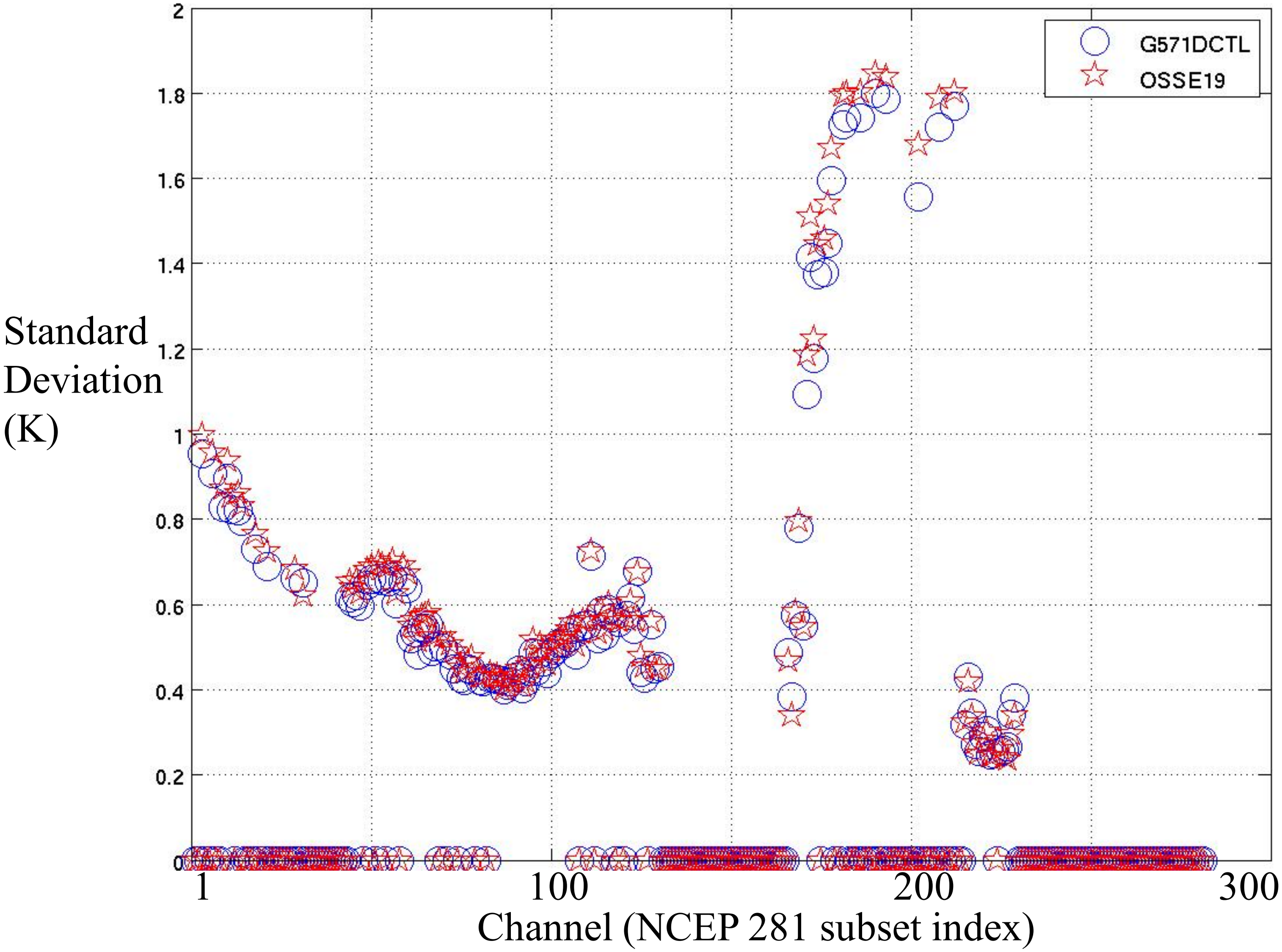
Real
(1647 obs)

Quality-Accepted Observation for Jan. 2006



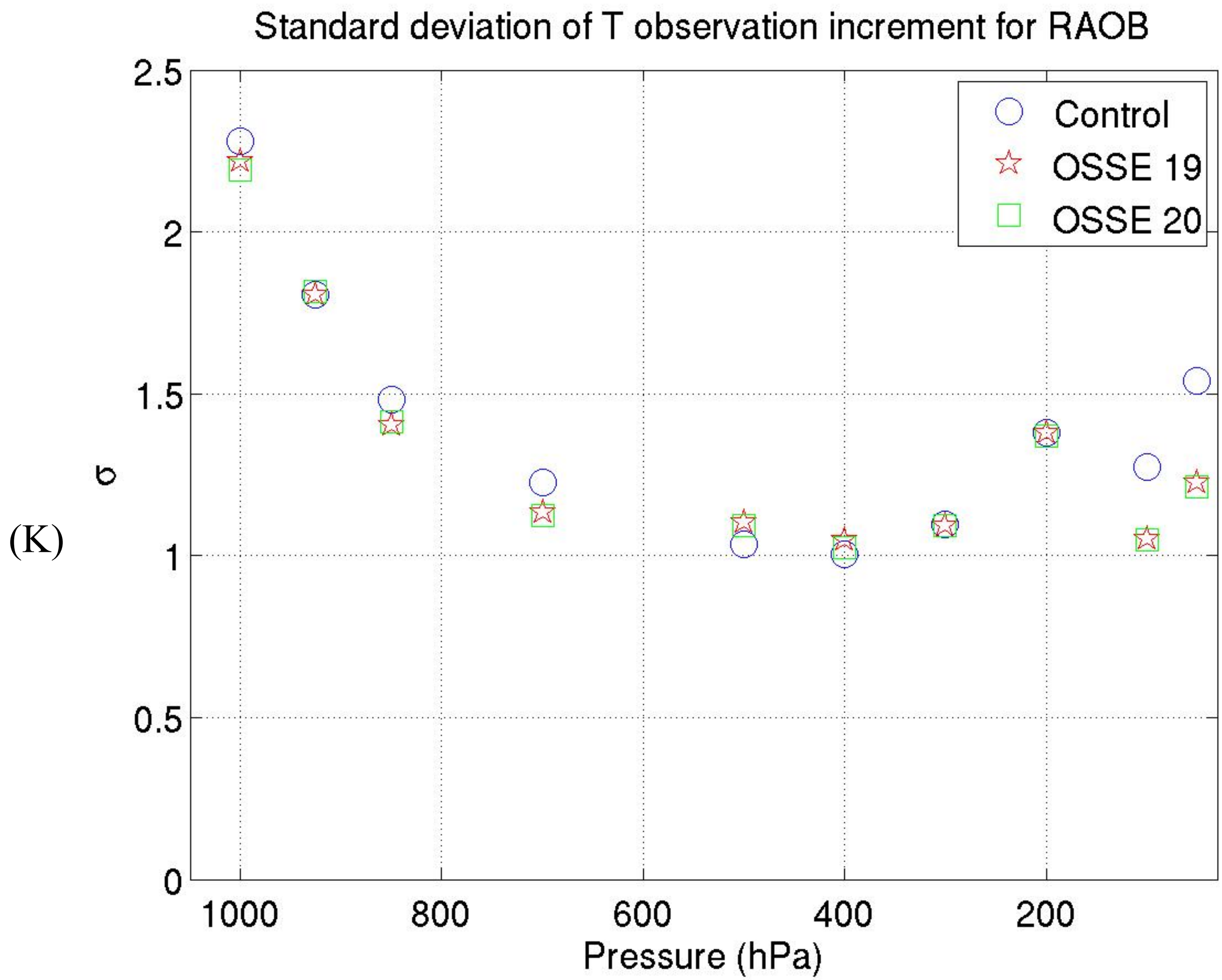
(from NCEP 281 chan. subset)

AIRS observation minus background [y-H(xb)]



CTRL

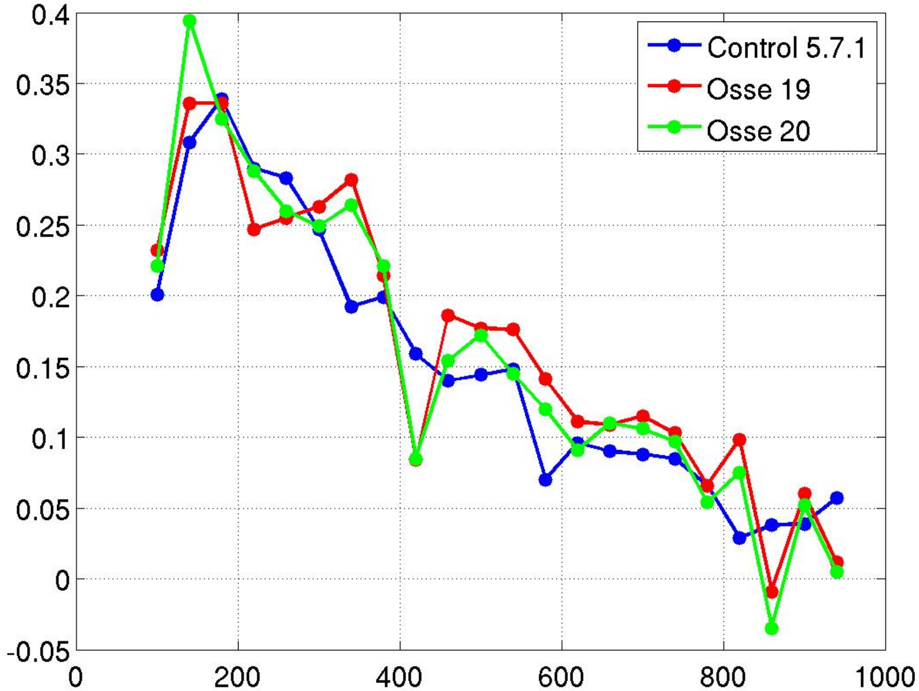
OSSE



Standard deviation of T observation increment for RAOB
σ
(K)
Pressure (hPa)
Control
OSSE 19
OSSE 20
2.5
2
1.5
1
0.5
0
1000
800
600
400
200

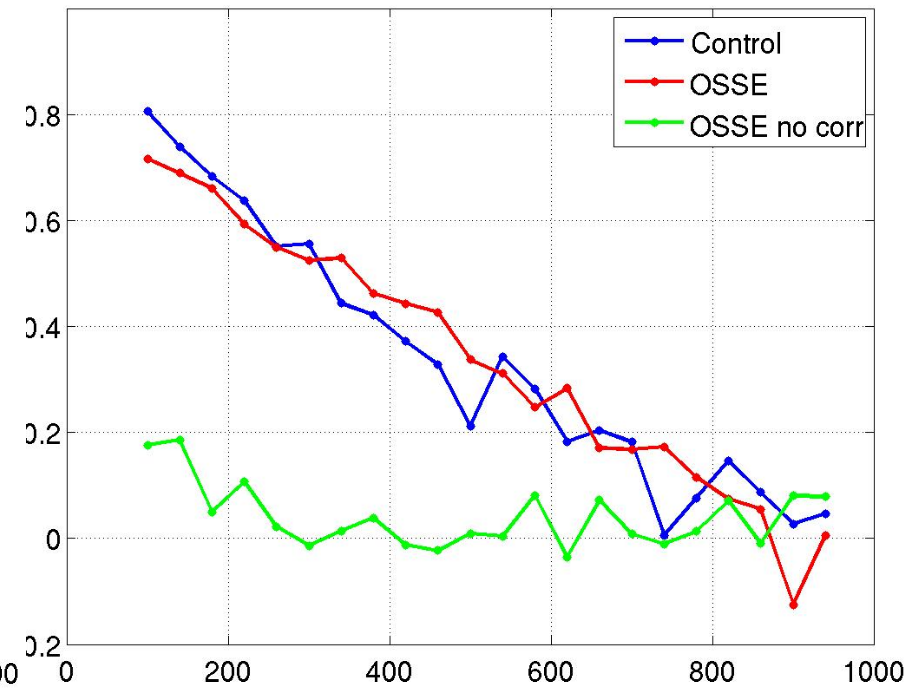
Horizontal correlations of y-H(xb)

RAOB T 20N-90N 850 mb



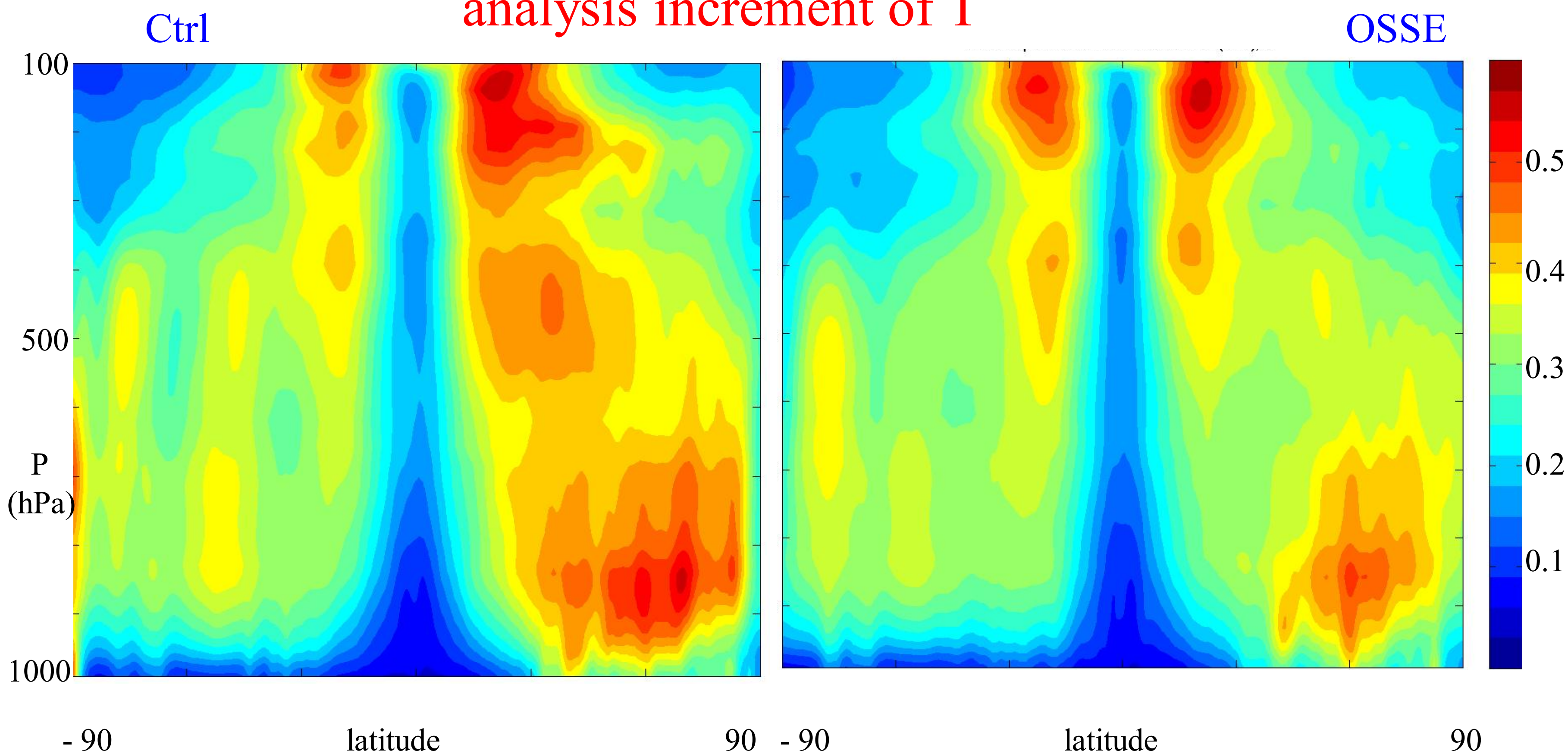
Separation Distance (km)

GOES-IR Cloud Drift u-wind 700 mb

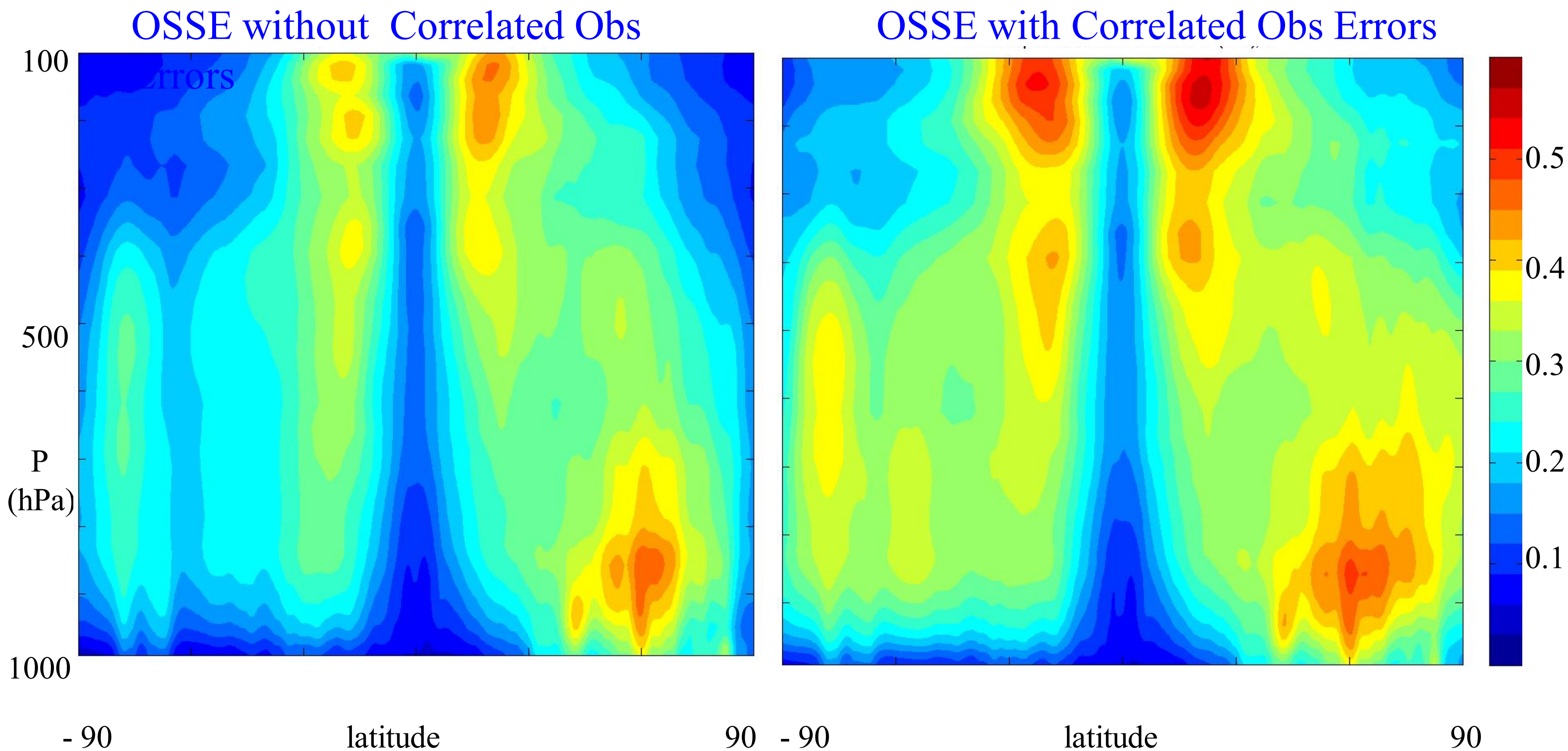


Separation Distance (km)

Square root of zonal mean temporal variance of analysis increment of T



Square root of zonal mean temporal variance of analysis increment of T



Summary

1. Our current focus is on producing a better validated framework.
2. We are automating the observation error tuning.
3. We are examining more validation metrics.
4. We are examining other time periods.
5. We are adding simulation of new observation instruments.
6. We are adding more realism to the observation simulations.
7. We are examining the OSSE model error.
8. We have several other studies planned.
9. GMAO has produced and is validating a new nature run on a 10-km grid.
10. A preliminary OSSE has been performed for the planned EU wind lidar.
11. We will welcome collaborators once we have an appropriate system.

The End
(almost)

Evaluation of an Observing System
Based on Potential Accuracy of Analyses Produced from it

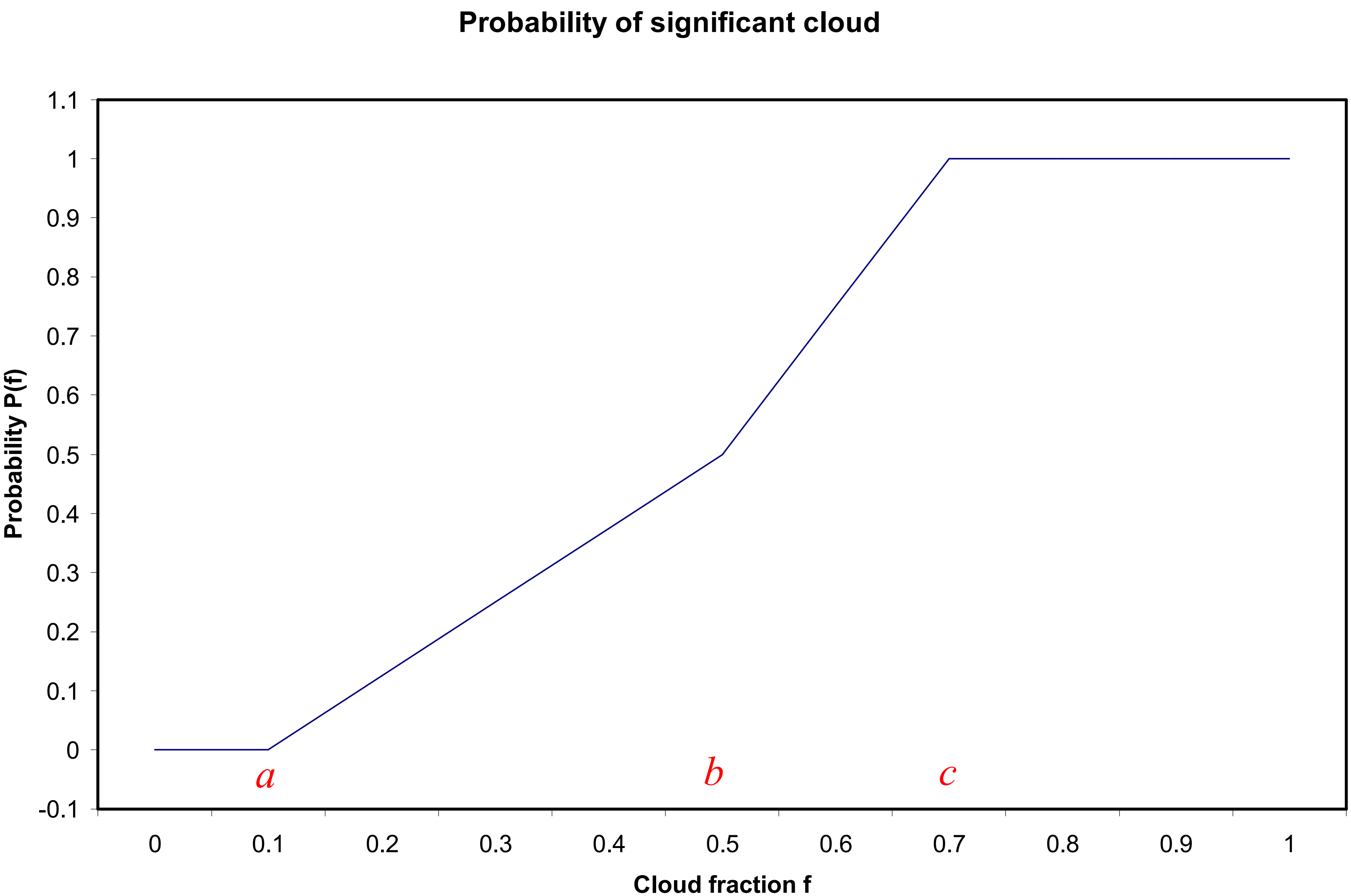
Analysis accuracy depends on:

- Errors due to imperfect observation instruments
- Errors due to imperfect representation of observations ($H(\mathbf{x})$)
- Errors introduced by time extrapolation or interpolation models ($\mathbf{Q}$)
- Errors introduced by the analysis technique
- Error modulation due to atmospheric chaos

Validity of the OSSE therefore depends in large part on how well all these *ERRORS* are simulated.

Requirements for an OSSE system

1. A self-consistent and realistic simulation of nature.
2. A data assimilation system (obviously).
3. Simulated observations, drawn from the Nature Run.
4. Simulated observation errors (implicit and explicit).
5. A validated baseline experiment using existing obs. types.


Probability of significant cloud
Probability P(f)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
a
b
c
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Cloud fraction f

Warnings

General criticisms of OSSEs

1. In OSSEs, the NR and DAS models are generally too alike, therefore underestimating model error and yielding overly-optimistic results.

2. When future specific components of the observing systems are deployed, the system in general will be different as will the DAS techniques, and therefore the specific OSSE results will not apply.

3. OSSE is now a popular buzzword.

Response to Warnings

1. Design OSSEs more thoughtfully.
2. Validate OSSEs more carefully.
3. Specify reasonable obs error statistics.
4. Avoid conflicts of interest.
5. Avoid over-selling results.
6. Only attempt to answer appropriate questions