Observing System Simulation Experiments

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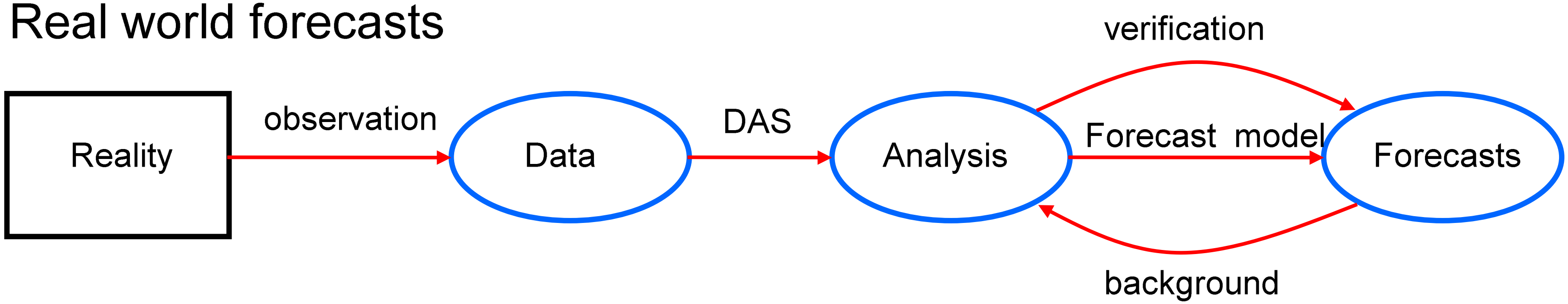
What is an OSSE?

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.

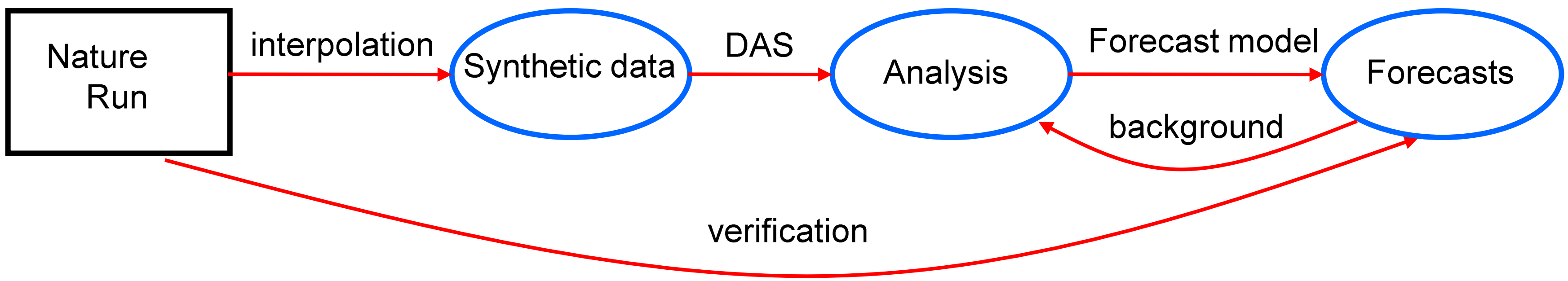
- A long free model run is used as the "truth" - the Nature Run
- The Nature Run fields are used to back out "synthetic observations" from all current and new observing systems.
- Suitable errors are added to the synthetic observations
- The synthetic observations are assimilated into a different operational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

OSSEs vs. the Real World

Real world forecasts



OSSE forecasts



Why do an OSSE?

1. You want to find out if a new observing system will add value to NWP analyses and forecasts

2. You want to make design decisions for a new observing system

3. You want to investigate the behavior of data assimilation systems in an environment where the truth is known

When not to run an OSSE

- When you can't model the phenomena you are interested in
- When you can't simulate your new observations
- When you can't assimilate your new observations

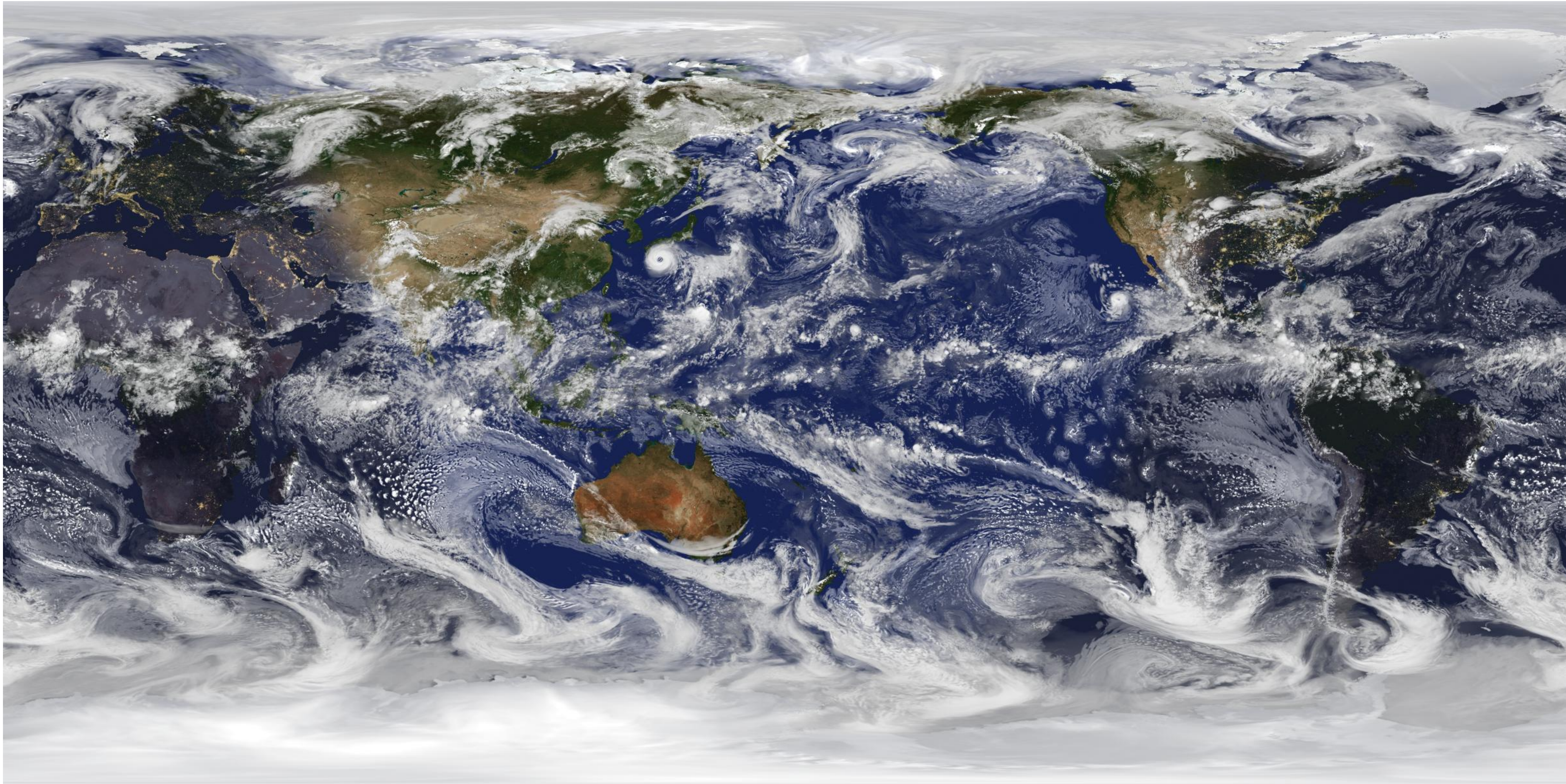
Nature Runs

- Nature Runs act as the 'truth' in the OSSE, replacing the real atmosphere.
- Usually, a long free (non-cycling) forecast from the best available model is used as the NR
  - Model forecast has continuity of fields in time
  - Sometimes an analysis or reanalysis sequence is used, but the sequence of states of truth can never be replicated by a model
- Always a push for bigger, higher resolution NR

Nature Run Requirements

- Must be able to realistically model phenomena of interest
  - Dynamics and physics should be realistic
  - Must produce fields needed for “observations”
  - Should be verified against real world
- Ideally is ‘better’ than the operational model to be used for experiments
- Preferably a different model base is used for the NR and the experimental forecast model to reduce incestuousness

G5 Nature Run



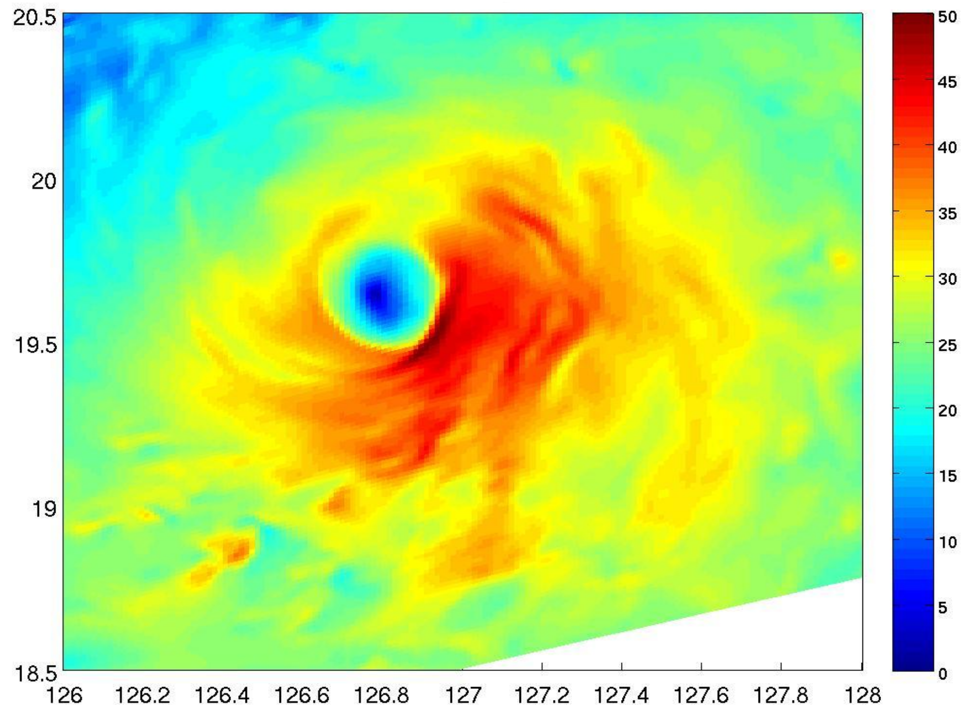
2 year, 7 km/72L, 30 minute resolution

15 aerosols, ozone, CO, CO_2

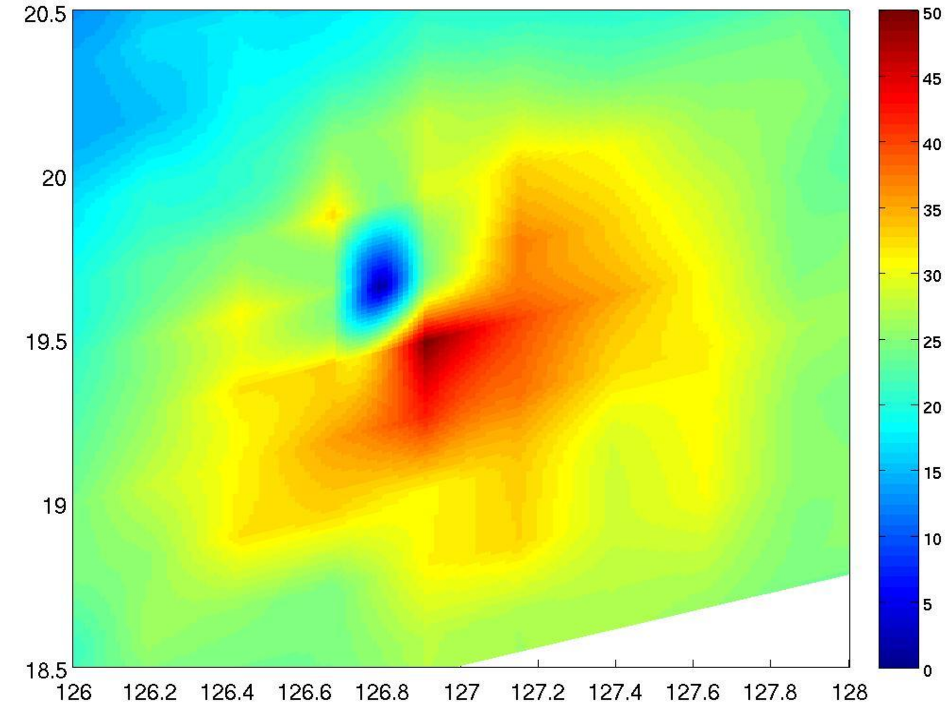
Common Problems with Nature Runs

- Nonexistence
- Identical or fraternal twins
- Outdated by the time you get to use them
- Gigantic output files and huge computational resource requirements
  - Output saved at full spatial resolution but 30 min + intervals

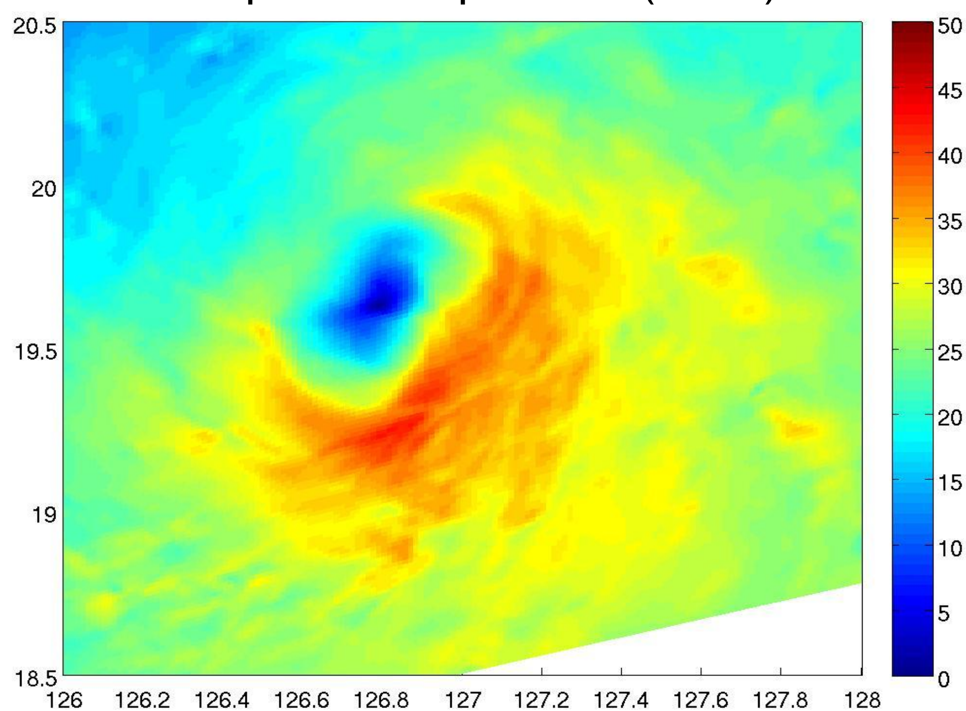
Full resolution (1.5 km, 10 min)



Spatial interpolation to 27 km



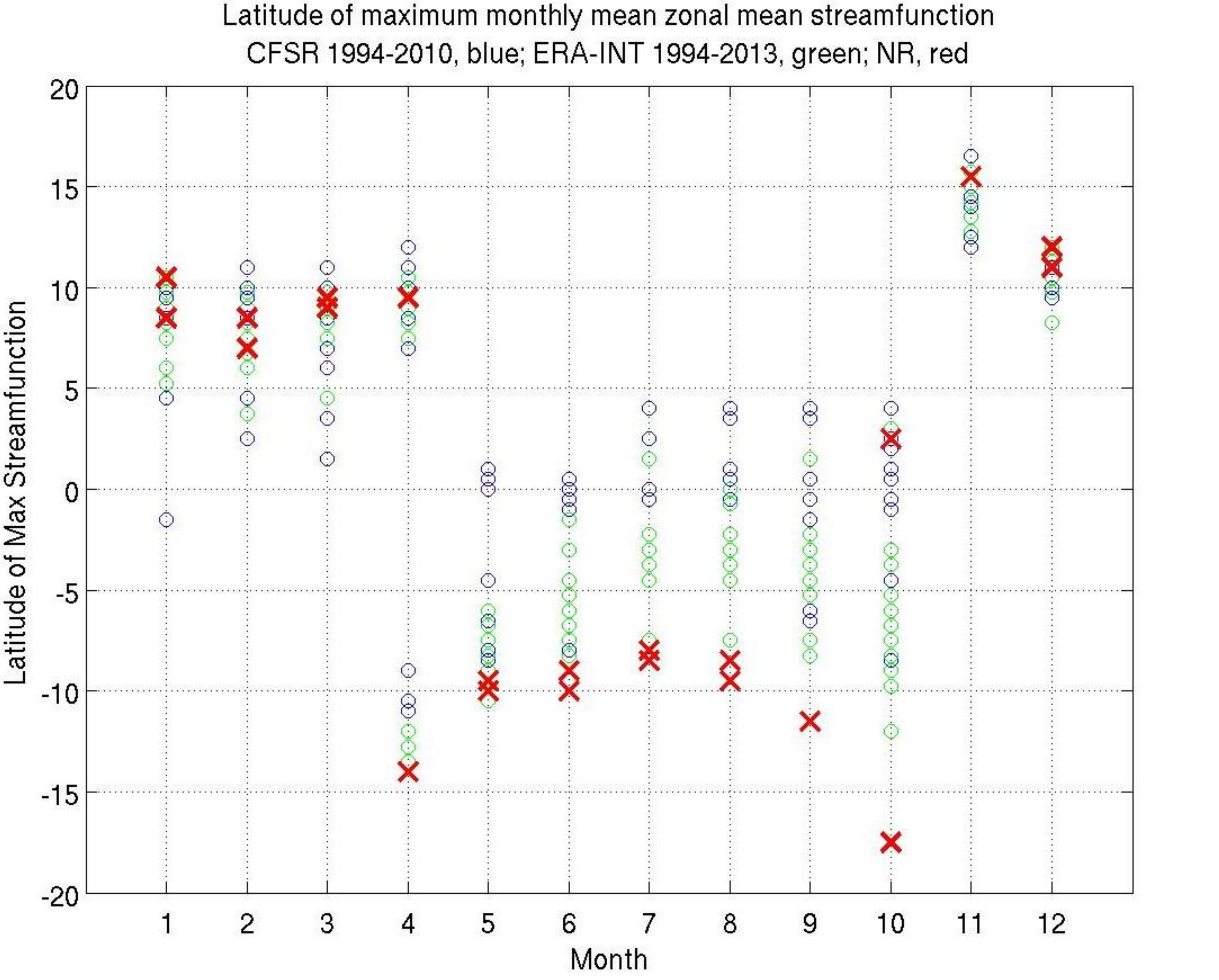
Temporal interpolation (3 hrs)



Comparison of temporal and spatial Interpolation errors compared to 1.5 km run for Typhoon Guchol (2012).

Nature Run Validation

- Evaluate if NR is sufficiently realistic to yield meaningful results
- In addition to the phenomena of interest, the NR needs to realistically replicate fields needed to generate synthetic observations
- Can't validate everything; corollary – don't expect a NR to come pre-validated for your needs

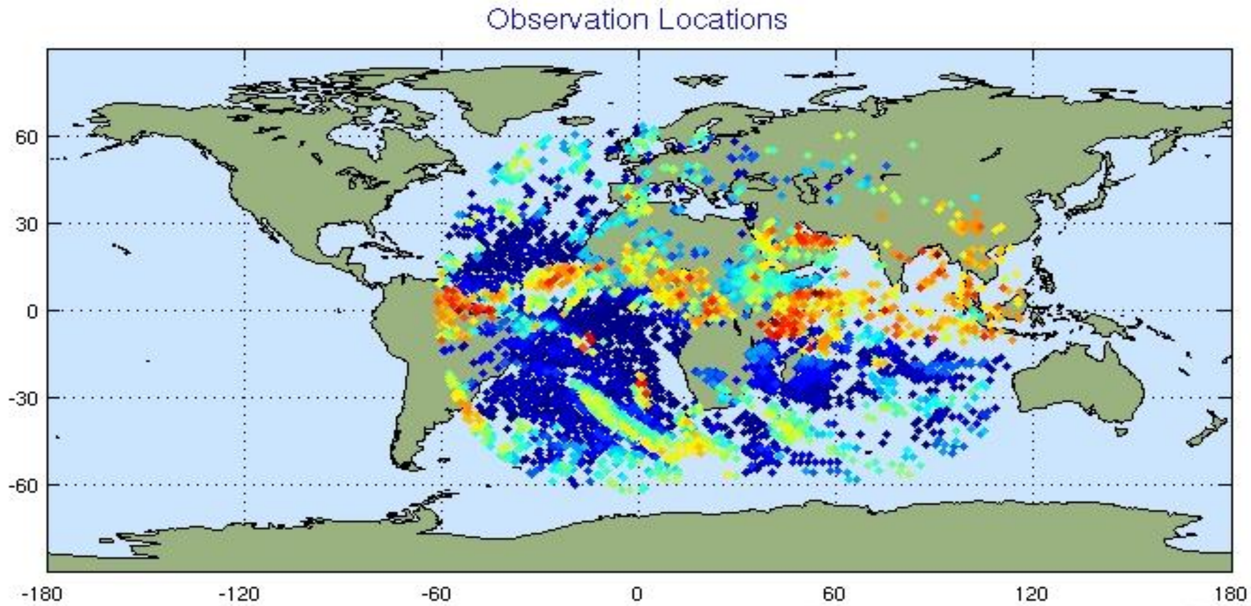


Latitude of maximum monthly mean zonal mean streamfunction
CFSR 1994-2010, blue; ERA-INT 1994-2013, green; NR, red
Latitude of Max Streamfunction
Month
20
15
10
5
0
-5
-10
-15
-20
1
2
3
4
5
6
7
8
9
10
11
12

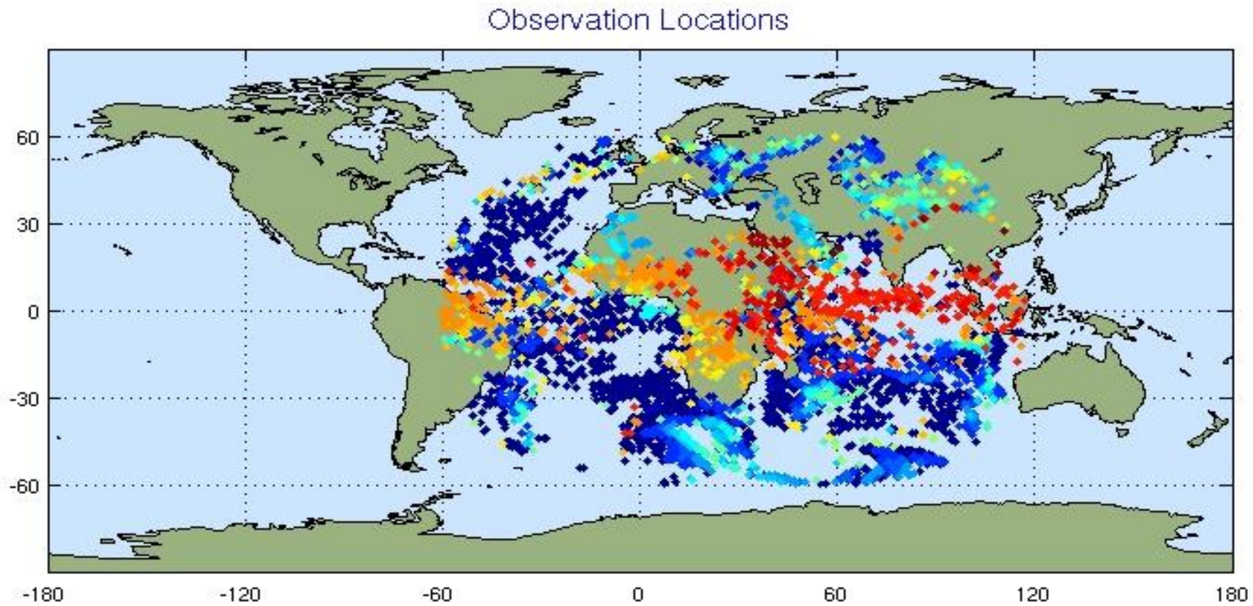
Synthetic Observations

Example of METEOSAT AMV observations at 0000 UTC 10 July

Real

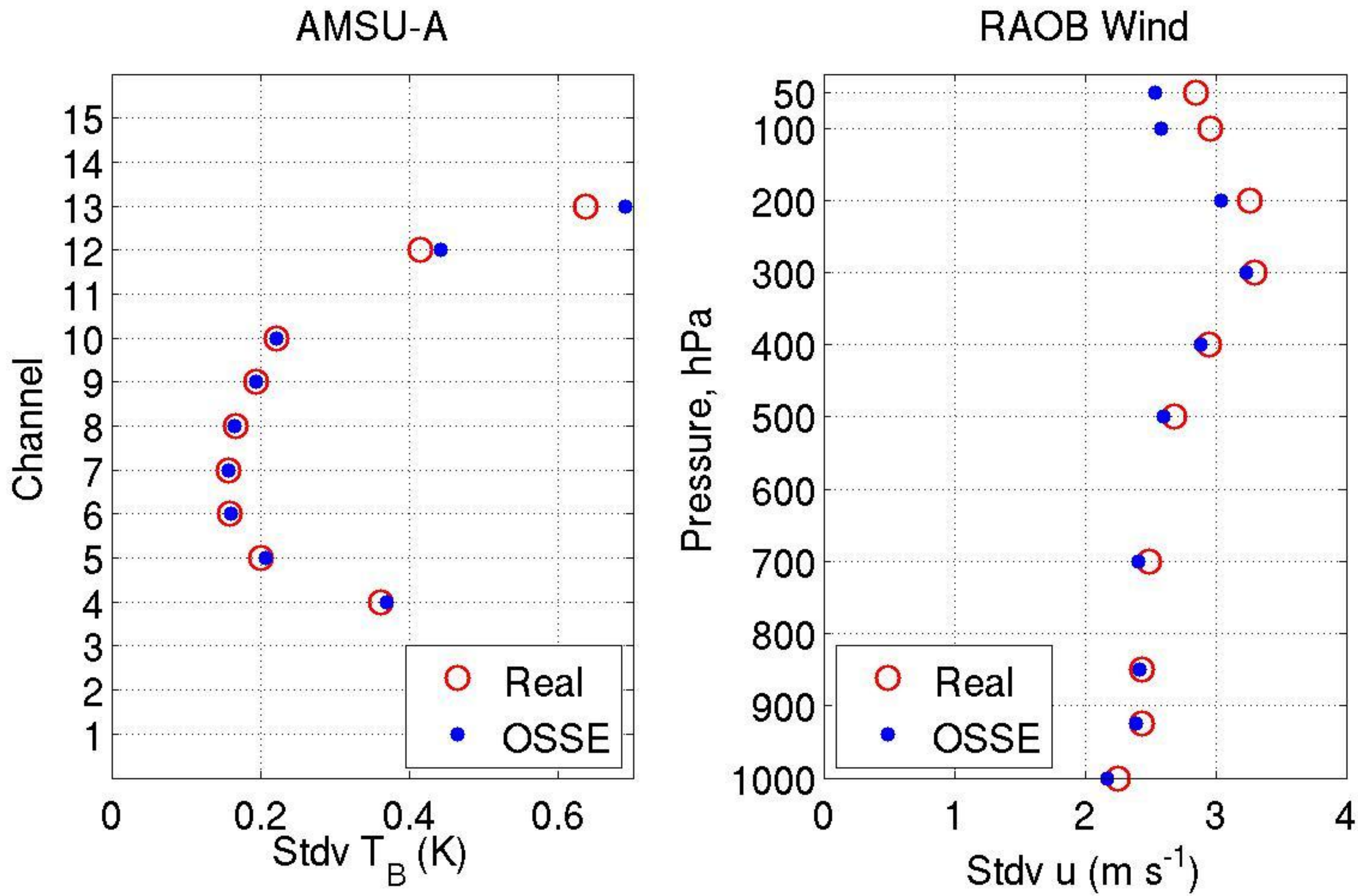


Simulated

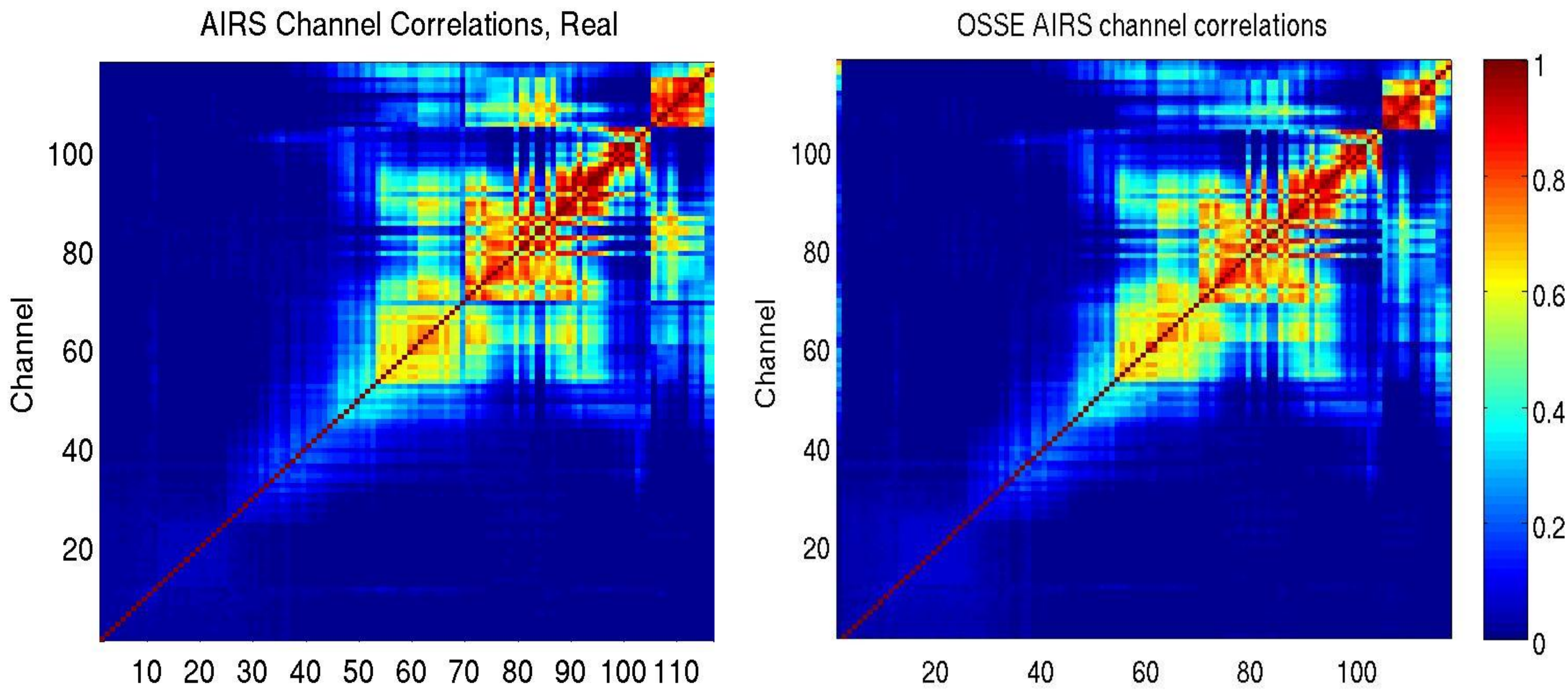


Observation Errors

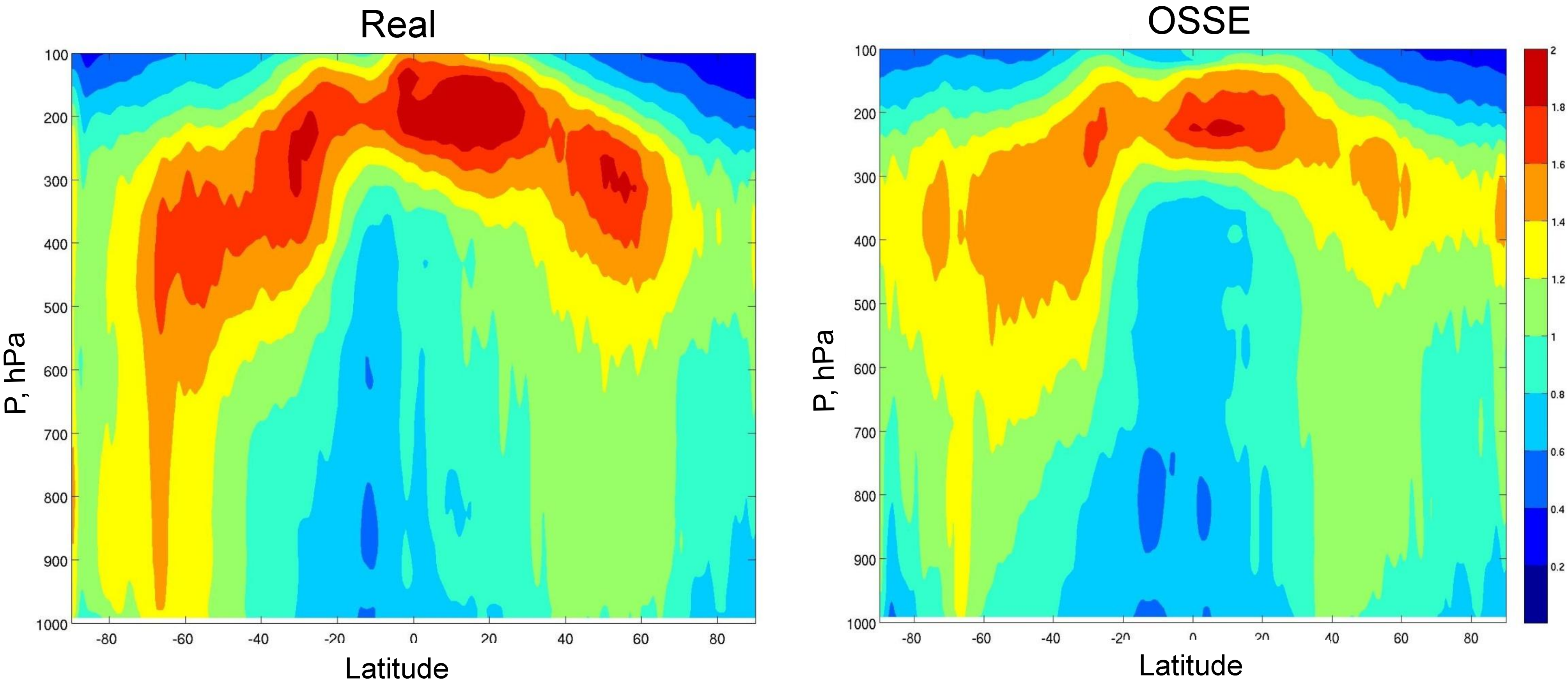
- Synthetic observations contain some intrinsic interpolation/operator errors, but less than real observations (usually)
- Synthetic errors are created and added to the synthetic observations to compensate
- Error is complex and poorly understood
  - Error magnitude
  - Biases
  - Correlated errors



O-F is fairly easy to calibrate because you can manipulate O directly.

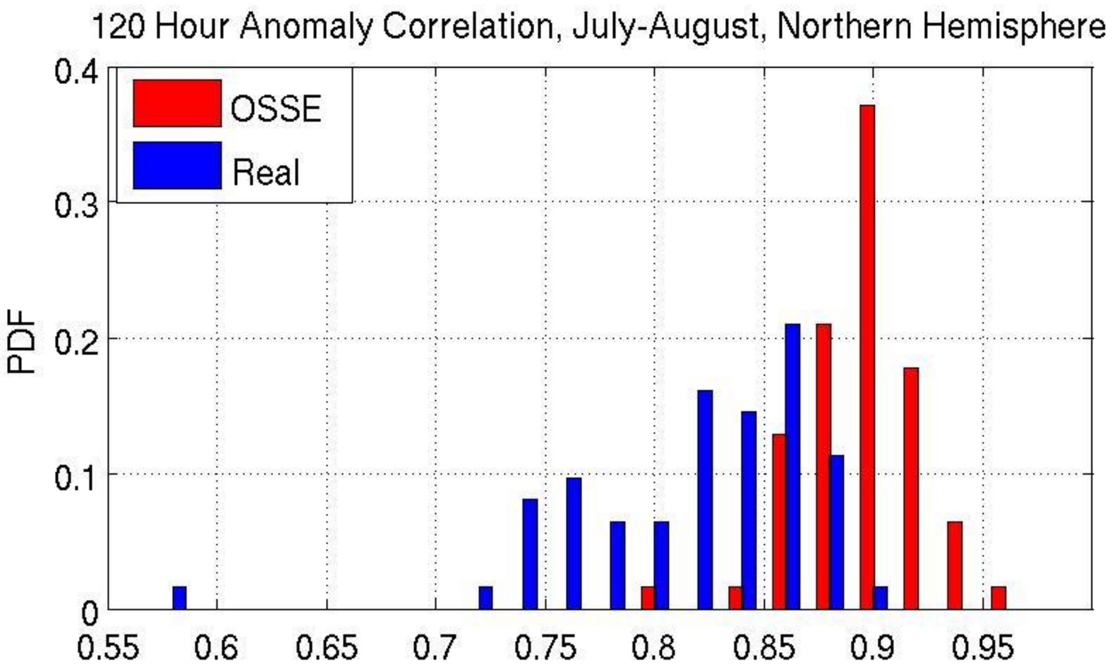


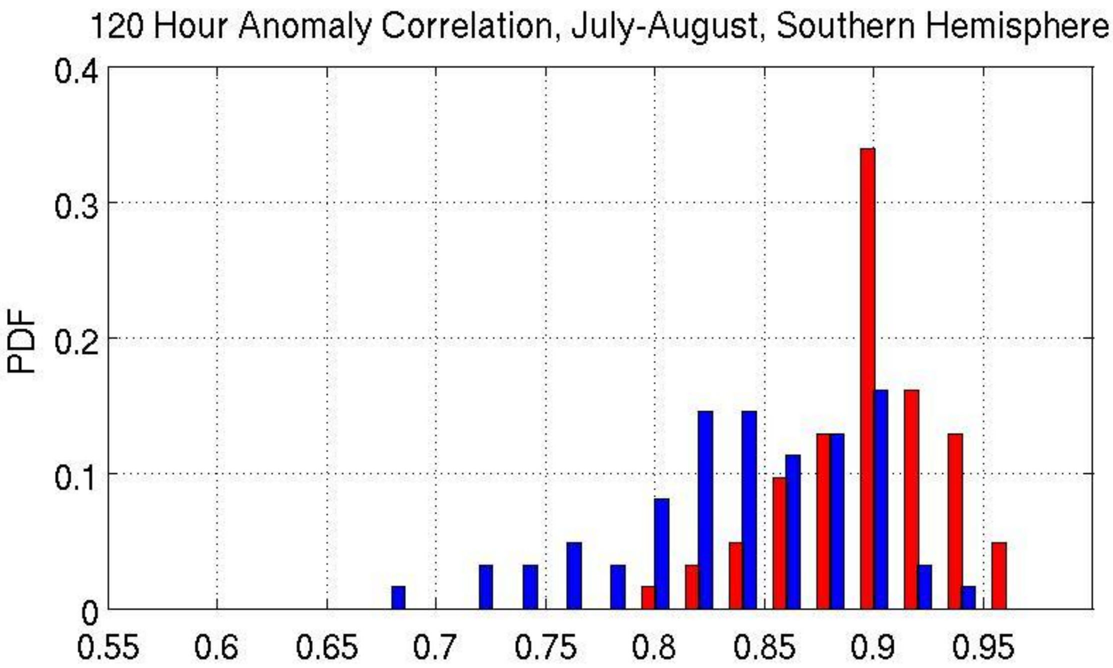
Some observation correlations are relatively easy to calibrate



A-B (analysis increment) is a little harder to calibrate, as A and B are not directly controlled

Model error strongly influences forecast skill in the longer term forecast, so calibration is not possible (unless you want to mess with your model).

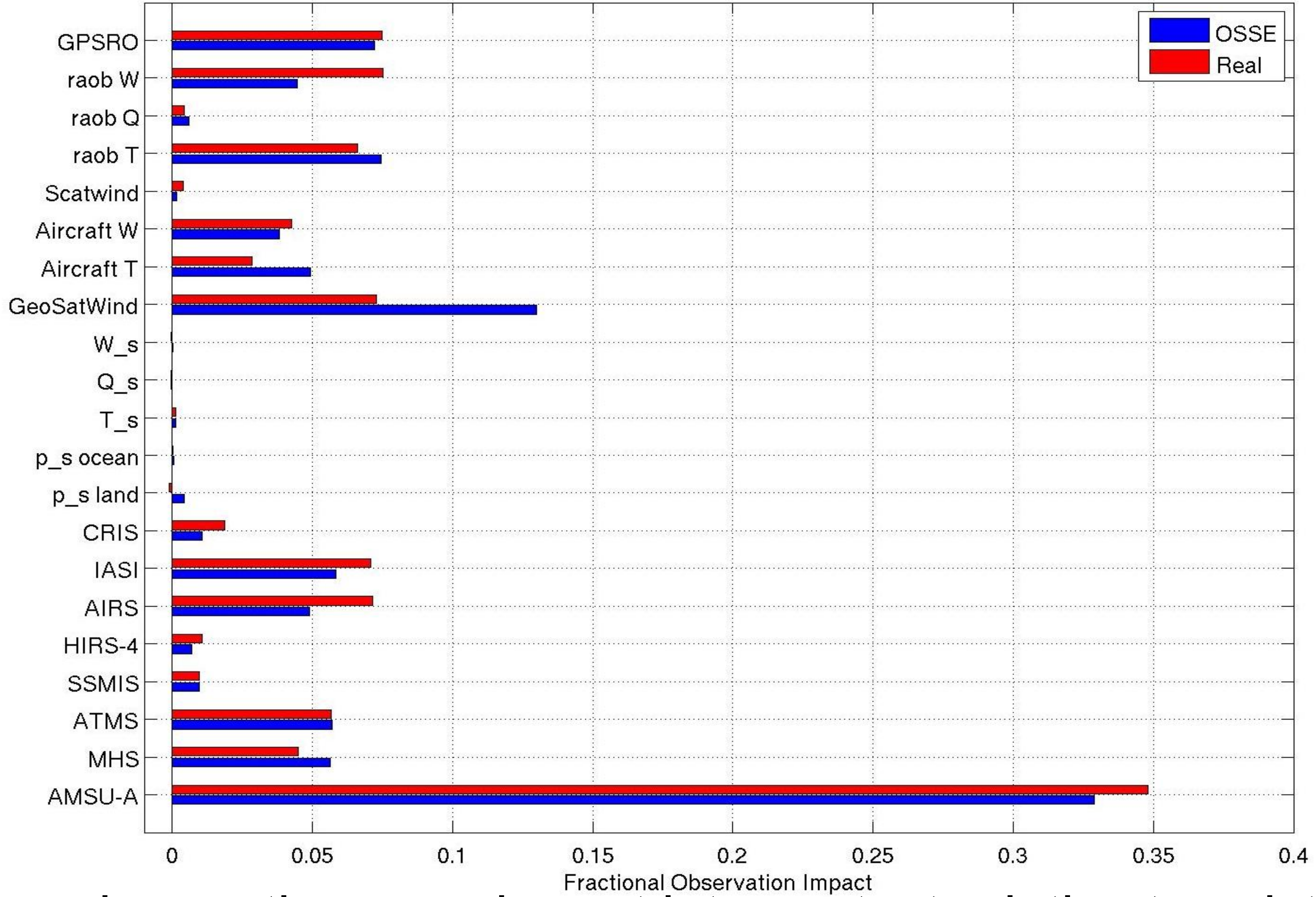




Red: OSSE
Blue: Real

500 hPa anomaly correlations of geopotential height, G5NR

Why believe OSSE results?



New observations can be put into context relative to existing observation impacts

Criticisms of OSSEs

- Results only apply within the OSSE system – no concrete connection to the real world
- Even the best OSSEs are far from perfect: incestuousness, difficulty in generating observations and errors, deficiencies of the Nature Run
- By the time the new instrument is deployed, both the global observing network and the forecast models/DAS will be different
- Examples of sloppy or unsuccessful OSSEs

Takeaway

- OSSEs can provide useful information about new observational types and the workings of data assimilation systems
- Careful consideration of research goals should guide each step of the OSSE process
- Validate your OSSE!
- OSSEs are hard, good OSSEs are harder