Observing System Simulation Experiments (OSSEs) as tools for the investigation of data assimilation systems

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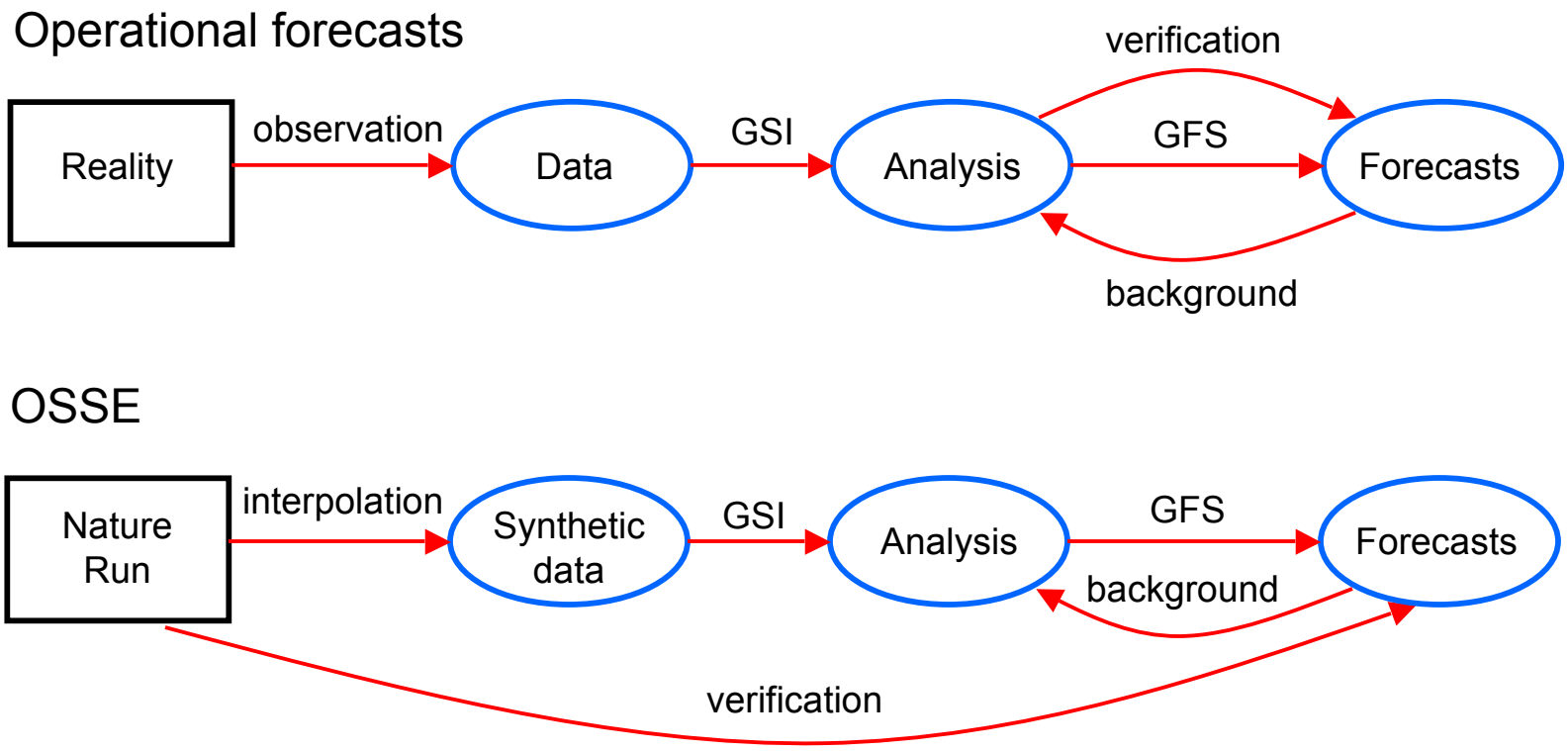
What is an OSSE?

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.
- 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

How OSSEs Work



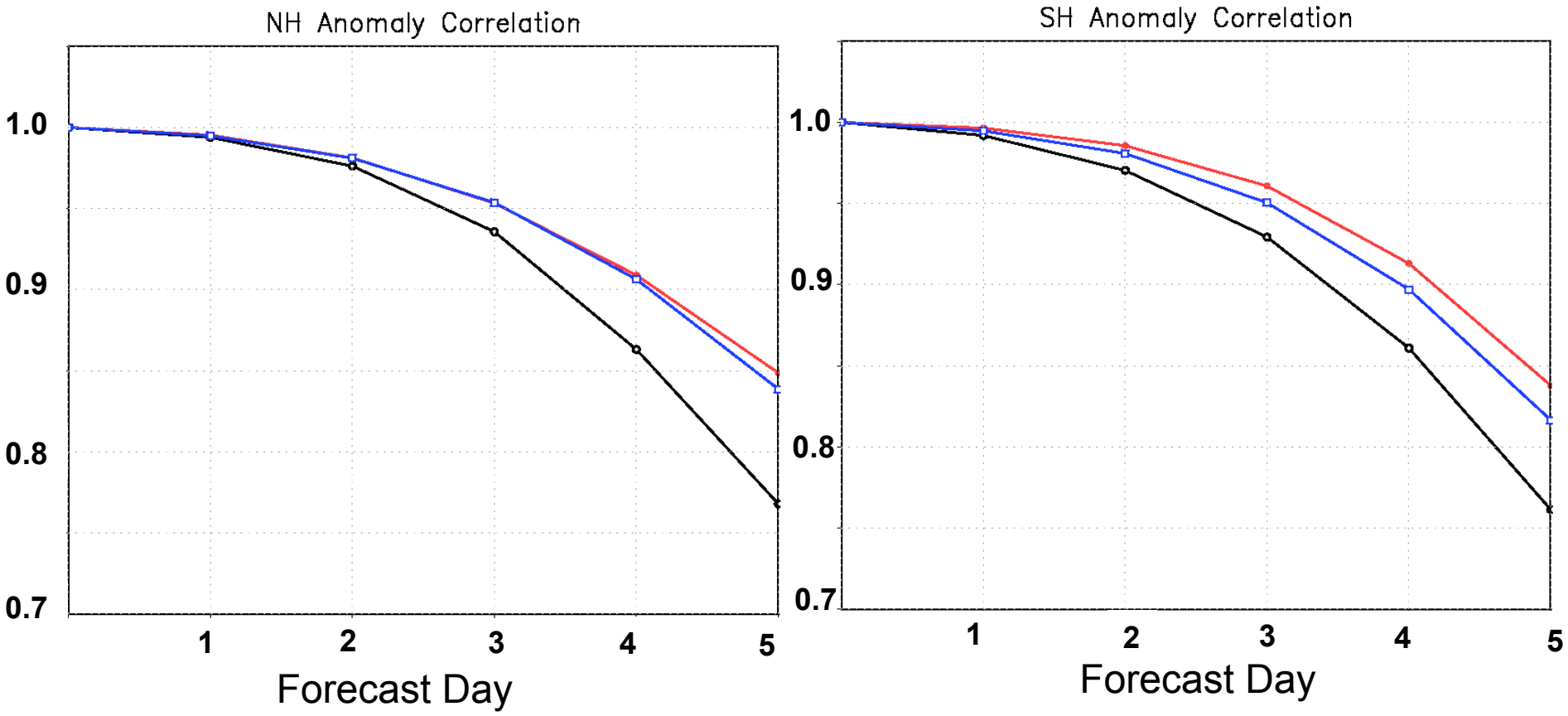
GMAO OSSE Setup

- Nature Run: 13 month run of the ECMWF operational model, T511/91L
- Synthetic Observations
  - Replicate archived observations from May 2005-May 2006
  - Includes conventional, satwind, HIRS2, HIRS3, AMSU-A, AMSU-B, AIRS, MSU types
  - Correlated errors added to ‘perfect’ observations
- Forecast Model
  - DAS: NCEP/GMAO GSI 3DVAR
  - Forecasts: GMAO GEOS-5 model with 0.5º x0.625º resolution, 72 levels

Experiments

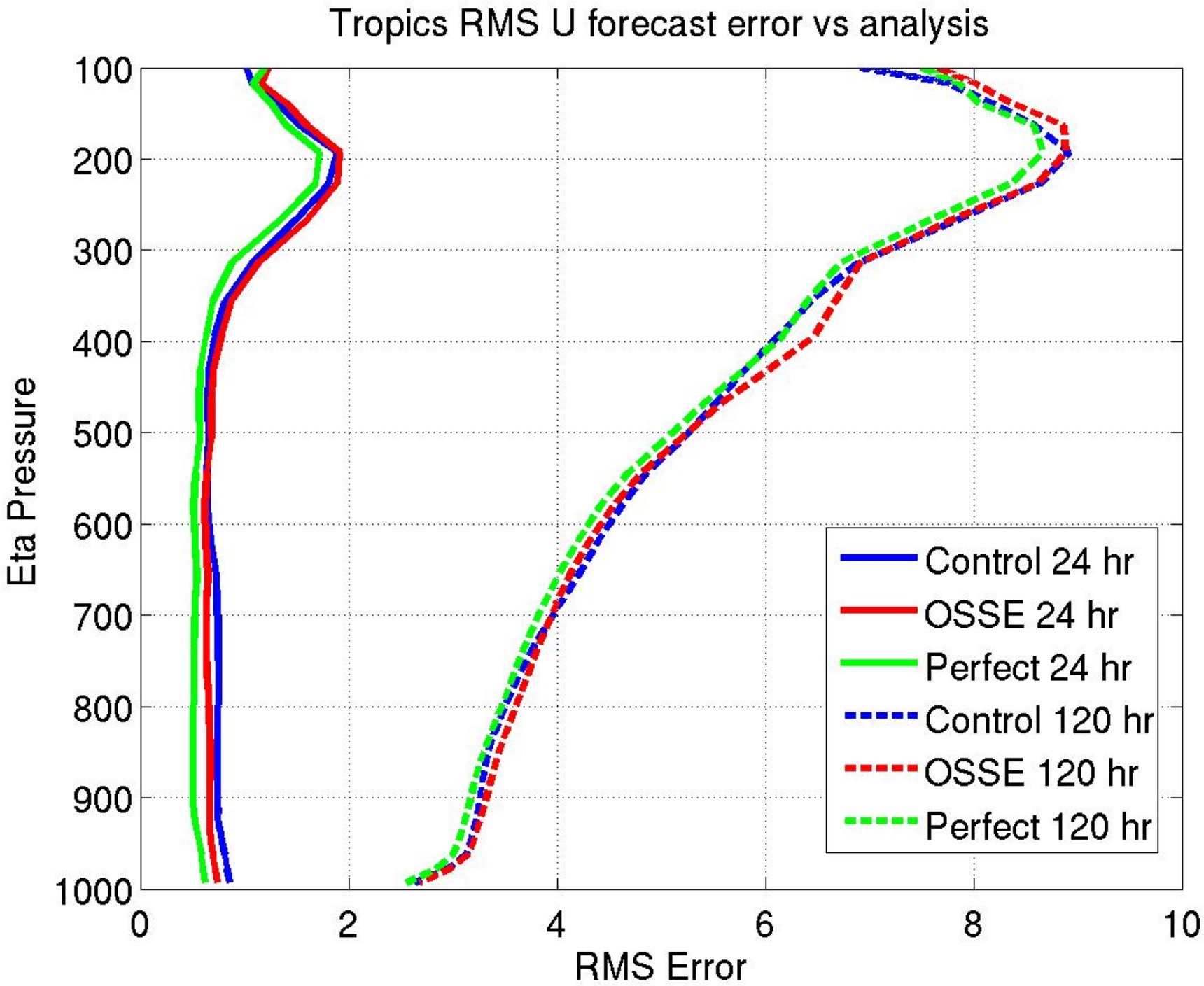
- Three cases:
  - Archived real data (Control)
  - Synthetic observations without error (Perfect)
  - Synthetic observations with added error (OSSE)
- Cycling from 10 Dec 2005 to 5 Feb 2006
- 120 hour forecasts launched daily at 00Z
- Comparison of Perfect and OSSE cases will show the impact of observation errors
- Comparison with Control case shows relative behavior of the OSSE system to reality

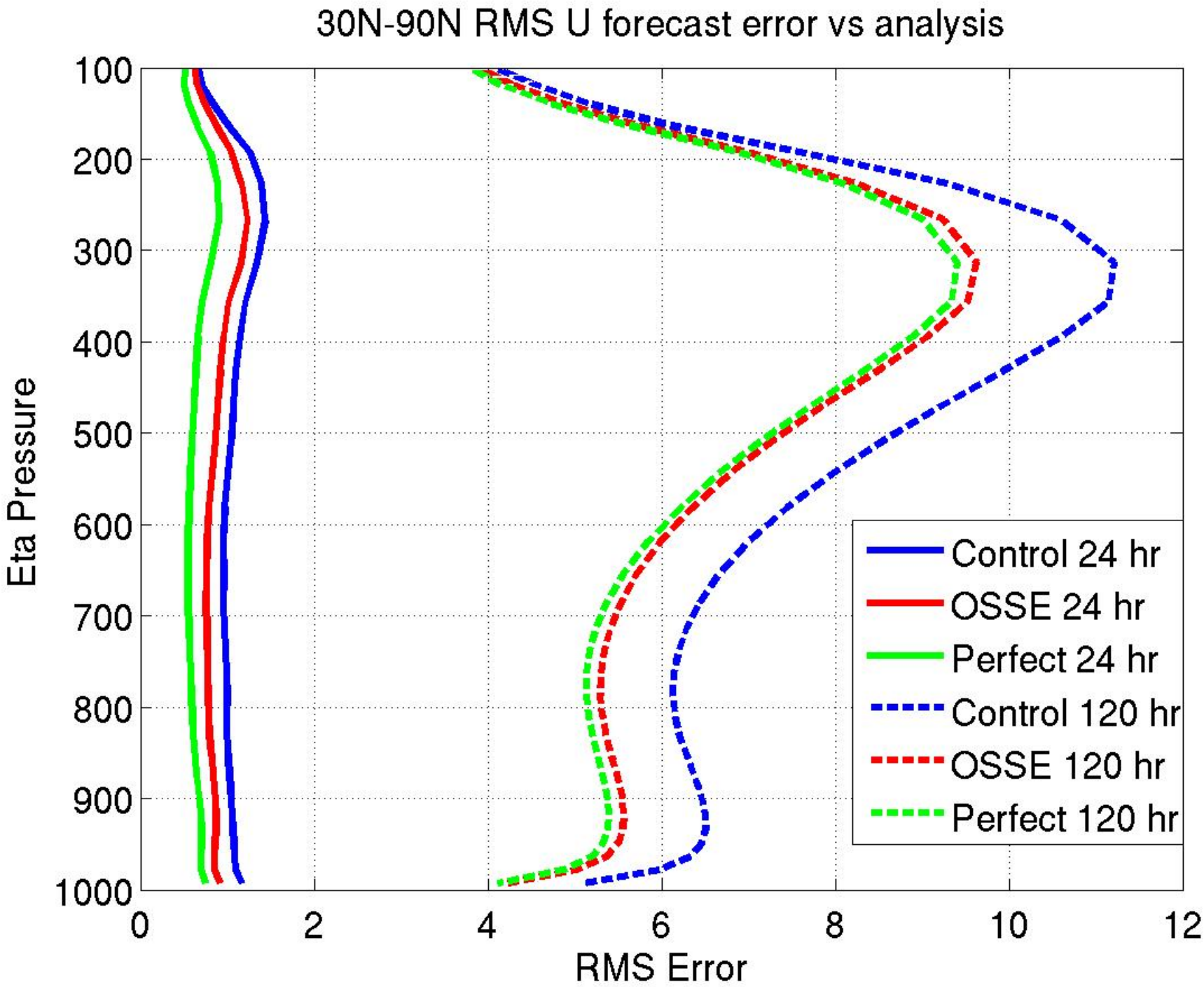
OSSE vs Real Data: Forecasts

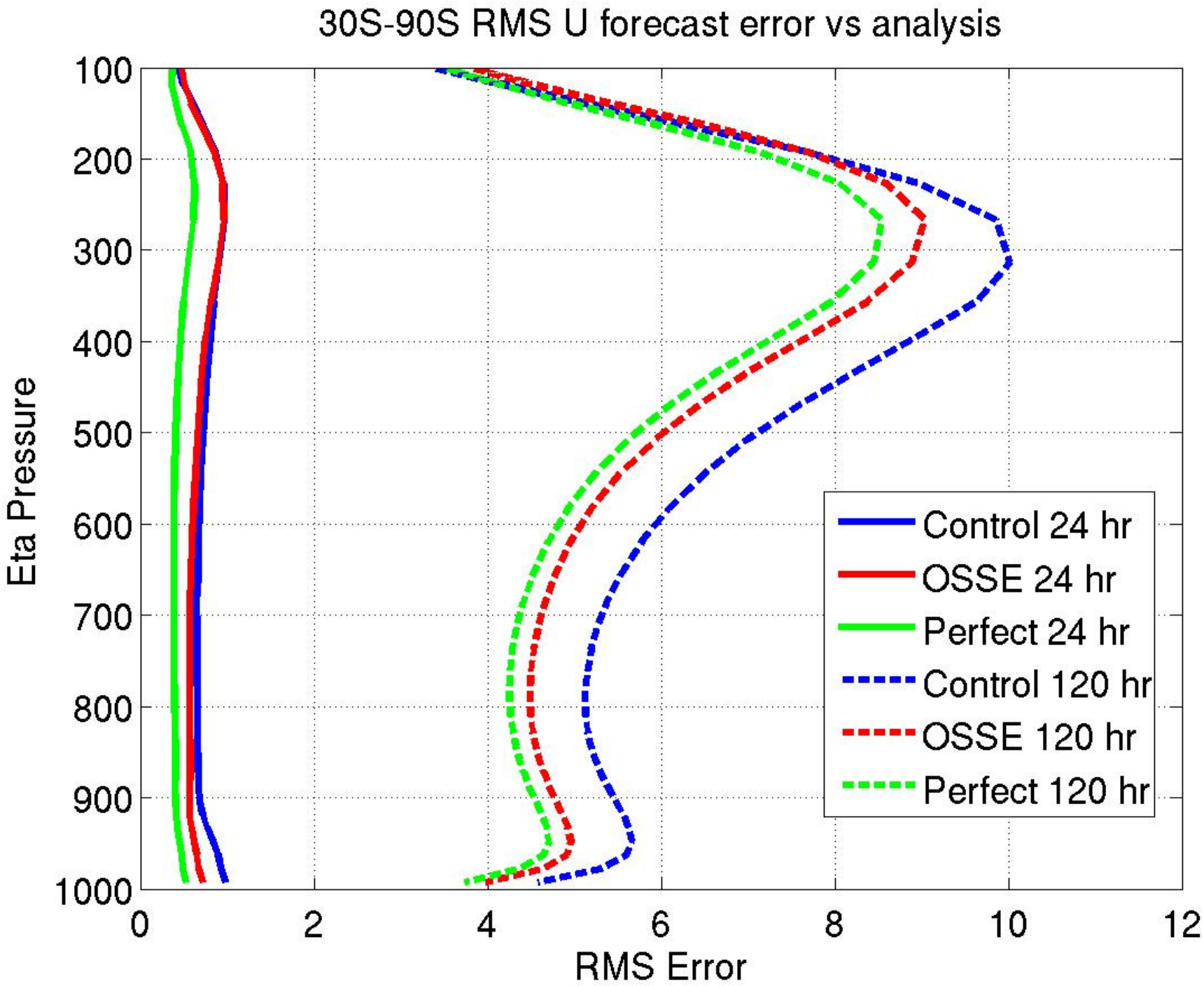


Anomaly correlations for January 2006

Control (Real)
OSSE (with Errors)
Perfect (without Errors)


Tropics RMS U forecast error vs analysis
Eta Pressure
RMS Error
100
200
300
400
500
600
700
800
900
1000
0
2
4
6
8
10
Control 24 hr
OSSE 24 hr
Perfect 24 hr
Control 120 hr
OSSE 120 hr
Perfect 120 hr


30N-90N RMS U forecast error vs analysis
Eta Pressure
RMS Error
100
200
300
400
500
600
700
800
900
1000
0
2
4
6
8
10
12
Control 24 hr
OSSE 24 hr
Perfect 24 hr
Control 120 hr
OSSE 120 hr
Perfect 120 hr


30S-90S RMS U forecast error vs analysis
Eta Pressure
RMS Error
100
200
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400
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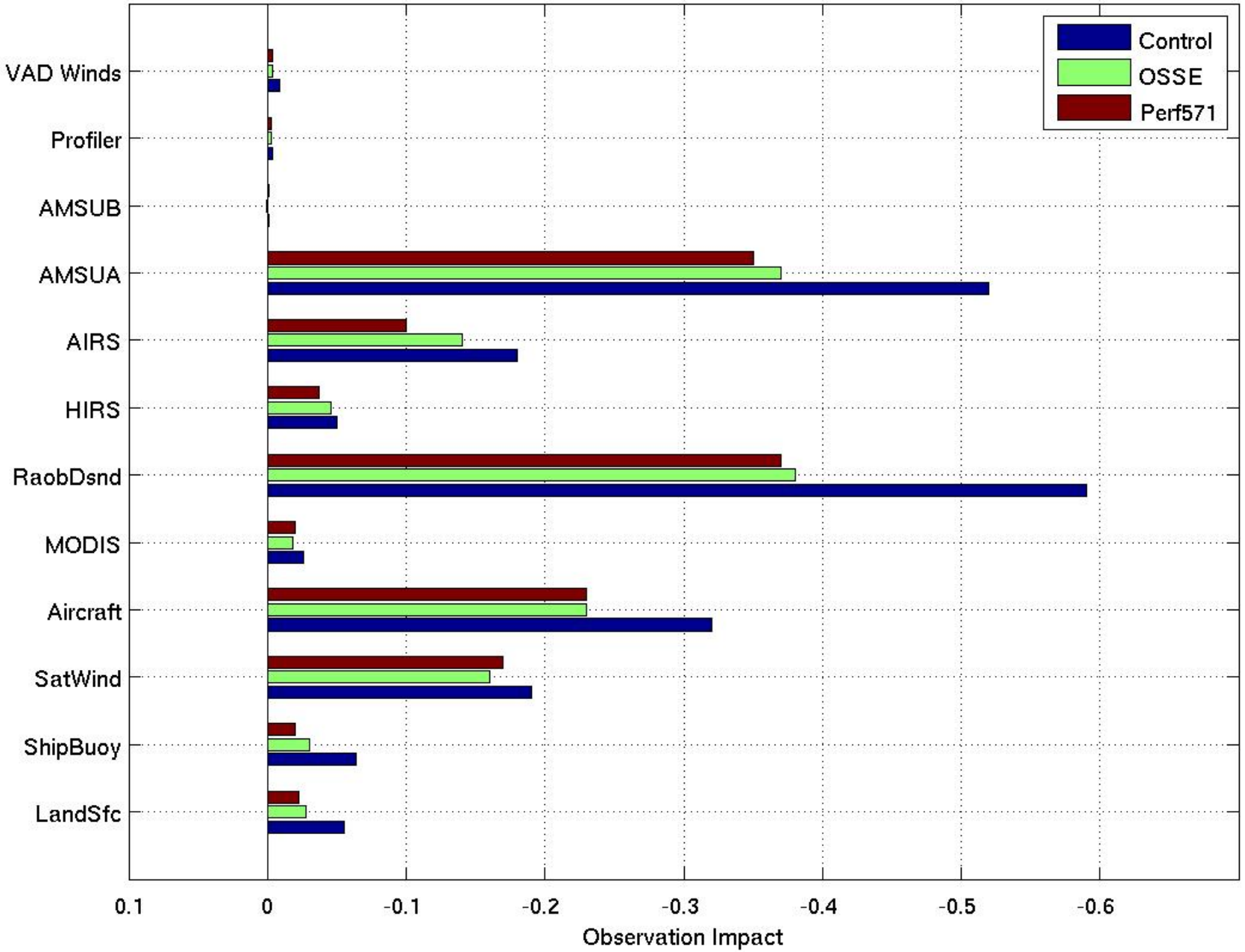
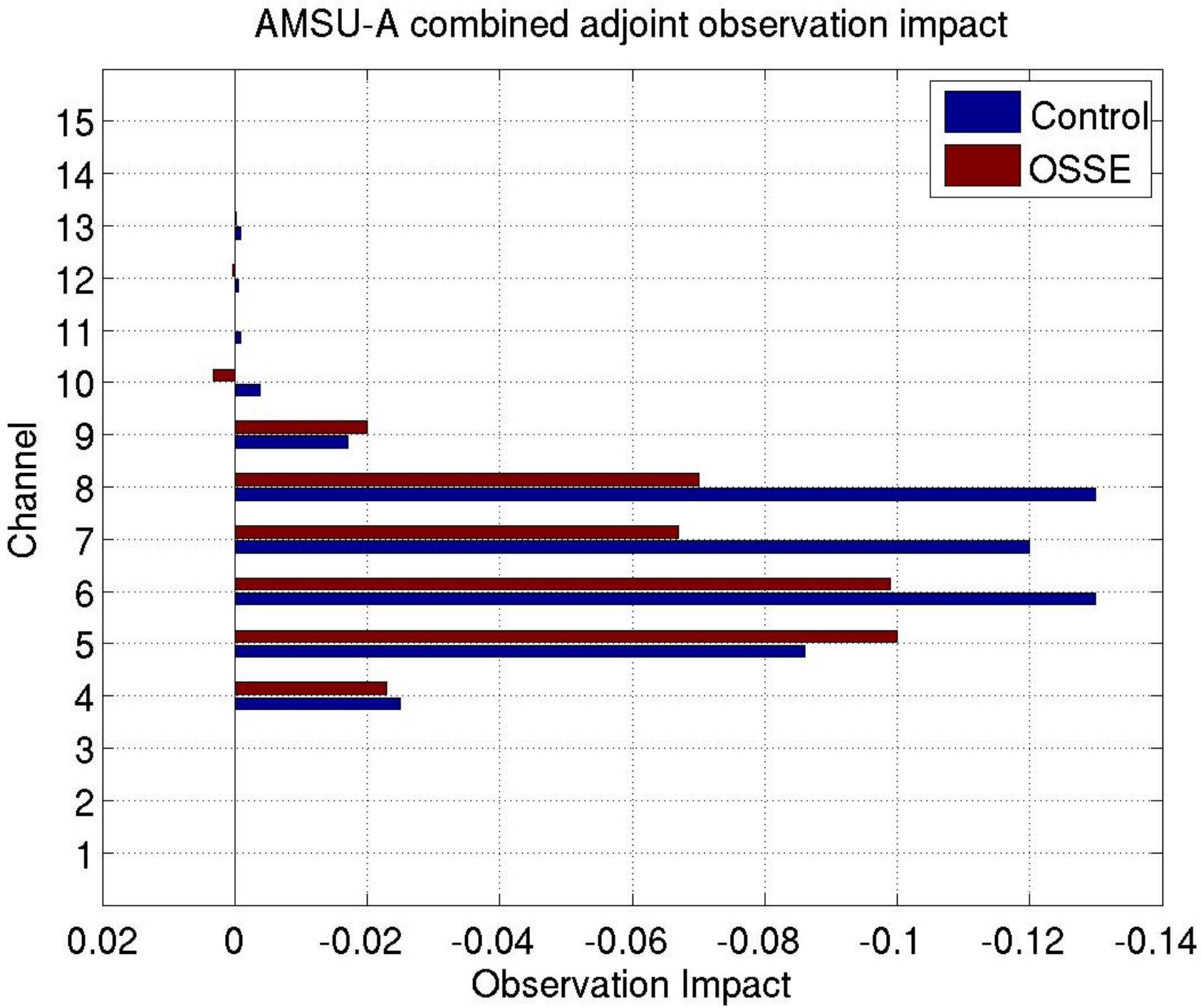
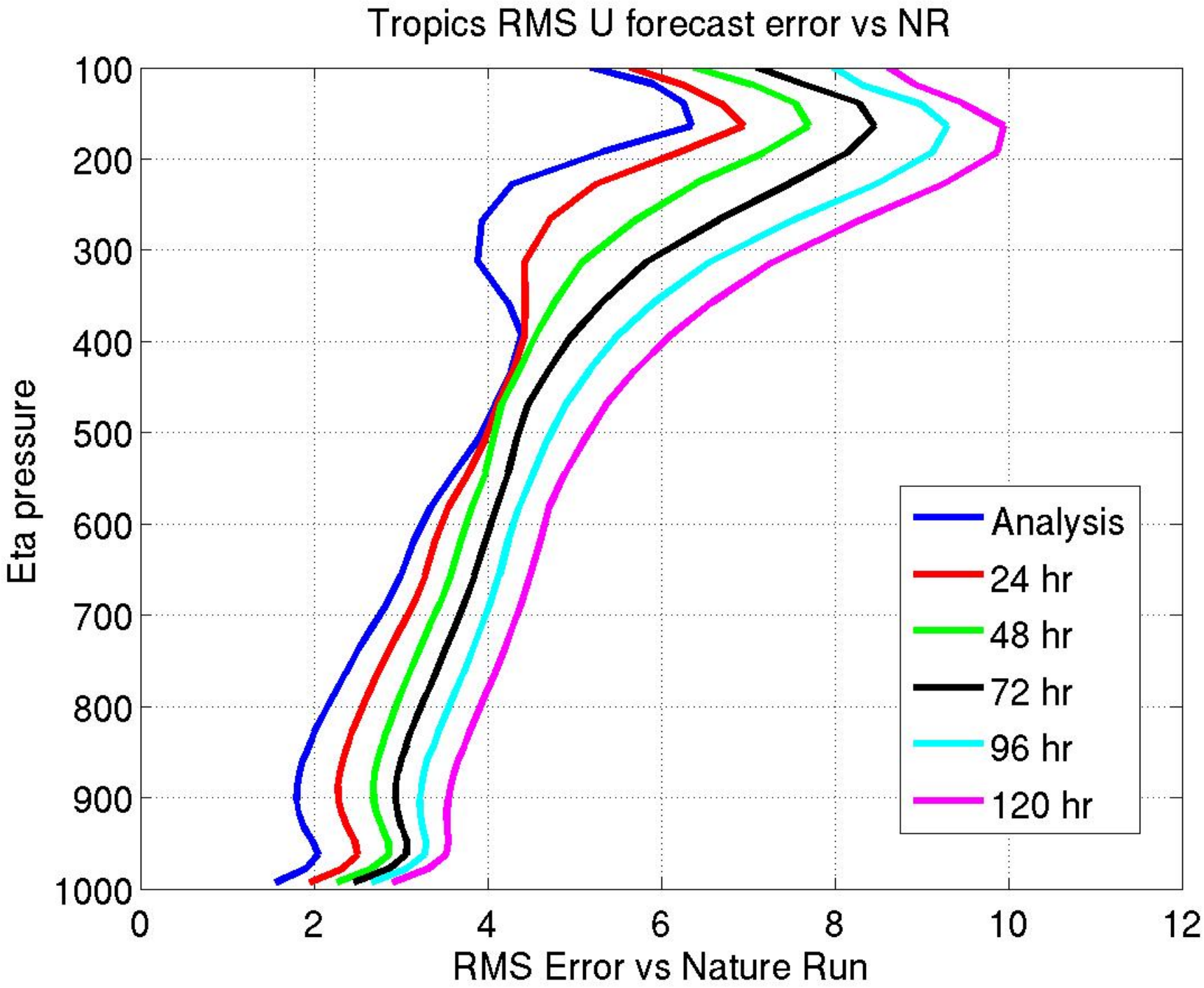
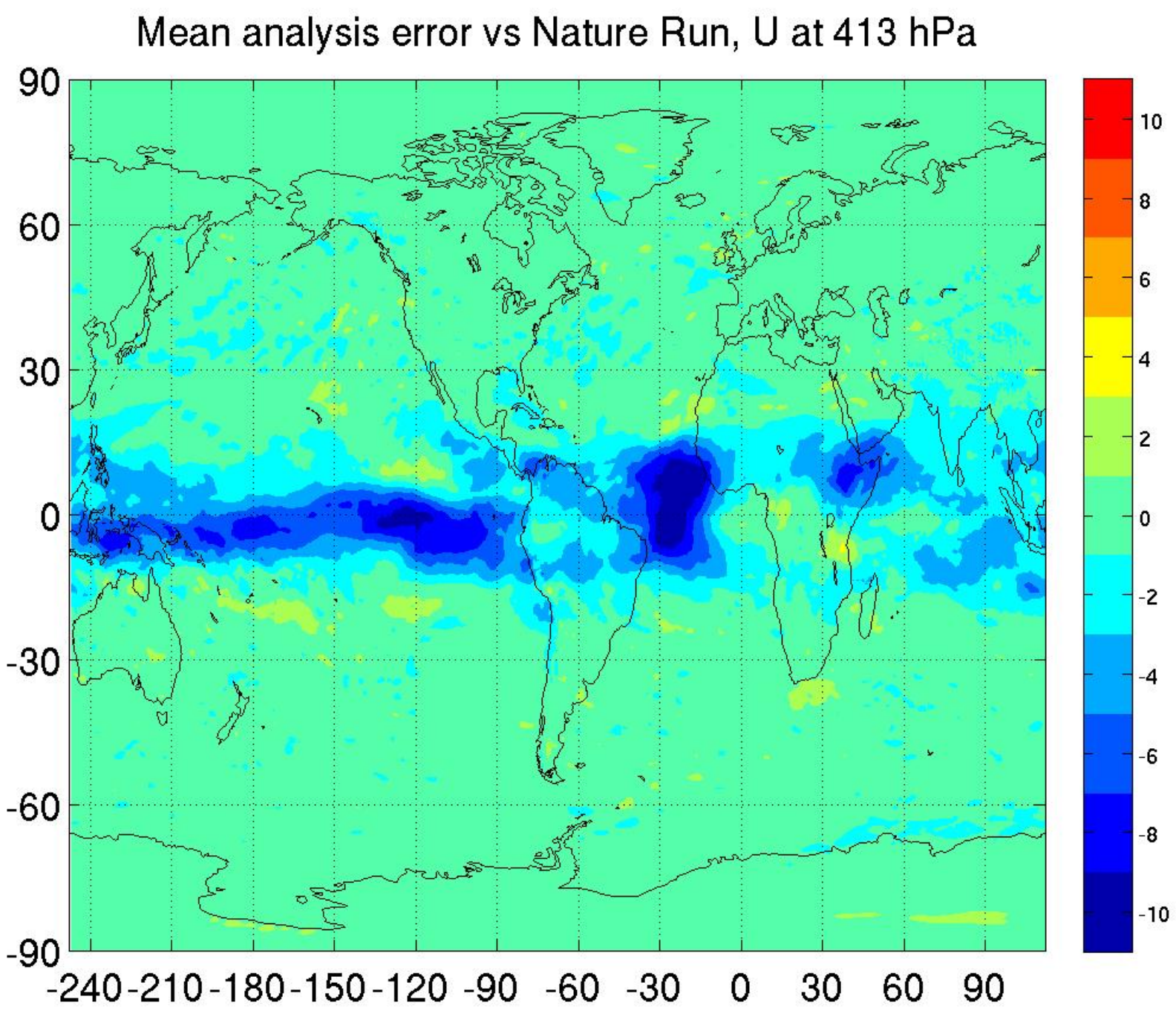
600
700
800
900
1000
0
2
4
6
8
10
12
Control 24 hr
OSSE 24 hr
Perfect 24 hr
Control 120 hr
OSSE 120 hr
Perfect 120 hr

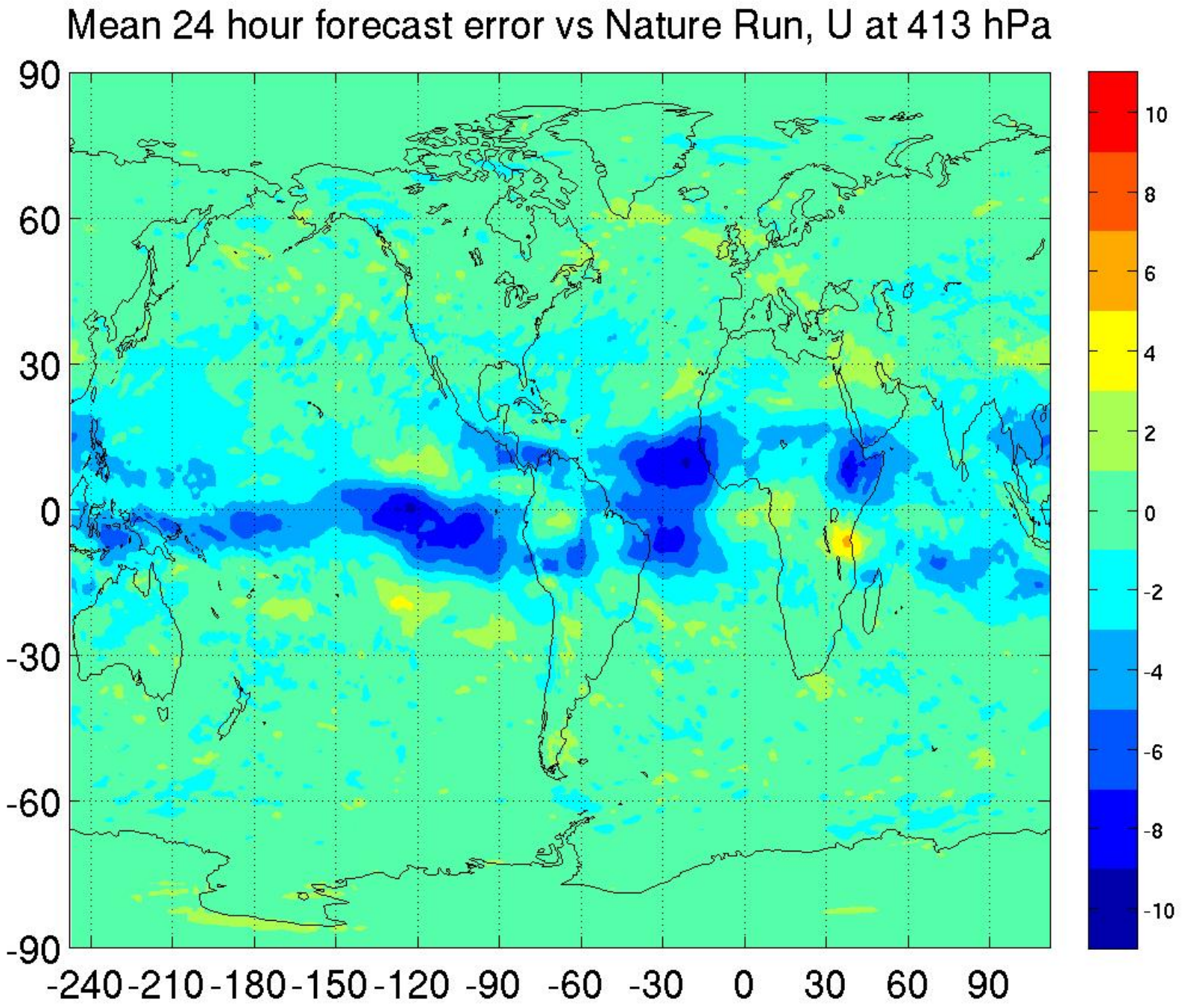
Adjoint-based observation impacts

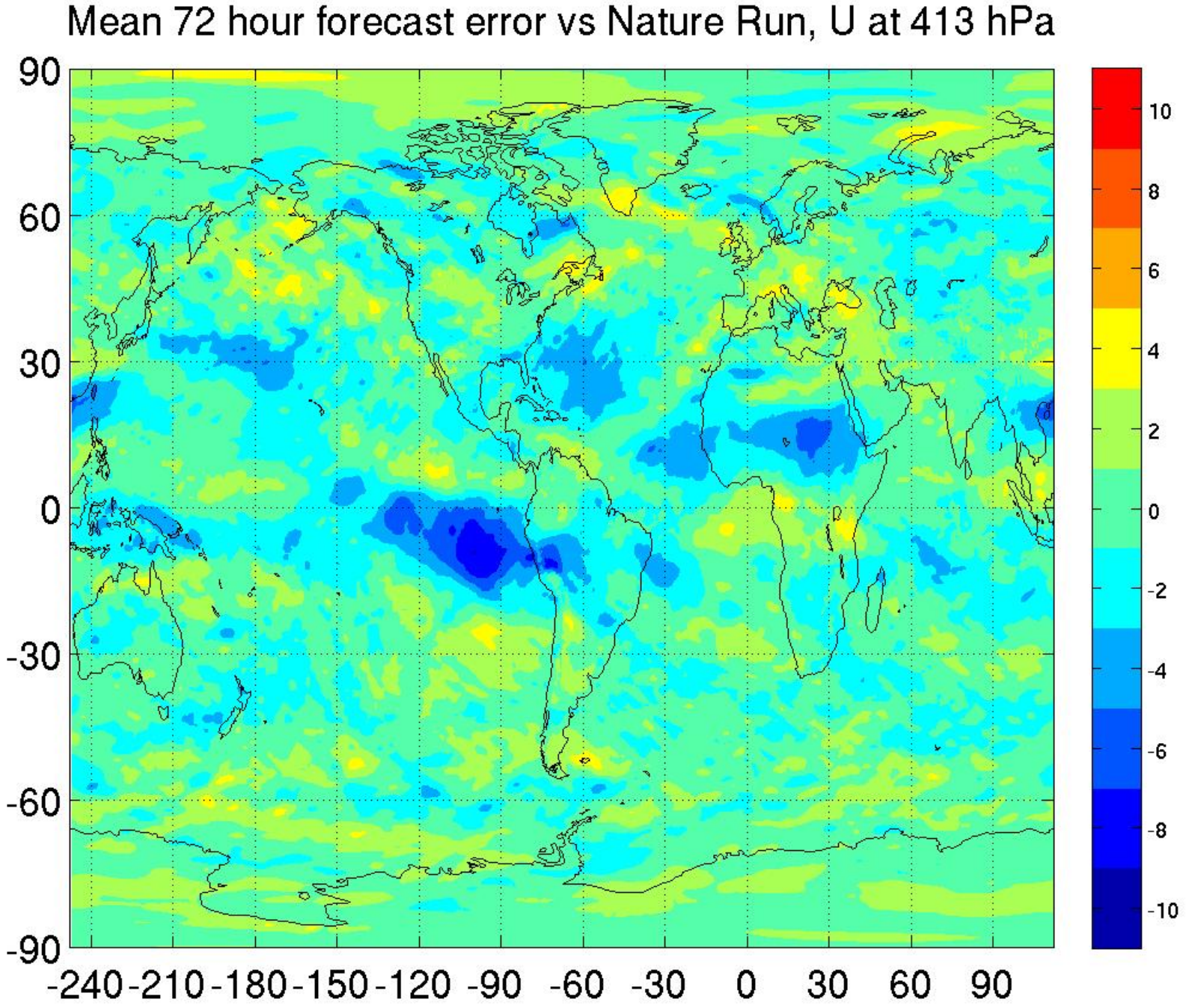


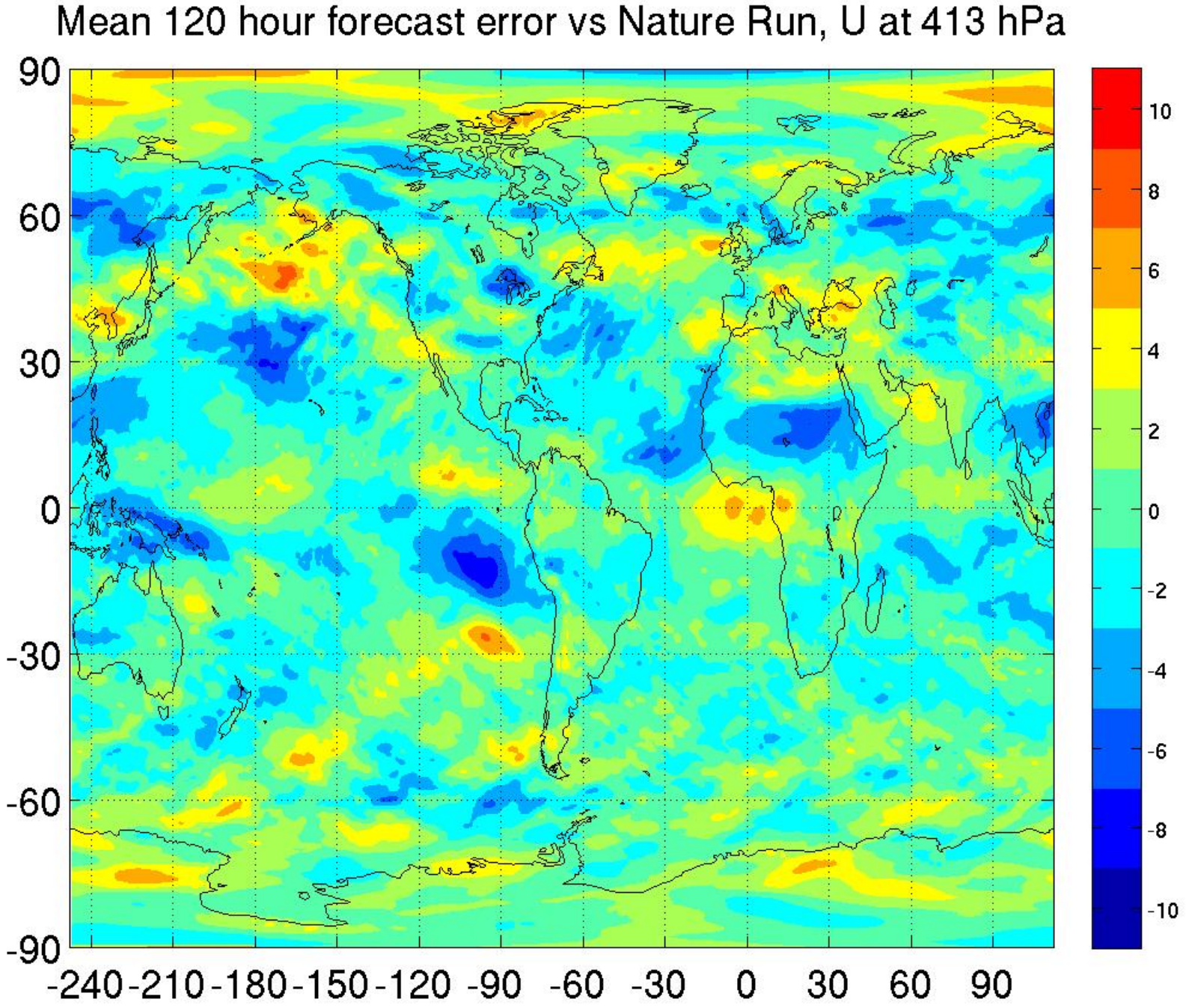

AMSU-A combined adjoint observation impact
Control
OSSE
Channel
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
Observation Impact


Tropics RMS U forecast error vs NR
Eta pressure
100
200
300
400
500
600
700
800
900
1000
0
2
4
6
8
10
12
RMS Error vs Nature Run
Analysis
24 hr
48 hr
72 hr
96 hr
120 hr


Mean analysis error vs Nature Run, U at 413 hPa
90
60
30
0
-30
-60
-90
-240 -210 -180 -150 -120 -90 -60 -30 0 30 60 90
10
8
6
4
2
0
-2
-4
-6
-8
-10


Mean 24 hour forecast error vs Nature Run, U at 413 hPa
90
60
30
0
-30
-60
-90
-240 -210 -180 -150 -120 -90 -60 -30 0 30 60 90
10
8
6
4
2
0
-2
-4
-6
-8
-10


Mean 72 hour forecast error vs Nature Run, U at 413 hPa
90
60
30
0
-30
-60
-90
-240 -210 -180 -150 -120 -90 -60 -30 0 30 60 90
10
8
6
4
2
0
-2
-4
-6
-8
-10


Mean 120 hour forecast error vs Nature Run, U at 413 hPa
90
60
30
0
-30
-60
-90
-240 -210 -180 -150 -120 -90 -60 -30 0 30 60 90
10
8
6
4
2
0
-2
-4
-6
-8
-10

Spatial correlation of analysis error verified against the Nature Run “truth”:

Perfect case error correlated with OSSE case error

Analysis error

Lower correlation => greater proportional influence of observation error