Experiments with Empirical Errors in Synthetic Observations to Improve Realism of the NCEP OSSE Assimilation System

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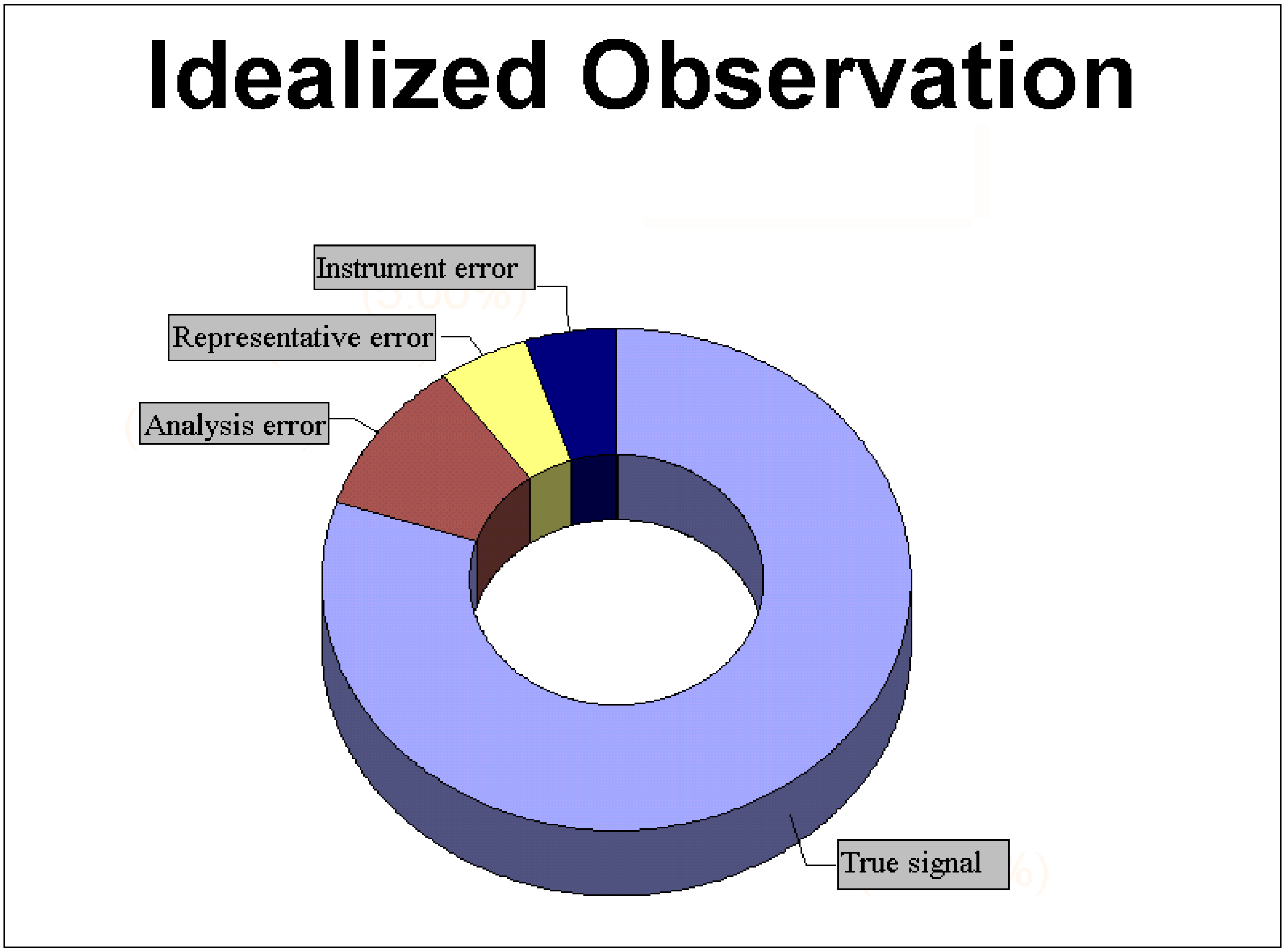
Abstract

1) Observations are synthesized for OSSE experiments by combining a "true" value (i.e., from a "nature" run background) with some type of noise, aka observation error.

2) Adding strictly random noise to synthetic observations does not appear to adequately model observation errors found in real data. Such experiments generally produce forecast results which are unrealistically good, especially in the Southern Hemisphere.

3) A method is desired for deriving more realistic synthetic observation error fields, which would model systematic errors of representativeness as well as the random components of observational errors. This report examines the use of an empirical estimate of observation error, namely ***observation-analysis*** *from a real assimilation, applied to synthetic observations at every corresponding point in space and time over the experiment period.*

4) Results of the experiments suggest that (o-a) is a suitable estimate of real observation error fields. Some adjustment of the magnitude of the ***o-a*** *fields were required in the SH, possibly to account for large scale unrepresentativeness of observations in data sparse regions.*



True Value - the perfectly true ob value at this point, wrt the model grid

Instrument error - errors from measuring/transmitting (not analyzed)

Representative error - unrepresentative components (not analyzed)

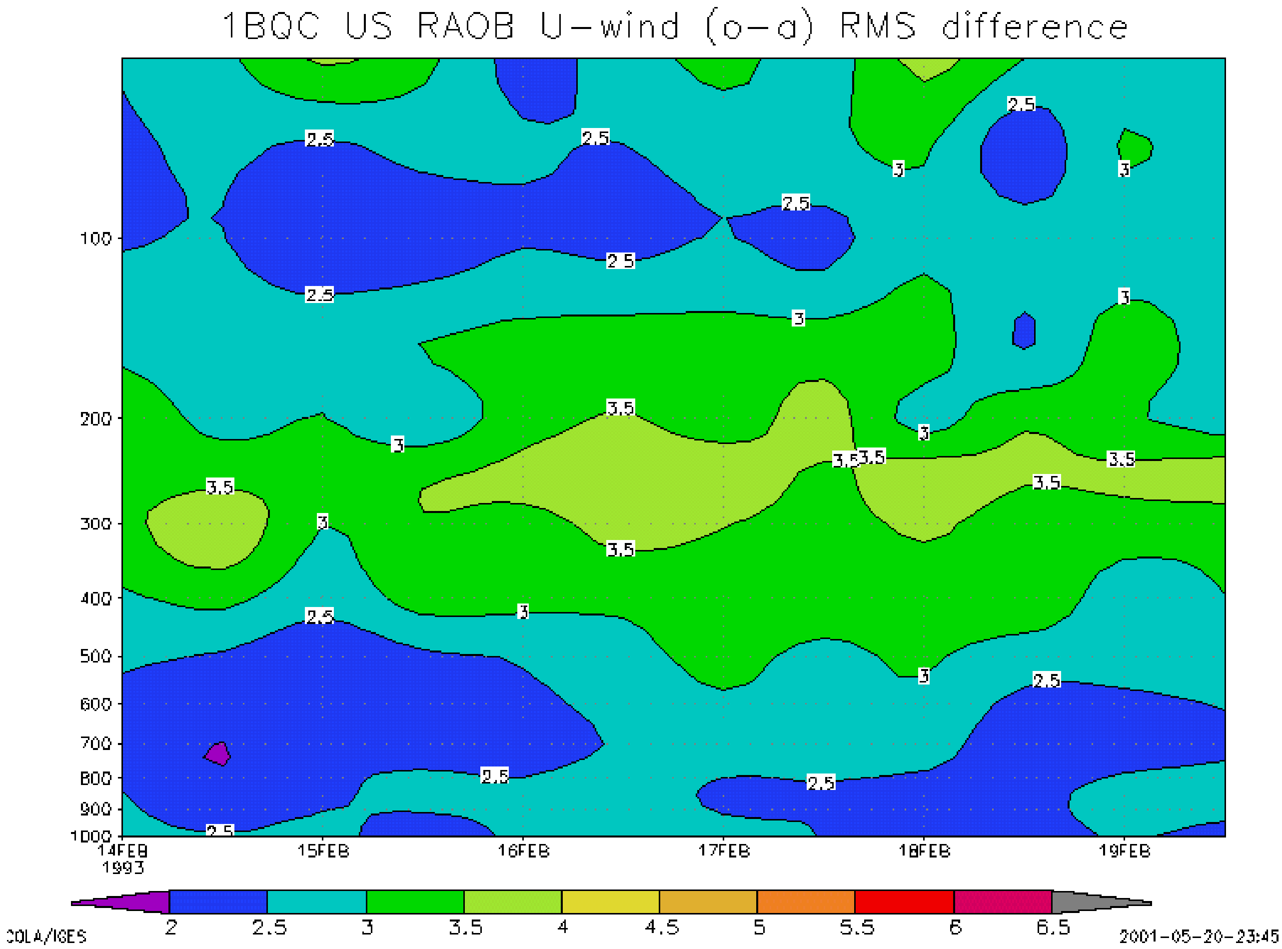
Analyzed error - observation content erroneously analyzed

1) Analyzed error has representative and instrument errors

2) Combination of unanalyzed errors ~ (o-a)*

* **(observation-analysis)** also contains forecast and other errors, and does not include analyzed ob error, but with an efficient assimilation, these should in general be small relative to the unanalyzed ob errors.

Reasons (o-a) is analogous to observation error



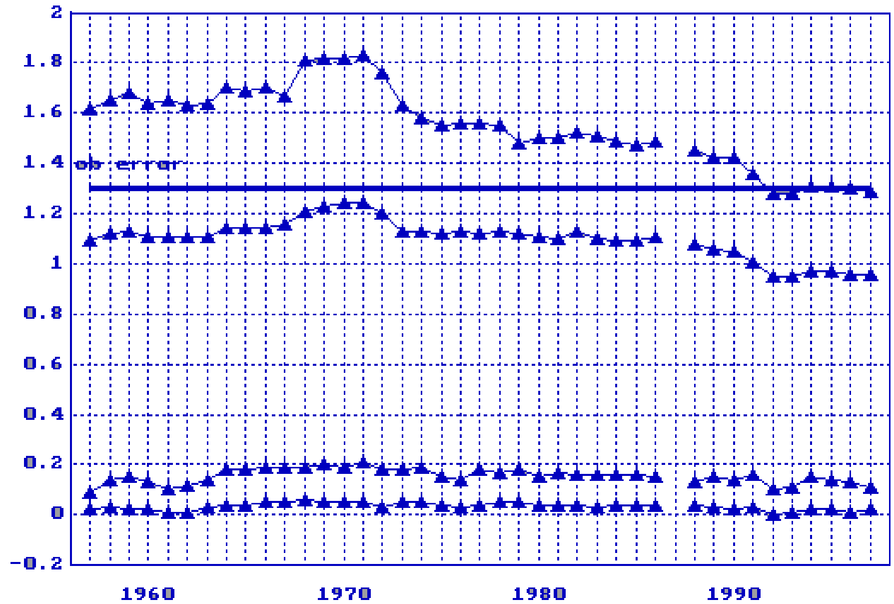
Given: <(o-a)2> = EoEo + EaEa - 2EoEa℘**

<u>If the assimilation system is efficient,</u>

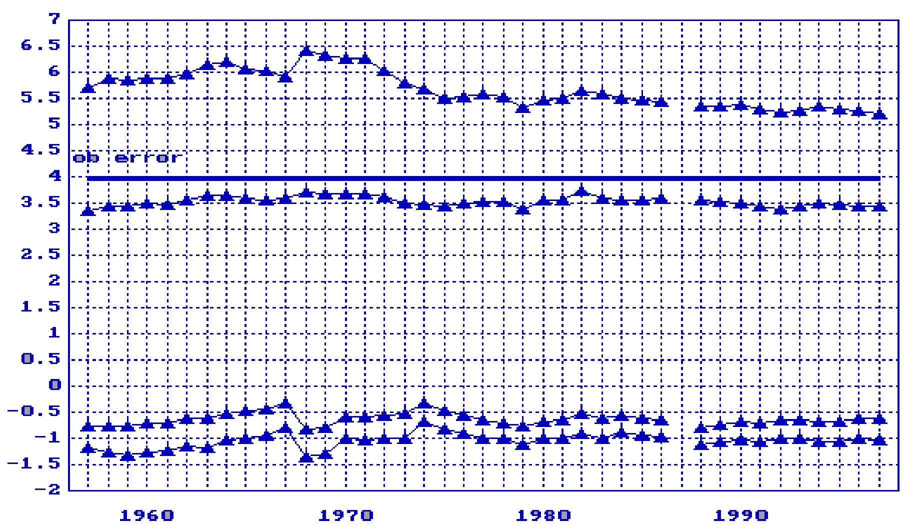
then, EaEa ≤ 2EoEa℘,

and, <(o-a)2> is a lower limit of EoEo .**

40 year global 500mb radiosonde fits to the reanalysis 6hr forecast and analyzed fields with ob error plotted.

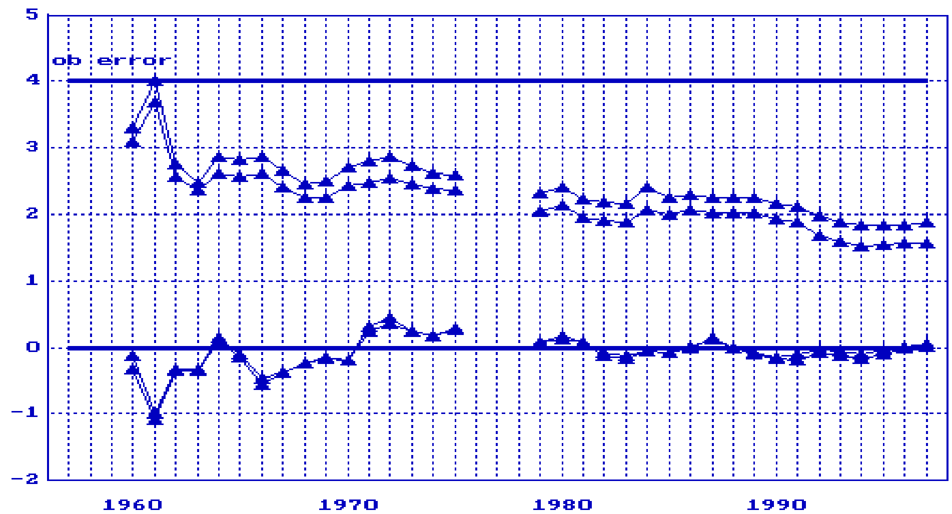


temperature mean and rms differences

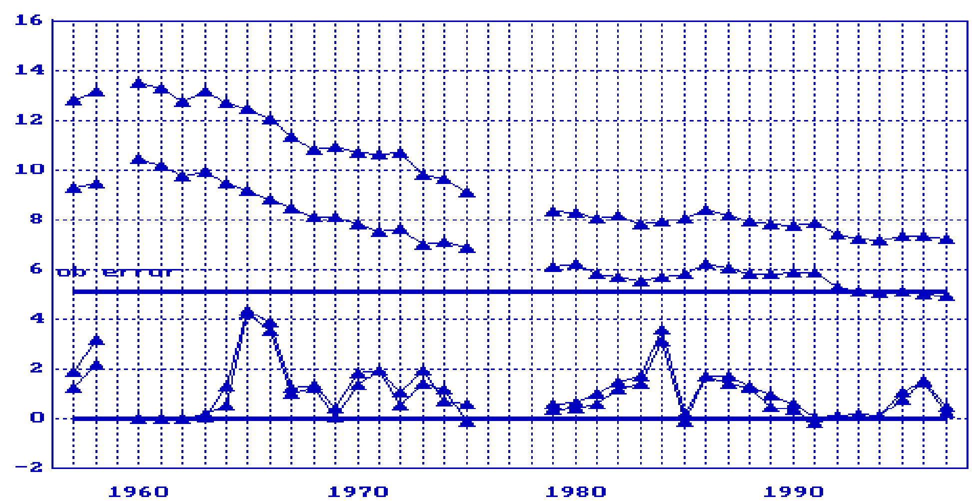


wind speed mean and rms vector differences

40 year global aircraftf fits to the reanalysis 6hr forecast and analyzed fields between 175 and 225 mb with observation error plotted.

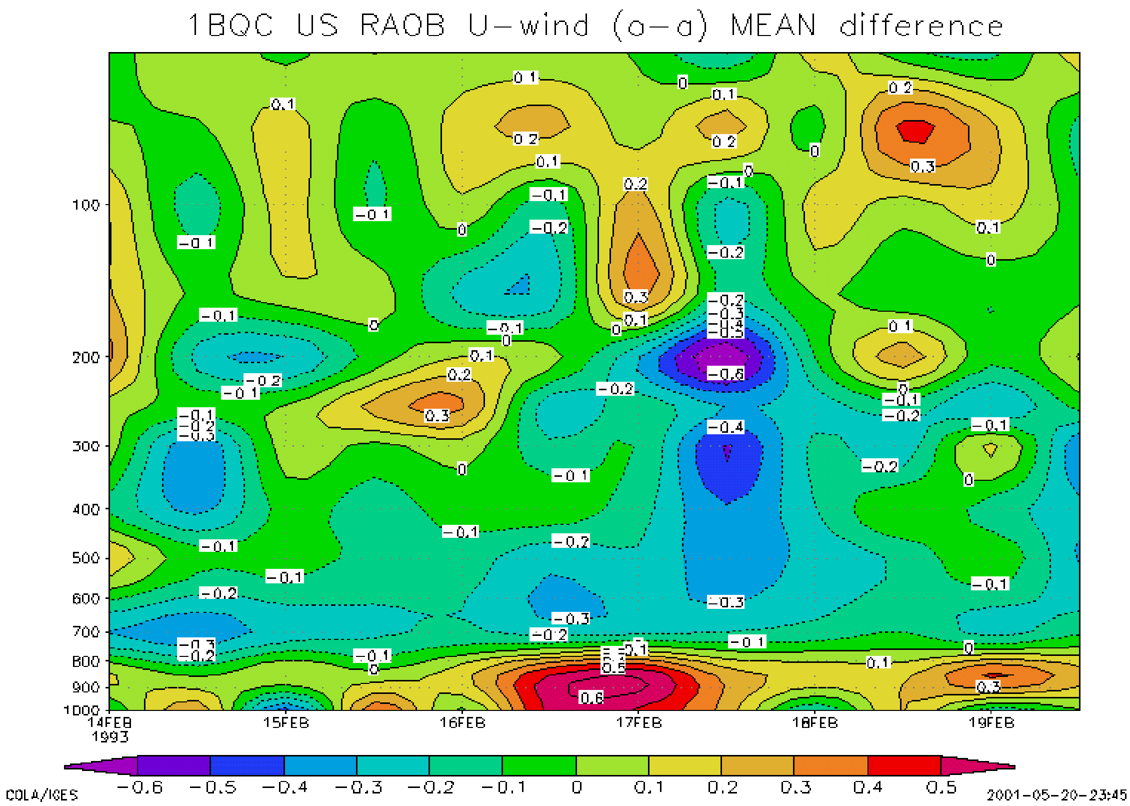


temperature mean and rms differences



wind speed mean and vector rms differences

Systematic error components in (o-a)



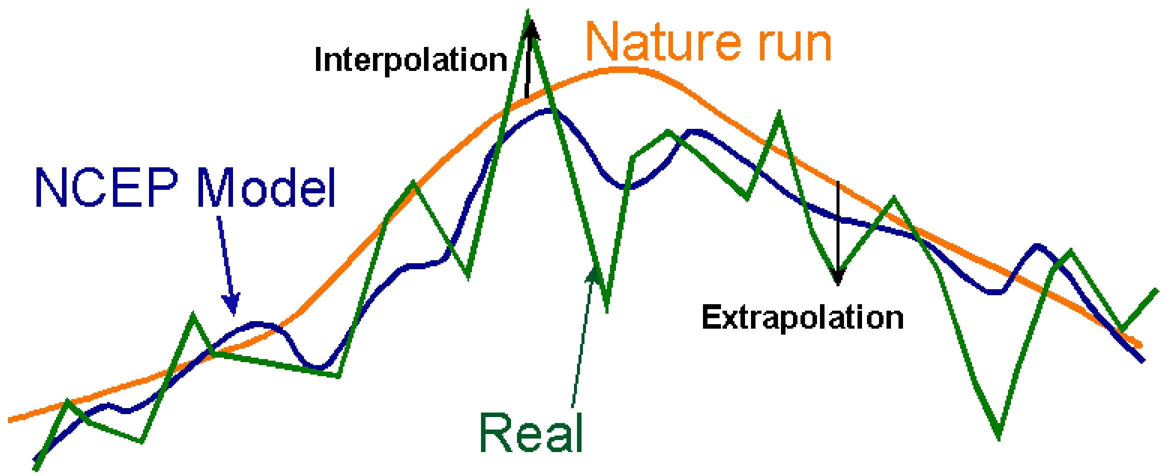
Significant biases in the o-a field do appear in the regions we would expect to find systematic representative errors, that is, in the jet region and near the surface. The implication is, these errors are similar to what we want to include in the synthetic data.

Meteorological significance of real (o-a) may not be just right in the nature run atmosphere. Future experiments include iteration of (o-a) fields from synthetic data experiments to see if the error fields adjust to the nature run synoptic regimes.

Components of OSSE Observation Files

Source	Contents	Component
ECMWF Nature Run 680x256x40 GRIB Sigma/Gaussian grid	PCL QCL TCL ZCL UCL VCL	**Nature run true values**
PREPBUFR from R-2 Feb-Mar 1993 No TOVS	POB QOB TOB ZOB UOB VOB	**Real obs**
Real NTV Assimialtion T62 28 sigma levels 6 hour forecast	PFC QFC TFC ZFC UFC VFC	**6 hr forecast**
Real NTV Assimilation T62 28 sigma levels Analysis	PAN QAN TAN ZAN UAN VAN	**Analyzed**

Fitting Real Topography in Synthetic Observations



Surface observation can be simulated either at the NR orography (——) or extrapolated or interpolated to the real (——). Surface observation simulated at the NR orography will produce much smooth and easier to assimilated.

- synthetic observations need real elevations

- use reported height plus instrument height

- extrapolation from NR introduces rep error

Extrapolations made to surface data

When the real elevation is lower than the NR:

a) NR surface pressure reduced hydrostatically to the real observation height. This becomes the "perfect" Ps.

b) NR temperature is lapsed in pressure to the perfect Ps obtained above.

c) NR moisture and winds are linearly extrapolated to the perfect Ps. The perfect Ps for winds is adjusted to reflect platform height.

d) Elevation reported in real data is retained in the synthetic observations.

Forecast results from 4 synthetic observation schemes compared to real cases

perfect data with real surface elevations

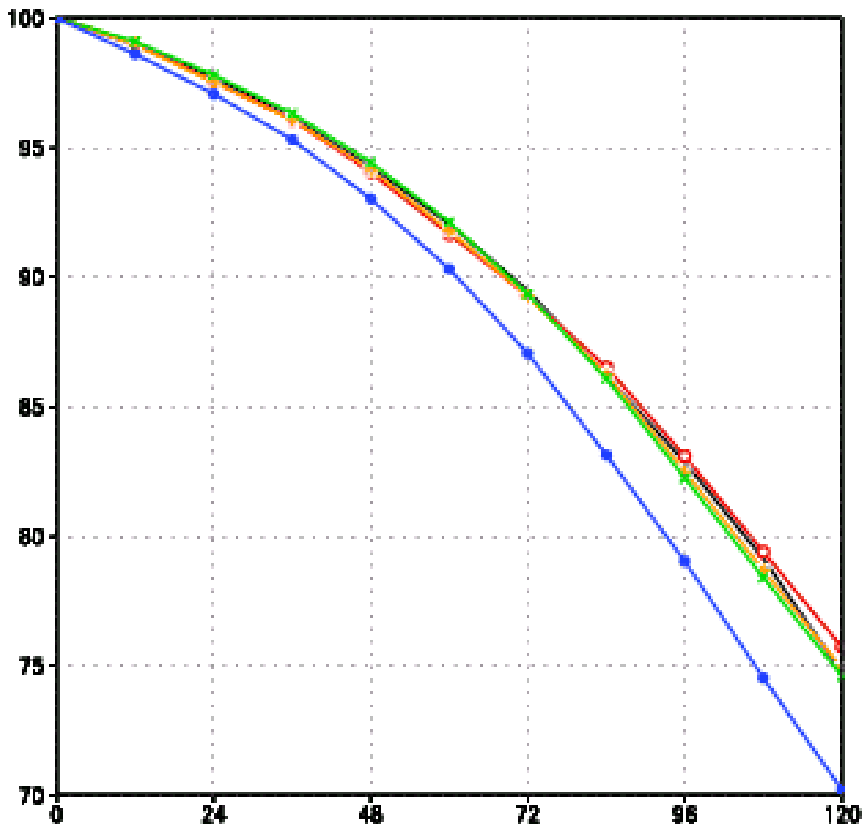
data with random error and NR surface elevations

data with (o-a) added to surface and ½(o-a) added above

data with (o-a) added to surface and 2(o-a) added above

real data assimilation results

Anomaly Correlation 1000 hPa Height NH extrop
Skill against own analysis wave 1-20
12 hourly forecast Verified vs. Itself
from 13FEB to 28FEB
Black:r.NTV Red(open_circle):jwp.NTV
Yellow(+):jt.NTV Green(x):s.adj.NTV
Blue(closed_circle):s.adj.u2.NTV



Anomaly Correlation 500 hPa Height NH extrop
Skill against own analysis wave 1-20
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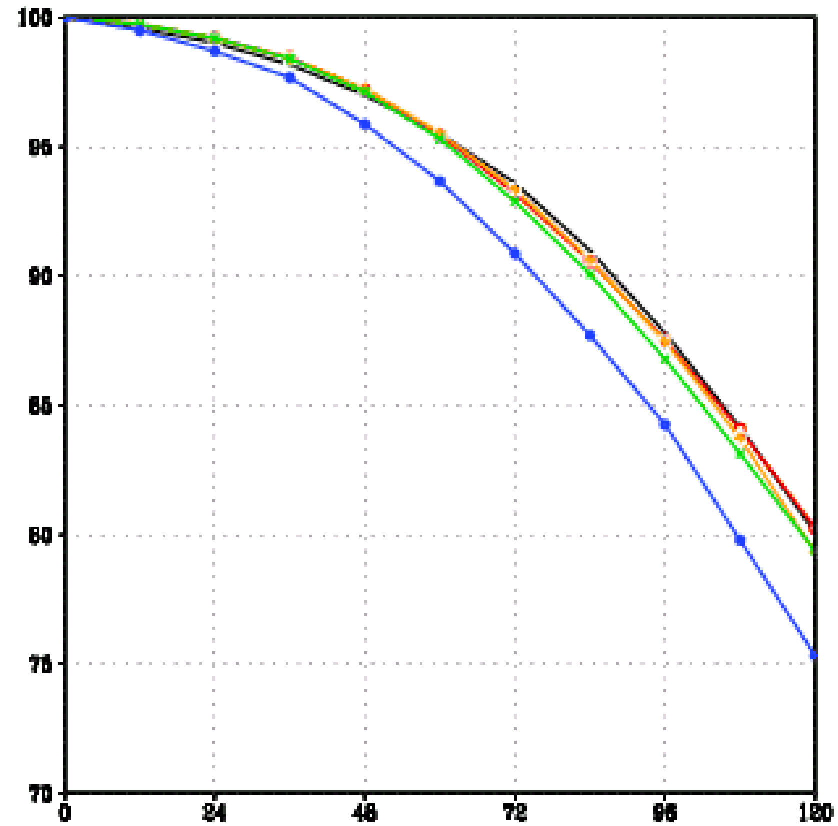

Anomaly Correlation 1000 hPa Height SH extrop
Skill against own analysis wave 1–20
12 hourly forecast Verified vs. Itself
from 13FEB to 28FEB
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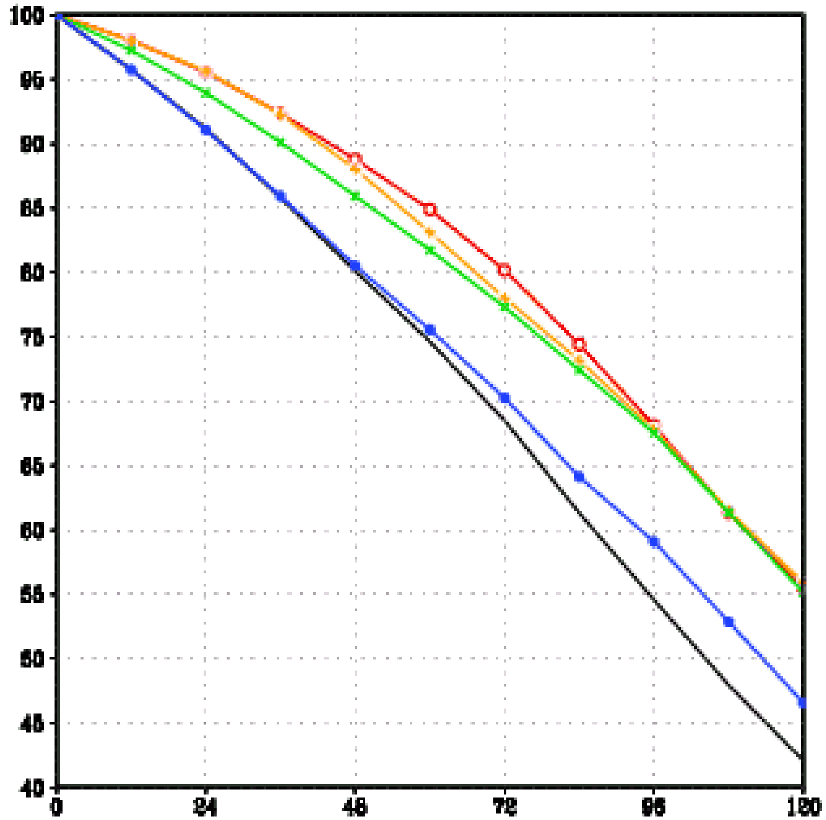
Yellow(+):jt.NTV Green(x):s.adj.NTV
Blue(closed_circle):s.adj.u2.NTV



Anomaly Correlation 500 hPa Height SH extrop
Skill against own analysis wave 1–20
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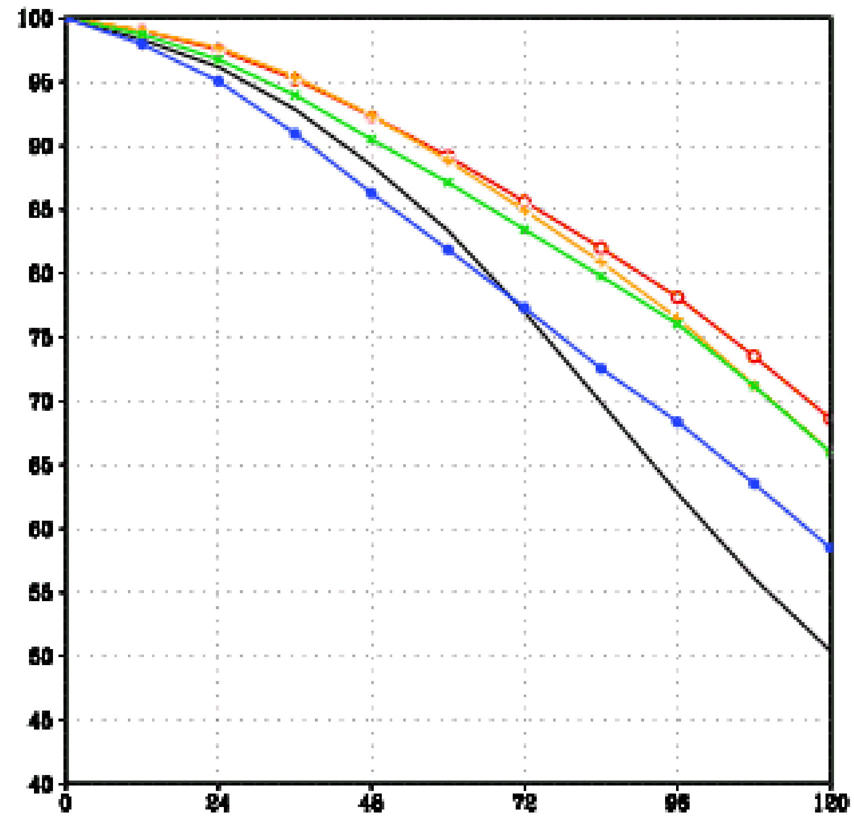
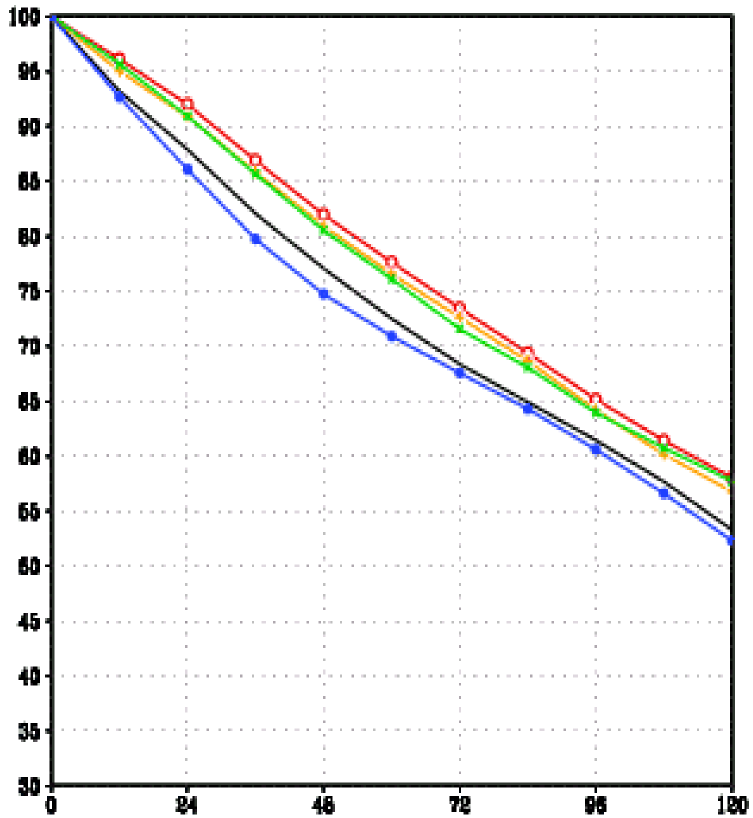


Anomaly Correlation 850 hPa U Tropics
Skill against own analysis wave 1-20
12 hourly forecast Verified vs. Itself
from 13FEB to 28FEB
Black:r.NTV Red(open_circle):jwp.NT'
Yellow(+):jt.NTV Green(x):s.adj.NTV
Blue(closed_circle):s.adj.u2.NTV



Anomaly Correlation 850 hPa V Tropics
Skill against own analysis wave 1-20
12 hourly forecast Verified vs. Itself
from 13FEB to 28FEB
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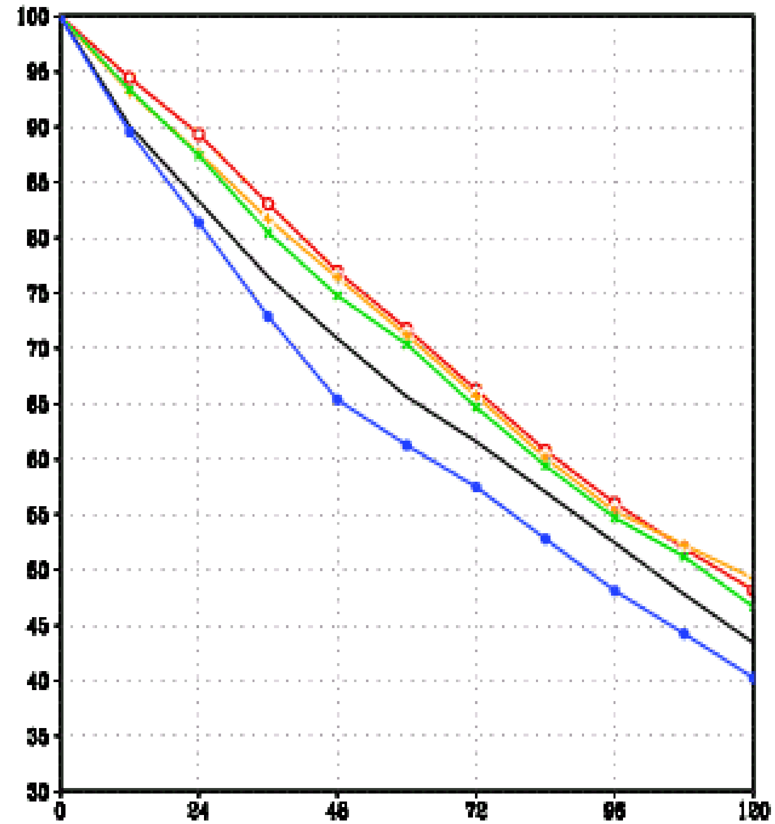
Yellow(+):jt.NTV Green(x):s.adj.NTV
Blue(closed_circle):s.adj.u2.NTV



Anomaly Correlation 200 hPa U Tropics
Skill against own analysis wave 1-20
12 hourly forecast Verified vs. Itself
from 13FEB to 28FEB
Black:r.NTV Red(open_circle):jwp.NTV
Yellow(+):jt.NTV Green(x):s.adj.NTV
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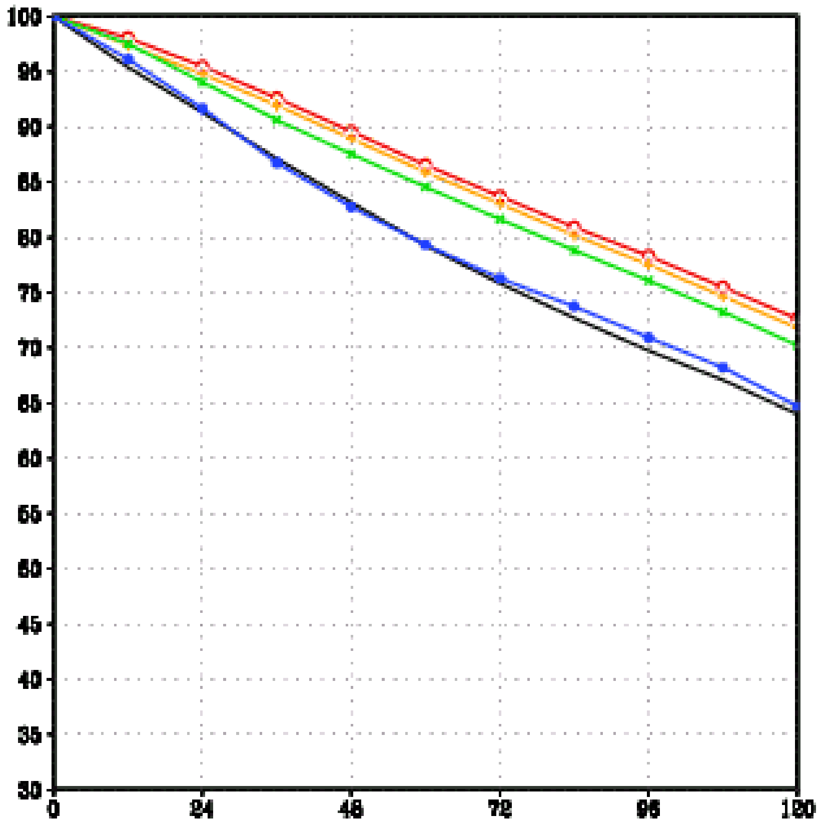

Anomaly Correlation 200 hPa V Tropics
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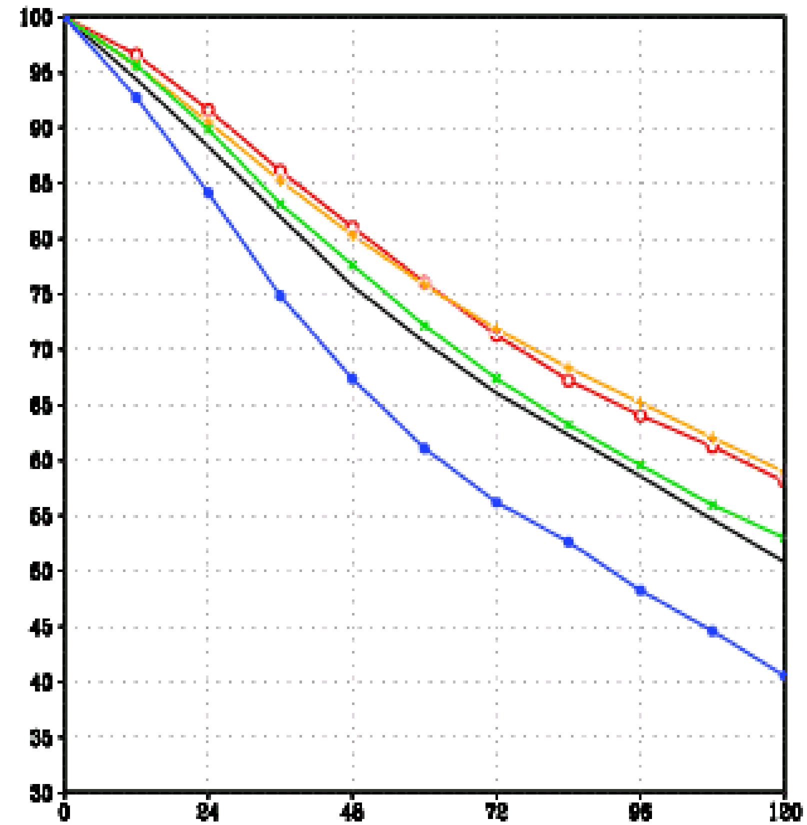

Conclusions

1) Using real (o-a) to supply random and systematic errors empirically to synthetic observations for OSSE experiments seems to be a viable concept.

2) Forecast results suggest that application of 1*(o-a) is suitable in the NH, and 2*(o-a) gives good results in the SH. A composite application of the errors then would be in order. For example, 1*(o-a) from 90N to 20N, a linear adjustment towards 2*(o-a) from 20N to 20S, and 2*(o-a) from 20S to 90S.

3) It may be possible to improve the synoptic correspondence of the synthetic errors by iterating (o-a) from calibration experiments.