Feasibility of Reanalysis before the Radiosonde Era (pre-1948)

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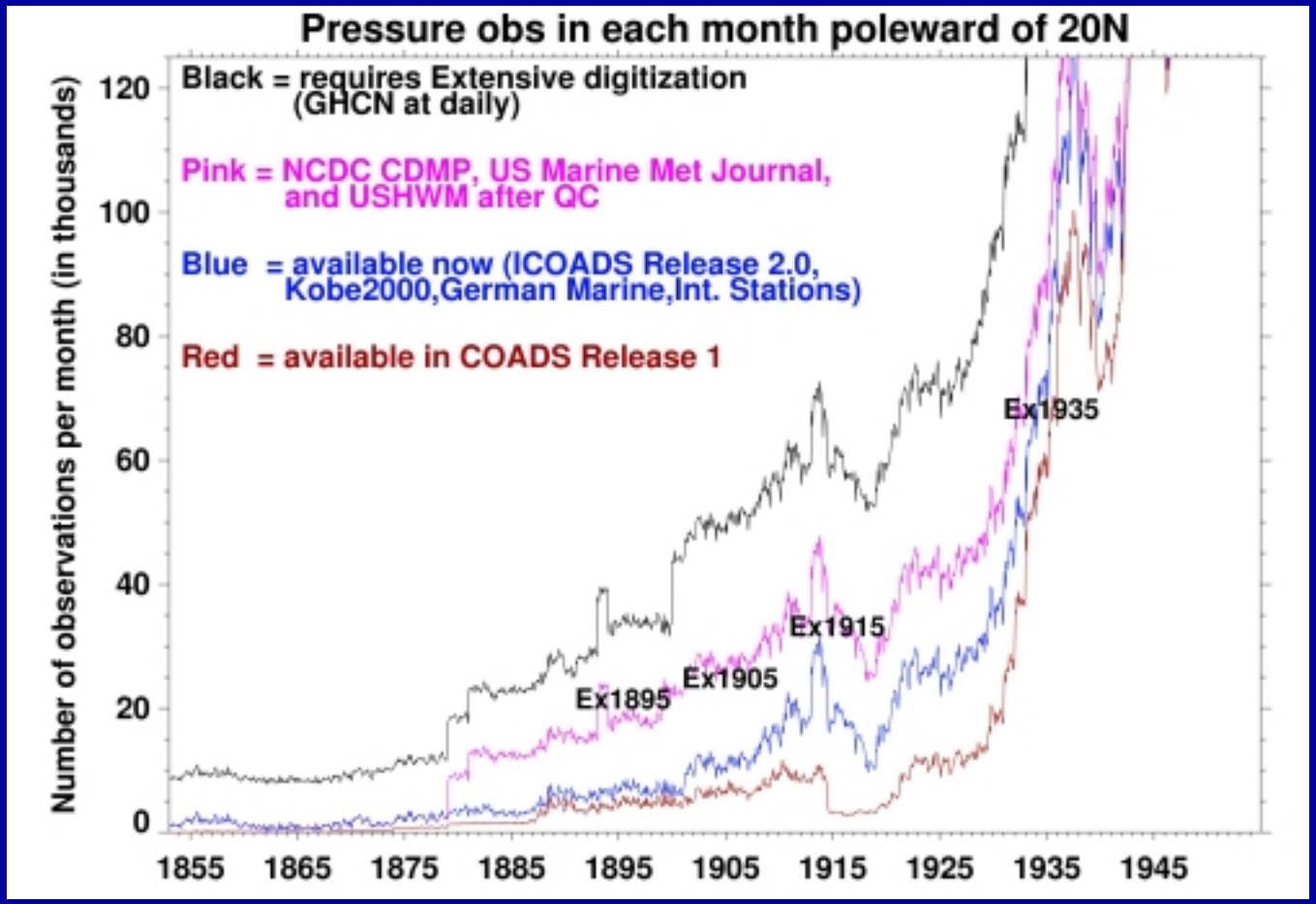
Motivation

1. Would like to determine storminess and blocking variations over last 100 years using gridded analyses. Currently available analyses are hand-drawn SLP maps, contain errors, and do not make use of all collected observations.
2. Modern data assimilation systems (DAS) have the potential to improve upon these analyses.
3. Prior to 1948, few radiosondes are available, but the many new surface pressure obs now “recovered” raise the possibility of generating useful “reanalyses” of at least the lower tropospheric circulation.

Experiment

1. In every 5°×5° box, reduce 2001-2002 observational network to only surface pressure observations at densities typical of 1895, 1905, 1915, and 1935.
   - No aircraft, balloon, satellite, or radiosonde data.
   - ***Using 1000 times fewer*** surface observations every 6 hours than currently used.
2. With the reduced network, make 6-hourly parallel assimilations for 2001-2002 using:
   a) Optimal Interpolation (OI) with climatological mean as the first guess and anomaly covariances as the error statistics of that first guess.
   b) The NCEP-NCAR CDAS with ***fixed*** "first-guess" error statistics derived from the NCEP medium range forecast model (MRF).
   c) An Ensemble square root filter (EnSRF) with the mean of a 100 member ensemble from MRF as the first-guess and the ***time-varying*** ensemble covariance as the error in that first-guess.
3. Compute error relative to the Full NCEP-NCAR reanalysis CDAS.

Historical surface pressure obs in each month (1855-1954) poleward of 20N



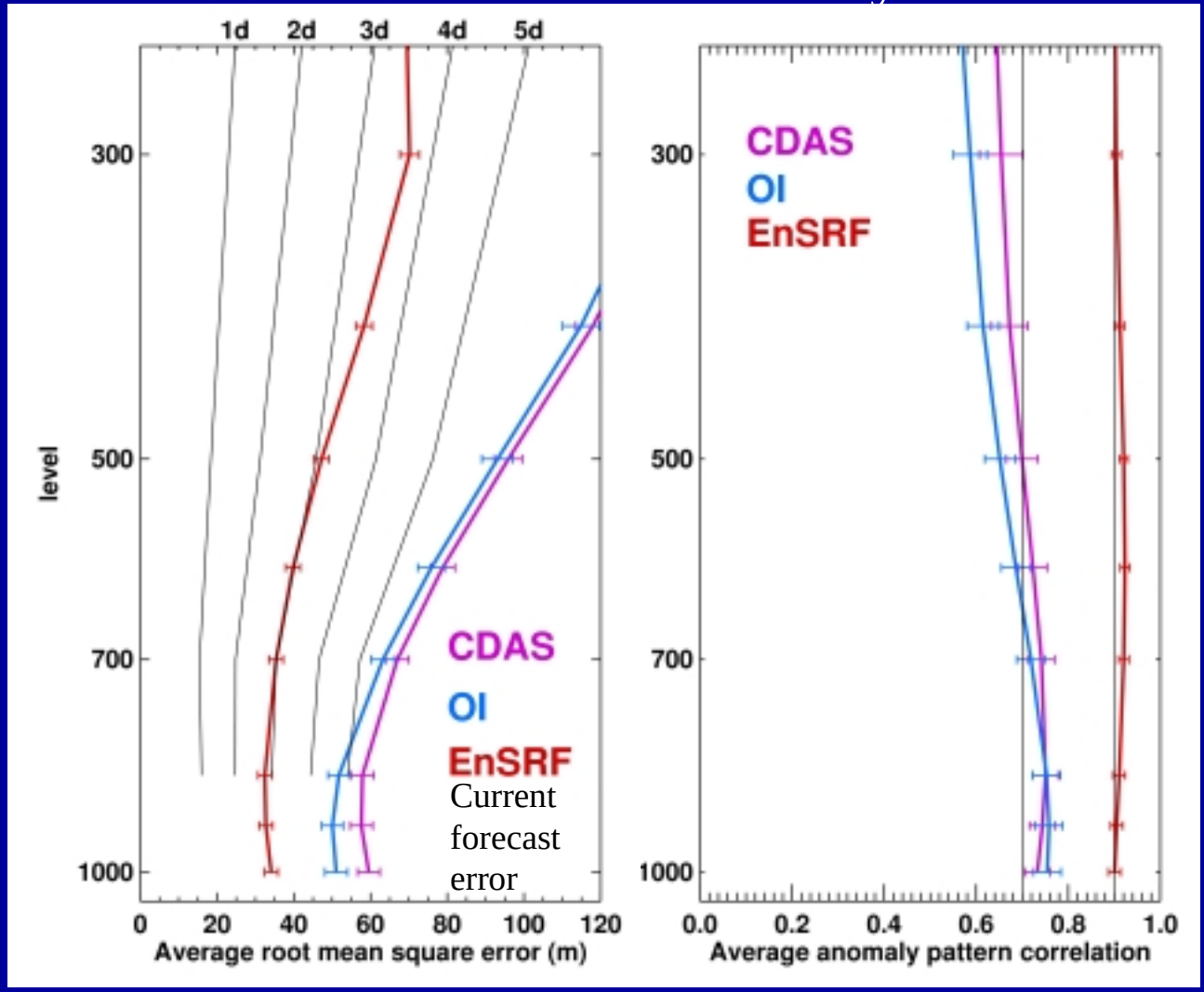
Skill of 6-hourly geopotential height analyses
from CDAS, Optimal Interpolation, and Ensemble Square Root Filter
Using Only Surface Pressure Obs at 1895 densities

RMS anomaly correlation

Surface pressure obs alone produce a good 6-hourly analysis even at 1895 densities.

Results obtained using EnSRF are significantly better than the traditional CDAS.

Expected error for 1895 circulation is comparable to a 3-day forecast error.



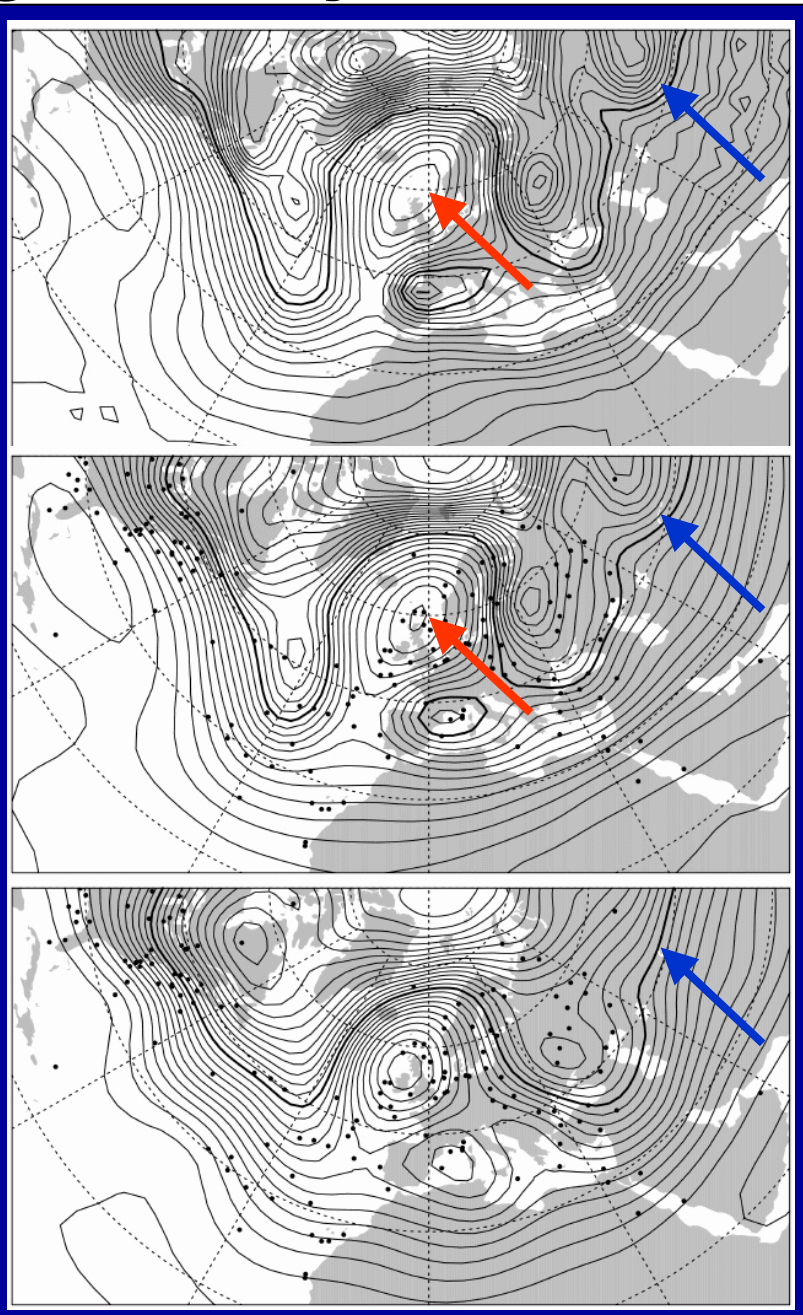
Simulating December 2001

500mb Height Analyses for 0Z 15 Dec 2001

Full CDAS
(120,000+ obs)

EnSRF 1895
(214 surface
pressure obs)

Optimal
Interpolation 1895
(214 surface
pressure obs)



5500 m contour is thickened

Black dots show pressure ob locations

RMS = 39.8 m

RMS = 82.4 m

Comparison of ICOADS and US Historical Weather Map Feb 1 1899

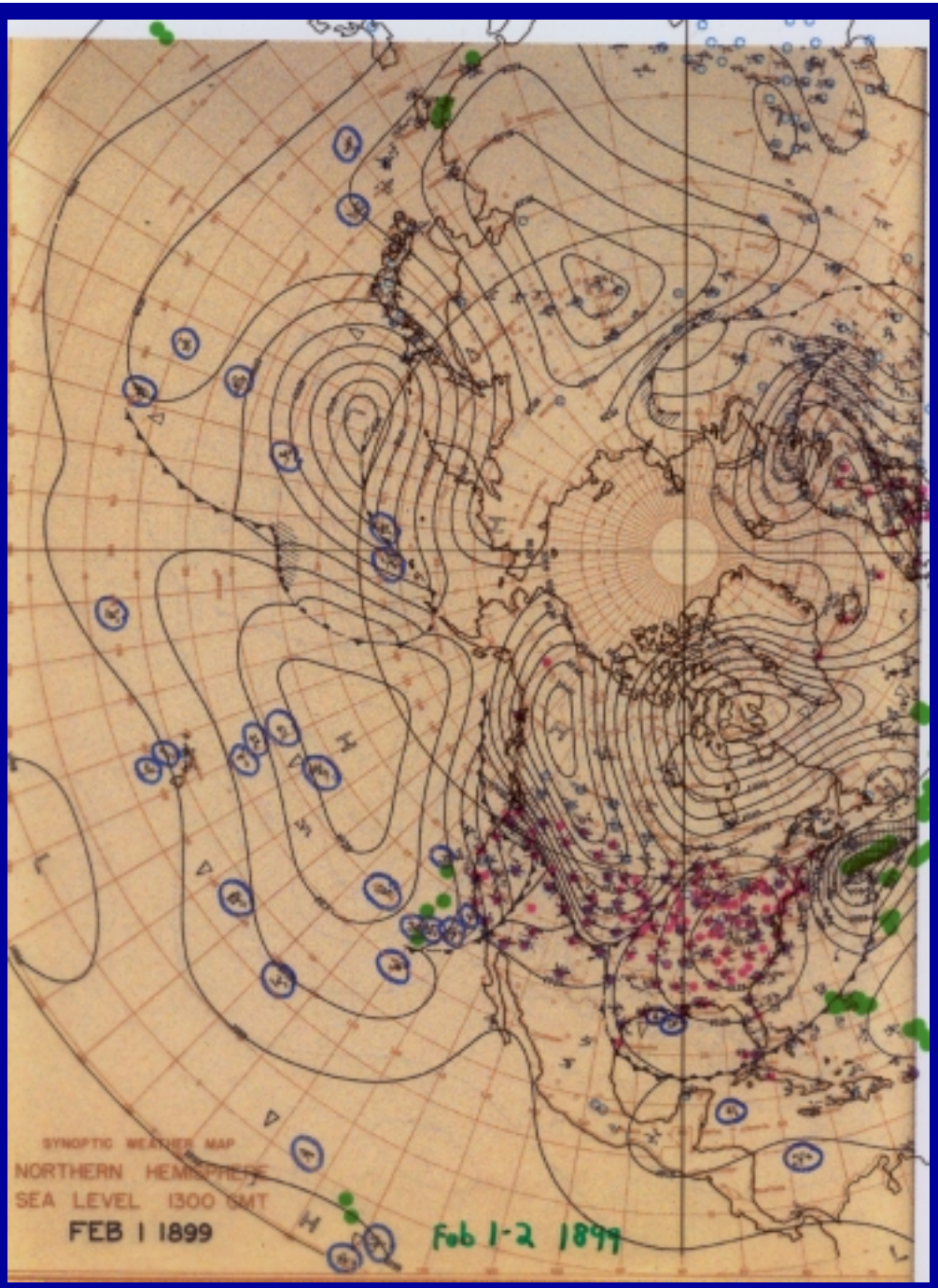
How many observations could be available?

Large open blue circles:

US Merchant Marine obs

Filled green circles:

ICOADS 2.0



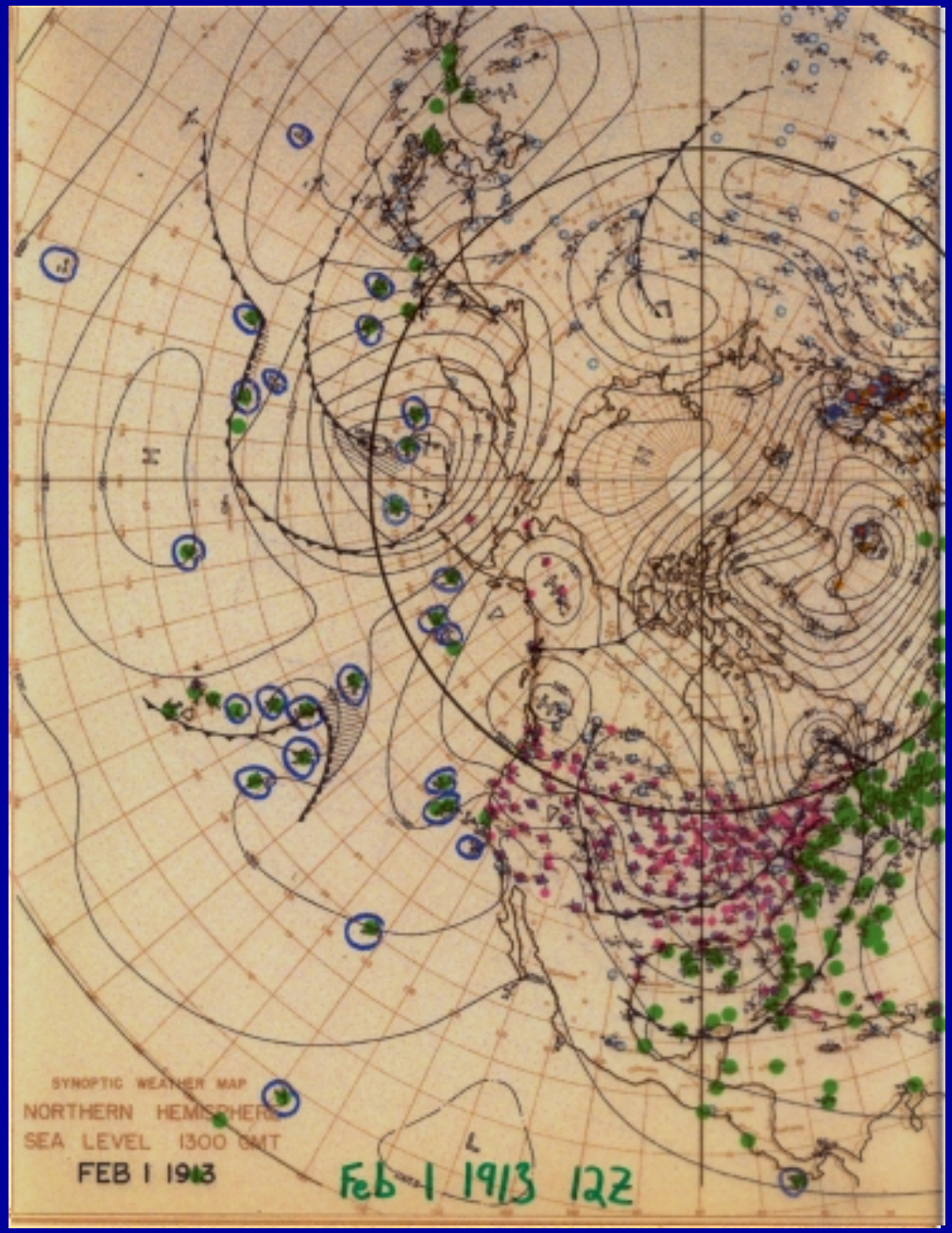
Comparison of ICOADS and US Historical Weather Map Feb 1 1913

Large open blue circles:

US Merchant Marine obs

Filled green circles:

ICOADS 2.0



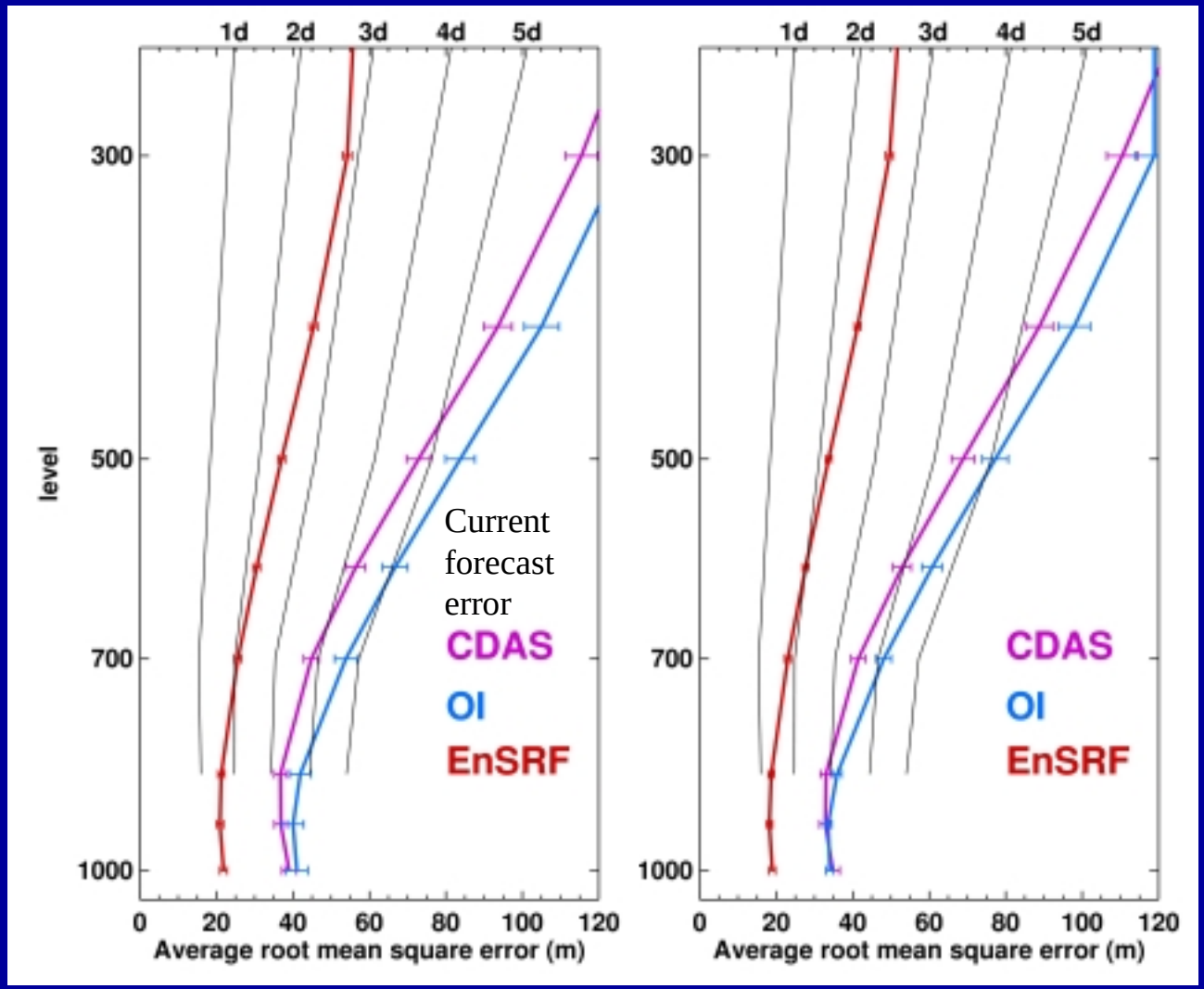
Root Mean Square Error of geopotential height analyses
CDAS, Optimal Interpolation, and Ensemble Square Root Filter
Using Only Surface Pressure Obs at 1915 Densities

6-hourly daily averages

OI {using ***climatology*** as first guess!} is competitive with CDAS for daily averages.

Results obtained using EnSRF are significantly better than the traditional CDAS.

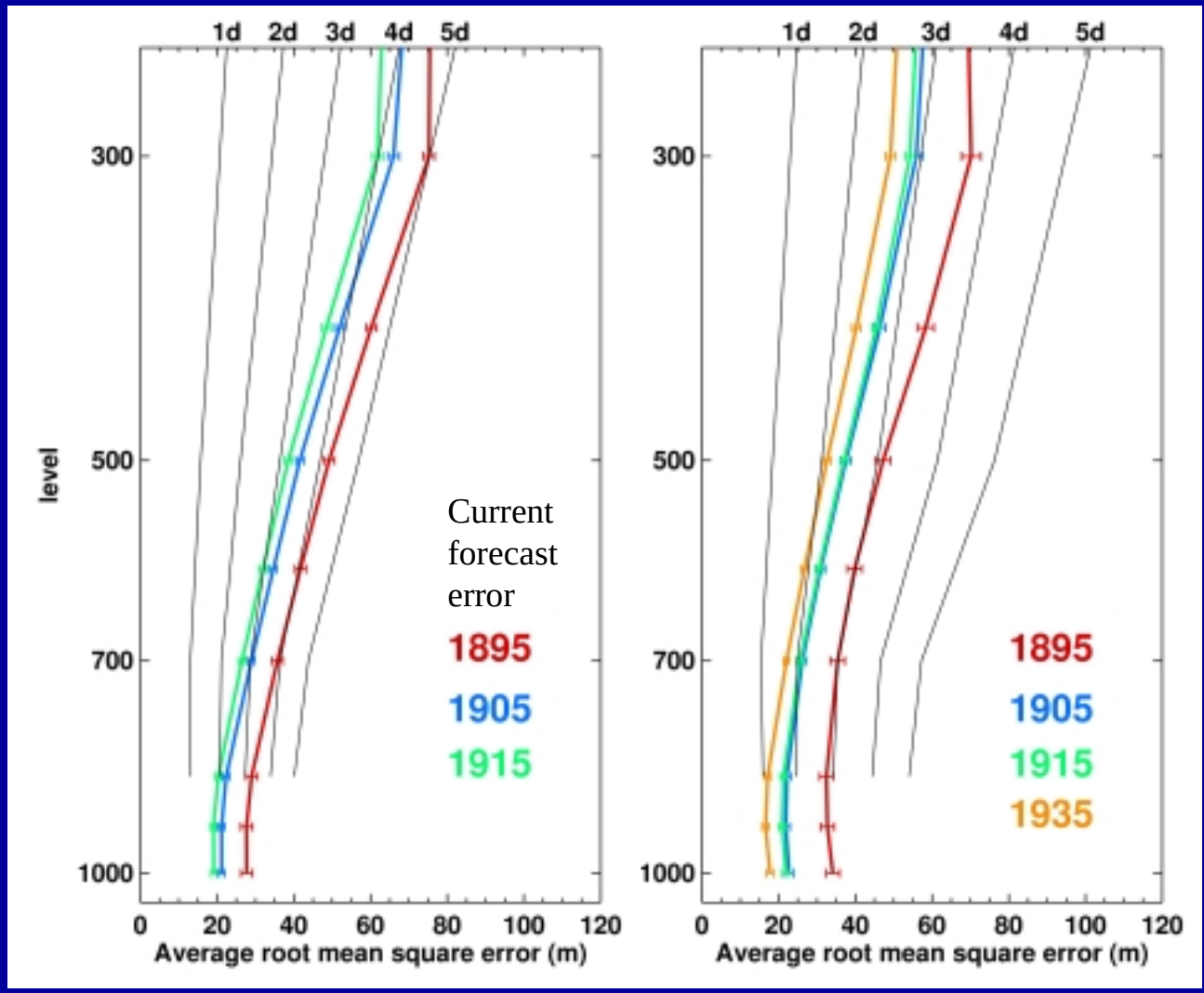
Errors are comparable to 2-3 day forecast



Root Mean Square Skill of analyzing 6-hourly geopotential height with EnSRF using
Only Surface Pressure Obs at 1895, 1905, 1915, and 1935 densities

Increasing number and coverage of observations will help greatly for 1895 period.

1905 only has 30 obs more per analysis, but much better coverage.



Conclusions

1. Reanalyzing the pre-1948 lower-tropospheric circulation is feasible ***using just the available surface observations***.

2. More advanced data assimilation methods will produce better results, especially in the ***upper*** troposphere.

3. Keying additional marine observations, particularly US Merchant Marine pre-1913 will greatly increase the fidelity of the reanalysis and give errors comparable to current 2-3 day forecasts.