

Updates to the 20CR reanalysis system and some preliminary test results

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The 20CR DA system

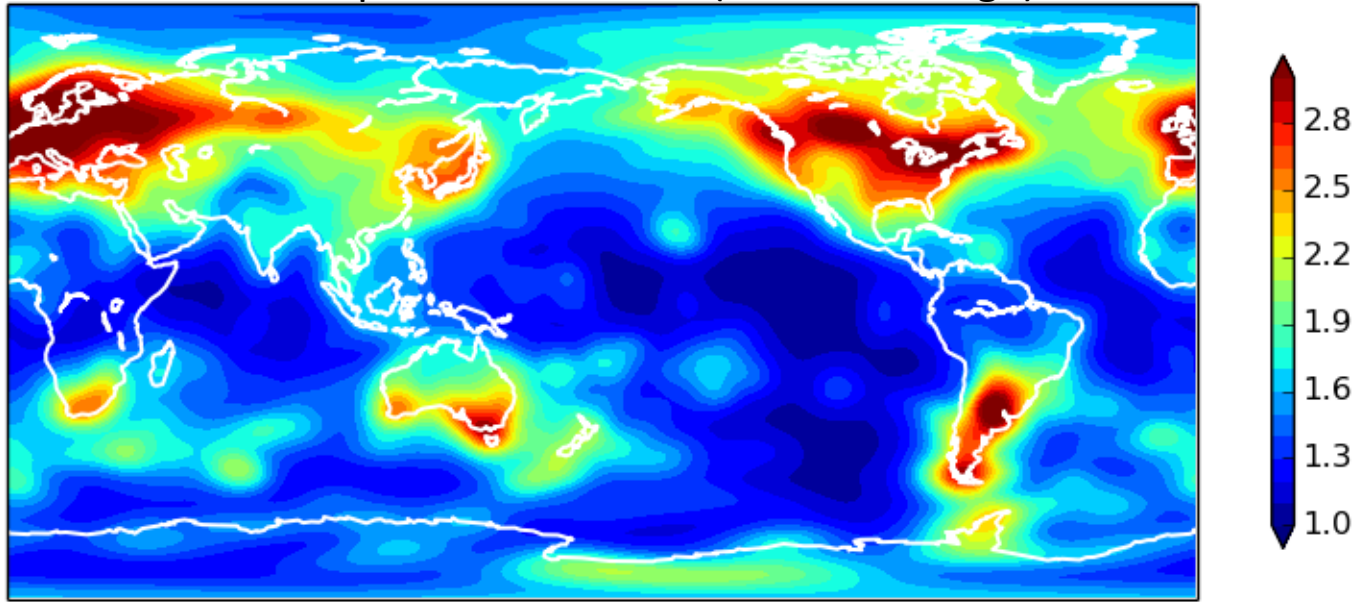
- Model: T62L28 GFS, circa 2009.
- 56 member EnKF
 - Fixed covariance localization (4000km, 4 scale heights)
 - Fixed covariance inflation
 - ‘Buddy check’ QC, simple observation bias correction based on time mean fcst-obs.
 - Digital filter initialization (DFI) first 3 hours of first-guess forecast.
- Known sea-ice problem (bug).

New 20CR DA system

- Model: T126L64 GFS, circa 2013.
- 64 member EnKF
 - Varying covariance localization (based on estimated observation impact)
 - ‘Relaxation to prior spread’ inflation (larger where obs are dense).
 - New QC that treats ob errors as non-Gaussian (based on Huber-norm VarQC algorithm developed at EC).
 - No DFI - incremental analysis update (IAU) ending at analysis time instead.
- Sea-ice problem fixed.

New covariance inflation

Surface pressure inflation (annual average)



Relaxation to prior spread (RTPS) $\sigma^a \leftarrow (1 - \alpha)\sigma^a + \alpha\sigma^b$
which implies $\mathbf{x}_i^{'a} \leftarrow \mathbf{x}_i^{'a} \sqrt{\alpha \frac{\sigma^b - \sigma^a}{\sigma^a} + 1}$

Here we use $\alpha = 0.9$

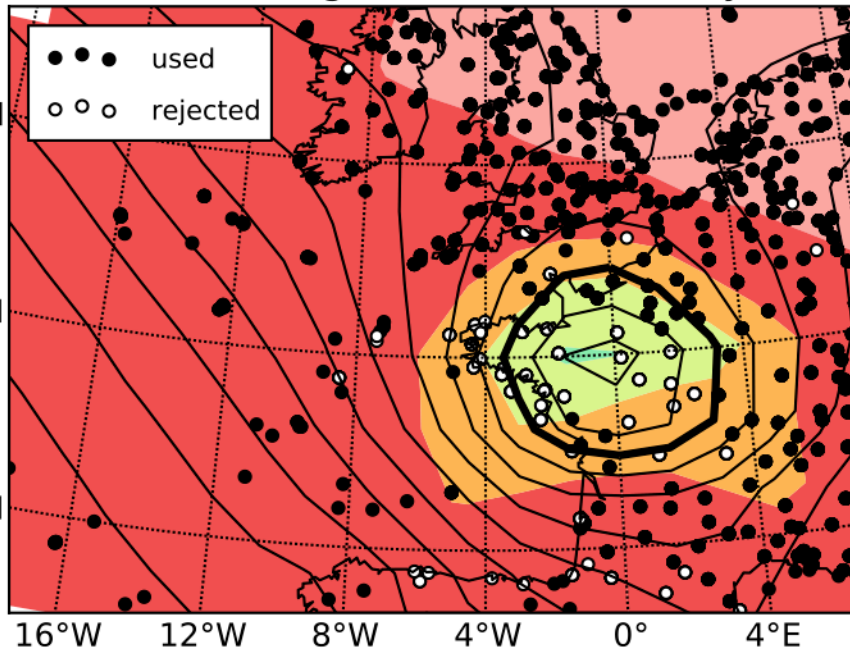
Previously, inflation was piecewise constant (NH,TR,SH)

Ref: journals.ametsoc.org/doi/pdf/10.1175/MWR-D-11-00276.1

New QC – ‘Lothar’ storm Dec. 1999

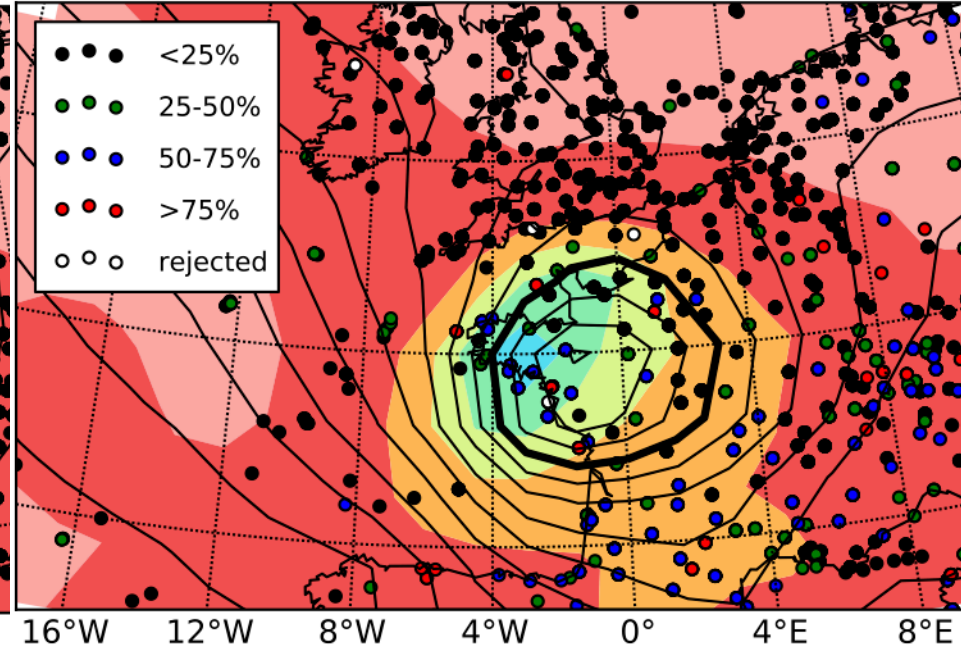
probability of gross error

Background check QC only



Ob rejected of departure greater than
3.2 times $\sqrt{\text{ens spread} + \text{ob error var}}$

Huber norm QC

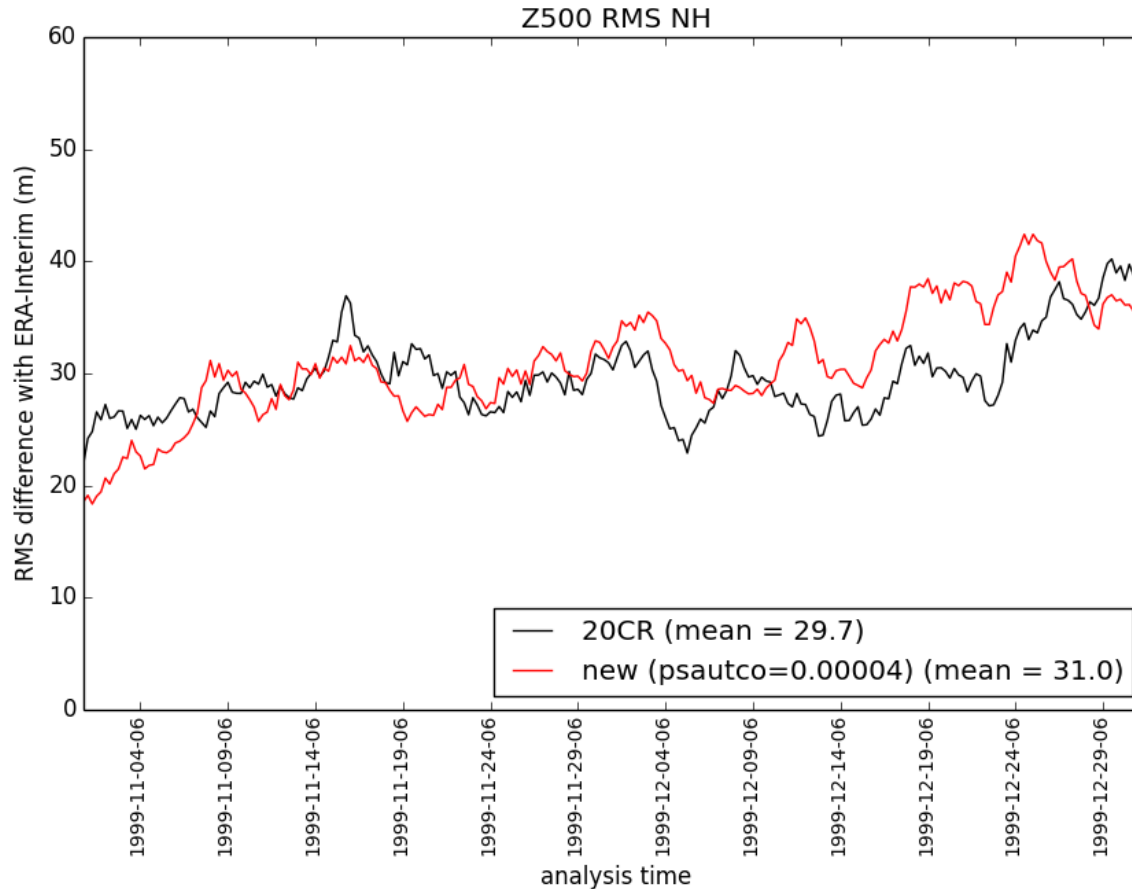


Ob rejected of departure greater than
16 times $\sqrt{\text{ens spread} + \text{ob error var}}$

Testing

- Start 9/1/1999 from 20CR ensemble.
- Use same obs and SSTs as 20CR, climo sea ice.
- Run through 12/31/2000.
- Verify against ERA interim analyses.

First try using default GFS parameters

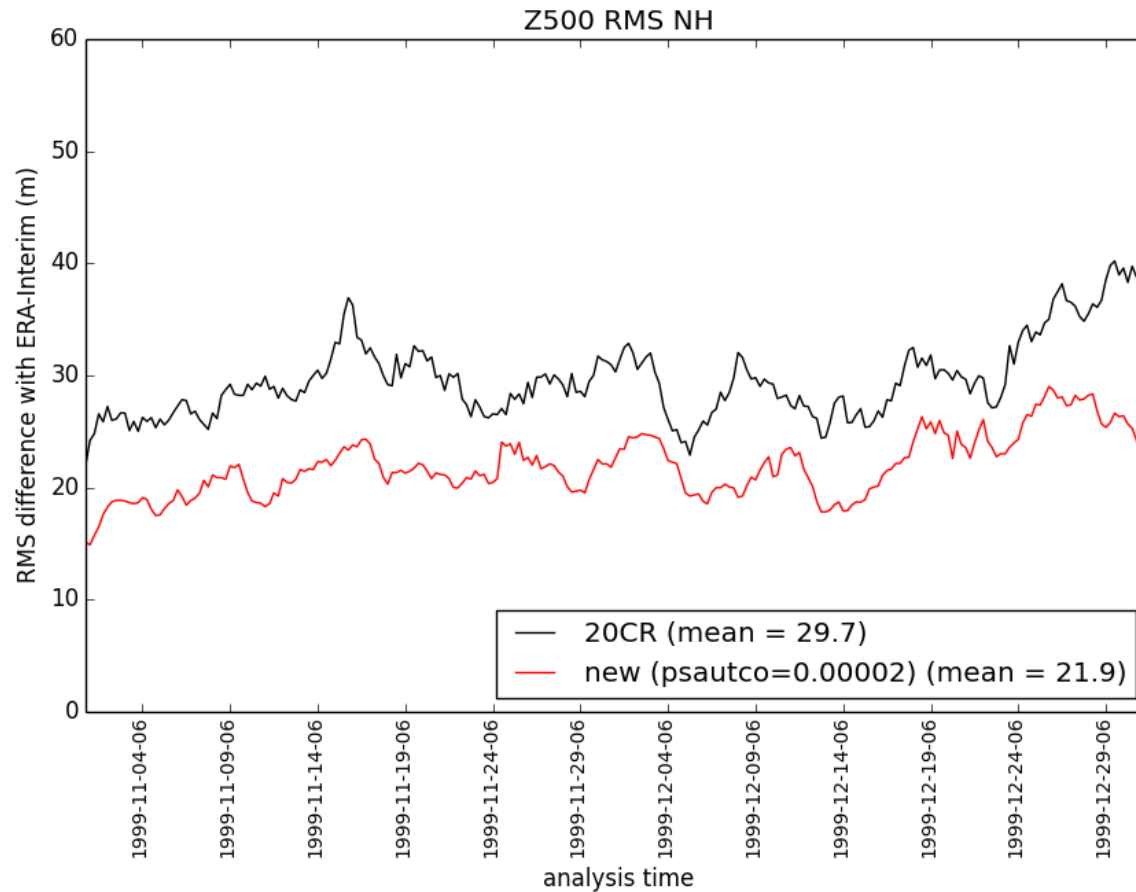


Worse than original 20CR. Large mid-upper tropospheric cold bias.

Cause: Not enough high cloud.

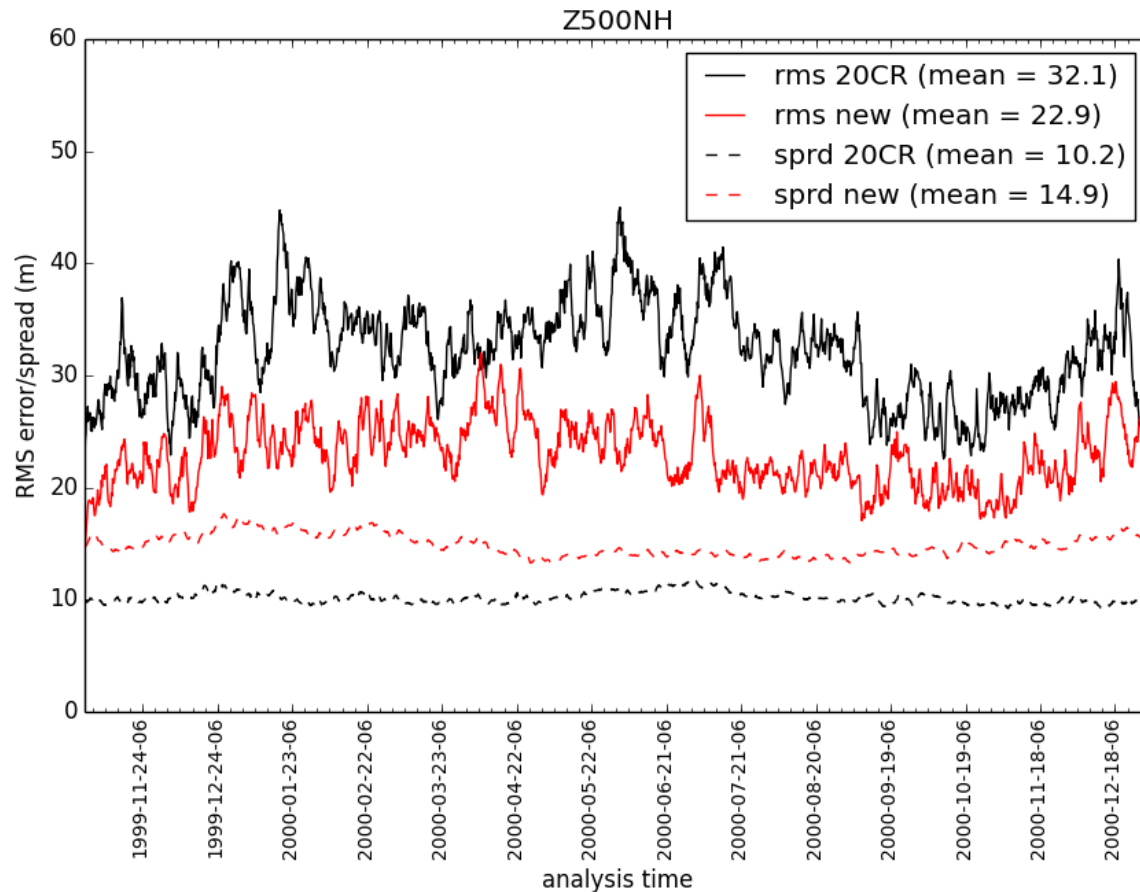
Solution: Reduce ice to snow auto-conversion rate in Zhao-Carr microphysics.

psautco halved



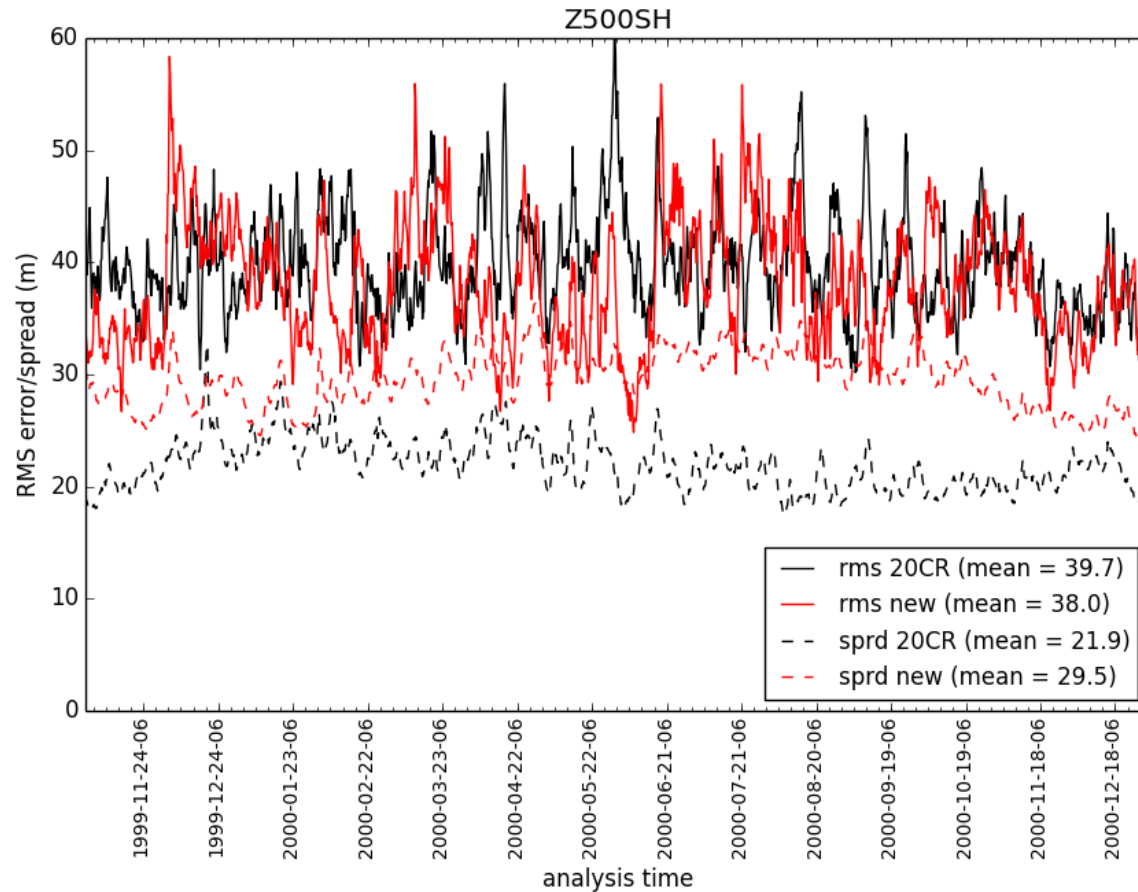
Now much better than 20CR in NH (almost 25% reduction in error)!

Results for full year



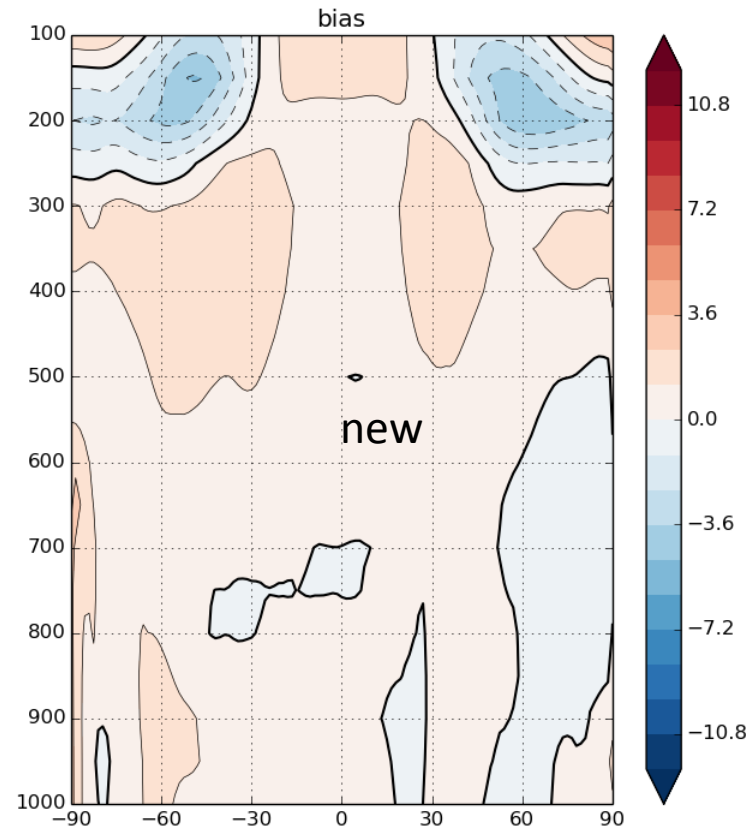
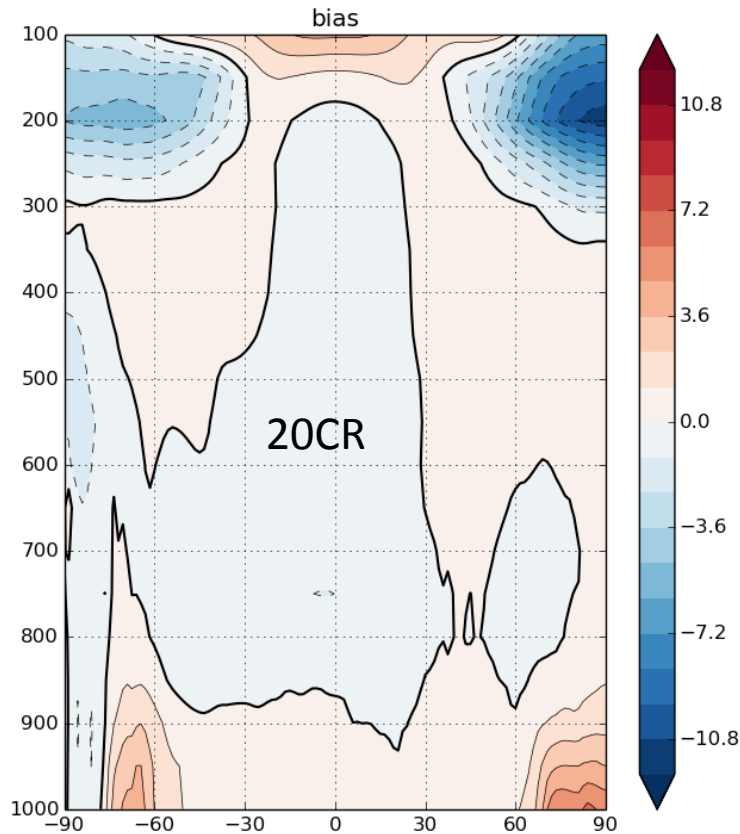
28% reduction in RMS, spread increased by 45% (now much closer to error)

Results for full year



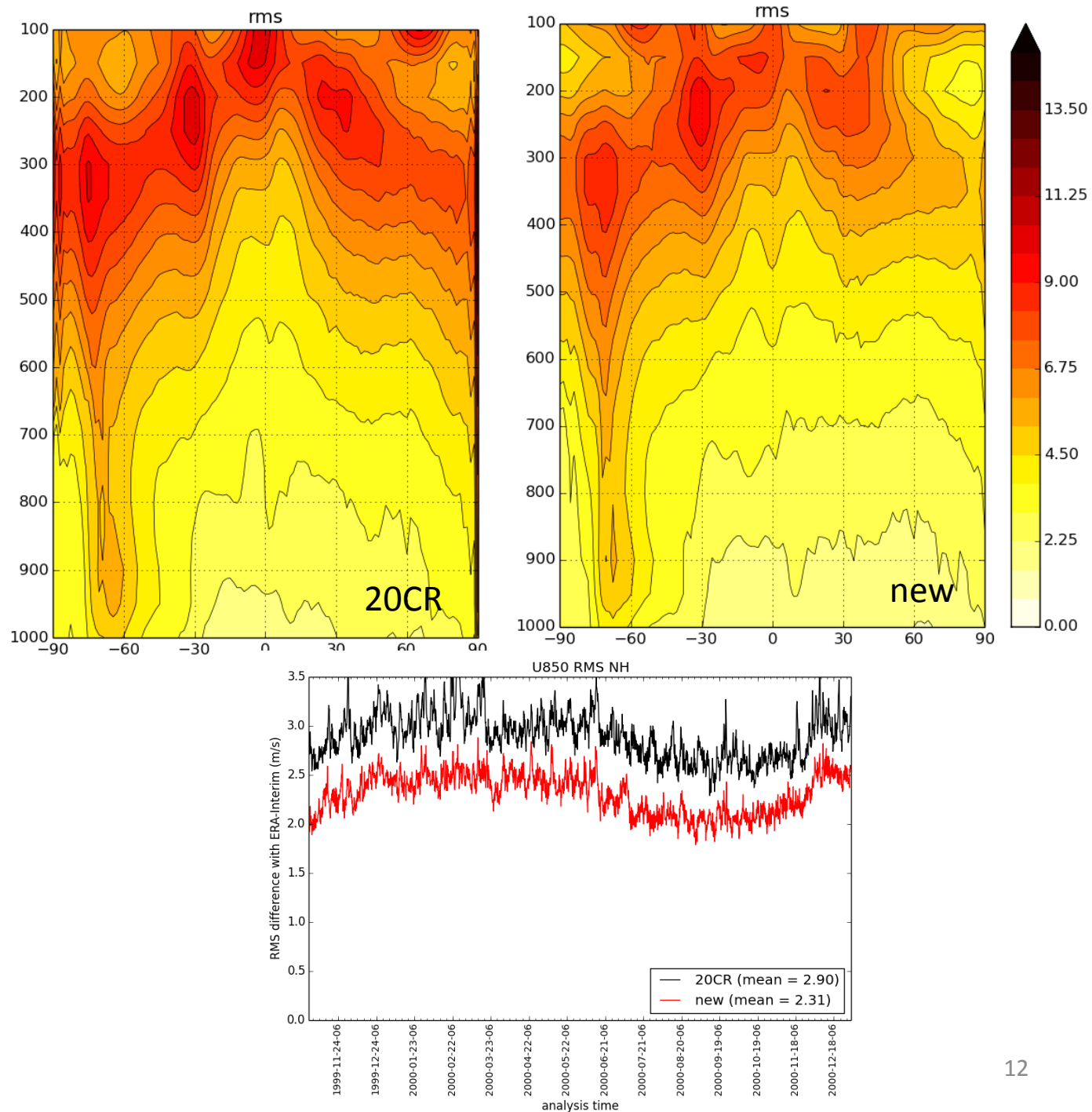
Not much reduction in RMS for SH (but spread to RMS consistency improved)

Zonal mean temp bias



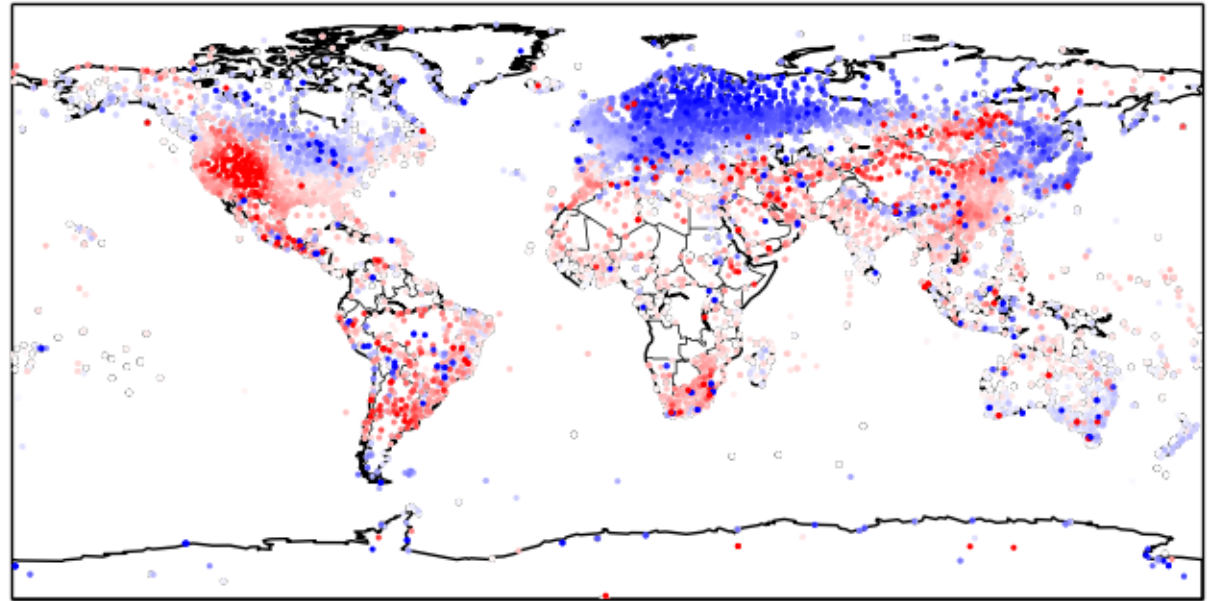
Upper trop warm bias in new system (too much high cloud?)
Near surface temp bias due to ice problem fixed.
Stratospheric cold bias reduced, but not eliminated.

Zonal wind RMS

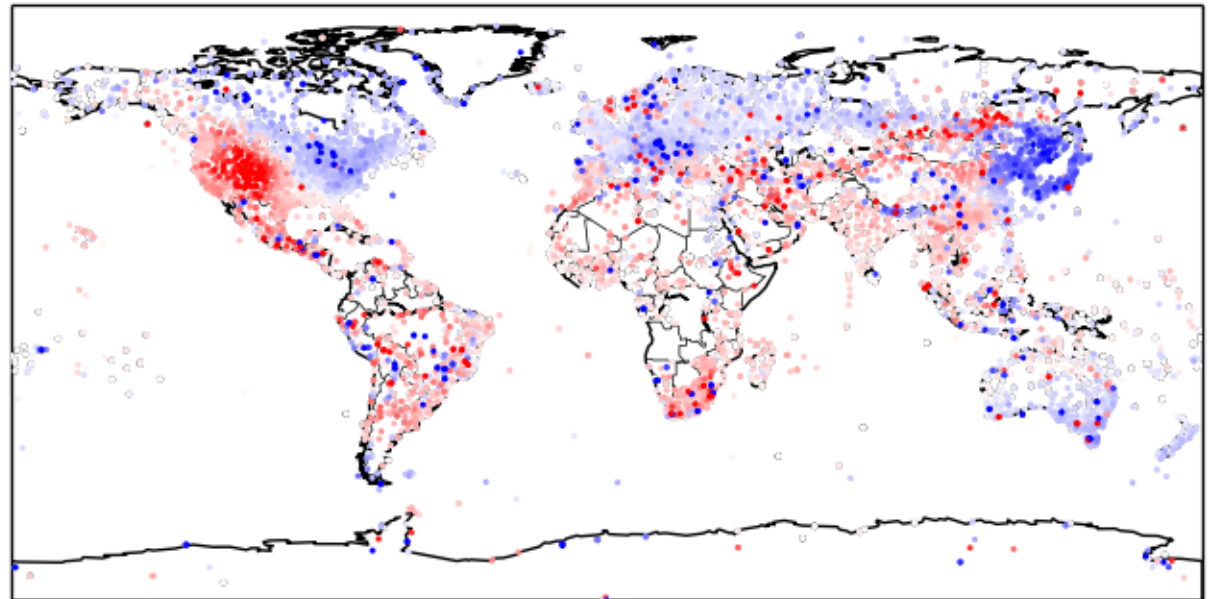


Observation Bias Estimates

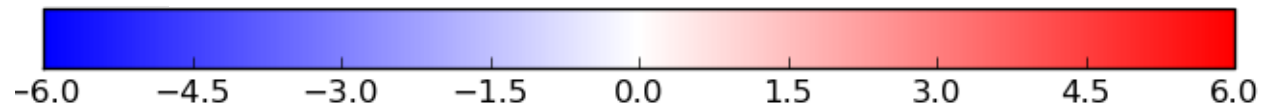
20CR bias for 2000



new 20CR bias for 2000



Less bias estimated over
Northern Europe, Russia.
Actually model bias in 20CR?



Conclusions

- New 20CR system should produce much improved analyses in tropics and NH (~15-25% reduction in error). Not much improvement to be expected in SH.
- Spread should be more representative of analysis error.
- Near surface temps in polar regions will be much better due to sea ice fix.
- Less model 'spinup' during first-guess forecast (IAU instead of DFI).

Remaining issues...

- Lower stratospheric cold bias (ozone?).
- SH climate.
- Untangling model and observation bias.