CORe

Convention ***O***bservation ***Re***analysis

Joint project with CPC (A. Kumar, W. Ebisuzaki, L. Zhang), EMC (J. Woollen) and PSD (J. Whittaker) + other CPCers for pre-FV3

Started as a project to fix the problems with CFSR and to create a system for a climate reanalysis. Tested GFS with GSI and hybrid. Ended up with FV3 with conventional observations and Ensemble Kalman Filter (ENKF) data assimilation.

CORe

Convention ***O***bservation ***Re***analysis

FV3, C128, 64 levels, Ensemble Kalman Filter

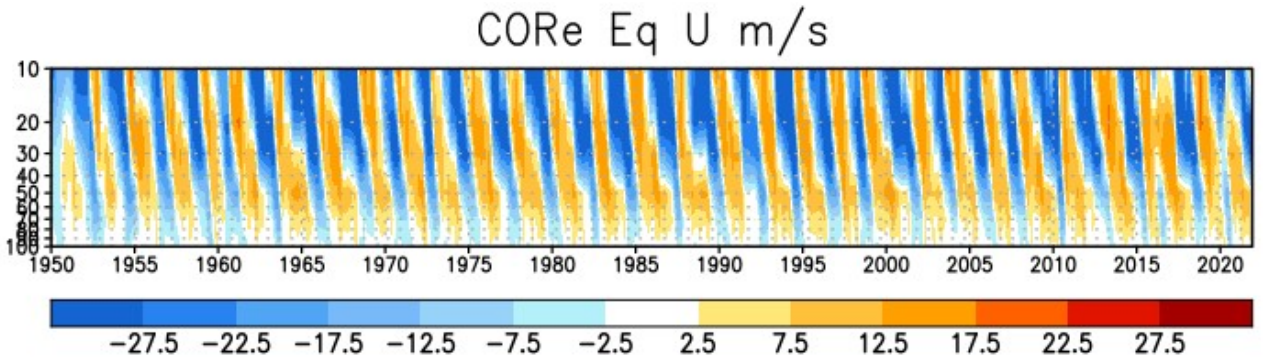
conventional observations and AMVs (Atmos. Motion Vectors)

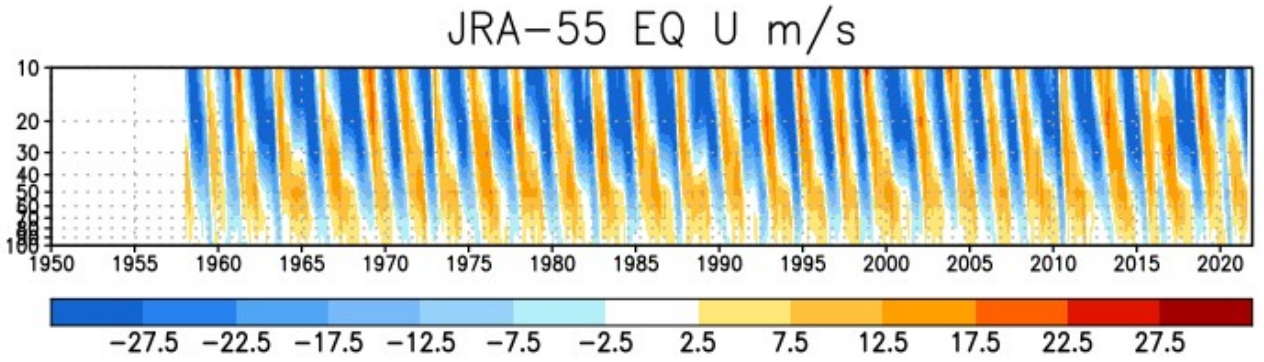
1950-present

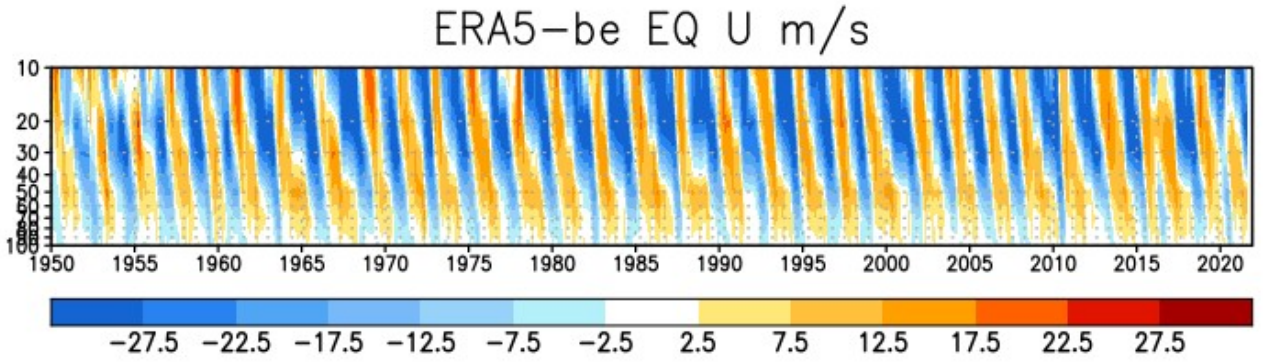
replacement for NCEP/NCAR Reanalysis (CDAS)

goals: climate reanalysis

- eliminate “climate jumps” found in CFSv2 from satellites
- fix problems found in CFSv2

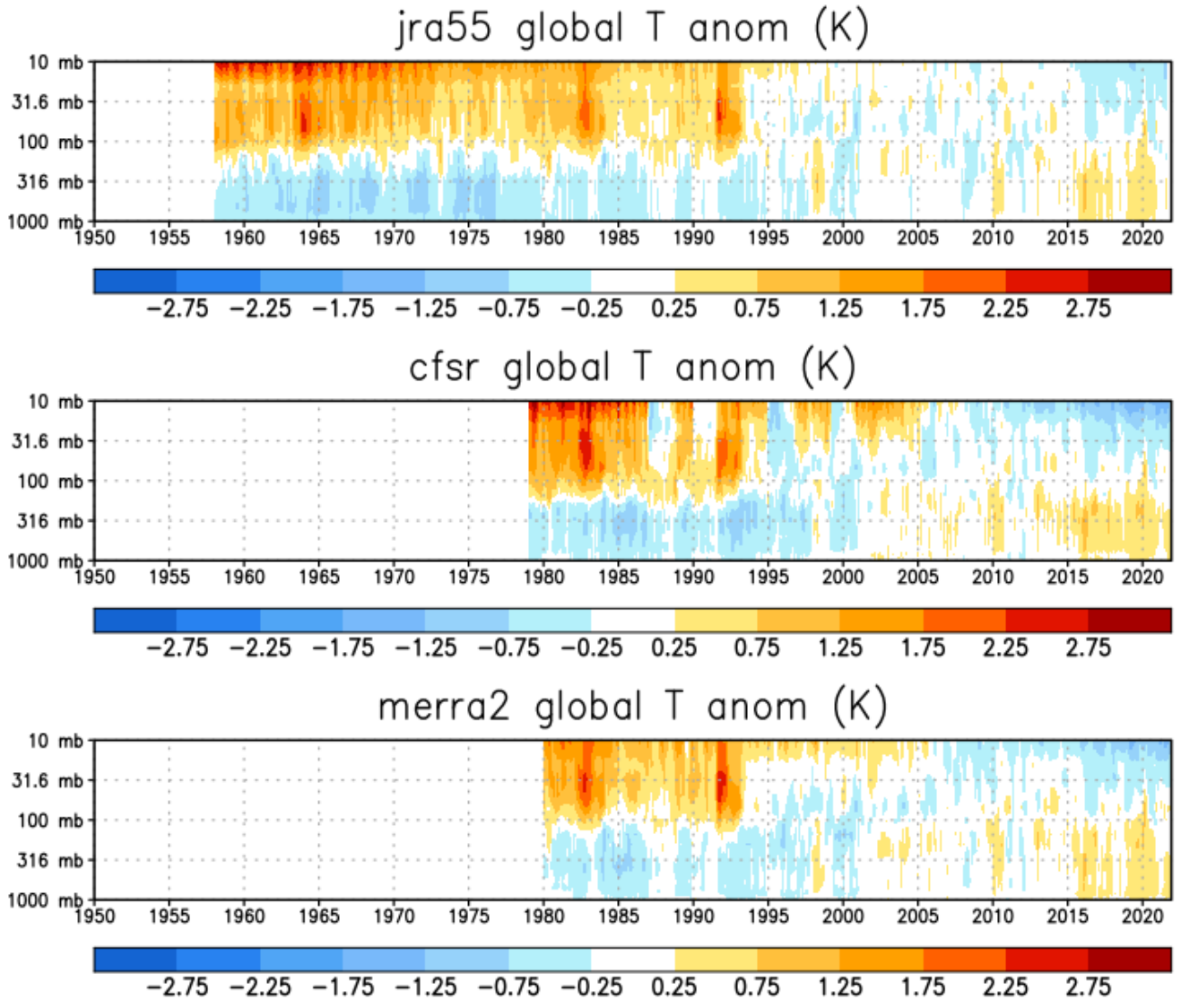






CFSR had to assimilate ERA-40 tropical winds in order to get the QBO prior to AMSU.

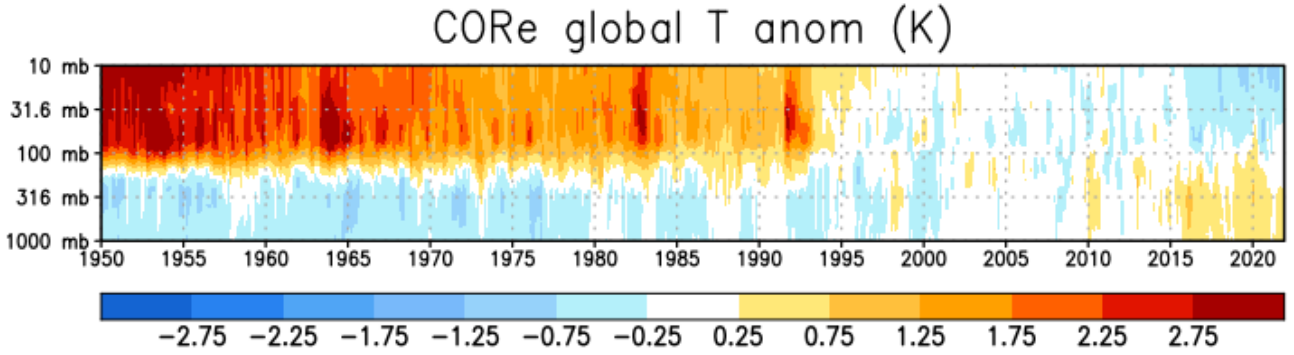
ERA-5, JRA-55 and CORe had no problems with the QBO.

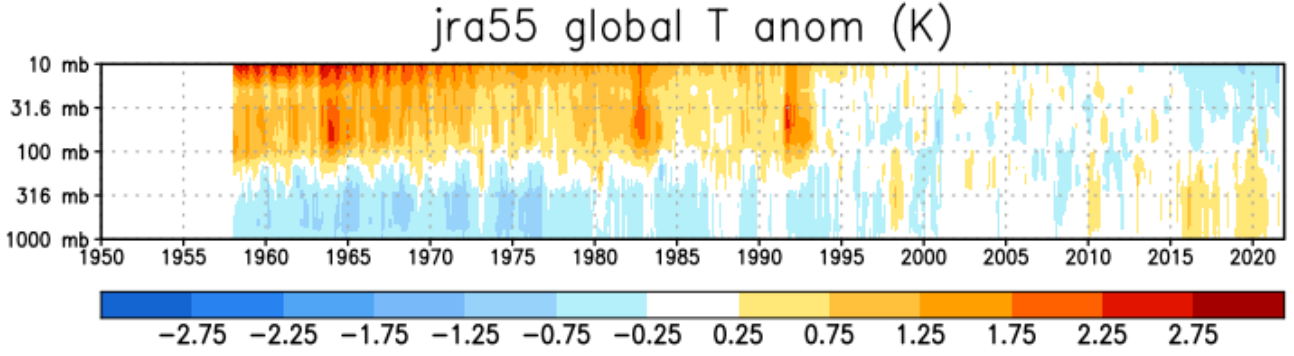


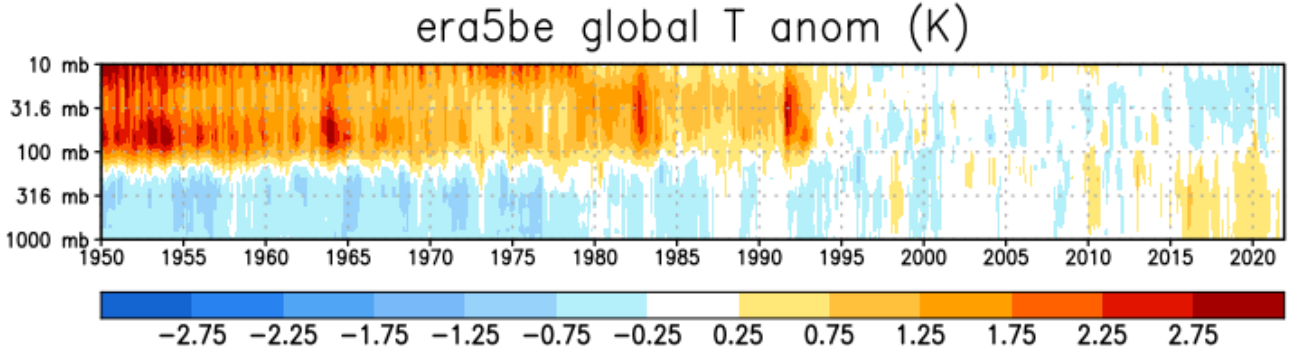
Older Modern Reanalyses

CFS has unusual pattern ~30mb, 1985-2005. Model problem ~10 mb, 1979-1987.

MERRA2 similar to JRA55 except for ~10mb 1982-2000.

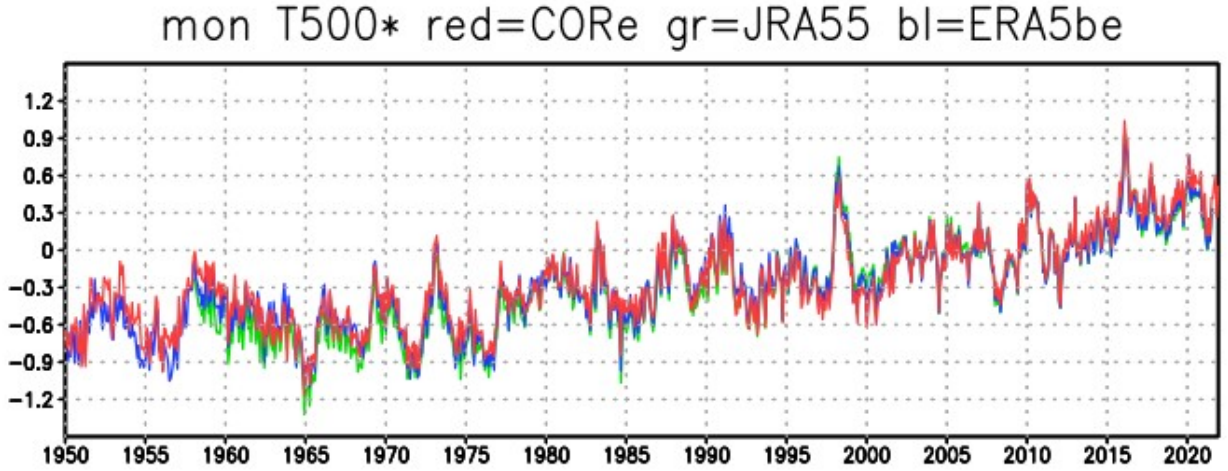


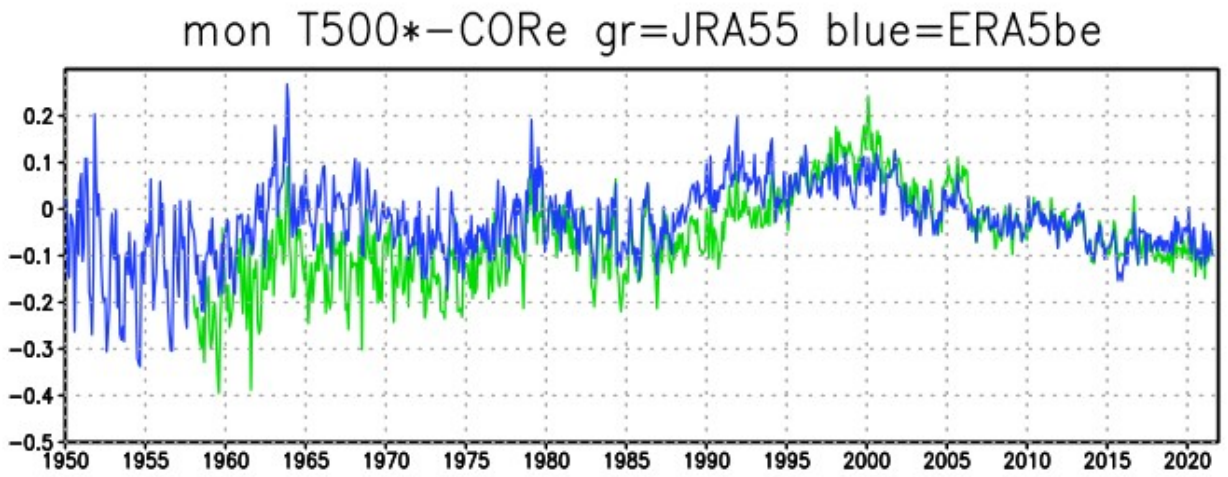




CORe, JRA55 and ERA5 are very similar. Gradual cooling in the stratosphere with volcanic warming, and gradual warming in the troposphere.

Theme: CORe, JRA55 and ERA5 are similar, and we are getting the climate trends.

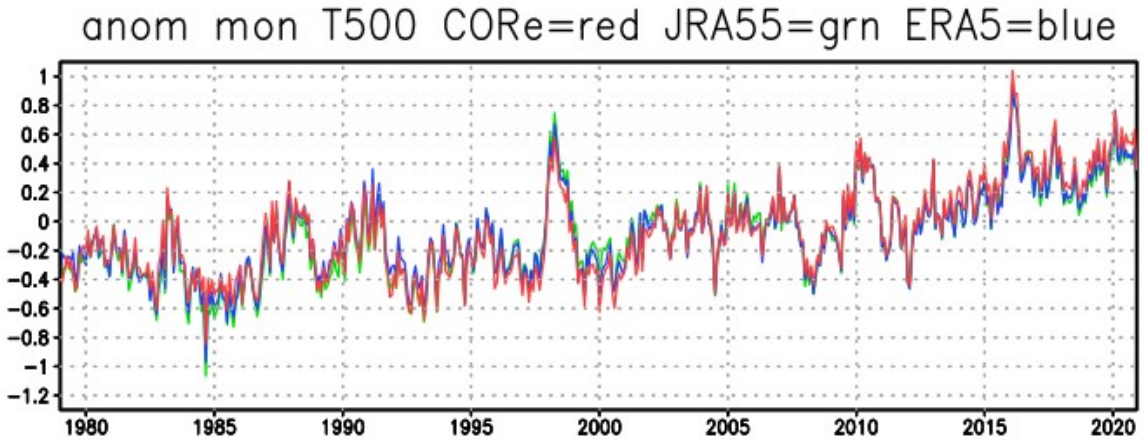


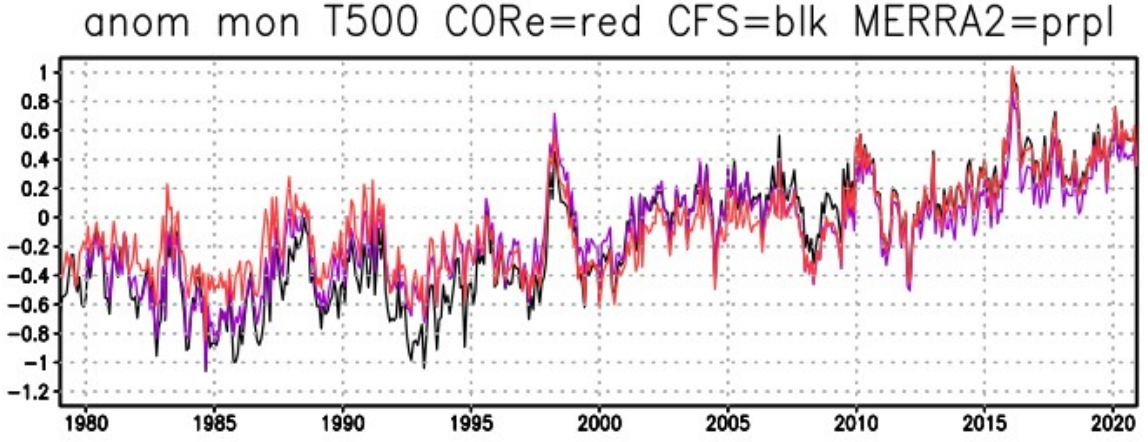


Anomalies of global monthly 500 mb temperatures. (1991-2020 clim)

Plot 1: CORe, ERA5 and JRA55 are in good agreement.

Plot 2: shows the differences from CORe anomalies. ERA-5 is in very good agreement with CORe. JRA55 is not as close to CORe but still in good agreement.





For the satellite period, CORe, JRA55 and ERA5 are in good agreement.

For CORe, CFS and MERRA2, they are very similar after 2010. For the 1979-2010 period, the deviations from CORe are O(0.4C). Since the expected trends are O(0.1C/decade), deviations are similar to the expected trends.

Things that we did differently:

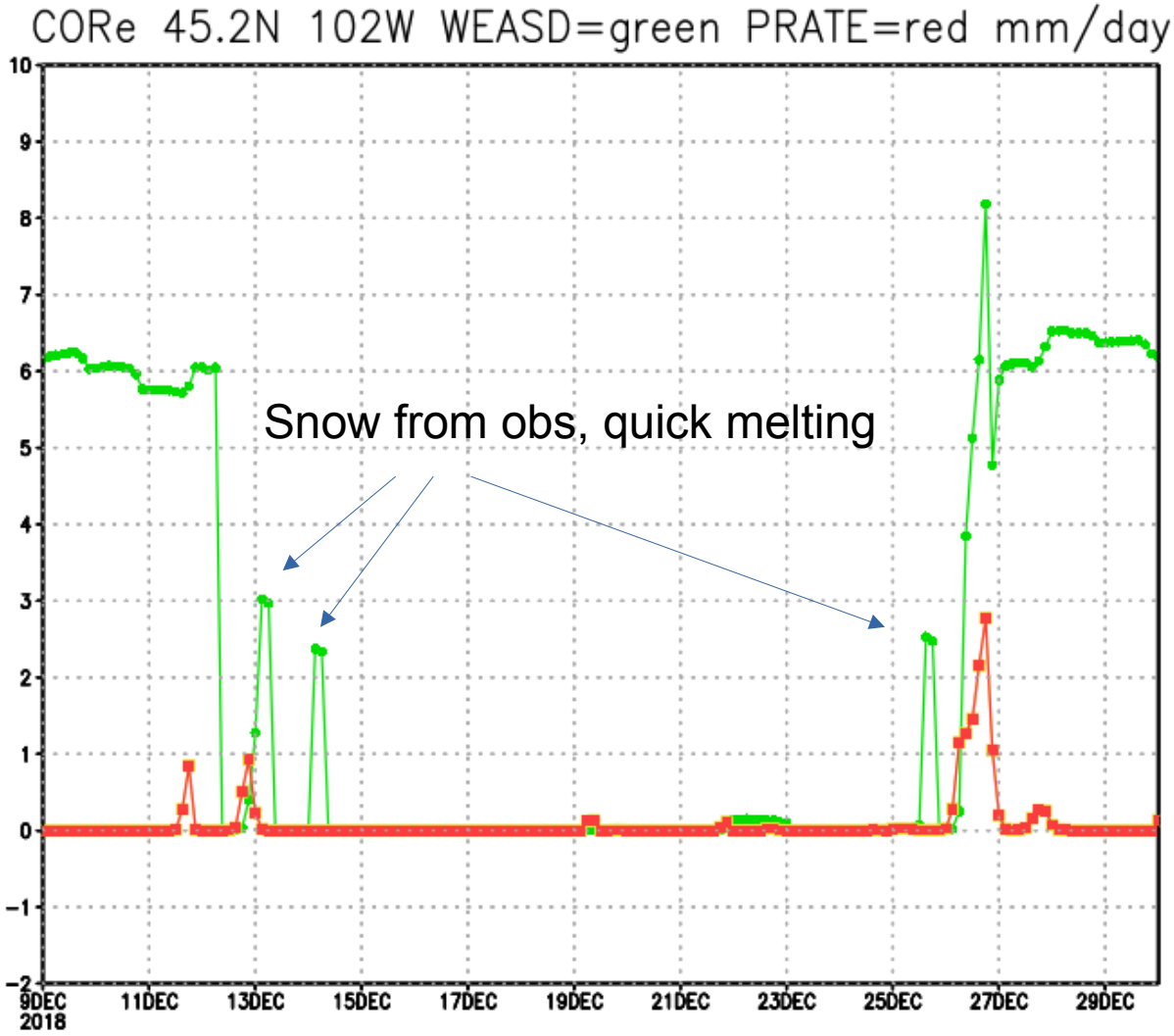
- Project for a climate reanalysis started as a fix for the problems with CFSR
  - Jumps with new satellite systems such as AMSU
  - QBO failed .. CFSR needed to assimilate ERA-40 tropical winds
  - Equatorial Z200, winds shear in hurricane genesis regions
- Solved some of the problems
  - Hybrid needed rocket sondes to get one QBO cycle .. pre-sat period?
  - Jumps from new satellite systems was proving to be extremely time consuming
  - Need to change course or failure!
- Jeff Whittaker suggesting using conventional obs ENKF system he developed
- Ran 1950-2016 using GFS-spectral ENKF, problem with excessive precip
- Funding: must use FV3 version of ENKF, FV3 fixed excessive precip

Advantages of ENKF

- No need to periodically calculate background error covariences
  - Limited manpower, only 2 FTE for CORe
  - JRA-55 (4D-Var) had problems because did not retune
- ENKF did a good job in the stratosphere
  - QBO compares well with ERA-5, JRA-55
- Ocean and land surface models are often based on ensembles, ENKF gives ensemble forcing

Things that we did differently

- Only used AMVs from satellites, no GPS-RO or thermal radiances
- No VAD winds, no profilers, no scatterometer for surface waves (and winds)
- No 5-day forecasts
  - Use other reanalysis for QC especially spectral-GFS ENKF
- Use model Gaussian grid for archives
  - Reduced interpolation error, important for low resolution analysis
- OSTIA SST when available
- AFWA snow depth for 1979+, “corrected” model snow prior to 1979
  - Every 2 days, remove snow if < 3mm, best (tested) fit to 2019 obs
- Save bfg/flux for each ensemble member as well as statistics file
  - Drive ocean models, land surface models, precip estimates
  - Other uses? Insurance?
- Save limited # pgb fields for ensemble members, space! Utility? Gaussian?


CORe 45.2N 102W WEASD=green PRATE=red mm/day
Snow from obs, quick melting
10
9
8
7
6
5
4
3
2
1
0
−1
−2
9DEC
2018
11DEC
13DEC
15DEC
17DEC
19DEC
21DEC
23DEC
25DEC
27DEC
29DEC

GrADS/COLA

Things that we would do differently

- Snow?
- Quality of historical AFWA snow depth varies.
- Sooner or later, model snow will be good enough
- Worried about mismatches in model and obs snow leading to excess SOILM
  - Satellite sees snow
  - Snow added to analysis
  - Model melts snow and adds to soil moisture
  - repeat

Processing

wgrib2 -ens_qc

- One member’s ozone was unreasonable (hardware problem)
- QC: ensemble member deviations from ensemble
- Calc Q= (max|min) deviation / std deviation for ensemble members
- Q for each grid point, and global value

Post Processing

- gfsnemsio2grb
- Convert nemsio to grib2
- Fortran code using wgrib2api
- Only handles fields with grib identifier

Post Processing

- NCEP post
- Fixes to code for CORe usage

Post Processing

- U, V to stream function & velocity potential
- grib2 → grib2
- Uses wgrib2api

Post Processing

- spost (simple post)
- Fast, used for pressure-lev post of ens. members
- Fortran code for very simple post
  - Input: grib2 data on hybrid pressure coordinates
  - Output: grib2 data on pressure, hgt coordinates
  - doesn’t require MPI
  - Uses wgrib2api

Post Processing

- Ensemble statistics
- wgrib2 -ens_processing
  - Ens mean, ens spread
  - 10%, 25%, 50% (median), 75%, 90%
  - Min, max values (per grid point)
  - Custom calculations for CORe
    - % of precip, % of precip > trace
    - % of T2m > 0C
    - 95% 10 meter wind speed

Misc

- Yet another MPMD
- Perl script using fork
- Very handy for post processing ensembles

Misc

- wgrib2 -ndates
- Generates a list of dates
- Do-loop syntax
- Turns out to be very useful in scripts