A Conventional Observation Reanalysis (CORe) for Climate Monitoring

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Outline of Presentation

1. What is CORe? Why another reanalysis?
   CORe = Conventional Observation Reanalysis
   Make a reanalysis that avoids the spurious jumps caused by satellite observations.
   Replacement for NCEP/NCAR Reanalysis for climate monitoring.

2. Status of satellite period reanalysis. Satellites affect a conventional obs reanalysis?
   1982-2020 period is being produced (80% done)
   Satellites are used for SST and snow cover analyses that used by CORe.

3. Status of pre-satellite period. Problems?
   There is no snow analyses. The model produces more snow cover than observed.
   If we use model generated snow, we will get a regional cooling in parts of the year.

4. What data is being archived and how do I obtain it?

What is CORe? Why another reanalysis?

CORe: Conventional Observation Reanalysis

Assimilate conventional observations and AMV (Atmospheric Motion Vectors like cloud track winds). Try to avoid the spurious jumps caused by assimilating satellite data found in the CFSR and most other reanalyses.

Make a reanalysis that trades some spatial accuracy for better trends for climate monitoring.

This reanalysis is designed to replace the NCEP/NCAR Reanalysis at the Climate Prediction Center for climate monitoring. It is not designed to produce the best initial conditions for model forecasts. We are trying to get a balance between trends and spatial accuracy.

When complete, CORe will cover 1950-present with a 0.7 degree grid (512x256 Gaussian)

Model: cubed sphere FV3-GFS model, 64 vertical levels, C128 grid.
The data assimilation is a Ensemble Kalman Filter (from ESRL), 80 ensemble members
80 analyses are produced which are equally likely (no control run)
6 hour incremental update, force the model for 6 hours, and then make short free forecast
03/09/15/21Z “analysis” at end of incremental update (forcing model)
00/06/12/18Z “analysis” 3 hour free fcst which allows for some spin-down from update

A prototype of this system using the GFS spectral model produced similar or better results than NCEP/NCAR Reanalysis which uses satellite data.

Status of Satellite Period CORe?

Multiple streams from 1982-03 – 2020-02. 80% done

Why 1982-03 not 1979-01?

Had a storage crash on Gaea and lost 1979-1982 (and data from other streams)

Managed to recover enough to start in 1982-03.

Used the restart to change SST from Reynolds to OSTIA when possible.

Too large precip in the prototype CORe has been reduced and is acceptable.

Global precip is larger than observed but similar to other reanalyses.

Global precip shows smaller trends than reanalyses which use satellite data

Early evaluation using ERA5 as truth

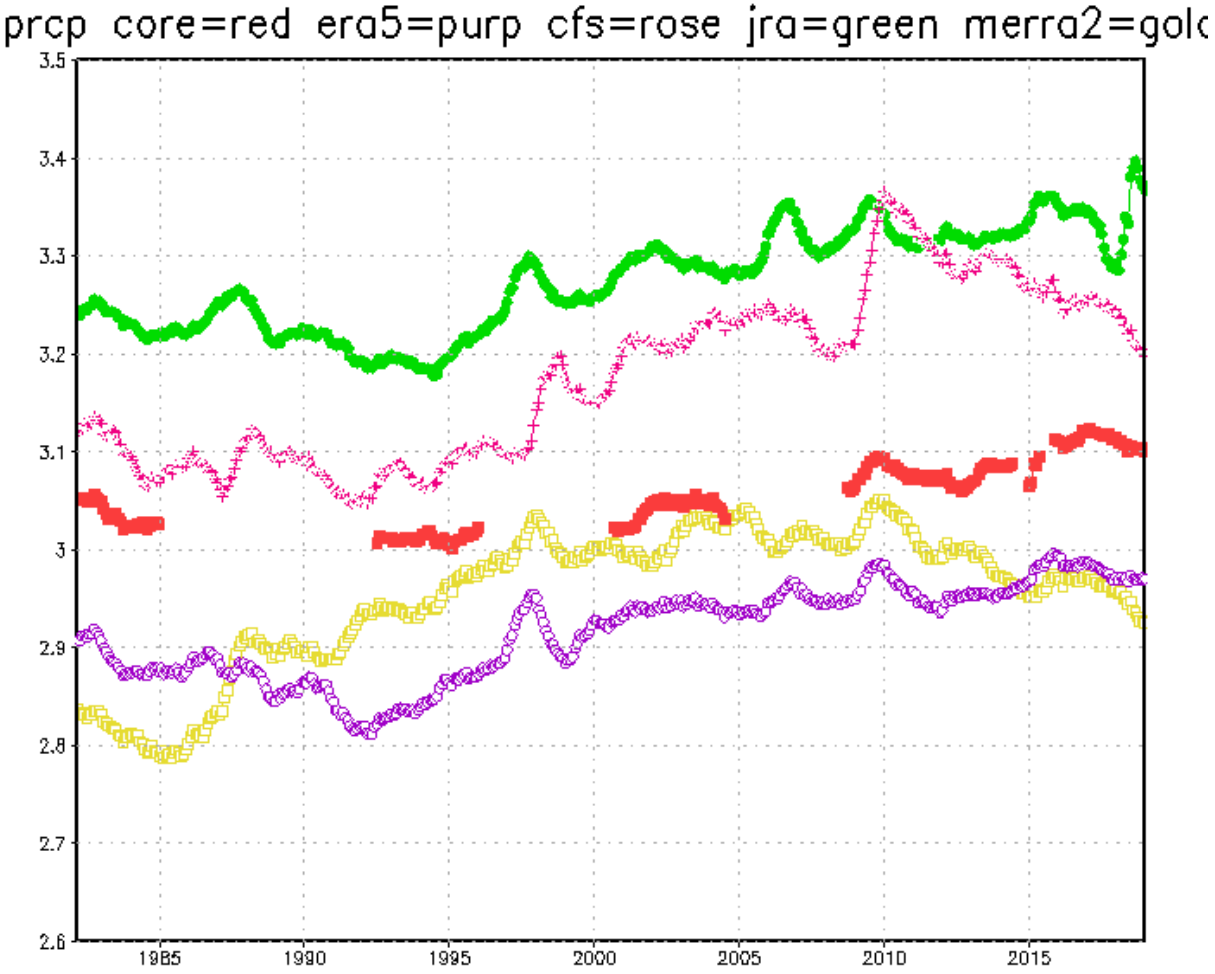
Fv3gfs and gfs-spectral are different models, so the results are not the same,

However, many common features.

Monthly means relative to ERA-5 are similar to prototype CORe but show

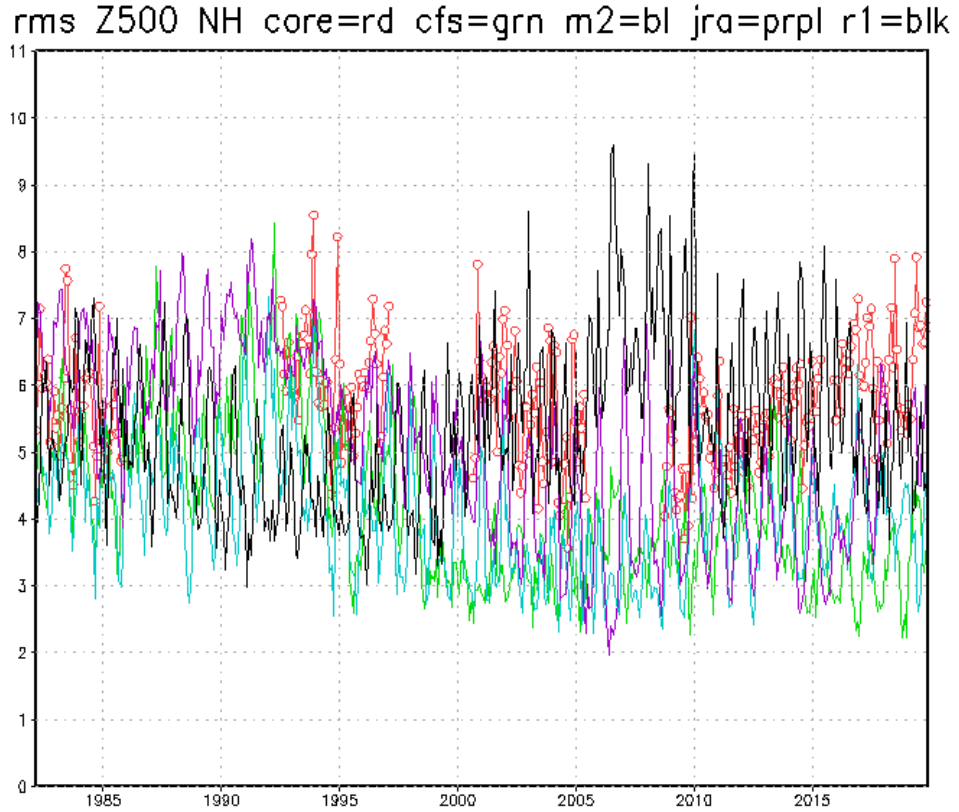
tropospheric heights are worse, tropospheric T, U are better.

Global Monthly Precip



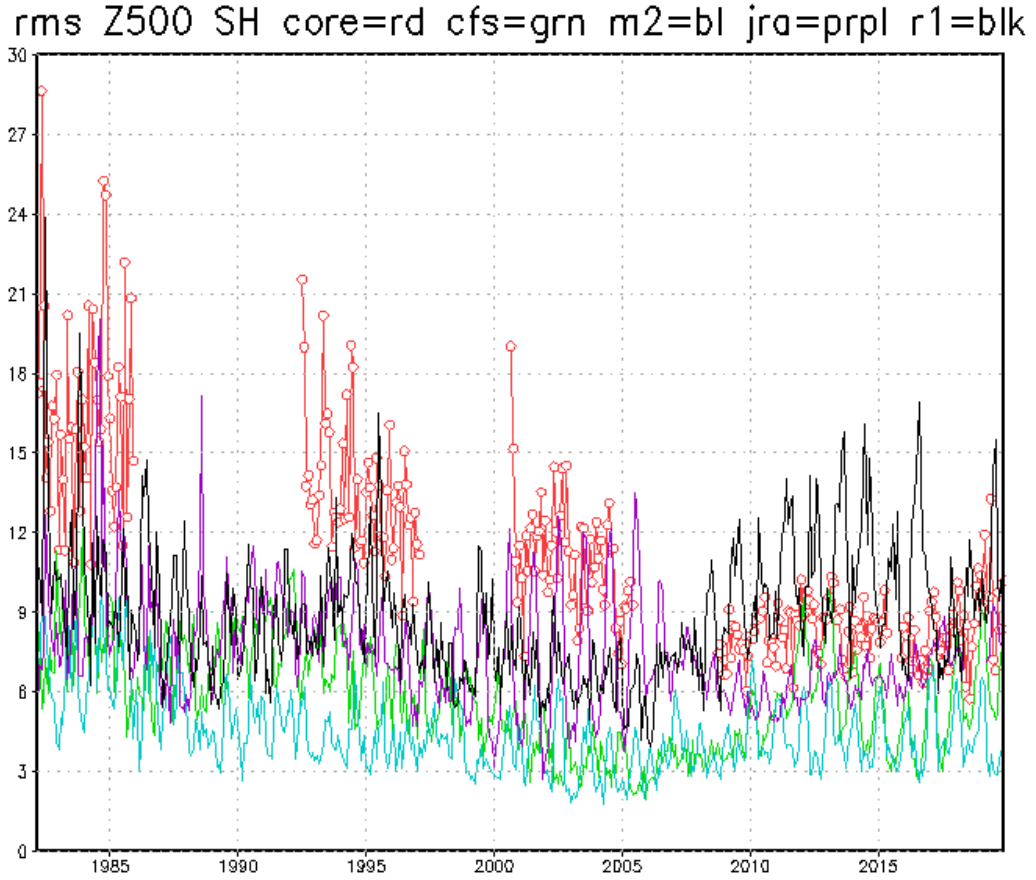
12 month running mean of global monthly precip. CORe (red) shows the smallest trends, followed by era-5 (purple). GPCP v2.3 (obs precip) has less trend than all the reanalyses.

RMS using ERA-5 as reference



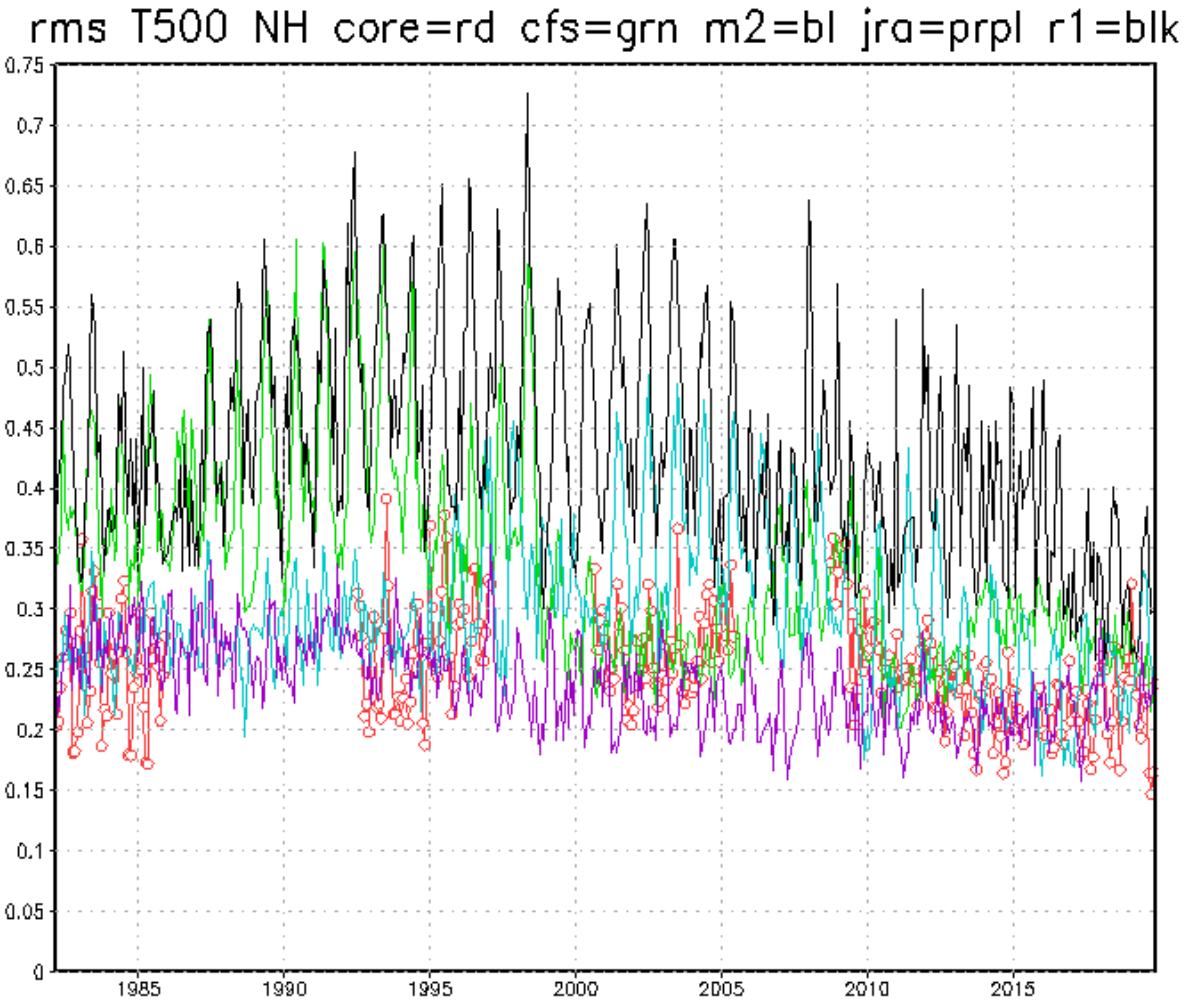
RMS of 500mb monthly mean height (30N-60N), CORe (red), R1 or NCEP/NCAR Reanl (black) are larger than CFSR (green), Merra2 (blue) and JRA55 (purple). The modern satellite reanalyses have a lower RMS but not by large margin.

RMS using ERA-5 as reference



RMS of 500mb monthly mean height (60S-30S), CORe (red) shows larger RMS differences until 2005 when it matches R1 and CFSR. This is more difficult case for CORe because the SH has fewer tropospheric observations unlike the other reanalyses which use satellite data

RMS using ERA-5 as reference



RMS of 500mb monthly mean TMP (30N-60N), CORe (red) is comparable toe JRA-55 (purple), Merra2 (blue) and better than R1 (black) and CFSR (green).

Satellite period summary

The precip time series is difficult for reanalyses that use satellite data. CORe had less trend than the reanalyses that were compared.

Using ERA-5 as a reference, monthly means from various reanalyses were compared. In data poor regions, the CORe was sometimes worse and sometimes better than R1. Sometimes CORe was comparable with the modern satellite reanalyses.

More plots are included after the summary slide.

Pre-satellite Period

No AMV (prior to mid-1970s)

AMV are assigned large errors (height errors)

AMV are not a crucial obs type because of the height errors

SST: analyses are monthly

Snow: big problem

Unlike the prototype CORe, we ran tests.

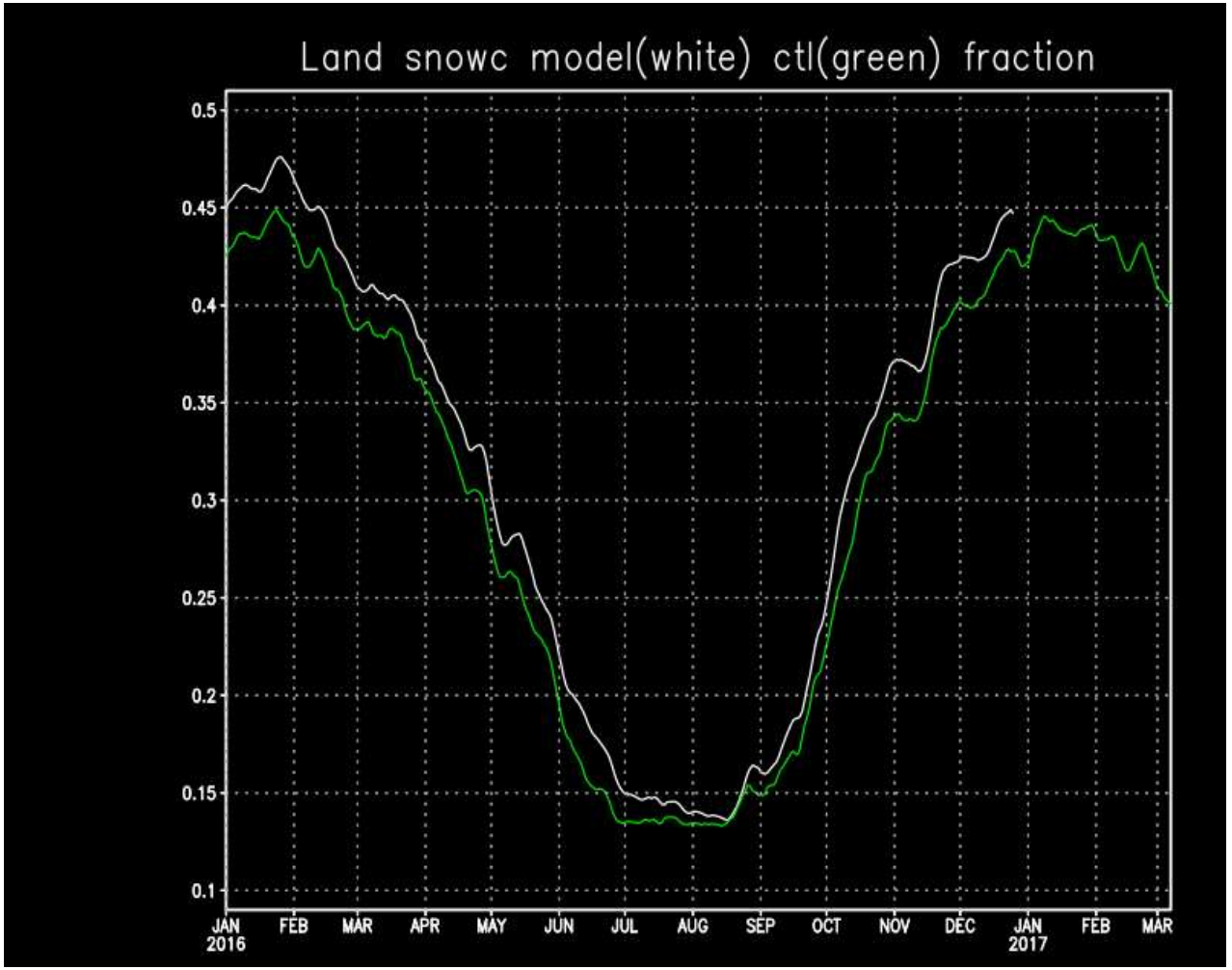
We assimilated 2016 with snow analysis, and again with model generated snow.

Selected 2016 because it was completed recent year

Found the model snow cover typically is 2.5% too large (global snow cover over land). 2.5% may seem small but a global number understates the regional value in certain seasons.

We limited our comparisons to snow cover because albedo is an important factor and snow depth analyses are inaccurate for deep snow.

Using Model Snow



The model snow (white) covers more land than the observed (green).

Snow experiments

Want to adjust the model snow otherwise will produce a cooling in the per-satellite period.
Don't want a scheme that would relax to a climatology because it would produce
a warming if the climatology is warm relative to the per-satellite period.
Want something that is physical justifiable.

What is the albedo of 2mm snow depth? The albedo of 2mm snow at a point will be different that 2mm average on a 70km x 70km grid cell. Maybe the surface features will mean the X% of the grid cell is covered. Maybe we should treat it as snow free?

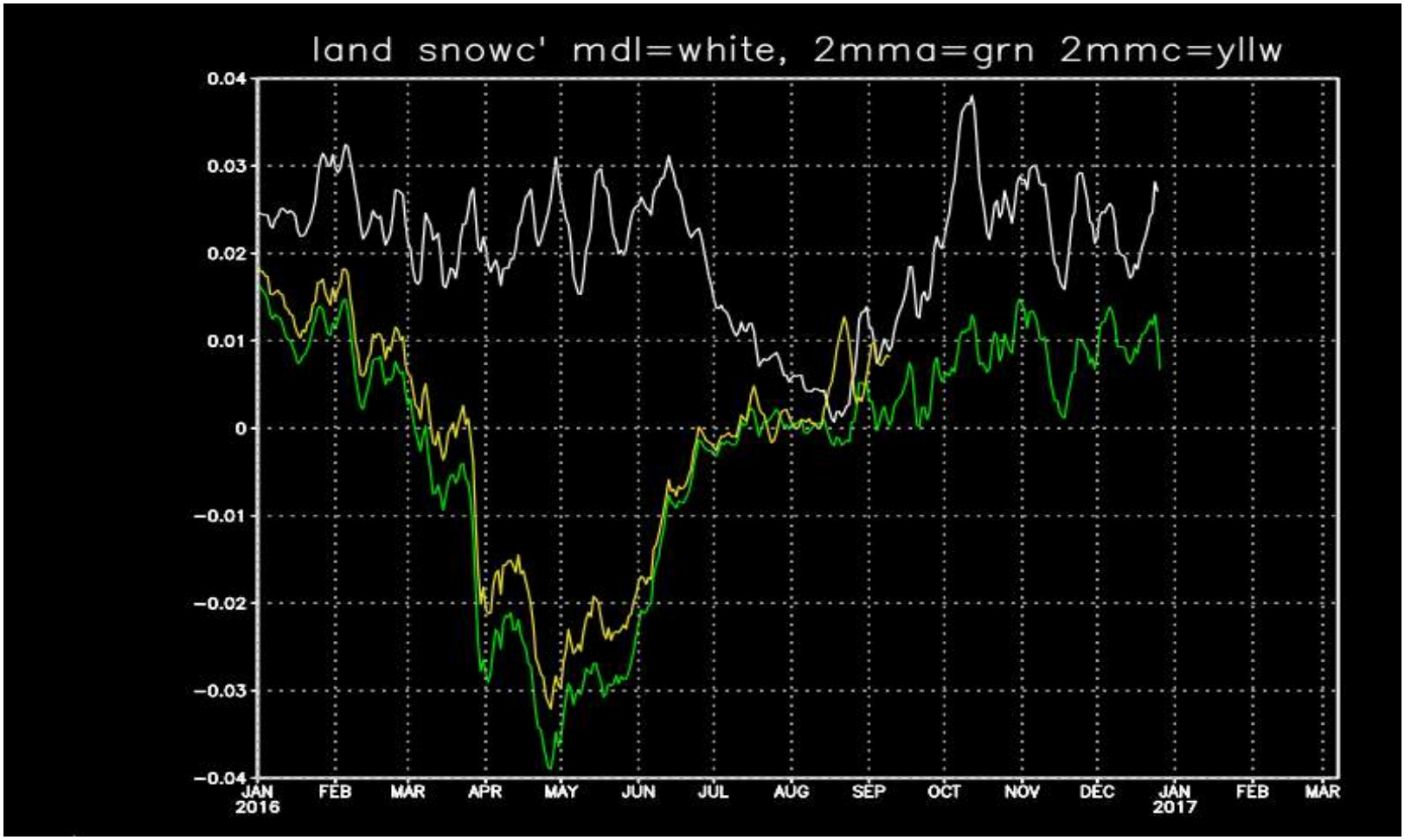
Experiments:
- Use a 1mm and 2mm snow depth threshold
- Every day or 2 days, take the model snow depth, remove snow and treat it as a snow analysis

Results: 2mm threshold, remove snow every day (others are incomplete)
- Bias in land snow cover is reduced 0.020 → -0.002 (fractional snow coverage)
- RMS error in snow cover is reduced 0.022 → 0.014

- The test with 2mm snow removed once every 2 days is incomplete but looks better.

Planning new set of tests assimilate the snow mass. Assimilating the snow depth has a problem with a different snow density used by the DA and model.

Snow experiments



The first test, 2 mm threshold applied one a day reduced the bias by 90% and RMS by 35%.

CORe Status

The 1982-03 to 2020-xx will be finished in months.
We may change 1982-03 to a later date for additional overlap from earlier stream.
2020+ will be run in a non-operational mode (not real-time)
Need to decide on how to handle the no snow analysis situation.
Cannot expect perfection .. require a better snow scheme.
Try to reduce the bias and rms error in snow cover (our criteria for a good scheme).
A scheme that works best for 2016 may not be best 2018 or 1960. So don't want to spend too much effort trying to optimize for 2016. Need to do 1950+.
Need to port and convert the code to run in real-time operations
Need to work with data archive sites (NCAR, ESRL) for distribution.

Increments from data assimilation step:
Need to develop codes to remove restricted data.
Need to useful codes to analyze the increments and make it useful to the users.
Never had time to develop the codes and will not happen until after the CORe is ported into operations.

CORe Grib2 Datasets

All grib2 files are on a 512x256 Gaussian grid (use wgrib2 to interpolate)
Sample files: https://ftp.cpc.ncep.noaa.gov/wd51we/reanal/core_sample/grib

Ensemble means
- 3 hours
- can be interpolated to other grids using wgrib2
- pgb files created by ncep-post (UPP)
- flux files directly from nemsio files

Ensemble members:
- every 3 hours
- limited variables and level pgb file created by spost
- flux files directly from nemsio files

Ensemble Summary
- every 3 hours
- summary variables 1-13:

  https://www.cpc.ncep.noaa.gov/products/wesley/wgrib2/ens_processing.html
  - spost_stats
  - flux_stats

CORe NEMSIO Datasets

NEMSIO files can be used restart the FV3gfs model and run the post-processing.
For restarting, you need a surface and atmospheric NEMSIO file.
Sample files are in https://ftp.cpc.ncep.noaa.gov/wd51we/reanal/core_sample/nemsio

Ensemble means (surface and atmospheric)
- 12 per day (8 analyses, 4 forecast for budgets)

6 Ensemble members (surface and atmospheric)
- 6 ensemble members at 00Z
- run forecasts

80 member surface nemsio files (optional, duplicated by grib flux files)

Suggested Software Tools

Grib inventory: wgrib2 v3.0.0
Grib interpolation: wgrib2 v3.0.0
Grib display: GrADS with alt_g2ctl/alt_gmp, g2ctl/gribmap (not for stat files)

Nemsio → grib: gfsnemsio2grb

Nemsio → pgb: ncep-post (modified)
Nemsio → pressure level: spost (simple post)
Nemsio → height levels: spost (simple post)
Nemsio → hybrid level: gfsnemsio2grb

Python: pywgrib2_s

These tools were used in the development and running of CORe
NCEP-post may be difficult to install and run.

Is XYZ Field Available?

Download the sample files from

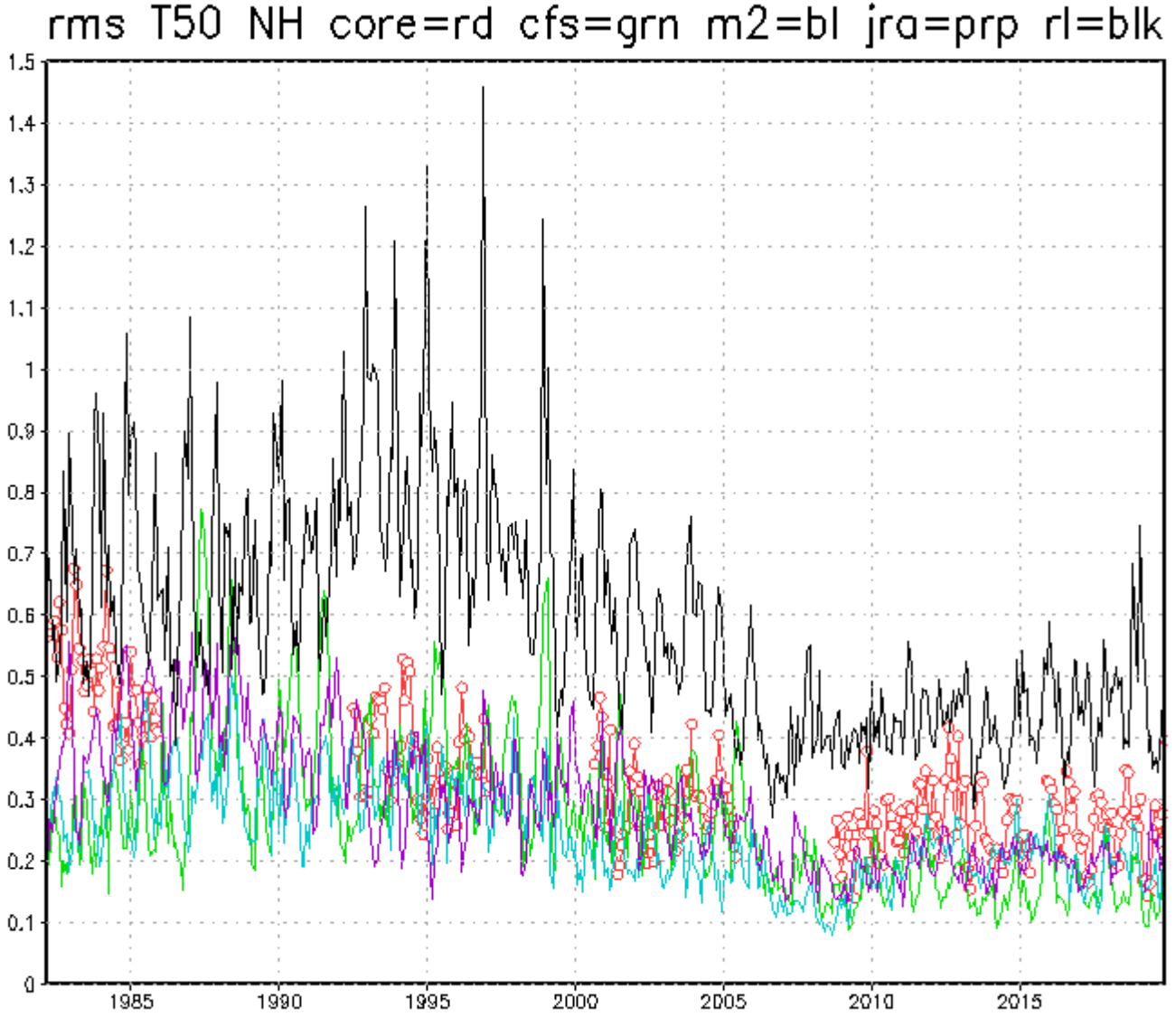
https://ftp.cpc.ncep.noaa.gov/wd51we/reanal/core_sample/grib/*.grb

The files are small because all the data has replaced by zero. Run wgrib2 -v on the sample file and grep for the field that you want. Easier than searching pages of inventories.

End of presentation

Questions? Email wesley.ebisuzaki@noaa.gov

More RMS differences of monthly fields follow.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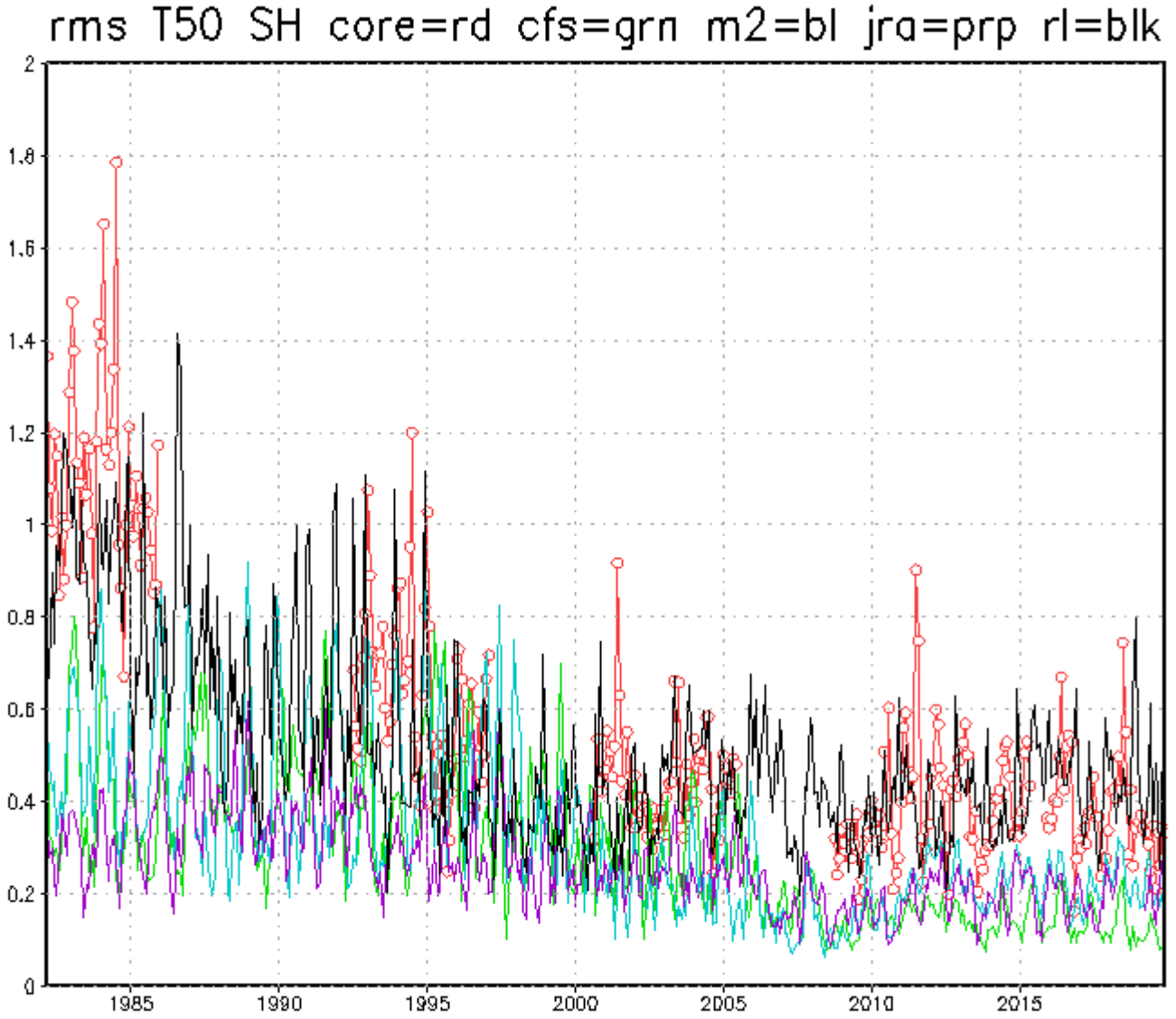
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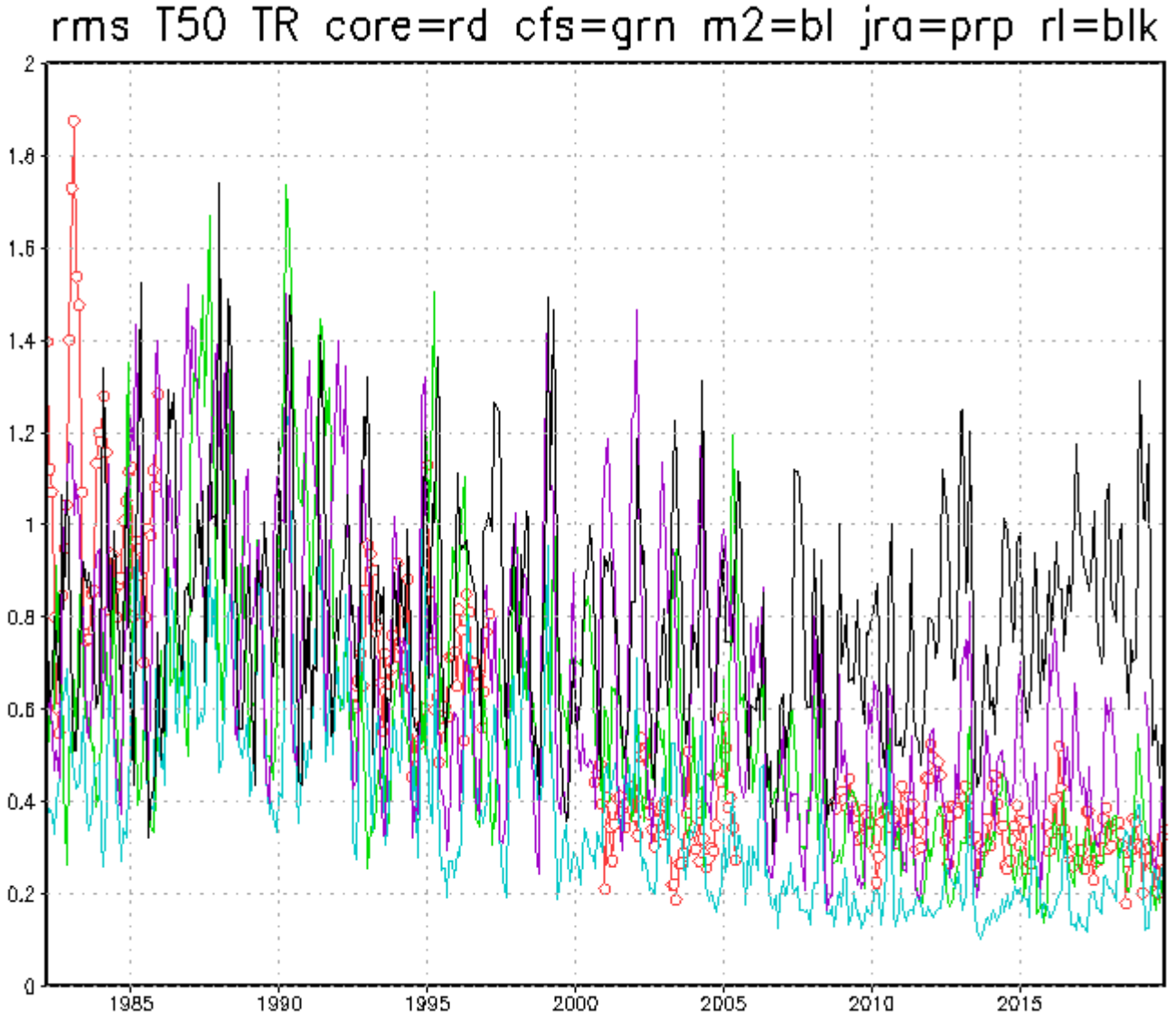
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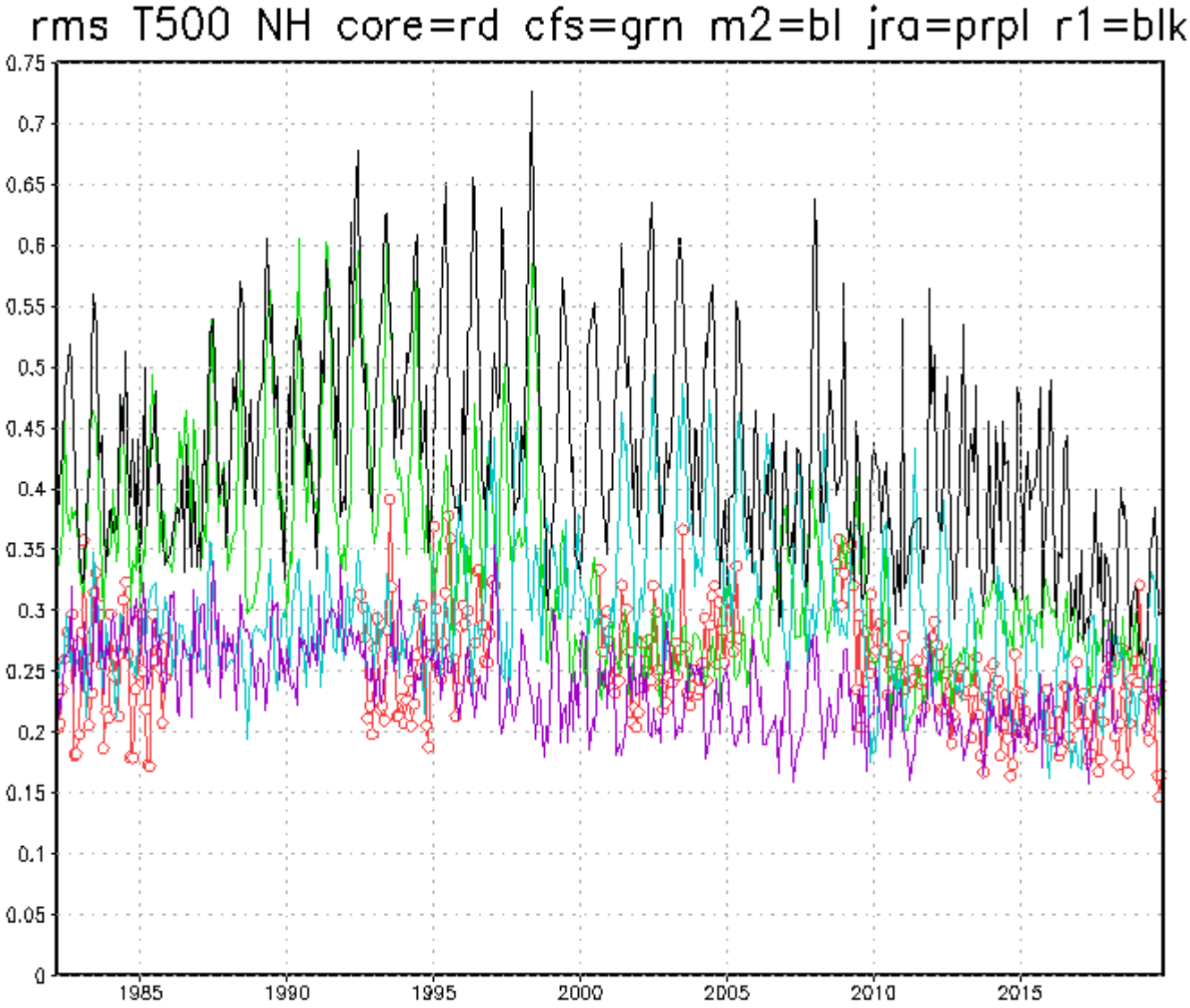
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0.65
0.6
0.55
0.5
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0.25
0.2
0.15
0.1
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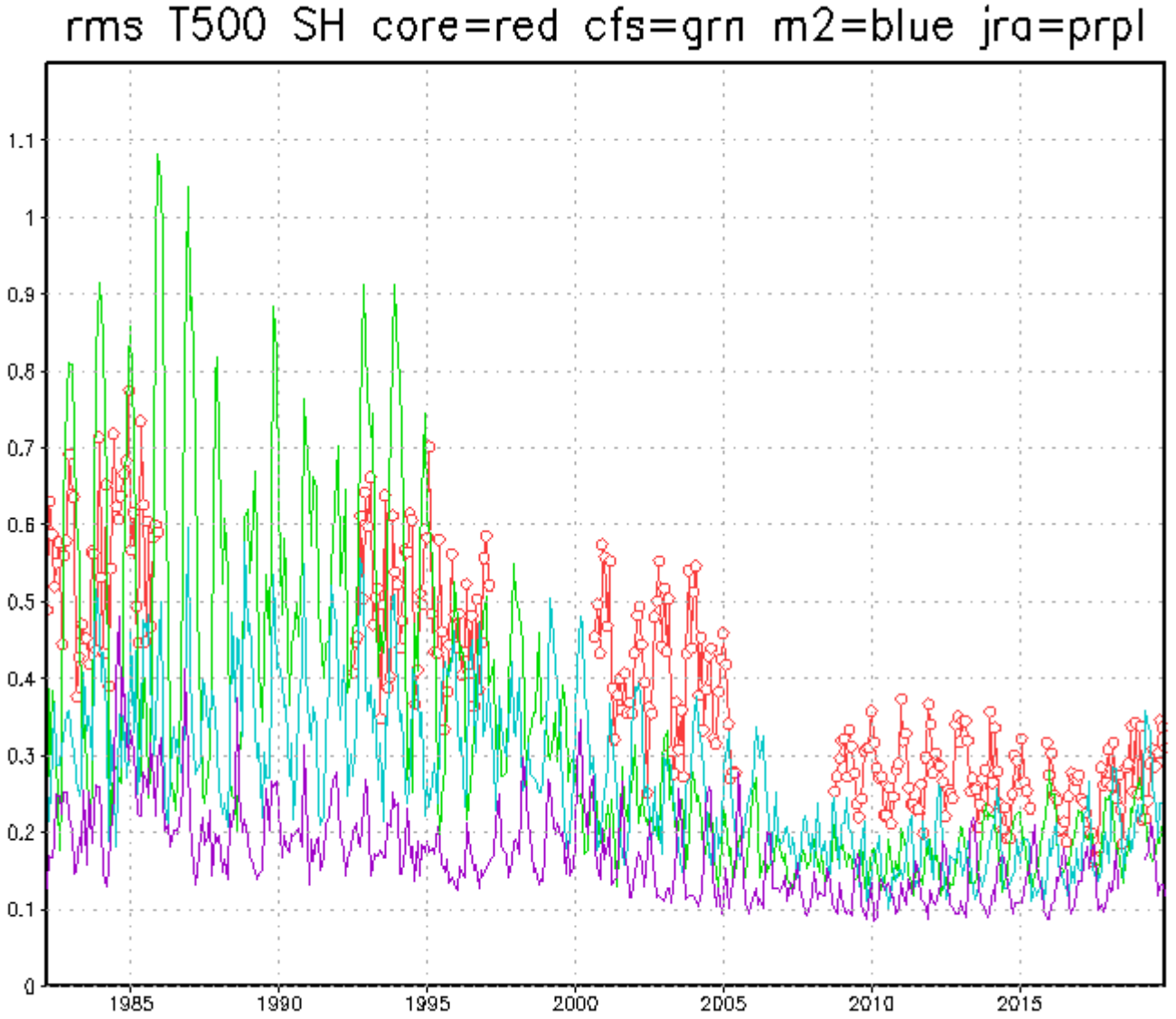
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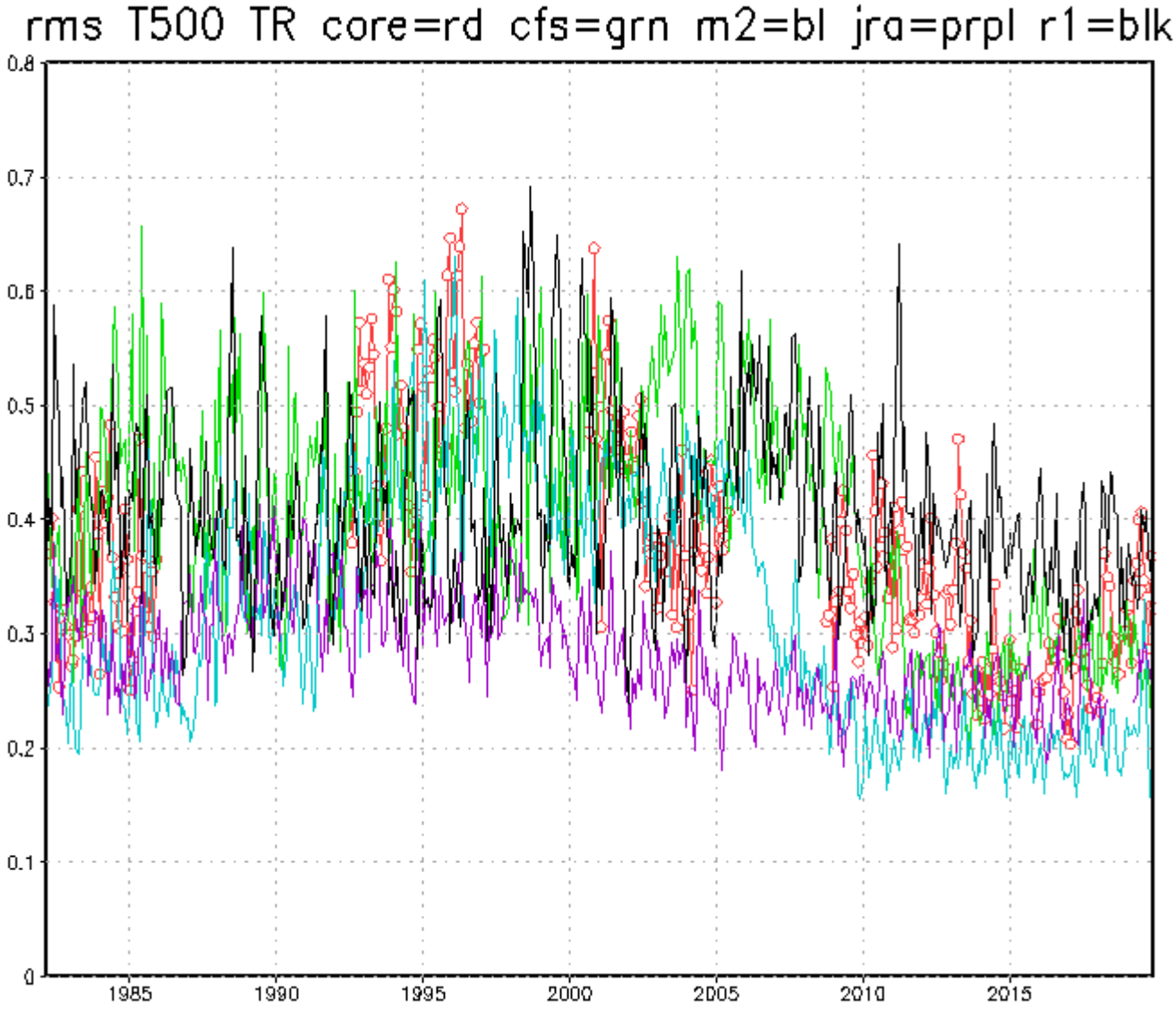
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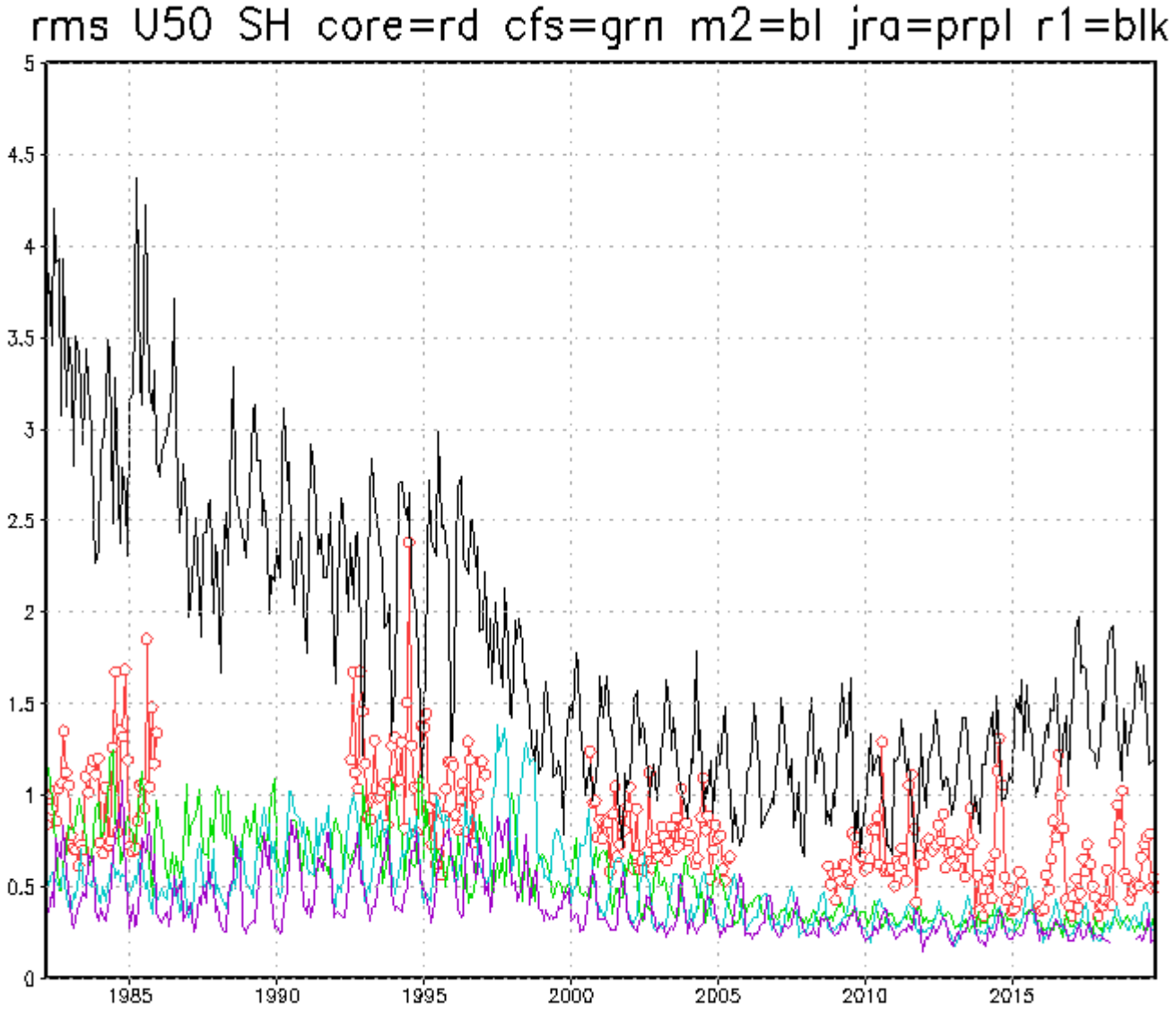
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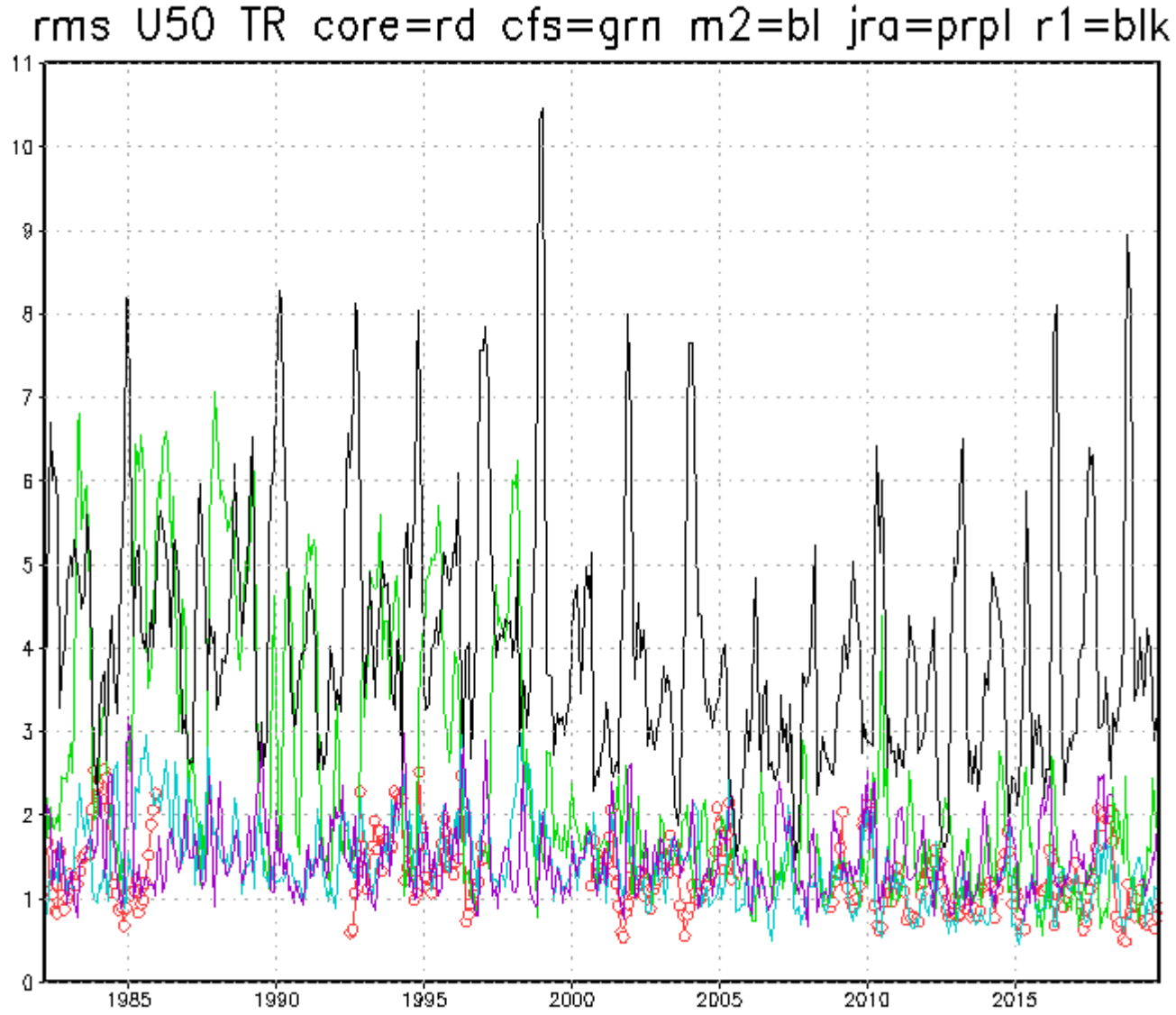
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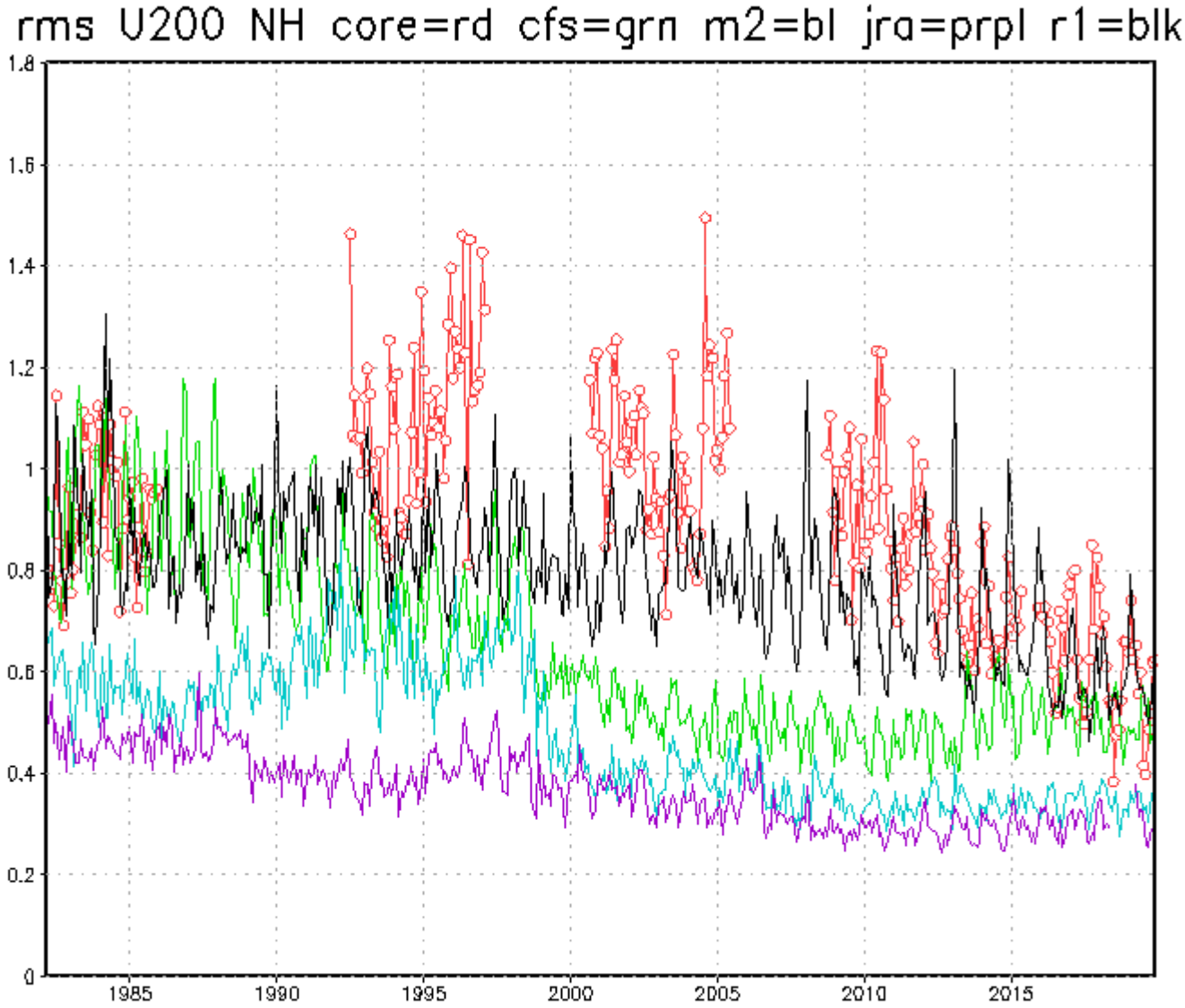
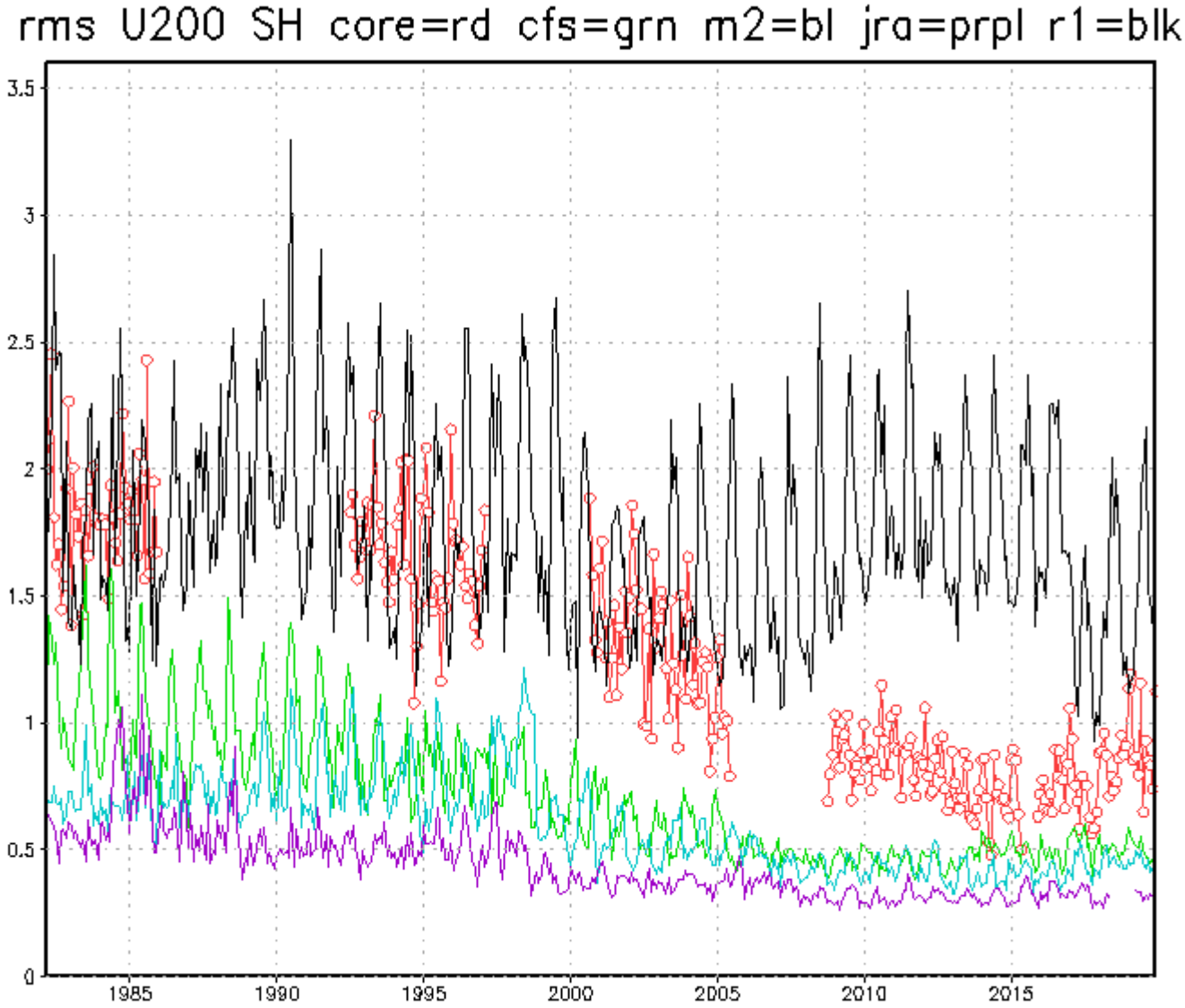


GrADS: COLA/IGES



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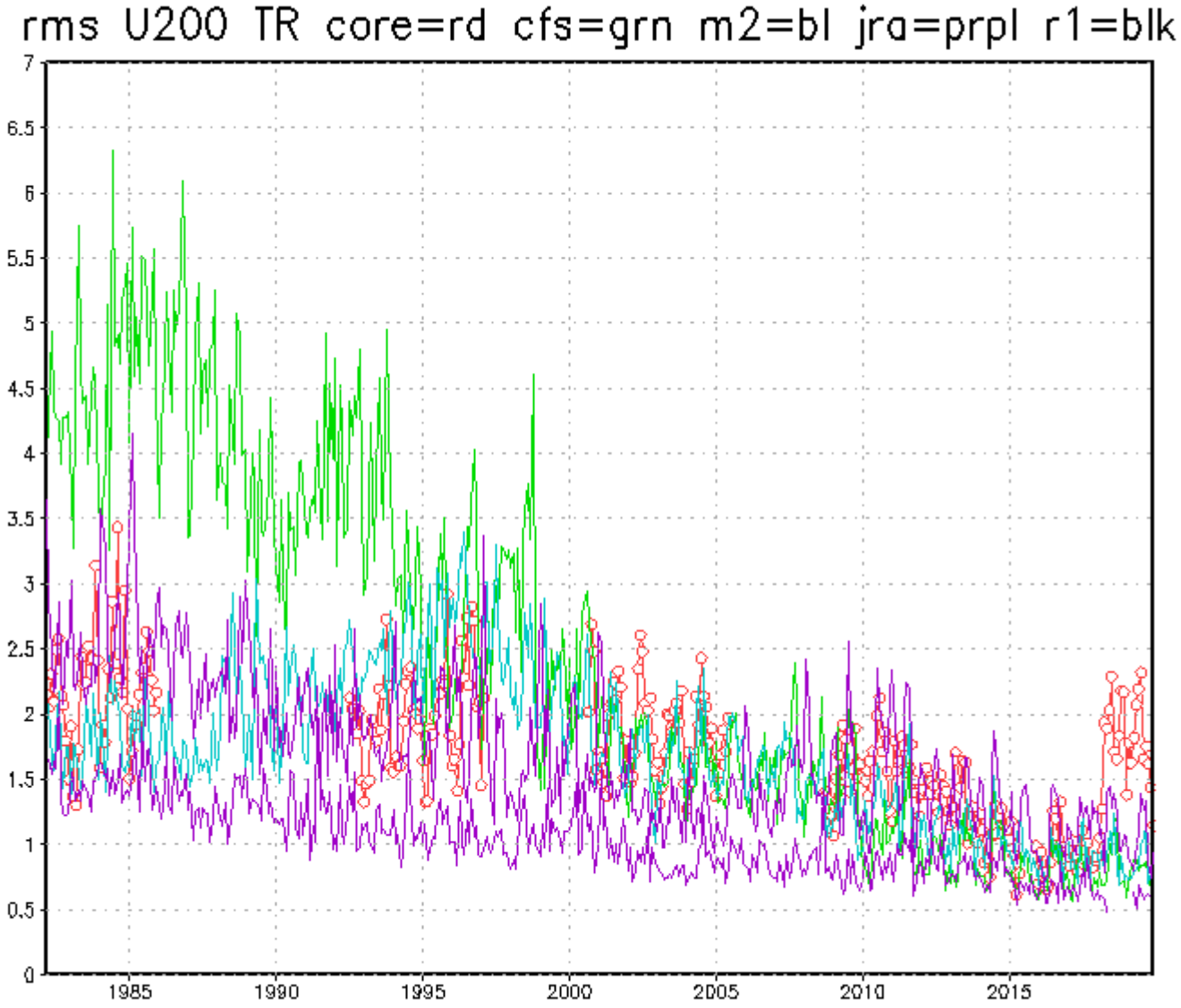

GrADS: COLA/IGES