Trends from Reanalyses: Progress over the last 10 years

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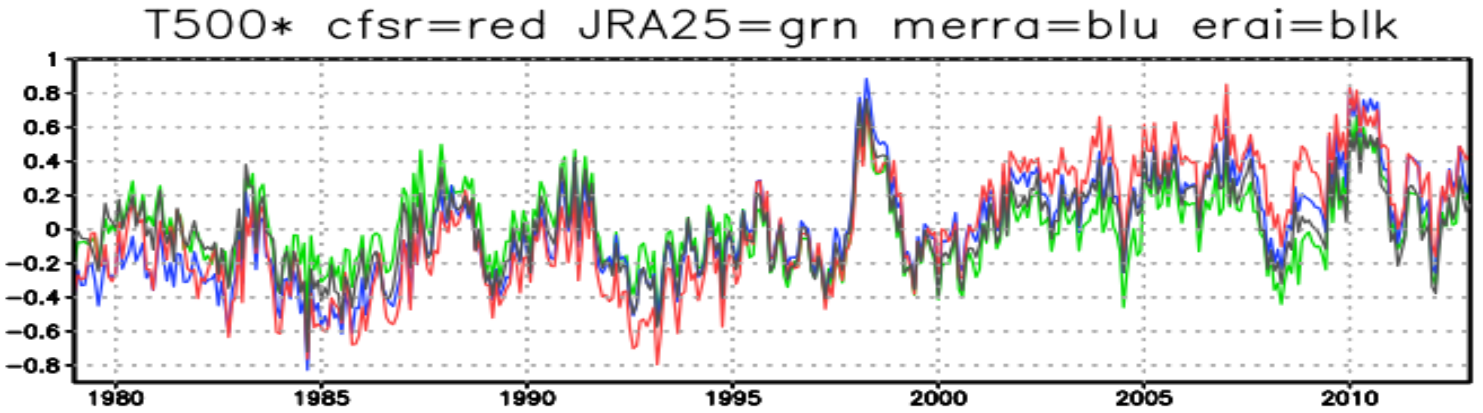
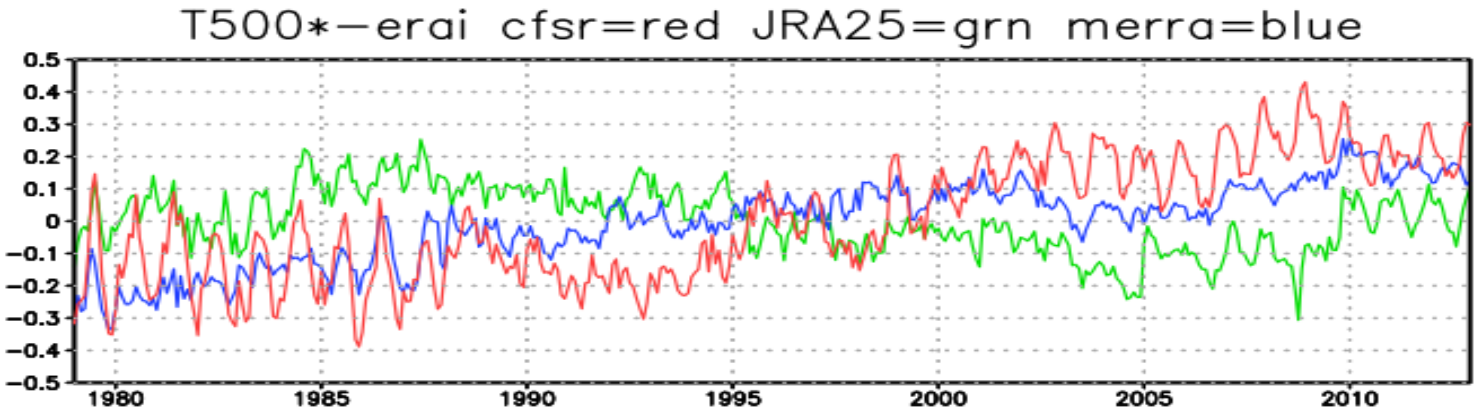
- 2012 the leading global atmospheric reanalyses were
  - CFSR (NCEP, ongoing)
  - ERA-interim (ECMWF, ended)
  - JRA-25 (JMA and CRIEPI, ended)
  - MERRA (NASA, ended)

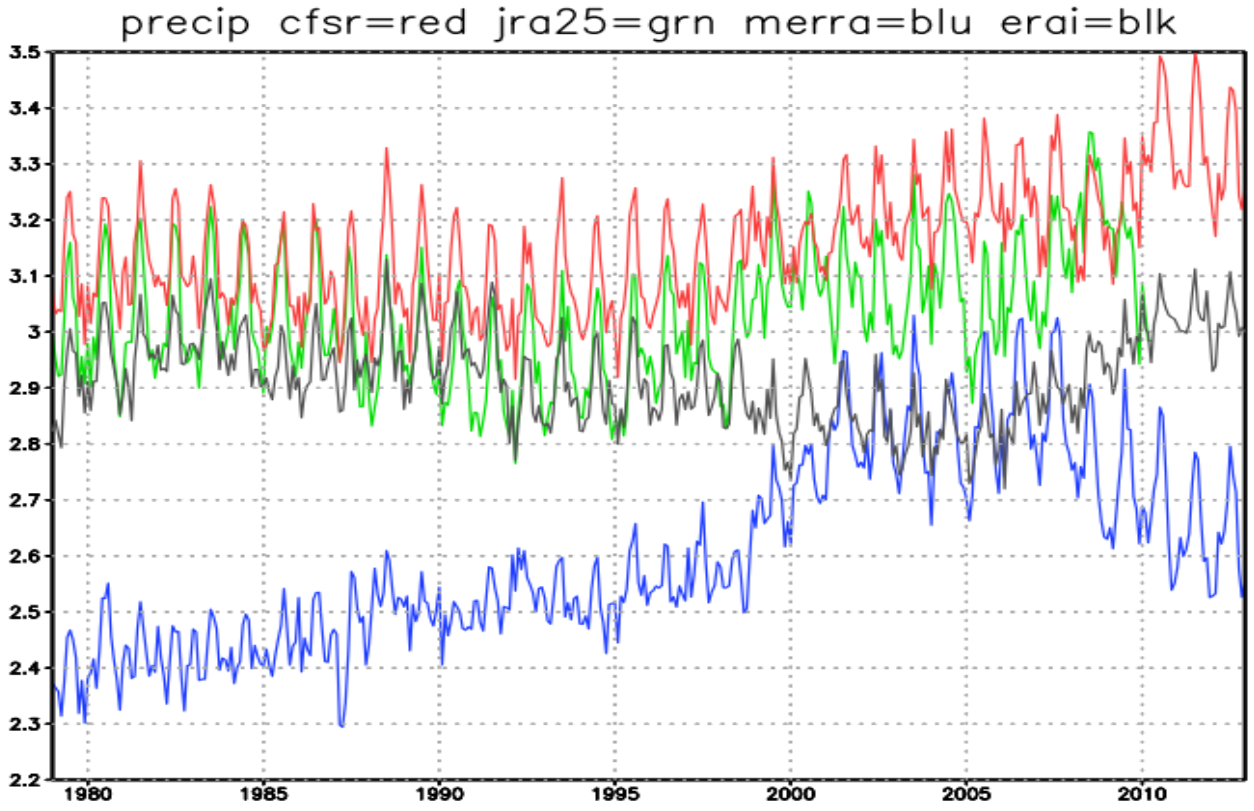
  - How did they do with trends?
  - Note all 4 reanalyses started in 1979.





Expect 0.1C/decade x 3 decades = .3C, Need agreement < .3C

1981-2010 climatology removed



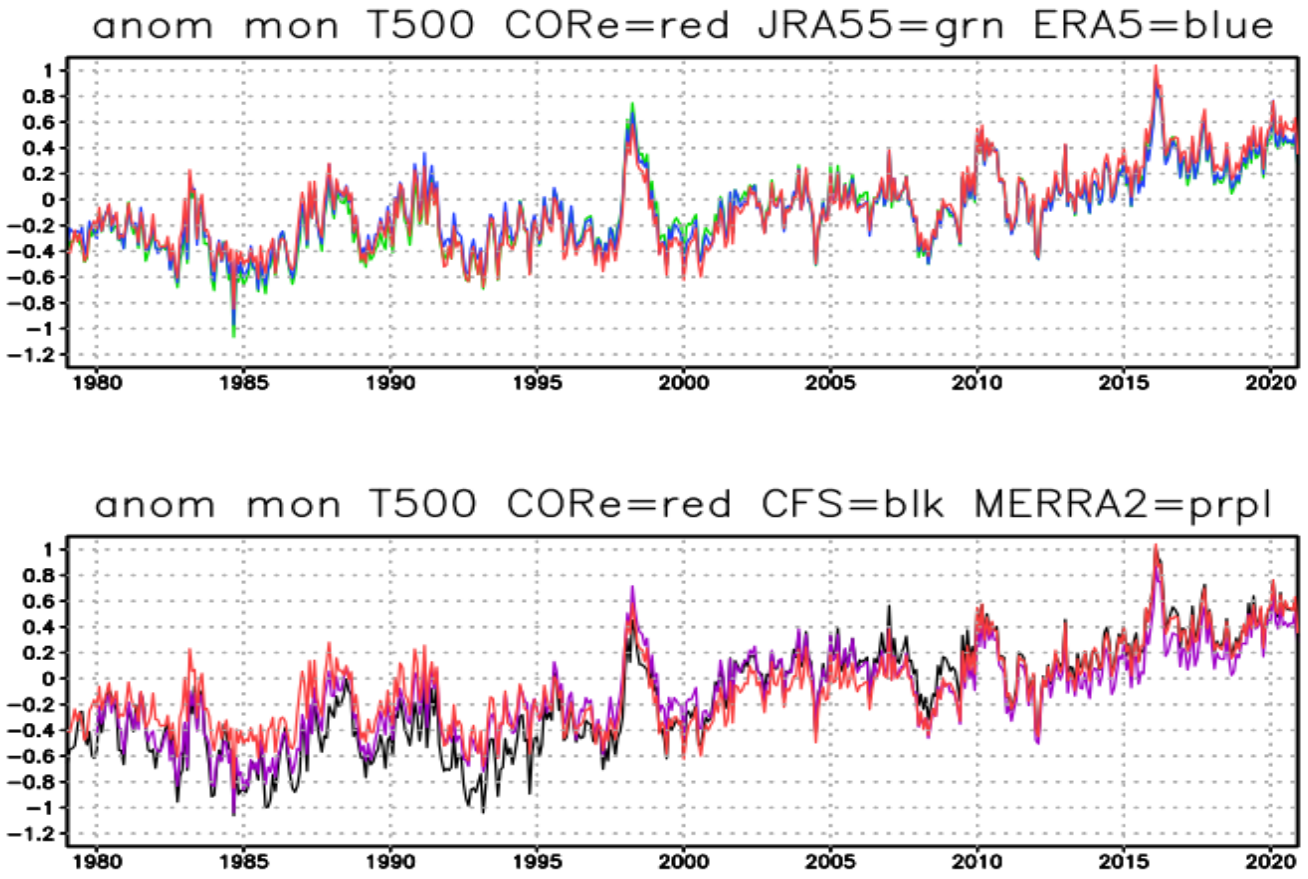
Precipitation trends are not consistent. Estimates from observations are more-or-less constant.

Situation in 2022

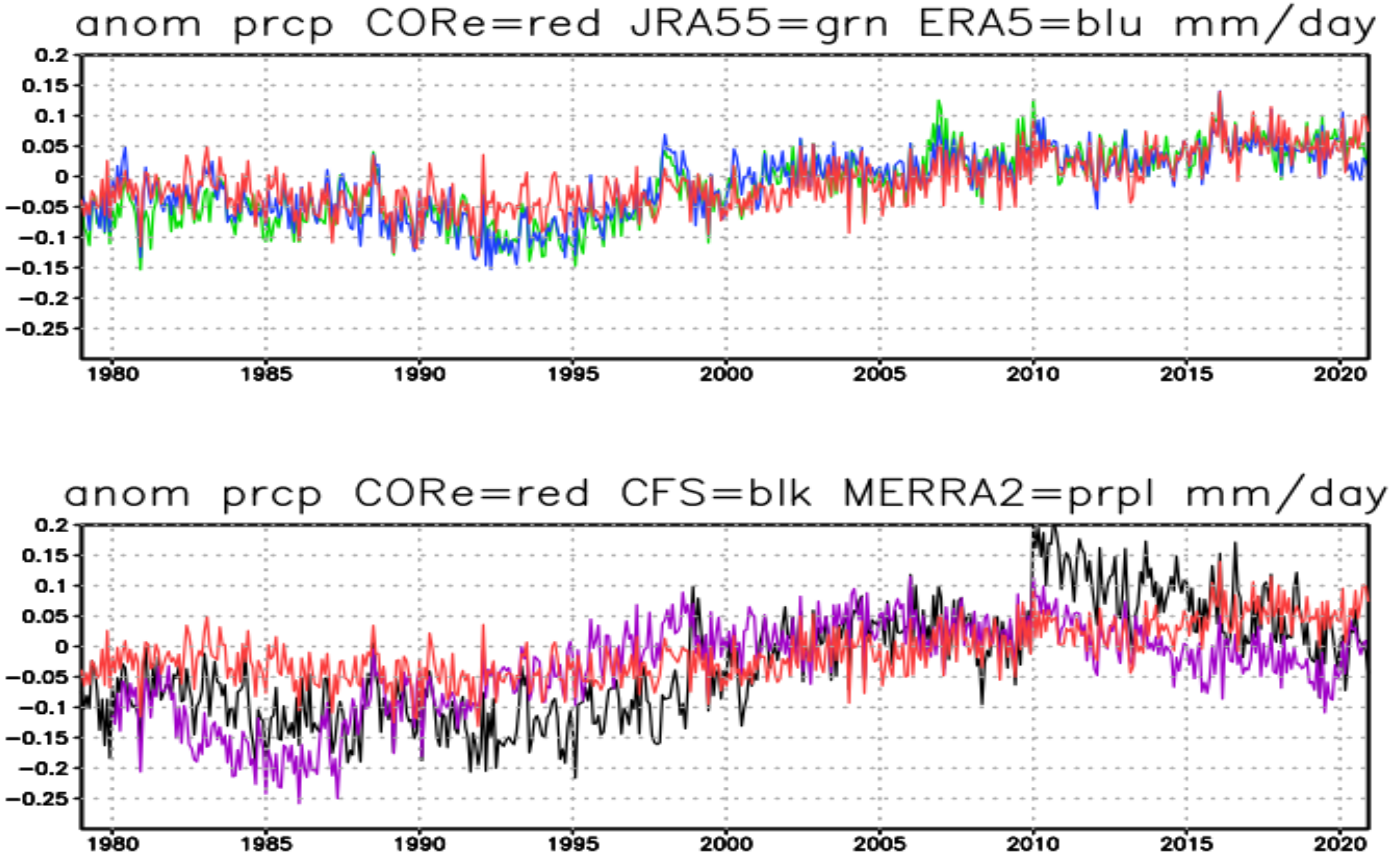
- CORe* 1950- NCEP Real-time version in development, Evaluation for operations.
- ERA-5 1950- ECMWF 1950-1958 is preliminary
- JRA-55 1958- JMA JMA is in production of next reanalysis

- MERRA2 1980- NASA
- CFSR 1979- NCEP

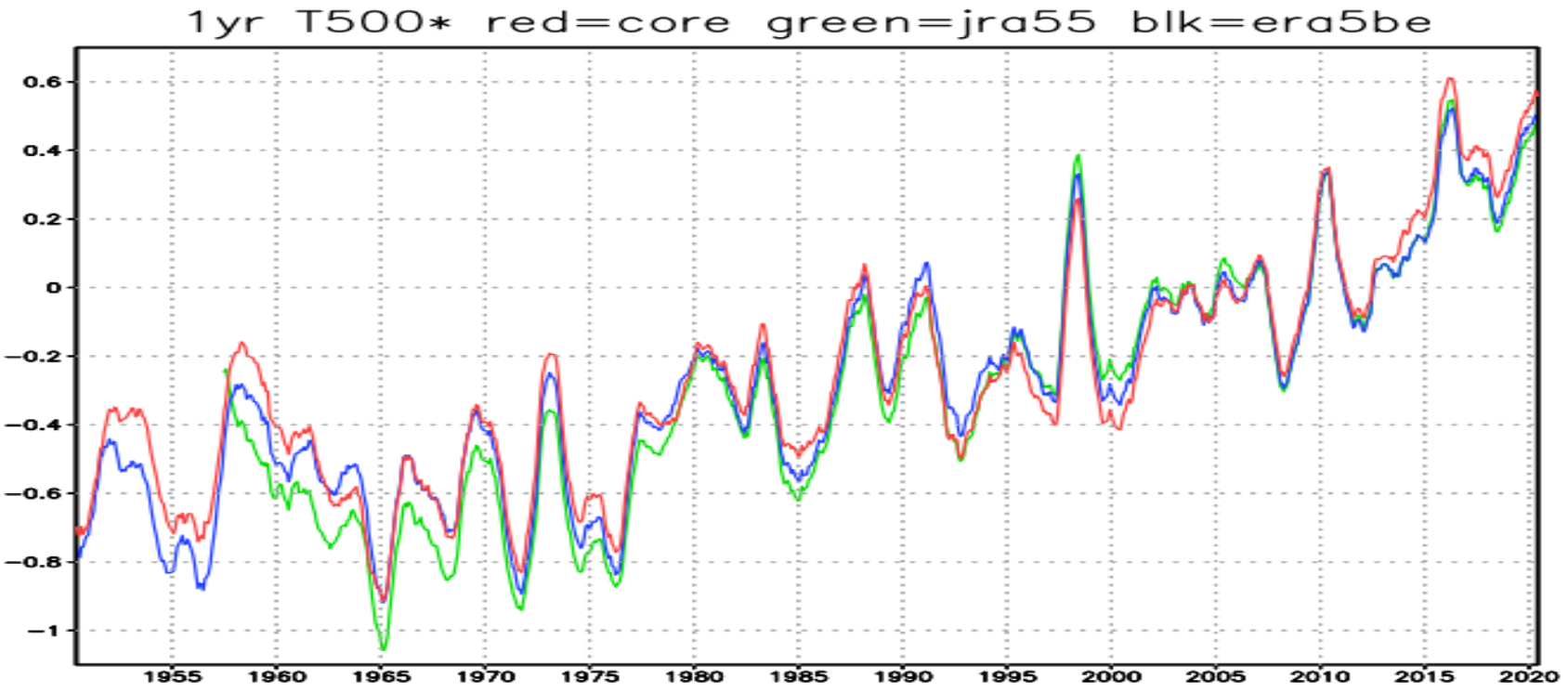
*will cover characteristics of CORe later
https://www.nws.noaa.gov/ost/STIClimateBulletin/45CDPW/45cdpw-WEbisuzaki.pdf



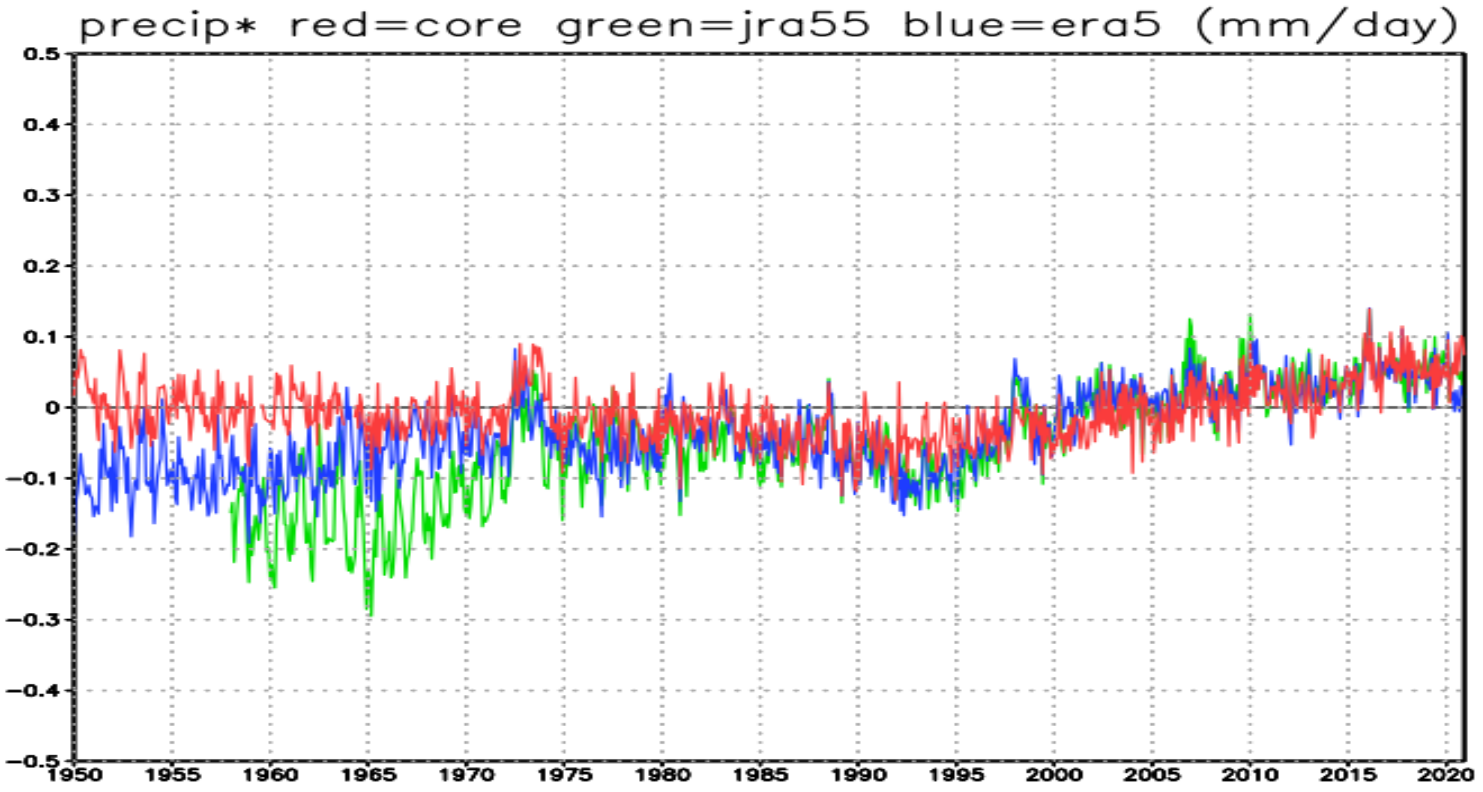
Global T500, 1979-2020, 1991-2020 climatology removed, CORe, ERA-5, JRA-55 consistent. CFSR and MERRA-2 deviate more from CORe. Interval = 0.2C



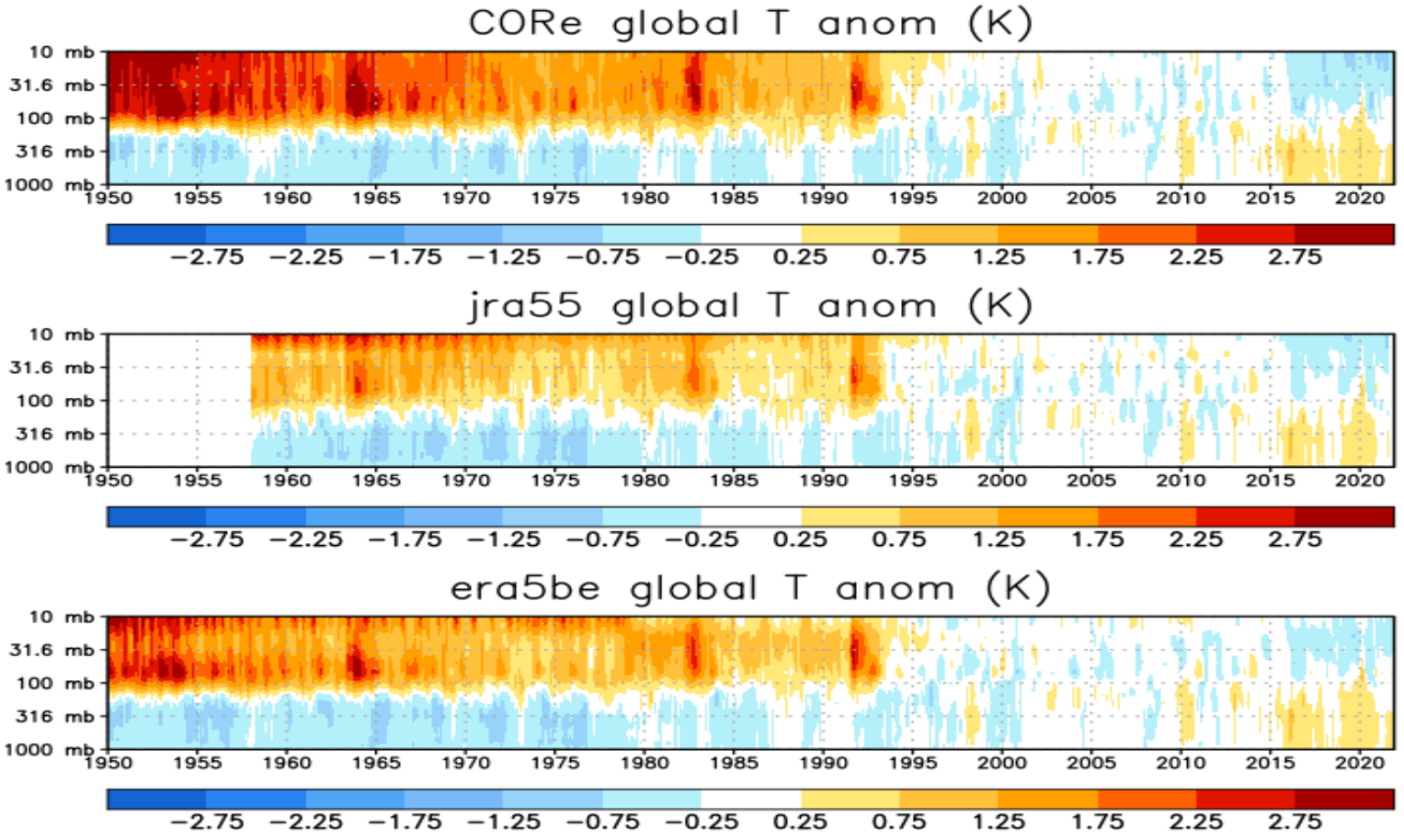
Global precip anomaly (mm/day), CFSR and MERRA-2 are not consistent with CORe, ERA-5 and JRA-55. Will only consider CORe, ERA-5 and JRA-55.



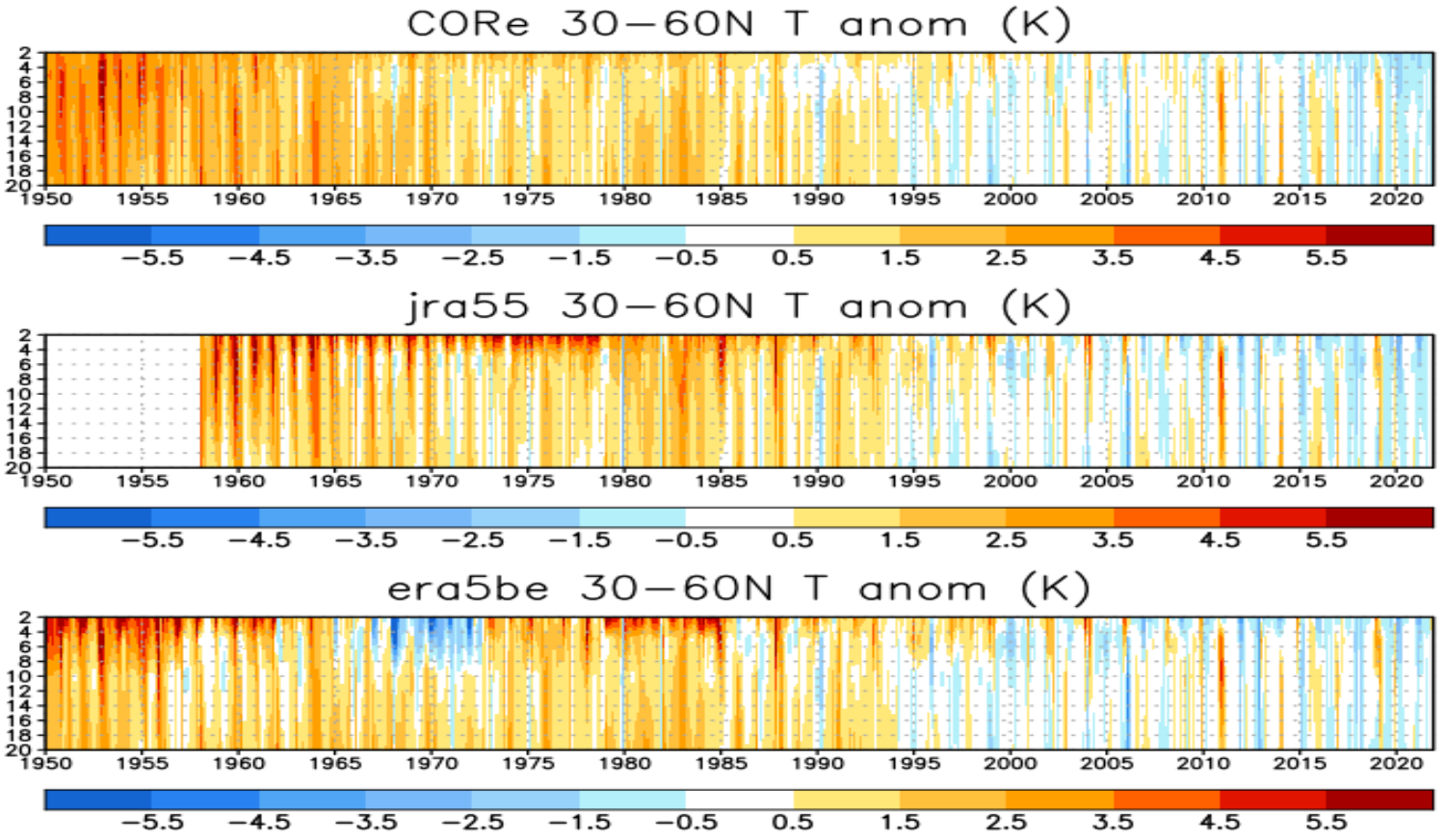
Global T500 anomaly with one-year running mean for 1950-2020. More differences in early period. Good for 70-year trend. Less so for decadal trend in the early record. Interval = 0.2C



Global precipitation anomaly for 1950-2022. Good agreement for 1973+. With a slight increase of precipitation with time. Interval = 0.1mm/day



Global T anomaly 1000-10 mb, 1950-2020. Good agreement in troposphere, and CORe is slightly warmer in early period stratosphere. Much of the warmth in the early CORe stratosphere is from the Southern hemisphere (not shown).



Global T anomaly 20-2 mb for 30N-60N, 1950-2020. This is a higher obs density latitude band. Are difficulties caused by satellite obs or lack of satellite obs? CORe did well in the modern period without satellites.

3 out 5 modern reanalyses have consistent trends. Are the three systems beginning to converge to the real answer?

CORe, ERA-5 and JRA-55 have much different treatment of satellites

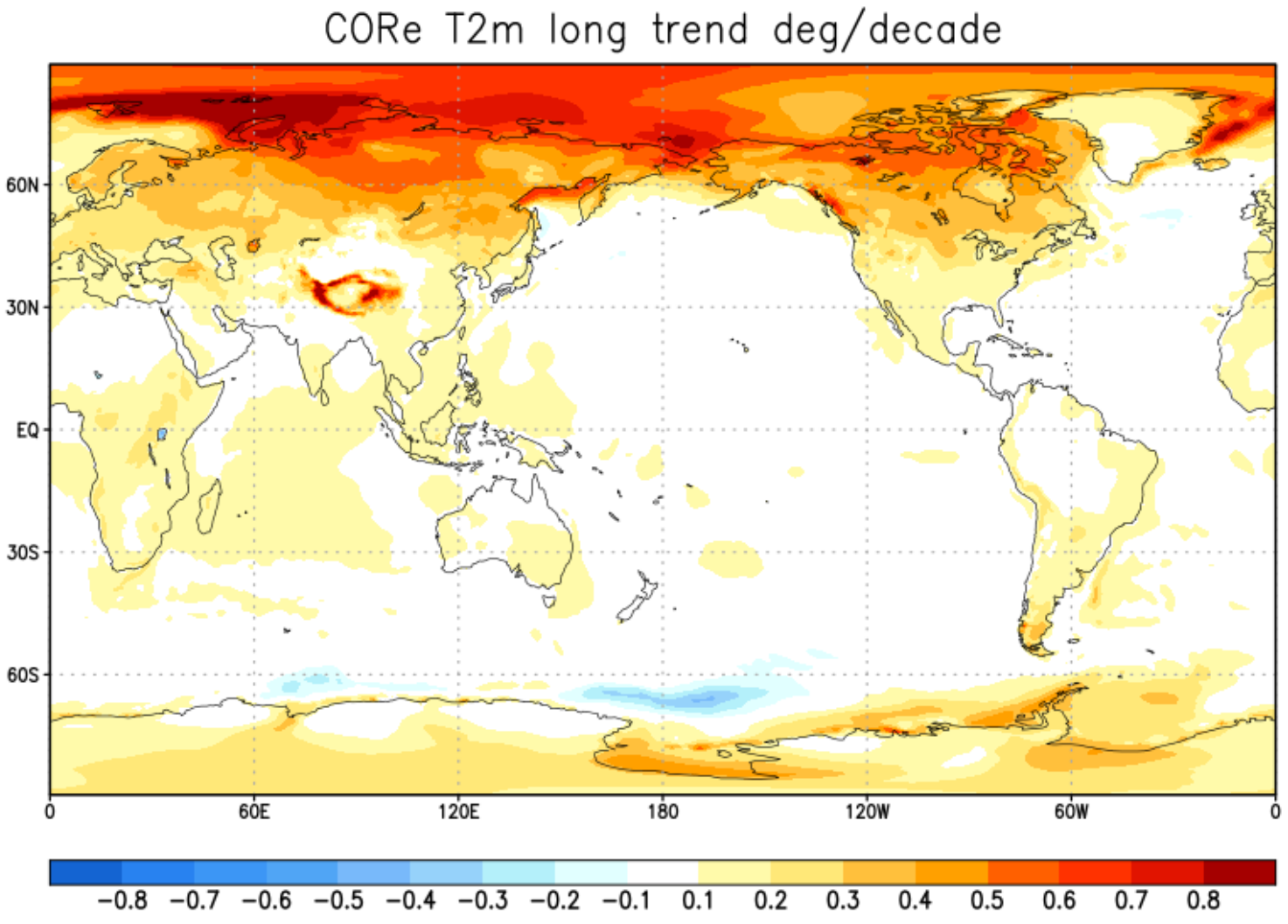
- ERA-5: use satellite observations including all-sky radiances
- JRA-55: uses satellite observations but not including cloudy radiances
- CORe: no satellite observations aside from Atmos. Motion Vectors

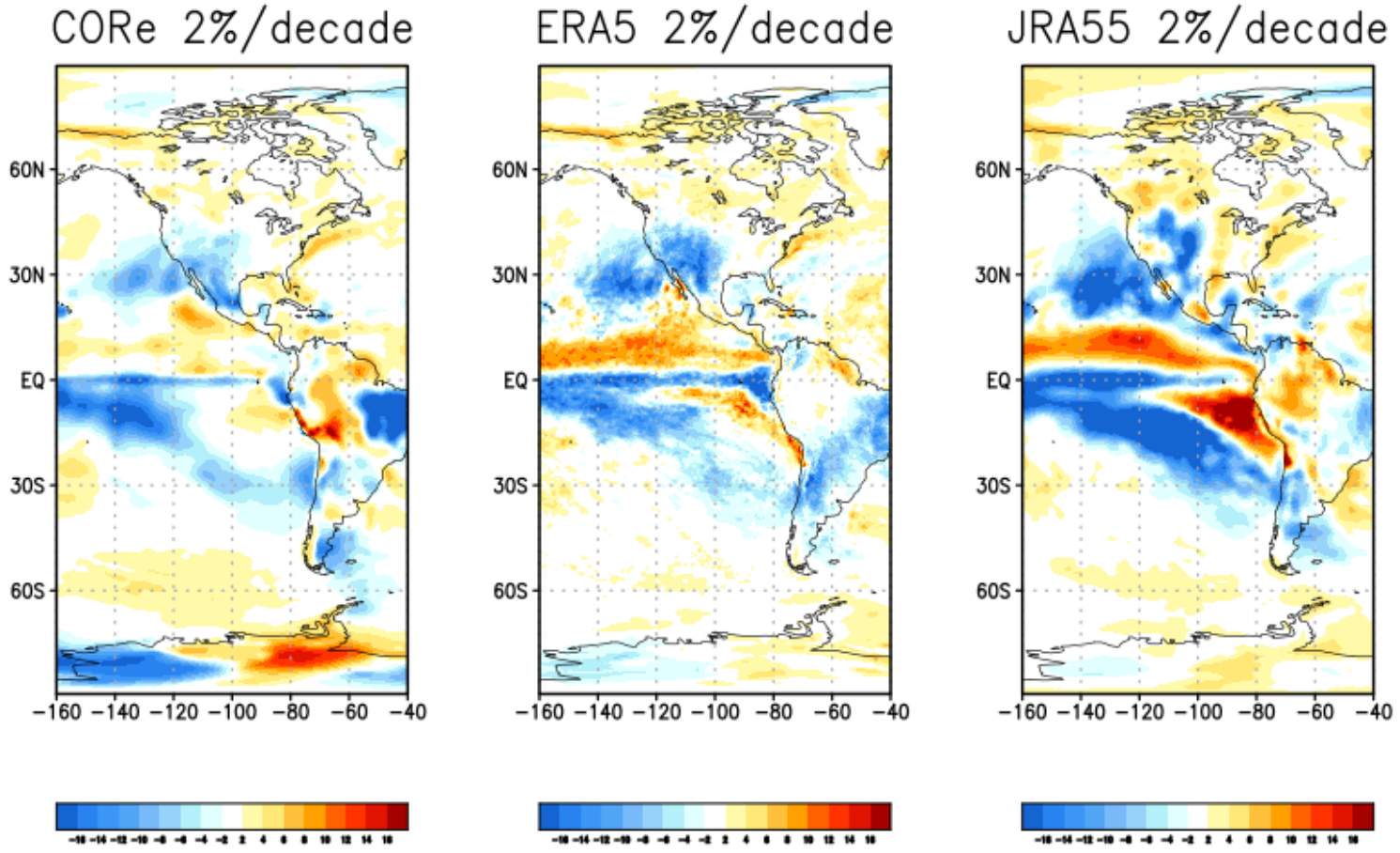
CORe, ERA-5 and JRA-55 have different data assimilation systems

- CORe: EnKF, dynamic background error covariance (BEC)
- ERA-5: 4D-var with weighted average of static and dynamic BEC
- JRA-55: 4D-var with static BEC, 1958-1978 and another for 1979+

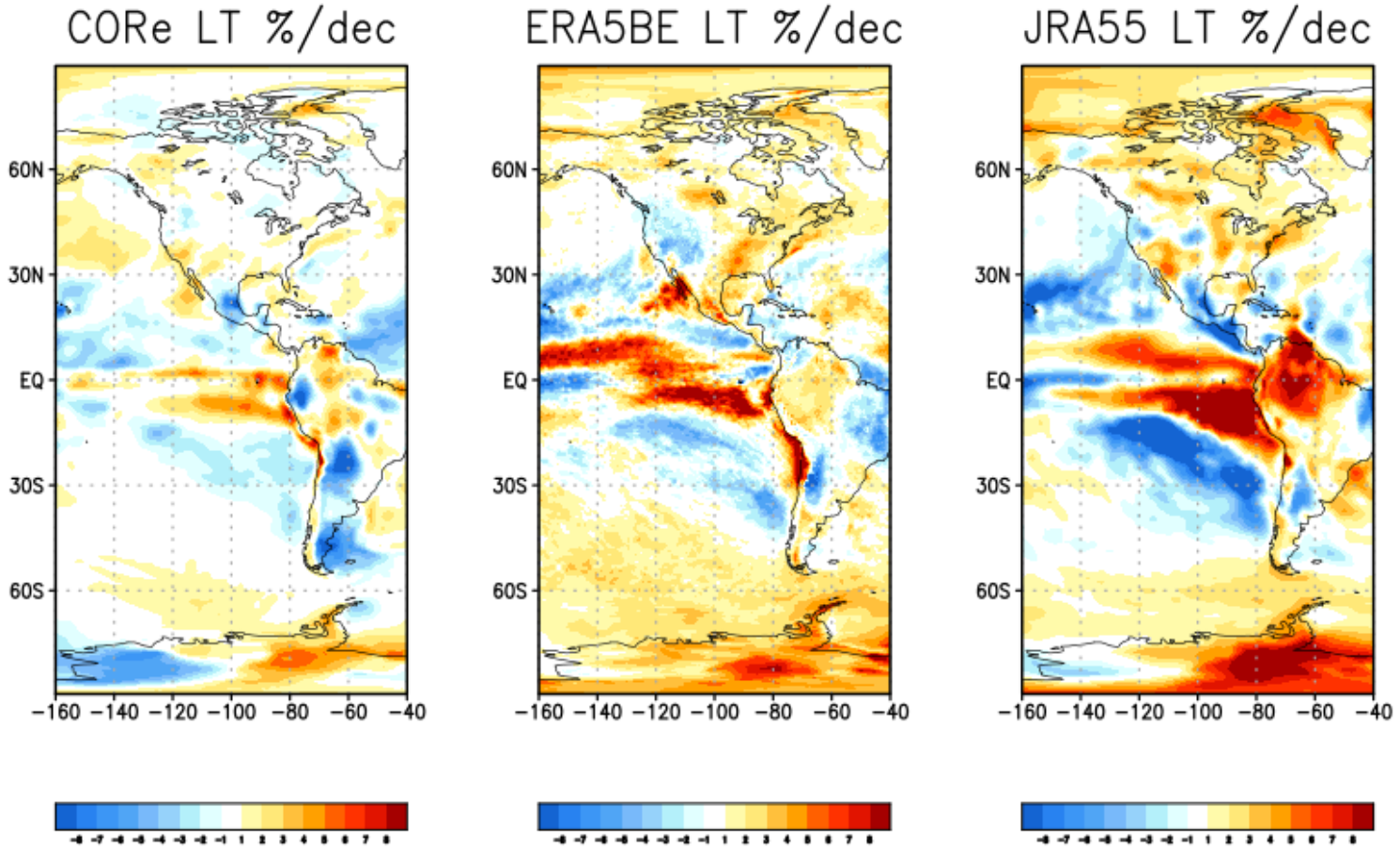
CORe, ERA-5 and JRA-55 have different models and QC procedures.

However, most of the conventional observations will be common. So any biases in the conventional observations can produce spurious trends.


CORe T2m long trend deg/decade
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8



Linear trend 1979-2020, contour interval 2% / decade base:1991-2020



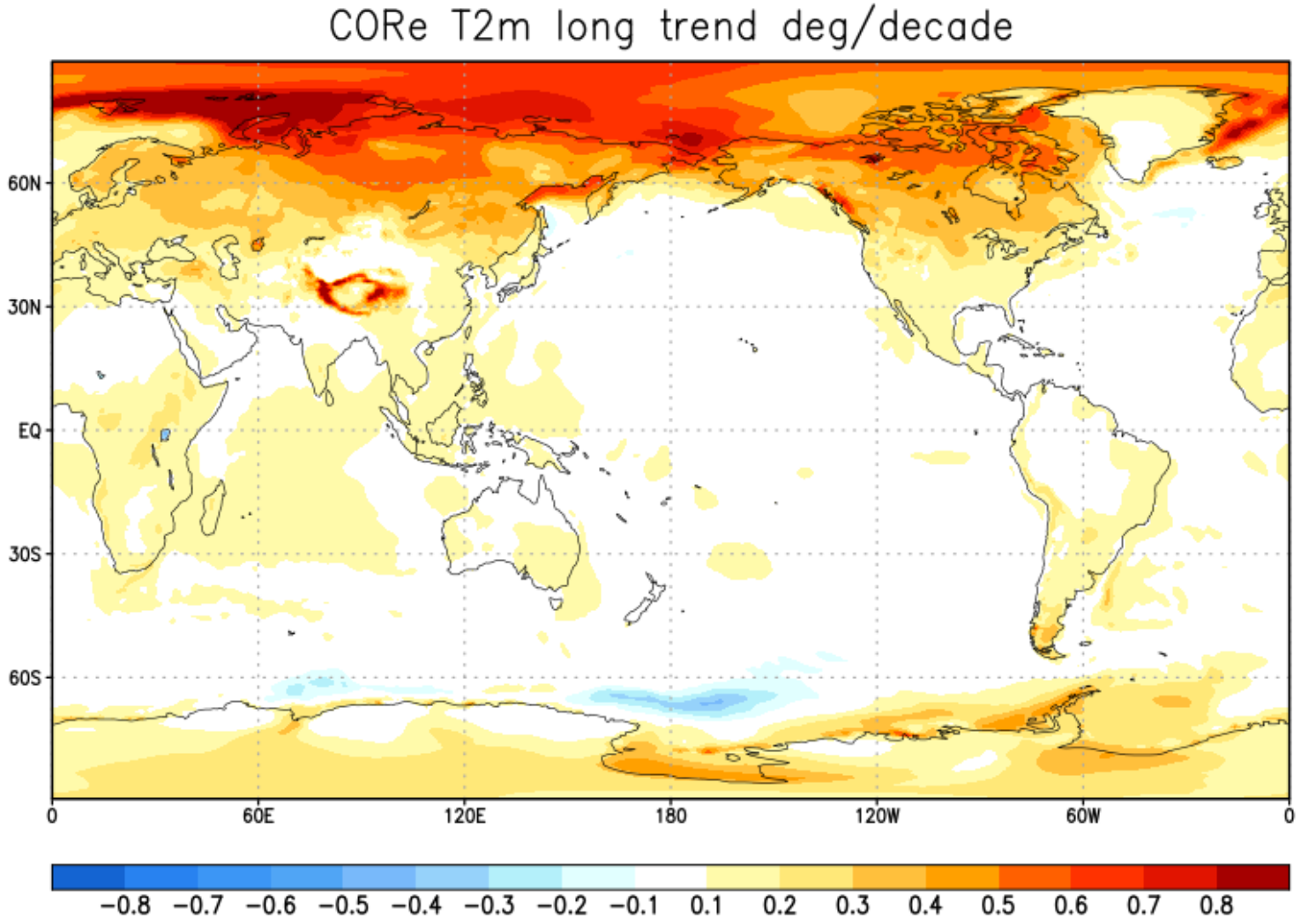
Linear trend 1950-2020, contour interval 1% / decade base:1991-2020

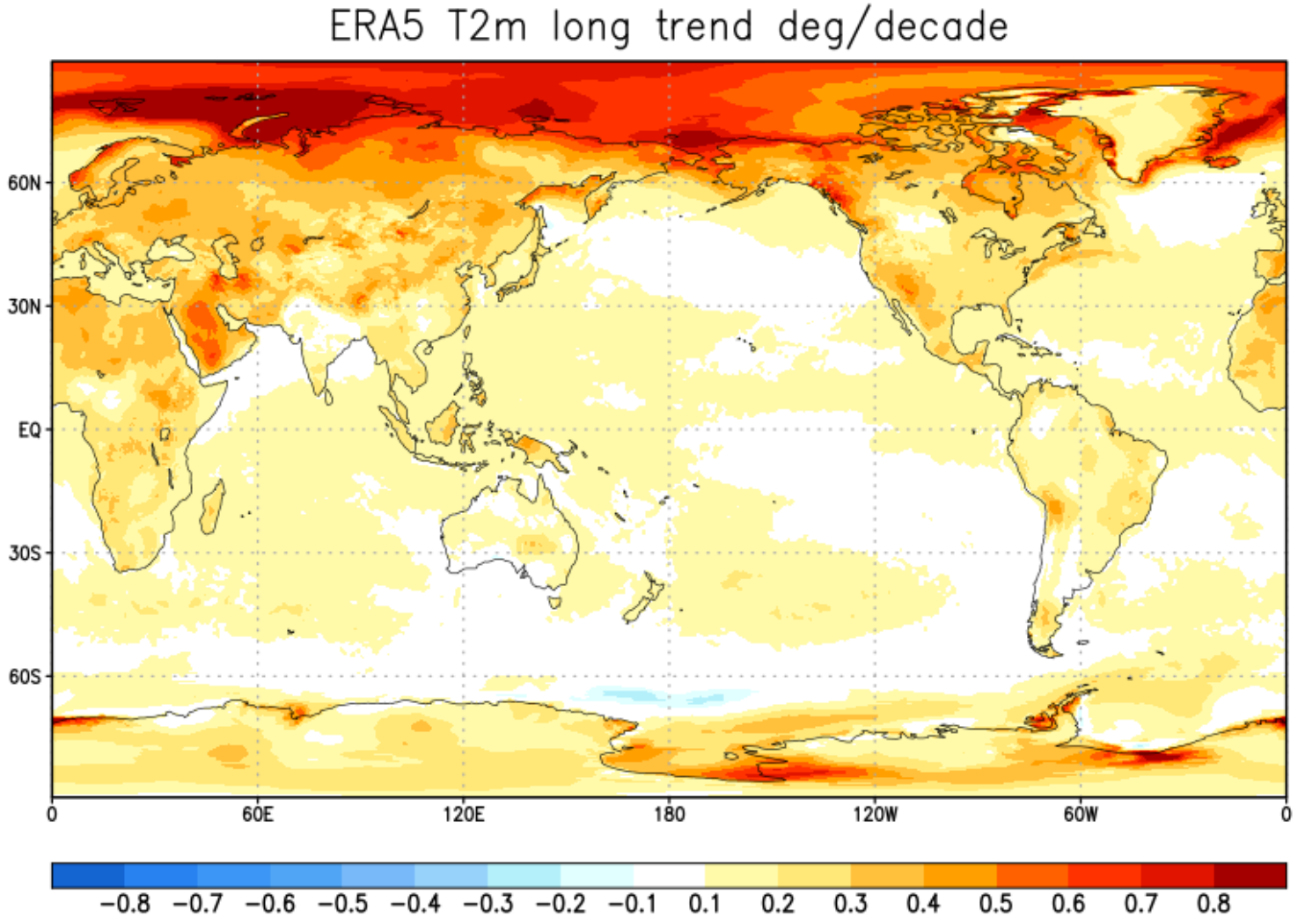
Summary

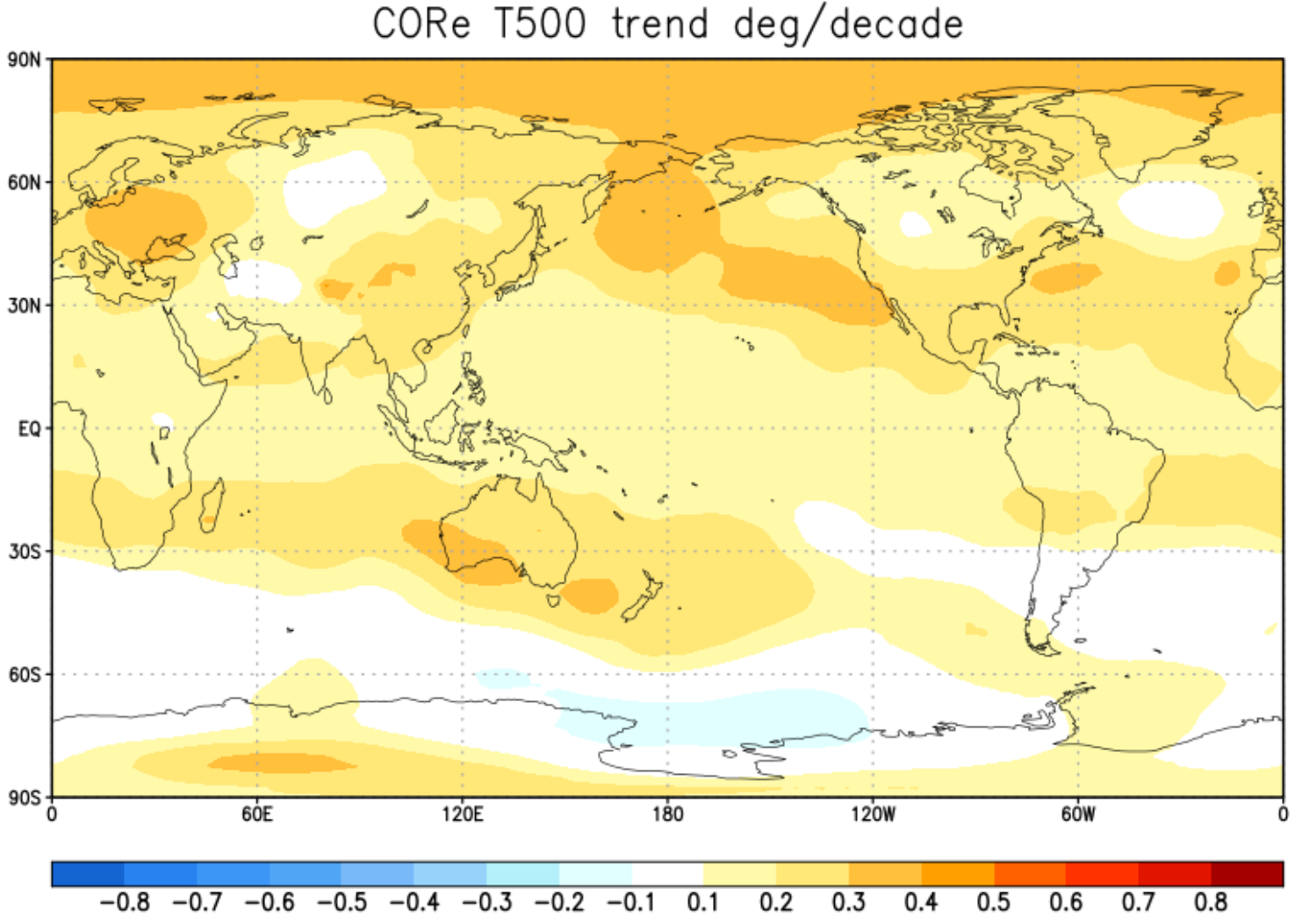
In 2012, the then-modern reanalyses were not good enough to examine the trends.

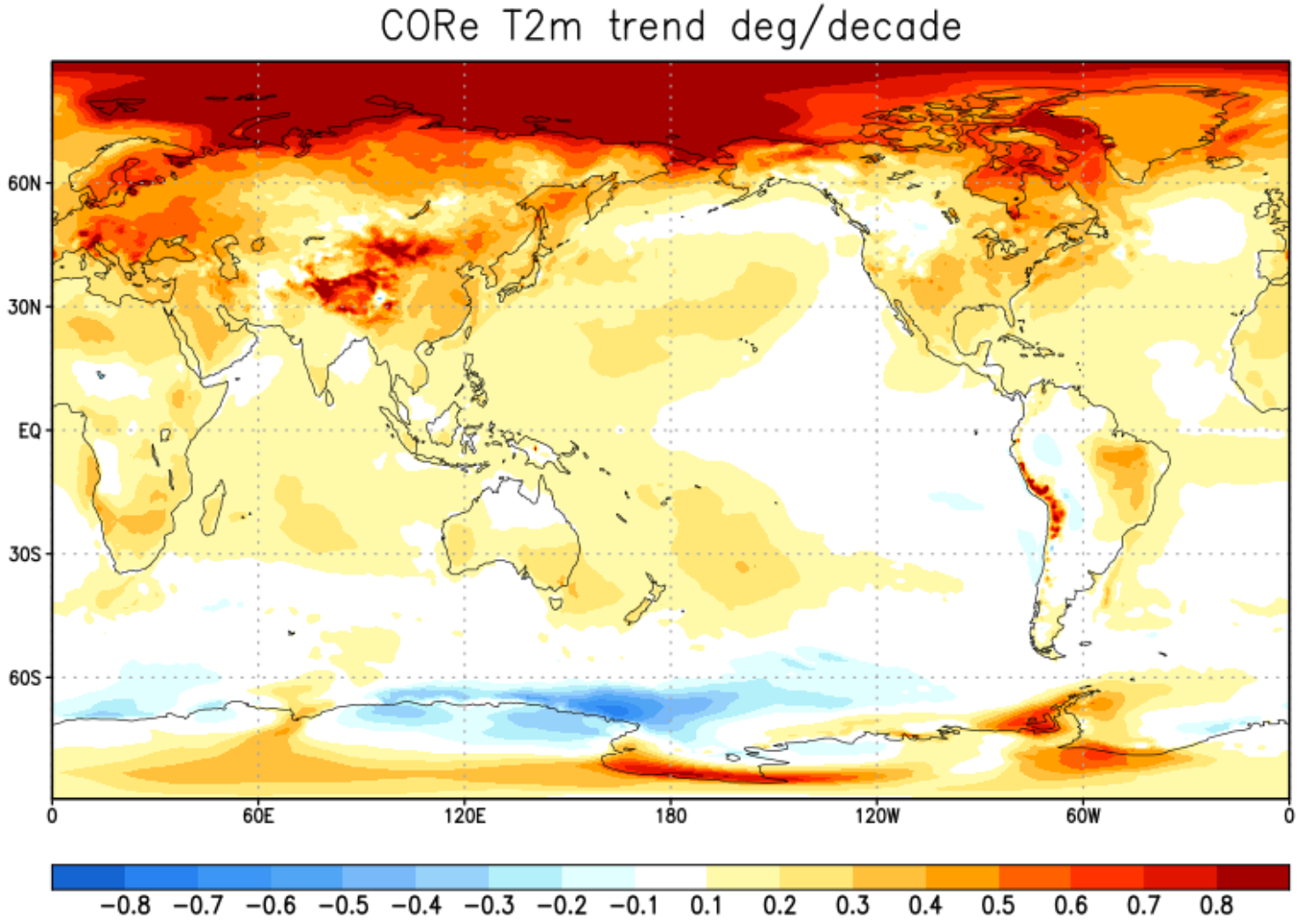
In 2022, three of the five modern reanalyses are consistent with each other. They good enough to start examining the trends of large regional averages. Not all variables and time periods are handled well, so one needs to examine the consistency of the reanalyses. (Use multiple reanalyses.)

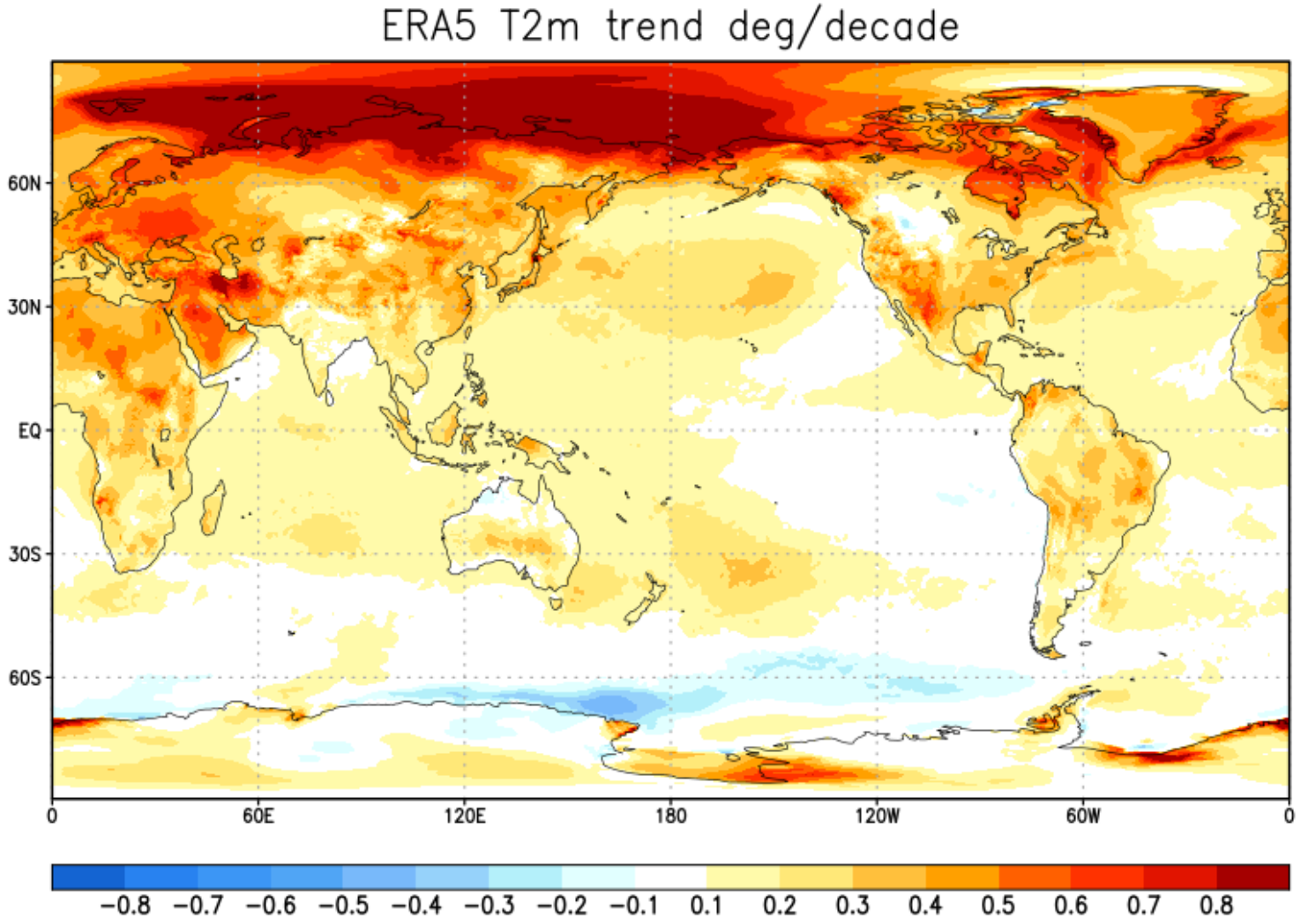
One of the original goals of the reanalyses was to study the trends, now we are getting there.

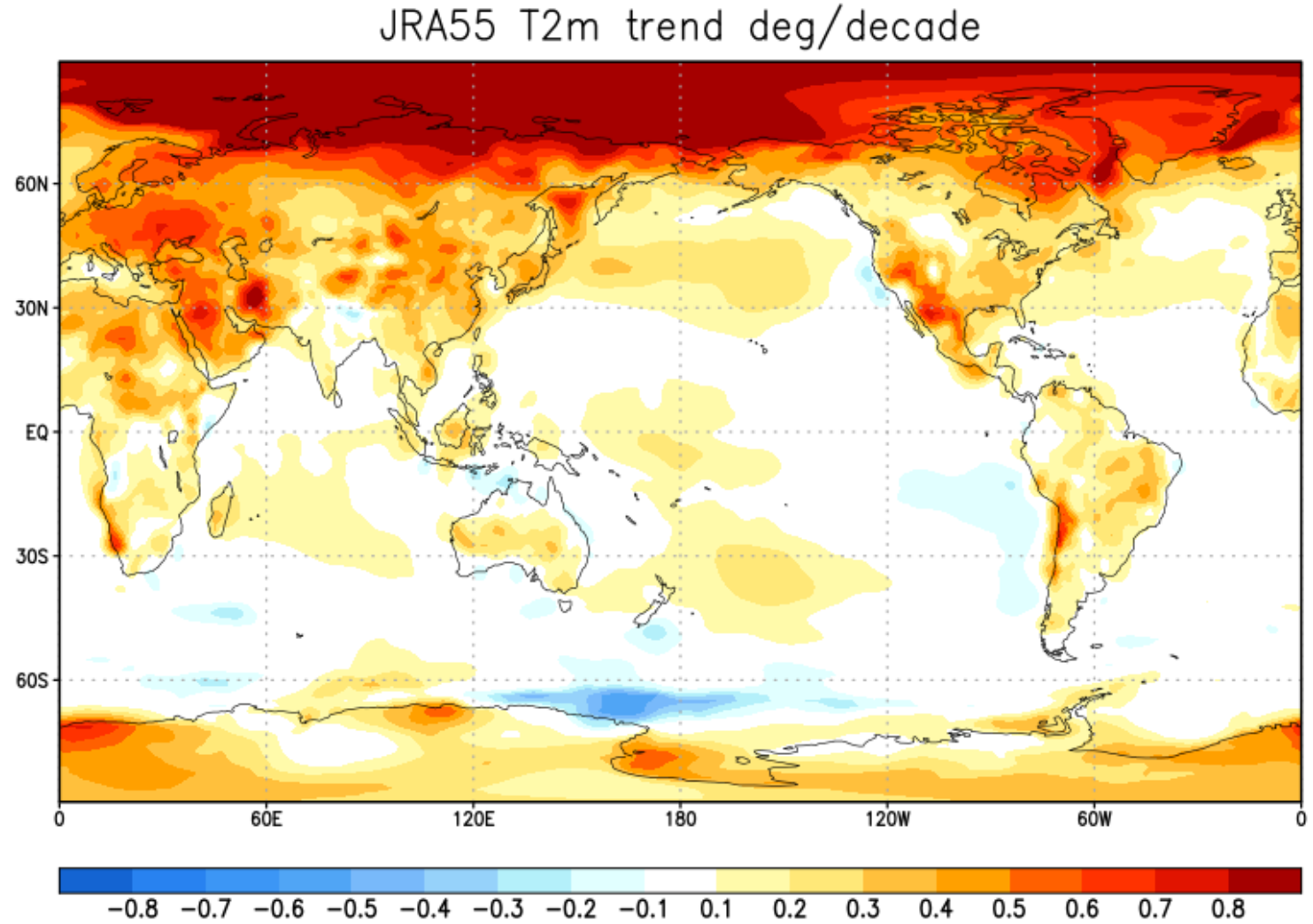

COReT2m long trend deg/decade
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8


ERA5 T2m long trend deg/decade
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8


CORe T500 trend deg/decade
90N
60N
30N
EQ
30S
60S
90S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8


COReT2m trend deg/decade
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8


ERA5 T2m trend deg/decade
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8


JRA55 T2m trend deg/decade
60N
30N
EQ
30S
60S
0
60E
120E
180
120W
60W
0
−0.8 −0.7 −0.6 −0.5 −0.4 −0.3 −0.2 −0.1 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8
GrADS/COLA