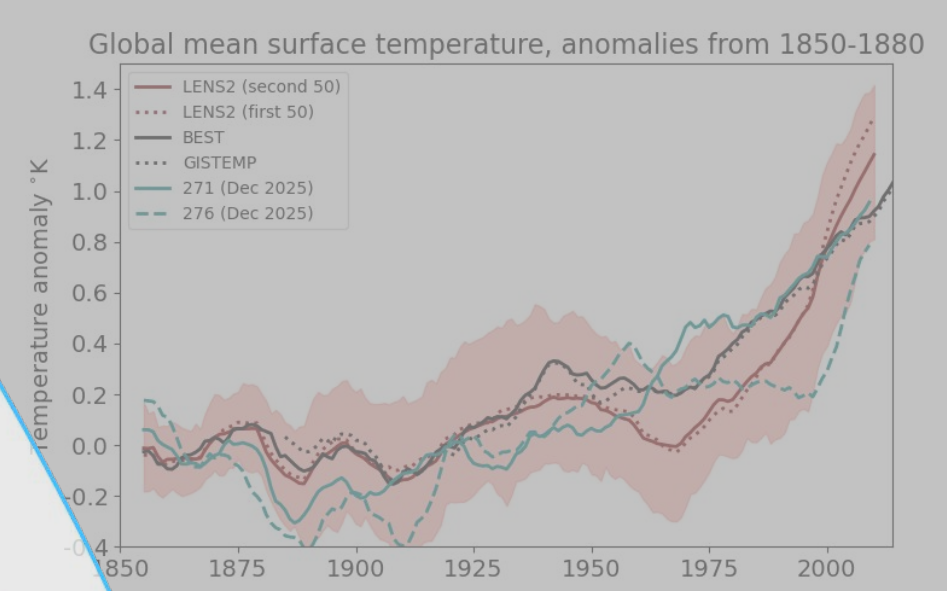
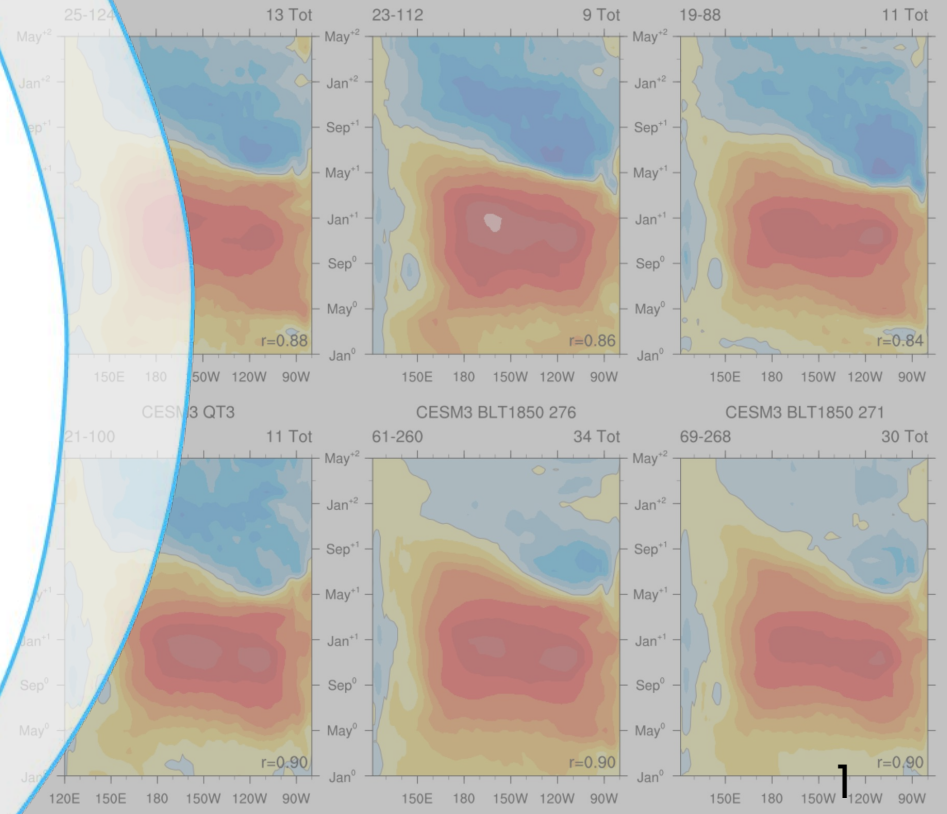
FEBRUARY 2, 2026

The current performance of CESM3 development simulations

Isla Simpson, with contributions from many others

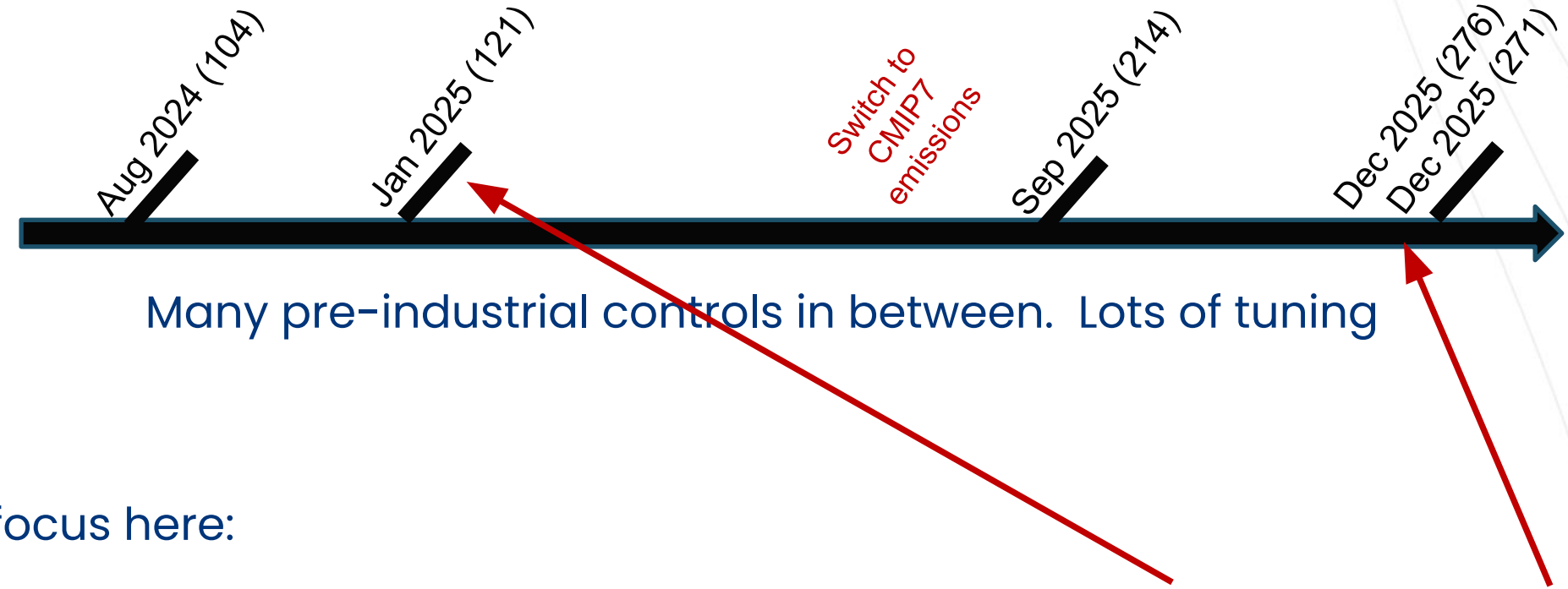




CESM3 development historical simulations

Many pre-industrial controls in between. Lots of tuning

CESM3 development historical simulations



The focus here:

- How things have evolved between this time last year (121) and now (271/276)

CESM3 development historical simulations

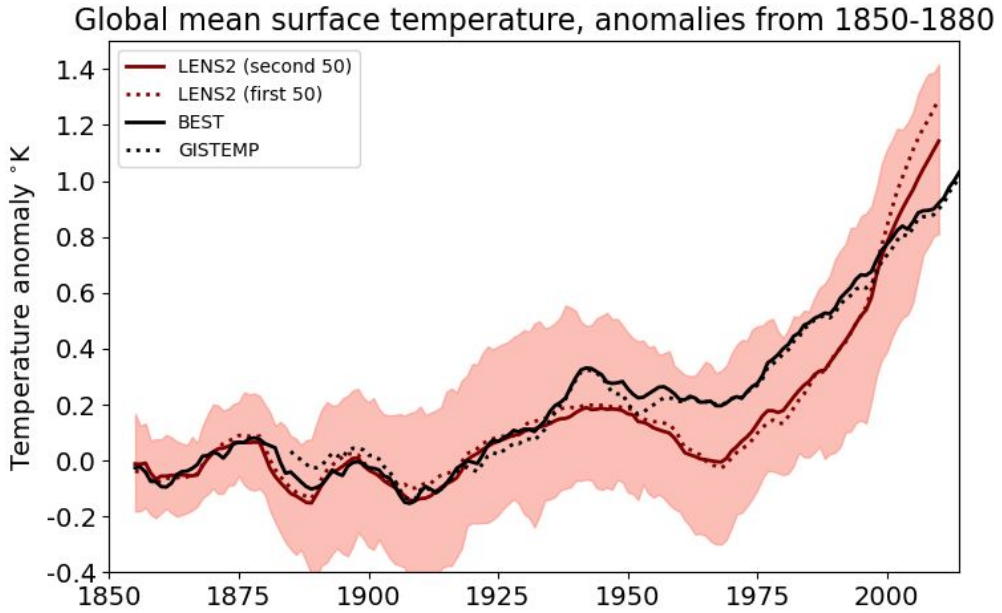
Many pre-industrial controls in between. Lots of tuning

The focus here:

- How things have evolved between this time last year (121) and now (271/276)
- The representation of basic features of the climate system in 271/276

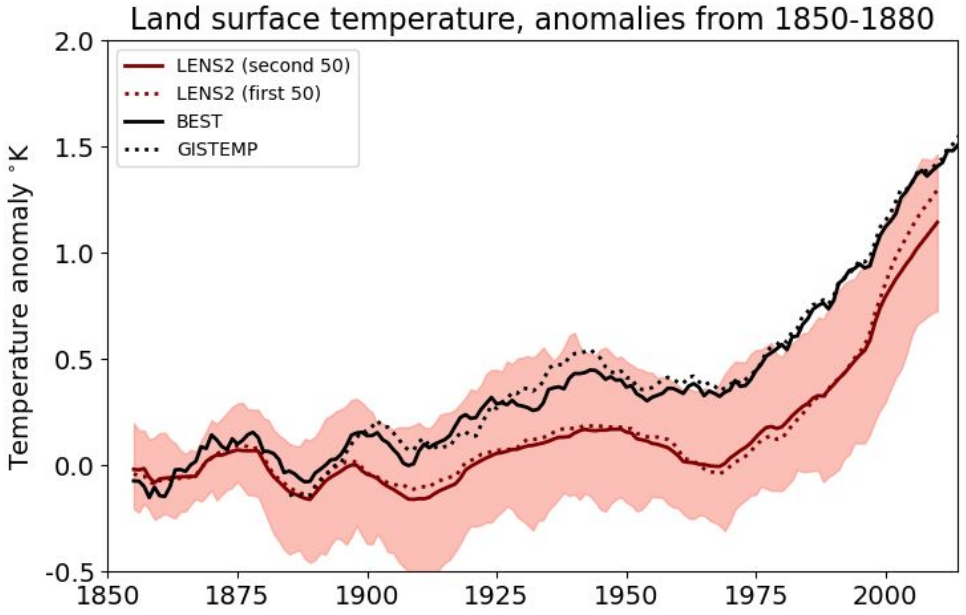
Global surface temperature evolution

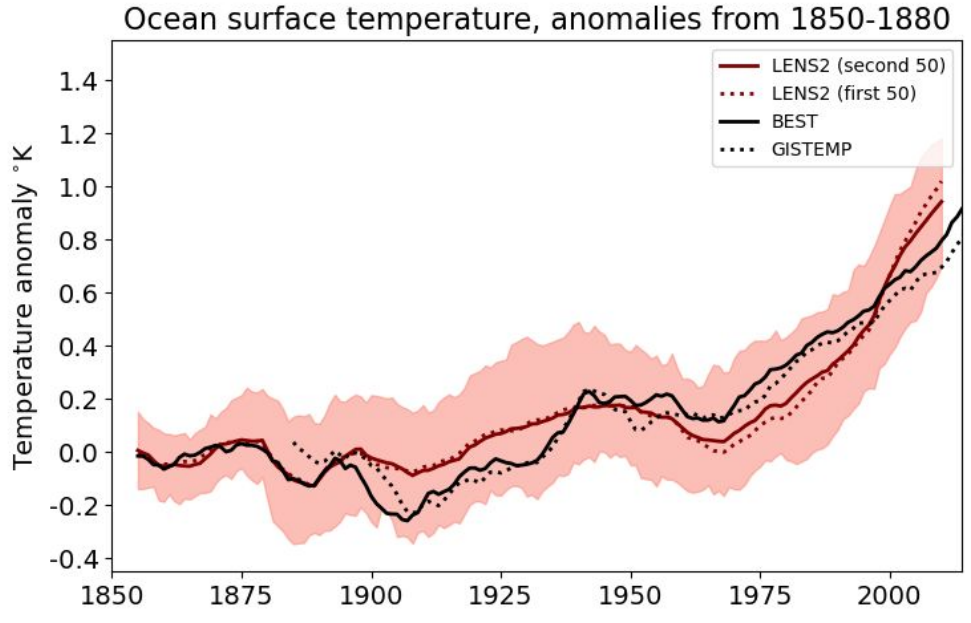
Global mean temperature



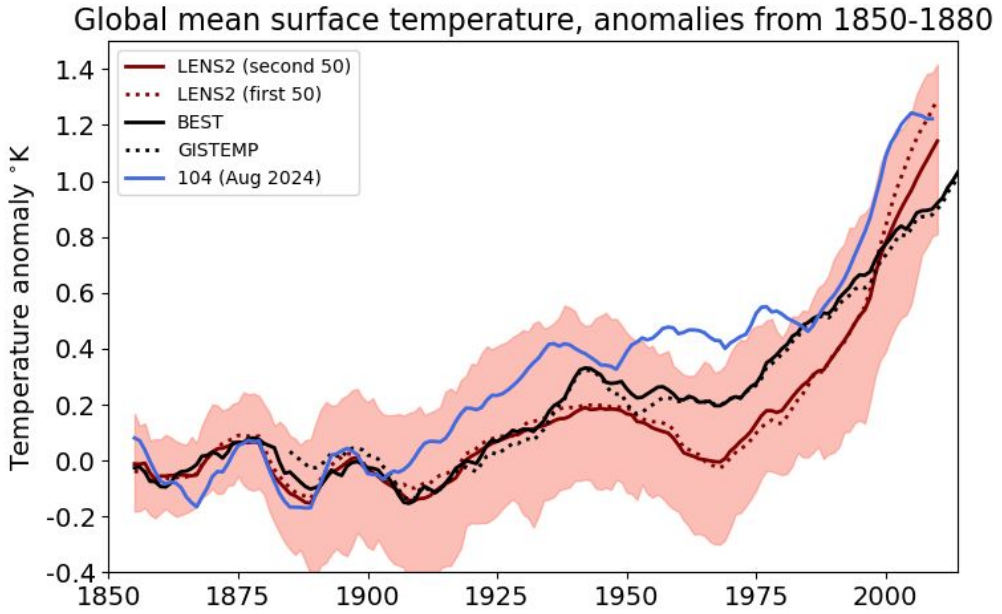
Surface temperature anomalies masked like BEST

10-year running means



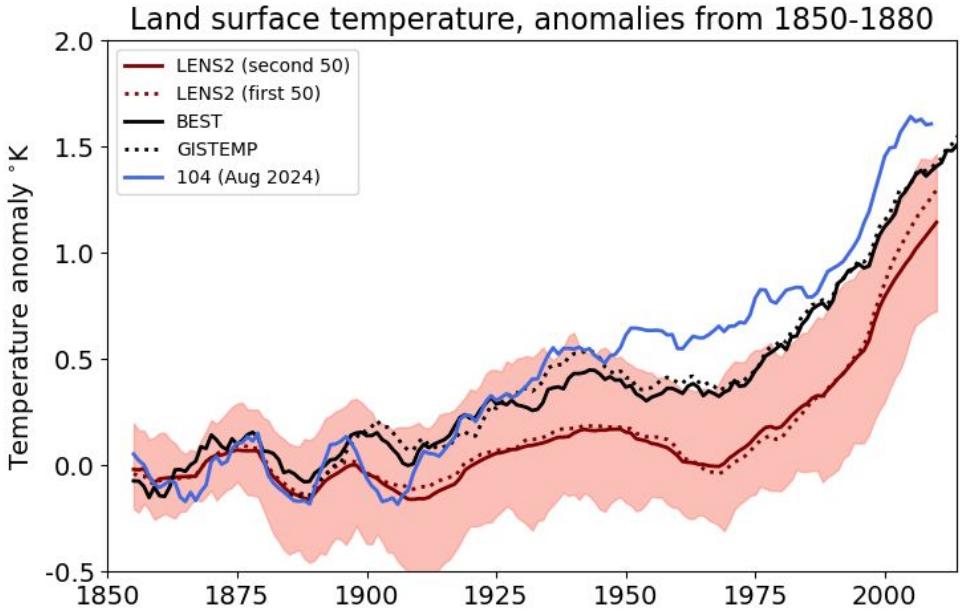


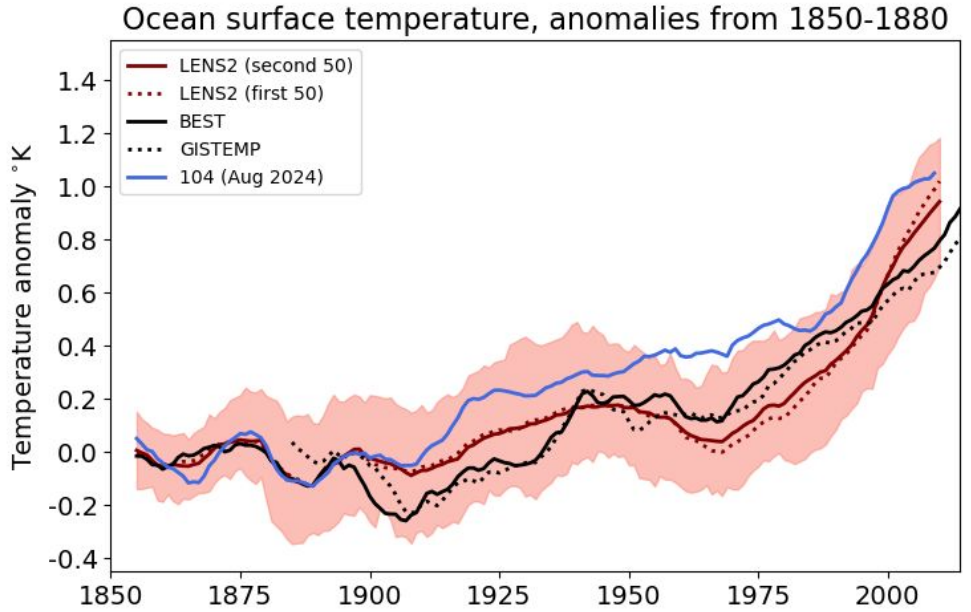
Global mean temperature



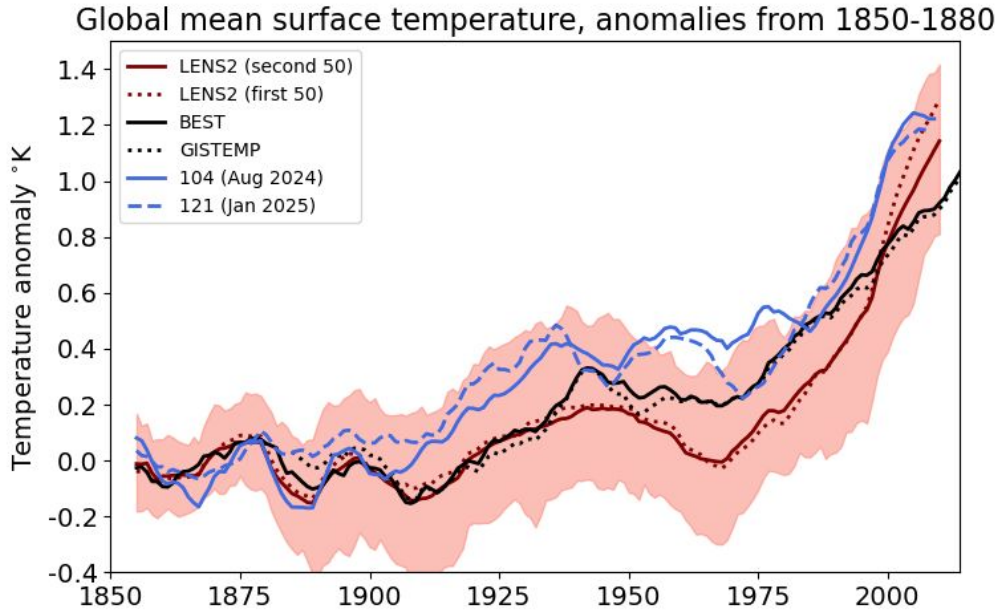
Surface temperature anomalies masked like BEST

10-year running means





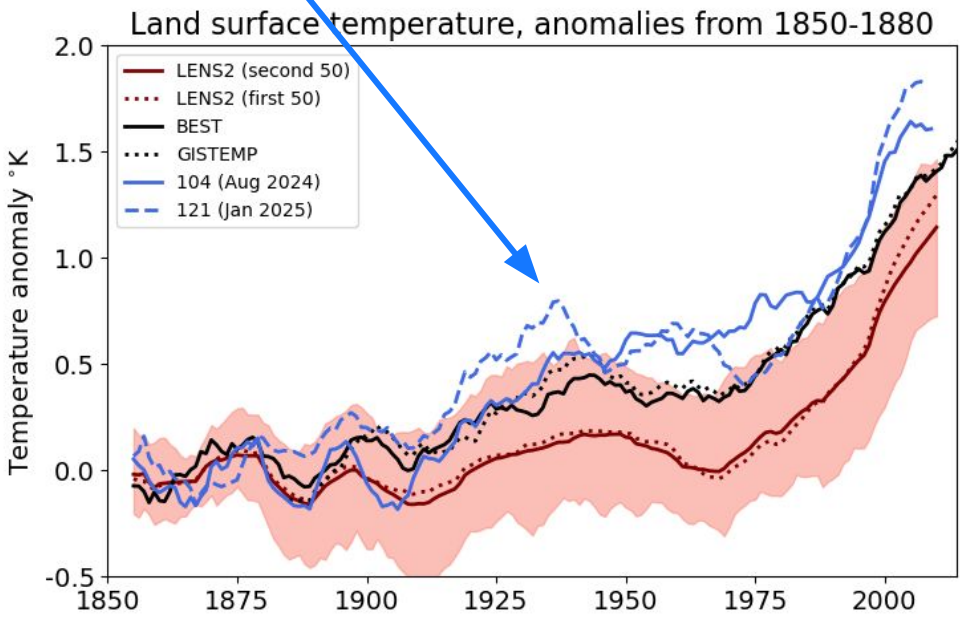
Global mean temperature

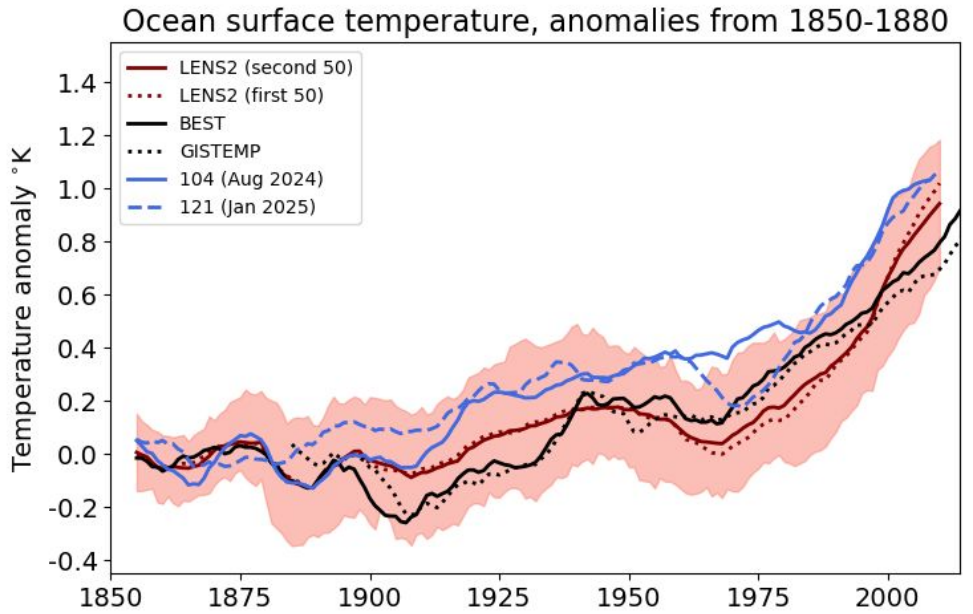


Surface temperature anomalies masked like BEST

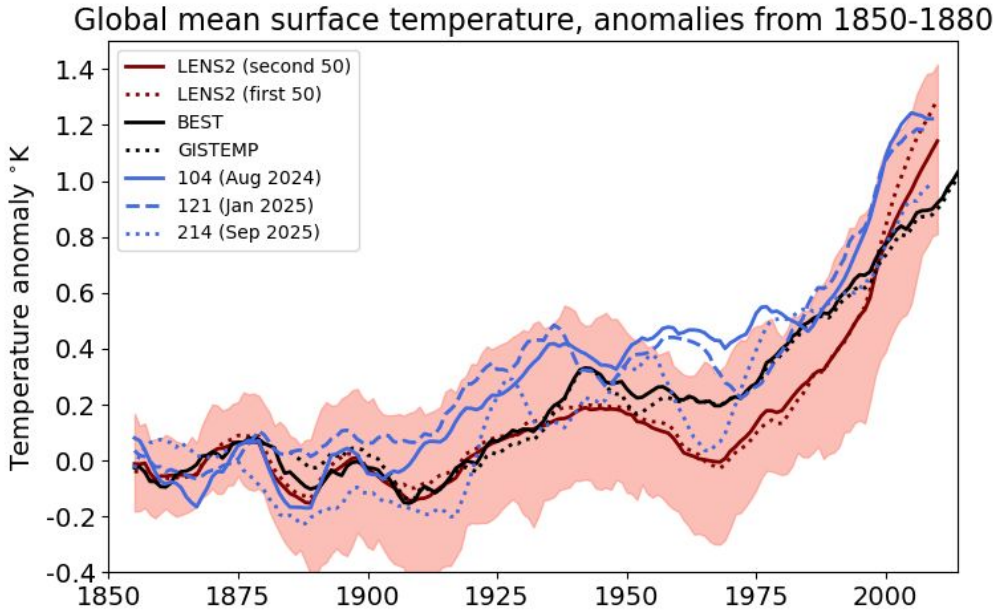
10-year running means

Indications that we might be doing better in representing land-surface temperature evolution than CESM2



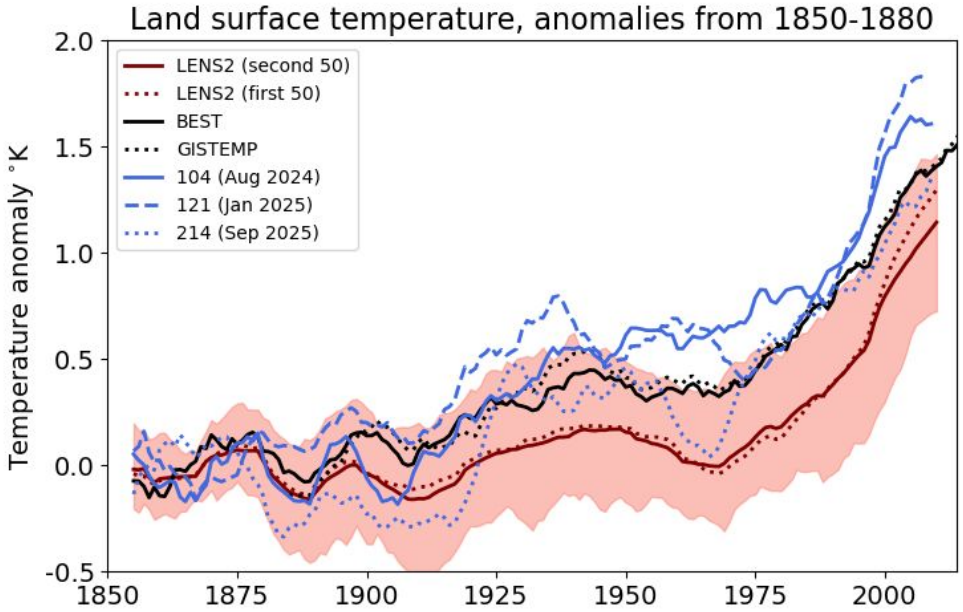


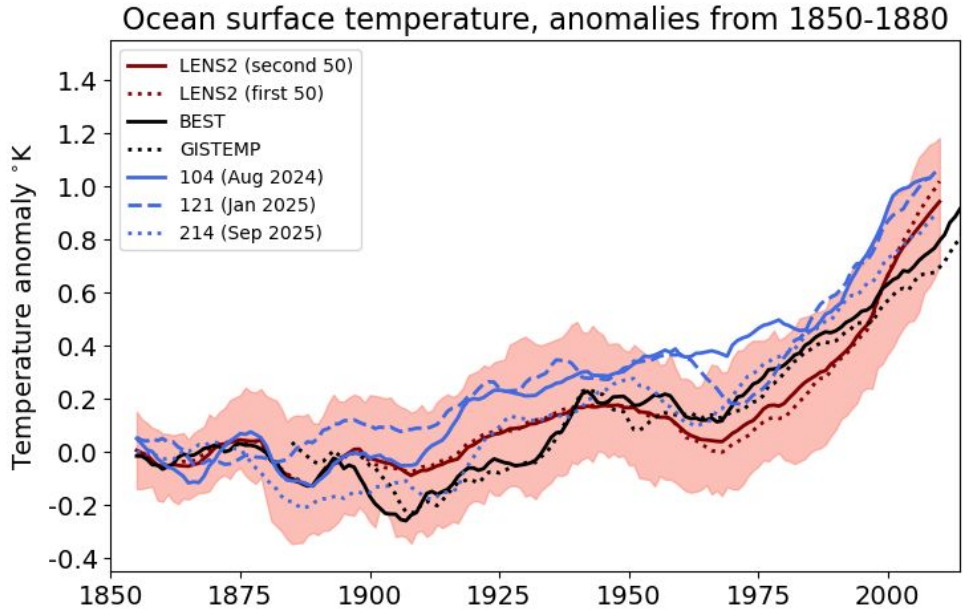
Global mean temperature



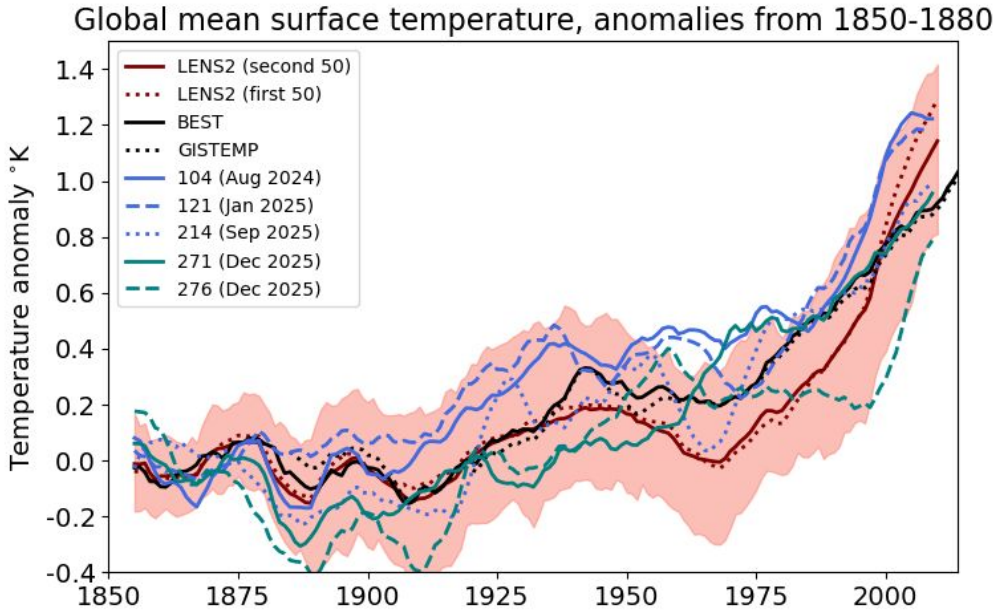
Surface temperature anomalies masked like BEST

10-year running means



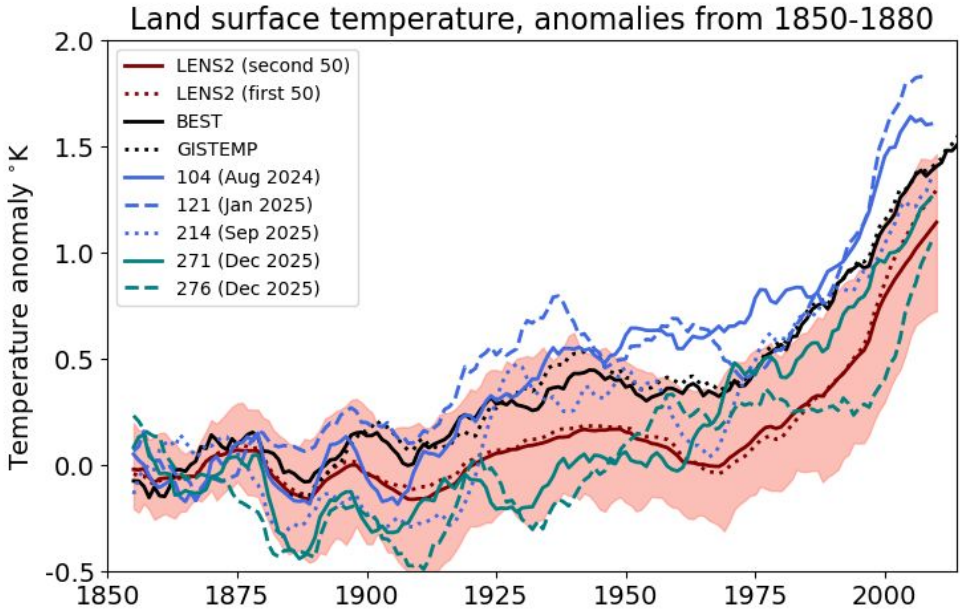


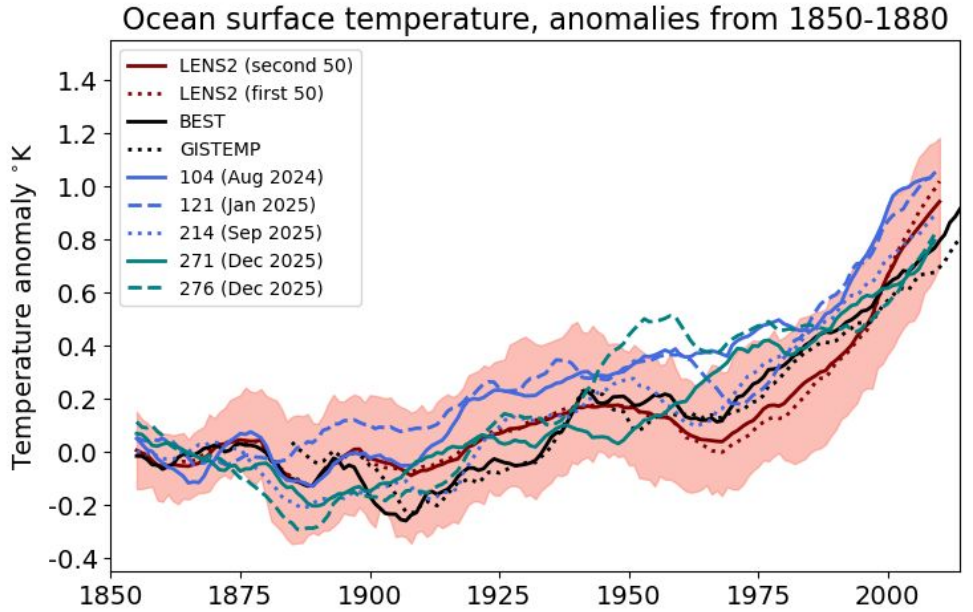
Global mean temperature



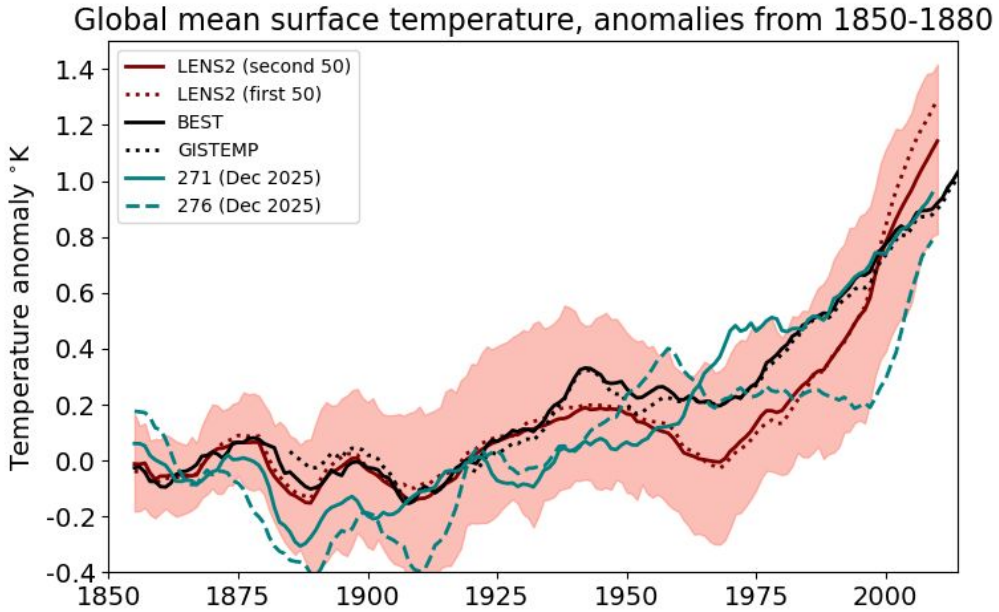
Surface temperature anomalies masked like BEST

10-year running means



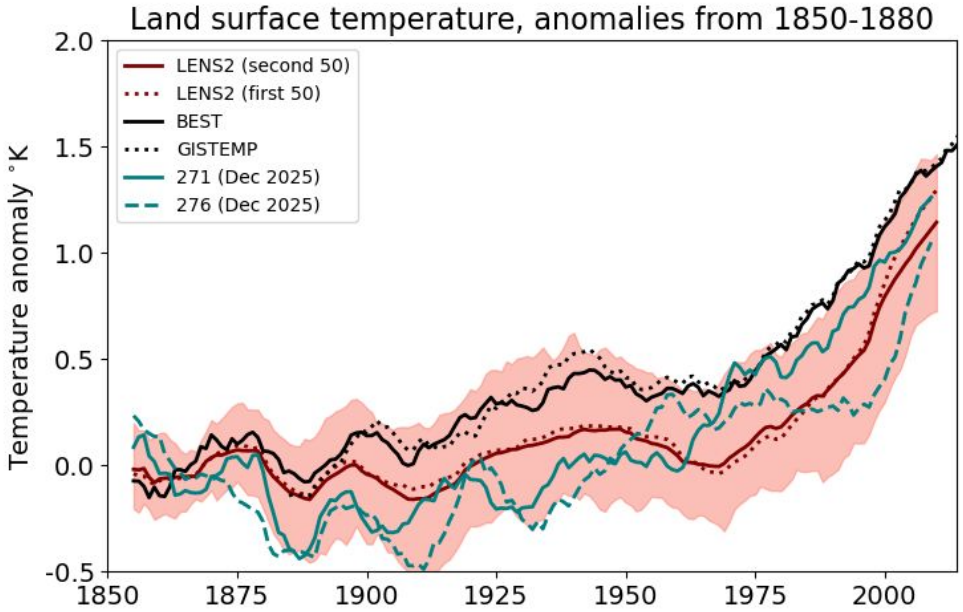


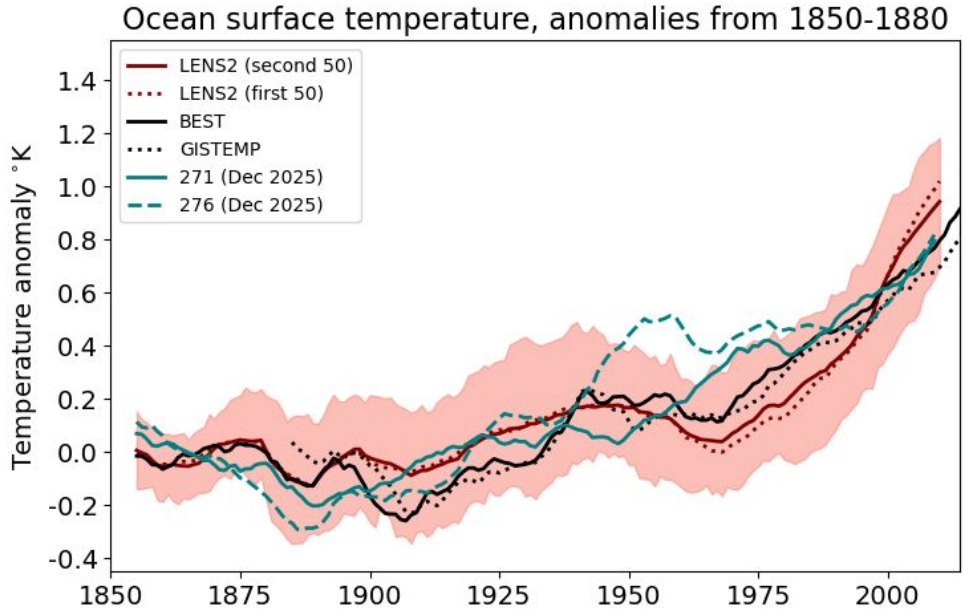
Global mean temperature



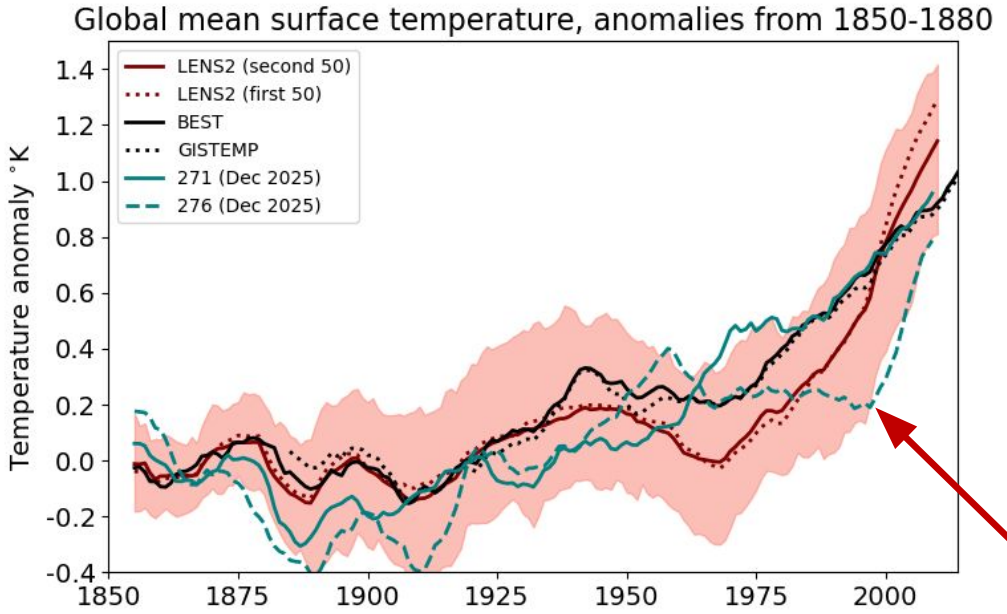
Surface temperature anomalies masked like BEST

10-year running means





Global mean temperature

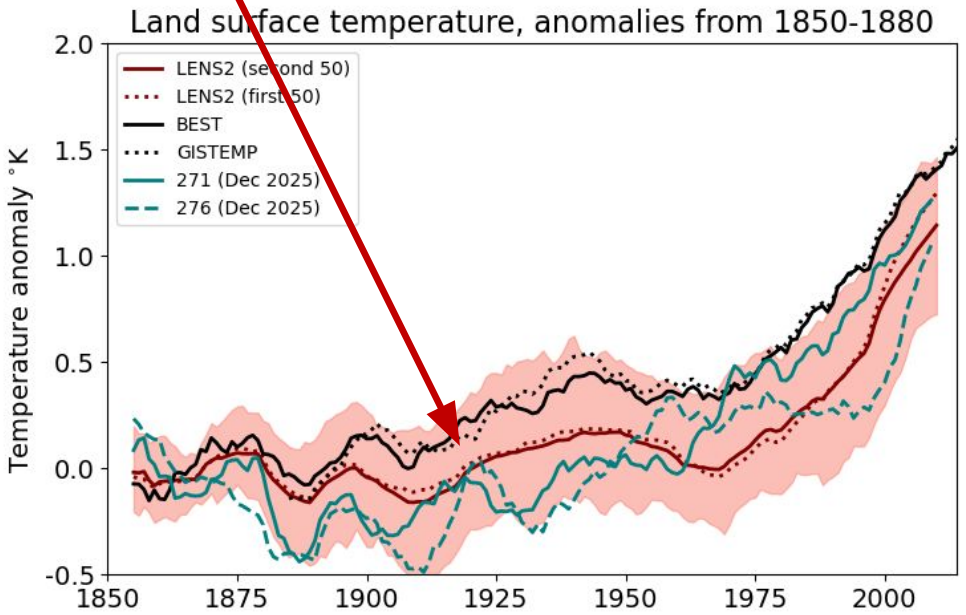


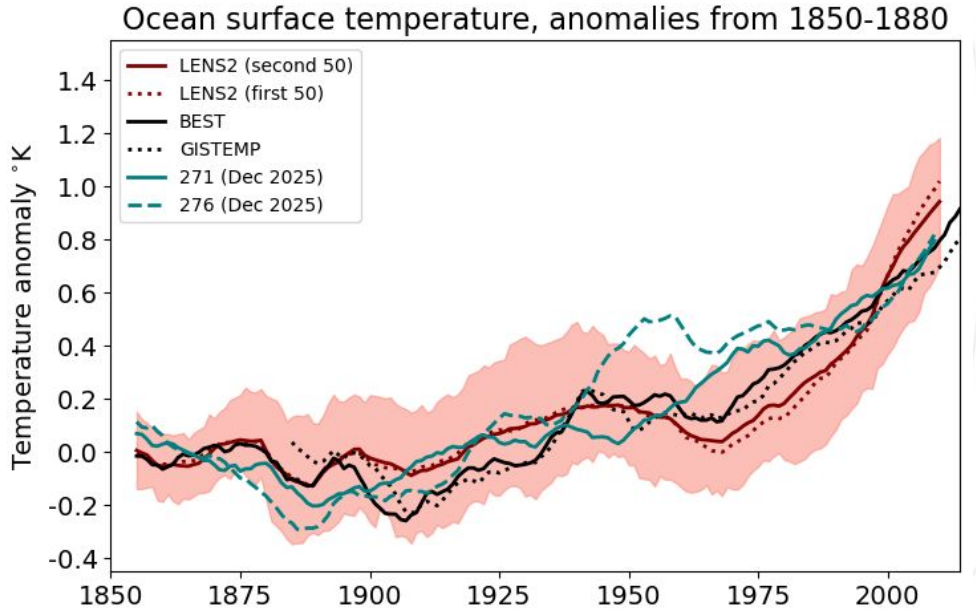
Surface temperature anomalies masked like BEST

10-year running means

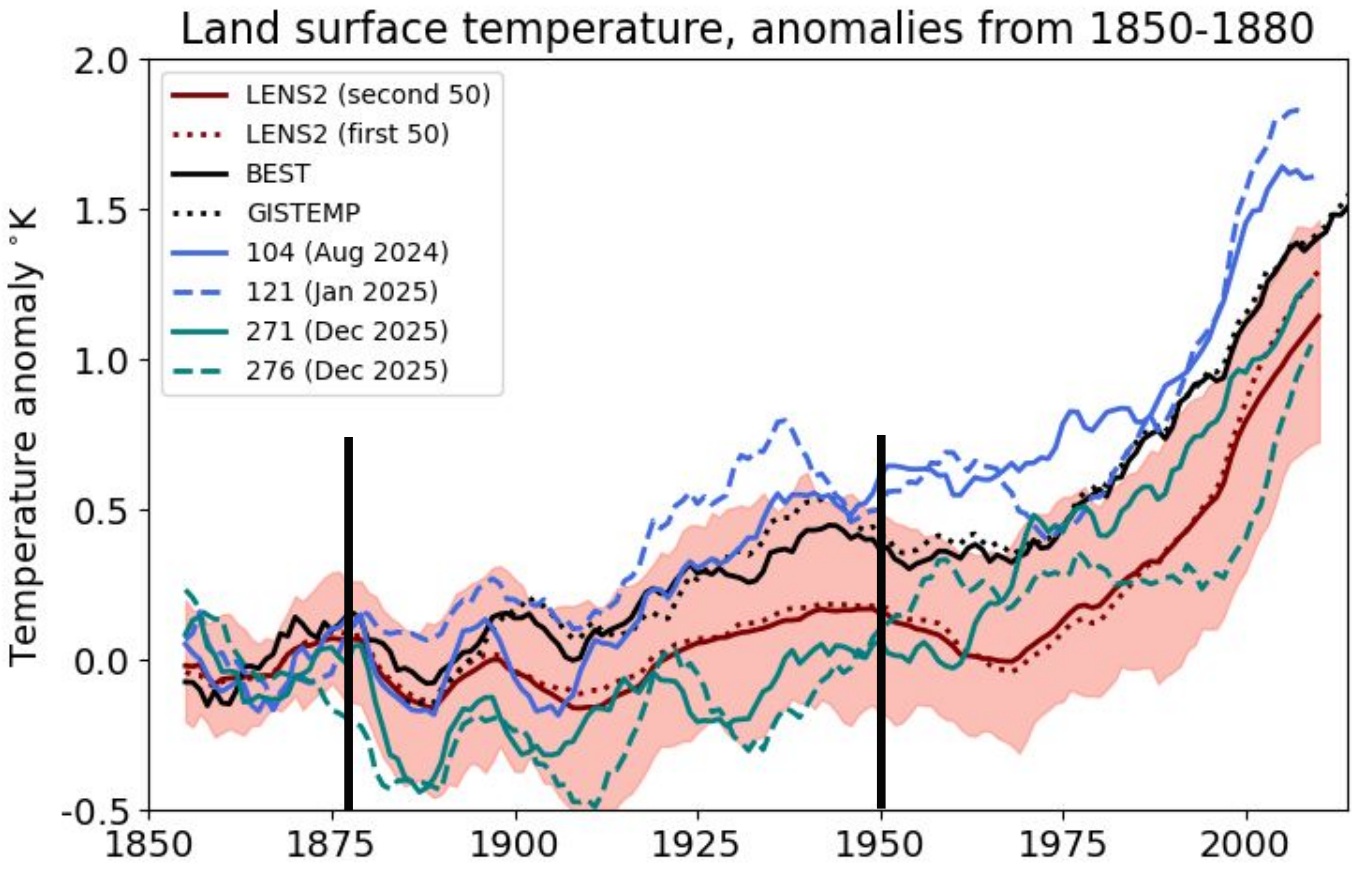
Did we lose something good in our early 20th century trends?

A lack of warming in the late 20th century in 276



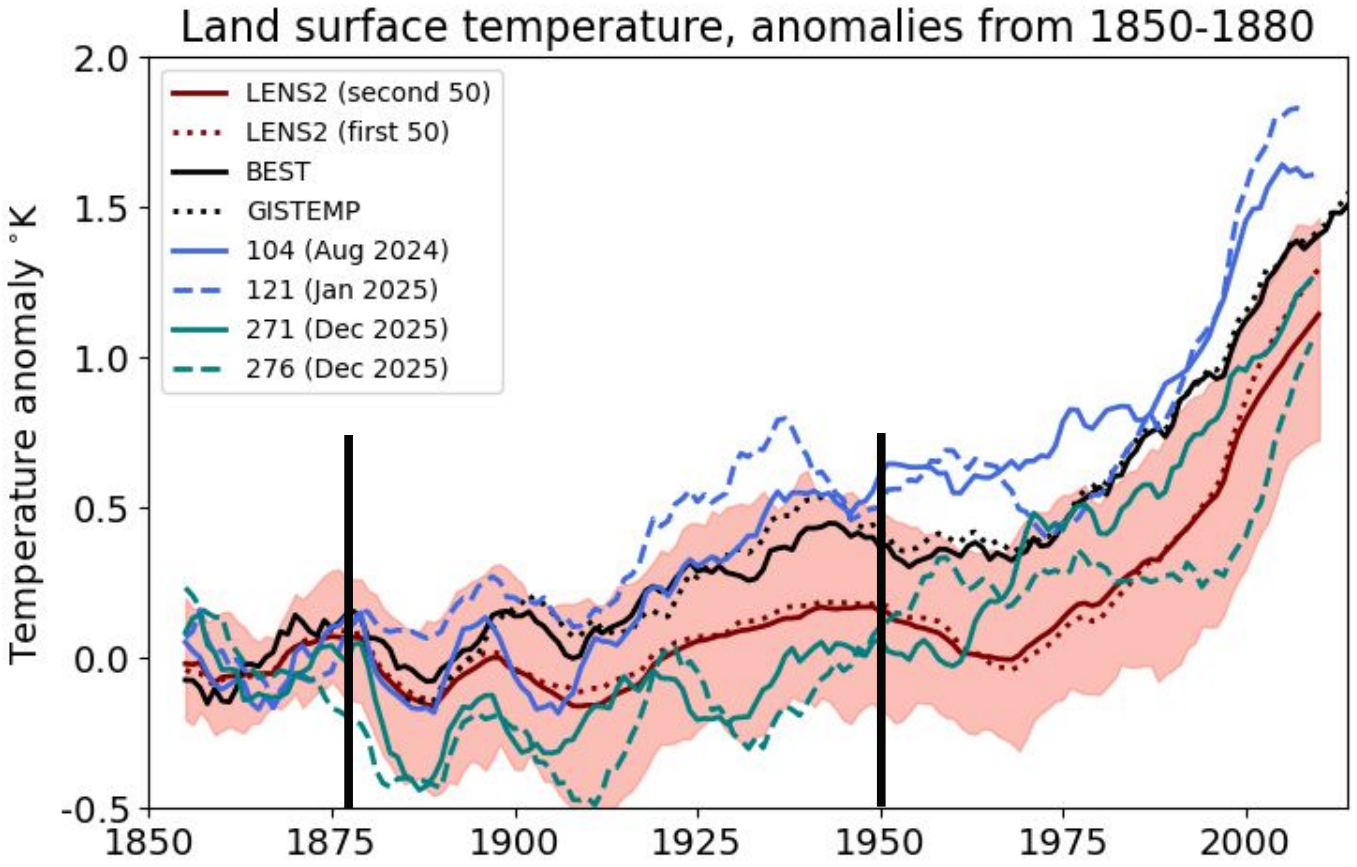


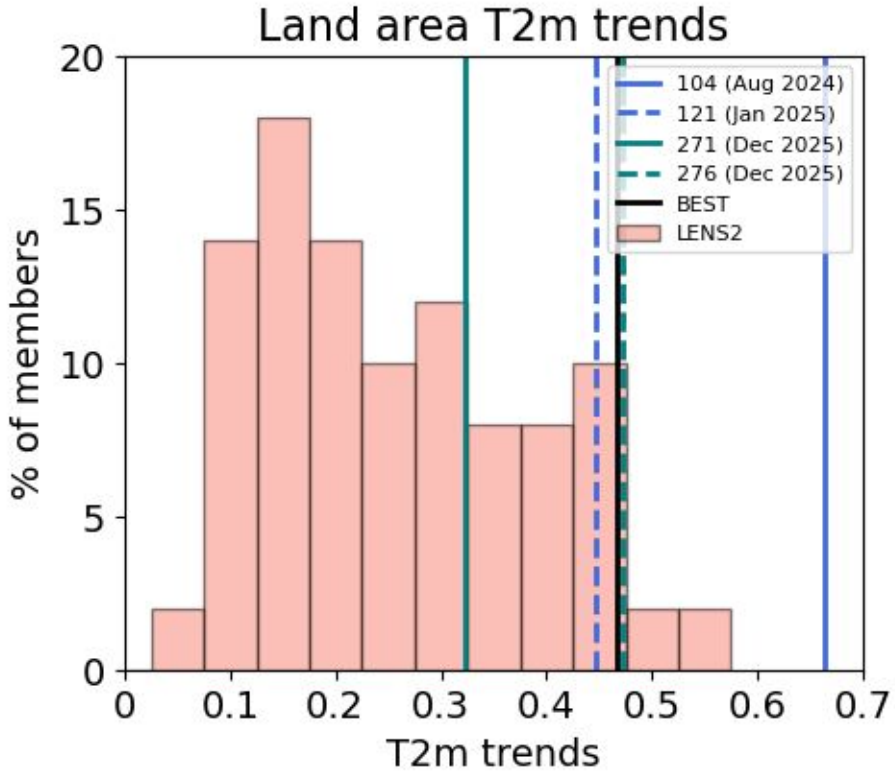
Early 20th century land temperature trends



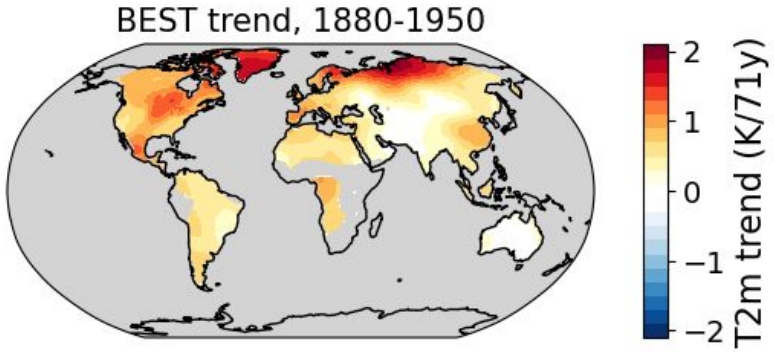
Will compare 1880-1950 trends between these four simulations

Early 20th century land temperature trends

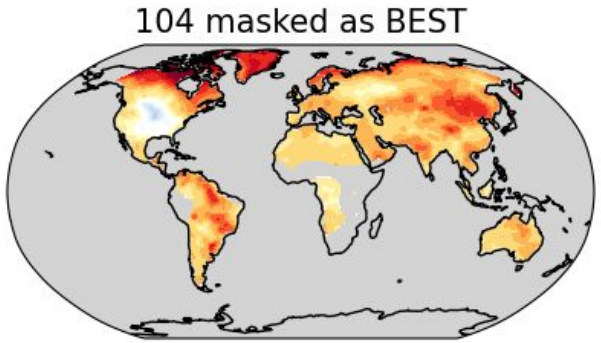


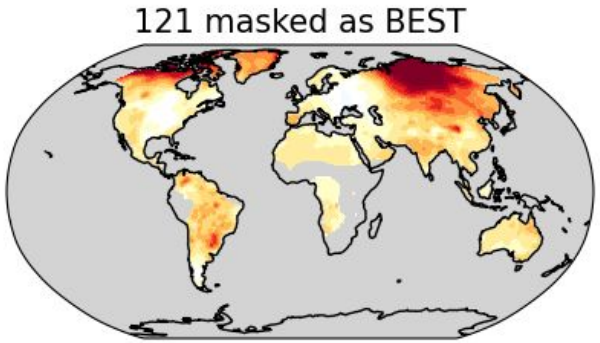


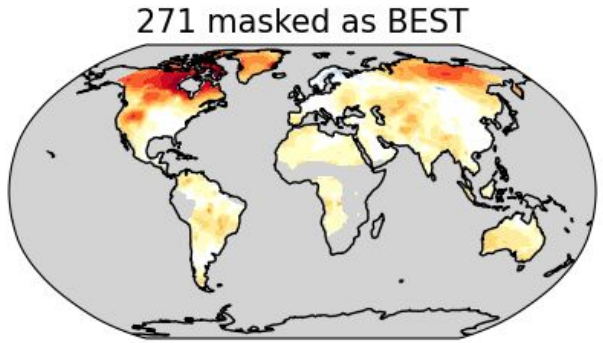
Early 20th century land temperature trends

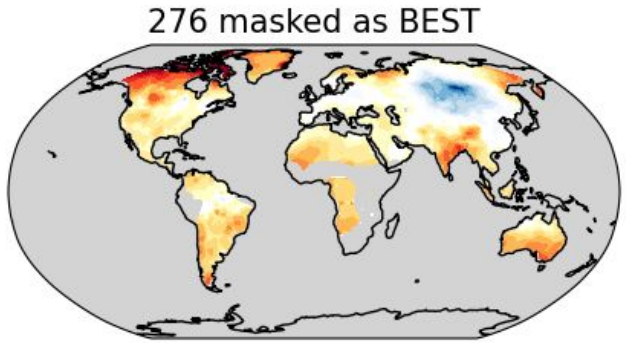


1880-1950 2m temperature trends



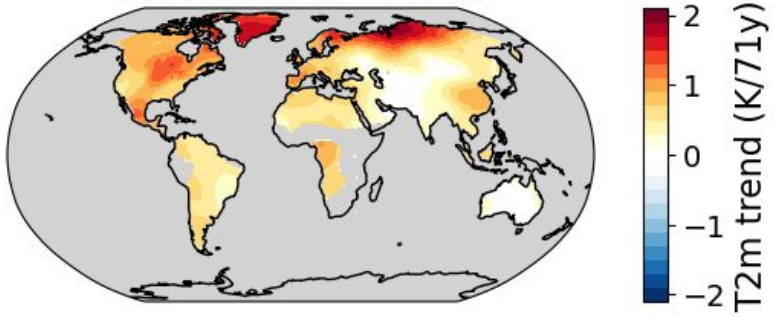






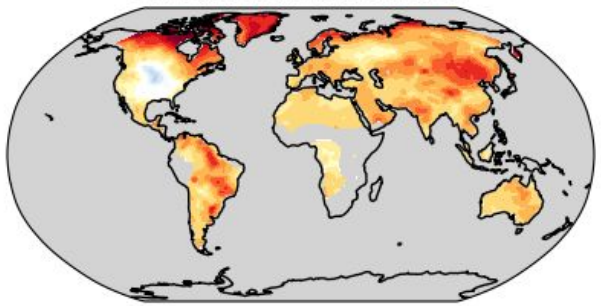
Early 20th century land temperature trends

BEST trend, 1880-1950

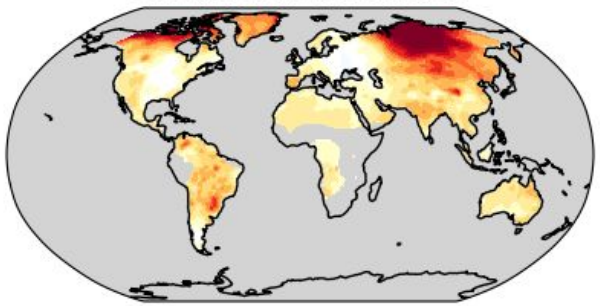


1880-1950 2m temperature trends

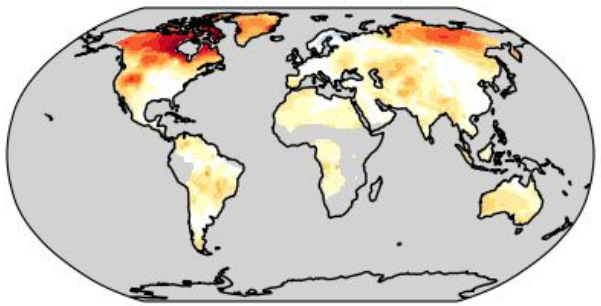
104 masked as BEST



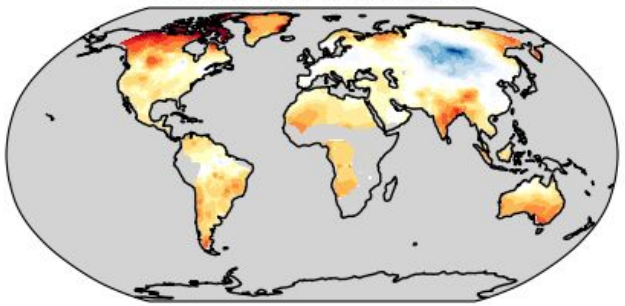
121 masked as BEST



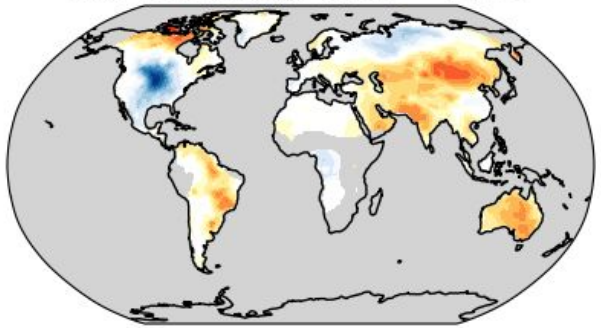
271 masked as BEST



276 masked as BEST



104 masked as BEST − BEST



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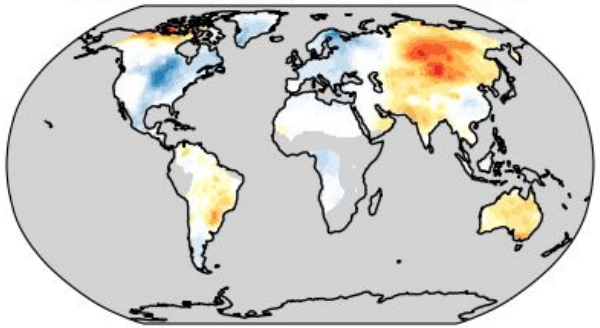

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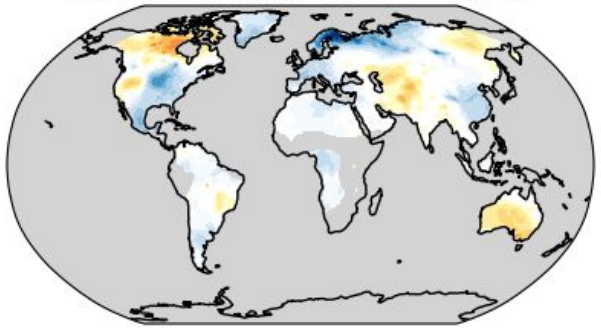

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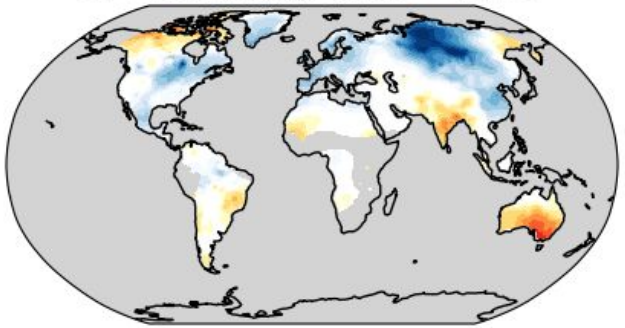
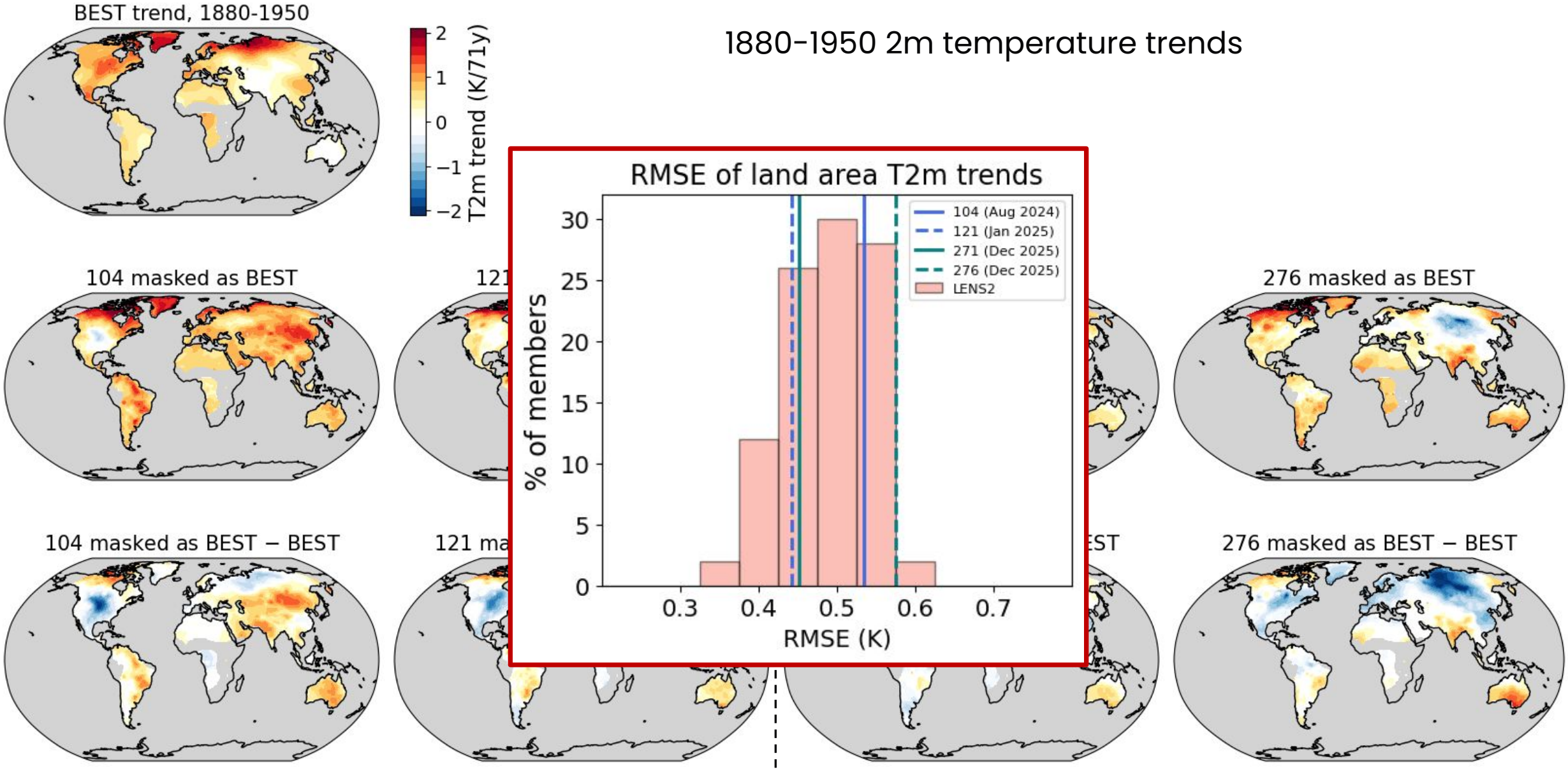
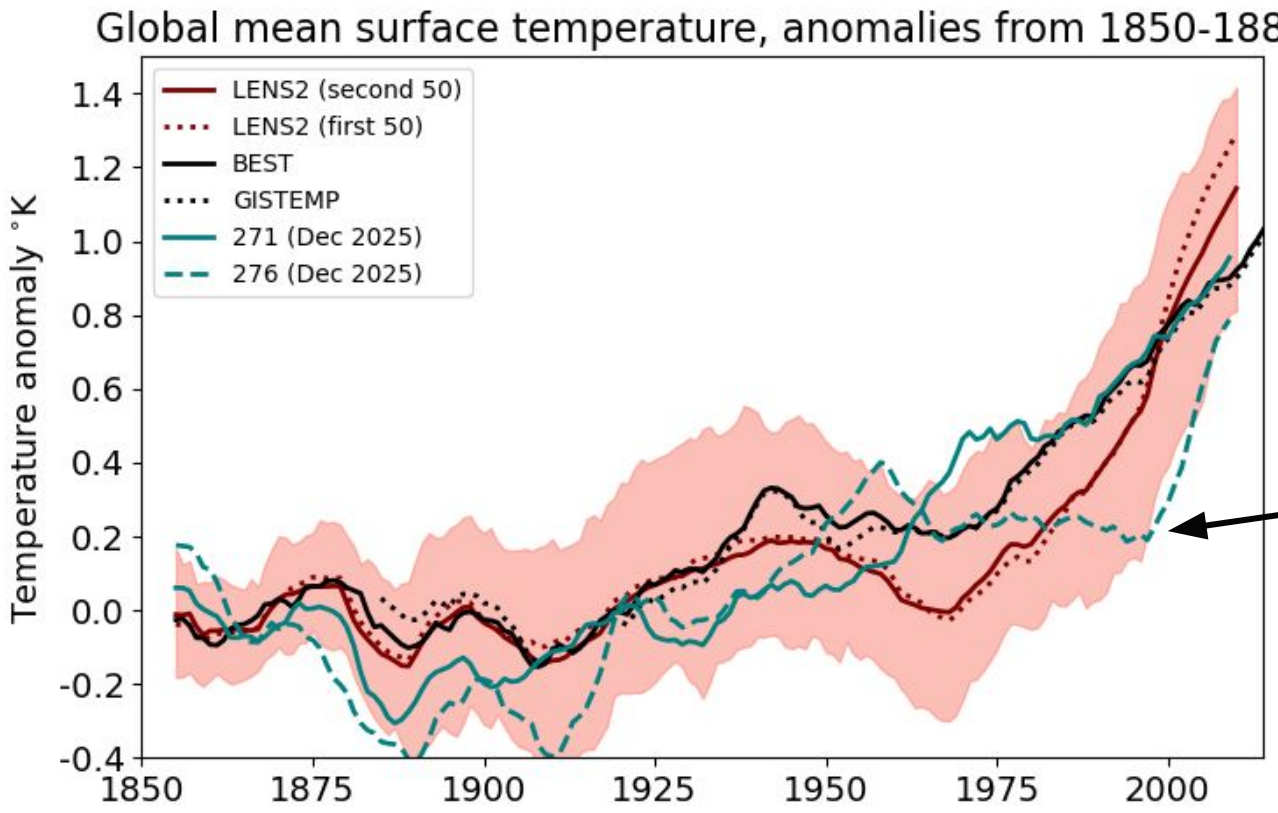


Early 20th century land temperature trends

1880-1950 2m temperature trends

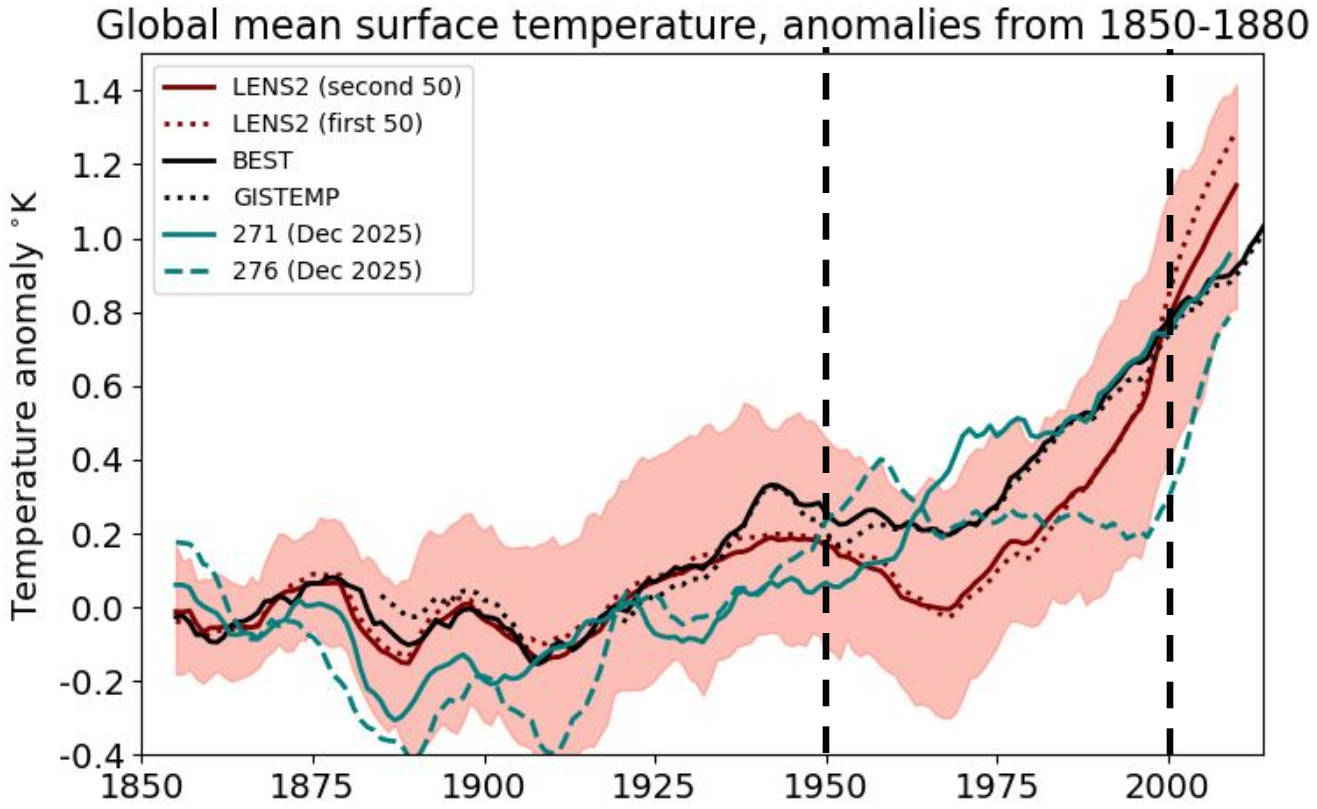


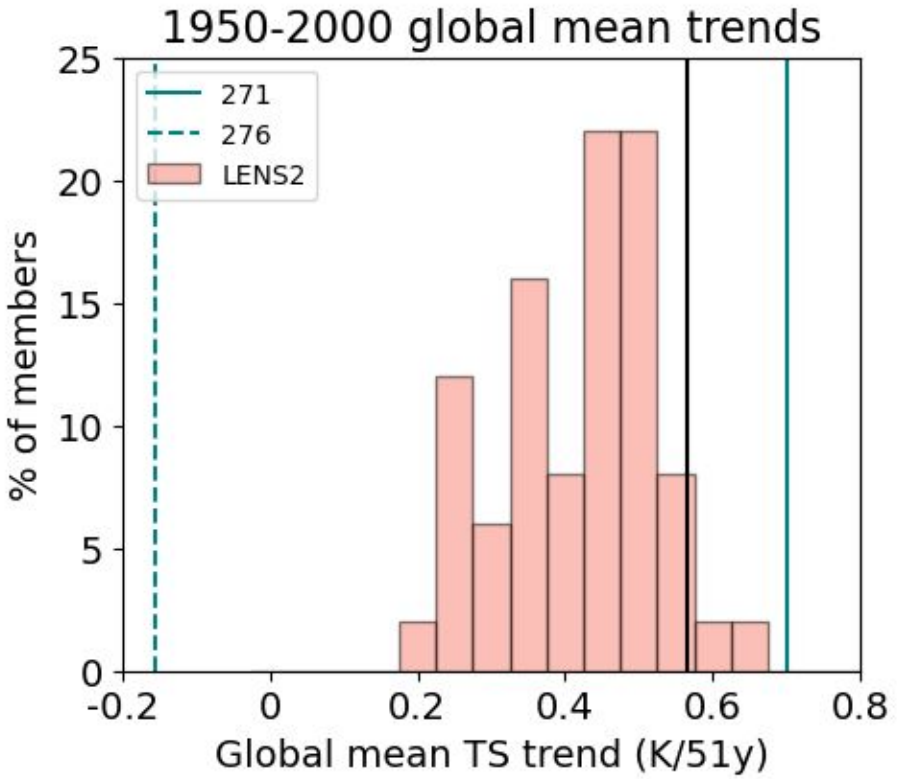
Lack of late 20th century warming in 276



Lack of warming in the late 20th century in 276

Lack of late 20th century warming in 276





Lack of late 20th century warming in 276

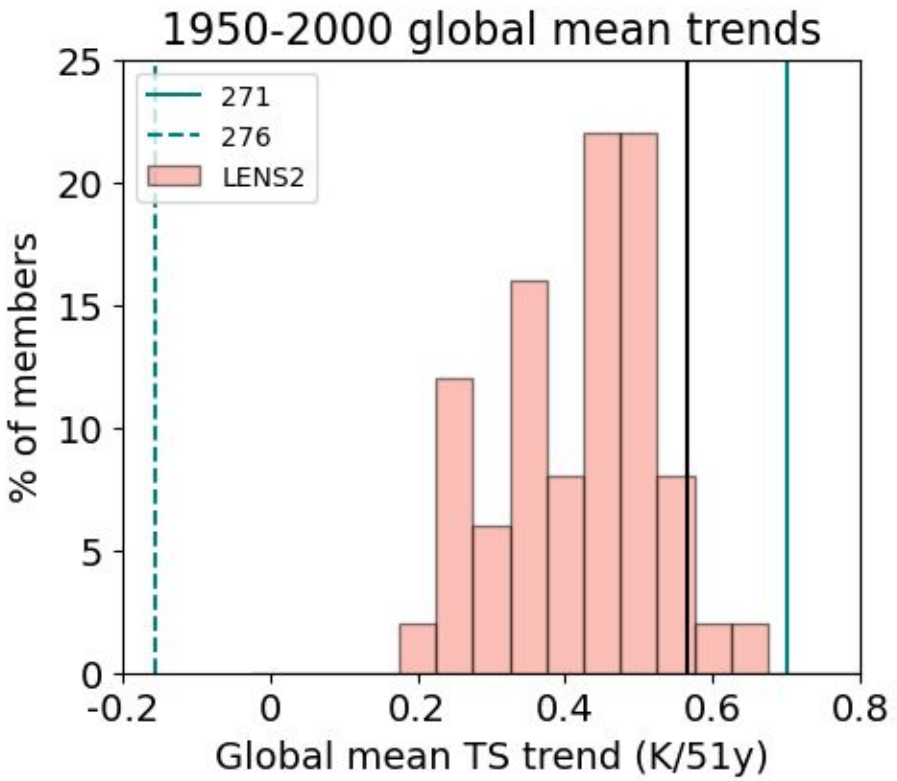
Two possibilities that have been investigated:

(1) Changed aerosol radiative forcing

Very similar between the two configurations

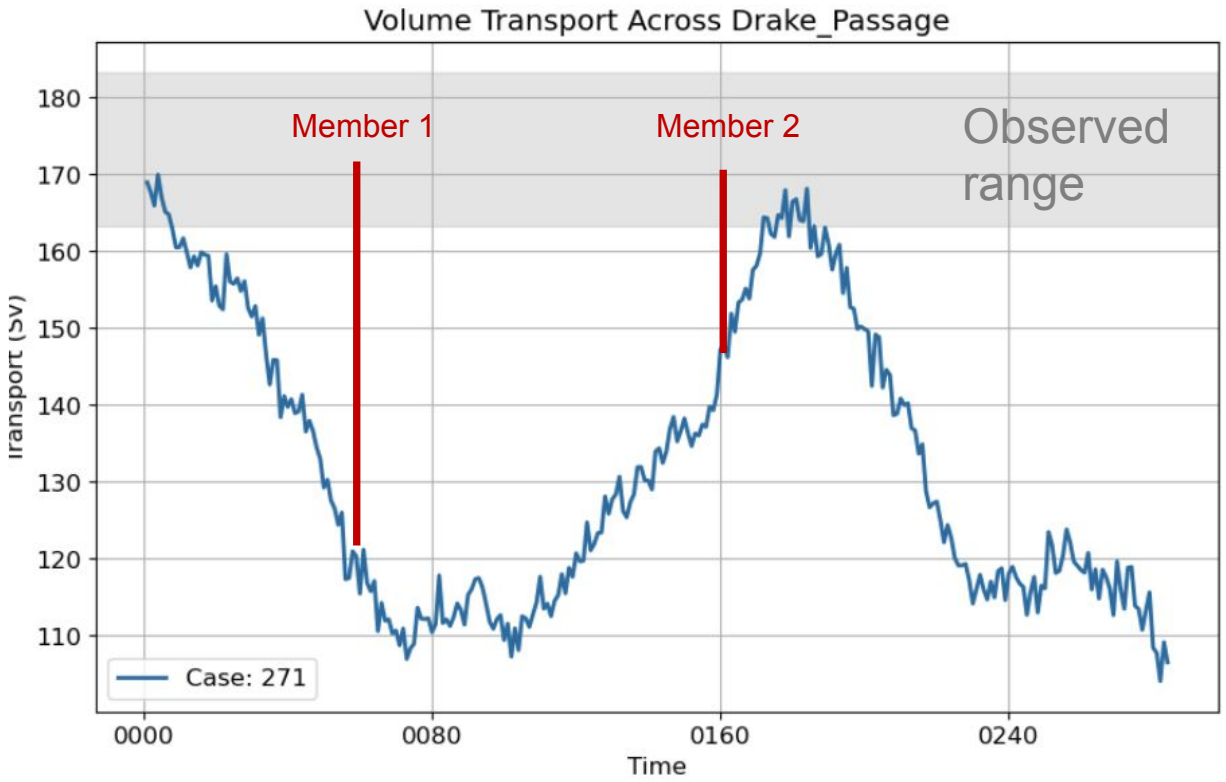
(2) Impact of spurious low frequency variability in the Southern Ocean

Investigating this now with two additional experiments initialized from different dates in the pre-industrial control

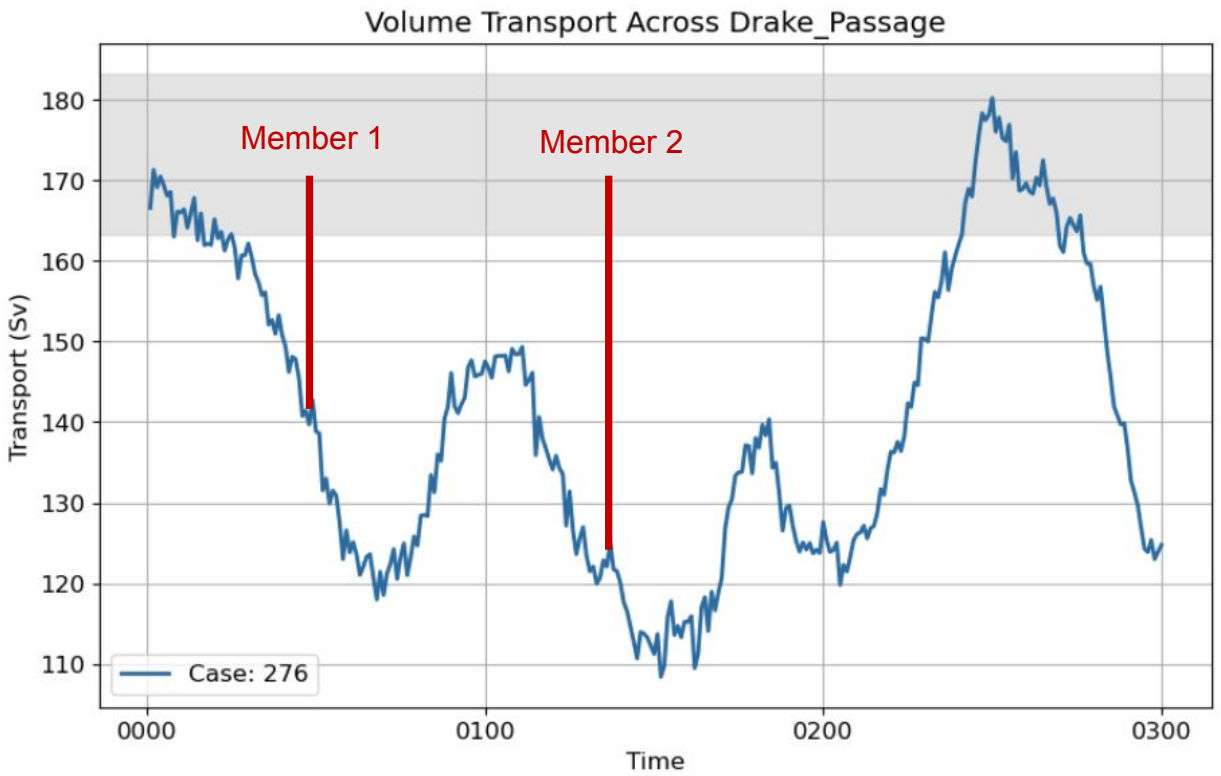


Spurious low frequency variability in Southern Ocean

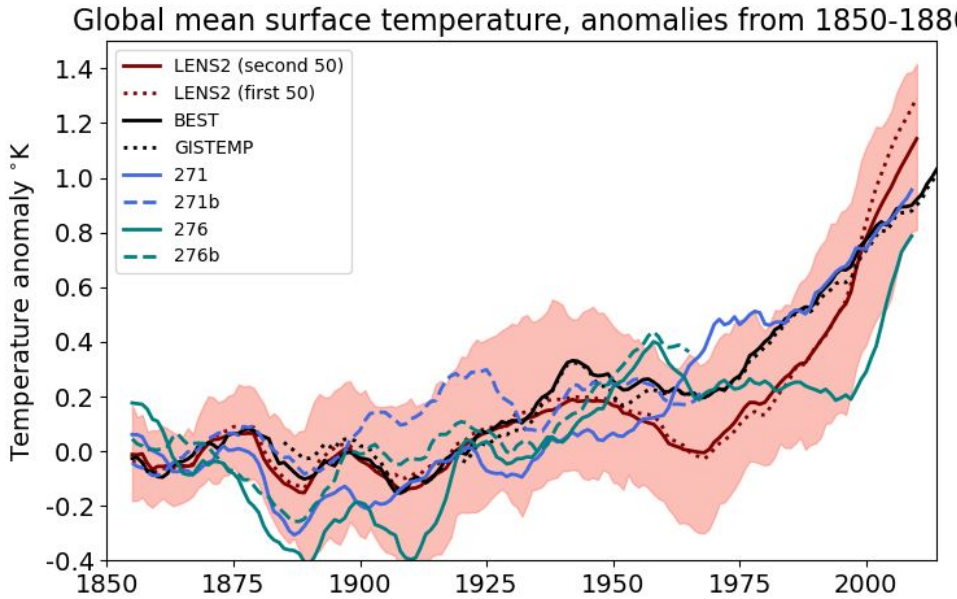
#271

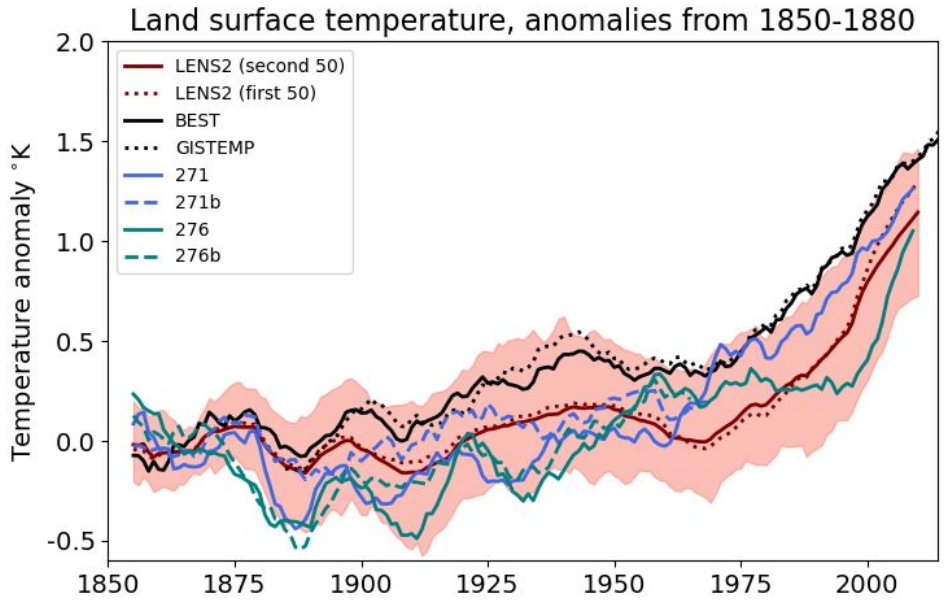


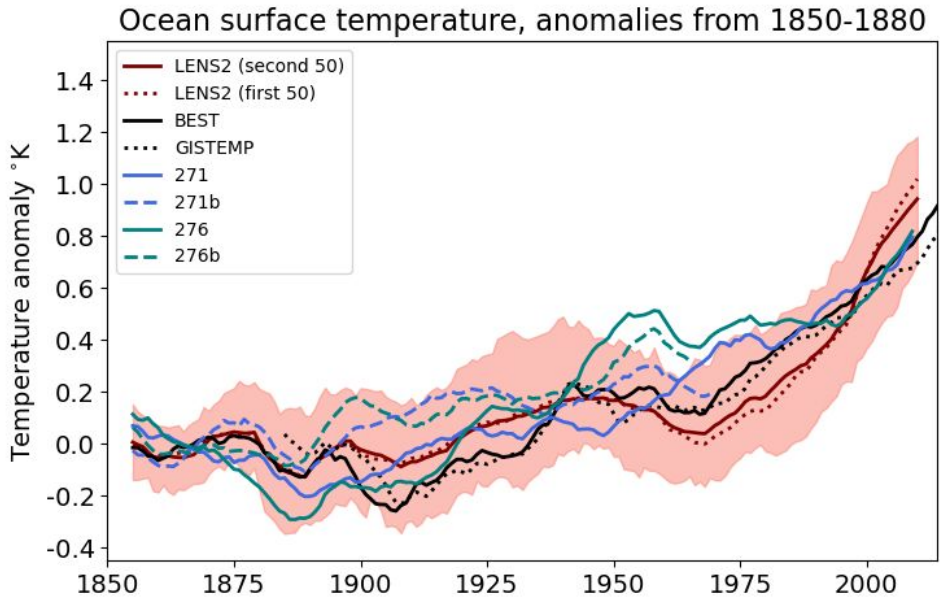
#276



Lack of late 20th century warming in 276

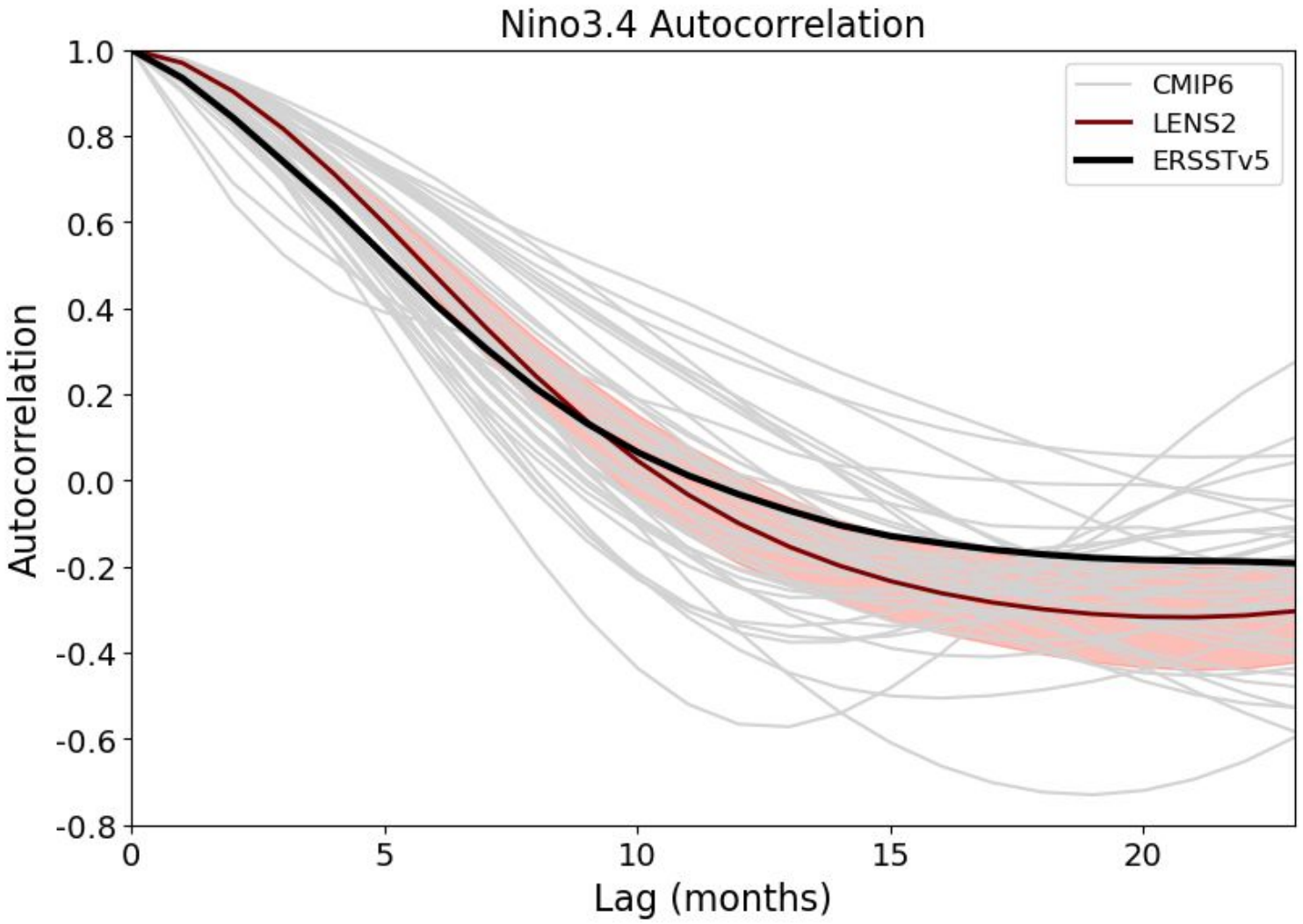






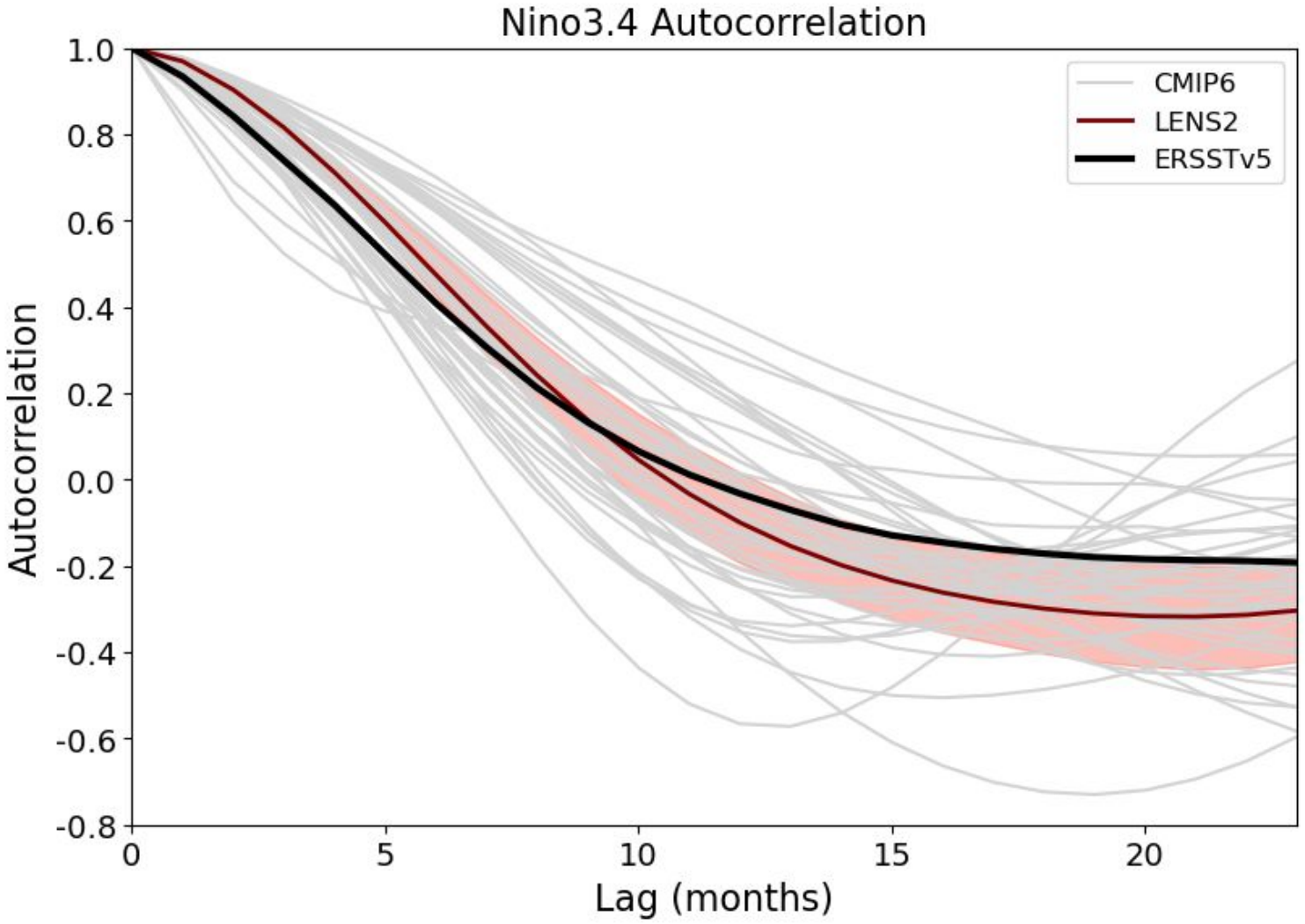
ENSO

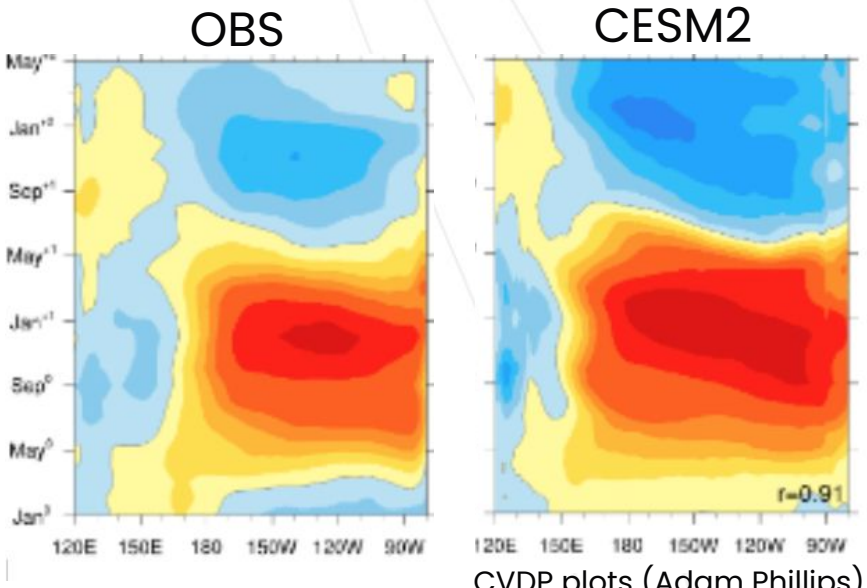
ENSO this time last year



CESM2 had a pretty good nino3.4 autocorrelation

ENSO this time last year

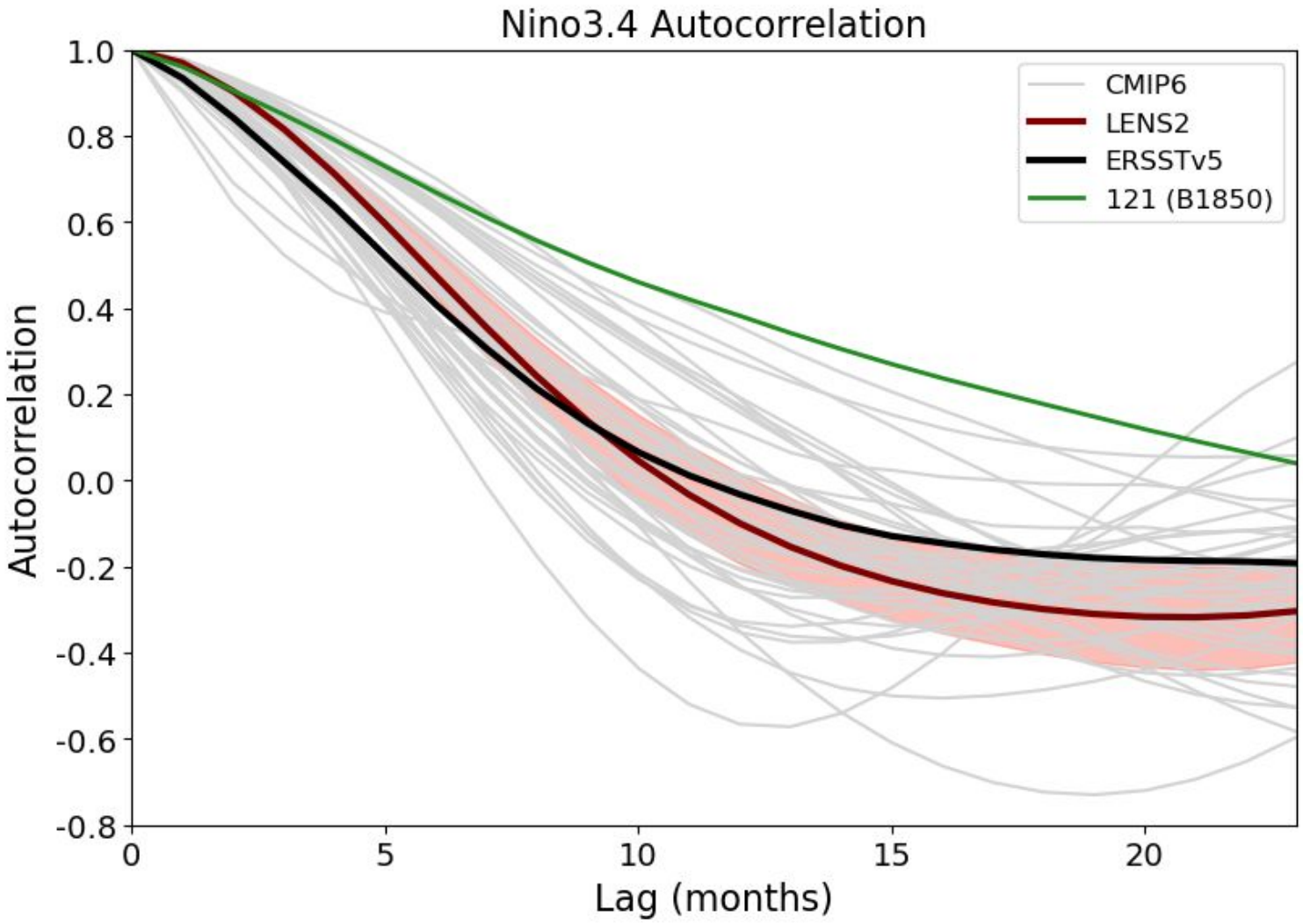




CVDP plots (Adam Phillips)

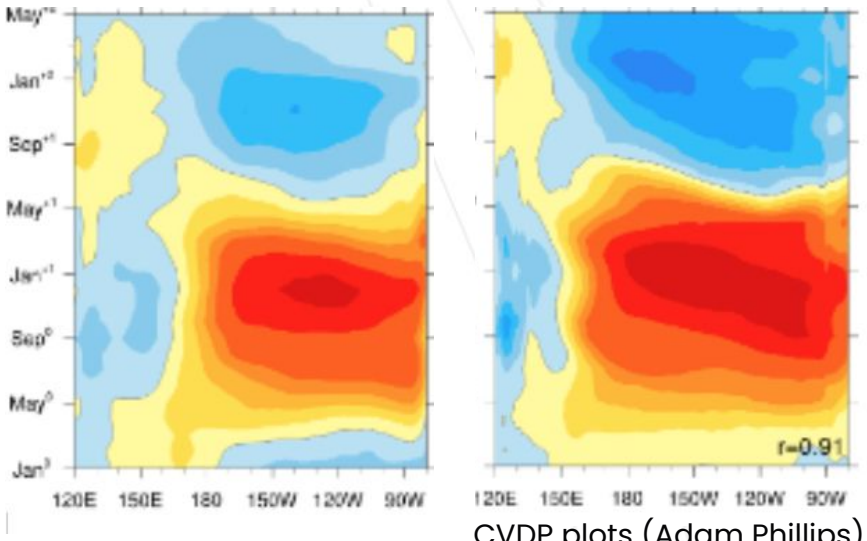
Hovmollers of tropical Pacific SSTs for El Nino events show it captured the transition from El Nino to La Nina well

ENSO this time last year



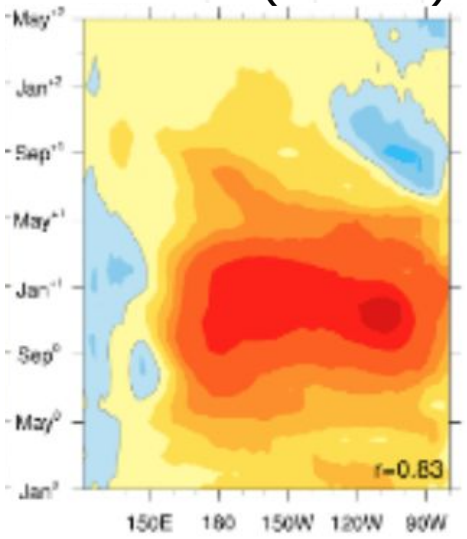
OBS

CESM2



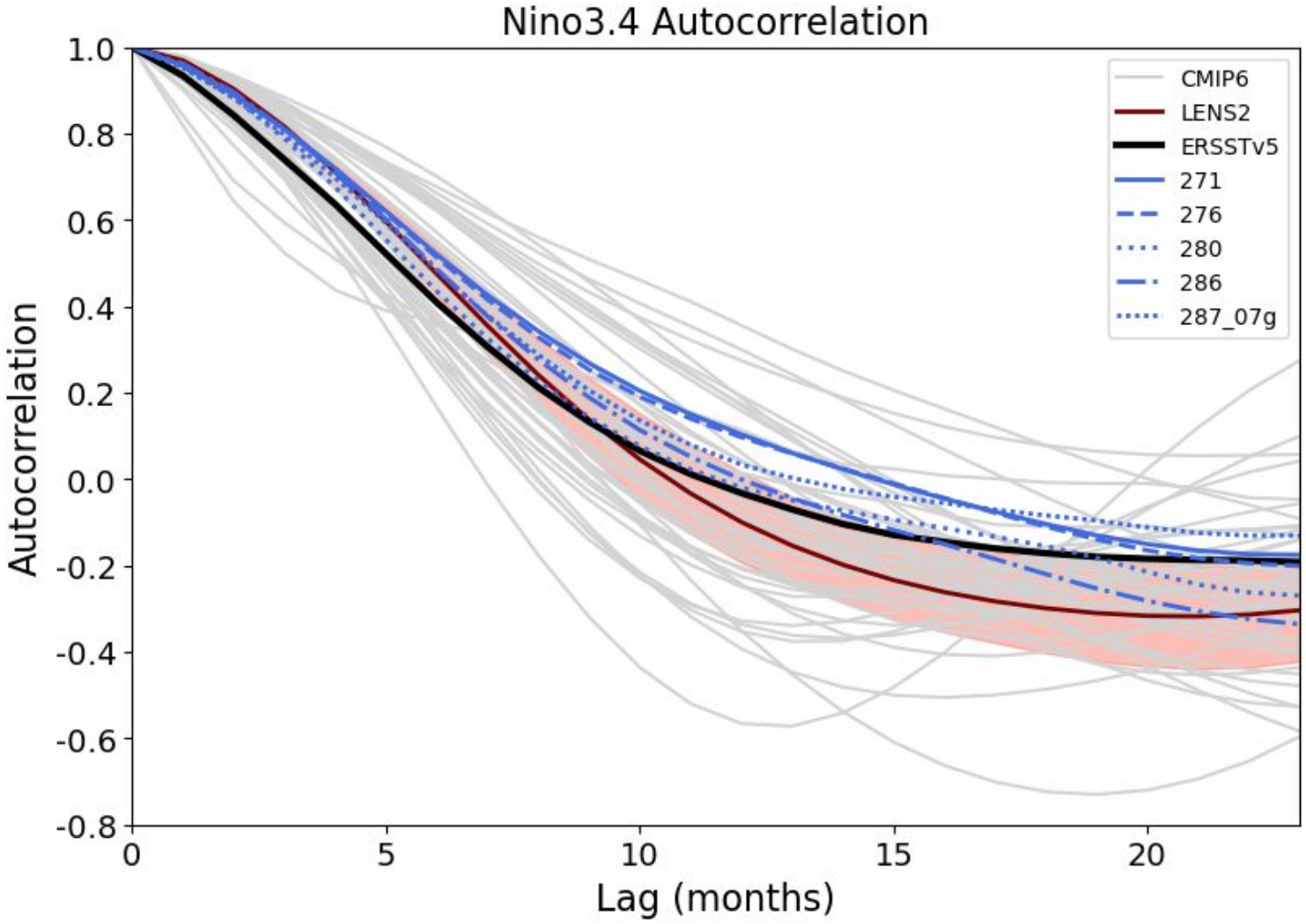
CVDP plots (Adam Phillips)

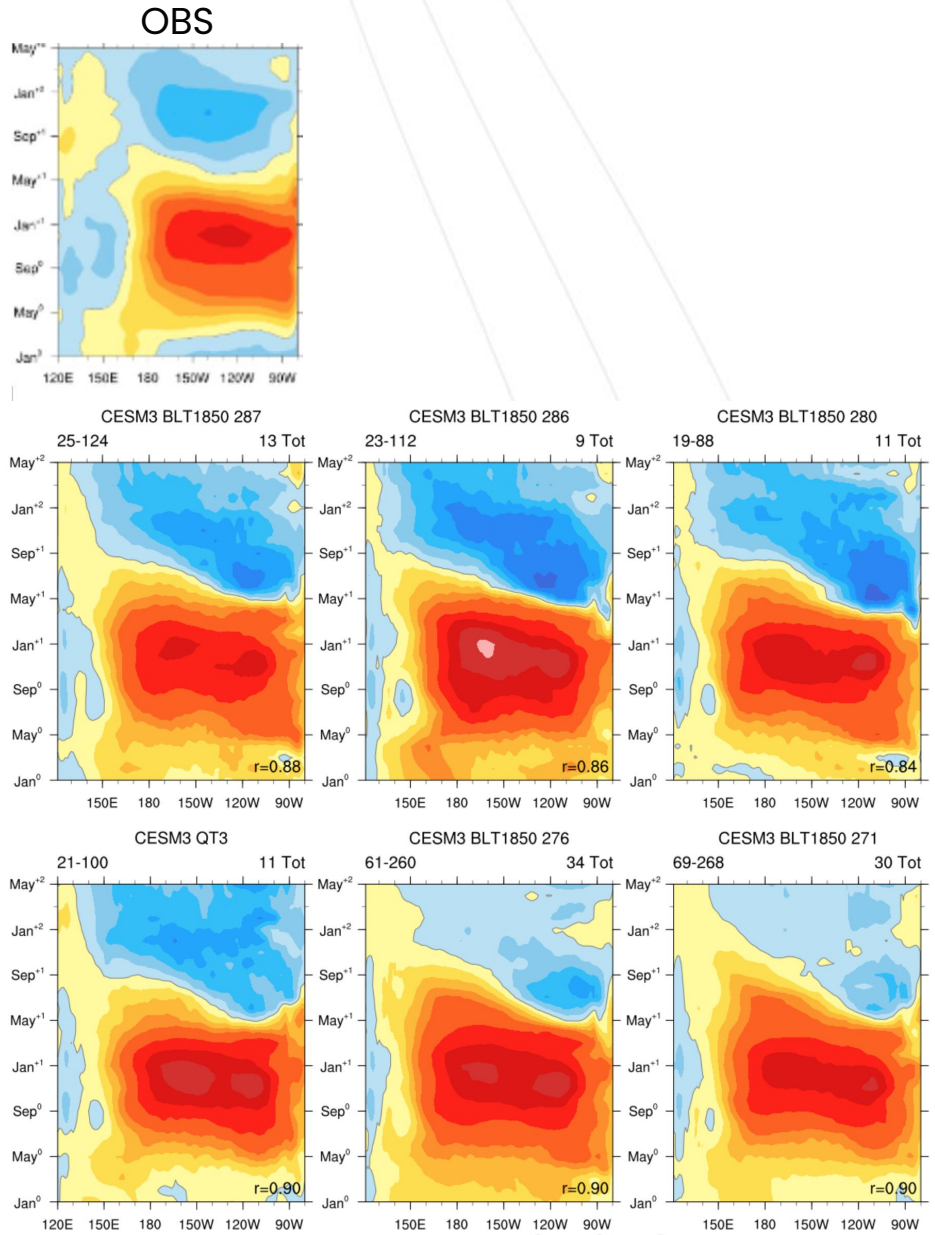
CESM3 (run 121)



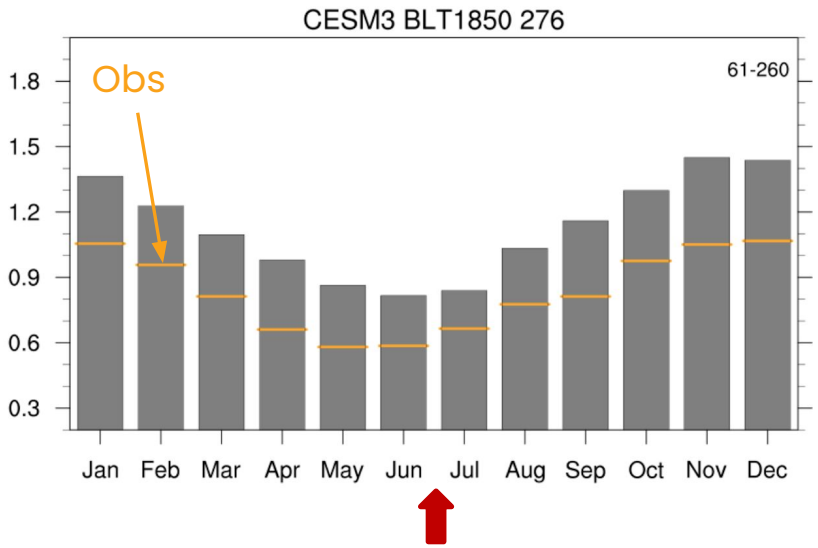
Didn't transition into La Nina after El Nino quickly enough

ENSO now

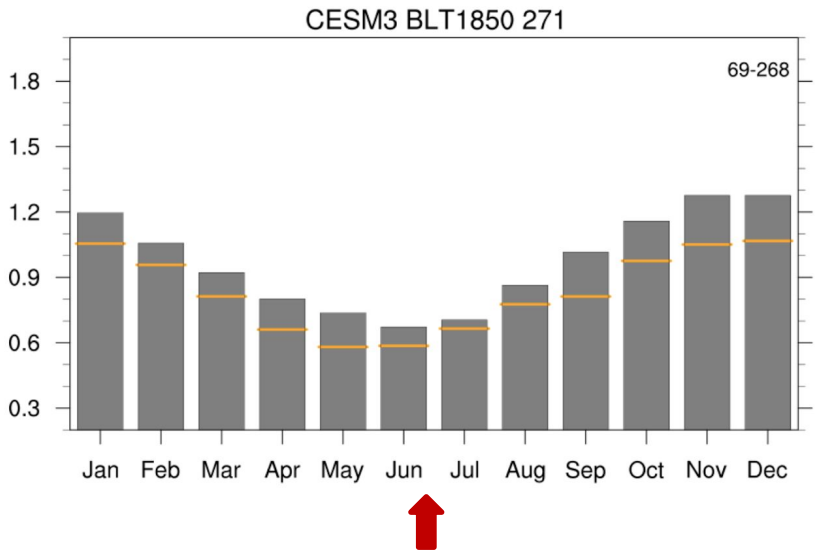

Nino3.4 Autocorrelation
Autocorrelation
Lag (months)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
0
5
10
15
20
CMIP6
LENS2
ERSSTv5
271
276
280
286
287_07g


OBS
CESM3 BLT1850 287
25-124
13 Tot
r=0.88
CESM3 BLT1850 286
23-112
9 Tot
r=0.86
CESM3 BLT1850 280
19-88
11 Tot
r=0.84
CESM3 QT3
21-100
11 Tot
r=0.90
CESM3 BLT1850 276
61-260
34 Tot
r=0.90
CESM3 BLT1850 271
69-268
30 Tot
r=0.90
120E 150E 180 150W 120W 90W

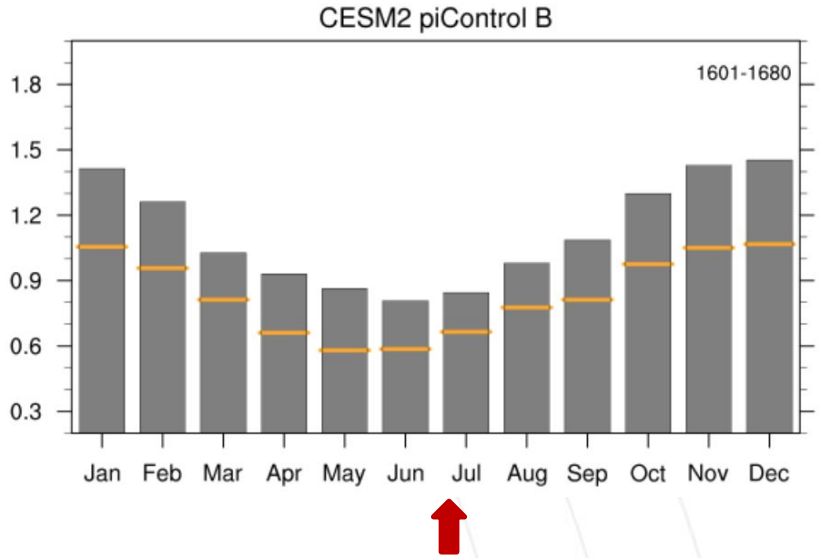
ENSO variance



Run 276 (Dec 2025)



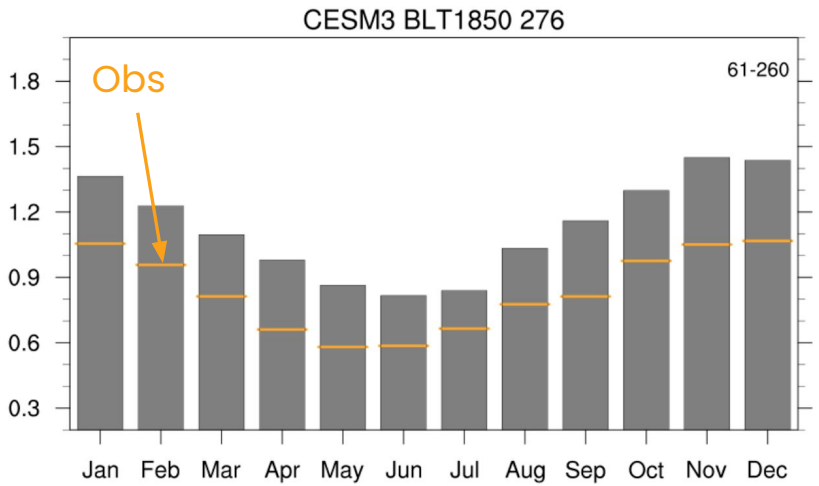
Run 271 (Dec 2025)



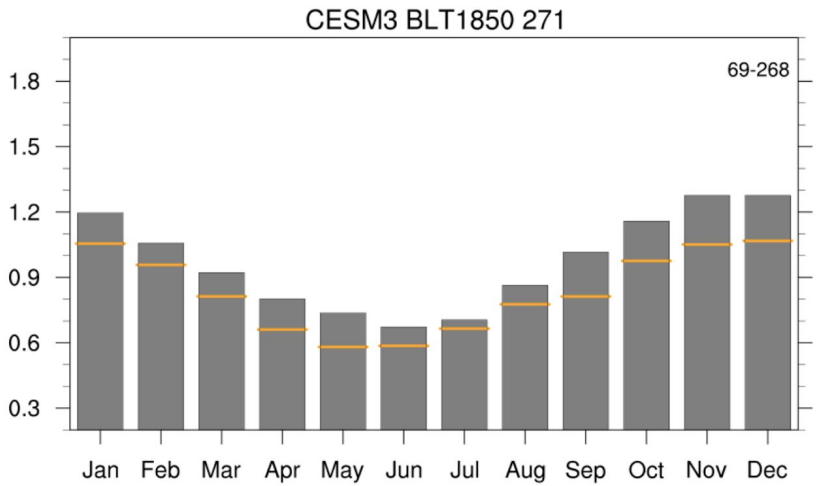
A CESM2 segment

Monthly Nino3.4 standard deviation

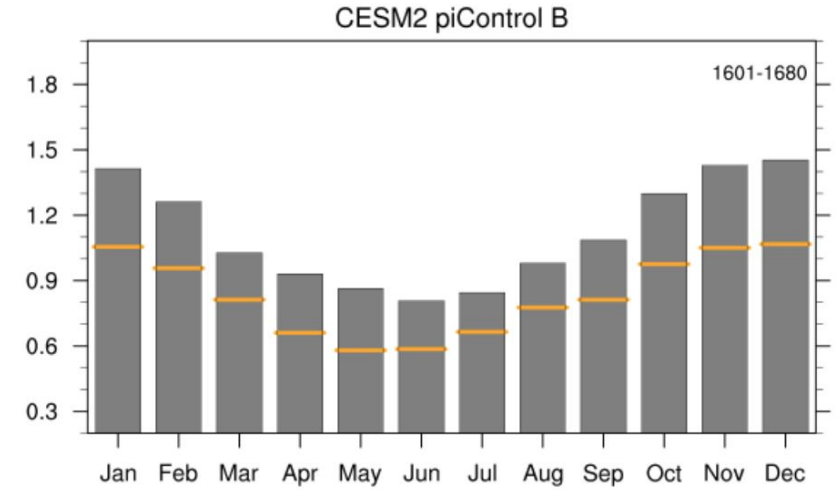
ENSO variance



Run 276 (Dec 2025)

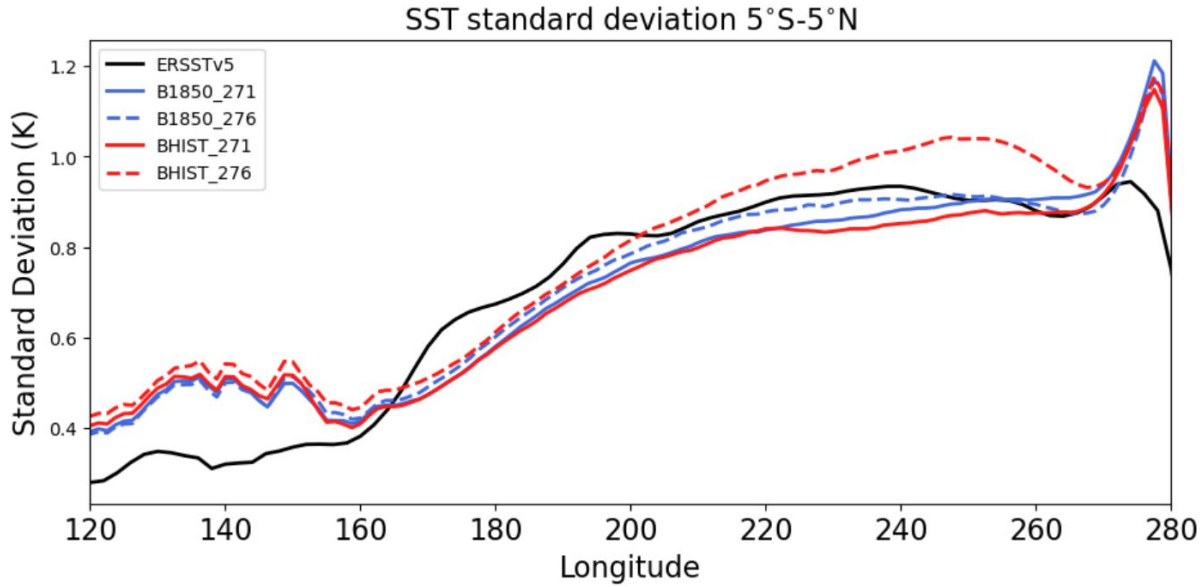


Run 271 (Dec 2025)



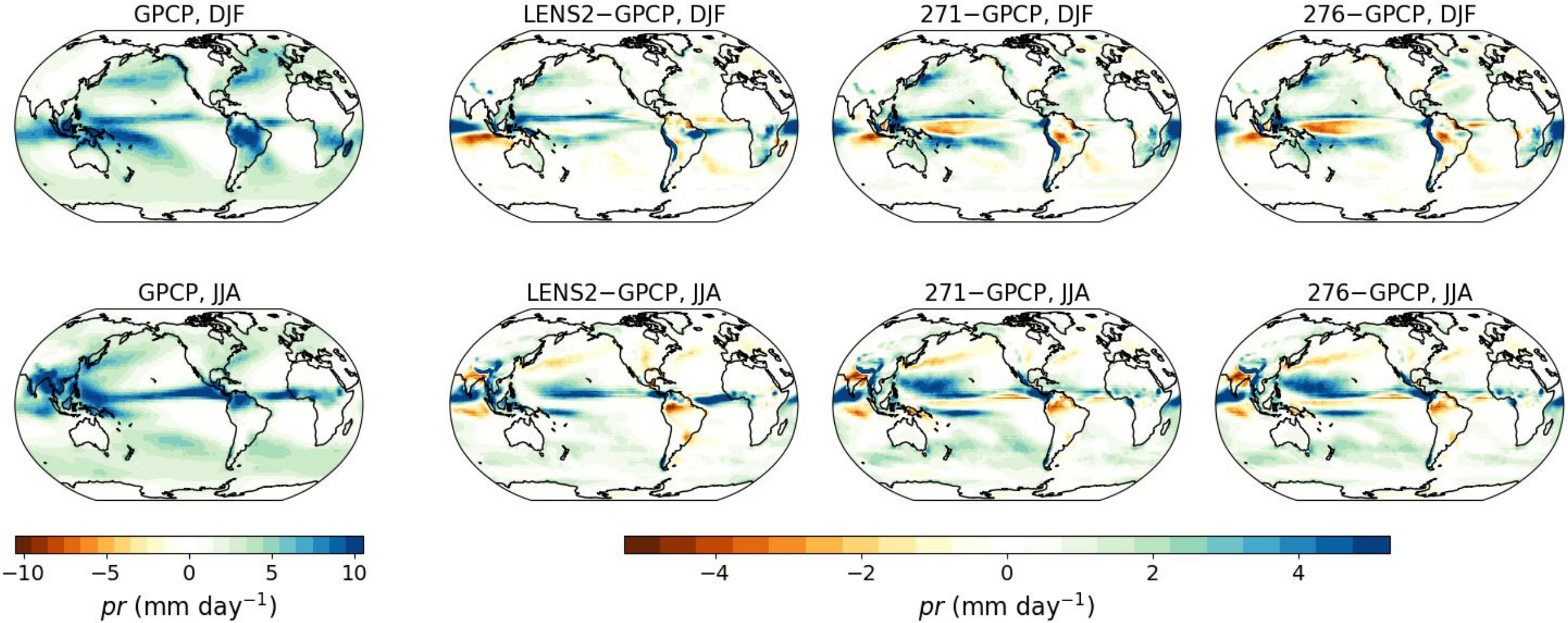
A CESM2 segment

Standard deviation of deseasonalized and detrended monthly SSTs averaged from 5S-5N

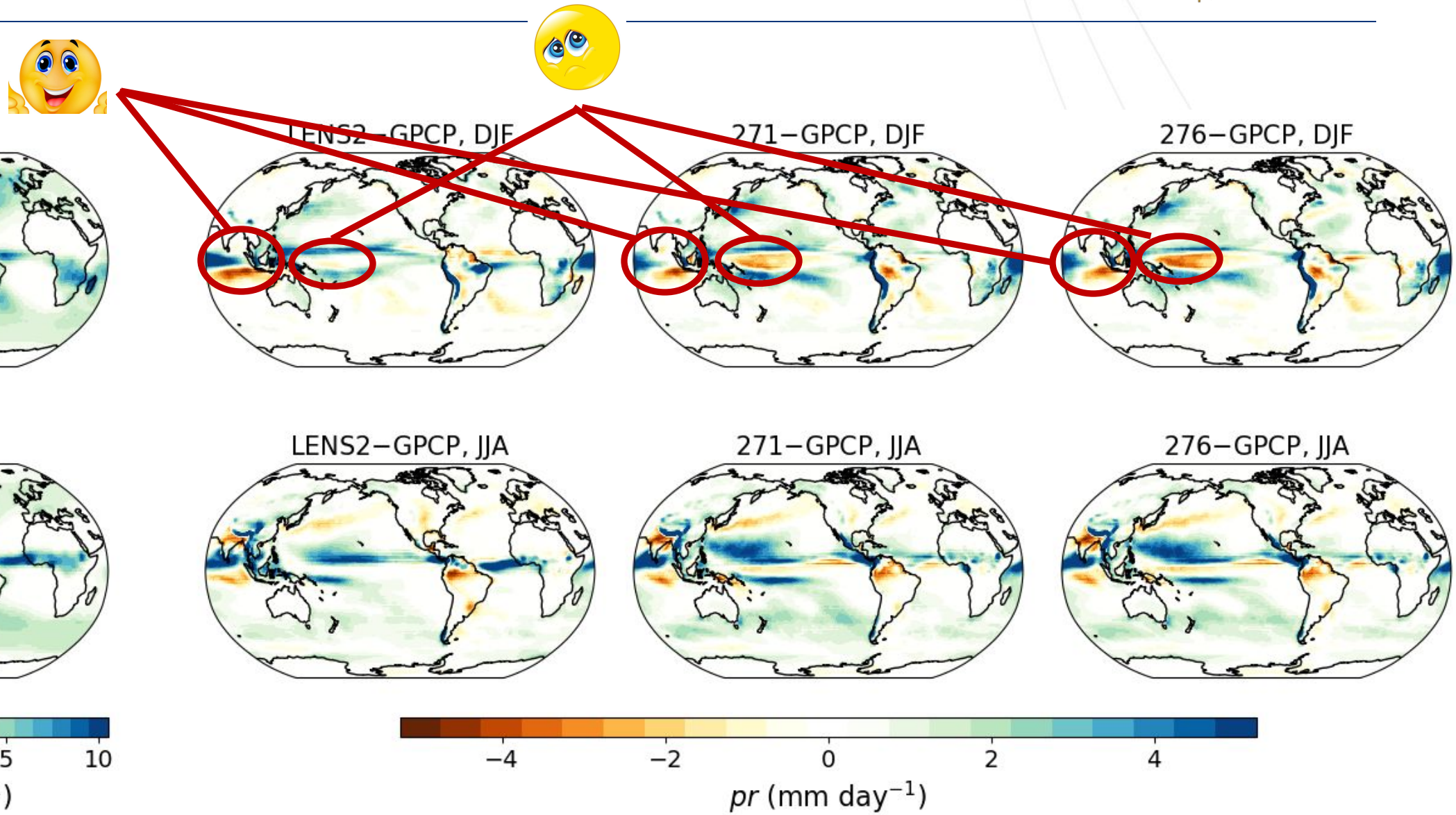


Basic large-scale climatological features

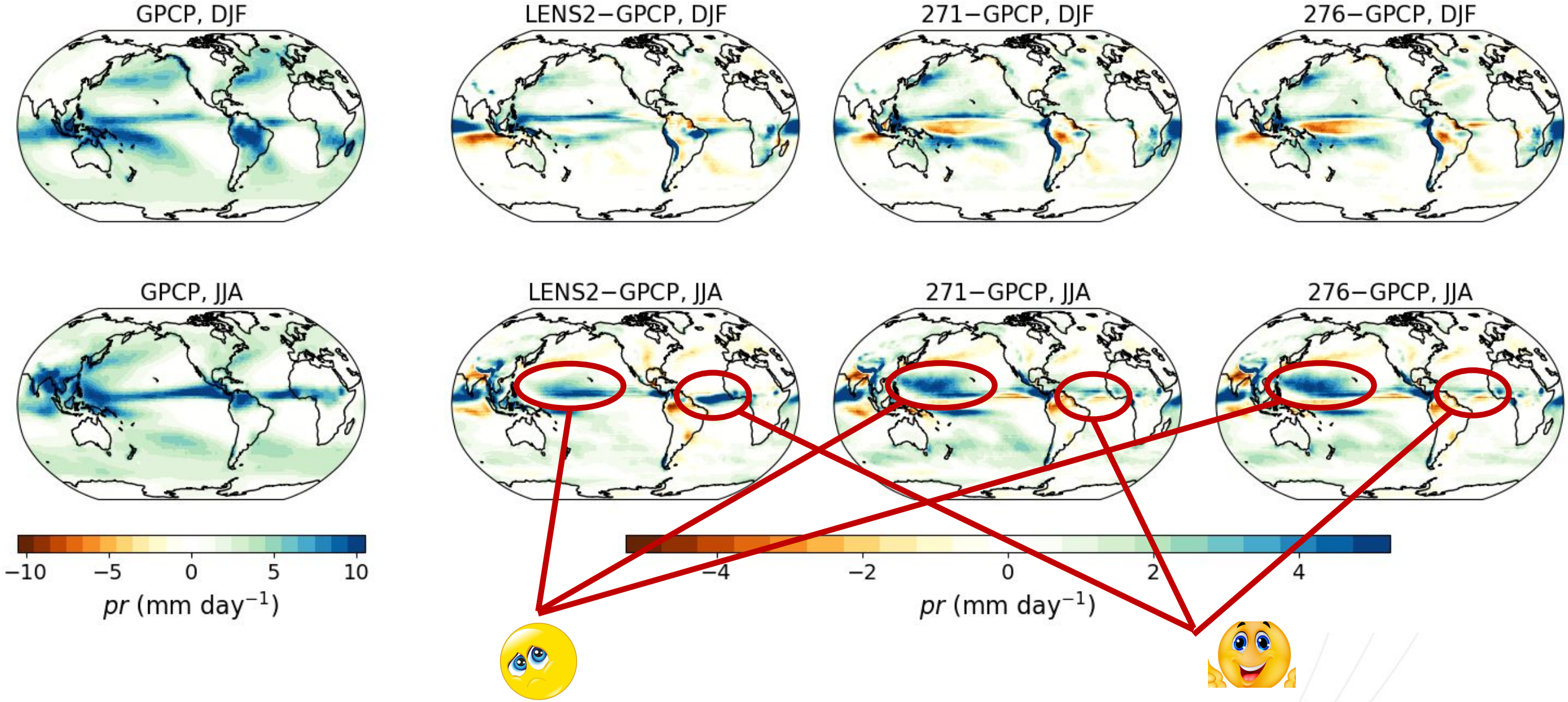
Precipitation



Precipitation

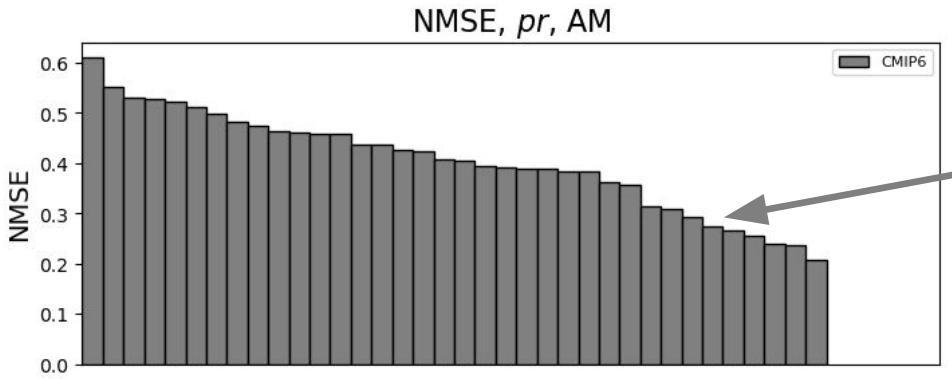


Precipitation

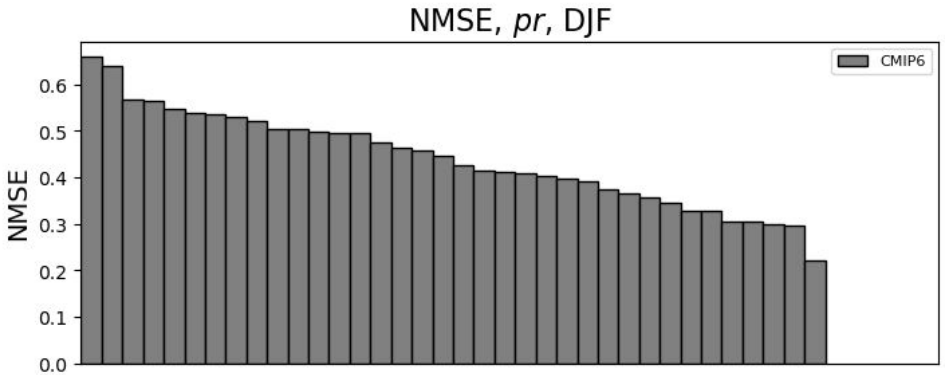


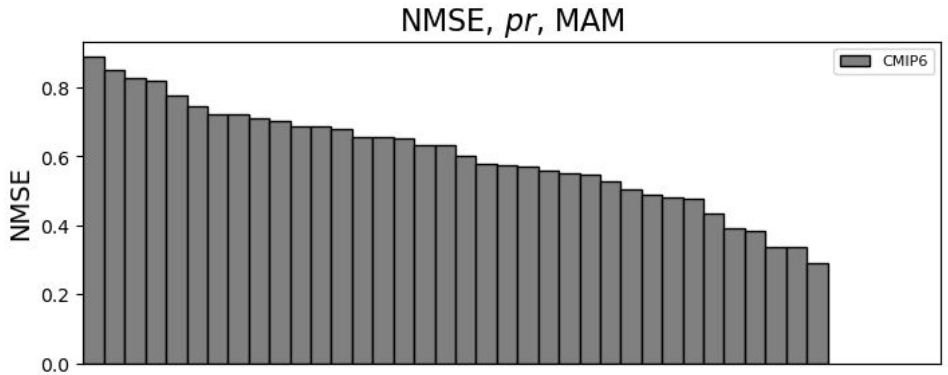
Precipitation

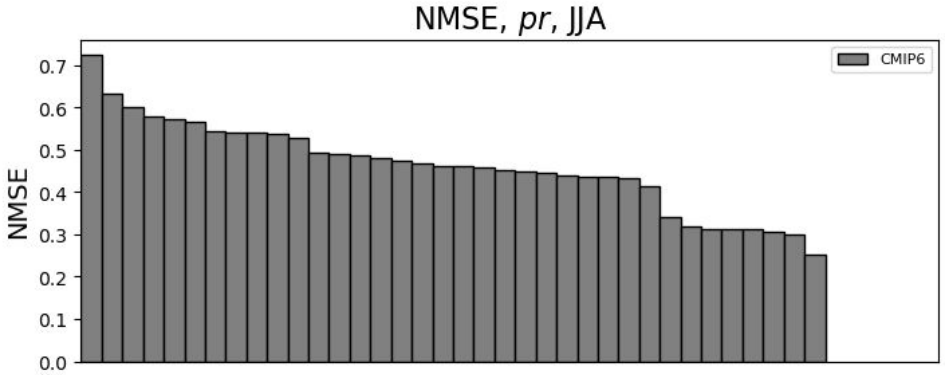
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

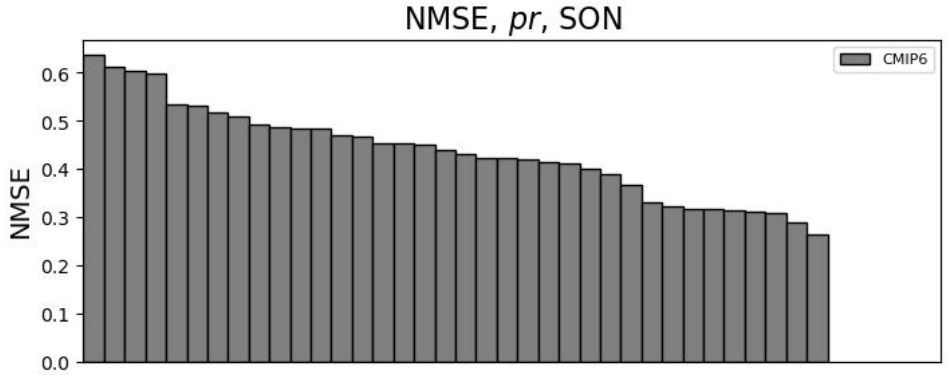


Each of the CMIP6 models



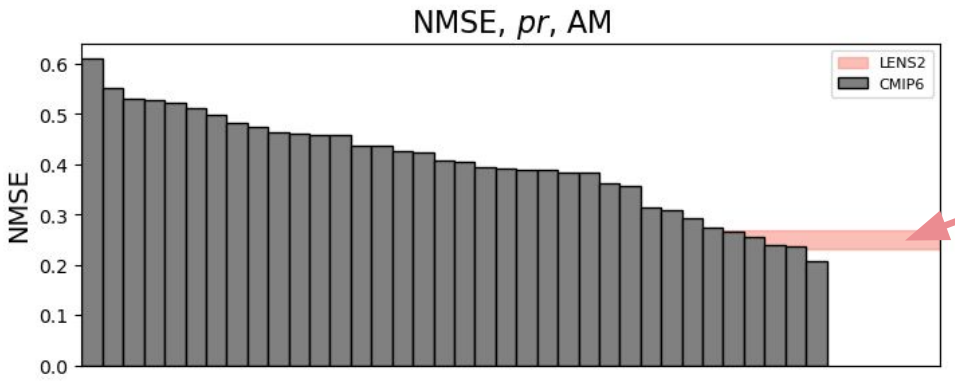




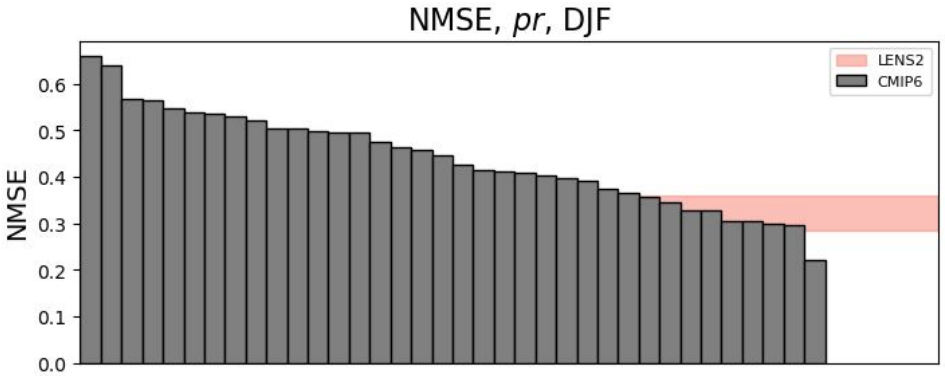


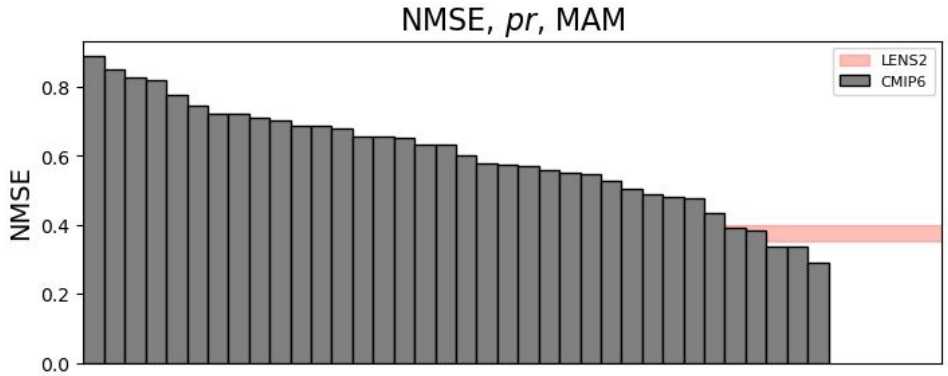
Precipitation

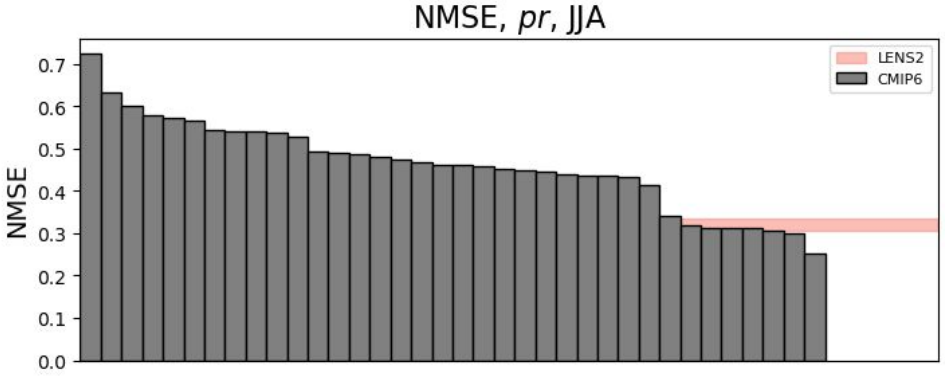
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

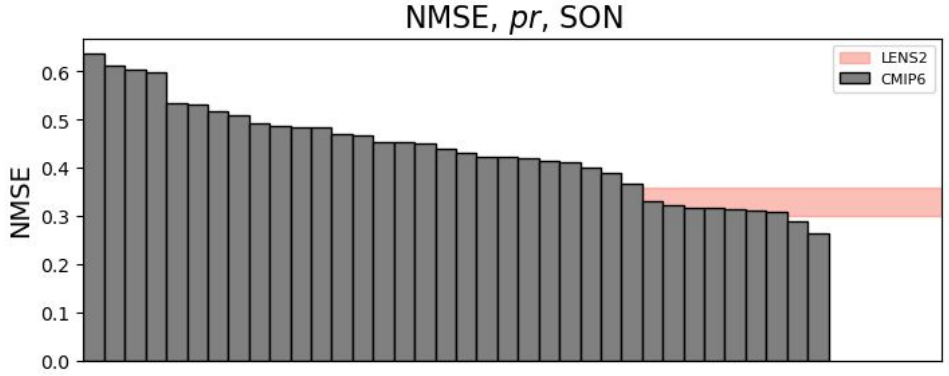


The minimum to maximum range of the CESM2 large ensemble



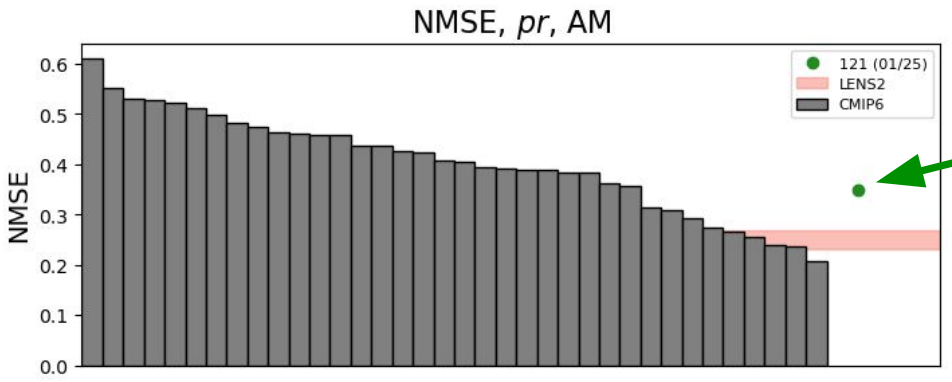




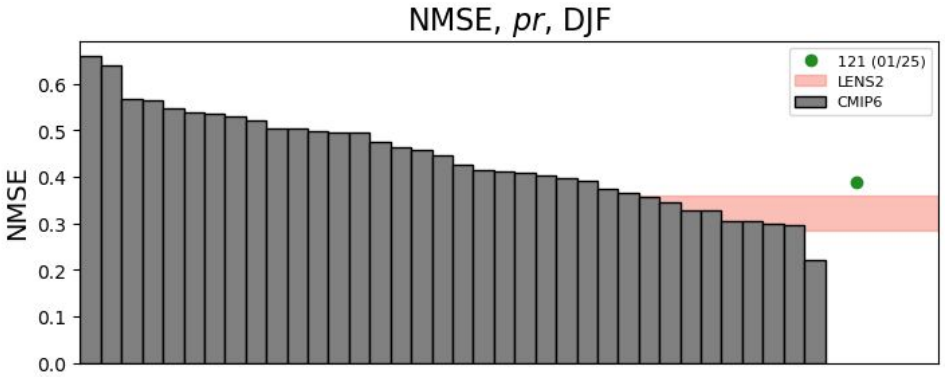


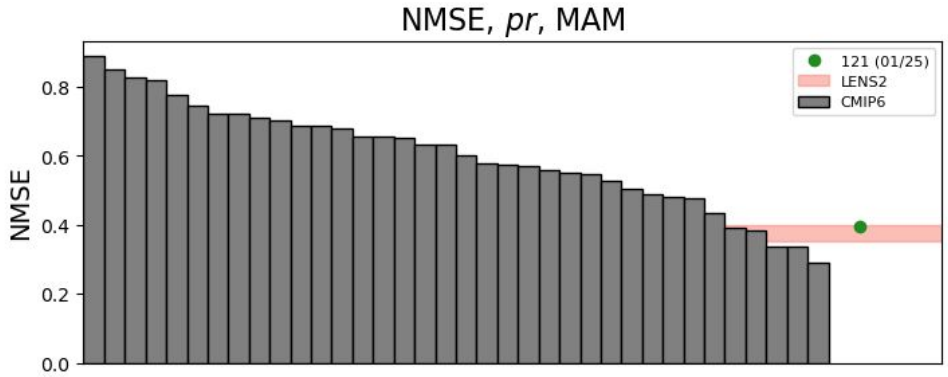
Precipitation

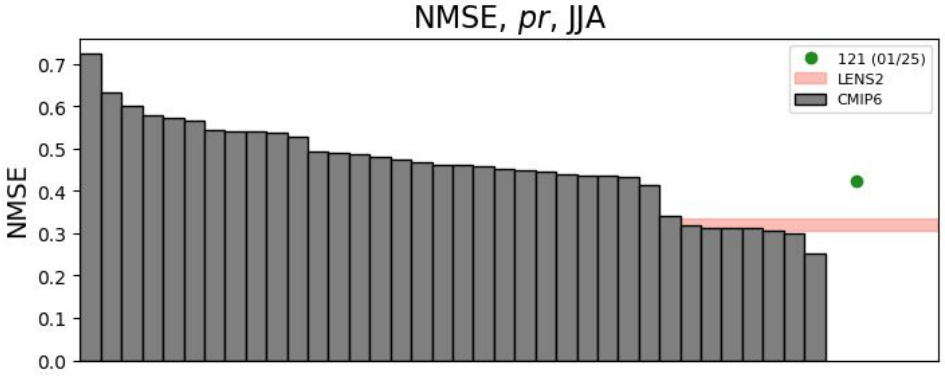
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

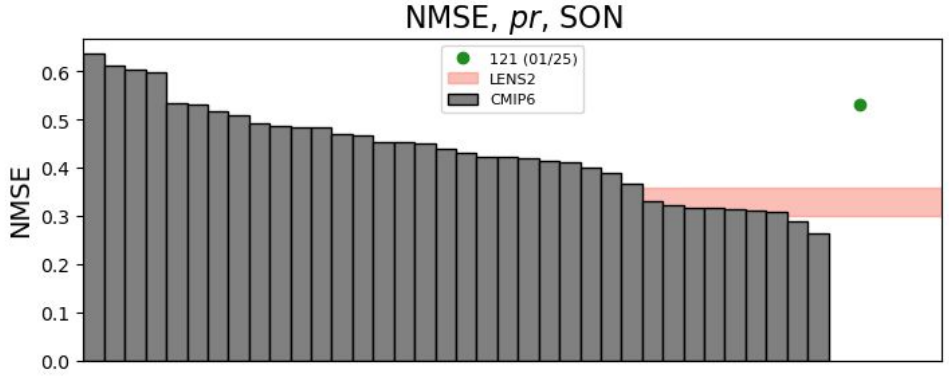


Development simulation this time last year



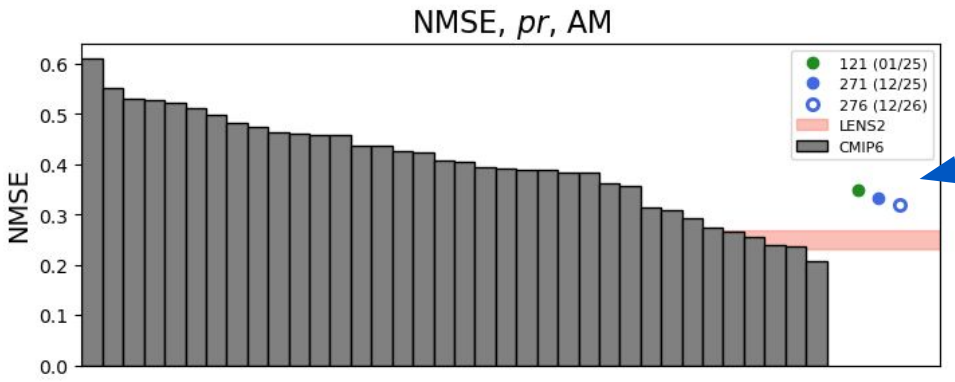




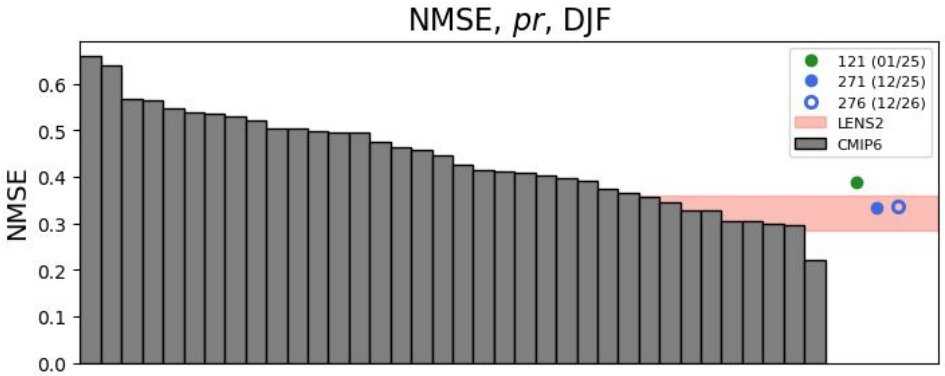


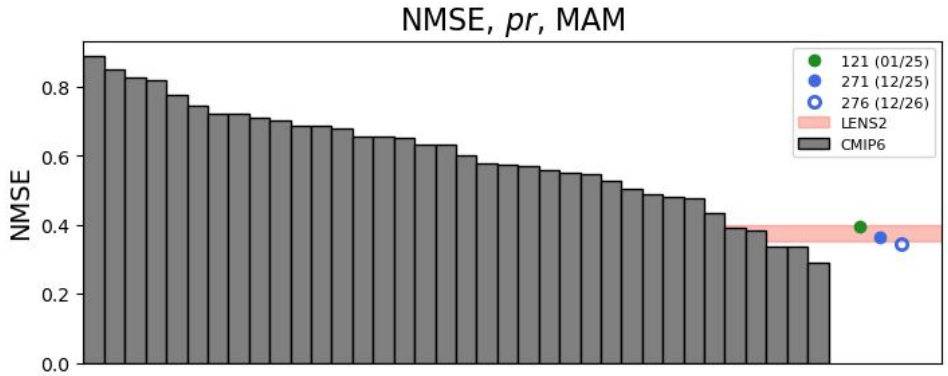
Precipitation

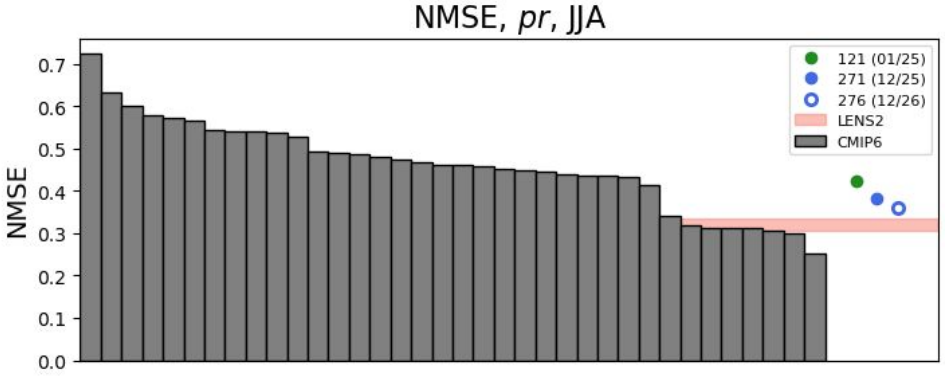
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

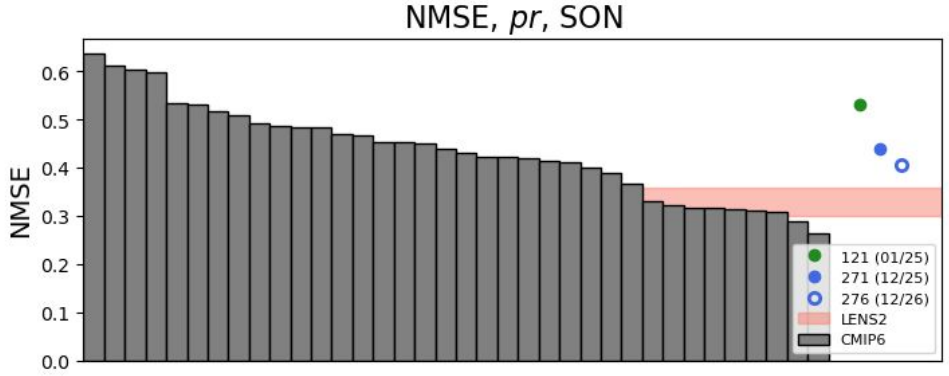


Current development simulations



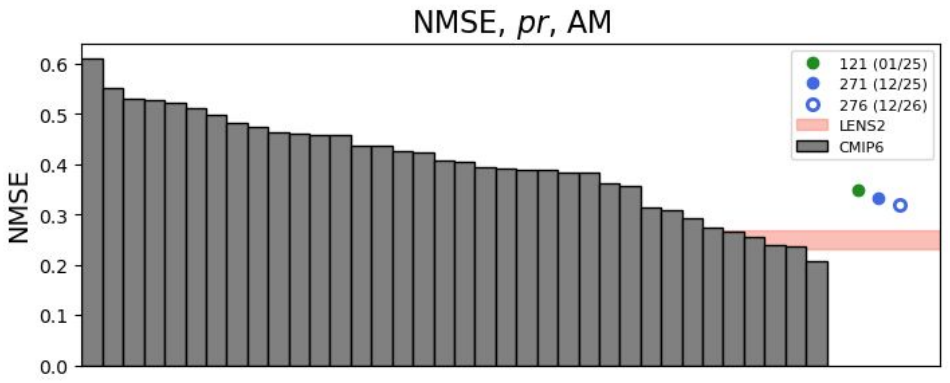




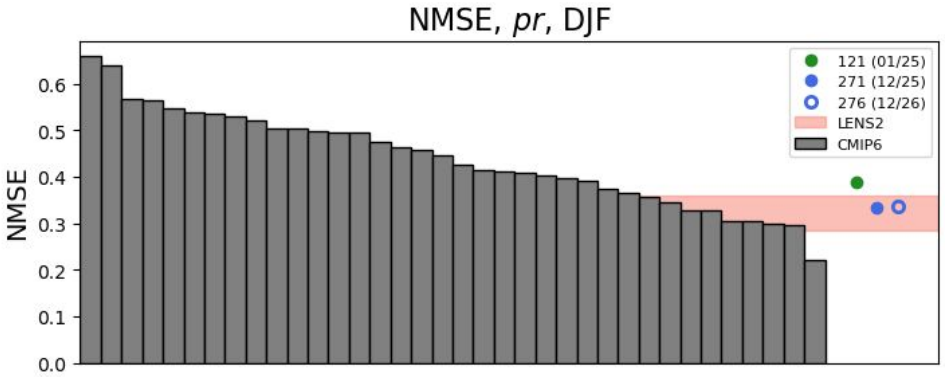


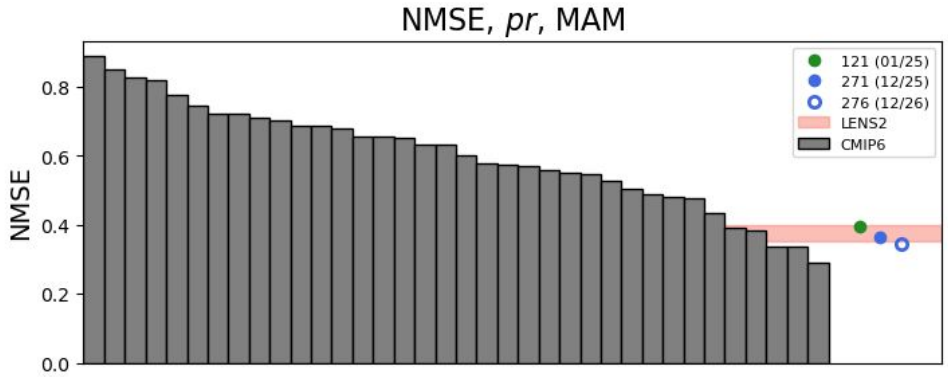
Precipitation

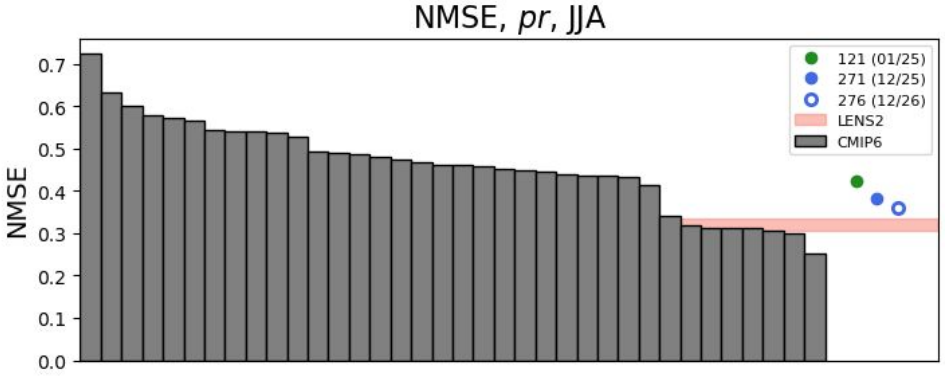
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

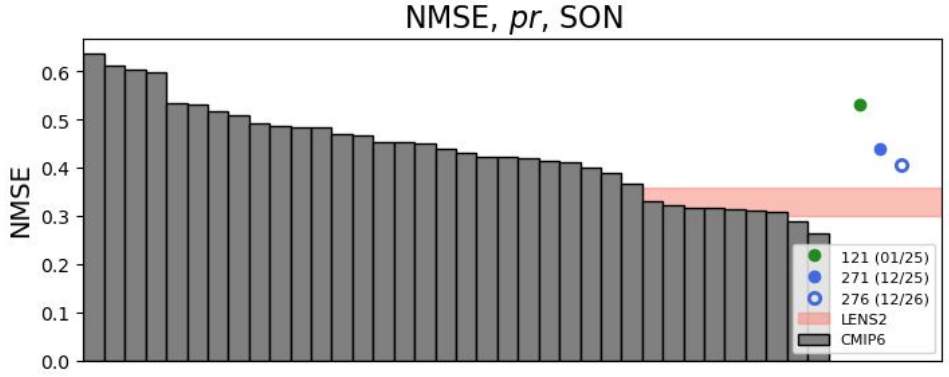


Doing slightly worse than CESM2, but have improved a bit over the last year. Still in the upper 25% or so of CMIP6 models



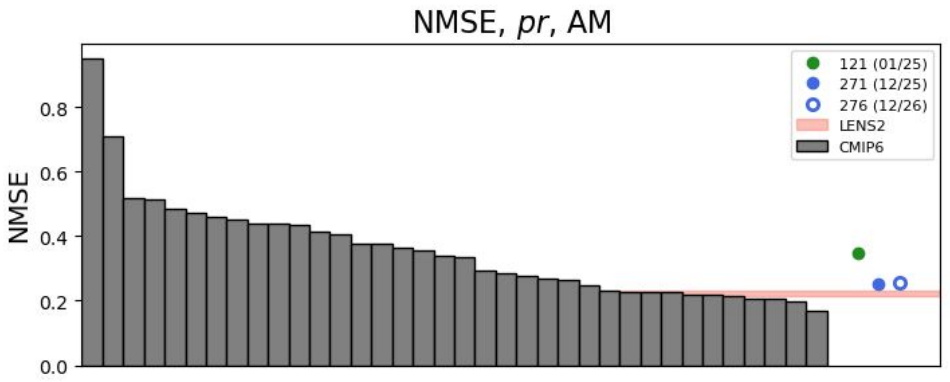




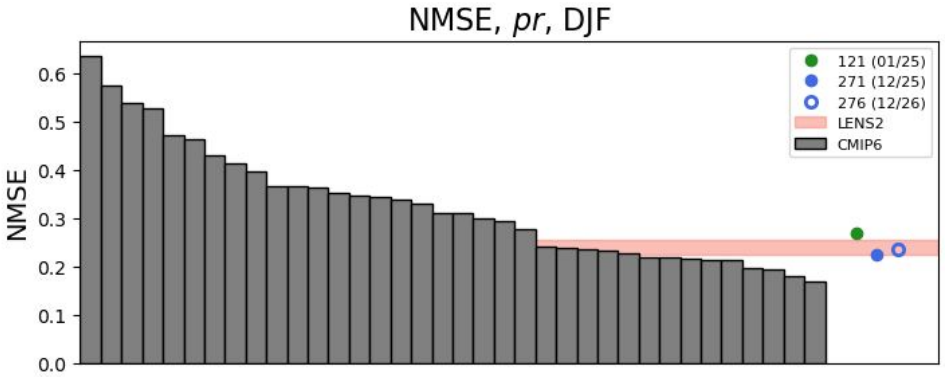


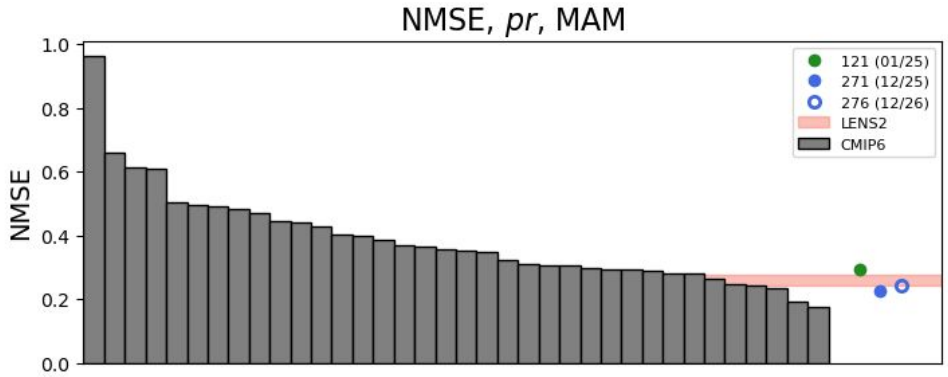
Precipitation (land only)

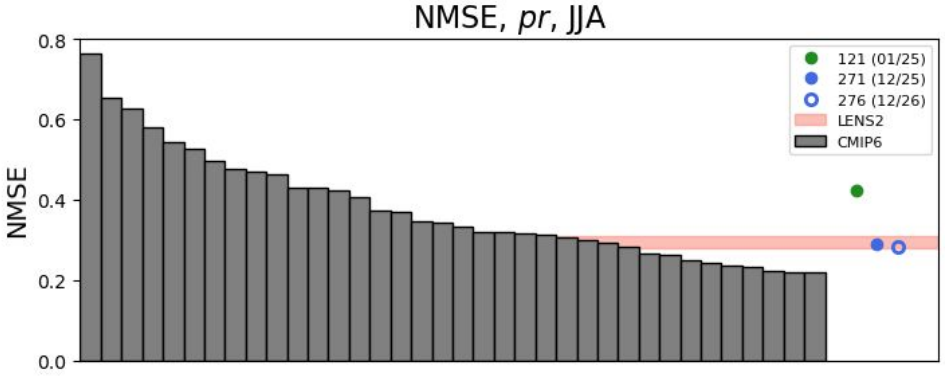
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

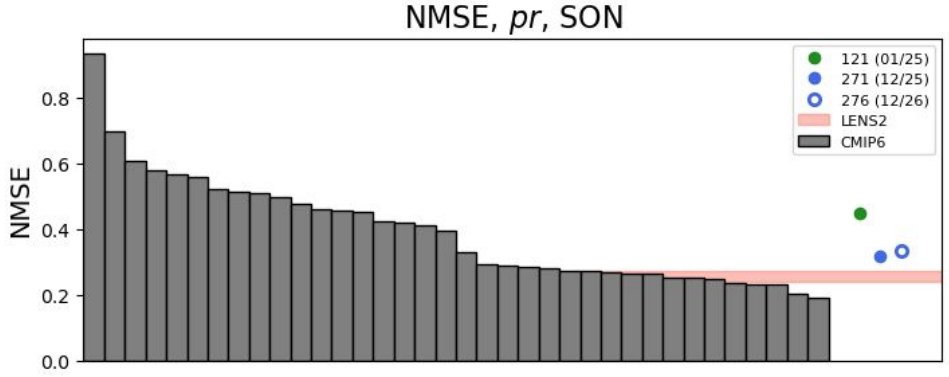


Improvements over land compared to this time last year



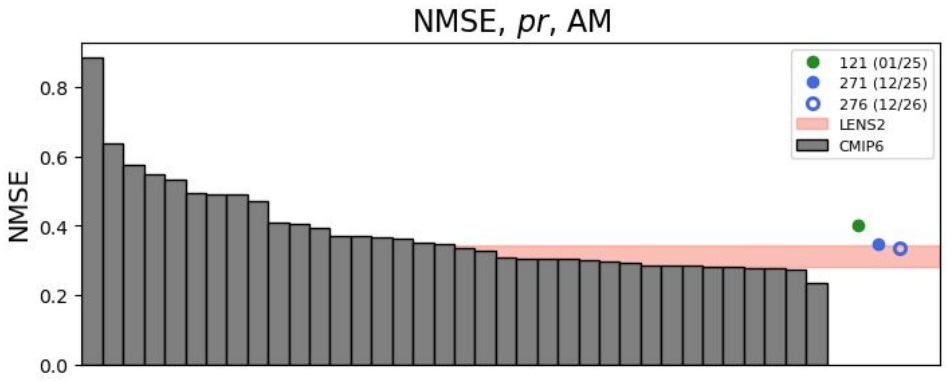




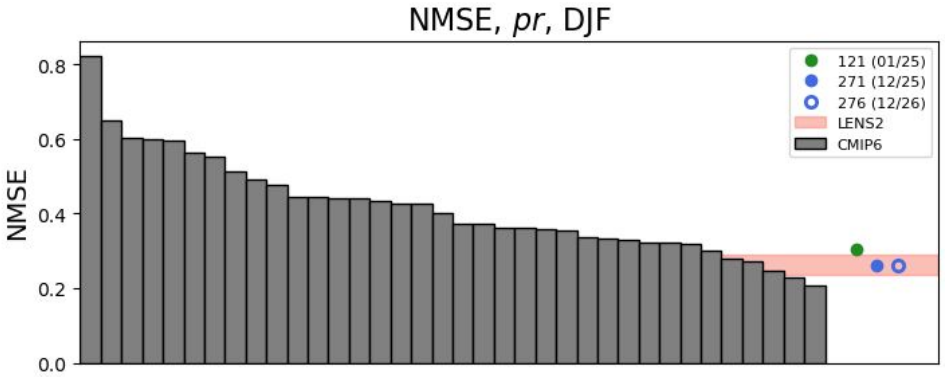


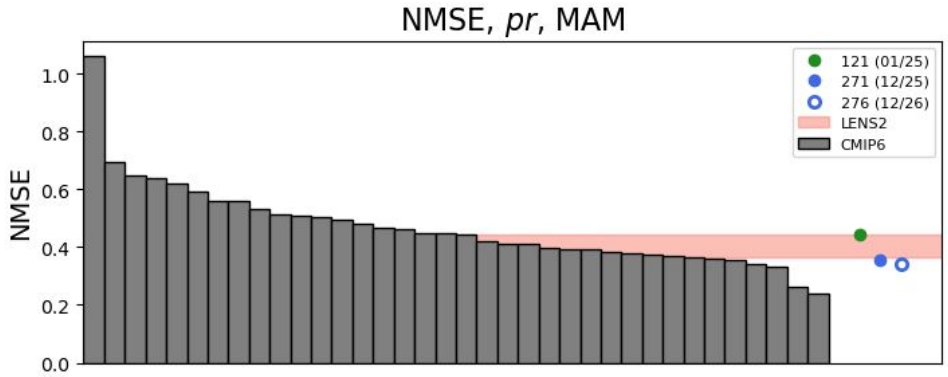
Precipitation (ocean only)

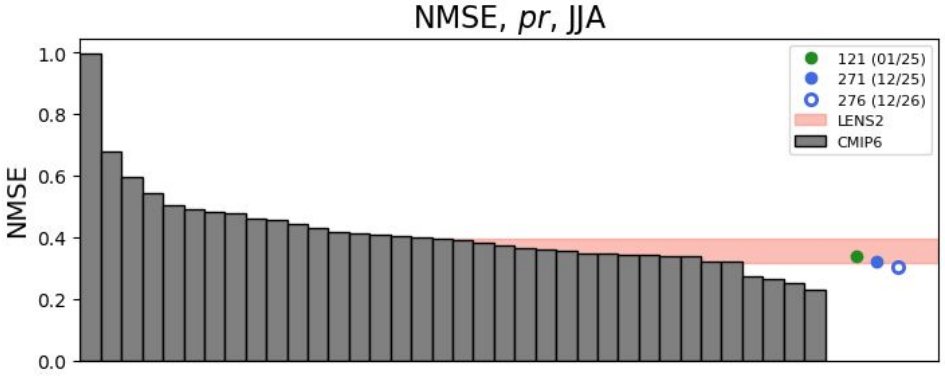
$$NMSE(X_m) = \frac{\overline{(X_m - X_o)^2}}{\overline{(X_o')^2}}$$

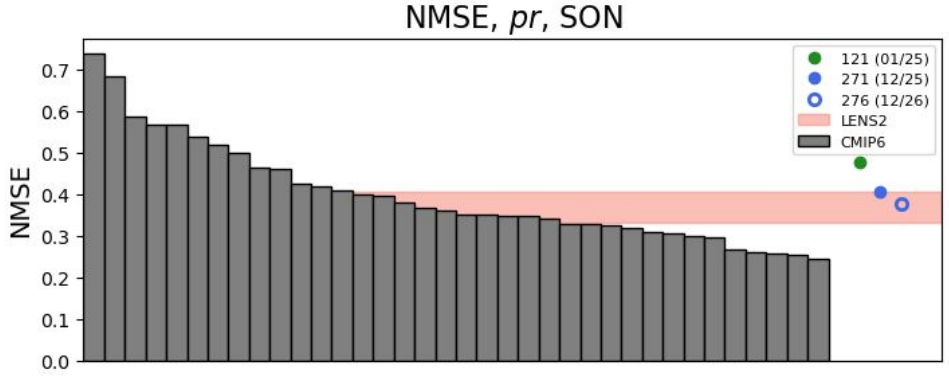


Improvements over ocean compared to this time last year

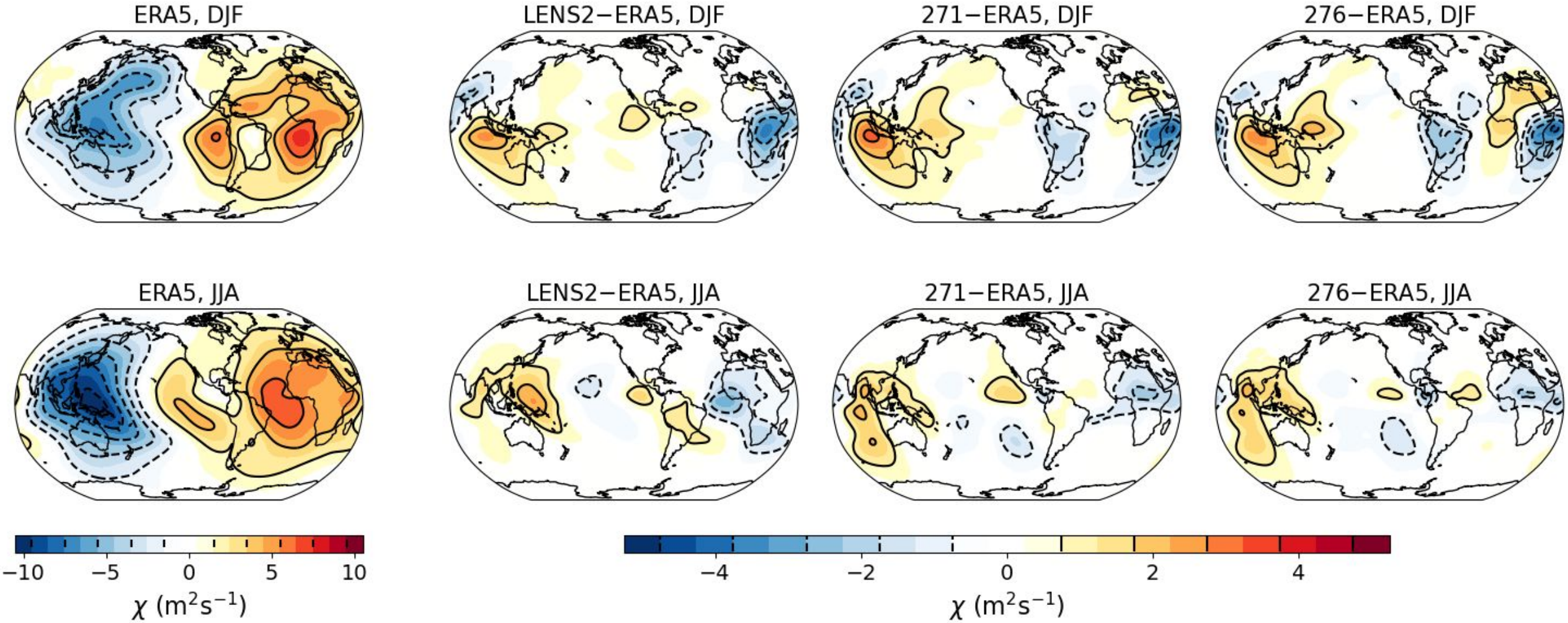




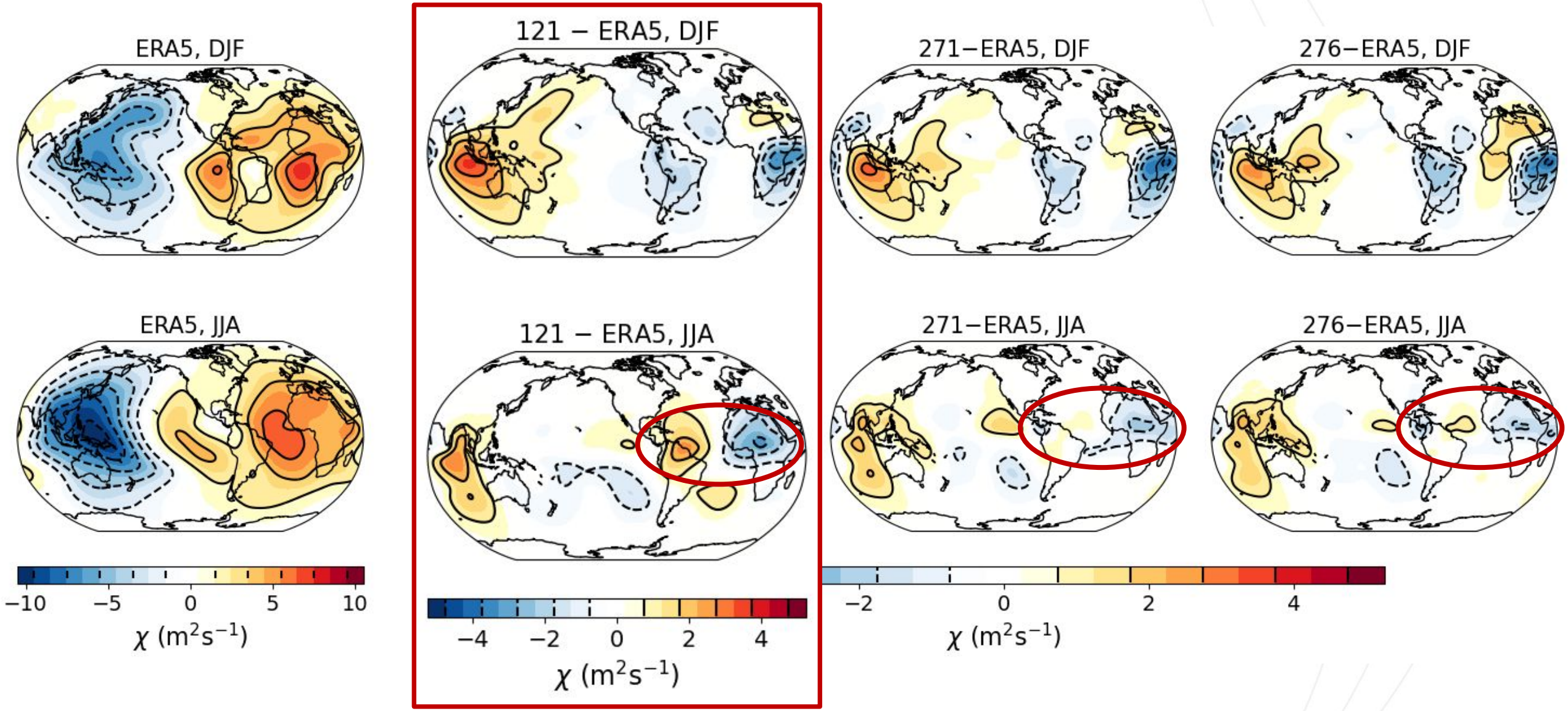




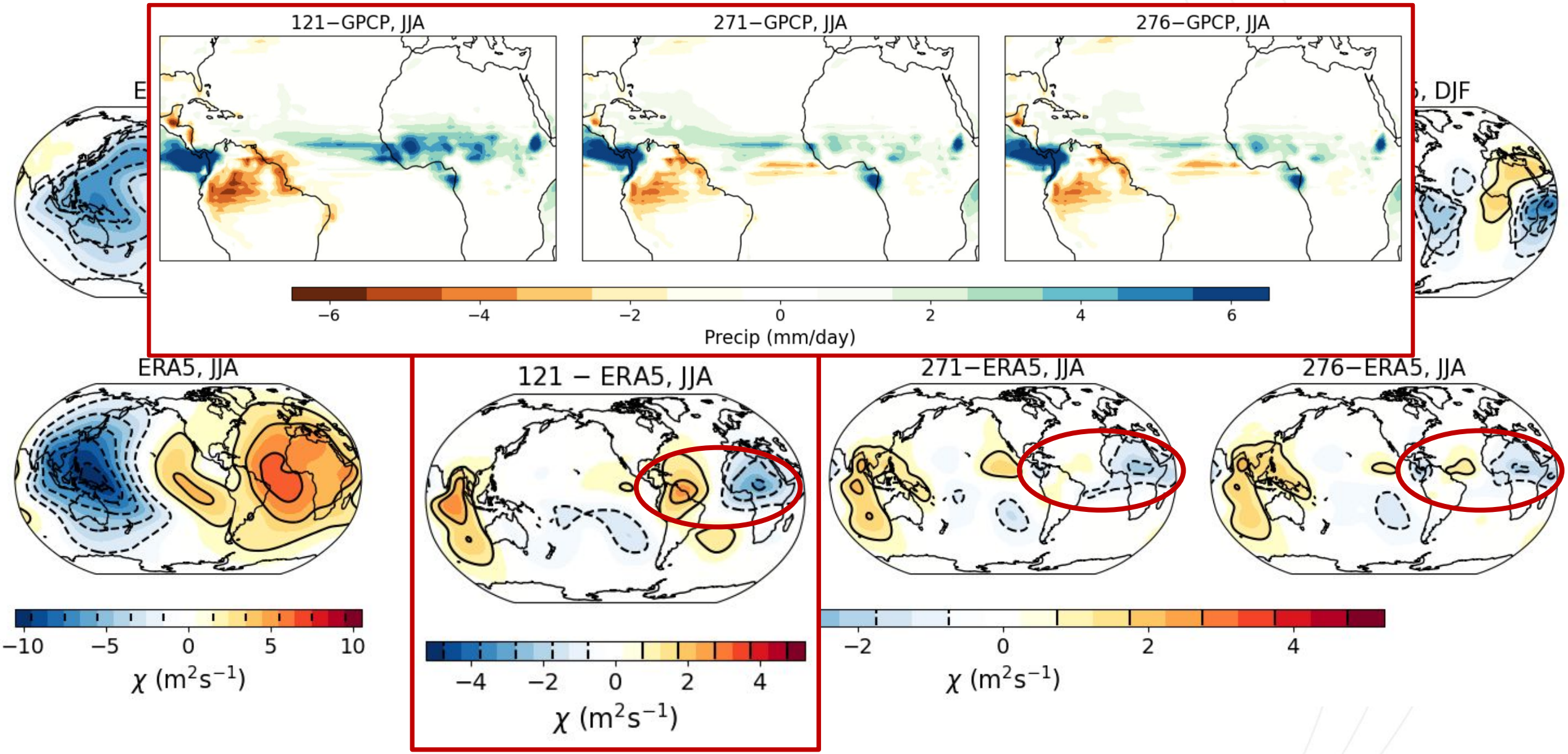
250 hPa velocity potential



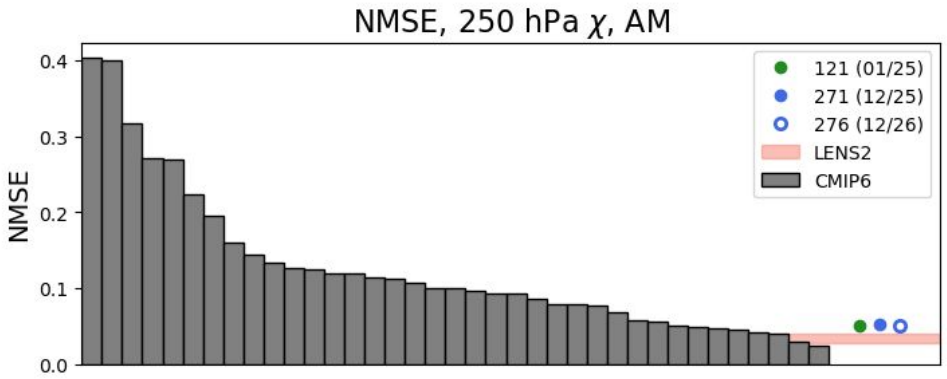
250 hPa velocity potential



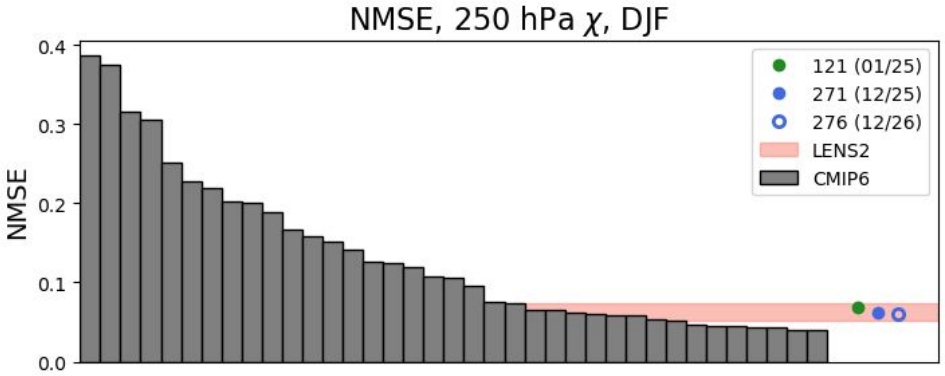
250 hPa velocity potential

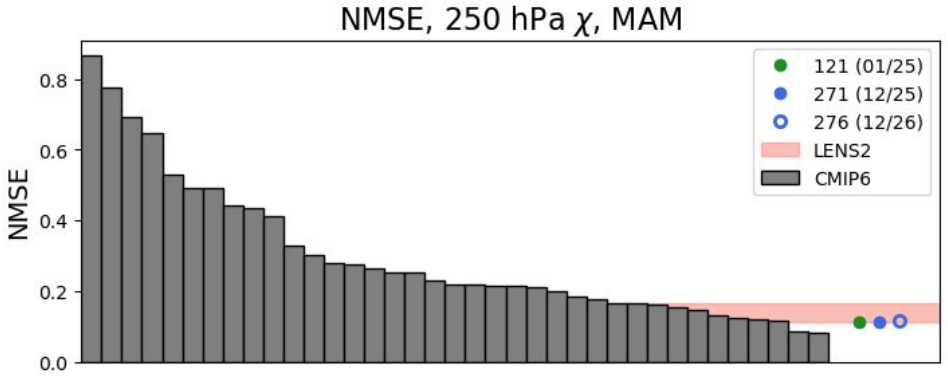


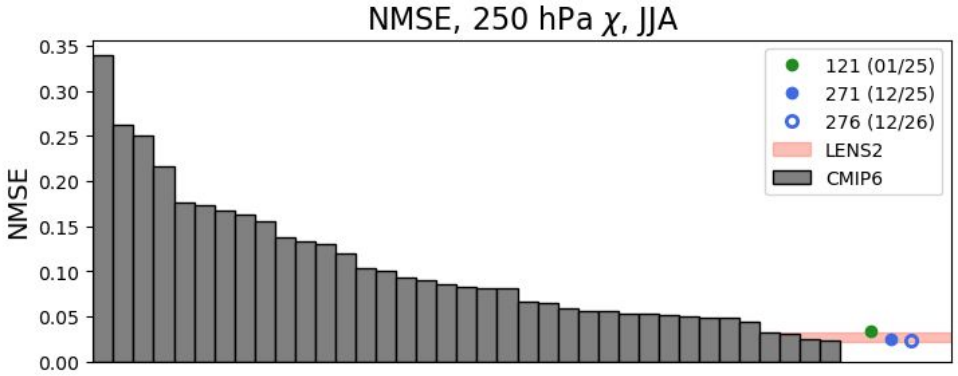
250 hPa velocity potential

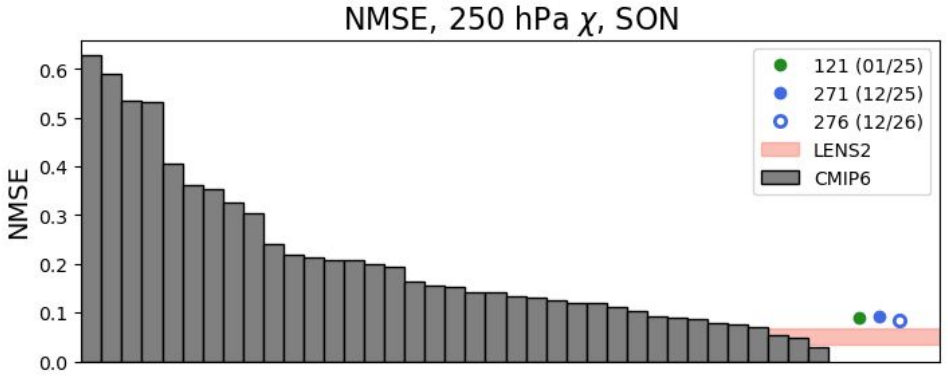


Still a really good model by CMIP6 standards

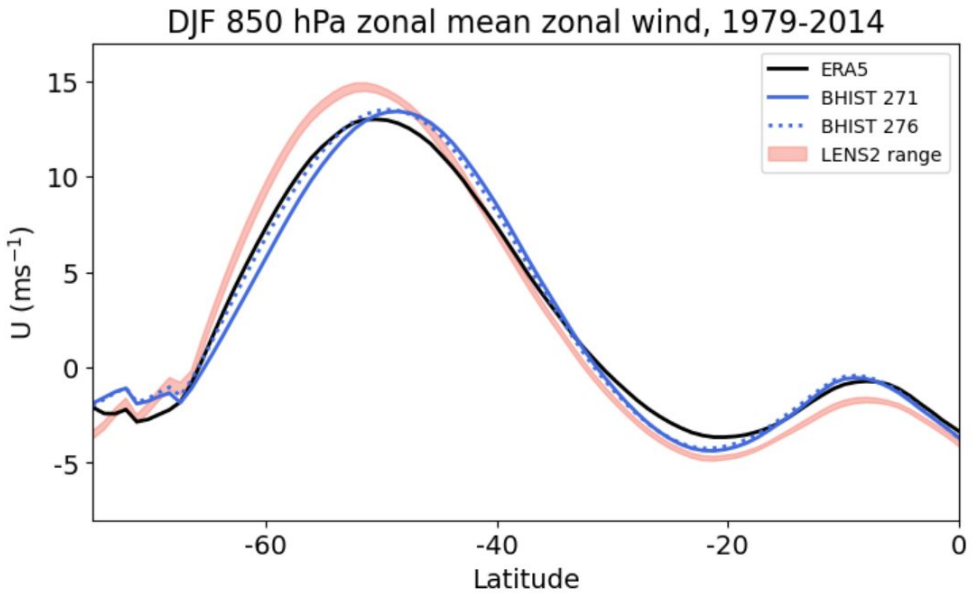


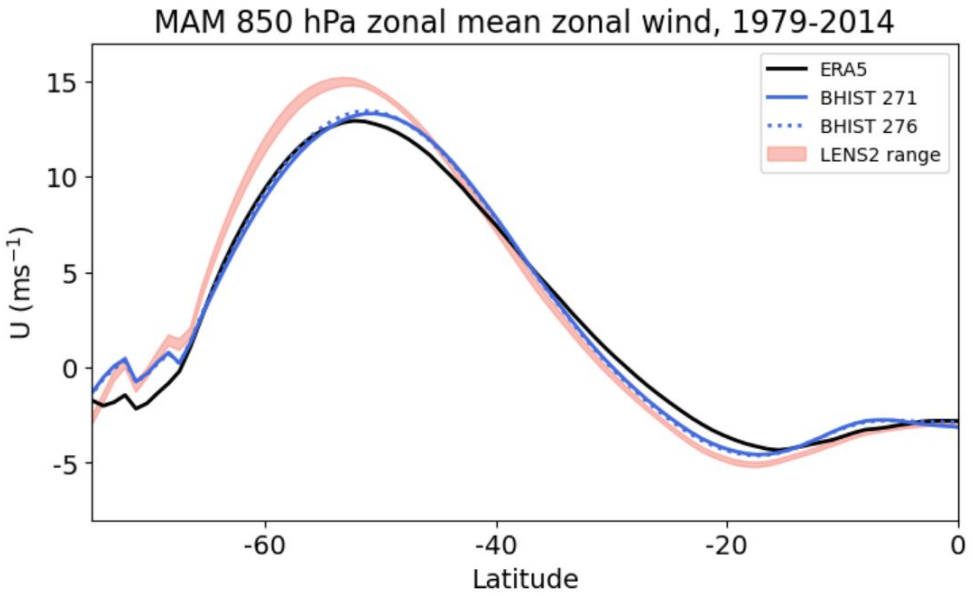


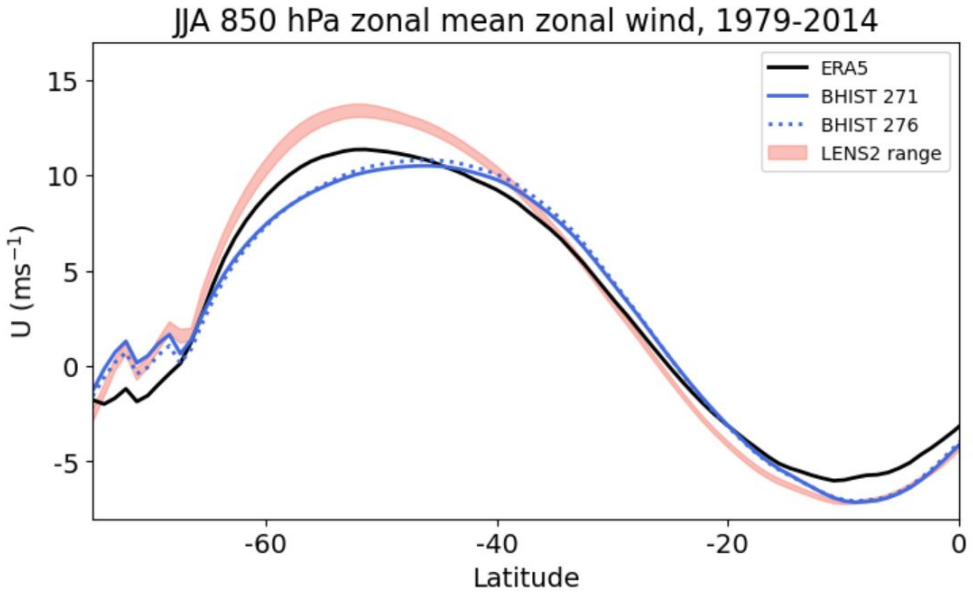


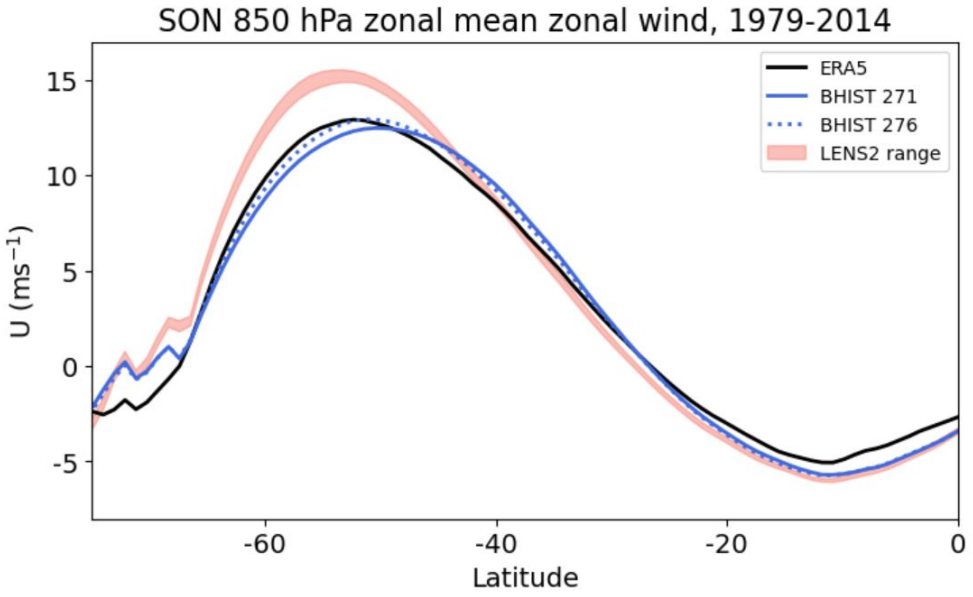


SH jet (850 hPa zonal mean zonal wind)



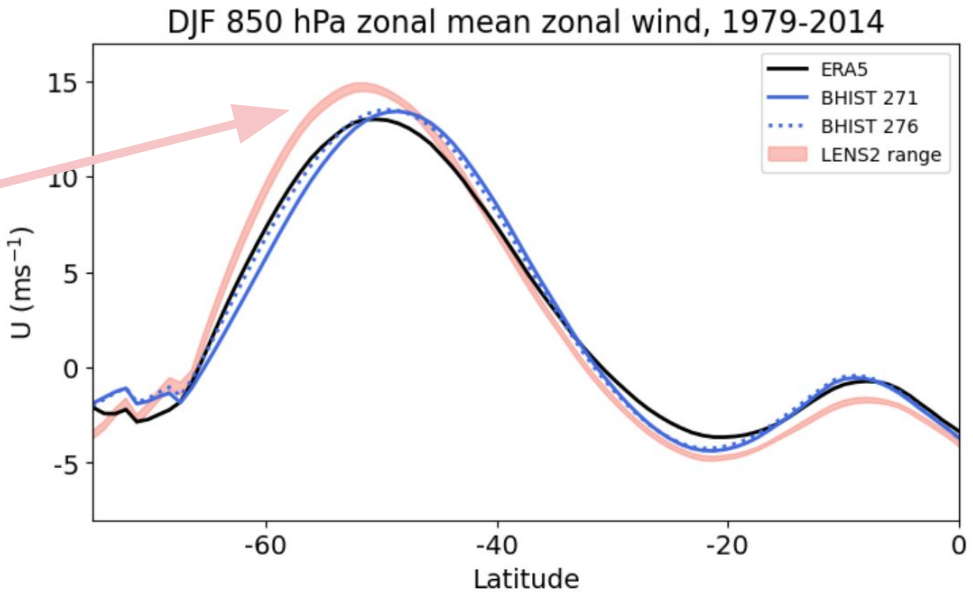


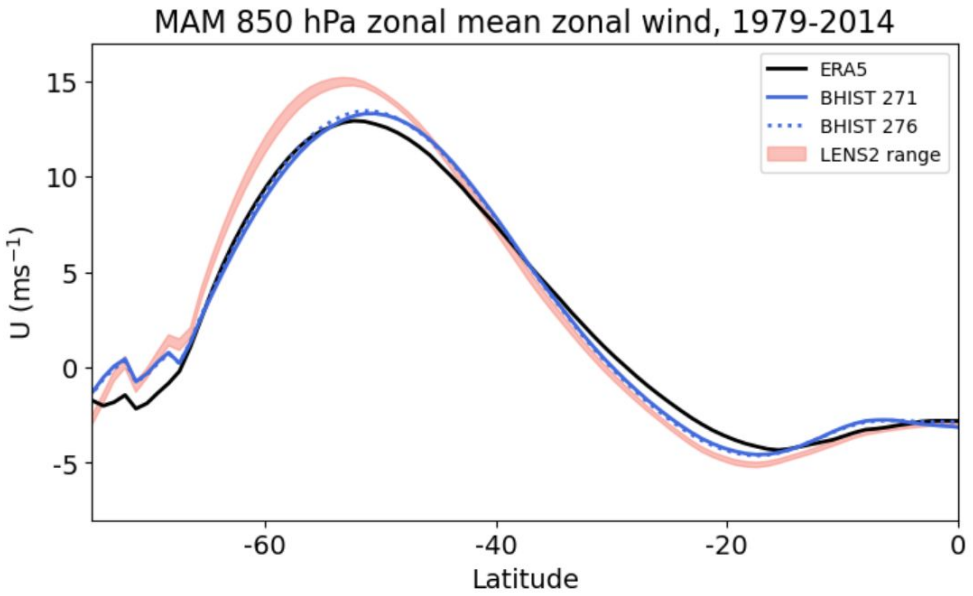


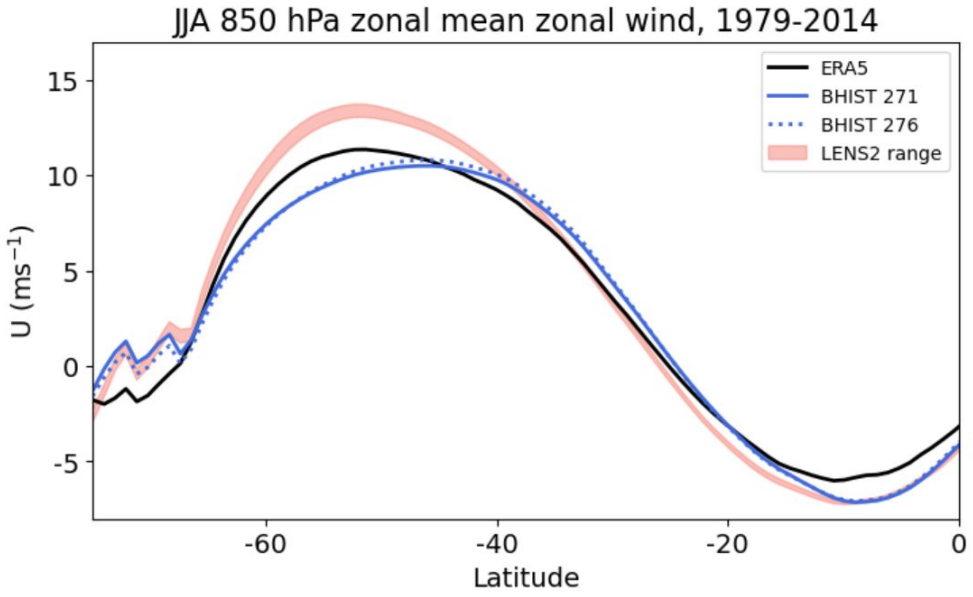


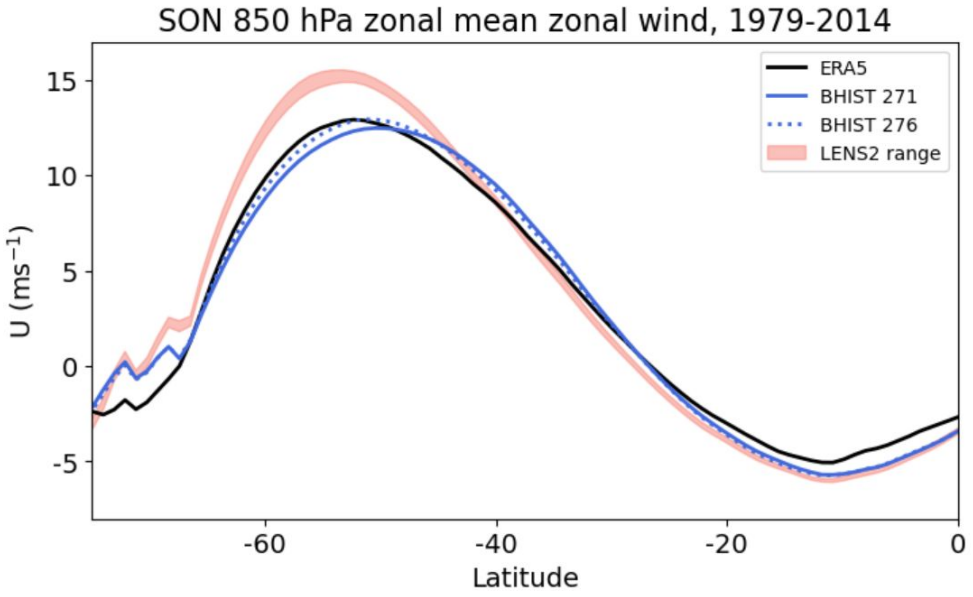
SH jet (850 hPa zonal mean zonal wind)

CESM2 jet stream too strong





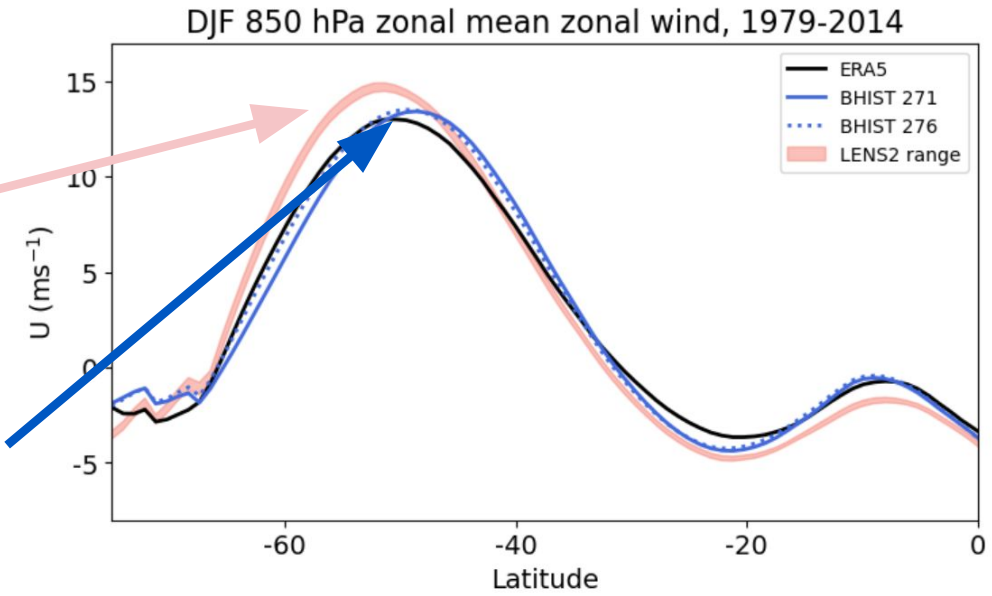


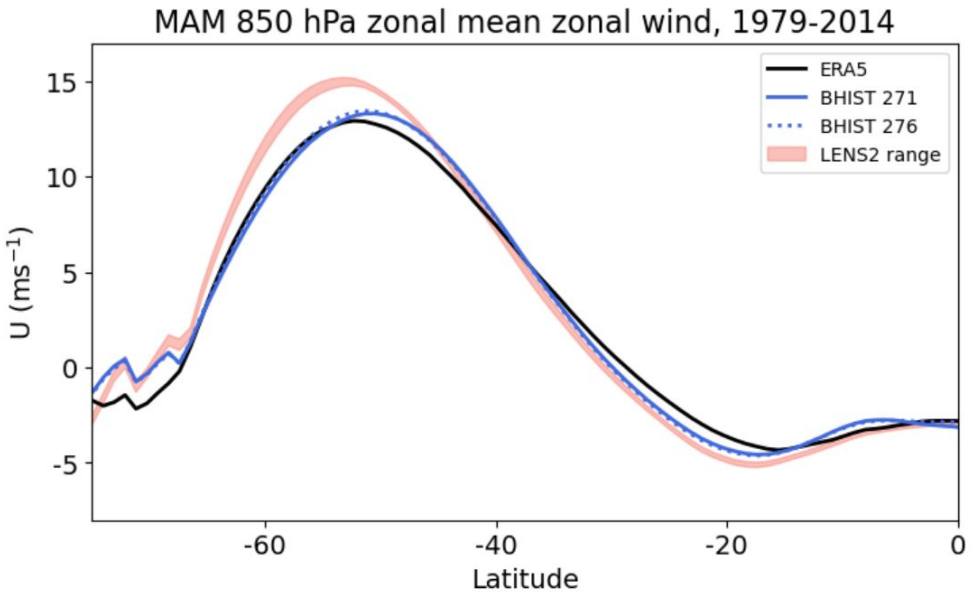


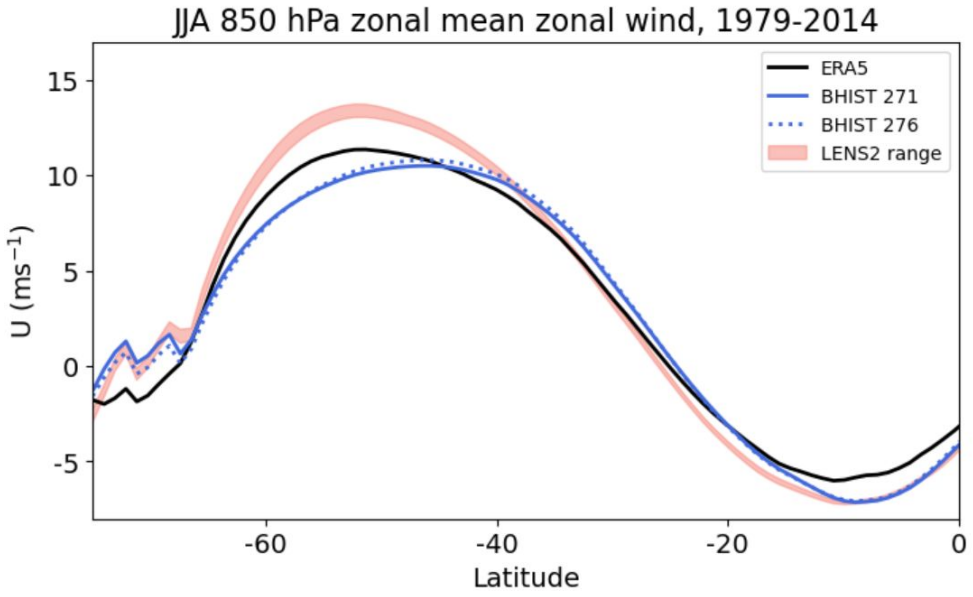
SH jet (850 hPa zonal mean zonal wind)

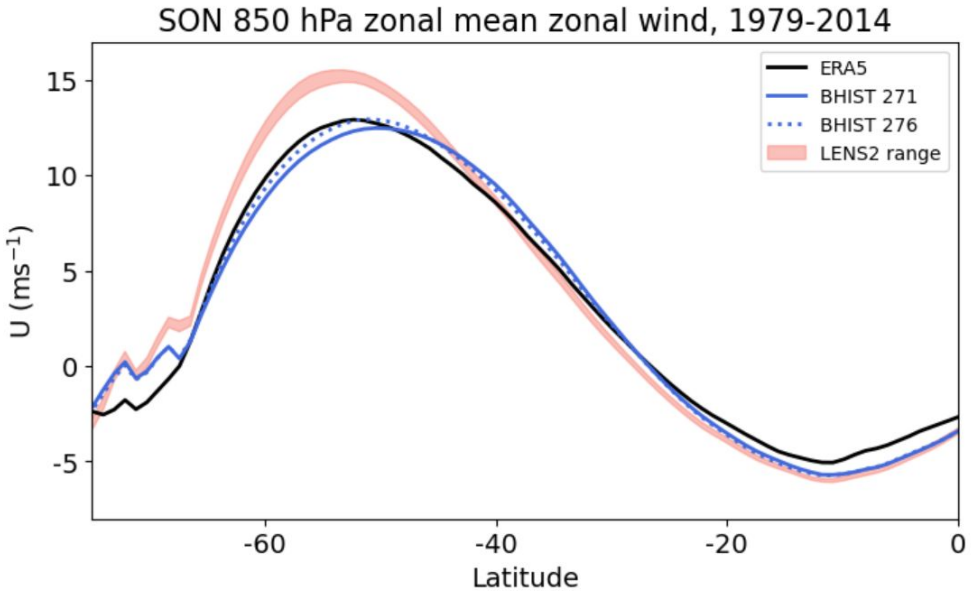
CESM2 jet stream too strong

CESM2 jet strength much better but an equatorward bias

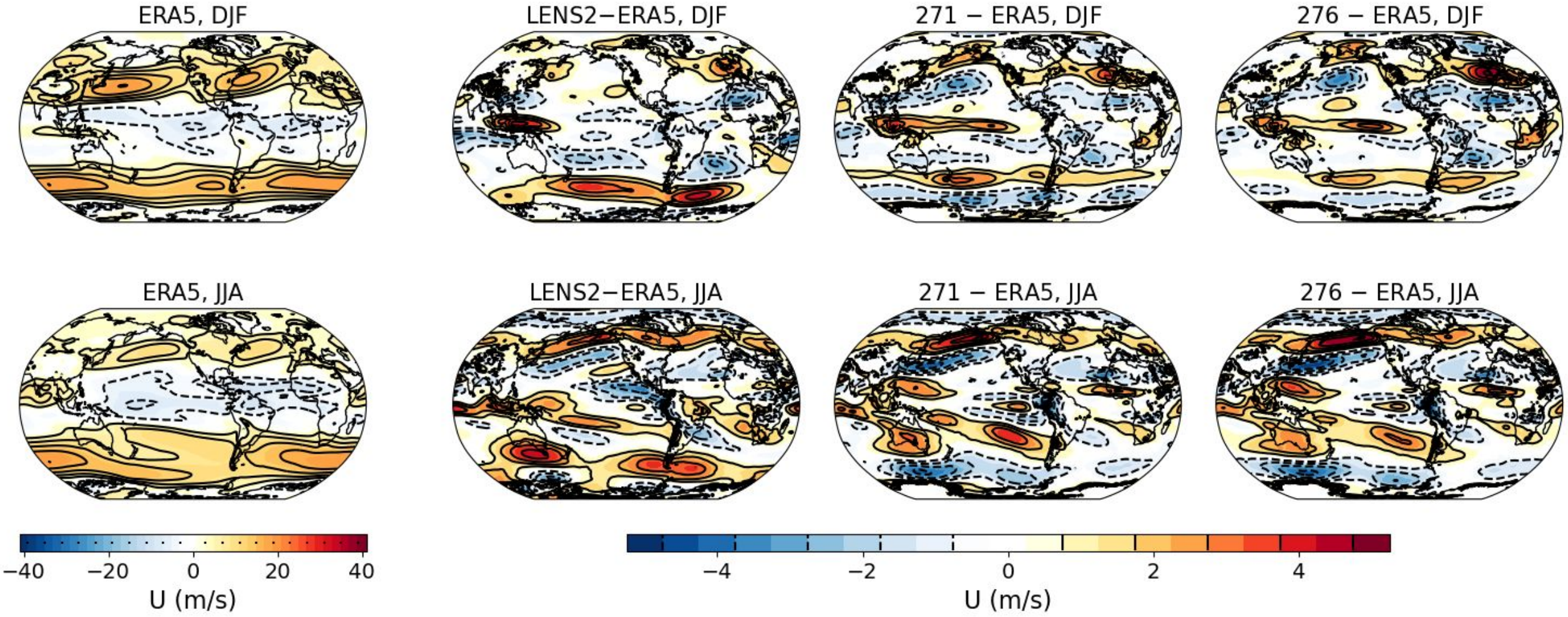






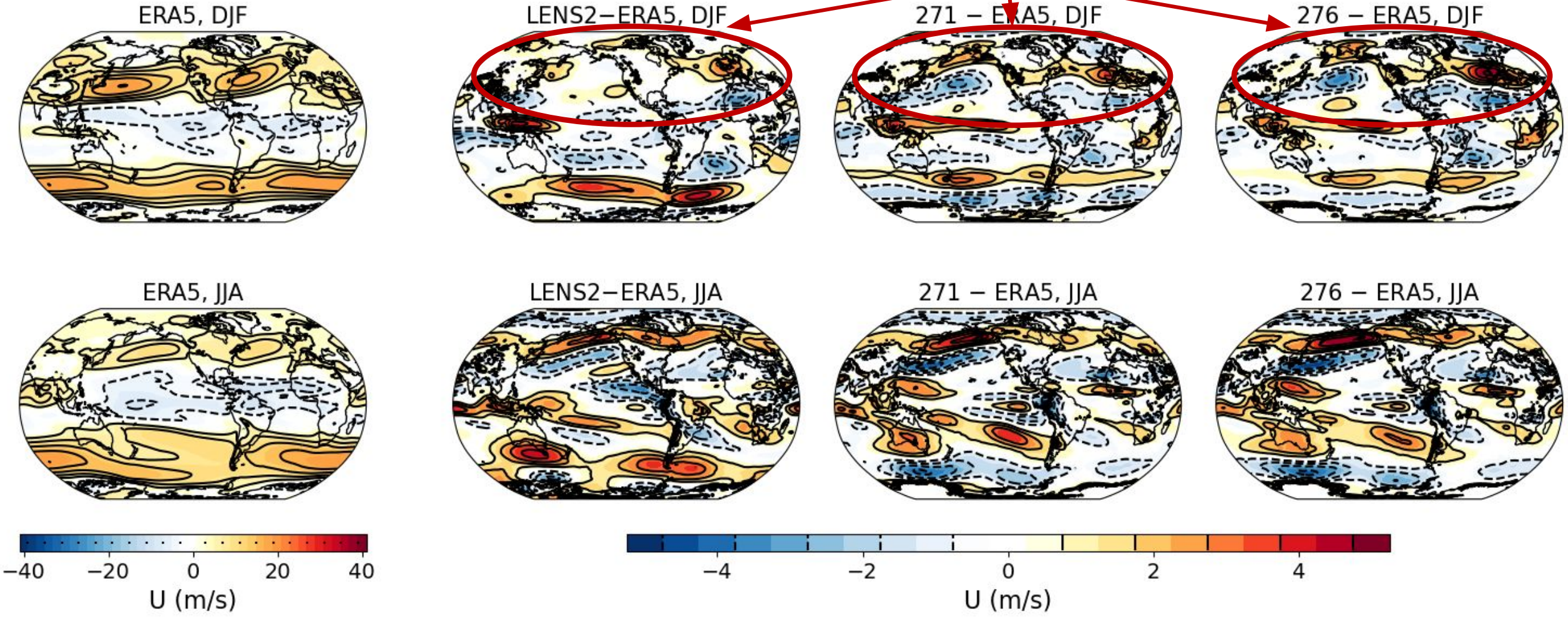


700 hPa zonal wind

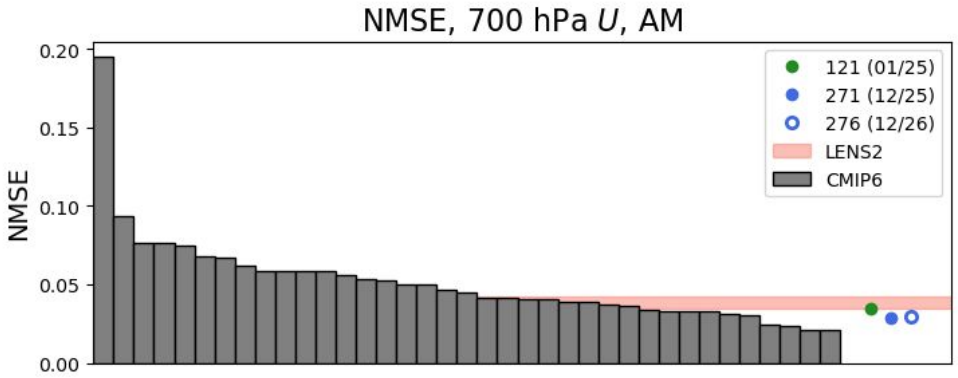


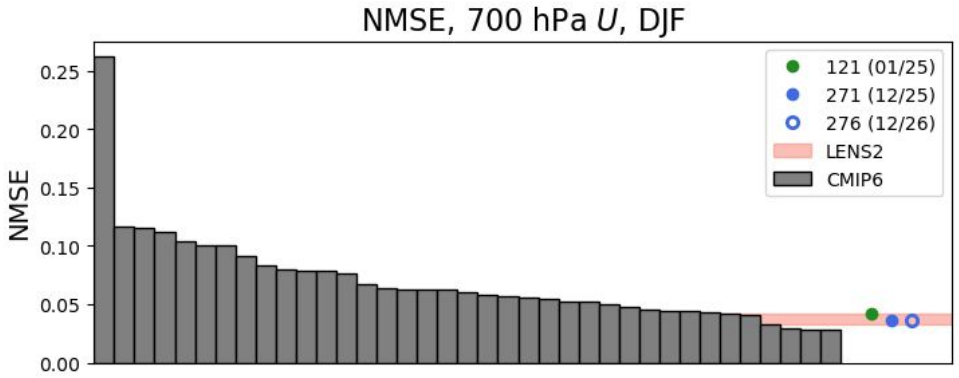
700 hPa zonal wind

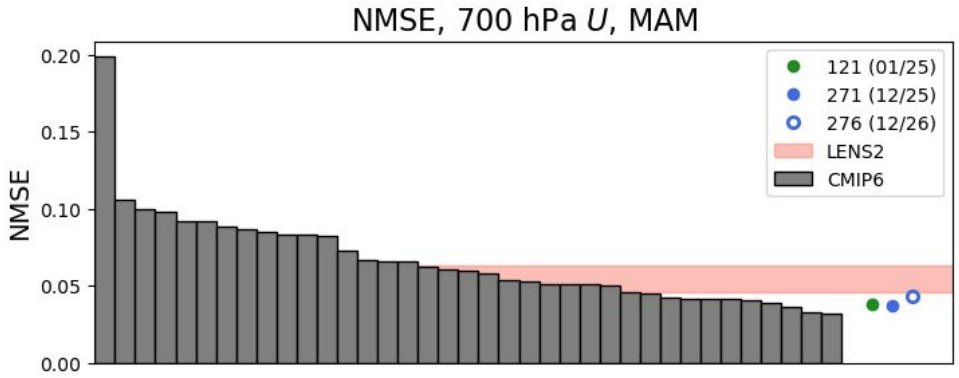
Degraded representation of the NH jet streams

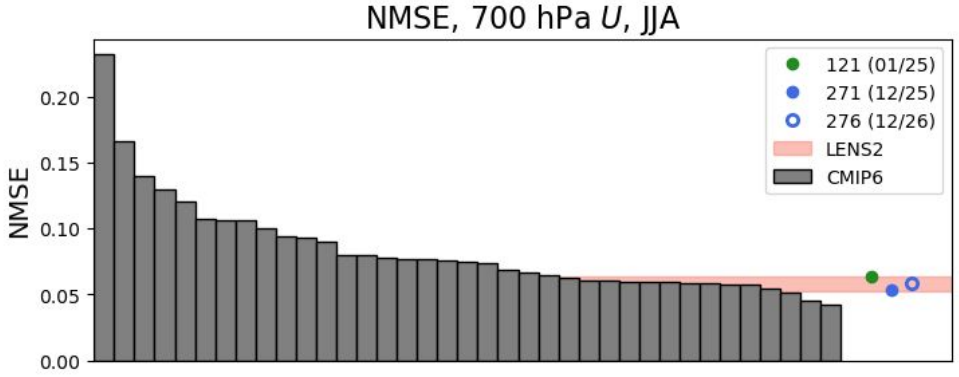


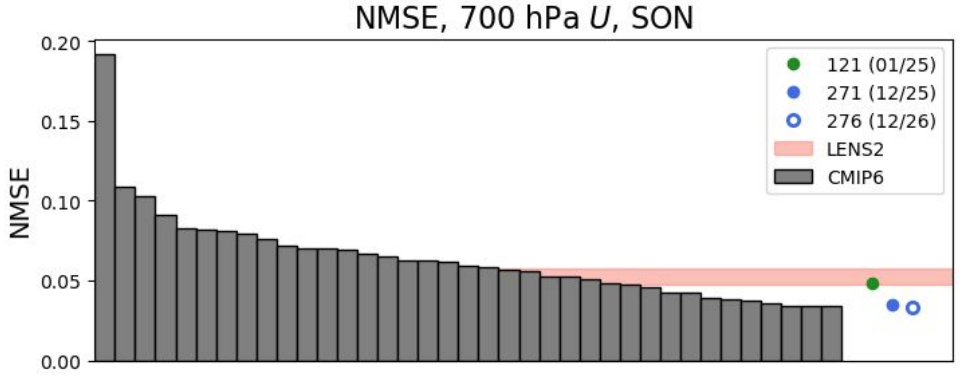
700 hPa zonal wind



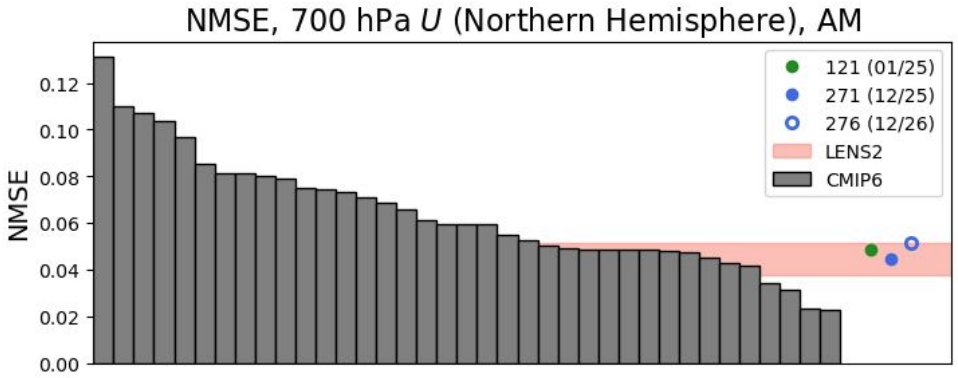


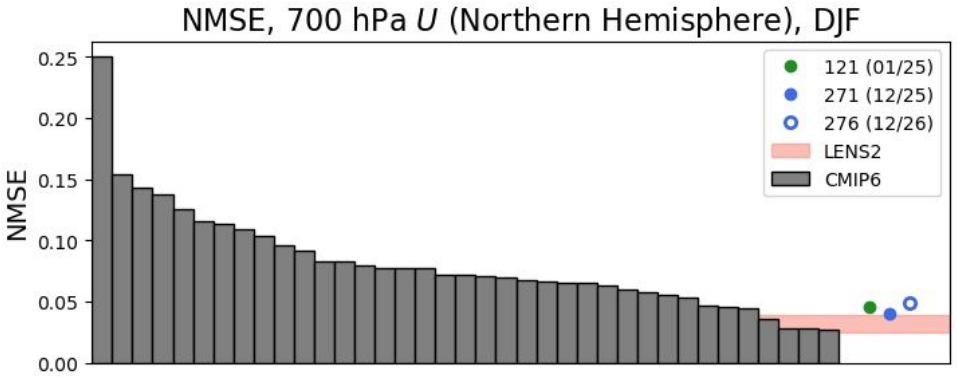


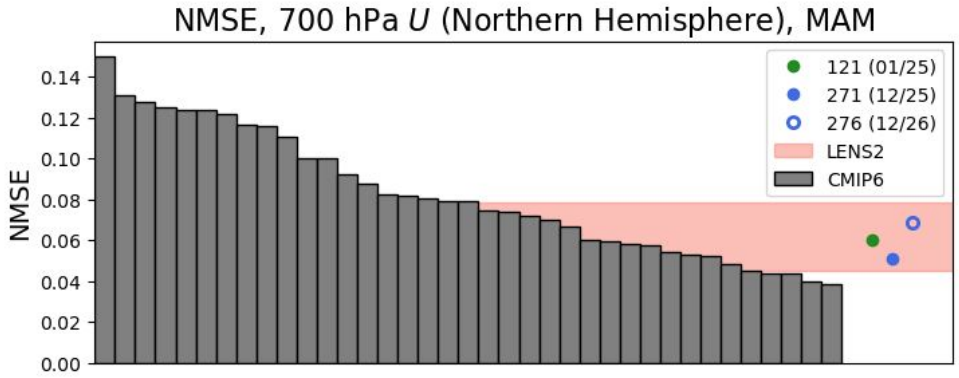


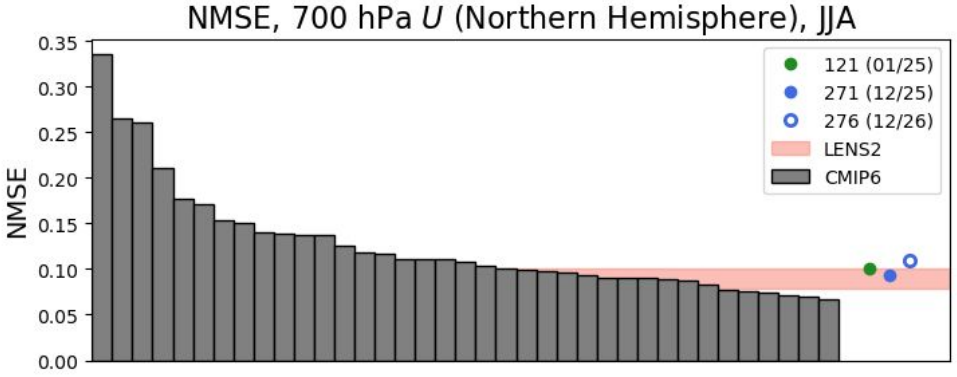


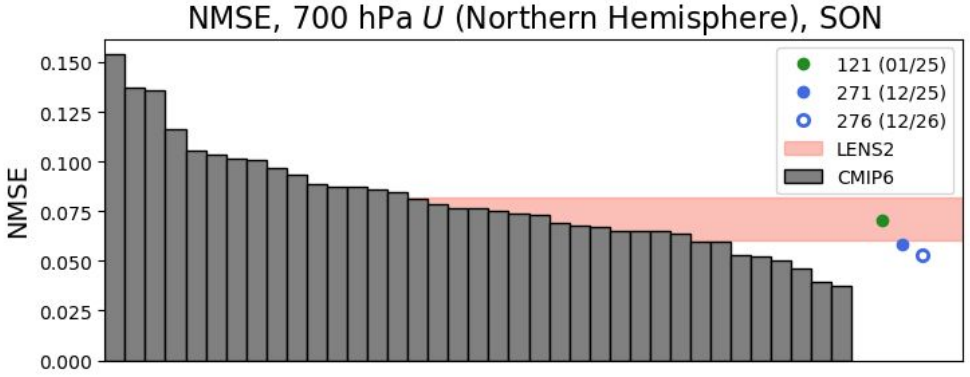
700 hPa zonal wind (Northern Hemisphere)



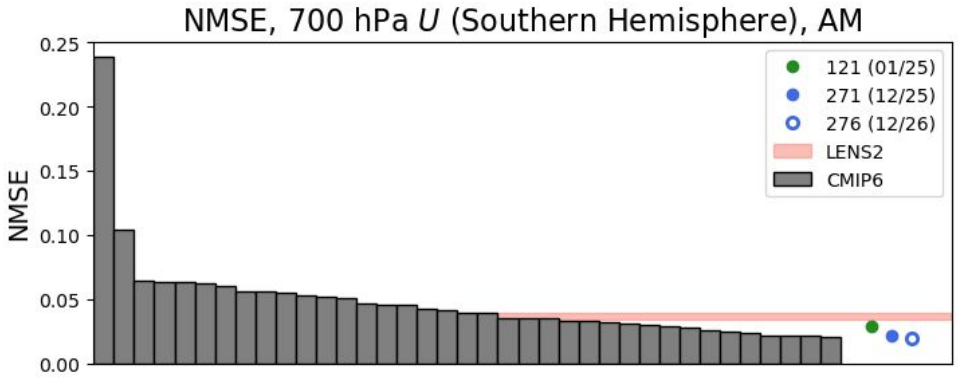


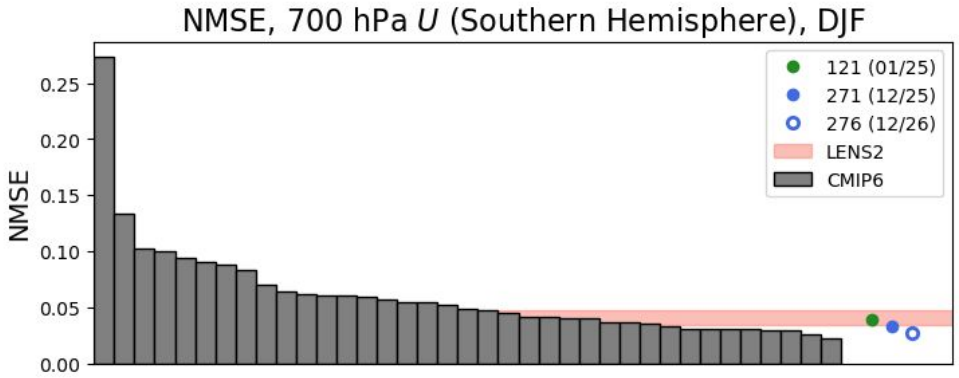


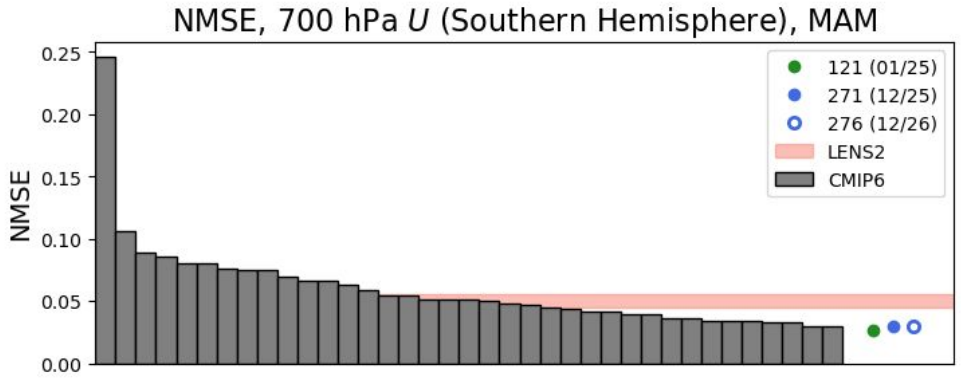


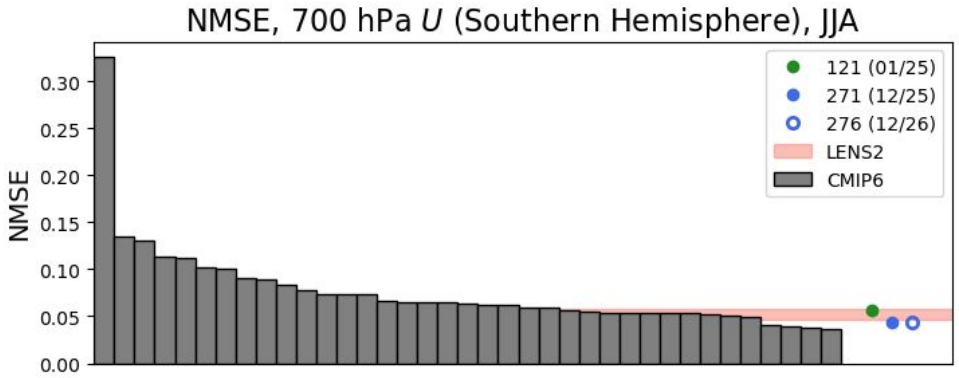


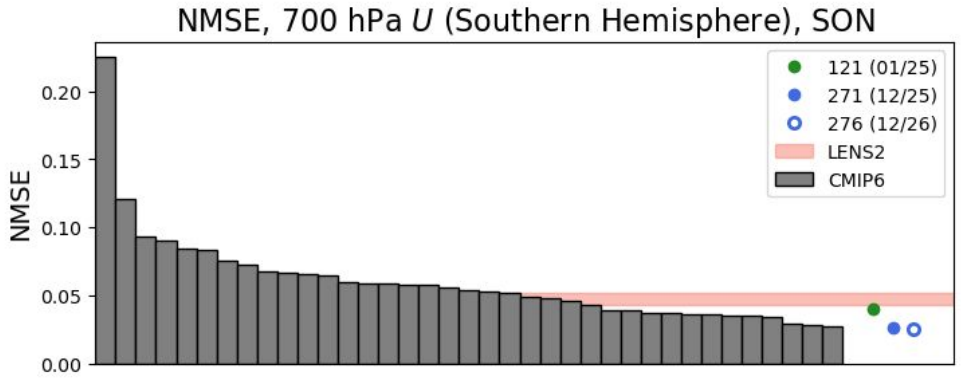
700 hPa zonal wind (Southern Hemisphere)



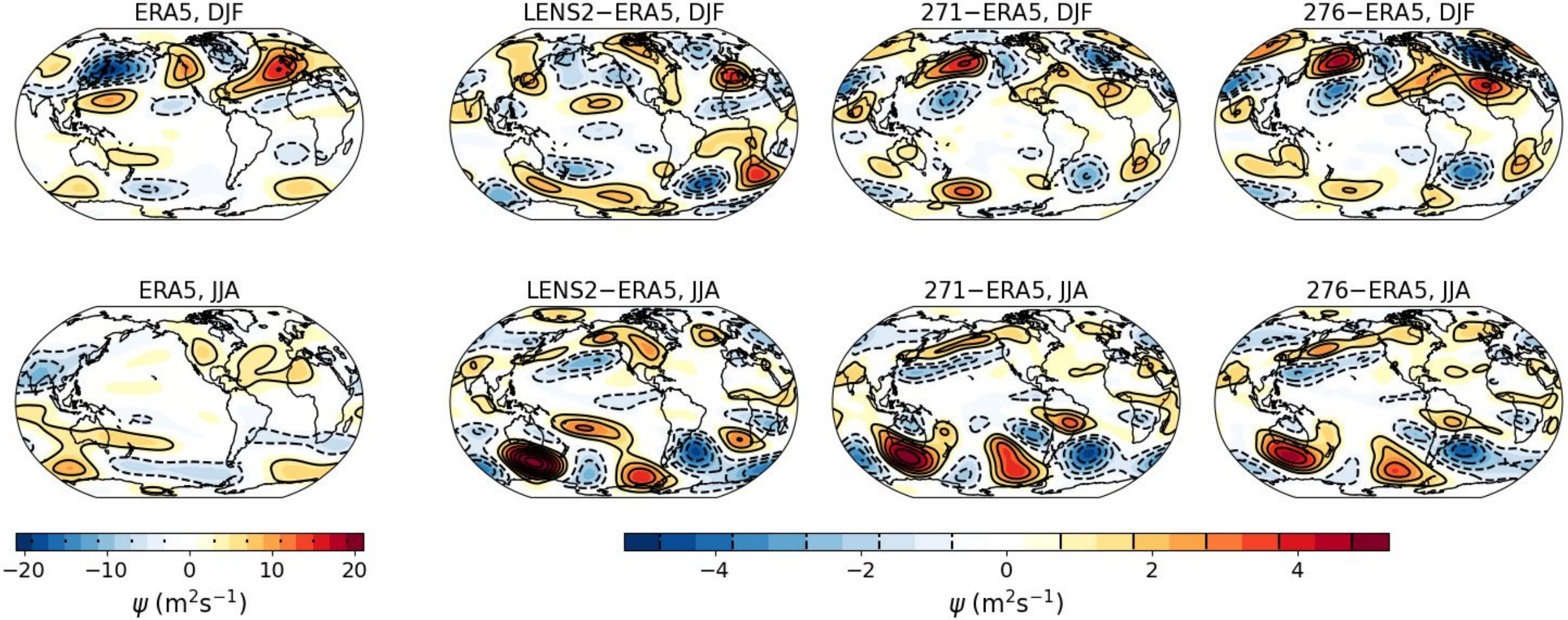






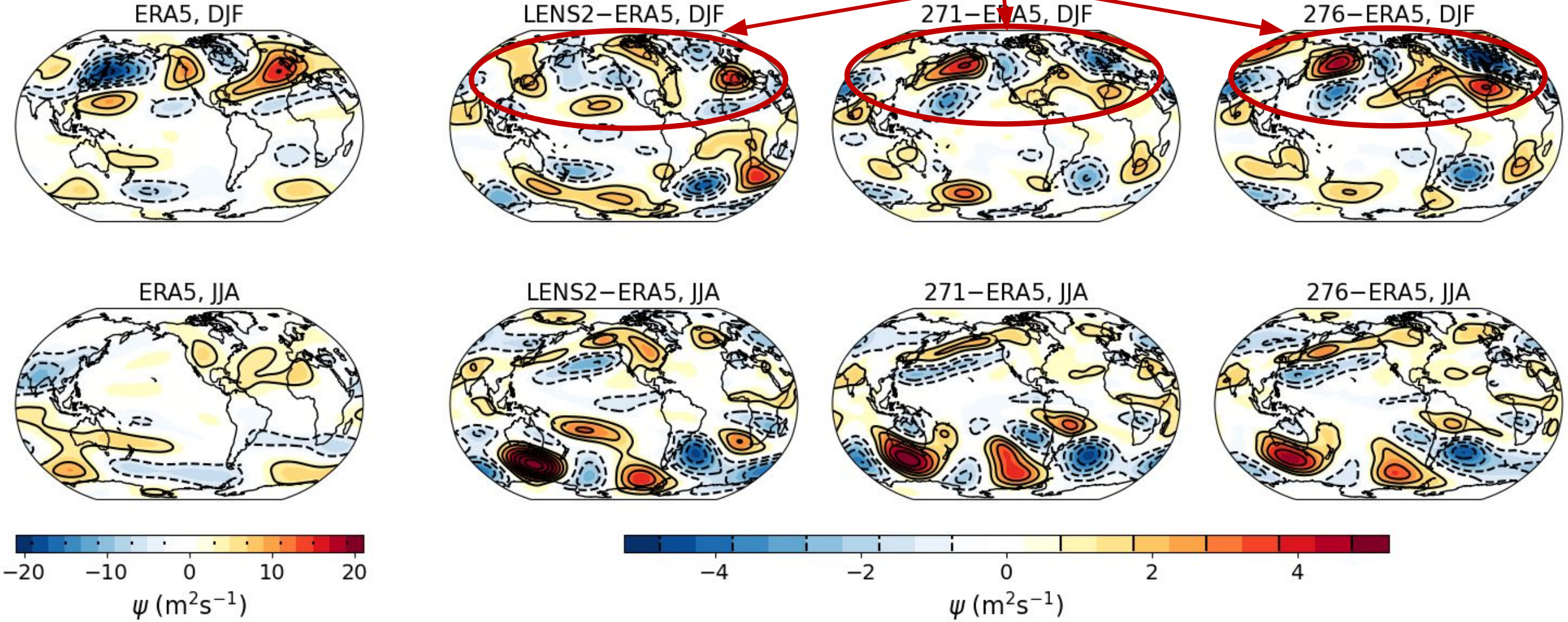


500 hPa eddy streamfunction

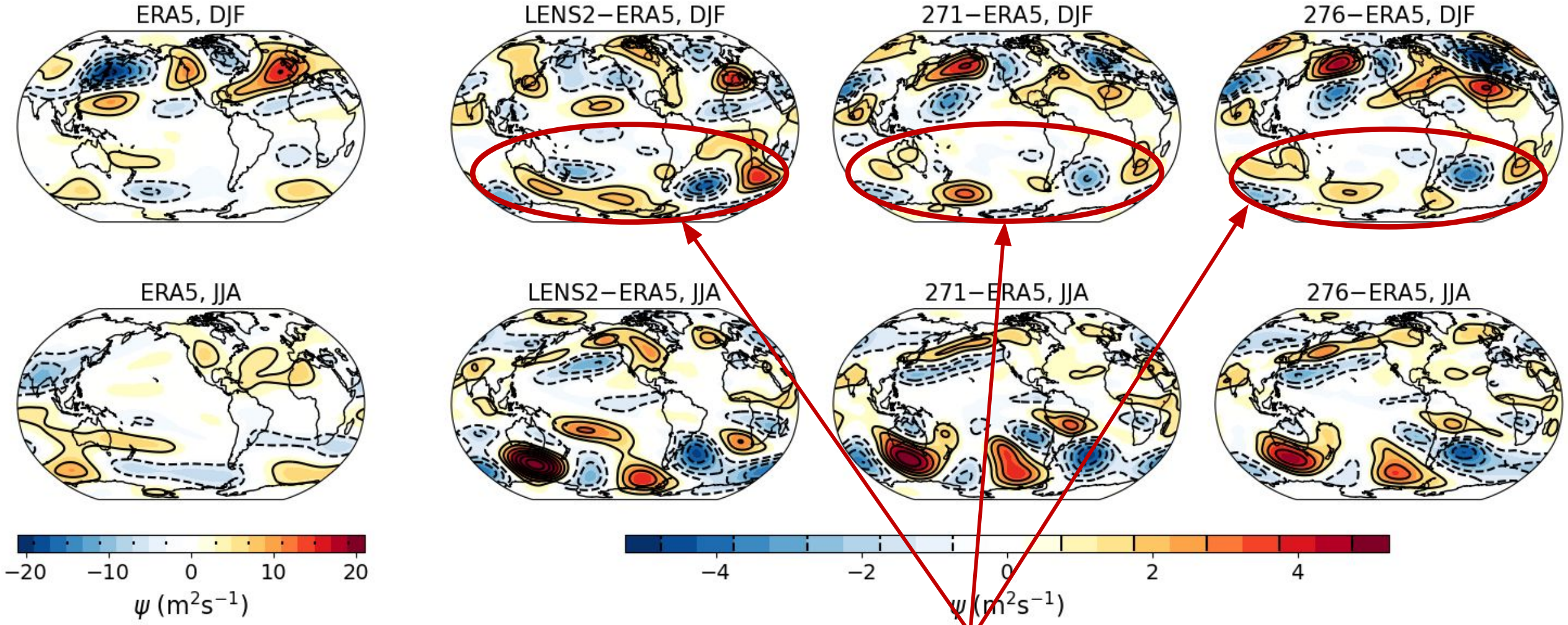


500 hPa eddy streamfunction

Degradation in NH stationary waves

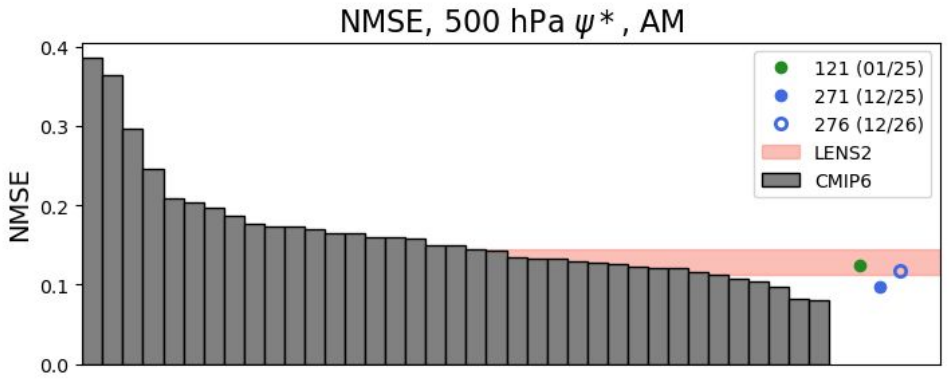


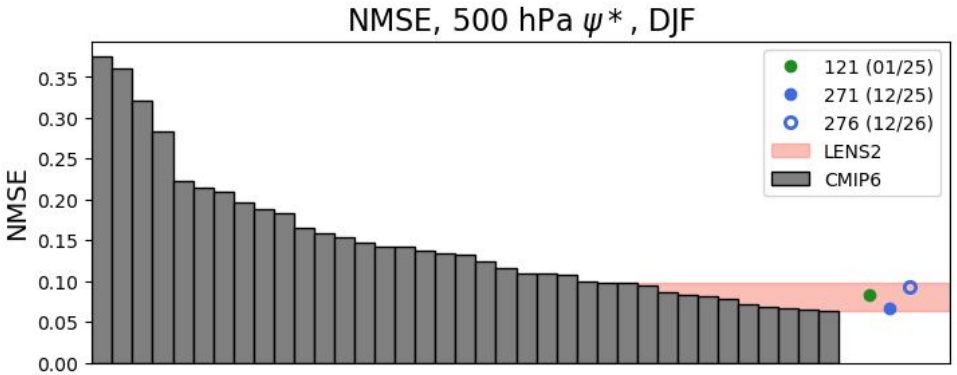
500 hPa eddy streamfunction

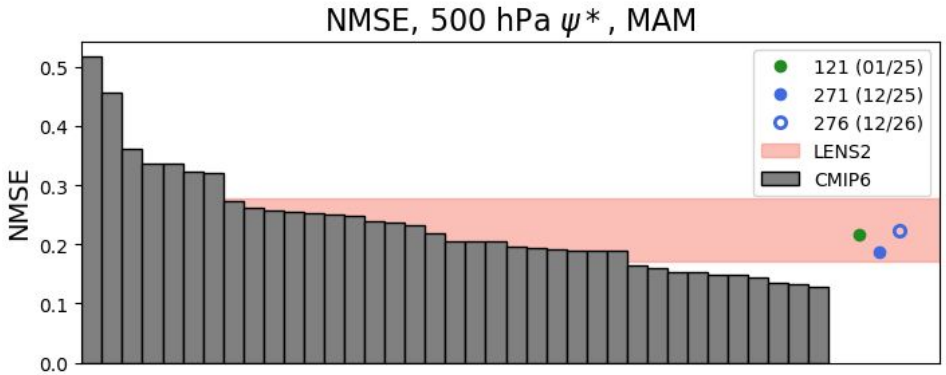


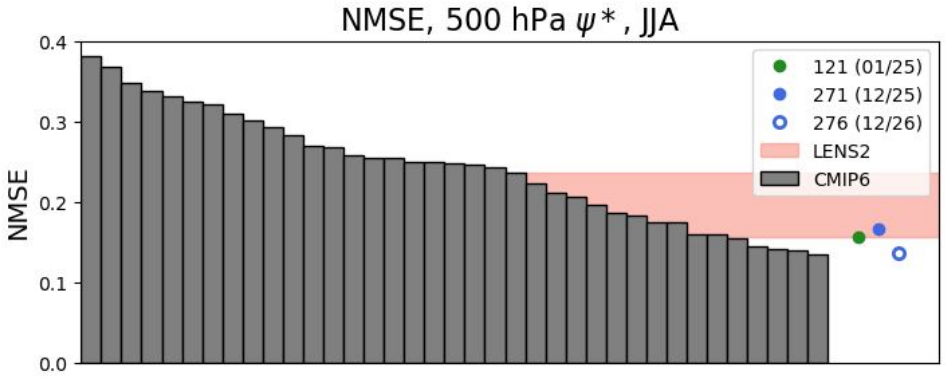
Southern Hemisphere Improvements

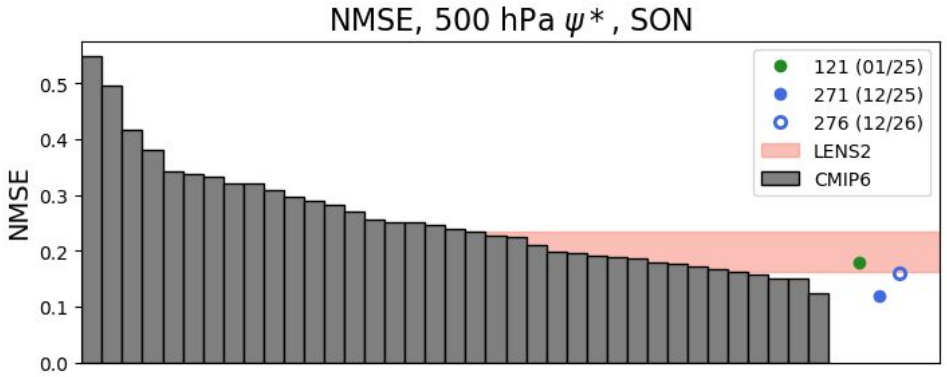
500 hPa eddy streamfunction



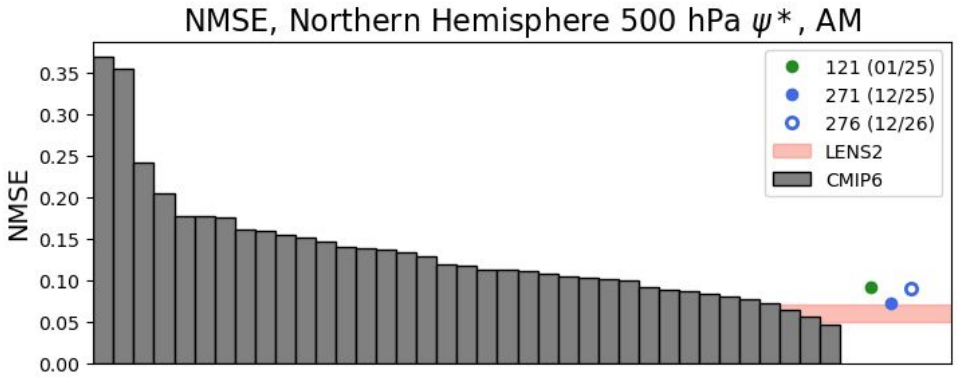


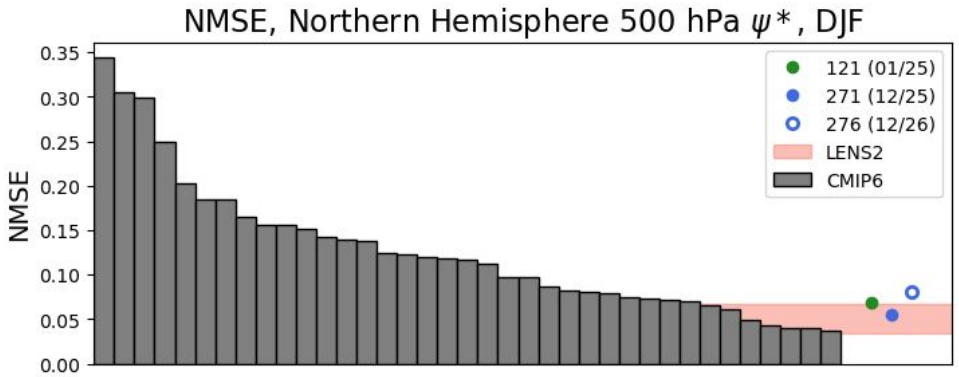


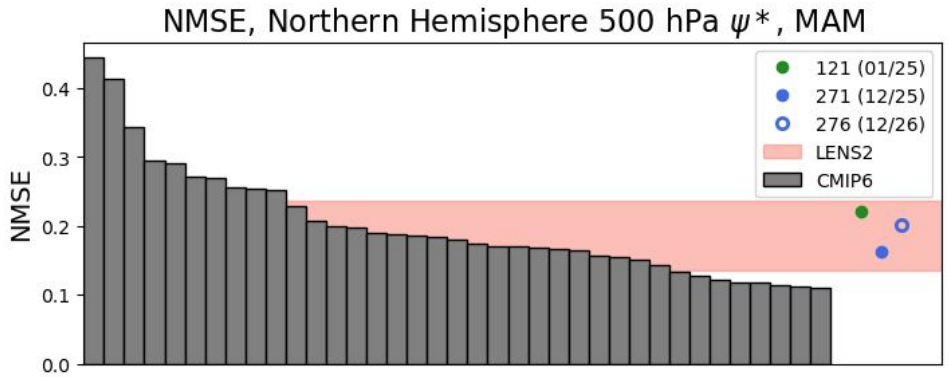


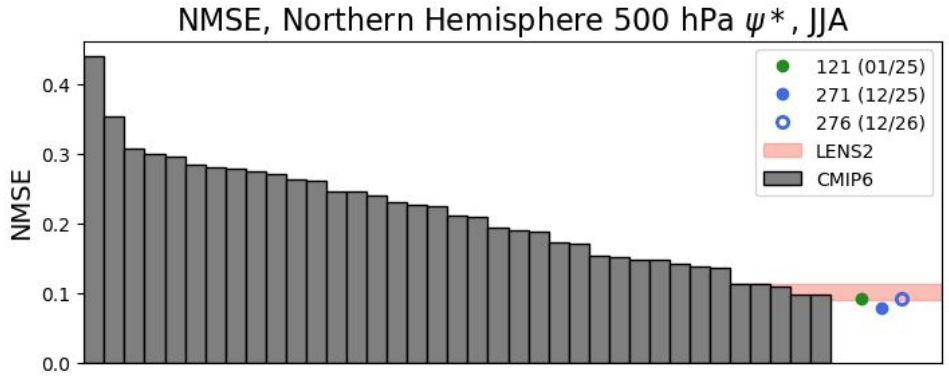


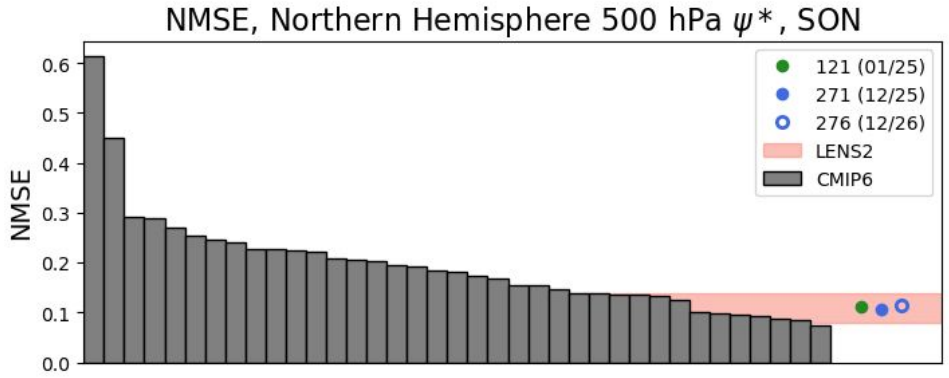
500 hPa eddy streamfunction (NH)



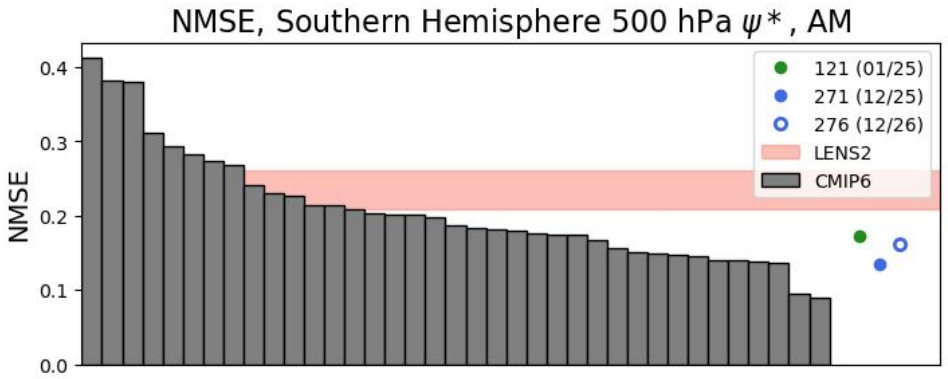


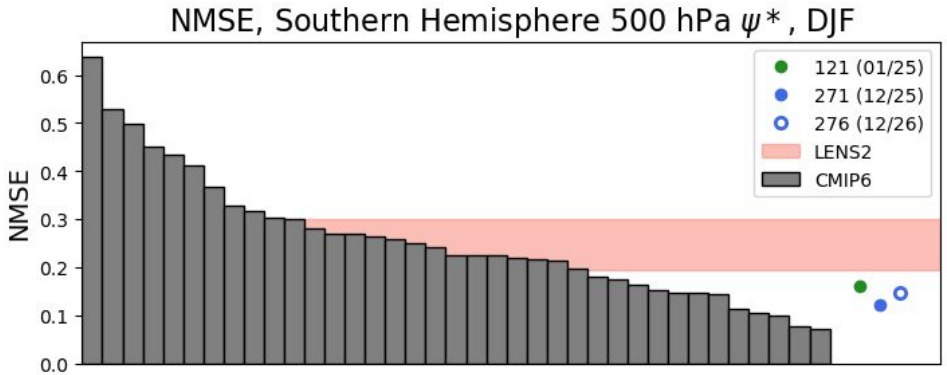


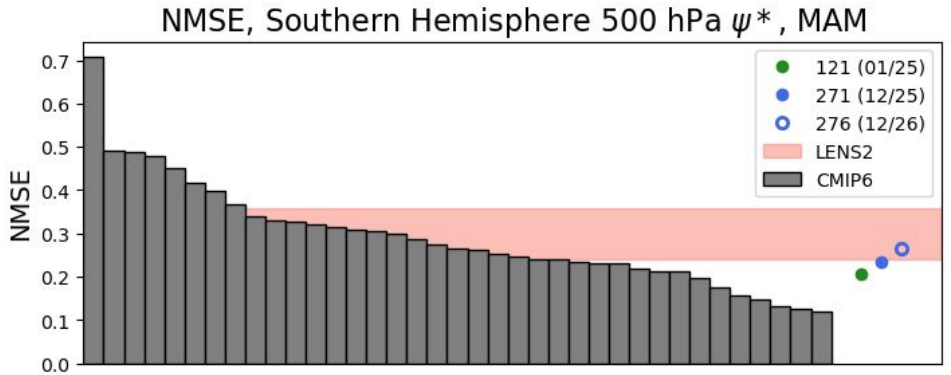


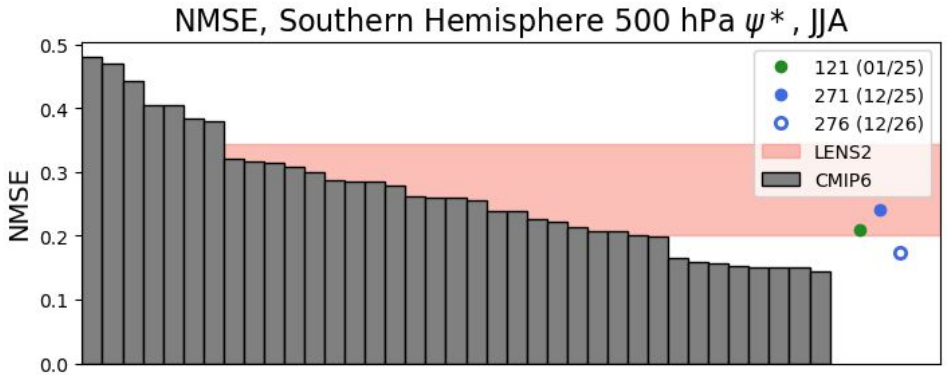


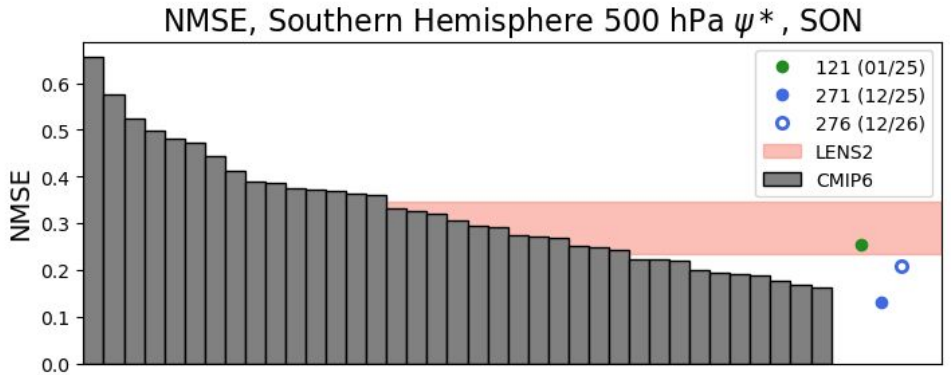
500 hPa eddy streamfunction (SH)











Conclusions

- From the perspective of the large-scale climate, things have improved since this time last year
- Problems that we were having with ENSO seem to be alleviated.
- For large-scale circulation metrics, CESM3 is comparable to CESM2 for many things and is on the good end of the CMIP6 distribution
    - We see substantial improvements in the SH circulation. Jet stream strength is better, stationary waves also better
    - Some degradations in the Northern Hemisphere, particularly in winter
- Work is ongoing to understand low frequency Southern Ocean variability and alleviate it