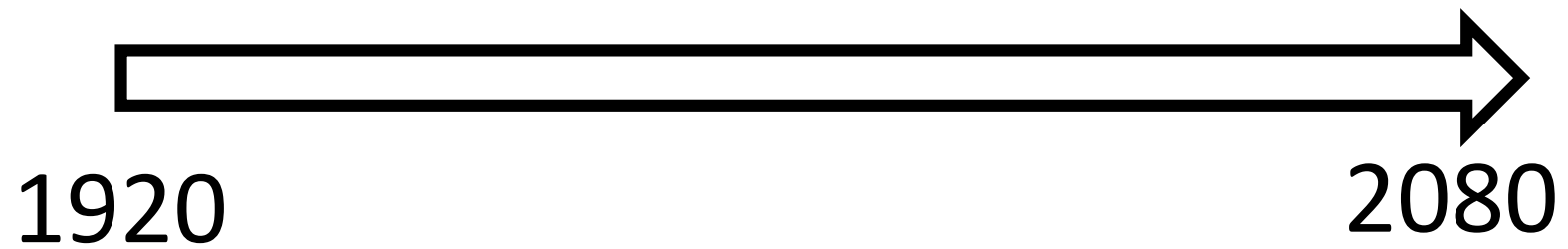# CESM1 Single Forcing Ensembles

Thanks to: Nan Rosenbloom, Dani Coleman, Gary Strand, and Isla Simpson for running and postprocessing

Available on the ESG
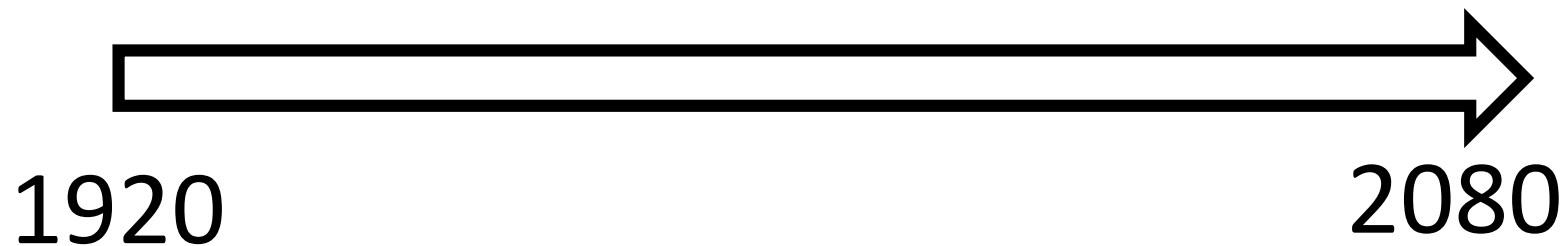
Clara Deser, CVCWG Winter Meeting, 27 Feb 2019

CESM1 Single Forcing Ensembles

1920   2080
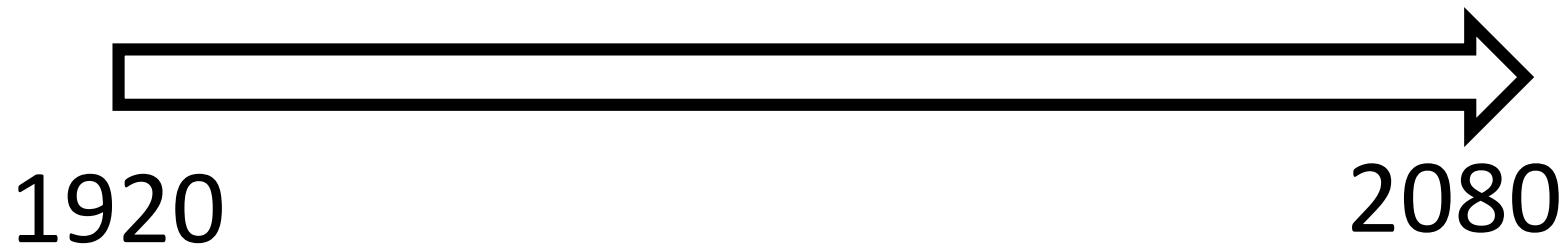
CESM1 Single Forcing Ensembles

Identical model configuration and forcings as the CESM1 Large Ensemble (LENS; Kay et al., 2015) except:

1920 ⟶ 2080
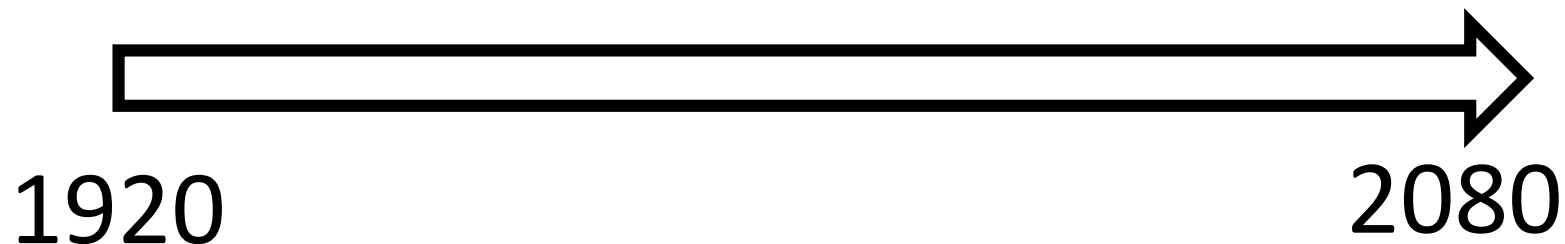
CESM1 Single Forcing Ensembles

Identical model configuration and forcings as the CESM1 Large Ensemble (LENS; Kay et al., 2015) except:

1) GHG held fixed at 1920 levels (20 members)

1920 ⟶ 2080

CESM1 Single Forcing Ensembles

Identical model configuration and forcings as the CESM1 Large Ensemble (LENS; Kay et al., 2015) except:

1) GHG held fixed at 1920 levels (20 members)

2) Anthropogenic aerosols held fixed at 1920 levels
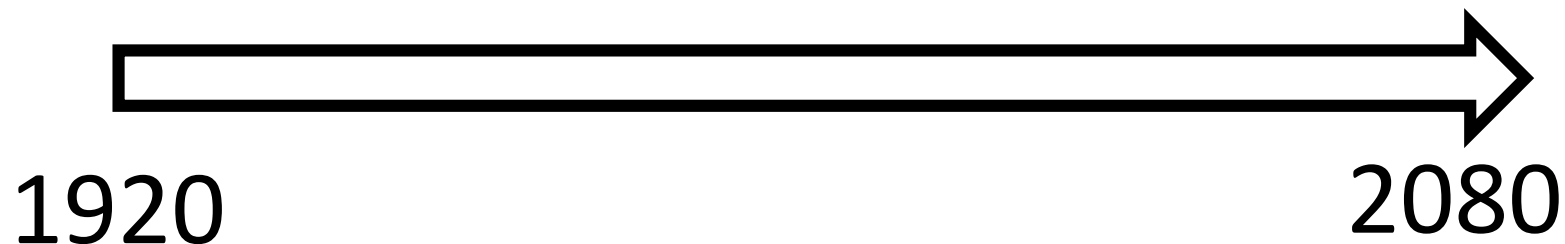   a) Energy sector (20 members)
   b) Biomass burning (15 members; to 2030)

1920 $\longrightarrow$ 2080

CESM1 Single Forcing Ensembles

Infer GHG and anthropogenic aerosol influences
by subtracting from all-forcing LENS

LENS − fixed GHG ⟹ inferred GHG influence

LENS − fixed AER ⟹ inferred AER influence

1920 ⟶ 2080

Some Results and Guiding Questions

1. What are the relative contributions of anthropogenic aerosols and greenhouse gases to evolving historical climate trends in the CESM1 Large Ensemble ?

2. How many ensemble members are needed to detect the forced responses?

Focus: 50-year trends in annual precipitation and SST
Deser et al., in preparation for J. Climate

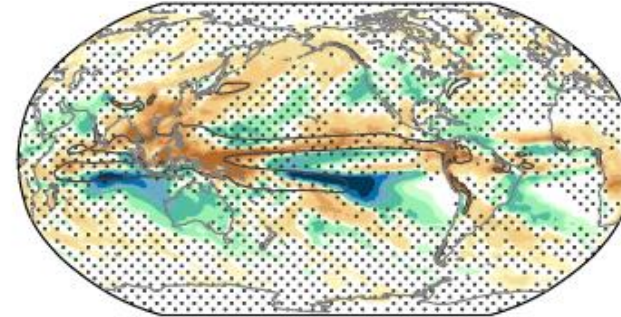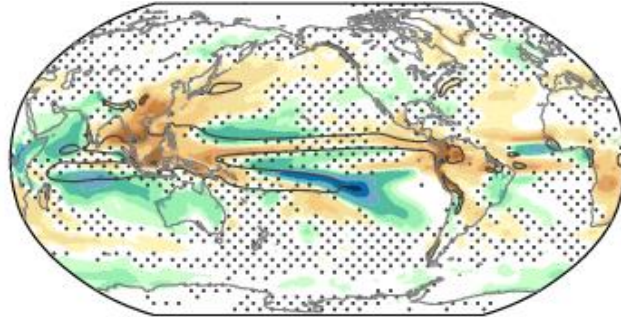# Ensemble Mean Precipitation Trends

LENS

1930-1980

1950-2000

1970-2020

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8

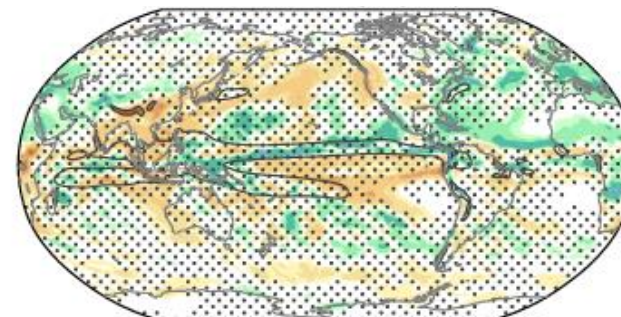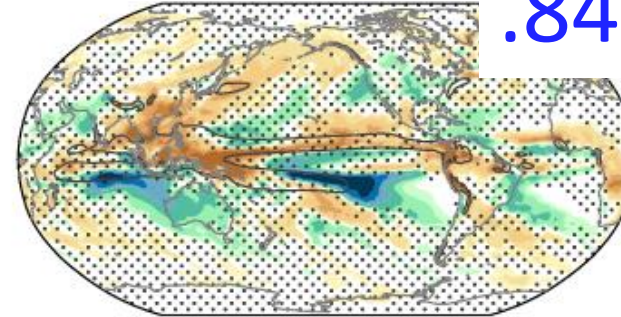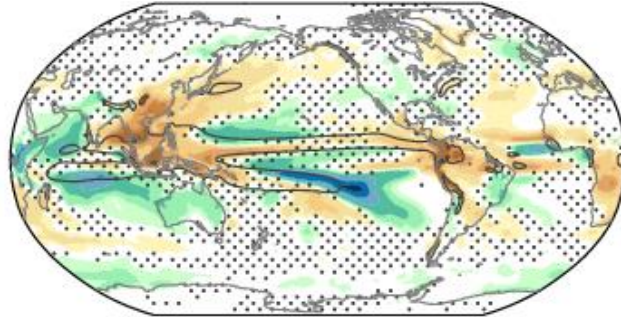Stippled areas insignificant (95%)

Ensemble Mean Precipitation Trends

LENS

1930-1980

1950-2000

1970-2020

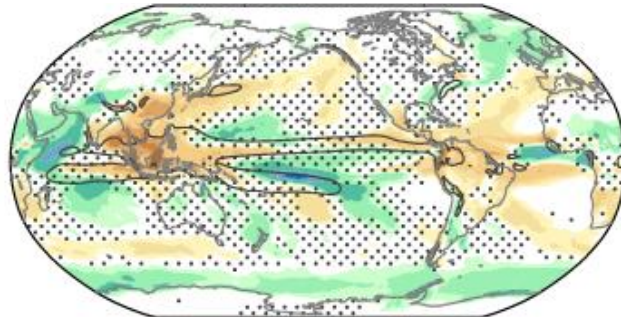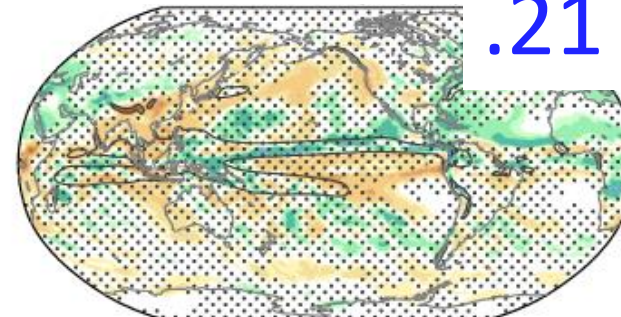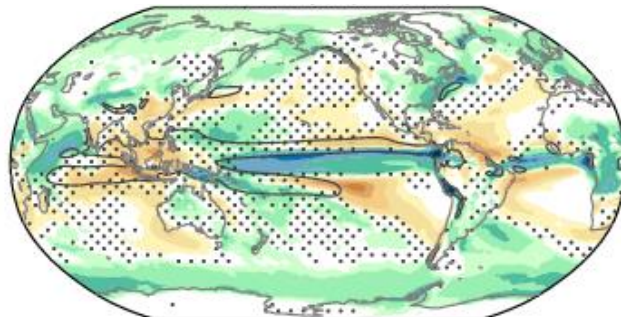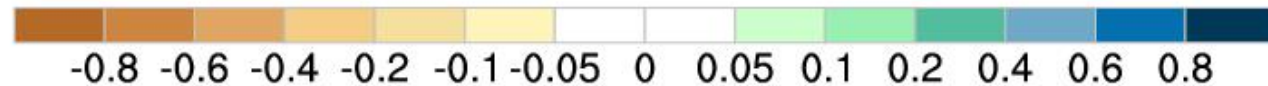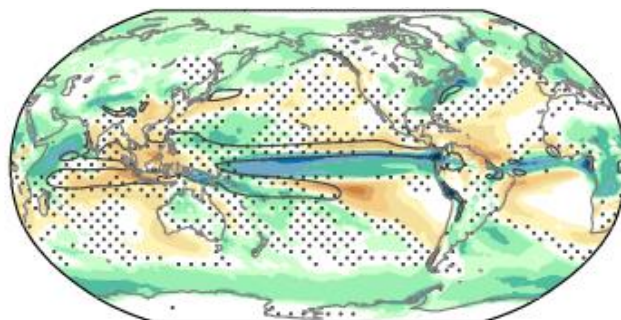-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8

Ensemble Mean Precipitation Trends

LENS

Stippled areas insignificant (95%)

1930-1980

1950-2000

1970-2020

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8
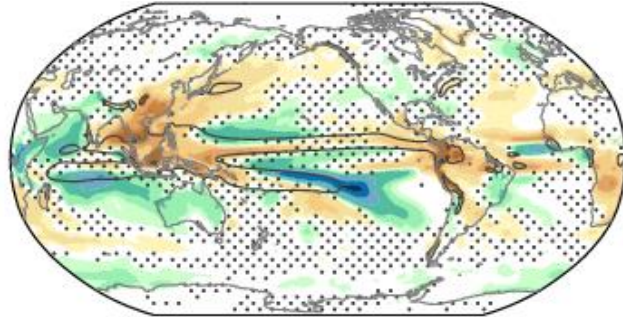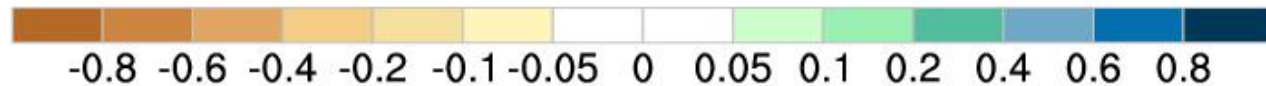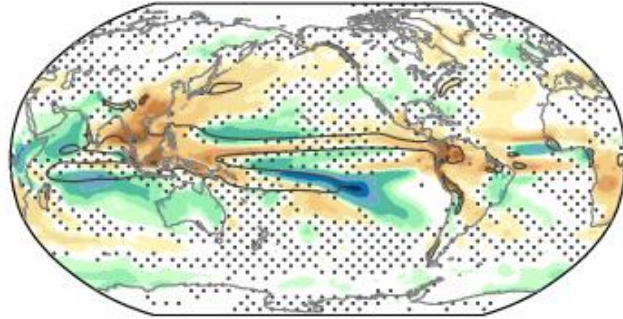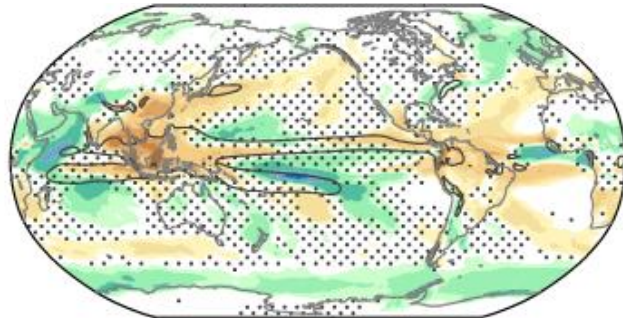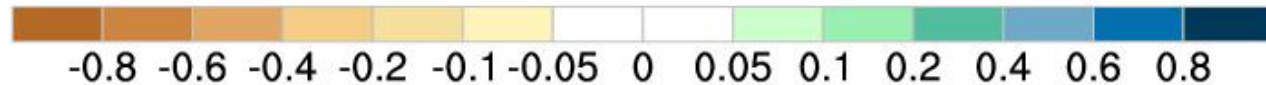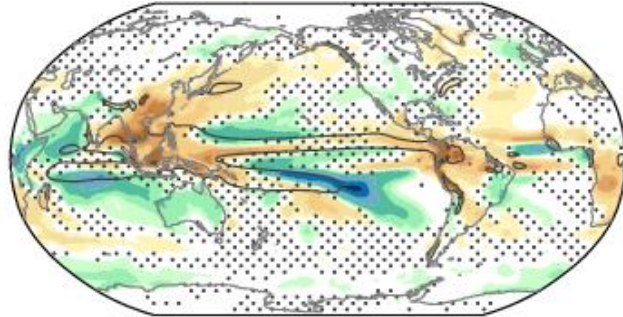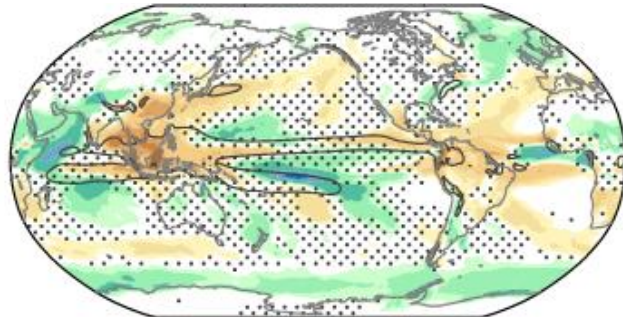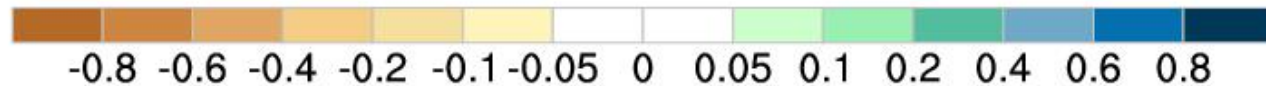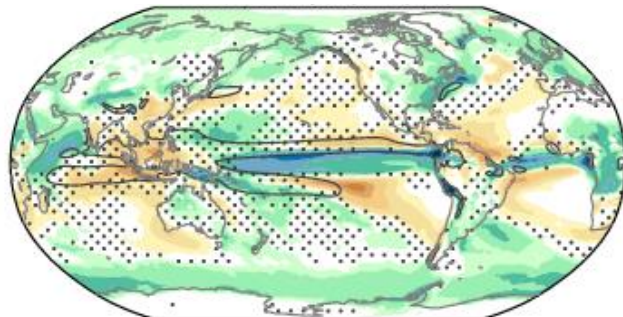
Ensemble Mean Precipitation Trends

Stippled areas insignificant (95%)

LENS   AER

1930-1980

1950-2000

1970-2020

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8
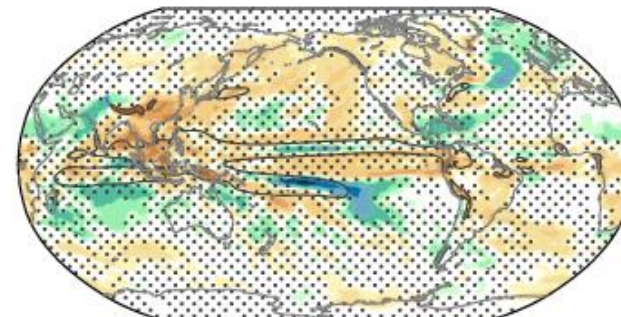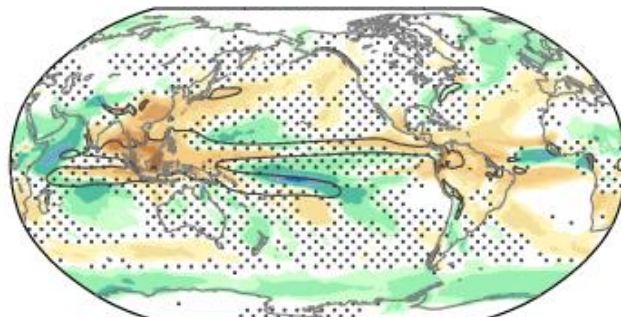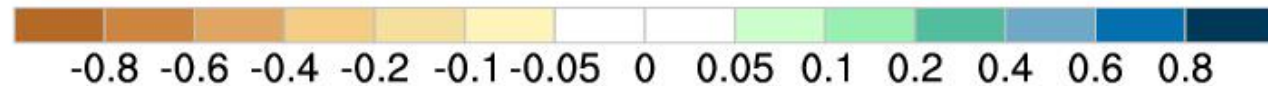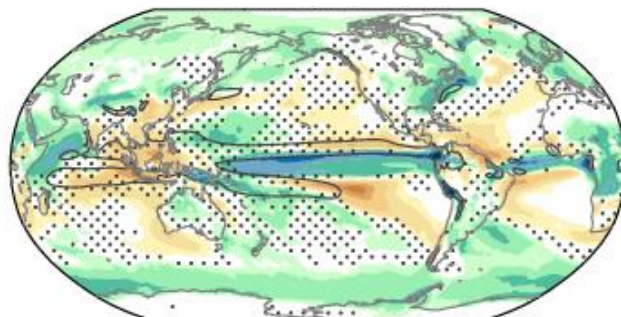
Stippled areas insignificant (95%)

Ensemble Mean Precipitation Trends

LENS

AER

.84

.21

1930-1980

1950-2000

1970-2020

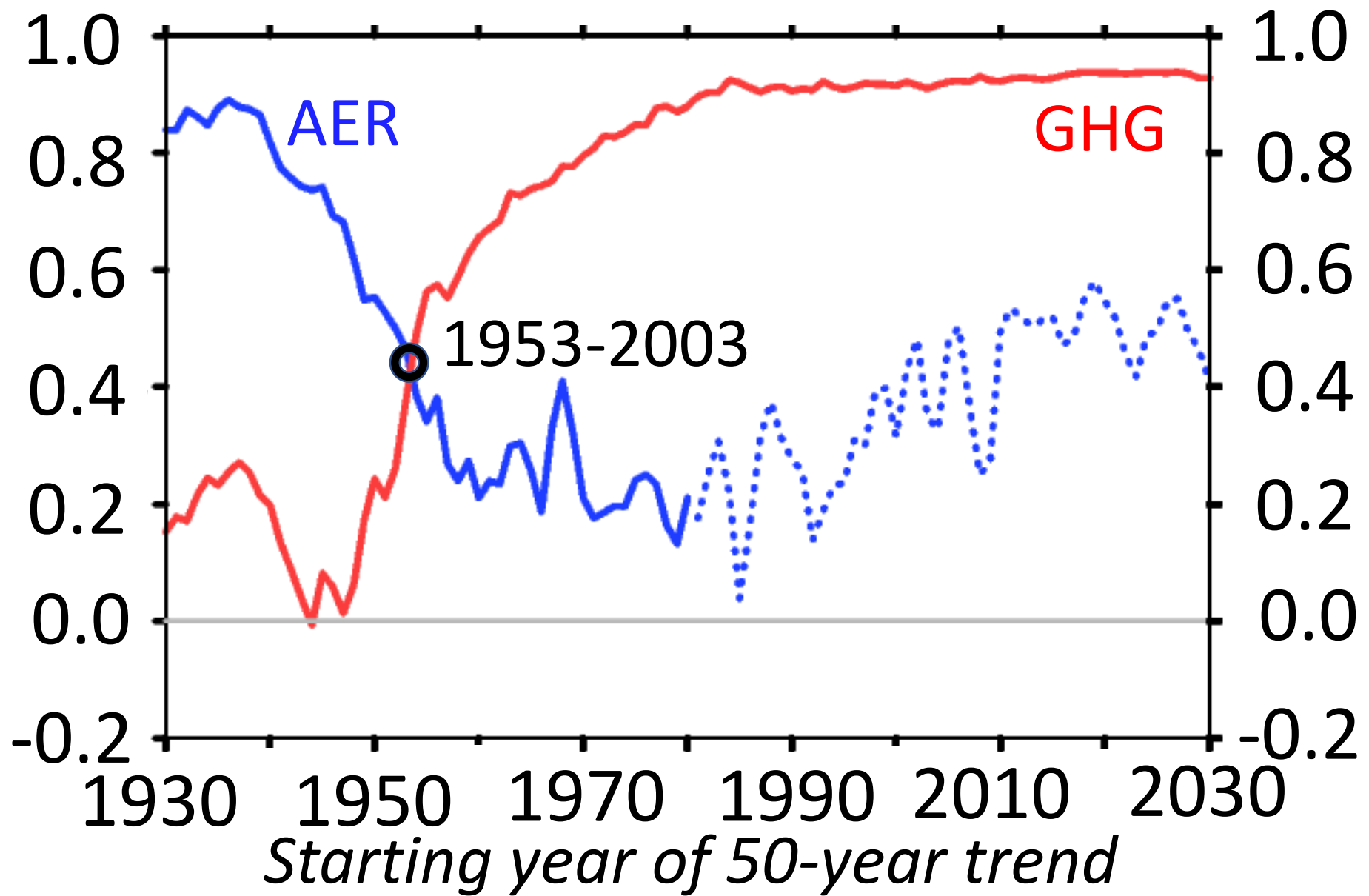-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8

Ensemble Mean Precipitation Trends
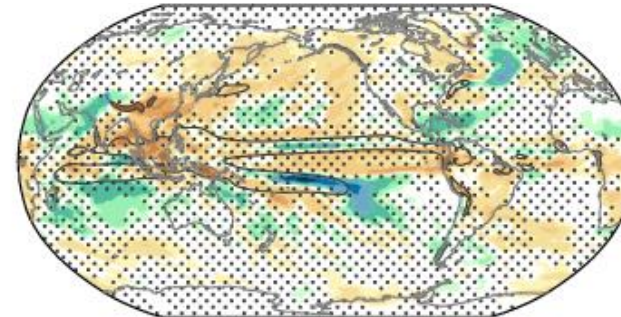
Stippled areas insignificant (95%)

Ensemble Mean Precipitation Trends

LENS   AER   GHG

1930-1980   .84   .15

1950-2000

1970-2020   .21   .79

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8
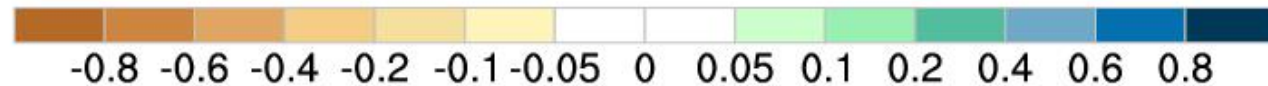
Pattern Correlation with LENS
Running 50 year Precipitation Trends

AER

GHG

1953-2003

Starting year of 50-year trend

How many ensemble members are needed to confidently detect the forced response?

How many ensemble members are needed to confidently detect the forced response?

Nmin (95% confidence)
= 8 x (σ trends / Ensemble Mean Trend)^2

Based on standard error of the mean (Deser et al., 2012)

LENS Precipitation Trends

1930-1980

Nmin

Mean

Nmin

3   6   9   12   15   20   30   40

Precipitation (mm mo⁻¹)

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8

1930-1980

LENS Precipitation Trends

Nmin Mean Member A Member B

Nmin

3 6 9 12 15 20 30 40

Nmin

Precipitation (mm mo⁻¹)

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8
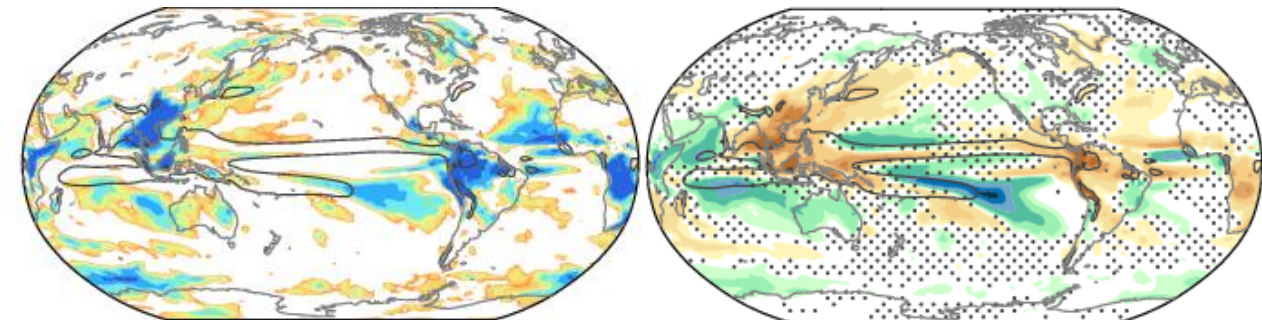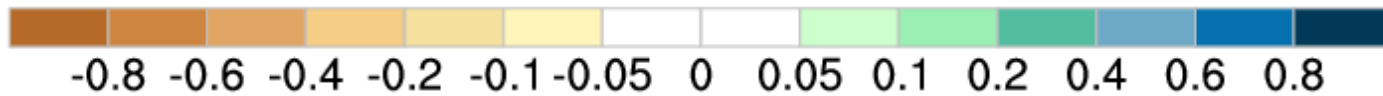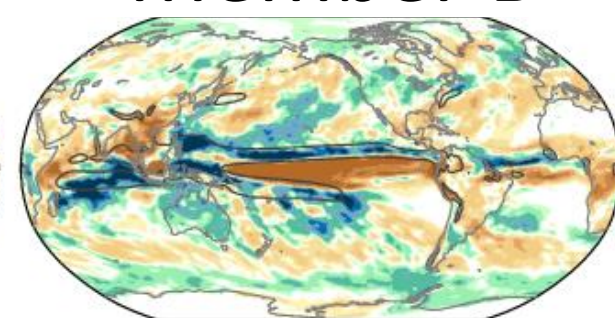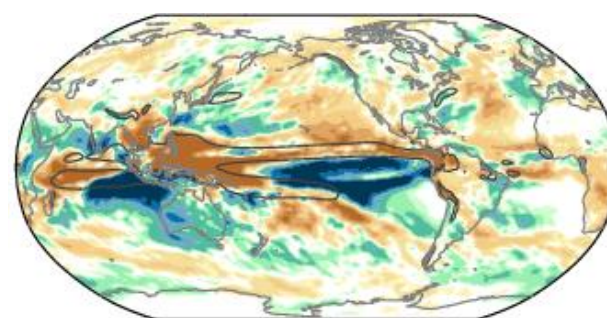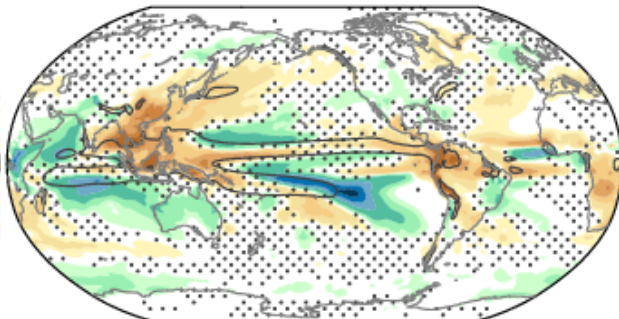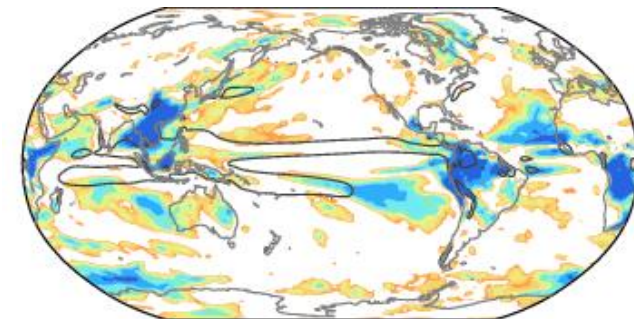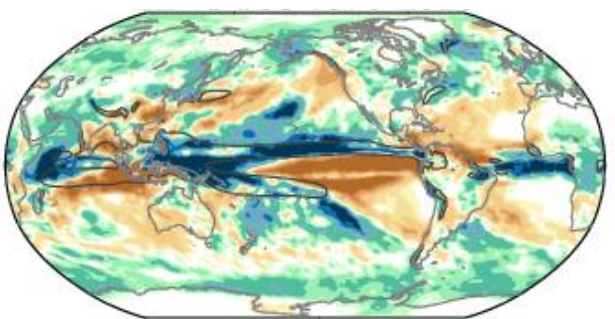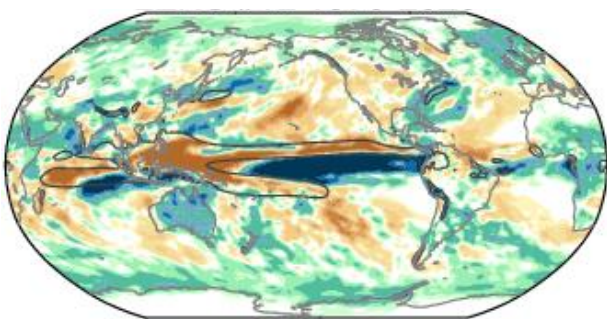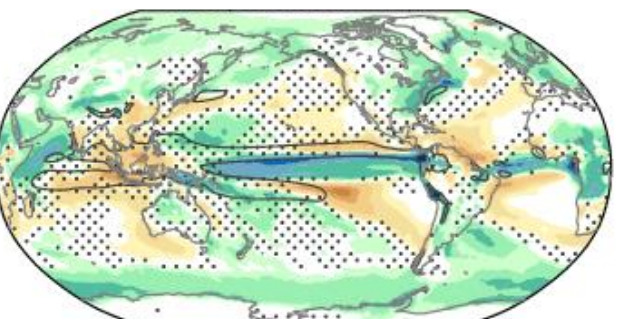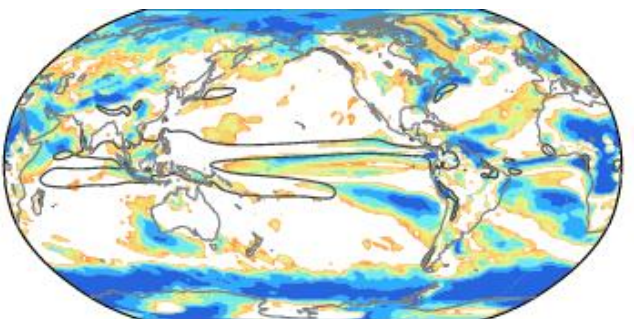
LENS Precipitation Trends

1930-1980

Nmin • Mean • Member A • Member B

1970-2020

Nmin • Mean

Nmin: 3 6 9 12 15 20 30 40

Precipitation (mm mo⁻¹)

$Precipitation\ (mm\ mo^{-1})$

-0.8 -0.6 -0.4 -0.2 -0.1 -0.05 0 0.05 0.1 0.2 0.4 0.6 0.8

LENS Precipitation Trends

How many ensemble members are needed to confidently detect the forced response?

Patterns

Pattern Correlation: Individual Members *vs.* Ensemble Mean
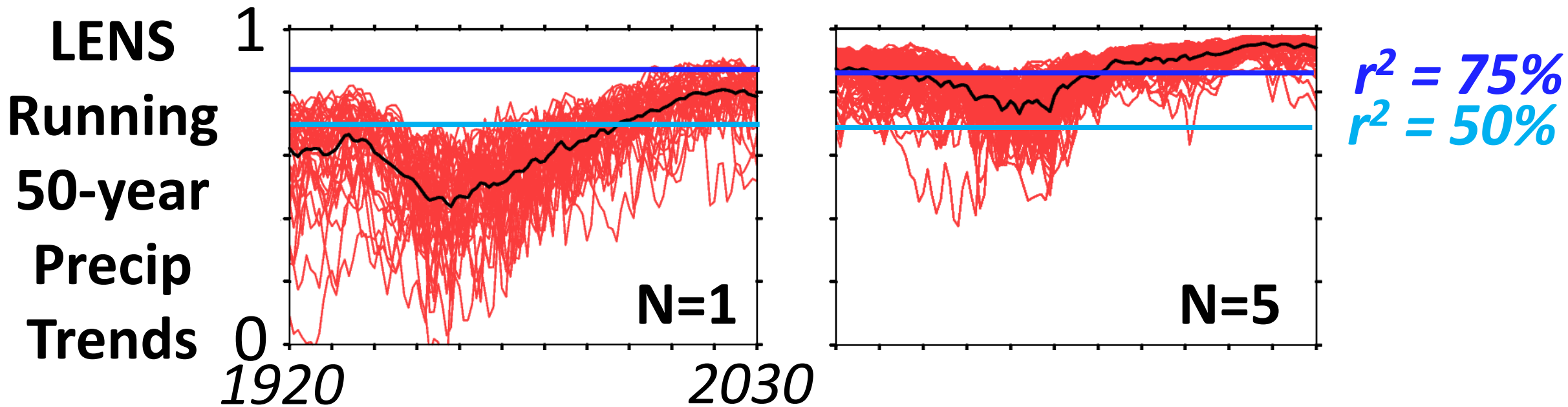
Running 50 year Precipitation Trends

LENS

Significant relative to control run

Starting year of 50-year trend
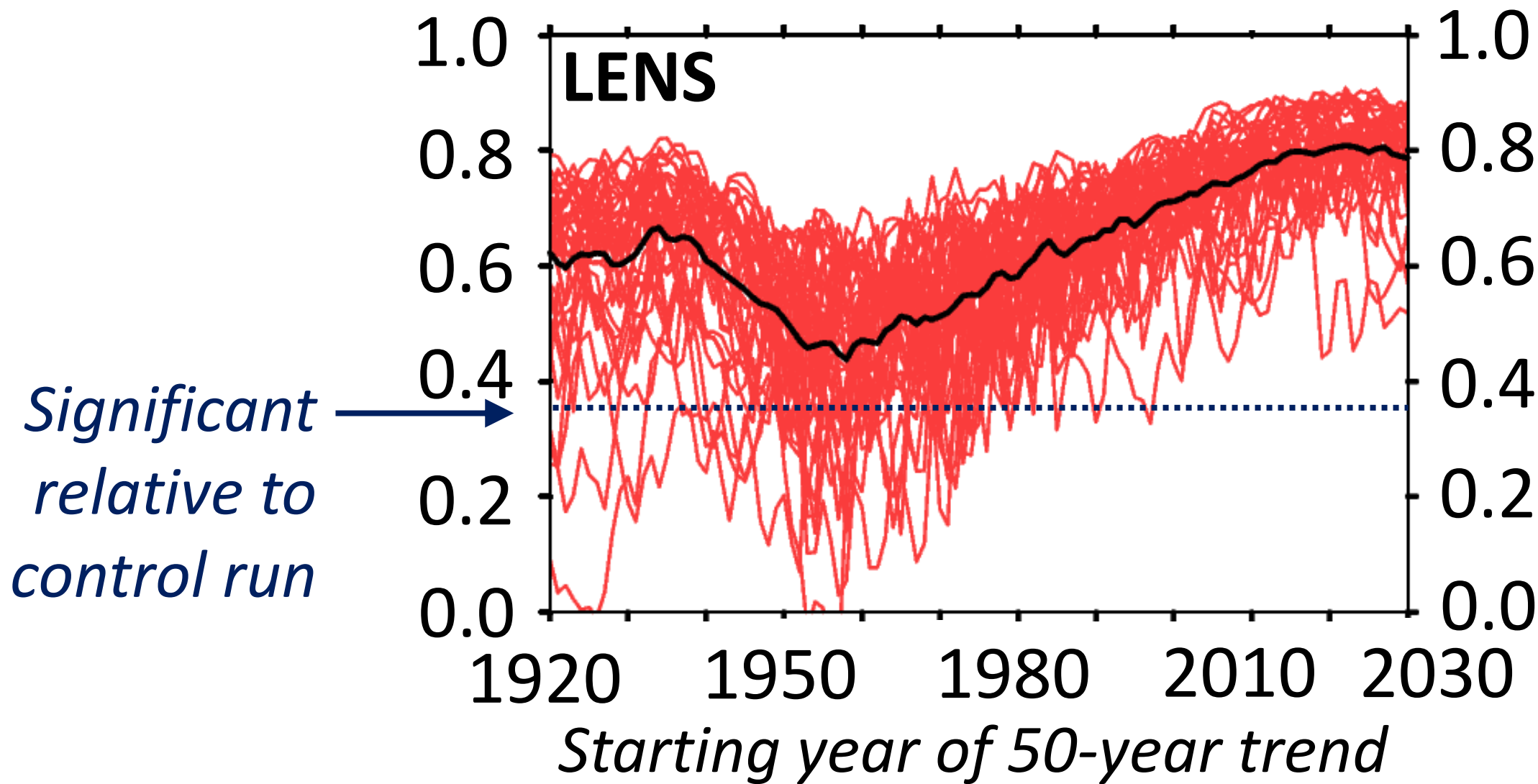
Pattern Correlation: Individual Members *vs.* Ensemble Mean
Running 50 year Precipitation Trends

Pattern Correlation: N-member *vs* 40-member averages
(200 bootstrapped samples)

LENS Running 50-year Precip Trends

N=1

N=5

1920   2030

$r^2 = 75\%$
$r^2 = 50\%$

Pattern Correlation: N-member *vs* 40-member averages (200 bootstrapped samples)

LENS Running 50-year Precip Trends

1

0

1920   2030

r^2 = 75%
r^2 = 50%

N=1

N=5

N=10

N=15

Pattern Correlation: N-member *vs* 40-member averages
(200 bootstrapped samples)

LENS Running 50-year Precip Trends

1

0

1920   *2030*

N=1

N=5

N=10

N=15

r² = 75%
r² = 50%
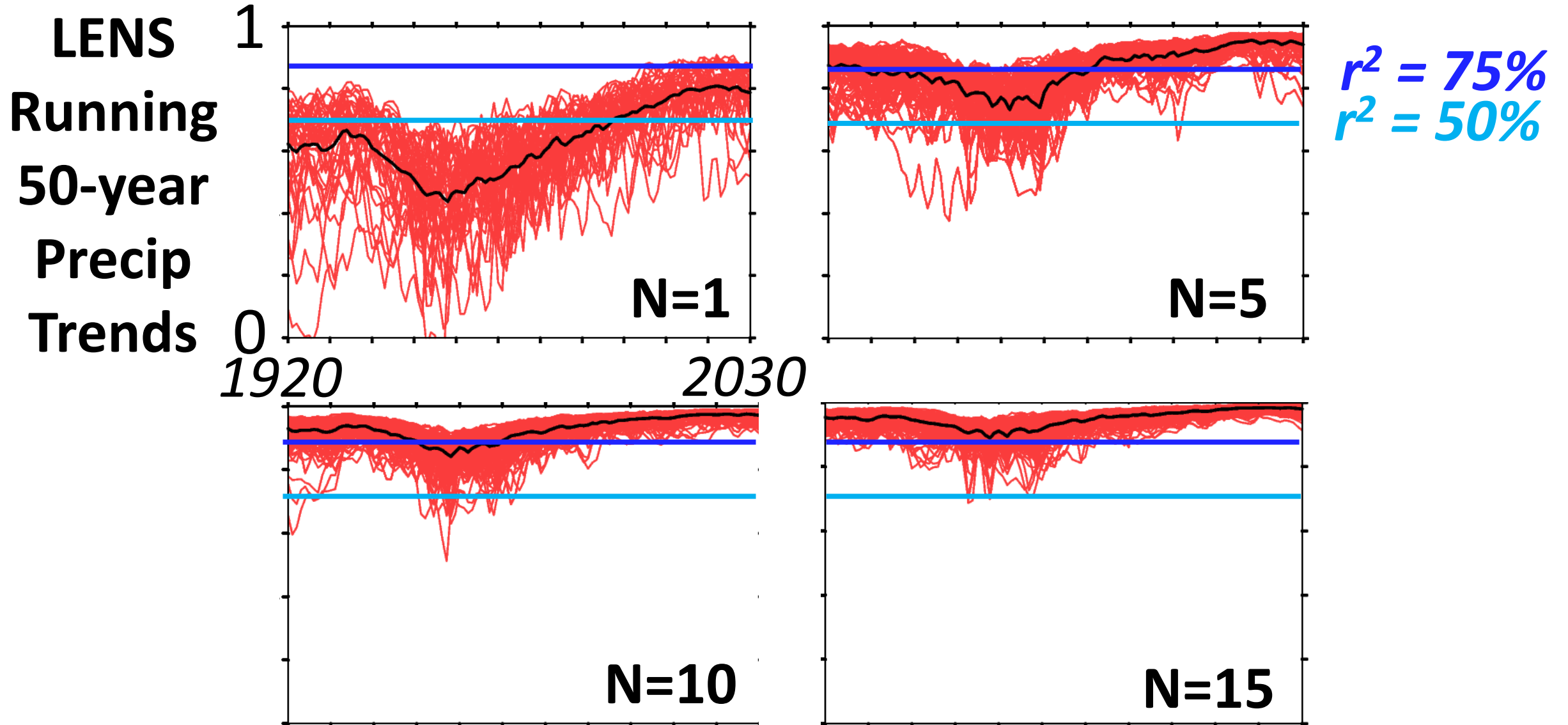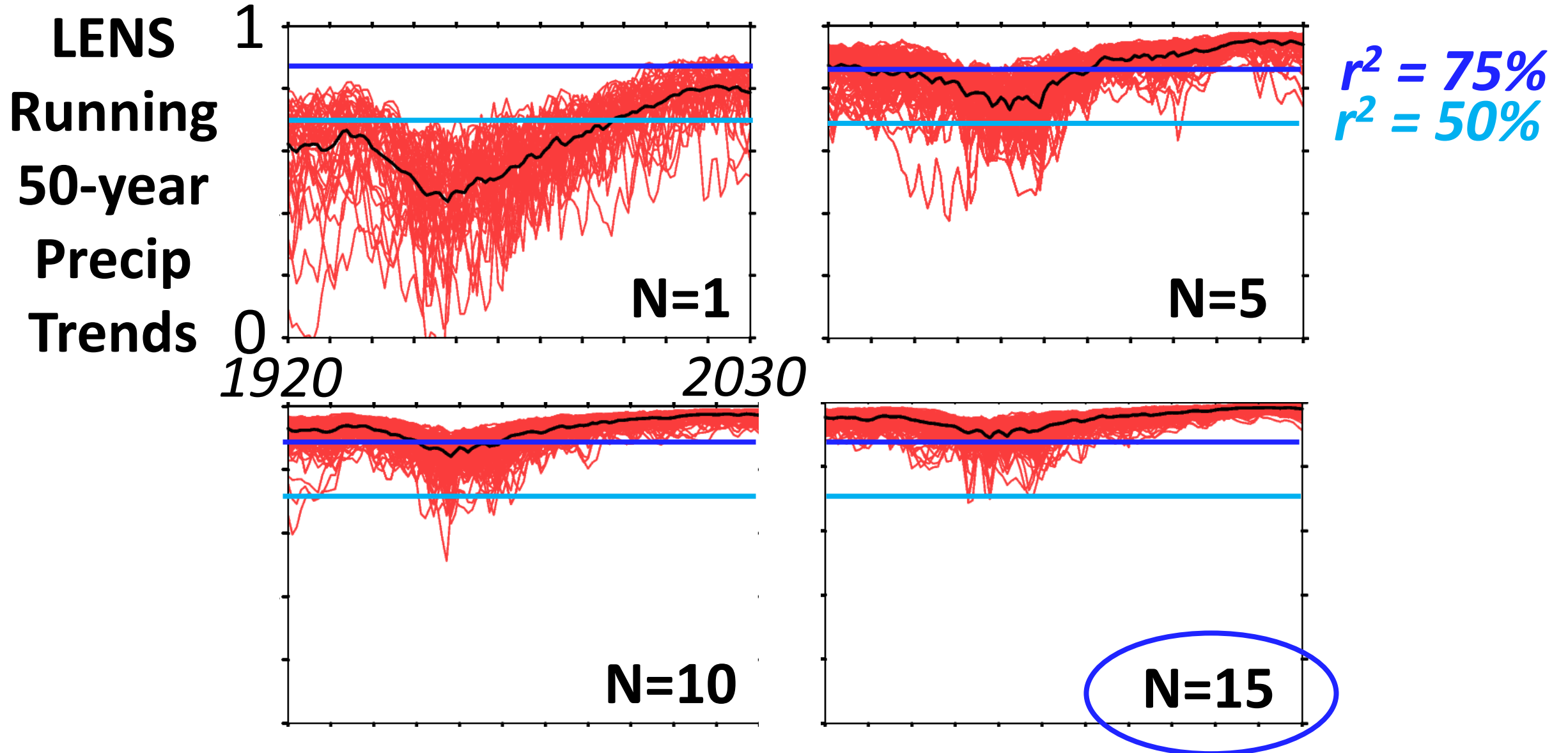
Thanks

Extra

Nmin (95% confidence)
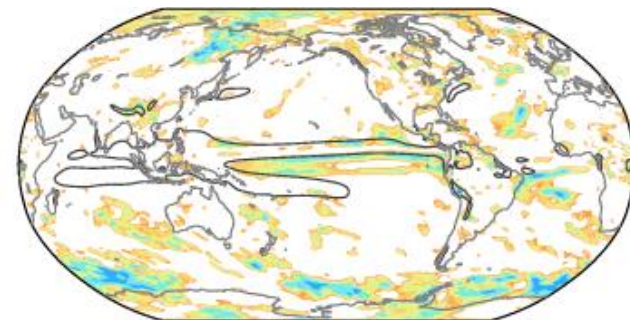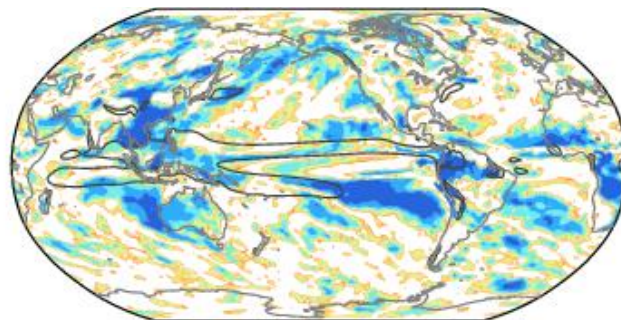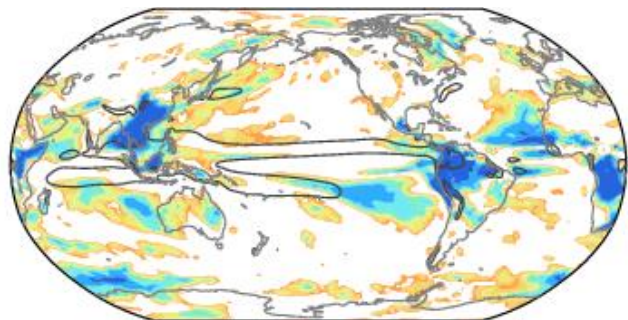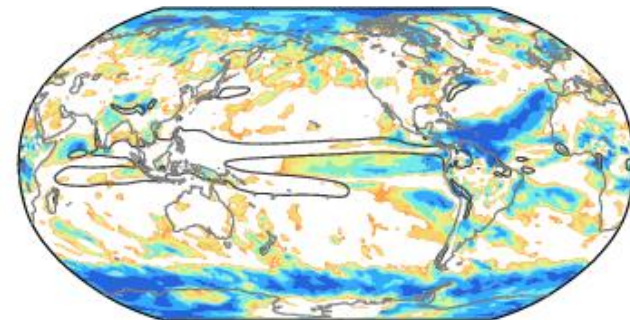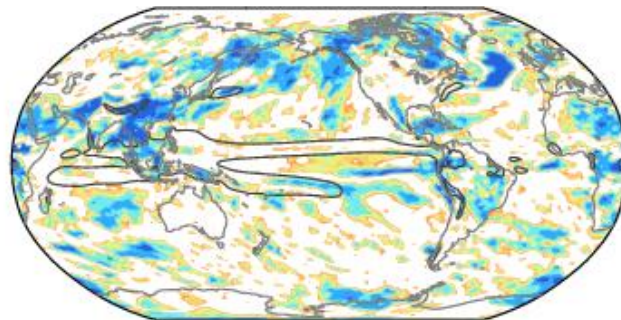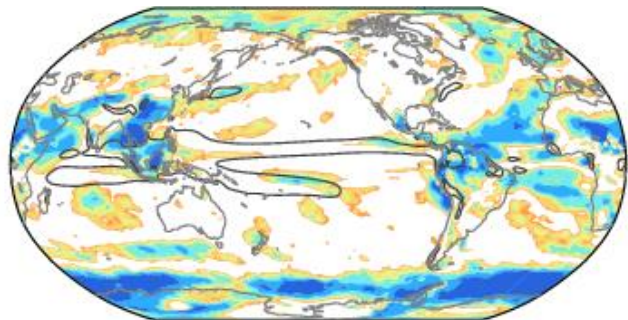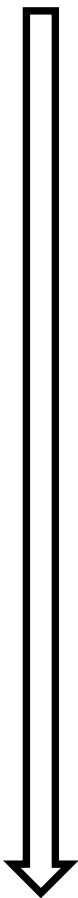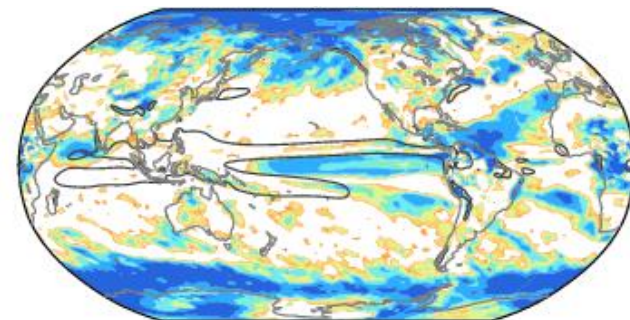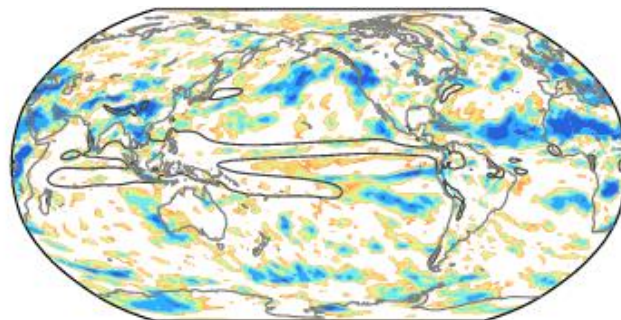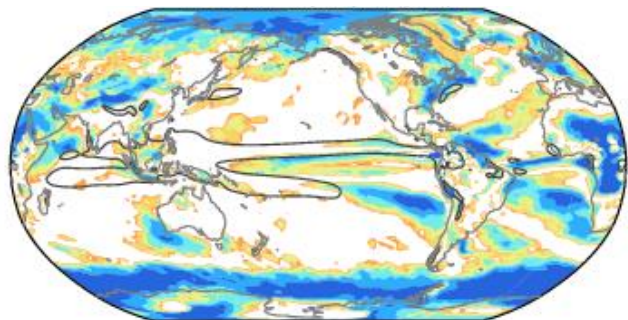
OBS (GPCC)   LENS Ens Mean

1930-1980
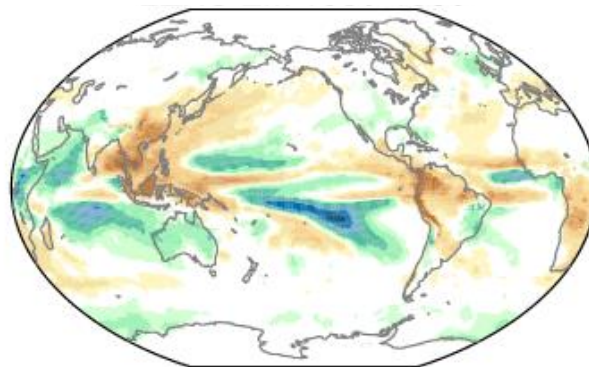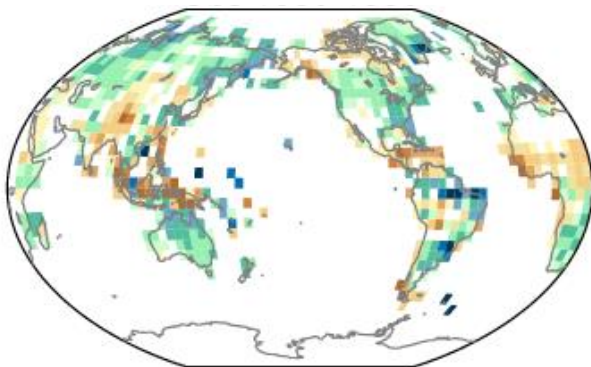
1950-2000
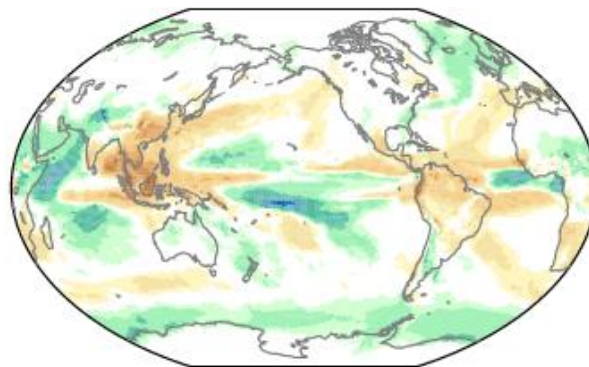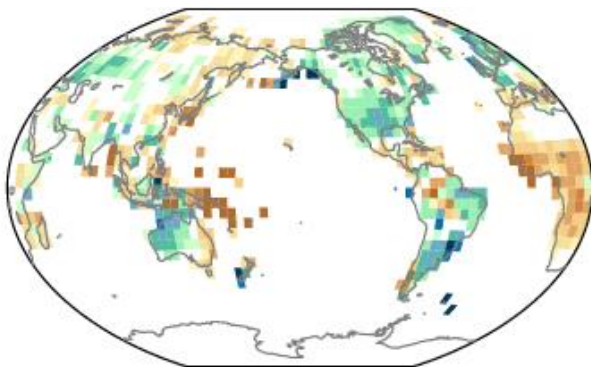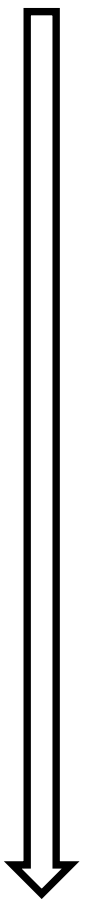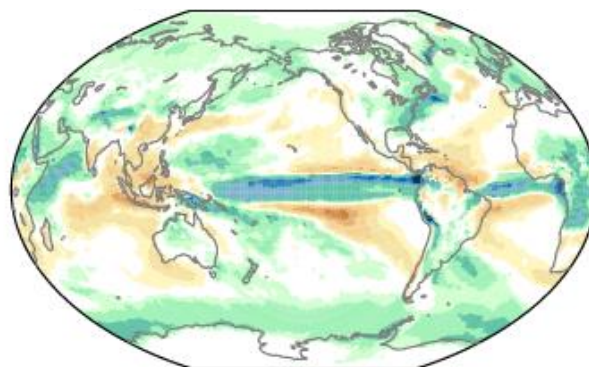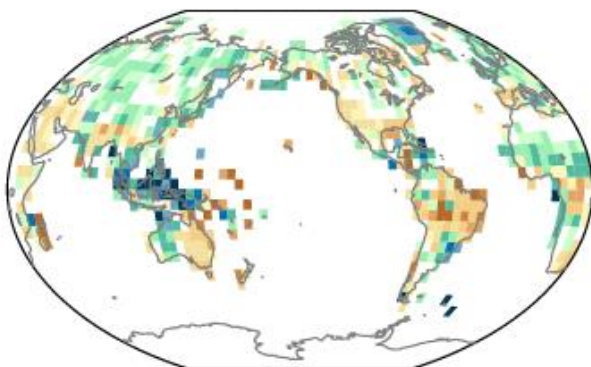
1970-2020

Pattern Correlation: Individual members *vs* ensemble mean
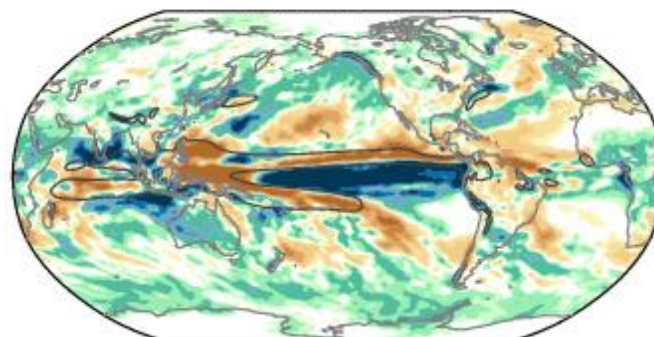

LENS Precip Trends

Significant relative to control run

GPCC
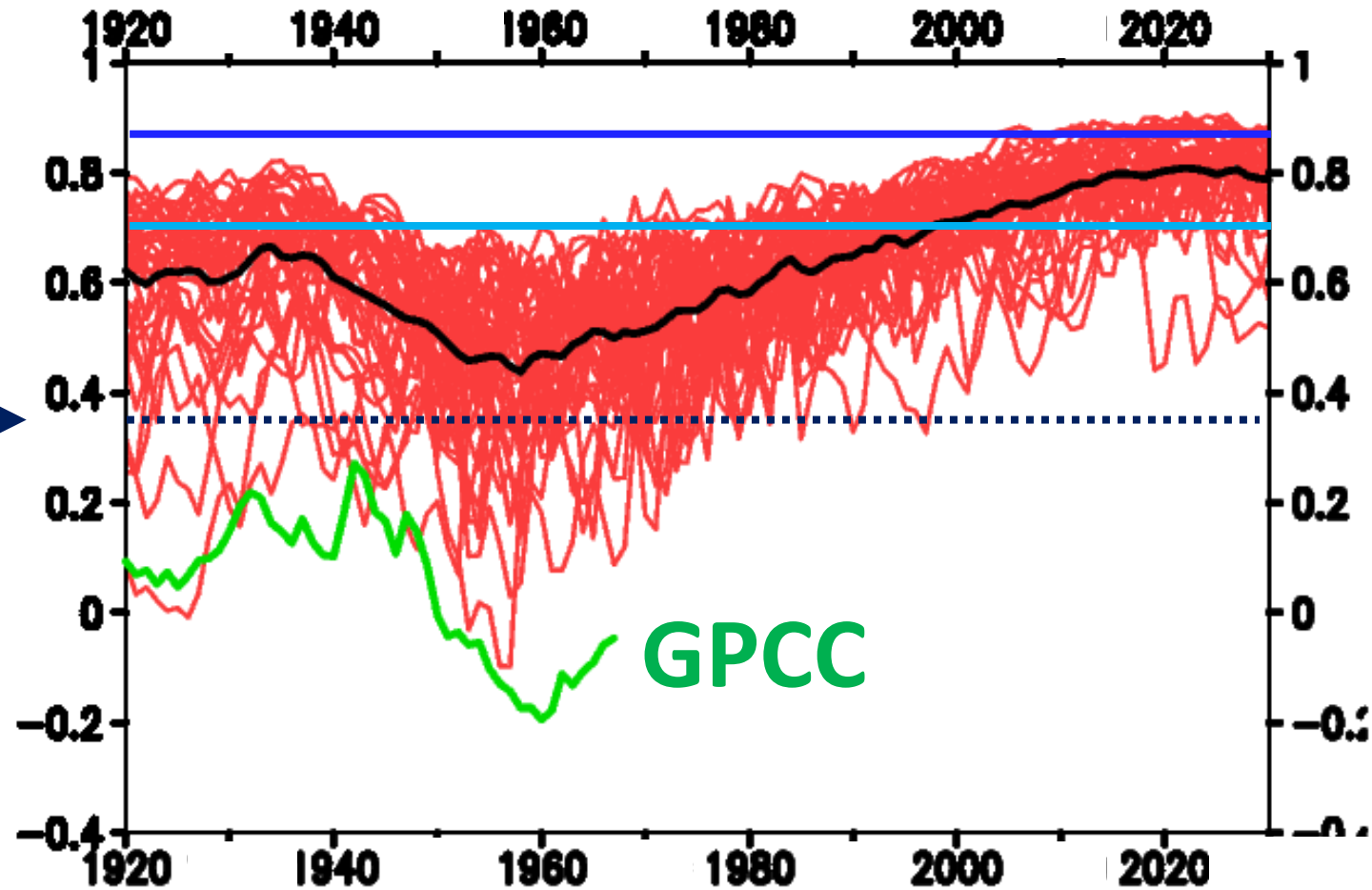
Starting year of 50-year trend

GHG Ensemble, 1970-2020 Trends
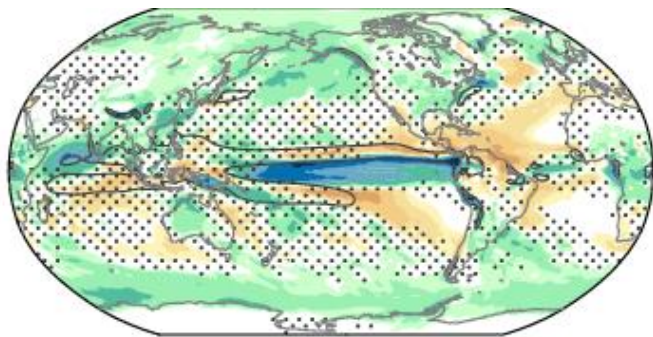
Ensemble mean   Member A   Member B
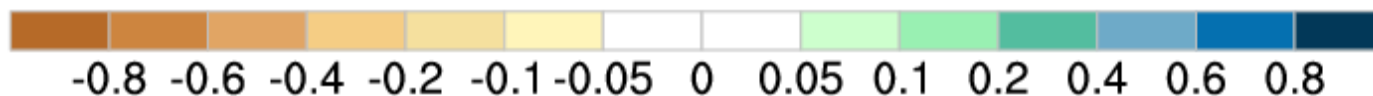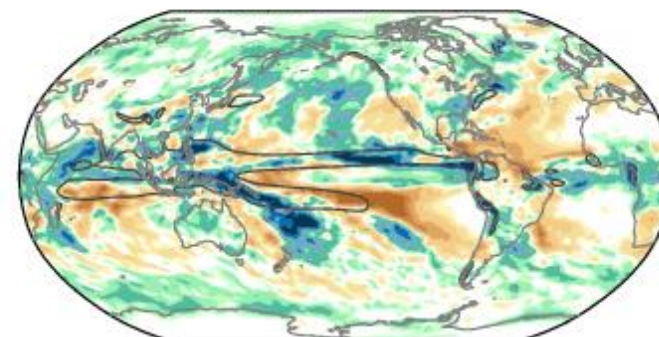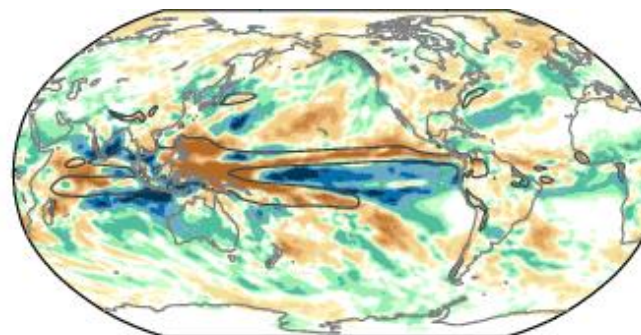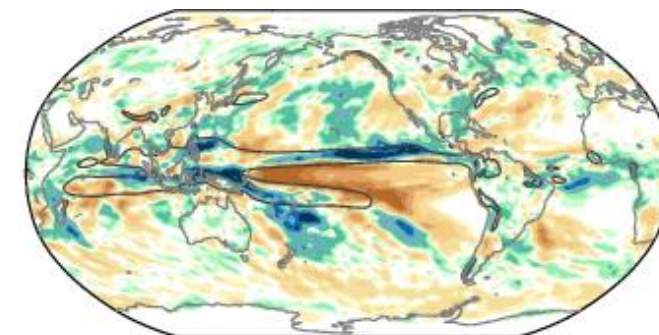
Internal (- EM)   Member A   Member B

Pattern Correlations of N-member ensemble means with the 40-member EM (all from LENS)

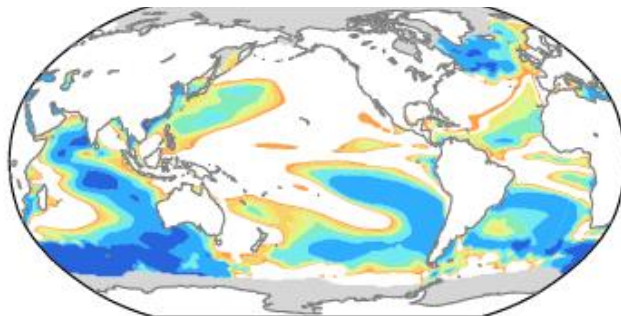Annual Tropical Precipitation 50-year running trends starting in 1920-2030
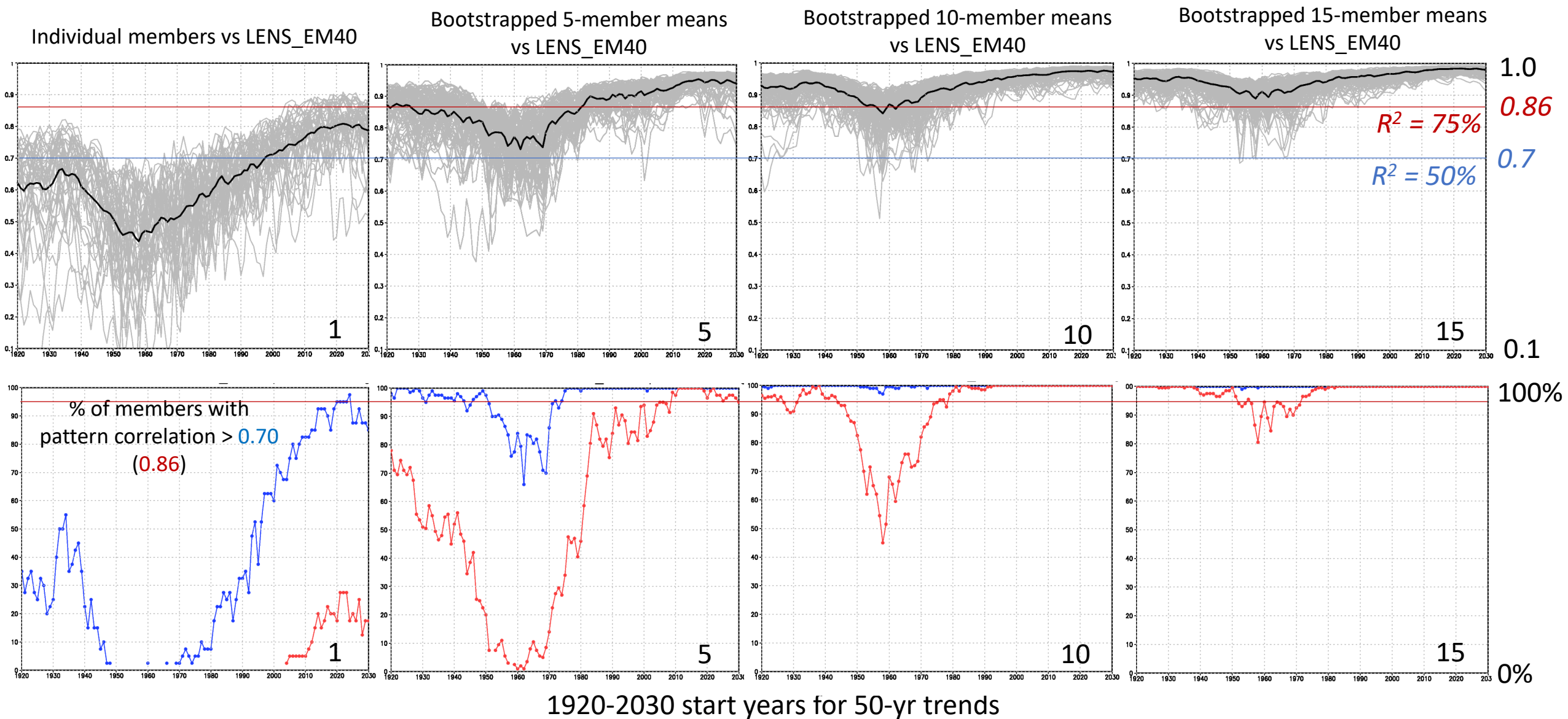
1920-2030 start years for 50-yr trends

How many ensemble members are needed?
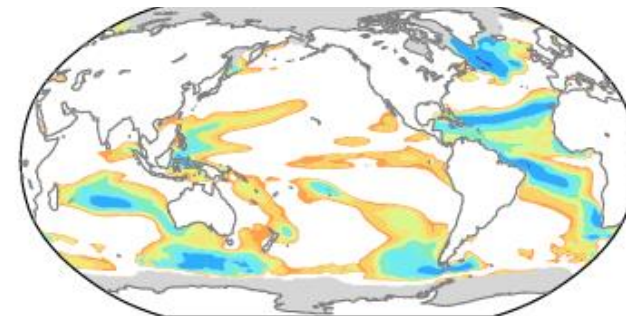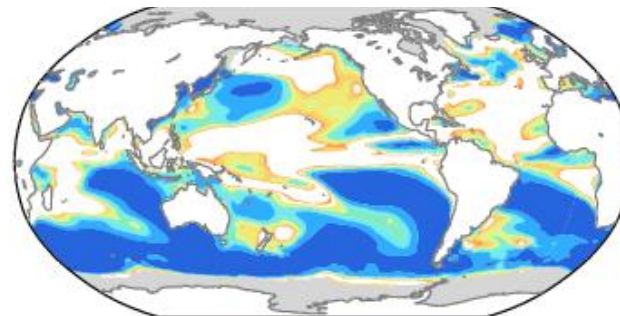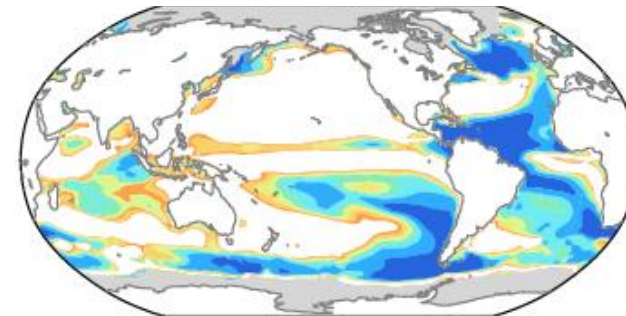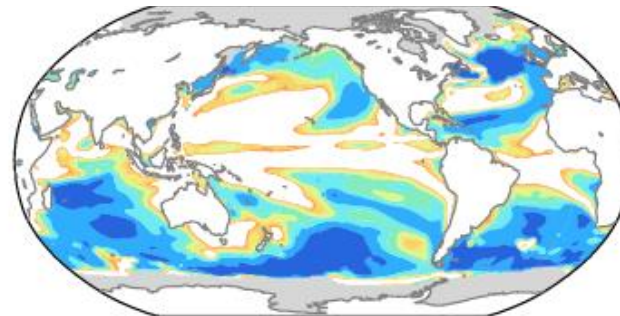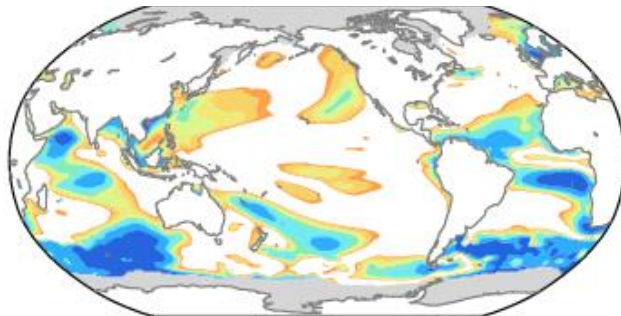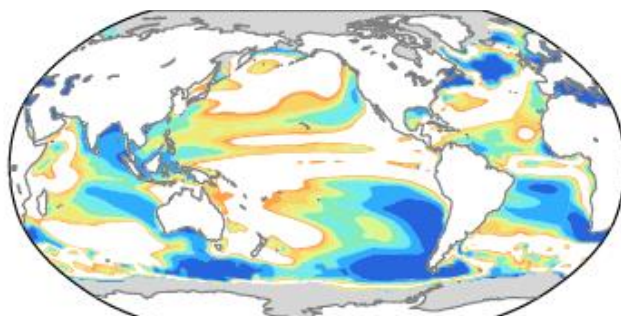
NH Air Temperature (°C)
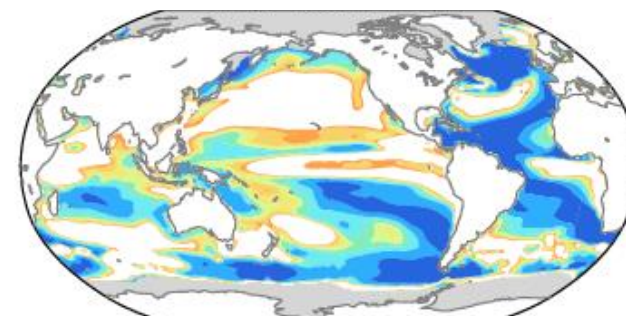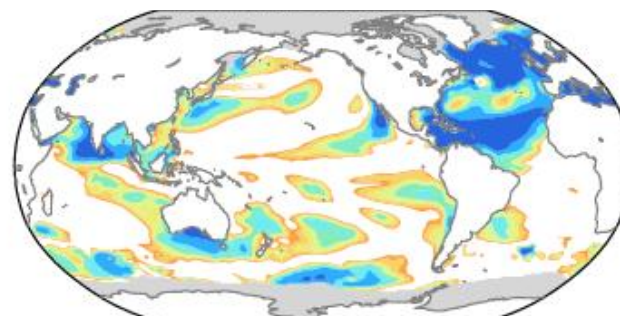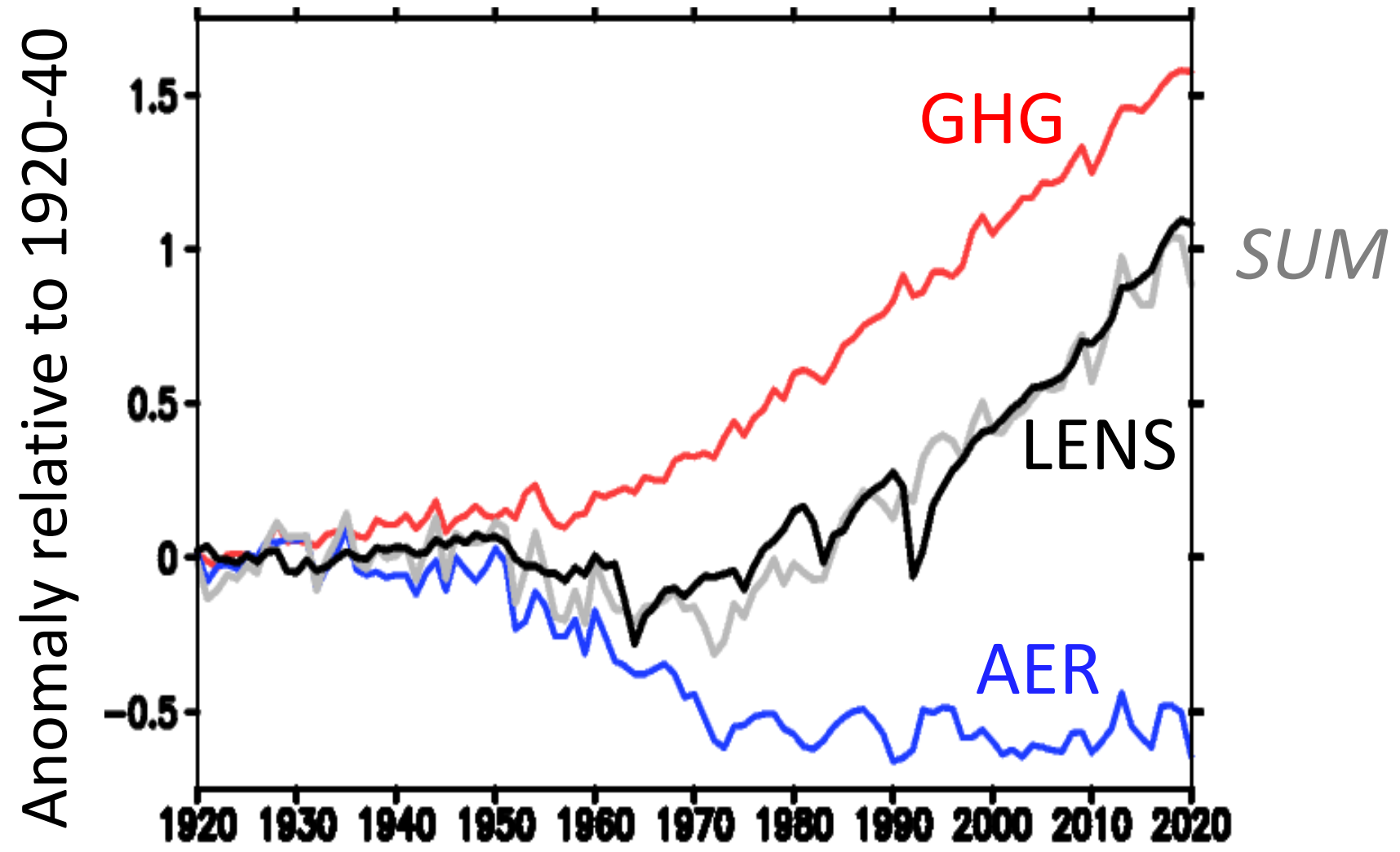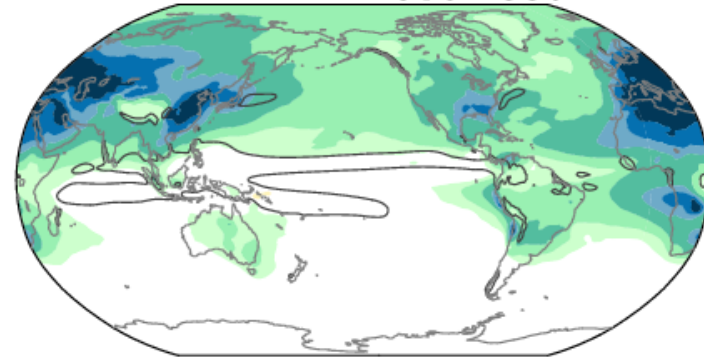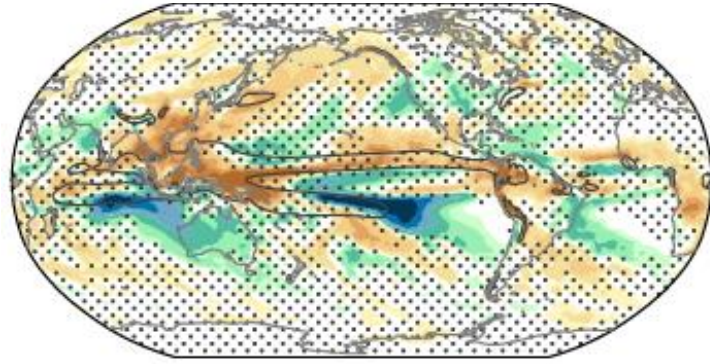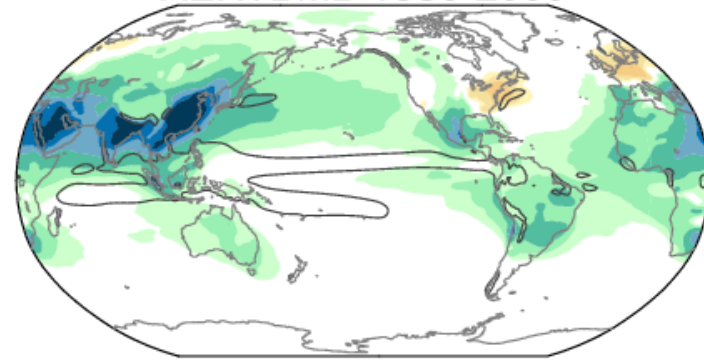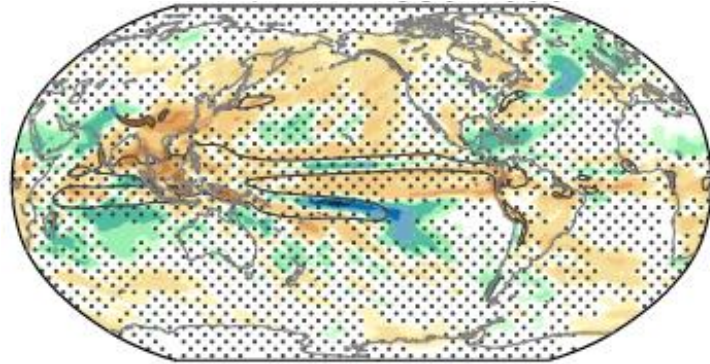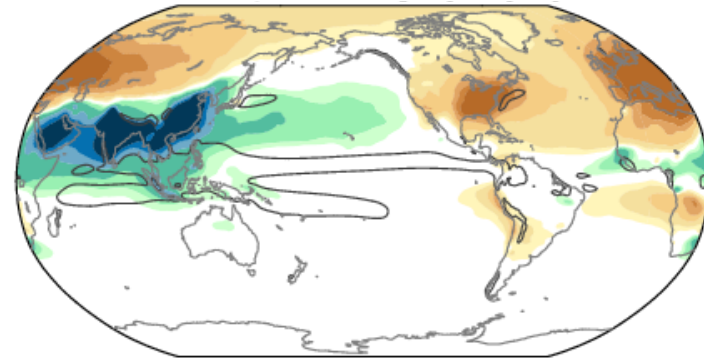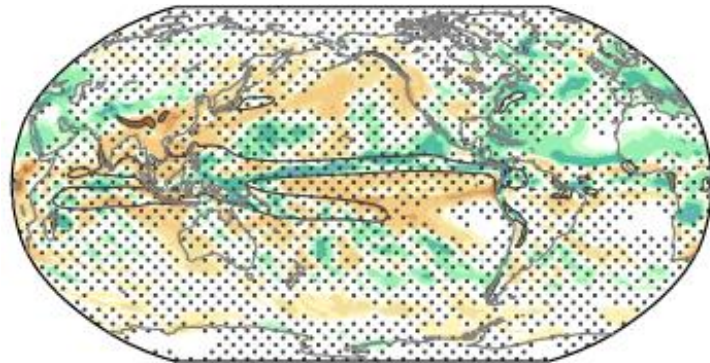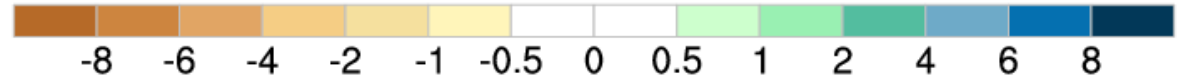
Evolving 50-year trends
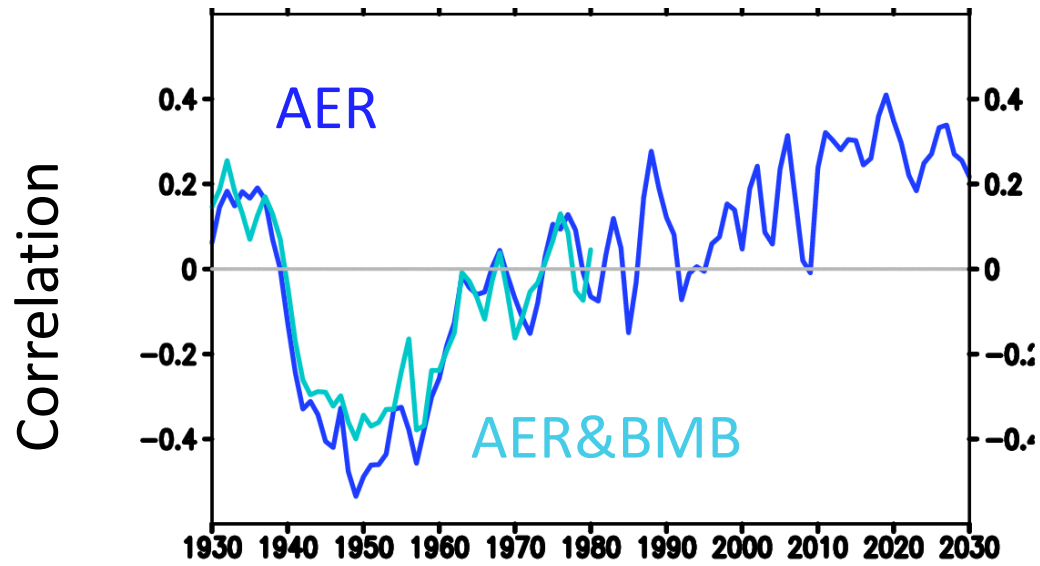
Precipitation   Sulfate Aerosol Burden

1930-1980

1950-2000
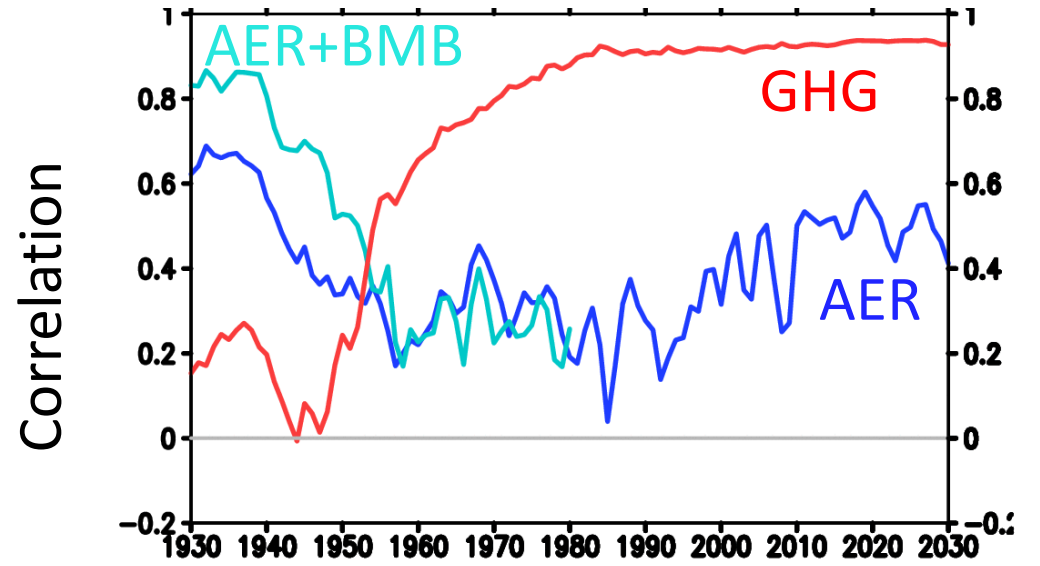
1970-2020

-8 -6 -4 -2 -1 -0.5 0 0.5 1 2 4 6 8

GHG *vs.*

LENS *vs.*