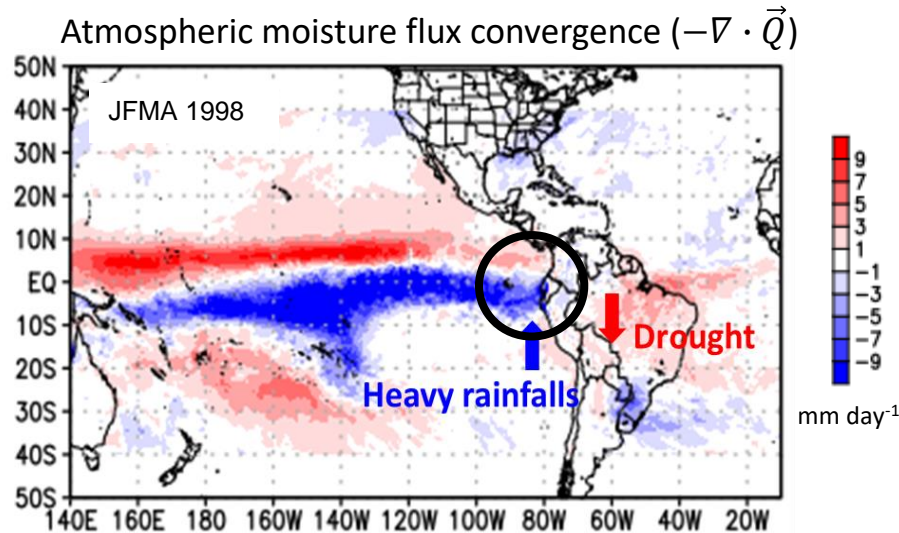


Extreme El Niño events and associated atmospheric moisture flux convergence patterns in observations and CMIP6 models

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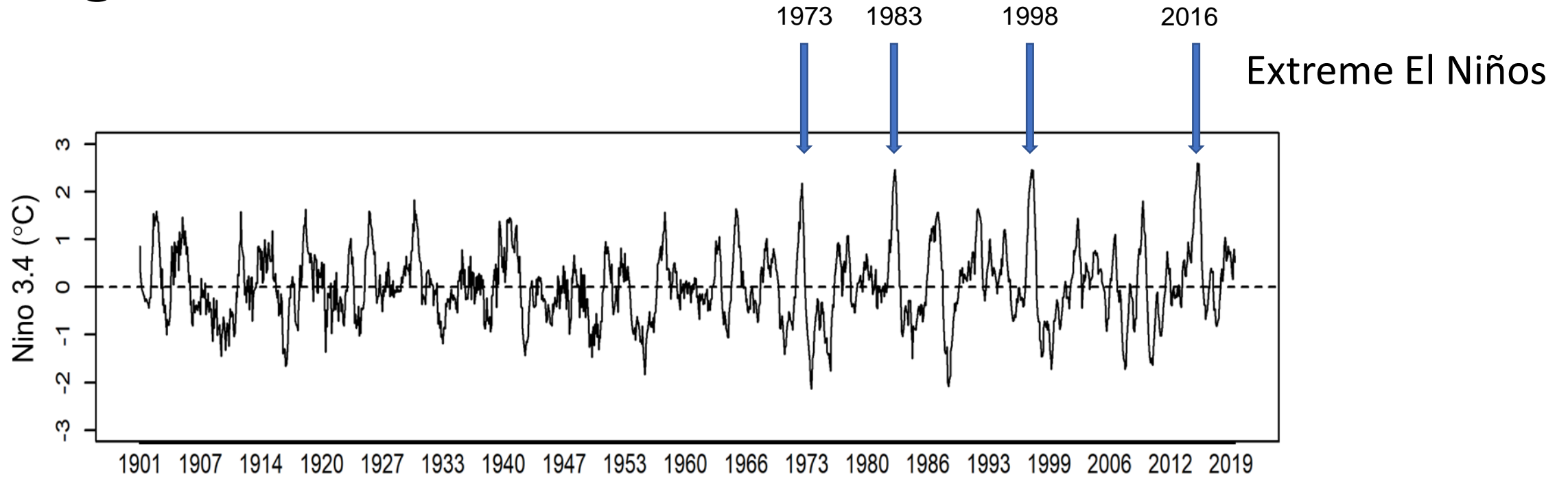
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Background



Source: <https://www.metoffice.gov.uk/hadobs/hadisst/data/download.html>

- Extreme El Niños have important socio economic impact in Peru and Ecuador tied to rainfall
- Assessing climate change impacts on these extreme El Niño is of paramount importance for informing adaptation. For this, we need GCMs that are able to simulate the dynamics of these events.

Research question and objectives

Research question

- Are Global Climate Models (GCMs) participating in CMIP6 able to reproduce the occurrence, evolution (seasonality) and dynamics of extreme El Niño episodes?

Objectives

- Examine occurrence and characteristics of extreme El Niños in observations
- Examine occurrence and characteristics of extreme El Niños in selected CMIP6 runs
- Identify models that perform satisfactorily with respect to extreme El Niños

Methods and data

We identify El Niño episodes and associated extremes using ...:

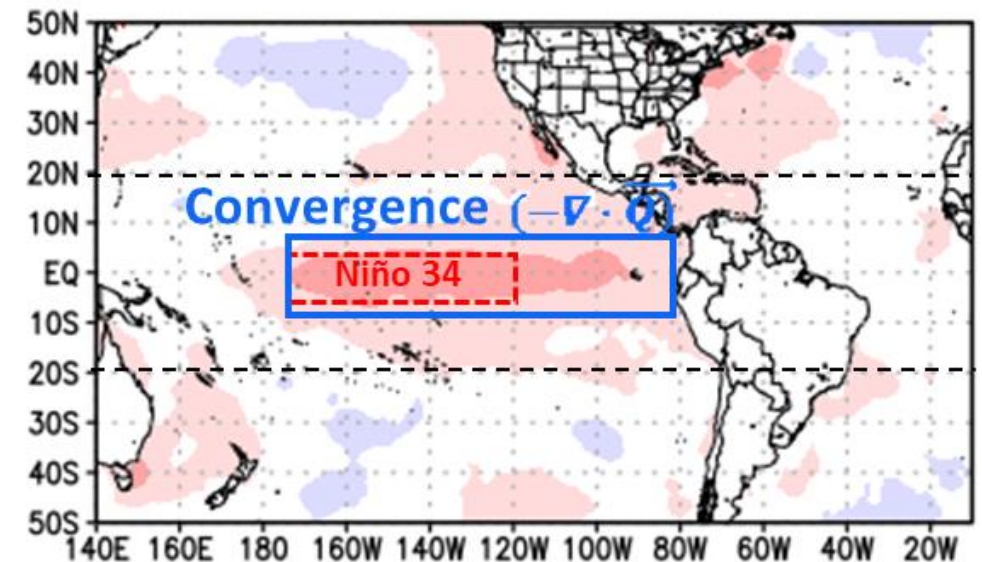
- ... the relative Niño 34 index (van Oldenborgh et al., 2021) , i.e.
SST anomaly in Niño 3.4 – SST anomaly in the band 20°N-20°S

We compute the atmospheric moisture flux convergence as follows:

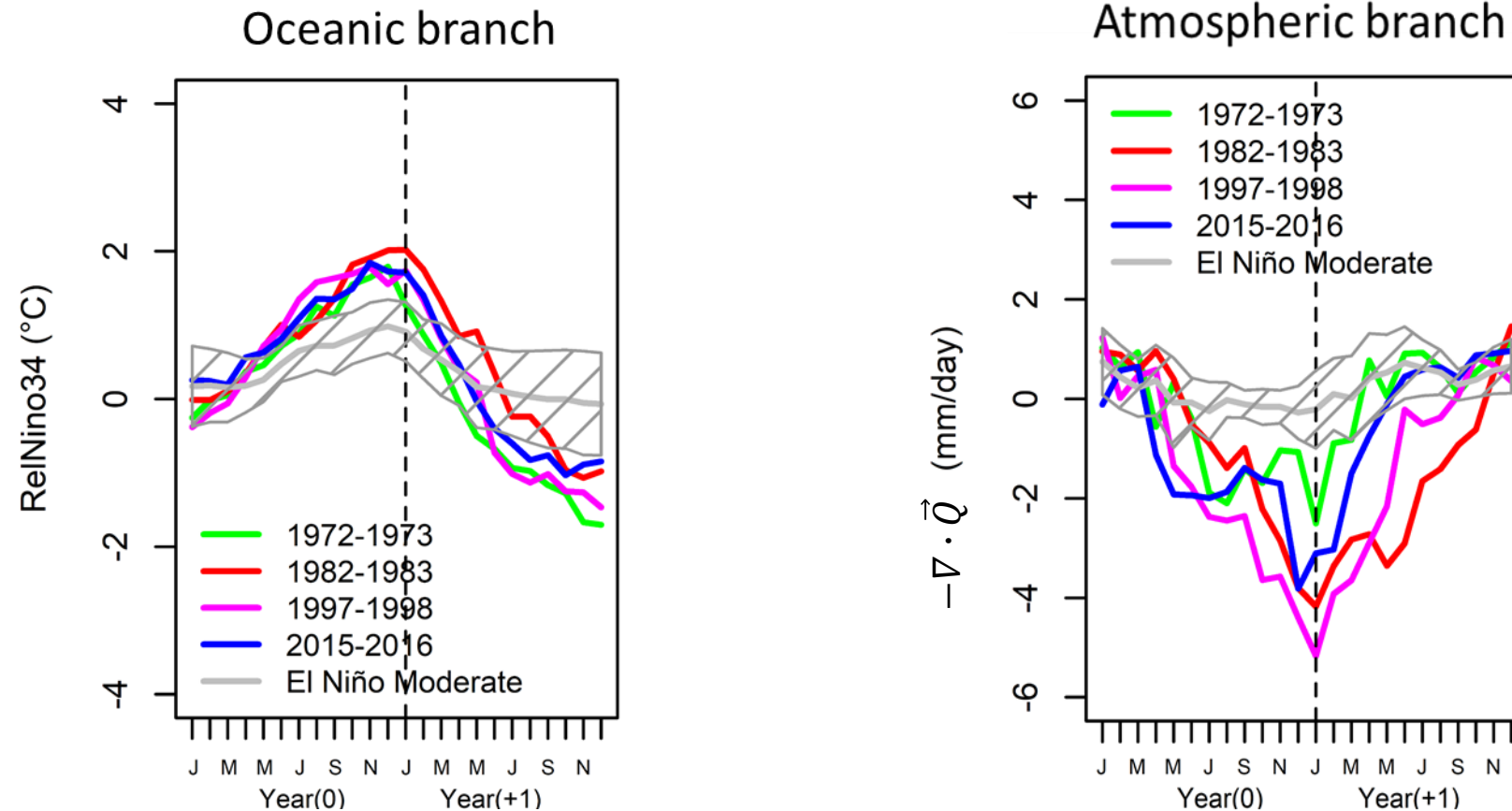
- $$-\nabla \cdot \vec{Q} = -\nabla \cdot \frac{1}{g} \int_{p_s}^{p_t} q \vec{v} dp$$

We use data from ...

- ... 13 GCMs from the CMIP6 repository
(Eyring et al., 2016) that provide access to all necessary fields



Characteristics of extreme El Niños: observations



→ Compared to moderate El Niños (grey), extreme episodes are characterized by a larger amplitude of the seasonal evolution of the SST anomaly and the atmospheric flux convergence, $-\nabla \cdot \vec{Q}$

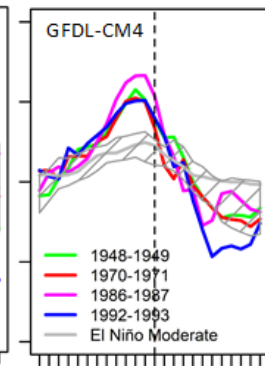
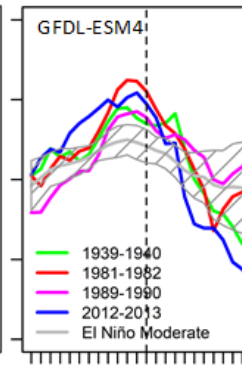
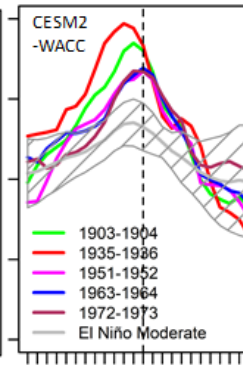
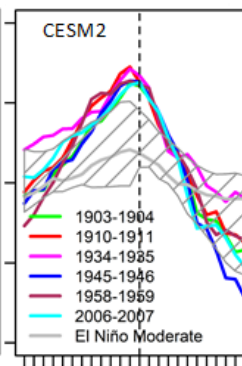
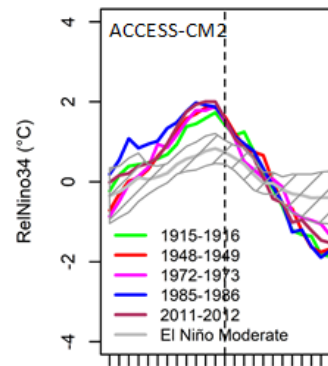
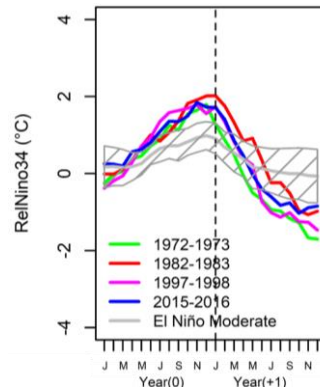
Extreme El Niños in CMIP6

- 5 out of 13 GCMs reproduce a realistic number of extreme El Niños (not shown)
- These 5 GCMs performs reasonably well with respect to the seasonal evolution of the SST anomaly in the Niño 3.4 area
- 3 do also realistically reproduce the seasonal evolution of $-\nabla \cdot \vec{Q}$

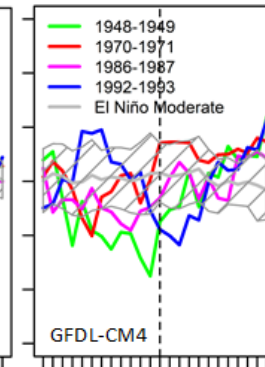
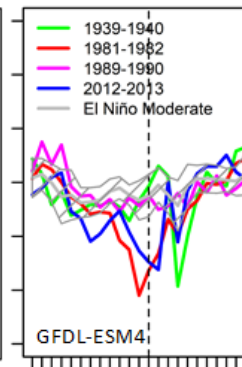
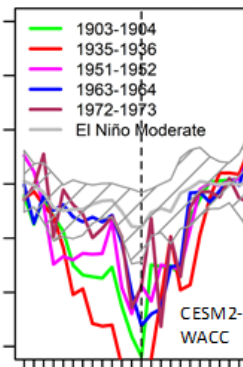
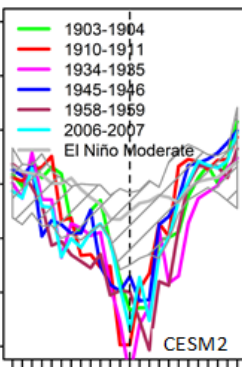
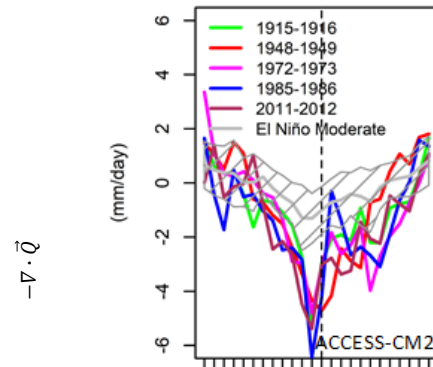
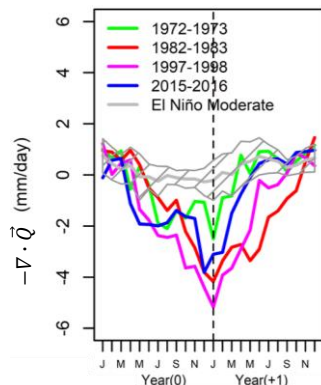
Observations

CMIP6 Models

Oceanic
branch

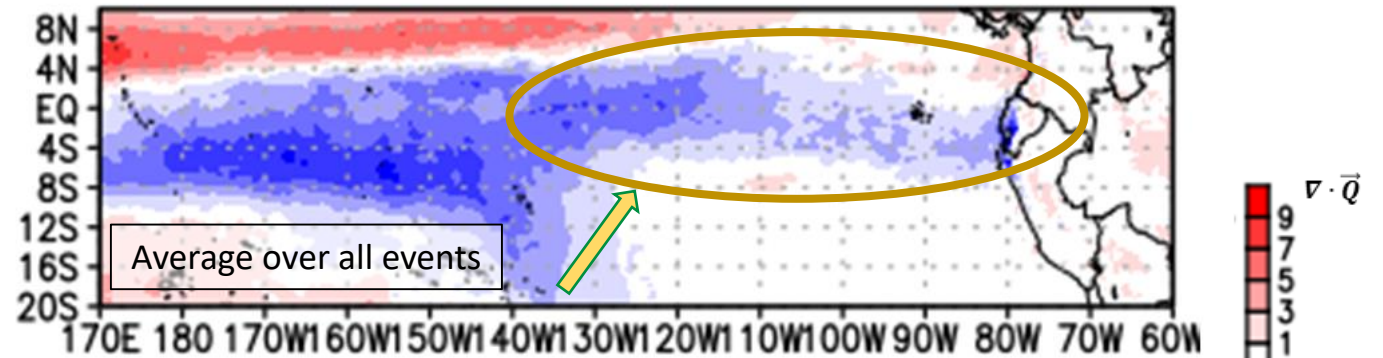


Atmospheric
branch

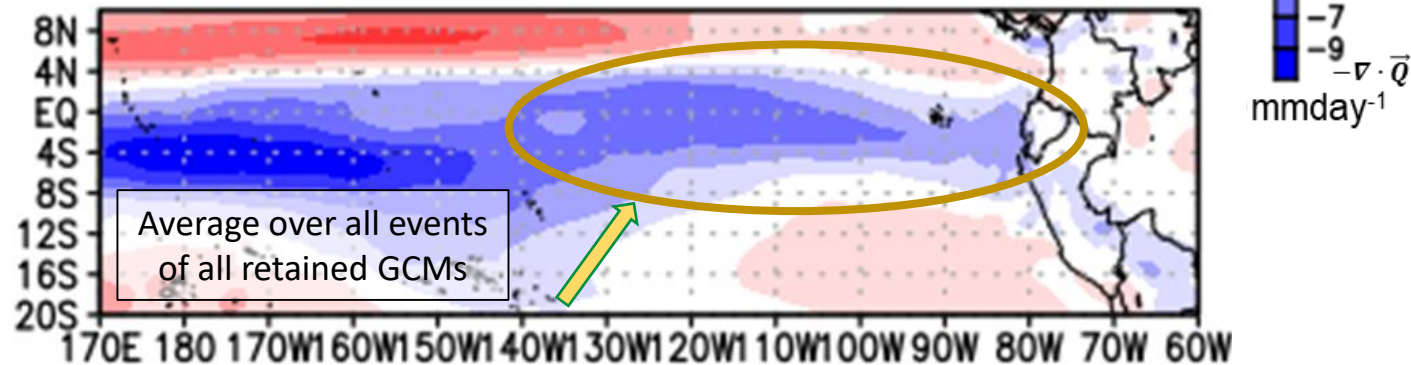


Spatial patterns of $-\nabla \cdot \vec{Q}$ during extreme El Niños

Observations



CMIP6
(ensemble mean
of 5 CGMs)



- The 5 retained GCMs reproduce well the average spatial patterns of $-\nabla \cdot \vec{Q}$ associated with extreme El Niños identified in the observations, in particular the branch of convergence (moisture excess) extending from 140°W to Ecuador / Northern Peru

Conclusions

- Occurrence and characteristics of extreme El Niños are captured by a few of the GCMs participating in CMIP6
- Overall, however, many aspects of ENSO dynamics that are relevant for extreme El Niños are still not adequately reproduced by GCMs
- Improving GCMs in this respect is particularly important for assessing the impacts of future climate change on extreme El Niños and in turn the implications of changes in the regime of these events for society

Thank you!

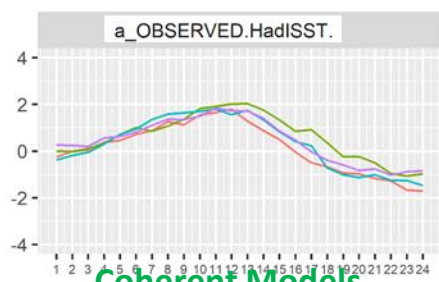
Gracias!

CMIP6 models

Model	Institution	Atmospheric grid spacing (lat x long)	Oceanic Horizontal Resolution (km)	Levels
ACCESS-CM2	CSIRO-ARCCSS, Australia	1.25° x 1.875°	100	19
CESM2	NCAR, USA	0.94° x 1.25°	100	19
CESM2-WACC	NCAR, USA	0.94°x1.25°	100	19
GFDL-ESM4	GFDL, USA	1° x1.25°	50	19
GFDL-CM4	GFDL, USA	1° x1.25°	25	19
ACCESS-ESM1-5	CSIRO, Australia	1.25° x 1.875°	100	19
HadGEM3-GC31-MM	MOHC, Hadley Centre, UK	0.55°x 0.83°	25	19
HadGEM3-GC31-LL	MOHC NERC, Hadley Centre, UK	1.25° x 1.875°	100	19
MIROC6	CCSR, Japan	1.4°x1.4°	100	19
MIROC-ES2L	MIROC, Japan	1.4°x1.4°	100	19
MPI-ESM1-2-HR	MPI, Germany	0.9375° x 0.9375°	50	19
MRI-ESM2-0	MRI, Japan	1.125° x 1.125°	100 x 50	19
UKESM1-0-LL	MOHC NERC NIMS-KMA NIWA	1.25° x 1.875°	100	19

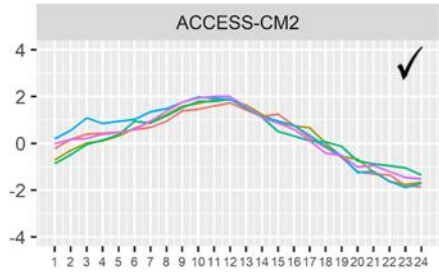
Available convergence data

Extreme El Nino cycle



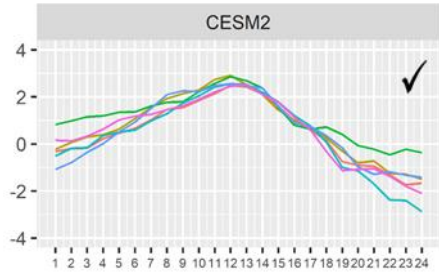
Extreme_Event

- 1972-1973
- 1982-1983
- 1997-1998
- 2015-2016



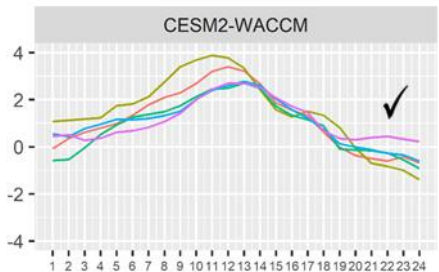
Extreme_Event

- 1915-1916
- 1948-1949
- 1972-1973
- 1985-1986
- 2011-2012



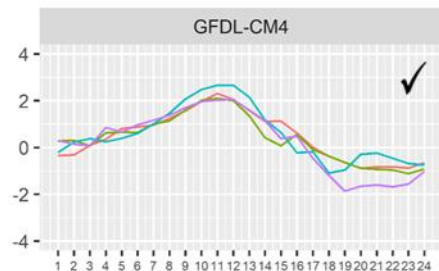
Extreme_Event

- 1903-1904
- 1910-1911
- 1934-1935
- 1945-1946
- 1958-1959
- 2006-2007



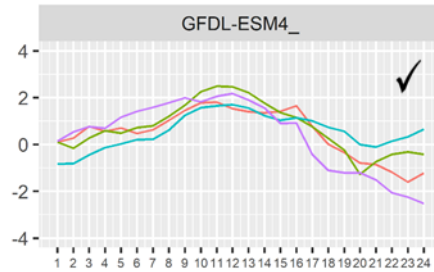
Extreme_Event

- 1903-1904
- 1935-1936
- 1951-1952
- 1963-1964
- 1972-1973



Extreme_Event

- 1948-1949
- 1970-1971
- 1986-1987
- 1992-1993

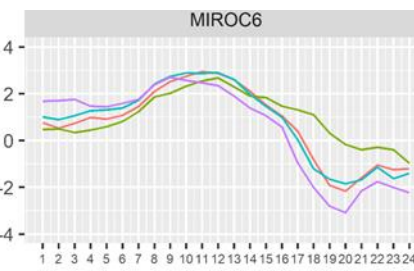
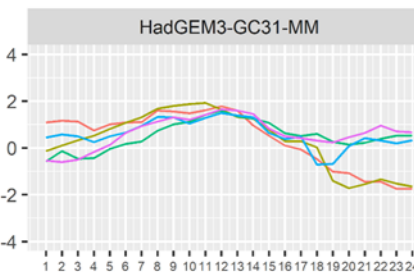
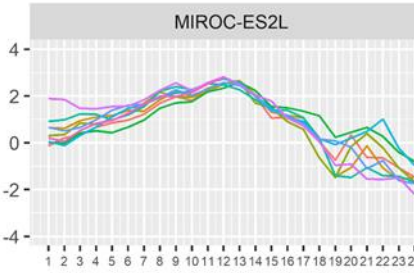
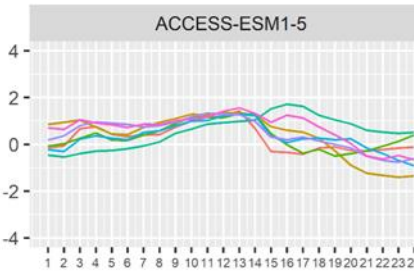


Extreme_Event

- 1939-1940
- 1981-1982
- 1989-1990
- 2012-2013

Extreme_Event

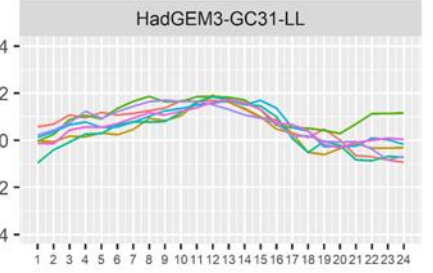
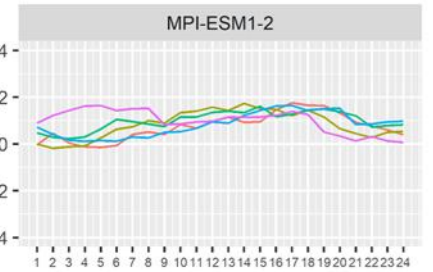
Incongruent Models



Bad Models

Extreme_Event

- 1923-1924
- 1962-1963
- 1968-1969
- 1972-1973
- 1983-1984
- 1995-1996
- 2001-2002
- 1901-1902
- 1911-1912
- 1944-1945
- 1969-1970
- 1985-1986
- 1990-1991
- 1996-1997
- 2004-2005



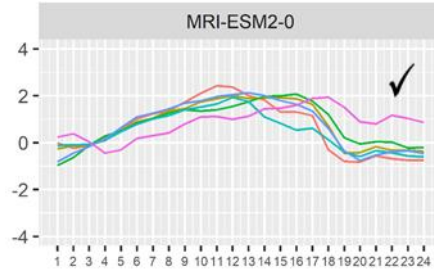
Extreme_Event

- 1917-1918
- 1924-1925
- 1936-1937
- 1986-1987
- 2011-2012

Extreme_Event

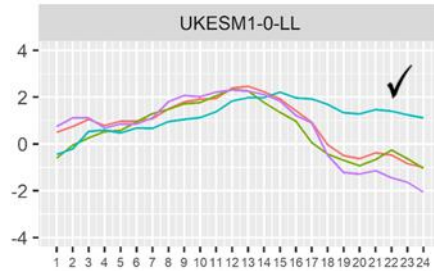
- 1962-1963
- 1967-1968
- 2008-2009
- 2013-2014

It could be Models



Extreme_Event

- 1922-1923
- 1935-1936
- 1954-1955
- 1970-1971
- 2000-2001
- 2004-2005



Extreme_Event

- 1929-1930
- 1935-1936
- 1953-1954
- 1965-1966