Experimentation on extended-range prediction and multi-year variability at ECMWF

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Outline

- **SEAS5** : the new seasonal forecast system of ECMWF (operational in autumn 2017)

- **METIS**: a COLA-ECMWF collaborative project on high-resolution seasonal and sub-seasonal predictions supported by NCAR Accelerated Scientific Discovery programme

- **PRIMAVERA**: a H2020 project on simulation of climate variability with high-resolution coupled models

SEAS5

- A new high-resolution seasonal system, SEAS5, will be introduced later this year (expected October)
- Re-forecasts have just started

	System 4	SEAS 5
IFS Cycle	36r4	43r1
Atm. resolution (grid spacing)	TL255 (80 km)	Tco319 (35 km)
Atmosphere levels	L91	L91
Ocean hor. resolution	ORCA1 (1°)	ORCA025 (0.25°)
Ocean levels	L42	L75
Sea-ice	Prescribed (last 5 years)	LIM2 model
Re-forecast years	1981-2010 (30y)	1981-2016 (36y)
Re-forecast ensemble size	15	25

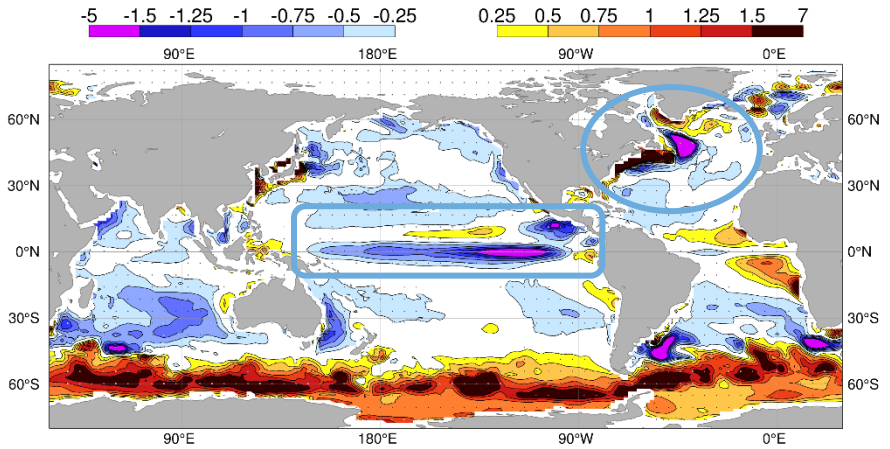
Global SST biases improve, especially in the ENSO regions

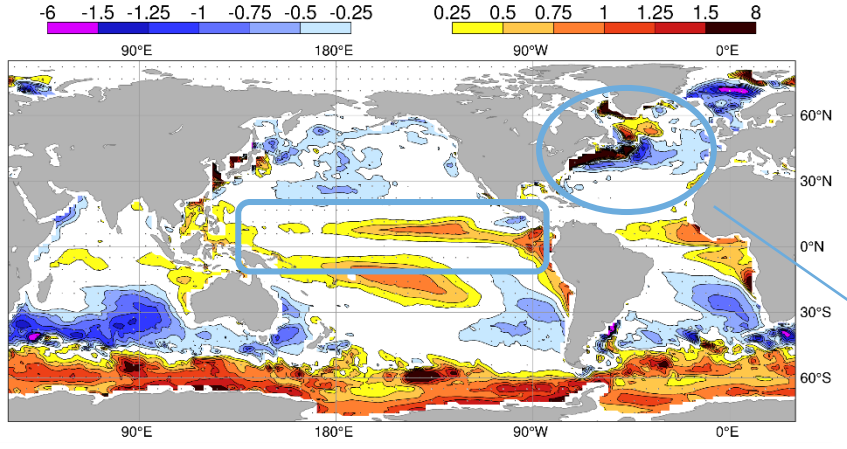
SEAS4 - ERAI

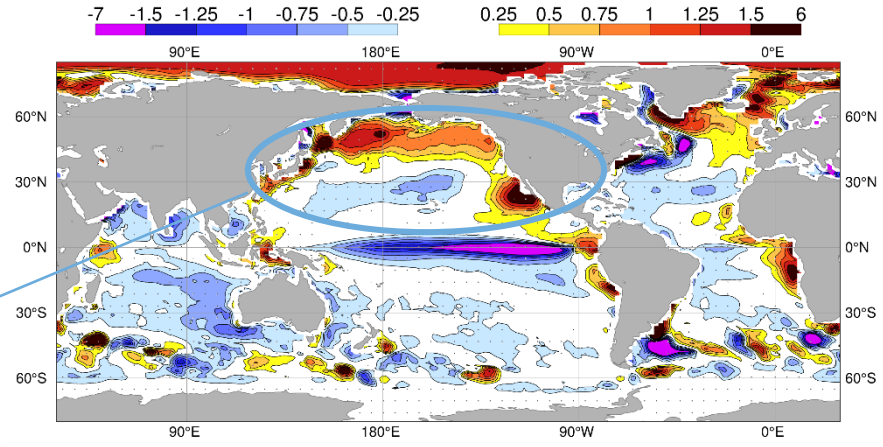
SEAS5 - ERAI

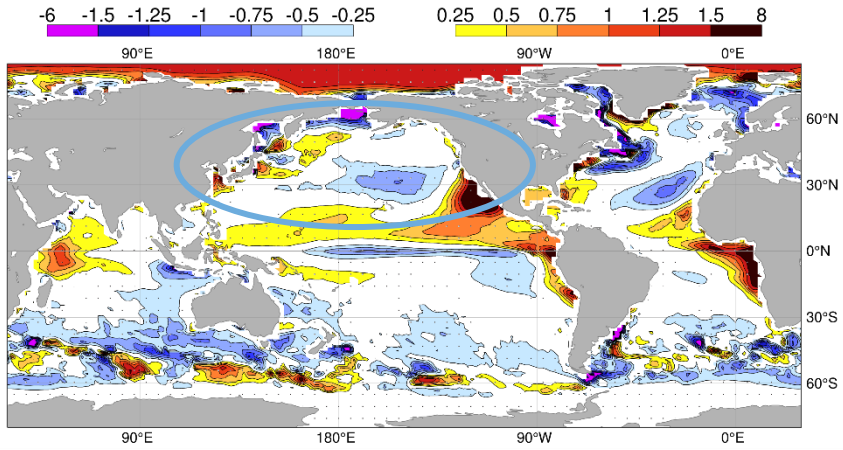
DJF

JJA





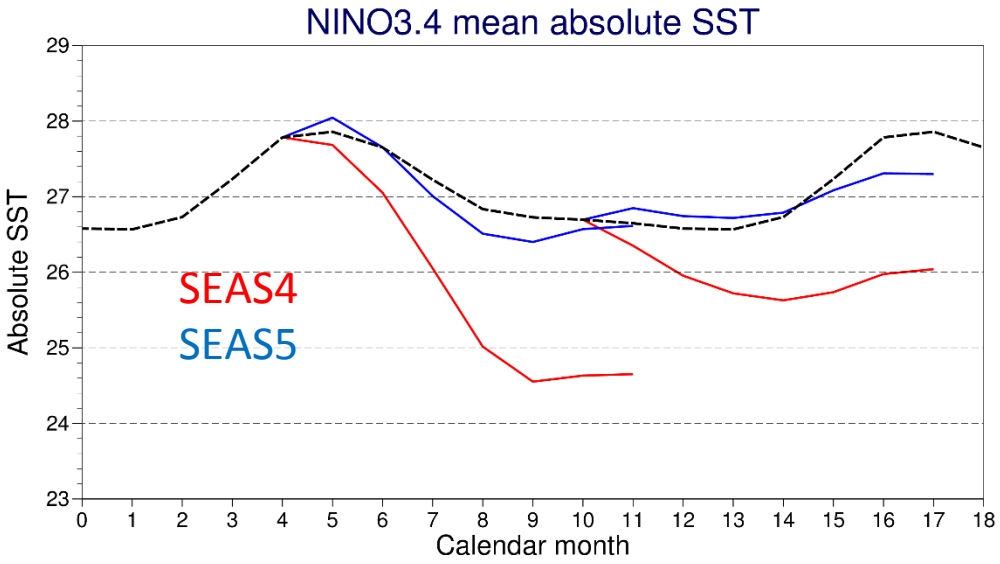


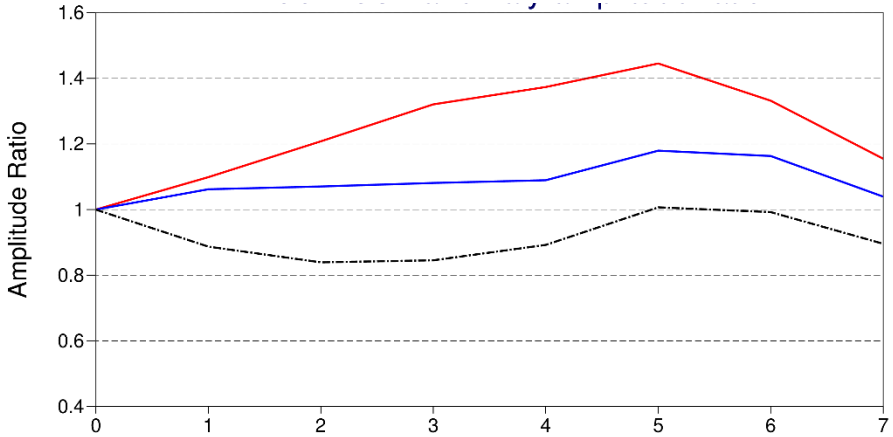


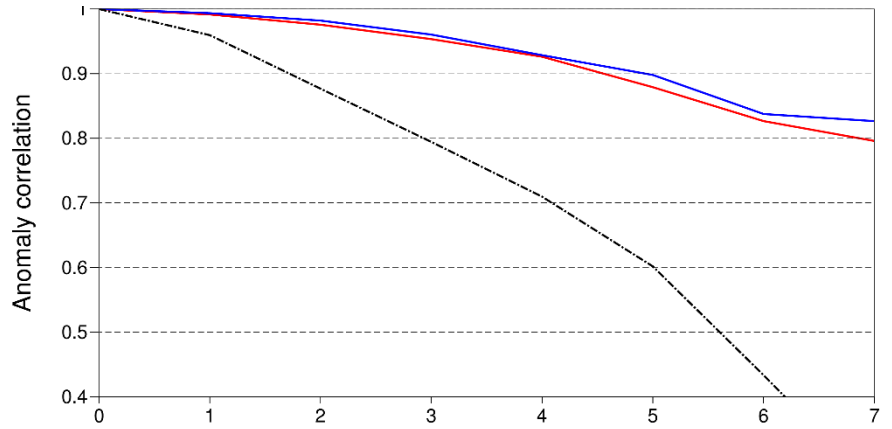
Ocea
horizo
resolut

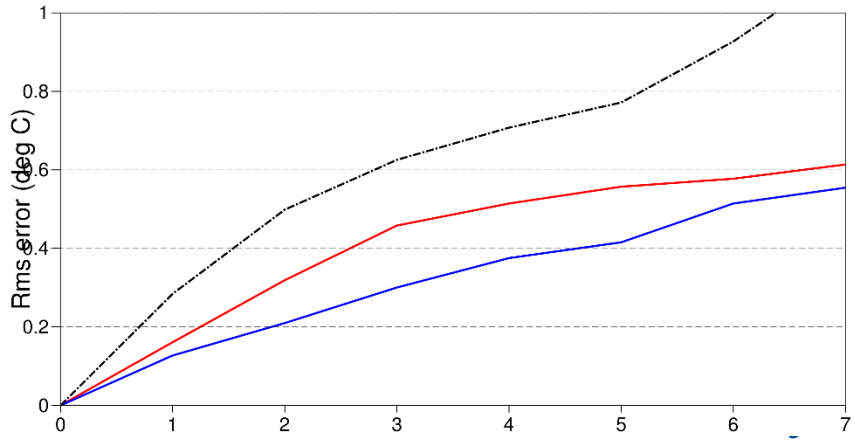
Ocean vertical mixing

ENSO scores







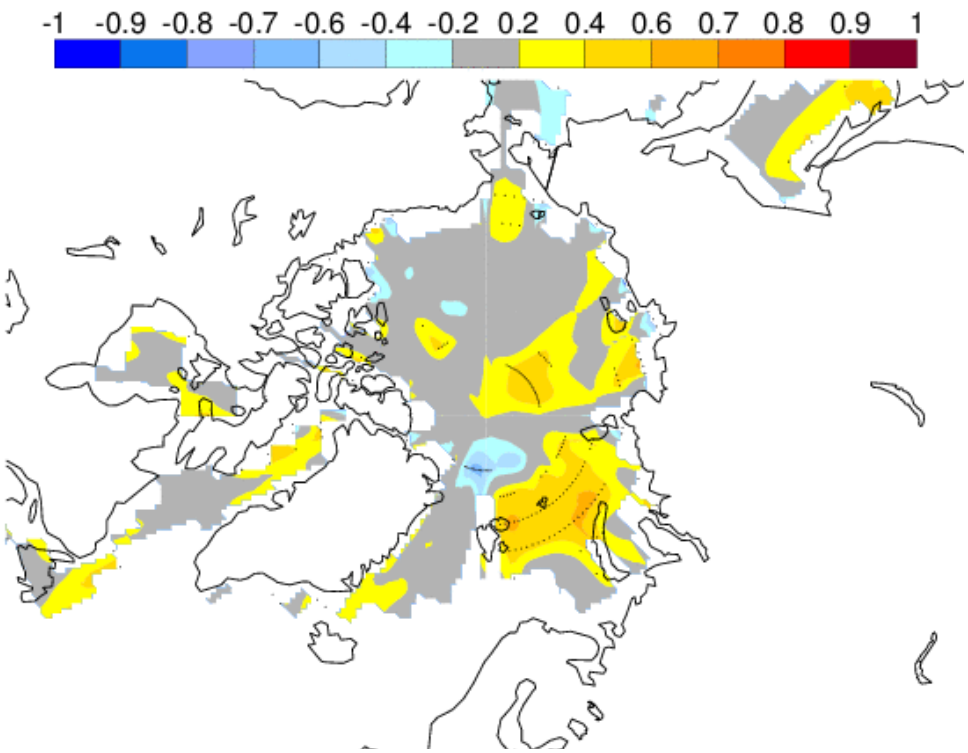


ENSO SST drift improves significantly. SEAS5 also shows an improvement in ENSO variance, a small increase in ENSO correlation score, and a decrease in RMS error (after bias correction).

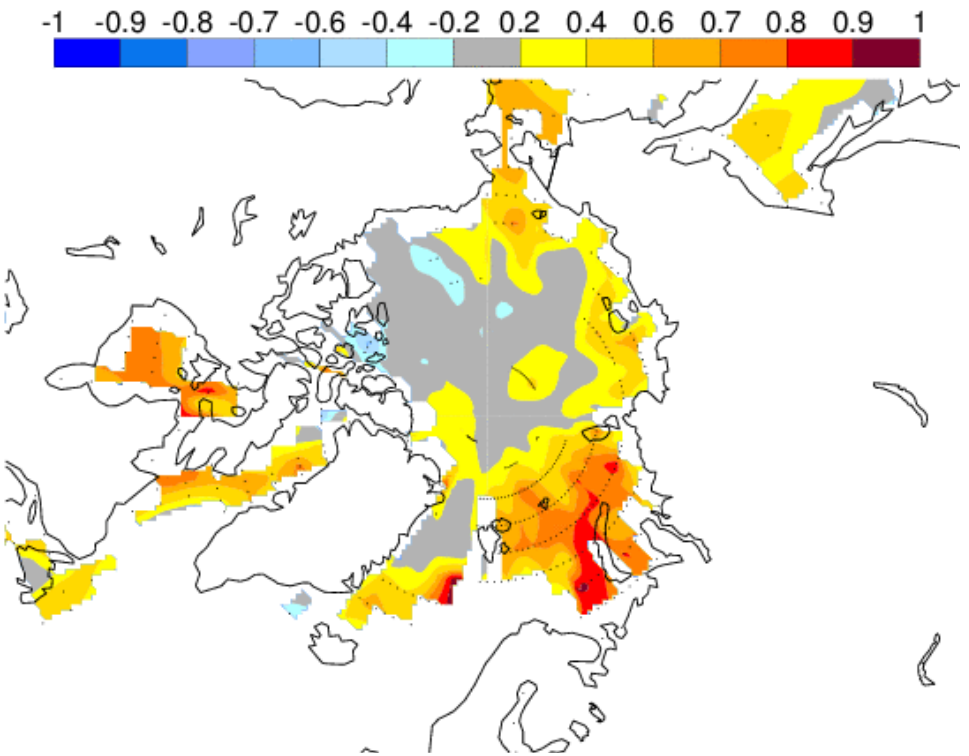
ECMWF

Sea ice cover - DJF anomaly correlations

SEAS4



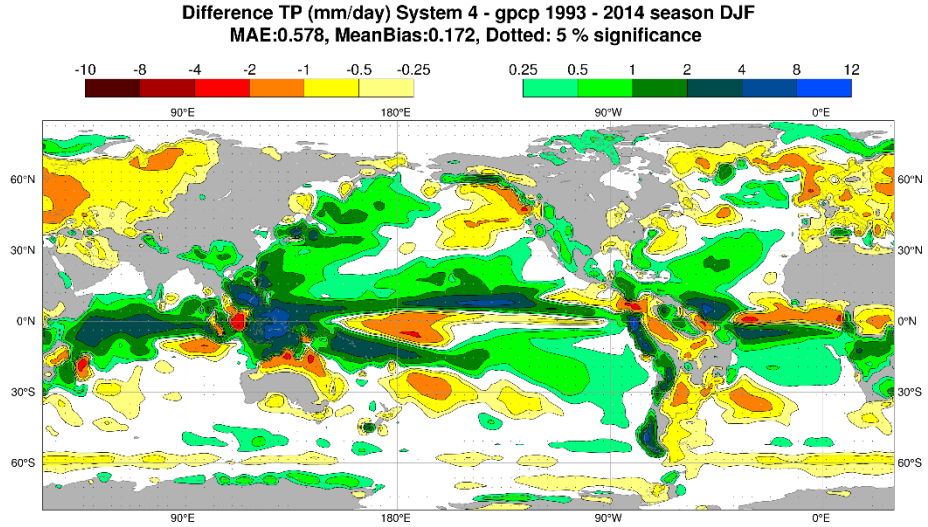
SEAS5

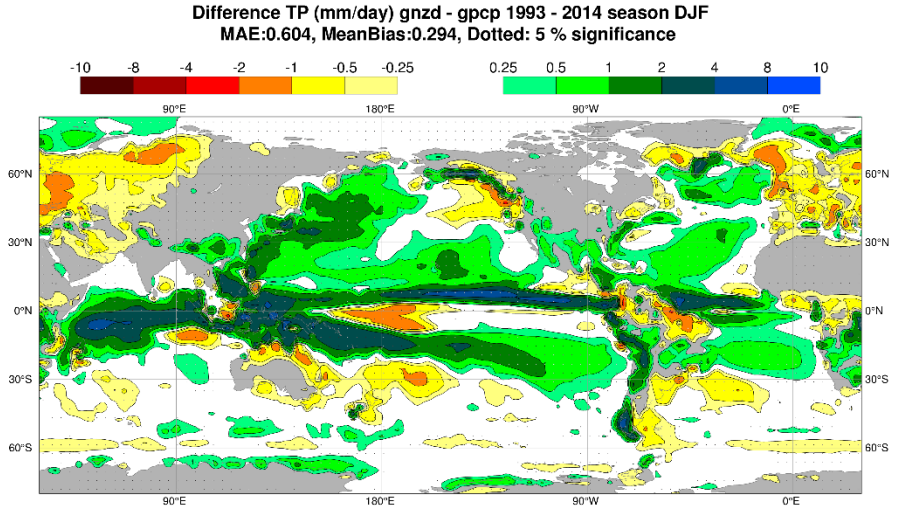


Sea ice cover predictions improve when we include the interactive sea ice model LIM2

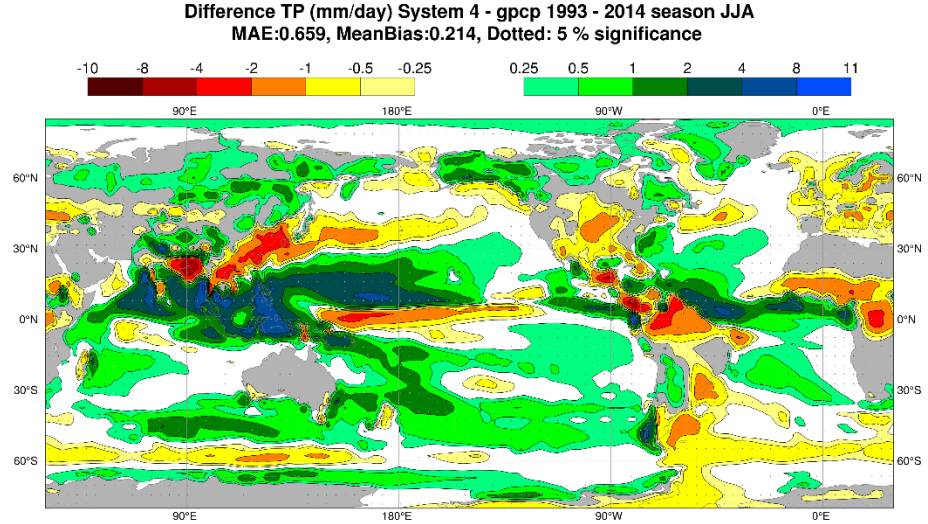
Precipitation biases

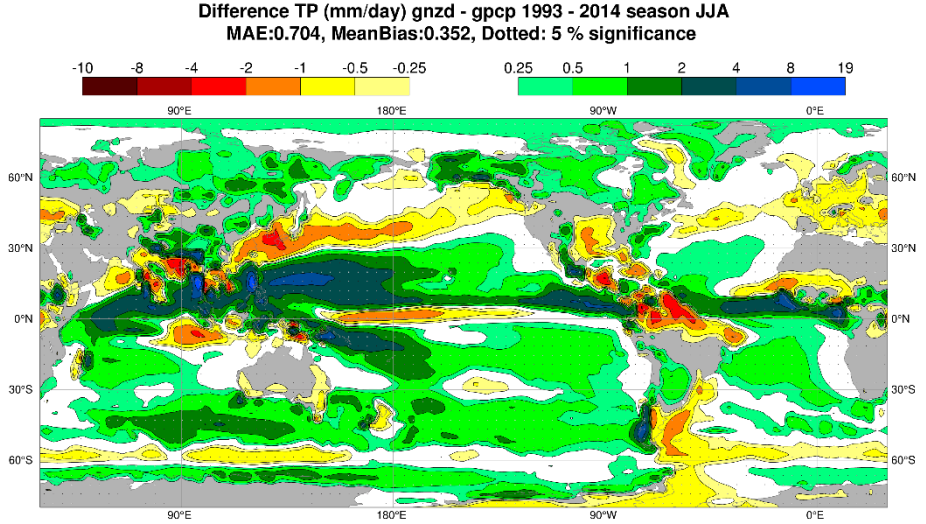
DJF





JJA



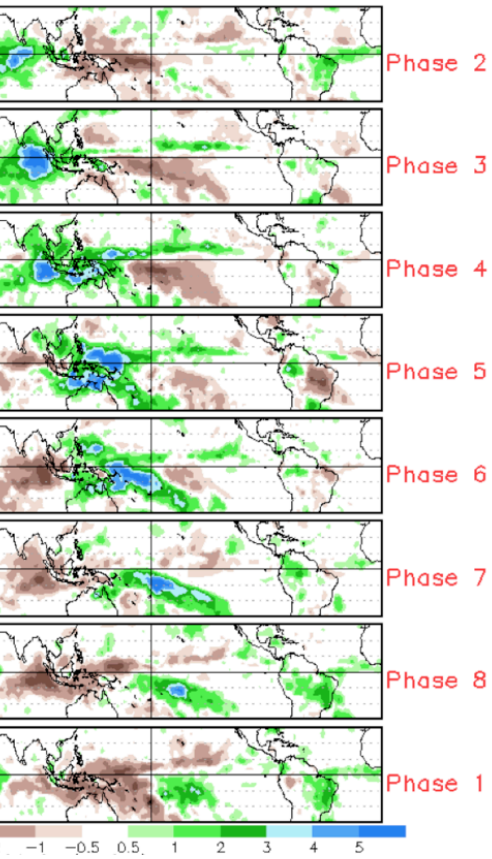


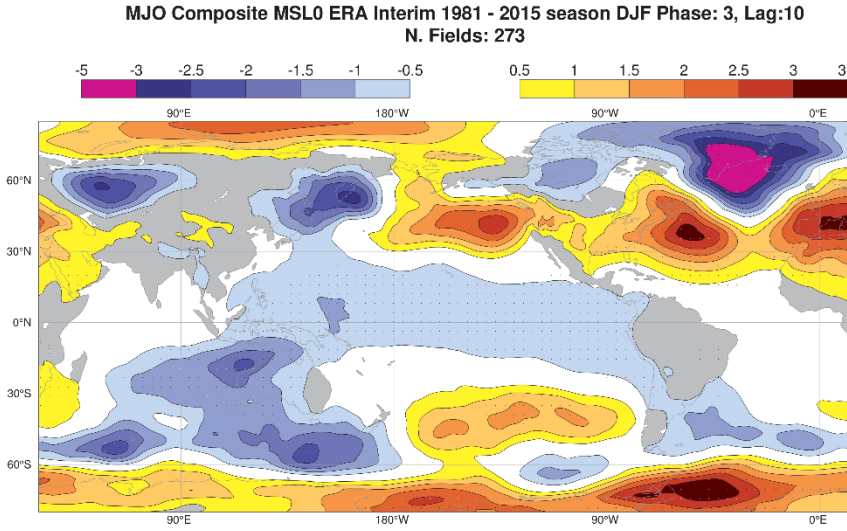
SEAS4 **SEAS5**

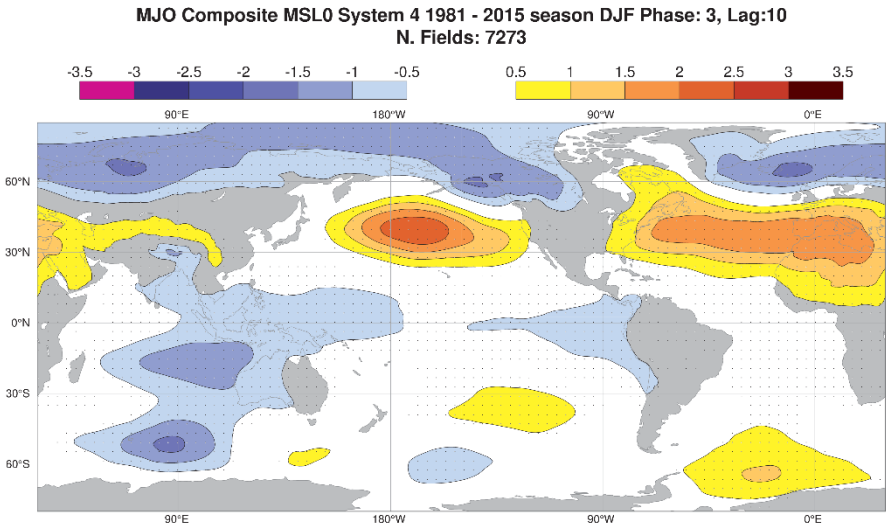
ECMWF

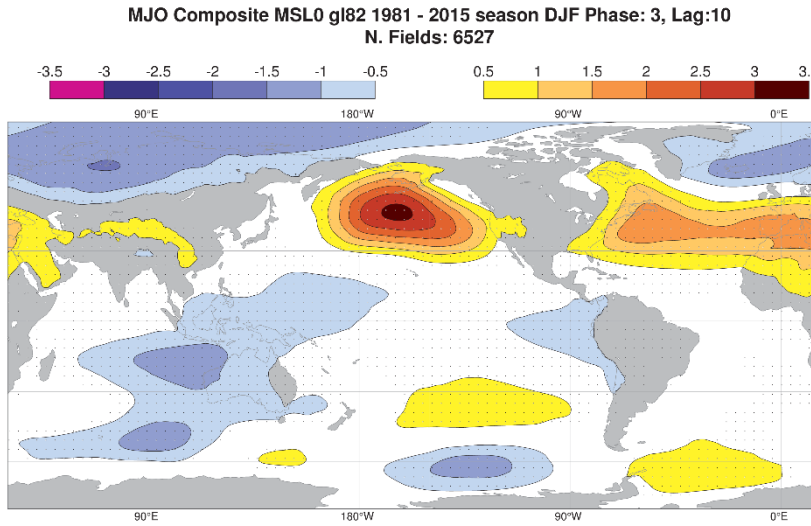
MJO teleconnections

Z 500 composite anomaly, 10d after Phase 3





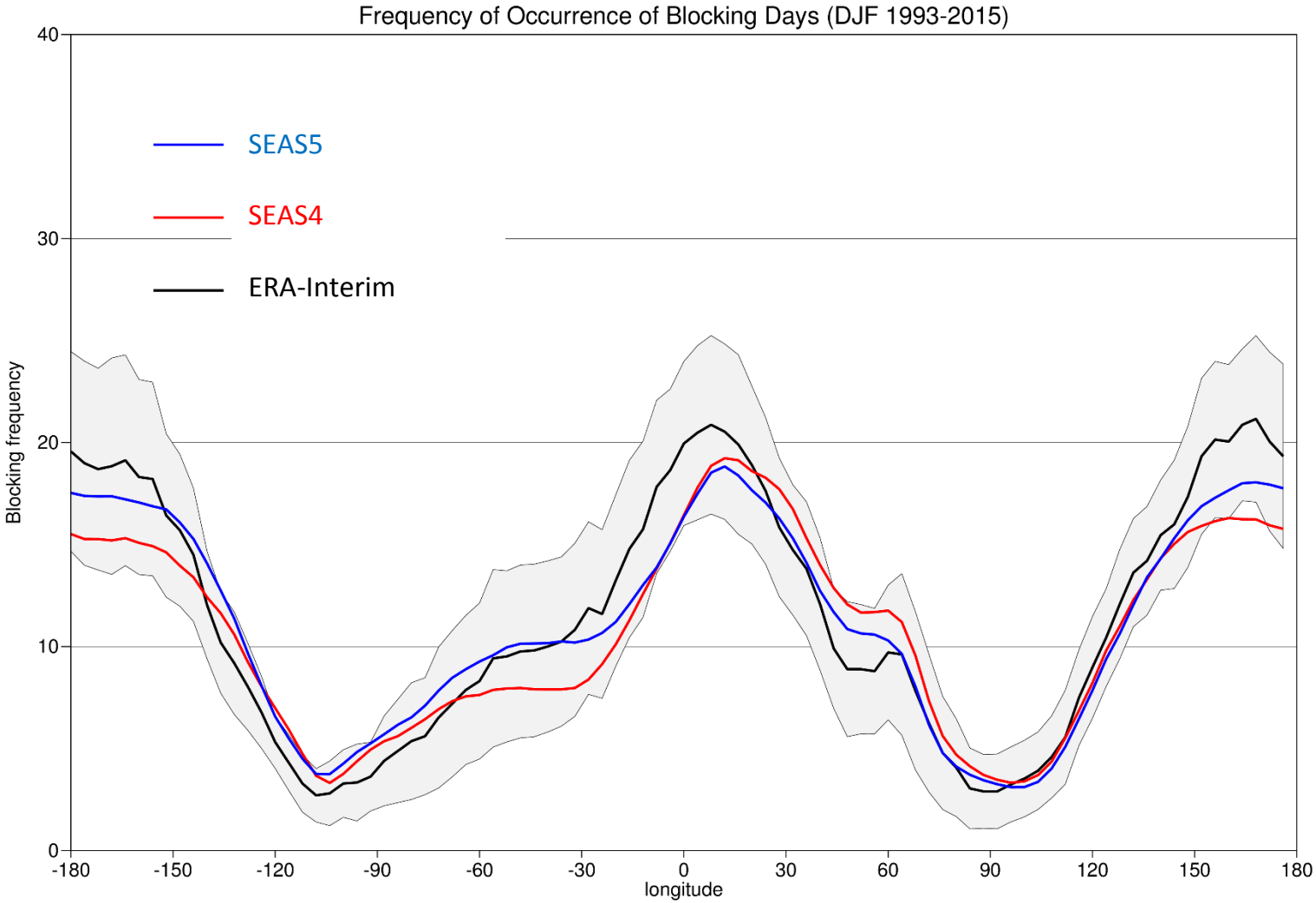




SEAS4 **SEAS5**

ECMWF

Blocking frequency



Blocking improves in the NW Atlantic and the Pacific.

METIS: a COLA-ECMWF collaborative project on
sub-seasonal & seasonal fc. funded by the 2016 NCAR ASD call
and running on the NCAR Cheyenne HPC.

COLA : Ben Cash, Jim Kinter
ECMWF: R. Buizza, D. Decremer, F. Molteni, S. Saarinen
(with support from the Coupled Processes team)

METIS experiment plan

Table 1: Core Hours

esolution	Years Spanned 1986-2015	Cases Per Year	Ens Size	Case Length (months)	Total Years	Core Hours Per Year	Total Core Hours (million)
L1: ₀199L91-N1.0	30	2 May Nov	25	6	750	4150	3.11
L2: ₀199L91-N1.0	30	6 Jun Jul Aug Dec Jan Feb	15	2	450	4150	1.87
M1: ₀639L91-N0.25	30	2 May Nov	25	6	750	25,000	18.75
M2: ₀639L91-N0.25	30	6 Jun Jul Aug Dec Jan Feb	15	2	450	25,000	11.25
H1: ₀1279L91-N0.25	30	2 May Nov	15	2	150	165,000	24.75
otal Core Hours							59.75

PRIMAVERA: a European Union Horizon-2020 project (www.primavera-h2020.eu)

Main goal: To develop a new generation of advanced and well-evaluated high-resolution global climate models, capable of simulating and predicting regional climate with unprecedented fidelity

Motivation for ECMWF: to explore the climatological attractor of the ECMWF Earth System model (mean state and variability) in a state of near-equilibrium (as opposed to the transient, drifting state experienced during sub-seasonal and seasonal forecasts)

ECMWF contribution based on multi-decadal historical runs (as in CMIP6 HighResMIP) with:

- **IFS Tco199 L91 + NEMO 1.0° Z75 + LIM-2**
- **IFS Tco399 L91 + NEMO 0.25° Z75 + LIM-2**

WP2: Provide a systematic assessment of the benefits of simultaneously increased atmospheric and oceanic resolutions and increased atmospheric resolution only in global coupled climate models for processes affecting European climate and its variability

WP3: Quantify the need for improved representation or levels of complexity of a range of physical processes within the atmosphere, ocean, land and *sea ice* in a high resolution environment

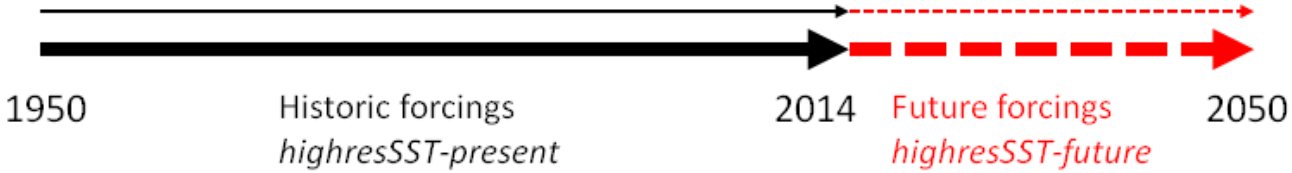
WP4: Develop the next generation of coupled models by testing different approaches to the representation of sub-gridscale processes and exploring the benefits of explicit representation at very high resolution

WP5: Improve understanding of the key oceanic physical and dynamical drivers and mechanisms leading to decadal variability of European climate, and assess the influences of regional climate phenomena such as the summer Arctic sea ice decline and Siberian snow cover reduction.

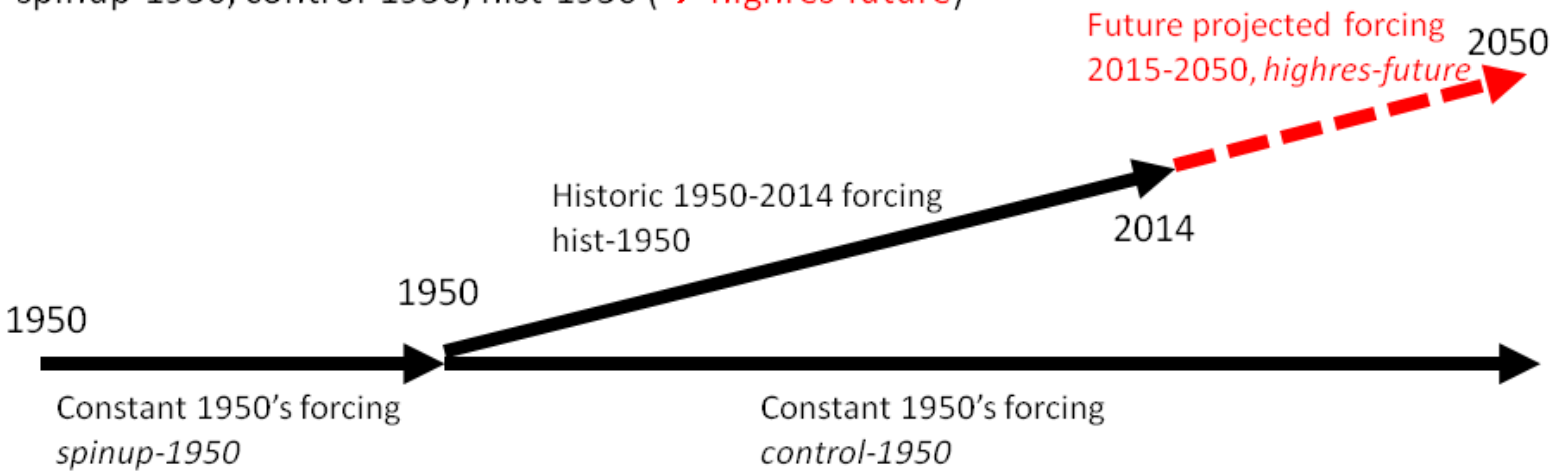
ECMWF

Stream-1 integrations:

Atmosphere-land-only, 1950-2014 (→ 2050)
Forced by observed SST and sea-ice and historic forcings (→ projected)
highresSST-present (→ highresSST-future)



Coupled climate, 1950-2014 (→ 2050)
Forced by constant 1950 and historic forcings (→ projected)
Initial coupled spin-up period ~ 30-50 years from 1950 EN4 ocean climatology
spinup-1950, control-1950, hist-1950 (→ highres-future)



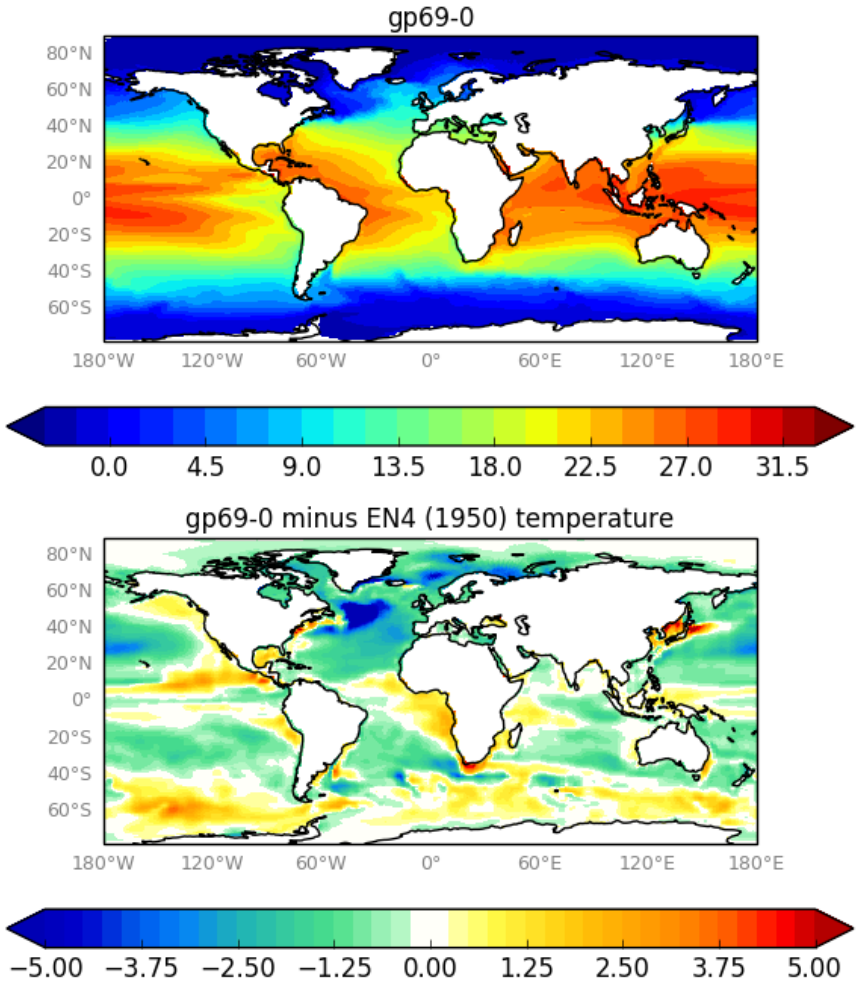
Runs completed:

Lres AMIP Tco199 (5 members)
Hres AMIP Tco399 (3 members

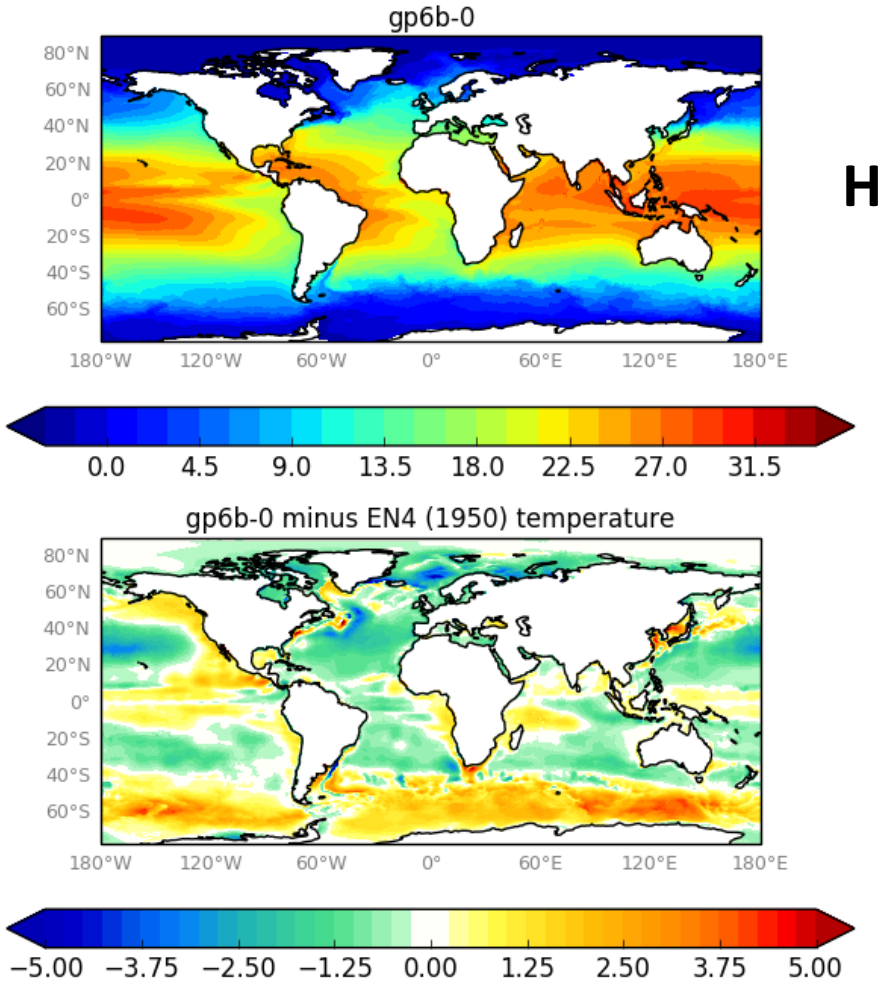
Coupled spin-up (csp):
Lres Tco199 – Nemo 1°
Hres Tco399 – Nemo 0.25°

SST climatology and bias in coupled spin-up runs

Lres

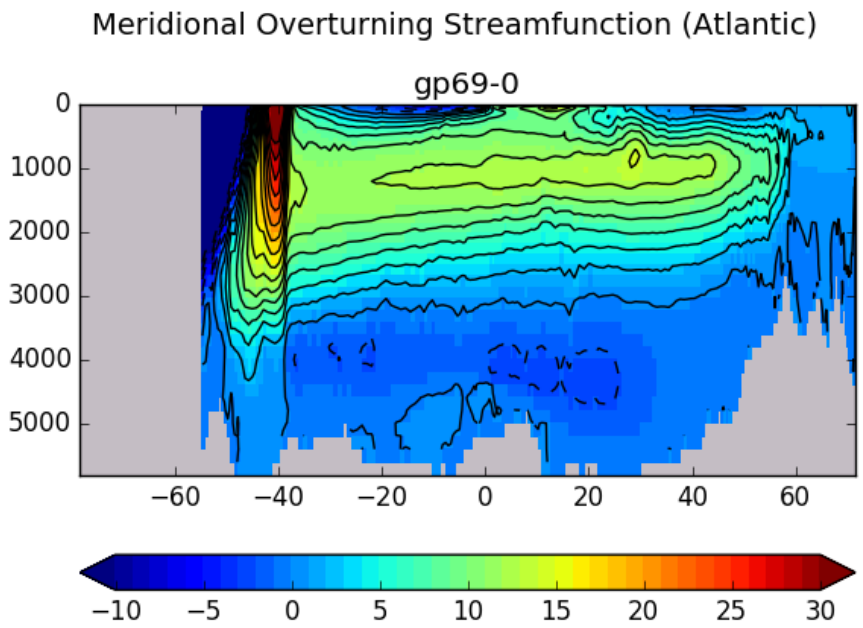


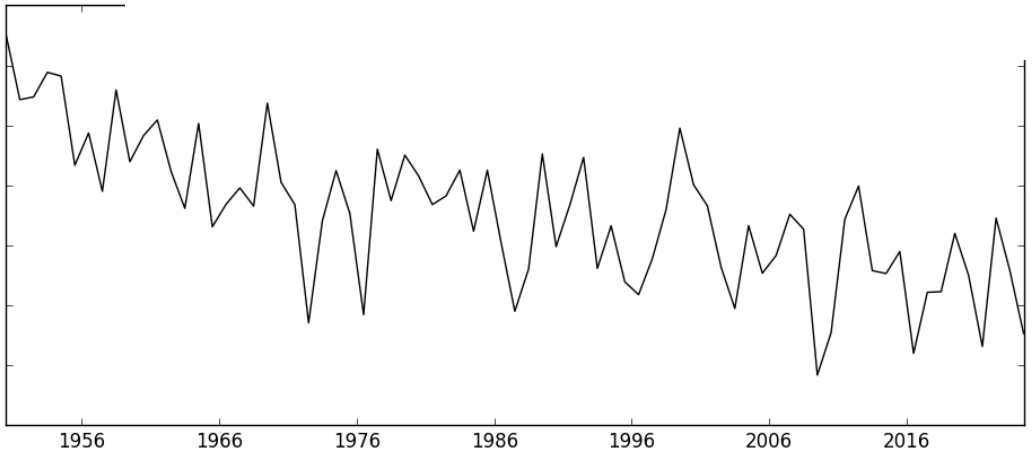
Hres

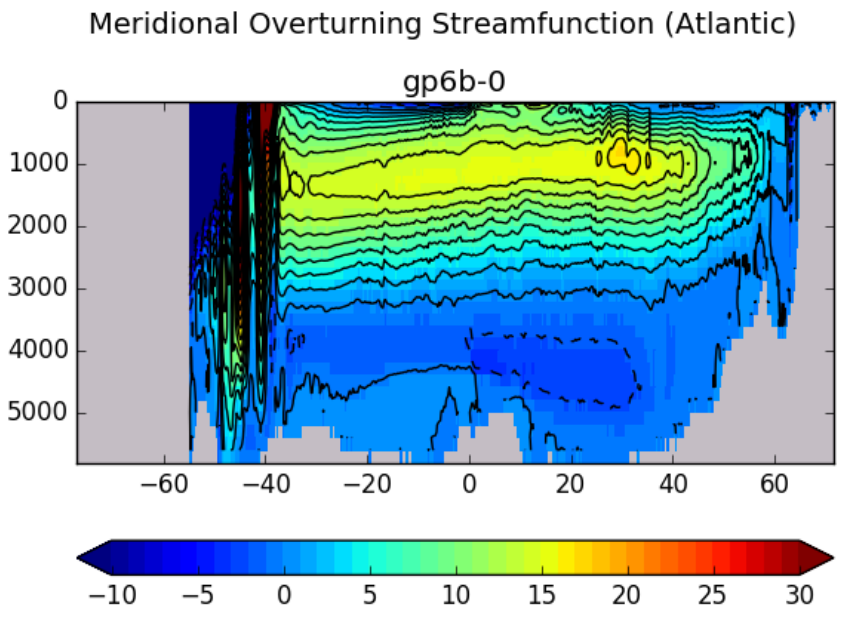


AMOC in coupled spin-up runs

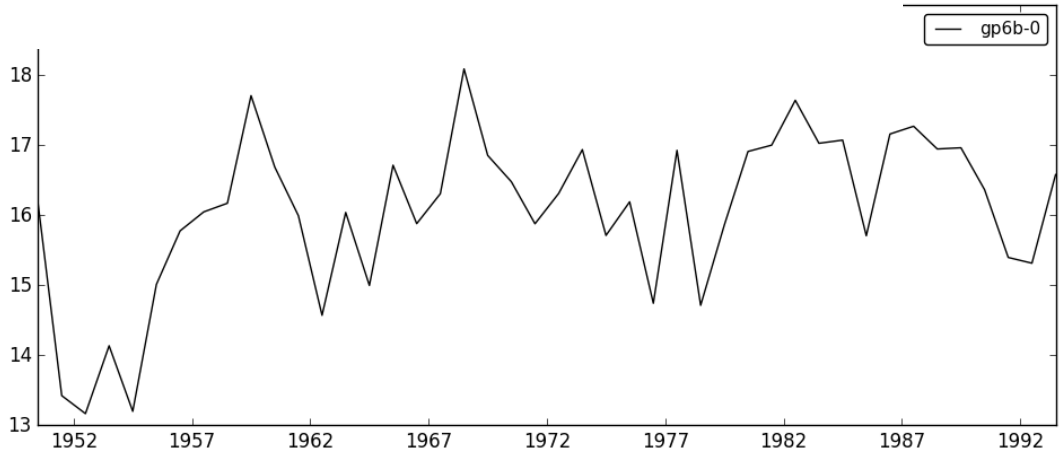
res



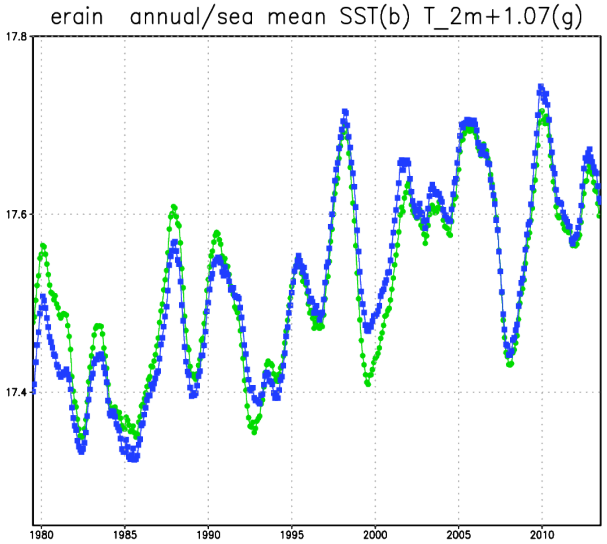


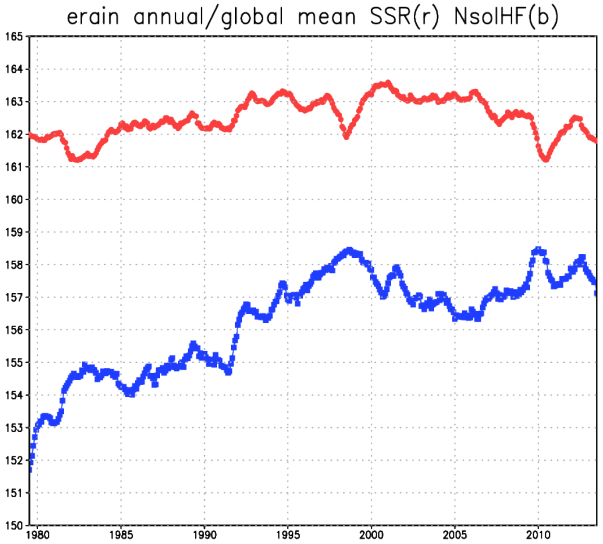


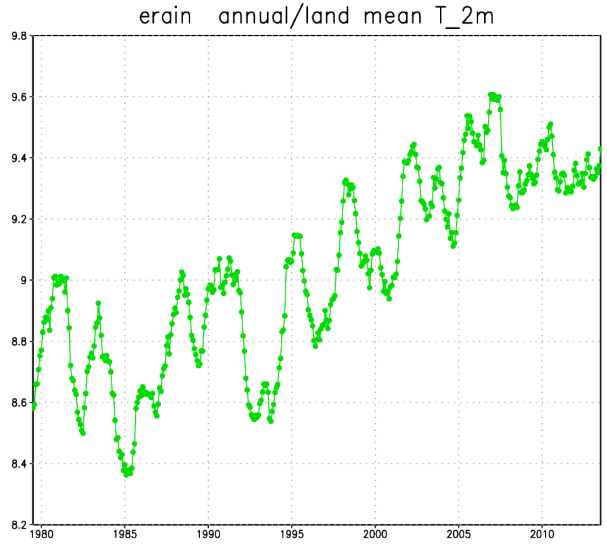
Hres

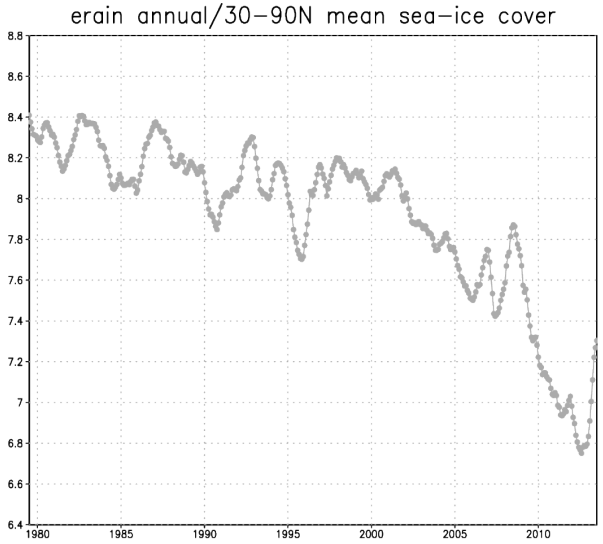


Variability and trend in global means: ERA Interim 1979-2013

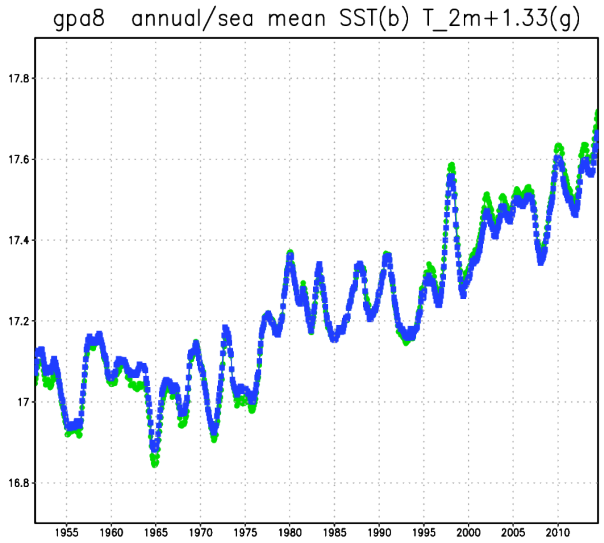


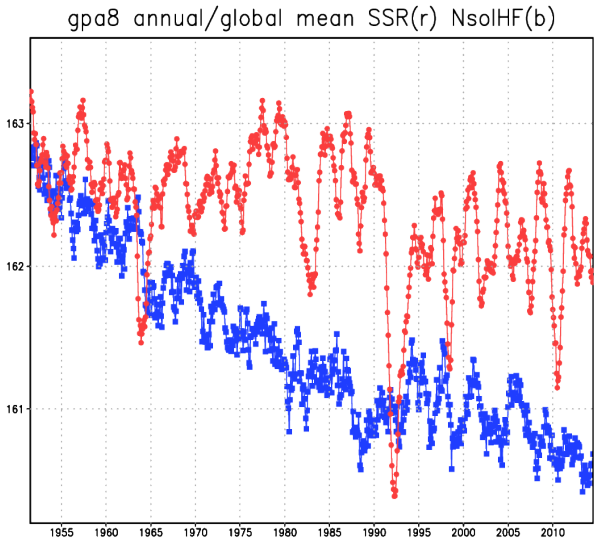


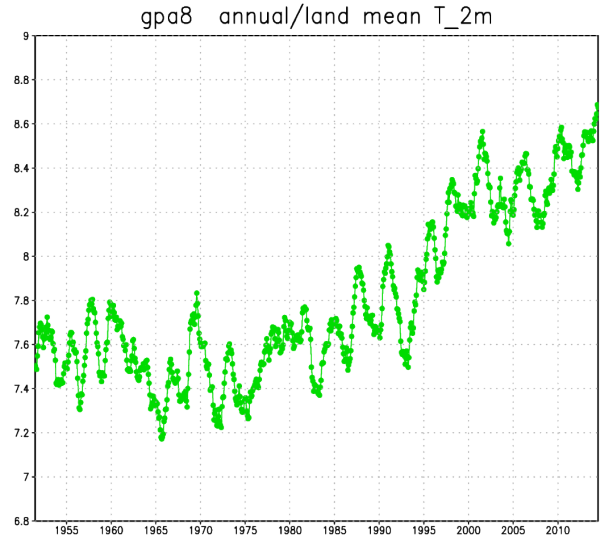


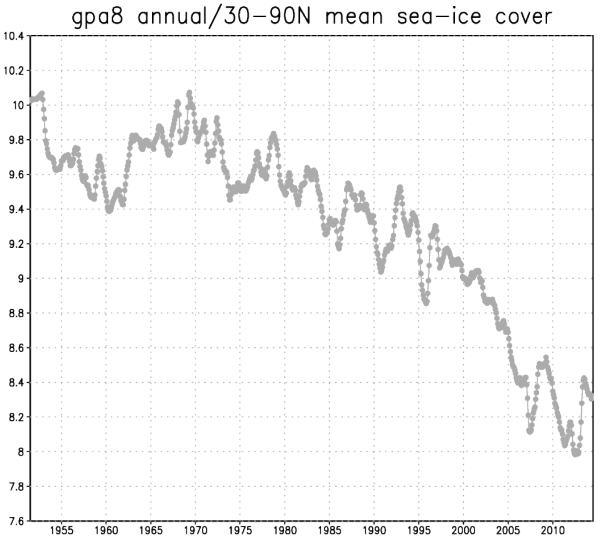


Variability and trend in global means: Hres AMIP 1951-2014

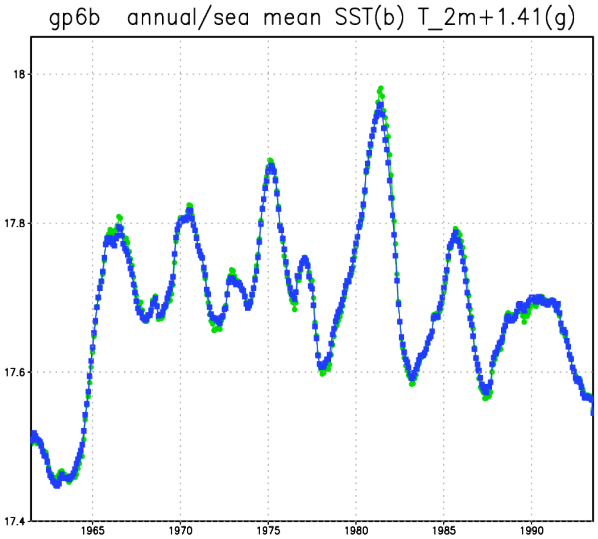


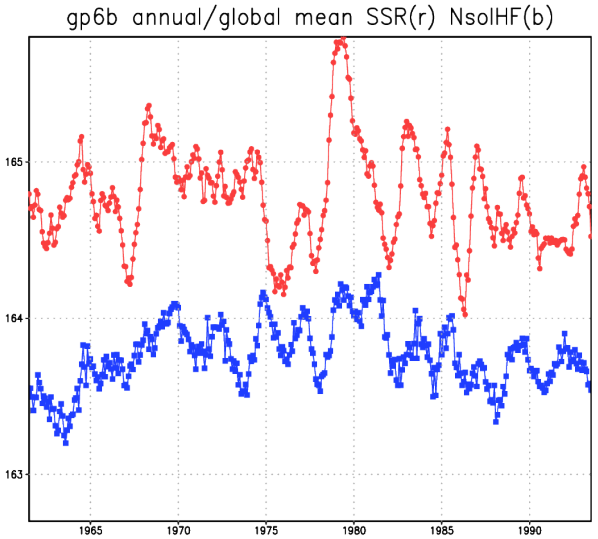


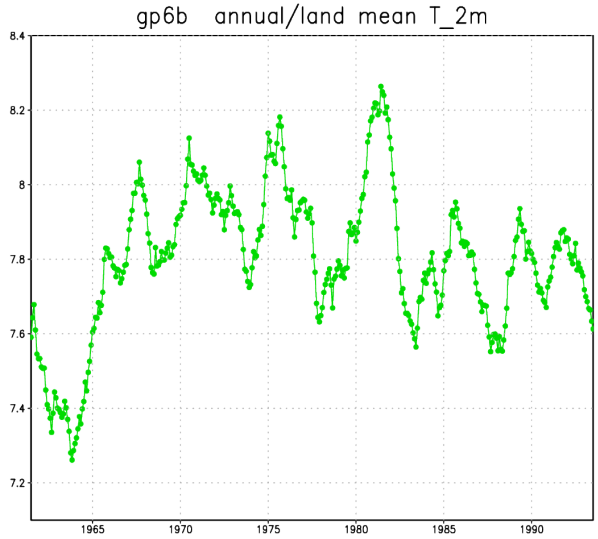


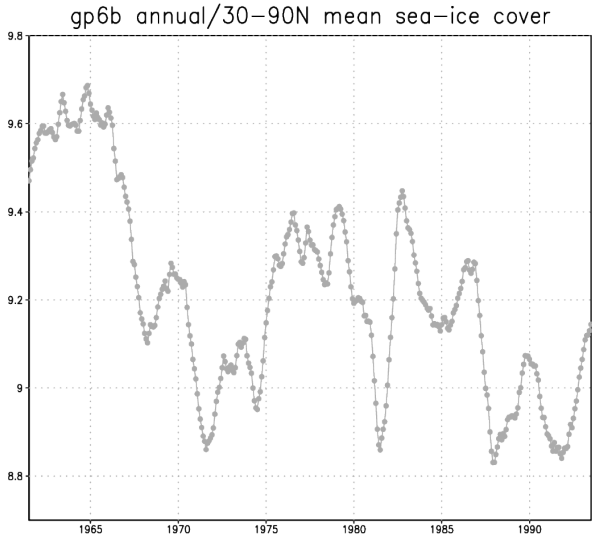


Variability and trend in global means: Hres 1950-csp yr 11-44

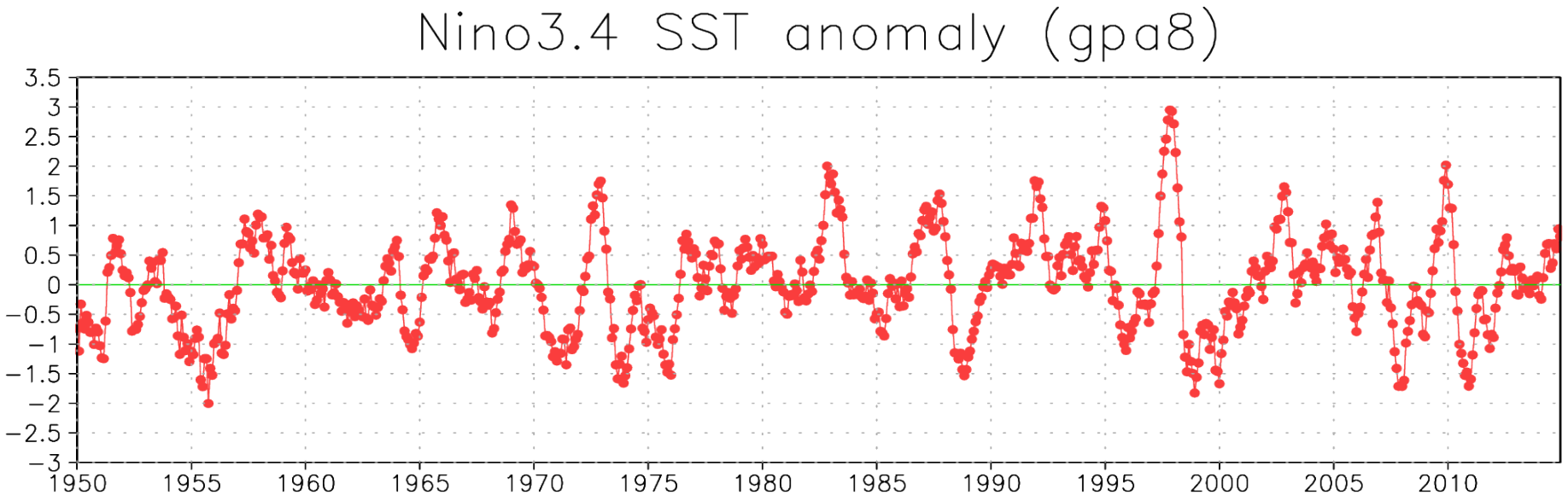


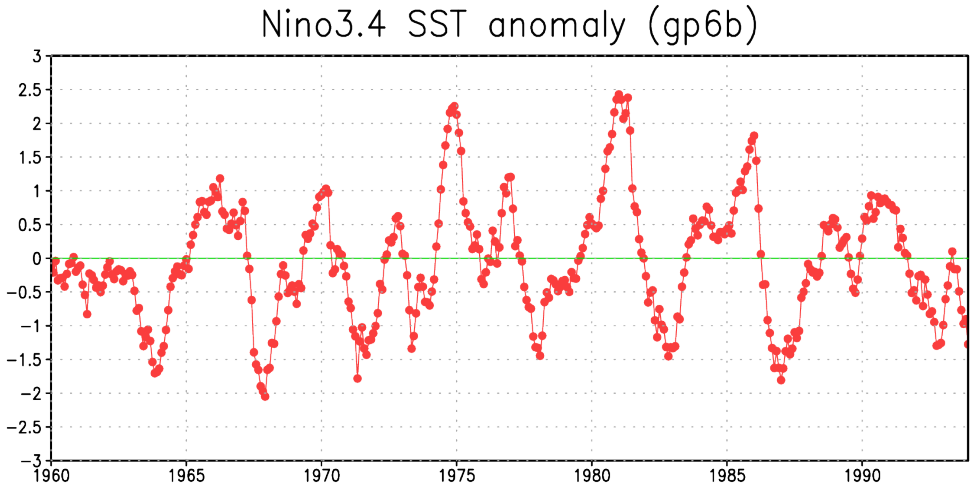




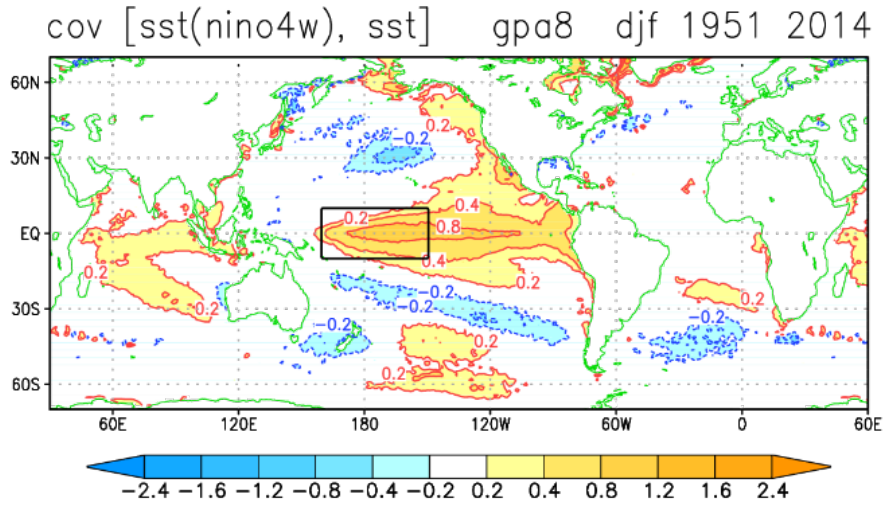


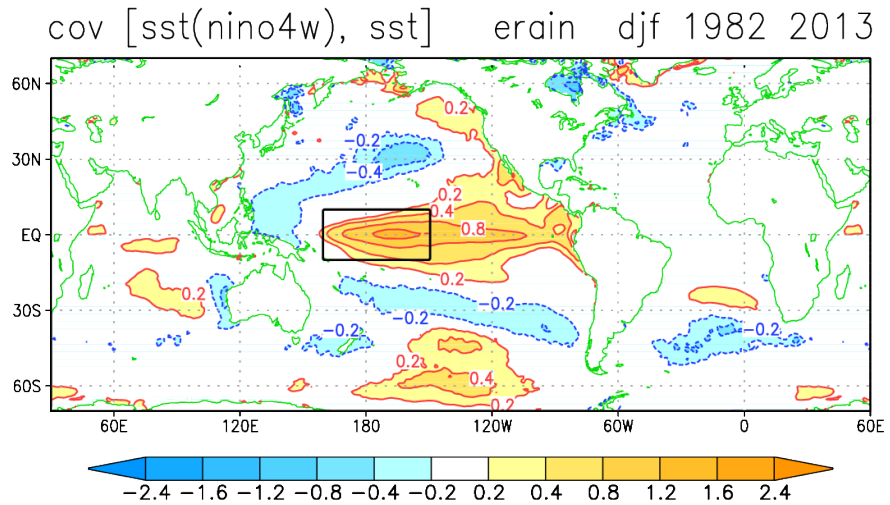
Nino 3.4 SST anomaly in Hres AMIP and 1950-csp

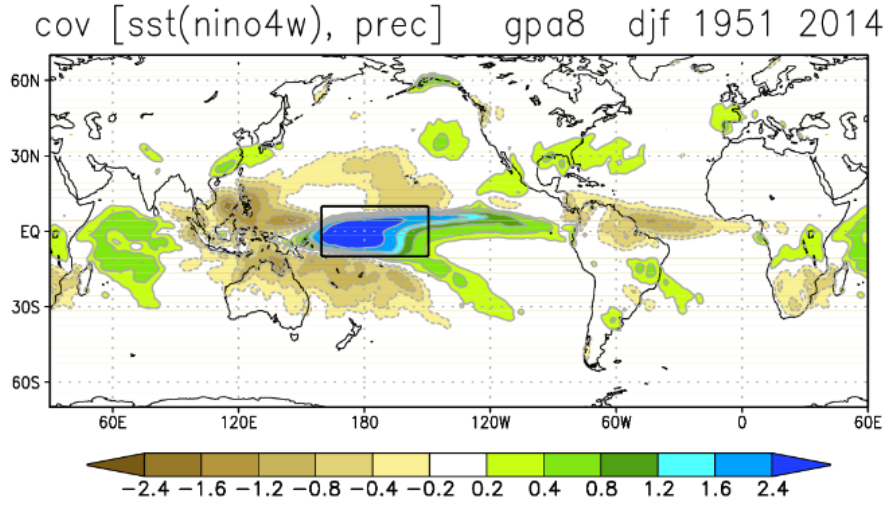


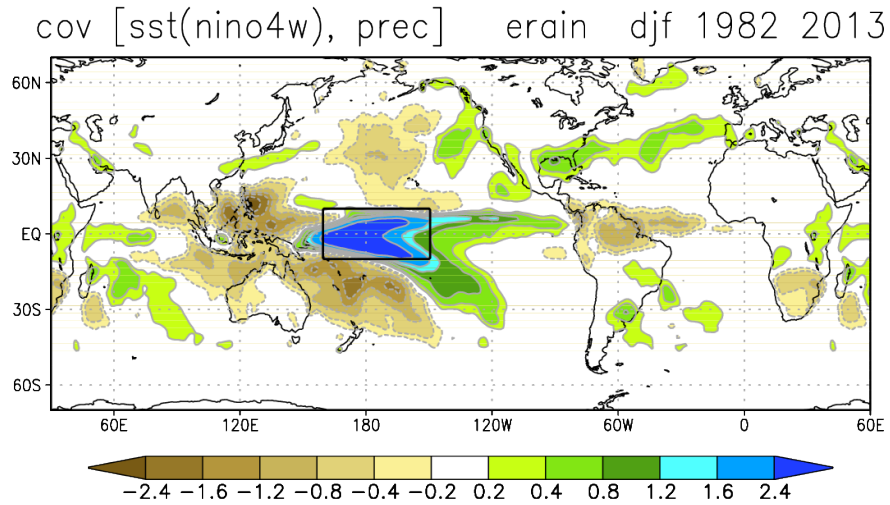


Tropical SST and rainfall (Nino4): Hres AMIP vs ERA-I/GPCP

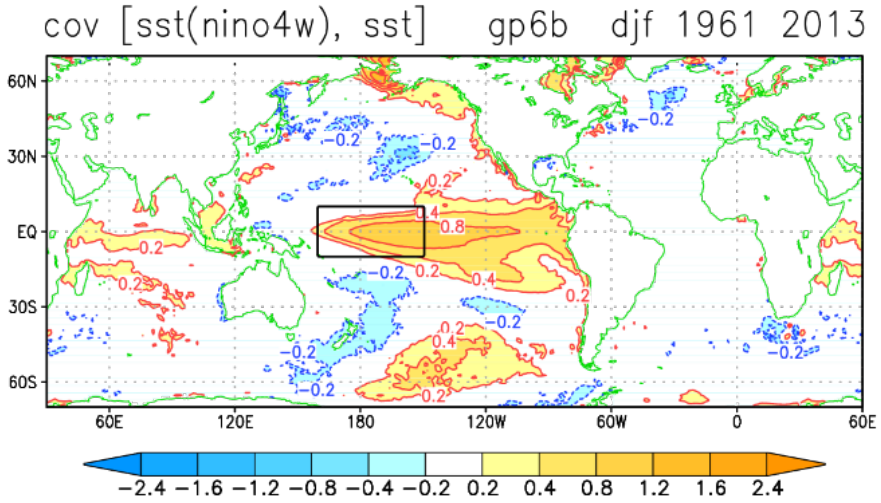


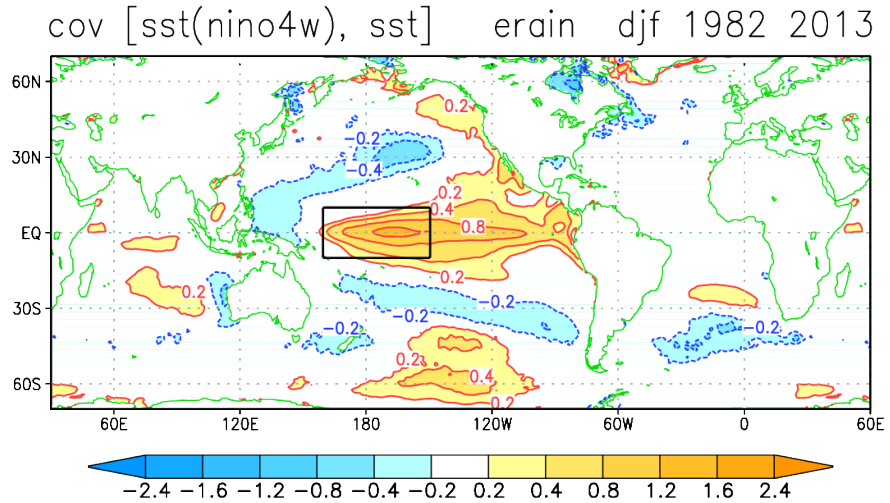


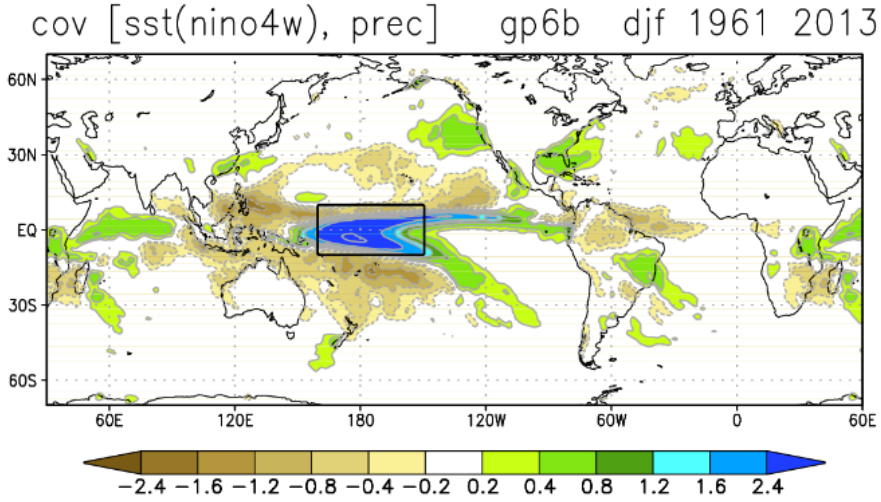


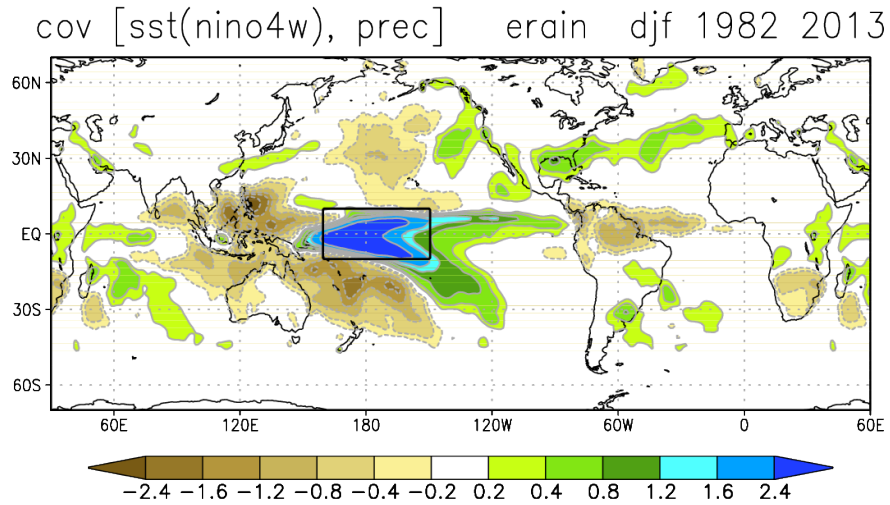


Tropical SST and rainfall (Nino4): Hres 1950-csp vs ERA-I/GPCP

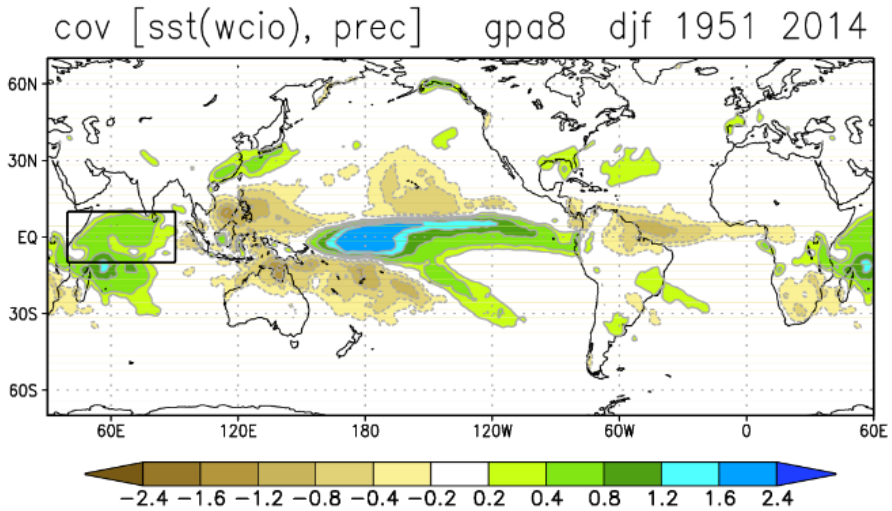


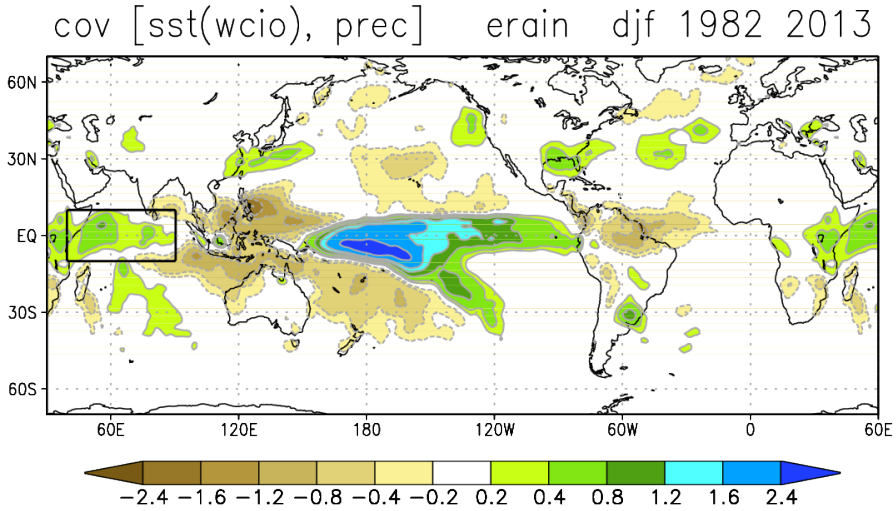


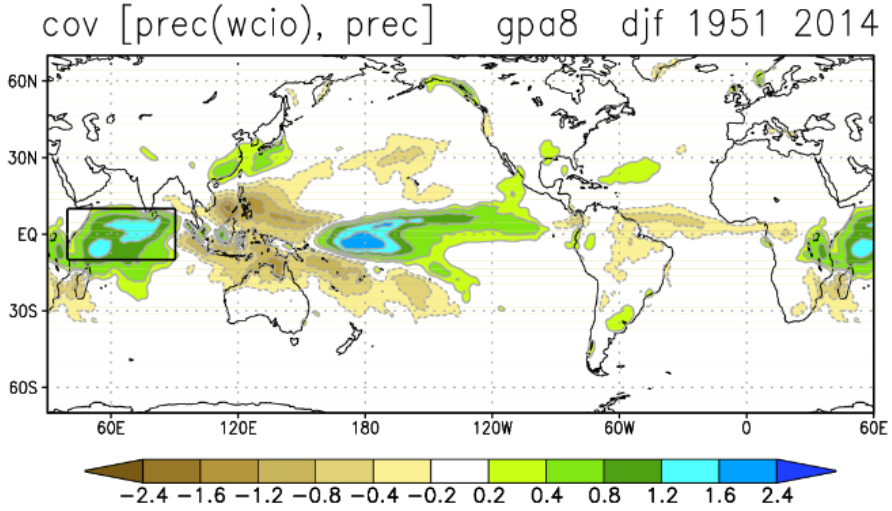


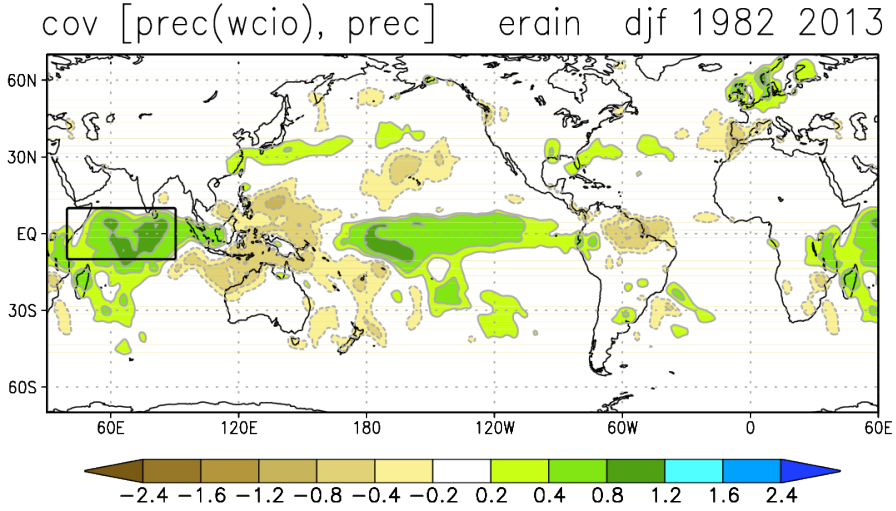


Tropical SST and rainfall (W Ind.Oc.): Hres AMIP vs ERA-I/GPCP

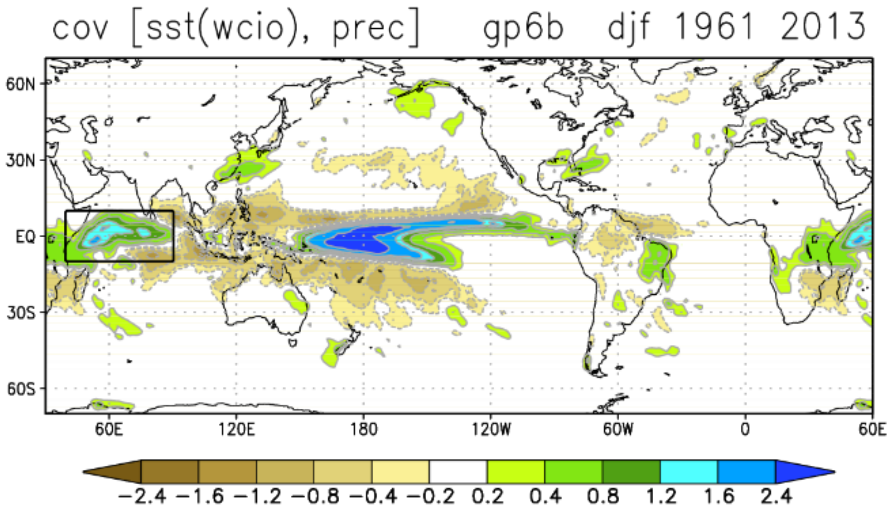


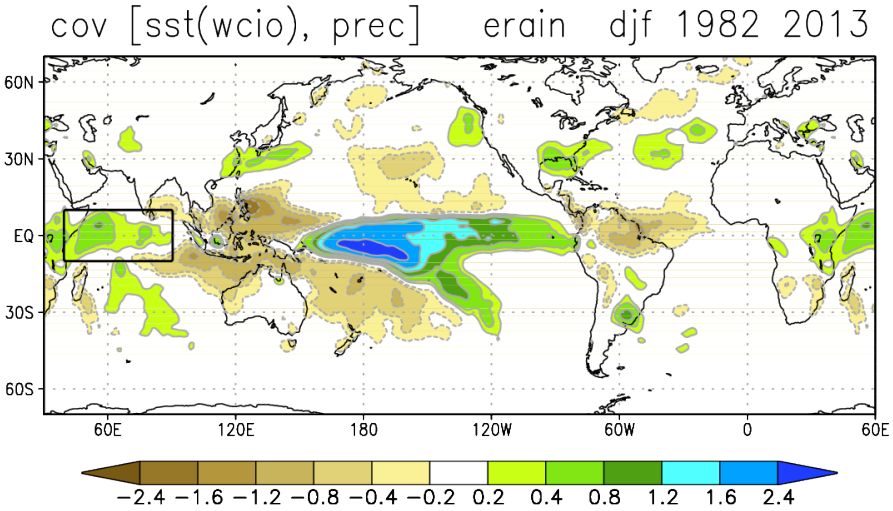


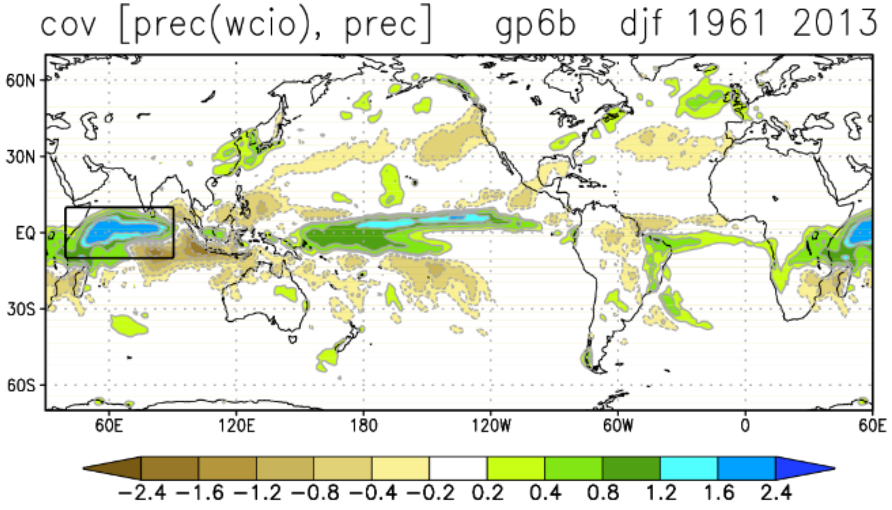


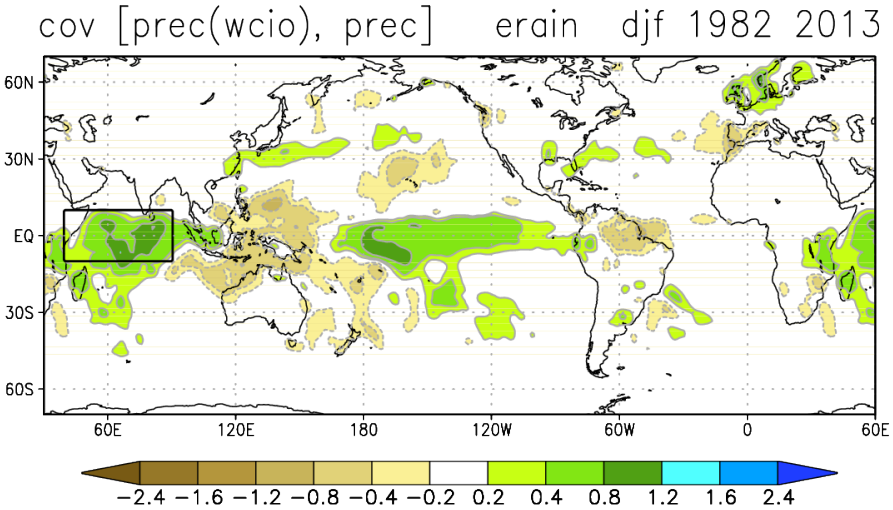


Tropical SST and rainfall (W Ind.Oc.): Hres 1950-csp vs ERA-I/GPCP

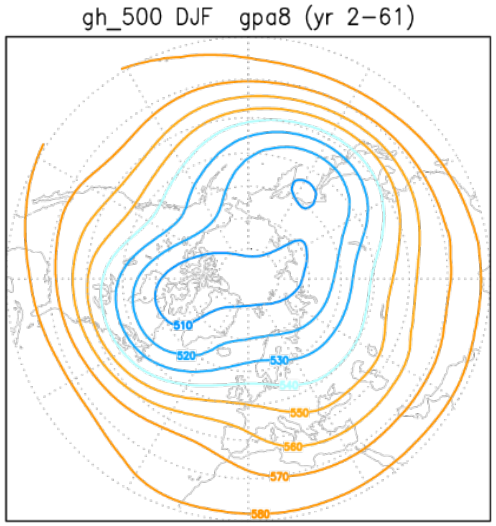


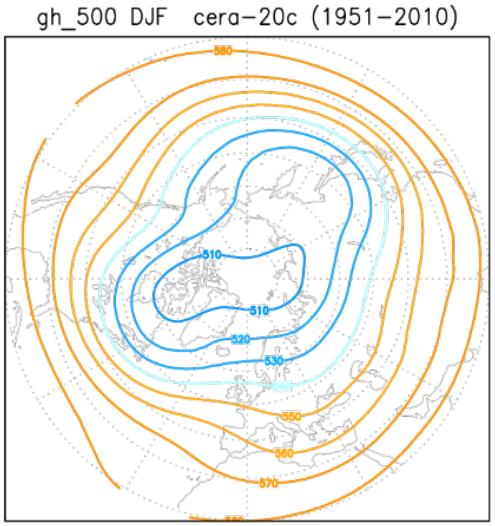


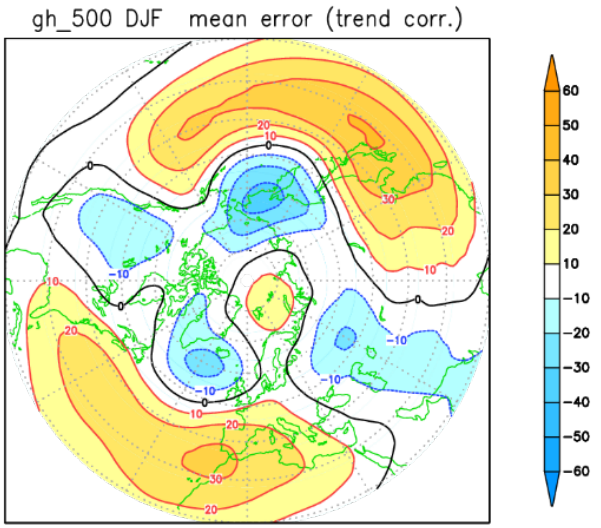




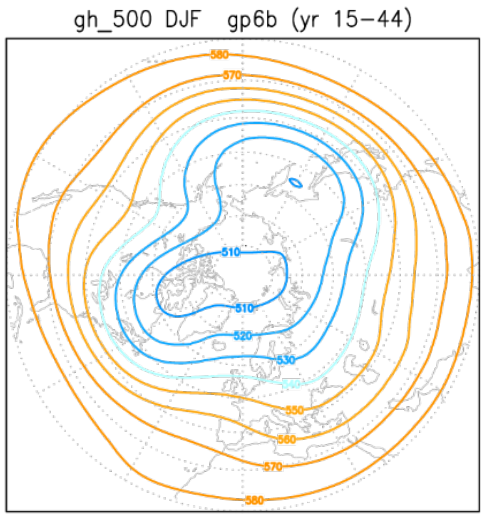
Mean climate of Z 500-hPa: Hres AMIP vs CERA-20C

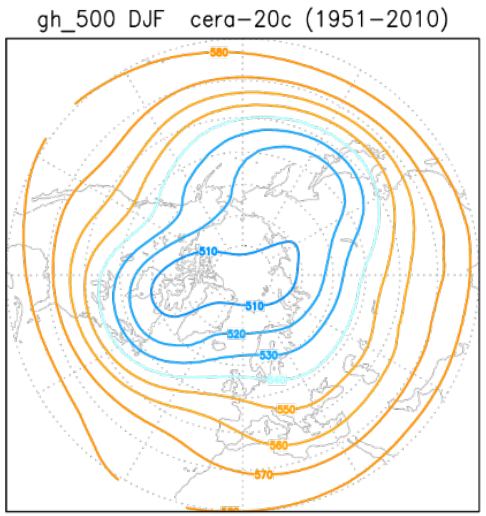


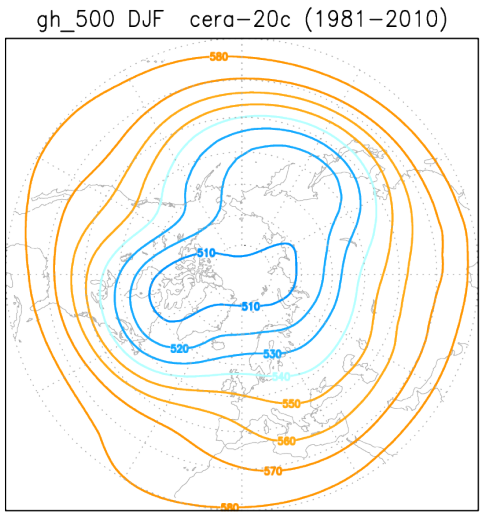


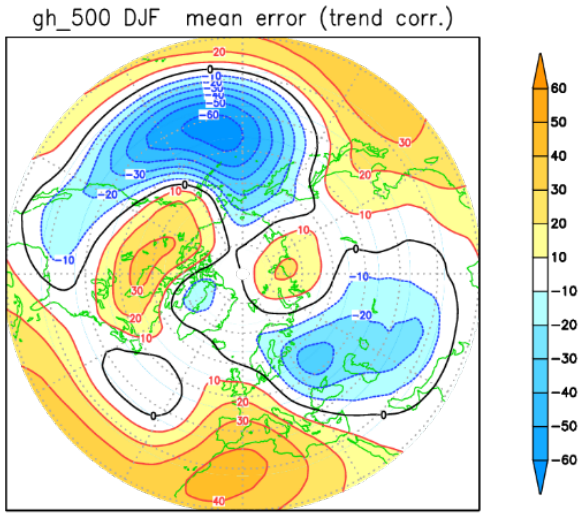


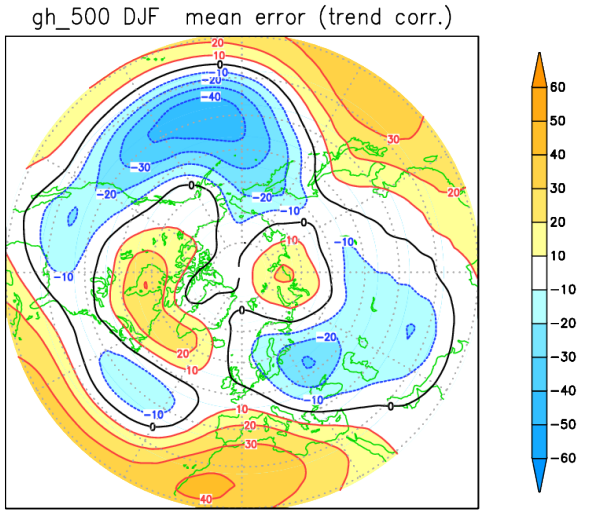
Mean climate of Z 500-hPa: Hres 1950-csp vs CERA-20C



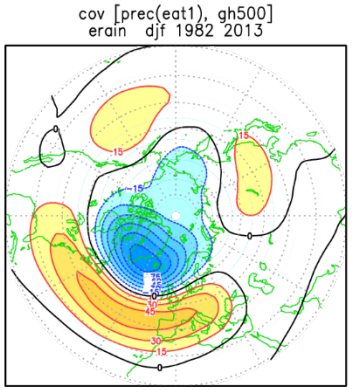
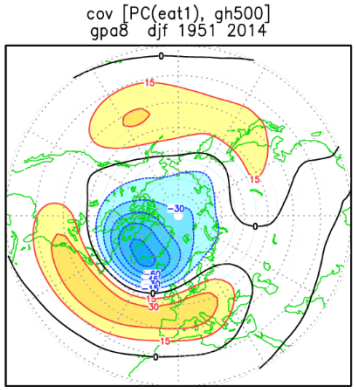
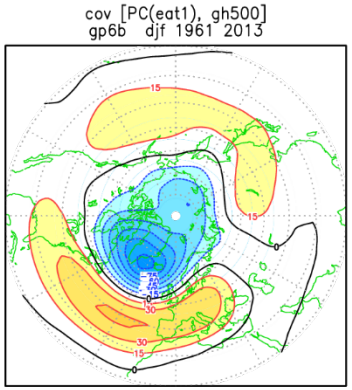
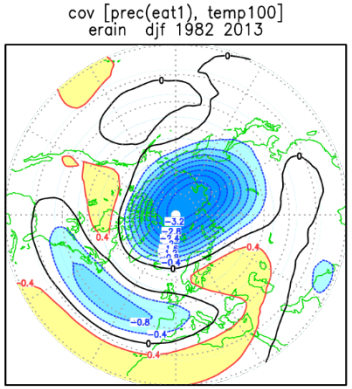
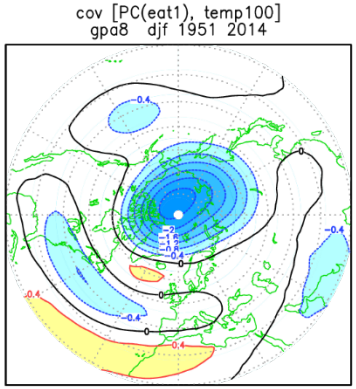
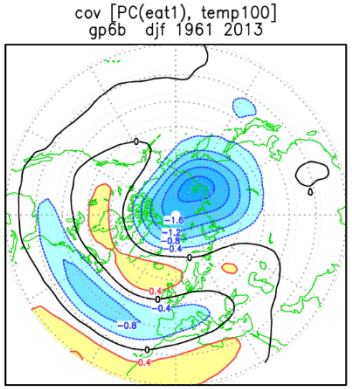
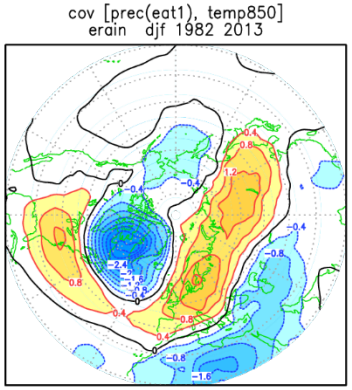
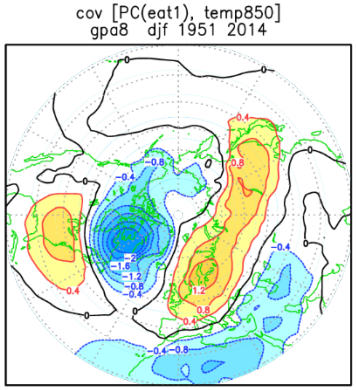
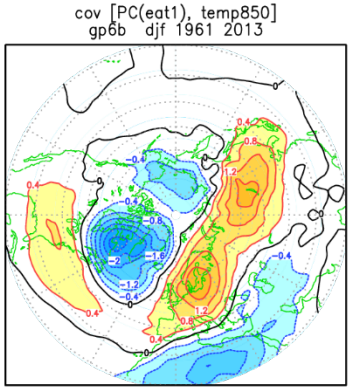








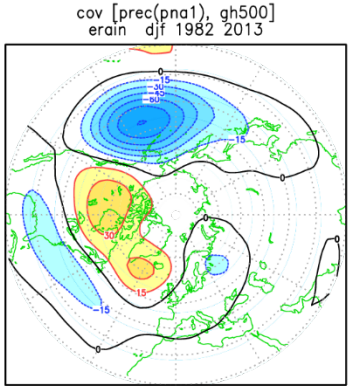
NAO (EOF-1 80W-40E):

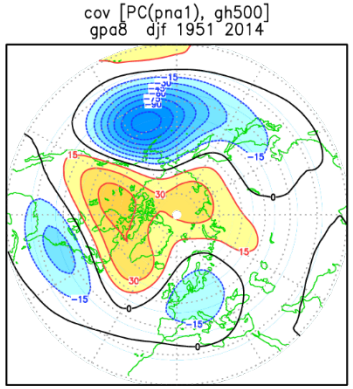
	ERA-Int	Hres AMIP	1950-csp
Z 500 hPa			
T 100 hPa			
T 850 hPa			

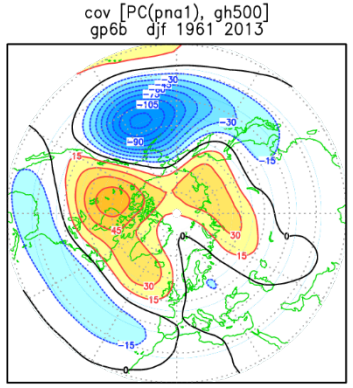
ECMWF

NA (EOF-1 160E-80W): ERA-Int Hres AMIP 1950-cntl

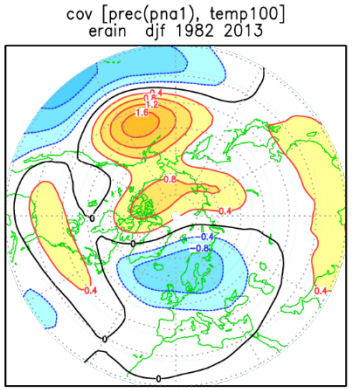
Z 500 hPa

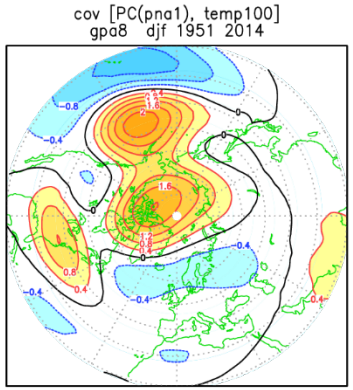


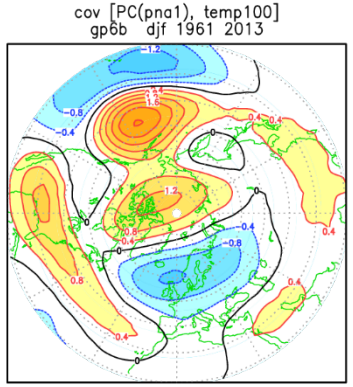




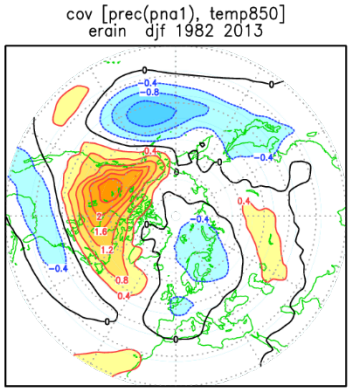
T 100 hPa

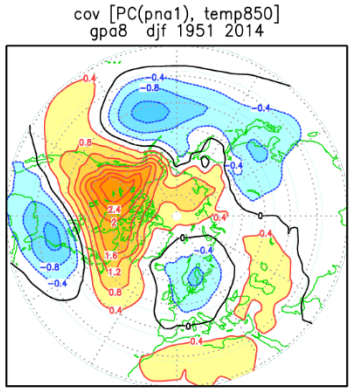


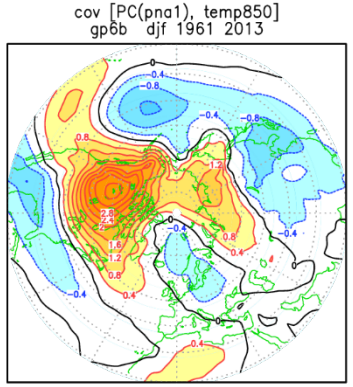




T 850 hPa







ECMWF

Summary

- The new ECMWF seasonal forecast system SEAS5 (operational in autumn 2017) shows reduced biases in tropical SST and improved skill in predicting ENSO indices with respect to the current system. Performance in the northern extratropics is comparable to System 4.
- The METIS experiments allow assessing the benefits of using high resolution (as in the ECMWF medium-range ensemble) in sub-seasonal and seasonal predictions.
- Historical multi-decadal experiments (1950-2014) run for the PRIMAVERA project will provide an assessment of the climatology (mean state, variability, teleconnections) of the ECMWF coupled model near in a state of near-equilibrium. A preliminary assessment of a coupled run with constant (1950) forcings shows encouraging results, with a fairly stable climate after ~20 years of spin-up and biases comparable to those of AMIP experiments.