MEDiterranean Services Chain based On climate PrEdictioncs

Climate predictions in the Mediterranean region to be used in agriculture, water management and renewable energy sectors

MEDSCOPE sensitivity experiments:

understanding teleconnections influencing the Mediterranean region and identifying sources of predictability at seasonal–interannual time scales

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Barcelona Supercomputing Center – Centro Nacional de Supercomputación

cmcc Centro Euro-Mediterraneo sui Cambiamenti Climatici

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METEO FRANCE

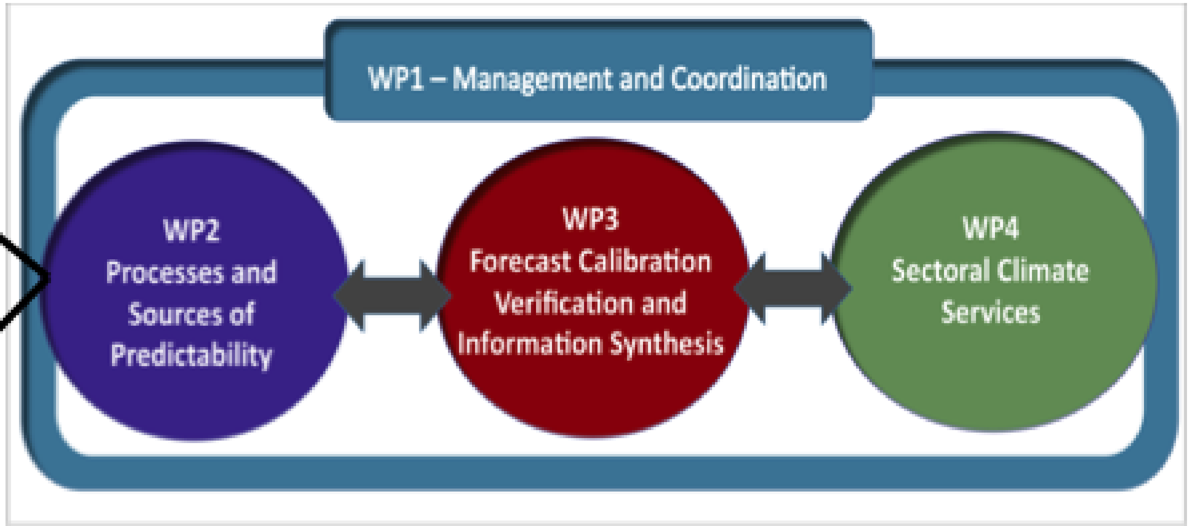
WMO Northern Africa RCC Network

WMO RA VI RCC Network

11th Session of the Mediterranean Climate Outlook Forum
20th Sessione of South East Eropean Climate Outlook Forum
13th Session of Climate Outlook Forum for Northern Africa
3rf Session of Arab Climate Outlook Forum

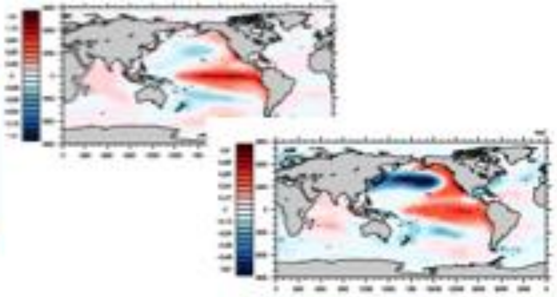
26 – 29 November 2018
Cairo, Egypt

WP2 (Processes and Sources of Predictability): **explore the mechanisms of variability and predictability** in the Mediterranean, focusing on those linked with predictable signals in the **oceans** or associated with **land-atmosphere interaction** processes (**telconnections**) → **sensitivity experiments**.

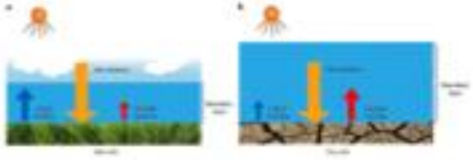


Physical processes driving possible sources of predictability for the Mediterranean region

ENSO teleconnections

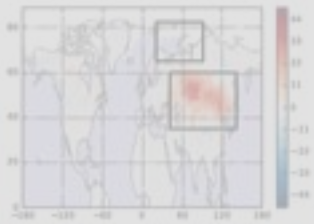


Soil moisture

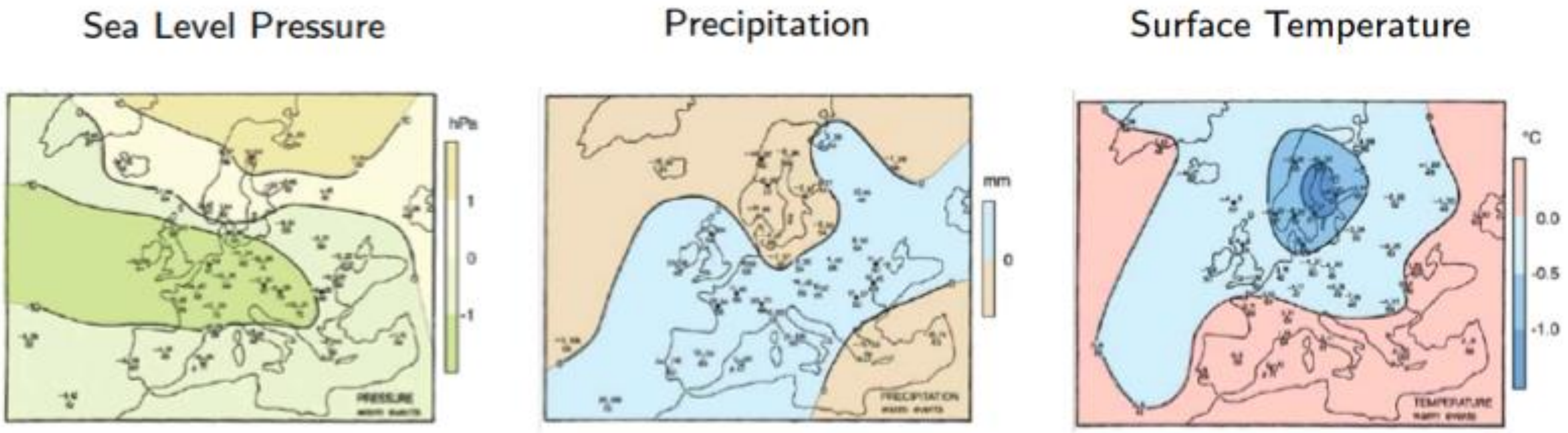


(source: Alexander, 2010: Extreme heat rooted in dry soils. *Nat. Geosci.*)

Sea–ice and snow cover



ENSO telconnection over the Mediterranean region: the canonical winter signal



adapted from Bronniman 2007)

High pressure and cold anomalies over the Scandinavian region

Low pressure anomaly over Central Europe

Enhanced precipitation over large part of Europe and western Mediterranean

ENSO telconnection over the Mediterranean region: the canonical winter signal

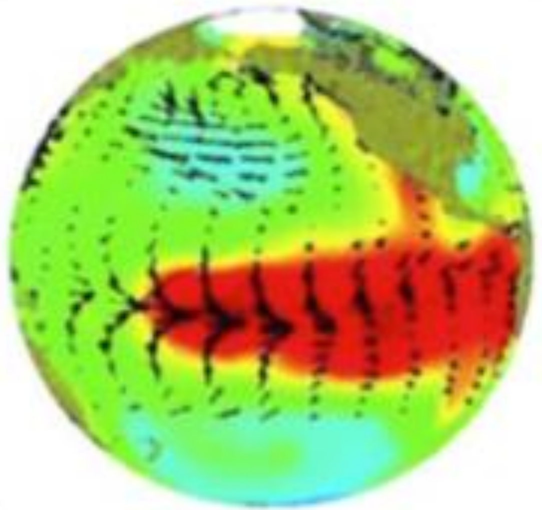
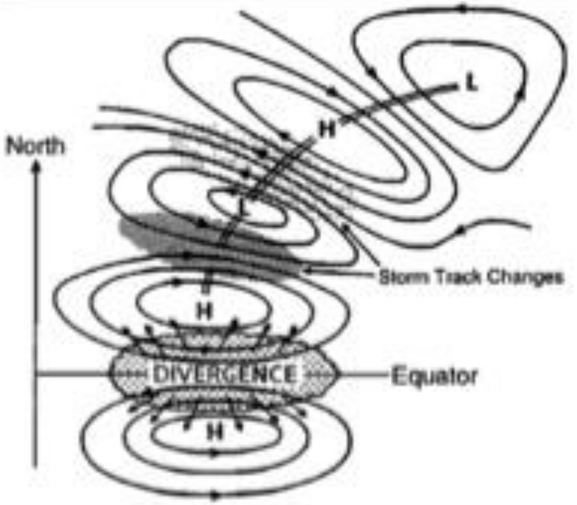


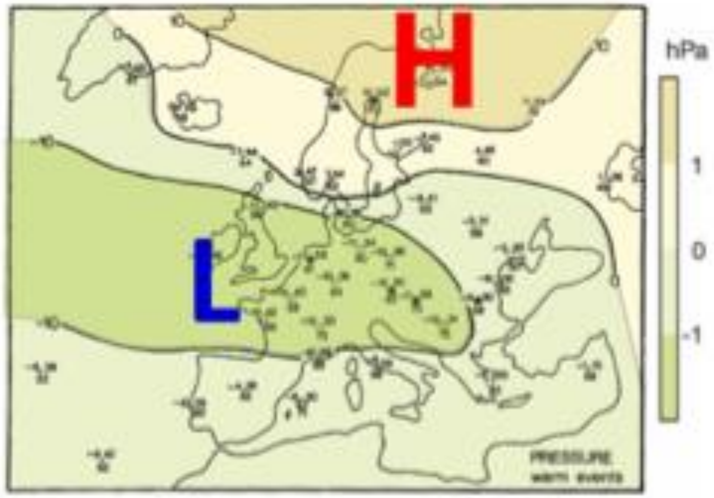
Image courtesy of University of Washington

El Nino Southern Oscillation



Trenberth et al. 1998

North Pacific-North America



Fraedrich and Müller [1992]

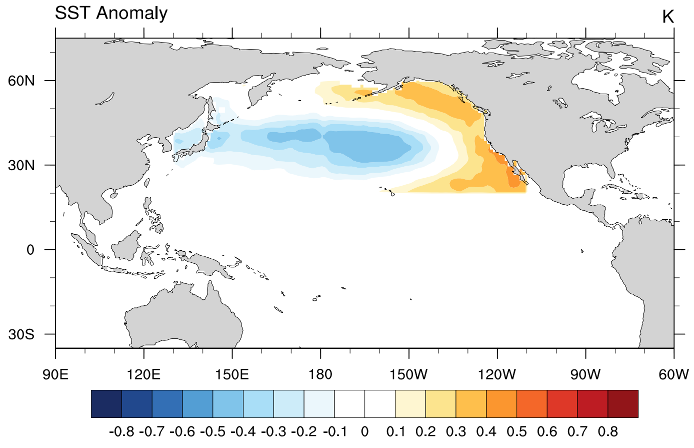
North Atlantic-European

well studied

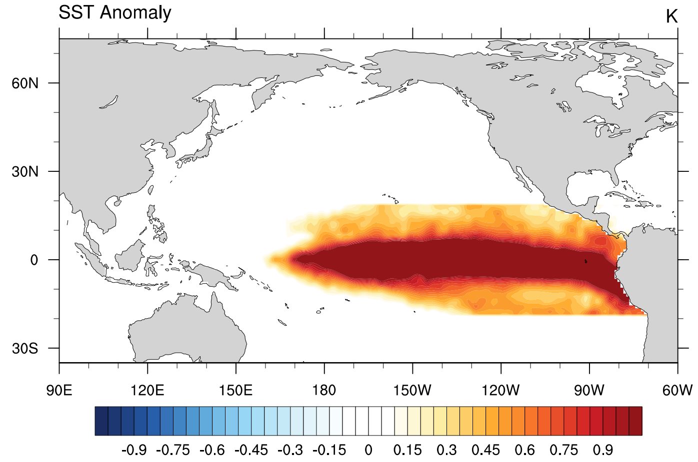
"Teleconnection": less certain

Ying LI @ CSU

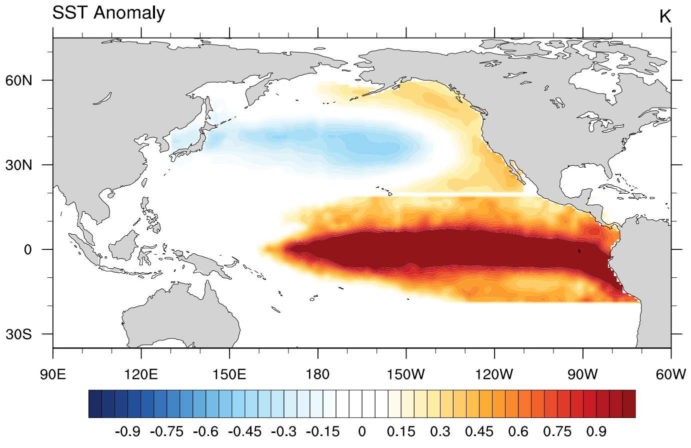
ENSO/PDO SST forcing



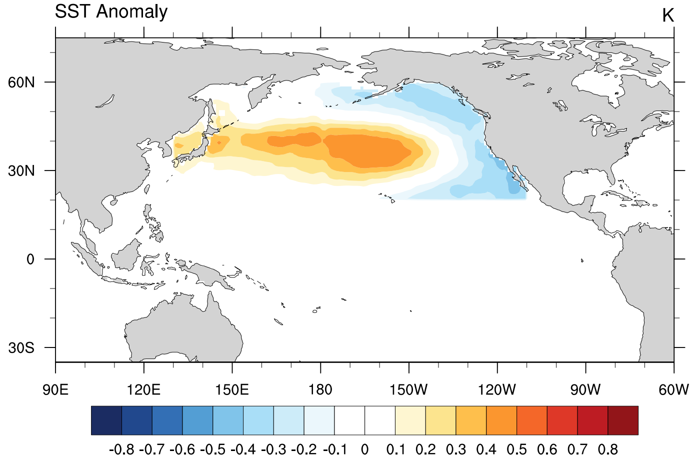
Extratropical Positive PDO



Positive ENSO-like

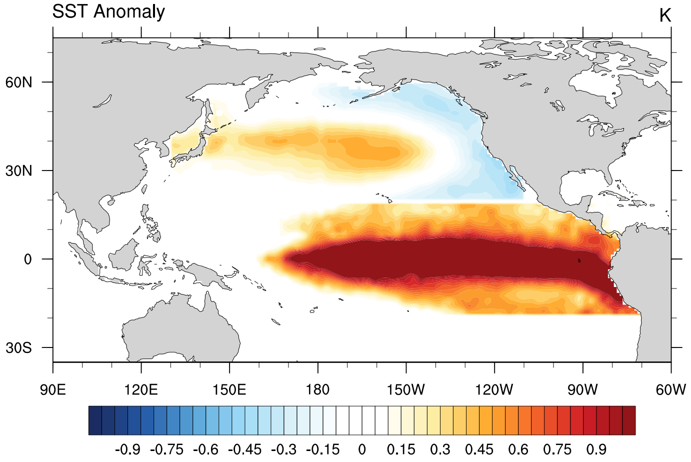


ENSO + ET positive PDO



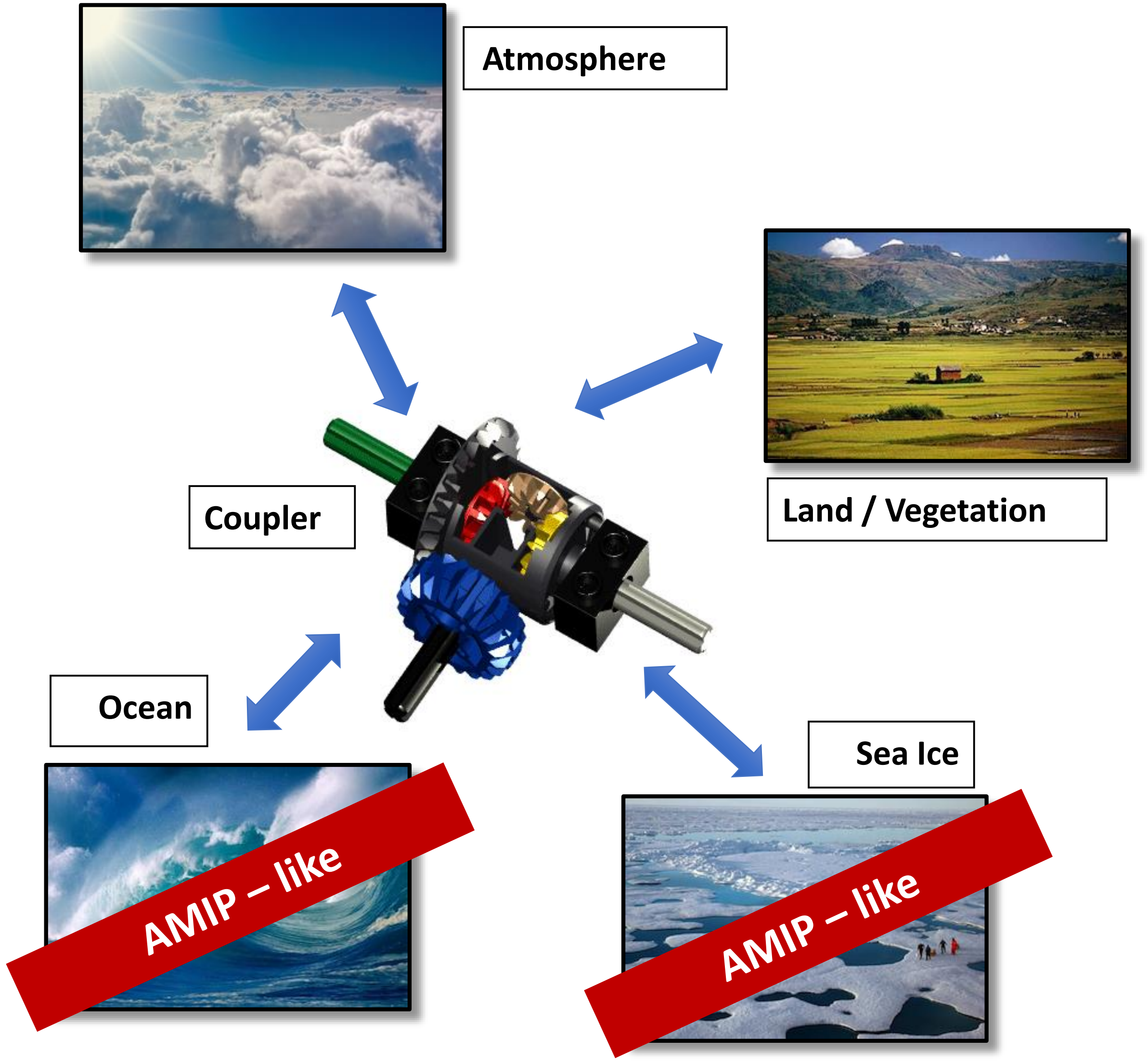
Extratropical Negative PDO

PDO-like pattern -> stationary
ENSO-like pattern -> annual cycle



ENSO + ET negative PDO

ENSO/PDO SST forcing



<u>AMIP–like simulations</u>
conducted with the atmospheric and land surface components of the seasonal prediction systems

prescribed SST and Sea–Ice distributions

Tier 1: El Niño + Positive/Negative ET -PDO

EXP NAME	ENSO	PDO	Initialization	Duration	Status
REF(B0)	None (HadISST 1981-2010 climatology)	None (HadISST 1981-2010 climatology)	20 year spin-up	50 years (70 total with the 20 year spinup)	COMPLETE
OC-1a	El Nino pattern	None	50 1st June conditions from REF	12 months (50 ensemble members)	COMPLETE
OC-1b	El Nino pattern	Positive phase	50 1st June conditions from REF	12 months (50 ensemble members)	COMPLETE
OC-1c	El Nino pattern	Negative phase	50 1st June conditions from REF	12 months (50 ensemble members)	COMPLETE

Tier 2: Positive/Negative ET -PDO

EXP NAME	ENSO	PDO	Initialization	Duration	Status
REF(B0)	None (HadISST 1981-2010 climatology)	None (HadISST 1981-2010 climatology)	20 year spin-up	50 years (70 total with the 20 year spinup)	COMPLETE
OC-2a	None	Positive phase	50 1st June conditions from REF	12 months (50 ensemble members)	COMPLETE
OC-2b	None	Negative phase	50 1st June conditions from REF	12 months (50 ensemble members)	COMPLETE

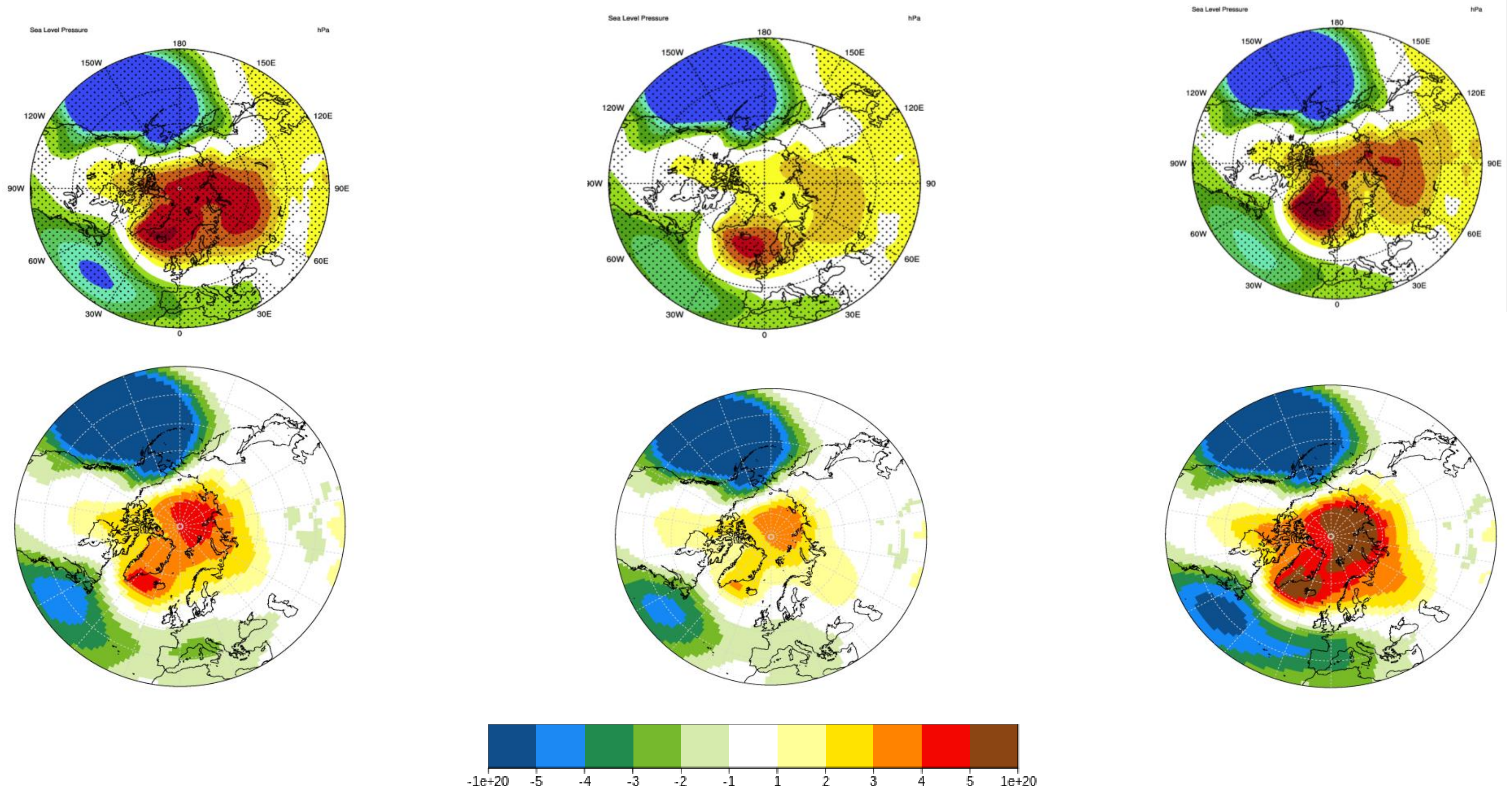
Tier 3: La Niña + Positive/Negative ET -PDO

EXP NAME	ENSO	PDO	Initialization	Duration	Status
REF(B0)	None (HadISST 1981-2010 climatology)	None (HadISST 1981-2010 climatology)	20 year spin-up	50 years (70 total with the 20 year spinup)	COMPLETE
OC-3a	La Niña pattern	None	50 1st June conditions from REF	12 months (50 ensemble members)	RUNNING
OC-3b	La Niña pattern	Positive phase	50 1st June conditions from REF	12 months (50 ensemble members)	RUNNING
OC-3c	La Niña pattern	Negative phase	50 1st June conditions from REF	12 months (50 ensemble members)	RUNNING

ENSO-PDO Preliminary Results

<u>Tier1</u> (ENSO/ENSO+ETPDO): impact on **SLP** **DJF**

ENSO only | ENSO with PDO+ | ENSO with PDO-

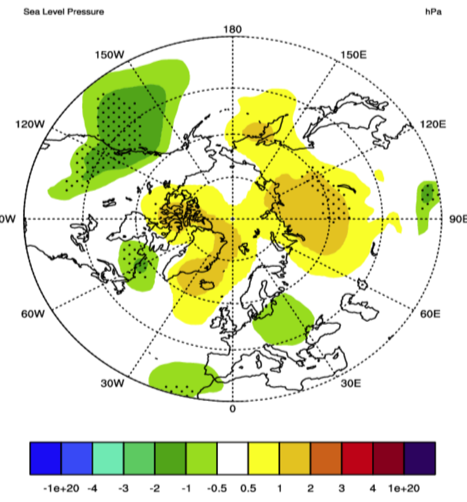


<u>50 member ensemble</u> mean differences with the **<u>reference experiment CTL</u>** (climatological SST)

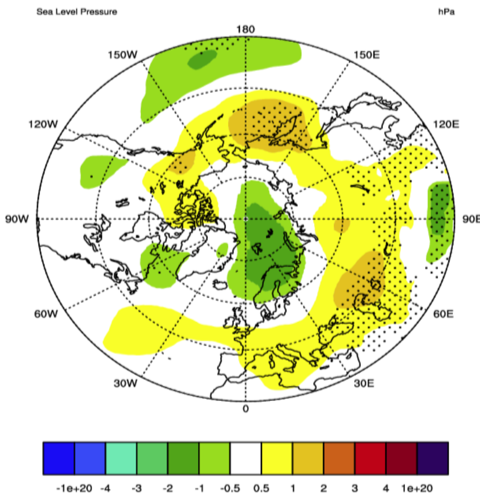
ENSO-PDO Preliminary Results

Tier2 (PDOPos vs PDONeg): impact on SLP DJF

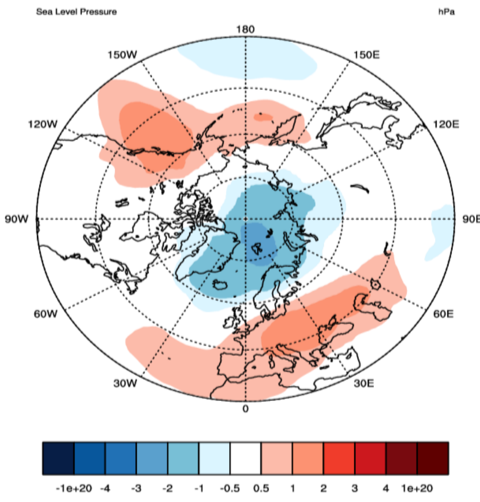
PDO+

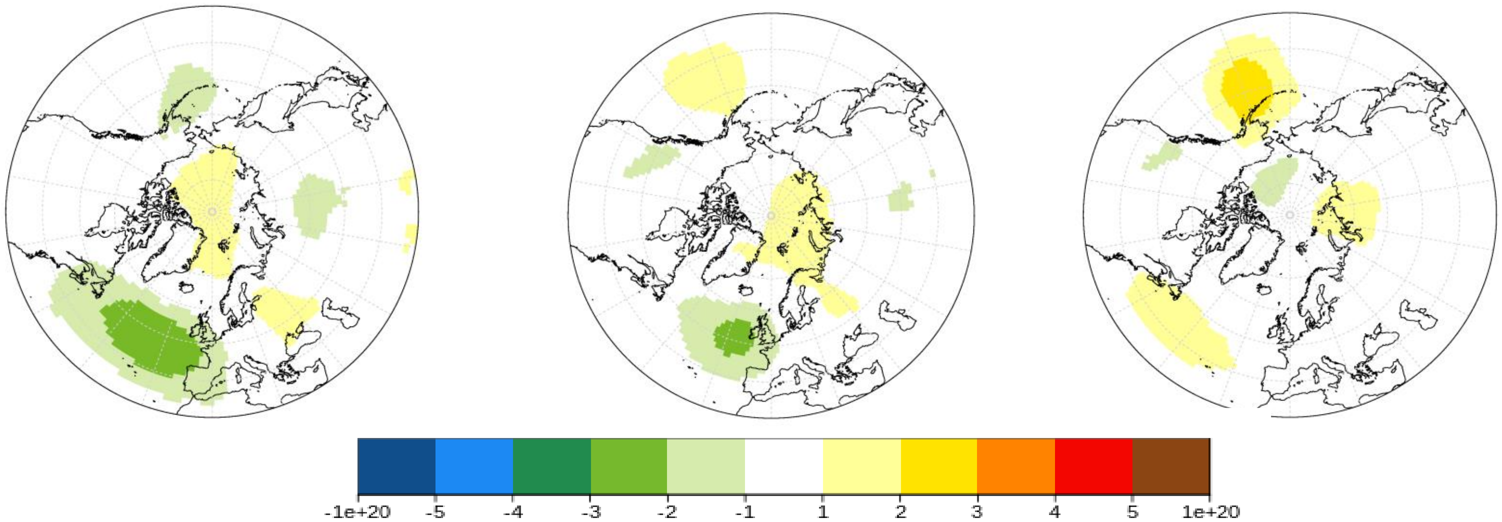


PDO-



(PDO-) – (PDO+)





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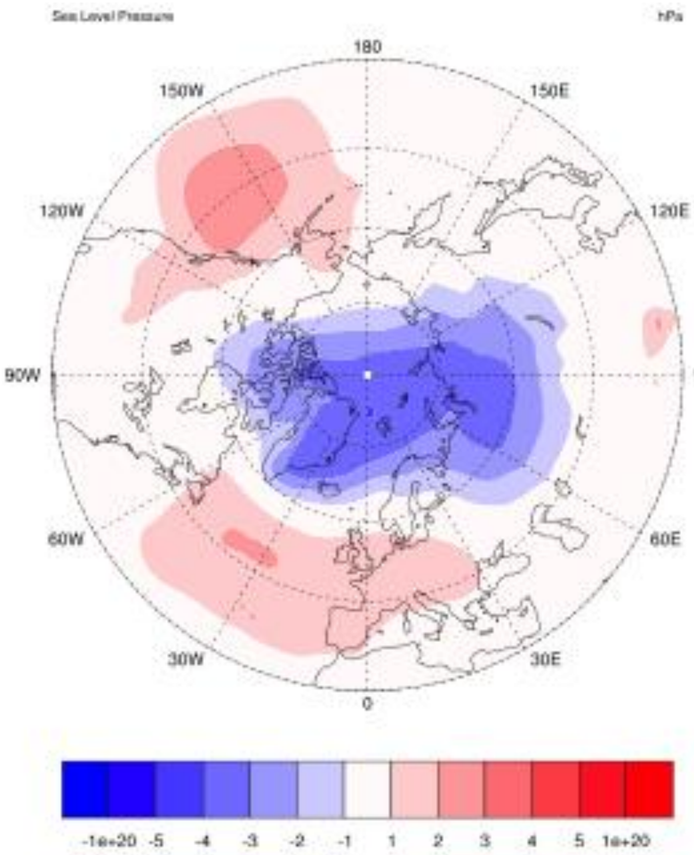
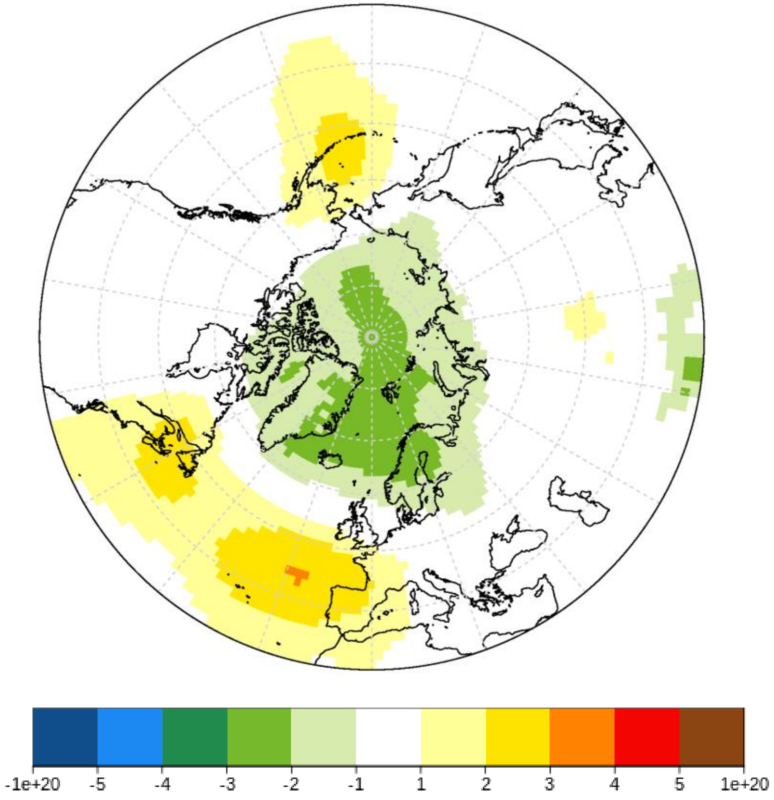
ENSO-PDO Preliminary Results

Tier 1&2: non linearities (ENSO + ETPDOP) SLP DJF

Non – linear component of the ENSO with PDO+ response:
[ENSO with PDO+] – [ENSO + PDO+]

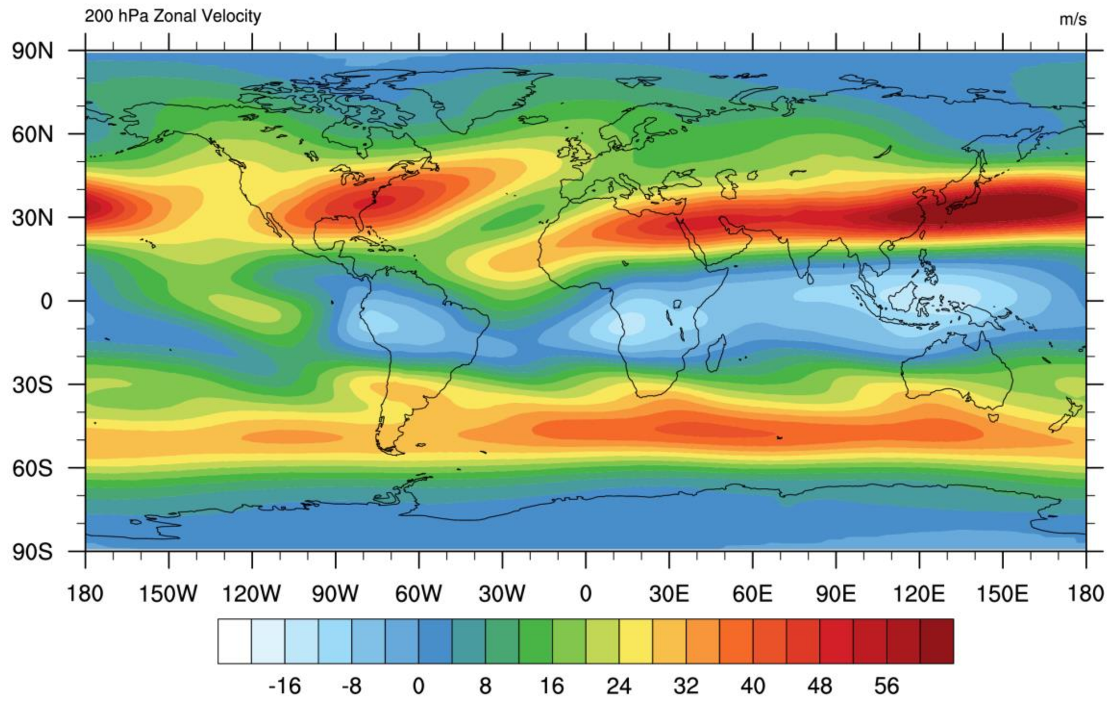




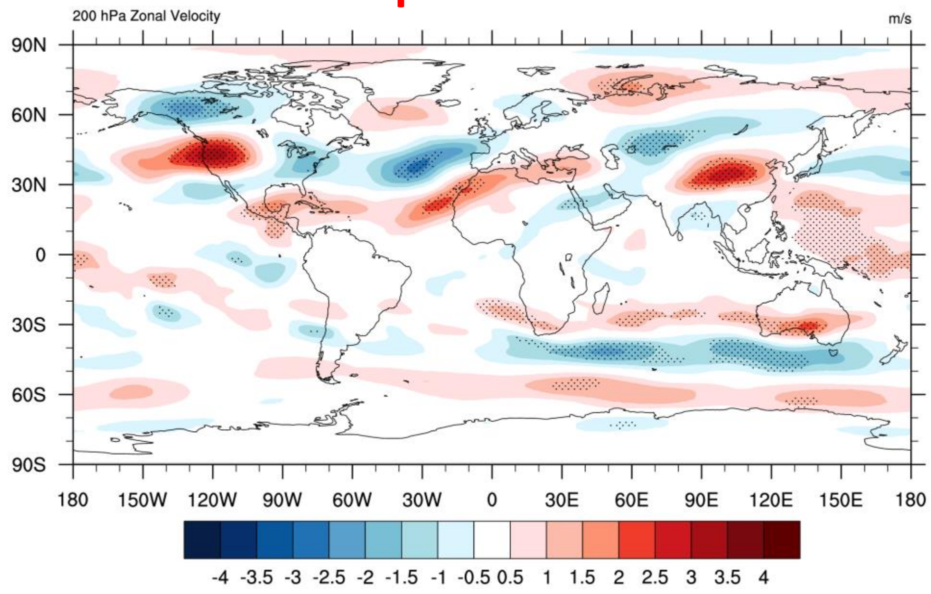
50 member ens mean ETPDOP/ENSO – (50 member ens mean ETPDOP+ 50 member ens mean ENSO)

ENSO-PDO Preliminary Results

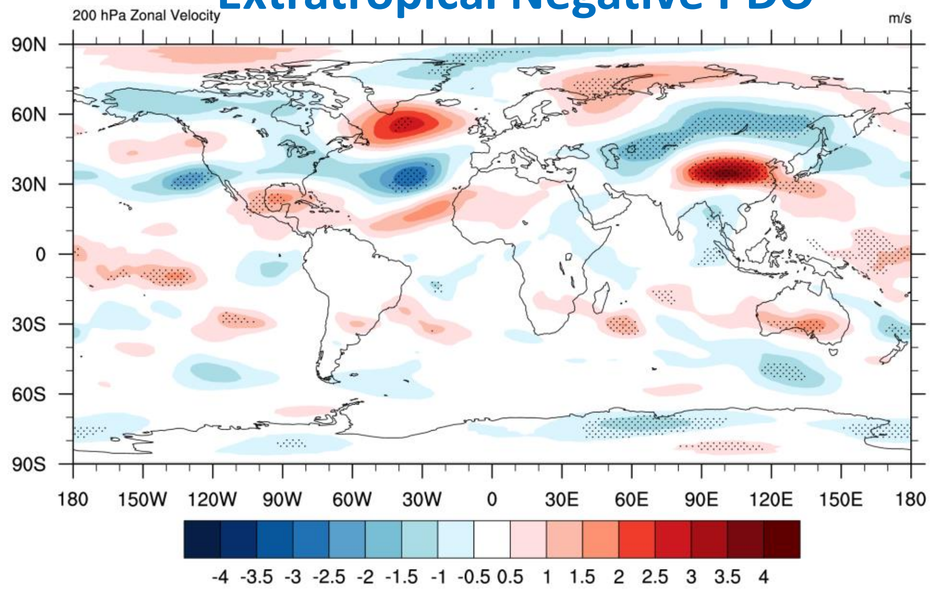
PDO Influence on the mean state



Extratropical Positive PDO

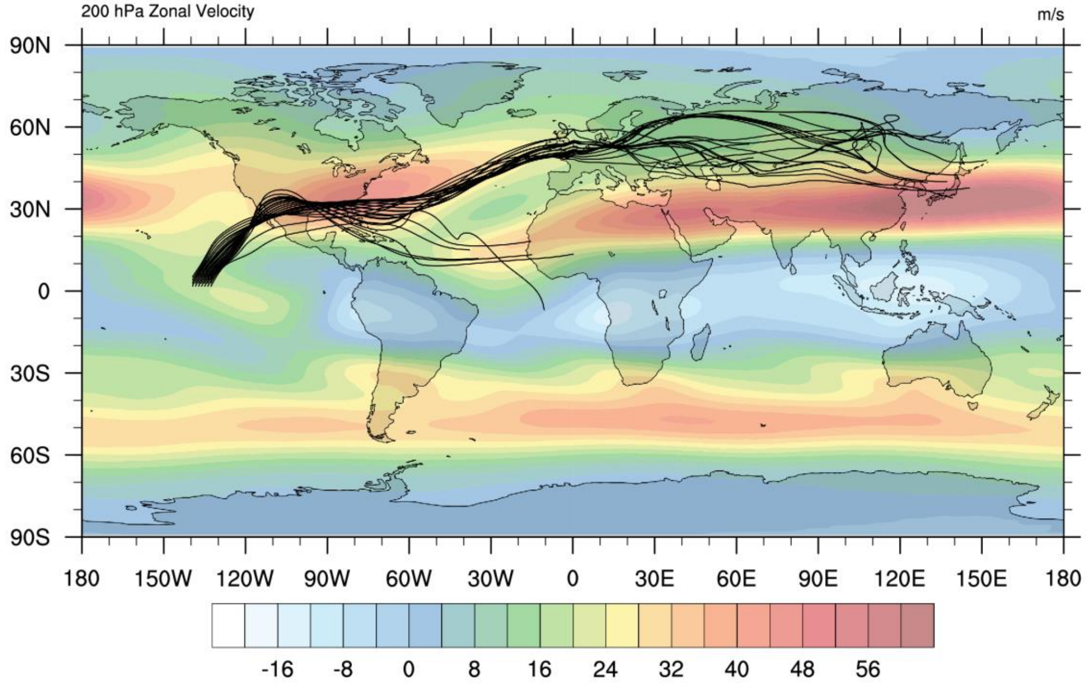


Extratropical Negative PDO

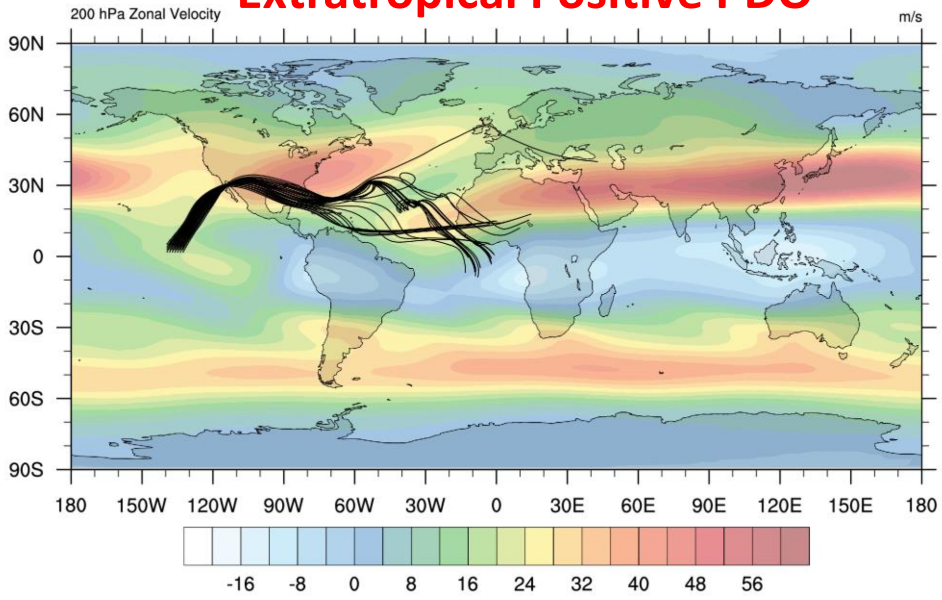


ENSO-PDO Preliminary Results

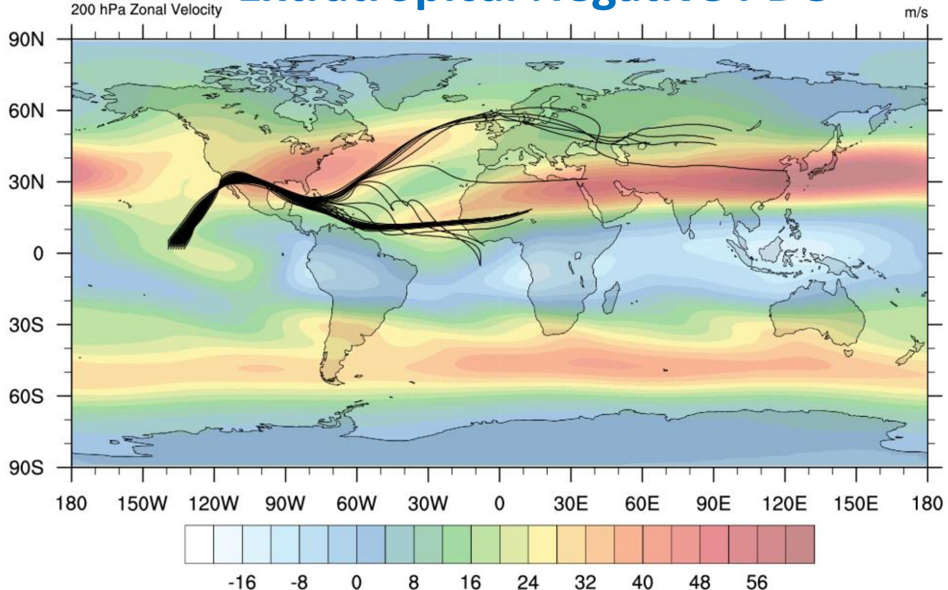
Rossby Wave Ray Tracing (k=4)



Extratropical Positive PDO



Extratropical Negative PDO



Soil moisture sensitivity experiments

- Soil moisture feedbacks to the atmosphere are known to amplify **European droughts** (Zampieri et al. 2009)

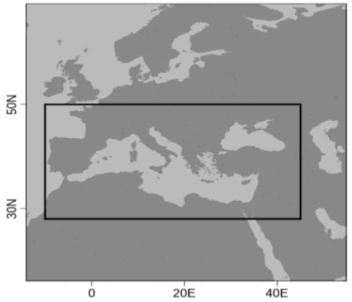
- **Hot extremes are more intense** in case of dry soil conditions over South East Europe (Hirschi 2011)

- Land-atmosphere interaction also impacts the **persistence of heat waves** (Fischer et al. 2007, Lorenz 2010)

- Hot day predictions could be improved in operational forecasts with the aid of soil moisture initialization

3 sets of experiments

- Each experiment => 50-member atmospheric (AMIP-like) simulations from May 1st to October 31st.
- Atmospheric initial conditions from a long AMIP-like simulation with climatological SSTs and GHG forcing fixed to year 2000.
- Land initial conditions: derived from a land-only simulation with **climatological** (1), **null** (2) or **excessive** (3) **precipitation** over a box encompassing the Mediterranean



1) **Climatological land initial conditions**
   - C1: soil moisture evolves freely ✓ $_{mfr}$ X $_{cmcc}$
   - C2: soil moisture constrained to a daily climatology ✓ $_{mfr}$ X $_{cmcc}$
2) **Dry land initial condition**
   - D1: soil moisture evolves freely ✻ $_{mfr}$ X $_{cmcc}$
   - D2: soil moisture constrained to the permanent wilting point ✻ $_{mfr}$ X $_{cmcc}$
3) **Wet land initial conditions**
   - W1: soil moisture evolves freely X $_{mfr}$ X $_{cmcc}$
   - W2: soil moisture constrained to the field capacity X $_{mfr}$ X $_{cmcc}$

- ✓ : Completed
- X : Yet to be done
- ✻ : To be rerun

Soil moisture experiments Preliminary results with CNRM simulations

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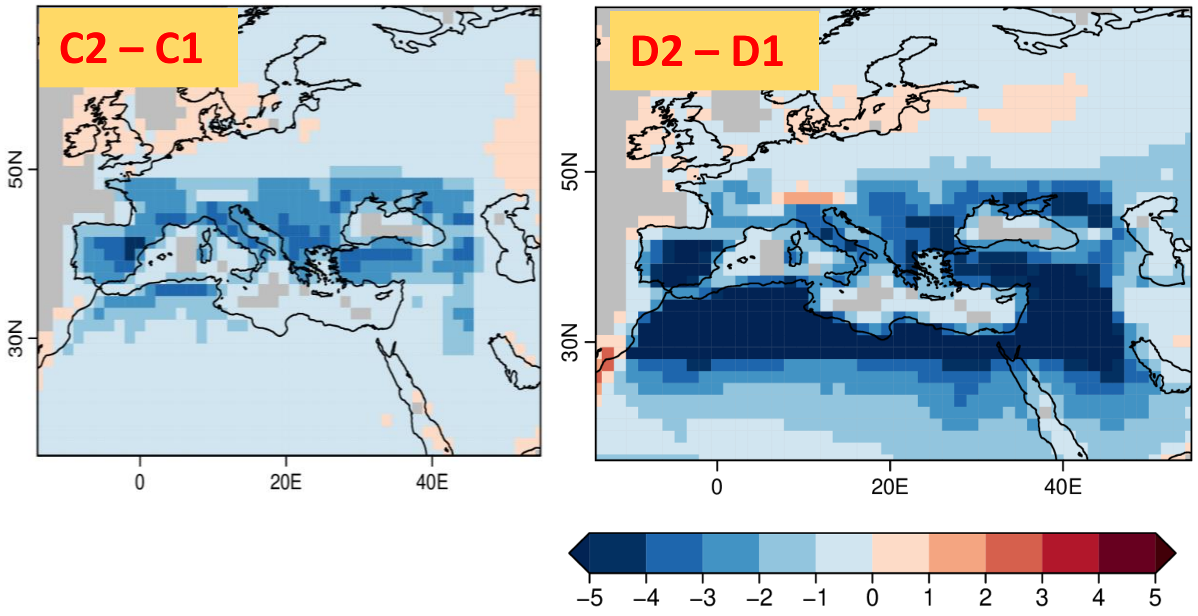
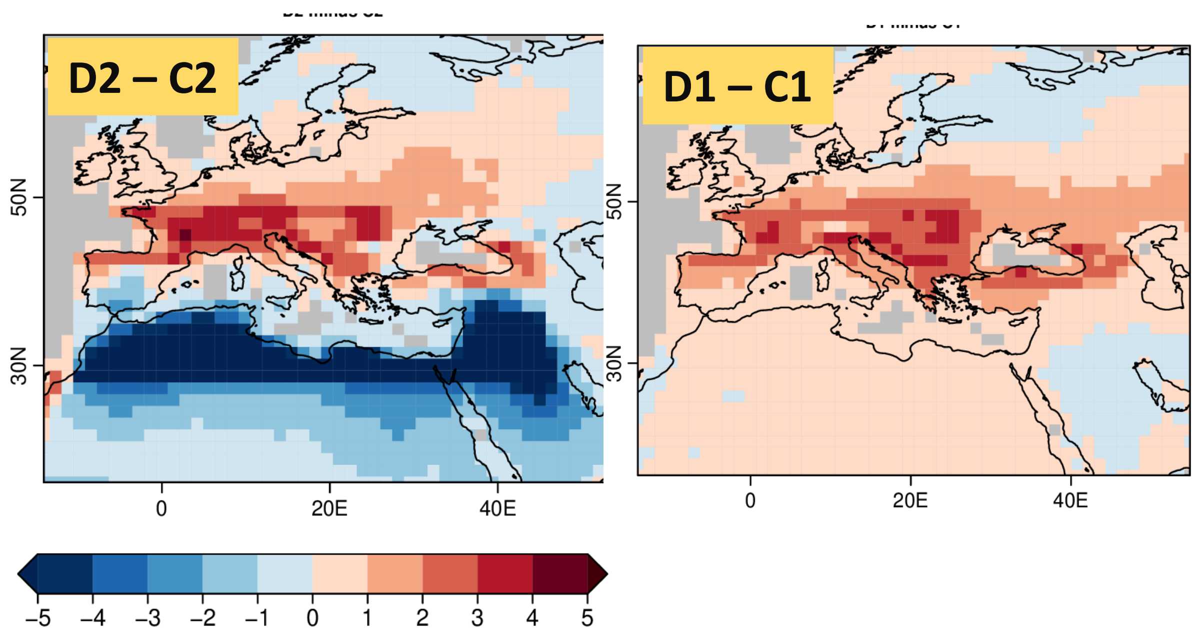
Comparison of the seasonal mean (average of JJA daily values) of the **90th percentile for Tmax**

Effect of **cutting land-atmosphere feedbacks** => widespread decrease of Tmax Q90



Effect of **drier IC** => higher Tmax Q90 in the northern basin, NOT in North Africa and Middle-East in D2 (cfr. D2 issue ?)

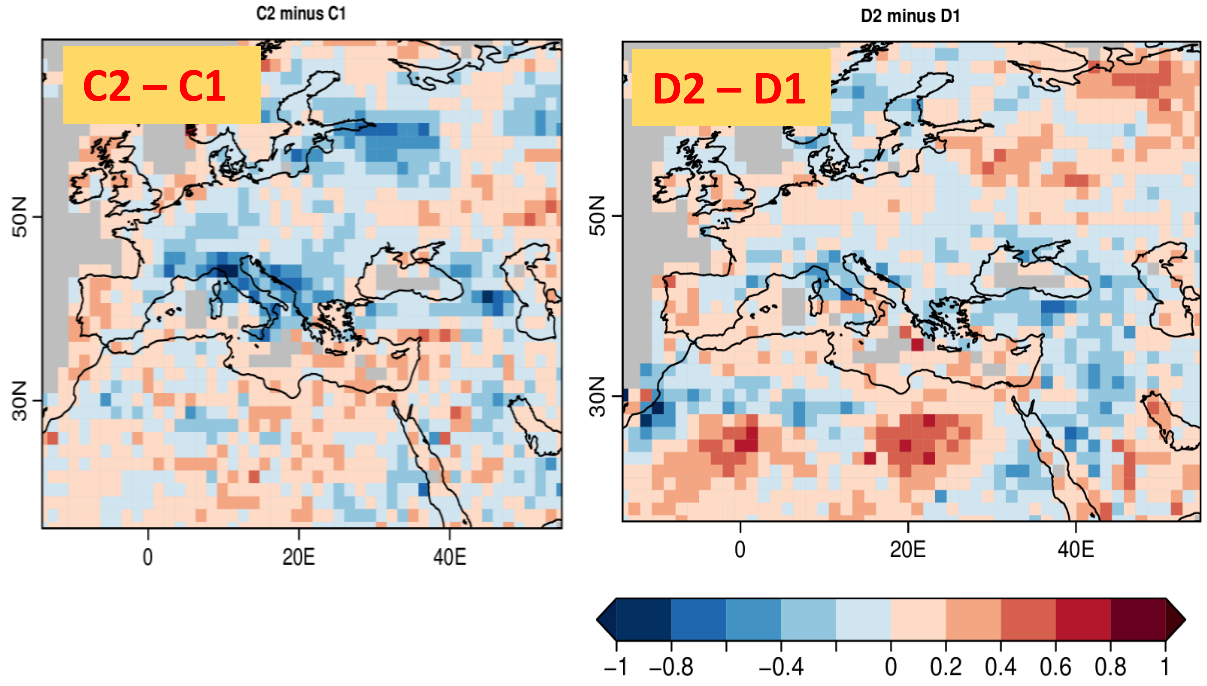


Soil moisture experiments Preliminary results with CNRM simulations

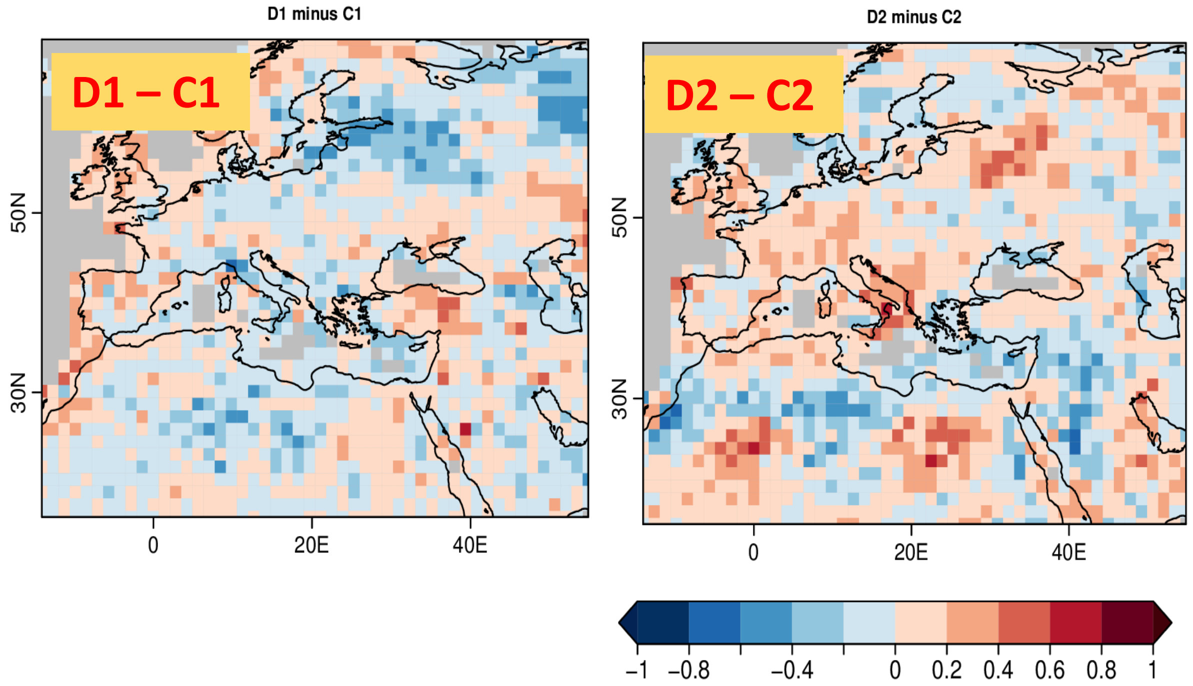
Mean heat wave duration index

(as hwdi* in Lorenz 2010)

Effect of **decoupling land and atmosphere** => heat waves get **slightly shorter** in central Med, when the atmosphere response to soil moisture dryness is removed



Effect of **drier IC** with respect to climatological IC => **slightly longer** heat waves in Southern Europe



Summary and Conclusions

• The aim of this research is to investigate the mechanisms behind potential remote sources of predictability for the Euro-Mediterranean climate.

• This new set of experiments will allow a deeper insight on the processes characterizing the low-mid latitude interactions, soil moisture atmospheric variability and the links between Eurasian snow variability and winter extratropical circulation.

• From the sensitivity analysis performed so far, we have detected a statistically significant change in the ENSO signal over Mediterranean due to a PDO-like forcing.

• A significant non linear component of the interaction between ENSO and PDO has been found over the Euro-Atlantic sector.

• Preliminary results from the Rossby wave ray tracing analysis suggest that different PDO phases may interfere with the planetary wave propagation from the low to the mid latitude

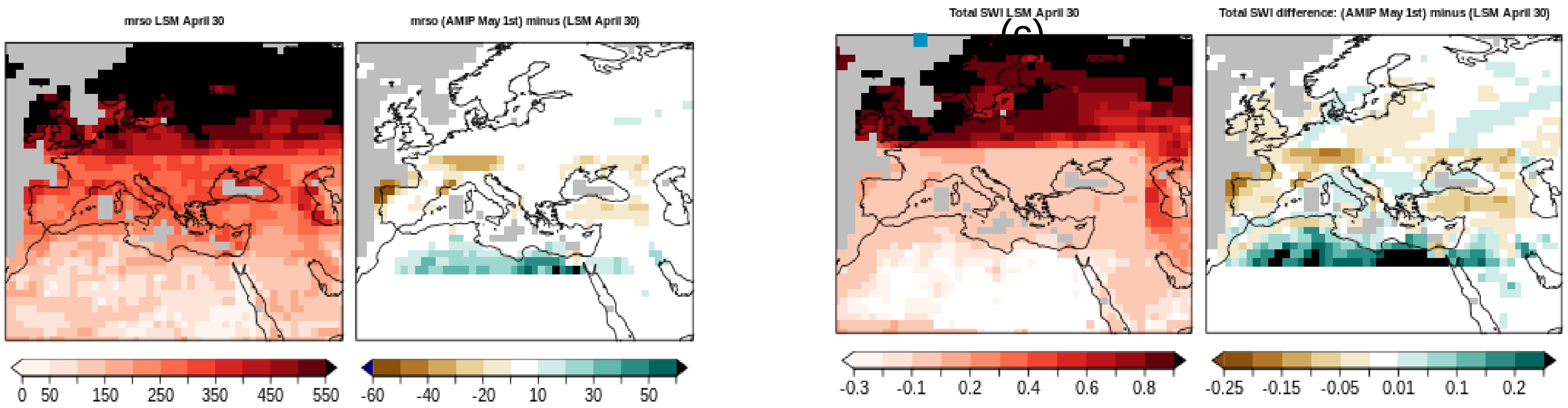
• Yet, no firm conclusions from the soil moisture sensitivity experiments.

MEDSCOPE

Thank you!

Potential issue with D2 setup

- At the end of the land-only simulation with zero precipitation over MED, the soil water content over deserts gets far below wilting point. This is perfectly OK.
- When prescribing soil water content to the wilting point, water is added into desert soils. This is the reason for cooler temperatures. In Lorenz 2010 (comparable setup), deserts are not shown...



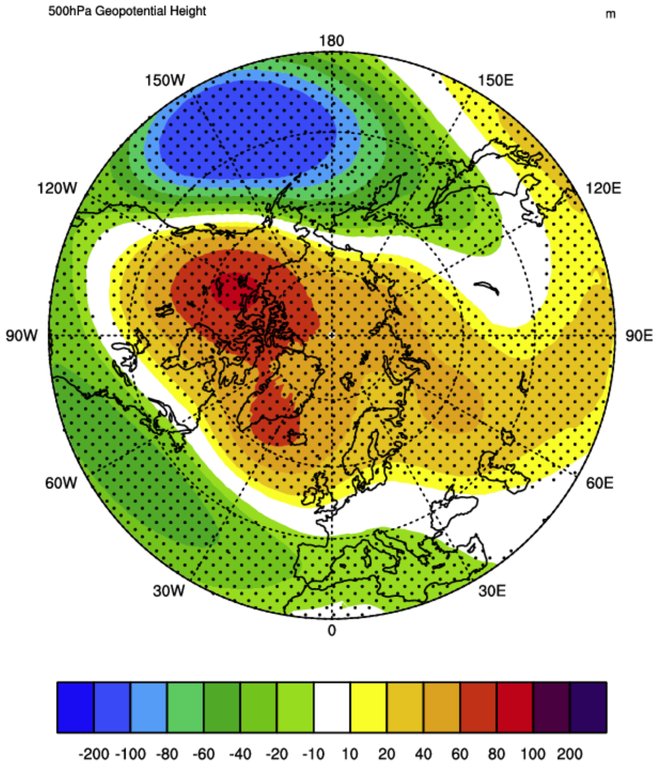
(a) (resp (c))Total soil water content (kg/m2) (resp. Total soil wetness index) in D1/D2 initial conditions
(b) (resp (d)) Soil water content (resp. Total soil wetness index) difference between D2 (after 1 day of simulation) and initial conditions

We slightly changed the protocol: the dry land only experiments will continue until the end of October. The resulting soil moisture ensemble mean climatology will be used as the constraint. In this way, in the African Mediterranean domain we do not risk to add soil water, instead of removing it.

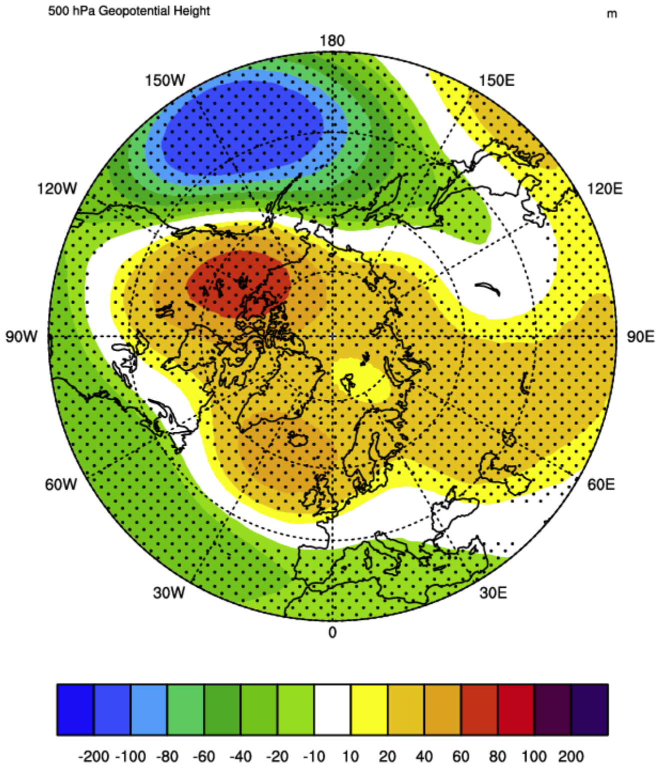
Preliminary Results

Tier1 (ENSO/ENSO+ETPDO): impact on **Z500** **DJF**

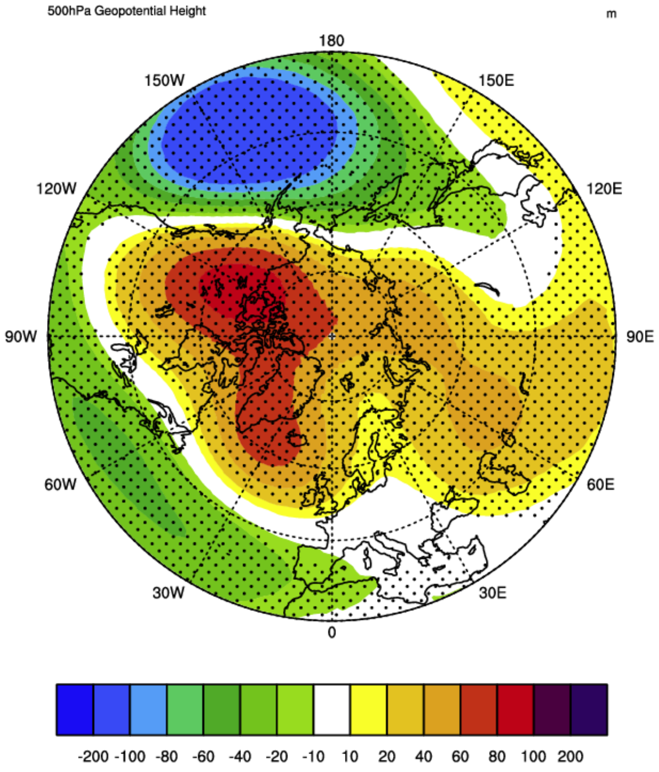
ENSO only - 50 members



ETPDOP/ENSO-CTL - 50 members



ETPDON/ENSO-CTL - 50 members



50 member ensemble mean differences with the reference experiment (climatological SST)

Preliminary Results

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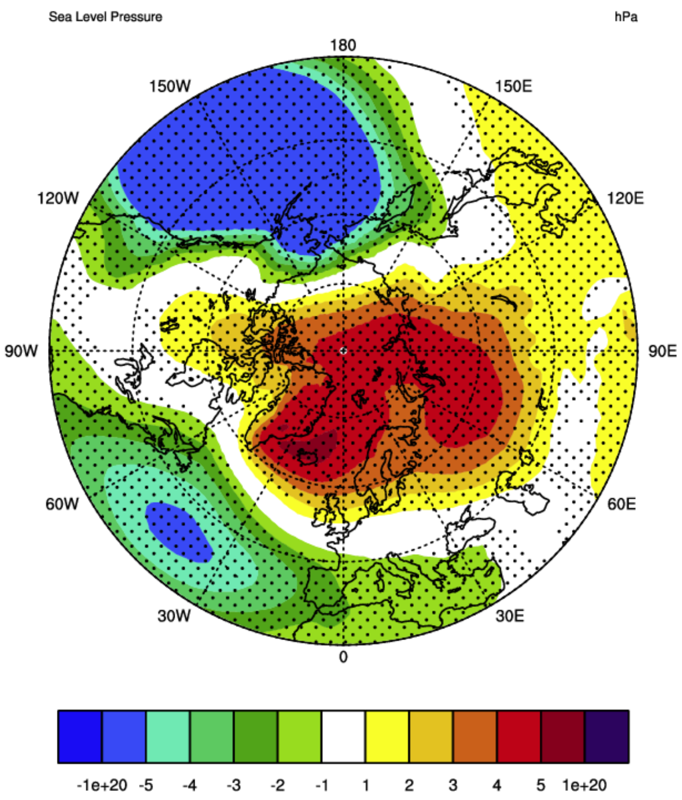
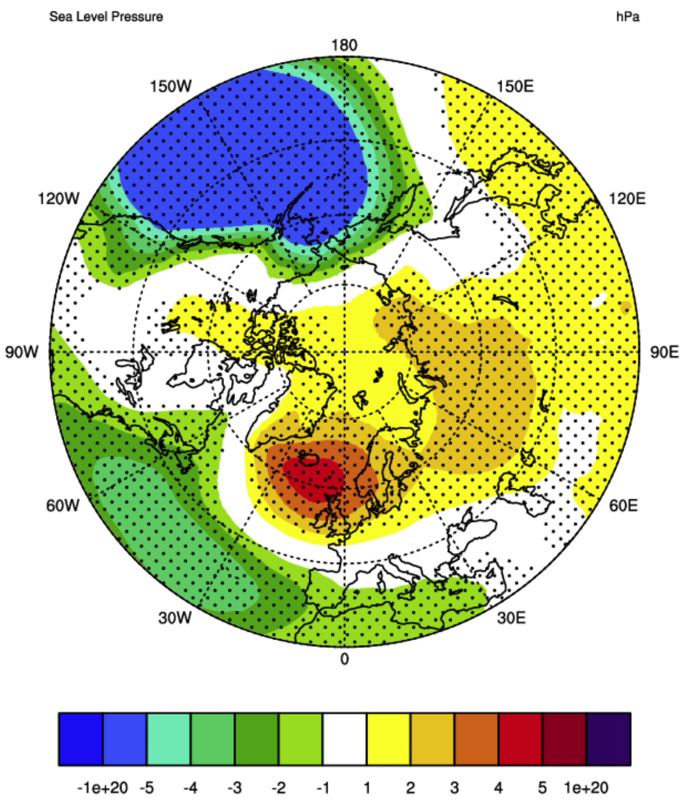
Tier1 (ENSO/ENSO+ETPDO): impact on SLP DJF

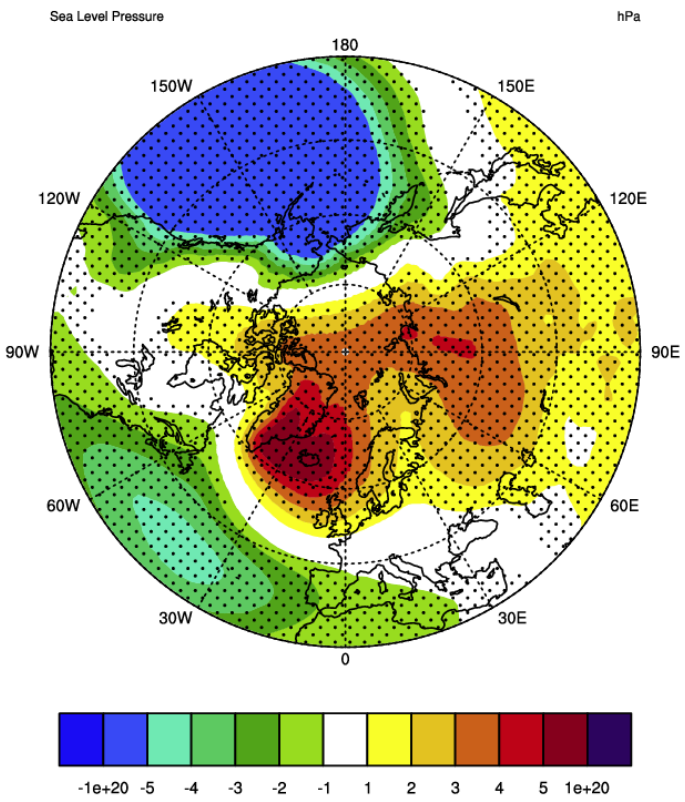
ENSO only - 50 members



ETPDOP/ENSO-CTL - 50 members



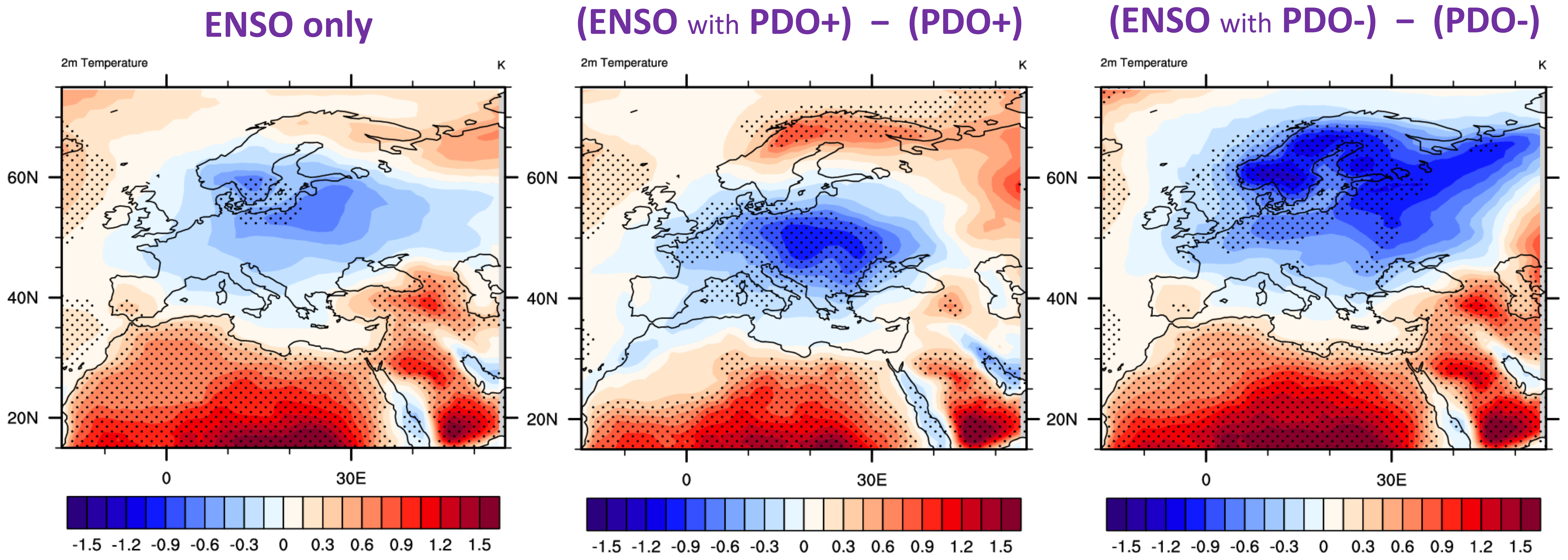
ETPDON/ENSO-CTL - 50 members



50 member ensemble mean differences with the reference experiment (climatological SST)

Preliminary Results

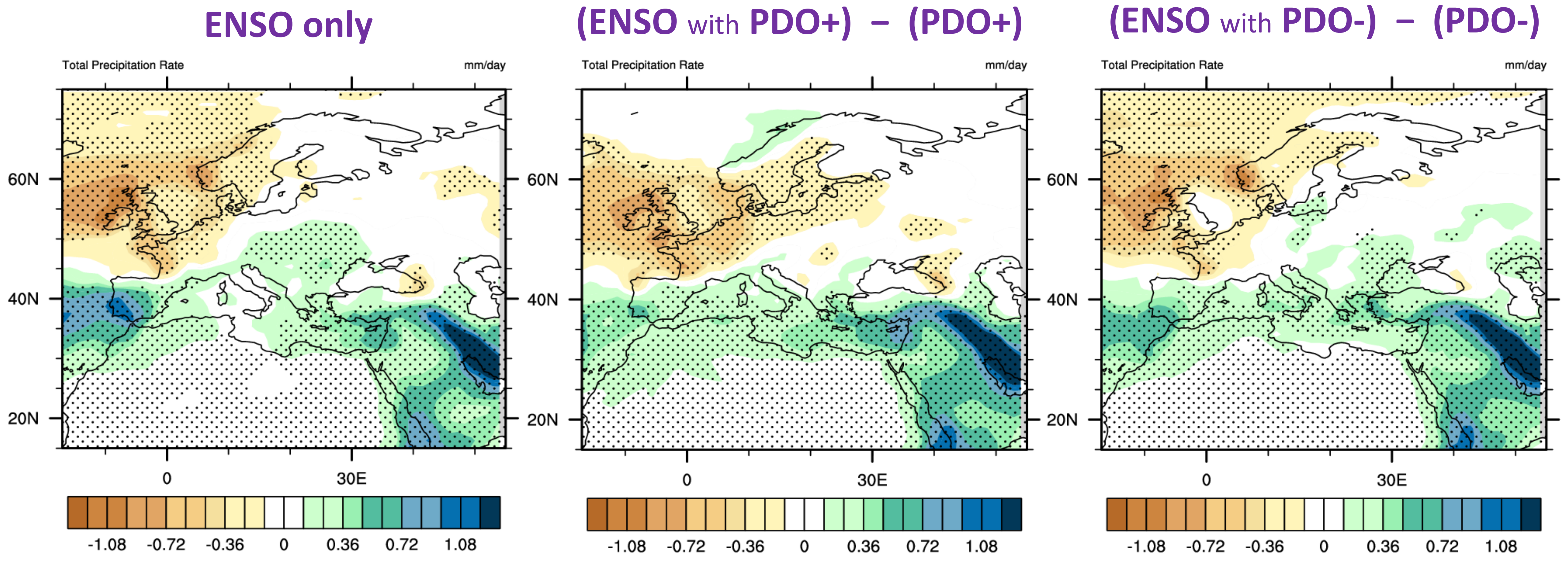
Tier1&2 (ENSO vs. ENSO with PDO): impact on **T2m** **DJF**



50 member ensemble mean differences with the reference PDO state (climatological SST/PDOP/PDON)

Preliminary Results

Tier1&2 (ENSO vs. ENSO with PDO): impact on **Precip** **DJF**

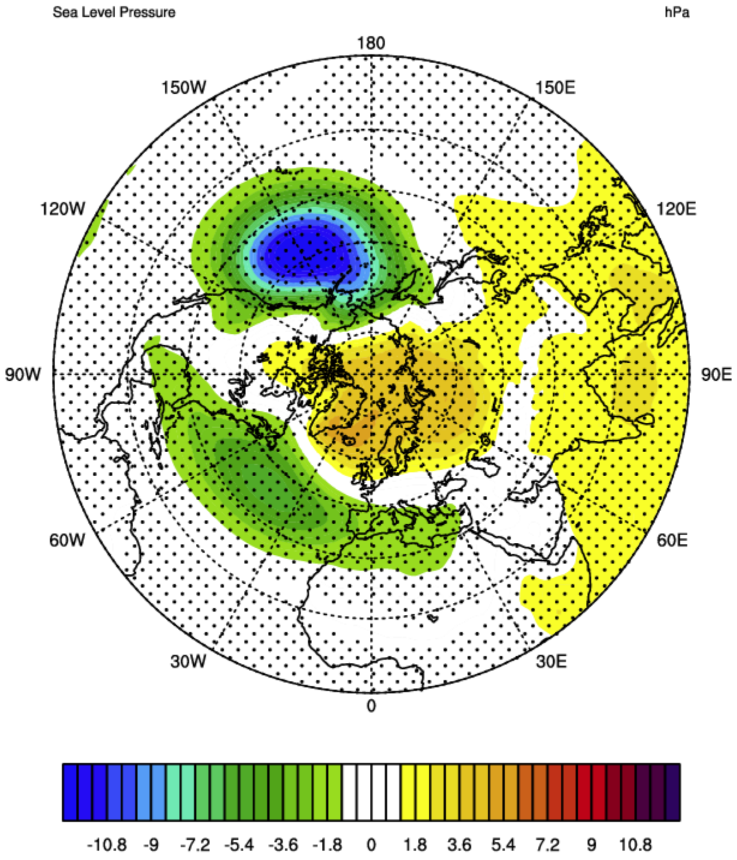


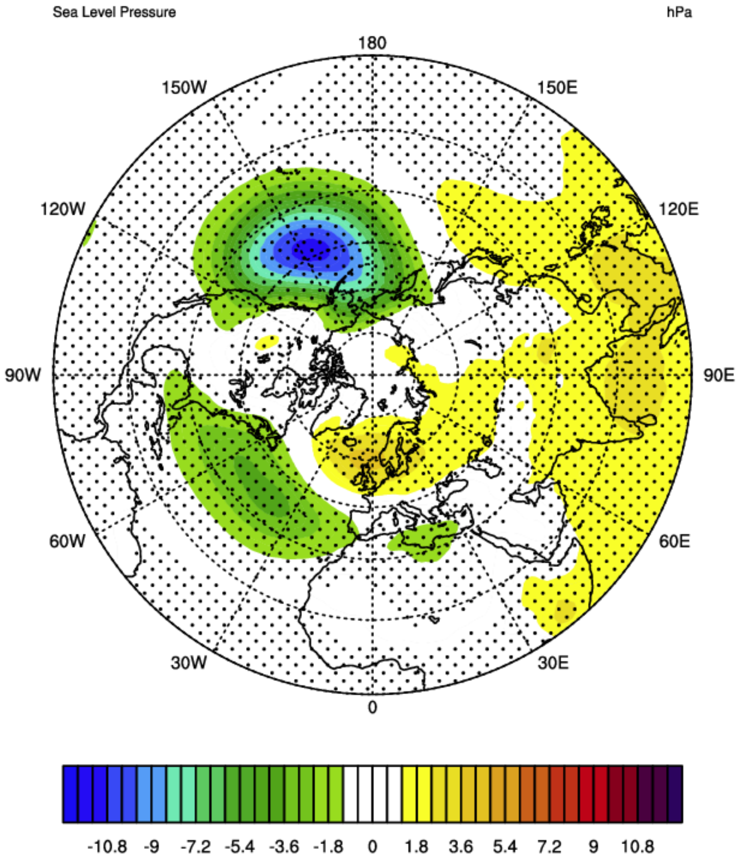
50 member ensemble mean differences with the reference PDO state (climatological SST/PDOP/PDON)

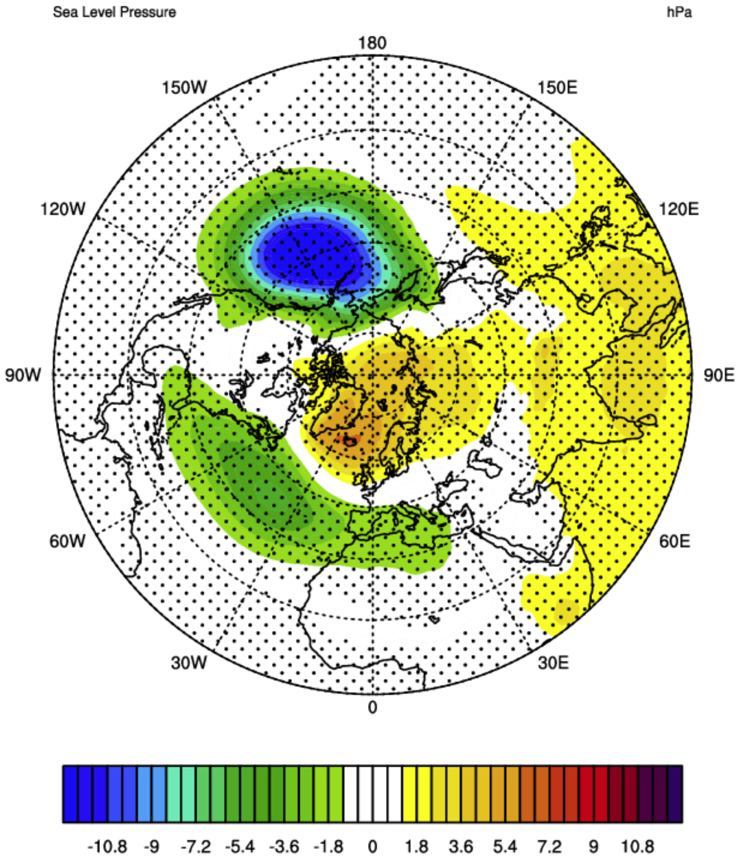
Preliminary Results

<u>Tier1&2</u> (ENSO vs. ENSO with PDO): impact on **SLP** **DJF**

ENSO only | **(ENSO with PDO+) – (PDO+)** | **(ENSO with PDO-) – (PDO-)**



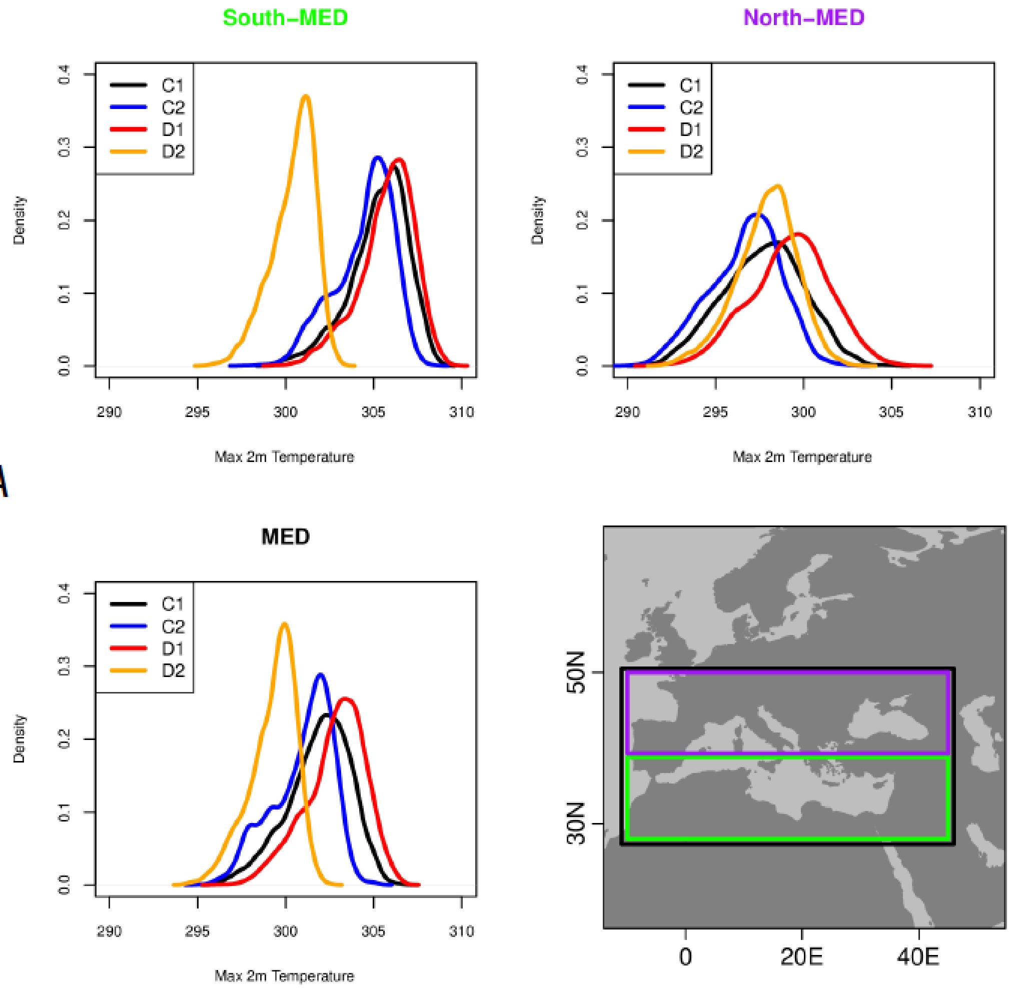




50 member ensemble mean differences with the <u>reference PDO state</u> (climatological SST/PDOP/PDON)

Preliminary results with CNRM simulations

PDF of daily Tmax for JJA

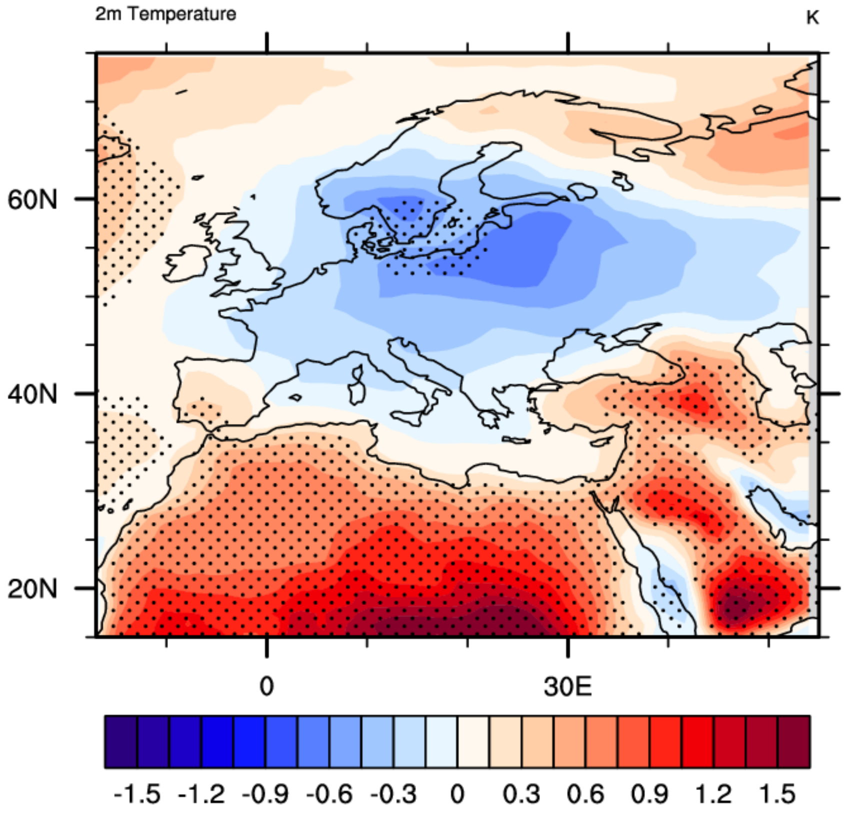


- The pdf of D2 (= simulation with soil moisture nudged towards the wilting point) is shifted towards cooler values over South-MED and MED. Likely a flaw in the D2 set-up (see last slide)
- Focusing on North-MED: C2 and D2 “colder” and more narrow than their coupled counterparts => Land-atmosphere feedbacks contribute to warmer and wider Tmax distribution

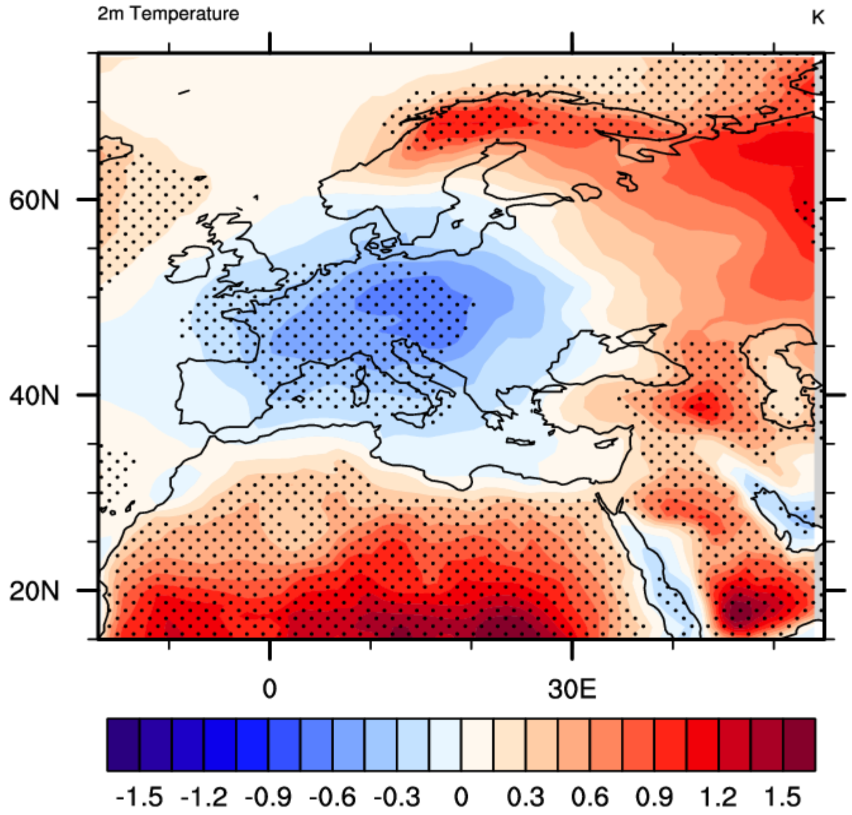
ENSO-PDO Preliminary Results

Tier1 (ENSO/ENSO+ETPDO): impact on **T2m DJF**

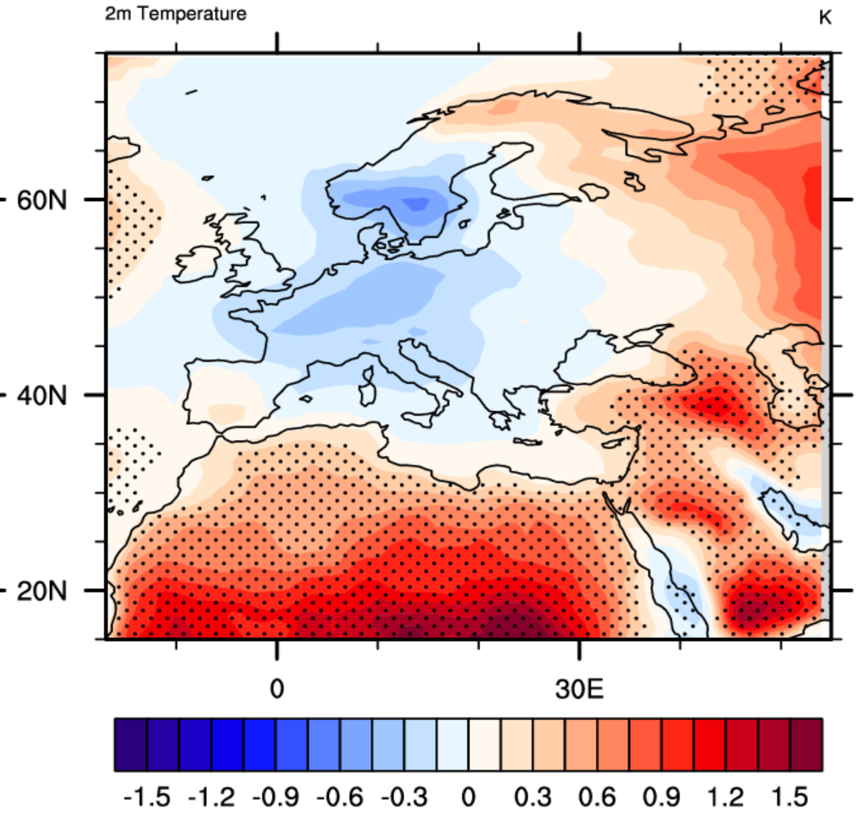
ENSO only



ENSO with PDO+



ENSO with PDO-

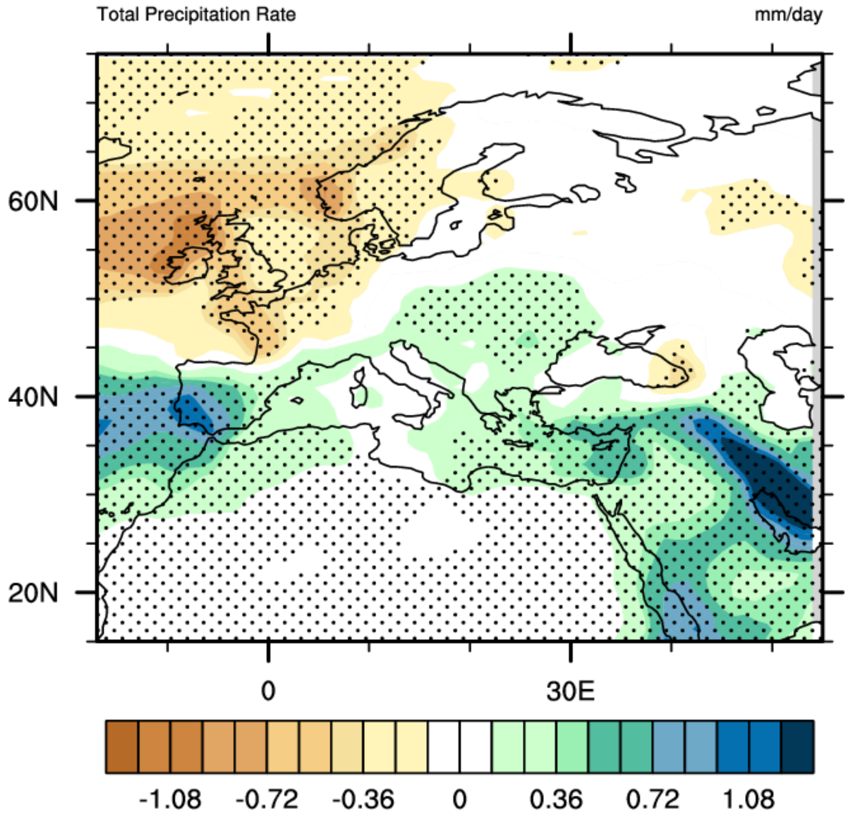


50 member ensemble mean differences with the **reference experiment CTL** (climatological SST)

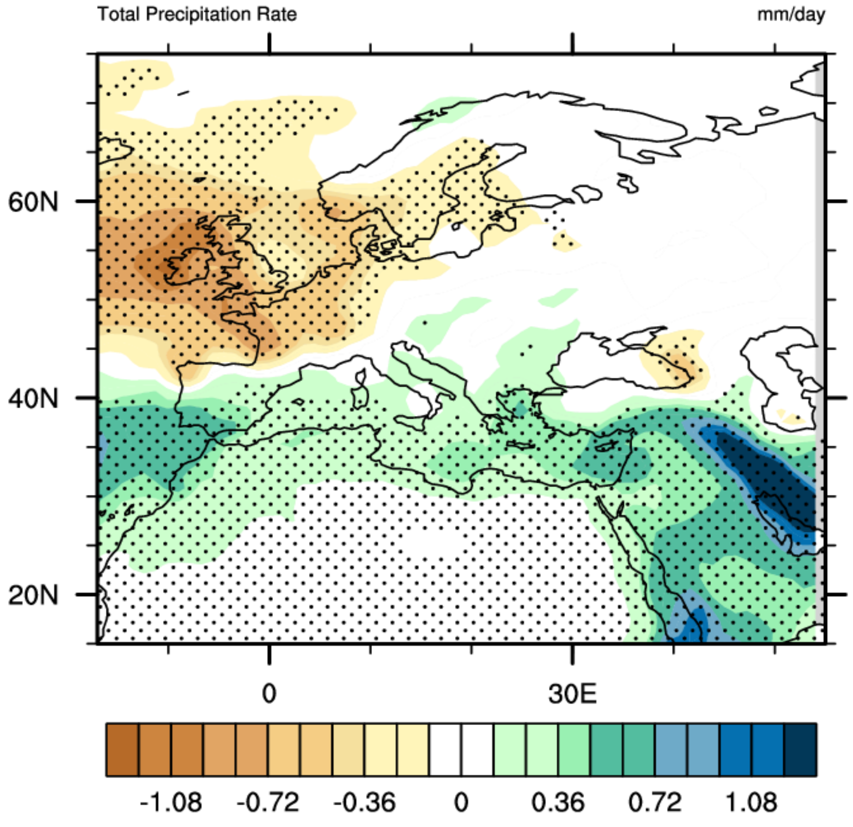
ENSO-PDO Preliminary Results

Tier1 (ENSO/ENSO+ETPDO): impact on **Precip DJF**

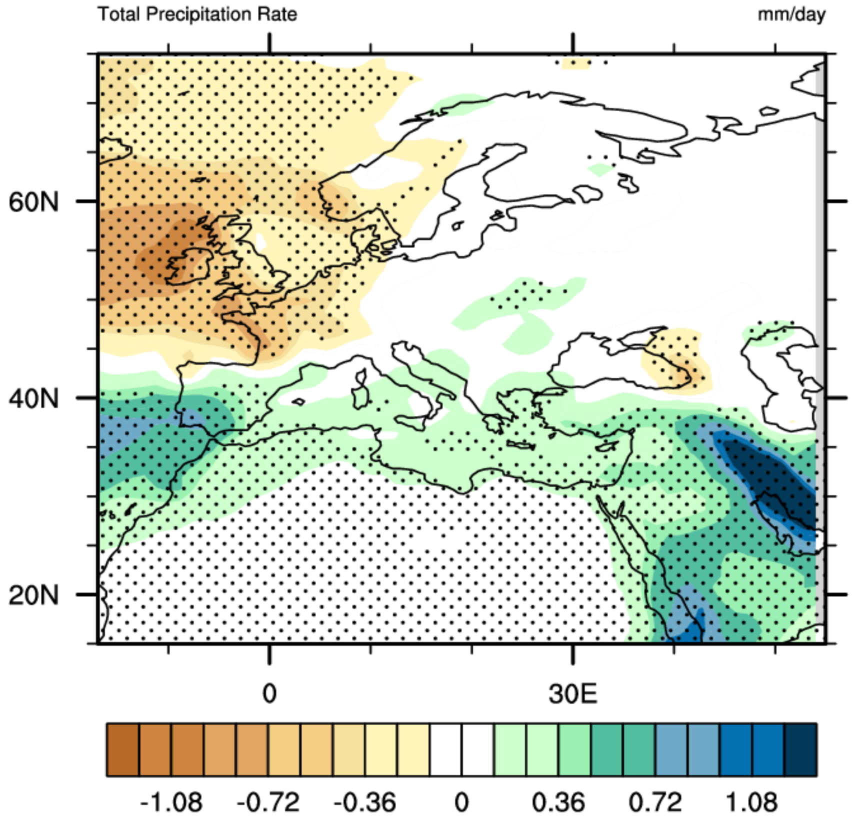
ENSO only



ENSO with PDO+



ENSO with PDO-



50 member ensemble mean differences with the **reference experiment CTL** (climatological SST)