Drivers of climate variability and sources of predictability for the Euro-Mediterranean sector from different Earth system components

Preliminary results from a set of idealised experiments (**MEDSCOPE** project)

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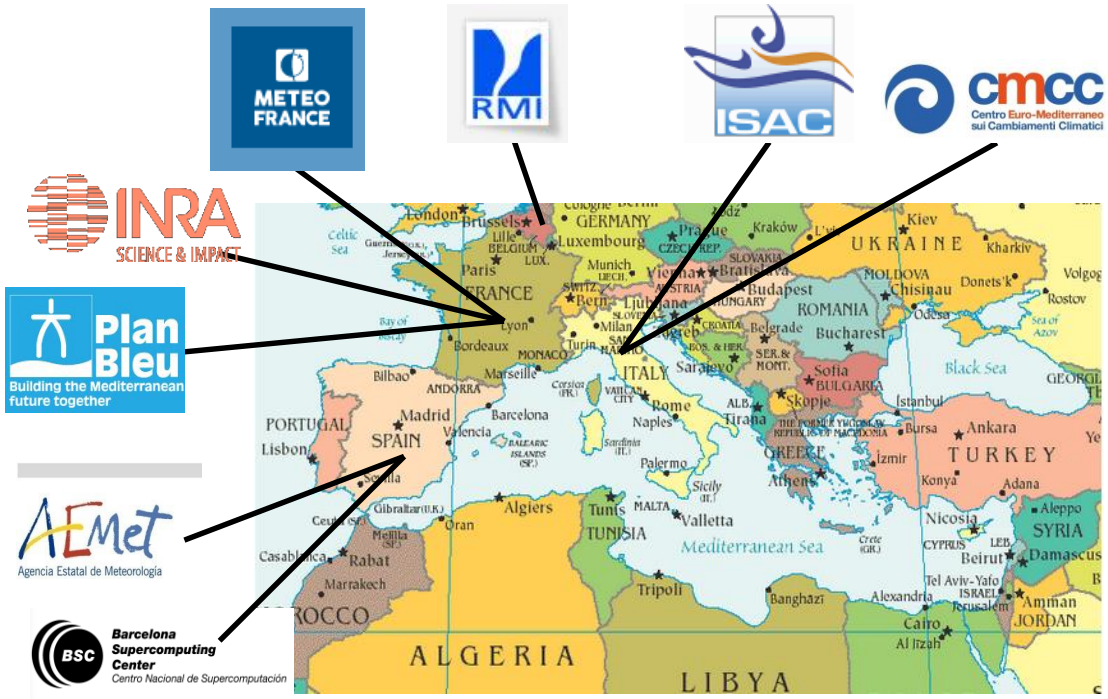
Centro Euro-Mediterraneo sui Cambiamenti Climatici

ERA4CS
European Research Area for Climate Services

MEDSCOPE

The MEDSCOPE Project

MEDSCOPE is a **three-year European project** that wants to **enhance the exploitation of climate predictions**, particularly seasonal forecast, maximising the potential of their **application in different economic sectors** of relevance for the **Mediterranean region**.



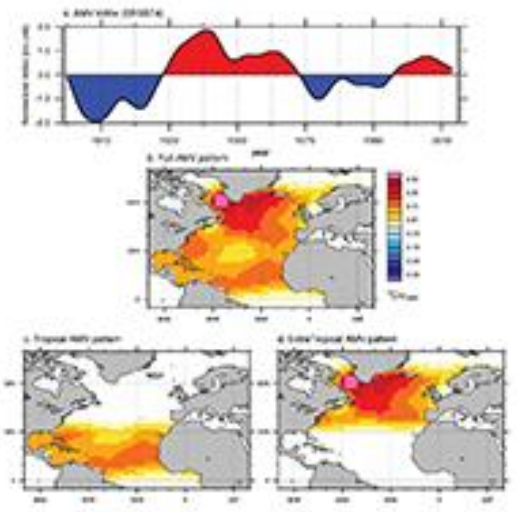
https://www.medscope-project.eu/

ERA4CS European Research Area for Climate Services

MEDSCOPE
MEDiterranean Services Chain based On climate PrEdictions

MEDSCOPE objectives

… provide a **substantial advancement of scientific understanding** of the climate predictability on interannual timescales in the Mediterranean.



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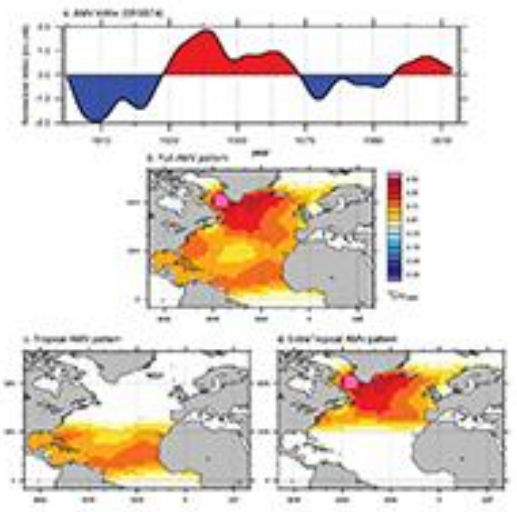

… develop and release **advanced tools** to improve the extraction of relevant information from climate predictions and assess their robustness and uncertainty.

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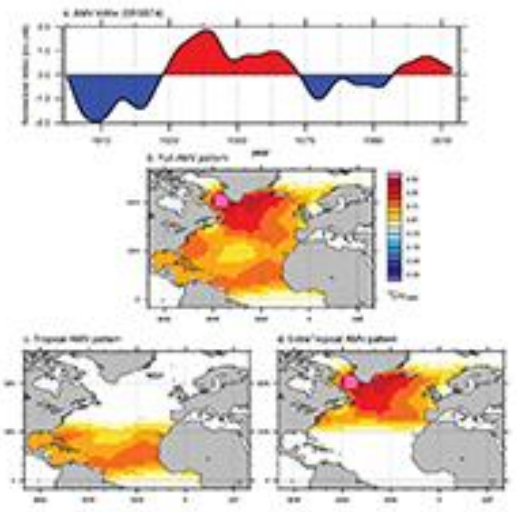


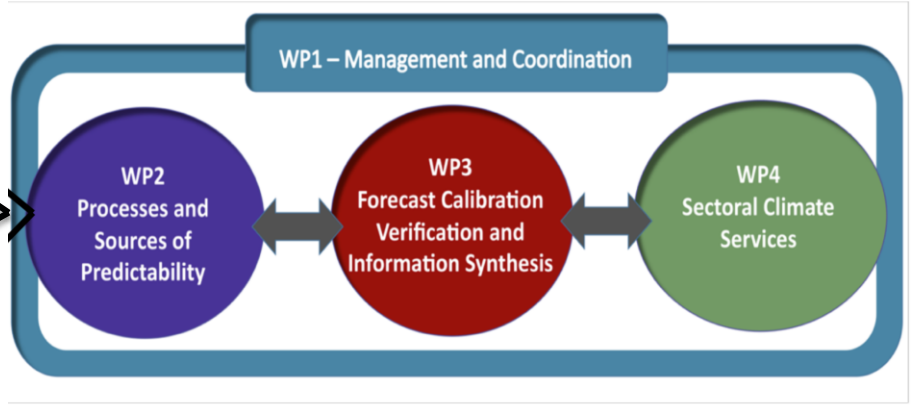
… develop and release **advanced tools** to improve the extraction of relevant information from climate predictions and assess their robustness and uncertainty.

… serve as a **community builder** for future **climate service** activities based on climate predictions in the **Mediterranean**, contributing to build common and shared knowledge.

Understanding Mechanisms

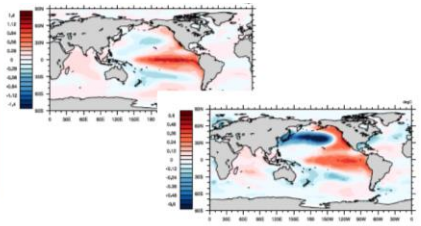
WP2 (Processes and Sources of Predictability):

SENSITIVITY EXPERIMENTS

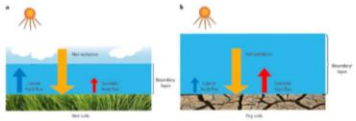


Physical processes driving possible sources of predictability for the Mediterranean region linked with the predictable signal in the **ocean (SST)** or associated with **land–atmosphere interaction**

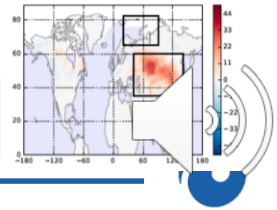
ENSO teleconnections



Soil moisture



Sea–ice and snow cover



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Understanding Mechanisms

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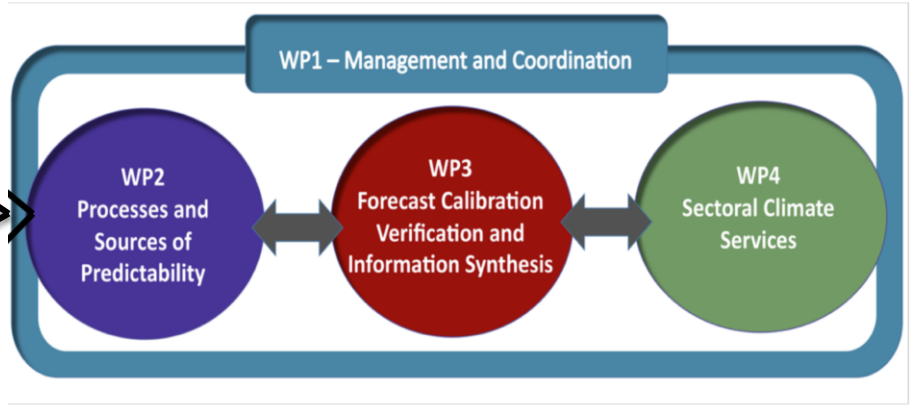

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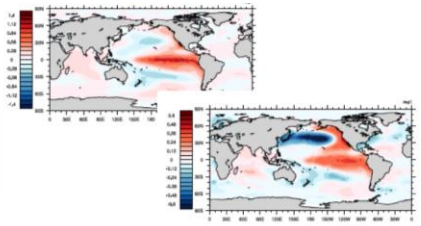
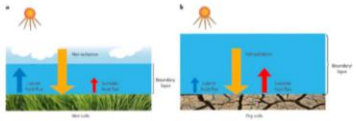


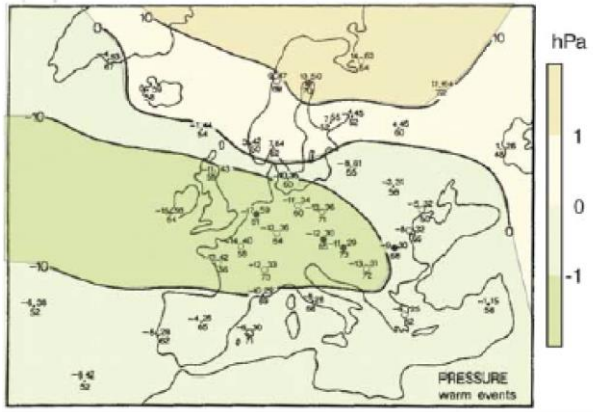
Soil moisture



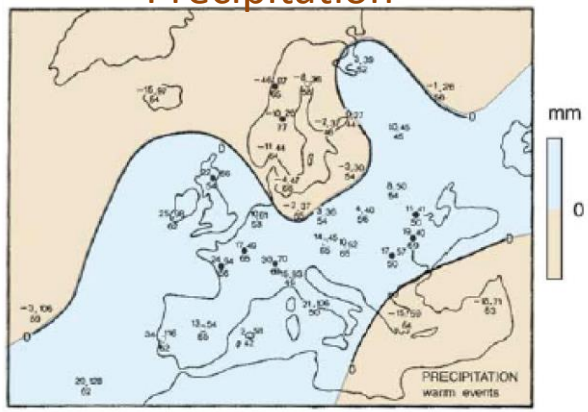
Understanding Mechanisms: Ocean-Atmosphere interaction

The **canonical** winter signal of ENSO over the **Euro-Mediterranean** domain

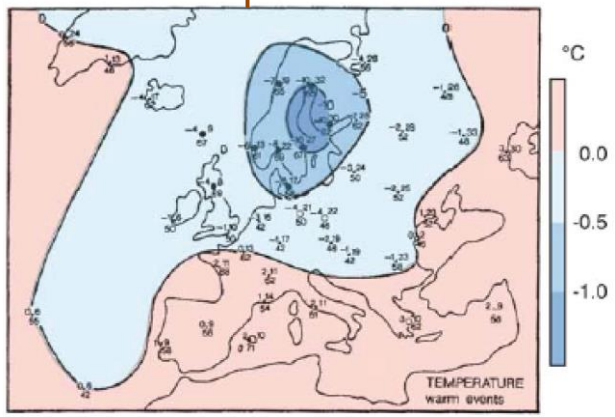
Mean Sea – level Pressure



Precipitation



Temperature



Signal of ENSO in the Euro – Mediterranean region is weak and erratic

Different mechanisms have been identified as involved in spreading the ENSO signal remotely (e.g. planetary wave propagation, changes in Hadley and Walker circulation). The **working hypothesis** is that **changes** in the **mean state** may affect these mechanisms.

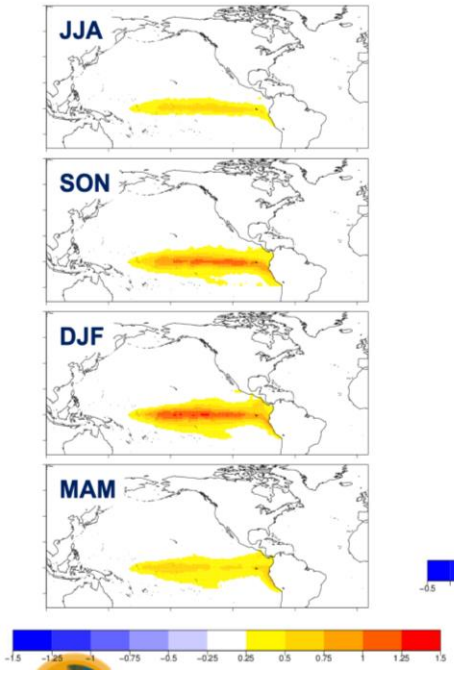
Understanding Mechanisms: Ocean-Atmosphere interaction

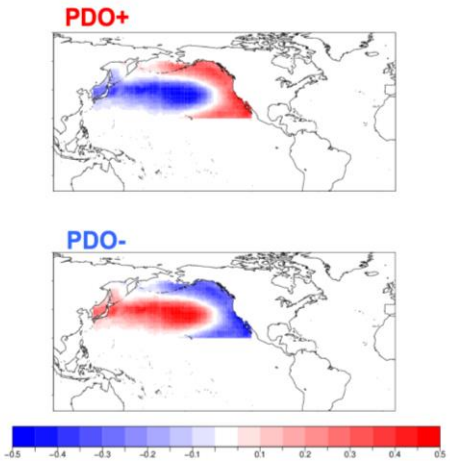
• Sensitivity experiments performed to **investigate if and how the low frequency variability** over the extratropical Pacific (e.g. different **PDO phase**) may modulate the ENSO teleconnection over the Euro-Mediterranean domain.

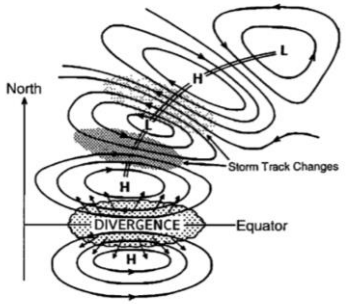
Understanding Mechanisms: Ocean-Atmosphere interaction

• Sensitivity experiments performed to **investigate if and how the low frequency variability** over the extratropical Pacific (e.g. different **PDO phase**) may modulate the ENSO teleconnection over the Euro-Mediterranean domain.

• **changes in the mean state**, linked to **different PDO phases, may affect planetary wave propagation** involved in spreading the ENSO signal across the globe.







[Trenberth et al. 1998]

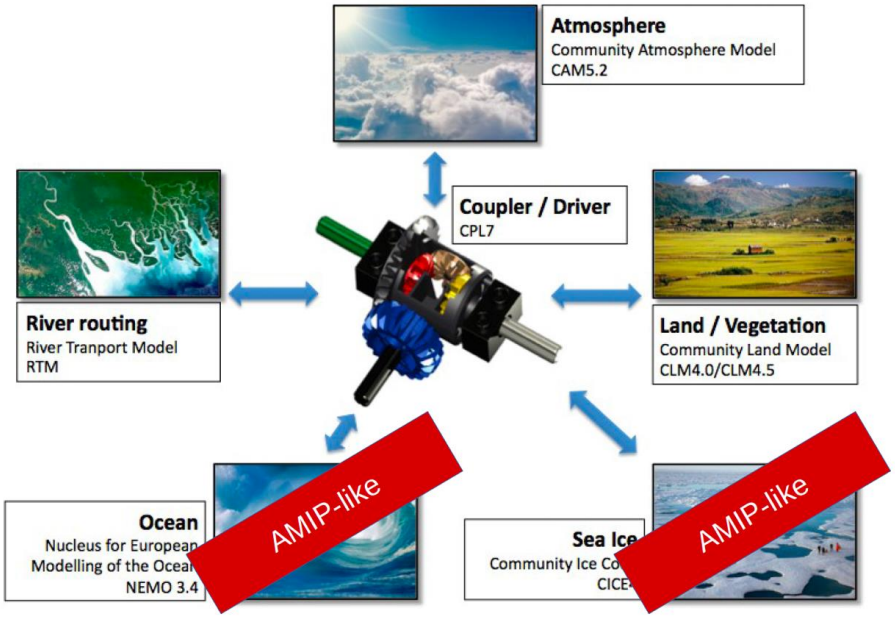
Understanding Mechanisms: Ocean-Atmosphere interaction

ENSO/PDO experimental setup

- **AMIP-like experiments accounting for different idealized SST forcings** focus on atmospheric response

- CTRL: 50–year recursive year 2000 condition control run (**climatological SST**)

- For each experiment: **50 member ensemble**

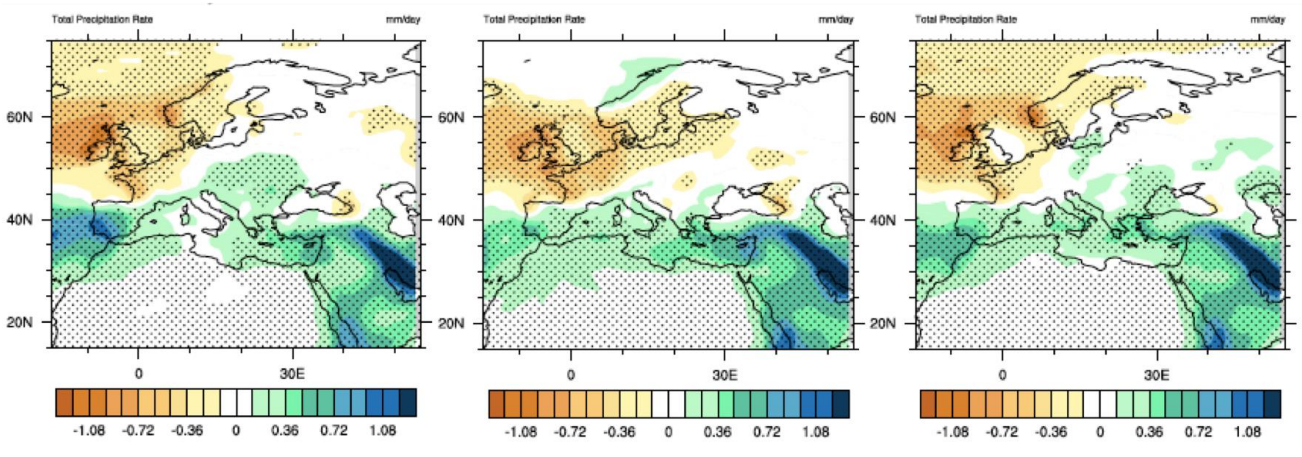


- Each simulation is **initialized from the control run** (each 1st June)
- The duration of each simulation **is one year (June to May)**
- SST boundary conditions computed from **HadiSST** reanalysis

Understanding Mechanisms: Ocean-Atmosphere interaction

NINO only **NINO with PDO+** **NINO with PDO-**

DJF Precipitation



PDO modulation of the **ENSO effects** on the **DJF European and Mediterranean climate**

Understanding Mechanisms: Ocean-Atmosphere interaction

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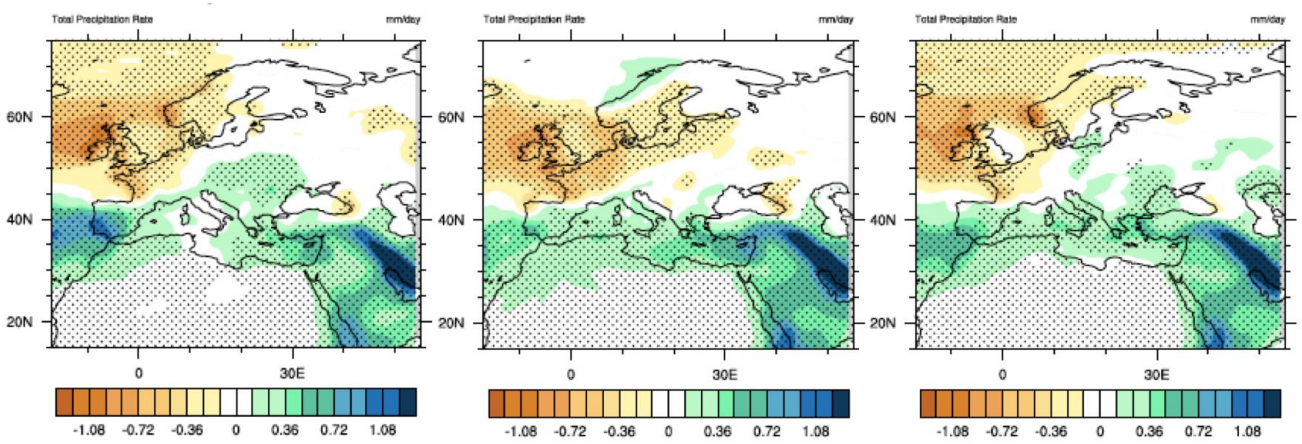
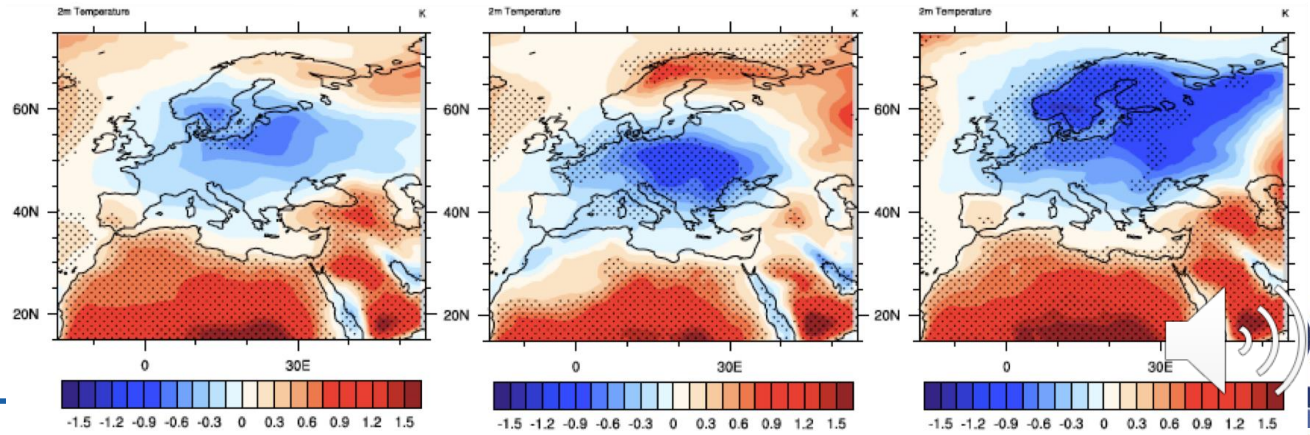
DJF Precipitation



DJF 2m–Temperature

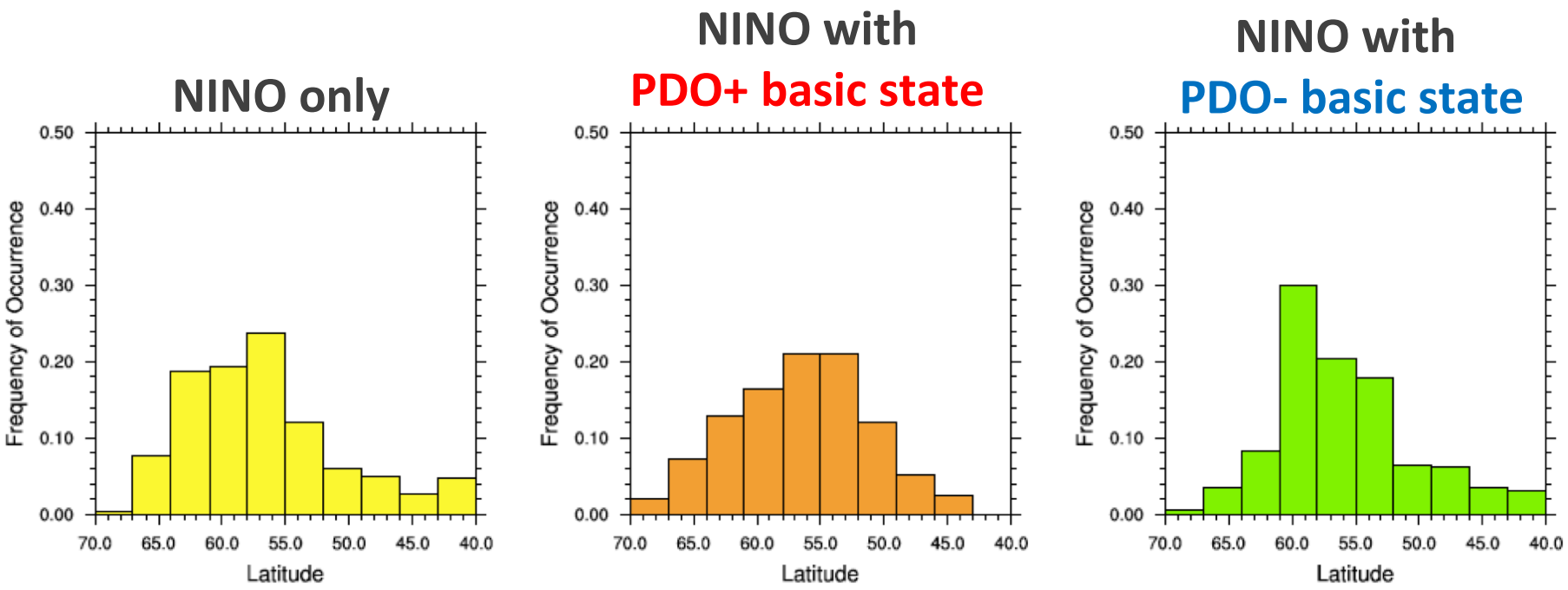


PDO modulation of the **ENSO effects** on the **DJF European and Mediterranean climate**

ERA4CS European Research Area for Climate Services

Chain based On climate PrEdictions

Understanding Mechanisms: Ocean-Atmosphere interaction



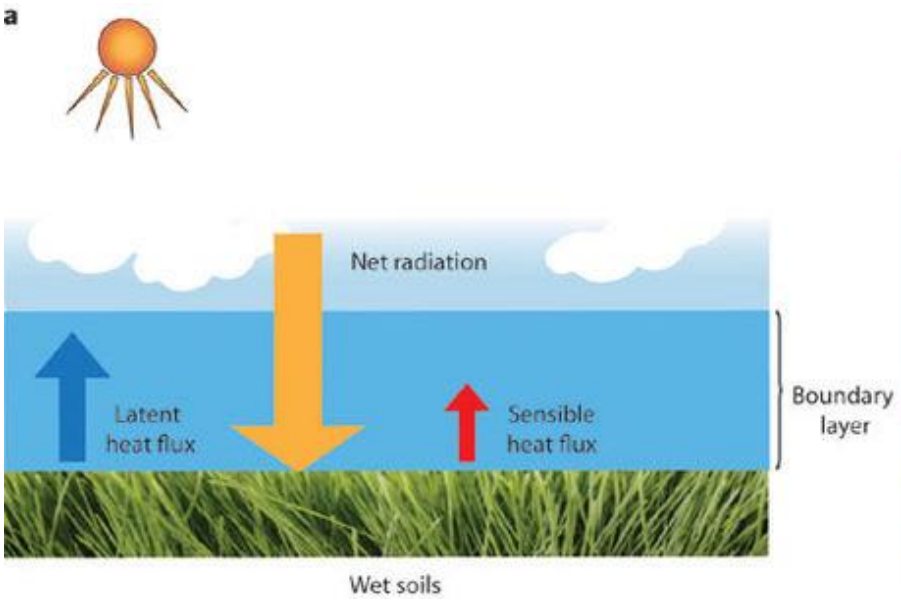
Probability distribution of Rossby Wave rays (k=2-5) entering in the Euro-Med domain

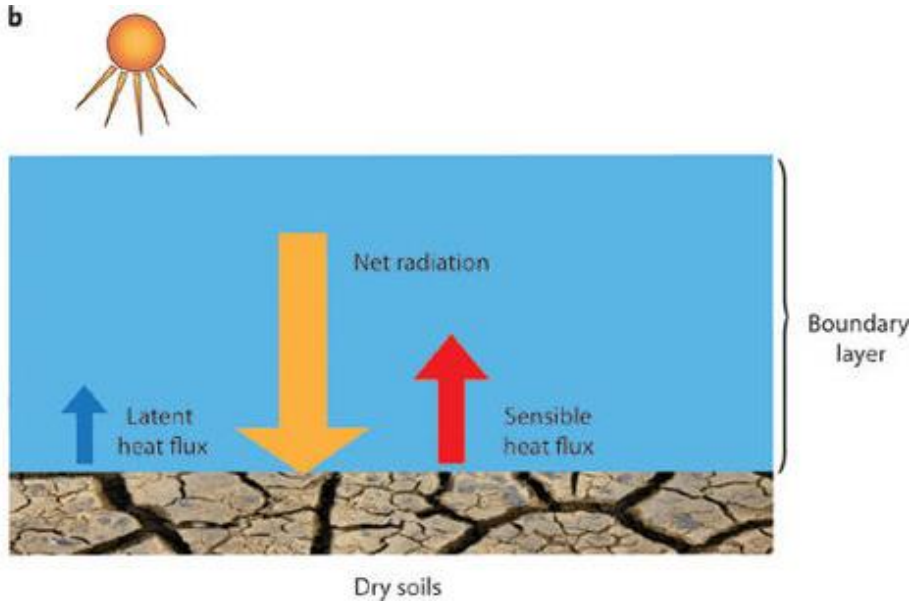
With negative **PDO-** conditions there is a **northward shift** of the distribution, whereas an enhanced **meridional spread distribution** is found with a positive **PDO+** mean state

MEDSCOPE

Understanding Mechanisms: Soil moisture–atmosphere feedback

Soil moisture feedbacks to the atmosphere play an important role in shaping **summer temperatures** and eventually in modulating duration and intensity of heat waves.





If **soil is wet**, the **latent heat flux** by evaporation and transpiration **dominates onto sensible heat flux**, favouring **cloud formation and a tendency for cooling**.

If **soil-moisture deficit** is high, **sensible heat flux increases**, producing a **deeper, warmer and drier low-level atmosphere**. This process inhibits convection and cloud formation and creates a **positive feedback loop**.

Understanding Mechanisms: Soil moisture–atmosphere feedback

Soil moisture experimental setup

three paired experiment initialized on May 1st and lasting six months, until October 31st

Climatological land initial conditions_

C1: soil moisture **evolves freely**, fully interacting with atm

C2: soil moisture **constrained to "a climatological state"**

Dry land initial condition

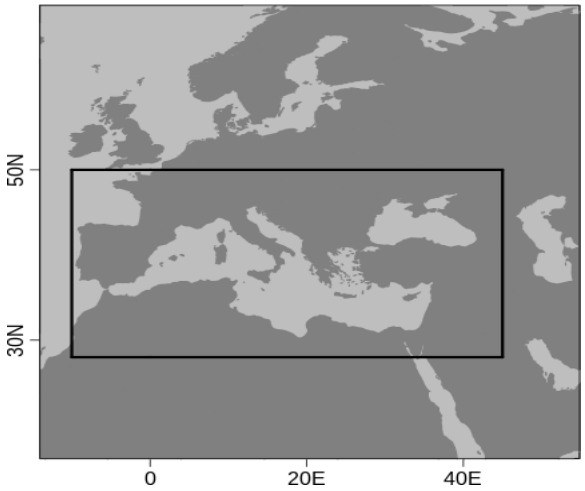
D1: soil moisture **evolves freely**

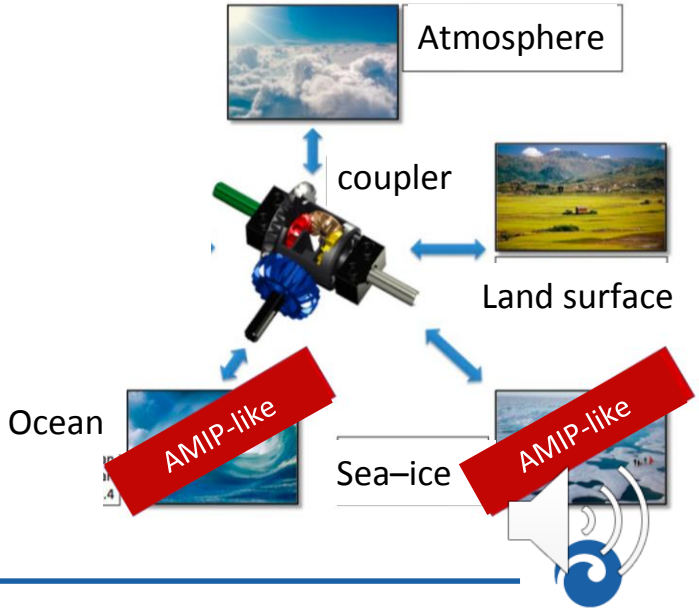
D2: soil moisture **constrained to "a dry state"**

Wet land initial conditions

W1: soil moisture **evolves freely**

W2: soil moisture **constrained "a wet state"**





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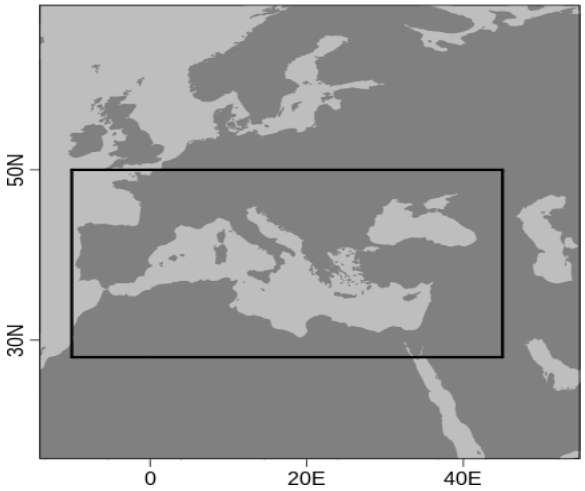
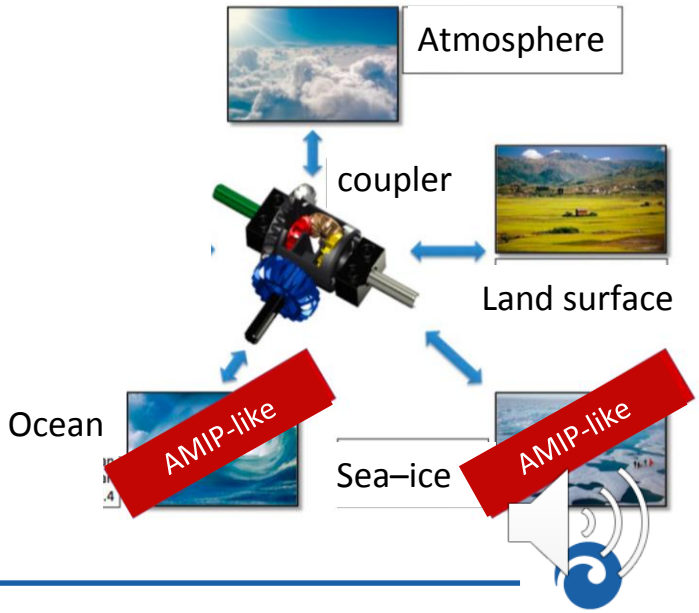
Wet land initial conditions

W1: soil moisture **evolves freely**

W2: soil moisture **constrained "a wet state"**

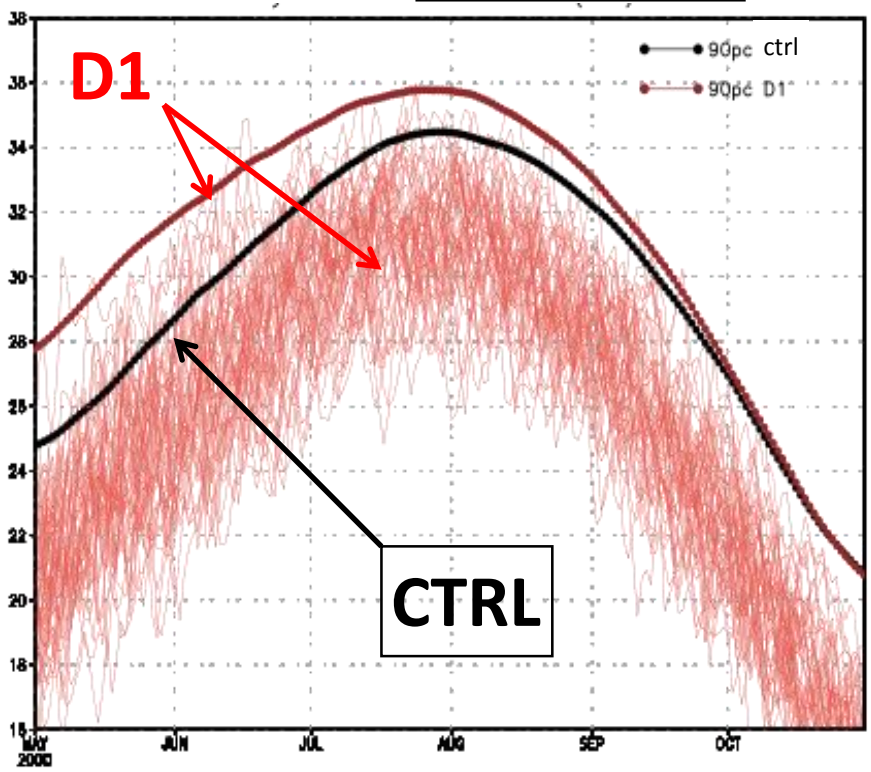
Each experiment is made of **50 simulation members**. The experiments are compared to a 50 ensemble member baseline run **(CTRL)**, climatological SST and GHGs prescribed to a 2000 value.



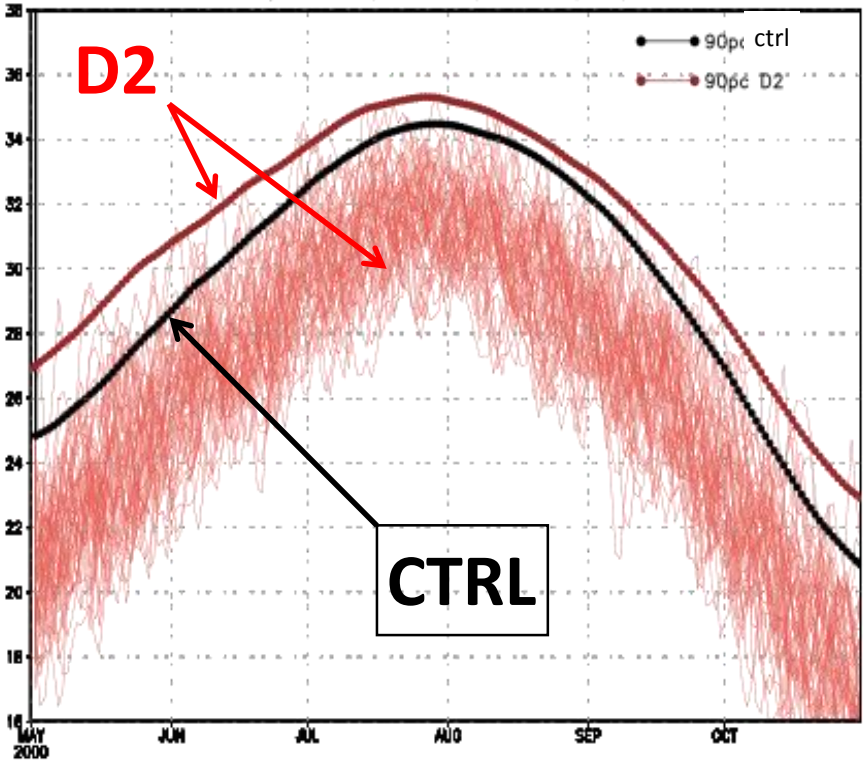


Tmax response

DRY soil **initialization**



DRY soil **prescription**

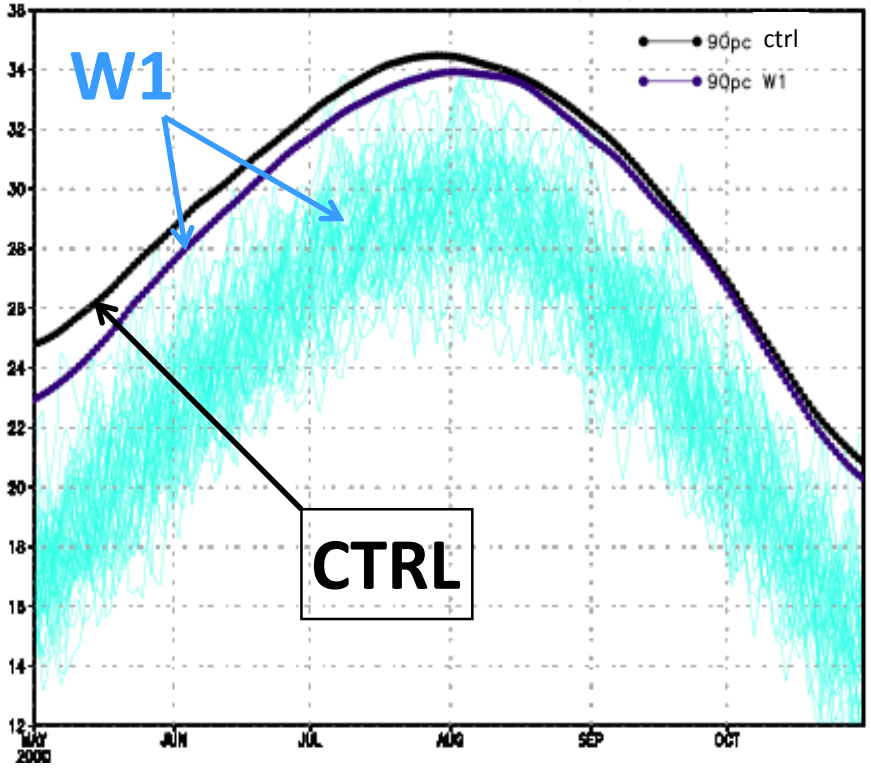


- extreme Tmax warmer than CTRL (about 3°C in early season and 1.5°C at the end of summer)
- effect lasting until the end of August.

- smaller differences with CTRL persisting also during wet season (Sep–Nov)

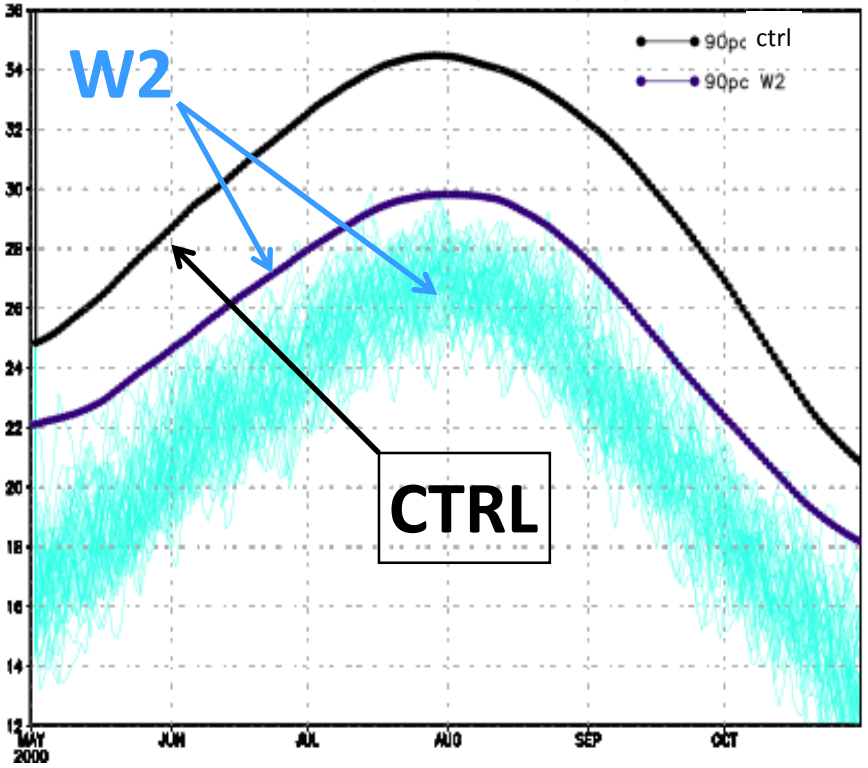
Tmax response

WET soil **initialization**



• impact is shorter-lasting than in the dry case, and at the end of June W1 and CTRL temperatures are very similar.

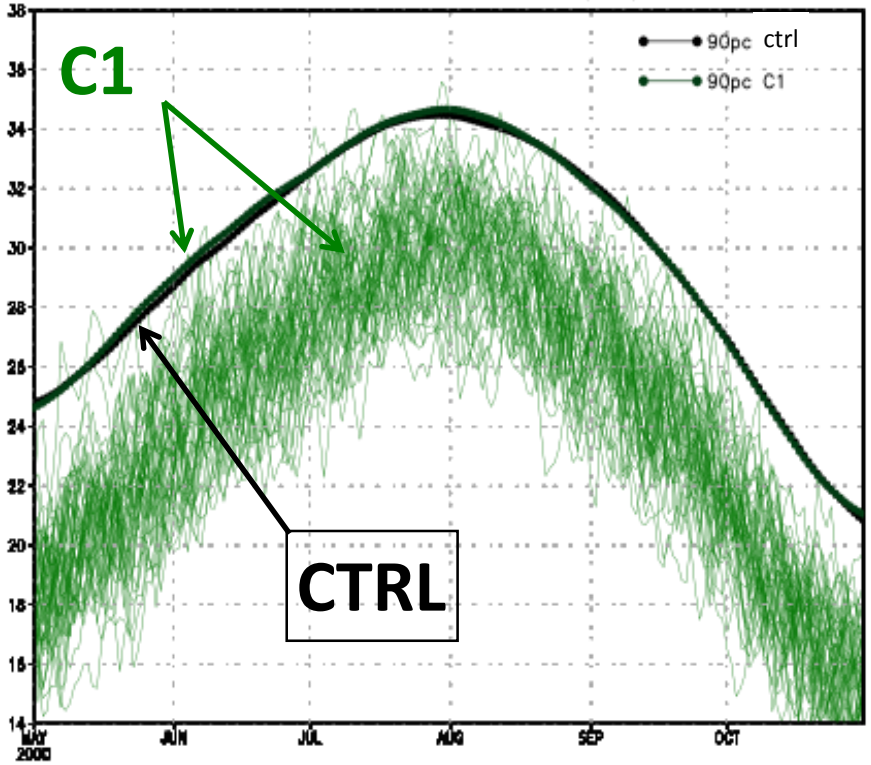
WET soil **prescription**



• considerable temperature decrease (about 3-4°C) persisting throughout the period.

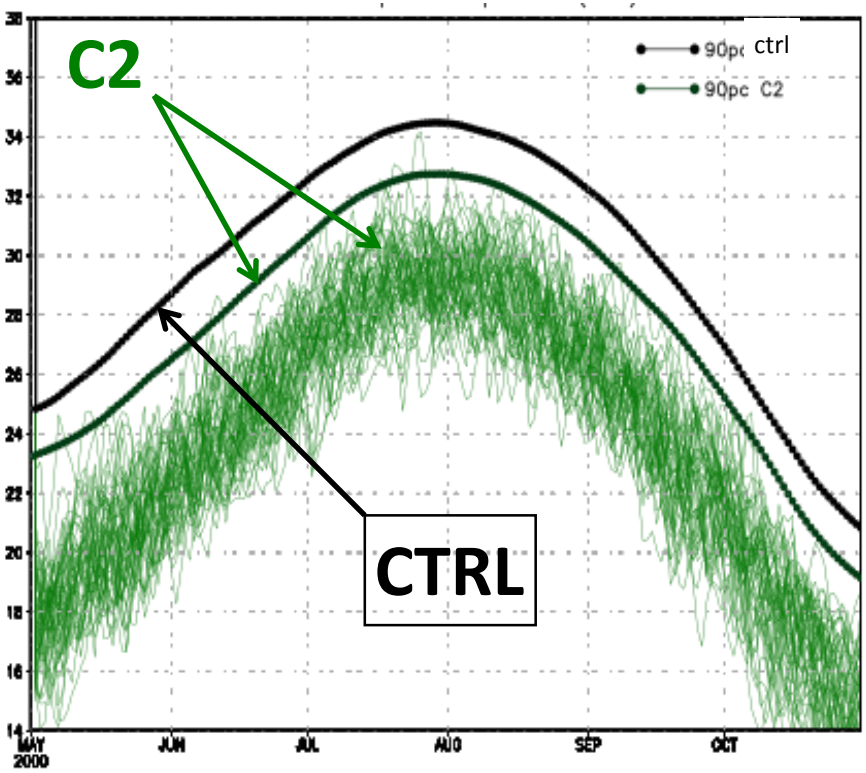
Tmax response

CLIM soil **initialization**



• temperature response comparable to the **CTRL** response.

CLIM soil **prescription**



• Tmax lower than in the CTRL.

• Land–atmosphere coupling generates higher Tmax values

Summary and Conclusions

This new set of sensitivity experiments aims to investigate the processes and the mechanisms behind remote and local sources of predictability for the Euro-Mediterranean climate

- ✓ A statistically significant modulation of the ENSO signal over the Euro-Atlantic region due to the PDO SST forcing is found, showing different sign across the multi-model ensemble
- ✓ The Rossby wave ray tracing analysis suggests that different PDO phases may potentially interfere with the planetary wave propagation from the low to the mid latitude, with a consistent signal over the Mediterranean sector
- ✓ Over the Mediterranean domain, a drier soil enhances higher temperature in summer, while wet conditions strongly reduce temperature extremes.
- ✓ The coupling between land and atmosphere is crucial in representing the variability and the extremes in summer temperature, regardless of the soil moisture state.

Thanks for your attention!

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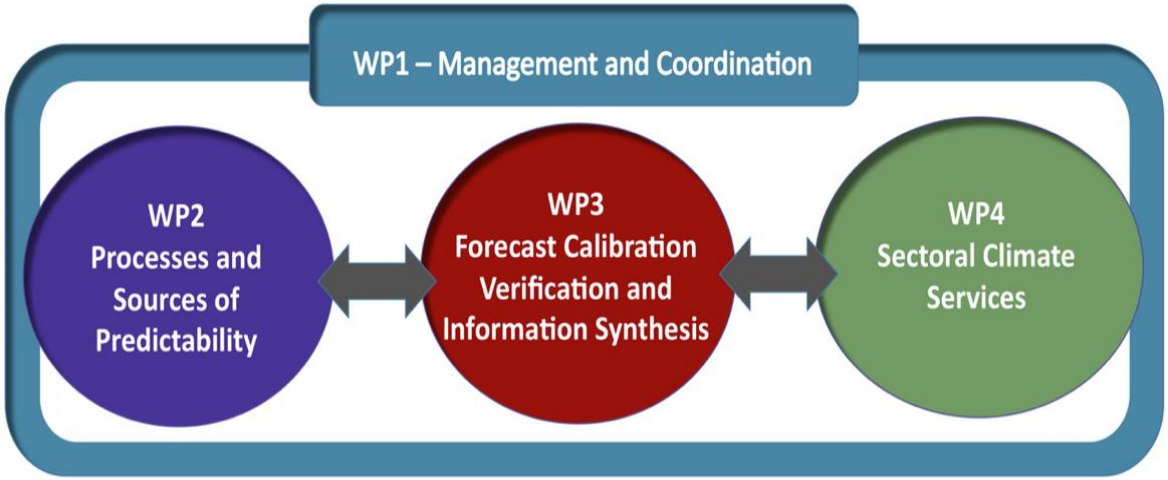
BACKUP SLIDES

MEDSCOPE objectives

➢ **WP2: Improve comprehension of the mechanisms** driving the climate variability in the Mediterranean area (e.g. teleconnections, land surface–atmosphere feedbacks, …).

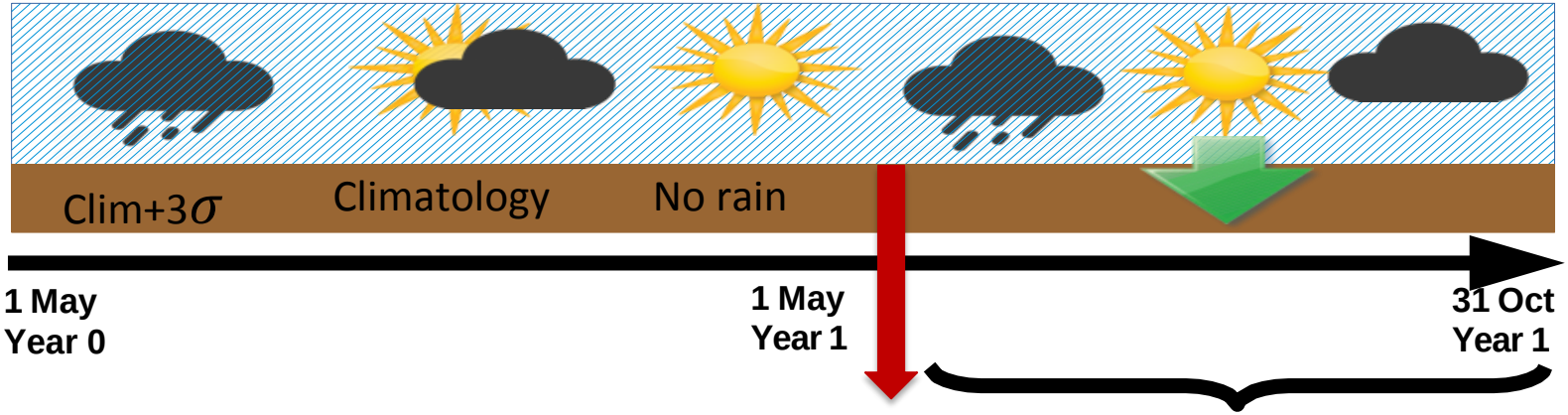


➢ **WP3: Provide a set of methods and ready-to-use tools** for **verification and skill assessment**, **downscaling**, **calibration** and **bias adjustment** of the forecasts.

➢ **WP4: Provide prototypes of end-user tailored products/services**, based on seasonal forecasts, in relevant economic sectors for the Mediterranean, such as **wind energy, water management (hydrology), agriculture and forestry (including fire risk)**.

Soil moisture experimental setup (I)

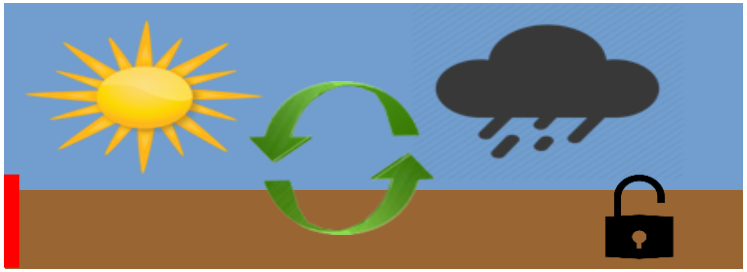
50x3 Land-Only simulations. Atmospheric forcing: **50 years of NOAA-20CR**: temperature, winds, humidity, solar radiation do not change, instead **precipitation** does.



50 **land initial conditions** for each soil state **(wet, climatological,** and **dry)**

50x3 **land daily time series** for each soil state **(wet**, **climatological**, and **dry)**

50x3 atmosphere-land simulations with **free-evolving land surface**



1 May Year 1 — 31 Oct Year 1

50x3 atmosphere-land simulations with **prescribed land surface**

1 May Year 1 — 31 Oct Year 1

Tmax response in transitional Mediterranean

The internal variability of the system is reduced when land – atmosphere are decoupled

The higher variability in the coupled experiments generates hotter temperatures despite occasional precipitation would wet the soil, increasing the soil moisture amounts.

Extreme temperatures (P90) are higher when land and atmosphere interact with each other, at least until late summer