Climate SPHINX

High-resolution climate simulations with an improved representation of small-scale variability

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CLIMATE SPHINX

*Climate **SPHINX** (Stochastic Physics High Resolution Experiments) **is a PRACE EU project which aims to investigate the sensitivity of climate simulations to model resolution and stochastic parameterizations**, and to determine if very high resolution is truly necessary to facilitate the simulation of the main features of climate variability.*

SPHINX is a project by **ISAC-CNR**, lead by Jost von Hardenberg, in collaboration with Oxford University (Tim Palmer and Antje Weisheimer group).

EC EARTH 3

ISAC

Consiglio Nazionale delle Ricerche

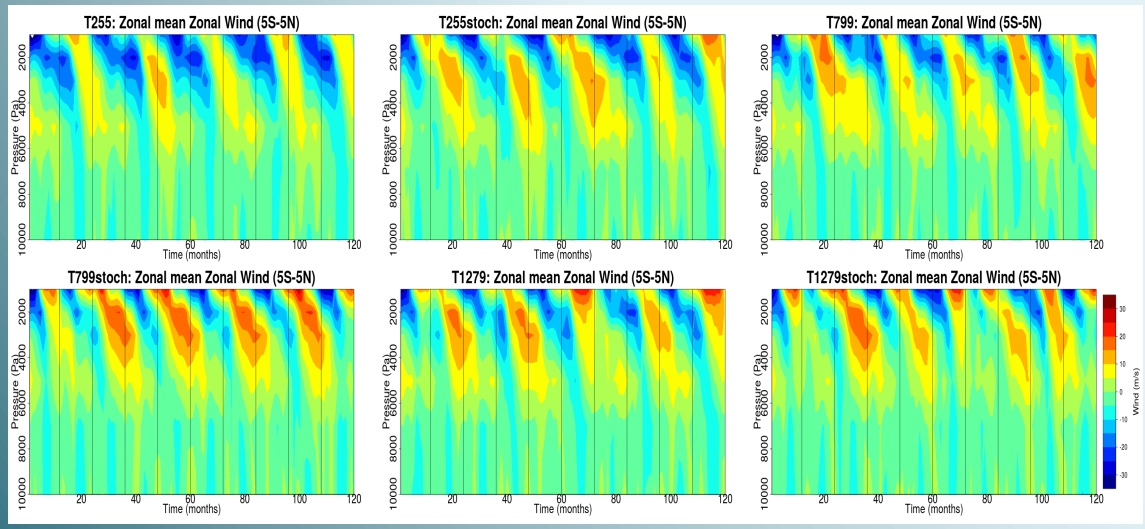
Istituto di Scienze dell'Atmosfera e del Clima

UNIVERSITY OF OXFORD

WHAT, WHEN AND WHERE?

- **20 millions of core hours** on **Supermuc** @ LRZ Computing Center, Garching, Germany.
- 1-year project will end in **March 2016**

lrz Leibniz-Rechenzentrum
der Bayerischen Akademie der Wissenschaften



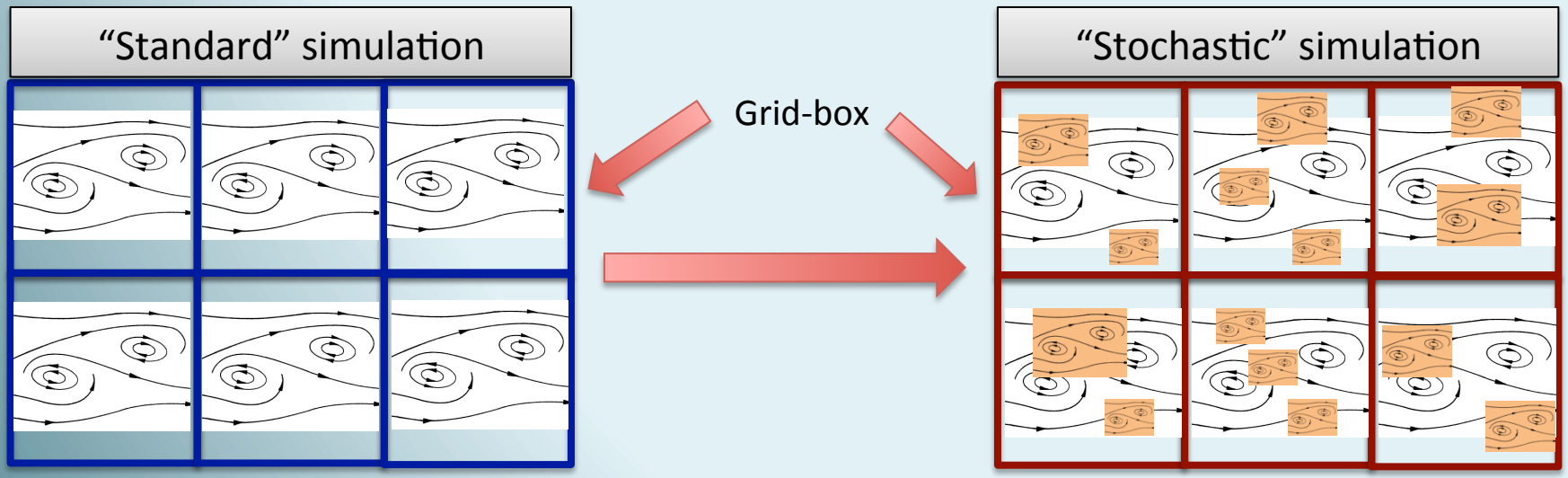
EC-Earth 3.1, with some supplementary tuning.

- **Adjusted gravity wave drag** to get QBO at every resolution.
- **Improved surface and TOA fluxes** with convection/ precipitation knobs.

STOCHASTIC PHYSICS

Instead of explicitly resolving small-scale processes by increasing the resolution of climate models, a **computationally cheaper** alternative is to **use stochastic parameterization schemes**.

A stochastic scheme includes a **statistical representation of the small scales**, and hence is able to represent the impact of such small-scale processes on the resolved scale.



Practically, there are **Gaussian perturbations applied on the 3D field tendencies**.

There is mounting evidence that stochastic parameterizations are beneficial for climate variability in GCM simulations (Dawson et al, 2012).

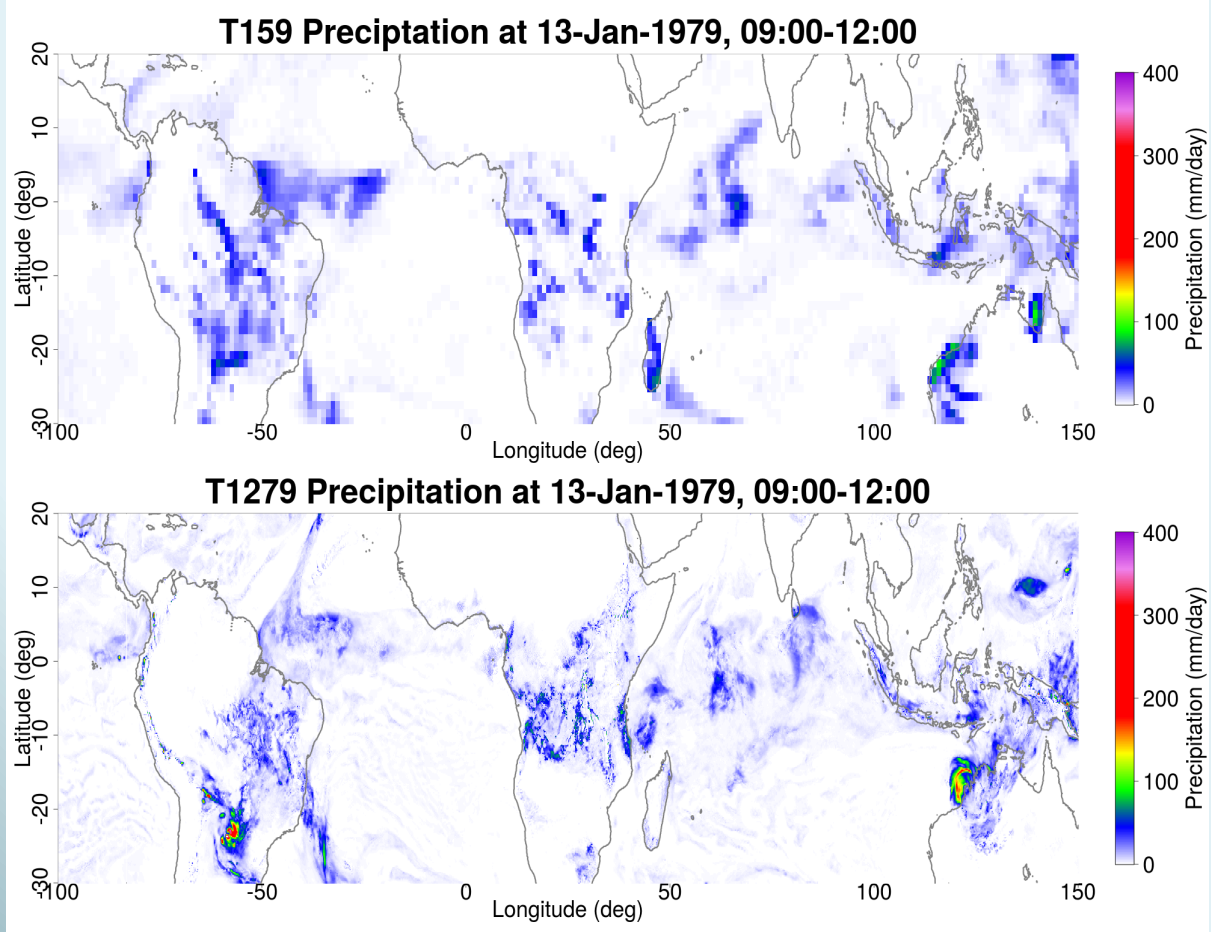
THE EXPERIMENTS

Atmospheric-only:
5 horizontal resolutions

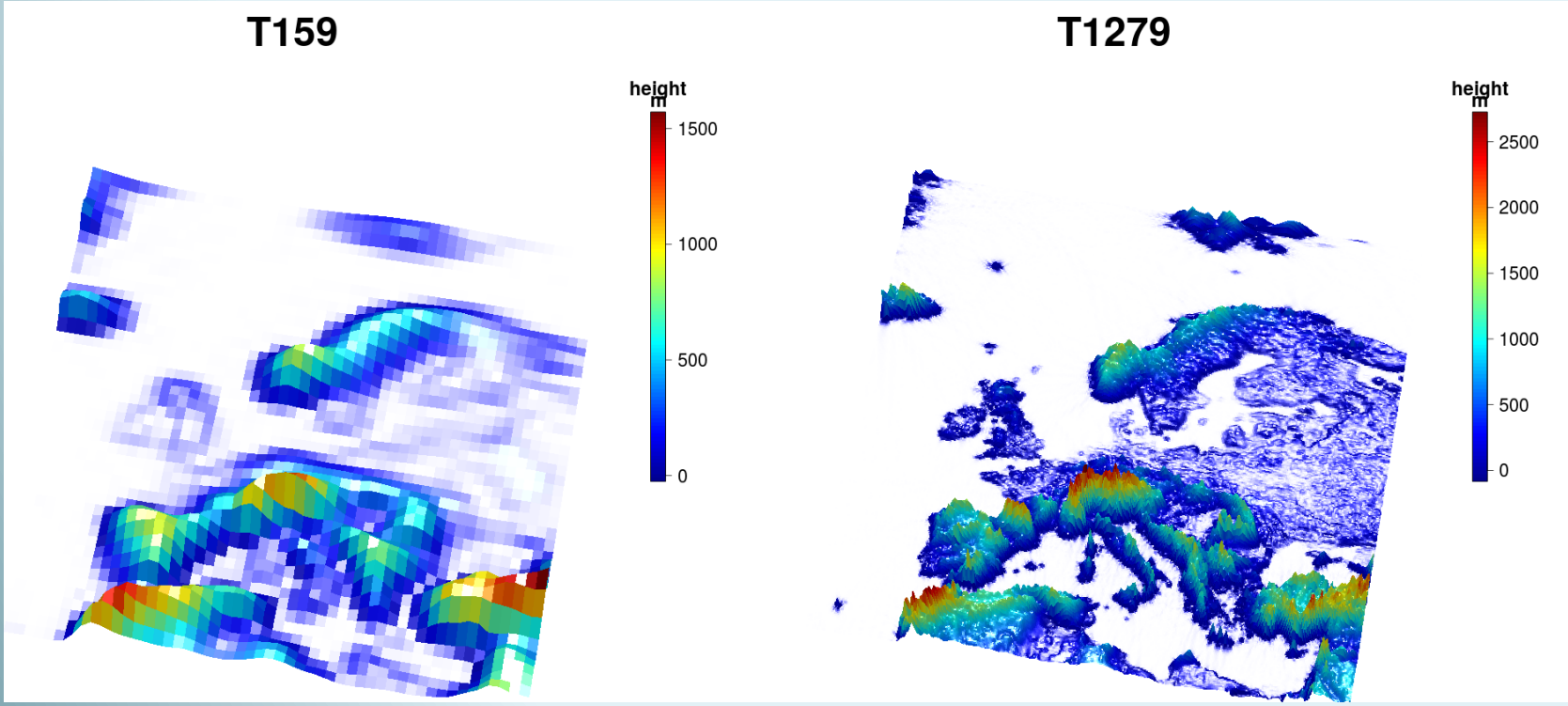
Present day
1979-2008

Future Scenario
2039-2068
RCP85

Coupled: T255L91
1850-2100, historical + RCP8.5 (still running)



RESOLUTIONS AND ENSEMBLES



T159L91 (125km): 10+10 ensemble members

T255L91 (80km): 10+10

T511L91 (40km): 5+5

T799L91 (25km): 3+3

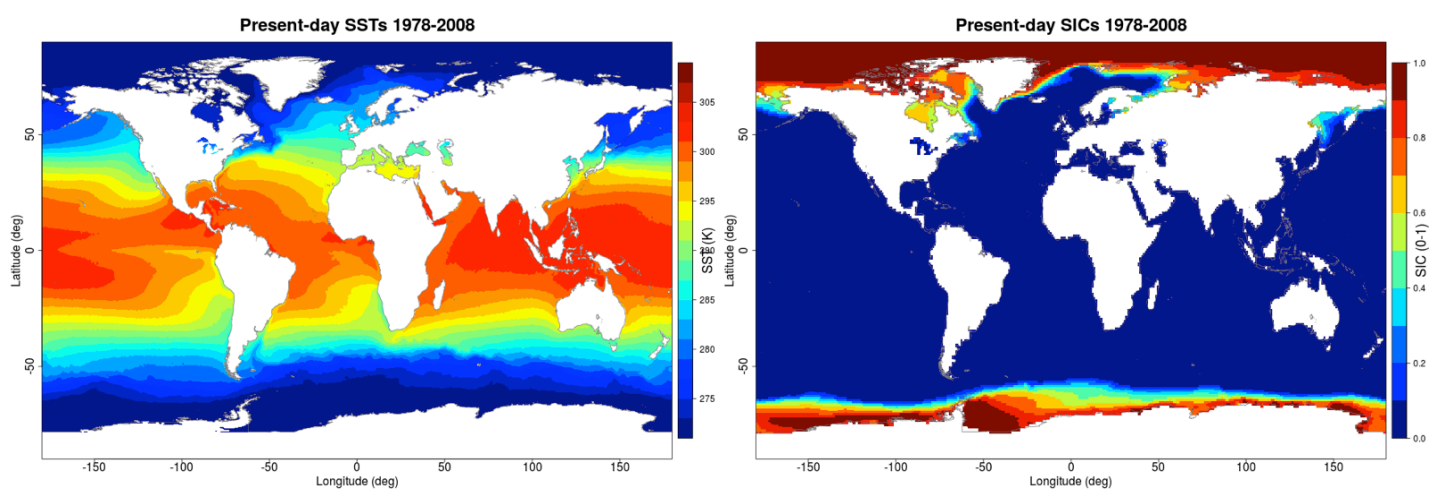
T1279L91 (16km): 1+1

Tuning has been performed once only for T255L91 with no stochastic physics!

More than 110 simulations available!

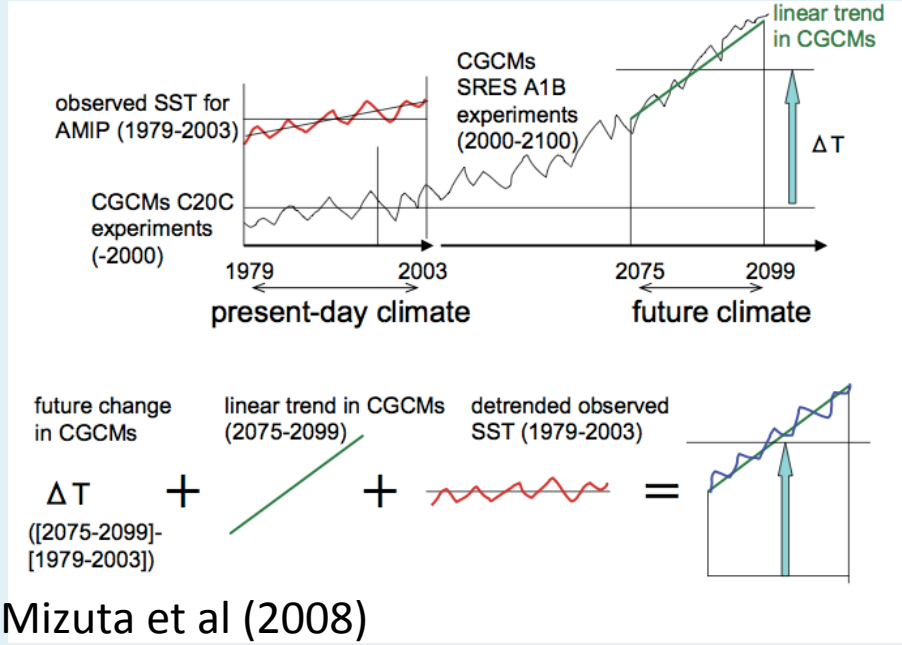
THE FORCING: PRESENT DAY

- New oceanic dataset: **HadISST 2.1.1** (Titchner et al., 2014; Kennedy et al, 2016)
- **Pentad-based daily 0.25x0.25 dataset for SST and and 1x1 for SIC.**
- ICs from ERAINTERIM 1979-01-01.
- 1979-2008: **Historical CMIP5 forcing for GHG.**
- Lake (not defined inland points): **ERAINTERIM 1-month lagged seasonal cycle** (Hersbach et al., 2015), ice when below zero.
- Coastal points (land-sea mask mismatch) are extrapolated.

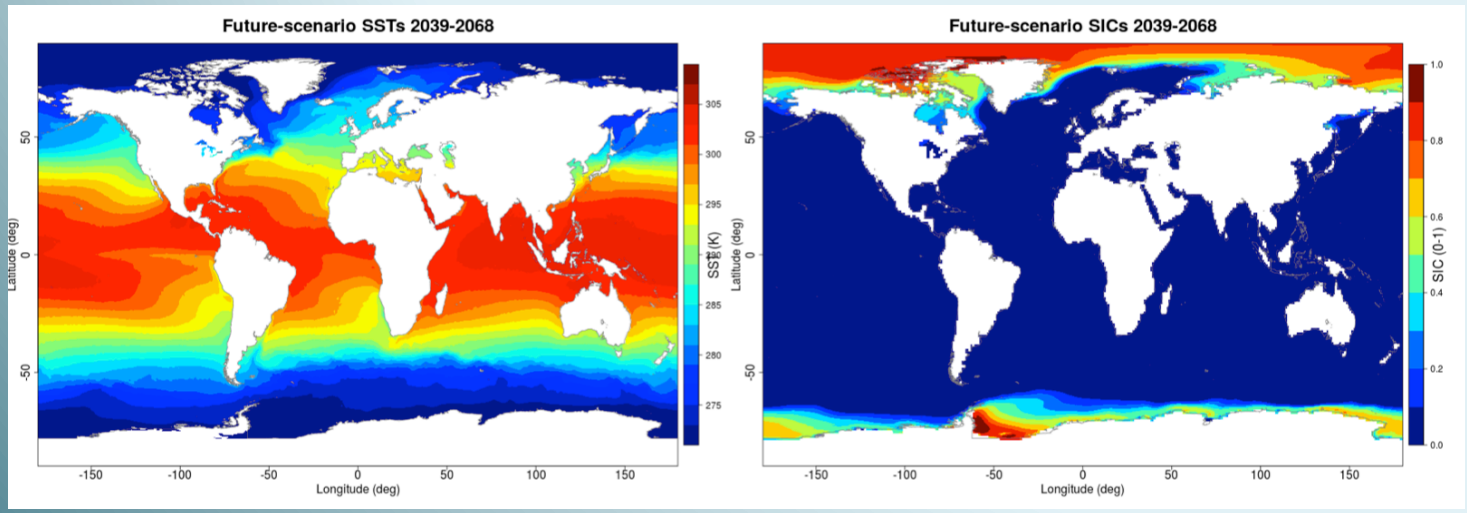


THE FORCING: FUTURE SCENARIO

- Future SSTs: **Adjusted Mizuta et al (2008) method.**
- EC-Earth 2 **CMIP5 ensemble mean for mean values and trend of SST**s.
- **Daily variability is taken from HadiSST 2.1.1**
- For SICs, we pick one ensemble member of EC-Earth CMIP5 representative of the dataset (i.e. closer to ensemble mean).

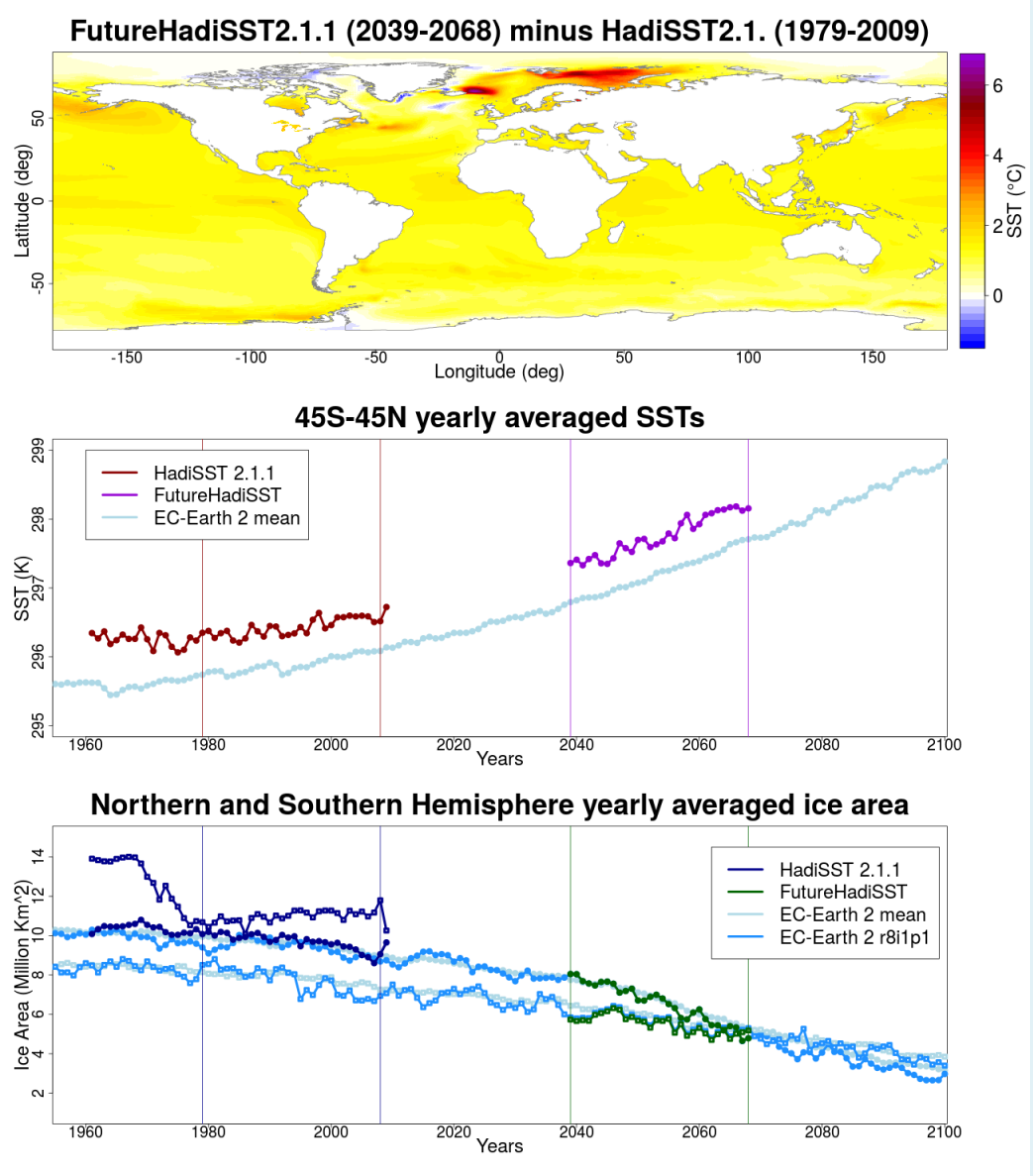


Mizuta et al (2008)



THE FORCING: FUTURE SCENARIO

- **Bare-points due to retreat of sea-ice:** specific filling combining a linear interpolation and HadISST 2.1.1 variability
- **The new dataset has the same variability of HadISST2.1.1 and the mean field and values of EC-Earth ensemble mean**
- **2039-2068**: **RCP8.5 CMIP5**
- ICs are indeed not available: we then used the ERAINTERIM 1979-01-01 + one year of spin up for land adjustment

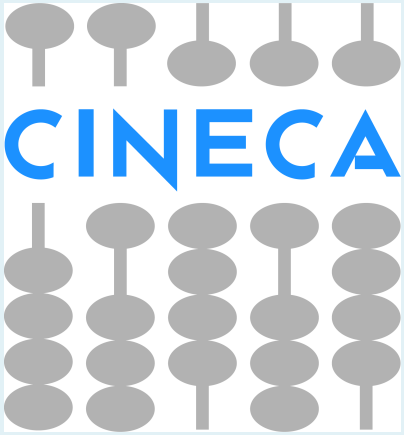


DATA AVALAIBILITY

- Archive of output, restart, post-processed data on TSM at Supermuc @ LRZ
- **DRES @ Cineca: EUDAT project to get operational a THREDDS server to share data**.
- Collaboration with COLA to share data.

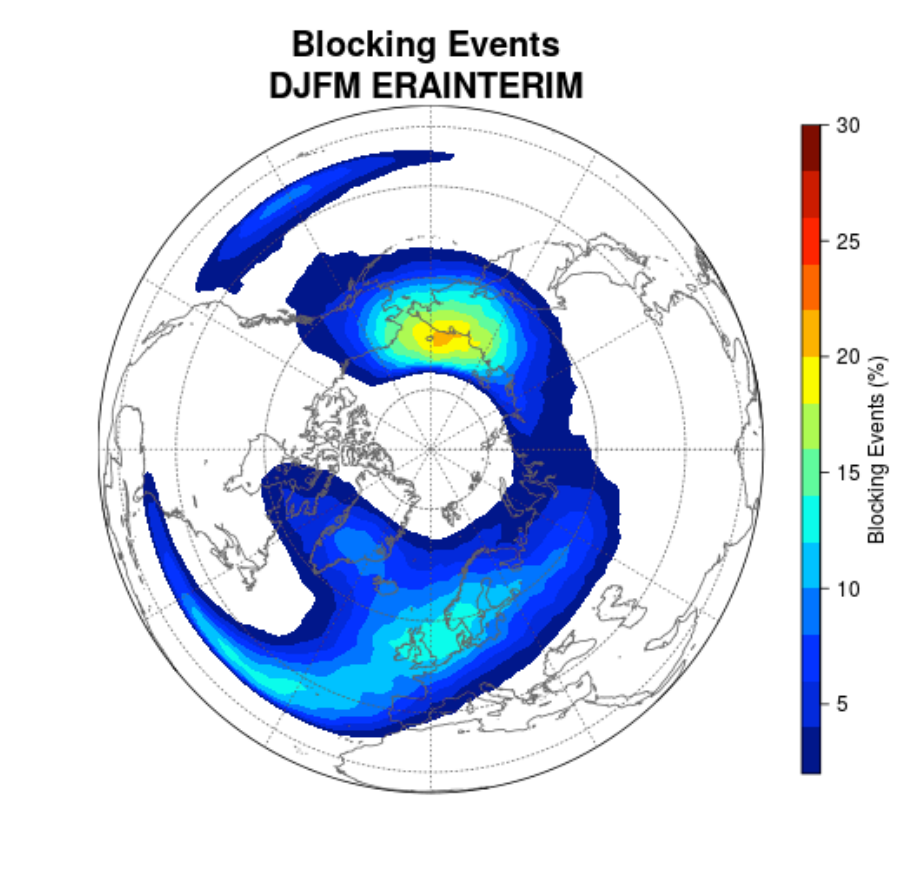
- **About 150 Tb of post-processed**
- Different set of variables, CMOR-like. Monthly mean, synoptic monthly mean, daily, 6hrs and on some selected domain also 3hrs.
- **About 50 different fields.**
- 3D fields downgraded to T255 to save disk space.
- NetCDF4 Zip (HDF5) reduces significantly the amount of space needed.

Whoever wants to have a look at these data feel free to take a step forward!



PRELIMINARY RESULTS: BLOCKING

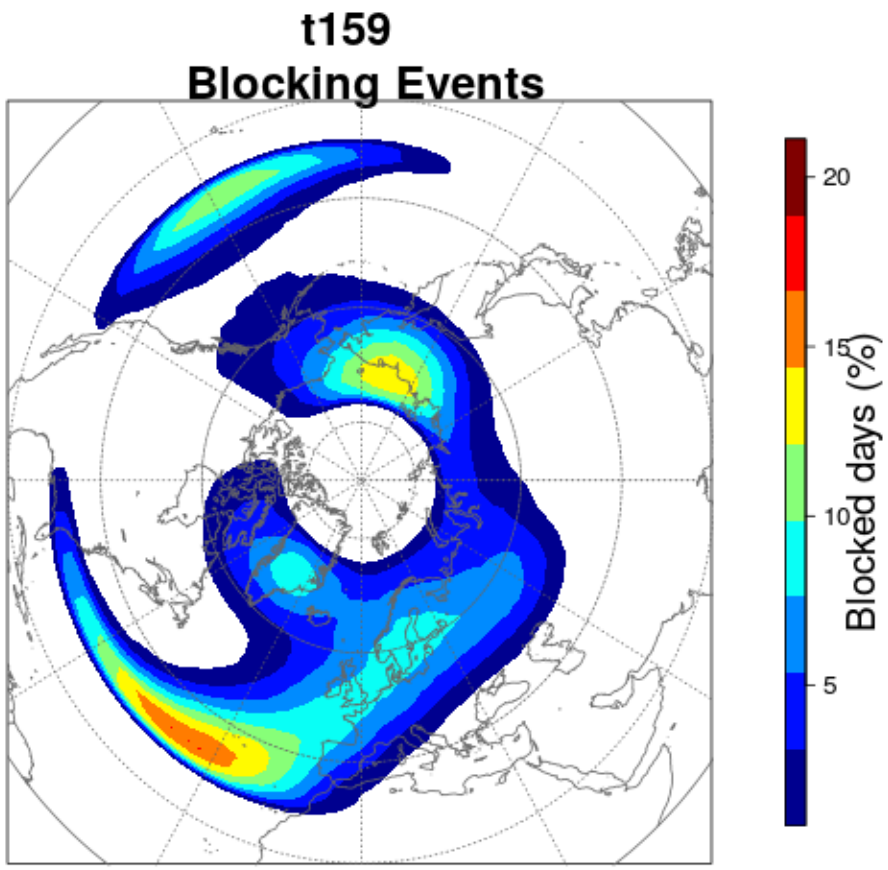
Evaluation of winter (DJFM) **atmospheric blocking** using the 2D index extension of Tibaldi and Molteni (Davini et al 2012) in the present day (30 years).

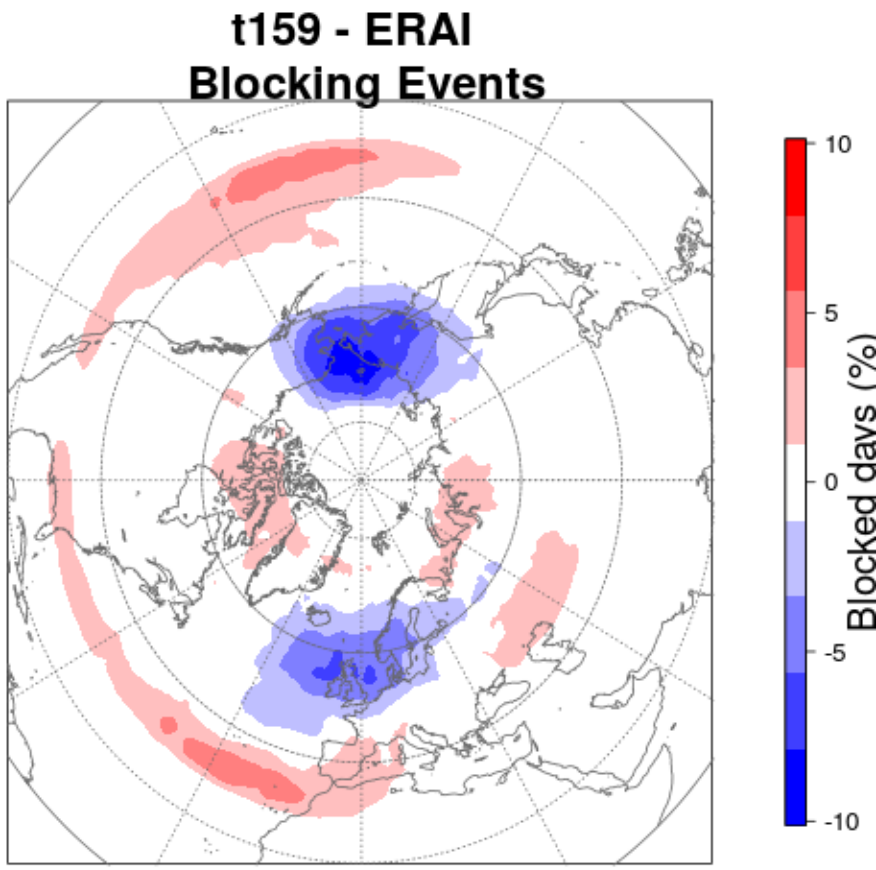


- Blocking over the **Pacific** and the **Atlantic**, at the exit of the jet stream.
- Captures the **RWB properties** even at low and high latitudes, i.e. variability related to the NAO and eddy-driven jet stream.
- A section of the 2D index taken at 60N roughly equals to Tibaldi and Molteni (1990)
- **Long-standing issue in GCMs**, large negative bias over Europe even in CMIP5 models.

PRELIMINARY RESULTS: BLOCKING

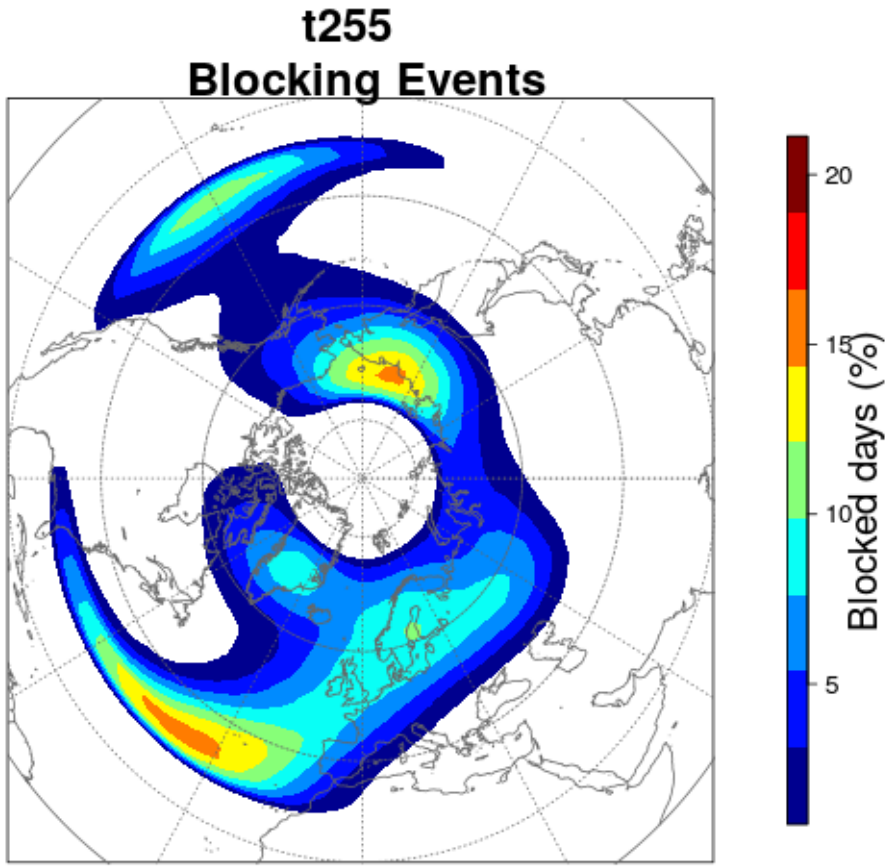
11 ensemble members, 125 km resolution, present day

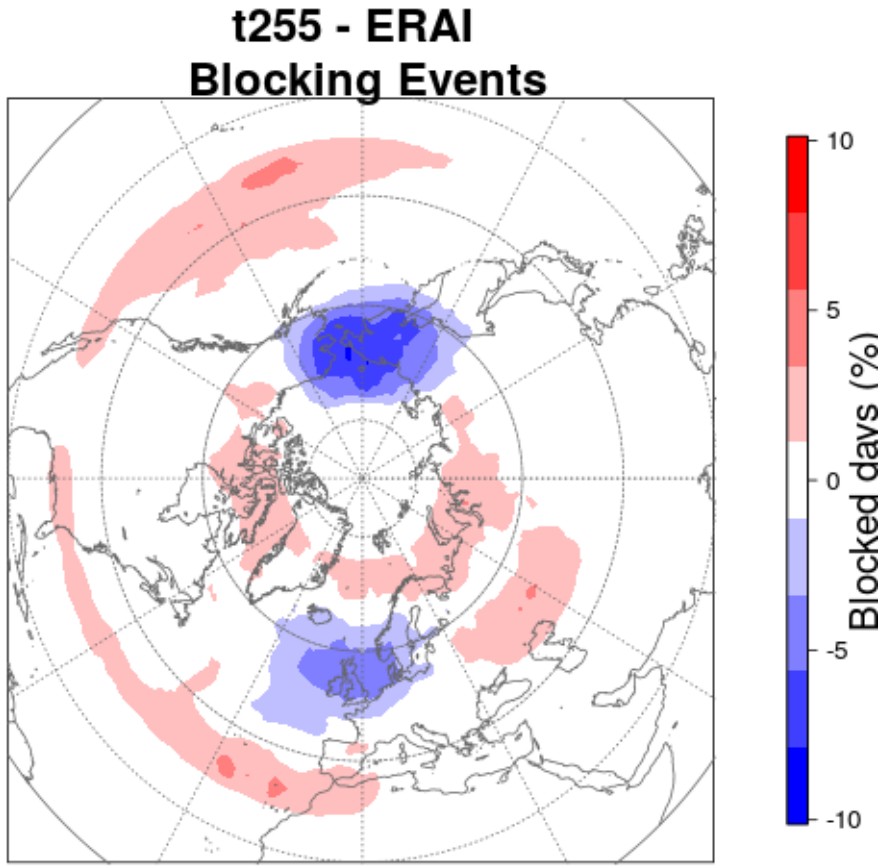




PRELIMINARY RESULTS: BLOCKING

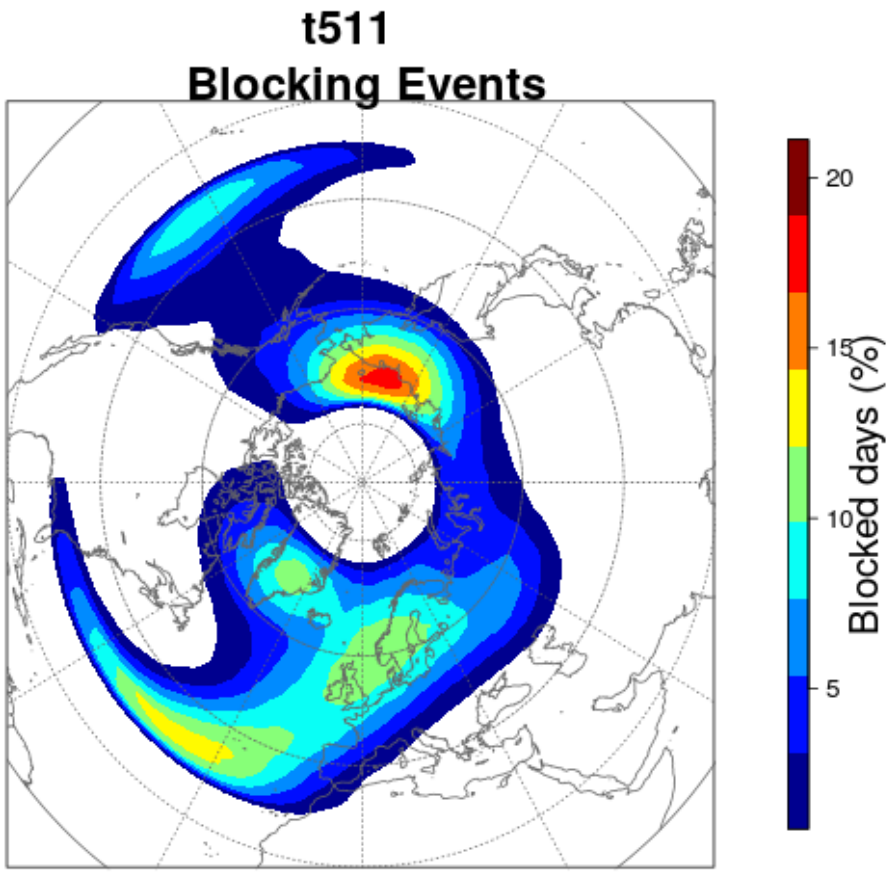
20 ensemble members, 80 km resolution, present day (tuned model)

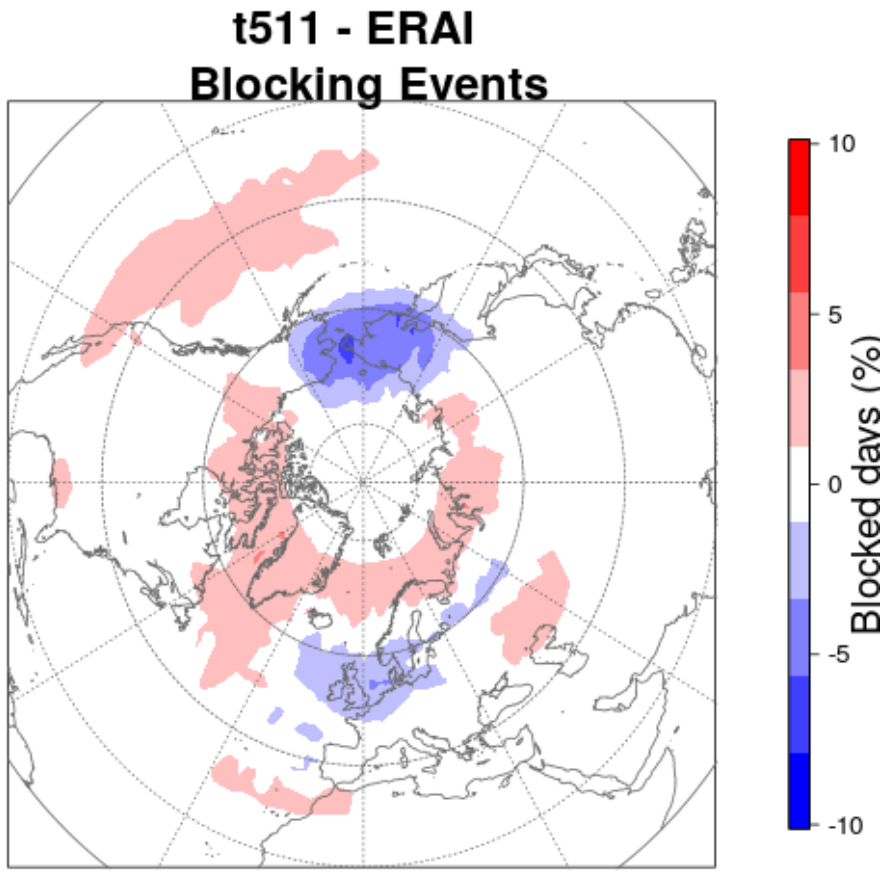




PRELIMINARY RESULTS: BLOCKING

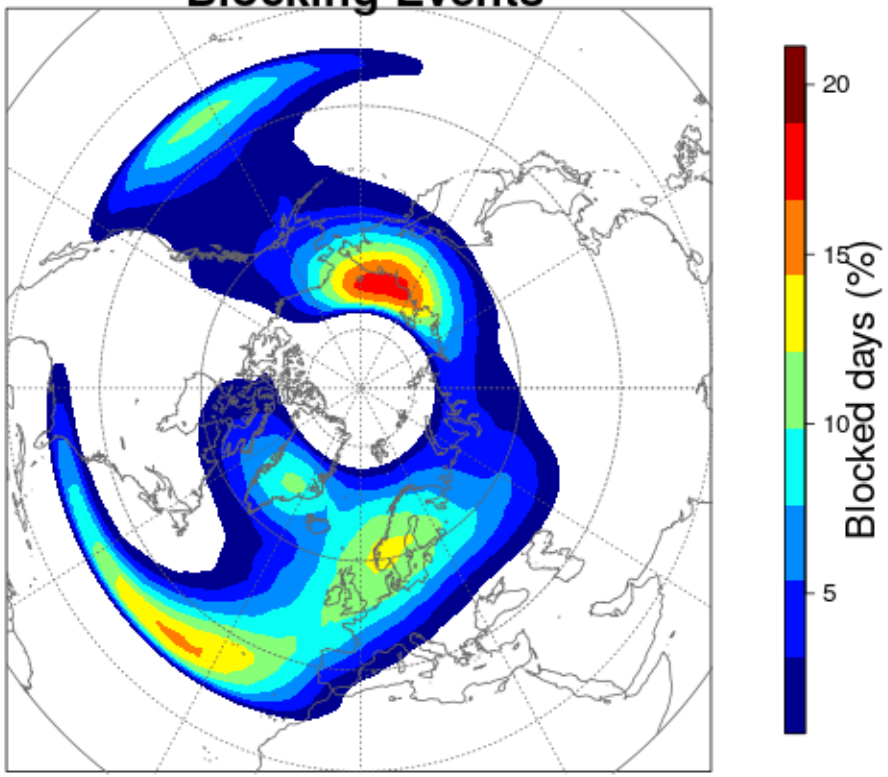
10 ensemble members, 40 km resolution, present day

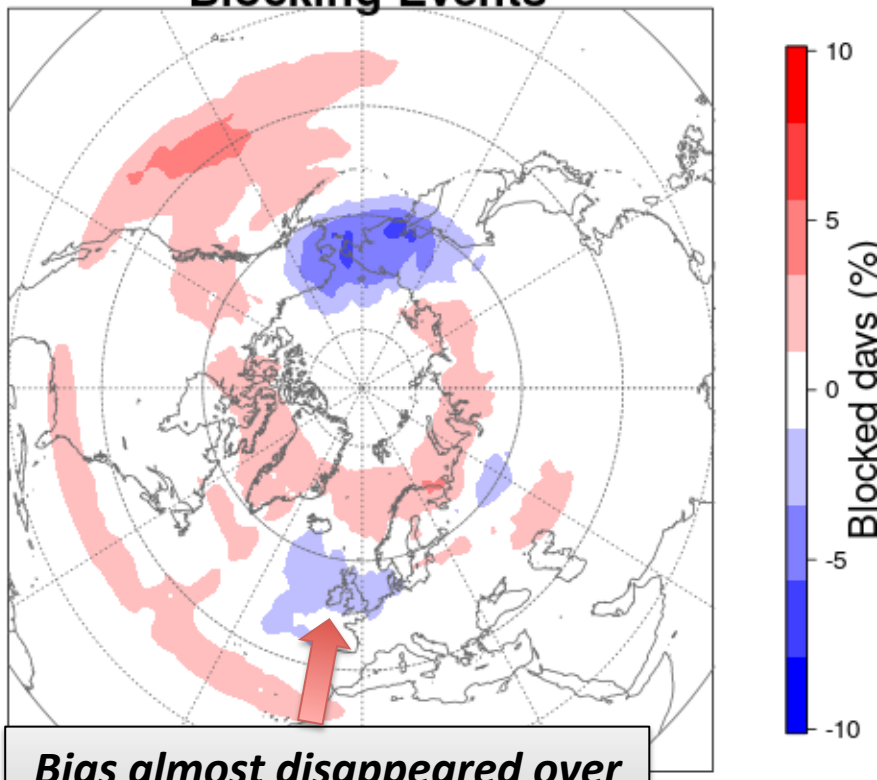




PRELIMINARY RESULTS: BLOCKING

6 ensemble members, 25 km resolution, present day





Bias almost disappeared over the Europe

FINAL REMARKS

- **Climate SPHINX**: Large dataset to test horizontal resolution and parameterization of stochastic physics under both present day and future scenario.

- Almost complete (deadline March 2016): about 110 simulations run, and only a few of them is still running.

- **150 Tb** of post-processed data.

- **Data access via THREDDS server @ CINECA**, already operative!

- First results show clear improvements in atmospheric blocking with increasing resolution.

- **If you want to participate, you are welcome! Please let us know!**

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