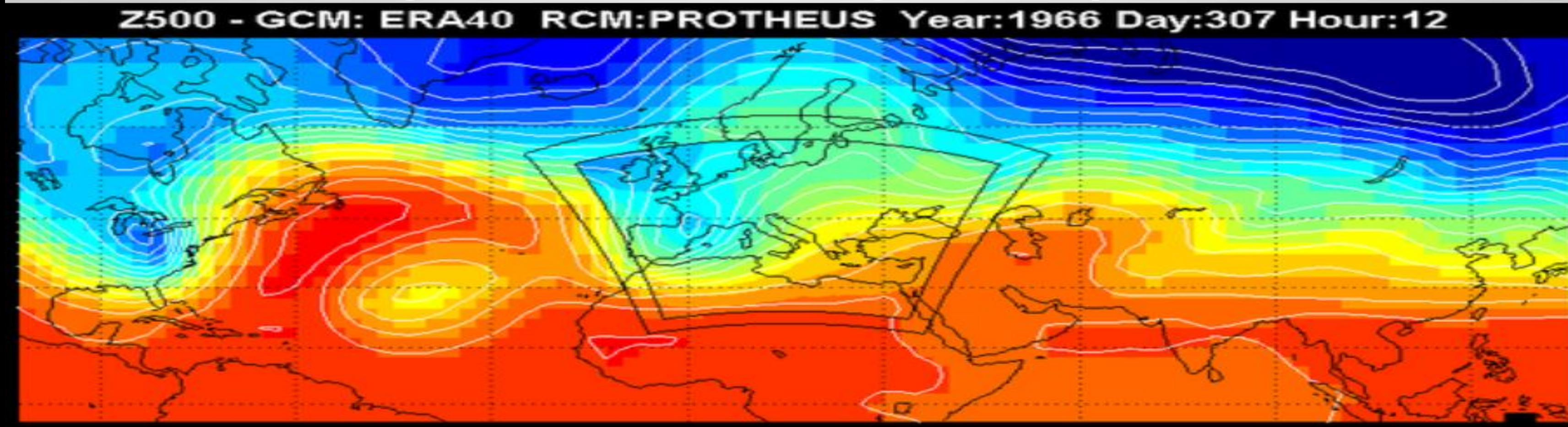
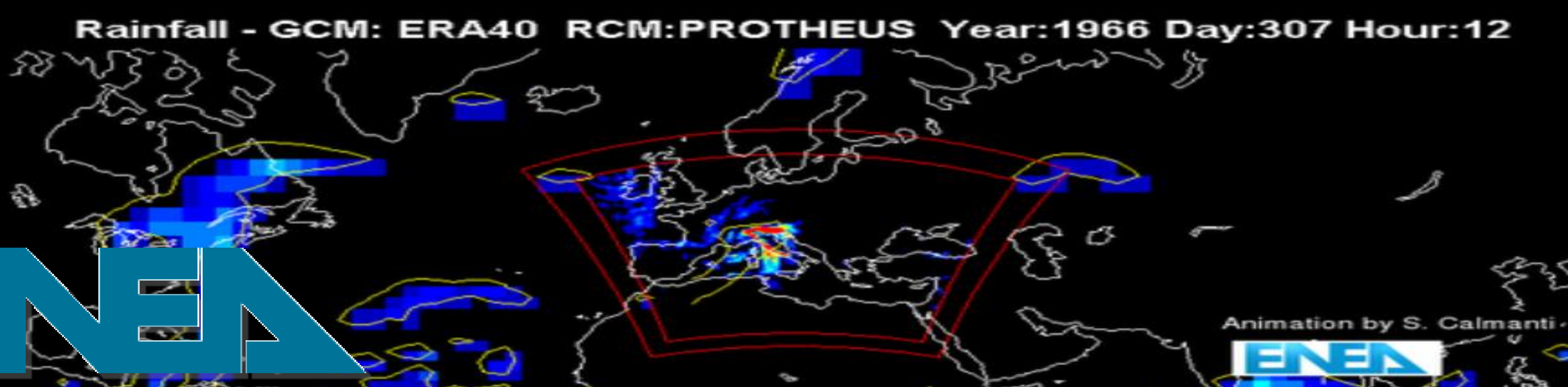
Understanding and attributing intense events signatures in a changing climate: from large scale to regional processes





ENEA

Ruti PM, **A Dell'Aquila, Calmanti S, Struglia M, Pisacane G, Carillo A, Sannino G, F Giorgi**

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SUMMARY

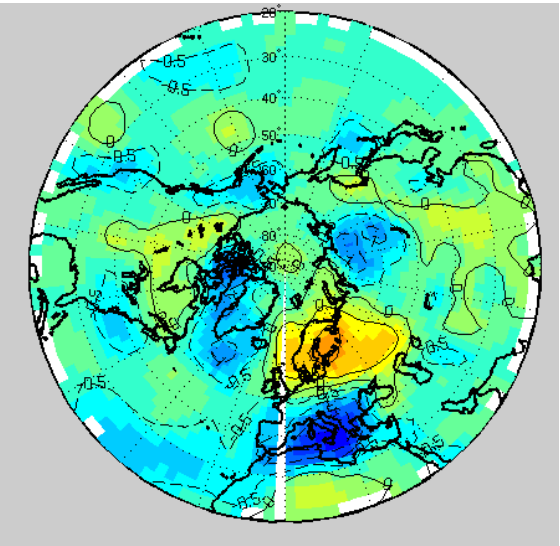
A general overview of ENEA UTMEA-CLIM lab activities about intense events at different spatial scales

(more details in http://utmea.enea.it/research/)

Analysis: Large scale features

Summer Euro-Russian Blocking

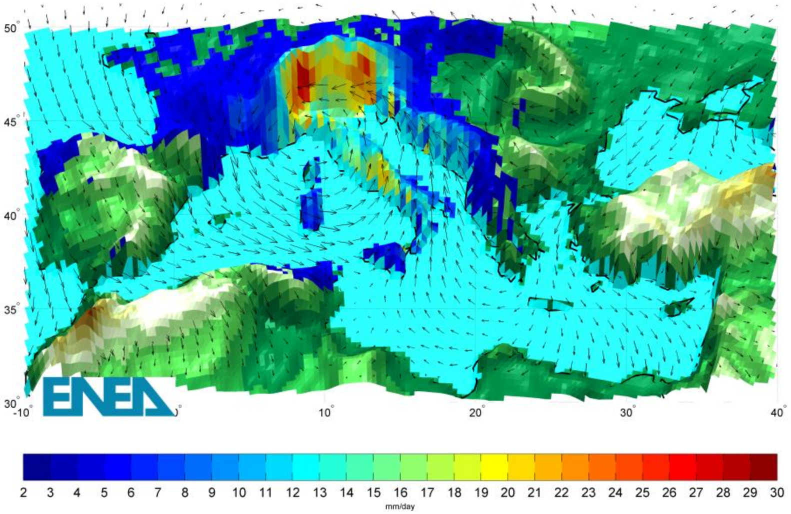
Global Reanalysis & Atmospheric global simulations (20th Century CLIVAR project)



Modelling: Regional processes

Regional Earth System model: Existing and ongoing simulations

Description of high-impact events



Large scale features: Euro-Russian summer blocking signatures

Datasets & Methodology

Two ensembles of 6 integrations performed by HadAM3 model (1869-2002) available from the C20C web site (http://www.hadc20c.org/). We consider 103-yr record (1901–2002) of daily 500-hPa height geopotential fields

1)Natural forcing simulations (hereafter **NATURAL**) take into account sea-surface temperatures, volcanic aerosols, solar variability, orbital changes.

2)Simulations with the with the full set of forcings (hereafter **ALL FORCINGS**) also the anthropogenic forcing such as greenhouse gas changes, atmospheric ozone change, sulphate aerosols and land-surface changes are considered.

As reference we also take into exam fields from **NCEP-NCAR** global Reanalysis dataset (1961-2010)

Blocking detection method

Tibaldi and Molteni index (1990):for each longitude we compute the southern and the northern 500hPa gradient *GHGS* and *GHGN*

$$GHGS = \left[\frac{Z(\phi_0) - Z(\phi_s)}{\phi_0 - \phi_s} \right];$$

$$GHGN = \left[\frac{Z(\phi_n) - Z(\phi_0)}{\phi_n - \phi_0} \right];$$

Where $\phi 0=60°N+\Delta$; $\phi s=40°N+\Delta$; $\phi N=80°N+\Delta$ and $\Delta =[-5° \; 0 \; 5°]$.

A given longitude is blocked if for at least one value of Δ

1) GHGS>0

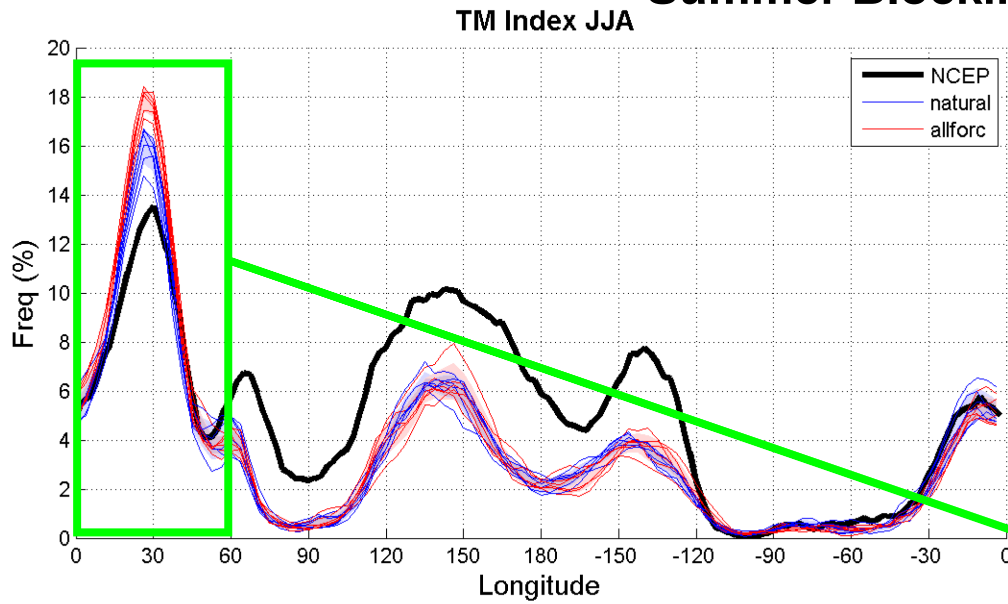
2) GHGN<-10m/deg latitude

We apply a 5-days running mean to the geopotential height field.

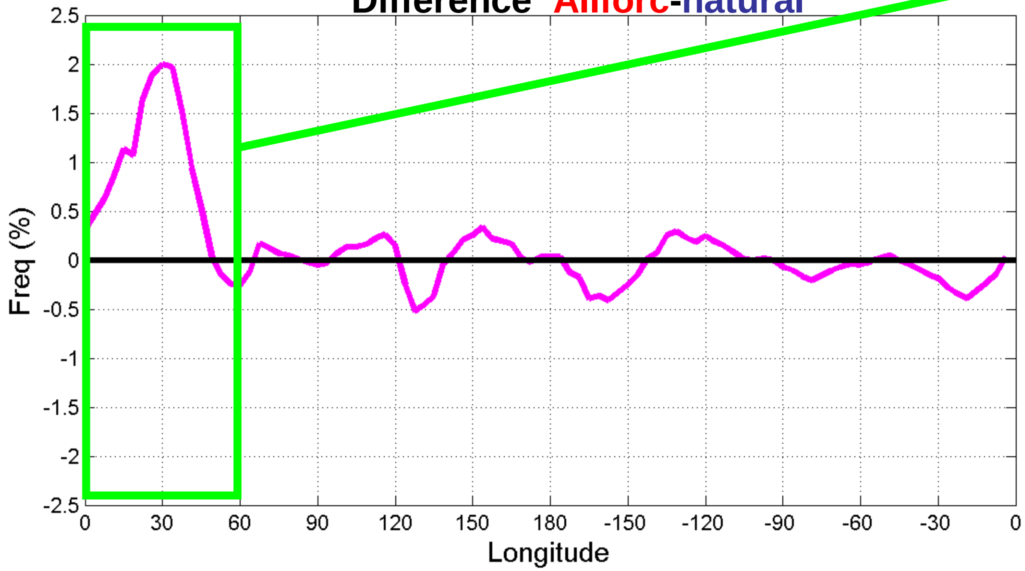
We focus onto the summer **JJA** season

Large scale features: Euro-Russian summer blocking signatures

Summer Blocking Frequency



Difference Allforc-natural

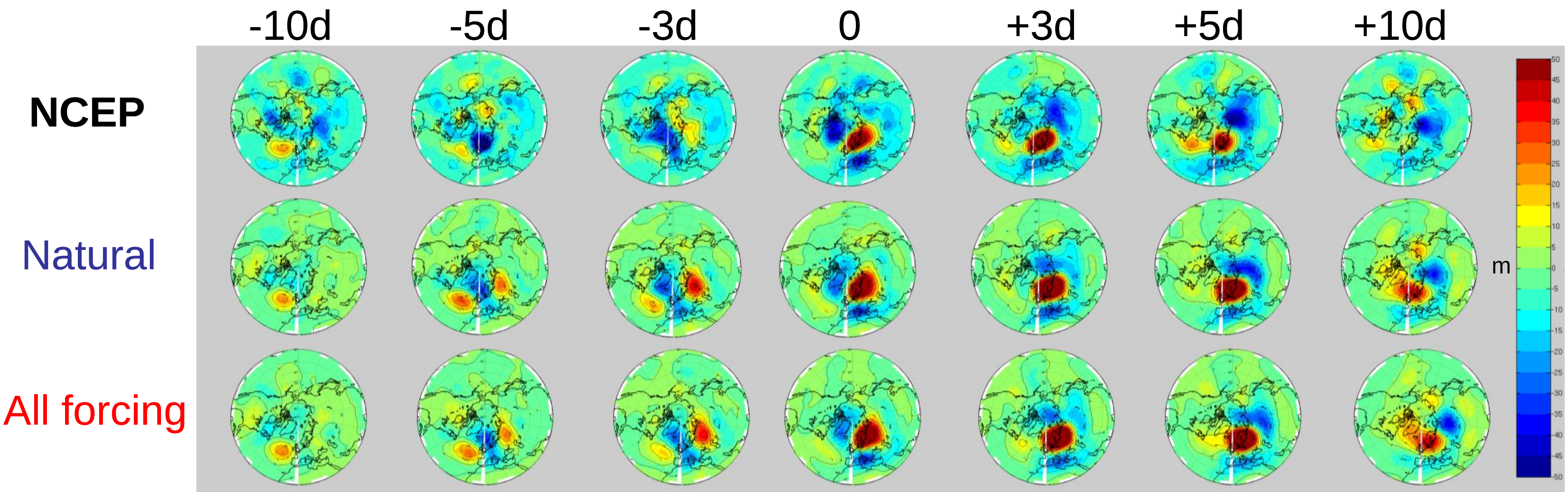


Euro-Russian sector

We assume that a given sector (in this case the Euro-Russian 0-60°E) is blocked if at least three adjacent grid points are blocked.

Large scale features: Euro-Russian summer blocking signatures

Euro-Russian sectorial blocking events: spatial patterns

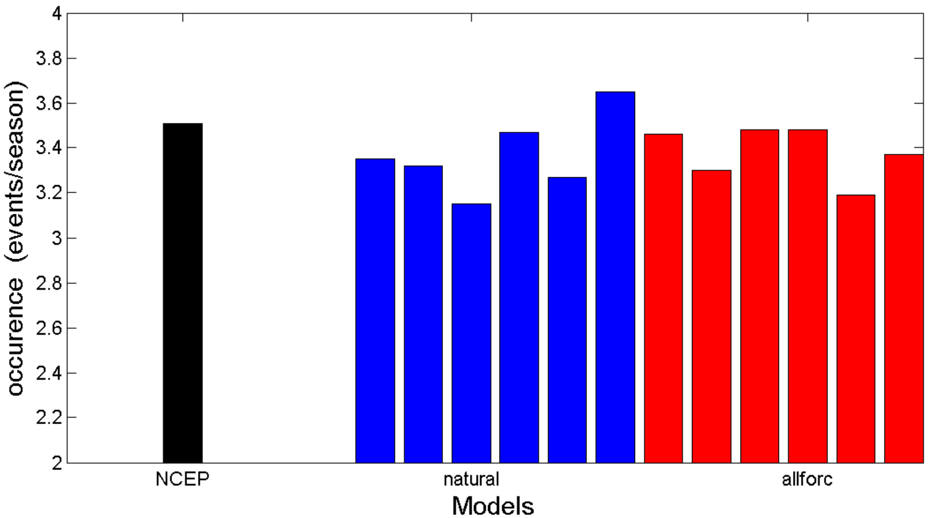


Life cycle of summer blocking events over Euro-Russian sector.

We composite the daily anomaly of 500 hPa geopotential height for all the events detected at different lags

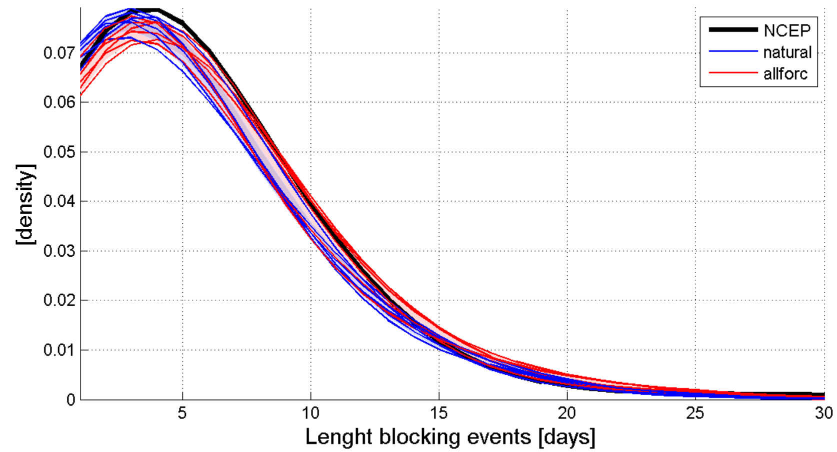
Large scale features: Euro-Russian summer blocking signatures

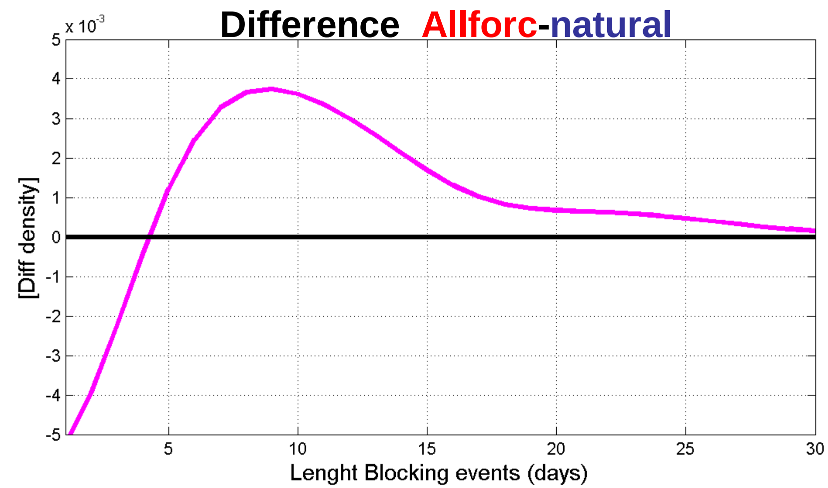
Euro-Russian blocking events: occurence



Number of blocking events/season over Euro-Russian sector. Results for all 6 members for each ensembles are shown.

Euro-Russian blocking events: duration





Probability Distribution Function of length (days) of Euro-Russian blocking events.

Large scale features: Euro-Russian summer blocking signatures

Conclusions: PART I

•Generally, the HadAM3 model simulations tend to overestimate in terms of frequency the summer blocking signature with respect to **NCEP** over the Euro-Atlantic sector (0-60°E). In this sector, the two experiments feature different frequency of blocked days. In particular, the **All forcings** simulations exhibit higher amount of blocked days

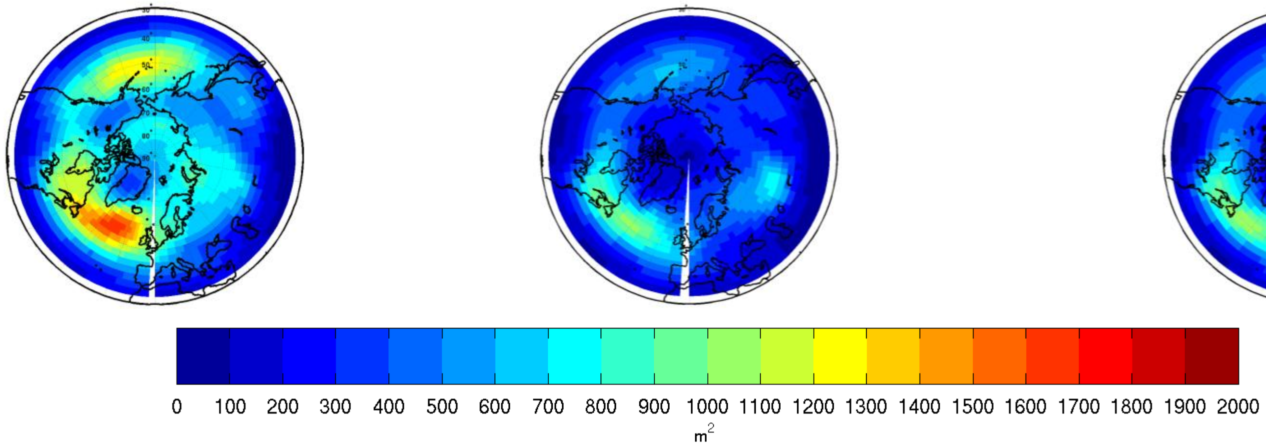
•The **All forcings** simulations are characterized by more persistent blocking events even if the occurrence remain the same (typically around 3 events/season)

•A possible explanation of this different behavior between **Natural** and **All forcings** simulations can lie in a different representation of high freq variability that can on its turn differently feed the low frequency variability i.e. the blocking events over Euro-Atlantic sector.

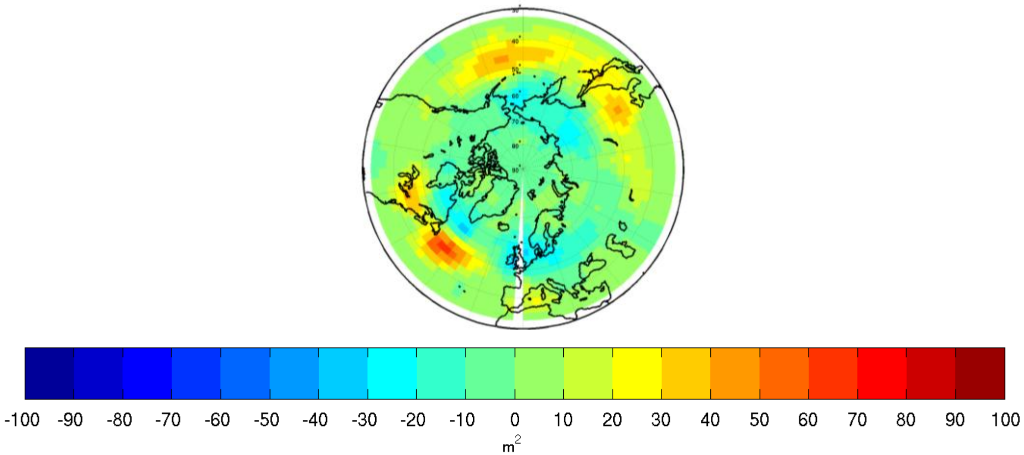
Large scale features: Euro-Russian summer blocking signatures

Conclusions PART I 2-6 days 500hPa Geopotential height JJA Variance

NCEP **Natural** **All Forcings**



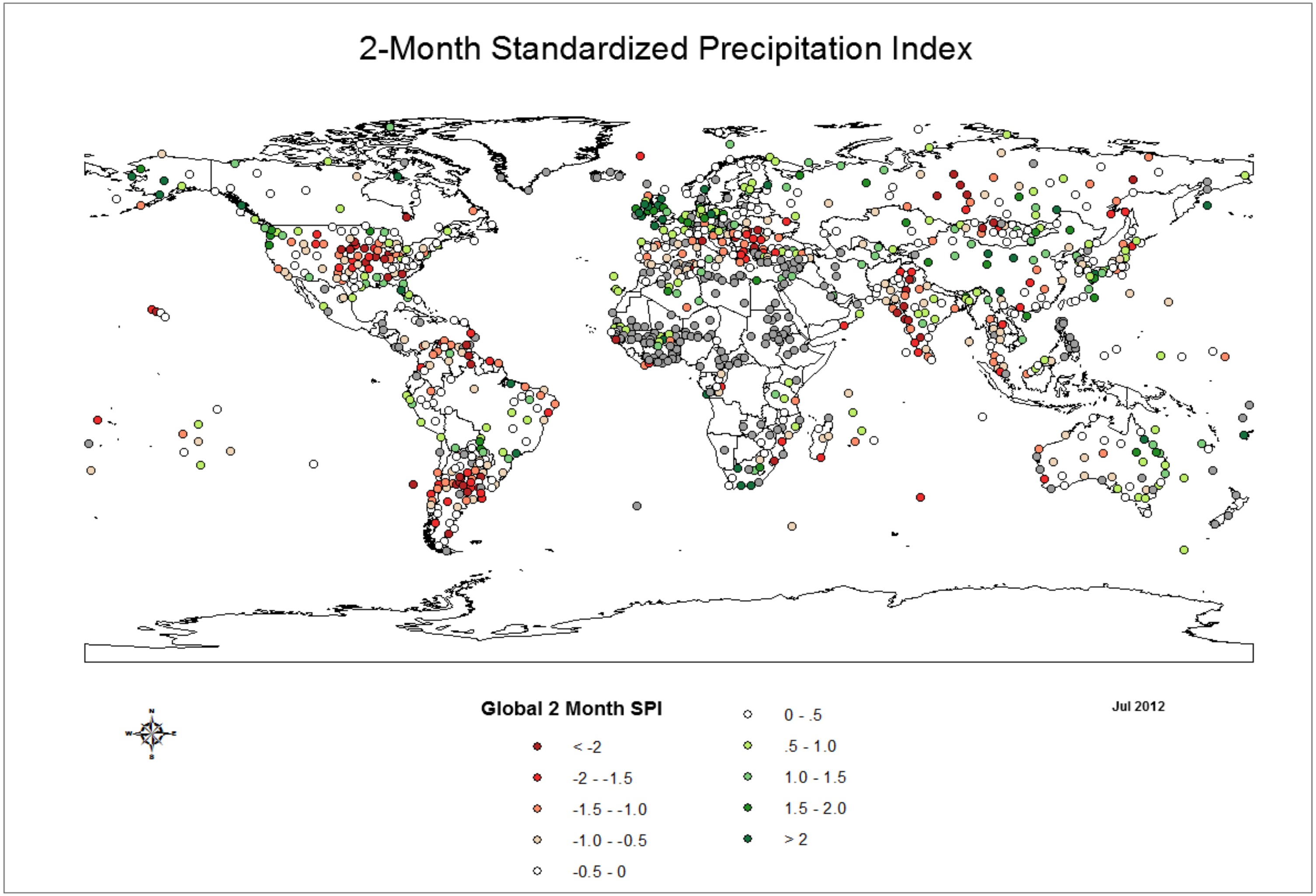
All Forcings - Natural



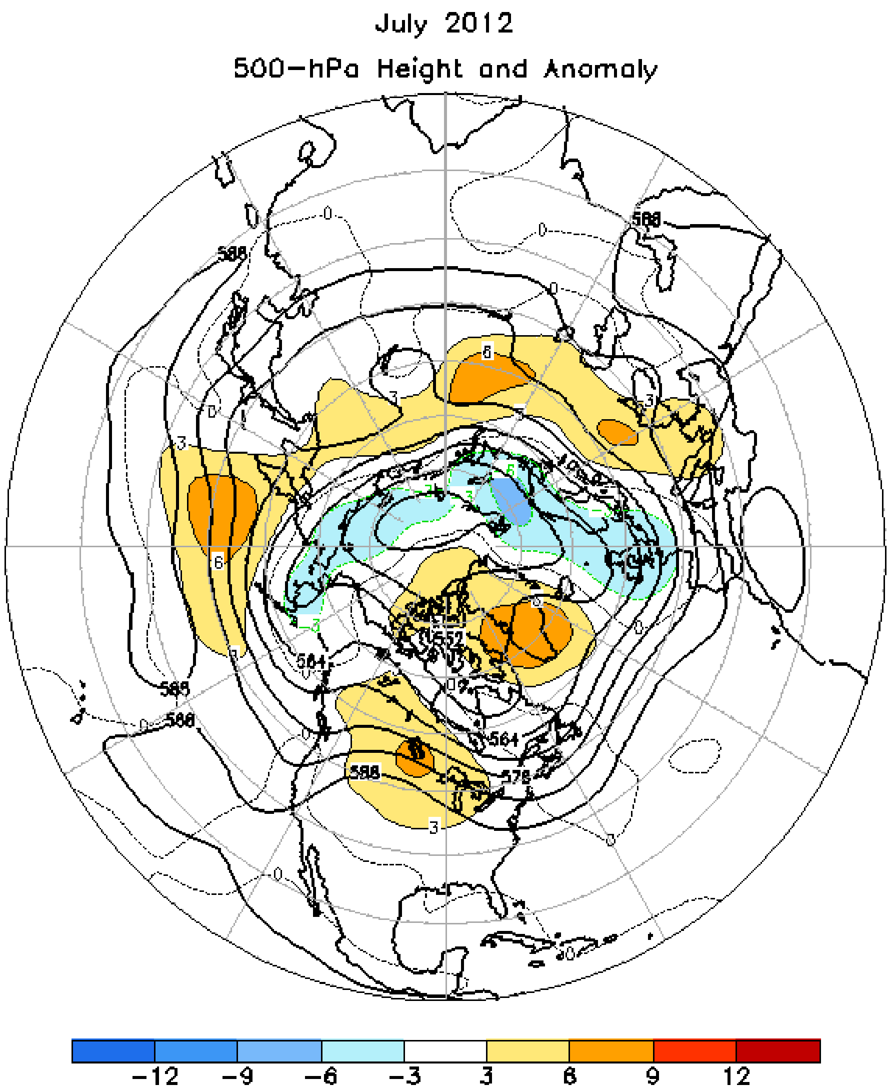
- Next steps: Analysis of CMIP5 ensembles; more in-depth analysis of land-atmosphere interaction (→ summer heat waves)

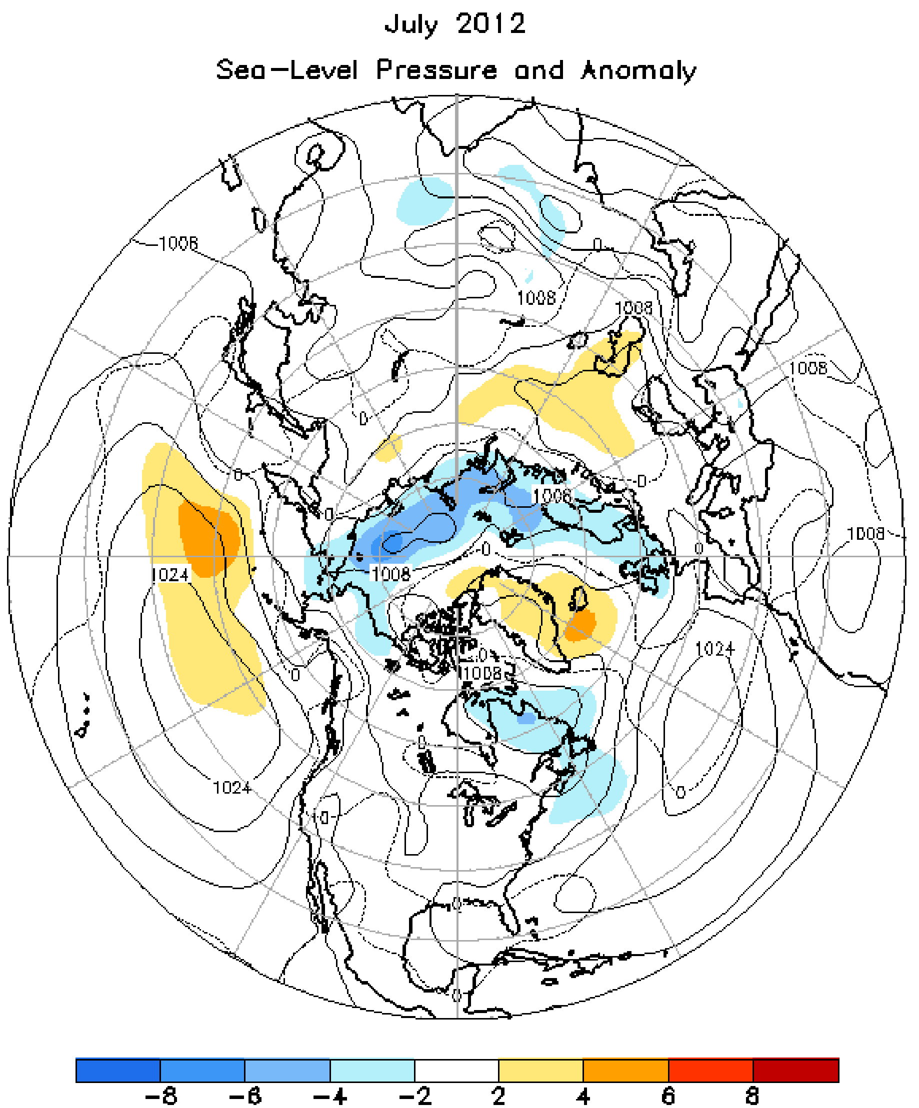
Large scale features: 2012 drought

Drought conditions July 2012



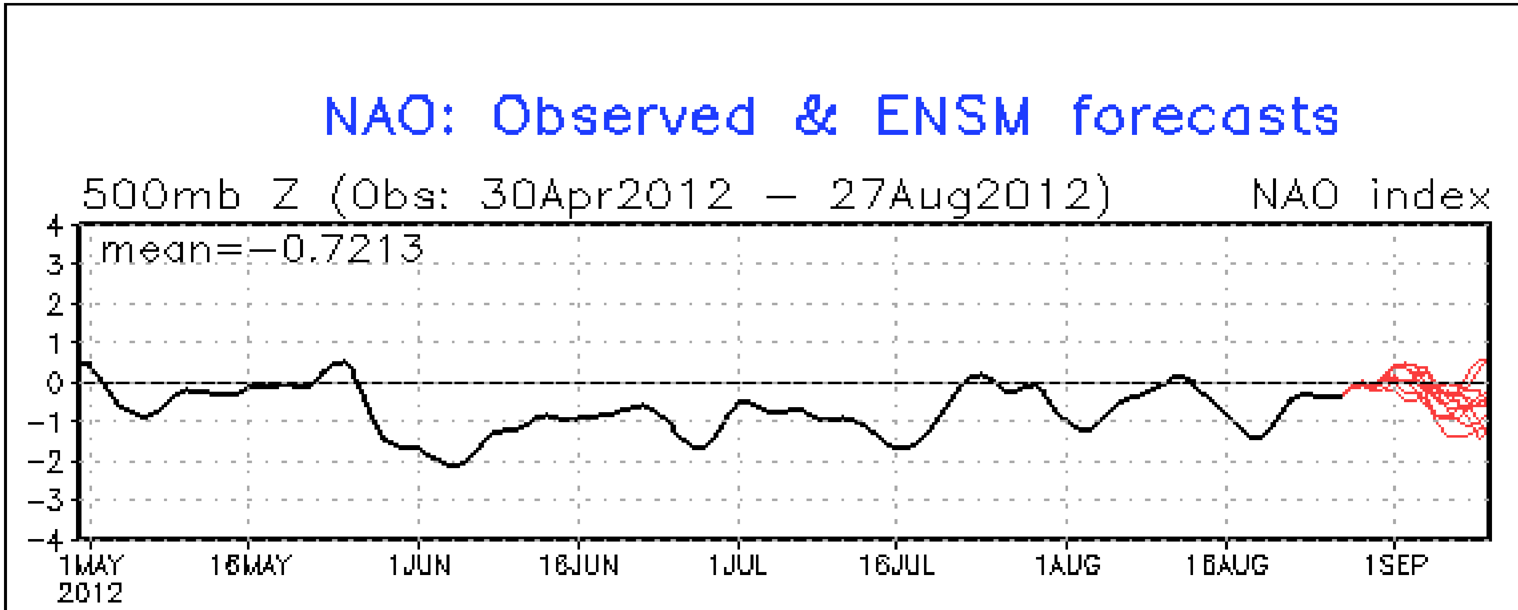
Large scale features

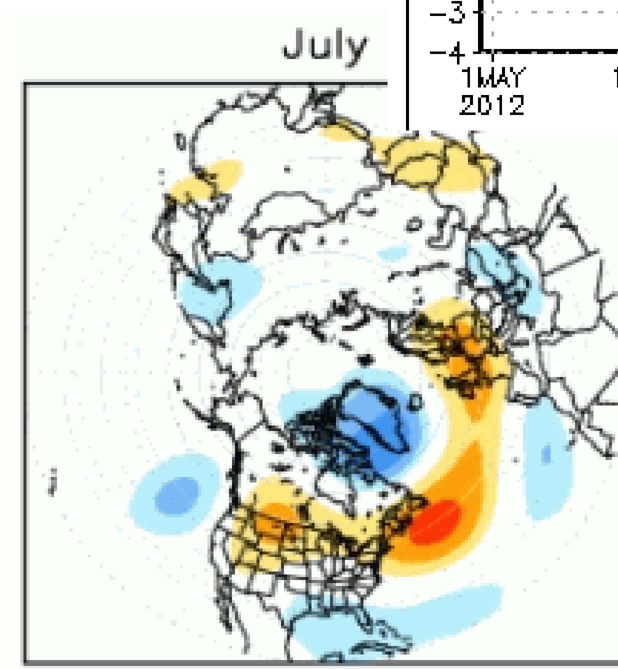




Large scale features: 2012 drought

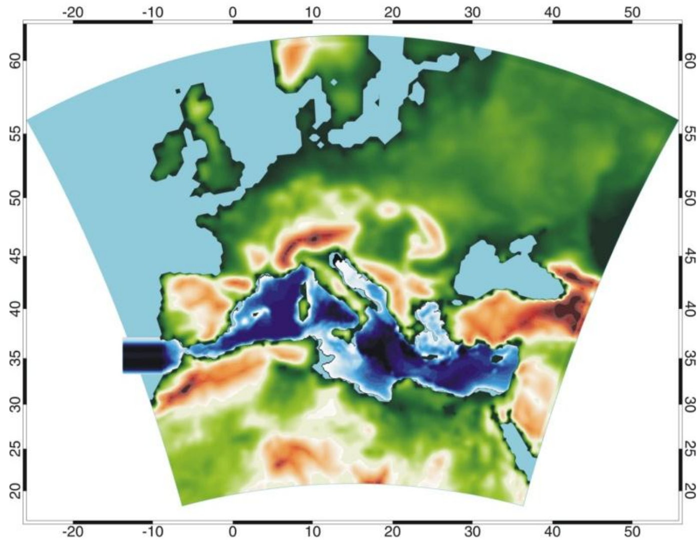
Summer NAO …



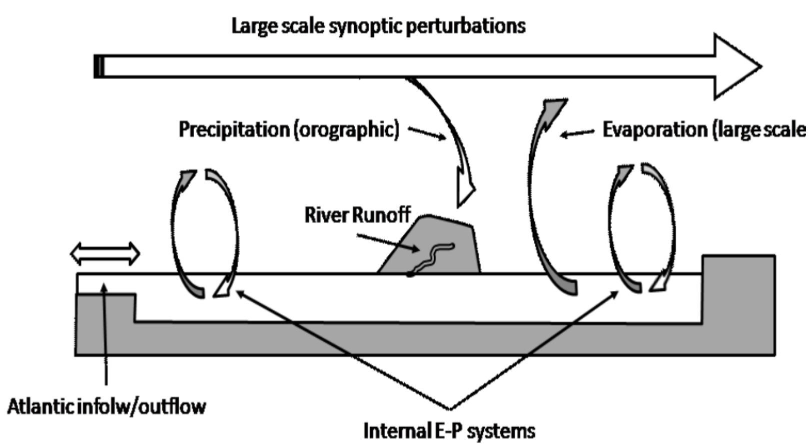


Motivation

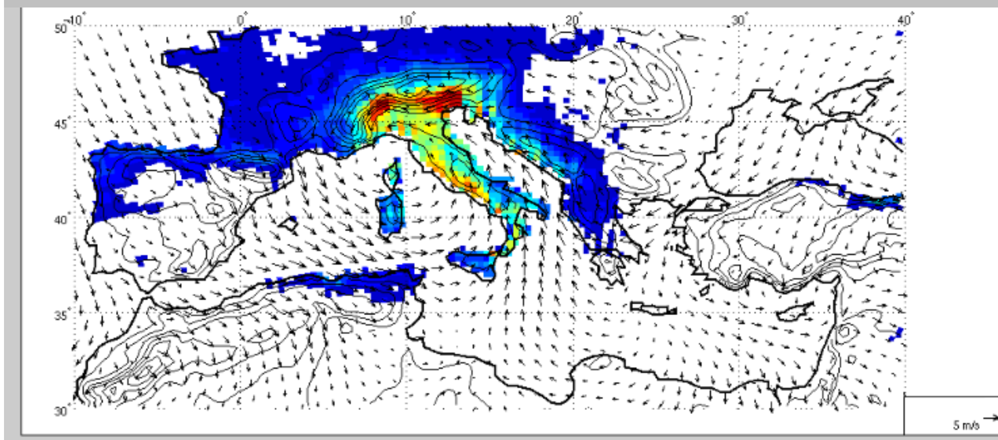
Region characterized by extremely complex coastlines and topographical features



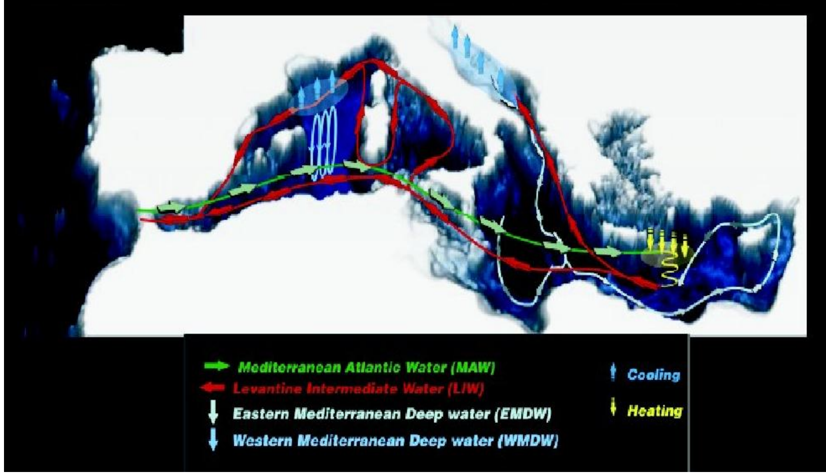
Hydrological cycle



Deep Cyclogenesis Events



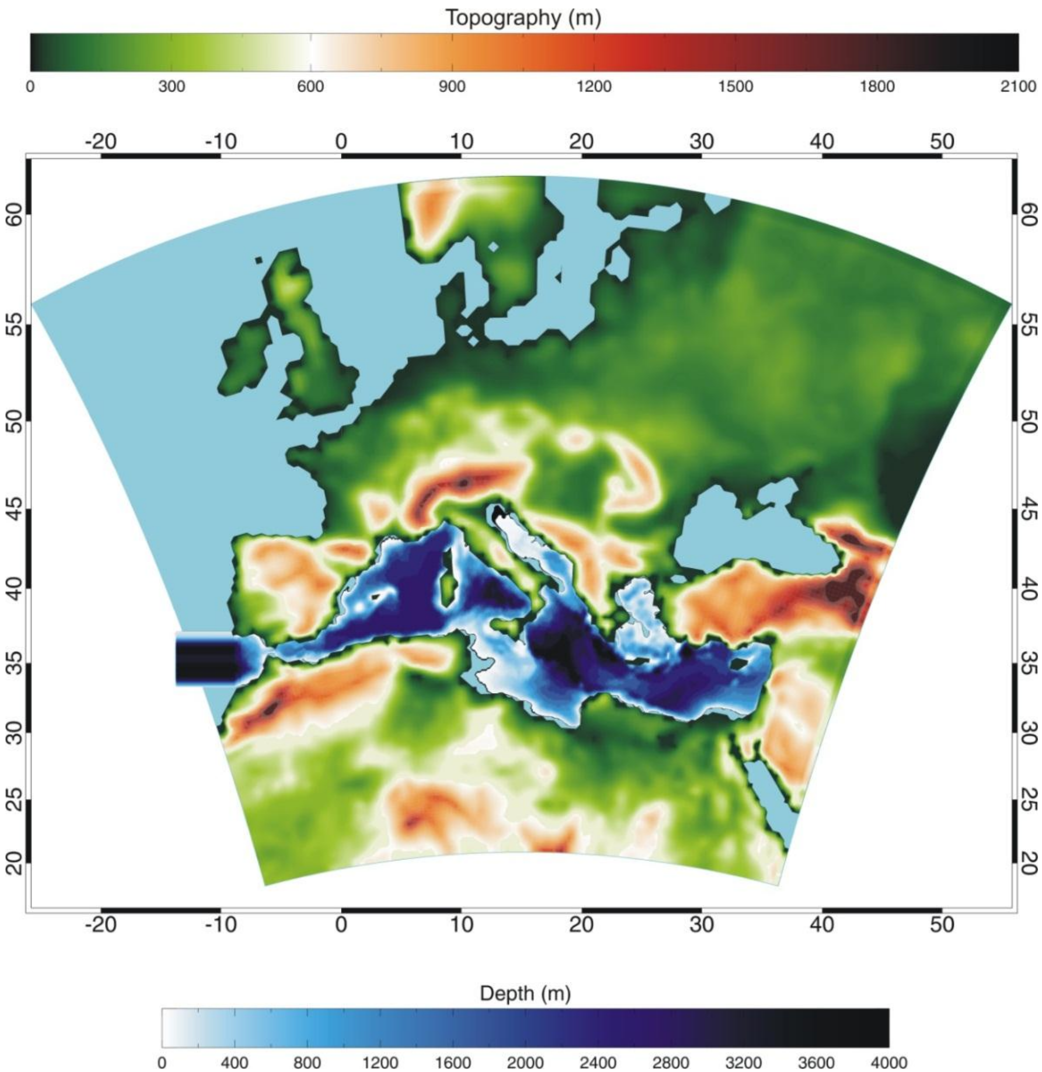
Deep Mediterranean water is produced at different locations by intense air–sea interactions: Gulf of Lions, the Southern Adriatic, the northeast Levantine basin, Aegean Sea…



Regional processes: A regional earth system model for the Mediterranean region

PROTHEUS model

Model domain



Model components

RegCM3

18 sigma vertical levels

30 Km horizontal resolution

BATS + IRIS

BATS: Biosph.-Atmosph. Transfer Scheme

IRIS: interactive RIvers Scheme

SST

OASIS 3
Freq. 6h

HF-WF-Wind

MedMIT

42 zeta vertical levels (partial cell)

1/8° x 1/8° horizontal resolution

PROTHEUS model

Pre-existing simulations

○**ERA40** reanalysis 1958-2000

○**20C:** Boundary condition from ECHAM5-MPIOM run performed in ENSEMBLES: 1951-2000 climate of the 20th Century experiment

○**SRES A1B:** Boundary condition from ECHAM5-MPIOM run performed in ENSEMBLES: 2001-2051 720 ppm stabilization experiment

(CIRCE EU-FP6 project)

Ongoing simulations
(expected for September 2012)

○**ERA-INTERIM** reanalysis 1982-2011

○**RCP 4.5** Boundary condition from CNRM-CM5 run performed for CMIP5: 1971-2100

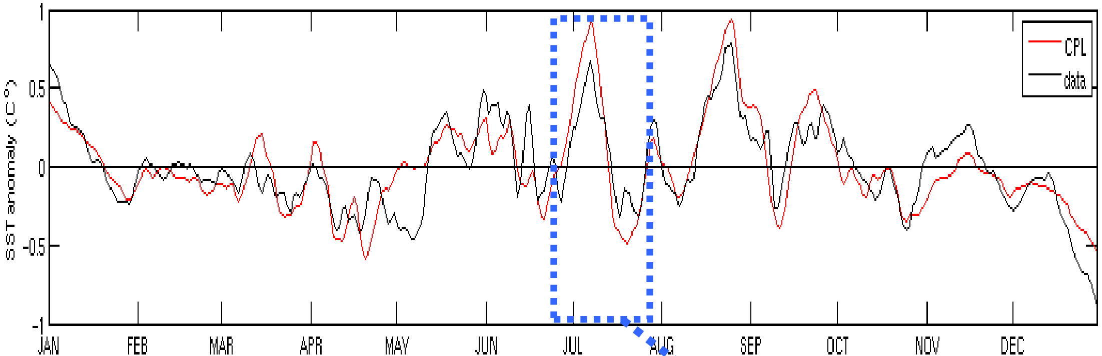
○***(planned) RCP 8.5*** *Boundary condition from CNRM-CM5 run performed for CMIP5: 1971-2100*

(IMPACT2C & CLIMRUN EU-FP7 project ; MED-CORDEX experiment)

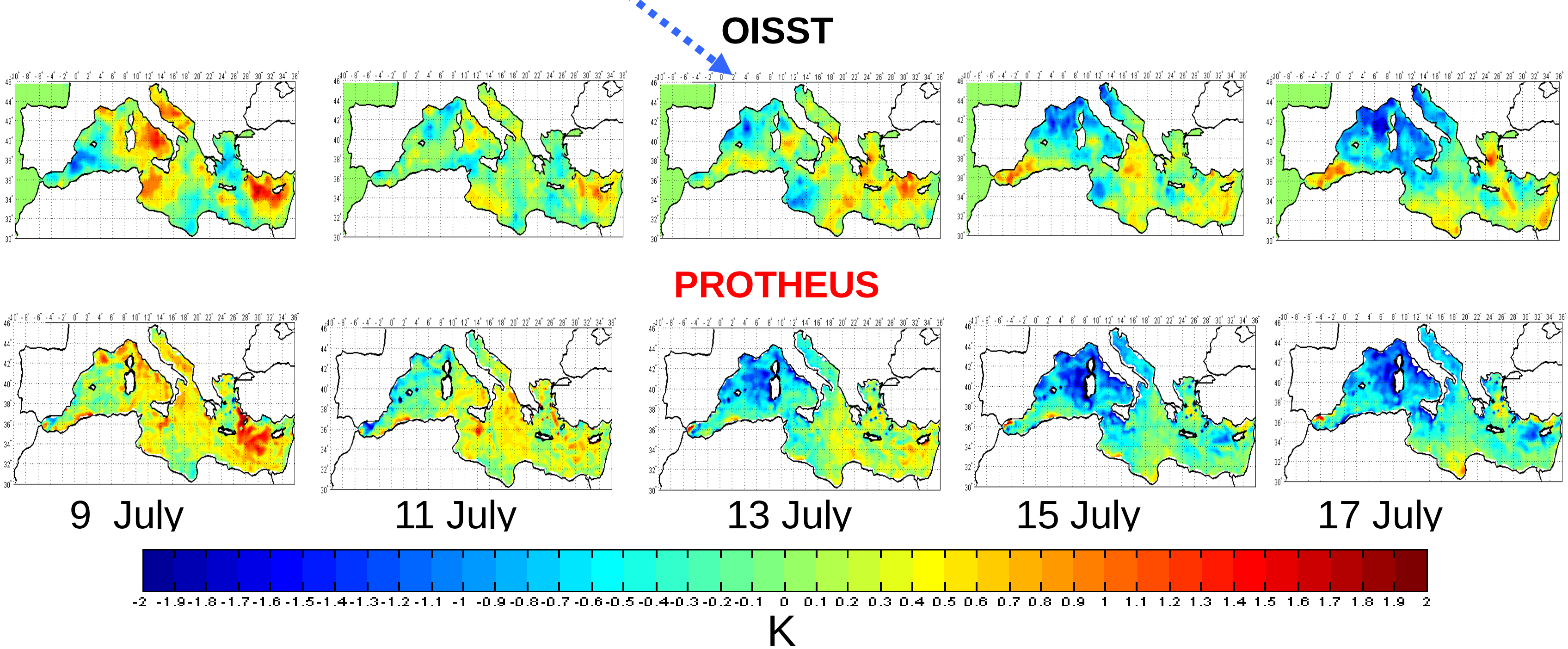
Regional processes: A regional earth system model for the Mediterranean region

PROTHEUS Model Validation: ERA40 simulation

Artale et al 2010, Clim. Dyn.



Time series of 2000 **SST anomalies** for PROTHEUS simulation (red line) and **satellite observations (black line).** Values are averaged over the whole basin.

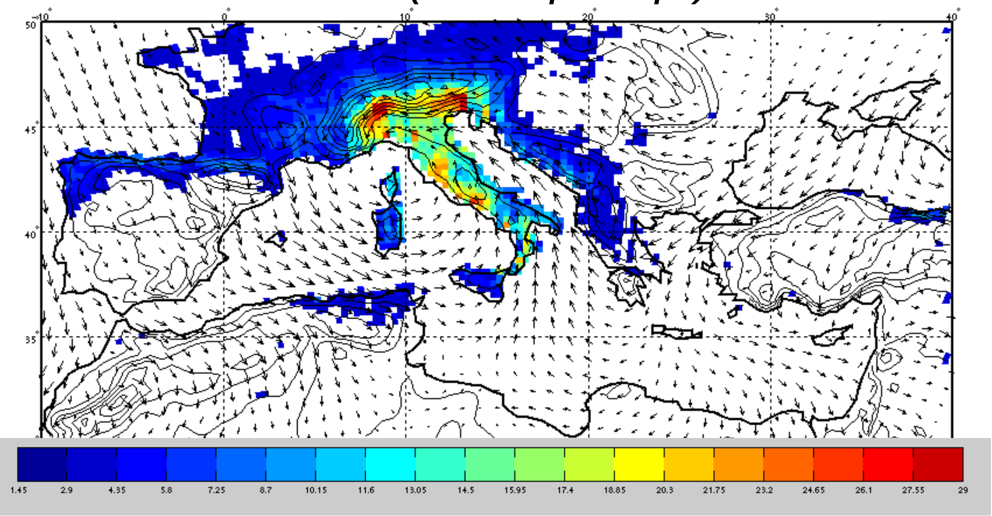


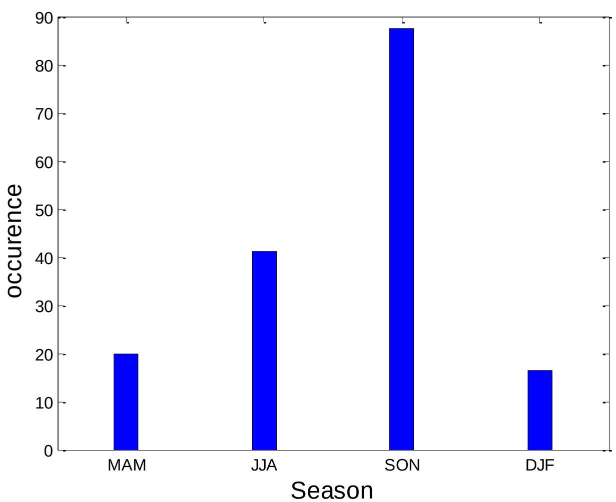
Regional processes: A regional earth system model for the Mediterranean region

PROTHEUS Model Validation: ERA40 simulation

Air-sea interaction: deep cyclogenesis events

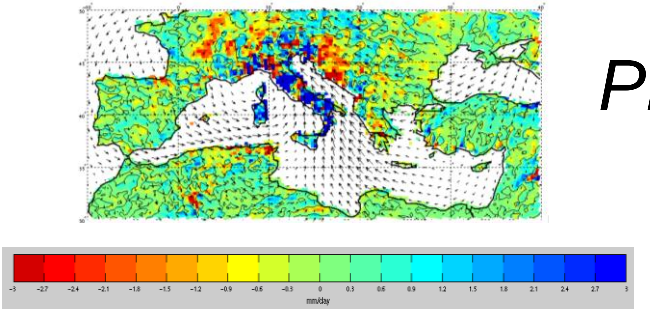
(wind+precip.)



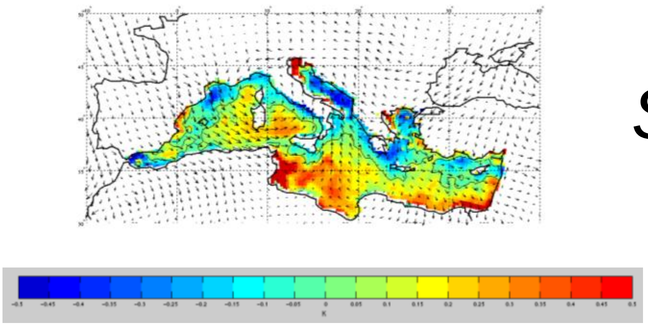


Differences

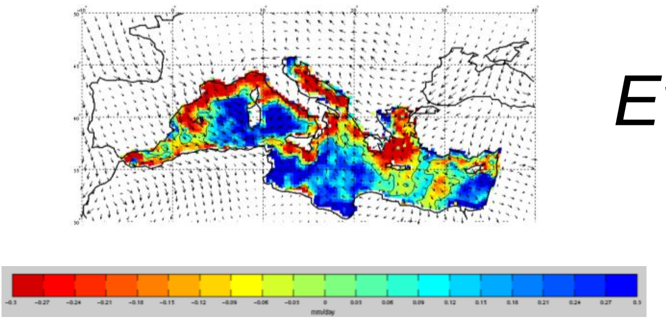
COUPLED-Stand alone simulations



Precip.



SST

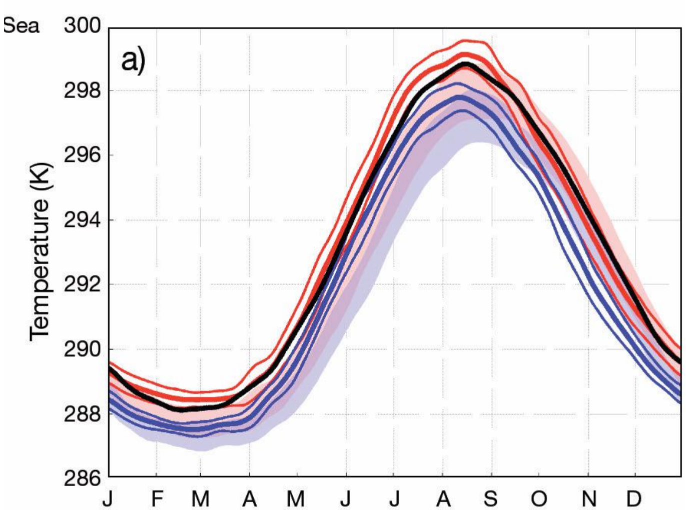


Evap.

Scenario Simulations: PROTHEUS driven by ECHAM5-MPIOM (1951-2050)

Global drivers and regional downscaling

Over sea



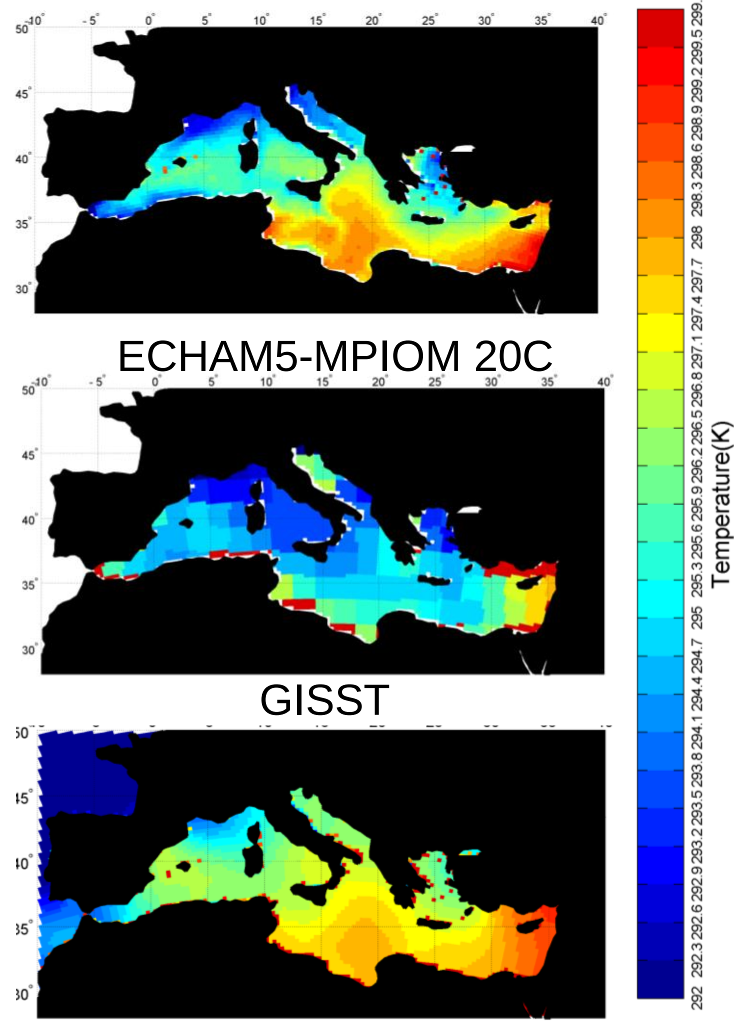
Dell'Aquila et al 2012, Clim. Res.

- PROTHEUS 20 C
- ECHAM5-MPIOM 20C
- PROTHEUS A1B
- ECHAM5-MPIOM A1B
- GISST

By adopting a regional coupled system we obtain partial reduction of the SST bias produced in the driving global simulation and a better representation of the corresponding patterns

JJA SST

PROTHEUS 20C

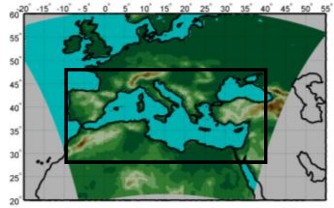


Regional processes: A regional earth system model for the Mediterranean region

Scenario Simulations: PROTHEUS driven by ECHAM5-MPIOM (1951-2050)

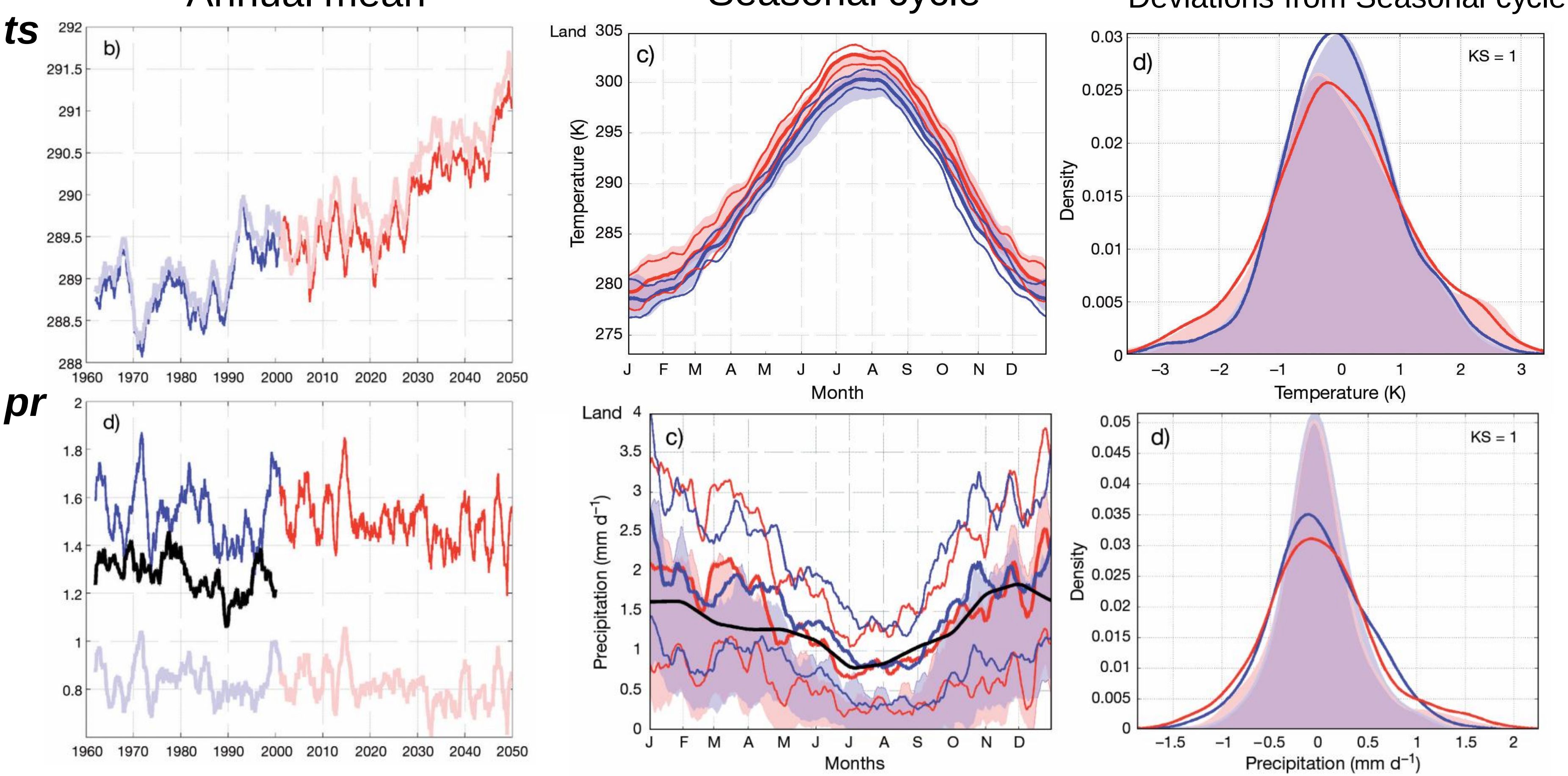
Global drivers and regional downscaling over land

Dell'Aquila et al 2012, Clim. Res.



- PROTHEUS 20 C
- ECHAM5-MPIOM 20C
- PROTHEUS A1B
- ECHAM5-MPIOM A1B

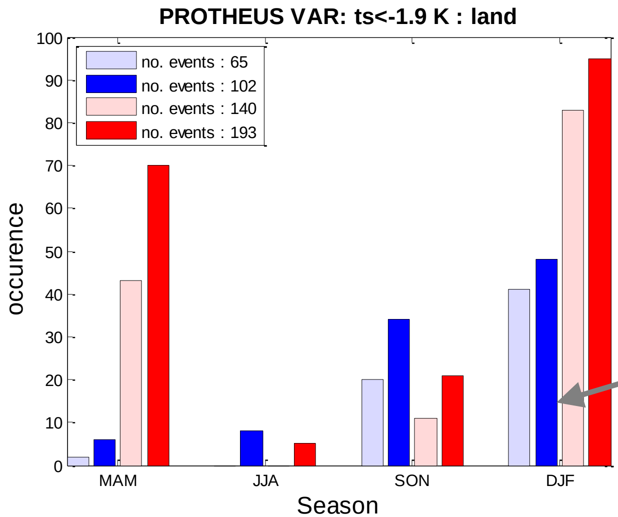
Annual mean — Seasonal cycle — Deviations from Seasonal cycle



Regional processes: A regional earth system model for the Mediterranean region

Scenario Simulations: PROTHEUS driven by ECHAM5-MPIOM (1951-2050)

Large anomalies from seasonal cycle



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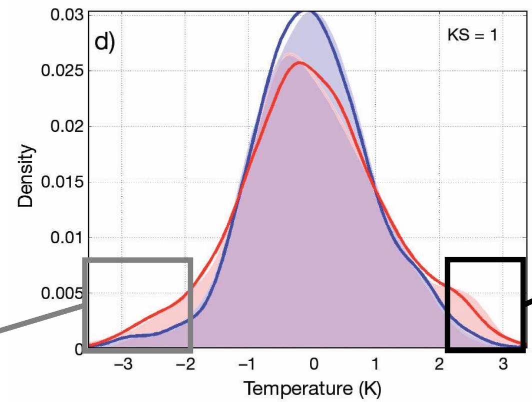

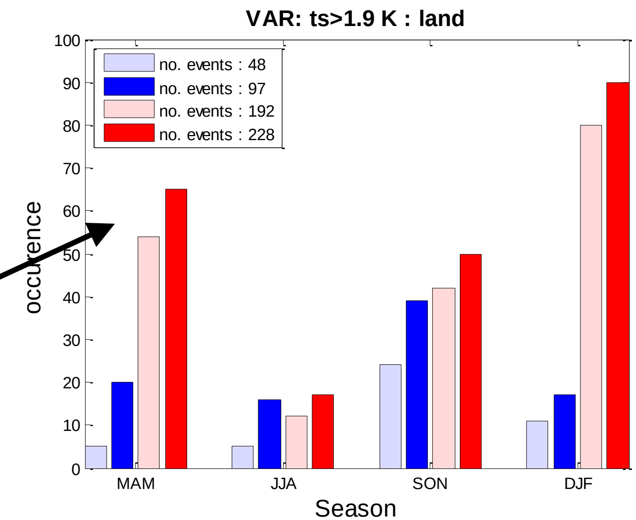

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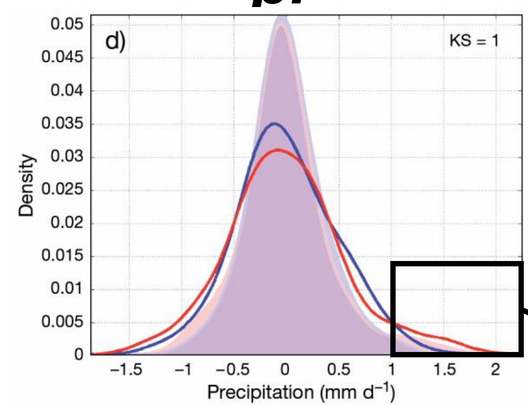
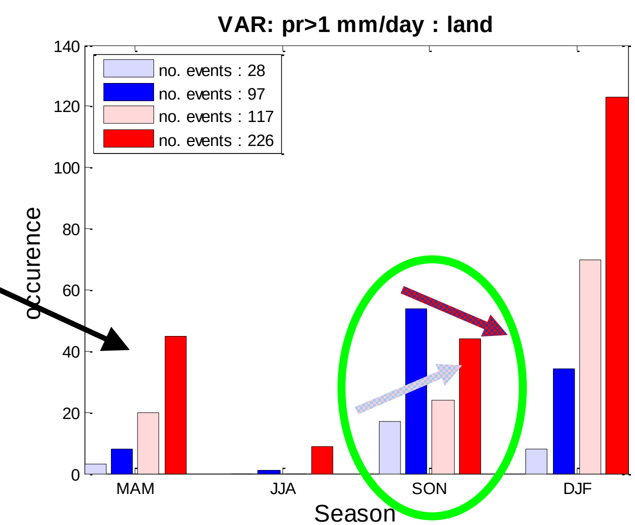
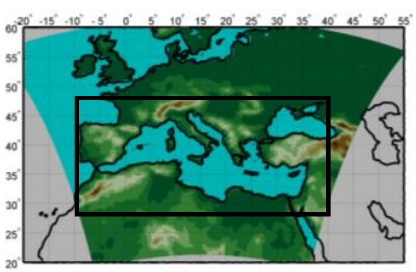




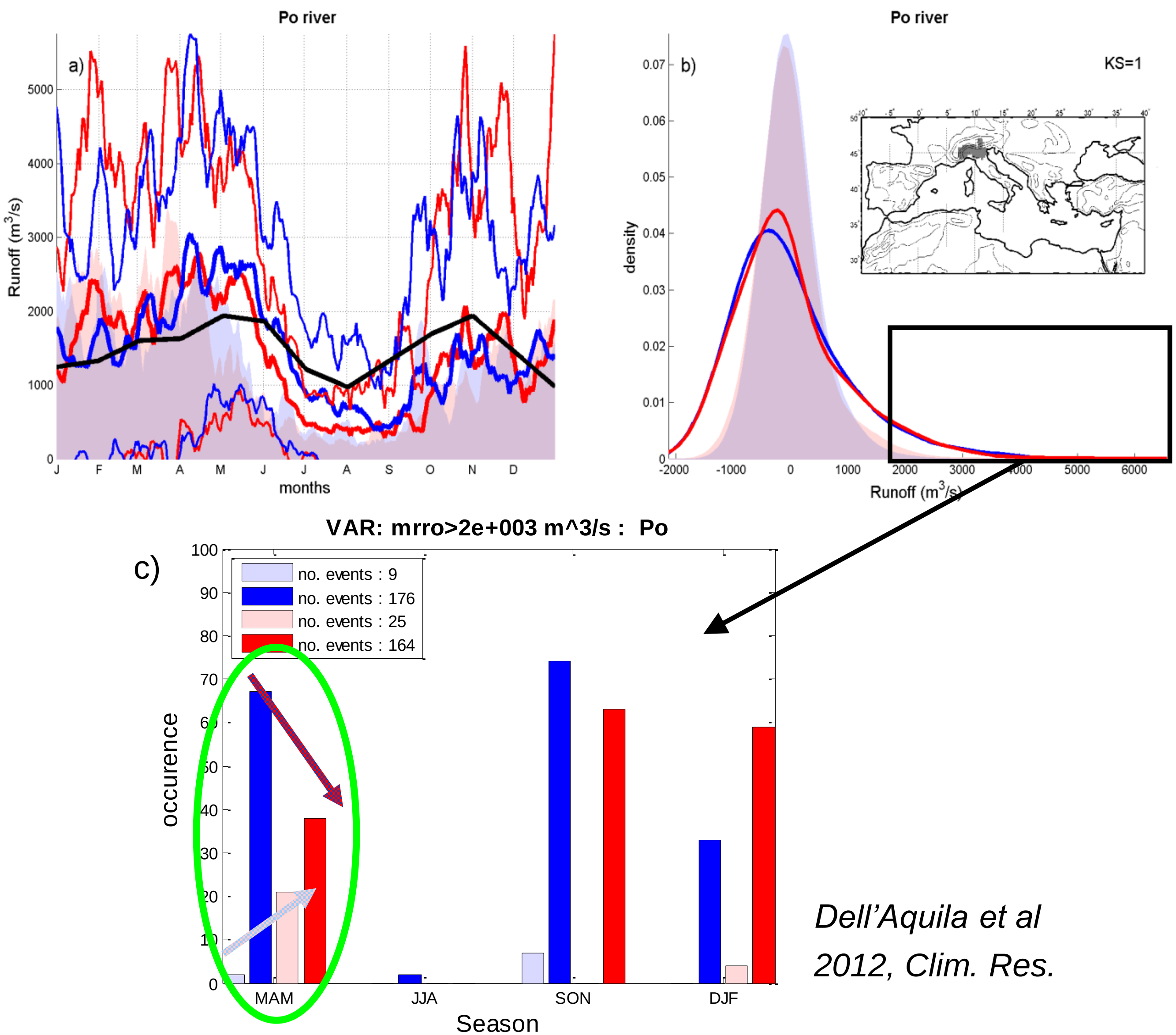


PROTHEUS 20 C
ECHAM5-MPIOM 20C
PROTHEUS A1B
ECHAM5-MPIOM A1B

Dell'Aquila et al 2012, Clim. Res.

Regional processes: A regional earth system model for the Mediterranean region

Scenario Simulations: PROTHEUS driven by ECHAM5-MPIOM (1951-2050)



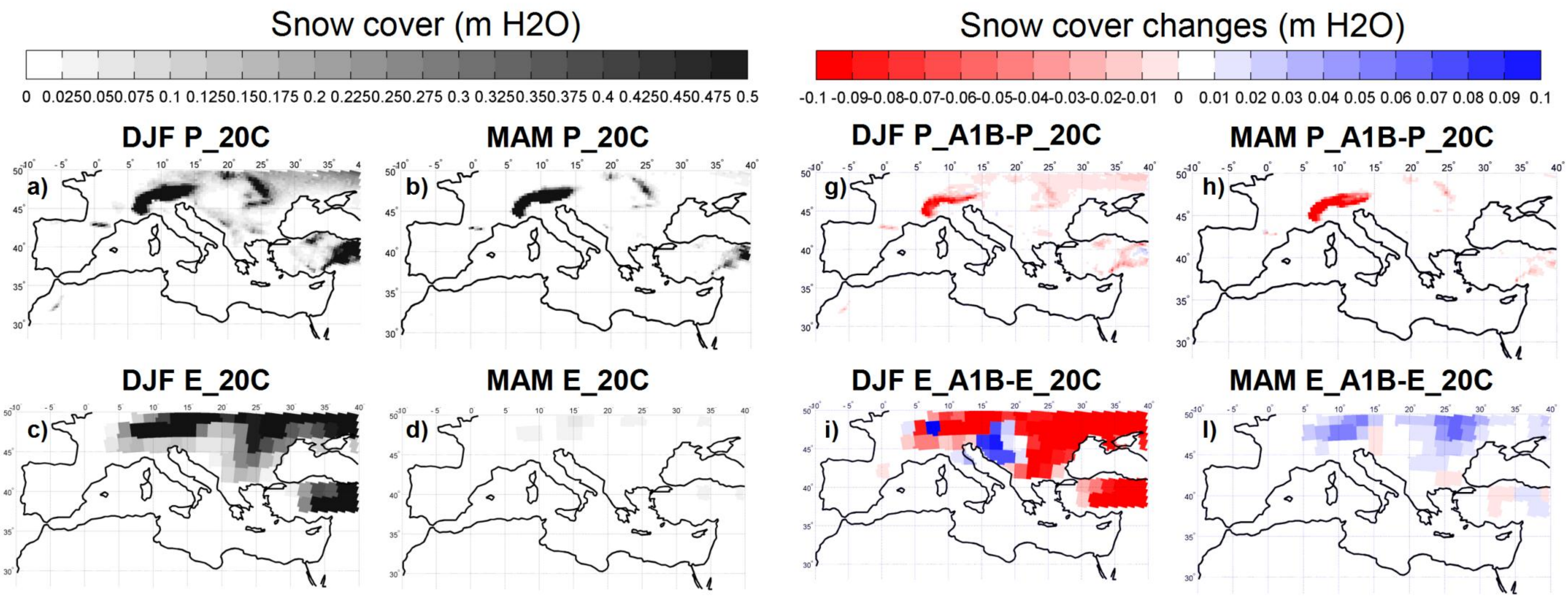
Po River discharge

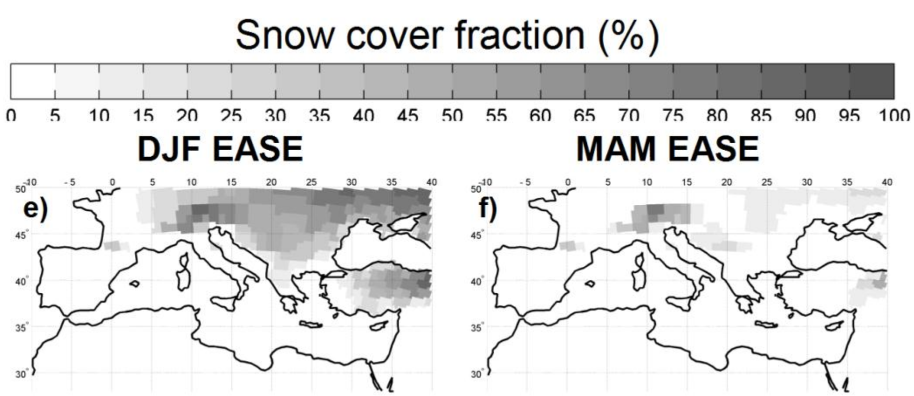
- PROTHEUS 20 C
- ECHAM5-MPIOM 20C
- PROTHEUS A1B
- ECHAM5-MPIOM A1B

Total Runoff (surface + drainage) ***mrro*** *integrated over the Po catchment basin. We also report the map of the associated catchment basin (TRIP dataset). The* ***black line*** *in the a) panel is the average seasonal cycle of the observed Po discharge in Pontelagoscuro. In c) we report the number of large anomalies of* ***mrro'*** *from seasonal cycle for each season*

Dell'Aquila et al 2012, Clim. Res.

SNOW COVER





Snow cover. a-c-e) Seasonal DJF 20C average in PROTHEUS, ECHAM5/MPI-OM simulations and in climatological EASE dataset, respectively. Unit are m H2O for PROTHEUS and ECHAM5/MPIOM while percentage fraction is used for EASE. b-d-f) as in a-c-e) but for MAM. DJF and MAM seasonal changes (A1B minus 20C) in PROTHEUS (g-h) and ECHAM5/MPI-OM simulations (i-l) respectively.

Regional processes: A regional earth system model for the Mediterranean region

Conclusions: PART II

•Over Mediterranean, a regional coupled model is capable of significantly improve the description of air-sea interactions especially for intense events

•In the scenario simulation a reduction of SST bias produced in the driving global simulation and a better representation of the corresponding patterns is pointed out

•The different representation of surface temperature affects air-sea fluxes and thereby the seasonality of the moisture availability in the atmosphere (→ differences in intense precipitation events)

•The regional downscaling permits more detailed and reliable description of river runoff on medium/small size river catchment basins that would hardly be captured in a global model