Sources of climate variability and predictability in the Mediterranean regions

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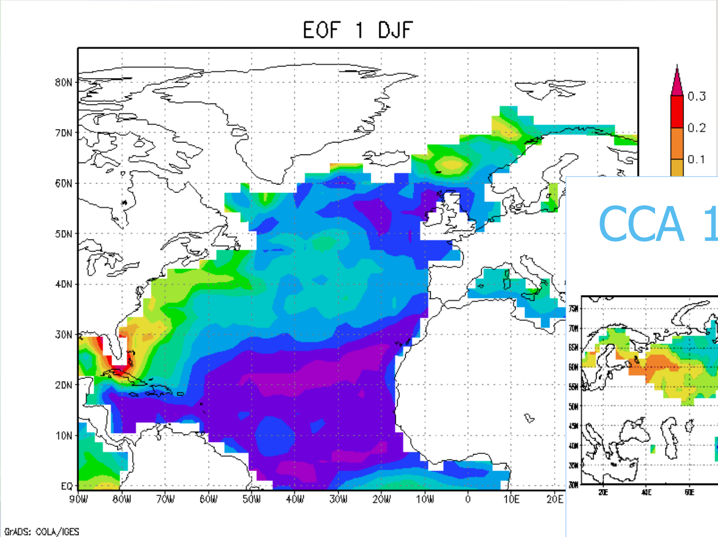
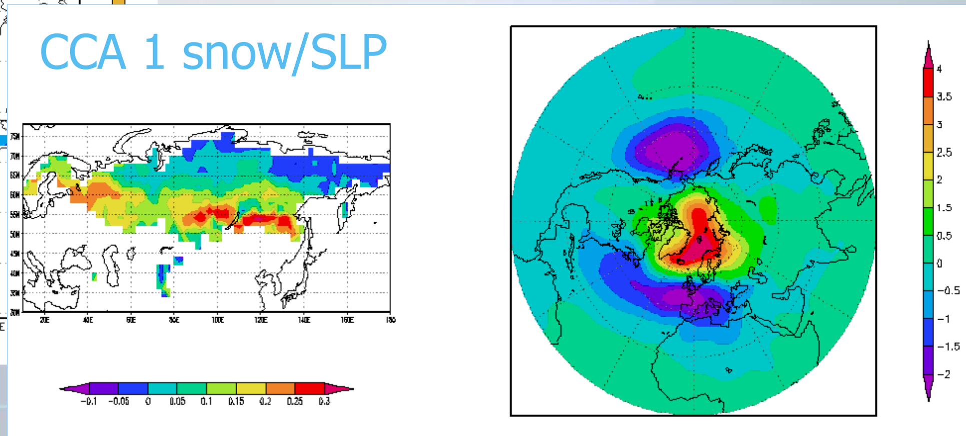
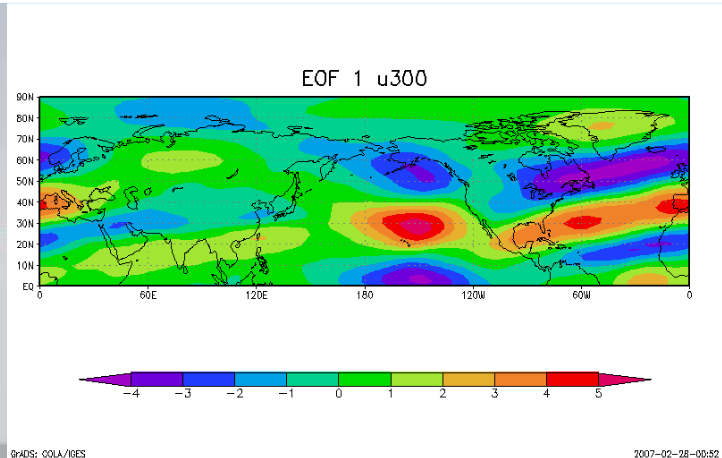
Outline

- **Recurrent patterns**
- **Recurrent climate patterns in the Mediterranean regions**
- **Sources of recurrent patterns in the Mediterranean regions**
  - **global warming signal;**
  - **natural modes of variability;**
  - **local mechanisms**
- **Preliminary conclusions and remarks**

Recurrent climate patterns







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Identification of recurrent patterns in data:

*Empirical Orthogonal Functions (EOF) analysis
*Canonical Correlation Analysis (CCA)
*Cluster analysis, etc

EOF

Data:

$$\mathbf{f}(t) = \sum_{m=1}^{M} c_m(t)\mathbf{e}_m$$

where $c_m(t)$ are projection of $\mathbf{f}$ on the eigenvectors $\mathbf{e}_m$ of the covariance matrix **R** associated to the analyzed data field.

$$\mathbf{R}\mathbf{e}_m = \lambda_m \mathbf{e}_m$$

$$\sum_{m=1}^{M} R_{mm} = \sum_{m=1}^{M} \lambda_m$$

For each eigenvalue λ_m, the fraction of total variance associated to each $\mathbf{e}_m$ is:

$$\lambda_m \Big/ \sum_{m=1}^{M} \lambda_m$$

The CCA selects pairs of spatial patterns of two variables **X** & **Y**, such that their time evolution is optimally correlated (Preisendorfer 1988; Zorita et al. 1992; Bretherton, 1992; Kharin, 1994; Von Storch 1995).

$$C_{xx}^{-1} C_{xy} C_{yy}^{-1} C_{xy}^{T} \mathbf{r}_k = \lambda_k^{2} \mathbf{r}_k$$

$$C_{yy}^{-1} C_{xy}^{T} C_{xx}^{-1} C_{xy} \mathbf{p}_k = \lambda_k^{2} \mathbf{p}_k$$

where C_{xx} and C_{yy} are the elements of covariance matrices for the data fields **X** and **Y**, C_{xy} are the elements of cross-covariance matrix associated with **X** and **Y**. **U** and **V** are the new, best correlated, time series. The spatial patterns associated to them are determined from:

$$\mathbf{g} = C_{xx}\mathbf{r} = \langle \mathbf{UX} \rangle$$

$$\mathbf{h} = C_{yy}\mathbf{p} = \langle \mathbf{VY} \rangle$$

Recurrent climate patterns in the Mediterranean regions

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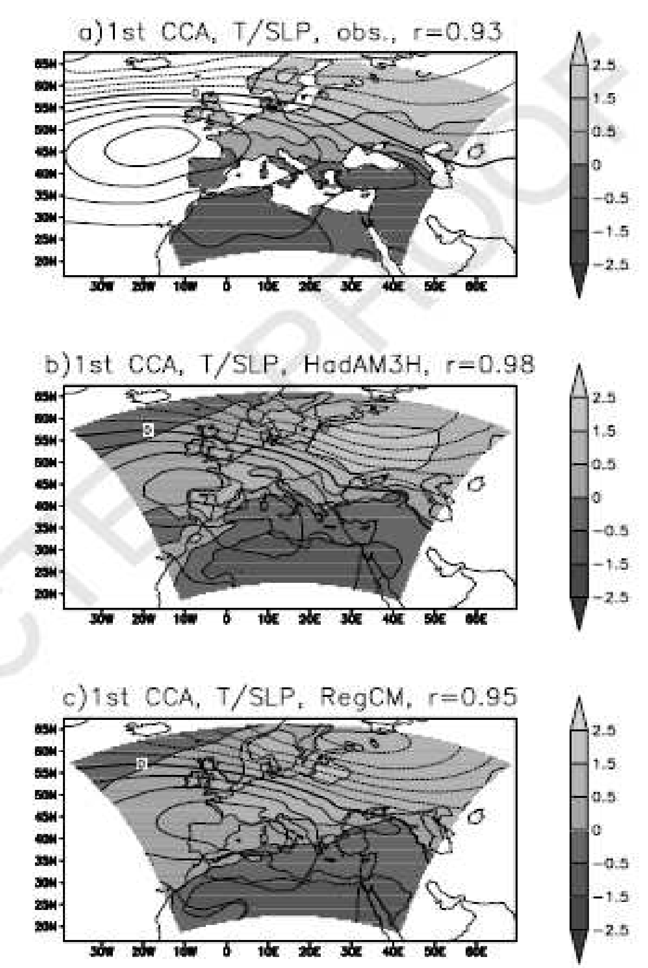
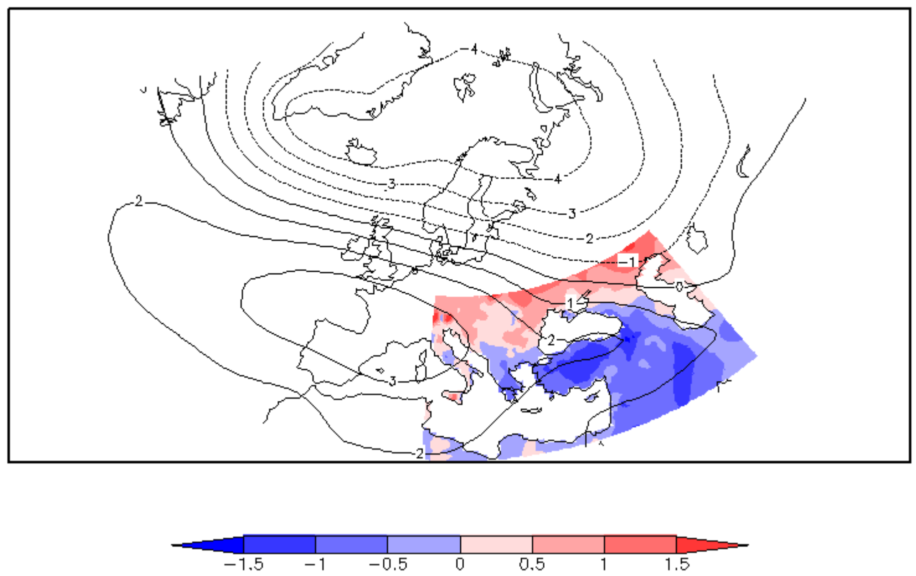


Fig. 4. Spatial pattern of the first CCA mode of DJF SLP (contoured, hPa) and temperature (shaded, °C) representing the observed (a) and the simulated NAO-related variability by the HadAM3H (b) and RegCM (c) over Europe for the period 1961–1990. The SLP contour interval is 1 hPa and solid (dotted) contours are used for the positive (negative) SLP. Zero lines are bold. The observed SLP pattern is the regional portion of the hemispheric patterns in Fig. 2.

Bojariu and Giorgi, 2005)



First spatial pattern of air temperature (in grd. C) and SLP (in hPa) in winter (DJF) for the period 1950-2011. Associated correlation of this CCA mode is 0.74 and associated variance is 40% and 18% of total variance for SLP, respectively, temperature field.

From draft paper on predictability in the South Eastern Europe

Recurrent climate patterns in the Mediterranean regions

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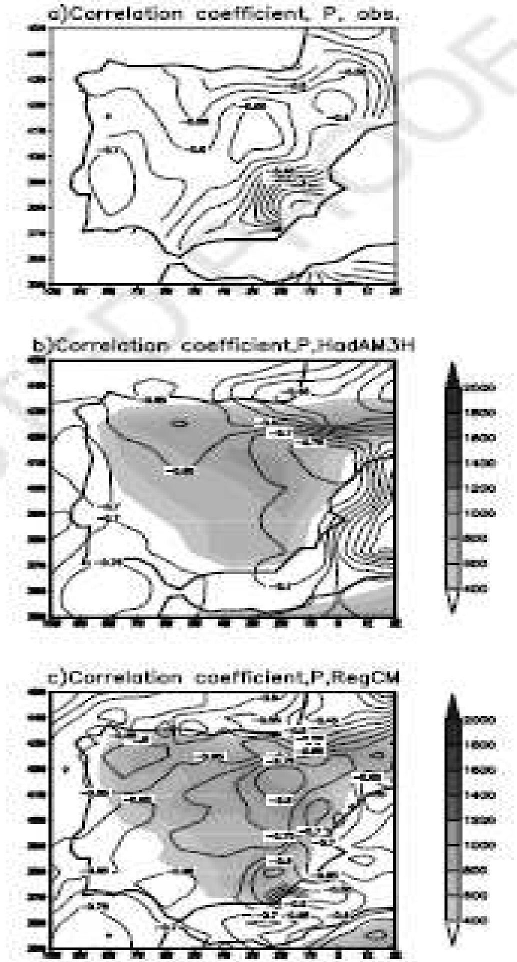
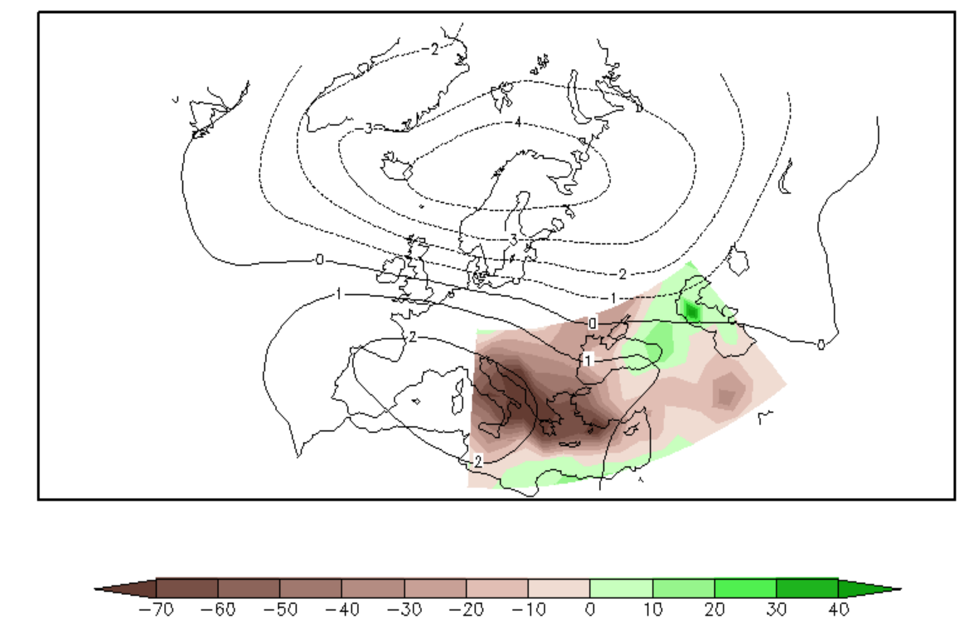


Fig. 7. Correlation coefficient between the first principal component of the DJF SLP and precipitation at each grid point of the Iberian Peninsula: (a) observations (CRU), (b) HadAM3H simulation, (c) RegCM simulation. Statistically significant coefficients at the 0.95 confidence level are smaller than −0.39. Shading indicates HadAM3H topography in (b) and RegCM topography in (c) (units of m).



First spatial pattern of precipitation (in mm/month) and SLP (in hPa) in winter (DJF) for the period 1950-2011. Associated correlation of this CCA mode is 0.90 and associated variance is 28 % and 26 % of total variance for SLP, respectively, precipitation field.

Bojariu and Giorgi, 2005)

From draft paper on predictability in the South Eastern Europe

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Global warming signal

Giorgi and Lionello (2008)

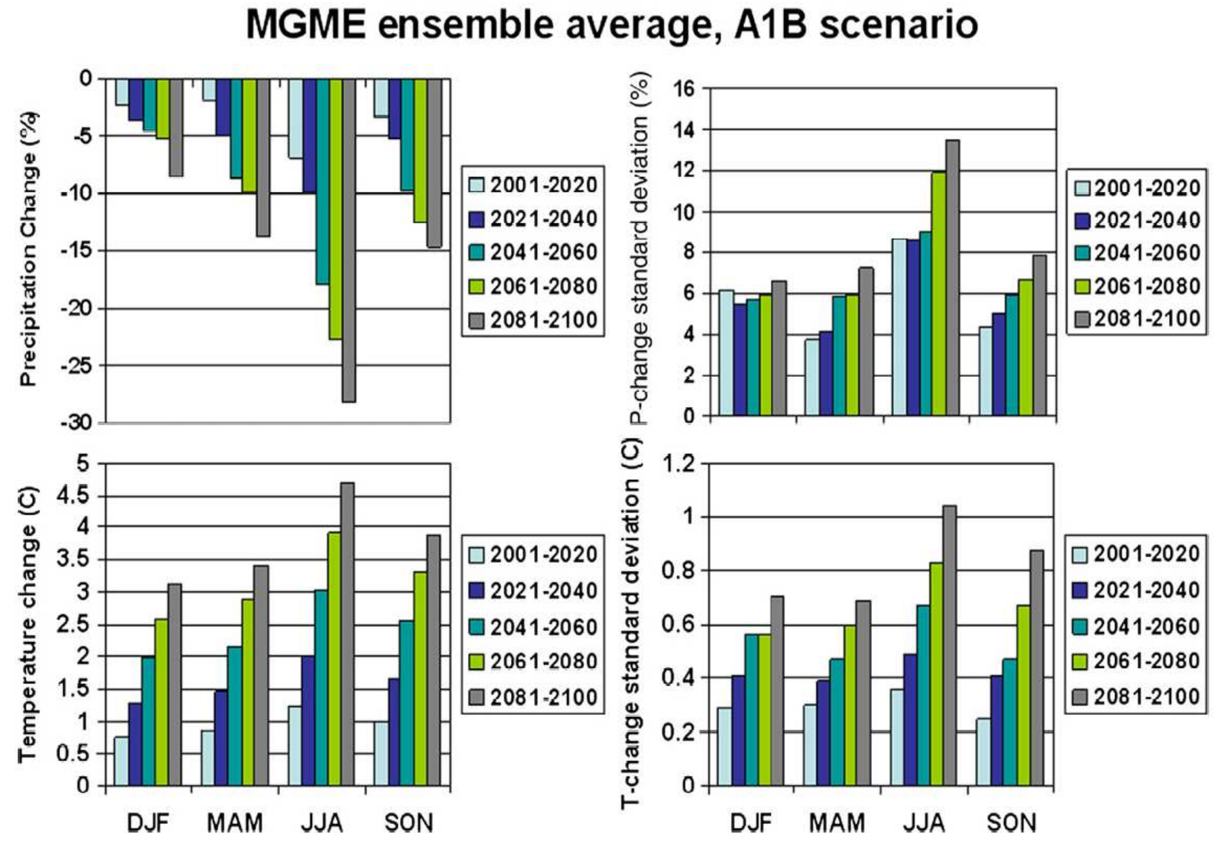

Fig. 11. MGME ensemble average change in mean precipitation (upper left panel), precipitation inter-model standard deviation (upper right panel), mean surface air temperature (lower left panel) and surface air temperature inter-model standard deviation (lower right panel) for the full Mediterranean region (see Fig. 1), the four seasons and different future time periods. The changes are calculated with respect to the 1961–1980 reference period and include only land points. Units are % of 1961–1980 value for mean precipitation, coefficient of variation and standard deviation, and °C for mean temperature.

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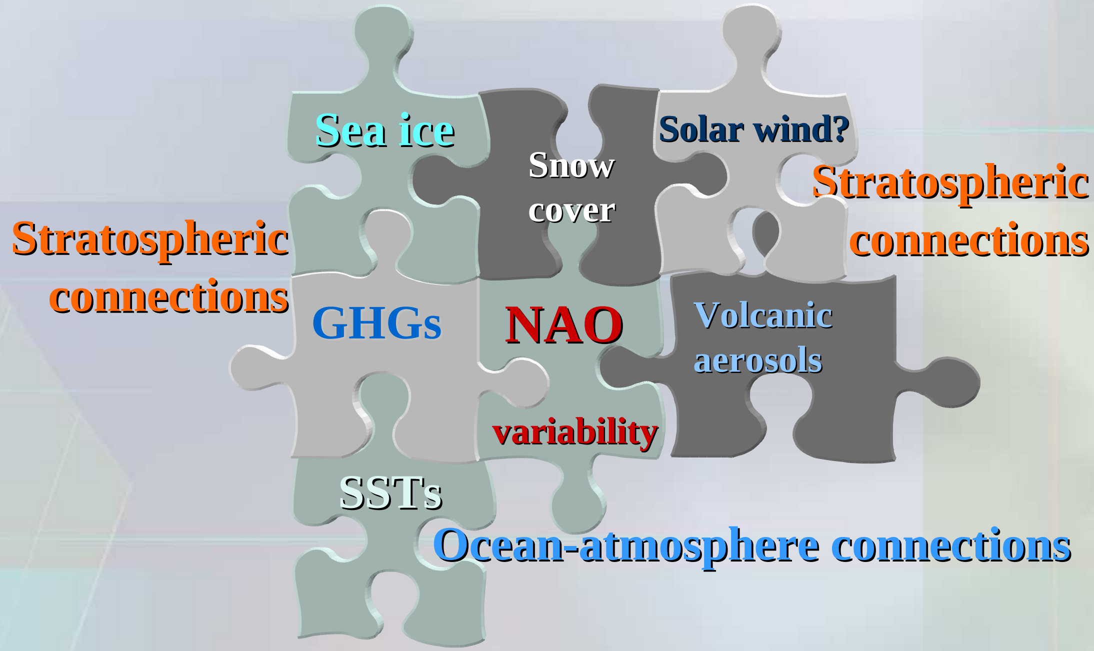
Natural modes of variability – teleconnections

North Atlantic Oscillation



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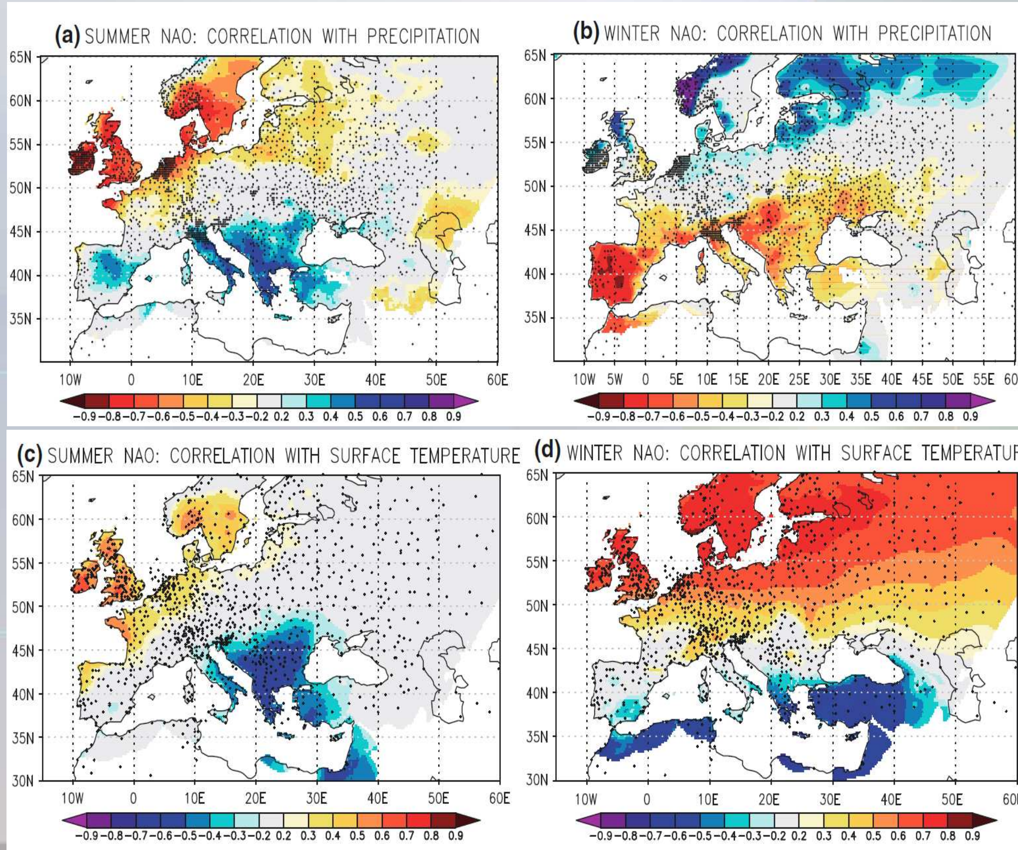
Natural modes of variability – teleconnections

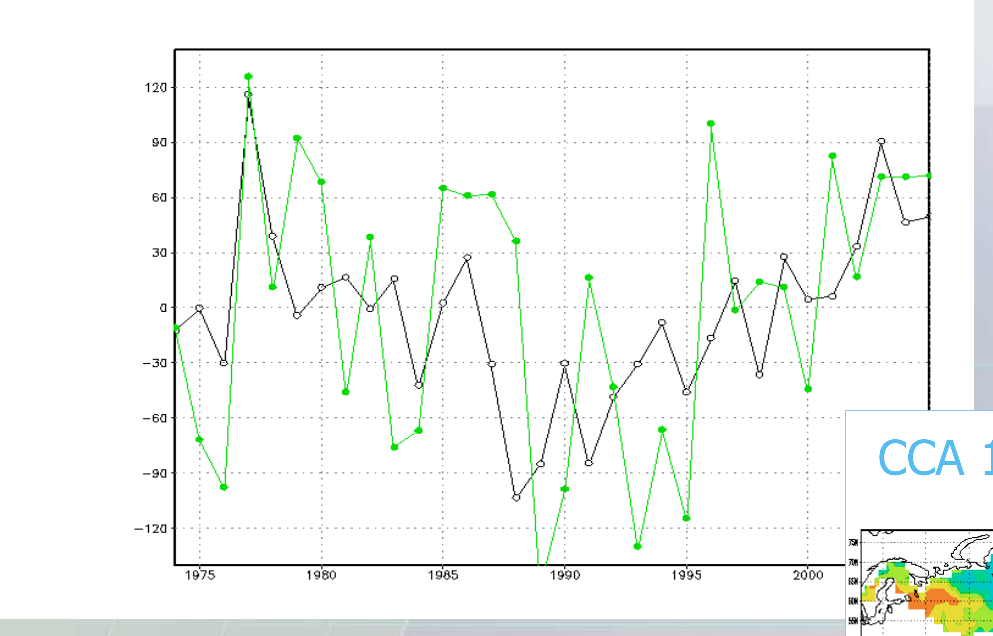
North Atlantic Oscillation

Blade et al., (2012)



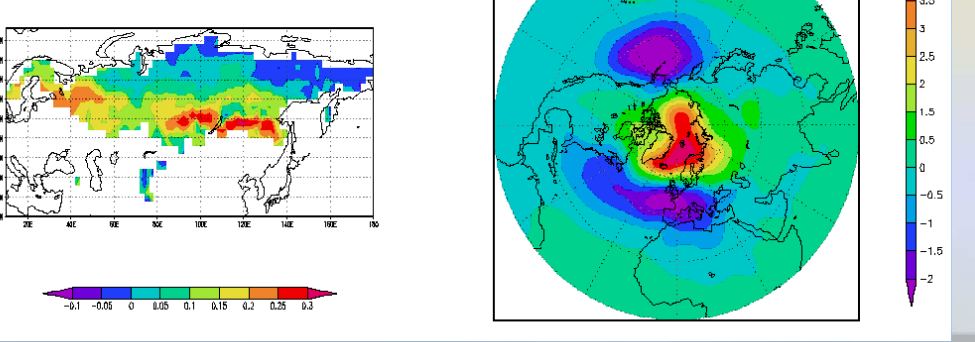
Sources of recurrent patterns in the Mediterranean regions
Natural modes of variability – teleconnections

North Atlantic Oscillation
NAO prediction



Prediction of NAO index with CCA-based model. The model uses the April to October signal in snow frequency over Eurasia and was cross-validated for the period 1973-2002. Correlation coefficient between observed and predicted - 0.5.

CCA 1 snow/SLP



Internal report, Meteo-RO, Bucharest

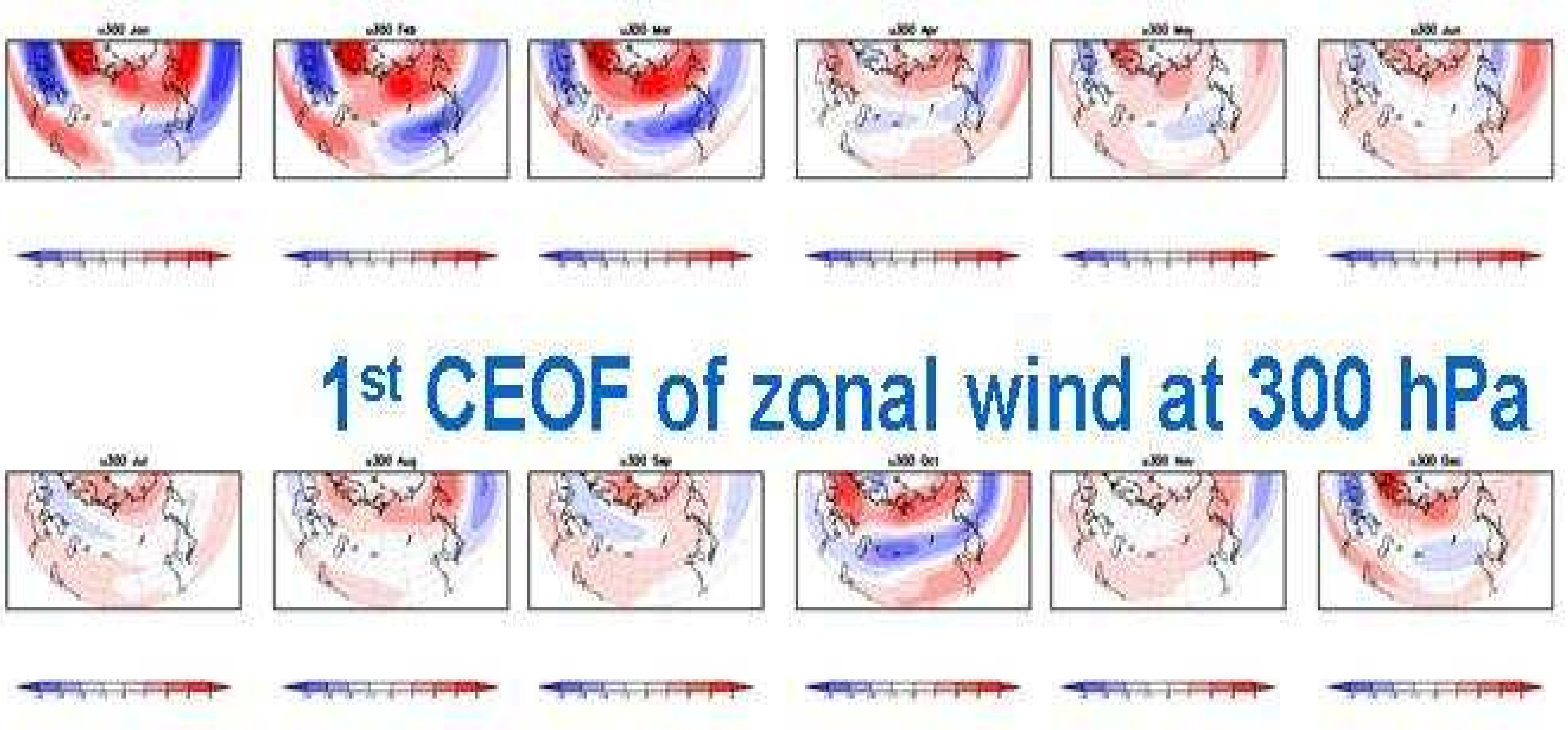
Sources of recurrent patterns in the Mediterranean regions

Natural modes of variability – teleconnections

North Atlantic Oscillation

NAO prediction

Bojariu et. al, 2008



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Natural modes of variability – teleconnections

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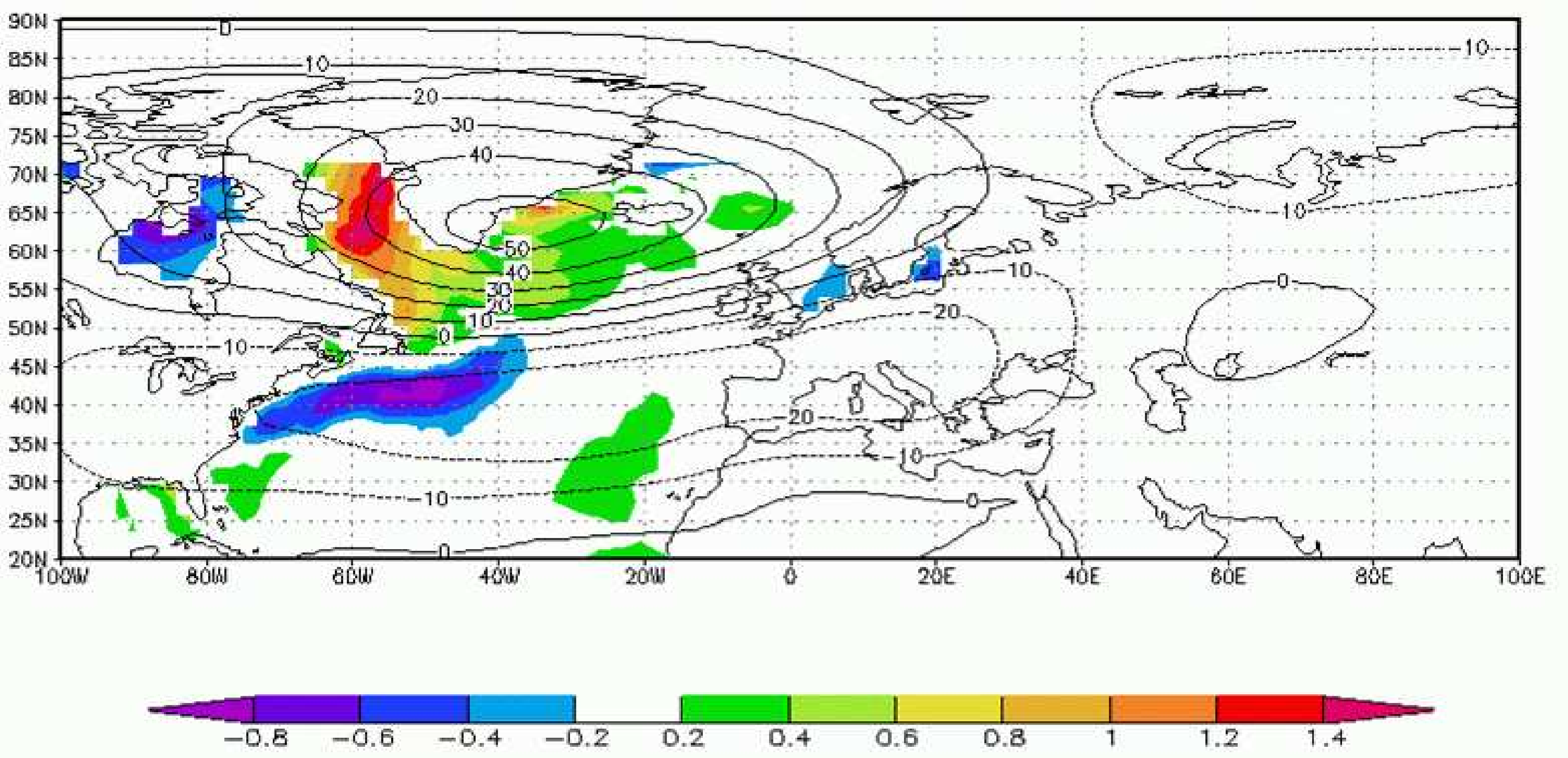
North Atlantic Oscillation
NAO prediction



ROC maps are made using Climate Predictability Tool - http://iri.columbia.edu/climate/tools/CPT/

Rodwell, M. J., D. P. Rowell, and C. K. Folland, 1999

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Natural modes of variability – teleconnections

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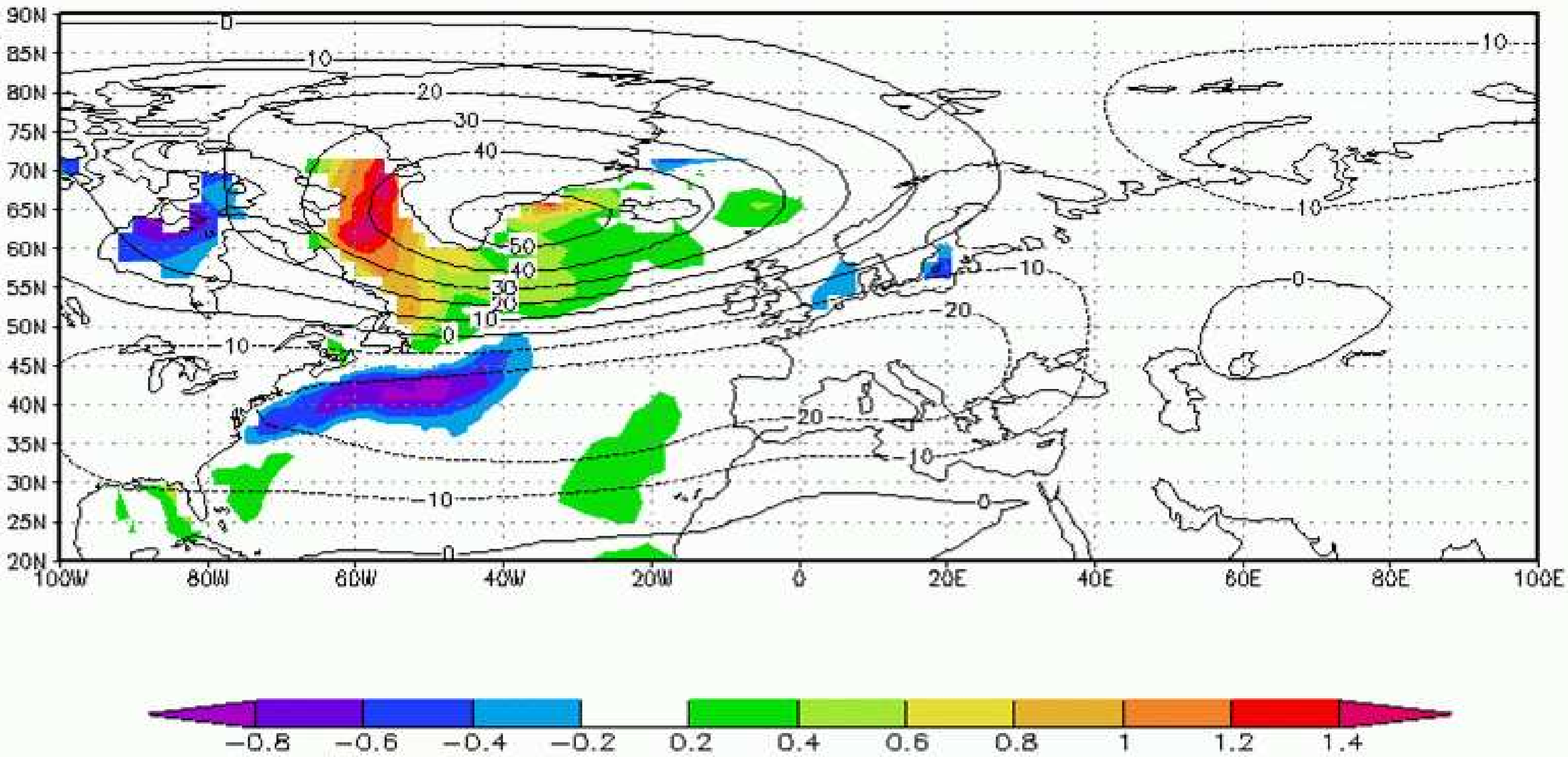
North Atlantic Oscillation
NAO prediction



Internal report, Meteo-RO, Bucharest

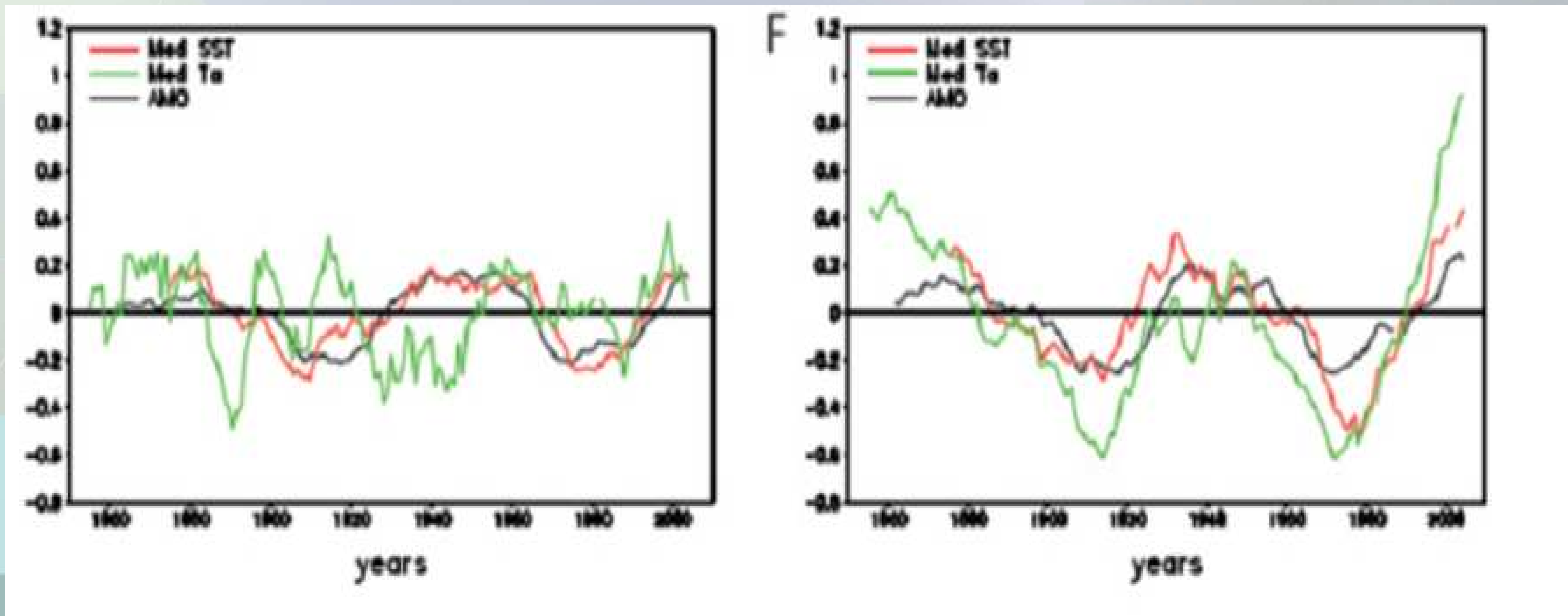
Rodwell, M. J., D. P. Rowell, and C. K. Folland, 1999

Sources of recurrent patterns in the Mediterranean regions

Natural modes of variability – teleconnections

Atlantic Multidecadal Oscillation

Mariotti and Dell'Aquila (2011)



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Natural modes of variability – teleconnections
El Nino – Southern Oscillataion

Mariotti et al. (2002)

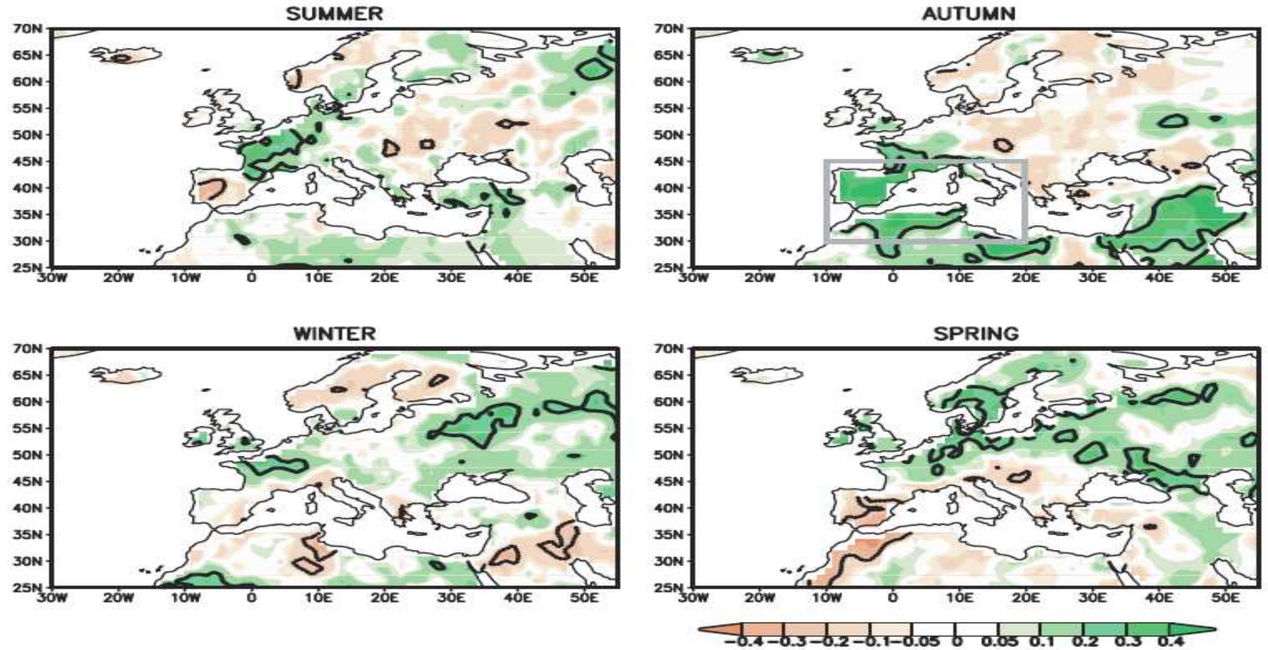

Figure 1. Seasonal correlation of rainfall in the Euro-Mediterranean region and the Nino3.4 index for the period 1948–1996. Rainfall data is from CRU. Correlation coefficients enclosed by contours are statistically significant at the 95% level. The grey box defines the region considered to compute western Mediterranean area-averages.

Sources of recurrent patterns in the Mediterranean regions

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Local mechanisms:
e.g. effect of soil moisture on local climate

Wang et al. (2011)

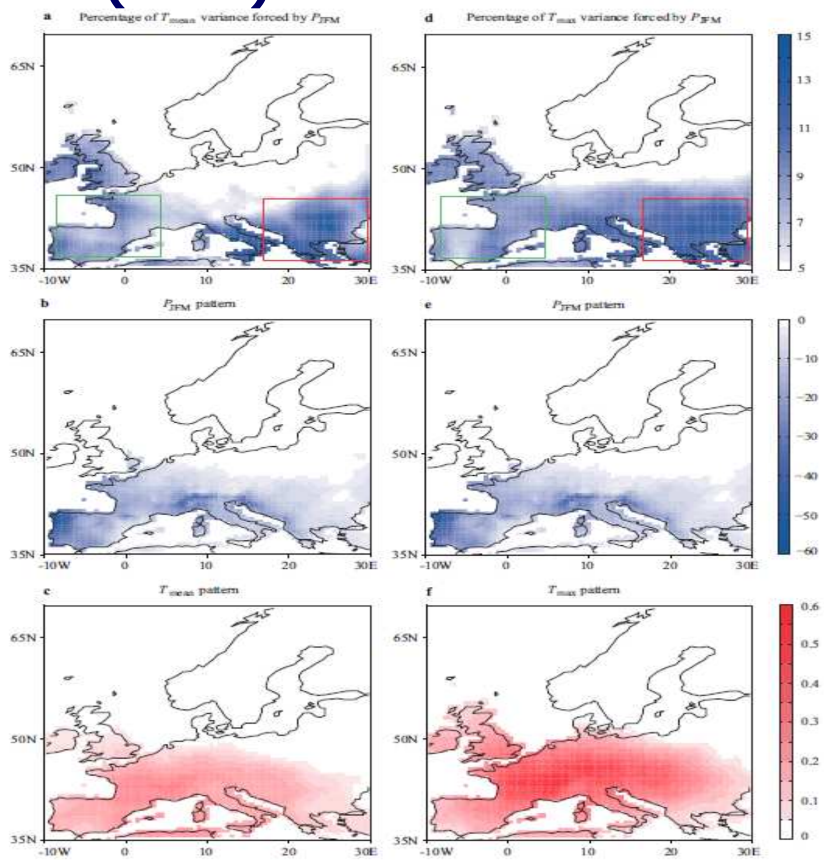

Fig. 1. T_{mean} as well as T_{max} variability forced by P_{JFM}. **(a)** Percentage of T_{mean} variance forced by P_{JFM} (sig = 0.10 in the red rectangle). The spatial patterns of **(b)** P_{JFM} and **(c)** its T_{mean} response. **(d)** Percentage of T_{max} variance forced by P_{JFM} (sig = 0.10 in the red rectangle). The spatial patterns of **(e)** P_{JFM} and **(f)** its T_{max} response for the 1st MCA mode. All the relevant time coefficient series mutually exhibit unit correlation ($r > 0.99$), shown in Fig 3. Units are K for T_{mean} as well as T_{max} and mm for P_{JFM}.

Sources of recurrent patterns in the Mediterranean regions

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Other local mechanisms influences:
e.g. Mediterranean cyclones, Saharan dust etc.

Alpert et al., 2006

Preliminary conclusions and remarks

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- **Climate predictability is regionally and temporally dependent; climate prediction strategy has to be regionally-orientated;**
- **Existence of scientific significance of climate prediction results does not guarantee socio-economic significance (cost/benefit ratio);**
- **IPCC AR5/CMIP 5 – new and updated information on decadal climate predictability**
- **There are deontological and ethical implications related to socio-economic fast response to climate prediction which should be taken into account.**

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