VARIABILITY OF THE MEDITERANNEAN CLIMATE

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OUTLINE

- Variability of the mediteranean climate
- Processes and phenomena driving mediteranean climate variability (ENSO, NAO, , Tropical North Atlantic SST, QBO, Tropical intrusion, trough/ridges, blockings,…)

MEDITERANEAN PRECIPITATION SEASONS

DJF brings more precipitation particularly over Eastern Mediterranean part of North Africa

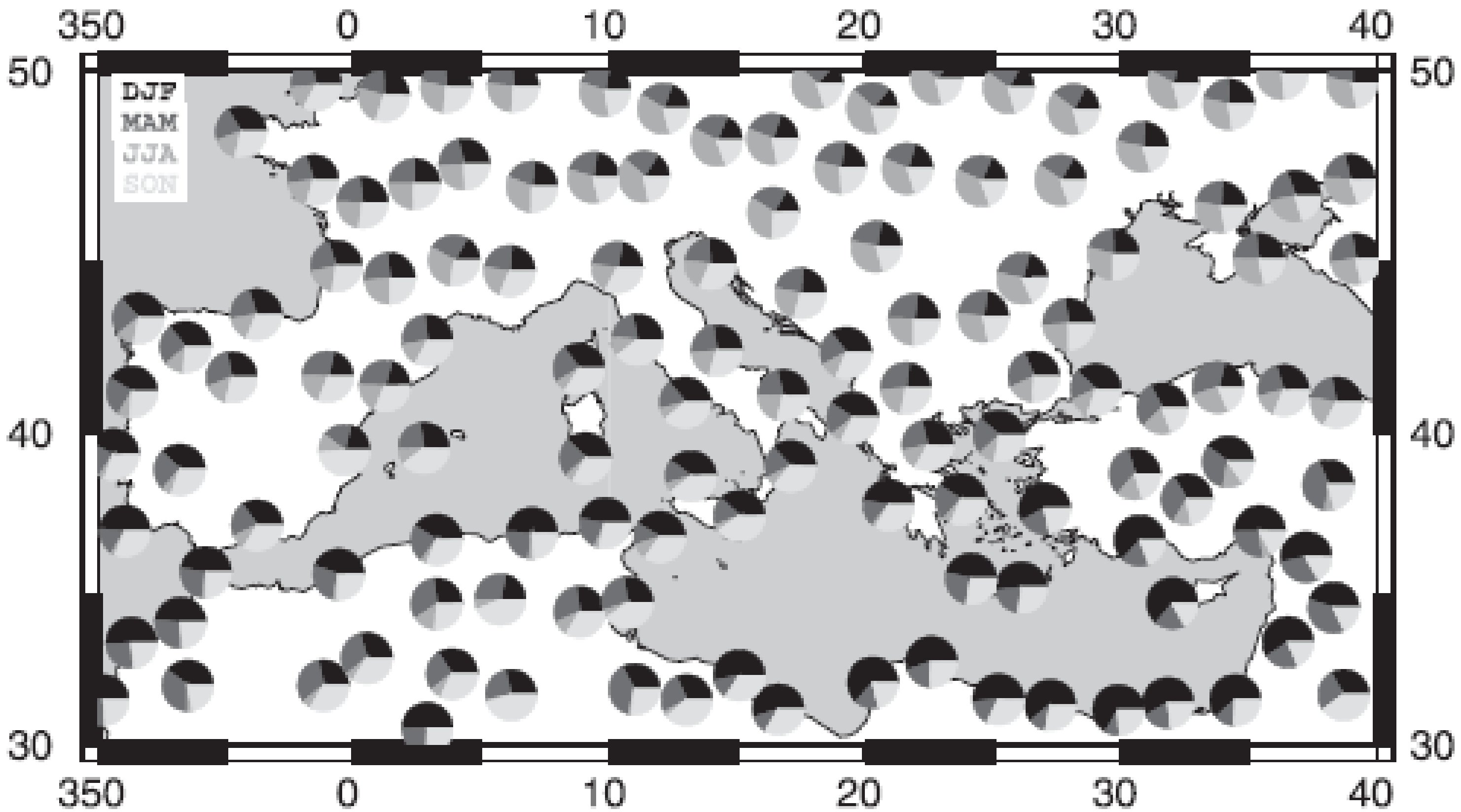


Figure 54: Seasonal distribution of precipitation over the entire Mediterranean Basin according to the monthly database from the Global Historical Climatology Network (GHCN). The stations from GHCN were randomly subsampled to evenly cover the area and the common period 1948–1990 was used (Adapted from Fernández et al., 2003).

Seasonal temperature forecasts important in Summer: precipitation forecasts important in winter ?

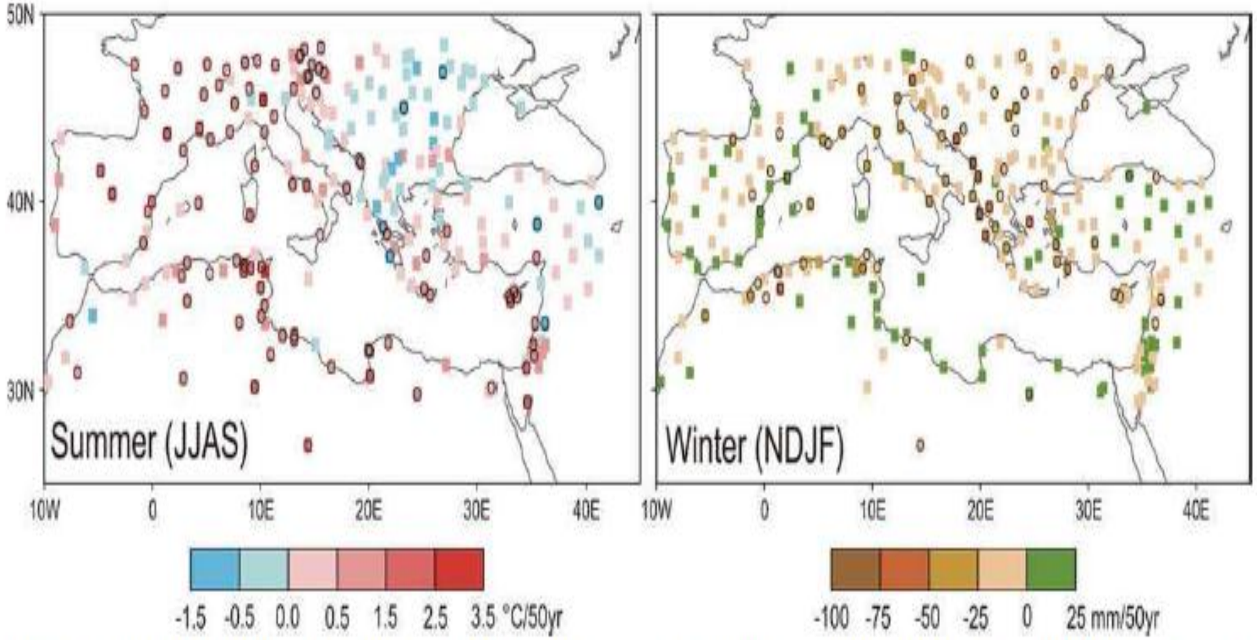
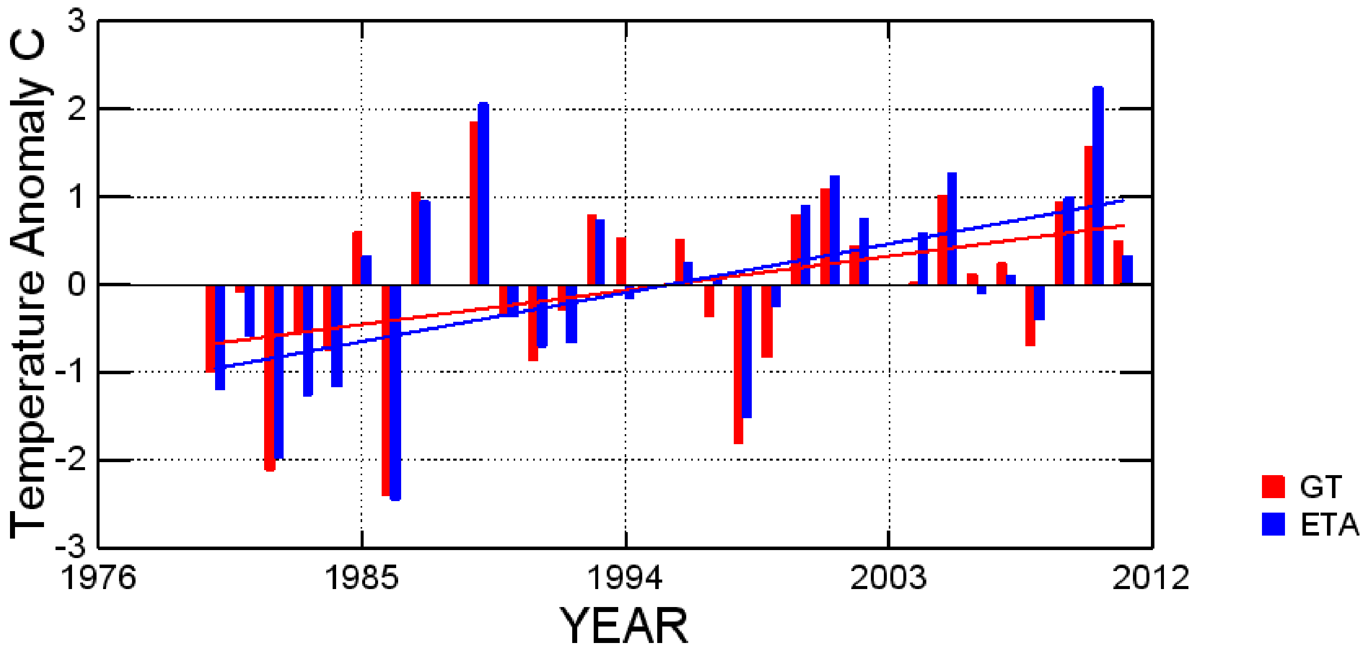


Figure 63: Right: Linear trends of winter (NDJF) station precipitation (mm/50 year). Left: Summer (JJAS) station air temperatures (°C/50 year) for the period 1950–1999. Stations with a significant trend (90% confidence level, based on the Mann–Kendall test) are encircled (from Xoplaki, 2002).

Result for November-December 2m temperature in central/north Sahara



- GT = GHCN 5x5 gridded product, (based only on station reports), averaged for Lon: 0-10E, Lat: 25-30N
- ETA = ECMWF INTERIM reanalysis, Lon: 6.75E, Lat: 26.25N
- Correlation between the two time-series is r=0.95

ACMAD

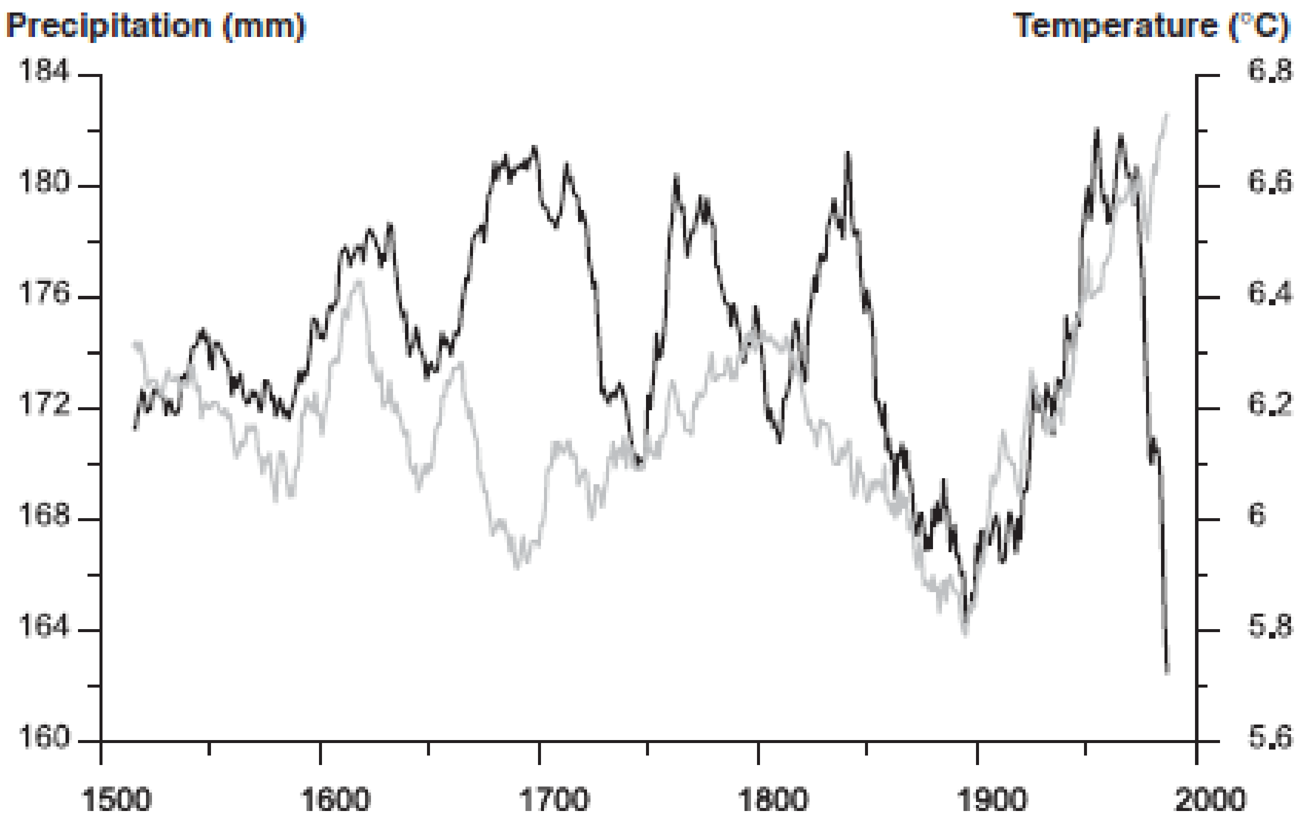


Figure 36: 31-year running averages of Mediterranean winter (DJF) temperature (grey line) and precipitation (black line) for the period 1500–2002.

The 2003 heat wave in Europe
Seasonal forecasting of summer temperature including extremes frequencies important with global warming?

- **The 2003 June–August mean temperature for the larger Mediterranean land area exceeded the 1961–1990 reference period by around 2.3C** (Luterbacher et al., 2004; Stott et al., 2004), and makes it the **warmest summer for more than the last 500 years** (Luterbacher et al., 2004). Stott et al. (2004) suggest, that **human influence has likely doubled the risk of a heatwave exceeding this threshold magnitude of around 2C in this area**.

NAO : Droughts and Floods

- Results of studies indicate rainfall fluctuations without abrupt changes in the following **alternating dry and wet phases: 1501–1589 dry, 1590–1649 wet, 1650–1775 dry, 1776–1937 wet and 1938–1997 dry**.
- Possible **causal mechanisms** for these variations **most likely include the NAO with drought (floods) being related to extreme positive (negative) NAO values**.

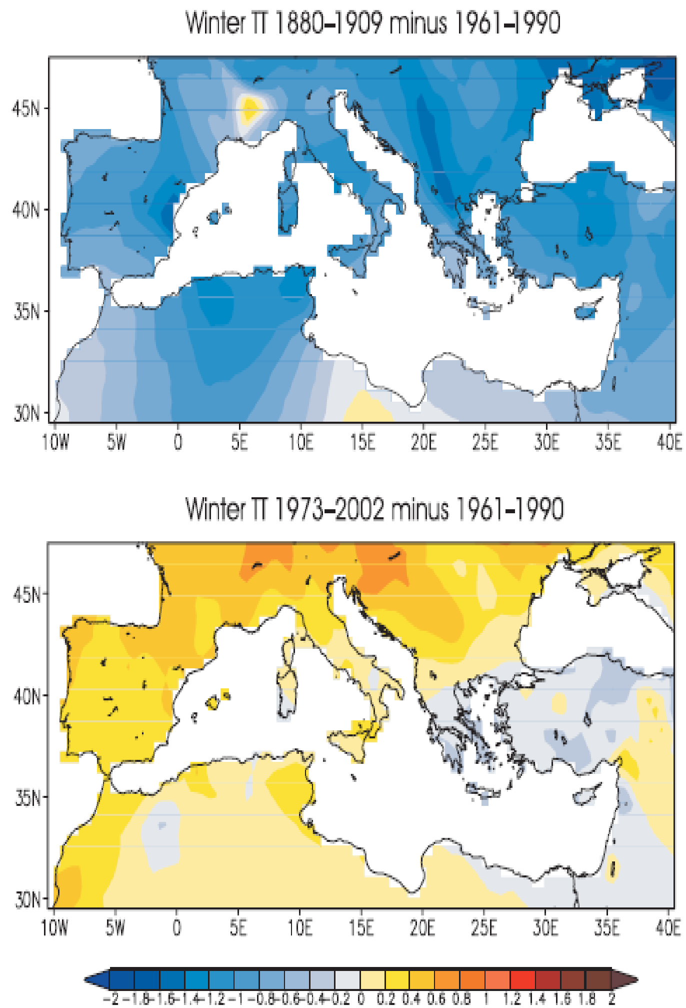


Figure 24: Anomalous winter (DJF) temperature composites. Top: Averaged-mean Mediterranean land surface air temperature for the 30 coldest winters in a row (1880–1909) over the last 500 years minus the 1961–1990 reference period (in °C). Bottom: As top, but for the 30 warmest winters (1973–2002 minus 1961–1990). Data from 1880–1900 are reconstructions, data from the twentieth/twenty-first century stem from Mitchell et al. (2004) and Mitchell and Jones (2005).

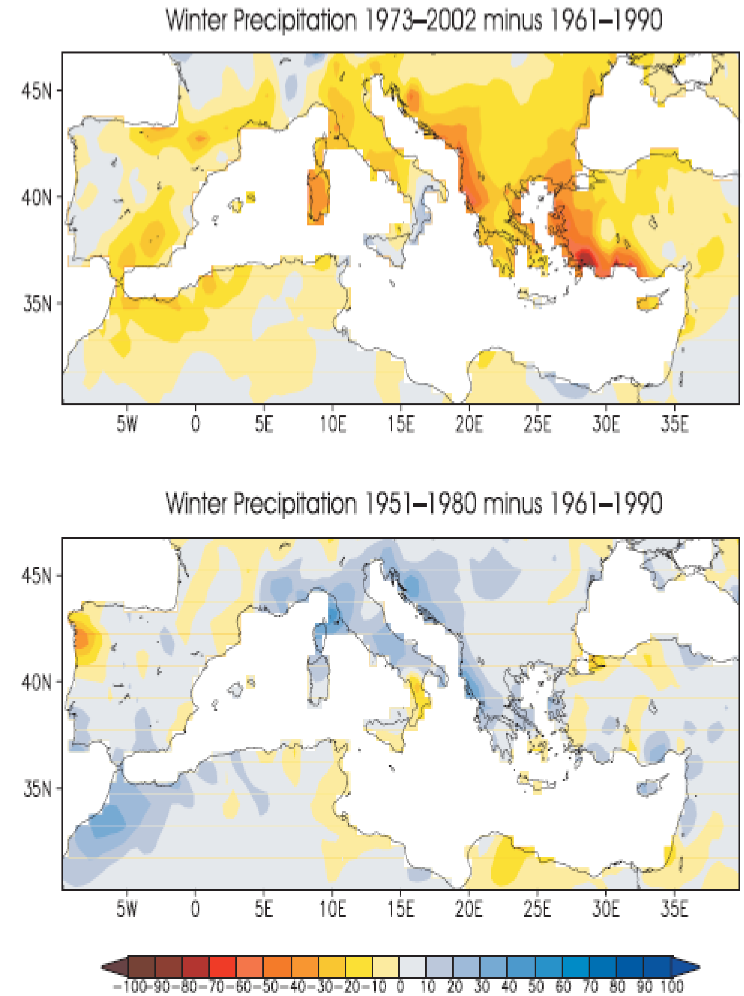
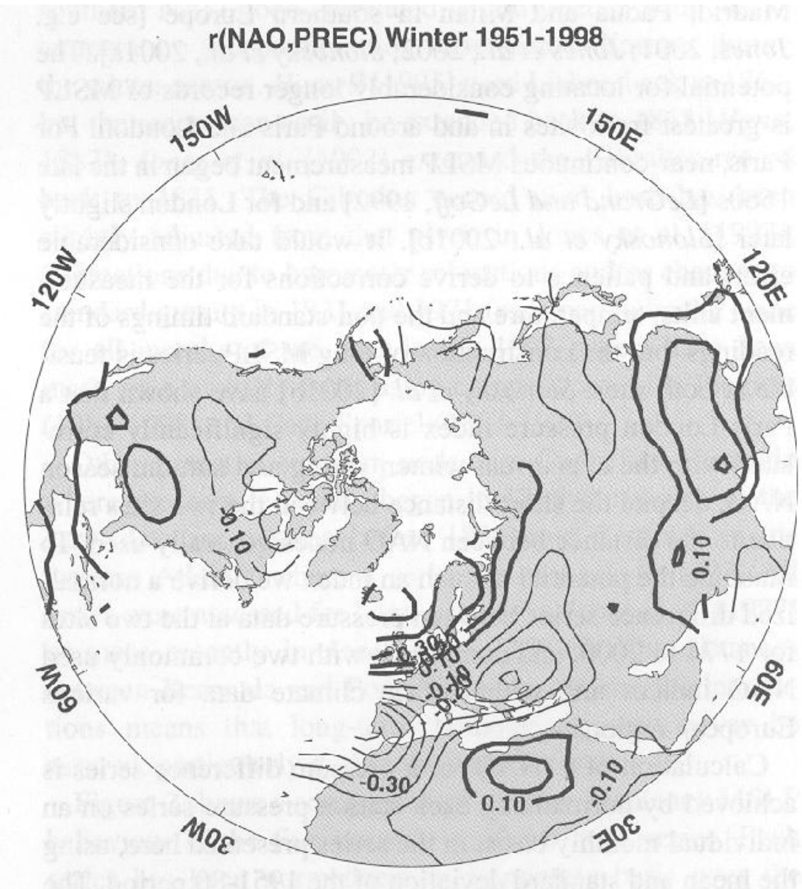
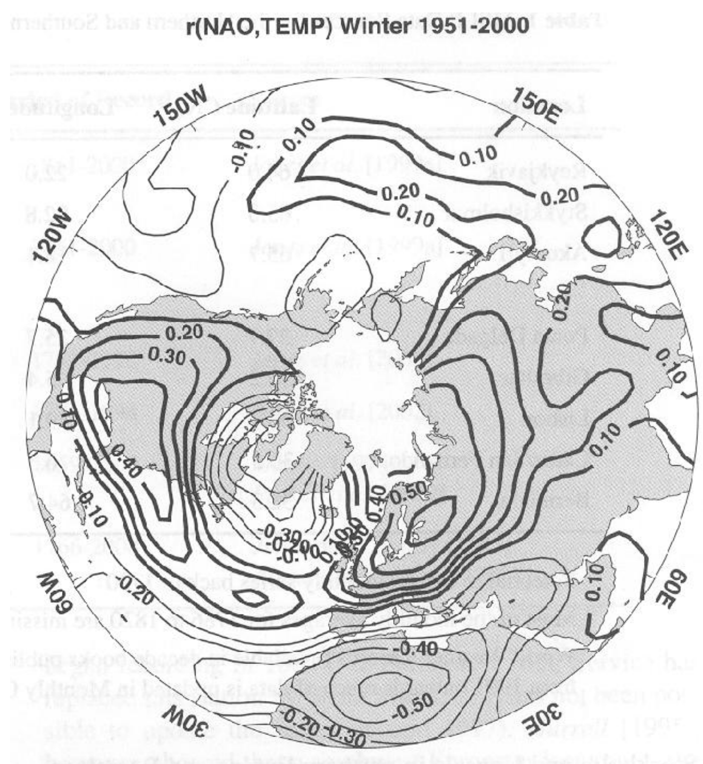


Figure 27: Anomalous winter (DJF) precipitation composites. Top: Mediterranean land precipitation for the 30 driest winters in a row (1973–2002) over the last 500 years minus the 1961–1990 reference period (in mm). Bottom: As top, but for the 30 wettest winters (1951–1980 minus 1961–1990). Data are taken from Mitchell et al. (2004) and Mitchell and Jones (2005).

Relationships between NAO and precip/Temp





Negative precipitation trend since 1960 is a striking phenomenon in the Mediterranean region partly explained by the positive trend in NAO

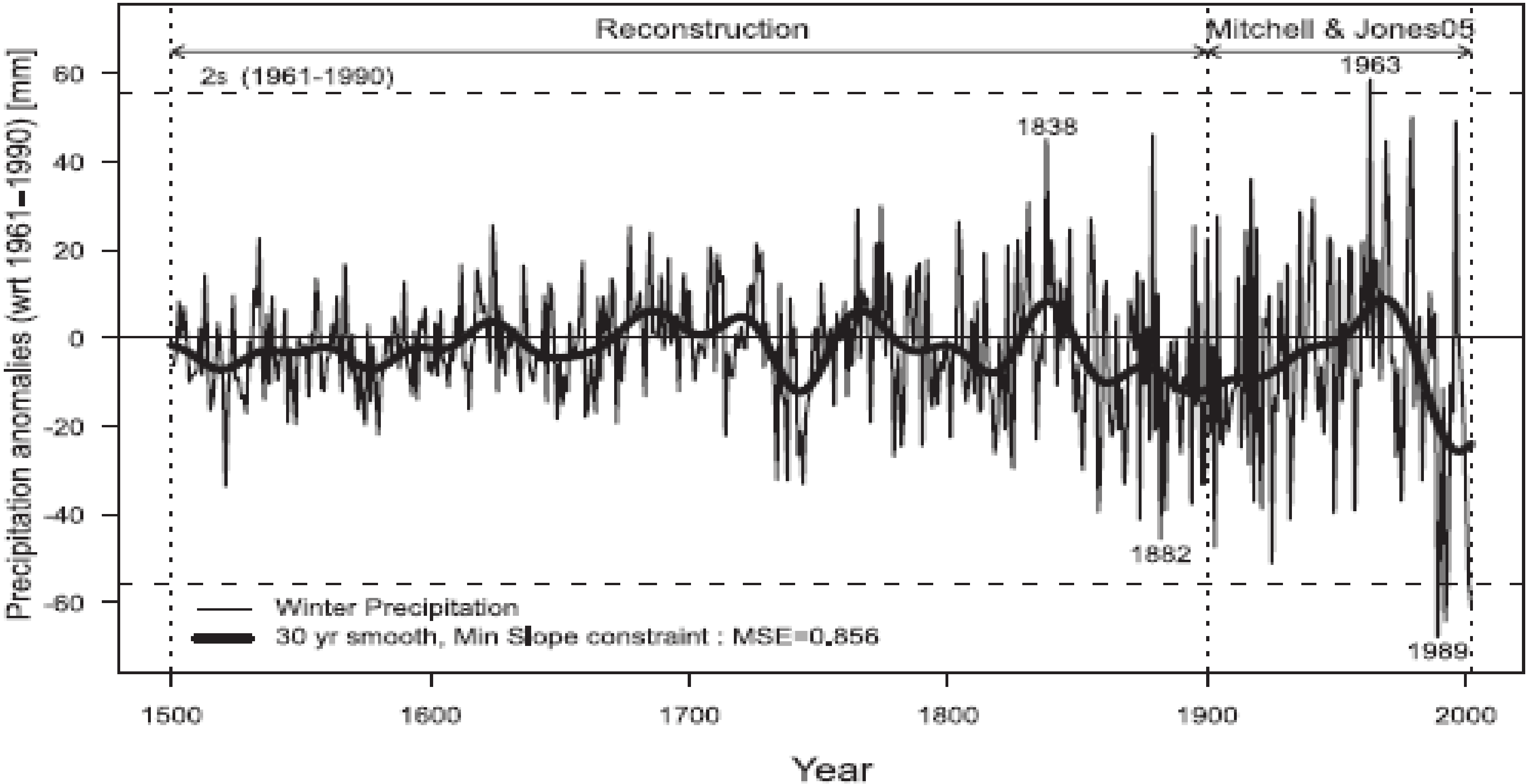


Figure 25: Winter (DJF) averaged-mean Mediterranean precipitation anomalies (with respect to 1961–1990) from 1500 to 2002, defined as the average over the land area 10°W to 40°E and 35°N to 47°N (thin black line). The values for the period 1500–1900 are reconstructions (Pauling et al., 2005); data from 1901 to 2002 are derived from Mitchell et al. (2004) and Mitchell and Jones (2005).

Tropical Processes/phenomena affecting mediteranean climate

- ENSO
- Atlantic hurricanes
- Asian and African monsoon

ENSO effects

- It has been proposed that **ENSO exerts a positive forcing on tropical North Atlantic SSTs and this effect is strongest in boreal spring**

- However, it has been argued that only when tropical SST anomalies are large (**strong ENSO events), the ENSO signal can be found in the extra-tropics**

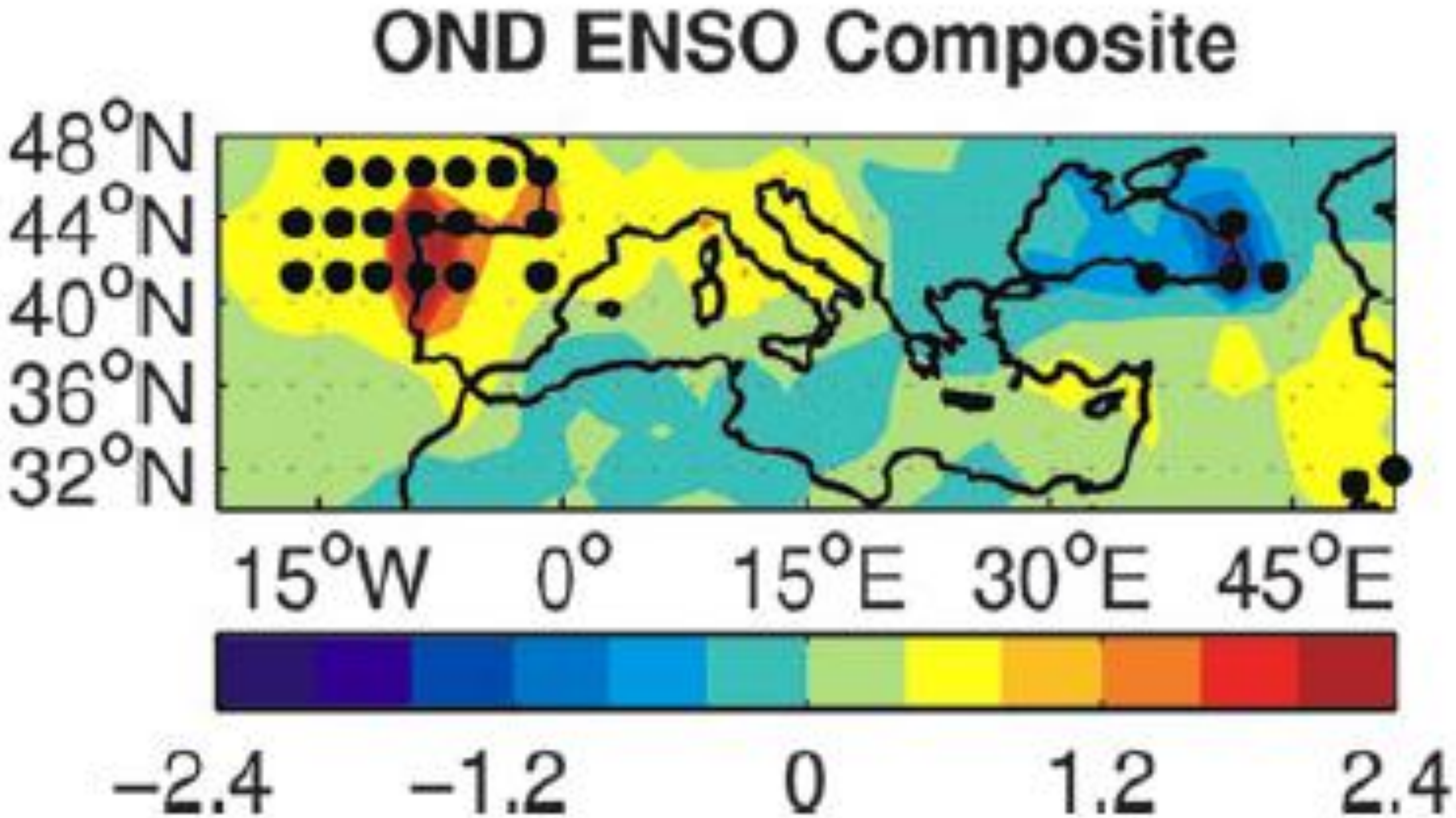
- It appears that the **possible influence of ENSO in the North Atlantic-European area is more likely to be found during extreme events of ENSO and during the winter**

ENSO and East Mediterranean Precipitation

- The seasonal stream flow in the Jordan River is significantly correlated (r=0.67) with the seasonal NINO4 temperatures
- significant connections between ENSO events and winter rainfall **in Israel**, both indicate **increased rainfall occurring in El Nino winters/ La Nina years were associated with below normal rainfall**.

Precipitation for El Nino MINUS La Nina

Black Dots indicate Statistical Significance



Weak picture from observations; but some GCM studies suggest:

El Nino = more blocking (not exactly negative NAO), Could imply wetter conditions in N Africa (no explicit studies?)

La Nina = less blocking, more Azores ridging Could imply drier conditions in N Africa (no explicit studies?)

For boreal spring (Mar-April)

Stronger picture from observations:

El Nino (or at least, warm tropical Pacific, or emerging warm tropical Pacific) = wet conditions in western half of N Africa

La Nina (or at least, cold tropical Pacific, or emerging cold tropical Pacific) = dry conditions in eastern half of N Africa

For Tropical North Atlantic SST

Generally, warm tropical North Atlantic slightly favors negative phase of the NAO (e.g., GCM study, Cassou and Terray 2001).

Also possible that tropical North Atlantic SST influences local pressure and moisture fields, with this directly impacting climate in North Africa

ENSO and West Mediterranean

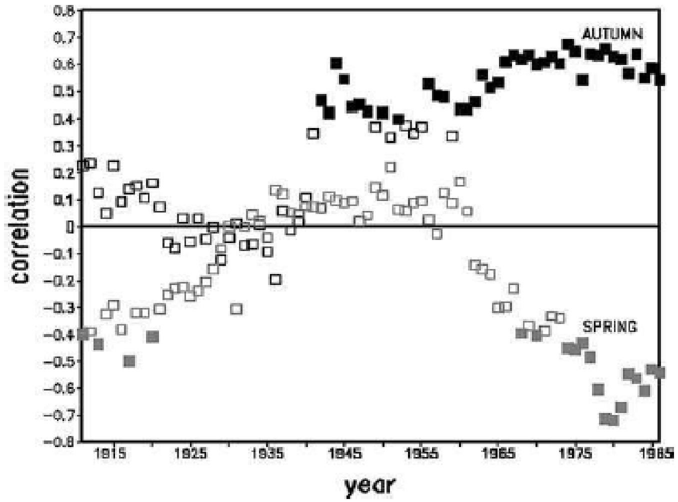


Figure 47: Correlations between western Mediterranean rainfall (from the data base of the Climate Research Unit (CRU), University of East Anglia (UK) and Nino3.4 indices in autumn (SON, black) and spring (MAM, grey). Each value refers to the correlation in a 20-year window centered at the symbol. Full symbols are for values at least 95% significant (After Mariotti et al., 2002, Fig. 6 therein).

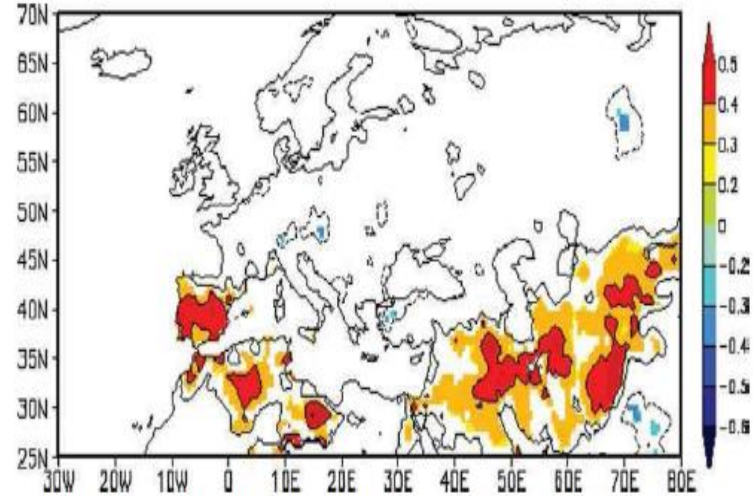


Figure 48: Correlations between Euro-Asian autumn rainfall and Nino3.4 indices for the period 1948–2000. Shading depict region where the correlation is at least 95% significant. Data is from CRU. (After Mariotti et al., 2005, Fig. 1a therein).

ENSO accounts for half of the total annual variance in southeast Spain and parts of Morocco.

ENSO&East Mediterranean Rainfall In El Nino year the Jet shift southwards by 50-100 km

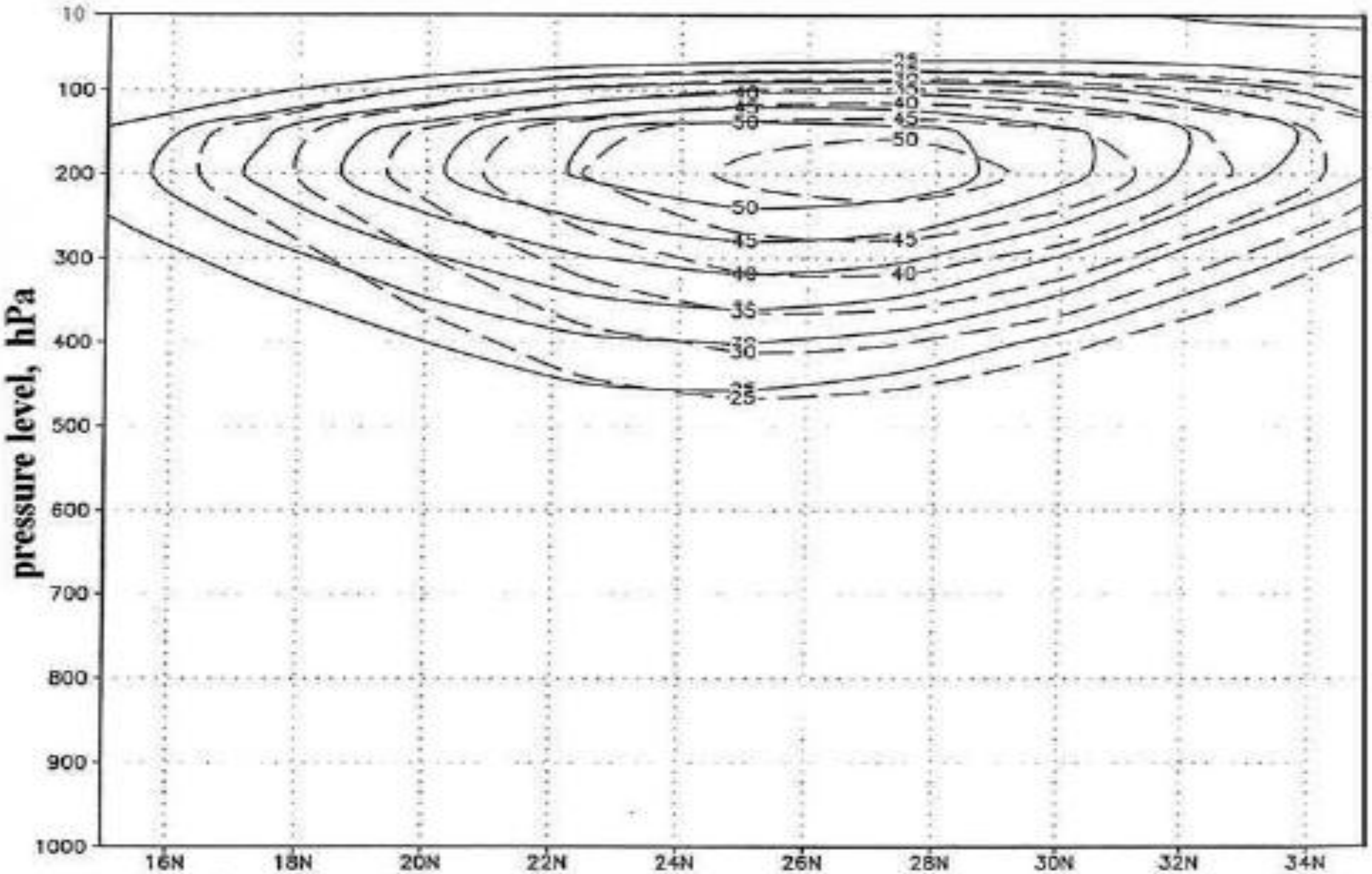


Figure 46: Zonal means (30°E–40°E) of west wind (m/s) in the winter period (December, January and February). The dashed lines correspond to the winters from 1982/83 to 1993/94, while the solid ones, to the El-Nino winters 1982/83, 1986/87 and 1991/92.

ENSO and Extreme mediteranean rainfall

- Torrential rainfall in Italy, above 128 mm/day, increased percentage wise by a factor of 4 between 1951 and 1995.

- **It is interesting to note that the torrential rainfall peaks were observed in the El-Nino years**.

Cyclones and Mediterranean climate

- Previous work has shown an ENSO-impact during boreal winters, with a trough (ridge) over southern Europe during El Nino (La Nina) events, accompanied by more (less) cyclones reaching the Mediterranean region
- Several cases of severe floods over the western Mediterranean could be traced back to hurricanes (December 2001)
- Rains in the Mediterranean basin take place mainly during winter, most of which is associated with Mediterranean baroclinic cyclones
- However, processes originating from tropical regime are also significant in its eastern part (Tropical intrusion)

ENSO IMPACTS DURING BOREAL WINTERS

- Previous work has shown an ENSO-impact during boreal winters, with a trough(ridge) over southern Europe during El Nino (La Nina) events, accompanied by more (less) cyclones reaching the Mediterranean region

NAO -EFFECTS

Since the pioneering work by Lamb and Peppler (1987), most work for the Mediterranean area have been focused on the impact of the NAO during the winter season (December to March) when its impact is greatest, particularly for precipitation

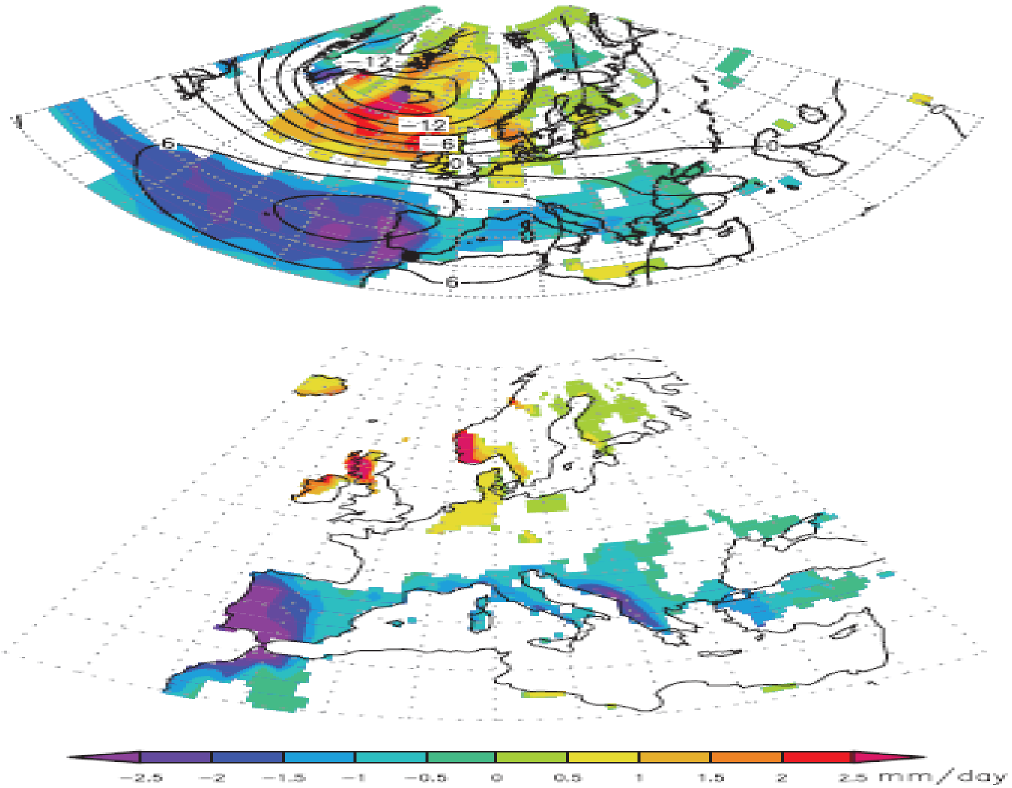


Figure 55: Top: Difference in SLP (hPa, solid contours) and NCEP precipitation rate (mm/day, colour) between winter months with a NAO index >1 and months with an NAO index <−1 (period 1958–1997). Precipitation rate differences are represented only if significant at the 5% level. Bottom: As in top but with high resolution precipitation field (mm/day) of New et al. (2000) (represented only if significant at the 5% level) (Adapted from Trigo et al., 2004a).

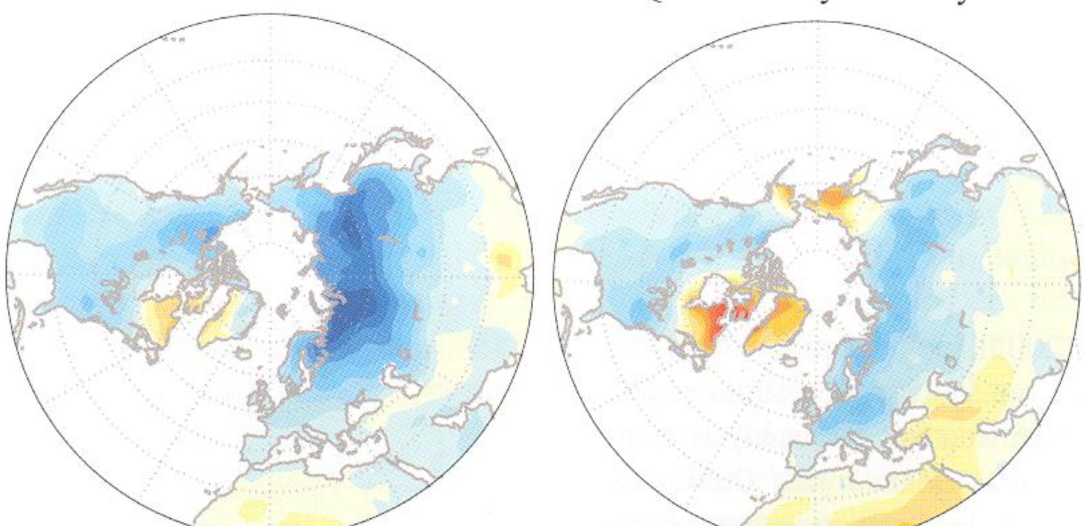
Stratospheric source of modest predictability?

a) Following onset of QBO easterly

Days 1-60 following stratospheric anomalies

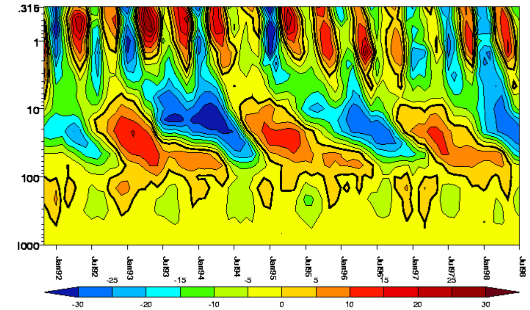
b) Simple composite for the two phases Ely MINUS Wly

QBO easterly-westerly



Difference in surface temperature (contour interval is 0.5C)

More recent work: Easterly QBO phase favors sudden stratospheric warming, GCMs show links to increased blocking (negative NAO), mainly late-winter? e.g. see Fereday et al., 2012 (UKMO)



Height (mb pressure)
QBO
between 10-100mb

Figures from Thompson et al., p81, in NAO book, 2003

African&Indian monsoons and the Mediterranean climate (mostly in boreal summer)

- Raicic et al. (2003) studied the relationship between the Asian and African Monsoon systems and **found a high correlation between the intensity of each of them and the pressure distribution over the Mediterranean on the interannual timescale**
- They identified a circulation connecting the upward motion maximum over the Himalayas with the downward motion over the Eastern Mediterranean during **summer.**

African&Indian monsoons and the Mediterranean climate (mostly in boreal summer)

- Ziv et al. (2004a) in their study of the summer regime, found a signature of the Hadley cell over eastern North Africa, connecting the EM with the African Monsoon.
- The relationship between them is manifested by a significant correlation between the ascent at 15N–20N latitudes and the descent at 30N–40N

African&Indian monsoons and the Mediterranean climate (mostly in boreal summer)

- Focusing on the summer season, Chen et al. (2002), **showed evidence for strengthening of the tropical general circulation in the 1990s**, **and in particular the West Africa monsoon**
- Is this why the Mediterranean region is in a dry period since about 1973?

Tropical intrusion and Mediterranean climate

- Some rainstorms originating from the tropics are associated with ‘‘tropical plumes’’. This is a long cloud band that extends from the ITCZ down to 30N–40N latitude, accompanied by a pronounced trough in the **Subtropical Jet** to its west combined with a ridge to the east,

NAO Effects on precipitation

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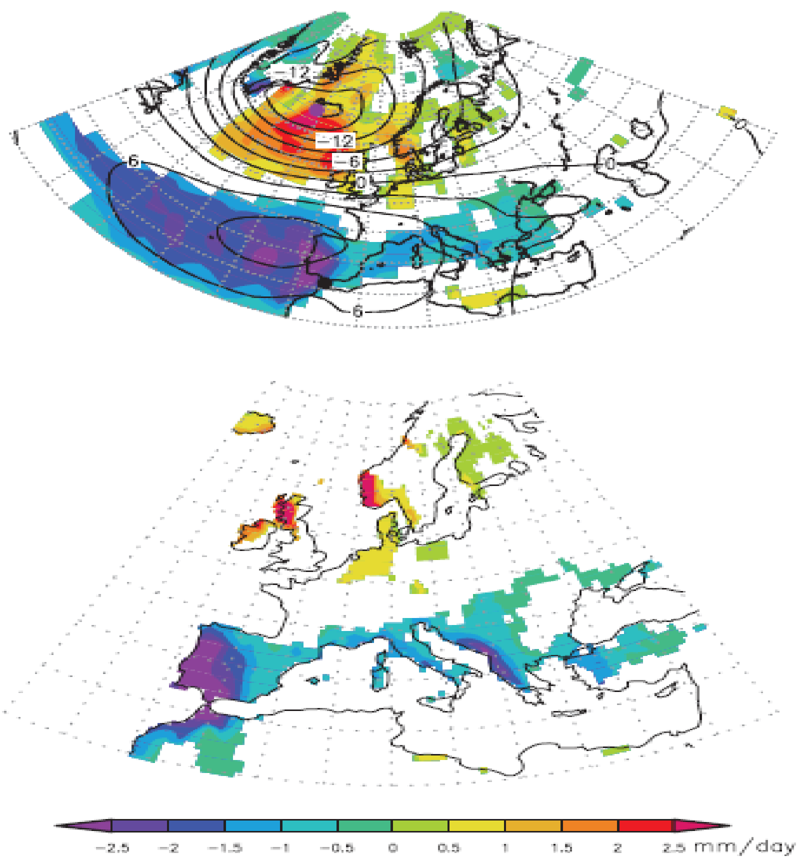

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NAO Effects on Tmax and Tmin

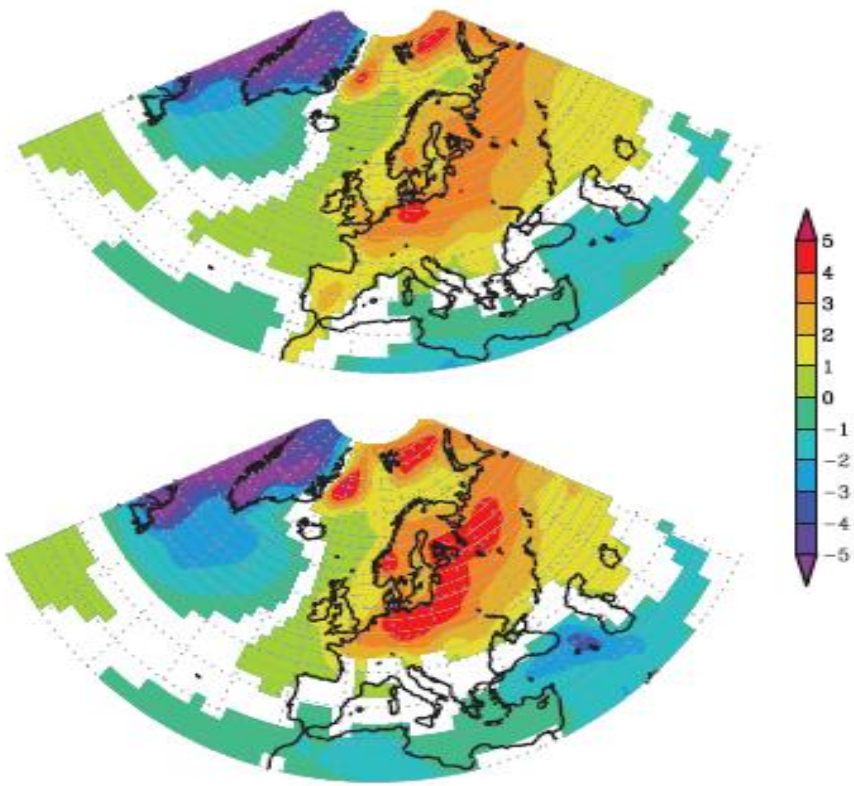

Figure 56: Top: Difference in maximum temperature (°C) between winter months with an NAO index >1 and months with an NAO index <−1 (period 1958–1997). Differences are represented only if significant at the 5% level. Bottom: As in top but with minimum temperature. Data from NCEP/NCAR reanalyses.

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