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Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

MedCOF workshop 2015

Drivers of mid-latitude seasonal forecasts

J. García-Serrano (BSC-ES)

Drivers of mid-latitude seasonal forecasts

- Spring

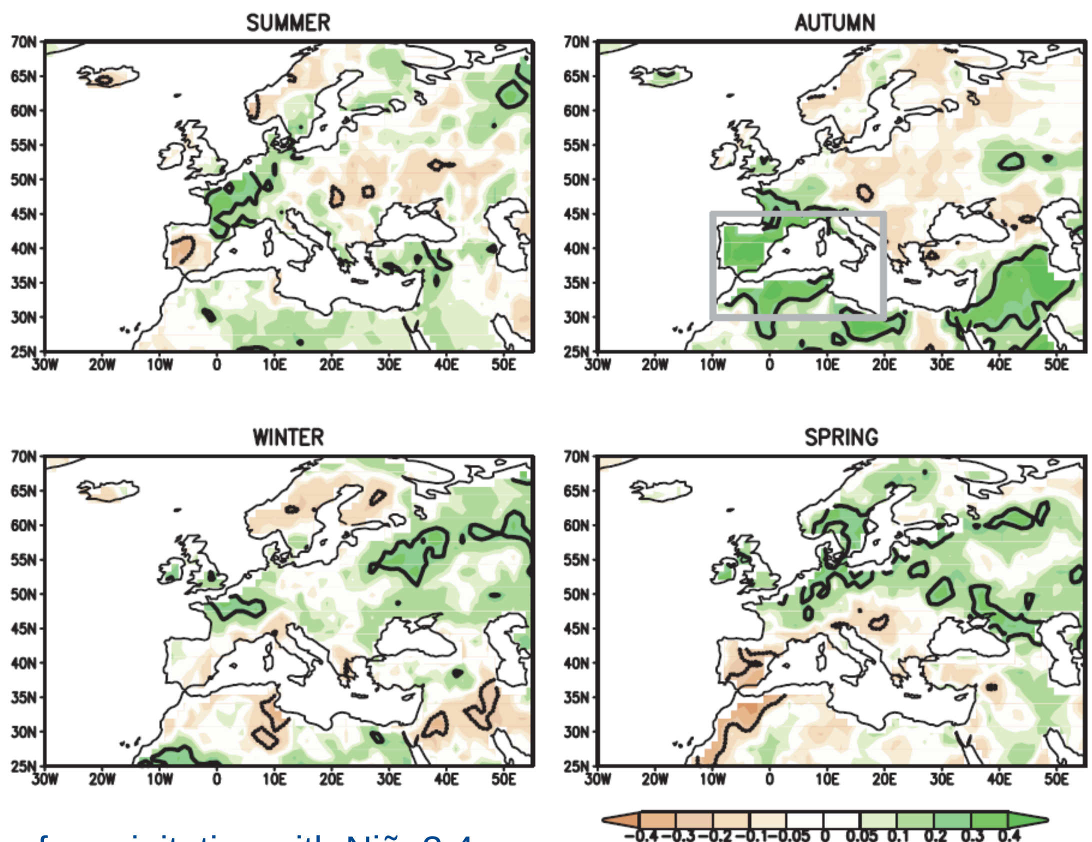
- Summer
  - Pacific Ocean – ENSO
  - Atlantic Ocean
  - Mediterranean Sea
  - Soil moisture
  - Arctic sea ice

- Autumn

- Winter
  - Pacific Ocean - ENSO
  - Atlantic Ocean
  - Eurasian snow
  - Arctic sea ice

ENSO is the leading mode of climate variability on seasonal-to-interannual timescales

ENSO is the most important source of predictability at seasonal timescales
[e.g. Doblas-Reyes et al. 2013]



correlation maps of precipitation with Niño3.4
[Mariotti et al. 2002]

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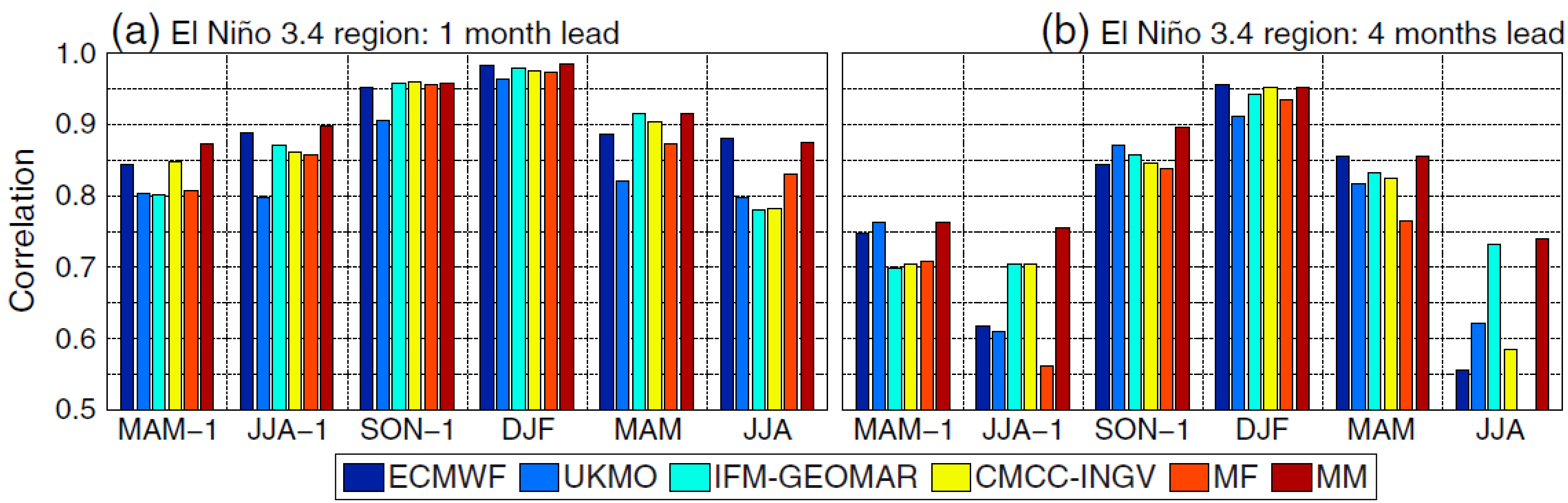

correlation skill of Niño3.4 in ENSEMBLES
[Manzanas et al. 2014]

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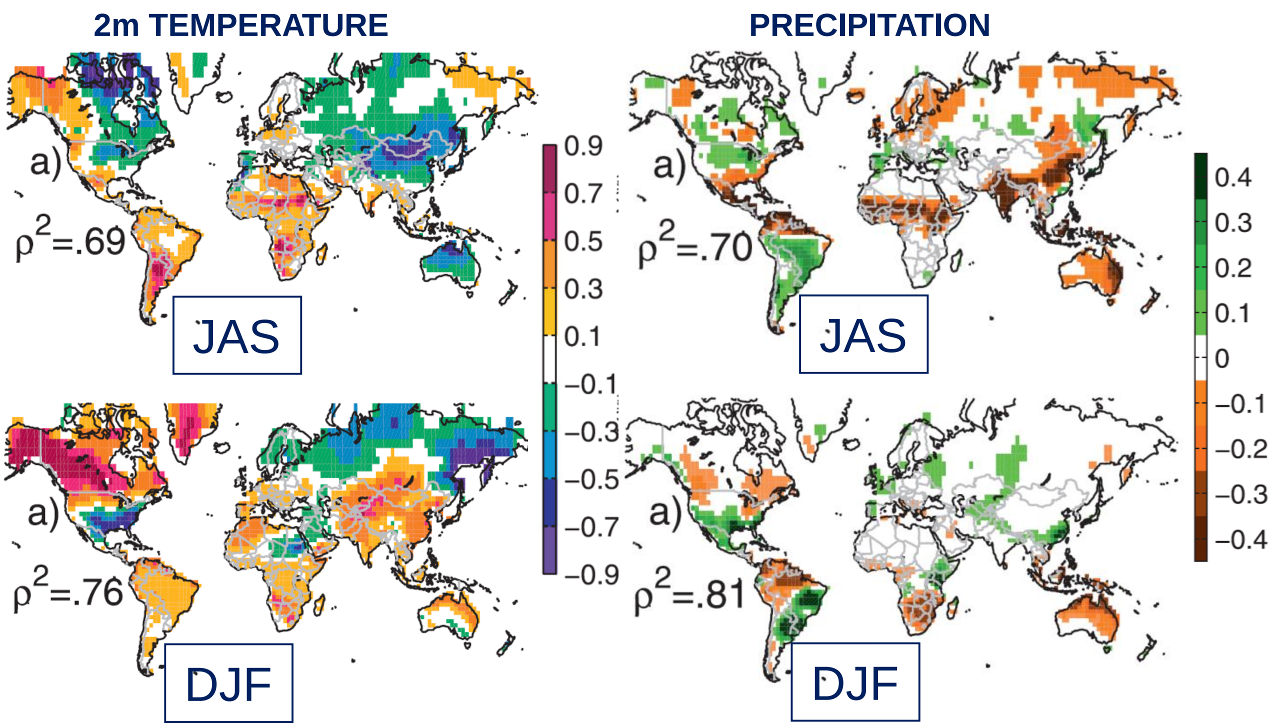
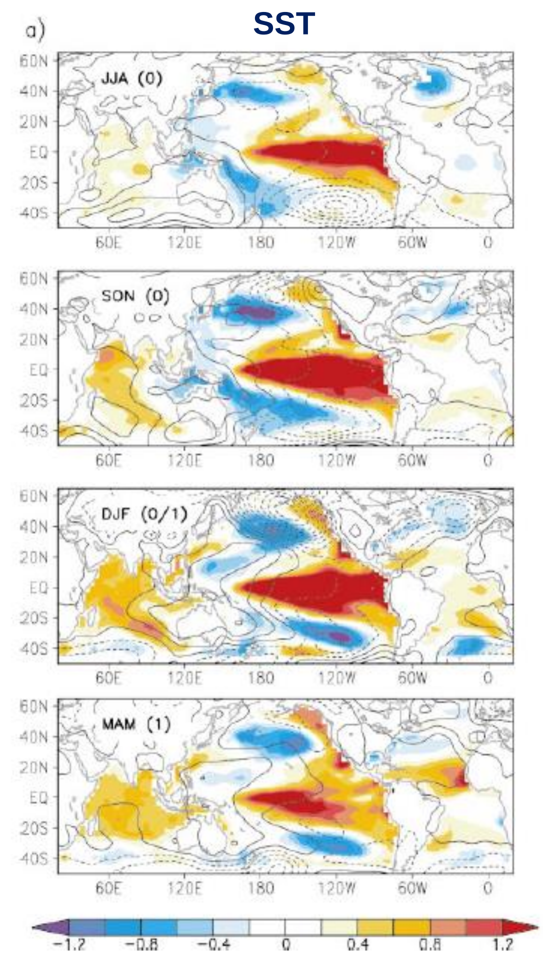
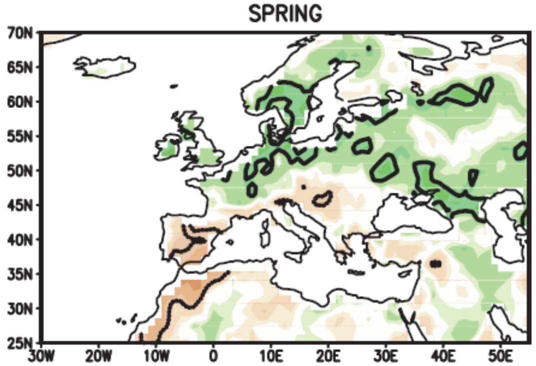




ENSO teleconnections: regressions onto Niño3.4
[Yang and DelSole 2012; Alexander et al. 2002]

SPRING



correlation map of precipitation with Niño3.4
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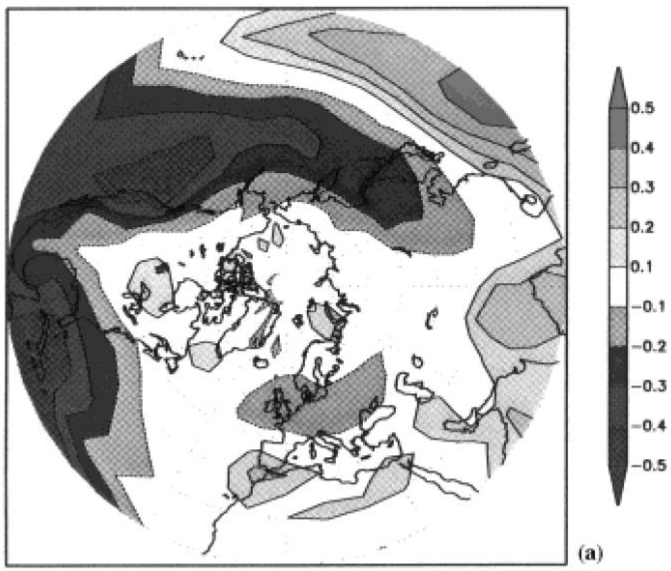
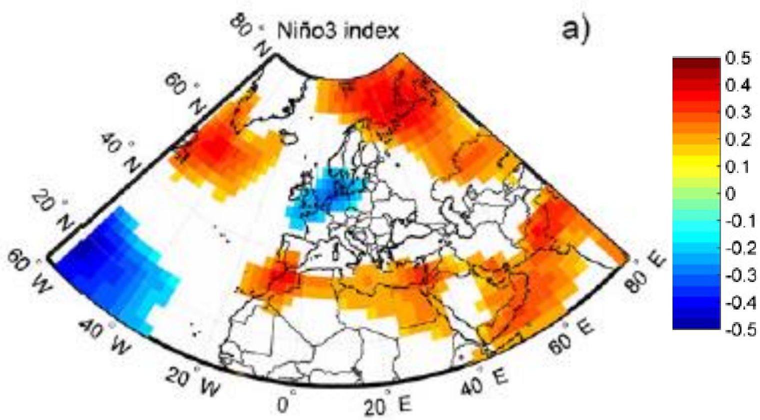
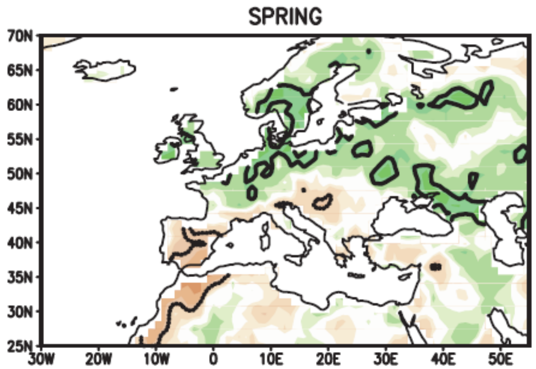


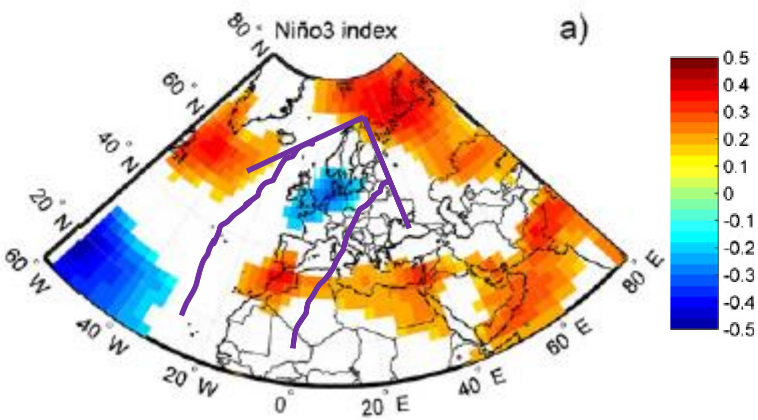
correlation map of SLP with Niño3 (in MAM)
[van Oldenborgh et al. 2000]



correlation map of MAM-SLP with DJF-Niño3
[Lorenzo et al. 2011]



correlation map of precipitation with Niño3.4
[Mariotti et al. 2002]



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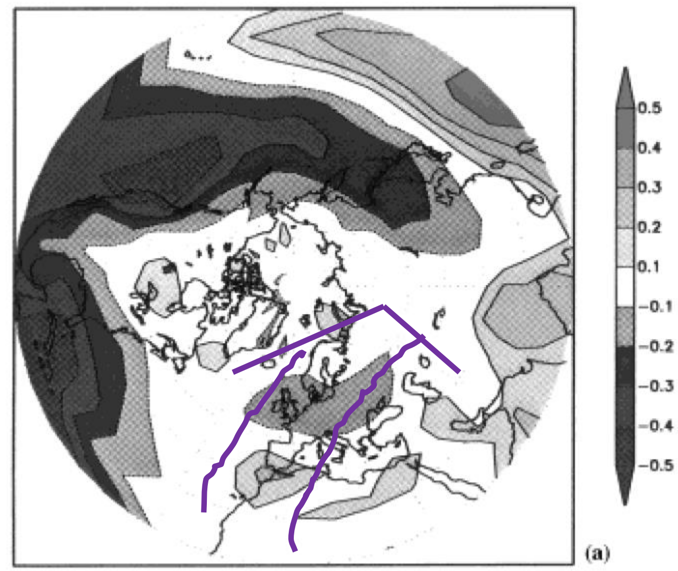
SPRING



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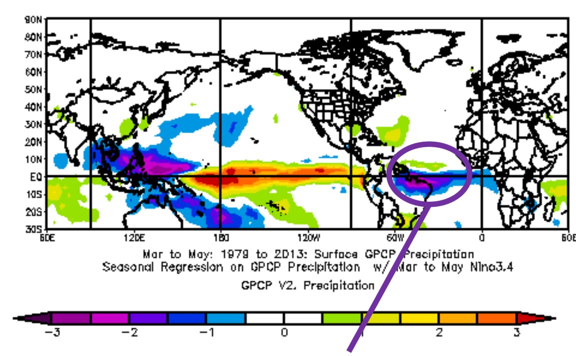
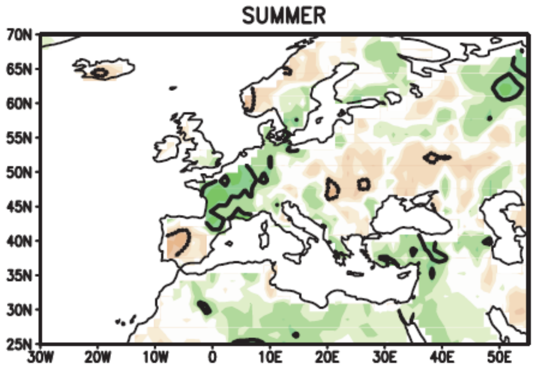
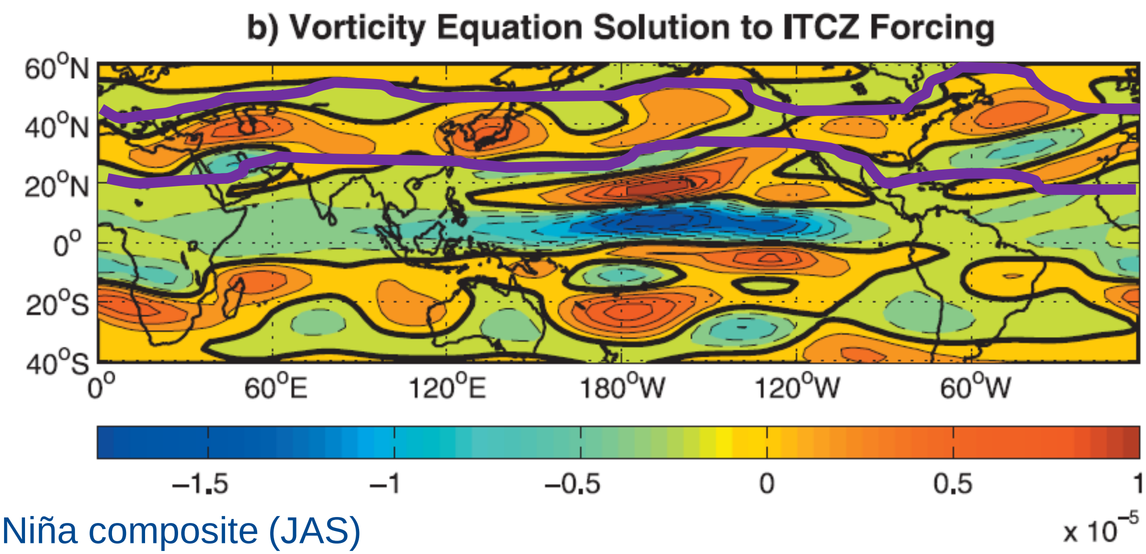


secondary Rossby wave source

SUMMER

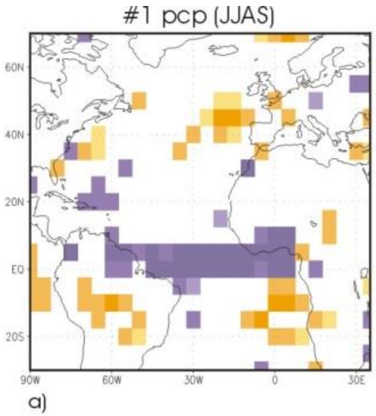


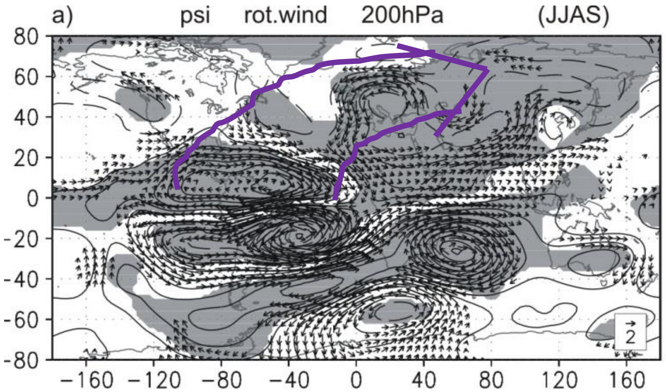
correlation map of precipitation with Niño3.4
[Mariotti et al. 2002]

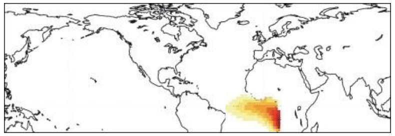


resembling El Niño-La Niña composite (JAS)
[Shaman and Tziperman 2007]

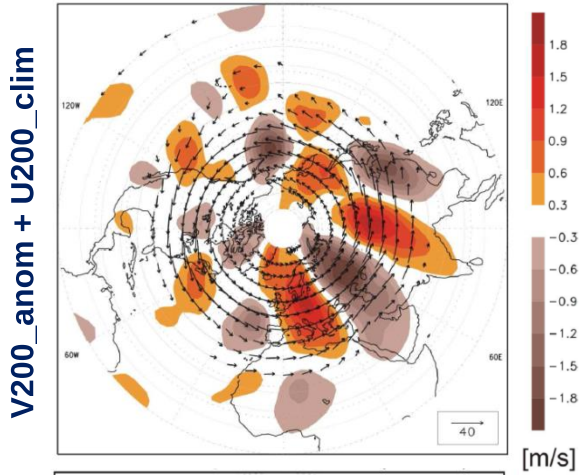
SUMMER

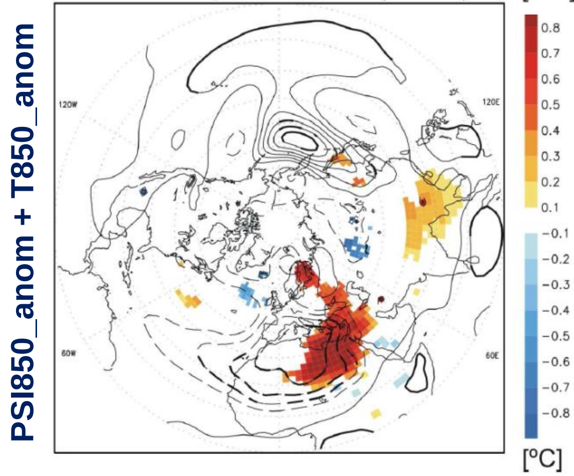


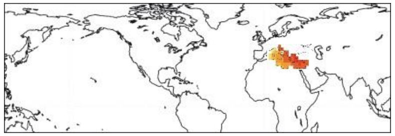




[Atlantic Niño](#)
[García-Serrano et al. 2008; 2011a]







eastern Mediterranean SST anomalies
[García-Serrano et al. 2013]

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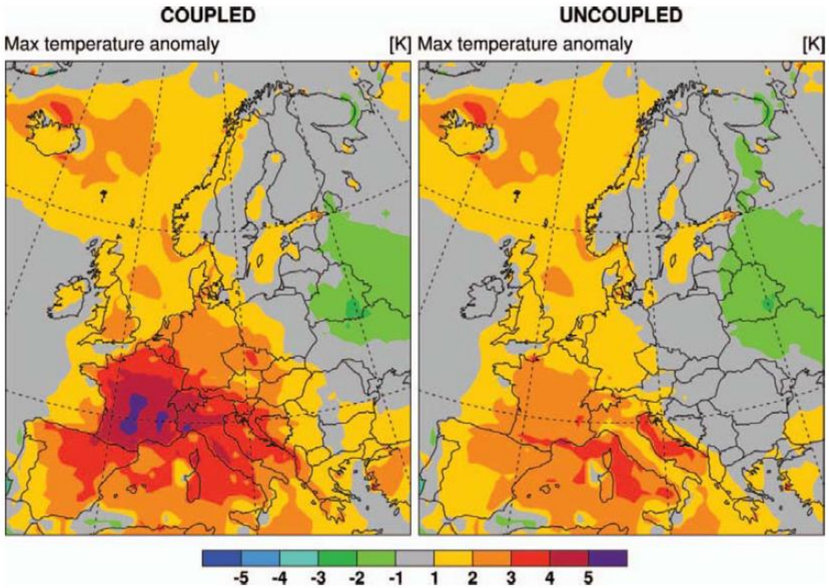
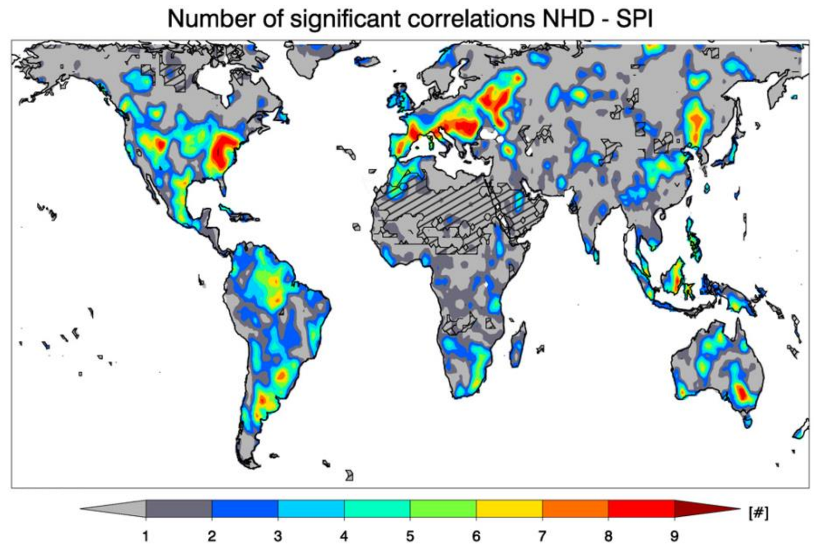


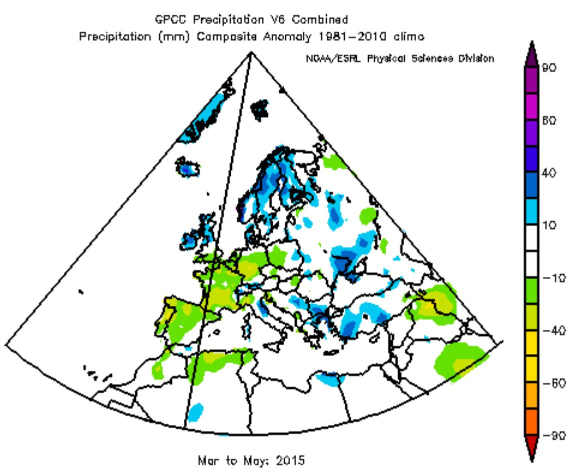
FIGURE 8. Average daily maximum temperature (at 2 m) anomalies in JJA 2003 in a regional climate simulation (CHRM model) with a fully interactive land surface scheme (left) and with prescribed climatological mean soil moisture conditions (see Fischer et al., 2007b, for details on the experimental setup). The anomalies were averaged for summer (JJA) 2003 wrt to a model climatology 1970–2000.

[García-Herrera et al. 2010]



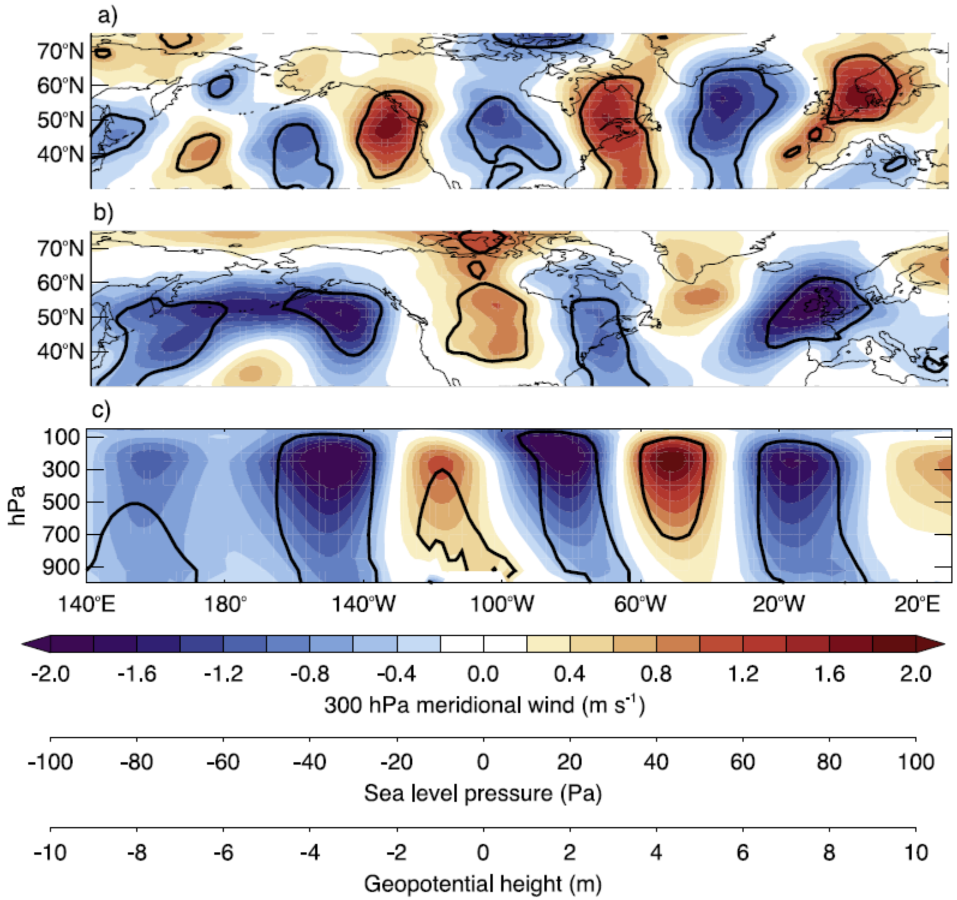
[Mueller and Seneviratne 2012]

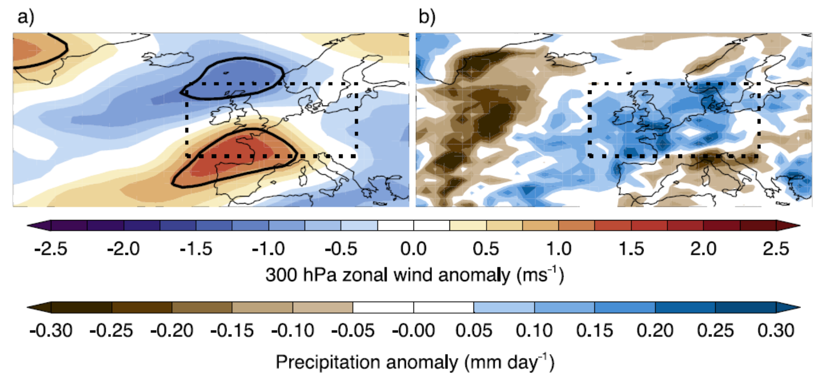
soil moisture could provide more accurate forecasts



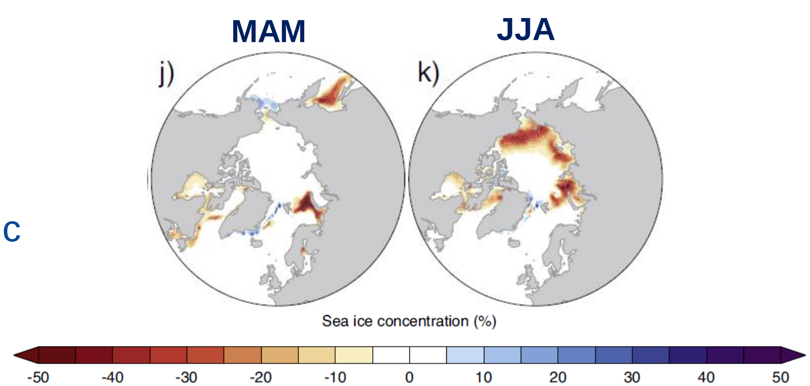
soil moisture feedback,
relevant for seasonal predictability
[Douville and Chauvin 2000; Douville 2010]

SUMMER

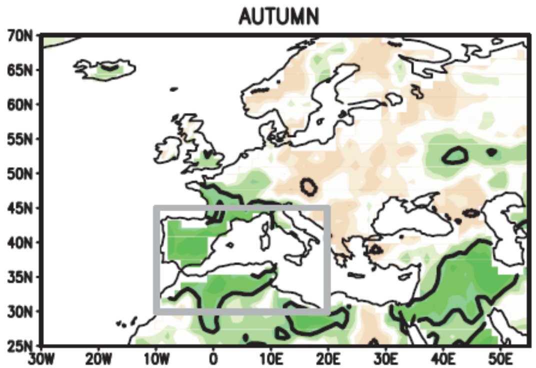




sea-ice reduction linked to weakening of the North Atlantic westerly-jet

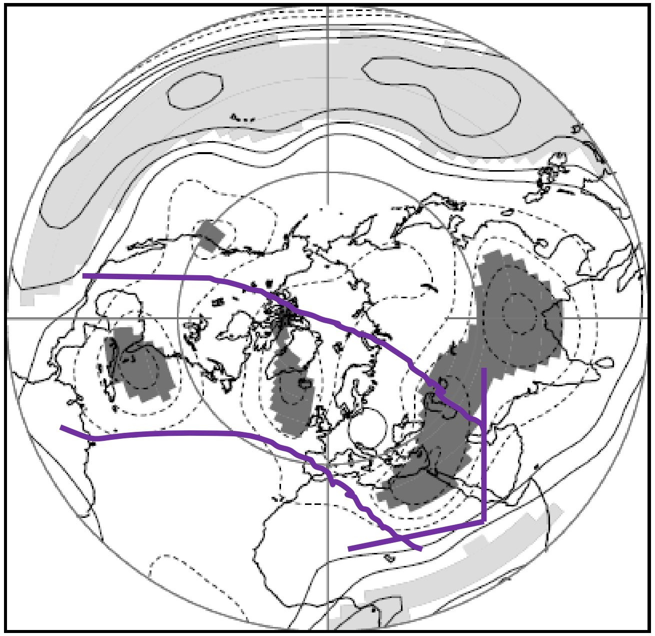


Arctic sea-ice is also a precursor for summer atmospheric circulation and rainfall anomalies over Europe
[Screen 2013]

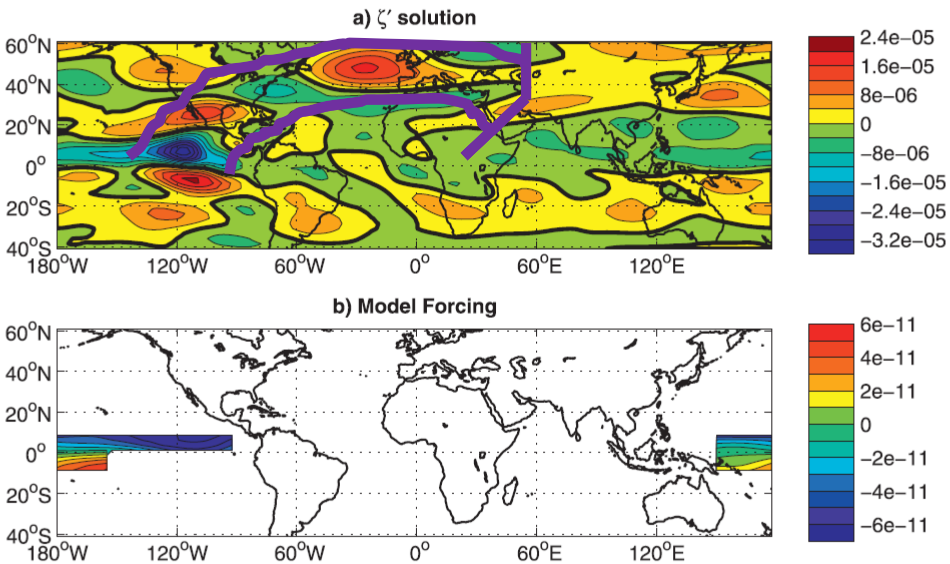


correlation map of precipitation with Niño3.4
[Mariotti et al. 2002]

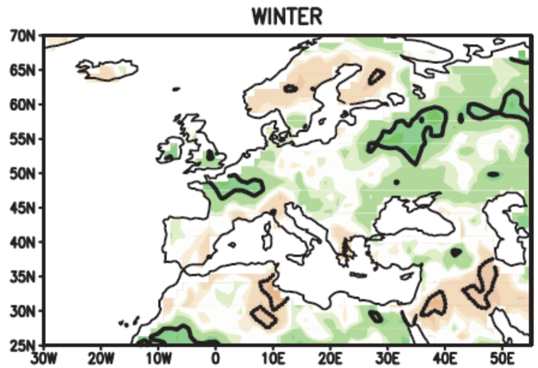
AUTUMN



composite of PSI200 linked to El Niño
[Mariotti et al. 2005]



[Shaman and Tziperman 2011]



WINTER

correlation map of precipitation with Niño3.4
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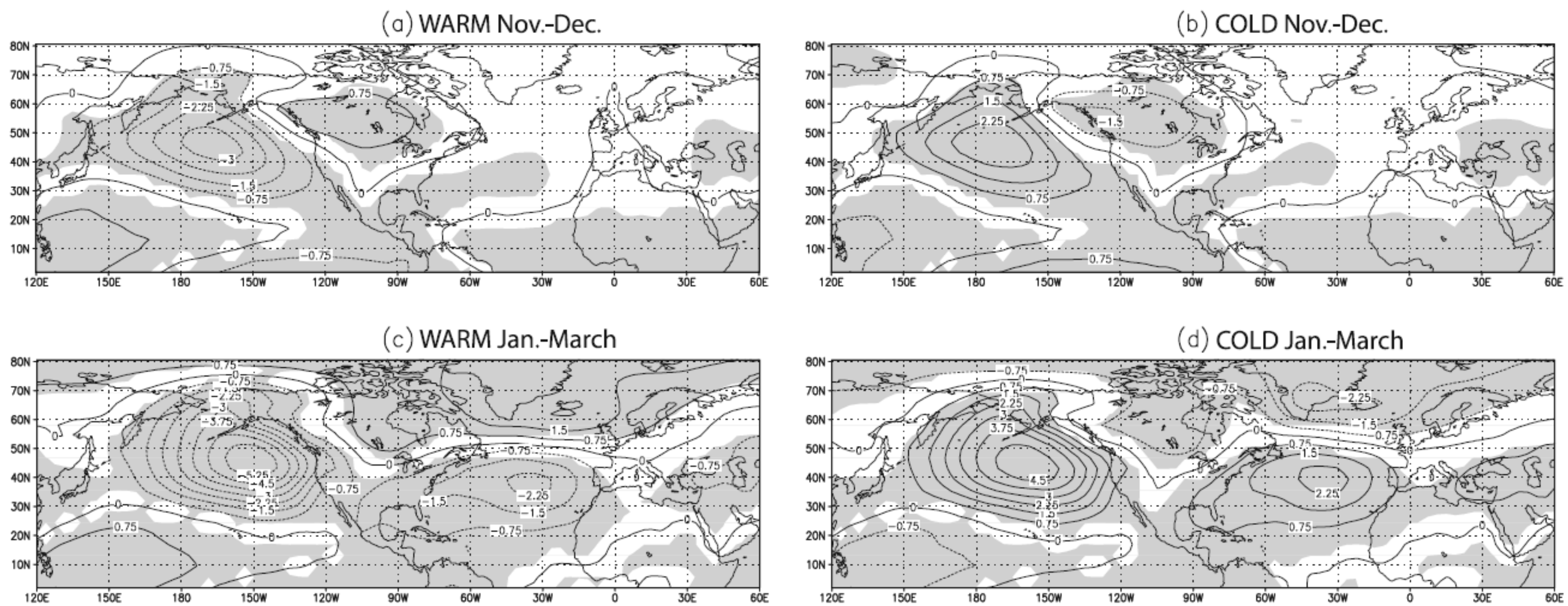
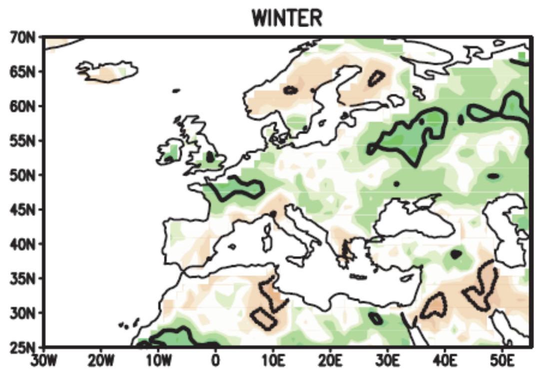


strong intra-seasonal modulation of the ENSO teleconnection: early-winter (ND) vs mid/late-winter (JFM)
[Gouirand et al. 2007]



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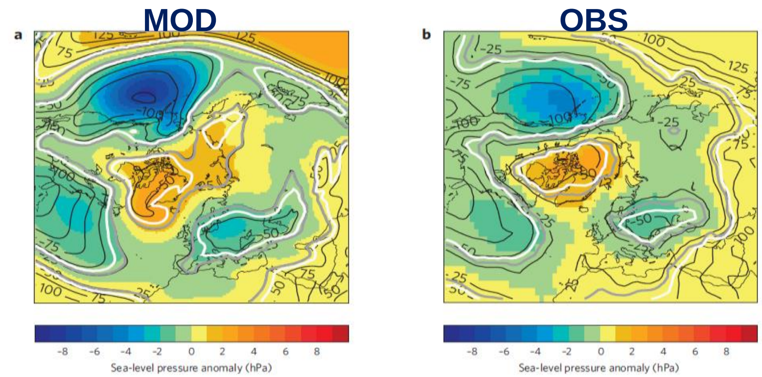
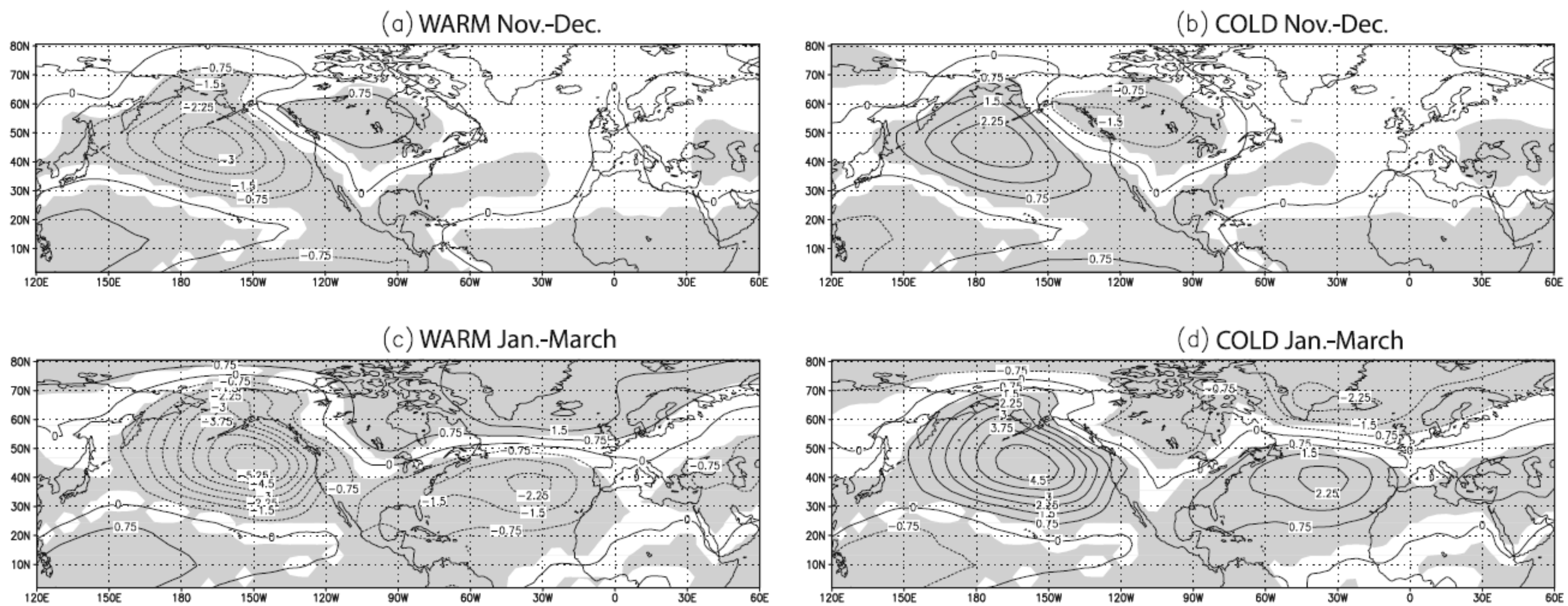


canonical signature in JFM [Ineson and Scaife 2009]



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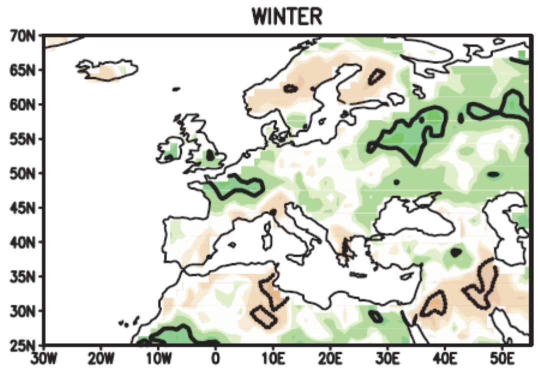

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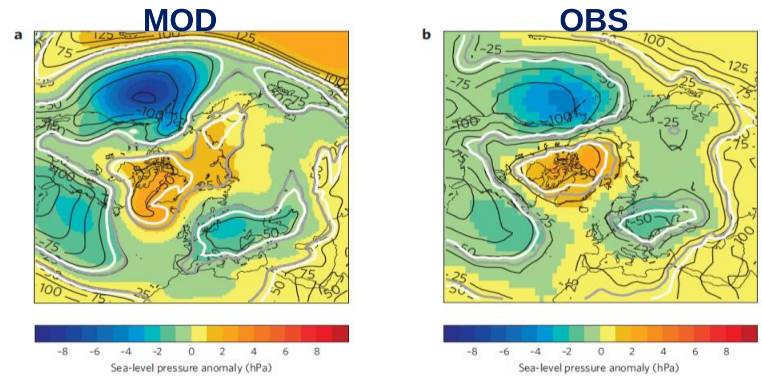
WINTER



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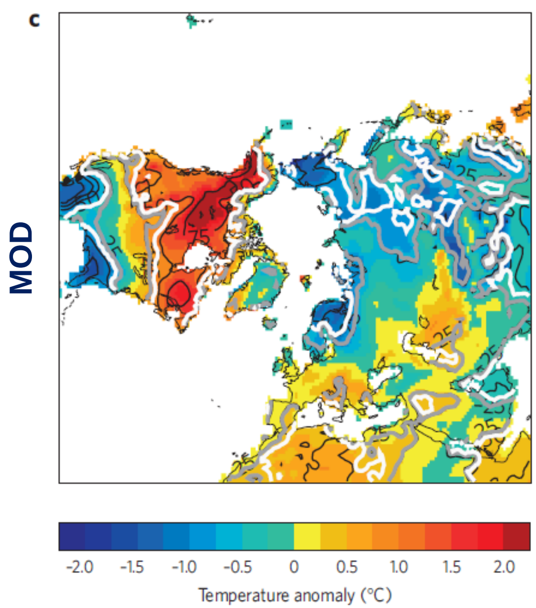
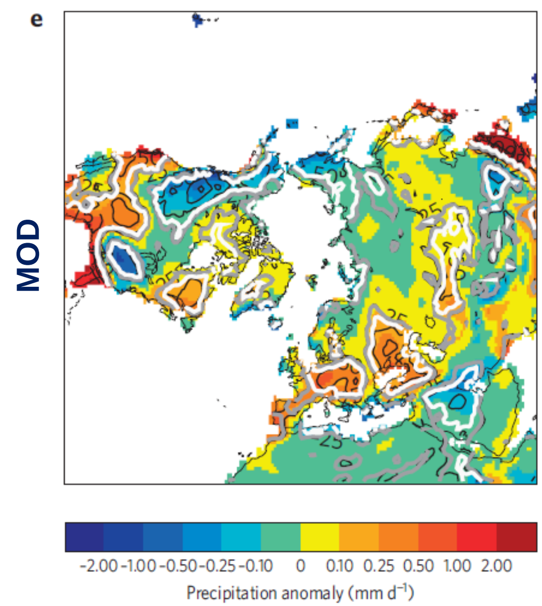


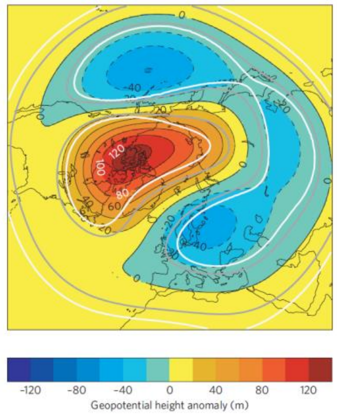


[Ineson and Scaife 2009]

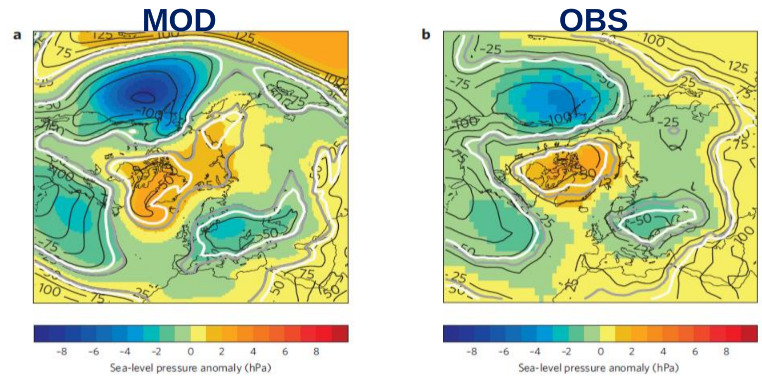
JFM: linear, robust and stationary over the past 300 years [review by Brönnimann 2007]

Z50 (lower stratosphere)

weakened polar vortex
[Ineson and Scaife 2009]



WINTER



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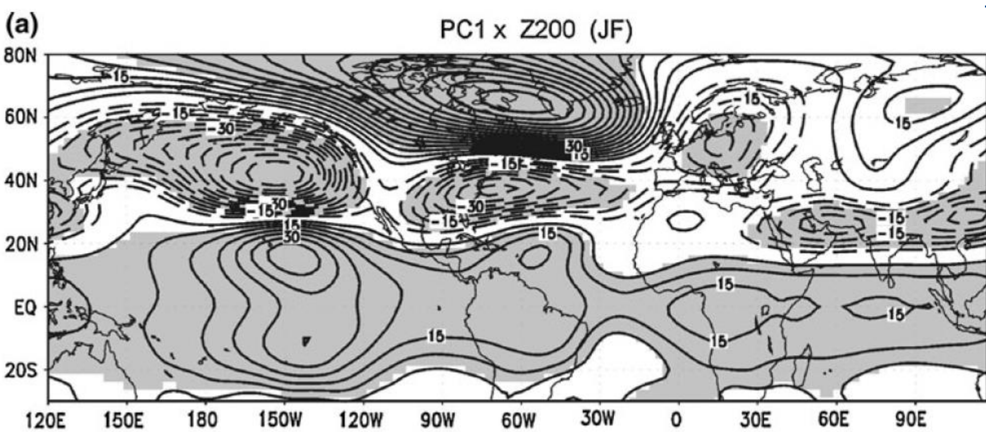
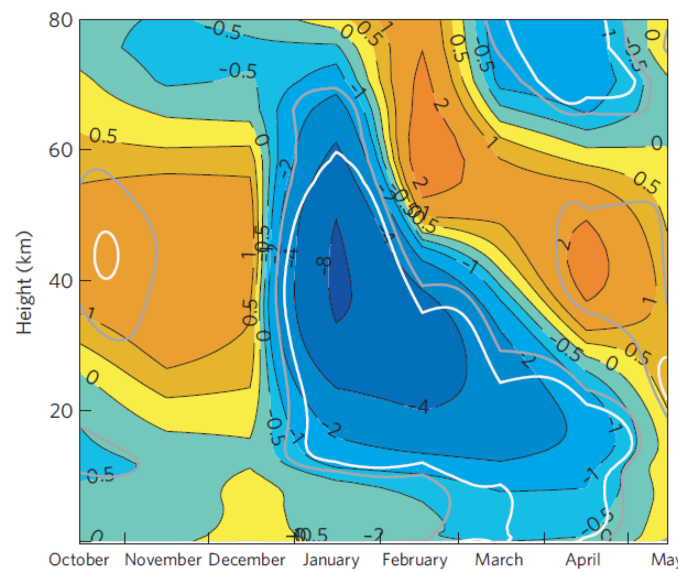


tropospheric pathway
[García-Serrano et al. 2011b]

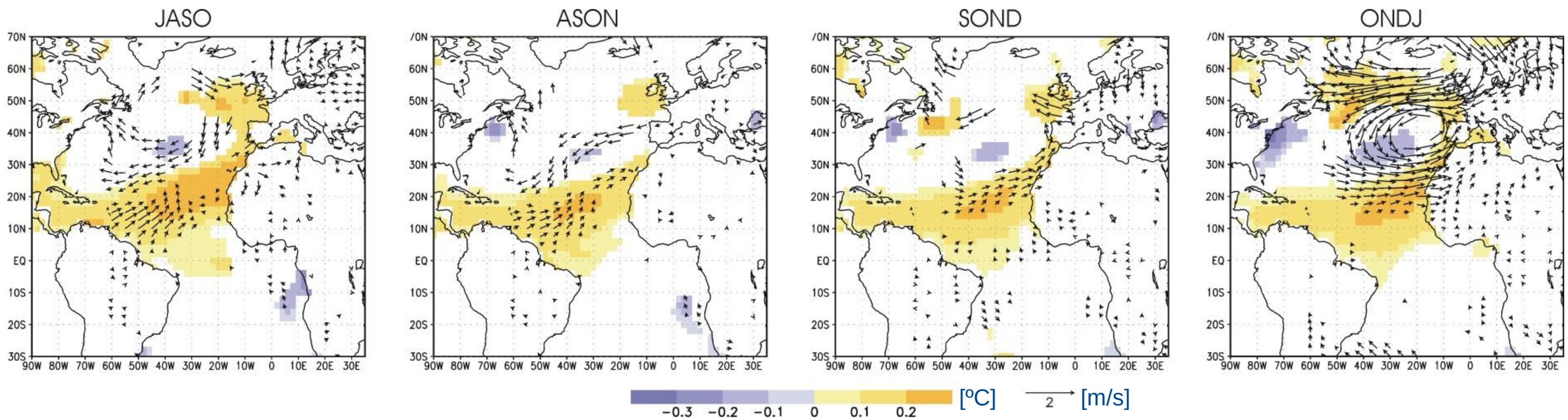


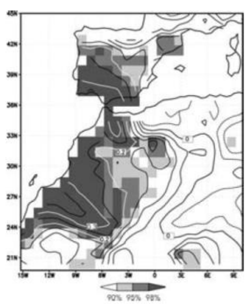
stratospheric pathway
[Ineson and Scaife 2009]

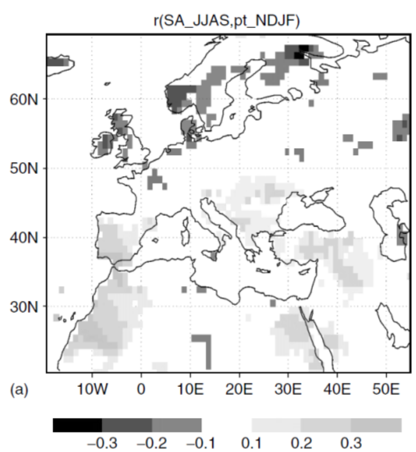
stratosphere as feedback for atmospheric persistence
[Cagnazzo and Manzini 2009]

WINTER

SST, 925wind



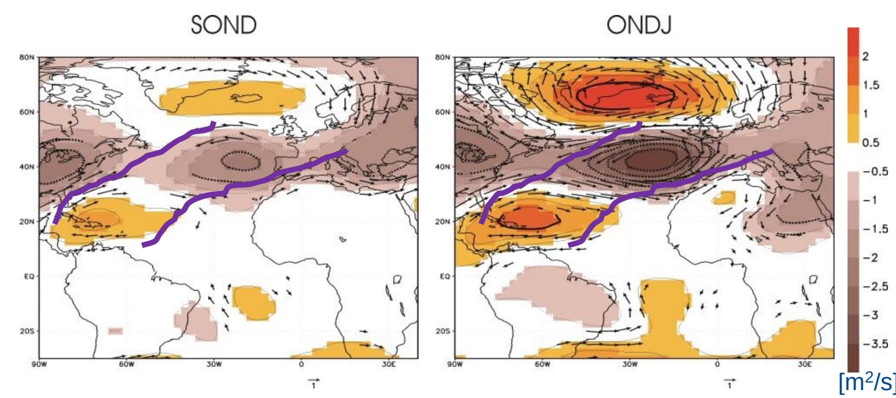




<u>subtropical North Atlantic SST</u> – predictor of winter European/North African precipitation

[Rodríguez-Fonseca and Castro 2002; Rodríguez-Fonseca et al. 2006]

PSI200, rot.wind



[García-Serrano et al. 2008]

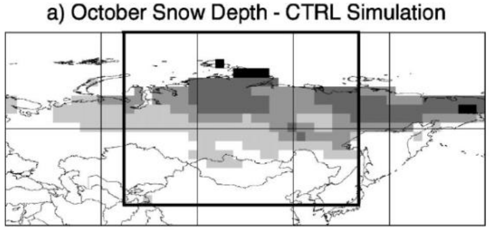
retained ITCZ + triggering Rossby wave

[Terray and Cassou 2002]

Eurasian snow cover in autumn (**OCT**)
[Cohen and co-authors]

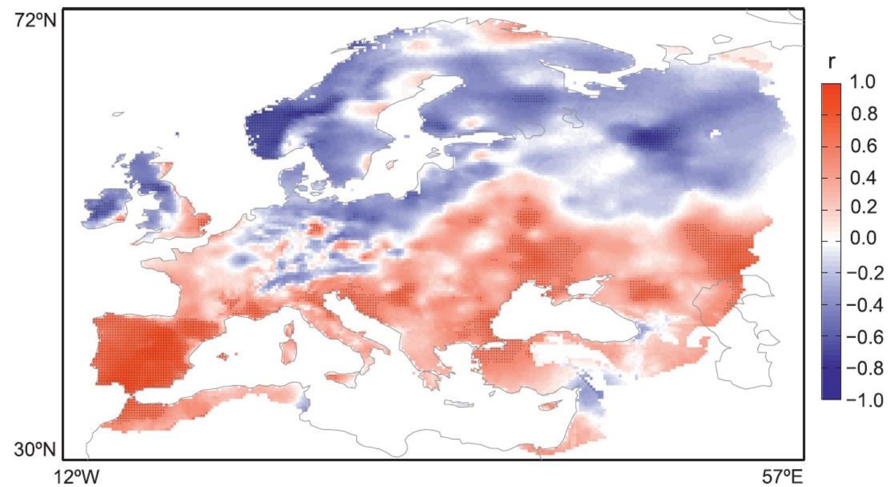
snow advance index - SAI / r(AO)=0.6-0.8
[Cohen and Jones 2011]

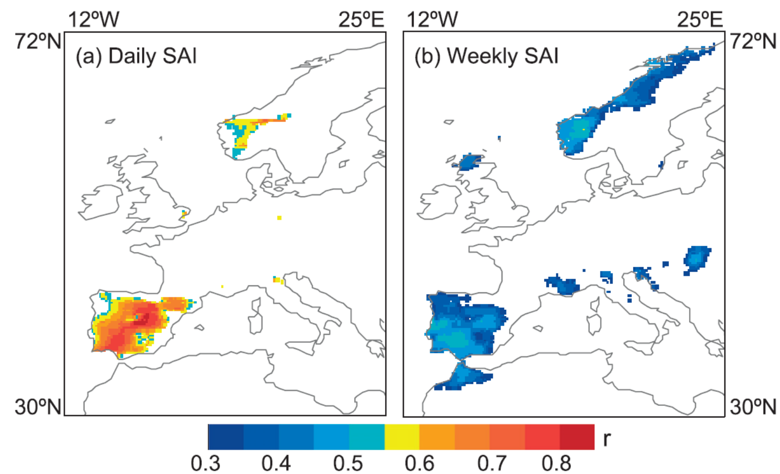
a) October Snow Depth - CTRL Simulation



[Gong et al. 2003]

WINTER





correlation / empirical prediction skill
[Brands et al. 2012]

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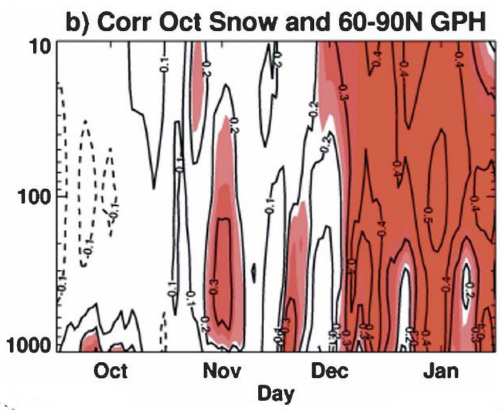
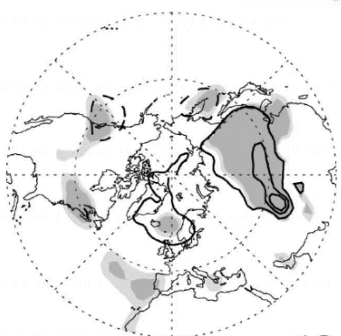
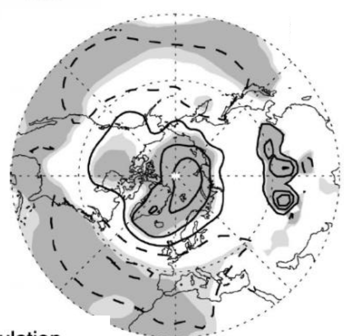
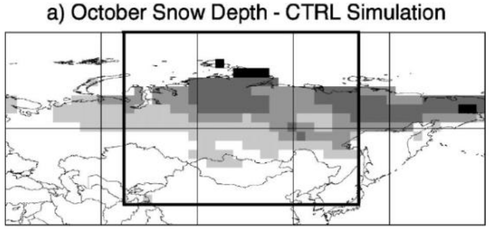


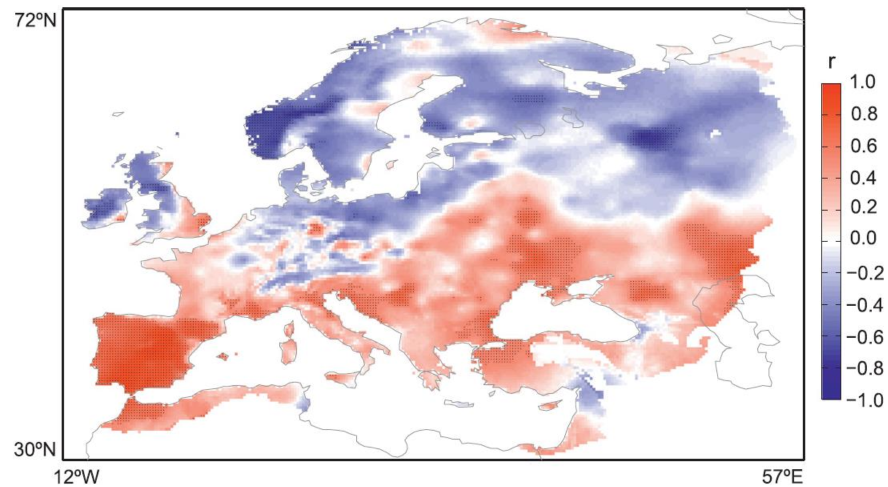


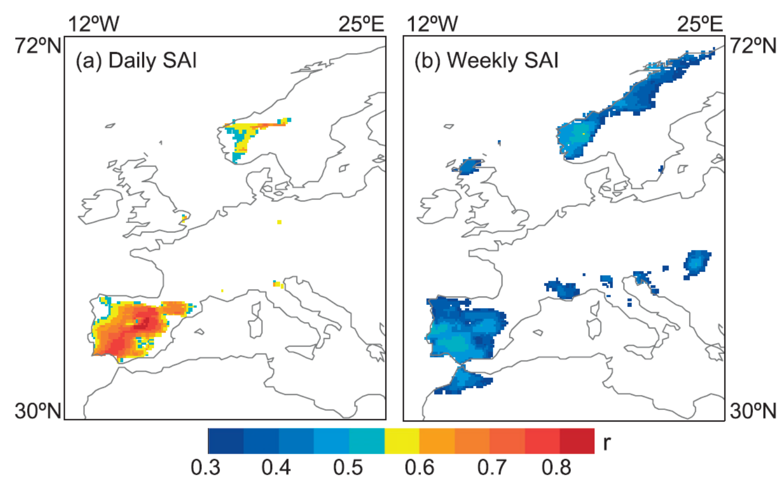




[Gong et al. 2003; Cohen et al. 2007]

WINTER

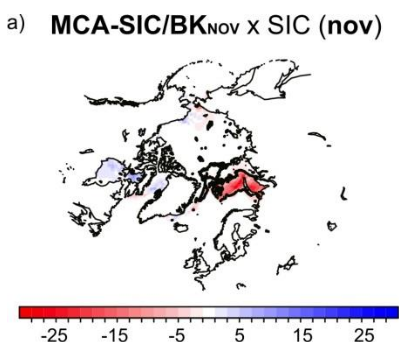




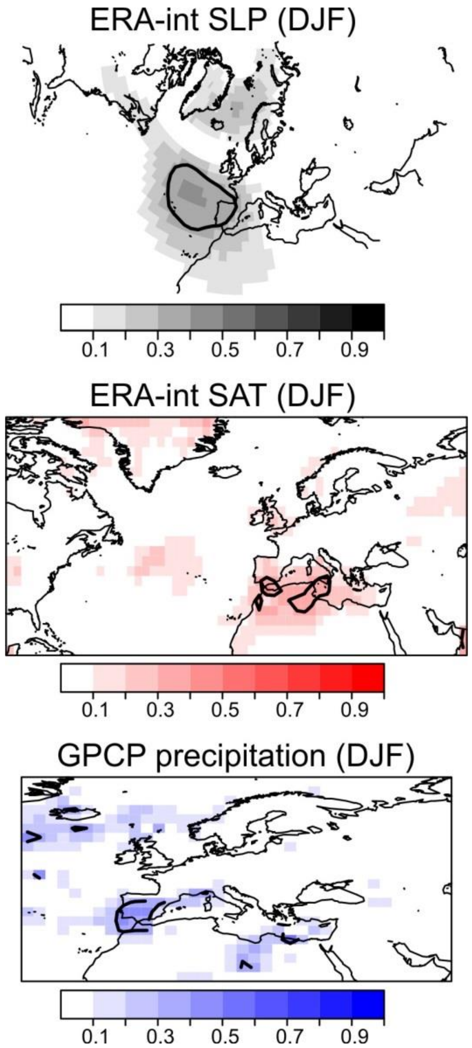
correlation / empirical prediction skill

[Brands et al. 2012]

Barents-Kara sea-ice concentration in autumn (**NOV**)
[García-Serrano et al. 2015; King et al. 2015; Koenigk et al. 2015]
[Scaife et al. 2014]



WINTER



empirical prediction skill
[García-Serrano et al. 2015]

Barents-Kara sea-ice concentration in autumn (**NOV**)

[García-Serrano et al. 2015; King et al. 2015; Koenigk et al. 2015]
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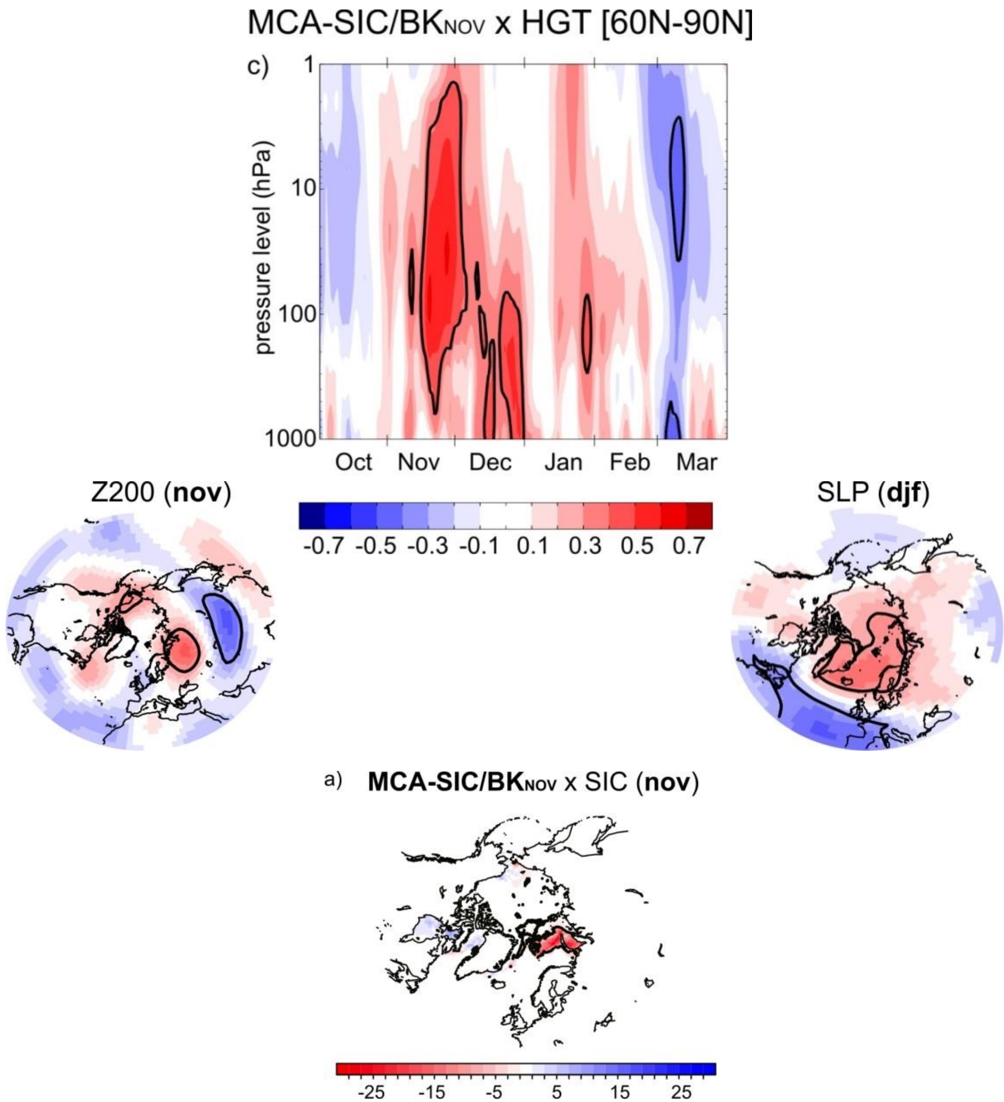

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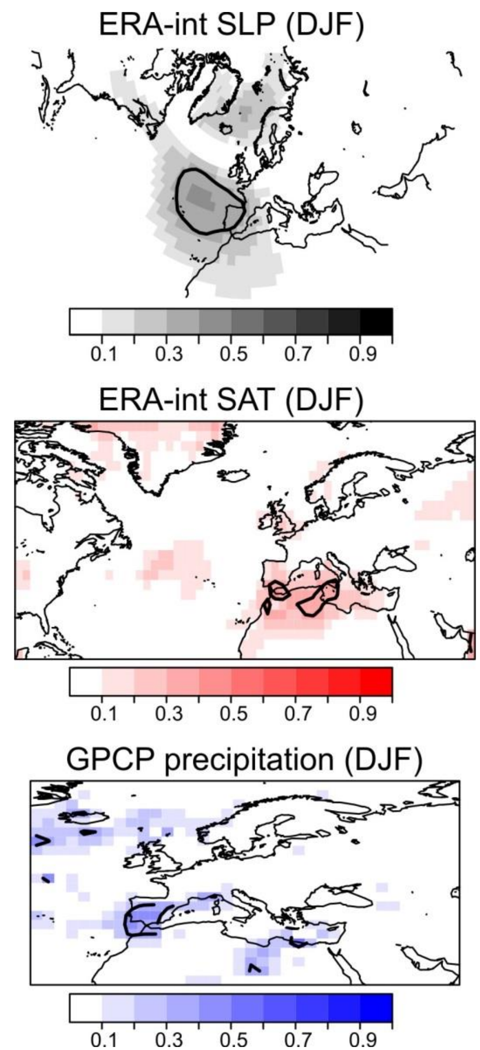


empirical prediction skill
[García-Serrano et al. 2015]

SUMMARY:

- ENSO is the most important source of predictability at seasonal time-scales…

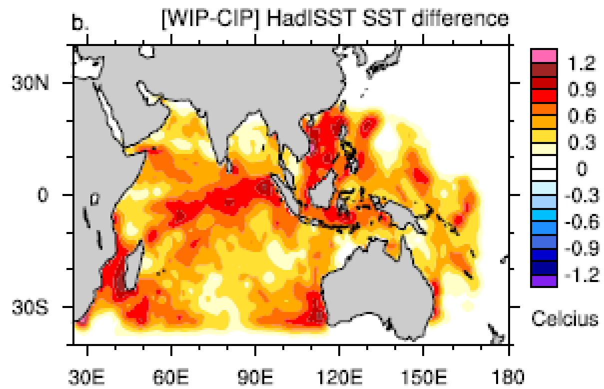
- …other oceanic basins may also provide predictability (e.g. Indian Ocean)

- …other forcings may play a larger role in seasons when ENSO signal is weak

- …other atmospheric phenomena might be important (e.g. MJO; QBO)

→ dynamical forecast systems will require a proper representation of stratosphere

→ there is room for comprehensively improving empirical prediction models



Indian Ocean in winter

[Sanchez-Gomez et al. 2008]

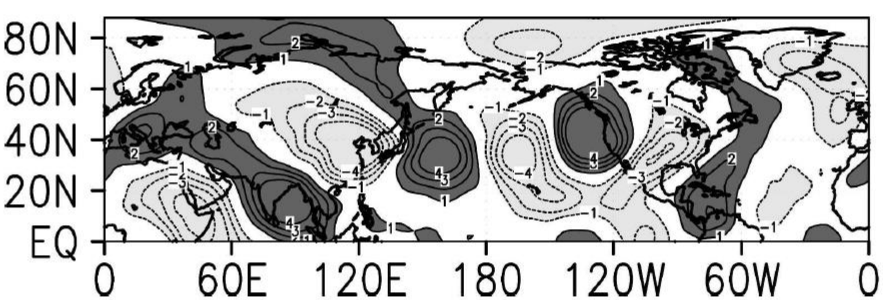
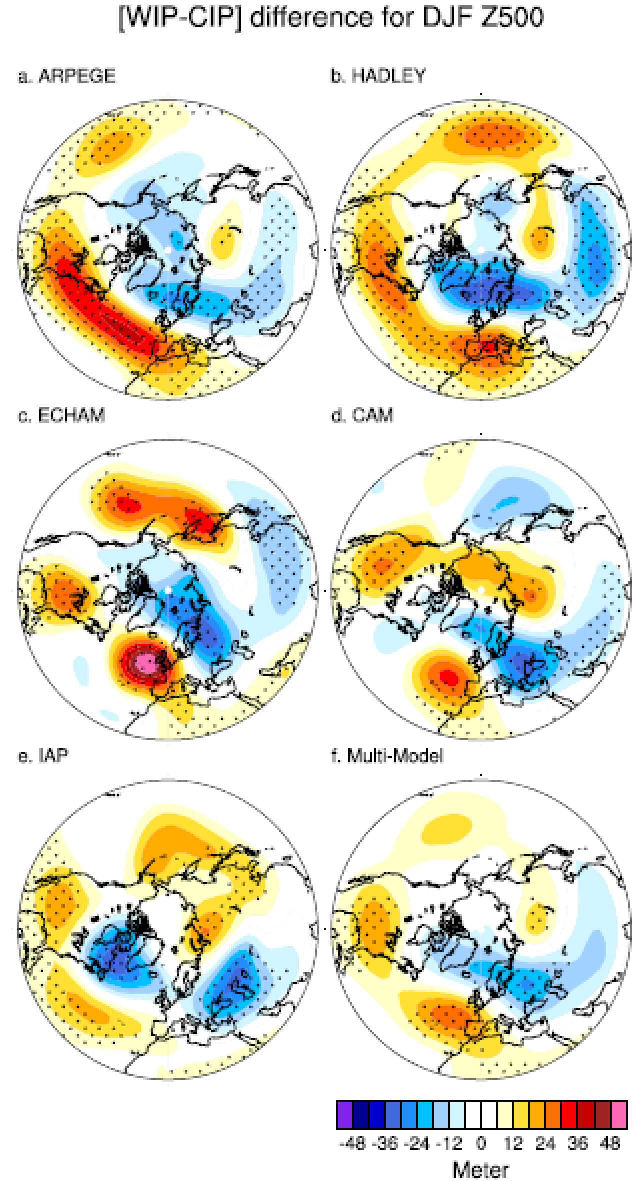
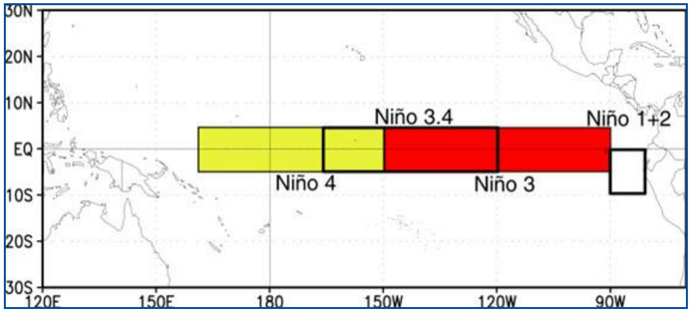
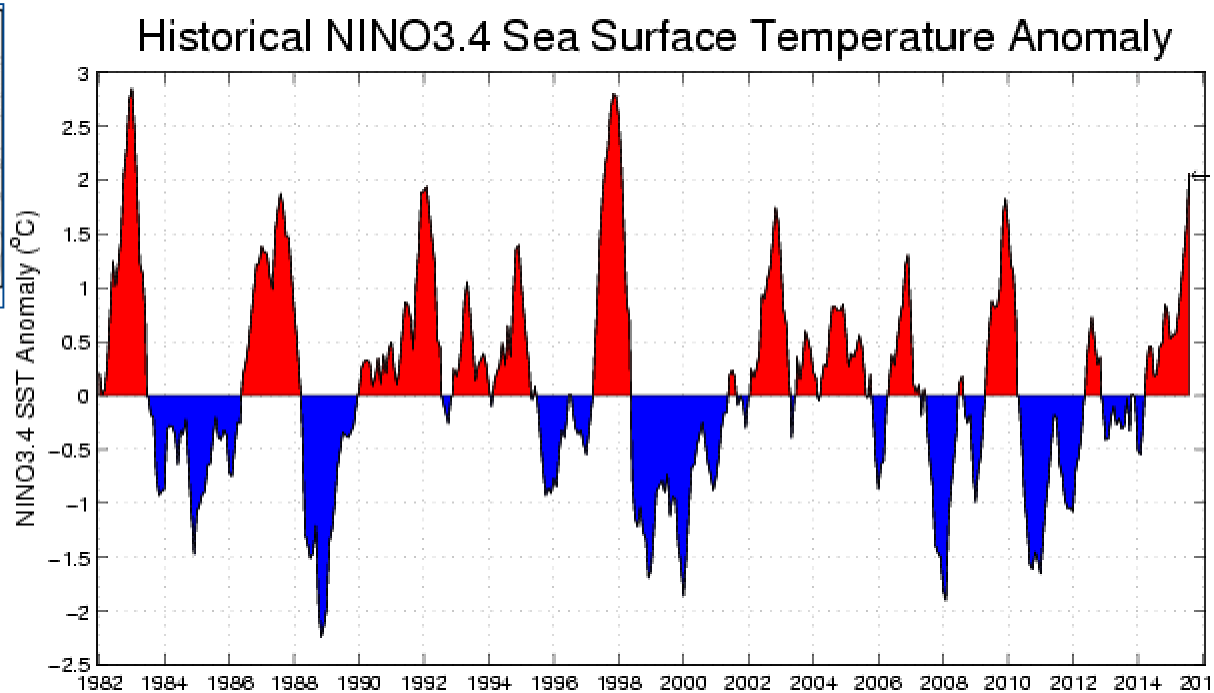


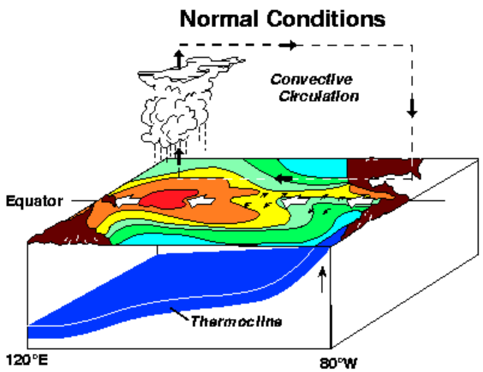
FIG. 14. Meridional 300-hPa winter (DJF) wind response for the "western Indian Ocean

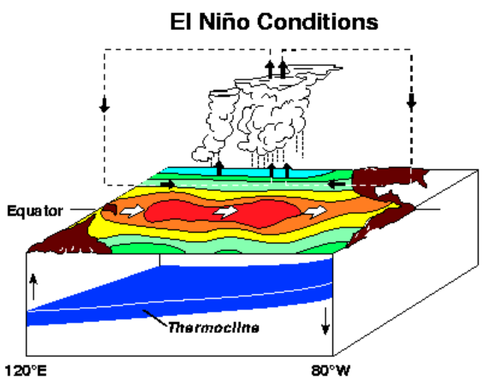
[Bader and Latif 2005]

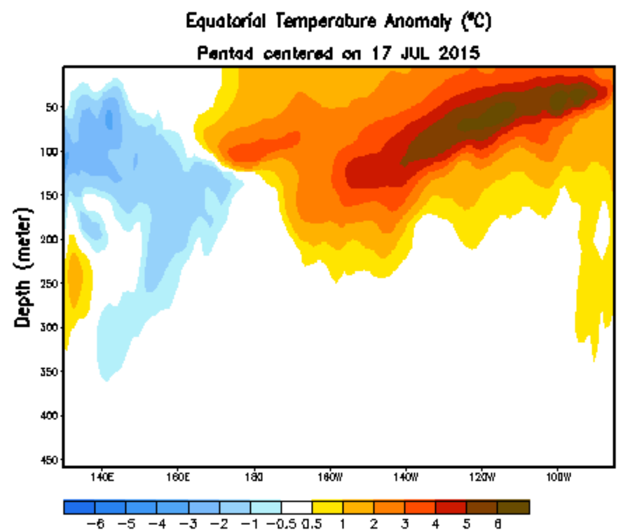


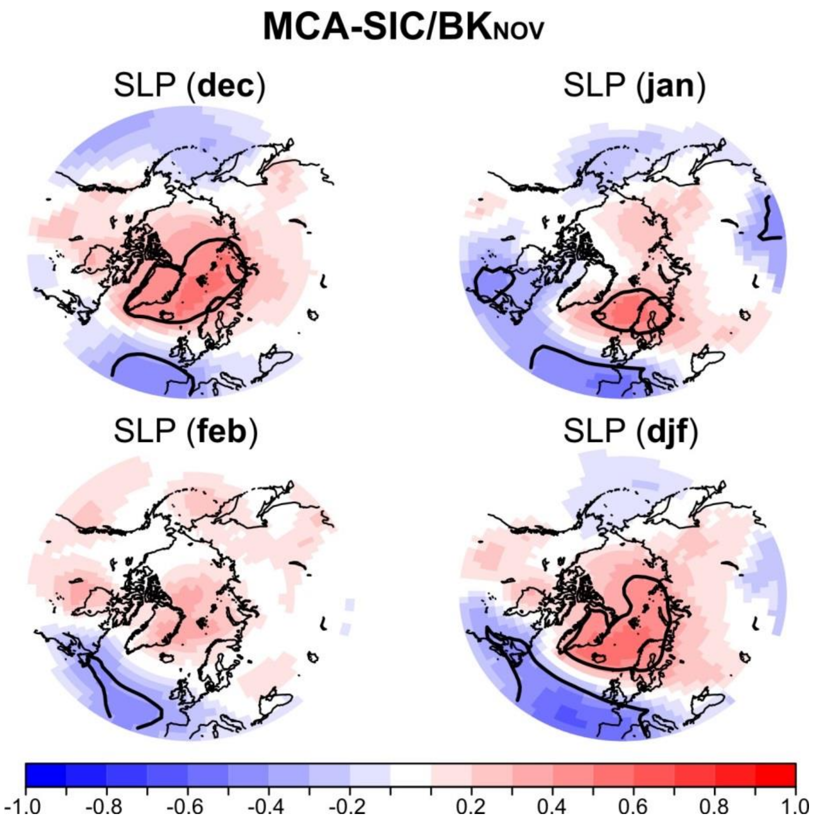

Niño 3.4
Niño 1+2
Niño 4
Niño 3
30N
20N
10N
EQ
10S
20S
30S
120E
150E
180
150W
120W
90W

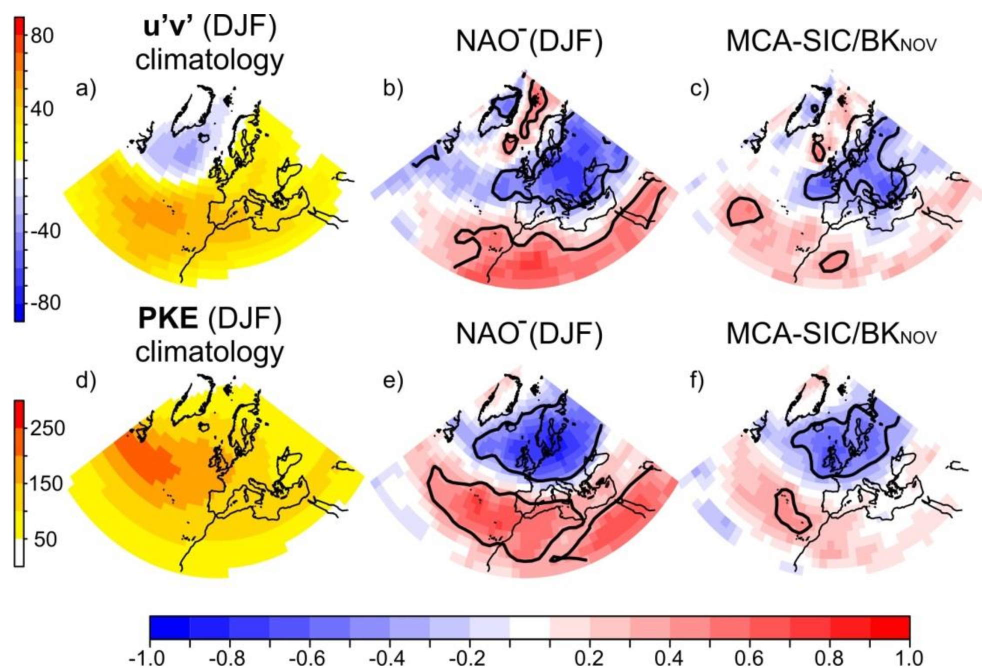

Historical NINO3.4 Sea Surface Temperature Anomaly
NINO3.4 SST Anomaly (°C)
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016


Normal Conditions
Convective Circulation
Equator
Thermocline
120°E
80°W


El Niño Conditions
Equator
Thermocline
120°E
80°W


Equatorial Temperature Anomaly (°C)
Pentad centered on 17 JUL 2015
Depth (meter)
140E
160E
180
160W
140W
120W
100W


MCA-SIC/BKNOV
SLP (dec)
SLP (jan)
SLP (feb)
SLP (djf)
-1.0 -0.8 -0.6 -0.4 -0.2 0.2 0.4 0.6 0.8 1.0


u'v' (DJF)
climatology
NAO⁻(DJF)
MCA-SIC/BKNOV
a)
b)
c)
80
40
-40
-80
PKE (DJF)
climatology
NAO⁻(DJF)
MCA-SIC/BKNOV
d)
e)
f)
250
150
50
-1.0 -0.8 -0.6 -0.4 -0.2 0.2 0.4 0.6 0.8 1.0