Madden Julian Oscillations effect on winter season precipitation of Morocco

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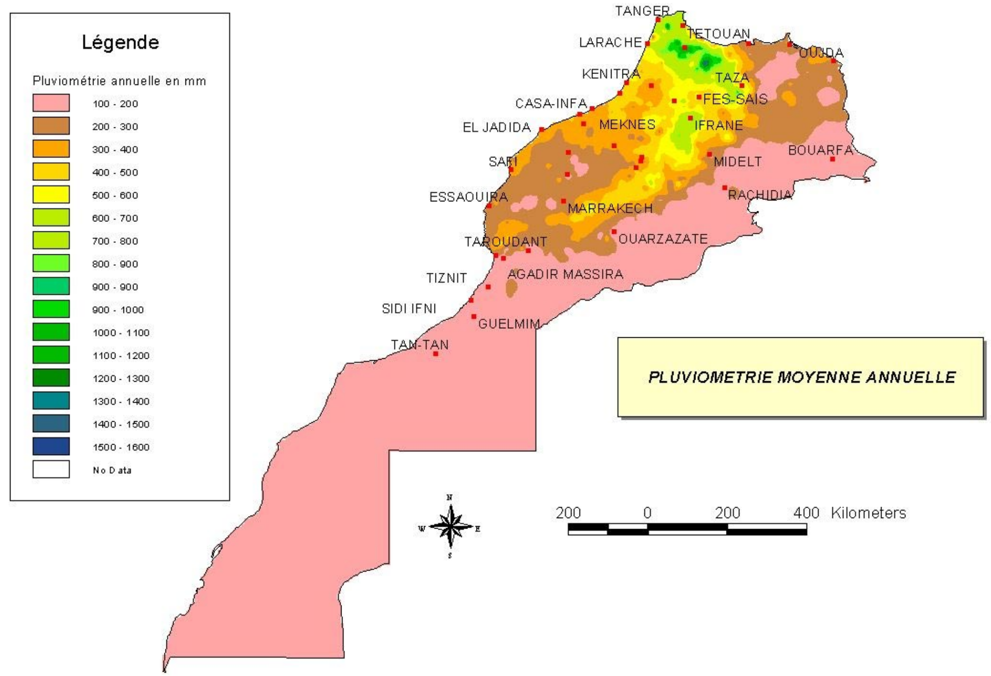
Outline

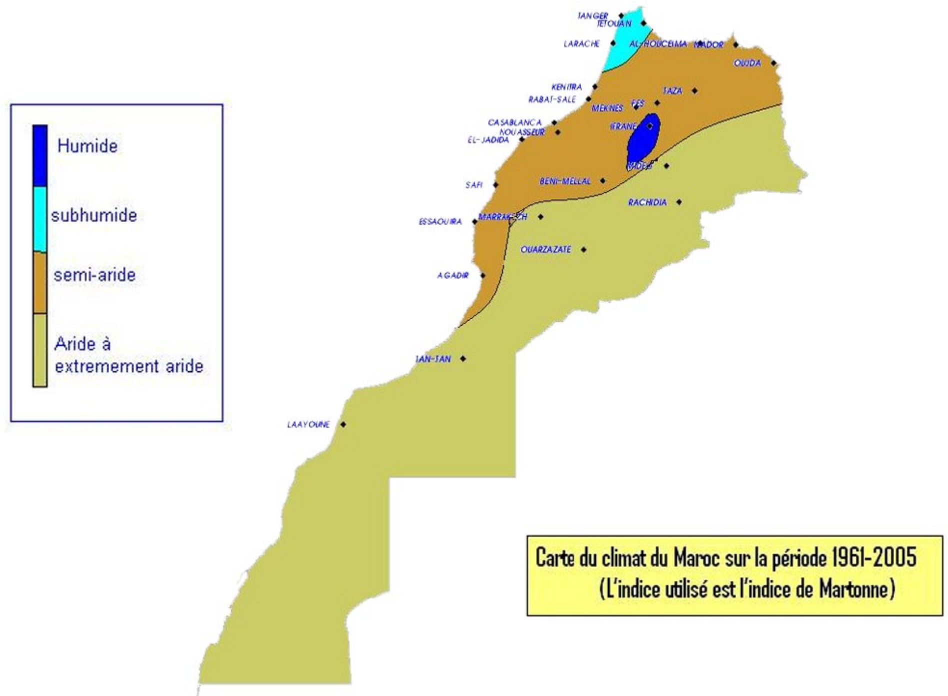
- Introduction
- Objectives
- MJO-NAO regimes connection
- Data and Methodology
- Results
- Summary

Introduction



- Under the influence of the mid-latitude weather systems
- Heterogeneous landscape (e.g., Atlas mountains, Atlantic Ocean in the west, Mediterranean in North and Sahara desert in the south)
- During wintertime (DJF), mid-latitude storms are major source of precipitation
- The north Atlantic large-scale circulation has the strong influence on the weather and climate

Introduction



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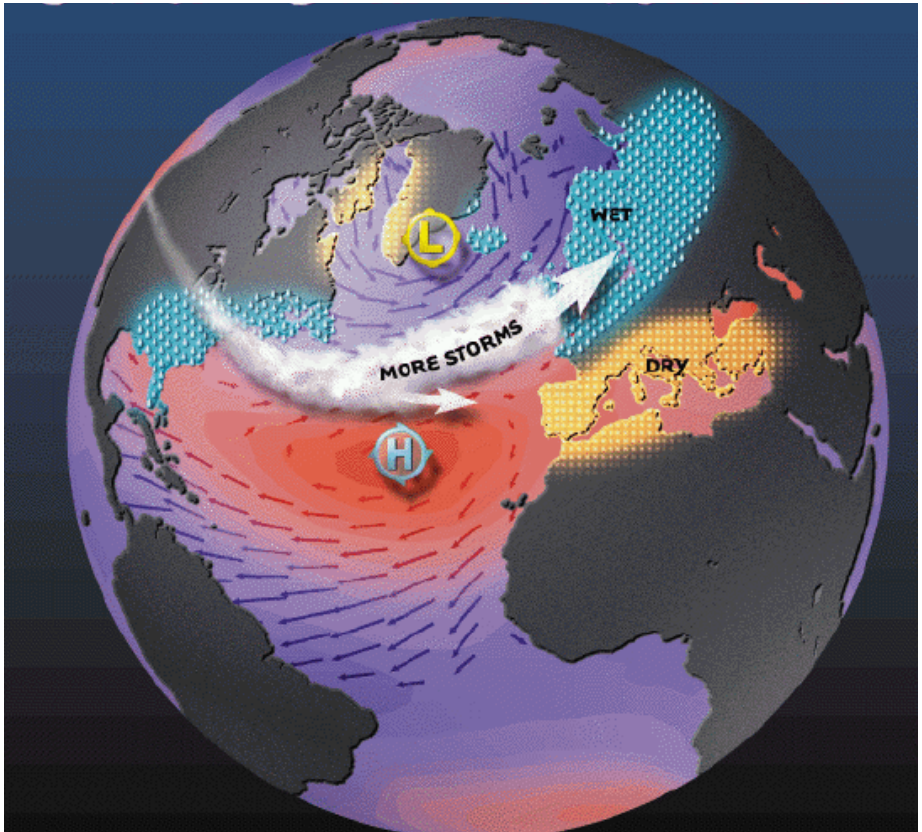
Objectives

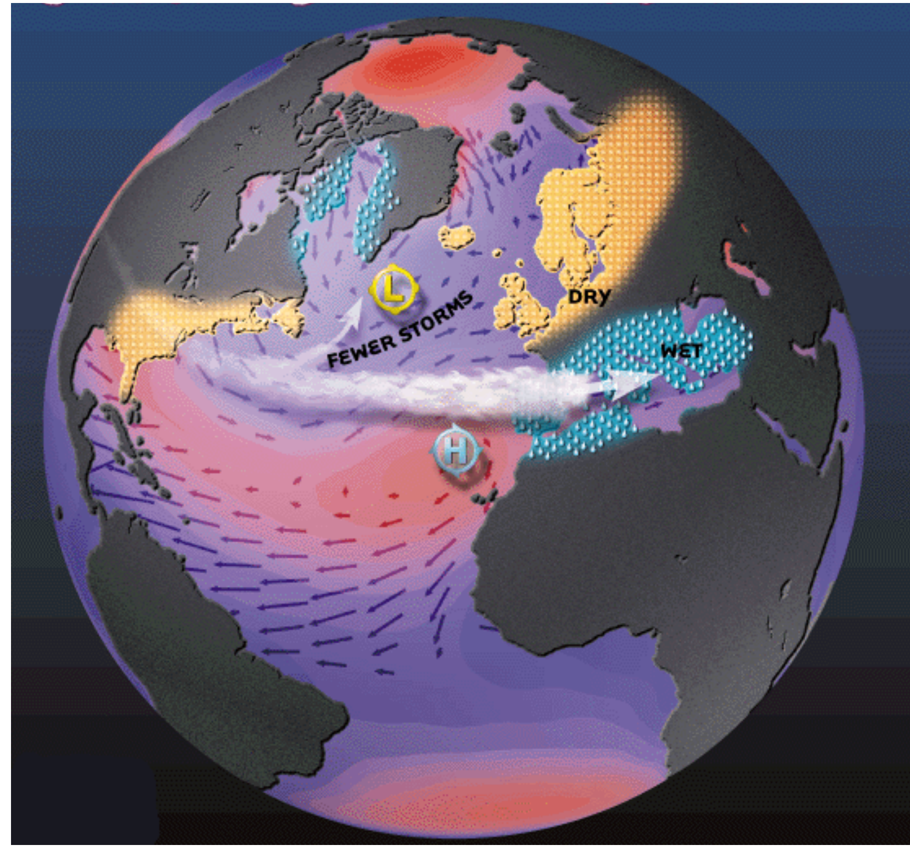
- Rainfall mechanisms (migratory North Atlantic disturbances, frontal weather systems, Mediterranean storms)
- Mostly rainfall is modulated by North Atlantic Jet oscillation from north to south
- Inter-seasonal rainfall variability is largely controlled by tropical and extra-tropical oscillations
- Dynamical characteristics of Tropical-extratropical oscillations
- Teleconnections between rainfall and Tropical-extratropical oscillations

North Atlantic Oscillation

NAO+



NAO-

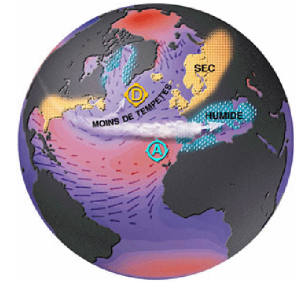


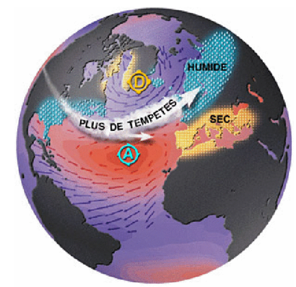
- A stronger than normal subtropical high pressure and a deeper than usual Icelandic low
- Stronger westerly winds and storm activity across the Atlantic Ocean
- Wetter winter in north-west Europe, drier conditions in Morocco

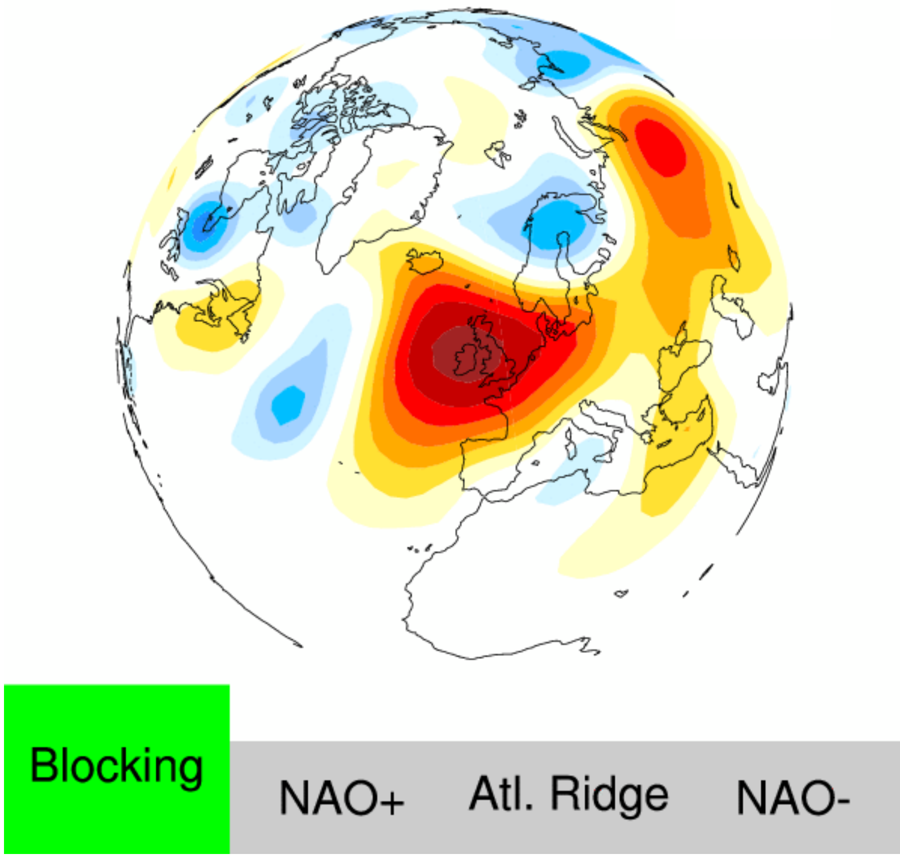
Opposite!

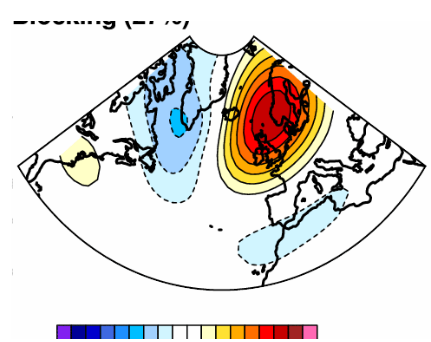
Cassou, 2008

Attribution to regimes





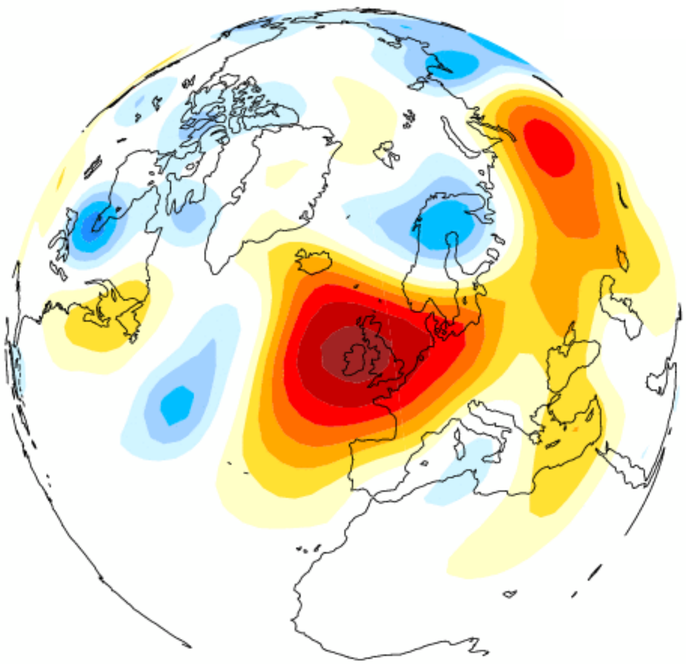




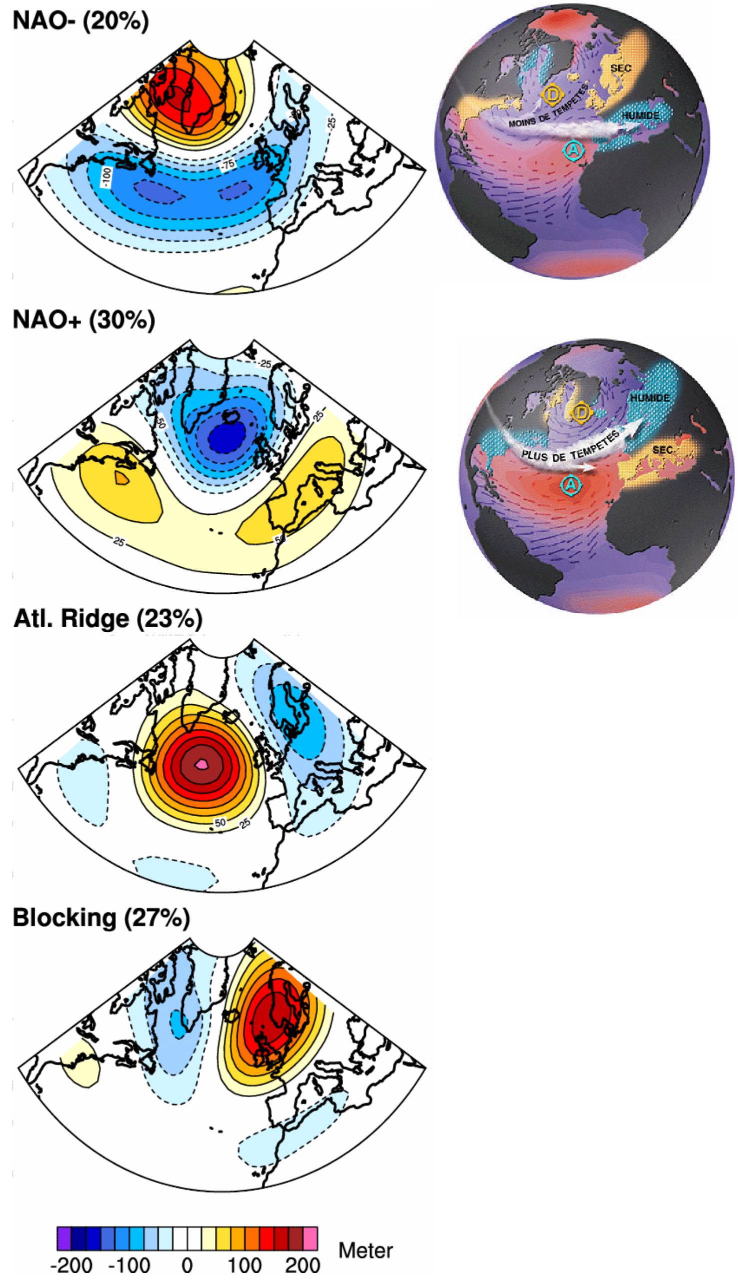
Attribution of daily anomalous circulation
to one of the 4 North Atlantic regimes

Cassou, 2008

Attribution to regimes



Blocking NAO+ Atl. Ridge NAO-



Attribution of daily anomalous circulation to one of the 4 North Atlantic regimes

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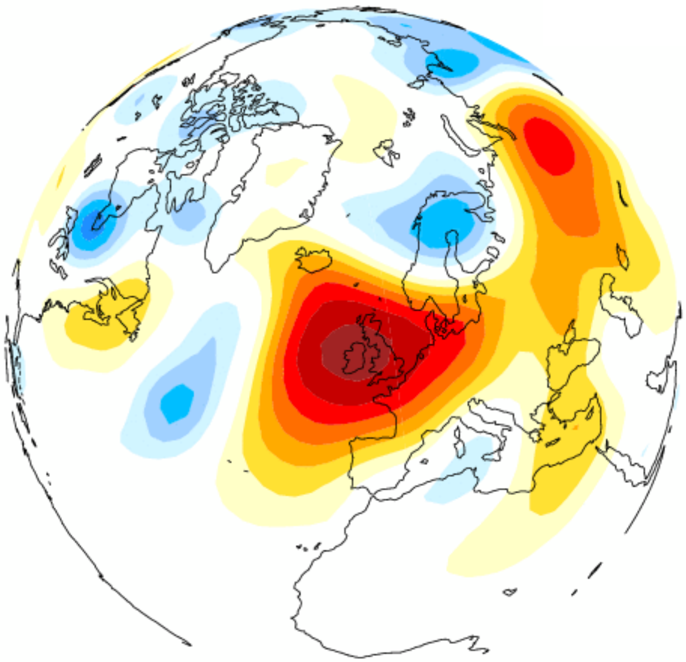
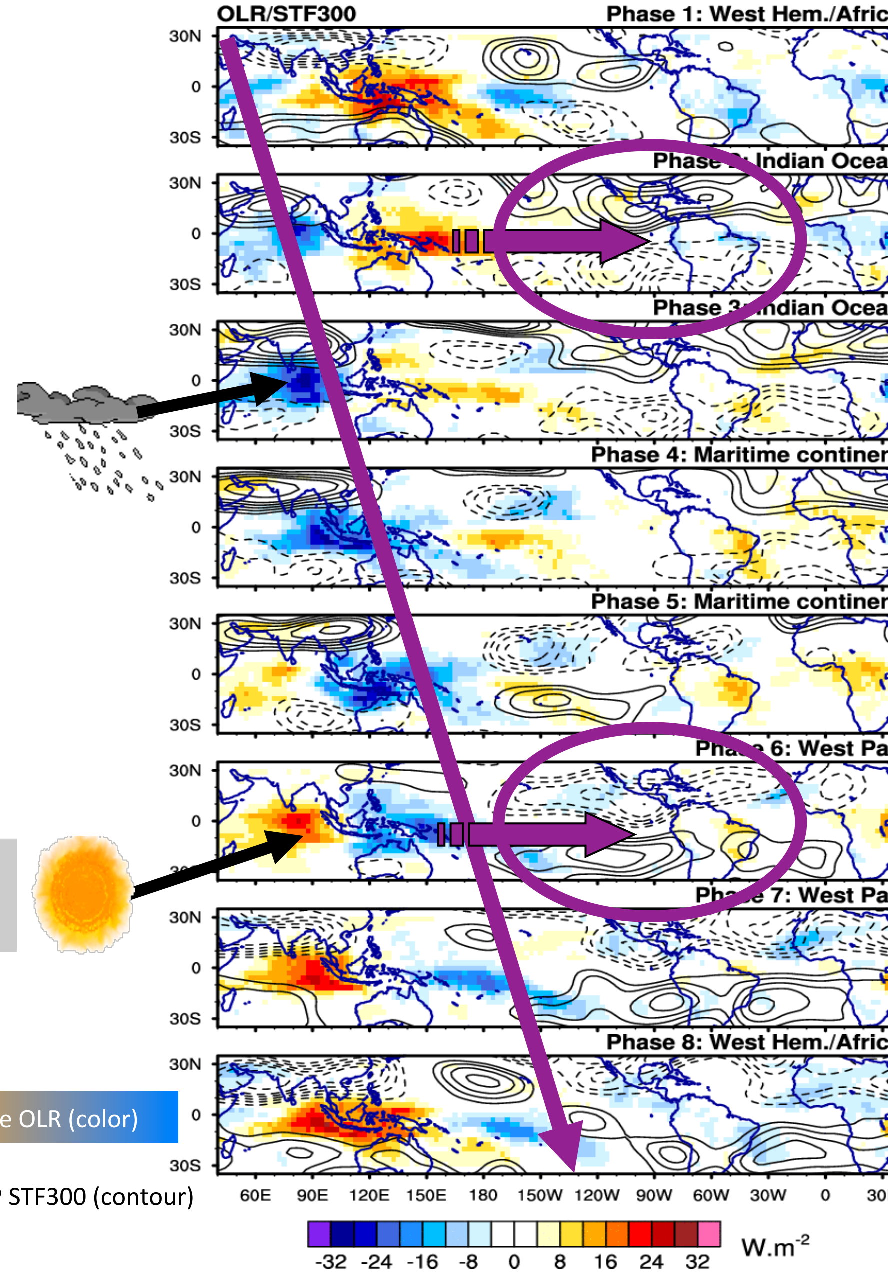




Blocking

NAO+ Atl. Ridge NAO-

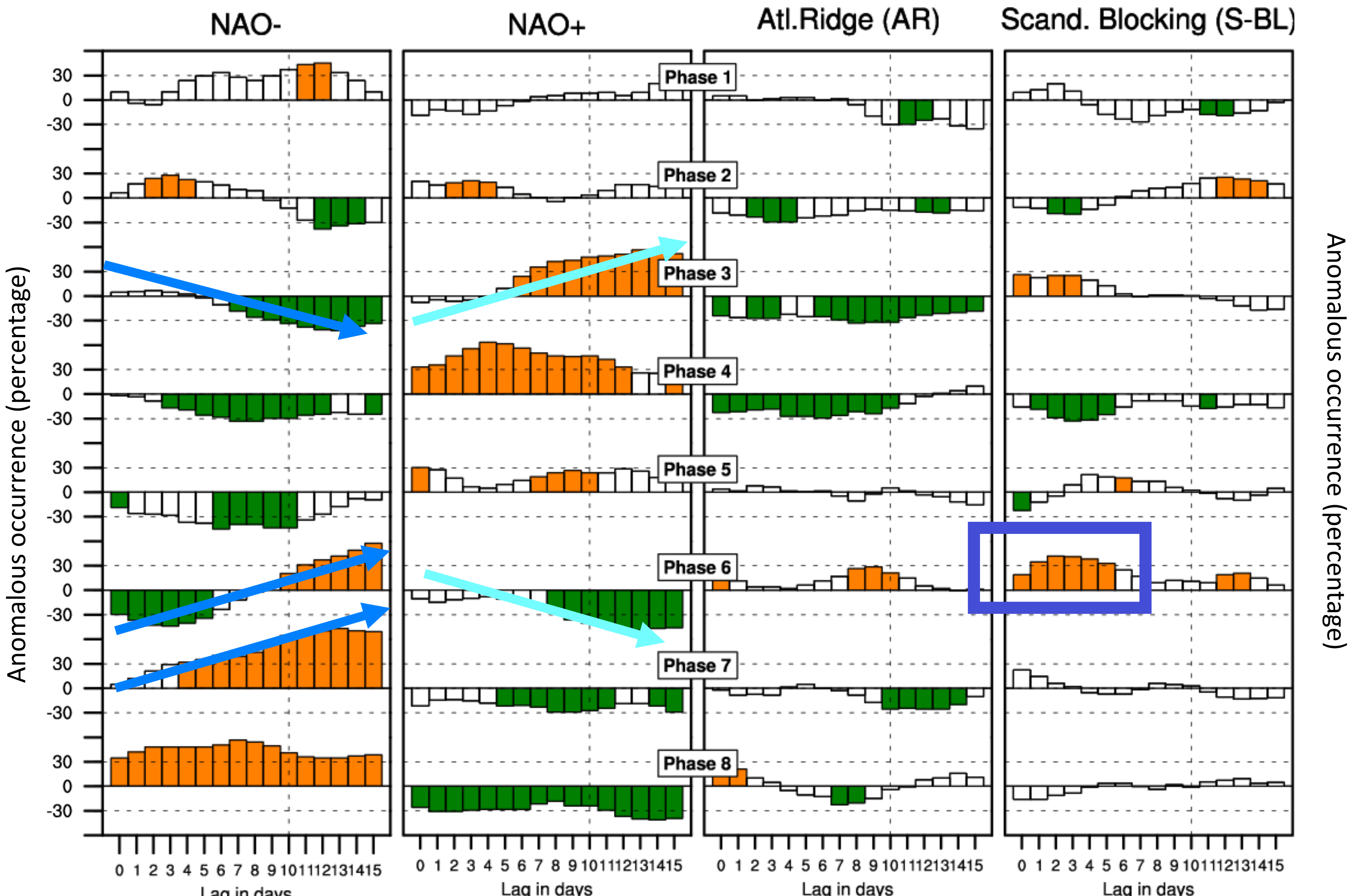
Satellite OLR (color)

NCEP STF300 (contour)

Attribution to 8 phases of the MJO

Cassou, 2008

Table of contingency between the MJO and the NAE regimes



Anomalous percentage occurrence for a given regime as a function of lags in days . %100 value would mean that this regime occurs twice as frequently as its climatological mean

Cassou, 2008

NAO+ regimes tend to be preceded by phase 3-4 of the MJO
NAO- regimes tend to be preceded by phase 6-7 of the MJO
S-Blocking tend to be present during phase 5 of the MJO

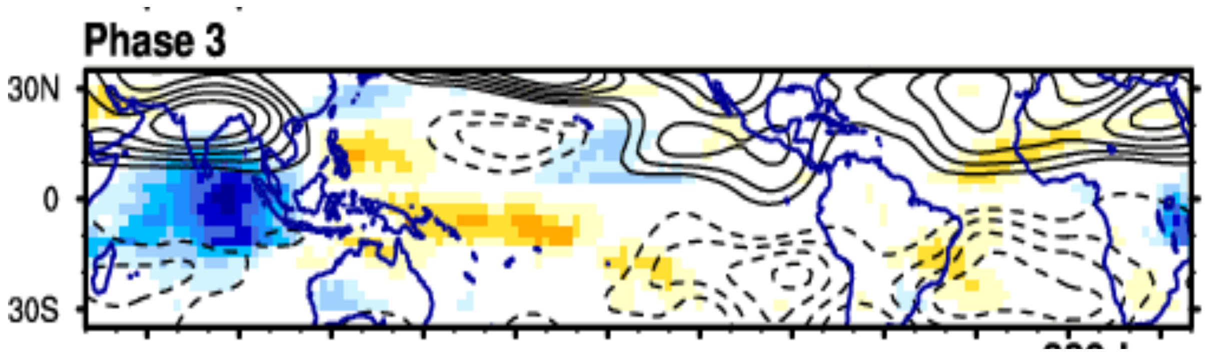
The time-scale of the MJO influence on the North Atlantic regimes is
About ~10/12 days

What are the physical mechanisms of the MJO-NAO regimes connection?

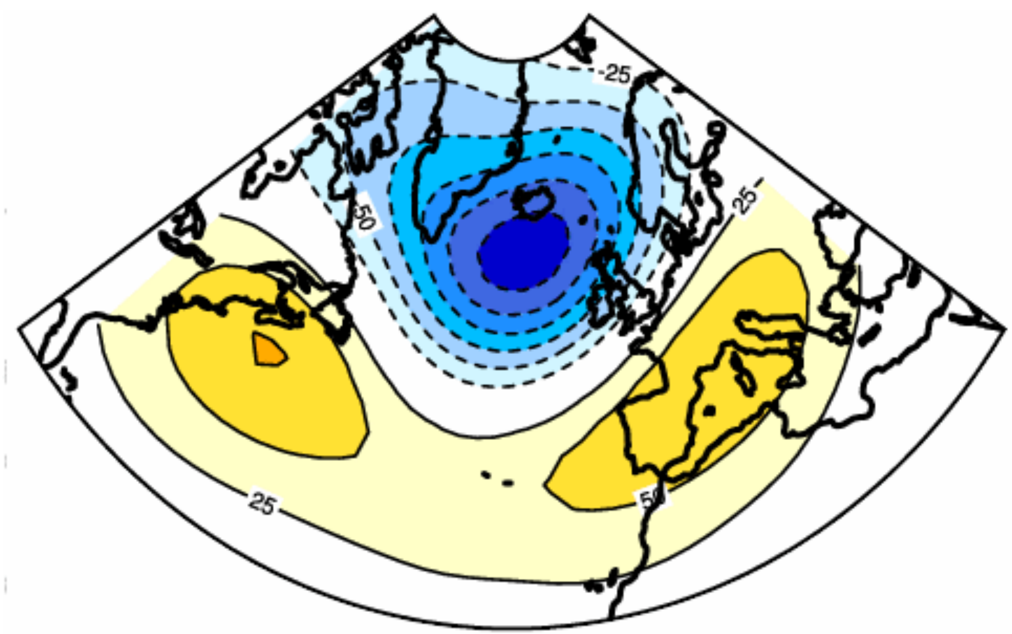
<u>Method</u>: Lagged composites for phase 3 (NAO+ favored excitation)
and phase 6 (NAO- favored excitation)

Relationship between MJO phase 3 and NAO regimes

Cassou, 2008



MJO Phase 3



NAO+ regime

Cassou, 2008

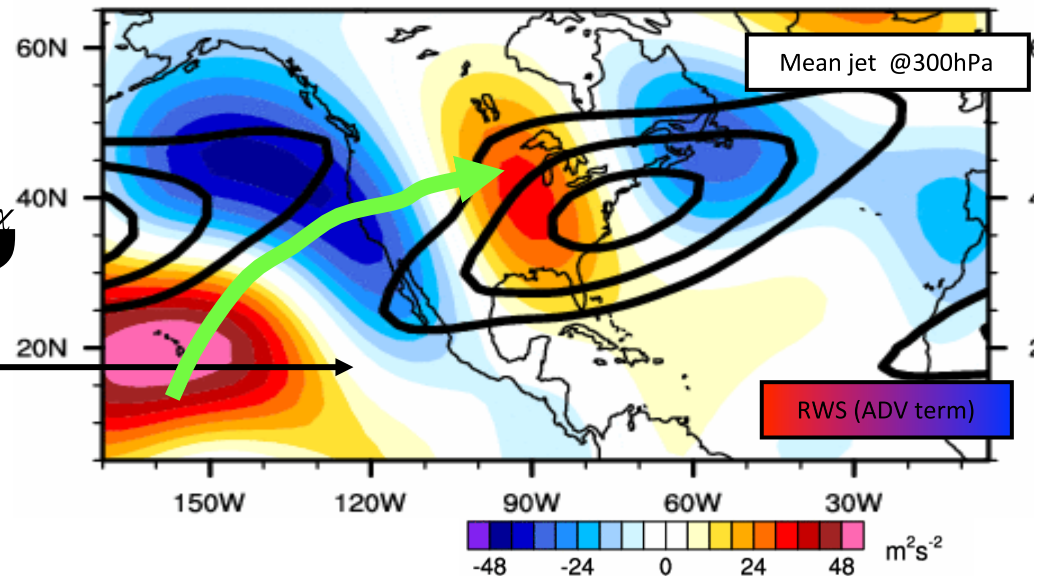
MJO Phase 3/NAO+

Rossby wave source:

$$RWS = -\nabla.[v_\chi(\xi + f)]$$
$$= \underbrace{-v_\chi.\nabla(\xi + f)}_{\text{Advection term}} \underbrace{-(\xi + f)\nabla.v_\chi}_{\text{Stretching term}}$$

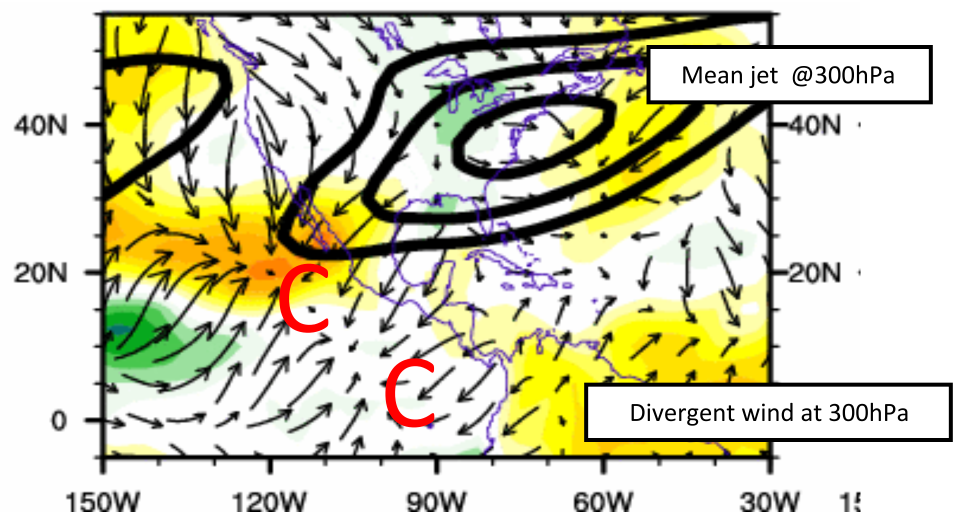
(Qin and Robinson, JAS, 1993)

Averaged anomalies From lag 0 to lag +5



- Strong Rossby Wave Source in the Central Pacific propagating Northeastward

Averaged anomalies From lag 0 to lag +5

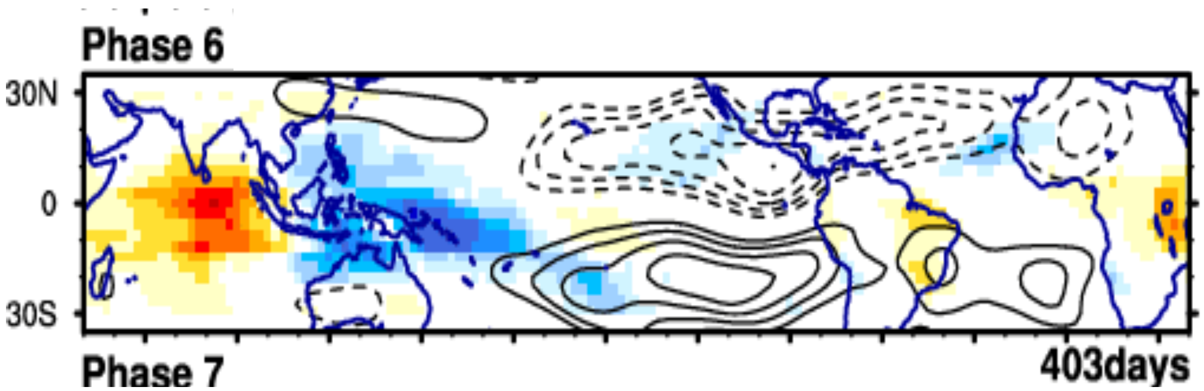


Precipitable water (color)/Divergent wind @300hpa

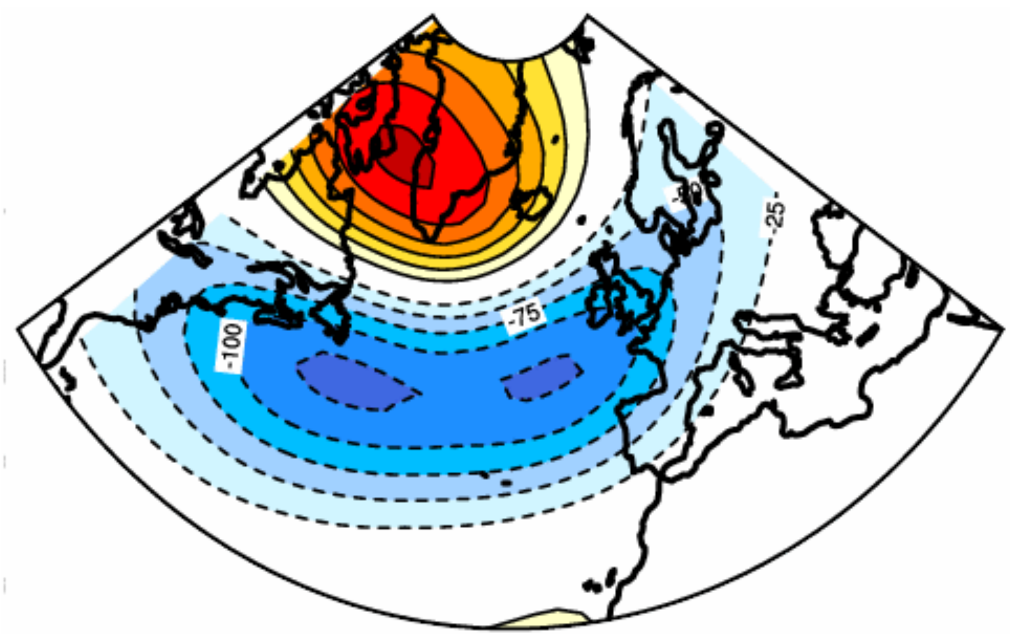
- Strong upper-level convergence on the Eastern Pacific and at the entrance of the Mean North Atlantic jet
- Dry conditions at the entrance of the jet

Cassou, 2008

Relationship between MJO phase 3 and NAO regimes



MJO Phase 6



NAO- regime

Cassou, 2008

MJO Phase 6/NAO-

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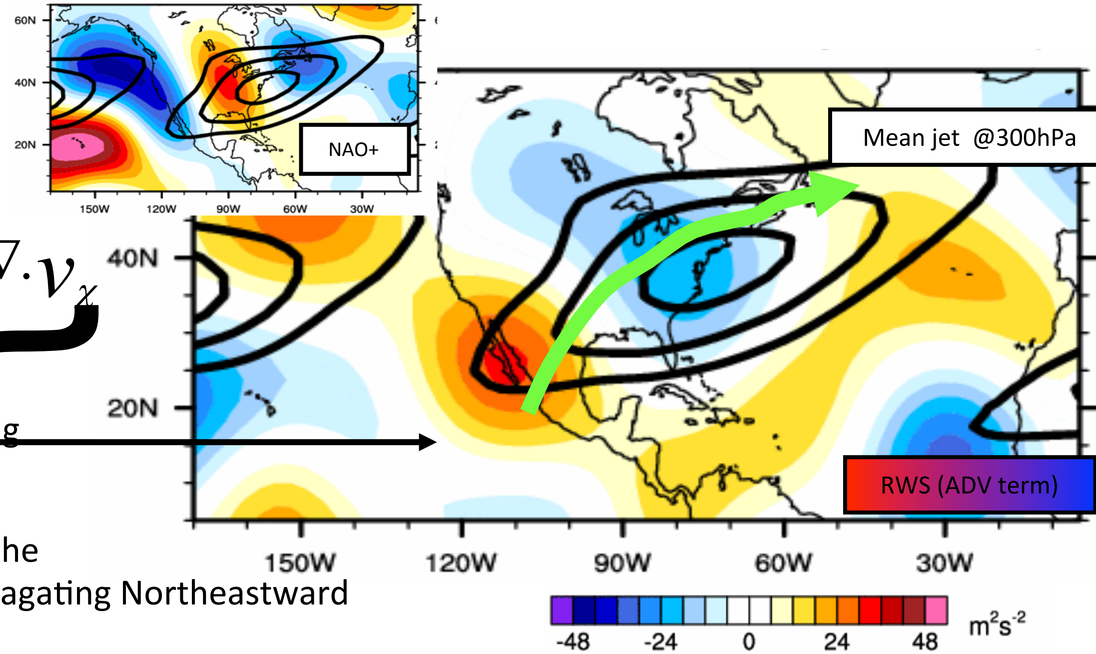
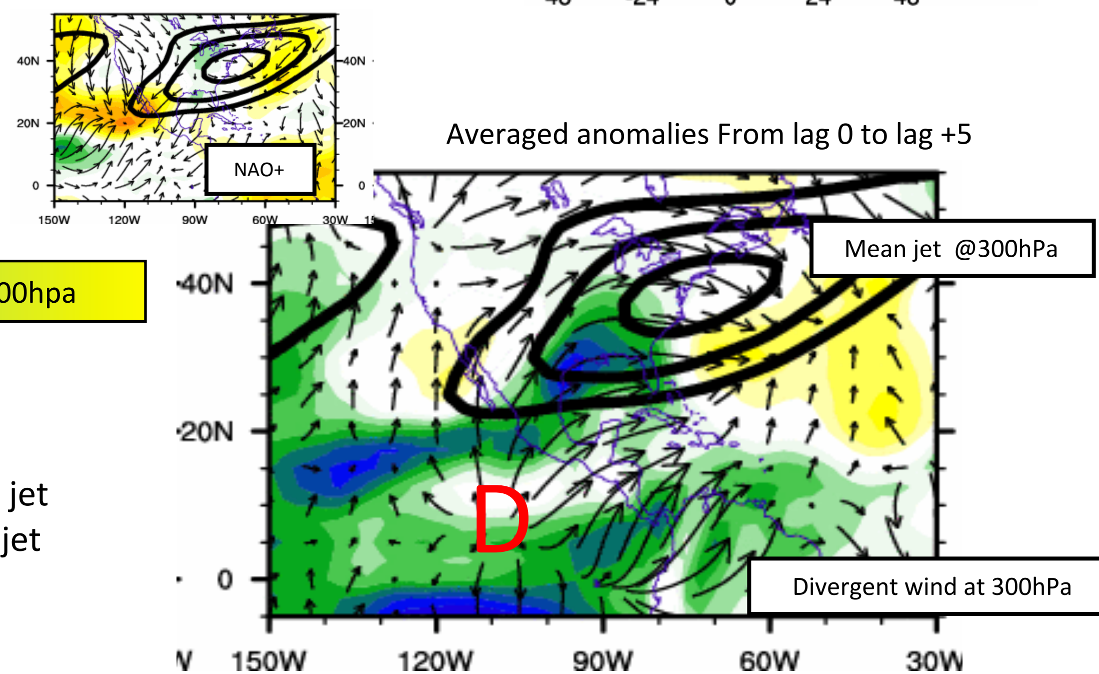


- Moderate Rossby Wave Source in the Eastern Pacific/West Caribbean propagating Northeastward

Ambrizzi and Hoskins (1997)

Averaged anomalies From lag 0 to lag +5



Precipitable water (color)/Divergent wind @300hpa

- Strong upper-level divergence on the Eastern Pacific and convergence at the Equator side of the mean North Atlantic jet
- Wet conditions at the entrance of the jet

Cassou, 2008: Intraseasonal interaction between the Madden-Julian Oscillation and the North Atlantic Oscillation
Nature, doi:10.1038/nature07286, 523-527):

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The time-scale of the MJO influence on the North Atlantic regimes is about ~10/12 days

MJO Phase 3/NAO+

MJO triggers forced Rossby waves
in the Pacific (Phase 2 and 3) propagating
eastward towards the NAE region,
modifying the background flow leading to
NAO+ due to interaction with North Atlantic
High frequency + intermediate transients (AWB).

Remote influence for NAO+ regimes

MJO Phase 6/NAO-

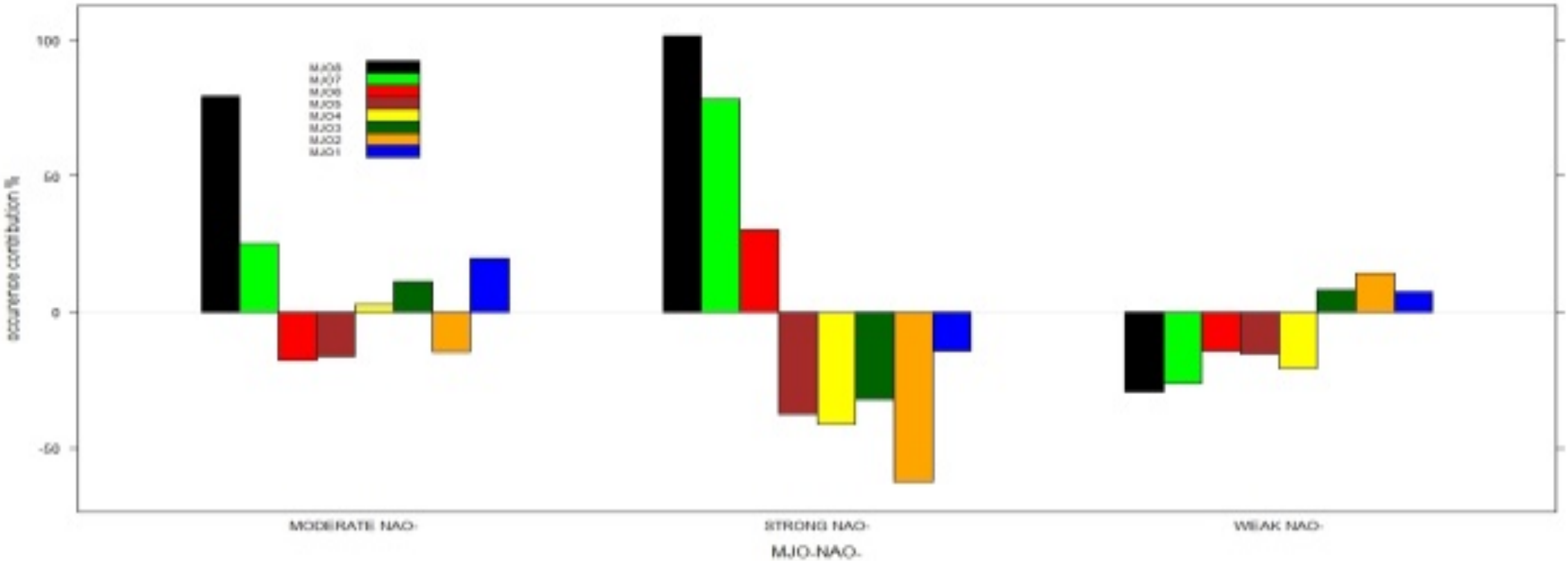
1. Development in situ favored by previous
Blocking conditions as part of the
NAO+ -> S-BL -> NAO- most favored transition path

Response to direct forced Rossby wave initiated
by MJO (Phase 6-7) in the eastern Pacific +
associated enhanced moisture leading to NAO-
after interaction with North Atlantic high frequency
Transients (CWB).

Local development for NAO- regimes

Data and Methodology

- MJO index, Wheeler and Hendon 2004 http://www.bom.gov.au
- NAO index: http://www.cpc.noaa.gov
- MOI index: https://crudata.uea.ac.uk/cru/data/moi
- Rain gauges : Weather stations Tangier and Agadir
- Period: Winter (DJF) 1985-2014
- For each MJO phase the number of days in which weekly rainfall was above the upper tercile (67^{th} percentile) is counted and divided by the total number of days in each phase to obtain the occurrence probability of exceeding the threshold



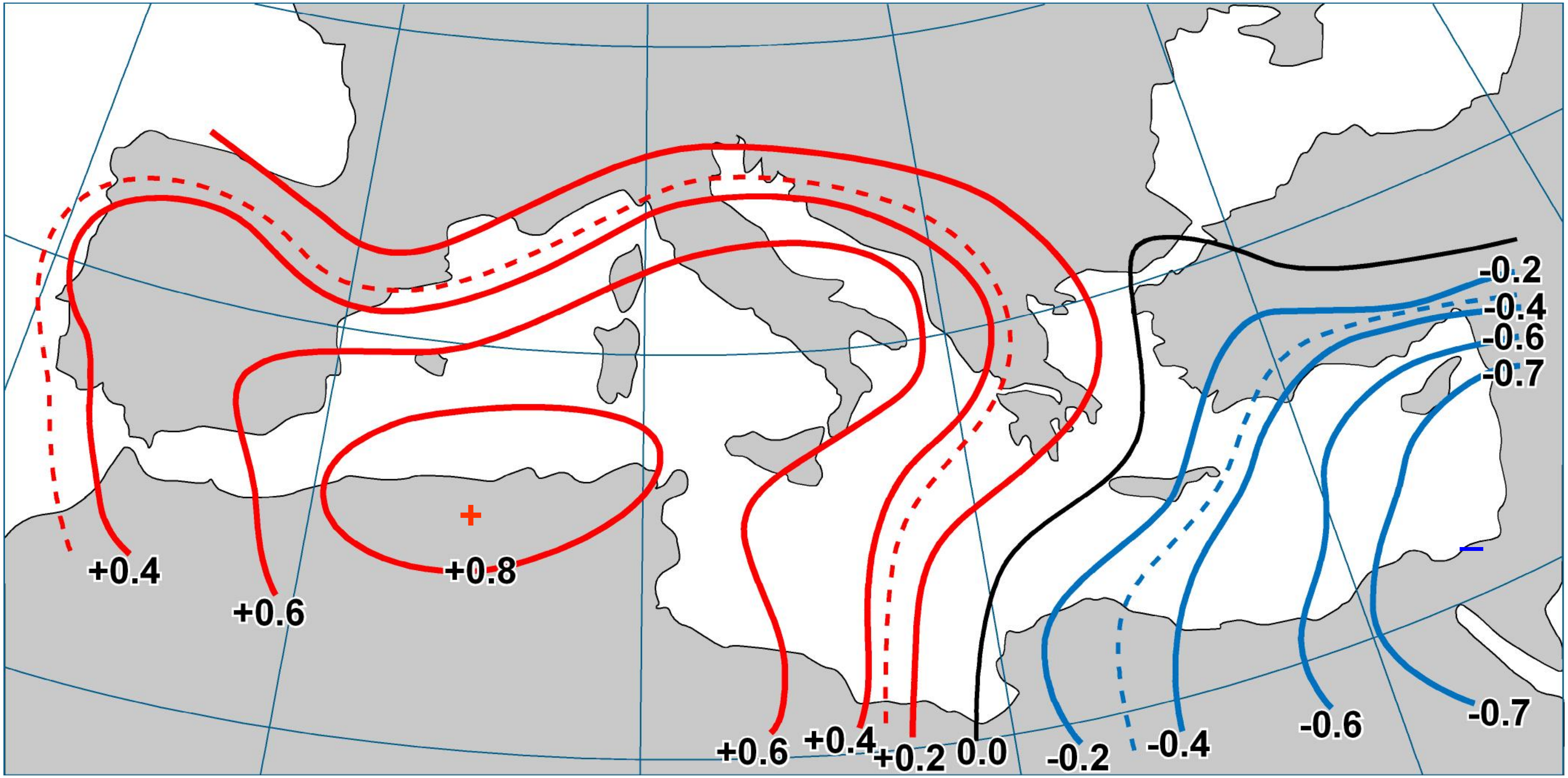
%100 value means that the event occurs twice as frequently as its climatological mean

For each MJO phase the number of days in which weekly Weak/Moderate/Strong NAO- was is counted and divided by the total number of days in each phase to obtain the occurrence probability of exceeding the threshold

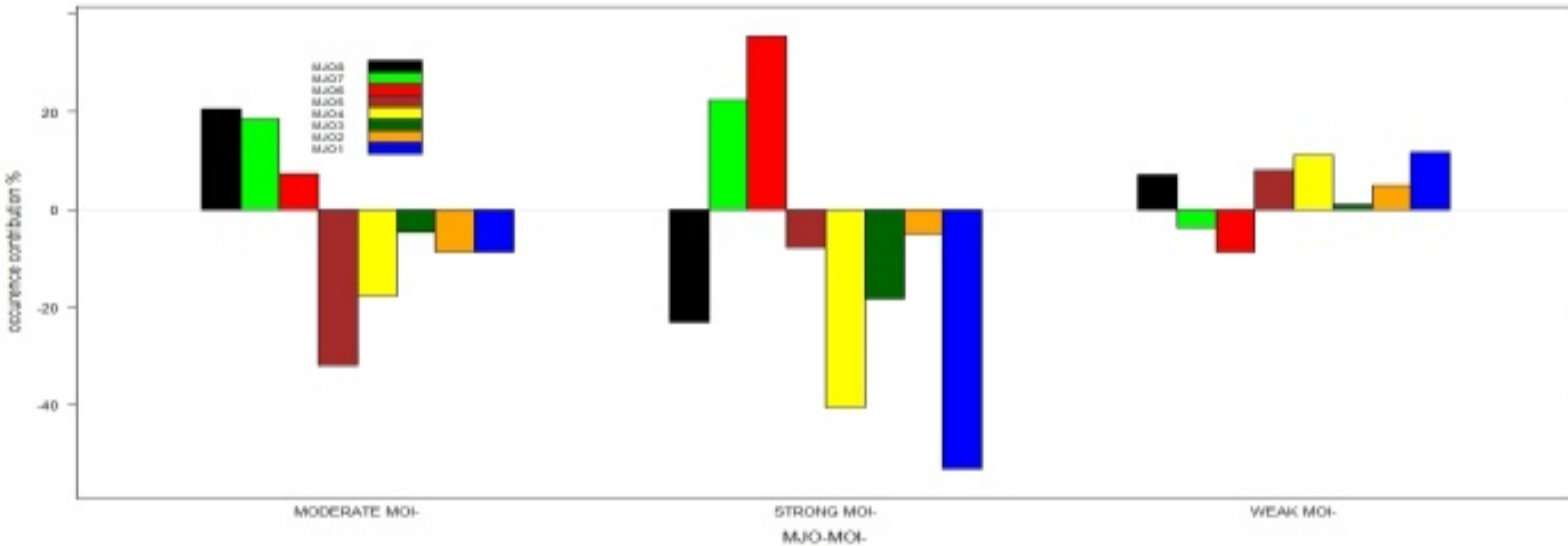
Weak NAO- : NAO- index above the upper tercile
Moderate: NAO- index between the lower and upper tercile
Strong NAO- : NAO- index below the lower tercile

Correlations of the Mediterranean annual mean 500 hPa geopotential heigths with those of Algiers

(inside the dotted lines: statistically significant at the 95% level of confidence)



The MOI is defined by Palutikof et al. (1996) and Conte et al. (1989) as the normalized pressure difference between Algiers (36.4°N, 3.1°E) and Cairo (30.1°N, 31.4°E)



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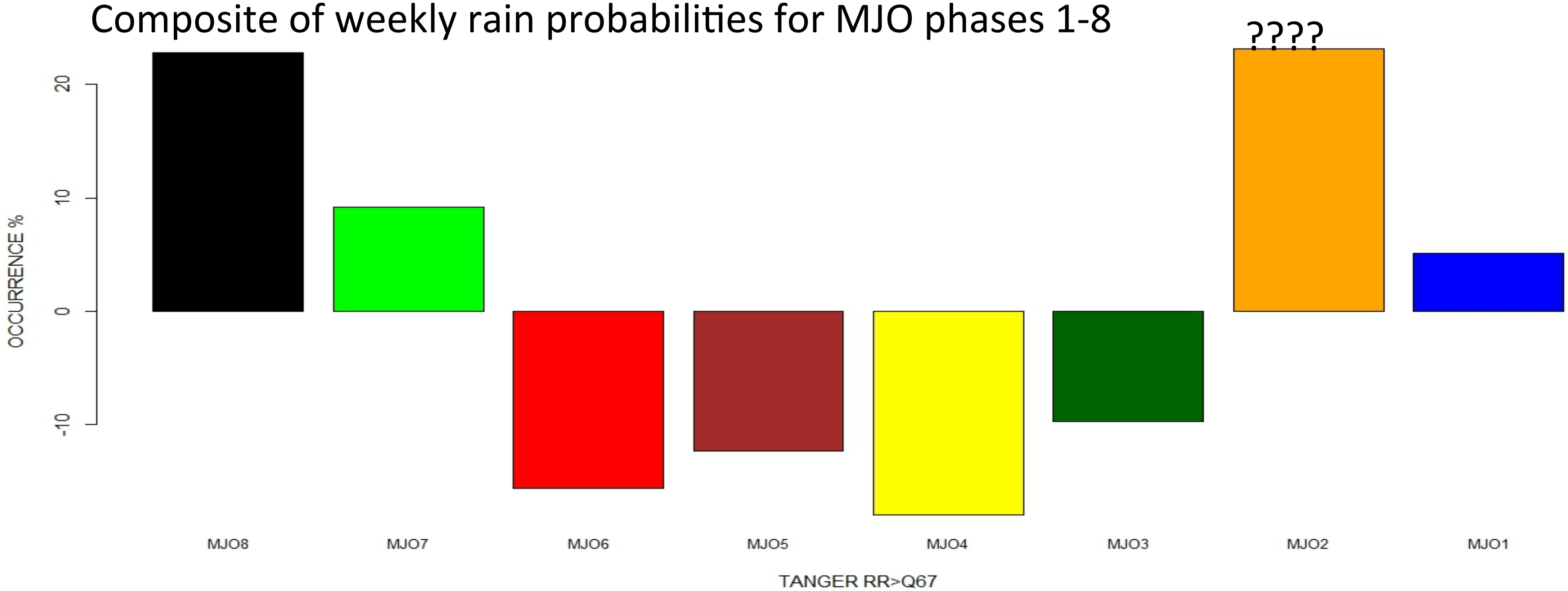
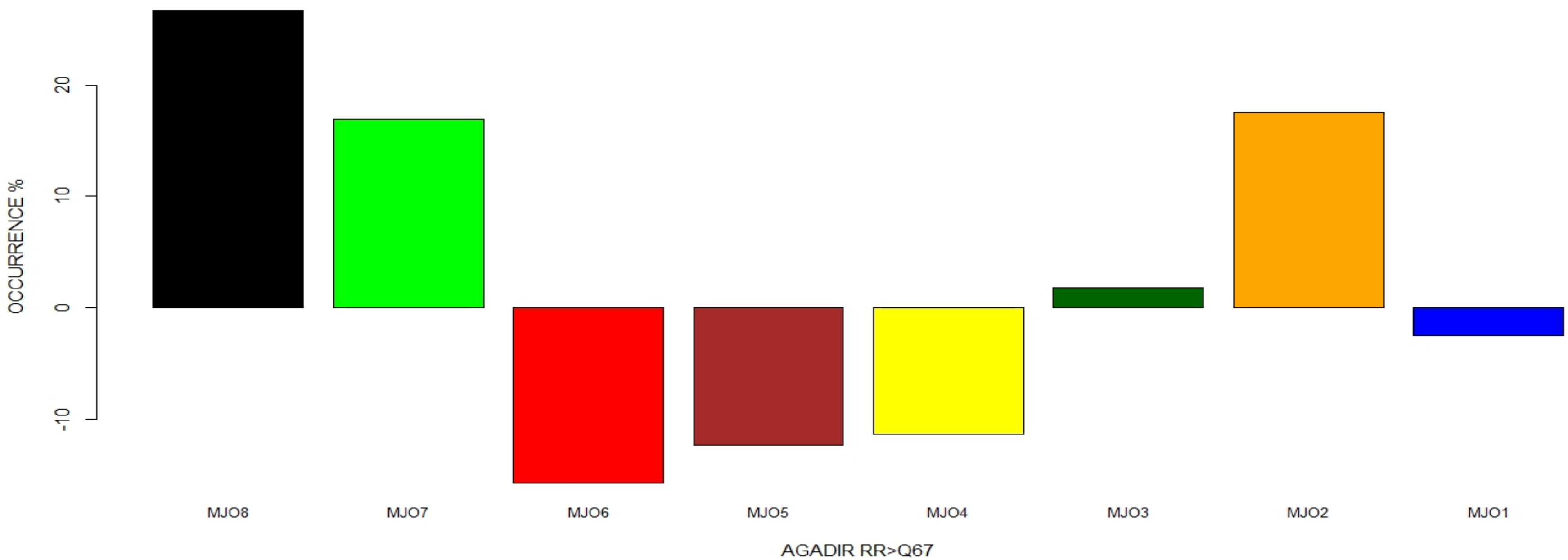
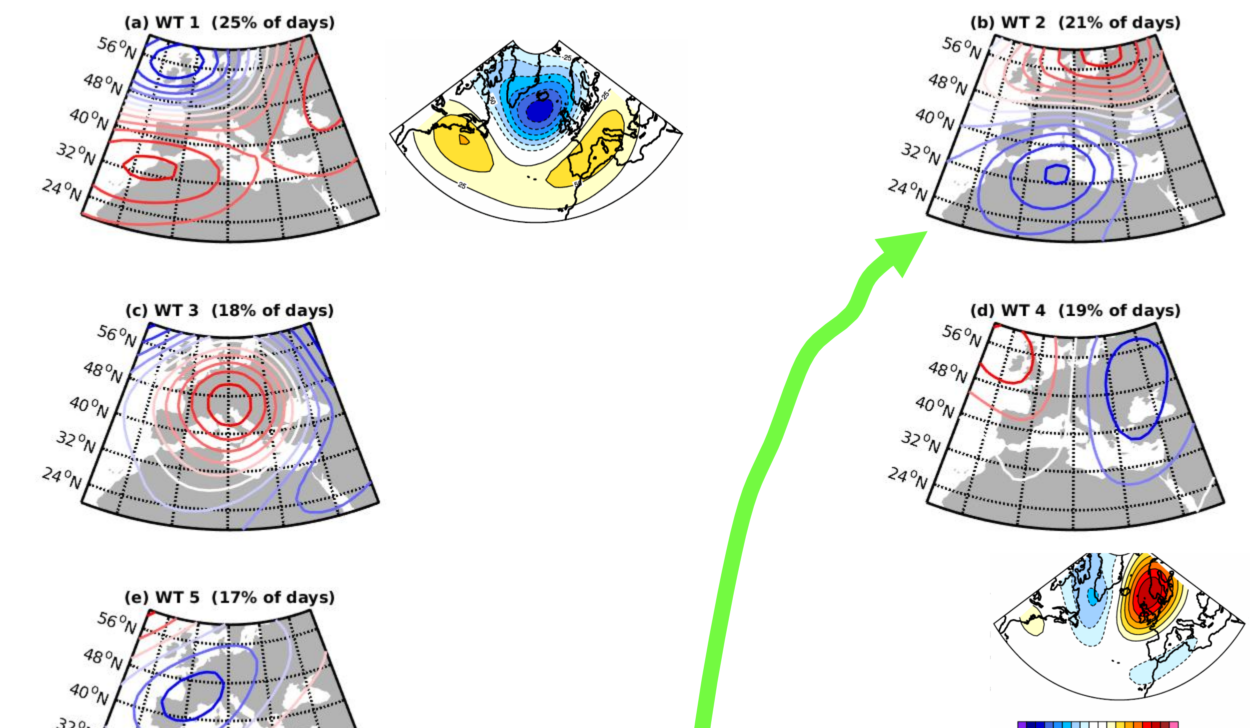
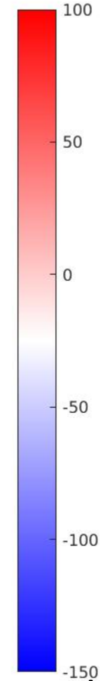
Composite of weekly rain probabilities for MJO phases 1-8



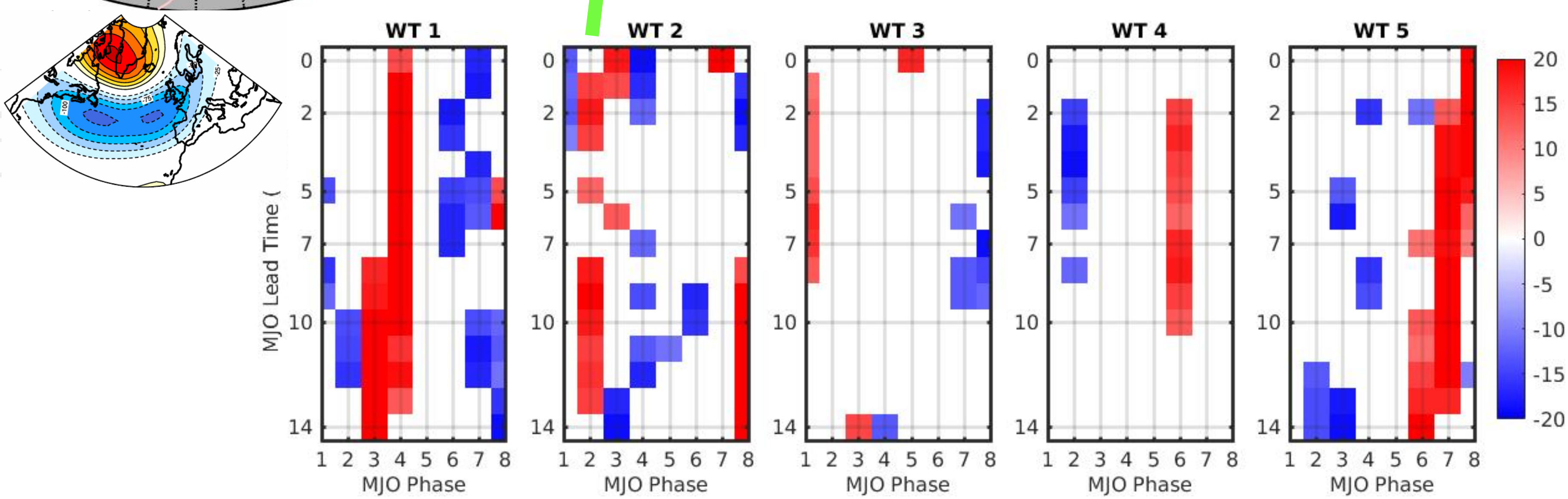
The probabilities refer to the chance of weekly averages rainfall exceeding the upper tercile







Thank you Angel…



Summary

- Similar results as Cassou Nature 2008 and Lin et al. JCLIM, 2009
- A particular weather type over the Euro-Mediterranean region relates to the MJO in phase 2.
- Using more rain gauges data to confirm the relationship between Phase 2 and the Euro-Mediterranean weather types