Multidecadal changes in the relationship of storm frequency over Euro-Mediterranean region and ENSO during boreal winter

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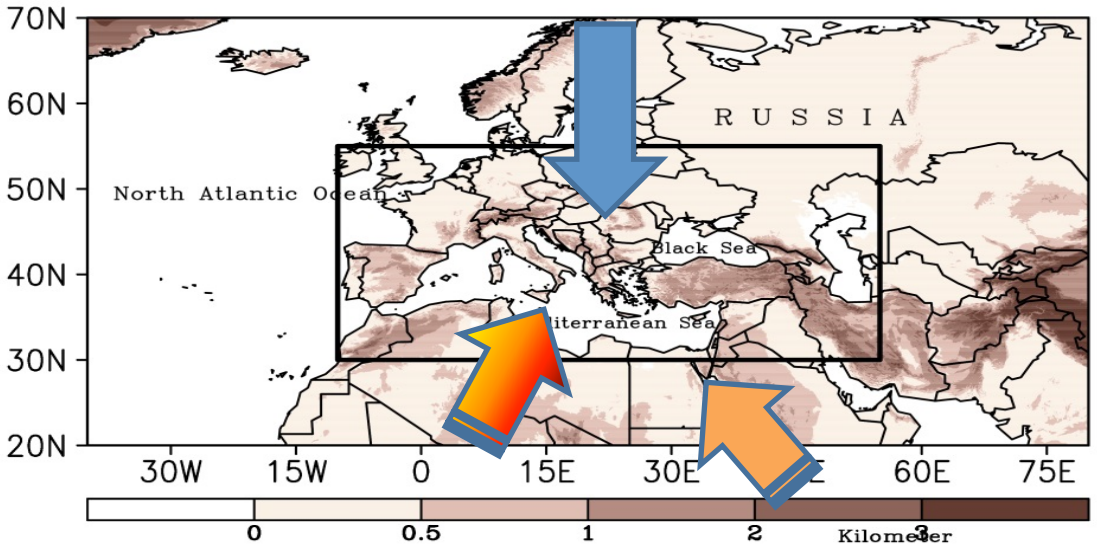
Outline

- **Introduction**
- **Objectives**
- **Experimental Setup**
- **Results and Discussion**
- **Conclusion**

Introduction: Euro-Mediterranean Climatic Characteristic



- Bounded by two different climate regimes
- Mediterranean climate: Mild, rainy winters and hot, dry summers
- Complex orography of the region contribute to the climate system The complex orography of the region sometimes triggers the development of storm centers and they feed on moisture and gain energy from the Mediterranean Sea (Trigo et al. 1999; (Lionello et al. 2006)

Euro-Mediterranean Rainfall Mechanisms

1. **Thermodynamical processes:**

   - Interactions between surface heating and atmosphere

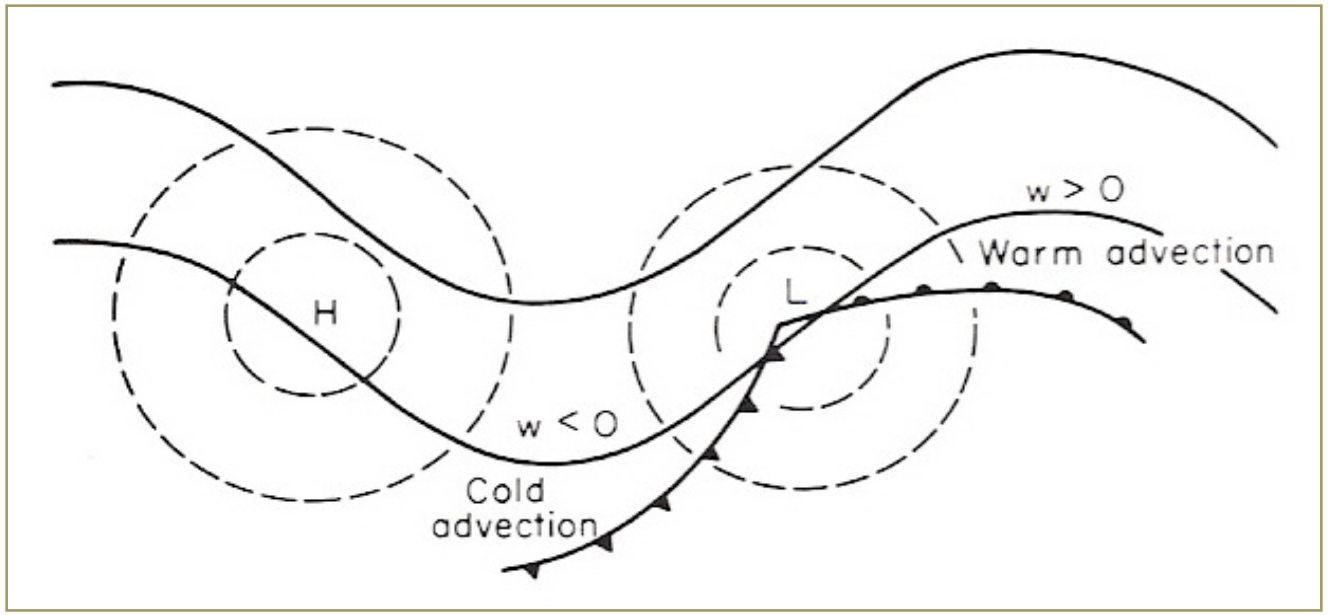
   (e.g., convective processes originating on the warm sea and sudden orographic lifting)

2. **Dynamical Processes:**

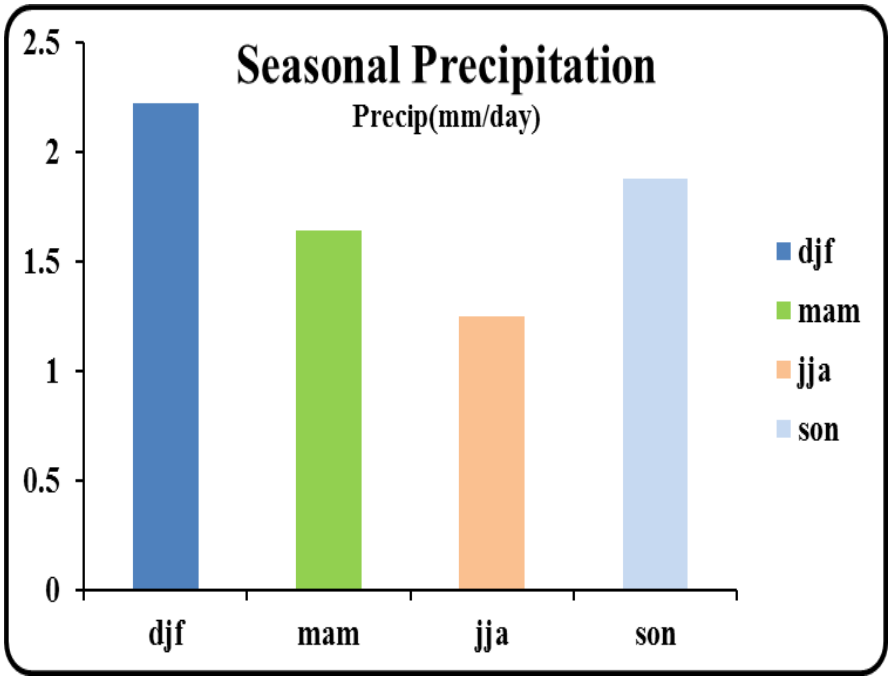
   -The trajectories of westerly lows/troughs

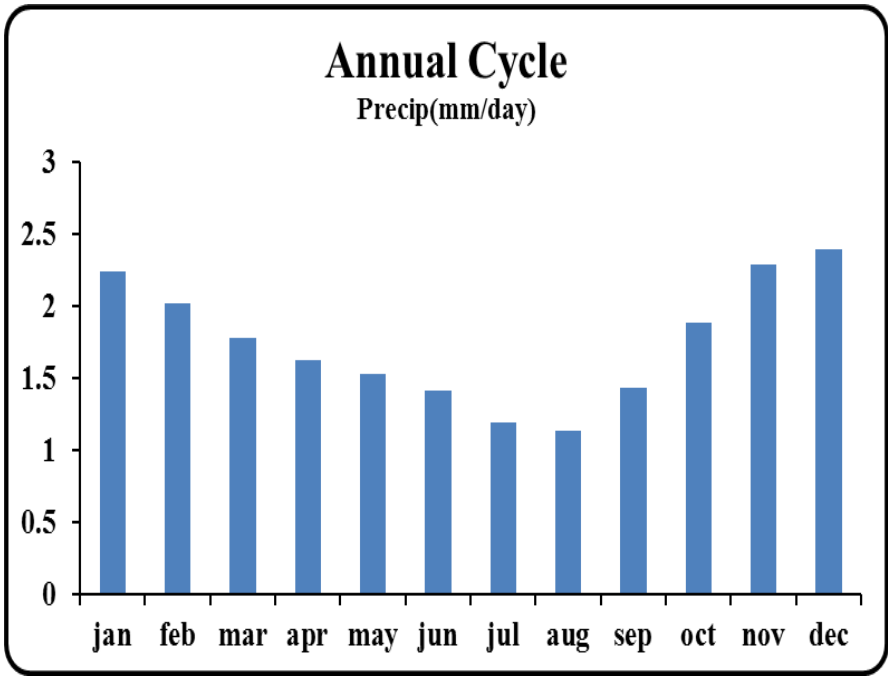
   - Northern Hemisphere circulation patterns

   - The position of Sub-tropical jet



Seasonal and Annual Cycle of Rainfall in the Study Region





Objective: ENSO Relationship

- ENSO has been known to considerably influence the global climate (Nakamura et al. 2004, Bronnimann 2007; Niranjan Kummar et al. 2016)

- Most climate prediction signals for the regional climate arise from the ENSO (Kang et al. 2015)

- Past studies show ENSO Euro-Mediterranean rainfall relationship (e.g., ; Mariotti et al. 2002; Hawcroft et al. 2012)

- Relationship b/w Euro-Mediterranean winter season storm tracks frequency and ENSO?

Experimental Setup

- **Observational datasets**

  - 200-hPa 6-hourly geopotential dataset from NCEP/NCAR with 2.5 x 2.5 degree resolution (1948-2016)

  - The monthly mean of Global SST data (COBE-SST) with 1.0 x 1.0 degree resolution from NOAA (1891-2016) (Ishii et al. 2005)

  - Global Precipitation Climatology Product (GPCP) is used as an observed rainfall dataset for the period 1979-2016

Methodology

- MS scheme is used to track the Euro-Mediterranean storm centers at 200-hPa geopotential height (Murray and Simmonds, 1991(a,b)
- Scheme uses relationship between geostrophic vorticity and and geopotential height to identify the storm centers

$$\zeta_g \equiv \frac{\partial v_g}{\partial x} - \frac{\partial u_g}{\partial y} = \frac{1}{f}\left(\frac{\partial^2 \Phi}{\partial x^2} + \frac{\partial^2 \Phi}{\partial y^2}\right)$$

- Positive values of the Laplacian of the geopotential height indicates the intensity of the storm centers

Case Study (23-30th Jan, 2009)

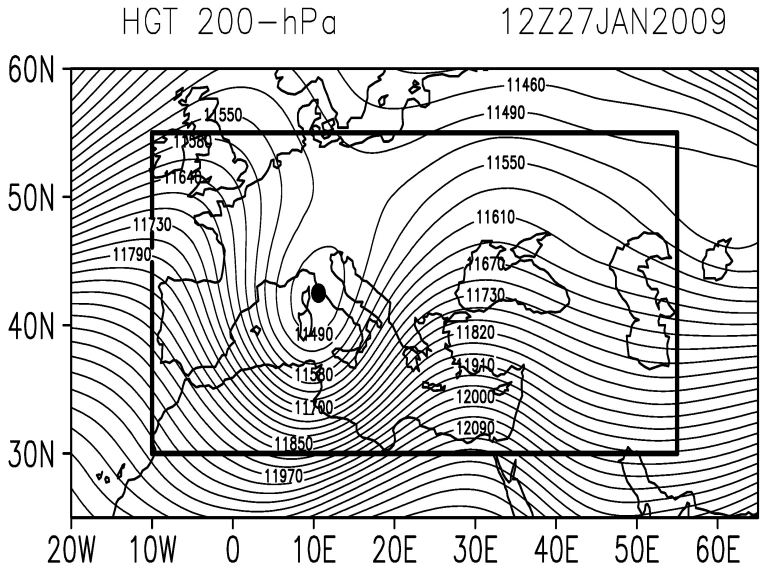
- 26 people died in France and Spain as a direct consequence of **storm Klaus.**
- Approx. 1.7 million homes suffered power cuts, trees and power lines were brought down
- Significant dislocation to all forms of transport with road and rail links blocked
- The most costly event of 2009 with over US$6 billion in losses
- Heavy rainfall/Flashfloods are reported in central and eastern parts of Euro-Mediterranean region.

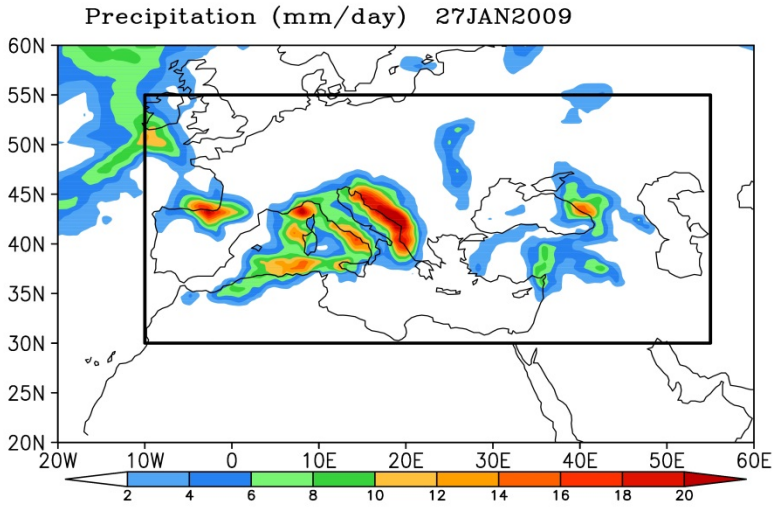
(Photograph courtesy of Pablo Herrero Isasi)

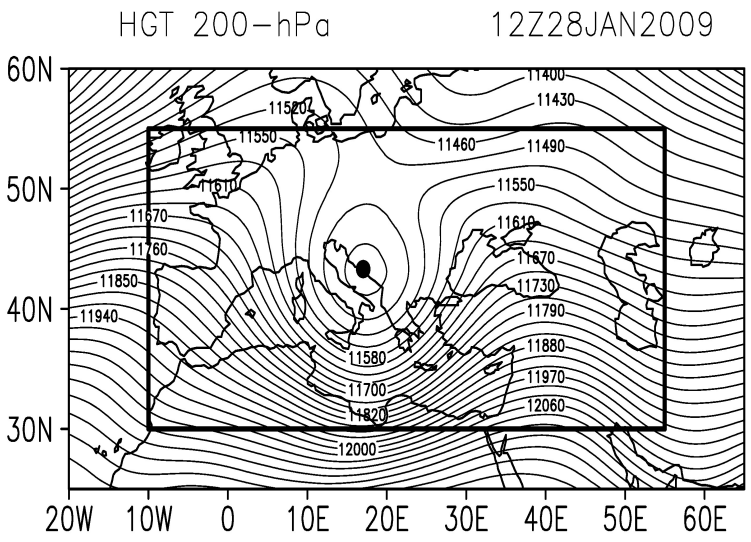
(Source: Liberato et al. 2011)

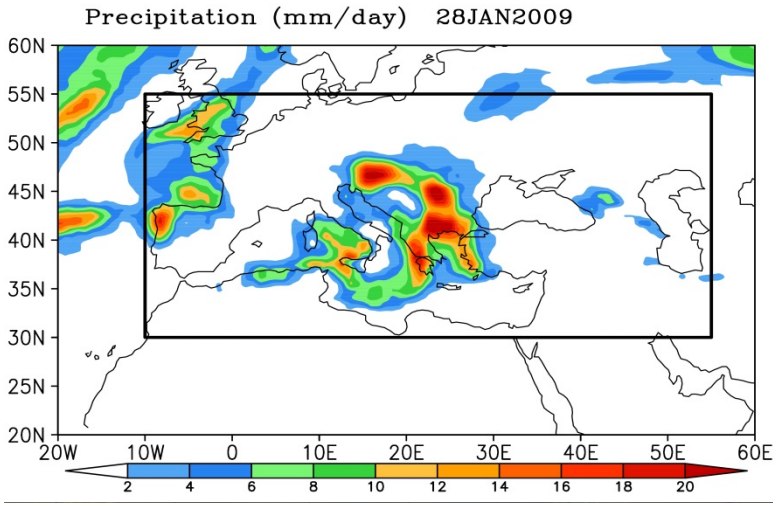
- Liberato MLR, Pinto JG, Trigo IF, Trigo RM (2011) Klaus an exceptional winter storm over northern Iberia and southern France. Wea 66:330–334. doi:10.1002/wea.755

Case sensitivity test of Mediterranean Storm Klaus Jan, 2009



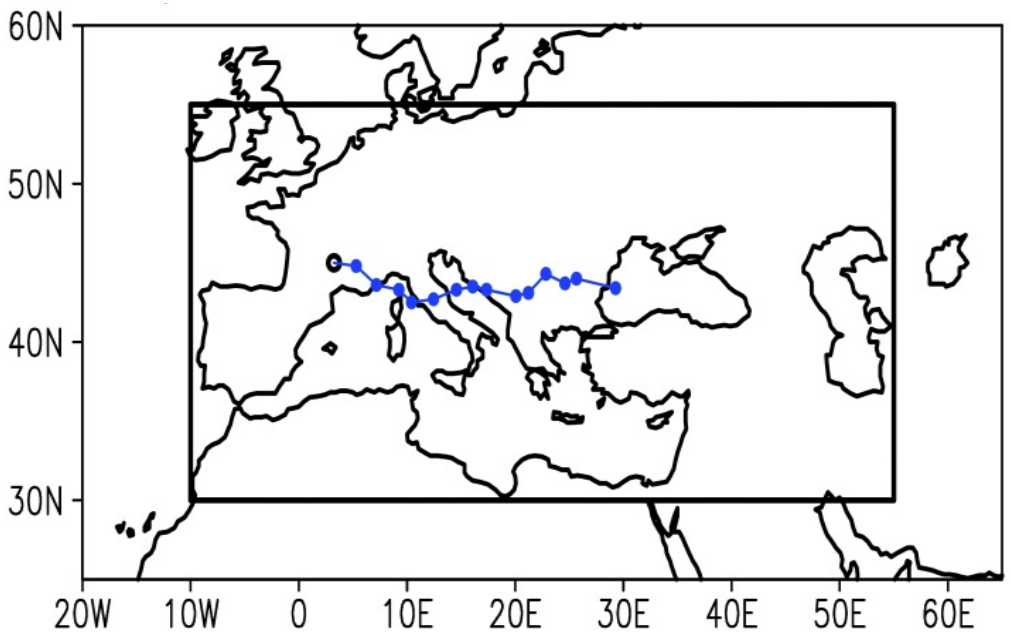






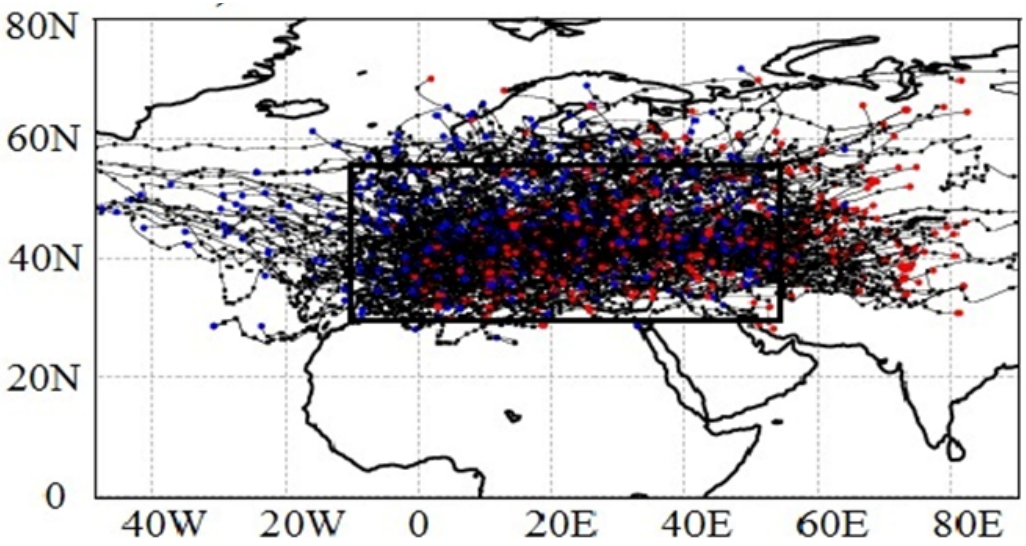
Euro-Mediterranean Storms

- Trajectory of Storm Tracks Klaus-II
- (26-30) Jan 2009
- Gensis region: Gulf of Genova
- Lysis region : Black Sea

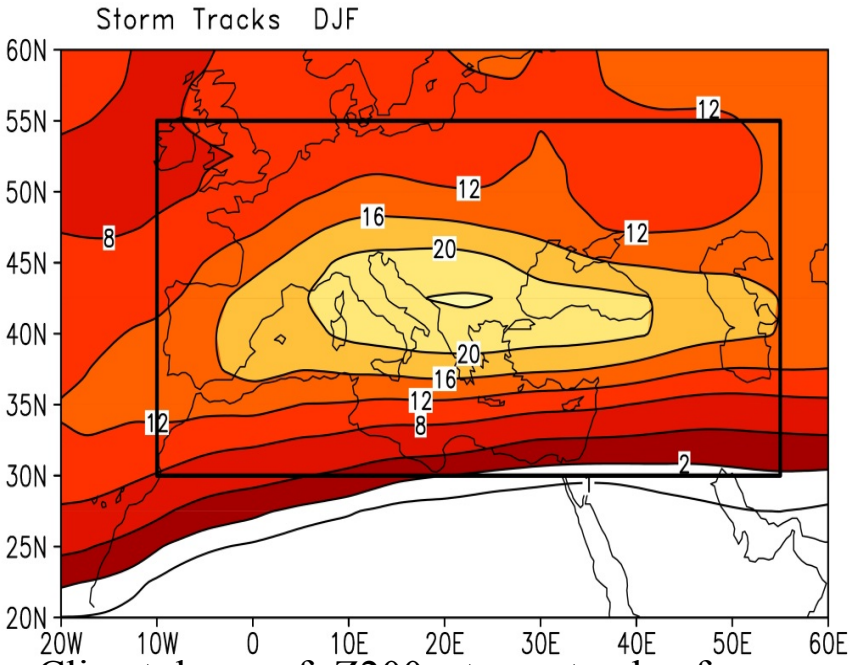


- Subset (2000-2010) of winter season storm tracks passing through the study domain

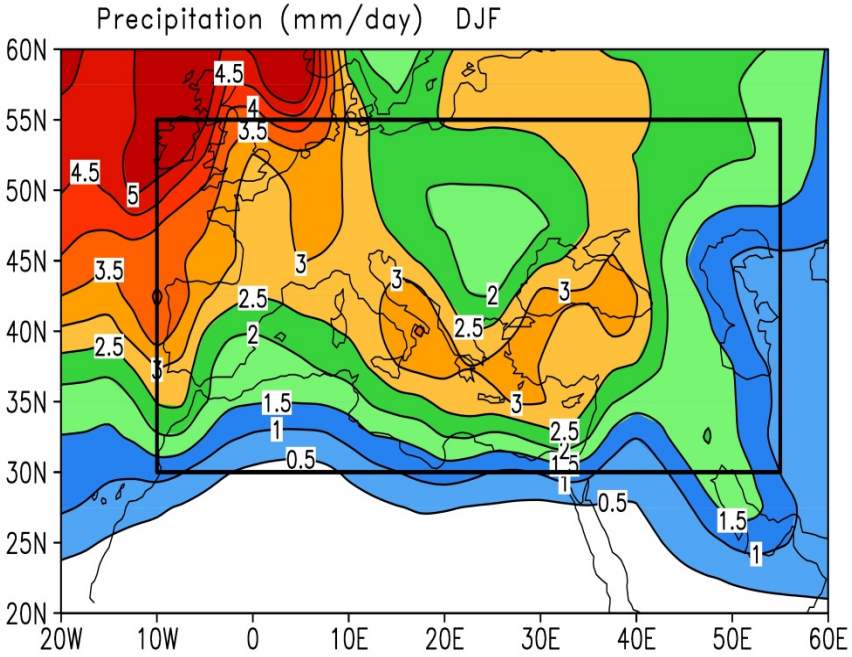
- Solid blue dots show genesis while Red dots represent lysis of the storm track centres.



Euro-Mediterranean Climatology DJF



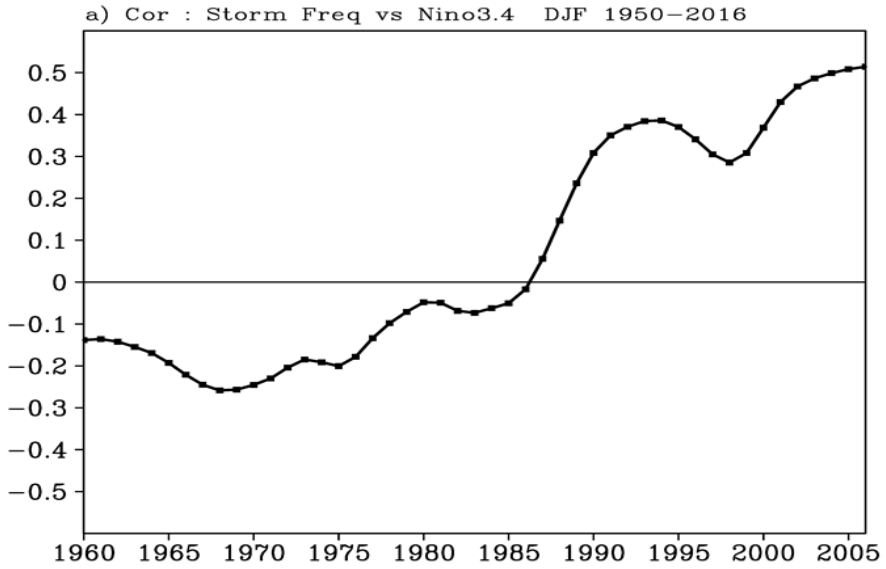
Climatology of Z200 storm tracks frequency (number of tracks per (deg.lat.)² per winter season)

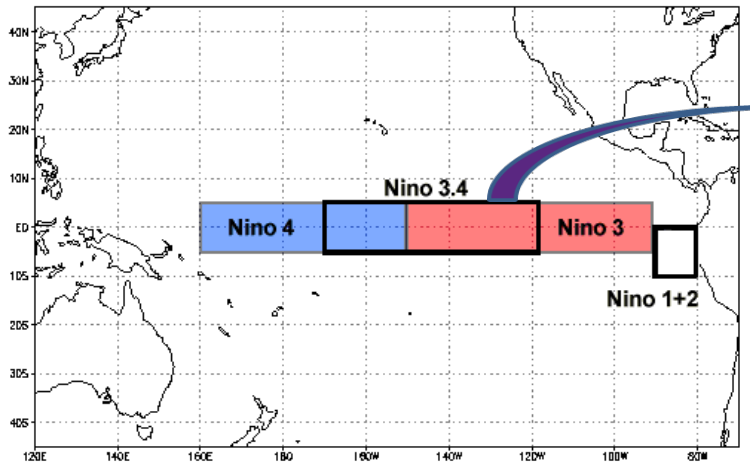


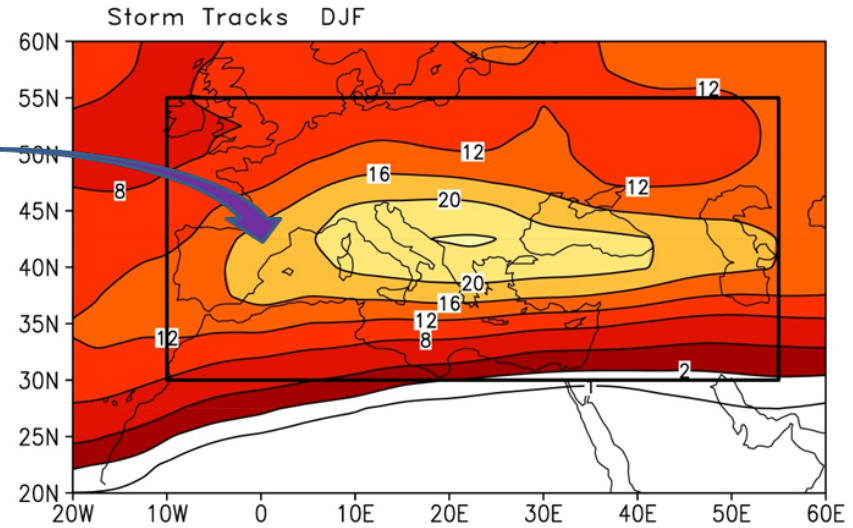
Climatology of winter season precipitation (Units: mm/day)

Euro-Mediterranean storm tracks frequency and ENSO relationship

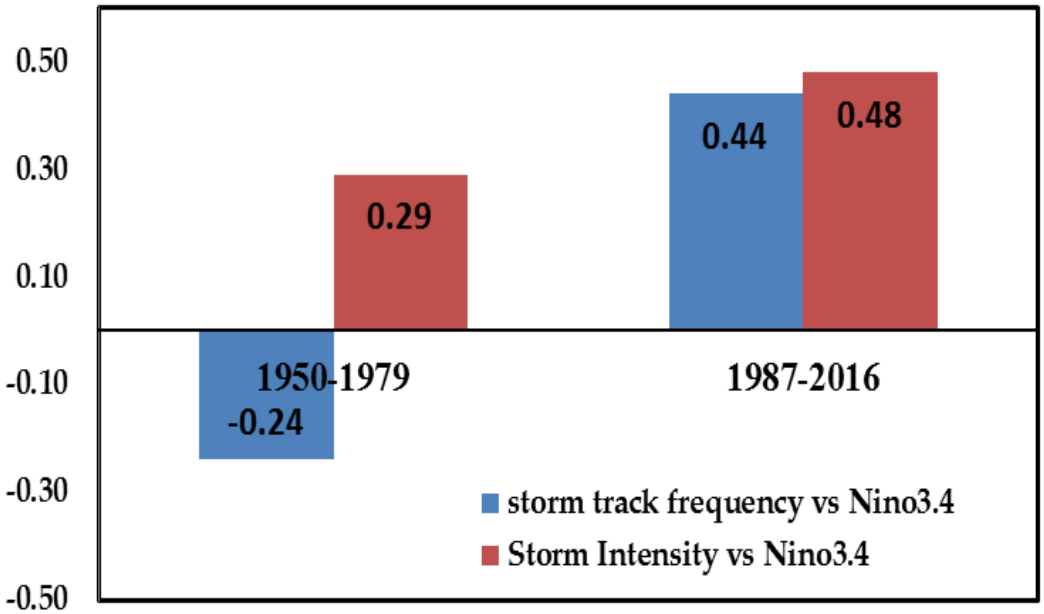
- Twenty-one year sliding correlation period (1950 to 2016).

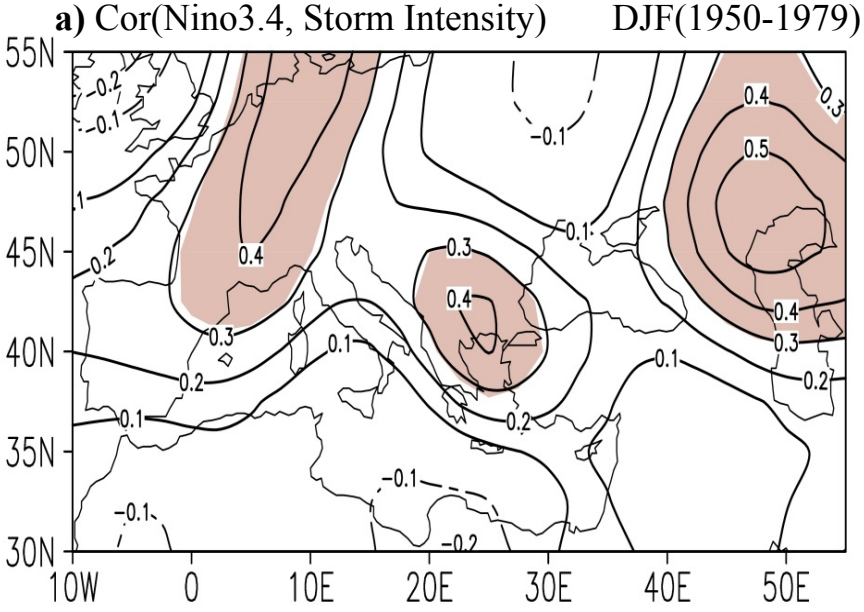


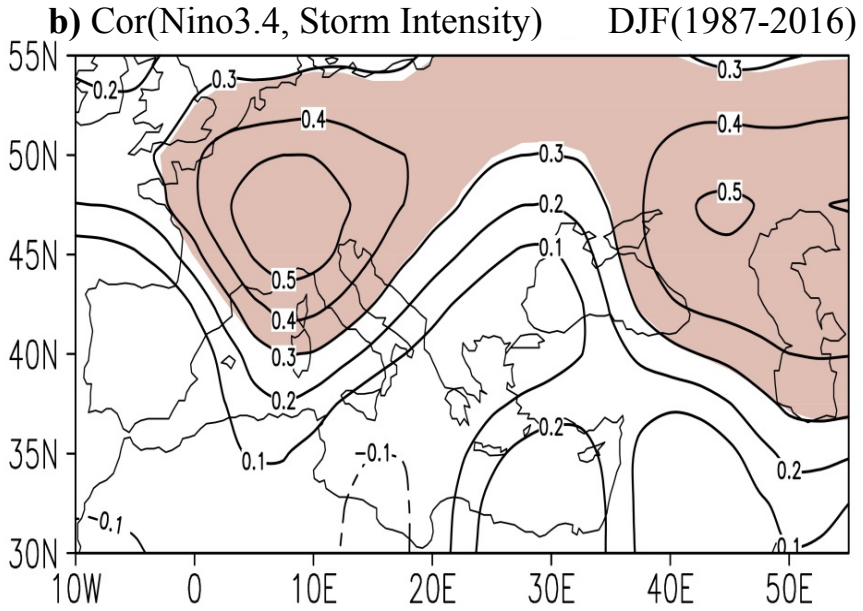




ENSO Relationship with seasonal storm intensities

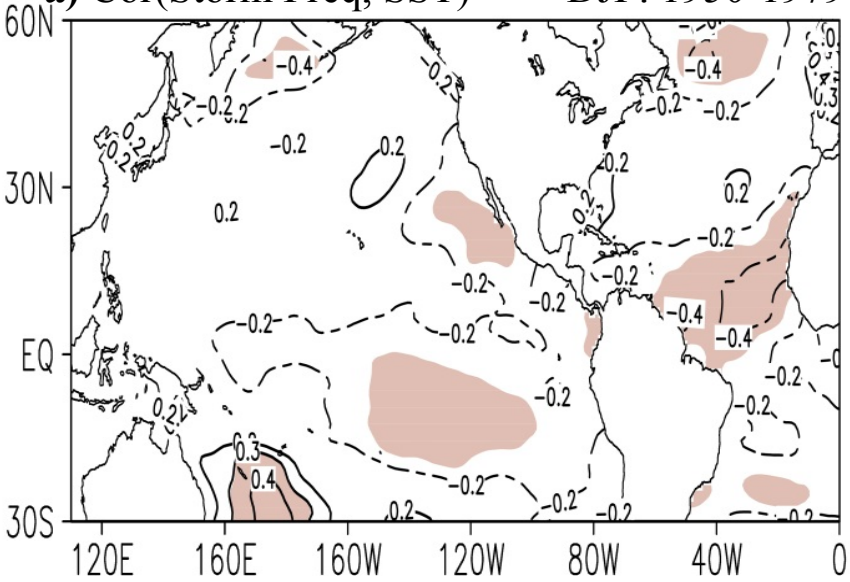




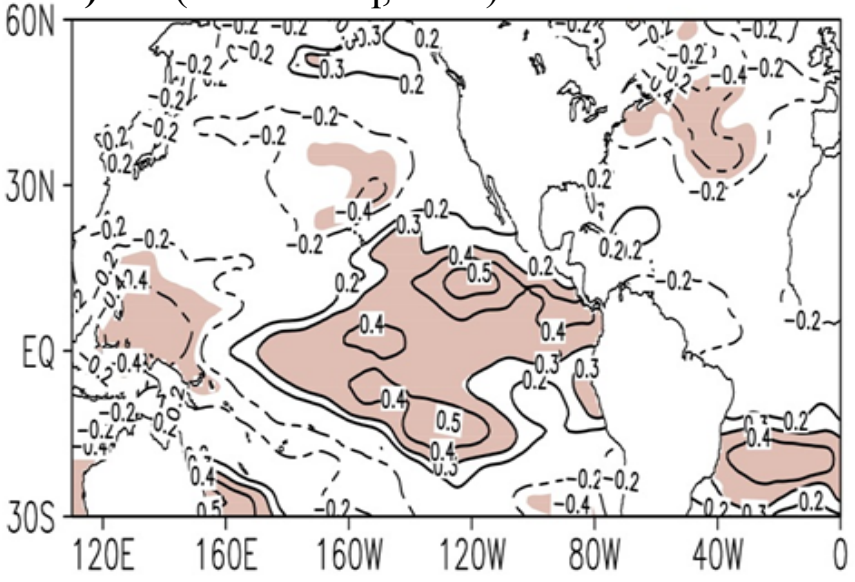


Euro-Mediterranean Storm activity and Global SST Correlation

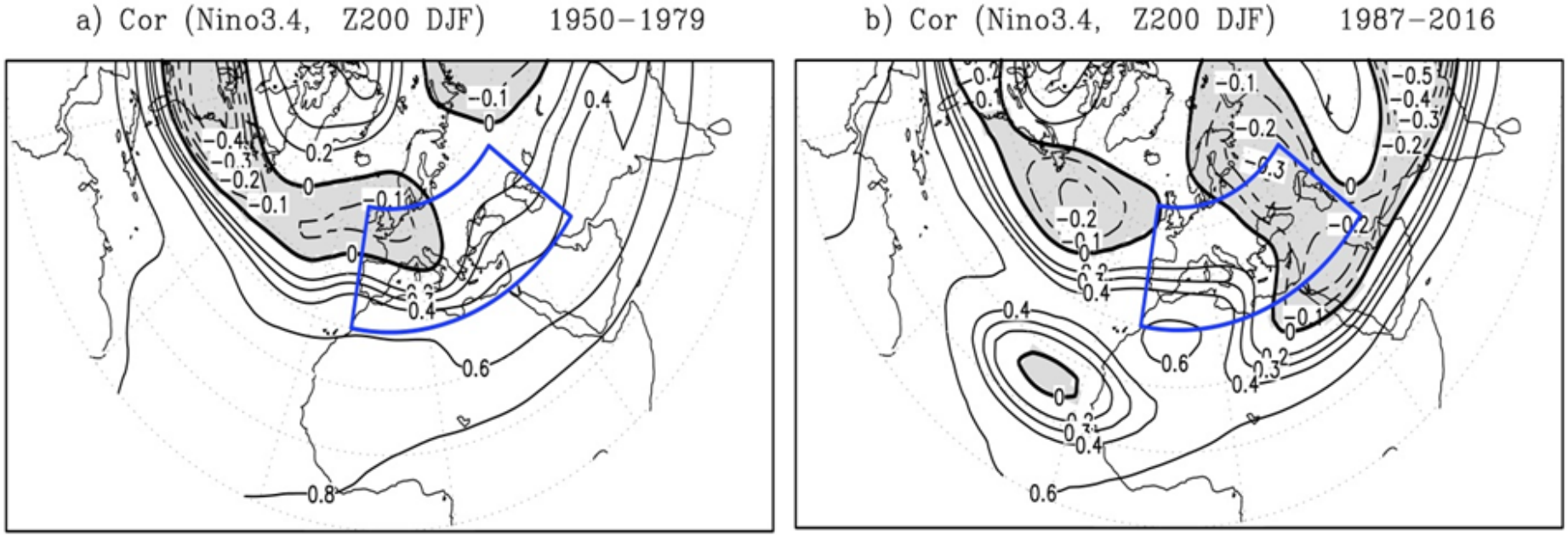
a) Cor(Storm Freq, SST) DJF: 1950-1979



b) Cor(Storm Freq, SST) DJF: 1987-2016

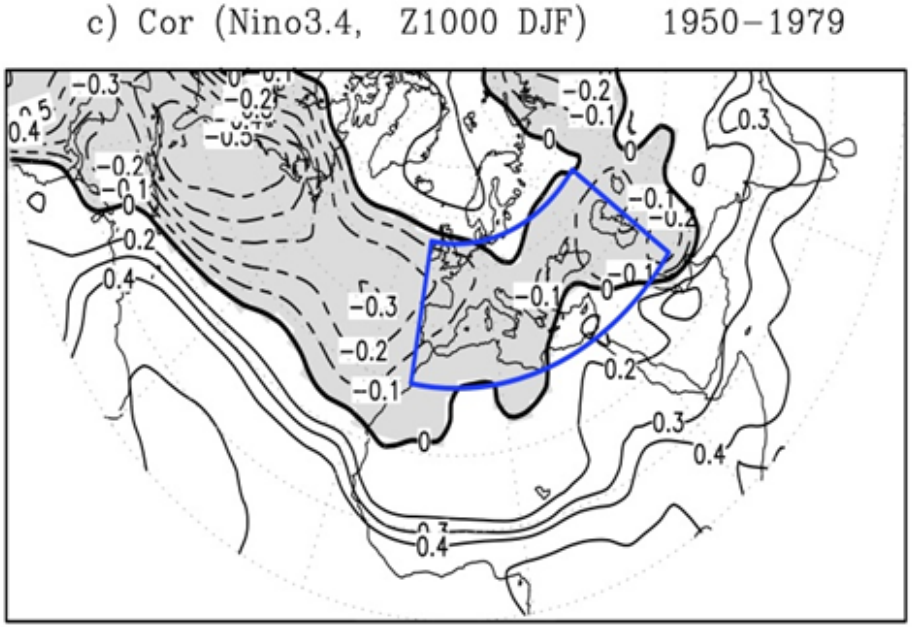


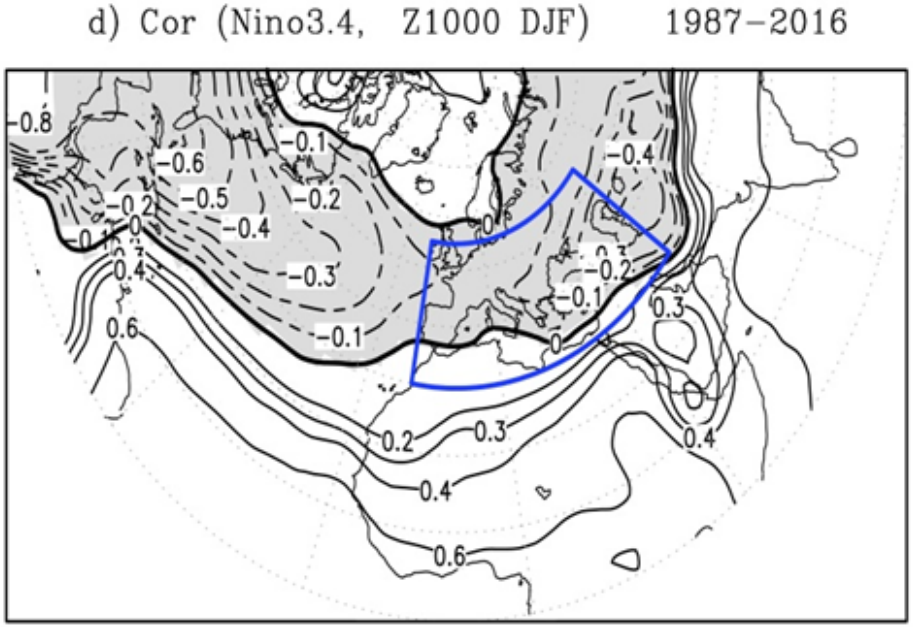
ENSO Relationship with upper level Circulation



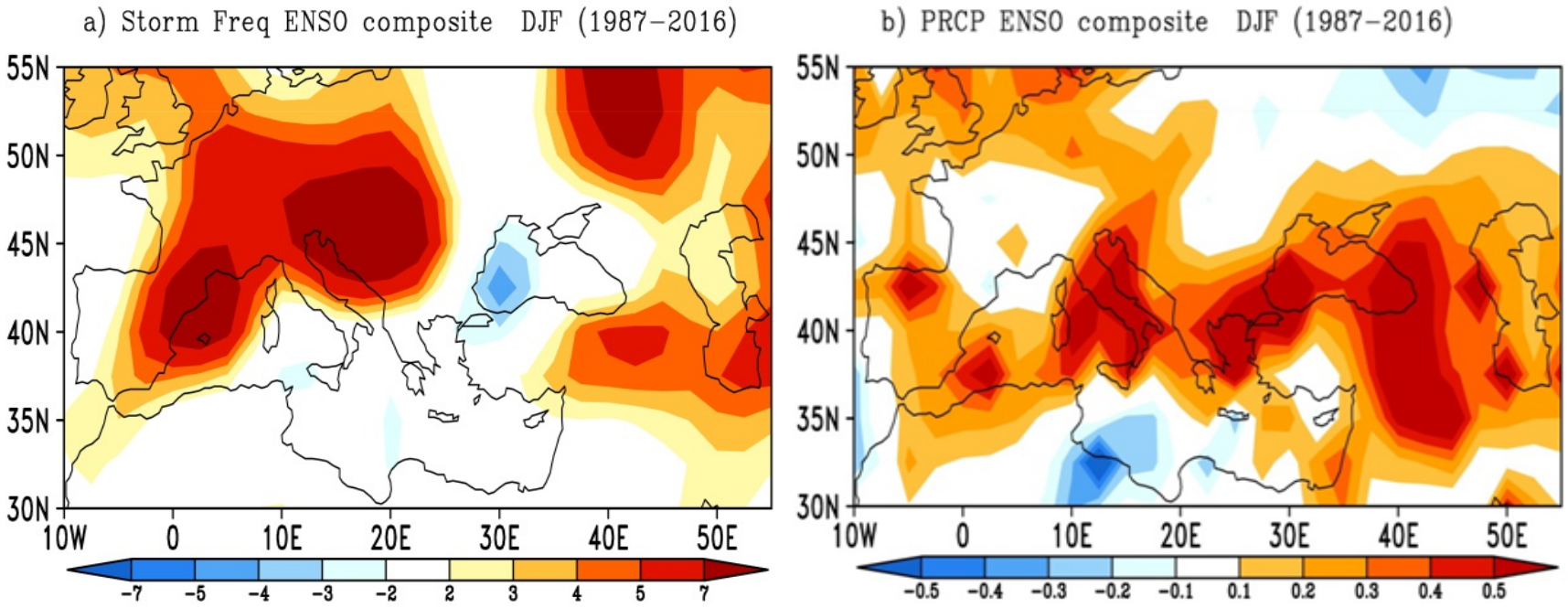
Anomalous warming in central and eastern Pacific Ocean during ENSO events causes an **equatorward shift of subtropical jet stream** from its mean position, and hence changing the position of low and high pressure systems along Rossby waves connected with the jet stream (Straus and Shukla 1997; Wang 2002)

ENSO Relationship with lower troposphere

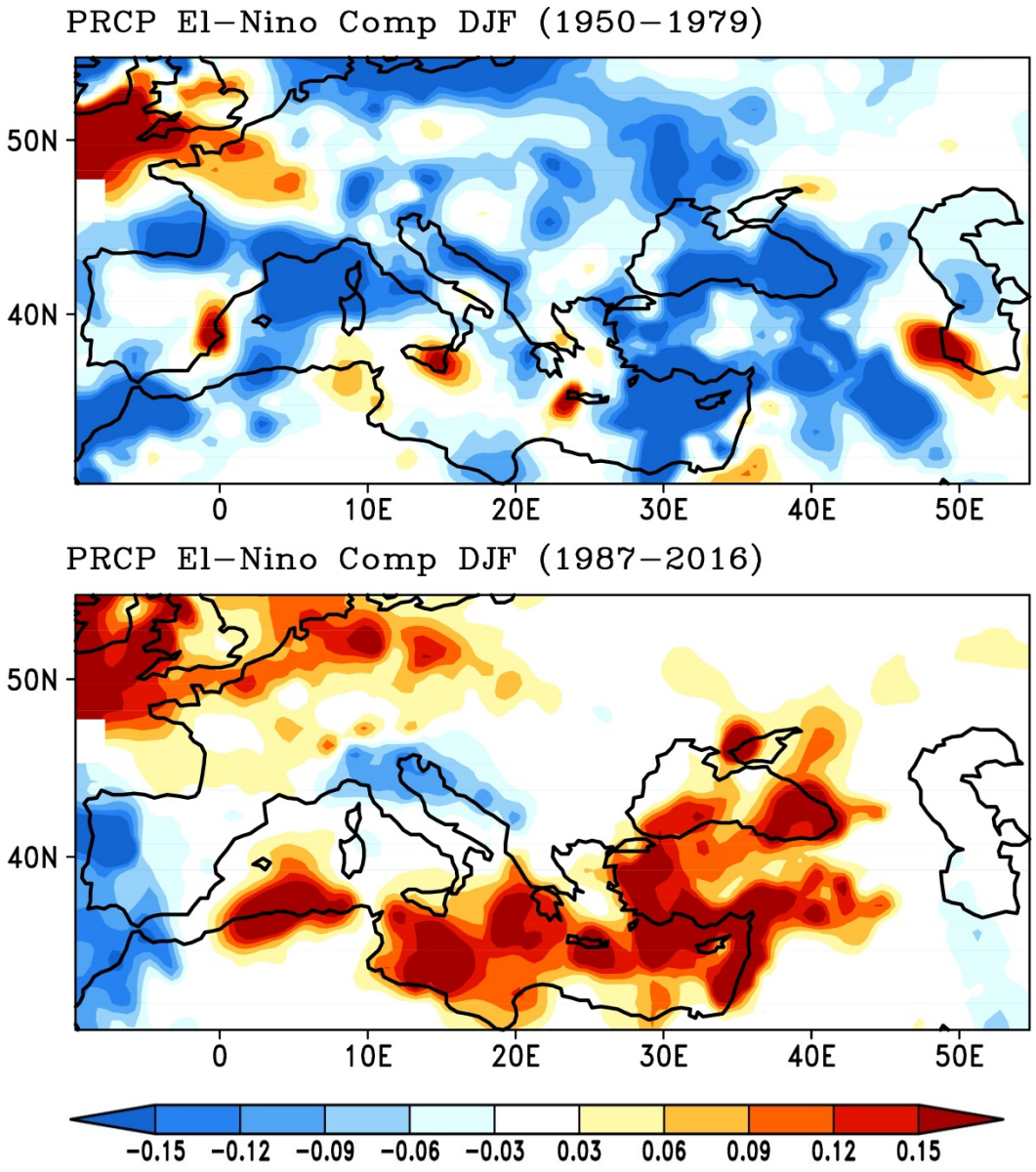




ENSO Composites



El-Nino Composites DJF



Summary and Conclusions

- The multidecadal changes show a phase shift in the relationship between storm track frequency and ENSO
- The ENSO associated significant changes are noted in the upper and lower troposphere in the recent period with respect to the earlier period
- These changes may largely influencing the storm frequency/ intensity which consequently affects the precipitation anomalies over the Euro-Mediterranean region
- These findings can have important implications in Euro-Mediterranean seasonal predictability

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ORIGINAL ARTICLE

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Questions??