Dust transfer through Mediterranean cyclones: relative contribution to aerosol climatology

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Abstract

One of the major cyclogenetic areas in the Mediterranean region is located over the north west African continent, at the proximity of the Atlas mountain. While cyclogenesis takes place over this area, heavy dust loads are uptaken due to the strong winds and are transferred over the Mediterranean basin. In many case studies, dust is observed to be trapped within the cyclones' mesoscale vortex and to be transferred in long distances along the cyclone tracks. In parallel, deep convection and clouds formation may be developed close to the cyclones core and over the frontal areas. The interaction between clouds and dust in the Mediterranean is a complex issue and still an open question, especially as related with cyclones. Furthermore, little is known on the cyclones contribution to the annual dust concentrations transferred over the Mediterranean region, as also to the seasonal and spatial dependency of cyclones that induce dust transfer over the basin.

To address the above questions in the frame of BEYOND project, in this study we perform tracking of all cyclones for the period 2005-2012 using the ERA-Interim reanalyses, at a resolution of 0.75°x0.75°. Cyclone tracks are then compared and associated with daily satellite estimations of the Aerosol Optical Depth, the UV aerosol index, the aerosol Angstrom exponent, the daily rain rates and lightning impacts to diagnose deep convection areas. The analysis is performed through enclosed contour techniques permitting us to investigate the cyclones relative contribution, to the annual dust load over the Mediterranean basin and to analyze the statistical relation between dust and rainfall at the proximity of cyclonic circulations.

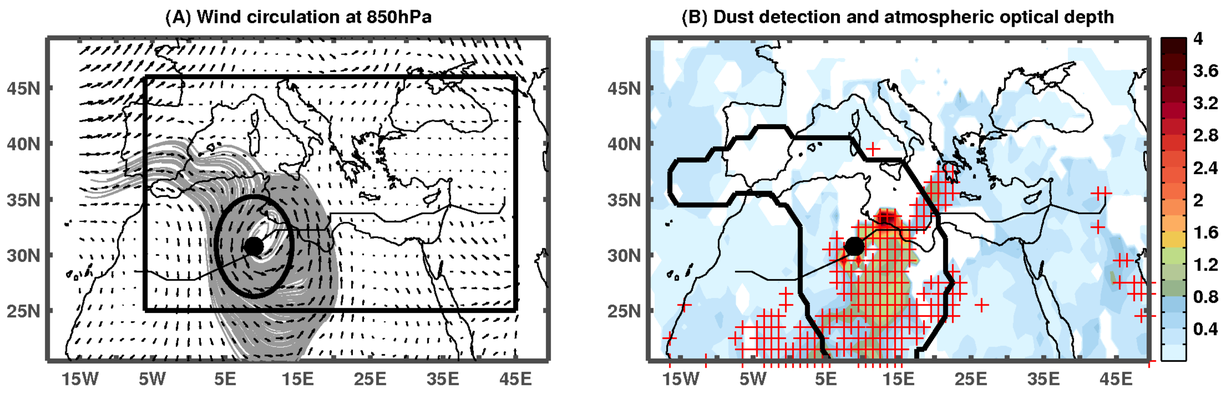
1 Methodology

1) Observations: Aerosol Optical Depth (AOD), UV index (UV) and Angstrom exponent (AEX)

2) Dust events correspond to grid points with UV>1 and AEX<0.7

3) AOD determines intenisity of dust event

4) Cyclones are tracked in ERA-Interim, for the period 2005-2012, and are associated with dust transfer . Figure offers an example of the methodology (cyclone case of 24 February 2007)

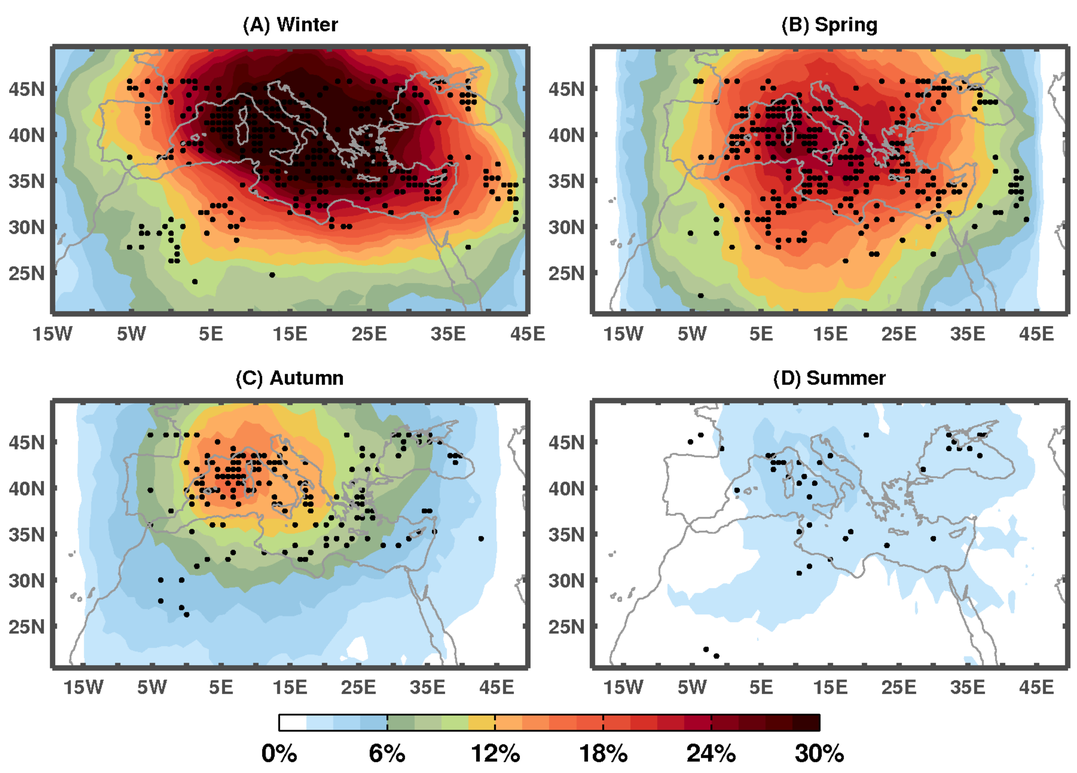


Left.. Wind circulation at 850hPa (arrows), streamlines ending within 500km radius around the cyclone center (black circle). Rectangle depicts cyclones tracking area.

Right. Dust episode intensity (AOD; in colorbar), cyclone streamlines affecting area (black contour) and grid points with dust load (red crosses). The cyclone-associated dust transfer correspond to the crosses within the contour.

2 Cyclones affecting areas

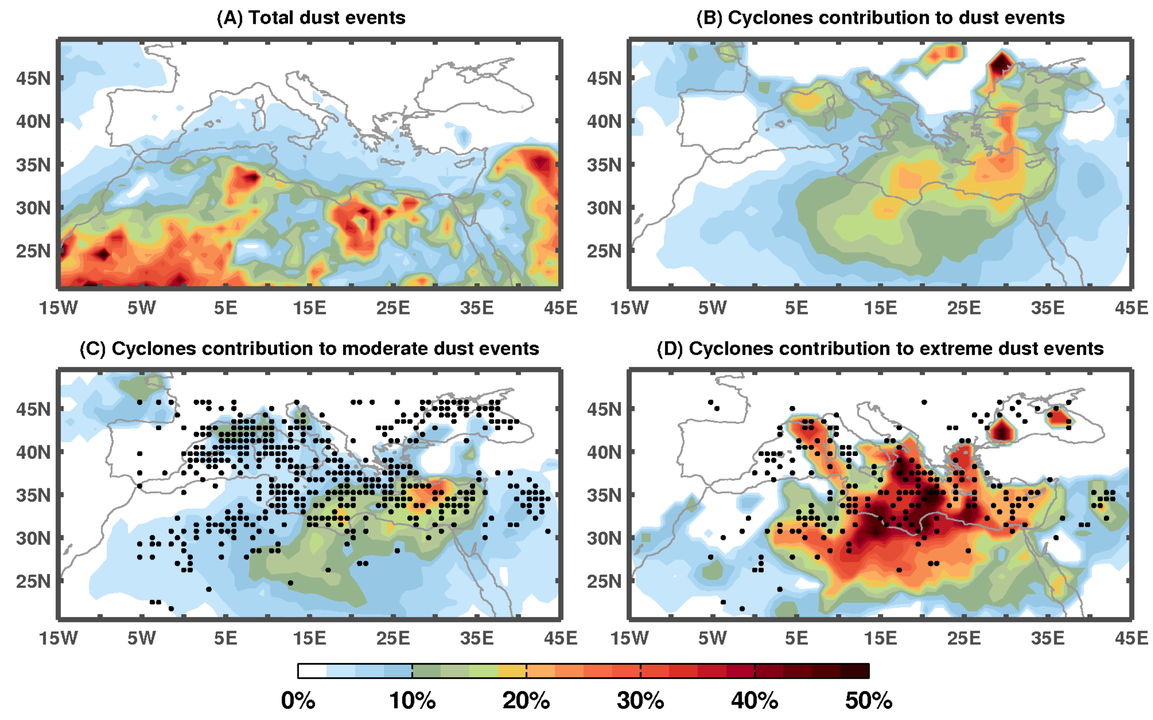
780 intense cyclones detected (relative vorticity >$8x10^{-5}$ s^{-1}). Cyclones mainly affect central and western Mediterranean



Frequency of cyclones circulation affecting areas per season (colorbar). All detected cyclones mature stage location (black dots).

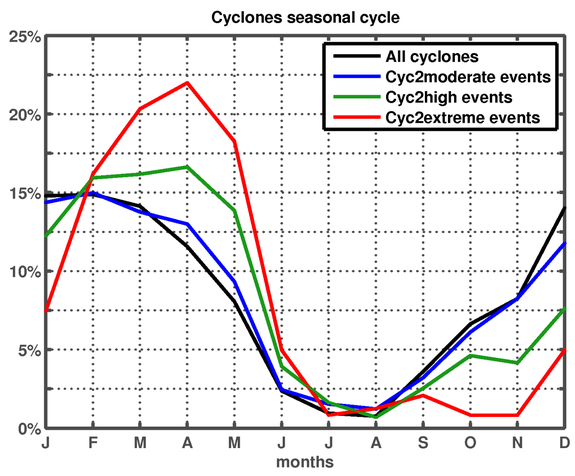
3 Cyclones contribution to dust events in the Mediterranean

All 780 cyclone circulations have been associated with the total of dust episodes over the Mediterranean, separated in moderate and extreme events



A. The frequency of dust events in the region during the whole 8-year period. **B**. Percentage of all dust events associated with cyclones. **C**. Cyclones contribution to moderate dust events, defined as 25th to 75th quantile of AOD of each grid point when dust is detected. **D**. Cyclones contribution to extreme dust events, defined by the 95th quantile of AOD at each grid point when dust is detected. Dots correspond to the cyclones location provoking moderate and extreme dust events.

4 Conclusion



Seasonal cycle of all detected cyclones, cyclones provoking moderate, high and extreme dust events over the Mediterranean.

- Our results showed that cyclones are strongly associated with dust events over the Mediterranean region. Indeed, the strong, high speed atmospheric circulations transfer Saharan dust, provoking at least half of the dust events over the central and eastern Mediterranean.

- Section 3 shows that intense cyclones tend to contribute more to extreme dust events than to moderate dust events, suggesting their high special weight on dust climatology over the region.

- While cyclones climatology is clearly associated with distinctive low activity during summer and high activity during winter, the Figure in the left shows that cyclones forming extreme dust events take place mainly during Spring mainly affecting northern Africa.

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