Variability of compound extreme events in the Euro-Atlantic region and its association to extratropical storms

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1. Introduction

A **compound extreme event is the concurrence of different weather variables in their extreme state** (Leonard et al., 2014). In the Euro-Atlantic region it is quite common to experience strong wind together with heavy rain during the passage of extratropical storms, mainly in the winter season.

Both precipitation and wind extremes have been individually studied over this region and the related disruptive impacts (landslides, flooding, human casualties and economic losses) have been assessed for specific case studies as well as over larger temporal and spatial scales.

This work aims at detecting, objectively attributing and characterizing compound events affected by both precipitation and wind extremes. The objective is **to link their variability to midlatitude weather features** as cyclones and atmospheric fronts.

2. Datasets

Atmospheric fronts: it relies on a Thermal Method (Schemm et al., 2015) designed to identify and locate synoptic-scale mobile fronts in the lower troposphere, based on the zero-crossing of the Thermal Front Parameter of choice (θ_e). An advection criterion allows for distinguishing cold and warm fronts. A threshold of 3.5K/100km for the thermal gradient to be recognized as a front is set: it allows all actual fronts to be detected and it prevent false fronts detection over topography and in correspondence of artificial gradients produced by the forecast model.

Cyclones: catalogue of cyclones tracks based on the storm detecting and tracking scheme described in Trigo (2006).

Precipitation:
IB02 – high-resolution ground-based dataset of daily precipitation over the Iberian Peninsula (Ramos et al., 2014);
ERA-Interim reanalysis (0.75°).

MSLP: ERA-Interim reanalysis (0.75°).

3. Ranking of extremes

Precipitation extremes: ranking of high-resolution daily precipitation extremes for the Iberian Peninsula (Ramos et al., 2014). Events are ranked according to the magnitude of the precipitation anomaly and to the area affected by the anomaly.

Wind extremes: ranking of the top potential wind loss events (Karremann et al., 2016). The maximum daily wind speed is considered for each grid point and the 98th wind percentile is used as a threshold for the loss model.

4. A new method to assign precipitation to fronts

In Hénin et al. (2018) a new methodology to objectively assign precipitation to fronts at a sub-daily basis is described. It is based on a stepwise procedure **to co-locate the precipitation at every grid point and the front type**:
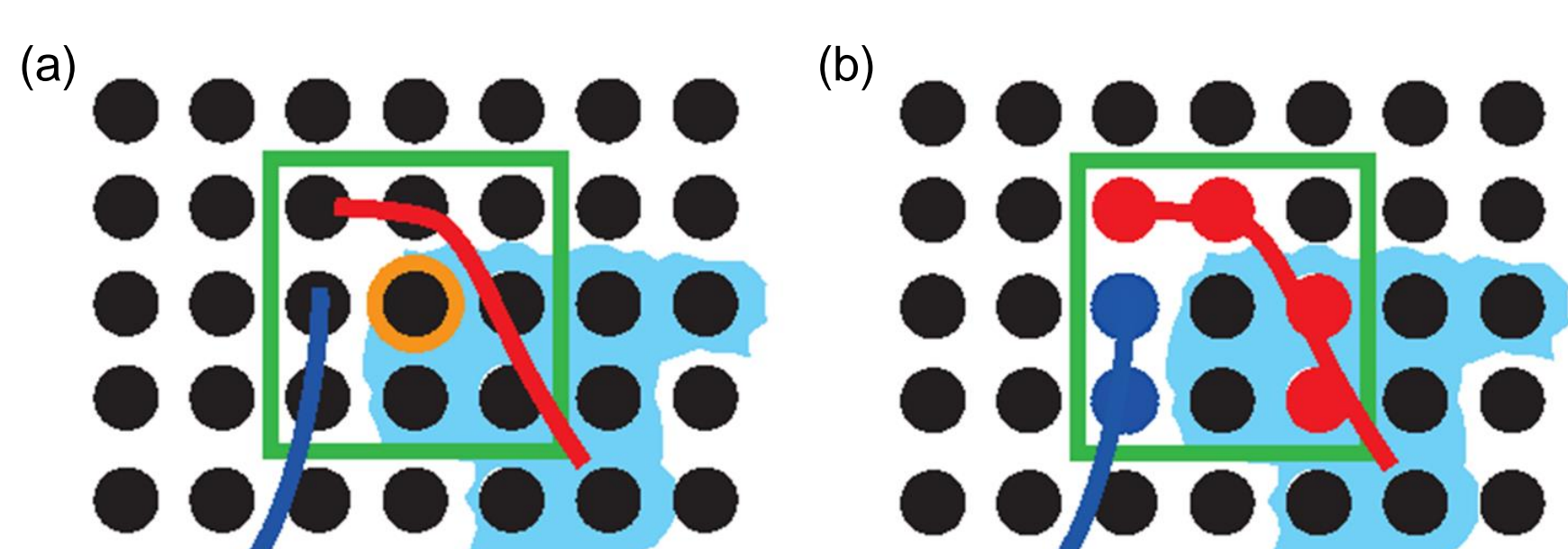

I. Run over the grid points until a precipitation spot is found;
II. Define a front-search box centred at the grid point;
III. Assign precipitation to the fronts within the box, on 6-hourly basis;
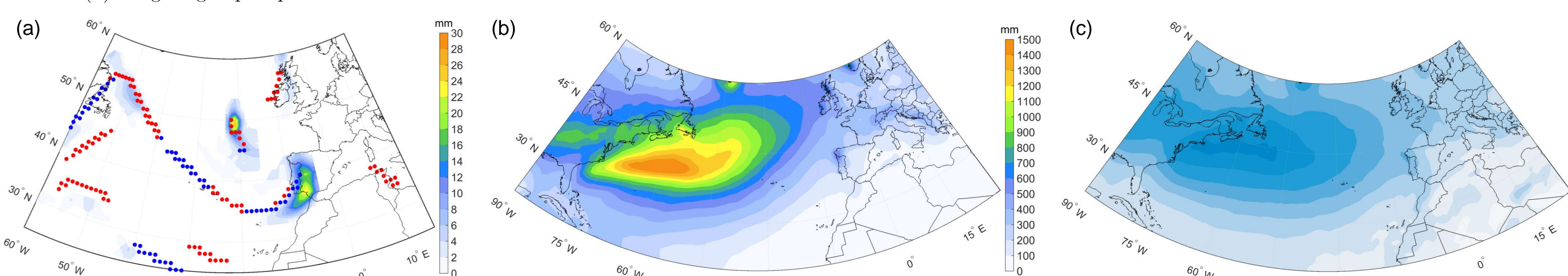IV. Weigh the precipitation in case more than one front type is found.

Fig. 1: Sketch of the co-location method for frontal precipitation:
(a) Definition of the front-search box;
(b) Weighting of precipitation.

Fig. 2: (a) Frontal precipitation during the event occurred on 06/11/1982, 18 UTC (accumulated precipitation over 18 UTC±3h). Blue (red) dots represent cold (warm) fronts. (b) Long-term mean (1979-2016) for annual frontal precipitation from ERA-Interim and (c) fraction of frontal over total precipitation.

5. Objective assignment of fronts and precipitation to cyclones: workplan

The following procedure is used:

1. Selection of an extreme precipitation event from the ranking;
2. Characterization of the event through synoptic charts and reanalysis;
3. Identification of the associated cyclone;
4. Characterization of the cyclone life-cycle.

Next:
➤ How to automatically perform it?
➤ How to objectively associate precipitation to the identified cyclone?
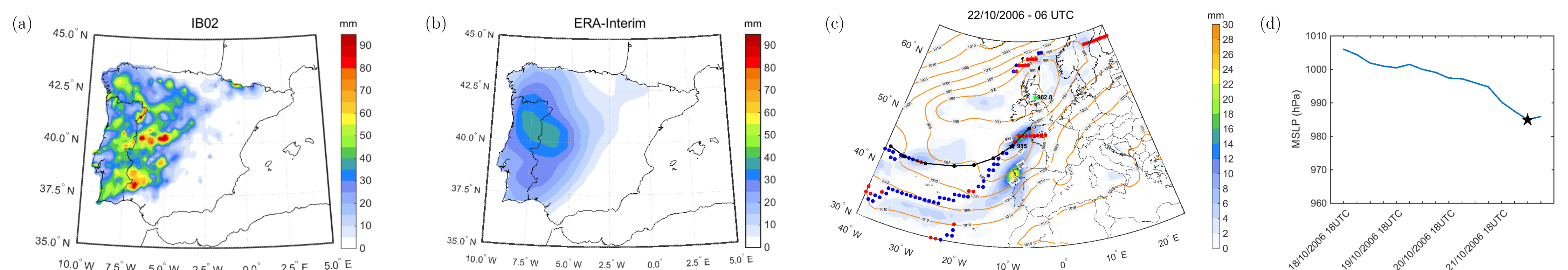

Fig. 3: Event occurred on 22/10/2006. Accumulated daily precipitation from IB02 (a) and Era-Interim (b). MSLP (orange contours), cold and warm atmospheric fronts (blue and red dots), accumulated precipitation (colour shading), cyclones centres (green stars) at 06 UTC and path of the assigned cyclone (black line) (c). Time evolution of MSLP for the centre of the assigned cyclone (d). The black star refers to the time instant plotted in (c).
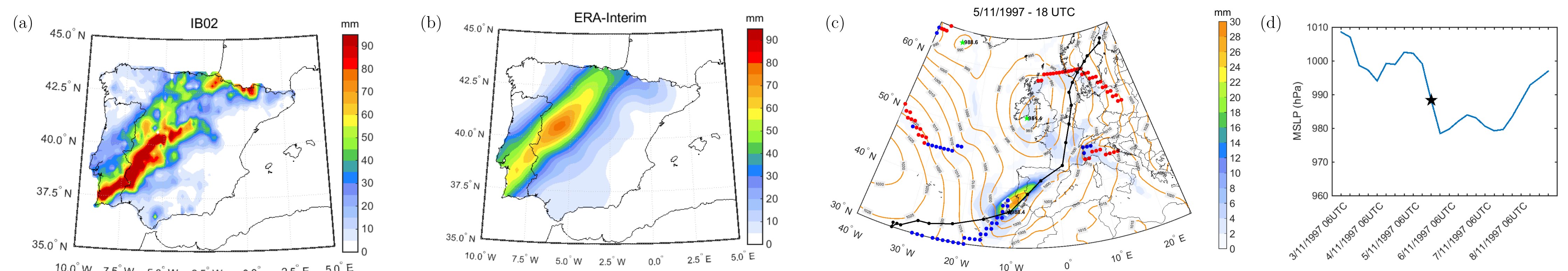

Fig. 4: Same as Fig. 3 but for the event occurred on 5/11/1997 (18 UTC).

6. Characterization of compound events

A subset of **14 compound events** for the common period 1979-2008 is produced by cross-checking the two rankings for precipitation and wind extremes.
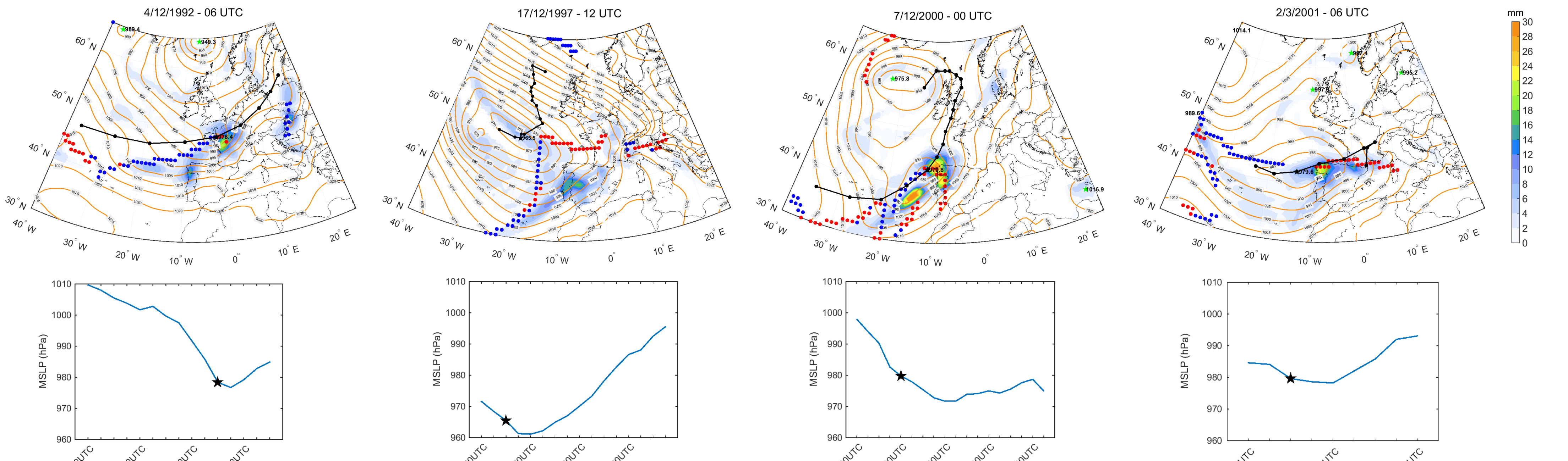Then, a procedure similar to the one described in box 5 is followed to characterize the main cyclones property.

Fig. 5: Top panels: MSLP (orange contours), atmospheric fronts (blue and red dots), accumulated precipitation (colour shading), cyclones centres (green stars) and path of the assigned cyclone (black line) for different events. Bottom panels: time evolution of surface pressure for the assigned cyclone. The black star refers to the time instant plotted above.

The objective identification of the associated cyclone is not always straightforward.
As in Karremann et al., (2016), events will be grouped according to the trajectories of the cyclones (North – West – Iberia – Hybrid).

7. Summary and future work

- **A new method to objectively assign precipitation to fronts at a sub-daily basis is developed** and tested over the Euro-Atlantic region.

- **A catalogue of extreme wind and precipitation compound events** occurred over the Iberian Peninsula and Western Europe **is produced**, based on two available rankings.

- An automated method to objectively assign fronts and precipitation to cyclones is currently under way.

- The methodology will be applied to selected compound events that affected the Euro-Atlantic region during the period 1979-2008.

8. References

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