Sub-Hourly Precipitation Extremes in Mainland Portugal and downburst events

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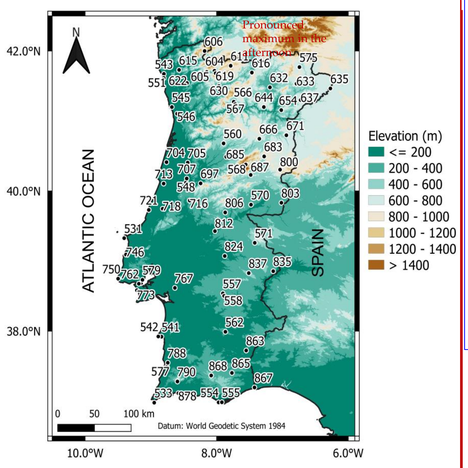
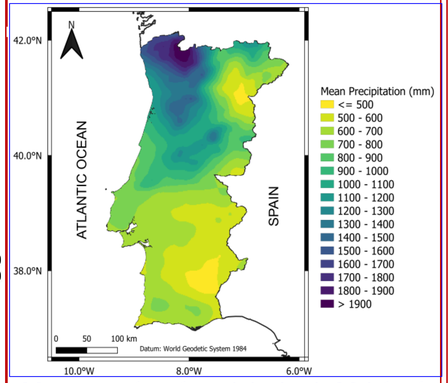
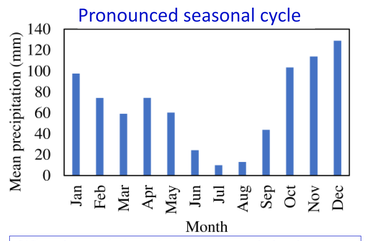
Period: 2000–2020, 71 stations, 10-minute data





Mean annual total precipitation in Mainland Portugal, for 1981–2010, varies from approximately 400 mm, in the southernmost areas to 2000 mm and more, in high-elevation areas of the northwest.



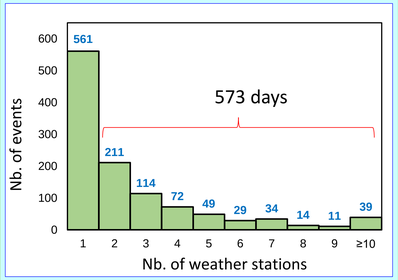
What is a sub-hourly heavy precipitation (SHHP) event?

It is day when at least one station measures 10-minute precipitation ≥ 5.0 mm

Why a 5 mm threshold?

- This correspond to 30 mm precipitation in one hour (orange warning: 20-40mm)
- 5 mm is more than the 3.9 mm (maximum value of the 99th percentile of 10-minute total precipitation for days with precipitation)

A total of 1134 SHHP days were identified (~15% of the total period)



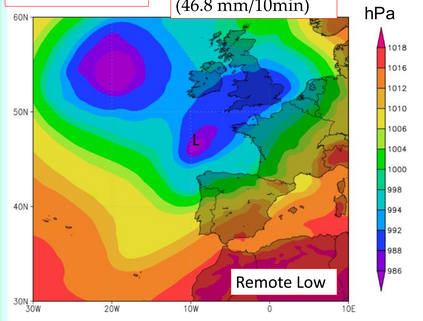
These 573 days were selected to establish the link to the underlying synoptic scale environment using hourly ERA5 data.

Meridional Pressure Gradient (MPG) index: MSLP at 40N - MSLP at 50N, zonally averaged within the belt 15– 5W.

Of the SHHP 573 days, 304 (~53%) are connected to positive MPG-index values (Remote Lows – RemL), whereas 269 (~47%) are associated with negative MPG-index values (Regional lows - RegL).

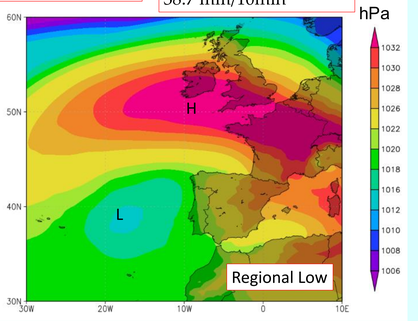
20 October 2004

Heaviest event (46.8 mm/10min)



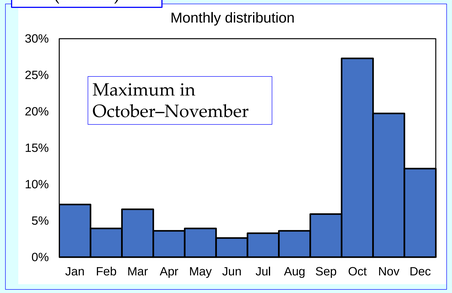
5 November 2006

Second-heaviest event: 38.7 mm/10min

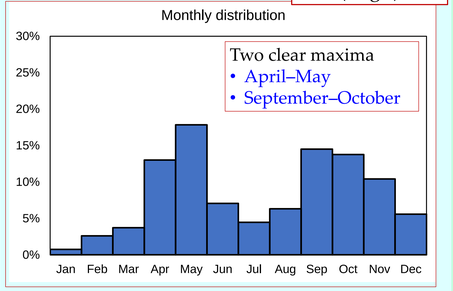


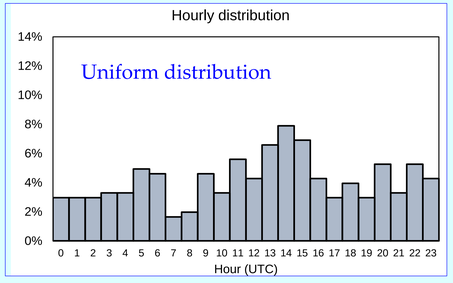
Seasonal and diurnal variability

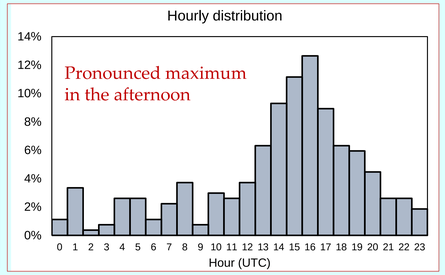
Remote lows (RemL)



Regional lows (RegL)







Link to severe convection: preliminary approach

Below thunderstorm's downdrafts, the cold and dense air may cause the surface air pressure to rise — sometimes several millibars. This relatively small, shallow area of high pressure is called a mesohigh (Ahrens, 1009).

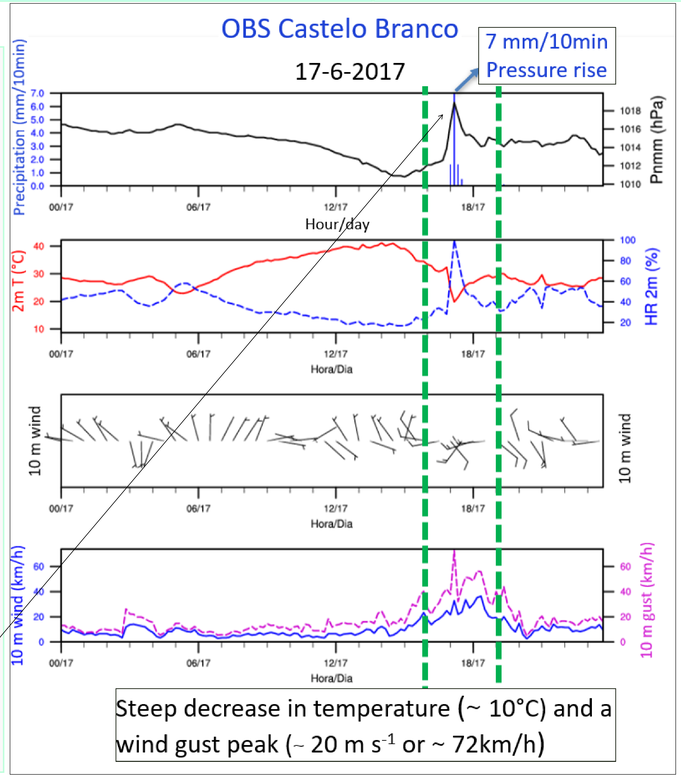
Two criteria based on surface pressure data (10-min observations) were used to identify mesohighs associated to short heavy rain events.

79 events were identified n mainland Portugal

- ❑28 episodes (RegL)
- ❑51 episodes (RemL)

On average, in these events pressure rise is ~2 hPa

On 17 June 2017, surface pressure increased 7 hPa



Conclusions and perspectives

The present study is the first to provide a comprehensive assessment of short-duration precipitation events in mainland Portugal, including an analysis of their underlying synoptic and mesoscale conditions, as well as their connection to MCS mesohighs (and implicitly to cold pools and possibly downbursts).

The episode of 17 June 2017 was considered as a case study, owing to its severity, but particularly to its linkage to the occurrence of unprecedented forest fires in Portugal, with losses of many human lives. The footprints of mesohighs, cold pools, and associated downbursts, are identified by weather stations. These signatures were also present in the AROME forecasts issued on the day before the event.

These downbursts were caused by an MCS (visible in satellite images and radar reflectivity), which developed in an environment characterized by weak synoptic forcing accompanied by moderate CAPE and an inverted V-profile, with a very warm and dry layer from the surface to 650 hPa, which is typical of hybrid downbursts.

A more comprehensive analysis will be required to assess the AROME performance under a wider range of conditions and for the whole set of the identified events.

More information in:

Santos, João A., and Margarida Belo-Pereira, 2022: "Sub-Hourly Precipitation Extremes in Mainland Portugal and Their Driving Mechanisms", *Climate*, https://doi.org/10.3390/cli10020028

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