DYNAMICAL CHARACTERIZATION OF THUNDERSTORM DAYS IN PORTUGAL

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INTRODUCTION:

Thunderstorms in the atmosphere are produced in large convection cells (*Cumulonimbus*) under conditions of strong atmospheric instability.

In Portugal, since 2002, the Meteorological Institute maintains four detection sensors (Figure 1) in order to effectively cover the national territory. Although this database is still very recent, the RAIDEN project (Lightning activity in Portugal: variability patterns and socioeconomic Impacts) intends to systematize all the available data so as to characterize its spatial and temporal variability and to assess the main dynamical mechanisms underlying the occurrence and development of thunderstorms in Portugal.

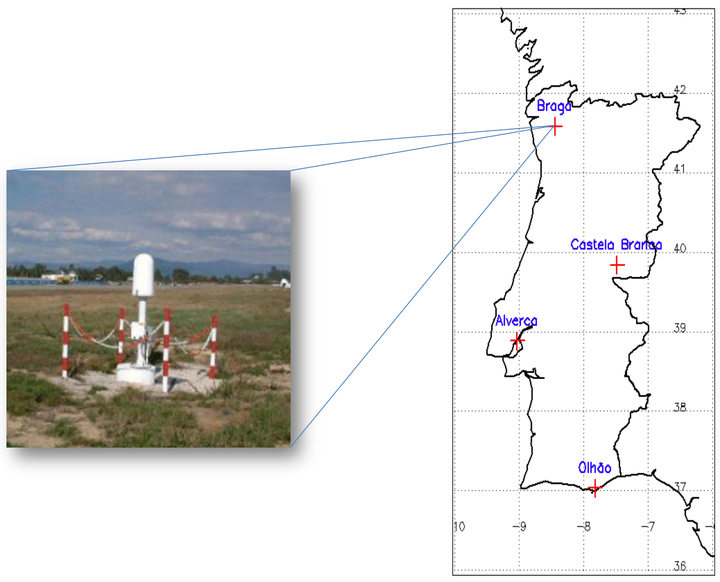

Figure 1. Map showing the locations of the lightning sensors in Portugal.

DATA AND METHODOLOGY :

In this study, the dataset of the atmospheric electric discharges (AED), collected by the four lightning sensors of the Portuguese Meteorological Institute, in the period between 2003 and 2009 (7 years) is analyzed. Further, in order to assess the dynamical features of the thunderstorm days in Portugal, several atmospheric fields from the NCEP-NCAR reanalysis data are considered on a daily basis (daily means), namely mean sea level pressure (MSLP), 500 hPa geopotential height, 500 hPa temperature, and 10 m zonal and meridional wind components (for streamlines computation). These fields are defined over a 2.5º x 2.5º latitude-longitude grid an only the geographical sector (30ºW-20ºE, 20-70ºN) is selected.

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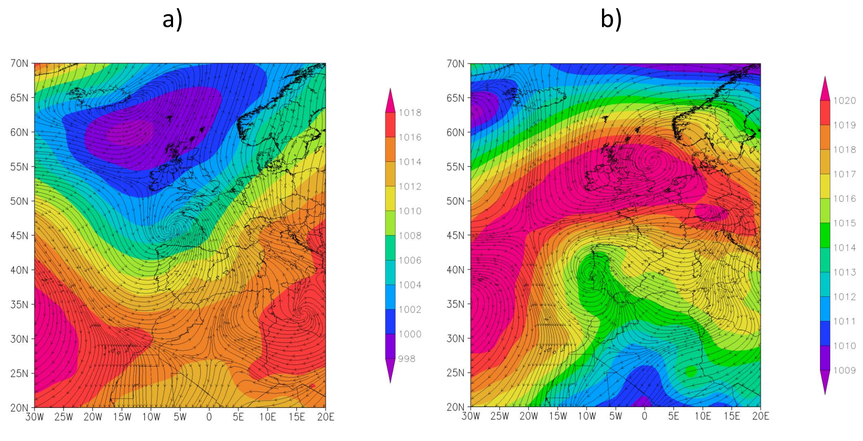

Figure 2. Composites of the MSLP and respective streamlines only for days with AED > 25 discharges:
(a) REM regime with 104 days; (b) REG regime with 272 days.

PRESENTATION OF RESEARCH:

Aiming to dynamically characterize the thunderstorm events in Portugal, only days with AED above the 50th percentile are herein considered. This threshold matches to 25 daily discharges over Portugal and a total of 376 days fulfill this criterion. A K-means clustering is directly applied to the reanalyzed mean sea level pressure (MSLP) and two different regimes of atmospheric circulation are clearly identified, i.e., the Remote regime (REM; Figure 2a) and the Regional regime (REG; Figure 2b). Their designations are related to the location of the low-pressure systems linked to thunderstorm occurrences in Portugal.

❖ The REM regime is characterized by a low pressure center northwards of the British Islands (remote location), but with a strong trough extending towards Portugal.

❖ The REG regime, a blocking anticyclone, extending from the Azores towards the British Islands, and a weak low pressure / inverse trough located over Portugal (regional location) can be observed.

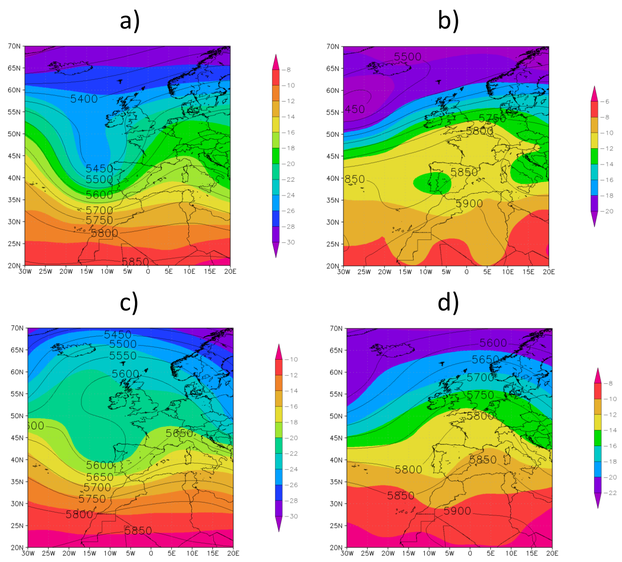

Figure 4. Composites of the 500 hPa geopotential height and air temperature only for days with AED > 25 discharges:
(a) REM_W; (b) REM_S; (c) REG_W; (d) REG_S.

Since the general atmospheric dynamics during the winter and summer halves are different, the winter (W; October-March) and summer (S; April-September) periods are considered separately. Hence, the two regimes are analyzed for W and S, i.e., REM_W with 70 days, REM_S with 34 days, REG_W with 76 days and REG_S with 196 days. Their corresponding patterns are depicted in Figure 3.

Some differences in detail can be found between the W and S patterns for each regime, though most of them are only a manifestation of seasonality.

The composites of the 500 hPa geopotential height and 500 hPa air temperature of these regimes are shown in Figure 4. These patterns are in clear agreement with the patterns in Figure 3.

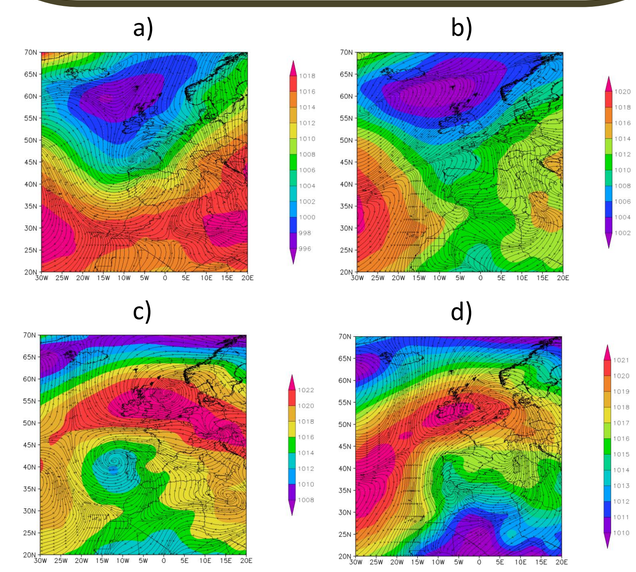

Figure 3. As in Figure 2, but for the winter (W) and summer (S) halves of the year: (a) REM_W; (b) REM_S; (c) REG_W; (d) REG_S.

RESULTS:

✓ Two regimes relevant to AED over Portugal are identified (REM and REG).

✓ The REM regime is dominant in the coldest period, whereas the REG regime is more prevalent in the warmest period.

✓ The most common regime is the REG_S with 196 days of a total of 376 days. This regime is characterized by an inverted trough extending from northwestern Africa towards Portugal and by high temperatures that are typically observed at this time of the year (‘thermal low pressure’).

✓ AED are much less frequent during the REM_S regime with only 34 days. This can be mainly attributed to the northward displacement of the low pressure systems over the North Atlantic during summer.