HAIL CLIMATOLOGY IN PORTUGAL AND SOME INSIGHTS INTO THE REGIONAL DYNAMICAL DRIVERS

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MOTIVATION

Important damages in several crops, such as grapevines, with high losses in key socioeconomic sectors in Portugal (e.g. winemaking sector)

Further research on **hail climatology** to assess hail risk patterns & on the **dynamical drivers of hailstorms** to improve hail forecasts

OBJECTIVES

1. To develop a first hail climatology for mainland Portugal based on the observations from a network of weather stations;

2. To compare and validate hail records with thunderstorm, convection and precipitation days;

3. To analyse the dynamical coherence between hailstorms and large-scale atmospheric flow using 3-dimensional weather typing.

DATA & METHODS

15 meteorological stations for **1971–2009 (39 years)** – maintained and updated by IPMA

Hailstorm, thunderstorm, **convection** and **precipitation days** are identified by the corresponding SYNOP codes (WMO, 2011)

ERA-Interim 0.75°: **12 UTC MSLP/Z500/PV250/CAPE/T850/T500/Td850**

Total-totals index: TT = T850 + Td850 – 2*T500

DATA & METHODS

For the hail records, a Cumulonimbus (Cb) cloud should also be recorded in the SYNOP code for consistency. For the codes 87, 88, 90, 93 and 94, the 2 m air temperature (T2 m) should by higher than 3ºC. This criterion for T2 m is critical to distinguish hail from snow pellets or mixed snow.

87	17.0	Slight shower(s) of snow pellets or small hail, with or without rain or rain and snow mixed.	Small hail not associated with thunder
88	5.9	Moderate or heavy shower(s) of snow pellets or small hail, with or without rain or rain and snow mixed.	
27	34.8	Shower(s) of hail or of rain and hail mixed.	Hail not associated with thunder
89	5.9	Slight shower(s) of hail, with or without rain or rain and snow mixed.	
90	6.4	Moderate or heavy shower(s) of hail, with or without rain or rain and snow mixed.	
93	2.3	Slight hail, or snow, or rain and snow mixed at time of observation. Thunderstorm during the preceding hour but not at time of observation.	Hail with thunder during the preceding hour but not at time of observation
94	1.6	Moderate or heavy hail, or snow, or rain and snow mixed at time of observation. Thunderstorm during the preceding hour but not at time of observation.	
96	19.3	Slight or moderate thunderstorm, with hail at time of observation.	Hail with thunder at time of observation
99	6.8	Heavy thunderstorm, with hail at time of observation.	

DATA & METHODS

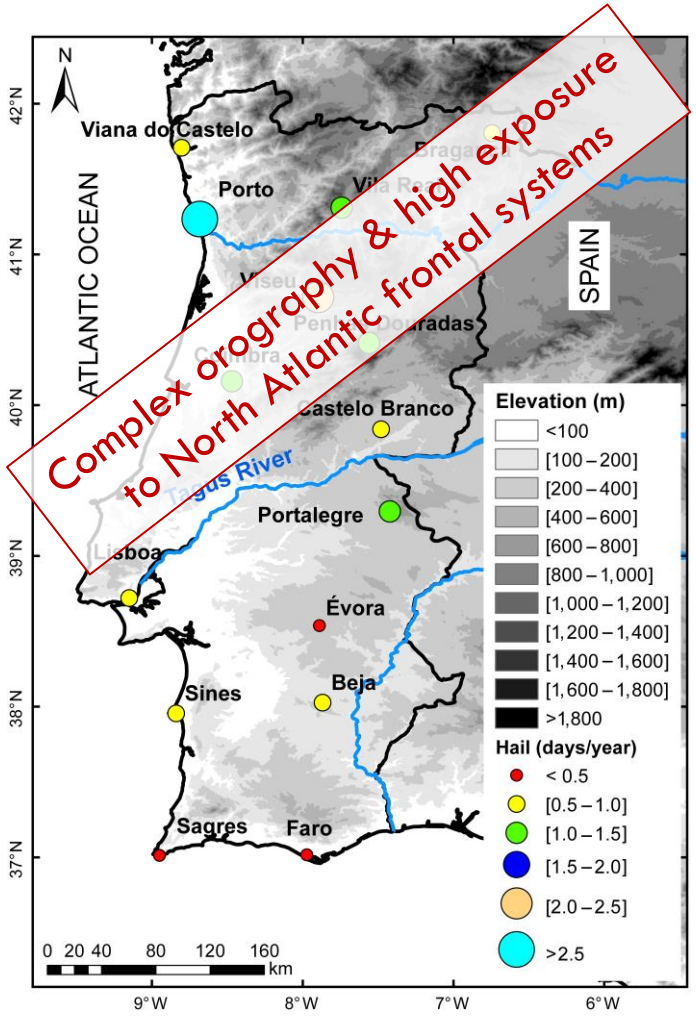
Thunderstorm day - if at least one of the two following conditions is verified at any hour of the day at a given weather station:

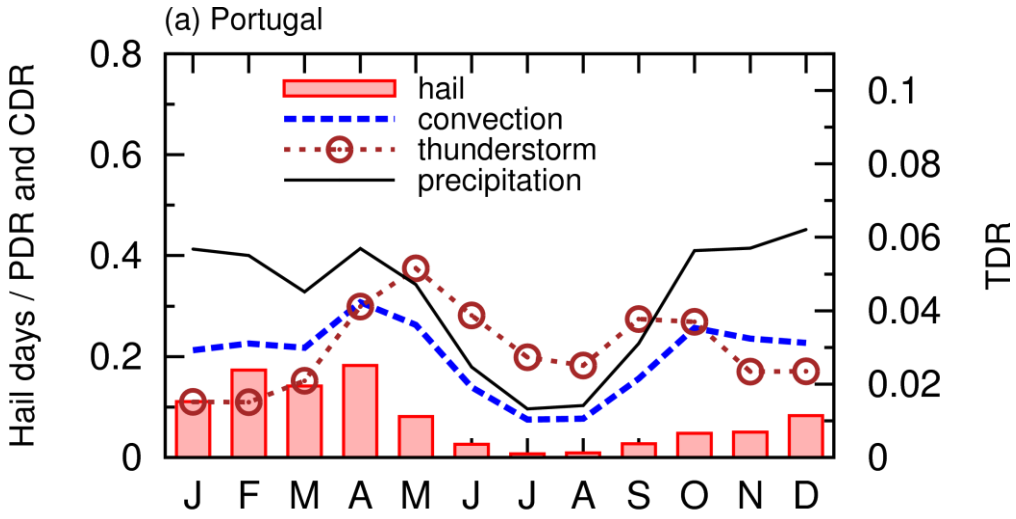
- thunderstorm was coded in past weather;
- present weather coded as any of the numbers 13, 17, 29, 91–99.

Convection day - if at least one of the two following conditions is verified at any hour of the day at a given weather station:

- an hourly precipitation record ≥20 mm;
- present weather coded as any of the numbers 17–19, 25–27, 29, 79–99.

RESULTS





Strong seasonality

Maximum in February–April

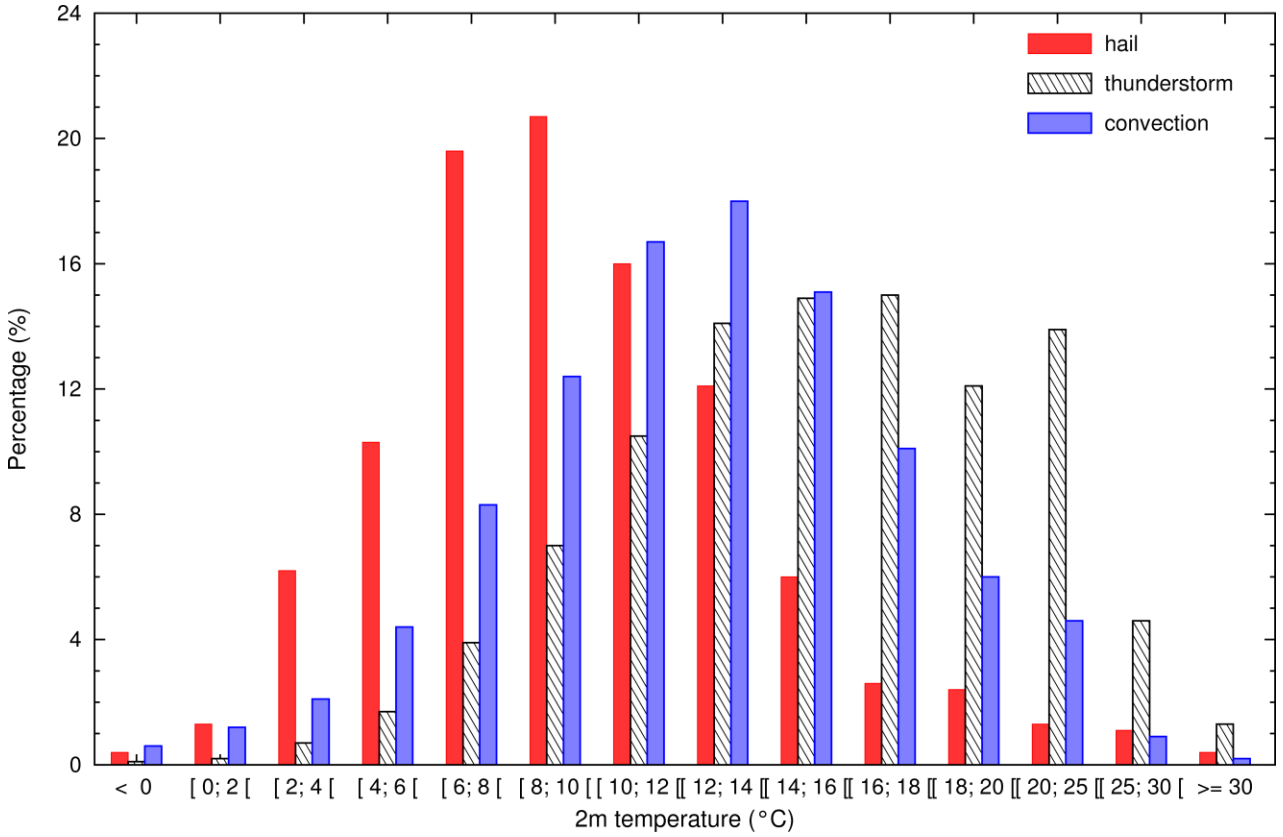
Minimum in July–August

Suppression of convection by the Azores high-pressure ridge in summer

No clear autumnal maximum…

RESULTS

Relative frequencies of occurrence (%); ≥1 record in the network



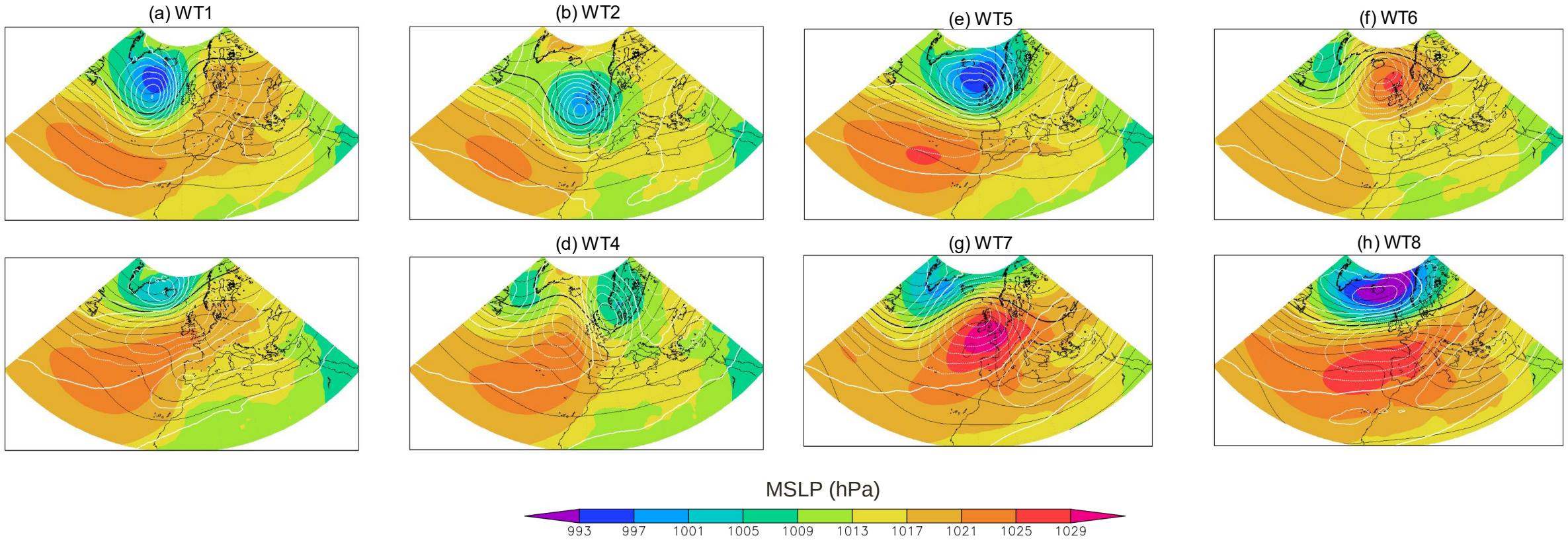
75% of thunderstorm days for T2 m >12°C

75% of hailstorms occur under cooler conditions (<12°C)

The high-freezing levels in Sep-Oct (hail melting) may underlie the absence of a clear autumnal maximum in hailstorms

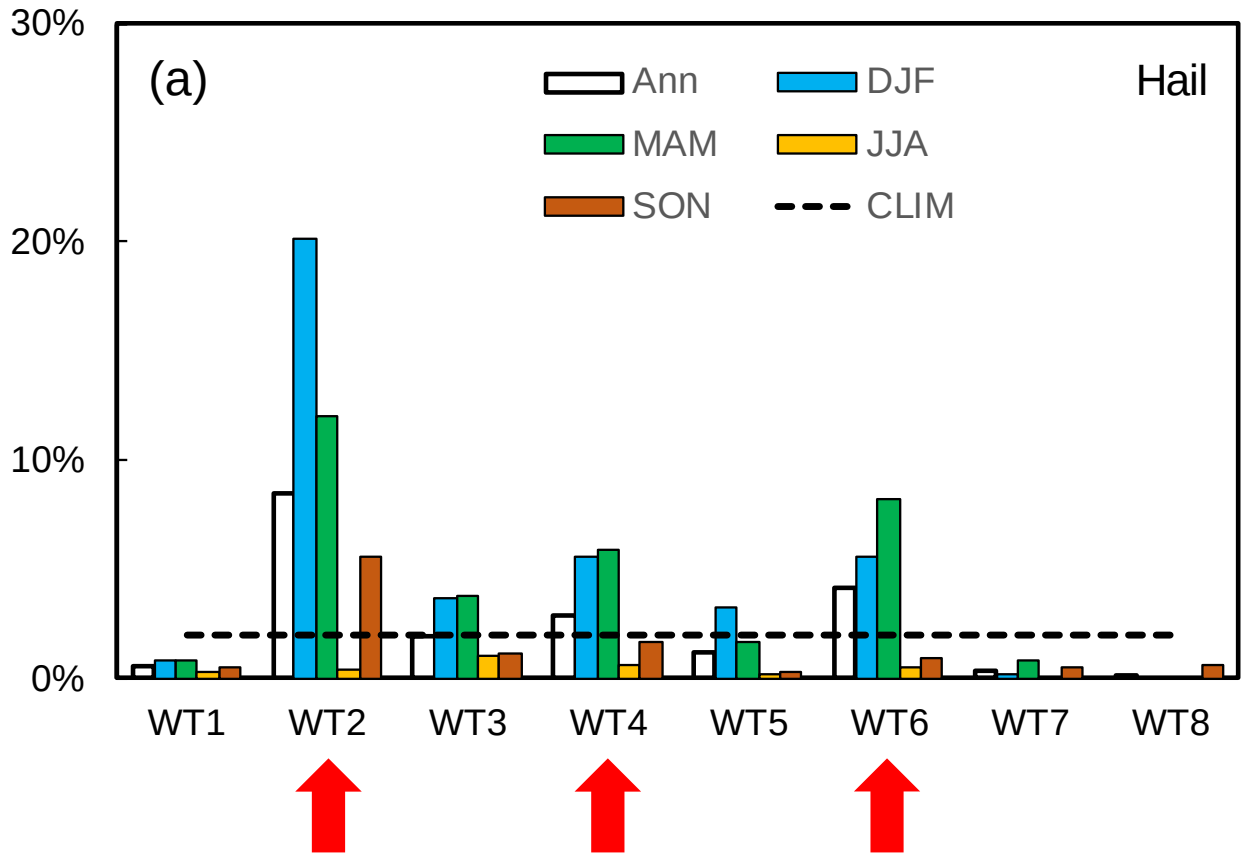
3-D weather type daily catalogue

WT=f(MSLP, Z500, PV250) – K-means clustering on the subspace of leading PCs (>90%)
Seasonality removed at each grid point and latitude scaling applied prior to PCA



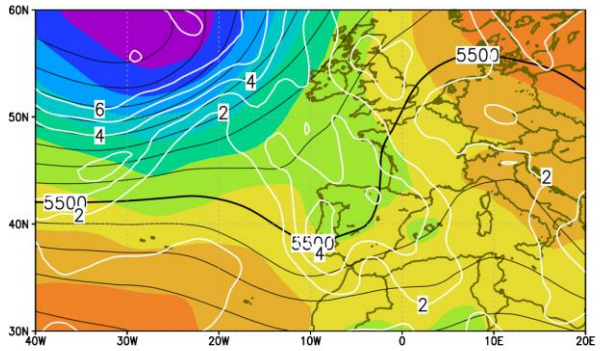
Composites of daily SLP (shading in hPa, intervals of 4 hPa), Z500 (black contours in gpm, intervals of 50 gpm) and the PV250 anomalies (white contours in PVU—1 PVU = 10^6 K m^2 kg^{-1} s^{-1}—intervals of 0.05 PVU, solid/dashed contours for positive/negative anomalies) for each weather type (WT1–8) over the period of 1979–2009 (Data source: ERA-Interim). Thick black contours for 5500 gpm and thick white contours for zero PV250

RESULTS

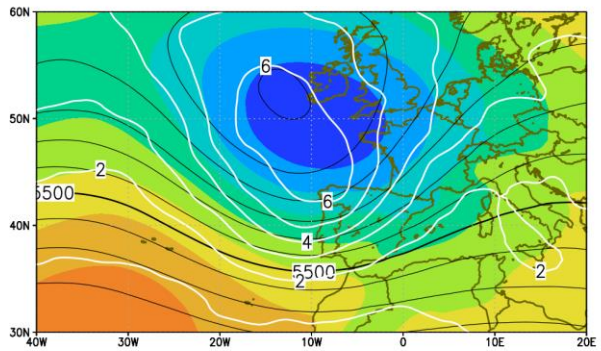

30%
20%
10%
0%
(a)
Ann
DJF
MAM
JJA
SON
CLIM
Hail
WT1
WT2
WT3
WT4
WT5
WT6
WT7
WT8

RESULTS

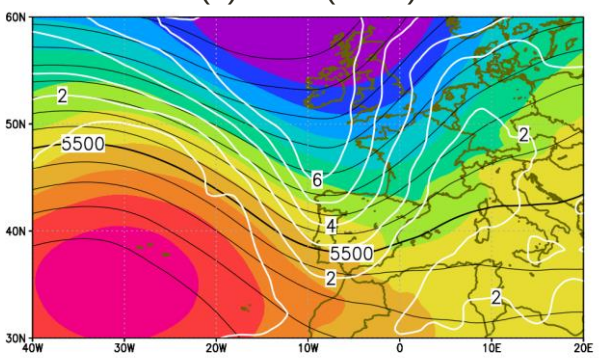
(a) WT1 (n=9)



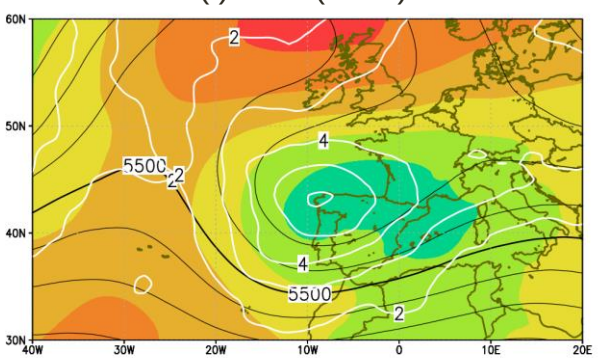
(b) WT2 (n=105)



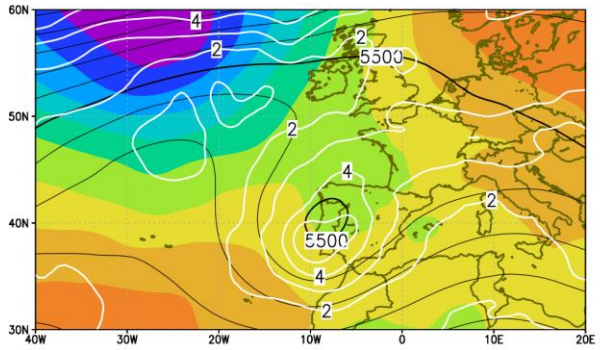
(e) WT5 (n=20)



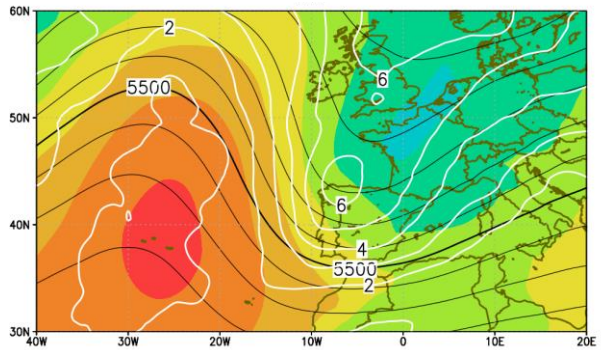
(f) WT6 (n=52)



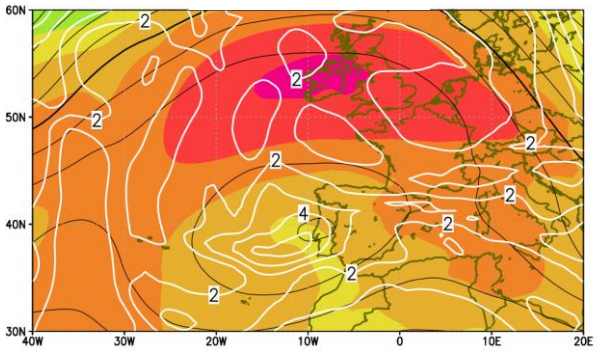
(c) WT3 (n=28)



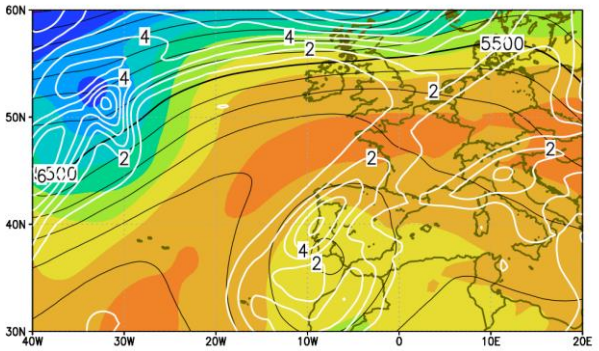
(d) WT4 (n=51)

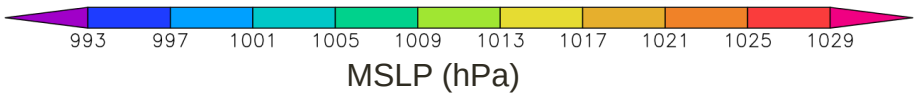


(g) WT7 (n=4)

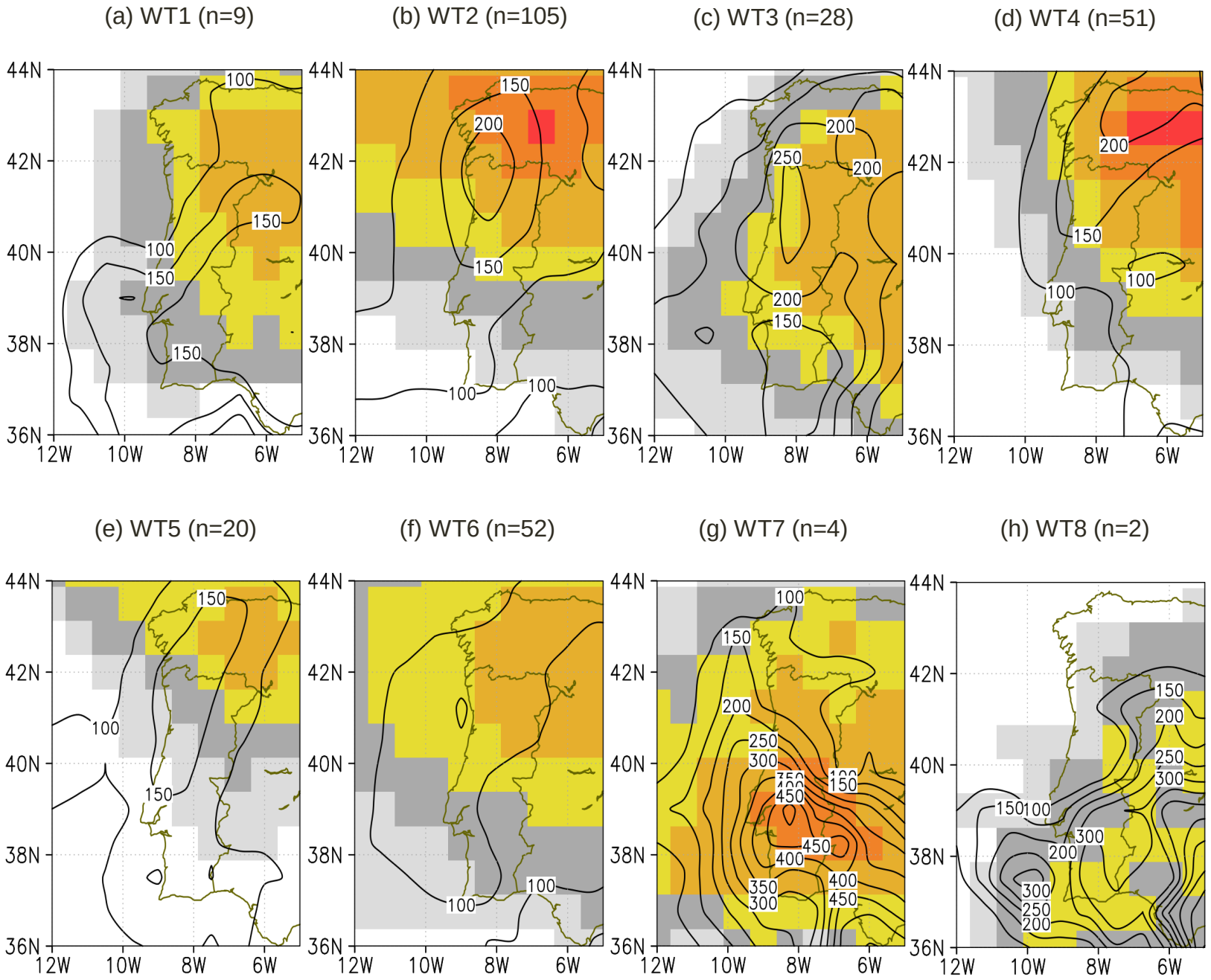


(h) WT8 (n=2)





MSLP (hPa)



Composites of the 1200 UTC CAPE (contours at 50 J kg^{-1} intervals) and TT (Total-Totals index, colour shading) for hail days in each WT for 1979–2009.

46–50°C:
Thunderstorms possible

50–54°C: Thunderstorms very likely, possibly severe

>54°C:
Severe thunderstorms very likely

SUMMARY

Hail events **more frequent in northern Portugal & during winter/spring**;

Hailstorm, thunderstorm & convection days present a maximum in April–May, but the secondary peak in autumn is frequently associated with convective storms without hailfall at the ground;

The typically higher temperatures in autumn than in February–April lead to high-freezing level heights that hamper hailfall at the surface;

SUMMARY

Three weather types are responsible for ca. 75% of hail events;

Overall, hail events are favoured either by **extra-tropical depressions, with cold front passages over Portugal**, or by **upper-level troughs/lows nearby Portugal**.

Hail occurrences under other WTs are mostly related to exceptional / atypical conditions of the corresponding WT, mainly driven by **mesoscale systems embedded in the large-scale pattern**.

FURTHER INFORMATION

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RESEARCH ARTICLE

A comprehensive analysis of hail events in Portugal: Climatology and consistency with atmospheric circulation

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White Paper video

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THANK YOU!