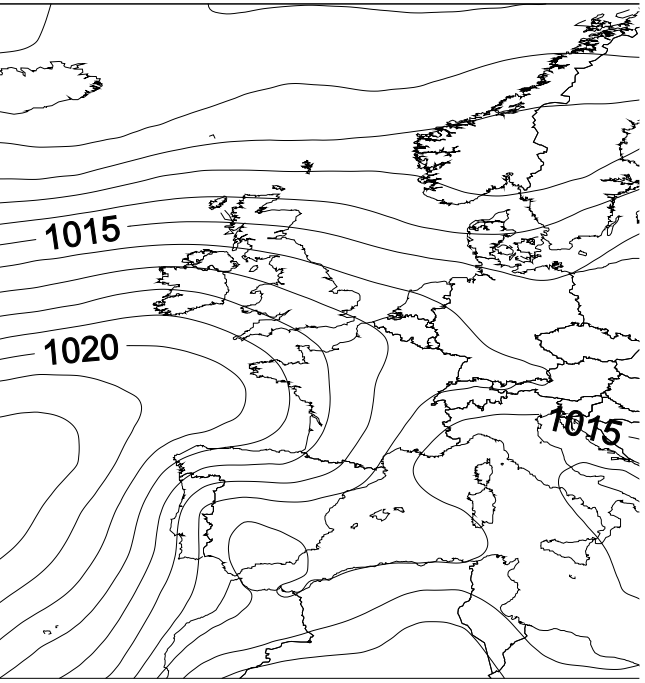
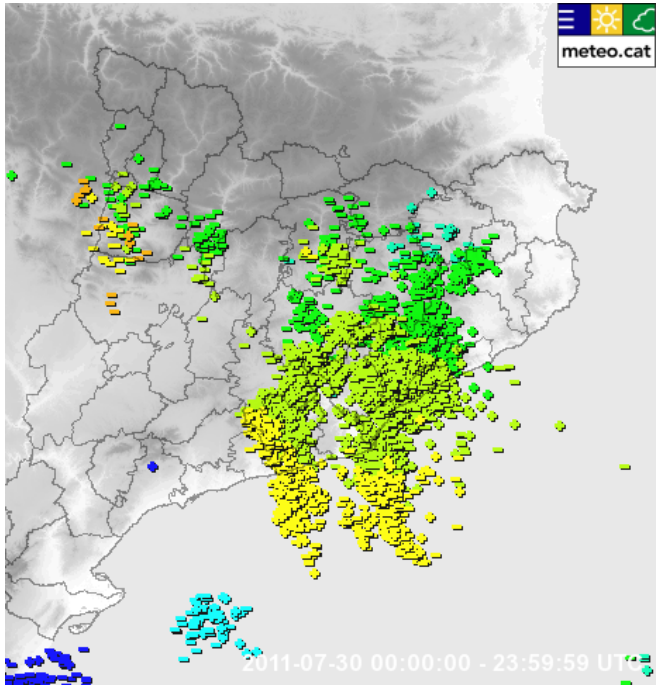
Synoptic patterns favouring lightning-ignited wildfires in Catalonia





Source @paigevincent09

Source @bomberscat

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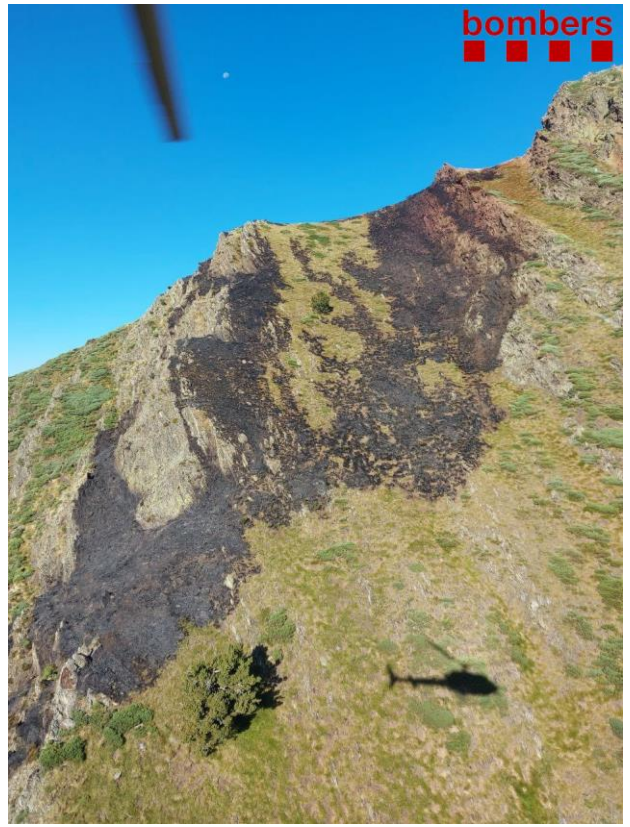
Wildfires

Wildfires cause substantial socio-economic losses and impact the natural biodiversity in Mediterranean areas. Lightning is a minor cause of wildfires (5-10%) in the southern EU countries. (European Fire Database, Camia et al. 2010)

Nonetheless, lightning ignited wildfires (LIW) must be considered a major disruptive agent in Mediterranean-climate regions as:

- They can trigger large fires
- LIW are frequently associated to extreme meteorological conditions, which may hamper extinction tasks, like the use of aerial resources.
- Due to the remote location of some of these LIW, fire brigades may be overwhelmed, resulting in longer response times and more difficult firefighting campaigns.



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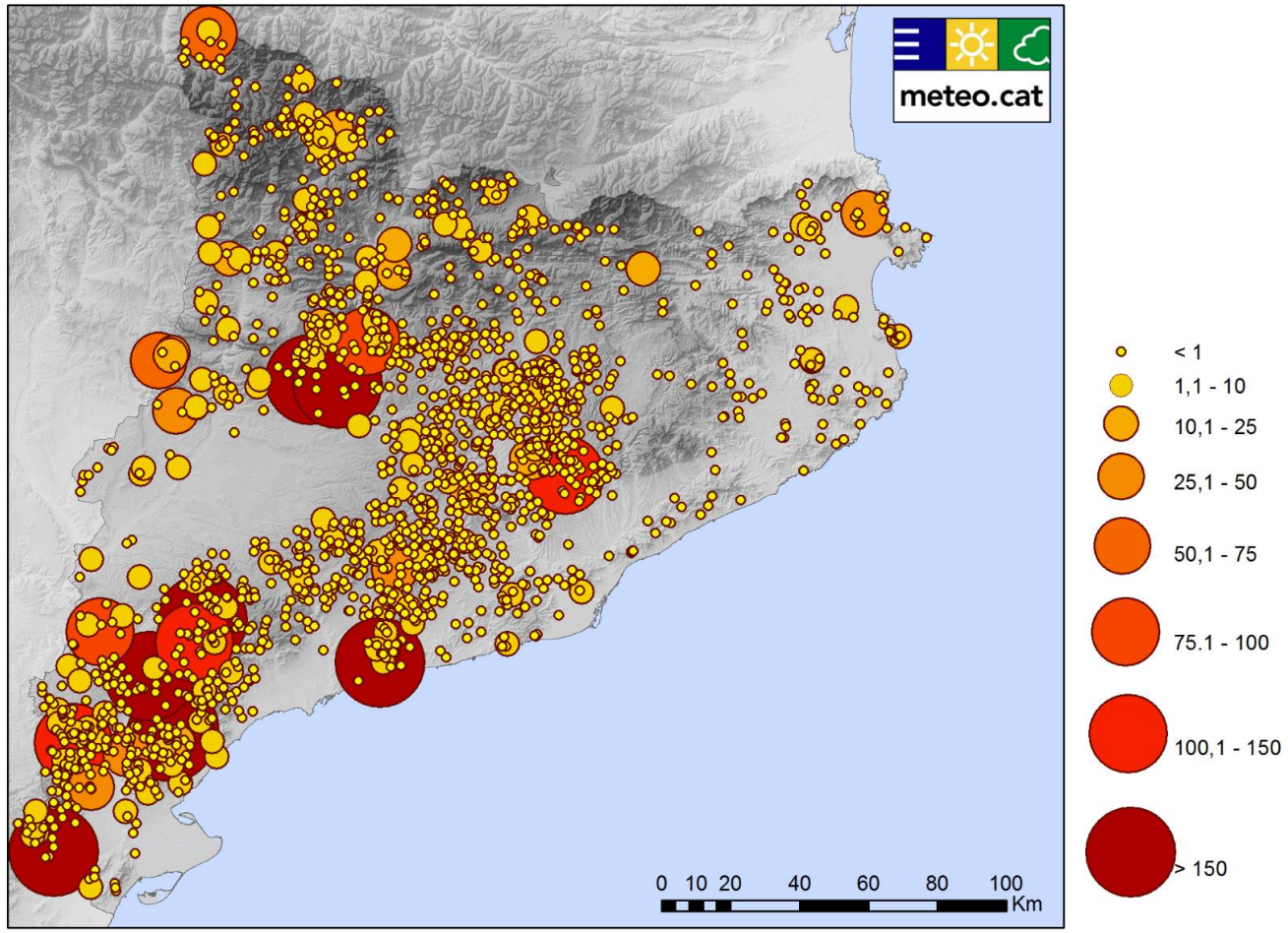
Lightning-ignited wildfires (LIW)



Geographical distribution of lightning ignited-wildfires for 2004–2018 in Catalonia. The size of the circle is proportional to the burned hectares.

- The annual average of wildfires in Catalonia is 640, burning 7,700 forested hectares/year (1986-2018).
- Large fires (> 100 ha) account for more than 88% of the burned area.
- LIW represent the 10.4% of the total number of wildfires (and 2% of the burned area).
- There have been 2,250 wildfires originated by lightning since 1986, thus an average of 66 LIW per year.
- Most of them occur during summer, the months from June to September encompassing 90% of the LIW.

Foto: Lluís Vila

Lightning efficiency

Photo: Jordi Recasens

The number of fires ignited per lightning strike is referred to as “lightning efficiency” (Podur et al., 2003).

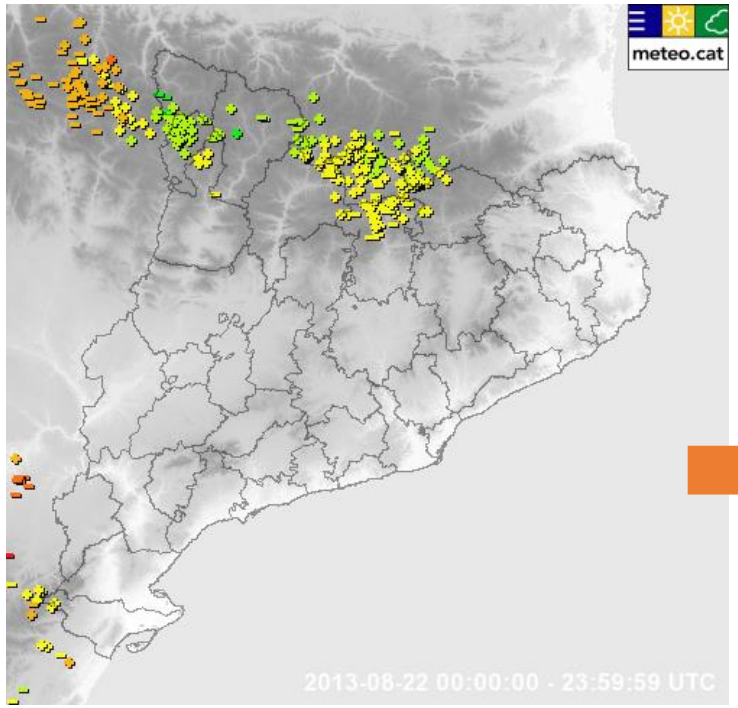
Catalonia: 32,000 km^2 / 65.0% of the surface is forestry (forest, shrublands, pastures)

Lightning cloud-to-ground flashes per year in the forestry area: 32,500 (Catalonia 46,500)

LIW per year: 66

$$\text{Lightning efficiency} = \frac{66}{32{,}500} \sim 1/500$$

Matching LIW with lightning data (ignition candidate)



Lightning Location Systems can accurately locate lightning strikes with high efficiency and precision.

Lightning Database (Met Service)

X

Wildfire Database (Forest Agency)

Forensic analysis by the Forest Protection Agency

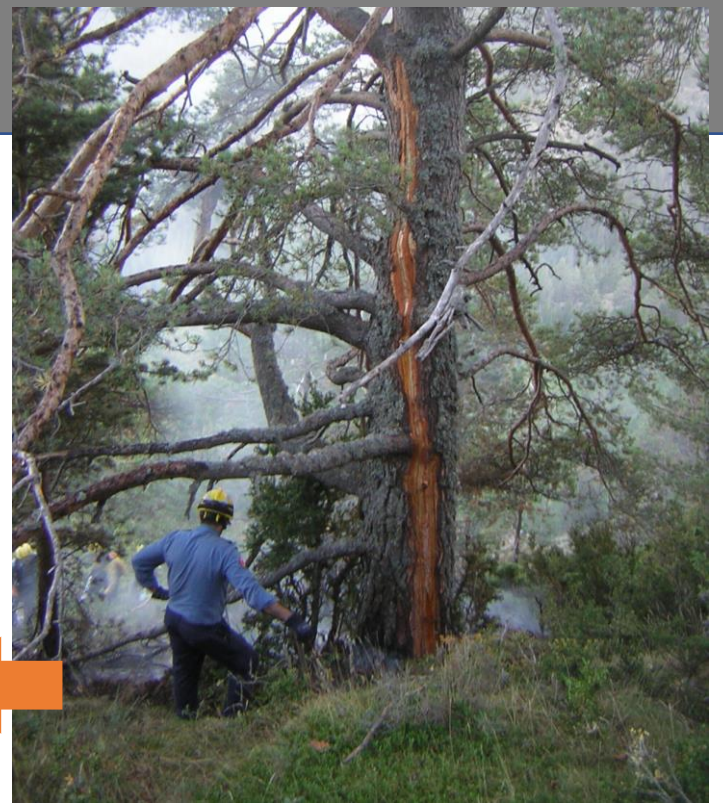
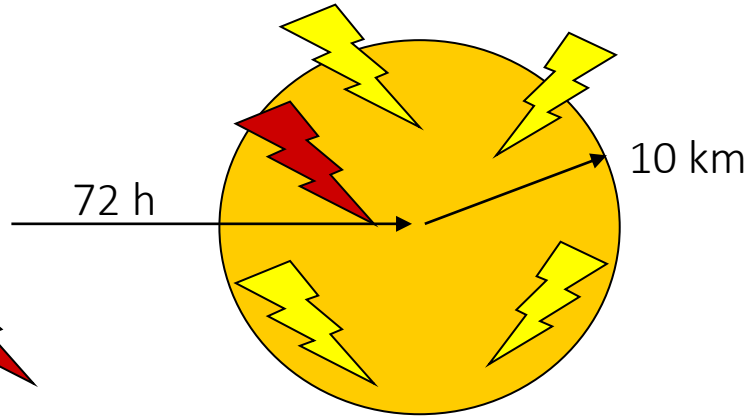


Photo: Lluís Vila

Proximity index

(Larjavaara et al. 2005)



Most Probable Candidate

(lightning causing the ignition)

Material & Methods

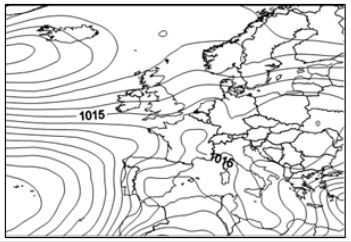
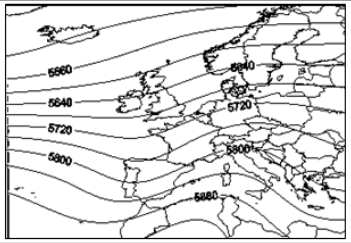
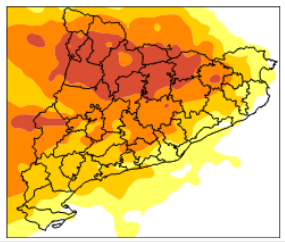
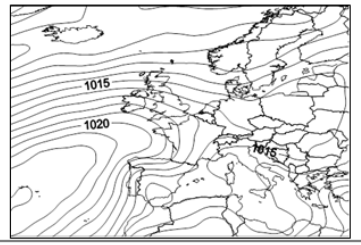
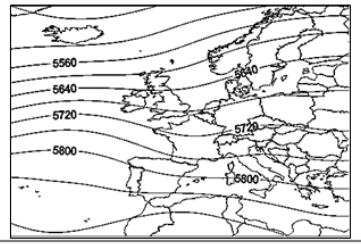
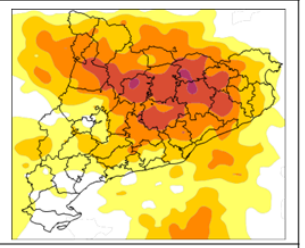
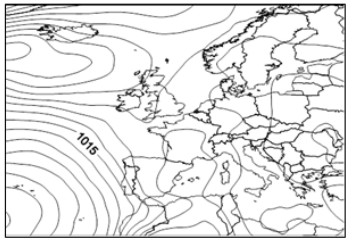
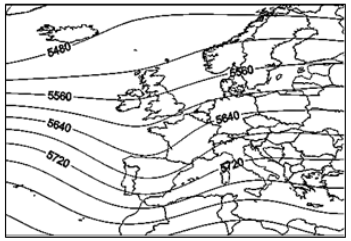
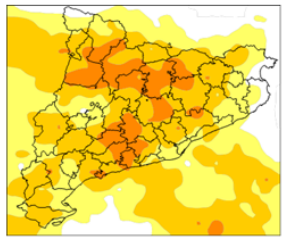
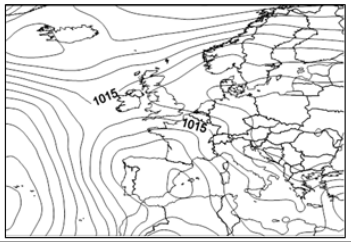
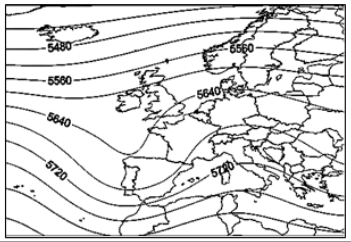
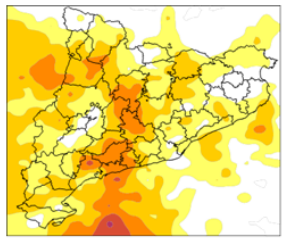
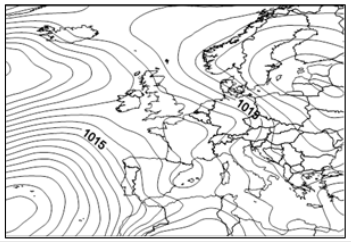
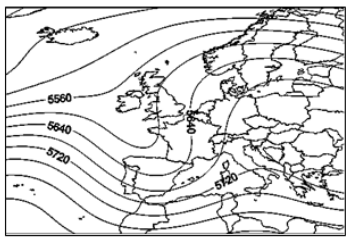
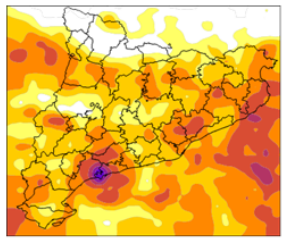
NCEP/NCAR Reanalysis at 2.5˚ resolution was used to classify the synoptic configuration for each 6-hour thunderstorm periods:

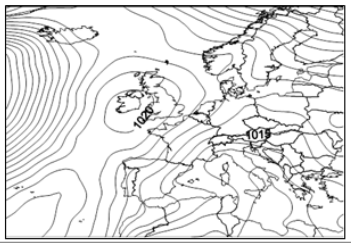
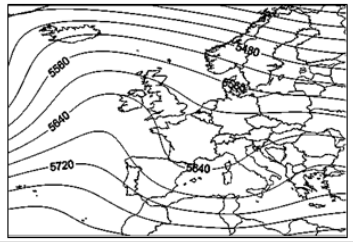
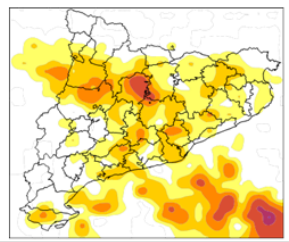
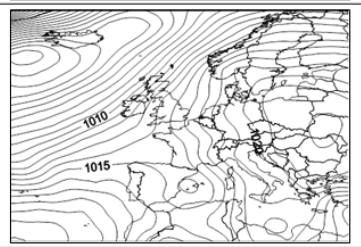
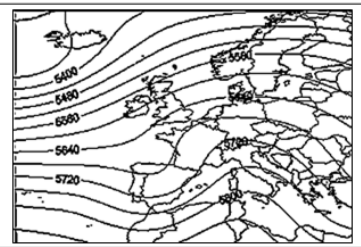
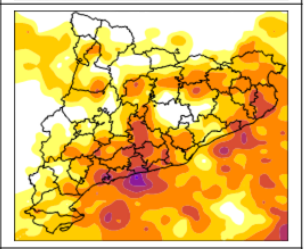
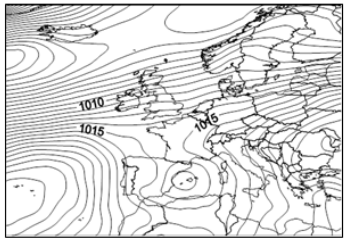
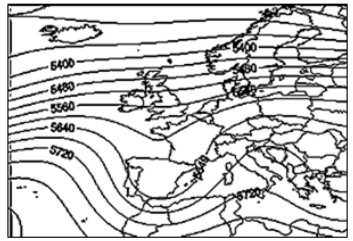
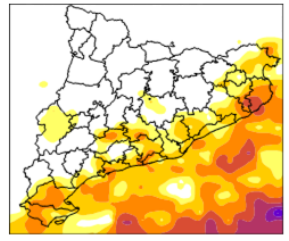
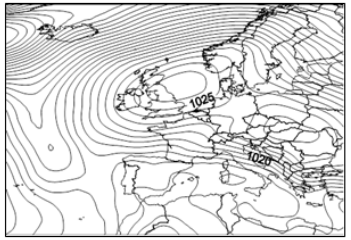
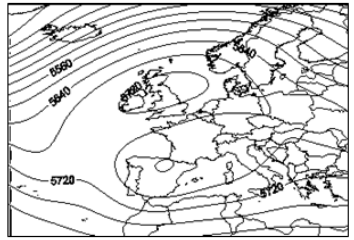
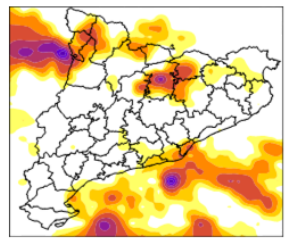
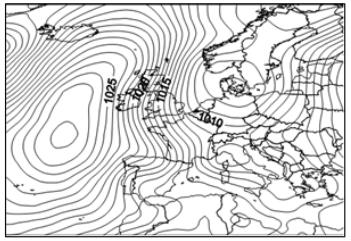
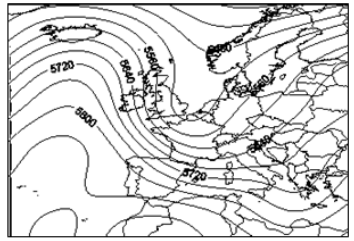
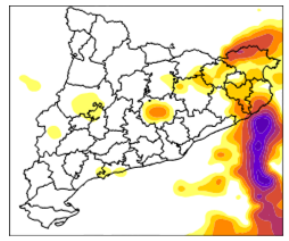
- Vertical Totals index, defined by VT= T850-T500, was chosen as it accounts for the static stability
- Relative humidity at 700 hPa and at 850 hPa (water content at the lower and mid levels)
- Mean Sea Level Pressure (SLP) and geopotential at 500 hPa (Z500) to analyse the obtained synoptic types.
- Ten years (2005-2014) of lightning data provided a total of 1505 significant thunderstorm 6-hour events

Methods

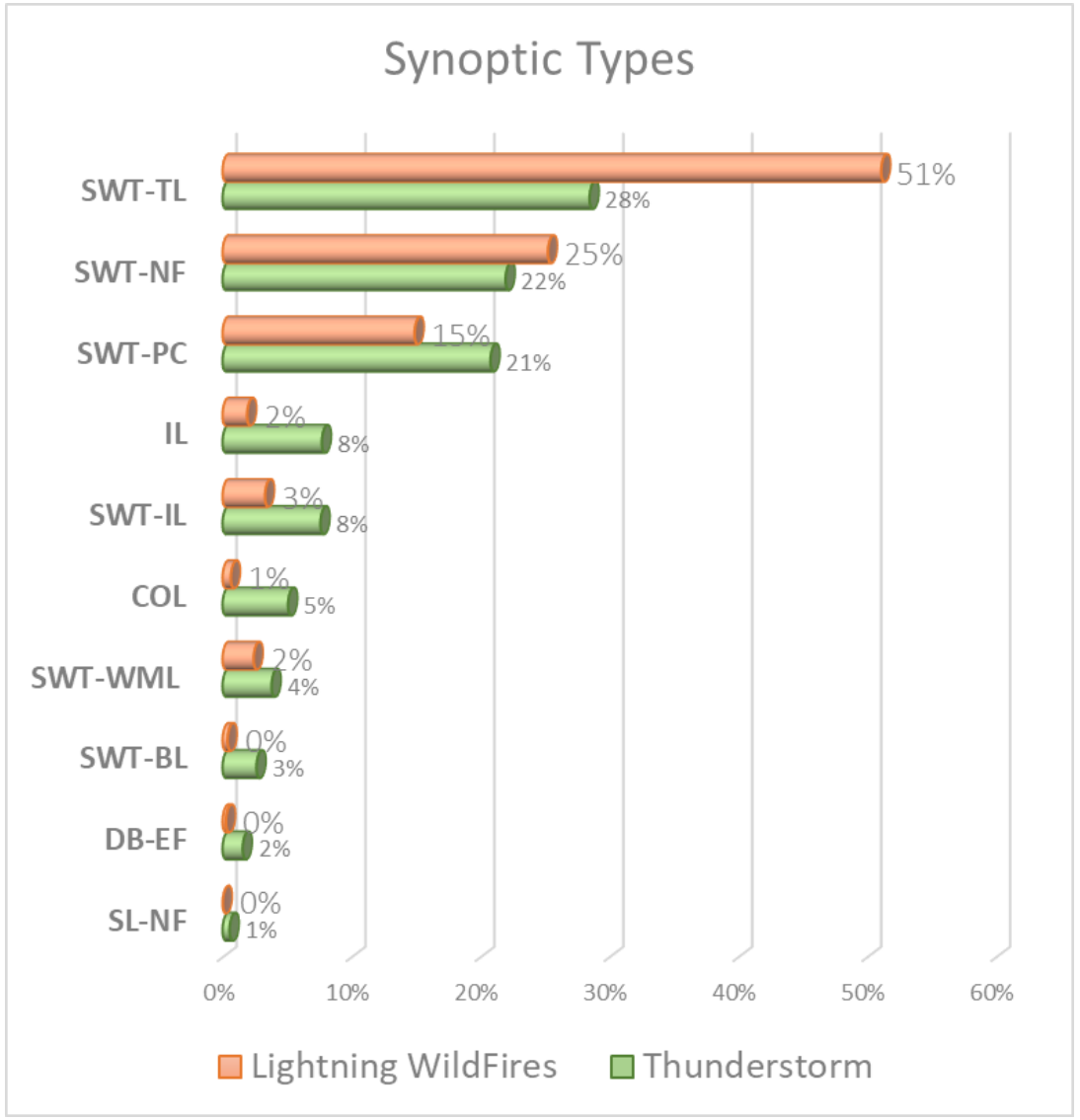
- Principal Component Analysis for data reduction
- Multivariate analysis for classification (Cluster Analysis) (2005-2014)
- Discriminant Analysis for validation (2015-2016)
- Discriminant functions can also be used to classify and/or predict future events in Catalonia (2017-)

10 Synoptic types conductive to lightning

Acronym	Sea Level Pressure (in hPa)	500 geopotential height (in meters)	Lightning activity
SWT-TL			
SWT-NF			
SWT-PC			
SWT-IL			
IL			

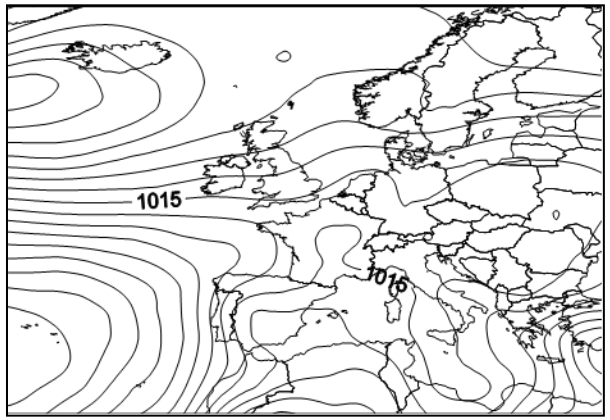
Acronym	Sea Level Pressure (in hPa)	500 geopotential height (in meters)	Lightning activity
SWT-WML			
SWT-IB			
COL			
BOB-EF			
SL-NF			

Synoptic types conductive to lightning-ignited wildfires

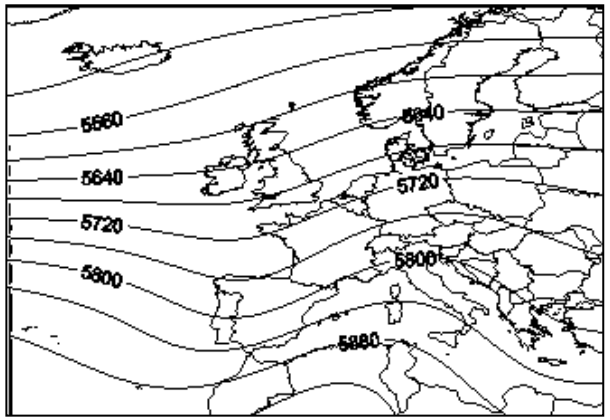


90% LIW concentrates in 3 types

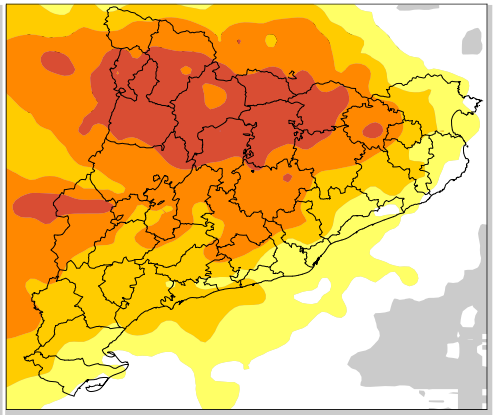
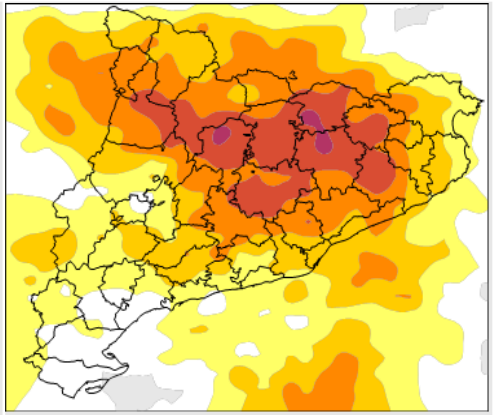
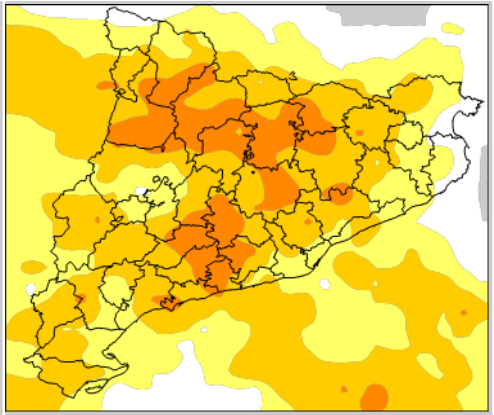
50% LIW occurs under SWT-TL
(Short-Wave Trough + Thermal Low)



Sea Level Pressure
(in hPa)



500 geopotential height
(in meters)

Type	TS events	Area (lightning)	Time (UTC)	Months	Short description	LIW
Short-Wave Trough + Thermal Low	28%		12-24	JAS	Iberian thermal low and a short wave trough at 500 hPa	51%
Short-Wave Trough + Northern flow	22%		12-18	JJAS	Atlantic short-wave trough associated with thermal waves passing in the middle levels of the troposphere. An anticyclonic ridge reaches Catalonia at the surface.	25%
Short-Wave Trough + Prefrontal convection	21%		12-24	MJ + SO	short-wave trough at 500 hPa level with relatively low pressures over Catalonia, especially on the south coast.	15%

Summary

- Thunderstorms in the region are mainly related to atmospheric convection caused by a short-wave trough at the mid-tropospheric level trough, north – south oriented (up to 70 percent of the total, namely the three most frequent categories)

- A thermal low at the surface level (mixed with a trough at mid-level) favours summer thunderstorms and lightning activity

- Surface flows modulate the differences on the spatial distribution of lightning

- Thunderstorms producing lightning-ignited wildfires (LIW) mostly occur under the synoptic types characterised by thermal dynamics (Short-Wave Trough with Thermal Low and SWT with Northern flow)

References (synoptic classification)

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