

# *Spatio-temporal characteristics of heavy precipitation observed over the last 20 years on French Riviera coastal catchments.*

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# Aim of the study

- Context: the French Riviera is often hit by floods caused by intense rainfall events
- Motivation: take advantage of new grided rain products to describe the past intense rainy events temporally and spatially

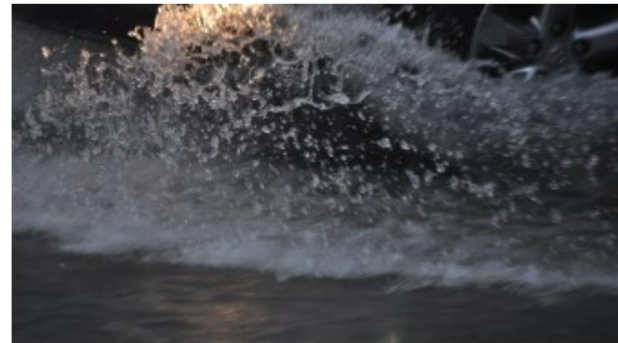


## 1 Dead, 3 Missing After Flash Floods in South East France

28 NOVEMBER, 2014

A heavy storm triggered flash floods in south east France yesterday, Thursday 27 November 2014. Later on Thursday the French Interior Ministry confirmed that one woman had died in the...

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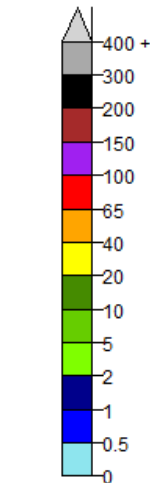
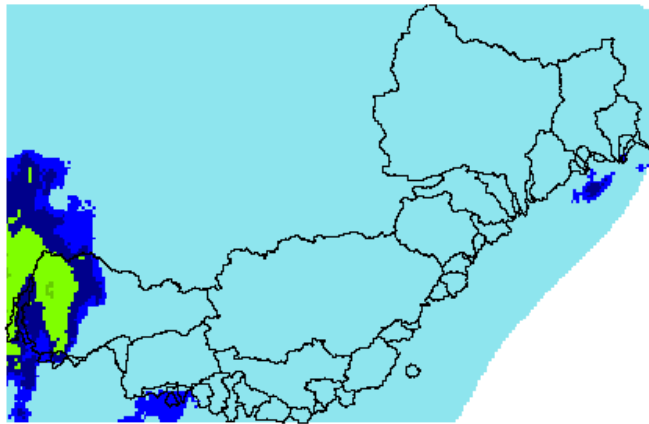
## France – Death Toll Mounts in Riviera Floods as Natural Disaster Declared

4 OCTOBER, 2015

Heavy storms, torrential rain and floods in the popular tourist area of Cote d'Azur in the south-east of France have left at least 16 people dead with 5 or more...

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COMEPHORE RAINFALL 1H  
2015-10-03 08:00:00



1H RAINFALL  
[mm]



## France – 2 Missing After Torrential Rain Triggers Floods in South

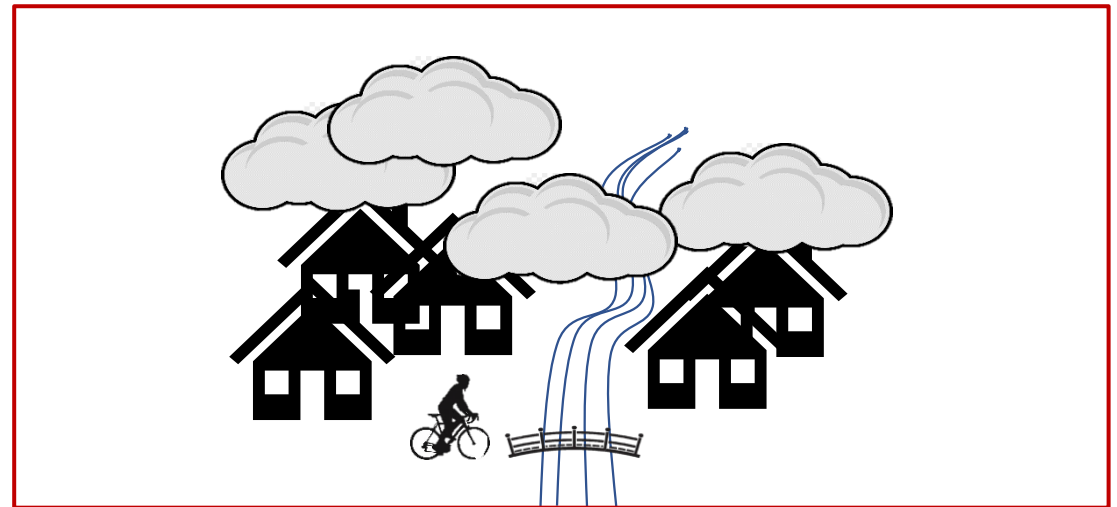
21 SEPTEMBER, 2020

At least 2 people are missing after torrential rain triggered flash flooding in the Gard, Lozère and Herault departments of southern France. Meteo France reported violent thunderstorms hit the foothills...

[Read Full Article](#)

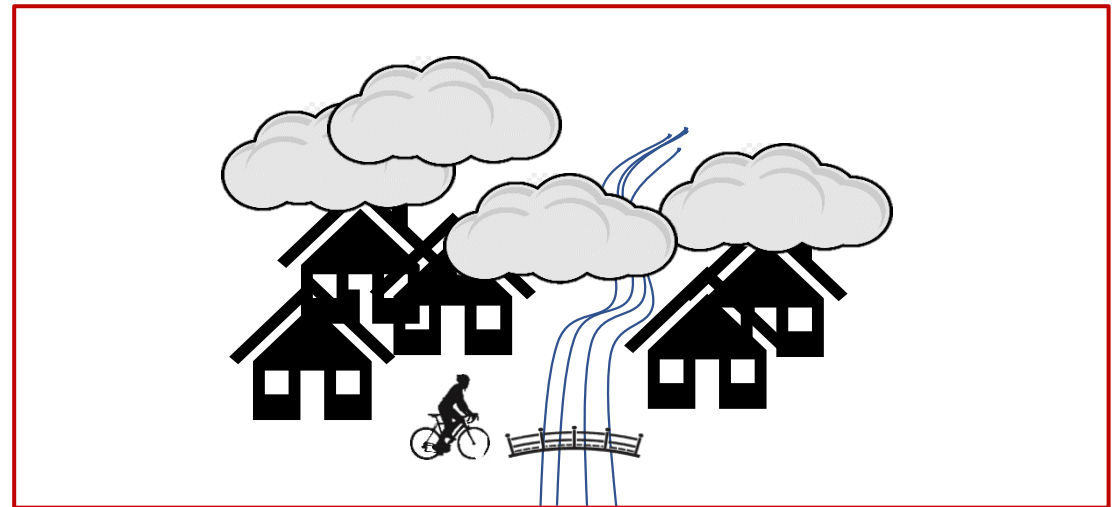
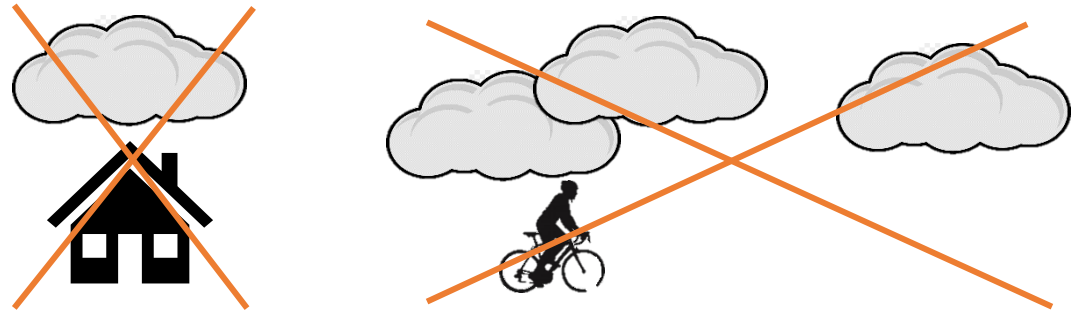
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- Motivation: take advantage of new grided rain products to describe the past intense rainy events temporally and spatially
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- Area: French Riviera (47 bassins, Total area = 12 000 km<sup>2</sup>)
- Time window: 1997-2020

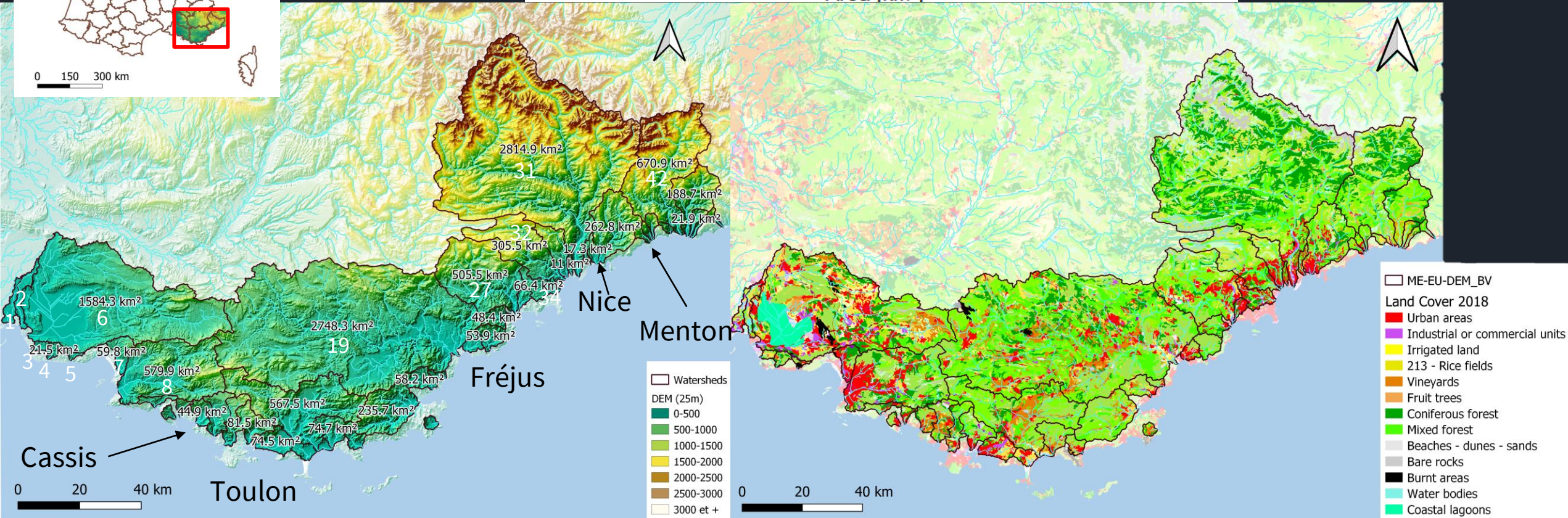
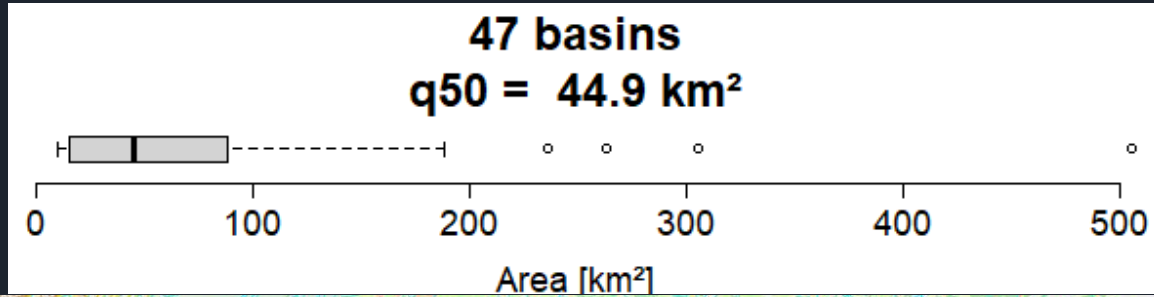
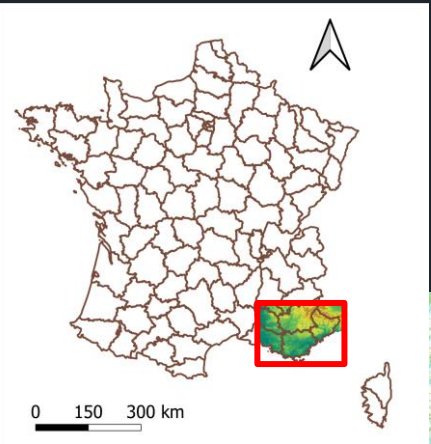


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- Objectives :
  - **How to define** an intense precipitation event?
  - **How to select** them?
  - **How to characterize** them?



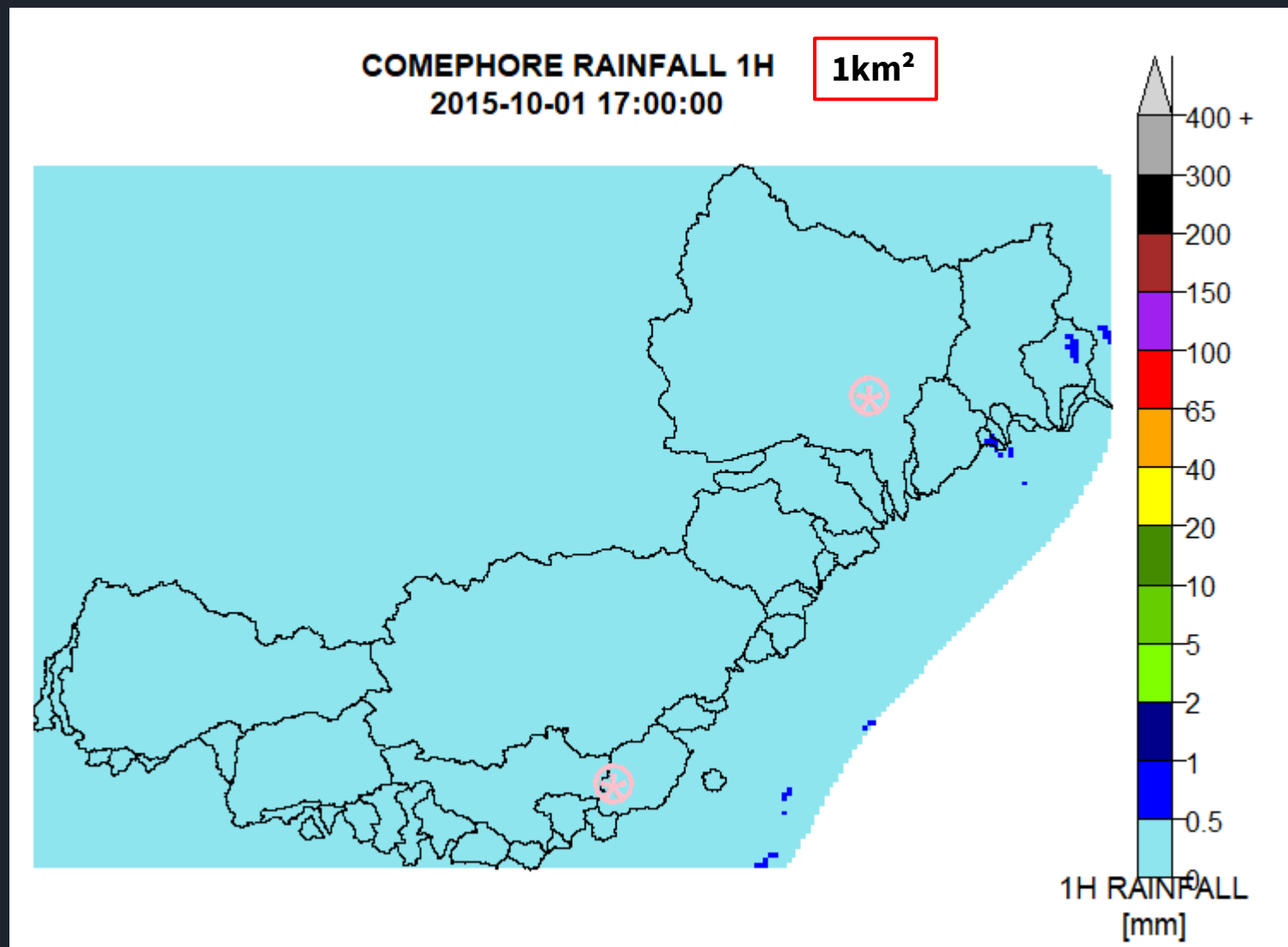
# Studied Area



25m DEM (*European Environment Agency, EEA*)

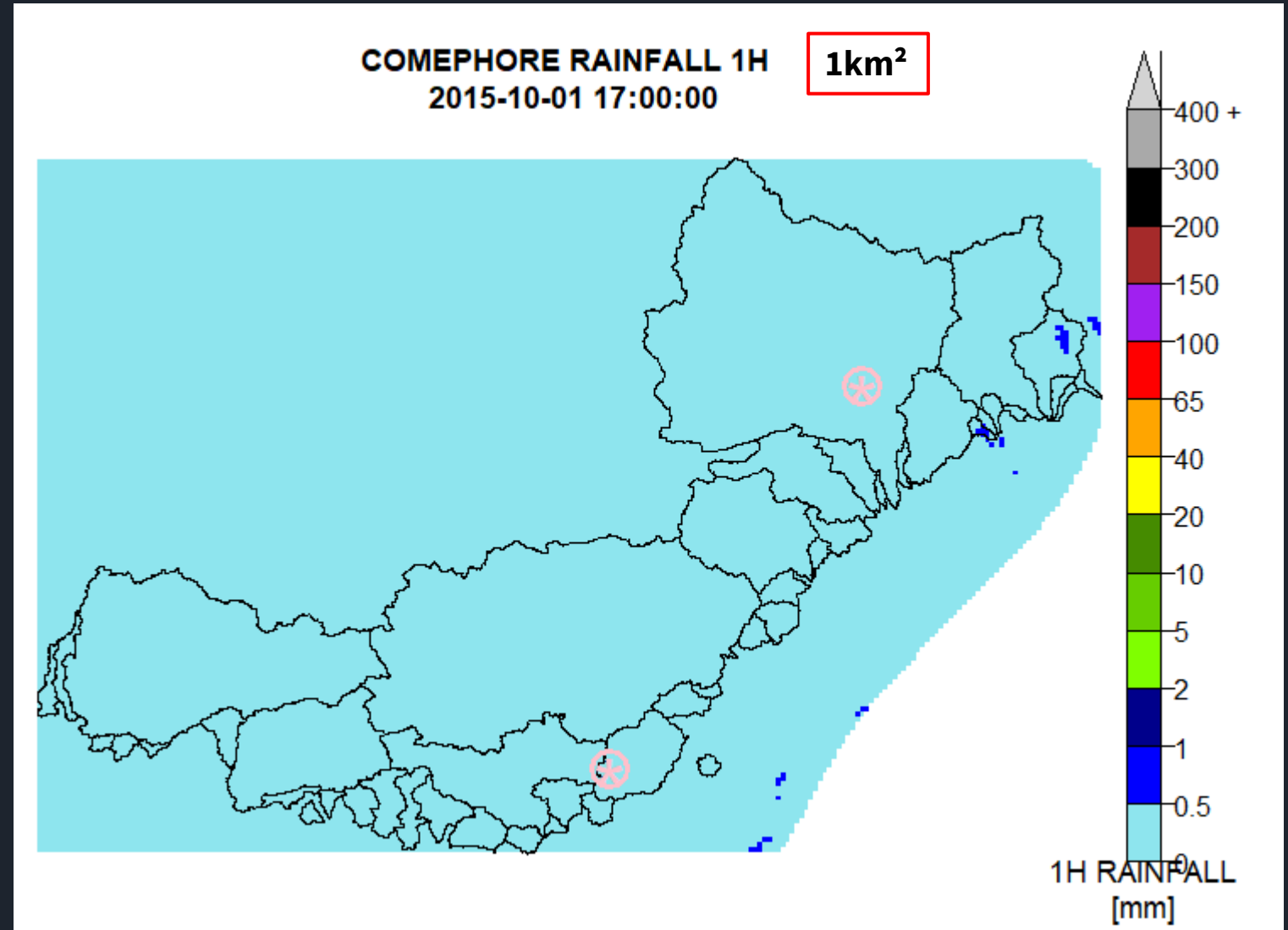
Land Use : Corine Land Cover 2018 (*Bossard et al., 2000*)

- Rainfall: **COMEPHORE** database (Tabary et al., 2012)
- Radar + raingages measurements
- Produced by Météo-France
- Spatial resolution: 1 km x 1 km
- Timestep: 1 hour
- From 1997 to 2021



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**!** different production methods used for the radar rainfall estimation in COMEPHORE between 1997-2006 and 2007-2019 and 2019-2021  
⇒ We only focus on the 2007-2019 period in the rest of this study





# How to define an intense event?

## Intense rainfall events automated selection

User-defined rainfall thresholds:

- 40 mm / 1 hr ;
- 65 mm / 3 hr ;
- 100 mm / 24 hr.

Selection area extent: 25 km<sup>2</sup>.

Time independence hypothesis:  
24 h minimum between 2 events.



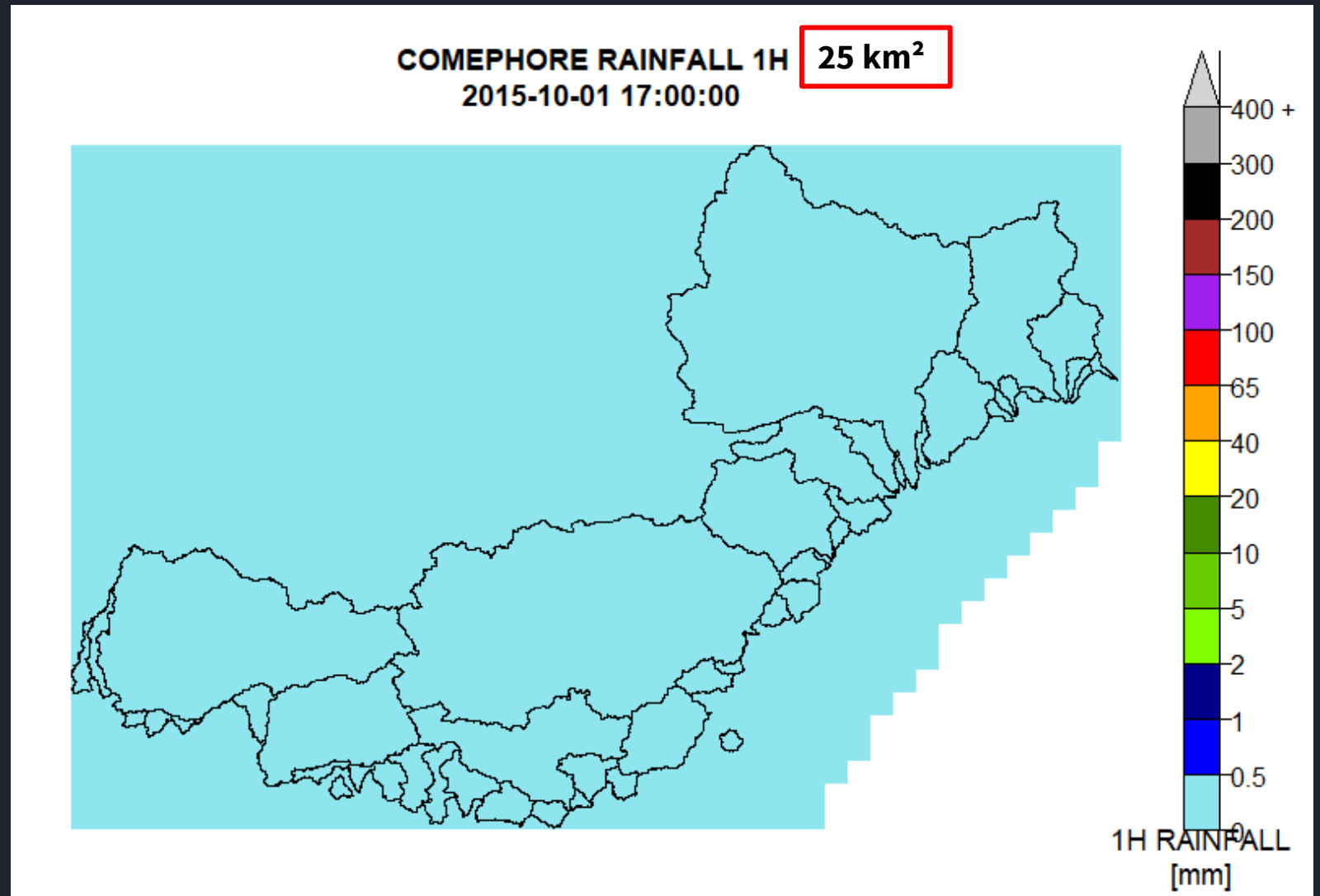
Source : <https://www.prometeo.asso.fr/membres/predict/>





# How to select all intense events?

- Automated selection
- degrade the COMEPHORE gridded data by averaging the rainfall over 25 km<sup>2</sup>.
- (Temporal aggregation by sliding average the rainfall over 3h / 24h)
- select the time steps for which the cumulative rainfall is above the rainfall thresholds defined for intense rainfall events
- collect time steps that are consecutive or less than 24 hours apart





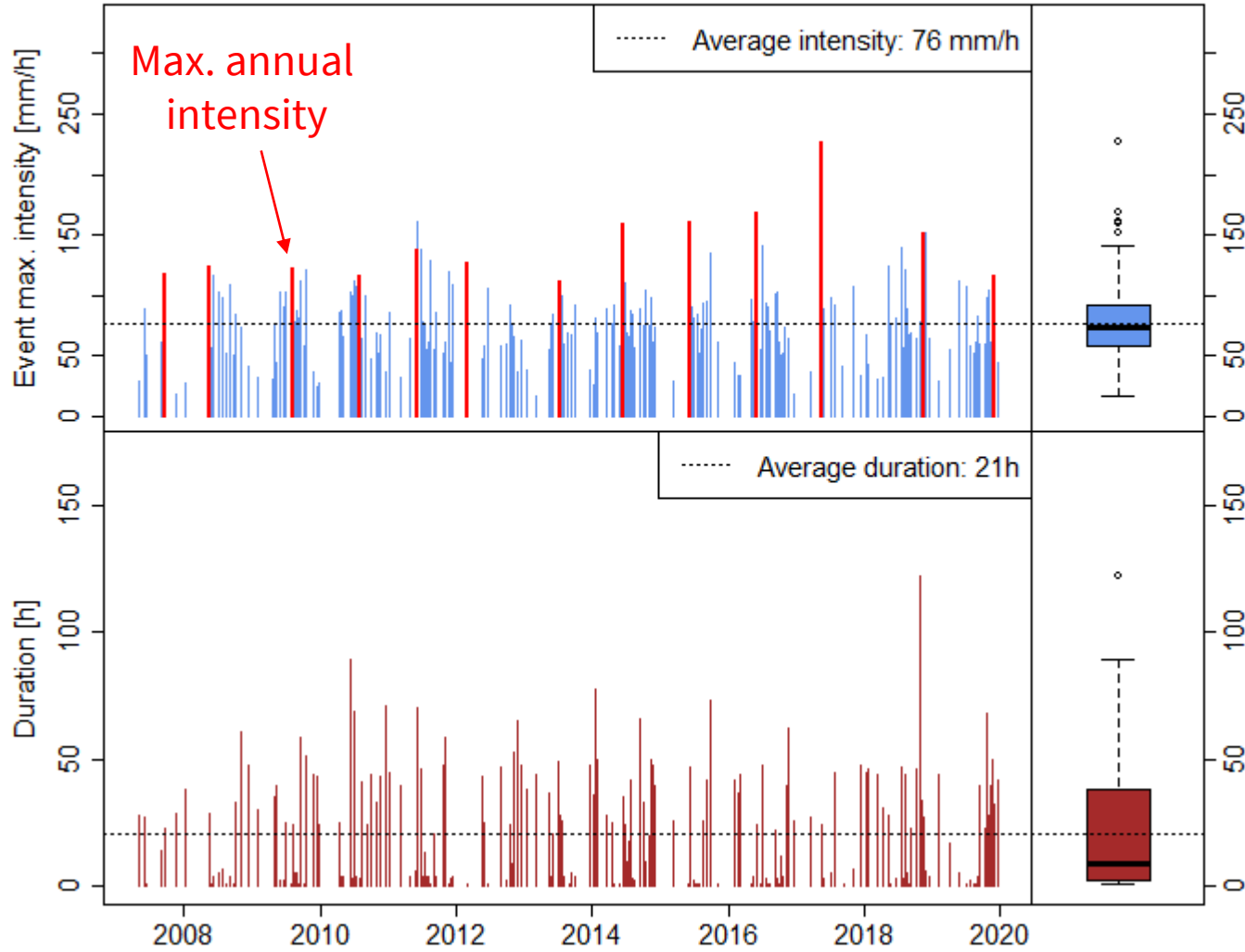
# How to characterize these intense events?

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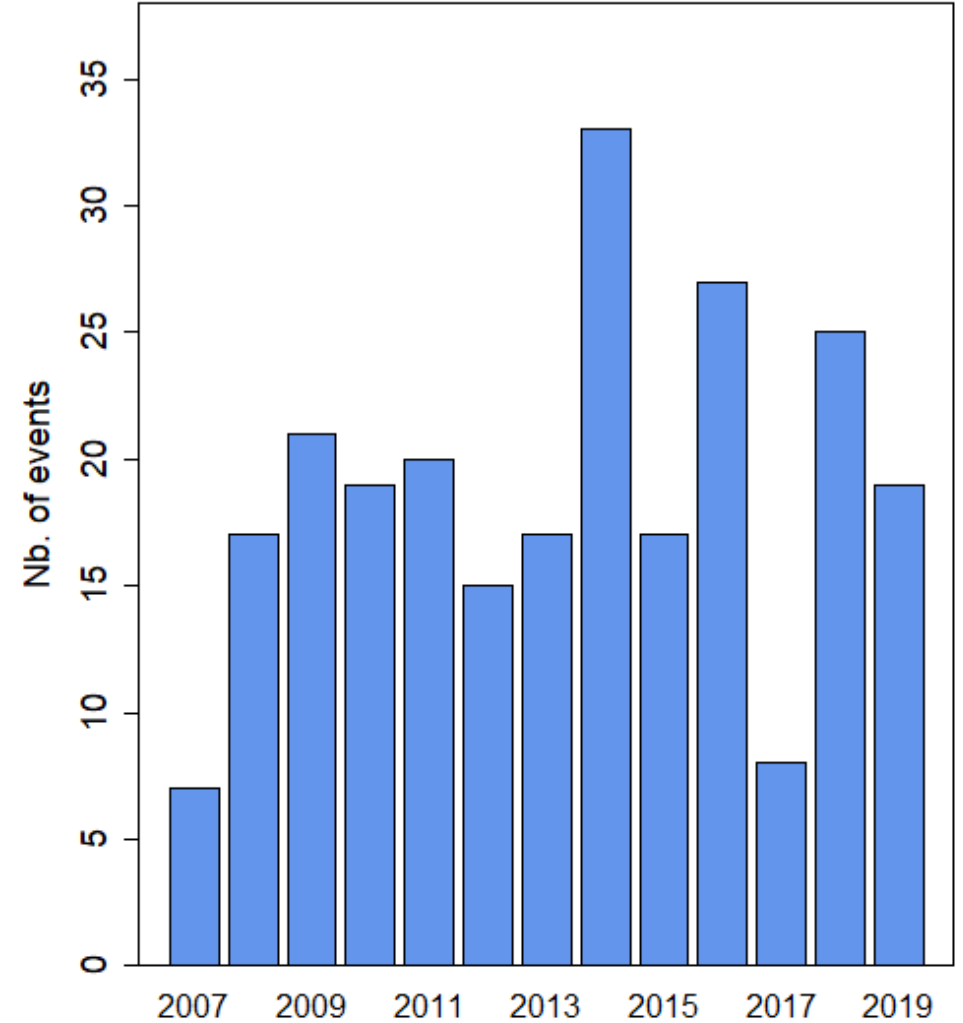
All events:

- Maximum point intensity (1km)
  - Duration
  - Frequency
  - Seasonality, regime: which time of the year is the most likely to observe these intense episodes
  - Weather pattern associated: determine whether a weather pattern is the most likely to generate intense rainfall on the studied area
  - Position of the cells observing the maximum point intensity: the area most likely to observe episodes defined as intense
- 
- Basins rainfalls at each time step
  - Portion of each basin impacted
  - Position of the cell with the maximum point intensity of precipitation at each time step: maximum point intensity tracking
  - How long each cell spends above each precipitation threshold

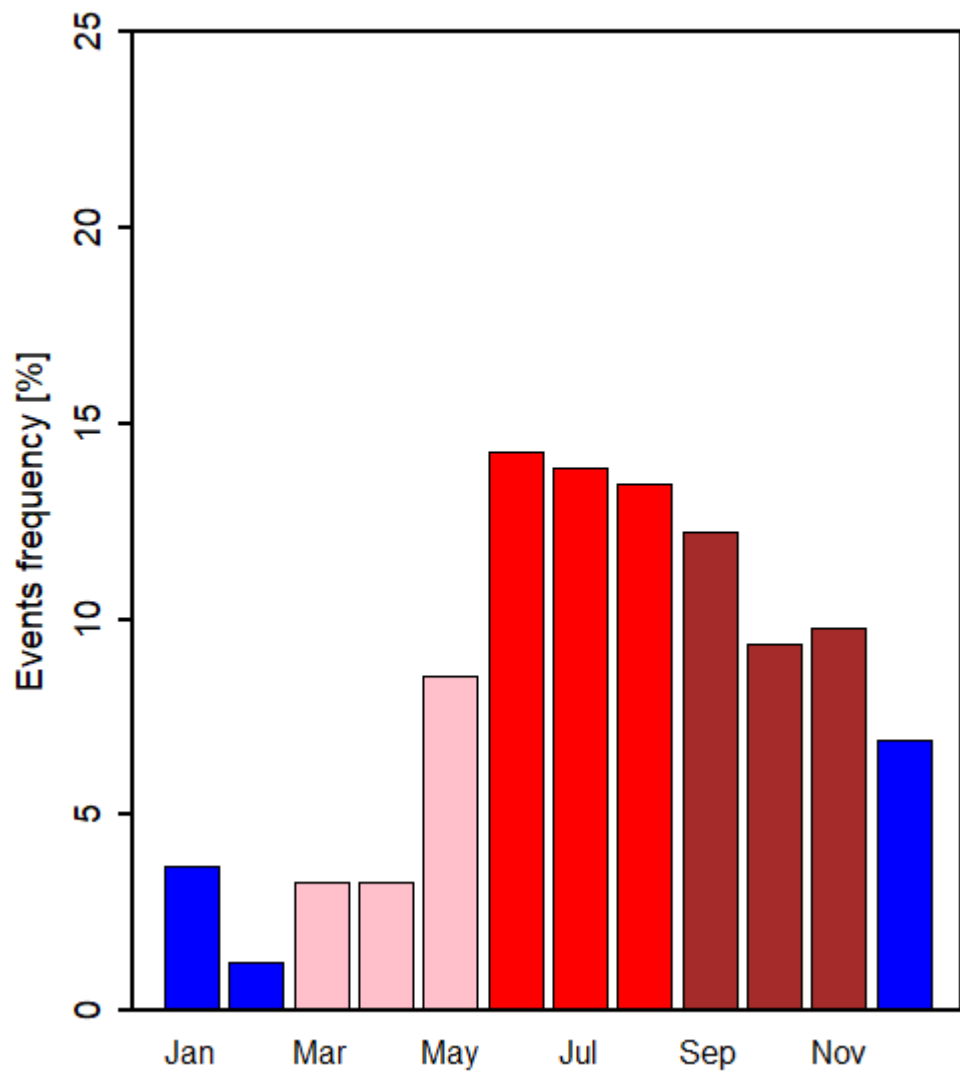
### 245 independent events



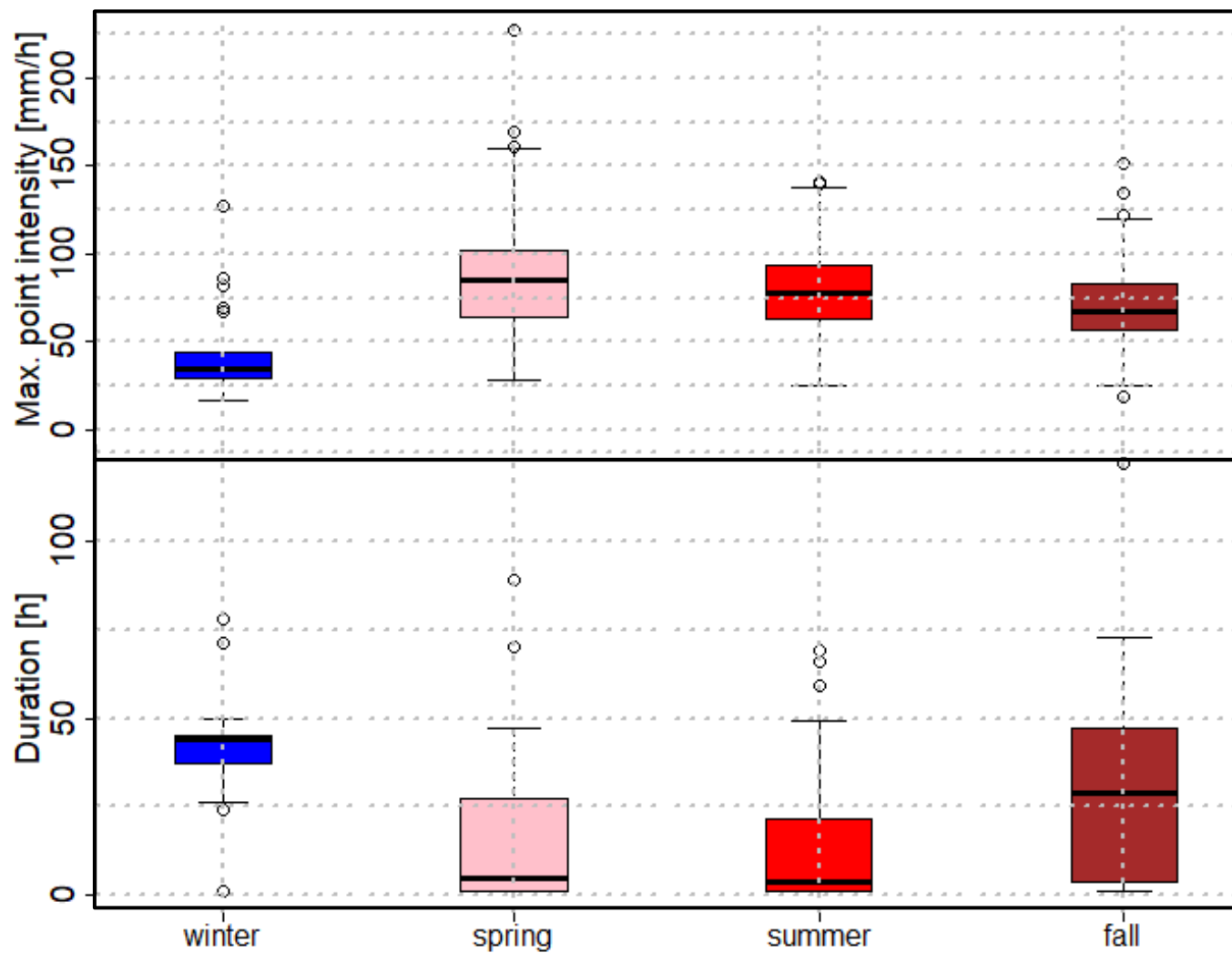
### 2007 - 2019



2007 - 2019



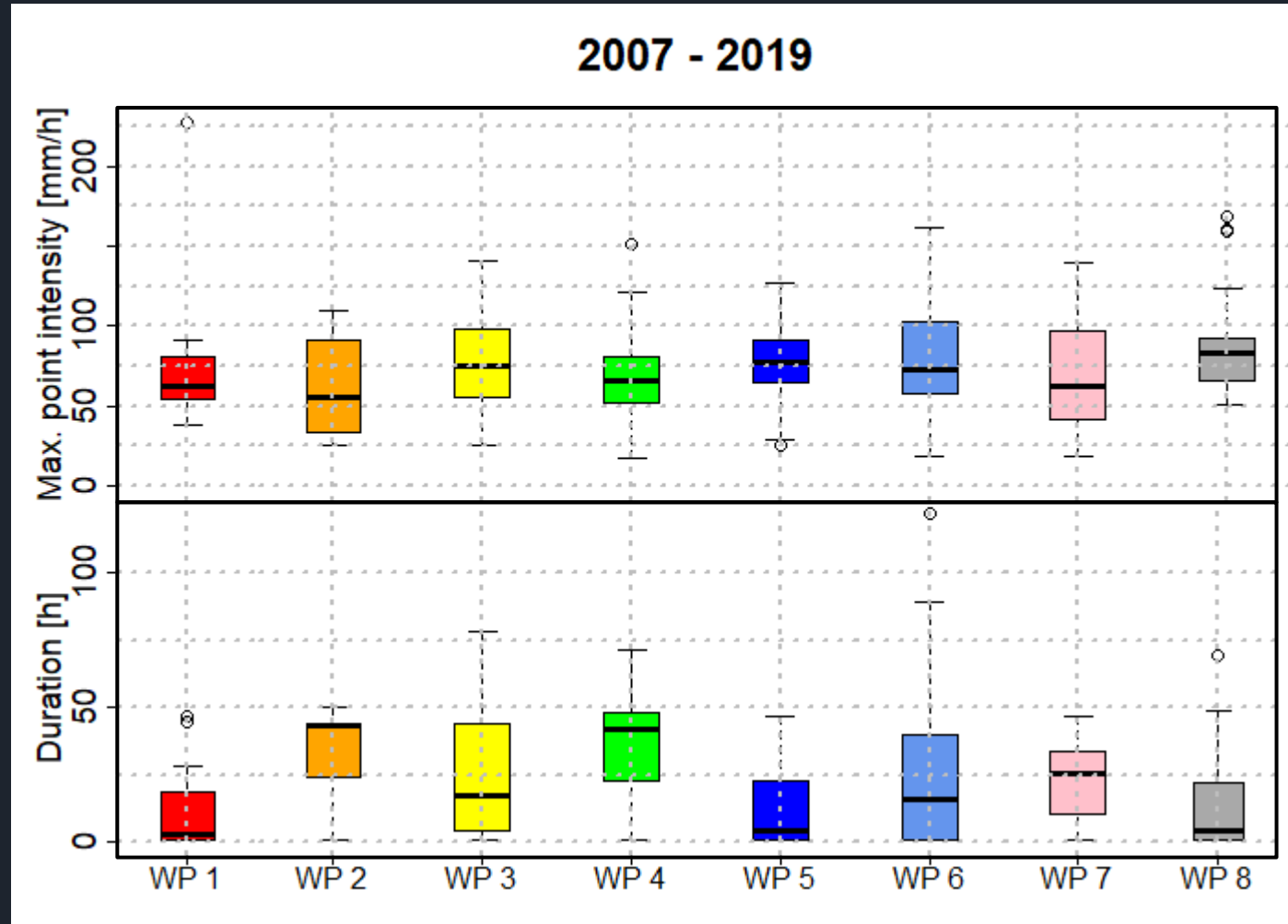
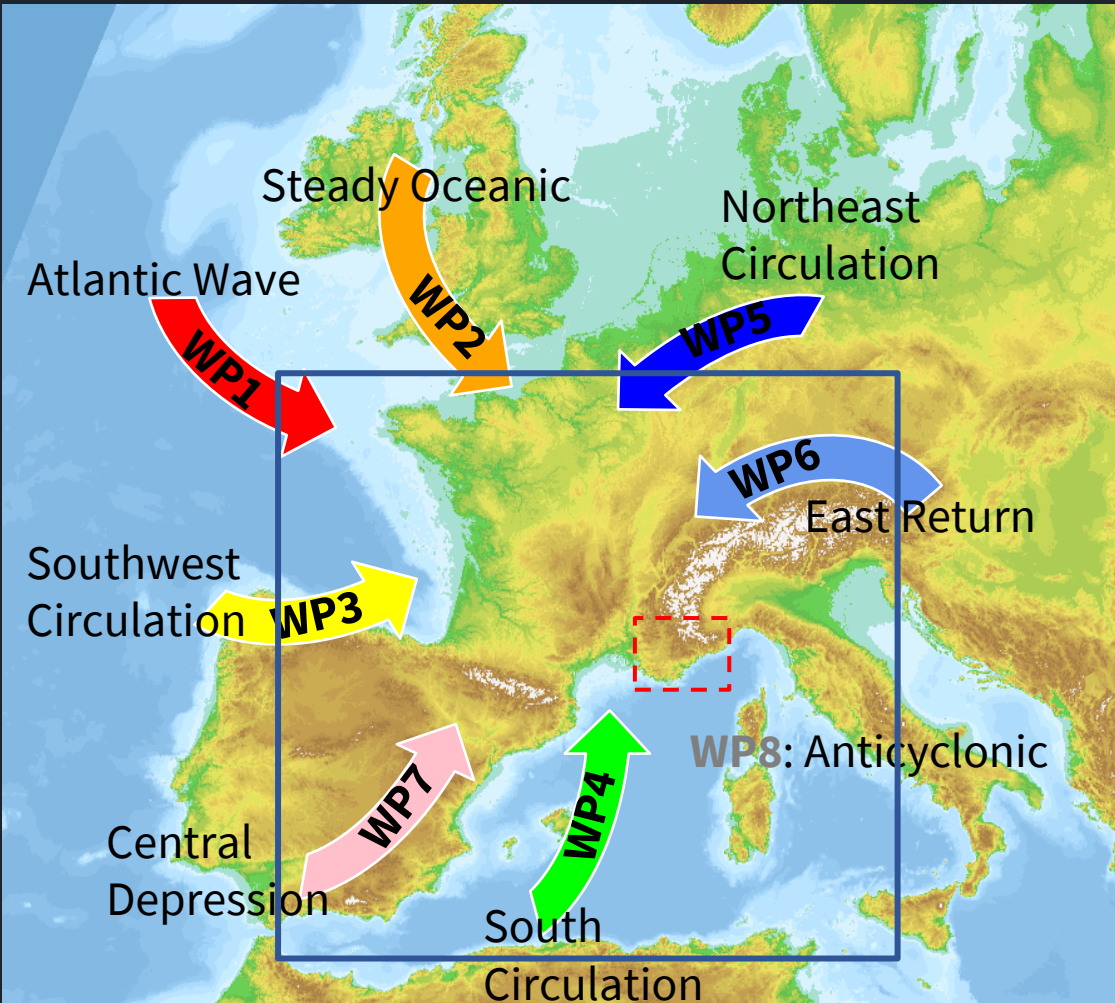
2007 - 2019





# Weather patterns (WP)

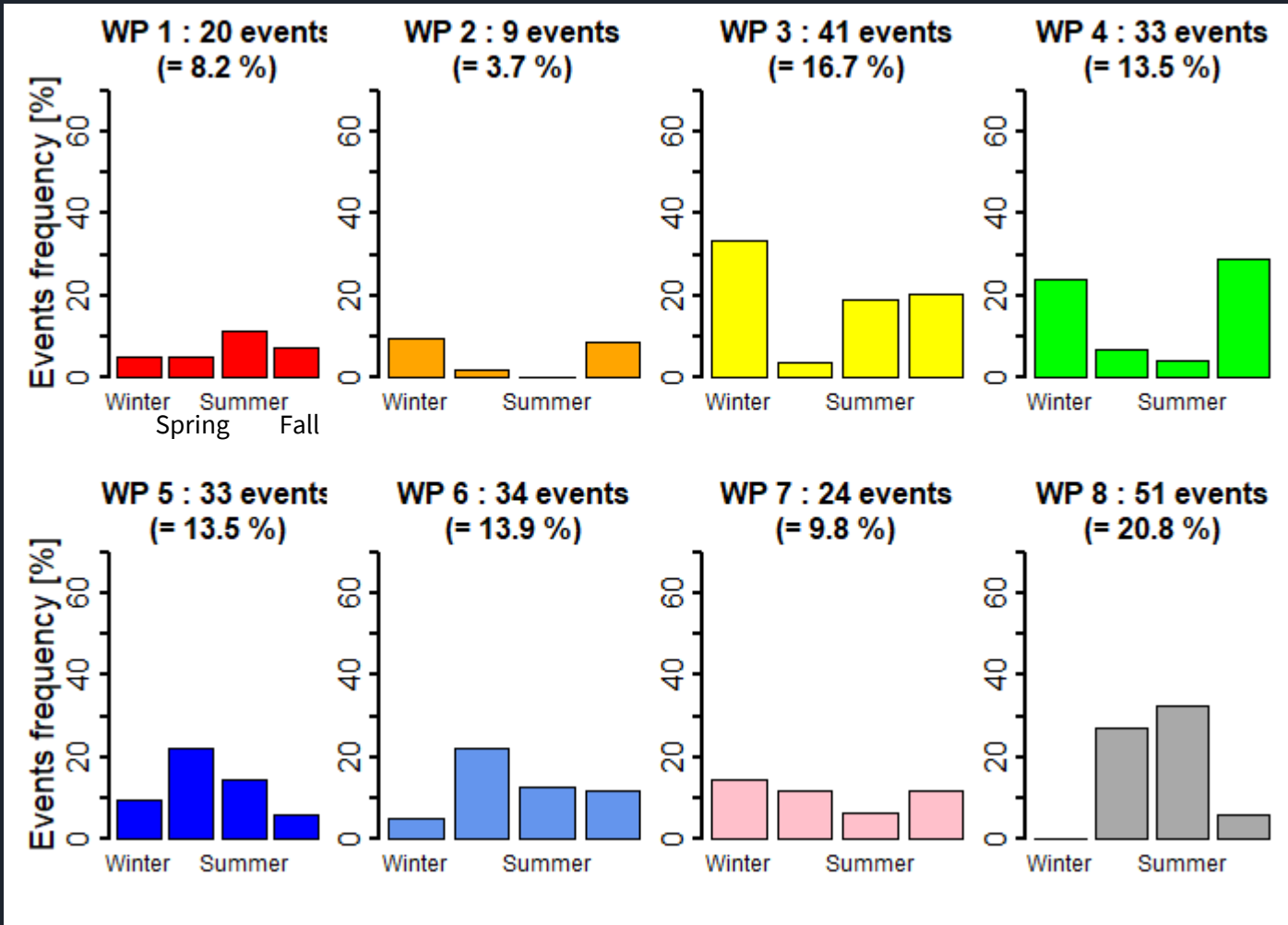
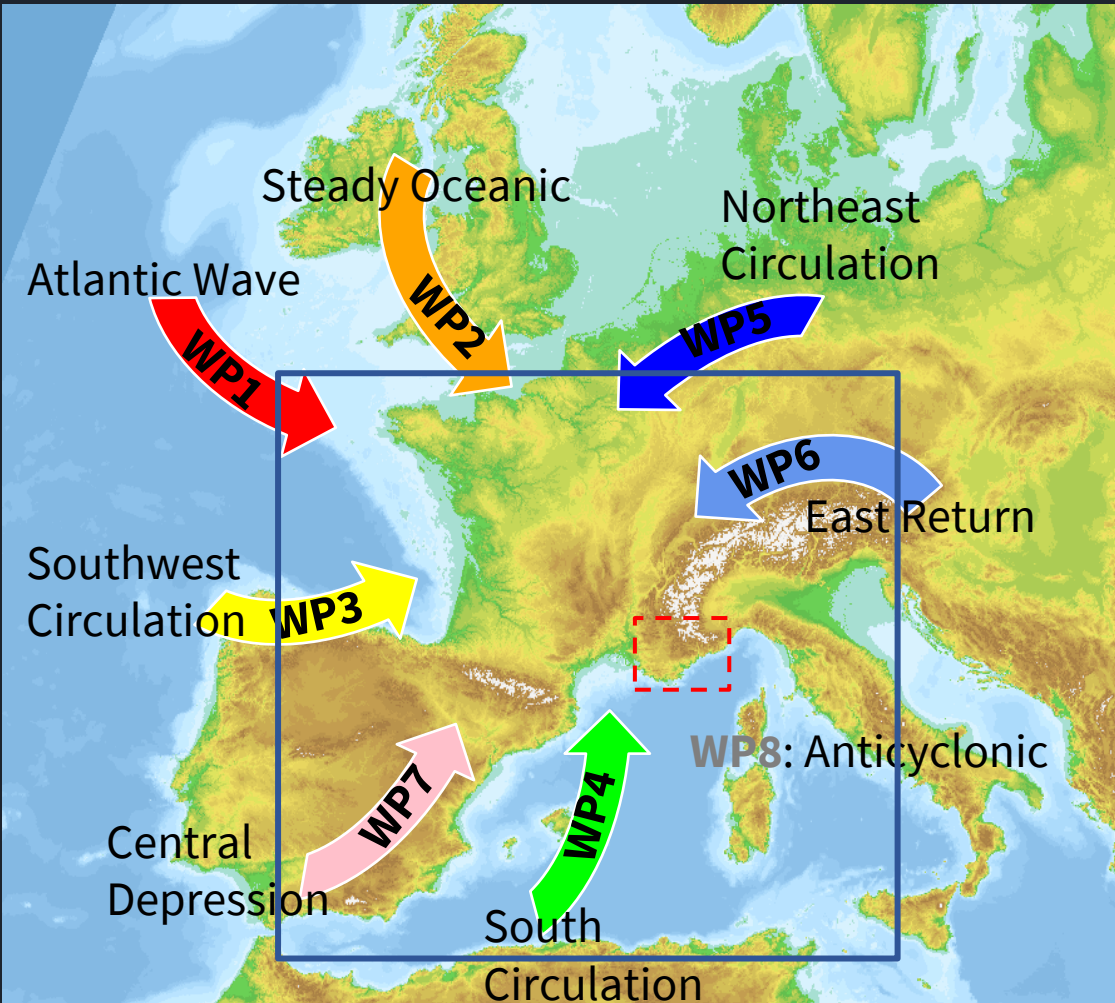
8 French WP defined by Garavaglia et al. (2010), defined at the daily time step over France (see Garavaglia et al., 2010 and Brigode et al., 2013 for more details):





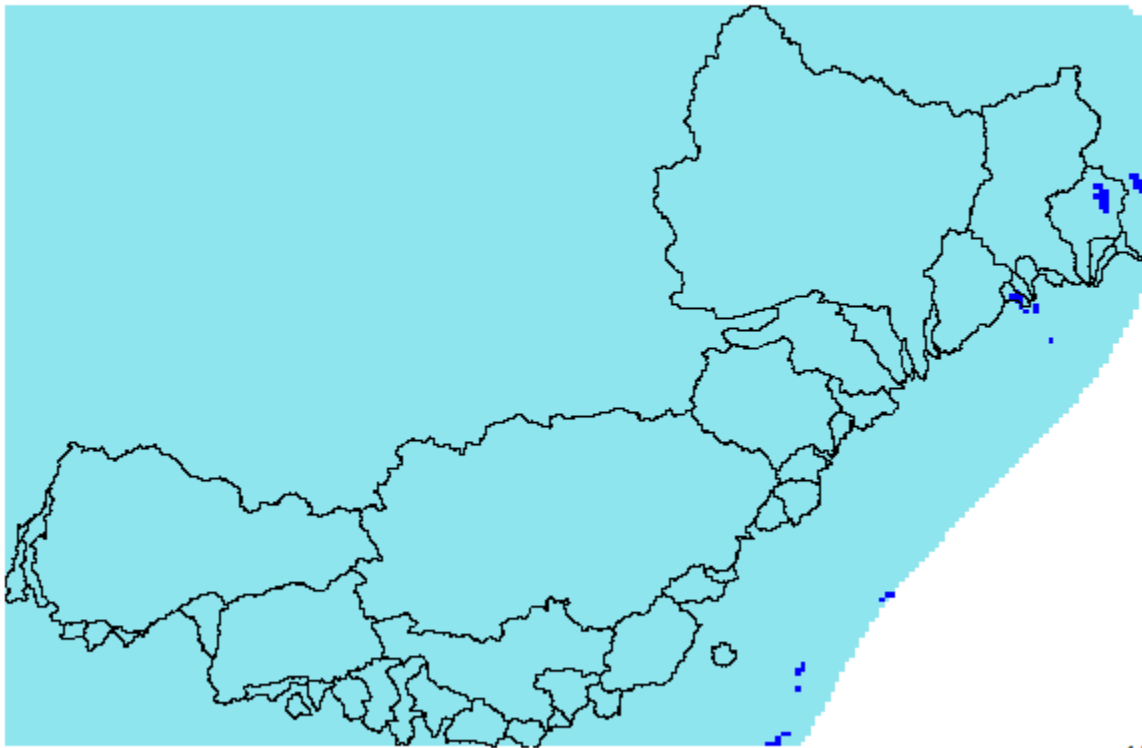
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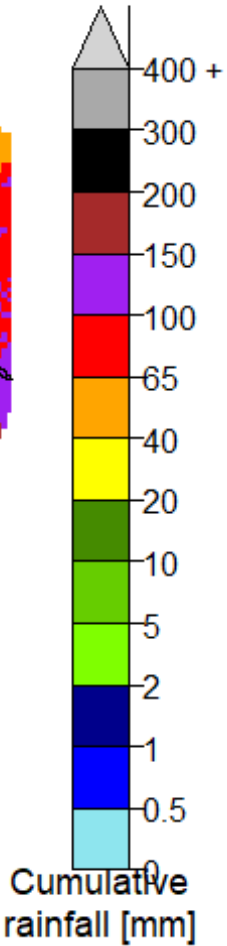
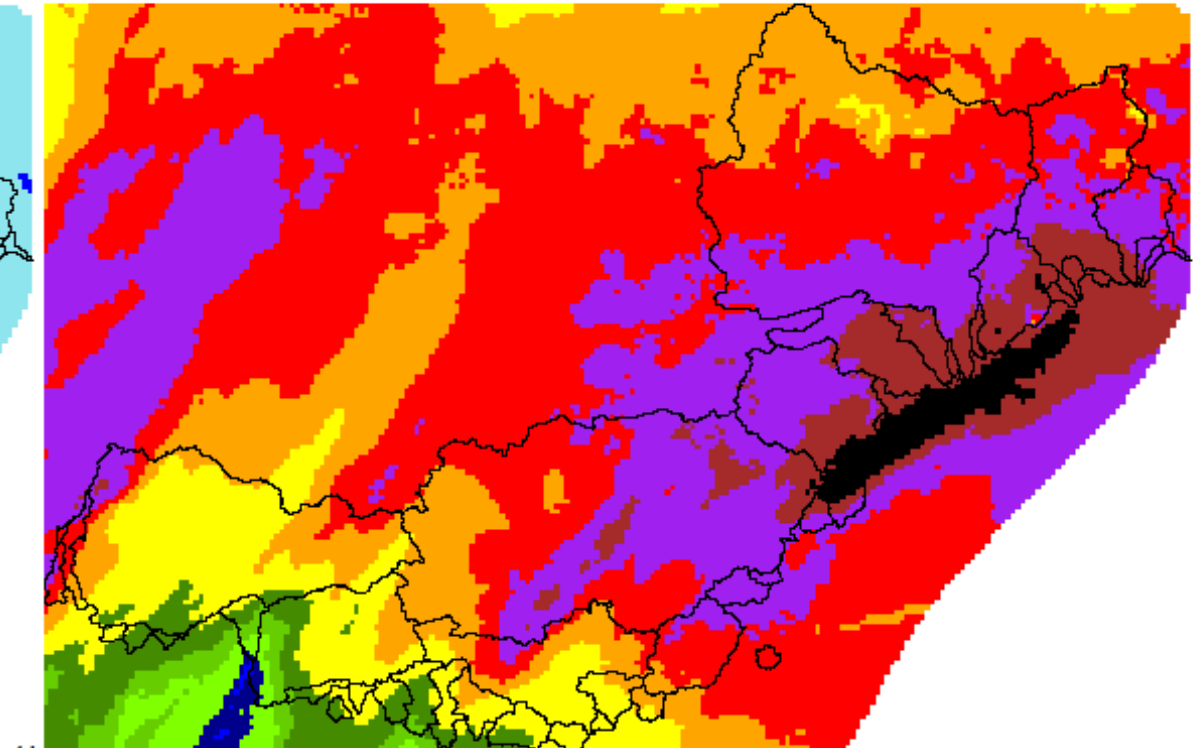




**COMEPHORE RAINFALL 1H**  
2015-10-01 17:00:00

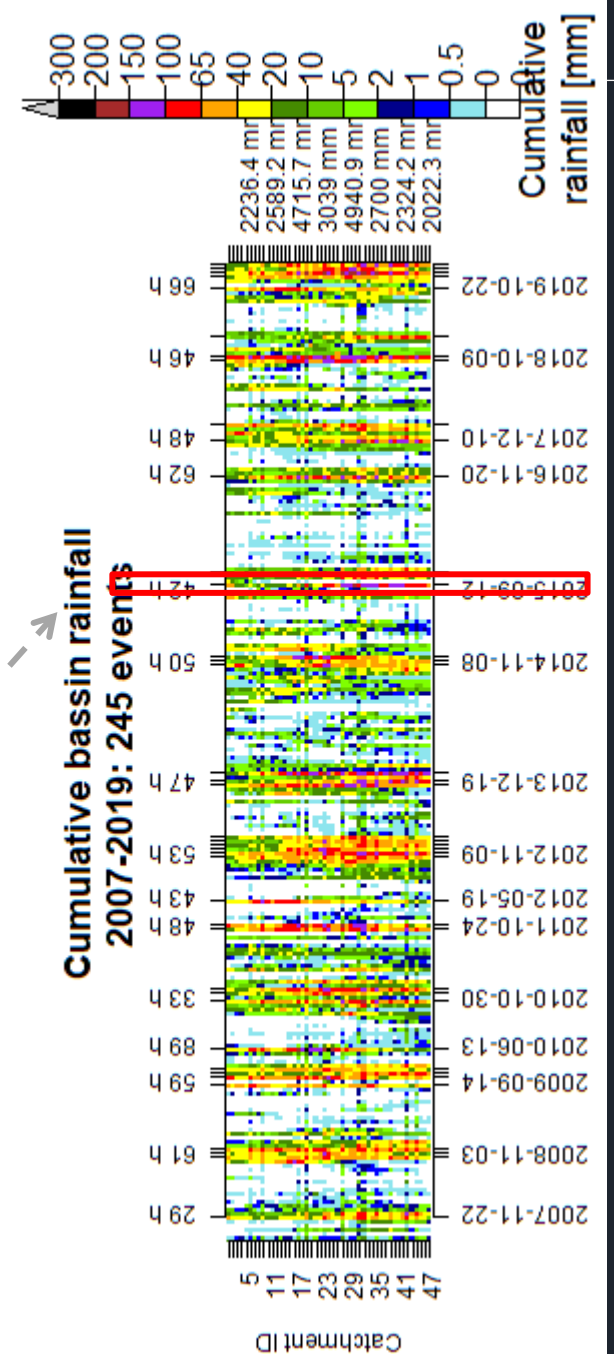
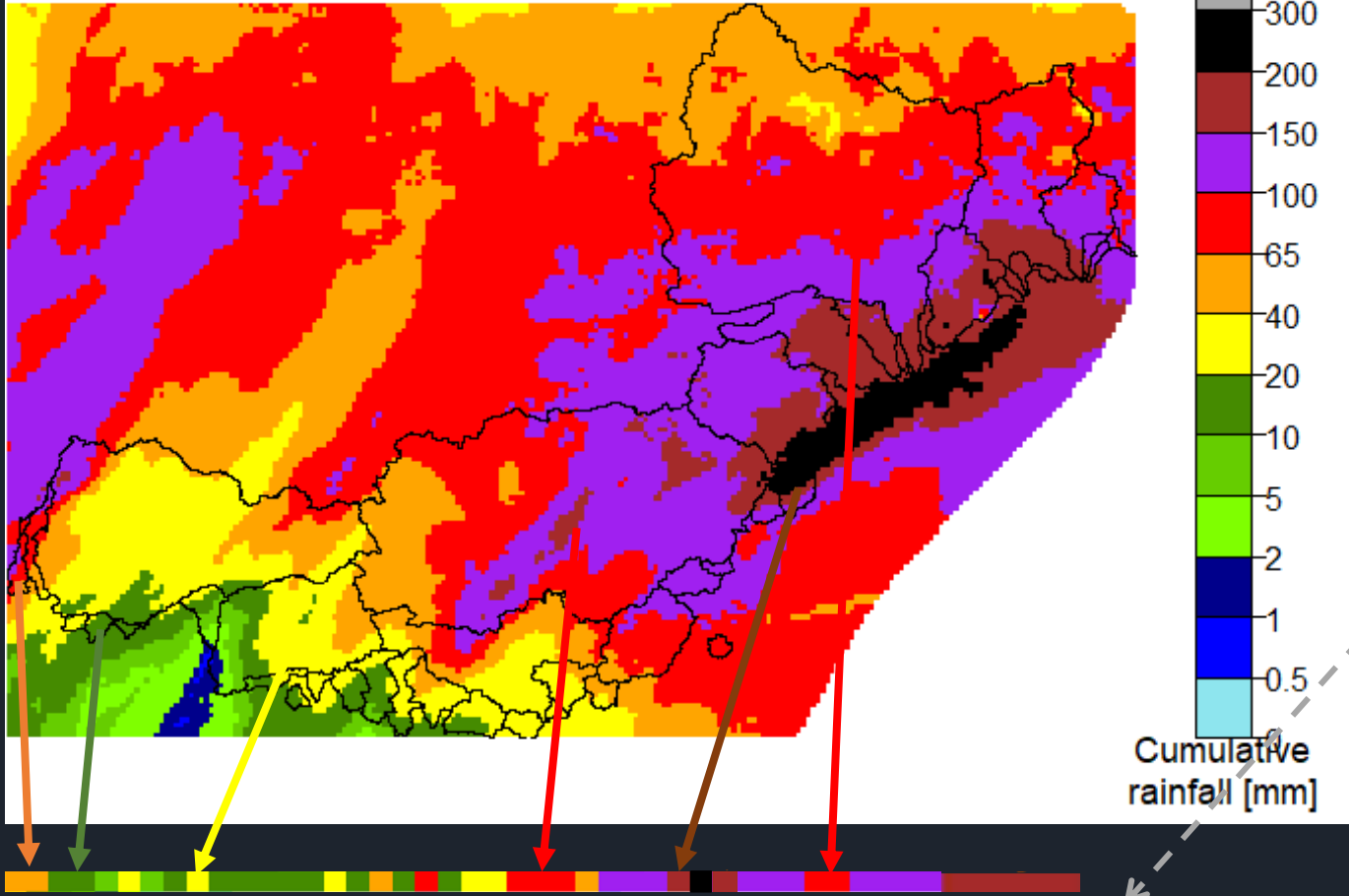


**COMEPHORE RAINFALL 74h**  
2015-10-01 17:00:00  
2015-10-04 18:00:00





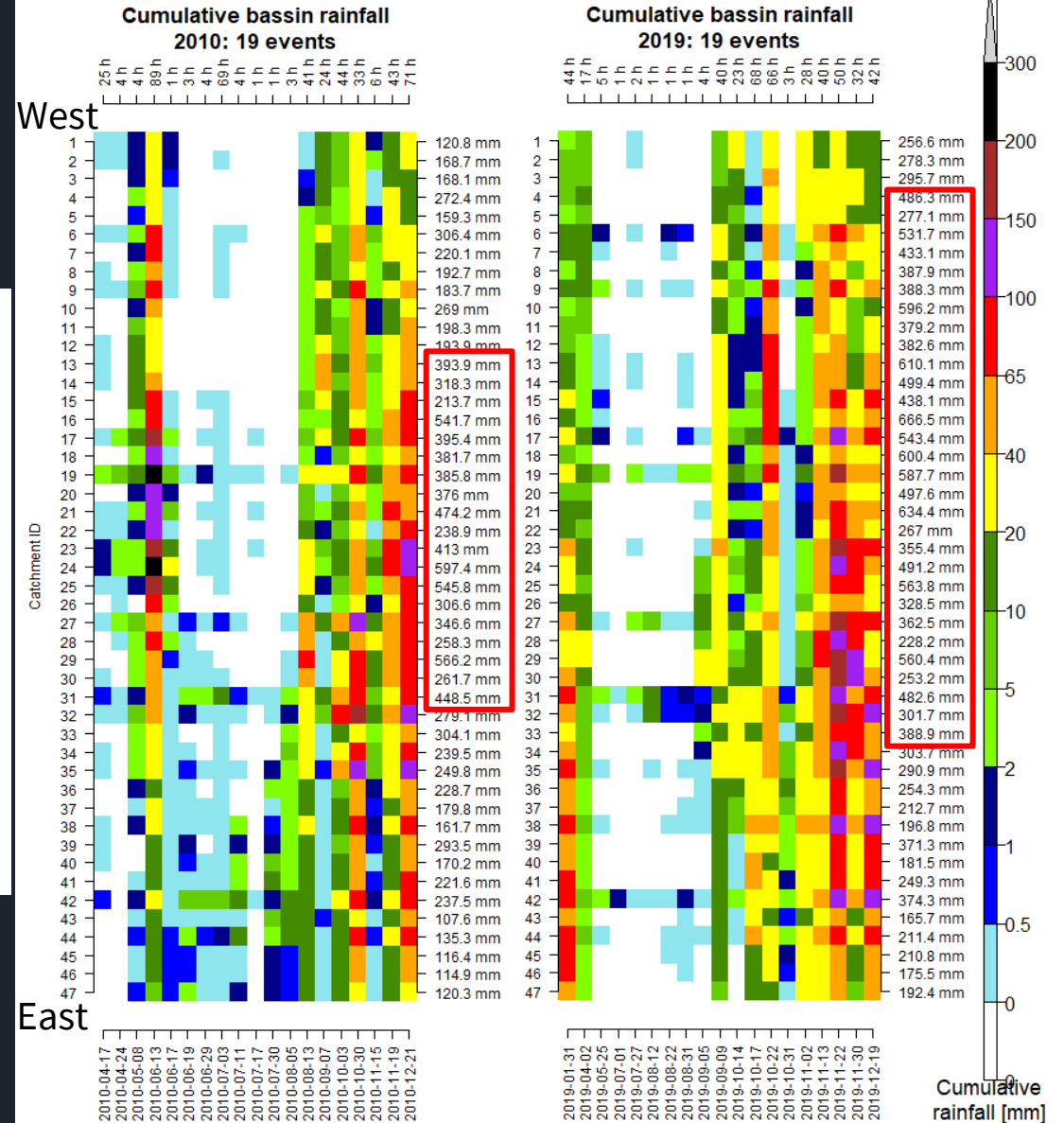
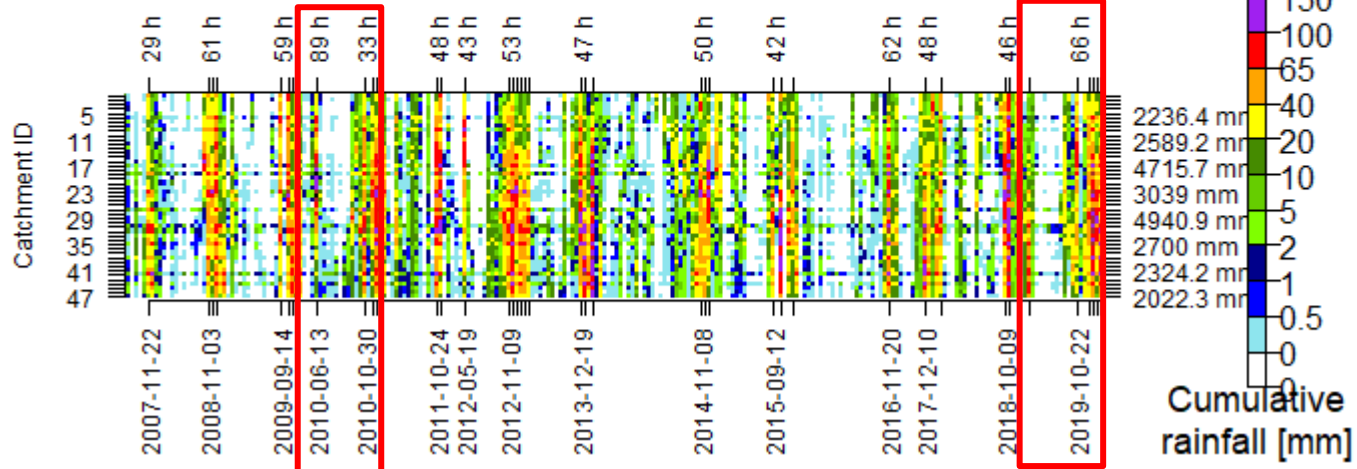
**COMEPHORE RAINFALL 74h**  
2015-10-01 17:00:00  
2015-10-04 18:00:00

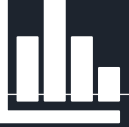




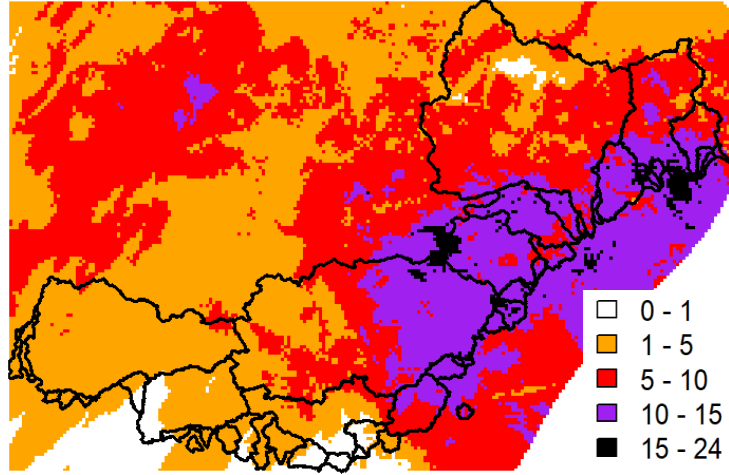
# Spatial characteristics

**Cumulative basin rainfall  
2007-2019: 245 events**

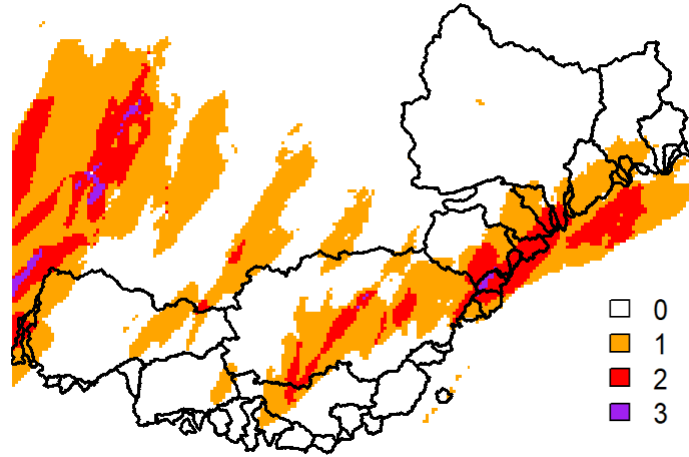




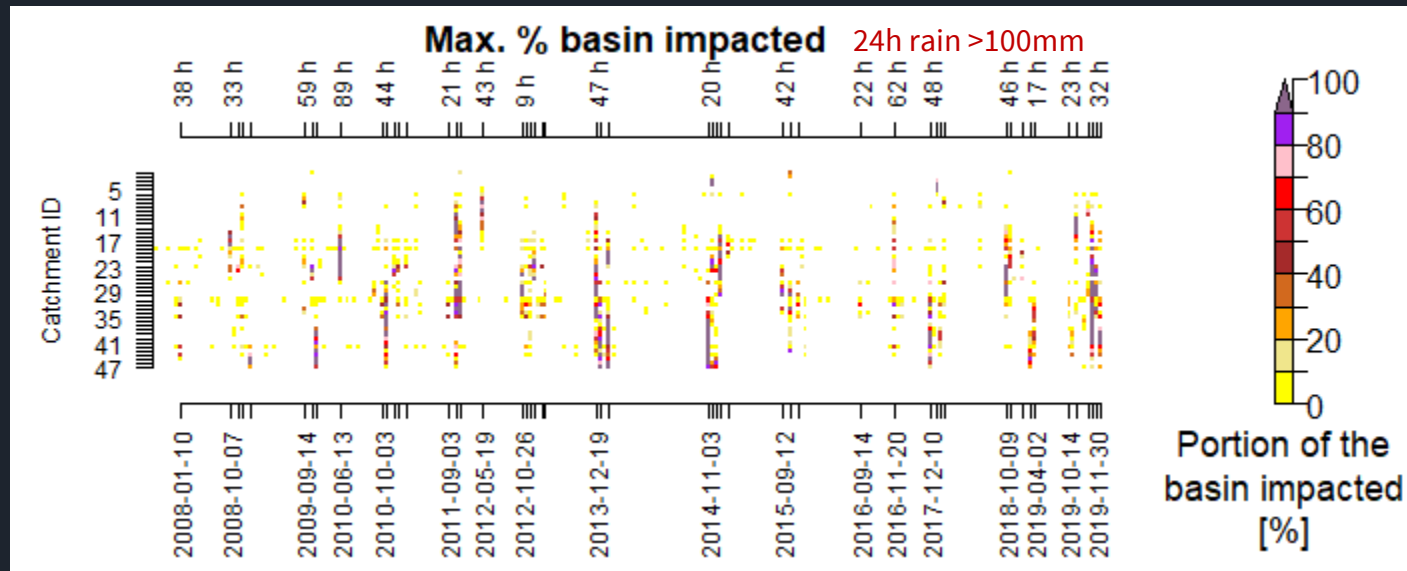
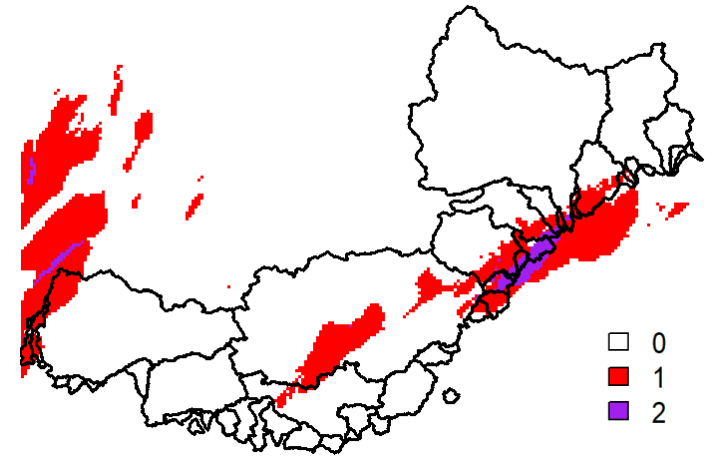
Number of times each cell exceeds the threshold over 24 hours: 4.2mm/h



Number of times each cell exceeds the threshold over 3 hours: 21.7mm/h

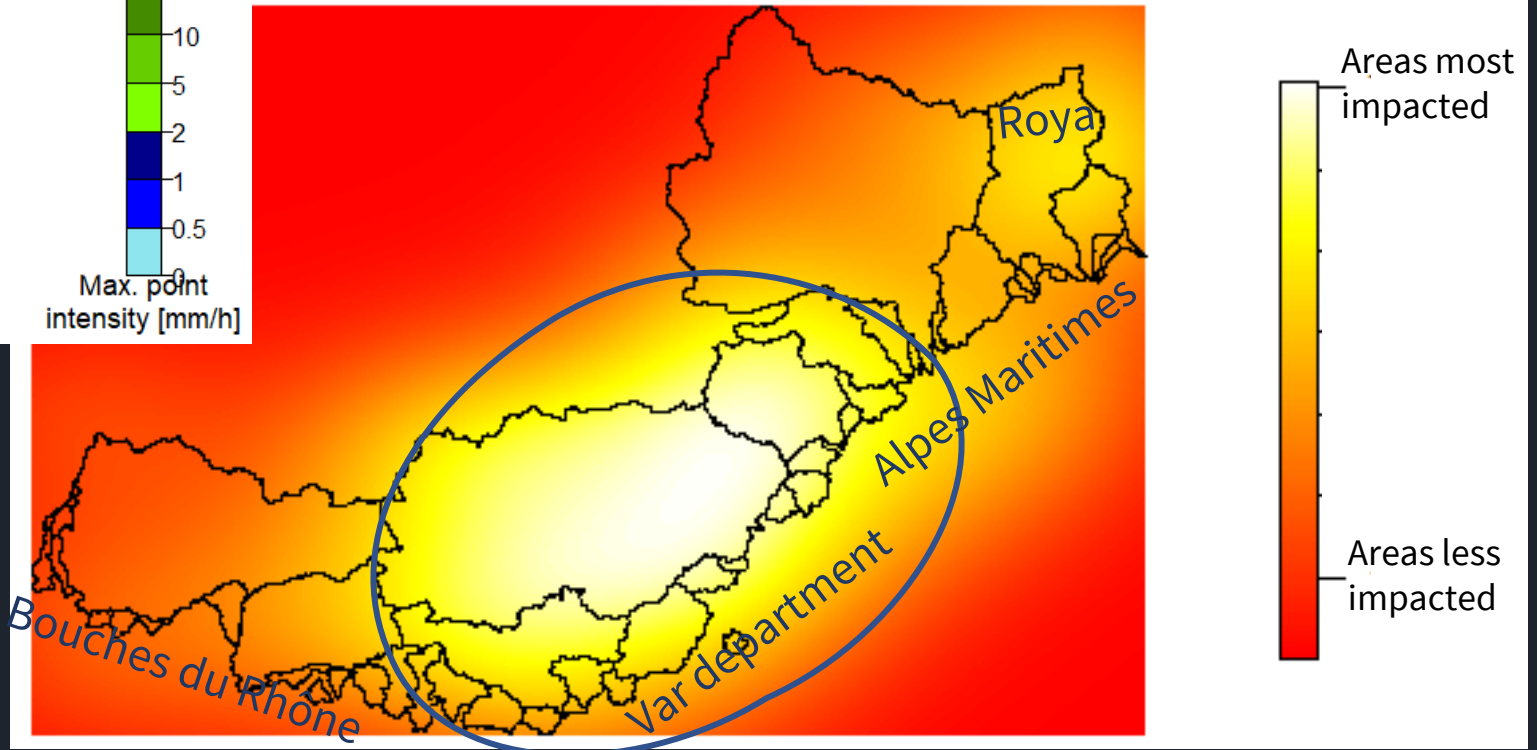
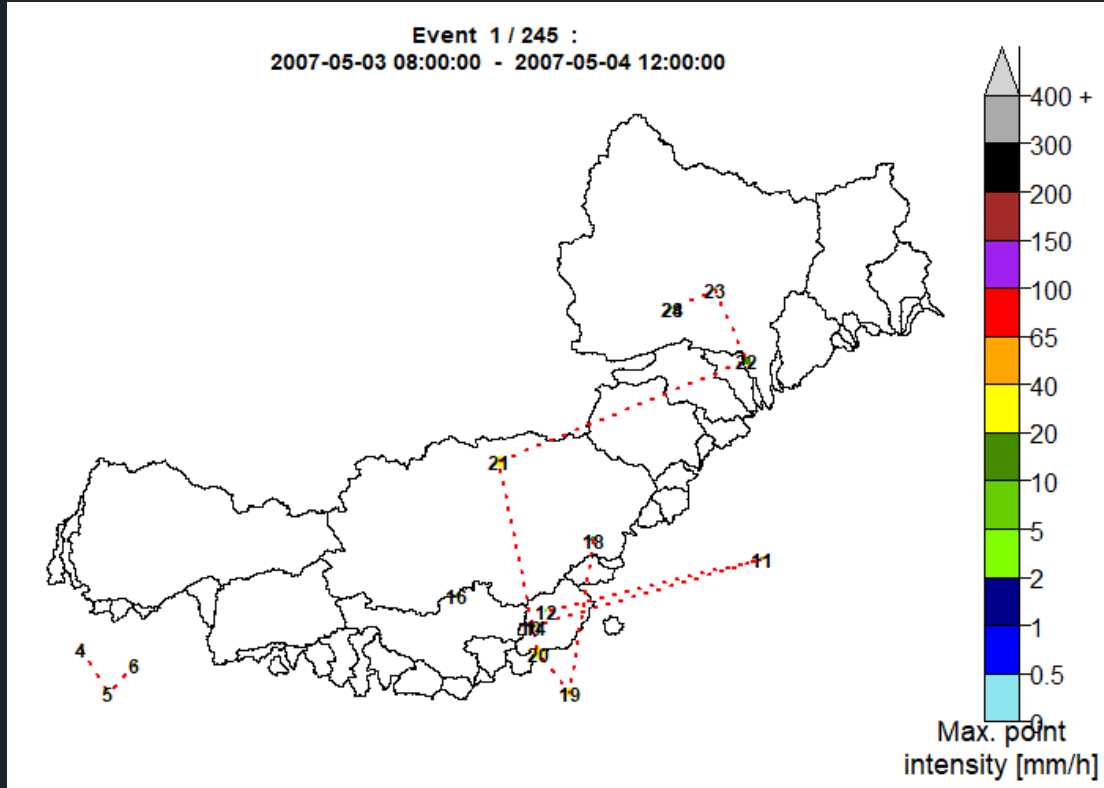


Number of times each cell exceeds the threshold over 1 hours: 40mm/h





# Areas most impacted by the intense events





- Point of view: basin manager, person in charge of alerting the municipalities in case of the flood risk
- Area: French Riviera
- Time window: ~~1997-2020~~, 2007-2019

→ **How to define** an intense precipitation event?

**Period** during which at least a defined **amount of water** falls on average **on a given surface**

→ **How to select** them?

**We propose to**

- Define one or more **thresholds of rainfall** accumulation in a certain duration
- Use a spatialized precipitation data degraded to **the selection surface** and **aggregated to the duration** of the considered threshold
- Select all the time steps for which at least one grid cell exceeds the cumulative rainfall threshold
- Gather all the consecutive time steps or time steps separated of less than a certain duration



→ **How to characterize** them?

## **Frequency/Seasonality:**

- Between 7 and 33 intense episodes per year can be expected,
- Mostly spread between summer and autumn

**Weather patterns associated to the intense events:** we cannot identify 1 weather pattern responsible for the most intense rainfall events

- During summer: 1/3 most intense episodes occur with an **anticyclonic pattern**, the others with a **southwest / northeast circulations or an east return**
- During fall: most intense episodes occur with **south / southwest circulations**

Areas or basins most affected: the downstream part of the Argens basin and, to a lesser extent, the Var basins and the Roya



## Way forward

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→ **How to characterize** intense rainfall events?

Identify stratiform convective orographic episodes

Identify the preferred movements of stratiform episodes

→ **How to anticipate** intense rainfall events?

Implement a machine learning method to try to predict the intensification of convective episodes and the displacement of stratiform episodes

Evaluate the performance of several forecasting methods on the intense episodes that affected the French Riviera



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Evaluate the performance of several forecasting methods on the intense episodes that affected the French Riviera



## Limitations

### → **Rainfall data (COMEPHORE):**

- evolves over time (new radars are installed and rain gauges are opened or closed) which implies variable data quality over the study period.
- we did not take into account the uncertainty associated with the COMEPHORE rainfall.

→ **Events duration:** highly dependent on the choice of the minimum duration between each episode to ensure temporal independence



*Thank you for  
your attention*

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for further information, please send me an email:  
**[vigoureux@geoazur.unice.fr](mailto:vigoureux@geoazur.unice.fr)**



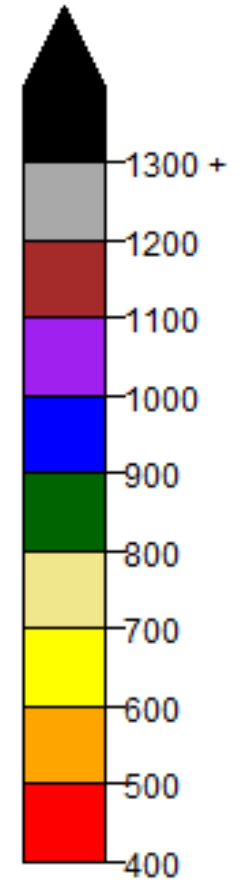
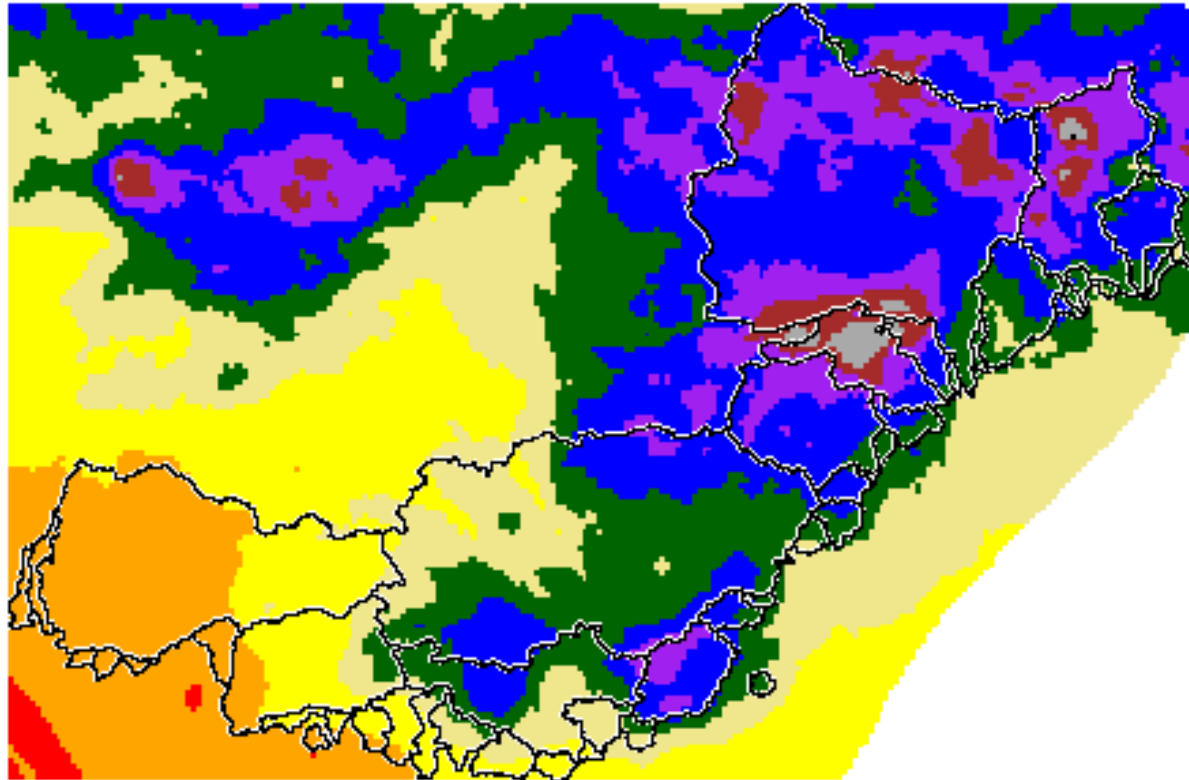
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- Bossard, M., Feranec, J., & Otahel, J. (2000). *CORINE land cover technical guide: Addendum 2000 (Vol. 40)*. Copenhagen: European Environment Agency.



# Average annual rainfall

average annual COMEPHORE rainfall



ANNUAL RAINFALL  
[mm]