



ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE



Variability of the spatial structure of intense Mediterranean precipitation

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Context



<http://pagesperso-orange.fr/meteo/special/09-09-02-cevenol/page10.htm>

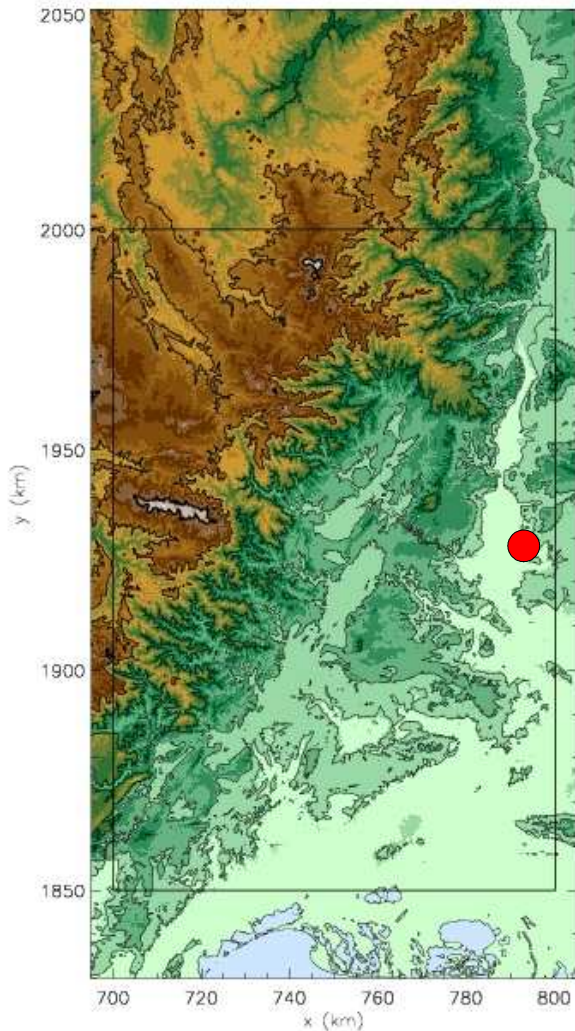
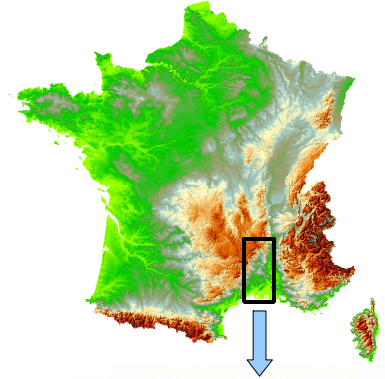
Mediterranean regions are regularly affected by intense rainfall (e.g. in France: Nîmes 1988; Vaison-la-Romaine 1992; Gard 2002)

Spatial and temporal variability of precipitation is the main controlling factor of the hydrological response of catchments.

→ it is of primary importance to identify and characterize the variability of intense Mediterranean rainfall to improve the understanding, the modelling and the forecasting of rain events generating flash floods

Automatic procedure so that large data set based on radar measurements at high time resolution can be analyzed.

Study area and data



Cévennes-Vivarais hydrometeorological observatory.

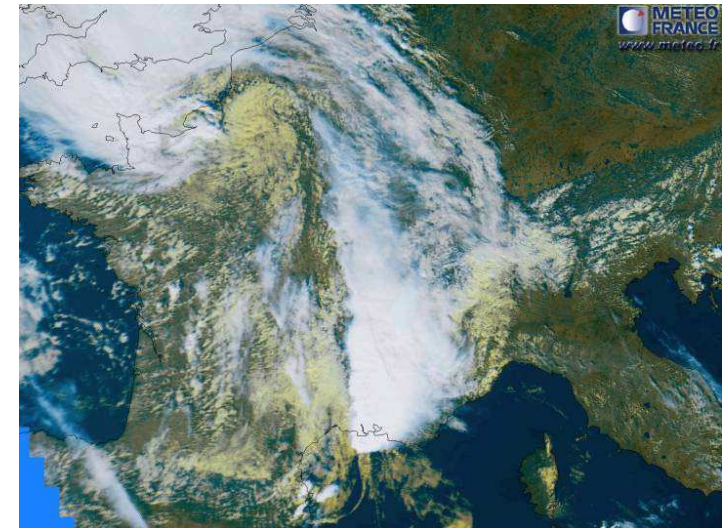
For this study: - operational S-band radar (Bollène),
- 150 hourly rain gauges.

Rainfall intensity obtained by combining radar and rain gauge data (1x1 km² every 5 min)

Focus on the intense rain event that occurred on the 8-9th September 2002.

Mesoscale convective syst.
that remained stationary
over the Gard region ~28h

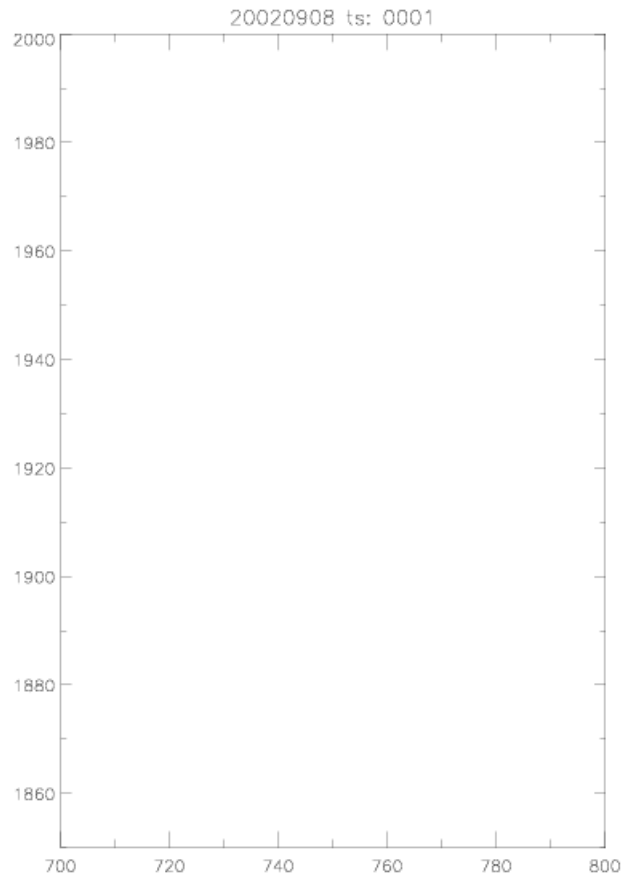
→ huge amount of rainfall



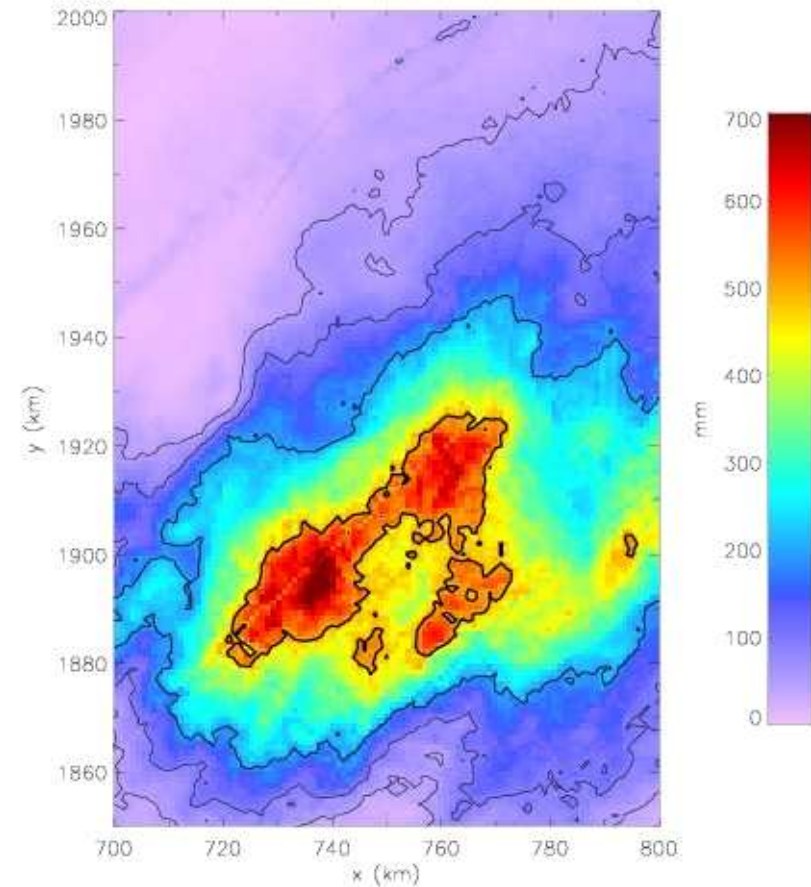
Rain events

8-9 September 2002

Animation of 15-min time steps



Total rain amount in mm



Max ~ 700 mm

$R > 400$ mm over ~ 2000 km²

$R > 200$ mm over ~ 5000 km²

Characterizing the structure

Geostatistical approach

Distribution of R values is skewed → variogram on R values is not representative

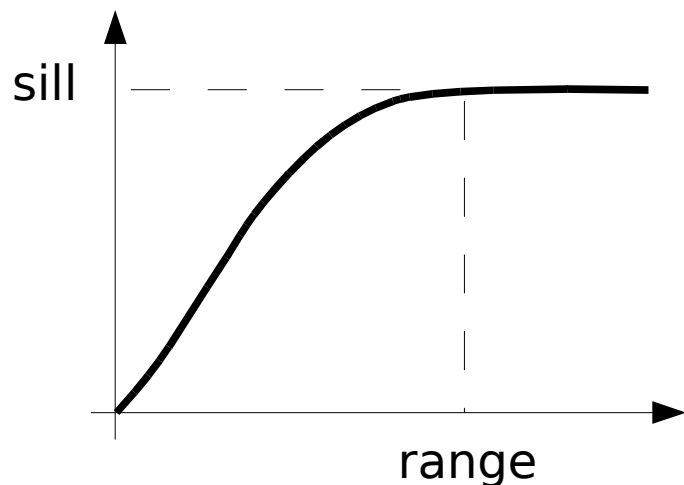
Indicator variogram (Journel, MG, 1983)

$$\gamma_I(h) = \frac{1}{2} \mathbb{E} \left\{ [I(x+h) - I(x)]^2 \right\}$$

where

$$\begin{cases} I(x) = 0 & \forall x/R(x) \leq \text{threshold} \\ I(x) = 1 & \forall x/R(x) \geq \text{threshold} \end{cases}$$

γ_I = probability of transition below → above threshold (or vice-versa)



sill product of total proportion above and below threshold.

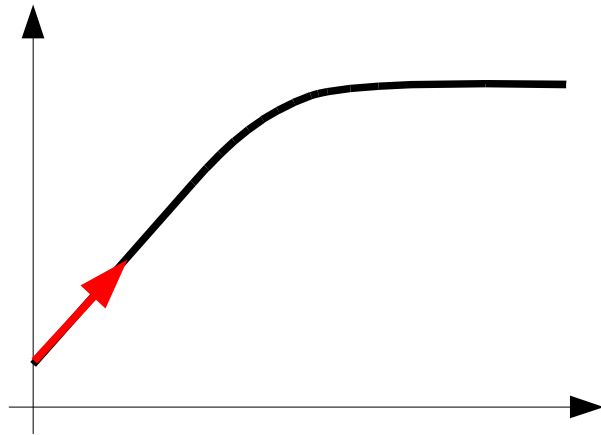
range depends on dimensions and spacing of zones above threshold.

(Barancourt et al., WRR, 1993)

Characterizing the structure

Identification of variogram range is difficult and cannot be completely automatic (especially for complex structures)

Derivative of indicator variogram at the origin is related to mean length of zones above threshold (Carle and Fogg, MG, 1996):



$$\bar{l} = \frac{p}{\left(\frac{\partial \gamma_I(h \rightarrow 0)}{\partial h} \right)}$$

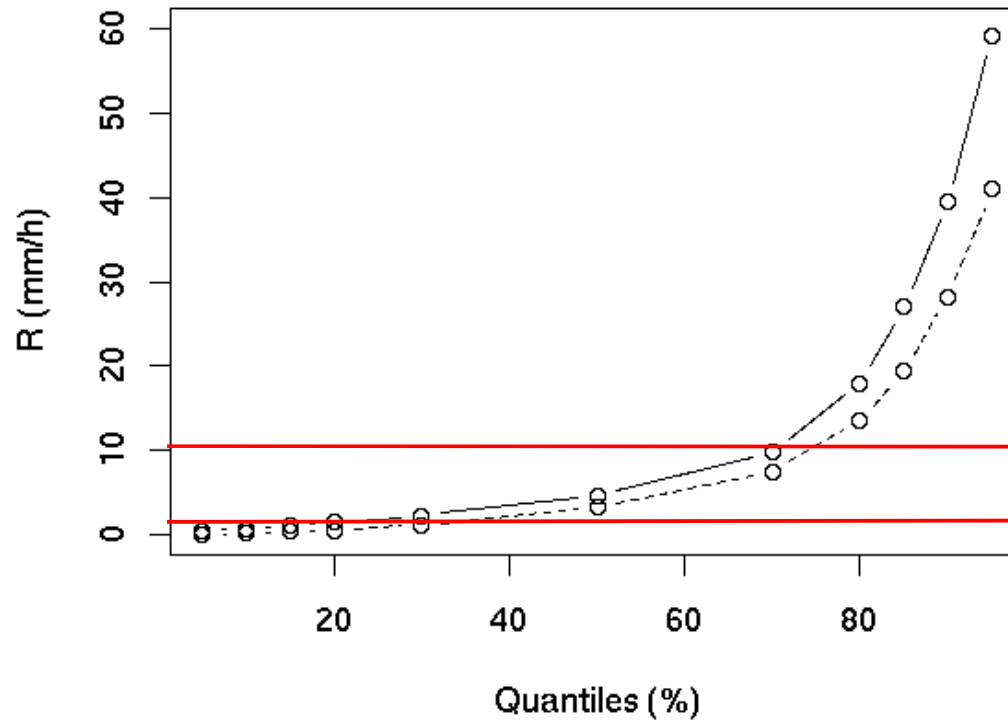
p = proportion of length $>$ threshold

- Automatically calculated.
- Requires only local stationarity.
- Implemented for many directions.

→ Mean length estimates in all directions for each time step

Defining thresholds

To determine threshold values, we use **quantiles of R values**

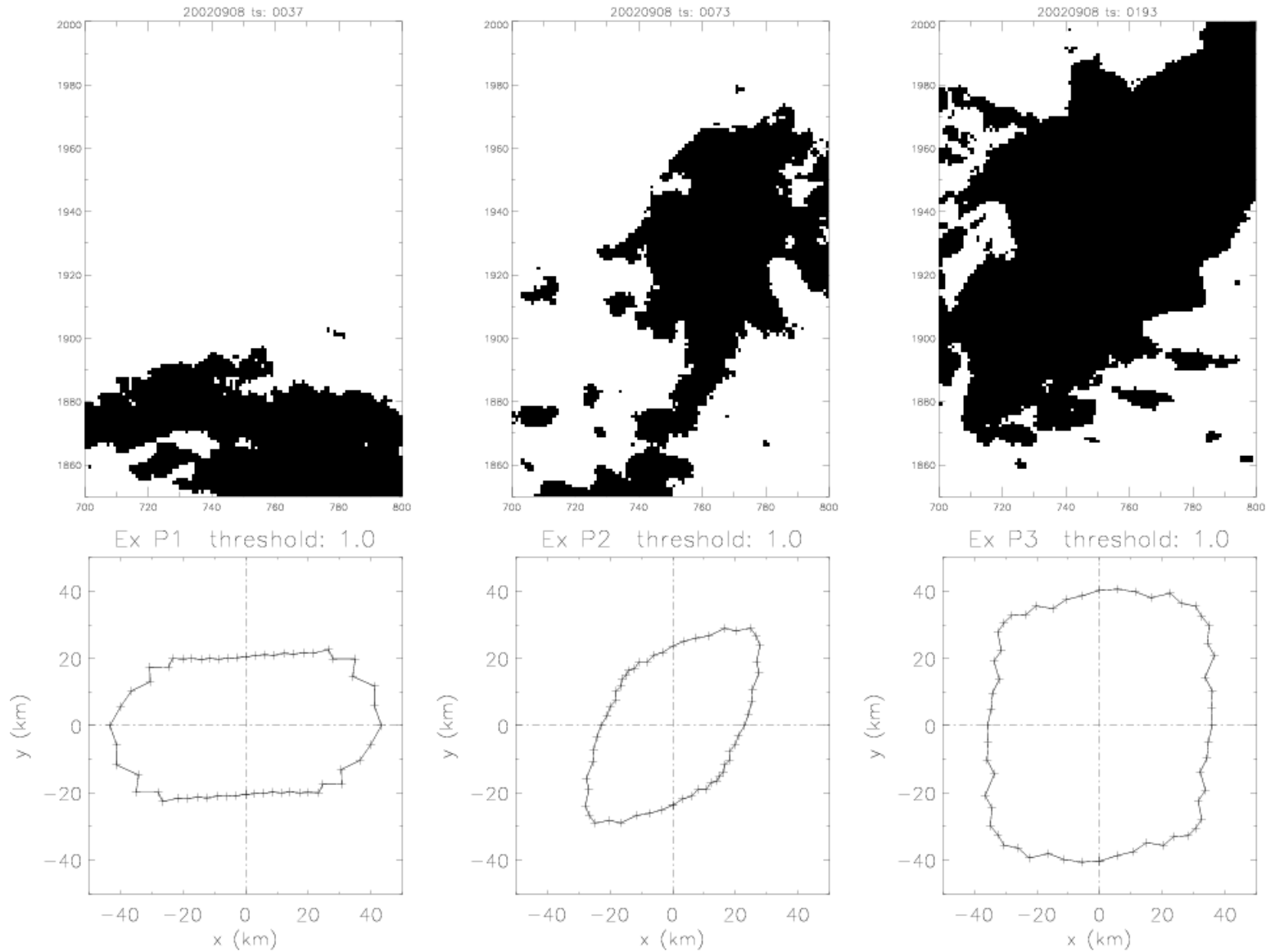


2 thresholds

1 mm h⁻¹ to characterize the raining system at large.
10 mm h⁻¹ to characterize intense rain cells.

Examples of estimated structures

Threshold = 1 mm h^{-1}

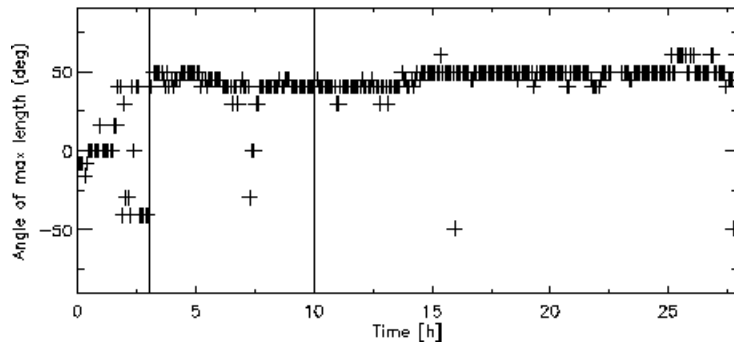
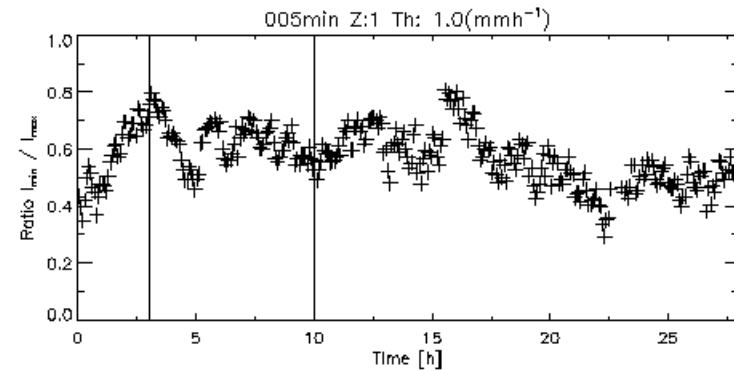
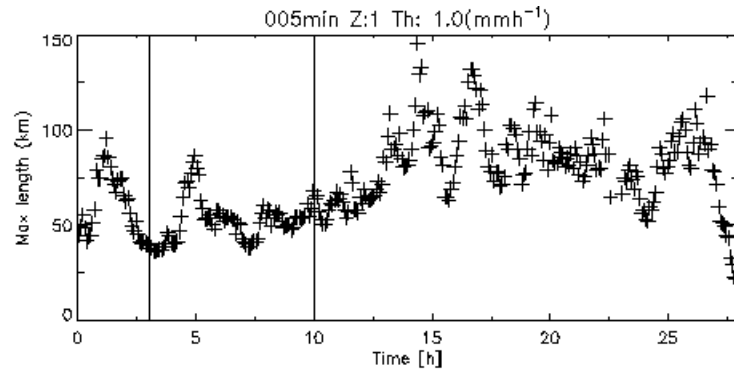


Evolution of the structure during a rain event

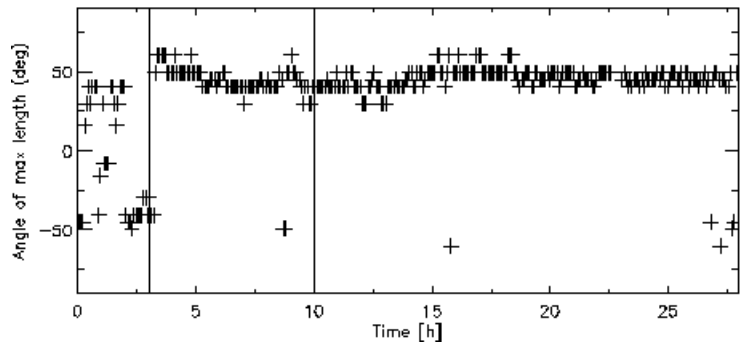
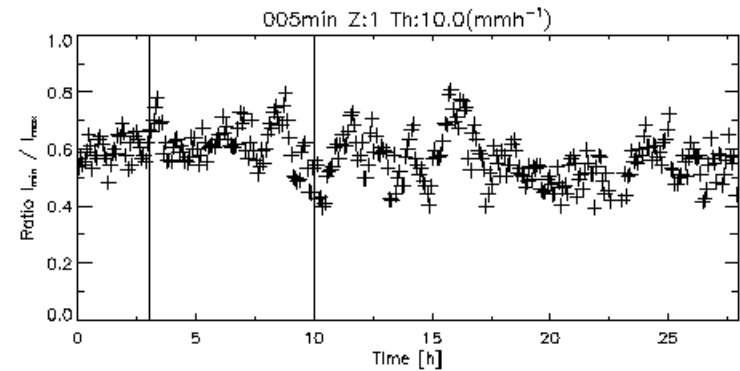
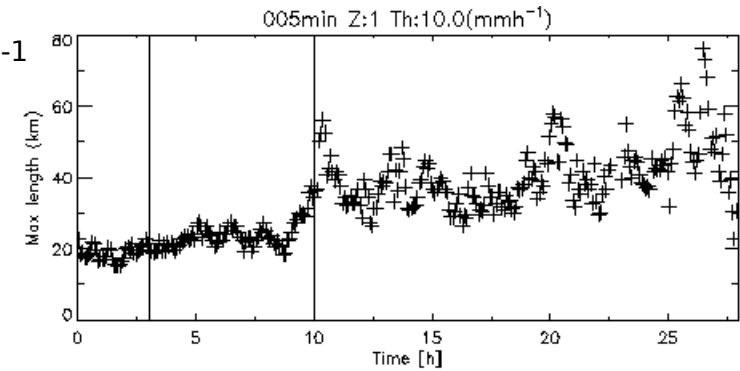
Spatial structure \sim elliptic.

- To describe temporal evolution of spatial structure -
- max (mean) length
 - ratio min/max length
 - direction of max length

1 mm h⁻¹



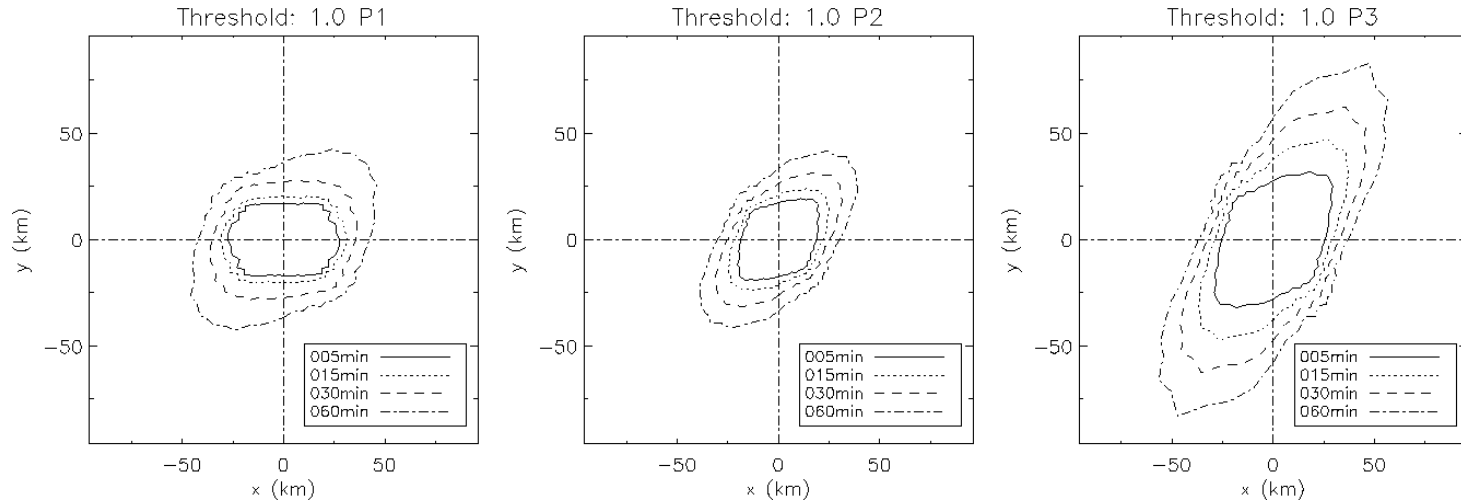
10 mm h⁻¹



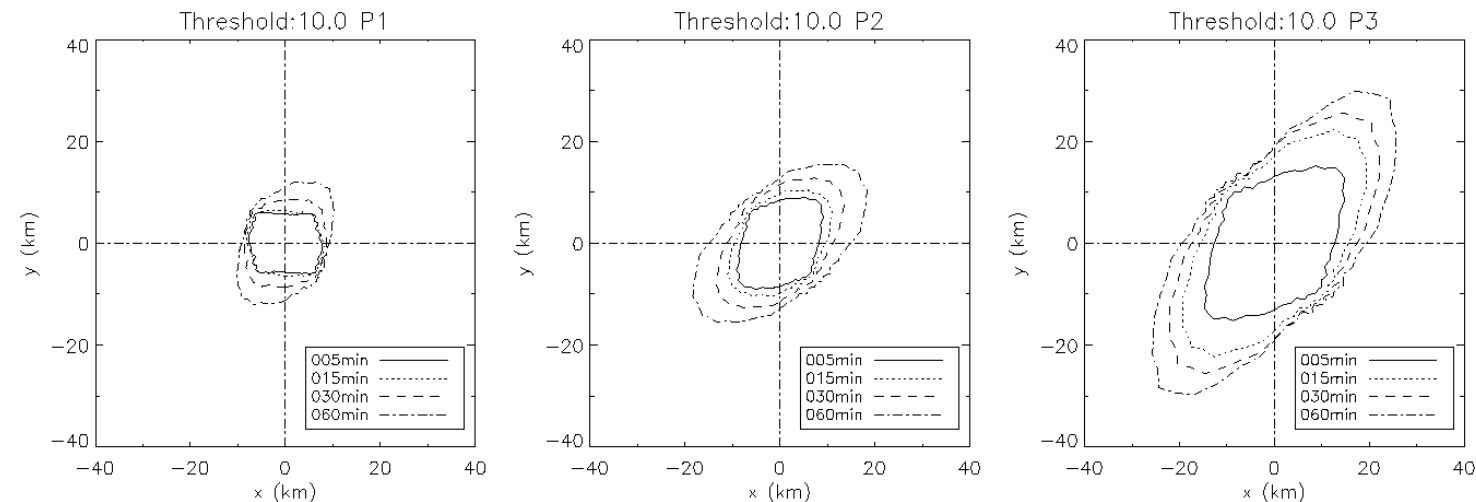
Influence of time resolution

- 3 periods of more or less homogeneous structure have been identified
- the average structure during each period is representative.
- estimate the average structure at different time resolution is relevant for hydrological applications (typical size of most reactive basins).

1 mm h⁻¹



10 mm h⁻¹



Time resolution ↗: basic structure is stretched in advection direction.

Conclusions

Using geostatistical tools, we have:

- Analyzed the variability of the spatial structure during an intense Mediterranean rain event in relation with its dynamics.
- Identified homogeneous periods during which estimating the mean structure makes sense.
- Investigated the influence of time resolution on the spatial structure in order to provide the typical scales of the basins that will strongly respond to intense precipitation.

Future work:

- Extend this analysis to a large data base of intense Mediterranean events.
- Apply the same approach to other climatic regions.