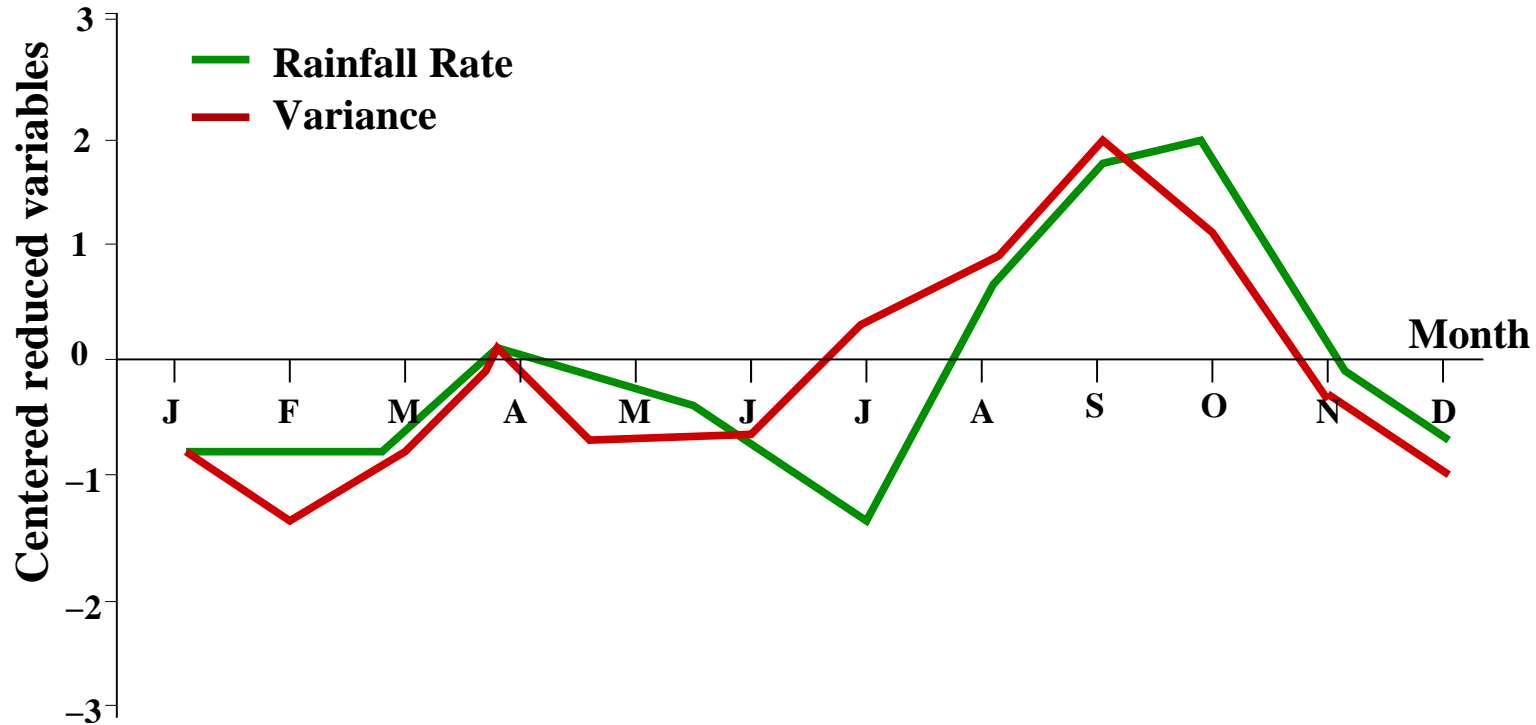


**Climatologie des pluies extrêmes en Cévennes-Vivarais : Résultats et perspectives.**

**Anquetin S., P. Bois, J. D. Creutin, A. Djerboua, T. Lebel, F. Miniscloux, G. Molinié, C. Obled,  
M. Slimani, T. NGuyen**

# 1 Extreme rainfall climatology

## 1.1 Maximum mean and variance rainfall $\Rightarrow$ ASON monthes

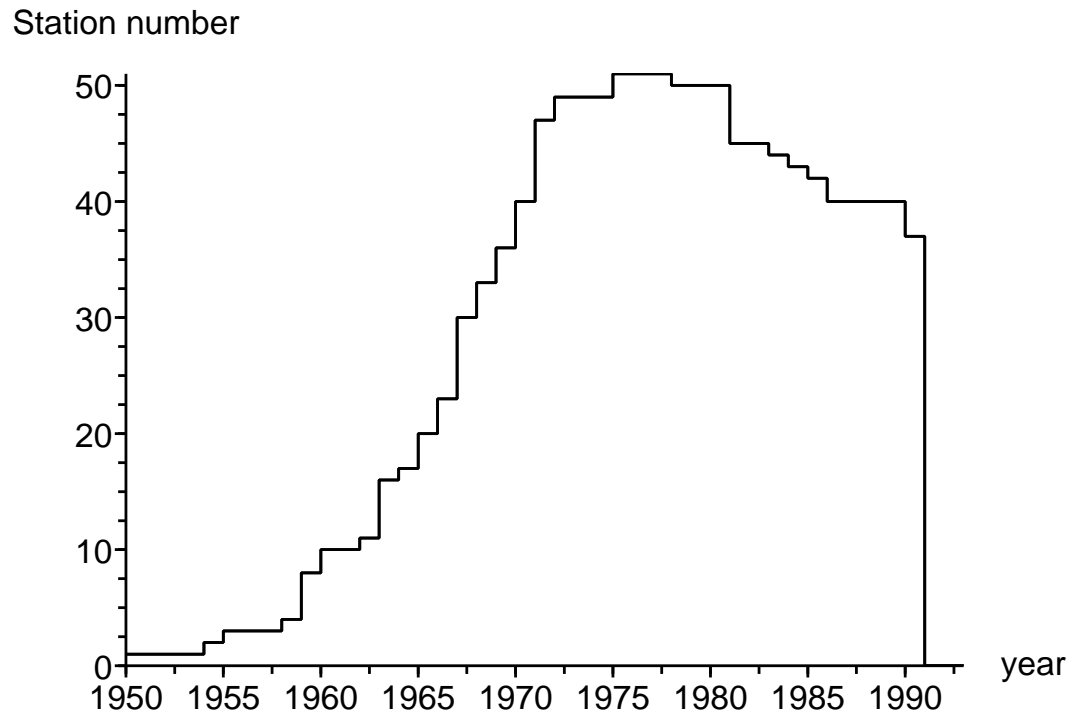


*Monthly mean of the average hourly rainfall rate and its variance.*

A. Kieffer Weisse, 1998, Thesis Dissertation, HMG INPG, Grenoble, France

## 1.2 Cévennes-Vivarais: a Surveyed Region

- After the 1958 flash flood → intensification of rainfall observations: The climatological network.

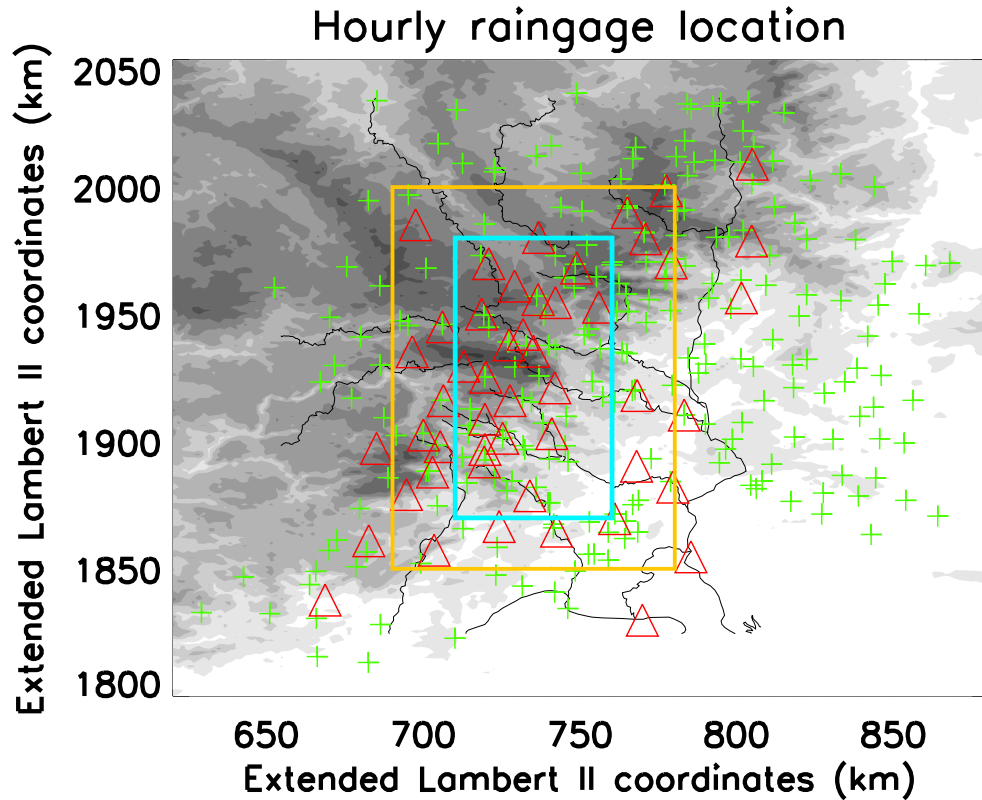


- Selected stations were available at least 10 years;
- Selected precipitating events: At least 1 station collect more than 50 mm;

*# of hourly raingauge stations available a year*

★ **Long climatological series allow studying extreme values**

### 1.3 The climatological Hourly Raingauge / the OHMCV Networks



Station locations:

$\Delta$ : climatological network ;

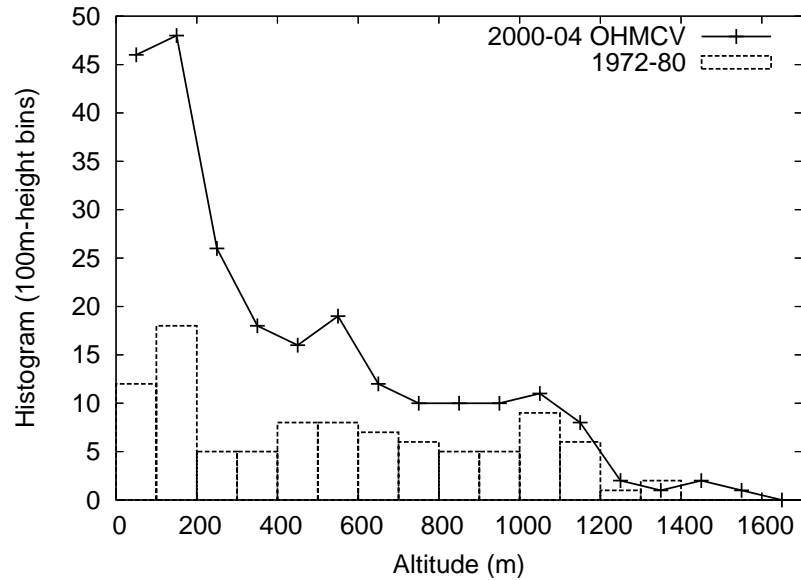
+ current OHMCV network.

Table 1: Mean distance between stations

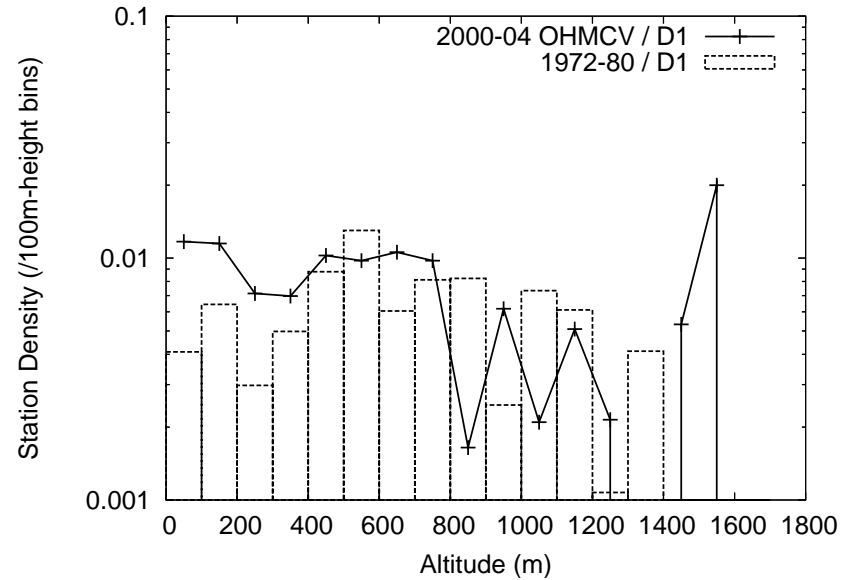
Domain area ( $km^2$ )	Databases	
	OHMCV	Climatological
D1 15000	11.5	18.9
D2 4400	10.3	17.7

★ Climatological data:  $\Rightarrow$  a relatively dense network over a  $\sim 150 \times 100 km^2$  area

### 1.4 The climatic Hourly Raingauge / the OHMCV Network altitude Coverage



*Raingauge altitude histogram*

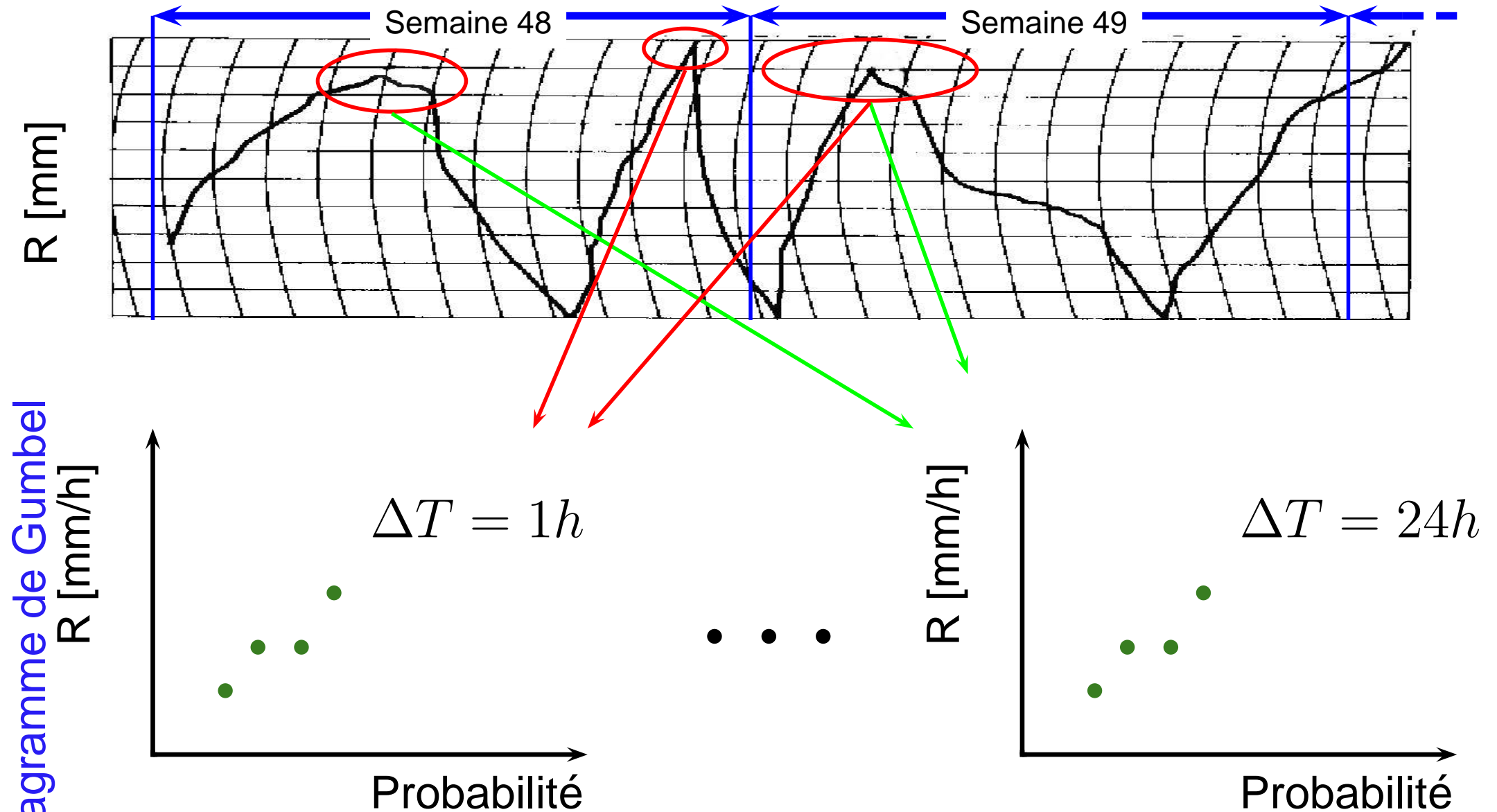


*Raingauge density as a function of altitude*

horizontal

resolution = 1km (Numerical Terrain Model);  
 boxes → climatological and crossed lines → OHMCV.

## 1.5 Extreme Event Selection



## 1.6 Inference of Extreme Rainfall features

Goal : estimating rainfall intensities with return period of 10 → 100 years (never observed). ⇒ need extrapolation throughout a modeled cumulative probability function (Gumbel law).

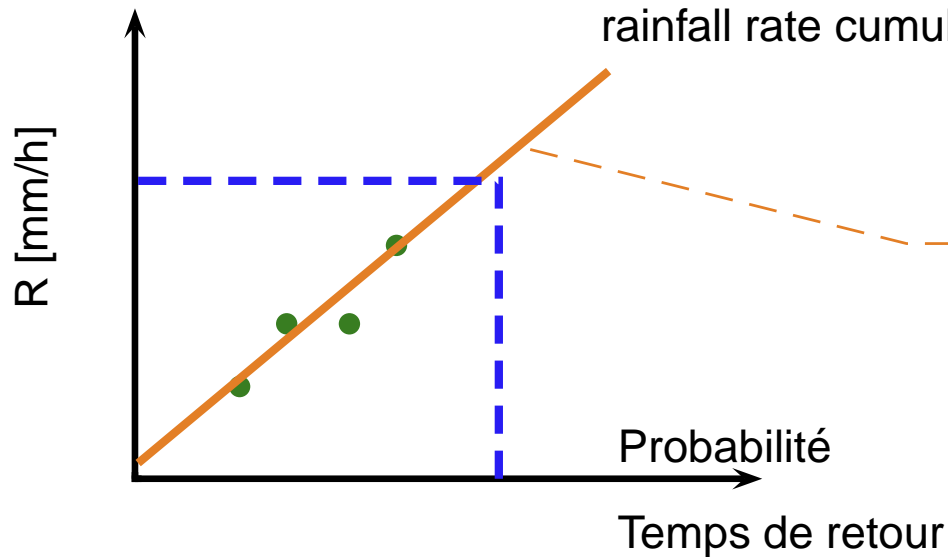
$$\text{Return period} = T = \frac{1}{1 - P(x)}$$

Example :

$$P(X < x) = 0.90 \equiv T = 10 \text{ years}$$

$$P(X < x) = 0.99 \equiv T = 100 \text{ years}$$

At each station, for each time step, a Gumbel law is fitted to the extreme rainfall rate cumulative distribution function (CDF).



$$P(x) = e^{-e^{ax}}$$

$$a = \text{gradex}$$

## 1.7 Relations morphométrie-précipitation

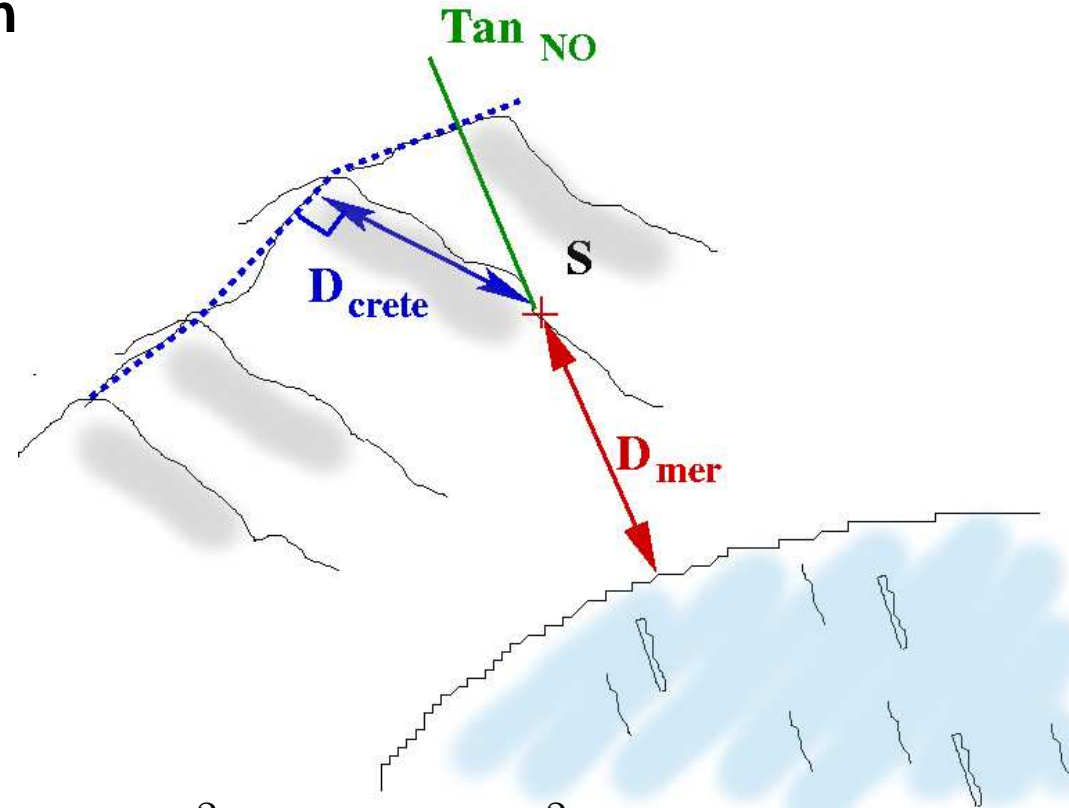
*Slimani, 1985, Thèse HMG, INPG.*

- 19 paramètres pluviométriques étudiés :

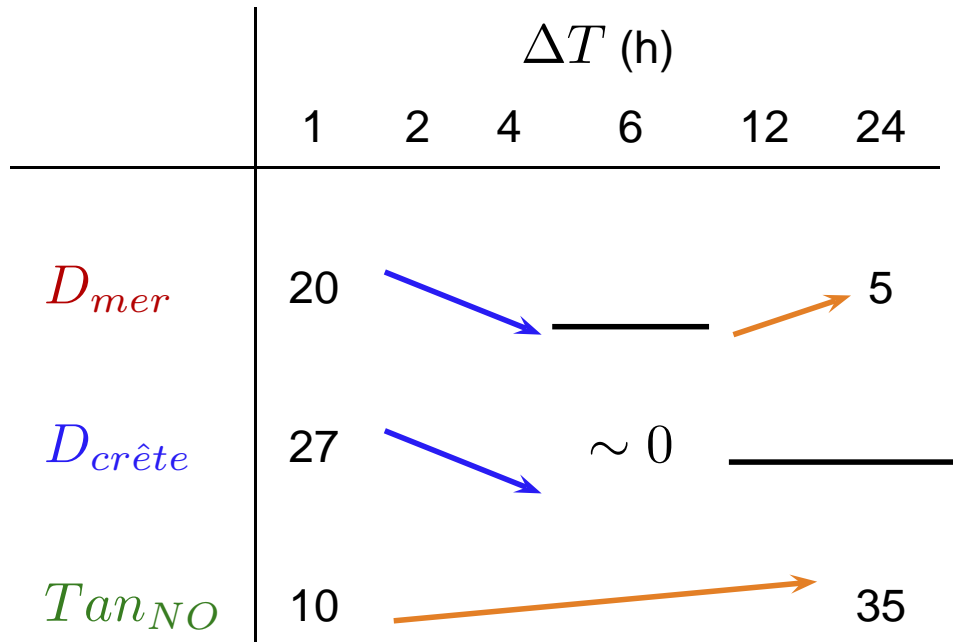
1.  $R_{10}$  pour  $\Delta T = 1, 2, 4, 6, 12, 24$  h
2.  $R_{100}$  pour  $\Delta T = 1, \dots$
3.  $Gradex$  pour  $\Delta T = 1, \dots$
4. ...

- 20 paramètres morphométriques :

1. Altitude de la station mesuré sur une grille de  $1 \times 1 \text{ km}^2, 1.5 \times 1.5 \text{ km}^2$
2. Distance à la mer ( $D_{mer}$ ),
3. Distance à la ligne de crête calculée de plusieurs manières ( $D_{crête}$ ),
4. Pente moyenne du relief depuis la station dans 8 directions ( $Tan_{NO}$ ),
5. ...



- ACP → proportion (%) de la variance des paramètres pluvios expliquée par la morphométrie



★ Suivant  $\Delta T \Rightarrow$  variables explicatives  $\neq$ ,



★ Différents mécanismes suivant  $\Delta T$ .

- Djerboua, 2001, Thèse HMG, INPG.

$$R_{\Delta T=1h} \nleftrightarrow R_{\Delta T=24h}$$

## 1.8 Spatial features of Extreme Rainfall Rates: Variogram Parameters

$$\text{Variogram} = \gamma(\text{distance}) \equiv (\text{spatial correlation coefficient})^{-1}$$

Table 2: Rainfall rate and Gradex variogram ranges at different time steps.

Time step (hour)	T = 10 years Range (km)	T = 100 years Range (km)	Gradex Range (km)
1	40	40	40
2	40	40	40
6	45	45	40
12	65	65	55
24	70	70	60

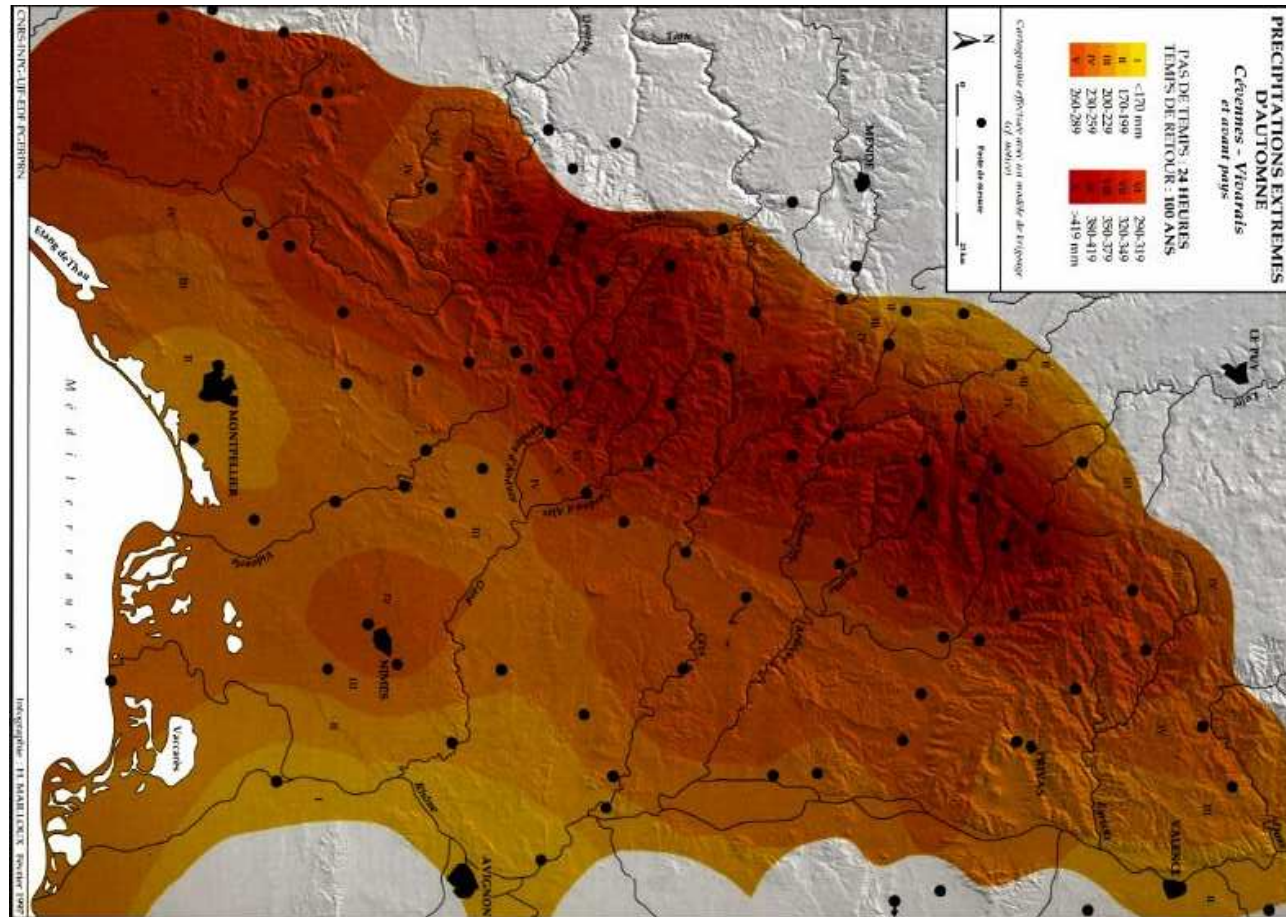
★ Whatever T, when Time step ↗, the range (i.e. distance of decorrelation) ↗

★ ⇒ Variogram parameters → optimal interpolation (kriging) → Extreme rainfall rate maps

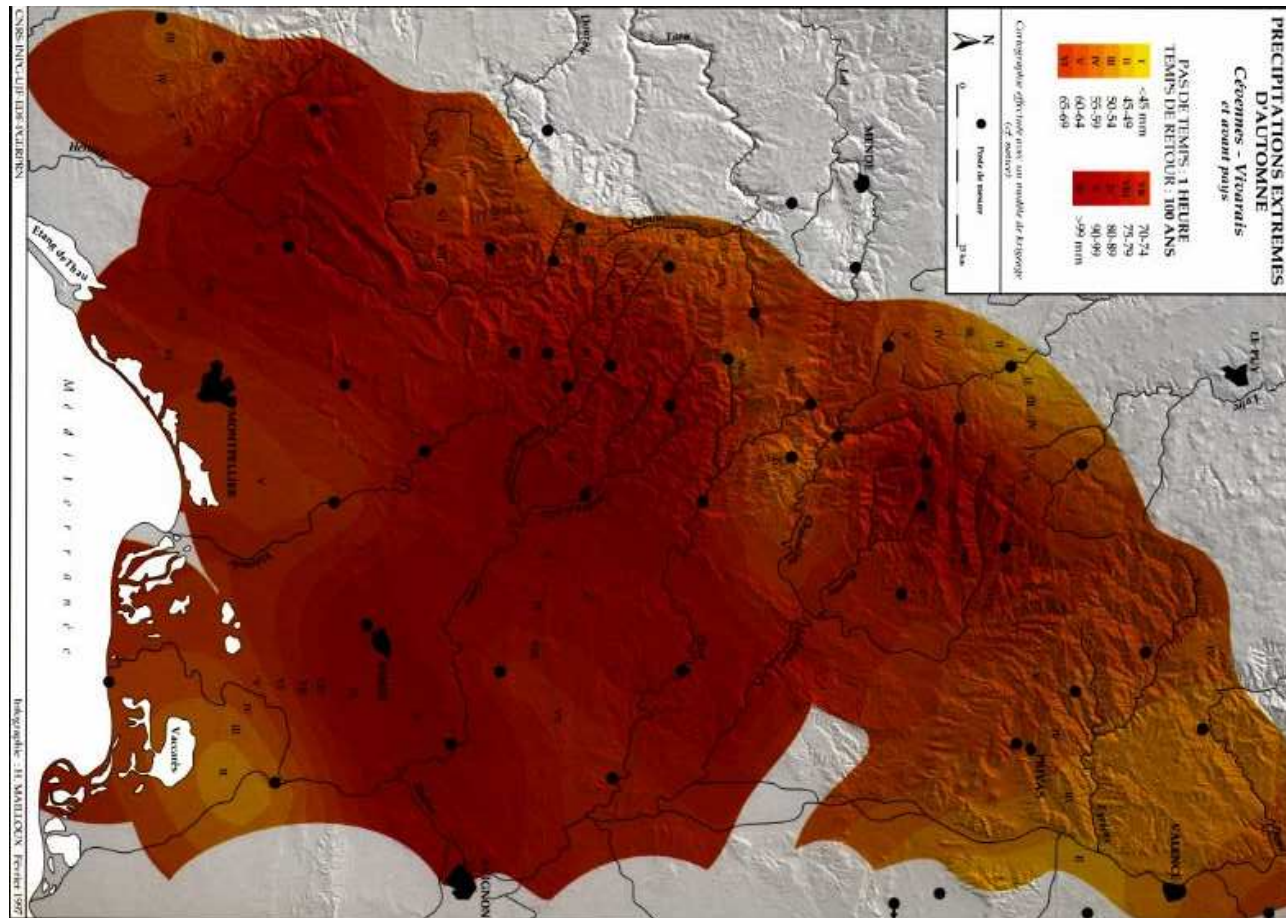
## 1.9 Extreme Rainfall Rate Maps: T=100 years

Rainfall rate for Time step = 24 hours.

Atlas expérimental des risques de pluies extrêmes, Bois et al. (1997)



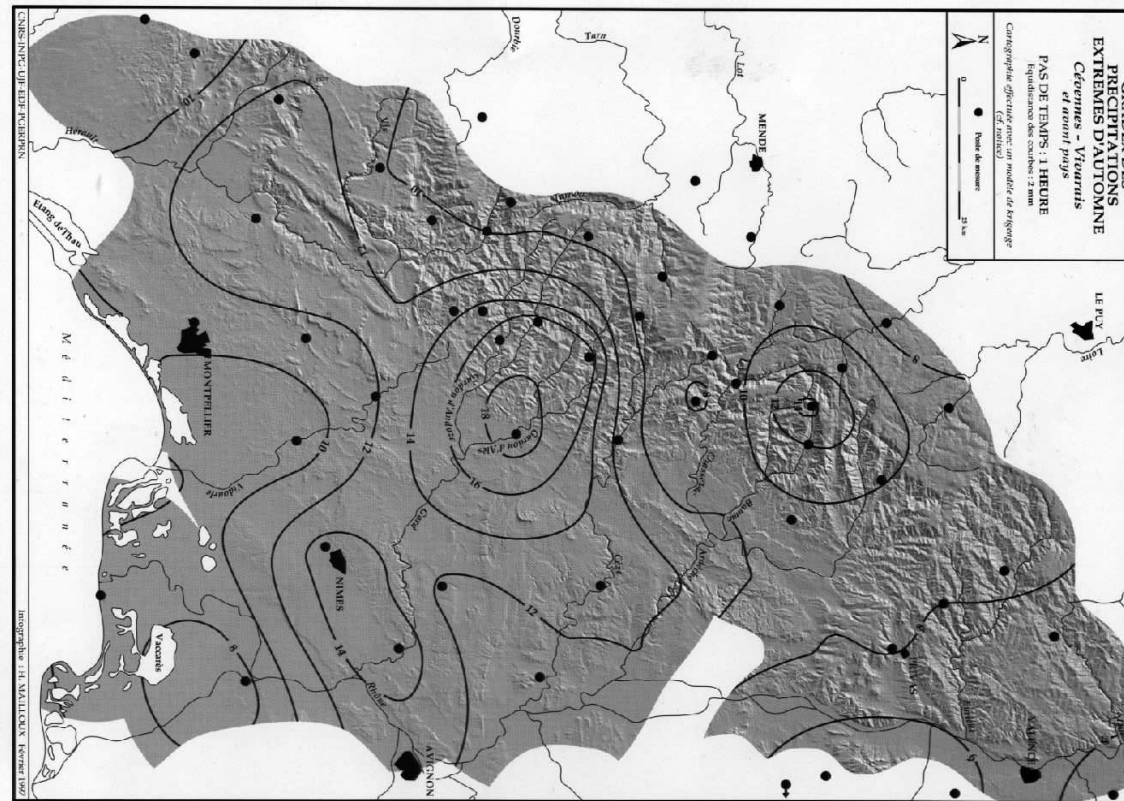
Rainfall rate for Time step = 1 hour.



- ★ Shortest time step (1 h.) extreme rainfall equally intense over the mountain and the valley.
- ★ As the time step ↗, the highest rainfall amounts become co-located with the mountain range.



Gradex for Time step = 1 hour.



- ★ Shortest time step (1 h.) → highest Gradex values (extreme rainfall variability) equally intense over the mountain and the valley.
- ★ As the time step ↗, the highest Gradex values become located over the mountain range.

## 2 Campagnes de mesures

### 2.1 Forçage du relief, convection peu profonde

Cévennes-Vivarais 86-88  
(Miniscloux et al., 2001)

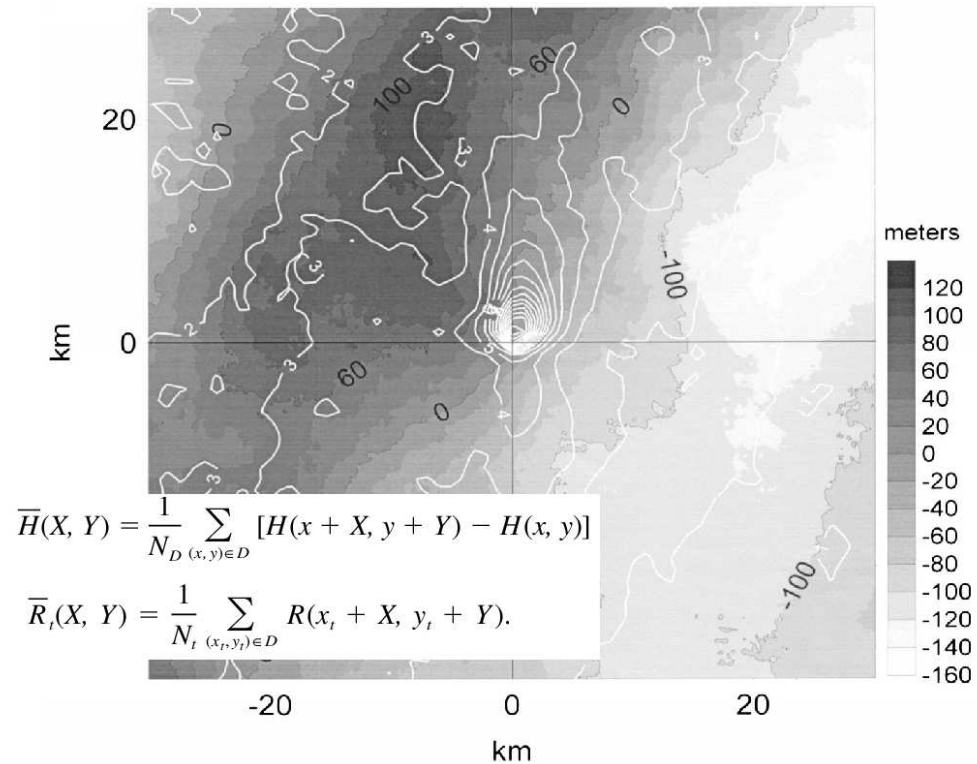
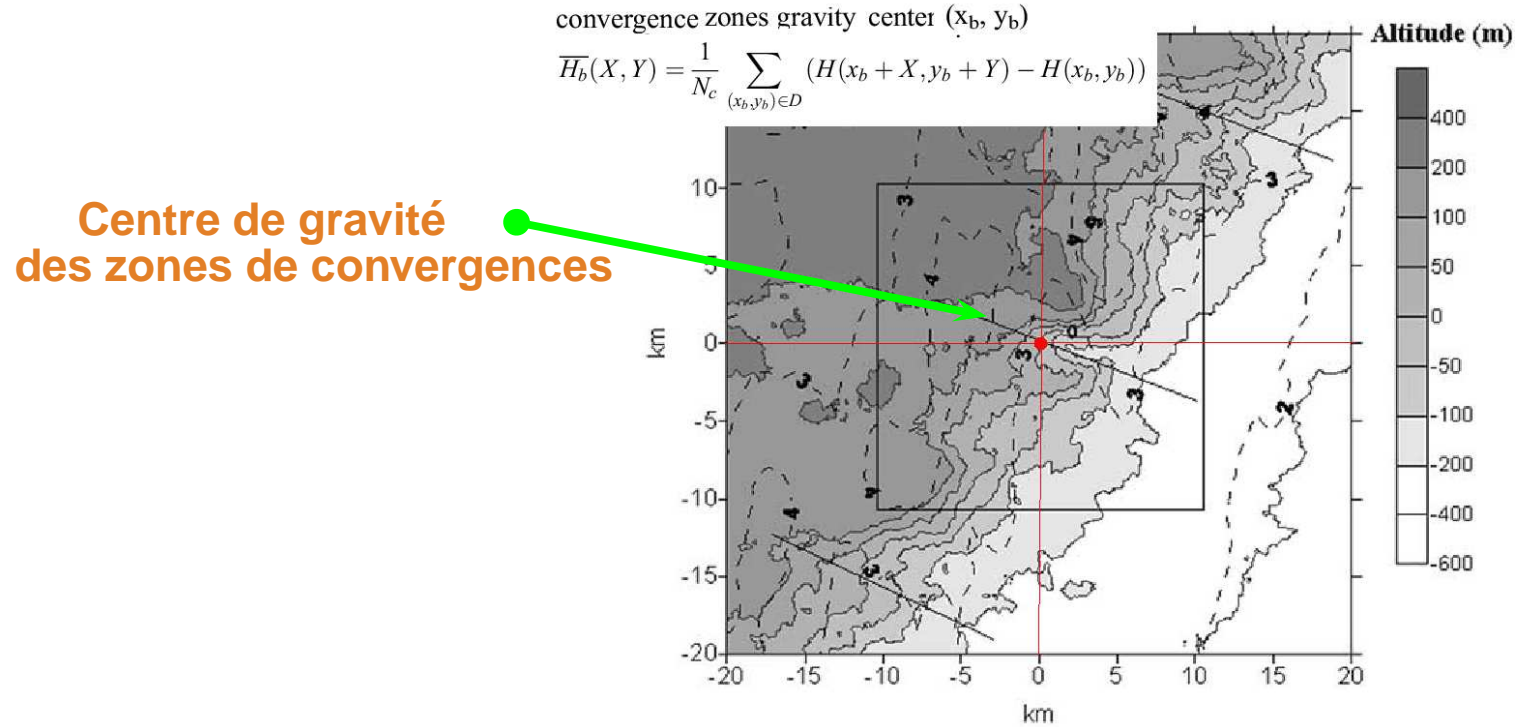


FIG. 15. Mean statistical rain field (white contours: mm) and corresponding mean underlying topographic deviation (gray scale) from the mean relief centered on the triggering point of identified rain cells.

★ Localisation des précipitations sur l'épaule du relief.

- **Circulation autour du relief académique : Cosma et al., 2002**

- **Cévennes-Vivarais 86-88 : Anquetin et al., 2002**



**Figure 6.** (a) Mean statistical rain field (dashed lines: mm) and corresponding mean underlying topography (gray scale) centered on the gravity centers of identified convergence zones.

★ **Convergence de basse couche sur le relief sous le vent déclenche la convection**

### 3 Conclusion and perspectives

- Variabilité des précipitations  $\leftrightarrow$  variété des mécanismes précurseurs.
  - Forçage du relief
  - Mais aussi autre forçages
- Nécessité d'une interaction entre les approches statistiques et simulations à base physique.
- Résultats obtenus reposent sur la modélisation des valeurs extrêmes

Then, our perspectives at LTHE on this topic are:

- **Gather again the hourly and daily raingauge climatological databases. Put together with the OHMCV rainfall measurement  $\Rightarrow$  47 years of data in 2005;**
- **Coupling the climatological series with OHMCV data will improve statistics reliability in the future.**
- **Investigate the role of the extreme rainfall forcing using statistical multivariate analysis and academic high-resolution meteorological simulations;**
- **Work around trends in chronological series of precipitation and possible links to climate change.**