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# Rainfall measurement comparison between two types of disdrometers

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## Introduction

Rainfall point measurements:  
 - Tipping bucket rain gauges (usually 0.2 mm tips)  
 - Disdrometers (binned size and velocity)  
 → The quantification of the uncertainty associated with these devices is still an open question.  
 → Preliminary results of a comparison campaign between two disdrometers types (Parsivel OTT and Campbell Scientific PWS100) are presented here.

## Campbell Scientific PWS100



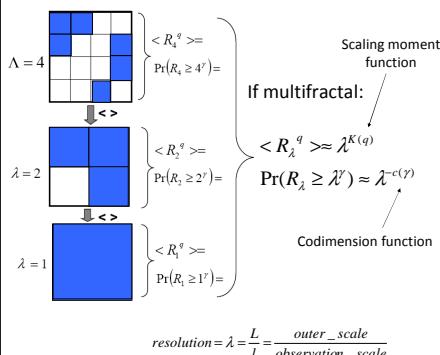
The transmitter generates four parallel laser sheets and the detectors measure the light refracted by the hydrometer (liquid drop) falling through the sampling area:  
 - Optical properties of refraction → the vertical detector receives signal slightly before horizontal one → estimation of the size of the drop  
 - 4 II sheets → periodic received signal → estimation of the velocity of the drop  
 (see Ellis et al., 2006)

## Multifractal analysis

### Estimating statistics across scales

Definition of the fractal dimension  $D_F$

$$\text{number of pixels with rain} = \lambda^{D_F}$$



$$\text{resolution} = \lambda = \frac{L}{l} = \frac{\text{outer\_scale}}{\text{observation\_scale}}$$

### Quantifying the scaling variability

#### In the framework of universal multifractals :

$$K(q) = \begin{cases} C_1 (\alpha - q) + Hq & \alpha \neq 1 \\ C_1 \ln q + Hq & \alpha = 1 \end{cases} \quad c(\gamma + H) = \begin{cases} C_1 \left( \frac{\gamma}{C_1 \alpha} + \frac{1}{\alpha} \right)^{\alpha} & \alpha \neq 1 \\ C_1 \exp \left( \frac{\gamma}{C_1} - 1 \right) & \alpha = 1 \end{cases}$$

Only three parameters (based on the behavior of the average field)

- H: degree of non-conservation ( $K(1)=H$ )
- $C_1$ : mean intermittency ( $K'(1)=C_1+H$ )
- $\alpha$ : multifractality index ( $K''(1)=\alpha \cdot C_1$ )

### Straightforward consequences on the extremes

- Large  $\alpha$  and  $C_1$  → strong extremes

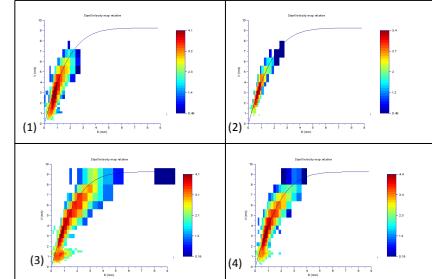
### Estimation of the three exponents with the help of the double trace moment technique (DTM)

## Comparison of 4 events

- (1): 15th May 2013 3h15 Light rain / long duration
- (2): 16th May 2013 10h18 Very light rain / Average duration
- (3): 29th May 2013 21h18 Intense rain / short duration
- (4): 9th June 2013 4h43 Average intensity rain / long duration

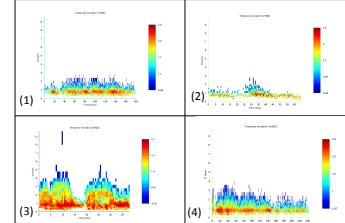
### Size/Velocity maps

- Along standard  $V(D)$  curves
- Heavier rainfall event → wider distribution
- For (3) and (4) a spot for small  $D$  (effect of the building?)



### Temporal evolution of $N(D)$

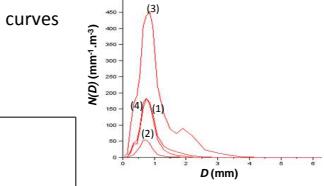
$$N(D_i) = \frac{1}{S_{\text{eff}}(D_i) \Delta D_i \Delta t} \sum_j \frac{n_{i,j}}{v_j}$$



### Raindrop diameter distribution

- Position of the peak similar for all curves
- Greater values for heavier event
- Wider tails for heavier event

### Rain rate



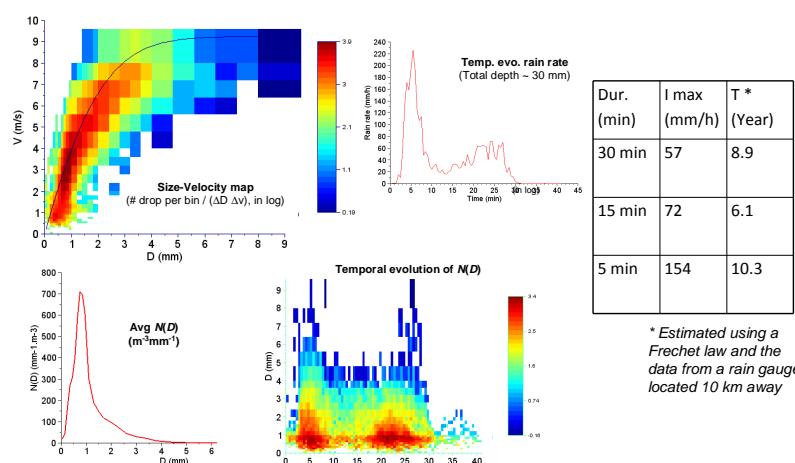
$$R = 6\pi 10^{-4} \sum_i N(D_i) v(D_i) D_i^3 dD_i \quad (\text{Blue})$$

$$R = \frac{\pi}{6 \Delta t} \sum_{i,j} \frac{n_{i,j} D_i^3}{S_{\text{eff}}(D_i)} \quad (\text{Red})$$

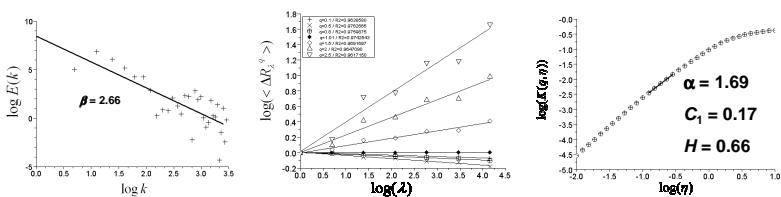
$$R_{\text{PWS100}} \quad (\text{Black})$$

## 19 June 2013, 17h20-17h50, a 10 year return period event !!

### General features



### Multifractal analysis on $R$

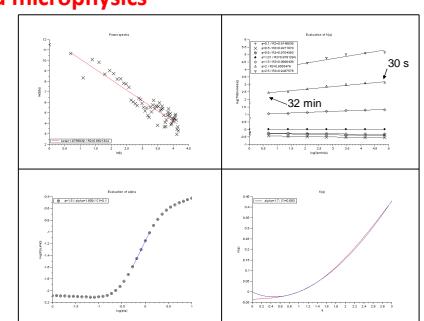


## Multifractal analysis and microphysics

Multifractal analysis tools applied to rain rate ( $R$ ), liquid water content ( $\rho_l$ ) and number density ( $n$ ).

$$n = \int_{D_{\min}}^{D_{\max}} N(D) dD$$

$$\rho_l = \rho_w \frac{\pi}{6} \int_{D_{\min}}^{D_{\max}} N(D) D^3 dD$$



Multifractal analysis on a 3 month mean for rain rate

	$R$	$\rho_l$	$n$
$\alpha$	1,61	1,59	1,34
$C_1$	0,10	0,14	0,10
$\beta$	1.98	2.00	1.82
$H$	0.58	0.62	0.49

### Conclusion

- Some standard values of  $\alpha$  (1.6-1.7),  $C_1$  (0.1-0.2) and  $H$  (0.5-0.6) during a rainfall event
- Multifractal tools can be used on disdrometers data to give an insight into the microphysical processes
- Only preliminary results, the two OTT parsivel still need to be installed...!

### References

- Ellis, R.A., et al., 2006. New laser technology to determine present weather parameters. *Measurement Science & Technology*, 17(7): 1715-1722.  
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