# Rainfall measurement comparison between two types of disdrometers

Samuel Fillon, Auguste Gires, Ioulia Tchiguirinskaia, D Schertzer, S. Lovejoy

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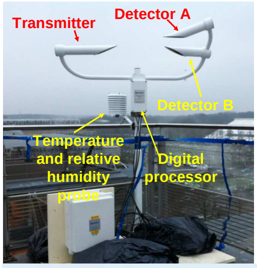
Chair "Hydrology for Resilient Cities" (*sponsored by Véolia*)

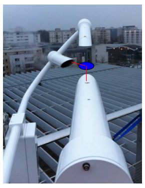
## Introduction

Rainfall point measurements:
- Tipping bucket rain gauges (usually 0.2 mm tips)
-Disdrometers (binned size and velocity)

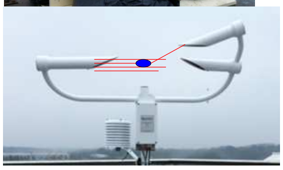
→ The quantification of the uncertainty associated with these devices is still an open question.
→ Preliminary results of a comparison campaign between two disdrometers types (Parsivel OTT and Campbell Scientific PWS100) are presented here.

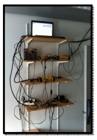
## Campbell Scientific PWS100



*Refraction towards the horizontal detector*





*Refraction towards the vertical detector*

The transmitter generates four parallel laser sheets and the detectors measure the light refracted by the hydrometor (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

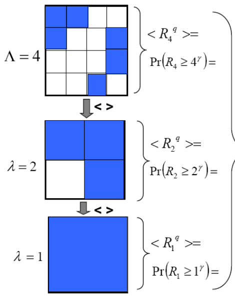
(see Ellis et al., 2006)

## Multifractal analysis

### Estimating statistics across scales

Definition of the fractal dimension $D_F$

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




Scaling moment function

If multifractal:

$$< R_\lambda^{\,q} > \approx \lambda^{K(q)}$$

$$\Pr(R_\lambda \geq \lambda^{\gamma}) \approx \lambda^{-c(\gamma)}$$

Codimension function

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

### Quantifying the scaling variability

**In the framework of universal multifractals :**

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

**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)
- α : multifractality index (K''(1)=α.$C_1$)

**Straightforward consequences on the extremes**

- Large α and $C_1$ → strong extremes

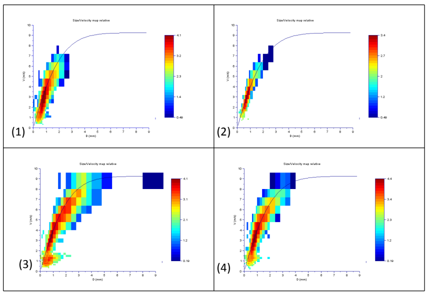
**Estimation of the three exponents with the help of the double trace moment technique (DTM)**

## 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

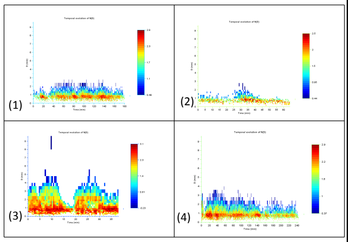
### Size/Velocity maps

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



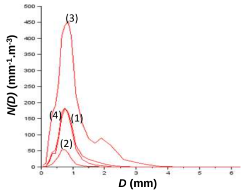

### Temporal evolution of *N*(*D*)

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

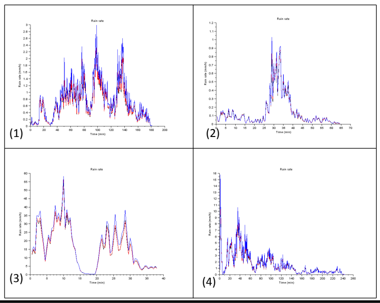



### Raindrop diameter distribution

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




### Rain rate




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

(Blue)

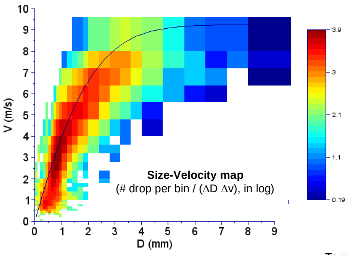
$$R = \frac{\pi}{6\Delta t}\sum_{i,j}\frac{n_{i,j} D_i^3}{S_{eff}(D_i)}$$

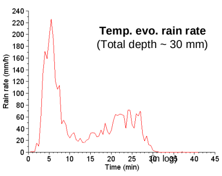
(Red)

$R_{PWS100}$ (Black)

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

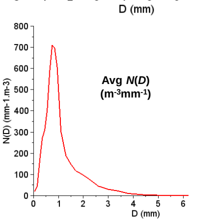
### General features

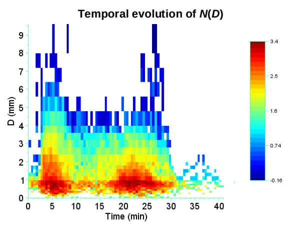


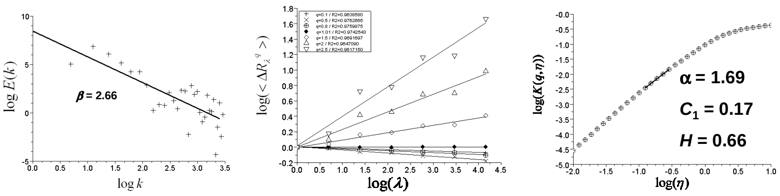

| Dur. (min) | I max (mm/h) | T * (Year) |
|---|---|---|
| 30 min | 57 | 8.9 |
| 15 min | 72 | 6.1 |
| 5 min | 154 | 10.3 |

** Estimated using a Frechet law and the data from a rain gauge located 10 km away*




### Multifractal analysis on *R*

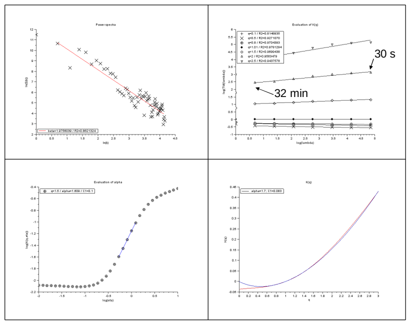



## Multifractal analysis and microphysics

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 |
|---|---|---|---|
| α | 1,61 | 1,59 | 1,34 |
| $C_1$ | 0,10 | 0,14 | 0,10 |
| β | 1.98 | 2.00 | 1.82 |
| H | 0.58 | 0.62 | 0.49 |

## Conclusion

- Some standard values of α (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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Schertzer D., Lovejoy S., 2008: Turbulence, raindrops and the $l^{1/2}$ number density law. *New Journal of Physics* 10