Influence of the DSD variability at the radar subgrid scale on radar power laws

Joël Jaffrain* and Alexis Berne

Environmental Remote Sensing Lab., École Polytechnique Fédérale de Lausanne, Switzerland
* Now at MeteoSwiss, Payerne, Switzerland

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ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

Spatial variability of the DSD

Drop Size Distribution (DSD)

- Concentration of drops / size.
- Rain variables: DSD moments.

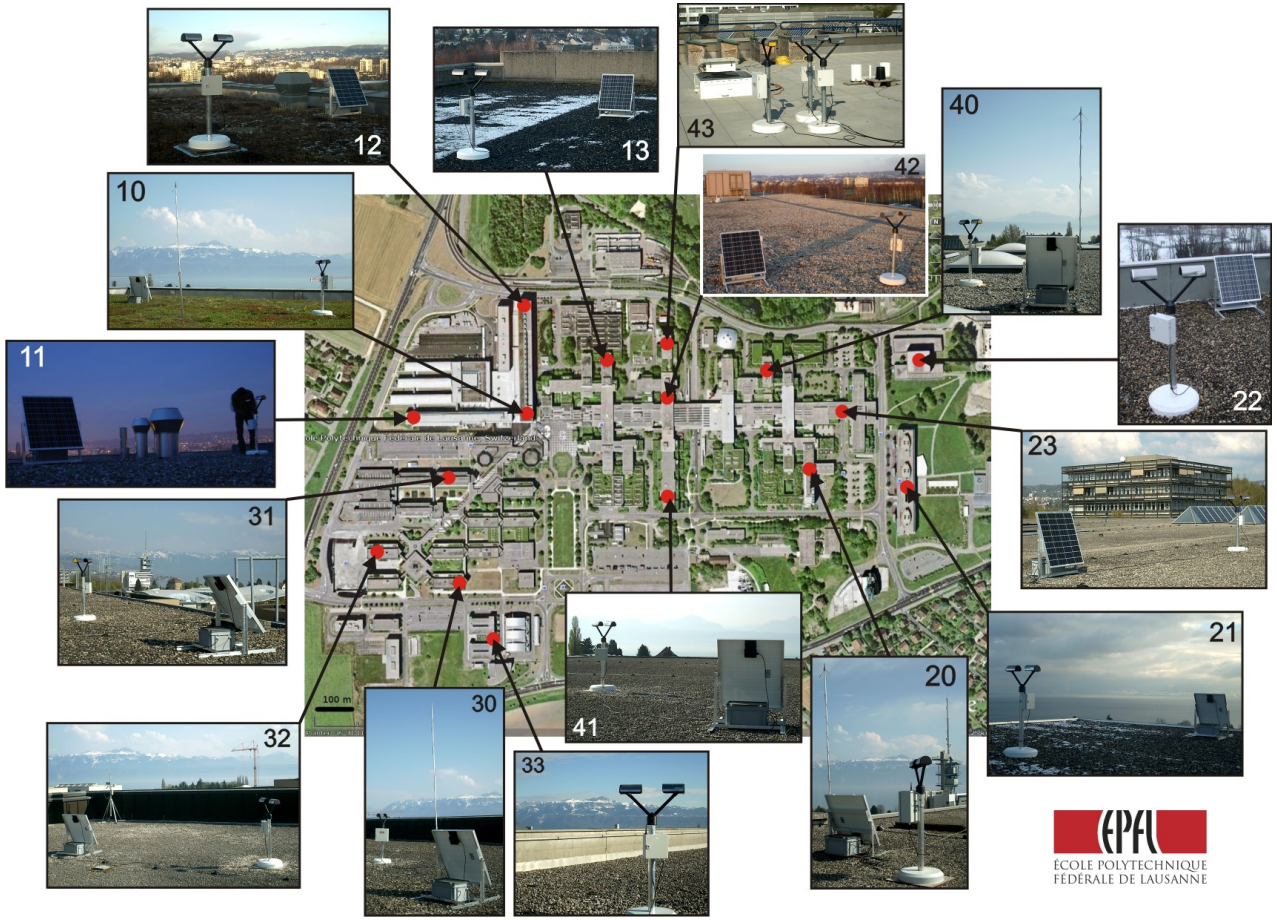
Precipitation variability

- Interactions cloud microphysics / atm dynamics.
- Strong variability of the DSD over a large range of scales.

Related questions

- Quantification of the DSD variability (at the radar pixel scale).
- Influence of this variability on radar rain-rate estimation?

Network of disdrometers



- 16 identical instruments (Parsivel 1) over $\sim 1 \times 1$ km^2 (radar pixel).
- Temporal resolution of 30 s + real-time access to data.

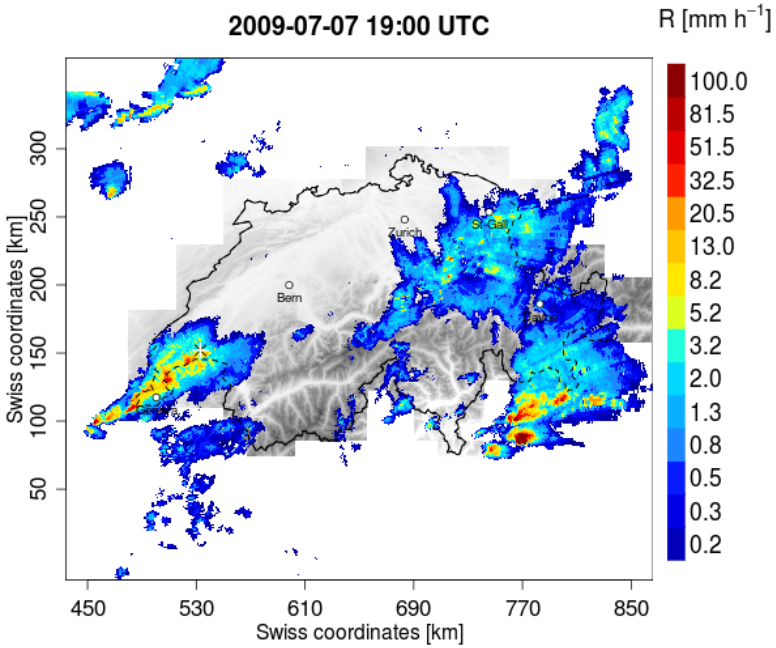
(Jaffrain et al., WRR, 2011)

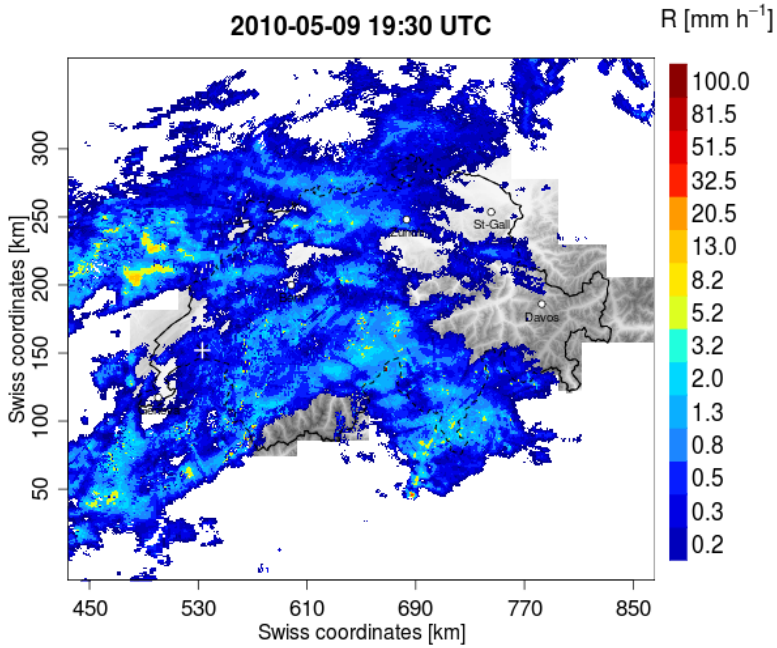
Data set

Selection of events

- Bias in rain amount from Station 43 / colocated rain gauge $< 10\%$.
- Classification in convective, frontal (stratiform) and transitional.

$\Rightarrow$ 36 events: 9 conv. (643 min), 8 front. (839 min), 19 trans. (3665 min).



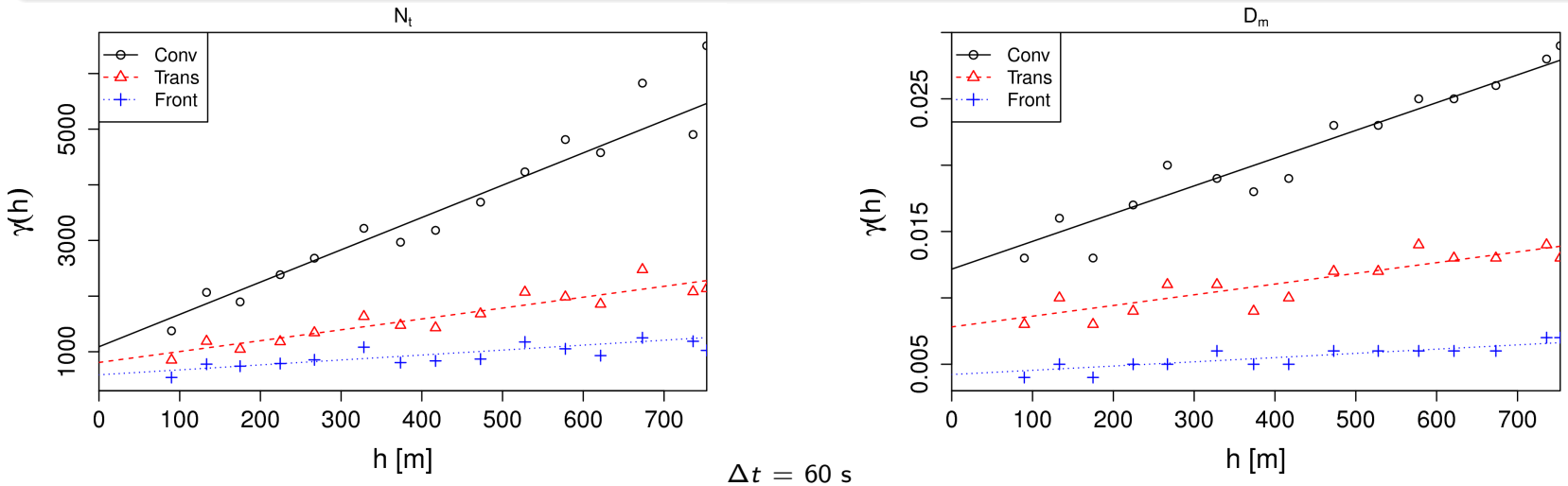


DSD variability within a radar pixel

- $N(D) = N_t f(D)$ where N_t is the total drop concentration and f is a pdf.
- DSD characterized by N_t and D_m (mass-weighted diameter $= M_4/M_3$).

Spatial structure of N_t and D_m

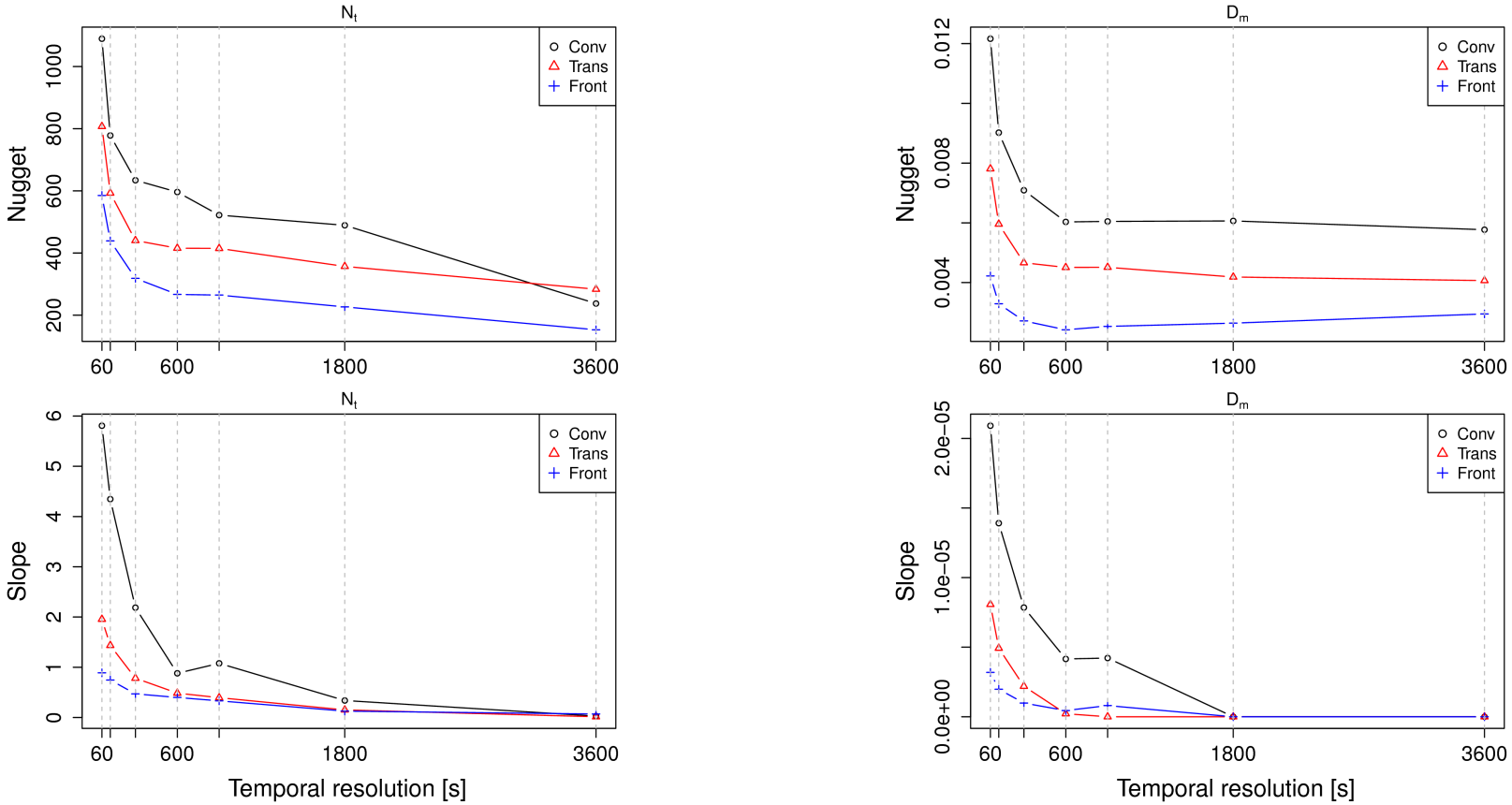
- Quantified by the quantile variogram γ (related to auto-covariance)
- Averaged over each class of event (convective, transitional, frontal).



$\Delta t = 60$ s

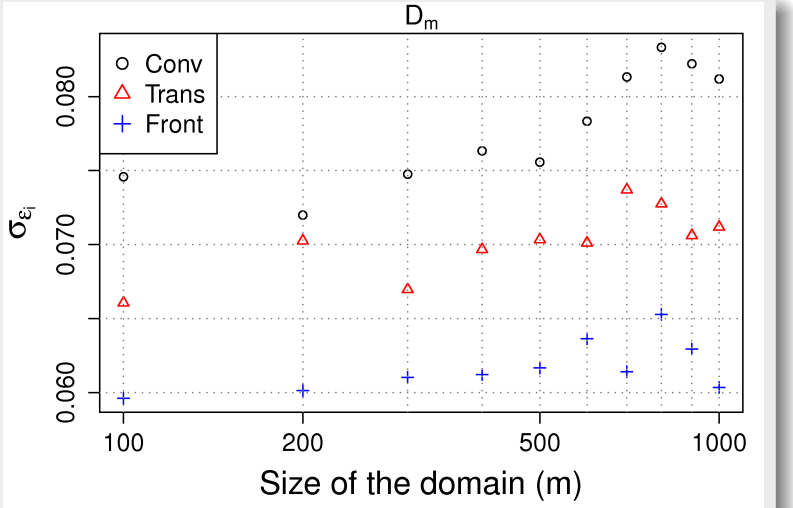
Significant natural variability of the DSD within a radar pixel.

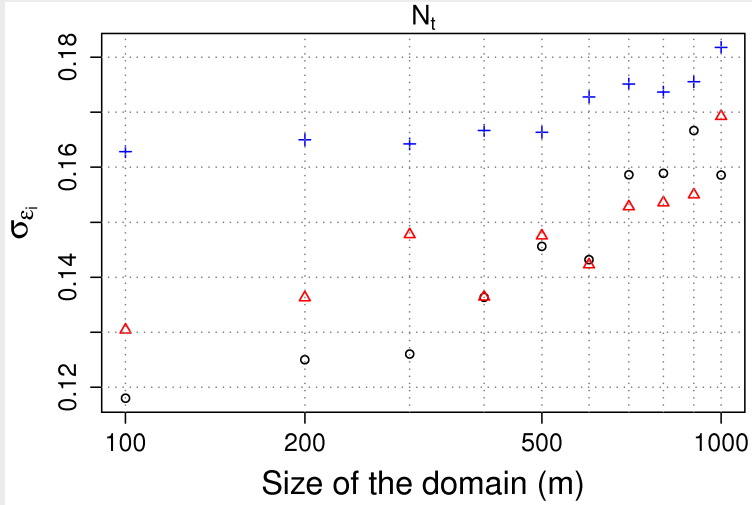
Influence of temporal resolution



- DSD variability decreases when temporal resolution decreases.
- DSD variability lower than measurement errors when $\Delta t \geq 30$ min.

Representativeness error / domain size





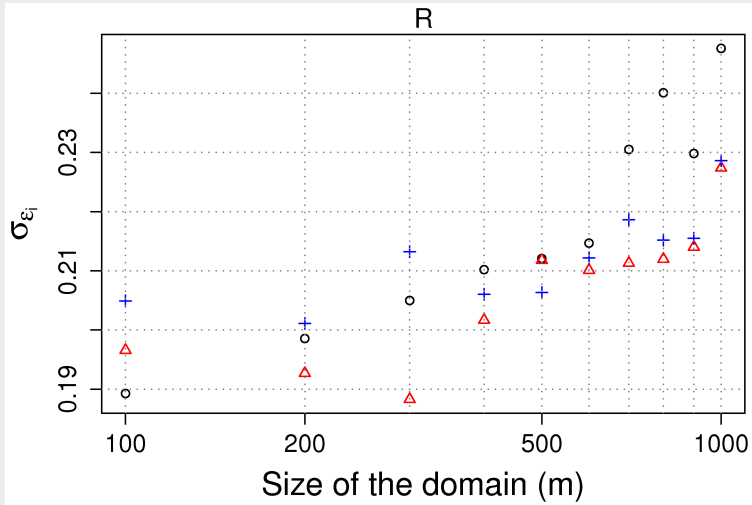
Representativeness error

$$\epsilon = \frac{V_p - V_a}{V_a}$$

V_p: point value

V_a: areal value

(Jaffrain and Berne, JAMC, 2012a)



Radar rain-rate estimators

Conventional radar

Power law between reflectivity Z [mm^6 m^{-3}] and rain rate R [mm h^{-1}]

$$Z = aR^b$$

Polarimetric radar

Power law between rain rate R [mm h^{-1}] and specific differential phase shift K_{dp} [deg km^{-1}]

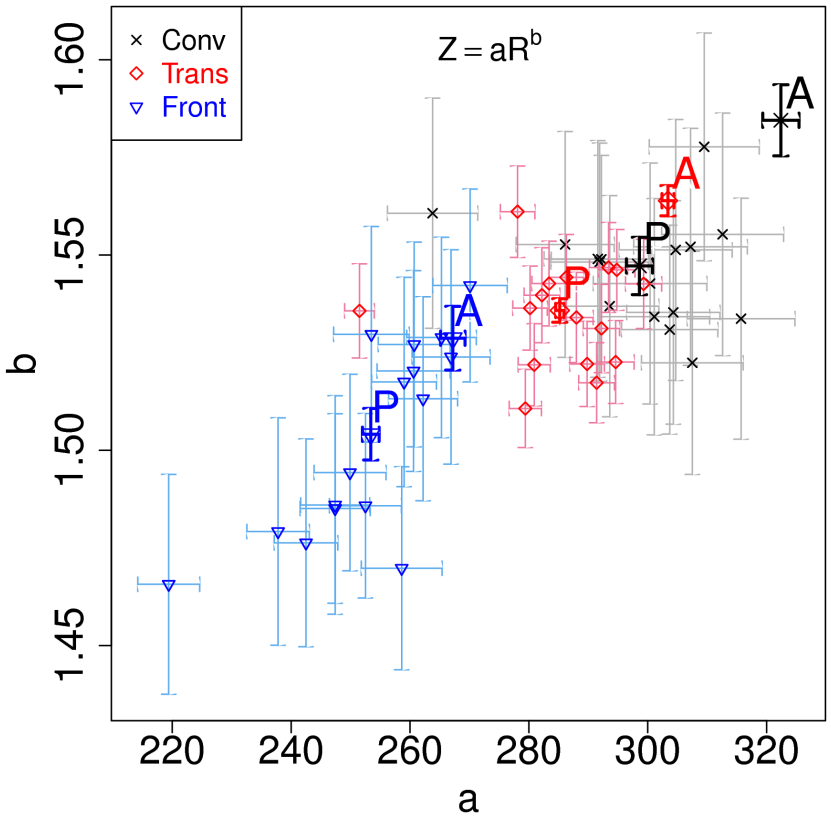
$$R = cK_{dp}^d$$

Influence of the DSD

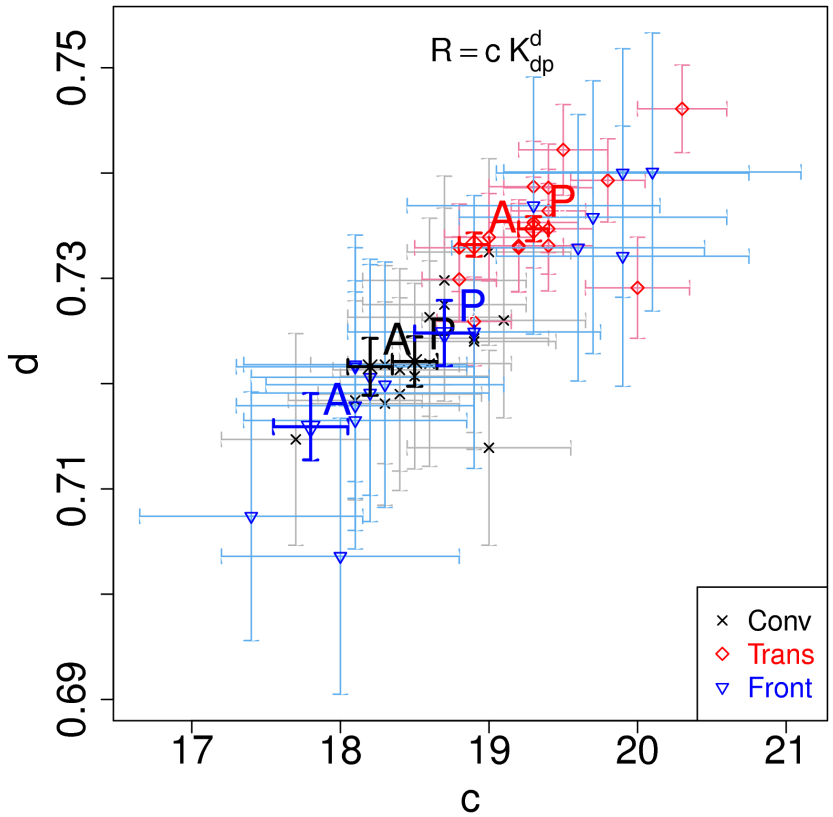
- (a, b) and (c, d) depend on the DSD.
- Their values are usually derived from disdrometer observations ($\sim$1 m^3), and then applied to radar measurements ($\sim$1 km^3). Hence radar subgrid variability of the DSD can be a source of error.

Influence on radar power laws

Coefficients a and b (at 5.6 GHz)

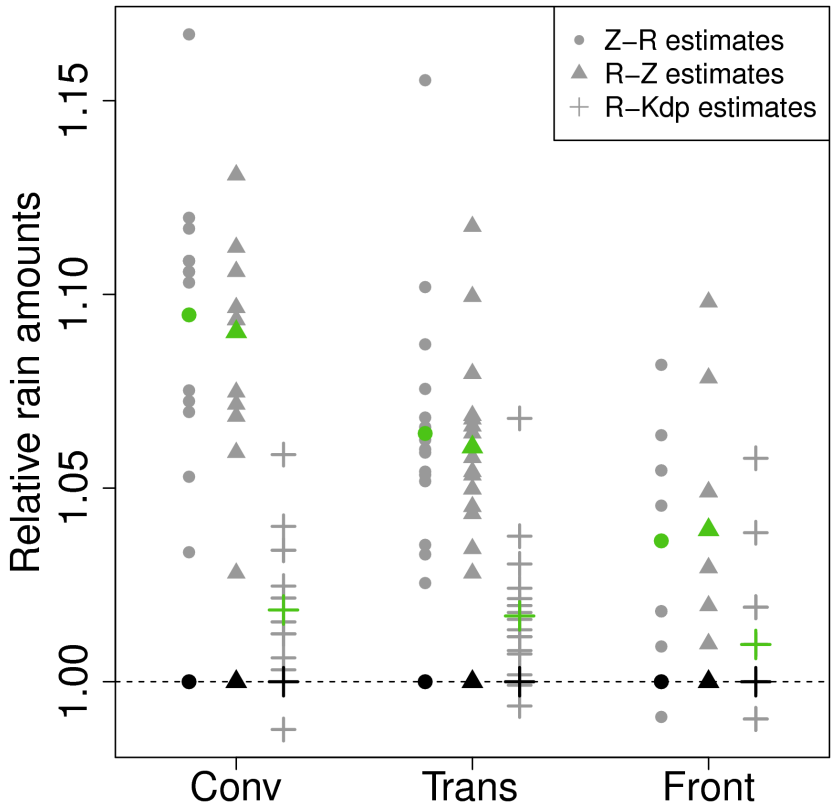


Coefficients c and d (at 5.6 GHz)



$\Delta t = 60$ s

Influence on total rain amount



- Apply (a,b,c,d) derived from point data to pixel values ($\simeq$ radar).
- Error in total rain amount for 3 types of rain is between -2 and +15%!

(Jaffrain and Berne, JAMC, 2012b)

Conclusions

DSD variability witin a typical radar pixel

- Designed and set up a network of disdrometers to get relevant DSD data.
- Spatial variability quantified using variograms and taking into account measurement errors.

$\Rightarrow$ DSD variability is significant within a radar pixel at high temporal resolutions (higher than 30 min).

$\Rightarrow$ Influence on derived radar rain-rate estimators can be up to 15%.

Thank you for your attention!