Spatial structure of the DSD within a typical weather radar pixel.

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1. Objectives:
Rainfall is highly variable at different scales in both time and space. From intra- to inter-event, the spatial and temporal variability of the rainfall drops size distribution (DSD hereafter) at small scale is poorly documented. Nevertheless, this variability of the DSD is an important issue with respect to radar rainfall estimation because the DSD is generally assumed to be uniform within the radar sampling volume.

This study presents analyses of the spatial structure of the DSD at small scales (~1 km²) using variograms and DSD observations collected by a network of 16 disdrometers. Because the DSD can be seen as the product between the total concentration of drops (N) and a probability density function (f)(D), structural analyses are conducted for N and the median-volume diameter D₀ (a commonly used first-order statistical descriptor of the probability density function (f)(D)) and the rain rate R.

2. Data collection:
The experimental variograms are plotted with blue points. A model of variogram is fitted on each data set collected by 16 disdrometers using isotropic variograms on a data set collected by 16 disdrometers deployed over a typical weather radar pixel (~1 km²).

The variogram is characterized by its:
- range: the decorrelation distance.
- sill: the variance of z, associated with the range.
- nugget: the variability at small inter-distances. Generally, two possible sources:
  - Large variability at micro-scale.
  - Measurements errors.

According to the distribution of the 16 stations, the 50 m inter-distance (denoted id) classes range from 90 to 735 m. The number of pairs per id class is between 3 (674 m) and 15 (134 m). For each quantity of interest (N₀, D₀ and R), an isotropic variogram is computed at each time step (30 s). The "averaged" variogram over the event is calculated using the median of all the semivariance values for each id class.

3. Filtering and data set:
The filtering data:
- Consider time steps for which all stations provide data (no missing values allow).
- Remove unrealistic drops based on Diameter-velocity relationship [Kogler and Krajewski 2002].
- Drops that deviate more than 40% from Beard's velocity model are disregarded.
- Removes between 25 and 40% of the total number of detected drops (~2 mm of rain).

Data set:
- 2 rainfall events:
  - 1.5 h of convective rain, total amount of ~8.6 mm.
  - 1.6 h of frontal rain, total amount of ~11.5 mm.

4. Geostatistical tools:
The variogram is a geostatistical tool that provides an estimation of the degree of correlation between two points as a function of their Euclidian distance. Considering a random function Z with a constant mean between two points as a function of their Euclidian distance. The variogram is expressed as:
\[ \gamma(h) = \frac{1}{2} \left( \frac{Z(x+h) - Z(x)}{h} \right)^2 \]

The exponential variogram model reaches its sill asymptotically (as h → ∞). The 'effective range', which is the distance where the variogram reaches 95% of its maximum semivariance (corresponding to 5% of covariance), is about 3 times the model range.

5. Results:
The experimental variograms are plotted with blue points. A model of variogram is fitted on each experimental variogram. The selected variogram model is the exponential one:

\[ \gamma(h) = \begin{cases} \gamma(0) & h = 0 \\ \gamma(0) e^{-h / \alpha} & h > 0 \end{cases} \]

The number of pairs per id class is between 3 (674 m) and 15 (134 m). For each quantity of interest (N₀, D₀ and R), an isotropic variogram is computed at each time step (30 s). The "averaged" variogram over the event is calculated using the median of all the semivariance values for each id class.

6. Conclusion:
This study presents a quantification of the spatial structure of the DSD using isotropic variograms on a data set collected by 16 disdrometers deployed over a typical weather radar pixel (~1 km²).

- Exponential variogram model was appropriate for all experimental variograms.
- Globally, the convective event exhibits a larger variability (y(h)) than the frontal one, independently of the quantity of interest.
- The effective range (decorrelation distance) is larger for the convective event for N₀ and D₀.
- For rain rate, the effective range is slightly larger for the frontal event.
- Effective ranges for N₀ and R are of the same order > effective range for D₀.

7. Perspectives and open issues:
- Take into account the sampling uncertainty associated with Parsivel measurements.
- Perform analyses on a larger data set (already 1 year collected).
- What is the influence of the variability of the spatial structure of the DSD on radar remote rain rate estimates (Z-R relationship)?
- Perform similar analyses in time domain.
- Perform structural analyses in 2D space (anisotropy).