

DEPARTMENT OF GEOGRAPHY

RESEARCH GROUP CLIMATE & EARTH

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URBANIZATION AND AIR POLLUTION EFFECTS ON PRECIPITATION MICROPHYSICS

DISDROMETER STUDY IN BELGIUM



Source: Klimaat & Aarde, (2026). *Vakgroep Geografie, Universiteit Gent*.
Retrieved from <https://www.geografie.ugent.be/klimaat-en-aarde>

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Abstract:



URBAN EFFECTS

Summary

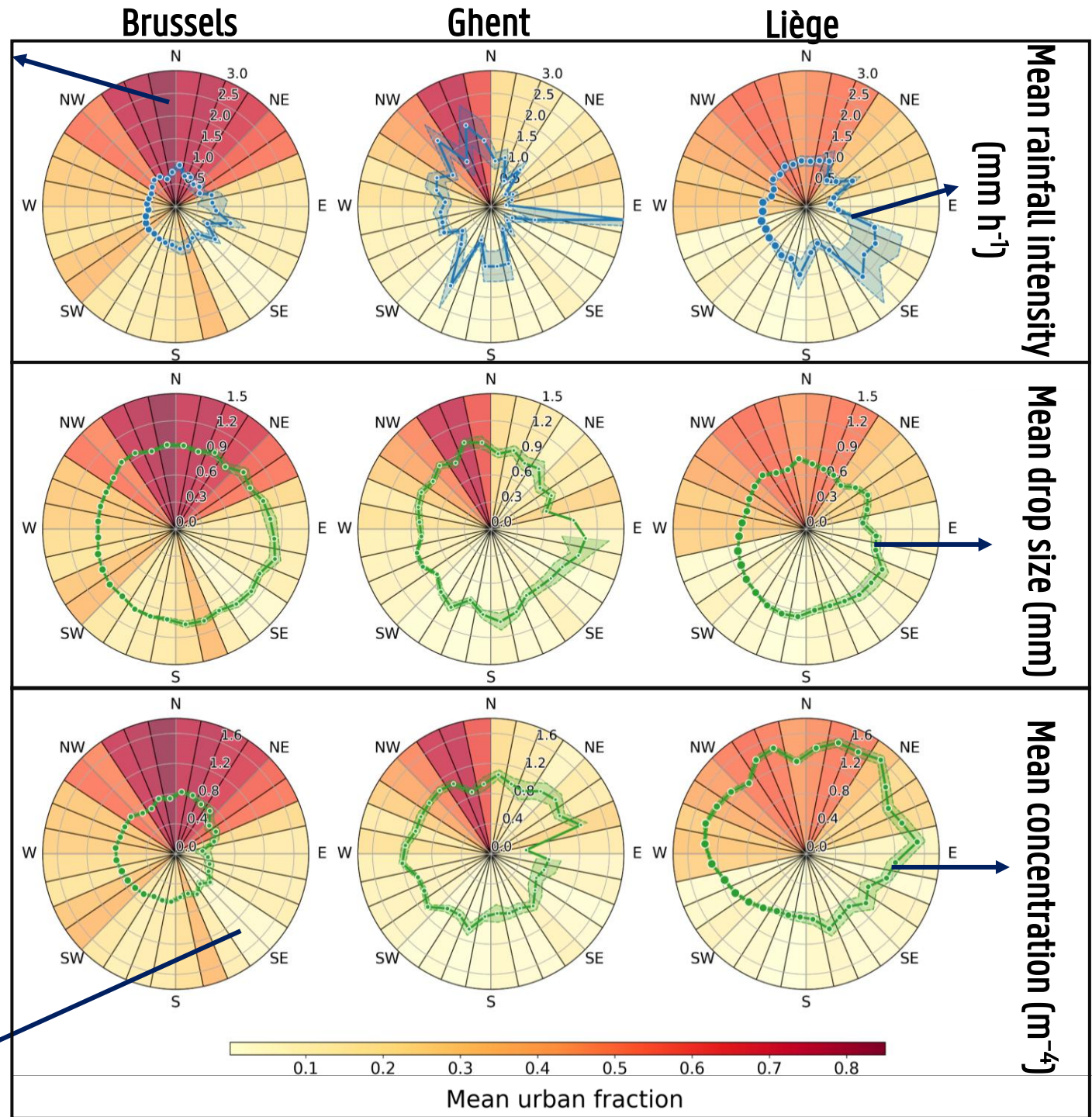
Weak and inconsistent urban signal

Rain rate & drop size decrease downwind of cities (2/3 sites)

Strong site dependence (proximity coast / urban structure)

Large-scale circulation as confounder

Urban upwind



Rural upwind

AIR POLLUTION EFFECTS

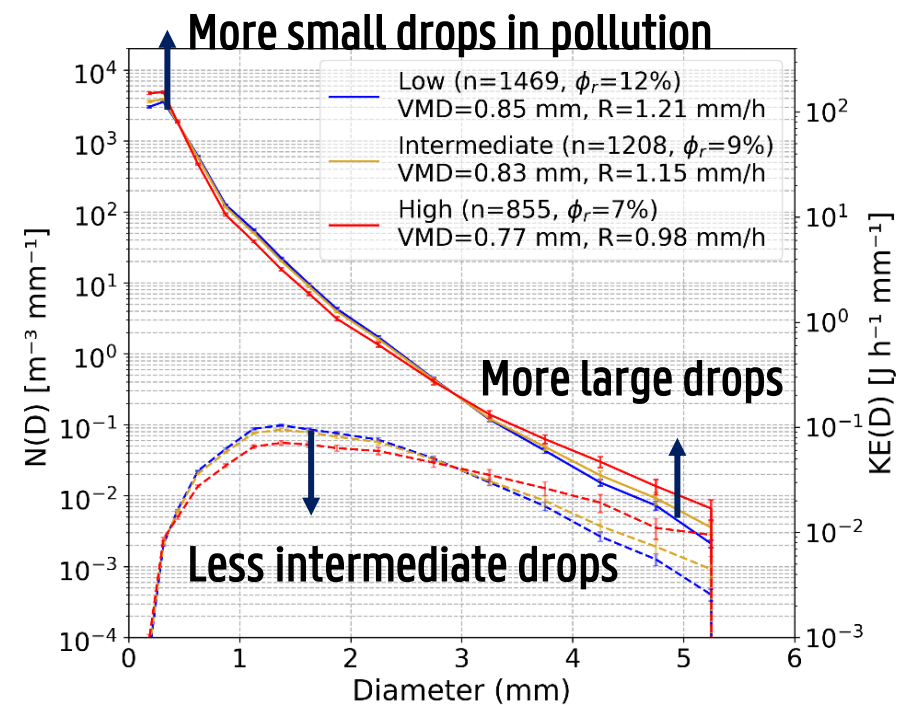
Summary

Suppression of daily rainfall

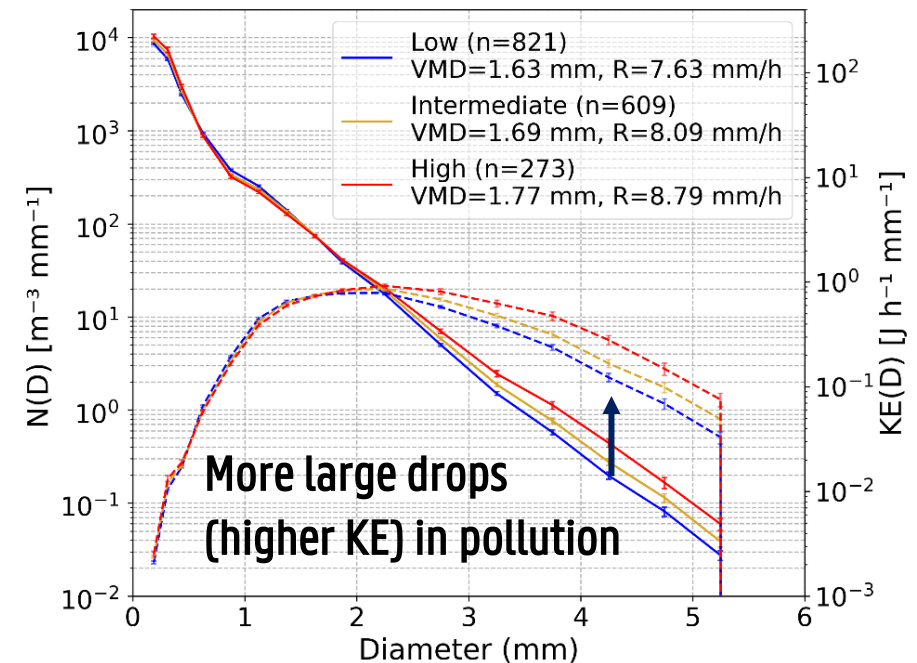
Intensification of convective rain

Results persist after controlling for confounding factors

- Number concentrations $N(D)$
- Rainfall kinetic energy $KE(D)$



Daily means



Convective events

DISCUSSION

RESEARCH CONTEXT

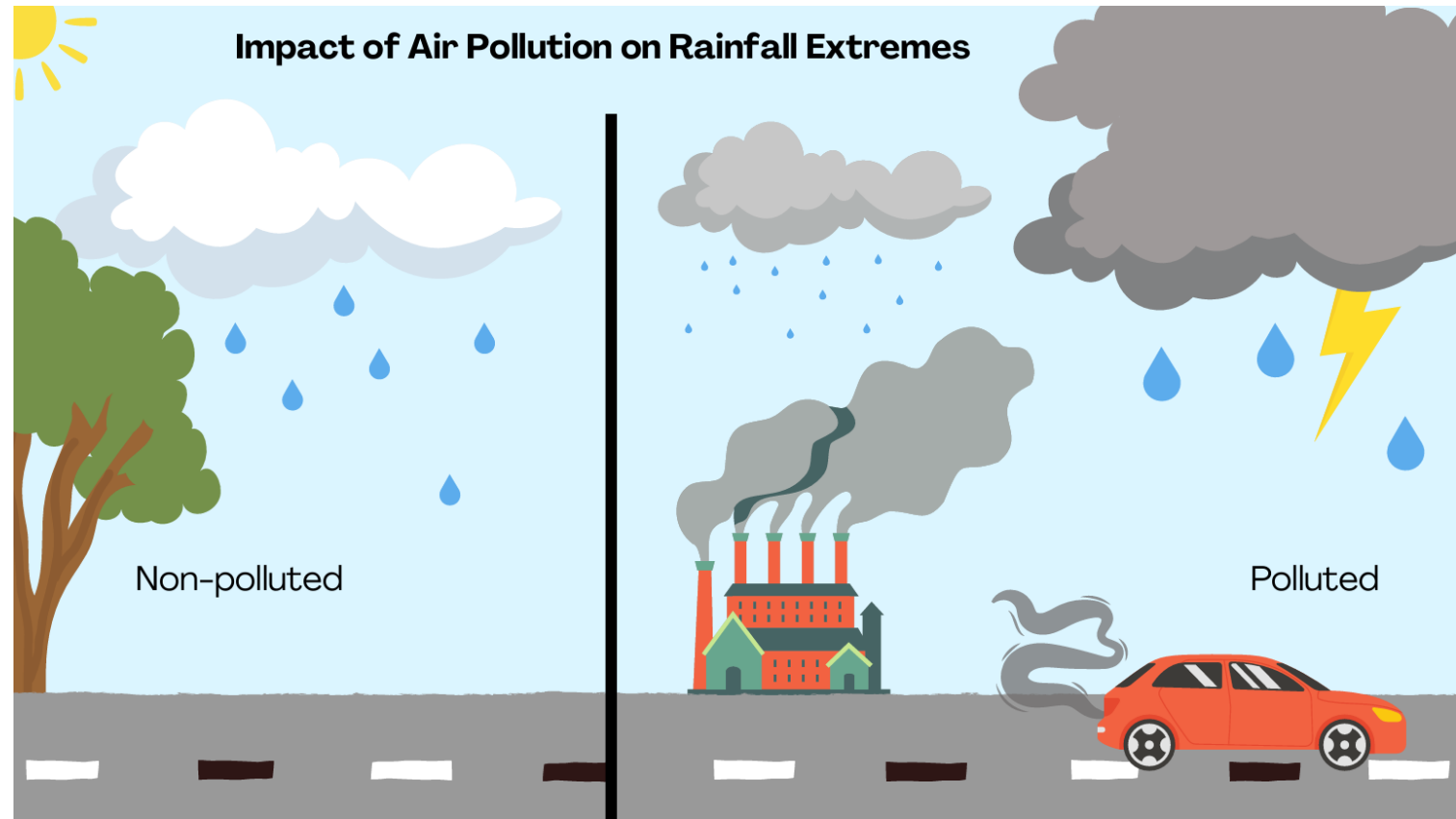
Societal importance

Impact of cities & air pollution

→ Disputed in literature

Urban precipitation or dry island?

Intensification or suppression?



INSTRUMENTS

Overview

- Disdrometers:

Measure v (m/s) and D (mm)

- Rain gauges:

Used for validation

- AWS:

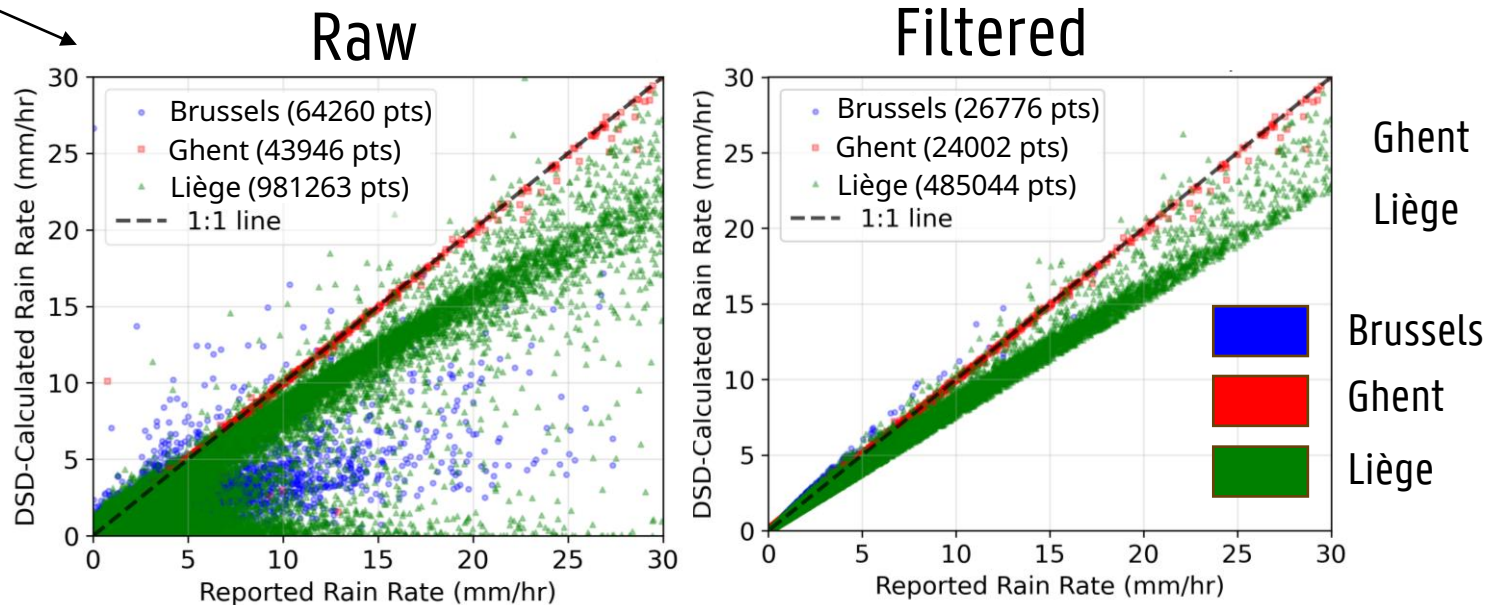
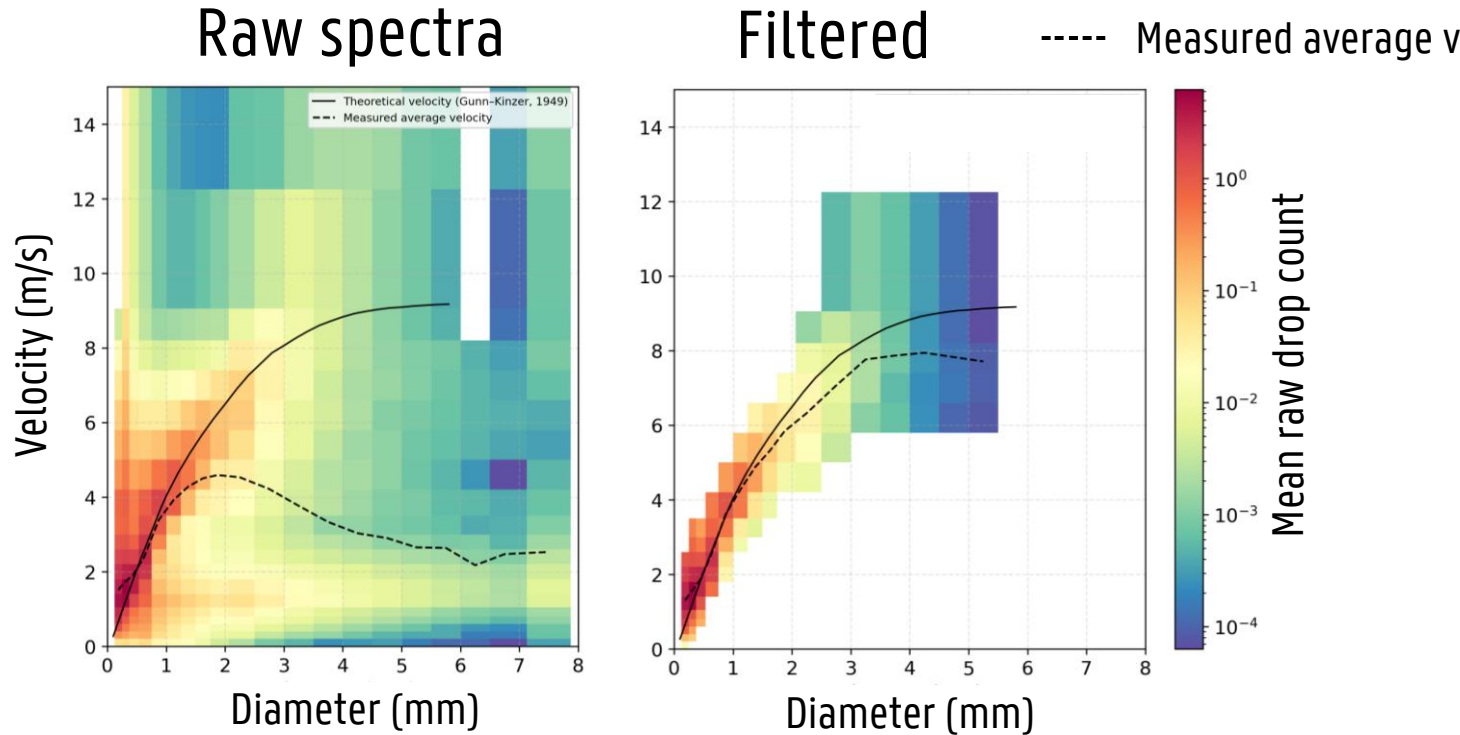
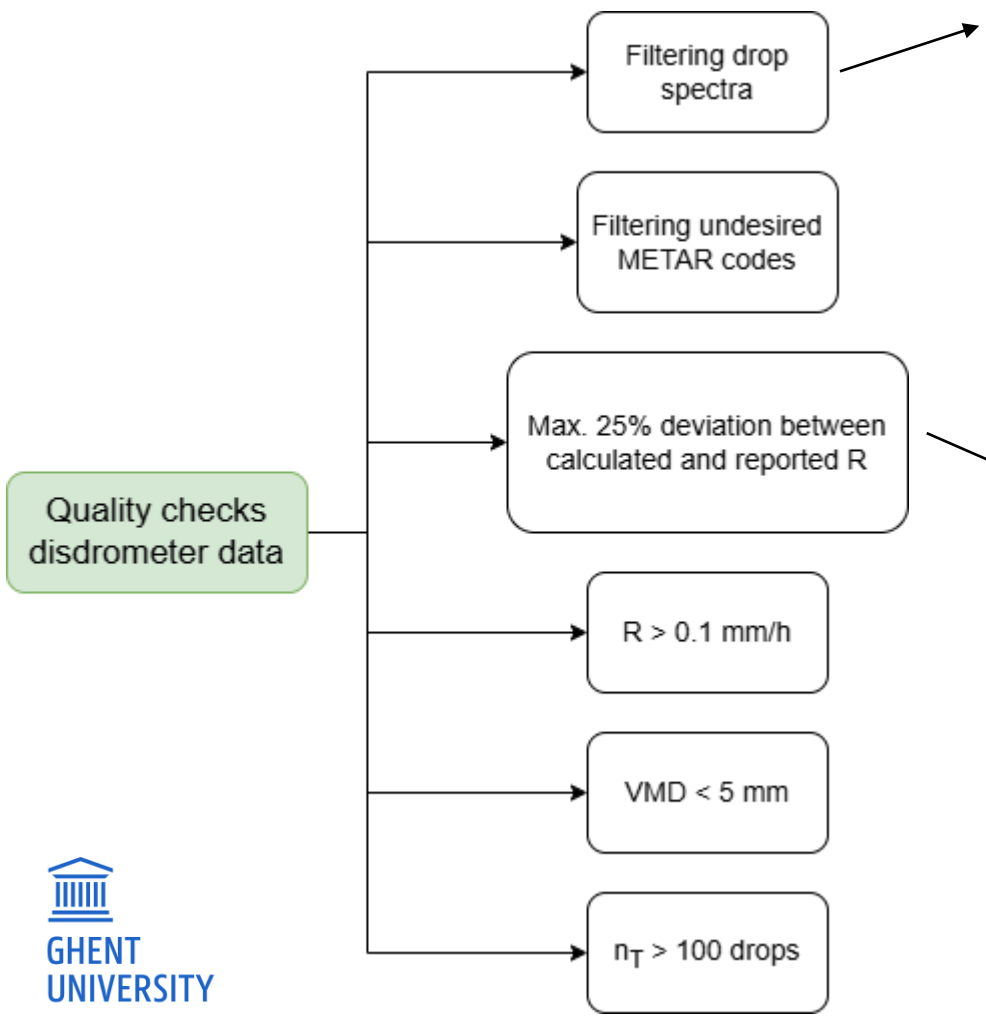
Meteorological variables (confounding factors)

- Ghent (2024 - ...)
- Brussels (2020 - ...)
- Liège (2006 - ...)



INSTRUMENTS

Disdrometer quality control



Ghent
Liège
Brussels
Ghent
Liège

INSTRUMENTS

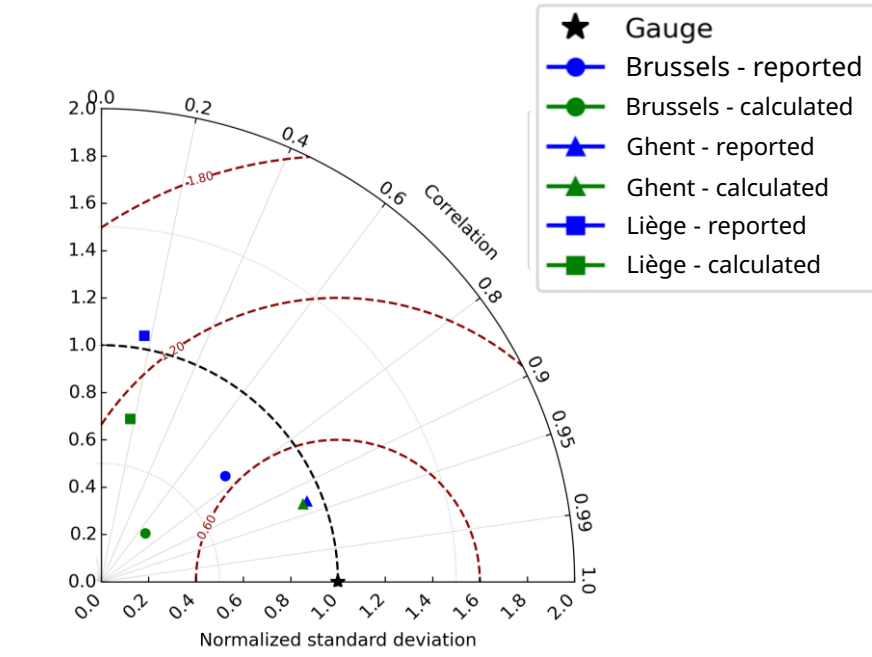
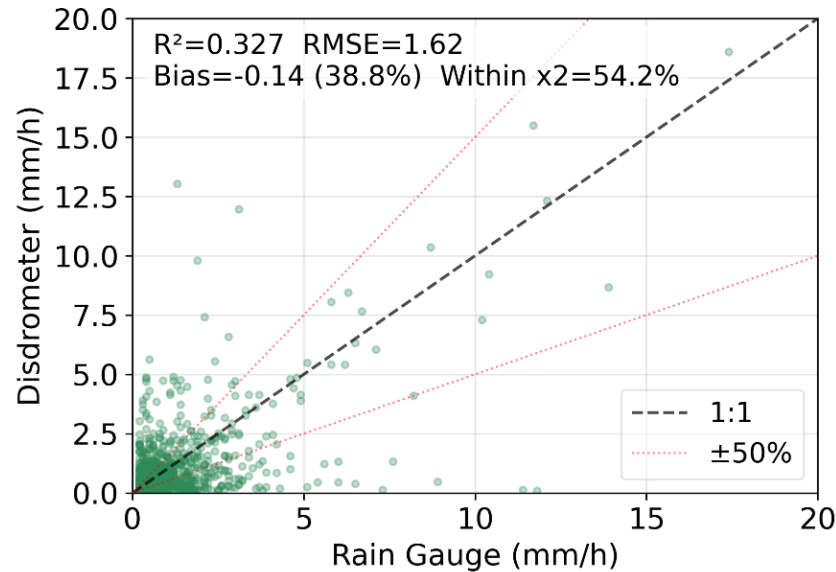
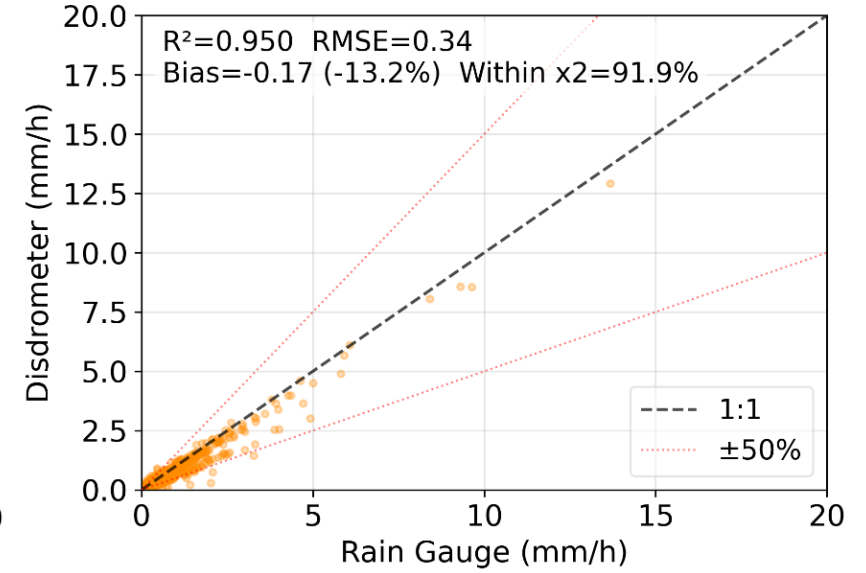
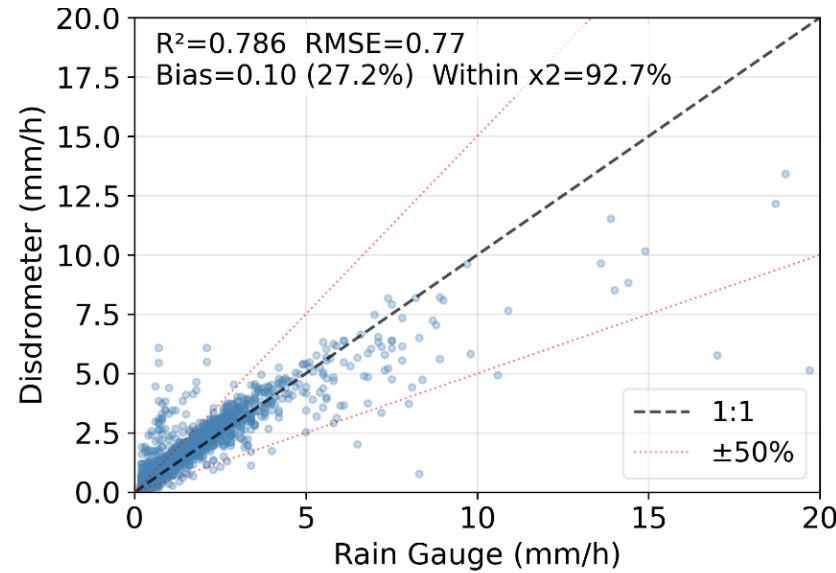
Disdrometer validation

Overall good performance

Temporal mismatch in Liège



Disdrometer vs rain gauge (hourly)

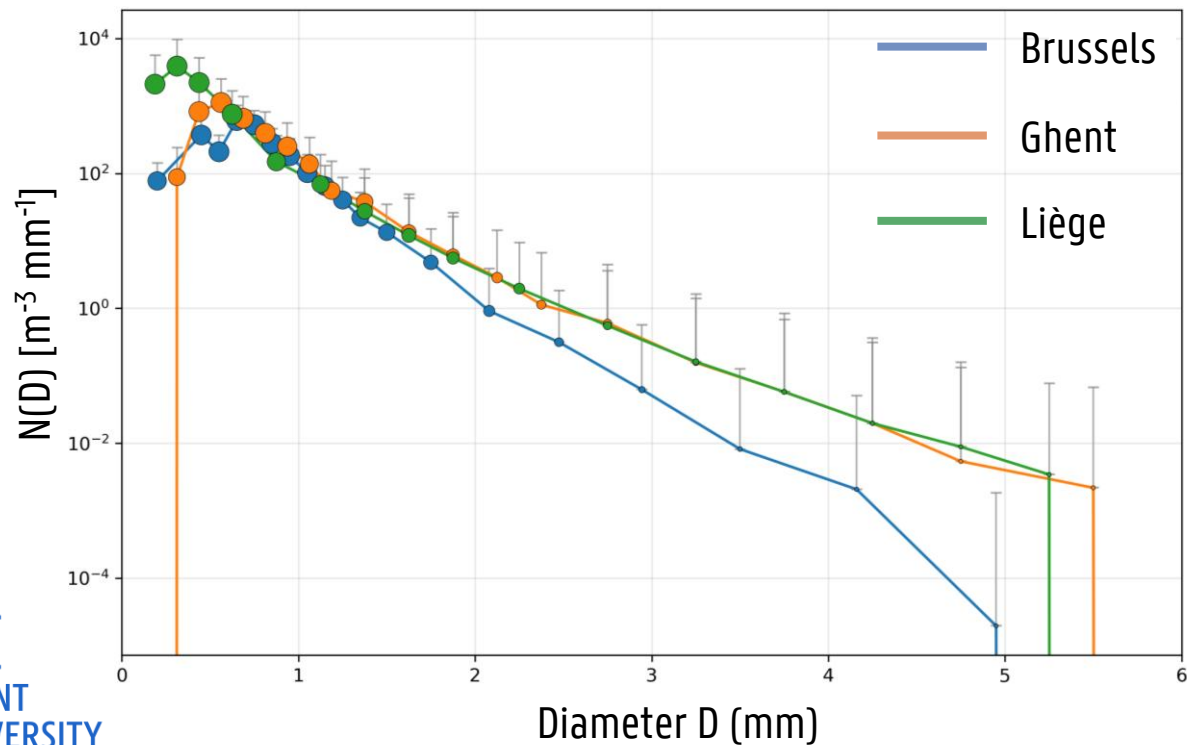


DROP SIZE DISTRIBUTION

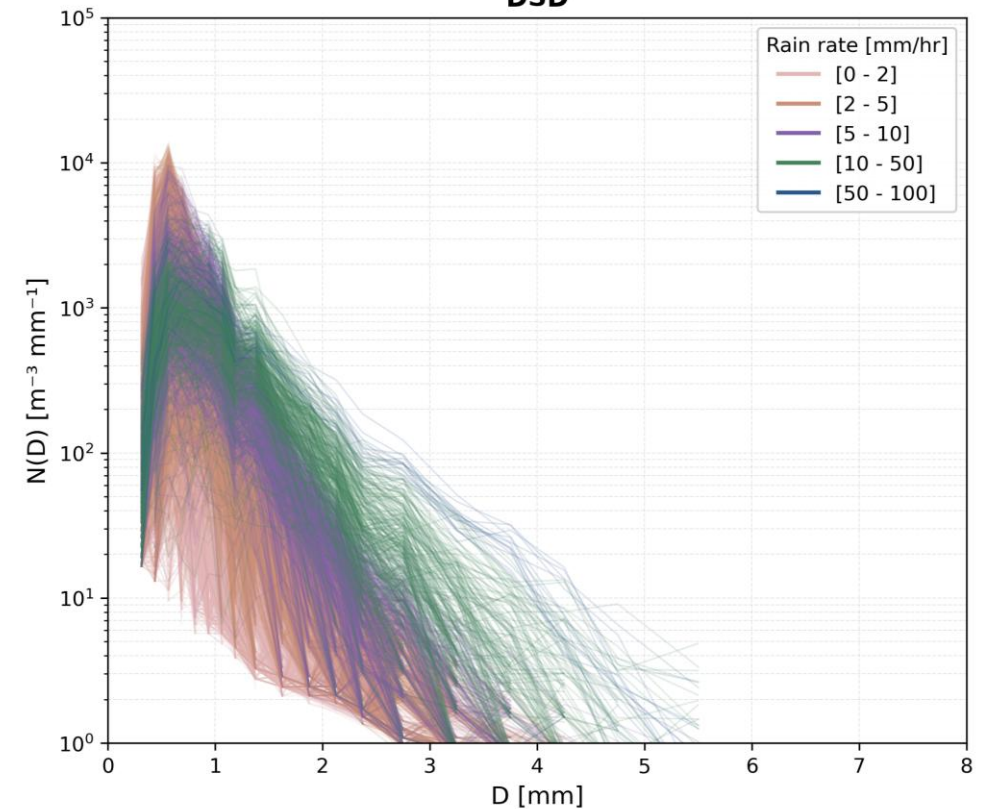
DSD structure

$N(D)$ concentrations \rightarrow used to derive other variables (VMD, KER, LWC, N_w , etc.)

Mean drop size distribution



DSD



RAINFALL REGIME CLASSIFICATION

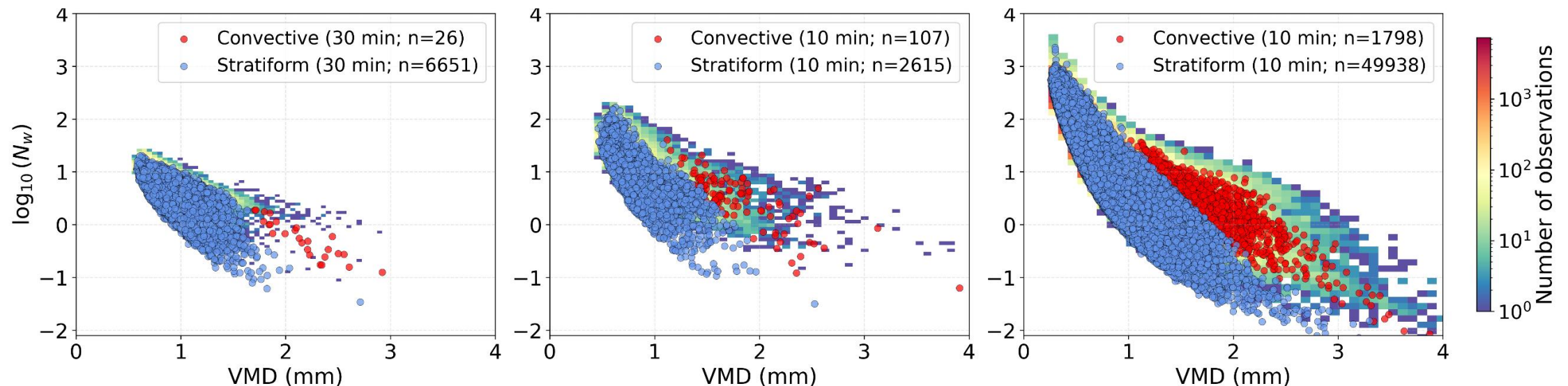
Convective – stratiform

10 or 30 minute events

Using instrument-specific Z-R relation

Reflectivity $Z > Z(5 \text{ mm h}^{-1})$ & $\sigma(R) > 1.5 \text{ mm h}^{-1}$

→ convective, stratiform otherwise



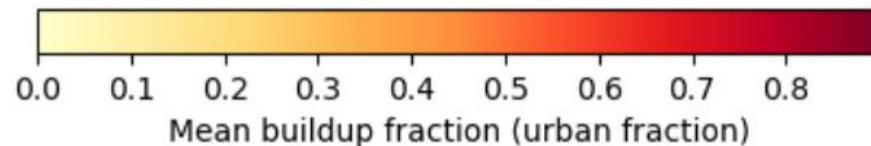
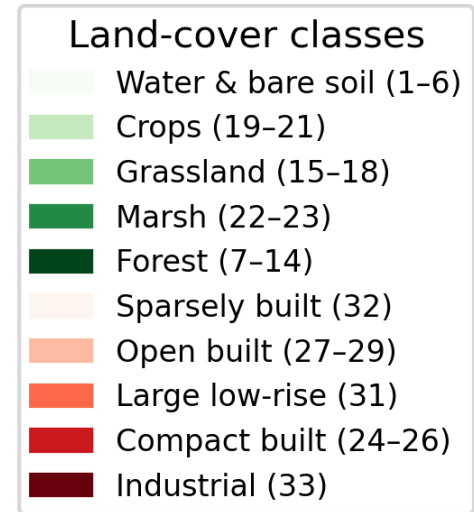
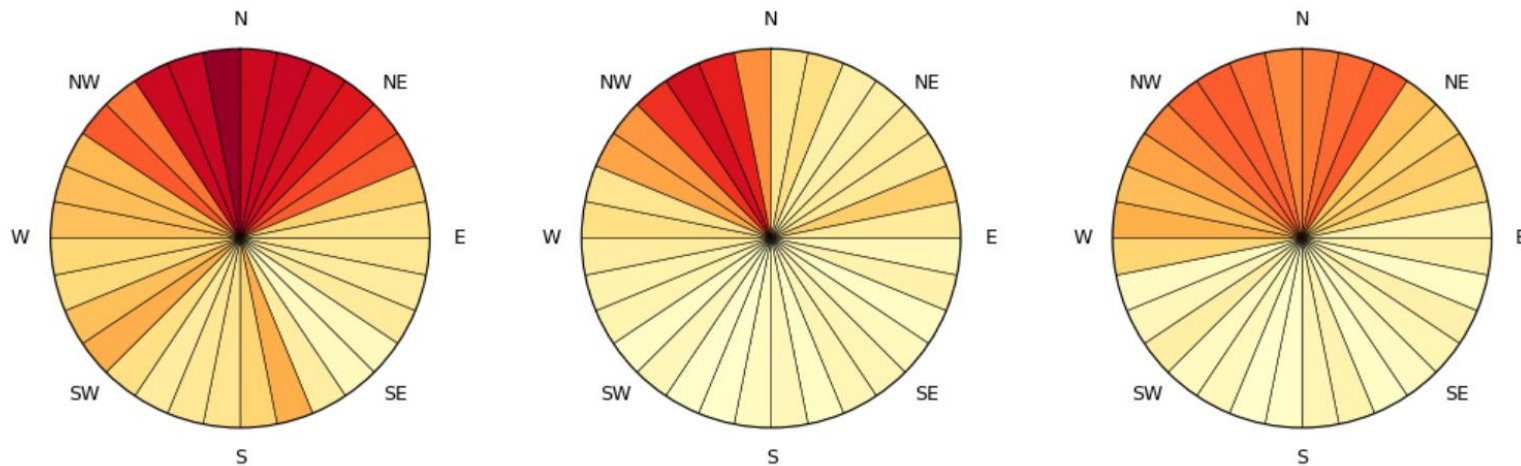
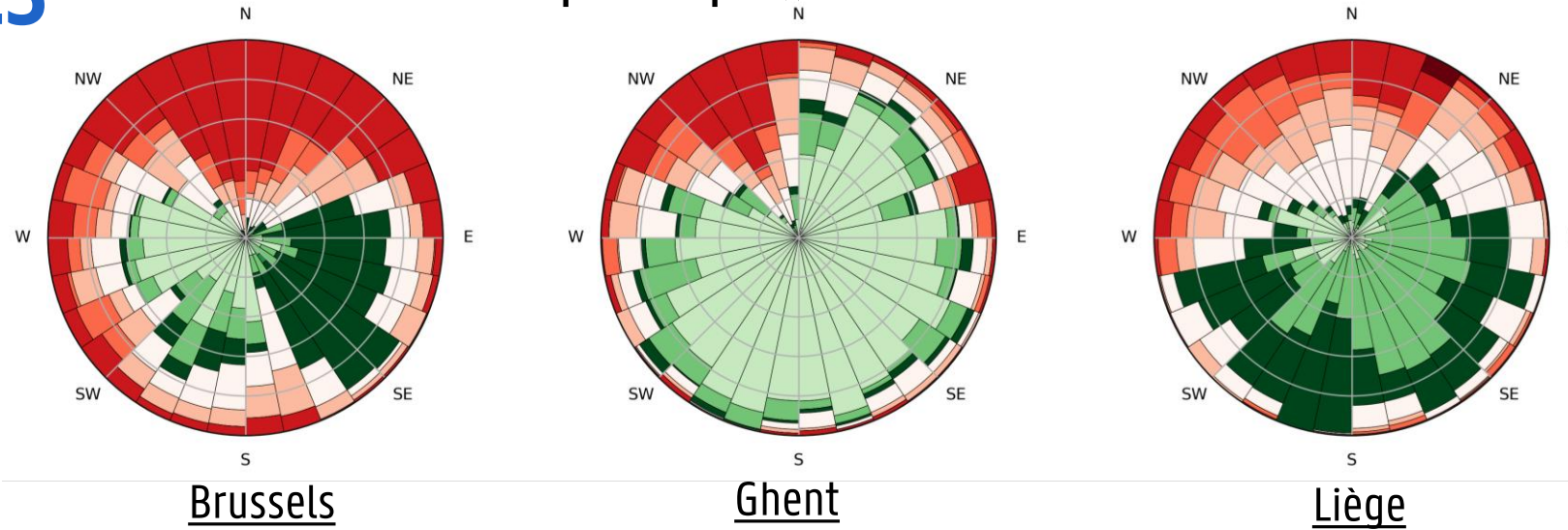
INFLUENCE OF CITIES

Methodology

ERA5 wind directions,
 Ecoclimap SG cover types &
 urban fraction

32 wind
 sectors, 10
 km buffer

Land-cover composition per wind sector



INFLUENCE OF CITIES

Urbanisation

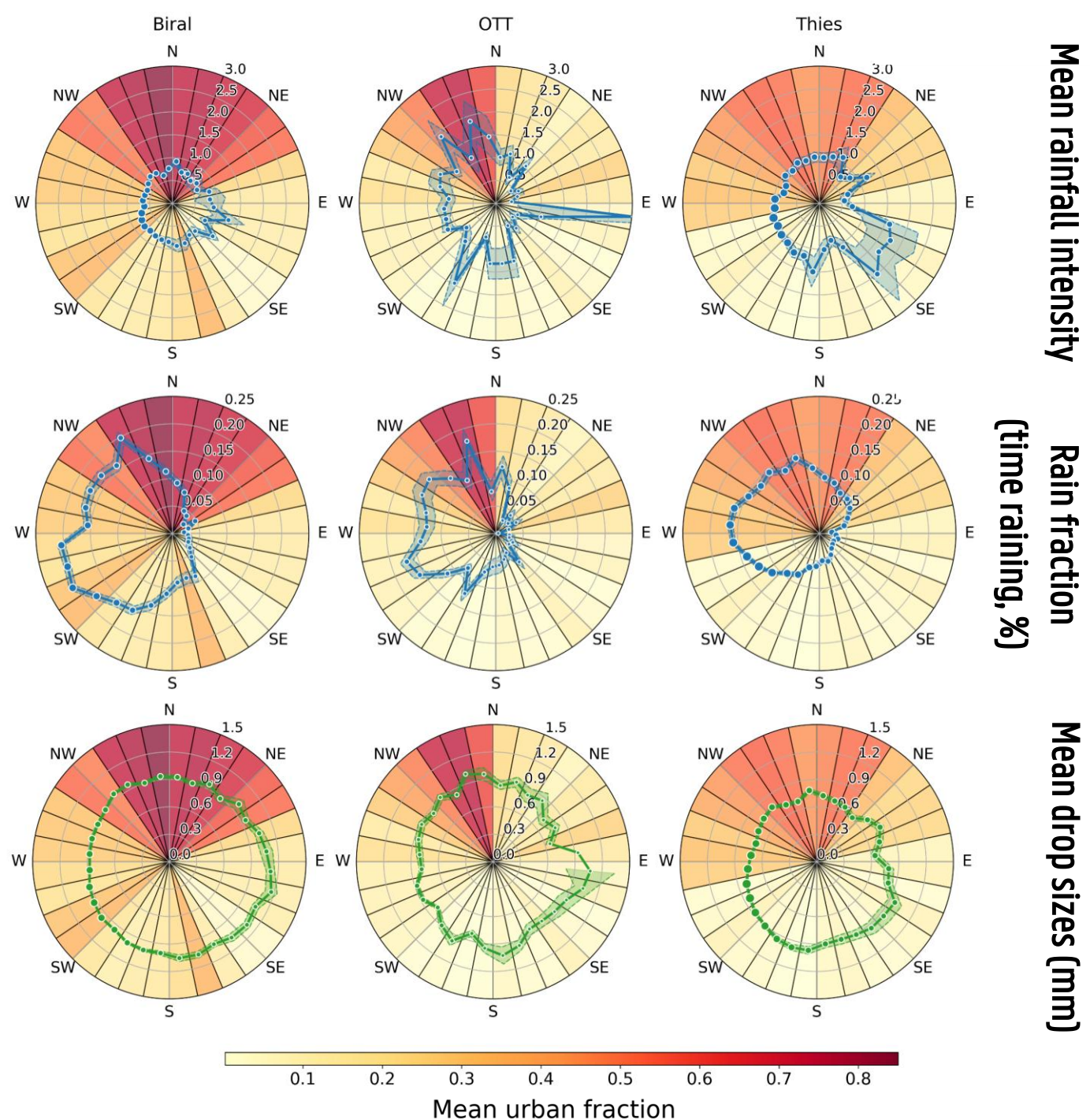
Smaller drops ($p < 0.001$) & lower intensity ($p < 0.05$) downstream of Brussels & Liège, no impact on Ghent

→ Possibly confounded by sea-effects

No significant difference between cover types

Stratification by season and wind speed did not change results

Convective events slightly smaller drops and higher concentrations



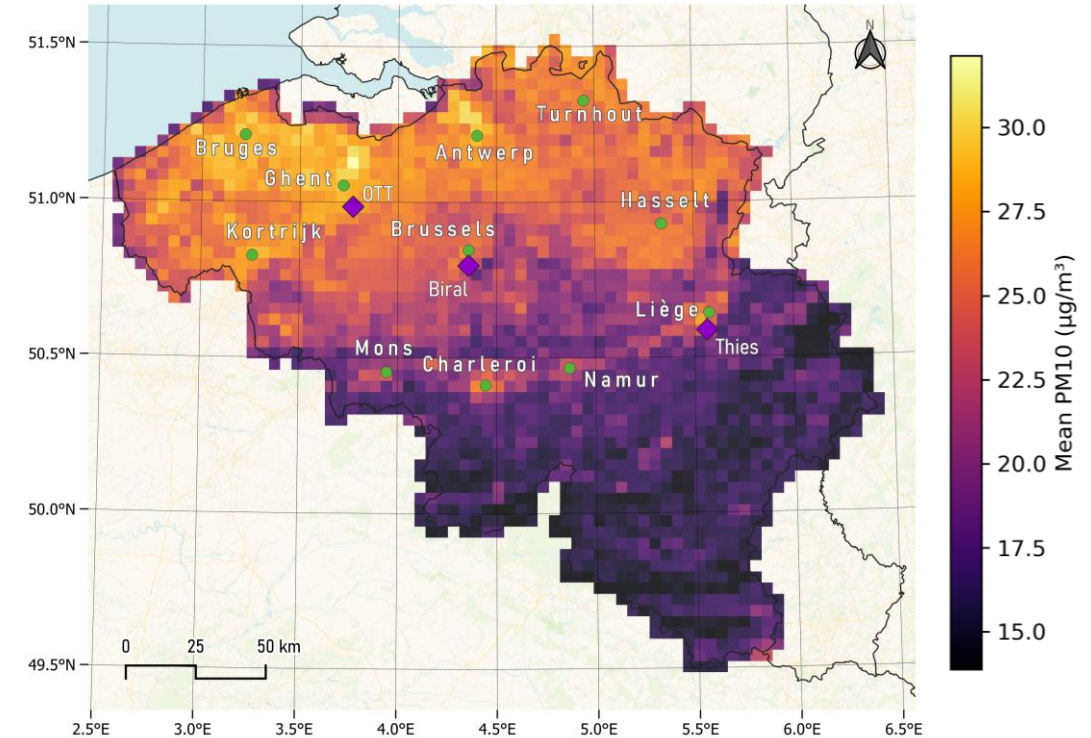
INFLUENCE OF AIR POLLUTION

Methodology

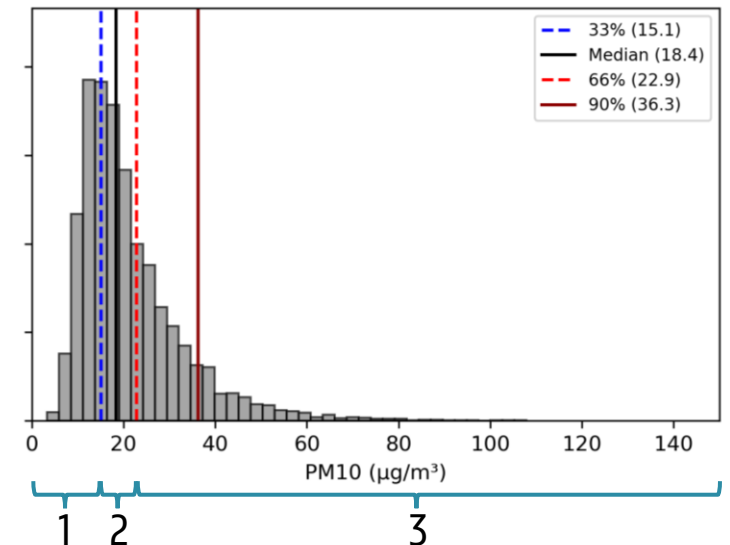
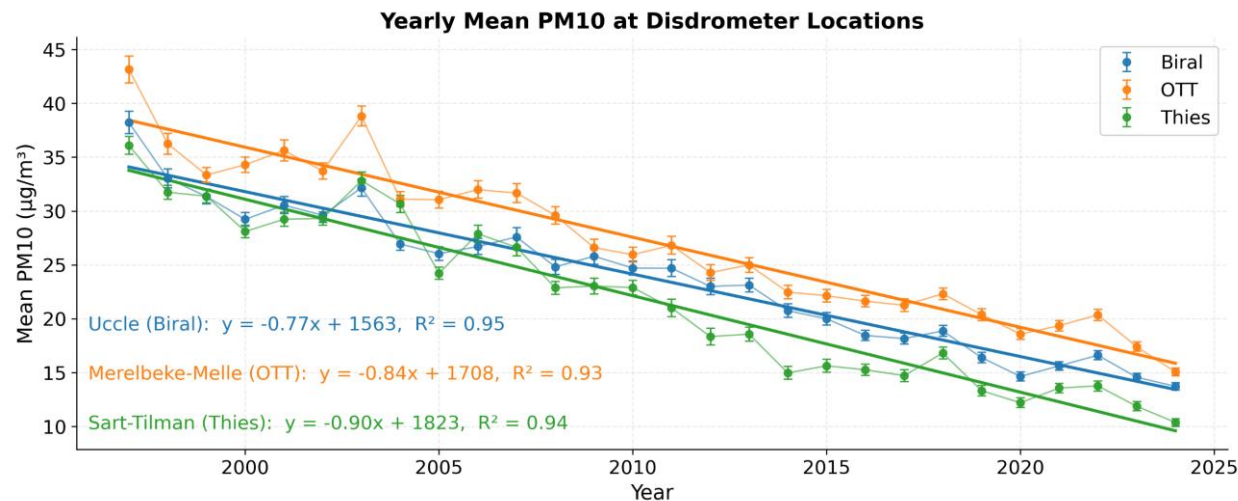
Daily mean gridded (4x4 km) PM₁₀ & PM_{2.5}
(IRCEL – CELINE)

PM categories: low (1), intermediate (2),
high (3) (→ terciles)

Mean PM10 (1997-2024)



- Brussels
- Ghent
- Liège



INFLUENCE OF AIR POLLUTION

Daily means

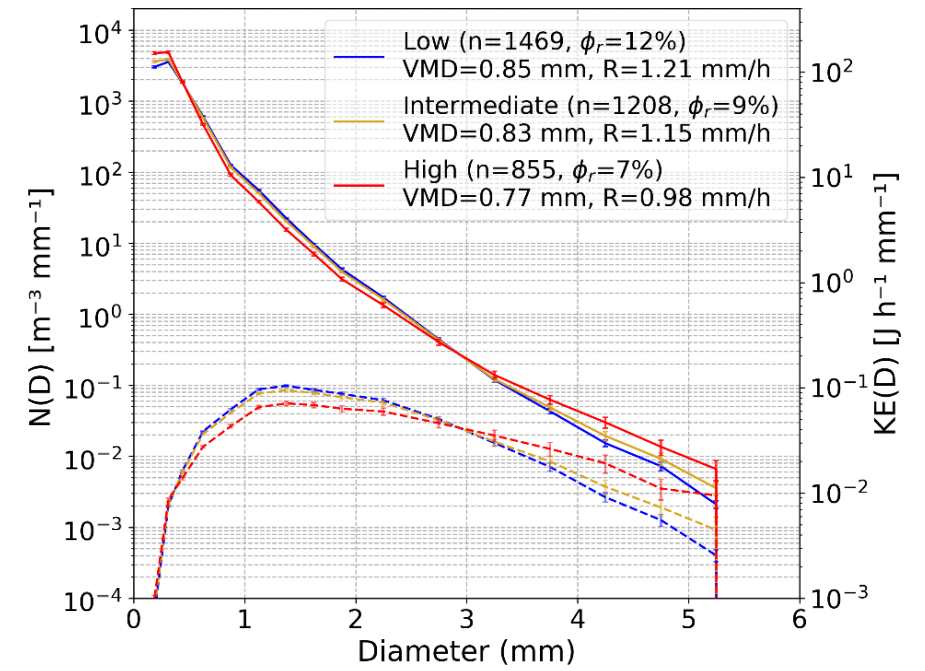
PM ↑:

- Less frequent rainfall
- More drizzle
- Smaller mean drop sizes

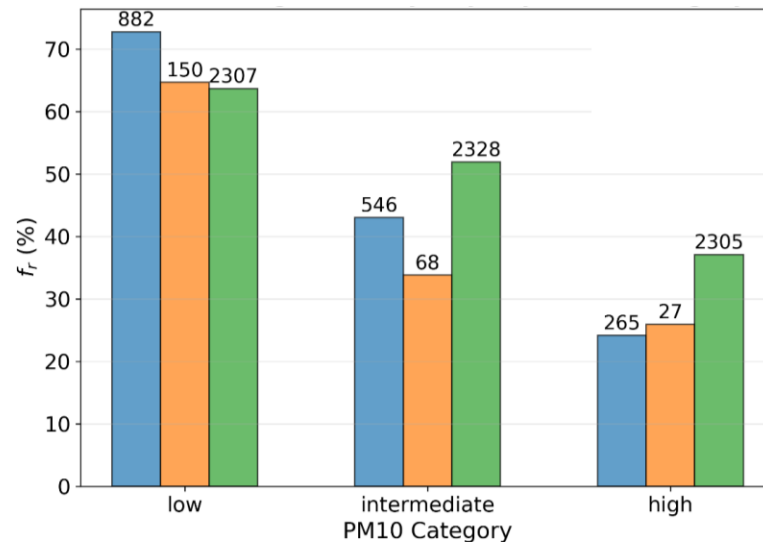
→ Confounding factors (high pressure)



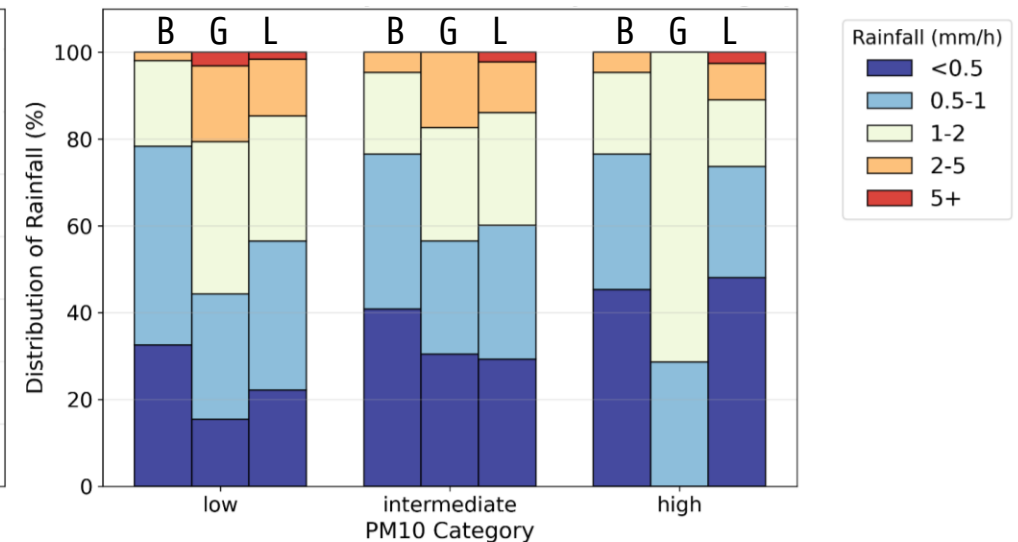
- (B)russels
- (G)hent
- (L)jège



Rain frequency (wet days / total days)



Rainfall intensity



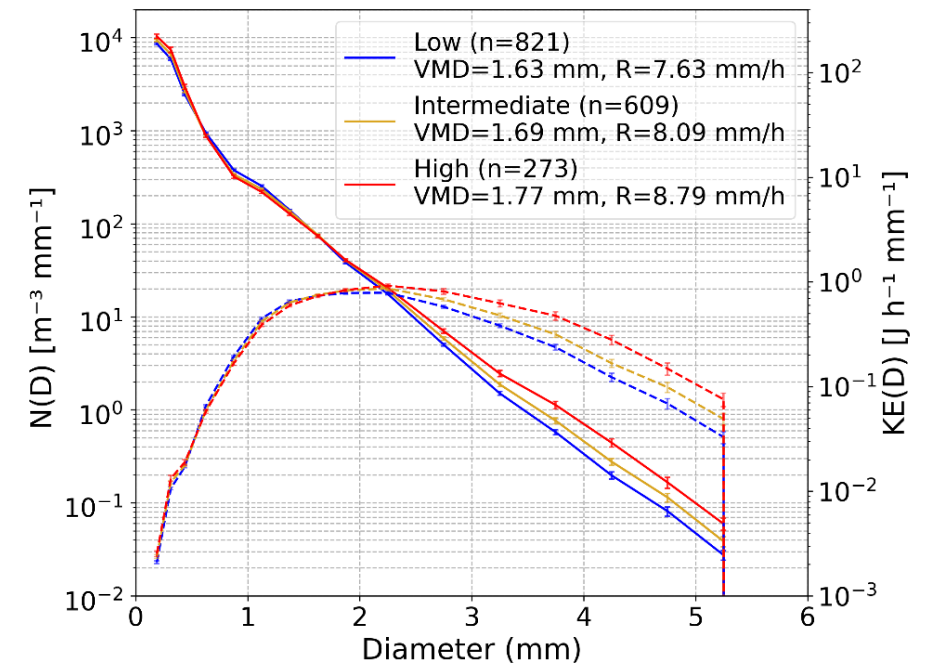
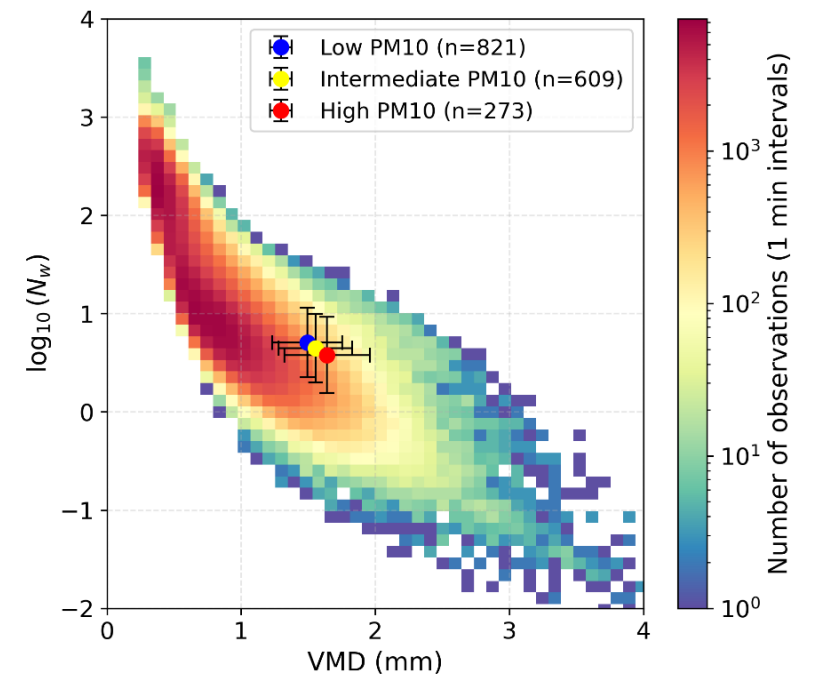
INFLUENCE OF AIR POLLUTION

Convective events

PM↑:

- Larger drop sizes & higher intensities
- Lower concentrations

→ Shift towards higher contribution of ice processes



INFLUENCE OF AIR POLLUTION

Confounding factors

Accounting for MSLP and wind speed

Signal persists:

- Lower daily mean rain rate ($p < 0.01$) at two sites

→ More pronounced for PM_{2.5}

- Larger drop sizes ($p < 0.001$) during convective events

→ More pronounced for PM₁₀ (possible contribution of giant CCN)

LIMITATIONS & UNCERTAINTIES

- Instrument calibration errors
- Limited number of instruments
- Limited temporal coverage in Ghent
- Temporal mismatch (daily vs event)
 - Need for higher resolution data
- Surface PM as proxy

CONCLUSIONS

- Impact of urban areas is unclear → opposing trends at different locations
- Higher air pollution leads to pronounced extremes → more light intensity + extreme intensity (convective events) is enhanced

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