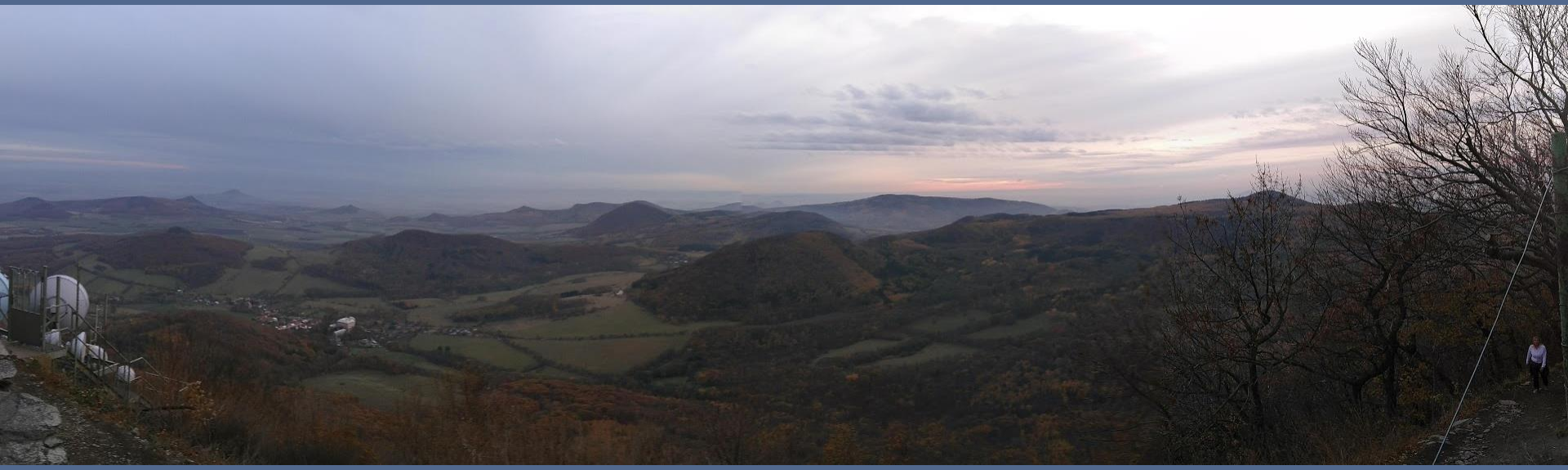
Time evolution of activated aerosol particles in low clouds



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Introduction

- At Milešovka st. in Czechia, fog/low cloudiness is present on almost 55 % of days [1]

[1] Fišák, J., Tesař, M., & Fottová, D. (2009). Pollutant concentrations in rime and fog water at the Milesovka Observatory. *Soil and Water Research*, *196*, 273–285.

Methods

Observatory of the Institute of Atmospheric Physics

- on the top of the Milešovka Mtn.
- full meteorological data (24/7)
- additional measurements on fog/cloud characterization
- vertical cloud profiler

- Online measurement AA particle number size distributions (PNSD):
  - size range 10 nm – 20 µm
  - SMPS and APS spectrometers

Methods

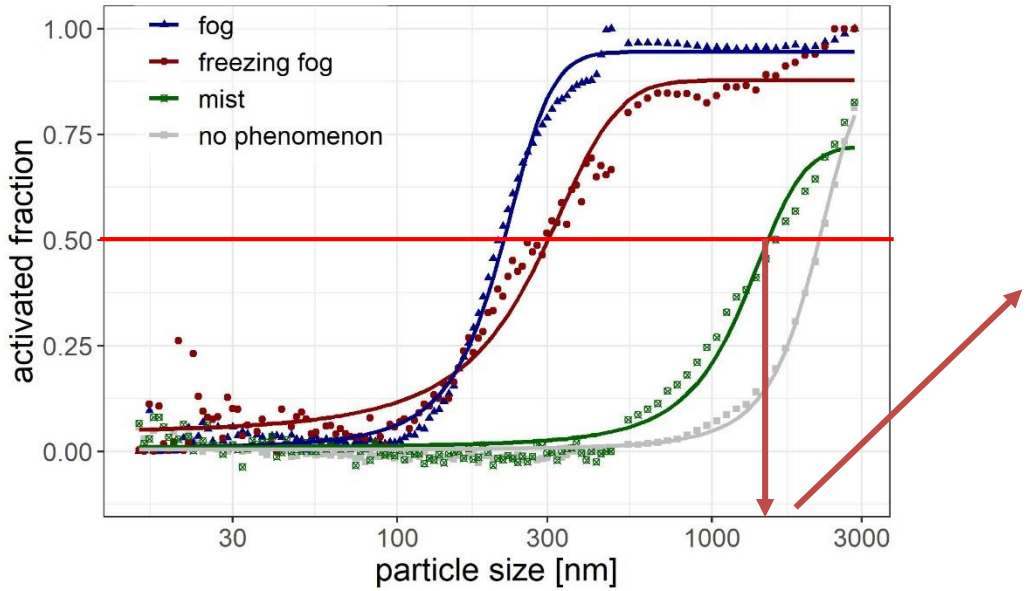
- heated whole air inlet (WAI), and $PM_{2.5}$ sampling head
  - switched by an automatic valve
  - drying by diffusion dryers
  - time resolution 5 min
- activated PNSD
  - aPNSD = WAI – $PM_{2.5}$

Methods

- WAI – $PM_{2.5}$ / WAI = activated fraction, AF [2]
- AF fitted with Sigmoidal function:

$$AF = \frac{Asym}{\left(1 + exp\left(\frac{D_{50} - x}{rate}\right)\right)}$$

- D_{50} .. lower estimate for an activation diameter [3]



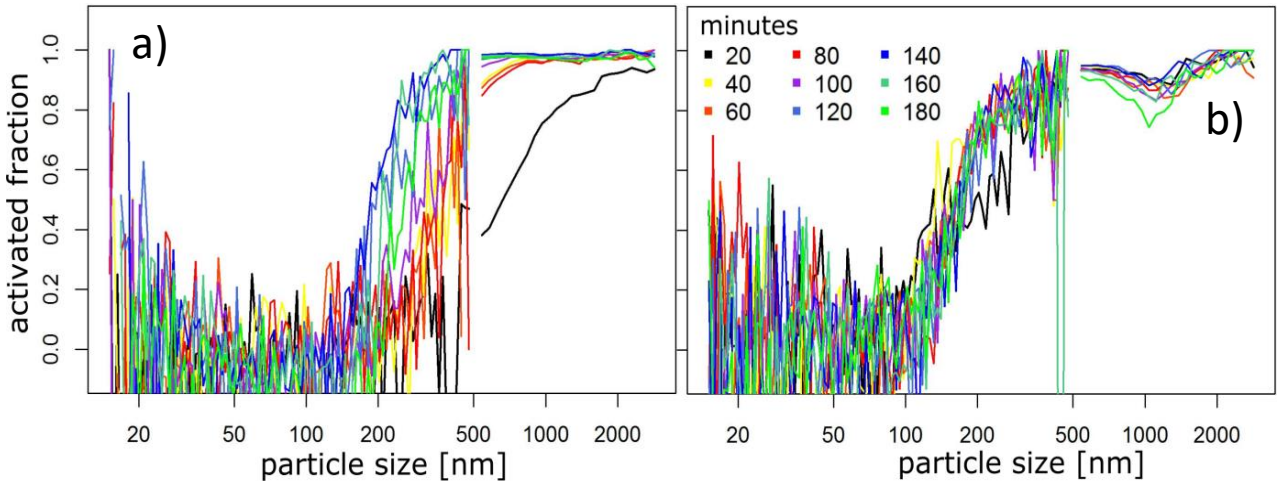
phenomenom	D_{50} [nm]
no phenomenon	2133 ± 36
mist	1266 ± 27
fog	212 ± 1
freezing fog	274 ± 6

[2] Asmi, E., et al. (2012). Aerosol cloud activation in summer and winter at Puy-de-Dôme high altitude site in France. *Atmospheric Chemistry and Physics*, *12*(23), 11589-11607.

[3] Hammer, E., et al. (2014). Size-dependent particle activation properties in fog during the ParisFog 2012/13 field campaign. Atmos. Chem. Phys. 14, 10517–10533.

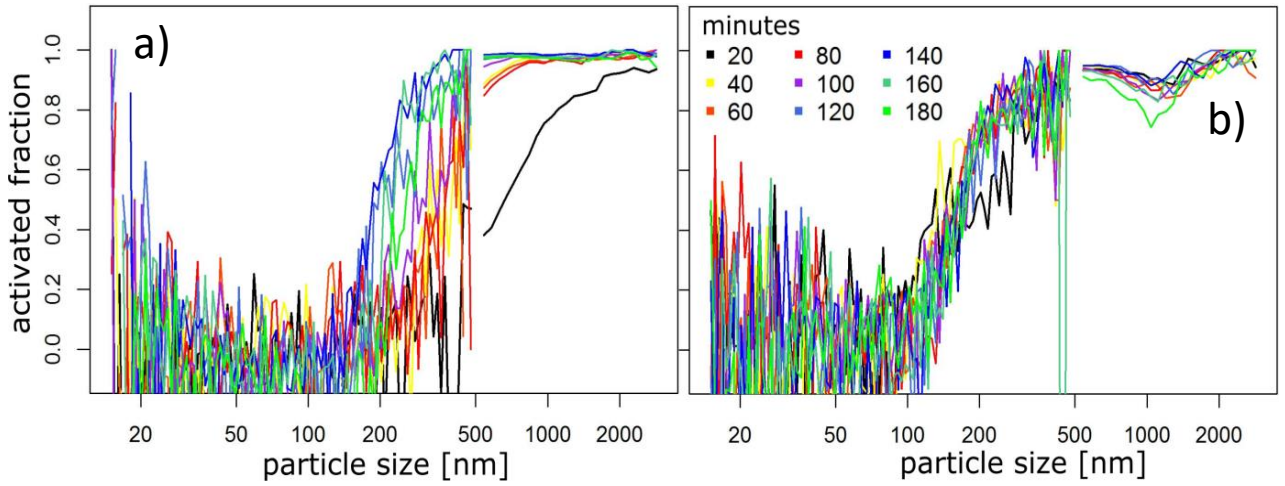
Results – AF time evolution

- changes in the aPNSD at the beginning of episode
- the largest changes found within the first two or three hours of the fog episode duration
  - shift of the AFi to the smaller particles (a)
  - AFi becomes steeper, D50 value moves to the left
  - after 120 minutes, situations become stable



Results – AF time evolution

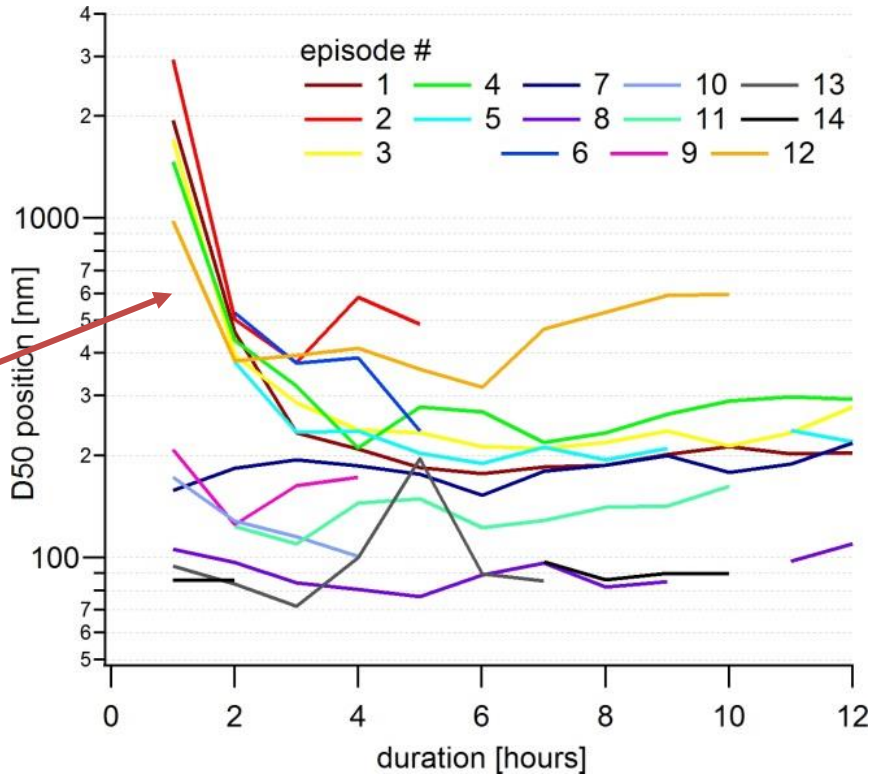
- During fog episodes that were preceded by another hydrometeor-related episode, the shift in the AFi was not observed
  - AFi would oscillate around the first measured AFi (b)
  - the steady state has been already reached during the preceding episode



Results – D_{50} time evolution

- D50 calculated for each hour of the episode duration
- two main groups of D_{50} behavior in time were found

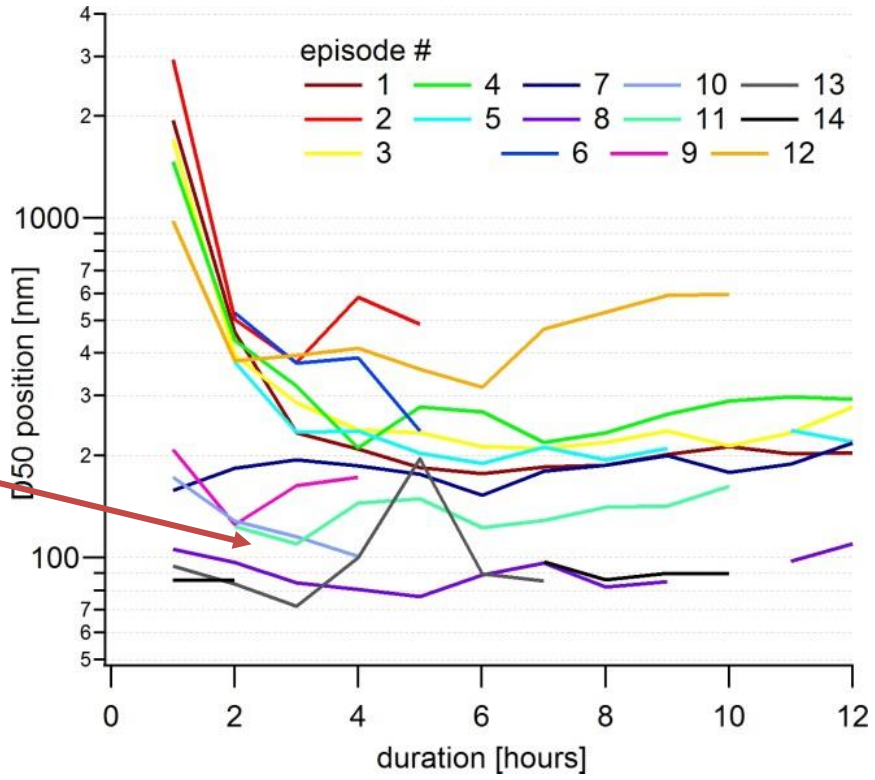
- strong decrease in the D_{50} in the first three hours, and later the D_{50} reaches almost a constant value
  - steady value is of about 200 nm for all the episodes, independently on the time of the fog occurrence (time of day, season)



Results – D_{50} time evolution

- D50 calculated for each hour of the episode duration
- two main groups of D_{50} behavior in time were found

- decrease at the beginning of the episode is not visible
  - D50 only fluctuates around its original value.
  - episodes that were a part of a long-term hydrometeor-related situations
  - constant value the D_{50} fluctuates around ranges from 90 to 200 nm



Summary

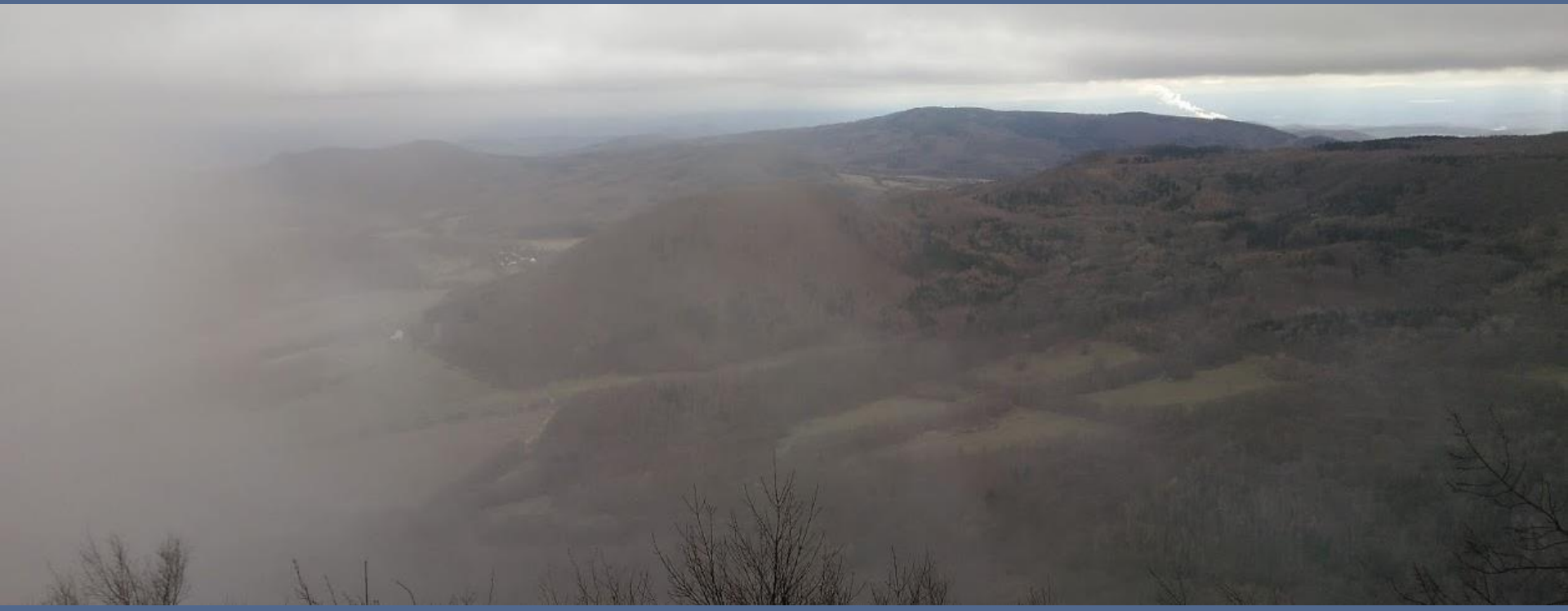
- almost 300 hours of fog and 45 hours of freezing fog measured
  - PNSD from 10 nm to 2.5 µm
- effectivity of activation reached over 90 % for particles larger than 450 and 510 nm for fog and freezing fog, respectively
- the smallest activated diameter was identical for fog and freezing fog, 130 nm
- activation process speed, considered as the time evolution of the D_{50} parameter, was also similar for fog and freezing fog
- AFi becomes steeper and the D_{50} value moves to the smaller particles during the activation process
- at about 120 minutes after the beginning of a fog episode, the process reaches a steady state
- effectiveness, speed, and also size dependence of the activation were found to be connected with air mass history
- For continental air masses, the Afi was independent on the air mass history
  - activated particles mode position varied only from 230 to 260 nm
  - AFi are almost identical
  - inversion layers influencing the stratus fog development and limiting the mixing and connection with free troposphere during slow continental masses can play a role
- For maritime air masses, smaller particles were activated
  - aPNSD were shifted to 120 nm

Summary

For more details please see the fresh AE paper:

Zíková, N., Pokorná, P., Makeš, O., Sedlák, P., Pešice, P., Ždímal, V. (2020). Activation of atmospheric aerosols in fog and low clouds. *Atmospheric Environment*, 117490.

Thank you for your attention!



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