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THE EFFECT OF ATMOSPHERIC AEROSOL PARTICLES ON CLOUD ICING RATE
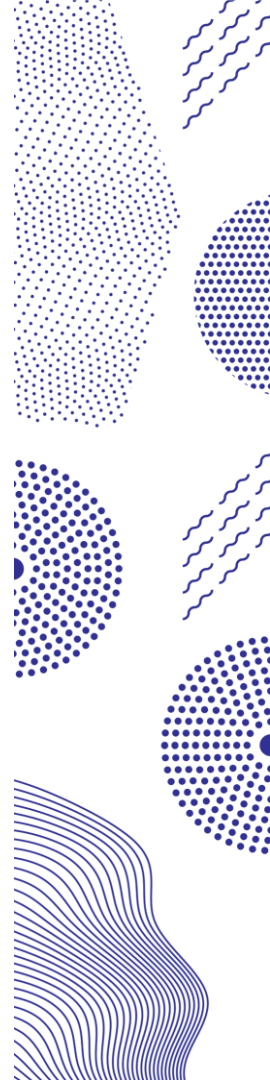
Antti Ruuskanen

Ari Leskinen, Mika Komppula, Harri Kokkola, Sami Romakkaniemi

Motivation

- Connection between aerosol particles, cloud microphysics, meteorology and icing rate

- Study the connection with measurements and model

- To get an idea how air quality (atmospheric aerosol particles) affect icing through their effect on clouds

Measurement sites

- Puijo tower
- Vehmasmäki mast

Kuopio

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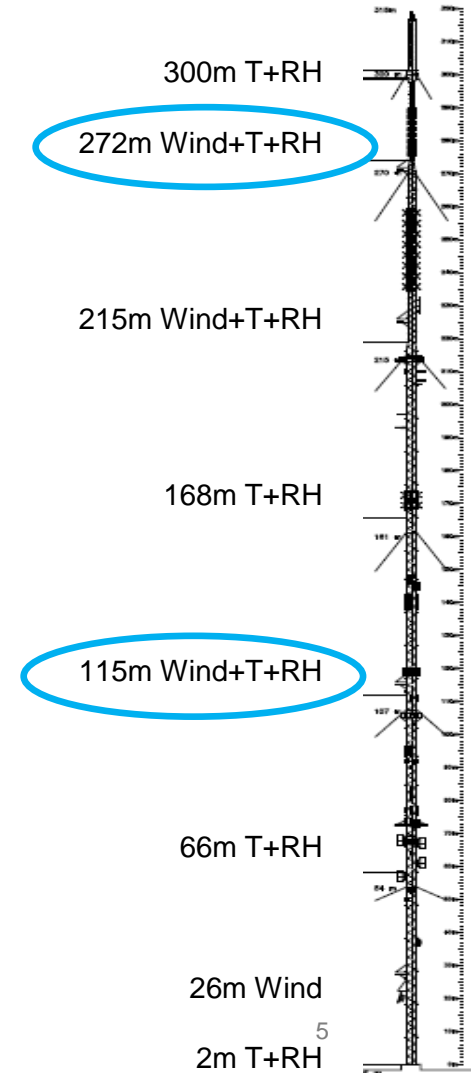FINNISH METEOROLOGICAL INSTITUTE
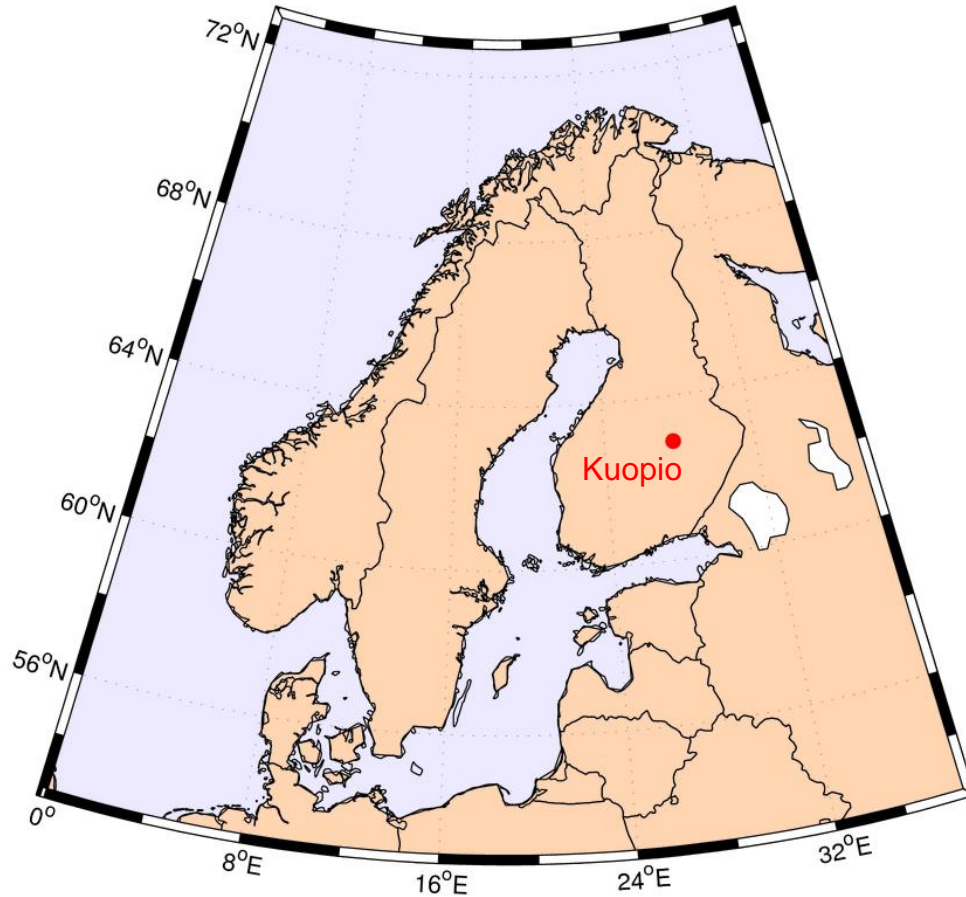
Puijo tower

- 224 m above the local lake level
- Inside a cloud for about 15% of the time
- **Icing sensors** at the moment: Goodrich 0872F1, Labkotec LID-3300IP (4 pcs) & Saab Combitech
- Ceilometer Vaisala CT25K
- **Weather parameters** (WS, WD, T, p, RH, vis, rain)
- **Cloud droplet size distribution** (3-50 µm) and many aerosol instruments

74m

232m   150m   224m   306m

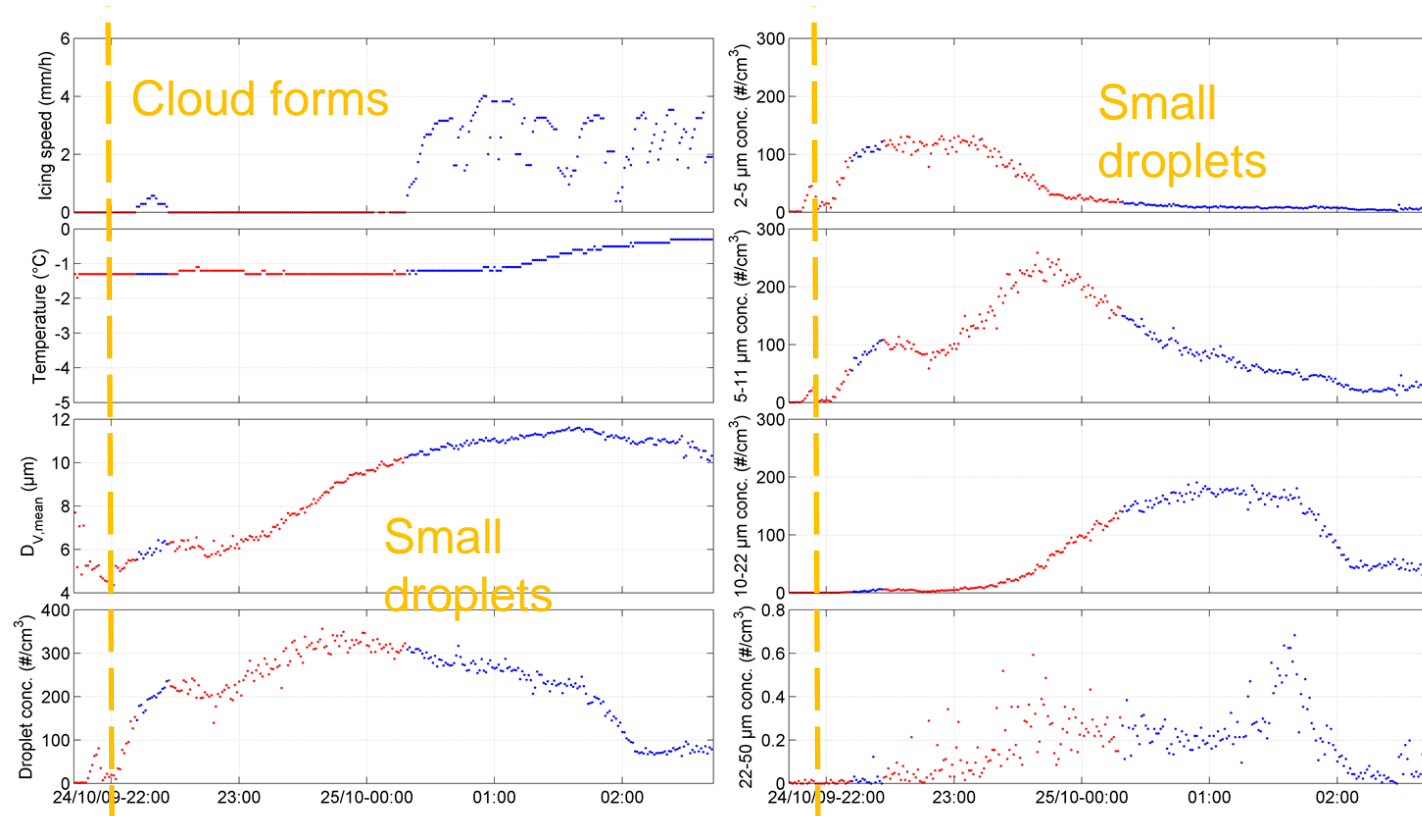Lake-Kallavesi level

82m

Sea level
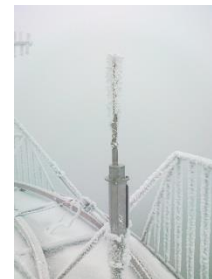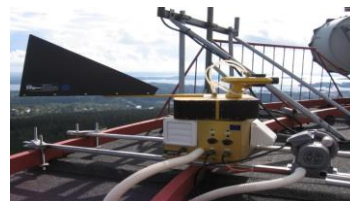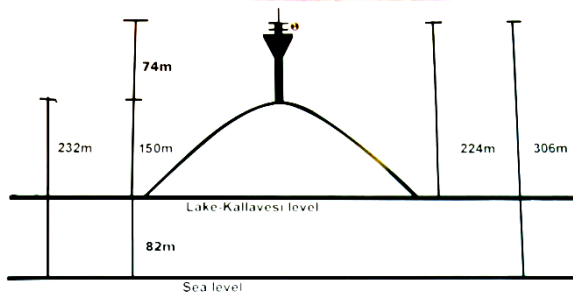
Vehmasmäki

- 20 km from Kuopio city, 318 m mast
- **Icing sensors** (115 & 272 m)
  - 2x Goodrich 0872F1 & 2x Labkotec LID-3300IP
- Ceilometer Vaisala CL51
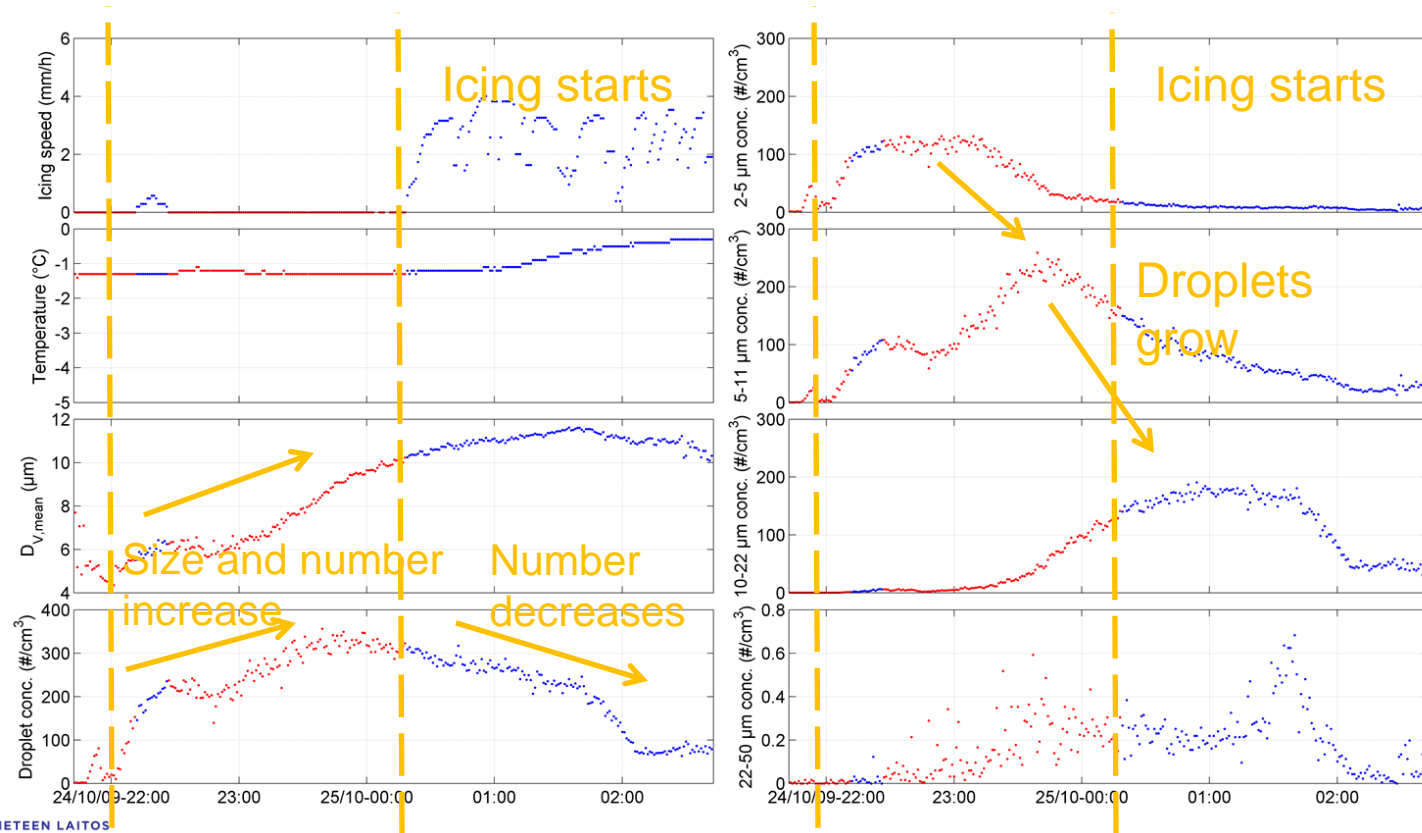- **Weather parameters** at multiple heights

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300m T+RH

272m Wind+T+RH

215m Wind+T+RH

168m T+RH

115m Wind+T+RH

66m T+RH

26m Wind

2m T+RH

Cloud droplet size and concentration during an icing case

red color = non-icing, blue color = icing

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Cloud droplet size and concentration during an icing case

Icing starts

Size and number increase

Number decreases

Icing starts

Droplets grow

red color = non-icing, blue color = icing

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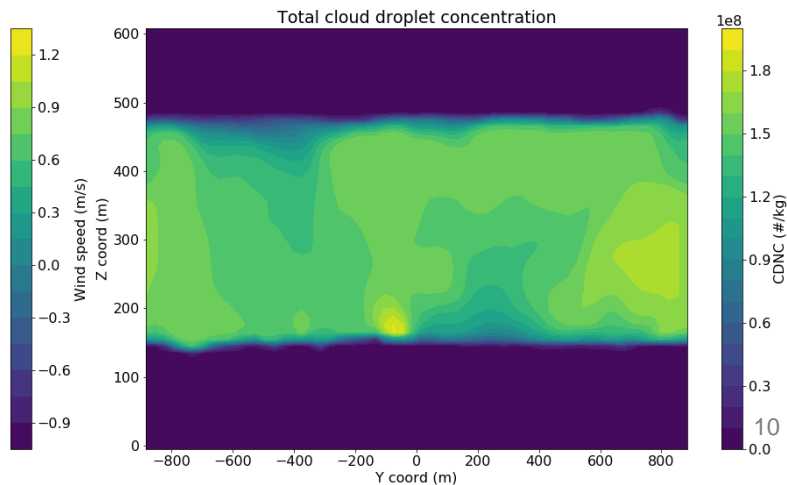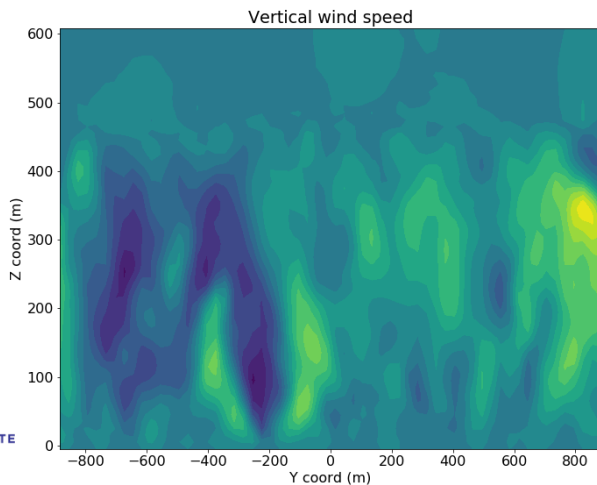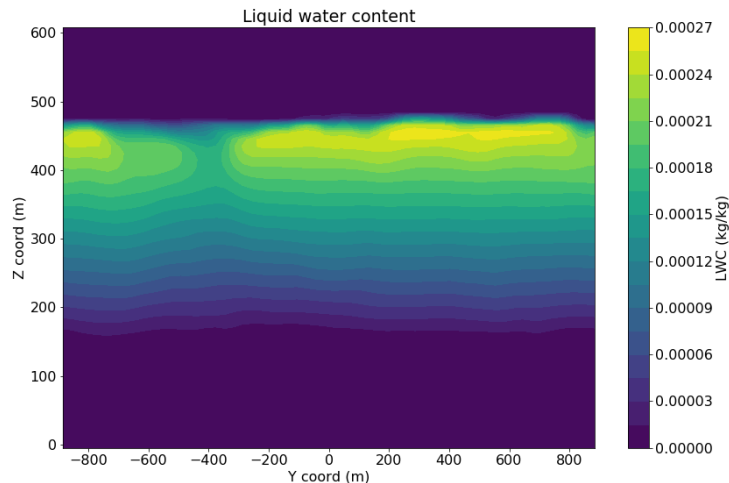
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Tools: UCLALES-SALSA

- Large-Eddy simulator UCLALES (Steven's et al. 2005)

- Resolves largest turbulent eddies, parameterized energy dissipation

- Idealized cloud-scale simualtions
- Resolution from tens to a few hundred meters
- Domain size up to 100 km (computational constraints) with cyclic lateral boundaries

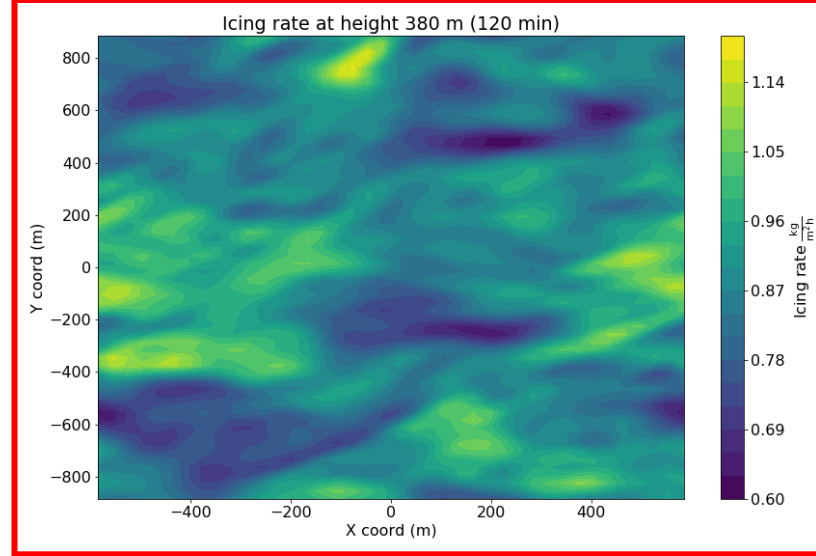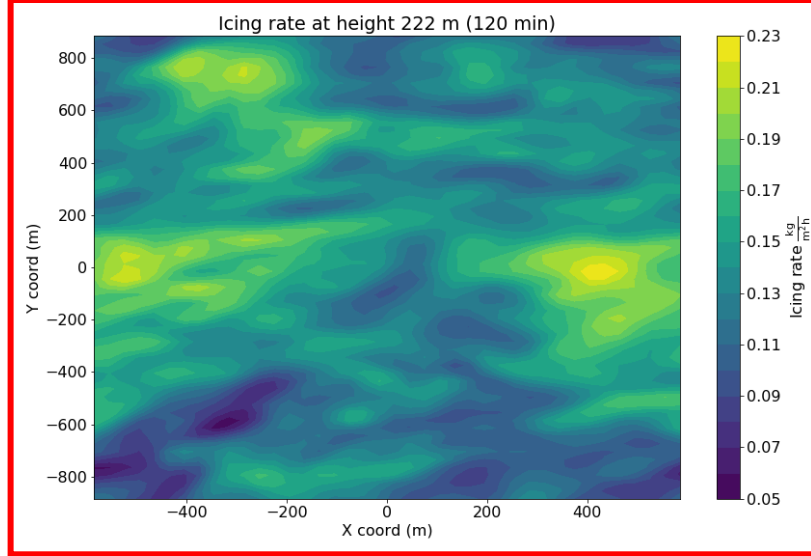- Includes a 4-stream radiation model and a simple surface scheme

Tools: UCLALES-SALSA
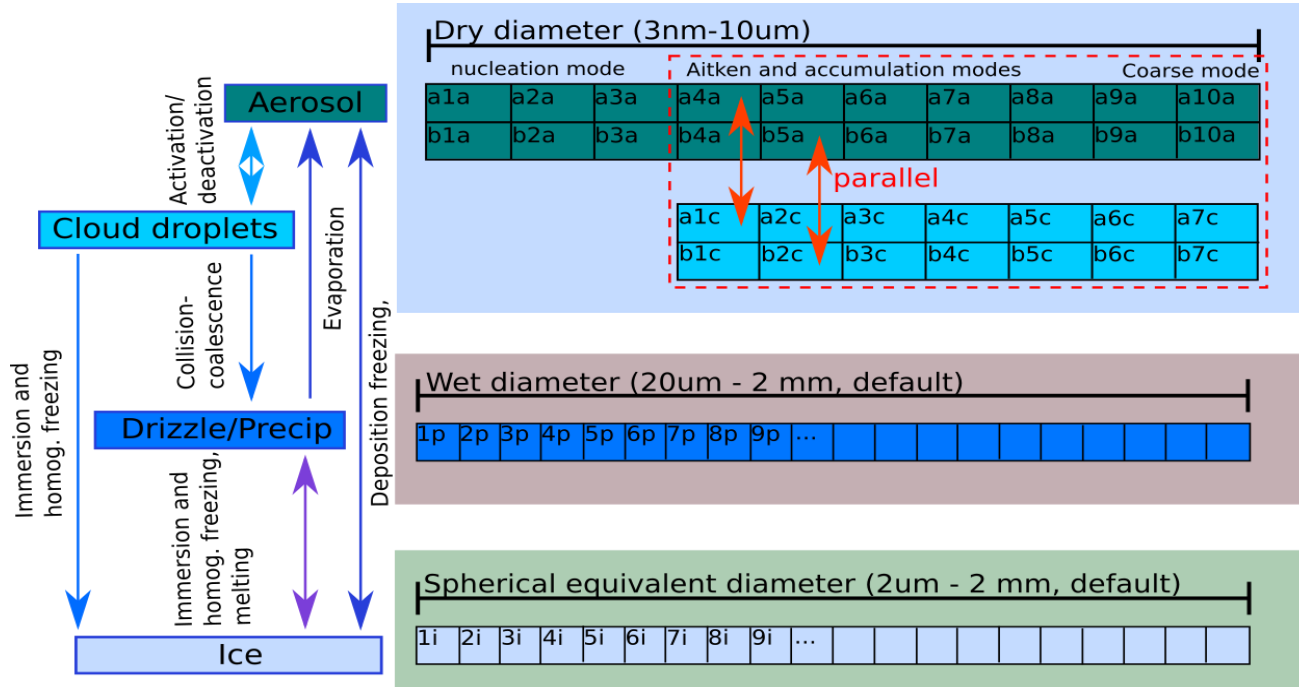
Model output

- Bin representation for 4 categories of particles
- Cloud related variables such as vertical wind and liquid water content

Icing rate at height 222 m (120 min)

Icing rate at height 380 m (120 min)

Ratio of icing rates on altitudes 380 m and 222 m (120 min)

- Icing rates for narrow cylindrical object

- Model especially good for studying icing on different heights

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Icing rate at height 222 m (120 min)

Icing rate at height 380 m (120 min)

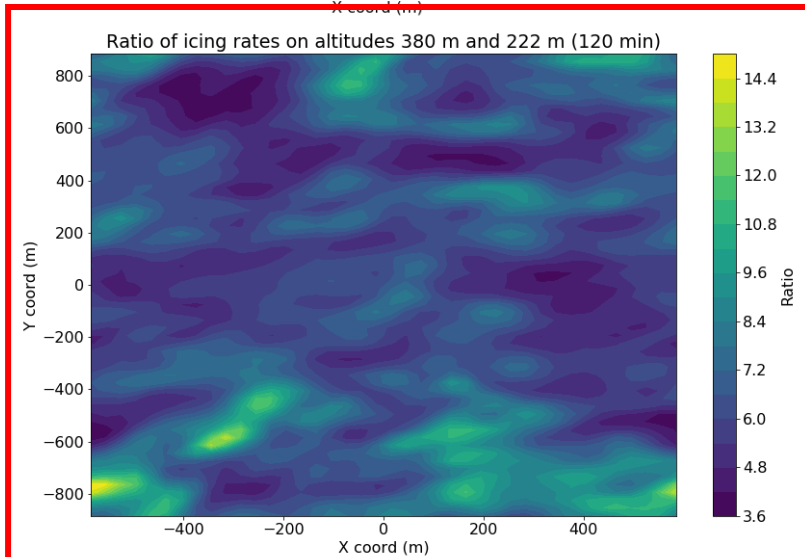Ratio of icing rates on altitudes 380 m and 222 m (120 min)

- Icing rates for narrow cylindrical object

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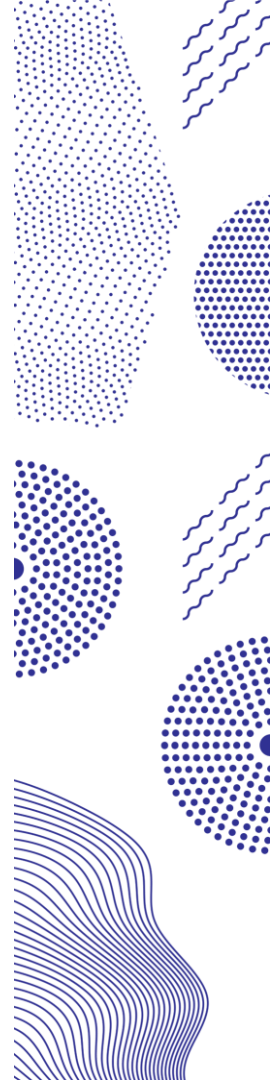FINNISH METEOROLOGICAL INSTITUTE
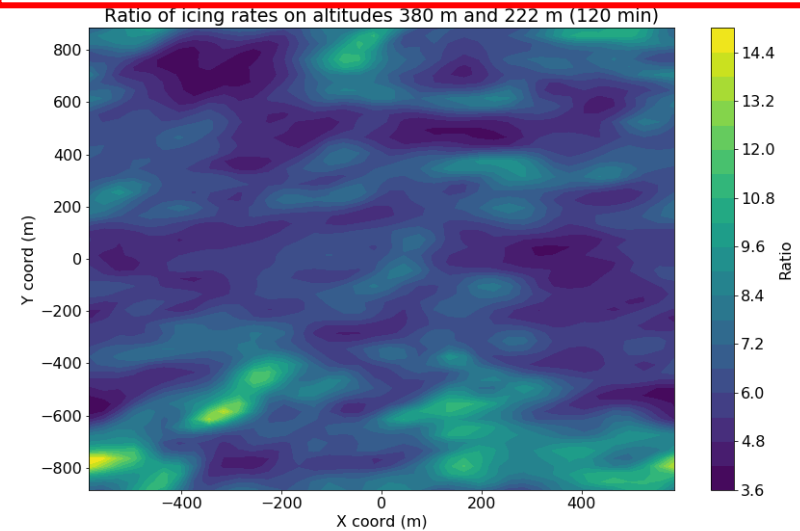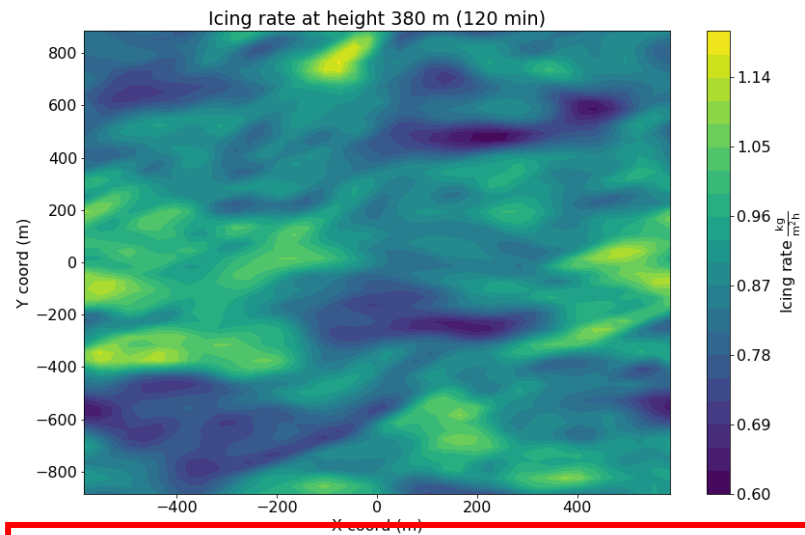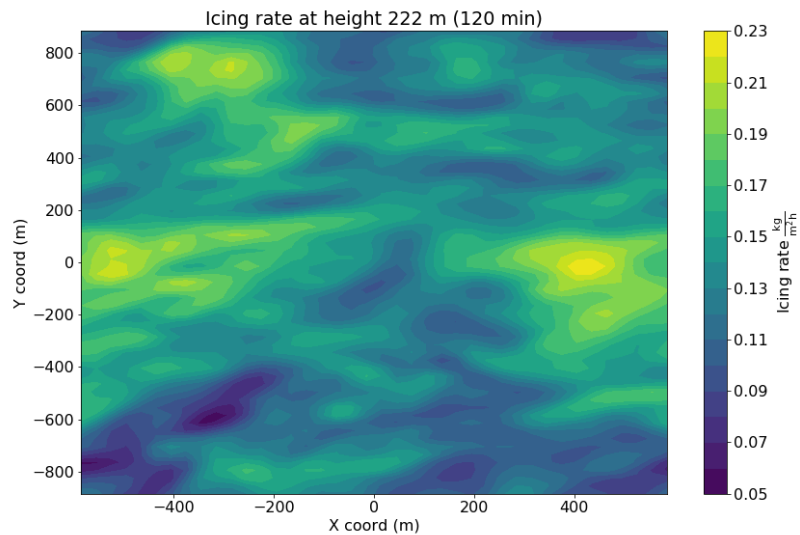
Results

- Initial results show:
  - Icing rates underestimated in model (bottom row) vs. measurements (top row)
  - Ratio of different measurement heights close to measured ones

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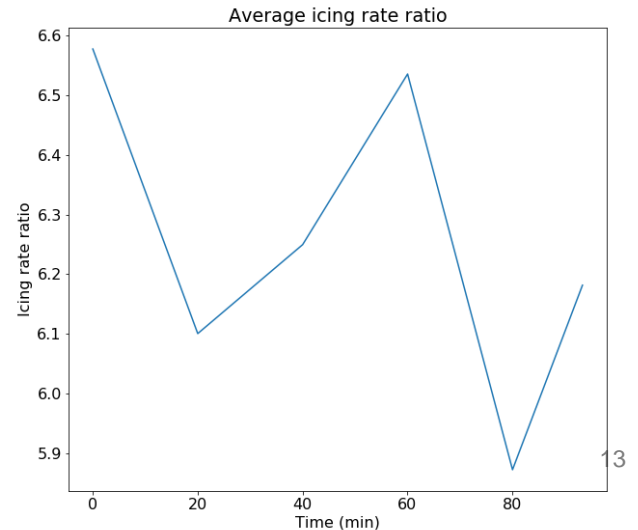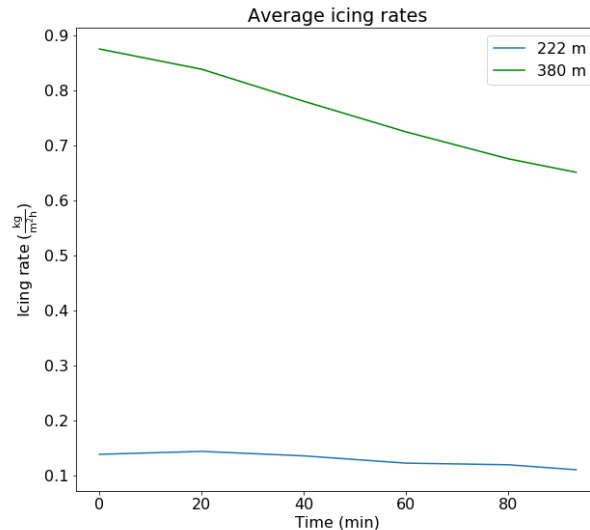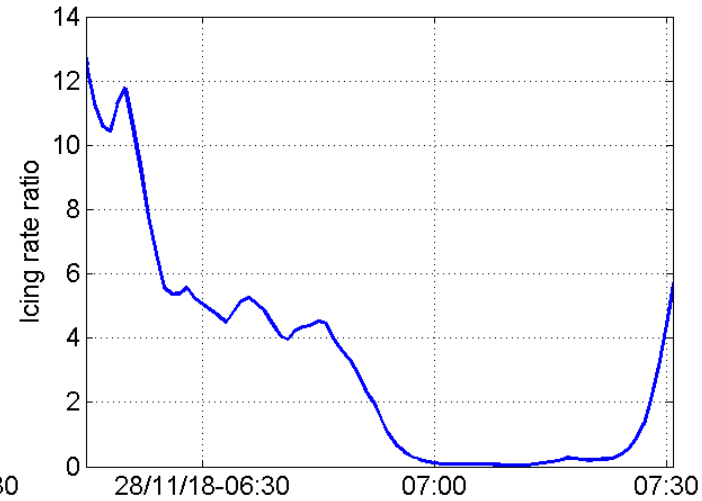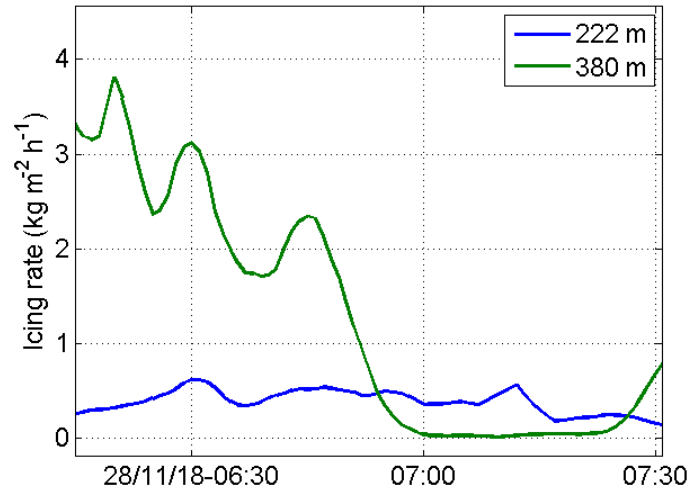
Next steps

- Simulating the effect of aerosols
- Sensitivity tests
- Comparison with the whole measurement dataset

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Thank you

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