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METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

Verification of Icing-model, in Finland.

IWAIS 2015, Uppsala, Sweden

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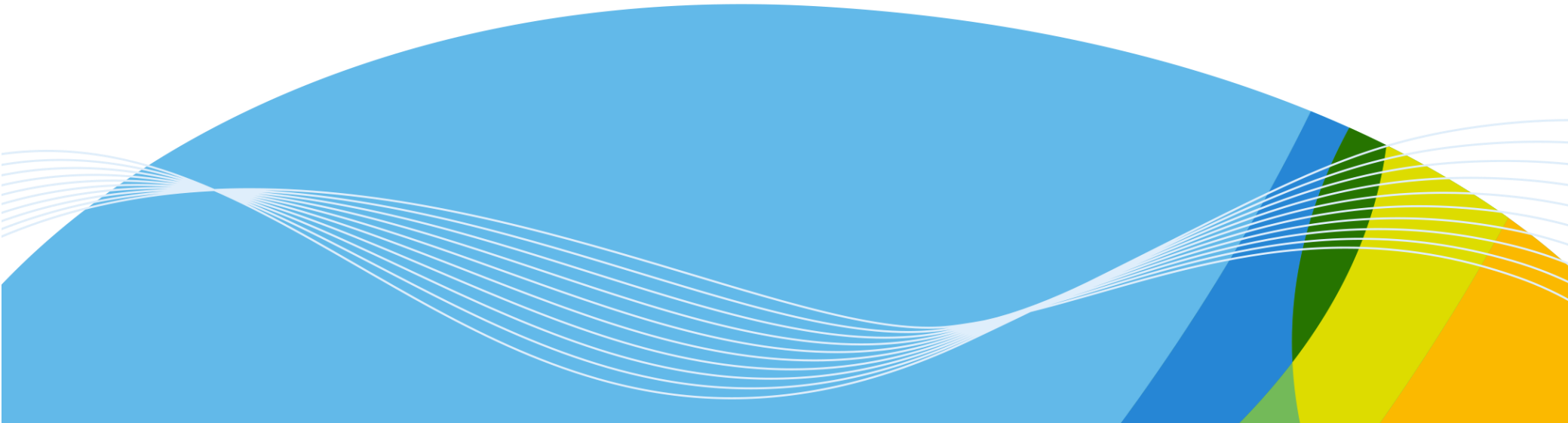
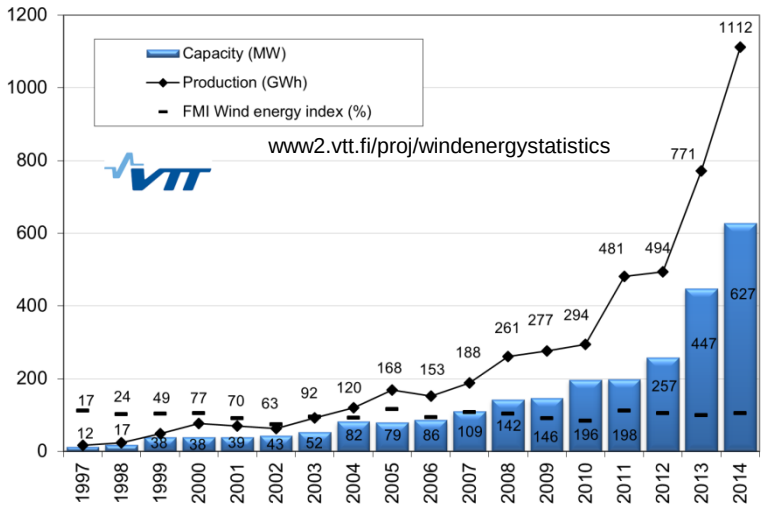


Content

- Motivation and background
- Icing-model
- Observation comparison
- Sensitivity tests
- Conclusions

Motivation and background

- Governments new energy strategy and goal for wind energy:
  - 6TWh (2000MW), year 2020
  - 9TWh (3750MW), year 2025
- After publishing Wind Atlas the installed capacity of wind power has grown fast.
- Where to invest?
  - Best wind conditions?
  - Is there wind during winter?

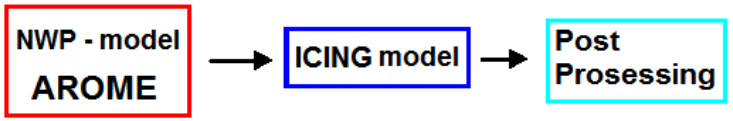


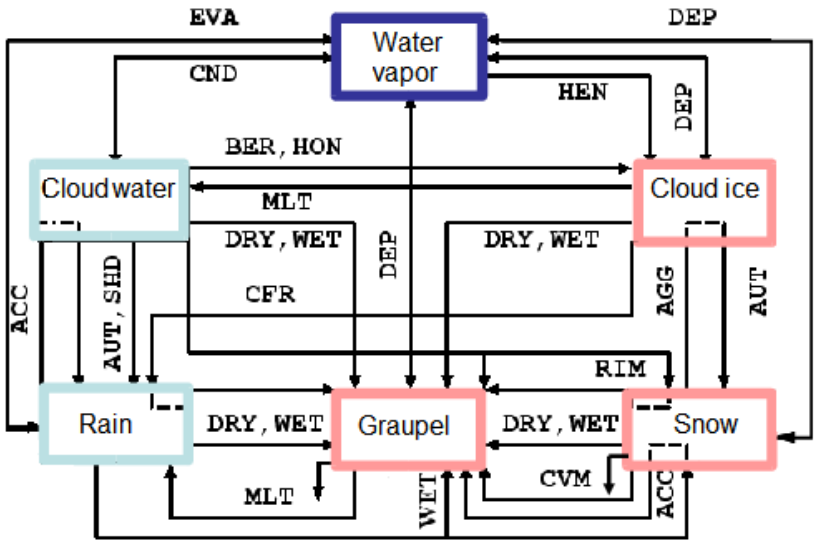
Icing Atlas : Icing-model

- Physic based on Standard ISO12494
  - Icing rate [g/h]:

$$\frac{dm}{dt} = \alpha_1 \alpha_2 \alpha_3 \cdot w \cdot A \cdot V$$

  - α_1= collision efficiency
  - α_2= sticking efficiency
  - α_3= accretion efficiency
  - *w* = mass concentration of particles
  - A = Surface area of freely rotating cylinder
  - V = Wind speed



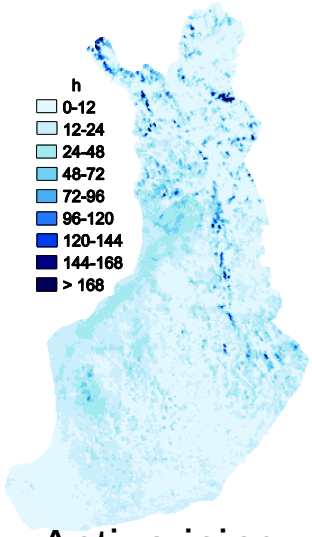


Microphysical Scheme diagram

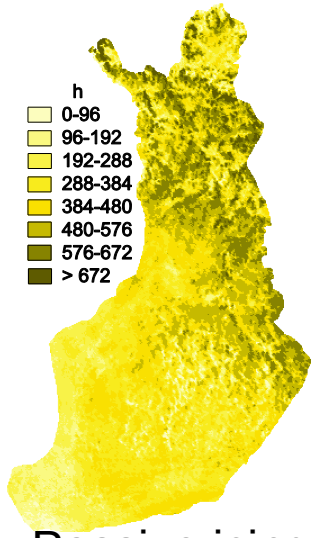
1st AROME training course, Poiana-Brasov, Romania, 21-25 November 2005

Icing Atlas

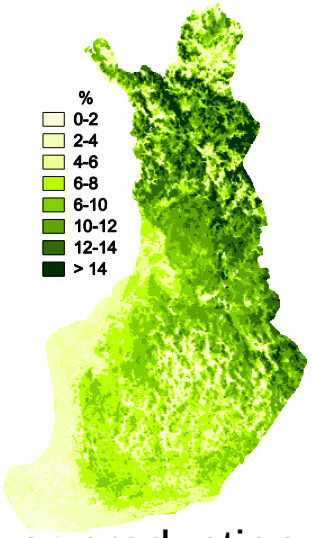
- Hours per month/annual.
- Active icing, passive icing and power production loss.
- Heights: 50m, 100m, 200m
- www.windatlas.fi/en



Active icing



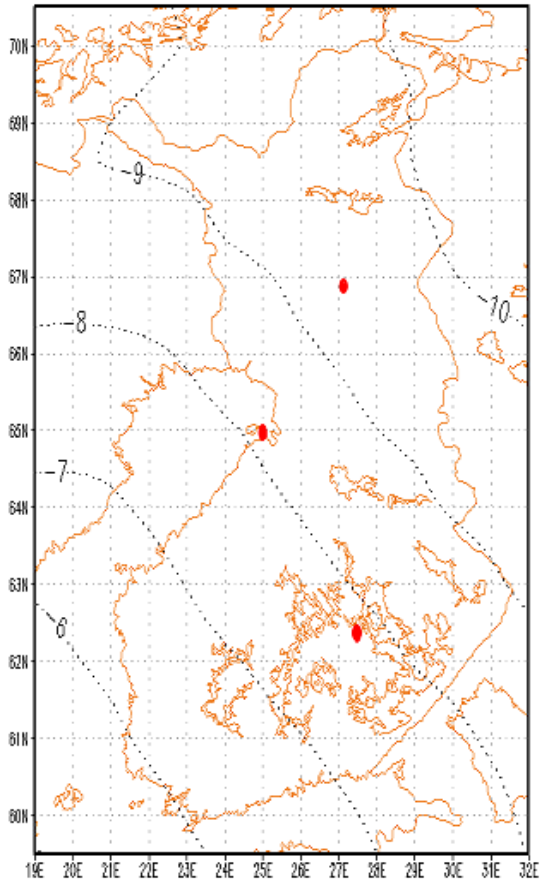
Passive icing



Power production loss

Observations

- Puijo, Eastern-Finland
  - Labkotec, LID-3300IP icing detector, raw data
  - Vaisala, FD12P visibility censor, On-Off
- Luosto, Lapland
  - Rosemount, icing detector, On-Off
  - Combitec, ice monitor, ice mass
- Riutunkari, West coast
  - Labkotec, LID-3300IP icing detector, On-Off



Challenges with observations

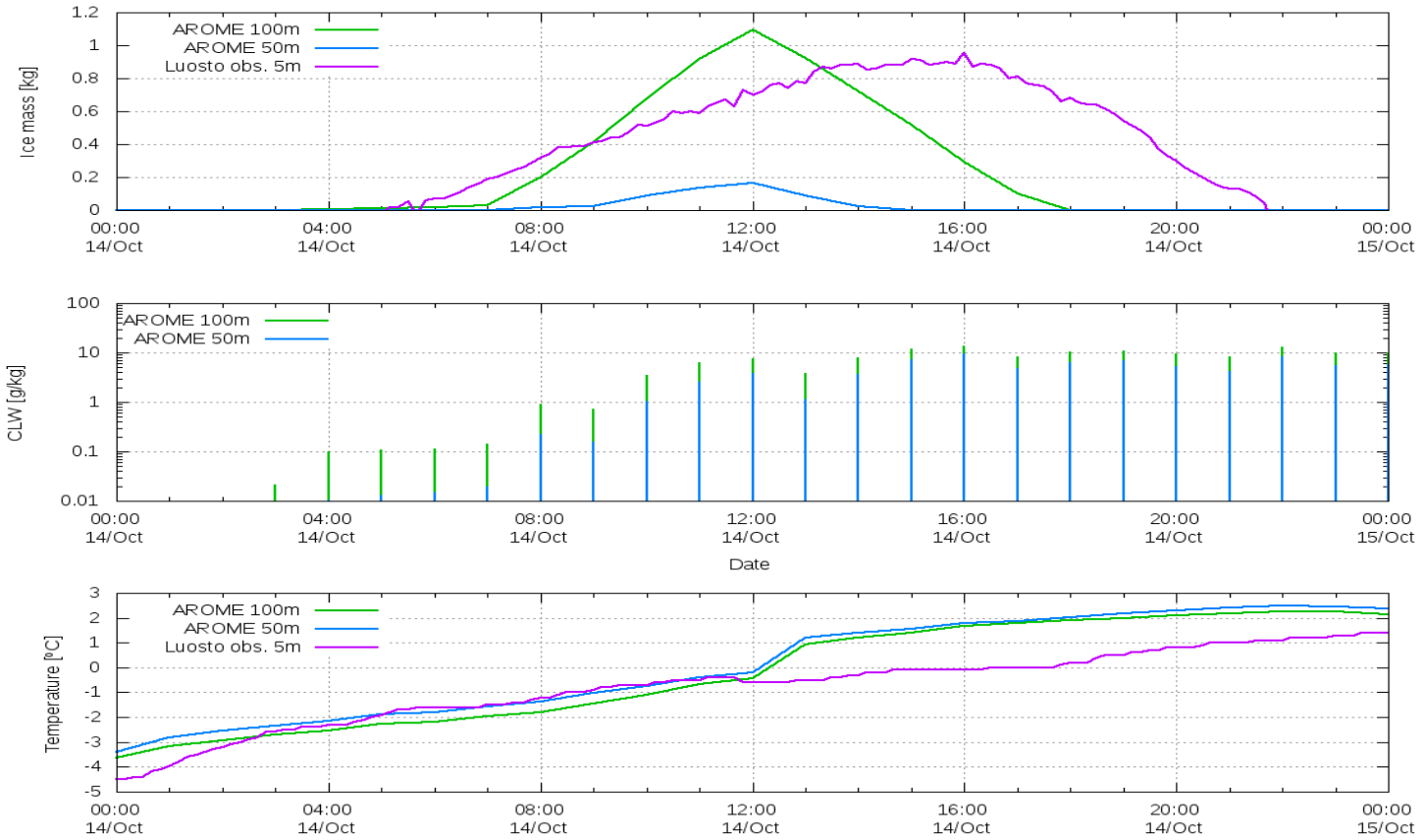
- Limited amount of measurement data.
  - Not part of FMI's daily routine.
- Data quality.
  - Video control at Puijo and Luosto stations.
- Representativeness.
  - Luosto fjell can not be seen by the NWP-model with horizontal resolution 2,5km.
- Model levels.
  - The lowest model level at 20m.

Observation comparison

- Luosto observations compared to Icing-model results, during November 2005.

Ice mass comparison

- Luosto observations compared to ice mass measurements, during October 14th to the 15th in 2007.



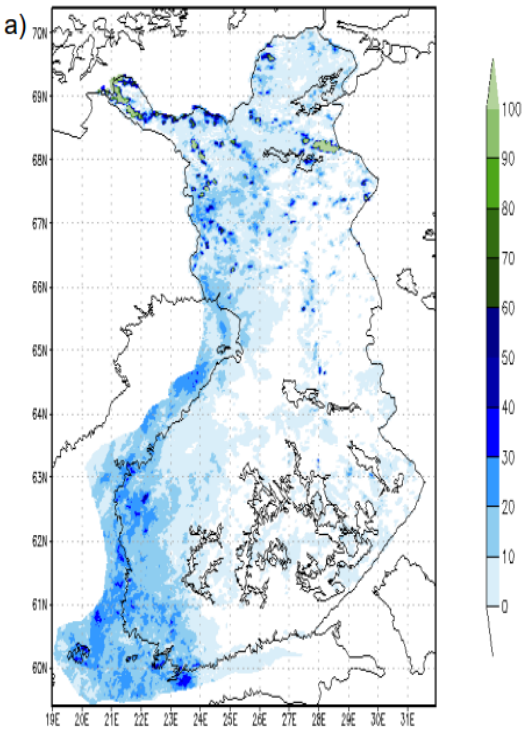
Sensitivity tests

- How sensitive is the Icing-model to the input?
- Difference in monthly averages?
- Perturbations that were made:
  - Temperature → ±2ºC
  - Wind speed → ±2m/s
  - Liquid water content → ±20%
  - Droplet number concentration → ±30%
- Temperature and Wind speed are being measured and verified.
- LWC and DNC are not measured.

Sensitivity tests

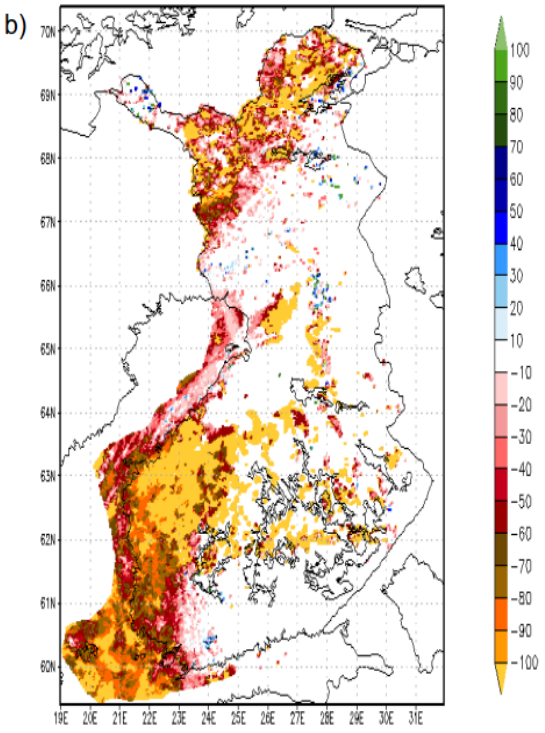
- Effects of perturbed temperature on hours of active icing, during February 2006.

h / month



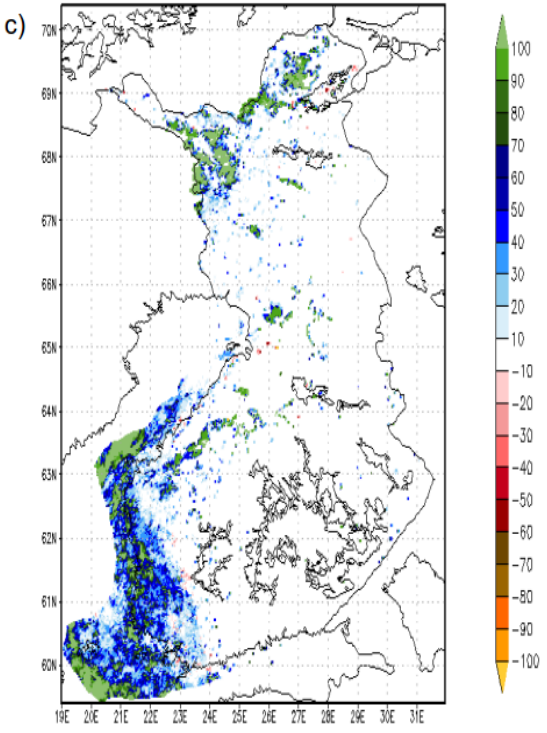
Original

% difference



+2ºC

% difference



-2ºC

Conclusions

- According to sensitivity tests the temperature, wind and liquid water content are the dominant variables.
- Droplet number concentration does not seem to cause significant errors if the liquid water content is ”constant”.
- Observation comparison show that the results are strongly dependent on temperature and liquid water content.
- Icing-model has the skill to detect icing events.
  - No skill to predict ice mass accumulation.

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