A novel approach for combining measurements and models for icing predictions

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Winterwind, Skellefteå, 07.02.2017

Overview

- Motivations
- Measurement site in the Frontlines project
- New Ice measurement instrument
- How to use this instrument to derive cloud water
- How to use the derived cloud water to calculate icing on structures
- How to use the derived cloud water to validate mesoscale models

Motivations:

- Lack of reliable measurements of one of the key driving ice accumulation parameters; cloud liquid water content (LWC).
- Need this in order to validate our mesoscale models used as input for icing calculations.
- If we have robust measurements of LWC we can use this to calculate icing on structures
- - which in turn can be used to e.g. calculate production loss due to icing.

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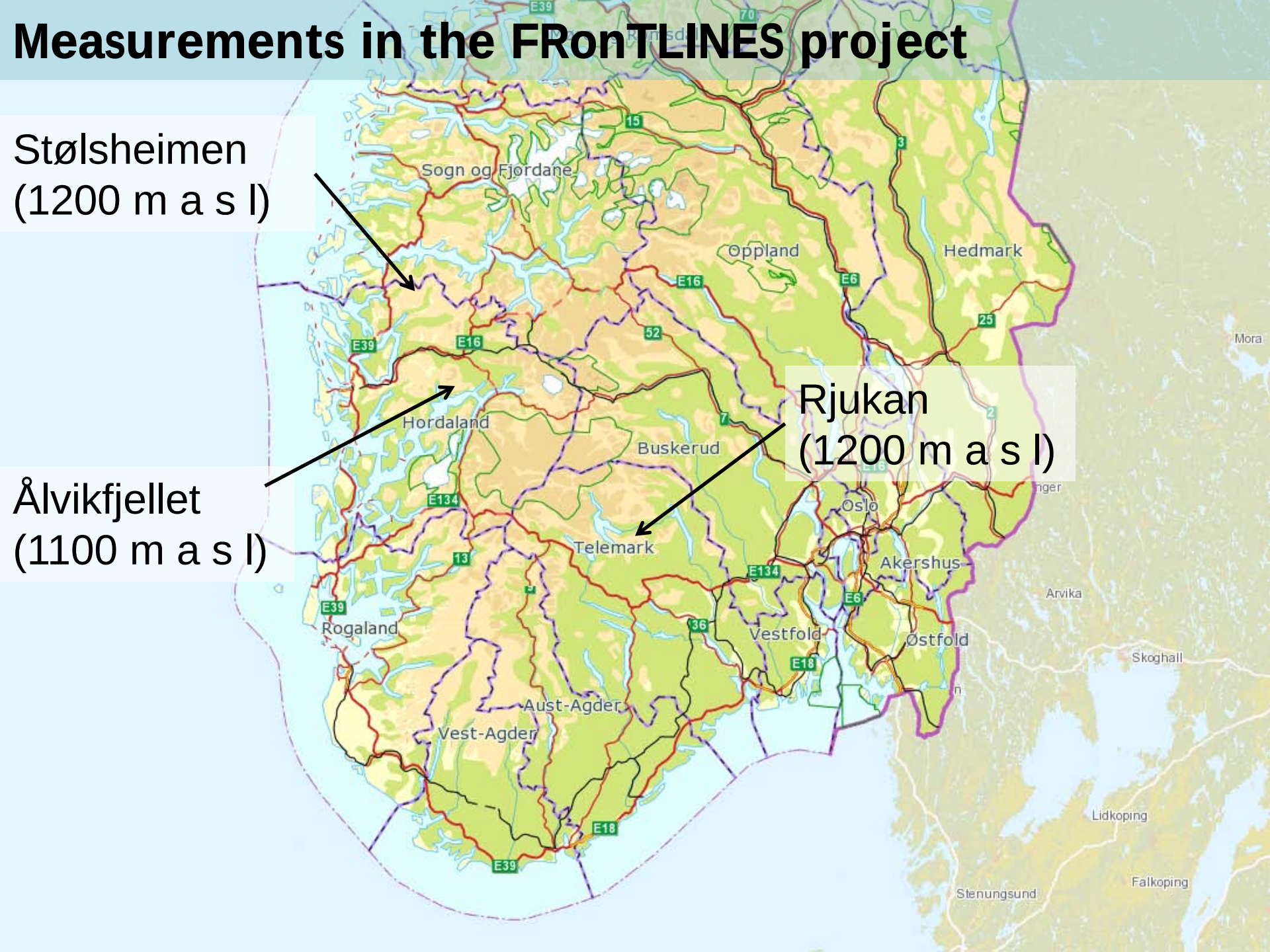
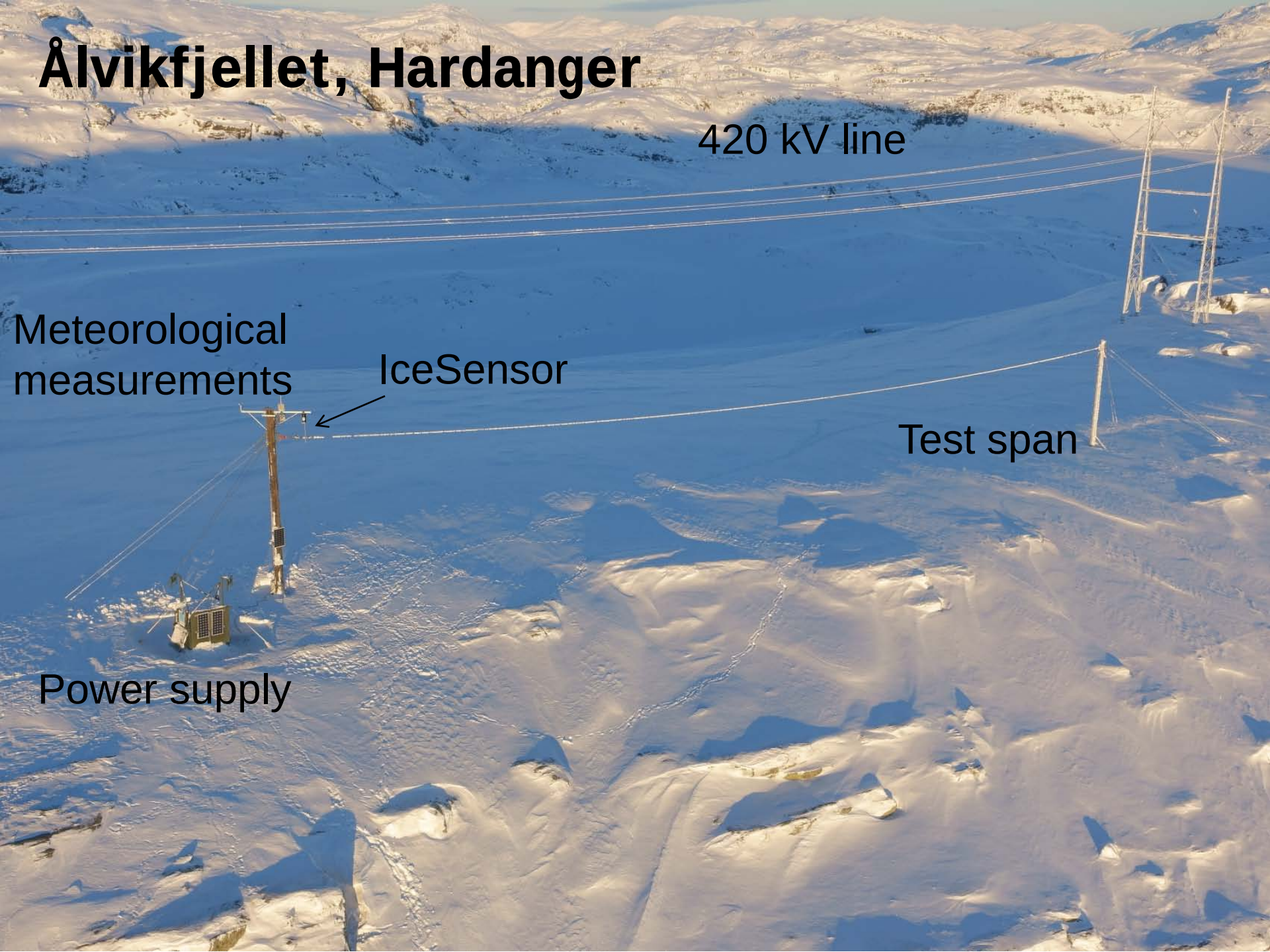
Measurements in the FRonTLINES project




Ålvikfjellet, Hardanger
420 kV line
Meteorological measurements
IceSensor
Test span
Power supply

New robust ice load sensor, KVT IceTroll

- Measure weight of accreted ice
- Forced rotation - 1 rpm
- Cylinder dimensions:
  - Length = 1m
  - Diameter = 30 mm
- Reference object (ISO standard)

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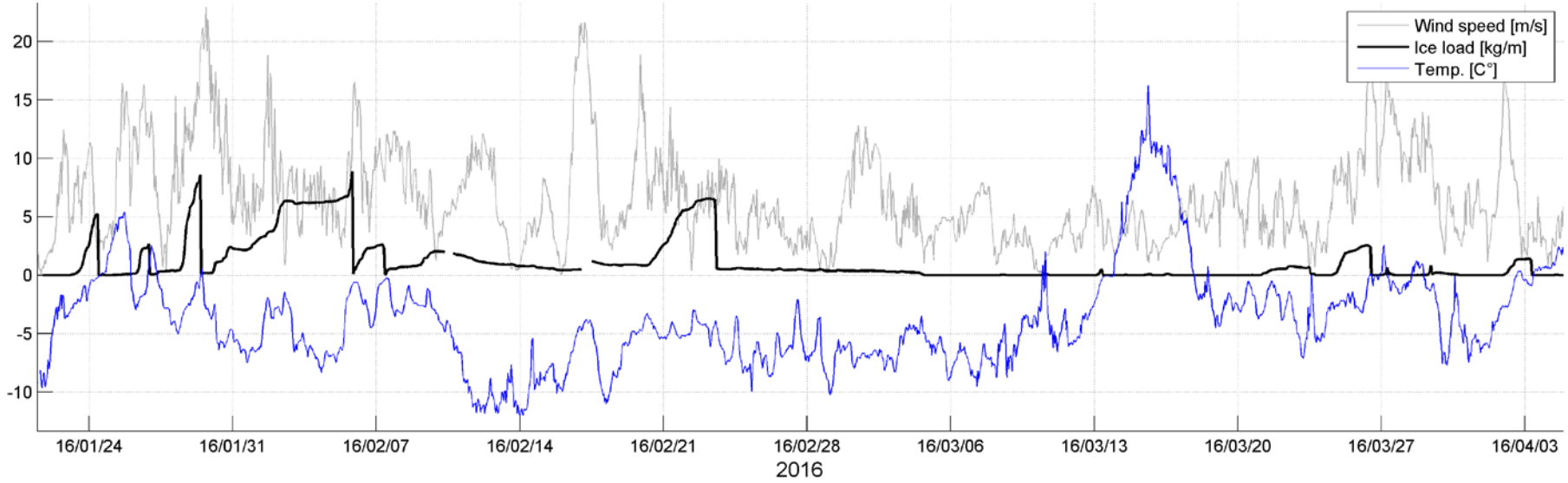
Complete time series of ice load on IceTroll, measured temperature and wind speed



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What can we do with the IceTroll?

- Better measurements of **ice load**
- Following the ISO standard we measure **icing intensity**
- Estimates of **Liquid Water Content (LWC)**
- Possibility to **calculate icing** on other structures
- Possibility to validate **mesoscale models**

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ISO standard (Finstad et. al 1988)

Icing intensity on rotating cylinder (reference object):

$$\frac{dM}{dt} = \alpha_1 \alpha_2 \alpha_3 \cdot LWC \cdot A \cdot V$$

α_1 – collision efficiency, $\alpha_1 = f(V,d,D)$
α_2 – sticking efficiency, $\alpha_2 \approx 1$
α_3 – accretion efficiency, $\alpha_3 = f(V,d,LWC,T,e,D,\alpha_1)$
LWC – cloud liquid water content
A – collision area, perpendicular to flow
V – Wind speed

Available:

- Ice mass on reference object (M)
- Wind speed (V)
- Temperature (T)

Assumptions:

- Ice density
- Droplet concentration

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Example of how to use the derived LWC to calculate ice mass on other structures (power line)

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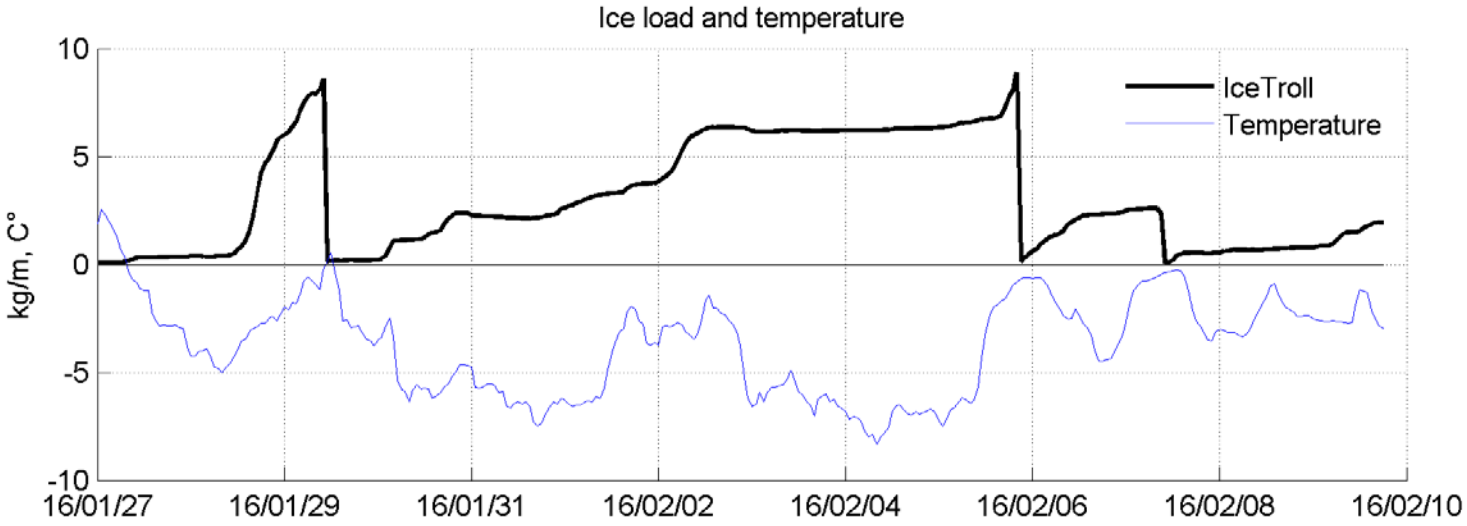
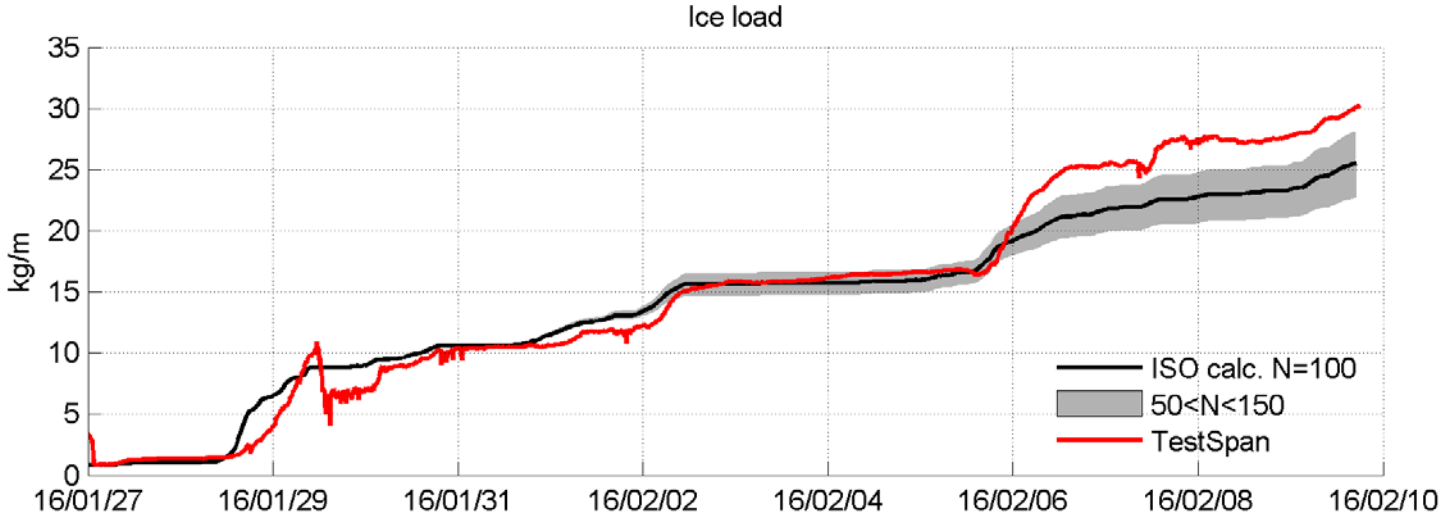
Ice load on power line (test span)

- Compare calculated ice load (ISO) with measured ice load on test span.
- Calculated ice load will vary with the choice of droplet concentration (N).
- Reasonably good fit





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Example of validation of LWC from mesoscale model (WRF)

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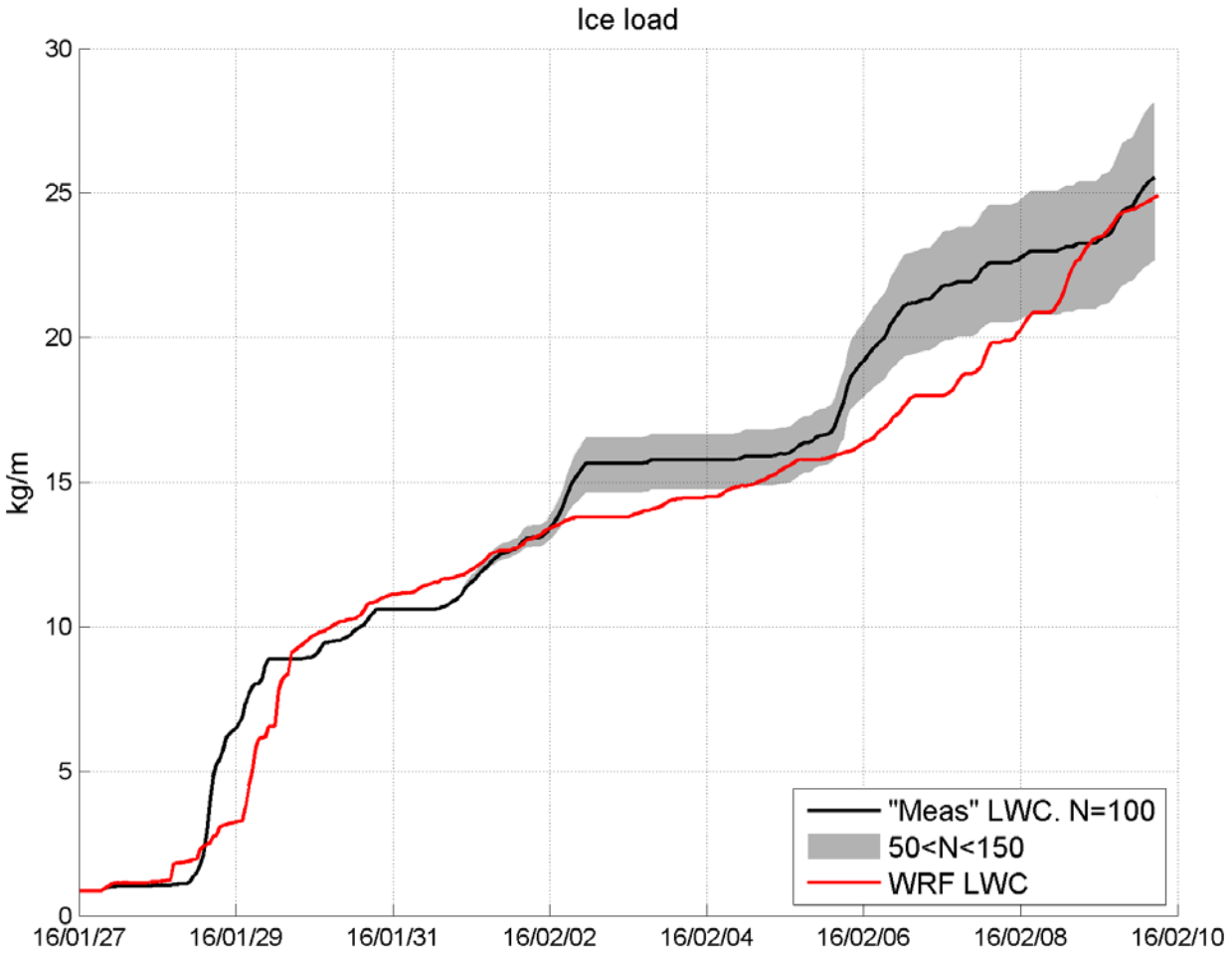
Ice load on power line (test span)

- Compare calculated ice load on test span with LWC from WRF and with “measured” LWC from IceTroll.
- Ice load will vary with the choice of droplet concentration (N).
- There is a relatively good fit which indicates WRF LWC is within reasonable limits.



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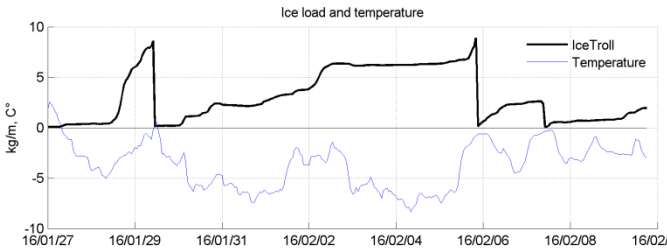
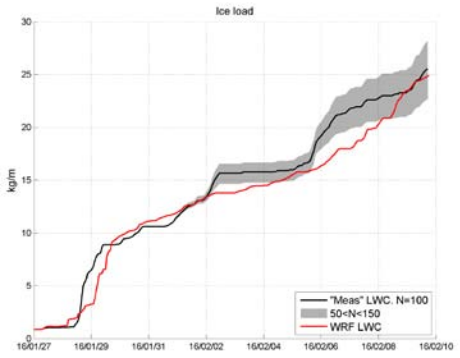
Summary

- A newly developed ice load sensor is tested
  - Forced rotation
  - Vertical cylinder

- Measurements of:
  - Ice load according to ISO 12494
  - Icing intensity according to ISO 12494
  - Liquid water content (post processing)



- Which can be used to:
  - Detect ice
  - Validate mesoscale models used for icing calculations
  - Calculate icing on structures



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Thank you for your attention!

The partners of the FRonTLINES project:

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Meteorologisk institutt
150 år

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