



# New advances in icing measurements and icing predictions

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Winterwind Åre, 09.02.2016

**Statnett**

# Overview

- Motivations
- The Frontlines project
- Measurement sites
- Model calculations and validations
- New Ice measurement instrument







Ålvikfjellet, 420 kV Sima-Samnanger, January 2014  
photo: Ole Gustav Berg, Statnett

- Kvilldal - Rjukan
- 4. mars 2014
- 12-15 kg/m ice load
- Estimated 30-50 year event



# FRonTLINES

- R&D Project: 2015-2018
- Develop a toolbox to assess the impact from frost and rime ice on overhead transmission lines:
  - Establish a new test station
  - Laboratory experiments of ice accretion on bundle conductors
  - Develop improved models for ice accretion on bundles
  - Calculate and forecast hoar frost and related losses on power lines
- Partners:
  - Statnett
  - Kjeller Vindteknikk
  - STRI
  - VTT
  - Narvik University College
  - The Norwegian Meteorological Institute
- Financed by:
  - The Norwegian Research Council: 50%
  - Statnett : 43 %
  - KVT, STRI, VTT: 7 %

# Frontlines - Field measurements

- Motivation:
  - Ice loads - mechanical design
  - Several failures 2013 - 2015
  - Statnett are currently expanding and upgrading the network significantly
  - Ice loads of simplex v.s. duplex is unknown for large loads
- Motivation 2:
  - Collect data for verification of meteorological models
  - Collect data for verification of ice accretion models





Stølsheimen  
(new 2015)

Ålvikfjellet  
(2014)



# Frontlines - Test sites

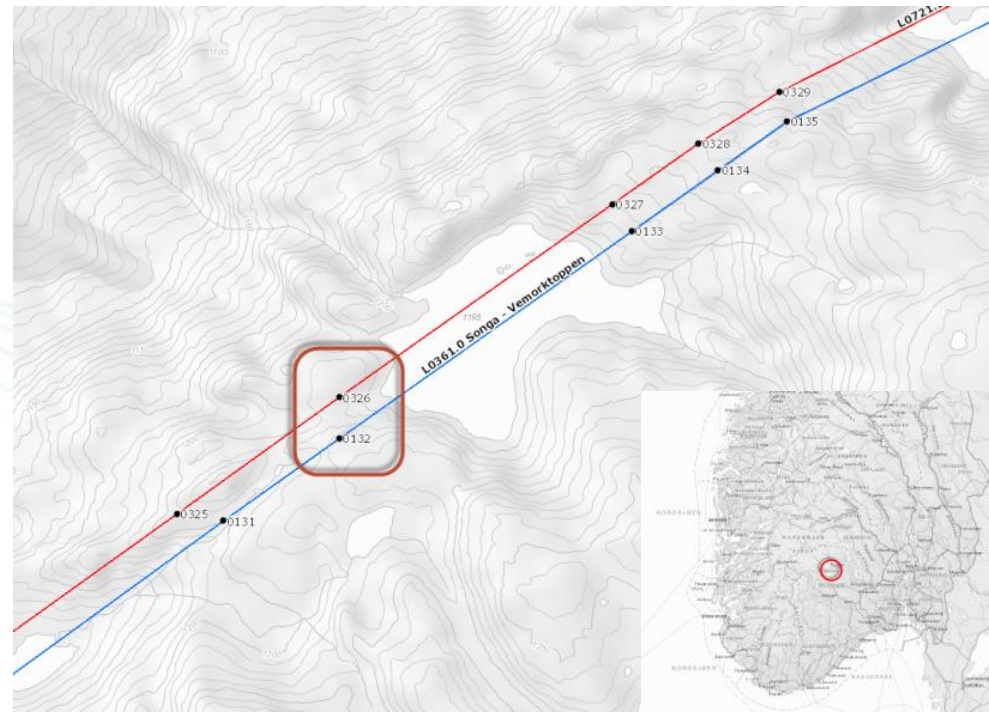
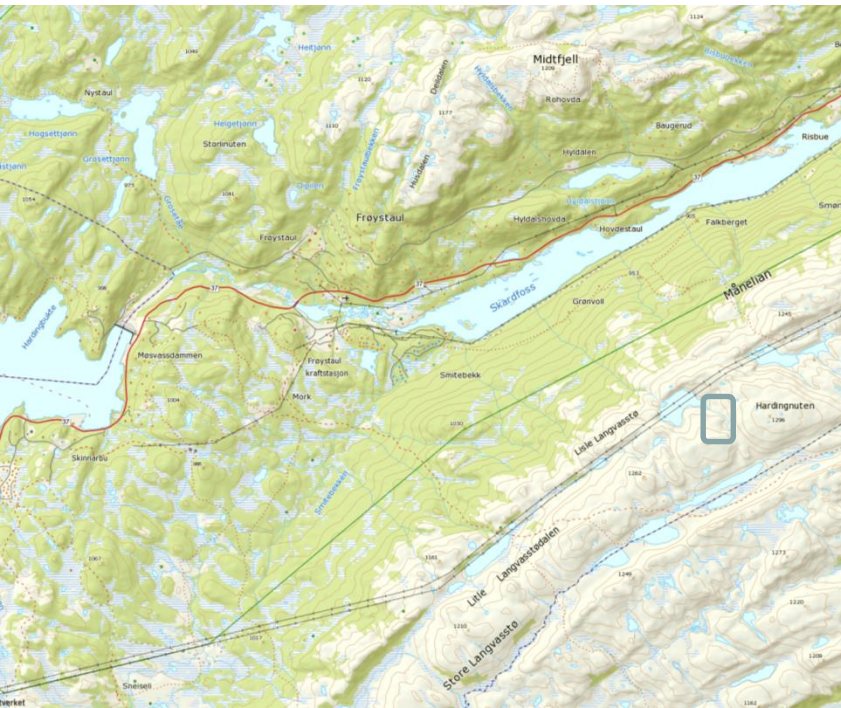
- Instrumentation at all sites:
  - Load sensors
  - Ultrasonic anemometers
  - Temperature
  - Heated Web cam
  - Live monitoring
- Load measurements:
  - Ålvikfjellet (test span + 420 kV)
  - Rjukan (420 kV + 300 kV)
  - Stølsheimen (Test span, simplex and duplex)





# Test site near Rjukan

- Two parallel transmission lines in exposed icing climate
- Two tower collapses 2013 and 2014.
- Measure ice loads on Simplex and Duplex phase conductors (lines in operation)
- The site is located at around 1200 m above sea level



# New test site at Rjukan



From installation : January 21 2016

# New test site in Stølsheimen

- BKK are planning 420 kV Modalen - Mongstad
- Crossing icing exposed mountains in Stølsheimen
- BKK erected two test spans (encouraged by Statnett).
- Estimated 50 yr ice load : 80 kg/m
- Elevation: 1200 m





# Test site Stølsheimen

Duplex

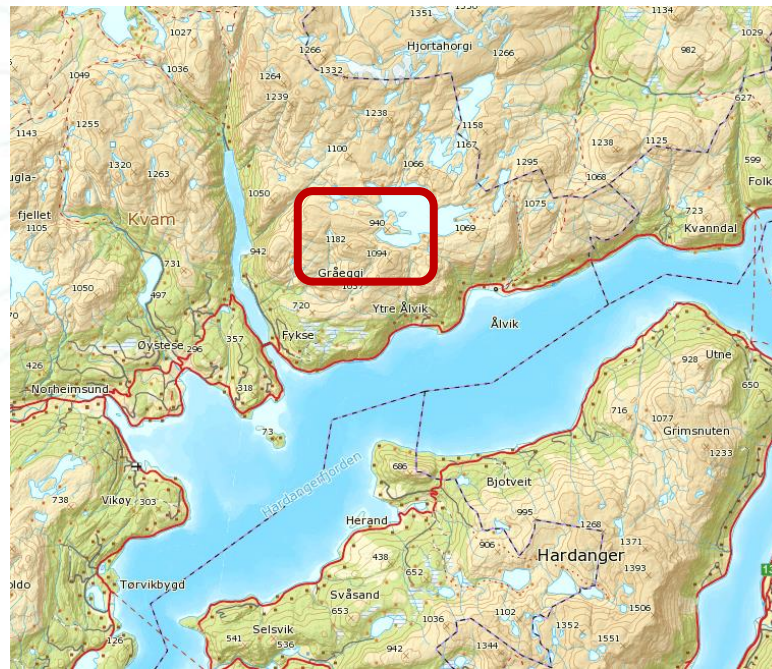
Simplex





# Test site at Ålvikfjellet, Hardanger

- A collapse of the top line in 2013
- Measure ice loads on Duplex phase conductors (420 kV) and on a Simplex test span
- The site is located at around 1100 m above sea level
- Test site installed in November 2014, new equipment installed in 2015/2016





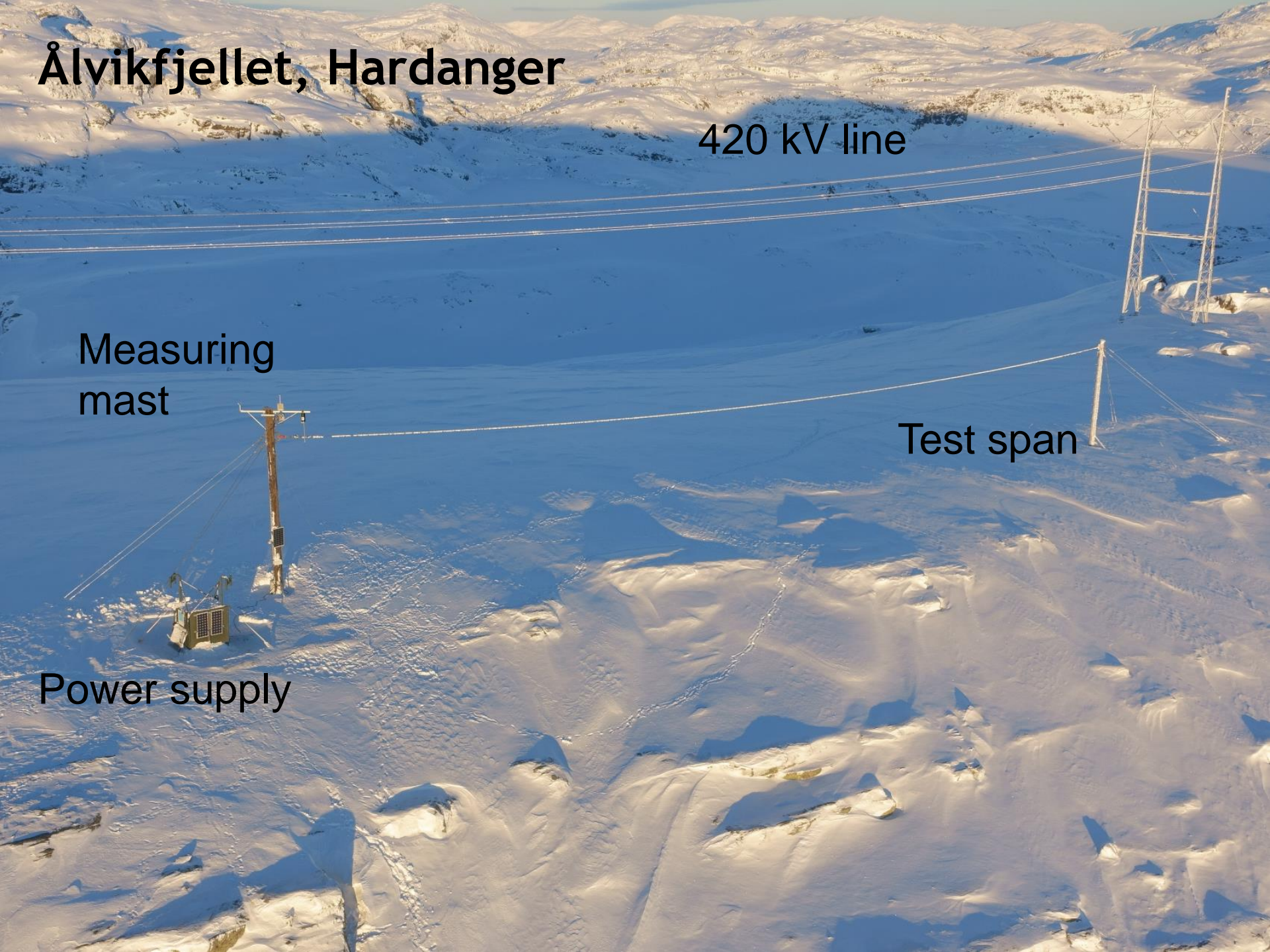
# Ålvikfjellet, Hardanger

420 kV line

Measuring  
mast

Test span

Power supply





# Load sensors

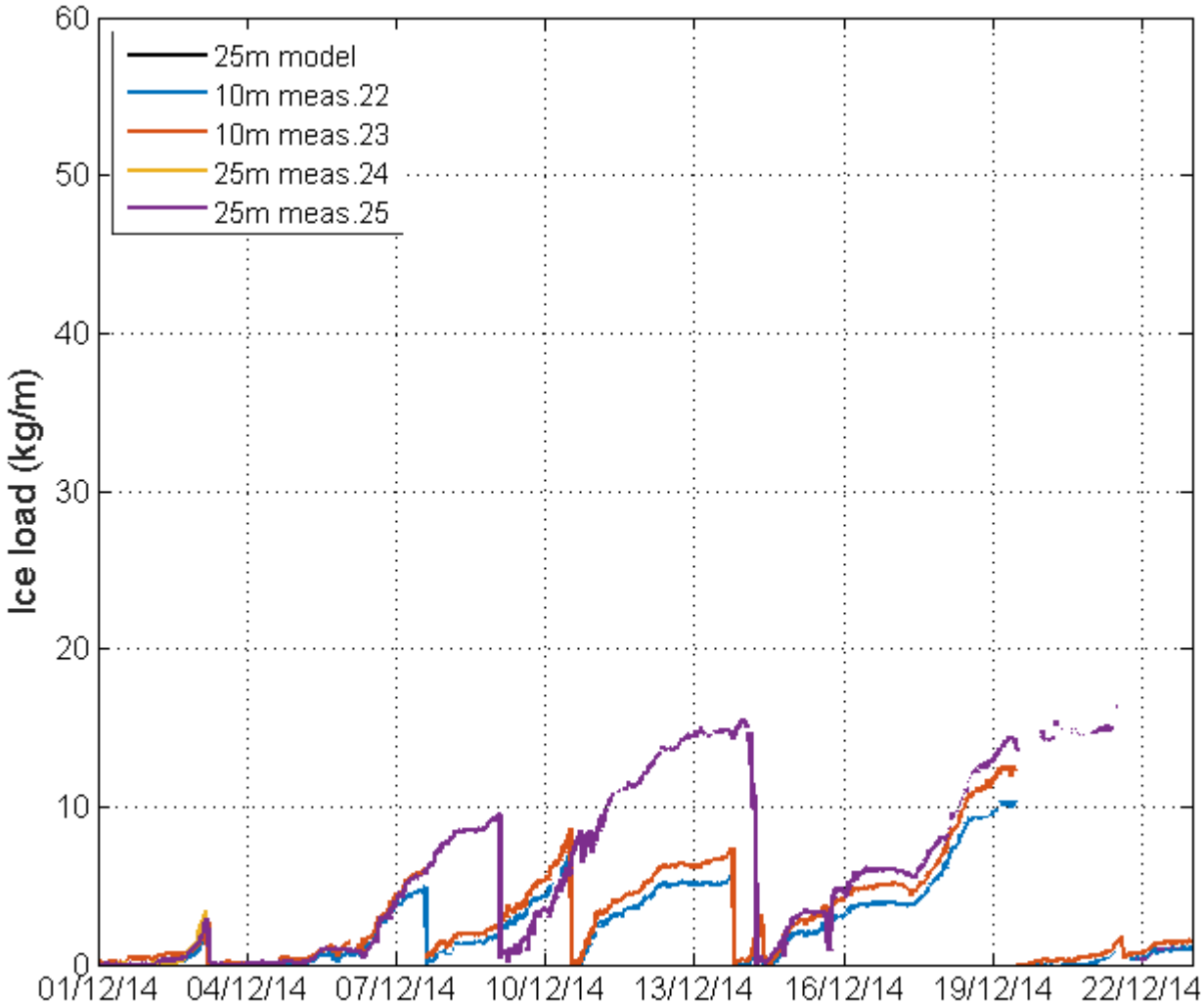
- Tension recorders IO-Keys (Iceland)
- Installed in insulator strings and test spans
- Save avg, min, max every 10 min
- Wireless data transmission
- Battery power supply



# Load tension measurements

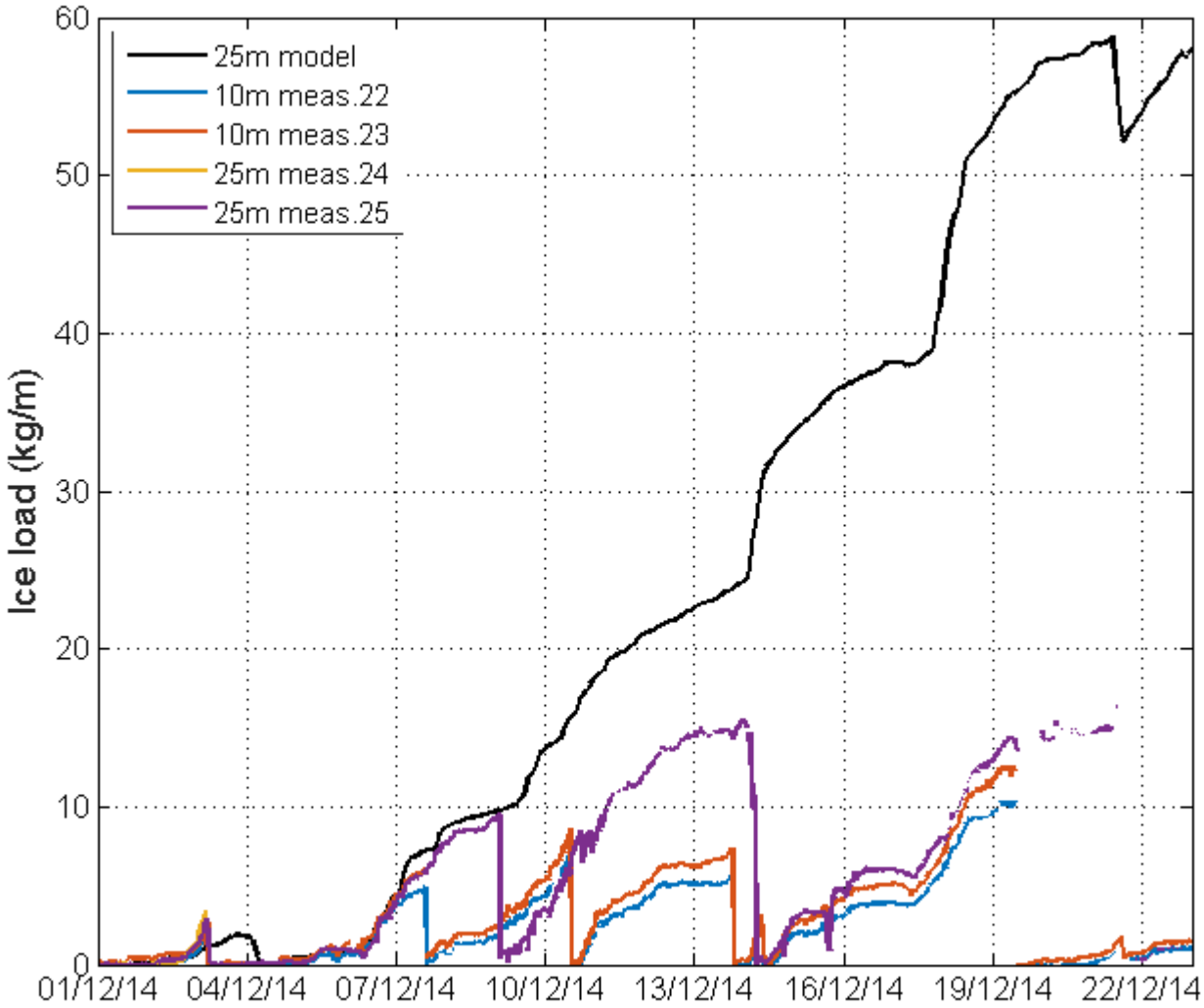
- Load tension measurements from Ålvikfjellet:
  - 2 tension recorders in the Simplex test span
  - 2 tension recorders instruments in the 420 kV Duplex
- LineLoads model
  - Based on ISO 12494 ice accretion model
  - Based on meteorological data from WRF simulations
  - Calculate both in-cloud icing and wet snow loads.
  - Ice accretion on the power line will be direction dependant
  - Calculate design loads: maximum ice load with different return periods

# Load tension measurements



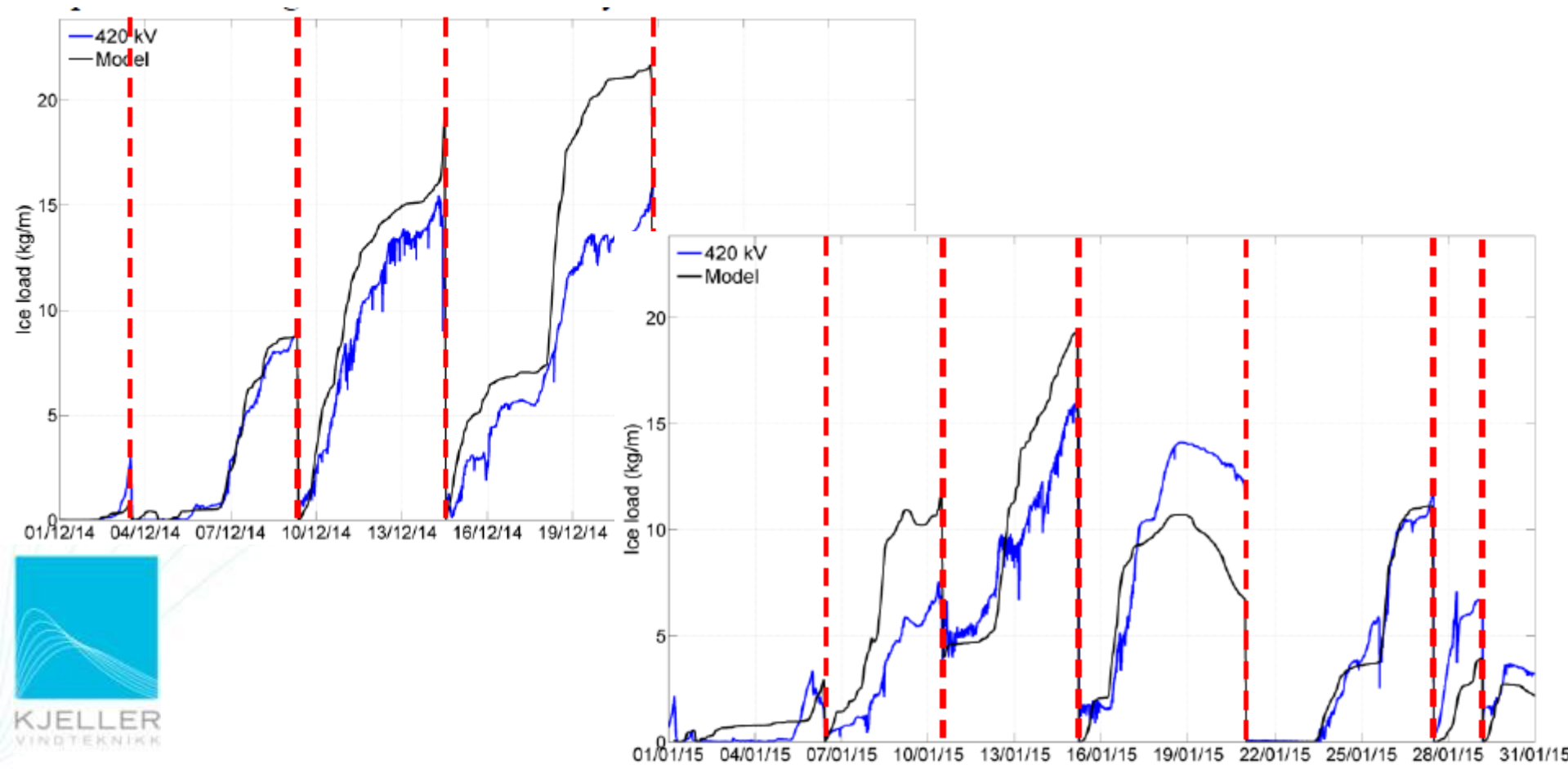


# Load tension measurements

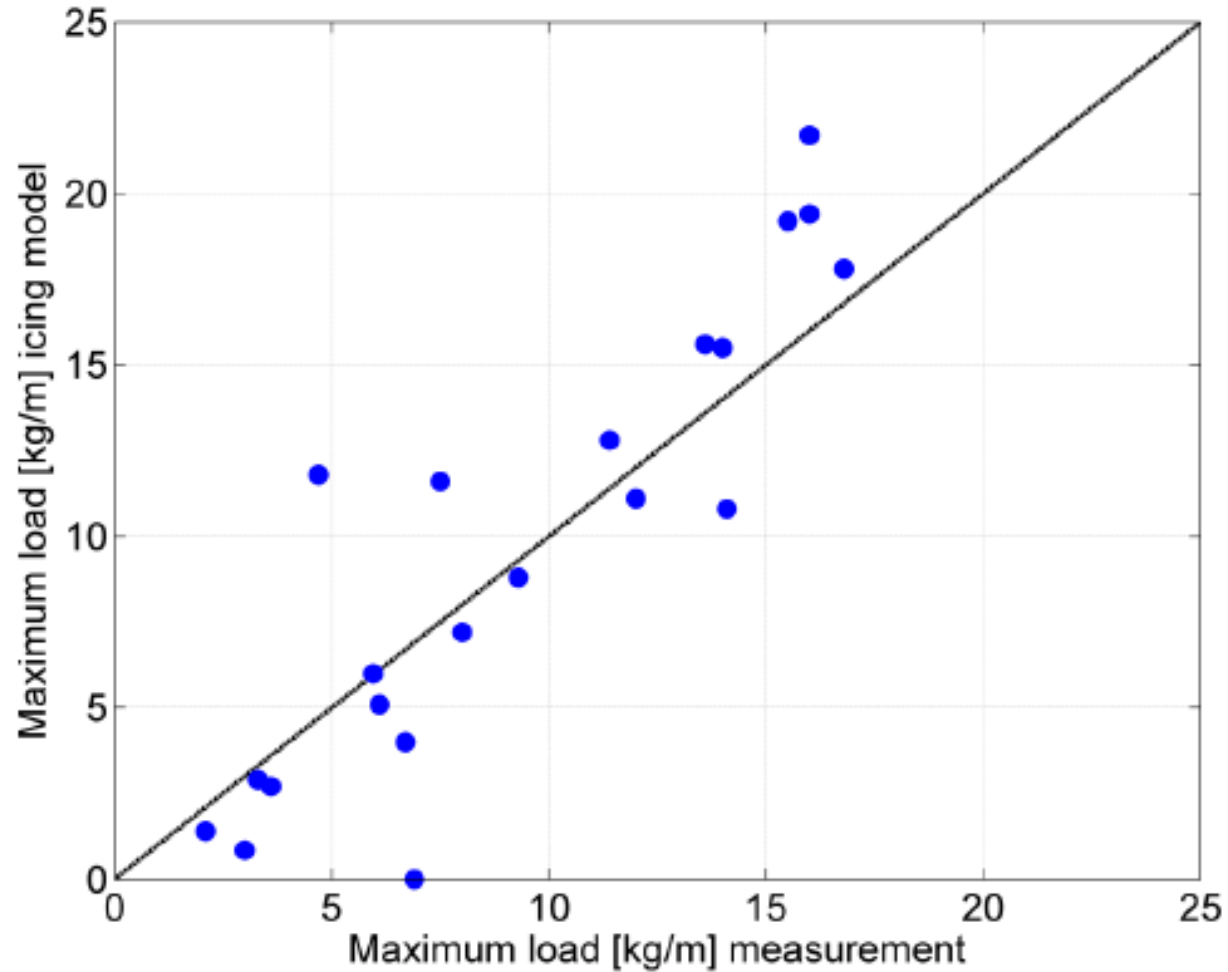


# Load tension measurements

- Ice shedding
  - Stochastic process
  - Not included in the LineLoads model
  - Ice Load manually reset after a shedding event



# Modelled and measured ice loads on 420 kV line 2014-2015





# New ice load sensor, KVT Ice-troll

- Measure weight of accumulated ice
- Forced rotation

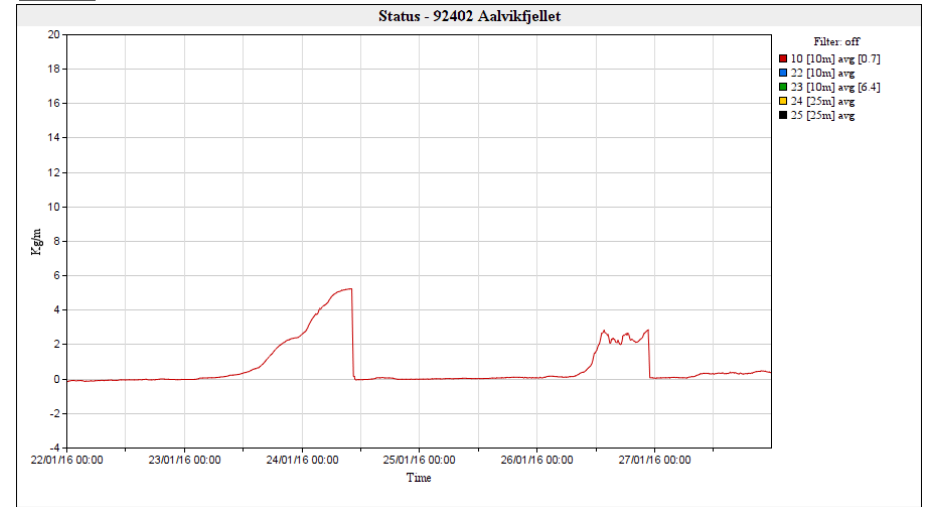


# New ice load sensor, KVT Ice-troll

- Installed at 2 sites (Ålvikfjellet and Rjukan) in January 2016
- Picture from Ålvikfjellet



# New ice load sensor, Measurements





# Summary

- 3 test sites are in operation at 1100-1200 m altitude in Norway
  - Load tension measurements
  - Wind measurements
  - Temperature
  - Webcamera
- A newly developed ice load sensor is tested
  - Forced rotation
  - Vertical cylinder

Thank you for your attention!

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