



# Risk of structural damage due to wind and icing

Modelling extreme weather loads

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# Freezing rain in Slovenia, February 2014



- Entire country covered with ice
- 25 % without power
- 50 % of the forest is damaged
- Costs 35 million euro every day



Foto: SRDJAN ZIVULOVIC / Reuters

# Power transmission in cold climate

- 420 kV line in Norway
- January 2014

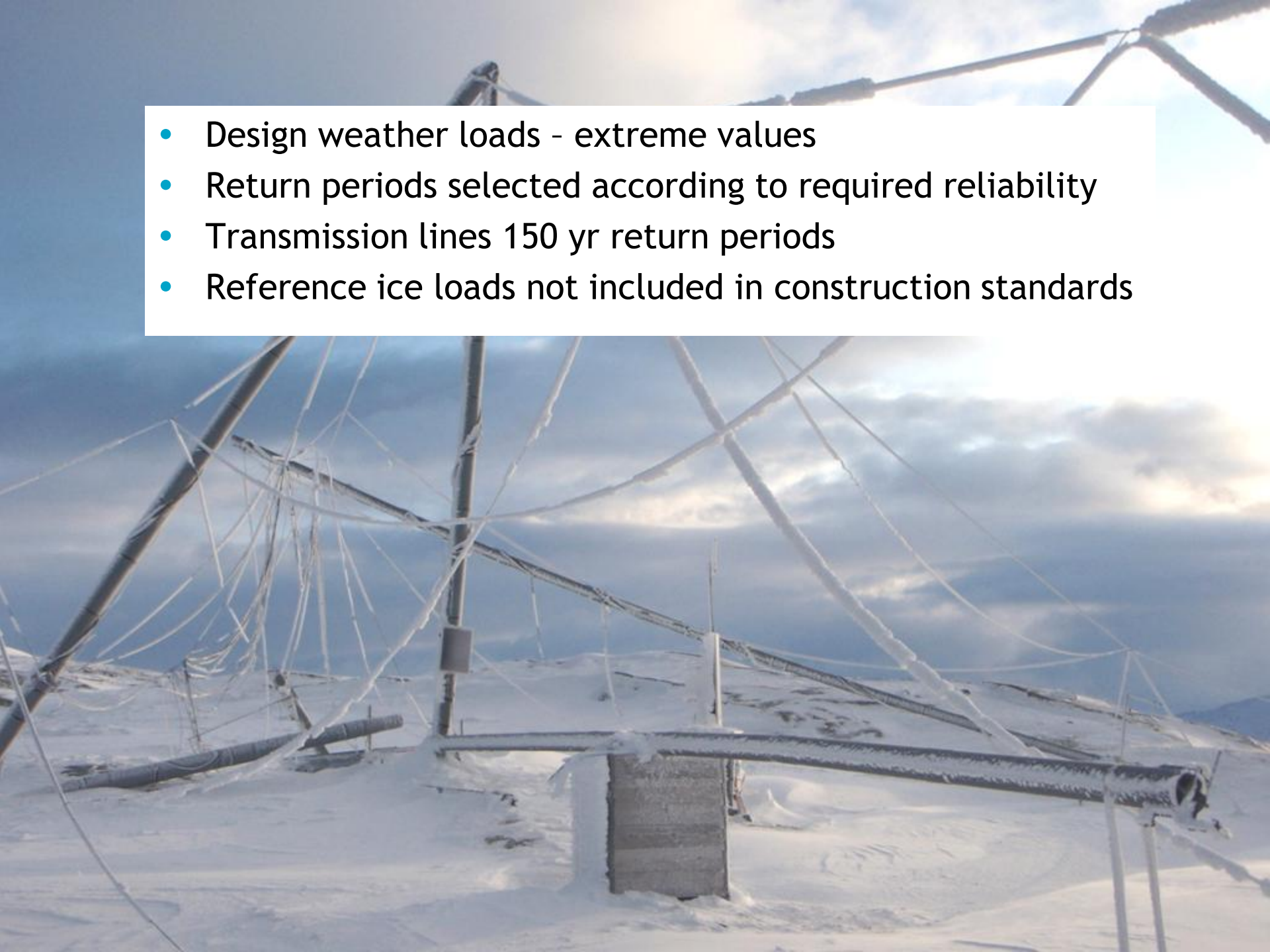


68 kg/m !!





- Design weather loads - extreme values
- Return periods selected according to required reliability
- Transmission lines 150 yr return periods
- Reference ice loads not included in construction standards



# Extreme weather and wind power projects

- Measurements/data
- Masts/instrumentation
- Power grid connection
- Safety issue

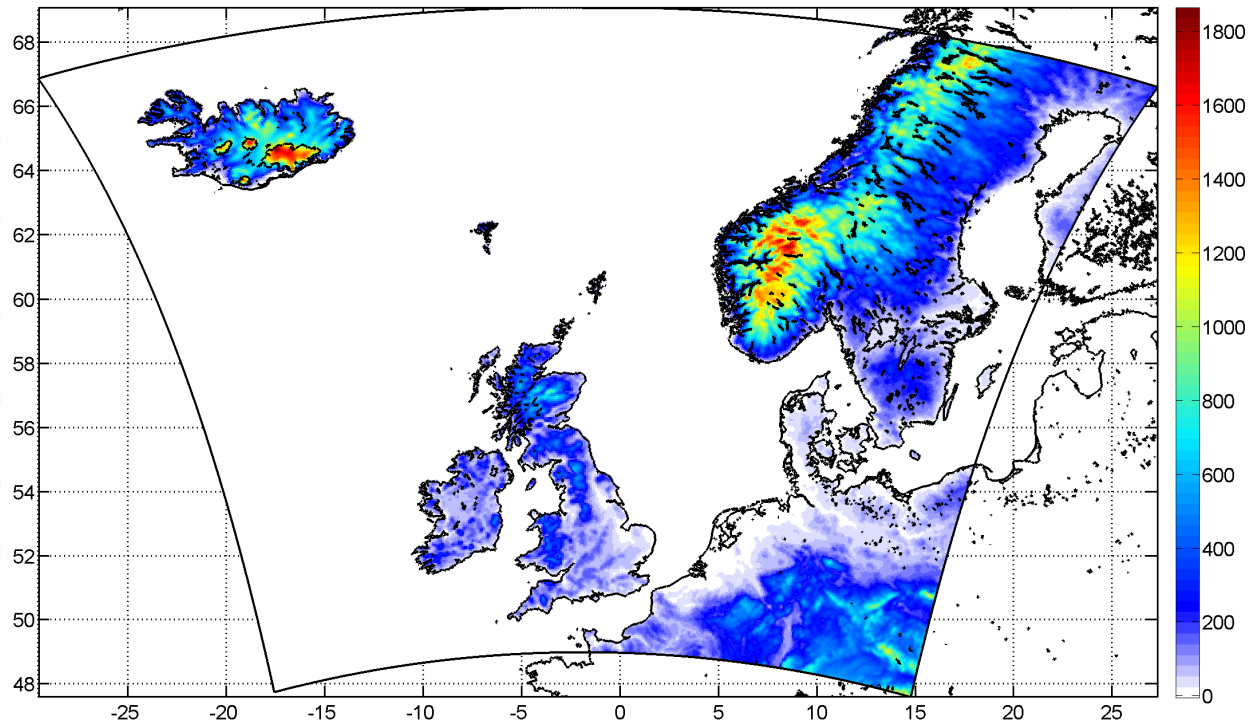


Remember!

Icing = Meteorological icing + Object

# Downscaled weather data

- WRF model with input from ECMWF (global model)
- Horizontal grid resolution of 6 km x 6 km
- Hourly data for 1979 - 2014
- Additional high resolution runs ( 0.5 - 1 km resolution)



# Three types of atmospheric icing

- Rime icing



- Wet snow



- Freezing rain



Frequency?

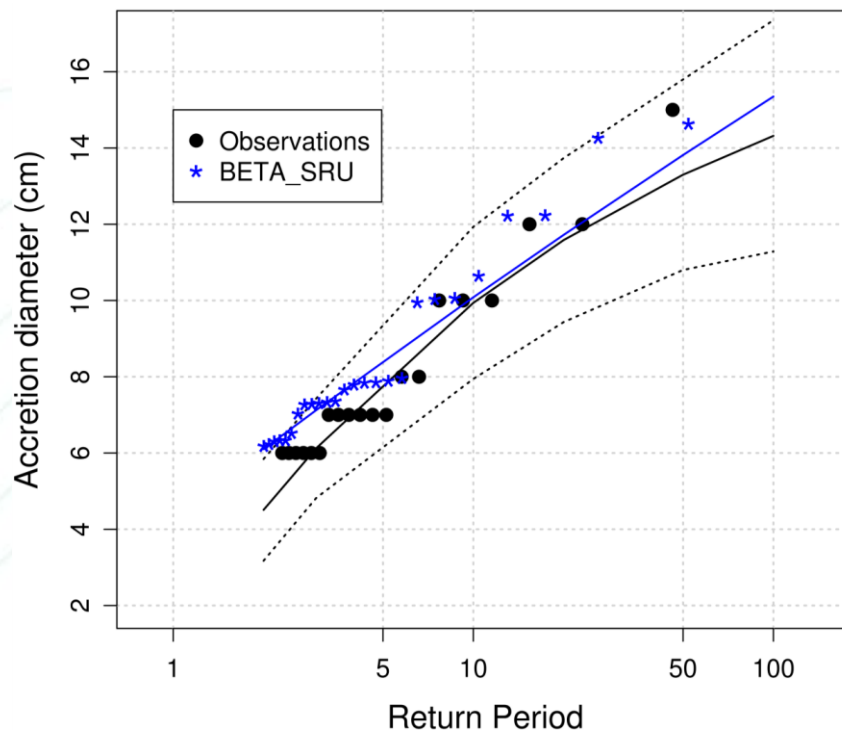
Expected extreme values

Combined with wind?



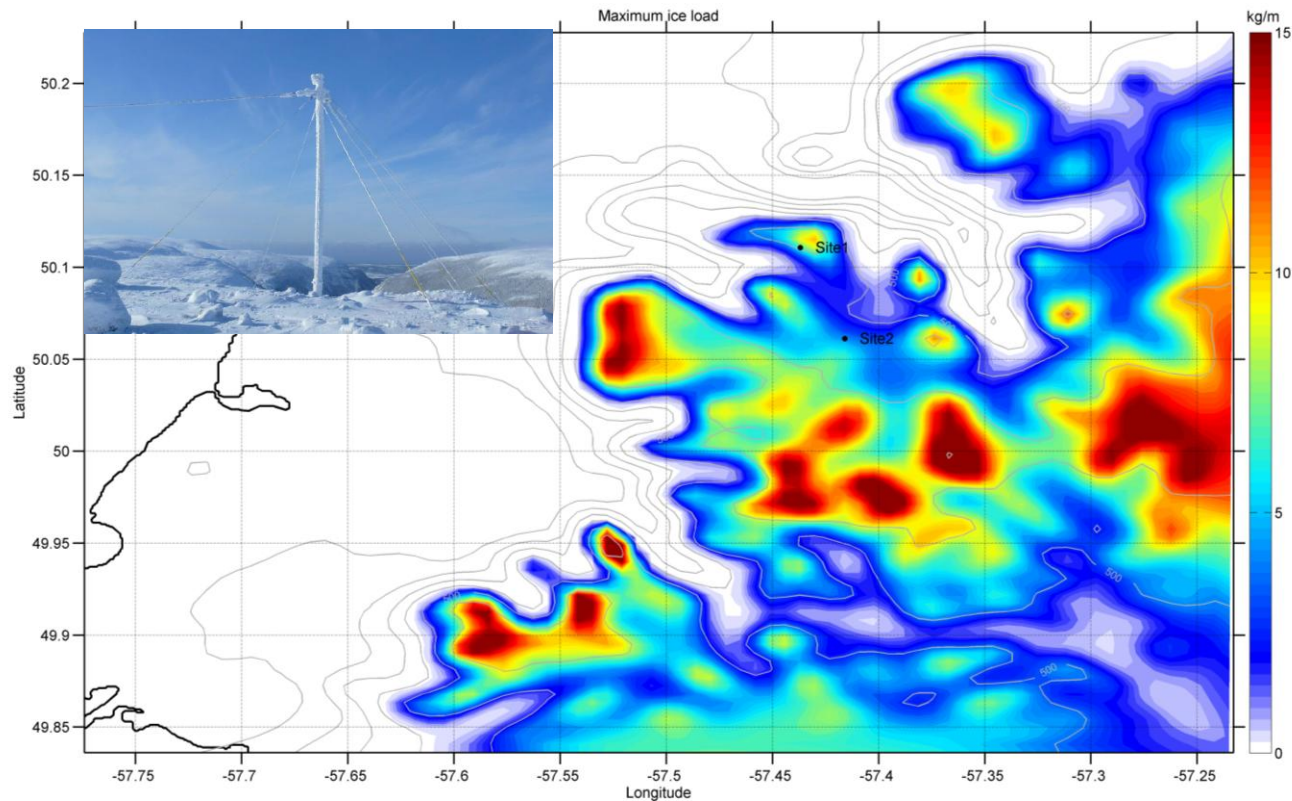
# Modelling wet snow accretion

- Estimated based on the WRF output
  - Precipitation rate, wind speed, temperature, humidity, liquid water in snow
- Model calibrated with observations from Iceland

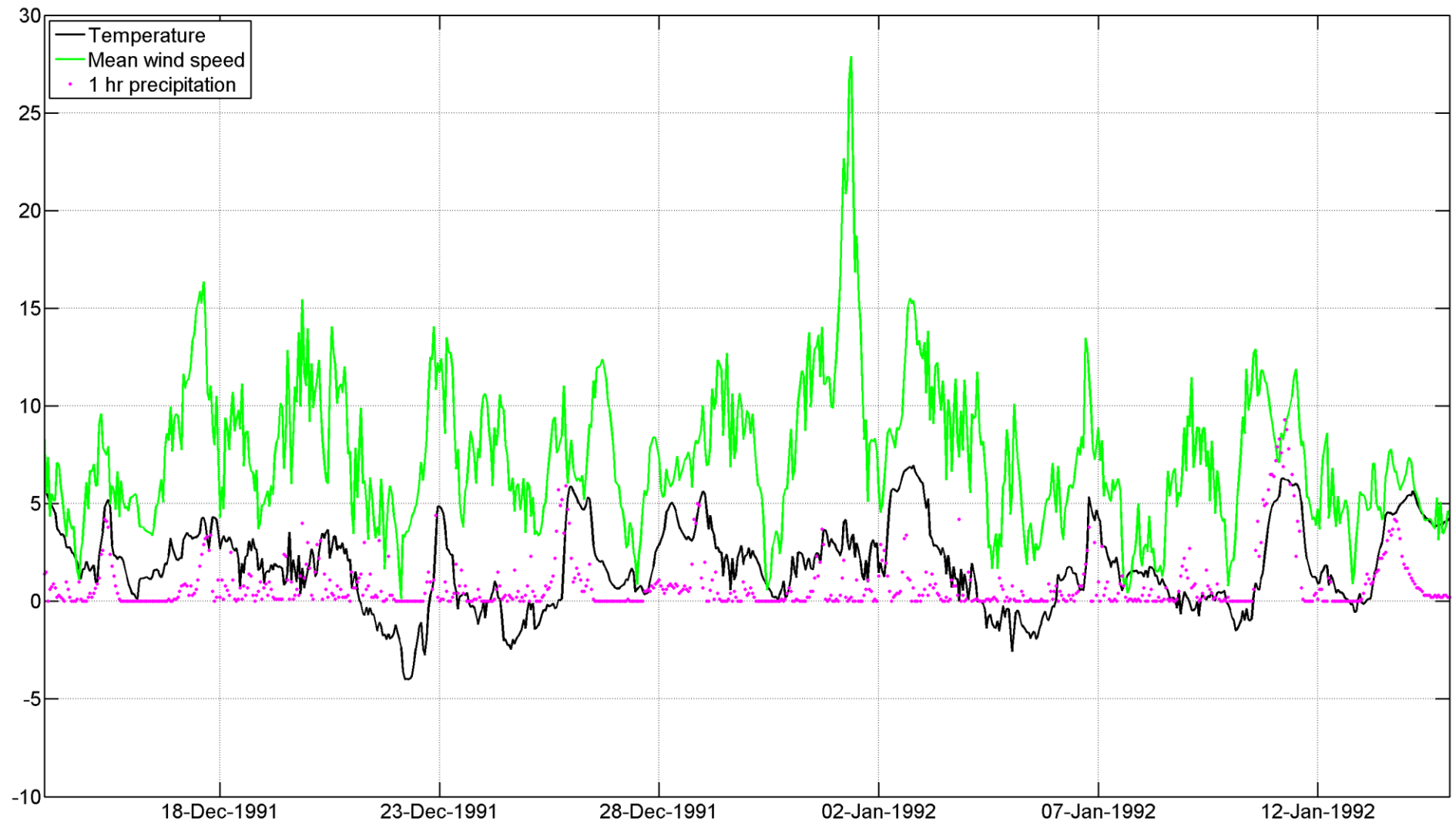


# Modelling rime icing

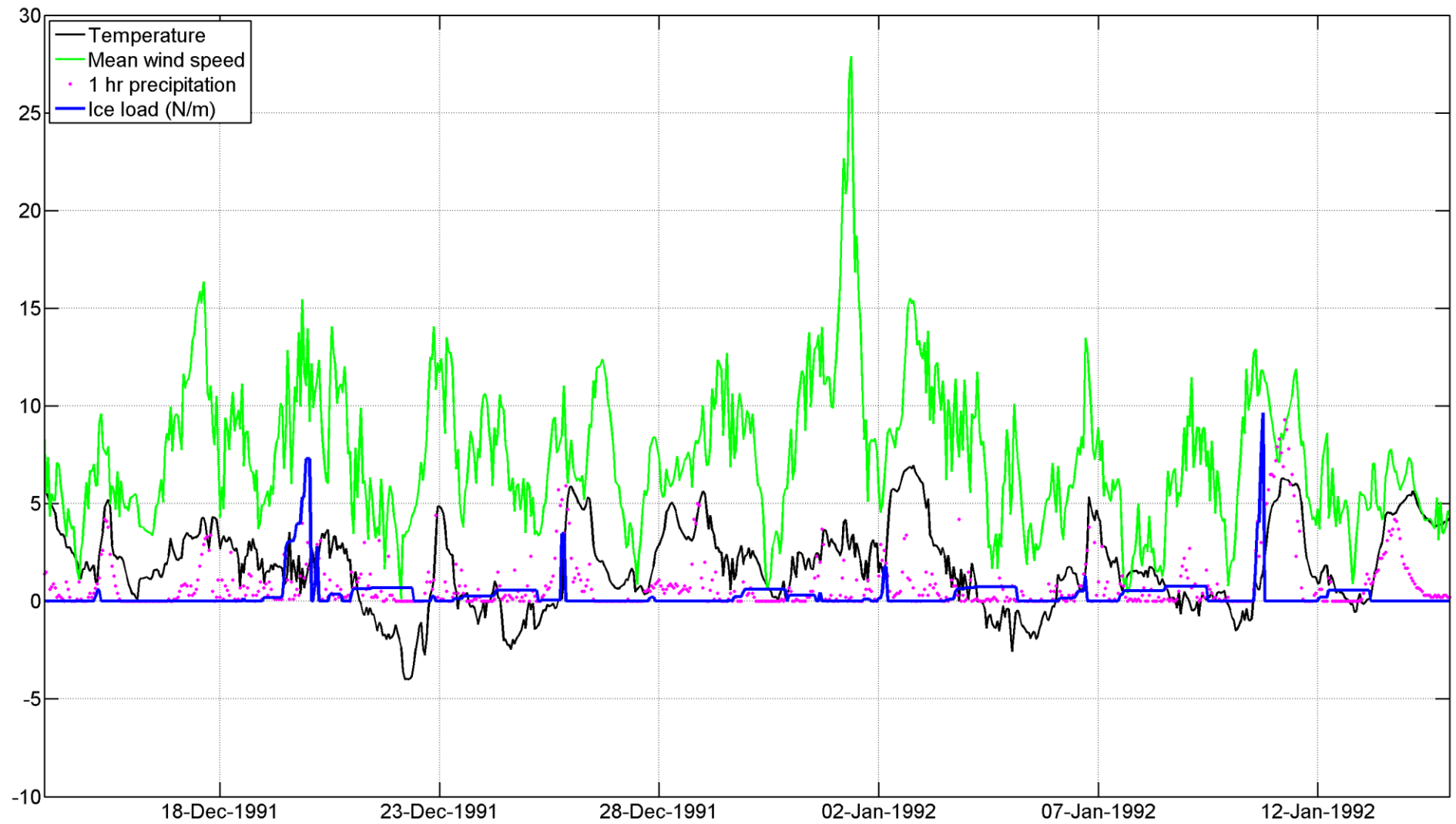
- Estimated based on the WRF output
  - LWC, droplet concentration, wind speed, temperature and humidity.
- Several ongoing verification projects
  - E.g. test spans at Newfoundland (Nalcor Energy)



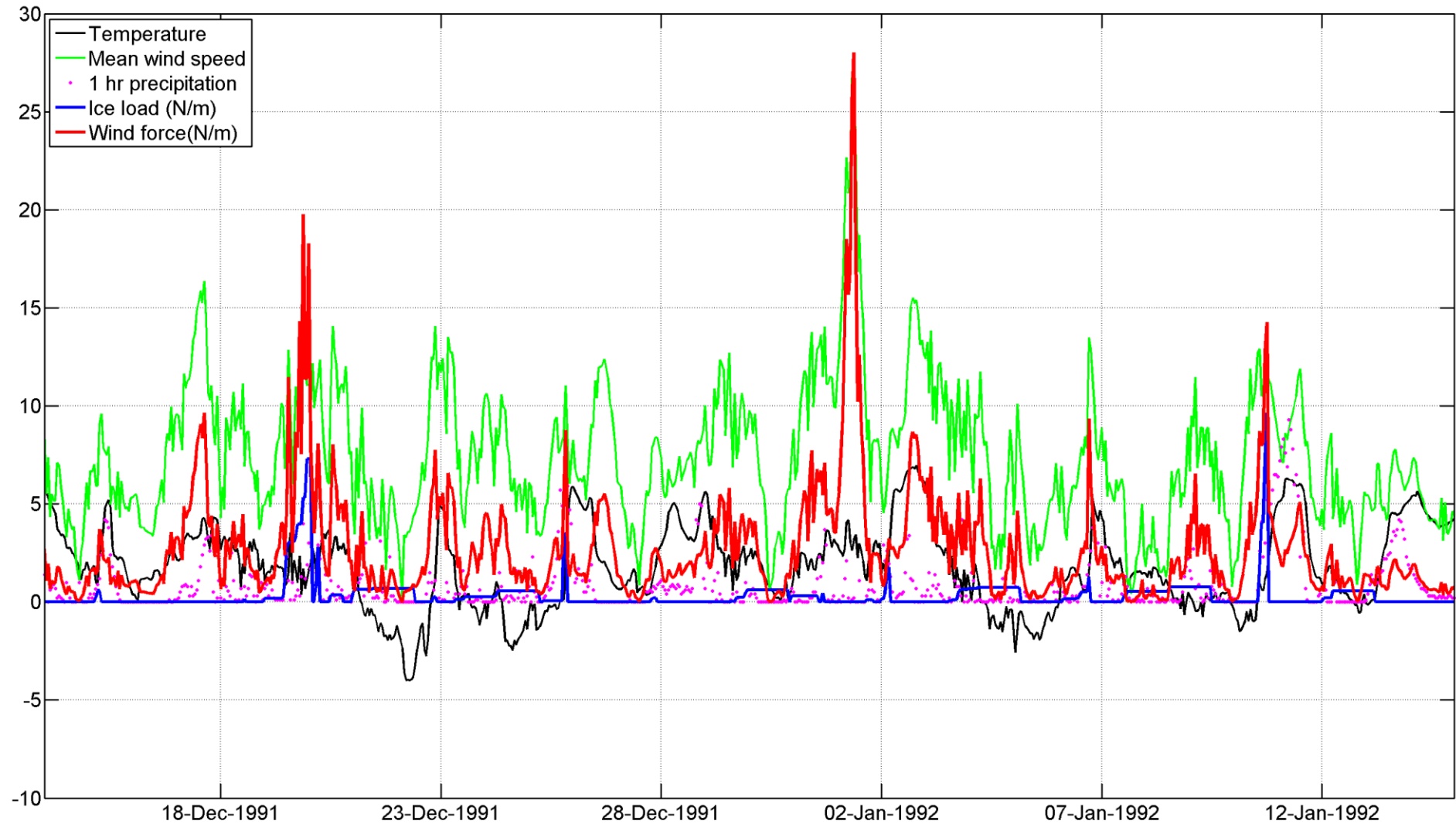
# WRF 6 km



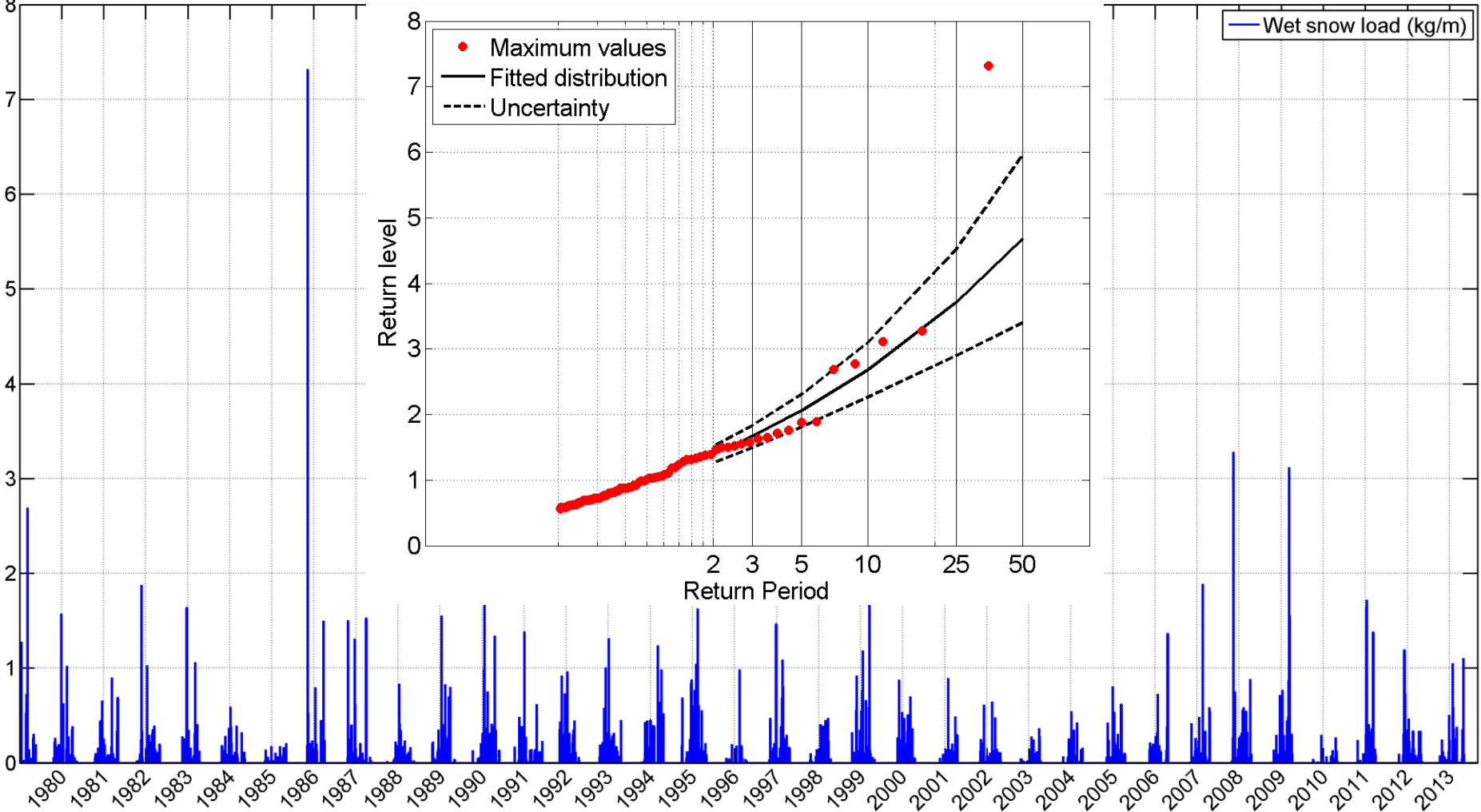
# WRF 6 km



# WRF 6 km. Wind force



# Estimating return values



# Estimating design weather loads

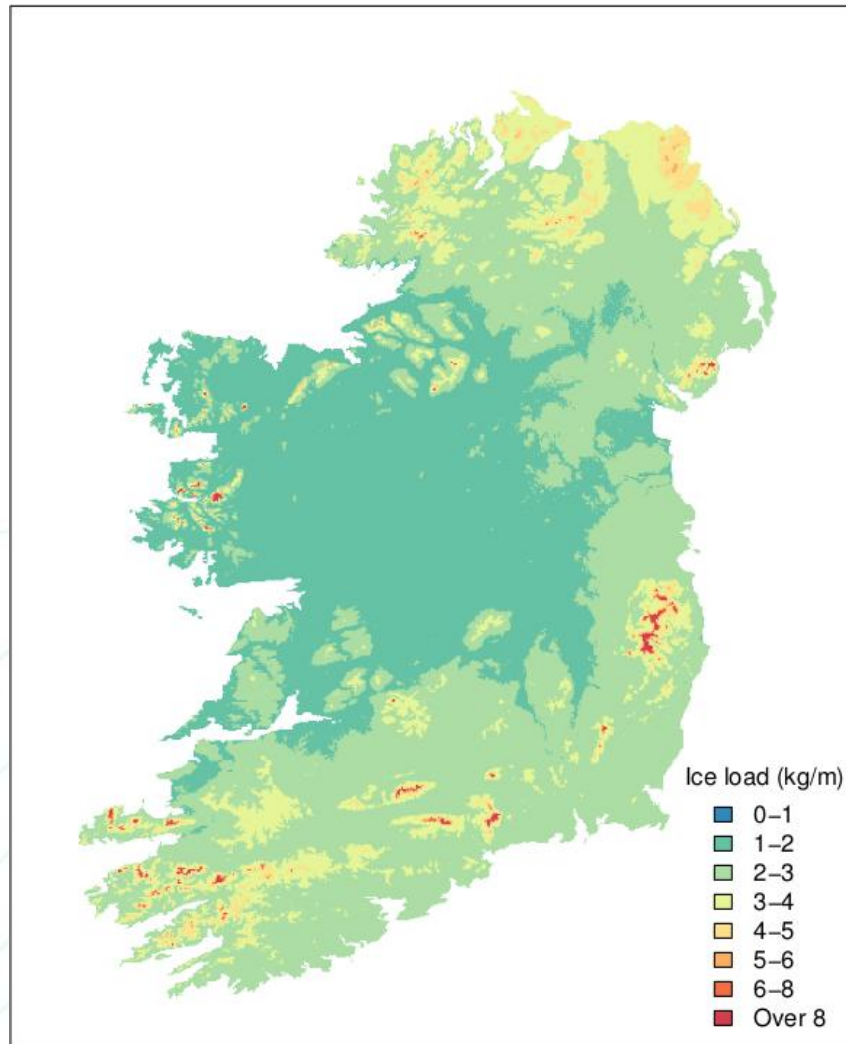
## Wet snow load (kg/m)

Line direction	Return period						
	2 yr	3 yr	5 yr	10 yr	20 yr	50 yr	150 yr*
N-S	2.0	2.4	3.1	4.3	6.5	8.8	11.0
SW-NE	1.8	2.2	2.8	3.9	5.9	8.2	10.3
W-E	1.7	2.0	2.5	3.3	4.7	6.0	7.5
NW-SE	2.0	2.3	2.9	3.6	4.9	6.1	7.6
Independent	2.4	2.9	3.6	4.8	6.8	8.7	10.9

## Rime ice loads (kg/m) vs. height a.s.l.

Height	Return period			
	3 yr	10 yr	50 yr	150 yr
950 m	3.9	5.2	7.5	9.4
900 m	2.3	3.5	6.3	9.0
850 m	1.2	2.0	3.6	5.0
800 m	0.8	1.2	2.0	2.5

# Icemap for Ireland



- Made for the Irish power grid industry
- Wet snow accretion and rime icing
- 50 years return values
- 500m x 500m grid resolution
- Will be included in the Irish standard



Thanks for the attention!



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