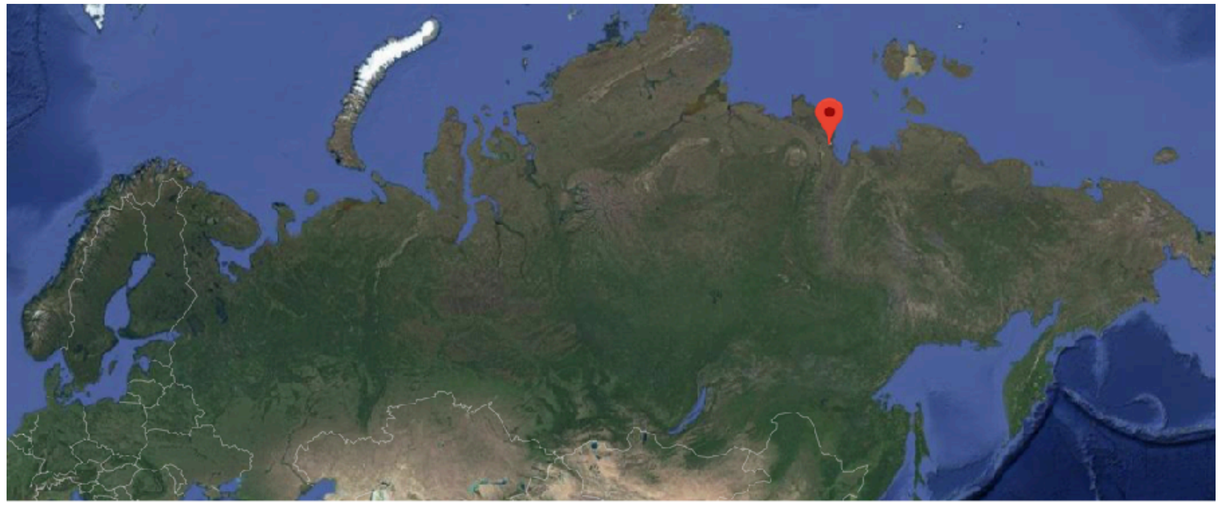
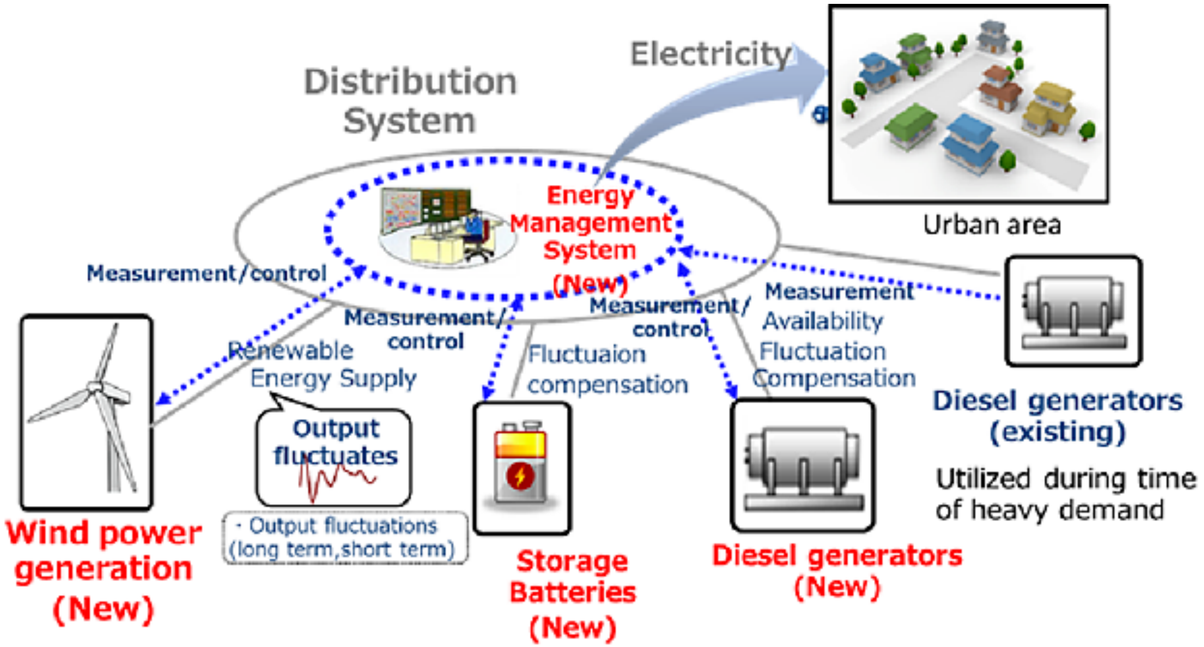
Wind turbine operations in northern Siberia

Masafumi Yamazaki

Shigeo KIMURA
Ken’ichi IWAI, Masao HOSOMI

Wind Turbine Operation in Tiksi





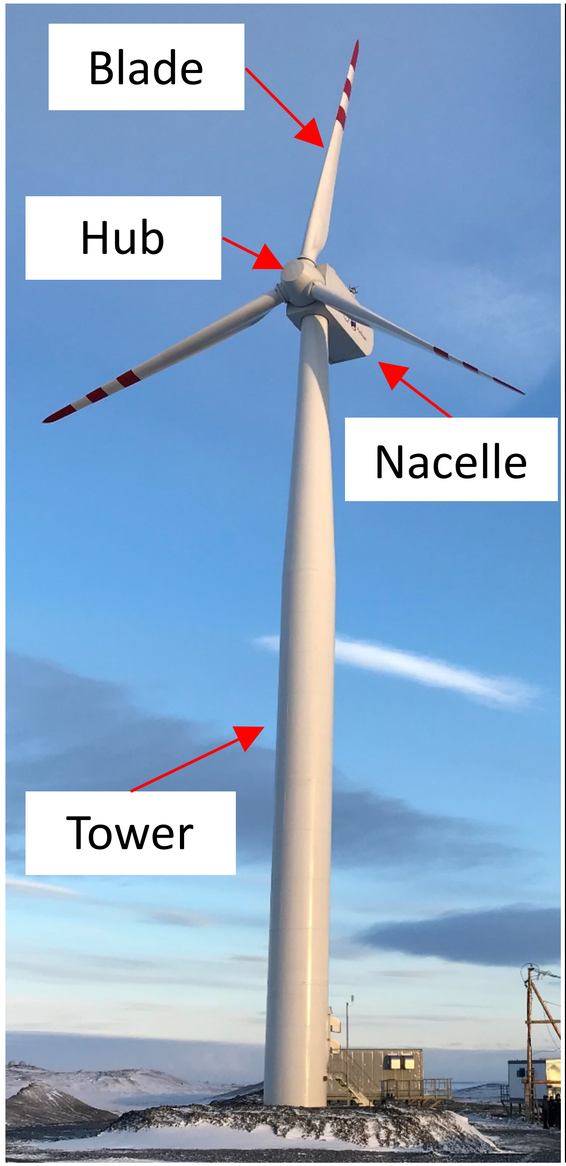
About Tiksi

- Located in the north of Sakha Republic
- Population: about 5,000
- Climate: Tundra
- Off-grid, Depend on diesel power generation
- Diesel is transported by tankers on Rena River during the short summer(2 months)
- Power plant was established in 1960s and regularly requires maintenance

Russian Far East Energy Infrastructure Demonstration Project as NEDO project of Japan

- Demonstrate the polar micro-grid system
- While producing electricity by wind turbines, diesel generators are used for the steady supply
- Three wind turbines were installed in Nov. 2018 manufactured by Komaihaltech Inc.

Specification of Wind Turbine: KW300

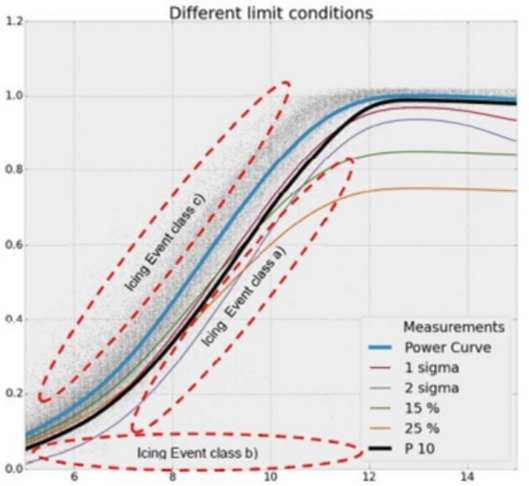


Wind turbine type	3-blades upwind type
Rated power	300 kW
Cut-in wind velocity	3 m/s
Cut-out wind velocity	25 m/s
Hub height	41.5 m
Blade length	16.5 m
Blade feature	Hard to get ice Easy to peel off ice
Nacelle feature	Have any sensors for detection icing Add Fan-heaters to protect some devices against low temperature
Tower feature	Keep tenacity at low temperature
temperature range	-35 ～ +30 °C (Operate) -50 ～ +40 °C (Standby)

Objective: Understand conditions for icing

- **Step 1 : Identify the blade icing time**
  - **Apply T19 Ice Loss Method (old version)**
  - **Compare with Ice detector (LIP-3000)**
- **Step 2 : Find possible source of water droplets**
  - **Combine the result of Ice Loss Method and operating data on site**
  - **Determine wind turbine status just before the icing event**
- **Step 3 : Verify the source from public data**
  - **Observed sea ice by satellite images provided by National Snow and Ice Data Center (NSIDC)**

LIP-3000

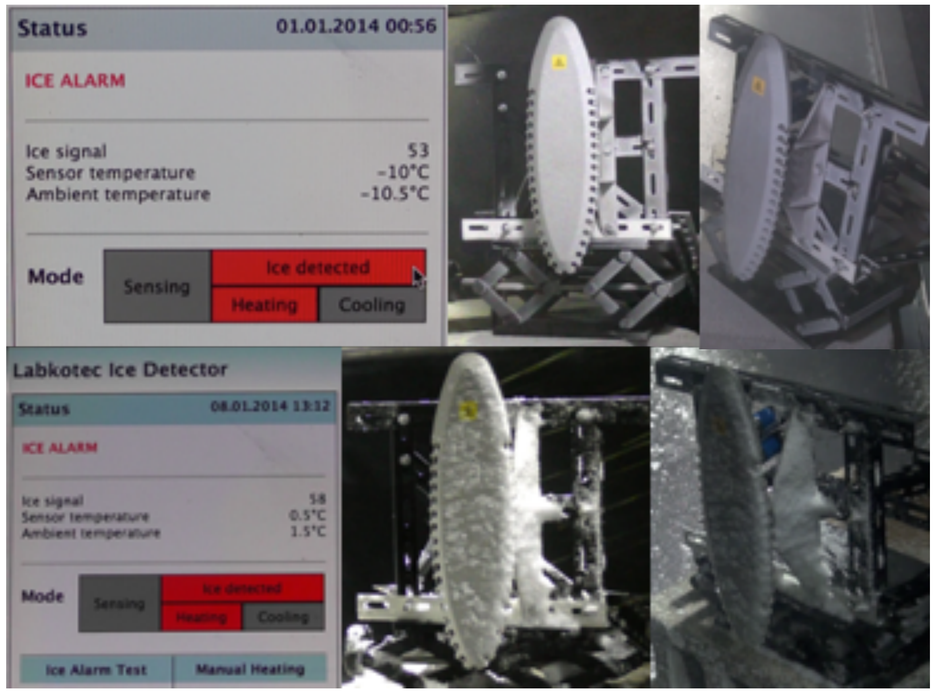


Ice Loss Mothod

Step 1 : Identify the blade icing time

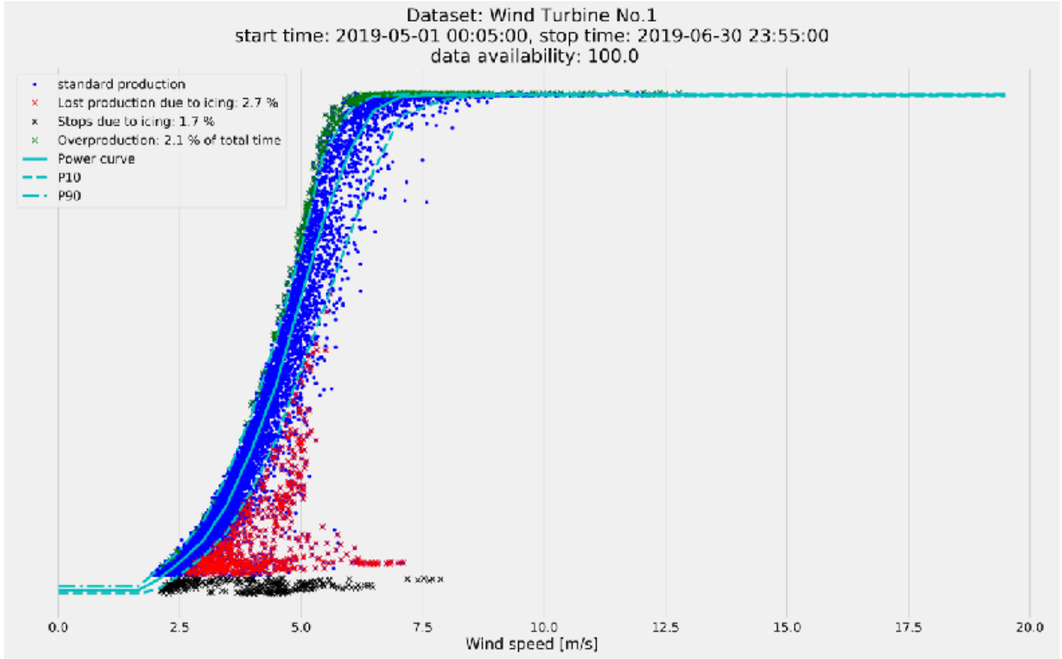
Ice detecter : LIP-3000 (Labokotech)

- Detect icing on aluminum wire
- The signal decreases from 100 (no ice) as ice grows on the wire
- Sends alarm when the signal is below 60
- Equipped heater turns on when it detects icing
- Back to detecting mode after cooling down
- **Sensitive to both ice and snow accumulation**

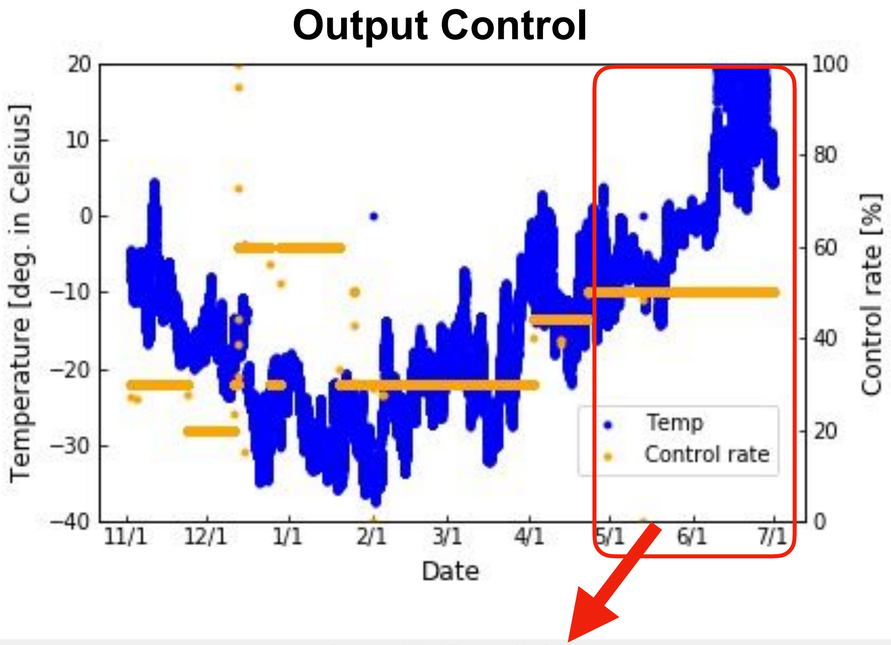


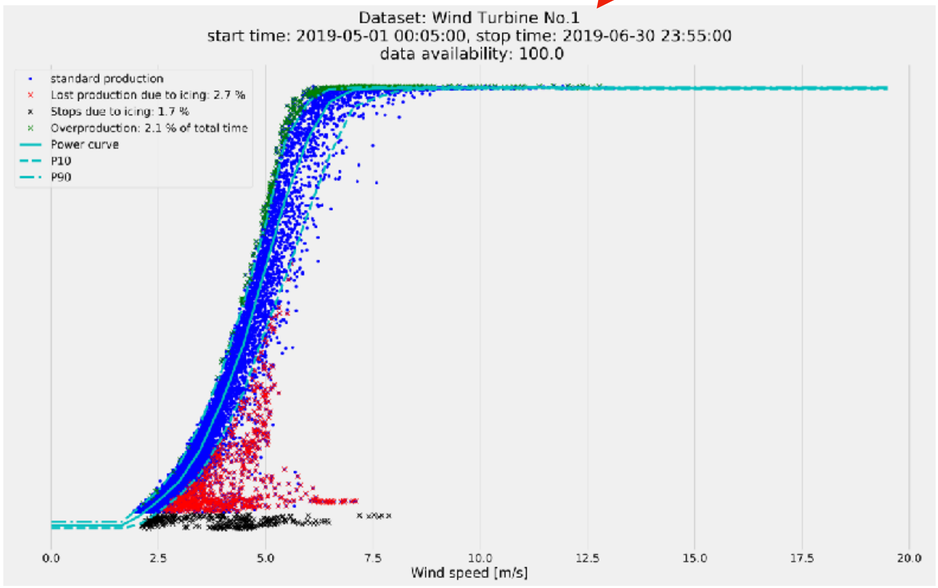
Ice Loss Method :

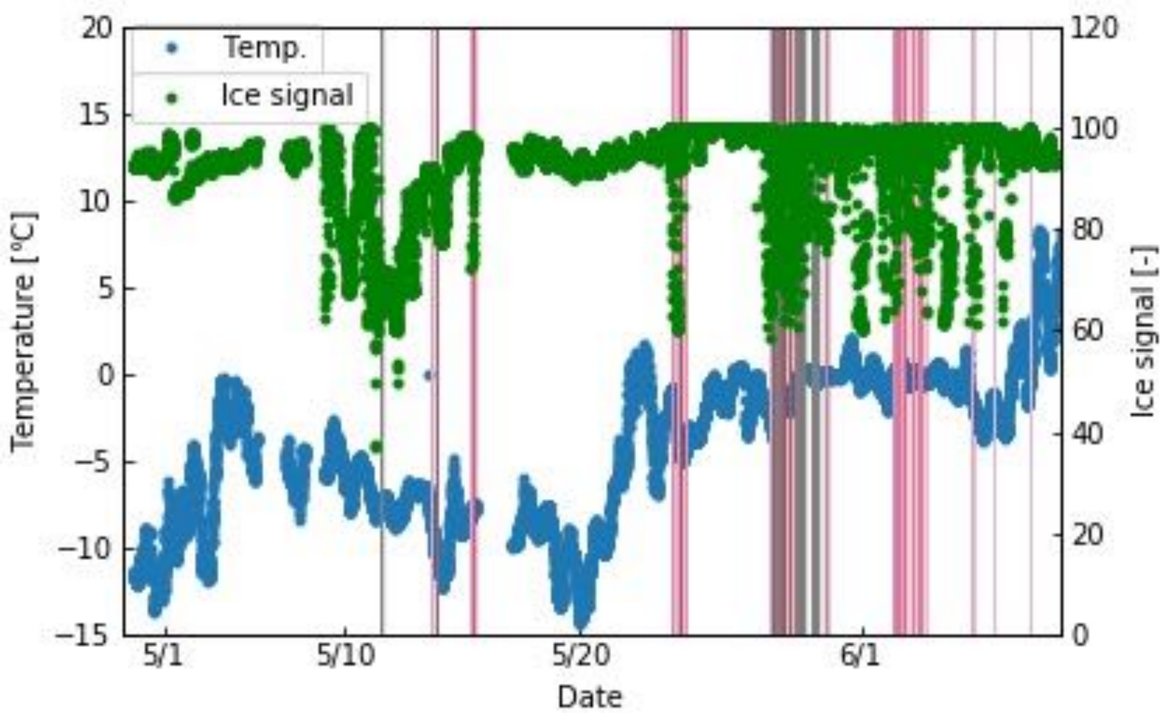
- Calculate the production loss / stops caused by icing on blades from SCADA data
- The amount of loss and duration
- Requires SCADA data when T > 3℃ in order to calculate the reference power curve
- **Unable to apply real time ice detecting**



Step 1 : Identify the blade icing time

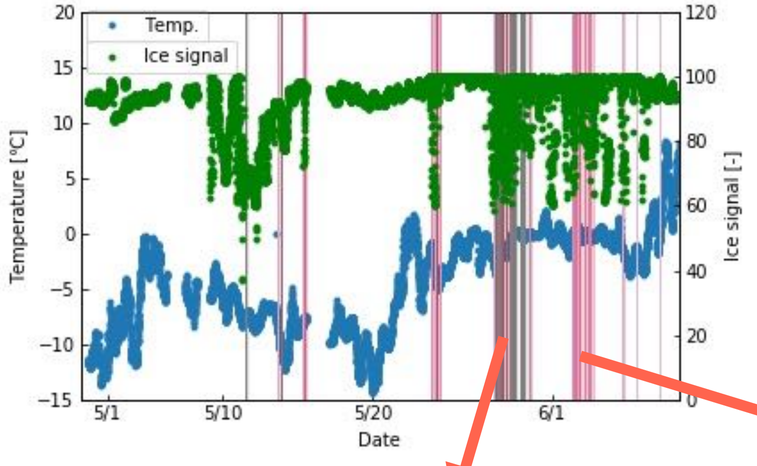




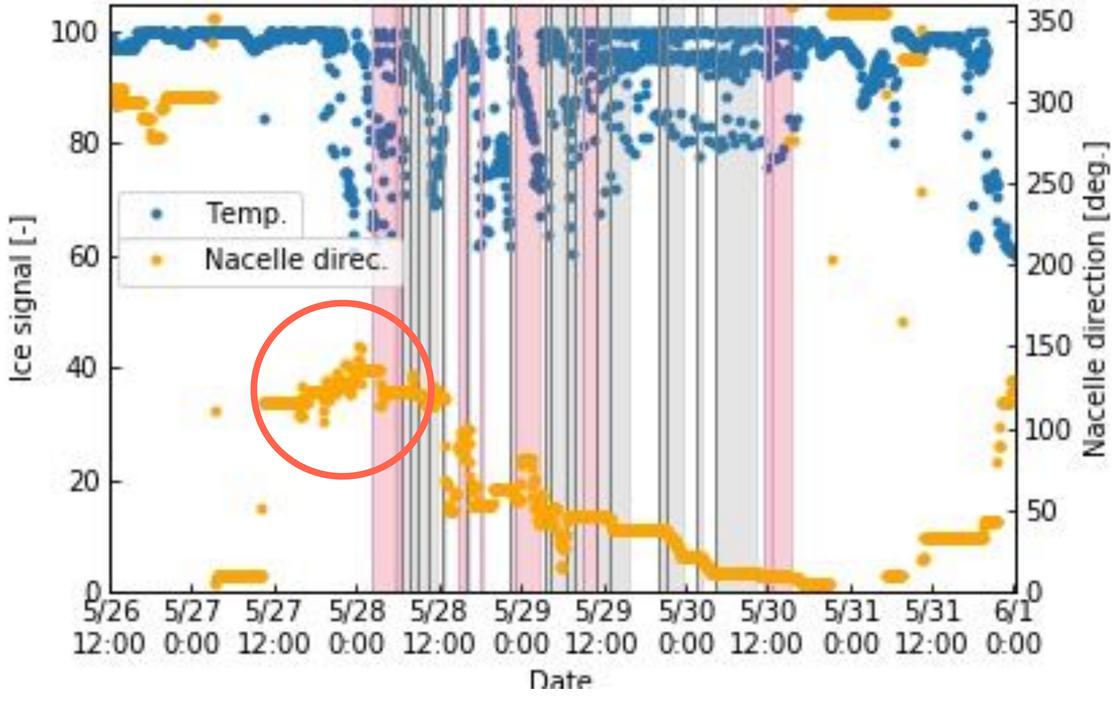


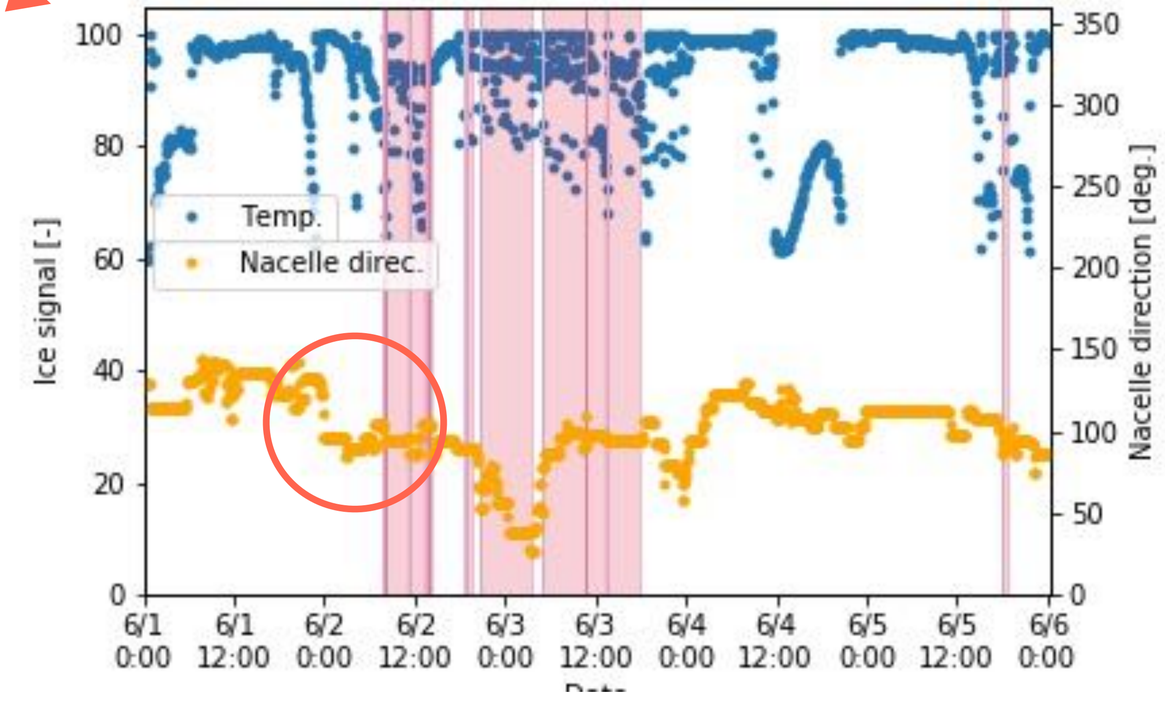
- Applied Ice Loss Method for SCADA data between 5/1 and 6/30 when the rated power was set to 150 kW
- Colored background in the fig. shows the production loss or stops due to icing
- Most icing time calculated by Ice Loss Method correspond to the measurement of ice detector.
- Icing was observed frequently from 5/20 to 6/3 when ambient temperature was slightly below 0 ℃

Step 2 : Find possible source of water droplets

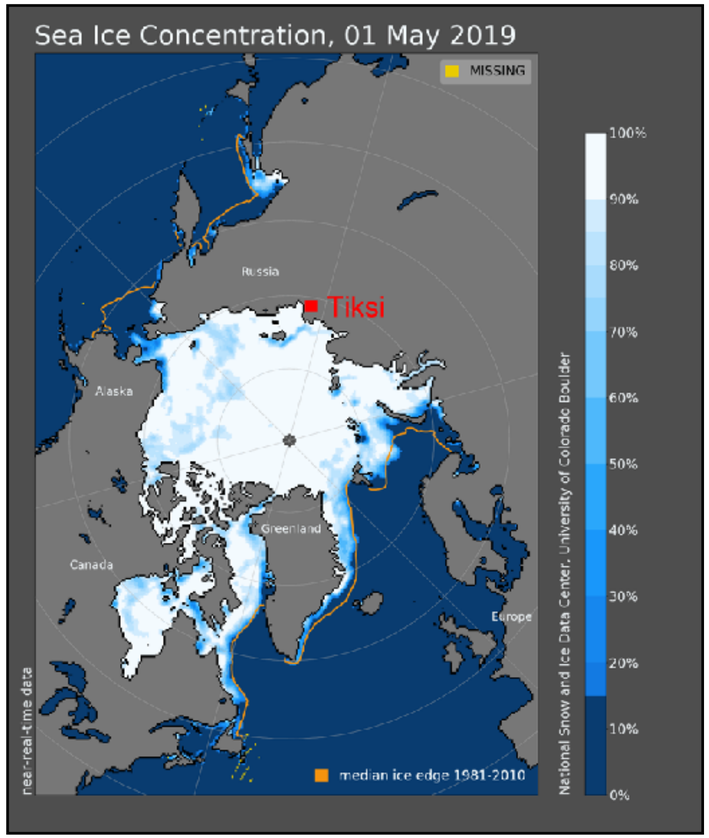


- Details of 2 icing events are shown below
- before production loss occurred, the turbine was in production facing toward between 90 and 135 deg.
- turned out that icing occurred when the turbine operated facing to the nearest sea





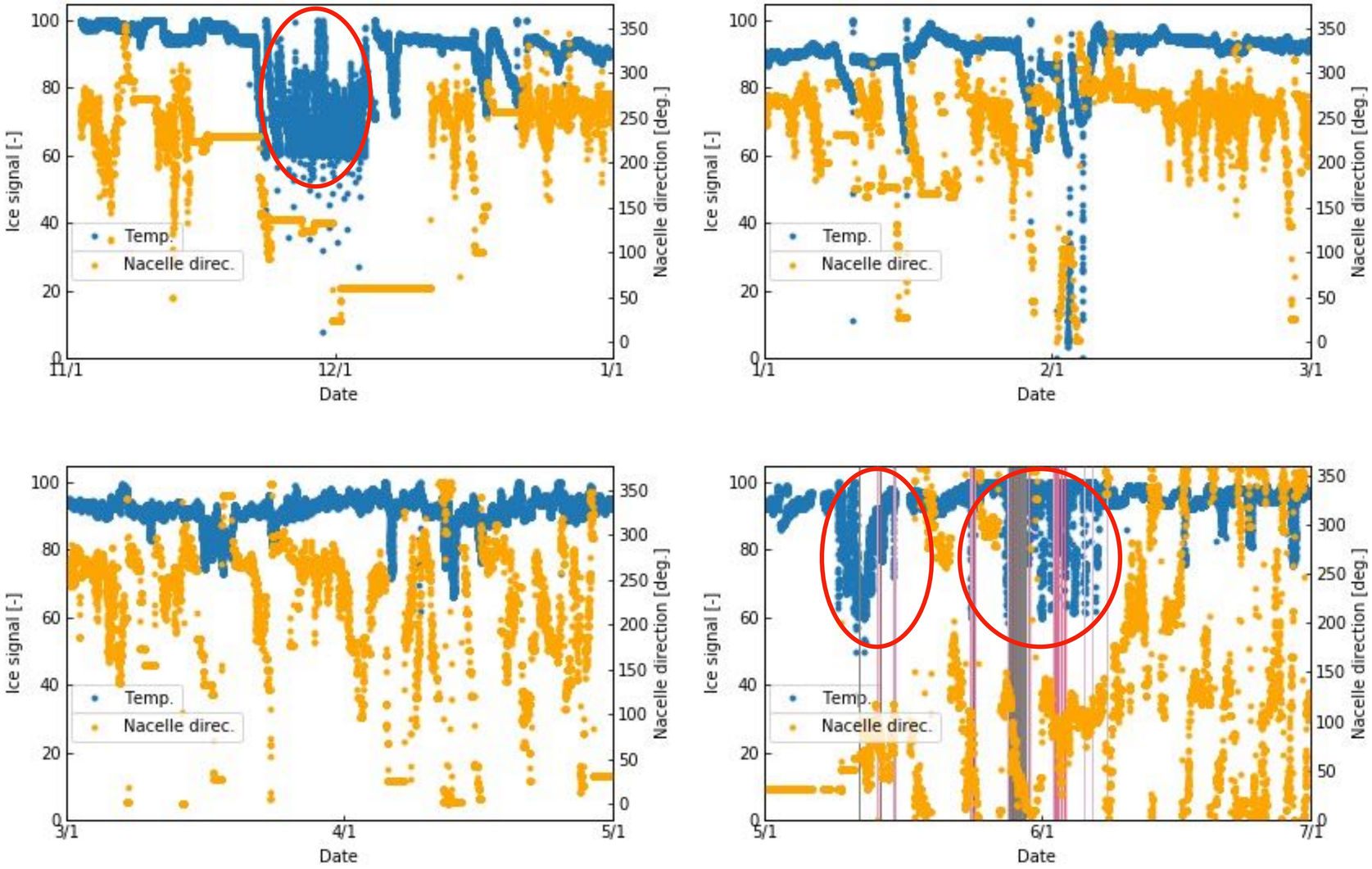
Step 3 : Verify the source from public data



- Nacelle direction from 5/1 to 6/30 is shown on the left map where the site is centered
- When icing occurred, nacelle was facing to the nearest sea where the sea ice seemed to melt
- While the sea places in the direction between 0 to 45 deg., production loss was not observed
- Since the site's elevation is 130 m, whether icing occurs or not seems to depend on the distance to the seashore

Expectation of icing condition in winter

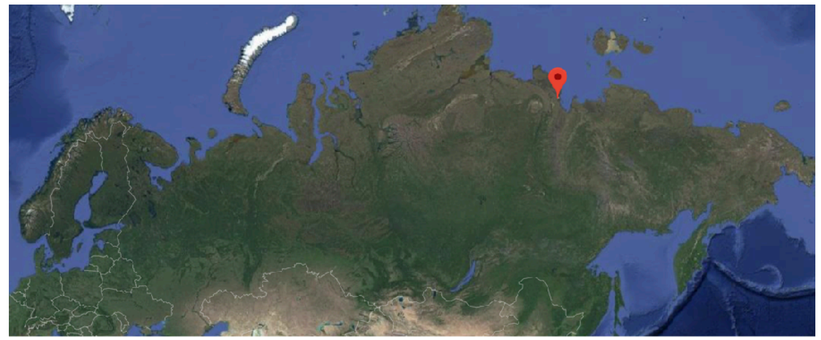
Ice signal & Nacelle direction from Nov. 2018 to Jun. 2019

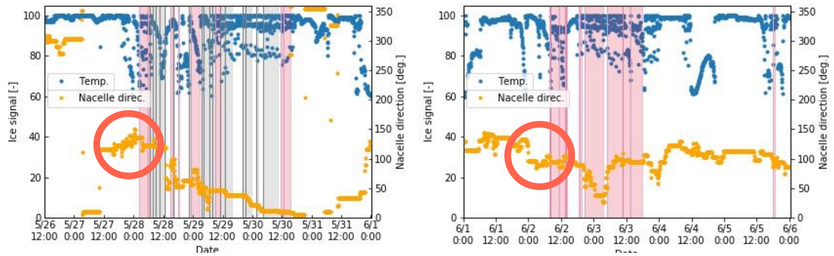


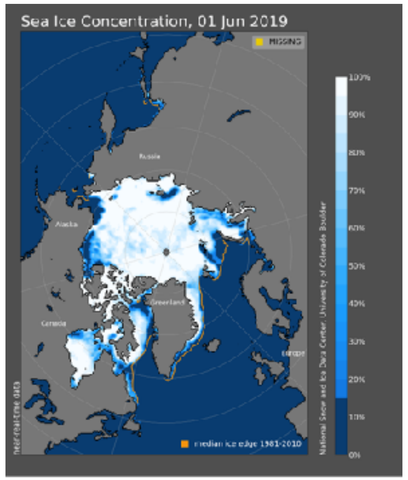
- If the slant of decreasing of ice signal is steep, it may indicate atmospheric icing. If it is gentle, it may be snow accretion.
- It is deduced that atmospheric icing occurred in the beginning and end of winter(Nov. and late May.).
- Production loss would be limited only when following conditions are accomplished.
  1. Ambient temperature is below 0 deg.
  2. Nacelle heads toward the south-east(about 90 to 135 deg.)
  3. The sea is not completely covered with ice

Summary

- Icing on wind turbines established in Tiksi has been investigated
- From Ice Loss Method, Ice detecter, and Nacelle direction, it is revealed that icing most likely happened by water vapor from the sea in the south-east of Tiksi
- Although the sea also lies in the north, icing did not occur; indicating that if the site is away from the sea for certain distance, water vapor would not cause icing for wind turbines at lower elevation. (Tiksi: 130 m)







Future work

- Confirm those findings from the last winter with data for this winter
- Find the boundary distance from the site to the sea whether it can cause the blade icing or not
- Reflect those on the safe and economical operation of the wind turbines