Wind conditions in a Norwegian fjord derived from tall meteorological masts and synchronized doppler LIDARs

Hálfdán Ágústsson, Martin S. Grønsleth, Ola Kaas Eriksen, Ove Undheim, Finn K. Nyhammer, Øyvind Byrkjedal, Kjeller Vindteknikk, Norway

halfdan.agustsson@vindteknikk.no

Ferry free E39 in West/Norway

- Eight fjords to cross
- Fjord widths 2-7.5 km
- Fjord depths 300-1300 m
- High and variable climate loads
- What are the appropriate design loads?

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Extensive observational campaign

- A 50 – 100 m high met mast at ends of each crossing.
- Min. 4 years of 10 Hz obs. of 3D wind at 3-4 elevations in masts.
- Additional masts to investigate horizontal coherence
- Wave and current buoys
- **Two pairs of synchronized LIDARs**

Observational data in the open domain. Corroborated by up to 10 years of meso-scale (500 m X 500 m) and CFD simulations (~100 m X ~100 m).

Lidar campaign in Halsafjorden: Sept. ’17 – ’18

Eastern side: Åkvika

Minni
WC400s-6
IP: 192.168.30.35

Klara Ku
Camera

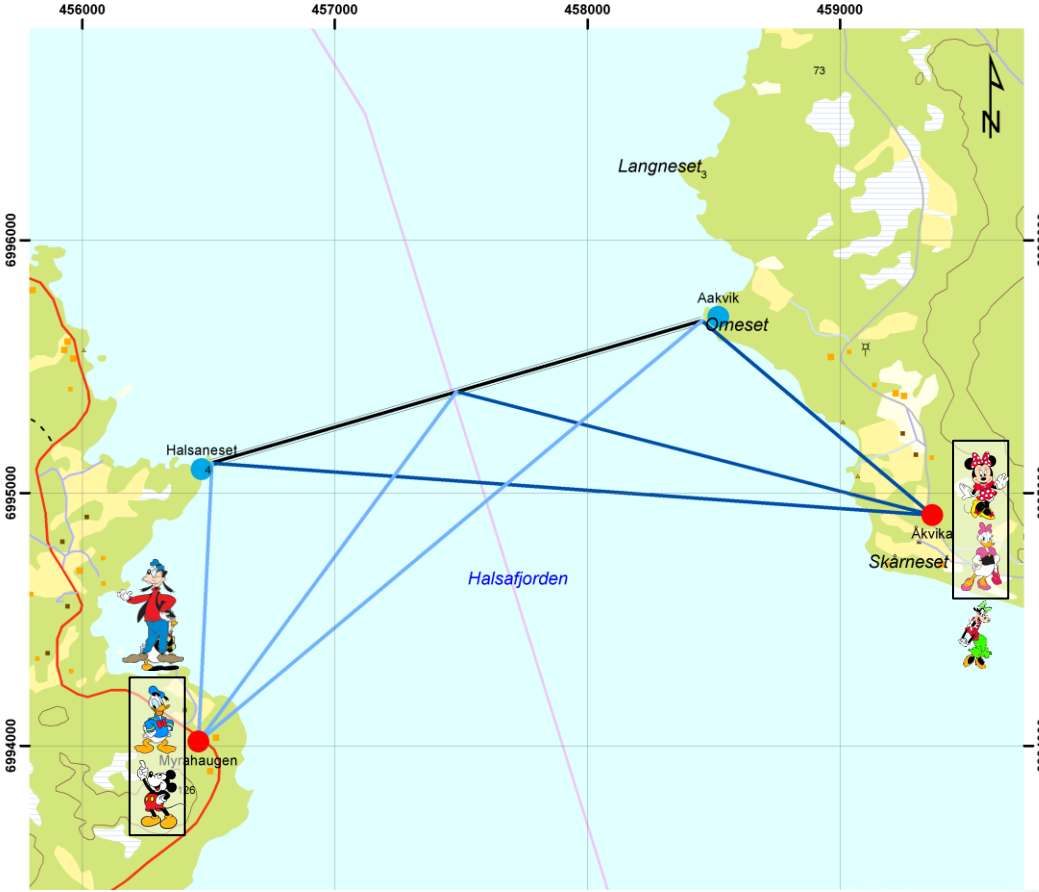
Dolly
WC400s-12
IP: 192.168.30.36

Western side: Myrahaugen

Mikke
WC400s-10
IP: 192.168.30.38

Langbein
Camera

Donald
WC400s-13
IP: 192.168.30.37



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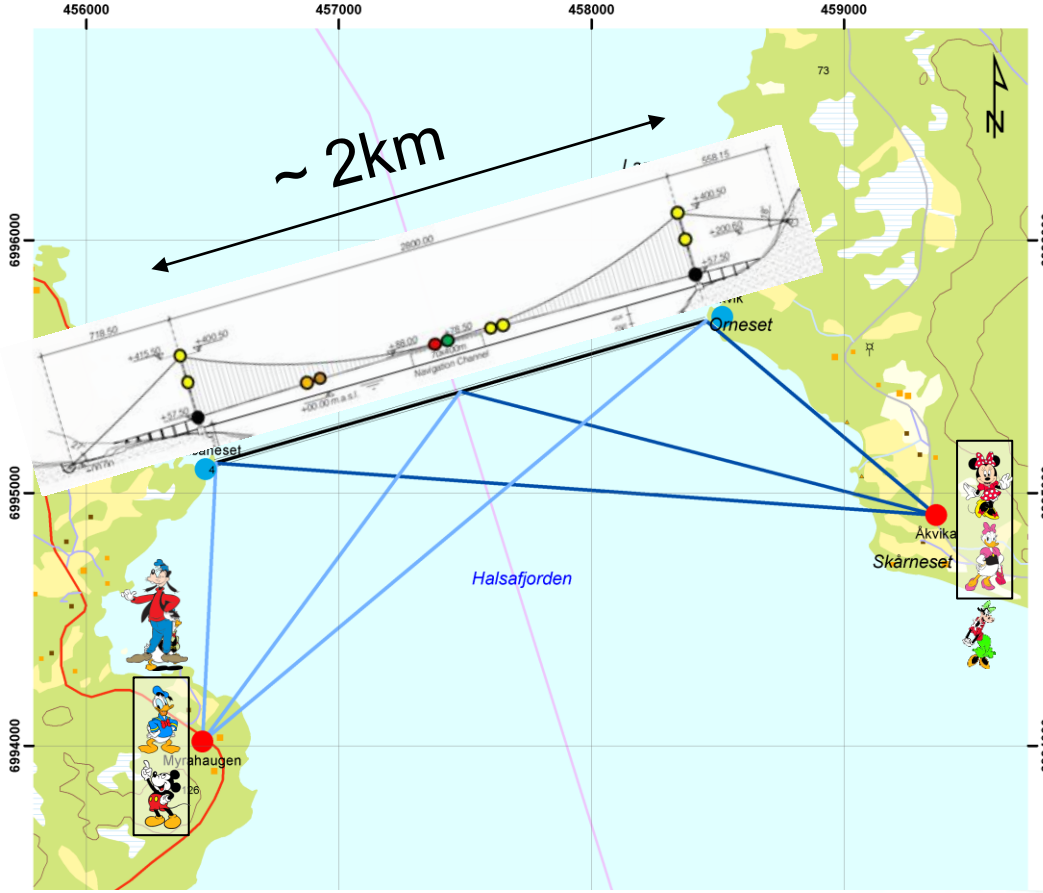
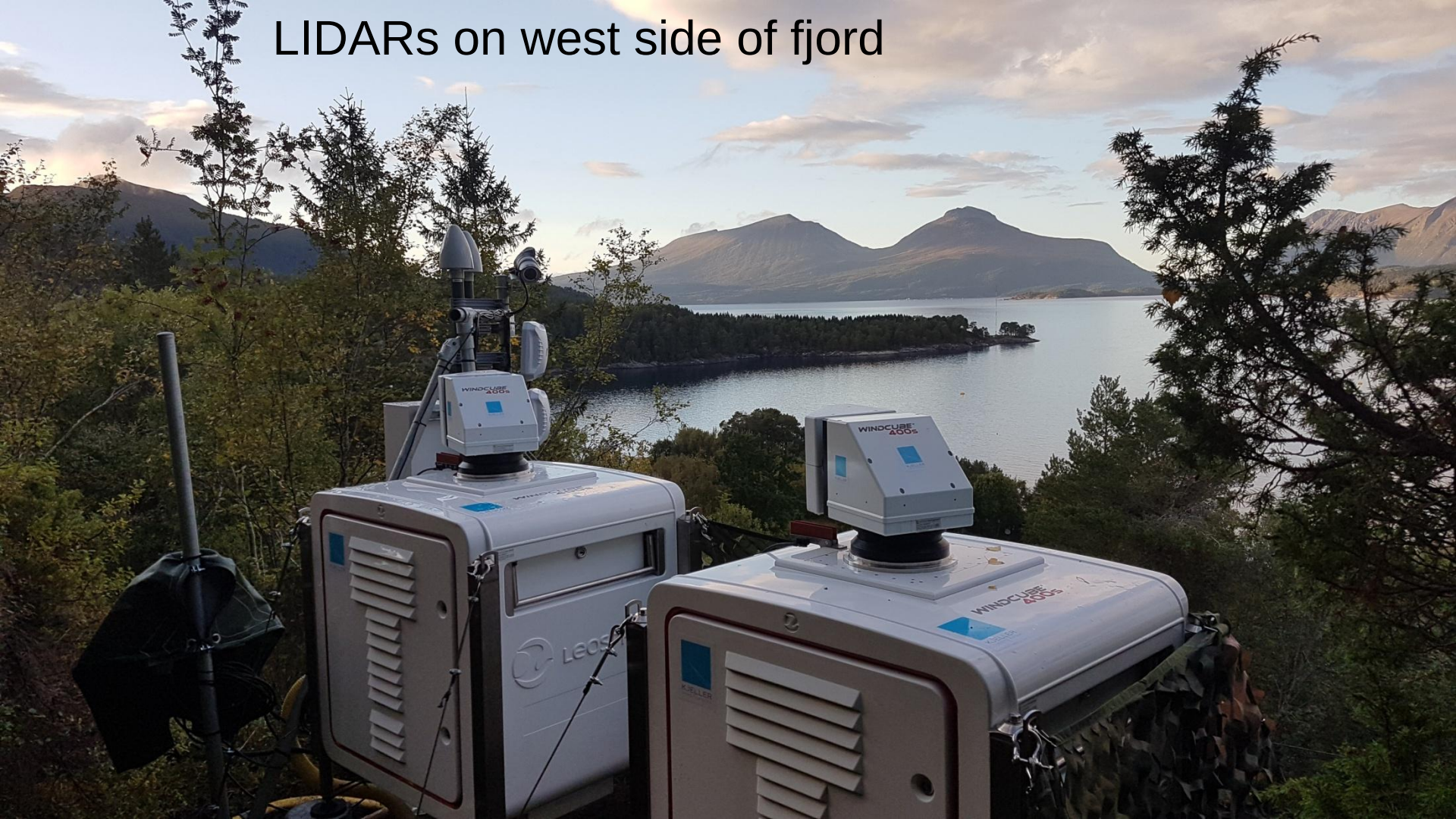
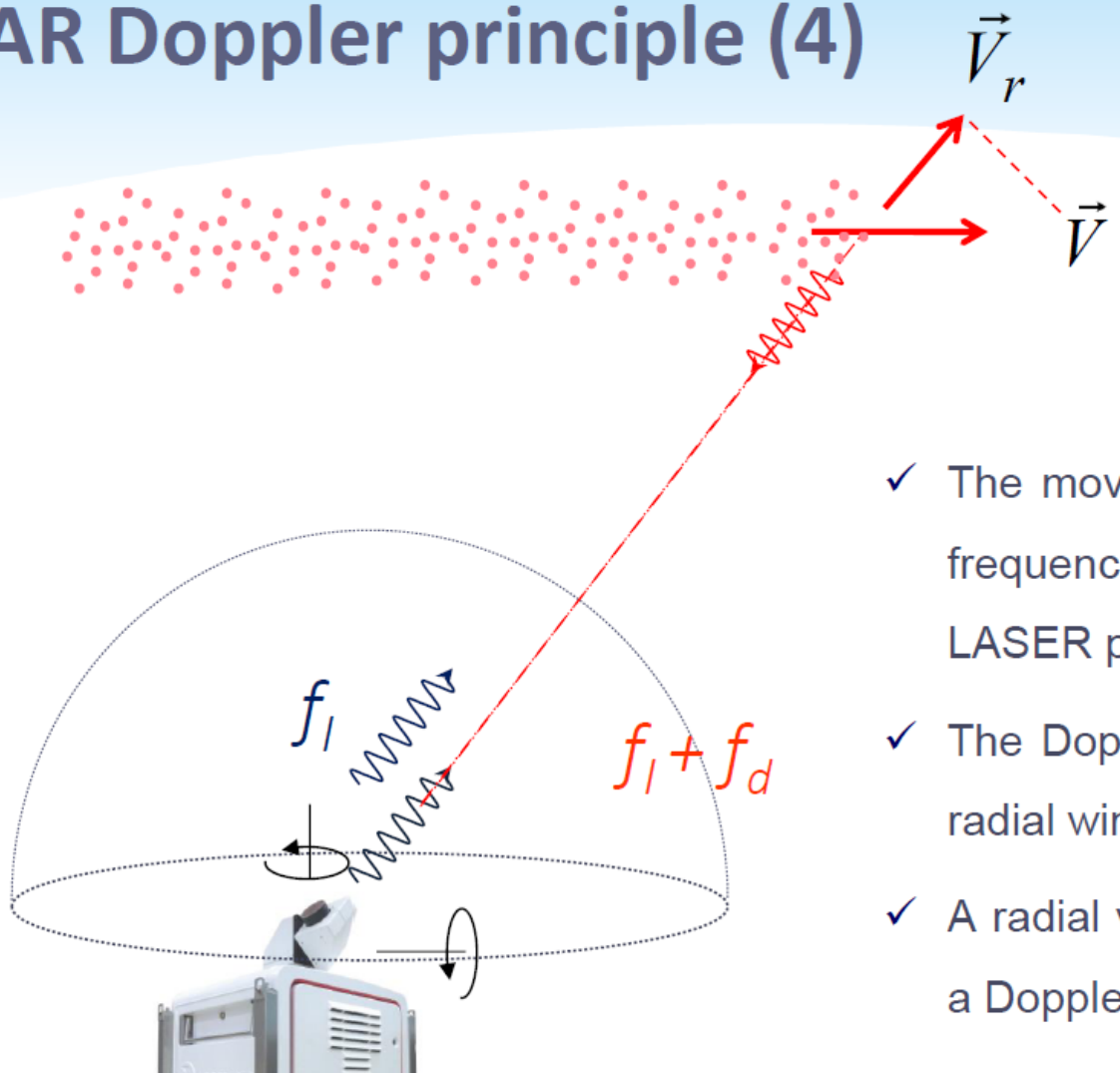


LIDARs on west side of fjord



LIDARs on east side of fjord

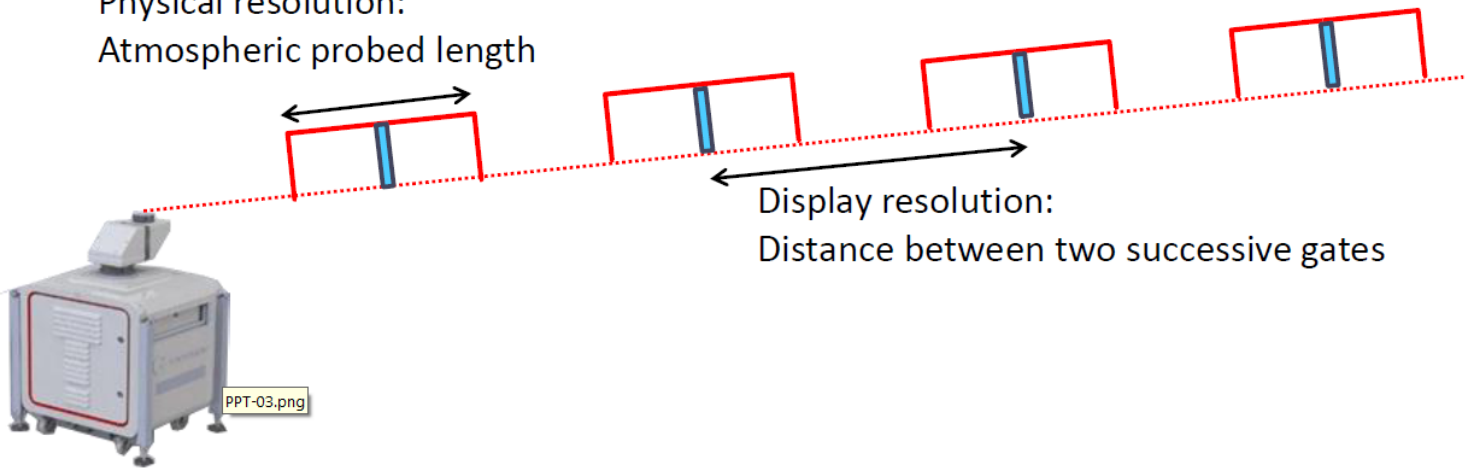
LIDAR Doppler principle (4)



- ✓ The moving aerosols induce an optical frequency change of the backscattered LASER pulse: Doppler effect.
- ✓ The Doppler shift is proportional to the radial wind speed.
- ✓ A radial wind speed V_r of 1m/s induces a Doppler shift of about 1,3MHz

Resolutions ? Physical VS Display resolutions

Physical resolution:
Atmospheric probed length



Physical resolution < Display resolution

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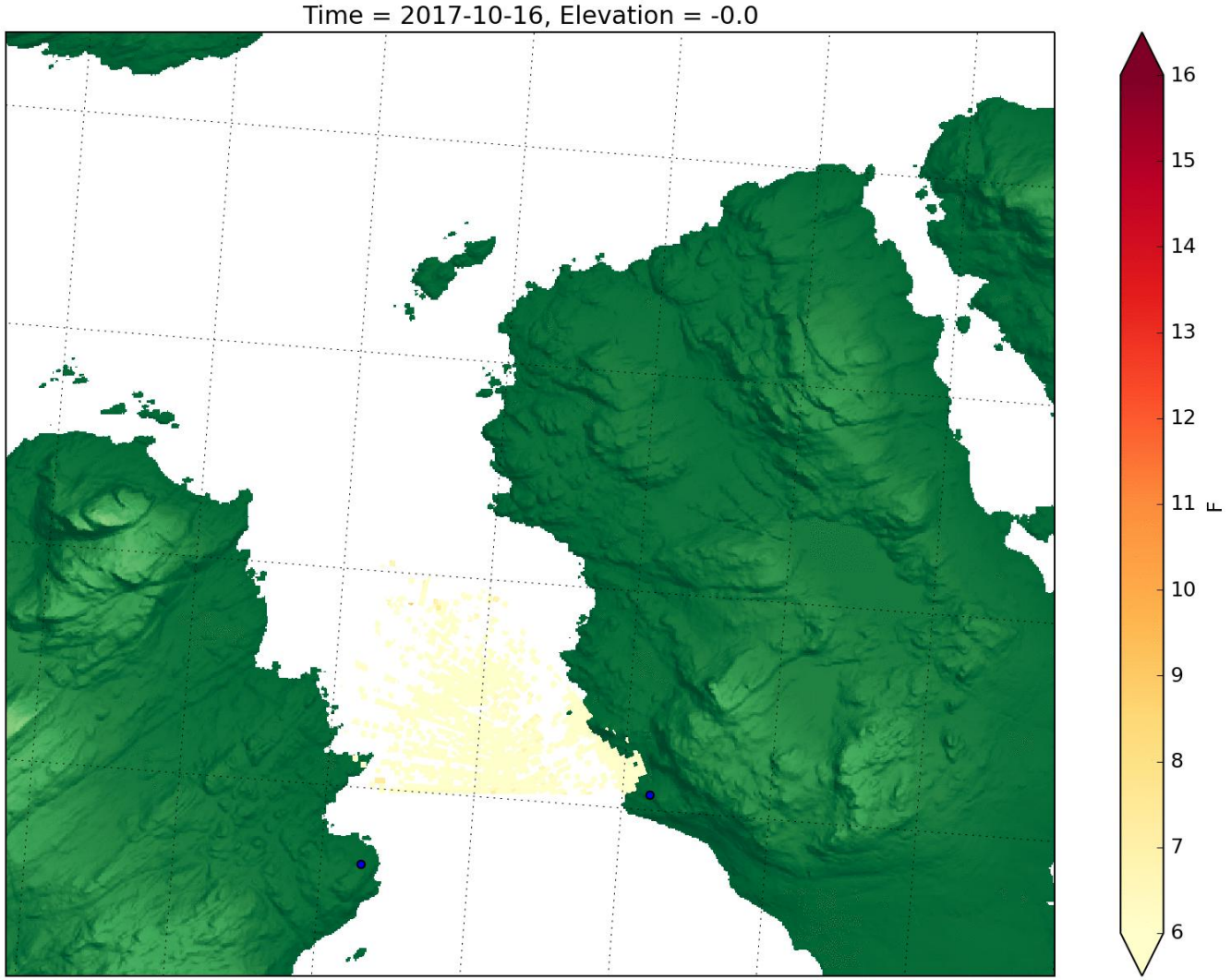
Descriptive planar scans

16. Oct. 2017
Dolly & Donald



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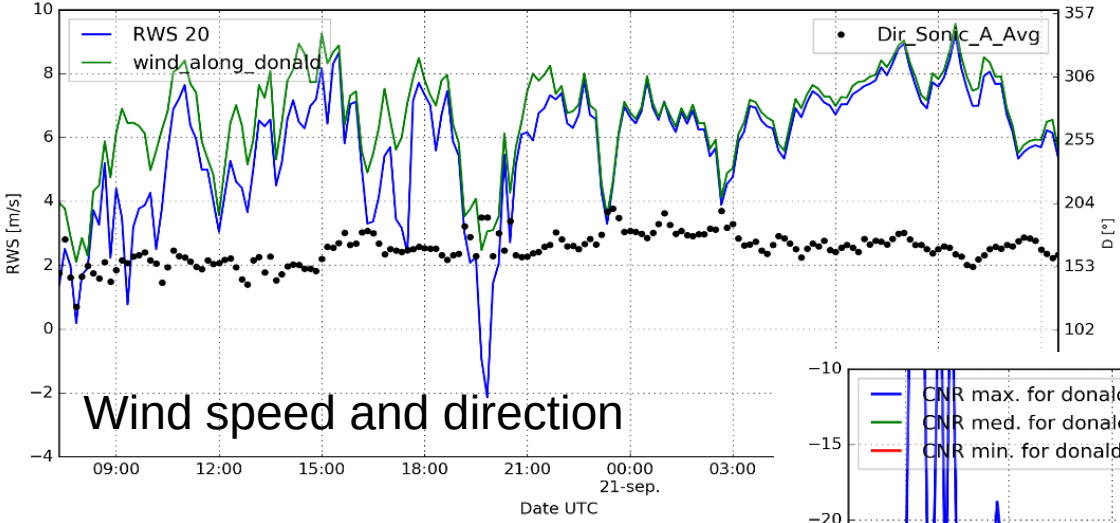
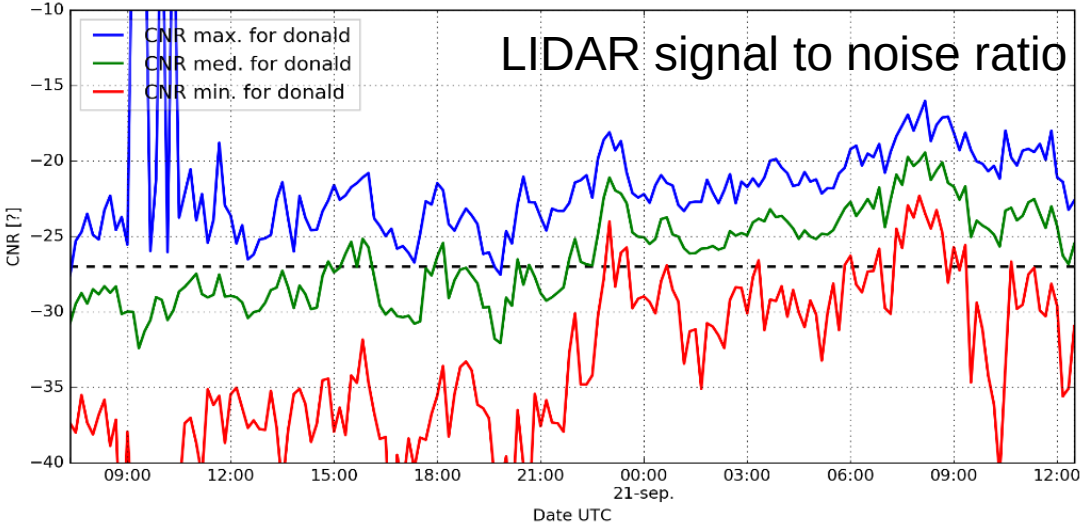
LIDAR vs mast





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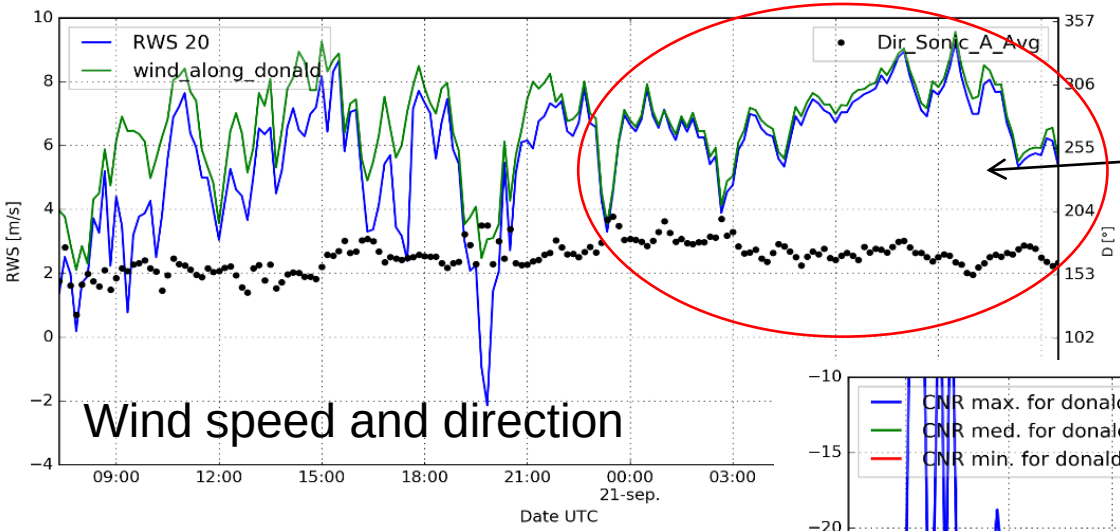
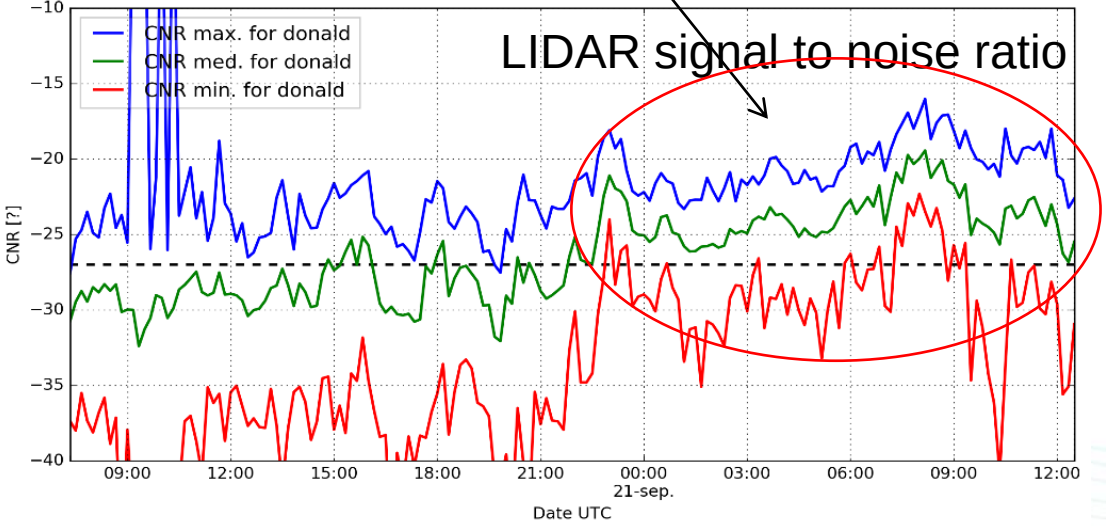
LIDAR vs mast



Wind speed and direction

Good signal



LIDAR signal to noise ratio

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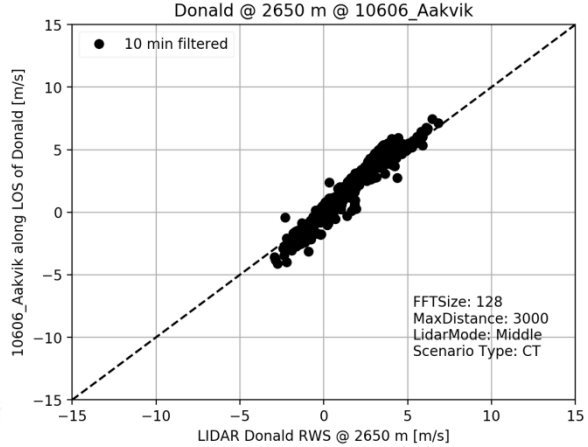
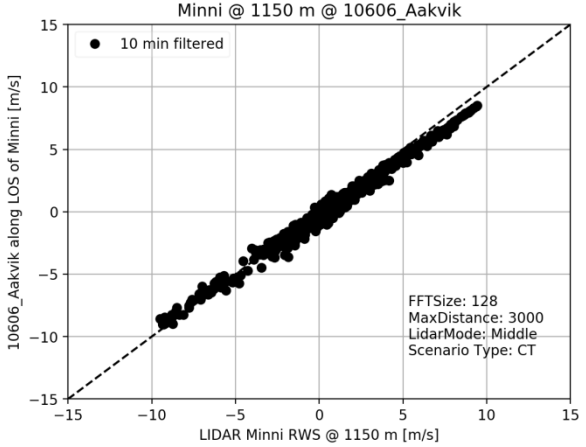
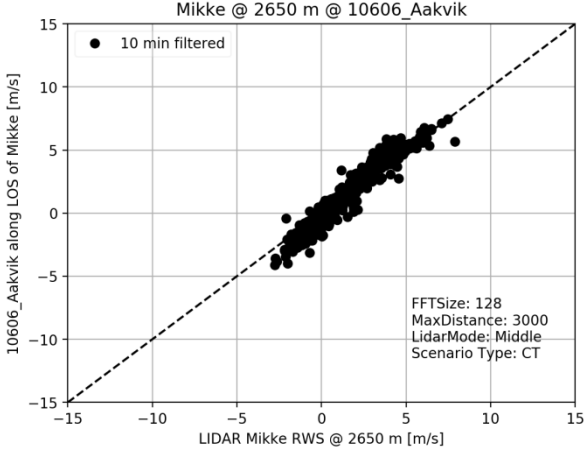
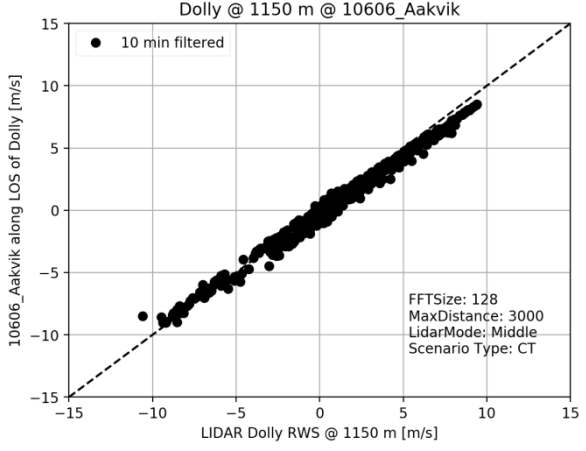
Radial wind speed - LIDAR vs mast









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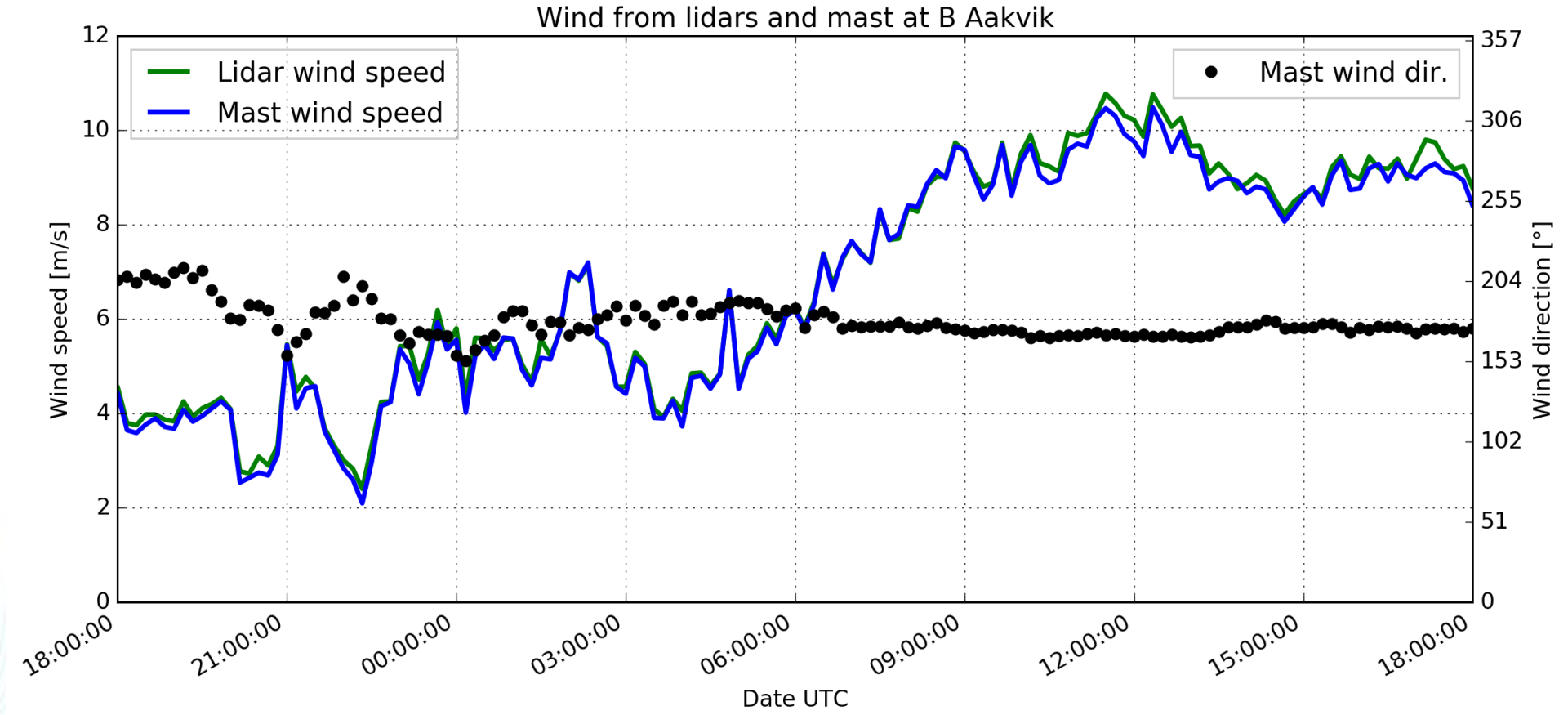
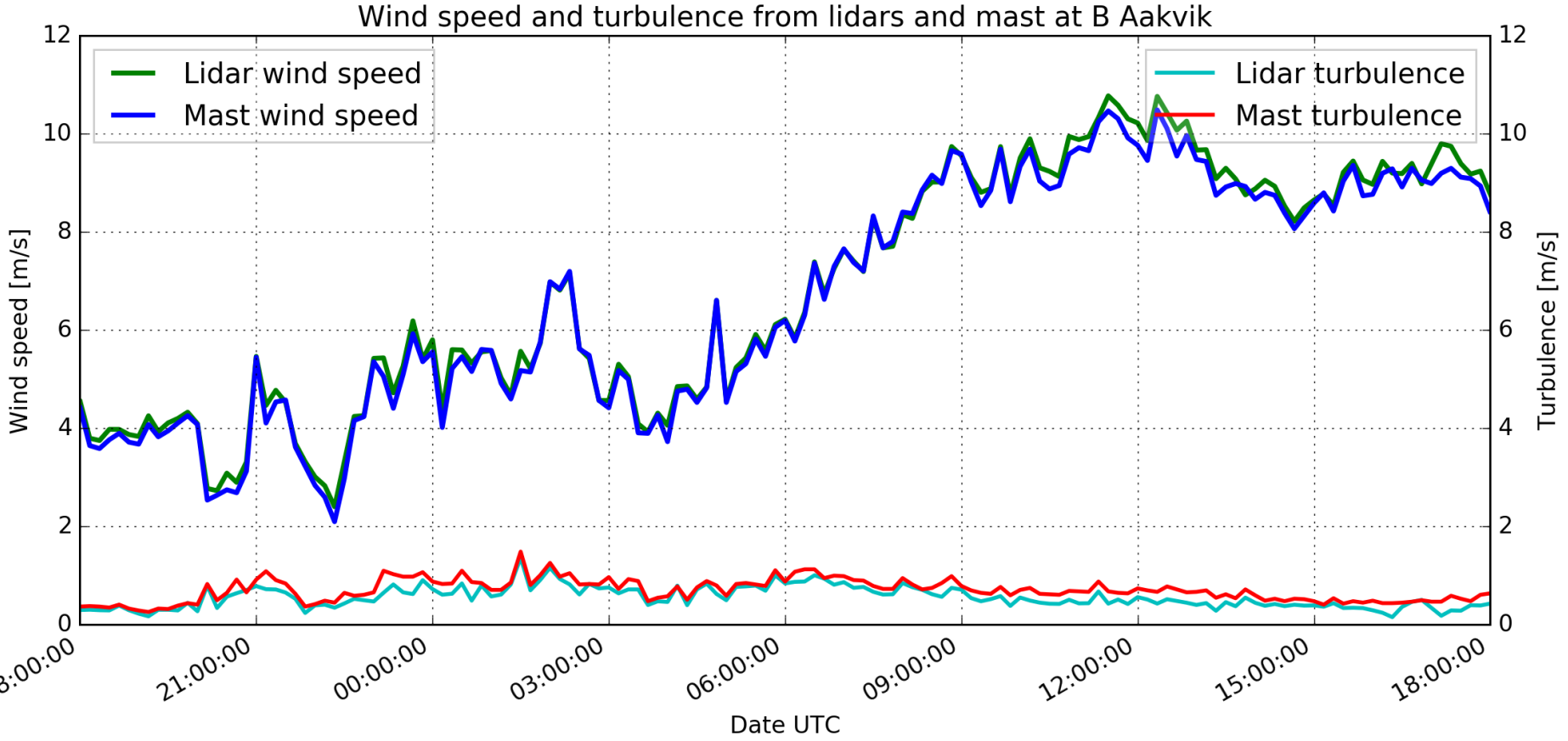
True wind - LIDAR vs mast

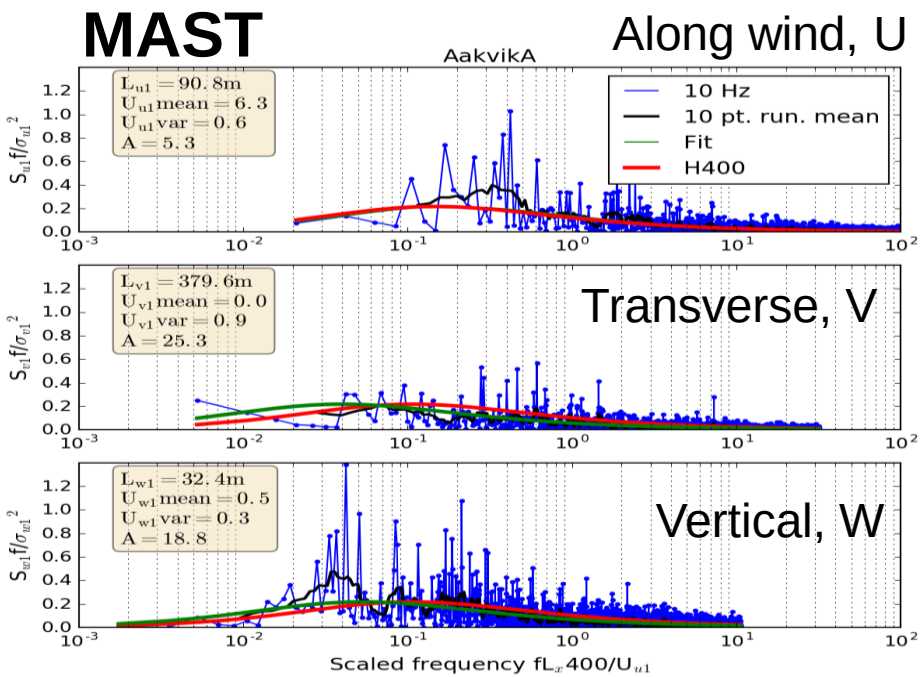


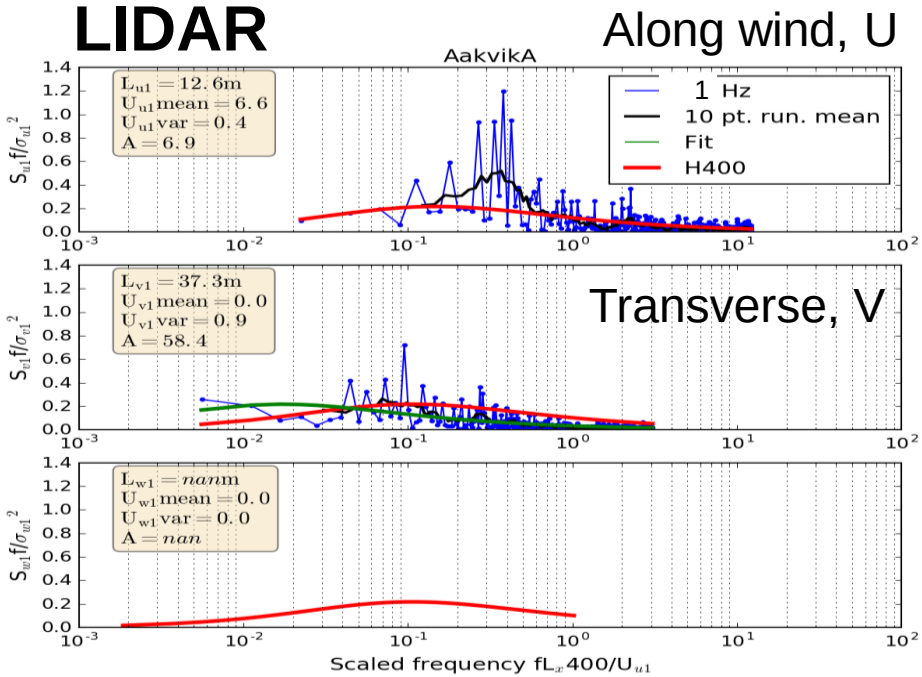
True wind - LIDAR vs mast



Example turbulence spectra - Mast vs LIDAR

1 Hz / 10 Hz temporal resolution, 20 min period, **50.3 m.**



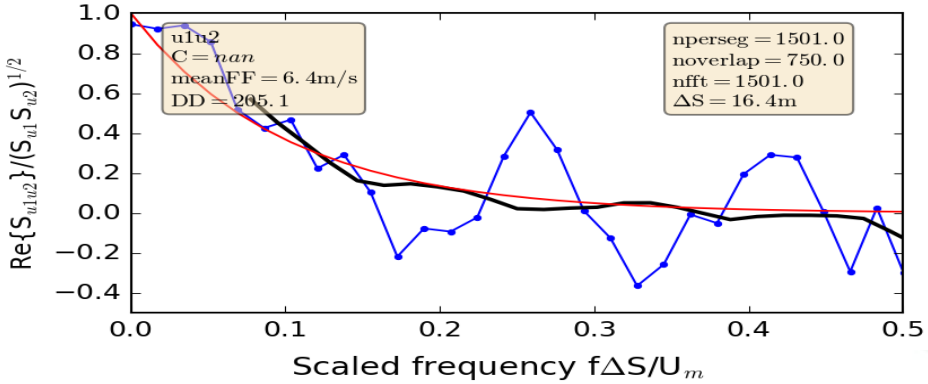


Example turbulence co-spectra - Mast vs lidar

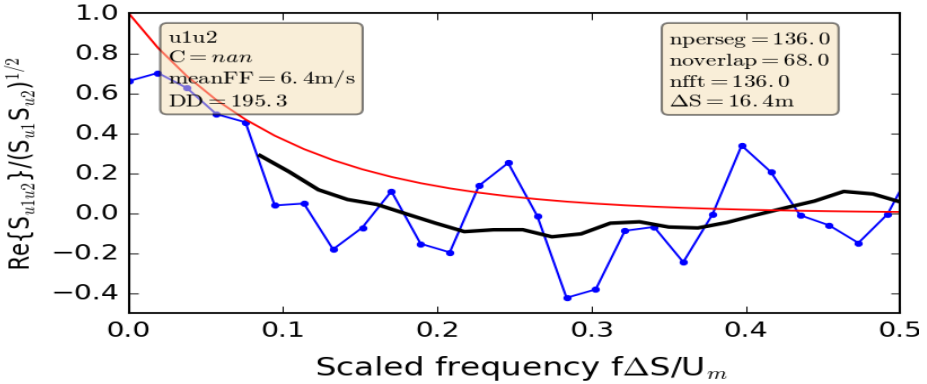
1 Hz / 10 Hz temporal resolution, 20 min period

Vertical co-coherence of along wind variation U, 50.3 m vs. 31.8 m

MAST



LIDAR



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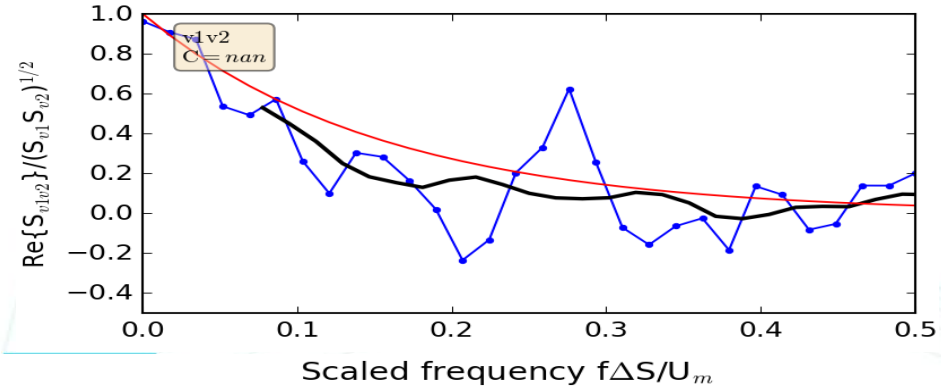
Example turbulence co-spectra - Mast vs lidar

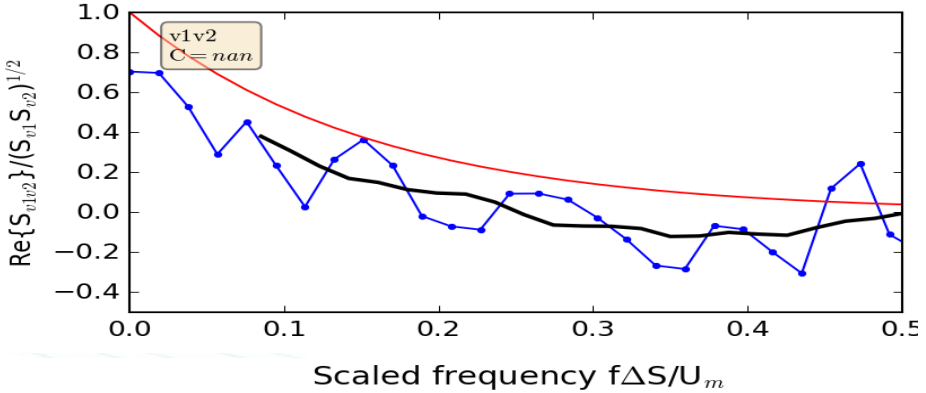
1 Hz / 10 Hz temporal resolution, 20 min period

Vertical co-coherence of transverse wind variation V, 50.3 m vs. 31.8 m

MAST



LIDAR



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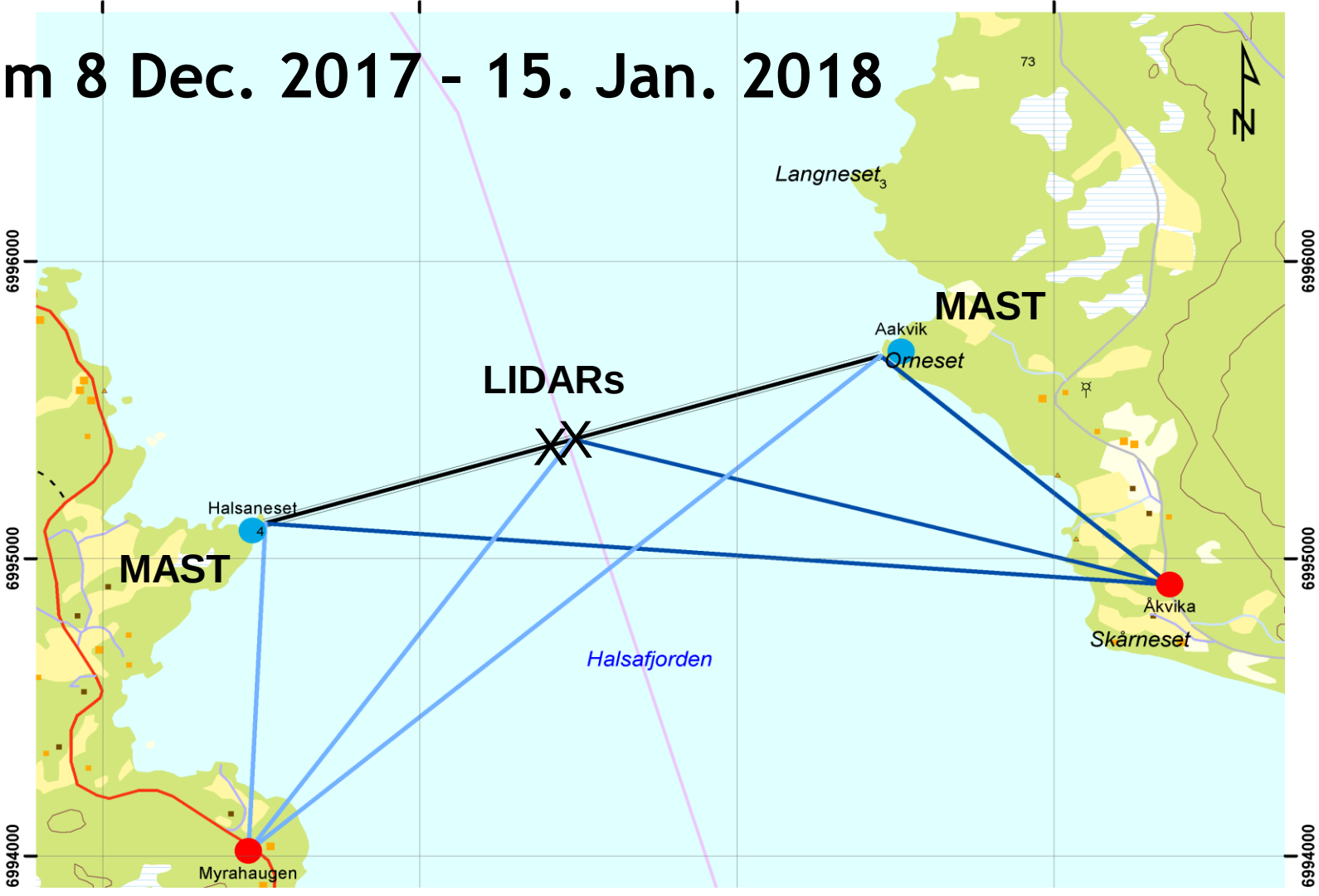
Wind from 8 Dec. 2017 – 15. Jan. 2018



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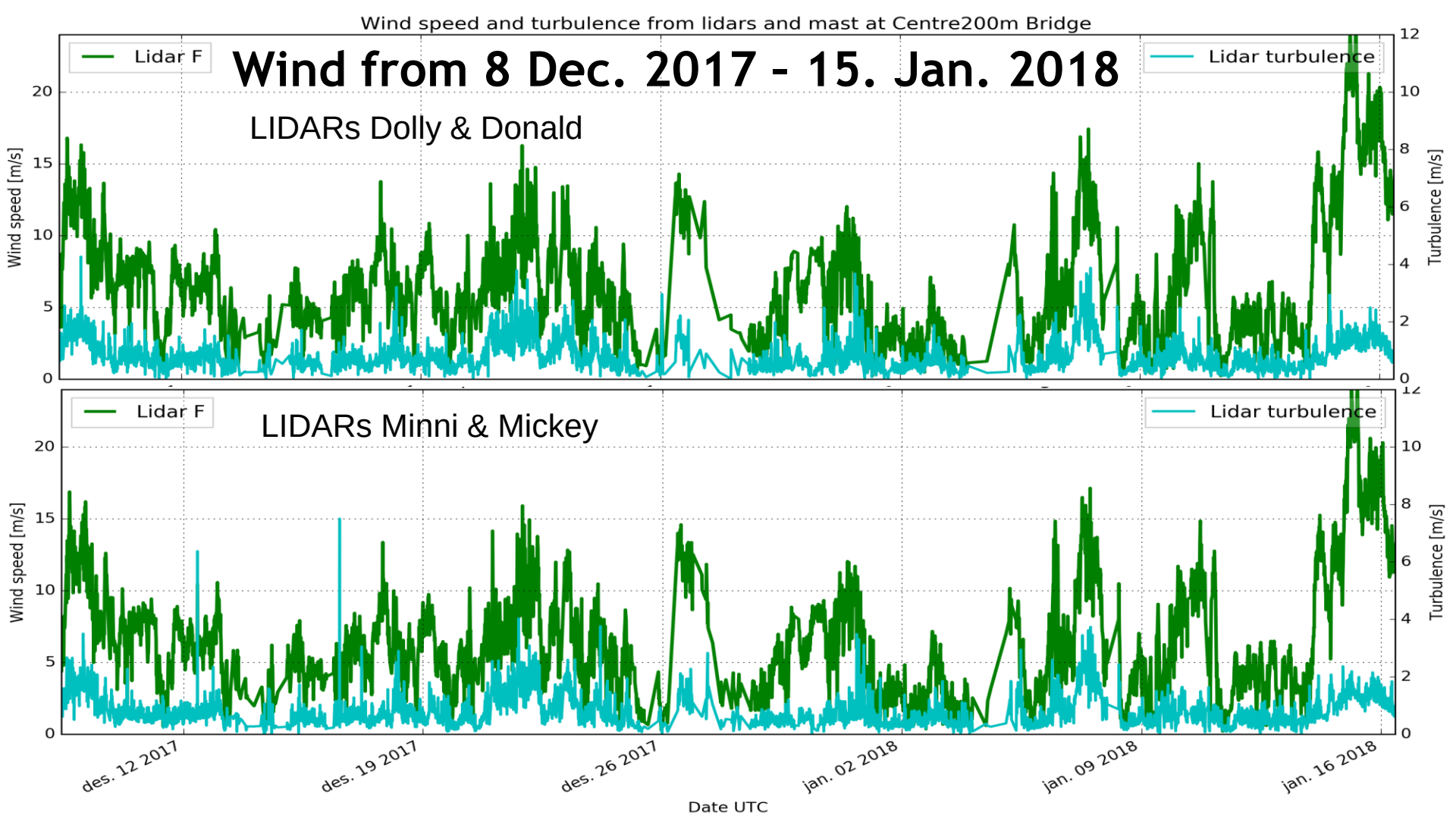
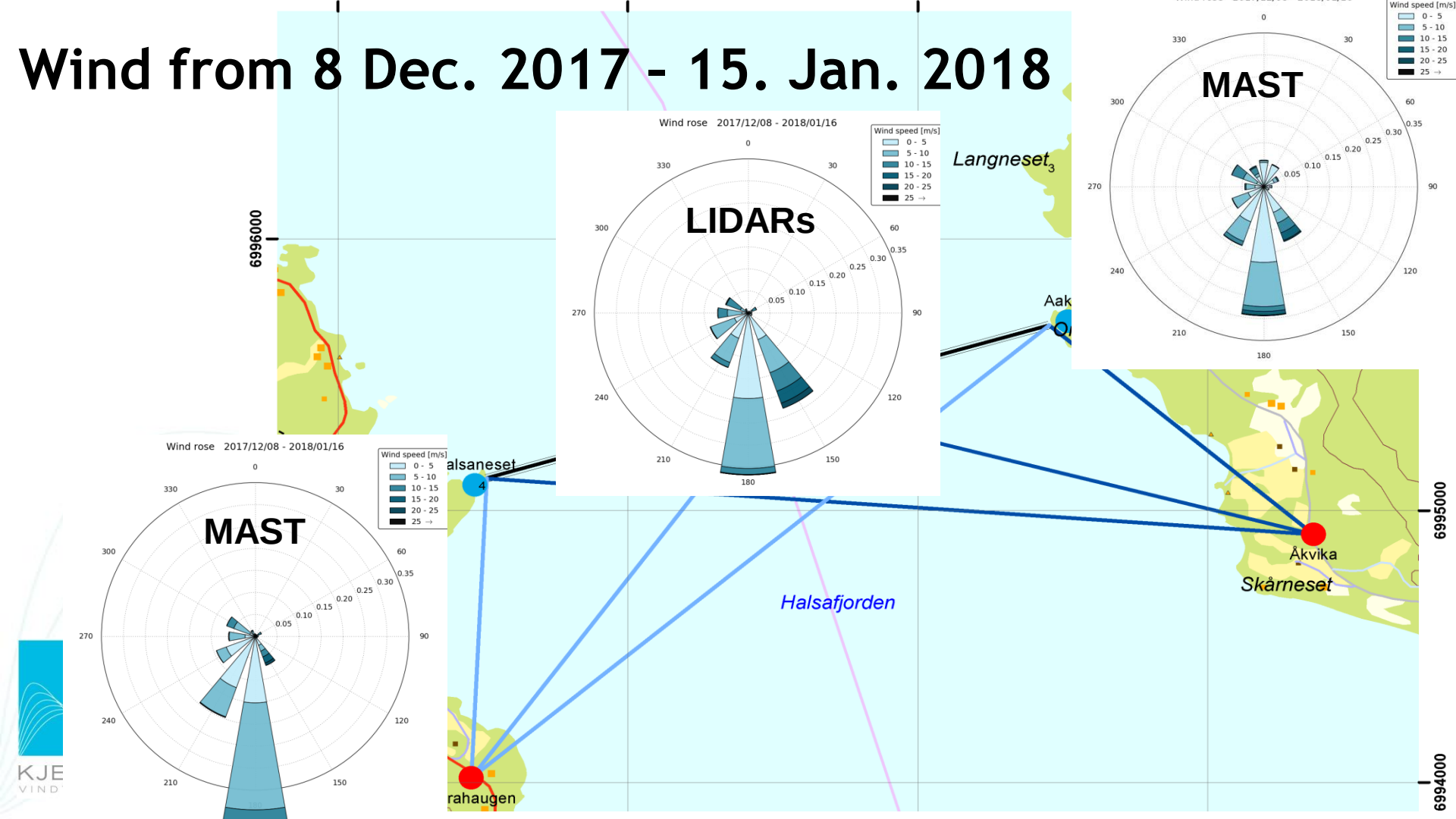

Wind speed and turbulence from lidars and mast at Centre200m Bridge
Wind from 8 Dec. 2017 - 15. Jan. 2018
LIDARs Dolly & Donald
LIDARs Minni & Mickey
Lidar F
Lidar turbulence
Wind speed [m/s]
Turbulence [m/s]
des. 12 2017
des. 19 2017
des. 26 2017
jan. 02 2018
jan. 09 2018
jan. 16 2018
Date UTC

Wind from 8 Dec. 2017 - 15. Jan. 2018



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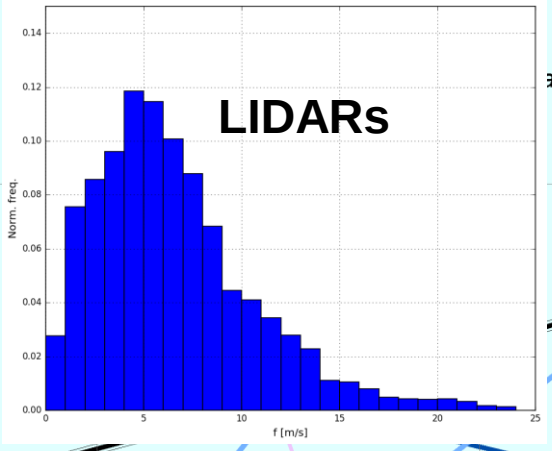

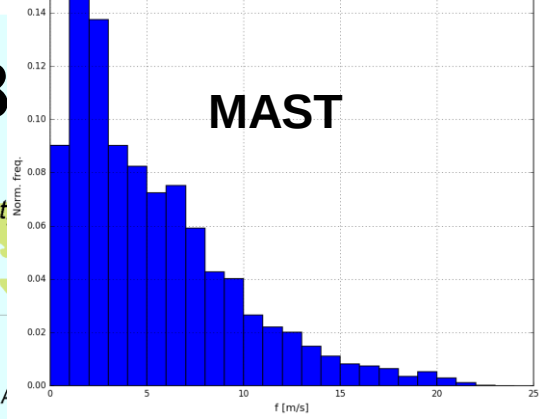

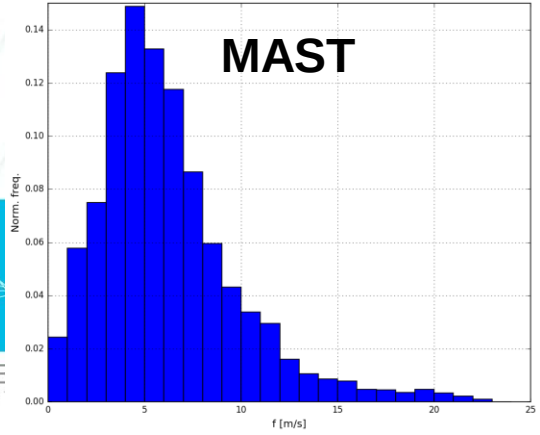

Halsaneset

Halsafjorden

Åkvika

Skårneset

Ørneset

6996000

6995000

6994000

Concluding remarks

• First results and examples from from four LIDARs observing atmospheric flow in Halsafjorden since autumn 2017.

• The synchronized LIDARs are a part of the extensive observation campaign pertaining to the ferry-free E39 project.

• Detailed description of key parameters of atmospheric flow away from the shore, here surrounded by complex orography

Acknowledgments

Important contributions and expert advice from:

• Michael Courtney and Guillaume Lea from the Danish Technical University

•Jasna Bogunovic Jakobsen and Etienne Francois Cyprien Cheynet from the University in Stavanger