Complementary use of wind lidars and land-based met-masts for wind measurements in a wide fjord

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HÁSKÓLINN Í REYKJAVÍK REYKJAVIK UNIVERSITY

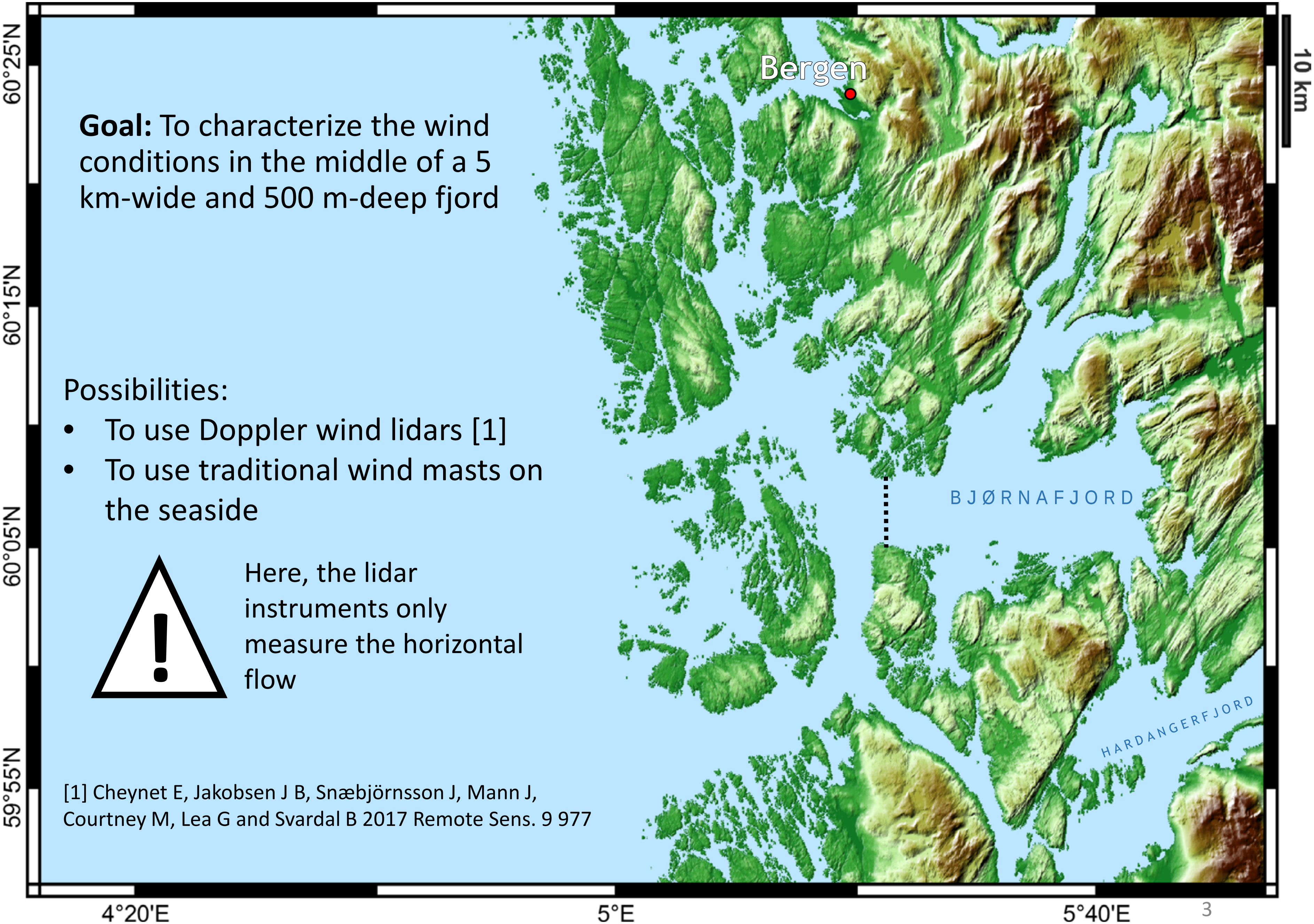
Bergen
10 km
BJØRNAFJORD
HARDANGERFJORD
60°25'N
60°15'N
60°05'N
59°55'N
4°20'E
5°E
5°40'E

Goal: To characterize the wind conditions in the middle of a 5 km-wide and 500 m-deep fjord

Possibilities:

- To use Doppler wind lidars [1]
- To use traditional wind masts on the seaside

Here, the lidar instruments only measure the horizontal flow



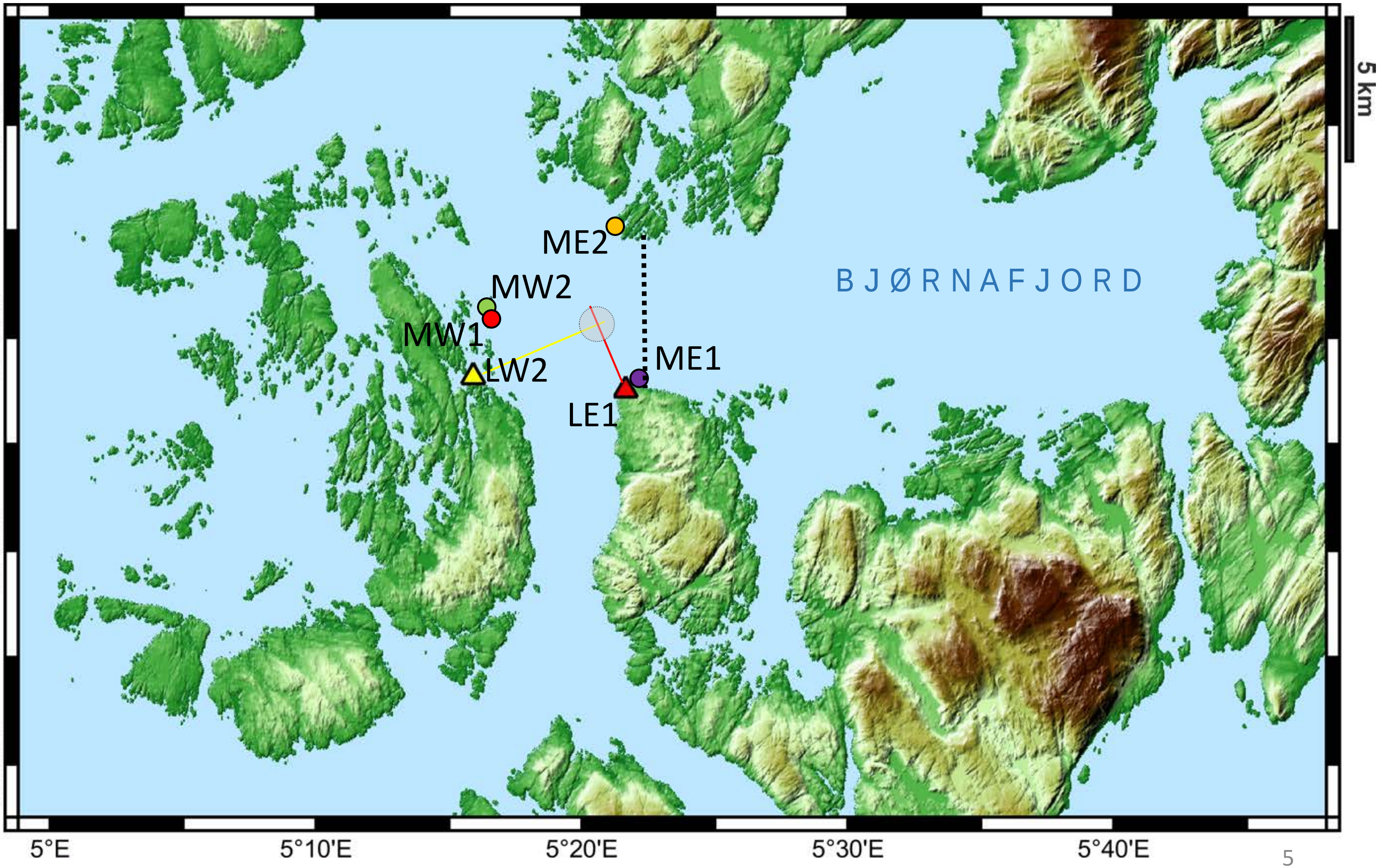
[1] Cheynet E, Jakobsen J B, Snæbjörnsson J, Mann J, Courtney M, Lea G and Svardal B 2017 Remote Sens. 9 977

Main questions

Are the lidar records and anemometer measurements consistent ?

To what extent are the wind velocity data on the shores of the fjord affected by the surrounding terrain ?

Location of the Sensors (1/2)

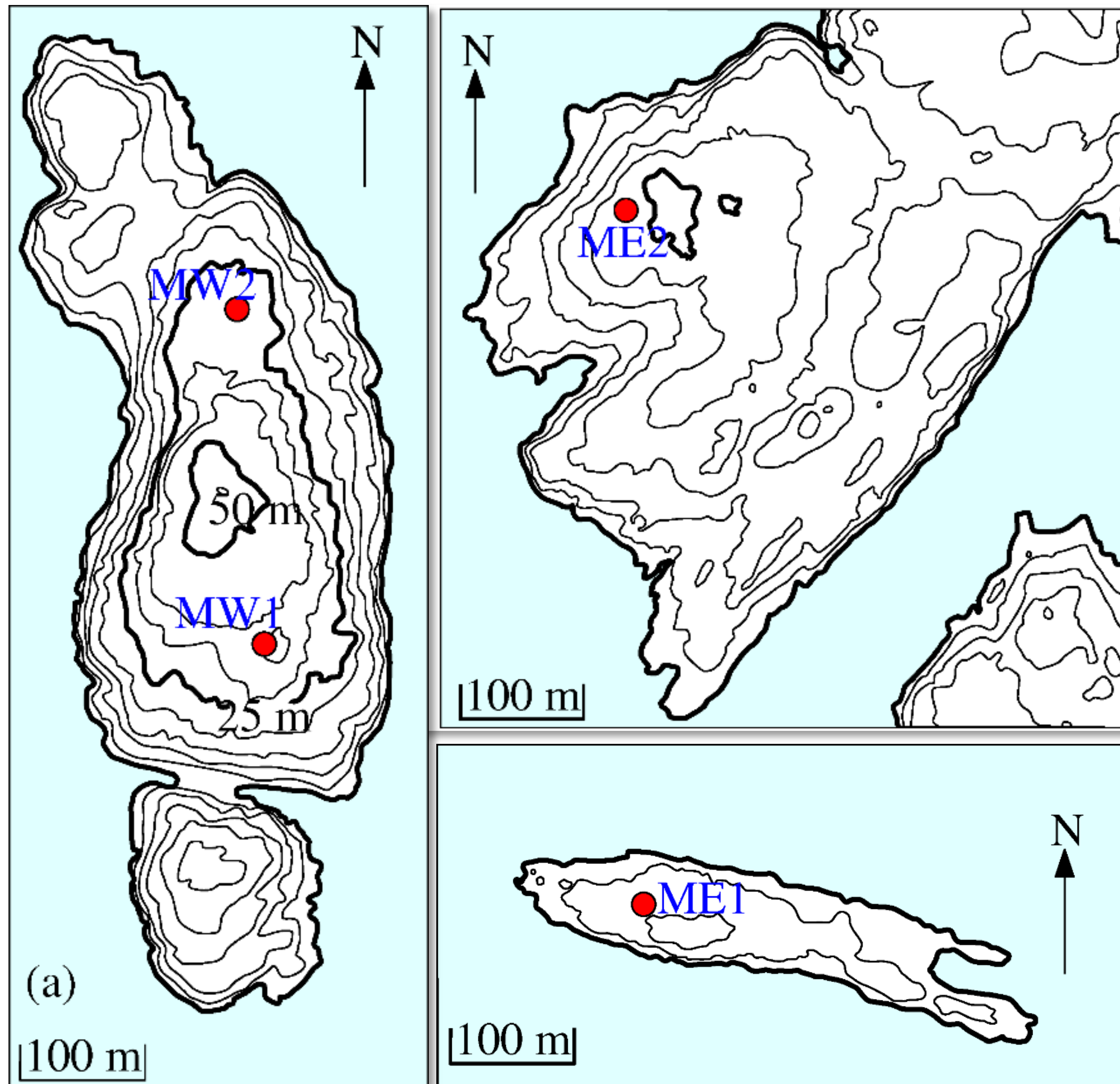


Location of the Sensors (2/2)

Each contour line corresponds to a height of 5 m

MW1 and MW2: One sonic anemometers at 33 m, and two at 49 m above the ground.

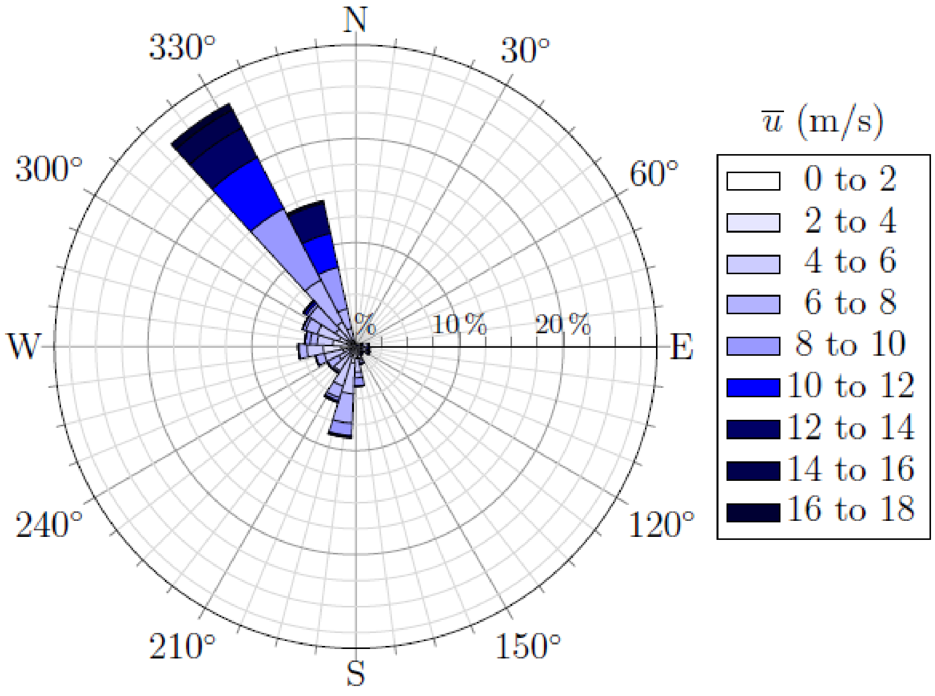
ME1 and ME2: Sonic anemometers at 12 m, 32 m and 48 m above the ground.



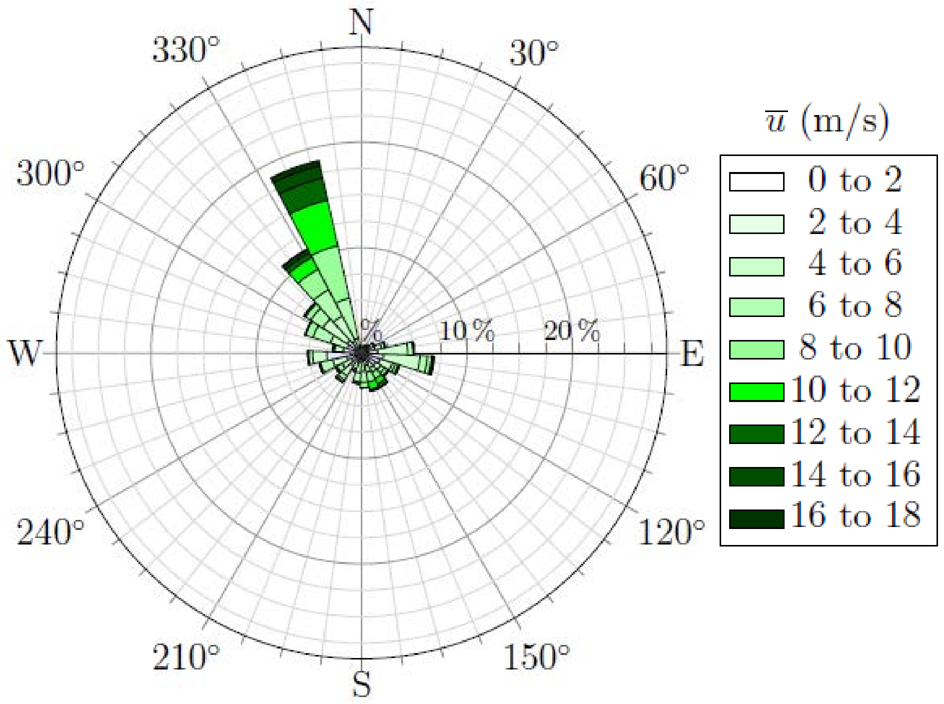
Overall wind conditions (1/2)

Record period: Mai-June 2016

Lidar records
(z = 25 m above sea level)



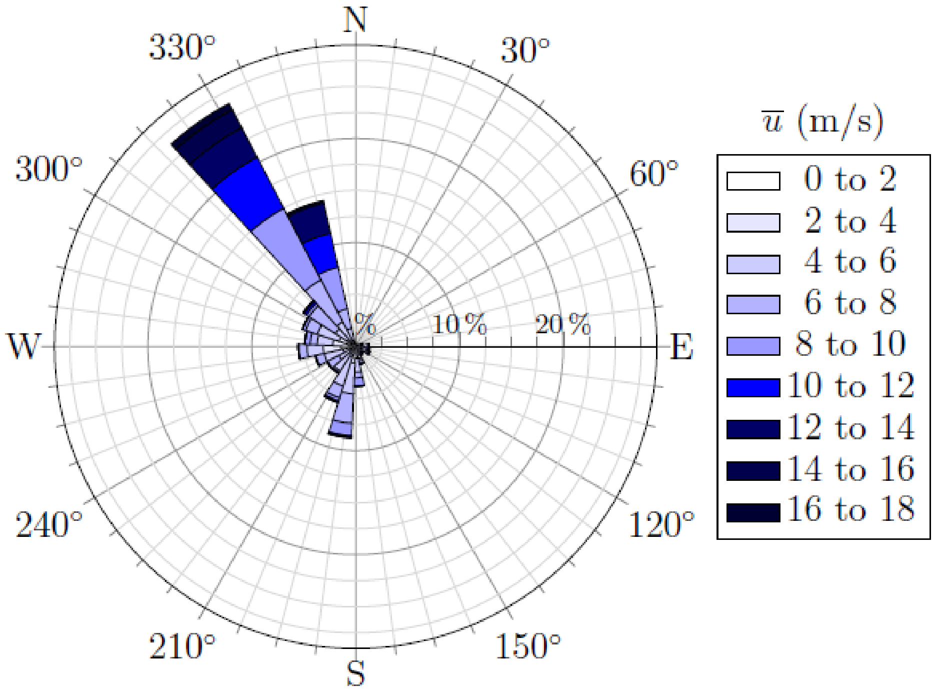
Anemometer records on MW1
(z = 33 m above ground)



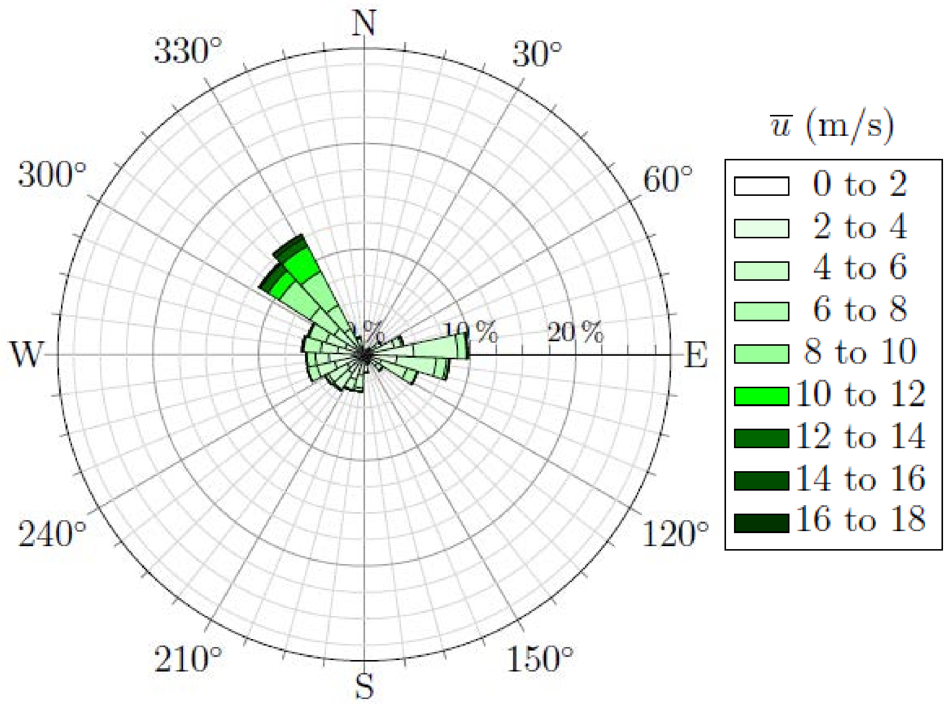
Overall wind conditions (2/2)

Record period: Mai-June 2016

Lidar records
(z = 25 m above sea level)

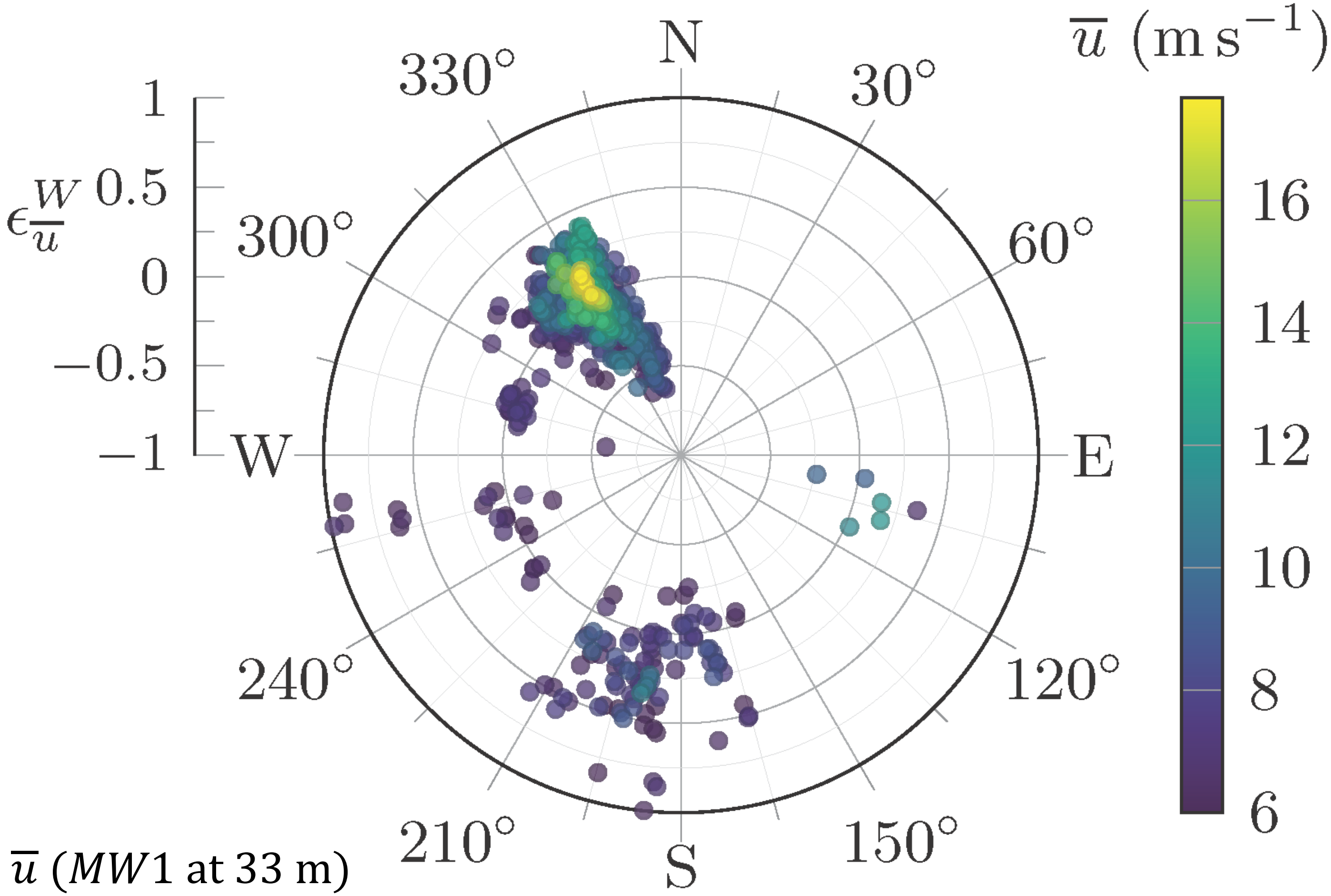


Anemometer records on ME1
(z = 32 m above ground)



Mast MW1 vs Lidar records (1/3)

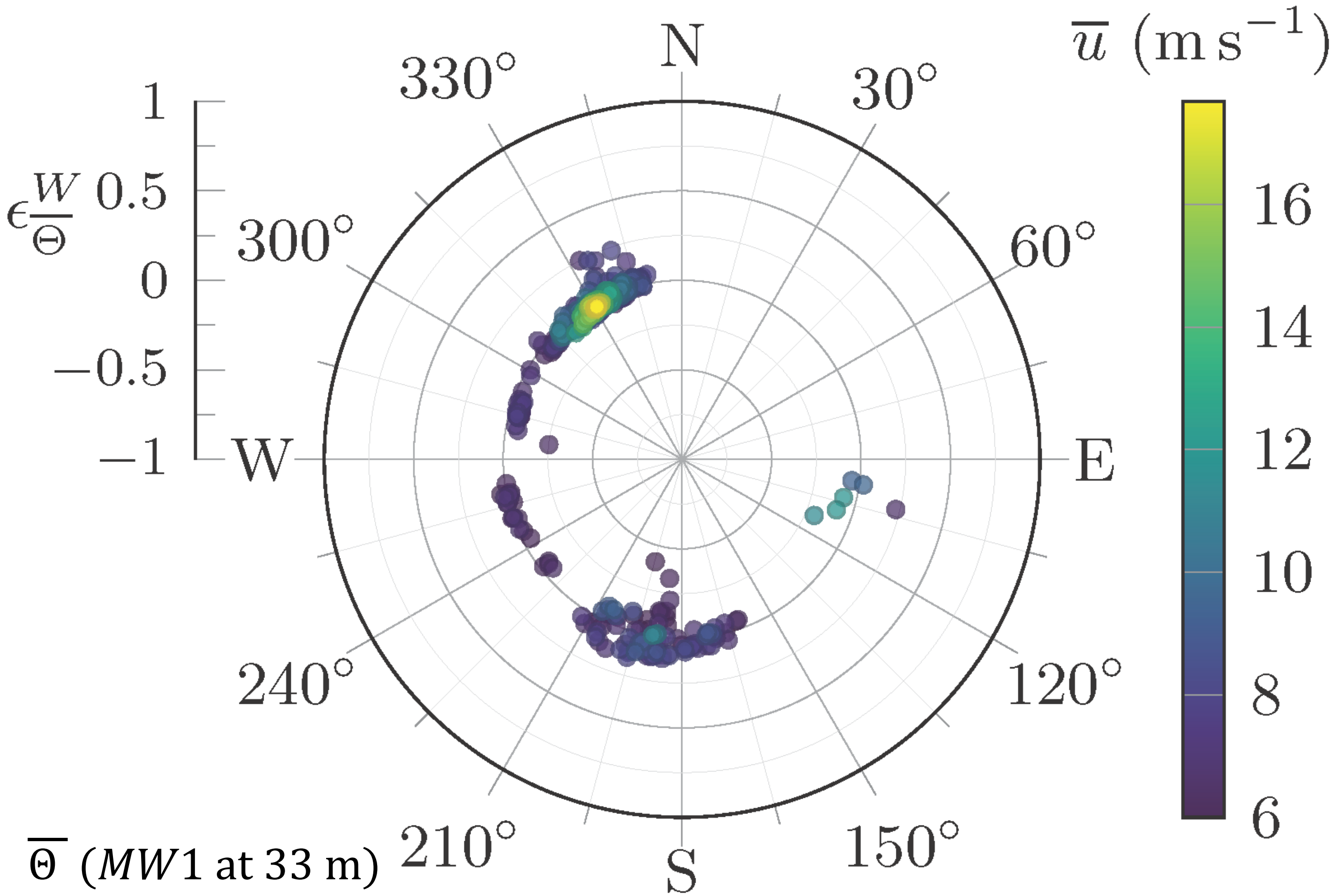
Relative difference on the mean wind velocity



$$\epsilon_{\overline{u}}^{W} = 1 - \frac{\overline{u}\ (MW1 \text{ at } 33 \text{ m})}{\overline{u}\ (Lidar)}$$

Mast MW1 vs Lidar records (2/3)

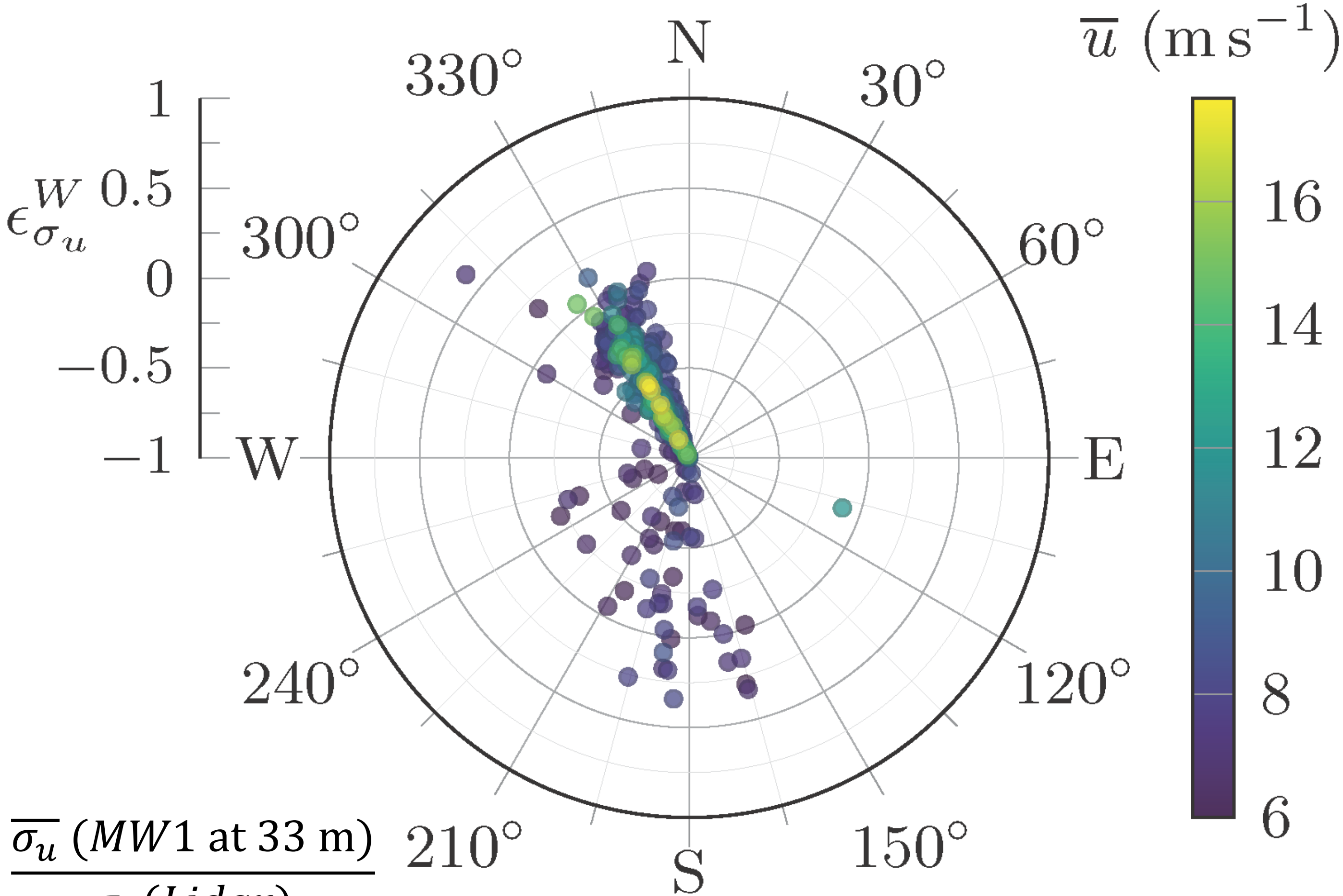
Relative difference on the mean wind direction



$$\epsilon^W_{\overline{\Theta}} = 1 - \frac{\overline{\Theta}\ (MW1 \text{ at } 33 \text{ m})}{\overline{\Theta}\ (Lidar)}$$

Mast MW1 vs Lidar records (3/3)

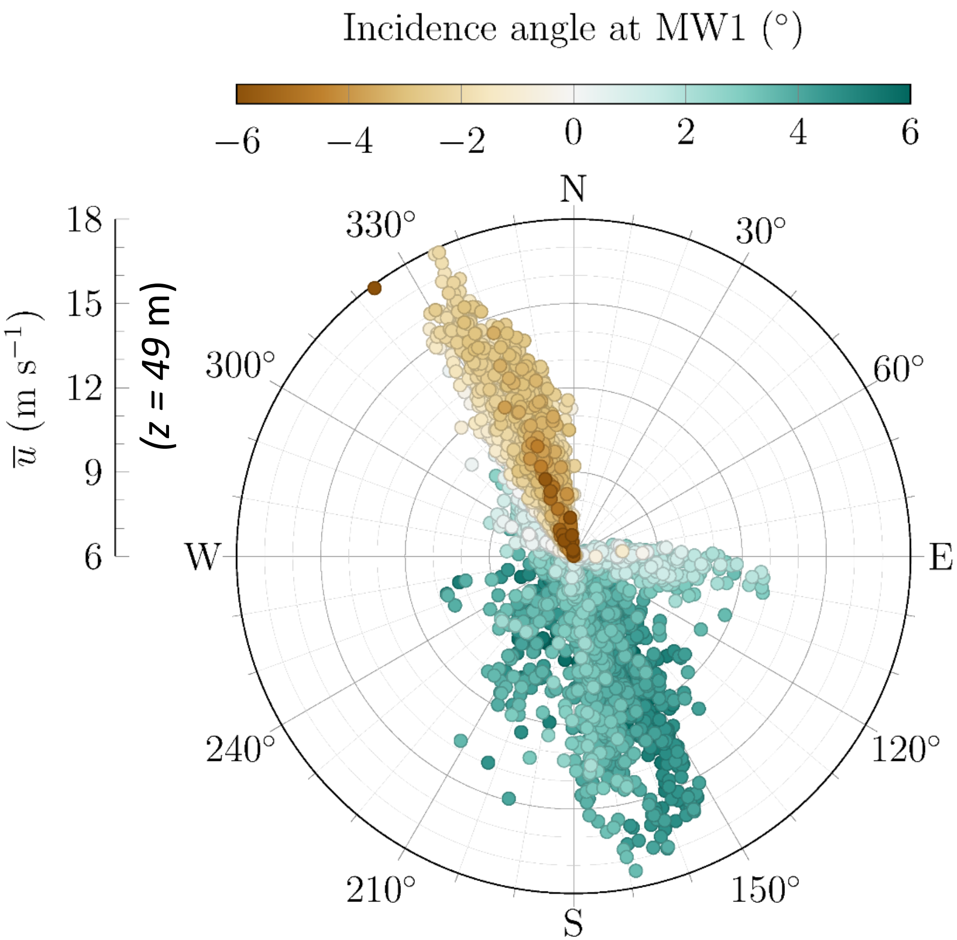
Relative difference on the standard deviation of the along-wind velocity component

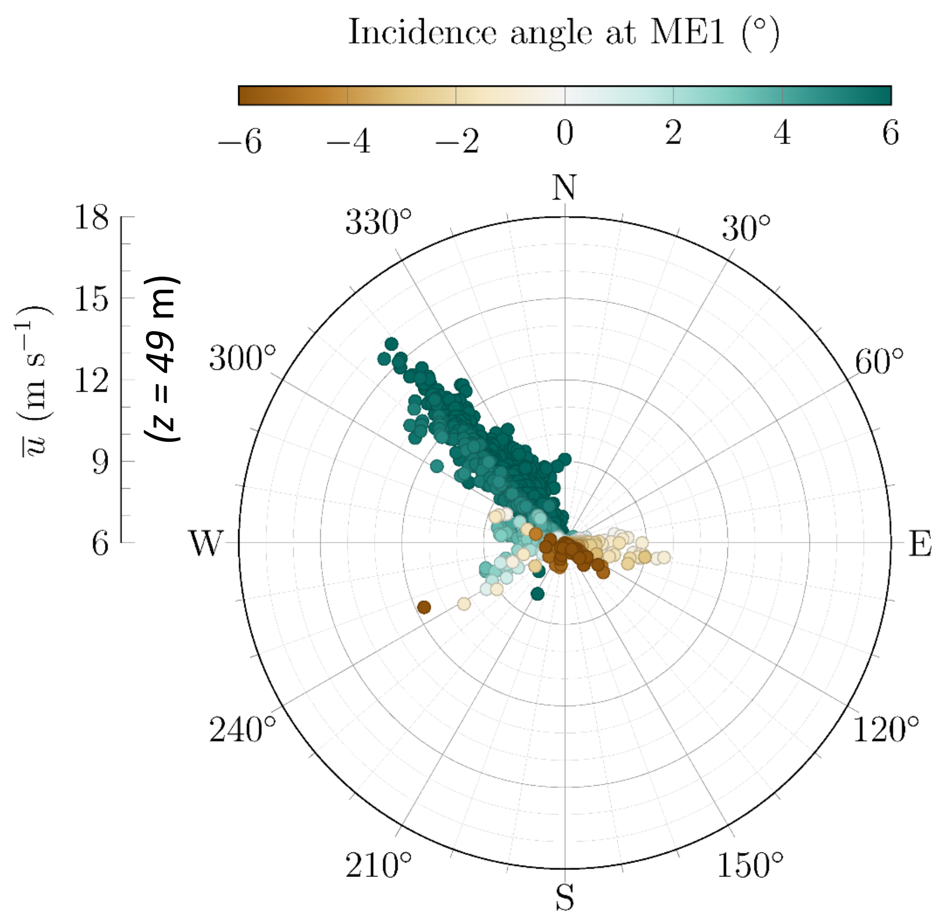


$$\epsilon^W_{\sigma_u} = 1 - \frac{\overline{\sigma_u}\,(MW1 \text{ at } 33\text{ m})}{\sigma_u(Lidar)}$$

Mean incidence angle

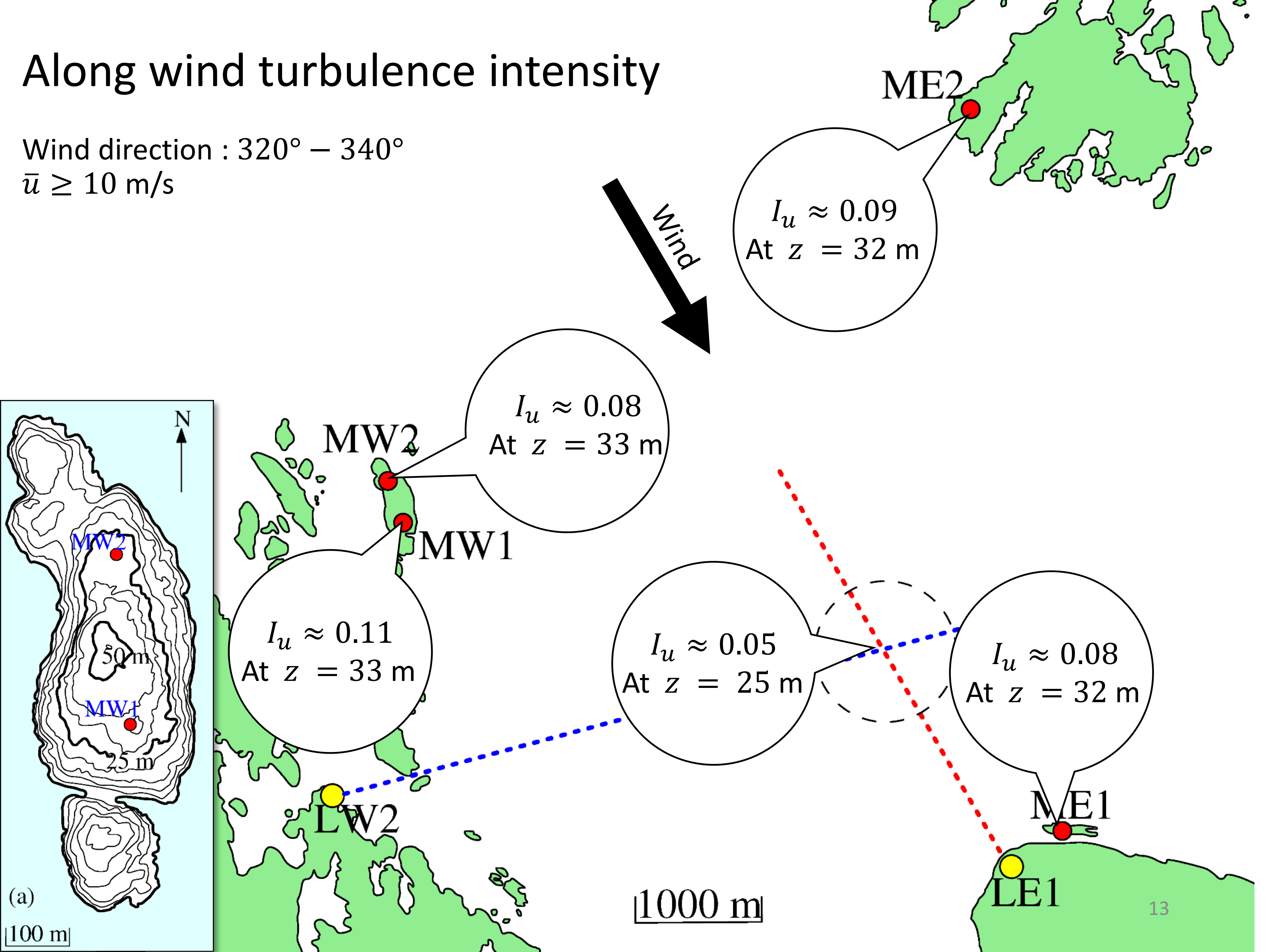
Relative difference on the mean wind velocity





Along wind turbulence intensity

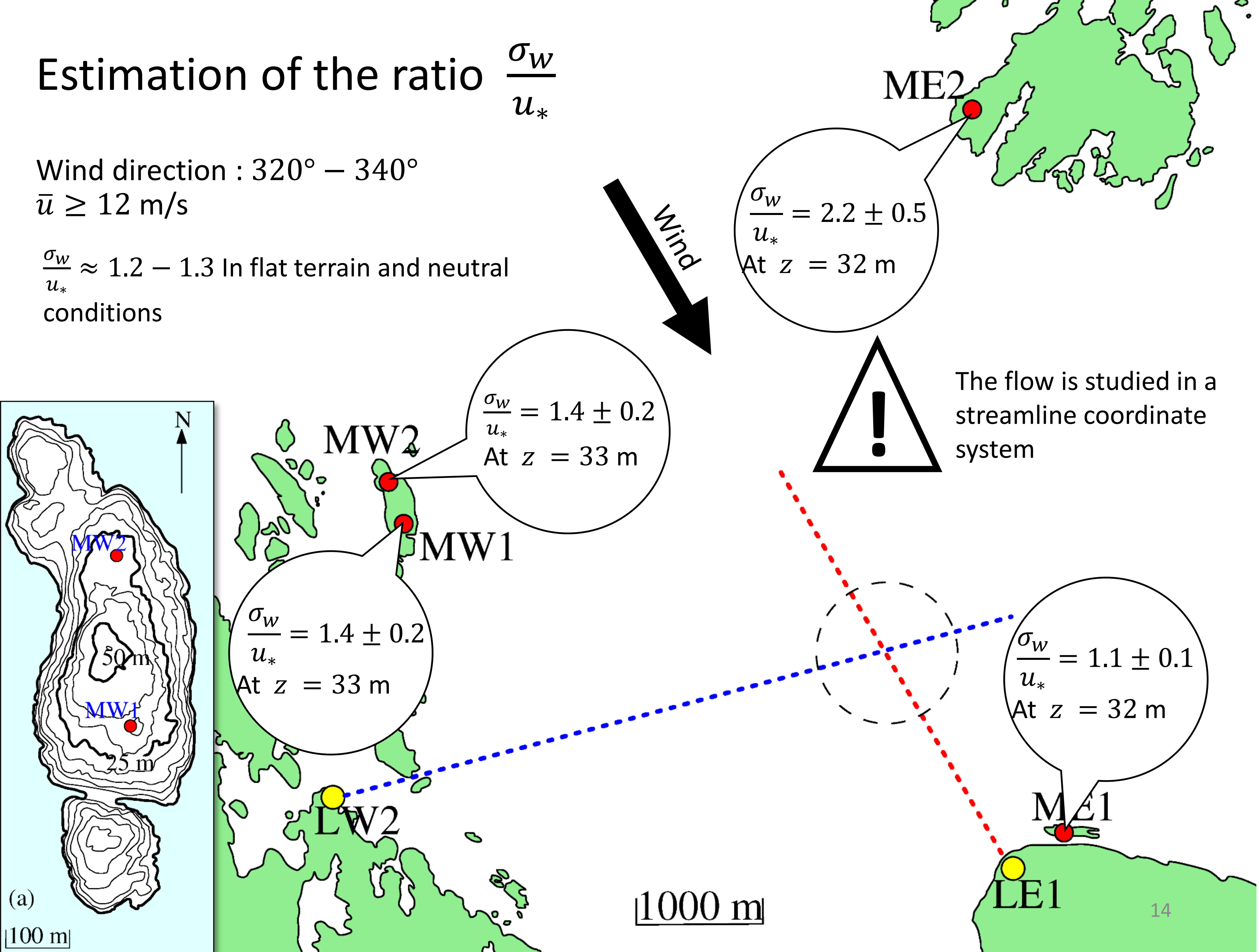
Wind direction : 320° – 340°
$\bar{u} \geq 10$ m/s



Estimation of the ratio $\frac{\sigma_w}{u_*}$

Wind direction : $320° - 340°$
$\bar{u} \geq 12$ m/s

$\frac{\sigma_w}{u_*} \approx 1.2 - 1.3$ In flat terrain and neutral conditions



The flow is studied in a streamline coordinate system

Conclusions

1. The lidar records are consistent with those from the anemometers for a limited number of sectors only.

2. There is a clear influence of the local topography on the anemometer measurements.

3. The combined use of Doppler Wind lidar with Sonic anemometer data is relevant for wind characterization in a wide fjord.

Photo: Jasna B. Jakobsen

Thank you

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