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

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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

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)
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)
Relative difference on the mean wind velocity

\[ \epsilon_{\frac{W}{u}} = 1 - \frac{\bar{u} \text{ (MW1 at 33 m)}}{\bar{u} \text{ (Lidar)}} \]
Mast MW1 vs Lidar records (2/3)

Relative difference on the mean wind direction

\[ \epsilon^W_\Theta = 1 - \frac{\bar{\Theta} (MW1 \text{ at } 33 \text{ m})}{\bar{\Theta} (Lidar)} \]
Mast MW1 vs Lidar records (3/3)

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

\[ \varepsilon^{W}_{\sigma_u} = 1 - \frac{\bar{\sigma_u}(MW1 \text{ at } 33 \text{ m})}{\sigma_u(\text{Lidar})} \]
Mean incidence angle

Relative difference on the mean wind velocity
Along wind turbulence intensity

Wind direction: $320^\circ - 340^\circ$

$\bar{u} \geq 10 \text{ m/s}$

- At $z = 25 \text{ m}$, $I_u \approx 0.05$
- At $z = 32 \text{ m}$, $I_u \approx 0.08$
- At $z = 33 \text{ m}$, $I_u \approx 0.08$, $I_u \approx 0.09$
- At $z = 32 \text{ m}$, $I_u \approx 0.09$
- At $z = 33 \text{ m}$, $I_u \approx 0.11$
Estimation of the ratio $\frac{\sigma_W}{u_\ast}$

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

$\frac{\sigma_W}{u_\ast} \approx 1.2 - 1.3$ in flat terrain and neutral conditions

The flow is studied in a streamline coordinate system

$\frac{\sigma_W}{u_\ast} = 1.4 \pm 0.2$
At $z = 33$ m

$\frac{\sigma_W}{u_\ast} = 1.4 \pm 0.2$
At $z = 33$ m

$\frac{\sigma_W}{u_\ast} = 2.2 \pm 0.5$
At $z = 32$ m

$\frac{\sigma_W}{u_\ast} = 1.1 \pm 0.1$
At $z = 32$ m
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.
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