Updates on wind speed and wind direction comparisons between lidar measurement and ERA5 model

Hamburg campaign

Aydin Uzun - FP

LiDAR measurement

Dataset

- Z -> Measurement height above ground level
- WSPD -> Horizontal wind speed
- WDIR -> Horizontal wind direction
- Vertical resolution and coverage : Z goes from 77 m to 2933 m, approximately one sample per 20 m, 149 altitude values -> good resolution
- WSPD and WDIR not available at all of these 149 altitudes
- Temporal resolution : per 10 mins
- Temporal coverage : from 01 Aug 21 to 09 Sep 21

ERA5 model

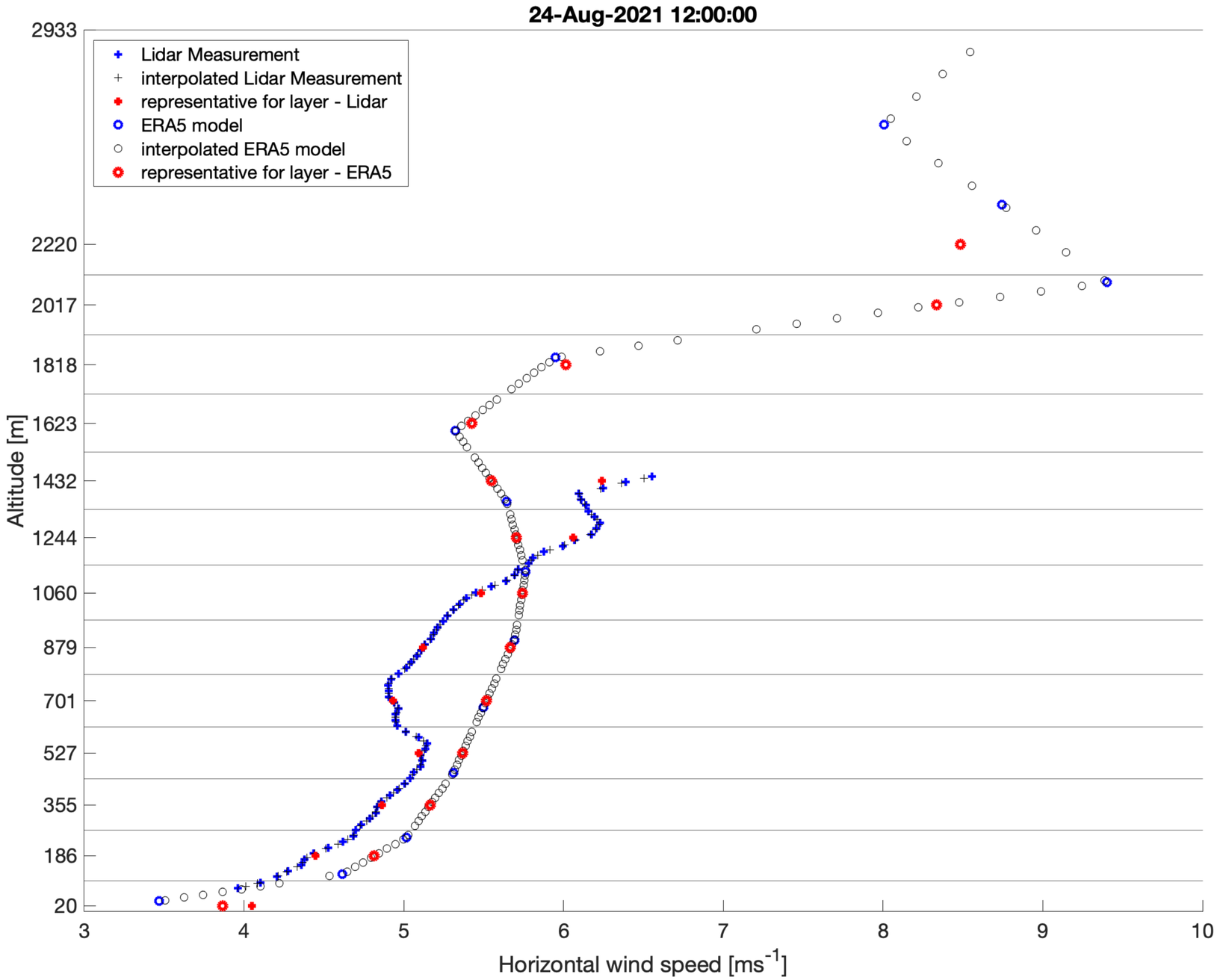
dataset

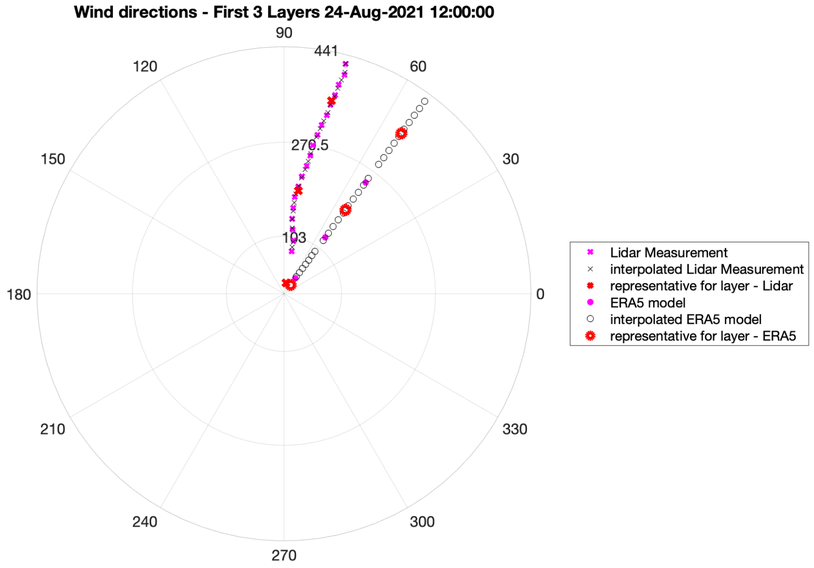
- Datatype: Gridded [0.5° x 0.5°]
- Temporal resolution : hourly
- Vertical resolution : 39 levels [37 levels from ‘ERA5 hourly data on pressure levels’, 2 levels [10m, 100m] from ‘ERA5 hourly data on single levels’]
- Longitude, latitude, level, Geopotential , U -component wind , V-component wind

Challenges

- Temporal resolution :
  - Lidar measurement per 10 mins but era5 model hourly

- Observation/Measurement local to a particular point in space and time but model represent average over a grid box.


24-Aug-2021 12:00:00
Lidar Measurement
interpolated Lidar Measurement
representative for layer - Lidar
ERA5 model
interpolated ERA5 model
representative for layer - ERA5
Altitude [m]
2933
2220
2017
1818
1623
1432
1244
1060
879
701
527
355
186
20
3
4
5
6
7
8
9
10
Horizontal wind speed [ms-1]


Wind directions - First 3 Layers 24-Aug-2021 12:00:00
90
120
60
150
30
180
0
210
330
240
300
270
441
270.5
103
Lidar Measurement
interpolated Lidar Measurement
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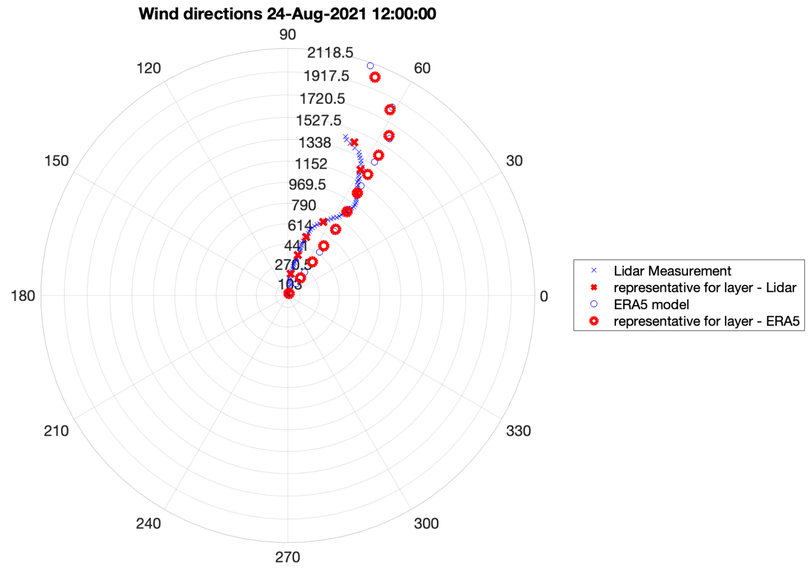
Wind directions 24-Aug-2021 12:00:00
90
120
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180
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2118.5
1917.5
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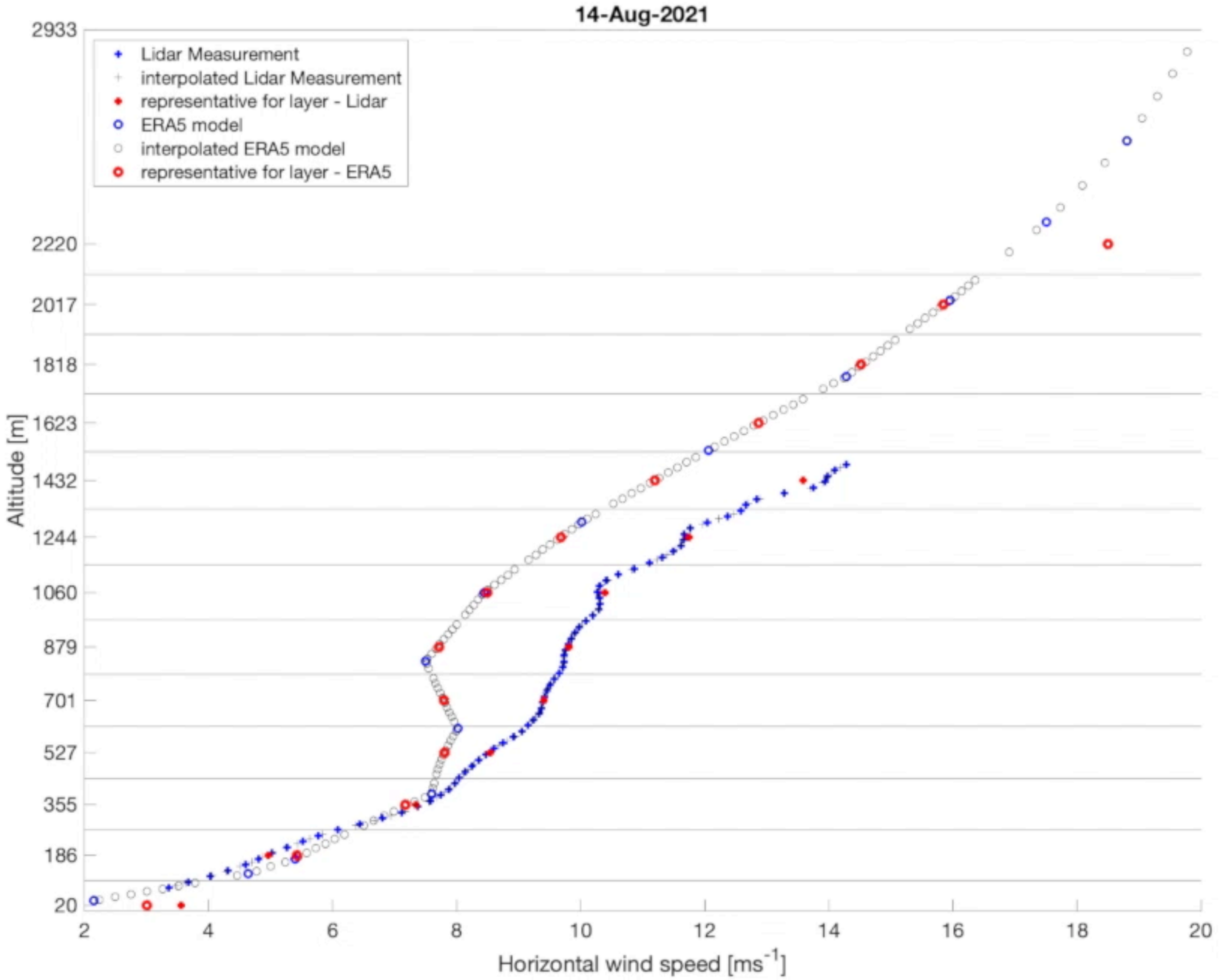
14-Aug-2021
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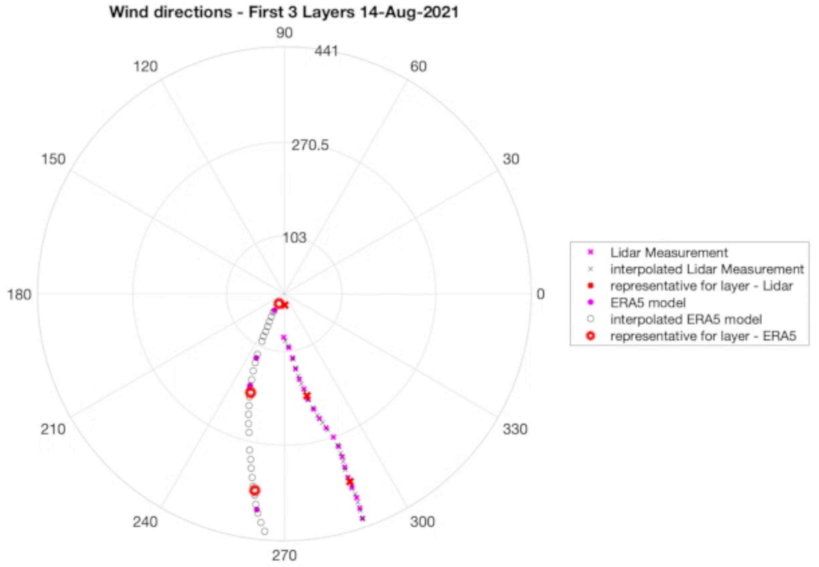
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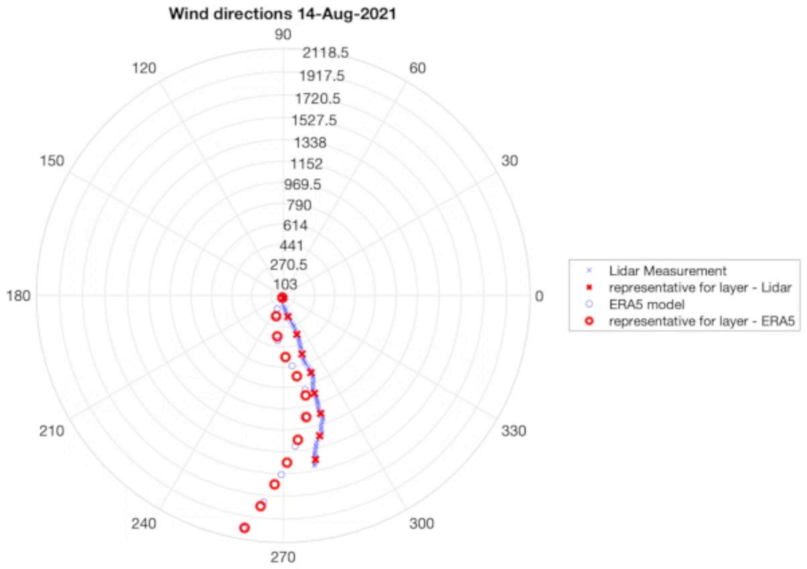
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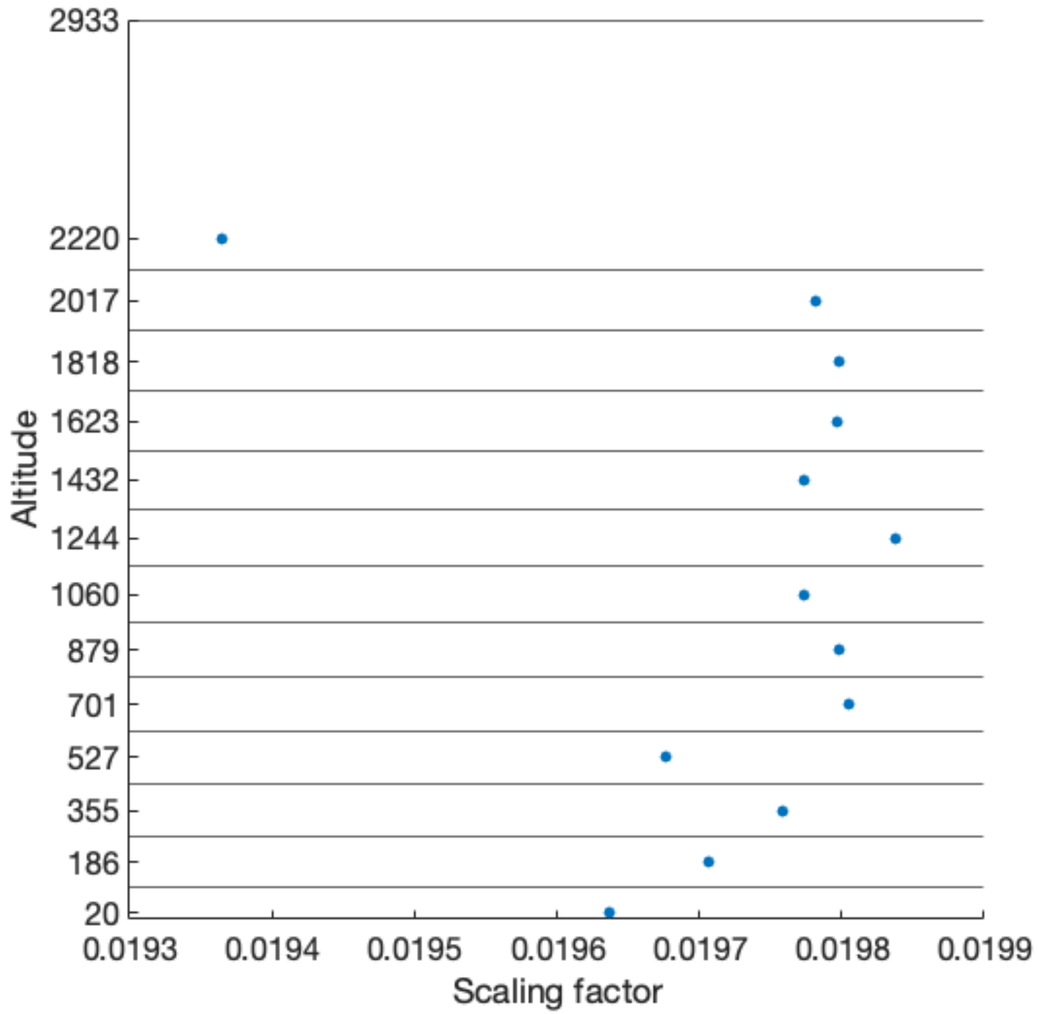
Calculate measurement - model

- For one day
  - Hourly data - 24 time points
  - 13 layers corresponding to particle release heights
  - 312 samples in total for one day

Vertical scaling factors



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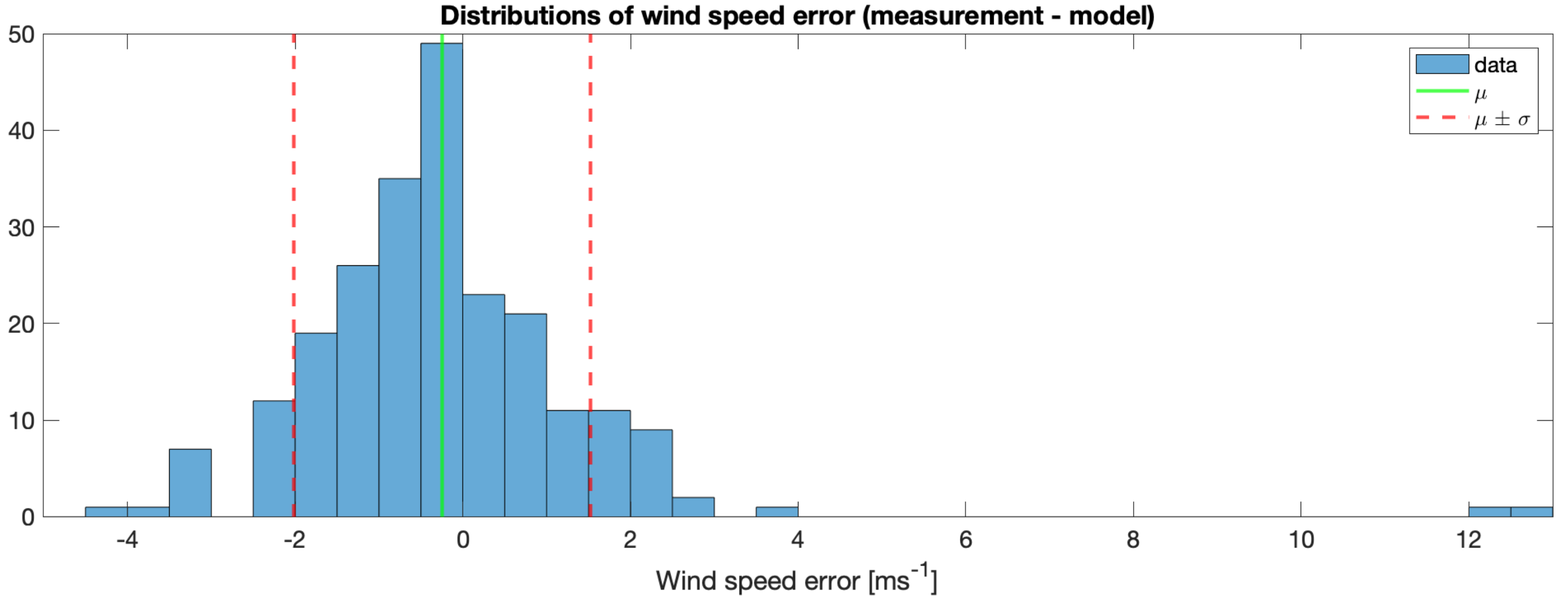
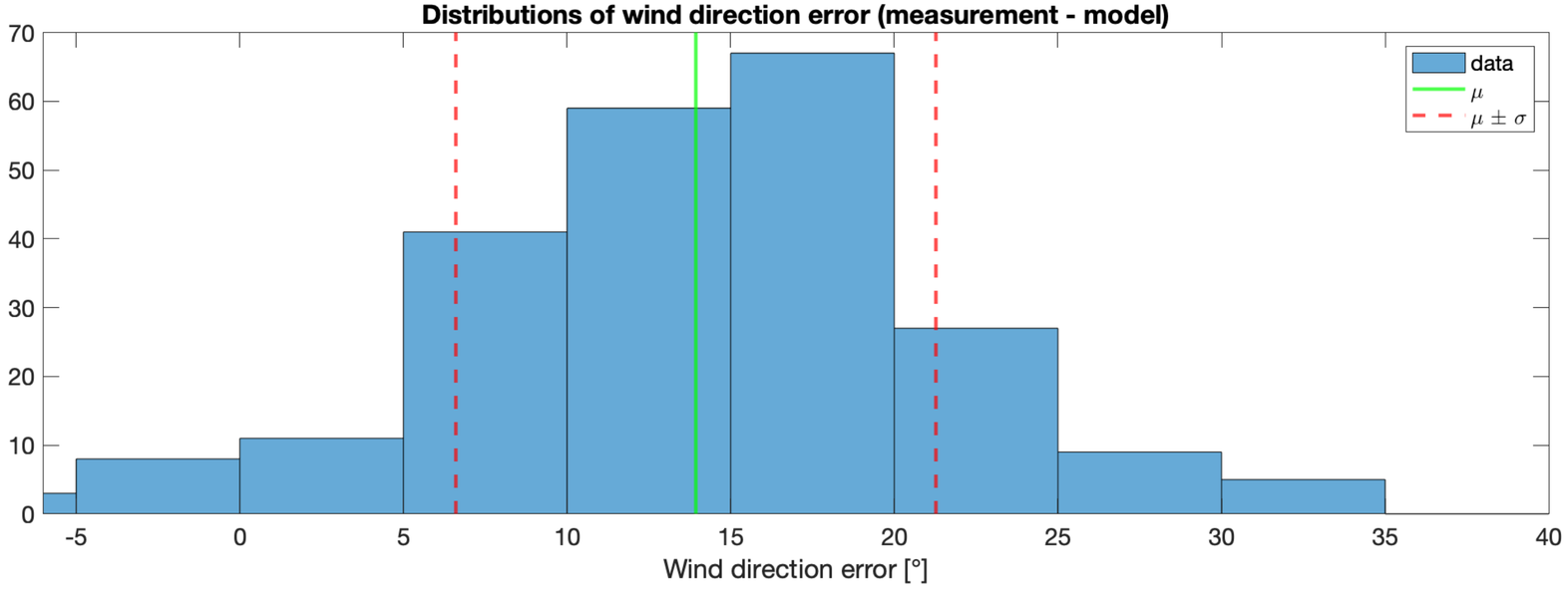

Distributions of wind speed error (measurement - model)
data
μ
$\mu \pm \sigma$
Wind speed error [ms^{-1}]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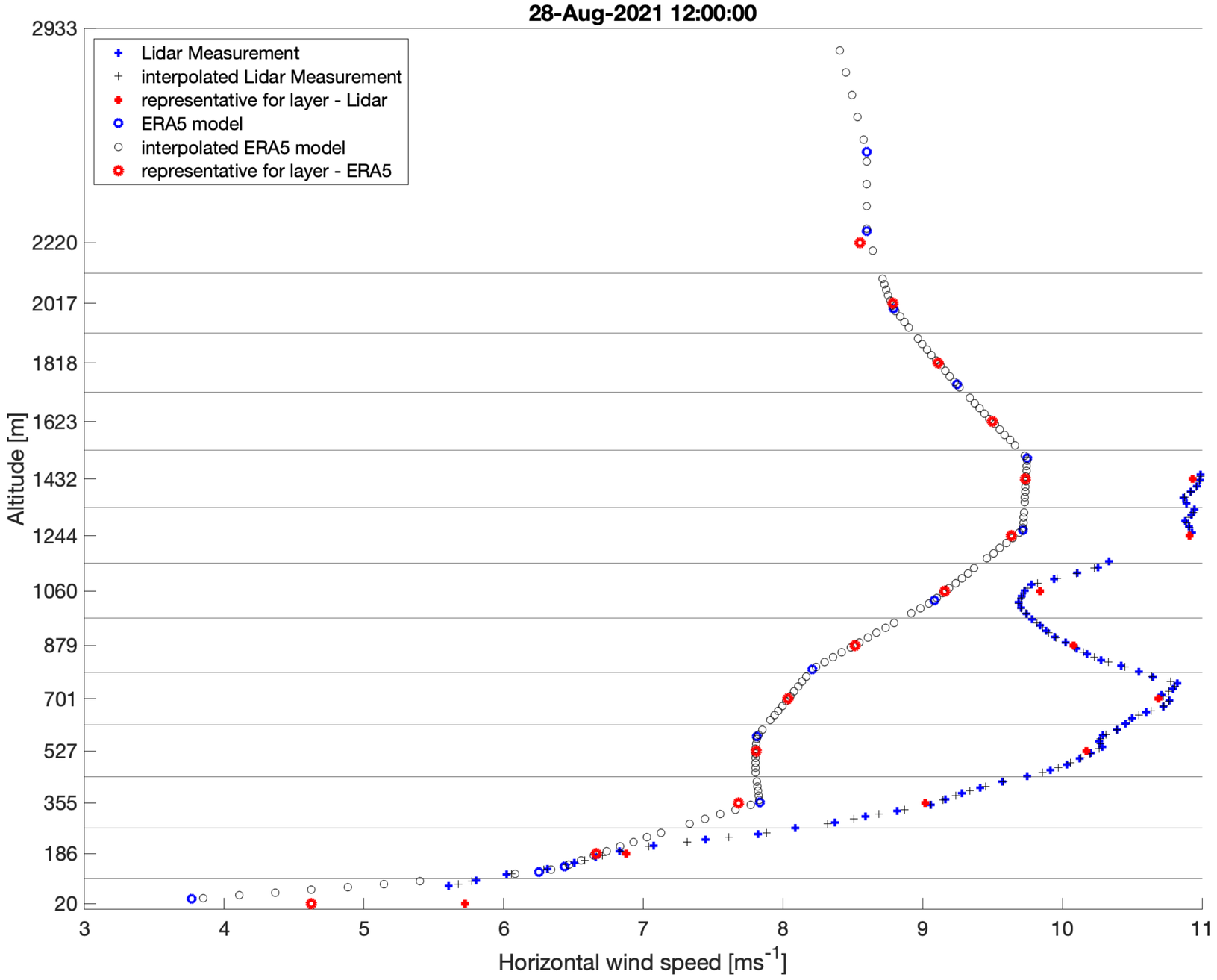
Wind direction error [°]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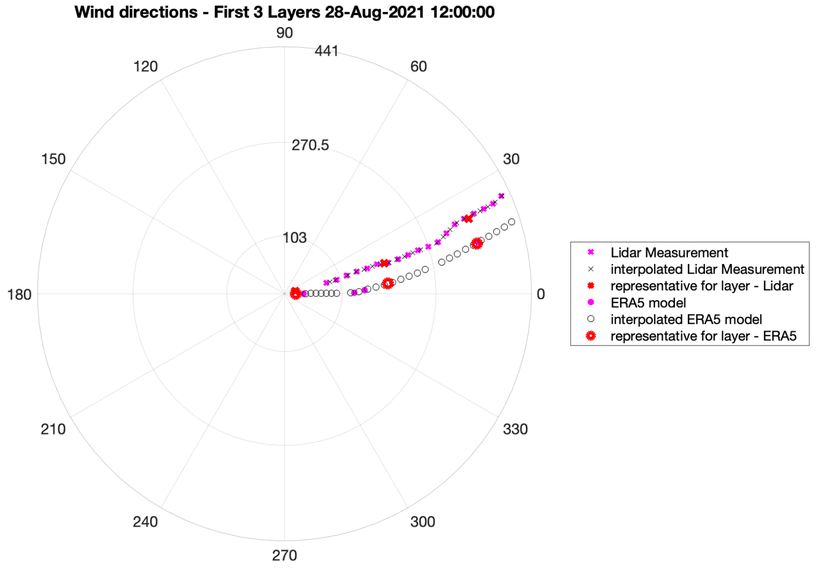
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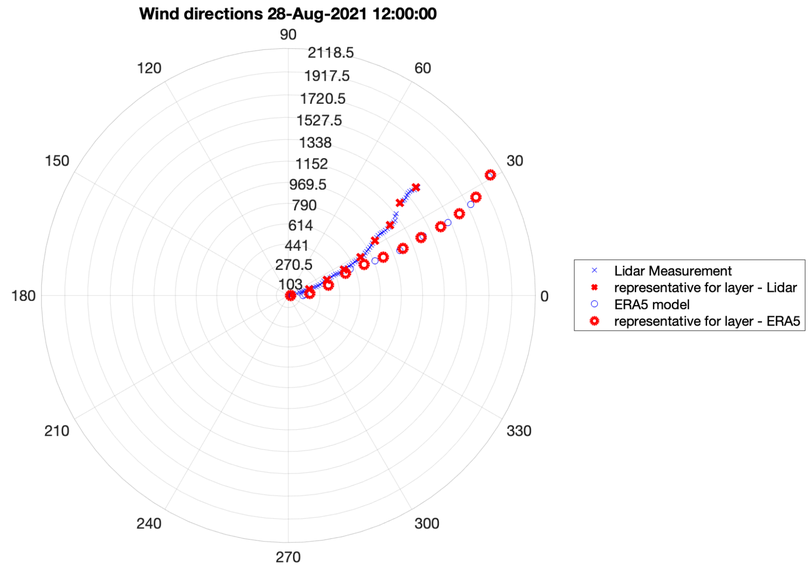
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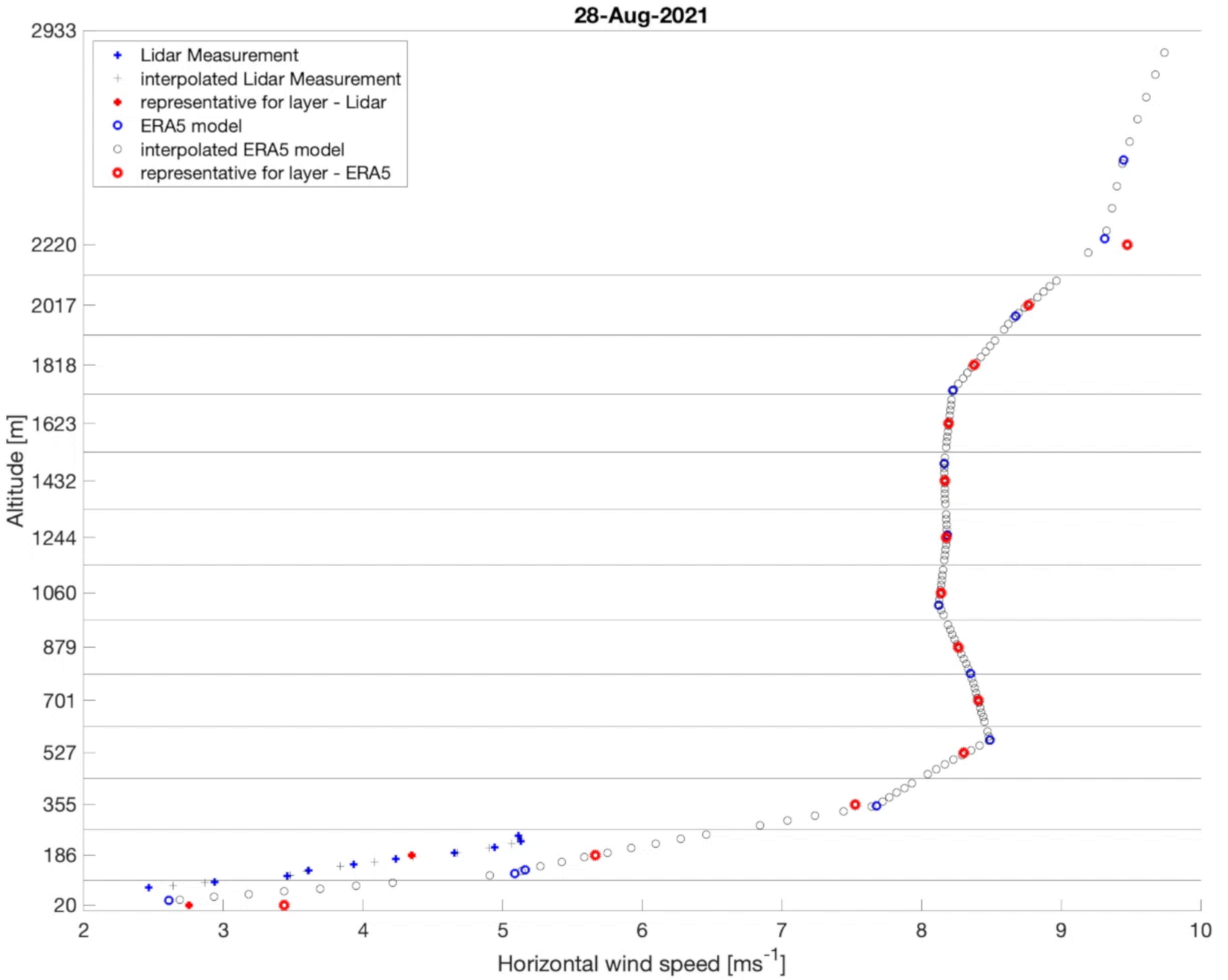
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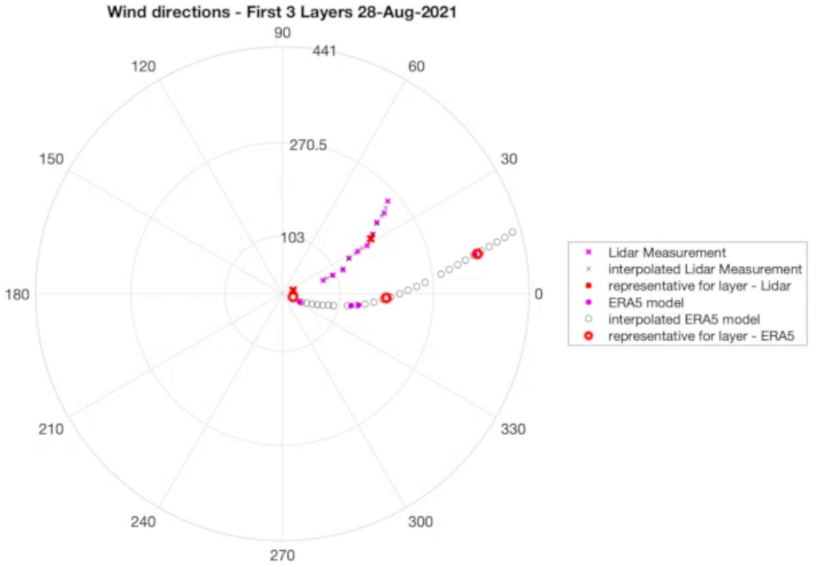
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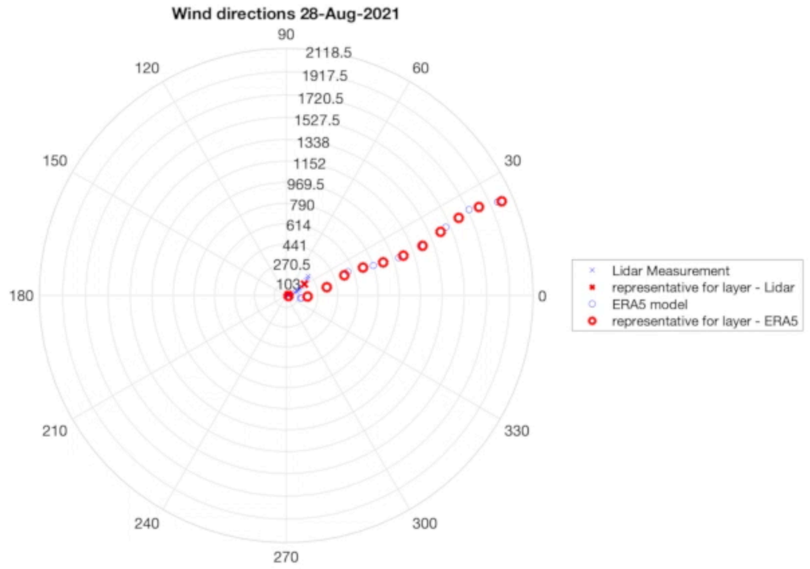
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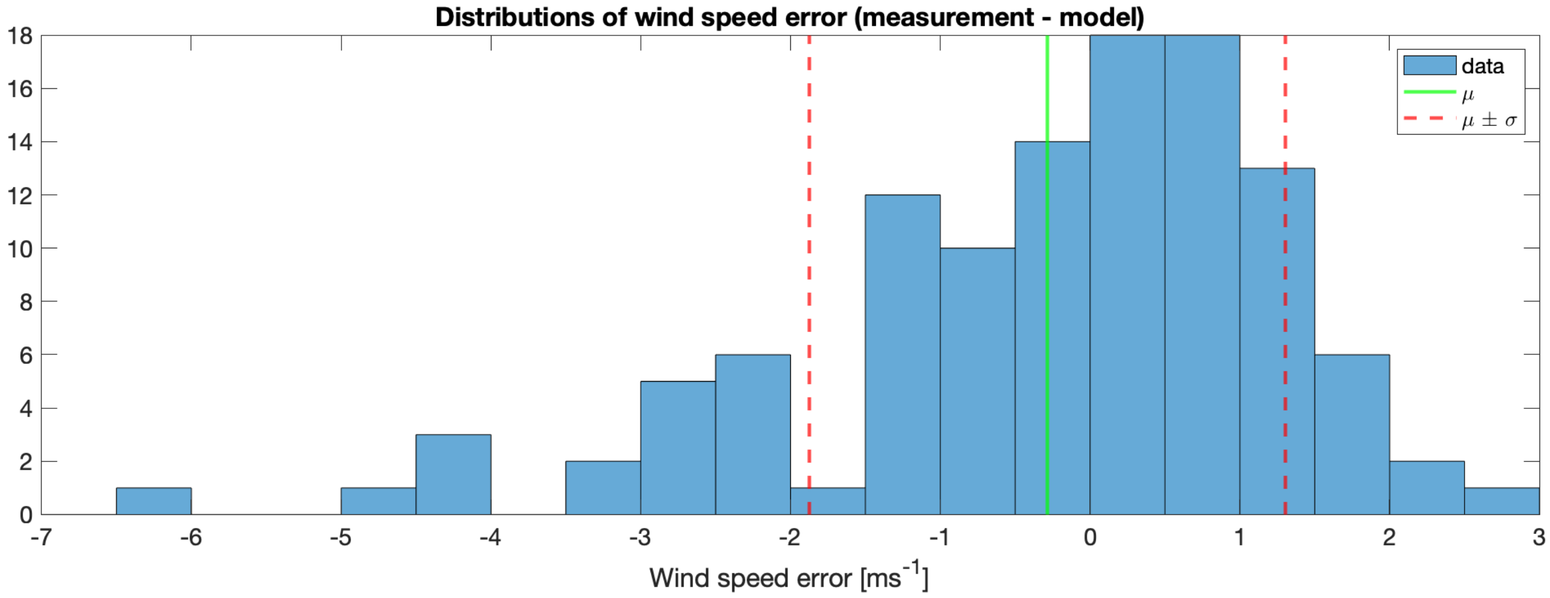
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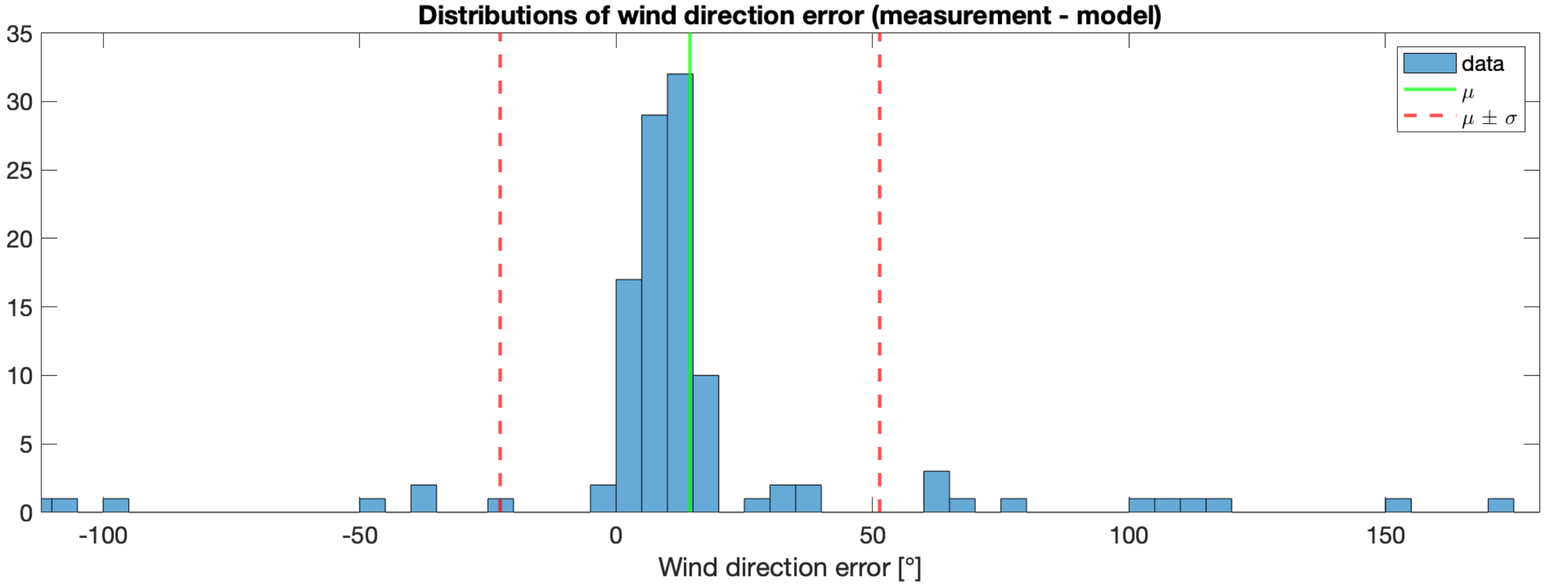
Wind speed error [ms^{-1}]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μ
$\mu \pm \sigma$
Wind direction error [°]

Questions

- What to do with “systematic” offset (if the mean-diffrence of LIDAR-Model ≠ 0)
- Do negative windspeeds for the trajectories (according to the standard deviation) make sense?
- Should we include not only the vertical scaling factors, but also the footprint intensity as well (as weigh for the histogram)?

Footprint intensity

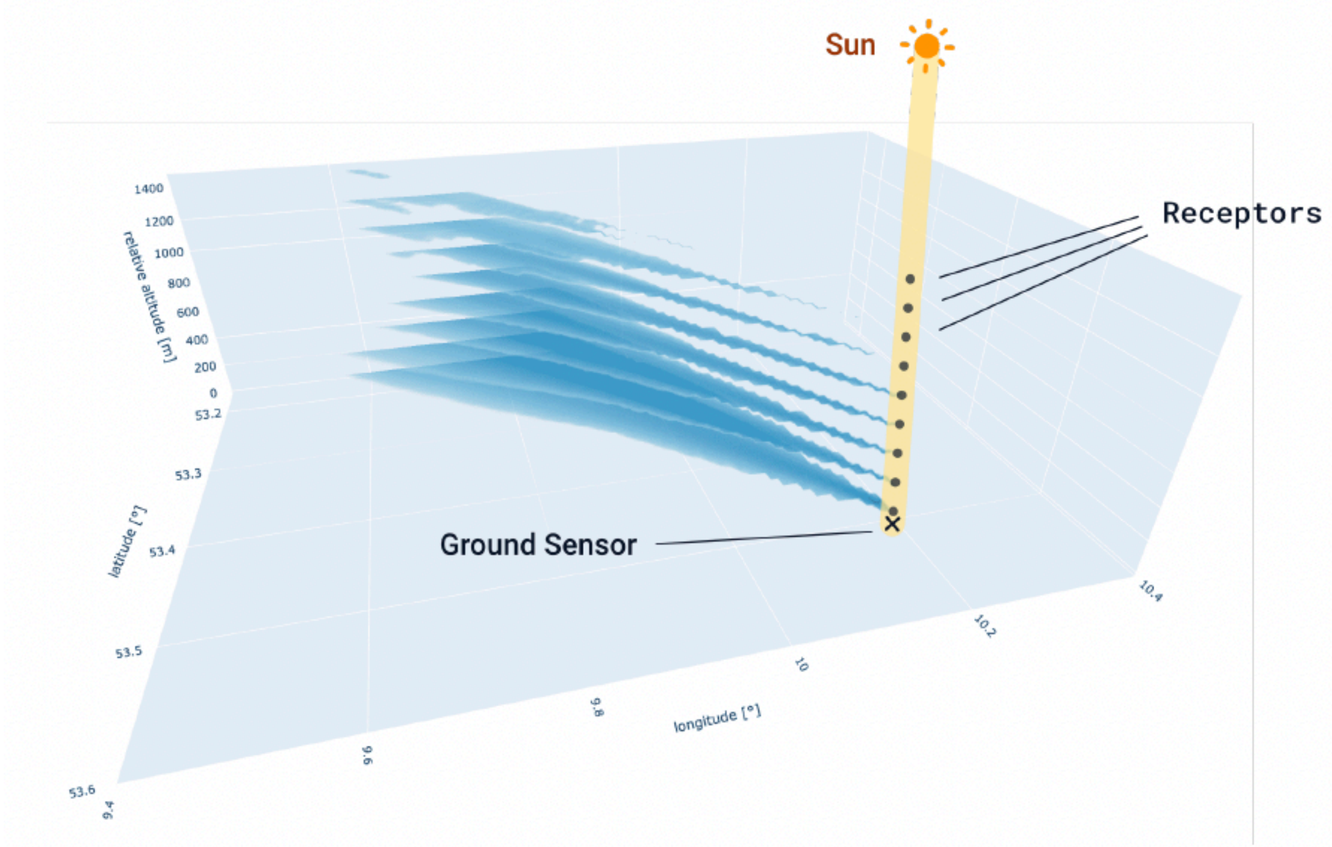

Figure 3.4.: Vertically layered footprints — the receptors at higher altitudes are not very sensitive to surface emissions. The z-axis (altitude) has been scaled up 15 times relative to the latitude- and longitude-axis, hence the sun elevation is almost 90 degrees in this plot.

Questions

Table 3. Mean and standard deviations of wind speed and wind direction differences between the NAM model winds and observations from the ALAR aircraft and the wind lidar. Negative values indicate that the NAM model value is greater than the observation. The ALAR–NAM standard deviations for each day were used in the transport error analysis.

Date	Wind speed model mismatch ($m s^{-1}$)				Wind direction model mismatch (°CW – degrees clockwise)			
	Mean		SD		Mean		SD	
	Lidar	Aircraft	Lidar	Aircraft	Lidar	Aircraft	Lidar	Aircraft
13 May	−3.4	−0.2	6.5	2.2	−39.2	−3.3	59.0	16.4
15 May	2.3	1.0	6.7	1.5	−23.3	2.1	32.8	11.4
18 May	−0.9	0.2	4.1	1.6	30.5	5.8	66.5	20.9
19 May	0.7	−0.3	2.4	2.0	−14.5	0.6	46.9	23.4
22 May	−1.3	–	3.7	–	36.2	–	42.0	–
Mean	−0.5	0.2	4.7	1.8	−2.06	1.3	49.4	18.0

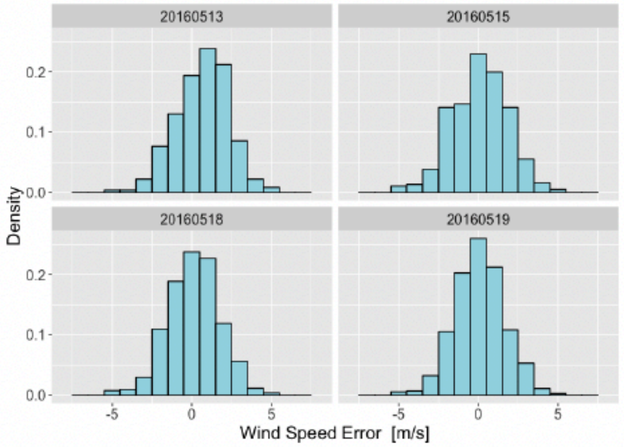

Figure S6. Distributions of wind speed error (model - measurement) for each flight throughout the campaign.

Jones, T. S., Franklin, J. E., Chen, J., Dietrich, F., Hajny, K. D., Paetzold, J. C., Wenzel, A., Gately, C., Gottlieb, E., Parker, H., Dubey, M., Hase, F., Shepson, P. B., Mielke, L. H., & Wofsy, S. C. (2021, September 6). *Assessing urban methane emissions using column-observing portable Fourier transform infrared (FTIR) spectrometers and a novel Bayesian Inversion Framework*. Atmospheric Chemistry and Physics. Retrieved February 9, 2022, from https://acp.copernicus.org/articles/21/13131/2021/acp-21-13131-2021-discussion.html