Deriving wind gusts from Doppler lidar measurements

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Better understanding of wind gusts needed







WMO
Standard operational measurements of wind gusts are calculated from high temporal resolution anemometer measurements, with a standard wind-gust duration defined in terms of a 3s moving average.

Can we derive wind gusts from DL measurements?

Challenges



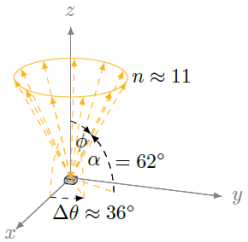
temporal

20 Hz vs. magn. 0.1 Hz

0.05 s vs. magn. 10 s

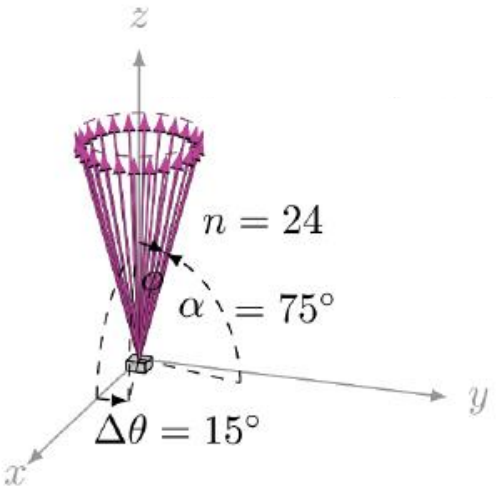
spatial

point **vs.** volume measurement





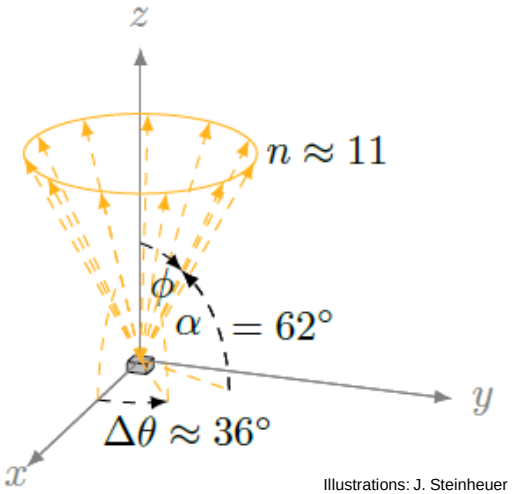
VAD-24



30.000 pulses/ray

120s scan duration

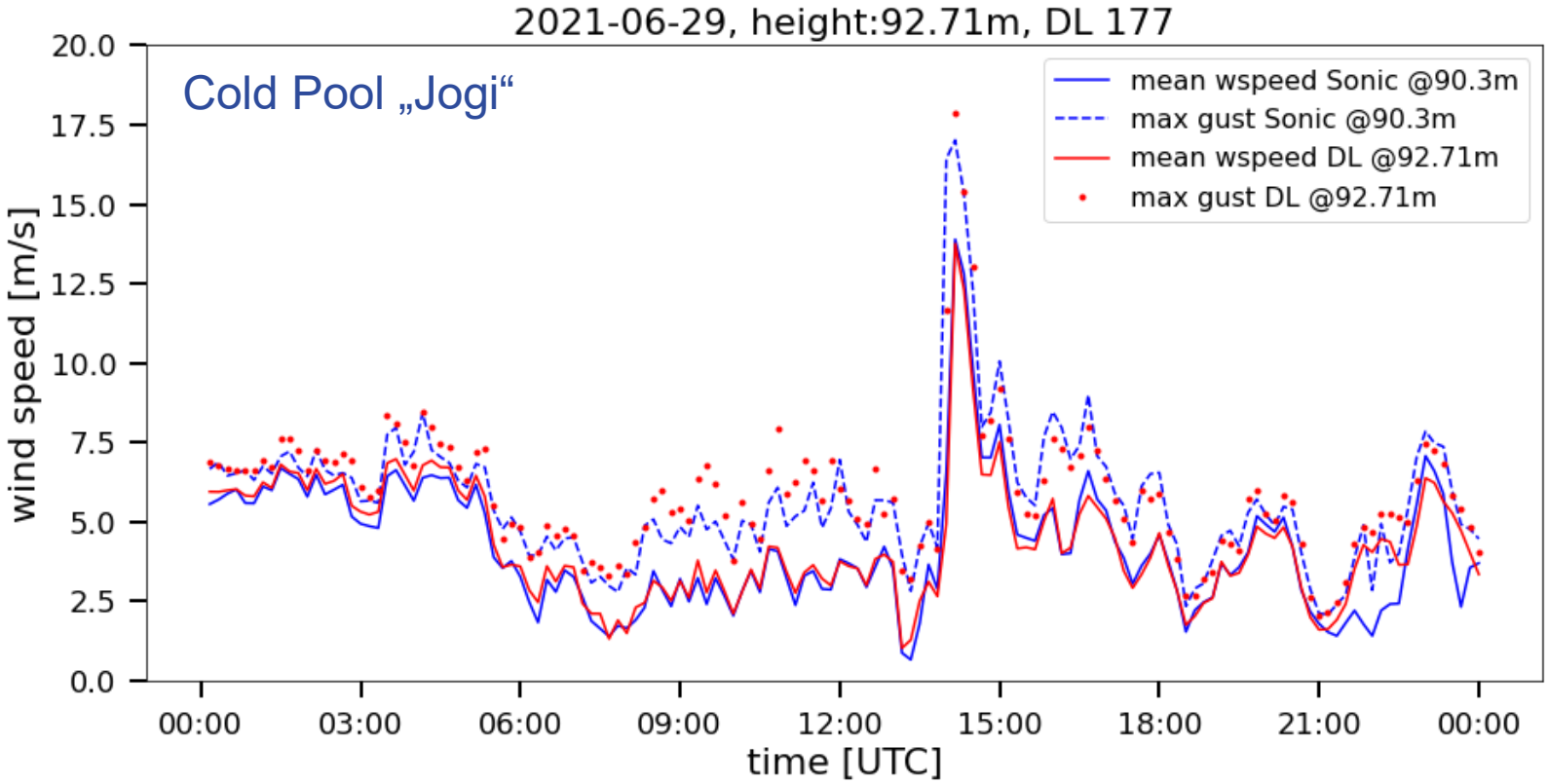
CSM gust

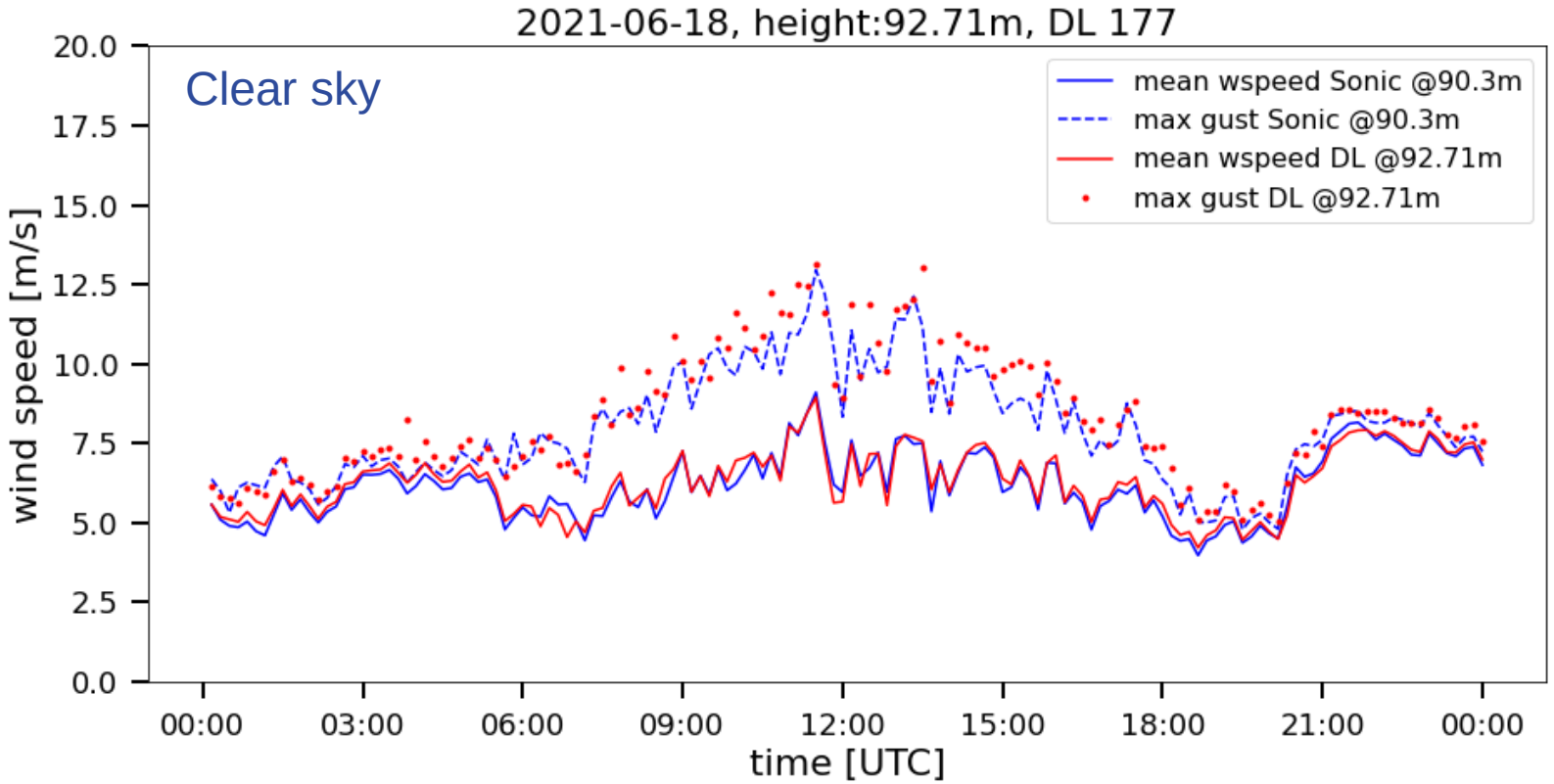


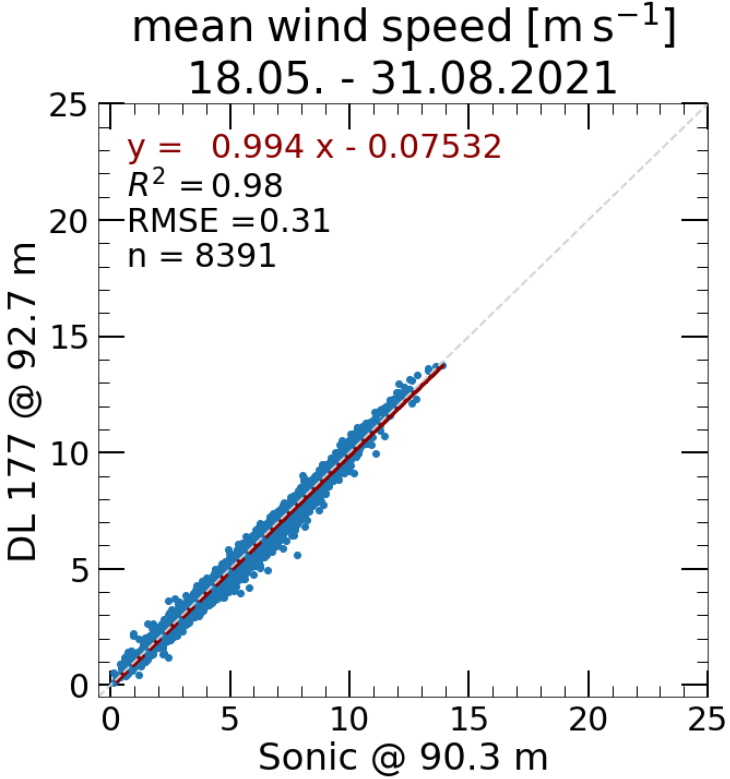
Illustrations: J. Steinheuer

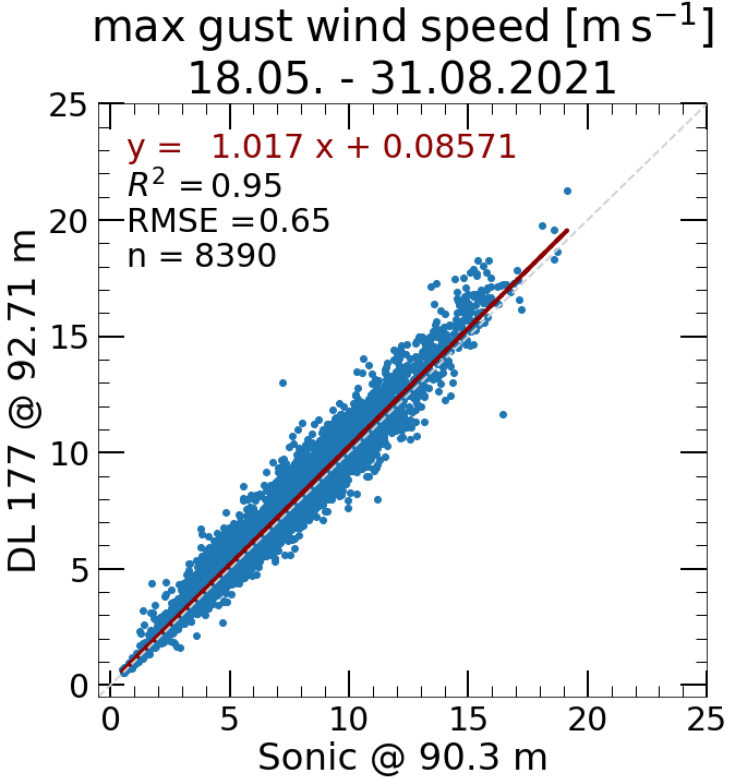
3.000 pulses/ray

~3.4 s scan duration

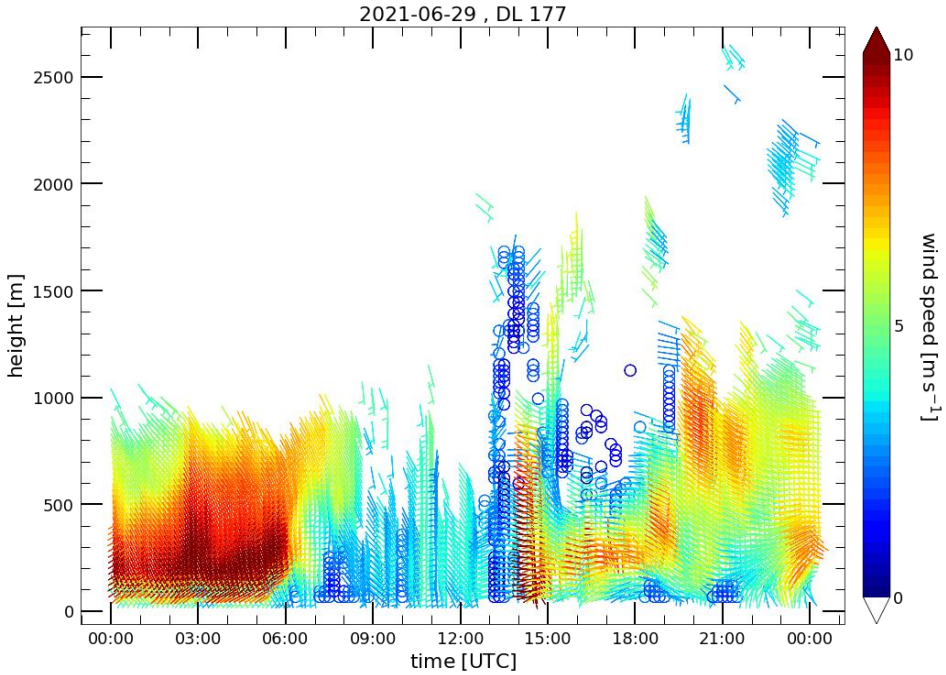

2021-06-29, height:92.71m, DL 177
Cold Pool „Jogi“
mean wspeed Sonic @90.3m
max gust Sonic @90.3m
mean wspeed DL @92.71m
max gust DL @92.71m
wind speed [m/s]
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
time [UTC]


2021-06-18, height:92.71m, DL 177
Clear sky
mean wspeed Sonic @90.3m
max gust Sonic @90.3m
mean wspeed DL @92.71m
max gust DL @92.71m
wind speed [m/s]
20.0
17.5
15.0
12.5
10.0
7.5
5.0
2.5
0.0
00:00
03:00
06:00
09:00
12:00
15:00
18:00
21:00
00:00
time [UTC]

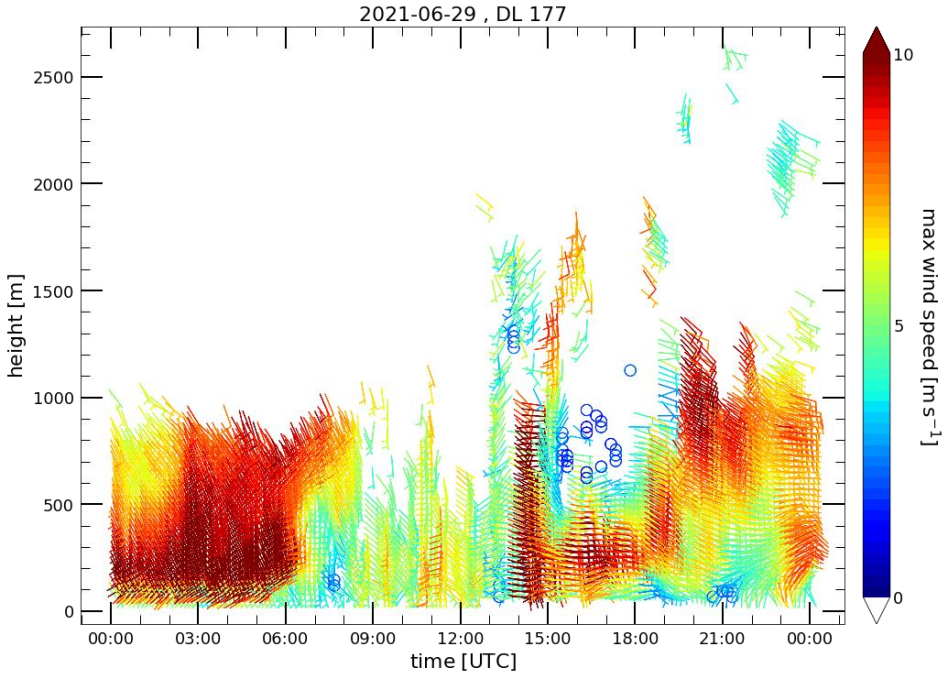

mean wind speed [m s^{-1}]
18.05. - 31.08.2021
y = 0.994 x - 0.07532
R^2 = 0.98
RMSE = 0.31
n = 8391
DL 177 @ 92.7 m
Sonic @ 90.3 m
0
5
10
15
20
25


max gust wind speed [m s^{-1}]
18.05. - 31.08.2021
y = 1.017 x + 0.08571
R^2 = 0.95
RMSE = 0.65
n = 8390
DL 177 @ 92.71 m
Sonic @ 90.3 m
0
5
10
15
20
25

mean wind speed



wind gust



Hamburg experiment 17.03. – 19.04. 2022



	R^2	RMSE	mean wind [m/s]
90 m	0.98	0.31	4.81
175 m	0.98	0.65	7.52
250 m	0.97	0.83	8.43

mean wind speed

	R^2	RMSE	mean max gust [m/s]
90 m	0.95	0.65	6.43
175 m	0.96	0.82	9.44
250 m	0.97	0.97	10.22

wind gust

Take home messages

- ✓ Can we derive wind gusts from Doppler lidar measurements?

  → Comparisons up to 250m show good agreement

  → Further validation with other independent measurements at larger heights desirable (e.g. UAV?, Virtual tower?)

- ➢ Next steps: case studies, behaviour of gusts with height, spatial variability, …

Want to learn more about

FESSTVaL
Field Experiment on Submesoscale Spatio-Temporal Variability in Lindenberg

?

- **UP1.5: Wed, 07 Sep**
  Atmospheric measurements: Instruments, experiments, networks and long-term programs using in-situ and remote sensing techniques

- **UP Keynote: Wed, 07 Sep, 17:30 – 18:00**
  Cathy Hohenegger “FESSTVaL: connecting dense surface networks, supersites and citizen to catch atmospheric variability at kilo- and subkilo-meter scales“