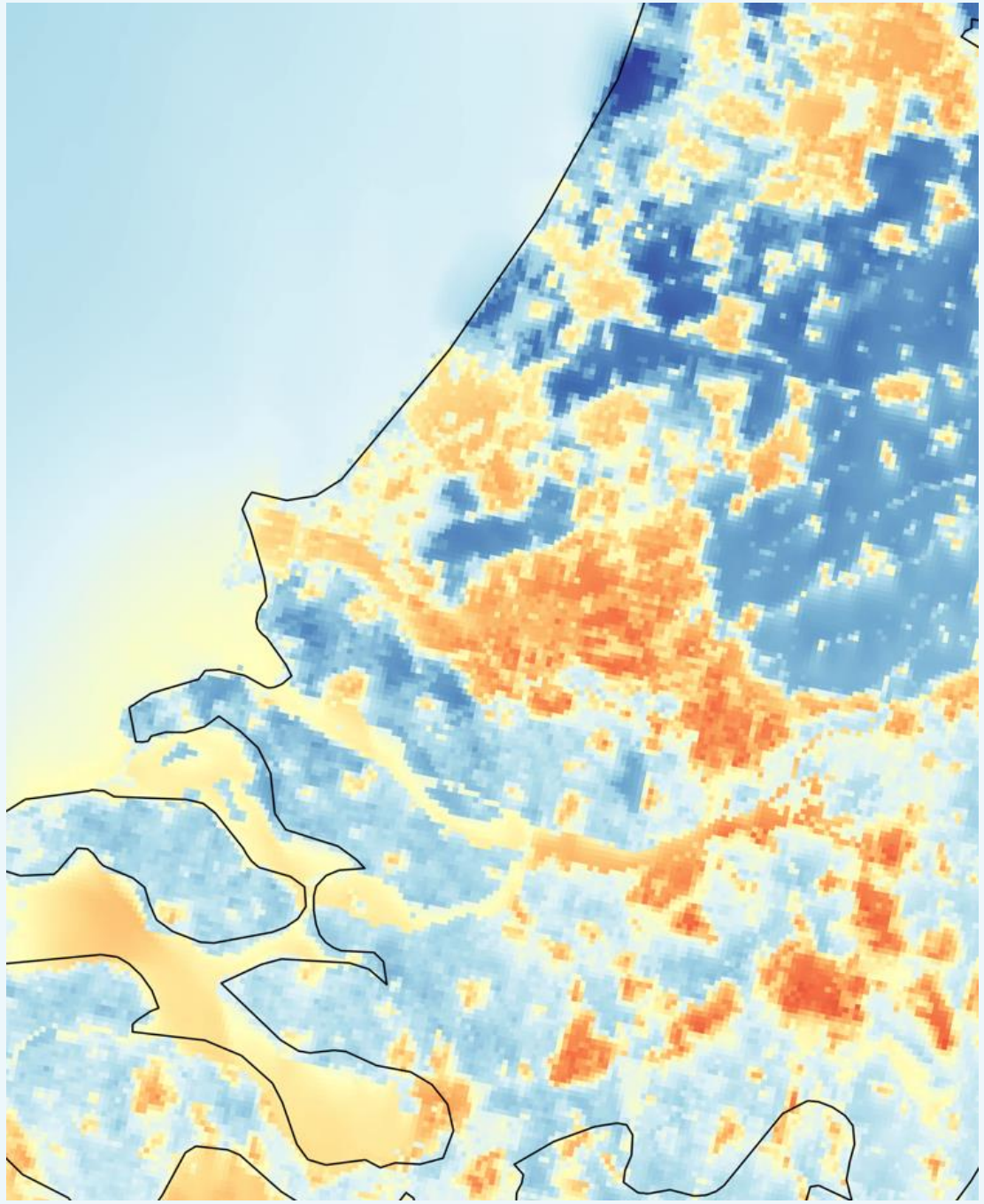


Royal Netherlands
Meteorological Institute
Ministry of Infrastructure
and Water Management

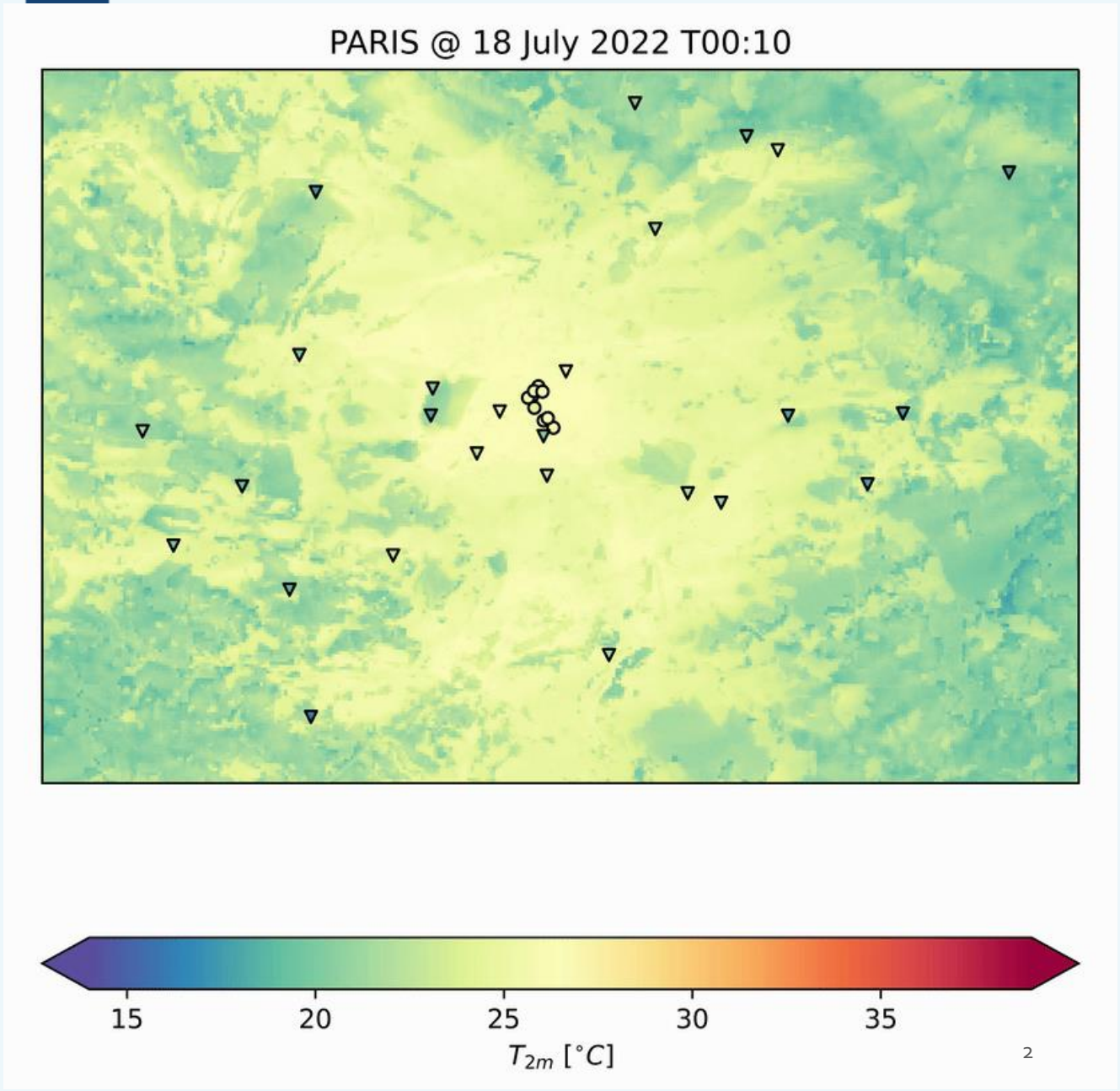
Using doppler lidar measurements to evaluate the representation of the boundary layer in high-resolution numerical models

Natalie Theeuwes[1], Steven Knoop[2]

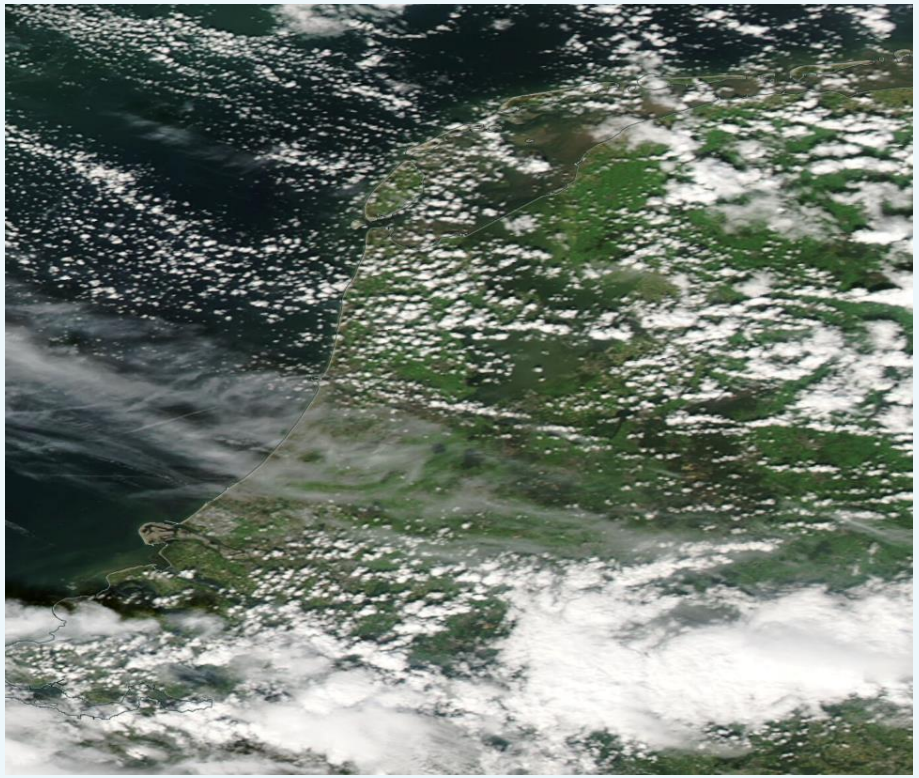
1. R&D Weather and climate modelling KNMI, the Netherlands
2. R&D Observations and data technology KNMI, the Netherlands

Motivation

- Evaluation of sub-km modelling
- Need for high density observations
- Towards turbulence-permitting modelling need for boundary-layer observations

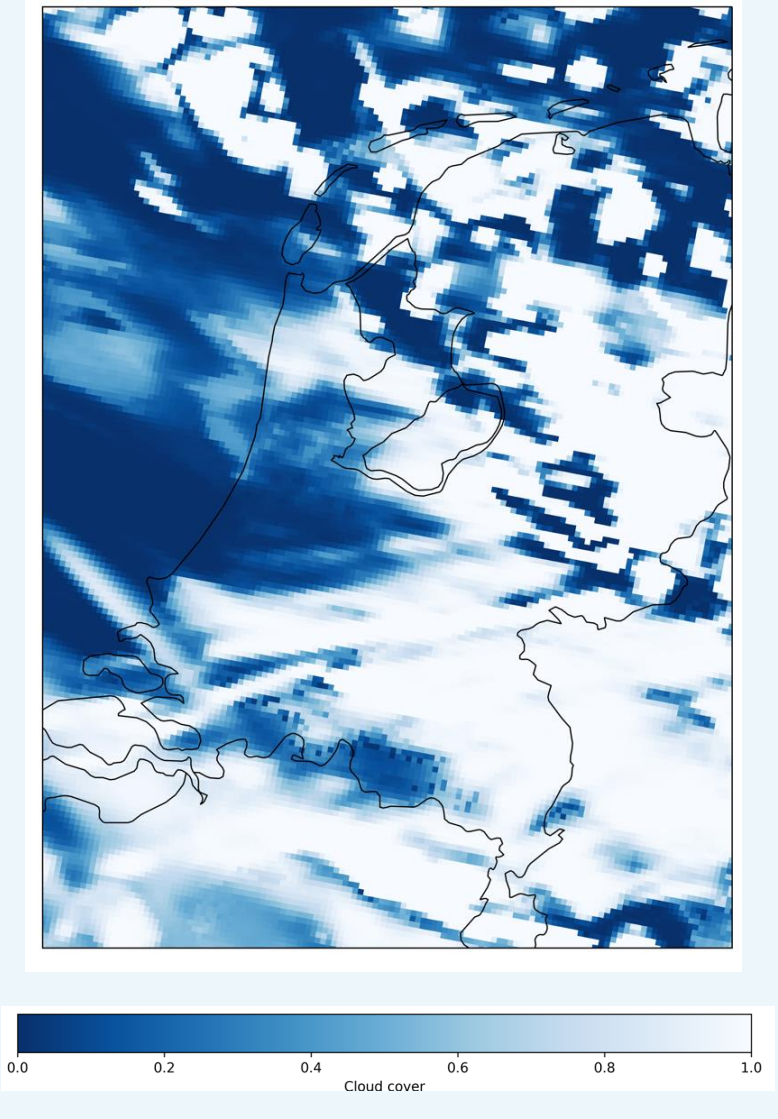


Clouds – case on 31 August 2023

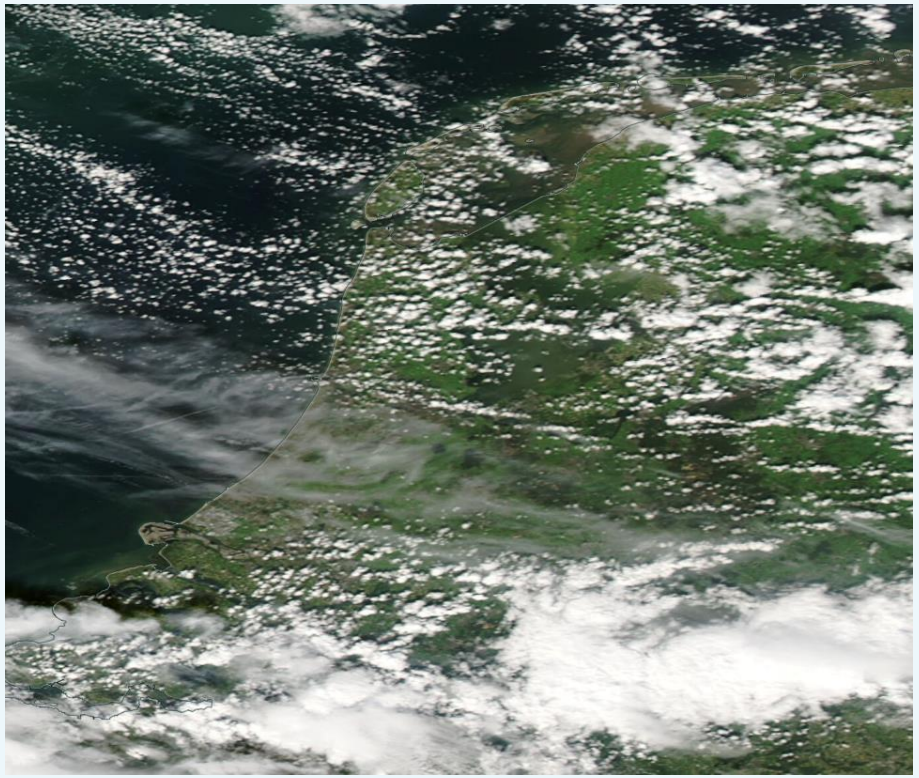


Aqua satellite ~13:30 – worldview (https://worldview.earthdata.nasa.gov/)

Operational forecast @ 2.5 km

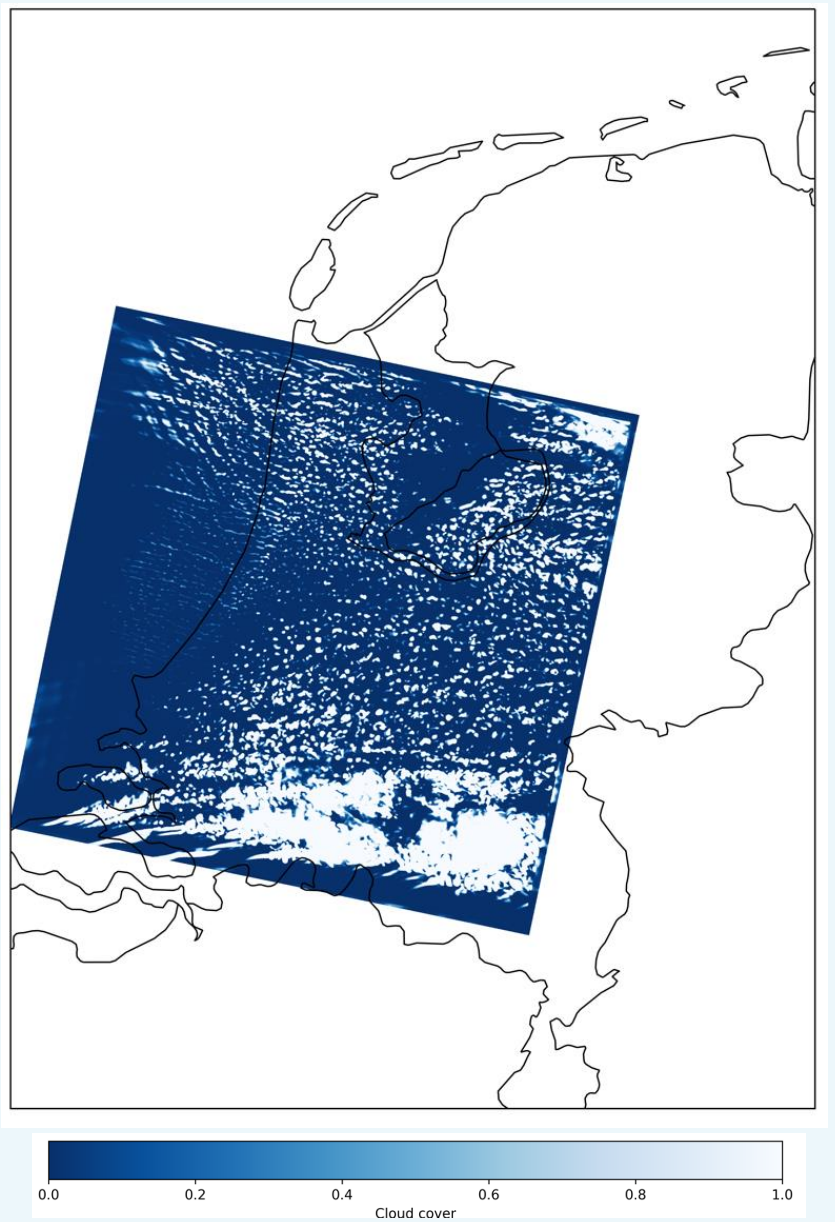


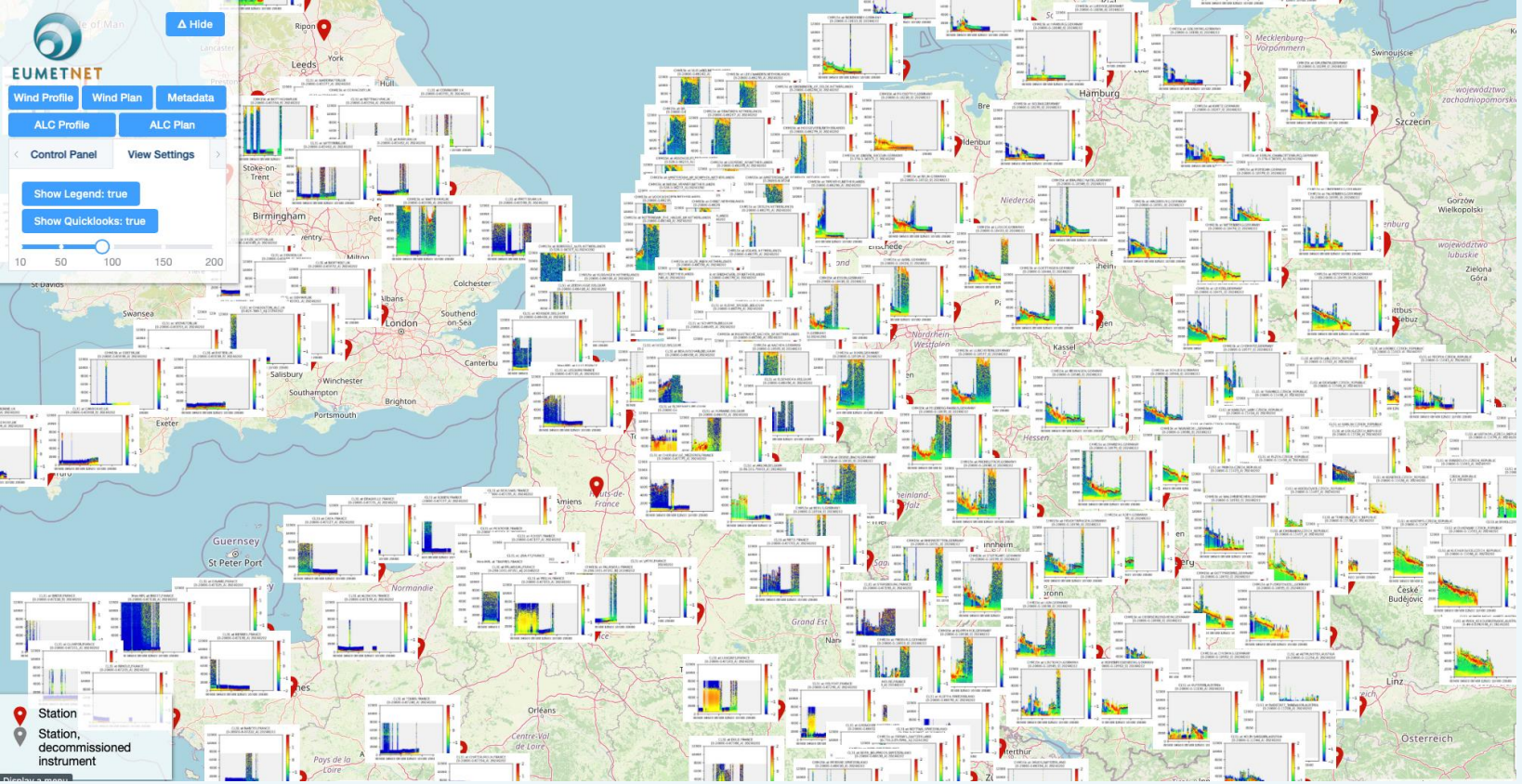
Clouds – case on 31 August 2023



Aqua satellite ~13:30 – worldview (https://worldview.earthdata.nasa.gov/)

150-m forecast




EUMETNET
Hide
Wind Profile
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Station
Station, decommissioned instrument
Ripon
York
Leeds
Hull
Stoke-on-Trent
Birmingham
Swansea
London
Southend on Sea
Colchester
Canterbury
Salisbury
Winchester
Southampton
Portsmouth
Brighton
Exeter
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Orléans
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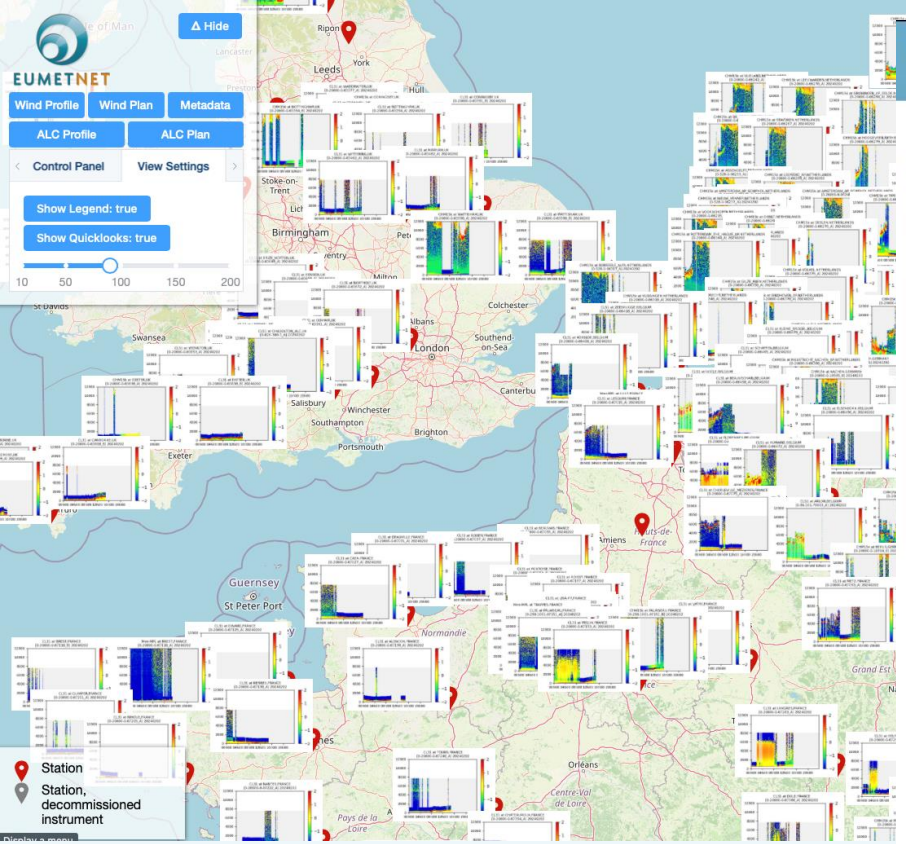
Gorzów Wielkopolski
Zielona Góra
Linz
Österreich



Cloudnet DATA PORTAL

Search data | Visualise data | Feedback | Measurement sites | Documentation

Location

Palaiseau ×

Show all sites

Date

2024-02-03

Product

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Show experimental products

Instrument

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View in data search →

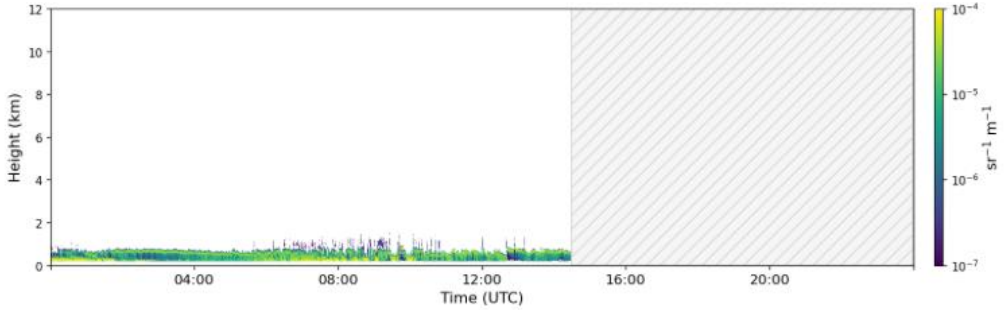
Reset filter

Visualisations for 3 February 2024

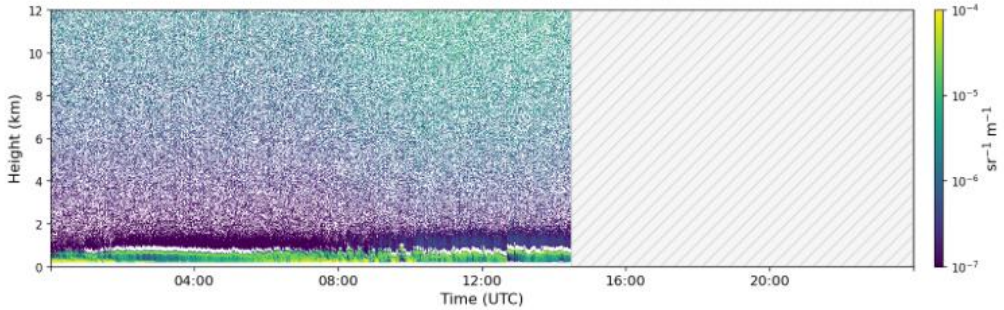
comparison view

Palaiseau CHM 15k ceilometer Volatile

Attenuated backscatter coefficient

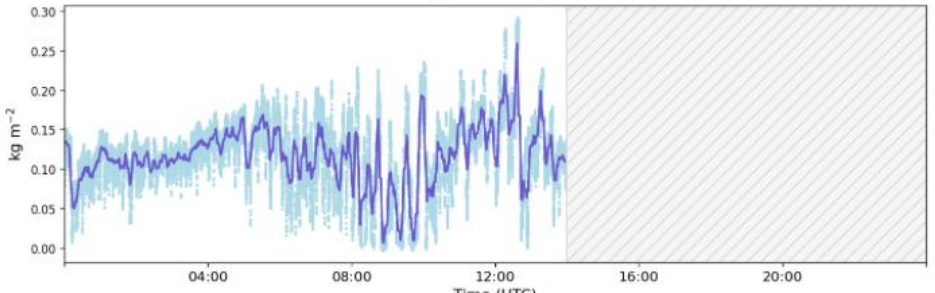


Non-screened attenuated backscatter coefficient



Palaiseau HATPRO microwave radiometer Volatile

Liquid water path



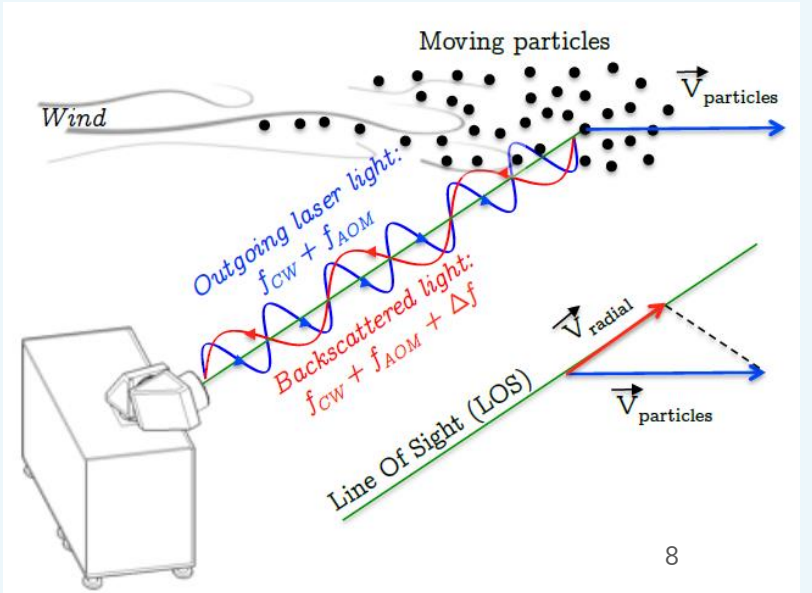
Cabauw, the Netherlands

Photo by Arnoud Apituley

Ruisdael observatory

Scanning Doppler lidar @ Cabauw

- WindCube200S (Leosphere/Vaisala)
- Remote sensing of wind (*but also aerosol and clouds*)
- Installed April 2021
- Maximum range 14 km (*but within boundary layer*)
- Resolution: 25m/50m/75m/100m
- 3D-scanning
  - Wind profiling (DBS)
  - Azimuth scans (PPI)
  - Elevation scans (RHI)
  - (Vertical) stare



Wind profiles

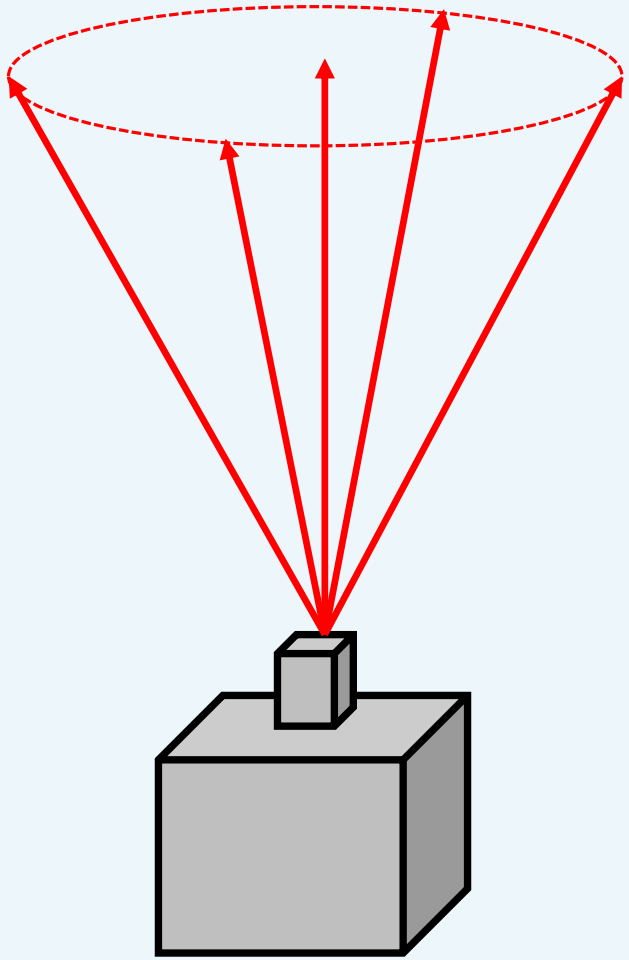
Doppler Beam Swing (DBS)

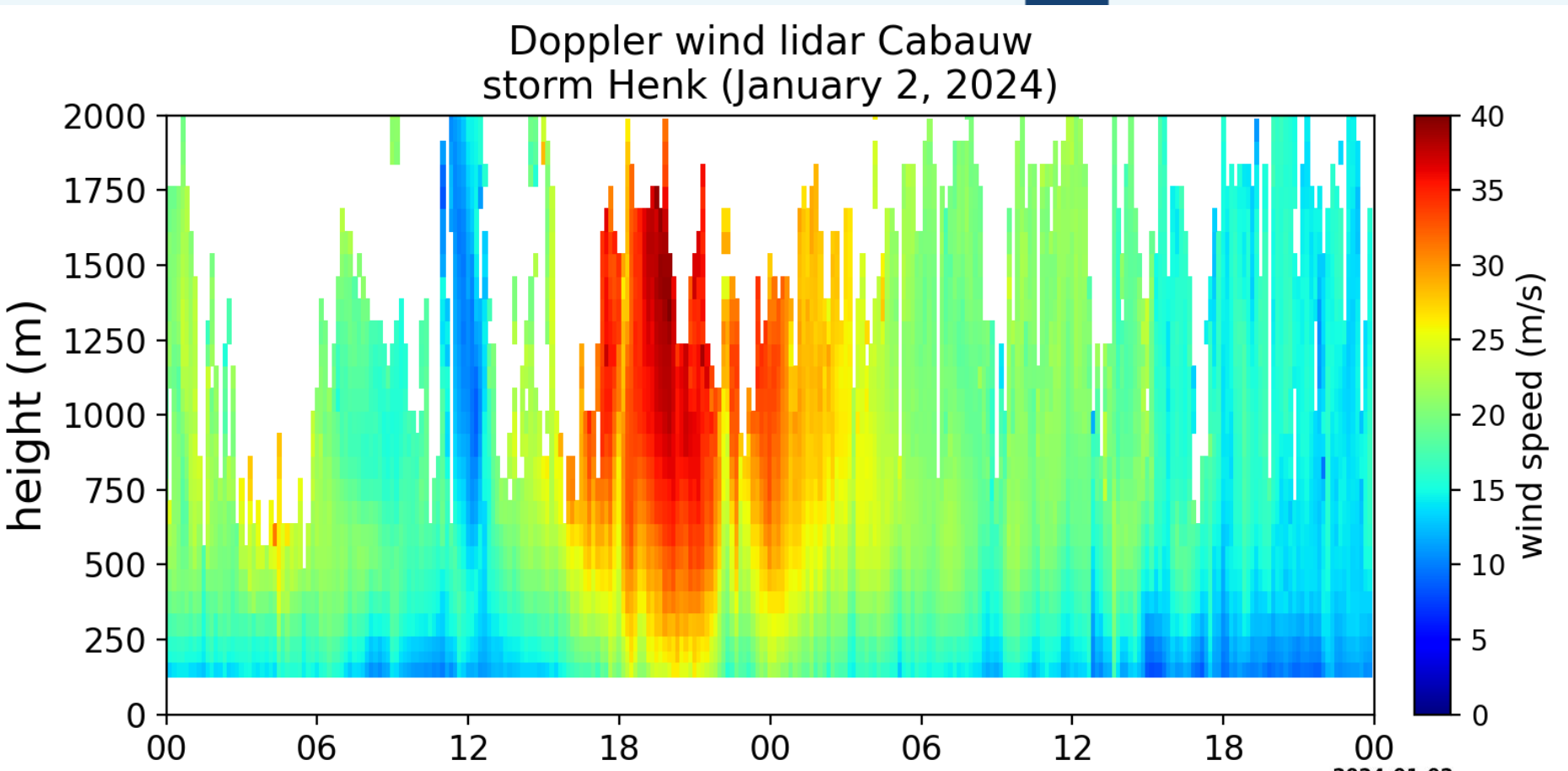
$u = \frac{V_0 - V_{180}}{2\cos\theta}$; $v = \frac{V_{90} - V_{270}}{2\cos\theta}$

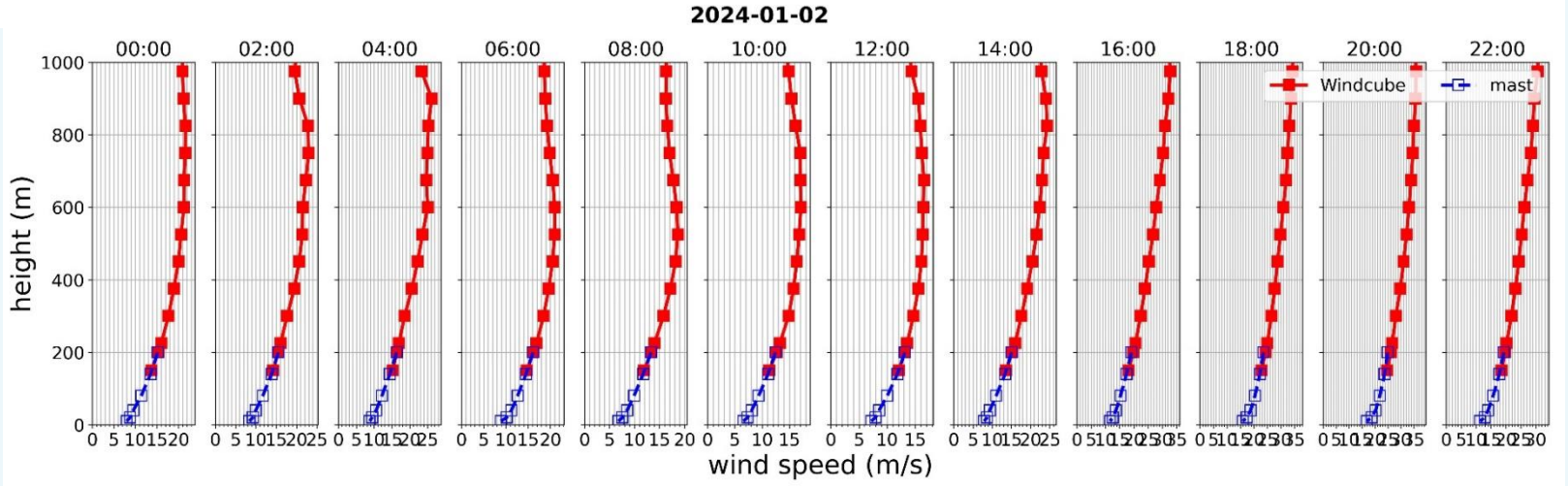
horizontal wind speed = $\sqrt{u^2 + v^2}$

wind direction = $\arctan(v/u)$

vertical velocity = V_v





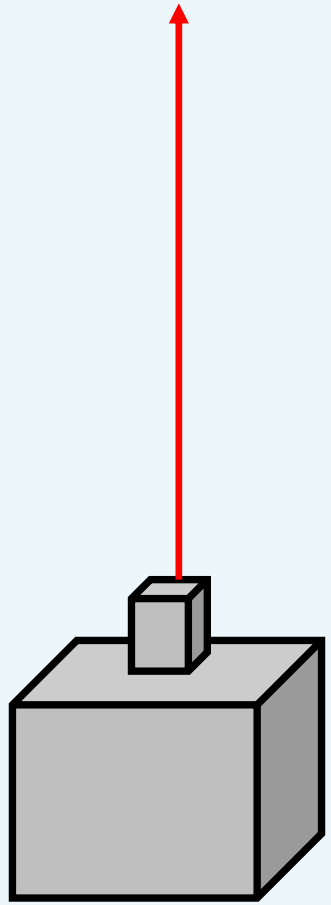


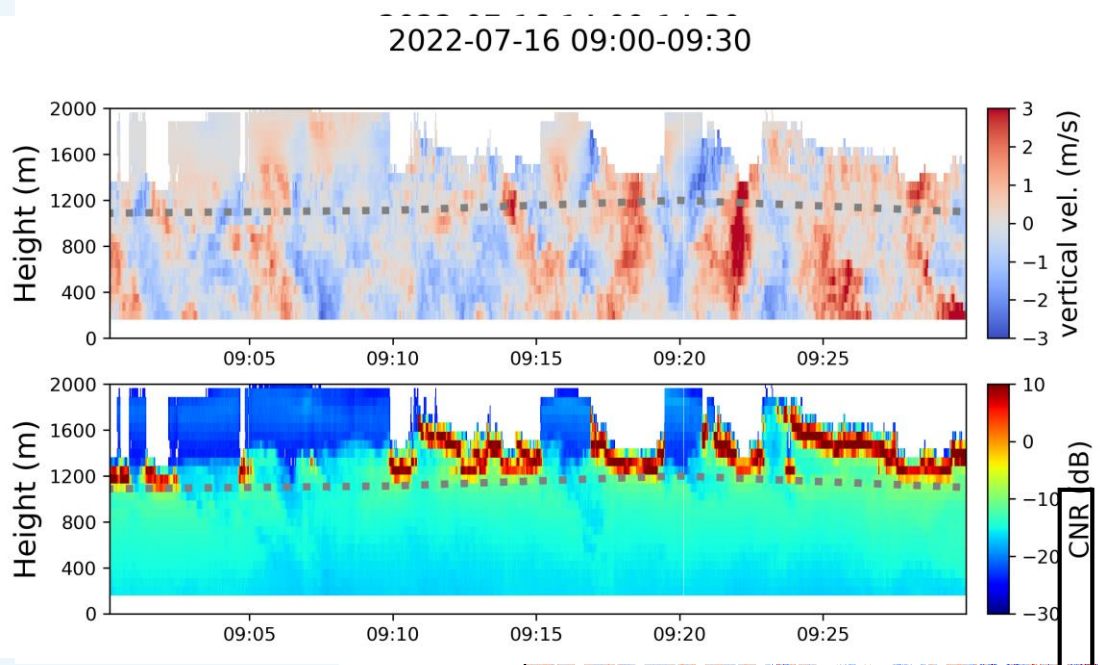
Mast + Doppler lidar

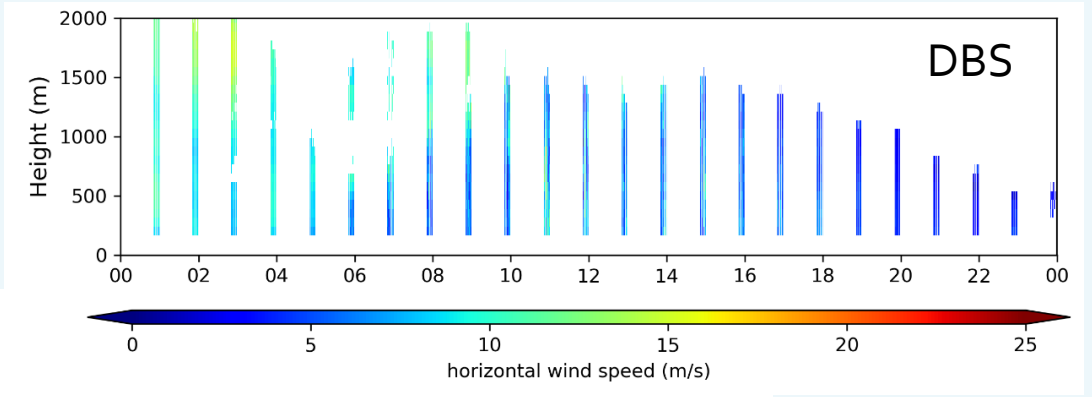
Vertical velocity

Vertical stare

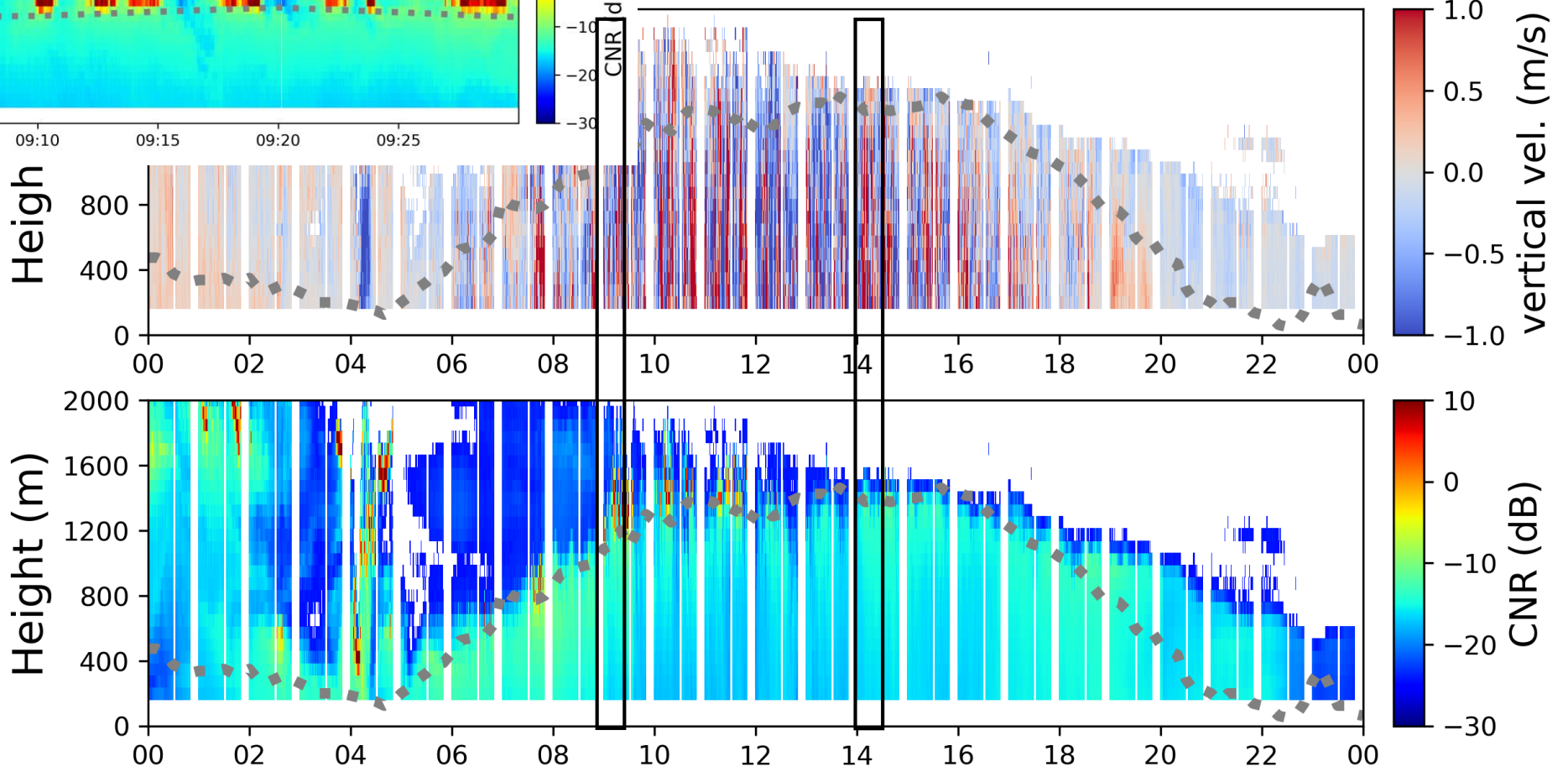
- *Most* of the time
- Frequency 1 Hz
- Vertical resolution 75 or 100 m
- June 22 to August 21, 2022





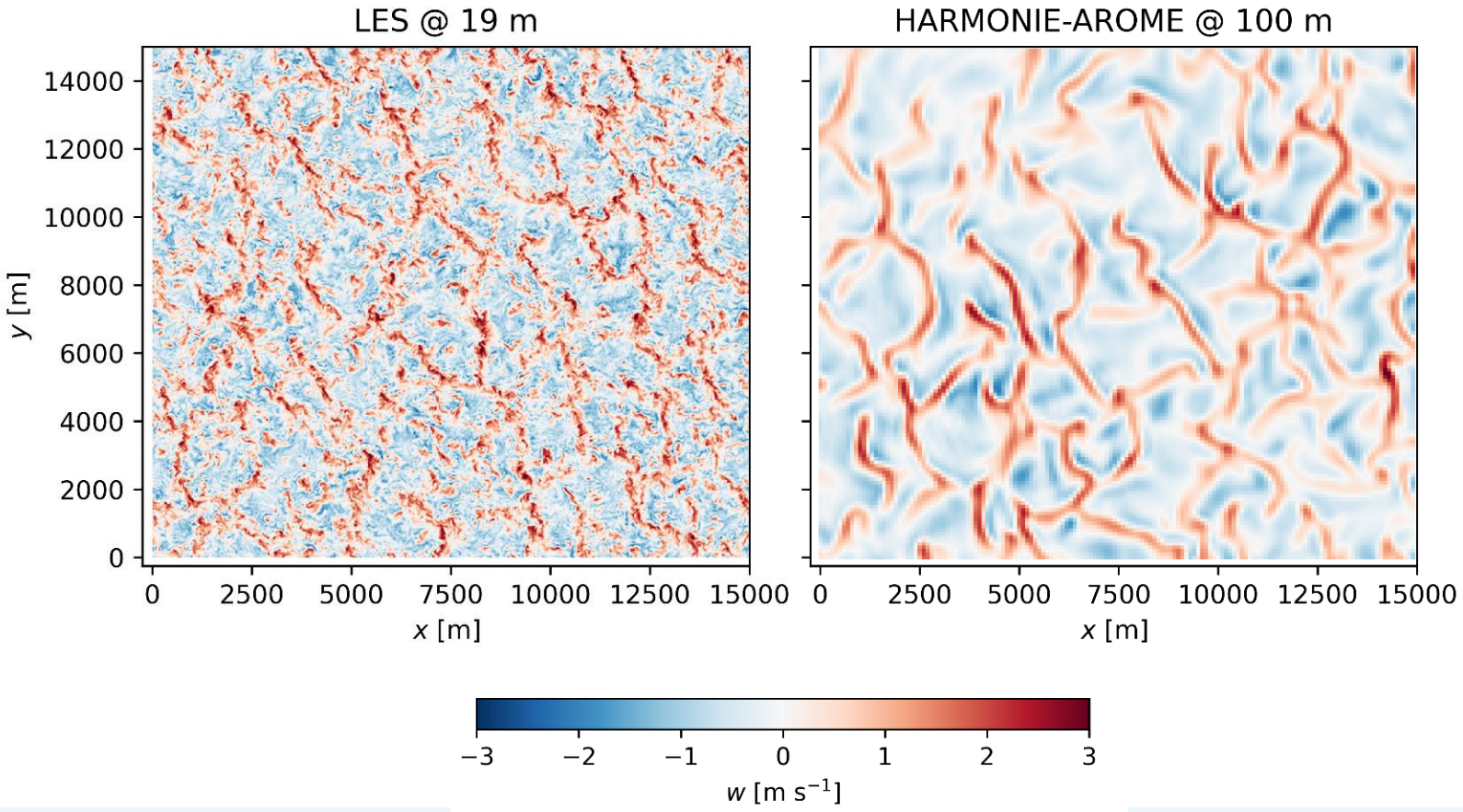


2022-07-16



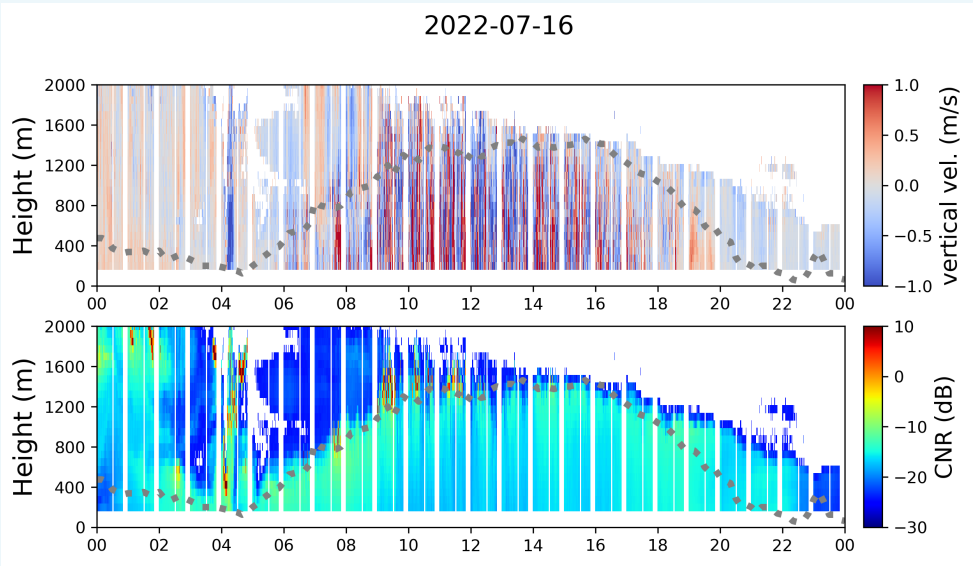
--- LCL (lifting condensation level)

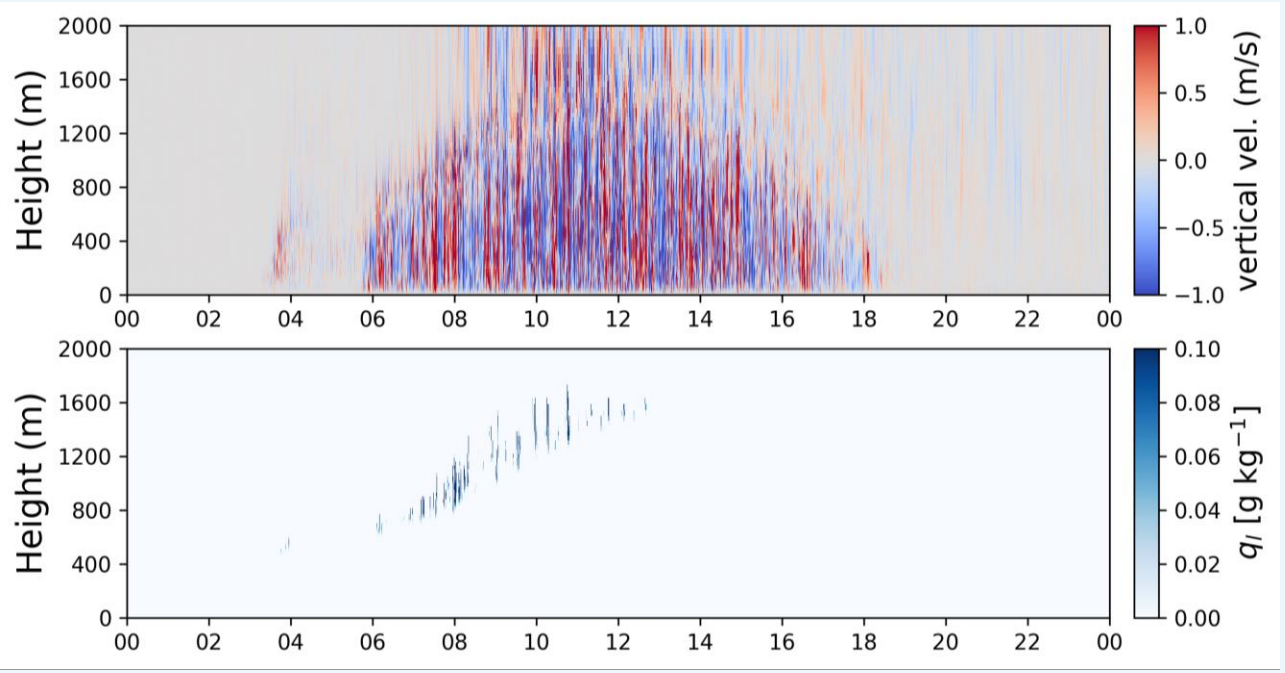
LES vs NWP



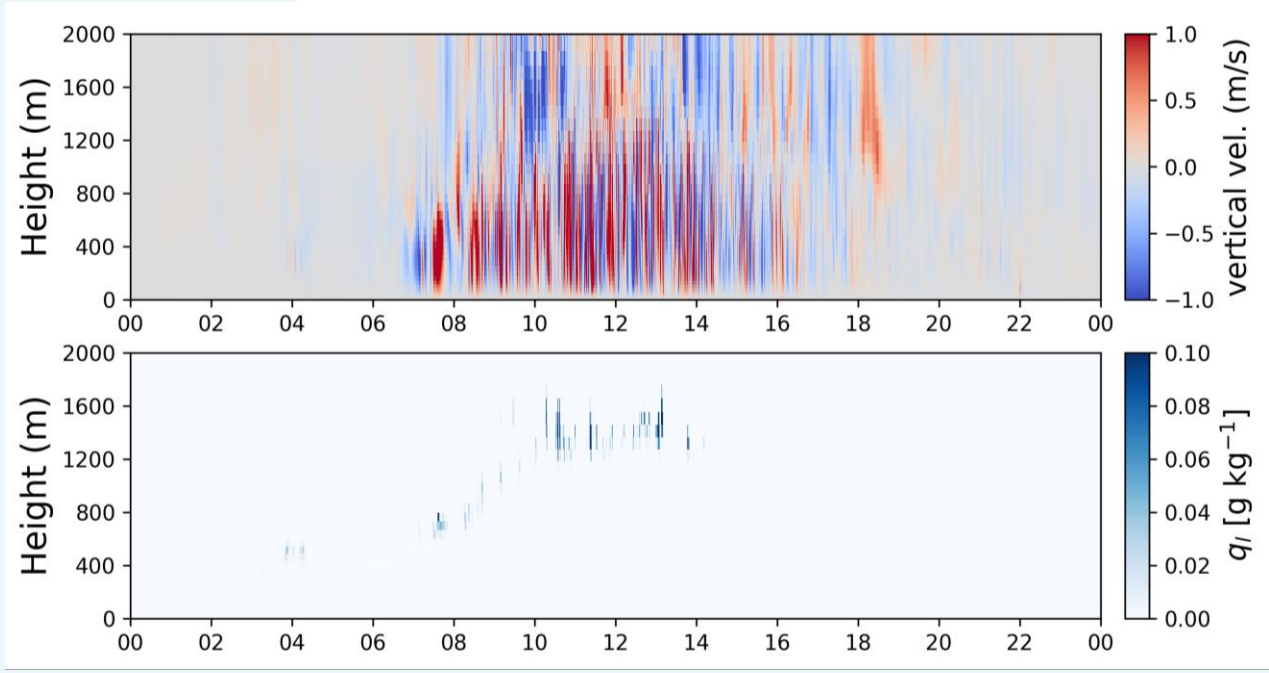
- 16 July 2022
- Both models centred around Cabauw
- HARMONIE-AROME:
  - 90 levels
  - Δx= Δy=100 m
  - No shallow-convection scheme
  - Nested in 500 m HARMONIE, nested in 2.5 km HARMONIE
- Large eddy simulation (DALES)
  - 160 levels
  - Δx= Δy=19 m
  - Using dynamical tendencies from 2.5 km HARMONIE
  - Periodic boundary conditions

Time-step output models



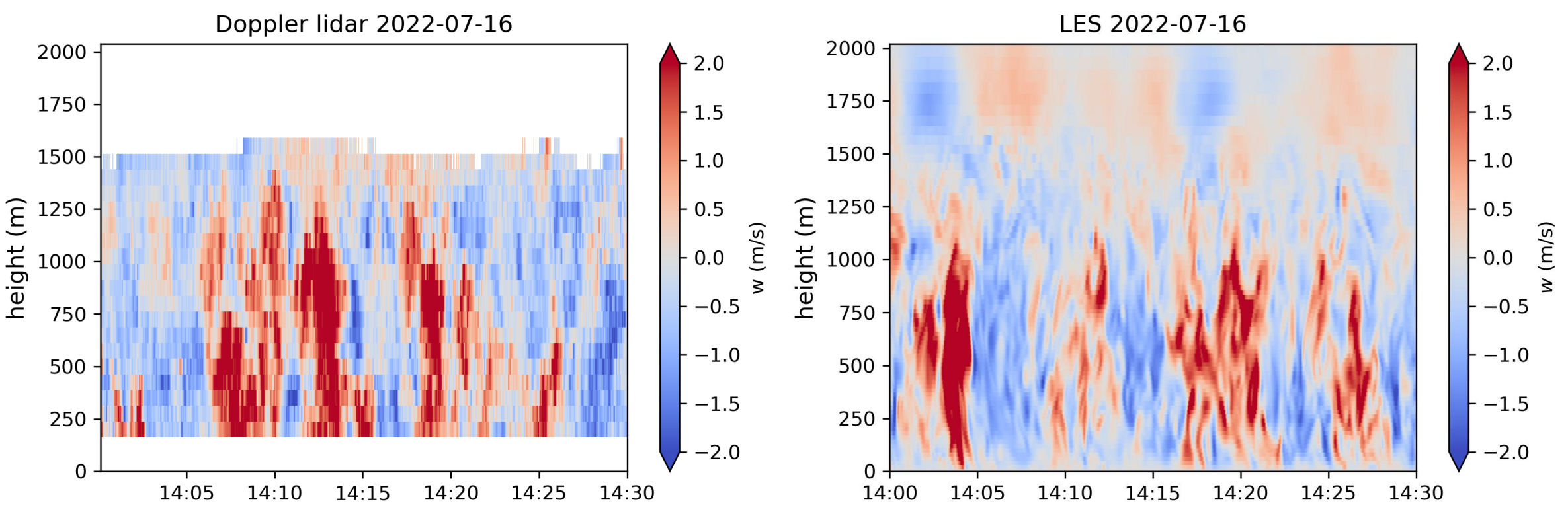


Large eddy simulation (DALES)
@ 19m resolution



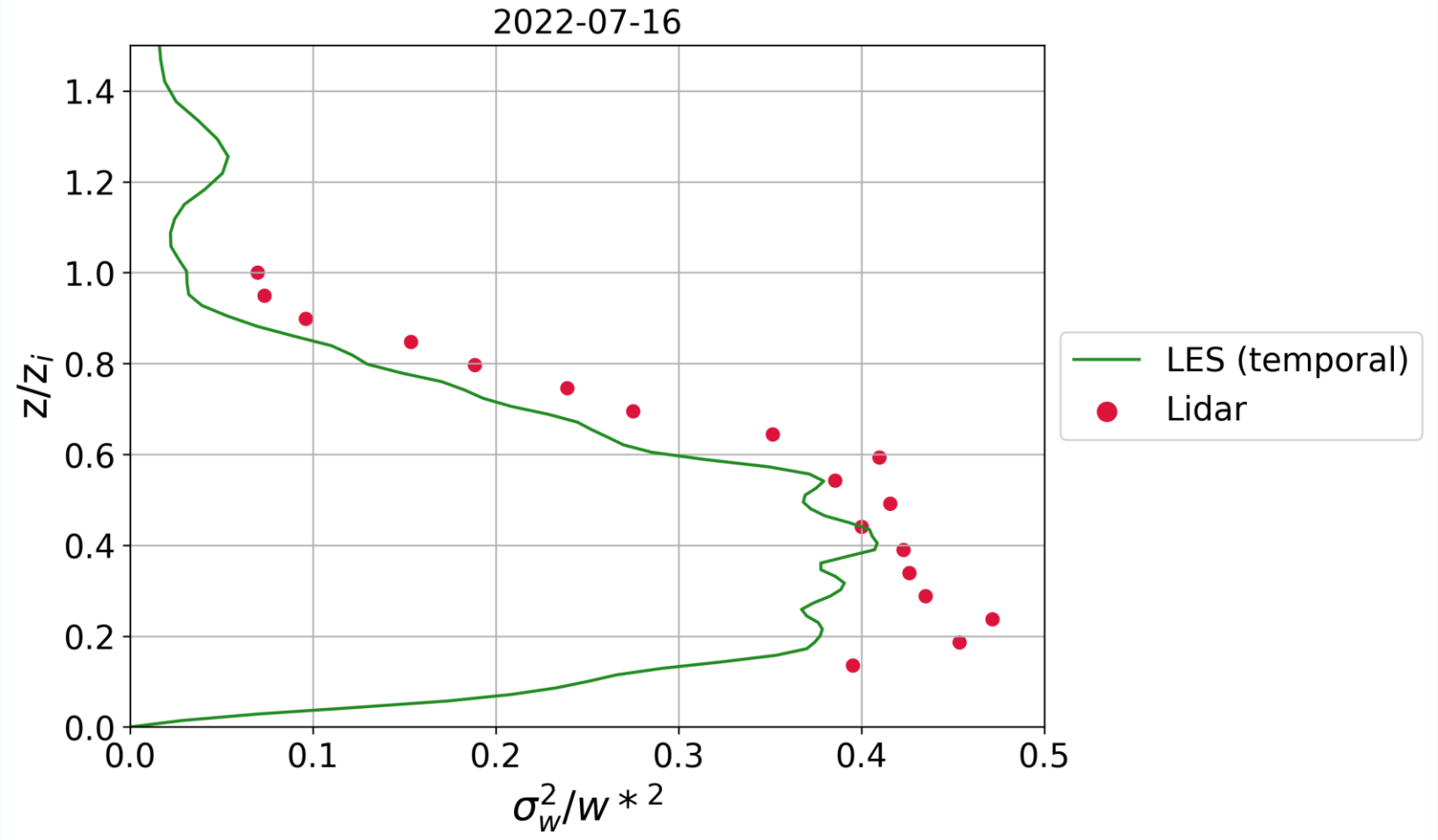
HARMONIE-AROME
@ 100m resolution

Comparison of the vertical velocity



Scaled variance

$$w^* = \left[\frac{g}{T_v}\, z_i \overline{w'\theta_v'}\right]^{1/3}$$



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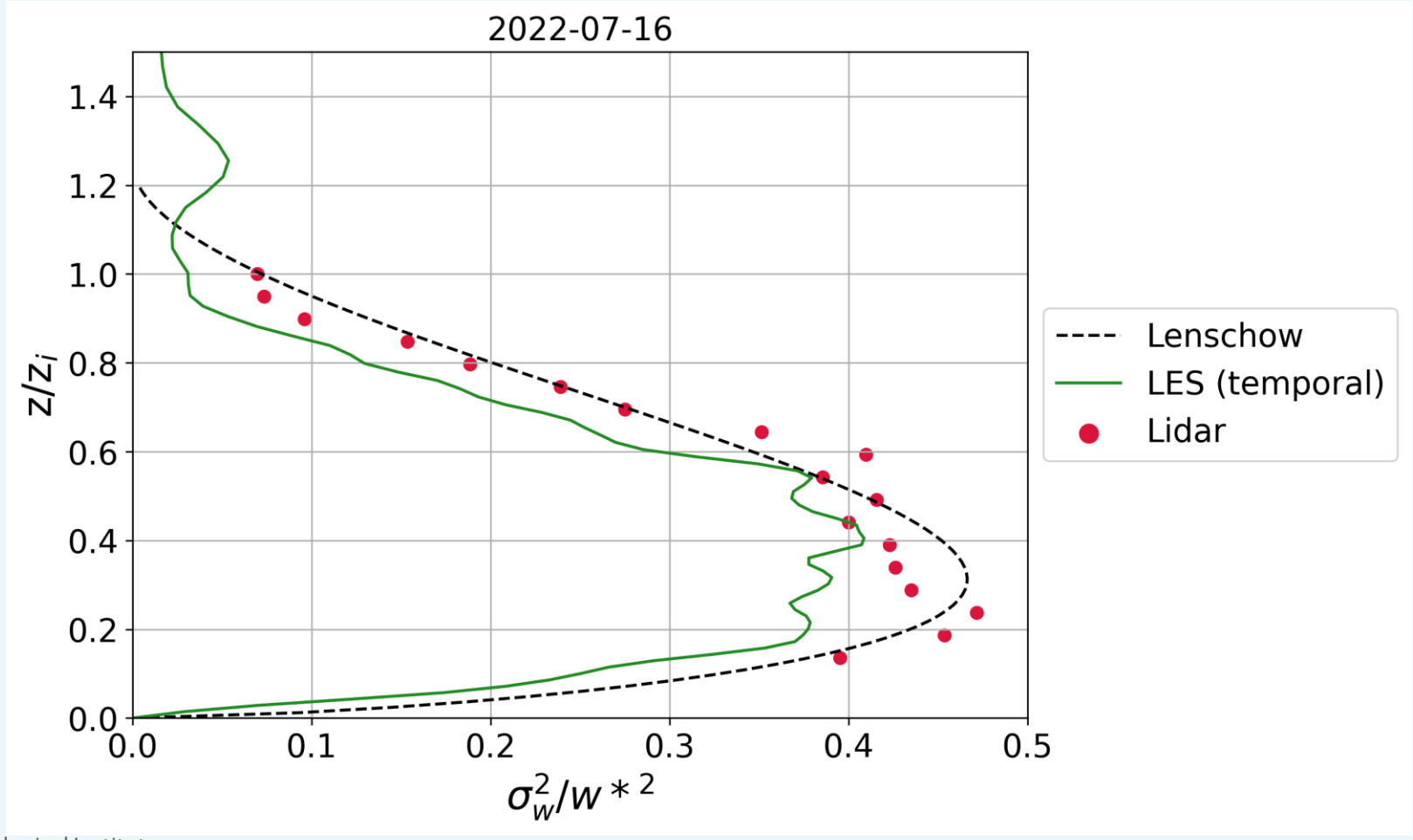
$$w^* = \left[\frac{g}{T_v} z_i \overline{w'\theta_v'}\right]^{1/3}$$



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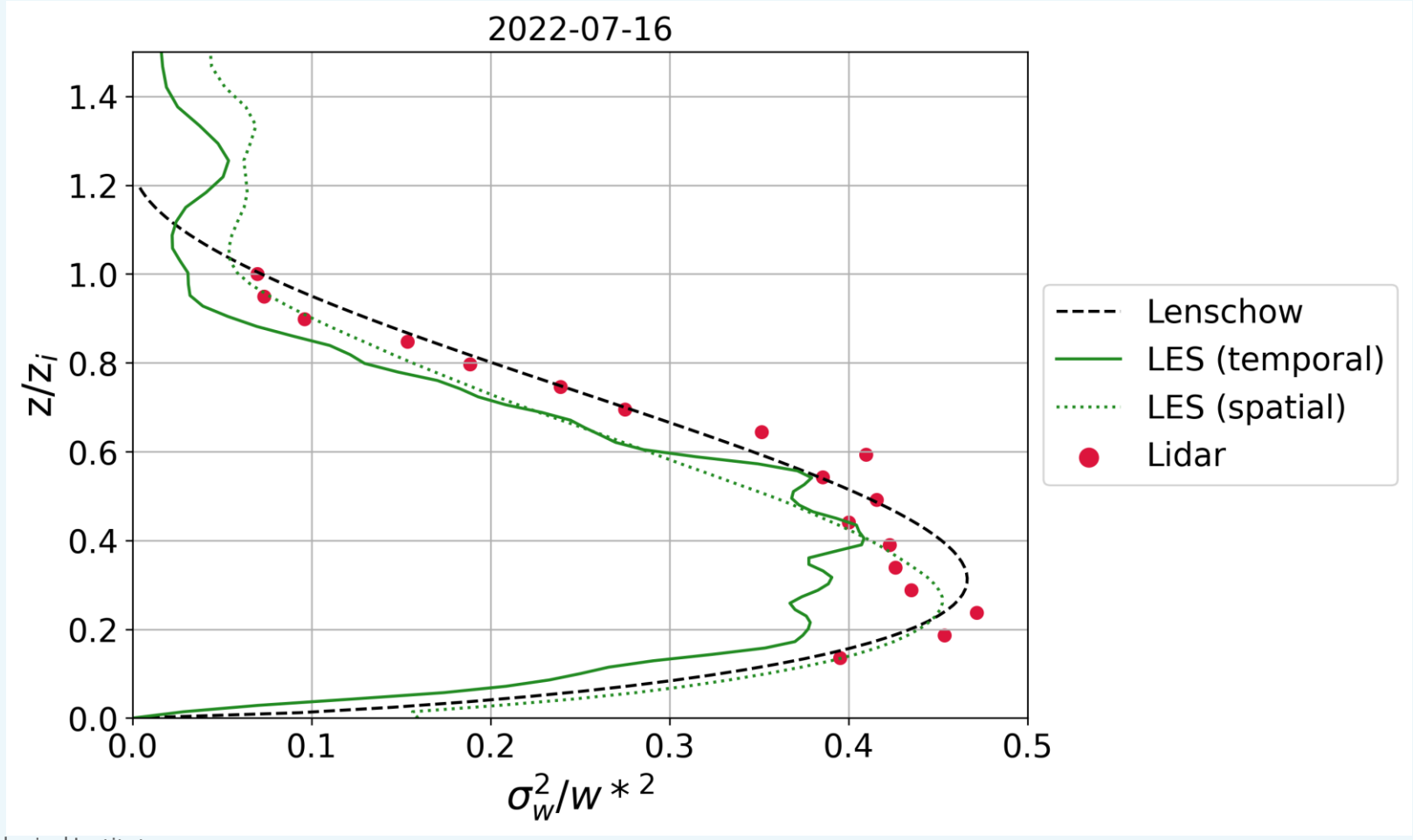

Scaled variance

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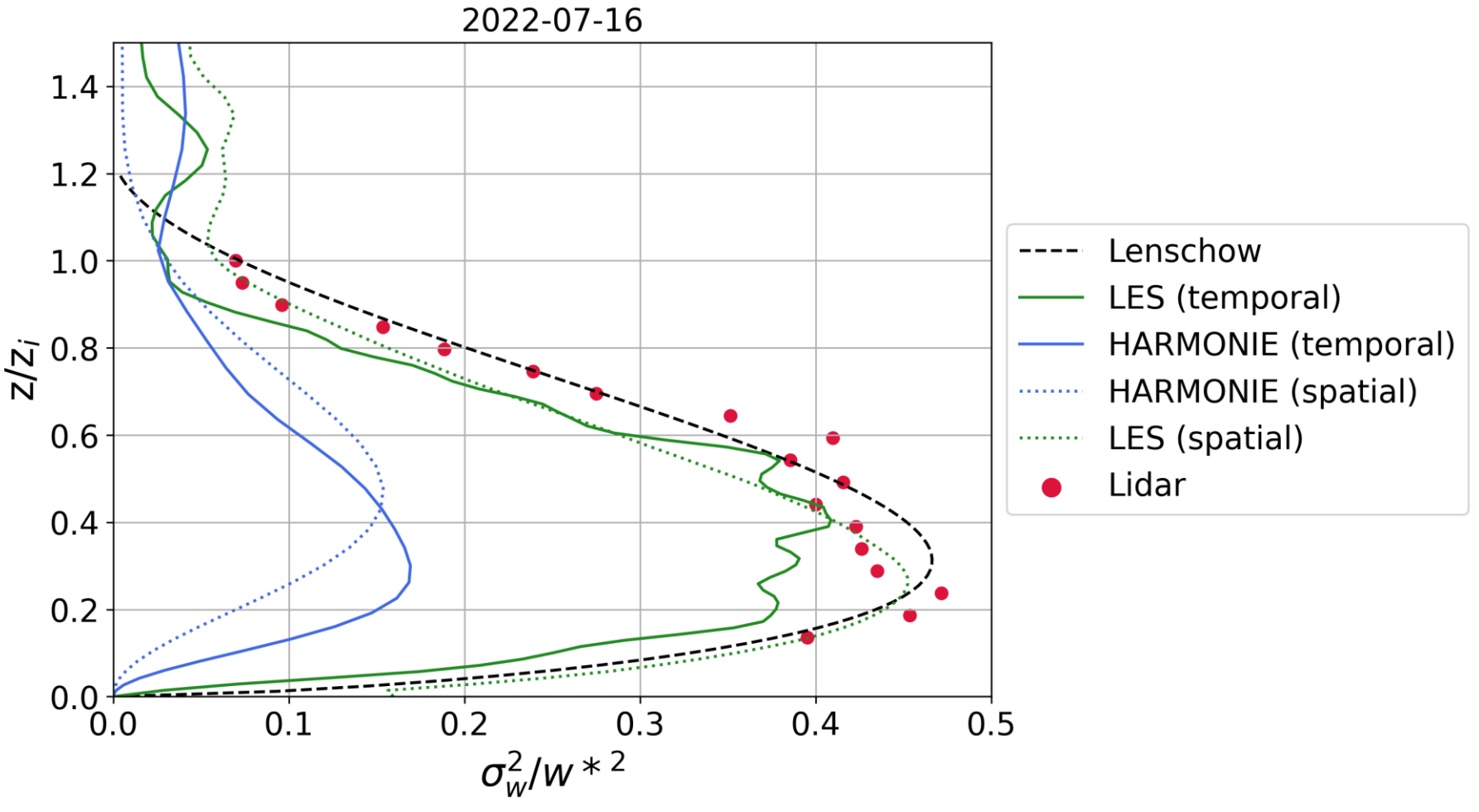
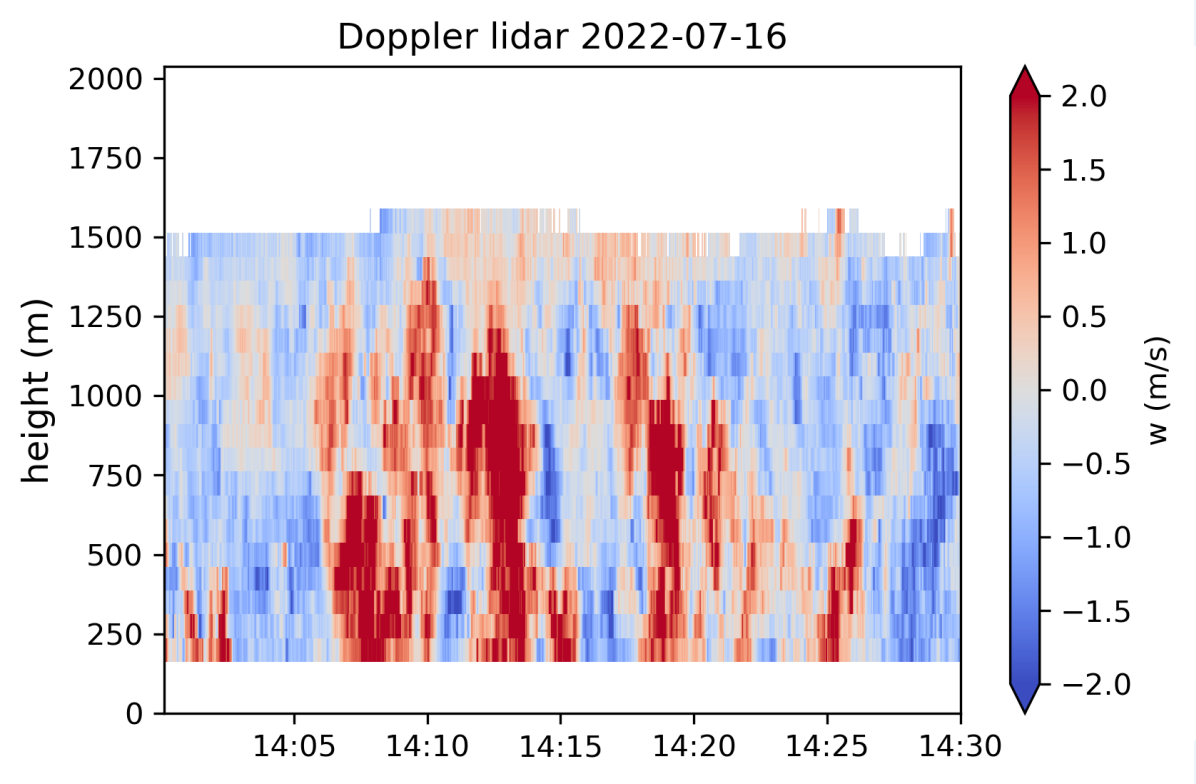
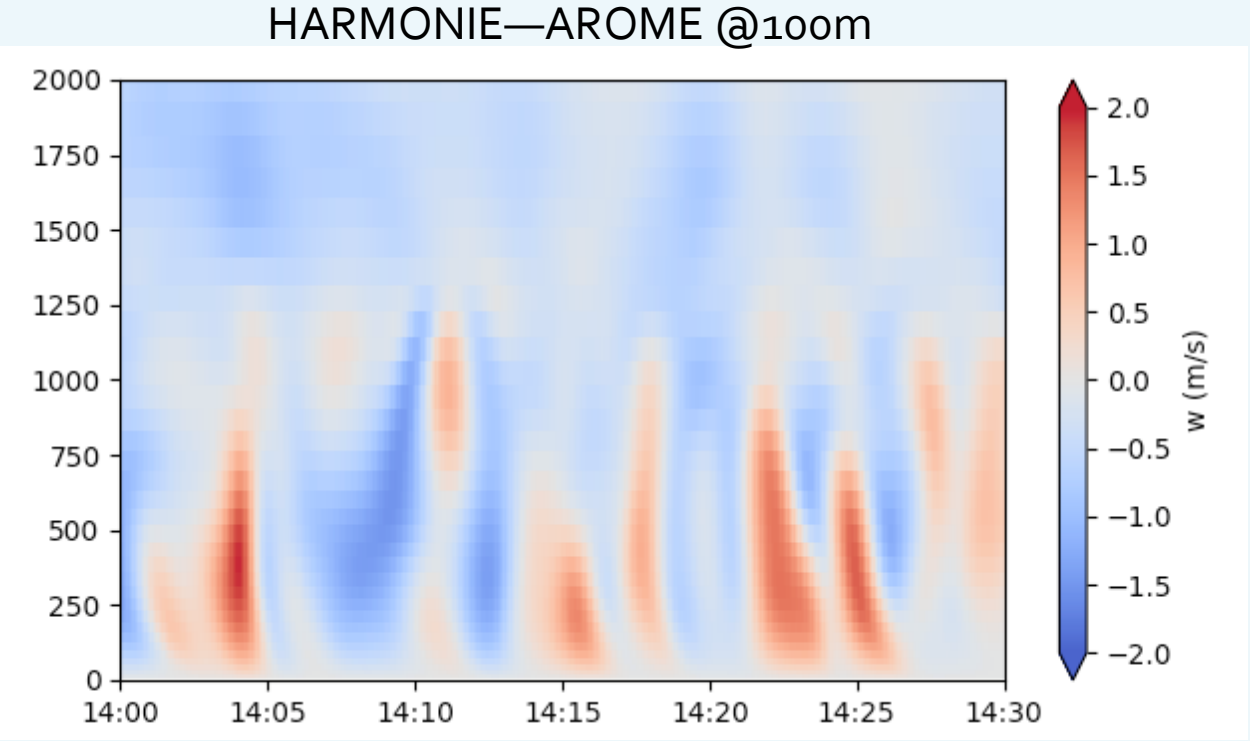


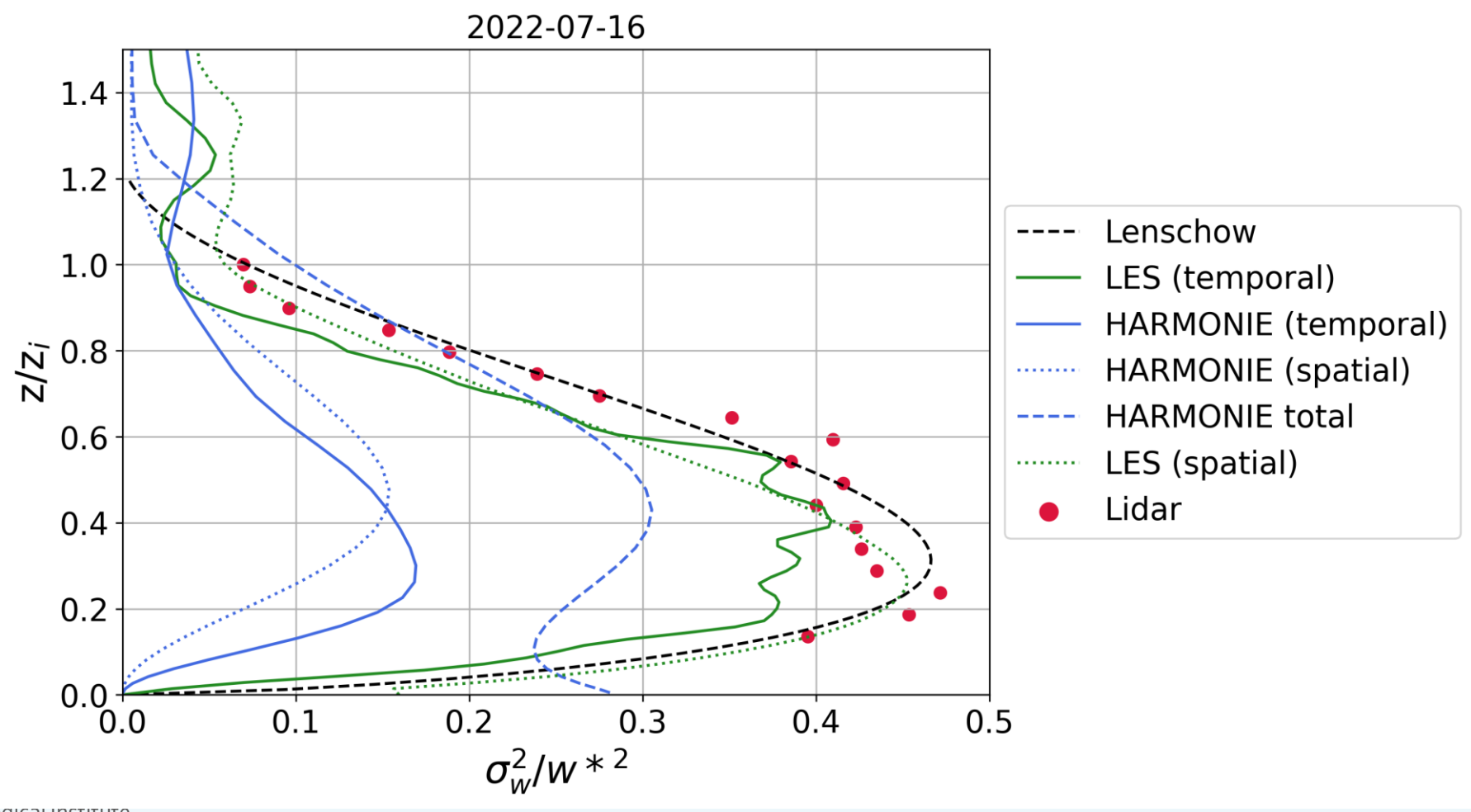
Comparison of the vertical velocity





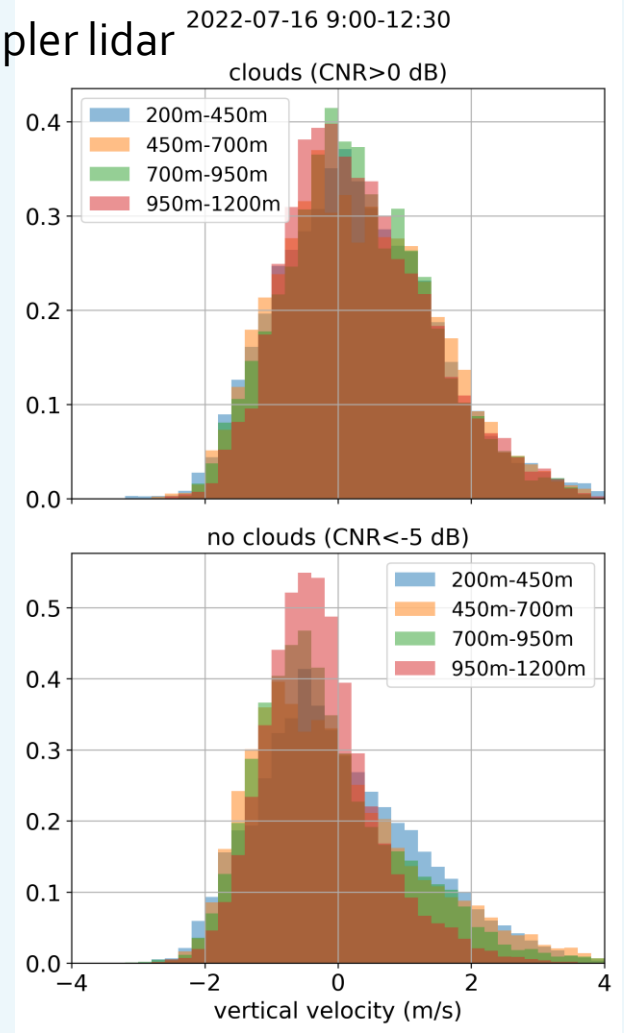
Scaled variance + add parameterised part

$$w^* = \left[\frac{g}{T_v} z_i \overline{w'\theta_v'}\right]^{1/3}$$

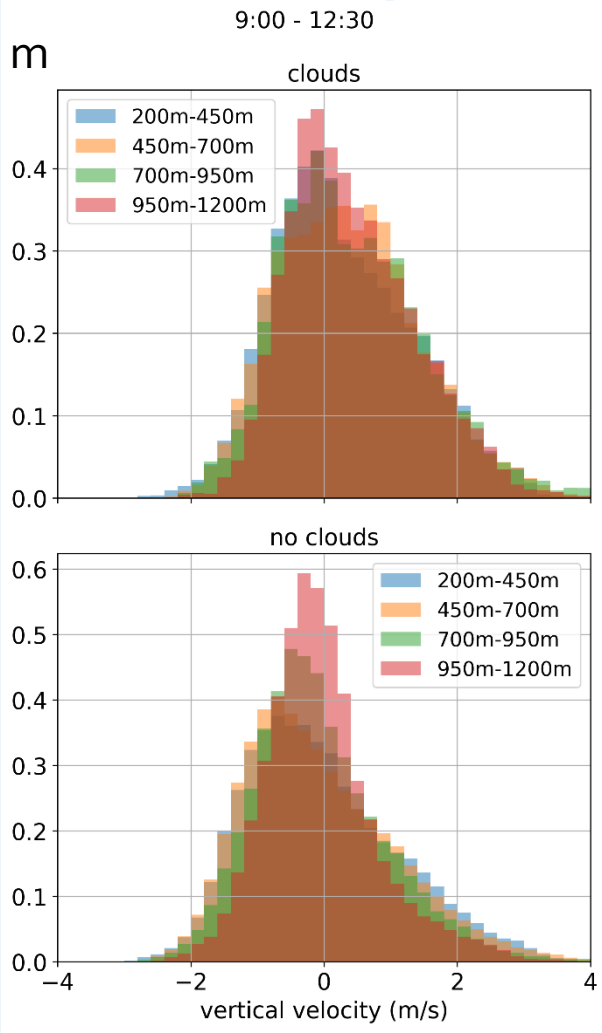


Distribution of vertical velocity

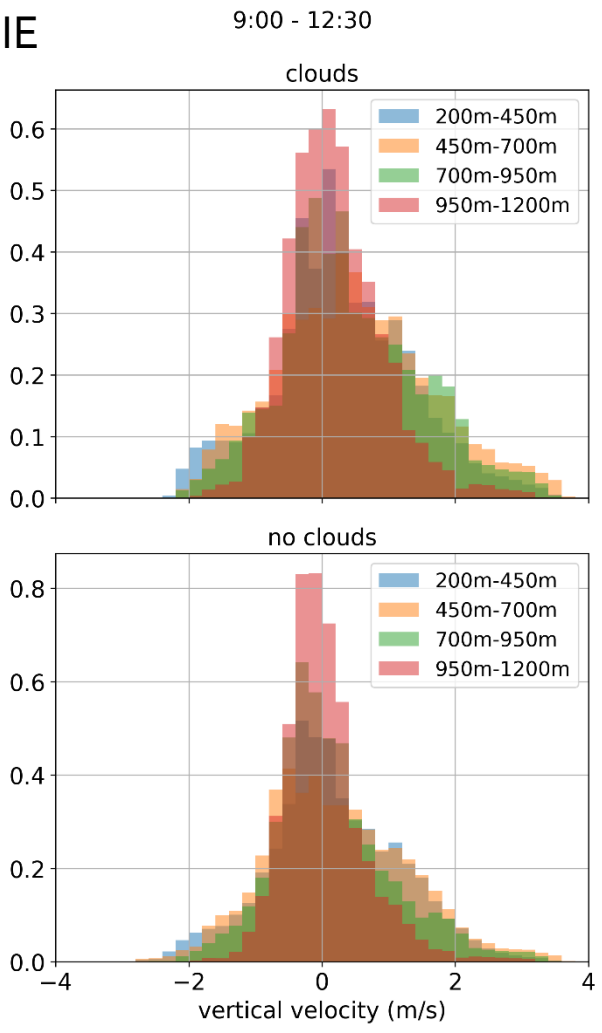
Doppler lidar



LES @19 m

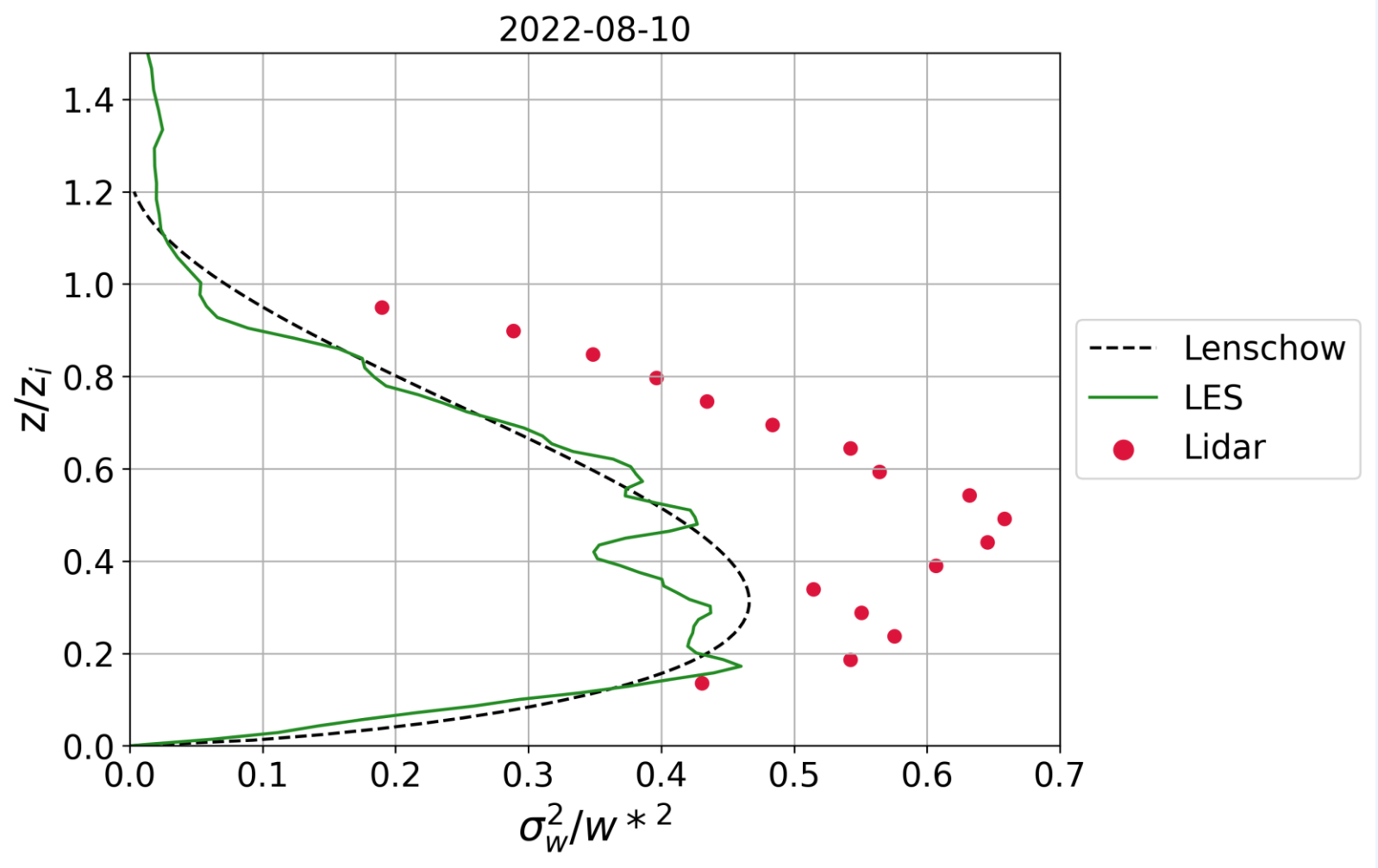


HARMONIE @100 m

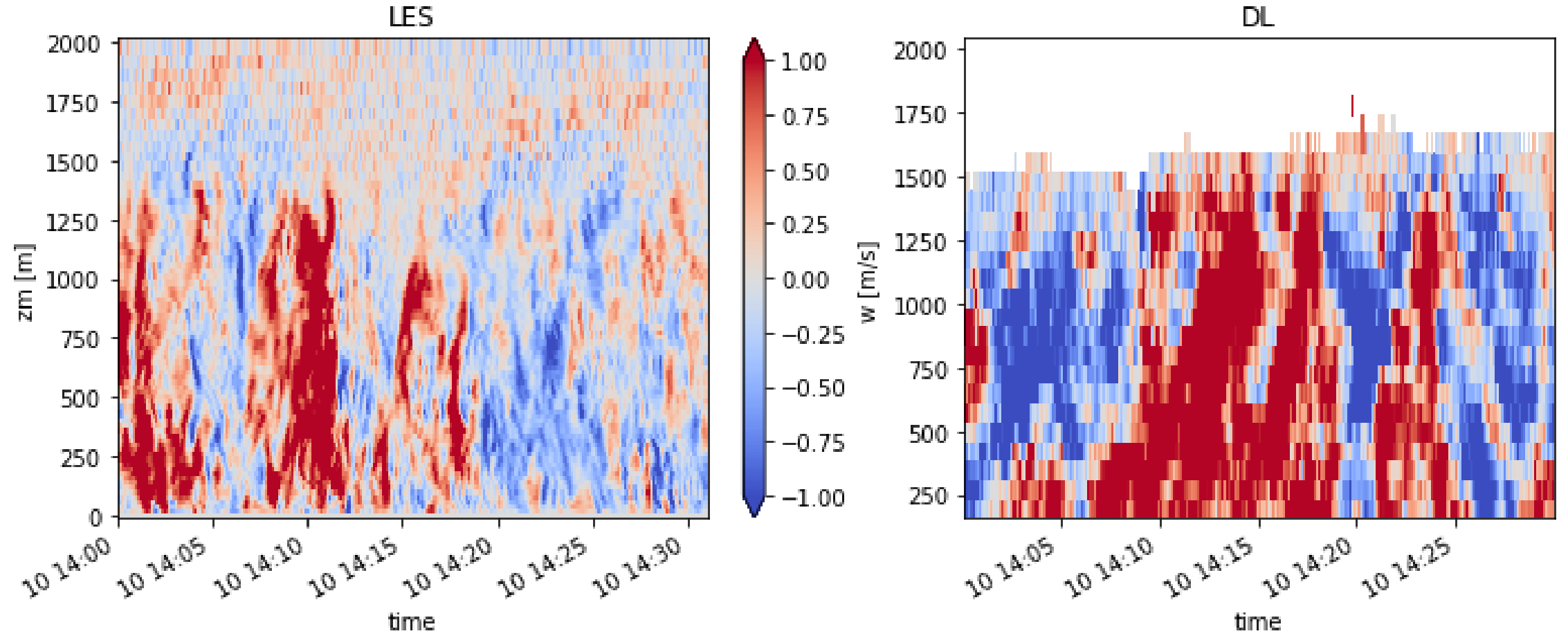


$$w^* = \left[\frac{g}{T_v} z_i \overline{w'\theta_v'}\right]^{1/3}$$

Does not always work



What's happening here?



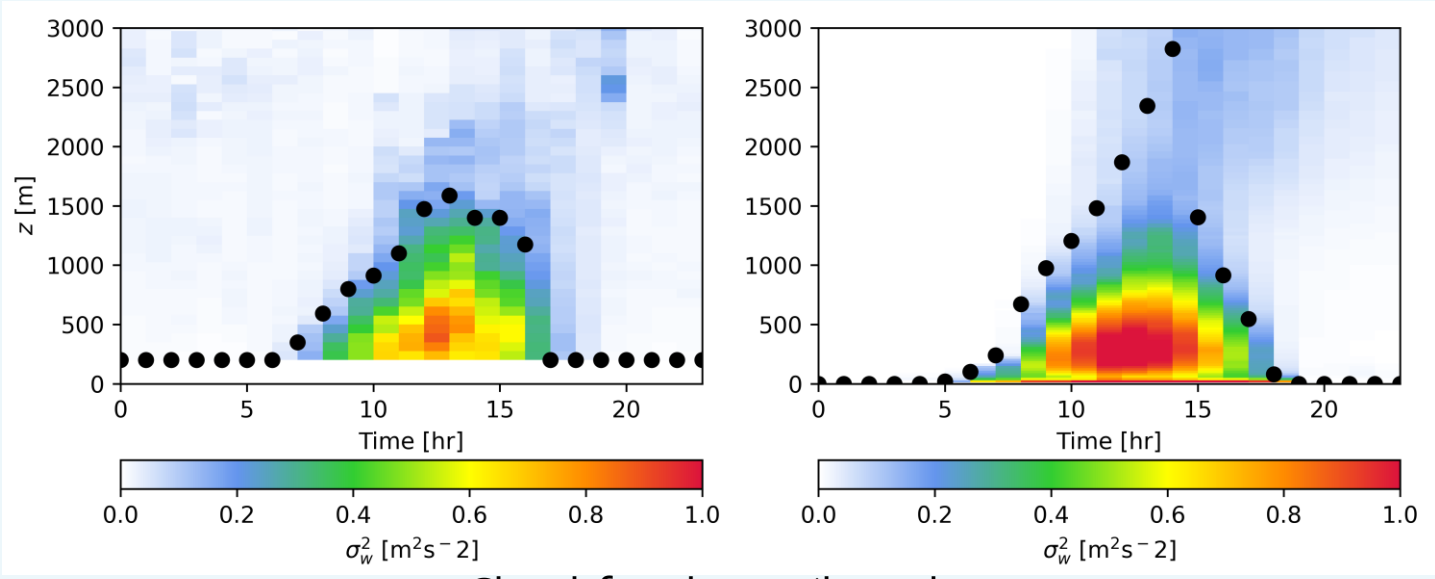
Velocity variance comparison

- Dates: 1 July – 21 August 2022
- Lidar: σ_w^2 over 1 hr (temporal)
- DALES: σ_w^2 over domain (spatial)
- Simple PBLH detection: Mixing height where σ_w^2>0.1

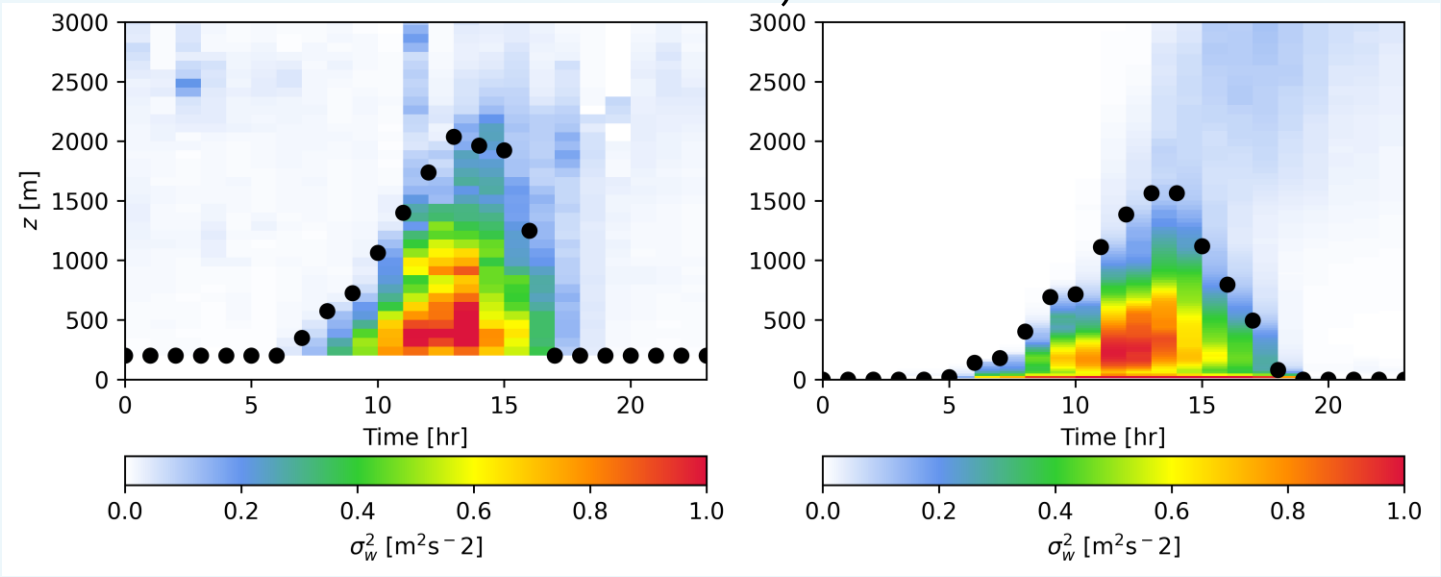
Doppler lidar

All cases

LES



Cloud-free hours (based on DALES)



Summary

- Lot of potential in doppler lidar measurements
- Combination with other remote sensing measurements
- LES valuable tool next to comparison of observations and NWP

Summary

- Lot of potential in doppler lidar measurements
- Combination with other remote sensing measurements
- LES valuable tool next to comparison of observations and NWP
- Much more to explore!