EMS 2023

Royal Netherlands Meteorological Institute
Ministry of Infrastructure and Water Management

Ruisdael observatory

Scanning Doppler lidar at Cabauw: study of the convective boundary layer in the summer of 2022

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KNMI, The Netherlands

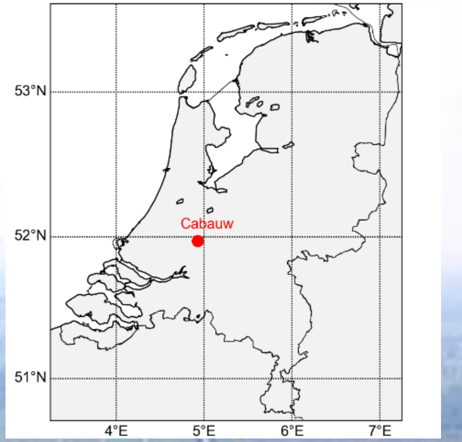
1) R&D **Observations** and Datatechnology

2) R&D Weather and Climate **Models**

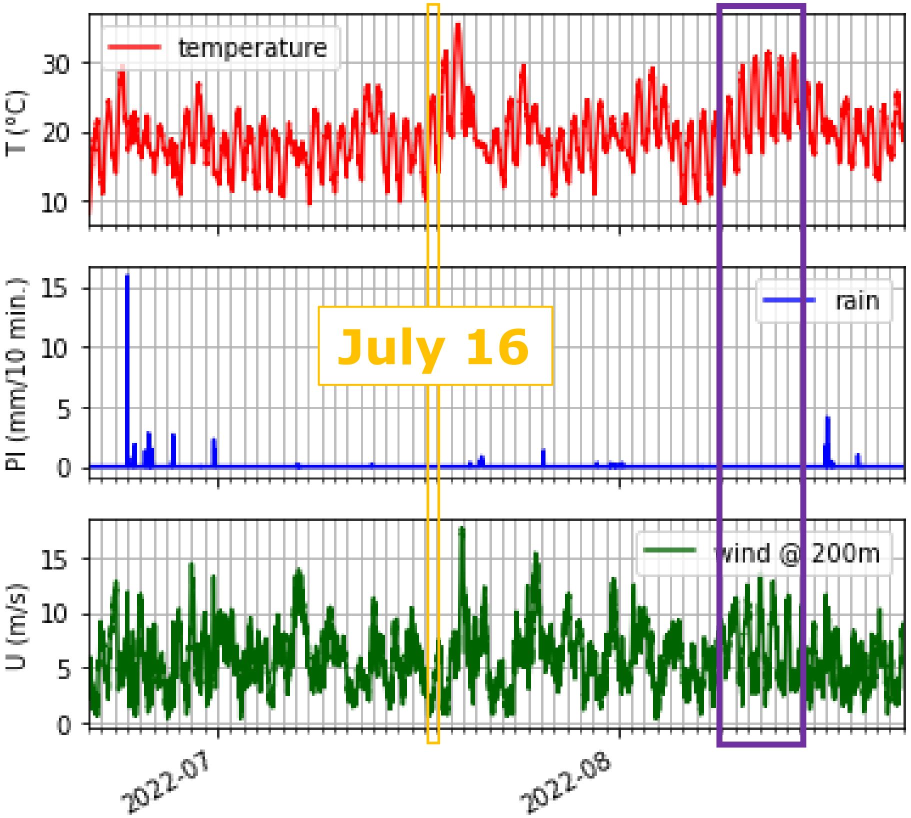
SCREEN CAPTURE WELCOME

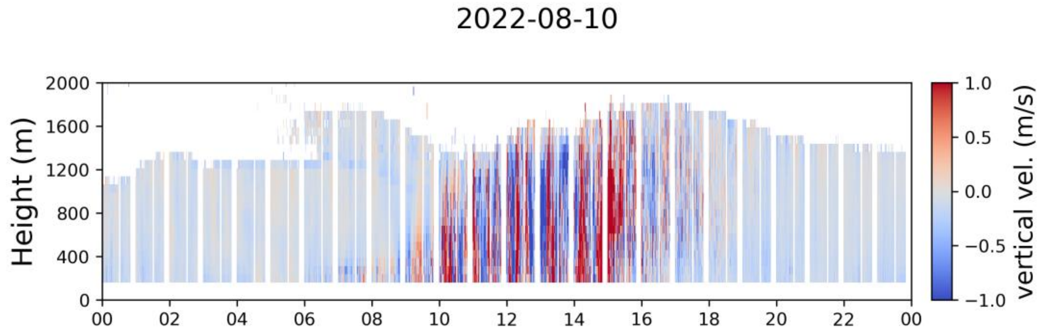
Summer 2022 Doppler lidar campaign

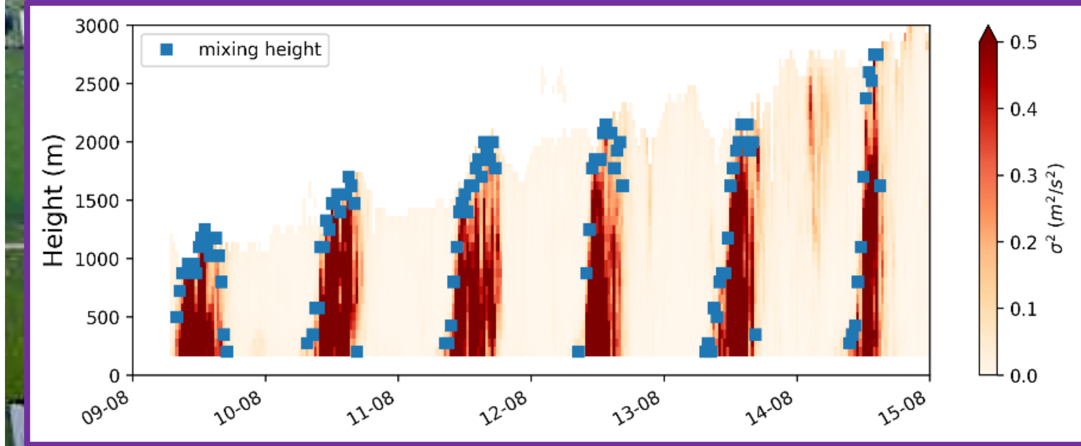
When: June 22 – August 21
Doppler lidar: Windcube200S
Vertical stare (1s) + DBS + PPI
100m/75m resolution

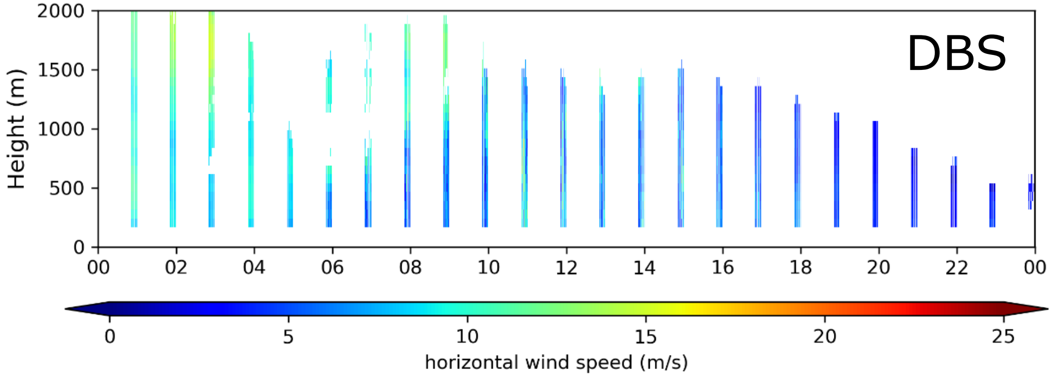


total days: 61
06:00-16:00 UTC
cloud free days: 4
(8 <7km)
rain days: 10
cumulus: ~20

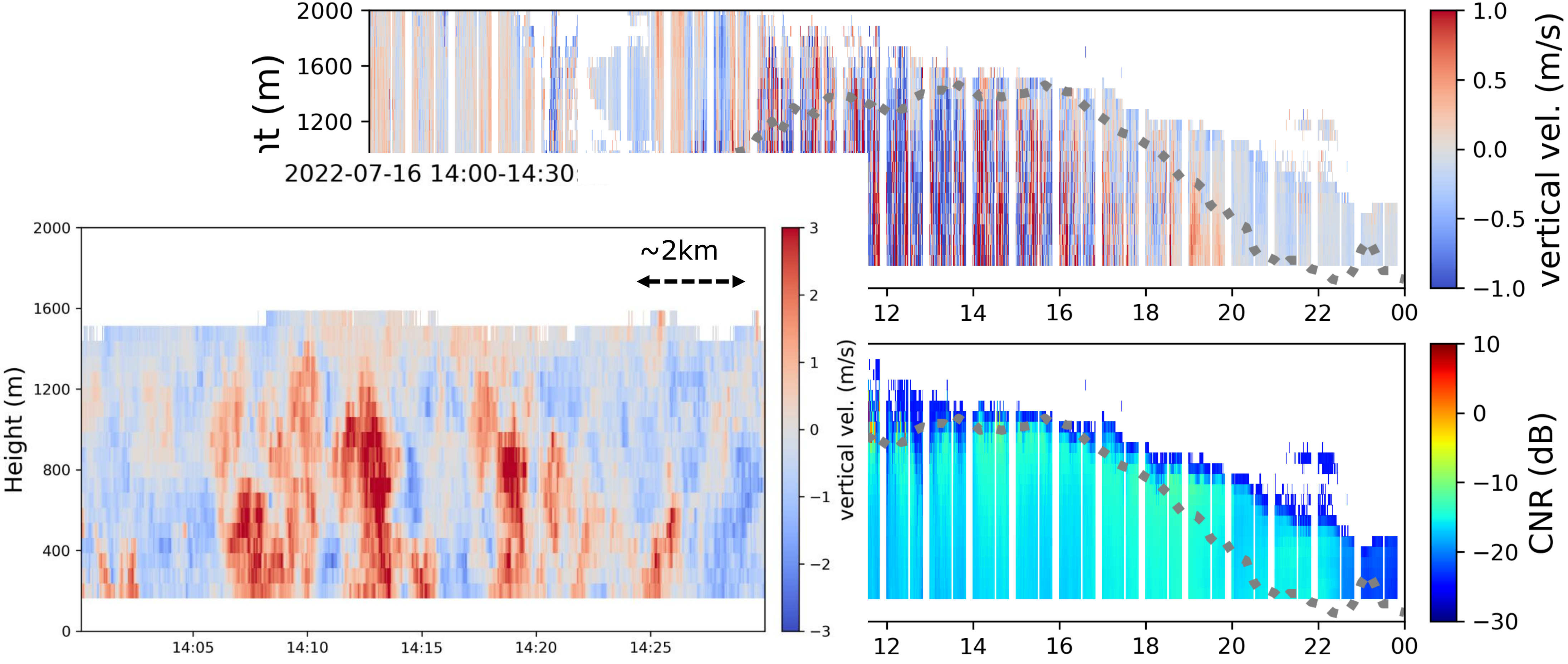








2022-07-16

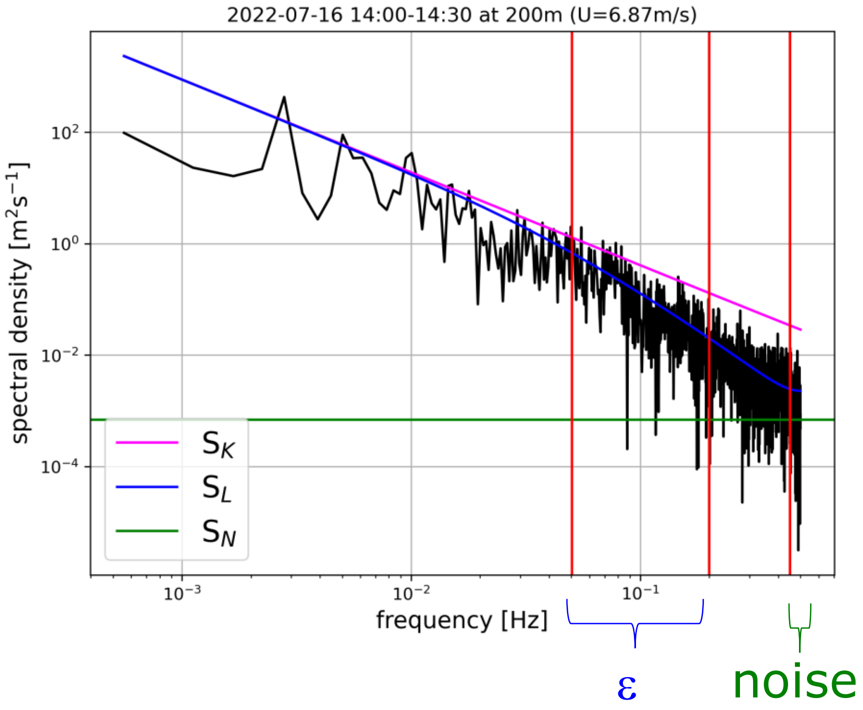


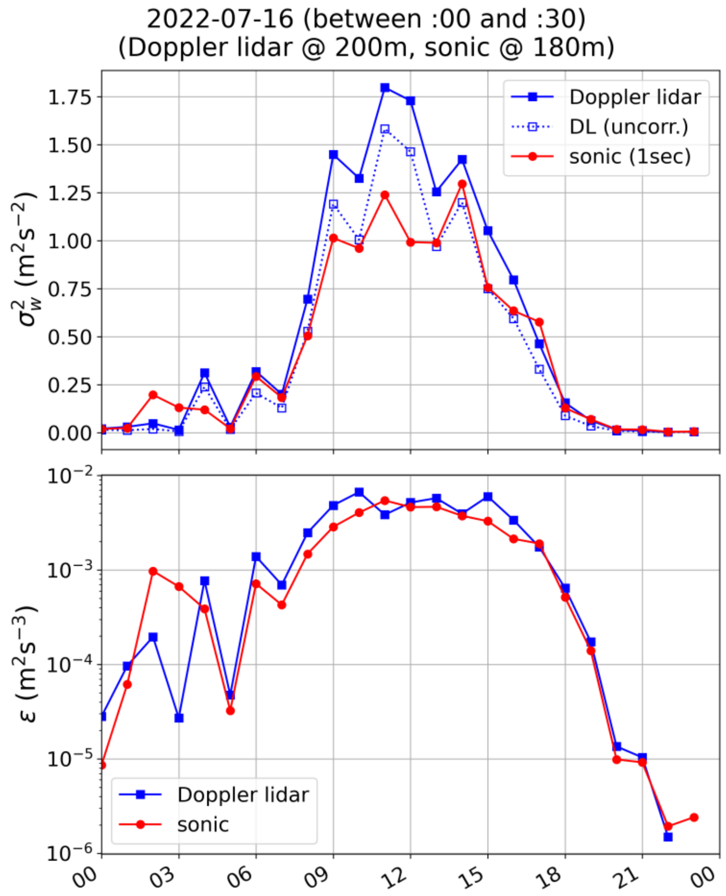
--- LCL

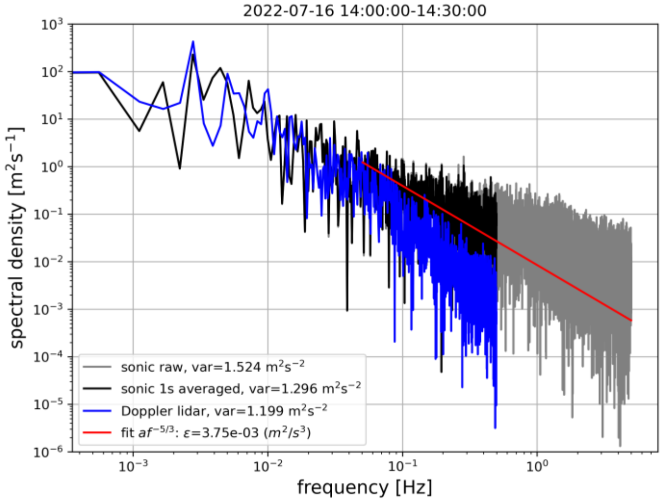
variance σ_w^2
Eddy dissipation rate ε

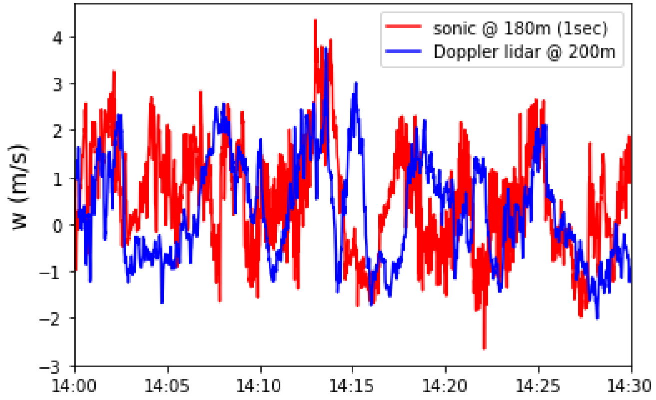
sonic comparison
(~300m away)

Spectral analysis (Banakh et al 2021)







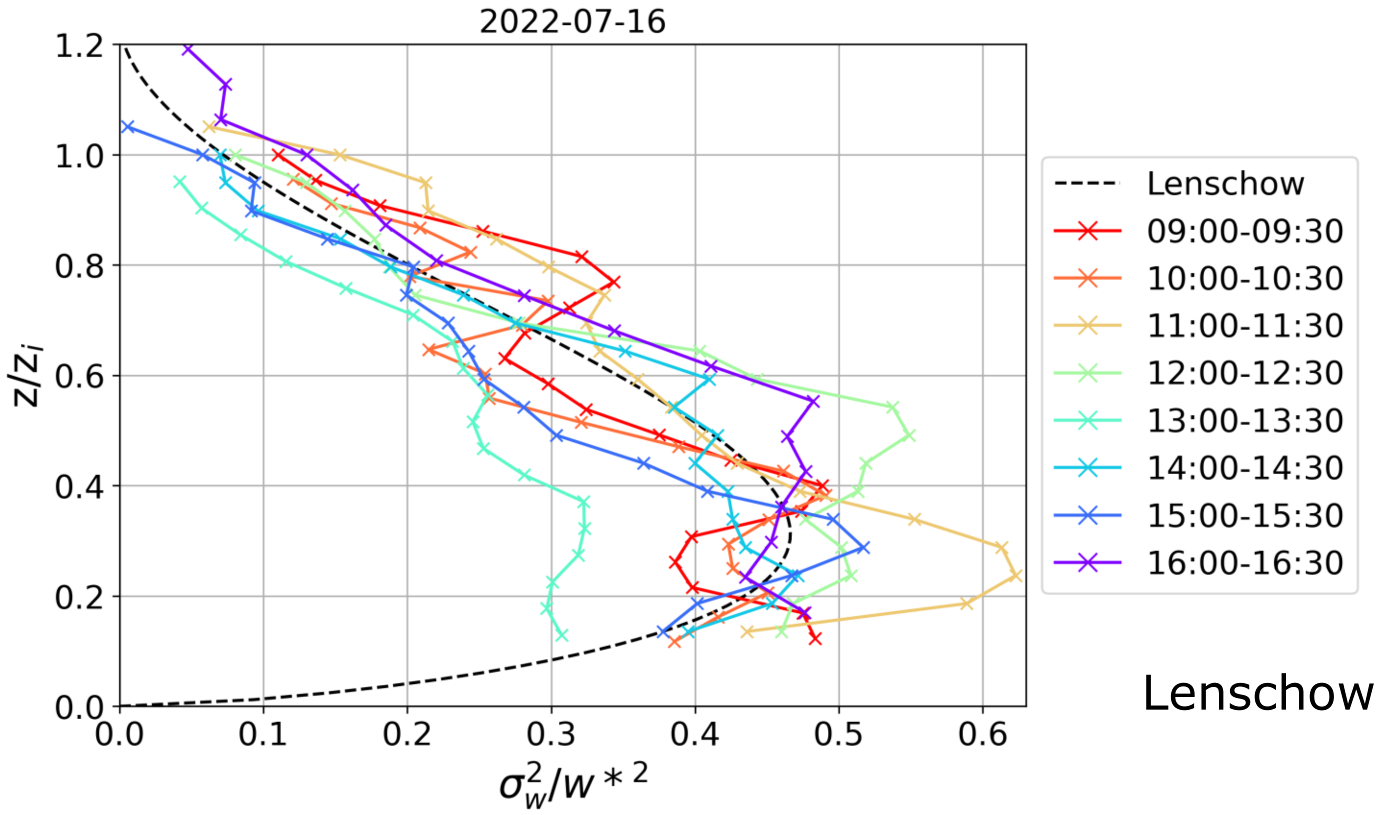


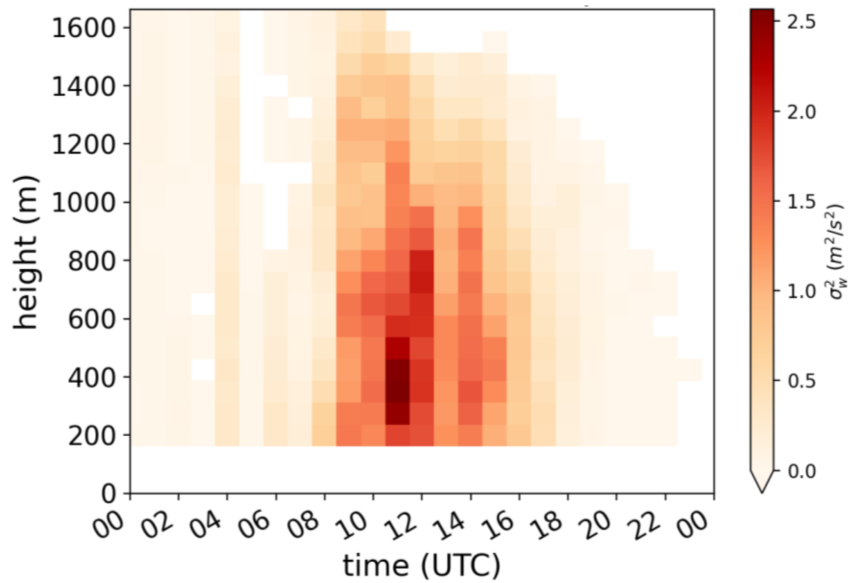
$$S_K = 0.0974(\varepsilon U)^{2/3} f^{-5/3}$$

S_L takes into account noise and probe volume (75m); requires U; outputs corrected σ_w^2 and ε

Banakh, Smalikho, Falits, Sherstobitov, Remote Sensing 2021
Estimating the Parameters of Wind Turbulence from Spectra of Radial Velocity Measured by a Pulsed Doppler Lidar

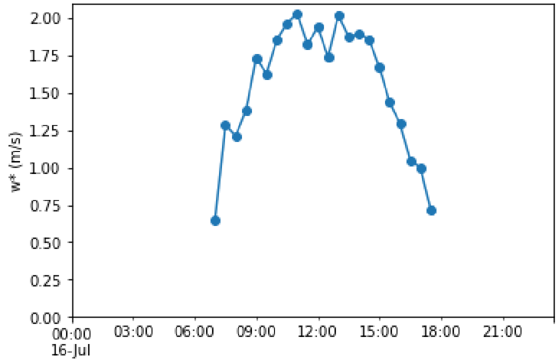
Scaled variance profiles





Deardorff convective velocity scale

$$w^* = \left(\frac{g z_i \overline{w'\theta'}}{\theta}\right)^{1/3}$$

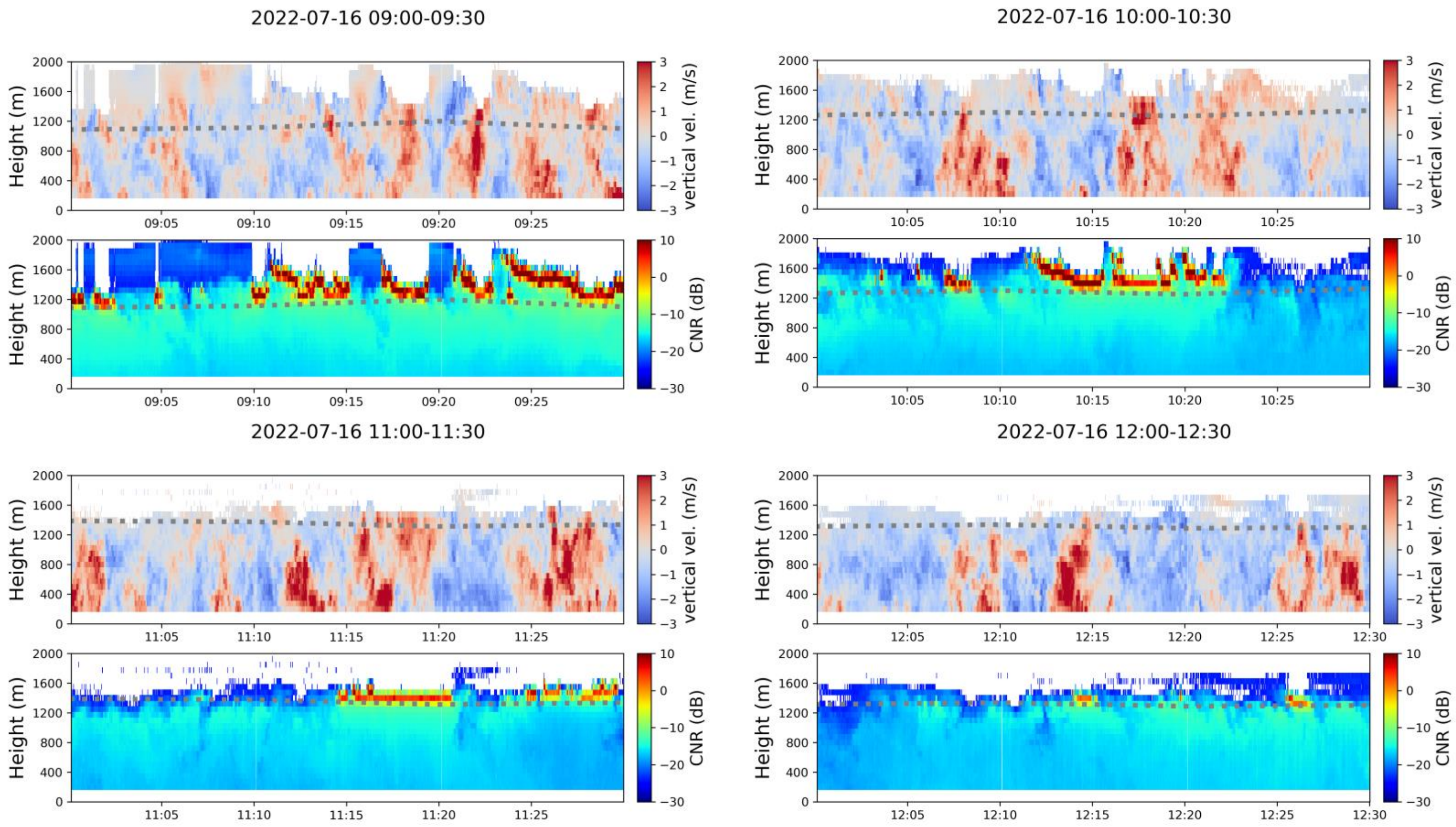


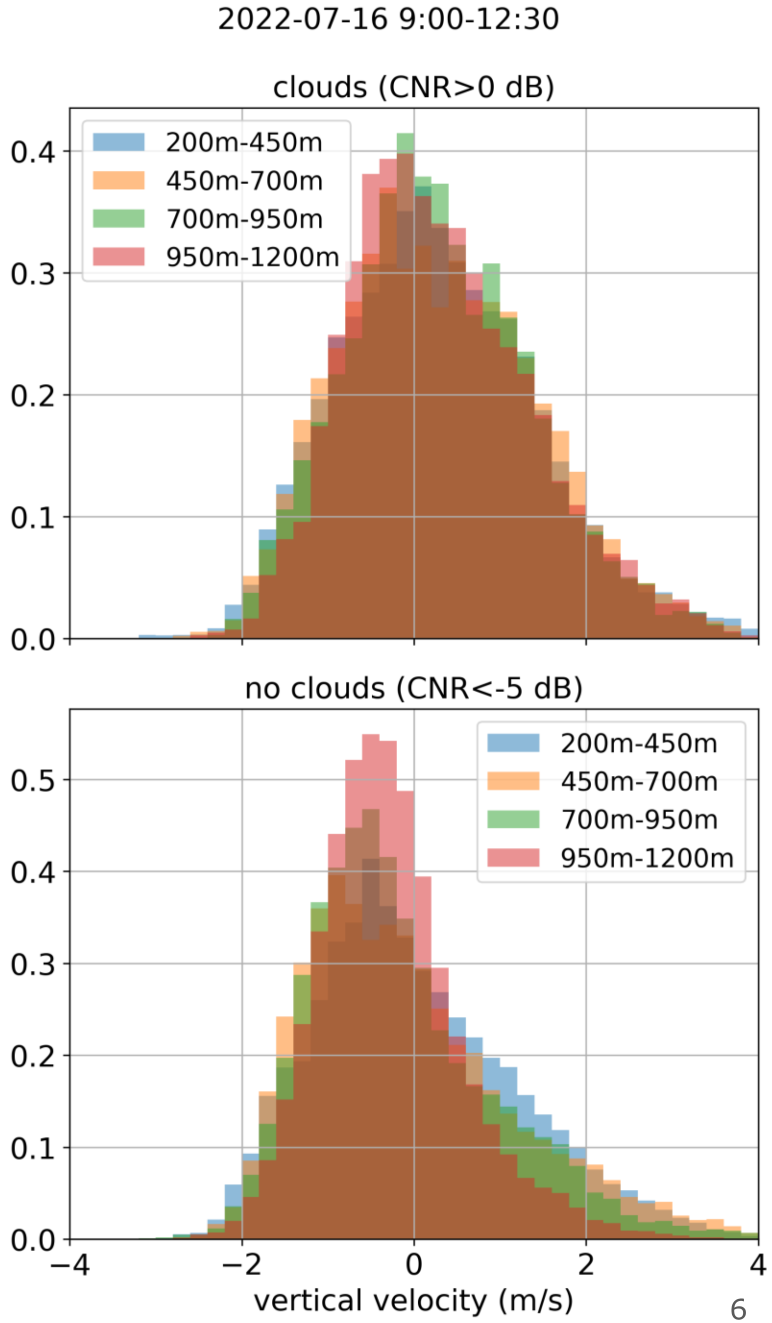
Lenschow et al (1980)

$$\frac{\sigma_w^2}{w^{*2}} = 1.8\left(\frac{z}{z_i}\right)^{2/3}\left(1 - 0.8\frac{z}{z_i}\right)^2$$

e. g. Dewani, Sakradzija, Schlemmer, Leinweber, Schmidli, Atmos. Chem. Phys. 2023
Dependency of vertical velocity variance on meteorological conditions in the convective boundary layer

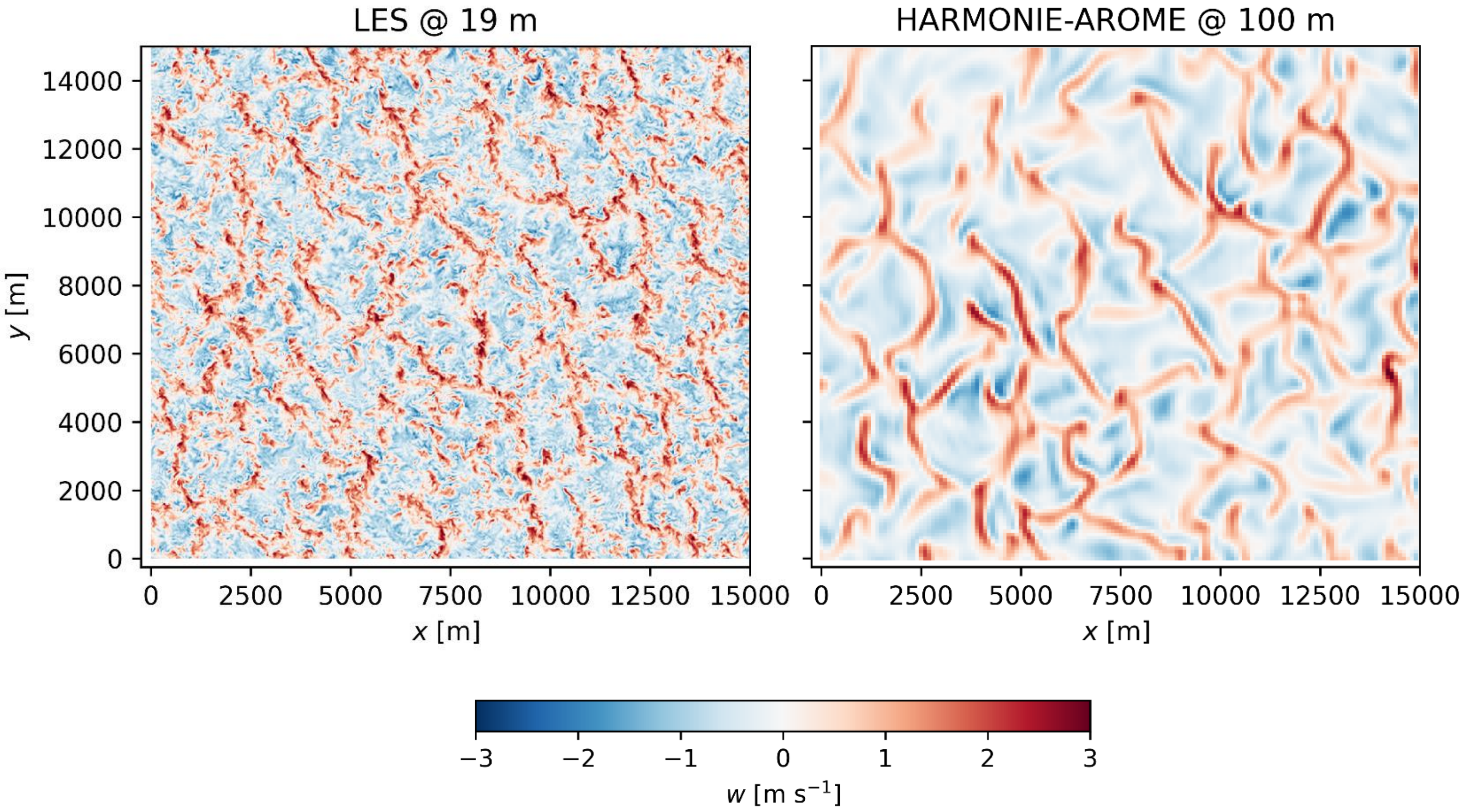
Distribution of vertical velocity





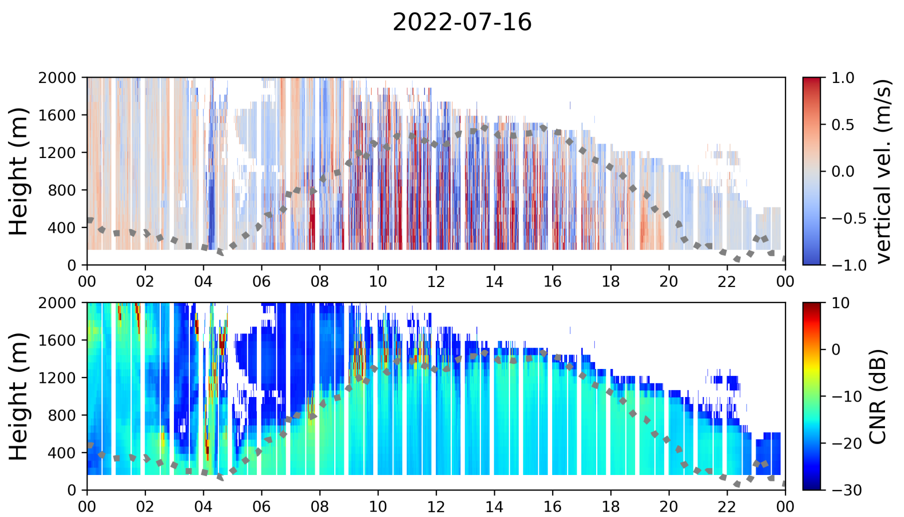
e. g. McMichael *et al*, Geophysical Review Letters 2020
Characterizing Subsiding Shells in Shallow Cumulus Using Doppler Lidar and Large-Eddy Simulation

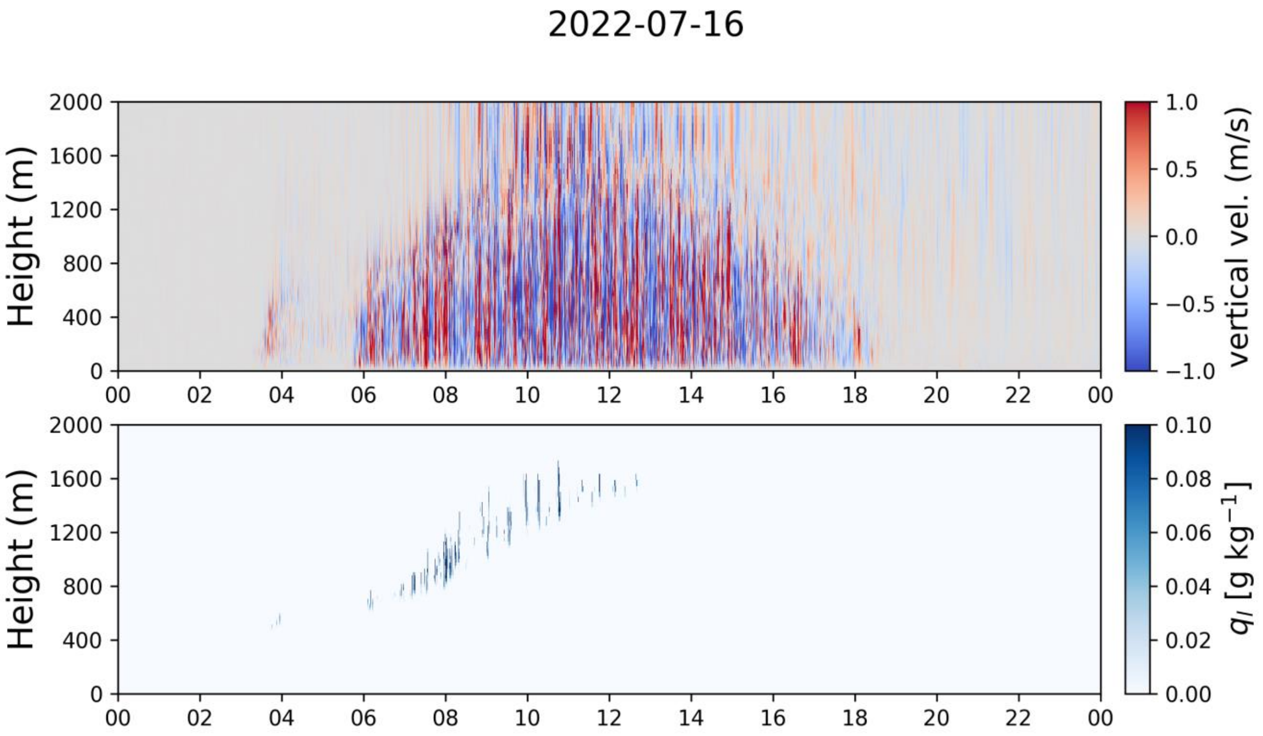
Numerical weather prediction modelling at 100-m scale



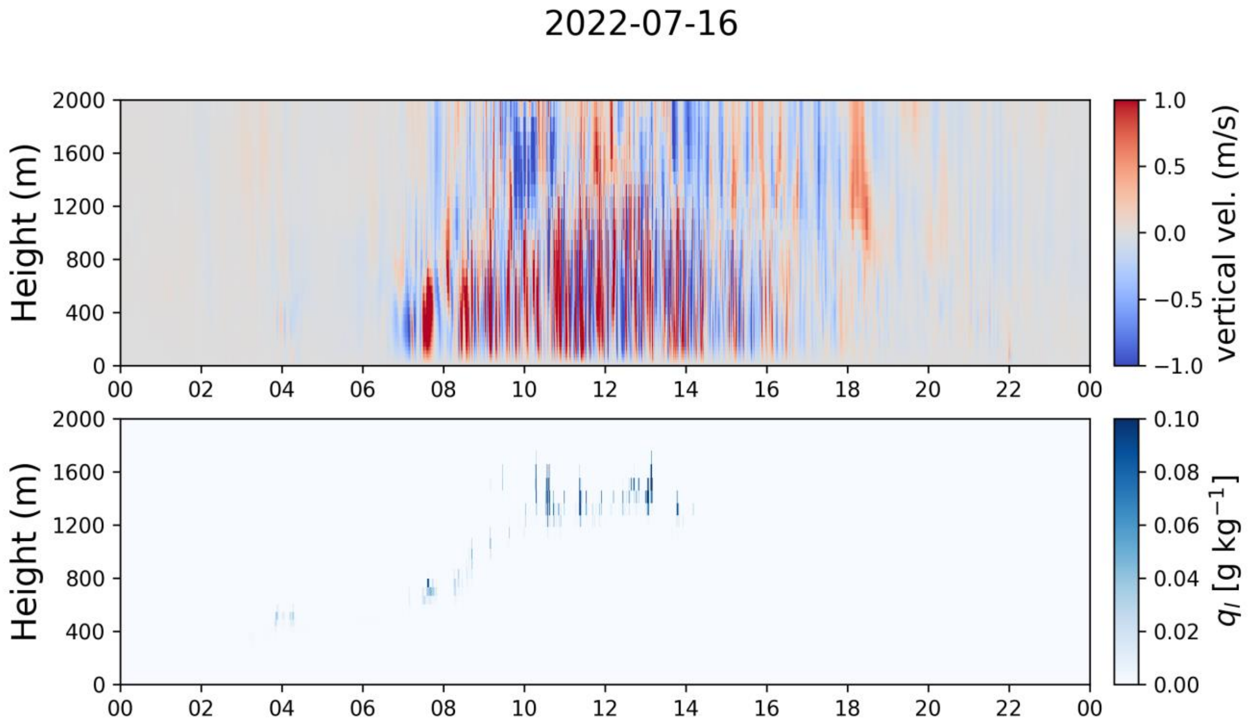
- 16 July 2022
- Both models centred around Cabauw
- HARMONIE-AROME:
  - 90 levels
  - Δx= Δy=100 m
  - No shallow-convection scheme
  - Nested in 500 m HARMONIE, nested in 2.5 km HARMONIE
- Large eddy simulation (DALES)
  - 160 levels
  - Δx= Δy=19 m
  - Using dynamical tendencies from 2.5 km HARMONIE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

Time-step output of the models



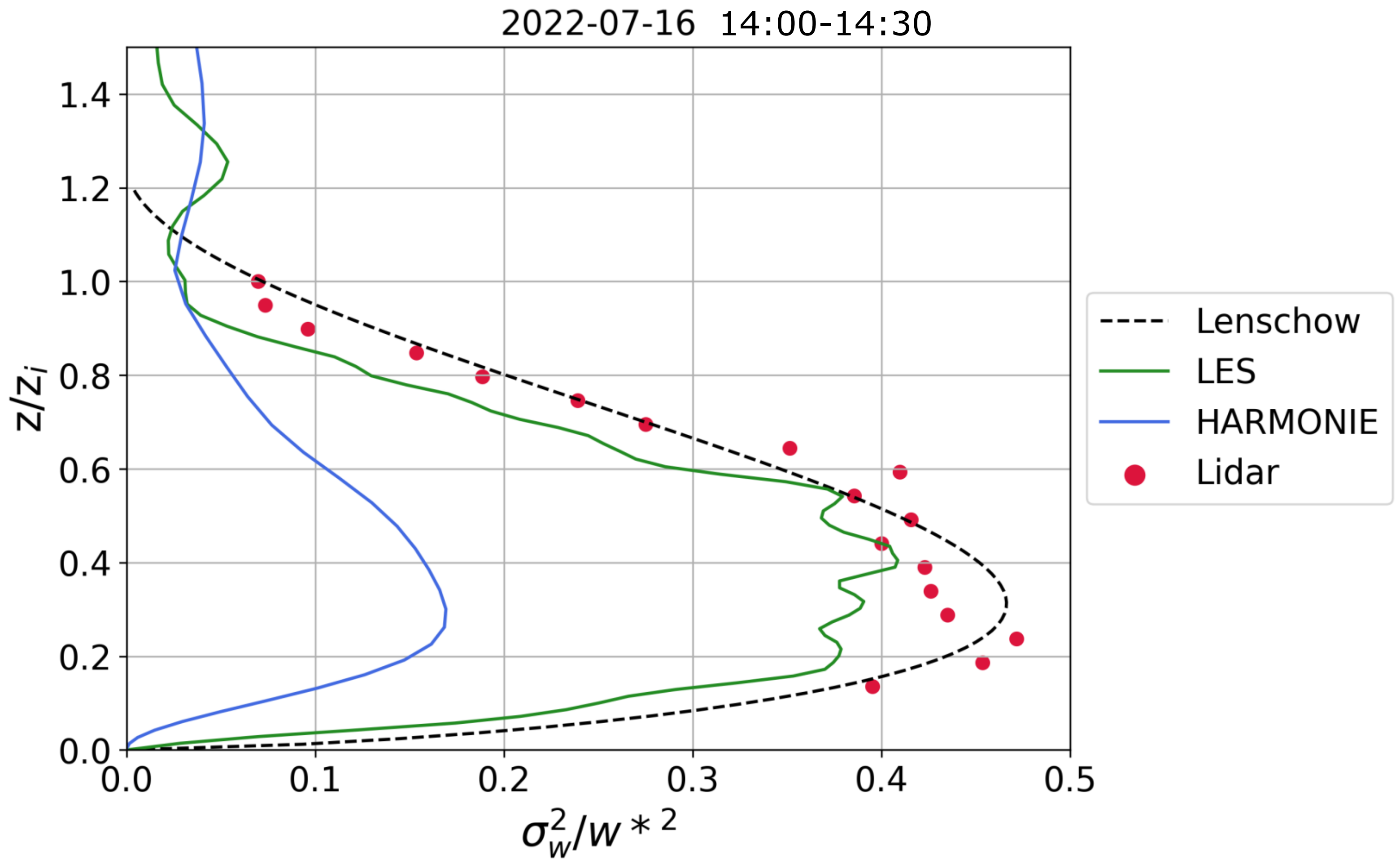


Large eddy simulation (DALES)
@19m resolution



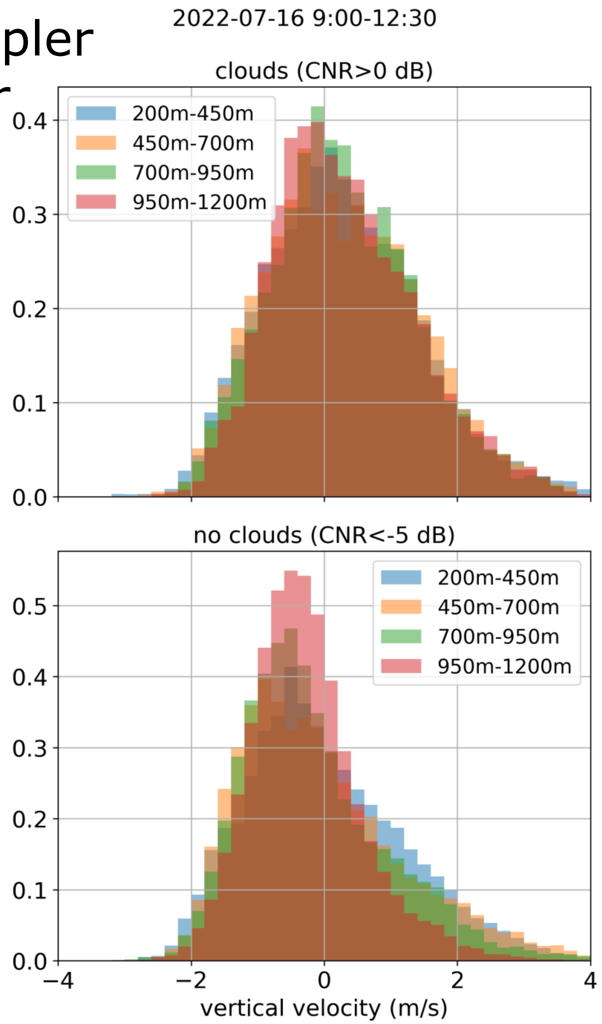
HARMONIE-AROME
@ 100m resolution

Scaled variance profiles

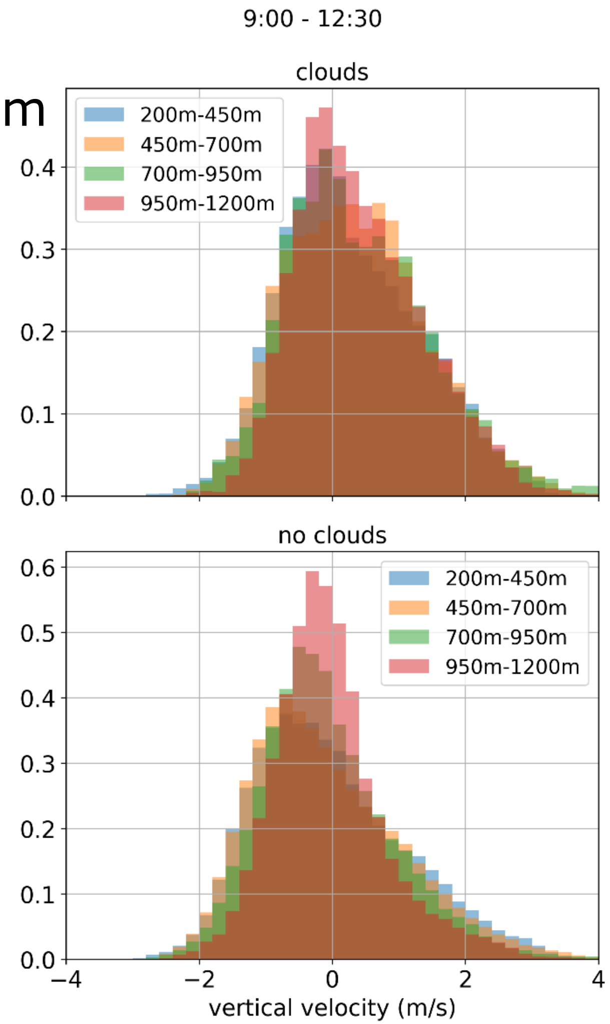


Distribution of vertical velocity

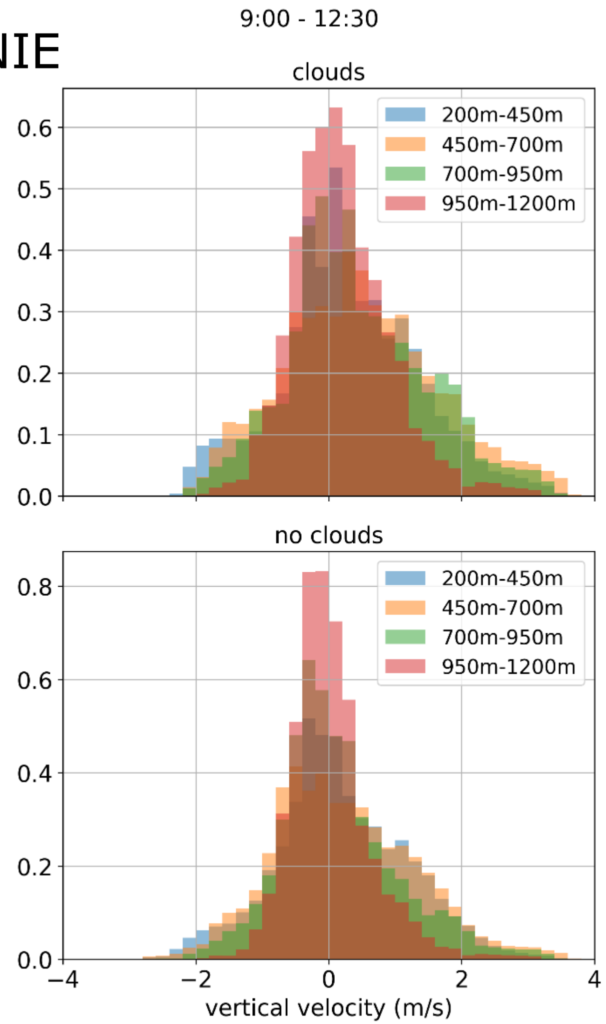
Doppler lidar



LES @19 m



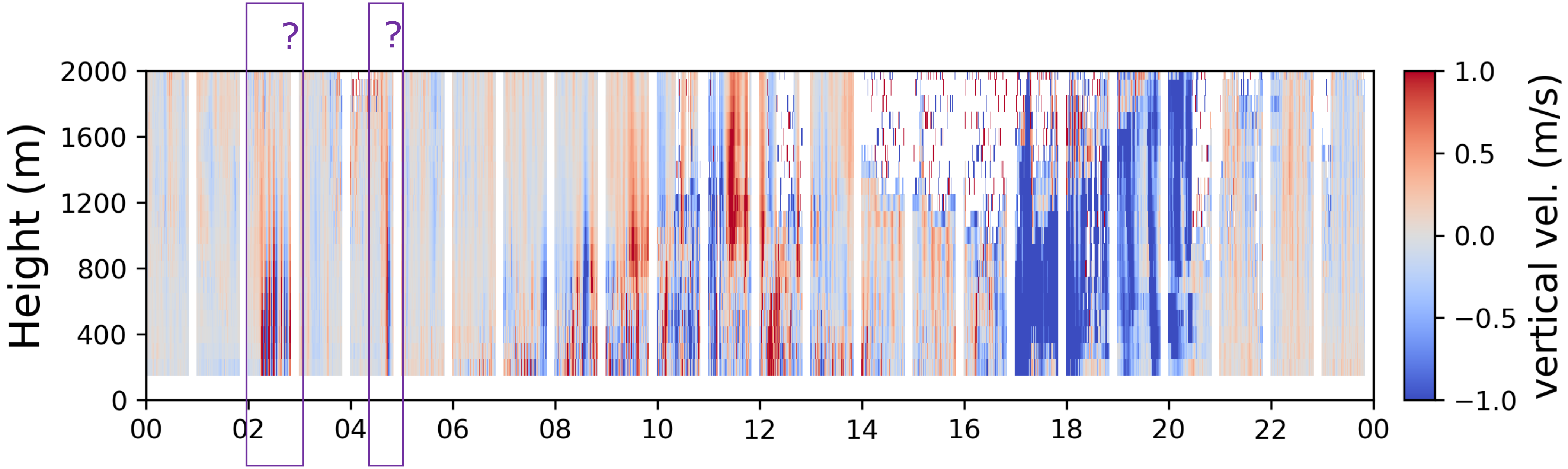
HARMONIE -AROME @100 m

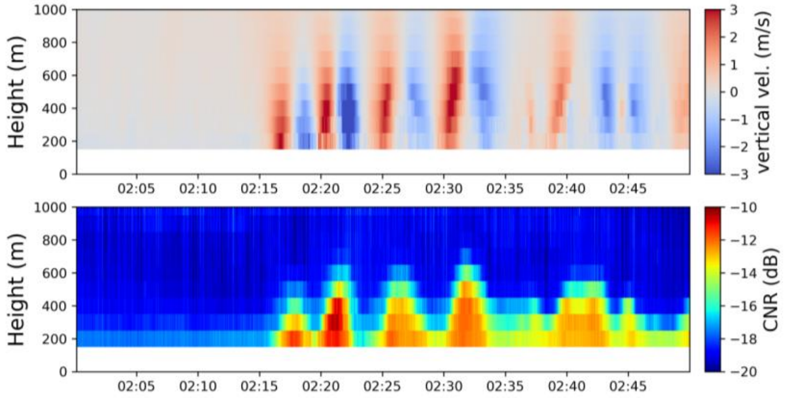


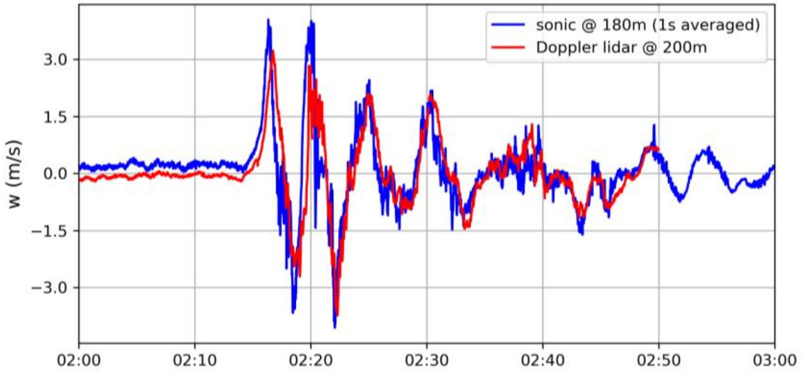
2022-07-20
2022-07-25

Boundary layer gravity waves

2022-06-30





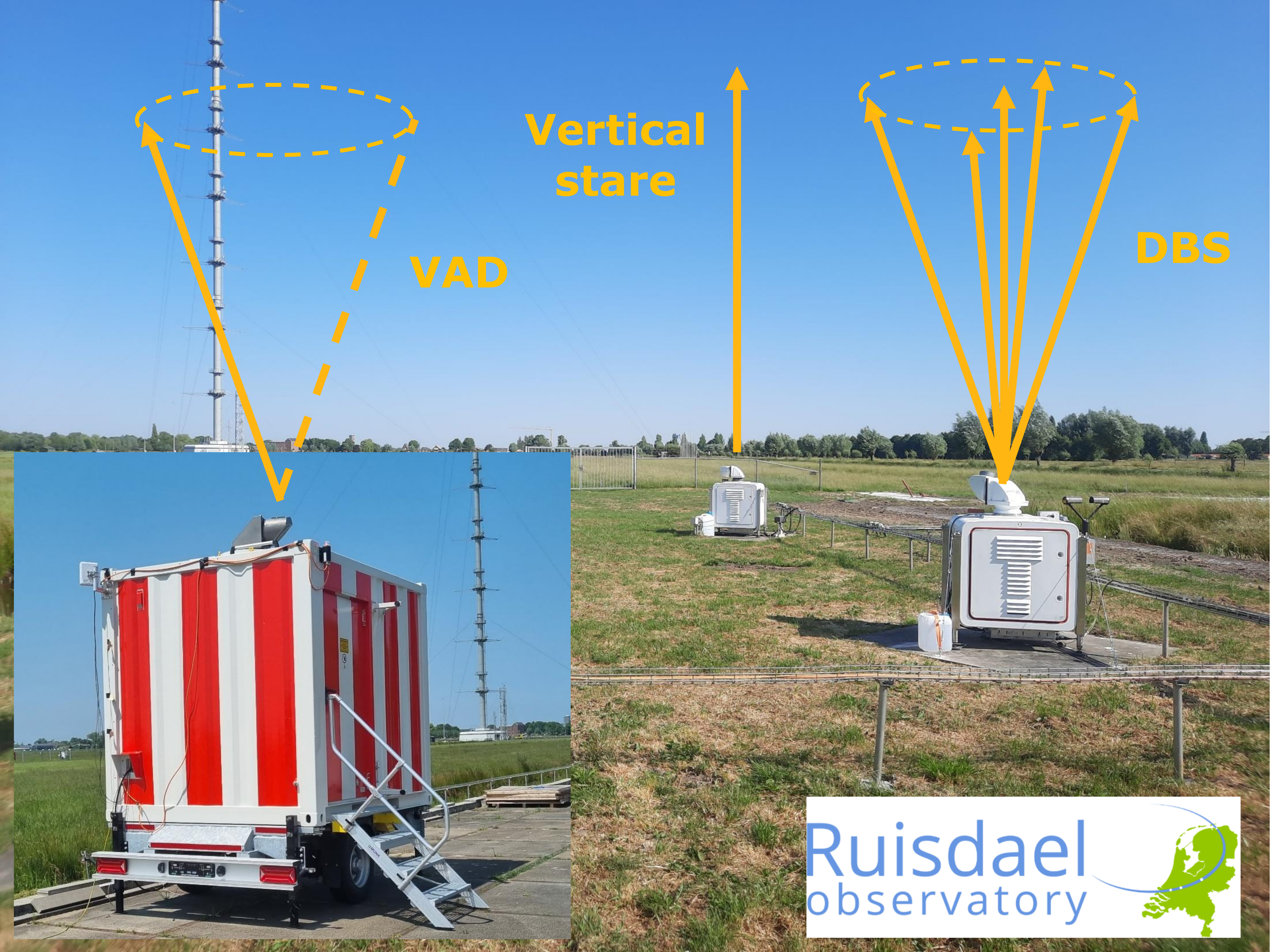


(see also Banakh & Smalikho, Remote Sensing 2023)

Conclusions & Outlook

- Doppler lidar summer 2022 campaign Cabauw: vertical stare
  - Banakh retrieval variance & EDR validation with sonics
  - Distribution (in relation to clouds), Up-/downdraft characteristics
  - ABLH increase Aug. 9-15, 2022
  - Doppler lidar gravity waves observations
- LES and NWP
  - Single case
    - LES represents BL convection
    - High-res NWP still misses part of BL turbulence
  - Direct comparison high-res NWP and observations
  - Doppler lidar vertical velocity observations for model development

Acknowledgement: Cabauw in-situ team (Mariska Koning, Cisco de Bruin, Jessica Strickland, Reinder Ronda), Wim de Rooy



Outlook II

Summer 2023:

2nd Windcube200S
from TU Delft
José Neto Dias
Louise Nuijens

- Continuous vertical stare and wind profiling
- 50m resolution

(also cloud radars
Christine Unal)

SKIRON3D (KNMI)
Tiemo Mathijssen