New ABL measurements of Lagrangian relative dispersion by means of radiosonde clusters

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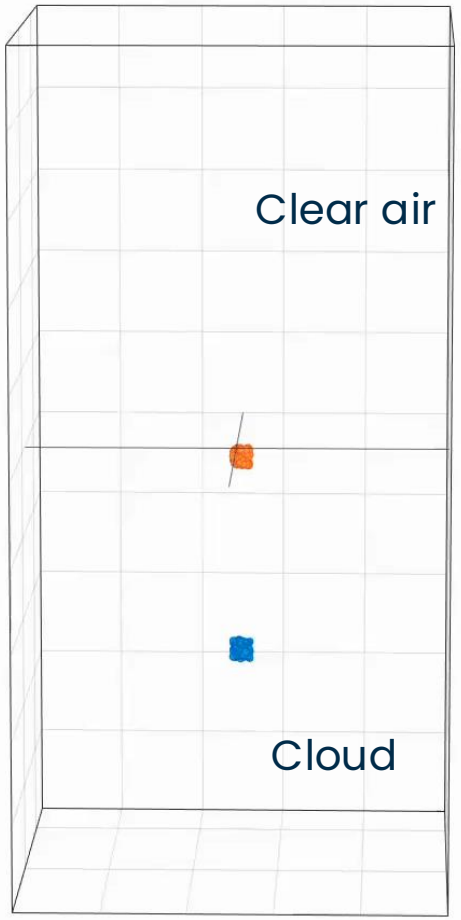
Politecnico di Torino

EGU25 – Vienna

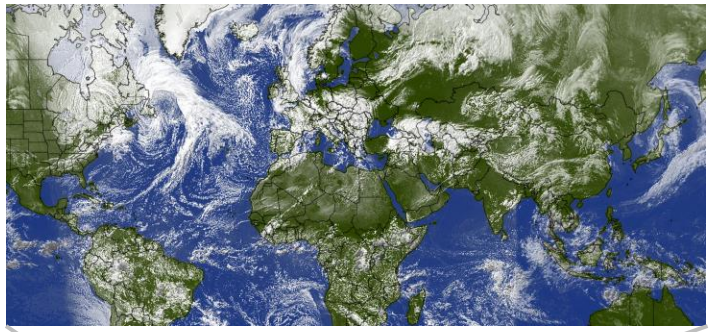
NP6.1 Characterizing complex systems using Lagrangian and time series perspectives

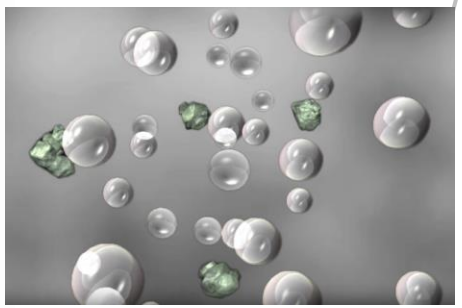
Turbulent relative dispersion



$TKE_{cloud}/TKE_{clear-air}$ = 7, from NS direct numerical simulation

windy.com





NASA/Goddard Space Flight Center
https://svs.gsfc.nasa.gov/10387

Turbulent relative dispersion

L. F. Richardson

Experimental dataset (1926)

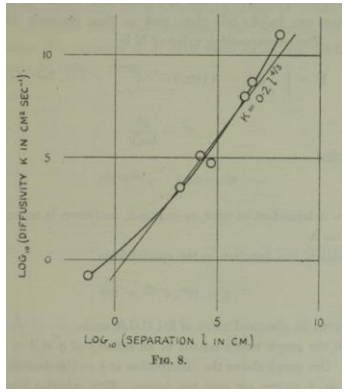
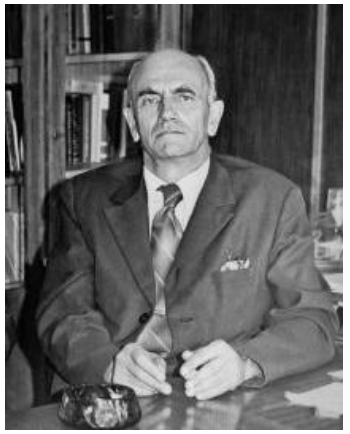


Fig. 8.

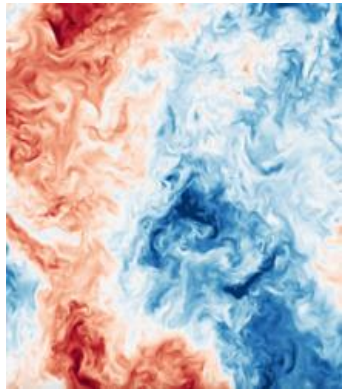
Essential theory

$$\ell^2 \propto t^3$$



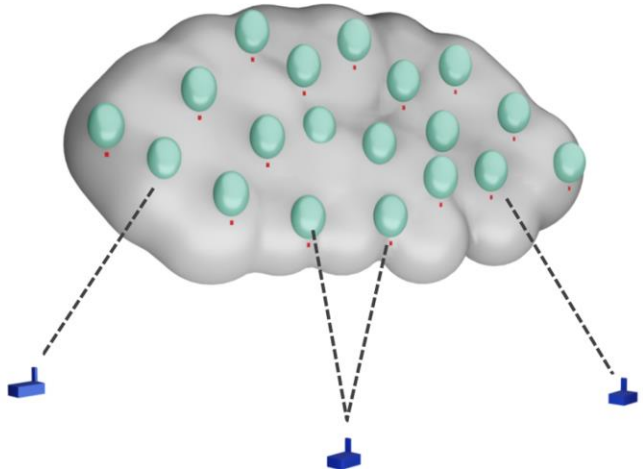
A. Obukhov

Similarity theory

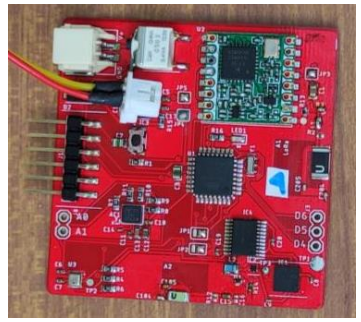


BUT: only valid in homogeneous, isotropic, stationary turbulence

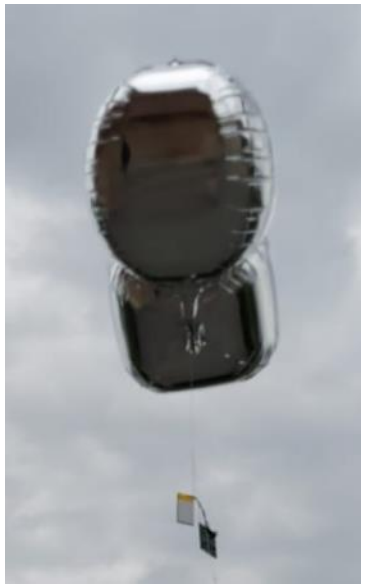
Miniaturized radiosonde clusters



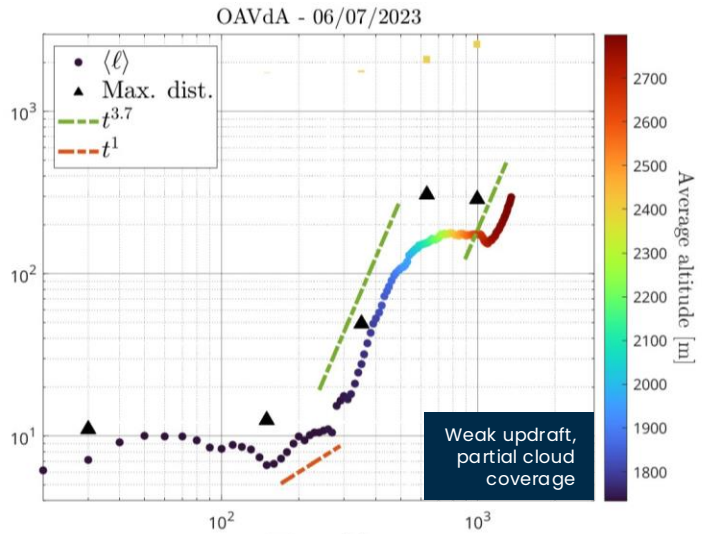
Sensors for:
Position (GNSS)
Temperature, pressure, humidity
Velocity, acceleration
Magnetic field

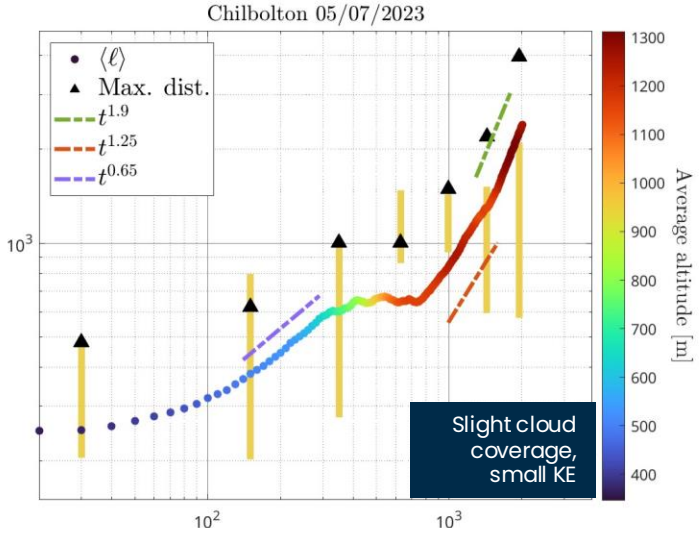


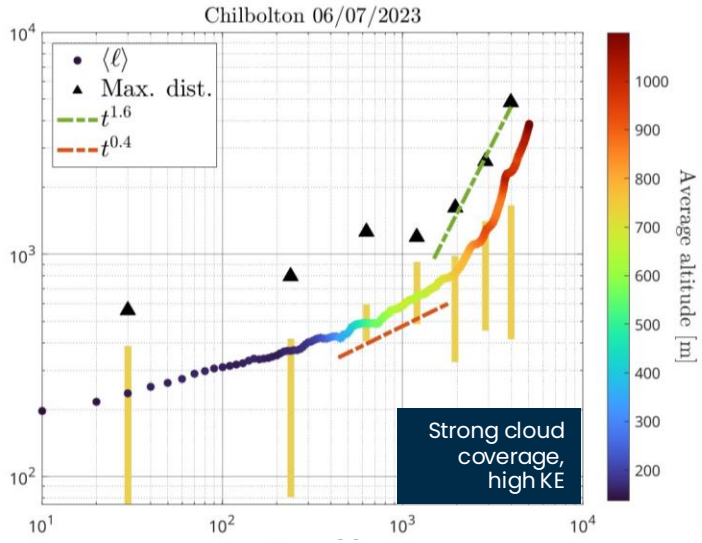
Passively transported

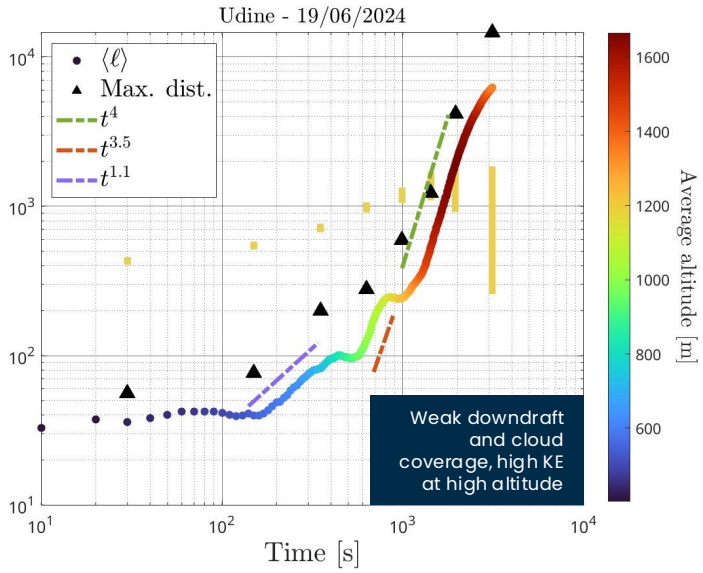


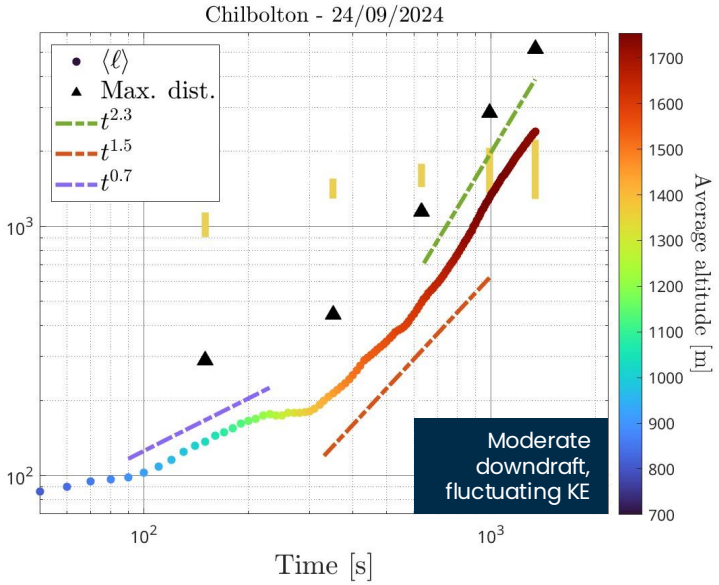
Six launches

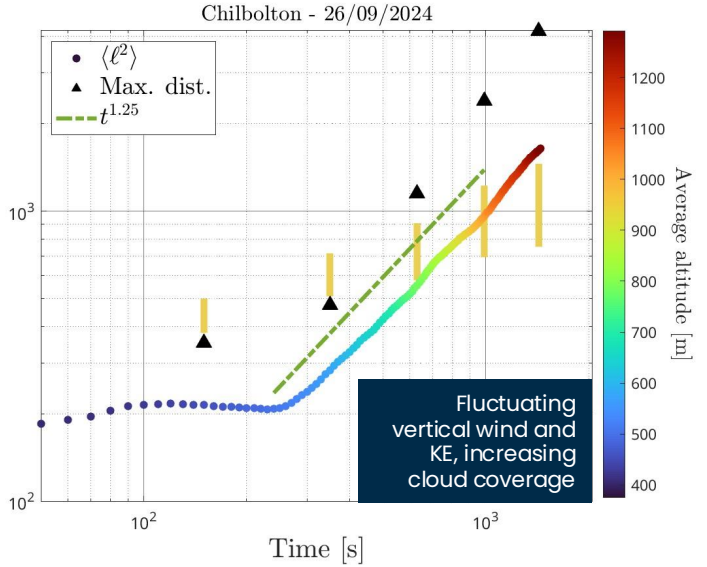








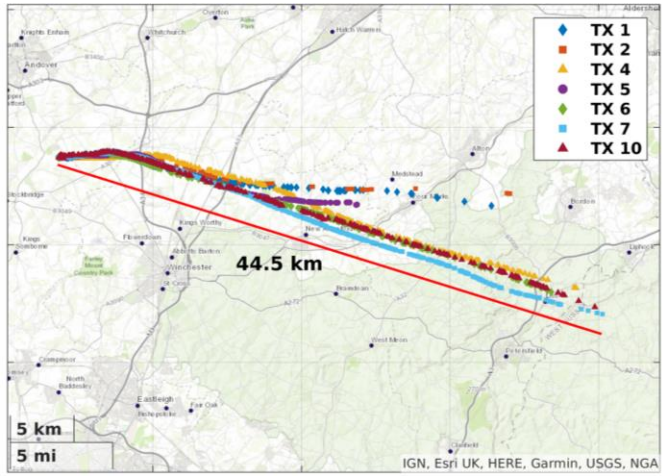


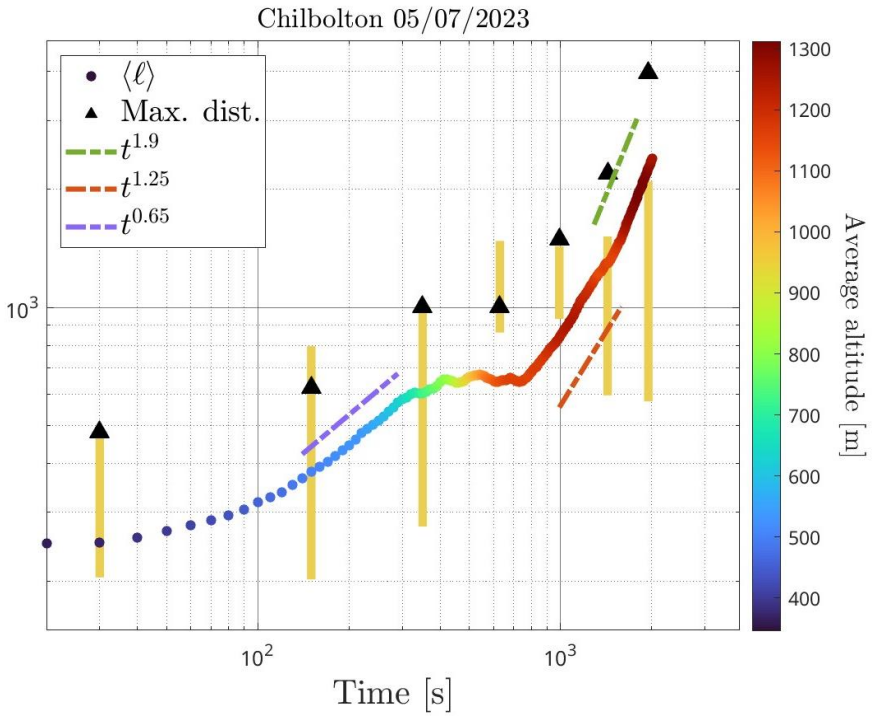


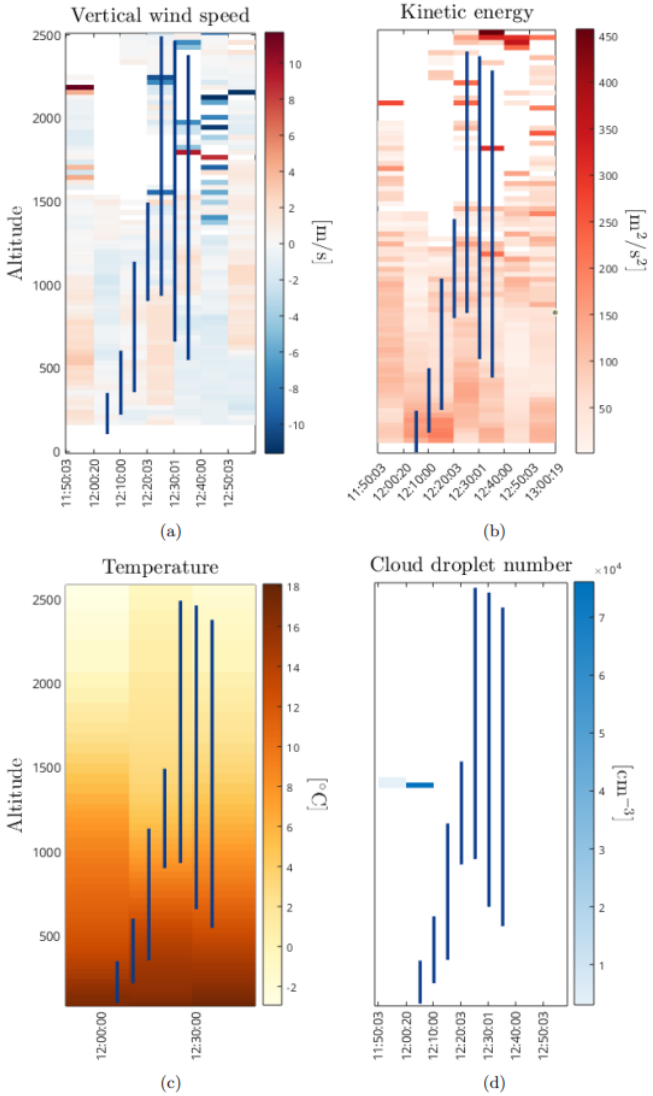
Chilbolton Observatory – July 5th, 2023

Data cross-comparison with fixed-point instrumentation:

- Doppler lidar
- Cloud radar
- Microwave radiometer



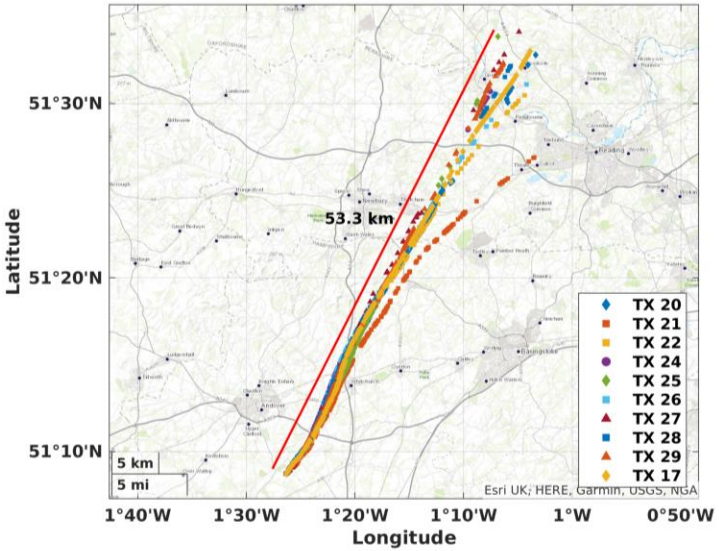


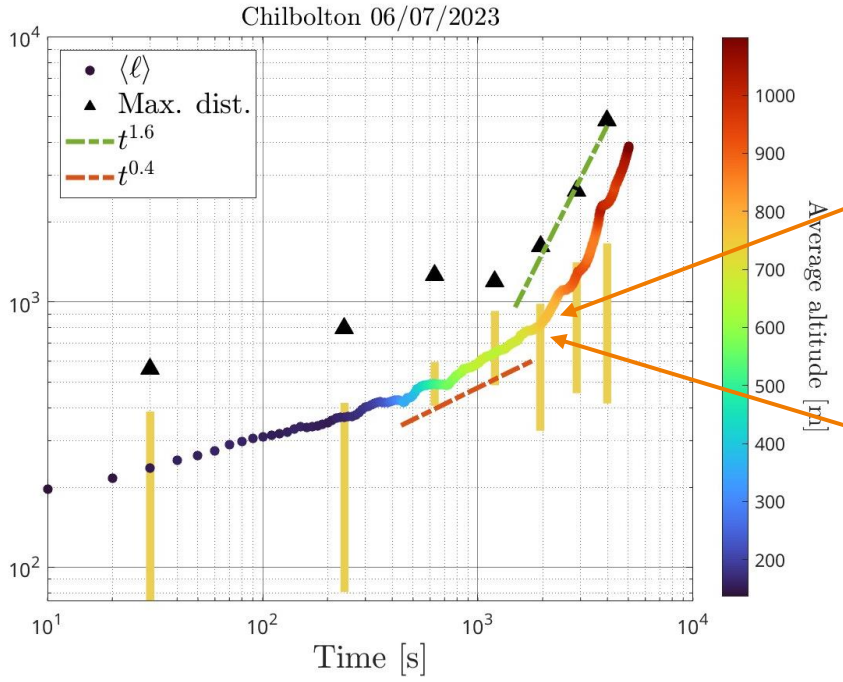


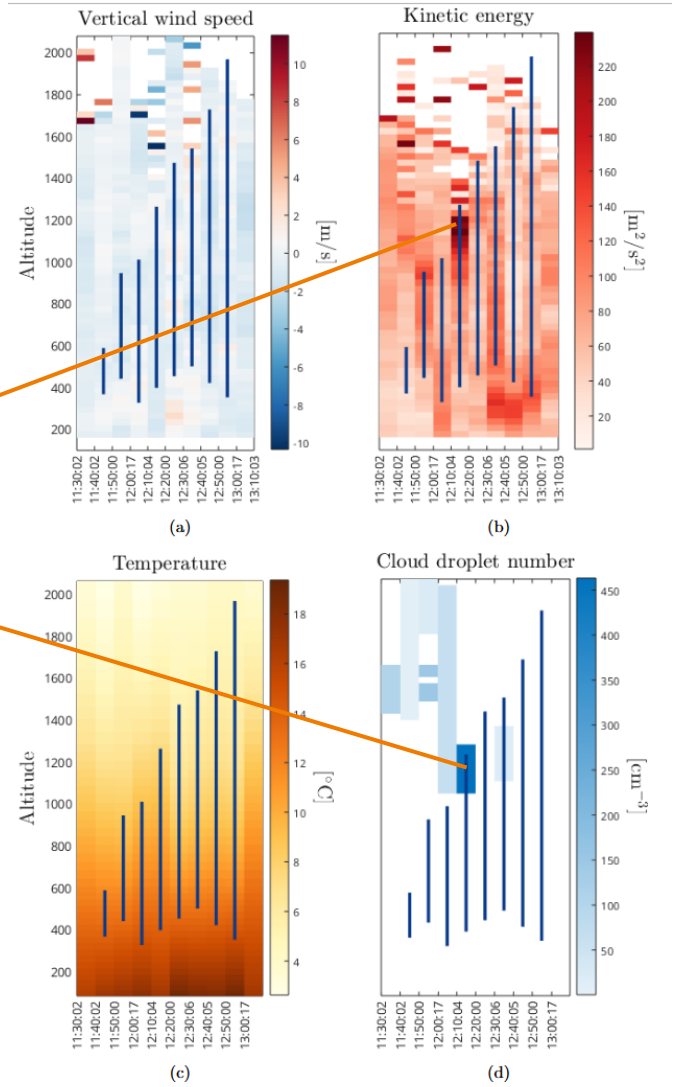
Chilbolton Observatory – July 6th, 2023

Data cross-comparison with fixed-point instrumentation:

- Doppler lidar
- Cloud radar
- Microwave radiometer





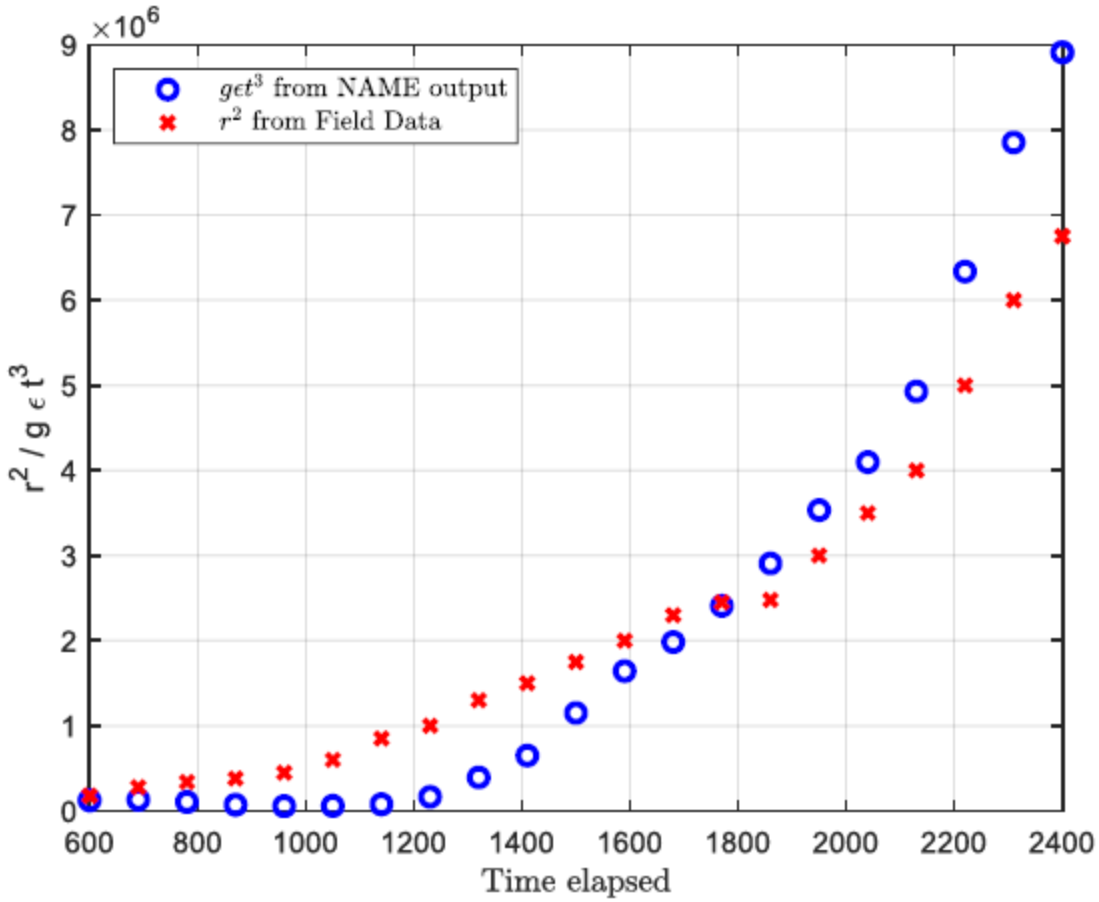


Comparison with dispersion model - NAME

Comparison performed with our July 5th, 2023 launch

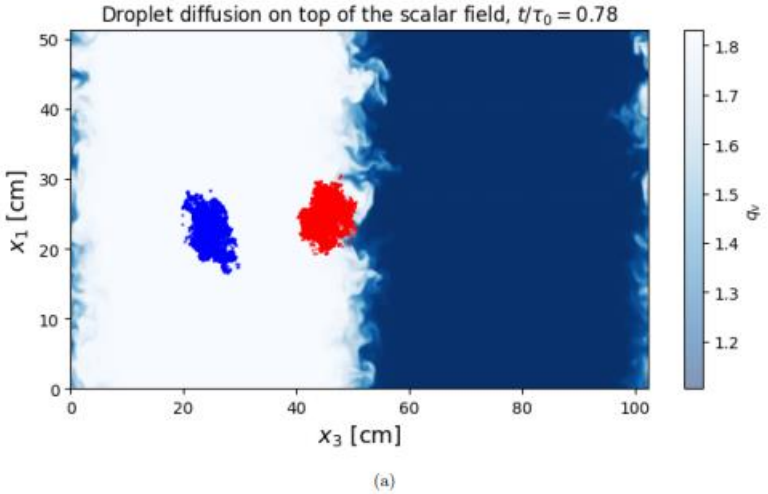
NAME assumes t^3 law, with ε based on altitude from a heuristic formula

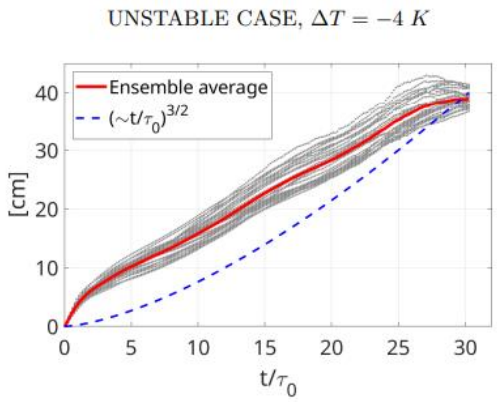
As expected, no match!



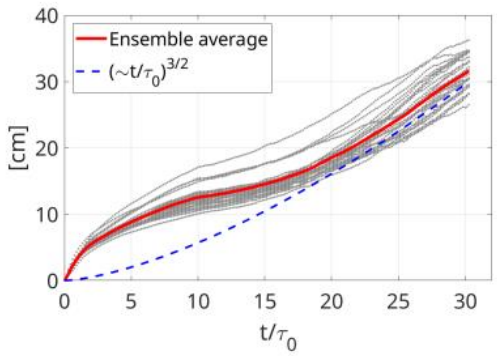
Numerical simulations – cloud border

DECAYING ANISOTROPIC TURBULENT CONTEXT

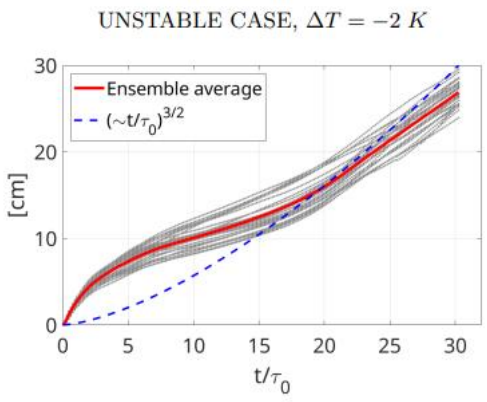




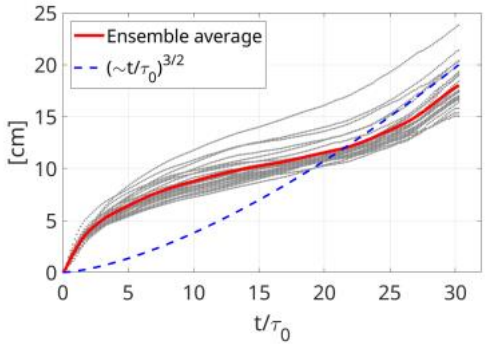
(a) mixing region



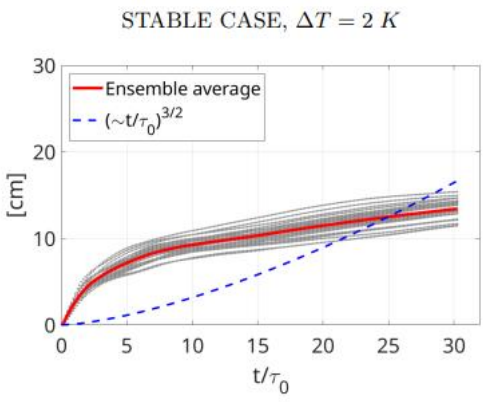
(c) cloud region



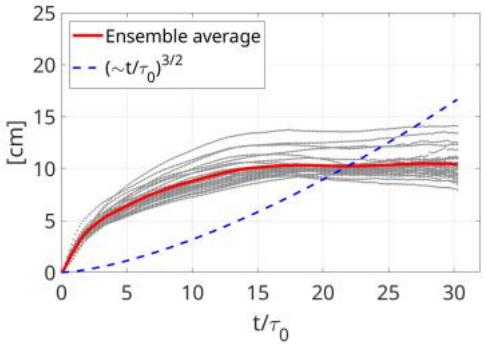
(a) mixing region



(c) cloud region



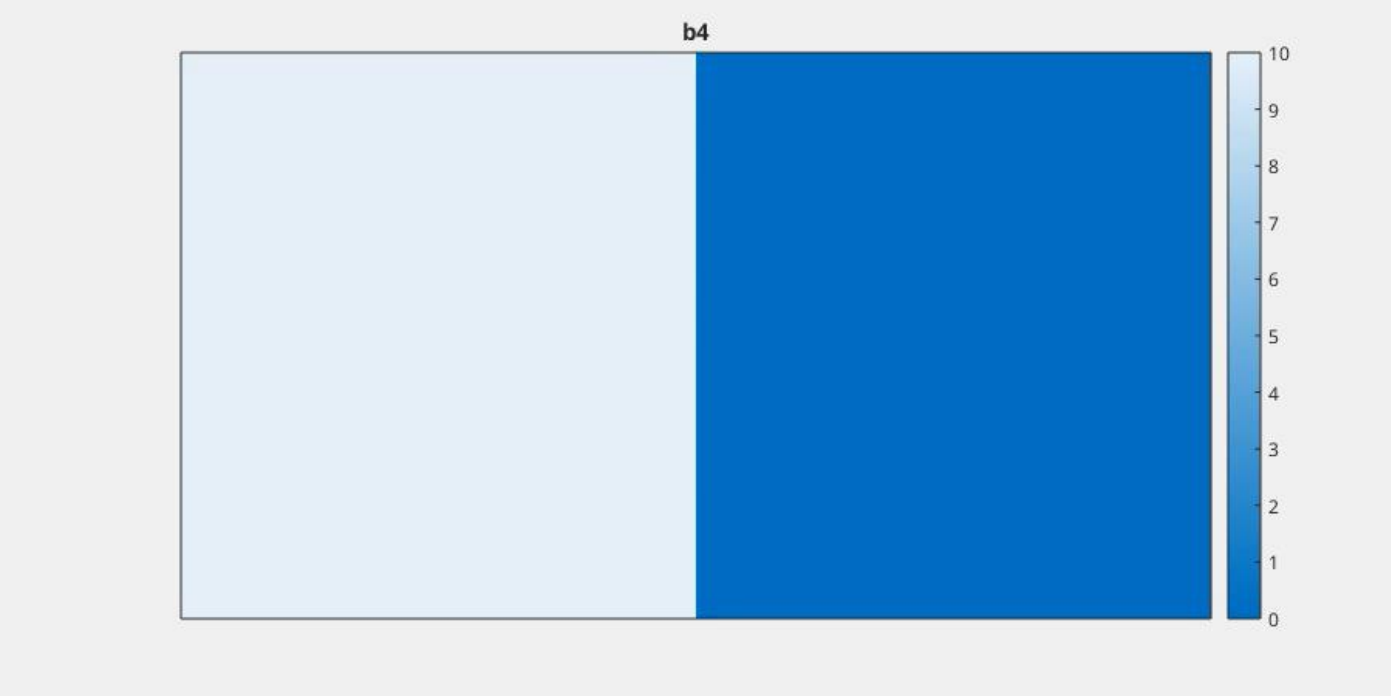
(b) mixing region



(d) cloud region

Conclusions – Future outlooks

- Larger clusters
- Second prototype (smaller and lighter)
- Third prototype (enhanced measurement capability)
- Data assimilation



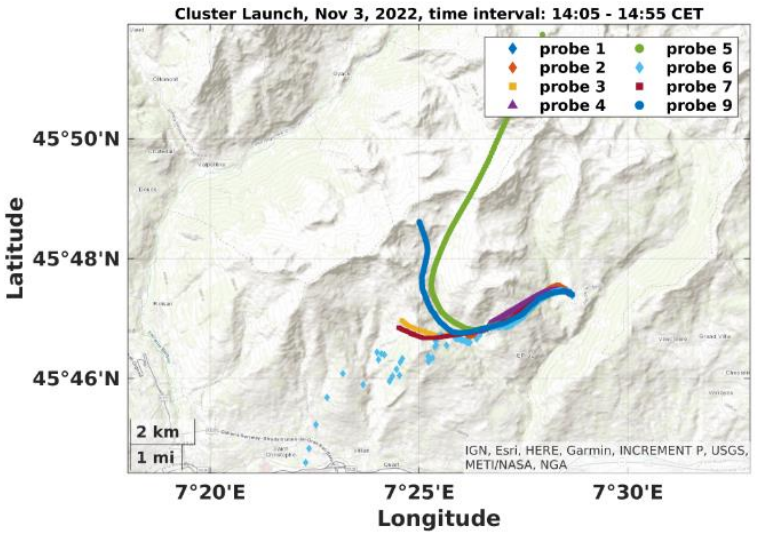
The end

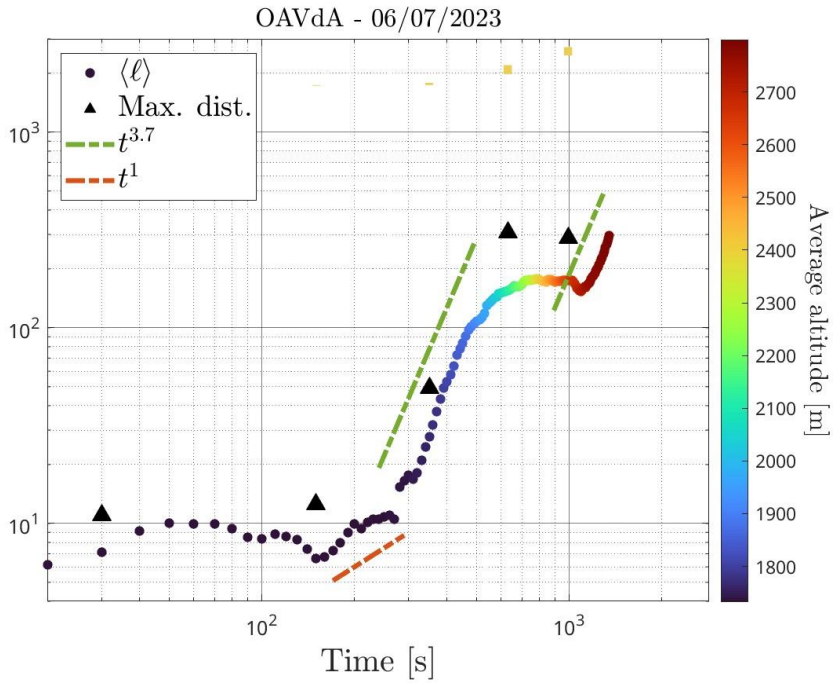
Thank you

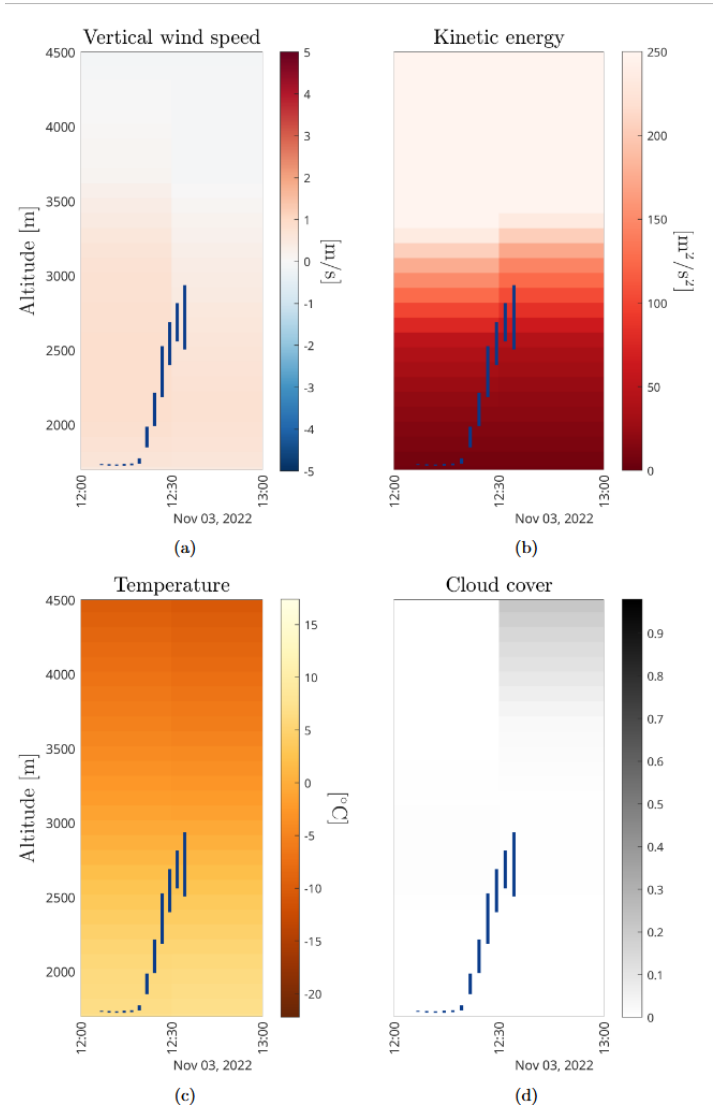
Osservatorio Astronomico della Valle d'Aosta – Nov 3rd, 2022

Data cross-comparison with ECWMF-ERA5 profiles:

- Wind speed
- TKE
- Temperature
- Cloud cover



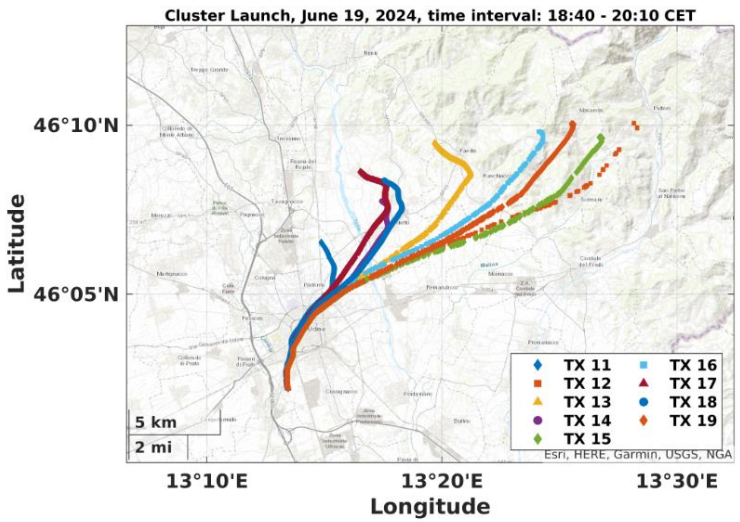


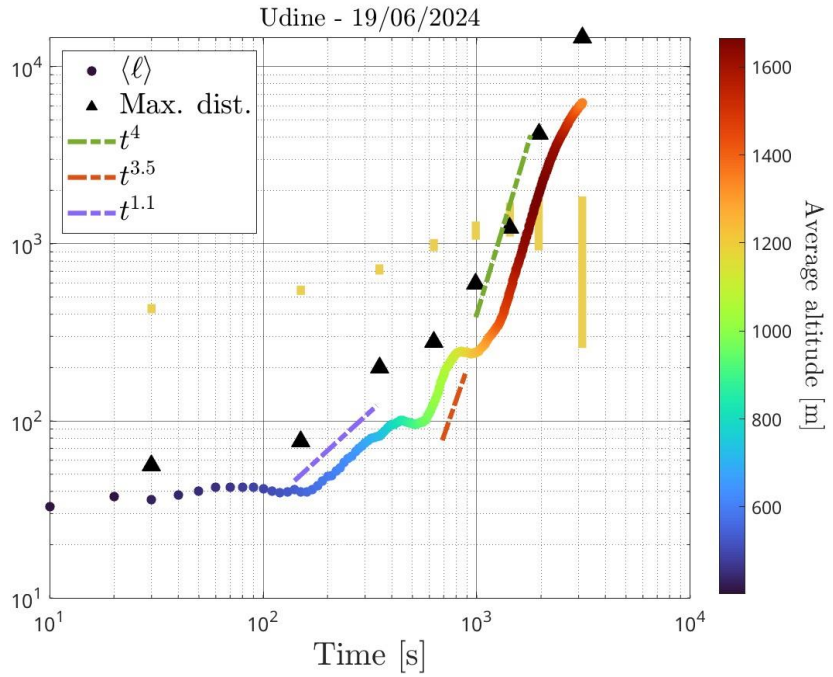


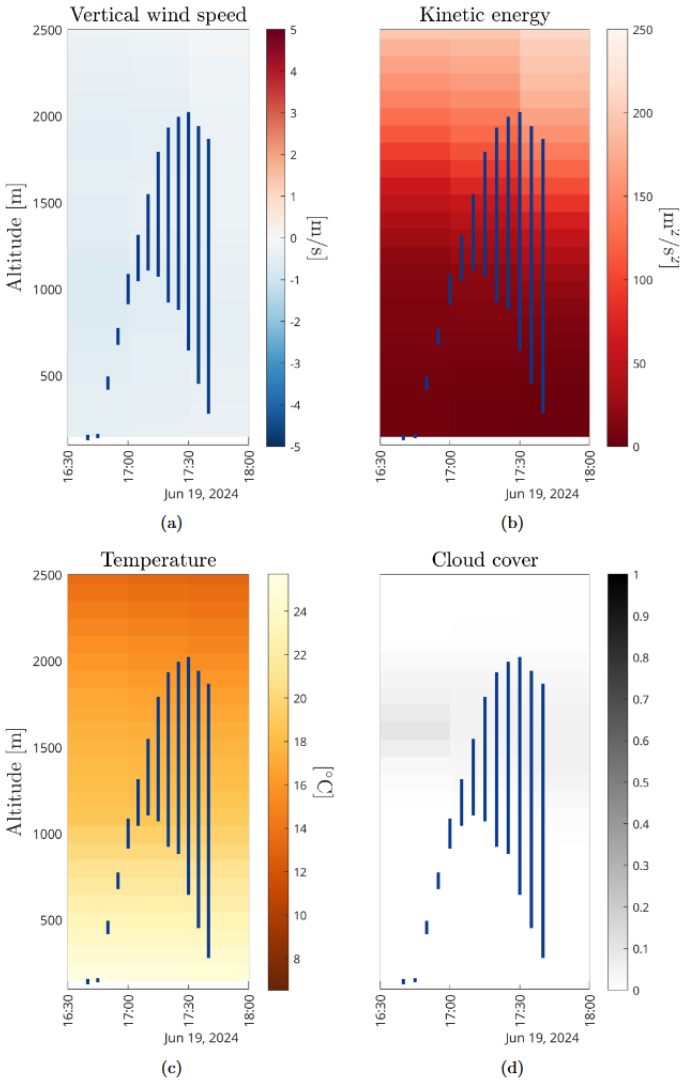
Udine, Italy – June 19th, 2024

Data cross-comparison with ECWMF-ERA5 profiles:

- Wind speed
- TKE
- Temperature
- Cloud cover



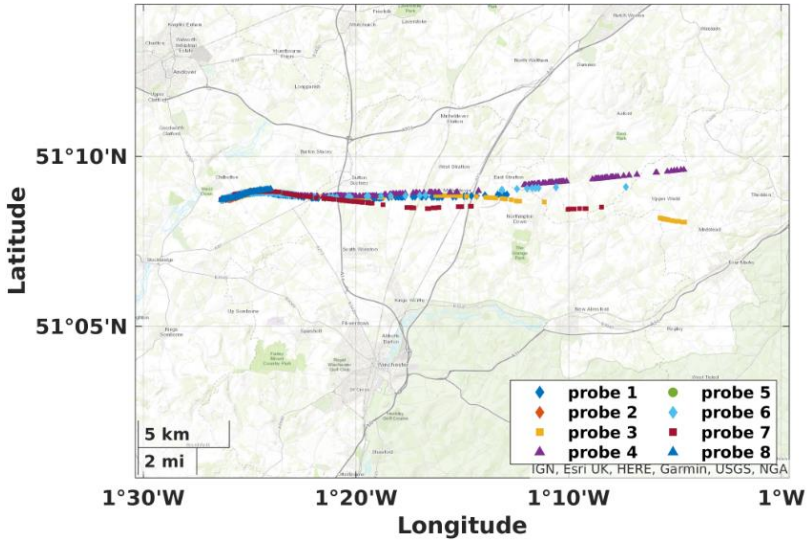


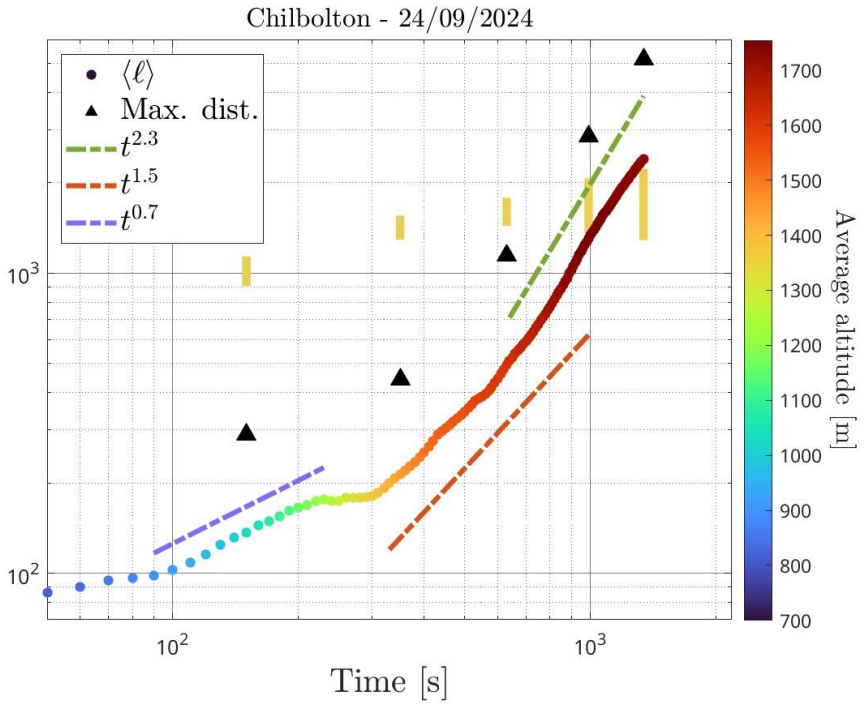


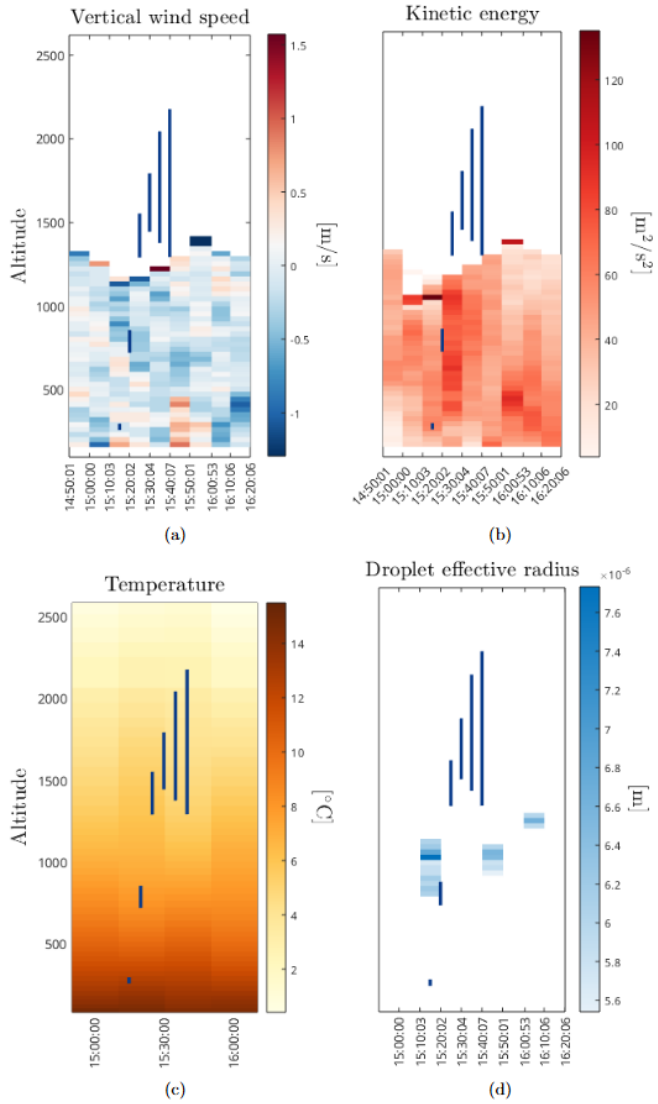
Chilbolton Observatory– September 24th, 2024

Data cross-comparison with fixed-point instrumentation:

- Doppler lidar
- Cloud radar
- Microwave radiometer



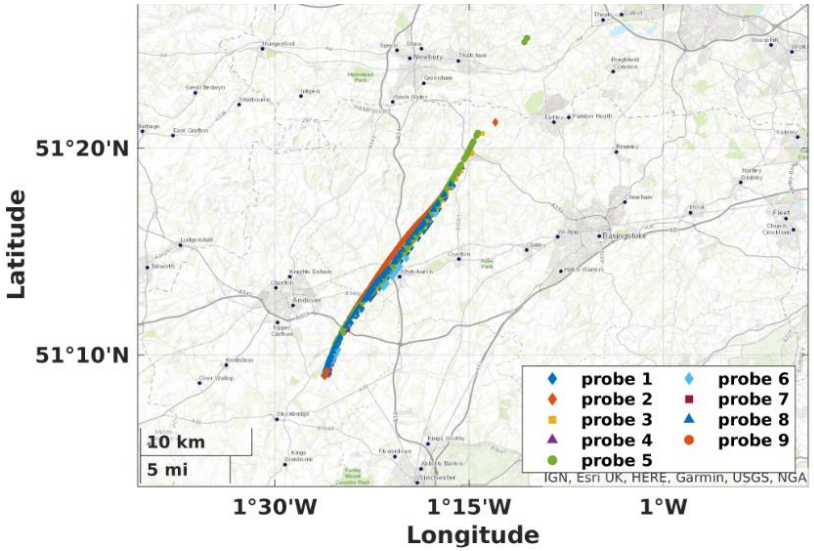


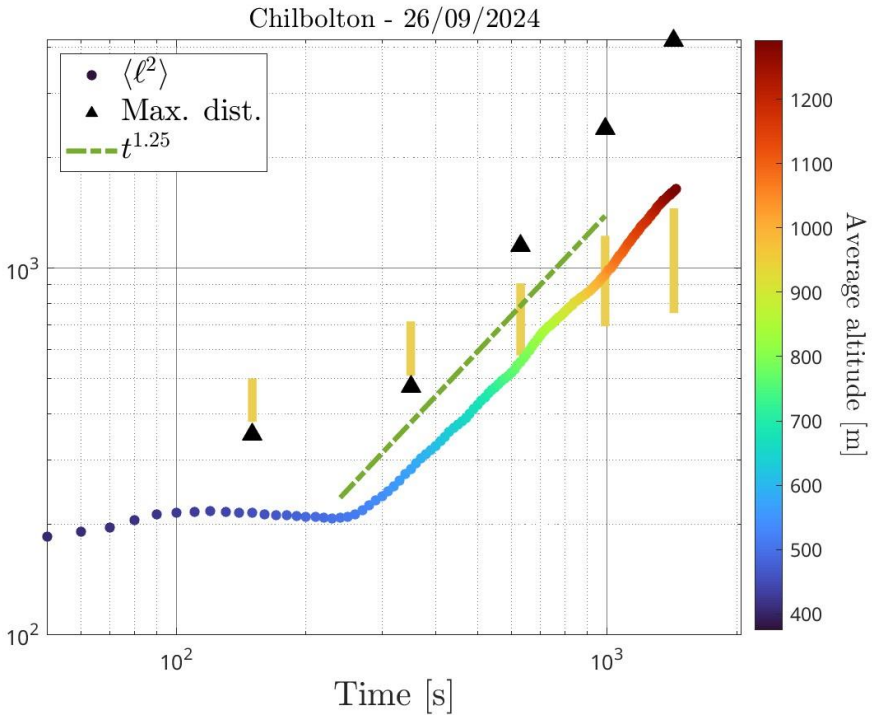


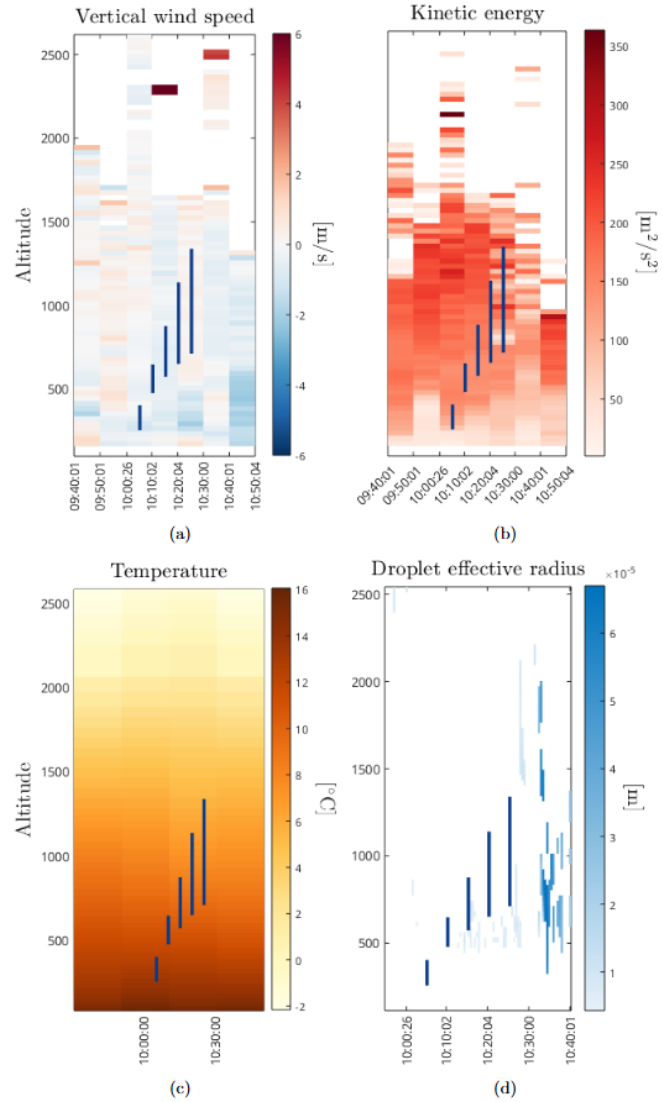
Chilbolton Observatory– September 26th, 2024

Data cross-comparison with fixed-point instrumentation:

- Doppler lidar
- Cloud radar
- Microwave radiometer

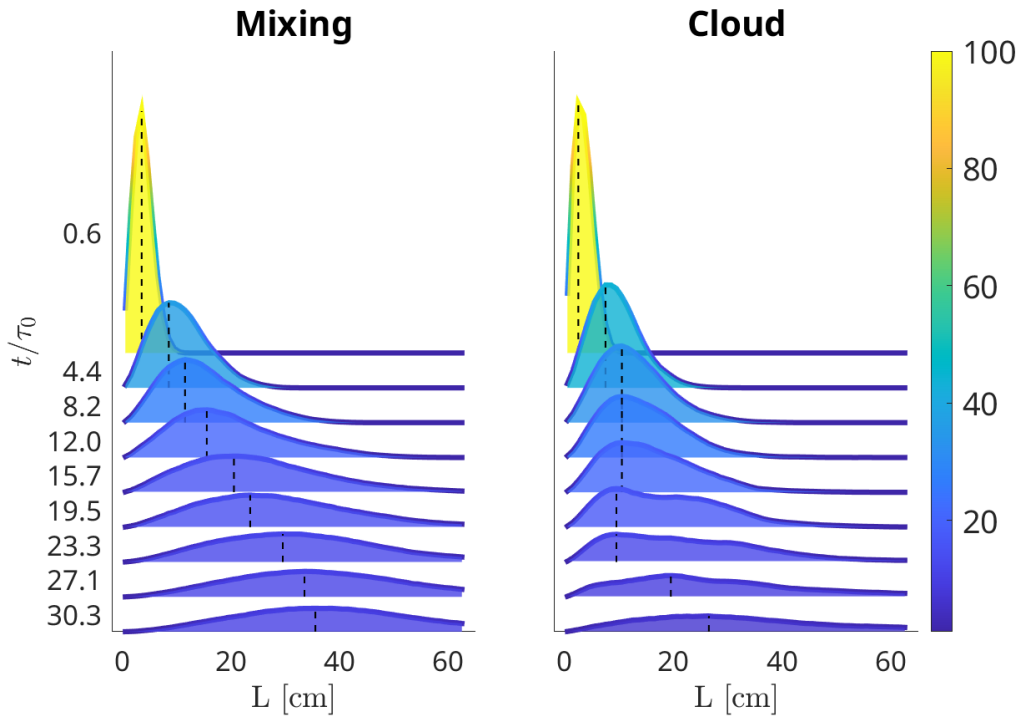




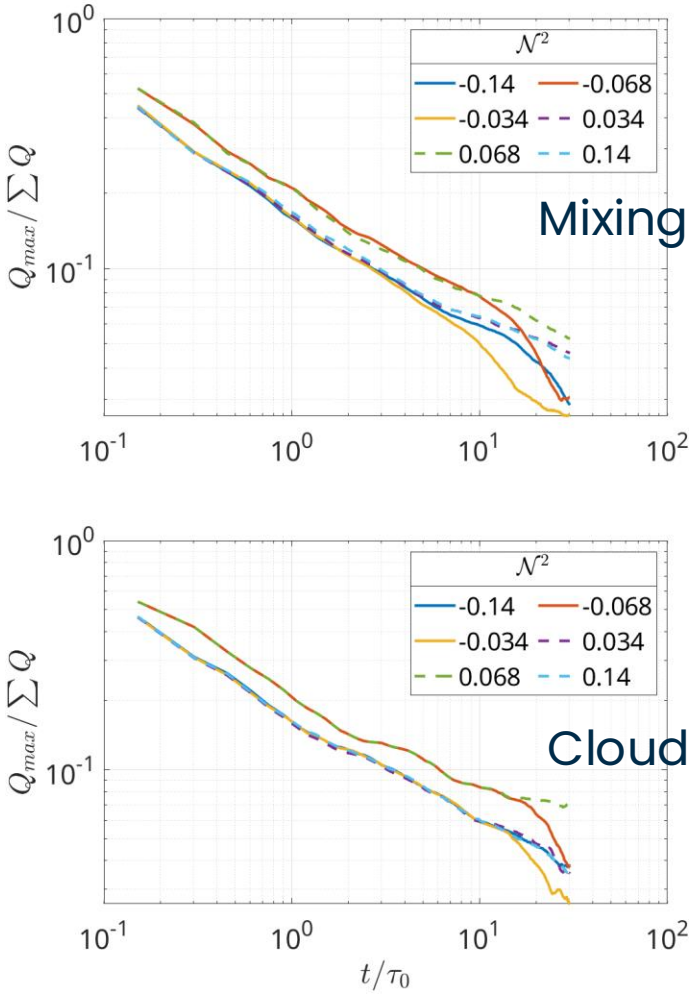


Numerical simulations – cloud border

DISTANCE-NEIGHBOUR GRAPH - PDF of particle separation



- Six DNS simulations were conducted: Three stable and three unstable stratified cases.
- The stability parameters are given as the initial value of Brunt-Vaisala frequency.
- The left graph corresponds to the most unstable case, where N2 = - 0.034.



Mixing region

Cloud region