DYNAMICS OF THE ATMOSPHERIC BOUNDARY LAYER OVER A PEATLAND WITH DOPPLER LIDAR

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Remote Sensing Laboratory

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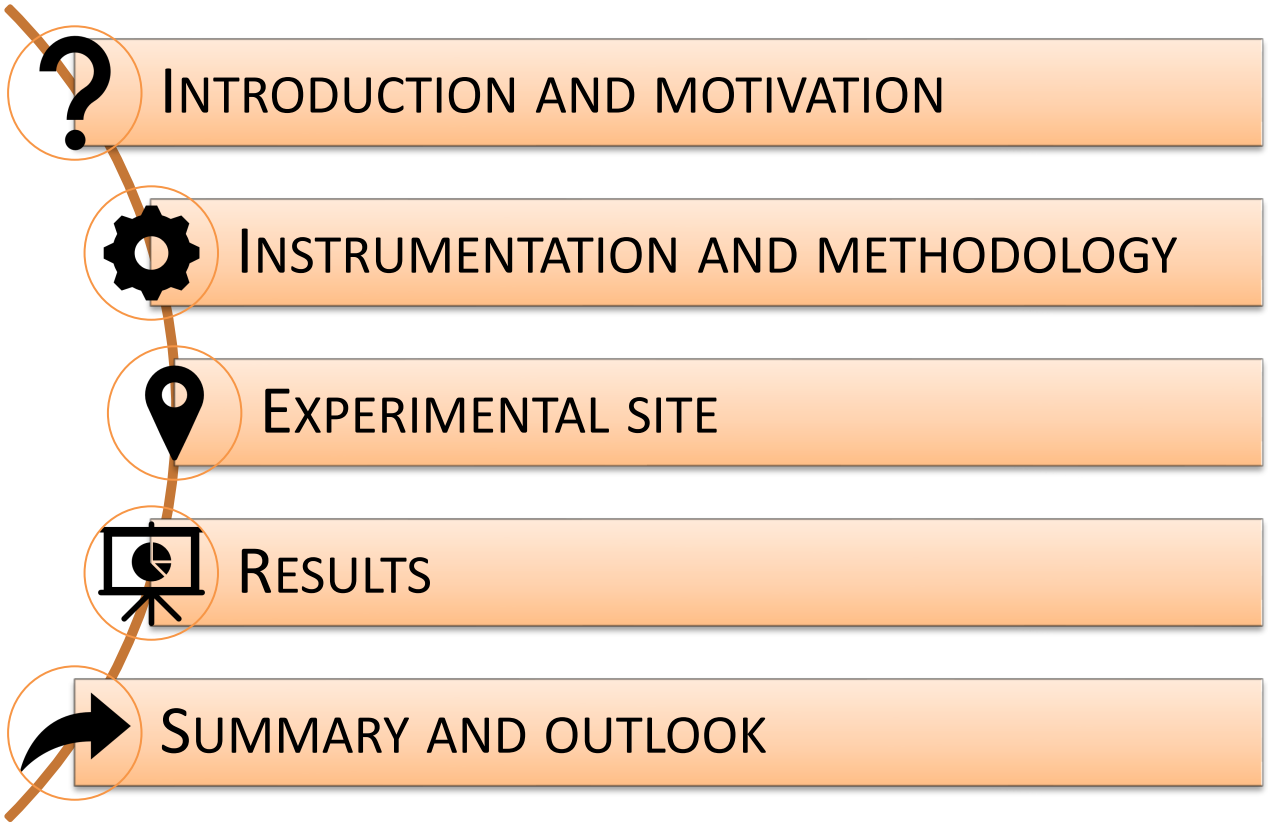
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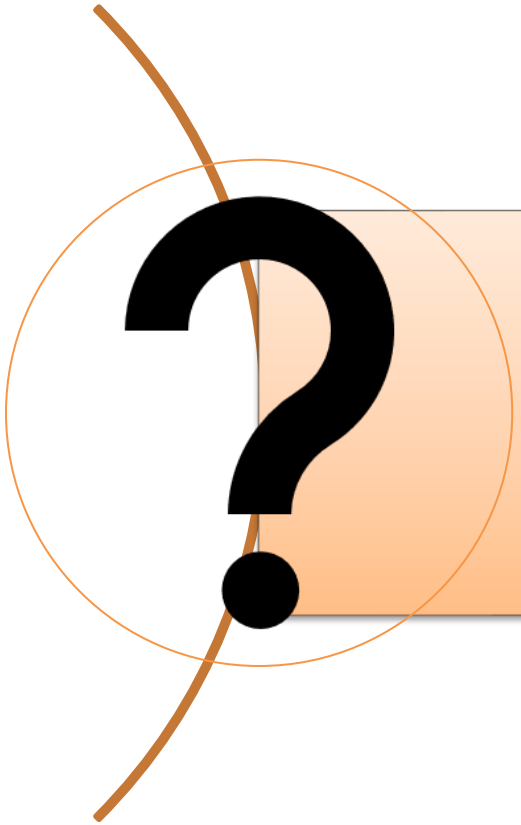
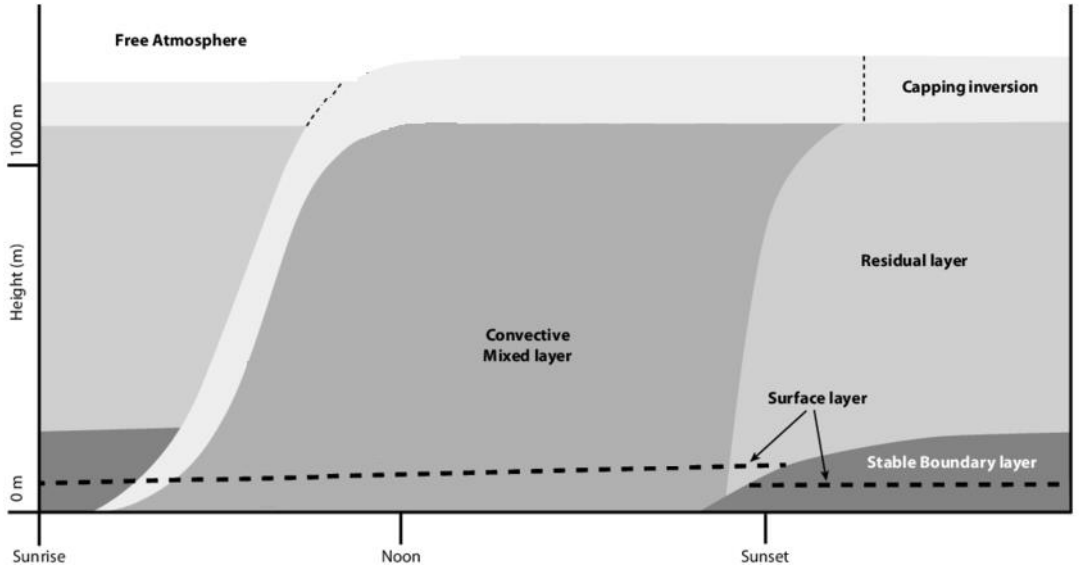


INTRODUCTION AND MOTIVATION

MOTIVATION

Atmospheric Boundary Layer: lowermost part of the atmosphere, directly influenced by the Earth's surface



Adapted from (Stull, 1988)

Importance:

-weather forecasting

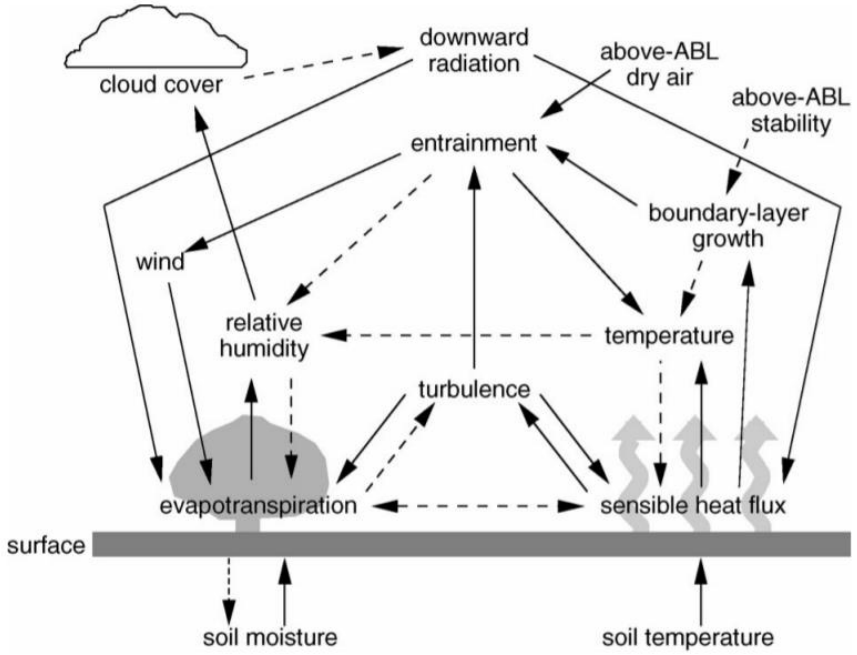
-climate studies

-pollutant dispersion

MOTIVATION

Complex description:

interactions among multiple variables and processes

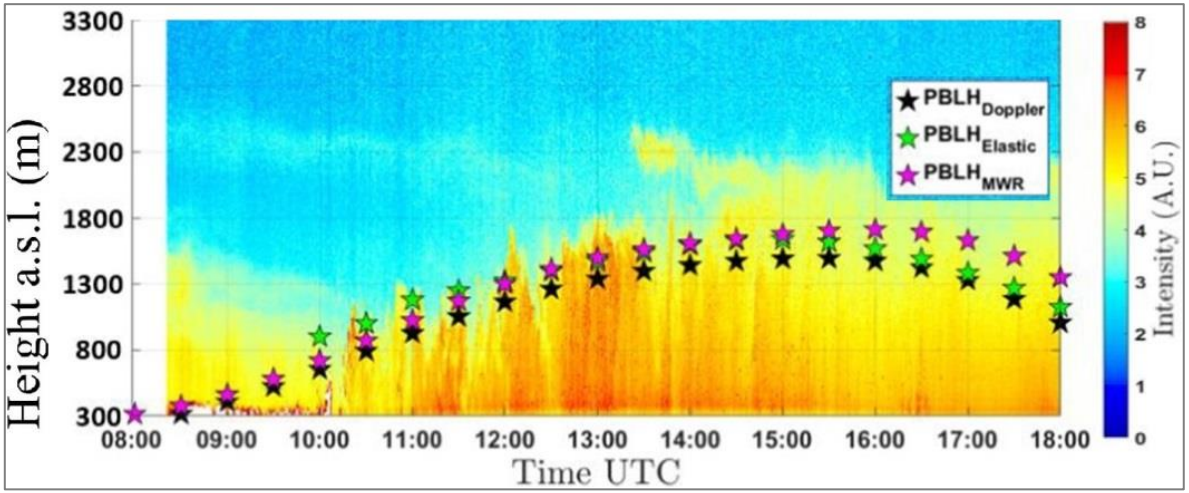


(Ek and Holtslag, 2004)

MOTIVATION

ABL height:

- Important for pollutant dispersion studies and meteorological modelling
- Strongly dependent on the tracer:



-Air movement (dynamics)

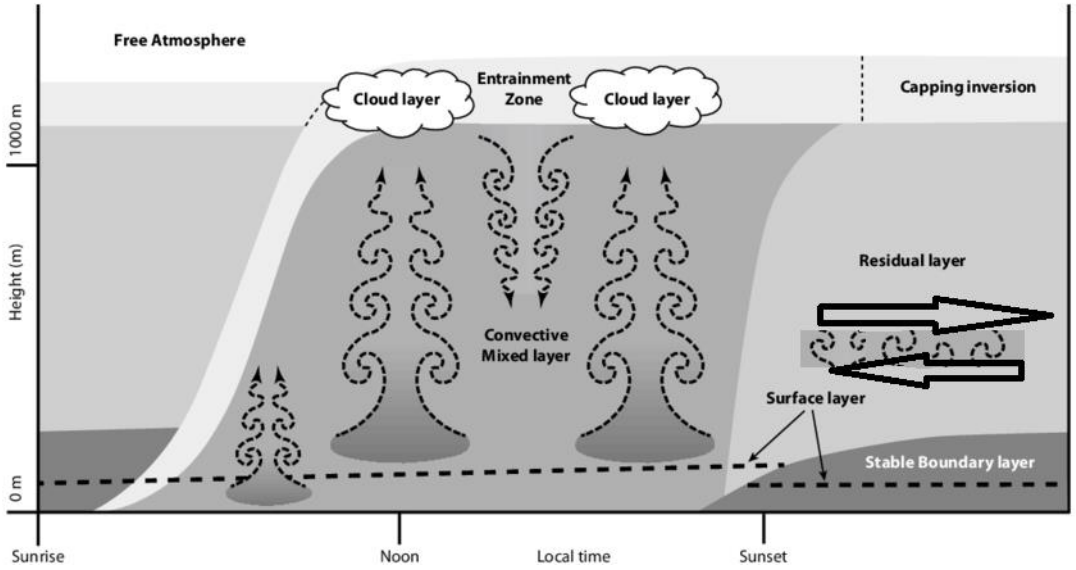
-Aerosol concentration

-Temperature behaviour (thermodynamics)

(Moreira et al., 2018)

MOTIVATION

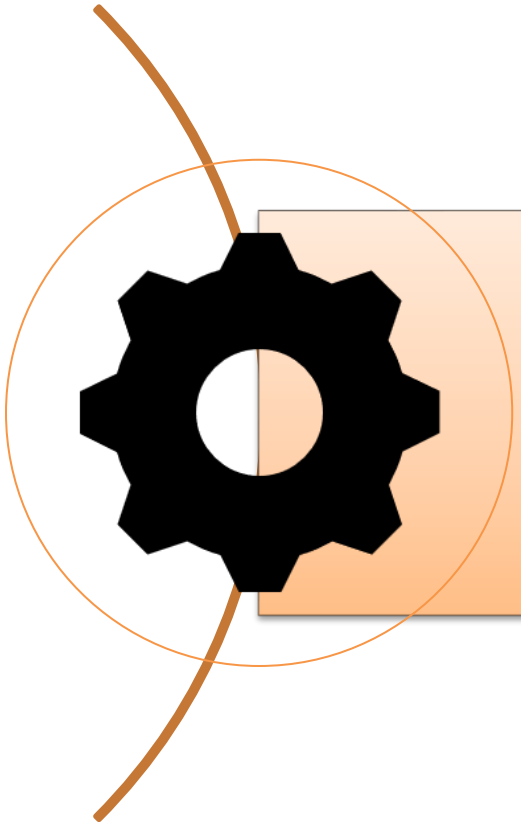
Dymanics of ABL: Turbulence



Adapted from (Emanuelson, 2013)

Turbulent eddies caused by mechanical and/or thermal processes

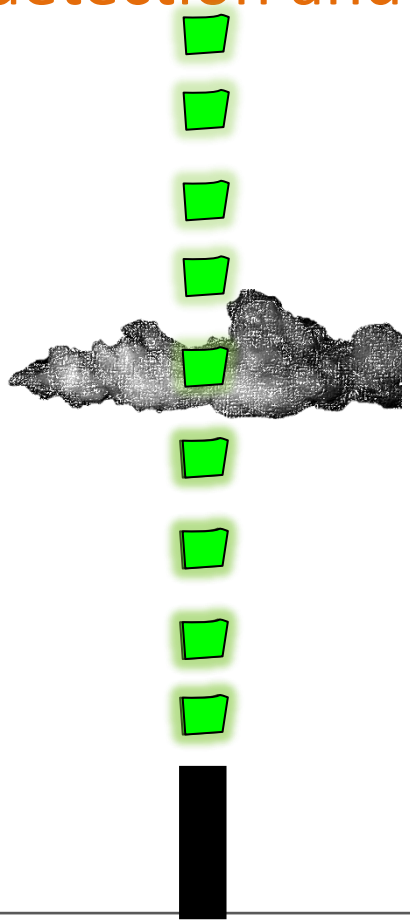
Statistical approach is needed

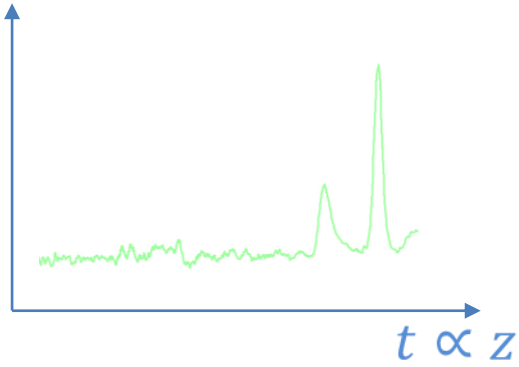


INSTRUMENTATION AND METHODOLOGY

Lidar

(Light detection and ranging)





Lidar

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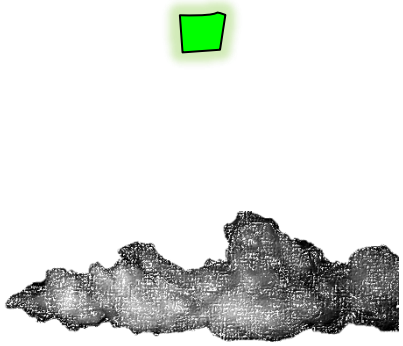
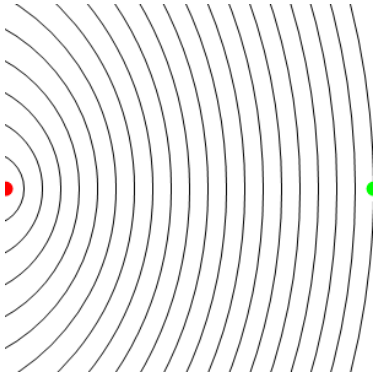
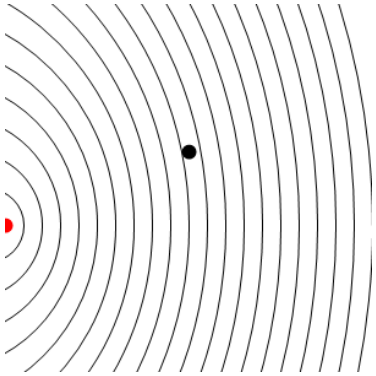


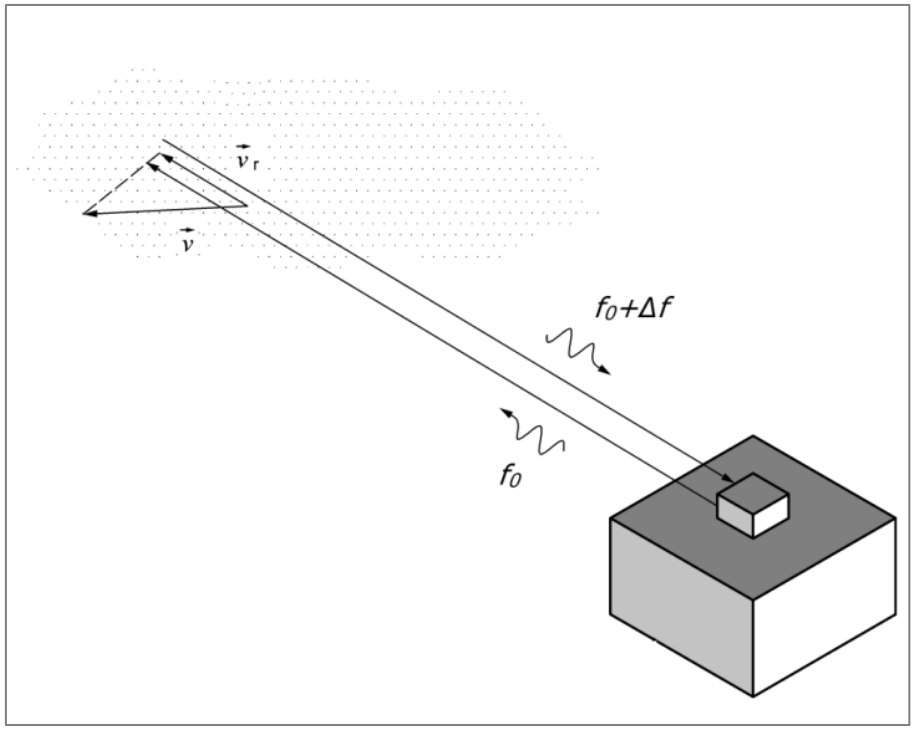
Doppler Effect





Doppler Lidar technique:

retrieval of radial wind with temporal and spatial resolution

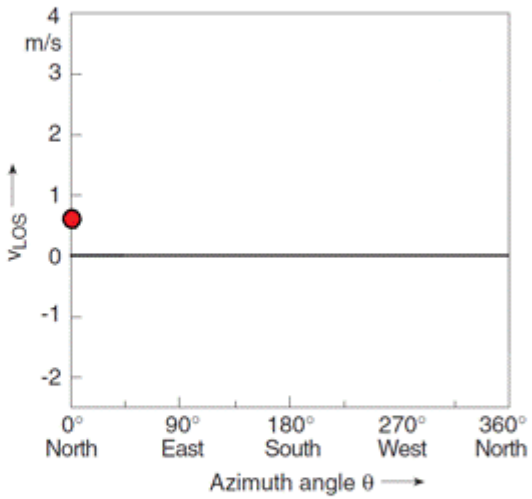


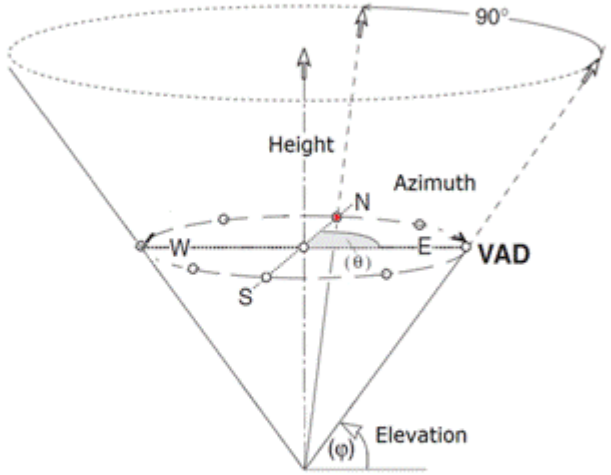
Emitted λ (nm)	1500
Detection type	Heterodyne
Range resolution (m)	30
Usual integration time (s)	~2

METHODOLOGY

Wind vector field retrieval:

Velocity-Azimuth Display (VAD) scan





METHODOLOGY

Wind vector field retrieval:

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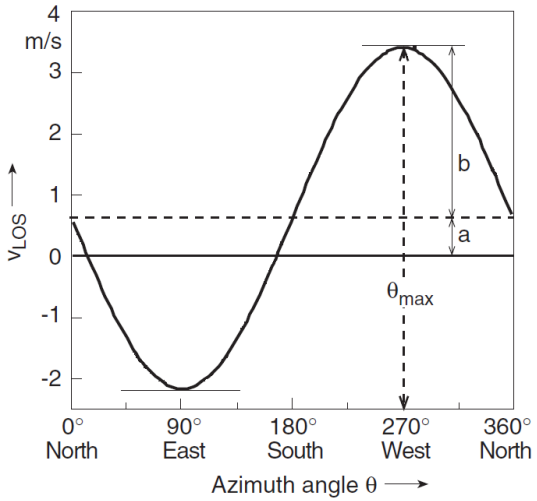
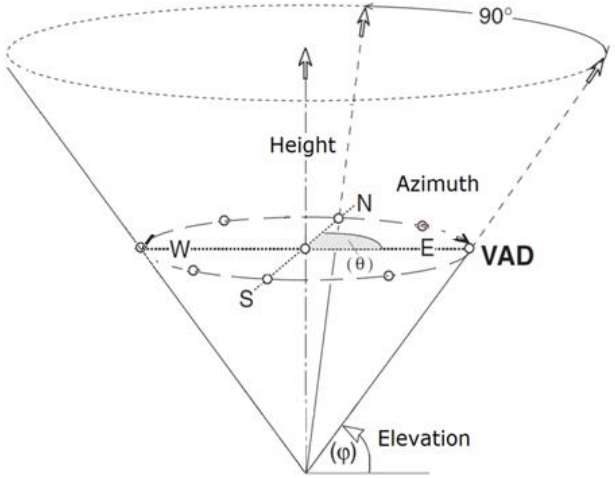
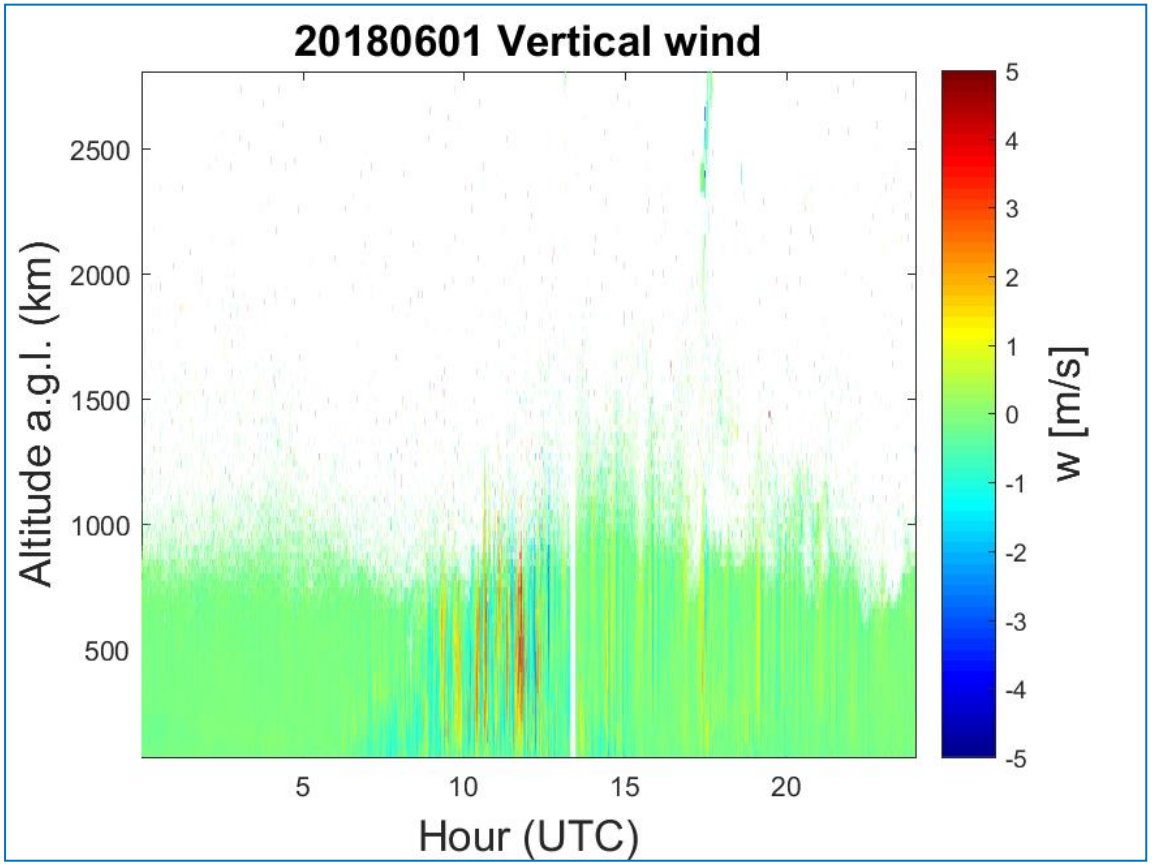




$$\vec{U} = \vec{U}(a, b, \theta_{max})$$

METHODOLOGY

Turbulence – vertical wind (w) statistical momenta



METHODOLOGY

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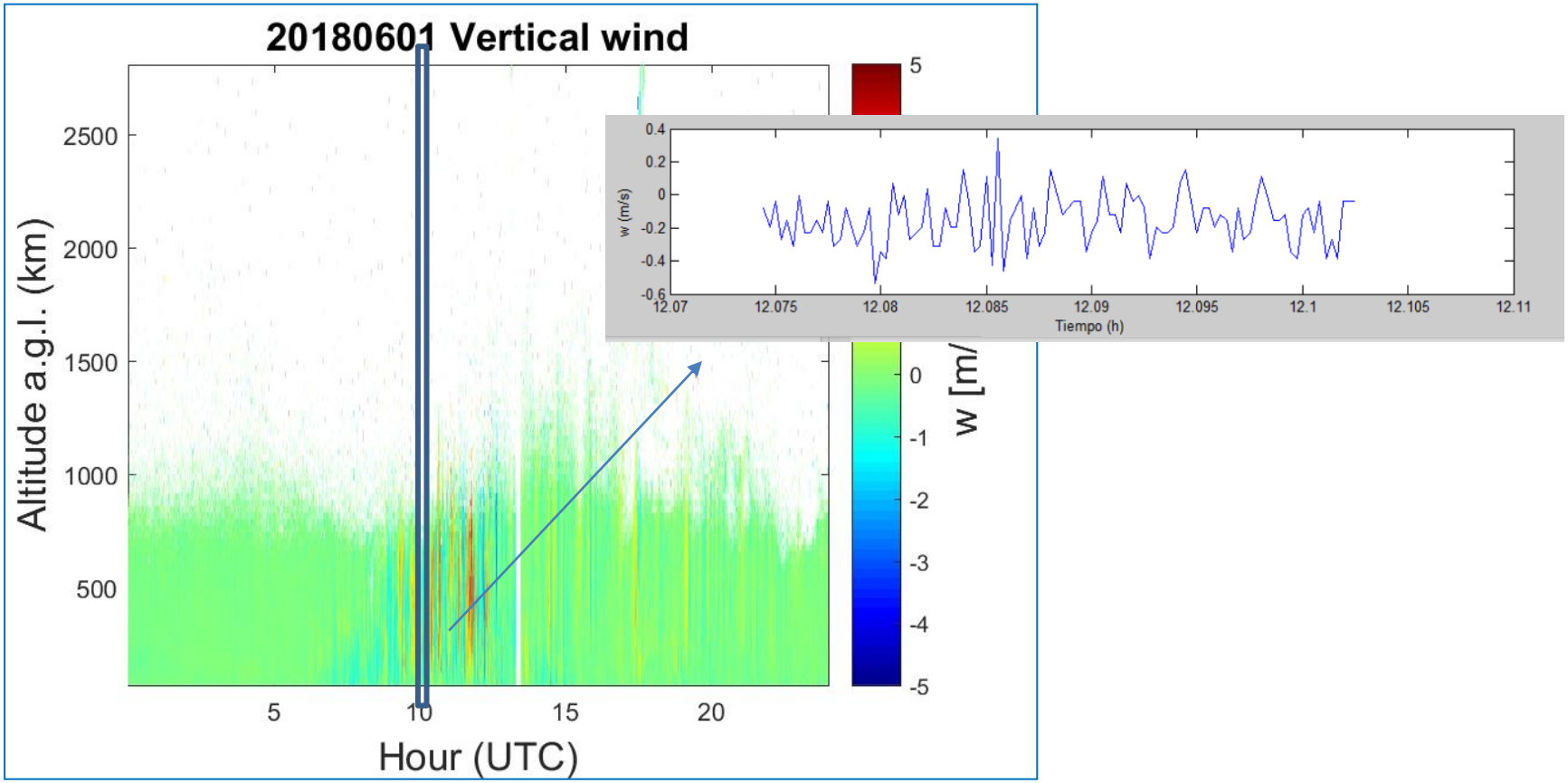
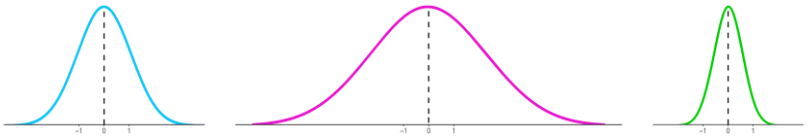


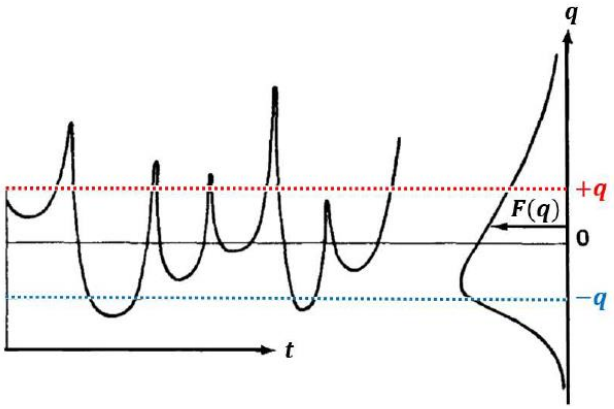
METHODOLOGY

Turbulence – vertical wind (w) statistical momenta

Variance:

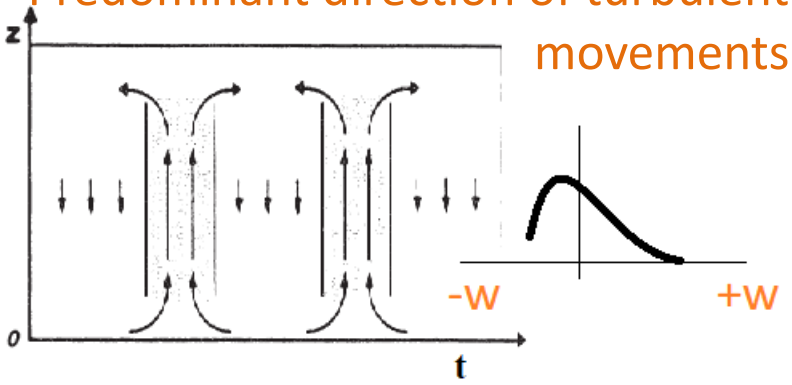
Proportional to Turbulent Kinetic Energy





Skewness:

Predominant direction of turbulent movements

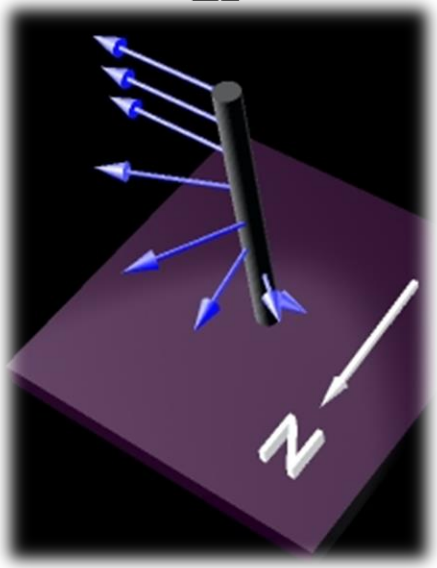


METHODOLOGY

Derived products:

Wind shear

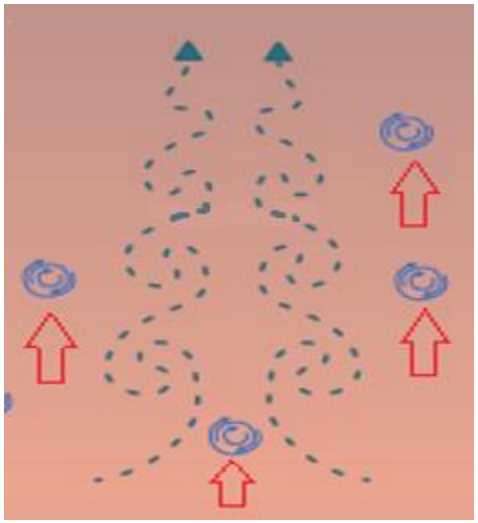
$$\frac{\sqrt{\Delta u^2 + \Delta v^2}}{\Delta z}$$



TKE dissipation rate:

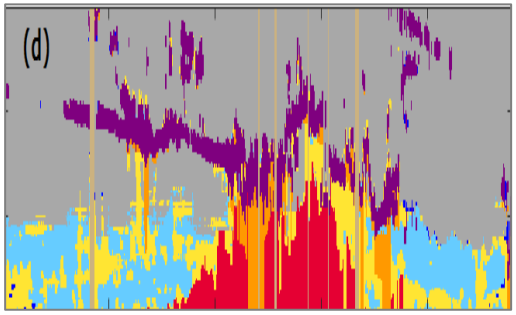
Proxy for turbulence presence

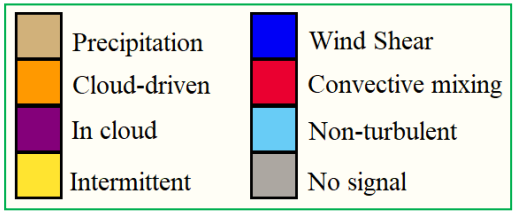
O'Connor et al. (2010)



Boundary Layer Classification

Manninen et al. (2016)





EXPERIMENTAL SITE

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PolWET site in Rzecin (PULS)

EXPERIMENTAL SITE

PolWET site in Rzecin (PULS)

- Peatland environment with:
  - 8,5 °C average T
  - 526 mm annual precipitation
  - Prevailing W surface wind
- Strong interaction with climate system

EXPERIMENTAL SITE

ICOS INTEGRATED CARBON OBSERVATION SYSTEM

Poland AOD Aerozolowa Sieć Badawcza

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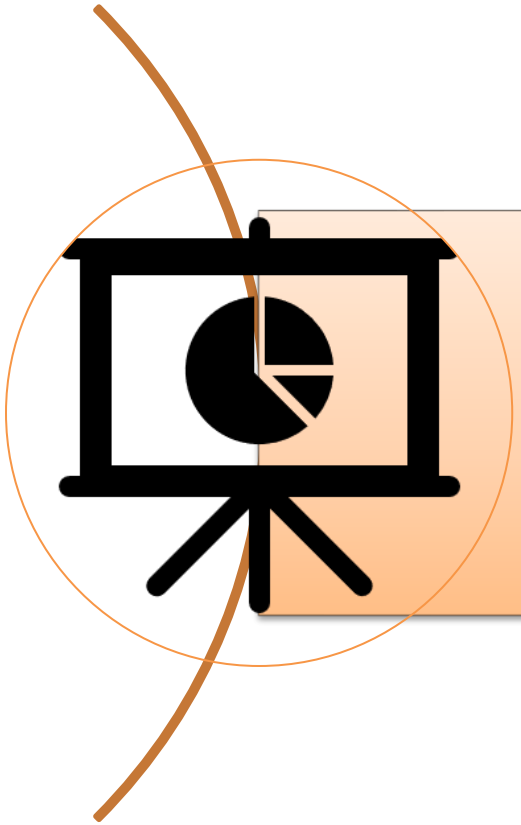
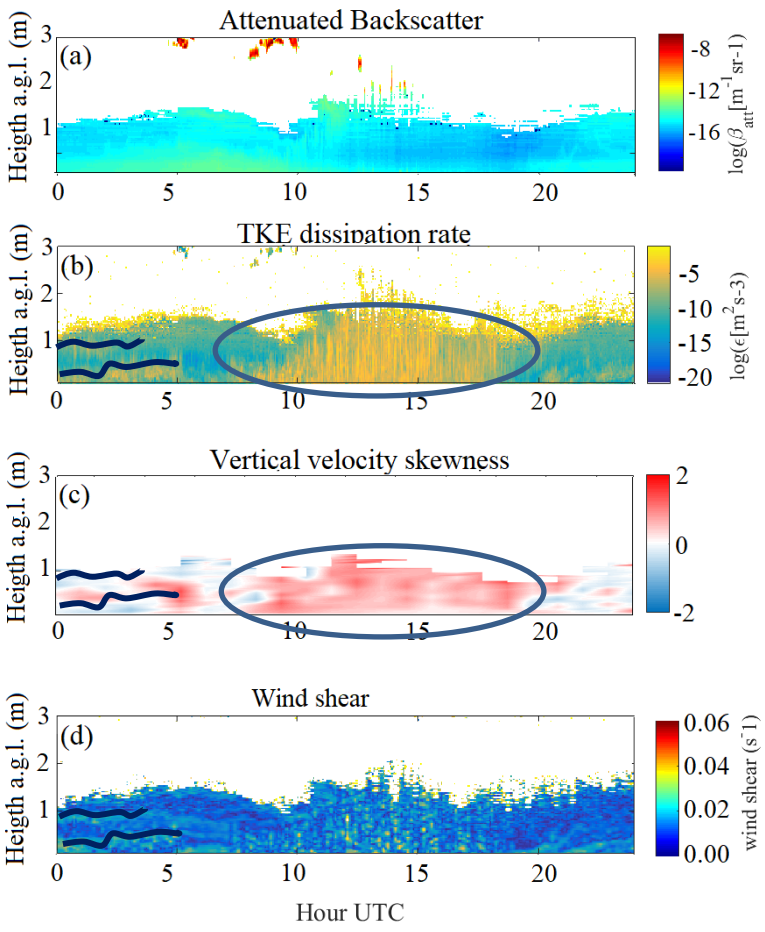
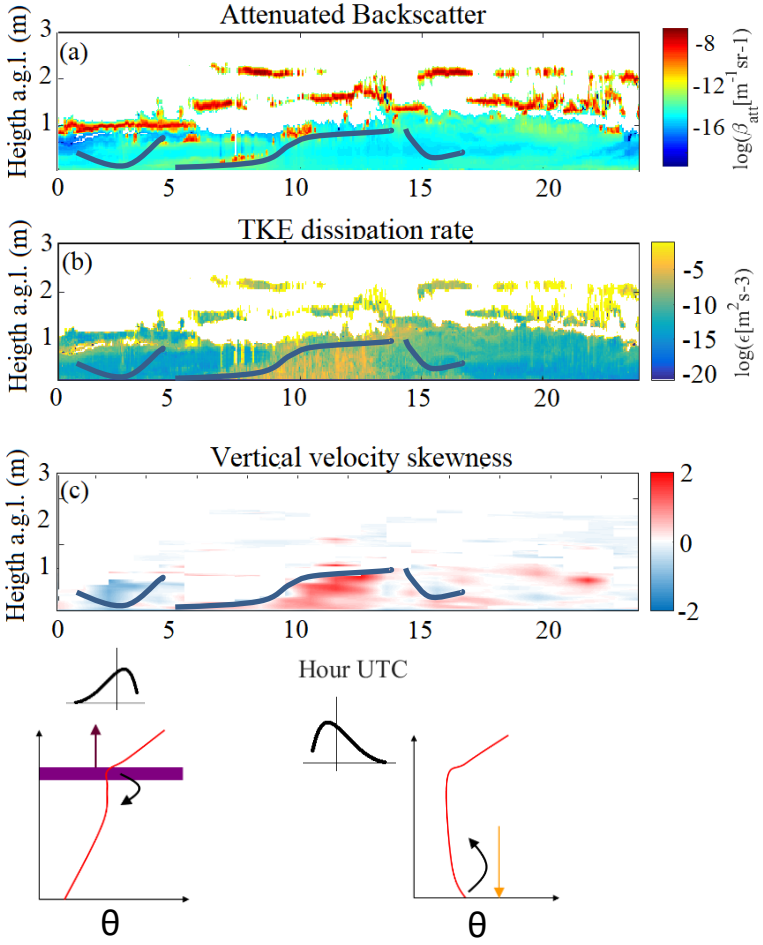
- POLIMOS campaign (ESA): 24 May – 24 September 2018



RESULTS

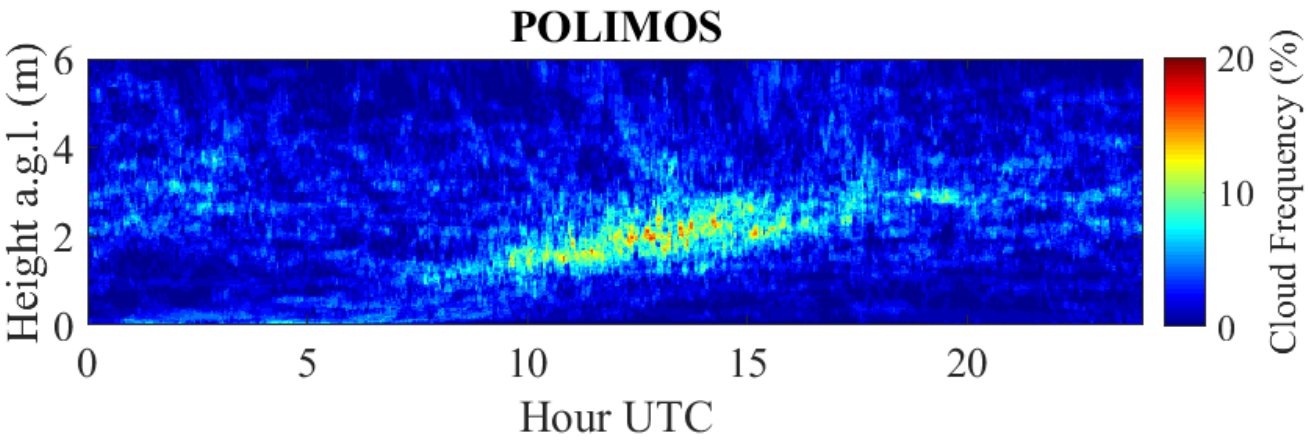
SAMPLE CASES





BL-CLOUD FREQUENCY

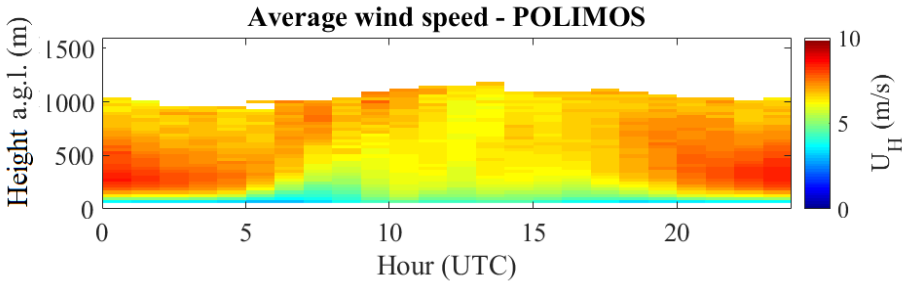
Clouds mostly at central hours, with height increasing with time



10-20 % cloud occurrence:

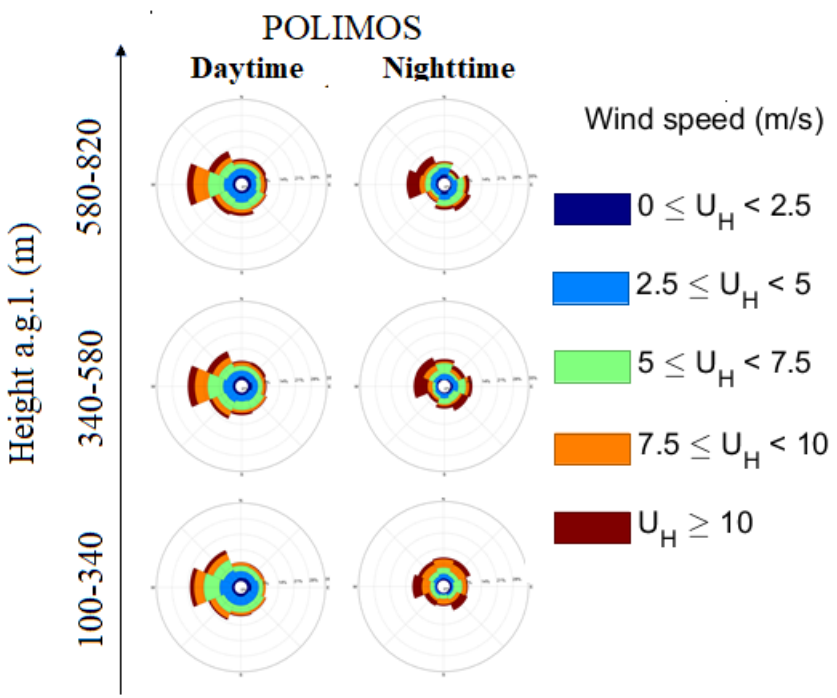
- from 10-16 h UTC
- increasing heights from 1 – 3 km a.g.l.

HORIZONTAL WIND



Wind Speed:

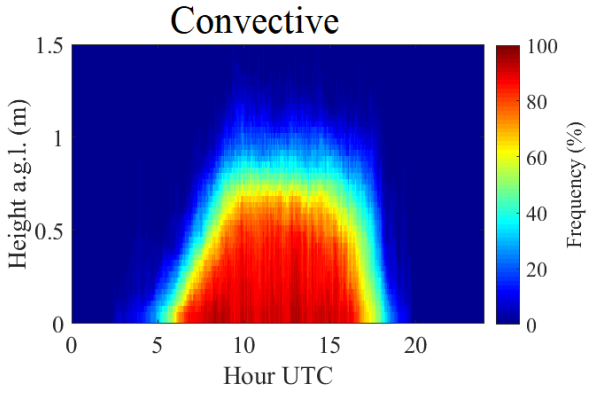
- High average wind speeds
- **Daytime**: diurnal pattern strongly influenced by the ABL development. Speeds increasing with height with minimum at noon
- **Nighttime**: strong winds, with maximum around 500 m a.g.l.



Wind Direction:

- **Daytime:** W-NW-N at all heights
- **Nighttime:** homogeneous distribution of winds.
- Strongest winds from NW

TURBULENCE SOURCES

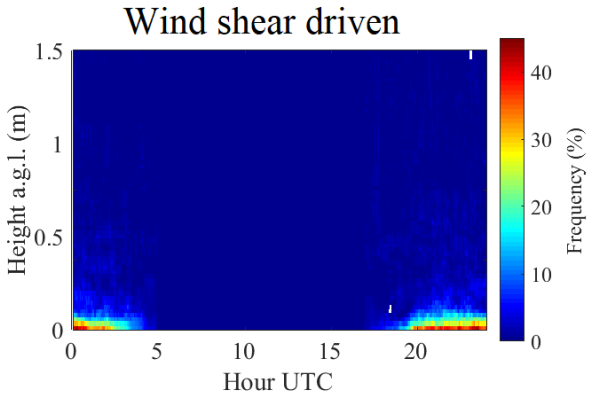


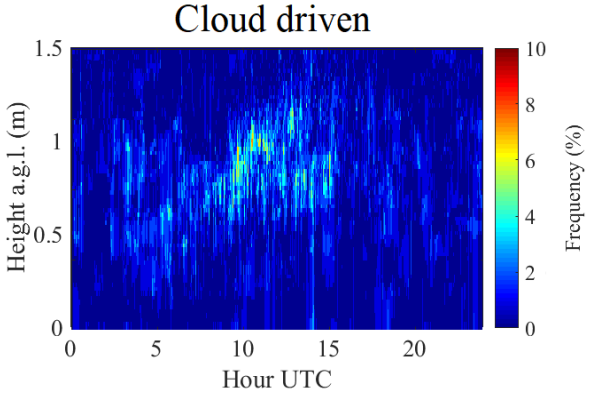
Convective mixing:

- Starts with sunrise in the lowest heights
- Gowing altitudes up to a maximum ~ 600 m a.g.l. (70 % of cases)
- Reaching almost 1000 m a.g.l. in ~40 % of cases.

Wind shear driven turbulence:

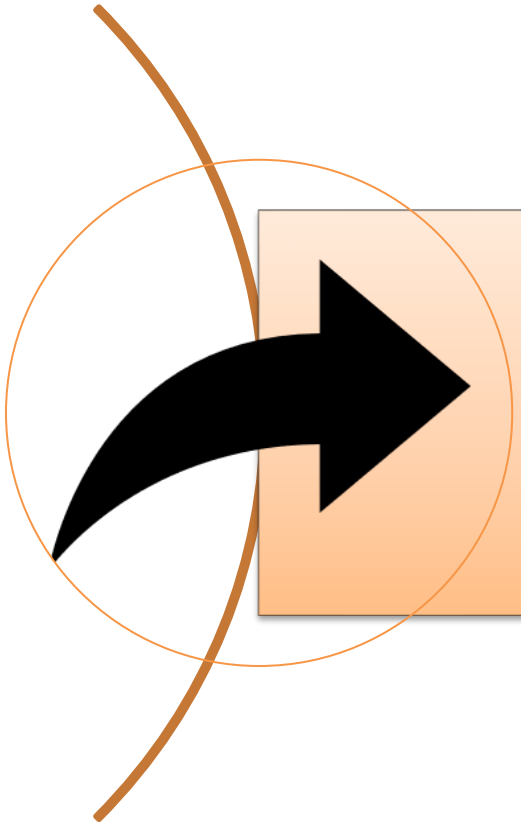
- Frequencies more than 40 % for some ranges and times
- Mostly detected < 100 m a.g.l.





Cloud driven turbulence:

- Mainly during central hours at heights of 600-1000 m a.g.l.
- Frequencies around 5 %



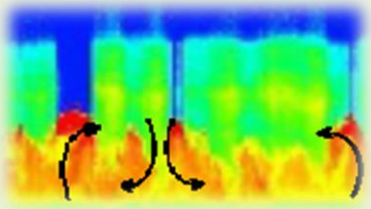
SUMMARY AND OUTLOOK

SUMMARY & OUTLOOK

- Most frequent **horizontal wind** from W with highest speeds during nighttime.
- **Convective mixing**: clear diurnal pattern up to 1 km a.g.l.
- **Wind shear driven turbulence**: important contribution below 100 m a.g.l.
- **Cloud driven turbulence**: non-negligible contribution during central hours.

SUMMARY & OUTLOOK

- Study of particular patterns with statistical techniques (e.g. PCA)
- Automatic detection of Low-level Jets
- Combination with Raman lidar: AEROSOL FLUXES



SEWTABLE

THANK YOU FOR YOUR ATTENTION

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