

“Two-year wind observation in Limassol, Cyprus: Monthly and Seasonal analysis from Doppler LiDAR at the CARO National Facility”

First ever look of the Doppler LiDAR in Cyprus

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This project is co-funded by the Cyprus University of Technology.

- To delve into and utilize the data of the only operating Doppler LiDAR instrument in Cyprus.
- To investigate the wind patterns that affect the city of Limassol, Cyprus.
 - Monthly and seasonal analysis of the average horizontal wind speed and direction.
 - To find how the island's geomorphology and the Mediterranean sea influence the observable wind patterns in Limassol.
- To investigate the formation processes and estimate the height of the Mixing Layer of each season.



Limassol is a coastal city that lies between the Mediterranean Sea and Troodos Mountain range.

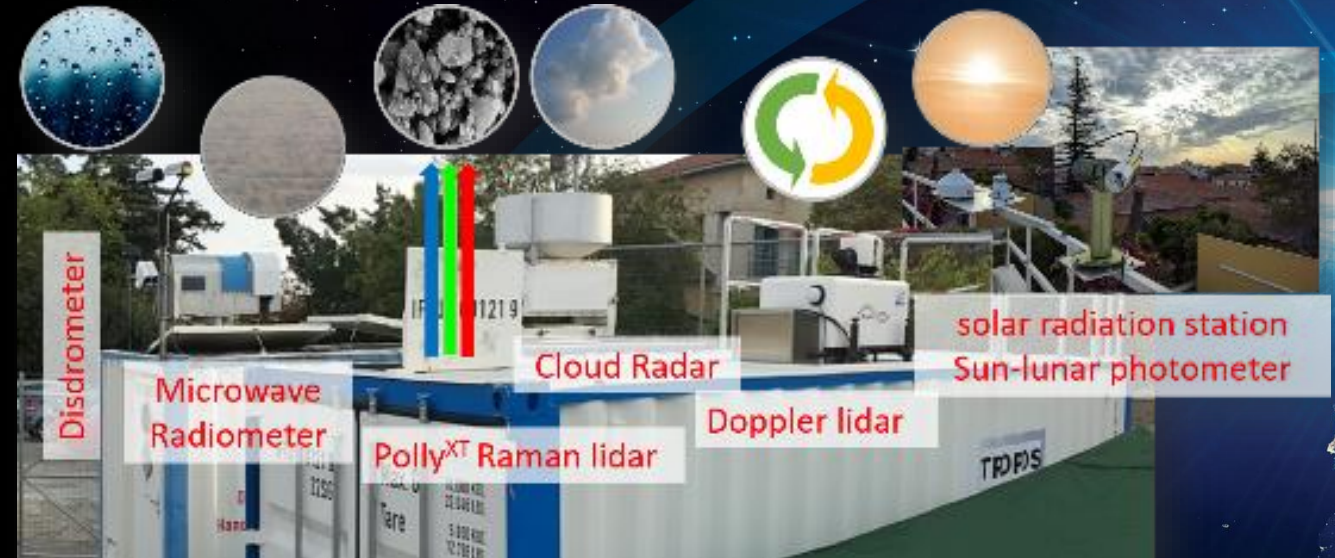
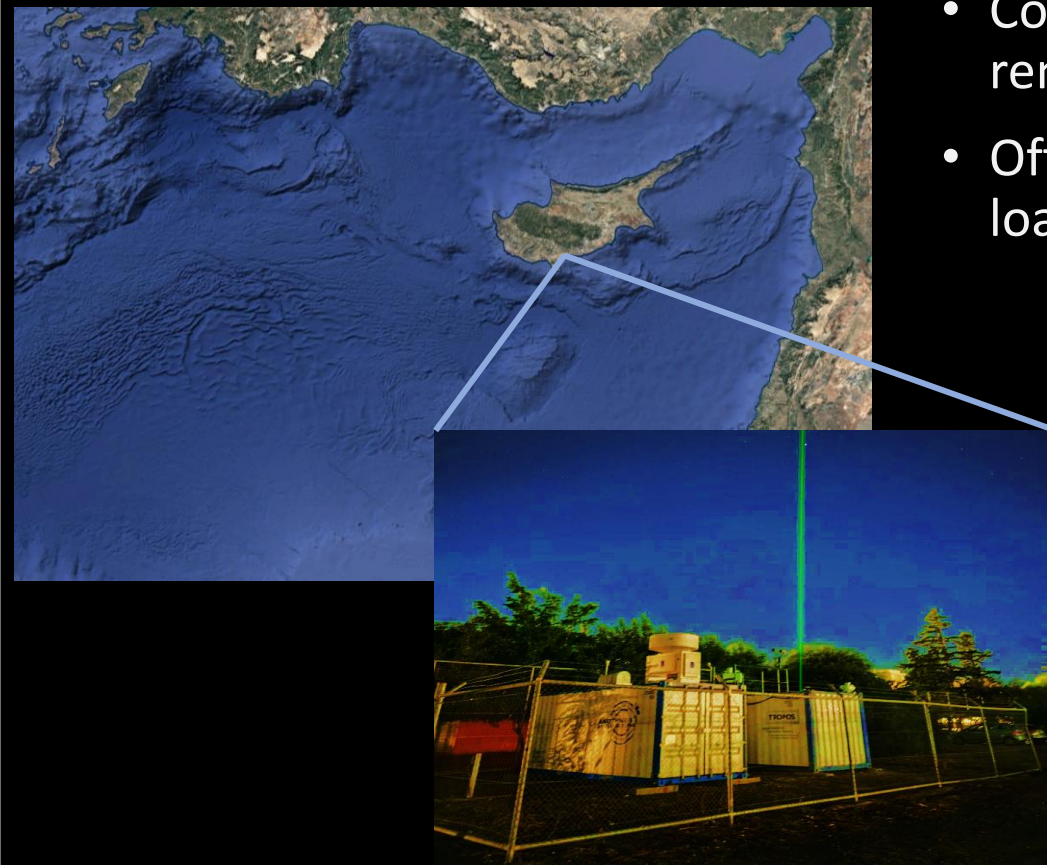


- ☐ Katabatic winds
- ☐ Land breezes
- ☐ Sea breezes

→ It is also a point where air masses of different origin meet.

- Saharan dust
- Middle Eastern dust
- Smoke plumes (Greece, Turkey, Canada, etc.)
- Continental air masses
- Marine air masses

- Ground-based station located in Limassol
- Consists of an aerosol remote sensing (ARS) and a cloud remote sensing (CRS) observational platforms.
- Offers complete insights into atmospheric dynamics, aerosol load, and cloud dynamics.



Halo Photonics Streamline XR Doppler Lidar

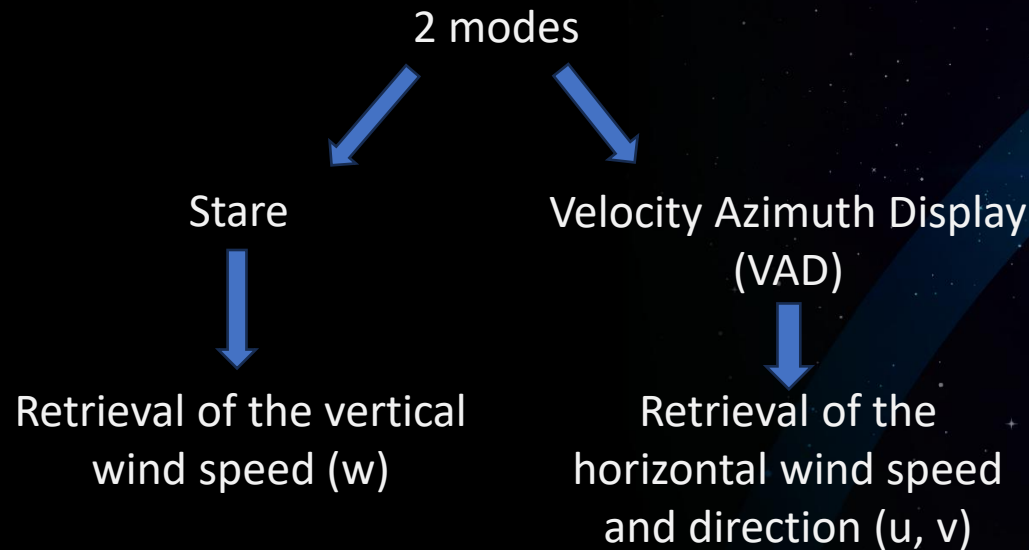


- Active Remote Sensing instrument
- It works by emitting laser pulses and measuring the frequency shift of the backscattered light due to the relative motion of air particles (*Doppler effect*)
- It provides high-resolution profiles of the vertical wind speed and horizontal wind speed and direction across different atmospheric heights

Table 1: Operational details of the Doppler LiDAR.

Parameters	Values
Wavelength	1540 nm
Laser Energy	0.99 μ J
Lens Diameter	10 cm
Beam Divergence	33 μ rad
Pulse Repetition Frequency	15 kHz
Range Resolution	48 m
Number of Pulses per Ray	50000
Number of Samples per Gate	1500
Pulse Duration	0.2 μ s

Spatial resolution: ~ 45 m
Temporal resolution: ~ 2 s
(vertical wind)



$$V_{HOR} = \sqrt{u^2 + v^2}$$

$$\theta = \arctan(v/u)$$

Monthly & Seasonal Wind

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Average monthly horizontal wind speed & direction

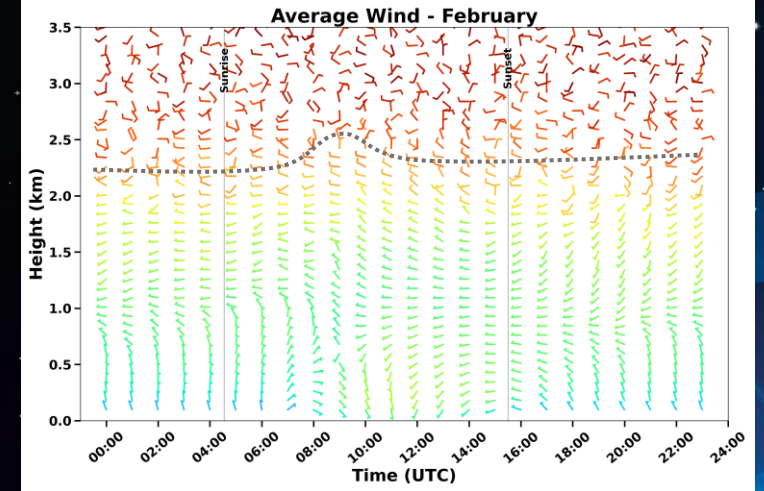
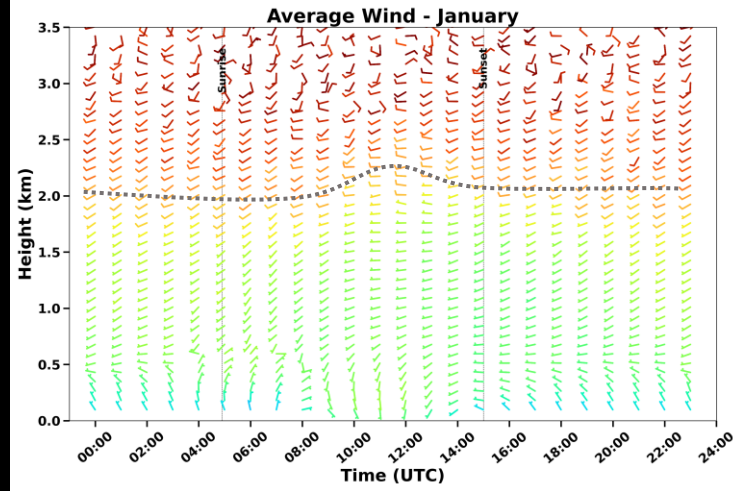
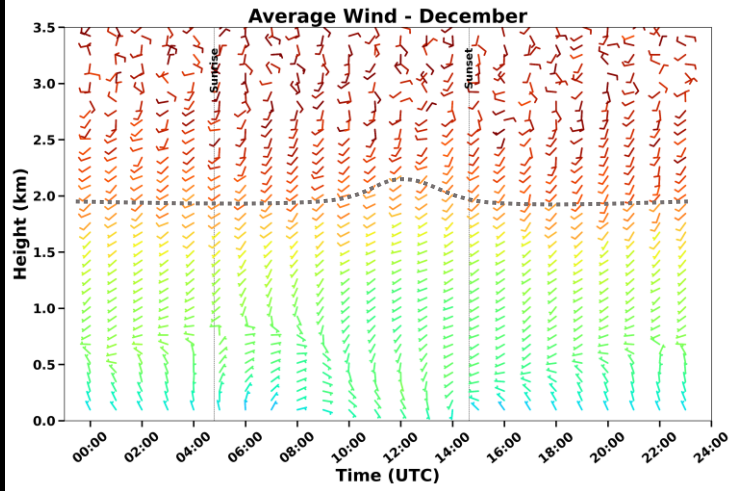
- **2 full years** of data of the **horizontal wind** between **February 2023** and **January 2025** were used.
- Daily wind speed and direction data were averaged for each one-hour interval and height bin.
- The resulting daily mean values were then averaged monthly for each respective one-hour and height bin.

Average seasonal horizontal wind speed & direction

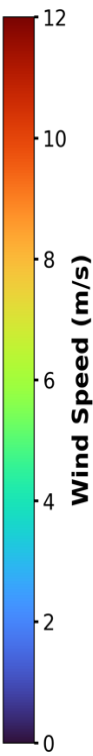
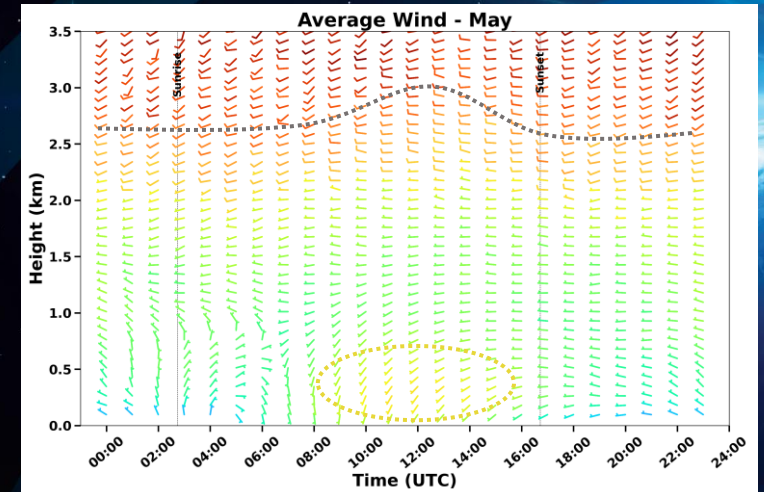
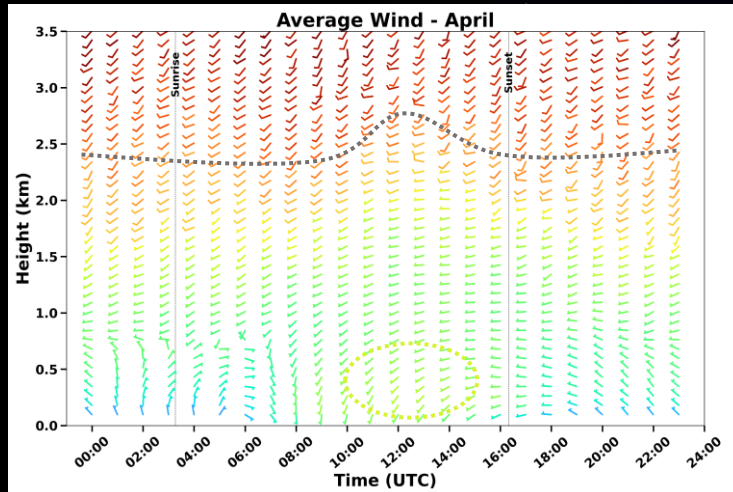
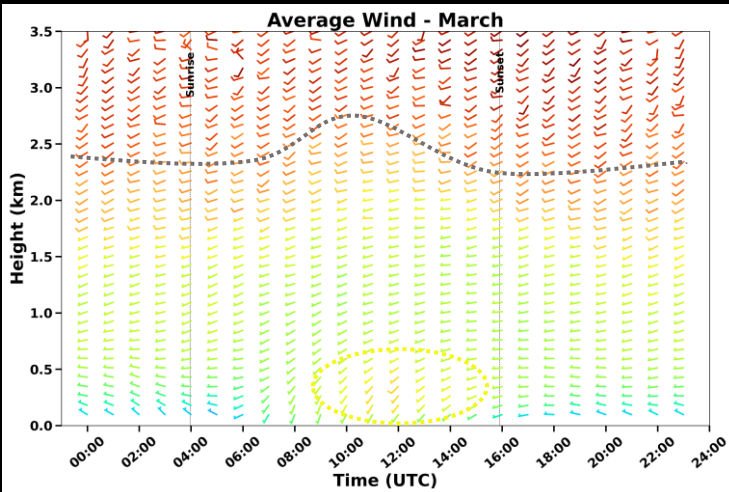
- 4 seasons: - Winter (Dec. to Feb.) => 180 days
 - Spring (Mar. to May) => 184 days
 - Summer (Jun. to Aug.) => 184 days
 - Autumn (Sep. to Nov.) => 182 days
- The same process as the previous one was followed.

Average Monthly Wind

Winter

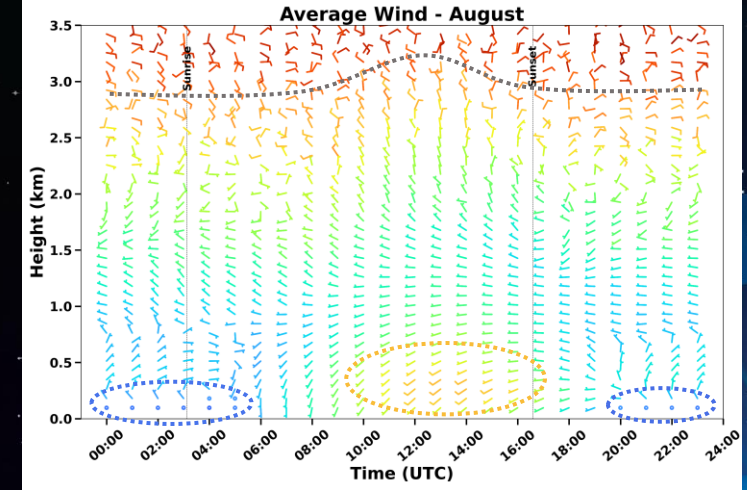
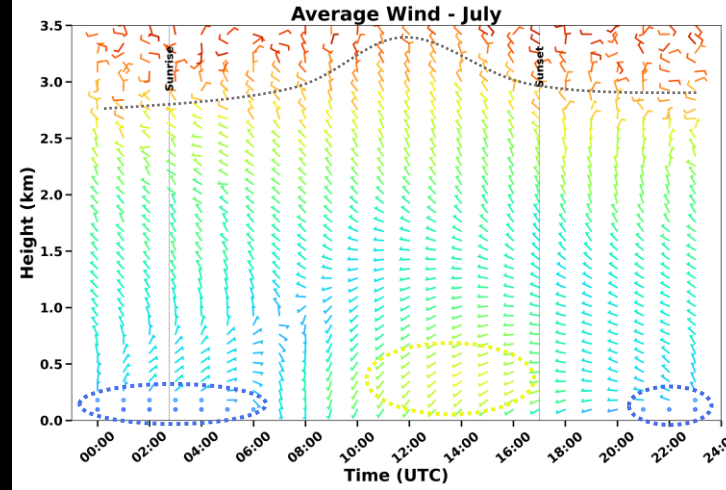
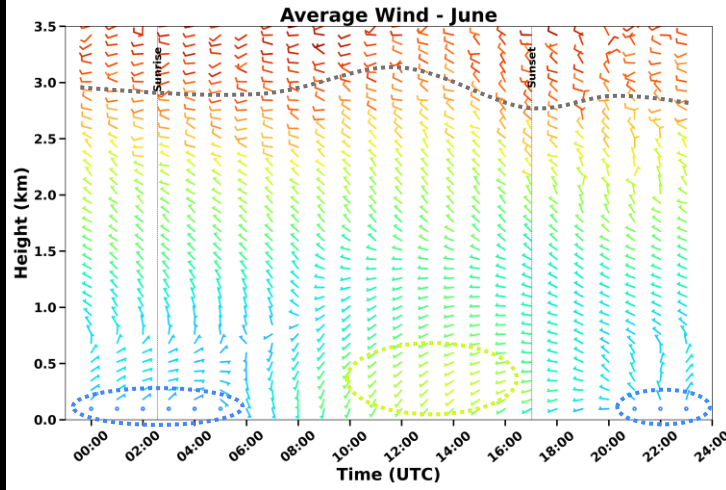


Spring

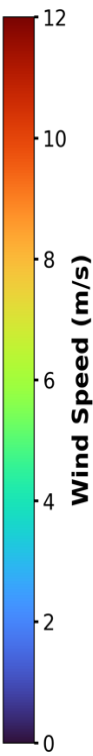
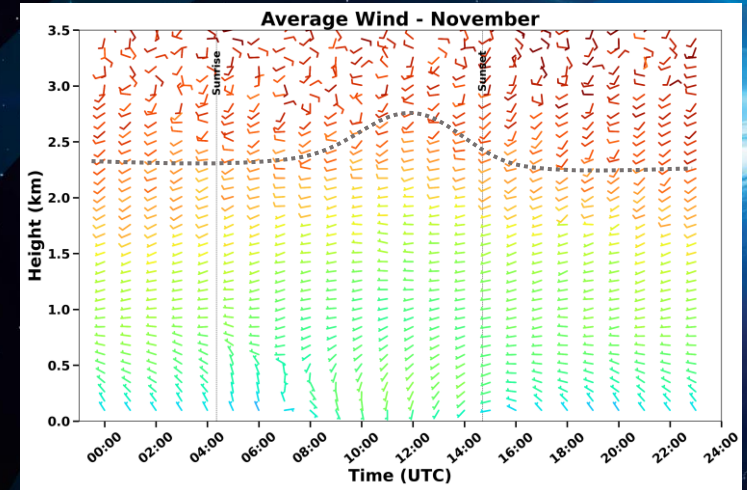
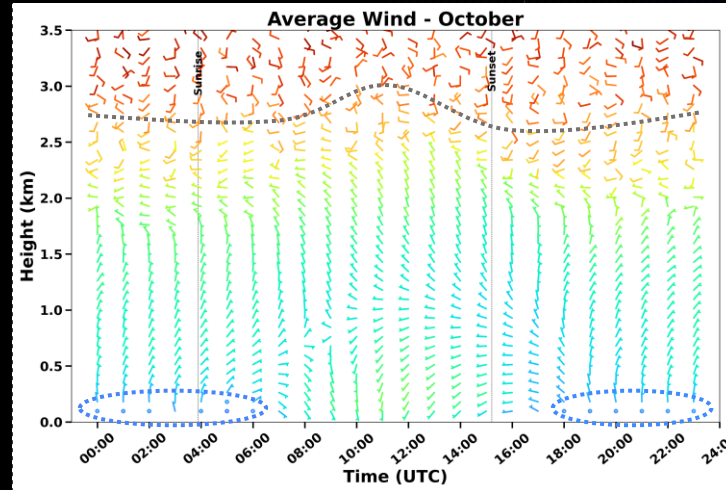
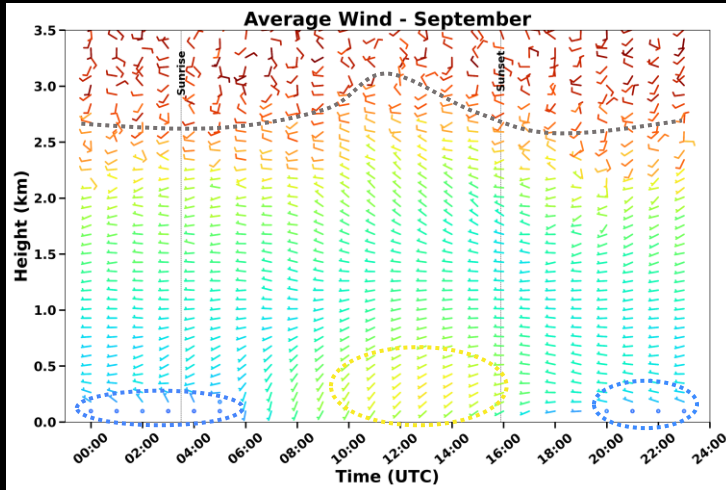


Average Monthly Wind

Summer



Autumn

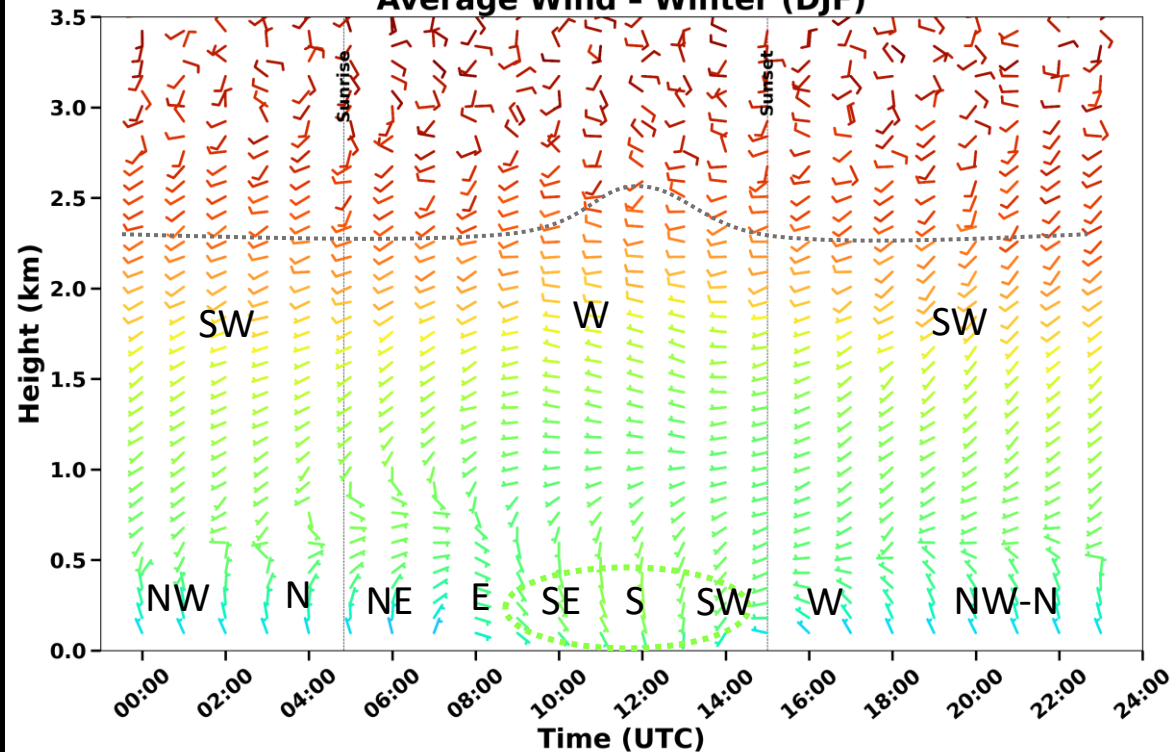


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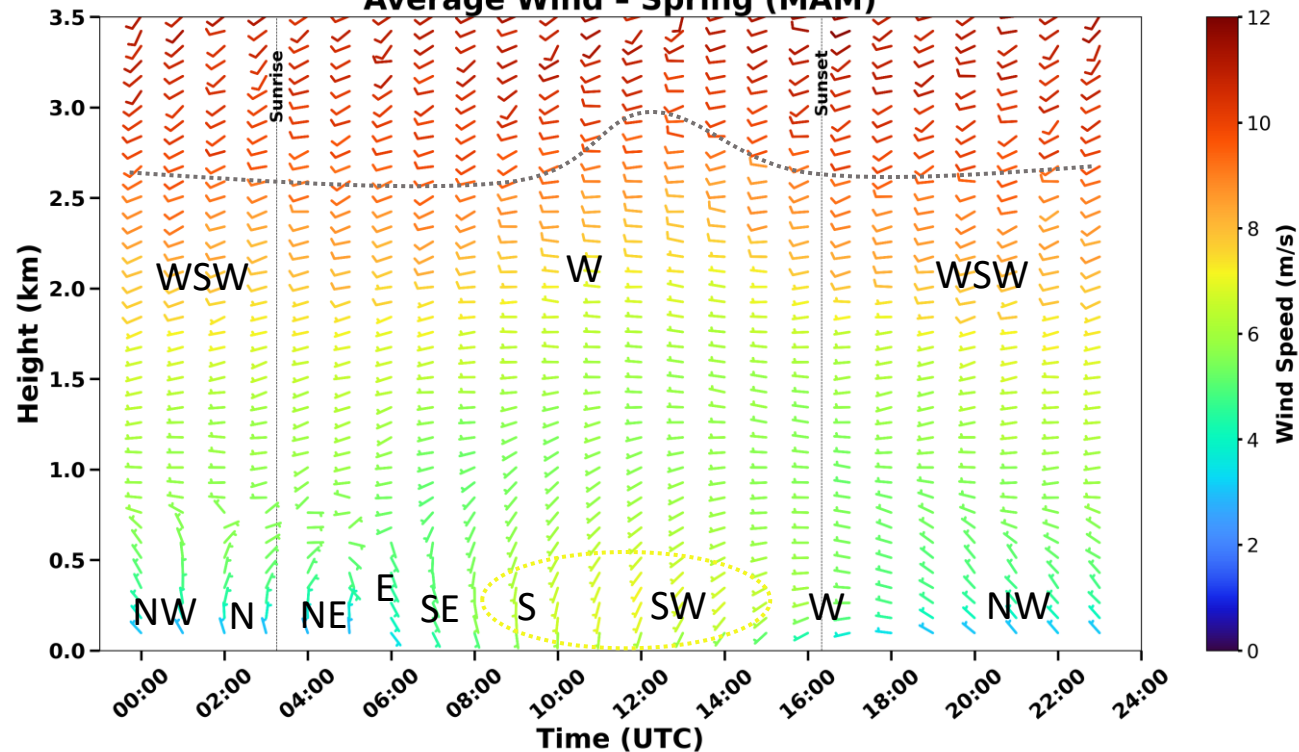
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Average Seasonal Wind

Average Wind - Winter (DJF)

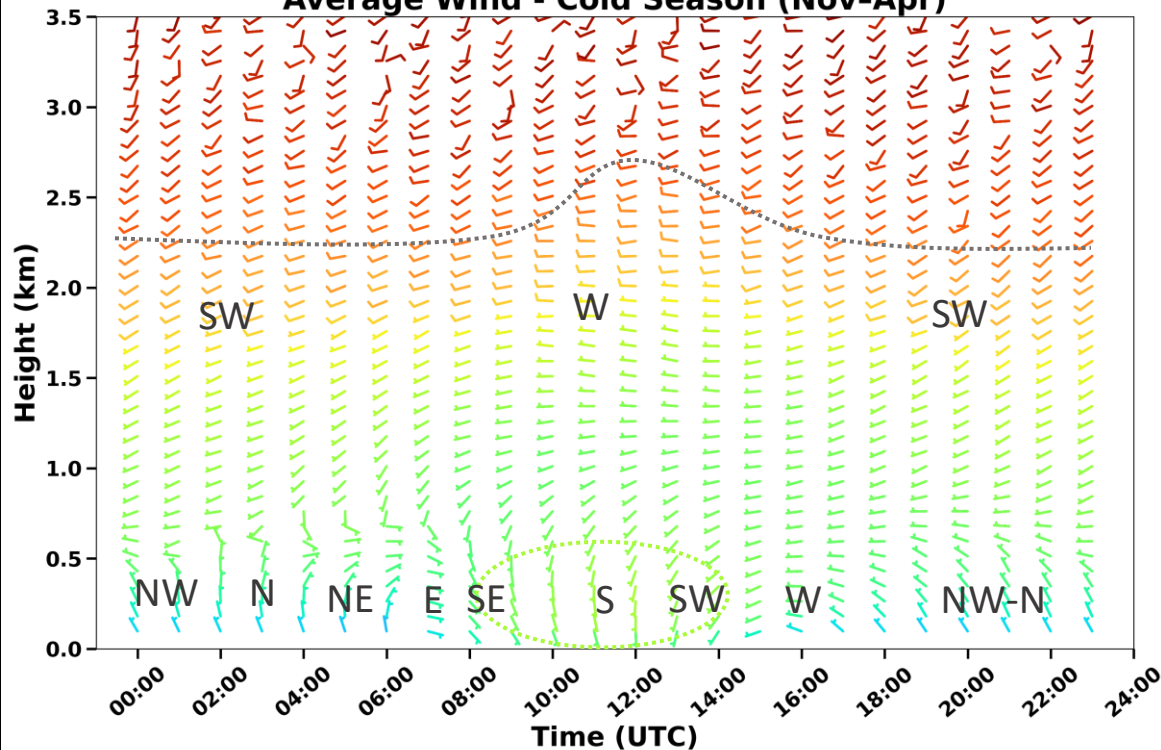


Average Wind - Spring (MAM)

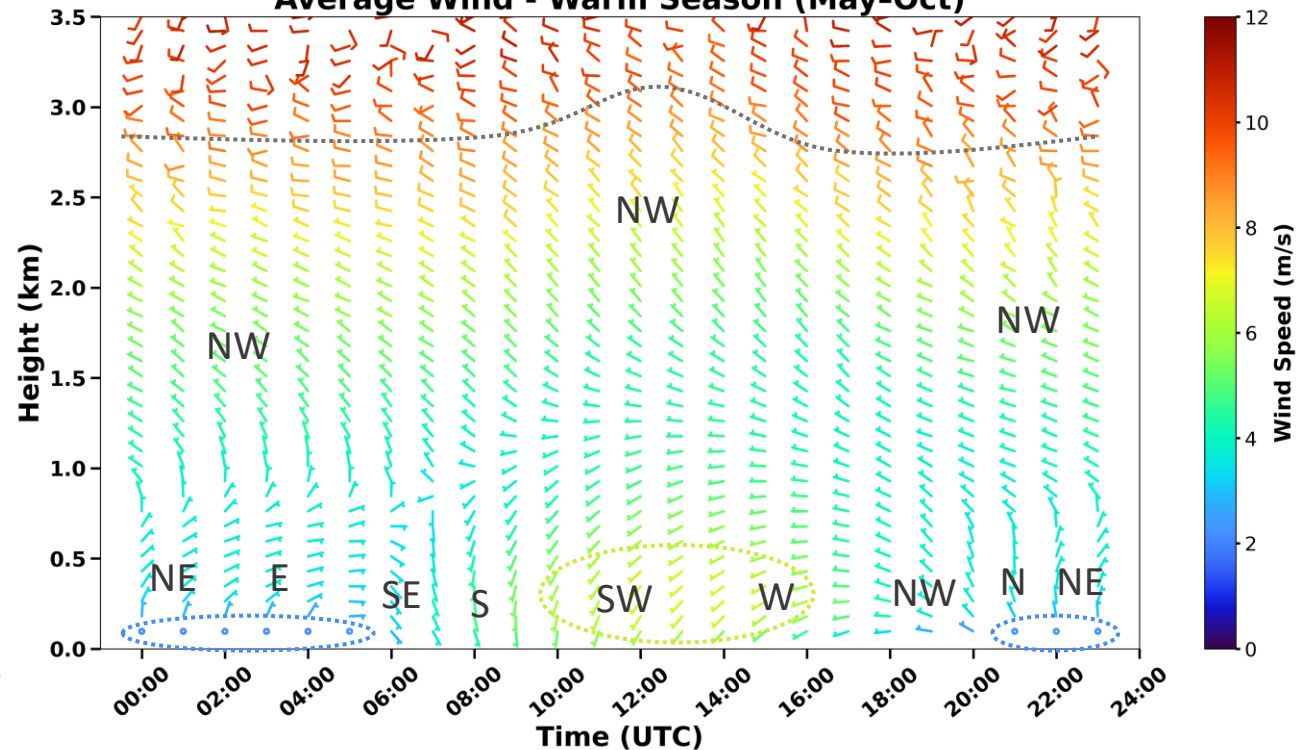


Average Semiannual Wind

Average Wind - Cold Season (Nov-Apr)



Average Wind - Warm Season (May-Oct)



Mixing Layer Height

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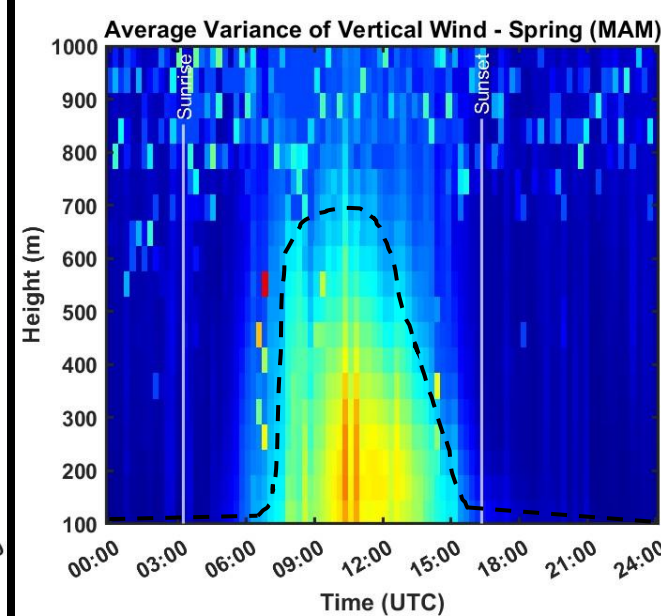
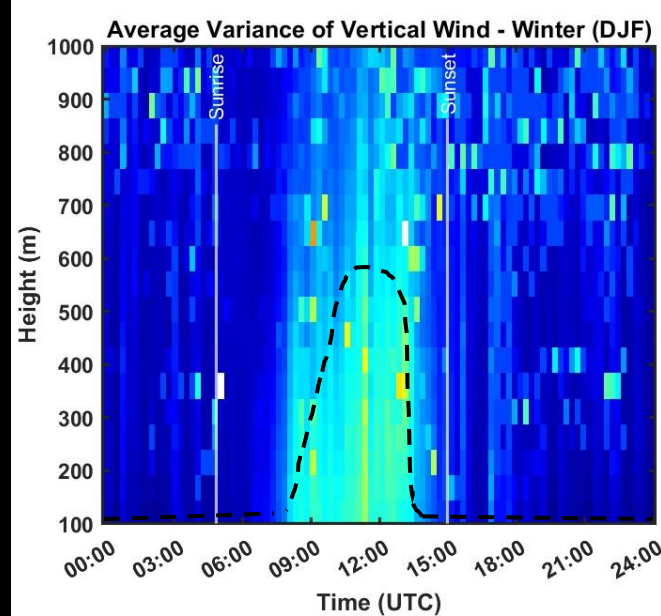
Seasonal Mixing Layer Height

- 2 full years of data of the vertical wind speed between February 2023 and January 2025 were used.
- The same 4-season categorization was used.
- The variance of the vertical wind (σ_w^2) was calculated along the time dimension within each 15-minute bin for each height level.
- This method was based on a combination of the papers of Bühl, 2015, Dewani et al., 2023, and Vakkari et al., 2015
- A variance *threshold-indicator* was chosen for each season:
 - Winter → $0.45 \text{ m}^2/\text{s}^2$
 - Spring and Autumn → $0.40 \text{ m}^2/\text{s}^2$
 - Summer → $0.35 \text{ m}^2/\text{s}^2$

Mixing Layer Results

Winter

Duration: 5.5 hours
Max height: < 600m

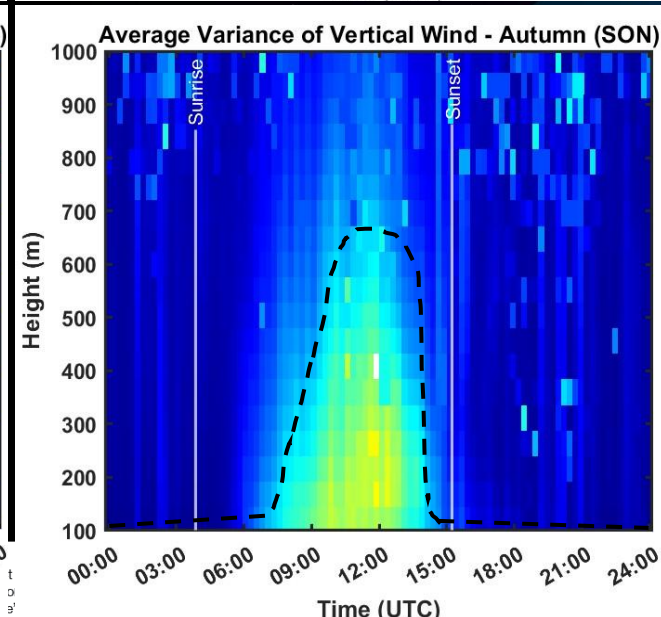
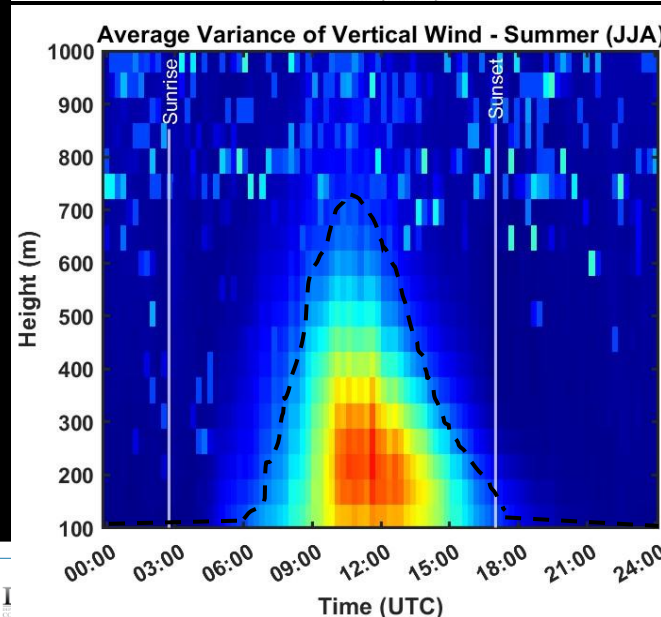


Spring

Duration: 8.5 hours
Max height: ~ 700m

Summer

Duration: 10 hours
Max height: > 700m



Autumn

Duration: 7.5 hours
Max height: ~ 650m

- Distinct patterns between day and night for both the wind speed and wind direction.
- The months, as well as the seasons, indicate the existence of two six-month periods: the cold one and the warm one, in which the wind can be sufficiently described.
- The local topographical factors influence the observed directional patterns of the wind; both sea and land breezes are observed.
- The σ_w^2 indicates the presence of a shallow Mixing Layer, the intensity as well as the extent of which presents a seasonal variation as expected, as it highly depends on the influence of the Sun.

THANK YOU

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