AWACA 2024-2025 CAMPAIGN: METEOROLOGY AND TURBULENCE IN THE ANTARCTIC BOUNDARY LAYER

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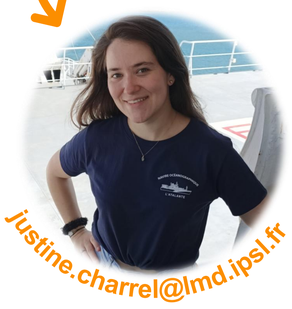

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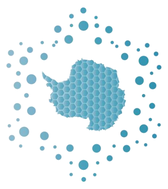
This poster presents a first analysis of AWACA meteorological towers, illustrating 3 events in February 2025 and instrument synergy from the coast to the Plateau.

SCAN ME !

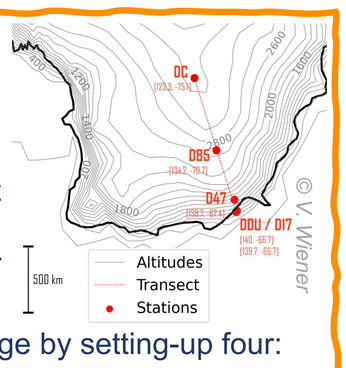
① What is AWACA ?



AWACA
Atmospheric WAter Cycle over Antarctica
past, present & future

See https://awaca.ipsl.fr/

Antarctica is the coldest, driest, windiest, and highest continent, with scarce, mostly coastal and summer weather observations.



The **AWACA** project aims to improve this coverage by setting-up four:

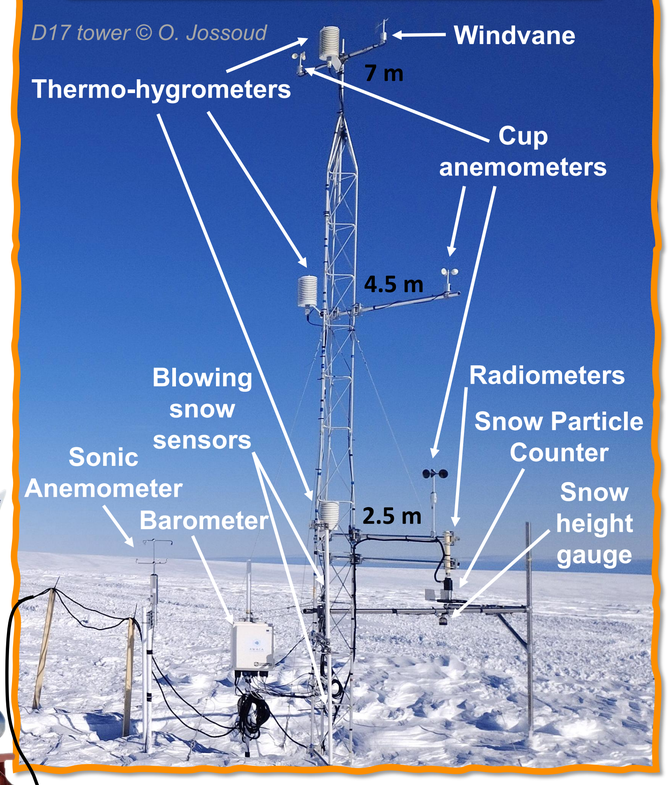
- ❑ *Autonomous Observation Platform Units (OPUs)*
- ❑ *7-meter meteorological towers*

along a transect ranging from coastal Adélie Land to the Dome C (DC) Plateau, 1100 km inland.

The OPUs operate all year long, measuring condensed water in the atmosphere, and water vapor and snowflakes isotopes. Additional instrumentation has been deployed at the Dumont d'Urville (DDU) station.

🎯 **OBJECTIVE:** Better understand past and future evolution of the Antarctic ice sheet, by calibrating and refining climate models physics.

② Meteorological tower



③ Turbulence data-processing

10 Hz temperature and 3D wind from **sonic anemometer** are processed over 30-minute intervals to obtain key **turbulence** variables as follows:

Friction velocity

$$u_* = \left(\left(\overline{u'w'} \right)^2 + \left(\overline{v'w'} \right)^2 \right)^{1/4}$$

Sensible heat flux

$$Q_s = \frac{p\, M_{air}\, C_p\, \overline{w'T'}}{R\, T_{2.5m}}$$

Turbulent kinetic energy

$$TKE = \frac{1}{2}\left(\overline{u'u'} + \overline{v'v'} + \overline{w'w'}\right)$$

Roughness length

$$z_0 = H\, exp\left(-\frac{\kappa\, |U|}{u_*}\right)$$

for neutral and stationarity conditions, with |U| > 5 m.s^{-1}

Anisotropy factor

$$Af = 3\,\lambda_s$$

$0 < Af < 1$ (perfect isotropy)

with λ_s the smallest eigenvalue of the Reynolds-stress tensor

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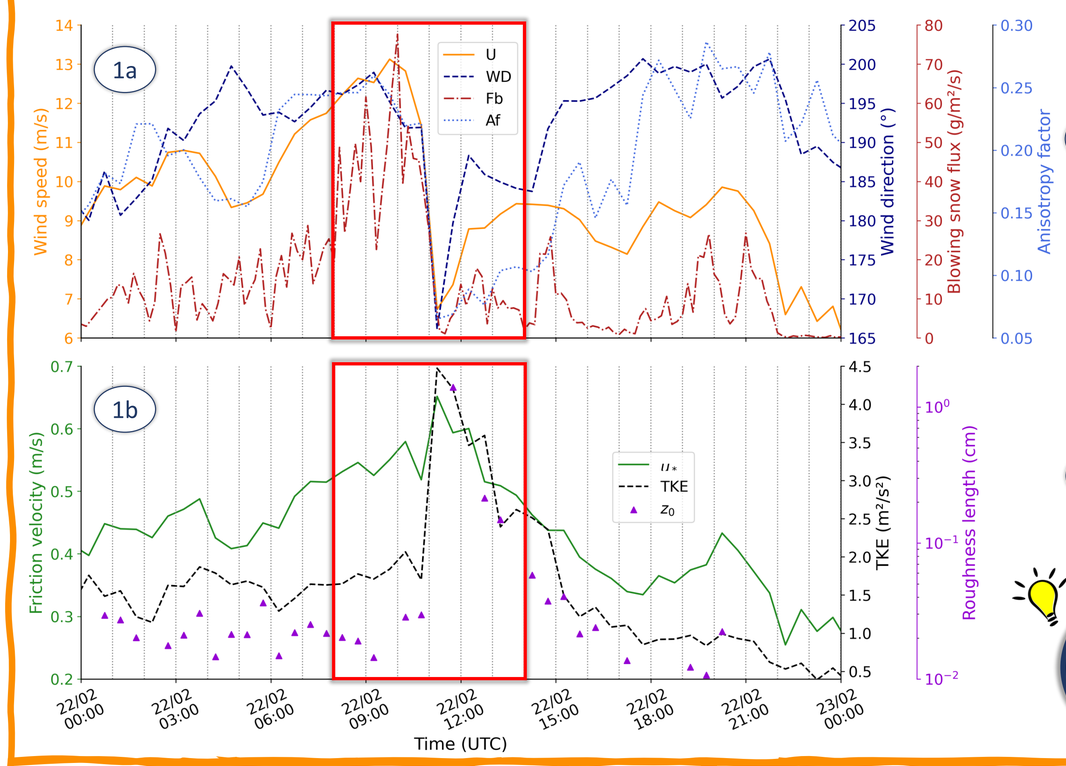
④ Key results

Turbulence at D17 on the 22 Feb. 2025 associated with a warm front passage



1a **Sonic anemometer wind speed, blowing snow flux and anisotropy factor at D17** showing a simultaneous decrease associated with a wind direction shift (SSW → SSE).

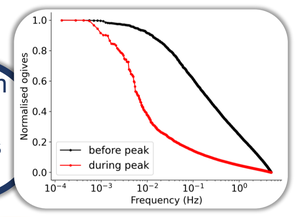
DID YOU KNOW ?

Sastrugi are snow ridges sculpted by the mean wind. Surface roughness may increase when abrupt wind shifts occur, as the sastrugi become misaligned.

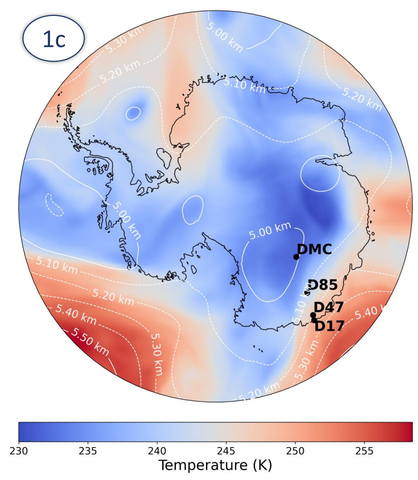
1b **Friction velocity, turbulent kinetic energy and roughness length at D17** showing a simultaneous peak.

DID YOU KNOW ?

Ogives are the cumulative sum of the fluctuations cospectra, indicating energy contributions from low or high frequencies.



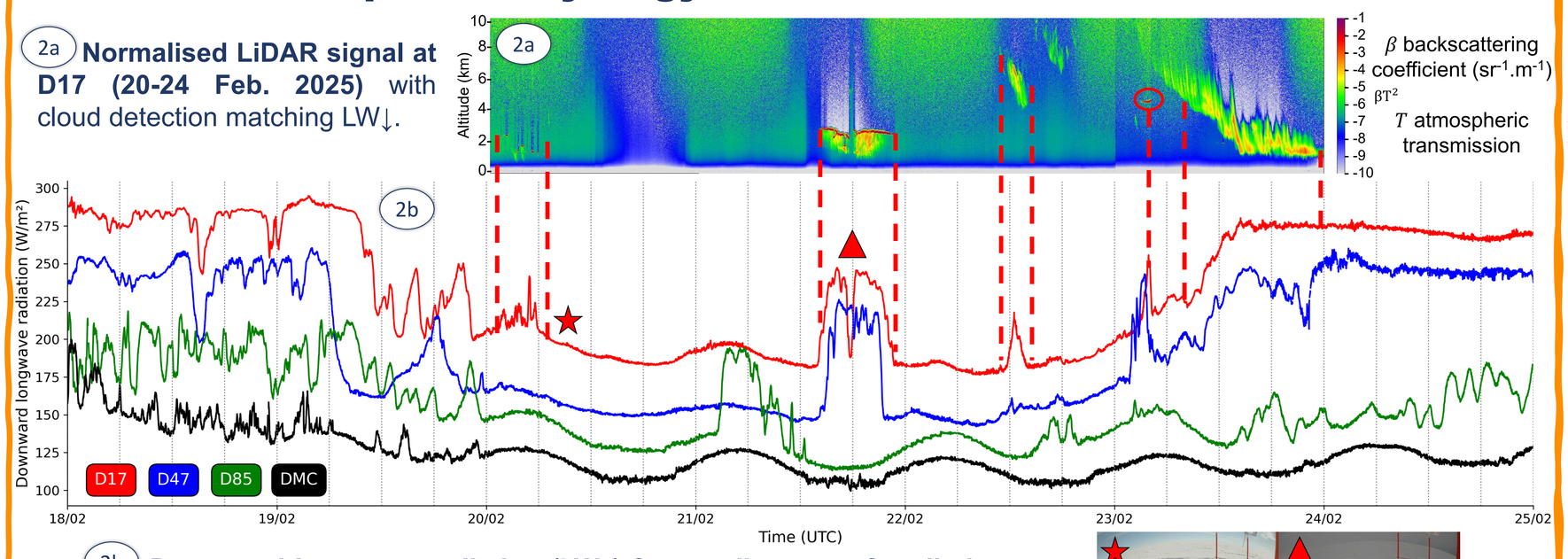
→ During the *turbulence peak*, the spectral energy shifts toward *lower frequencies*, indicating a dominant influence of *large-scale eddies*.



1c **500 hPa air temperature and geopotential height from ERA5** showing a warm front passage at D17

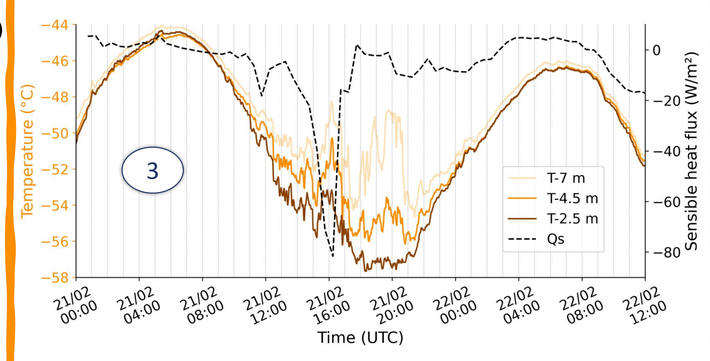
Clouds are spotted : synergy between surface meteo and LiDAR

2a **Normalised LiDAR signal at D17 (20-24 Feb. 2025)** with cloud detection matching LW↓.



2b **Downward longwave radiation (LW↓) from radiometers for all sites (18-25 Feb. 2025)** showing cloud presence. The signals timing between sites suggests clouds moving from the coast toward the Plateau, or conversely.

Temperature inversion at Dome C



3 **3-level temperature and sensible heat flux at Dome C (21 Feb. 2025)** showing temperature inversion (up to 10 K in 4.5 m) during local night, associated with the strongest negative sensible heat flux of Feb. 2025.

The temperature inversion is confirmed by the "American" 40-meter tower (not shown).

⑤ What's next ?

Extend analysis
deepen the analysis of these case studies

Evaluate parameterizations

- ❑ turbulent diffusion (Vignon et al. 2024)
- ❑ blowing snow (Vignon, Chiabrando et al., 2025, in prep.)
- ❑ mixed-phase clouds (Raillard et al., 2025, submitted)

Model evaluation
compare the LMDZ atmospheric circulation model with observations

Towards new parameterizations
snow cover dynamical, thermal and optical properties (Wiener et al., 2025, submitted)

References

Raillard, L., Vignon, É., Riviere, G., and Madeleine, J.-B. (2025). A turbulence-informed parameterization of phase partitioning in stratiform mixed-phase clouds for the ICOLMDZ model. *Journal of Advances in Modeling Earth Systems*, [submitted].

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Wiener, V., Vignon, É., Caton Harrison, T., Genthon, C., Toledo, F., Canut-Rocafort, G., Meurdesoif, Y., and Berne, A. (2025). An extensive investigation of the ability of the ICOLMDZ model to simulate a katabatic wind event in Antarctica. *EGUsphere*, [preprint]. https://doi.org/10.5194/egusphere-2025-2046

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