Atmospheric boundary layer structure at the head of a small Alpine tributary valley detected by UAS

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1. Background

- **Exchange** of mass, energy, and momentum in the **atmospheric boundary layer (ABL)** is more complex in **mountainous terrain** than in flat terrain → need to **improve understanding** and model parameterizations
- **Turbulent fluxes** and **thermally-driven winds** contribute to exchange in the mountain ABL

Fig. 1: Measurement location Nafingalm, view from North towards South. QR code: video about the TEAMx pre-campaign [2].

2. Knowledge gap

- **3D turbulent fluxes** and **mean wind** are difficult to measure simultaneously at multiple locations, in-situ, flexibly, and at low cost → **fleets of uncrewed aerial systems (UAS)** can provide a solution
- Which **measurement strategies** with the UAS fleet are suited to capture phenomena in the mountain ABL?

3. Methods

- **Framework:** TEAMx program (multi-scale Transport and Exchange in the Atmosphere over Mountains – programme and eXperiment) → pre-campaign in summer 2022 (TEAMx-PC22) [3]
- **Where:** Nafingalm, Austria
- **What was measured:** mean quantities of U, T, RH
- **Instrumentation: 3 UAS from SWUF-3D fleet** + ground-based instruments
- **UAS fleet strategies:** hovering, vertical/horizontal profiles

4. Results

- UAS + ground-based data show different meteorological phenomena occurring in the valley in the course of the day: **valley winds, interaction with foehn winds, formation of stable boundary layer**

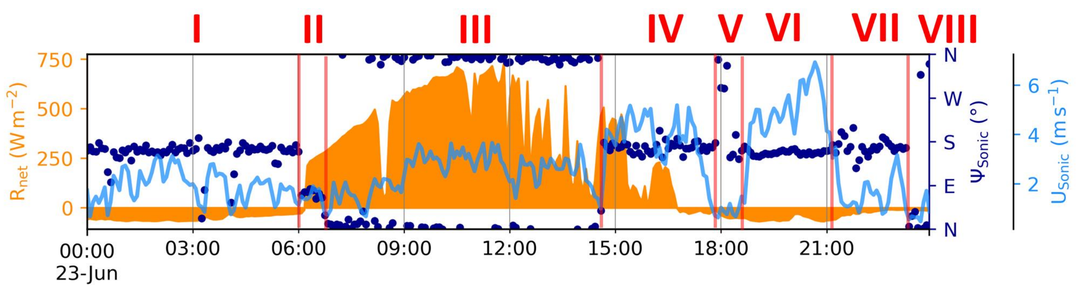

Fig. 2: Different wind regimes dominate different phases of the day. Shown are ground-based measurements from a summer day in 2022, averaged over 5 min.

5. Conclusion & Outlook

- **Conclusion:** UAS fleet flights provide insight into horizontal and vertical mean flow structure within the valley
- **Outlook:** further measurements in autumn 2024 and 2025 in the framework of TEAMx Observational Campaign (TOC) with **larger UAS fleet + fast sensors for turbulence analysis**

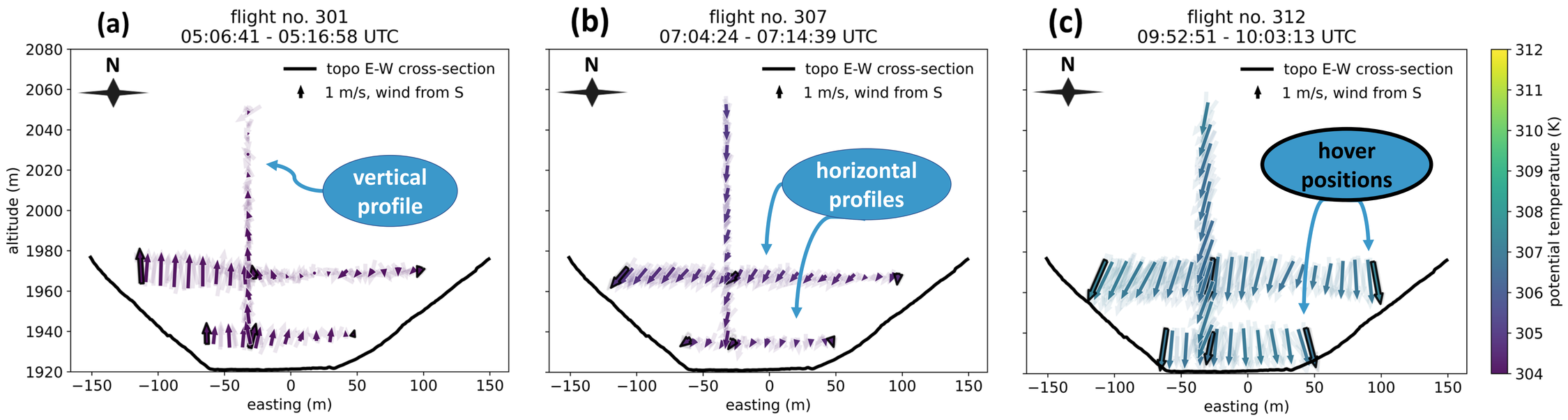

Fig. 3: Morning transition from southerly downvalley winds (a) via easterly winds (b) to northerly upvalley winds (c) during phases I to III (see Fig. 2), measured by three UAS simultaneously along a cross-valley section.

[1] Alexa, A., 2023: Atmospheric boundary layer structure at the head of a small Alpine tributary valley detected with uncrewed aerial systems (UAS). M.S. thesis, University of Innsbruck, https://ulb-dok.uibk.ac.at/urn/urn:nbn:at:at-ubi:1-142279

[2] Gohm, A., 2022: TEAMx-PC22 (TEAMx pre-campaign 2022) – video clip (Version v1). Zenodo, https://doi.org/10.5281/zenodo.7118576

[3] Pfister, L., et al., 2024: The TEAMx-PC22 Alpine field campaign -- Objectives, instrumentation, and observed phenomena. [preprint] https://doi.org/10.48550/arXiv.2401.06500