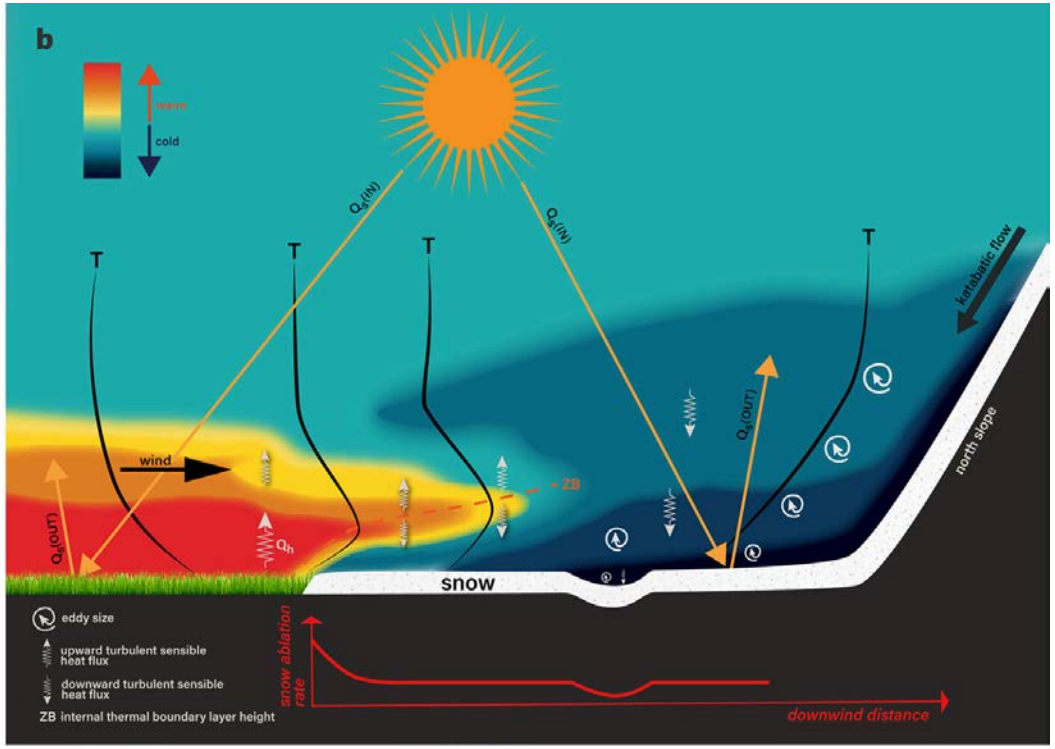
A novel method to understand the interaction between a patchy snow cover and the adjacent atmosphere

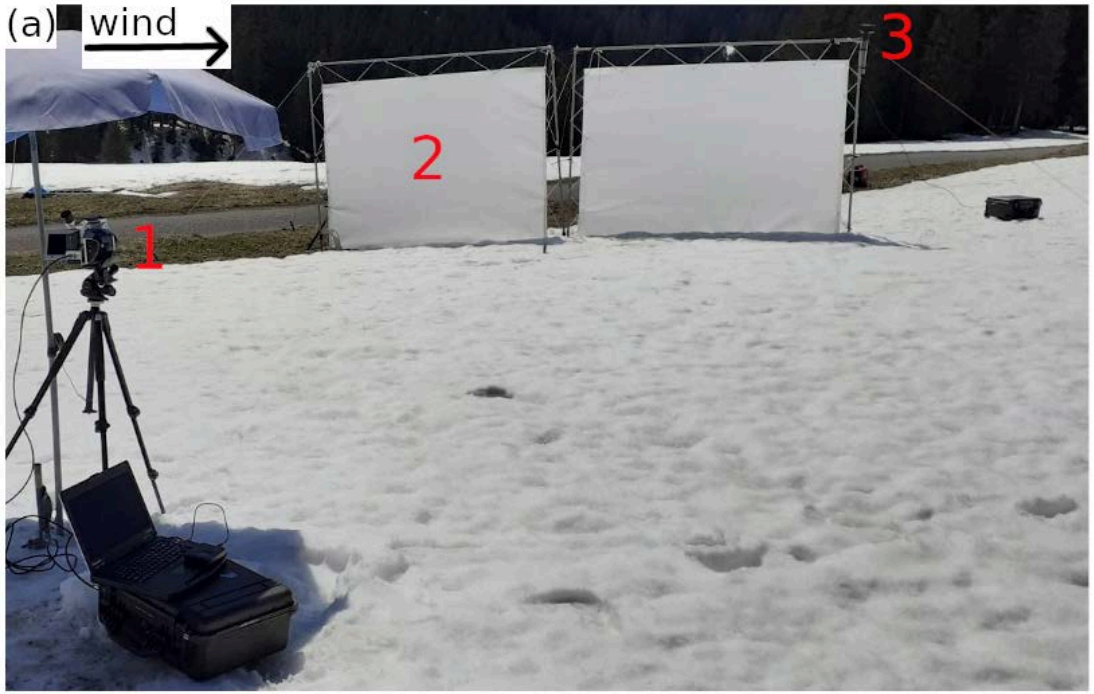
M. Haugeneder, M. Lehning, D. Reynolds, T. Jonas, R. Mott

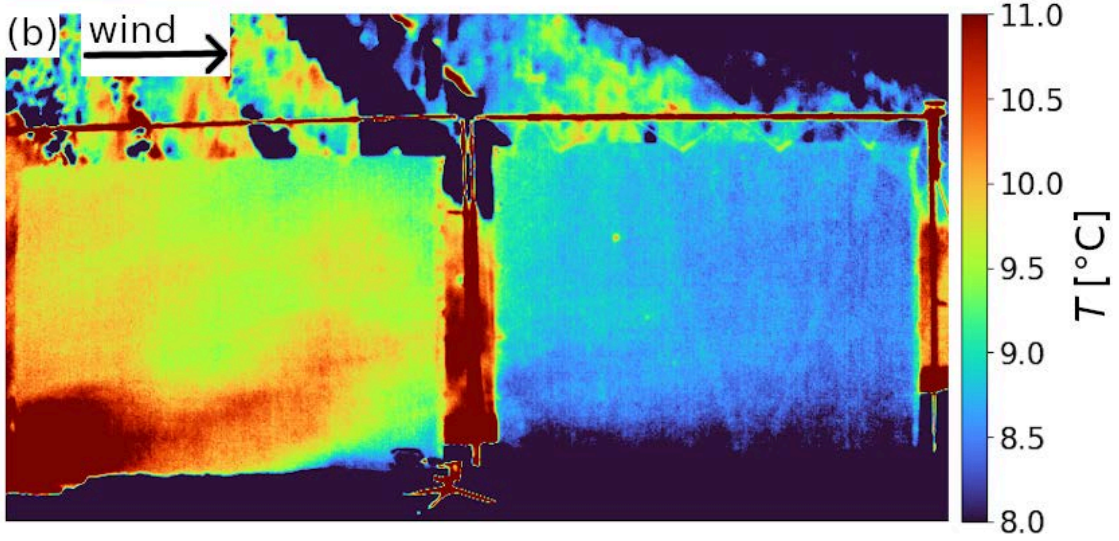


Mott et al. (2018)

michael.haugeneder@slf.ch

Setup





a)

- Setup adapted from Grudzielanek et al. (2015)
- **1**: sun-shielded thermal InfraRed camera
- **2**: thin, synthetic screens (T_{surf} serves as proxy for T_{air})
- **3**: 2D ultrasonic for information on wind direction

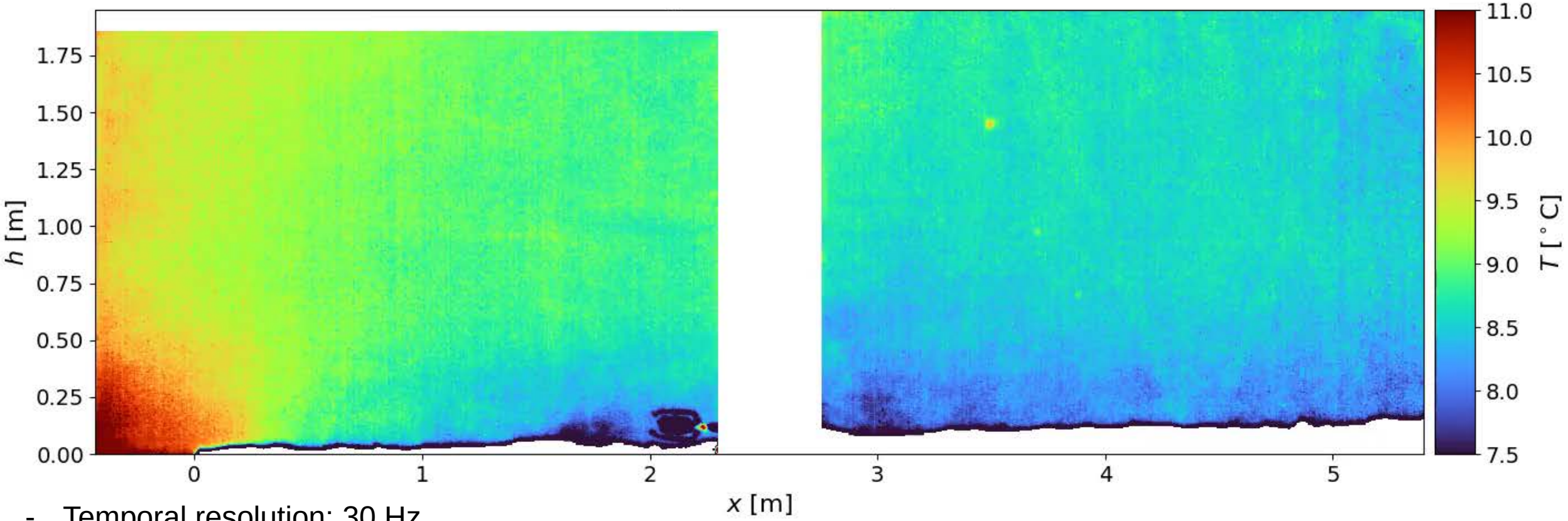
- parallel alignment of the screens with the prevailing wind direction essential

b)

- Warm air plume advected from bare ground over the snow surface
- Further downwind still layer of cold air adjacent to snow surface

michael.haugeneder@slf.ch

Real-time near-surface boundary layer dynamics

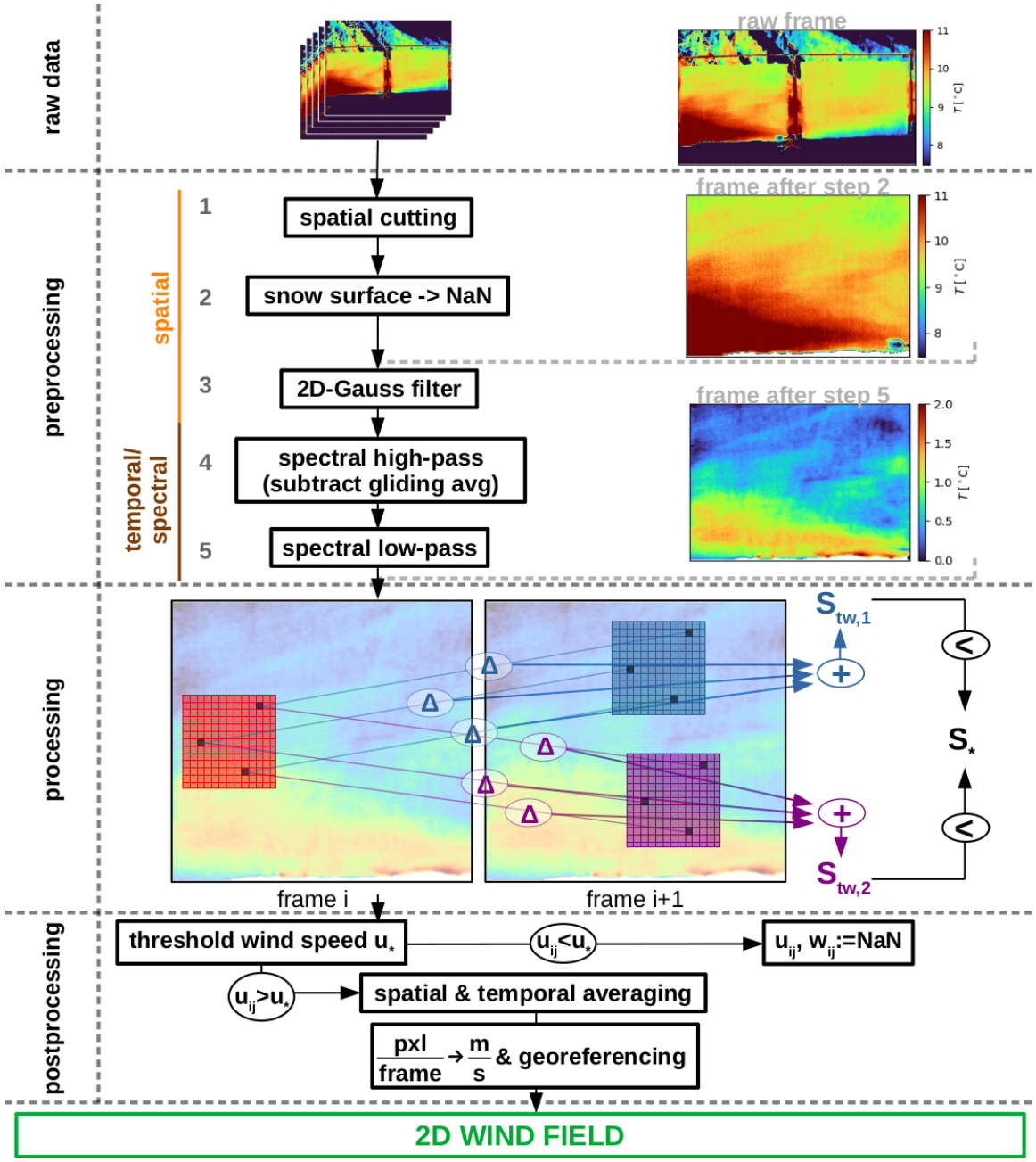


- Temporal resolution: 30 Hz
- Spatial resolution: 0.5 cm

Extreme spatio-temporal heterogeneity:
- Advection of warm air and entrainment down to the snow surface
- Calm periods with development of statically stable, cold layer adjacent to the snow surface

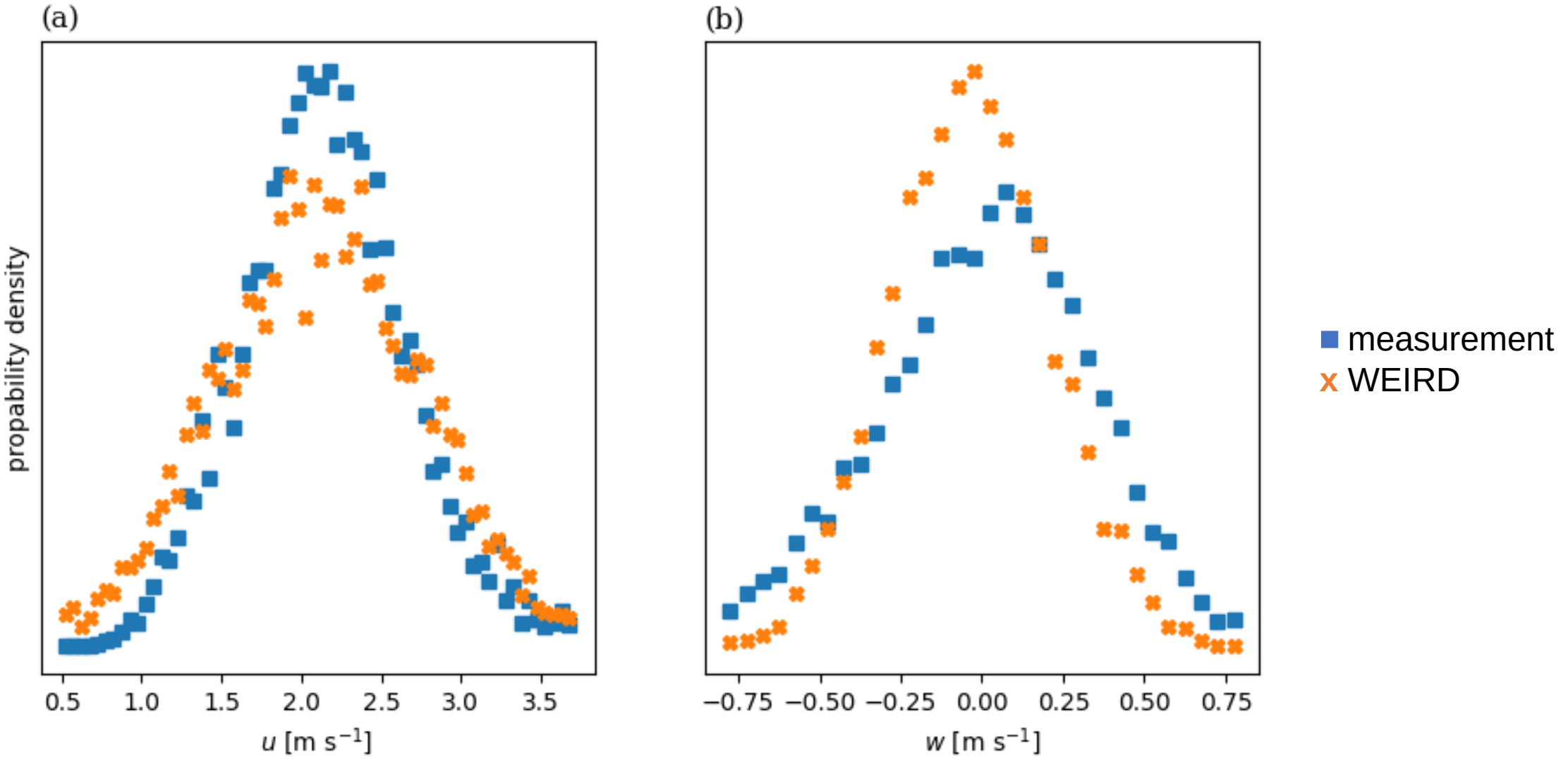
michael.haugeneder@slf.ch

Wind Field **E**stimation from **I**nfra**R**ed **D**ata (WEIRD)



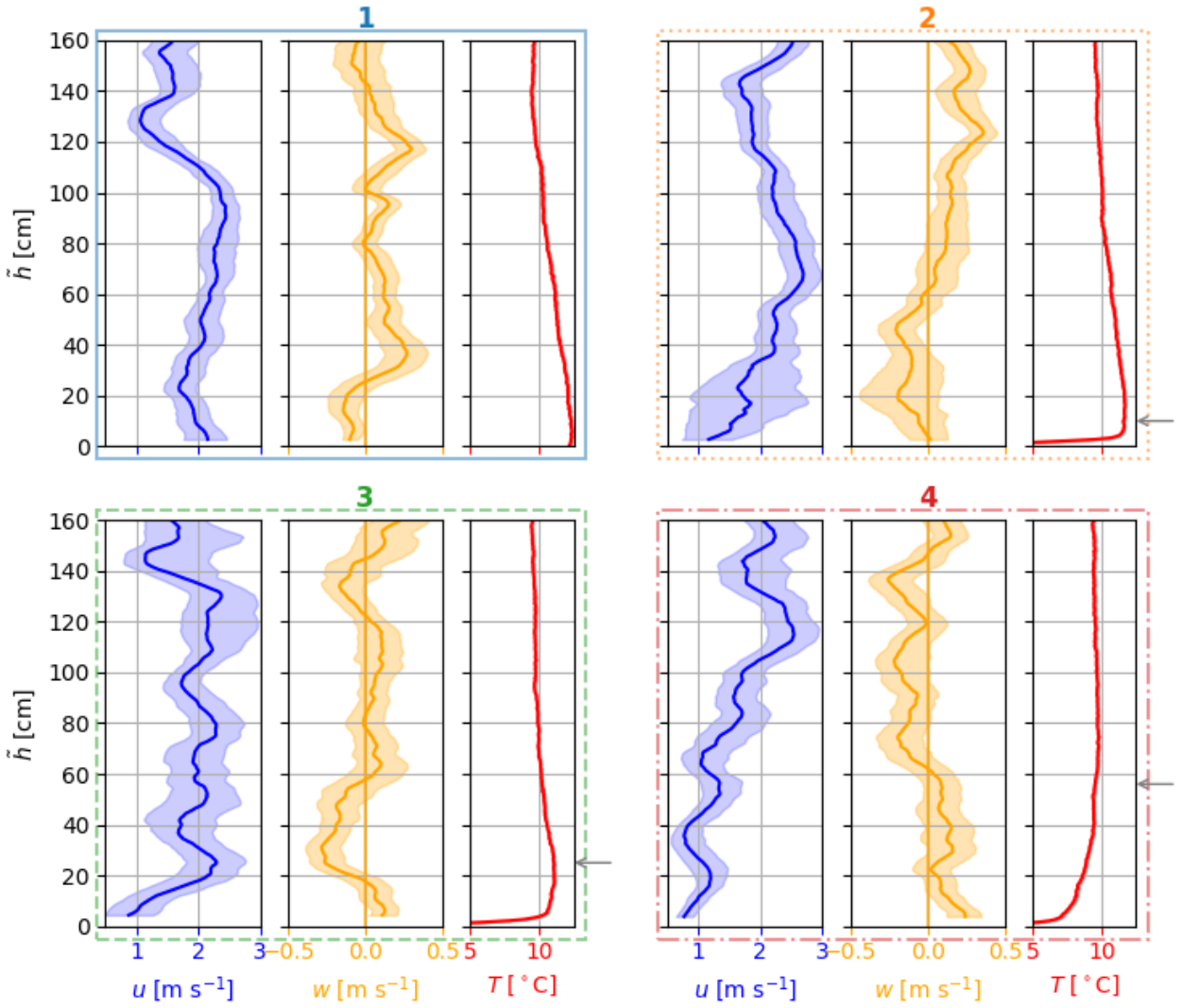
michael.haugeneder@slf.ch

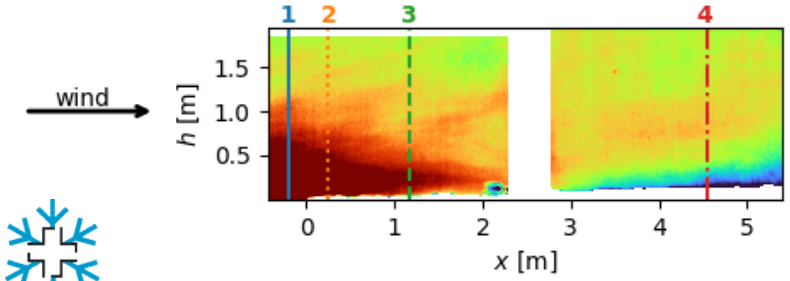
Validation of Wind Field Estimations using Ultrasonic Measurements



michael.haugeneder@slf.ch

Vertical profiles (u, w, T) at 4 fetch distances

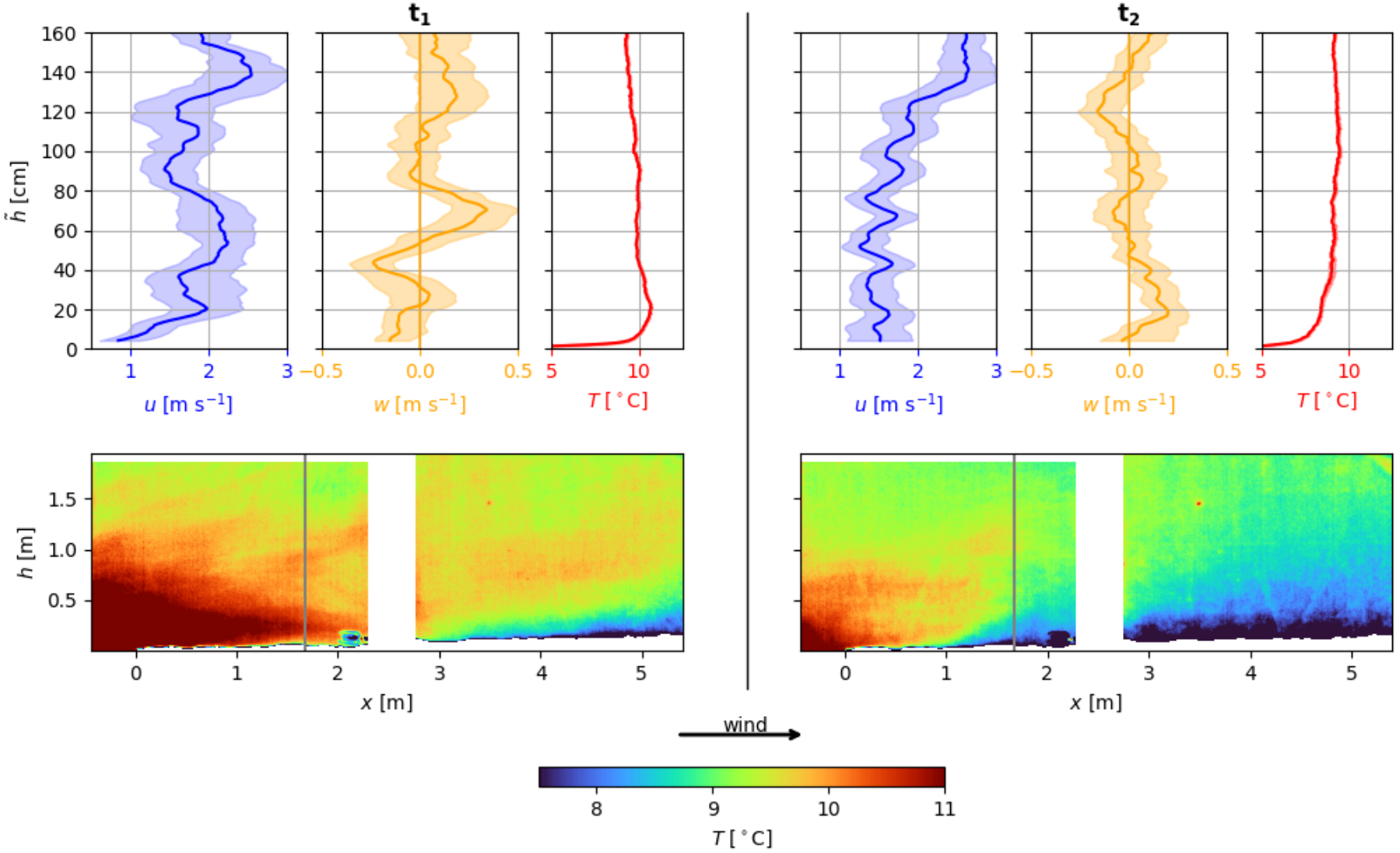




- Instantaneous vertical profiles (averaged over 0.5 s) of horizontal wind speed (u, blue), vertical wind speed (w, orange), and screen temperature (T, red) along the transition from bare ground to snow
- Entrainment of warm air to the snow surface at the leading edge
- Growing statically stable layer near-surface (stable **I**nternal **B**oundary **L**ayer)
- Grey arrows (on the right) indicate IBL height approximation according to Granger et al. (2006)

michael.haugeneder@slf.ch

Comparison of two situations



t_1: entrainment of warm air down to the snow surface

- Shallow (20 cm) statically stable layer adjacent to the snow surface (T-profile)
- High magnitude of vertical wind speeds at upper boundary of warm air plume (w-profile)
- High horizontal wind speed down to 20 cm due to pronounced vertical mixing (u-profile)

t_2: stable IBL

- 80 cm statically stable layer (T-profile)
- Smaller vertical mixing (w-profile)
- Reduced horizontal wind speed below 120 cm (u-profile)

michael.haugeneder@slf.ch

Summary and Outlook

- 2D ultra-high resolution measurement of near-surface atmosphere dynamics
- Estimation of 2D wind fields by tracking pattern of air plumes (WEIRD)
- Validation using ultrasonic wind speed and sensible heat flux measurements

- Possible applications for the screen-method: near-surface atmosphere over debris-covered glaciers, characterization of slope flows (thermal updrafts, drainage, katabatic)

Ongoing research:

Combine data from screen method with traditional EC-measurements from a comprehensive field campaign to gain in-depth understanding of the relation between heat advection and vertical turbulent transport at the patch scale