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Air temperature distribution and structure of katabatic wind on a shrinking mountain glacier

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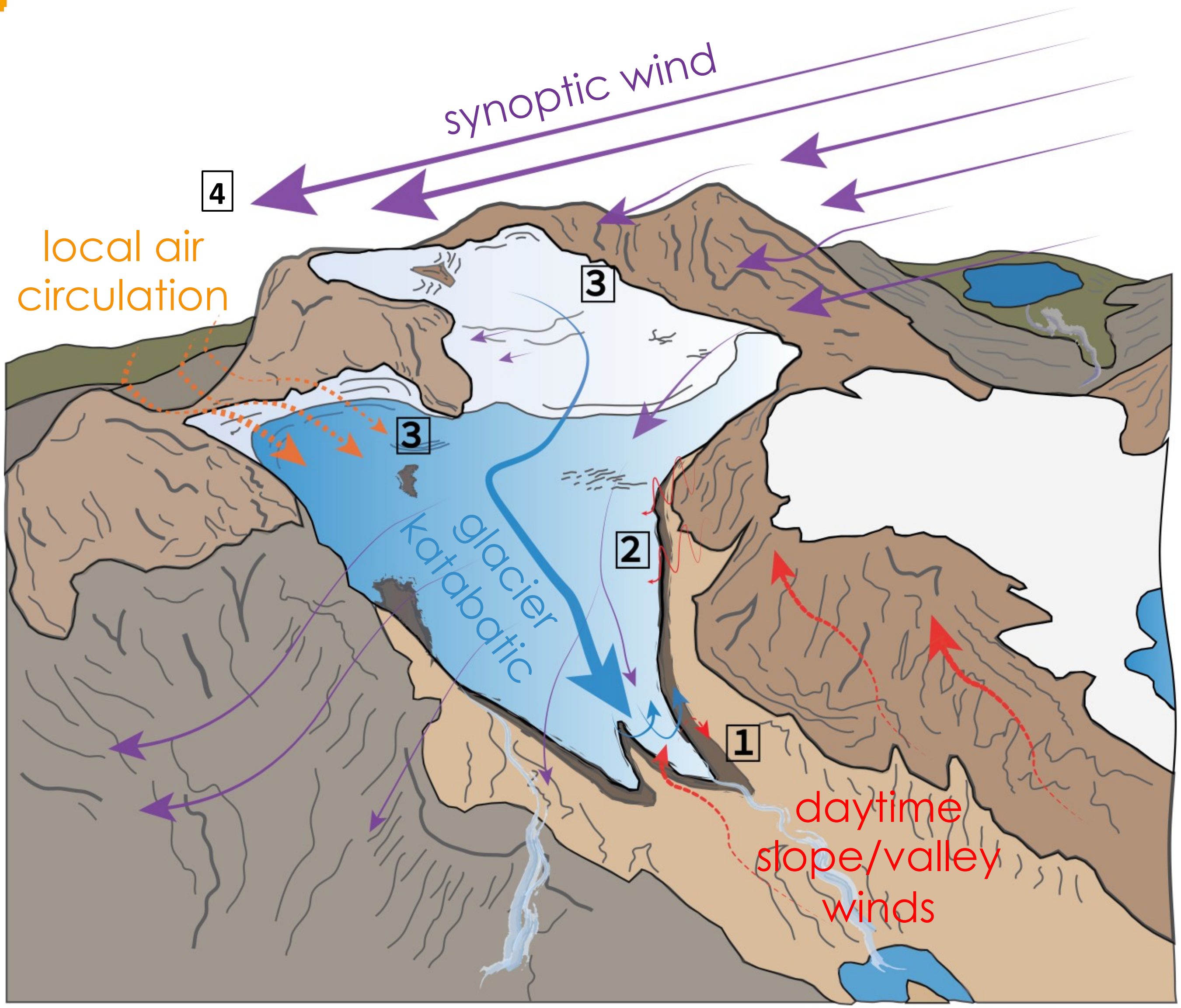
Motivation



(1) interactions of down-glacier katabatic winds and up-valley winds/local heat sources

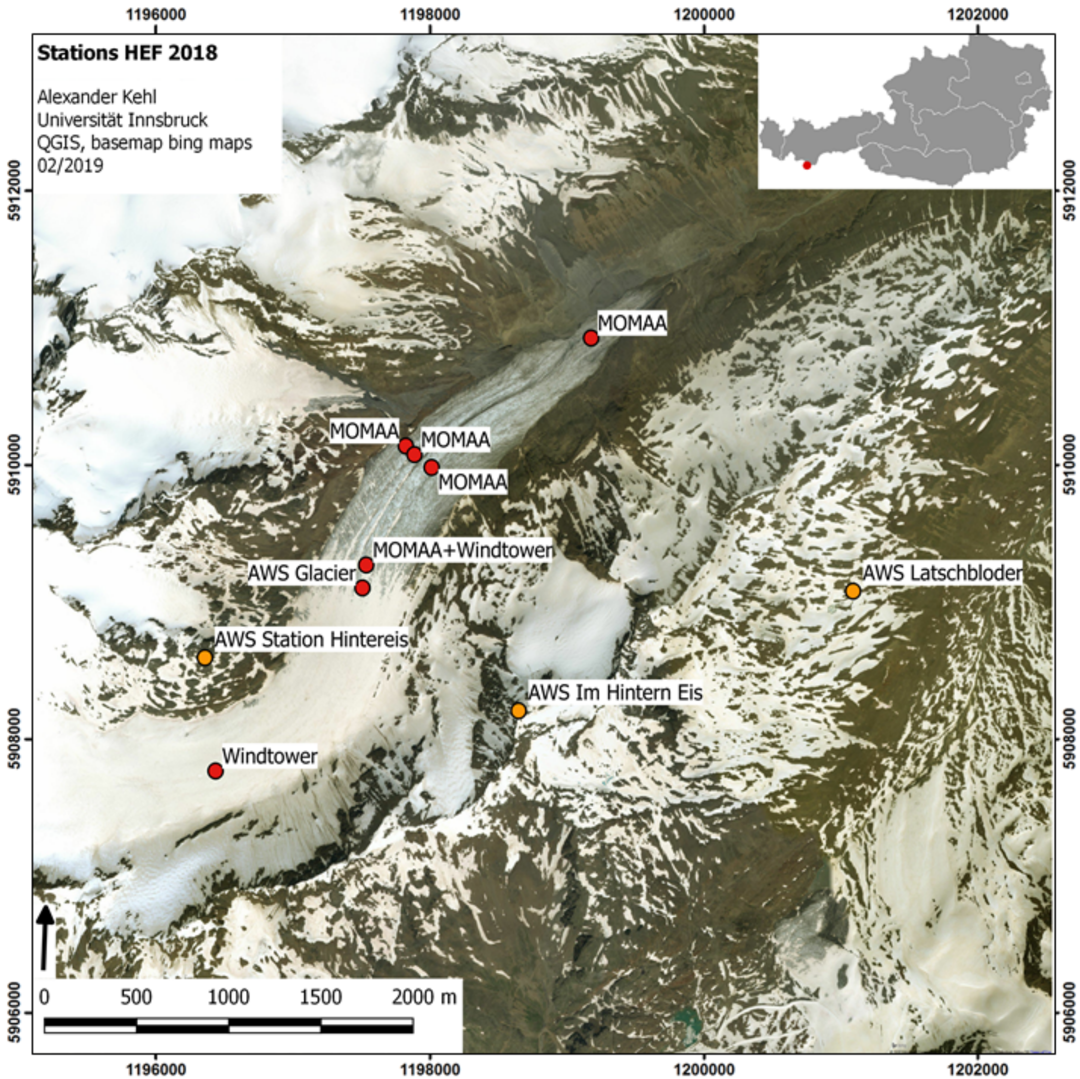
(2) potential heat emitted from the warm valley surroundings

(3) localised surface depressions forming 'cold spots' during calm, high pressure conditions

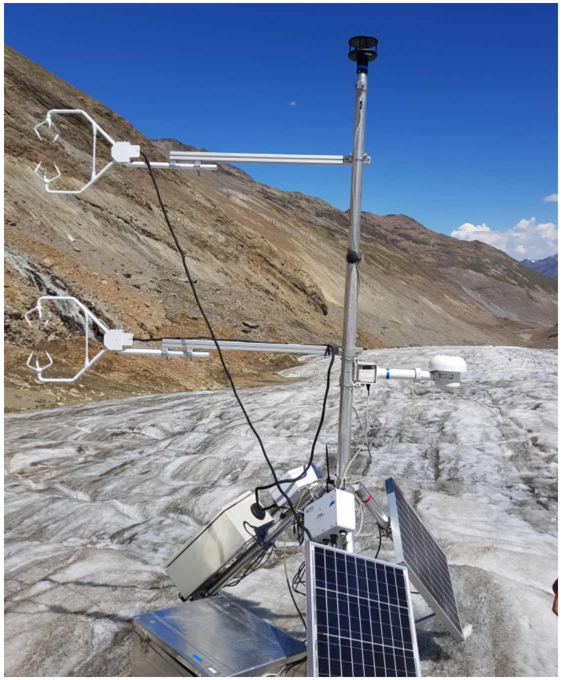
(4) exchange between valley circulation and synoptic flow

Image credit: Thomas Shaw (EGU Cryosphere Blog 2017)

Data from field measurements in August 2018



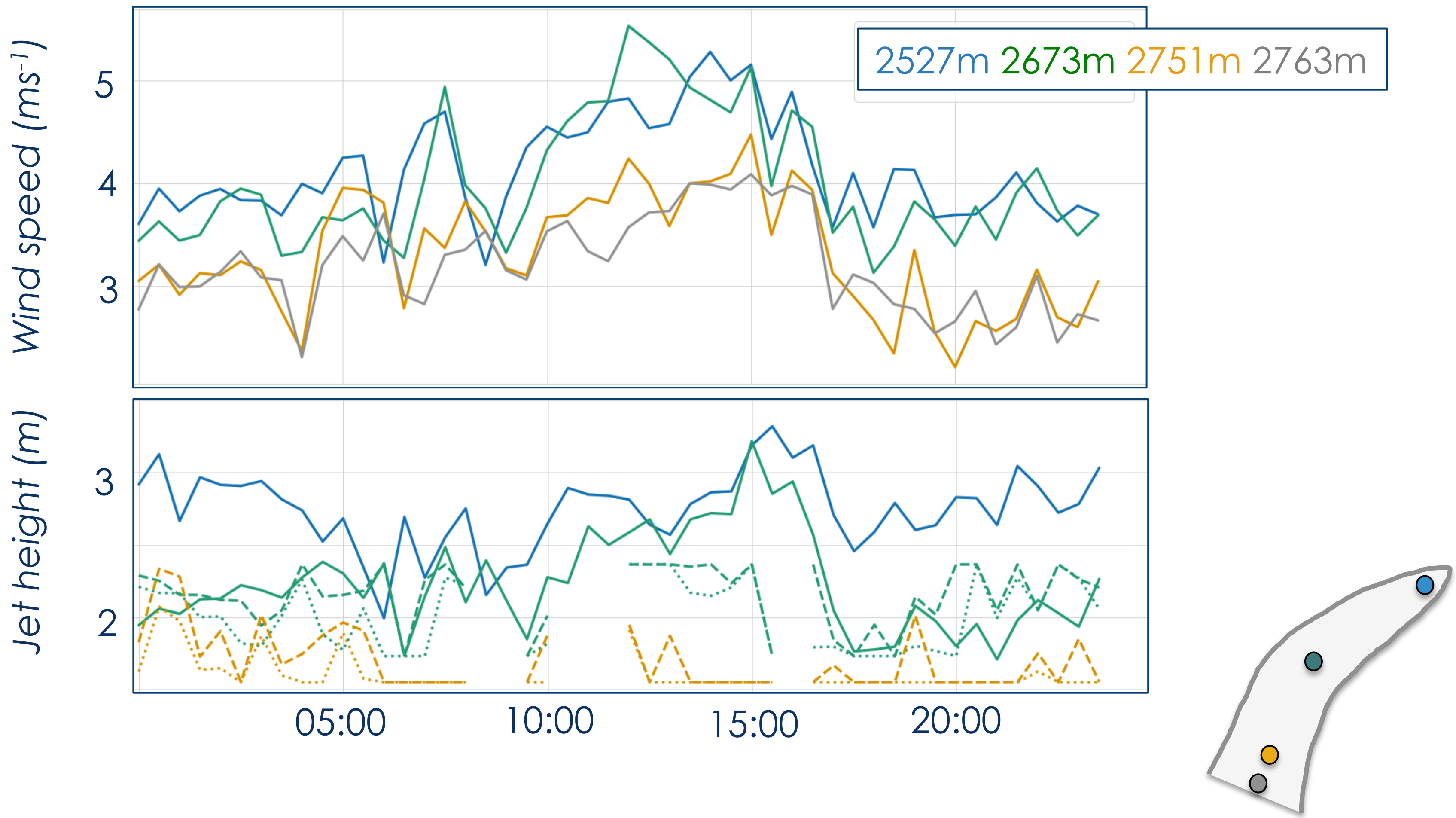
- Permanent AWS
- Temporary AWS
  - 1 x SEB station 1 level
  - 2 x wind tower at 3 levels
  - 2 x wind towers at 5 levels
  - 4 x ECs at 2 levels



Mott, R., Stiperski, I., and Nicholson, L.: Spatio-temporal flow variations driving heat exchange processes at a mountain glacier, The Cryosphere, 14, 4699–4718, 2020.

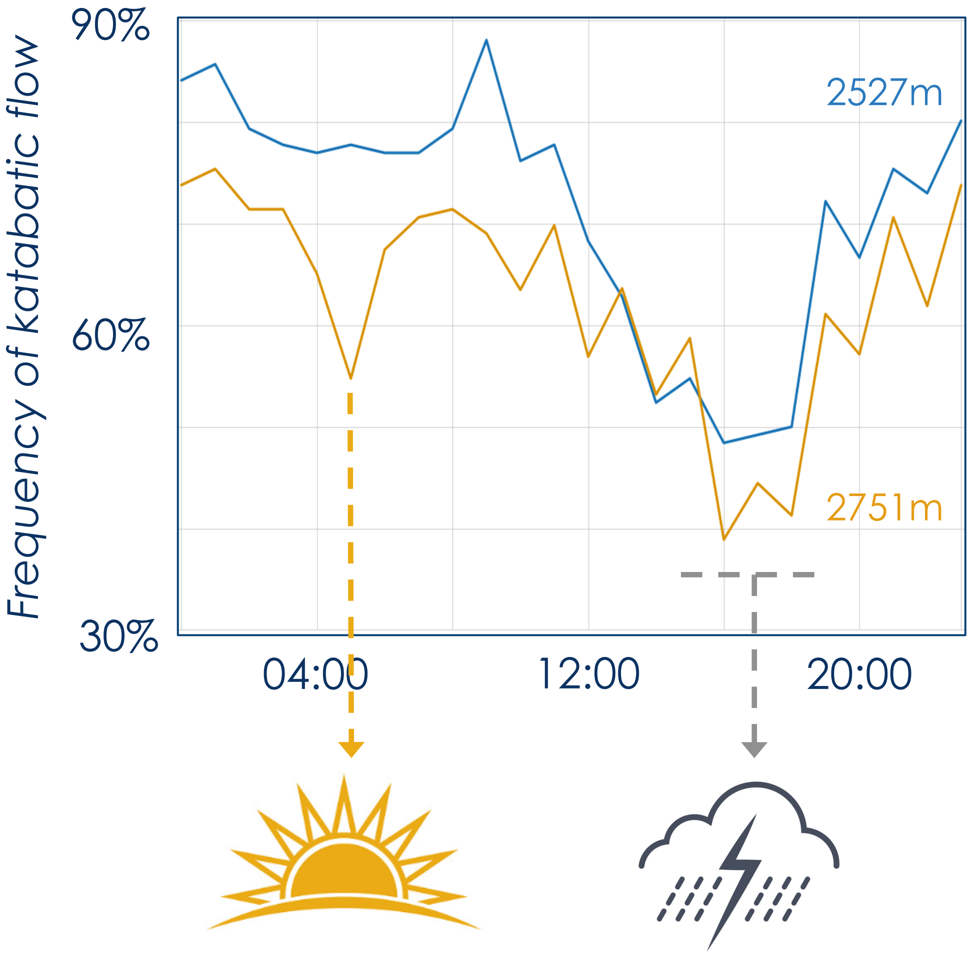
Characteristics of glacier katabatic flow

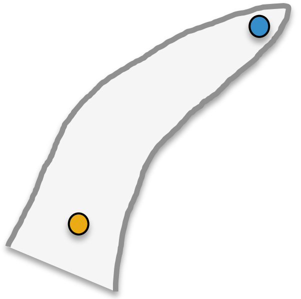
Hintereisferner: 2550-3700m elevation range; <6km long
Katabatic wind accelerates and deepens down glacier centerline



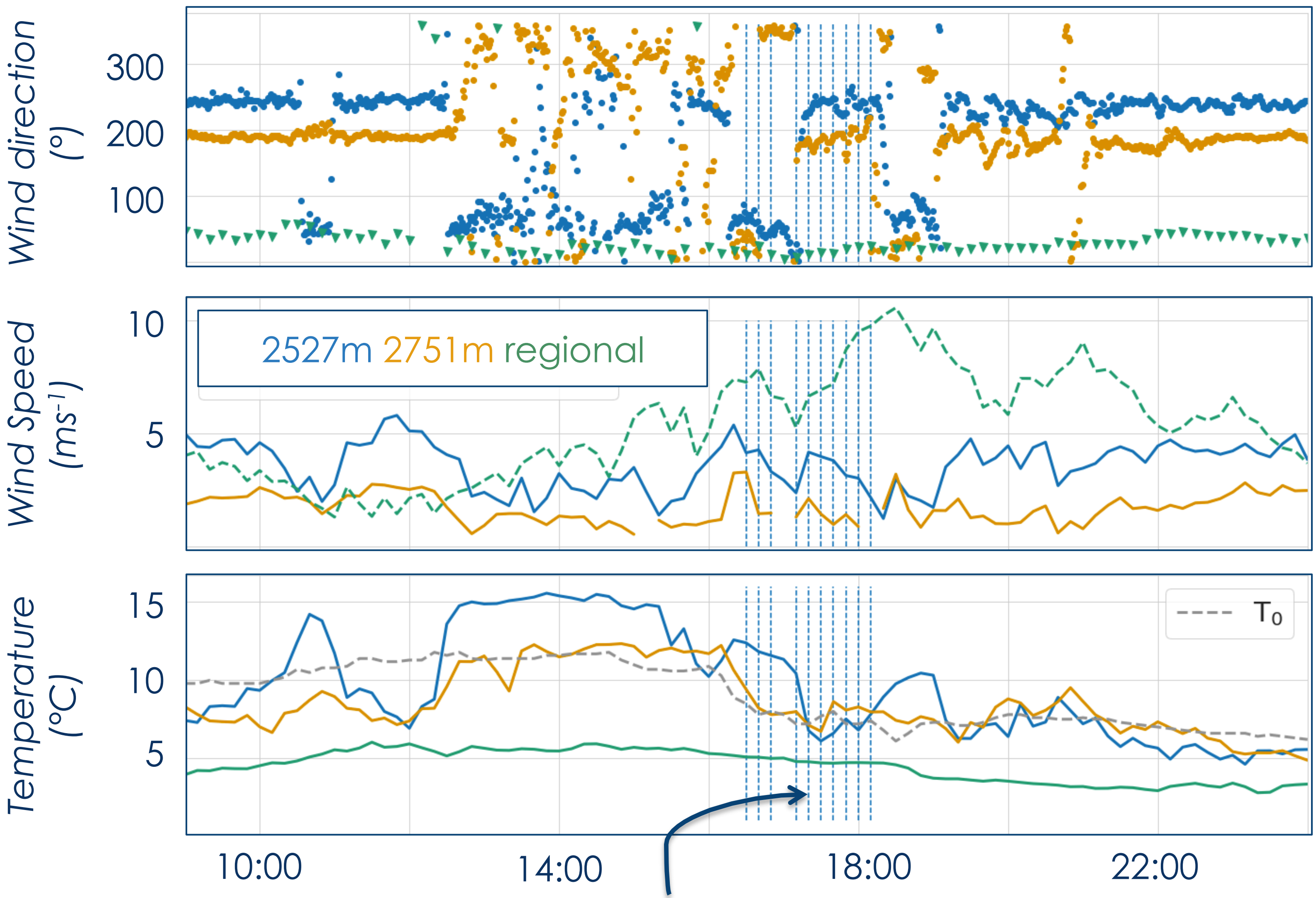
Persistence of glacier katabatic

Katabatic wind 75-80% of the time at glacier centerline stations





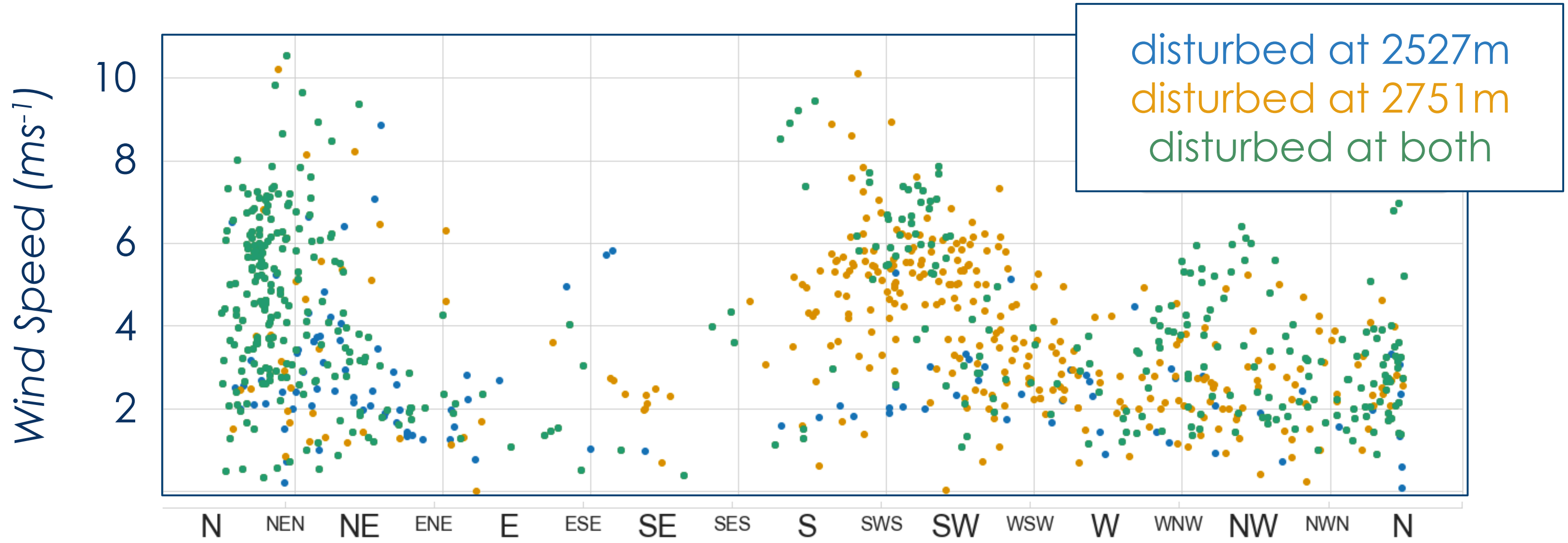
Disruption of katabatic: e.g. convective storms



rainfall at Latschbloder station, over ridge to east

Disruption of katabatic: synoptic/valley flow

Katabatic flow can be established even under strong orthogonal/ upglacier **regional airflow**, but is more often disturbed during these flow directions (NW to E sector), especially with higher windspeed.



Katabatic wind did not form with anabatic **valley wind** > $2ms^{-1}$.

Föhn winds in this region align with the glacier katabatic and cause higher but more variable windspeeds over the glacier.

Summary

Despite data land model limitations, results show that katabatic wind deepens and speeds up downglacier, and is **present 75-80% of the time** under a wide variety of strengths and directions of synoptic or valley flow.

Typical values of katabatic flow at Hintereisferner terminus were **windspeeds of 4-5 ms^{-1} and jet height between 2-3m**.

Cold fronts and rain events disrupted katabatic wind from minutes to hours (or days in the case of one cold front), with katabatic flow typically re-established during or shortly after the rain events.

Katabatic wind was established under many different synoptic conditions, but **katabatic disruption was more likely during (strong) orthogonal or upvalley regional flow**; however a predictive synoptic wind speed/direction condition to distinguish pure and influenced katabatic flow was not found.

Next steps: **HEFEX II** planned 2023

More glacier and forefield coverage

- *characteristics of flow in katabatic initiation zone?*
- *contribute to optimal spatial extrapolation methods*
- *does katabatic extend downvalley?*

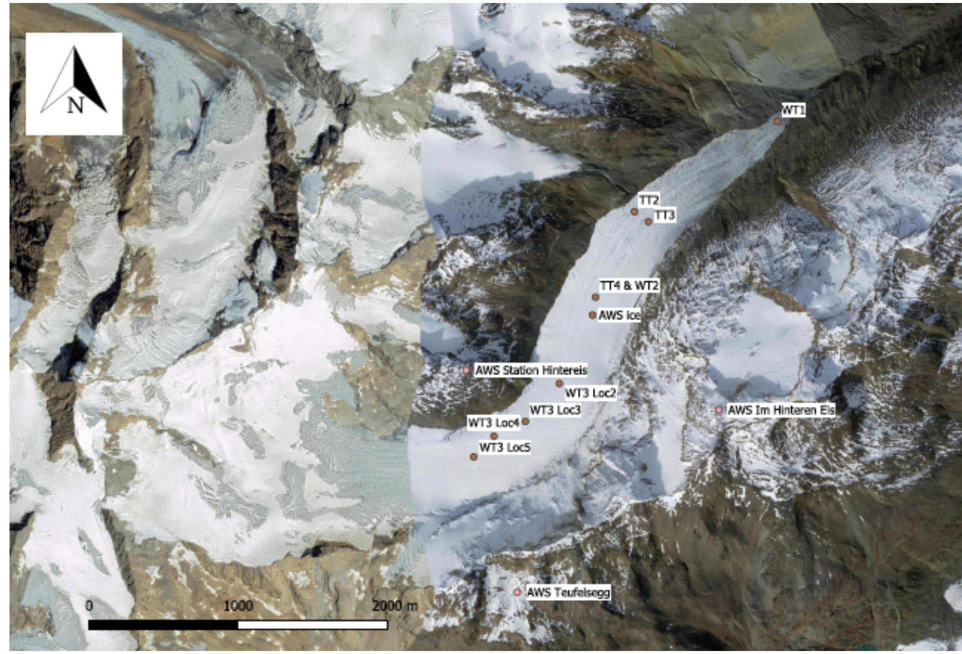
3D sampling of valley flow with UAV/ balloons

- *how do the wind systems interact aloft?*

High resolution (LES) atmospheric modelling

- *can we study realistic circulation and experiment with glacier shrinkage scenarios?*

Station details



Station name	Elevation [m]	Flow path length [m]	Parameter	Mounting
WT1	2527	5230	$\|u\|$, u, v, ϕ, T, RH, p	floating, not self-levelling
TT1	2662		u, v, w, T, RH, p	——"——
TT2	2669		u, v, w, T, RH, p	——"——
TT3	2673	4051	u, v, w, T, RH, p	——"——
TT4	2751	3373	u, v, w, T, RH, p	——"——
AWS_{ice}	2763	3248	$\|u\|$, ϕ, T, RH, p, L, K	floating, self-levelling
WT2	2751	3370	$\|u\|$, ϕ, T, RH	drilled into ice
WT3	2673–2896 [1]	1863–2744 [1]	$\|u\|$, ϕ, T, RH	drilled into ice
Im Hinteren Eis	3289		T, RH, p, L, K	off-glacier
Hintereis	3026		T, RH, p, L, K, precip	off-glacier
Latschbloder	2910		T, RH, p, L, K, precip	off-glacier