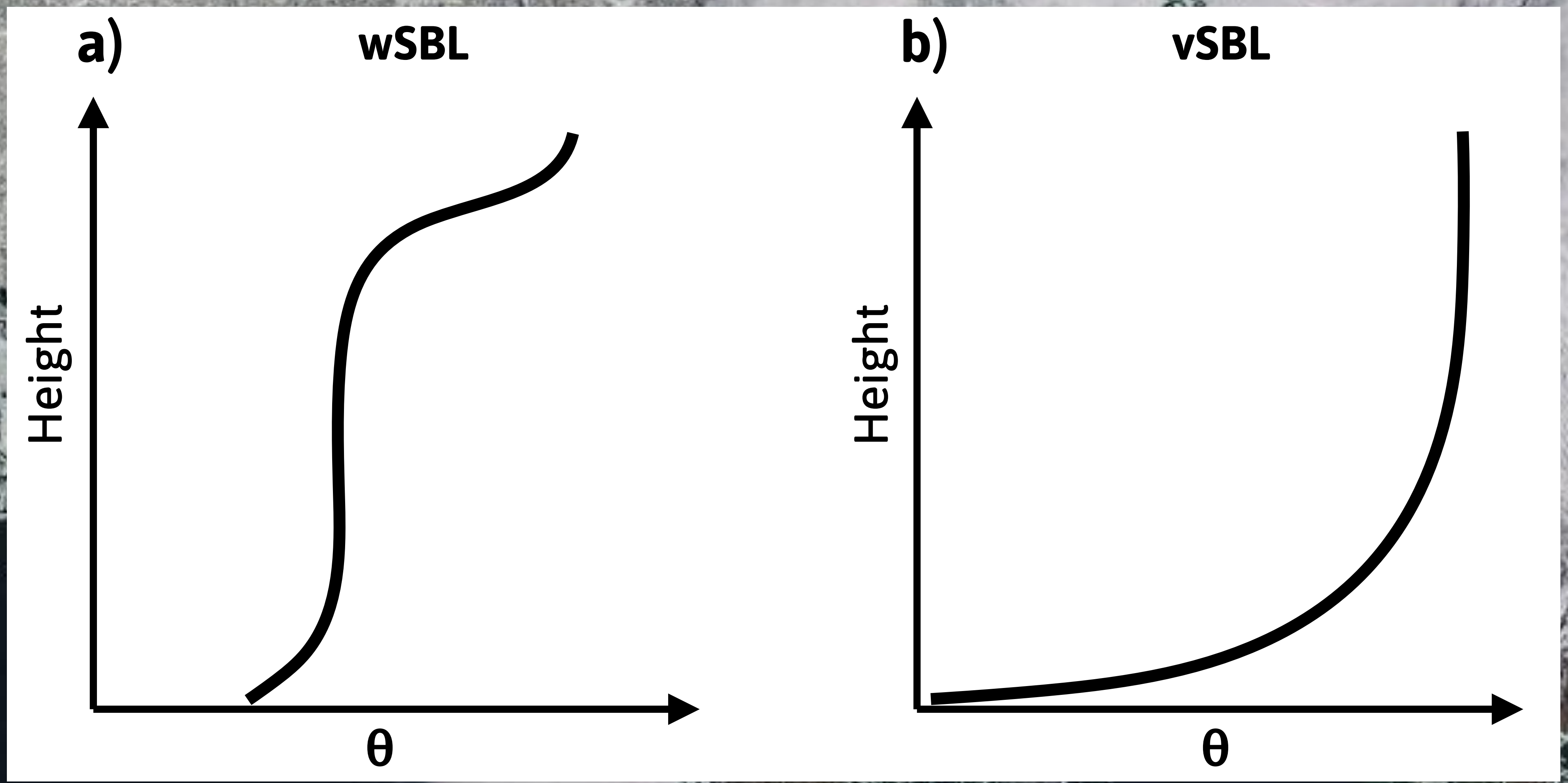
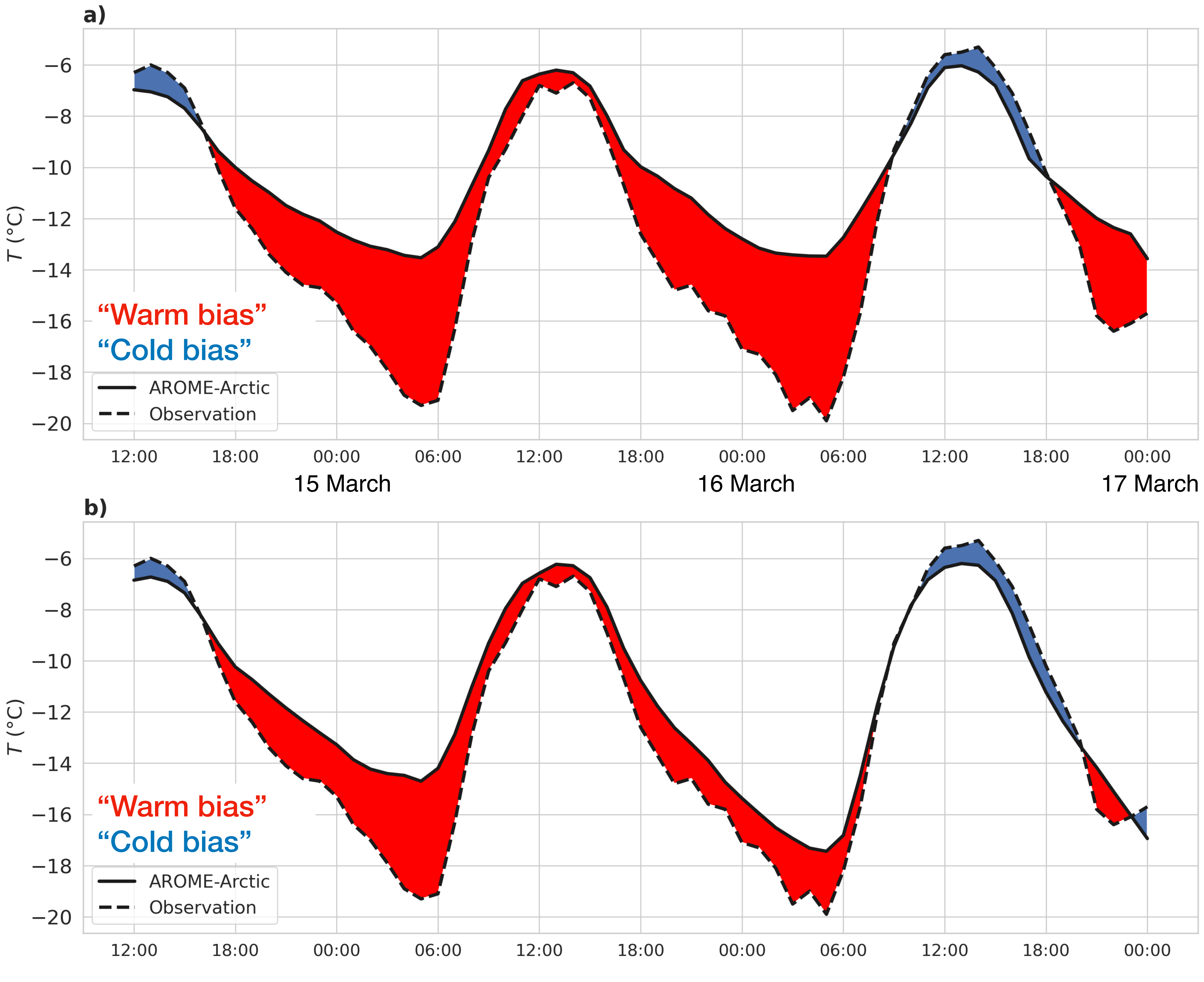
The SBL in HARMONIE-AROME

Ongoing developments at MET-Norway

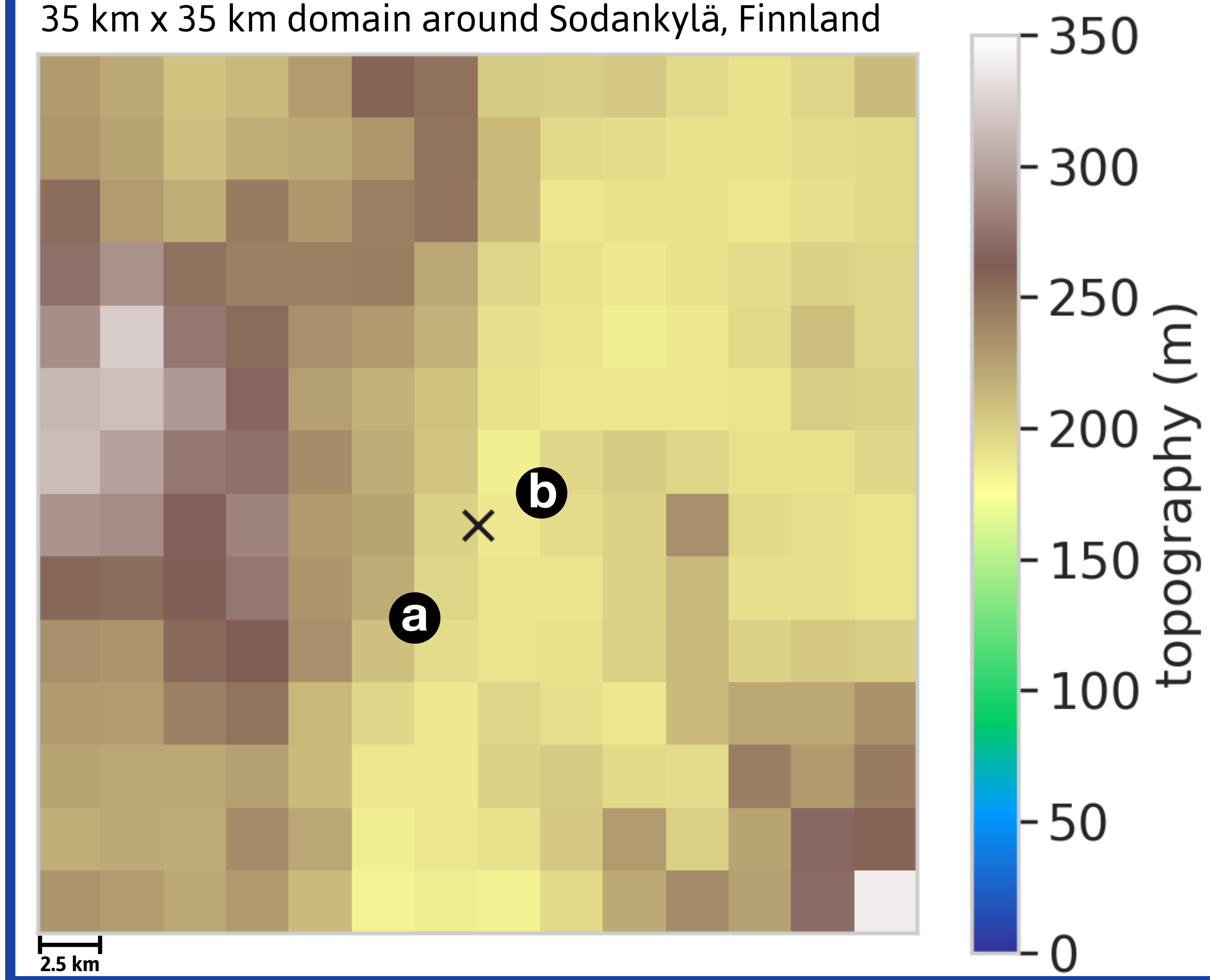


Marvin Kähnert

Differences on small scale



35 km x 35 km domain around Sodankylä, Finnland



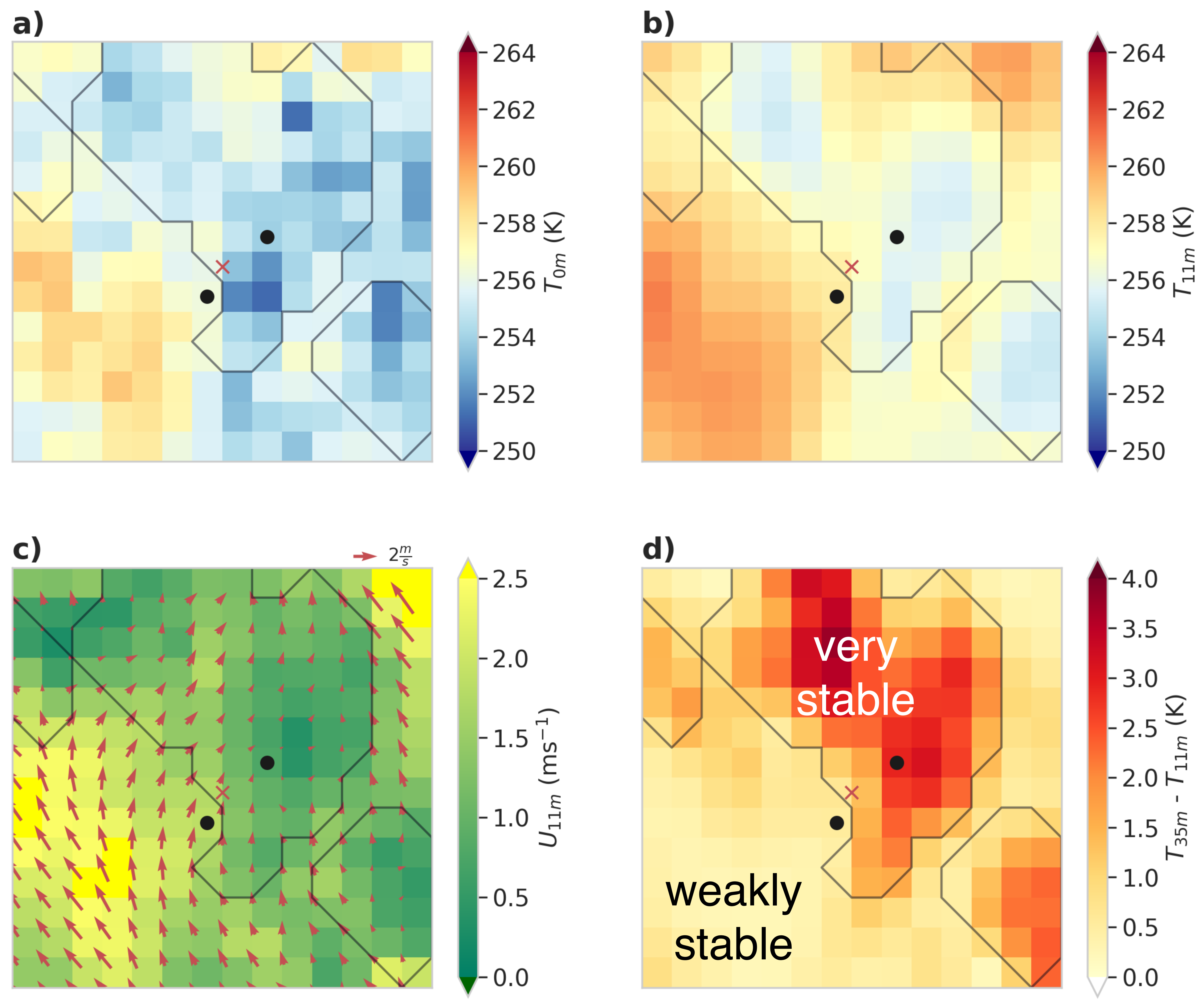
Points depicted in a) and b) are both covered by boreal needleleaf forest and exhibit similar roughness lengths and snow depth in the model. The x denotes the position of the observations.

Stability regimes in AROME-Arctic

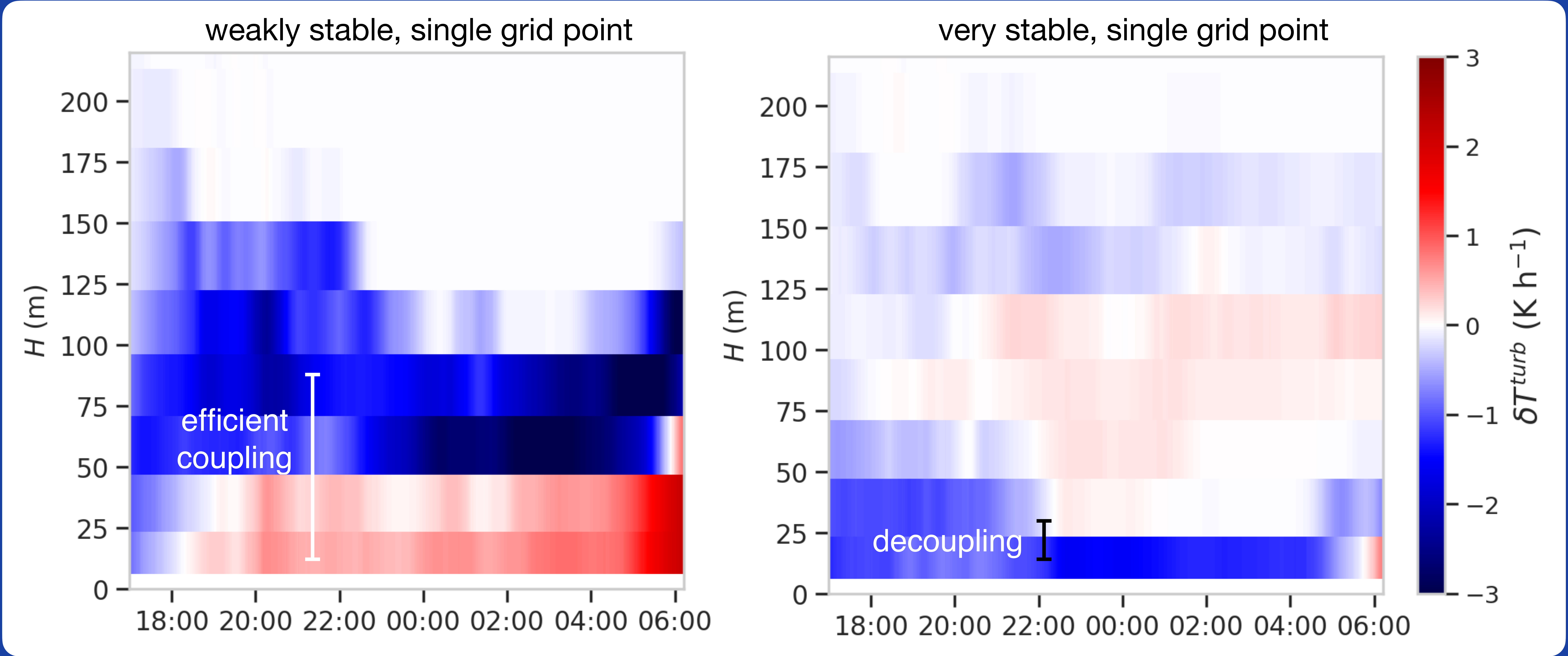
Differ between weakly stable and very stable regimes

McNider et al. 1995,
Derbyshire et al. 1999,
Zilitinkevich et al. 2008

- area around Sodankylä
- distinct characteristics on T and U model fields
- regimes occur on small scales in the model
- Criteria for boundary: mean nocturnal inversion strength > 1.5 K



Turbulence in the stability regimes

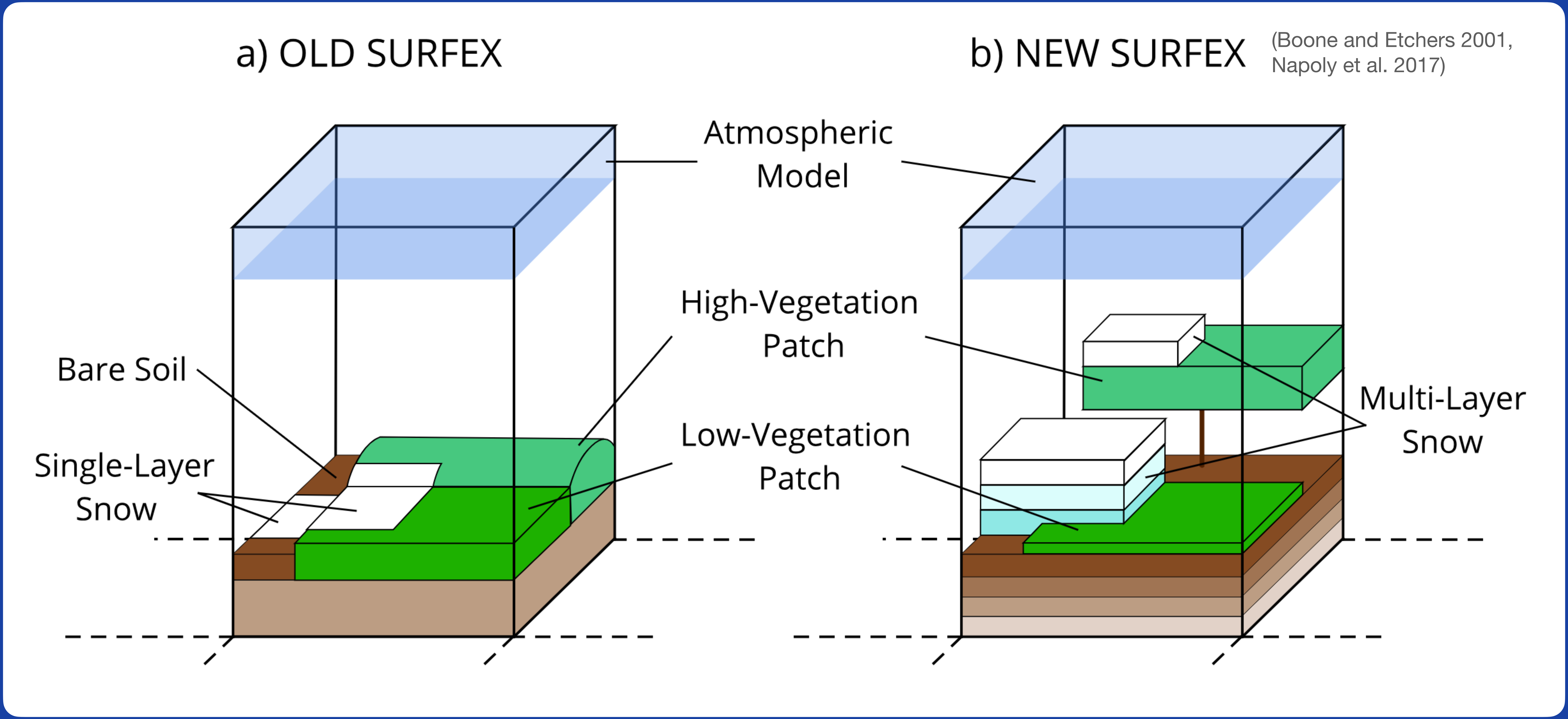


Efficient heat transport due to coupling by turbulence.

Decoupling and strong cooling of lowermost model level due to heat loss to surface.

Important to consider for both model development and validation!

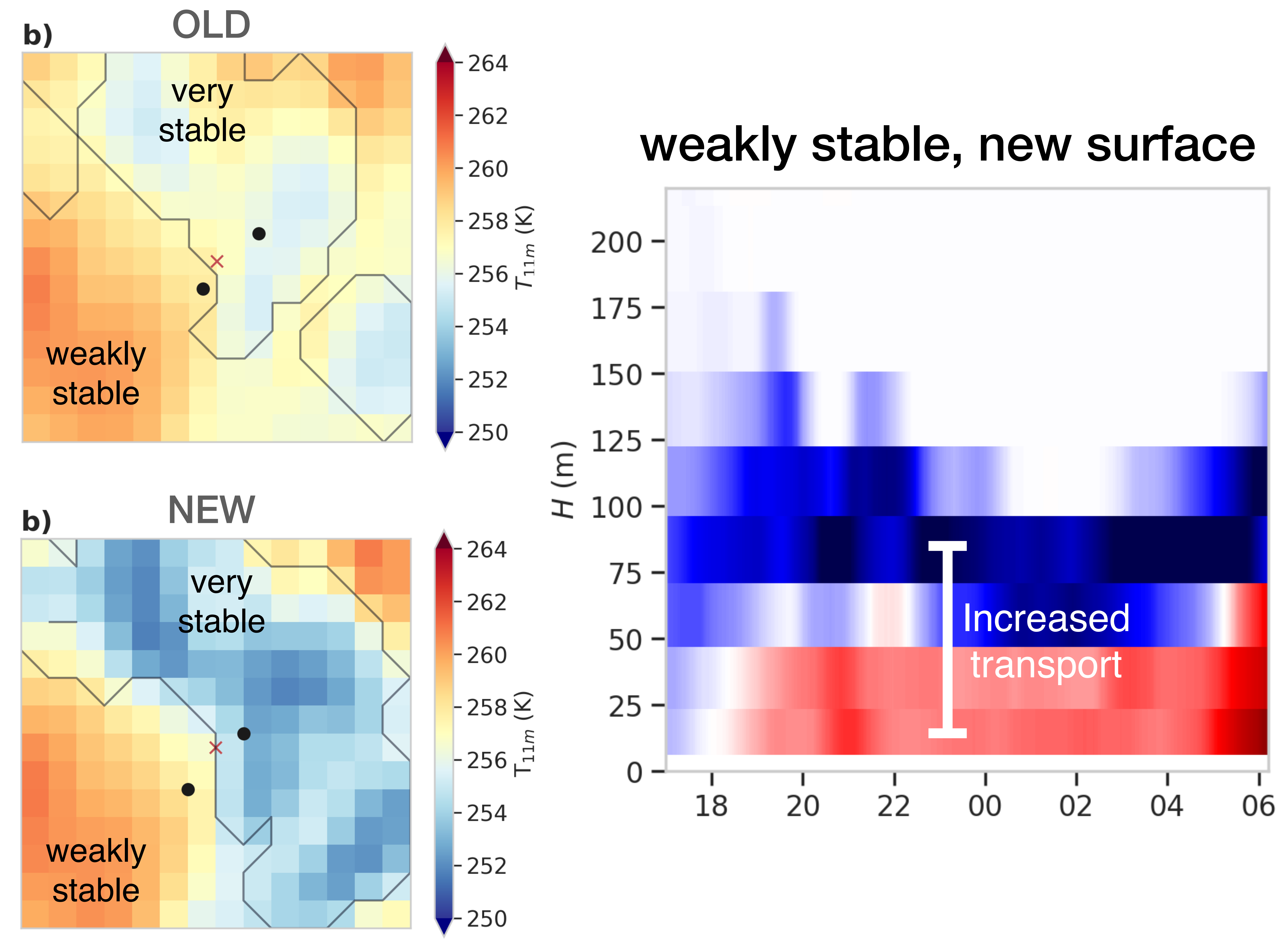
Example: update the surface



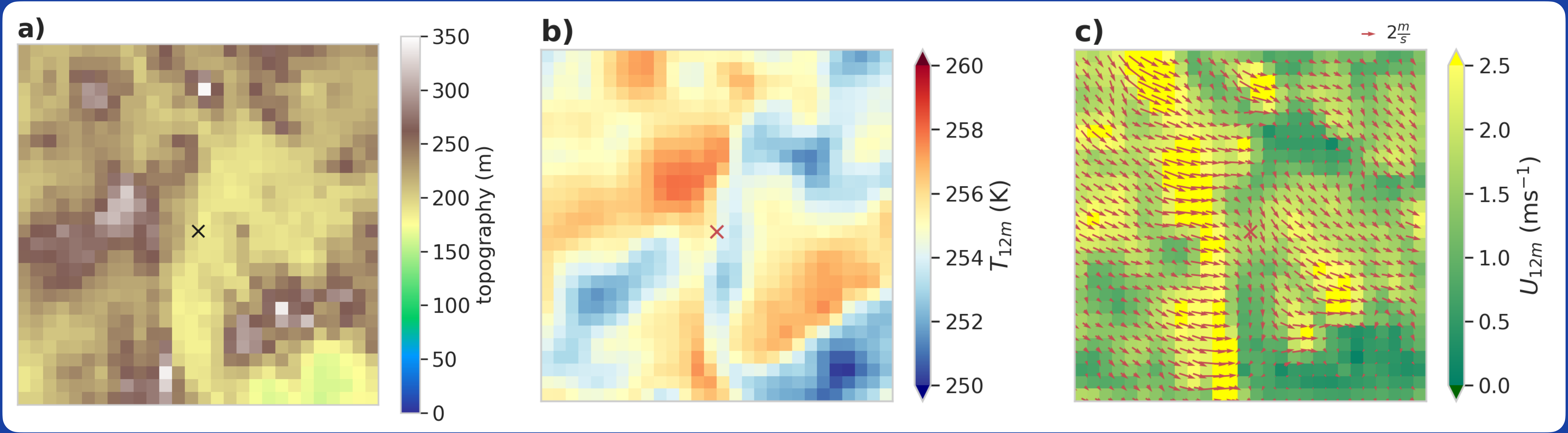
In short: should yield more efficient surface cooling!

Adaption to new surface scheme

- Similar occurrence of stability regimes
- Colder temperatures in very stable regime, agreeing better with observations
- In weakly stable regime turbulence counteracts surface changes



Occurrence of stability regimes



very-stable regime collocated to low wind speed / lee side of topography

weakly-stable regime collocated to higher wind speed / windward side of topography

Note: not overly steep or complex topography around Sodankylä, still apparent effect

Current research questions

- How do model updates affect these stability regimes?
    - Contrasting XRIMAX = 0 / XRIMAX = 0.4
    - Using 90 vertical levels

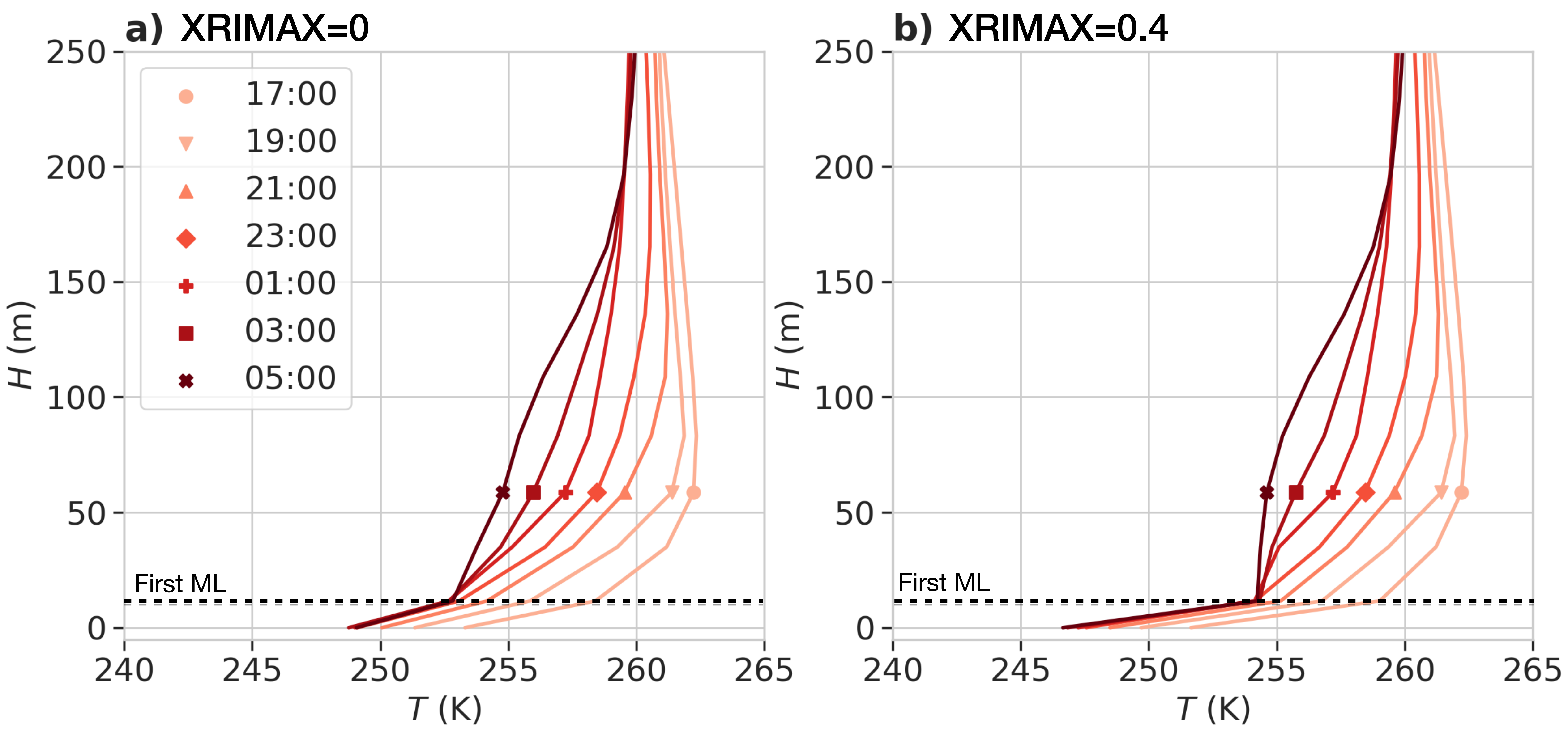
- Does the model adequately represent the occurrence of different stability regimes?

- Can a data-driven approach improve the representation of the (very) stable boundary layer?

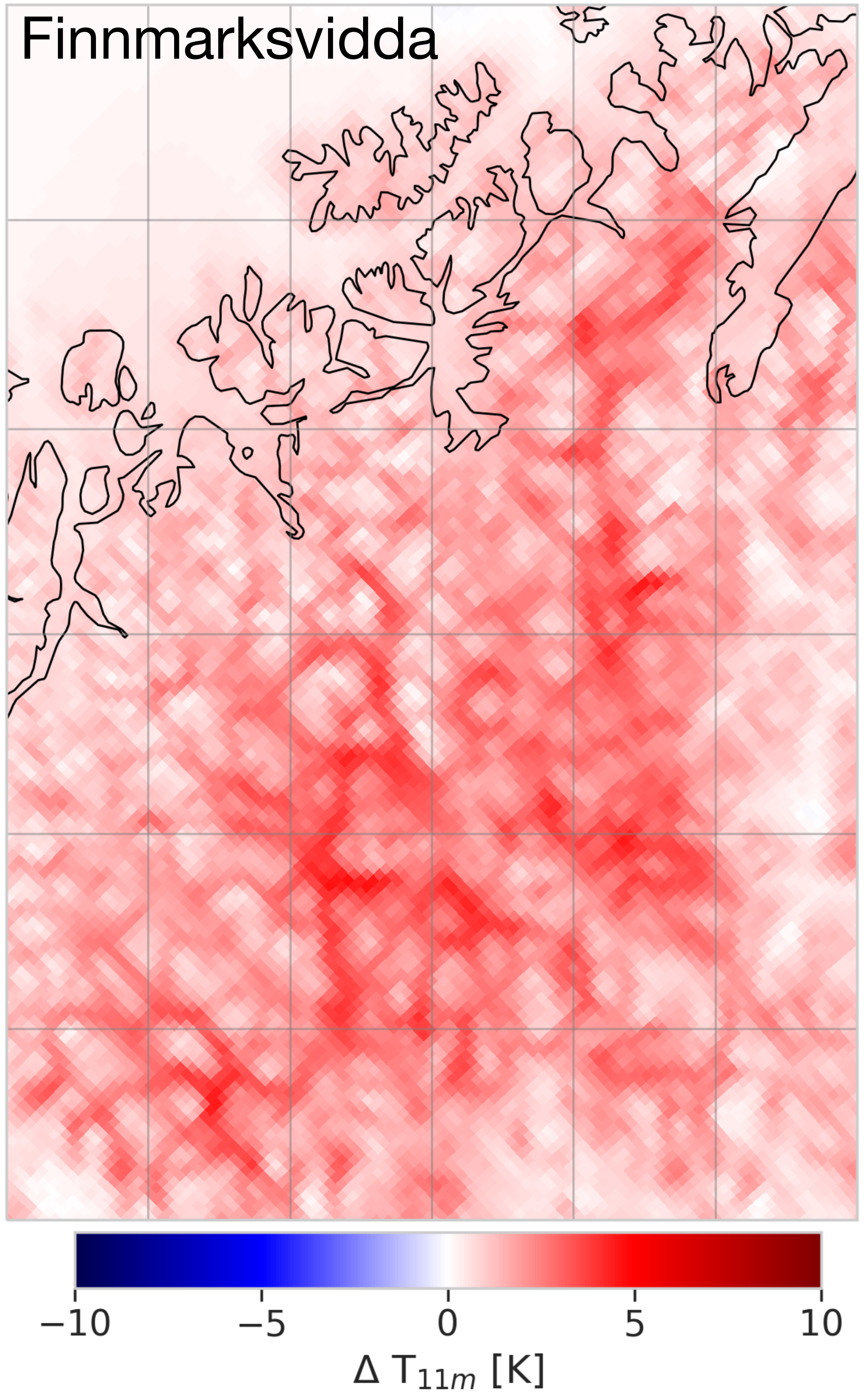
PhD student Laura Mack, University of Oslo

Impact of model updates on stability regimes

Contrasting XRIMAX = 0 / XRIMAX = 0.4



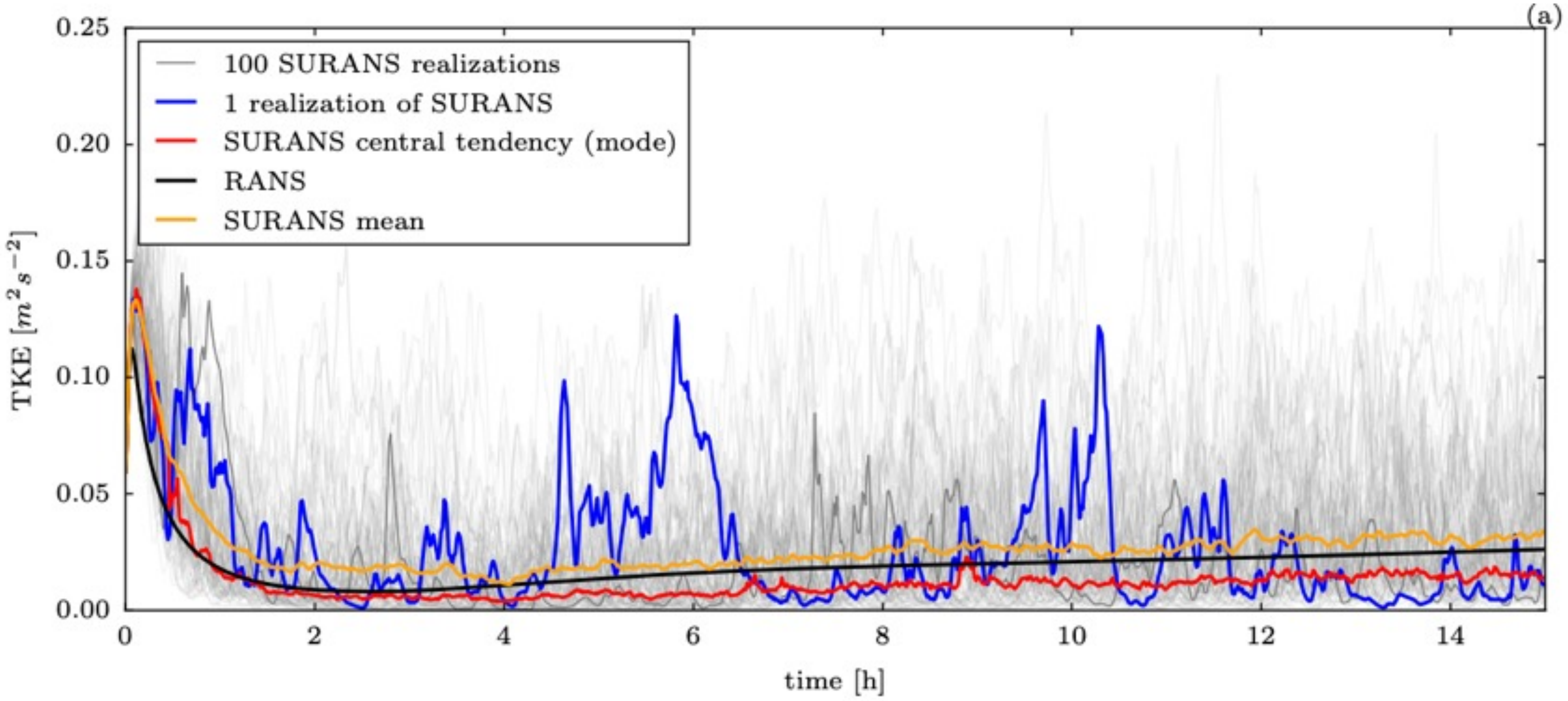
Surface decouples from atmosphere yields colder surface temperatures, but weaker atmospheric inversion



Pronounced difference in steep valleys/ clear nights

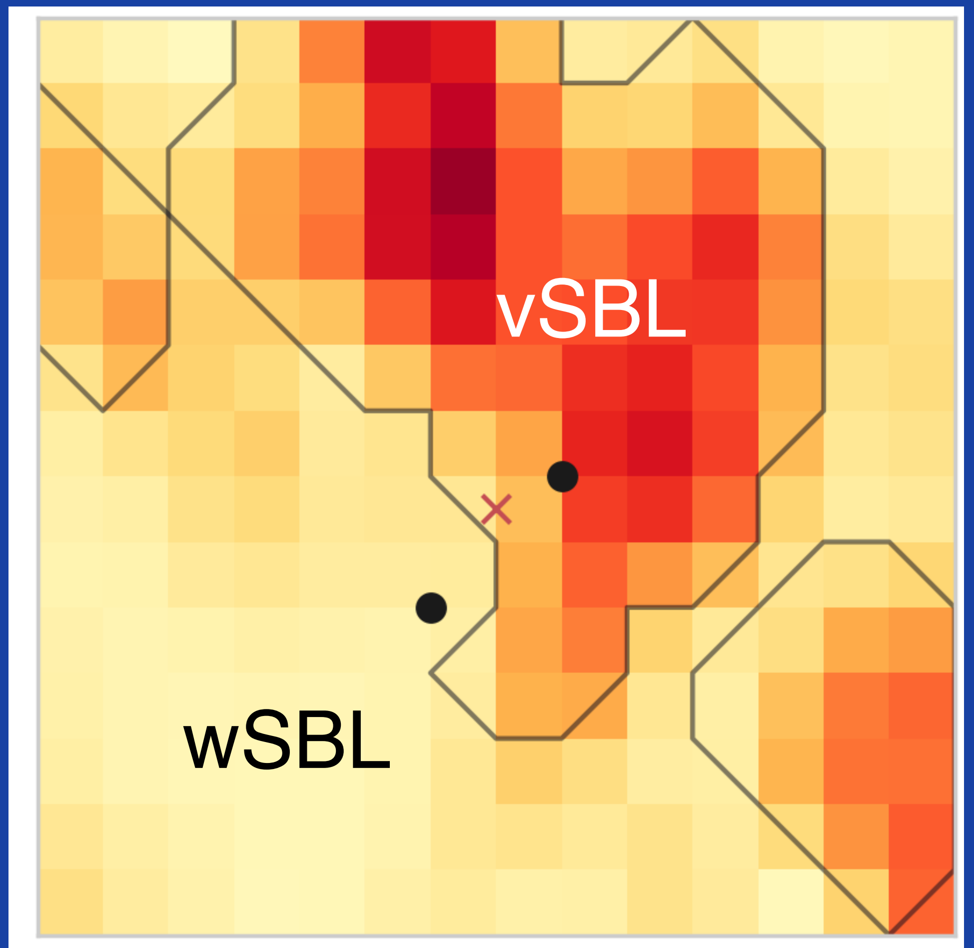
A stochastic stability correction, PhD Laura Mack

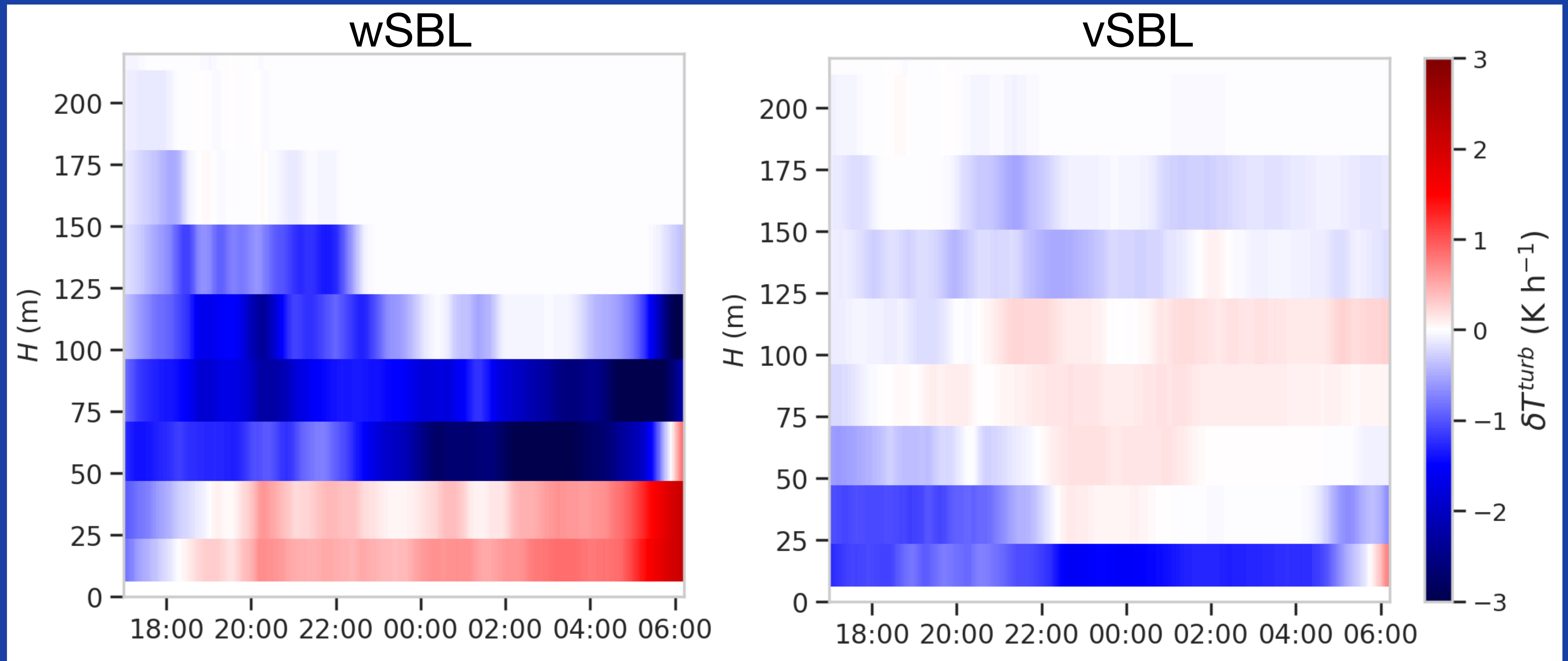
Images taken from Vercauteren 2022

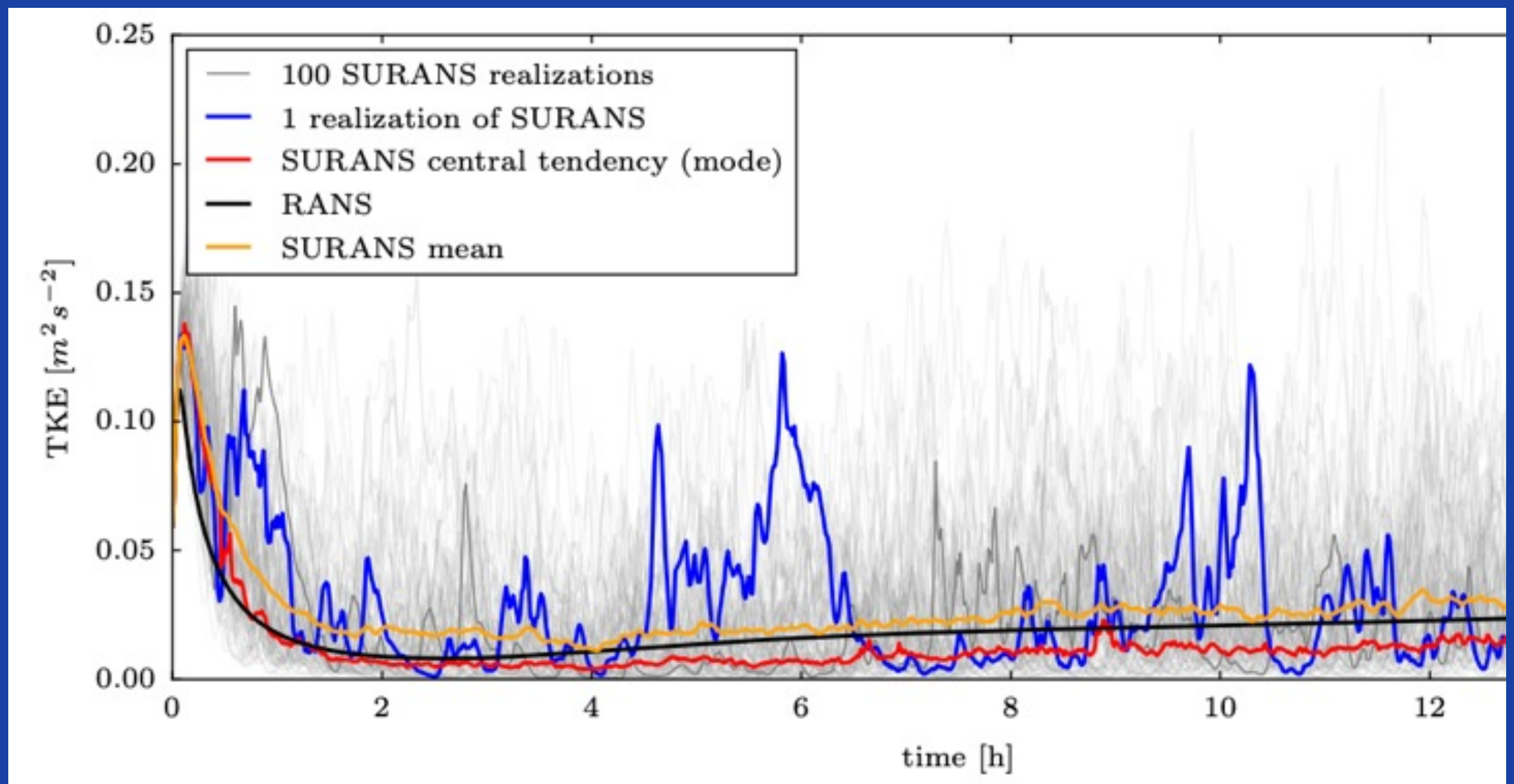


- Sophisticated observation at an Alpine glacier
- Use data to train on intermittent turbulence
- Check validity for other locations (Sodankylä)
- Test in MUSC
- Test in AROME-Arctic

Summary







- AROME-Arctic introduces both SBL regimes on small spatial scales

- Different feedback mechanisms between physical schemes in wSBL and vSBL aligns with conceptualisation: wSBL is coupled by turbulence, vSBL exhibits decoupling

- Important to consider for validation, model analysis, and model development, and forecasting

- Ongoing work for a data-driven, stochastic stability correction for the turbulence scheme (PhD at UiO)

- Ongoing work of studying the occurrence and transition of stability regimes