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Thermodynamics and airstreams of a South Foehn event in different Alpine valleys

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Check out the accepted article:

Jansing, L. and Sprenger, M. (2022), Thermodynamics and airstreams of a South Foehn event in different Alpine valleys. *Quarterly Journal of the Royal Meteorological Society*. Accepted Author Manuscript. https://doi.org/10.1002/qj.4285

Objectives of the paper

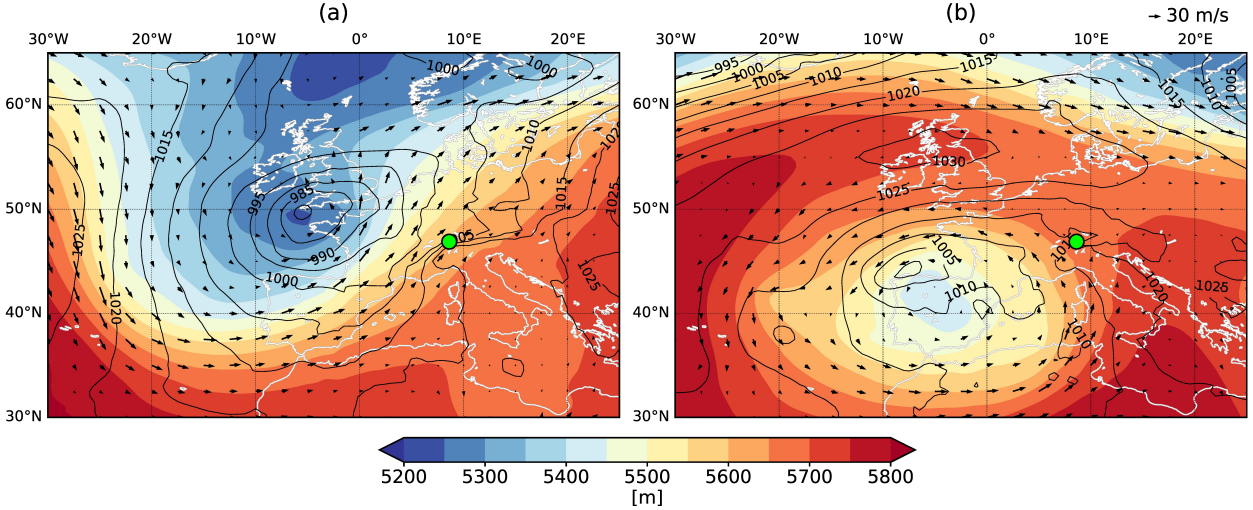
Investigate a South Foehn case study from November 2016:

- Long-lasting event (5-6 days), very intense, lots of preciptation on the Alpine south side
- Goal: Quantify all possible Foehn air warming mechanisms
- Link the warming to upwind airstreams

For six different Alpine valleys

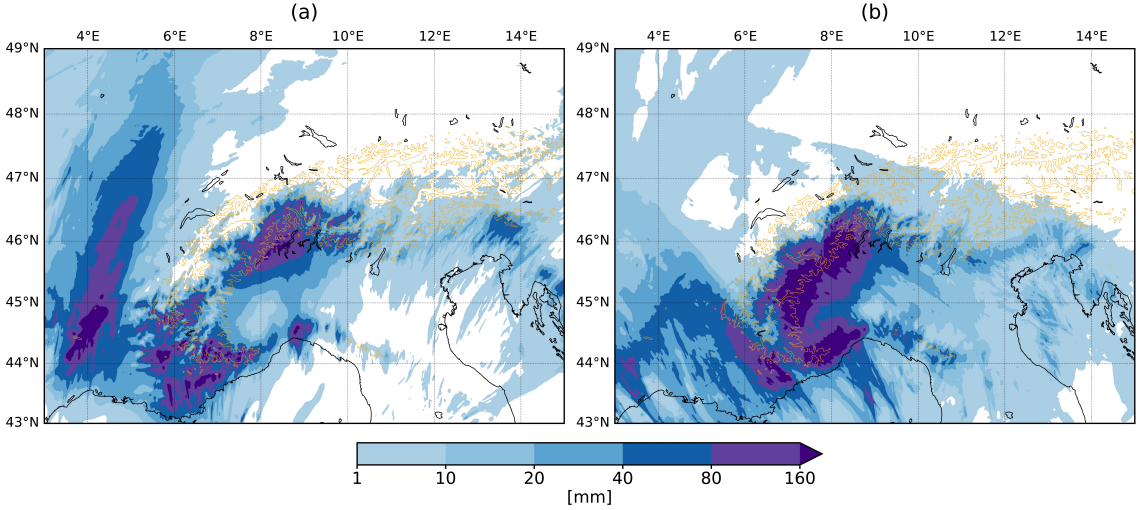
Geopotential height and wind @ 500 hPa, SLP:

12 UTC 21 Nov 2016 (a) | 12 UTC 24 Nov 2016 (b)



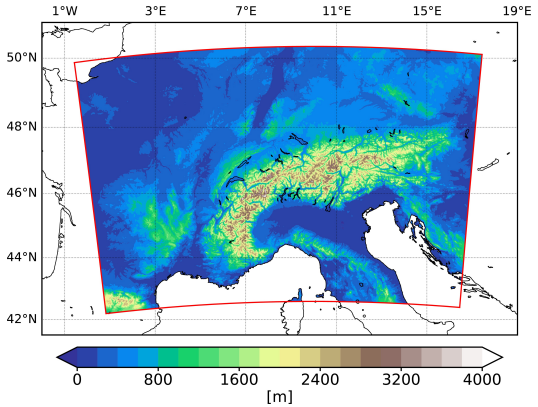
Accumulated surface precipitation:

18 UTC 19 Nov – 18 UTC 22 Nov (a) | 18 UTC 22 Nov – 18 UTC 25 Nov (b)



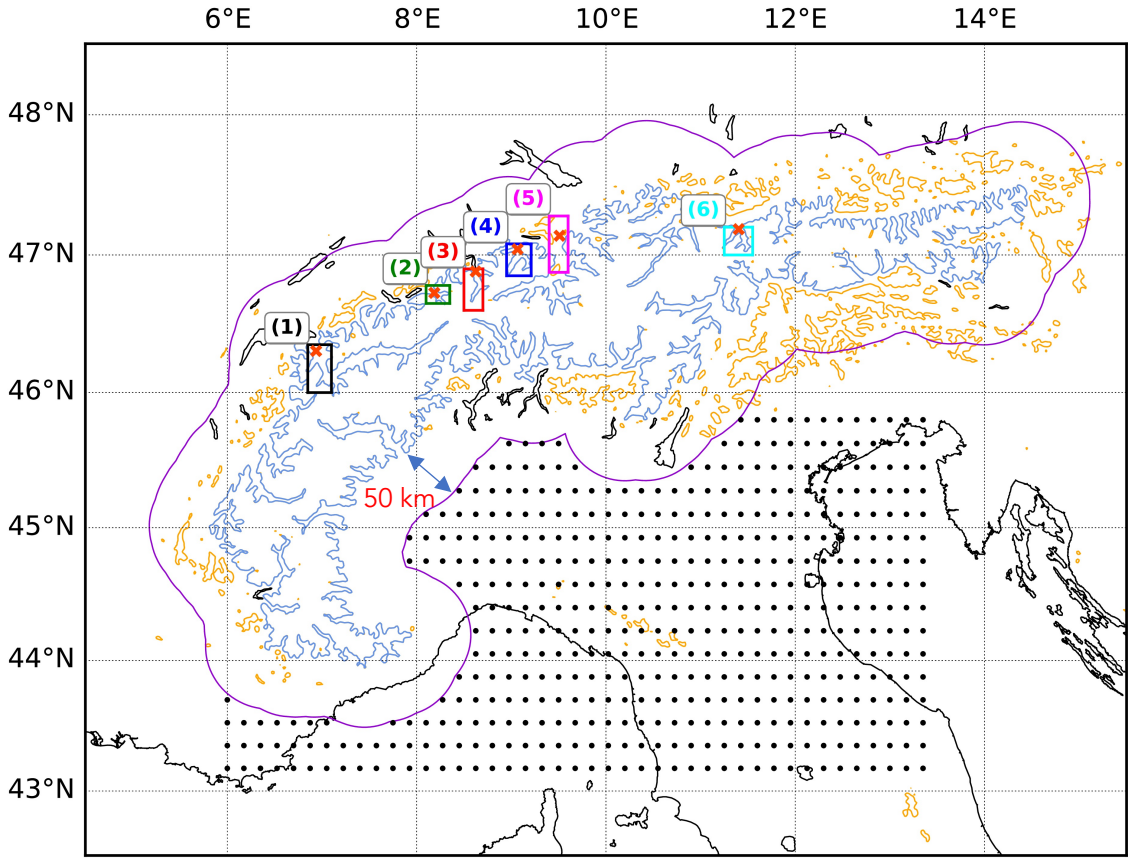
Foehn air warming – methods

- COSMO-1 model simulation (Steppeler er al., 2003; Baldauf et al., 2011):
  Setup very similar to MeteoSwiss, IC/BC from COSMO-1 analysis



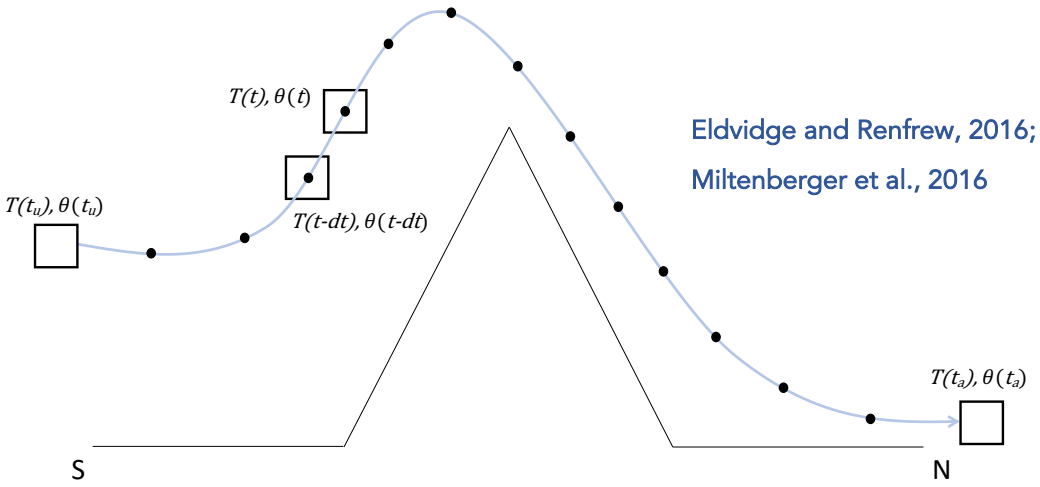
- Online trajectories (Miltenberger et al., 2013)

- Trajectory selection based on altitude AGL in valley boxes



1) Lower Valais
2) Hasli Valley
3) Reuss Valley
4) Linth Valley
5) Rhine Valley
6) Wipp Valley

Foehn air warming – heat budget framework



Eldvidge and Renfrew, 2016;
Miltenberger et al., 2016

Hermann et al., 2020

$$\frac{DT}{Dt} = \frac{\kappa T \omega}{p} + \frac{D\theta}{Dt} * \left(\frac{p_0}{p}\right)^{-\kappa}$$

1)

$$\Delta T_{diab} = \sum_{t \in \{t_{u+dt}, \dots, t_a\}}^{n} (\theta_t - \theta_{t-dt}) * \left(\frac{2p_0}{p_t + p_{t-dt}}\right)^{-\kappa}$$

2)

$$\Delta T_{adiab} = \Delta T - \Delta T_{diab}$$

2)

3)

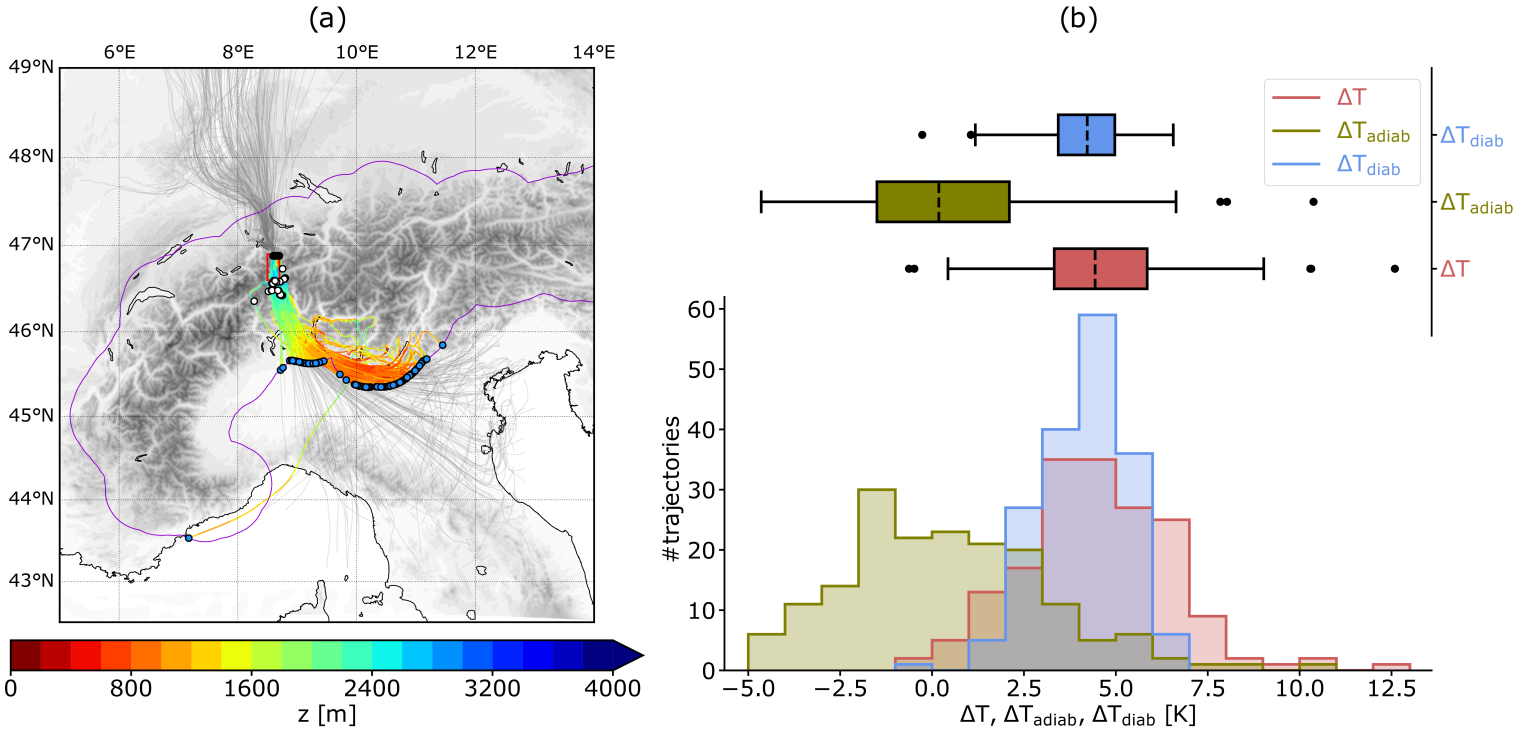
$$\Delta T_{diab} = \sum_{t \in \{t_{u+dt}, \dots, t_a\}}^{n} \left(\frac{\partial T}{\partial t}_{mphys} + \frac{\partial T}{\partial t}_{tur} + \frac{\partial T}{\partial t}_{rad}\right) * dt + \Delta T_{residual}$$

Joos and Wernli, 2012;
Papritz and Pfahl, 2016

Foehn air warming – examle of heat budget

Example for heat budget:

Trajectories arriving in 6-hourly window centered around 21 Nov 2016 12 UTC



Foehn air warming – bulk warming

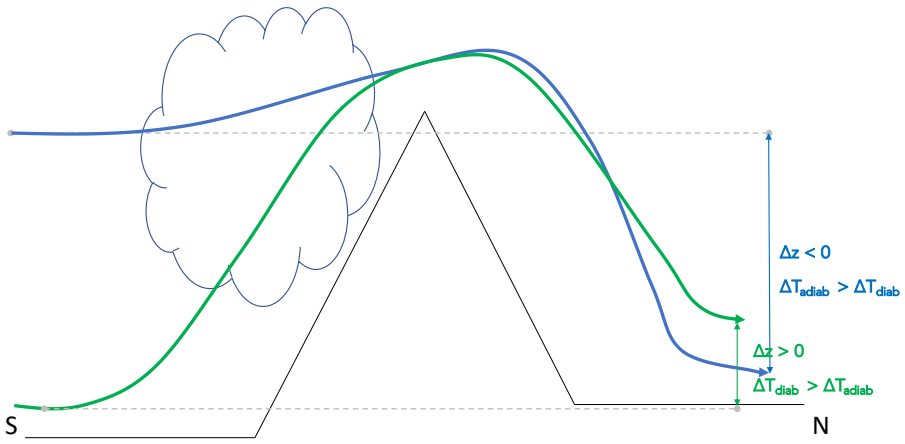
Warming phase space for all trajectories from all valleys

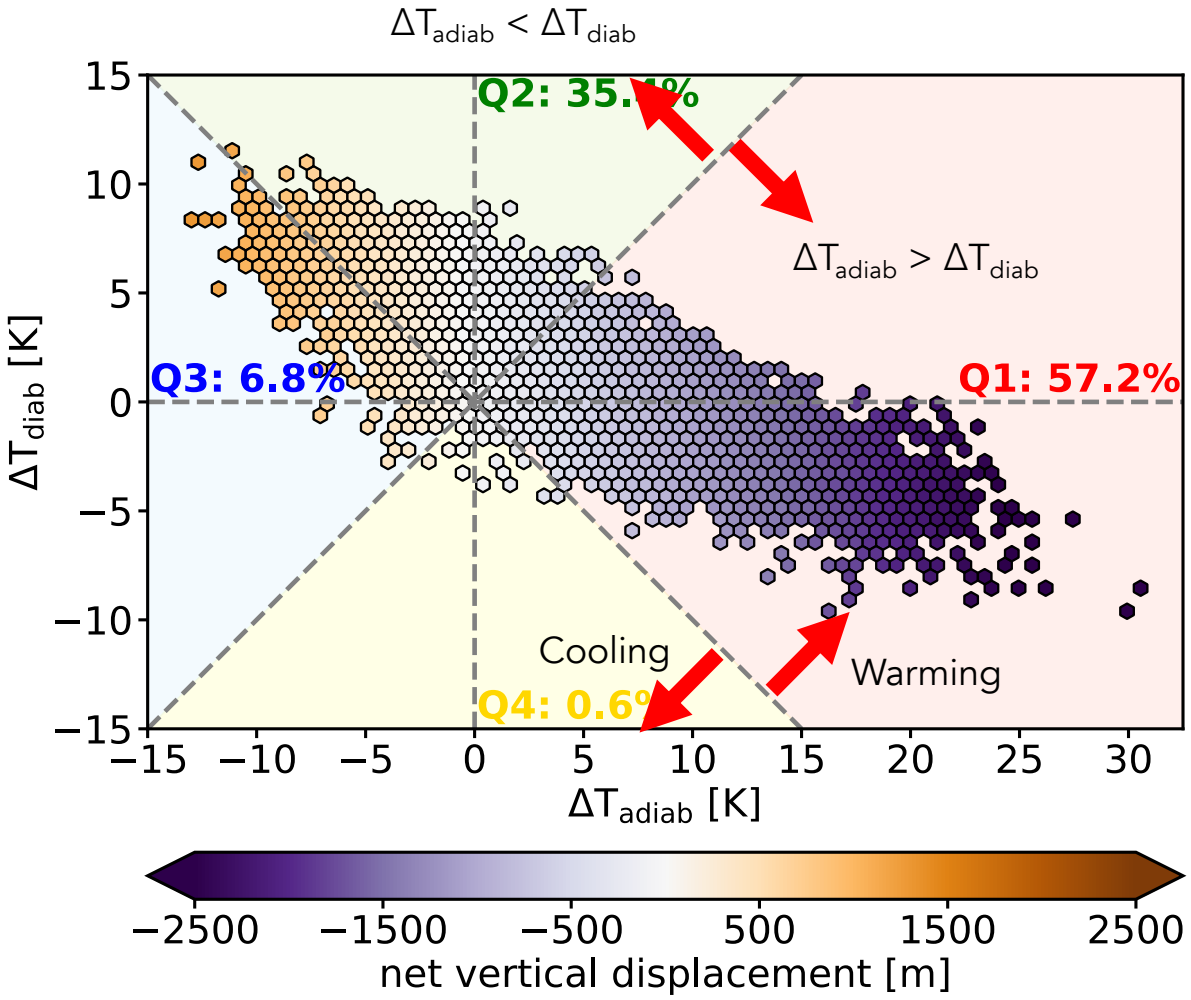
Q1 Warming dominated by adiabatic descent

Q2 Warming dominated by diabatic heating

Q3 Cooling dominated by adiabatic ascent

Q4 Cooling dominated by diabatic cooling



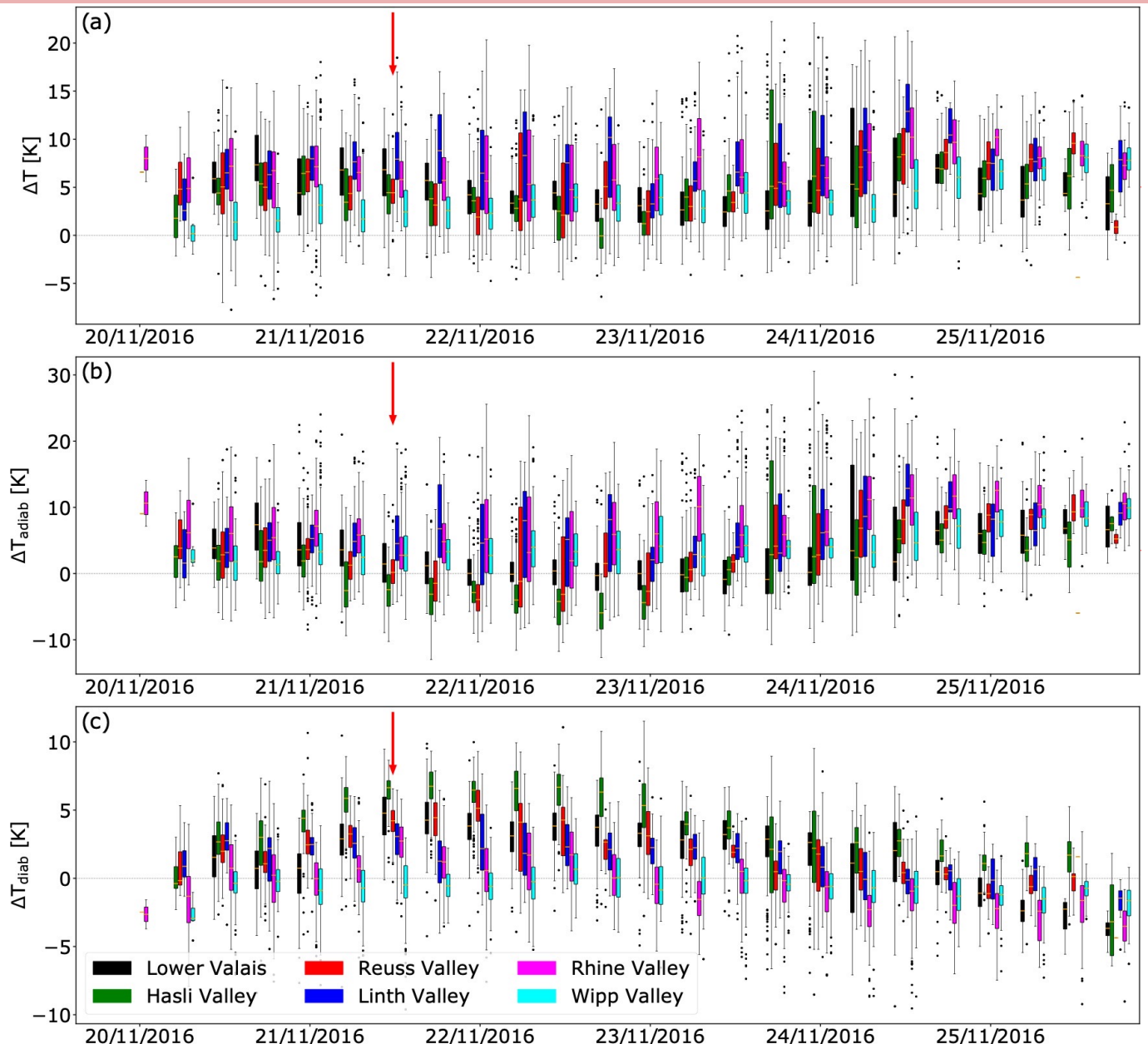


Foehn air warming – temporal evolution

Net warming:

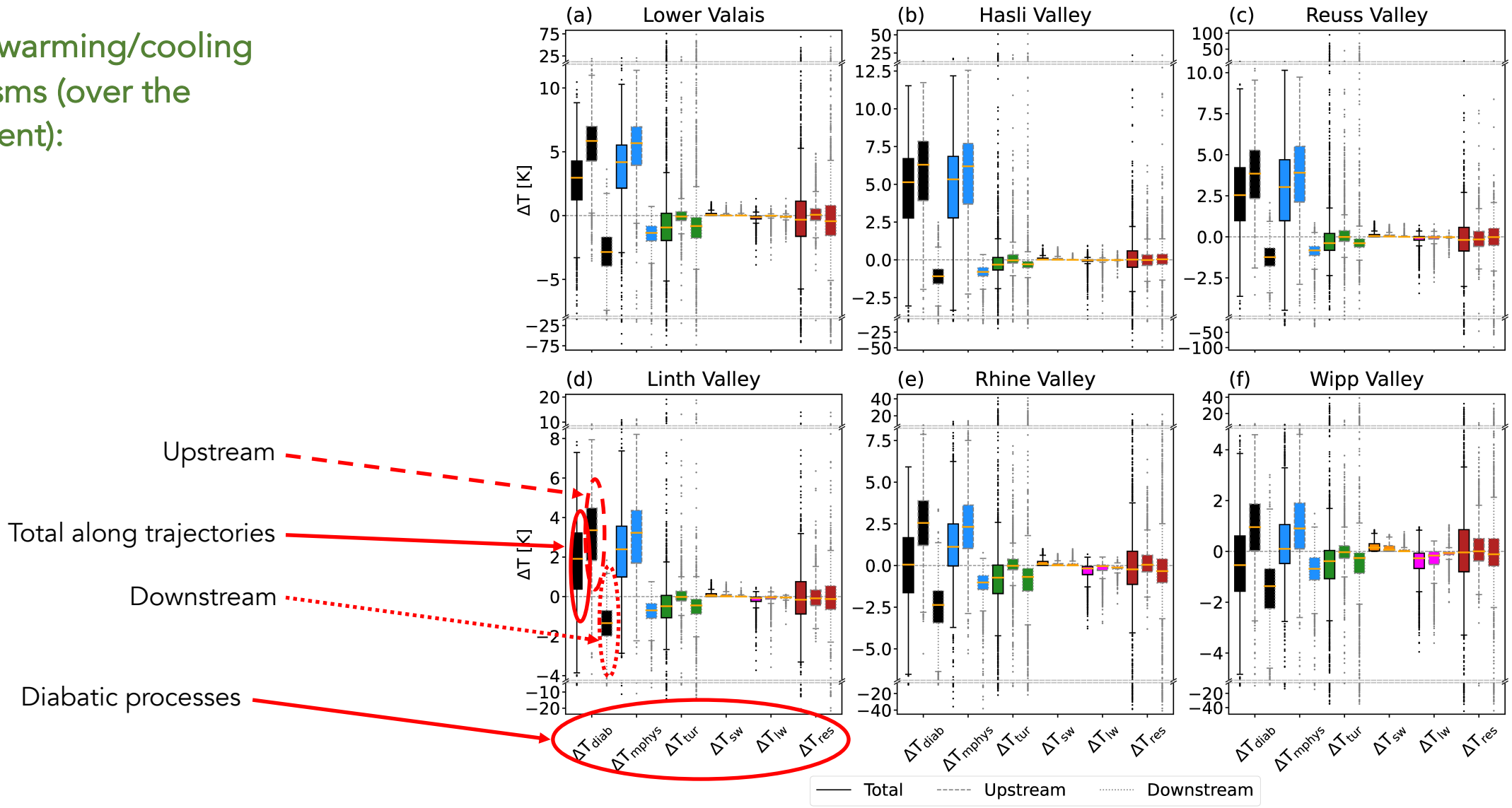
Adiabatic warming:

Diabatic warming:



Foehn air warming – diabatic processes

Diabatic warming/cooling mechanisms (over the whole event):



Diabatic airstreams – definition

Define simple trajectory categories based on diabatic heating:

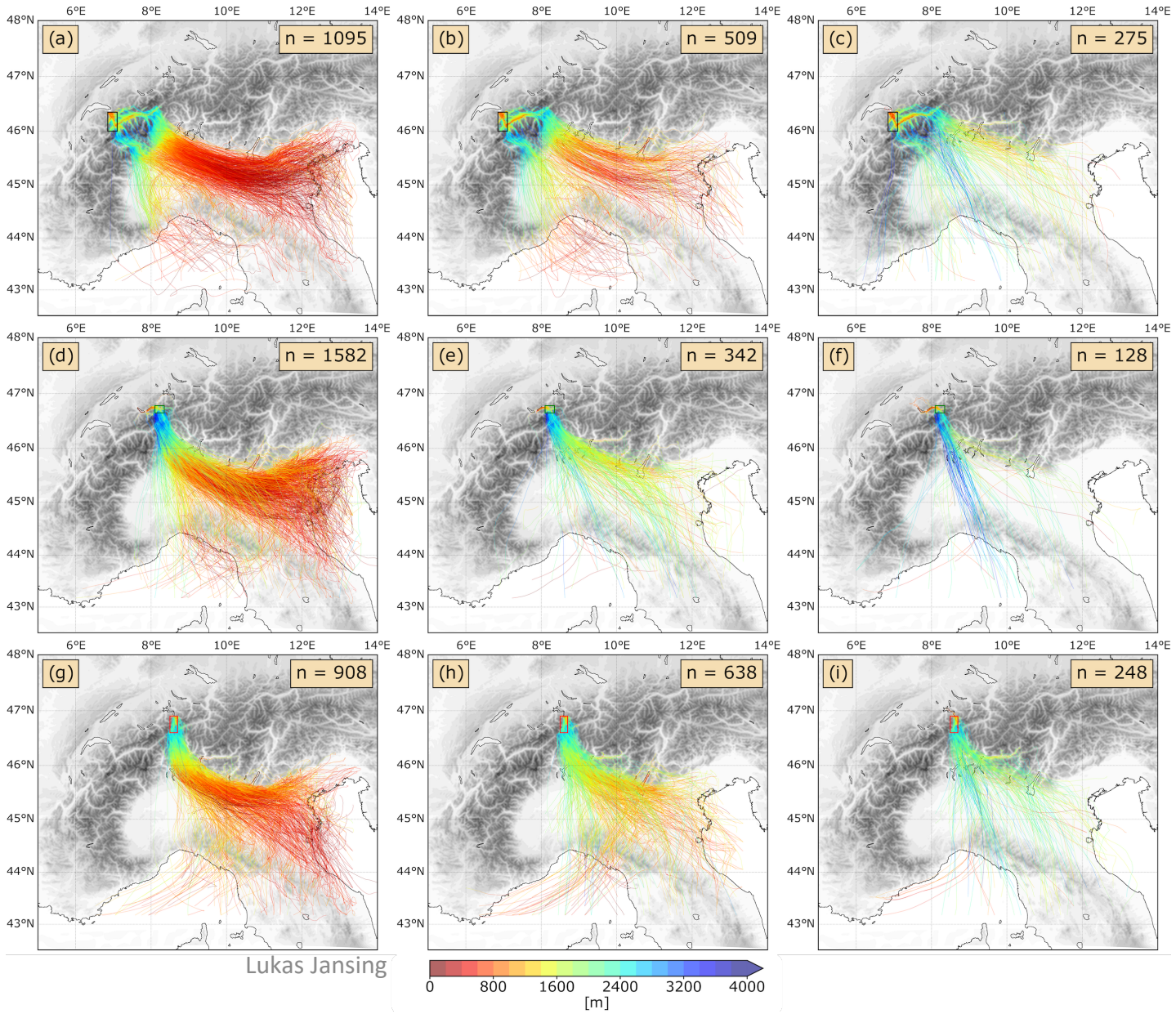
- Diabatic warming >= 2.5 K → category 1
- 0 K <= Diabatic warming < 2.5 K → category 2
- Diabatic cooling → category 3

Diabatic airstreams – western valleys

Lower Valais

Hasli Valley

Reuss Valley

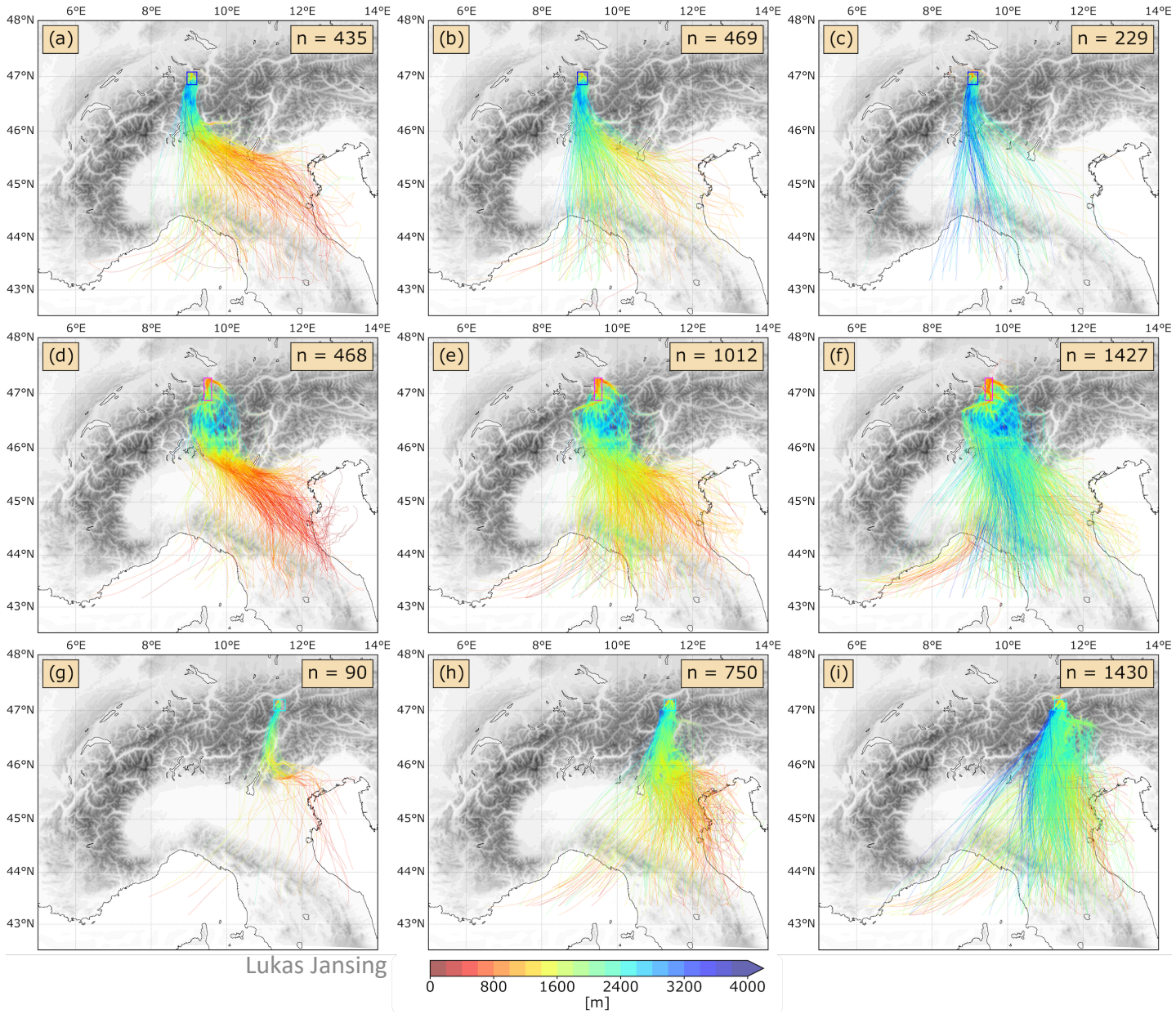


Diabatic airstreams – eastern valleys

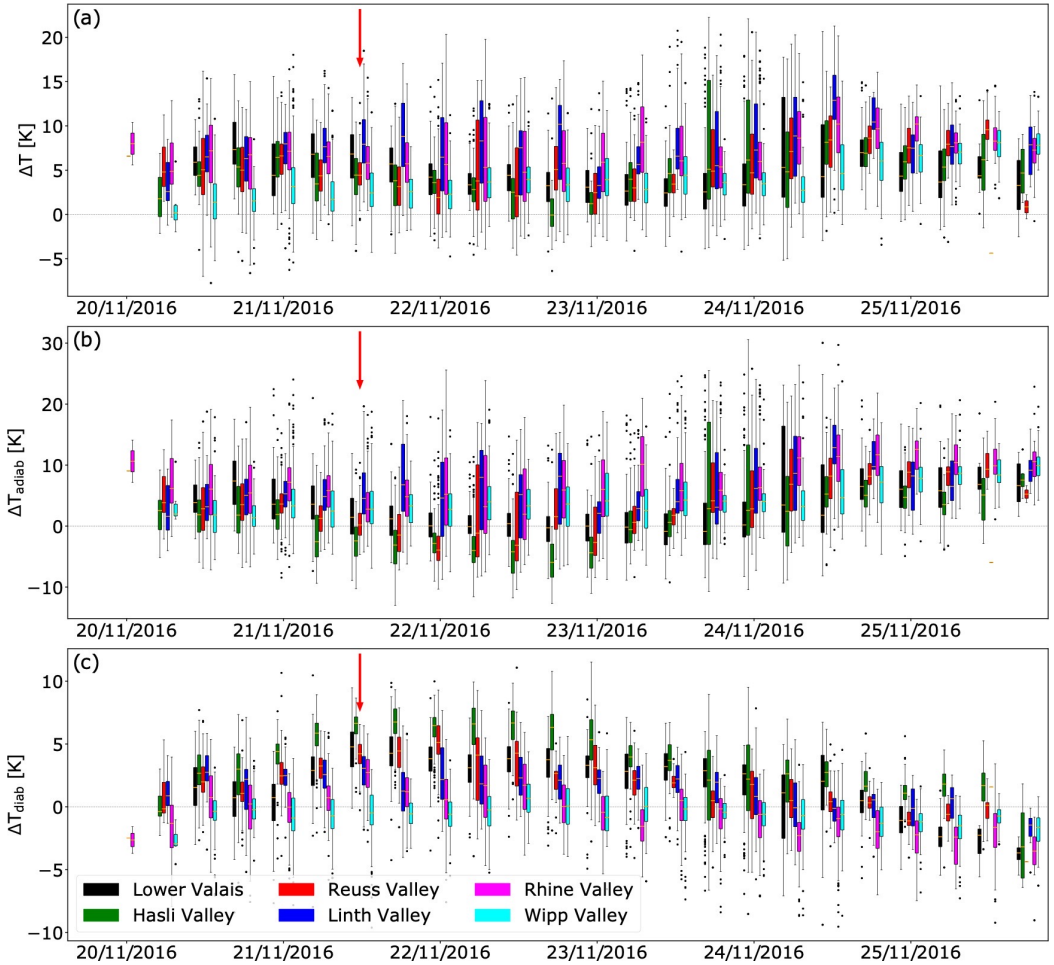
Linth Valley

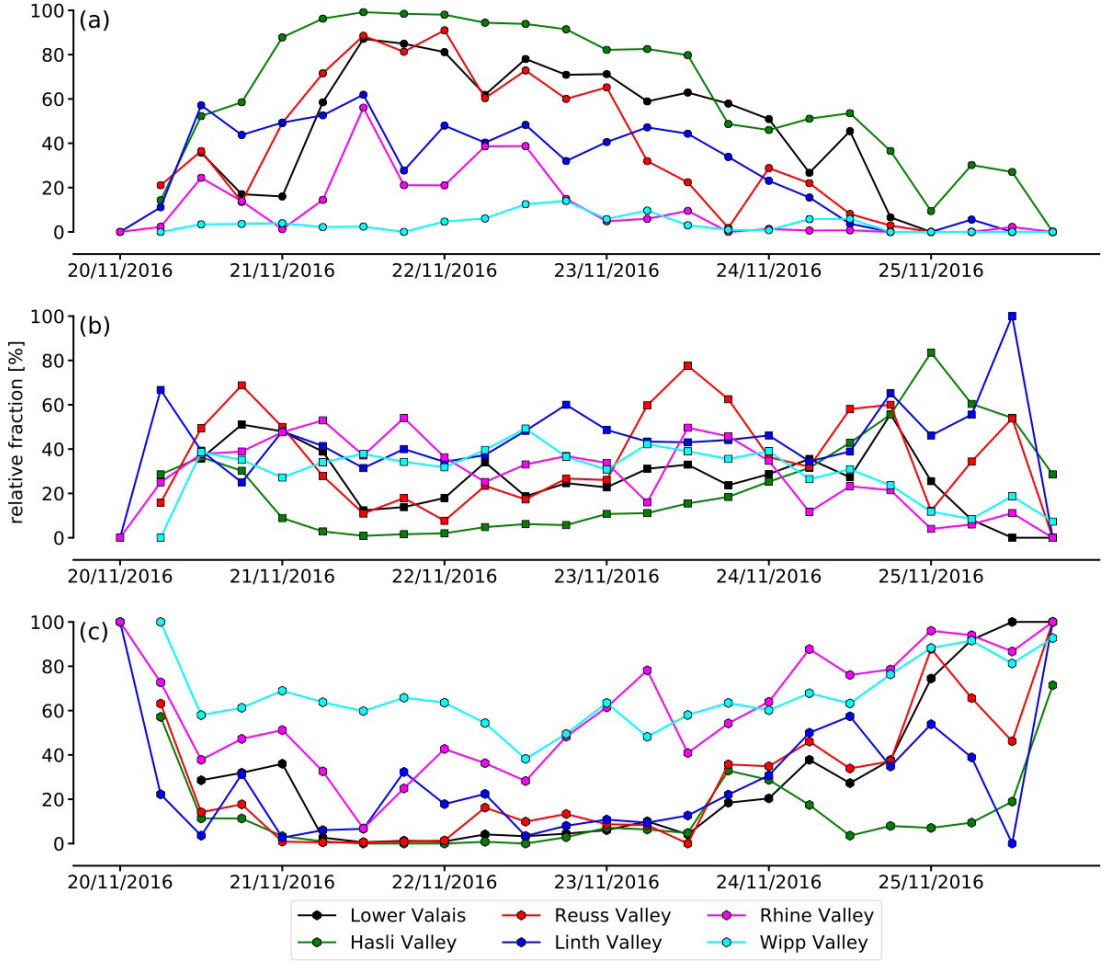
Rhine Valley

Wipp Valley



Diabatic airstreams – temporal evolution of airstreams





Foehn case study Nov 2016

Interested?

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→ Listen to the EGU talk at Wed, 25 May, 08:54–09:01, Room M1:

Jansing, L. and Sprenger, M.: Foehn air warming in six Alpine valleys: Lagrangian heat budget analysis and relation to airstreams, EGU General Assembly 2022, Vienna, Austria, 23–27 May 2022, EGU22-1483, https://doi.org/10.5194/egusphere-egu22-1483, 2022.

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