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Supplement of

Classification of Alpine south foehn based on 5 years of kilometre-scale analysis data

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Supplementary material

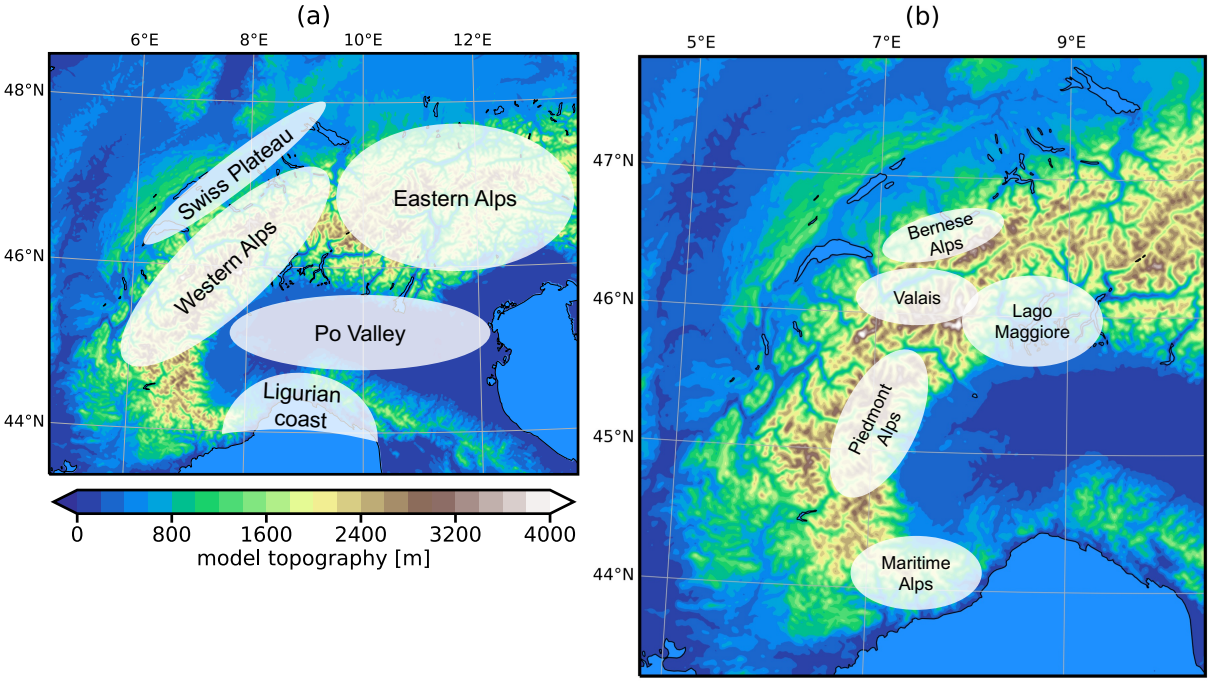

Figure S1. Key geographical regions used for the study. (a) Regions on the Alpine scale. (b) Regions of the Western Alps.

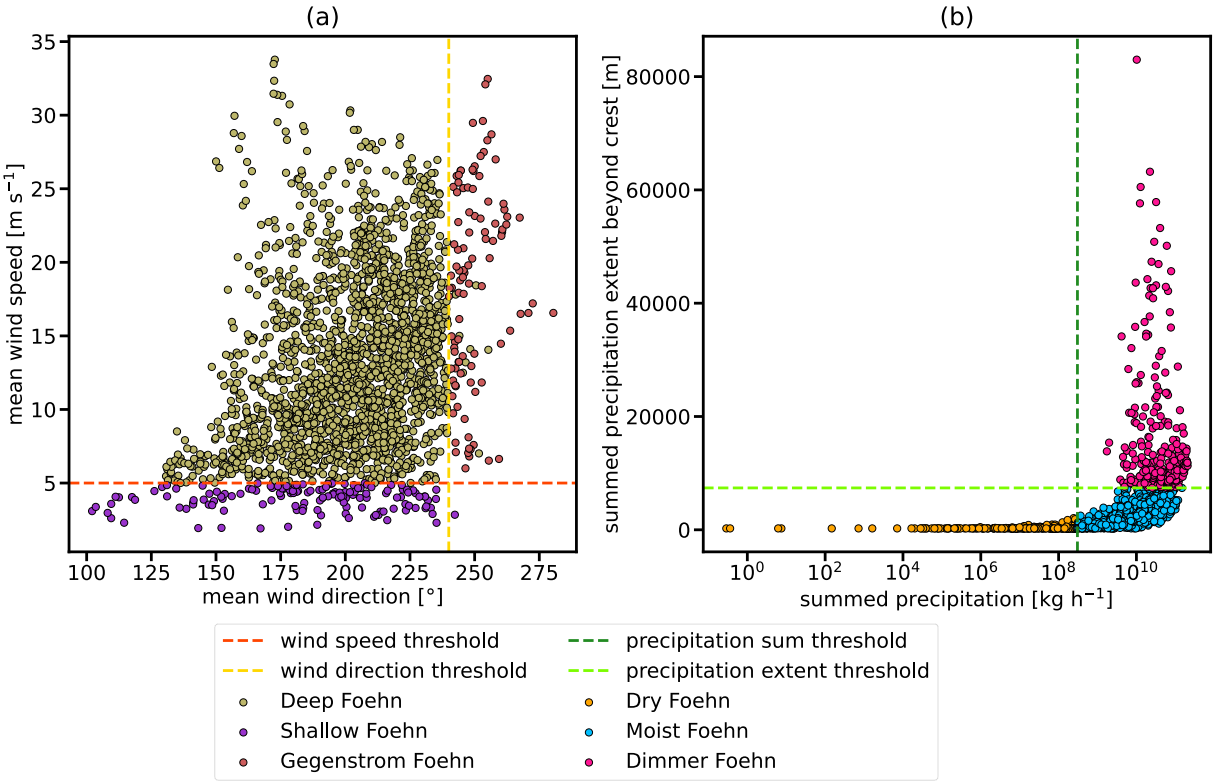

Figure S2. Distribution of the features used to classify the main Foehn types (a) and the *Deep Foehn* subtypes (b). Note the logarithmic scale of the x-axis in (b). Some caution is required with respect to *Gegenstrom Foehn* hours, where the shear between 500 hPa and 700 hPa is used as an additional criterion (not displayed in the figure). This explains the occurrence of *Deep Foehn* hours above the wind direction threshold of 240° (yellow dashed line). More details regarding the classification is found in Section 3.

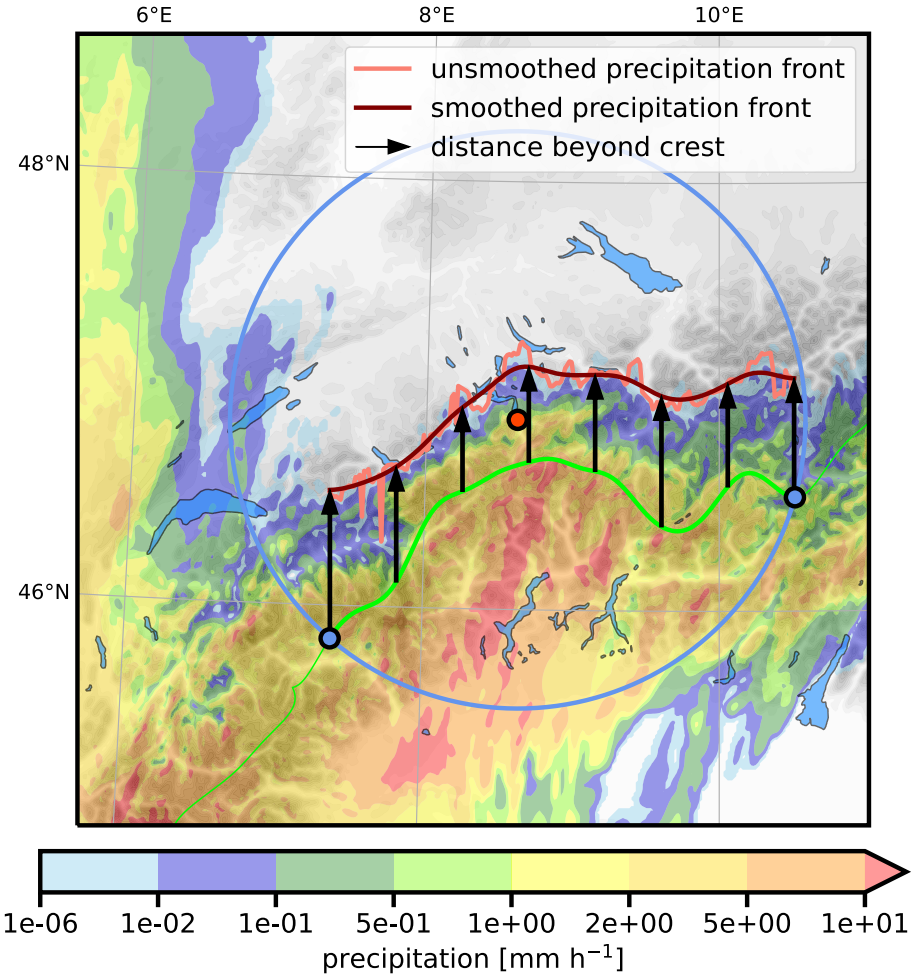

Figure S3. Example from 02 Nov 2020 19 UTC to illustrate how the northward extent of precipitation is extracted from the COSMO-1 analysis to classify *Dimmer Foehn*. Precipitation is included (transparent colors) as well as the position of Altdorf (red dot with black edge). The light blue circle around Altdorf and the associated blue dots define the segment of the crestline (bold lime line) which is considered to extract the northward extent of precipitation. The unsmoothed (light red) and the smoothed precipitation front (dark red) derived from the precipitation field are shown as well. Furthermore, exemplary arrows are shown to demonstrate the distance metric used to classify *Dimmer Foehn*, namely the sum of the distances between crest and the smoothed precipitation front.

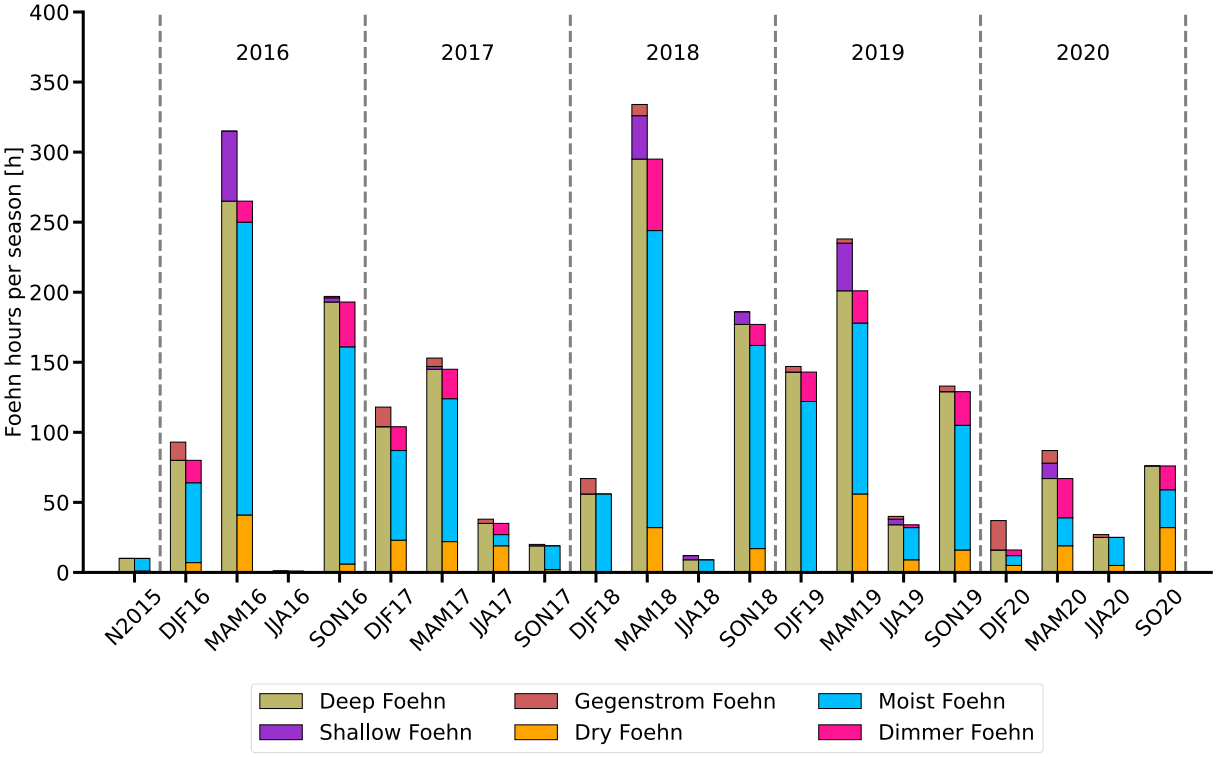

Figure S4. Timeseries of Foehn hours per season for the different main Foehn types and *Deep Foehn* subtypes. Note that the sum of the main Foehn types corresponds to the total Foehn hours.

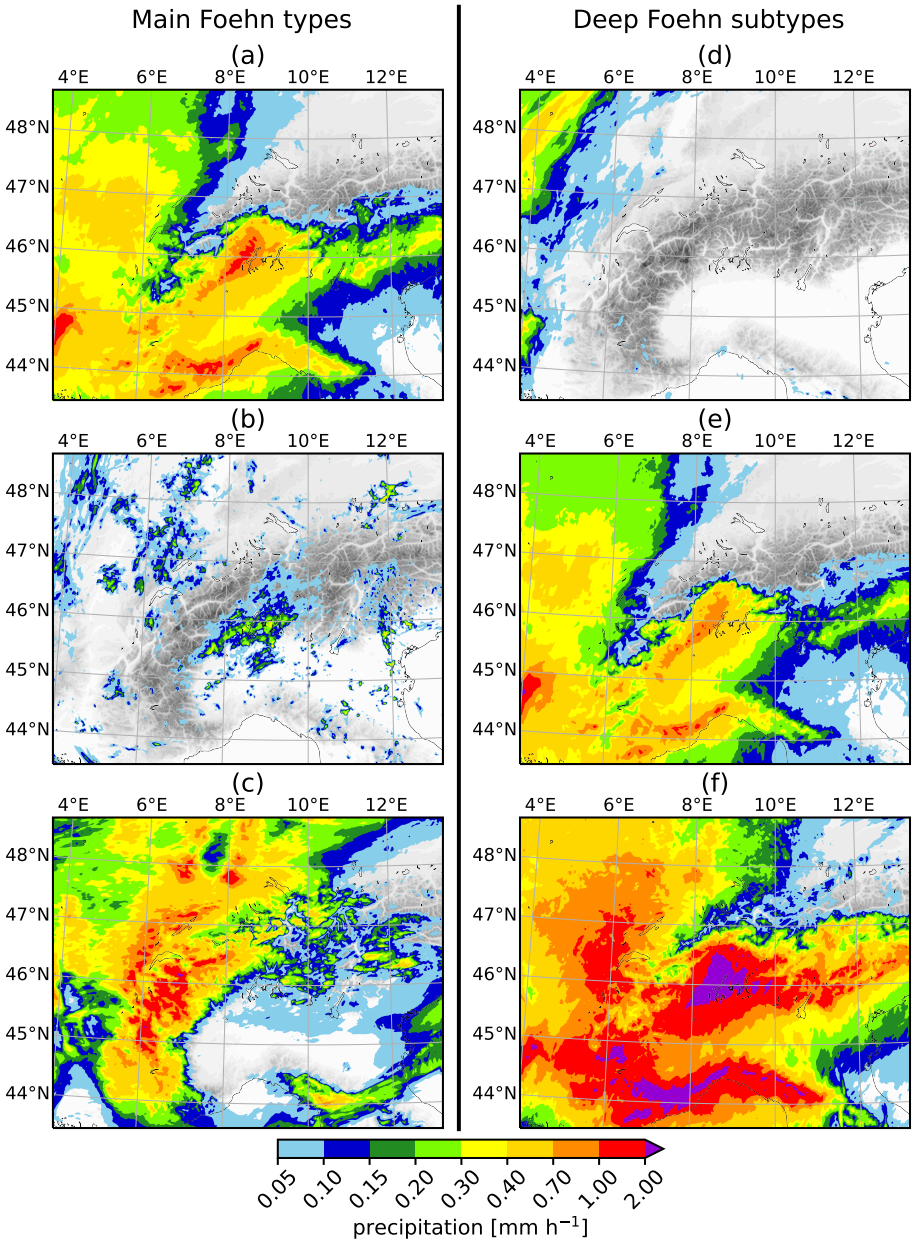

Figure S5. COSMO-1 composites of surface precipitation (color) for the different main Foehn types and *Deep Foehn* subtypes. (a) *Deep Foehn*; (b) *Shallow Foehn*; (c) *Gegenstrom Foehn*; (d) *Dry Foehn*; (e) *Moist Foehn*; (f) *Dimmer Foehn*. The topography is included in grey shading.

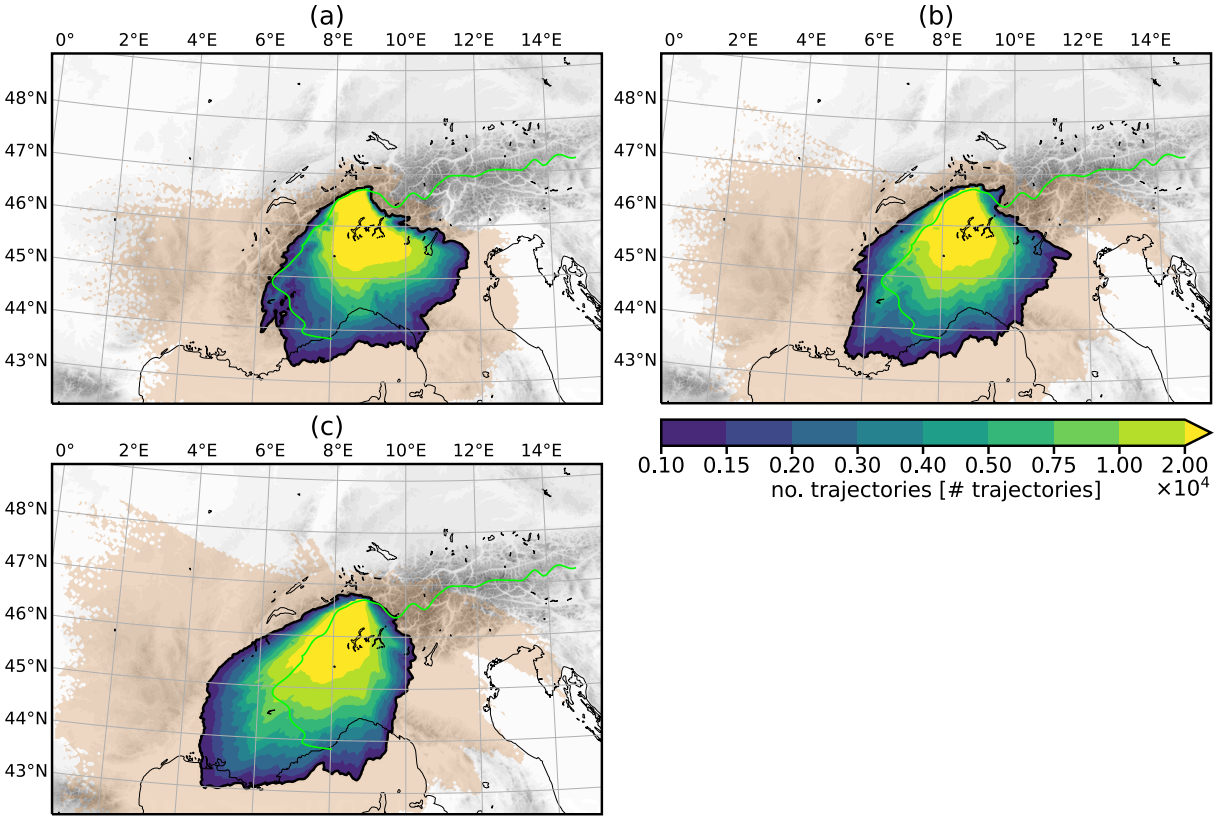

Figure S6. Same as Fig. 8 but showing the number of trajectories within each bin for the different trajectory clusters: (a) cluster 1; (b) cluster 2; (c) cluster 3. Besides, areas masked owing to small sample size are indicated by brownish, transparent colors.

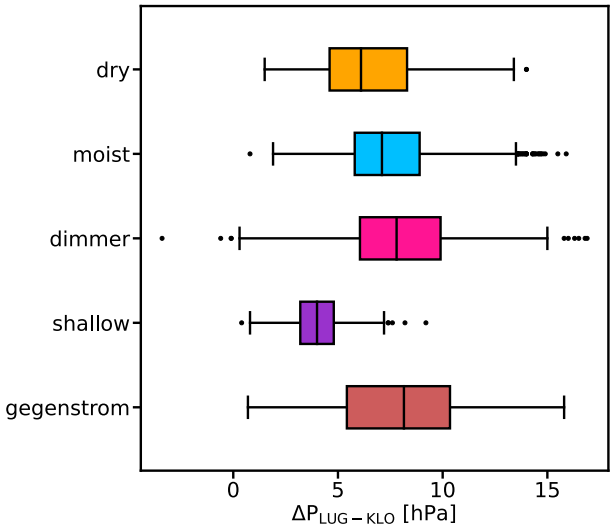

Figure S7. Boxplots of station measurements depicting the difference in reduced sea level pressure between Lugano (Alpine south side) and Kloten (Alpine north side) for the different Foehn types.

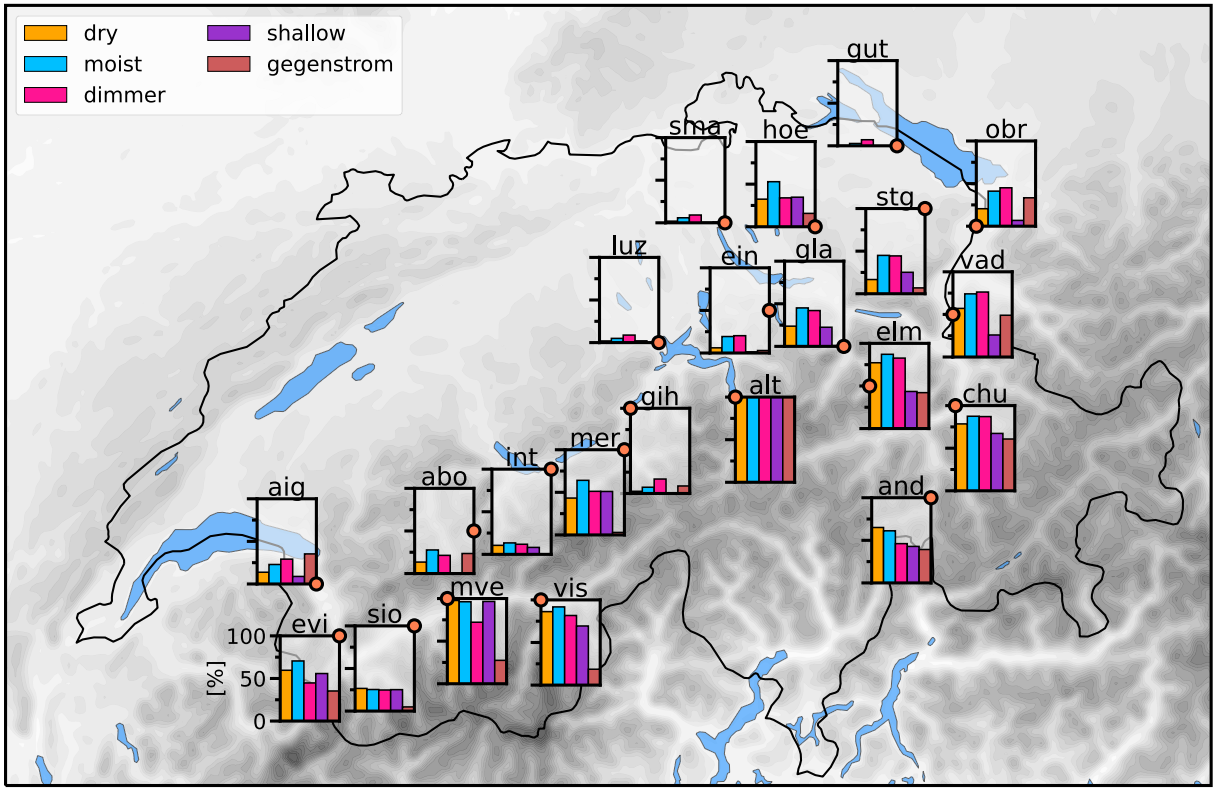

Figure S8. Occurrence frequency of Foehn at various stations in Switzerland conditional to the occurrence of a certain Foehn type in Altdorf. The COSMO-1 topography is included in the background for orientation. A detailed list of the stations can be found in Table S1.

Table S1. Overview of the stations used in the spatial analysis in Fig. S8 (station name, abbreviations, mean yearly frequencies and relative frequencies with respect to Altdorf).

station	abbreviation	z AMSL [m]	frequency [h year^{-1}]	frequency relative to alt [%]
Visp	vis	639	817	175
Montana	mve	1423	1027	220
Sion	sio	482	145	31
Evionnaz	evi	482	436	94
Aigle	aig	381	130	28
Adelboden	abo	1321	157	34
Meiringen	mer	589	274	59
Interlaken	int	577	58	12
Giswil	gih	471	47	10
Luzern	luz	454	25	5
Altdorf	alt	438	466	100
Einsiedeln	ein	911	77	17
Zuerich / Fluntern	sma	556	27	6
Elm	elm	958	554	119
Glarus	gla	517	182	39
Hoernli	hoe	1133	257	55
St. Gallen	stg	776	195	42
Guettingen	gut	440	13	3
Andeer	and	987	719	154
Chur	chu	556	726	156
Vaduz	vad	457	360	77
Oberriet / Kriessern	obr	409	180	39

Table S2. Comparison of *Gegenstrom Foehn* and *Dimmer Foehn* hours as diagnosed with the decision tree and diagnosed with the station-based Foehn index (see also Section 2.1). To ensure that events where the same Foehn types occur according to both classifications, while the occurrence exhibits a minor temporal shift, a time lag increment of 6 hours is considered in the comparison. This is done by adding six hours prior and after each *Gegenstrom Foehn* hour in both of the timeseries. Each of the approximate timeseries (i.e., including the time lag increment) is compared to corresponding exact timeseries (without the time lag) to quantify the correspondence of the two classifications.

	Gegenstrom Foehn	**Dimmer Foehn**
hours in classification	102 h	295 h
hours in Foehn index	60 h	219 h
approximate overlap of the classification	50 h / 49%	165 h / 56%
approximate overlap of the Foehn index	52 h / 87%	165 h / 75%