Review egusphere-2024-670

Analysing CMIP5 EURO-CORDEX models in their ability to produce south foehn and the resulting climate change impact on frequency and spatial extent over western Austria (Maier et al.)

Summary

The manuscript studies south foehn in parts of the Austrian Alps and how its spatio-temporal characteristics might change in the future. It uses an algorithm to diagnose foehn at several locations. This foehn diagnosis is then used as a response variable in the training of machine learning models to diagnose foehn using reanalysis and climate simulation data, respectively. At first glance the paper seems to be a replica of Mony et al. (2021) albeit with spatially higher resolution reanalysis and climate simulation data and for the Alpine region immediately east. At a closer look, though, the paper has major shortcomings and lacks reproducibility in essential details as explained in the next section. Therefore rejection of the paper is recommended.

Reasons for rejection

1. **Misclassification of foehn events:** The objective foehn classification method was inappropriately applied by extending a potential temperature difference specific to one location to all locations. Foehn strongly depends on the topography such as the presence of tributary valleys upstream from which cold air can drain into the valley where the foehn blows, the presence of cold pools, the distance from the crest, and the altitude difference to the upstream crest. However, the authors use the potential temperature difference between crest and valley station from Fig. 4a in Plavcan et al (2014), which was determined for a specific location (Ellboegen). This threshold needs to be derived from the data for each station separately. Since the remainder of the paper builds on the foehn classification its results are dubious.
2. **Inappropriate clustering of foehn locations:** Foehn frequencies will only to a small degree be affected by being somewhat more west or east on the northern side of the Alpine crest and to a much larger degree by their specific location and the specific processes at work (cold pool formation, flow separation, drainage of cold air from tributary valleys, …). The locations aggregated into the three groups are thus expected to have foehn frequencies that might differ by one order of magnitude. All the analyses starting with the foehn classification would need to be performed separately for each location and only at the very end an examination of regional differences be performed.

Major comments

1. Since foehn is very sensitive to the details of the underlying topography and one of the major goals of the paper is to investigate future changes of foehn frequency, ERA5 reanalysis data should be interpolated to the finer grid of the climate simulations (instead of the other way round as done in the paper).

2. Unclear how a foehn *day* is diagnosed from hourly measurements. The paper states “whereas the most extended event observed within the day’s 24 hours is used”. Does this mean that a “foehn day” is one with at least one hour of foehn?
3. Foehn diagnosis not reproducible and possibly inappropriate:
    a. Table 2 does not state a wind sector for foehn at a valley station. Please supply. If none was used but only the exceedance of 50 (90) % of wind speeds at the crest then e.g. situations with southerly flow aloft but diurnal upvalley winds will be misclassified.
    b. Wind speed thresholds at the crest station (given that the wind is in the appropriate sector) are unnecessary and eliminate many foehn hours. Potential temperature difference and appropriate wind at the valley station will suffice. No wonder that hardly any widespread events are classified if they require top 10% wind speeds at crest.
    c. Missing results of the foehn diagnosis
4. In-sample model results: From what I read in the manuscript, the authors performed a hyperparameter grid search to determine the tuning parameters of the xgBoost model. The data used for the grid search can then no longer be used to determine the expected model performance.

Minor comments

1. The title is too long and confusing as it implies that south foehn leads to climate change
2. Line 72: Does the statement of the “binary nature” of foehn contradict how it is treated in 3 categories in equ(1)?
3. Note that you do not need pressure data to use the foehn classification method of Vergeiner (2004). As this method checks whether air could have dry-adiabatically descended from the crest station to the valley station, reducing the temperature from the crest station to the valley station with a (linear) dry-adiabatic temperature gradient will do and only needs station elevations.
4. Table 2: Is the crest wind speed threshold chosen only from the wind speed distribution of winds from 135 - 225 degrees or from all directions (which would not be appropriate)?