Evaluation of WRF model and development of an algorithm for downscaling temperature minima over complex terrain in Trentino

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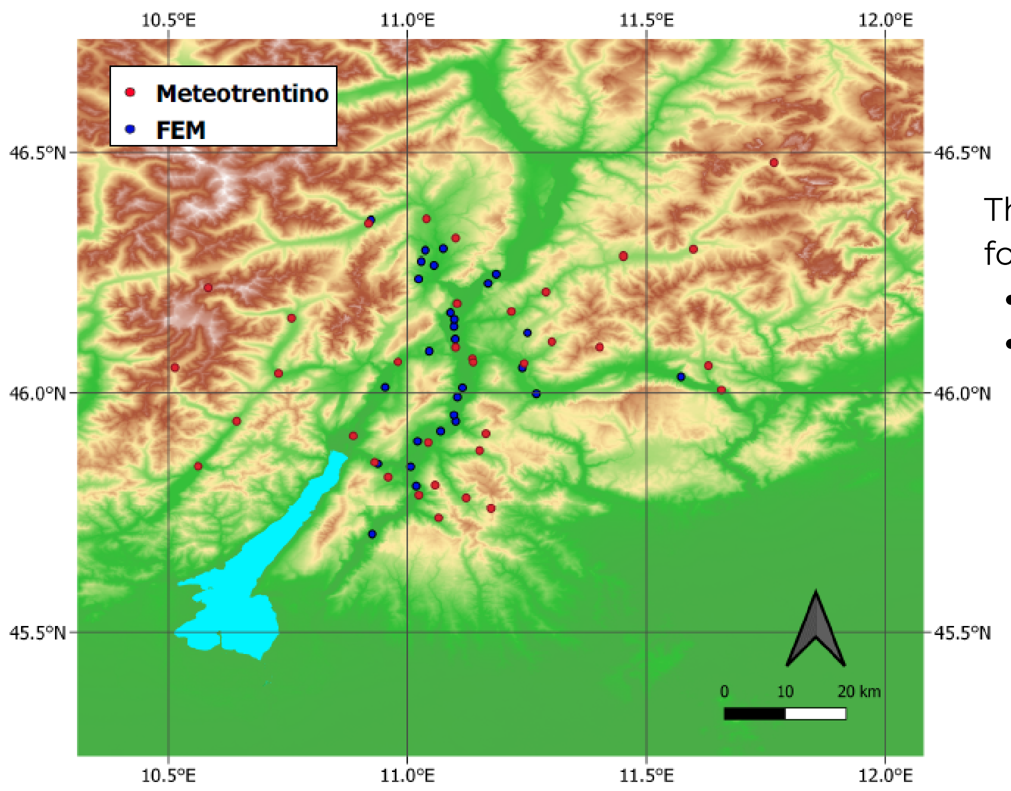
INTRODUCTION

The aim of this work is to develop and test a statistical downscaling post-processing procedure to improve deterministic forecasts of minimum temperature provided by a numerical weather prediction system in the Province of Trento. meteorological forecasts elaborated from simulations with the Weather Research and Forecasting (WRF) model are verified against data from observations, and suitable corrections to systematic errors were evaluated.

PRELIMINARY ANALYSIS

To carry out this analysis data from various weather stations belonging to the Edmund Mach Foundation and to Meteotrentino are used. These institutions operate two separate networks of meteorological stations, whose data are adopted to evaluate the deterministic forecasts and to test the statistical downscaling algorithms.



The 62 stations used for the analysis:

- 29 FEM
- 33 Meteotrentino

Correlation between the WRF model errors and static (i.e. topographic) and dynamic (i.e. meteorological) factors was therefore evaluated, to understand if the parameters can have an influence on the model error in forecasting the minimum temperature.

TOPOGRAPHIC FEATURES

- Altitude difference
- Slope
- Longitudinal curvature
- Cross-sectional curvature

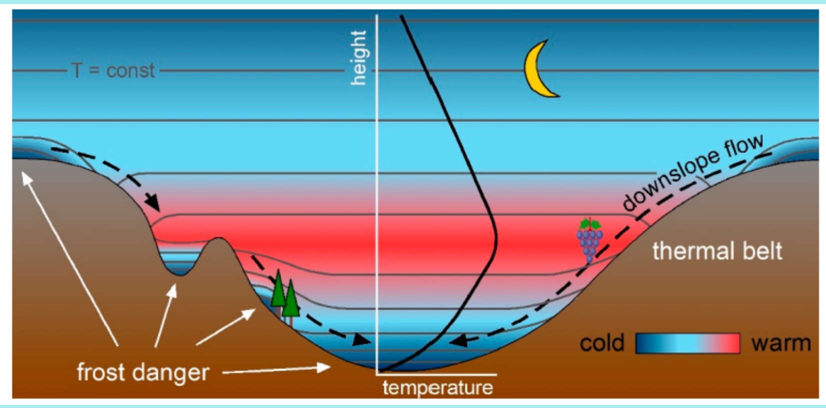
METEOROLOGICAL VARIABLES

- Net radiation
- Wind at 10 m AGL
- Wind at 500 hPa
- Relative Humidity at 2 m AGL

FROSTS

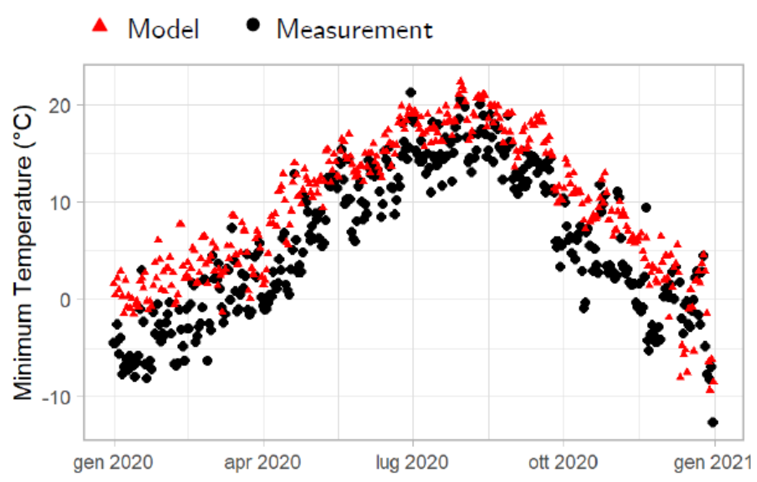
In Trentino, late frosts affecting flowering plants are particularly dangerous and they represent one of the most significant natural hazards for fruit production. During nights with clear skies, the heat received during the day is rapidly transferred from the earth's surface to the atmosphere: the air temperature then drops very quickly near the ground, causing the formation of a thermal inversion layer.

Frost in an agricultural area in the Adige valley, March 2020
(https://www.rainews.it/tgr/trento/articoli/2020/03/)

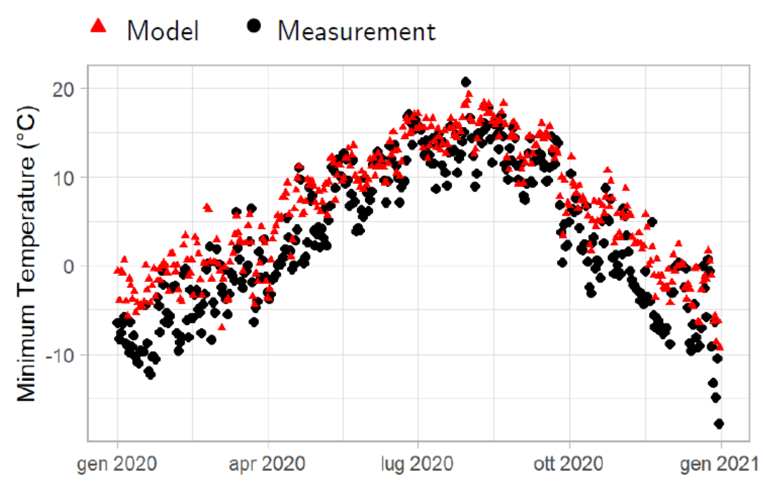


Schematisation of a thermal inversion across a valley during a calm clear night
(de Wekker et al., 2018)

The comparison between predicted and measured temperature minima, suggested that the model overestimates the temperature minima in most of the stations.



Predicted and measured temperature minima in Brancolino (Val d'Adige, 172 m a.s.l.) throughout 2020



Predicted and measured temperature minima in Flavon (Val di Non, 548 m a.s.l.) throughout 2020

METHODS

The dataset containing all the variables was firstly divided into a "training" and a "test" part, totally independent from each other.

Training dataset

- Period: 1° January - 31° October 2020
- n° stations: 42

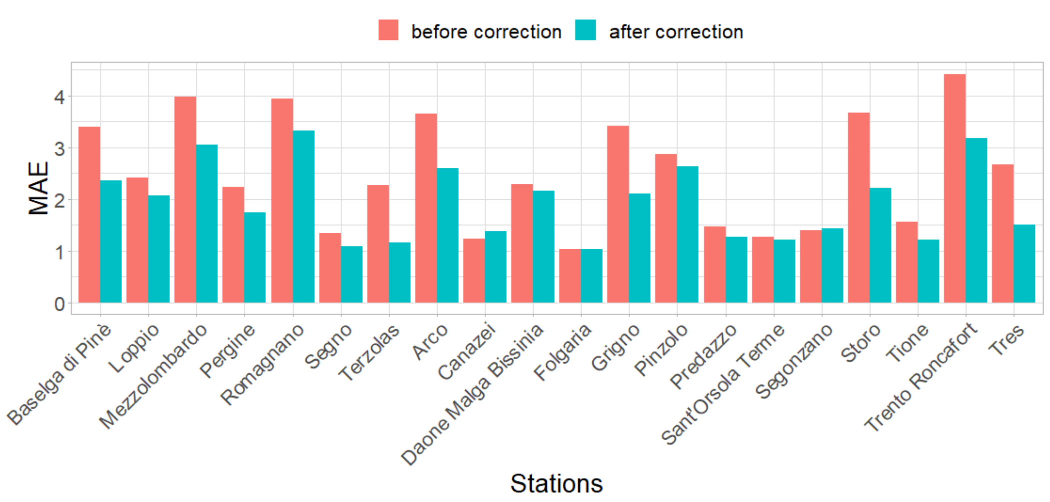
Test dataset

- Period: 1° November - 30° November 2020
- n° stations: 20

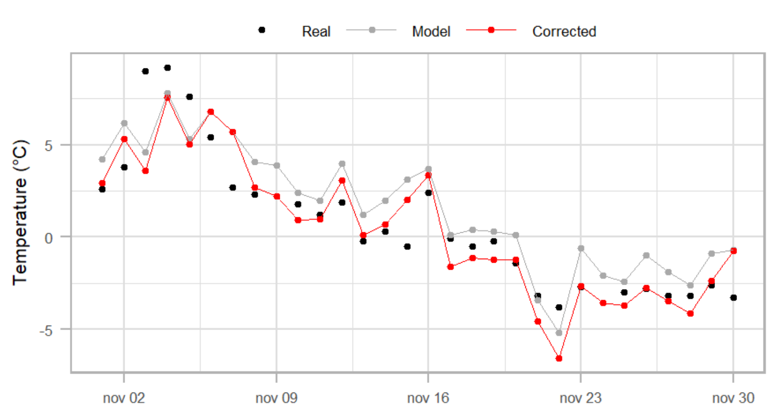
The corrective algorithm is implemented by relating the model error with topographic and meteorological data. To do this, a 2nd-order polynomial regression model is employed using the training dataset to fit the parameters. Then, the resulting "fit model" is used to predict responses for the observations in the test dataset.

RESULTS

The implemented corrective algorithm had a positive impact on the WRF model's performance, as the accuracy of the forecast improved in the majority of the stations.



Mean Absolute Error (MAE) in the stations of the test dataset



Observed (black), predicted (gray) and corrected (red) temperature minima in Tione (Valli Giudicarie, 533 m a.s.l.)

CONCLUSIONS

- The discrepancy between forecasted and measured temperature minima can be explained by topographic and meteorological parameters
- This method is general enough to be applied where no measurements are available
- The corrective model could be upgraded by integrating other weather stations, extending the period of training, refining the accuracy of the predicted meteorological variables and considering other parameters which influence temperature minima.