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Topoclimatological investigation of surface inversions over complex terrain

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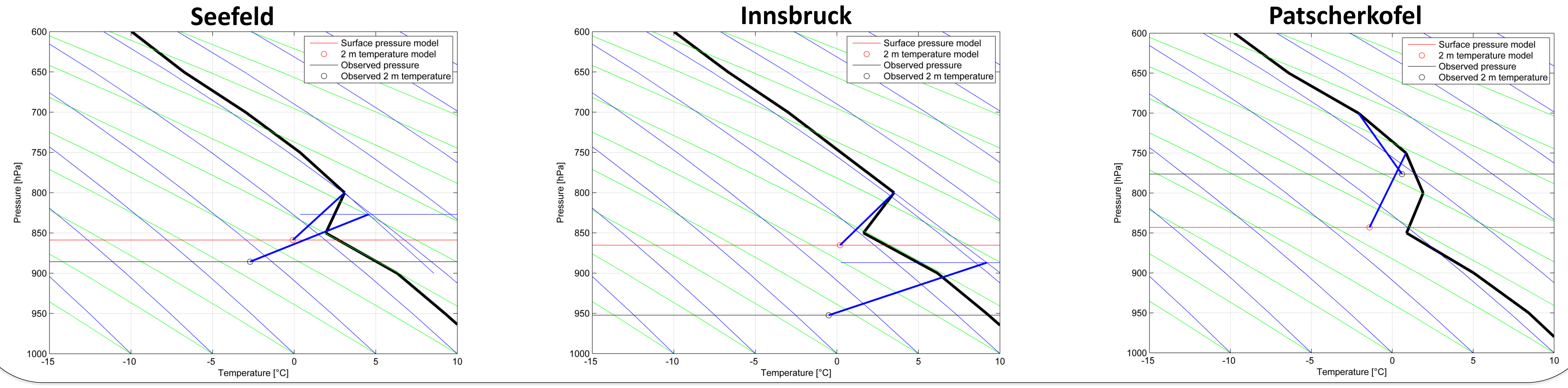
Introduction

- This study focuses on the establishment of a robust relation between night time surface inversion formation and topographic features like slope angles, concavity or convexity and elevation variations, land type, etc. at different scales. For that purpose observed surface temperatures and additionally temperature data from ERA Interim [1)] at several pressure levels have been used to obtain a statistic of inversion strength at each surface station location in Austria. The correlation between inversion strength and the topographic and land type characteristics is used, to estimate the inversion strength on a fine grid along the topography in the whole Alpine region.

Data and data processing

- Temperature data from ERA Interim for the period 1st of January 2008 to 30th of April 2014 at several pressure levels (1000 hPa to 600 hPa in 50 hPa steps), the 2 metre temperature and the surface pressure from 00, 06, 12 and 18 UTC have been used. Additionally observed surface temperatures and observed pressure data of each Austrian weather station were consulted.
- First of all the ERA Interim data were interpolated to each station to bring them in a relationship with the observed data. These data were plotted for each station (as an example temperature profiles from three stations in Tyrol on the 7th of January 2014 are shown below) for each time step for the whole period. In the graphics the bold black line symbolizes the temperature at the several pressure levels from ERA Interim.
- To transfer the information of the temperature at the several pressure levels to the observation, two different methods were applied:
  1) If the surface pressure of the model is less than the observed pressure at the station (valley station), the two metre temperature from the model (small red circle) is connected to the temperature, which is two main pressure levels lower. This blue line represents the lapse rate of the model. The bold black line between the 2nd and the 3rd main pressure levels above the surface pressure level is extended downwards. Also the pressure difference between surface pressure level (red line) and the observed pressure (black thin line) is added to the main pressure level, that is two levels lower as the surface pressure level. This intersection is connected with the observed temperature (small black circle) and this blue line is the lapse rate of the observation (see graphic Seefeld and Innsbruck).
  2) If the surface pressure of the model is larger than the observed pressure at the station (mountain station), the lapse rate of the model was determined in the same way as in method 1. The observational lapse rate was found while connecting the observed temperature (small black circle) with the temperature, which is two main pressure levels lower (see graphic Patscherkofel).

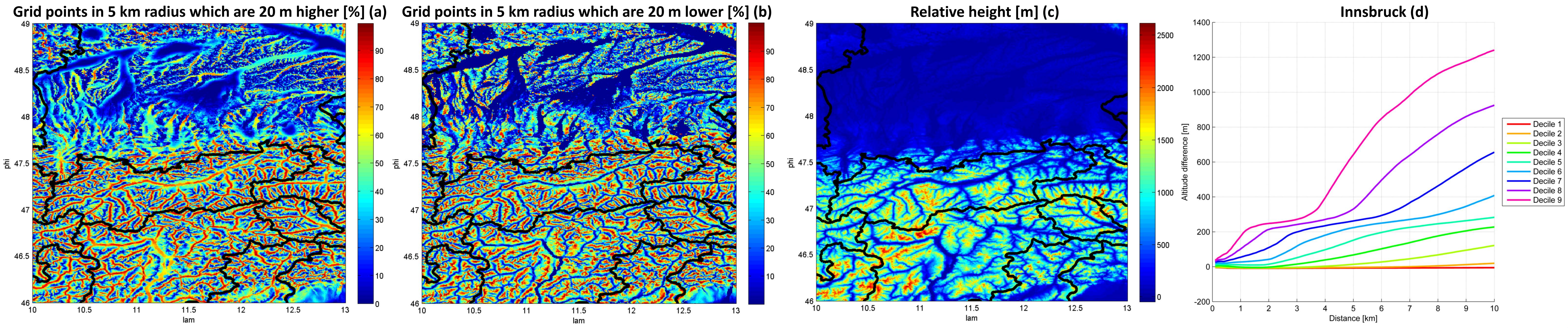
Examples of temperature profiles on the 7th of January 2014 06:00 UTC



- With the time series of the lapse rates, the 90th percentile of the lapse rate of each Austrian station for both the model and the observation was determined. If the number of dates, where the lapse rate at observations is larger than the 90th percentile, is less than 100, these stations were not considered. So 157 Austrian weather stations were evaluated, which were fulfilling this criterion. For each station the mean of the lapse rates, which are higher than the 90th percentile, was calculated. With this mean several statistics were made (see below).

Topographic analyses

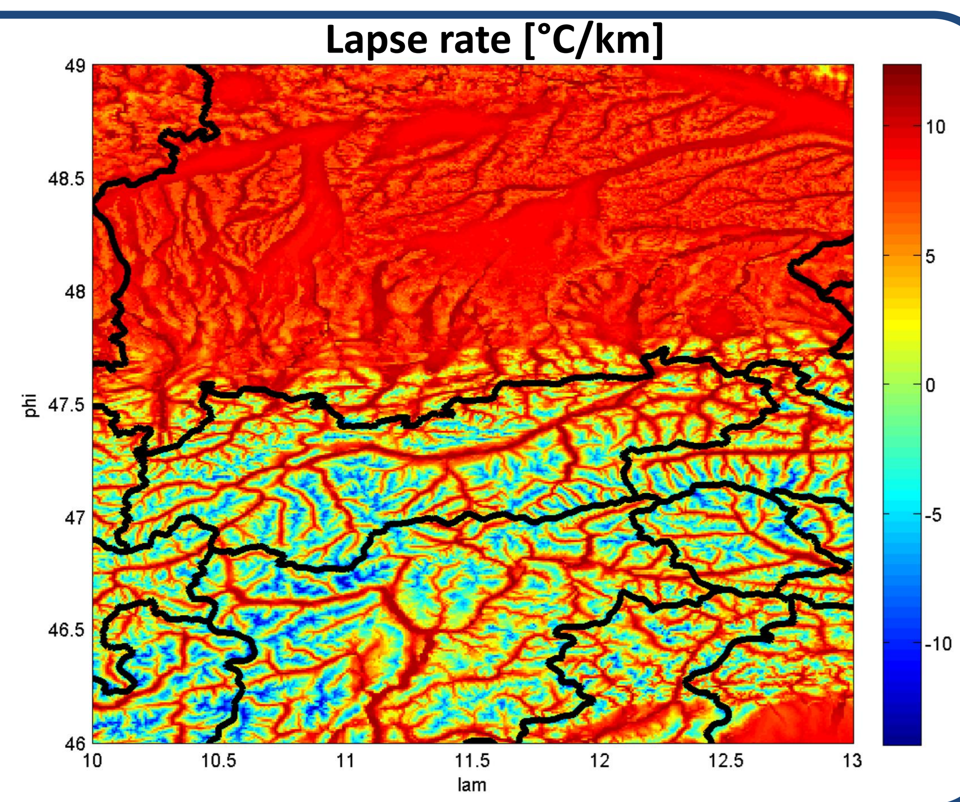
- To get information about the topographic conditions in the surrounding of each station, such as slope angles, concavity or convexity etc., different statistic analyses were performed. The following graphics show the percentage of grid points in a 5 km radius of each grid point, which are 20 metre higher (a) or 20 metre lower (b) than the respective grid point. The relative height (c) is the difference between topographic height and minimum topographic height (lowest height in a radius of 10 km for each grid point). Also decile evaluations in a 10 km radius of each station were realised (d).



Results

- Various correlations have been made with the deciles for different distances and the mean of the lapse rates, that are higher than the 90th percentile. Also multiple linear regressions with different parameters, like the percentage of grid points in a 5 km radius which are 20 m higher or 20 m lower than the respective grid point, the relative height, decile for different distances etc., were calculated.
- The best **correlation coefficient** with **0,78** was reached with the first three parameters, which are shown above in the topographic analyses: Percentage of grid points in a 5 km radius which are 20 m higher or 20 m lower than the respective grid point, relative height and the mean of the lapse rates, that are higher than the 90th percentile.

Lapse rate [°C/km]



Conclusions & Outlook

- In conclusion, the found lapse rates show a good pattern of the inversion strength.
- Several additional tests will be carried out to further improve the topoclimatological relation of surface inversions.
- The resulting high resolution patterns will be used for the downscaling procedure (as fingerprints) for the VERA (Vienna Enhanced Resolution Analysis) scheme [2)].

References

1) Dee, D. P., et al., 2011: The ERA-Interim reanalysis: configuration and performance of the data assimilation system. *Quarterly Journal of the Royal Meteorological Society*, **137**, 553-597.
2) Steinacker, R., M. Ratheiser, B. Bica, B. Chimani, M. Dorninger, W. Gepp, C. Lotteraner, S. Schneider, and S. Tschannett, 2006: A Mesoscale Data Analysis and Downscaling Method over Complex Terrain. *Monthly Weather Review*, **134**, 2758-2771.

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