

Interactive comment on “Downscaling ERA-Interim temperature data in complex terrain” by L. Gao et al.

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We would like to thank Rev. #1 for her/his very helpful comments. We agree that some aspects of the paper needed further improvement and extension in order to make it more generally valid and suitable for publication. We still believe that the presented study is very useful for conducting a fast and simple temperature correction of the ERA – Interim model. To support a more widespread use, we have added a number of additional stations that demonstrate a more general successful application of the presented technique. In the following we address all the major and minor comments made in more detail. Answers to major comments:

-Question 1: The usefulness of the current study is still limited by the fact that only
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one individual region with good observational data coverage is considered, and a more widespread usage is questionable.

-Answer: We agree with this comment and have added nine further stations (Tab1-3 / supplement) which are also located in mountainous terrain for underlining the transferability of the presented approach. These measurements are provided by MeteoSwiss (IDAWEB system) with a temporal resolution of 10 minutes (Tab. 1). All the measurements were aggregated to 3-hourly and daily averages for the presented comparison with ERA-Interim data. We applied the same 4 methods as presented for the German sites and received comparable results. We would include these results into a potential revision of our paper for making our statements more valid.

-Question 2: It is important to know whether data of the three observational stations (or a subset thereof) has been assimilated into ERA-Interim. If yes, the model data would not be independent of the observations, as claimed by the authors. Could the authors provide such information? It might also be useful to know which radiosonde sites in the vicinity were assimilated (see above).

-Answer: The number of observations assimilated in ERA-Interim is huge and increasing with time on the basis of ERA-40 observations. From 1989 to 2010, the volume increased from approximately 106 per day to nearly 107 per day. Near-surface air temperatures from around 8000 stations are assimilated (Dee et al., 2011; Simmons et al., 2010). Members of ECMWF staff told us that the WMO listed Synop stations are very likely assimilated. Hence, the stations at Zugspitze, Garmisch and Sion should be assimilated while the stations at Zugspitzplatt, Fey, Les Diablerets, Engelberg, Gütsch ob Andermatt, Titlis, Scuol, Buffalora and Naluns/Schlivera should be independent. So, a certain number of the stations may be assimilated but the independent stations show comparable results with respect to the elevation correction. This is a strong indication that the presented methods can be also used at sites on which the model is not conditioned to surface measurements. We will discuss this important point in a very detailed way within the revised version.

-Question 3: some of the results are not very astonishing and could be expected beforehand because of the dependency of mean air temperature on elevation. -Answer: Of course we agree with this comment, as it is standard textbook. However, the question is, what is the specific value of lapse rate and how does it change with time. The accuracy of any scaling procedure depends on a definition of a temperature gradient per time step which allows for an as good as possible adaption of the ERA-Interim temperature on the measurements. This could be achieved by using the information's by the internal lapse rate of ERA-Interim. This is astonishing to some degree because the internal lapse rates differ partially significant from the measured. But it was shown that this lapse rate is often more suitable for reducing the RMSE and MAE at the high altitude stations than the observed lapse rate. We think that this is helpful information for scientists which are working in high mountain areas. -Question 4: the overall (larger scale) temperature bias of ERA-Interim is not assessed at all. This would be important and to put the results obtained (remaining RMSE and MAE after elevation correction) into perspective.

-Answer: This is an important topic. The large scale error is generally small in Europe (Simmons et al., 2010). Simmons et al. (2010) compared ERA-40 and ERA-Interim against CRUTEM3 (gridded observation data) in $5^\circ \times 5^\circ$ grids. They found a high correlation ($r = 0.997$) between CRUTEM3 and ERA-Interim data for the period from 1989 to 2001 for Europe. The agreement between ERA reanalysis and CRUTEM3 are generally good with respect to large-scale patterns and magnitudes (Simmons et al., 2010). We will include this aspect into a revised version of the manuscript.

-Question 5: ERA Interim provides atmospheric parameters on a T255 grid (79km), but the authors use a refined 25 km version. No details on their interpolation method are provided, but are important for interpretation of the results. Which interpolation method has been used, and was the elevation dependency of 2m temperature accounted for during the interpolation of this parameter? Has the ERA-Interim model orography been interpolated with the same method?

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-Answer: We will clarify this point in a revised version. The used data is a standard product of the ECMWF. ECMWF provides a variety of data in uniform lat/long grids ($0.25^\circ, 0.5^\circ, 0.75^\circ, 1^\circ, 1.125^\circ, 1.5^\circ, 2^\circ, 2.5^\circ, 3^\circ$). The parameters (except vegetation, soil type fields and wave 2D spectra) are interpolated from the original N128 reduced Gaussian grid using bilinear methods. The elevation dependency of 2m temperature is not accounted during this interpolation.

-Question 6: The naming scheme for the different lapse rate approaches is rather confusing and non-intuitive (E2s, E2fa, ...). I'd suggest to rethink the naming scheme and maybe also to include a table indicating which lapse rate approach has been used in which method and using which reference temperature.

Answer: We would like to suggest the following hopefully more intuitive notations for the used methods. Please see fig. 4

Question 7: Concerning Method III: Why is T_ERA2m used for Garmisch, but T_ERApI for Zugspitze and Zugspitzplatt? Please explain the reasoning behind this choice.

-Tabony (1985) mentioned that a transition level between local dominated circulations and the free air flow can be found at approx. 1400 m a.s.l. within the Austrian Alps. We used this knowledge for splitting up the used temperature gradient into a lower, local flow dominated and a higher, free air flow dominated, gradient. This was done on the basis of the 850mb level which is closest to 1400m a.s.l. and varies around 1500 m a.s.l.. Therefore, we chose T_ERA2m as reference temperature for Garmisch within Method III, because Garmisch is located below of the transition level. The elevation of station (Zugspitze and Zugspitzplatt) is higher than the transition level and we used T_ERApI as reference temperature in consequence.

-Question 8: Page 5941, lines 1-5: Given the systematic underestimation of observed lapse rates by ERA-Interim (Figure 4) I'd strongly doubt this statement.

-Answer: The Reviewer is right. The sentence must be rewritten. What we tried to say

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is, that the ERA-Interim internal lapse rates are a useful tool for downscaling the original output data to the station scale, even if they underestimate the observed lapse rates. And that this is true for the whole season with all of the occurring variations.

-Question 9: The Title should use the term “Elevation correction of” instead of “Down-scaling”.

-Answer: We would change the title to: Elevation correction of ERA-Interim temperature data in complex terrain.

-Question 10: NSE is not generally familiar to readers. A brief explanation might be helpful.

-Answer: We will include the formula and an additional explanation.

-Question 11: Page 5939, lines 1-2: Is the reason the strong underestimation of lapse rates by the literature values during summer? (See Figure 4)

-Answer: yes, the lapse rate from literature is strongly underestimating the observed values, which results in an only moderate improvement compared to the other three methods.

-Question 12: page 5932, line 7: “downscale” instead of “scale”.

-Answer: It should be “we have developed a new downscaling method able to down-scale 3-hourly ERA-Interim temperature data.”

-Question 13: page 5932, line 17: “near-surface air temperature” instead of “surface air temperature”.

-Answer: Thanks for pointing this out. We will correct this within the revision.

-Question 14: page 5934, line 10: “0.25° ERA-Interim results” instead of “0.25° results”.

-Answer: “0.25° ERA-Interim results” is more specific. We will correct it in revisions.

-Question 15: page 5936, line 10: “four” instead of “three”.

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-Answer: The reviewer is right, we will correct this within the revision.

-Question 16: Page 5936, line 10: “Method I applied specific : : :”.

-Answer: Thanks for pointing this out. We will correct it.

-Question 17: Page 5936, line 13: “Methods III and IV” instead of “Method III”.

-Answer: we agree.

-Question 18: page 5938, line 12: “: : : lapse rates were generally smaller ..”.

-Answer: The reviewer is right; we will correct this within the revision.

-Question 19: page 5941, lines 16-17: This sentence seems to be incomplete.

-Answer: It could be “It should also be investigated that whether other global reanalysis products, using different land surface representations in their climate models can be used in context with the presented approach.”

-Question 20: Figure 1: The upper panel seems to be a 3D representation of the topography with an inclined view angle. If it is a 3D representation the length scale is definitely not correct for the entire picture. I'd suggest to replace the panel by a simple 2D horizontal plot.

-Answer: The upper panel is 2D DEM plot to show the location of study area. The length scale is for the upper panel, not for entire picture. We will enhance the readability in our revisions.

-Question 21: Figure 2: Do the elevations of the light-blue lines represent the mean geopotential height of the respective pressure level over the period 1979-2010? Please indicate for completeness.

-Answer: The light-blue lines actually represent the mean geopotential height of pressure levels in 1979-2010. We will label the values and describe in the revisions.

Fig. 2. Schematic illustration of measured lapse rate and ERA-Interim derived lapse

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rates, the light-blue lines represent the mean geopotential height of pressure levels in period of 1979-2010.

-Question 22: figure 4: Gamma_S (literature lapse rate) is only represented by a single horizontal bar in the plot. This bar should also be used in the legend (instead of a white box).

Fig. 4. Boxplot of monthly lapse rates variability in 1979-2010, ΔS (short horizontal line), ΔS_M (light gray), ΔS_{700_925} (medium gray) and $\Delta S_{850_925} / \Delta S_{700_850}$ (dark gray). Thick horizontal lines in boxes show the median values. Boxes indicate the inner-quantile range (25% to 75%) and the whiskers show the full range of the values.

-Question 23: Figures 3, 5 and 6: The panels in these figures are too small, and the axis labels and error metrics are hardly readable. Please enlarge the panels.

-Answer: We will enlarge these panels for a better readability.

-Question 24: Figures 5 and 6: The columns (Garmisch, Zugspitze, Zugspitzplatt) and rows (Method I, II, III and IV) should be labeled with a larger font, this would enhance the readability.

-Answer: thanks for this suggestion. We will label the stations and methods in a large font for a better readability.

Dee D.P., Uppala S.M., Simmons A.J., Berrisford P., Poli P., Kobayashi S., Andrae U., Balmaseda M.A., Balsamo G., Bauer P., Bechtold P., Beljaars A.C.M., van de Berg L., Bidlot J., Bormann N., Delsol C., Dragani R., Fuentes M., Geer A.J., Haimberger L., Healy S.B., Hersbach H., Holm E.V., Isaksen I., Kallberg P., Kohler M., Matricardi M., McNally A.P., Monge-Sanz B.M., Morcrette J.J., Park B.K., Peubey C., de Rosnay P., Tavolato C., Thepaut J.N., Vitart F. (2011) The ERA-Interim reanalysis: configuration and performance of the data assimilation system. *Quarterly Journal of the Royal Meteorological Society* 137:553-597. DOI: 10.1002/Qj.828.

Simmons A.J., Willett K.M., Jones P.D., Thorne P.W., Dee D.P. (2010) Low-frequency C3525

variations in surface atmospheric humidity, temperature, and precipitation: Inferences from reanalyses and monthly gridded observational data sets. *Journal of Geophysical Research-Atmospheres* 115. DOI: 10.1029/2009jd012442.

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/9/C3519/2012/hessd-9-C3519-2012-supplement.pdf>

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 5931, 2012.

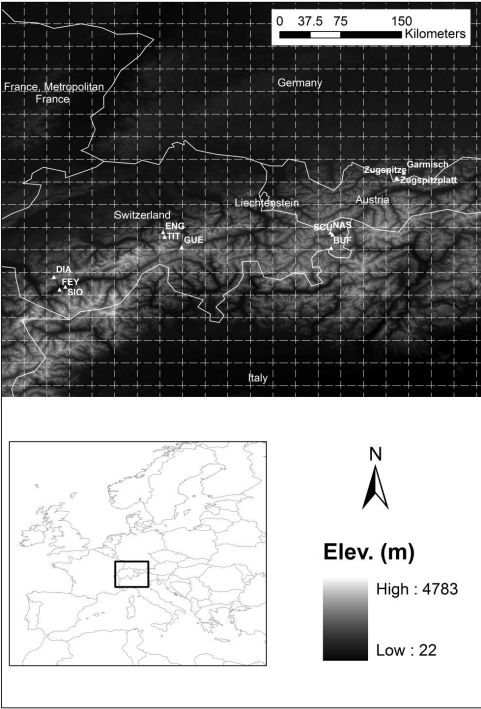


Fig. 1.

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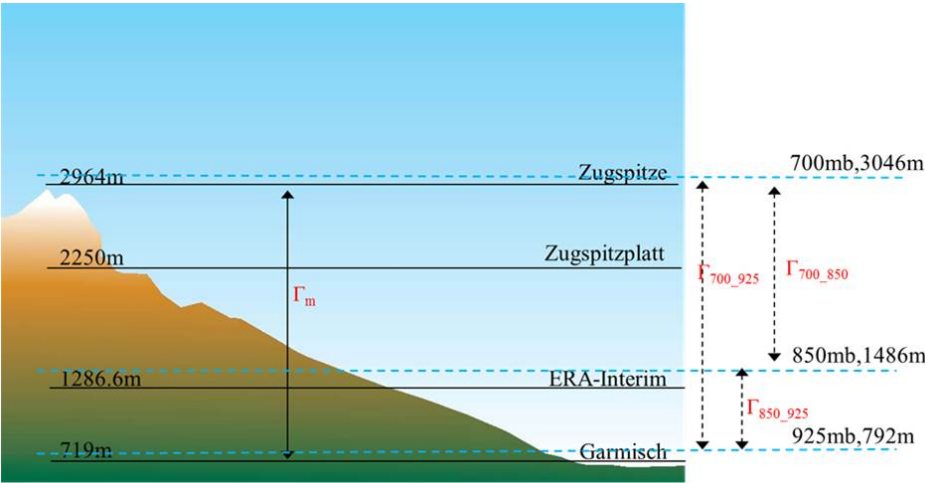


Fig. 2.

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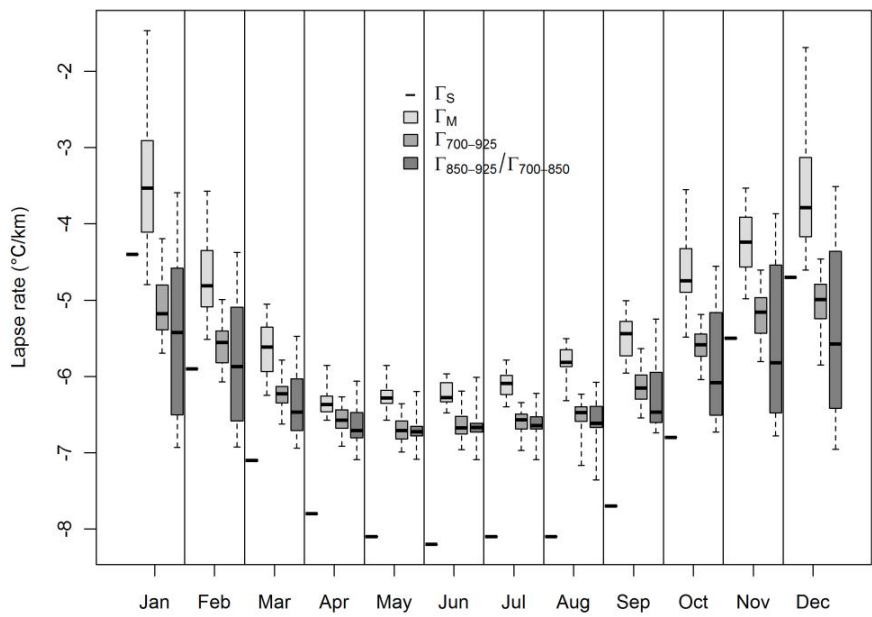


Fig. 3.

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Old	Renamed
Γ_s	Γ_s
Γ_m	Γ_m
Γ_{E_I}	$\Gamma_{700-925}$
Γ_{E_2fa}	$\Gamma_{700-850}$
Γ_{E_2s}	$\Gamma_{850-925}$

Lapse rates and reference temperatures for each model.

	Lapse rate	Reference temperature	sta
Method I	Γ_s	T_{ERA2m}	All
Method II	Γ_m	T_{ERA2m}	All
Method III	$\Gamma_{700-925}$	T_{ERA2m}	Sta be
	$\Gamma_{700-925}$	T_{ERApl}	Sta ab
Method IV	$\Gamma_{850-925}$	T_{ERA2m}	Sta be
	$\Gamma_{700-850}$	T_{ERApl}	Sta ab

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