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Hydrology and Earth System Sciences Discussions

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

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Thank you very much for your valuable comments.

-Question 1: As pointed out by reviewer A, a key problem is that the ERA-Interim lapse rates might be close to the observed lapse rates because of the assimilation of temperature and other data from the area. No information on this is given in the paper and instead it is claimed that the relatively realistic lapse rates indicate that ERA-Interim parameterisations that are relevant for the lapse rate work well and that this good skill can be expected also in other areas. The claims made are not supported by any evidence and a revised version should include a systematic discussion of the potential reasons for errors in lapse rates in reanalyses, of what is known about these

errors already, and of what is known and not known about the spatial variability of the errors.

-Answer: Reviewer his point has to be discussed in more detail within the revised version. In general it can be stated that the number of observations assimilated in ERA-Interim is huge and increasing with time. From 1989 to 2010, the volume increased from approximately 106 datasets per day to nearly 107 datasets 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. We have also added some additional stations from Switzerland and have shown that our method works also well at these locations. We hope that this will underline the transferability of the presented scheme. The respective measurements are provided by MeteoSwiss (IDAWEB system) with a 10 minutes resolution (Tab. 1). All of the measurements were aggregated to 3-hourly and daily data for comparing them with ERA-Interim data. We applied the same methods as we did in Germany. Please also see the supplements

Table 2 shows the comparison of the ERA-Interim 2m temperature with 3-hourly and daily data. Significant differences between measurements and ERA-Interim 2m temperature can be found for higher elevated stations.

Tables 3-5 show the comparison of the measurements with 3-hourly and daily data. The similar conclusion can be found, Method I is not appropriate for higher elevated stations such as DIA and TIT station. Method II works well for lower elevated stations.

Method III and Method IV significantly improve the results when compared to measured data. The additional test indicates that our approach is not limited to a single region.

-Question 2: As stated in eqn.1 the temperature estimate for a specific location is based on a temperature estimate for a reference level plus an estimate for the lapse rate times the elevation difference between the reference level and the target location. As the error in the elevation difference is negligible the error for the estimate at the target location is thus the sum of the error for the temperature at the reference level plus the elevation difference times the error in the lapse rate. The validation of the temperature estimates in the manuscript quantifies the total error, the discussion implicitly suggests that the total error is dominated by the error in the lapse rate but no evidence for this is given. This point is linked to the points raised by reviewer A about the large-scale biases in ERA-Interim temperatures, as the reference level error can be thought of as a sum of a large-scale, temporal mean bias and time-dependent, small-scale errors. This point is also related to reviewer A's question on how the interpolation on the 0.25 deg grid has been performed, in particular how the varying elevations are dealt with in the interpolation. A revised version should include a systematic discussion of the various error components and clarify which errors are addressed in a particular part of the analysis. It should also clarify the purpose of the three different skill measures (in particular the NSE coefficient needs explanation and the wording should be made consistent with respect to the use of 'MAE' and 'bias', which are the same.

-Answer: We will discuss the error components in more detail within a potential revision. 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 the revised paper.

The used 0.25° data is a standard product of the ECMWF. ECMWF provides a variety of data in uniform lat/long grids (0.25°,0.5°,0.75°,1°,1.125°,1.5°,2°,2.5°,3°). 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.

We will give an explanation of the NSE in our revised version.

-Question 3: I agree with reviewer A that the title should use 'elevation correction' rather than 'downscaling'. Although an elevation correction is a form of downscaling if high resolution elevation information is used, many other effects that introduce small-scale horizontal variability and that are usually approximately represented by downscaling models are not included in the elevation correction. It thus seems better not to use the phrase downscaling in the title to avoid misunderstandings. The link between elevation correction and downscaling could then be discussed in the introduction. Please note in this context that the elevation corrections are conceptually close to Model Output Statistics approaches but differ from those (and from Perfect Prog Downscaling) as no observations of the predictand variable are used to fit a statistical model (for a recent review on downscaling see Maraun et al., Geophys. Rev. Lett, 2010).

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

-Question 4: A minor point that should be clarified is why for the second half of the day the forecasts initialised with the 00:00 UTC analysis have been used despite the fact that forecasts initialised at 12:00 UTC are available.

-Answer: ERA-Interim provides two 10-day forecasts per day, initialized at 00:00 UTC and 12:00 UTC. Observations between 15 UTC on the previous day and 03 UTC on the present day were used for 00 UTC analyses, and observations from 03 UTC two 15 UTC were applied for 12 UTC. These two forecasts data only have insignificant difference. In order to compare ERA-Interim data with observations, we must adjust the

UTC to local observed time. The forecasts initialized at 00:00 UTC is more convenient for time shift. We will clarify this point in the revisions.

-Question 5: How can the MAE in Table 3 be different for 3h and daily resolution? Are the daily values not simply the mean of the 3h values and thus the MAE should be identical?

-Answer: The MAEs is different for 3h and daily owing to data gap in observations. When we calculated daily mean temperature from 3h data, the day which has missing data was excluded for further analysis. Normally, daily mean temperature is the average of eight 3h temperature values. But if there is data gap, even only one missing value, this day is rejected. Therefore, the total data volumes are different between 3h and daily data, and then the MAEs are different. We will clarify this within the revision.

-Question 6: The units used in Fig.1 should be 'hPa' rather than 'mb'.

-Answer: We will change this in figure 2

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 L., 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 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/C3531/2012/hessd-9-C3531-2012-supplement.pdf

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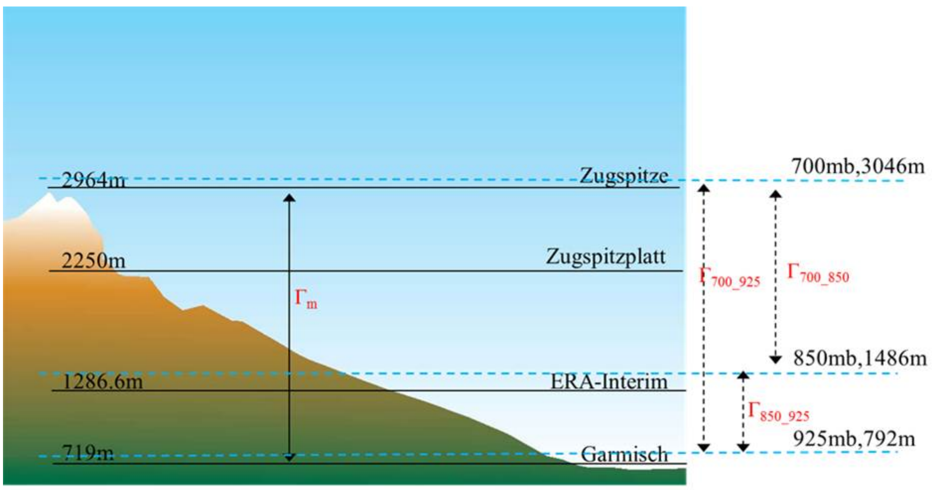
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ERA-Interim
Γ_{850_925}
719m
Garmisch
925mb,792m

Fig. 1.