Hydrol. Earth Syst. Sci. Discuss., 4, S1744–S1748, 2007
www.hydrol-earth-syst-sci-discuss.net/4/S1744/2007/

Hydrology and Earth System Sciences Discussions

Interactive comment on "Utility of daily vs. monthly large-scale climate data: an intercomparison of two statistical downscaling methods" *by* E. P. Maurer and H. G. Hidalgo

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Received and published: 18 December 2007

As with all of the reviews, we are grateful to reviewer 3 for the thoughtful and careful reading of the manuscript, and the helpful comments. Our responses to each comment are listed below, following the reviewer's numbering.

1) Per the reviewer's request, a table has been added that lists the indices used for daily extreme evaluation. All are derived from the STARDEX effort, described in the revised first paragraph of section 2.5.2: "To characterize precipitation and temperature at the daily scale, we use a subset of the indices that were developed as part of the Statistical and Regional dynamical Downscaling of Extremes for European re-

gions (STARDEX) project, which provides standard diagnostics that have been used for the systematic inter-comparison of different downscaling methods (e.g., Harpham and Wilby, 2005; Haylock et al., 2006; Schmidli et al., 2006). Table 1 lists the indices used in this study, which are from the STARDEX framework, with the exception of the two temperature indices, which are tailored here to apply to daily average values. Statistics were computed on a seasonal (December-February; March-May; June-August; September-November) and annual level at each 1/8° grid cell in the western United States. In computing the statistics (for the projection period of 1977-1999) for each grid cell, if fewer than 15 years were available for calculation of the statistic (such as many occurrences of zero precipitation amounts), that index was excluded for that grid cell."

2) The reviewer raises some interesting questions, which are addressed in the revised text. Specifically:

The reason for excluding seasons other than winter in Figures 6 and 7 are now stated in the revised text. In addition, the low overall skill in the domain, as well as the contrast between skill for wet and dry precipitation extremes, is now elaborated in the text. These revisions are contained in the first two paragraphs of the revised Section 3.2:

"There is only modest skill with either the CA and BCSD method for dry (20th percentile) daily precipitation extremes in winter (Figure 6), and this limited skill is generally focused in coastal areas of the Pacific Northwest. Other seasons show lower skills, with much greater extent of area with insufficient data to calculate the statistics (as described in section 2.5.2 above). There is no statistically confident difference between the methods for this measure. For wet (90th percentile) daily precipitation conditions both methods show some skill in winter, when most precipitation occurs (Figure 7). As with Figure 6, in general most of the domain has insufficient data for calculating this statistic during seasons other than winter. The CA method exhibits slightly higher correlations over certain regions such as the Sierra Nevada in California, but as with dry daily extremes, there is no statistically significant difference in the skills exhibited by

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the two methods. The lack of statistical significance to the differences suggests there is limited skill for extreme precipitation anomalies in the reanalysis, and neither method can recover daily skill. Where skill is exhibited, it is thus attributable to skill at longer time scales (monthly and seasonal), equivalently captured with both methods.

The stationarity of the transfer scheme is the key to the success of either the BCSD or CA method in translating large-scale climate to a fine scale. While the skill in simulating fine-scale dry or wet daily extremes (shown in Figures 6 and 7) is generally low with either method, it is evident that wet extremes are captured more accurately for both methods, as also had been exhibited at the monthly level in Figure 3. This suggests that the relationship established for the spatial transfer scheme, based on 1950-1976, holds to a greater degree under wet conditions than dry for the latter period of 1977-1999. One possible factor influencing such a change could be the PDO phase shift from negative in the earlier period to positive in the latter. The PDO has been shown to have a strong hydroclimatic teleconnection to the Pacific Northwest (Mantua and Hare, 2002), especially in its negative phase (Maurer et al., 2004), and the phase of PDO strongly influences the effect of ENSO on the region, amplifying dry extremes under a PDO warm phase (Hamlet and Lettenmaier, 1999). While many factors beside PDO influence this relationship, the differing skill in spatially downscaling precipitation under wet and dry extremes indicates that the transfer scheme may be disrupted more for dry extremes than wet for the periods used in this study."

3) The reviewer comments that paper should include some discussion of why there is little skill in most locations for precipitation using with downscaling method. While the above modifications of the text (especially comment 2 above) partially address this, the modified conclusions emphasize the role of large-scale skill in determining both overall downscaling skill as well as how these two methods compare. For example, the revised second and third paragraphs of the conclusions now include:

"...Considering daily precipitation, both methods exhibit some skill in reproducing observed wet and dry extremes, generally in the Pacific Northwest, and the difference

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between the methods is not significant. This reflects the general low skill in daily precipitation variability in the large-scale reanalysis data over the domain, thus neither method can generate the skill absent in the large-scale signal. For reproducing fine scale observed consecutive sequences of wet and dry days, the CA method shows greater skill in winter in the Southwest, reflecting the presence of some reanalysis skill in simulating these daily precipitation characteristics. For other seasons and in other regions the methods are in general not statistically different.

The skill in downscaling daily temperature extremes exceeds that for precipitation extremes, which is not surprising given that temperature observations are assimilated in the reanalysis product, but precipitation is simulated..."

4) The reviewer requests a discussion of the wider implications of the study for the downscaling community. The conclusions now expand on this in a more clear fashion, with the revised third paragraph of Section 4 reading:

"The skill in downscaling daily temperature extremes exceeds that for precipitation extremes, which is not surprising given that temperature observations are assimilated in the reanalysis product, but precipitation is simulated. For low temperature extremes, the CA method produces greater downscaling skill than BCSD for fall and winter seasons. For high temperature extremes, CA demonstrates higher skill then BCSD in summer, though for other seasons differences are not significant. Contrasting the results from daily temperature and precipitation downscaling with these two methods, it is clear that as model (GCM) daily skill declines, the difference between using a downscaling technique based on daily model output versus applying a random daily distribution becomes less evident. As daily GCM skill, especially in regard to extreme events, continues to be assessed (Kharin et al., 2007; Tebaldi et al., 2006), the extent to which the daily GCM output exhibits skill in a region of interest will determine the utility of incorporating daily GCM output in a downscaling technique."

Minor Comments

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1) The second paragraph of Section 3.1 now mentions the motivation for selecting the three points displayed in Figure 3:

"Three points were selected to provide an example of the performance of the methods for different climate regimes: snow-controlled regions, snow-free regions and arid regions."

Also, a shaded relief map with the three points noted is included in the revised Figure 3.

2) All Figures now refer to CA and BCSD with consistent abbreviations, as recommended by the reviewer.

3) Figure 3 has been completely redesigned for clarity, and the panels referring to CA and BCSD and T/P are clear.

4) The caption to Figure 4 now states that "Biases in mean precipitation (mm day-1) and temperature (oC) using CA and BCSD methods, based on monthly data for 1977-1999."

5) The caption to Figure 7 has been corrected as noted by the reviewer.

Typos:

1) Typographical error has been corrected.

2) The section with the typo has been completely rewritten.

3) Typo has been corrected as suggested.

4) Typos have been corrected to section 2.5.2 as suggested.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 3413, 2007.