**Electronic Supplementary Material:** A comparison of 2 statistical methods for downscaling daily temperature and rainfall data in the Languedoc-Roussillon (LR) region, France.

**Objectives and methods**

We compared the performance of two different methods for interpolating daily temperature and precipitation from a 8 km spatial resolution to a 1 km spatial resolution over the LR region. To do that, we used each of the two methods to downscale the gridded SAFRAN database (see Habets et al. 2008; Quintana Segui et al. 2008 for details on the SAFRAN database) from its original resolution (8 km) to a 1 km grid and compared the results with local weather observations for the 2000-2005 period. Weather data was collected from more than 30 Météo-France weather stations (French national meteorological services) sparsely distributed over the LR domain and covering a wide range of elevations (see Fig. S1). Only stations with homogeneous measurement methodology and with uninterrupted series over 2000-2005 were used. The two following downscaling methods were compared:

1. The first downscaling method is a hybrid kriging method (hereafter KRIG_RESID) used in several impact studies that require fine scale climatic data (Randin et al. 2009; Lavoir et al. 2011; Ruffault et al. 2013). This method proceeded in three steps: (i) First, a cubic spline lapse rate (i.e. function defining a variable rate of change along elevation) was fitted for the climatic variable of interests (i.e. temperature or precipitation) at a monthly (for precipitation) or a daily (for temperature) time step. This previously calibrated spline was used to normalize to the sea level (0 m) all the daily meteorological data that we meant to downscale (SAFRAN dataset). (ii) The standardized daily climatic data was then spatially interpolated on the final resolution grid using an ordinary kriging method calibrated with Spherical Semi variogram. Parameters for the spherical model (see Cressie 1991) were automatically set using the ‘gstat’ package in R (V0.9, Pebesma 2004). (iii) Finally, climate data was spatially re-interpolated according to an actual digital elevation model (DEM) at 1 km resolution using the initial cubic spline function used for standardization.

2. The second downscaling method involved fitting a multidimensional thin plate spline function accounting for altitude, latitude and longitude at a daily time step to the source data (SAFRAN). For both variables (temperature and precipitation), a thin plate spline model was fitted at a daily time step using the function ‘Tps’ of the R package ‘fields’ (V. 6.6.1, Furrer et al. 2012). The model was then used to re-interpolate the source data to the actual DEM (at the final 1 km resolution). This method allowed us to capture the effects related to elevation gradients but also other effects implicitly included in the coordinates (e.g. the distance from the sea). This
method has been shown to perform well in comparative tests of multiple interpolation techniques (Jarvis and Stuart 2001; Hijman et al. 2005).

For both methods all precipitation events below the 0.1 mm threshold (matching the minimum value recorded in weather stations) were set to zero in order to avoid an overestimation of the number of wet days. We assessed the efficiency of each statistical downscaling method by comparing the interpolated climatic values to surface observations using several metrics: root means square error (RMSE), $R^2$, slope and intercept of the linear relationship between surface observations and interpolated data. These metrics were computed at annual and seasonal time scale for all methods as well as for the SAFRAN base at its original 8km resolution to check if downscaling could have improved the prediction of spatial heterogeneity of climate.

**Results and discussion**

Both statistical downscaling methods (RESID_KRIG and SPLINE) led to some improvements in the estimations of surface climatic observations compared to the original 8 km SAFRAN dataset (Fig. S2 and Fig. S3). At annual scale RESID_KRIG and SPLINE methods performed similarly for temperature (with $R^2$ and RMSE of 0.57 and 1.95 for RESID_KRIG model and 0.58 and 1.95 for SPLINE). However the SPLINE method yielded significantly better predictions than the RESID_KRIG method for precipitations ($R^2=0.66$ and RMSE=220 mm for RESID_KRIG and $R^2=0.89$ and RMSE=164 mm for SPLINE). It should be noted that the lower improvement in temperature estimations might be partly attributed to the low accuracy of the SAFRAN analysis at capturing the temperature variations over the northern part of the Mediterranean area (see Quintana-Segui et al. 2008). At seasonal scale, the performance of the downscaling changed between season (see Table S1 for precipitation and Table S2 for temperature). Both RESID_KRIG and SPLINE method led to significant improvements in the estimation of climatic features over LR region compared to gross SAFRAN dataset. As observed for the annual scale, the SPLINE downscaling method yielded better results than the RESID_KRIG method.
Figure S1: Location of weather stations used for the evaluation of downscaling methods. 32 temperature weather stations (grey squares) and 37 rainfall weather station (black circles) were used.
Figure S2: Comparison of gridded temperature with surface observations from 32 contrasted weather stations averaged at an annual time scale for the 2000-2005 period. SAFRAN at its original 8 km resolution (SAFRAN), as well as the downscaled product (at 1 km resolution) using either a hybrid kriging method (KRG_RESID) or a thin plate spline interpolation method (SPLINE) are compared with surface observation using a linear regression model for which statistics are given in the upper-left corners of panels. Seasonal statistics are given in table S2.
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Ruffault et al.

Figure S3: Comparison of gridded rainfall with surface observations from 37 contrasted weather stations averaged at an annual time scale for the 2000-2005 period. SAFRAN at its original 8 km resolution (SAFRAN), as well as the downscaled product (at 1 km resolution) using either a hybrid kriging method (KRIG_RESID) or a thin plate spline interpolation method (SPLINE) are compared with surface observations using a linear regression model, for which annual statistics are indicated in upper-left corners of panels. Seasonal statistics are given table S2.
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**Table S1**: Seasonal statistics for the comparison of gridded temperatures with surface observations from 32 contrasted weather stations averaged at a seasonal time scale for the 2000-2005 period. Surface observation are compared with SAFRAN at its original at 8 km resolution (SAFRAN), and with SAFRAN downscaled at 1 km resolution using either a hybrid kriging method (RESID_KRIG).
### Table S2: Seasonal statistics for the comparison of gridded precipitation with surface observation from 32 contrasted weather stations cumulated at a seasonal time scale for the 2000-2005 period. Surface observations are compared with SAFRAN at its original at 8 km resolution (SAFRAN), and with SAFRAN downscaled at 1 km resolution using either a hybrid kriging method (RESID_KRIG).
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Ruffault et al.

References


