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Guidance on the use of bias corrected data

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Guidance on the use of bias corrected data

1. Guidance

Climate models provide projections of future climate changes derived from fundamental principles of the climate system. One advantage of this approach is that future changes in all climate variables are derived together in a physically consistent way. One disadvantage is that the models often display biases in their modelled climates. For some applications these biases may present significant difficulties when attempting to use the projected climates, particularly if the impact or application is sensitive to non-linearities in the system such as threshold effects.

Statistical methods can be used to correct this model bias, though doing so also removes the physical consistency between climate variables.

Here we present some simple guidelines to consider when deciding whether to use actual model output or bias-corrected data.

Note that only precipitation and temperature (minimum & maximum) are bias corrected as they are the only variables with long, reliable observational time series.

Do use bias corrected data if

- Your application only requires precipitation and/or temperature
- Your application is sensitive to non-linearities (such as thresholds) in precipitation and/or temperature
- Your application requires variables other than precipitation and temperature but it is not sensitive (or has little sensitivity) to the coupled affect of other variables with precipitation & temperature

Do not use bias corrected data if

- Your application has strong sensitivities to the combined affect of temperature and/or precipitation with other climate variables such as humidity or wind (in which case physical consistency may be a dominant requirement).

In many cases it may not be known whether sensitivities to coupled climate variable affects are strong enough to warrant not using bias corrected data. In these cases we recommend using both sets of data in your application, and through evaluation against observations determine whether using the bias corrected data is adequate for your purpose.

2. Bias Correction Technique

Correcting Precipitation biases is more difficult than temperature because its spatial and temporal distribution are significantly more complex. In addition, precipitation correction also has to deal with the frequency of wet days to obtain a product that is adequately corrected. Therefore, a suitable correction method was designed for precipitation and then a similar methodology is applied to maximum and minimum temperature.

2.1. Precipitation bias correction

Precipitation bias correction was performed using the gridded observational dataset from the Australian Water Availability Project (AWAP) [Jones et al. 2009]. The original AWAP grid at 5-km spatial resolution was resampled to WRF grid using inverse distance weighting.

It should be noted that there are a few instances where the model suffered from some numerical instability that resulted in an isolated grid point registering precipitation several orders of magnitude higher than realistic, without effecting neighbouring grid points. The majority of these occurred over tropical ocean regions in domain 1, though a few instances did occur in the NARCliM domain (domain 2). Before applying the bias correction technique described here, these errors are removed by applying a precipitation filter. The filter is applied such that any event above the maximum ever observed worldwide (1200mm/day) is replaced by the highest value in the surrounding eight grid cells.

The core of the bias correction technique is based on Piani et al. (2010), who proposed an adjustment of the simulated daily precipitation cumulative probability density function (CDF) towards the observed CDF as given by fitting gamma distributions. The bias correction was applied to each grid point separately.

Firstly, only wet days were selected from the observations. A threshold of 0.2 mm was chosen to define wet days. Other thresholds could also be chosen, but a previous study showed that the method was not sensitive to the choice of the threshold in the range 0-1mm [Berg et al. 2012]. Then the threshold to define wet days in the model was chosen to match the number of rain days in the observations, so that the probabilities in the CDF represent the same number of days and both the daily intensity and monthly accumulated precipitation are corrected adequately. It is known that models show a tendency to generate more light precipitation at coarser resolutions [Argueso et al. 2013]. Therefore, the threshold used in WRF grid points to match the observed precipitation was often slightly larger than 0.2mm.

Once rain days from observations and WRF were extracted as described above, the empirical CDF of both simulated and observed daily rainfall intensity were calculated for each grid point. The empirical CDFs are then fitted to gamma distributions (F_m and F_o). For each simulated event (M^i) the corresponding cumulative probability (CP_m^i) is found in F_m. In the function used to fit observations (F_o), that cumulative probability (CP_m^i) corresponds to an intensity O^i. The simulated intensity M^i is replaced with O^i. A schematic of the algorithm is shown in Figure 1.

However, there are areas of Australia where the lack of observations produces artefacts that make AWAP unreliable. In those areas, a regionalisation approach was adopted to correct WRF precipitation. A number of climate divisions were identified using a multi-step regionalisation

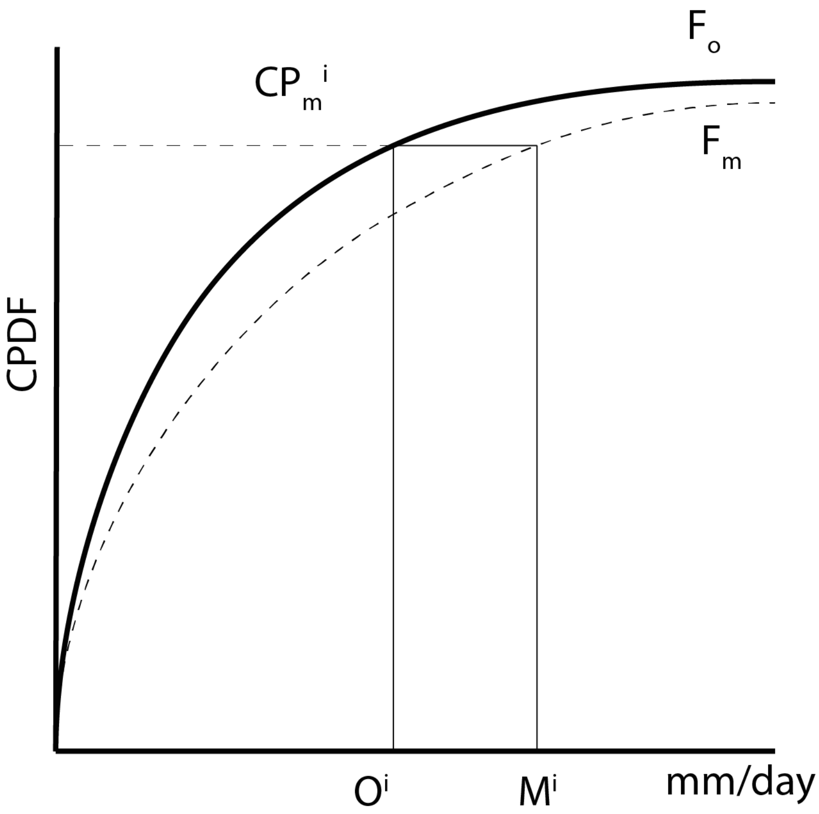

Figure 1: Schematic of the bias correction proposed by Piani et al. (2010). M^i is the intensity of an event in the model and O^i is intensity of an observed event with the same cumulative probability (CP_m^i) as defined by F_m and F_o, which are the cumulative probability functions for the model and the observations.

method based on Argueso et al. [2011] but modified to incorporate both temperature and precipitation in a single set of climate divisions (Figure 2). For grid points within areas where AWAP is unreliable, the same correction method is applied, but the reference gamma function is calculated for the entire region instead of a single grid point.

The reference period to calculate the gamma functions was 1990-2009, which is common to all simulations (including the reanalysis-driven runs) and the observational dataset. Future climate projections are corrected using the gamma distributions from the reference period, assuming that present climate biases will be maintained in time. Such an assumption is necessary because there is no reference dataset available for the future climate.

2.2. Temperature correction

As mentioned before, the method used to correct temperature was derived from the algorithm designed for precipitation correction. The AWAP database was also adopted in the correction of temperature and the grid was also resampled to WRF grid in order to perform a correction for each grid point. Daily maximum and minimum temperature were corrected independently.

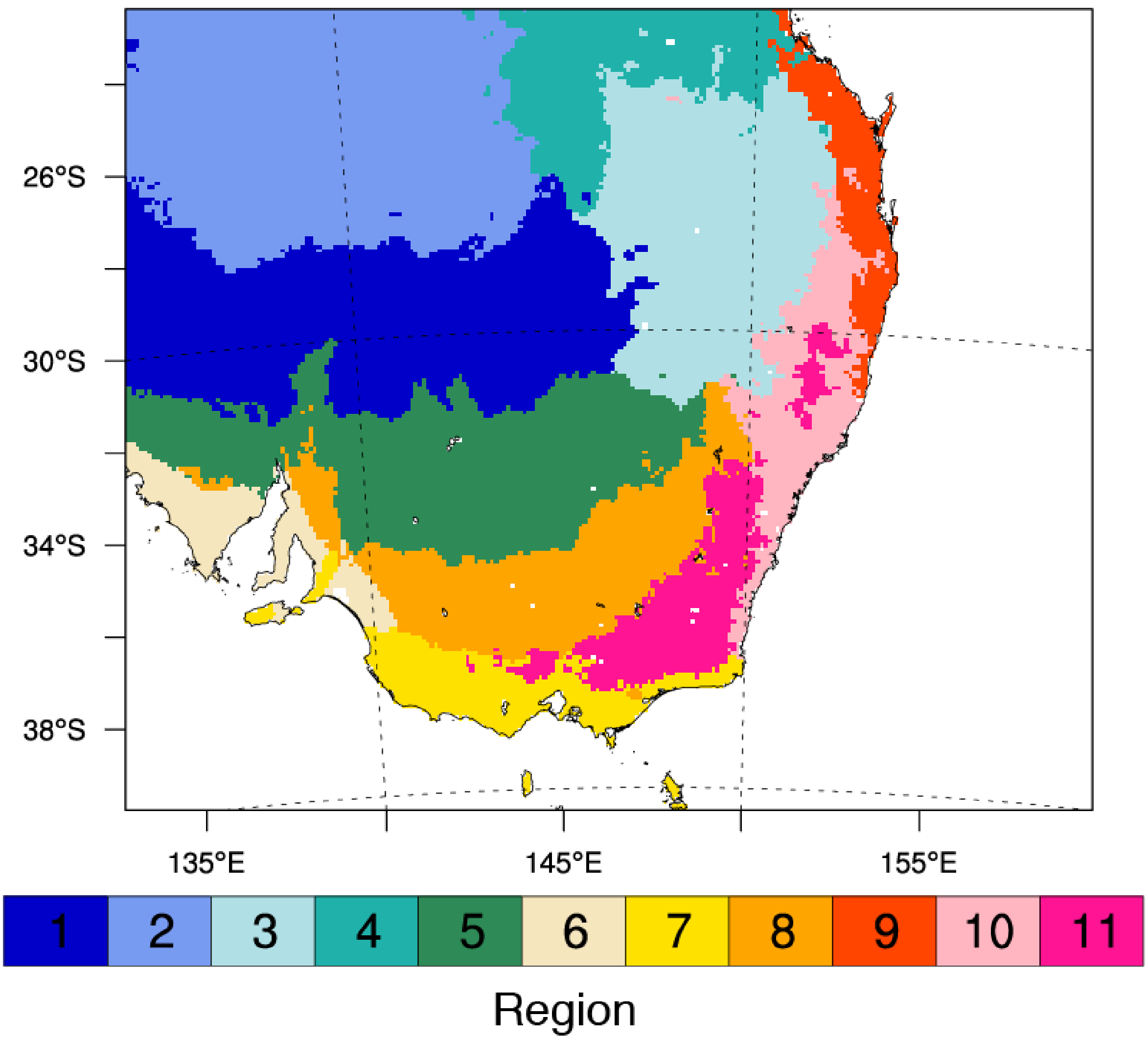

Figure 2: Objectively derived climate regions for south-east Australia.

Unlike precipitation, temperature did not require to be screened in terms of occurrence and all values were considered for the calculation of the empirical CDF. The algorithm is similar to that devised for precipitation since both observation and model temperature CDFs were fitted to a theoretical distribution. However, a Gaussian distribution was chosen for temperature instead of the gamma distribution because it better represents the temperature CDF.

The reference period chosen for temperature was also 1990-2009, and future climate projections are corrected using present climate correction factors.

References

Argueso, D., J.M. Hidalgo-Muñoz, S.R. Gámiz-Fortis, M.J. Esteban-Parra, Y. Castro-Díez, and J. Dudhia. 2011. "Evaluation of WRF Parameterizations for Climate Studies Over Southern Spain

Using a Multi-Step Regionalization." Journal of Climate 24(21): 5633–51, doi: 10.1175/JCLI-D-11-00073.1.

Argueso, D., J.P. Evans, and L. Fita. 2013. "Precipitation Bias Correction of Very High Resolution Regional Climate Models." Hydrology and Earth System Sciences 17(11): 4379–88, doi: 10.5194/hess-17-4379-2013.

Berg, P., H. Feldmann, and H.J. Panitz. 2012. "Bias Correction of High Resolution Regiopnal Climate Model Data." Journal of Hydrology 448-449: 80–92, doi: 10.1016/j.jhydrol.2012.04.026.

Jones, D.A., W. Wang, and R. Fawcett. 2009. "High-Quality Spatial Climate Data-Sets for Australia." Australian Meteorological and Oceanographic Journal 58(4): 233–48.

Piani, C., J.O. Haerter, and E. Coppola. 2010. "Statistical Bias Correction for Daily Precipitation in Regional Climate Models Over Europe." Theoretical and Applied Climatology 99(1): 187–92, doi: 10.1007/s00704-009-0134-9.