An alternative method for model weighting applied to climate projection

Noël C. Baker and Huei-Ping Huang

School for Engineering of Matter, Transport, and Energy, Arizona State University, Tempe, AZ, USA

Email: Noel.Baker@asu.edu

Abstract

This study explores an alternative scheme for multimodel averaging of precipitation used in climate model prediction. The classical equal weight scheme estimates the trend by the simple arithmetic mean of the trends produced by the individual models. In the alternative scheme, the trend in precipitation is estimated by the observed present climatological value of precipitation times the average of the percentage change in precipitation predicted by the individual models. This method effectively leads to unequal weighting in the multimodel averaging. Unlike other recently developed unequal weight schemes, the alternative scheme does not penalize a model with a greater bias by reducing the weight applied to it. Instead, the underlying philosophy is that a model that has a greater bias is as useful as other models except that it needs a greater bias correction which is facilitated by the unequal weighting. The feasibility of the alternative scheme is tested on the CMIP3 prediction of precipitation. It is found that the new scheme and the equal weight scheme do not produce radically different large-scale patterns of the trend. Nevertheless, notable differences emerge in the regional scales that may be large enough to have implications for local stake holders.

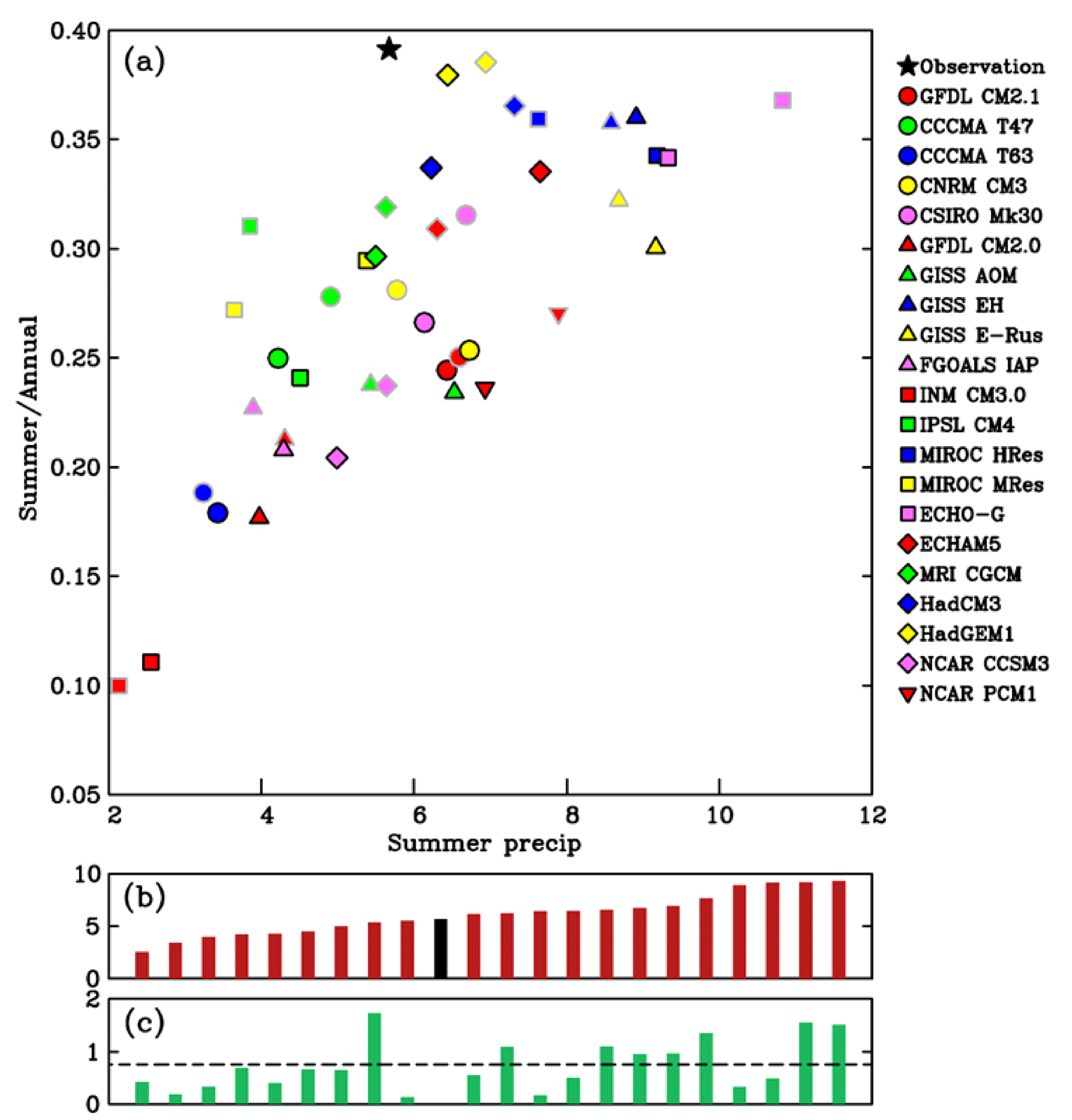

***Figure 1**: The summer (July-September) precipitation (abscissa, in mm/day) versus summer-to-annual ratio of precipitation (ordinate) simulated by the CMIP3 models listed at right. 1980-1999 mean from the 20C3M runs: black border, 2080-2099 mean from the SRES A1B runs: gray border, observational 1980-1999 CMAP data: black star. (b) The CMIP3 simulations of the 1980-1999 summer precipitation arranged with the driest model to the far left and wettest model to the far right. The length of each red bar indicates the amount of precipitation (in mm/day) simulated by a model. The black bar is observation. (c) The length of each green bar indicates the absolute value of the trend in summer precipitation simulated by a CMIP3 model, corresponding to the red bar in Fig. 1b immediately above it. The dashed line indicates the multimodel mean of all green bars.*

Methodology

Our scheme utilizes the relative trend in precipitation to develop a weighting scheme that applies a bias correction to each ensemble member. The trend is defined as,

$T_j = C_{MOD21,\,j} - C_{MOD20,\,j},$

where "*j*" indicates the *j*-th model, and "MOD21" and "MOD20" indicate the simulated future (2080-2099) and present (1980-1999) climate. We have defined a new variable to apply a bias correction to the multimodel ensemble trend,

$R_j = C_{OBS20}/C_{MOD20,\,j}.$

The new method effectively becomes an unequal weight scheme in which each model is weighted by a factor of W_{NEW}, defined as

$W_{NEW} = (1/N)(C_{OBS20}/C_{MOD20,\,j})$

where N is the number of models in the ensemble.
Notably, this scheme varies spatially; that is, the weight is dependent on the location, and two different locations for the same model may have an entirely different weight. This scheme also applies a bias correction that does not "punish" poorer models; instead, it weights model data to correct for discrepancies from observational data.
Our unequal-weight scheme implicitly relies on the assumption that a model that is too dry (wet) in the present climate will remain too dry (wet) in future climate.

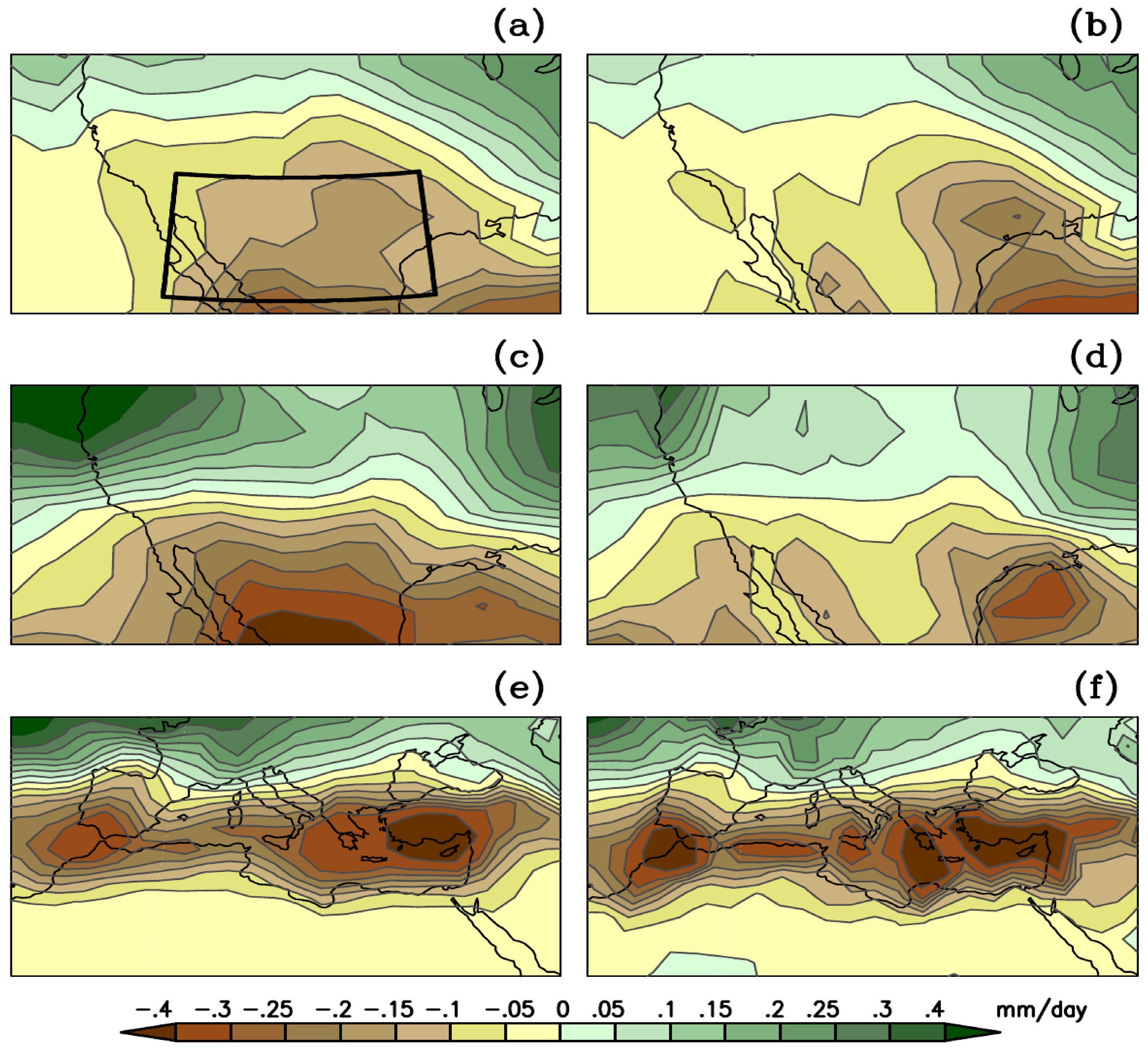

***Figure 2**: Multi-model mean changes in precipitation over the southwestern US region (mm / day) are annual means for the SRES A1B scenario for the period 2080 to 2099 relative to 1980 to 1999 (a) equal weight, (b) unequal weight. (c)and (d) are similar to (a) and (b) but for winter (December-February) precipitation. (e) and (f) indicate the winter precipitation for the Mediterranean region for the equal and unequal weight schemes, respectively.*

Results and discussion

Figure 3 shows the projected trend of annual precipitation based on the equal weight scheme (Fig. 3a) and the unequal weight scheme (Fig. 3b). While the two schemes lead to similar global-scale structures of the trend in precipitation, regionally they produce notable differences. For example, Fig. 2a and 2b show the detail of the trend of annual precipitation for Western U.S. and Northern Mexico based on the equal weight and unequal weight schemes, respectively. While both indicate drying in the Southwest U.S. (*Seager et al.* [2007]), with the unequal weight scheme the reduction of precipitation is projected to be less severe for Arizona but more severe for part of Texas. Over the black box in Fig. 3a, the projected reduction of rainfall is 40 mm/yr from the unequal weight scheme, compared to 55 mm/yr from the equal weight scheme. Fig. 2e and 2f also show the projected trend in winter precipitation for the Mediterranean region; notably, our unequal weight scheme (f) shows a similarity to the wet season projections for the same future-present time period performed by Mariotti et al. [2008].

This study illustrates just one of many possibilities of applying unequal weighting to multimodel climate prediction. A preliminary analysis indicates that this may be a reasonable assumption for CMIP3 models. We will next apply the scheme and its variations to the new CMIP5 data.

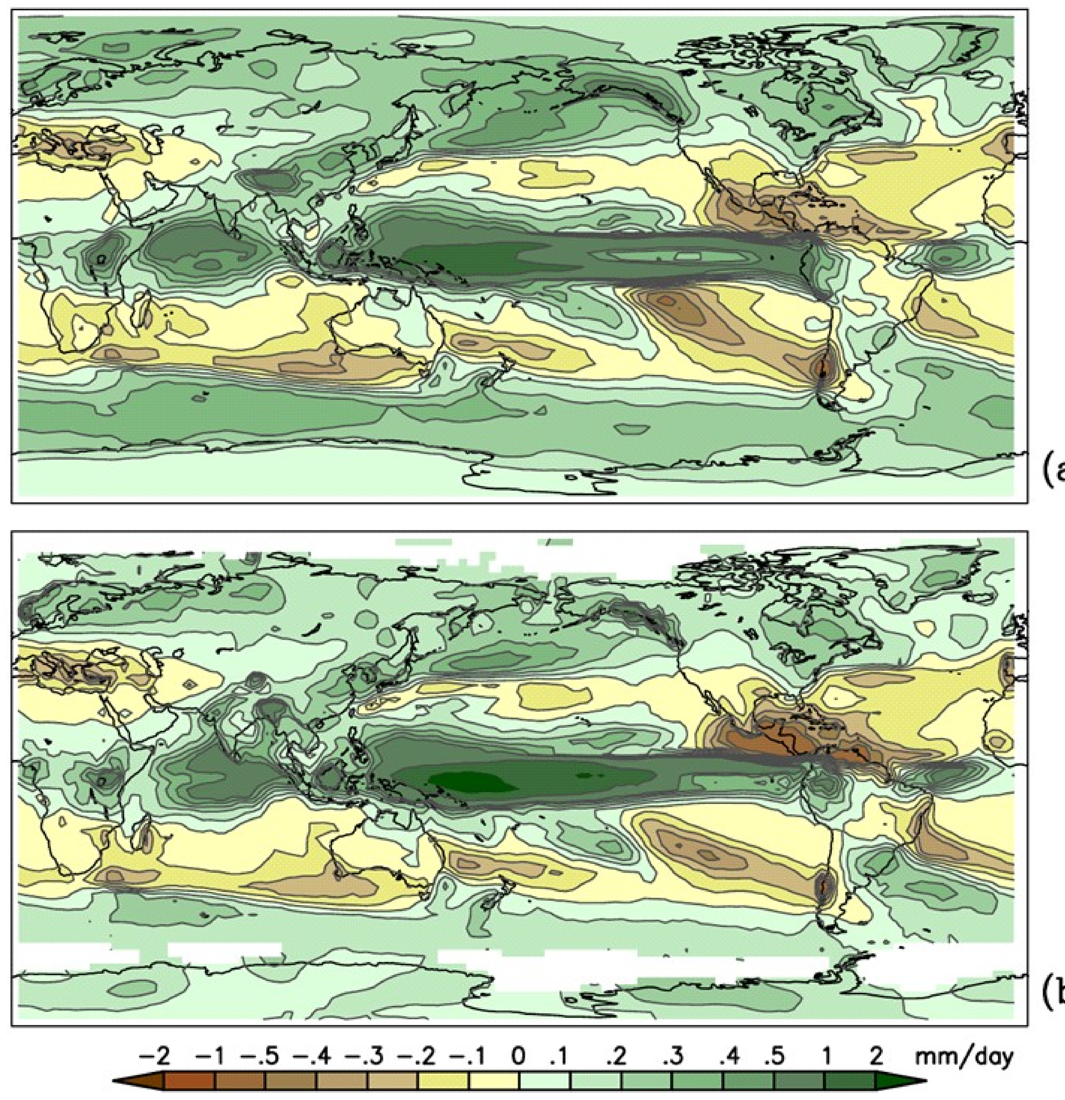

***Figure 3**: The CMIP3 multimodel average of the trend in annual precipitation as estimated from the (a) equal weight, and (b) unequal weight, schemes. Color scale is shown at bottom. White areas indicate where observation data is missing.*

References

Mariotti et al., 2008: Mediterranean water cycle changes: trasition to drier 21st century conditions in observations and CMIP3 simulations, Environ. Res. Lett. 3, 044001.

Seager, R., et al., 2007: Model projections of an imminent transition to a more arid climate in southwestern North America, Science, 316, 1181-1184.