# Attribution of surface radiation errors near the Southern Great Plains in numerical weather prediction and climate models

*Van Weverberg, K., C. J. Morcrette, J. Petch, S. A. Klein, H.-Y. Ma, C. Zhang, S. Xie, Q. Tang, W. Gustafson, Y. Qian, L. Berg, M. Wang, Y. Liu, M. Ahlgrimm, R. Forbes, E. Bazile, R. Roehrig, J. Cole, W. Merryfield, W.-S. Lee, F. Cheruy, L. Mellul, Y.-C. Wang, K. Johnson*

Many NWP and climate models exhibit too warm lower tropospheres near the midlatitude continents. This warm bias has been extensively studied before, but evidence about its origins remains inconclusive. Large surface radiation biases in these models likely play a critical role in the inception and growth of the warm bias.

This paper presents an objective and systematic attribution study to quantify the origin of net radiation biases in 9 model simulations, performed in the framework of the CAUSES project (Clouds Above the United States and Errors at the Surface). Contributions from deficiencies in surface properties, clouds, column water vapor (CWV) and aerosols are quantified, using observations from the ARM Southern Great Plains site.

Furthermore, an in depth-analysis is performed to attribute radiation errors to specific cloud regimes. A unique feature of this analysis is its emphasis on the co-evolution of radiation and cloud errors, rather than an evaluation of these two properties separately.

The net surface SW (LW) radiation is over-(under-)estimated in all models. Cloud errors are shown to contribute most to this overestimation in all but one simulation, which has a dominant albedo issue. The contribution from the albedo in other models is positive, but of secondary importance. CWV and aerosol contributions are small, but significant.

The main cloud issue contributing to radiation errors in all models is the inability to reproduce the frequency and/or radiative effect of the deep cloud regime. Some models have compensating errors between excessive triggering of deep cloud, but largely underestimating their radiative effect, while other models miss deep cloud events altogether.

This paper has been able to identify the root causes of radiation errors in all models concerned, and is a first step towards improving the representation of clouds and radiation, and hence potentially alleviating the warm bias over the midlatitudes.

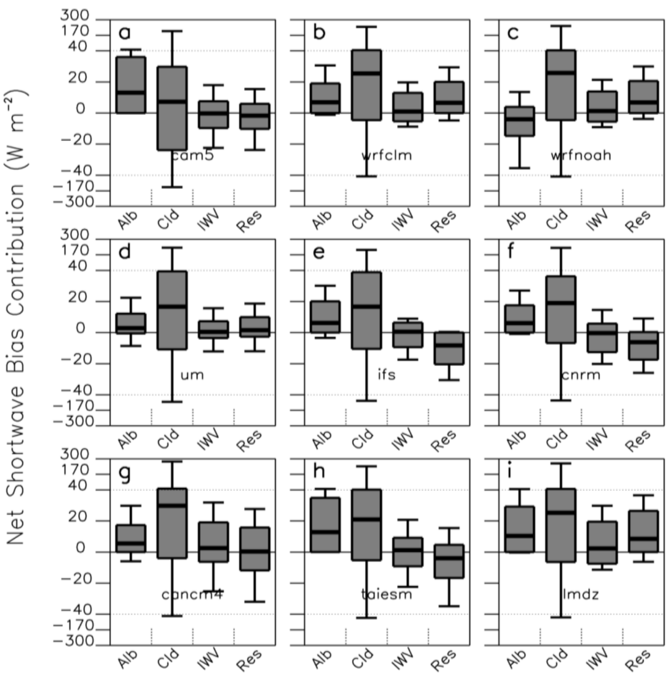


*Figure 1: Net SW bias attribution in all models. Contributions from albedo (Alb), clouds (Cld), integrated water vapor (IWV) and residual processes (Res) are provided. Boxes contain the 15th - 85th percentile of the distribution containing the full simulation period. The mean contribution is indicated by the bold horizontal line and whiskers indicate the 5th and 95th percentiles. Contributions that are significantly different from zero, based on a Wilcoxon Rank-Sum test (with 5 % confidence interval) are highlighted by bold box edges. For the SW biases shown here, all contributions are significant and hence all boxes have bold edges. Observational data used in this analysis are obtained using the continuous forcing by Xie et al. (2004).*