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Interactive Comment

Interactive comment on "Metrics for linking emissions of gases and aerosols to global precipitation changes" *by* K. P. Shine et al.

Anonymous Referee #1

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The authors attempt to develop metrics for global precipitation changes in responses to various emissions, based on simple energy budget equations. The referee understands the usefulness of such metrics. The attempt to build up these metrics is highly valued. The major concern is that the simplification used in deriving these metrics bypasses the interactions of convective processes and the general circulation that remain the largest uncertainty in the model-based estimates of global climate precipitation changes. Using energy budget equations, these convection-associated processes are reduced to parameters as the efficiency of surface temperature and radiative forcing changes to precipitation. These values, however, are generally model dependent, due to the formulation of cumulus and cloud parameterization in the model. As more and more models focus on the biases of global energy budget balance by "turning" the cumulus and cloud parameterizations. Recent studies show that in the CMIP5

GCMs, although the global averaged radiation budget biases are reduced compared to observation, the reduction actually arises from the cancellation of negative/positive biases over ocean and land (Li et al. 2013, JGR Atmos.). This puts more doubts on parameterizations used in current models. Further more, the precipitation efficiency coefficients are generally not constant values or simple linear functions. Interactions such as "wet get wetter" or "warmer get wetter" (Chou et al. 2009, J. Climate; Huang et al. 2013, Nature Geoscience) can significantly modify the precipitation efficiency related to temperature and radiative forcing. The issues associated with the convection and the general circulation produces very different mean state among the models, hence difference precipitation efficiency.

Applying the energy budget equations for the short-lived aerosols such as the black carbon can be questionable due to the fact that they barely transport globally. This suggests that the impacts are generally on the regional scale. Relating these emissions to global precipitation change has a larger uncertainty since the local change might not agree on the sign of precipitation change at different location simply because the background circulation is different. In addition, the coefficient derived by the single forcing experiments (Andrew et al., 2010) might have non-linear effects when combining two or more different emission sources together. These emissions interact with convection differently through direct or indirect effects of cloud and aerosols and their interactions with the large-scale circulation can differ significantly. Not to mention these values are highly model dependent.

I believe the authors understand the above simple arguments on the importance of convection variability on the global precipitation changes. It is however very difficult to rationalize such simplification from a convection/precipitation perspective.

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