EGUsphere, referee comment RC2
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Comment on egusphere-2022-777

Anonymous Referee #2

Referee comment on "Equilibrium climate sensitivity increases with aerosol concentration due to changes in precipitation efficiency" by Guy Dagan, EGUsphere, https://doi.org/10.5194/egusphere-2022-777-RC2, 2022

Review of "Equilibrium climate sensitivity increases with aerosol concentration due to changes in rain efficiency" by Guy Dagan

The author explores in a series of modeling experiments the synergistic effects of an increase in CO2 (global warming) and changes in aerosol loading. He takes the two most important contributors to the climate prediction uncertainties and explores their joined effects on clouds (forcing and feedback) from the perspective of a radiative-convective equilibrium assumption using an idealized SAM model with two-moment bulk microphysics. He shows that the equilibrium climate sensitivity increases with an increase in aerosol loading and explains it in an increase in the shortwave cloud feedback driven by an increase in precipitation efficiency in a warming climate.

The study is important, interesting, and well-presented. However, since the core of this study relay on the way by which the model can capture the right cloud trends in the phase space of CO2 vs. aerosol concentrations, more description and discussion on the model's assumptions and limitations is needed.

More details on the RCE model are needed with respect to the type of clouds that are considered. Is it only precipitating clouds? What about the portion of the non-precipitating and specifically the shallow clouds? Are they considered in the model? If not how it is justified? After all the effects on shallow clouds are considered a major source of uncertainty. Is it negligible because the model mimics tropical conditions? If yes, we know that even on tropical thermodynamics shallow clouds form. Does the study consider feedback between clouds (i.e. preconditioning and/or how changes in one type affect another)?

Is the model use saturation adjustment? If yes, can it capture all the delicate aerosol effects on the microphysics right? Can it represent the onset of rain and rain efficiency

right? This is important as rain processes play a key role in the study.

What about cloud invigoration by aerosol? Such an effect was not discussed in the paper. I miss the discussion on some of the aerosol effects on the buoyancy and vertical velocities, and mobility of the hydrometeors. As well as a discussion of the aerosol effect on the mixed phase. Does to model show invigoration? Are the polluted clouds reaching higher levels of the atmosphere? Does the model show larger transport of condensate to the upper parts of the cloud?

Last question - delay on the onset of rain by aerosol was shown to have an opposing effect later for deep clouds. It was suggested that when rain processes start in deep polluted clouds, higher rain yields are possible due to a larger integrated collection of falling drops in the invigorated clouds. Is it considered or maybe the model does not show it?