

*Anonymous Referee #1*

*As some reviewers pointed out in previous submission, the simulation improvement of the new source-oriented approach is marginal but the computational cost increases a lot. The application of such method in operational forecasts is deemed to be impractical. Therefore, the current study raises speculations from readers about the importance of the new methodology. The best way to demonstrate the merit of the approach is to conduct idealized simulations under highly controlled conditions to explore the sensitivity of simulated clouds and radiative feedback to a wide range of parameter space. Then the best application of this methodology is to come up with novel parameterizations based on idealized results that can improve the simulations by the simple approach, such as the internal mixture method.*

Reply: The authors appreciate the reviewer's suggestions on a different research aspect of using a source-oriented atmosphere-chemistry model. We would like to point out that both types of studies are important as each has its own merit and both should be encouraged. The first type of studies, suggested by the reviewer, is to improve the parameterizations of cloud activation, ice nucleation and aerosol internal mixing in numerical models. This type of study is important and can be very beneficial to the scientific community and most importantly to the operational centers. However, since cloud and aerosol microphysical processes can vary significantly in time and space and are highly nonlinear, it is difficult to parameterize for a wide range of weather and air pollution conditions, in particular for extreme ones. Thus directly applying source-oriented (i.e., aerosol external mixture) models to study real cases, the second type of studies, should be considered if computational resources are affordable. The source-oriented approach is an original approach, which has fewer assumptions and thus can be applied to a wider range of conditions. The purpose of the study is not to improve the internal mixture parametrization, but to assess the influence of different aerosol mixture methods on fog formation, cloud optical properties and the surface energy budget using exactly the same model, except the aerosol mixture methods.

In scientific communities, using simplified parametrization in numerical simulations is often under the constraint of computational power and/or the limitation of numerical tools. Since we have both, it seems a natural step to move onto the next stage of research, directly applying a source-oriented model to study aerosol-cloud-radiation interactions.

In the past decades numerical studies on Tule fog have been rare. This is in part due to model's difficulty to simulate fog reasonably. We chose this challenging weather system for our first study of this kind since Tule fog is important in safety, hydrology and agriculture in California. But more importantly fog is an excellent scientific subject that can isolate cloud activation and diffusive growth, the first step of aerosol-cloud-radiation interactions, from other microphysical processes which usually do not occur in fog. Compared to the internal mixture method, the source-oriented method does improve model results (even if the effect in this case is slight) which is in fact a positive contribution to the science. The modest amount of improvement implies that the parameterization of the internal mixture method provides a good approximation to the external mixture method for the studies of fog, a mild weather phenomenon. However, this does not imply that the internal mixture method will do well for other

weather and pollution conditions, in particular for those very nonlinear weather systems. The reason why we chose this particular phenomenon for our first study has mentioned above. We are now conducting more numerical studies on different weather systems to explore the full range of responses. We have added the following in the revised manuscript.

**“We chose this challenging weather system for the first study of this kind since Tule fog is important in safety, hydrology and agriculture in California. Fog is also an excellent scientific case study that can isolate cloud activation and diffusive growth, the first step of aerosol-cloud-radiation interactions, from other microphysical processes which usually do not occur in fog.”** Line 274-278.

**“We are now conducting more numerical studies on different weather systems to explore the full range of responses.”** Lines 632-633.