Geoscientific Model Development Discussions

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Comment on gmd-2020-423

Anonymous Referee #2

Referee comment on "A discrete interaction numerical model for coagulation and fragmentation of marine detritic particulate matter (Coagfrag v.1)" by Gwenaëlle Gremion et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2020-423-RC2, 2021

In this paper, a model representing the dynamics of marine organic particles by coalescence and fragmentation is developed. Coagulation and fragmentation are key microphysical processes in cloud and aerosol physics, since they affect size distribution of aerosols and droplets. In explicit models at cloud scale, coagulation is usually modelled by solving the kinetic collection or Smoluchowski equation (Pruppacher and Klett, 1997), or by using the stochastic approach with Monte Carlo methods (Shima, 2009). The coalescence process for multiple components has also been addressed in previous works, by treating unactivated aerosols and cloud droplets in a joint two-dimensional size distribution (Bottt, 2000).

The aim of this work is to implement an explicit treatment of the coagulation-fragmentation processes in order to avoid parameterizations. Within the approach adopted by the authors, the particle size distribution is discretized into size bins, with a discretization that can be linear or non-linear. The final aim is to incorporate this processes into Ocean General Circulation Models by solving a set of differential **kinetic equations for each size bin.**

I recommend publication of this paper after some minor revision considering the following:

- Bin microphysical models for coagulation are widely used in cloud and aerosol physics. There are many studies that addressed this problem and some excellent reviews (Jacobson, M.Z., 2005; Khain et al., 2015). I would suggest the authors to cite and briefly discuss some papers from these research areas. This can help place the current work in a more general context, and exhibit the advances compared with studies from other fields.
- In Eqs. (8) and (9), the triplet operator that represents both coagulation and fragmentation for a given bin, should be discussed in more detailed. It is clear from Eq (9), that the increase in the number of particles in bin k is proportional the product of

particles number concentrations in bins i and j. However, the coagulation and fragmentations rates (coagulation kernels) from Table 2 are considered constant, and not depending on particle radius, chemical composition or terminal velocity of the particles.

- The mechanisms for particle coagulation are not emphasized or discussed. For example, in Jackson (2001) three mechanisms for particle coagulation are discussed: Brownian diffusion, shear (laminar and turbulent), and differential sedimentation. It is not clear if coagulation and fragmentation rates are considered constant just to check the performance of the algorithm, or as some kind of approximation for different physical processes like differential sedimentation.
- In page 14, line 218, it is written that "Coagulation of particles belonging to bins 1 μm and 10 μm would ideally produce particle size 11 μm", which is in general not true for the radius of the resulting particles after coagulation.
- In the discussion of simulation results, authors stated that "coagulation leads to a reduction of Cp in small size bins and an increase in larger ones for both LR and HR, resulting in a linearly increasing distribution of Cp over the resolved size range". And "fragmentation yields a reduction of Cp in larger size bins to the benefit of an increase in the small ones", as in general expected. However, it could be interesting to check further the performance of the model for the coagulation case only, by comparing the results obtained from the kinetic equations developed by the authors with analytical solutions of the Smoluchowski equation for a constant coagulation kernel (for example).

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