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BiOMi: A binomial stochastic framework on microgrids for efficiently modeling discrete statistics of convective populations

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Understanding the coupling between convective clouds and the general circulation, as well as addressing the grey zone problem in convective parameterization, requires insight into the genesis and maintenance of spatial patterns in cumulus cloud populations. In this study a simple toy model for recreating populations of interacting convective objects as distributed over a two-dimensional Eulerian grid is formulated to this purpose. Key elements at the foundation of the model include i) a fully discrete formulation for capturing discrete behavior in convective properties at small population sample sizes, ii) object age-dependence for representing life-cycle effects, and iii) a prognostic number budget allowing for object interactions and co-existence of multiple species. A primary goal is to optimize the computational efficiency of this system. To this purpose the object birth rate is represented stochastically through a spatially-aware Bernoulli process. The same binomial stochastic operator is applied to horizontal advection of objects, conserving discreteness in object number. The applicability to atmospheric convection as well as behavior implied by the formulation is assessed. Various simple applications of the BiOMi model (Binomial Objects on Microgrids) are explored, suggesting that important convective behavior can be captured at low computational cost. This includes i) subsampling effects and associated powerlaw scaling in the convective grey zone, ii) stochastic predator-prey behavior, iii) the down-scale turbulent energy cascade, and iv) simple forms of spatial organization and convective memory. Consequences and opportunities for convective parameterization in next-generation weather and climate models are discussed.