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Effect of Mushball on Jupiter's Ammonia Distribution: a General Circulation Model Study

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Recent Juno microwave observations have revealed puzzling features of Jupiter’s ammonia distribution, including an ammonia-poor layer extending down to levels of tens of bars outside the equatorial region to at least ±40° [Li et al. 2017]. Guillot et al. [2020] showed that ammonia-rich hail, or “mushballs”, formed during a powerful thunderstorm, can efficiently transport ammonia to the deeper atmosphere and hence could cause the observed ammonia depletion. However, this mechanism has not been tested in numerical simulations in which convective events are self-consistently determined.
We have developed a simple parameterization scheme for the mushball process and implemented it into a Jupiter GCM [Young et al. 2019] that includes the following relevant parameterizations: a simple cloud microphysics model for water and ammonia, a water moist convection scheme that transports ammonia as a passive tracer, a dry convection scheme, and a two-stream, semi-grey radiative transfer scheme. In the two-dimensional setup of the aforementioned GCM, we show that mushball precipitation can produce an ammonia depletion qualitatively similar to the Juno observations.
We present our preliminary results in three-dimensional simulations, in which a Jupiter-like zonal jet profile emerges spontaneously. We will show the role of different processes, including the mushball process, moist convection and meridional circulation in shaping ammonia distribution. Further, we compare our model output with Juno MWR result, and discuss the implication to future observations.