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Stochastic parameterization of atmospheric convection in a GCM (Planet Simulator)

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A stochastic parameterization for atmospheric convection is developed and tested in an intermediate complexity general circulation model (Planet Simulator). The parameterization is realized through a Markov chain lattice model of the cloud population similar to what proposed by other authors in a idealized setting. Each grid-box of the GCM is divided into a rectangular lattice. Each site of the lattice can be in one (of three) convective regimes: no, shallow, and deep convection. The time evolution at each lattice site is given by a non-stationary Markov chain characterized by transition probabilities which depend on large-scale (grid-box) quantities representative of the convective activity. Characteristic time-scales of convection and threshold values for the representative large scale quantities quantify the transition probabilities, which allows a full two-way coupling between small-scale stochastic (lattice) and large-scale deterministic (grid-box) dynamics. In order to make the parameterization feasible for general circulation models we derive an analytical form of the statistical properties of the cloud fractions directly from the transition matrix thus avoiding a computationally expensive MonteCarlo simulation of the entire lattice. The parameterization is tested in the single-column and full versions of Planet Simulator in different settings and the results are compared with the standard model set-up.