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Global Deep Convection Models of Saturn's Atmospheric Features

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The Cassini mission, along with previous missions and ground-based observations, has revealed a rich variety of atmospheric phenomena and time variability on Saturn. Some examples of dynamical features are: zonal flows with multiple jet streams, turbulent tilted shear flows that seem to power the jets, the north polar hexagon, the south polar cyclone, large anticyclones in "storm alley", numerous convective storms (white spots) of various sizes, and the 2010/2011 great storm, which destroyed an array of vortices dubbed the "string of pearls". Here we use the anelastic dynamo code MagIC, in non-magnetic mode, to study rotating convection in a spherical shell. The thickness of the shell is set to approximate the depth of the low electrical conductivity deep atmosphere of Saturn, and the convective forcing is set to yield zonal flows of similar velocity (Rossby number) to those of Saturn. Internal heating and the outer entropy boundary conditions allow simple modelling of atmospheric layers with neutral stability or stable stratification. In these simulations we can identify several saturnian and jovian atmospheric features, with some variations. We find that large anticyclonic vortices tend to form in the first anticyclonic shear zones away from the equatorial jet. Cyclones form at the poles, and polar polygonal jet streams, comparable to Saturn's hexagon, may or may not form, depending on the model conditions. Strings of small scale vortical structures arise as convective plumes near boundaries of shear zones. They typically precede larger scale convective storms that spawn propagating shear flow disturbances and anticyclonic vortices, which tend to drift across anticyclonic shear zones, toward the equator (opposite the drift direction of Saturn's 2010/2011 storm). Our model results indicate that many identifiable dynamical atmospheric features seen on Jupiter and Saturn arise from deep convection, shaped by planetary rotation, underlying and interacting with stably stratified, or near neutrally buoyant shallower atmospheres.