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Circulation Models of Close-In Exoplanet Atmospheres

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Abstract

Many exoplanets, including those best suited for characterization, are on close-in orbits and are likely tidally synchronized. Atmospheric circulation affects the temperature distribution and thus transit observations of these planets. In particular, hot spots shifted by broad, steady, superrotating jets have been emphasized in the literature. We present results from a general circulation model, solving the primitive equations with thermal relaxation. The mini-Neptune GJ1214b and hot Jupiter HD209458b are used as reference planets.

We explore a variety of conditions for forcing and initialization which lead to different states. The resulting states have in common a low number of jets, but large-scale vortices also play a big role and often exhibit time variability (with corresponding variability in the position of relative hot and cold regions). In contrast to many studies, we find and explore cases where the equatorial jet can be westward as well as eastward (superrotating) for tidally locked forcing conditions. For a given forcing, varying initial conditions leads to different states, but a given run also exhibits transitions between distinguishable long-lasting (hundreds or thousands of planet rotations) states during its long term evolution.