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Storms and Variability on Tidally-Locked Extrasolar Planets

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Transiting extrasolar planets are expected to be in a tidally-synchronized, 1:1 spin-orbit state. Currently, the flow and temperature structures of these planets – needed to characterize them – are not known. General circulation simulations of the lower atmospheric region ($\sim$1 bar to $\sim$1 mbar) on tidally-locked extrasolar planets show a surprisingly homogeneous temperature distribution over large height ranges. The atmospheres are characterized by transient storms and one or two coherent vortex-dipoles ("modons") and extrasolar planet analogs of terrestrial Hadley and Walker circulations – overturning cellular flow patterns in the meridional (north-south) and zonal (east-west) directions, respectively. In general, marked variability of large-scale flow and temperature structures are present, particularly near the 1 bar level. Our simulations strongly motivate repeated observations for accurately characterizing extrasolar planets.