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A critical analysis of standard approximations canonically invoked in dynamical modeling of exoplanet atmospheres.

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Abstract

Most models of hot Jupiter atmospheres have used the so-called primitive equations of meteorology, involving several approximations. Such approximations, in general, are valid for large scale motions on the Earth but may break down in more exotic flow regimes such as those found for hot Jupiters. We present results of dynamical models of HD209458b solving the unsimplified dynamical equations for a rotating atmosphere, as well as models with increasing simplification to these equations. These results show that the bulk atmospheric flow is largely robust to the canonical simplifications if short integration times and small vertical domains are used (i.e. shallow weather layers). However, for longer integrations and models incorporating a 'deeper' (i.e. larger in vertical extent) atmosphere such simplifications to the dynamical equations produce different flows.

The presented models have all been run with the same global circulation model (GCM), the unified model (UM) used by the UK Met Office for climate research and numerical weather prediction for Earth. We have adapted the dynamical components of this model for the study of hot Jupiters and used a parameterised radiative transfer scheme. We are also adapting a more complete radiative transfer scheme for the physical conditions of hot Jupiters and I will outline progress and plans for the coupling of this to the dynamical code.