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Zonal flow structure in Boussinesq and anelastic numerical models of rotating convection

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The surface winds of Jupiter and Saturn are primarily zonal. Each planet exhibits strong prograde equatorial flow and weaker but well-defined bands of East-West flow in alternating directions at higher latitudes. The depth to which these flows penetrate has long been debated and is still an unsolved problem. Both Boussinesq and anelastic rotating convection models have reproduced the general surface flow structure. However, anelastic models, while being more realistic are also more computationally expensive, and have not so far produced multiple high latitude jets comparable to those of Jupiter and Saturn. In both types of models the dominant Coriolis force leads to axially symmetric cylindrical columns that underlie the surface zonal flows. Whereas the equatorial flows span the northern and southern hemispheres outside the tangent cylinder, high latitude zonal flows are truncated at the inner boundary of the rotating convection model. Boussinesq and anelastic dynamo models with radially decreasing electrical conductivity have shown that the penetration of fast equatorial flows can be limited by Lorentz forces that increase strongly with depth. However, in those models well defined high latitude zonal flows tend not to develop. This discrepancy between non-magnetic rotating convection models and dynamo models presents a challenge to understanding the nature of high latitude zonal flows. Here we compare the results of Boussinesq and anelastic models of rotating convection. All of the models employ a free-slip outer boundary condition. We study the effects of different thermal boundary conditions, as well as the effect of a no-slip bottom boundary condition. The results show that, as in Boussinesq models, a thinner shell geometry in anelastic models leads to a higher wave number for high latitude jets. Also, we confirm previous work which showed that a no-slip bottom boundary condition hinders the formation of high latitude jets. For those models solar heating outer thermal boundary conditions favours the development of strong high latitude zonal flows.