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Time dependent β-convection in rapidly rotating spherical shells

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A quasi-geostrophic, or β, model of non-linear thermal convection in rapidly rotating spherical fluid shells is investigated. We study time dependent instabilities for a range of Rayleigh number and Ekman number with a Prandtl number set to the unity. Above the onset of convection, increasing the Rayleigh number for a given Ekman number, we reproduce the sequence of bifurcations described by Busse [Phys. Fluids **14**, No.4, 1301 (2002)] for the three dimensional case: a first transition results in vacillating flow; a second transition gives rise to chaotic oscillations in time and localized convection in space; then a third leads to quasi-periodic relaxation oscillations. This study shows that the quasigeostrophic model encompasses the desired bifurcation sequence. It allows the investigation of a range of Ekman numbers unavailable to three dimensional models with present computing resources. Decreasing the Ekman number, we unexpectedly found that all three transitions occur for marginally supercritical Rayleigh number. The range of Rayleigh number for which the amplitude of convection is steady vanishes in the asymptotic limit of small Ekman numbers. This effect could significantly alter the nature of the instability characterizing the onset of convection in particular whether it is a supercritical or subcritical bifurcation.