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Baroclinic stationary waves in aquaplanet models

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An aquaplanet model is used to study the nature of the highly persistent low frequency waves that have been observed in models forced by zonally symmetric boundary conditions. Using the Hayashi spectral analysis of the extratropical waves, we find that a quasi-stationary (QS) wave five belongs to a wave packet obeying a well defined dispersion relation with eastward group velocity. The components of the dispersion relation with k>5 baroclinically convert eddy available potential energy into eddy kinetic energy, while those with k<5 are baroclinically neutral. In agreement with the Green's model of baroclinic instability, the wave five is weakly unstable, and the inverse energy cascade, which had been previously proposed as a main forcing for this type of waves, only acts as a positive feedback on its predominantly baroclinic energetics. The QS wave is reinforced by a phase lock to an analogous pattern in the tropical convection, which provides further amplification to the wave. We also find that the Pedlosky bounds on the phase speed of unstable waves provide guidance in explaining the latitudinal structure of the energy conversion, which is shown to be more enhanced where the zonal westerly surface wind is weaker. The wave energy is then trapped in the wave guide created by the upper tropospheric jet stream. In agreement with Green's theory, as the equator to pole SST difference is reduced the stationary marginally stable component shifts toward higher wavenumbers, while the wave five becomes neutral and westward propagating. Some properties of the aquaplanet QS waves are found in interesting agreement with a low frequency wave observed by Salby (1982) in the southern hemisphere DJF, so that this perspective on low frequency variability might be, apart from its value in terms of basic geophysical fluid dynamics, of specific interest for studying the Earth's atmosphere.