Summary and recommendation:

The main aim of this paper is to challenge the reliability of the observational basis for the 'too-fast' Rossby waves evidenced by Chelton and Schlax (1996) based on 4 years of Topex-Poseidon satellite altimeter data. The authors derive their conclusion from showing that it is possible to construct a synthetic Rossby wave signal composed of 20 to 50 sine waves with random known speeds, which standard techniques such as the Radon and Fourier transforms fail to identify accurately. In a previous study, Paldor et al. had showed such techniques to work well for a synthetic signal composed of three basic waves only, so the difficulties experienced by the Radon and Fourier transforms in this paper appear to result from the increase in many more basic waves in the synthetic signal constructed. As to the motivation for the present study, Nathan Paldor's group has been working on the 'too-fast' Rossby wave issue for many years, promoting the view that the observed phase speed enhancement results from latitudinal trapping due to Earth's curvature. So far, however, Paldor's group appear to have found it difficult to vindicate their theory from observations; but rather than concluding that the problem might rest with their theory, as others theoreticians may have done, the present study proposes that the blame should lie with the observations and the kind of techniques used to analyse them instead, not their theory.

As far as presentation is concerned, the paper is clearly written, and the analysis appears to be competently done. However, as a contribution to the general issue of what satellite altimeter data actually tell us about westward propagation in the ocean and about the usefulness/validity of the standard Rossby wave theory, this study appears to be very biased in its approach and therefore of very little scientific value, clearly failing to meet the required standards for publication. This is unfortunate, because I otherwise find Paldor's work on the rigorous analysis of the waves supported by the shallow water equations to useful and valuable. As far as I understand the issue, their work appears to be essentially concerned with refining the standard flat-bottom, no mean flow, linear theory of the shallow-water waves on the sphere, and has therefore no bearing with real Rossby waves, which theoretical advances over the past 50 years have clearly showed to be strongly affected by both the background mean flow and topography. The rationale for my assessment is contained in the following remarks and observations.

Main points

1. The authors fail to mention that the reliability of Chelton and Schlax (1996)'s conclusions has already challenged by Dudley Chelton himself and his collaborators in Chelton et al. (2011), in which the authors argue that westward propagation in the oceans is dominated by meso-scale eddies rather than linear Rossby waves in contrast to what CS96 had previously assumed. Since then, how to disentangle the meso-scale eddy field from the background Rossby wave field has been a major challenge that only a few authors have tried to tackle. Since we know that meso-scale eddies tend to have an equatorward or poleward drift depending on whether they are cyclonic or anti-cyclonic, it is clear that determining their propagation characteristics cannot be easily achieved from the use of Hoevmuller diagrams in longitude/time, which is why eddy tracking algorithms have been developed. Since we don't really know to what extent the propagation speed of eddies differs from that the more linear background Rossby wave field, it seems clear that there is some

degree of uncertainty about how CS96's results should be interpreted. In any case, it is clear from Chelton et al. (2011) that there is no observational basis for their synthetic signal.

2. Theoretical developments prompted by Chelton and Schlax (1996) have clearly revealed that the background mean flow and bottom topography have a major impact on the propagation and vertical structures of Rossby waves, and hence that the standard theory can never be a satisfactory description of actual Rossby wave propagation regardless of what satellite altimeter data actually tell us. Indeed, Aoki et al. (2009) and Hunt et al. (2012) have both convincingly established that the standard theory cannot account for the features of simulated Rossby waves propagation, which can only be satisfactorily explained when both the mean flow and bottom topography are accounted for. Flat bottom, no mean flow, modes are completely unable to capture the vertical structure of simulated Rossby wave variability. Irrespective of what the observations tell us, I believe it is pretty clear that the authors' approach cannot tell us anything about actual Rossby waves.
3. Contrary to what this paper and previous ones assert, theoretical studies of the standard theory based on the WKB approximation are able to account for both the trapping of the Rossby waves as well as for Earth curvature, and it is misleading to refer to such theories as harmonic theories. In WKB theory, one will typically express the pressure anomaly in the form

$$p = A(x, y, z, t)\, e^{i\Sigma(\mathrm{x,y,t,})}$$

$$k = \nabla\Sigma, \quad \omega = -\frac{\partial\Sigma}{\partial t}$$

In such an approach, the amplitude is slowly varying, and will in general decay with latitude, thus capturing the trapped wave behaviour emphasised by the authors. The function Σ is a rapidly varying phase function, allowing to define a local wave vector and frequency. Note that a single WKB wave mode is able to represent the observed beta-refraction and a latitudinally varying phase speed. In contrast, the basic wave mode considered by Paldro's group is separable in latitude, and typically chosen of the form

$$p = A(y)e^{i(kx-\omega t)}$$

Arguably, if the term 'harmonic mode' needs to be used, it seems more appropriate to the modes considered by Paldor's group, since it is clearly what they chose for the temporal and zonal dependence of their mode. As a result, such a mode does not capture the beta-refraction pattern described by Shopf et al. (1981) for instance, raising the question of how useful this kind of mode is to describe mid-latitude Rossby waves.

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References:

Aoki et al., 2009:. Mid-latitude Rossby waves in a high-resolution numerical model simulation. JPO, 39, 2264-2279.

Hunt et al. 2012: The vertical structure of oceanic Rossby waves: a comparison of high-resolution model data to theoretical vertical structures. Ocean Sciences, 8, 19-35.