PAST, PRESENT, AND FUTURE DEVELOPMENTS IN ROSSBY WAVE THEORY

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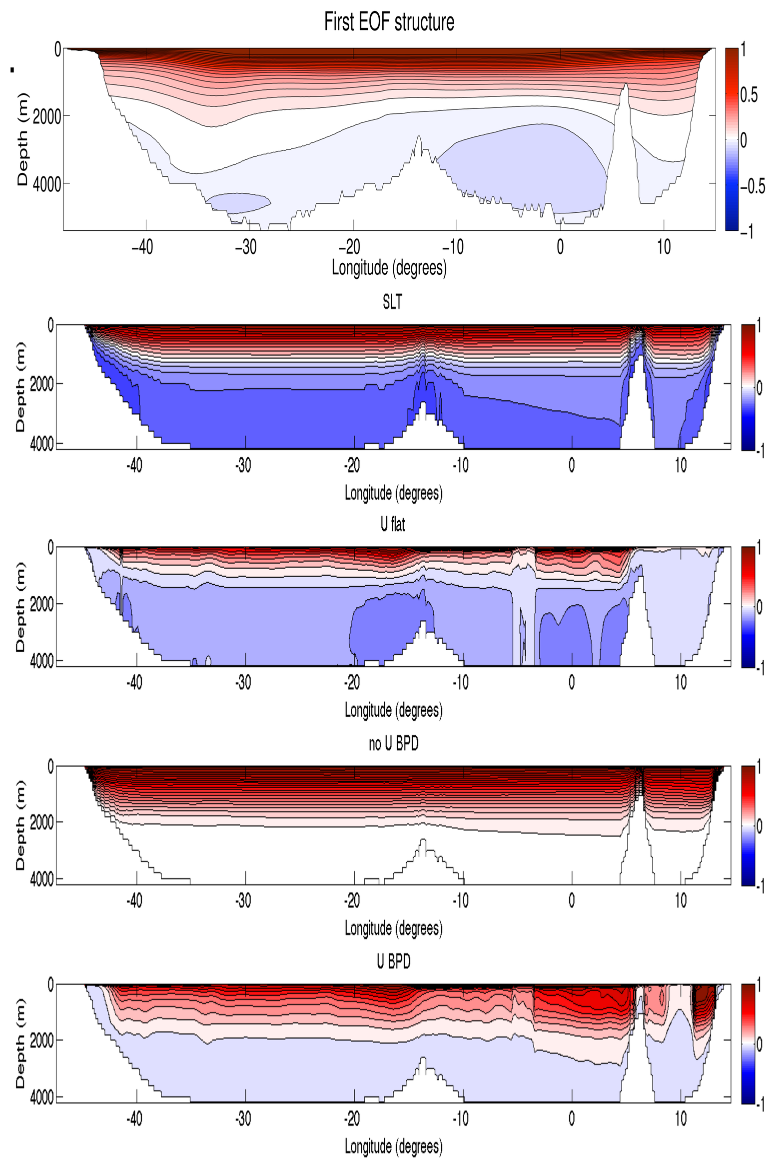
SUMMARY

Satellite altimetry prompted renewed interest in Rossby wave theories, but owing to the lack of suitable in-situ data, new theories have been mostly tested on their ability to account for the surface signature of the waves only. This is not sufficient, however, to discriminate between theories based on different physical assumptions. To make progress, theories need to be tested on their predictions for the Rossby wave vertical structures, which for the moment can only be meaningfully explored in high-resolution numerical simulations. The poster reports on work seeking to link simulated vertical structures with generalized linear normal modes depending on mean flow, topography, and spatial scales. The realisation that the meso-scale eddy field dominates westward propagation in the SSH poses new challenges to study the relative properties of waves and eddies and their interactions.

3D FROM 2D PROBLEM: GENERALISED LINEAR THEORY

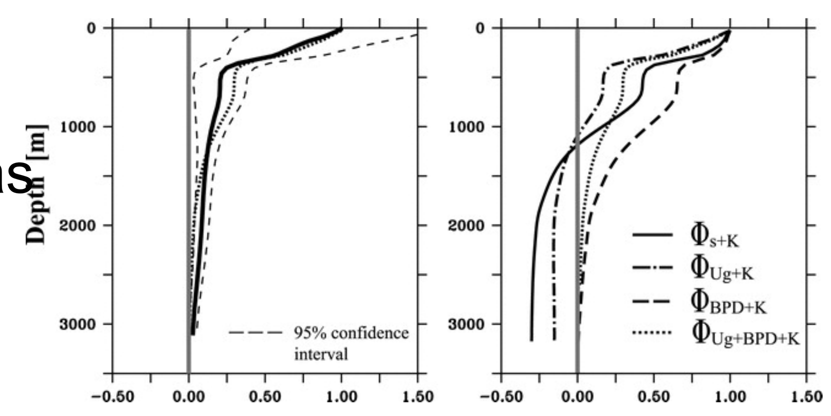


From Hunt, Hirschi and Tailleux (2012)

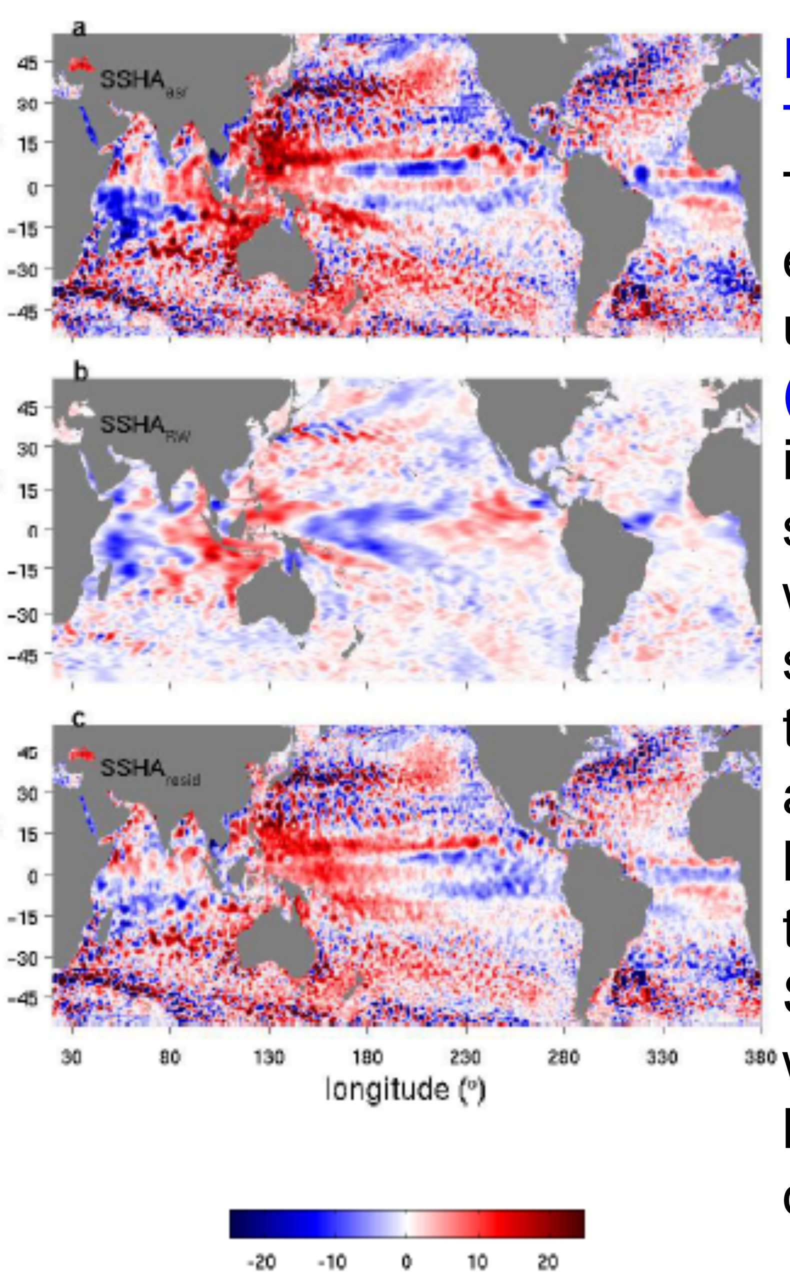
Empirical vertical structures of westward propagating signals in the 1/6 degree CLIPPER model are compared with that predicted with 4 different theories:

1) Standard linear theory (flat bottom, no mean flow)
2) Zonal mean flow only (flat bottom, as in KCS97)
3) Bottom compensation Theory only (TMC01)
4) Zonal mean flow + bottom compensation theory

Although mean flow + topography theory 4 provides the best agreement with empirical structures, better agreement was found in Aoki et al. (2009) when computing different vertical structures for different scales



SEPARATING LINEAR WAVES FROM NONLINEAR EDDIES

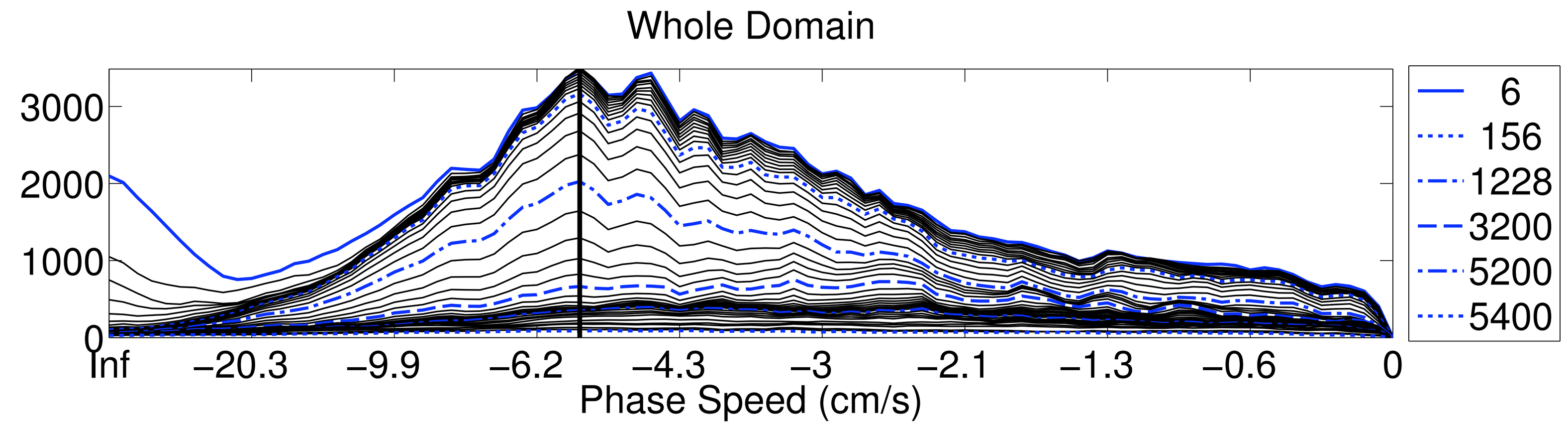


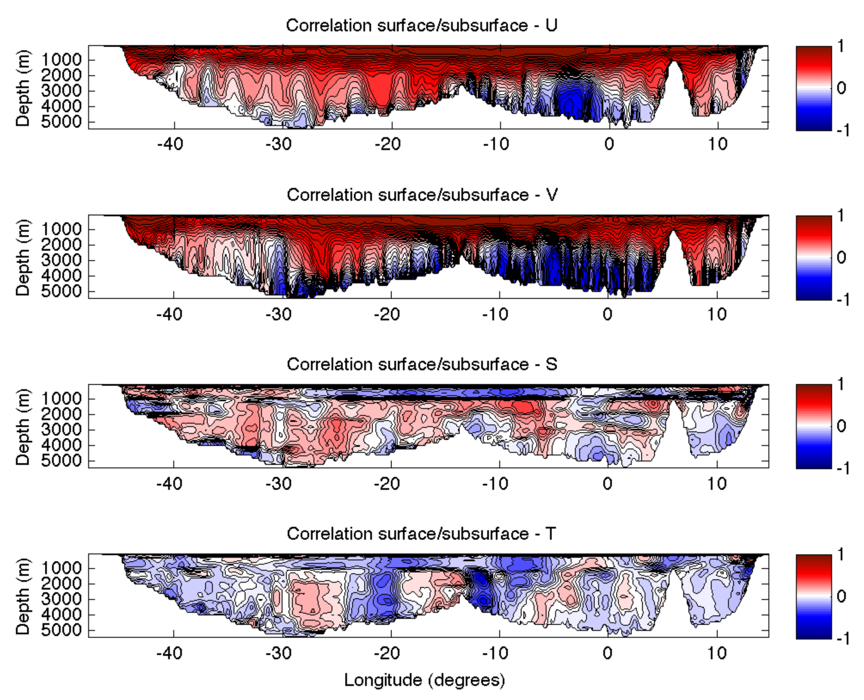
From Thomas, Cipoolini and Tailleux (2012, in prep)

The dominance of meso-scale eddies in the SSH obscures the underlying linear Rossby wave field (Chelton et al. 2011). The fact that isolated features have significant spectral power around zero wavenumber prevents the use of standard spectral filters to separate the two fields. The figure illustrates a new method at separating the linear waves (middle panel) from the eddies (bottom panel) from the SSH field (top panel). The linear waves occur predominantly at low latitudes and their amplitude decreases as latitude increases.

3D FROM 2D PROBLEM: VERTICAL WAVE COHERENCE

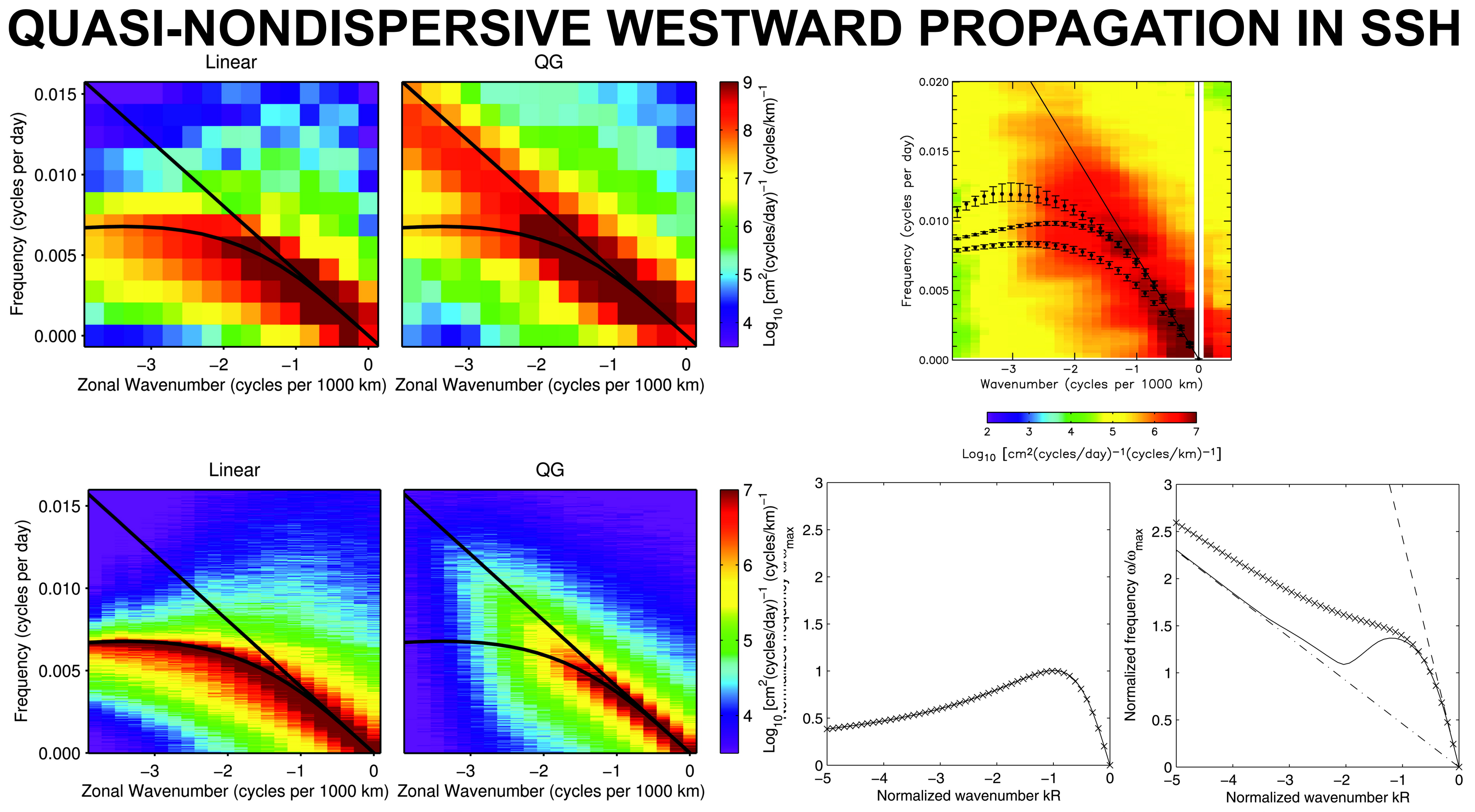
From Hunt, Hirschi and Tailleux (2012) Applying the Radon transform on meridional velocity anomalies at different depths in 1/6 degree CLIPPER model simulations suggest that the assumption of Rossby wave theory that Rossby waves are vertically coherent is valid, in contrast to Lecointre et al. 2008





Pearson correlation coefficient between interior and surface values suggest that velocity anomalies may have simple modal structures, but that is not so for temperature/salinity anomalies, presumably because the latter are strongly affected by mean T/S gradients

QUASI-NONDISPERSIVE WESTWARD PROPAGATION IN SSH



Zonal wavenumber/frequency power spectrum of SSH often displays appearance of quasi-nondispersive westward propagation (top right corner), which contrasts to the usual linear Rossby wave dispersion. Although linear theory can yield quasi-nondispersive dispersion at high wavenumbers (bottom corner, from Tailleux 2012), this occurs when the wave speed is close to that of the background mean flow at some depth and has a rather unphysical vertical structure. A better explanation is offered by Early et al. 2011, which finds that the dispersion characteristics are much closer to observed one when the advective nonlinearity is retained in a one-layer QG mode (left panels).

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References:

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Lecointre, A. et al. 2008: Depth-dependence of westward-propagating North Atlantic features diagnosed from altimetry and a numerical model. *Ocean Sci.*, **4**, 99

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FUTURE ISSUES Evidence of vertical coherence and good agreement of observed vertical structures with theoretical ones, provided that spatial scales are taken into consideration, is incentive to develop generalised linear theory further as a tool to project surface information onto the vertical (the 3D From 2D problem). Further work also needed to cleanly separate waves from eddies, and for understanding the nature of the meso-scale eddy fields, and whether they interact with each other.