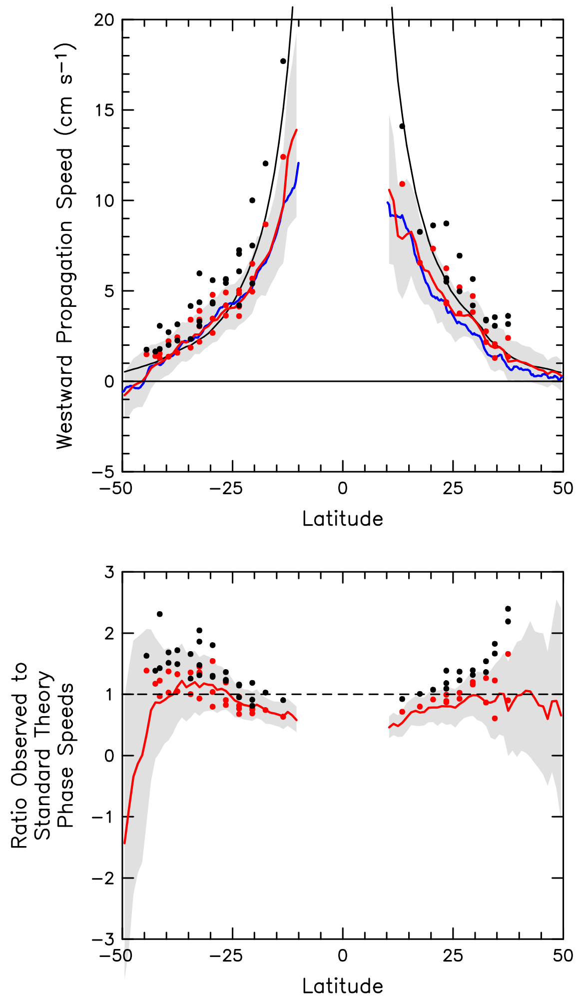

Fig. 22. The latitudinal variation of westward zonal propagation speeds estimated by a variety of different methods. The black dots are the Radon transforms of the 20° × 10° high-pass filtered SSH fields along the 45 zonal sections shown in Fig. 21 and the red dots are the average along the propagation speeds of eddies with lifetimes ⩾16 weeks within ±1.5° of latitude of the center latitudes of the same 45 zonal sections. The latitudinal profile of the global zonal average of the propagation speeds of all of the eddies with lifetimes ⩾16 weeks is shown by the red line, with gray shading to indicate the interquartile range of the distribution of the eddy speeds in each latitude band. The black line is the latitudinal profile of the zonally averaged westward phase speeds of long baroclinic Rossby waves. The ratios of the various speed estimates to the local long baroclinic Rossby wave phase speed are shown in the bottom panel. The blue lines in the upper panel (barely distinguishable from the red line over much of the southern hemisphere) is the latitudinal profile of the global zonal average of the eddy propagation speeds estimated by space–time lagged cross correlation analysis by Fu (2009).

speeds obtained from the Radon transform can therefore be interpreted as an indication that features in the SSH field with scales larger than the compact mesoscale eddies that are the subject of this investigation propagate about 25% faster than the mesoscale eddies. A possible interpretation of this apparent scale dependence of propagation speed is that SSH variability consists of a superposition of nonlinear mesoscale eddies and larger-scale, linear Rossby waves that recent theories have shown should propagate faster than predicted by the classical theory because of the effects of background mean currents and bottom topography (see the discussion in Section 1). At least some, if not most, of this linear Rossby wave variability likely consists of the non-compact contributions to mesoscale variability (e.g., the interconnecting ridges and valleys between eddies arising from an up-scale energy cascade) that generally have larger scales and smaller amplitudes than the compact eddies and can therefore behave more linearly.

This speculation appears to be confirmed from the quasi-geostrophic model studies by Early (2009) and Early et al. (in press).

Aside from the speed differences reported here, we have not been able to identify an unambiguous SSH-based diagnostic to the top panel of separate nonlinear eddies from linear Rossby waves. If Rossby wave-like features are in fact detectable in the SSH fields analyzed here, they evidently have amplitudes that are small compared with the amplitudes of the nonlinear eddies.

A global summary of the propagation speeds of all of the ~36,000 eddies with lifetimes ⩾16 weeks was obtained analogous to the 45 estimates shown by the red dots in Fig. 22 by zonally averaging all of the eddy speed estimates at 1° intervals of latitude. The latitudinal variation of these zonal averages is shown by the red lines in the two panels of Fig. 22. The gray shaded regions are the interquartile ranges of variability of the individual eddy speeds within each latitude band. From separate analyses of the propagation speeds of cyclones and anticyclones, we determined that these speed estimates do not depend significantly on eddy polarity (see, for example, Fig. 24b and c below).

The latitudinal variation of the mean eddy speed computed here from the eddy trajectories can be compared with the estimates obtained independently by Fu (2009) based on space–time lagged cross correlation analysis of SSH variability. The global zonal average of his correlation-based eddy speed estimates (the blue lines in the upper panel of Fig. 22) is almost indistinguishable from our global zonal average in the southern hemisphere. His estimates are mostly slightly slower than ours in the northern hemisphere, although well within the interquartile range of variability of our speed estimates.

The differences between the eddy speed estimates along the 45 sections in Fig. 21 that were discussed above (the red dots in Fig. 22) and the zonally averaged eddy speeds shown by the red lines suggest that this subset of speed estimates is not entirely representative of the global eddy dataset. Although slower than the speeds estimated by the Radon transform as discussed above, many of these 45 estimates are somewhat fast compared with most of the other eddies at the same latitude (the red lines in Fig. 22). This conclusion should be interpreted with some degree of caution, however, since the geographical distribution of the 45 sections in Fig. 21 is limited. Moreover, very few of these 45 eddy speed estimates exceed the interquartile range of variability shown by the gray shading in Fig. 22, and hence they are not out of the range of expected variability of the speed estimates.

An important feature of the red lines in both panels of Fig. 22 is that the zonally averaged eddy speeds are closer to the long baroclinic Rossby wave phase speed than are the faster propagation speeds estimated by Radon transforms. Except at the high southern latitudes poleward of 45°S where the ratios of the eddy speeds to the local long Rossby wave phase speeds become negative from eastward advection of the eddies by the Agulhas Return Current and the Antarctic Circumpolar Current, and in the tropical band 20°S–20°N where the speed ratios decrease to less than 1 in both hemispheres, the eddy speeds generally differ from the long baroclinic Rossby wave phase speeds by less than 20%.

The similarity of the eddy speeds to the long baroclinic Rossby wave phase speeds is consistent with theories for large, nonlinear vortices. These theories conclude that eddies with radii as large as the mesoscale eddies analyzed here and in regions where background mean currents are negligible should propagate westward with speeds approximately equal to the phase speeds from the classical theory for long baroclinic Rossby waves (McWilliams and Flierl, 1979; Killworth, 1986; Cushman-Roisin et al., 1990).

Although within the interquartile range of variability, the small but systematic trends from slightly low eddy speeds compared with long Rossby wave phase speeds at low latitudes to slightly higher eddy speeds at high latitudes that are evident in both