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Effects of wind shear and curvature on parametrized global and regional gravity wave torque

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A new linear model of gravity wave drag (Teixeira and Miranda 2006) incorporates the effect of wind profile shape on the surface drag. The theory uses a second order WKB approach and offers a closed analytical expression, where the surface drag is computed as a function of low-level wind and stability, and of wind shear and curvature. In the present study, we assess the impact of the new scheme at the global scale, computing the corrected gravity wave stress from ERA-40 fields.

While the theory shows that wind profile effects may lead to either a reduction of surface drag, associated with the effect of linear shear, or to its enhancement, due to wind curvature, the present results indicate that drag enhancement is highly dominant. However, the enhancement occurs preferentially in regions of easterly gravity wave stress, namely in Antarctica and East Africa, where curvature terms appear more relevant. Because of that, the overall impact of these effects on gravity wave drag is towards a reduction of the global westerly torque.

The impact of shear and curvature on the global torque is found to be rather modest, below 10% in the annual mean, but in the right sense considering previous studies (Huang et al 1999, Egger et al 2007). However their regional impacts appear very significant, especially in Antarctica where these effects lead to an enhancement of the local easterly torque by about 50%. The implied impact on the polar vortex is likely to be substantial.

The study also looks at the annual cycle of gravity wave drag, its interannual variability and regional aggregations around the major mountain chains.