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Interactive comment on "Quasi-geostrophic turbulence and generalized scale invariance, a theoretical reply" *by* D. Schertzer et al.

Anonymous Referee #1

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I agree with the basic thesis that it is necessary to go beyond the QG equations in discussing the observed behaviour of the atmospheric spectrum; and that it is necessary to derive better analytical models. However, I have reservations about the focus of the author's scaling analysis on the vorticity dynamics when much of the smaller-scale behaviour of the atmosphere is strongly controlled by stratification. Though the necessary terms are derived, (32), the discussion is strongly focussed on the different behaviour of vortex dynamics as if classical 2d and 3d turbulence are the main options.

Detailed comments:

p.3303. I agree that the analytical properties of any proposed simple model (such as QG) are the important thing to study. In the case of QG, the proof that the QG equations could be solved for large times and approximated the Navier-Stokes equations to the

expected order of accuracy, Bourgeois and Beale, SIAM J. Math. Anal., 1984, showed that QG was self-consistent beyond the initial scale analysis. It is important that this step is carried out for models which apply outside the region of validity of QG.

Eq. (10) Since these are supposed to be the true equations, the neglect of compressibility and the true equations of state should be mentioned. The common use of pressure coordinates avoids this issue on scales large enough for QG to be valid. The incompressible assumption is justifiable on small scales.

Start of section 3. QG is not valid on large scales because of the assumptions of a uniform reference state density and the simplified representation of the Coriolis parameter. It is valid on rather restricted intermediate scales.

p.3308 end. The model of TO used a rigid upper boundary. In the absence of their Ekman layer this would mean that the barotropic solution behaved like classical 2d turbulence which is known to be unrealistic on large scales. The actual behaviour would be strongly affected by the choice of Ekman damping.

End of section 3. Worth saying that on scales smaller than the deformation radius the natural limit equations are not QG, but 2d incompressible flow on each layer, with no vertical coupling. This regime is self-destructive, e.g. Billant et al., J. Fluid Mech. 2010, and the resulting stratified turbulence requires much more complete equations.

p. 3311 The treatment of stratification should be a major part of this discussion.

p. 3315 More needs to be said about the effects of the baroclinic terms.

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