Comments on “Barotropic vorticity balance of the North Atlantic subpolar gyre in an eddy-resolving model” by Le Corre et al..

I have enjoyed reading this manuscript and consider it to be an excellent piece of work that I recommend for publication after minor revision. The important role played by the nonlinear terms in the dynamics of the subpolar North Atlantic was anticipated by Wang et al. (2017) but is comprehensively demonstrated in this manuscript using a very thorough and detailed analysis of the barotropic vorticity balance in a model for the subpolar gyre with kilometer resolution. The manuscript is an impressive piece of work and forces a change in our view on how the subpolar gyre in the North Atlantic is driven and maintained. I do, nevertheless, have one major comment for the authors to address in addition to a number of minor comments.

Major Comment

Abstract and elsewhere: The authors claim that the Northwest Corner is a source of vorticity through the non-linear terms for driving the subpolar gyre in the North Atlantic. But I do not see how this is possible dynamically. The problem is that information propagates westwards along potential vorticity contours – either lines of latitude, as in the formulation of the barotropic vorticity balance given by equation (1), or along f/H contours as in the formulation used by Wang et al. (2017) (see comment 10. below). In either case, it is not possible for a vorticity forcing applied at the northwest corner to influence the gyre interior. It seems to me, therefore, that it is the eastern boundary regions that are important for driving the gyre and not the Northwest corner. Unfortunately, one cannot appeal to non-linear advection to get around this problem. To be influential, the non-linear term must be important in the eastern part of the gyre or in the gyre interior itself.

Minor Comments:

1. Line 31: Why mention Munk (1950) but not Stommel (1948)? I would refer to both.
2. Line 35: An important role for the bottom pressure torque is also anticipated in the early, diagnostic model of Greatbatch et al. (1991) – their Figure 6.
3. Lines 51-52: Wang et al. also showed the importance of the nonlinear terms in the subpolar gyre for driving the so-called Lavender recirculation – see their Figure 2c.
4. Line 80: From Chelton et al., I would say that the radius of deformation for the 1^{st} baroclinic mode has trouble exceeding 10 kms and certainly does not reach 20 kms – see their Figure 6.
5. Line 97: From Figure 2, the vertical grid does not look to be particularly bottom intensified?
6. Figure 3: It is not easy to see all the details in this figure – although I do not have specific suggestions for improvement.
7. Line 156-157: As noted above, Wang et al. find an important role for what they call “mean flow advection” for driving the Lavender recirculation along the slope around the Labrador Sea.
8. Paragraph beginning on line 165: Could refer to Brandt et al. (2004, JGR).
9. Line 175: How is EAPE defined? This should be given somewhere.
10. Line 186 and equation (1): Should mention that this is the vorticity equation for the vertically integrated flow. There is also an equivalent vorticity equation for the vertically averaged flow.

11. Lines 205-206: Do the acronyms for these different models get defined somewhere?
12. Line 218: …also the subpolar North Atlantic, as noted above (point 3).
13. Line 221: I would not say the “advection of vorticity” when you are referring to the nonlinear term. It is easy to confuse with the “advection of planetary vorticity”.
14. Line 280: Should “over” be replaced by “within”? Actually, the integral of this term should be very close to zero by construction.
15. Line 294: My only objection here is that the Csanady paper uses dynamics linearized about a state of rest which means that the NL term plays no role, as could, perhaps, be made clearer. However, the comparison with the arrested topographic wave is certainly illuminating.
16. Figure 12: The dashed lines show isopycnal surfaces but which density is this? From the labelling, it must be a potential density of some kind. Please make clear.

Typos and language issues:

1. Line 18: “this” -> “these”
2. Line 19: “drives” -> “drive”
3. Line 31: “low” -> “weak”
4. Line 62: “coordinates” -> “coordinate” in both occurrences.
5. Line 65: “confronted” -> “compared”
6. Line 67: “analuze” -> “analyse”; “it more details” -> “it in more detail”
7. Caption to Figure 2: “of the Irminger Sea” -> “in the Irminger Sea”
8. Line 147: “coherent” -> “consistent”
9. Line 148: “which” -> “who”
10. Line 159: “center” -> “centre of the”
11. Line 160: “North” -> “northward”
12. Line 233: “Gaussian” -> “Gaussian”
13. Line 237: “than” -> “as”
14. Line 303: “Figu.” -> “Fig.”
15. Line 311: “along the Greenland area” -> “near Greenland”
16. Line 317: “transferring” -> “transfer”
17. Line 336: “differs” – “differ”
18. Caption to Figure 13: “hacthes” -> “hatches”
19. Line 388: “inside” -> “interior”
20. References: The reference to Le Bras et al. has some repeat. Please check all the references!