We wish to thank both referees and all those who provided comments for this manuscript for their thorough reading of the manuscript and useful comments. We addressed all points raised as follows:

Anonymous Referee #1

The paper contains interesting and useful results from two experiments reproducing stratified flows: one with heat forcing and one with concentration forcing. Spectra are discussed and spectral law evidenced.
The second experiment using a fresh water source could be better introduced in section 2. It is not clear if a steady state is sought for or if the whole experiment is transient.
page 1511 - para 25 imager should be image ?
Response: No, the imager is the sensor of the video camera.

page 1514 - para 10 There is a typo in Rayleigh
Response: Corrected

page 1518 - para 10 'The values of KR are marked ...' I think what is meant is 'The location of KR' ?
Response: Corrected

In Figure 5 it could be useful to indicate Kf
Response: Done

page 1520 - para 20
'..., the instability as a source of ...' there seems to be a verb missing in the sentence.
Response: Corrected

W.-G. Fruh (Referee #2)

Overall, the paper presents new, interesting and useful experiments and results. Some aspects of the experimental set-up and method are not as clear as they could be. The approach taken for the spectral analysis and some of the key results should be discussed more.

Questions or suggestions to the authors
Thermal forcing
1. Thermal forcing: I found it difficult to interpret the results in Figure 3 without knowing the shape and size of the heating elements. It would help to describe the heating wires in a bit more detail in the experimental technique section (and show a top view of the tank to show the wires). My initial thought was that it would be a spiral of a resistive wire, from the centre to the perimeter but looking at the results it appears to be a set of parallel wires. What is the spacing of the wire? Are the wires on top of the bottom surface as Figure 1 suggests, or are they embedded in the base – if so, how deep? As that

would expect how strongly localized the heat source is to the line of the wire or slightly broadened through the heat conduction through the base.

Response: Following the suggestion of the referee we described the shape of the heating wire and included a figure (Fig. 1 b) which shows the wire pattern and the view of the flow in the beginning of the experiment.

2. Thermal forcing and experimental time: I presume the clock starts counting after the (initially stagnant and isothermal) fluid has reached solid-body rotation, and at the instant when the heating is switched on. Is that right? Is the heat dissipation from the wires maintained at a constant level throughout the duration of the experiment?

Response: Yes, the clock starts when the heating is switched on. It is the constant heat flux setup and the system was not thermally insulated. At certain point in time (after about 45 min) a balance between heat supply and heat loss was achieved.

Saline forcing

3. Salinity: Can you explain the procedure in a bit more detail? If I understand it correctly, the forcing is more through the baroclinicity caused by the density difference between the salt and fresh water, rather than by salinity gradients. Is that right? If so, what is the temperature difference (or the corresponding BruntVaissala frequency / Froude number)? Also, the instability will depend on the depths of the two layers. Can you quantify that?

Response: Yes, the forcing is due to internal dynamics of the stratified sheared flow, the baroclinicity. The salinity difference is 30 ppm. The instability can theoretically be dependent on the depth ratio of the layers. The depth of the upper (fresh) layer varies with radial distance though, so it is far from an idealized constant depth setup. Also, the perturbations seem to be correlated in the radial direction that is perhaps more dynamically significant than a possible dependence on the depth ratio.

4. Fundamental mechanism: If I understood the previous item correctly, I presume that the forcing mechanism is through baroclinic instability rather than direct forcing, since you are setting up a stably-stratified two-layer system. Is that right?

Response: Yes, please see our comment above.

5. Implementation: How do the fresh-water addition and the experimental observation actually relate? It seems from some late comments, that the experiment time starts at the end of the water addition. Is that correct? If so, could you explain what actually happens during the fresh water addition and after? And, would then seem that the experiment would go through a cycle of baroclinic instability (caused by the velocities set up during the water addition), growth of 'baroclinic waves', followed by decay of these waves through friction and possibly other instabilities (e.g. wave breaking / frontal barotropic instability / vertical mixing of fresh-salt water). If so, what are the typical life-spans of the various stages, or the total cycle? As you can see, I struggle to understand and interpret your saline forcing experiment and its results and would welcome more explanation.

Response: We expanded the description of the flow dynamics in Sec. 3.1 to clarify the points raised by the referee.

Spectral Analysis
I am not entirely sure on the area over which you carry out the spectral analysis, and how valid your assertion is that the Cartesian FFT-based spectral analysis is sufficiently accurately in the cylindrical domain is not entirely clear without getting a bit more information.

6. Can you explain and discuss the domain for the spectral analysis a bit better, and what effects turning the cylindrical coordinates into a local Cartesian has? Did I understand it correctly that you are using an annular domain with an inner radius of 8 cm and an outer radius of 42 cm? It might be helpful to show an illustration of the tank and of the analysis domain (with a highly reduced set of points for the 'Cartesian' grid); maybe something like

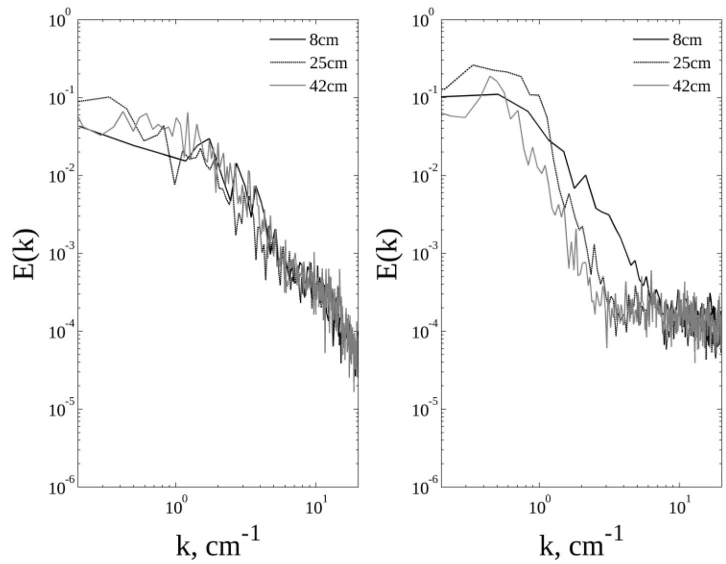
Response: We chose not to include an additional figure in this relatively short paper because the coordinate system is described in the beginning of Sec.3.2 and it is one widely used in oceanography. For the discussion of issues of the wide-gap geometry please also see our response to #8.

7. If the coordinate system is Cartesian centred at r0 = 25 cm, then the distance between two adjacent points on the inner-most ring is made equal to that at the outermost ring. With a radius ratio or 8cm/42cm = 0.19, or a width-to-mean radius of curvature of 34cm/25cm = 1.36, your analysis domain is definitely a 'wide-gap' geometry, where the changes in local curvature would be expected to be fairly large.

Response: Please see our response to #8.

8. Presumably the wave numbers are equally stretched/compressed at radii different from r0 ? What does that mean for 'equating' kx at r = 8 cm (or y= – 17cm) with the same kx at r= 42 cm (or y = + 17 cm)? Would you not expect that small-scale turbulence (of length scale << 2πr) should not be expected to be effected much by the curvature (and hence a true size of a certain size is dynamically similar to features of the same size but at a different radius)? At the other end of the scale, for features approaching the 'length' of the channel, eg. 2πr/N, where N is smaller than, say 5, the 'available' space affects the feature. Would we not expect the wave number N to be more important than the local length scale – and the stretching of the tangential component is valid? Do you think it might be worth generating contour plots of spectral amplitude of in the tangential direction (ie, plot contours of E(kx, y) against kx and y) ?

Response: Yes, indeed, there is an issue of kx wavenumbers being quite different along the inner and outer rings. This results in spectra being somewhat diffused along kx-axis. An advantage of the wide cap is, of course, better resolution of smaller ky wavenumbers. Thus, it is a trade-off. We have also calculated the spectra for a narrow gap of only 3 cm half-width (not shown here). The spectra are somewhat more concentrated in kx-direction but the resolution in the ky is lost. Perhaps, the better thing to do here is to do the Fourier-Bessel decomposition. We are working on this and will report the results elsewhere. We followed the suggestion of the referee and plotted spectra E(kx) measured along three circles of radius r = 8, 25 and 42 cm (see below). The spectra look similar to each other. We did not show this figure in the paper as it only serves as a diagnostic.



9. By the way, the circles and figure-of-eight in Figure 4 are virtually invisible. Is there any way you can make them more prominent?
Response: Done

10. For the discussion of the 1D spectra in Figure 5, it would be helpful to indicate the location (e.g. by a vertical line) of the forcing length scale (spacing of the heating wires 1.4 cm–1 and/or of the thermal forcing length scale 2.5 cm–1 ; the radius of deformation 1.2 cm–1 and the most unstable wave number 0.77 cm–1) and the Rhines scale of 0.45 cm–1
Response: Done

11. Any ideas what determines the length scale of the thermal forcing?
Response: Yes, it is Rd that determines the scale of eddies. Please see discussion in the beginning of Sec 3.1.

12. How do you achieve a spectral range for the 1D wave number of substantially larger than 10 cm–1 with your spatial resolution of 0.2cm x 0.2cm (as you stated earlier)?
Response: there is a factor of 2π there.

13. Page 1520, line 1: 'The steeper slope in the second experiment is due to the particular nature of this two-layer baroclinic flow.' Can you explain or interpret this a bit more?
Response: We believe that the steeper slope is due to the baroclinic nature of this flow (in contrast to barotropic and, therefore, almost 2D flow in the thermal experiment). We modified this discussion to make it clearer.

14. Not everybody might be familiar with the Sobel gradient operators (p.1512, line21). Could you provide a reference?
Response: Done

Typographical points Convention used: ; delete ; {comments}

• p.1508, line 5: top of saline layer • line 16: β-effect …
• line 17: spectra in the wavenumber space {either: become} of a {or: form} a figure eight {It is more commonly referred to as 'figure-of-eight' rather than just 'figure eight'}
• p.1511, line 7: surface of rotating
• line 10: obtain velocity
• line 18: It , however is perfectly
• line 20: paraboloidal … used as a mirror of the Newtonian
• p.1512, line 3: barotropic
• p.1513, line 1-2: Note that in a stratified fluid (as … forcing) velocity.. is, in fact , a barotropic …
• line 6: 2015) and is
• p. 1514, line 12: Rayleigh {missing i}
• p. 1515, line 9: water, an
• line 10: Thus, two-layer
• p.1517, line 2: two-dimensional…
• p.1518, line 21: resembles figure eight
• p.1519, line 2: that turbulent
• line 5: instead (linear)
• line 6: towards k_y
• line 28: presence of – 3 slope
• p.1520, line 1: steeper…
• line 5-6: {This is a bit ambiguous as to whether 'both' refers to the two references cited in the previous sentence or to your two experiments. It would be much clearer to refer to your experiments if you simply started a new paragraph.}
• line 9: wavenumber that indicates
• p.1521, line 2: {'certain': what do you mean by 'certain universality? As opposed to uncertain? If so, why are you certain? If not, do you mean certain as in synonymous with 'specific'? If so, be specific and explain which universality it is}
• line 4: is in a reasonable agreement

Response: All typos are corrected as suggested by the referee.

J. D. Tellez Alvarez
jackson.david.tellez@upc.edu

The interest of this paper in using laboratory experiments to model geophysical complex flows is dual: Besides confirming the role of Coriolis beta effect on the latitudinal range of vortex sizes, the presentation and use of AIV (Altimetric Imaging Velocimetry) may be used both in the laboratory and in Geophysical and Environmental field and satellite analysis.
The technique of applying PIV like spatial and temporal correlation analysis on the Gradients of measured height and presenting its spectra provides very interesting turbulence information in order to examine the rotating stratified flows.

It would be interesting to detail more the way in which the gradient vector field is presented it the plots as a scalar, and what is the range of precision in determining actual heights.

Response: The velocity gradient is represented by color (which can be considered as 2-parameter space). Please see more details of the method in Afanasyev et.al., Exp Fluids 2009

How the Spectra of the height variation of the flow relates to actual Lagrangian Tracer Spectra is assumed from a barotropic behavior of the flow, can you detect any actual baroclinic mixing events and local vorticity production ?

Response: The QG velocity field should be close to one obtained from Lagrangian Tracers if the Rossby number is not too large. It is the case here.

Some specific comments and questions:

1,- in the page 1510 – line 10: you have a concentration of salt 30 ppt, in the brine, why do you decide this kind of concentration, Was the reason to mach the concentration of salt, so the buoyancy was comparable to that due to the heat flux and the thermal gradient experiments?. It would be important to present the Richardson numbers or the buoyancy fluxes for both types of experiments.

Response: We actually did a series of experiment with different salinity difference. They are qualitatively similar and we chose this particular one to discuss spectra in this paper.

2,- page 1511 – line 5. From your comments: Do you think this technique, not only can be extrapolated to determine the vortices in oceanografic context, maybe if can also possible to calculate the vortex induced deformations of the surface in some river estuaries, or in some areas where the river outflow mixes with the ocean salty water. Or in the situation of the Mediterranean outflow in the Atlantic (Meddies)

Response: Altimetry is of course widely used in oceanography. It is all about the sufficient resolution of the data and the applicability of the QG approximation (for velocity calculation).

3,- in page 1512: Because you comment that the velocity was calculate using a (quasi-) geostrophic approximation, which is an indirect method, did you check this method with independent measurements, or have you considered the possibility to generate an alternative field of velocity with direct PIV or with the dispersive characteristic velocity obtained with some floating tracers.

Response: Yes, we did. Please see Afanasyev et.al., Exp Fluids 2009.

4,- From Figure 1: what is the heigh of the camera position in the experiments, and if the position of the camera is vertical. How do you avoid the errors due to the video parallaxing, and how does the rotation affect the sides and centre of the tank, because you have both the slope of the surface flow and the slope (parabolic) of the (salt or heat) interface?

Response: Parabola is not very steep here. We don’t correct for camera parallax because the camera lens is quite good. But it can be done, of course, if need to be.

5,- Figures 4 and 5 showing the spectra of both heat and salt experiments should have the same axes so comparisons are better made

6,-Can you estimate the pdf of vortices (heigh structures) as a function of (Latitude) radial position within the tank, It is clear that vortices near the (Pole) centre are smaller than near the (Equator) sides of the tank. In both experiments plots will be different (as Spectra are also) but could it be possible to collapse the data with a suitable length scale ?

Response: This is a good suggestion, we will look into it and report elsewhere.