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Nonlinear Processes in Geophysics
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Interactive Comment

Interactive comment on "Complex environmental beta-plane turbulence: laboratory experiments with altimetric imaging velocimetry" *by* A. M. Matulka et al.

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The results and presentation of the paper are interesting, the mechanism of generation of Rossby waves and the interaction between buoyancy and rotating effects needs much clarification and a new generation of geophysical fluid dinamics laboratory experiments. It would be interesting to also adress the points on Velocity and Vorticity pdf evolution and Prandtl number depedence on these types of rotating stratified experiments. Other important points adressed in previous work (Matulka 2010, Matulka et al. 2014) are the distributions of stratified vortices and their structure.

With the PIV method it is also posible to estimate eddy diffusivities for scalar transport in order to model the turbulent fluxes in terms of mean gradients. For the velocity correlations or momentum fluxes Boussinesq model gives

$$\overline{u_i' u_j'} = K_{Mij} \frac{\partial U_i}{\partial x_j} \tag{1}$$

Similarly for vertical mass transport, it is assumed that

$$\overline{\rho' u_3'} = K_\rho \frac{\partial \rho}{\partial x_3}$$

The definition of relevant scales in convective and stratified driven flows, include $L_o = (\epsilon/N^3)^{1/2}$ the Ozmidov, scale, $L_b = w'/N$ the overturning scale. defining the Brunt Vaisalla frequency N as,

$$N^2 = -\frac{g}{\rho}\frac{\partial \rho}{\partial z}$$

. With these scales it could be interesting to also state the ratios of N and the Coriolis parameter f for the different experiments performed. Also the differences between the molecular diffusivity of salt solutions and heat

Eddy diffusivities in the geophysics exhibit a large variation and show a marked anisotropy, not only horizontal values are much larger than vertical ones but there is a strong dependence on the spatial extent of the tracer and at larger scales the topology of the basic flow is very important. When buoyancy effects are important, then it is usefull to define the Richardson number

$$Ri = \frac{g \Delta \rho \ell}{\rho u'^2} \ ,$$

where g is la gravity, $\Delta\rho$ the driving density difference, ρ the average density of the fluid, ℓ, the integral scale of the turbulence and u' the r.m.s. velocity produced by turbulence. The Rayleigh number if convection drives the flow should also be presented.

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At the much larger scales, seen in the visualizations of both experimental configurations, some zonal averaging should be presented because large eddies, that are expected to scale on the local Rossby deformation radius, L_R, may also be affected by the tank walls.

This Rossby deformation radius is relevant where there is a balance between rotation and stratification and is defined as

$$L_R = \frac{Nh}{f}$$

where N is Brunt-Vaisalla frecuency, h is the relevant depth and f the Coriolis parameter. The beta plane modification of the local potential vorticity allows a much wider range of local conditions so an statistical valoration of eddy sizes and vorticity pdf's as in (Tarquis et.al 2014, Matulka et al. 2014) is interesting.

A zero - mean correction by filtering under the Rossby radius of deformation estimated for the area as a pass band has been applied to both SAR intensity and the altimeter composite plots. In previous work spatial correlations $R'(r, x, y)$ and the local integral scale ℓ were calculated as

$$< R'(r)(x,y) >= \frac{< h'(x)h'(x+r) >}{\sigma_h'^2}$$

with $<>$ indicating the mean, h' the fluctuating height (or fluctuating SAR intensity) and σ_h' the standard deviation of that value measured locally in order to avoid non-homogeneities which may arise from dynamic effects. Then the integral length scale calculated for the fluctuations as $< \ell'(x,y) >= \int_0^{oo} R'(r)dr$.

This is an alternative way to extract informmation from the spectra as seen in both the experiments presented so some information on the zonal scales and of their autocorrelations may be calculated as a way of detecting dynamically relevant lengthscales.

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The two dimensional spectra of signals such as those shown in figures 3,4, of the NPGD paper could confirm that slope in (+) is greater than that in (o) (-2.26 vs - 1.12) showing larger predominant 2D structure in the first one. The figures show an example of multifractal (akin to spectral) analysis of a section of the non-homogeneous flow with the histogram of vorticity values (Matulka 2010). Note that k^{-3} spectra is typical of 2D turbulence, while $k^{-5/3}$ is typical of 3D turbulence (Kolmogorov spectral law) when both effects appear at different scales, probably the scale needs to include more dimensionless numbers.

It would be interesting to try and set up a wider comparison of different types of Laboratory experiments on mixing in a rotating stratified fluid, which are essential for the development of computer models of geophysical phenomena, because, if better predictions are to be made, the distributions of potential and kinetic energy have to be correctly assessed for each process under study.

Oceanic and atmospheric flows due to their high Reynolds numbers, are turbulent motions under the constraints of geometry, stratification and rotation. At large scales these flows tend to be along isopycnal surfaces due to the combined effects of the very low aspect ratio of the flows (the motion is mostly confined to thin layers of fluid) and the existence of stable density stratification. The effect of the Earth's rotation is to reduce the vertical shear inthese almost planar flows. The combined effects of these constraints produces approximately two-dimensional turbulent flows termed also as geophysical turbulence. In a strictly two-dimensional flow with weak dissipation, energy input at a given scale is transferred to larger scales, because these constraints stop vortex lines beingstretched or twisted. Physically this upscale energy transfer occurs by merging of vortices and leads to the production of coherent structures in the flow that contain most of the energy.

This process seems to lead to the appearance of order from chaos. This scenario is an attractive model for geophysical flows which are known to contain very energetic vortices; these are often the source of helical instabilities that lead to tornados and hurricanes, and the role of convection is fundamental in mantaining these. The mesoscale oceanic eddies and atmospheric highs and lows typical of the weather patterns show an accumulation of energy at the dominant length scale given by their equilibrium Rossby deformation Radius. This scale marks where and when the rotation induced Coriolis forces are in equilibrium with the effect of buoyancy. The upscale transfer of energy is inhibited at the Rossby deformation scale by baroclynic instability at larger scales, which accounts for the dominant observed sizeof geophysical vortices. Different regions of the parameter space based on the local versions of the Reynolds number, the Richardson number and the Rossby number should also be used to compare both laboratory observations and field data as well as the different experiments between themselves (Matulka 2010).

Matulka, A. (2010) Turbulence structure in environmental flows: Effects of stratification and rotation PhD. Thesis. UPC, Barcelona

Matulka, A. , López, P., Redondo, J. M. and Tarquis, A., (2014) On the entrainment coefficient in a forced plume: quantitative effects of source parameters, Nonlinear Processes in Geophysics, 21, 269-278, *http://www.nonlin-processes-geophys.net/21/269/2014/*.

A.M. Tarquis , A. Platonov, A. Matulka , J. Grau, E. Sekula, M. Diez and J. M. Redondo (2014) Application of multifractal analysis to the study of SAR features and oil spills in the ocean surface. Non-Linear Processes in Geophysics 2014, 21, 439-450.

Interactive comment on Nonlin. Processes Geophys. Discuss., 2, 1507, 2015.

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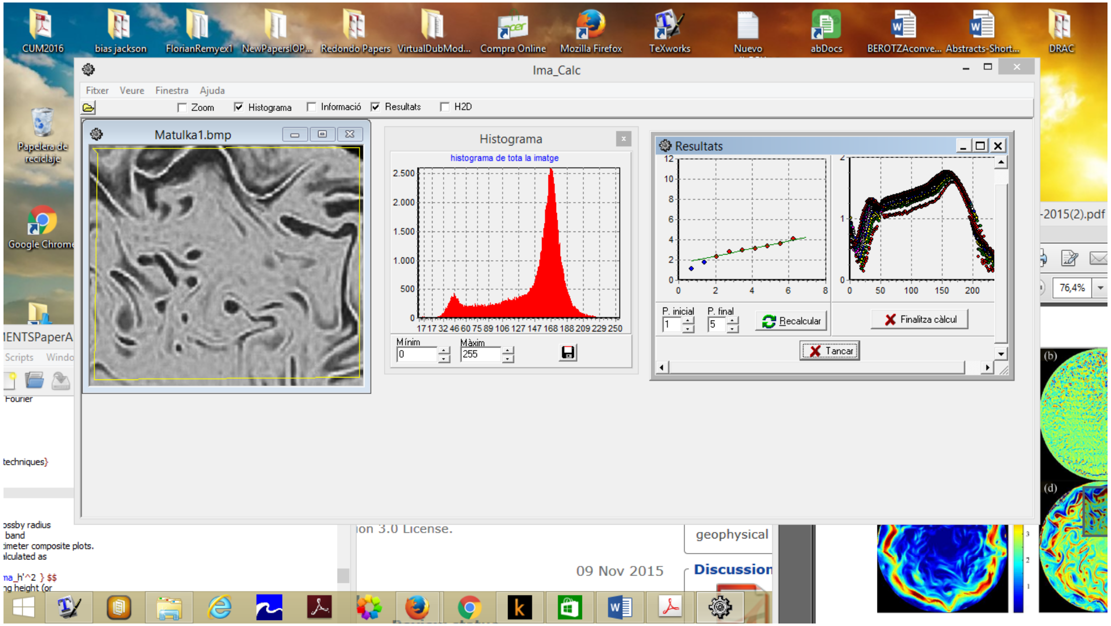

Fig. 1.

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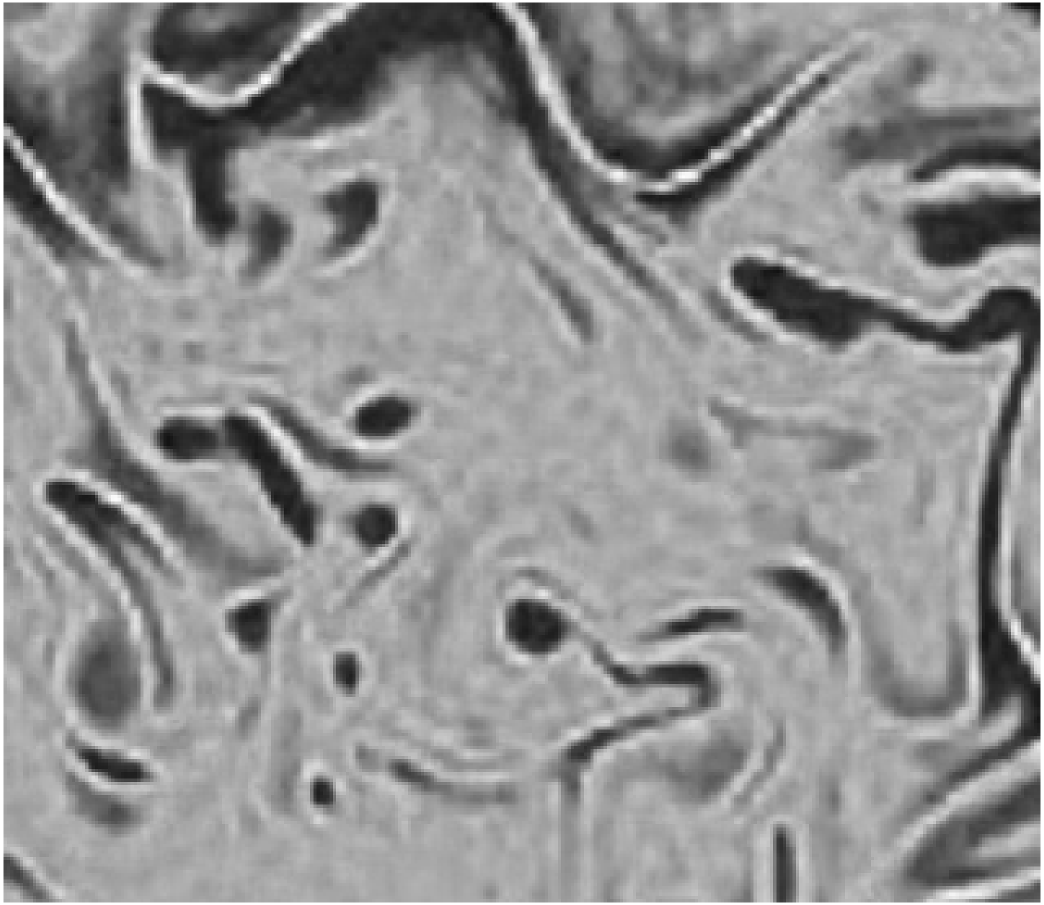

Fig. 2.

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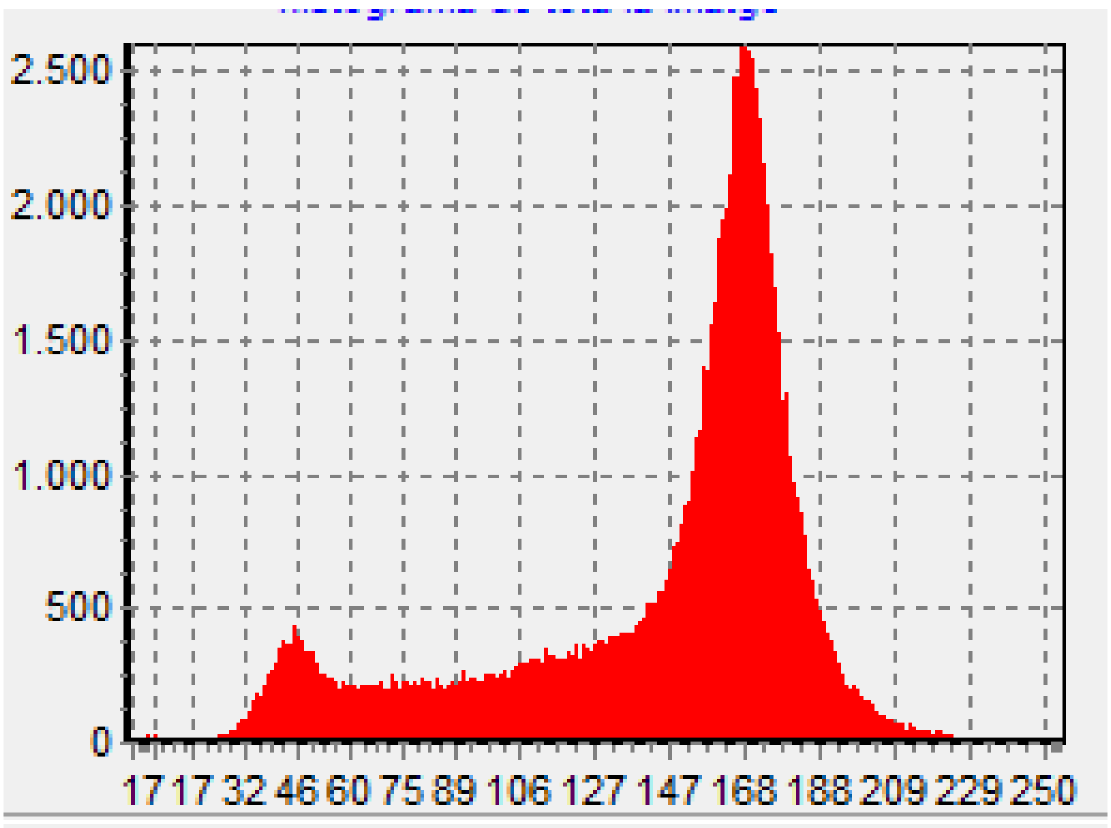

Fig. 3.

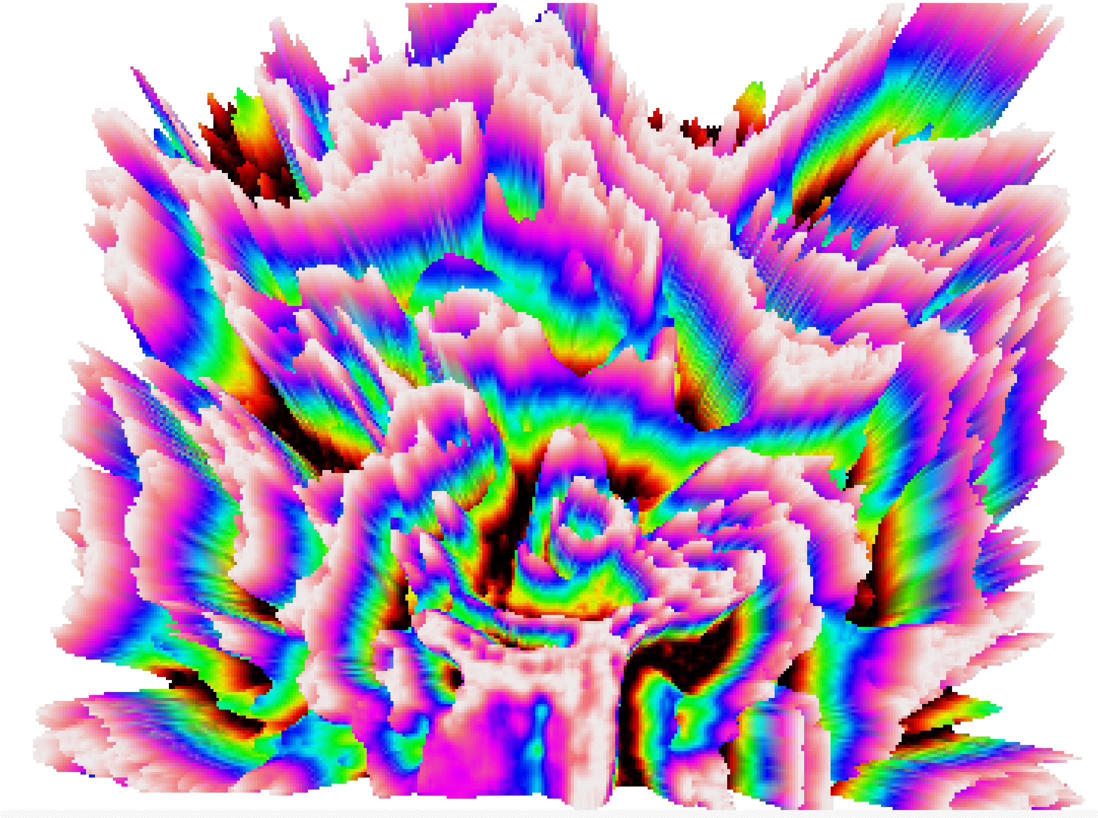

Fig. 4.

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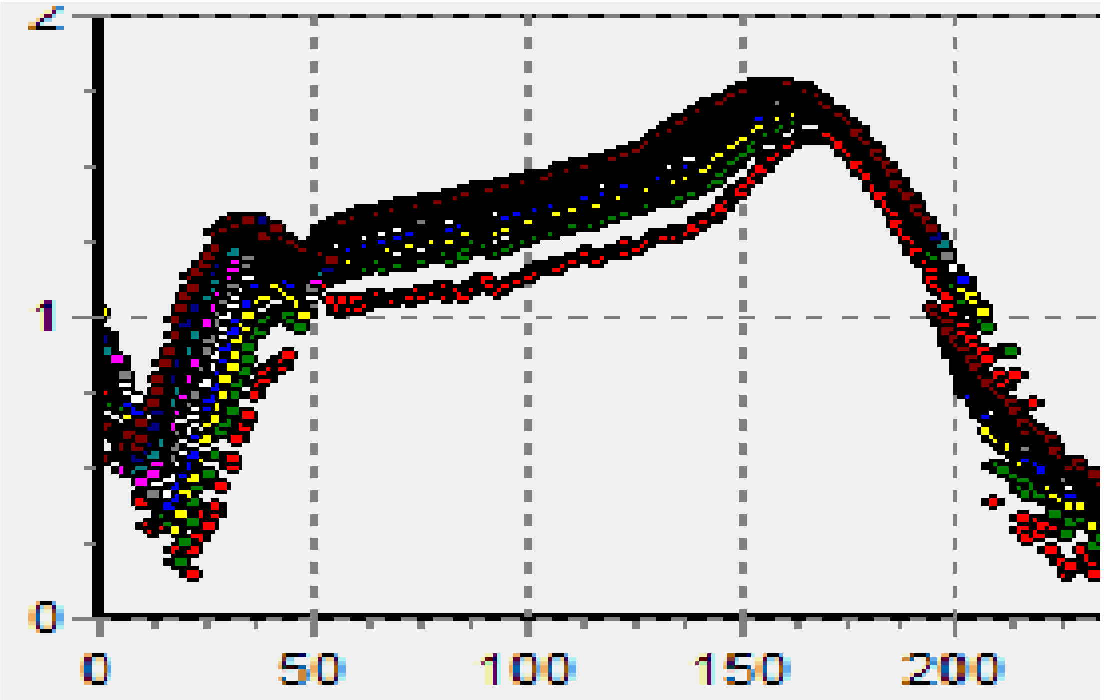

Fig. 5.

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