Vortex tubes in shear-stratified turbulent flows

Marie FARGE[1], Alexandre AZZALINI[1], Alex MAHALOV[2], Basil NICOLAENKO[2], Frank TSE[2], Giulio PELLEGRINO[3] & Kai SCHNEIDER[3]

[1] *LMD-CNRS, École Normale Supérieure, Paris*
24, rue Lhomond, 75231 Paris Cedex 5, FRANCE
farge@lmd.ens.fr

[2] *Department of Mathematics, Arizona State University,*
Tempe, AZ 85287-1804, USA

[3] *Centre de Mathématiques et d'Informatique, Université de Provence,*
39, rue F. Joliot–Curie, 13453 Marseille Cedex 13, FRANCE

Abstract Coherent vortex extraction using wavelets is applied to a shear-stratified turbulent flow computed by Direct Numerical Simulations (DNS) to compute the atmospheric jet stream at the tropopause. The basic state is characterised by a jet centred at the tropopause and stable density stratification profile with increased stratification above the tropopause. Quasi-equilibrium turbulent flow-fields are obtained after long-time integration of the governing equations written in primitive variables using adaptive spectral domain decomposition method. The coherent vortex tubes are extracted from the vorticity and potential vorticity fields, using a nonlinear filtering in wavelet space. It is finally checked that the coherent vortex tubes exhibit the same dynamics as the total flow and therefore drive the residual background flow.

I use without any compunction
A well-chosen wavelet function;
With theorems nice,
And methods concise,
My results are immune to debunction.

1. Shear-stratified turbulent flows

We study a generic situation encountered in geophysical turbulence where there is competition between shear and stable stratification. Stratification produces sheet-like structures ('pancakes') and waves which may inhibit turbulence caused by the shear, and therefore reduce the turbulent mixing. Shear ($\partial_z U(z)$ where $U(z)$ is the mean horizontal velocity profile) tends to destabilise the interfaces and gives rise to Kelvin-