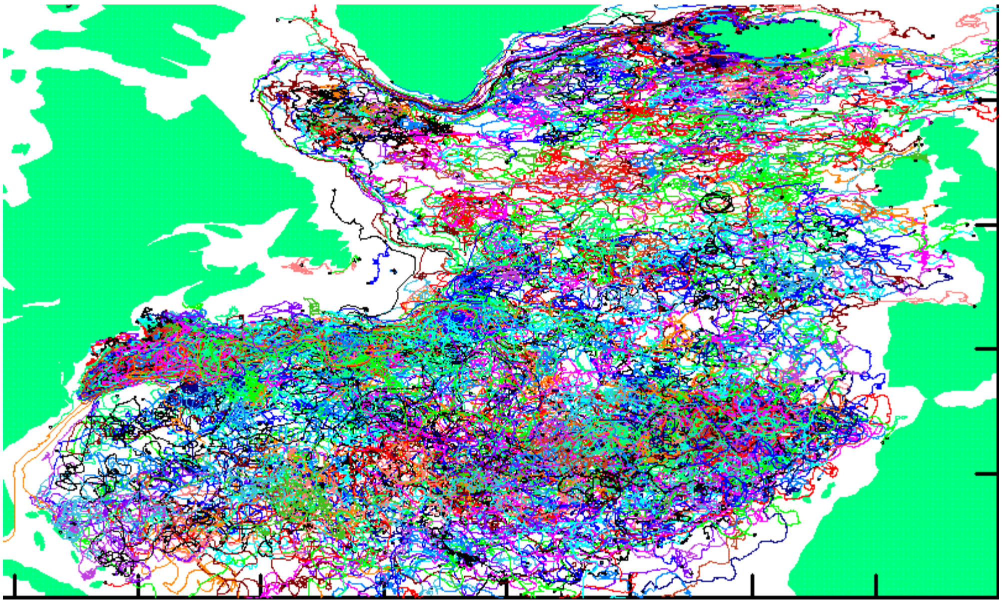
Proposed PhD Research Project:
Material Transport and Stirring in the Ocean

1. Statement of the Problem



Ocean currents and eddies constantly transport and stir huge amounts of water masses and their properties. An efficient way of detecting these processes is by releasing neutral floats and tracking their trajectories (see on Figure a superposition of observed float trajectories in the North Atlantic, indicated by different colors — this is so-called "spaghetti diagram"). An alternative diagnostics of the oceanic material transport and stirring is provided by tracking passive tracer concentrations. On the one hand, the observations show enormous complexity of the transport induced by the combined action of large-scale currents, mesoscale eddies and small-scale processes. This transport turns out to be not only spatially inhomogeneous and anisotropic but also significantly non-diffusive. On the other hand, oceanic general circulation models routinely approximate the unresolved, eddy-induced material transport as homogeneous and isotropic diffusion process. This dire situation ensures great potential not only for upgrading the diffusion approach, but also for developing new simple models of material transport, that are physically consistent and more accurate.

The *goal of this Project* is to investigate material transport and stirring properties in idealized but dynamically consistent and structurally rich eddying-flow simulations, and to use these analyses for developing a new generation of simple transport models.

2. Milestones of Analysis

The Project will involve simulations of several idealized types of geostrophic turbulence. Subsequent kinematic analyses of these solutions aimed at their transport and stirring properties will be used for developing simple stochastic and deterministic transport models for practical applications. The following research agenda is planned.

• Statistical analyses of ensembles of Lagrangian particles; single- and two-particle dispersion laws, Lagrangian autocorrelations, Lyapunov exponents, etc.;

• Estimates of effective diffusivities, quantification of non-diffusive behaviours, transport barriers and surf zones;

• Inhomogeneous and anisotropic diffusion modelling of transport;

• Direct modelling of transport (high-order Markov models, Levy flights, fractional Brownian motion, etc.);

• Indirect modelling of transport by random kinematics;

• Dynamical underpinnings and interpretations for kinematical transport and stirring properties.

References

Rypina, I., I. Kamenkovich, P. Berloff, and L. Pratt, 2012: Eddy-induced particle dispersion in the near-surface North Atlantic. *J. Phys. Oceanogr.*, **42**, 2206–2228.

Berloff, P., and J. McWilliams, 2003: Material transport in Oceanic Gyres. Part III: Randomized stochastic models. *J. Phys. Oceanogr.*, **33**, 1416–1445.

Berloff, P., and J. McWilliams, 2002: Material transport in oceanic gyres. Part II: Hierarchy of stochastic models. *J. Phys. Oceanogr.*, **32**, 797–830.