Geophysical Research Abstracts,
Vol. 11, EGU2009-6535-3, 2009
EGU General Assembly 2009

Deep Water Oceanic Wakes: a simple case study

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In present study we investigate the formation and evolution of oceanic wakes generated by obstacle of a real island shape (in our case – Madeira island) but without consideration of bathymetry around it.

Numerical simulations using Regional Ocean Modeling System (ROMS) are presented. ROMS is a free-surface, terrain-following, primitive equations ocean model (Shchepetkin and McWilliams, 2005). Numerical models are often used to study the formation and evolution of the leeward, mesoscale and sub-mesoscale flows around of islands (Dietrich et al., 1996; Dong et al., 2007; Heywood et al., 1996).

Madeira archipelago is a group of deep-sea islands located at Northeast Atlantic at about 33ºN, 17ºW. The biggest island of the archipelago is Madeira Island with about 50 km in east-west and 20 km in north-south direction. Its obstruction to the incoming oceanic and atmospheric flows induces leeward wake instabilities. This phenomena is observed using remote sensing and field data (Caldeira et al., 2002).

We use the similar methodology to study Madeira island wakes problem as it was presented at Dong et al., 2007. The main difference between their study and ours is that they carried out experiences with an idealized cylindrical obstacle and we are using an island with its real shape at the surface and with vertical sides.

The island was centered in a geostrophic channel like configuration with a prescribed surface intensified meridional (southward) inflow at the upstream boundary (i.e., our study is dedicated to the wakes, generated at the eastern and western part of Madeira Island). Eastern and Western channel boundaries were set to slippery-tangential and zero normal conditions, whereas boundaries around the island were set to zero-normal and no-slip flow. A clamped condition with a sponge layer was applied at the southern outflow boundary for outgoing current and density profile. The initial conditions for the entire domain were set equal to the upstream boundary condition expect at the island points.

Our numerical simulations were devoted to study of various dynamical flow regimes. Obtained results showed that oceanic wakes formations were sensitive to three dimensionless parameters that representing a ratio between inertial and frictional forces – Reynolds number (Re), rotational effects – Rossby number (Ro) and stratification effects – Burger number (Bu). Wake asymmetries induce different behaviour for cyclonic and anti-cyclonic eddies than that showed by Dong et al., 2007.

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