Island wake dynamics: Madeira Archipelago case study

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Abstract

Madeira is a deep-sea island located in NE Atlantic ($33^{\circ}N; 17^{\circ}W$), its obstruction to the incoming oceanic and atmospheric flows induce leeward wake instabilities. The phenomena is frequently observed using remote sensing and field data [1]; [2]. Numerical models are often used to study the evolution of the leeward, mesoscale and sub-mesoscale, flows around the archipelagos [3]; [4]; [5]. The Regional Ocean Modeling (ROMS) is a free-surface, terrain-following, primitive equations ocean model. The hydrostatic primitive equations for momentum are solved using a split-explicit time-stepping scheme. A cosine shape time filter, centered at the new time level is used for the averaging of the barotropic fields. Time-discretized uses a third-order accurate predictor (Leap-Frog) and corrector (Adams-Molton) time-stepping algorithm. A third-order upstream biased was used for advection in order to allow for the generation of steep gradients in the solution. A methodology similar to [4] was followed to study the deep-sea island wake problem, in a three-dimensional mode. Nevertheless, unlike [4], a realistic representation of Madeira Archipelago bathymetry replaced the idealized cylinder. The depth was assumed uniform around the islands, in order to be able to isolate the effect of the islands per se, from the effect of the surrounding seamounts. The island was centered in a geostrophic channel like

configuration with a prescribed inflow at the upstream boundary such that the zonal current depended only on the vertical shear. East(E) and West(W) channel boundaries were set to slippery-tangential and zero normal conditions, whereas boundaries around the islands were set to zero-normal and no-slip flow. Results showed that oceanic wakes regimes were sensitive to three dimensionless parameters [6]: Reynolds number (Re), Rossby number (Ro), and Burger number (Bu). Von Kármán vortex street generation was showed in regimes of Re$\geq$100 .Wake asymmetries induce different behaviour for cyclonic and anticyclonic eddies than that showed by [4] . Multiple islands wake interferences affect eddy shedding behavior.

Keywords: island wakes, ROMS- Regional Ocean Modeling System, wake instability, eddy shedding, mesoscale flows, Madeira Archipelago.

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