

Simulating the Possible Long-term Fate of Oil Released in the Deepwater Horizon Incident

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An ensemble of idealized tracer-release simulations have been performed with an eddy global ocean circulation model in order to understand the possible fate of oil discharged in the Deepwater Horizon incident. Based on statistics of the resulting dispersion, it is found that tracer in the top 800 meters of the ocean is likely to exit the Gulf of Mexico within approximately 6 months. However, this should be interpreted as an extreme scenario because this idealized tracer does not include many important physical and chemical processes that affect real oil in the ocean.

An oil-well blowout occurred at the Deepwater Horizon Mississippi Canyon 252 wellhead on 20 April 2010, at a depth of 1522 meters in the Gulf of Mexico. One issue of concern is whether the oil will enter the swift Gulf of Mexico loop current and ultimately be transported into the Atlantic Ocean. The loop current, which is a part of the large-scale western boundary current system of the Atlantic, enters the Gulf through the Yucatan Channel and exits in the Florida current via the Florida Straits. The clockwise configuration of the current is highly variable in both space and time. Due to dynamical flow instabilities, the current sheds loop current eddies at irregular intervals. These eddies typically travel west, dissipating weeks to months later in the western Gulf, but sometimes reattaching to the loop current a number of times before remaining fully detached.

It is not possible to deterministically forecast the fate of the oil on a time scale of weeks to months. However, it is possible to run a large number of ocean model simulations, each of which is characterized by a very different loop current evolution, and obtain a statistical (ensemble averaged) understanding of where a passive dye released at the site of the spill is likely to go, and on what time scales. Dye tracers are routinely used in ocean circulation models to help quantify dispersion.

We investigated a suite of scenarios for the possible fate of the oil on a time scale of several months to a year from the time of the spill. We employed an eddy-resolving (1/10th degree) global ocean model for an ensemble of dye-tracer-release simulations, each experiencing a different

realization of ocean currents. The simulations used a fully global configuration of the LANL Parallel Ocean Program (POP), now the ocean component of the National Center for Atmospheric Research (NCAR) Climate Community System Model (CCSM). The goal of this study was to provide a range of scenarios tracking where a dye released at the Deepwater Horizon spill site is likely to go and to provide estimates of the possible range of time scales over which dye would be likely to exit the Gulf and join the basin scale surface circulation in the western North Atlantic Ocean. The model is not a forecast model (such as a weather prediction model)—rather, the result is a statistical ensemble of simulations to bracket the range of likely outcomes under climatological atmospheric forcing. The simulations also do not account for losses of oil due to skimming and burning of surface slicks, or to chemical, biological, or physical degradation of oil or oil-dispersant mixtures. As such, the model provides an upper bound of dispersal relative to actual oil.

We conclude that dissolved oil, or an oil-water-dispersant mixture, in the top 800 meters of the ocean is likely to enter the Atlantic Ocean within roughly 6 months from the initial spill date (Fig. 1). The amount of oil may be significantly reduced, however, if physical, chemical, and biological processes act strongly on time scales of weeks. If the oil leaving the Gulf is in the form of tiny droplets in the water column, it will not be detectable as a surface slick. Since the model dye remains offshore in the gulf stream, it appears to be unlikely that large amounts of oil will reach the shores of eastern North America unless it is driven

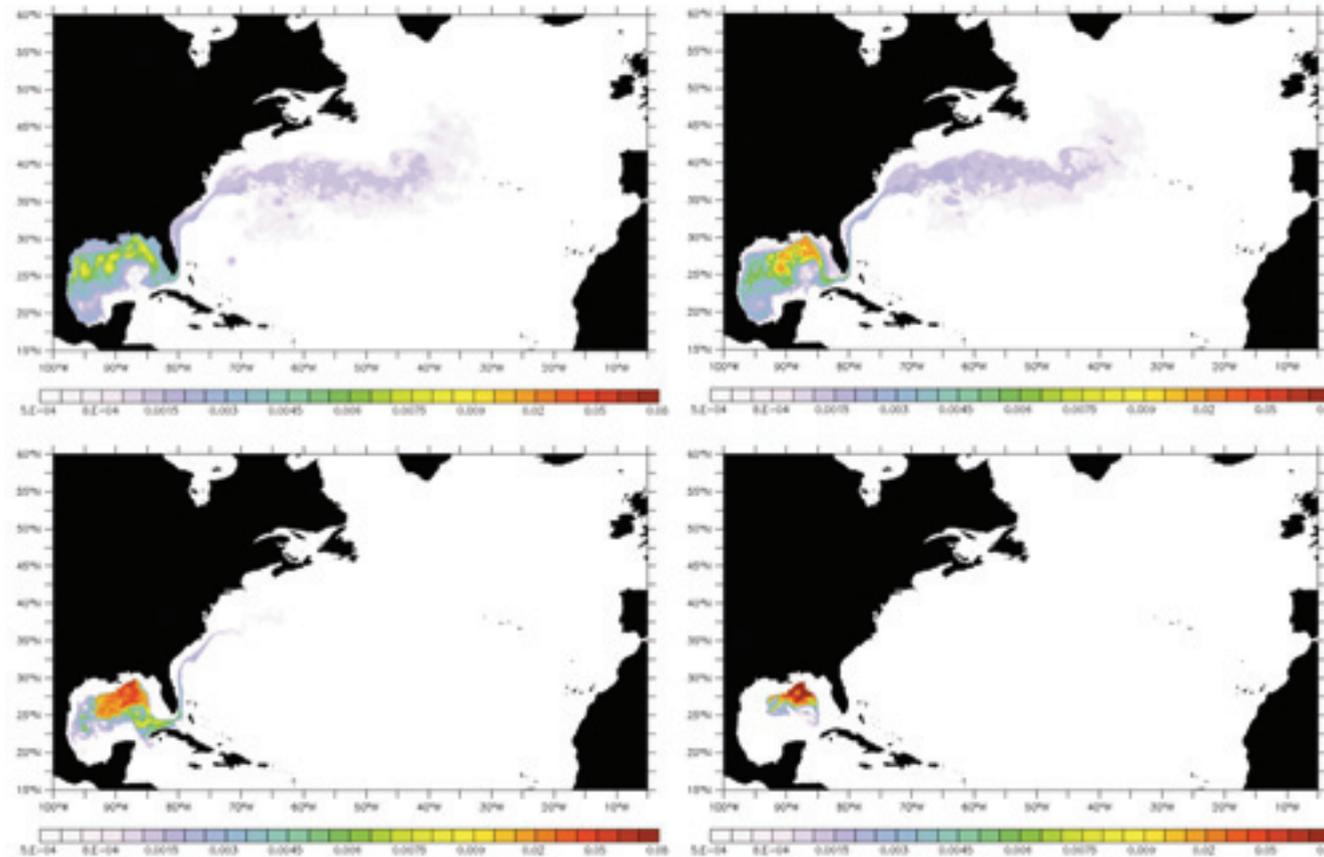


Fig. 1. Mean dilution factors (ratio of total amount of dye in the water column to the amount injected at the source) based on a five-member ensemble 1 year after the initial spill: (upper left) dye release at 0-20 m depth; (upper right) dye release at 20-210 m depth; (lower left) dye release at 210-800 m depth; (lower right) dye release at 800-1500 m depth. Color represents dilution factor on a logarithmic scale.

there by strong winds or small-scale currents. We conclude that it is even more unlikely that any of the oil or oil-water-dispersant mixture released in the Deepwater Horizon incident will reach Europe in detectable amounts—rather it will most likely become highly diluted in a region centered around the gulf stream within the North Atlantic Ocean. The researchers expect that oil at the greatest depths will undergo relatively little mixing and advection by the sluggish currents at 800–1500 meters. Therefore the deepest oil is likely to remain largely confined to an area within a few hundred miles of the spill site 1 year later.

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