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Deposition of Deepwater Horizon oil spill on Florida and Alabama beaches: At the surface and beneath

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The April 20, 2010, explosion of the Deepwater Horizon (DWH) offshore drilling rig led to the largest oil spill in U.S. waters. An estimated 4.9 million barrels of crude oil was released during an 84-day period. The directly spilled oil has been depositing on the sandy beaches along the northeast Gulf of Mexico over a 3-month period. In this field-oriented study, we investigate the deposition of oil along 300 km of sandy Alabama and Florida barrier-island beaches. Five physical forms of oil contaminations are distinguished: 1) tar balls: discrete accumulations of oil <10 cm in diameter; 2) tar patties: discrete accumulations of oil >10 cm in diameter; 3) tar cakes: tar patties exceeding 3 cm in thickness; 4) oil sheets: discrete, but spatially continuous accumulation of oil >5 m in length or width; 5) oil stains: a visible thin veneer of oil coating sediment grains, which cannot be mechanically separated from the sediment, as compared to the other four forms of oil contamination.

Beach oiling from the DWH spill has been occurring sporadically over time, rather than at a constant and predictable rate. The initial beach-fall of oil along the Florida and Alabama coasts occurred in late-May to early-June 2010 in the form of tar balls and tar patties, identified along a 160 km stretch of beach. Another major beach-fall event occurred in late-June, with oil deposits taking the form of tar balls, tar patties, and oil sheets, but at a smaller longshore length scale of approximately 20 km. The above two beach-fall events are associated with an extended period of calm wave conditions, typical of May and June climate in the northern Gulf of Mexico region. Although Hurricane Alex, the first tropical storm of the 2010 season, made landfall over 800 km to the southwest of the research sites, it resulted in higher wave energy and deposition of all five forms of oil contamination along the studied beaches.

Cross-shore deposition of oil on the beach surface is found to be related to wave runup, including both runup of individual waves as well as maximum runup associated with high-tide. The deposition of oil contaminants follows the path of individual wave runup. Compared to the typically thin line of oil deposition associated with the individual runup, a more concentrated zone of oil is deposited at the maximum runup during high-tide, representing a longer temporal scale (∼ one hour) than individual wave runup (seconds). Surficial beached oil tends to distribute between the active berm crest landward to the maximum wave runup.

In addition to the surficial oil deposition, all forms of oil contamination were also observed beneath the surface of the beach, buried at various depths of up to 60 cm within several tidal cycles. Particular beach environments have specific oil contamination signatures; for example, buried oil is the dominant mode of oil contamination in the foreshore, while surficial oil dominates areas of maximum high-tide runup. Between the active berm crest and maximum high-tide runup, both surficial and subsurface oil contamination are present.

Although the longshore distribution of oil contamination intensity along the 300 km stretch of studied beaches shows a general decreasing trend towards the east, substantial local scale variations, on the order of 5 km, were observed. The variations at a local scale are controlled by the chaotic migration of the oil patches offshore and the erosive/accretionary tendency of the beach. Although not directly visible, buried oil may have a more detrimental and longer-lasting impact to the beach and nearby environments as compared to surface oil.