Tropical System Impact on Oil Spills

A compilation of theories

Major contributors:
Jeff Masters, Weather Underground and Dennis Feltgen, National Hurricane Center

A major concern with the Deepwater Horizon oil spill is the possibility for the oil to move southwards and become entrained into the mighty Gulf of Mexico Loop Current, which would rapidly transport the oil through the Florida Keys, impacting northwest Cuba, South Florida, the western Bahamas, and the U.S. East Coast all the way to Cape Hatteras, North Carolina. As summer gets closer, the incidence of cold fronts making it far enough south to bring an extended period of offshore northerly winds to the Gulf of Mexico decreases.

That makes a tropical storm or hurricane as perhaps the most likely weather event to push a significant amount of oil, even heavy concentrations of oil, into the Loop Current. A tropical storm hitting the Panhandle of Florida would do the trick, by bringing northerly winds over the oil spill location, thanks to the counter-clockwise flow of air around the storm. Looking ahead to June, June tropical storms tend to form in the Gulf of Mexico, and we've been averaging one June storm every two years since 1995. This year, the odds of a June Gulf of Mexico storm are probably a little lower than usual. While Gulf of Mexico sea surface temperatures are near average, wind shear from our lingering El Niño will probably be above average. Since 1995, there have been three June tropical storms in the Gulf of Mexico that have followed a track capable of pushing oil into the Loop Current. These storms were Hurricane Allison of 1995, Tropical Storm Allison of 2001, and Tropical Storm Arlene of 2005.

From May 6, 2010. A comparison of the size of 2008's Hurricane Gustav with the size of the Gulf oil spill. The spill is only about 60 miles in diameter, while a hurricane like Gustav is typically 400+ miles in diameter.

With hurricane season fast approaching and the oil spill in the Gulf of Mexico likely to still be around once hurricane season starts in June, how will oil affect any hurricanes that might traverse over the spill and how might a hurricane's wind and storm surge affect the spill?

From the time of the ancient Greeks to the days of the wooden ships and iron men, mariners dumped barrels of oil onto raging seas to calm them during critical moments of violent storms. Oil does indeed calm wind-driven waves, thanks to the reduction in surface tension of the water that oil causes. The reduction of surface tension impacts the flow of air above the water, and reduces the amount of sea spray thrown into the air, both of which could affect the wind speed. Oil also helps calm raging seas by switching off of the wind energy input needed by the wave to break. This occurs because the surface film of oil prevents the generation of ripples on the exposed crests of the waves, and this smoother surface makes the wind less able to grab onto the wave and force it to break.

So, what would happen to a hurricane that encounters a large region of oily waters? A 2005 paper by Barenblatt *et al.* theorize that spray droplets hurled into the air by a hurricane's violent winds form a layer intermediate between air and sea made up of a cloud of droplets that can be viewed as a "third fluid". The large droplets in the air suppress turbulence in this "third fluid", decrease the frictional drag over the ocean surface, and accelerate the winds. According to this theory of turbulence, oil dumped on the surface of the ocean would reduce the formation of wind-whipped spray droplets, potentially calming the winds. However, the turbulence theory has been challenged by other scientists. Turbulence expect Julian Hunt at University College London, UK, remarks, "I am very doubtful about this approach." Hunt studies turbulence both theoretically and in the laboratory, and believes that the high wind speeds in a hurricane are not caused by sea spray.

Oil reduces evaporation: Hurricanes are sustained by the heat liberated when water vapor that has evaporated from warm ocean waters condenses into rain. If one can reduce the amount of water evaporating from the ocean, a decrease in the hurricane's strength will result. Oil on the surface of the ocean will act to limit evaporation, and could potentially decrease the strength of a hurricane. However, if the oil is mixed away from the surface by the strong winds of a hurricane, the oil will have a very limited ability to reduce evaporation. Dr. Kerry Emanuel of MIT performed some tests in 2002 to see if oil on the surface of water could significantly reduce evaporation into a hurricane. He found that the slick quickly dissipated under high wind conditions that generated rough seas.

Conclusion

A tropical cyclone in its formative stage--as either a tropical depression or a tropical storm with 40 mph winds--might be adversely affected if it encountered the Gulf of Mexico oil slick, due to the reduction of evaporation into the storm. However, a full-fledged hurricane would mix the oil into the ocean to such a degree that the storm would not see any significant reduction in strength nor have an impact on a hurricane's path or storm surge levels. Oil would also not have significant effect on water temperatures, which need to be about 80 degrees for hurricane formation.

The oil slick is currently Puerto Rico-sized. While a hurricane tends to be Texas-sized, the oil slick at its current size is not large enough to have a significant impact on a hurricane's intensity. The heavier concentrations of the slick are about 60 miles across, and it would take a hurricane about four hours to traverse the spill at a typical hurricane forward speed of 15 mph, which would be an insufficient amount of time to have any appreciable impact. Furthermore, the slick is within 50 miles land, and interactions with land will dominate the behavior of a hurricane that gets that close to the coast.

A hurricane would significantly dilute the oil, but it also could scatter the oil over a wider area. If the layer of oil is thin, high winds and seas will mix and 'weather' the oil, which helps accelerate the biodegradation process. However, there is the chance for windborne oil particles from sea spray to be moved inland. Also, strong winds and the resulting wind driven storm surge could potentially move large quantities of offshore oil closer or even onto shore. It would likely be in the form of tarball or tarmats since rough wave action would likely break any large segments or oil apart, but if a large storm surge impact was expected, tarballs could be carried as much as 2-6 miles inland, which could pose significant ecological impacts.

Unfortunately, there is a chance that we'll get a real-world opportunity to see what will happen. June tropical storms tend to form in the Gulf of Mexico, and we've been averaging one June storm every two years since 1995. This year, the odds of a June Gulf of Mexico storm are probably a little lower than usual, but Jeff Masters believes there is a 20% chance that a June tropical storm in the Gulf of Mexico could interact with the oil spill and transport more oil into the Loop Current. Other scientists place the odds at little higher around 40%.