Insights from oil spill air pollution study have applications beyond Gulf

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In a study published in the journal *Science*, scientists from the University of Miami and NOAA formed part of a national research team to find two plumes of oil-based pollutants downwind of the BP Deep Water Horizon oil spill. The publication offers new insight into the mechanism by which the crude oil traveled from the sea surface to the atmosphere. Aerosol concentrations were tested during two flights, on June 8 and June 10, aboard a specially equipped NOAA WP-3 Orion aircraft. Credit: Dan Lack/NOAA

During a special airborne mission to study the air-quality impacts of the BP *Deepwater Horizon* oil spill last June, NOAA researchers discovered an important new mechanism by which air pollution particles form. Although predicted four years ago, this discovery now confirms the importance of this pollution mechanism and could change the way urban air quality is understood and predicted.

The NOAA-led team showed that although the lightest compounds in the oil evaporated within hours, it was the heavier compounds, which took longer to evaporate, that contributed most to the formation of air pollution particles downwind. Because those compounds are also emitted by vehicles and other combustion sources, the discovery is important for understanding air quality in general, not only near oil spills.

"We were able to confirm a theory that a major portion of particulate air pollution is formed from chemicals that few are measuring, and which we once assumed were not abundant enough to cause harm," said Joost de Gouw, lead author of a new paper on the finding, published in the March 11 edition of *Science*.

De Gouw is an atmospheric scientist in the Chemical Sciences Division of NOAA's Earth System Research Laboratory in Boulder, Colo. and a Fellow at CIRES, the Cooperative Institute for Research in Environmental Sciences at the University of Colorado at Boulder.

NOAA sent a research aircraft to the Gulf region in June 2010 to help other agencies assess pollutant levels in the air (data are published here). The Lockheed WP-3D Orion aircraft, best known as NOAA's "hurricane hunter," was in California for an air quality and climate science mission. When diverted to the Gulf, the P-3 was already loaded with instruments designed to measure many types of air pollution particles — including "organic aerosol" — and the chemicals from which they are formed in air.

Organic aerosol, or OA, makes up about half of the air pollution particles in polluted U.S. cities. Air pollution particles can damage people's lung and heart function, and they also affect climate, with some aerosol, including OA, partially offsetting the warming from greenhouse gases by reflecting incoming sunlight or changing cloud properties, and other aerosol amplifying warming by increasing the amount of sunlight absorbed in the atmosphere.

De Gouw said he and his colleagues knew where to expect OA particles downwind from the oil spill based on conventional understanding: OA should form when the most lightweight, or "volatile," components of surface oil evaporate, undergo chemical reactions, and condense onto existing airborne particles.

Twenty to 30 percent of the surface oil fell into this volatile category, evaporating into the atmosphere within hours, according to the new analysis. That gave it little time to spread out, so emissions came from the area immediately surrounding the spill. A steady wind — such as the one blowing during a June 10, 2010 research flight — drew those emissions into a thin, linear streak of pollution in which organic aerosol was expected to form.

"But that's not what we saw," de Gouw said. "We saw this very broad plume of organic aerosol instead." OA levels in that plume were similar to levels found in U.S. urban air.

So de Gouw and his colleagues set about trying to figure out what else might have contributed to the pollution particles. In 2007, other atmospheric scientists had proposed that heavier or "less volatile" components could theoretically help to create OA, but it had proven to be near impossible to study this process in the real world.

"The problem is that the heavier and lighter species are emitted at the same time from the same sources, so we could not study them separately in the atmosphere until *Deepwater Horizon*," de Gouw said.

Heavier components of oil take longer to evaporate, so they had more time to spread on the surface farther from the spill source than their lightweight siblings. When de Gouw and his colleagues ran a series of models showing how spilled oil spread across the Gulf, and how long it should take for various heavy, medium, and light fractions to evaporate, the conclusion was clear. The heavier, less-volatile compounds from the oil — that were not actually measured by all the sophisticated instruments onboard the aircraft — were the culprit.

These heavier compounds are not measured in most air quality monitoring programs, which were designed to capture the conventional contributors to poor air quality. The new findings may also help understand why there is more organic aerosol in the polluted atmosphere than scientists can explain.

"This chemistry could be a very important source of aerosol in the United States and elsewhere," de Gouw said. "What we learned from this study will actually help us to improve air quality understanding and prediction."

Provided by NOAA