Scientists and the Navy Join Forces

NATO SEEKS ADVICE TO AVOID COLLATERAL ENVIRONMENTAL DAMAGE

by Lonny Lippsett

An intriguing email landed in Chris Reddy's inbox in February 2016. It was the electronic equivalent of a cold call from Lt. Cmdr. Jason Ziebold of the U.S. Navy, who was soliciting Reddy's help.

Reddy, a marine chemist at Woods Hole Oceanographic Institution, is an expert on oil spills, and Ziebold knew that he had played a big role during the Deepwater Horizon disaster in 2010. So when Reddy called back, he presumed Ziebold might be an environmental health and safety officer.

"He said, 'Nope, I blow [stuff] up,' " Reddy said. "But he had the presence of mind to know that when you do, you can make a big mess. He was asking for expertise on how to avoid a Deepwater Horizon-like oil spill."

Ziebold was planning for a North Atlantic Treaty Organization military exercise called Cold Response 16, which was desginated to take place in and off the coast of Norway. In the scenario, an adversary country, Norlandia (northern Norway), invaded a NATO ally, Highland (central Norway). NATO forces were charged with repelling the Norlandian invasion.

Among the exercise's goals was to defeat the enemy while limiting causalities and damage to allies' critical infrastructure, such as power plants, airports, and hospitals. But commanders and planners for Cold Response 16 also wanted to limit harm to fisheries and aquaculture from the sinking of ships designed to refuel other ships. Norway has the largest fishing industry in Europe and second by value in the world. Ziebold was charged with researching ways to minimize significant environmental, economic, political, and publicity impacts of a potential oil spill.

Reddy briefed Cold Response 16 planners on various case studies of previous oil spills, including Deepwater Horizon,

To Forecast Rain, Look to the Ocean

SCIENTISTS EXPLORE COMPELLING NEW WAY TO PREDICT SEASONAL RAINFALL

by Lonny Lippsett

Ever since humans have existed on Earth, they have looked to the heavens to forecast rain. But more reliable clues may lie in the ocean.

New research by scientists at Woods Hole Oceanographic Institution has found clear links between saltier regions in the North Atlantic Ocean in the spring and increased rainfall during the following summer over areas of Africa and the United States. The discovery offers potential breakthroughs to predict rainfall in regions "where even slight variations in rainfall can be a matter of life or death for millions of people," said Laifang Li, a WHOI physical oceanographer.

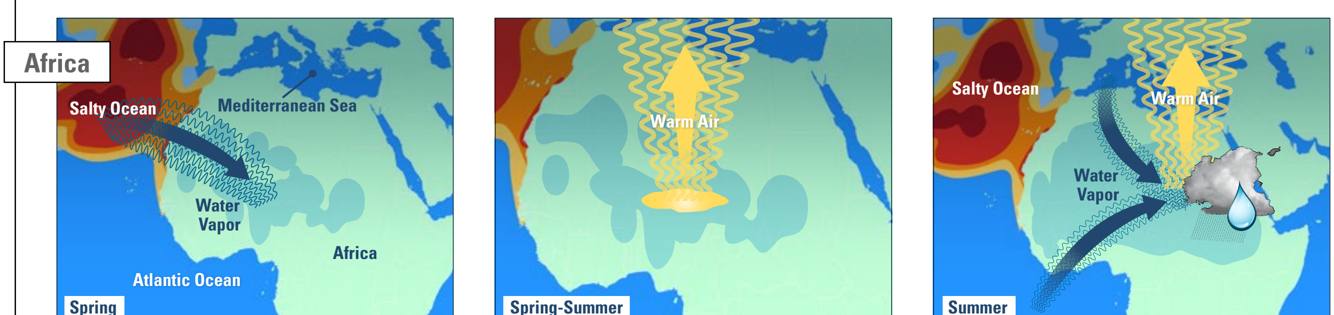
Li and colleagues suggest that saltier-than-normal areas in the ocean indicate places where evaporation has increased—leaving salt behind and putting more fresh water vapor into the atmosphere. The researchers tracked how water that evaporated over ocean regions eventually rained on certain regions on land.

Each year, an estimated 100,000 cubic miles of water evaporates from the ocean's surface—enough to flood our entire lower 48 states to a depth of 180 feet. About 90 percent of this moisture precipitates right back into the ocean—a vast recycling of moisture that represents the bulk of our planet's water cycle. But about 10 percent of the evaporated water gets carried over land and precipitates there.

Li and WHOI colleagues Ray Schmitt, Caroline Ummenhofer, and Kris Karnauskas analyzed 60 years of data on rainfall and ocean salinity. Schmitt and colleagues used detailed salinity maps generated by NASA's *Aquarius* satellite to identify a patch of the North Atlantic with the highest salt concentrations anywhere in the open ocean.

Li and Schmitt drew a box around the area and explored the central question: Where did all the evaporated fresh water from that area go? They found that it went to the Sahel region in northern Africa. And across the ocean, they found that evaporation that left saltier areas in the western Atlantic and the Gulf of Mexico led to more rainfall in the United States Midwest.

The water isn't directly or quickly transported from ocean to land, however. Upon closer analysis, they found a more complicated process that creates a three-month lag time.



Evaporation leaves ocean saltier. Water vapor is transported to Africa, where it builds up soil moisture.

Moist soil draws heat from the sun, warming and moistening the air above the soil. Warm, moist air rises.

Rising air draws in moist air from surrounding oceans, increasing rainfall.

and put them in touch with other academic, government, and industry experts. They advised Navy officials on how jet fuel behaves differently than diesel fuel in the environment and how each affects marine life differently.

They recommended that military planners avoid sinking a ship in shallow waters near land and that they take advantage of offshore winds and outgoing tides that would move oil away from shore. They also provided information on environmental impacts in the event of a shallow-water sinking. Based on their recommendations, NATO forces fictionally "sank" a Norlandia refueling ship during the exercise, choosing a time and area with near-ideal conditions to mitigate environmental damage.

"We saw this as a successful, mutually beneficial exercise in communication between the military and academic researchers," Reddy said. "This case exemplifies the value of stakeholders taking the simple but often overlooked step of 'exchanging business cards' in the planning stages of events, rather than during active crises. Someday, Lt. Cmdr. Zeibold's email perhaps could protect untold lengths of coastline, people's livelihoods, and the country's relationships with allies."


U.S. Marine Corps photo by Gunnery Sgt. Bryson K. Jones/Released

The dock landing ship USS *Fort McHenry* is towed to a pier in Trondheim, Norway, as a part of a NATO miliary exercise in 2016 that involved about 16,000 troops and 12 partner nations.

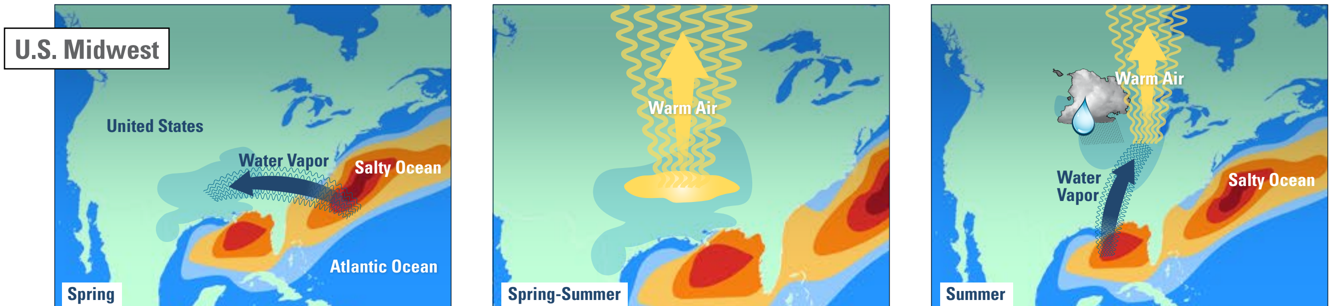
The process works like this: Water vapor evaporated from the ocean is transported through the atmosphere to Africa. It falls as rain, gradually soaking the region's bone-dry landscape through the spring. The soil moisture draws energy from the sun, which warms the ground and evaporates water into the air above it. Warm, moist air rises like a hot-air balloon. That draws in huge amounts of moisture-laden air from the surrounding Atlantic Ocean and Mediterranean Sea, resulting in heavier rainfall when the summer monsoons hit North Africa.

A similar process occurs in the U.S.: Water evaporated from the Atlantic is transported to the southern U.S. in the spring, moistening soil there. Rising warm, humid air eventually draws in more moisture from the Gulf of Mexico. That moist air heads north in the summer, increasing rainfall and sometimes causing flooding in the Midwest.

In 2014, the researchers successfully used their method to predict the Midwest floods of 2015. Then the team extended their technique to the U.S. Southwest. Conventional forecasting methods had predicted above average rainfall for that region during a strong El Niño year. The WHOI ocean salinity-based method, however, predicted low rainfall, which turned out to be the case.

"We see a great deal of potential for applying the same techniques to also improve forecasts in China, India, and other regions," Schmitt said. "If farmers know it's going to be a relatively dry year, they may decide to not plant certain crops, plant water stress-resistant crops, or start planting earlier in the year. Water managers would know whether to release more or less water from reservoirs and when to impose water restrictions. And relief agencies could move supplies around based on the amount and timing of droughts or flooding expected during the monsoon season. It could help save millions of lives."

This research was funded by the National Aeronautics and Space Administration, the National Science Foundation, the WHOI Ocean and Climate Change Institute, and the WHOI Postdoctoral Scholar program. The study was published May 2016 in the journal Science Advances.



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Moist soil draws heat from the sun, warming and moistening air above the soil. Warm, moist air rises.

Rising air draws in moist air from the Gulf of Mexico, which heads north and increases rainfall in the Midwest.

Illustration: Eric S. Taylor, WHOI Graphic Services