Researchers Explore Mystery of Hurricane Formation

September 26 2005

All Atlantic hurricanes, no matter how grand they may become, begin the same. Each starts as a small disturbance in the atmosphere above equatorial Africa. These disturbances, called tropical waves, head west and, if conditions are just right, they increase in size and start spinning. Some develop into tropical depressions, grow into tropical storms and finally evolve into full-blown hurricanes.

"The mystery is why does it happen," says JPL researcher Bjorn Lambrigtsen, "There is a constant stream of these tropical waves coming off the coast of Africa, but most don't turn into hurricanes." Lambrigtsen is the microwave instrument scientist on the Atmospheric Infrared Sounder on NASA's Aqua satellite. "Understanding how hurricanes form will help us be able to predict how they evolve and where they may go."

This past summer Lambrigtsen headed off to Costa Rica with a group of NASA researchers to learn more about the birth of hurricanes and to test some of the latest weather technology. He took along a special instrument designed and built at JPL with hurricanes in mind. T

he High Altitude Monolithic Microwave Integrated Circuit Sounding Radiometer uses the latest microwave technology to make three-dimensional measurements of temperature, water vapor and liquid water in the atmosphere. Because it uses microwaves, it can see through clouds to the inside of a storm. It is a prototype for instruments that will fly on the next generation of weather satellites.

"For a tropical wave to turn into a hurricane, it needs something to give it a twist and it needs convection," says Lambrigtsen. A hurricane is a giant heat engine like a boiler, he explains, taking moisture from the surface and shooting it skyward.

"As water vapor condenses into rain, evaporates and condenses again, it releases energy that helps drive the engine. "Our microwave atmospheric profiler measures how temperature and water vapor are distributed inside the hurricane," says Lambrigtsen," so we get a picture of the storm's internal processes and how energetic it is."

Researchers picked Costa Rica for this latest hurricane field experiment, called the Tropical Cloud Systems and Processes mission, because of its geography. "There was an idea that tropical waves coming across the Atlantic might just get that little twist they need to turn into hurricanes by coming across land," says Lambrigtsen. "We thought that this might be where Eastern Pacific hurricanes get their start."

"Atlantic hurricanes typically evolve into tropical storms while still over open water far out in the Atlantic - often so far that it is difficult to reach them," he explains. "Eastern Pacific hurricanes also often have their origin in Africa, but in their case they do not evolve into tropical storms until they pass over Central America into the Pacific -- the cyclogenesis takes place during the crossing or soon afterward.

"We realized that we stood a greater chance of being able to fly over an early-stage system in the vicinity of Central America, and we'd be able to reach both Atlantic hurricanes that formed in the Gulf of Mexico, as some of them do, and Eastern Pacific hurricanes that formed not too far out in the Pacific."

For their experiment, they brought together six specialized weather instruments, including the microwave atmospheric profiler, to fly on

NASA's ER-2 aircraft, a research version of the famous U-2 spy plane. They planned their flights to coincide with overflights of NASA and National Oceanic and Atmospheric Administration satellites to get the maximum amount of information possible.

Comparing data from the airborne instruments with that from the satellites helps validate the satellite measurements, another of the field campaign's goals. Data from the JPL profiler are especially useful for validating satellite observations by the Atmospheric Infrared Sounder's suite of instruments, which includes microwave sensors.

In early July, Lambrigtsen and his colleagues mounted the 50-kilogram (100-pound) instrument on the wing of the ER-2 aircraft, and hoped for the best. This was only the second outing for the microwave profiler; its first was in a similar field experiment in 2001. The researchers didn't have long to wait.

Hurricane Dennis, the first major storm of the 2005 Atlantic hurricane season, was taking shape unusually early in the nearby Caribbean. "We flew over Dennis three times in five days," says Lambrigtsen. "We were able to catch its evolution from a tropical storm into a hurricane."

"Hurricanes are such severe storms that it is hard to fly through them," Lambrigsten says. "The Air Force flies just twice a day through hurricanes to measure wind speed. Most satellites can see only the tops of the storms, only a few can look through the clouds and they mostly get only a fleeting glance as they pass overhead. Having our instruments on the ER-2 flying above the storm, we were able to look down and into the hurricane. It's like having our own little satellite that we can dedicate to that one storm."

In addition to being able to view Dennis' growth, the researchers also caught a glimpse of their primary target -- the moment when a tropical wave starts spinning. "We were able to catch cyclogenesis near Central America," says Lambrigtsen.

"We observed one wave that developed cyclonic winds and started to become an organized storm but later fizzled out and several tropical waves that didn't evolve very far. Once we have had a chance to study our data, we may be able to answer some of the questions about when this happens and when it doesn't. This is tricky stuff, we're not normally aware of what is happening with a hurricane until it has been named and well on its way to becoming a big monster."