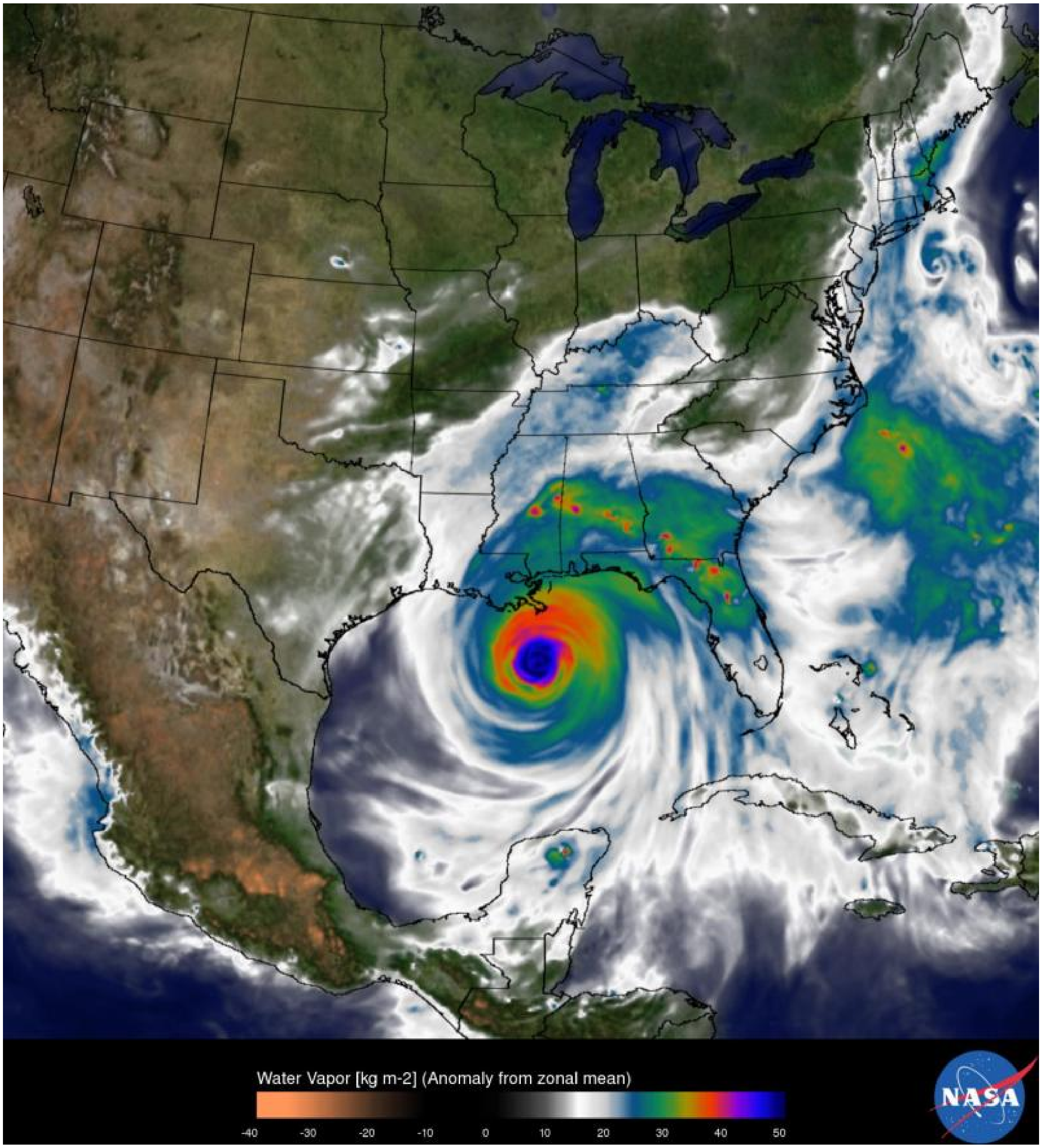
Since Katrina: NASA advances storm models, science

August 21 2015, by Kasha Patel



Credit: NASA

On Aug. 28, 2005, the National Hurricane Center issued a public notice warning people in New Orleans of "devastating damage expected...power outages will last for weeks...persons...pets...and livestock left exposed to the winds will be killed," from the ensuing Hurricane Katrina.

The storm had formed near the Bahamas and south Florida before becoming a Category 2 hurricane over the Gulf region northwest of Key West. Then, in two days, the hurricane's winds almost doubled to 175 mph, creating Category 5 Hurricane Katrina— the most intense hurricane in the past 36 years.

By the time Hurricane Katrina hit the U.S. Gulf Coast, the storm had lost strength but was still able to cause immense damage. Even though the destruction was high, the damage could have been worse if it were not for the forecasts. But no matter how accurate the track forecast, there are still mysteries to solve about hurricane behavior to further improve forecasting.

Researchers are particularly interested in improving forecast lead-time, track and intensity forecast, which are essential to plan successful evacuations. With its expertise in space and scientific exploration, NASA provides help for essential services to the American people, such as hurricane weather forecasting. NASA satellites, computer modeling, instruments, aircraft and field missions provide valuable information to help scientists better understand these storms.

Since Katrina, researchers have made strides in understanding the inner-core processes and environmental factors that affect the path and intensity of a hurricane. When a hurricane strikes now, scientists have a better understanding of where it's going and what's going on inside it than they did in 2005.

"NASA's role in observations, data assimilation and increased modeling abilities will continue to contribute greatly to further advance hurricane research," said Reale.

More Scientific Insights

Since Katrina, scientists have learned a tremendous amount about the environmental conditions and inner-core processes that affect a hurricane's path and intensity.

"It used to be that we always looked for the mechanisms that allow hurricanes to rapidly intensify, but as of late, the question has gotten flipped around," said Scott Braun, research meteorologist at Goddard. "Now we ask what are the factors that prevent a hurricane from intensifying."

Around the time of Katrina, scientists thought the presence of "hot towers"— tall thunderstorm clouds that carry a lot of heat upward—could increase the intensity of a hurricane. Since Katrina, scientists have been learning that it's not necessarily whether these deep towers of clouds are present or not, but where the drafts of rising air, or updrafts, are positioned in great quantity and in specific locations inside of the cyclone.

To intensify a hurricane, a large amount of rising air needs to be concentrated in a specific region: between the center of the cyclone and the band of its strongest winds. Within this radius, the more rising air, the greater the potential intensification of the storm. The lifting of air can be accomplished by a small number of deep and intense hot towers or by a larger number of weaker updrafts. If a large amount of air circulating within that region rises, then the hurricane will spin up. Think of it like lifting a heavy box—it can be lifted by one or two strong people or by a large number of weaker people.

Another factor that inhibits intensification is high wind shear, or a large change in winds with height, in the storm's environment. If a hurricane's environment has winds that are changing speed or direction significantly with height, the winds will cause a shearing force that tends to tilt or rip apart the storm. Hurricanes with high wind shear tend to fall apart quickly.

During the Hurricane and Severe Storm Sentinel (HS3) field campaign in 2014, using airborne instruments including the TWiLiTE Doppler wind lidar, the Cloud Physics Lidar (CPL), the HIWRAP conically scanning Doppler radar, the HIRAD multi-frequency interferometric radiometer, and the HAMSR microwave sounder, NASA scientists observed how wind shear affected the strength of Hurricane Edouard over the Atlantic. Based on observations and modeling work, scientists observed that the storm rapidly intensified as wind shear decreased and the storm went from being strongly tilted to being upright. For more information on the specific instruments, visit the HS3 website.

"At the time of Katrina, we knew that wind shear was a strong negative influence, but now we're learning much more about how it interacts with storms to affect their structure and intensity," said Braun, HS3 Principal Investigator.

HS3 data also showed that Hurricane Nadine in 2012 had dry Saharan air circulating near it—another potential inhibitor of intensification. In general, dry air can sink to the surface creating pools of cold air. The cold air often weakens the storm because it steals energy that would otherwise be available to the storm to grow stronger.

While it's unclear if the dry air acted as an inhibitor in Nadine, scientists are learning about the relationship between wind shear and dry air. If a storm is being tilted by wind shear, then the shear could also create an opening for outside elements—like dry air and Saharan dust—to get inside.

NASA has become the first to incorporate dust observations from satellites into hurricane models. While scientists are investigating the specific role of dust, they know that dust can affect the speed and formation of cyclones. Including the dust parameters in the models is one way for scientists to better understand factors in a hurricane's environment.

More data input

In the past decade, NASA and agencies worldwide have significantly increased the number of sensors in space, on aircraft and on the ground to collect relevant hurricane data. NASA has numerous Earth observing satellites and many more satellite sources from worldwide partners. Since Katrina, NASA has also launched three field campaigns covering 5 hurricane seasons.

Satellites allow scientists to look within and at the environment surrounding hurricanes with a global perspective. Satellite data include sea-surface temperature, precipitation, surface winds and pressure, dust, atmospheric temperature and water vapor and more. Two satellites used to measure precipitation from space are the Global Precipitation Measurement Mission and former Tropical Rain Measuring Mission.

Field campaigns, on the other hand, gather more focused data on specific hurricanes by flying manned and unmanned aircrafts into the hearts of the storms. During HS3, NASA's unmanned Global Hawk dropped small devices called dropsondes within and around storms while also collecting data on storm cloud tops and Saharan dust. The dropsondes collect information such as temperature, humidity, pressure and wind speed and direction.

But it's a combination of the availability and better integration of these data sets into models that have helped scientists understand and forecast hurricane behavior better.

At NASA's Global Modeling and Assimilation Office (GMAO) in NASA's Goddard Space Flight Center in Greenbelt, Maryland, scientists are developing global models and data assimilation systems that ingest satellite, upper-air and surface observations to simulate hurricanes and improve our understanding of hurricane behavior.

"The idea is that we have all of these millions and millions of observations and these observations are essentially ingested into what is called a data assimilation system," said Reale. Researchers incorporate as many observations as they can.

The data assimilation system also allows for quality control. It compares observations from different sensors, gives each observation proper weight and merges all the information on a homogenous grid, which is a representation of the state of the atmosphere at a specific time.

A Model View of a Hurricane

Hurricane models can be likened to video games—although instead of an ancient charmed forest, these models use Earth as the backdrop. Just as video games have developed better graphics, become more realistic and include a lot more information, hurricane models have developed in a similar way.

In the past ten years, scientists have significantly improved the models' resolution, largely enabled by more powerful supercomputers. GMAO uses supercomputers at NASA's Center for Climate Simulation at Goddard.

"By going to a higher resolution, we have this process by which the resolved scale of the storm becomes smaller and smaller and closer and closer to reality," said Oreste Reale, a meteorologist at NASA Goddard. Reale is part of a team that, among other duties, assesses the ability of the GMAO suite of models to produce realistic hurricanes.

With past versions of NASA's GMAO model, scientists could detect the circulation in a cyclone, but the size of the cyclone was too big in comparison to the real storm and the intensity of the cyclone was typically underestimated. Today's models have up to ten times the resolution than those during Hurricane Katrina and allow for a more accurate look inside the hurricane. Imagine going from video game figures made of large chunky blocks to detailed human characters that visibly show beads of sweat on their forehead.

Increasing the resolution is especially helpful to study and forecast a hurricane's intensity. "For the intensity of a hurricane, so much comes down to the details of the really small processes and specifics in the inner core," said Dan Cecil, atmospheric scientist at NASA's Marshall Space Flight Center in Huntsville, Alabama.

Since Katrina, researchers have used better data assimilation techniques, higher resolution models, more observations and deeper scientific insights to improve hurricane forecasting and understanding of physical processes. NASA does not release hurricane public forecasts, which are exclusively provided by the National Hurricane Center, but collaborates closely with NOAA to improve our understanding of hurricanes.

More information: For NASA's Hurricane web page, visit www.nasa.gov/hurricane

To learn more about the NASA's satellites and field and air campaigns that study hurricanes, visit www.nasa.gov/feature/goddard/h … asa-study-hurricanes

For more information on the NASA Center for Climate Simulation www.nccs.nasa.gov

Provided by NASA's Goddard Space Flight Center