Ocean and wave models complement atmosphere-only storm predictions

Researchers upgrade tropical cyclone modeling system to simulate storm intensity at landfall

A view of Zhuhai, a coastal city in Guangdong, prior to Typhoon Chaba making landfall (Photo taken at 0450 UTC 1 July 2022 by Si Gao)

BEIJING, CHINA, July 5, 2022 /EINPresswire.com/ -- For a long time, researchers have used atmosphere-only models to study the intensity changes in tropical cyclones. But the atmosphere-only models leave some questions unanswered. A research team has extended the atmosphere-only model to include ocean and wave models to create an air-sea-wave fully-coupled model. This improved model system allows the researchers to better predict tropical cyclone intensity changes near coastal regions.

The research team, including researchers from City University of Hong Kong and Imperial College London, has recently published their findings in Advances in Atmospheric Sciences.

Tropical cyclones form and gather strength over a large area of warm ocean water. As they make landfall, these storms can cause great damage to coastal regions. Scientists understand that interactions between the ocean and the lower atmosphere play a crucial role in the evolution of tropical cyclones.

Because of this, scientists have conducted extensive research to better understand the air-sea interaction of tropical cyclones.

To study the air-sea interaction that occur in these storms, researchers have used numerical weather prediction models. The atmosphere-only model provides useful information, but has its limitations. Tropical cyclones can undergo rapid intensification just before they make landfall. Researchers needed to be able to better understand and predict why this intensification happens in some, but not all tropical cyclones. So the research team extended the atmosphere-only model that had been traditionally used to study the storms to include an ocean model and a wave model.

With their upgraded model system, they re-simulated 642 tropical cyclones that made landfall in South China between 1990 and 2010. These storms had previously been simulated using the atmosphere-only model. With the new upgraded modeling system, the team specifically examined the contribution of solar radiation in heating the ocean, which could be significant near the coast with a continental shelf. They also explored how this heating is affected, depending on whether the cyclone is a slower-moving or faster-moving storm.

The team drew two conclusions from the simulations they ran with their upgraded model. First, for coasts with an extensive continental shelf, a tropical cyclone with a small extent of cloud cover can allow solar radiation to heat up the ocean near the coast, causing the tropical cyclone to rapidly intensify as it moves over the continental shelf. This rapid intensification can pose a severe threat to the coastal areas.

Their second conclusion was that fast-moving tropical cyclones do not induce much upwelling and thus their intensity may not be reduced much. So if the tropical cyclone has a small cloud cover, its intensity can be rapidly enhanced when it makes landfall. On the other hand, a slow-moving tropical cyclone with a large cloud cover would tend to weaken more.

These two observations are very important in predicting tropical cyclone intensity changes near the coastal regions. “Given the better skills of the new model system, it can be used either in the prediction of intensity of individual tropical cyclones as they make landfall, or in projecting possible variations in the intensity of these cyclones in the future,” said Johnny C.L. Chan, emeritus professor in the School of Energy and Environment, City University of Hong Kong.

"The study shows the potential benefits of high resolution coupled ocean-atmosphere models for operational forecasts of landfalling cyclones," said Ralf Toumi, Professor and Co-Director of Grantham Institute - Climate Change and Environment at Imperial College London.

Looking ahead, the researchers want to verify their modeling results and conclusions from actual observations. With further modeling studies, they will examine the model’s sensitivity in simulating and predicting the intensity changes. “The ultimate goal is to help forecasters in making more accurate intensity change predictions of tropical cyclones as they make landfall, which will be of significant benefit to people living in the coastal areas affected by tropical cyclones,” said Chan.

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Jenny Lin
Advances in Atmospheric Sciences
aas@mail.iap.ac.cn
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