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Reckoning with Winds [1]

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New wind data are opening the facts on typhoon transitions to mid-latitude storms, and on the ocean monsoon breeding grounds.

- About Physical Oceanography DAAC (PO.DAAC) [2]

1996 was a record year for tropical cyclones. Of 43 such storms, 20 intensified to typhoons, and six more to super-typhoons. The storms levy lasting devastation, claiming lives, inflicting injuries and causing millions of dollars in property damages.

For instance, September 22, 1996, Typhoon Violet slammed Tokyo with winds up to 78 miles per hour. Deluged by 10 inches of rain in 24 hours, train, air and ferry services shut down. According to news reports, at least 80 landslides resulted from the flooding, and wind and mud combined to take three lives. Another 28 people were injured in the storm, 41 homes were destroyed, and more than 2,000 homes were flooded.

Typhoon Tom was born in the tropical Pacific at the same time as Violet. But instead of making landfall, Tom engulfed a low pressure system, became a mid-latitude storm carrying gale-force winds and proceeded out across the most well-trafficked of Pacific shipping lanes.

Although over the last decade reasonably accurate numerical weather prediction models have been developed to forecast typhoon movement, the models' predictive abilities are only as good as the input data. "We don't know much about typhoons, and we know even less about the thermodynamics during a typhoon's transition into a mid-latitude storm, because essentially we don't have data," said Timothy Liu, NASA Scatterometer (NSCAT) project scientist and team leader of the Air-Sea Interaction and Climate group at the Jet Propulsion Laboratory. Key are data about wind currents and pressure systems, which determine storm force and direction.

Wind observations are usually made by merchant ships, Liu said, "but nobody goes to measure a typhoon in the ocean." Satellite imagery may help to locate storms, but do not reveal surface intensity, he said. Models are similarly inadequate.

"Simulations by numerical models do not help our understanding significantly because the models do not have the right physics or sufficient resolution," Liu said. "Yet mid-latitude storms resulting from typhoons usually have gale force winds and heavy precipitation. Storm transition is a fascinating science problem, with important economic consequences. Transitions occur over the busiest trans-ocean shipping lanes, and, if resulting storms ever hit land, they usually devastate populated areas."

The significance to human lives and activities of being able to "see" and measure wind speed and direction accounts for the general elation within the scientific community, when, shortly after Typhoons Tom and Violet had spent themselves, the first wind data taken by NSCAT were downloaded.

Launched aboard the Japanese ADEOS satellite in August 1996, the scatterometer takes 190,000 wind measurements each day, mapping more than 90 percent of the world's ice-free oceans every two days. The instrument is expected to provide more than 100 times the amount of ocean wind information currently available from ship reports. A radar instrument, the scatterometer is capable of taking data day or night, regardless of sunlight or weather conditions.

NSCAT was activated on September 15. In October, data from the scatterometer began to pour in. The early images clearly displayed Typhoons Tom and Violet.

To learn about the typhoons' growth process and thermodynamics, Liu said, "we combined data from two different DAACs to show the relationship between the dynamics, which is the wind, and the thermodynamics, the moisture, which is given by the water vapor."

Applying the NSCAT wind vectors to the SSM/I precipitable water color image was particularly revealing of the physics in action, Liu said. "You can see Violet, just before it hits Japan, changing. Shear and frontal systems develop, dry air enters the picture. Similarly with Tom, you can see the storm's evolution very well."

Liu expects NSCAT winds, with their high spatial resolution, when combined with SSM/I precipitable water measurements, to improve storm diagnostics, vorticity, divergence, heat sources, and moisture sinks, without which it's hard to know, for instance, whether a typhoon will continue straight ahead and strike land, or whether a low pressure trough is present to send it back out to sea. Will a storm continue as a typhoon, or will it gather force and evolve into an even more dangerous system?

The next step for Liu's team is quantitative analyses. "With NSCAT winds and other satellite data, we can develop physical parameters to describe the thermodynamic transitions and calculate the convergence and heat balance to try to understand what happens in the storm transitions," he said.

Tracking Monsoons

Research at the Jet Propulsion Laboratory and elsewhere is showing that NSCAT imagery can shed welcome light on a multitude of tropical atmospheric and oceanic systems. The data are fueling new studies on the relationship between wind and ocean currents, tropical storm patterns, and the behavior of El Niño.

Early NSCAT imagery coincided with the onset of the Asian winter monsoon. "Over land, the consequences of monsoons are well-observed, but monsoon ocean breeding grounds have been insufficiently monitored," Liu said. Monsoons are seasonal wind changes caused by the contrast in heating over land and ocean from season to season. Accompanied by damaging surface winds, flood or drought, the annual onset, intensity and retreat of monsoons differs from year to year. Economic impacts of such weather extremes can be severe, Liu explained.

By superimposing coincident sea surface temperature imagery and precipitable water on the NSCAT wind vectors, Liu and colleagues could at last track the patterns of atmospheric and oceanic changes following wind changes.

"We're combining data sets from different DAACs and three sensors to solve a scientific problem: the cause of the monsoon occurs over oceans, where formerly we had no data. The essence of EOS is to be able to synthesize data sets from different sensors to do science," he said.

Resource(s)

NSCAT measures near-surface wind speed and direction over Earth's oceans at high resolution. Winds over the oceans are retrieved because the water's surface roughens rapidly with increasing wind speed, which increases the backscatter detected by this specialized radar instrument. NSCAT scans two 600 km bands of the Earth -- one band on each side of the instrument's orbit path, separated by a gap of 330 km. The instrument also provides data over land and ice surfaces under all weather conditions. NSCAT ocean wind products are available from the Jet Propulsion Laboratory (JPL) Physical Oceanography DAAC (PO.DAAC).

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