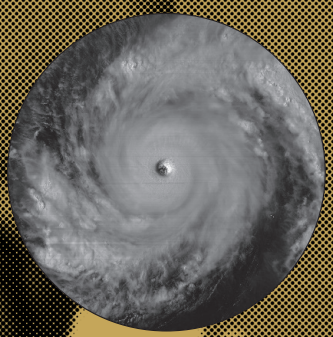
S-face

SFC makes the future through researches

Understanding the Mechanisms Causing Sudden Structural Changes in Typhoons

Yoshiaki Miyamoto



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From Basic Research to Business Applications
Making Meteorology More User-Friendly

**It seems like every year Japan suffers immense damage from typhoons that make landfall.
The mechanisms of these typhoons mostly remain a mystery.
However, in 2018, a research team led by the assistant professor Yoshiaki Miyamoto discovered
a new theory to elucidate the mechanisms that form an "outer eyewall cloud",
which cause sudden changes to the structure and strength of a typhoon.
It is anticipated this theory will remarkably improve the accuracy in estimating how strong a typhoon will become.
Assistant professor Miyamoto is also actively working on projects aimed at finding applications for meteorology in society and business.**

Predicting the Possible Position and Timing of Outer Eyewall Clouds

Inside a developed typhoon is the cloudless "eye" near the center, and the ring-shaped cloud of the "eyewall cloud" that surrounds the eye. Water vapor drawn up from the sea collect and condense (into water droplets) in the eyewall cloud, and this keeps the typhoon rotating. So the eyewall cloud is the so-called "engine" propelling the typhoon, and the amount of condensation within it affects the structure and strength of a typhoon.
Another collection of ring-shaped clouds called the "outer eyewall cloud" can suddenly form outside the eyewall cloud in strong typhoons. Once formed, this outer eyewall cloud rapidly grows in size, and in around 20 to 30 hours it replaces the original eyewall cloud to become a "new eyewall cloud"; this is also when the typhoon's structure and strength drastically changes. It basically becomes a completely new typhoon, and such dramatic changes make it extremely difficult to predict the typhoon's strength. This is why, particularly in the past decade, many preeminent researchers of typhoons have been working on clarifying the mechanisms behind the formation of an outer eyewall cloud. Although over 20 theories have been proposed, so far none of them have elucidated the mechanisms. Our research team has successfully revealed the mechanisms behind this phenomenon, which has remained a mystery for many years. We were the first researchers in the world to establish a theory that can predict when and where an outer eyewall cloud will form. It is anticipated this theory will remarkably improve the accuracy in estimating how strong a typhoon will become.

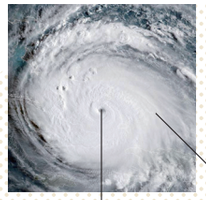
Establishing a Theory Derived from Basic Meteorology, and that Overturns Conventional Knowledge

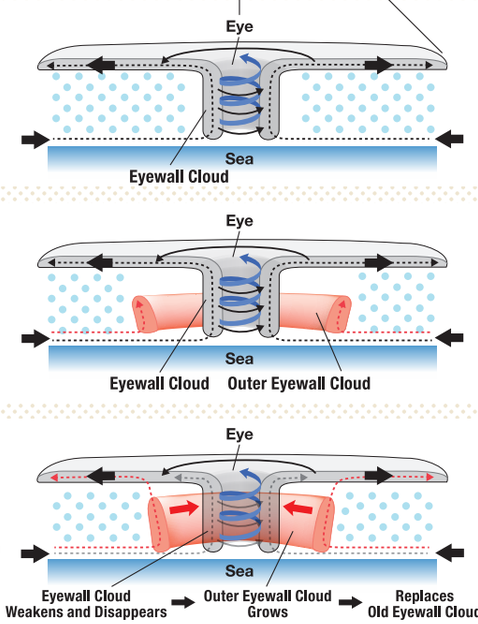
We used this theory to estimate the formation placement and timing of an outer eyewall cloud, and we were able to get almost identical matches with the existing values observed in actual typhoons. We also ran computer simulations of typhoons and found it is possible to predict when an outer eyewall cloud can form several hours before it actually does.
Our theory on the mechanisms that form of an outer eyewall cloud has been developed from the Ekman theory of basic meteorology.
Swirling the surface of water will create a whirlpool, and stopping the movement will make it naturally disappear; the Ekman theory explains why the whirlpool disappears. This is why the Ekman theory normally describes why a typhoon moves in a direction that weakens its momentum.
However, we discovered the reverse to be true; if a typhoon's wind distribution meets certain conditions, the Ekman theory explain why the outer eyewall cloud updraft grows and moves the typhoon in a direction that strengthens its momentum. Specifically, the updraft can grow if the following two conditions are met: 1. A typhoon slowly weakens as the wind becomes quite stronger and moves away from the center, and 2. 1. Occurs at a distance of 2 to 7 times the eye's radius. So when the eyewall cloud's radius is around 30 to 50km, and an outer eyewall cloud can form at a radius of 100 to 150km from the eye, then it's possible to predict its sudden formation.

Applying Meteorological Data to Create New Business

Meteorology is an intricate aspect of people's daily life; it is used to forecast the weather, study global warming, and measure air pollution, among other uses. Meteorology in Japan is very much connected with what's happening on the ground when it comes to weather forecasts and disasters; yet there has hardly been any progress in finding business applications for meteorology. So in 2017, the industry, government and academia in Japan came together to set up the Weather Business Consortium (WXBC) to facilitate the application of weather data and other weather-related information in business. I am also a member of this consortium as an expert on weather, and through the WXBC I have been holding workshops and carrying out joint studies with companies.
The potential business applications of meteorology are expanding to encompass a diversity of industries, from agriculture and clothing to finance. Recently there has also been a surge in the development of applications using weather data, such as those that suggest outfits for the day based on forecasts of the chance of rain, temperature, humidity, and other data.
The Japanese Meteorological Agency (JMA) has accumulated a vast amount of weather observation and forecast data (called "big data"). However, this data is difficult to understand and handle for the average company, and it is safe to say the data hasn't been used effectively so far. I believe meteorological researchers, such as myself and my team, need to work with the WXBC and similar organizations and provide companies with ways to read, understand and handle weather data. This is how we can stop such data from being nothing more than a useless treasure.

Mechanisms that Form an Outer Eyewall Cloud





1

Schematic diagram of the structure near the center of a typhoon. Water vapor drawn up from the sea condenses in the eyewall cloud and generates an updraft, which becomes the typhoon's engine.

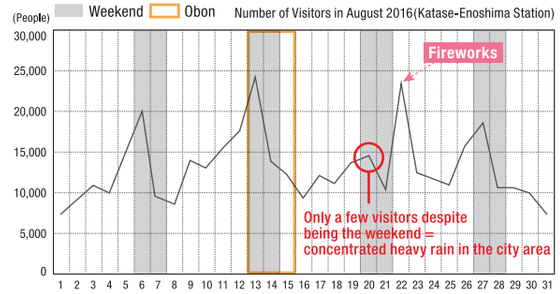
2

Another newly formed cloud can form a water vapor upward region outside the eyewall cloud. The ring shaped cloud grows in size from the water vapor collected from around the typhoon, and it then forms an outer eyewall cloud.

3

As the outer eyewall cloud starts to rapidly form, the supply of water vapor dries up and the internal eyewall cloud weakens and eventually disappears; this causes the typhoon to temporarily lose momentum. However, as the outer eyewall cloud approaches the typhoon's center and replaces the old eyewall cloud to become the new eyewall cloud, the typhoon picks up speed and strength again.

Researching the Applications of Meteorology



This graph is part of the research being carried out by students at Assistant Professor Miyamoto's lab. It shows the effect of the weather on the number of tourists to the Enoshima area. In addition to basic research, the students at this lab are researching a diverse range of themes on the applications of meteorology, such as this study on the weather and Enoshima. These themes include the meteorological fields that cause meteorotropic diseases, how changes in the weather affect women's skin, and developing temperature-indexed financial products and a "touchable" weather forecast system.

Profile
Yoshiaki Miyamoto

Assistant professor, Faculty of Environment and Information Studies, Keio University. Completed the Doctoral Program for Earth and Planetary Science at Graduate School of Science, Kyoto University. After working as a Special Postdoc Researcher in Basic Science at the RIKEN Advanced Institute for Computational Science (R-CCS) and completing an Overseas Research Fellowship at the Japan Society for the Promotion of Science (JSPS), he assumed his current position at Keio University in 2018. Ph.D. (Science). Specializes in Meteorology.

Please visit S-face website for details!

There are more articles and video of Yoshiaki Miyamoto.

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