nearby reef and buried in a deep hole. However, these tales had never previously been validated by scientific evidence.

In a previous study, the remains of a 50-year-old male estimated to have lived during the 1800s were found in one of the tombs. Prior researchers had therefore concluded that the tombs were built approximately 200 years ago. Precise analysis of the coral has demonstrated that the tombs were built in the 14th century; thus, Prof. Shen's team deduced that the 19th-century body belonged to the last king to have participated in the ancient burial ceremony. Although the reason why this king's remains were not relocated is unknown, the study findings validate previous tales indicating that the tombs were repeatedly used as temporary burial sites.

Reference

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Professor Chuan-Chou Shen
High-Precision Mass Spectrometry and Environment Change Laboratory (HISPEC)
Department of Geosciences
river@ntu.edu.tw

Does a warmer ocean guarantee stronger typhoons?

A reinterpretation of tropical cyclone and ocean interaction

Taiwan is located in the northwestern Pacific Ocean and experiences destructive tropical cyclones (TCs; also called typhoons in Asia) every year. Typhoons can cause damage and they have become one of the most popular research topics in Taiwan. Dr. I-I Lin, a professor in the Department of Atmospheric Sciences at National Taiwan University (NTU), has published several important papers that describe new discoveries in the interaction between tropical cyclones and the ocean. These works demonstrate successful national and international cooperation including by researchers from the National Taiwan Normal University (NTNU) and Academia Sinica in Taiwan as well as groups from the USA, China, and Hong Kong.

The condition of the ocean has long been considered a key factor in TC research because of how it may affect TC development and intensification. However, there is still no complete theory that

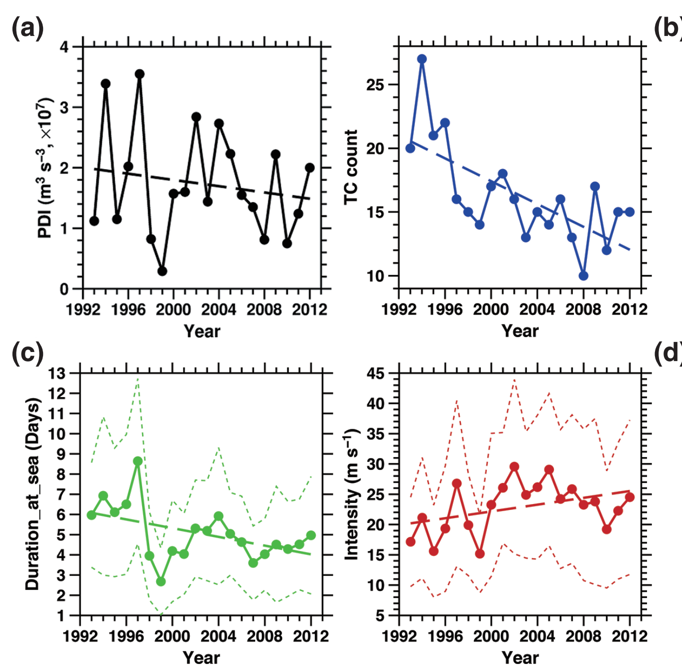

Fig. 1. Time series of the observed PDI and other parameters over the western North Pacific over the past two decades. (a) PDI, (b) annual number of typhoons during the typhoon season (July to October), (c) the average typhoon duration, and (d) the typhoon intensity. [1]

can fully explain TC-Ocean interactions. Traditionally, a warm ocean with a high sea surface temperature (SST) has been assumed to provide a large amount of sensible heat and latent heat, which contributes energy for the TC. Therefore, warmer ocean conditions are believed to nurture more destructive TCs. However, when the TC passes through an ocean, the high wind stress it brings will accelerate the upper ocean layers, mixing in colder water from below and dropping the SST.

Recently, the damage caused by typhoons has been more severe, which is believed to be related to global warming. However, I-I Lin from NTU and Johnny C.L. Chan from the City University of Hong Kong published an article in Nature Communications in 2015 [1] stating that typhoon destructive potential has decreased in recent decades. They found that the high SST provides a favourable environment for typhoon development and dramatically strengthens typhoon intensity, as expected. However, at the same time, the annual number of TCs during typhoon season and the average TC duration have decreased (Fig. 1). This is believed to be because, under global warming, atmospheric circulation is strengthened. Therefore, both the lower-tropospheric easterly trade winds and the upper-tropospheric westerlies are enhanced and the vertical wind shear (the difference between the two) is increased. The increased vertical wind shear,

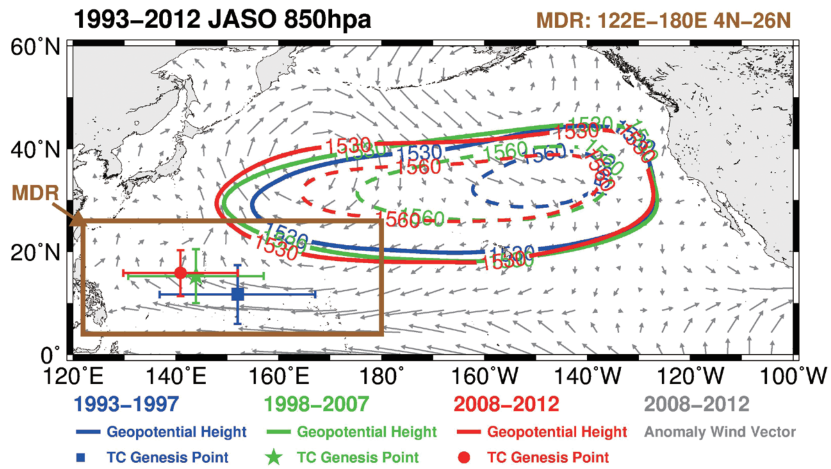

Fig. 2. The averaged typhoon genesis positions (with 1 standard deviation) over three different periods in the past 20 years (1993-2012) and the strengthening of the subtropical high at 850 hPa. [1]

along with a decrease in the low-level relative vorticity in the typhoon genesis region, creates poor atmospheric conditions for typhoon formation and results in fewer typhoons per season.

To adjust to these new conditions, the genesis position of typhoons was found to shift to the northwest, as shown in Fig. 2. When a TC forms farther westward, the path that it travels is shorter than normal, resulting in the lower durations observed. This pattern is also supported by the 35% decrease of the Power Dissipation Index (PDI) in recent decades, as shown in Fig. 1. The PDI is a quantified index of the destructive potential of typhoons and includes interactions among typhoon frequency, duration and intensity. Under a global warming scenario, the PDI could decrease by as much as 15%.

Another study, also published in Nature Communications by Taiwanese-Chinese collaborators [2], found that the ocean conditions may suppress the intensification of TCs under global warming. The authors investigated outputs from 22 climate models under a global warming scenario and focused on the western North Pacific (WNP) and the North Atlantic (NA) regions. The research focused on the ocean cooling effect (OCE) produced when a TC passes over the ocean, allowing strong winds to mix colder subsurface (deeper) water with water near the surface. Such mixing reduces the SST and decreases the available air-sea sensible and latent heat fluxes. In addition, because the subsurface ocean temperature warms more slowly than the surface ocean, under global warming, a steeper vertical temperature gradient is expected. As a result, the OCE will be even more effective at decreasing SST under global warming. While the OCE is a function of the initial vertical temperature profile of the ocean and the particular TC conditions, any expected strengthening of the cooling effect will in turn prevent TC intensification.

There is a final interesting research report, published by a Taiwan-USA partnership in Scientific Reports, which addresses the typhoon-El Niño relationship [3]. During El Niño, the eastern Pacific is warmer than normal, providing a favourable location for TC genesis and causing a positive feedback for TCs. The TC genesis region shifts southeastward, and any resulting TC would travel a longer distance before it dissipates. Consequently, a TC could achieve a higher intensity during El Niño. However, this research identified a negative feedback to TC intensification that works as a damper to restrain typhoons from becoming over-intensified. During El Niño, there is a strong pre-existing subsurface shoaling over the western North Pacific Ocean, and the subsurface water is much colder than in normal years. The stronger OCE during El Niño reduces the heat flux supplied to TCs, providing a damper on TC intensification. A schematic of this Gaia[i]-like process, in which different Earth mechanisms help to maintain stable conditions, is shown in Fig. 3.

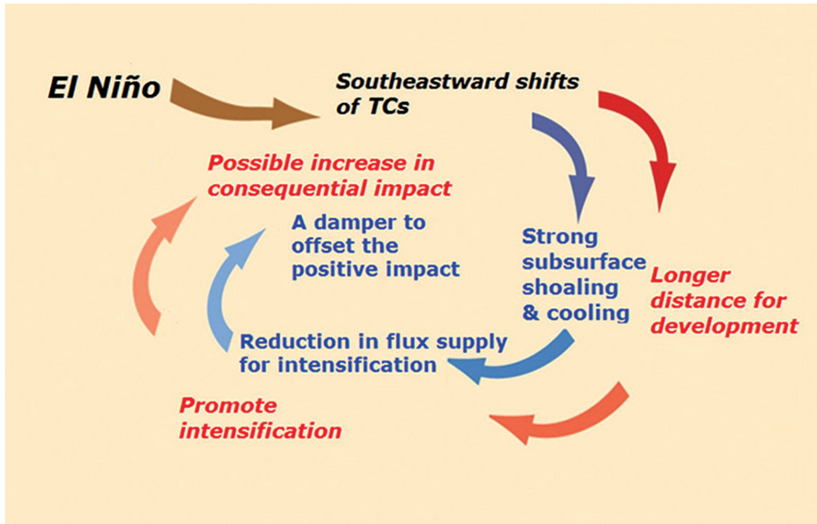

Fig. 3. Schematic of the Gaia-like mechanism in the El Niño-TC relationship. [3]

The formation of TCs is related to both atmospheric and oceanic conditions. These studies have analysed huge amounts of climate data and have shown how complex these interactions can be. However, the new interpretations of TC-ocean interaction can lead to a better understanding of how and when TCs will evolve.

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i. Gaia: a hypothesis stating that there are self-regulation mechanisms among the organisms and inorganic surroundings on Earth, which work to keep our planet suitable for life.

Reference

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Professor I-I Lin
Department of Atmospheric Sciences
iilin@as.ntu.edu.tw