

Typhoon-Ocean Interaction: Biogeochemistry, Record-Breaking Super Typhoons and Global Warming

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摘要

Tropical Cyclone-Ocean interaction is an important and active current international field of research, especially with the recent occurrences of the record-breaking ‘category-6’ super cyclones like Haiyan (2013) and Patricia (2015). How tropical cyclone interacts with the earth natural and anthropogenic climate variability and carbon system is an interesting cross-disciplinary field required atmospheric, ocean, and biogeochemical sciences. In 2001, when Prof. KK was the Director of the National Center for Ocean Research (NCOR), we started a series of research on typhoon-ocean interactions. After 15 years’ of efforts, significant progress has been made, with considerable international attention. How I wish KK is still with us, to continue in this field.....

溫馨感言

Professor KK was a true gentleman and a great scientist. He was my boss when we were in NCOR, back in 2000. He (and Prof. George Wong) were also my oceanography mentors. They kept talking and talking things like carbon cycle, biogeochemistry, and oceanography, with so much zeal. I then started to learn oceanography from them and got ‘brain-washed’ by them!

On the first day of meeting KK, he told me that he was also a Christian and shared with me his story. Soon he knew my 1-year old son had to go through several heart operations, he always asked about my son and encouraged me in faith. He also gave me the 2 books he wrote about the passing of Jiayu’s mother. His true faith and love in the book really touched my heart and encourage me, during the challenging time. From 2002 to 2004, everything was more stable and we enjoyed very happy scientific team-ship together. Discussing and thinking together new ideas in oceanography, worked late at night to write reports/proposals for NCOR, went to cruises together, and enjoyed the happy Texan BBQ prepare by Dr. Cat Wen and the team. Prof. KK would bring Mrs. Liu (Margaret) and the 2 younger boys (Jiashiang and Jiashu). It was a very happy and fruitful period. We enjoyed his warm leadership,

chatting about family, life and faith during the many BBQ and social gathering events. It was a happy time to learn from his rich life experience and be influenced by his strong love in oceanography.

His love to his family was very evident to me. There was once we went together to Kaohsiung for business trip. It was very tiring and there was no high speed rail then. However, after the trip, he did not want to come back with us to Taipei, because he would like to take a bus to Tainan to see his elder son, Jiayu. He was very tired on that day already, but he told me he wants to see him, even just for few hours. The love of a father touched my heart. With the ending of NCOR in 2004, he left for NCU and I left for NTU/Atmospheric Sciences. We continued to have much interactions. From time to time when he has some meetings in Taipei, he would pop by the Atmospheric Department to say hi and care about my son and talk about science.

It was also always wonderful to see him and Mrs. Liu to be so 'lovely-duvy' and happily together, e.g. in Wu-Yi mountain and in so many other places. Sometimes when I have disagreements with my own husband, I would wonder why Prof. KK can be such a gentle husband. Each year his annual newsletter is also an encouragement. He shared about faith, science, and family. He is a great scientist and his faith in Jesus shines in our hearts. It was also a wonderful time to go to Prof. KK's eldest son, Jiayu's wedding last year, so marvelous to see the whole family in the big celebration. It was really so sad and sudden to hear about the passing of Prof. KK this summer.....However, I was reminded that I have HOPE and WILL SEE Prof. KK in heaven because Jesus has conquered death! This is the biggest comfort and assurance. I believe Prof. KK wants to see many of us to turn to God, because he really loves and concerns for us. He also wants to see all of us again. I prayed that as many of Prof. KK's family members, colleagues and students will come to know Jesus and we can all see KK together in heaven.

Bible: Romans 8 Verse 38-39: Neither death nor life....., neither the present nor the future, nor any powers, neither height nor depth, nor anything else in all creation...will be able to separate us from the love of God that is in Christ Jesus our Lord.

Research Highlights – Part 1: Ocean Remote Sensing

1. When I first joined NCOR, Prof. KK was very interested in satellite remote sensing. Perhaps he was worried (or curious), he unexpectedly came to see what I would do on OR2 (Ocean Research 2), because it was my first leading-cruise! It turned out to be fun and fruitful. It was one of the very first cruises from Taiwan which has co-ordinated simultaneous multiple satellite acquisitions of ocean colour and

Synthetic Aperture Radar (SAR, thanks to CSRSR, the Remote Sensing Center of NCU!) observations. We first waited around the region of interest and waited for the 10.30am SAR acquisition. The image was quickly processed by CSRSR and faxed to OR2 (because no internet on OR2 then). We then quickly rushed to the feature location, to obtain in situ observations (Fig. 1).

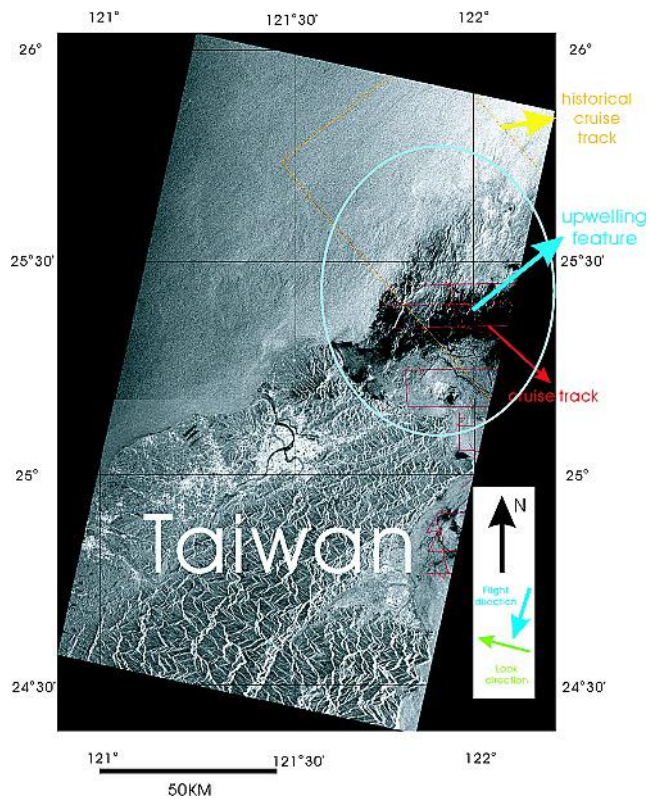


Figure 1: The ERS-2 SAR image acquired at 02:28 UTC 19 August 2000 was processed in near real-time to aid in situ cruise campaign. The cruise track (red) is determined according to the location of upwelling feature (dark region) in SAR image. Historical cruise track [Liu et al. 1992] is shown in yellow [After Lin...Liu et al. 2002].

2. Subsequently, KK ‘attracted’ me to work on the South China Sea. He (gently) asked me and my lab to process loads (> 10 years) of SeaWiFS ocean colour data, because he would like to know the synoptic situation of the South China Sea. He told me that though SEATS time series station is very important, it is a single point and he needs satellite observations to provide synoptic, 2D observations, for his biogeochemical model validation! Again, I was persuaded or ‘brain-washed’, and we had 3 papers for this project [Tseng., Lin...Liu et al. 2005; Liu...Lin et al. 2007; Liu...Lin 2010].

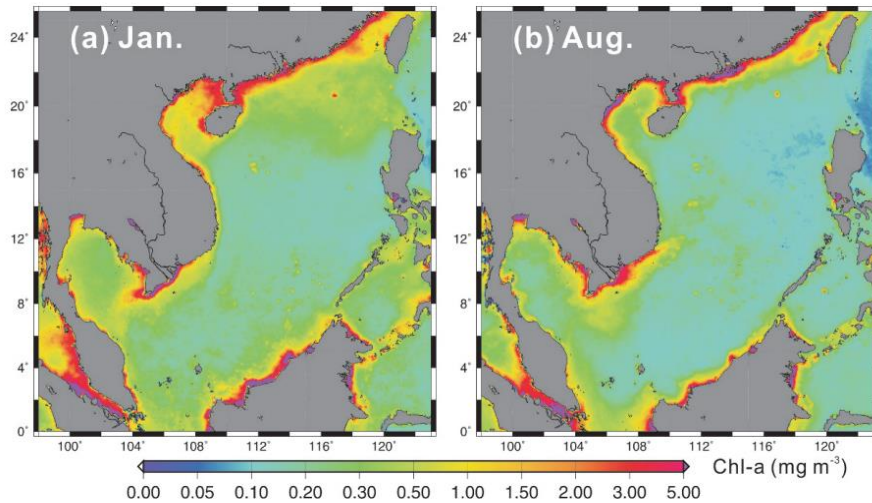


Figure 2: Composite Chl-a distribution derived from SeaWiFS ocean color imagery from 1998 to 2000 for (a) January and (b) August. In January the elevated Chl-a concentrations in the northern SCS northwest of Luzon and in the southern SCS over the Sunda Shelf are attributed to monsoon-induced upwelling. In August a similar process occurred off Vietnam [After [Liu et al. 2010](#)].

Research Highlights – Part 2: Typhoon-Ocean Interactions

3. In 2001, together with Dr. Yih Yang, from NCOR, we found the very strong ocean biogeochemical response and intense sea surface temperature (SST) cooling ($\sim 10^{\circ}$ C) induced by typhoon Kai-Tak in the South China Sea (Lin [Liu, 2003](#)). This paper attracted considerable interests and following-up studies.

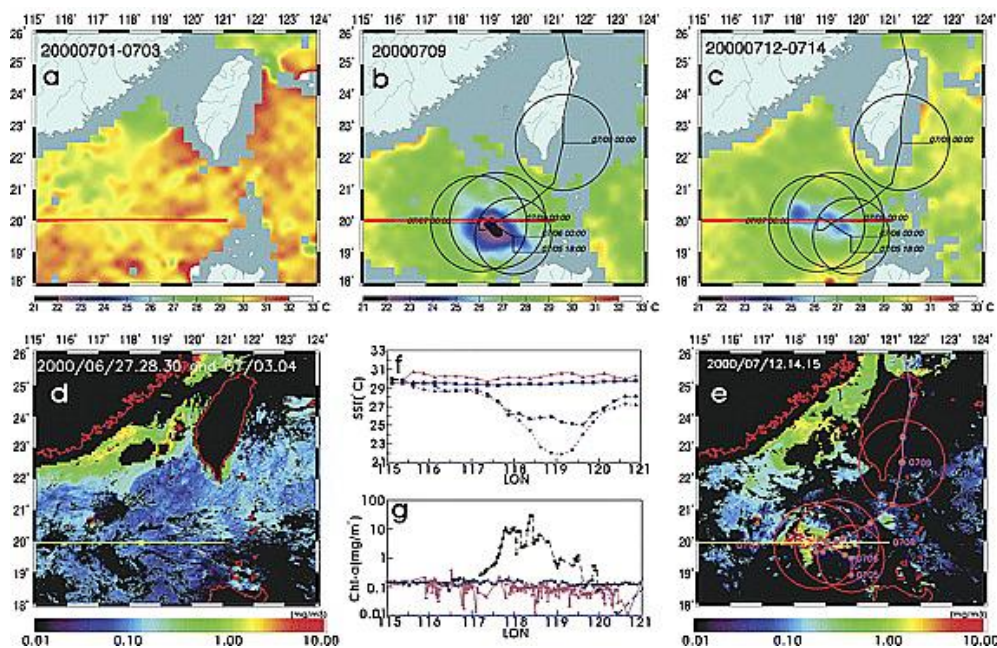


Figure 3: TRMM TMI/SST image on (a) 1–3 July 2000, before the arrival of typhoon Kai-Tak; (b) 9 July 2000, after typhoon Kai-Tak; (c) 12–14 July 2000,

illustrating the match between cold SST pool (Figure 1c) and the bloom patch (Figure 1e). SeaWiFS surface Chl-a image composite on (d) 27 June–4 July 2000, before Kai-Tak; and (e) 12,14,15 July 2000, after Kai-Tak. The circle denotes Kai-Tak's RMW (Radius of Maximum Wind). The location of the transect tr1 is depicted as the red/yellow line crossing the longitude. (f) Comparison of the SST distribution along tr1. Pink: before, (from Figure 1a). Brown: after, (from Figure 1b). Green: after, (from Figure 1c) Blue: The 3-year (1998, 1999, 2001) climatological average of SST for July. (g) Comparison of the surface Chl-a distribution along tr1. Pink: before (from Figure 1d). Green: after, (from Figure 1e). Blue: The 3-year (1998, 1999, 2001) climatological average of surface Chl-a concentration for July. [After Lin..... **Liu** 2003].

4. Though Prof. KK has left, his research ‘DNA’ appears to be ‘imprinted’ on me. His zeal and attitude influence many of my new papers on global warming, super-typhoon and ocean warming (Lin and Chan 2015; Zheng, Lin et al. 2015; Huang, Lin et al. 2015). Whenever I encountered difficulties, his spirit and passion will always remind me to ‘never give up’.

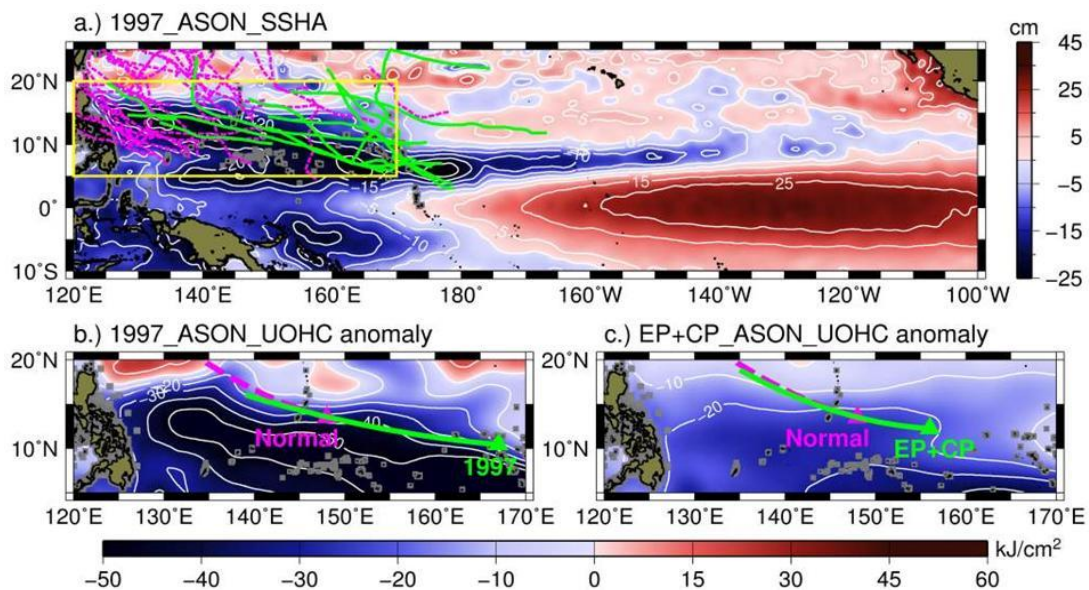


Figure 4: The linkage between typhoon, ocean and ENSO. As ocean shoals during ENSO, it acts as a natural damper from the mother nature (Gaia) to prevent typhoons from over-intensifying [After Zheng, Lin et al. 2015].

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