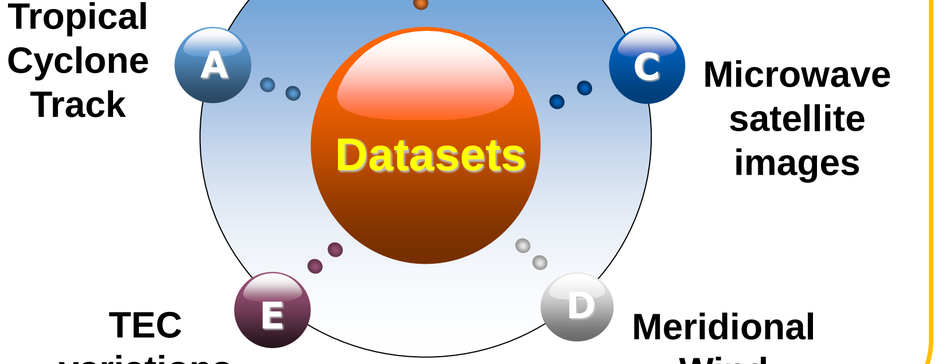
Analysis of Atmospheric anomalies versus ionospheric variations over a severe typhoon (1822)

Mohamed Freeshah[1,4,5], Xiaohong Zhang[2,3,4], Erman Şentürk[6], Mervat Refaat[5,8], and Muhammad Arqim Adil[7]

[1] State Key Laboratory of Information Engineering in Surveying, Mapping and Remote Sensing, Wuhan University, Wuhan 430079, China
[2] School of Geodesy and Geomatics, Wuhan University, 129 Luoyu Road, Wuhan 430079, China
[3] Key Laboratory of Geospace Environment and Geodesy, Ministry of Education, 129 Luoyu Road, Wuhan 430079, China
[4] Collaborative Innovation Center for Geospatial Technology, 129 Luoyu Road, Wuhan 430079, China
[5] Department of Surveying Engineering, Shoubra Faculty of Engineering, Benha University, Egypt (Mohamedfreeshah@whu.edu.cn)
[6] Department of Surveying Engineering, Kocaeli University, Kocaeli, Turkey
[7] Department of GNSS, Institute of Space Technology, Islamabad, Pakistan
[8] Department of Civil Engineering, Canadian International College, Cairo, Egypt

Abstract

North–West Pacific Ocean is one of the most regions has hit by typhoons. In 2018, Mangkhut was the 22nd Tropical Cyclone (TC) over the North–West Pacific Ocean regions (so, it was numbered as 1822). In this study, we investigate the highest amplitude ionospheric variations and the atmospheric parameter anomalies during an extremely powerful typhoon in September 2018 that caused extensive damage in Guam, the Philippines, and South China. The atmospheric parameters such as Air Intensity, the wind structure's variation, and the meridional and Zonal wind were retrieved from Honk Kong Observatory and National Oceanic and Atmospheric Administration-Physical Sciences Laboratory (NOAA-PSL) to analyze their behavior during Mangkhut. Besides, total electron content (TEC) were created through Hong Kong SatRef (HKCORS) and IGS data around the area of Mangkhut typhoon. TEC sequences are utilized to analyze the ionospheric response by interquartile range approach (IQR) over the maximum wind speed points after taking the solar-terrestrial environment and geomagnetic storm indices into consideration.



Methods

Atmospheric Analysis → Ionospheric Response → atmosphere ionospheric coupling

The Tropical Cyclone Track, Air Intensity, variation of wind structure were retrieved from **HKO**. The atmospheric parameters were retrieved from **NOAA-PSL**. The anomaly maps of days represent differences from the mean value of the previous 5 days for the meridional and Zonal wind.

The **TEC** sequences over the two maximum spots for 17 days were analyzed by the interquartile range approach (**IQR**). To discover the possible anomalous signals of the TEC variations

According to the evolution of the atmosphere-ionosphere coupling theory. We tried to enhance the understanding of the tropospheric-ionospheric coupling,

Many of previous works missing atmospheric parameters and their possibilities impact analysis on the ionosphere response to Tropical Cyclones (Ke et al., 2019); (Jun Chen et al., 2020).

Results

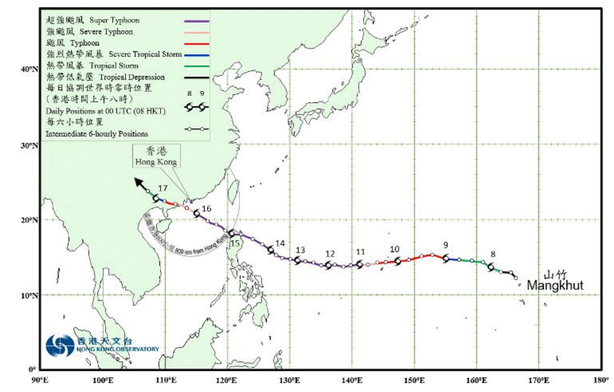


Fig 1. Tropical Cyclone Track in September 2018

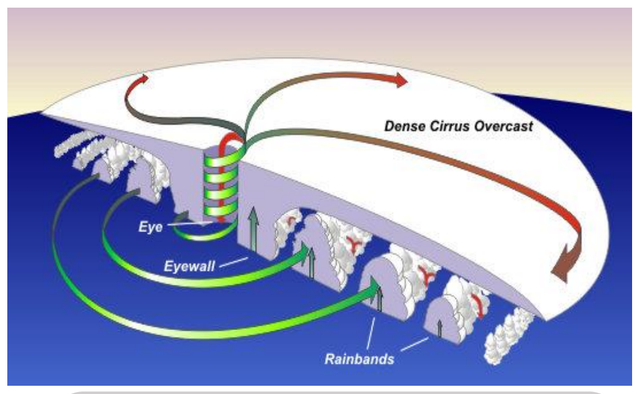


Fig 2. Cross sectional in a Typhoon

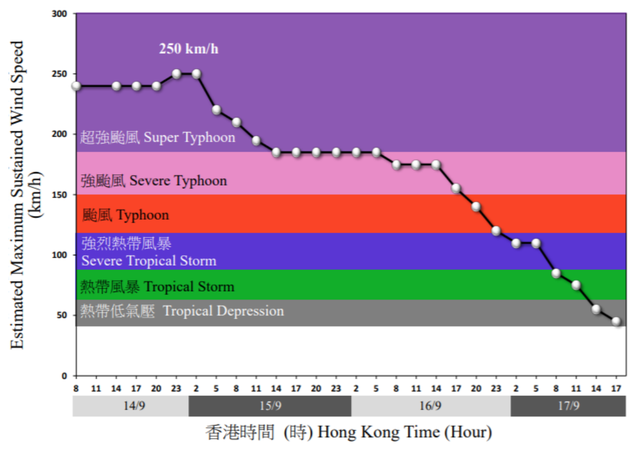


Fig 3. AI Horizontal Profile from September 14th -17th.

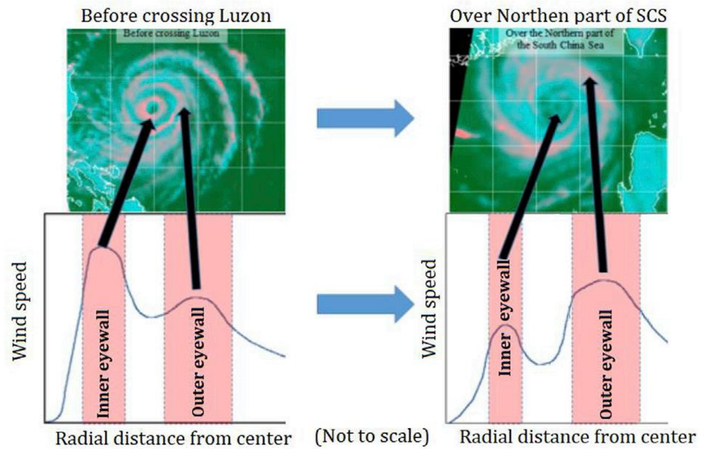


Fig 4. the wind structure's variation of Mangkhut before crossing Luzon island and over the northern part of SCS

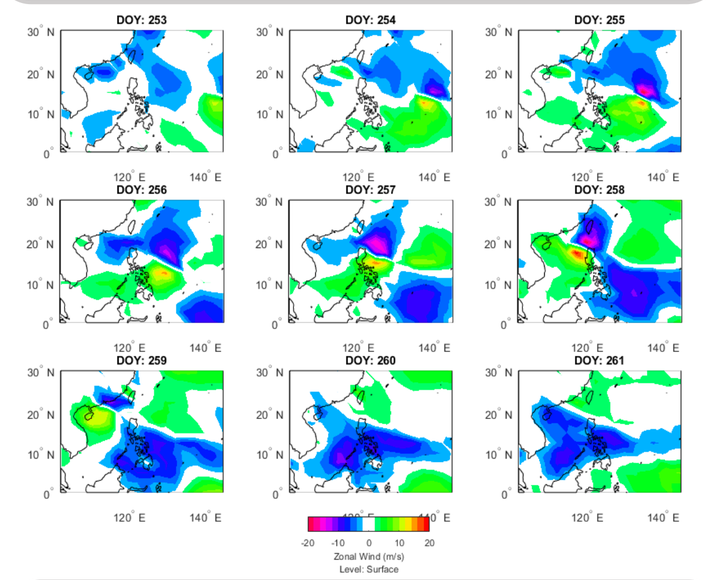


Fig.5. Anomaly maps of Zonal Wind represent differences from the mean value of the previous 5 days

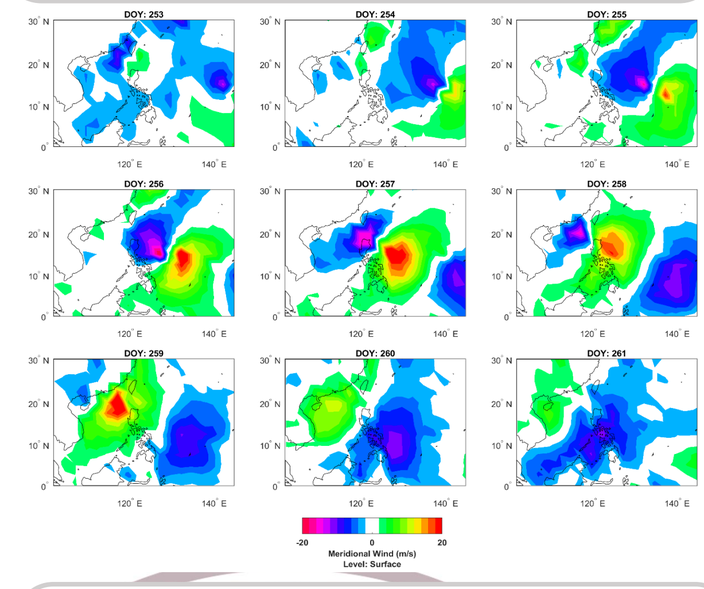


Fig. 6. Anomaly maps of Meridional Wind represent differences from the mean value of the previous 5 days

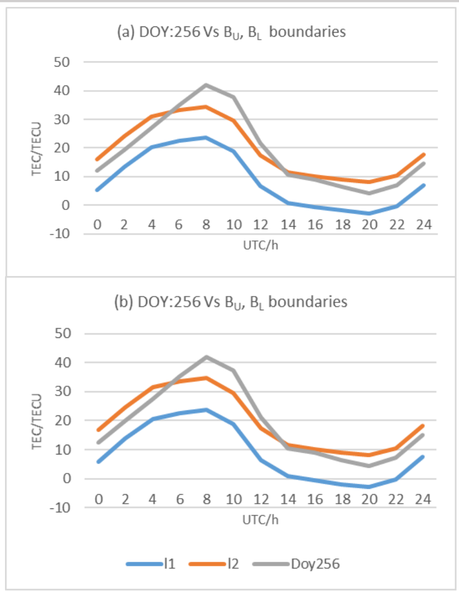


Fig.7 TEC lower and upper boundaries of IQR method vs TEC of DOY:256

Discussion

Fig. 5 shows the behavior of the typhoon in the zonal flow's direction tends to be weaker and has fast-moving which causes a relatively slight impact on the local weather. Meanwhile, Fig. 6 shows the meridional flows tend to be stronger with slow-moving. We can see DOY:256 implies a threshold value in meridional wind. Also, the threshold of meridional wind happened on the maximum ionospheric variations DOY:256 (Fig. 7). These may be a possible reason that the meridional winds and their resulting waves may contribute to upper atmospheric coupling.
I1 and I2 are the lower and upper boundaries, respectively. Fig.7 (a) and (b) show significantly increased in TEC over the two maximum wind speed points (Fig.3, Fig.7) last about 6–14 UT. The lower and upper boundaries used to discriminate the ionospheric anomalies response to typhoon depend on the IQR through the 10 previous days before the cyclone converted into a super typhoon.

Conclusions

- In this study, the atmospheric anomalies and ionospheric disturbances observed during powerful typhoon Mangkhut in the North–West Pacific Ocean are analyzed using the derived data from HKO and NOAA-PSL before, during, and after the typhoon and its max wind speed points.
- The research findings indicate that TEC's highest variations observed during the second-highest wind speed with few hours before max wind speed.
- In addition, the threshold value of meridional wind happened on the same day of maximum ionospheric variations DOY:256. These may be a possible reason that the meridional winds and their resulting waves may contribute in one way or another to upper atmospheric coupling.