

# NIE22054 - Key Drivers to the 'Once-in-100-years' Flood

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## Motivation

During 16-18 December 2021, Peninsular Malaysia received a record-breaking rainfall, causing an unprecedented flooding that resulted in 51 deaths and economic loss up to USD\$ 1.5B. With the aim of providing an auxiliary decision-making support to the development of flood mitigation strategies, this project proposes to:

1. Examine the reasons behind this catastrophic flood, which was deemed as a 'once-in-100-year' event;
2. Provide a quantitative method for the outlook of its return period in the future warming climate.

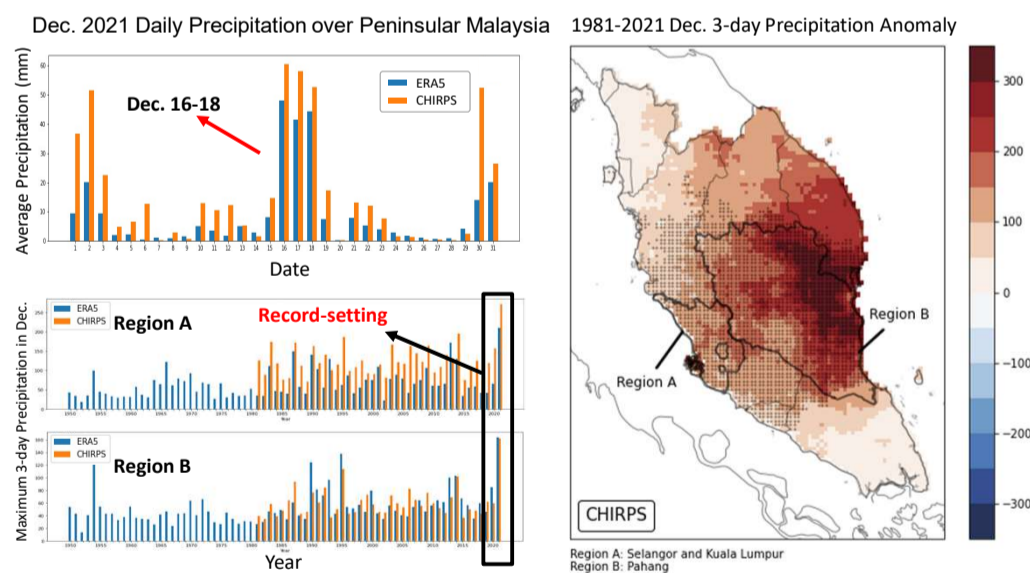


Source: <https://www.thestar.com.my/news/focus/2022/09/18/be-prepared-for-floods-in-the-next-six-months>

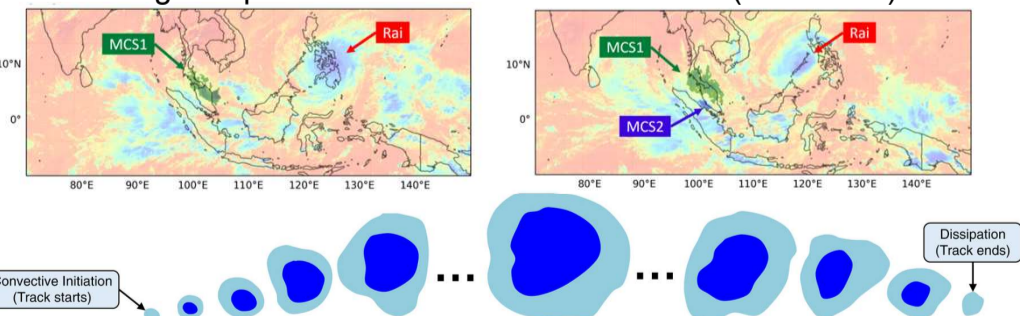


Source: <https://floodlist.com/asia/malaysia-floods-december-2021>

## Methodology

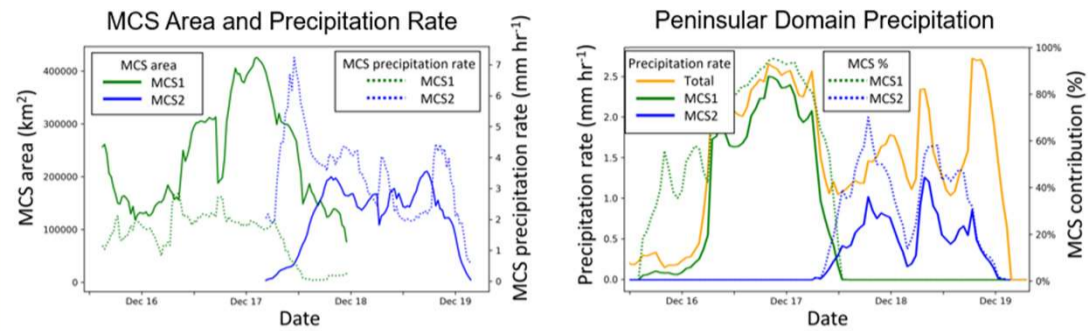


By analyzing ERA5-Land and CHIRPS data, we identified the period with the most intense rainfall in December 2021 were from 16<sup>th</sup> to 18<sup>th</sup>. Compared to historical records, these 3 days corresponds to the largest positive anomalies with the majority of peninsula exceeding 99<sup>th</sup> percentile of the historical records (black dots).



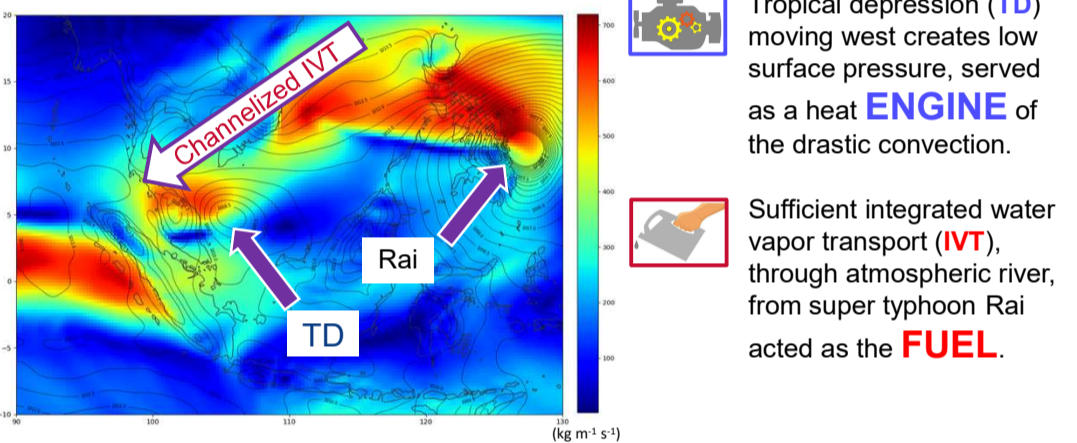
A refined storm tracking algorithm was deployed, and two consecutive mesoscale convective systems (MCSs) were identified that made significant contribution to flood event (contribution to the total peninsula precipitation of 42% and 17% respectively).

## Results



The spatiotemporal evolution of the flood-causing MCSs. Both systems followed the typical MCS lifecycle with the stages of initiation (emerging), genesis (upscale growth of convective core), mature (expansion of stratiform rain), and dissipation (diminishing spatially).

Dec. 16-18 Mean Pressure and Water Vapor Transport



This joint histogram shows the distribution of minimum mean sea level pressure (MSLP) and the mean IVT over the peninsula in three days mean. The joint probability for the event of study was 0.6% (4/630), and the corresponding return period was 158 years, indicating the return period of the 2021 Peninsular Malaysia flood was more severe than 'once-in-100-years'.

## Conclusion & Discussion

- We found that the 2021 Peninsular Malaysia flood was caused by two consecutive MCSs producing heavy precipitation. Regarding the direct contribution to the flood, the first MCS produced 2.5 times more rainfall than the second one.
- The two key drivers of the flooding event are identified: the slow-moving tropical depression (TD) that drove the convective updraft, and the long-range water vapor corridor (IVT) that fueled excessive moisture from the super typhoon Rai to the TD.
- By calculating the joint frequency of low MSLP and high IVT, we provided a quantitative way to estimate the return period of such catastrophic event (158 years), which can be used to improve the operational weather forecast and outlook, as well as assist in the development of more resilient flood mitigation strategies and infrastructure design in Peninsular Malaysia.

### Reference

Dong, L., Wang, J., Zhi, X., Park, E., Wang, X., Yim, S. H-L, Zhang, H., Lee, J. and Tran, D. D. (2023). Unprecedented Devastation: The 2021 Peninsular Malaysia Flood Far Surpasses the 'Once-in-a-Century' Scale, *Earth's Future*, Under Review.