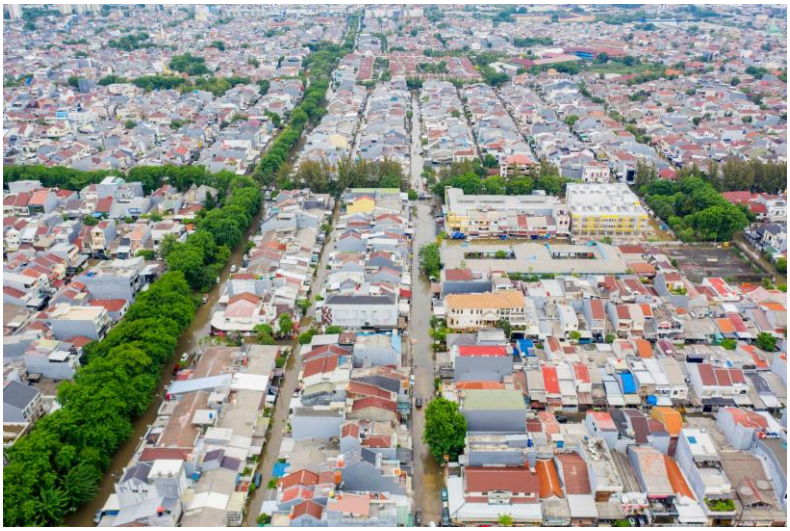
CASE STUDY: Better understanding of high-impact weather events in Southeast Asia for improved early warning

Executive Summary: The Weather and Climate Science for Service Partnership (WCSSP) Southeast Asia project has improved understanding and forecasting of high-impact weather events such as heavy rainfall, floods, and landslides, enabling more accurate early warnings and better disaster preparedness across the region. Through international research collaboration, knowledge exchange, and the development of advanced forecasting tools, the programme has strengthened forecasting capabilities in partner countries while also enhancing weather process understanding and prediction models that benefit the UK and the global meteorological community.

The Challenge: High-impact weather (HIW) events, such as heavy rain and consequent flooding and landslides, can be devastating to the livelihoods of local people and the economy of Southeast (SE) Asian countries. This region is also considered the heat engine of the tropics and has a significant impact on regional and global weather patterns, including over the North Atlantic and Northwest Europe. Improving understanding of the physical processes that lead to HIW in Southeast Asia and its improved representation in weather forecasting models will ultimately result in better weather forecasts over the UK and globally.



Flooded streets in Southeast Asian city

Through close collaborative research by UK academia, the Met Office and major governmental organisations from Indonesia (BMKG), Vietnam (VNMHA), the Philippines (PAGASA), and Malaysia (Met Malaysia), the Weather and Climate Science for Service Partnership (WCSSP) Southeast Asia project has made significant progress in improving our ability to forecast HIW in SE Asia. Improved physical understanding of tropical weather processes has allowed a set of cutting-edge model evaluation tools to be developed and used routinely by Southeast Asian partners and the Met Office to identify and implement significant improvements to the performance of global and regional weather forecasting modelling systems. These tools have also been made openly available for the global weather community to utilise. This is contributing towards better informing disaster management and stakeholders for improved preparedness in Southeast Asia, the UK and globally. Despite this progress much more work is needed, and Southeast Asian partners have highlighted priority research topics to further improve their capacity to respond to their countries' weather forecasting needs.

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The Approach: To respond to these needs, the FORecasting high-impact Weather And extreme Rainfall Drivers and Dynamics for Southeast Asia (FORWARDS) project, funded by WCSSP Southeast Asia and led by the University of Leeds along with the Universities of Reading, East Anglia and the National Centre for Atmospheric Science, is conducting research into these priority areas. Focus is on better understanding the atmospheric processes that are known to lead to HIW but have yet to be studied in sufficient detail, both as they occur in nature and as they are represented in weather forecasting models at the Met Office and partner countries.



Space view of tropical cyclone

Pathway to Impact: The outputs from this new work are providing the basic research needed for supporting operational weather forecasters as well as improving weather models to advance their ability to forecast HIW events on the regional and country scale in SE Asia. This is further improving the capabilities of the partner countries against HIW, positively impacting a wide range of human activities and all population sectors. The dissemination of this new knowledge includes guidance materials co-developed with in-country forecasters as well as an 'Introduction to the Meteorology of SE Asia' textbook aimed at forecasters and researchers in the region and which summarises the increased knowledge as well as new forecast products developed across the WCSSP Southeast Asia project. A significant focus is on explicit collaborative activities with scientists and forecasters at the national weather services in the four partner countries. These include researcher exchanges between Southeast Asia and UK partners for up-to 4 weeks at a time for more close research collaboration and exchange of knowledge and expertise.



Generic image of operational meteorologist using a forecast tool.

Although the focus is on partnering countries, much of the research carried out will have impact more widely in the Southeast Asia region and globally. With the Maritime Continent being the heat engine of the tropics, impacting on regional and global weather patterns, the improved physical understanding from this work is resulting in significant improvements to the performance of global and regional weather forecasting modelling systems, not just over Southeast Asia but in other regions including the UK. The work is also

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feeding into the global stage via the World Meteorological Organization Early Warnings for All initiative and High Impact Weather Project (HIWeather), with knowledge and experience from the project contributing to the authoritative voice on best practice approaches, supporting the global weather and climate community. Improved early warnings of high impact weather allowing for better preparedness and reduced impacts will contribute towards the foundations of a stable economy, a key milestone in the UK Governments Plan for Change and is vital to ensuring the United Kingdom remains resilient and responsive in the face of potential future shocks.

Strengthening Collaboration:

The project has held several workshops, hosted by one of the UK partners, to ensure appropriate engagement between activities across the project. These have been scheduled to coincide with UK exchange visits by in-country partners which have helped maximise the collaboration aspect and knowledge sharing of the events. In addition, non-WCSSP funded PhD students based at UK Universities, and whose research topics are highly relevant to the FORWARDS project aims have also attended, facilitating the building of wider research networks and exchange of knowledge and experiences which will help maximise the impact and benefits from this project. The events have clearly demonstrated how the project is supporting the personal development of many early career researchers, equipping them with training, skills and real-world experience which is contributing towards building the next generation of researchers critical in helping to tackle the shared global challenges posed by extreme weather and climate change.



Attendees of the FORWADS Annual Workshop hosted by NCAS/University of Leeds, January 2023

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Diong Jiong Yik, Assistant Director of Research and Technical Development at the Malaysian Meteorological Department said *"The FORWARDS project addresses several key challenges in tropical weather forecasting and provides valuable insights, enhancing forecasting accuracy and decision-making. This contributes to improving our organisations operational efficiency."*

Nurdeka Hidayanto, Operational Weather Forecaster at BMKG said *"The FORWARDS project provides an invaluable opportunity to enhance our understanding of tropical atmospheric dynamics and their role in driving heavy rainfall events in Sumatra and the surrounding regions. By improving weather model performance in Southeast Asia, this research will support better preparedness and resilience against extreme weather impacts in vulnerable communities."*

Muhamad Sofian Bin Muhamad Yusof, Model Development Lead at the Malaysian Meteorological Department said *"The FORWARDS project is providing valuable opportunities to connect with researchers at the Met Office and UK Universities regarding research related to weather processes of high relevance to Malaysia. I am very hopeful that this new knowledge and capability can be implemented to further improve the forecasting of HIW in Malaysia."*

Mohamad Husein Nurrahmat, Research Scientist at BMKG commented that *"The FORWARDS project provides advancements in understanding of important drivers of Indonesian weather which influence extreme rainfall and tropical cyclone formation. By refining process-based insights and improving numerical weather prediction models, this initiative significantly enhances BMKG's forecasting capabilities to detect extreme weather, allowing more accurate early warnings and better disaster risk management."*

Juliane Schwendike, Associate Professor in Meteorology at the University of Leeds and principal investigator for the FORWARDS project said: *"The FORWARDS project enables us to improve our fundamental understanding of high-impact weather systems in SE Asia and to empower forecasters in the region to make use of the best new science to forecast these weather events. This will help them provide early warning for hazards such as floods, coastal inundation, and landslides."*

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