Supercomputer makes it possible to predict the evolution of the large-scale atmospheric circulation of tropical storms

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To accurately predict weather and climate, scientists need to simulate the large-scale patterns that exist in global atmospheric circulation. One of the largest circulation patterns, the Madden–Julian Oscillation (MJO), is associated with heavy rainfall and drought across the tropics. Due to the sheer size and complexity of the MJO, however, researchers have so far struggled to perform sufficiently detailed simulations over a broad enough area to accurately predict this oscillation.

Hirofumi Tomita and co-workers at the RIKEN Advanced Institute for Computational Science, in collaboration with researchers from the Japan Agency for Marine-Earth Science and Technology and the University of Tokyo, have now exploited the power of Japan's K computer—currently the fourth most powerful supercomputer in the world—to perform a series of MJO simulations with unprecedented resolution.

The MJO develops as a result of coupling between atmospheric circulation and warm, rising air in the tropics. It typically appears as a band of enhanced convection that progresses eastward across the Indian and Pacific oceans. The movement of the MJO results in 30- to 60-day cycles of enhanced wet and dry phases in tropical regions.

This interaction between global-scale movement and localized effects is difficult to resolve in global climate models because of the limitations of available computing power, which means that simulations need to be run on only small scales or with large geographic cell-sizes and simplified cloud modeling schemes in order to obtain results with realistic timeframes.

To resolve the MJO in more detail, Tomita and his colleagues used a modeling scheme called the Nonhydrostatic Icosahedral Atmospheric Model (NICAM), which can explicitly resolve clouds on the fine scales needed to reproduce the MJO, in combination with the K computer. They ran the simulations 54 times using a 14-kilometer mesh, resolving cloud systems as small as 20 kilometers in size.

"Detailed MJO simulations have been possible since 2007, but only for small case studies," explains Tomita. "Using the K computer, we acquired many simulation results, meaning we can discuss the statistical aspects of NICAM's potential and the extended predictability of the MJO."

The research team estimates that the NICAM can predict the evolution of the MJO over an impressive 27 days, matching measured solar radiation, rain, humidity and wind data obtained during an intensive ground-based, airborne and shipborne weather observation campaign in the Indian Ocean. The results demonstrate the power of the NICAM for detailed MJO studies. "Our approach shows great potential for numerical weather forecasting," says Tomita.

More information: Miyakawa, T., Satoh, M., Miura, H., Tomita, H., Yashiro, H., Noda, A. T., Yamada, Y., Kodama, C., Kimoto, M. & Yoneyama, K. Madden–Julian "Oscillation prediction skill of a new-generation global model demonstrated using a supercomputer." *Nature Communications* 5, 3769 (2014). DOI: 10.1038/ncomms4769

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