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A Daily Disturbance from the Upper Atmosphere Leaves its Footprints on Tropical Rainfall

No matter where you live, rain seems to fall more often at certain times of day, whether it is seen in the daily afternoon rainstorm or a typical overnight shower. Indeed, statistically, long-term average rainfall tends to cluster at certain times of the 24-hour cycle, but that time frame varies depending on location. A team of scientists led by postdoctoral researcher **Takatoshi Sakazaki**, from the University of Hawai‘i at Mānoa’s International Pacific Research Center (IPRC), has analyzed satellite-based observations and computer model simulations of tropical rainfall variation throughout the day in an effort to determine the root cause of the temporal patterns. Their results, **published** recently in *Geophysical Research Letters*, show that daily tropical rainfall distribution is significantly shaped by heating of the upper atmosphere.

Continental settings often receive their peak rainfall in the late afternoon, after sunlight has heated the land surface throughout the day. Conversely, in tropical ocean settings, the maximum rainfall comes in the late night/early morning. In fact, detailed examination of observed tropical patterns reveals that rainfall often clusters into two uneven peaks, separated by roughly 12 hours, a pattern reminiscent of the familiar twice-daily ocean tide heights (Fig. 1, “Observed” curve).

In fact, the atmosphere also experiences a type of daily tide. It has been long recognized that a global-scale pressure wave passes through the upper atmosphere, forced by the daily cycle of sunlight heating the ozone layer and propagating down towards the land surface. In the tropics, this wave can be seen in the daily fluctuations in barometric pressure, which peak at about 10 am and 10 pm.

Sakazaki and his team speculated that the tropical rainfall patterns are also intimately tied to this sun-driven atmospheric wave. By modeling rainfall patterns both with and without the forcing by upper atmospheric heating, they were able to show that the double peak of rainfall abundance in many tropical locations is accounted for only if the 12-hour atmospheric wave is included (Fig. 1, red curve).

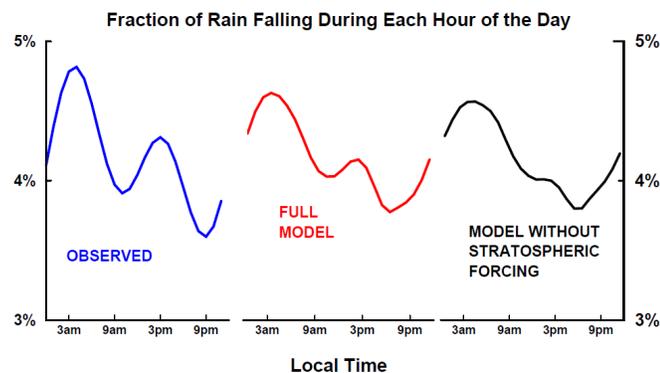


Fig. 1. Fraction of the total rainfall, as a function of time of day, for a region including much of Indonesia and its surrounding oceans. Observations show strong peaks at early morning and mid-afternoon. IPRC modeling captures the observed modulation only when upper atmospheric forcing is included.

“It is exciting to find that rainfall has distinct ‘footprints’ of the stratospheric ozone heating, which occurs very far above us,” said Sakazaki. “Weather at the ground may be influenced by a much higher layer of the atmosphere than previously thought.”

Kevin Hamilton, a collaborator on this project and retired IPRC Director, noted, “Understanding the self-organization of rainfall over periods of hours to days, and over large distances, is critical for improving forecasts of our day-to-day weather in the tropics.” In addition, he emphasized that this strong link between the rainfall patterns and the atmospheric tides provides a unique feature whose presence, or absence, can be used to evaluate the accuracy of rainfall pattern forecasting in atmospheric models.

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Citation:

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The International Pacific Research Center (IPRC) of the School of Ocean and Earth Science and Technology (SOEST) at the University of Hawai‘i at Mānoa, is a climate research center founded to gain greater understanding of the climate system and the nature and causes of climate variation in the Asia-Pacific region and how global climate changes may affect the region. Established under the “U.S.-Japan Common Agenda for Cooperation in Global Perspective” in October 1997, the IPRC is a collaborative effort between agencies in Japan and the United States.