Identifying individual atmospheric equatorial waves from a total flow field

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Clouds over Australia are shown. Credit: NASA

Owing to the opposite vertical orientation with respect to the plane of Earth's rotation across the equator from the Southern Hemisphere to Northern Hemisphere, the equator serves as a waveguide that houses all kinds of atmospheric waves propagating along the west-east direction, which are referred to as "equatorial waves." Equatorial waves are generated from spatially non-uniform diabatic heating fields, including latent heating releases from convective storms. These equatorial waves in turn initiate and organize new convections as they propagate out of their genesis locations, triggering a new set of equatorial waves propagating both eastwards and westwards along the equator. As a result, equatorial waves play important roles in organizing large-scale circulation disturbances and regulating large-scale diabatic heating patterns in tropics.

On intraseasonal time scales or longer, equatorial waves play critical roles in several prominent low-frequency oscillations that have far-reaching consequences for Earth's global weather and climate, including the Madden-Julian Oscillation in the tropical troposphere, Quasi-Biennial Oscillation in the equatorial stratosphere, and El Niño-Southern Oscillation over the equatorial Pacific basin.

"The accuracy of extended-range forecasts therefore hinges on the faithful representation of these equatorial waves in numerical models," explains Dr. Ming Cai from Florida State University, the corresponding author of a recently published study in *Advances in Atmospheric Sciences*. "For this reason, equatorial waves have been a target of atmospheric research for many decades."

The paper presents a method for identifying individual equatorial waves in wind and geopotential height fields using horizontal wave structures derived from classical equatorial wave theory. This approach, the equatorial wave expansion of instantaneous flows (EWEIF), decomposes instantaneous flow fields into its constituent equatorial waves.

According to Dr. Cory Barton, the first author of the study, the benefit of using EWEIF over a traditional spectral analysis technique is its primary strength; namely, that the decomposition requires only a single snapshot of the atmospheric state without using temporal or spatial filtering a priori. Applying EWEIF analysis to flow fields at different times can be used to obtain the temporal and spatial evolution characteristics of equatorial waves, including their initiations, propagations, and amplitude vacillations, as well as their interactions with tropical convections and ever-changing background flow.

"Along with validating current theories for weather and climate variability, EWEIF allows us to address several pertinent questions regarding the configuration and strength of the wave spectrum, the evolution of the waves from genesis to breaking, and their interactions with the background flow," Dr. Barton concludes. "Answering these questions has the potential to advance not only our understanding of the tropics, but also our predictive skill for the global atmosphere."

The study is published in *Advances in Atmospheric Sciences*.

More information: Cory Barton et al, Equatorial wave expansion of instantaneous flows for diagnosis of equatorial waves from data: Formulation and illustration, *Advances in Atmospheric Sciences* (2017). DOI: 10.1007/s00376-017-6323-z

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