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## First measurements of fine-vertical-scale wave impacts on the tropical lower stratosphere

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Atmospheric waves in the tropical tropopause layer are recognized as a significant influence on processes that impact global climate. For example, waves drive the quasi-biennial oscillation (QBO) in equatorial stratospheric winds and modulate occurrences of cirrus clouds. However, the QBO in the lower stratosphere and thin cirrus have continued to elude accurate simulation in state-of-the-art climate models and seasonal forecast systems. We use first-of-their-kind profile measurements deployed beneath a long-duration balloon to provide new insights into impacts of fine-scale waves on equatorial cirrus clouds and the QBO just above the tropopause. Analysis of these balloon-borne measurements reveals previously uncharacterized fine-vertical-scale waves (<1km) with large horizontal extent (>1000km) and multiday periods. These waves affect cirrus clouds and QBO winds in ways that could explain current climate model shortcomings in representing these stratospheric influences on climate. Accurately simulating these fine-vertical-scale processes thus has the potential to improve sub-seasonal to near-term climate prediction.