First Detection of the Pekeris Internal Global Atmospheric Resonance: Evidence from the 2022 Tonga Eruption and from Global Reanalysis Data

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We used observations and model simulation to examine the atmospheric pulses that dominate the far field in the hours after the January 2022 Tonga eruption. We analyzed radiance observations taken from the Himawari-8 geostationary satellite and showed that both a Lamb wave front with the expected horizontal phase speed ~315 m-s^{-1} and a distinct front with phase speed ~245 m-s^{-1} can be detected. The slower phase speed is consistent with that expected for the global internal resonant mode that had been proposed by Pekeris in 1937 and in other idealized theoretical studies over the past century, but which had never been detected in the atmosphere. A simulation of the eruption aftermath was performed with a high resolution atmospheric general circulation model. A hot anomaly over the volcano location was introduced instantaneously to the model fields and the model was integrated for another 12 hours. This produced a simulated wave pulse that, in the far field, agreed reasonably well with barograph observations of the Lamb wave. The model results also showed the presence of the slower pulse and that this disturbance had a vertical structure with a 180^{o} phase shift in the stratosphere, in agreement with the theoretical prediction for the internal mode. An implication of this result is that the continuously ringing Lamb wave global normal modes that have been seen in analysis of long observational records ought to have lower frequency internal Pekeris mode counterparts, a prediction that we confirm though analysis of 57 years of hourly global reanalysis data.

Figure: The 10-minute difference of the 9.6 μm brightness temperature observed by Himawari 8 plotted about 4 hours after the eruption (difference of 08:40UT –08:30UT, 15 January 2022). Our identification of the wave fronts associated with the Lamb and Pekeris modes are marked.

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