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Title: Enhanced stratospheric water vapour from the eruption of Hunga Tonga- Hunga Ha'apai: Observations and impacts

Abstract:

On 15 January 2022, Hunga Tonga-Hunga Ha'apai, an underseas volcano approximately 65 km north of Tonga underwent a paroxysmal eruption with plume heights reaching the upper stratosphere and lower mesosphere, the deepest eruption observed during the satellite era. Reports suggest the energy released by the eruption equivalent to that of the 1883 eruption of Krakatoa. At 400 kt emitted, sulphur dioxide amounts were small compared to historical eruptions of similar magnitude and the typical impacts seen with these types of eruptions were expected to be minimal. However, the eruption also produced an unprecedented cloud of water vapour in the middle stratosphere, with elevated concentrations that have dispersed over much of the Southern Hemisphere.

Observations from the Microwave Limb Sounder (MLS) onboard the NASA Aura satellite document the evolution of this unprecedented water vapour cloud. Much of the water vapour is observed between the 30 and 10 hPa pressure levels, approximately 20-30 km altitude. Strongest zonal mean anomalies are centred around 20 S, although currently extend from just north of the equator to approximately 60 S. The magnitude of the anomalies is slowly declining; peak anomalies initially exceeded 10 ppmv but have reduced to 3-4 ppmv by September 2022.

The impacts on climate are largely unknown at this time but are potentially significant and remain a topic of ongoing research. Water vapour in the lower stratosphere has been shown to produce feedback onto tropospheric temperatures, potentially increasing global warming. There is also concern that the enhanced water vapour may impact springtime Antarctic ozone depletion, although as the cloud has not infiltrated the polar vortex in 2022, enhanced ozone depletion from this source is unlikely to occur this year. A prolonging of the polar vortex into the summer season is also forecast, which may drive anomalous conditions in surface weather in the Southern Hemisphere midlatitudes. The possible influence of the water vapour cloud on this aspect of the stratospheric circulation also remains under investigation.

Given the long timescale of stratospheric processes, the cloud is expected to remain for several years. This suggests that any climate effects may persist or, with possible enhanced Antarctic ozone depletion, be delayed until next year. While it is certain that the strength of the anomaly will continue to decline, how the cloud impacts the climate until it does dissipate remains highly uncertain.