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Wildfire Smoke Highlights Troposphere-to-Stratosphere Pathway

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The extensive wildfires during December 2019 – January 2020 in South-East Australia released a mass of smoke into the stratosphere comparable to large volcanic eruptions. The smoke was observed throughout the southern hemisphere stratosphere months after the fires. Pyrocumulonimbus clouds (pyCb) are commonly presented as the main mechanism able to transport wildfire smoke across the tropopause into the stratosphere and were assumed as the driving mechanism also in this case. However, the smoke only appeared in the higher stratospheric levels downstream of the fires in the central south Pacific. Furthermore, there is indication that pyCb were not active when the smoke was first seen in satellite images.

In this study, using Lagrangian air mass trajectory analysis together with satellite observations we are able to fill the gap and identify the pathway of the smoke, its entry point into the upper levels and the mechanism that allows the smoke to enter the stratosphere. We find that the transitioning tropical cyclone Sarai merged with an extratropical cyclone to form a troposphere-wide cyclonic system, with a deep potential vorticity cutoff above it. Initially, the smoke traveled in the isentropic layer between 340 and 350 °K, just below the tropopause. Having reached the cyclone, the smoke changed direction, circulated around the low and entered the stratosphere through a dip in the tropopause height within the cutoff.

The cyclonic system described in this case study is not uncommon in these regions, possibly underlining the importance of this mechanism for troposphere-to-stratosphere exchange.