Idealized modeling of diabatically-forced anticyclonic plumes from wildfires and volcanic eruptions in the stratosphere

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Anticyclonically-trapped plumes were first discovered following the 2020 Australian fires. Since then, they have been reported after several extreme wildfires and volcanic eruptions, including the 2017 Canadian wildfires, the 2019 Raikoke and the 2022 Hunga Tonga-Hunga Ha'apai eruptions. They appear as coherent plumes of aerosols and combustion/volcanic compounds confined within mesoscale anticyclones (100s to 1000 km diameter), which for several months resist dispersion and dilution by the large-scale stratospheric flow. Due to their unusual composition, large radiative forcing is prevailing inside the plumes, generating significant diabatic responses in terms of vertical motions (ascent or descent) and potential vorticity.

This presentation will be focused on the analysis of idealized numerical simulations of the ascending vortices. The mechanisms governing their formation, maintenance and evolution will be discussed and the simulations confronted to theoretical investigations. In particular, after an appropriate coordinate transformation, the dynamics of the diabatically-forced flow can be to a good approximation reduced to a 1 dimensional Burgers'equation for the tracer, to which potential vorticity responds, resulting in anticyclonic PV formation at the location of the tracer front.