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Direct stratospheric injection of biomass burning emissions: a case study of the 2009 Australian bushfires using the NASA GISS ModelE2 composition-climate model

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Direct stratospheric injection (DSI) of forest fire smoke represents a direct biogeochemical link between the land surface and stratosphere. DSI events occur regularly in the northern and southern extratropics, and have been observed across a wide range of measurements, but their fate and effects are not well understood.

DSIs result from explosive, short-lived fires, and their plumes stand out from background concentrations immediately. This makes it easier to associate detected DSIs to individual fires and their estimated emissions. Because the emissions pulses are brief, chemical decay can be more clearly assessed, and because the emissions pulses are so large, a wide range of rare chemical species can be detected. Observational evidence suggests that they can persist in the stratosphere for several months, enhance ozone production, and be self-lofted to the middle stratosphere through shortwave absorption and diabatic heating. None of these phenomena have been evaluated, however, with a physical model.

To that end, we are simulating the smoke plumes from the February 2009 Australia 'Black Saturday' bushfires using the NASA GISS ModelE2 composition-climate model, nudged toward horizontal winds from reanalysis. To-date, this is the best-observed DSI in the southern hemisphere. Chemical and aerosol signatures of the plume were observed in a wide array of limb and nadir satellite retrievals. Detailed estimates of fuel consumption and injection height have been made because of the severity of the fires. Uncommon among DSIs events was a large segment of the plume that entrained into the upper equatorial easterlies. Preliminary modeling results show that the relative strengths of the equatorial and extratropical plume segments are sensitive to the plume's initial injection height. This highlights the difficulty in reconciling uncertainty in the reanalysis over the Southern Hemisphere with fairly-well constrained estimates of fire location and injection height at the source.