Systemic swings in end-Permian climate from Siberian Traps carbon and sulfur outgassing

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Siberian Traps flood basalt magmatism coincided with the ~252 Ma end-Permian mass extinction, the greatest loss of floral and faunal diversity since the Cambrian radiation. Proposed kill mechanisms linking magmatism and outgassing to ecological catastrophe include global warming, global cooling, acid deposition, ozone depletion, and changes in ocean chemistry. However, the critical combinations of environmental changes that trigger global mass extinction remain unknown. In particular, the combined and competing effects of sulfur and carbon outgassing on Earth systems remain to be quantified. Here we present results from global climate model simulations of flood basalt outgassing that account for sulfur chemistry and aerosol microphysics in a coupled Earth systems framework. We consider the effects of sulfur and carbon in isolation and in tandem, and find that carbon and sulfur emissions combine to generate large swings in temperature, ocean circulation, and hydrology within a longer-term trend towards a greenhouse world, unifying observed changes in climate and geochemical cycles with feedbacks initiated by Siberian Traps magmatism.