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Decadal ozone and climate changes caused by the super-size, sulfur and halogen rich, Los Chocoyos eruption 84 kyrs ago

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The Los Chocoyos eruption (Magnitude ∼8, dated to 84 kyrs before present) was one of the largest volcanic eruptions during the past 100,000 years. Originating from present-day Guatemala, the eruption formed the current stage of the large Atitlán caldera. Los Chocoyos released more than ∼1100 km3 of tephra and the eruption is used as a widespread stratigraphic key marker during that time. The ash layers can be found in marine deposits from offshore Ecuador to Florida over an area of more than 107 km2. Using a new estimate of erupted magma mass and recent volatile measurements we estimate that the Los Chocoyos eruption released >1045 Mt SO_2, ∼1200 megatons of chlorine, and ∼2 megatons of bromine, which classifies it as a super-size eruption.

Most simulations of super-size volcanic eruptions so far (e.g. Toba ∼75 kyrs ago) have focused on the sulfur injection to the stratosphere. But since large amounts of halogens, especially bromine and chlorine, are emitted during explosive eruptions, as evident for Los Chocoyos, their impact on the Earth system need to be considered.

In this study we model the super-size, sulfur and halogen rich Los Chocoyos eruption and it's impacts on the environment and climate. We perform simulations with the new coupled chemistry climate model CESM2(WACCM) where sulfur aerosols are modeled interactively in addition to atmospheric chemistry, including volcanic halogens. We have performed an ensemble of simulations with injections of sulfur and halogen into stratosphere, taking different phases of the Quasi-Biennial Oscillation (QBO) and El Niño Southern Oscillation (ENSO) for initial conditions into account to address different modes of natural variability.

Our simulations show large changes to the composition of the atmosphere with massive ozone depletion lasting more than 10 years. The temperature profile of the stratosphere is radically changed and the period of the QBO is extended. Surface climate cooling, partly caused by increases in sea ice, lasts 20-30 years. Finally, the wide spread relevance of such eruptions is discussed for paleo and future atmospheric conditions.