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Quantifying the processes contributing to the anomalous methane growth rate after the eruption of Mt. Pinatubo

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The evolution of methane in the past two decades is not entirely understood. Its growth rate showed particularly large fluctuations after the eruption of Mount Pinatubo in June 1991. Being able to quantify the processes that determined these fluctuations can help us gain a better understanding of the methane budget.

Methane concentrations are determined by methane emissions and methane lifetime. Its lifetime is determined by OH concentrations, which are affected by UV radiation levels and by non-linear tropospheric chemistry. OH is produced by ozone photolysis and photolysis frequencies are determined by the amount of UV radiation reaching the troposphere. OH reacts with other chemical species, such as NO_X, CO and NMVOC, and thus its concentration is also driven by the concentrations of these species.

The Pinatubo eruption injected about 18.5 Mt of SO_2 in the stratosphere, and triggered different photochemical effects, including feedbacks between climate and atmospheric photochemistry. These processes had both positive and negative impacts on the methane growth rate, affecting methane emissions and methane lifetime. SO_2 and sulfate aerosols formed from SO_2, as well as stratospheric ozone depletion observed after the eruption, determined changes in tropospheric UV levels, thus in OH and methane lifetime. The temperature decrease in the years after the eruption led to changes in chemical reaction rates, in water vapour, as well as in natural emissions of methane and NMVOCs.

We represent the globally yearly averaged state of the troposphere in a column chemistry model, which accounts for non-linear CH_4-NO_X-CO-NMVOC-O_3 photochemistry. The effect of atmospheric perturbations on photolysis frequencies is calculated with the radiation transfer model TUV, and then used in the chemistry model.

We model the transient response of methane and methane growth rate using the observed atmospheric changes after the eruption of Pinatubo. Using this setup, we try to quantify the different processes described above and find which of them contributed significantly to the observed methane growth rate in the following years.