# Comparison of the CCMI and CMIP6 stratospheric aerosol data sets in REF-C1 simulations

Laura Revell[1,2], Andrea Stenke[2], Timofei Sukhodolov[3], Beiping Luo[2], Eugene Rozanov[2,3] and Thomas Peter[2]. [1]Bodeker Scientific, Christchurch, New Zealand. [2]Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland. [3]Physical-Meteorological Observatory/World Radiation Center, Davos, Switzerland. **Contact: laura@bodekerscientific.com**.

## Introduction

The stratospheric aerosol data sets developed for CCMI and CMIP6 differ in terms of the satellite sources used, and how gap-filling was performed following the Mt. Pinatubo eruption when the stratosphere was optically too thick for SAGE II to measure the lower stratosphere (**Table 1**).

## Methods

We performed historical ensemble simulations based on REF-C1 with the SOCOLv3 CCM[1] using the stratospheric aerosol data sets developed for CCMI and CMIP6. Five simulations used CCMI stratospheric aerosol and five simulations used CMIP6 stratospheric aerosol. We evaluated stratospheric temperature and ozone responses to the Mt. Pinatubo eruption of June 1991 using each data set[2].

## Results

SOCOLv3 simulations using the CCMI aerosol data set show tropical warming of up to 5 K following the Mt. Pinatubo eruption (**Fig. 1a**); this is 3 K warmer than in ERA-Interim[3] and MERRA[4] reanalyses, and in simulations using CMIP6 stratospheric aerosol.

The extra heating in the CCMI simulations comes from additional aerosol loading in the tropical lower stratosphere due to different gap-filling procedures (**Fig. 2**).

Dynamical and chemical changes in the stratosphere lead to ozone reductions of ~0.5 ppmv in the middle stratosphere (**Fig. 1b**). The CMIP6 simulations are in better agreement with SWOOSH observations[5] than the CCMI simulations.

Tropical upwelling strengthens less in the CMIP6 simulations compared to the CCMI simulations (**Fig. 3a**).

Heterogeneous chemical reactions, and therefore gas-phase $NO_x$ and $Cl_x$ ozone destruction reactions, are different in the two ensembles **(Fig. 3b).**

## Conclusions

When using CMIP6 stratospheric aerosol, SOCOLv3 simulates stratospheric temperature and ozone changes following the Mt. Pinatubo eruption more accurately compared with reanalyses and observations than when CCMI stratospheric aerosol is used.

We suggest that other CCMI modelling groups perform REF-C1 simulations using CMIP6 stratospheric aerosol to assess the robustness of our findings.

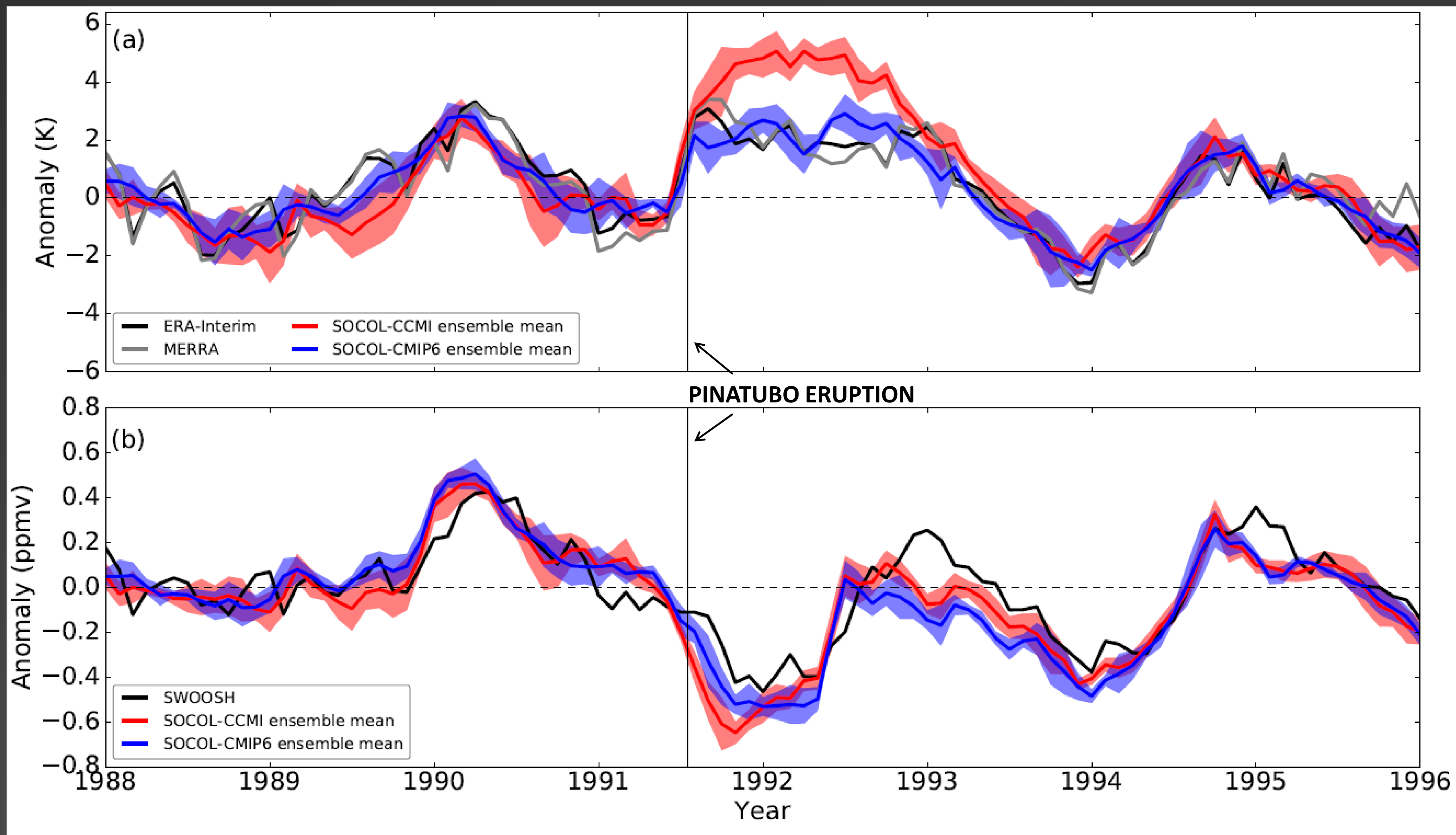


**Fig. 1.** Time series of temperature anomalies (calculated by removing the annual cycle from 1986-2005) at 30 hPa, 15°N-15°S. The red and blue lines denote the ensemble mean of the SOCOLv3 CCMI and CMIP6 ensembles, respectively. The shaded areas denote the ensemble mean +/- 1σ.

**Table 1: Stratospheric aerosol data sets used in SOCOLv3 CCM simulations**

| | CCMI | CMIP6 |
|---|---|---|
| Period | 1960-2010 | 1850-2015 |
| Data used | SAGE II | SAGE I, SAGE II, SAM, CALIPSO, OSIRIS; OPC < 20 km |
| Data filling following Mt. Pinatubo eruption | Lidar measurements | CLAES observations |

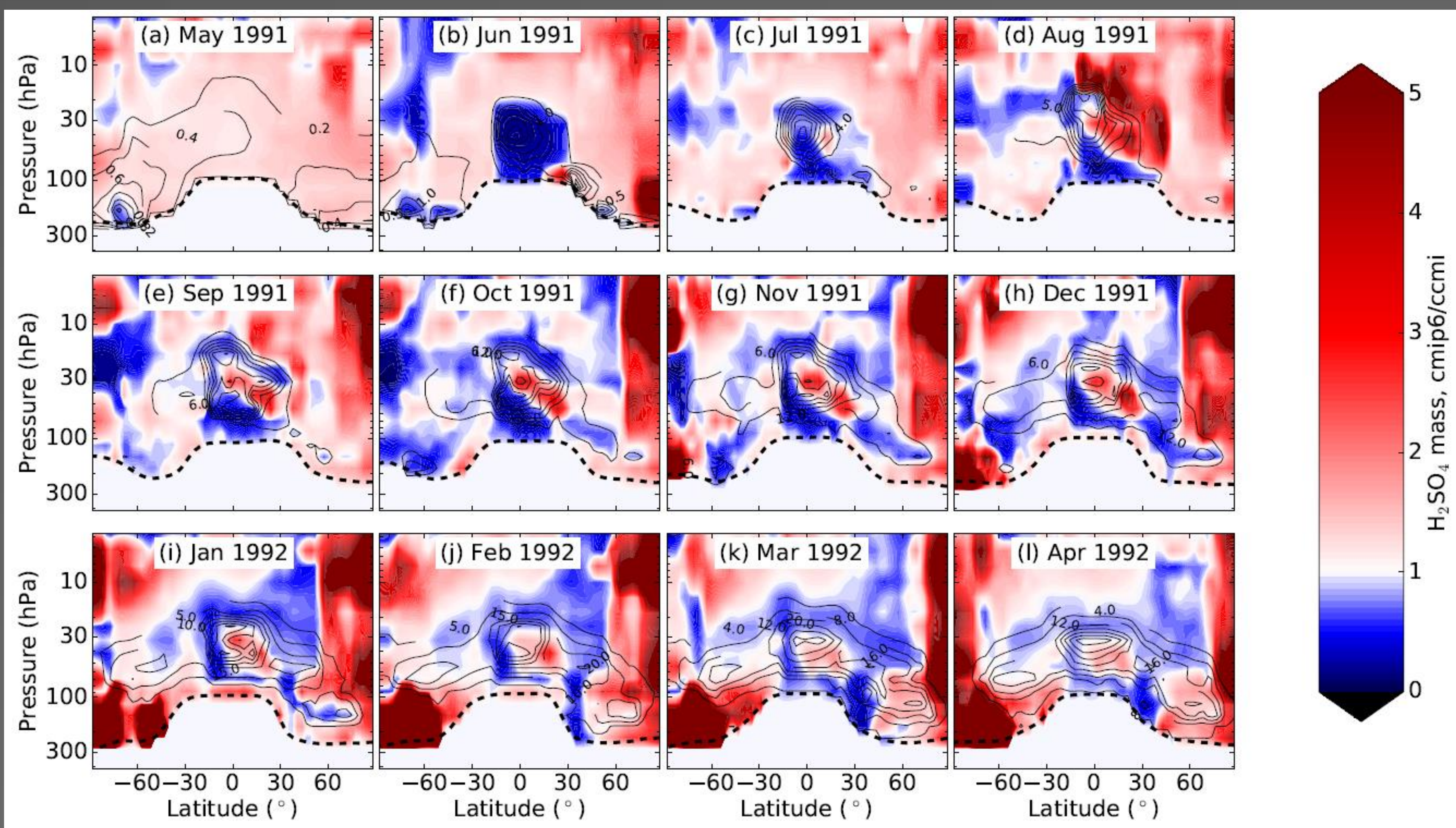


**Fig. 2.** Ratio of $H_2SO_4$ mass in the CMIP6 and CCMI stratospheric aerosol data sets for 12 months around the Mt. Pinatubo eruption in June 1991. Black contours show the CCMI $H_2SO_4$ mass ($10^9$ molecules $cm^{-3}$). The dashed black line shows the location of the tropopause.

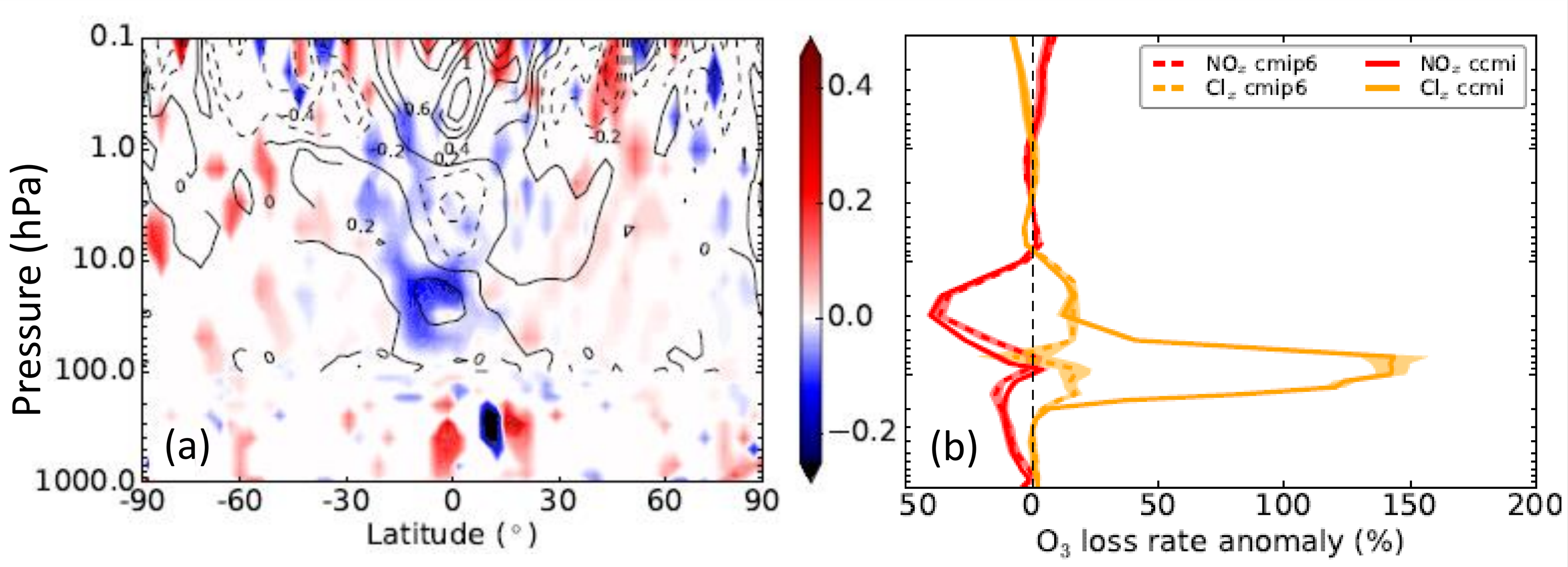


**Fig. 3.** Differences in ensemble-mean, zonal-mean anomalies averaged over the 6 months following the Mt. Pinatubo eruption between the ensembles using CMIP6 and CCMI stratospheric aerosol (CMIP6 minus CCMI). **(a)** Difference in vertical residual circulation anomalies (red/blue shading). The black contours represent the CCMI anomalies over the same period (dashed contours indicate negative values). Regions that are not statistically significant at the 95% level of confidence (as calculated with Student's t test, $p<0.05$) are set to zero. **(b)** Anomalies in tropical (15°N-15°S) ozone destruction rates by the $NO_x$ and $Cl_x$ ozone destruction cycles in the CMIP6 and CCMI ensembles. Negative anomalies indicate slower ozone destruction. Shading indicates the ensemble standard deviation.

**References:** [1]Stenke et al. (2013), doi:10.5194/gmd-6-1407-2013. [2]Revell et al. (2017), in prep. [3]Dee et al. (2011), doi:10.1002/qj.828. [4]Rienecker et al. (2011), doi:10.1175/jcli-d-11-00015.1. [5]Davis et al. (2016), doi:10.5194/essd-8-461-2016.

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Bodeker Scientific