Impacts of Mt. Pinatubo volcanic aerosol on the tropical stratosphere in chemistry-climate model simulations using CCMI and CMIP6 stratospheric aerosol data

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One model.
Two data sets.
Which data set best allows the model to capture reality?

ONE MODEL: SOCOLv3, the Solar-Climate Ozone Links chemistry-climate model

- SOCOL consists of a general circulation model (ECHAM5) coupled to a chemistry transport model (MEZON).
- Online aerosol microphysics is not included in SOCOLv3 (not to be confused with SOCOL-AER – see poster by Timofei Sukhodolov).
- Instead, temporal and spatially resolved information about stratospheric aerosols must be prescribed, such as:
  - aerosol size parameters for heterogeneous chemistry.
  - aerosol radiative properties as a function of wavelength.

TWO DATA SETS: Stratospheric aerosol data sets compiled for CCMI and CMIP6

- CMIP6: phase 6 of the Coupled Model Intercomparison Project
- CCMI: the Chemistry-Climate Model Initiative
- Notable differences:

	CCMI data set (SAGE-4λ)	CMIP6 data set (SAGE-3λ)
Period	1960-2010	1850-2015
Data used	SAM, SAGE I, SAGE II, CALIPSO, sun-photometer data, AER stratospheric aerosol model.	Also: OSIRIS And: mass, volume density and r_{eff} corrected for very small particles below 20 km by OPC measurements.
Gap filling following Pinatubo eruption	Lidar measurements.	Predominantly CLAES observations.

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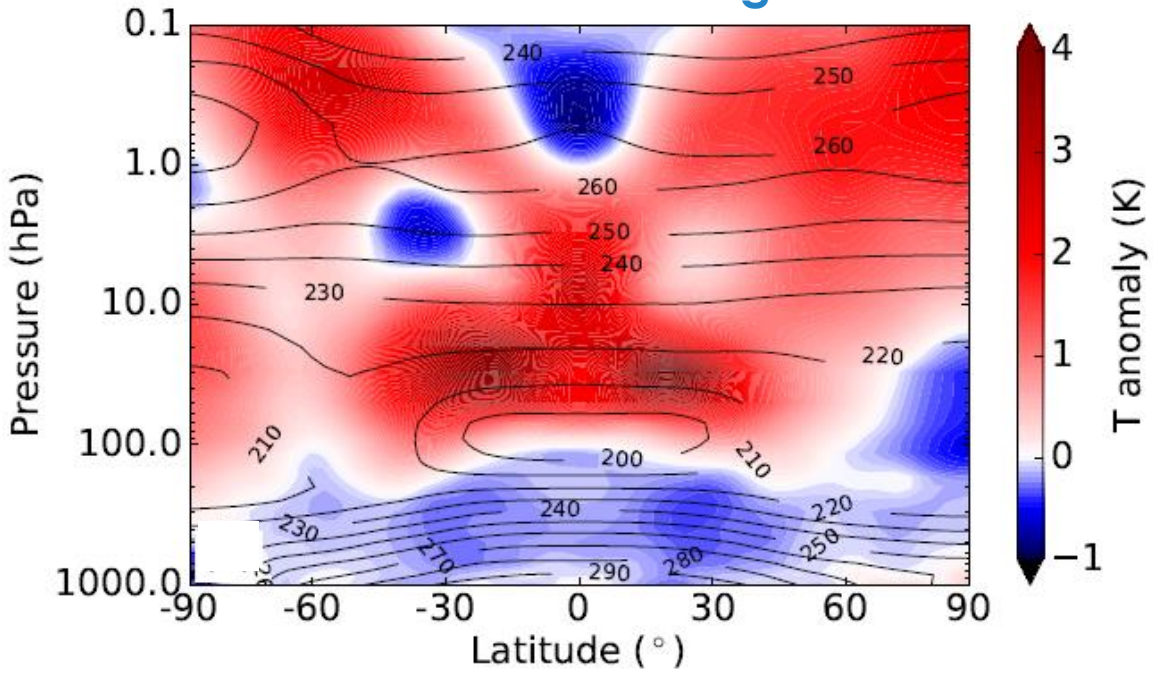
We performed 5 SOCOLv3 simulations (1986-2005) with each dataset.

The tropical stratosphere warms after the Pinatubo eruption in both ensembles…

Temperature anomalies in the 6 months after Pinatubo: Simulations using CCMI aerosol



Ensemble-mean, zonal-mean anomalies.

The tropical stratosphere warms after the Pinatubo eruption in both ensembles… but less so when CMIP6 aerosol is used.

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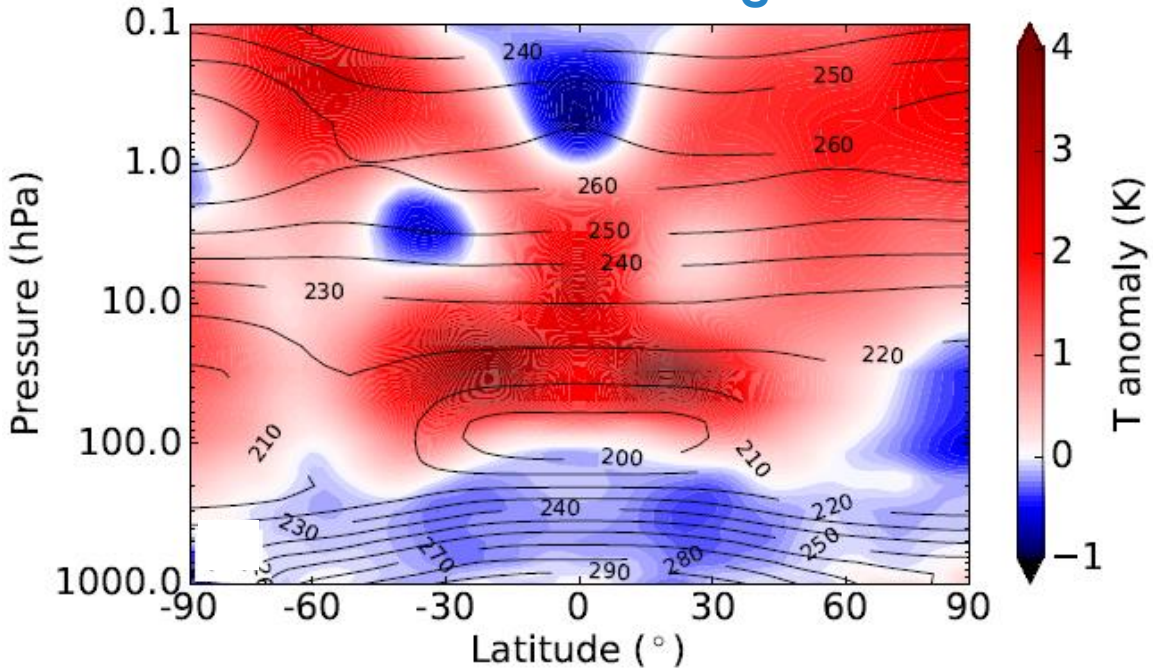
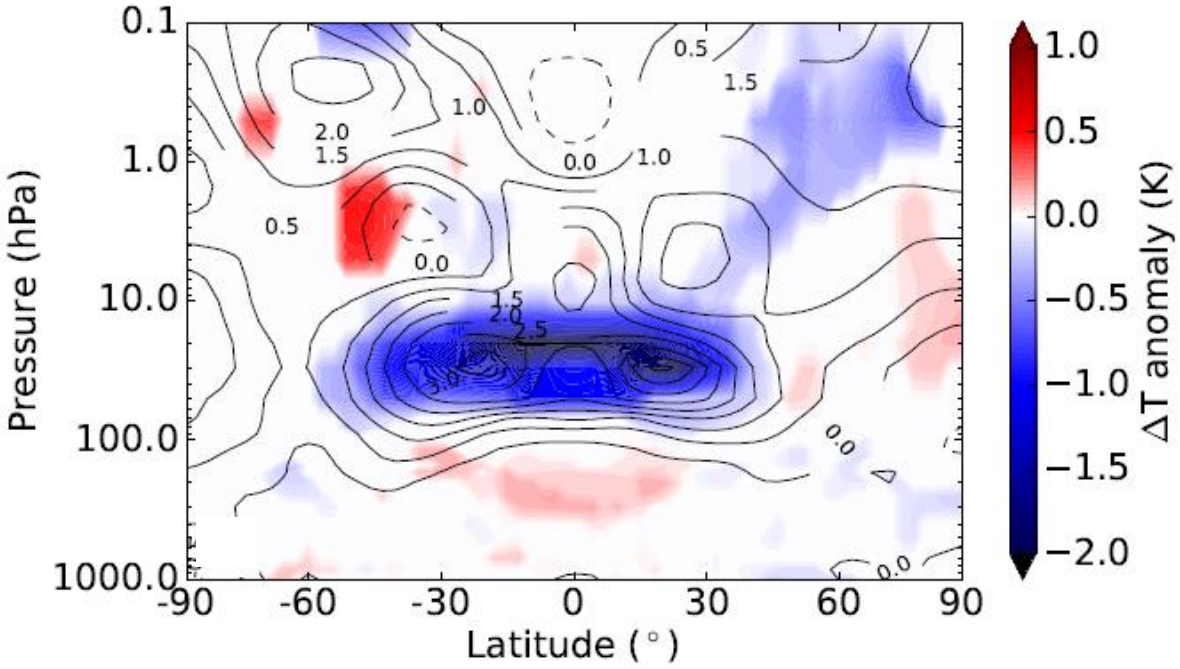
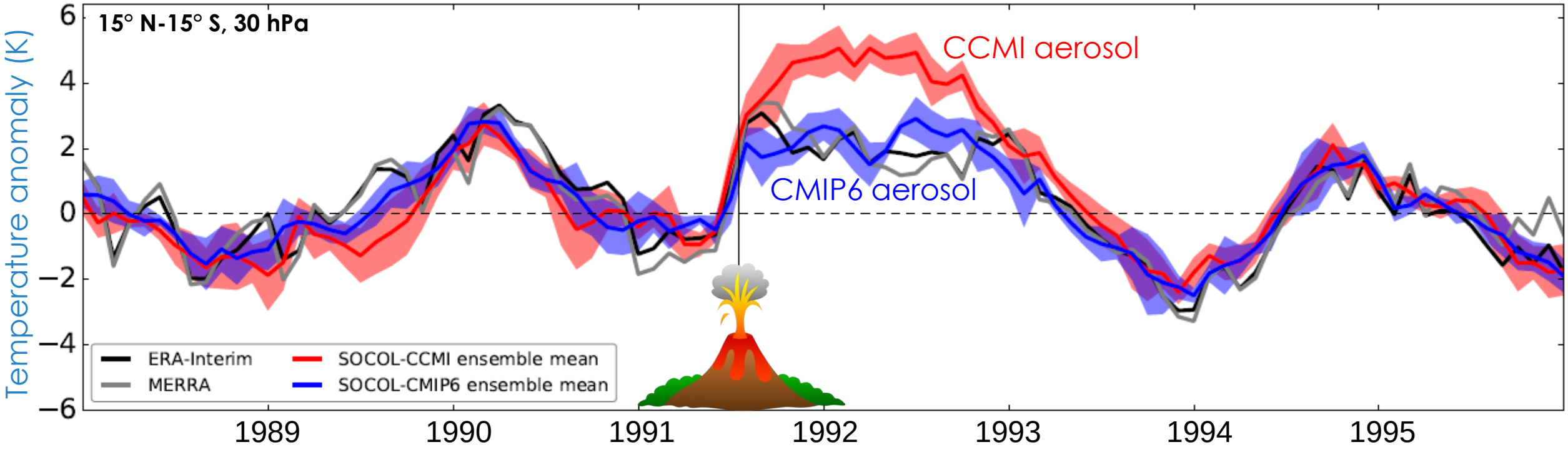


Temperature anomalies in the 6 months after Pinatubo: CMIP6 minus CCMI.

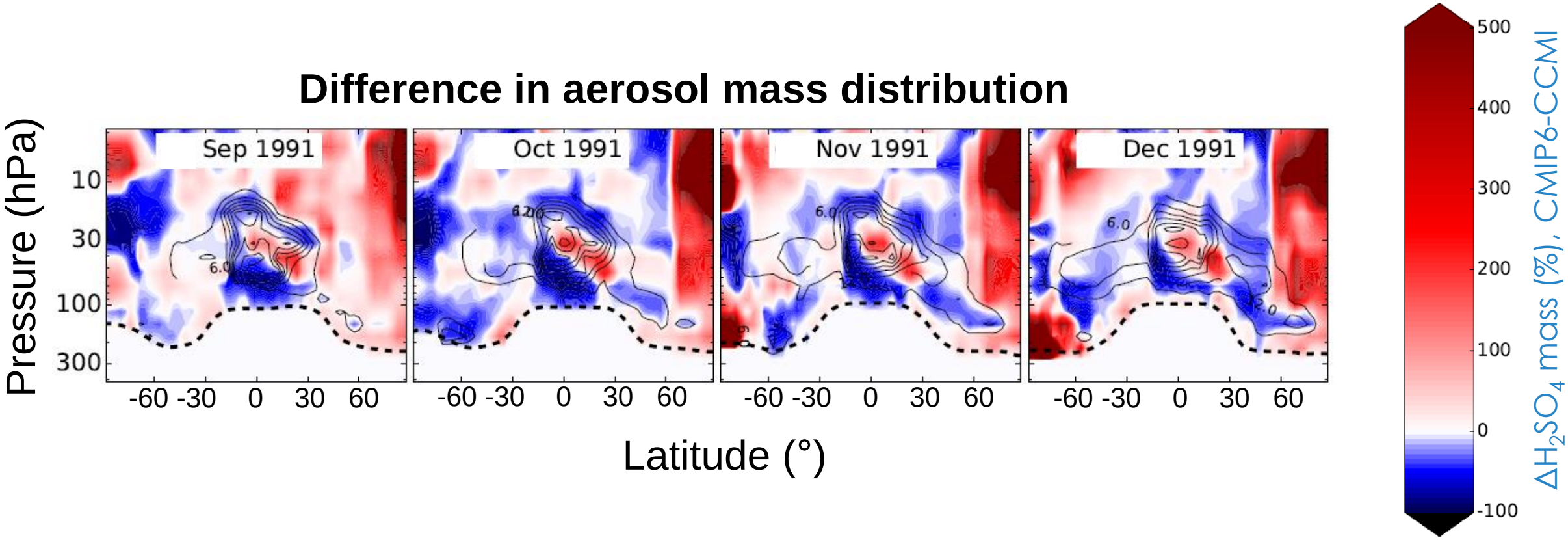


Ensemble-mean, zonal-mean anomalies.

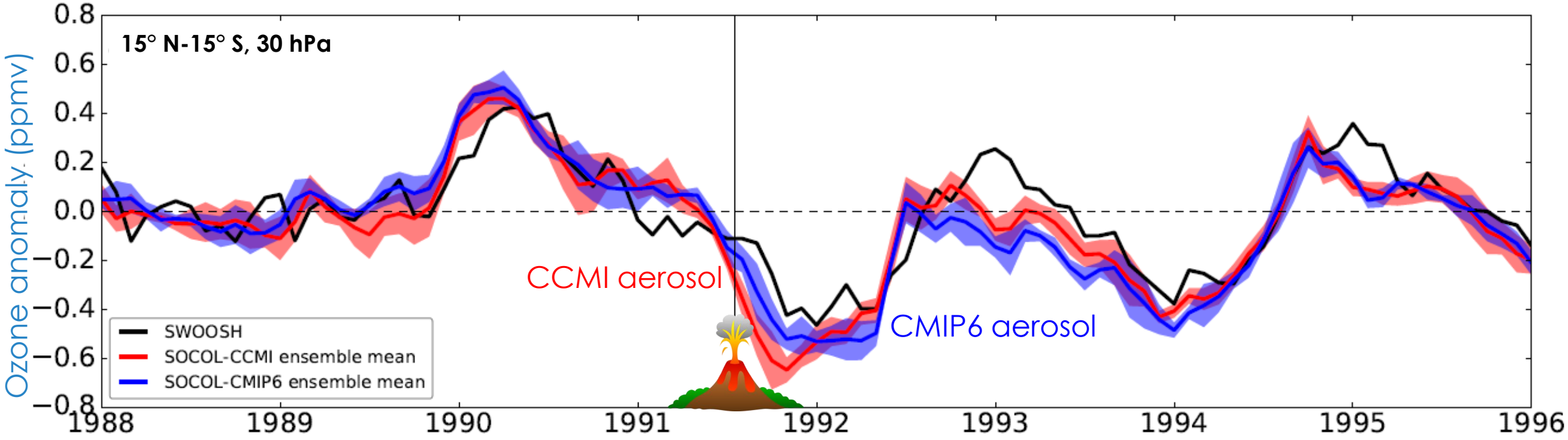
Simulations with CCMI aerosol overestimate warming after Pinatubo by ~2 K. Simulations with CMIP6 aerosol agree well with reanalyses.



Cooling by infrared emission at ~30 hPa exceeds warming by infrared absorption.



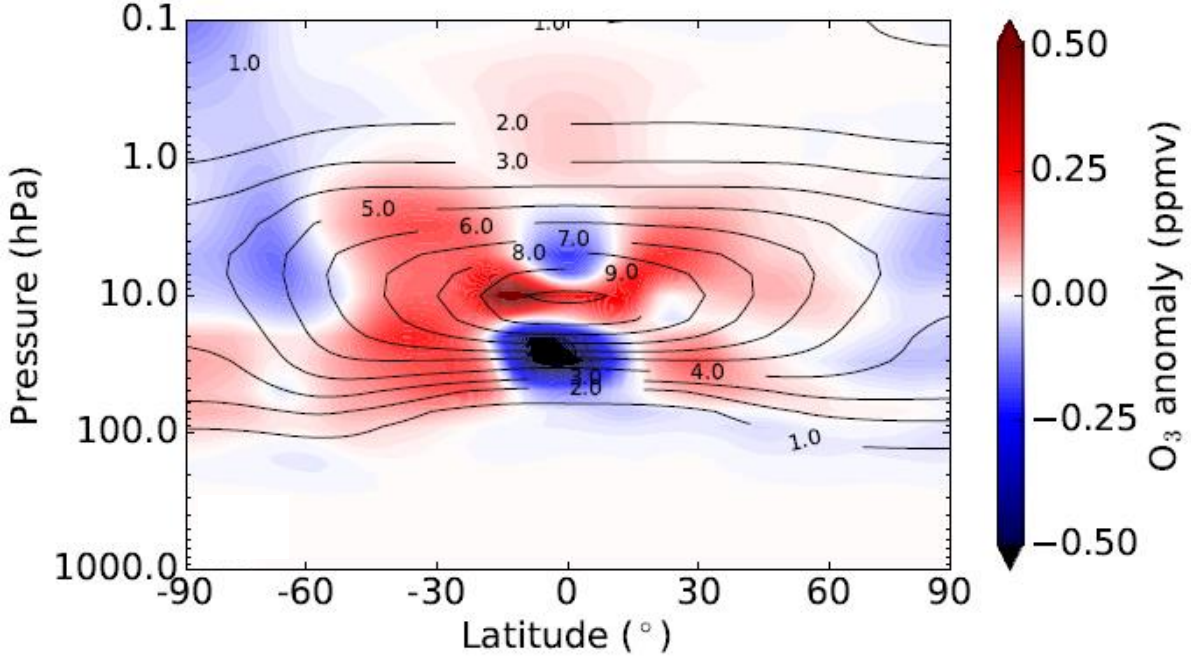
Why does the stratospheric ozone response after the Pinatubo eruption differ?



Both data sets lead to overestimated ozone loss in the model, but more so in simulations with CCMI aerosol.

Volcanic aerosol from Pinatubo caused ozone loss via changes in chemistry and dynamics.

Ozone anomalies in the 6 months after Pinatubo: Simulations using CCMI aerosol



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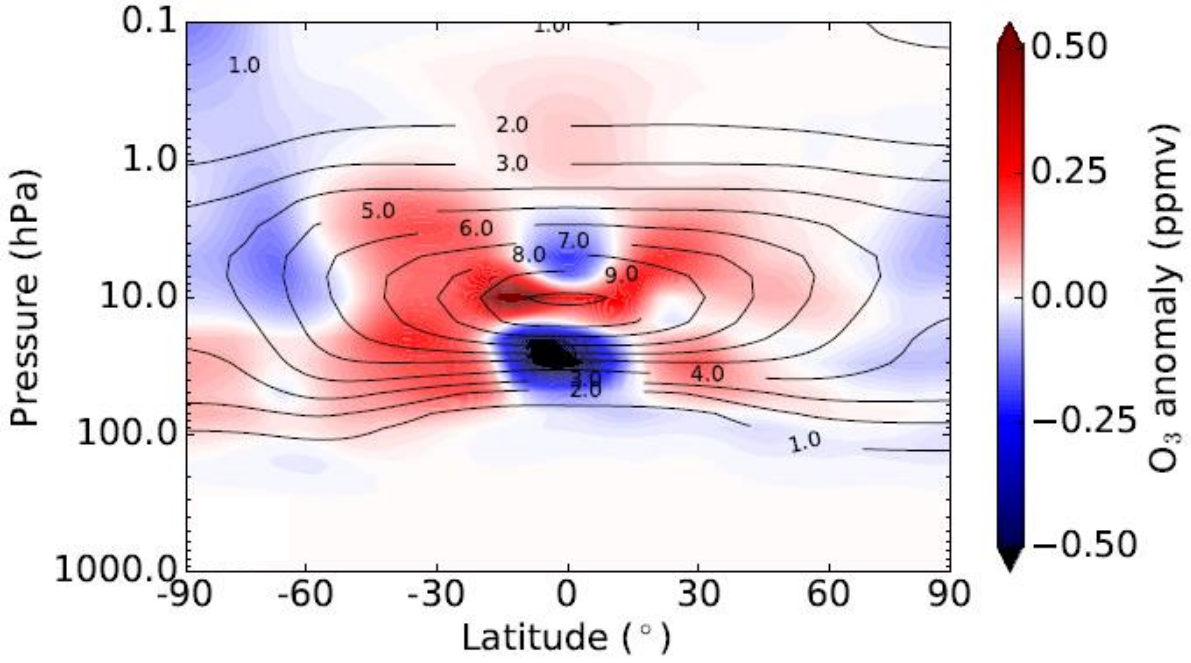
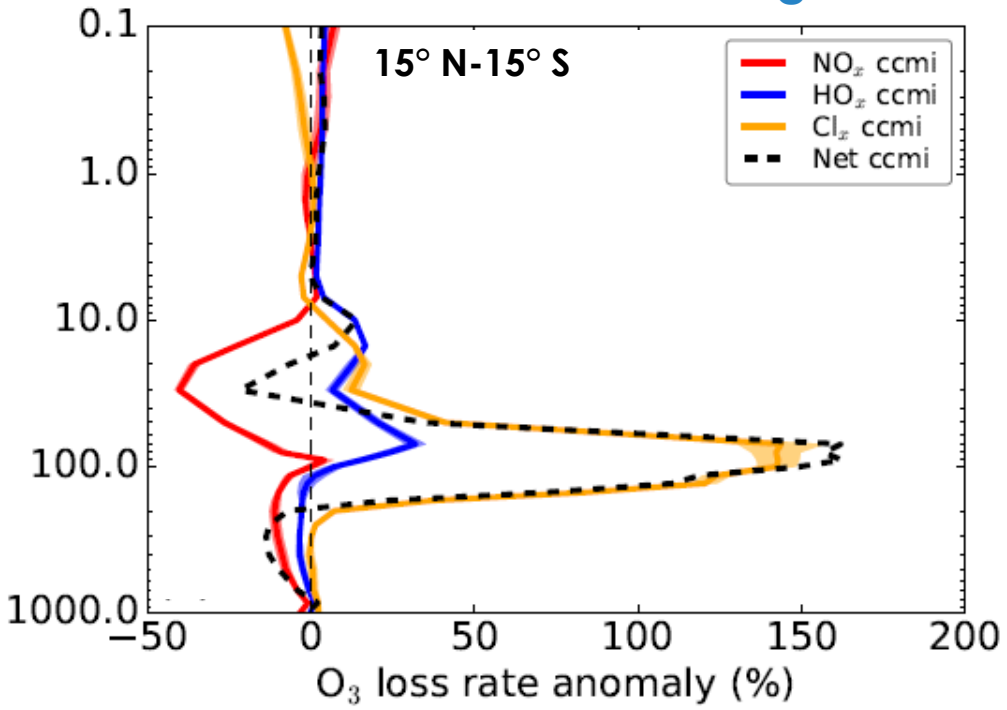


Gas phase O_3 loss rate anomalies in the 6 months after Pinatubo: Simulations using CCMI aerosol



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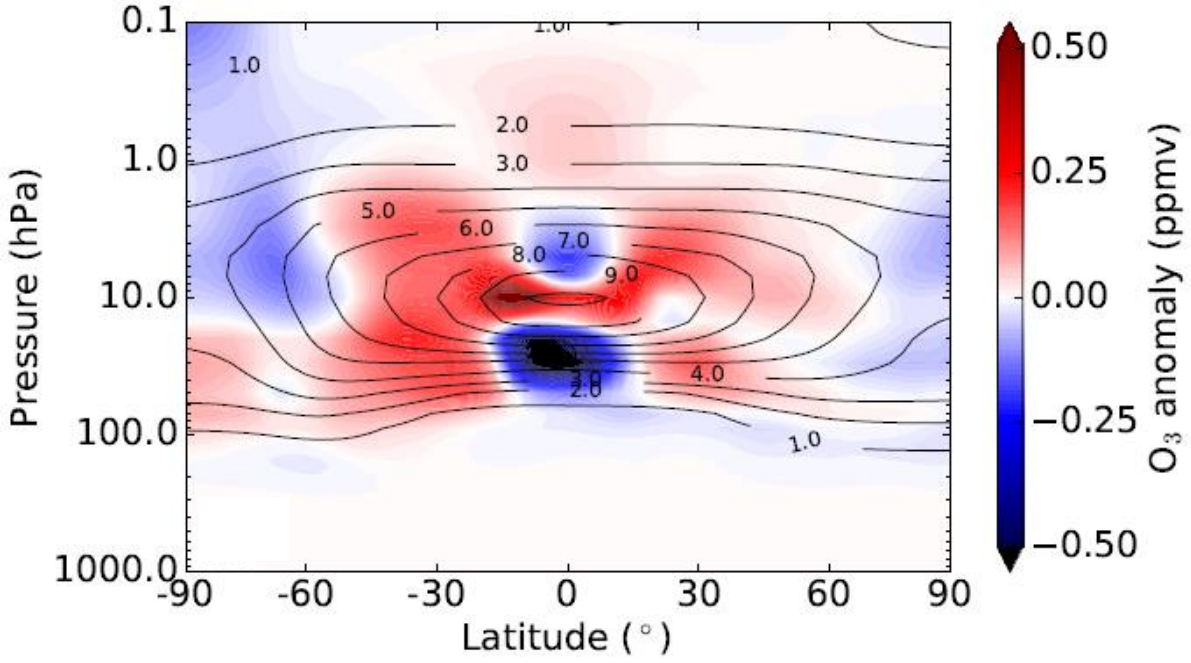

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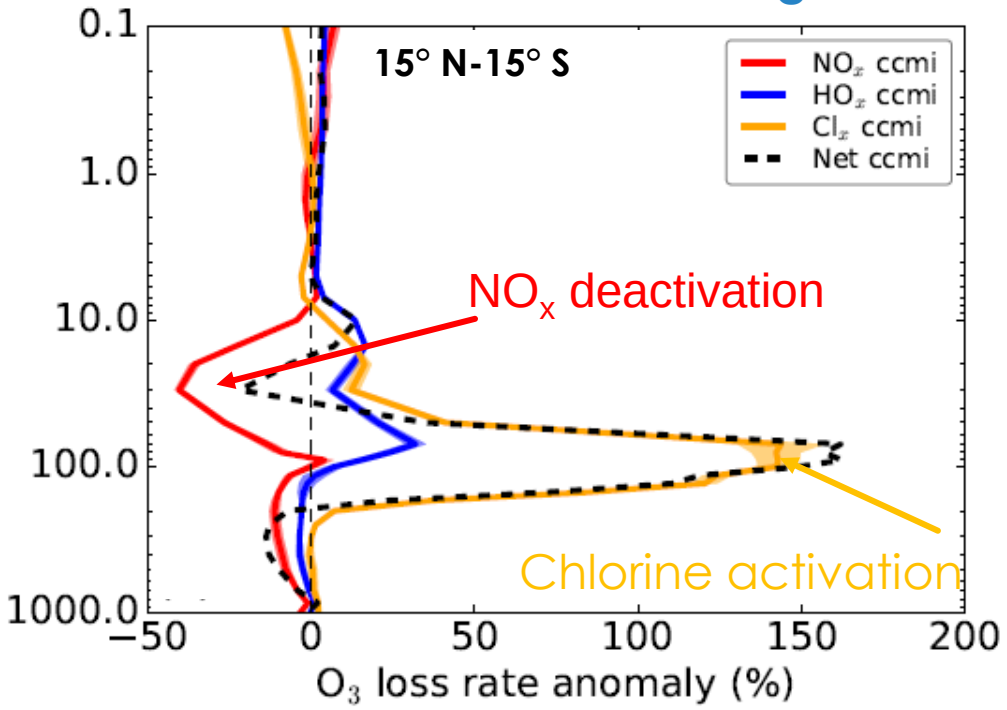
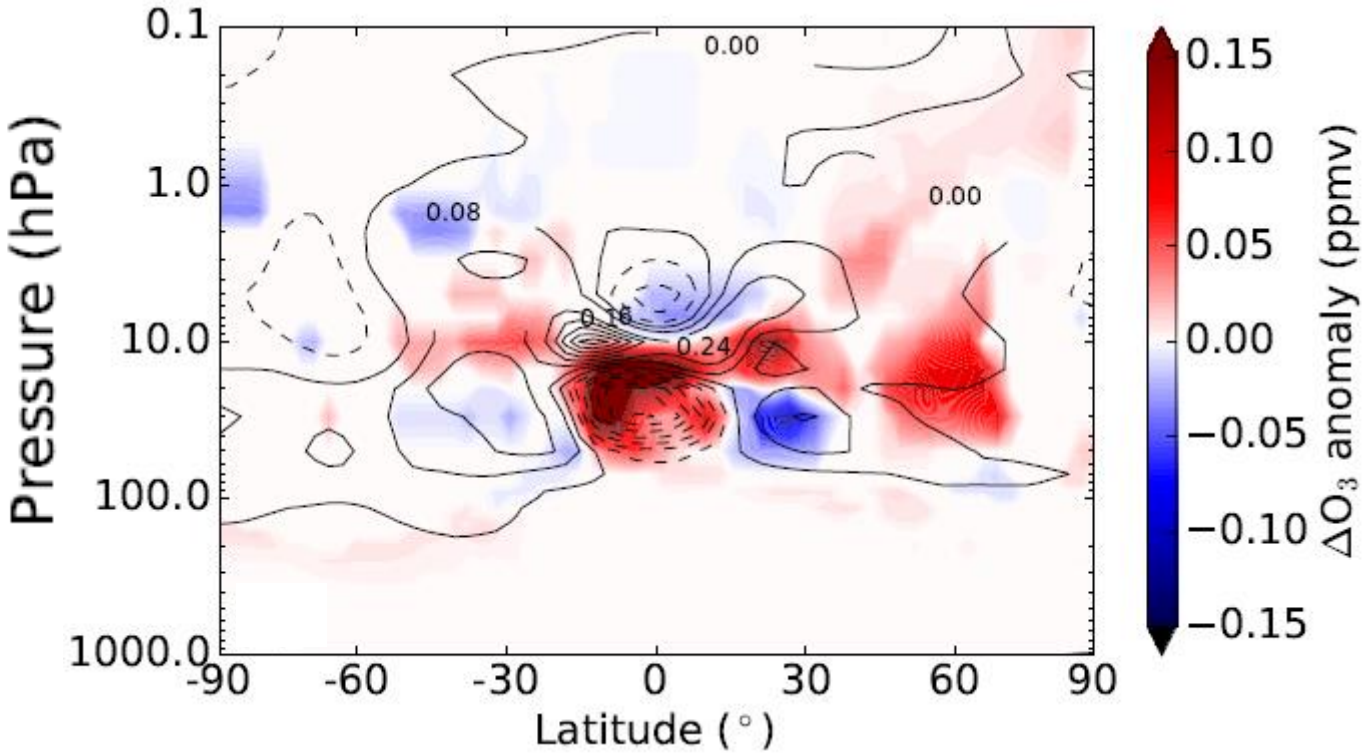


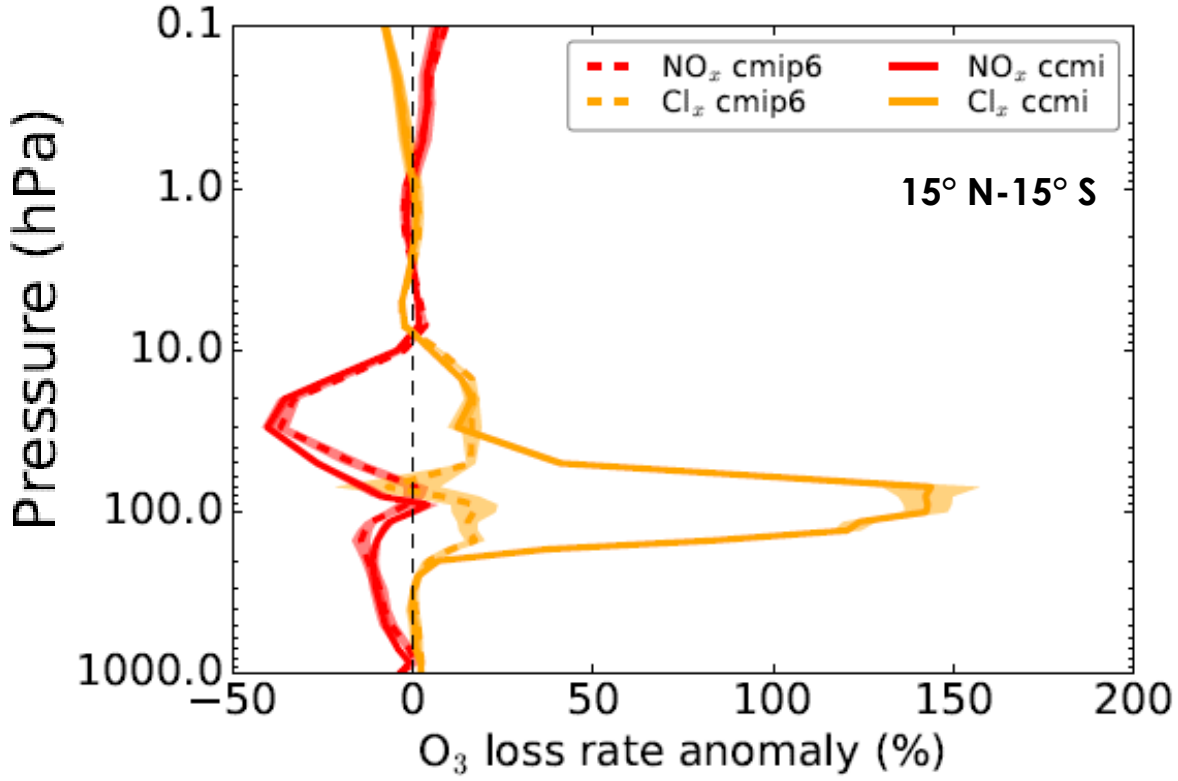
Ozone differences between simulations with CCMI and CMIP6 aerosol are centered in the tropics.

Ozone anomalies in the 6 months after Pinatubo: CMIP6 minus CCMI



Lower stratospheric chlorine-induced ozone loss slows in simulations with CMIP6 aerosol.

Ozone anomalies in the 6 months after Pinatubo: CMIP6 and CCMI simulations



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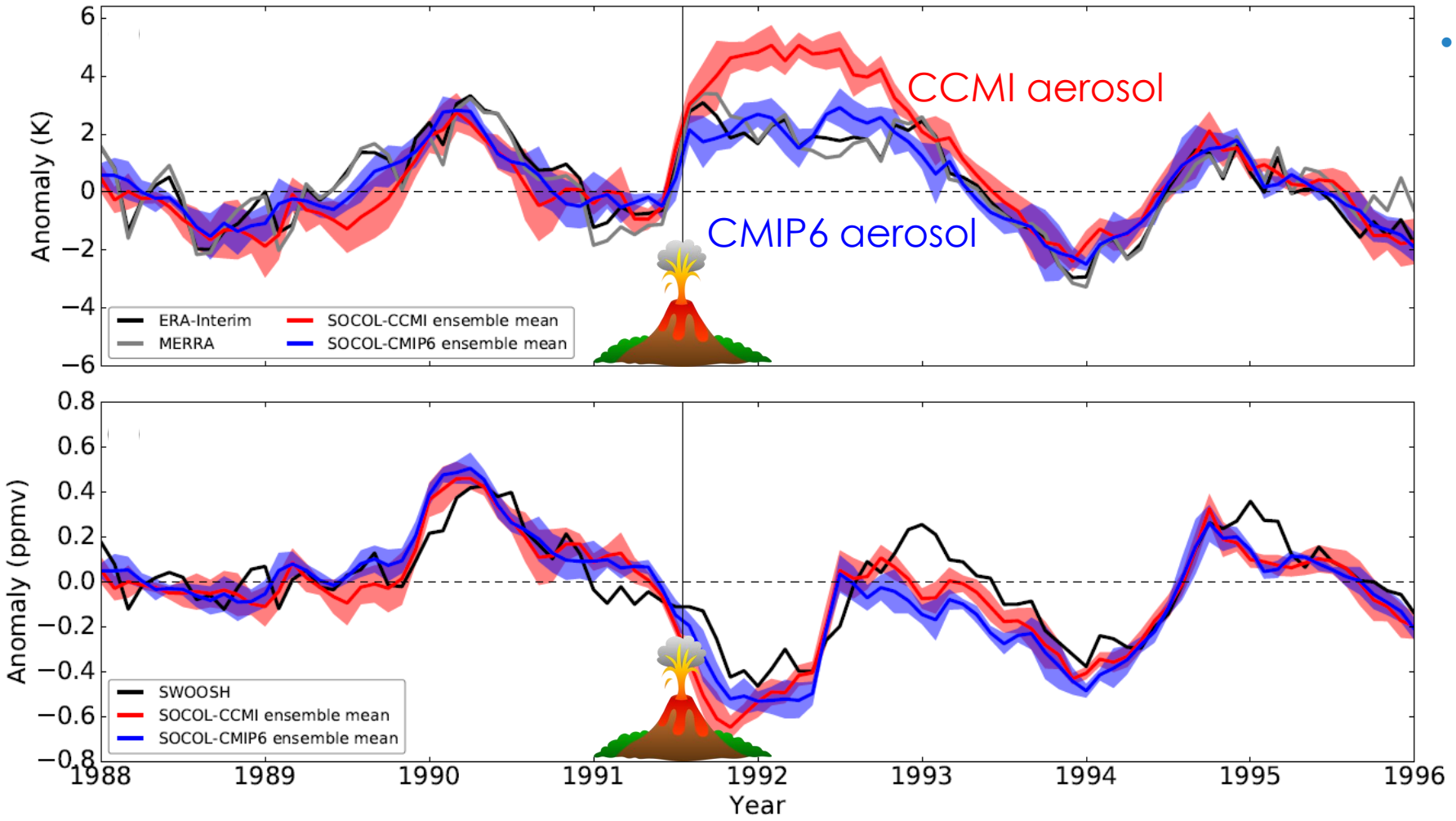

- The CMIP6 data set allows SOCOLv3 to better simulate the response of tropical stratospheric temperature and ozone to aerosol from the Mt. Pinatubo eruption.

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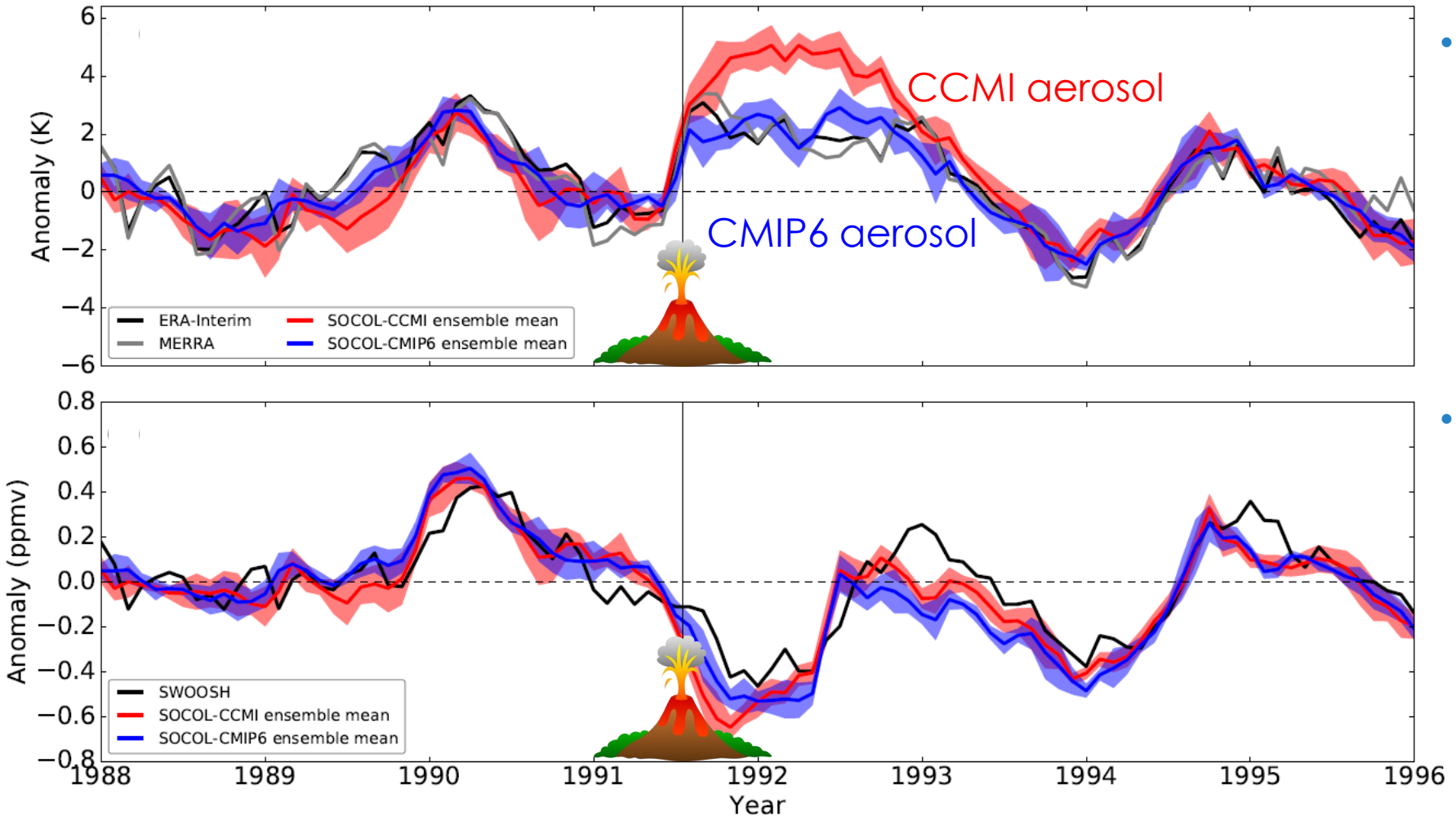

- The CMIP6 data set allows SOCOLv3 to better simulate the response of tropical stratospheric temperature and ozone to aerosol from the Mt. Pinatubo eruption.

- For more information, see the paper: Revell et al. (2017), ACP (CCMI special issue)or email: laura@bodekerscientific.com