CONFESS
Consistent representation of temporal variations of boundary forcings in reanalyses and seasonal forecasts

Implementing the capability to respond to large volcanic eruptions in the C3S prediction systems.

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CONFESS will improve the reliability and usability of information provided by the **Copernicus Climate Change service (C3S)** by capitalising on the synergies between Copernicus services, and pave the way for a continuous evolution of the service.

Aim: Improve the representation of global trends and regional extremes in next generation of C3S earth system reanalyses and seasonal forecasts, by taking stock of observational data sets and model developments across different Copernicus Services on vegetation, land cover, atmospheric composition and biomass burning.

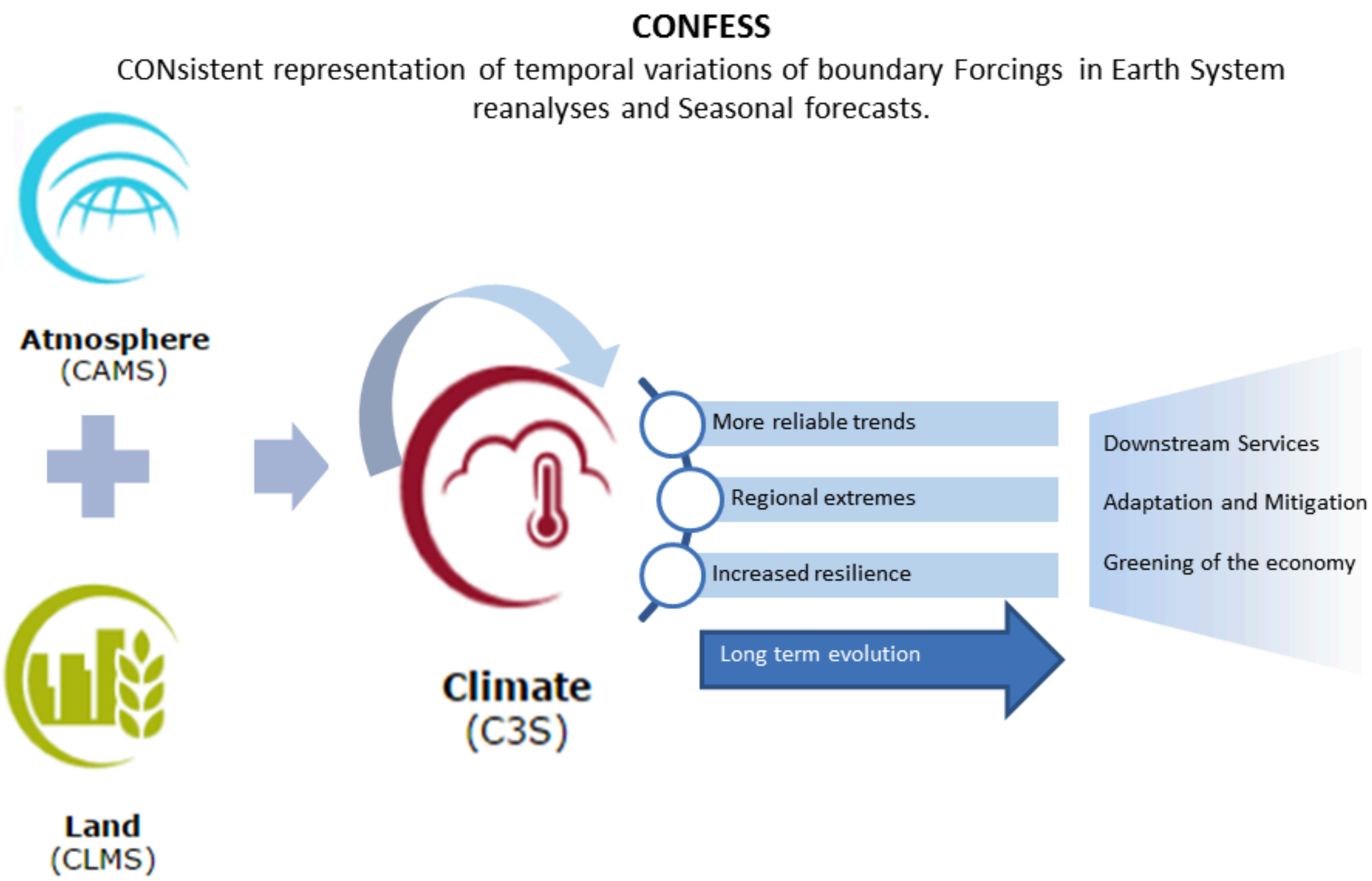


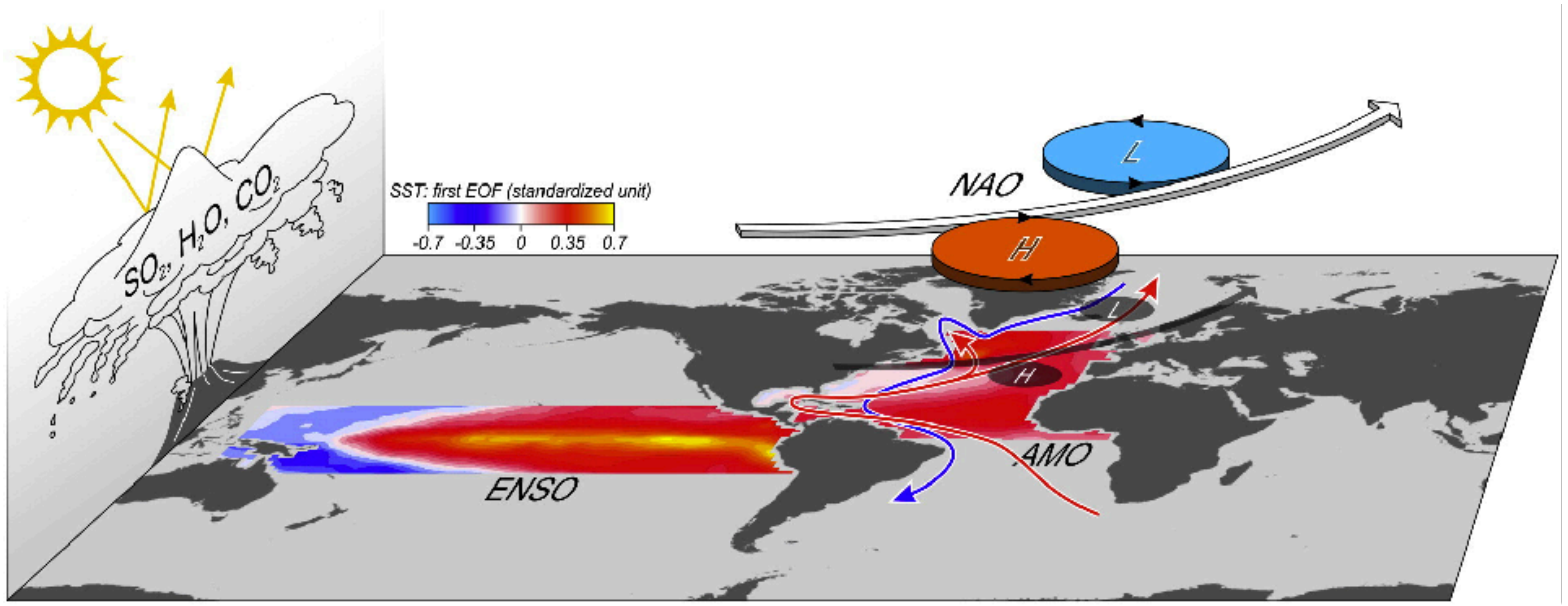
Figure 1: CONFESS will leverage efforts across Copernicus Services to improve the usability and reliability of the C3S information.

Climate Impacts of Explosive Volcanic Eruptions

Explosive volcanic eruptions have climate impacts on seasonal-to-decadal time-scales. Volcanic eruptions inject large amounts of sulphate dioxide into the stratosphere, producing an aerosol which reflects incoming solar radiation, altering the Earth's energy balance (Robock, 2000).

The atmospheric radiative effects of volcanic eruptions include surface cooling and lower stratosphere warming. Studies have also shown the impact on the main modes of climate variability such as ENSO or the NAO (e.g. Swingedouw et al., 2018).

Studies have shown that these climate impacts have high predictive potential (e.g. Timmreck et al., 2016, Menegoz et al., 2018, Hermanson et al., 2020), and could therefore be exploited to improve operational climate predictions whenever a new explosive volcanic eruption happens.



Schematic of the main consequences of volcanic eruptions in the atmosphere and their possible interactions with the main climatic modes (Swingedouw et al., 2018).

Responding to Volcanic Eruptions

One of the objectives of CONFESS is to implement the capability to respond to large volcanic eruptions in the C3S monitoring and prediction systems:

- Technical developments in the IFS (the atmospheric model of the European Center for Medium-range Weather Forecasting) to improve the model representation of volcanic aerosols.

- In a real-time situation following a major volcanic eruption, forecasts of the evolution of the stratospheric sulphate aerosol are needed. A feasible method to estimate the volcanic forcing is to produce them with the recently enhanced idealised model EVA_H (Aubry et al., 2020).

Eruption of Mount Pinatubo (1991).

Responding to Volcanic Eruptions

Currently the IFS has a simplified representation of volcanic aerosol, in particular the vertical distribution. Within CONFESS the representation of volcanic aerosols in the IFS will be improved by including the vertical distribution of the forcing, as done in EC-Earth3 (Doscher et al., 2021). This development is expected to result in a more realistic stratospheric temperature response, as shown for EC-Earth3.

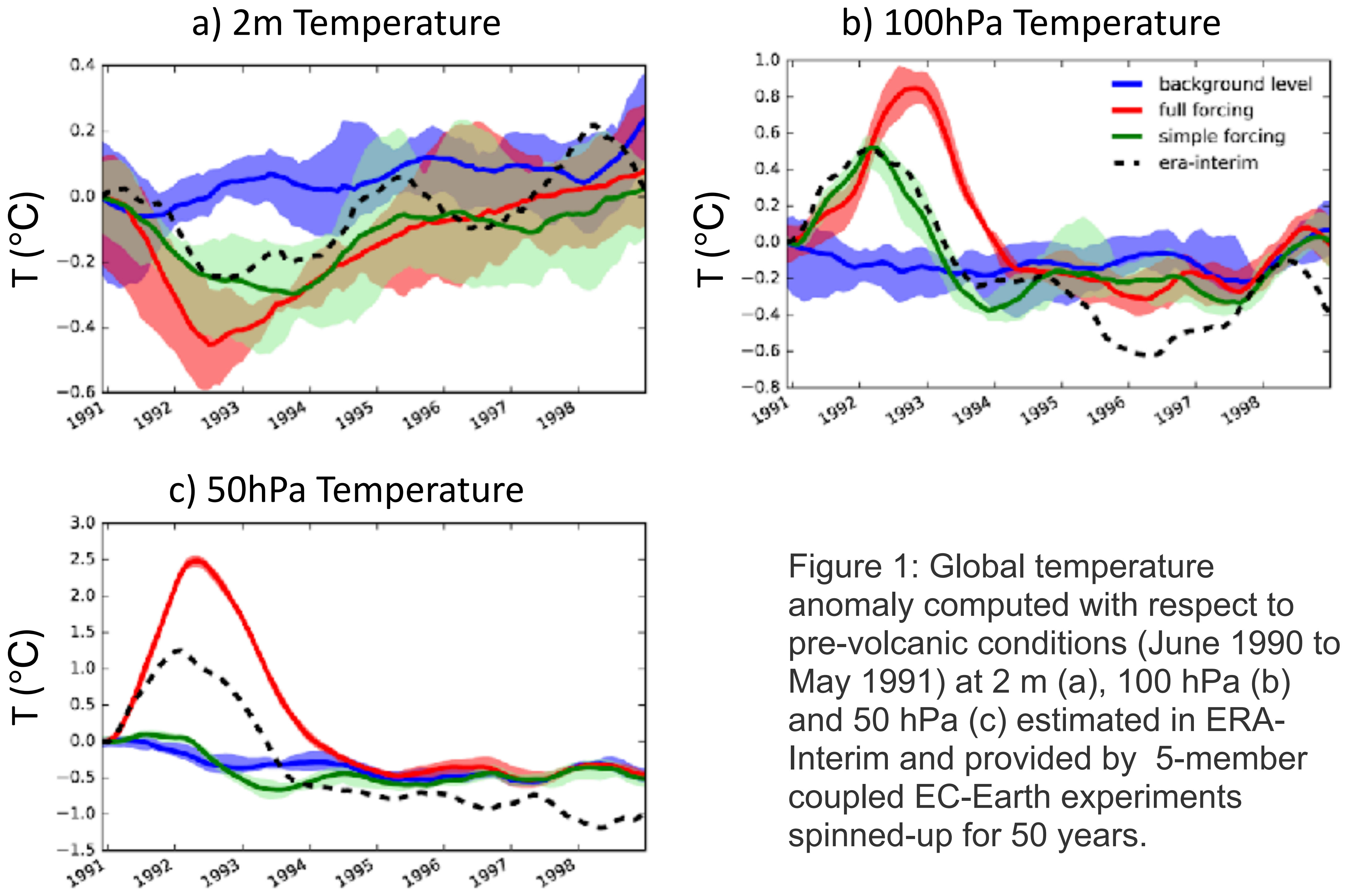


Figure 1: Global temperature anomaly computed with respect to pre-volcanic conditions (June 1990 to May 1991) at 2 m (a), 100 hPa (b) and 50 hPa (c) estimated in ERA-Interim and provided by 5-member coupled EC-Earth experiments spinned-up for 50 years.

Responding to Volcanic Eruptions

In a real-time situation following a major volcanic eruption, forecasts of the evolution of the stratospheric sulphate aerosol are needed. A feasible method is to generate the forcings with the Easy Volcanic Aerosol model (EVA) (Toohey et. al., 2016) and in particular its recent upgrade EVA_H (Aubry et al., 2020), which has a better treatment of the vertical distribution.

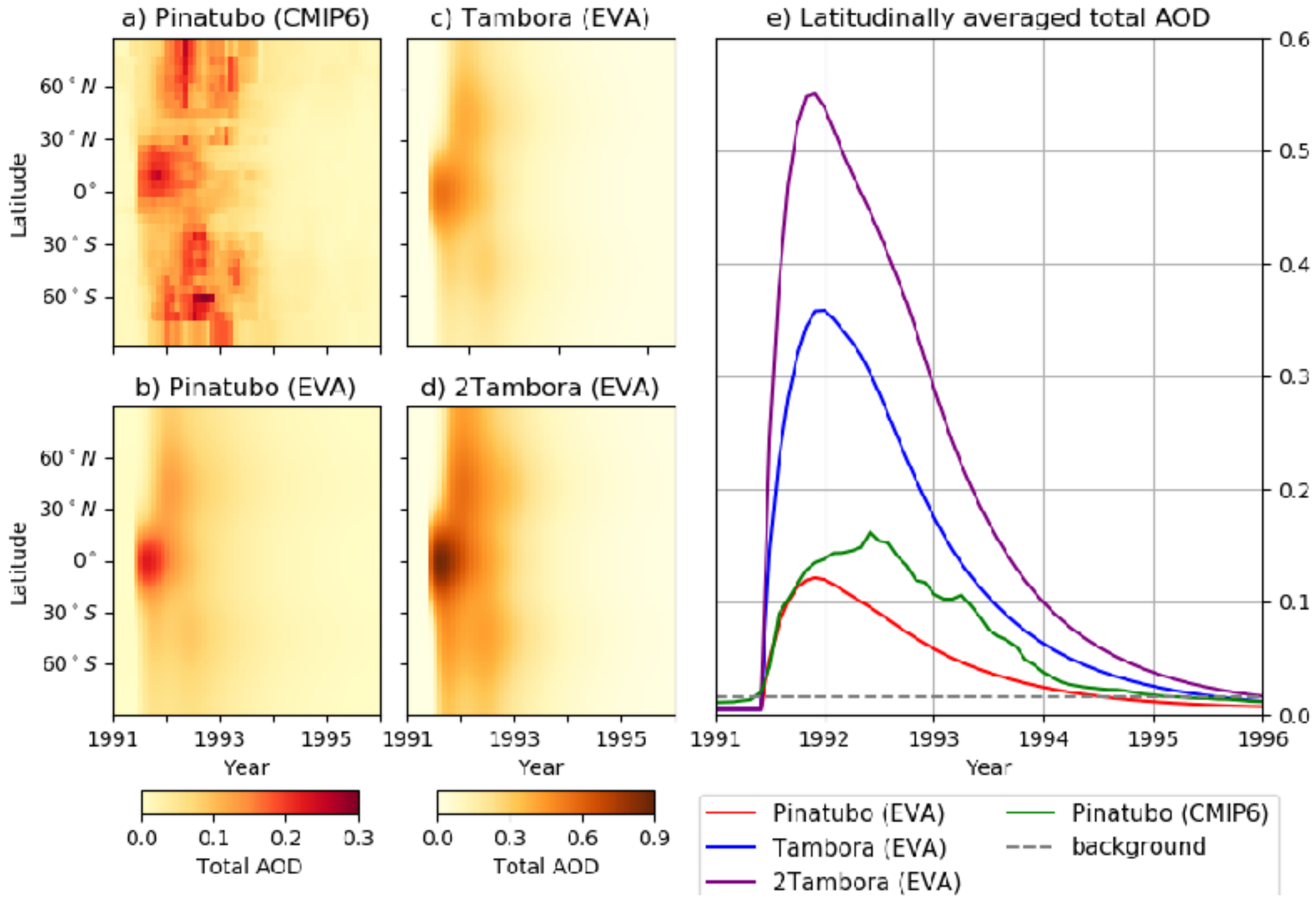


Figure 2: Total AOD at 530 nm as a function of the latitude and time : Pinatubo forcing estimated from CMIP6 (a) and produced with the EVA model (b and d) and Tambora forcing produced with EVA (c). The AOD values used in figures (a) and (b) are different from those used in (c) and (d) to highlight the magnitude differences between Pinatubo and Tambora. (e) Latitudinally integrated total AOD as a function of time for the different forcings and a background level (given by the 1850-2014 total AOD mean). Martin et al. (in prep).

Responding to Volcanic Eruptions

To validate the model improvements and the EVA_H idealised forcings, the climate response in seasonal and multi-annual re-forecasts of the past volcanic eruptions (Mount Agung, El Chichón and Mount Pinatubo) will be analysed.

A special focus will be made on the fidelity of the response to the predicted volcanic forcing estimates from EVA_H, when compared to the response to the CMIP6 forcing.

The analysis also focus the longer-term response of the climate system to volcanic forcings, including changes mediated by the ocean.

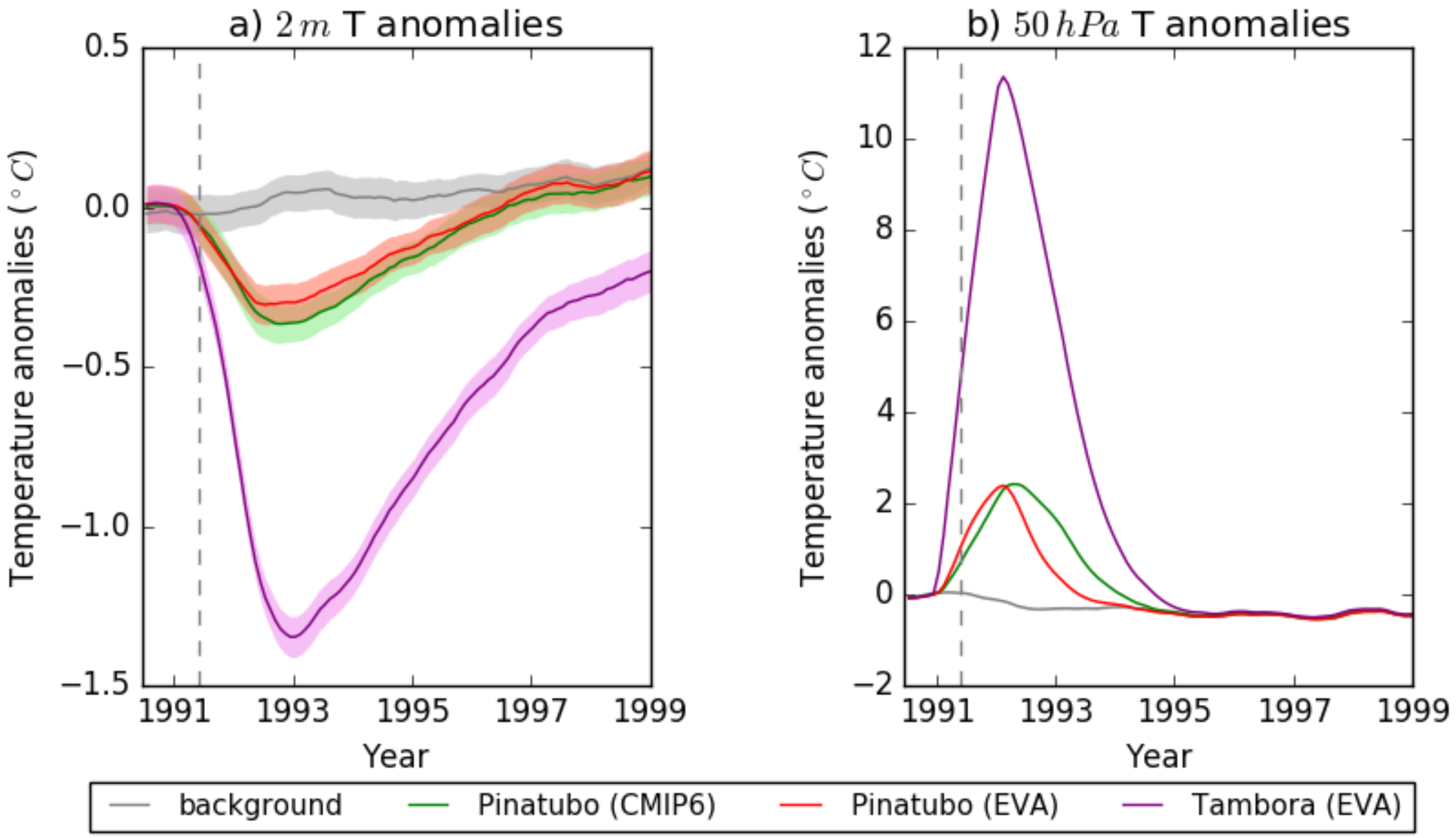


Figure 3: Global average atmospheric temperature anomalies for Pinatubo-EVA, Pinatubo-CMIP6 , Tambora-EVA and background experiments at 2m (a) and at 50hPa (b). The time series are plotted with a 12 months low-pass filter. The shaded area denotes the spread of the mean (standard deviation of the sample divided by the square root of the number of members). The anomalies have been computed taken the pre-eruption year as climatology. Martin et al. (in prep).

Acknowledgements

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