ModE-Sim - A medium size AGCM ensemble to study climate variability during the modern era (1420 to 2009)

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The Making of ModE-Sim

- produced with ECHAM 6.3.5p2
- T63 horiz. resolution (~1.9°), 47 vertical levels, up to 0,1 hPa
- 2 different volcanoe forcings:
  - Standard PMIP4 forcing for most of the simulations
  - Additionally 20 member EVA ensemble to account for uncertainties in timing and strength of volcanic eruptions within the period 1420 to 1849
- 2 different prescribed SST forcings:
  - Ensemble of novel proxy-based SST recontructions (Samakinwa et al, 2021), to account for uncertainties in the SSTs for the period 1420 to 1850 (with assimilations of observed SSTs after 1780)
  - HadISST for the period 1850 to 2009
- 3 different prescribed sea ice forcings:
  - Sea ice analogues based on the reconstructed SSTs and sea ice observations for 40 simulations covering the 1420 to 1850 period
  - Climatological Sea ice for the other 20 simulations covering the 1420 to 1850 period
  - HadISST sea ice for the period 1850 to 2009

ModE-Sim in a nutshell

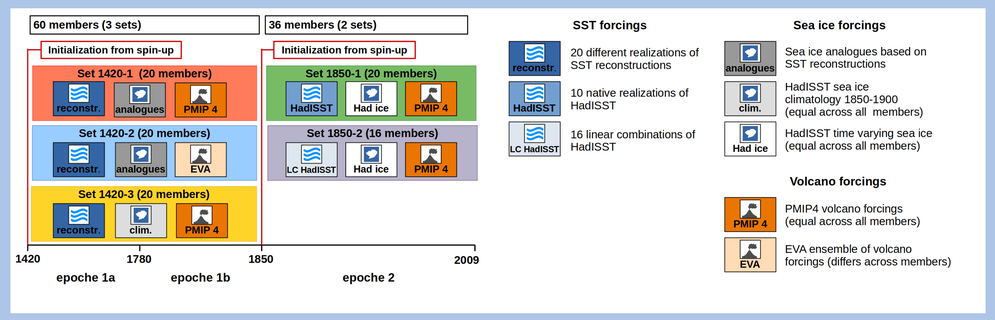
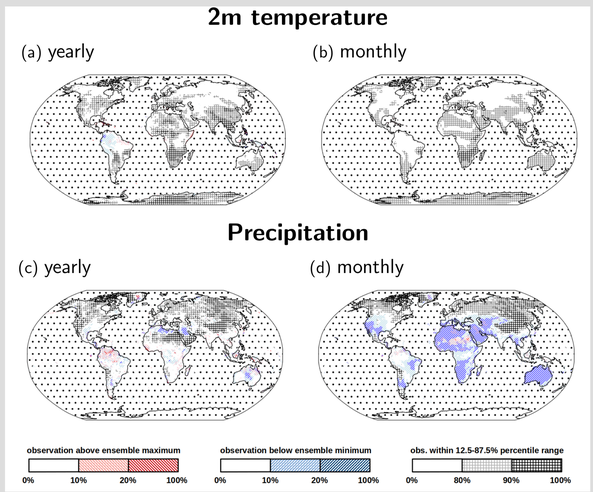


Figure 1: Overview on the experiments in ModE-Sim and their forcings

31560 simulated years in total - Up to our knowledge no other ensemble covers such a long period at a comparable number of ensemble members.

Evaluation of ModE-Sim



- ModE-Sim captures internal variability and can be used to disentangle forced signals from internal variability (Fig. 2).
- ModE-Sim shows a reasonable response to external forcings, like volcanoes (Fig. 3).
- ModE-Sim can even reproduce some extreme events like, e.g. heat waves (see box to the right and Fig. 4).

← Figure 2. Ability of ModE-Sim to capture internal variability for 2m temperature and precipitation.
red/blue hatching: ModE-Sim's ensemble spread is too small
grey hatching: ModE-Sim's ensemble spread is too large.
stippling: number of observations too low
Shown is the percentage of timesteps within the period 1950-2005 where observations (Berkeley Earth for temperature, GPPC for precipitation) lie above or below the ModE-Sim ensemble spread, respectively within the 12.5 to 87.5% percentile range.

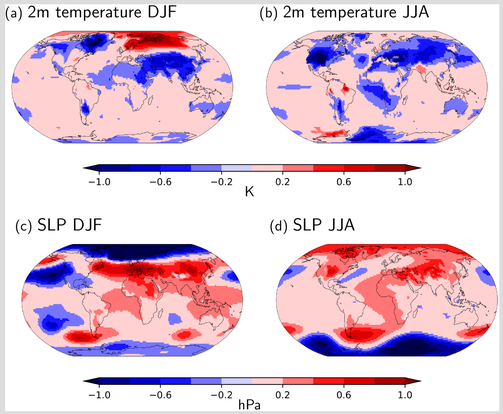


Figure 3. Response to volcanic forcing
Averaged response to 15 maior eruptions as difference of the ensemble mean of the first winter (DJF, left column) and summer (JJA, right column) after an eruption w.r.t. the 5 previous summers/winters.

First applications of ModE-Sim

ModE-RA - A global monthly paleo-reanalysis of the modern era

- ModE-RA was the the original purpose to create ModE-Sim.
- ModE-Sim formed the prior for an offline data assimilation of historical climate data (early instrumental data, proxy data, and documentary data).
- The result is a global monthly 3-dimensional reanalysis of the climate during the modern era (1421-2008).
- ModE-RA is published in a data structure consistent to ModE-Sim (see link below) to fascilitate joint analysis of the reanalysis product and the underlying model ensemble.

Visit our companion abstract on MoDE-RA@EGU2023:
https://doi.org/10.5194/egusphere-egu23-386

Get the MoDE-RA dataset:
https://www.wdc-climate.de/ui/entry?acronym=ModE-RA

A global assessment of heatwaves since 1850

- ModE-Sim can reproduce a reasonable number of heat waves and heat wave duration on global and regional scale, consistent with observations and reanalysis data.
- It is possible to disentangle regions where the external forcing has a strong influence on the occurence heat waves from those where they are mainly caused by internal variability.
- Promising results from this period motivate extending this analysis further back into the past, to better understand pre-industrial heat waves and long-term changes in heat wave mechanisms.

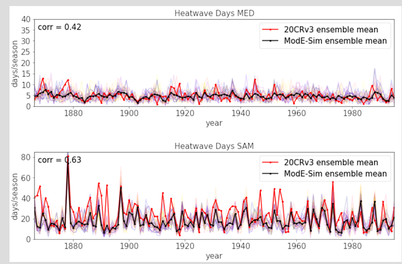


Figure 4: Number of heat wave days per summer (May to September/November to March) in ModE-Sim and 20CRv3 for the Mediterranean (MED) and the South African Monsoon Region (SAM)

Visit our companion abstract on heatwaves@EGU2022:
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Interested in using ModE-Sim for your research? Get the data:
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