PALEOSTRAT: PALEOmodelization from a STRATospheric perspective

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1. The Last Millennium

• Our knowledge of the Last Millennium (LM, 850-1850 CE) depends on understanding the internal and externally-forced mechanisms behind past changes.

• State-of-the-art reconstructions suggest more complex responses than currently available model simulations of the LM (*Figure 1*), particularly for the Medieval Climate Anomaly (MCA, ~950-1250) and its transition to the Little Ice Age (LIA, ~1400-1700).

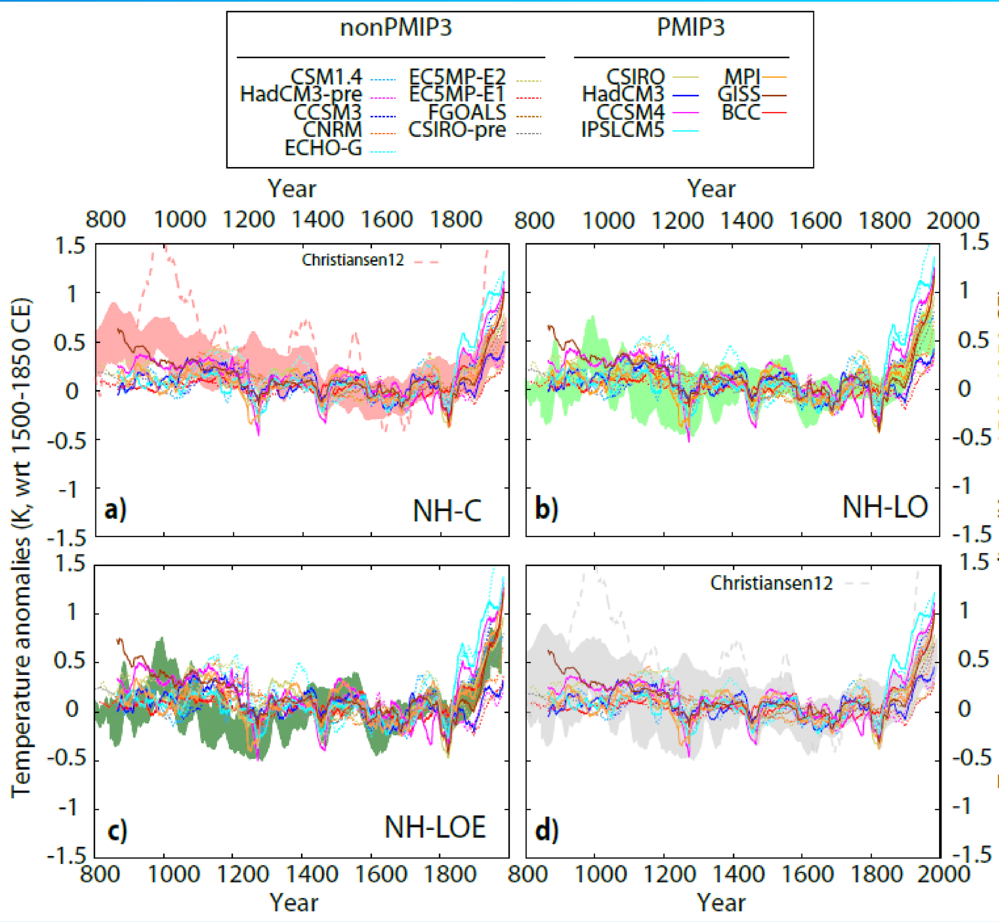


Figure 1. LM temperature (ºC) reconstructions (shading) and simulations (lines) for: a) NH; b) NH continents; c) NH extratropical continents; d) all reconstructions [1]

2. The Stratosphere

• Recent studies have demonstrated the influence of the stratosphere on the surface trough the so-called vertical coupling (e.g., *Figure 2*), with implications in the ongoing climate change and in future climate projections.

• The limited period of observations prevents us from obtaining a clear picture of the stratospheric influence on the present climate and of its potential contribution to explain anomalous periods before the industrial era.

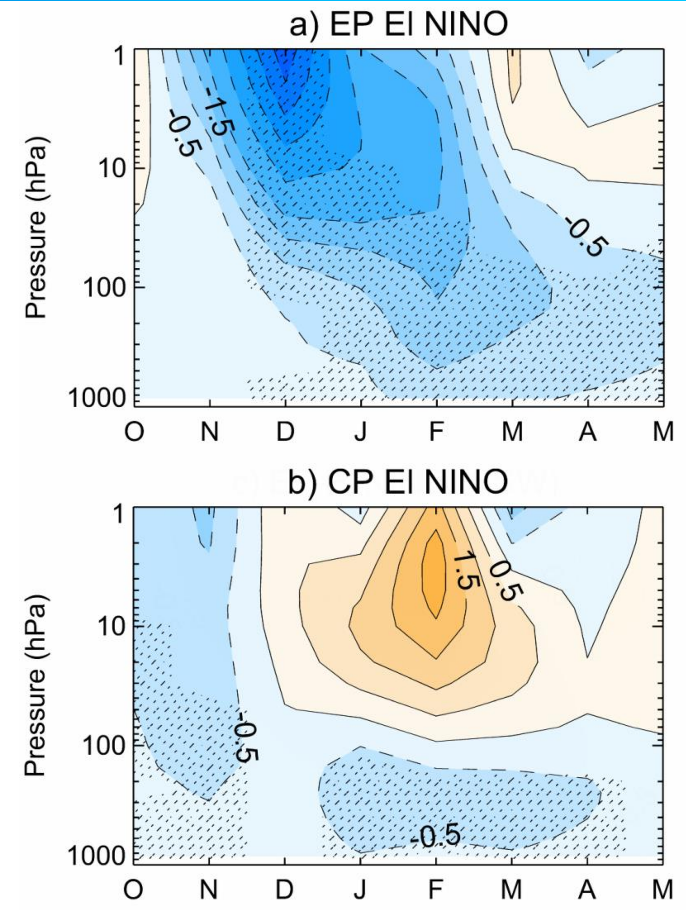


Figure 2. Downward propagating ENSO signal in 50-60 ºN zonal mean zonal wind (m s^{-1}) [2]

3. Synergies

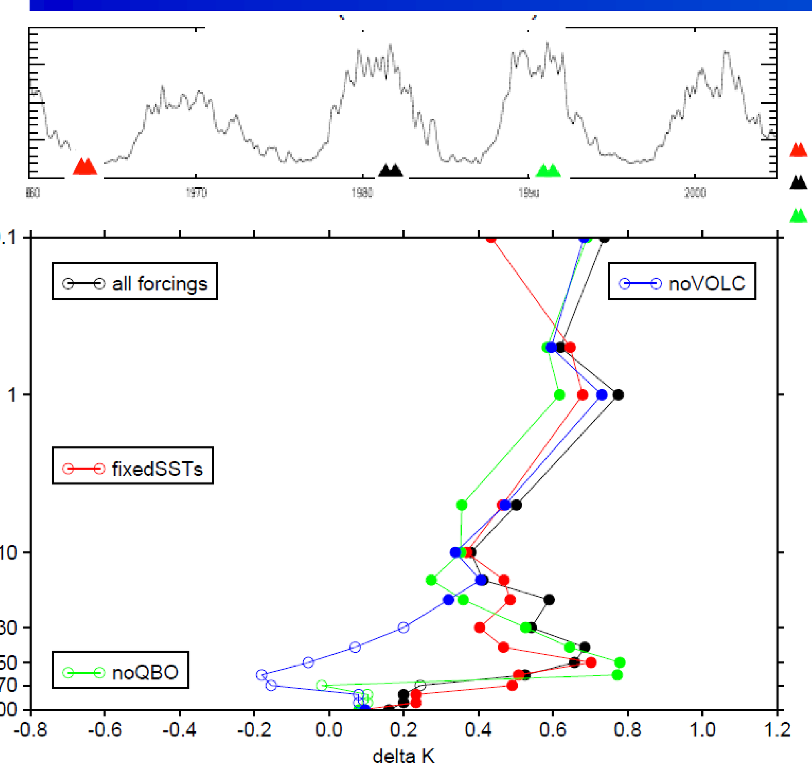


Figure 3. 11-year solar signal in vertical temperature (ºC) for different forced simulations [3]

• Discrepancies between models and reconstructions could be due to uncertainties in:

i) climatic signals (e.g., short observational record, aliasing effects, *Figure 3*, non-linear interactions, *Figure 4*);

ii) external forcings (e.g., volcanic forcing reconstructions and misrepresentation of the response to volcanic eruptions in the PMIP3 and CMIP5 models, *Figure 5*);

iii) model physics (e.g., high-top model simulations coupled to a microphysical model have been able to reduce biases in the response to volcanic forcing, *Figure 6*).

• The bulk of models employed in the last generation of LM simulations did not have a well-resolved stratosphere (oversimplification of the represented processes).

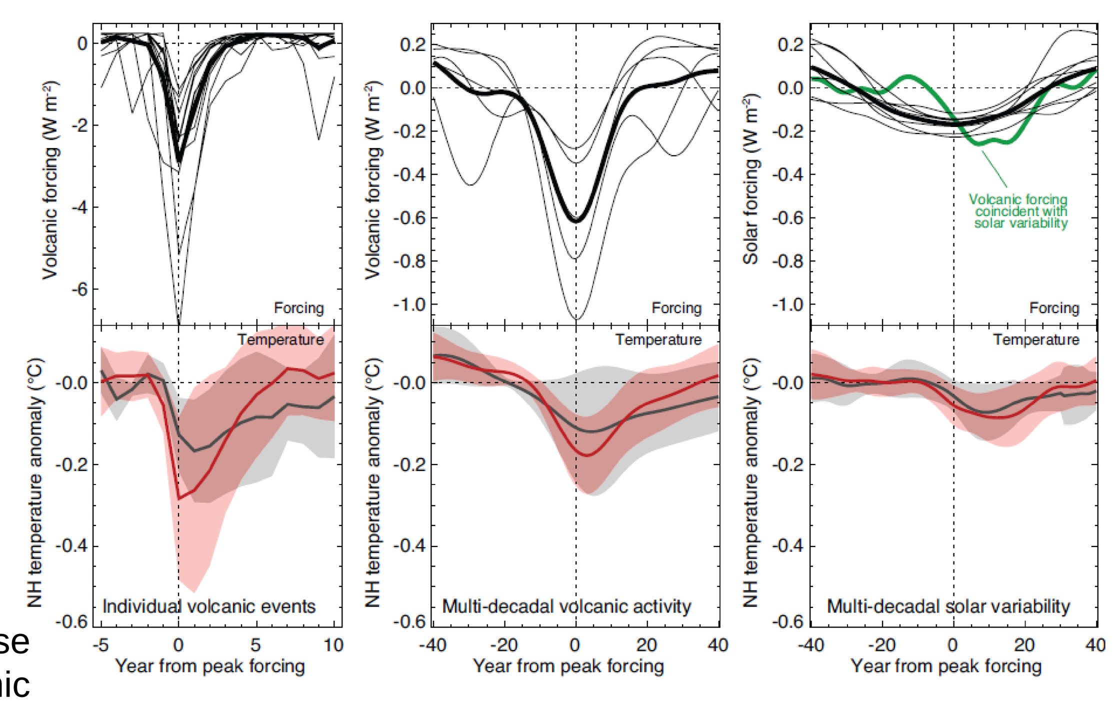


Figure 5. NH reconstructed temperature response (ºC) to different external forcings: volcanoes, volcanic clusters and decadal changes in solar activity [5]

• LM simulations with high-top models offer a unique opportunity to unravel the stratospheric impacts on climate and to better understand the mechanisms behind anomalous periods of the LM.

• PALEOSTRAT (PALEOmodelization from a STRATospheric perspective) [7] provides a novel and synergistic view of the paleoclimate and the stratosphere in order to: i) better understand the role of the stratosphere in the internal and forced variability of the Earth System and, ii) improve current understanding of the LM by incorporating knowledge of the middle atmosphere.

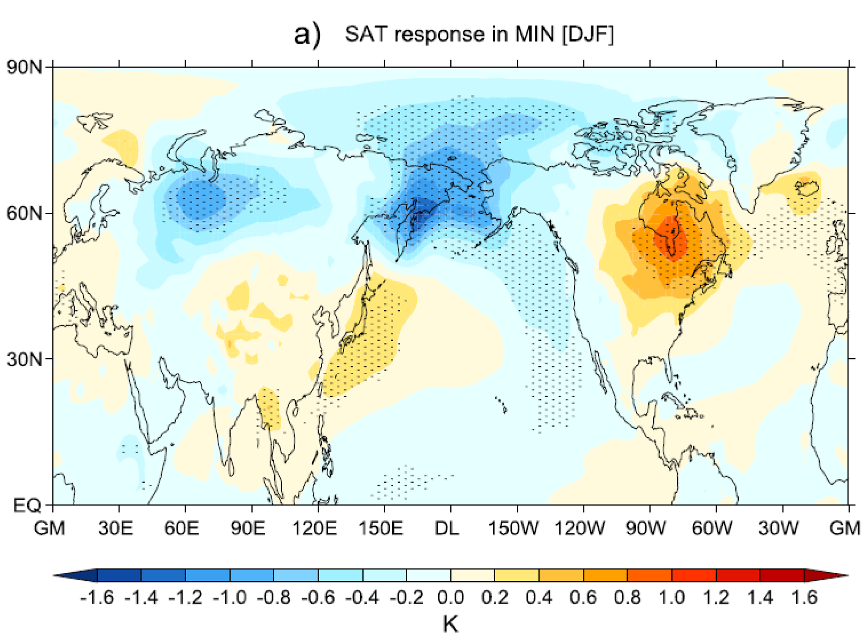


Figure 4. Winter temperature response (ºC) to a future solar minimum in RCP4.5 scenarios [4]

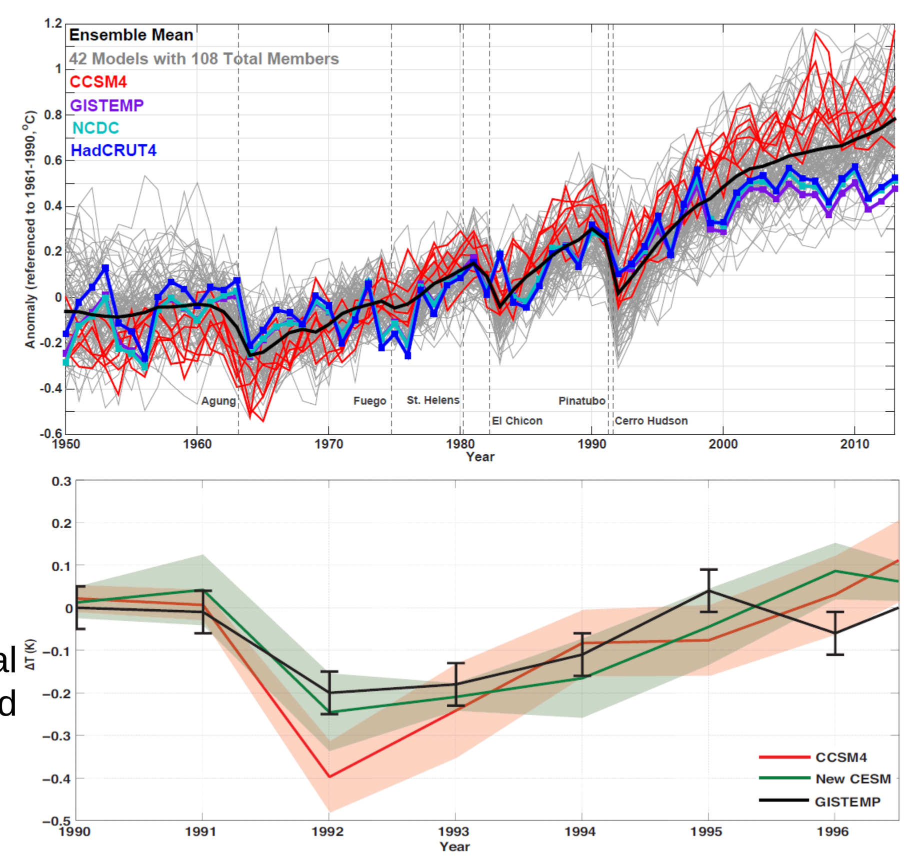
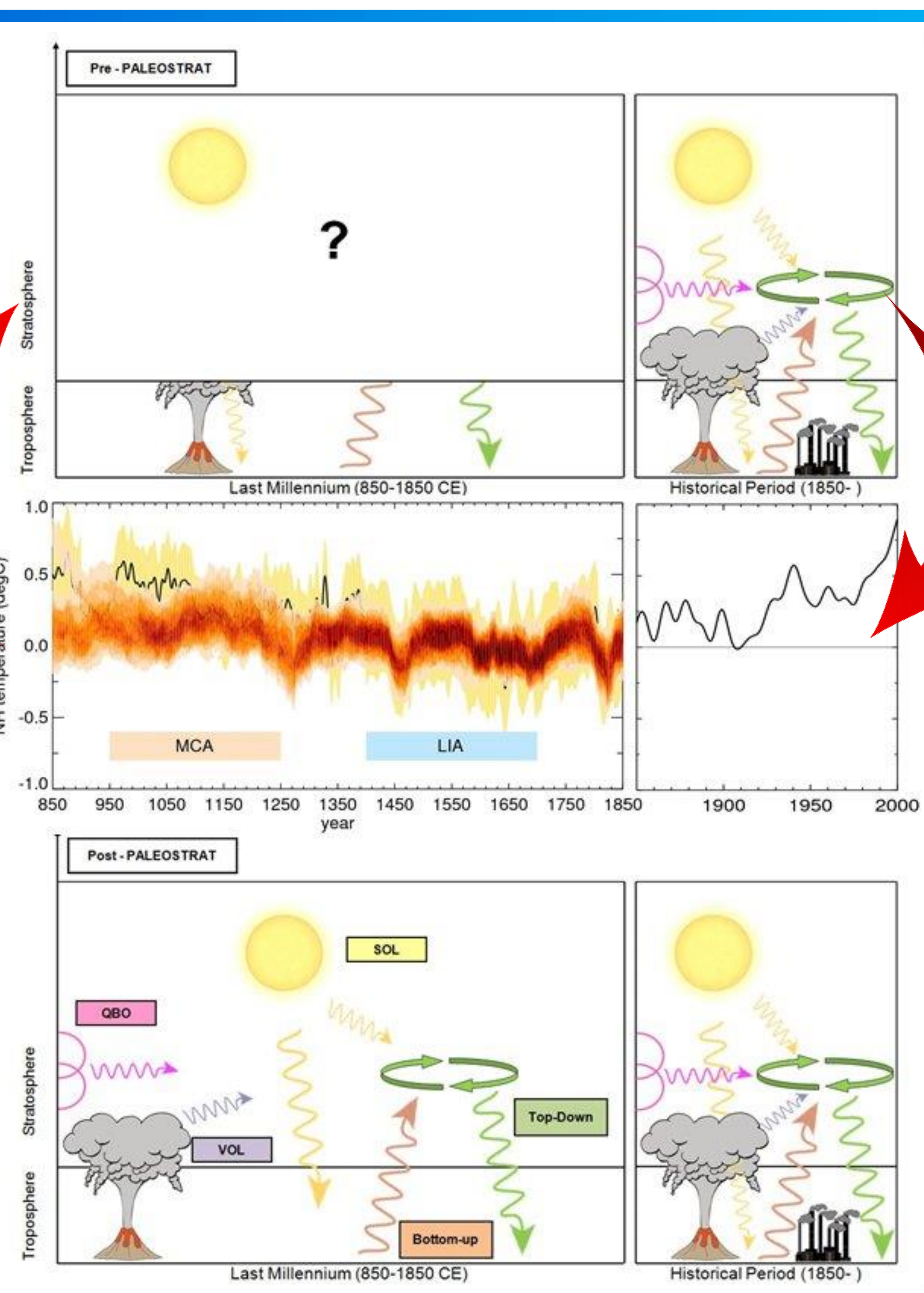


Figure 6. Global temperature anomalies (ºC) in (Top) historical CMIP5 simulations (1950-2012) (Bottom) CESM runs with and without interactive volcanic aerosols (1990-1997) [6]

4. PALEOSTRAT project

Paleo ⇨ Stratosphere

- Revisit external forcings
- Run LM simulations with high-top and low-top models
- Characterize multidecadal and centennial variability
- Describe the responses to internal and external forcings
- Isolate climatic signals and explore non-linear interactions



Stratosphere ⇨ Paleo

- Improve the representation of external forcings
- Quantify the internal vs externally-forced variability on the climate of the LM
- Evaluate the role of the stratosphere in driving regional and global responses
- Pin down the origin of discrepancies between models and reconstructions

• The project will be addressed by a suite of LM coupled simulations with an Earth System Model, which only differ in the representation of the stratosphere, the external forcings and the implementation of volcanic aerosols (*Table 1*).

• PALEOSTRAT will allow investigating: i) the stratospheric variability and its influence in the surface climate at a wide range of time-scales; ii) the impact of the stratosphere on the climate of the LM and its added value in reproducing the regional responses to forcings (*Figure 7*).

• The model output will be available to the scientific community, including PMIP (PAGES), SPARC (WCRP) and CMIP (IPCC).

Forcing / Run	Control (1000 yrs)	Basic (850-1850 CE)	New (850-1850 CE)
Anthropogenic	Fixed (1850)	PMIP [8]	PMIP [8]
Solar	Fixed (1850)	PMIP [8]	PMIP [8]
Land	Fixed (1850)	PMIP [8]	PMIP [8]
Volcanic	No	[9] Prescribed	[9] Interactive
Chemistry	Specified (1850)	Specified (1850)	Interactive

Table 1. LM simulations within the PALEOSTRAT project. Each simulation will be run with the high-top model and its low-top version.

Figure 7. Current knowledge on the role of the stratosphere in climate for: (Left panels) the LM; (Right panels) the instrumental period; (Top panels) before and (Bottom panels) after PALEOSTRAT. Boxes highlight the main objectives.

References

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