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# ANOTHER SIDE OF THE ANTHROPOCENE: HUMANS INCREASED ECOSYSTEM VULNERABILITY TO CLIMATE VARIABILITY


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## Hypothesis

Paleoecological methods provide a long-term insight on ecosystem trajectory and have hence been viewed as an opportunity to study how climate variability can shape ecosystems in the absence of a strong human component (i.e. before the onset of the Anthropocene). Yet, such an approach tacitly assumes that **ecosystems vulnerability to climate fluctuations has been constant and independent from local human disturbances.** However:

- Ecosystems can respond in a non-linear way to perturbations (i.e. regime shift trajectory) [1],
- There is a recovery debt for ecosystems even years after they have been restored [2],
- Lake that underwent more important eutrophication are more vulnerable to recent climate change [3].

Our aim is **to quantify Lake Geneva ecological vulnerability to climate variability over the past 1300 years**.

The null hypothesis is that the ecological vulnerability to climate variability was constant over time.

The alternative hypothesis is that local human pressures, by rearranging both the horizontal and vertical diversity of ecosystems, may have modified their resistance, resilience and therefore vulnerability to successive perturbations since entering the Anthropocene.

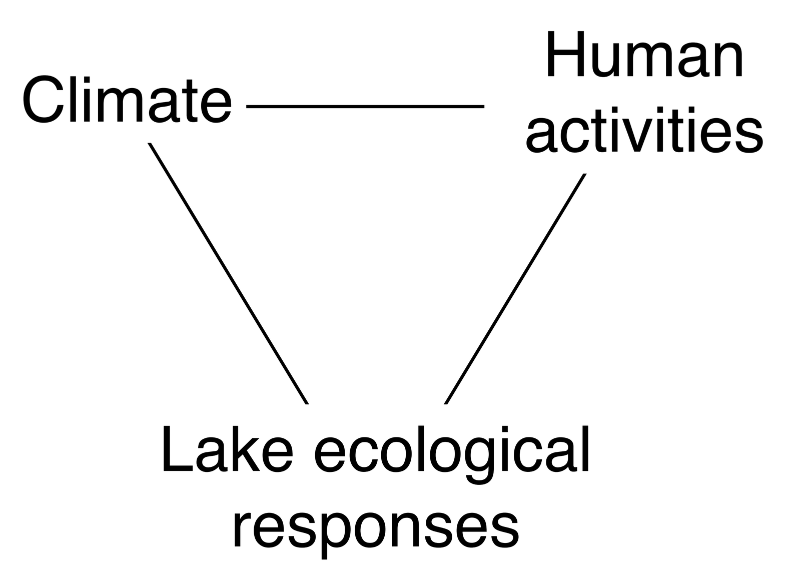


**Figure 1.** Interactions between pressures = difficulty to quantify responses

## Materials & methods

We relied on a well dated core of Lake Geneva (FR, CH) from which we reconstructed diatoms and cladoceran assemblages.

- **Climate**: summer air temperature (SAT) anomalies (Rhone valley, CH) [4]
- **Human activities**: worldwide, the main forcing on lakes is eutrophication ➔ diatom-inferred total phosphorus (DI-TP)
- **Lake ecological response**: cladocera (pelagic & littoral distribution, central position in the food web: vulnerable to both bottom-up and top-down changes)

Ecological variability was summarized through PCA. Main drivers were identified by GAM, and potential influence on ecological vulnerability to climate of the period (pristine vs. human impacted) was tested by an ANCOVA.

## Results

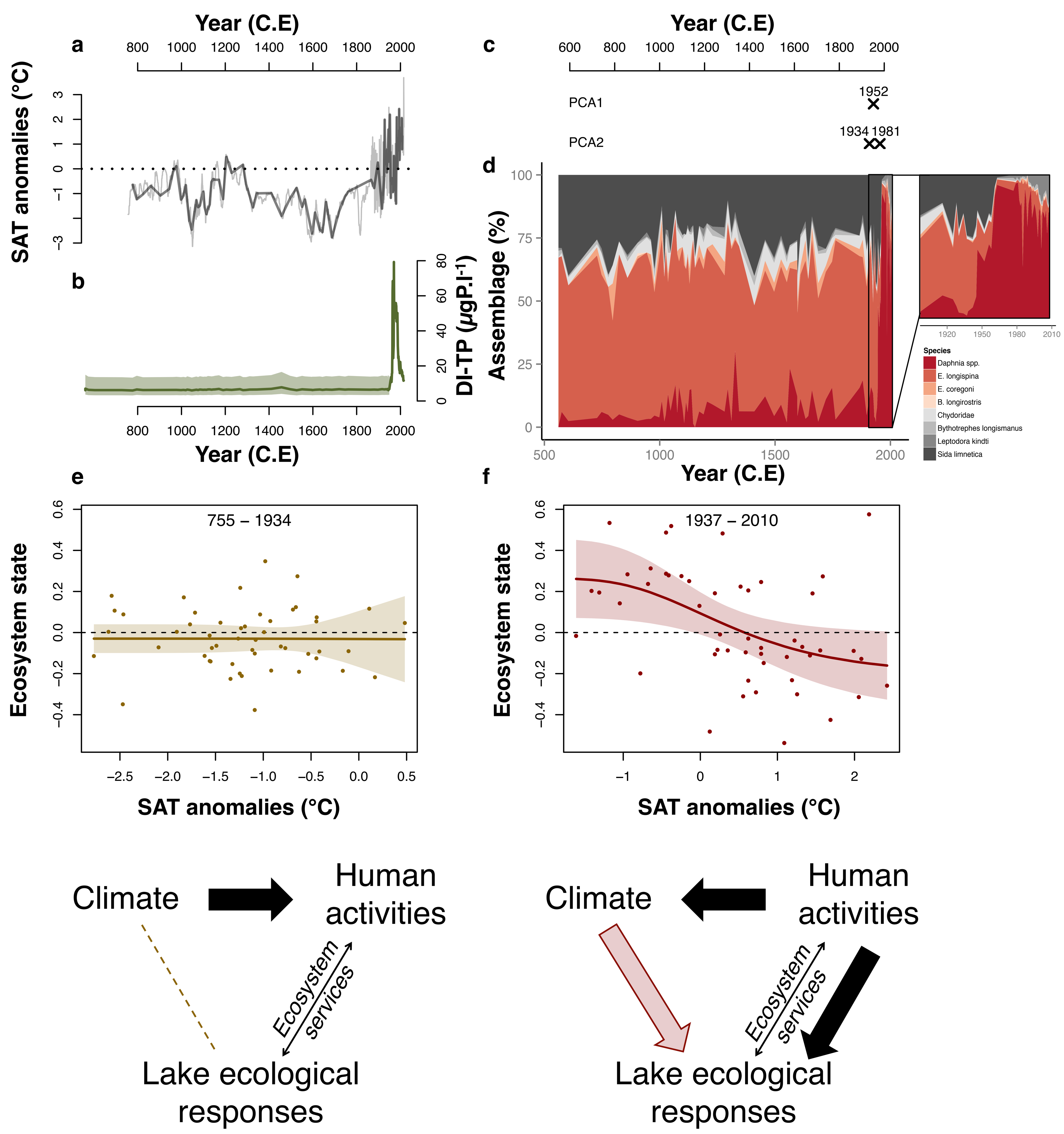


**Figure 2. a)** SAT anomalies 755-2010 C.E., **b)** DI-TP 563-2010 C.E., **c)** Change-points in ecosystem assemblage, **d)** Cladoceran communities composition 563-2010 C.E.. Ecosystem vulnerability to climate as a function of SAT anomalies for the **e)** 755-1934 C.E. and **f)** 1937-2010 C.E. period. Dark arrows in **e)** and **f)** indicates the strength of the relationship and the direction illustrates which compartment impact the other.

## Conclusions & perspectives

Herein, we show that for 1200 years (755-1934 C.E.), Lake Geneva ecological status was strongly resilient to climate variability, despite an amplitude of thermal changes that were similar to those observed during the 20th and 21th centuries.

Over the last 80 years, the amount of ecological changes attributable to climate fluctuations has significantly increased. Local human impacts, responsible for the 1960s eutrophication, have made this large aquatic system vulnerable to climatic fluctuations, despite the adaptation of management practices that took place as soon as the 1970s.

**In a world where all ecosystems are responding to climate change, the urge to reduce local human impact is compelling, as it appears as a major resilience disruptor.**


**[1]** Scheffer *et al.* 2001, Nature 10.1038/35098000, **[2]** Moreno-Mateos *et al.* 2016, Nature Comm. 10.1038/ncomms14163, **[3]** Perga *et al.* 2015, Frontiers in E&E 10.3389/fevo.2015.00072, **[4]** Büntgen *et al.*, 2006 , Journal of Climate 10.1175/JCLI3917.1



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