Exploring potential influences of climate on archaic human habitats, species successions and extinctions.

Keywords: numerical transient climate simulation, Cumulative Distribution Function-transform (CDF-t) technique, spatiotemporal habitat suitability, human evolution, climatic envelope model, Plio-Pleistocene.

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Host institution: EPOC laboratory, Team Paleoclimate in collaboration with PACEA laboratory

Application: We are looking for a motivated Master 2 candidate with background in geosciences, climate modeling or statistics. Candidates with basic notions of paleoclimate, paleontology and programming skills in Python, R, have an advantage.

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Abstract of the project:

Recent studies highlight the influence of climate on archaic human habitats, species successions and extinctions (Timmermann et al., 2016 ; Raia et al., 2020 ; Gibert et al., 2022 ; Timmermann et al., 2022; Ruan et al., 2023 ; Zeller et al., 2023). To examine these potential relationships, the use of transient numerical climate simulations in conjunction with fossil and archaeological data to examine spatiotemporal habitat suitability is necessary. Available complete transient simulations over the last 3 million years (Ma) that incorporate a 3D earth system model are rare (only one by Yun et al., 2023). The latter presents limitations for the period between ~3 to 1 Ma due to inappropriate insolation forcing and potential biases in the applied GHGs forcing. In addition, fossil and archaeological records between 4–2 Ma are limited. Together, these shortcomings hamper detailed investigations of the role of climate shifts during the last 4 million years on the evolution of archaic human habitats, species successions and extinctions.

In this Master 2 project, we propose to combine new results from a 3D transient climate simulation covering the last 4.5 Ma produced with the iLOVECLIM coupled numerical model (Caley and Extier, in progress) with published paleontological and archaeological contexts over the last 4.5 Ma in order to examine and eventually quantify relationships between climate shifts and changes in archaic human habitats, species successions and extinctions.

Because climate model simulations are inherently biased, we will correct climate model outputs using the 'Cumulative Distribution Function-transform' (CDF-t) technique, which allows to account for climate change within the bias-correction procedure (Zapolska et al., 2023).

Then, to study the spatiotemporal habitat suitability, we propose to employ a set of Plio-Pleistocene climatic variables simulated with the iLOVECLIM model in order to produce a climatic envelope model that is based on the known distribution of hominin occurrences in an effort to approximate the hominin existing fundamental niche (see Soberón and Nakamua, 2009), and this via different correlative methods (Timmermann et al., 2022, Gibert et al., 2022). Results will be used to bring new insights on the potential role of climate changes in the evolution of archaic human habitats, species successions and extinctions.

References:

Gibert, C., Vignoles, A., Contoux, C., Banks, W. E., Barboni, D., Boisserie, J. R., ... & Ramstein, G. (2022). Climate-inferred distribution estimates of mid-to-late Pliocene hominins. *Global and Planetary Change*, *210*, 103756.

Raia, P., Mondanaro, A., Melchionna, M., Di Febbraro, M., Diniz-Filho, J. A., Rangel, T. F., ... & Rook, L. (2020). Past extinctions of Homo species coincided with increased vulnerability to climatic change. *One Earth*, *3*(4), 480-490.

Ruan, J., Timmermann, A., Raia, P., Yun, K. S., Zeller, E., Mondanaro, A., ... & Melchionna, M. (2023). Climate shifts orchestrated hominin interbreeding events across Eurasia. *Science*, *381*(6658), 699-704.

Soberón, J., Nakamura, M. (2009). Niches and distributional areas: Concepts, methods, and assumptions. Proc. Nat. Acad. Sci. 106, 19644–19650.

Timmermann, A., & Friedrich, T. (2016). Late Pleistocene climate drivers of early human migration. *Nature*, *538*(7623), 92-95.

Timmermann, A., Yun, K. S., Raia, P., Ruan, J., Mondanaro, A., Zeller, E., ... & Ganopolski, A. (2022). Climate effects on archaic human habitats and species successions. *Nature*, *604*(7906), 495-501.

Yun, K. S., Timmermann, A., Lee, S. S., Willeit, M., Ganopolski, A., & Jadhav, J. (2023). A transient coupled general circulation model (CGCM) simulation of the past 3 million years. *Climate of the Past*, *19*(10), 1951-1974.

Zapolska, A., Vrac, M., Quiquet, A., Extier, T., Arthur, F., Renssen, H., & Roche, D. M. (2023). Improving biome and climate modelling for a set of past climate conditions: evaluating bias correction using the CDF-t approach. *Environmental Research: Climate*, *2*(2), 025004.

Zeller, E., Timmermann, A., Yun, K. S., Raia, P., Stein, K., & Ruan, J. (2023). Human adaptation to diverse biomes over the past 3 million years. *Science*, *380*(6645), 604-608.