**Contrasted hindcast performances demonstrate the need for more realistic models**

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Ecological forecasting has become a critical tool for managers and decision makers, and robust models are indispensable to provide reliable projections of species geographic range shifts and ecosystem functioning. Process-based approaches are expected to improve predictions under novel environmental conditions, wherein the trustworthinessof correlative approaches is questioned. However, this common assumption has never been properly verified.

Using late-Quaternary paleoclimate simulations specifically generated for this work, we compared several process-based and correlative species distribution model projections with fossil pollen records of various tree species in Europe, taking also into account dispersal constraints. We examined different versions of the models which differ in complexity and calibration methods in order to test different hypotheses about what conveys model robustness. We were then able to extrapolate these results under two future climate change scenarios, to get an estimation of model prediction uncertainties.

We find that under past climates, moving away from current conditions, the performance of both correlative models and classical process-based models decreases. Only one approach, which benefited both from the causal relationships described in process-based models and the richness of current species distribution data to calibrate them, stood out and provided the best predictions. However, by the end of the century, none of these methods will likely be able to provide reliable projections in growing non-analogous environments.

Our results provide a simultaneous evaluation of the transferability of predictive species distribution models, as well as a clear identification of the tenets of model robustness. Understanding and leveraging these differences is crucial for increasing awareness on model weaknesses and strengths and improving species distribution forecasting. Moreover, while the incorporation of realistic processes is a great challenge in predictive ecology, our work also highlights a promising perspective to scale up complex models and spread their use in a rapidly changing world.