**Contrasted hindcast performances calls for more realistic models.**

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While process-based models are expected to provide better species range shift predictions under novel environmental conditions than correlative counterparts, this hypothesis has yet to be tested.

We used both process- and correlative-based species distribution models to hindcast the range shift of 5 tree species across Europe for the last 15,000 years and evaluate these outputs against fossil pollen records. Using these results and considering the expected magnitude of climate novelty, we then quantified model uncertainties under future climate scenarios.

We show that long-term hindcast decreases the overall model performances and even the most promising approach (process-based models calibrated using occurrence data) is unlikely to provide any reliable projections under future non-analogues conditions.

Our results (*i*) challenge the concept of transferability in species distribution modelling, (*ii*) highlight the prerequisites for ensuring model robustness and (*iii*) provide a promising framework to scale up complex models and promote their use in a global warming context.