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Angaben zur Veröffentlichung / Publication details:

Adeleke, Emmanuel, Christian Merckenschlager, Mandy Schäfer, Renke Lühken, Patrick Gutjahr, Christian Voll, and Elke Hertig. 2026. "Regional and seasonal variability in the impacts of the North Atlantic Oscillation and other European North Atlantic teleconnections on mosquito populations in Germany [Abstract]." In *EGU General Assembly 2026, Vienna, Austria, 3–8 May 2026*, EGU26–15200. Göttingen: Copernicus. <https://doi.org/10.5194/egusphere-egu26-15200>.

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Regional and Seasonal Variability in the Impacts of the North Atlantic Oscillation and Other European North Atlantic Teleconnections on Mosquito Populations in Germany

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Previous modelling studies of mosquitoes in Europe have primarily focused on local and regional climate drivers, while the influence of large-scale atmospheric teleconnection patterns on mosquito populations remains poorly understood. This study examines how major European–North Atlantic (EUNA) teleconnection patterns—including the North Atlantic Oscillation (NAO), Arctic Oscillation (AO), East Atlantic (EA), East Atlantic/Western Russia (EAWR), Scandinavian (SCAND), and Summer East Atlantic (SEA) patterns—influence mosquito abundance across Germany. Using nationwide mosquito surveillance data (2016–2024), we combined rotated temporal-mode principal component analysis (T-mode PCA) of mean sea level pressure fields with spatiotemporal generalized linear mixed models (GLMMs) to quantify regional- and seasonal-specific relationships among circulation modes, local weather anomalies, and mosquito abundance. Results reveal pronounced regional and seasonal variability in the climate-mediated associations between circulation patterns and mosquito abundance. Effects were strongest and predominantly positive in the Continental Dry, Northwest Cool, Warmest, and Coastal regions, particularly from summer to early autumn, whereas responses in Alpine and other mountainous regions were weaker or negative due to cooler, wetter and windier conditions that constrain mosquito activity. Local temperature and humidity anomalies associated with EUNA circulation patterns were consistently linked to increases in mosquito abundance while precipitation and windspeed anomalies showed negative effects. Positive temperature and negative humidity anomalies during EA, EAWR, SCAND, and SEA phases exhibited the most consistent positive relationships with mosquito abundance. These findings demonstrate that large-scale climate variability plays a significant role in shaping mosquito population dynamics in central Europe and highlight the value of incorporating teleconnection indices into early-warning and forecasting systems of mosquito-borne diseases.