Simulating Atmospheric CO\textsubscript{2} Levels Using CH\textsubscript{4} and Temperature Proxy Records by ANN-Wavelet technique

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Investigating climate change through the reconstruction and modeling of atmospheric CO\textsubscript{2} provides valuable insights for scientists aiming to unravel climate-carbon cycle feedback. The correlation between temperature and greenhouse gases, as inferred from ice core records, holds the potential to improve the accuracy of simulating CO\textsubscript{2} variations. This study sought to investigate modeling approaches for accurately simulating atmospheric CO\textsubscript{2} concentrations. To address data gaps in CO\textsubscript{2}, CH\textsubscript{4} concentration, and temperature proxies (\delta D and \delta^{18}O) from Antarctica ice cores were incorporated. The study utilized Artificial Neural Network (ANN) and Wavelet Transform (WT) techniques to enhance precision in these simulations. Three distinct ice cores were utilized in this study, specifically the EPICA Dronning Maud Land (EDML) core for 70-115 thousand years ago (ka), the Dome Fuji (DF) core spanning 9-120 ka, and the West Antarctic Ice Sheet (WAIS) Divide core covering the period of 9-70 ka. The findings affirmed that the implementation of the WT-ANN model proved to be a successful approach for simulating CO\textsubscript{2} concentrations throughout the study timeframe. The results highlighted the notable impact of time resolution in influencing the outcomes of the AI model. Particularly, utilizing high-resolution data from the WAIS Divide spanning 9-70 ka resulted in an impressive R\textsuperscript{2} value of up to 0.96, indicating a strong correlation between the model predictions and the ice core records using the hybrid method. Applying the WT-ANN hybrid methodology, which integrated WAIS (training periods of 9-29 and 57-70 ka) and DF data (training periods of 9-29 and 57-120 ka), a simulation of CO\textsubscript{2} concentrations spanning 29-57 thousand years ago (MIS3) was carried out. The model demonstrated superior performance during the MIS3 test phase for the WAIS, with an R\textsuperscript{2} value of 0.85 and an RMSE of 3.62 ppm, compared to the DF core, where the R\textsuperscript{2} was 0.74 and the RMSE was 6.91 ppm. In our future initiatives, we intend to broaden our modeling efforts by integrating diverse AI techniques and employing numerous ice core samples across various time periods. Through the pursuit of this strategy, we aim to create exceptionally accurate simulations of CO\textsubscript{2} levels. This not only advances our comprehension of historical climate dynamics but also addresses research gaps, paving the way for future investigations.