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Was the Antarctic Ocean warmer at the last glacial maximum than at present? - CLIMAP revisited.

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Accurate quantification of past sea surface temperatures (SSTs) using Imbrie-Kipp transfer functions (IKTF), the modern analog technique (MAT; and its derivatives RAM and SIMMAX), the weighted-averaging partial least squares (WAPLS) regression, maximum likelihood (ML), and artificial neural network (ANN) methods based on faunal abundance data has been the consistent quest among paleoceanographers. Recent studies have suggested that ANNs may represent the most optimum procedure for estimates of paleo-SSTs. We therefore employed ANN together with other methods to estimate Antarctic Ocean Austral summer (February-April) and winter (August-October) season SSTs at 30-50 m water depth for the last glacial maximum (LGM) at $\sim$18,000 years B.P. (18k) using CLIMAP's Antarctic modern radiolarian core top and 18k data sets. The average root mean square error of prediction (RMSEP) is as low as $\sim 1.3^{o}$C for summer and winter in independent test sets of observations not included in the training of the ANNs. Correlation coefficients between observed and estimated SSTs in these test sets are 0.97 for both seasons. ANN-derived RMSEPs are considerably lower (28-33%) than those ($\sim 2^{o}$C) obtained using other methods. ML produced the coolest ($\geq 0^{o}$C) SSTs, IKTF and MAT produced intermediate values ($\geq 2^{o}$C), whereas ANN and WAPLS estimates were warmer ($\geq 4^{o}$C) during the LGM Austral summer. ANNs also produced warmer LGM Austral winter SSTs than other methods. ANN-based SST reconstructions are intriguing in showing higher SSTs at the LGM than in the modern ocean, and in recording considerably higher SSTs than those estimated by CLIMAP, whereas the general trends in the isotherms are similar. Higher SSTs during LGM than in the modern ocean may be attributed to higher

($\sim$6 W/m^2) Austral summer solar insolation maximum at 18k in the Antarctic than in modern times.