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Deep learning reveals the impact of tropical convection on Antarctic sea ice

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Recent observations have revealed an unprecedented and abrupt decline in Antarctic sea ice extent since 2016, raising fundamental questions about its underlying drivers. Previous studies suggest that tropical variability—particularly signals associated with ENSO and the Indian Ocean Dipole (IOD)—may play a key role in shaping Antarctic sea ice variability. In this study, we develop a deep learning–based framework that jointly incorporates Antarctic sea ice concentration and tropical climate variables to investigate the influence of low-latitude forcing on sea ice changes. By explicitly integrating tropical precipitation and related equatorial signals into the training process, the deep learning model captures complex teleconnections and provides skillful representations of cross-latitude linkages. To further disentangle these relationships, we apply an occlusion-based explainability method, which allows us to systematically quantify the sensitivity of Antarctic sea ice to tropical signals under different sea ice states. Our results demonstrate that ENSO- and IOD-related signals exert distinct and state-dependent impacts on Antarctic sea ice variability, with stronger sensitivity during periods of rapid decline. These findings highlight the power of deep learning combined with explainable AI techniques for uncovering tropical–polar teleconnections and underscore the necessity of accounting for tropical variability to improve our understanding and prediction of Antarctic sea ice change.

Key words: Antarctic, Sea ice, Deep learning