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Polar climate predictability seasonal to multi-decadal: The combined influences of tropical SST trends and stratospheric ozone depletion in shaping Antarctic climate change

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Climate trends in the Antarctic present a number of paradoxes, such as a modest increase in sea ice extent and cooling in East Antarctica, contrasted with rapid warming on the Peninsula and across West Antarctica. Previously, the spatial patterns of trends in Antarctica have been interpreted as the signature of a persistent positive trend in the Southern Annular Mode (SAM), the leading mode of variability in the extratropical atmospheric circulation, thought to be forced by stratospheric ozone depletion. However, the observations, particularly the warming of West Antarctica, and the overall warming of the continent since the late 1950s, present some challenges to attributing Antarctic trends to a single mechanism. In this contribution, we first assess the robustness of the trends by analyzing multiple datasets (including in-situ, satellite, and derived reconstructions) of Antarctic surface temperatures and related physical variables such as sea ice and atmospheric circulation. We find that along with an annual-mean trend during the past 50 years of about 0.1oC/decade averaged over Antarctica, there is a distinct seasonality to the trends, with insignificant change (and even some cooling) in austral summer and autumn in East Antarctica, contrasting with warming in austral winter and spring. Second, using a variety of polar and tropical observational datasets, we examine the seasonally dependent spatial patterns of tropical climate signals over Antarctica. It is observed that the strongest teleconnection of tropical and Antarctic climate occurs in the austral spring via the Pacific South American pattern (PSA), a wave train with a center of action in the South Pacific. A secondary tropical teleconnection operates in the austral summer and projects onto the SAM, representing another way that the SAM can be forced. Next, we use a statistical congruency analysis, together with modeling, to illustrate the contribution of tropical SST trends to a trend in the PSA and the warming of West Antarctica in the austral spring. Similarly, trends in the SAM more than account for East Antarctic cooling trends in austral summer and autumn, though separating the roles of SST and ozone forcing remains a challenge. This has implications for our ability to predict 21st Century Antarctic climate change, as we cannot rely on estimates of a single forcing (e.g. staratospheric ozone) to accurately predict future changes.