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Long-term climate change signatures in polar wander

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Polar wander represents long-term variations of the north-pole position (or polar motion), and is generally believed to be driven by long-term mass change in the mantle and core of the solid Earth. Modern space geodetic observations show that since around mid or late 90's, the polar wander rate appears to depart from its normal trend in the past several decades. Using satellite gravity measurements from the Gravity Recovery and Climate Experiment (GRACE) and estimates from advanced climate models, we demonstrate that polar wander is also closely connected to long-term variability (i.e. air, water, and ice mass change) in the climate system, and the 'abnormal' polar wander variability in the past decade or so is mainly driven by accelerated polar ice sheet melting, global sea level change, and terrestrial water storage change in the recent decade. Furthermore, polar motion time series shows significant decadal variability during the past 50 years (1962 – 2011), which is also likely connected to unquantified climate change events in the past, based on the remarkable agreement between GRACE data and polar motion measurements in the recent decade. This study has demonstrated that accurately measured polar motion time series provides observational constraints on long-term large-scale climate change events in the Earth climate system, and offers a possible means for studying long-term climate change variability in the past (when adequate spaceborne observations were not available).