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Climate and polar motion during the GRACE observing period: 2002-2015: Implications for decadal scale oscillations during the 20th Century

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The motion of the Earth's pole in space has been observed with great accuracy for the last 115 years. The angular variations of the pole position away from its mean are a well explained at annual and 434-day periods. Variations at annual periods are caused by changes in the mass and angular momentum forced by all Earth surface changes that have near seasonality. The 434-day period is explained as a resonance between the cumulative driving forces having periods near the Chandler wobble free eigenmode of the Earth and is well understood theoretically. The Earth also has a longer-term drift that is explained primarily as a response to the ice age changes in the moments of inertial of the Earth. However, there has been a long-standing search for the origins of pole variations that have a period near 10 years. Using GRACE space gravimetry we show that ice mass losses from Greenland and Antarctica, and when combined with changes in continental hydrology, explain almost all the main features of interannual time scale polar wander. The discovery has broad interdisciplinary implications, as we show that decadal scale pole variations are directly linked to global changes continental water. The energy sources for these pole position changes are, therefore, likely to be associated with decadal scale ocean and atmospheric oscillations that also drive 20th Century on-land wet-dry oscillations at decadal-scale across the globe. Variability in pole position, therefore, offers a tool for assessing past stability of our climate, and for the future, now faced with an increased intensity in the water cycle and more vulnerable to ice sheet instability.