Can climate change signals be detected from the terrestrial water storage at daily timescale?

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The global terrestrial water storage (TWS), the most accessible component in the hydrological cycle, is a general indicator of freshwater availability on earth. The global TWS trend due to climate change is harder to detect than global mean temperature due to the highly uneven hydrological responses across the globe, the brevity of global freshwater observations, and large natural noises. To overcome the climate noise and small sample size of observations, we leverage the vast amount of observed and simulated meteorological fields at daily scales to project global TWS through its fingerprints in weather patterns. The novel method identifies the relationship between annual global mean TWS and the daily surface air temperature and humidity fields using multi-model hydrological simulations. We found that globally, approximately 50% of days for most years since 2016 have climate change signals emerged above noise. Climate change signals in global mean TWS have been consistently increasing over the last few decades, and in the future, are expected to emerge from the natural climate variability. Counterintuitively, the signal of forced climate change under a high radiative forcing scenario (RCP6.0) emerges later than that under a relatively lower radiative forcing scenario (RCP2.6) due to higher climate variability under higher emission scenarios. The global mean TWS is projected to decrease twice as fast under RCP6.0 compared to RCP2.6 at the end of the 21st century. Our research indicates the urgency to limit carbon emission to not only avoid risks associated with warming but also sustain water security in the future.