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The time of emergence of Arctic warming, wettening and sea ice melting

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The strongly warming and wettening Arctic exhibits considerable temporal interannual and decadal variability. A conclusive transition point to a new climate state – the time of emergence (ToE) – occurs when the forced signal exceeds natural variability. Uncertainties in model-simulated climate trends and variability, as well as in methods, have thus far resulted in diverging estimates of Arctic ToE. Here we use a detailed, robust method applied to state-of-the-art climate model projections to show that in most seasons Arctic sea ice thickness emerges first (2038-2043), followed by surface air temperature (2037-2053) and sea ice cover (2050-2074). Since precipitation/rainfall variability is comparatively high, these variables emerge relatively late (after 2080). Autumn generally exhibits the earliest ToE-values due to strong sea ice retreat and associated warming and surface evaporation. Spatial variations in Arctic trends and variability cause ToE for temperature and sea ice thickness to emerge first in the Central Arctic, whereas for sea ice cover and rainfall this primarily occurs in the North Atlantic – Barents Sea region. Evidently, parts of the Arctic are close to entering a new climate state in terms of temperature and sea ice changes, with wide-ranging, long-term and possibly irreversible consequences for vulnerable Arctic ecosystems and human activities.