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Statistical analysis of global surface temperature and sea level using cointegration methods

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Global sea levels are rising which is widely understood as a consequence of thermal expansion and melting of glaciers and land-based ice caps. Due to the l University of Copenhagen, Copenhagen, Denmark ack of representation of ice-sheet dynamics in present-day physically-based climate models, semi-empirical models have been applied as an alternative for projecting of future sea levels. There are in this, however, potential pitfalls due to the trending nature of the time series. We apply a statistical method called cointegration analysis to observed global sea level and land-ocean surface temperature, capable of handling such peculiarities. We find a relationship between sea level and temperature and find that temperature causally depends on the sea level, which can be understood as a consequence of the large heat capacity of the ocean. We further find that the warming episode in the 1940s is exceptional in the sense that sea level and warming deviates from the expected relationship. This suggests that this warming episode is mainly due to internal dynamics of the ocean rather than external radiative forcing. On the other hand, the present warming follows the expected relationship, suggesting that it is mainly due to radiative forcing. In a second step, we use the total radiative forcing as an explanatory variable, but unexpectedly find that the sea level does not depend on the forcing. We hypothesize that this is due to a long adjustment time scale of the ocean and show that the number of years of data needed to build statistical models that have the relationship expected from physics exceeds what is currently available by a factor of almost ten.