This paper "Temperature trends, climate attribution, and the nonstationarity question," returns to the question; are the time series for surface temperature trend stationary or do they contain a unit root (i.e. they are I(1))? As explained by the authors on page 3, the mean value of a trend stationary time series changes over time because the time series increases/decreases by the same quantity period-after-period. Conversely, the mean value of a time series that contains a unit root changes over time due to accumulation of random changes.

Differences between trend stationary and nonstationary processes are important for efforts to attribute climate change to human activity. According to the anthropogenic theory of climate change, observed changes in radiative forcing are driven by economic activities that emit climate change. These activities, along with the long residence time in the atmosphere, imply that the time series for radiative forcing contain a unit root (Kaufmann et al., 2013). These nonstationary changes should appear in the time series for temperature if human activity drives climate change (unforced temperature is not I(1)). Conversely, the time series for temperature will be trend stationary (with or without a break) if some 'unknown' deterministic process changes climate.

In this manuscript, the authors argue that the temperature time series are trend stationary after allowing for a single structural break in trend. They use this result to revisit conclusions about cointegration between time series for radiative forcing and surface temperature. Although interesting, it is difficult to interpret results and evaluate the reliability of this conclusion because the current manuscript contains several difficulties and ignores previous research.

One important issue is the time series used by the authors to represent the radiative forcing of aerosols in particular and radiative forcing in general. The forcings used by the authors are obtained from CMIP5 (page 15) and shown in their Figure 3. These time series are highly stylized (and linearized) and are used to simulate climate models, but they are very different from the time series used by statistical analyses of temperature. For example, the time series for the radiative forcing of aerosols in Figure 3b is nearly flat. This is very different from the forcing associated with anthropogenic sulfur emissions, which become increasingly negative from 1950 through the early 1970s, flatten out through the late 1990's, and becomes increasingly less negative thereafter (e.g. Figure 1, Kaufmann et al., 2011). These changes play a critical role in statistical explanations for historical changes in global temperature; temperature declines slightly between the end of WWII through the mid 1970's because the radiative forcing of anthropogenic sulfur emissions increases (in absolute terms) slightly faster than increase in the radiative forcing of greenhouse gases (Kaufmann et al., 2006). Global temperature increases rapidly thereafter when efforts to reduce acid deposition reduce the radiative forcing of anthropogenic sulfur emissions relative to the radiative forcing of greenhouse gases (Kaufmann et al., 2006) Finally, the hiatus in global temperature from 1998 to 2008 is associated with an (absolute) increase in the radiative forcing of anthropogenic sulfur emissions (Kaufmann et al., 2011).

Given these effects, the authors need to describe why they use the highly stylized forcings from CMIP5 as opposed to the forcing used by statistical analyses, which are the focus of the authors' efforts. These time series used in statistical analyses are readily available. For example, they can be downloaded from http://www.sterndavidi.com/datasite.html or they can request them from the authors of papers that they cite.

The results of the paper also are obfuscated by the way that the authors analyze the time series for temperature that are simulated by climate models (Tables 1 & 2). The authors test the temperature time series that are simulated by the "under anthropogenic-only forcing" scenario for a linear trend. These authors find a general increase in temperature. But these increases in temperature are not generated by a deterministic trend. They likely are generated by the "anthropogenic-only forcings" that are used to simulate the models. But there is no reason to believe that these increases in radiative forcing are trend stationary (with or without a break). Human activities that generate emissions of radiatively active gases are not trend stationary. Furthermore, long residence times in the atmosphere impart a unit root.

Indeed, finding that the temperature time series generated by the climate models are trend stationary with a break undermines their basic hypothesis. If the temperature generated by climate models are trend stationary with a break, that implies that the forcings used to simulate the model are trend stationary with a break. So, the authors should test the time series used to simulate the climate model are trend stationary with a break. Such a result would contradict previous analyses that indicate these time series are not trend stationary with a break (Kaufmann et al., 2013). Furthermore, there is no physical mechanisms that will generate time series for radiative forcing that re trend stationary with a break. Conversely, if the authors believe that there is something about the climate system that causes temperature to be trend stationary (with or without a break), they should test the temperature data that are generated by control scenarios, in which radaitive forcing does not systematically increase or decrease over time.

I also find that the authors ignore previous efforts to determine whether the temperature time series are trend stationary with a break or whether they cointegrate with radiative forcing. Beyond simple tests, Kaufmann et al (2010), which the authors cite, compare the in-sample accuracy for surface temperature generated by a trend stationary model (with a single break) against a simulation generated by combining cointegration and error correction models. Their results indicate the cointegration error correction approach generated a more accurate in-sample simulation of temperature than the trend stationary model with a single break. This seems to be a much more power approach than relying on a single test statistic. At a minimum, I ask the authors to compare the accuracy of their trend stationary model (with a single break) against that generated by a cointegration/error correction approach that are estimated using the time series for radiative forcing that are used by previous statistical models.

Page 2 "That temperatures are composed of a nonstationary forcing component and stationary weather noise which biases the unit root tests towards non-detection of the stochastic trend." This statement ignores a more sophisticated analysis by Stern and Kaufmann (2000). They use multivariate structural time series techniques to decompose Northern and Southern Hemisphere temperatures into stochastic trends and autoregressive noise processes (i.e. stationary weather noise). Their results show that there are two independent stochastic trends in the data. One is similar to the radiative forcing due to greenhouse gases and solar irradiance and a second trend, which represents the non-scalar non-stationary temperature differences between the hemispheres that reflects radiative forcing due to tropospheric sulfate aerosols. They confirm these results by analyzing temperature data generated by the Hadley Centre GCM SUL experiment. In short, the authors should explain how their analysis extends/supersedes Stern and Kaufmann (2000).

I also have concerns about the section on cointegration analysis. The authors focus on cointegration between global temperatures and global forcing but ignore analyses that look at hemispheric relations. Kaufmann and Stern (2002) estimate a cointegrating vector autoregression model (Juselius, 2006) and use the Johansen trace statistic to find that differences in hemispheric temperature are associated with differences in the hemispheric temperature effects of greenhouse gases, anthropogenic sulfur emissions, and solar irradiance. I also find the focus on cointegration between forcings and temperatures simulated by climate models misleading. Any failure to find cointegration likely represents failings of the climate models rather than any real-world decoupling between observed values for radiative forcing and observed temperature.

It is not fair to dismiss the results found by Dergiades et al., (2016) with the innuendo on page 9 "The transition from I(0) to I(1) behavior in the Wahl and Amman (2007) chart may thus be an artifact of the climate proxy choice." The authors need to demonstrate that the 'choice' of the "Wahl and Amman (2007) chart" creates this result by using a different proxy for temperature and repeating the analysis by Dergiades et al., (2016). Short of that, this sentence is speculation, which really does not belong in a scientific paper.

Page 3 "There is no established label for a trending series with an I(1) random component, so we adopt the label 'trend stationary-random component or the more compact label 'trend stationary' for such a process. This is incorrect. There is a well-recognized term for such a series, a random walk with drift (Enders, 1995).

Page 6 "What happens if different unit root tests yield conflicting results?" No need to ask this question, it has been answered by Stern and Kaufmann (2000). Their Table I reports results of the ADF, Phillips-Perron, Schmidt-Phillips, and KPSS test statistics as applied to both global surface temperature, temperature in the Northern Hemisphere, and temperature in the Southern Hemisphere.

Literature Cited (not cited by McKitrick et al, 2023)

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