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Changes in the Frequency of Warm Nights – observations versus models

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How did the frequency in warm nights change during 1951-1999? Can this trend be reproduced in climate model simulations of the 20th century? And how does this trend compare to the trend in monthly averaged changes in minimum, mean and maximum temperature?
In this study we combine gridded observed and modeled data sets of the number of warm nights, as well as observed data of minimum, mean and maximum surface temperature in order to answer this question. The index for the number of warm nights counts the percentage of days where the 90th percentile of the minimum temperature is exceeded. Due to a spatial restriction of the coverage of the observational data, this work focuses on thirteen selected, mostly Northern Hemispheric regions.
As the model data only extends to 1999, we compared the period 1951-1999 between models and observations, and extended the comparison to observations for the period ending in 2003.
We found that not only the two observed, but also most of the 15 modeled data sets show a positive trend for all considered regions within this 49 year period (1951-1999) and an even stronger positive trend for the subperiod 1970-1999. The results also point out that, apart from the central, eastern and south-eastern North-American regions, the trend in the observational based indices is higher than the one of the model mean.
We calculated scaling factors to determine by how much the average model fingerprints would need to be scaled to reproduce the observed values. For about 50 percent of the considered regions this scaling factor is significantly larger than zero, which means that it is lying outside the range expected for trends due to internal variability only and hence represents significant forced change. This is consistent with changes in mean temperature, which have been attributed largely to greenhouse gas increases.
The trend in TN90 can also be found in the minimum, mean and maximum temperature recordings, mostly showing, as expected, the highest correlation between TN90 and the monthly averaged minimum temperature.
We speculate that in addition to greenhouse gas increases, a cause of this strong observed night warming could be enhanced downwelling long-wave radiation from aerosol and cloud particles.