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Long-range persistence in the global mean surface temperature and the global warming "time bomb"

M. Rypdal (1) and K. Rypdal (2)

(1) University of Tromsø, Department of Mathematics and Statistics, Tromsø, Norway (martin.rypdal@uit.no, +47 77620754),
(2) University of Tromsø, Department of Physics and Technology, Tromsø, Norway (kristoffer.rypdal@uit.no, +47 77645580)

Detrended Fluctuation Analysis (DFA) and Maximum Likelihood Estimations (MLE) based on instrumental data over the last 160 years indicate that there is Long-Range Persistence (LRP) in Global Mean Surface Temperature (GMST) on time scales of months to decades. The persistence is much higher in sea surface temperature than in land temperatures. Power spectral analysis of multi-model, multi-ensemble runs of global climate models indicate further that this persistence may extend to centennial and maybe even millennial time-scales. We also support these conclusions by wavelet variogram analysis, DFA, and MLE of Northern hemisphere mean surface temperature reconstructions over the last two millennia. These analyses indicate that the GMST is a strongly persistent noise with Hurst exponent H>0.9 on time scales from decades up to at least 500 years. We show that such LRP can be very important for long-term climate prediction and for the establishment of a "time bomb" in the climate system due to a growing energy imbalance caused by the slow relaxation to radiative equilibrium under rising anthropogenic forcing. We do this by the construction of a multi-parameter dynamic-stochastic model for the GMST response to deterministic and stochastic forcing, where LRP is represented by a power-law response function. Reconstructed data for total forcing and GMST over the last millennium are used with this model to estimate trend coefficients and Hurst exponent for the GMST on multi-century time scale by means of MLE. Ensembles of solutions generated from the stochastic model also allow us to estimate confidence intervals for these estimates.