Human influence on the seasonal cycle of tropospheric temperature

NASA MAP NNX13AN49G (PI: Q. Fu)

Background: Fingerprint studies use pattern information to separate human and natural influences on climate. Most fingerprint research relies on patterns of climate change that are averaged over years or decades. Few studies probe shorter time scales. We consider here whether human influences are identifiable in the changing seasonal cycle. We focus on Earth's troposphere, which extends from the surface to roughly 16 km at the tropics and 13 km at the poles. Our interest is in TAC, the geographical pattern of the amplitude of the annual cycle of tropospheric temperature. Information on how TAC has changed over time is available from satellite retrievals and from large multimodel ensembles of simulations.

Results and conclusion : The simulated response of the seasonal cycle to historical changes in human and natural factors has prominent mid-latitude increases in the amplitude of TAC. These features arise from larger mid-latitude warming in the summer hemisphere, which appears to be partly attributable to continental drying. Because of land-ocean differences in heat capacity and hemispheric asymmetry in land fraction, mid-latitude increases in TAC are greater in the Northern Hemisphere than in the Southern Hemisphere. Qualitatively similar large-scale patterns of annual cycle change occur in satellite tropospheric temperature data. By applying a standard fingerprint method, We find that the model fingerprint of externally forced seasonal cycle changes is identifiable with high statistical confidence in five out of six satellite temperature datasets. In these five datasets, S/N ratios for the 38-year satellite record vary from 2.7 to 5.8. Our positive fingerprint detection results are unaffected by the removal of all global mean information and by the exclusion of sea ice regions. On time scales for which meaningful tests are possible (one to two decades), there is no evidence that S/N ratios are spuriously inflated by a systematic model underestimate of the amplitude of observed tropospheric temperature variability. Our results suggest that attribution studies with the seasonal cycle of tropospheric temperature provide powerful and novel evidence for a statistically significant human effect on Earth's climate.

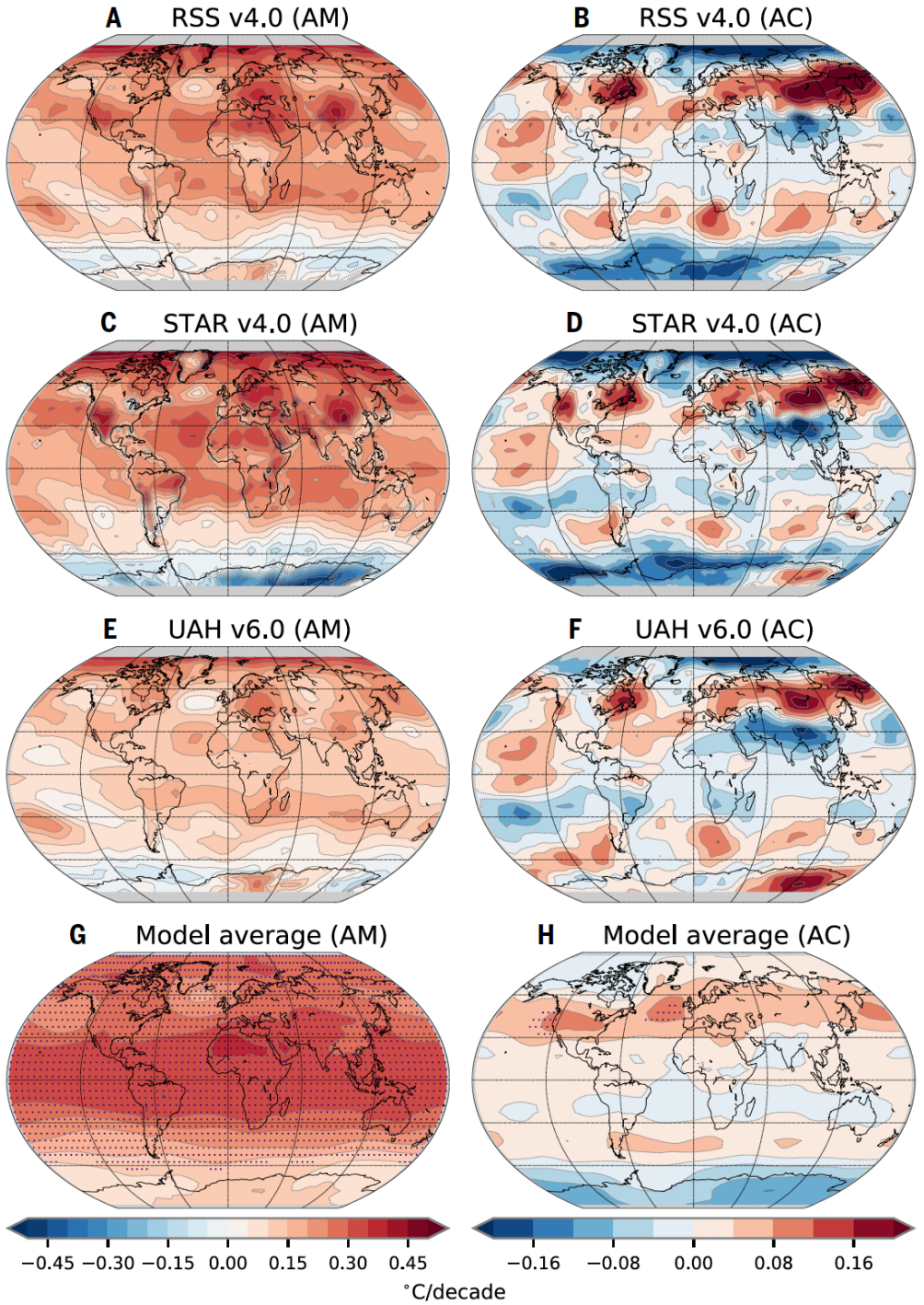

Figure caption. Trends over 1979 to 2016 in the annual mean (left column) and annual cycle (right column) of corrected TMT from satellite TMT data (A to F) and model TMT data (G and H). The stippling in (G) and (H) denotes grid points where the multimodel average trend in the annual mean or annual cycle exceeds the between-model standard deviation of the trend by at least a factor of 1.5. For the annual mean, tropical warming in UAH is noticeably reduced relative to RSS and STAR. Results are displayed on a common 5° x 5° latitude/longitude grid.

Citation: Santer, B. D., S. Po-Chedley, M. D. Zelinka, I. Cvijanovic, C. Bonfils, P. J. Durack, Q. Fu, J. Kiehl, C. Mears, J. Painter, G. Pallotta, S. Solomon, F. J. Wentz, and C.-Z. Zou, 2018: Human influence on the seasonal cycle of tropospheric temperature. Science, 361, 6399, doi:10.1126/science.aas8806.