

Contributions of natural and anthropogenic forcing to changes in temperature extremes over the U.S.

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“Explaining changes” implies attributing those changes to some cause

There are few attribution studies to date for changes of extremes

Typically the candidates are natural factors (inherent variability, volcanoes and solar), or anthropogenic (GHGs, aerosols, ozone)

Observations

Three of the Frich et al. (2002) extremes temperature indices (HadEX dataset, Alexander et al., 2006; updates provided by Tom Peterson) and heat wave intensity index:

frost days: nighttime minimum temperature below freezing

growing season length: length of the period between the first spell of five consecutive days with mean temperature above 5°C and the last such spell of the year

warm nights: percentage of time in the year when minimum temperature is above the 90th percentile of the climatological distribution for that calendar day

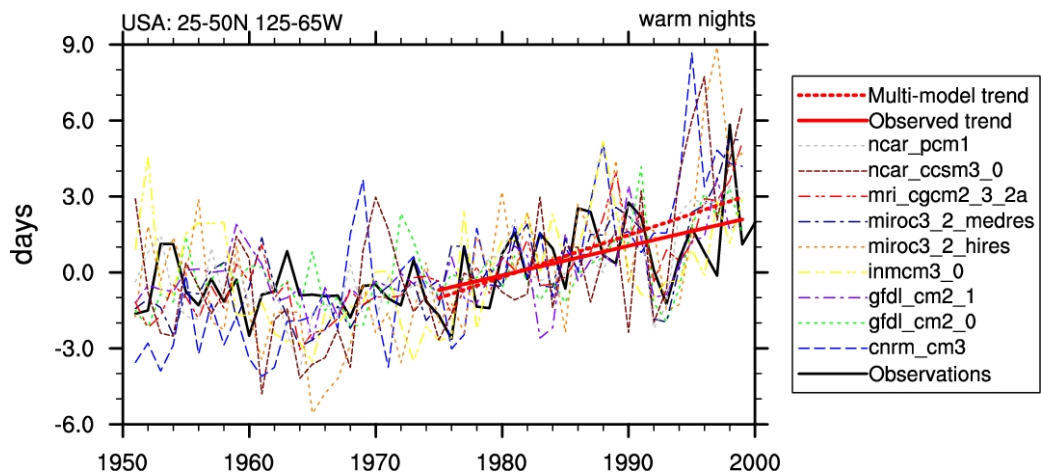
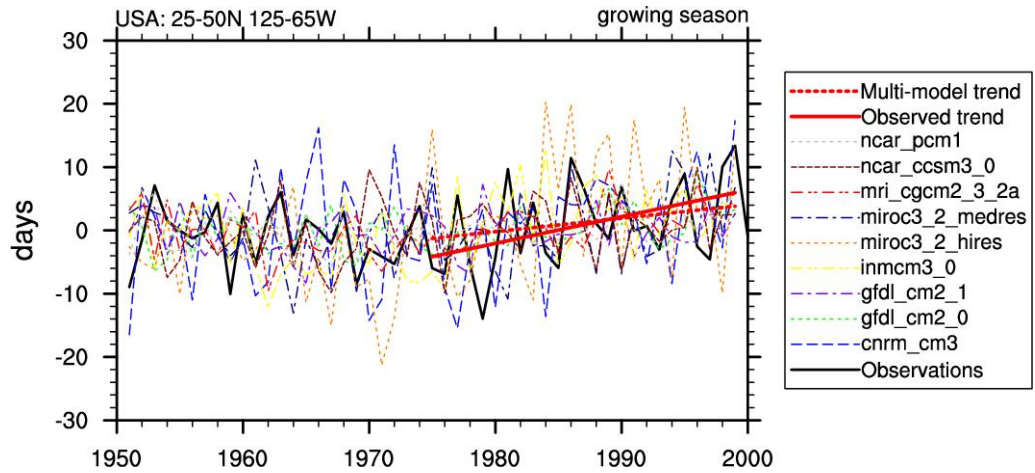
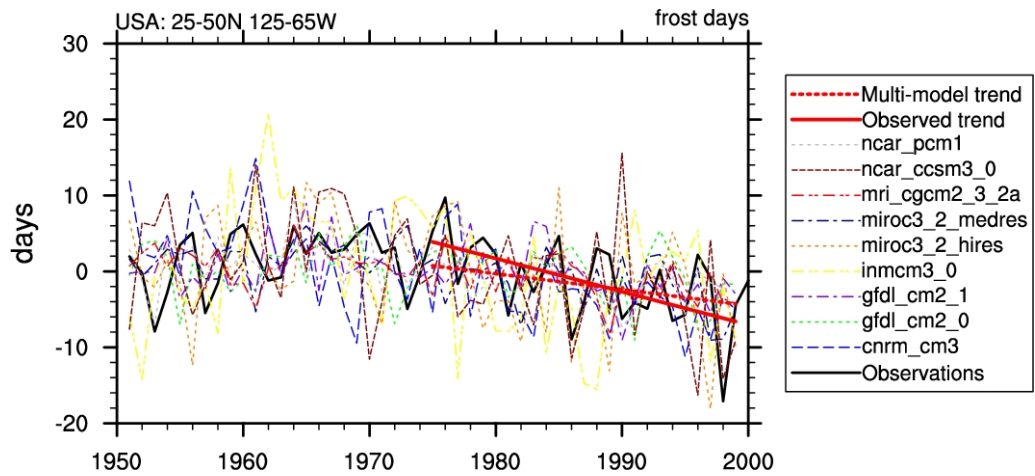
heat wave intensity index (Karl and Knight, 1997): mean of the annual three consecutive warmest nights

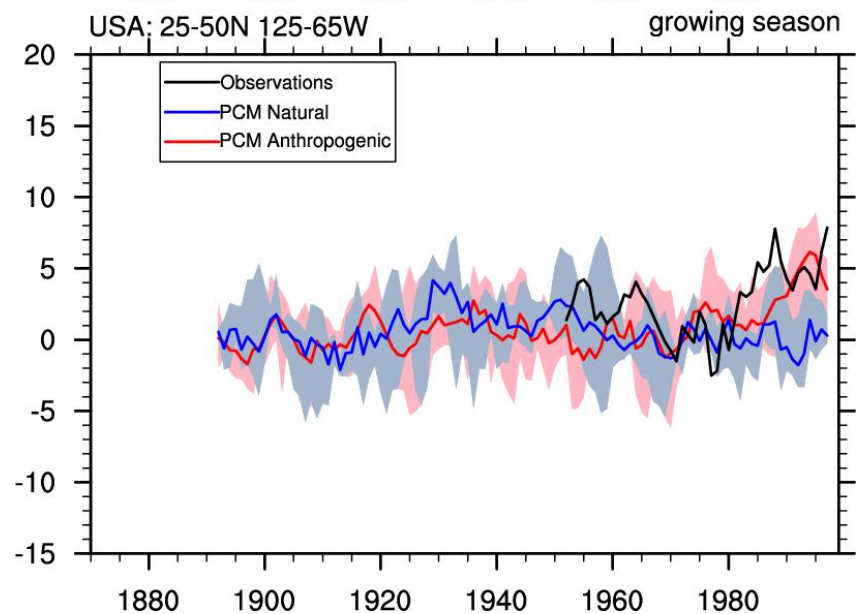
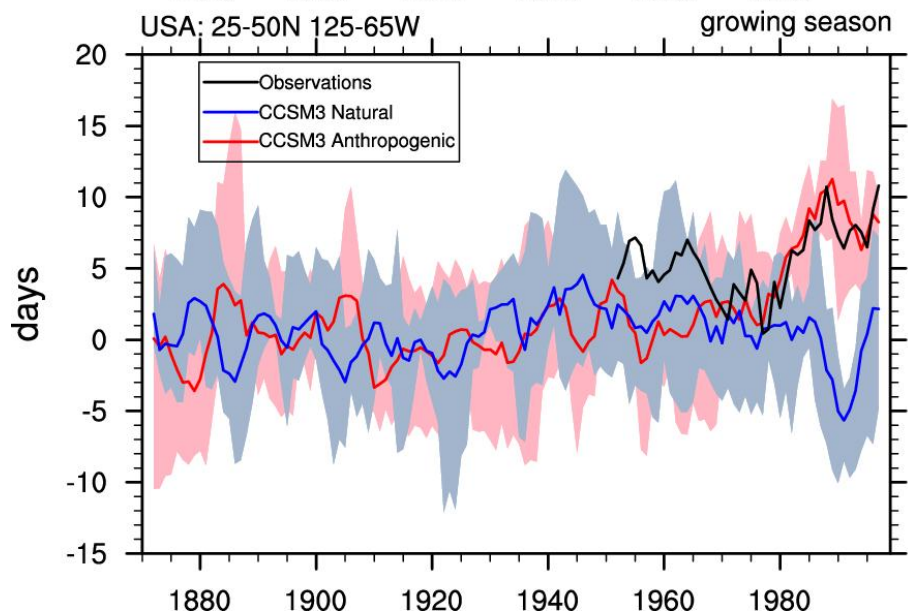
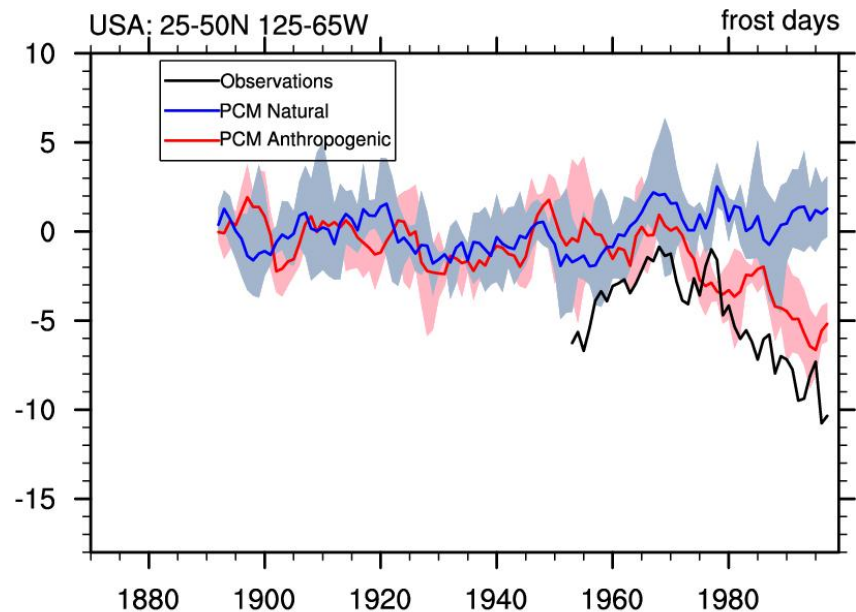
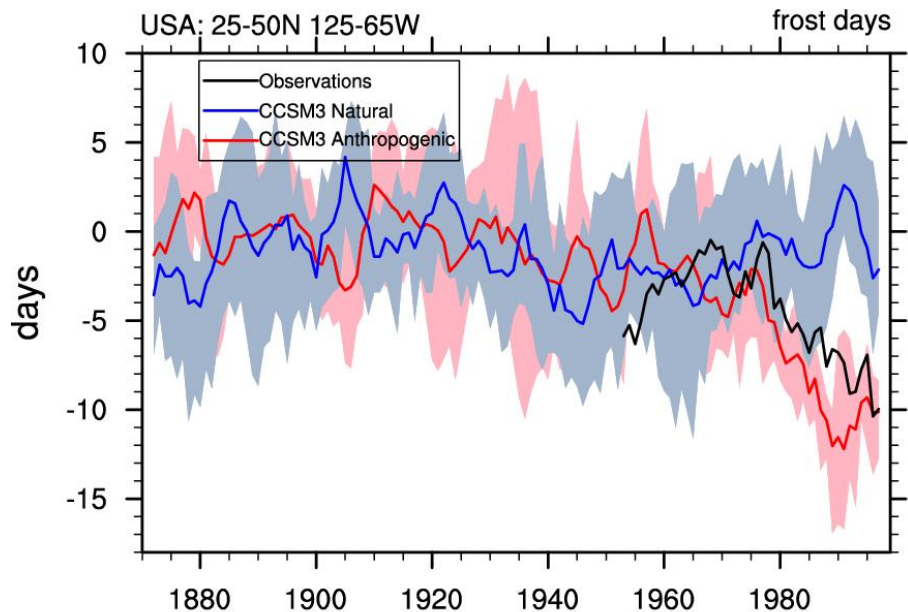
Models

nine models from CMIP3 multi-model dataset at PCMDI: PCM, CCSM3, GFDL-CM2.0, GFDL-CM2.1, MIROC3.2-hires, MIROC3.2-medres, CNRM-CM3, MRI-CGCM2.3.2, and INMCM3_0. (combined natural and anthropogenic forcings)

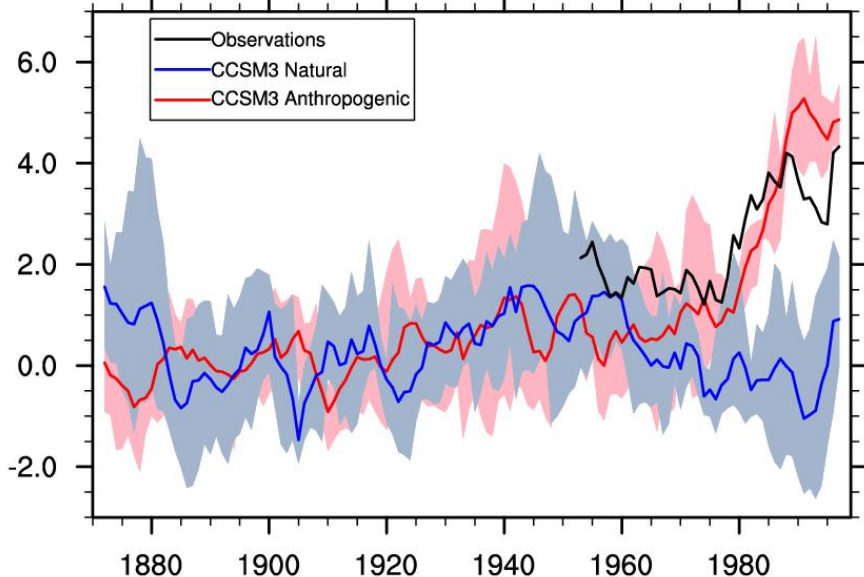
PCM (T42) four member ensembles for natural forcings (solar and volcanoes) and anthropogenic forcings (GHGs, sulfate aerosols, ozone)

CCSM3 (T85) five member ensembles for natural forcings (solar and volcanoes) and anthropogenic forcings (GHGs, sulfate aerosols, black carbon aerosols, ozone)

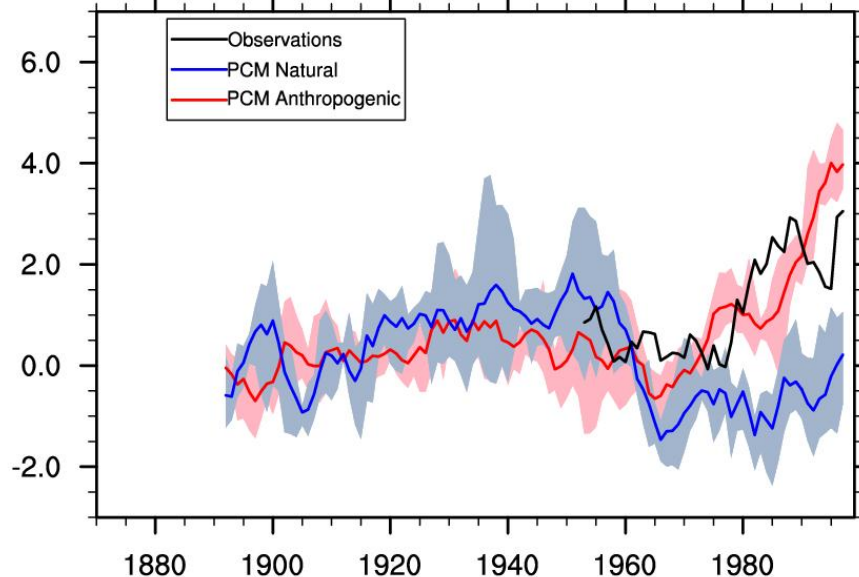




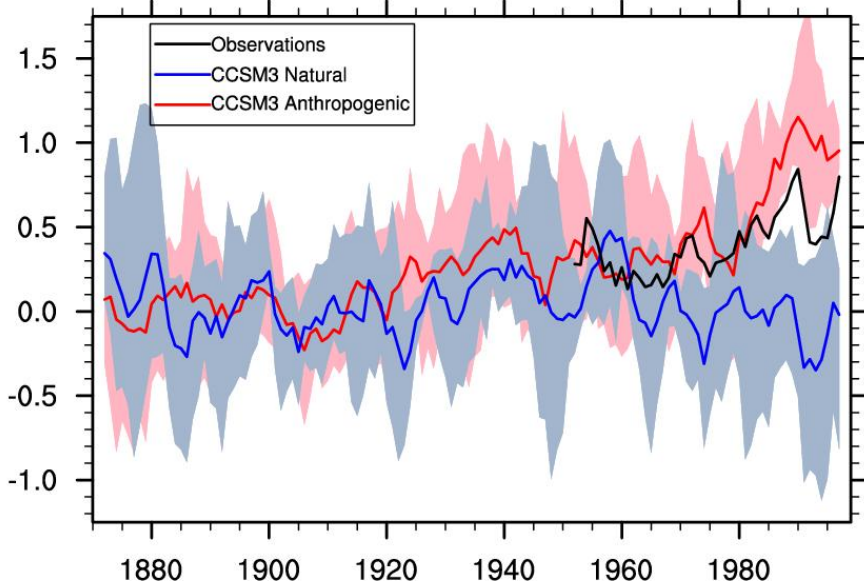
USA: 25-50N 125-65W warm nights



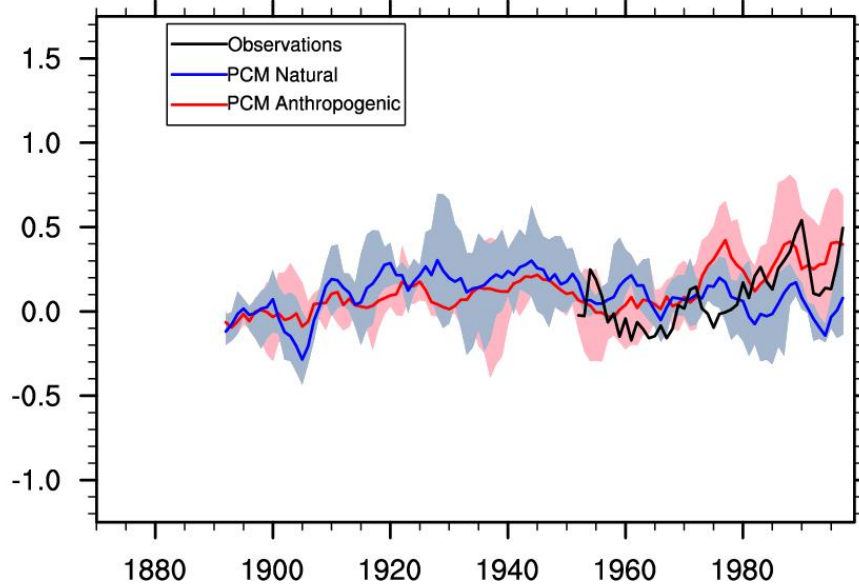
USA: 25-50N 125-65W warm nights



USA: 25-50N 125-65W heat wave intensity



USA: 25-50N 125-65W heat wave intensity



Linear trend 1975-99	Observations	Multi-model average	CCSM3 anthro	CCSM3 natural	PCM anthro	PCM natural
Frost days (days/25 yrs)	-10.9*	-5.2*	-8.8*	+0.0	-3.1	+0.6
Growing season length (days/25 yrs)	+10.5*	+5.3*	+7.6*	-1.0	+3.6*	-1.0
Warm nights (%/25 yrs)	+2.9*	+4.2*	+5.1*	+0.9	+3.8*	+0.8
Heat wave intensity (° C/25 yrs)	+0.4	---	+0.7*	-0.2	+0.0	-0.1

Summary

1. There have been few attribution studies done on extremes
2. Observations averaged over the U.S. for the second half of the 20th century show a decrease of frost days, an increase in growing season length, an increase in warm nights, and an increase in heat wave intensity
3. A nine member multi-model ensemble (combined natural and anthropogenic forcings) shows similar changes over the U.S. for the first three of those extremes indices for 20th century experiments, though the relative contributions of each are unclear
4. Two models run with anthropogenic and natural forcings separately show that the observed changes in the four temperature extremes are accounted for with anthropogenic forcings, but not with natural forcings.