

Assessment of US climate variations using the US Climate Extremes Index

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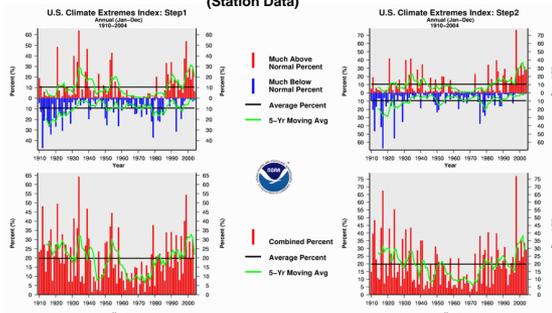
NOAA National Climatic Data Center

Background

Karl et al. (1996) introduced the US Climate Extremes Index (CEI) for monitoring climate within the contiguous United States. The CEI is comprised of several temperature and precipitation indicators and quantifies observed changes in climate extremes. It was created with the purpose of informing users about the current state of the U.S. climate. The CEI is updated seasonally and is available online from NCDC at <http://www.ncdc.noaa.gov/oa/climate/research/cei/cei.html>. An assessment of variations of the CEI over the twentieth century has been undertaken, including comparison of the observed indices with those calculated from global climate model simulations.

Each of the components in the CEI involves the percentage of land area within the U.S. that is "extreme" given the relevant definitions. For each indicator, much above (below) normal or "extreme" conditions are defined as those falling within the upper (lower) tenth percentile. For each case, the percentile statistics were calculated using the entire period, 1910-2004.

Observations: Temperature Indices (Station Data)



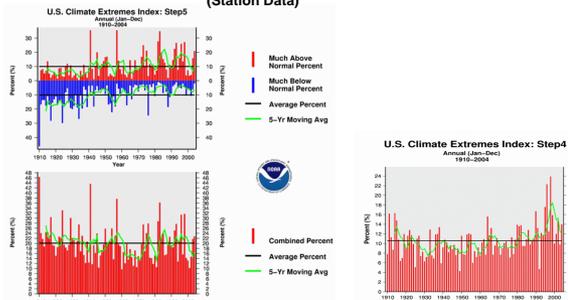
CEI Step 1: Maximum temperatures
The sum of (a) percentage of the U.S. with annual mean maximum temperatures much above normal and (b) percentage of the U.S. with monthly mean maximum temperatures much below normal.

CEI Step 2: Minimum temperatures
The sum of (a) percentage of the U.S. with annual mean minimum temperatures much above normal and (b) percentage of the U.S. with monthly mean minimum temperatures much below normal.

Discussion

Opposite variations in the upper and lower tenth percentile cancel in steps 1, 2, and 5 where they are added. Long term trends in the areas above (below) the upper (lower) tenth percentile lead to a "V" shape in the CEI steps 1 and 2. Hence, a **modified CEI** is defined which enhances these trends by subtracting the percentage area much below normal from the area much above normal.

Observations: Precipitation Indices (Station Data)



CEI Step 5: Rain days
The sum of (a) percentage of the U.S. with much greater than normal number of days with precipitation and (b) percentage of the U.S. with much greater than normal number of days without precipitation.

CEI Step 4: Precipitation intensity
Percentage of the U.S. with a much greater than normal proportion of precipitation derived from extreme (equivalent to the highest tenth percentile), 1-day precipitation events.

Conclusions

Opposite variations in the upper and lower tenth percentile cancel in several CEI components, leading to small trends in their sum. Hence, interpretation of trends in the CEI is difficult.

A modified CEI has been defined. Significant increasing trends are found in the components of the modified CEI associated with extreme maximum and minimum temperatures, due to fewer cold extremes and more hot extremes. These variations are outside the range of internal climate variations simulated by climate models and are consistent with the models' responses to increasing greenhouse gases and sulfate aerosols. Hence, it is likely that anthropogenic climate change is contributing to changes in temperature extremes in the United States.

There also have been recent significant increases in the component of the CEI associated with more intense precipitation. The increased precipitation intensity in the continental US is consistent with the modeled response to anthropogenic forcing.

Modified CEI Step 1: Maximum temperatures

The difference between (a) percentage of the U.S. with annual mean maximum temperatures much above normal and (b) percentage of the U.S. with monthly mean maximum temperatures much below normal.

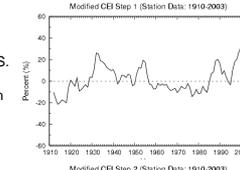
Modified CEI Step 2: Minimum temperatures

The difference between (a) percentage of the U.S. with annual mean minimum temperatures much above normal and (b) percentage of the U.S. with monthly mean minimum temperatures much below normal.

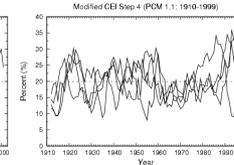
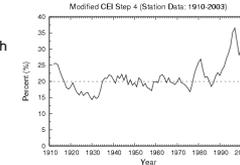
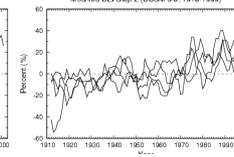
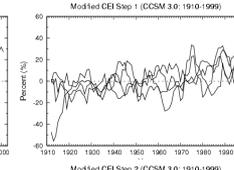
CEI Step 4: Precipitation intensity

Twice the value of the percentage of the U.S. with a much greater than normal proportion of precipitation derived from extreme (equivalent to the highest tenth percentile) 1-day precipitation events.

Observations (Station Data)



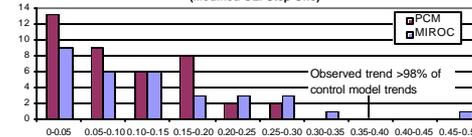
Climate models (20th Century Simulations)



Attribution of the observed trends

The observed increasing trends over the last 30 years in modified CEI steps 1, 2, and 4 are compared with climate model simulations of the 20th century to assess whether these trends are consistent with the climate response to anthropogenic forcing. They are also compared with control climate model simulations with no changes in external forcing, to assess whether the trends can be explained by natural internal climate variations.

Frequencies of Absolute Values of Thirty-Year Trends from the Model Pre-Industrial Control Runs (Modified CEI Step One)



30-year trends from observations and model simulations of the 20th century

20th Century Realizations	Modified CEI Step One	Modified CEI Step Two	Modified CEI Step Four
Observational trend	0.368	0.443	0.111
PCM: ensemble mean	0.067	0.119	0.119
PCM: range	-0.062, 0.250	-0.009, 0.298	0.027, 0.229
CCSM: ensemble mean	0.247	0.316	-0.008
CCSM: range	0.005, 0.395	0.177, 0.506	-0.031, 0.007
MIROC: ensemble mean	0.357	0.364	N/A
MIROC: range	0.285, 0.489	0.147, 0.567	N/A

Acknowledgements

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References

Karl, T.R., R.W. Knight, D.R. Easterling, and R.G. Quayle, 1996: Indices of Climate Change for the United States. *Bull. Am. Meteor. Soc.*, **77**, 279-292.