United States
Environmental Protection
Agency

Research and Development

Atmospheric Research and Exposure
Assessment Laboratory
Research Triangle Park NC 27711

EPA/600/S3-89/025 Aug. 1989

EPA

Project Summary

A Climatology of Temperature and Precipitation Variability in the United States

Brian K. Eder, Lawrence E. Truppi, and Peter L. Finkelstein

This summary examines the seasonal and annual variance and standardized range for temperature and the seasonal and annual coefficient of variation and normalized standardized range for precipitation on a climatic division level for the contiguous United States for the period 1895 to 1985.

Examination of the temperature variance revealed a continentality phenomenon in which the largest variance occurs in the upper midwest section of the country, while the smallest variance is generally found in coastal regions along the west coast, the Gulf coast, and southeastern states. The winter season displayed roughly twice the amount of seasonal variance as did spring and roughly four times that of summer or autumn. Analysis of the standardized temperature range supports the continentality phenomenon; however, the transitional seasons, spring and autumn, displayed the largest amount of within-season variability, with winter and summer displaying the least amount.

Examination of the coefficient of variation for precipitation depicted a propensity for the largest seasonal and annual variation to occur over the southwestern states from Texas to California. Conversely, the smallest coefficient of variations were found over the northeastern sections of the country from New England into the mid-Atlantic and Great Lakes states. Analysis of the seasonal and annual standardized precipitation range reveals that the pattern mimics the coefficient of variation patterns but exhibits less of a gradient, resulting in a smoother pattern. Areas of greater than normal seasonal and annual precipitation ranges include the southwestern states from Texas to California, while areas of less than normal ranges include the northeastern and Ohio River Valley states.

This Project Summary was developed by EPA's Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Despite the increasing interest shown by the scientific community in climate and its interactions with the evolution of ecosystem structures, there continues to be a lack of a consensus among climatologists and ecologists concerning the future of global climate and its possible impact upon ecosystems. Policy makers and planners need plausible descriptions of possible long-term changes of such ecologically important variables as temperature, precipitation, evaporation, and soil moisture conditions on all spatial and temporal scales.

Such descriptions may be found with climatic scenarios, which are sets of solutions either derived empirically from observational data (paleoclimatic or instrumental analogues), or from Global Climate Models (GCMs), often in the form of seasonal maps showing the range of conditions or possible variances that may occur in the future.

Although research has begun in EPA's Atmospheric Research and Exposure Assessment Laboratory, the development of climatic scenarios that have real utility for ecological impact assessment is still rudimentary. Subsequently, this development must be supported by an enhanced understanding of the climatic sensitivities of a broad range of ecological activities and of the detailed nature of recent and past climatic patterns and their variability. Two such variables which should receive a concentration of research efforts are temperature and precipitation. From these two measured variables, numerous derived parameters relevant to local ecosystems, such as surface moisture stress, duration of rainless periods, and length of growing season, can be calculated. The development and evolution of ecosystems are as sensitive to the ranges and variances of temperature and precipitation as they are to mean conditions. Because of this, ecosystems evolving in regions that have exhibited little variance in temperature and precipitation over the years are likely to be more sensitive to climatic changes that those ecosystems which evolved in regions exhibiting larger variability. Therefore, a need exists to not only delineate these regions of differing variance, but to also establish monitoring networks within both types of regions, which may provide an understanding of potential ecological responses toward future climatic change.

Though the delineation of such regions may seem to be trivial, little, if any, literature concerning the subject is available. This summary therefore represents an initial effort toward the fulfillment of the requirements mentioned above through the delineation of areas of the country which experience differing amounts of temperature and precipitation variability. This is accomplished through the examination of the variance and standardized range of temperature data and the coefficient of variation and standardized range of precipitation data across the contiguous United States, on a climatic division level, from the period 1895 through 1985. Establishment of monitoring networks within these delineated regions will help provide a new understanding of key ecosystem processes, as well as their responses to possible climatic change, which should therefore enhance their treatment in GCM based scenarios as well as pave their way for their representation in observationally based scenarios.

Data

The monthly temperature and precipitation data employed in this analysis were obtained from the National Climatic Data Center (NCDC) located in Asheville, NC. These data, which cover the period 1895 to 1985, are collected on a climatic division basis, where each climatic division is designed to represent regions within a state that are climatically homogeneous or consistent. Within the contiguous United States, there are 344 such divisions, the areal coverage of which, can vary tremendously, with the largest divisions generally found in the western states and the smallest found in the east.

Stations used in calculating the divisional monthly averages of temperature (measured to the nearest tenths in degrees F) and the monthly totals of precipitation (measured to the nearest hundredths in inches) include all first order stations and those cooperative stations which have maintained consistent records.

Methodology

The seasonal and annual variability of both temperature and precipitation were examined in order to better understand the variability of climate within the contiguous United States. For temperature data this consisted of examining the variance from season to season, and by examining the standardized range within seasons over the United States. Standardization of the temperature range allows for direct comparison between individual climatic divisions and the country as a whole.

Due to the tremendous range in normal precipitation exhibited over the United States, a different approach was necessary for the seasonal and annual precipitation analysis. Rather than take the variance, which would be biased towards areas of high precipitation, the coefficient of variation was examined which "normalizes" the variance. Similarly, calculation of the standardized range also considered this extreme variability in precipitation and was therefore normalized.

Results

Examination of the annual temperature variance revealed several interesting features. Most notable of these features was the tendency for the largest variance to occur in the upper midwest portions of the country, especially in North and South Dakota and eastern Montana where the annual temperature variance exceeds 3° F. A trend toward decreasing annual variance is exhibited as climatic divisions approach coastal regions. This pattern was depicted especially well along the west coast from Washington and Oregon to California, and again along the Gulf coast and southeastern states where the annual temperature variance reached a minimum of less than 0.5° on the southern Florida peninsula.

The standardized temperature range maps exhibited, in a somewhat different manner the same continentality as seen with the variance figures Consistent with the annual variance map, the largest annual standardized ranges occurred in the upper midwest, especially in the states of North and South Dakota and Minnesota. A trend toward decreasing ranges was found near the coastal areas especially along the Pacific Coast states and the Gulf Coast states.

Unlike the seasonal variance maps which depicted winter as the season having the most variance, the seasonal standardized range maps depict the transitional seasons, spring and autumn as exhibiting the most variability within their seasons. This phenomenon is not unexpected since the range of monthly temperature would be greater during the transitional seasons than during winter or summer.

Examination of the annual precipitation coefficient of variation (%) also revealed several interesting features. Unlike the temperature analysis, which indicated a north-south gradient, the precipitation analysis depicts somewhat of an eastwest gradient. This is supported by the propensity for the largest coefficient of variation to occur over the southwestern states from Texas to California where the values exceeds 25.9%, while the smallest variation generally occurs over the eastern sections of the country from the mid-Atlantic and Great Lake States into New England, where values are less than 14.0%. The maps depicting the coefficient of variation for seasonal precipitation are, with only a few exceptions, similar to the annual map Most notable of these exceptions is the extension or shift of high variations into the lower midwestern states during the winter season, and into the Pacific coast states during the summer season.

Examination of the annual standardized precipitation range, revealed patterns similar to those of the precipitation coefficient of variation. The southwestern states from New Mexico to California tend to have larger annual ranges when compared to the rest of the country. Another area exhibiting annual ranges which are greater than "normal" is found in the upper midwest from North and South Dakota into Montana. Areas exhibiting smaller than "normal" annual ranges include the New England and Appalachian Mountain states. The standardized seasonal ranges of precipitation again somewhat mimic the annual map; the patterns, however, tend to be somewhat flatter, indicating less within seasonal variability. Areas of greater than "normal" precipitation ranges include the southwestern states from Texas to California, while the eastern states, especially those in New England and the Ohio River Valley, tend to exhibit less than "normal" ranges.

Conclusions

Because there continues to be no consensus among climatologists and ecologists concerning climate change and its possible impact upon ecosystems, the development of climatic scenarios will be necessary in order to assist scientists in evaluating possible adverse effects of climatic change on the ecology. Unfortunately, the development of such scenarios as a utility in assessing this impact is still somewhat in a rudimentary stage, and therefore must be supported by an enhanced understanding of recent and past climatic patterns and their variability. In an initial attempt to assist in this understanding, this summary has examined the seasonal and annual variance and standardized range for temperature and the seasonal and annual coefficient of variation and normalized standardized range for precipitation, on a climatic division level for the contiguous United States for the period 1895 to 1985.

Examination of the temperature variance and standardized range revealed a continentality phenomenon in which the largest variance occurred in the upper midwest section of the country, while the smallest variance were generally found in coastal regions along the west coast, the Gulf coast and southeastern states.

Examination of the coefficient of variation and standardized range for precipitation depicted a propensity for the largest seasonal and annual variation to occur over the southwestern states from Texas to California. Conversely, the smallest variation was found over the northeastern sections of the country from New England into the mid-Atlantic and Great Lakes states.

Successful climate scenarios, whether derived from climate models or analogue techniques, should duplicate the patterns produced in this summary as well as the simple mean patterns. Present models are, for the most part, unable to do this. The design of ecological monitoring networks, both for base line stations, which require some climatic stability, and for stations where a range of climatic conditions is required should also be cognizant of the information developed in this and similar studies.

*The EPA authors **Brian K. Eder, Lawrence E. Truppi,** and **Peter L. Finkelstein** are with the Atmospheric Research and Exposure Assessment Laboratory, Research Triangle Park, NC 27711.*
***Brian K. Eder** is the EPA Project Officer (see below).*
The complete report entitled "A Climatology of Temperature and Precipitation Variability In The United States," (Order No. PB 89-165 930/AS; cost: $13.95, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
Atmospheric Research and Exposure Assessment Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

United States
Environmental Protection
Agency

Center for Environmental Research
Information
Cincinnati OH 45268

EPA/600/S3-89/025