Changes in Historical Precipitation Rates over the Coterminous United States

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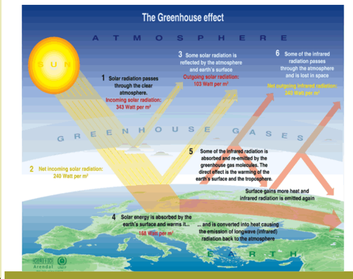
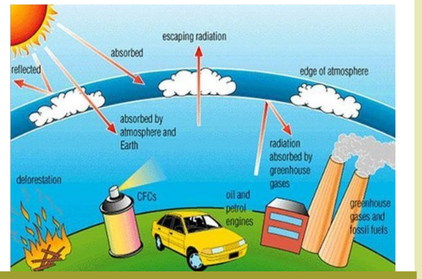
Abstract

Planet Earth's climate has changed over the last century, since the beginning of the industrial era, due to the increasing concentration of greenhouse gases (GHG), which has resulted in warming of the planet's atmosphere. Observations show that global mean near-surface temperature has increased about 0.75 degree Celsius since the beginning of the 20th century. This warming may have resulted in alteration of the global hydrological cycle and precipitation patterns and increases or decreases in average annual precipitation over different regions which can result in flooding or drought events. Increased precipitation in some arid areas could be advantageous, whereas an increase in precipitation in wet areas could result in more flooding events which could bring devastating effects. Changes in annual distribution of precipitation may also affect the available freshwater resources due to the limited capacity of reservoirs to capture excessive river flows. The present research aims to study the historical observational precipitation data in the coterminous U.S. to investigate the changes in annual precipitation rates over different U.S. regions over the past decades. Calculations in high-level programming languages such as Matlab as well as Excel were implemented to achieve this goal. With this, we found that there has been an increase in precipitation over the Northeast areas and decrease in western areas.

Background

Greenhouses gases in the Earth's atmosphere, including carbon dioxide and water vapor, absorb infrared radiation emitted by the Earth and therefore warm the surface. This occurs because humans are constantly using cars, electricity and building fabrics which dispel a huge amount of carbon dioxide. All the gases that they expulse get trapped in the atmosphere creating a stronger and thicker layer. As the atmosphere gets thicker, the temperature increases, melting the Polar ice caps and evaporating more water that can thus lead to drought or floods and lead to migration on a global scale.



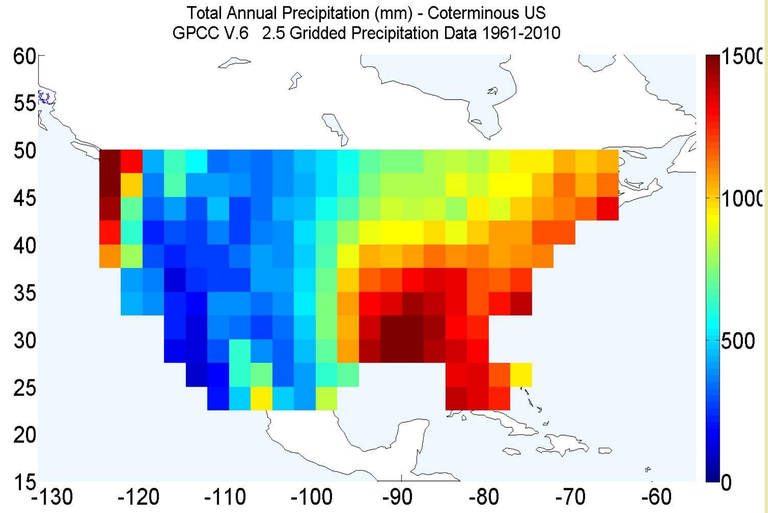


Objectives

- **The main objective of this work was to estimate how precipitation has changed over the U.S. from 1961 to 2010**

Changes in precipitation can affect society. They can be advantageous because there are some areas that need water and an increase in precipitation will bring that water needed. However, there are some areas that do not need an increase in precipitation because they already have enough water; instead, they could suffer disasters such as flooding. Observing changes in precipitation allows scientists and communicators to help society to be aware of these changes and avoid disasters.

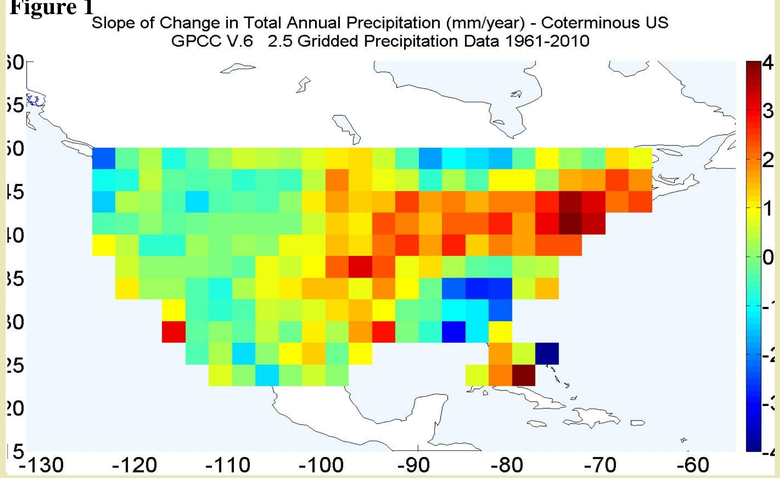
Methods



This map shows the total annual precipitation between 1961-2010. Precipitation is water that falls from the atmosphere due to gravity, such as rain, drizzle, and sleet. Precipitation changes every year, partly depending on temperature, because more heat leads to evaporation which forms clouds. The PRCP (Precipitation) dataset shows how the precipitation is changing throughout the years in different parts of the United States. The data form an 11x24x50 array as there are 11 columns, 24 rows and 50 years of data (1961 to 2010). Those values were obtained from the GPCC (Global Precipitation Climatology Center), which provides the full data reanalysis product from 1901-2010. Each grid-cell in the dataset represents the precipitation in that specific part or square with sides of around 200 kilometers (2.5 degrees latitude and longitude). Linear regression of the average precipitation at each grid-cell over 50 years provides the slope which is the change in precipitation and each grid cell will be compared with the other 264 grid-cells that also contain 50 years of precipitation to observe how much precipitation has changed. The numbers on the bottom and left side of each map represent the coordinates where the map is located worldwide. The calculations are made with Matlab by creating a nested loop and the results are displayed on maps to show the change in precipitation over 50 years.

Results

Figure 1



Results

Figure 1 shows the slope, which means that in every year the precipitation tended to increase or decrease a certain number of millimeters. An example of a big slope is the red region in the Northeast. In the slope of change in precipitation map, red means an increasing trend in precipitation, blue means a decreasing trend in precipitation and green means almost no change in precipitation over the past 50 years. The color bar shows these relationships, with units of mm per year.

Figure 2

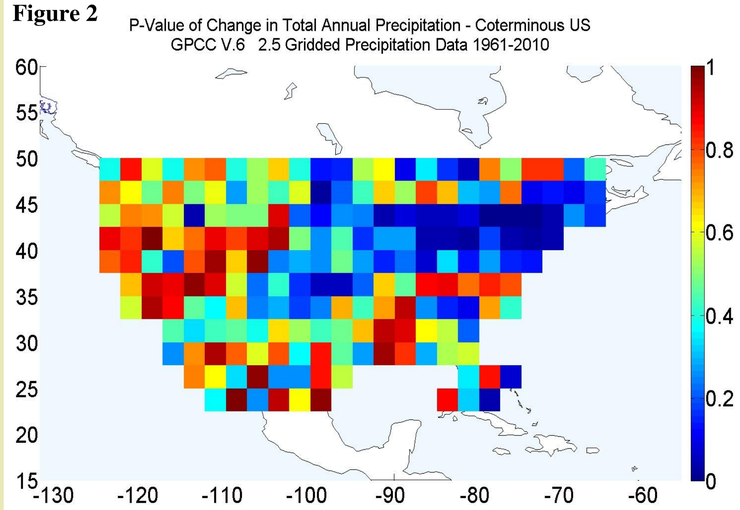


Figure 2 shows the p-values for the slopes of each grid cell. The p-value is the probability to obtain a slope equal to that observed if precipitation varied randomly from year to year and actually had no trend. P-values close to 0 (dark blue) show places where the trends in precipitation are statistically significant. This helps to show how much change there really is in precipitation each year.

Conclusions

Our results show that the Northeast U.S. shows fast increases in total annual precipitation and that this positive trend is statistically significant based on the low p-values, while most other parts of the U.S. do not show significant trends. This change in precipitation can be a good thing if those states can supply water to other states, such as in the West, that are more dry. With global warming, it is good that there is some increase in precipitation because if not, drought could result. However, big increases in precipitation can also increase the danger of flooding because there is not sufficient space to collect all the water that falls in a short period of time.

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