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CLIMATE CHANGES MAY INCREASE EXTREME RAIN/SNOW EVENTS IN CALIFORNIA

Increasing carbon dioxide levels in the atmosphere may lead to a rise in the number of annual extreme precipitation events in the Sierra Nevada Mountains, which in turn could increase the frequency of flooding in California, a NASA-funded study finds.

These figures show the present and projected future changes in the intensity of daily rain/snow as a result of increasing atmospheric carbon dioxide (CO2), according to the regional climate

Image 1

One of the missions of NASA's Earth Science Enterprise (ESE), which funded this research, is to better understand how the Earth system is changing. Within this framework, NASA is committed to studying variability in global precipitation, how well we can predict future changes in the earth system, and what are the consequences of change in the Earth system for human civilization.

Based on computer model simulations of the next 40 to 50 years, Jinwon Kim, an atmospheric scientist at the University of California, Los Angeles (UCLA), found that the Sierra Nevada region may experience substantial increases in heavy precipitation (exceeding 2 inches of rain/day), and extreme precipitation events (exceeding 4 inches of rain/day). Most of these increases occur during the winter, currently the wettest season in the region.

"The frequency of extreme precipitation may increase, in general, and the most notable increase of extreme events may occur in areas characterized by heavy winter precipitation in today's climate," Kim said. Kim recently presented his results at the 83rd Annual Meeting of the American Meteorological Society in Long Beach, Calif.

cloud to ground lightning

Image 2

Existing projections from Hadley Centre for Climate Prediction and Research (HCCPR) HadCM2 computer model suggests that increases in carbon dioxide (CO2) are likely to substantially alter the hydrologic cycle in the Western U.S. That's because increasing levels of CO2 in the atmosphere trap heat, and warm the air. Warmer air holds more water, and when parcels of saturated air rise, they tend to rain water back to Earth.

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Normalized Difference Vegetation Index (NDVI)

The Advanced Very High Resolution Radiometer (AVHRR)

Viewable Images

Caption for Image 1: **CLIMATE CHANGE SIGNALS: FREQUENCY OF HEAVY AND EXTREME PRECIPITATION EVENTS**

These figures show the present and projected future changes in the intensity of daily rain/snow as a result of increasing atmospheric carbon dioxide (CO2), according to the regional climate change study by Kim (2001) that is based on the global projection made by Hadley Center for the 1995 IPCC report (Johns et al. 1997).

There are six maps in the figure. The top, mid, and bottom maps (CNTL, TRAN, TRAN-CNTL) are the estimation of the frequency for today's climate, altered climate, and the difference between the two. The three maps in the left-hand-side column present the 'Number of days/year on which the daily precipitation exceeds 50.8mm or 2 inches. The three maps in the right-hand side column show the days on which the daily precipitation exceeds 101.6mm or 4 inches.

Kim used his regional computer model (MAS) to make two fine-scale precipitation projections for the decade of 2040 to 2049 based on different values of CO_2 in the atmosphere from the coarse global projections by HCCPR, United Kingdom.

Some of the background data input into the computer model included NASA-derived Normalized Difference Vegetation Index (NDVI) data, which measures the amount of solar energy reflected and absorbed by vegetation. This is important data for computing transpiration. NDVI was created by Compton Tucker of NASA Goddard, using data from the National Oceanic and Atmospheric Administration's (NOAA) Geostationary Environmental Orbiting Satellite (GOES) Advanced Very High Resolution Radiometer (AVHRR) instrument.

The first projection assumed that greenhouse gas concentrations will stay at levels equal to those of the late 1900s. The second projection represented the climate of the same period assuming increases in greenhouse gas levels by 1 percent per year from the year 1990.

Compared to the first projection, the second projection showed increases in both the number of wet days and, more importantly, large increases in heavy precipitation events for the region during the cold season from October to March. The model showed increases of heavy precipitation events increased by 10 to 15 days per year. It also showed that extreme precipitation events increased by 5 to 10 days per year.

Comparing the two projections, the average number of wet days per year over the southern and northern Sierra Nevada basins (divided along the area near Sacramento) increased by 37 percent for the southern basin and 32 percent for the northern basin in the second projection. While light precipitation events (less than 5mm or .2 inches/day), stayed the same or decreased slightly for both basins, the occurrence of heavy precipitation events rose from 1 percent of wet days annually to 3 percent in the second projection. Extreme events rose from .1 percent of wet days annually to 1 percent. Similar changes are projected for all major California basins. These projections suggest that the intensity of the hydrologic cycle will increase as levels CO_2 continue to climb.

The second model-based projection scenario also showed that elevation levels in the mountains where freezing occurs will rise as temperatures rise. That means that much of the precipitation that currently falls in higher altitudes as snow may come down as rain in future years. Snow stores water during the cold season and releases it gradually in spring and summer. Hence, a substantial increase of cold season rainfall at the expense of snowfall reduces the buffering effects of snow and could result in more flooding.

These changes, combined with more heavy rain events and steep mountain slopes, could therefore lead to a greater frequency of flooding in the future.

"Since the primary concern for reservoir management is to reduce flooding risks that require maintaining the storage space

The main points of these plots are that 'based on the projection by this study, it is likely that the events of heavy (2"/day) and extreme (4"/day) precipitation will increase by 10-15 days per year and 5-10 days per year, respectively, in the Sierra Nevada region (indicated by larger, darker areas) as well as in the northern California Coastal Range.

Most of these increases occur during the winter, which is the wettest season in the region. Combining the effects of local orographic characteristics (steep slopes), wet soils during the winter and changes in the precipitation characteristics (increased/reduced rainfall/snowfall) due to increased CO_2, the increases in the number of extreme precipitation is likely to increase the frequency of flooding. This result suggests that it may be necessary to revise water management/flood preparation for the region. CREDIT: Jinwon Kim, UCLA

Caption for Images 2 and 3:
POSSIBLE INCREASED EXTREME PRECIPITATION EVENTS

The frequency of extreme precipitation may increase, in general, and the most notable increase of extreme events may occur in the areas characterized by heavy winter precipitation in today's climate.

Credit for Image 2: Michael Phelps, Storm Photographer

Credit for Image 3: CLPX NASA Land Surface Hydrology Program

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to capture excessive runoff, the reservoirs may have to maintain lower water levels," Kim said. "This directly decreases the water resources."

The climate change signals projected in this study are based on a single global projection and are expected to include an unknown amount of uncertainties. Hence, the projections here must be taken as qualitative, rather than quantitative. The author is planning additional studies using global projections from multiple Global Climate Models.

This research was funded by NASA's ESE and NOAA. NASA's ESE Applications Division applies the results of the nation's investment in ESE to issues of national concern, such as water and resource management, environmental quality, community growth, and disaster management to support policy makers at the state and local levels.

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