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THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES

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Abstract:

Climate change will affect water resources through its impact on the quantity, variability, timing, form, and intensity of precipitation. This paper provides an overview of the projected physical and economic effects of climate change on water resources in North America (with a focus on water shortages), and a brief discussion of potential means to mitigate adverse consequences. More detailed information on this complex topic may be found in Adams and Peck (forthcoming) and in the Intergovernmental Panel on Climate Change Fourth Assessment Report (IPCC AR4).

Introduction

Models of climate change (GCMs) predict U.S. annual-mean temperatures to generally rise by 2° C to 3° C over the next 100 years, with greater increases in northern regions (5° C), and northern Alaska (10° C). Numerous other climatic effects are also expected. For example, U.S. precipitation, which increased by 5 to 10% over the 20th century, is predicted to continue to increase overall. More specifically, an ensemble of GCMs predicts a 20% increase for northern North America, a 15% increase in winter precipitation for northwestern regions, and a general increase in winter precipitation for central and eastern regions. Despite predictions of increased precipitation in most regions, net decreases in water availability are expected in those areas, due to offsetting increases in evaporation. A 20% decrease in summer precipitation, for example, is projected for southwestern regions, and a general decrease in summer precipitation is projected for southern areas. Although projected regional impacts of climate change are highly variable between models, the above impacts are consistent across models.

Literature Survey - Mishra and Desai (2005) used linear stochastic models known as ARIMA and multiplicative Seasonal Autoregressive Integrated Moving Average (SARIMA) models to forecast droughts. The models were applied to forecast droughts using the Standardized Precipitation Index (SPI) series in the kansabati river basin in India, which lies in the Purulia district of West Bengal state in eastern India. The predicted results using the best models were compared with the observed data. The predicted results show reasonably good agreement with the actual data, months ahead. The predicted value decreases with increase in lead-time. Hence, the models can be used to forecast droughts up to 2 months of lead-time with reasonable accuracy.

Mishra and Desai (2006) compared ARIMA/SARIMA, recursive multistep neural network (RMSNN) and direct multi-step neural network (DMSNN) for drought forecasting using SPI series in the Kansabati River Basin, in West Bengal, India. It was observed that SPI 1 and SPI 3 are having good correlations with River flow discharge and SPI 3, SPI 6 with the storage in the reservoir over different months. The results show that recursive multi-step approach is best suited for 1 month ahead prediction.

Kirtman and Shukla **(2000)** used the historical records (approximately 100 years) of Indian summer monsoon rainfall and **El**

Nino Southern Oscillation **(ENSO) indices,** which shows a strong negative correlation. This negative correlation is strongest for east Pacific sea sin lave temperature anomalies (SS1 A) that occur during the months of December to March, which is about three to six months immediately following the monsoon season (June to September) Based on this correlation, they reported that monsoon variability affects ENSO variability. Using simple statistical techniques, it is found that a weak (strong) monsoon results in a weakening (strengthening) of the trade winds over the tropical Pacific.23

Rainfall and ENSO has strengthened and became statistically significant after the mid-1970s.

Research Elaborations

There are many parametric and non-parametric methods that have been applied for detection of trends. Parametric trend tests are more powerful than non-parametric ones, but they require data to be independent and normally distributed. On the other hand, non-parametric trend tests only require the data be independent and can tolerate outliers in the data.

MANN-KENDALL (MK) TEST

The MK test, also called Kendall's tau test due to Mann (1945) and Kendall (1975), is the rank based nonparametric test for assessing the significance of a trend, and has been widely used in hydrological trend detection studies. The slope (P) of a trend in sample data is estimated using the approach proposed by Theil (1950) and Sen (1968). The original sample data .V, were unitized by dividing each of their values with the sample mean E (AY) prior to conducting the trend analysis (Yue et al, 2002). By this treatment, the mean of each data set is equal to one and the properties of the original sample data remain unchanged. If the slope is almost equal to zero, then it is not necessary to continue to conduct trend analysis. If it is differs from zero, then it is assumed to be linear, and the sample data are de-trended by:

$$X'_t = X_t - T_t = X_t - \beta \cdot t$$

Result & Discussions

Rising surface temperatures are expected to increase the proportion of winter precipitation received as rain, with a declining proportion arriving in the form of snow. Snow pack levels are also expected to form later in the winter, accumulates in smaller quantities, and melt earlier in the season, leading to reduced summer flows. Such shifts in the form and timing of precipitation and runoff, specifically in snow-fed basins, are likely to cause more frequent summer droughts. Research shows that these changes are already taking place in the western United States. Changes in snow pack and runoff are of concern to water managers in a number of settings, including hydropower generation, irrigated agriculture, urban water supply, flood protection and commercial and recreational fishing. Timing of runoff will affect the value of hydropower potential in some basins if peak water run-off occurs during nonpeak electricity demand. Energy shortages and resulting energy price increases will provide incentives to expand reservoir capacities or develop alternative energy sources.

Conclusion

The ability to anticipate and efficiently prepare for future water resource management challenges is currently limited, in part, by imprecise regional climate change models and long-term weather forecasts. Uncertainty about future climate conditions makes it more difficult to optimally prepare for and adapt to associated changes in water resource availability and quality. Imagine, for example, trying to prepare optimally for a water shortage when you are uncertain of when it will occur, how severe it will be, or how long it will persist. It may be tempting to make management plans based on the worst-case scenario; however, the opportunity cost of this "safety-first" approach can be high if the worst-case does not occur.

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