DOE/ER/60372D-1

RECENT CHANGES OF WEATHER PATTERNS IN NORTH AMERICA

PROGRESS REPORT FOR PERIOD

8/15/92 - 4/1/93

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April 1993

Prepared for

The U.S. Department of Energy

Carbon Dioxide Research Division

AGREEMENT NO. DE-FG02-85-ER60372

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OBJECTIVES

- 1) Analyse the time related changes and variability in the properties and frequency of air masses and weather extremes over North America.
- 2) To determine the degree to which the observed changes agree with climate model predictions.

RATIONALE

Climate models predict a general increase of surface air temperature and drought frequency in parts of the North American continent due to increased CO₂ concentrations. Regional climate change results in part from the changed frequency of the atmospheric and oceanic circulation patterns in addition to the changed properties of the different air mass types. We are investigating the frequency and properties of the air mass types differentiated by moisture dependent variables and comparing the findings to that simulated by numerical climate models.

Earlier work has shown a decrease of the diurnal temperature range over North America (Karl et al., 1984). Additional research has identified similar trends over some land regions of the Northern Hemisphere (Karl et al., 1991). A decrease of the temperature range coupled with a decrease in the frequency of weather extremes would be likely to have a mitigating effect on the impact of a greenhouse warming.

RESULTS TO DATE

We have continued to investigate the decreasing diurnal temperature range which is a dominant trend observed not only in North America but also in the former Soviet Union, China, and Africa, for example (Karl et al., 1991; Kukla and Karl, 1991). A compilation of temperature maximum, minimum, mean, and range is currently available for 37% of the global land area. Overall, the decrease of the diurnal temperature range is reported to be equivalent to the increase in the mean temperature.

Temperatures simulated by three general circulation /mixed- layer ocean models have been compared with the observed seasonal surface air temperatures over three regions of the central United States. The models, which include the diurnal cycle, are the Oregon State University (OSU), Canadian Climate Centre second generation (CCC) and the United Kingdom Meteorological Office (UKMO). The observations are based on the HCN stations averaged for 1966-75. During this interval the CO₂ concentrations as recorded at Mauna Loa approximate that used in the model control runs. The simulated temperatures represent a 10-15 year average after reaching equilibrium. Averaged over all models, seasons and regions the simulations show a smaller temperature range by 3.2°C than the observations. Additionally, spring maxima are consistently cooler in all of the models in each region by an average 4.1°C.

This points to a potential problem in the construction of the models, especially with respect to the handling of atmospheric water vapor. Another factor contributing to the observed difference could be the impact of tropospheric aerosols which may cool the surface, especially in summer. The impact of aerosols was not included in the models.

The tentative conclusion drawn from the discrepancy, is that either the current temperature change is to a large degree caused by variables other than CO₂, or that the models incompletely portray some of the feedback mechanisms which could mitigate the CO₂ impact on the daily maxima (such as e.g. cloud cover, or tropospheric aerosols). Thicker cloud cover which seems to accompany the trend would result in the reduction of the daily maxima and increase of daily minima. We are further investigating potential causes of the discrepancy.

The on-going analysis of the upper air data, designed to investigate the short term variations of the atmospheric water vapor content and the seasonal changes of its vertical distribution, will enable to test how reliably is this variable represented in climate models.

Because of the discrepancy between the paleoclimate evidence and the GISS general circulation model of the onset of the last glaciation (Rind et al., 1989), we have paid increased attention to the climatology of the precipitable water over the globe particularly in the vicinity

of North America. We found that the concentration of atmospheric water vapor has a pronounced seasonal cycle which is significantly delayed behind the seasonal insolation forcing. Using dew point temperatures at the 850 mb level as a proxy for the precipitable water cycle, we found that the cycle of the water vapor greenhouse forcing shows intriguing relationships with the orbital changes over the past 150 millenia and we concluded that the greenhouse cycle had at least a contributory role in the Pleistocene climate variations (Kukla and Karl, 1991).

When analyzing the geographic pattern of the current 1945-1986 surface air temperature trends over USA and the rest of the globe, we noted a qualitative resemblance to some aspects of the ongoing insolation shifts caused by changing orbital configuration. The changes are negligible with reference to the recently observed trends. However they do illustrate possible mechanisms through which the climate system can shift from an interglacial into a glacial mode (Kukla et al., 1992; Kukla and Gavin, 1992).

In preparation for the comparison of the free atmosphere moisture variables with the surface climate we have analyzed on the daily basis the fluctuations of the air masses defined by surface dew point in the years 1969, 1970, 1977-1979.

In our ongoing work we are concentrating on the impact of increasing greenhouse gases on the North American continent, assuming that both, the general circulation of the atmosphere, as well as the properties and vertical structure of the air masses are affected.

RESULTING PUBLICATIONS

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