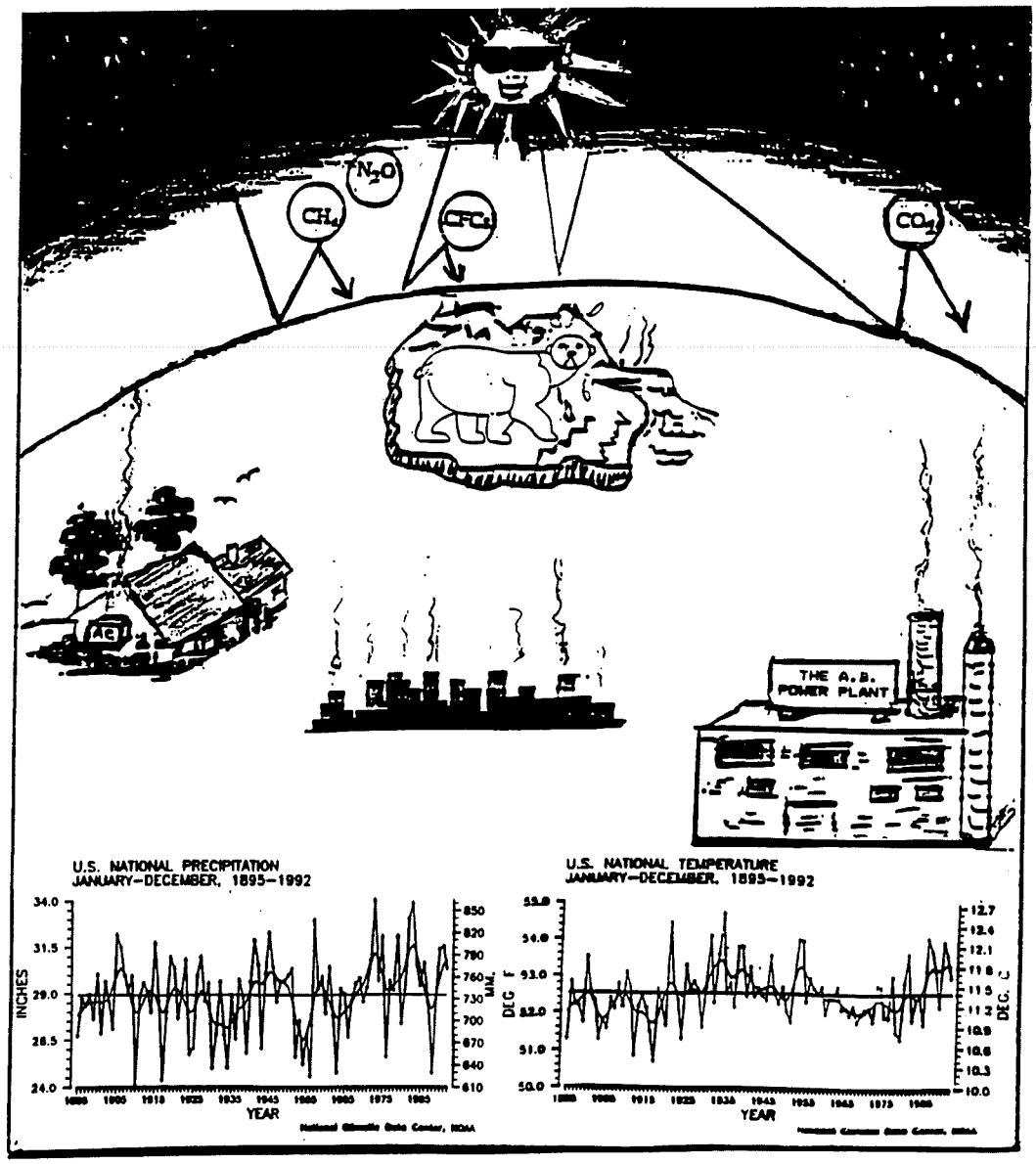
ENVIRONMENTAL INFORMATION SUMMARY C-29

CLIMATE CHANGE ISSUES



NOAA/NCDC DRAFT 09/17/92

Introduction.

The Greenhouse Effect is real... it's what makes the Earth habitable. The Greenhouse Effect is undergoing some change, because the atmosphere is unquestionably undergoing a change of constituents. Therefore we will have to, and are already, living with its consequences. It may well be an important factor in the recent warmer temperatures, but to argue that the Greenhouse Effect is comparable to Global War or will actually turn out to be a Garden of Eden is tenuous at best.

The problems are: (1) to monitor how climate really is changing where we live, work, and grow our food, and (2) to narrow the range of possibilities of climate change induced by the emissions of greenhouse gases so that we can take appropriate action, if necessary, to mitigate undesirable consequences. To monitor climate we need both satellites and good long-term weather stations. The primary tools which provide us an opportunity to look into the future are computer climate model simulations. Many different types of computer models have been run and a significant number of these models, not necessarily all models, suggest that some very unpleasant changes in climate may occur over a period of several decades if we continue with business as usual. That is, we continue to release greenhouse gases into the atmosphere at the rate we are releasing them today.

According to climate theory and models, the following are characteristics of the Greenhouse Effect (question marks denote significant uncertainties):

1) Reduced pole to equator temperature gradient;

2) Decrease in stratospheric temperature, increase in tropospheric temperature;

3) Faster rate of temperature increase over land compared to ocean;

4) Accelerated hydrological cycle
   - wetter winters mid-high latitudes?
   - drier summers mid latitude continental interiors?

5) Cloud cover ---
   Slight decrease? More high clouds? Less low clouds?

6) Reduced snow cover;

7) Increase in tropical storms?

8) Extreme events?

Topical Items.

1) Double CO_2. During 1991 new estimates for the expected range of global temperature increases with a doubling of CO_2 concentrations have actually

widened from 3-8 degrees F to 2-9 degrees F. This is stated in the latest National Research Council Policy Implications of Global Warming.

2) Drought. Recent work has shown that there is no evidence for increasing drought frequency or intensity in the US. Because of the nature of precipitation variability we now know that it would take many decades for us to detect a 10% change in precipitation. If a 10% decrease in precipitation were to occur however, this would be very significant, the difference of precipitation between the extremely dry 1930s and the wet 1970s nationwide was less than 10%.

3) Heat Island. Recent work with urban heat island biases suggests that they seem to be offset in the station records by such characteristics as station relocations to cooler airport locations, changes in observation times, and instrument changes. We have now looked at the differences of temperature between the sites used to calculate global temperature change and rural locations in Australia, USA, large portions of China and the Western USSR. The results suggest that the urban bias contributes less than 10% to the calculated rates of global warming.

4) Satellite Data. Recent satellite microwave sounding unit data suggest that the temperature trend over the last decade is extremely close to the trend calculated since the late 19th Century. Specifically about 1 degree F per 100 years.

5) Hurricanes. Our records show that over the N. Atlantic Ocean, where we have the best and longest data set on the maximum wind strength of hurricanes, the average year-by-year peak wind speed of hurricanes has actually decreased by 10 to 20 MPH over the last few decades. Furthermore, in some areas the correlation of SST with the number of tropical cyclones is actually opposite to that implied by greenhouse disaster scenarios. In the North Indian Ocean and the Western North Pacific anomalously warm SSTs are associated with fewer tropical cyclones. Furthermore, the North Indian Ocean temperature has risen more than any other ocean basin over the past two decades and simultaneously we find a significant decrease in the number of tropical storms in that region.

6) Sea Level. Despite the difficulties of estimating changes in sea-level we now have numerous studies which suggest that over the last 100 years sea level has risen and continues to rise at a rate of about one-half foot per Century. The change in sea level nicely tracks the increase of global mean temperature.

7) Global Temperature. We now have a number of independent sources of information which are all consistent with each other regarding global trends of temperature. Specifically, the rise of sea level, the increase of ocean temperatures measured by ships of opportunity, satellites and buoys, land surface temperatures, nighttime marine air temperatures measured by ships of opportunity, and worldwide mountain glaciers which are in a state of decline. There is little doubt that the earth's climate is getting warmer.

8) Daily Maximum and Minimum Temperatures. The causes of temperature variation in the climate record are unresolved. For example, in many land areas of the world most of the warming over the last 30 years has been due to a rise of the nighttime temperature. Some have postulated that this may be due to offsetting effects of sulfur dioxide emissions, which primarily stem from coal burning. One of the puzzles, however, is that emissions of sulfur in the United States and Northern Europe have actually decreased over the past several decades. The rise of nighttime temperature versus the daytime temperature is very interesting. If this is a signal of the greenhouse effect it may imply that the effects of an enhanced greenhouse must be studied closely before we can begin to anticipate its impact. However, global climate models do not project a significantly greater rise of the minimum (nighttime) temperature relative to the maximum (daytime) temperature. So here's another puzzle that requires explanation. New analyses on this subject with much more extensive data sets are now under way.

9) Volcanoes. Major volcanic eruptions can inject gaseous sulfur dioxide and dust, among other chemicals, into the stratosphere. The SO_2 quickly converts to sulfuric acid aerosols. If present in sufficient quantity in the stratosphere where their fallout rate is slow (about 1 year) these aerosols can significantly affect the climate of the Earth. Many empirical studies show that individual volcanoes have had little or no effect on decadal time scales, but tend to cool the earth for a year or two after major volcanic eruptions (of which there have only been a handful since the 19th century). It has been estimated that sustained intense volcanic activity might lead to temporary cooling of the planet by a few degrees F.

10) Solar Variability. The lack of direct measurements of solar irradiance prior to 1967 has led to the use of proxy measurements of solar variation such as sunspots, the size of the solar disk, etc. Many attempts have been made to relate variations in these proxy measurements to the thermometric record, but the impact of solar variability on the climate record is a matter of considerable controversy. Current measurements suggest an 11-year cyclic variability of the sun's irradiance, which is too short of a periodicity to have a major impact on the earth's temperature. Longer solar cycles have been detected, one of which spans about 80 years. These may have a more significant impact on the climate record, and it has been suggested that solar variations may explain the rapid rise of temperature in the 1930s, but with an 80 year cycle we should have already reached the minimum. The data are just too speculative to be very certain.

11) Snow Cover. The warmer temperatures in the 1980s compared to the 1970s are also reflected in less extensive snow cover over the Northern Hemisphere over this time, but the satellite record of snow cover is not long enough to claim that there is a worldwide trend toward reduced snow cover. In fact, sea ice extent shows little or no trend over the last two decades.

12) Model-Data Consistencies. The nearly 1 degree F rise in temperature we have observed since the late 19th Century is comparable to the rate expected if the sensitivity of the climate system to a CO_2 doubling were between 2 to 3 degrees F. This is derived by comparison of the observed climate record with simplified (2D) model calculations.

13) Model-Data Inconsistencies. It is difficult to link all of the rapid global warming between 1920 and 1940 to increases in greenhouse gases. The rapid rise of temperature at that time may be partially due to the natural variability of the climate system or possibly the absence of volcanic activity at that time.

14) Natural Climate Variability. Since the end of the last glacial advance, about 10,000 years BP, global average temperature has probably fluctuated by about 2-4 degrees F on Century time scales due to natural climate fluctuations. The fluctuation this Century has been about 1 degree F. It is not possible to prove that the present rise in temperature is solely due to natural causes, nor is it possible to prove that anthropogenic releases of greenhouse gases have significantly contributed to the increase in temperature.

15) Fingerprint. Stratospheric temperatures are decreasing while surface temperatures are increasing. This is a fingerprint of the greenhouse effect, but part of this change is due to ozone losses. Moreover, arctic temperatures have not warmed at a rate significantly faster than tropical temperatures, a projected pattern in a greenhouse enhanced world. Present attempts to attribute global climate change to the greenhouse effect remain elusive.

16) Chaos. One of the major difficulties we face in trying to understand consistency of the observed temperature record with an enhanced greenhouse world is that we know the global temperature record can slosh around quite a bit just due to natural climate variations. These variations are referred to as climate chaos. It is now impossible to separate these variations from other variations in the climate record. Models suggest that these variations can be large enough to obscure our ability to detect the greenhouse effect.

17) Models. It has been suggested that some models do so poorly that (for example) they suggest the climate of the Sahara is similar to the UK during the summer. There are many versions of climate model simulations. Comprehensive models do produce more rain in the UK than in the Sahara during the summer. Despite model limitations on regional climate change, it is possible to take model output and produce some very realistic climate simulations by using sophisticated statistical procedures. In fact, such techniques are used in the USA every day to help predict the weather. This is done because even today's weather forecasting models do not produce information which is directly translated into weather forecasts. Few if any atmospheric scientists suggest that today's weather forecasting models are not very useful because of this.

18) Clouds. A recent Phd dissertation from CSU has shown that during anomalously warm years in the Tropical Pacific there were more high clouds and fewer low clouds. This is considered a positive feedback effect because with more high clouds and fewer low clouds the climate would warm even more than if we only had the direct effects of CO_2 to consider. The entire (and very critical) question of cloud feedback in a greenhouse world is far from settled.

19) CH_4. Methane is not an unimportant greenhouse gas. It is produced by biomass burning, wetlands, rice patties, enteric fermentation, termites, landfills, mining, and gas drilling activities. Today it makes up about 15% of anthropogenic greenhouse gases.

20) Normals. Climatic normals are calculated every 10 years based on 30 consecutive years of data (e.g., 1961-90). Normals are intended to give users a common base period for computation of averages and departures from average. Since climate varies on all time scales, it is not possible to infer the existence of long-term trends from comparisons of differing normals periods alone. Many additional analyses would be required to ascribe definitive causes to changes from one normals period to the next. Nevertheless, a preponderance of changes of similar sign and magnitude would be one of several factors that should be considered in the study of climate changes.

Summary and Conclusions.

The climate record contains many inhomogeneities which are the basis for some measure of uncertainty regarding observed changes.

1) Certain >99%:

   a) CO_2 and other greenhouse gases have rapidly increased over the past century.

2) Nearly Certain >95%:

   a) Global temperature increase of $0.45°C \pm 0.15°C$ (past 100-125 years);

   b) Sea level increase of 10-15 cm (past 100-125 years);

   c) Warming over past few decades primarily reflected in the first half of the year;

   d) Worldwide glacier retreat.

3) Likely >75%:

a) Warming over land during past few decades has occurred primarily at night, with a reduction of the diurnal temperature range;

b) No apparent decrease of the pole-to-equator temperature gradient;

c) No increase in the frequency of tropical storms (yet);

d) Cooling of lower stratosphere (prior to Mt. Pinatubo) and warming of tropospheric temperatures;

e) Slight cooling of the upper troposphere;

f) No apparent change in sea ice concentration over past few decades.

4) Probable >60%:

a) Precipitation has increased in the high latitudes;

b) Snowfall has increased in the high latitudes of North America;

c) Cloudiness has increased over the past century.

5) Possible >50%:

a) Rate of warming over land may now be significantly greater than warming over oceans.

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