POLICIES AND METHODS TO REDUCE THE IMPACTS OF EXTREME HYDROLOGICAL EVENTS IN EUROPE

(Compiled by- Er. Arnab Sarma, Ph. D. Scholar,
Water Resources Engineering, MU, Brno, Czech Republic, Year: 2000)

Introduction

During the late 1980s and 1990s, the alleged Greenhouse Effect captured the interest of news magazines, radio and television programmes. Predictions from various scientists range from a coming cataclysmic, worldwide impact to little or no impact at all. However, those scientists on the apocalyptic side seem to have captured the greatest interest from the media as well as policy-makers, from state governments and international organisations, such as the World Bank. Foreboding scenarios are conjured; including world food shortages, melting polar ice caps accompanied by severe flooding of coastal landmasses, destruction of ecosystems and greatly increased severity of storm activity (hurricanes, etc.). Most of the greenhouse effect is attributed to the burning of fossil fuels, which releases tremendous amounts of carbon dioxide and other gases into the atmosphere, trapping heat and warming the planet [1].

Because of the many ominous predictions for the climate, policy-makers from both national governments and international organisations are demanding policy adoptions in the form of carbon taxes, mandated efficiency measures and subsidies for non-carbon dioxide-emitting technologies to roll back greenhouse gas emissions to their 1990 levels [2]. While there is disagreement among climatologists regarding the significance of the greenhouse effect, there seems to be more agreement among other investigators that cutting back significantly on greenhouse gas emissions would have more serious negative world-wide impacts, with large Gross Domestic Product reductions, resulting in lower living standards in the long run [3]. Looking back to the recent past, it is now all but forgotten that some outspoken climatologists in the late 1970s predicted a completely opposite scenario, a return to an ice age with cataclysmic (catastrophic/calamitous) impacts, which also demanded immediate attention.

The Use of Climate Models

To measure historical as well as future impacts of carbon dioxide emissions on climate variables, scientists have developed mathematical climate models, whose features are discussed in a recent book by Robert Balling [4]. ***He points out that many of these climate models predict substantial increases in global temperature for increases in carbon dioxide levels and it is these predictions that have attracted the attention of policy-makers and the media [5].*** For example, a doubling of carbon dioxide levels results in an increase in global temperatures in eight climate models mentioned by Balling [6]. Based on these models, global average temperature increases from a low of 1.9 to a high of 4.8 ^{0}C. **What is generally not appreciated is that the models also unanimously predict increases in precipitation as well as increases in temperature and these levels range from 3 to 15%[7]. What is also usually neglected in the popular press is that the climate models have significant limitations on the simulation of the ocean-atmosphere interaction, which is not yet well understood.** Balling says- until we have better knowledge of the coupling between oceans and the atmosphere, the model predictions must be treated with considerable caution [8]. **Another very significant difference among the models is their cloud-climate responses.**

The Historical Temperature Record and Future Implications

It can be seen from Figure 1 the global average temperature anomalies for the period from 1881 to 1990 [9]. If a linear trend line through the data is fit, it can be found that global average temperature has increased by about 0.56^{0}C. However, over this same period, equivalent carbon dioxide levels have increased by about 40%. Assuming that there is a relationship between carbon dioxide levels and temperature change, this would imply an increase in temperature of about 1.4^{0}C for a doubling of carbon dioxide levels, which is below the temperature range predicted by the climate models as reported by Balling.

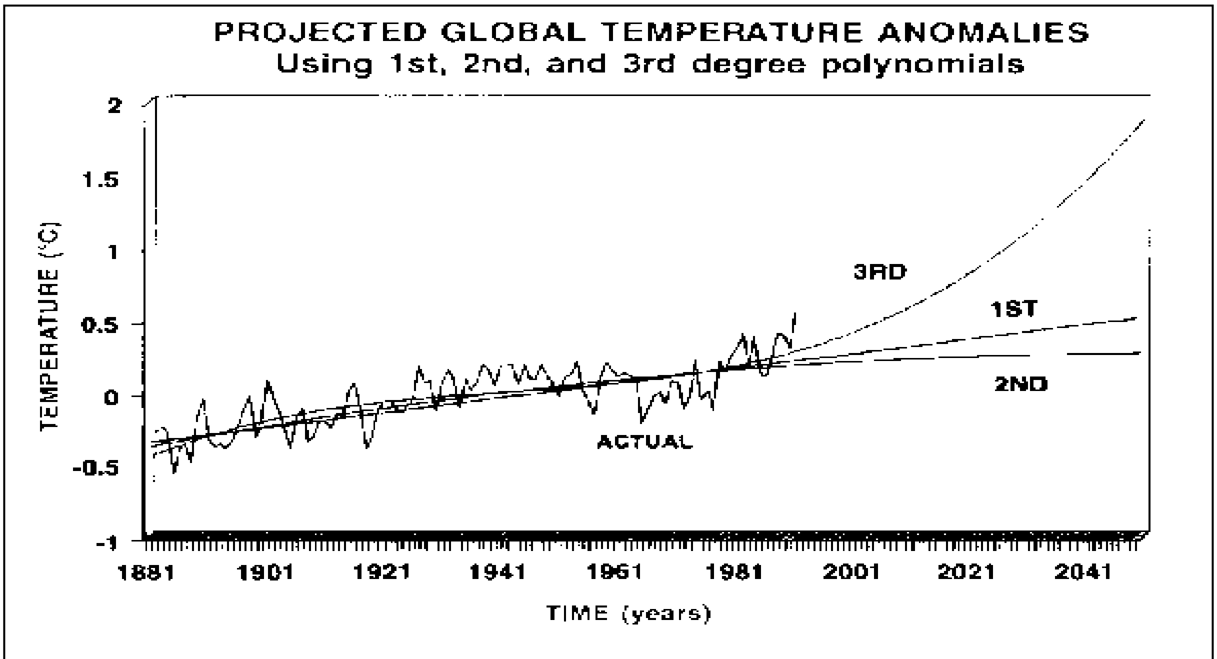

Figure 1 Projected Global Temperature Anomalies

However, it often can be misleading to fit a linear trend-line through historical data and draw firm conclusions from it. Referring to Figure 1 again, we have fit two additional trend-lines through the historical temperature data- **a quadratic and a cubic trend**. Using these three trend equations, we have extrapolated temperature anomalies from 1991 to 2050 and we observe a wide range of temperature differences, depending upon which historical trend is used. Thus, historical data may not determine a unique trend and can be highly misleading in predicting future temperature changes.

The interpretation of the temperature data in relation to carbon dioxide levels becomes even more difficult when the global average temperature is separated into northern and southern hemisphere temperature anomalies. For example, if the period in which most of the temperature increases occurred is examined (1881 to 1940), we find that the northern and southern temperature series are not related to each other in a stable manner [10]. In contrast, we do find a stable relationship between the northern and southern hemisphere temperatures for the period 1941 to 1990. Thus, different factors may have been at work.

Stabilising Factors at Work

Dr. Sherwood B. Idso, a research physicist with U.S. Water Conservation Laboratory, Phoenix, Arizona, has found that the "greenhouse effect" could in fact turn out to be beneficial rather than harmful to the planet [11]. In his experiments, Dr. Idso has found that plants, when enriched with more carbon dioxide, grow bigger and better, much like the plants of past geological epochs of biological prominence. Furthermore, the efficiency with which plants use water to produce organic matter essentially doubles with a doubling of the atmospheric carbon dioxide concentration. Moreover, for a tripling of the amount of carbon dioxide in the air, it nearly triples [12]. According to Dr. Idso, because plants use water more efficiently with higher carbon dioxide concentrations, they will grow in places where they have not been able to grow in the past. Below the ground, the soil will become more enriched, which will increase microbiological activity, such as increasing the supply of earthworms. Dr. Idso also has found that some plants increased net photosynthesis rates of exposed leaves by approximately 50%. In an experiment with orange trees exposed to increased carbon dioxide levels, he found after a 30-month period that the enhanced carbon dioxide-exposed trees were more than twice as large as the trees exposed to ambient air. Dr. Idso concludes, "It could be that the rising carbon dioxide content of Earth's atmosphere is actually a blessing in disguise and one of the better things that could happen to mankind & nature" [13].

Global Warming and the Pre-Flood Era

Although the results of Dr. Idso's research need to be studied further, it is intriguing to speculate about the implications of plants growing larger and becoming more environmentally efficient as carbon dioxide levels increase. Could it be that during the pre-flood time, not only was there a water-vapour canopy and a tropical environment, there also were significantly increased carbon dioxide levels than what is contained in the earth's atmosphere today? [14]. If this was the case, then there might have been much greater vegetation than we have today. With increased vegetation, there would have been a great need for large plant-eating animals such as dinosaurs to control vegetation levels. In addition, the large vegetation levels could have provided more than adequate material for the production of great quantities of fossil fuels during Noah's Flood.

Flooding in Europe

Projections

Derived from an UKMO GCM transient experiment, future climate change for mean precipitation in winter and summer was estimated by Viner and Hulme (1993). Seasonal results are depicted in Figure 9a-b. Increases (20 to 30%) are noted in large parts of northern and north-western Europe (a maximum of more than 20% in the Belgium/Northern France area), and in the Baltic region. In summer, rainfall is higher in northern Europe and lower in large parts of southern Europe.

Consistent with more rainfall in northern Europe is the prediction of a northward shift and intensification -probably with greater precipitation- of the North Atlantic storm track by Hall et al. (1994) (using the UKMO GCM). Von Storch (1991), giving an example of a statistical approach in the downscaling of climate estimates (MPI) to regional scales that is consistent with observations, projected a decreasing trend in winter rainfall over the Iberian Peninsula.

Observations

Bardossy and Caspary (1990) studied changes in time series of classified European atmospheric circulation patterns for the period 1881-1989. They concluded that frequencies of several circulation types did indeed change considerably. The frequency of zonal circulations in winter has increased since 1973. Correspondingly, a decrease in meridional "blocking" circulations has been observed since 1980. The climatological consequences are: relatively warm and humid winters in Western and Central Europe, with precipitation mostly falling as rain.

Schönwiese (1993) indeed observed upward trends in rainfall during winter in Western and Central Europe (period 1891-1990). The statistical significance are highest for the North Sea basin and Scandinavia ($p<0.05$). However, similar trends for the period 1961-1990 are not significant in statistical terms. Over the period 1961-1990, summers became drier in the North Sea basin (not significant). A decrease in rainfall is observed in the Mediterranean area (Spain, Southern France, Italy and Greece) during the period 1891-1990 (not significant). He also notes a decrease in pressure over Northern Europe and an increase in pressure over Southern Europe in the winter period (over the period 1961-1990). This induces an intensification of zonal circulations in winter.

At a weather station in the Netherlands (De Bilt) the annual means of total precipitation amount and duration increased (+5% and +11%, respectively) for the period 1961-1990 compared to 1931-1960 (Zwart, 1993). (However, one station is not representative for a larger area.) Also, precipitation amounts increased significantly in Bavaria (Germany) during the last 3 decades (Dister, 1995). The precipitation time-series produced by Jones et al. (1994) for England and Wales confirm these long-term trends in seasonal rainfall.

Flooding

Concerned by the 1993 flooding of the Meuse (see section 4.1.4.), Dutch authorities launched a extensive study on the possible causes (Waterloopkundig Laboratorium, 1994). One result can be seen in Figure 10, where the behaviour of peak runoff in the Meuse near Maastricht is depicted. A rising trend of 10 to 12% has been estimated since 1911. After comparing the frequency of peak water levels before and after 1911, more runoff peaks were observed in the recent period. This increase is ascribed to changes in land use and river infrastructure, and urbanisation. **In contrast to what is often believed, deforestation cannot be the reason.** Over the period 1834-1992 forest area grew in the Ardennes (+10%). However, nearly all the floods of the Meuse took place in winter and were preceded by much precipitation in a large area (van Meijgaard, personal communication, 1995).

In this respect, it is remarkable that the Waterloopkundig Laboratorium, 1994) also reveals that in the catchment area of the Meuse in Wallonie the precipitation in wintertime this century (1911-1993) has increased with more than 20% relative to 1882-1910. The KNMI (1995) points to the persistence of zonal circulations during the 1993 and 1995 winters (causing the excessive frontal rainfall). In 1993/94 a westerly flow occurred on 55% of the winter days (average is 40%). In the winter of 1994/95 this is above 60%.

Analysing runoff conditions over the last sixty years in Germany, Schumann (1993) finds similar trends. In total, 14 runoff series from rivers in different regions in Germany were analysed for the period 1931-1988. It appeared that the winter runoff of alpine-influenced river basins has increased by warmer winters since 1965. For non-alpine influenced river basins, average runoff values for the months March to June were larger after 1964. The average runoff values were increased by 26% as compared to the time period 1931-1963. It was also found that the average discharge of annual low water periods was increased. The annual lowest 60-day average of daily runoff was, on average, 29% higher from 1964 to 1988 than in the period 1931-1963. These results were found to hold for river basins differing in size and situated in different hydrological regions of Germany. Because mostly large river basins were analysed, Schumann assumes that changes reflecting human intervention can be neglected. In this context, the remark of Dister (1995) is noteworthy: "Apart from infrastructural changes, the main cause for the 1995 flooding of the river Rhine is a climatological one, i.e. the increase of 40% in precipitation in Bavaria between 1960 and 1990".

A study by Boardman et al. (1994) reveals that, in the last twenty years, there has been an increase in the incidence of flooding of property by runoff from agricultural land in certain areas of northwestern Europe. Some of the high risk areas considered were the Ardennes and the south part of the Dutch province of Limburg. The Royal Meteorological Office at Ukkel (Demaree, 1990) found evidence of an increase in the maximum precipitation intensity for the first catchment over the period 1934-1976/1983, which explains in part the observed increase in flooding incidents in this area. However, in the southern Limburg area, the changes in land use were identified as important factors contributing to the increase in runoff. The final conclusion for these catchments was that "increases in flooding in recent years are primarily the result of changes in land use and the intensification of farming, and that changes in climate (if any) are unimportant" (for the period under consideration). An explanation why the observed increase of rainfall intensity in certain regions is not important was not given.

In the period 1950-75 there were 66 floods in Italy (2.5 per year). During the 17-year period thereafter (1976-1993), the frequency was 4 floods per year (with a total of 126). Since 1950, there have been seven severe droughts, of which four were concentrated in the 1980s. These data seem to confirm that Italy is undergoing a "climate partitioning" into a wet northern region and a southern semi-arid region. This "splitting" is in agreement with general circulation model predictions: rainfall trends should go towards extremes (Ferrara, 1993).

Kwadijk (1993), and Kwadijk and Middelkoop (1994) estimated the impact of climate change on the peak discharge probability of the Rhine river by means of a water balance model. Scenarios for temperature changes between 0oC and 4oC and precipitation changes between plus 20% and minus 20% have been applied. Within this range, flood frequencies appear to be more sensitive to a precipitation change than to a temperature change. From the study it can be deduced that a biennial flood doubles in frequency to become an annual occurrence under the influence of a 20% increase in precipitation. The associated peak flow volume raises by approximately 30%. (The method was only applied for estimation of probability changes of events having relatively low recurrence times).

From the application of the Business-as-Usual (BaU) scenarios developed by the IPCC (1990; 1992), it became evident that in the Alpine part of the basin winter discharge will increase and over time, as snow and ice have melted, summer discharge will decrease. In winter, the ratio rain/snow changes due to an increase of the winter temperature, and from a shift of maximum precipitation from summer to winter. The summer discharge will decrease, due to an increased evapotranspiration and decreased melt water availability. Downstream effects from precipitation changes become increasingly dominant over those related to temperature changes. The river regime at the Lobith gauging station (where the Rhine enters the Netherlands) will change from a combined snow-melt/rain-fed river to an almost entirely rain-fed river. Application of the BaU scenario ("best guess") reveals that at Lobith winter runoff will increase by 17% and summer runoff will decrease by 15% in the course of the next century.

That changes in magnitude and frequency of heavy floods accompanied changes in the (European) climate has already been observed earlier (Lamb, 1977): Many parts of Europe experienced anomalous wetness and great floods from about AD 1150 onward till about AD 1500 (Medieval warm period). However, southern Europe experienced very rare flooding in that period (which agrees with current GCM projections, showing that regional responses to climate change may differ).

Analyses of Recent Floods

Germany, France, Belgium and the Netherlands, 21-31 December, 1993. In north-western Europe, the worst flooding in 60 to 100 years took place just before Christmas 1993. In Germany, the flooding was most severe through the Rhineland and neighbouring regions. River water poured into many riverside towns. Cologne experienced its the worst flood in 100 years. In France, the flooding burst the banks of the Oise, Meuse and Moselle. Hundreds of people had to be evacuated. In Belgium, the river Meuse cut off the city of Dinant. It was the highest flood since 1926. The Dutch government declared a state of emergency along the basin of the Meuse. In total, 170 sq km of Dutch territory was inundated. The water level at Maastricht was 10 cm higher than measured. The 1993 peak runoff volume in Maastricht (3120 m3/s) was higher than it was in 1926 (3000 m3/s). It was thought that a flooding of this magnitude occurred once every 155 years. The total estimated damage was 265 million Dutch guilders (Rijkswaterstaat, 1994).

Excessive rainfall over a large area was the primary cause of these floods. December 1993 was a very wet month in large parts of west and central Europe. Active western circulation forced repetition of active rainstorms in central Europe. Along the French-Belgium border, 100 mm fell in two days. Fortunately, there was no snow in the Ardennes. Otherwise, water levels in the Meuse would have risen considerably higher (several decimeters).

There is a clear relation between daily rainfall and runoff. On 19 December, over 30 mm had already fallen in the French part of the Meuse catchment. The precipitation on 20 December originated from a disturbance passing somewhat more north compared to the rainfall of 19 December. Hence, the rain fell in an area that had already suffered from higher levels due to the upstream rainfall. This coincidence might be the reason that water levels were higher than expected. A statistical survey of rainfall data for three stations in the Ardennes on the prevalence of two- to four-day rainfall events revealed that such events take place once every 10 to 20 years (van Meijgaard, 1994). However, the recurrence period will be larger over the whole catchment area of the Meuse. Indeed, the total precipitation in December 1993 in Belgium was characterised by the Belgium Meteorological Organisation (KMI) as very exceptional, which means that the event has an occurrence of the order of one in the 100 years (van Meijgaard, 1994). The precipitation amount was 2.6-3.6 times the average precipitation.

Germany, France, Belgium and the Netherlands, 24 January-4 February, 1995

January was wet: the precipitation amount in this month was 1.5 to 3 times the average monthly total. The flooding of the rivers Rhine and Meuse was of comparable magnitude with the 1993 flooding. Again, it was called "the flood of the century". Over a period of 9 days the water level rose above the critical level (when inundation begins). In 1993, this period was 5 days. Although information is not yet fully consistent, it is generally assumed that compared to the 1993 flood, the rainfall was less intense but of a longer duration, and coincided with frozen soils (which enhances surface runoff) and later snow melting in the Ardennes and the Alpes. The peak runoff of the Meuse at Maastricht was around 3100 m3/s. The peak runoff of the Rhine was six times as high as the average runoff (2200 m3/s). The precipitation in the period 22-30 January in the catchment areas of the Rhine and the Meuse is characterised by the Royal Netherlands Meteorological Organisation (KNMI, 1995) as exceptional: in this century it only occurred two times earlier (1926 and 1993).

Alps: France, Italy, Switzerland, 23 September-8 October 1993

After 3 days of heavy rain, rivers overflowed and mudslides occurred. Flooding in the Savoie region was the worst in 35 years. In Italy, towns were flooded all along the Ligurian coast and up into Piedmont towards the Alps. In the port of Genoa it rained non-stop for 22 hours: 525 mm in 4 days compared to an annual average of 250 mm. Obviously, flooding was caused by the abundant rainfall.

Conclusions

It seems that today's environmental policy-makers could learn a great lesson from pre-flood history as depicted in the Bible. If carbon dioxide levels were much higher during the pre-flood era, then this implies that there are built-in global stabilising factors provided by the cosmos that can accommodate changes in carbon dioxide levels from the burning of fossil fuels and other man-made greenhouse emission activities. Once again, reference to Mother Nature’s word can give tremendous insight into solving today's scientific problems as has always been the case.

Role of Water Vapour in Global Warming Highlighted

Carbon dioxide gets most of the attention in discussions about greenhouse gas, but water vapour plays an even bigger role in heating up the Earth's atmosphere. This is because of water's unique molecular structure and potential heat stored within water that has an influence on storm formation and atmospheric circulation.

The latest research regarding water vapour’s link to global warming and climate change will be presented October 12-15 in Potomac, Md at the American Geophysical Union Chapman Conference on Water in the Climate System.

Georgia Institute of Technology atmospheric scientist Rong Fu will discuss how warmer sea surface temperatures in tropical oceans lead to an increase in atmospheric water vapour. Because sea surface temperatures heat up during an El Nińo, it is important to understand how El Nińo climate patterns can change the amount of water vapour in the atmosphere, says Fu -- "***Especially because climate models predict that water vapour contributes more to global warming than carbon dioxide.***"

Colorado State University atmospheric scientist David Randel uses satellite data to understand the Earth's water cycle. Randel will report results from the first study to combine all the components of the hydrological cycle, including water vapour in the atmosphere, cloudiness, rainfall and evaporation.

Randel said that scientists are concerned with the impact of warmer global temperatures on the water cycle because warmer temperatures may increase the frequency and magnitude of tropical storms, flooding and severe weather. Normal changes in the water cycle occur as seasons change over the course of a year, causing increasing temperatures that result in an increase of water vapour, clouds and rainfall, making it difficult to understand the system, Randel says.

Steven Businger, an atmospheric scientist at the University of Hawai'i, has pioneered the use of Global Positioning System (GPS) technology to isolate water molecules in the Earth's atmosphere. "Water plays a crucial role in weather and climate," says Businger, "And identifying the amount of water vapour in the atmosphere will help scientists understand clouds, severe weather, precipitation, hydrology and global climate change."

Since GPS signals are strongly refracted by water molecules, the amount of time it takes a signal to travel from the satellite to an Earth-based receiver increases, causing a delay. Water vapour delays the signal differently than do other particles in the atmosphere and this delay can be used to measure the total water vapour in the atmosphere between a GPS satellite and an Earth-based receiver. The ability to better monitor the amount of water vapour in the atmosphere helps scientists investigate a range of questions related to weather and climate, Businger says. Businger will report results of his study at the conference. Several other researchers at the conference will discuss new ways to achieve a better understanding of the relationship between water vapour and climate.

References

1. This topic also was discussed in an earlier "Impact" article. See Larry Vardiman, "The Christian and the Greenhouse Effect," Impact, No. 204, ICR, June 1990.

2. World Bank, 1992 World Development Report.

3. Peter Hoeller, Andrew Dean, and Jon Nicolaisen, "Macroeconomic Implications of Reducing Greenhouse Gas Emissions: A Survey of Empirical Studies," OECD Economic Studies, No. 16, Spring 1991, pp. 45-78.

4. Robert C. Balling, Jr., "The Heated Debate: Greenhouse Predictions Versus Climate Reality," Pacific Research Institute for Public Policy, San Francisco, California, 1992. 5.Ibid., pp. 17-32. 6.Ibid., p. 40. 7.Ibid., Table 2, p. 41. 8.Ibid., p. 44.

5. All data series used in this analysis were obtained from Trends '91: A Compendium of Data on Global Change, Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory.

6. For a description of testing for unit roots and cointegration, see Andrew C. Harvey, Forecasting, Structural Time Series Models, and the Kalman Filter, Cambridge University Press, Cambridge CB2 1RP, England, 1991.

7. Sherwood B. Idso, "Carbon Dioxide Can Revitalize the Planet," OPEC Bulletin, March 1992, pp. 22-27.

8. For a discussion of the pre-Flood environment, see Henry M. Morris, The Genesis Record, Baker Book House, Grand Rapids, Michigan, 1976.