

Statement on Tropical Cyclones and Climate Change

Submitted to CAS-XIV under Agenda Item 7.3 by Dr G. B. Love, Permanent Representative for Australia

Prepared by the WMO/CAS Tropical Meteorology Research Program, Steering Committee for Project TC-2: Scientific Assessment of Climate Change Effects on Tropical Cyclones. February 2006

PURPOSE:

To provide an updated assessment of the current state of knowledge of the impact of anthropogenically induced climate change on tropical cyclones.

BACKGROUND:

The WMO CAS Tropical Meteorology Research Program has undertaken a series of assessments of the potential influence of climate change on global tropical cyclone activity. The most recent was published in the Bulletin of the American Meteorological Society by Henderson- Sellers et al (1998) and had the following major conclusions:

- Whilst there was evidence of substantial multidecadal variability (particularly for intense Atlantic hurricanes), there was no clear evidence of long-term trends;
- The Maximum Potential Intensity of cyclones will remain the same or undergo a modest increase of up to 10-20%. These predicted changes are small compared with the observed natural variations and fall within the uncertainty range in current studies;
- Little can be said about the potential changes of the distribution of intensities as opposed to maximum achievable intensity;
- Current knowledge and available techniques are not able to provide robust quantitative indications of potential changes in tropical cyclone frequency;
- The broad geographic regions of cyclogenesis and therefore also the regions affected by tropical cyclones are not expected to change significantly;
- The modest available evidence points to an expectation of little or no change in global frequency. Regional and local frequencies could change substantially in either direction, because of the dependence of cyclone genesis and track on other phenomena (e.g. ENSO) that are not yet predictable;
- The rapid increase of economic damage and disruption by tropical cyclones has been caused, to a large extent, by increasing coastal populations, by increasing insured values in coastal areas and, perhaps, a rising sensitivity of modern societies to disruptions of infrastructure.

A number of high-impact tropical cyclone events have occurred throughout the globe during 2004 and 2005, including:

- Ten fully developed tropical cyclones made landfall in Japan in 2004, causing widespread damage.
- Southern China experienced much below-normal tropical cyclone landfalls and subsequently suffered a severe drought;
- Four major hurricanes caused extensive damage and disruption to Florida communities in 2004;

- In March 2004 southern Brazil suffered severe damage from a system that had hurricane characteristics, the first recorded cyclone of its type in the region;
- Five fully developed cyclones passed through the Cook Islands in a five week period in February-March 2005;
- The 2005 North Atlantic Hurricane Season broke several records including number of tropical cyclones, number of major hurricanes making landfall and number of category 5 hurricanes. In particular, the landfall of Hurricane Katrina at New Orleans and Mississippi caused unprecedented damage and more than 1300 deaths.

The IPCC Third Assessment Report concluded that "most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations." There is now additional supporting evidence for this conclusion. There is strong and growing evidence that a warming signal has penetrated into the global oceans over the past 40 years and was likely caused primarily by anthropogenic forcing. At the regional scale, sea surface temperatures in the major tropical ocean basins have warmed, with a likely substantial contribution from anthropogenic forcing indicated in several of the basins. Further, two scientific papers appeared during 2005 in highly visible journals (*Nature* and *Science*) providing evidence for an increase in the number of the intense cyclones.

This combination of events has led to statements in the world press that the recent hurricane disasters can be directly attributed to the impact of global warming.

Hence it is appropriate that the Tropical Meteorology Research Program Panel of Experts make a statement to guide member countries. The membership of this panel includes two of the authors of the *Nature* and *Science* papers, as well as prominent tropical cyclone researchers from USA, Australia, UK and China:

Dr. John McBride, Dr Jeff Kepert (Australia)

Prof. Johnny Chan (Hong Kong, China)

Julian Heming (United Kingdom)

Dr. Greg Holland, Professor Kerry Emanuel, Thomas Knutson, Dr Hugh Willoughby, Dr. Chris Landsea (USA)

STATEMENT ON TROPICAL CYCLONES AND CLIMATE CHANGE:

We consider that the following conclusions of Henderson-Sellers et al (1998) remain valid:

- Current knowledge and available techniques are not able to provide robust quantitative indications of potential changes in tropical cyclone frequency;
- The modest available evidence points to an expectation of little or no change in global frequency. Regional and local frequencies could change substantially in either direction, because of the dependence of cyclone genesis and track on other phenomena (e.g. ENSO) that are not yet predictable;
- The rapid increase of economic damage and disruption by tropical cyclones has been caused, to a large extent, by increasing coastal populations, by increasing insured values in coastal areas and, perhaps, a rising sensitivity of modern societies to disruptions of infrastructure.

However, further elaboration is required on the conclusions by Henderson-Sellers et al. relating to changes in cyclone intensity. Whilst there is substantial debate on this topic, we consider that the following statements can be made:

- No single high impact tropical cyclone event of 2004 and 2005 can be directly attributed to global warming, though there may be an impact on the group as a whole;
- Emanuel (2005) has produced evidence for a substantial increase in the power of tropical cyclones (denoted by the integral of the cube of the maximum winds over time) during the last 50 years. This result is supported by the findings of Webster et al (2005) that there has been a substantial global increase (nearly 100%) in the proportion of the most severe tropical cyclones (category 4 and 5 on the Saffir-Simpson scale), from the period from 1970 to 1995, which has been accompanied by a similar decrease in weaker systems.
- The research community is deeply divided over whether the results of these studies are due, at least in part, to problems in the tropical cyclone data base. Precisely, the historical record of tropical cyclone tracks and intensities is a byproduct of real-time operations. Thus its accuracy and completeness changes continuously through the record as a result of the continuous changes and improvements in data density and quality, changes in satellite remote sensing retrieval and dissemination, and changes in training. In particular a step-function change in methodologies for determination of satellite intensity occurred with the introduction of geosynchronous satellites in the mid to late 1970's.
- The division in the community on the Webster et al and on the Emanuel papers is not as to whether Global Warming can cause a trend in tropical cyclone intensities. Rather it is on whether such a signal can be detected in the historical data base. Also it can be difficult to isolate the forced response of the climate system in the presence of substantial decadal and multi-decadal natural variability, such as the Atlantic Multi-decadal Oscillation.
- Whilst the existence of a large multi-decadal oscillation in Atlantic tropical cyclones is still generally accepted, some scientists believe that a trend towards more intense cyclones is emerging. This is a hotly debated area for which we can provide no definitive conclusion. It is agreed that there is no evidence for a decreasing trend in cyclone intensities.

Besides the above comments on tropical cyclone intensity, based on the published, literature it is appropriate to make the following additional statements:

- The geographical extents of the existing regions of cyclogenesis and the existing regions affected by tropical cyclones still are not expected to change significantly. However, superimposed on the multi-decadal fluctuations, interannual variations such as the El Niño-Southern Oscillation (ENSO) are a major influence on cyclone development and the subsequent paths in most parts of the world. There is no consensus among current climate models regarding how ENSO variability may change in the future, although any such changes in ENSO would be expected to alter Tropical Cyclones regionally.
- In the context of changing regions of cyclogenesis, we note the debate concerning the hurricane-like system in the South Atlantic, but consider no conclusions can be made based on a single system.
- A robust result in model simulations of tropical cyclones in a warmer climate is that there will be an increase in precipitation associated with these systems

(for example, Knutson and Tuleya, 2004). The mechanism is simply that as the water vapor content of the tropical atmosphere increases, the moisture convergence for a given amount of dynamical convergence is enhanced. This should increase rainfall rates in systems (viz tropical cyclones) where moisture convergence is an important component of the water vapor budget. To date no observational evidence has been found to support this conclusion; so no quantitative estimate can be given for the anticipated rainfall increase without further research.

- While demographic trends are the dominant cause of increasing damage by tropical cyclones, any significant trends in storm activity would compound such trends in damage.
- Projected rises in global sea level are a cause for concern in the context of society's vulnerability to tropical cyclones. In particular for the major cyclone disasters in history the primary cause of death has been salt-water flooding associated with storm surge.
- Because of the problems of the tropical cyclone databases utilized for studies on trends in these extreme events, there is an immediate need to conduct an in-depth storm-by-storm reanalysis of tropical cyclones in all basins. Currently, a reanalysis is underway only for the Atlantic basin.
- The research issues discussed here are in a fluid state and are the subject of much current investigation. Given time the problem of causes and attribution of the events of 2004-2005 will be discussed and argued in the refereed scientific literature. Prior to this happening it is not possible to make any authoritative comment.

FURTHER ACTION:

The Project TC-2 Committee will produce an update to the Henderson-Sellers et al paper documenting the state of the science, explaining the basic principles, and outlining the sources of disagreement. This will be presented for discussion and ratification at the Sixth International Workshop on Tropical Cyclones (IWTC-VI) to be held in Costa Rica in November 2006. Subsequently it will appear as a WMO TMRP Report and be submitted to the refereed literature.

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