ABSTRACT

Approaches to Defining Dangerous Climate Change: A Southern Hemisphere Perspective

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Perceptions of dangerous climate change by decision-makers and the community are influenced both gradually as the symptoms of climate change impact on daily lives, and more rapidly as major events are shown to be climate change related. Because of this duality the science community must analyse the impacts on, and adaptability of, local and regional scale biological and sociological systems to ongoing climate change, as well as assess the likelihood of larger scale extreme events. The role of the science community is to establish what (and if) relationships exist between specific events and changing greenhouse gas concentrations in the atmosphere, and it is the community's role to decide what is acceptable and what poses unacceptable dangers on the basis of the science advice. This paper will present some scientific perspectives on the issue of dangerous climate change from a southern hemisphere and Australian viewpoint.

The southern hemisphere, which is largely oceanic, differs in many ways from the northern hemisphere but is no less important for understanding global climate. We now know, for example, that the Southern Ocean is a sink for some 40% of global oceanic carbon, and that the Antarctic circumpolar deep water formation is a critical process for oceanic productivity and global climate. However, we know much less about the behaviour of the Southern Ocean overturning circulation than we do about North Atlantic circulation.

As suggested above, there is risk in limiting approaches to defining dangerous climate change to only one perspective. With regard to resource management, we propose that dangerous climate change can best be defined from the perspective of the various systems or sectors that are impacted by a changing climate. The critical issues to be examined are the level of vulnerability of systems or sectors to climate now and what measures they can take to adapt to a changing climate in the future. A particularly important aspect of the analysis is to examine the limits to adaptability - at what point can a system no longer adapt to a changing climate and significant damage or disruption to the system occurs. Limits to adaptability are often related to nonlinear change in the impacted system that can be triggered by gradual change in climate.

The IPCC's qualitative representation of degree of risk for five major areas of concern provides a useful framework. We use specific examples from Australia to estimate the magnitudes and/or rates of climate change that may cause unacceptable levels of damage or risk. A sensitivity approach to increases in temperature and changes in precipitation can provide a first-order analysis of the degree of risk of various impacted systems. Vulnerable Australian systems that the community perceive to be impacted by climate change include:

- *Agriculture* - Australian agriculture has adapted to one of the most variable climates on the planet, and there are undoubtedly lessons learnt relevant to agricultural management in the context of climate change elsewhere.

Nevertheless, major droughts in Australia typically cause declines in Gross Domestic Product (GDP) of around 1% (A$6.6 billion), with much larger regional impacts in affected areas. The 2002-2003 drought is estimated to have cost 1.6% of GDP (A$10 billion) and about 70,000 jobs. There are concerns about the sector's ability to adapt to a potentially drier climate and to more /hotter droughts.

- *Water Resources* – The demands of irrigated agriculture, biodiversity protection and urban supply are placing Australia's scarce water resources under increasing pressure. Higher temperatures in the future and possible rainfall decreases are likely to increase water demand and reduce supply, further increasing the pressure on this key resource. Increases in the intensity of daily rainfall are likely to place increased pressure on urban drainage capacity and catchment management.
- *Coral reefs* - Reefs are under pressure from increasing acidity in the surface waters, increasing sea surface temperature and other human-induced stresses. Australia's Great Barrier Reef, a global biodiversity hotspot and one of the best managed reefs in the world, may be significantly affected by climate change under even moderate emission scenarios. Australia has a key role in leading global research through the GEF project on coral reefs and climate change.
- *Biodiversity* - Australia has the highest fraction of endemic biotic diversity of any continent but also has the highest extinction rate for vertebrates, largely due to land-use change and introduction of exotic species. The ability of species to adapt to future changes in climate by migrating with climatic zones will be limited by habitat fragmentation. Climate change may thus exacerbate loss of species. This issue is under further research.
- *Sea-level rise* (low-lying island states) - The modest levels of sea-level rise predicted for the 21st century, particularly in combination with larger storm surges associated with more-intense tropical cyclones, will create problems for lowlying regions and islands in the Indian and western Pacific Oceans. Australia has led international research efforts to more rigorously assess the extent to which sea level will change as the Earth warms, and has developed the first global outline of regional differences in sea level rise, reconciling earlier 'inconsistent' estimates.

Large-scale discontinuities in the climate system – often called abrupt changes - provide another approach to defining dangerous climate change. The issue here is the degree or rate of climate change at which the risk of such abrupt changes becomes unacceptably high. The most well-known example of a large-scale discontinuity is the potential shift in the thermohaline circulation in the north Atlantic Ocean. From an Australian perspective, abrupt shifts in the behaviour of known modes of climate variability such as ENSO or the Asian Monsoon system would have potentially very significant consequences.

Finally, the context of anthropogenic climate change, coupled with other changes in the global environment due to human activities, must be considered in the broadest definition of dangerous change. The ice core records from the Vostok and Dome C sites show that for the last 420,000 years at least, the Earth has cycled between two fundamental states - glacial and interglacial. The current concentration of CO_2 in the atmosphere (ca. 380 ppm) is already about 100 ppm higher than the level associated with interglacial states and thus represents a doubling of the operating range between glacial and interglacial states. The overall implications of these changes for the resilience of the Earth system need consideration.

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