Perceived change in risk of natural disasters caused by global warming

Contrary to insurance company perceptions, *Chris de Freitas* argues that although the future state of global climate is uncertain, there is little scientific evidence to suggest any change will result in an increased risk of natural disasters.

By C R de Freitas, School of Geography and Environmental Science, University of Auckland, PB 92019, Auckland, New Zealand

Natural hazards causing disasters that lead to human suffering are as much a product of the social, political and economic environment as they are of the natural environment. It follows, therefore, that the risk associated with natural hazards is in part a social construct that, as Young (1998) has pointed out, is perceived differently by all of us and must be defined with this mind. For example, risk is defined by Emergency Management Australia (1995) as the perceived likelihood of given levels of harm.

With this in mind, one major determinant of risk is the perceived trends in disasters. Given that a) weather hazards are the most significant natural hazards in Australia (Coates, 1998) and elsewhere (Downing et. al., 1996; Dlugolecki et. al., 1996; Kattenburg et. al.,1996; McCarthy et. al., 2001) and that b) in the latter part of the 20th century insured losses have been unprecedented (Dlugolecki et. al., 1996; Kattenburg et. al.,1996), the possibility of worsening trends have, understandably, attracted the attention of the insurance industry.

There are a number of possible reasons for increasing losses: a) a greater concentration of people and high value property in vulnerable areas, mainly coastal; b) business processes have become more susceptible to damage; or c) that changes have occurred in the frequency and severity of extreme climatic events. The last of these is in line with expectations of climate change resulting from an enhanced greenhouse effect and this too has attracted the attention of the insurance industry. Dlugolecki et. al. (1996, p. 541) comment "It is a common perception in the insurance industry that there is a trend toward an increasing frequency and severity of extreme climate events." The important question arises as to the extent to which these expectations are justifiable.

Evidence versus perceptions of worsening conditions

It is not uncommon to see media reports attributing the occurrence of extreme climate events to global warming. The problem is that no matter how outrageous the tale it becomes the truth if it is told often enough, or at the very least shapes perceptions of shifting risk. According to the United Nations Intergovernmental Panel on Climate Change (Houghton et. al., 1996, p. 173), "Overall, there is no evidence that extreme weather events, or climate variability, has increased, in a global sense, through the 20th century…" The 2001 IPCC Report (Houghton et. al., 2001b, p. 5) states that "no systematic changes in the frequency of tornadoes, thunder days, or hail are evident..." The increasing dollar cost of storm and other weather related events could be accounted for by a rise in the value of development and number of properties, especially in tropical cyclone prone areas (Changnon et. al., 1997; Pielke and Lansea, 1998; Kunkel, Pielke and Changnon, 1999). In fact, there is great deal of research which, taken together, suggests that extreme climate events may become both less frequent and less severe when the planet warms. Some of this work is discussed here.

Storms

In the Atlantic region, the number of intense hurricanes declined during the 1970s and 1980s, and the period 1991–1994 experienced the smallest number of hurricanes of any four years over the last half century (Idso et. al., 1990; Landsea et. al., 1996; Bengtsson et. al., 1996; Zhang and Wang 1997; Murphy and Mitchell, 1995). There is also evidence from Europe that suggests a similar trend. For the period 1896–1995, Bielec (2001) analysed thunderstorm data obtained at Cracow, Poland, which is "one of the few continuous records in Europe with an intact single place of observation and duration of over 100 years." From 1930 onward the trend is negative, revealing a linear decrease of 1.1 storms per year from 1930 to 1996. Bielec (2001)

Future global warming may lead to fewer and less intense El Niño events. (Andrus, 2002)

also reports there has been a decrease in the annual number of thunderstorms with hail over the period of record, and there has been a decrease in the frequency of storms producing precipitation greater than 20 mm.

Pirazzoli (2000) analysed storm surges, atmospheric pressure and wind change and flooding probability on the Atlantic coast of France over the period 1951–1997. He found that climate variability is decreasing. Specifically, the work shows that the number of atmospheric depressions and strong winds that cause storm surges in this region are becoming less frequent resulting in reduced frequency and severity of coastal flooding.

Nguyen, and Walsh (2001) simulated the occurrence of hurricanes in the Australia region using a general circulation model (GCM) that assumes a tripling of the atmospheric concentration of carbon dioxide. The results showed that the numbers of hurricanes declined in a greenhouse-warmed world and that the decline is statistically significant. In a study of Atlantic hurricanes, Goldenberg et. al. (2001) show that they occur in distinct multidecadal cycles and are linked to sea-surface temperature anomalies in the Atlantic Ocean's main hurricane development region. Warm anomalies are associated with increased major hurricane activity; cold anomalies with suppressed activity. Goldenberg et. al. (2001) suggest that increases in the frequency of big Atlantic hurricanes are due to the natural variations in hurricane frequency and intensity rather than global warming.

The most important energy source for extratropical storms is the temperature difference between the tropics and the poles. Most GCMs predict that the greatest warming will occur over the high latitudes in winter with relatively little warming in the tropics and around equatorial latitudes. This implies reduced temperature variation since such variations result from air moving from one latitude to another. Thus, according to these predictions, the future contrast between the polar and equatorial latitudes will lessen, producing a weaker gradient and fewer and less intense storms. Consistent with this, the IPCC 2001 Summary for Policymakers (Houghton, 2001b) notes that no significant upward trends have been identified in tropical or extratropical storm intensity and frequency.

Floods and droughts

Lins and Slack (1999), concerned about possible increases in floods and droughts accompanying global warming, looked directly at stream flow from hundreds of rivers in the United States. They state:

> *"The pattern indicates that baseflows are increasing (which suggest that drought is decreasing), median or average flow stream flow is increasing, but annual maximum flows (including floods) are neither increasing nor decreasing. Hydrologically, the nation appears to be getting wetter, but less extreme."*

Lins and Slack (1999) conclude that, as the surface air temperature of the globe gradually increased through 20th century, the conterminous United States became

Table 1: Day-to-day air temperature variability for the United Sates, Peoples Republic of China and the former Soviet Union, shown as mean linear trend (°C per decade) in daily temperature variability values (Michaels et. al., 1998).

Air temperature	USA	China	USSR
Maximum			
January	–0.19	–1.13	0.07
July	–0.13	0.06	–0.02
Minimum			
January	–0.26	–1.32	–0.37
July	–0.19	0.06	–0.08

wetter but less variable at the extremes, where floods and droughts occur. In a similar study, Molnar and Ramirez (2001) analysed precipitation and streamflow trends for the period 1948–1997 in the Rio Puerco Basin of New Mexico found no change in high-intensity precipitation.

Working on the assumption that the best real-world analogue of future global warming is past periods of global warming, Nesje et. al. (2001) analysed a sediment core from a lake in southern Norway to determine the frequency and magnitude of prior floods in that region over the past thousand years. The results showed an extended phase characterised by very little flood activity coincided with the Medieval Warm Period (AD 1000–1400). This was followed by a period of extensive flood activity that corresponded with the period known as the Little Ice Age, which was characterised by lower air temperature, thicker and more long-lasting snow cover, and more frequent storms.

There has been other research carried out using long-term data. For example, the results of research by Andrus et. al. (2002) confirm the findings of several other studies that indicate the mid-Holocene was significantly warmer than it is currently. Andrus et. al. (2002) show a situation where a considerably warmer climate than that of the present was apparently unable to sustain significant El Niño activity. This demonstrates that future global warming may lead to fewer and less intense El Niño events.

Focussing specifically on droughts, several studies have examined the past 300 years during which global climate has been recovering cool conditions of the Little Ice Age and is bringing conditions closer those experienced earlier during Medieval Warm Period conditions. These studies have shown convincingly that not only does global warming not produce more frequent and severe droughts, it does just the opposite. For example, in the United States, Cronin et. al. (2000) using sediment cores from Chesapeake found that conditions were wetter than normal and droughts uncommon during the Medieval Warm Period. At other times the region had experienced several extreme droughts lasting from 60-70 years, many of which were more severe than droughts of the twentieth century. In a review of the subject, Woodhouse and Overpeck (1998) have come to a similar conclusion. Gan (1998), using data sets for the North American Midwest from the last century showed that warming is not associated with increased occurrence of drought. Benson et. al. (2002) studied sediments from Pyramid Lake, Nevada. They found that over the past 2700 years drought lasted from 20 to 100 years, while droughts of the recent historical period have generally lasted less than a decade. Similarly, Fritz et. al. (2000) used sediment cores to construct a 2000-year history of drought for a part of the Northern Great Plains of North America. Their results indicated that droughts equal or greater in severity to those of the 1930s Dust Bowl were a common occurrence during the last 2000 years. Likewise, Stahle et. al. (2000), using tree rings to develop a long-term history of drought over all of North America, found that drought during 16th century was the most extreme and prolonged in the past 2000 years, far exceeding any drought of the 20th century, including the Dust Bowl drought.

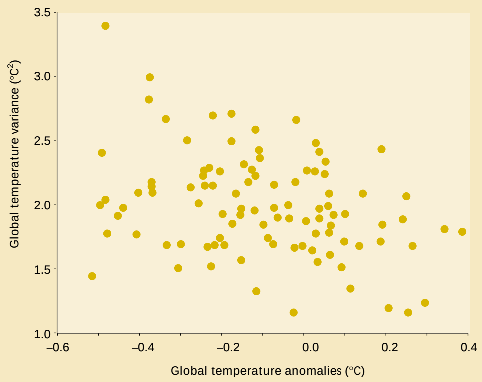
Temperature extremes

Coates (1998) has stated that heatwaves are the most significant natural hazard in Australia in terms of loss of life. There is speculation that global warming will increase climate variability and thus the frequency of heat waves. Michaels et. al. (1998) show there is little support for this, or for the popular perception that temperatures have become more variable. They examined daily maximum and minimum temperatures from the United States, China and the former Soviet Union for day-to-day variability in January and July and most of the trends indicated declining variability (Table 1).

Several other studies have found that more warmth leads to more stable climate. Karl et. al. (1995) point out that an increase in the atmospheric concentration of carbon dioxide should decrease temperature variability. Balling (1998) examined changes in the spatial variability of mean monthly and daily temperatures that

Figure 1: Inter-annual surface temperature variability vs. global temperature anomalies for the 1897–1997 time series

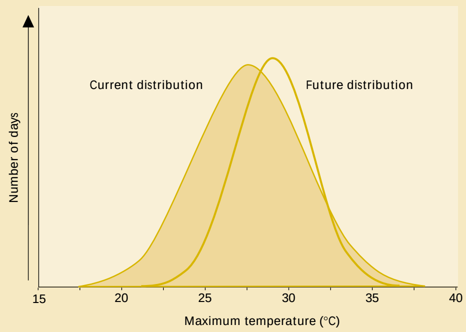
showing the warmer the surface temperature, the less variable climate becomes



Source: Michaels et. al. (1998).

Figure 2: A realistic forecast of future maximum air temperature distribution

If forecasts by Easterling et. al. (1997) and Karl et. al. (1997) are correct, variability in the data will shrink more than the predicted mean warming and give a distribution shown schematically here



After: Michaels and Balling (2000).

have occurred during the historical climate record. His research showed that, overall, the spatial variability in temperature anomalies has declined, and that the interannual variability in temperature anomalies is negatively correlated to mean hemispheric temperatures. Balling et. al. (1998) and Michaels et. al. (1998) both show that as the atmosphere warms, the month-to-month variability also declines (Figure 1).

Karl et. al. (1997) state that GCMs predict temperatures will be confined to a tighter range. This is confirmed by Easterling et. al. (1997) who found that most of the increase in global temperatures has been occurring during the winter and at night. Summer maximum air temperatures in the Northern Hemisphere showed no statistically significant trend. If these forecasts are correct, variability in the data will shrink more than the predicted mean warming and give a distribution shown schematically in Figure 2.

Conclusion

Global warming involves a scientifically realistic mechanism that links climate change to the concentration of greenhouse gases in the atmosphere. Although the future state of global climate is uncertain, there is little reason to believe that catastrophic change is underway. Moreover, there is little or no evidence to suggest any change will result in an increased risk of natural disasters caused by increased frequency and severity of climate extremes. Climate models suggest that increases in greenhouse gases are likely to give rise to a warmer and wetter climate in most places. Generally higher latitudes would warm more than lower (equatorial) latitudes. This means milder winters and coupled with increased atmospheric carbon dioxide, which is food for plants, it also means a more robust biosphere with more forest, crops and ground cover for more animals and people.

References

Andrus, C. F. T., Crowe, D. E. Sandweiss, D. H., Reitz, E. J. and Romanek, C. S., (2002), 'Otolith ó^{18}O record of mid-Holocene sea surface temperatures in Peru.' *Science*, Vol. 295, pp. 1508–1511.

Balling, R. C. Jr., (1998), 'Analysis of daily and monthly spatial variance components in historical temperature records.' *Physical Geography*, Vol. 18, p. 544–552.

Balling, R. C. Jr., Michaels, P J. and Knappenberger, P. C., (1998), 'Analysis of winter and summer warming rates in gridded temperature time series.' *Climate Research*, Vol. 9, p. 175–181.

Bengtsson, L. Botzet, M. and Esch, M.,, (1996), 'Will Greenhouse Gas-induced Warming Over the Next 50 Years Lead to a Higher Frequency and Greater Intensity of Hurricanes?' *Tellus*, Vol. 48A, pp. 57–73.

Benson, L., Kashgarian, M., Rye, R., Lund, S., Paillet, F., Smoot, J., Kester, C., Mensing, S., Meko, D. and Lindstrom, S., (2002), 'Holocene multidecadal and multicentennial droughts affecting Northern California and Nevada.' *Quaternary Science Reviews*, Vol 21, pp. 659–682.

Bielec, Z., (2001), 'Long-term Variability of Thunderstorms and Thunderstorm Precipitation Occurrence in Cracow, Poland, in the Period 1896–1995.' *Atmospheric Research*, Vol. 56, pp.161–170.

Changnon, S.A., (1999), 'A Rare Long Record of Deep Soil Temperatures Defines Temporal Temperature Changes and an Urban Heat Island.' *Climatic Change*, Vol. 42, pp. 531–538.

Changnon, S. A., (Changnon, D., Fosse, E. R., Hoganson, D. C., Roth, R. J. and Totsch, J. M., (1997), 'Effects of recent weather extremes on the insurance industry: Major implications for the atmospheric sciences.' *Bulletin of the American Meteorological Society*, Vol. 78, 425.

Coates, L., (1998), 'Deaths and ENSO: Fate, Chance or Change?' *Natural Hazards Quarterly*, Vol. 4, No. 4, pp. 2–3.

Cronin, T., Willard, D., Karlsen, A., Ishman, S., Verardo, S., McGeehin, J., Kerhin, R., Holmes, C., Colman, S. and Zimmerman, A., (2000), 'Climatic variability in the eastern United States over the past millennium from Chesapeake Bay sediments.' *Geology*, Vol. 28, pp. 3–6.

Dlugolecki, A.F., Clark, K. M., Knecht, F., McCaulet, D., Palutikof, J. P., Yambi, W., (1996), 'Financial Services.' In Watson, R.T., Zinyowera, M.C., Moss, R.H. eds.1995, *Climate Change 1995 – Impacts, Adaptations and Mitigation of Climate Change.* Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York, 539–560.

Downing, T. E., Olsthoorn, A. A. Tol, R. S. L. eds., (1996), *Climate Change and Extreme Events*. ECU Research Report Number 12. Vrije Universiteit, Amserdam, 309 pp.

Easterling, D. R., Horton, B., Jones, P. D., Peterson, T. C., Karl, T. R., Parker, D. E., Salinger, M.J., Razuvayev, V., Plummer, N., Jamason, P., and Folland, C.K., (1997), 'Maximum and Minimum Temperature Trends for the Globe.' *Science*, Vol. 277, pp. 364–367.

Emergency Management Australia, (1995), *National Emergency Management Competency Standards*, EMA, Canberra.

Fritz, S.C., Ito, E., Yu, Z., Laird, K.R. and Engstrom, D.R., (2000. 'Hydrologic variation in the Northern Great Plains during the last two millennia.' *Quaternary Research*, Vol. 53, pp. 175–184.

Gan, T.Y., (1998), 'Hydroclimatic trends and possible climatic warming in the Canadian Prairies.' *Water Resources Research*, Vol. 34, pp. 3009–3015.

Goldenberg, S., Landsea, C. W., Mestas-Nuñez, A. M. and Gray, W. M., (2001, 'The Recent Increase in Atlantic Hurricane Activity: Causes and Implications, *Science*, Vol. 293, pp. 474–479.

Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., van der Linden, P. J. and Xiaosu, D. eds., (2001a), *Climate Change 2001: The Scientific Basis*. Contribution to Working Group 1 to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), Cambridge University Press, New York.

Houghton, J. T., Ding, Y., Griggs, D. J., Noguer, M., van der Linden, P. J. and Xiaosu, D. eds., (2001b), *Summary for Policymakers, Third Assessment Report*. *Climate Change 2001: The Scientific Basis.* Cambridge University Press, New York.

Houghton, J. T., Meira Filho, L. G., Callander, B. A., Harris, N., Katenberg, A. and Maskell, K. eds., (1996), *Climate Change 1995: the Science of Climate Change.* Contribution to Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York, 572 pp.

Idso, S. B., Balling, R. C. and Cerveny, R. S., (1990), 'Carbon Dioxide and Hurricanes: Implications of Northern Hemispheric Warming for Atlantic/Caribbean Storms.' *Meteorology and Atmospheric Physics*, Vol. 42, pp. 259–263.

Karl, T. R., Knight, R. W. and Plummer, N., (1995), 'Trends in high frequency climate variability in the twentieth century.' *Nature*, Vol. 377, pp. 217–320.

Karl, T. R., Nicholls, N. and Gregory, J., (1997), 'The Coming Climate.' *Scientific American*, Vol. 276, pp. 79–83.

Kattenburg, A., Giorgi, F., Grassl, H., Meehl, G. A., Mitchell, J. F. B., Stouffer, R. J. Tokioka, T., Weaver, A. J., Wigley, T. M. L. eds., (1996, 'Climate Models – Projections of Future Climate'. In Houghton, J. T., Meira Filho, L. G., Callander, B. A., Harris, N., Katenberg, A. and Maskell, K. eds., (1996), *Climate Change 1995: the Science of Climate Change.* Contribution to Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York, pp. 285–357.

Kunkel, K. E., R. A. Pielke and S. A. Changnon,, (1999), 'Temporal fluctuations in weather and climate extremes that cause economic and human health impacts: A review.' *Bulletin of the American Meteorological Society*, 80, 1077.

Landsea, C. W., Nicholls, N., Gray, W. M. and Avila, L. A., (1996), 'Downward Trends in the Frequency of Intense Atlantic Hurricanes During the Past Five Decades.' *Geophysical Research Letters*, Vol. 23, pp. 1697–1700.

Lins, H. F. and Slack, J. R., (1999), 'Streamflow Trends in the United States.' *Geophysiccal Research Letters*, Vol 26, pp. 227–230.

McCarthy, James J., Canziani, Osvaldo F., Leary, Neil A., Dokken, David J., White, Kasey S. eds., (2001), *Climate Change 2001: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, New York.

Michaels, P. J and Balling, R. C. Jr., (2001), *The Satanic Gases*. Cato Institute, Washington, D.C. 235 pp.

Michaels, P. J., Balling, R. C. Jr., Vose, R. S. and Knappenburger, P. C. 1998, 'Analysis of trends in the variability of daily and monthly historical temperature measurements.' *Climate Research*, Vol. 10, 27–33.

Molnar, P. and Ramirez, J.A., (2001), 'Recent trends in precipitation and streamflow in the Rio Puerco Basin.' *Journal of Climate*, Vol. 14, pp. 2317–2328.

Murphy, J. M. and Mitchell, J. F. B., (1995, 'Transient Response of the Hadley Centre Coupled Ocean-atmosphere Model to Increasing Carbon Dioxide. Part II: Spatial and temporal structure of response.' *Journal of Climate*, Vol. 8, pp. 57–80.

Nesje, A., Dahl, S. O., Matthews, J. A. and Berrisford, M. S., (2001), 'A ~ 4500-yr record of river floods obtained from a sediment core in Lake Atnsjoen, eastern Norway.' *Journal of Paleolimnology*, Vol. 25, pp. 329–342.

Nguyen, K. C., and Walsh, K. J. E., (2001), 'Interannual, Decadal, and Transient Greenhouse Simulation of Tropical Cyclone–like Vortices in a Regional Climate Model of the South Pacific.' *Journal of Climate*, Vol. 4, pp. 3043–3054.

Pielke, R. A. and Landsea, C. W,, (1998), 'Normalized Hurricane Damages in the United States 1925–1995.' *Weather Forecasting*, Vol. 13, pp. 621–631.

Pirazzoli, P. A., (2000, 'Surges, atmospheric pressure and wind change and flooding probability on the Atlantic coast of France.' *Oceanologica Acta*, Vol. 23, pp. 643–661.

Stahle, D.W., Cook, E.R., Cleaveland, M.K., Therrell, M.D., Meko, D.M., Grissino-Mayer, H.D., Watson, E. and Luckman, B.H. 2000), 'Tree-ring data document 16th century megadrought over North America.' *EOS, Transactions, American Geophysical Union*, Vol.81, pp. 121, 125.

Woodhouse, C.A. and Overpeck, J.T., (1998), '2000 years of drought variability in the central United States.' *Bulletin of the American Meteorological Society*, Vol. 79, pp. 2693–2714.

Young, E., (1998, 'Dealing with hazards and disasters: risk perception and community participation in management.' *Australian Journal of Emergency Management*, Vol. 13, No. 2, pp. 14–16.

Zhang Y. and Wang, W. C., (1997), 'Model Simulated Northern Winter Cyclone and Anticyclone Activity Under a Greenhouse Warming Scenario. *Journal of Climate*, Vol. 10, pp.1616–1634.

About the author

Chris de Freitas is a climate scientist and Associate Professor in the School of Geography and Environmental Science at the University of Auckland, New Zealand. He is also an editor of the international science journal *Climate Research*. He was an expert reviewer of the 1995 and the 2001 Scientific Assessment Reports of UN's IPCC, and the UK Department of the Environment 1996 Report *Potential Effects of Climate Change in the United Kingdom.*

For further information contact: c.defreitas@aukland.ac.nz