Climate change and disaster losses: understanding and attributing losses and projections

Hervé Grenier [1]
AXA Re
Paris, France

Question 1: What factors account for the dramatically increasing costs of weather-related disasters (specifically, floods and storms) in recent decades?[2]

Losses (adjusted for inflation) caused by natural catastrophes, as defined by the US property insurance industry, have risen by a factor close to 100 between the 1950s and the past decade (Changnon et al. 2000). For a storm to create significant economic losses, two conditions have to be met: storm occurrence at a sufficiently high intensity, and exposition of vulnerable assets to this hazard. Losses increases have to be driven by one of these two factors, or recent appearance of new loss drivers.

Could part of these losses increases be driven by greenhouse induced global warming? Over the tropical North-Atlantic, the tropical cyclone record extends back to 1900. The North-Atlantic is the basin where data is the most complete, but it is only since 1970 that the data set is considered appropriate for detection of trends. Prior to that date, storms may have been missed. Post-1970 hurricane wind speed records indicate a clear increase in hurricane activity over the past decades (Emanuel 2005, Webster et al. 2005) which is well correlated with North-Atlantic Sea Surface Temperatures (SST) trend. At least part of this trend is attributed to anthropogenic activities (Pierce et al, 2006). However, even for this modern era record, there is some controversy in hurricane wind speed estimates (Landsea, 2005). Added to the short duration of the record, this makes Landsea (2005) question whether the observed recent increase in hurricane activity is forced by anthropogenic activities. Longer records over the US continent show that in the past, hurricane activity did fluctuate at multi-decadal time scales (Landsea 2005), and that these fluctuations correlate well with the principal modes of low-frequency variability in the Tropics (Bell and Chelliah 2006). This low-frequency tropical cyclone variability is evidenced through coherent behaviour of the entire circulation in the Tropics (Bell and Chelliah, 2006) and affects mostly the annual rate of occurrence of major events (Goldenberg et al. 2001). From the current literature, it is therefore not quite clear whether the recent increase in hurricane dissipation power (Emanuel 2005) is a manifestation of global warming (through SST increase) or whether it reflects natural climate variability, or a combination of both.

Modelling studies regarding the intensification of hurricanes as a result of warmer SSTs can help resolve this issue. Oouchi et al (2005) report results obtained with a very high horizontal resolution climate model (20 km grid resolution) that show an increase in maximum wind speed as a result of anthropogenic activities, but a significant decrease in cyclone frequency (except over the North-Atlantic). These results obtained with a model that explicitly resolves tropical cyclone circulations, are in line (in terms of intensity) with those reported by Knutson and Tuleya (2004) and with theoretical considerations (Emanuel 1987). However, it is worth noting that up to now, no trends in maximum hurricane wind speed have been detected from the data (Webster et al. 2005). One reason for this may be that hurricane maximum intensity has a short tail distribution and therefore an upper bound, obtained from theoretical considerations (Bister and Emanuel 1998, Emanuel 1999) or from modelling the data with extreme value distributions.

[1] The views expressed are those of the author and do not necessarily reflect the views of the AXA group

[2] Answer is provided in the context of the tropical cyclone discussion

Because storms only occasionally reach this theoretical upper limit, and because this particular moment in the storm life cycle may not be properly reported in 6-hourly records, it may be a while before trends in hurricane maximum intensity are actually detected from observational data.

Hurricane losses records properly normalized reflect the multi-decadal variability of hurricane activity over the North-Atlantic and the US coast, but do not reflect any long-term trend (Pielke and Landsea, 1998, Pielke 2005). For eleven years, the activity has been intense if not extreme across the North-Atlantic and losses are very significant over the past two years, but *normalized per-storm loss* does not show evidence of a trend over the 20th century (Pielke 2005). Over a sufficient amount of time, trends in hazard should manifest in trends in per-storm loss (after proper normalization, a manifestation of increasing severity), and/or trends in annualized cumulative losses (after normalization, a manifestation of increasing annual rate of occurrence). As none can be detected today, it seems premature to attribute recent hurricane losses to trends in hazards resulting from global warming, although following Trenberth (2005) we note that non-detecting does not enable to conclude regarding the existence.

Corrected for inflation, the cause of increasing disaster losses over the past century is for a very large fraction a result of increasing asset exposure to natural hazards (Changnon et al. 2000, Pielke 2005). In the past (centennial time scales) variability of natural geophysical hazards (including possible trends) has been orders of magnitude smaller than trend implied by economic or population growth: Hurricane Andrew loss estimate doubled in just 10 years because of migration and rise in assets values.

Recently, new loss drivers have contributed to record loss amounts. We specifically refer to demand surge, generally understood as the temporary increase in repair prices (building materials and labour costs) resulting from the surge of demand for rebuilding homes and services, following major events. Industry surveys, professional sources and CAT models vendor's communications indicate that in 2004 and 2005, demand surge was a very significant, non-linear component of the overall reported loss. Demand surge is a complex phenomenon, difficult to quantify and model, as it depends on micro- and macro-economical aspects, but also behavioural, environmental and political drivers. It is probably becoming an increasingly important component of the overall loss as the economy tends to operate in a particularly tense demand and supply environment. Another potential current and future loss driver is inflation of legal costs.

Question 2: What are the implications of these understandings, for both research and policy?

We provide an answer to this question in the context of assessing the economical cost of natural disasters for the society. Consequently, the metric needed for this assessment shall reflect the cost, for the society, of a given disaster economic loss. As the society – irrespective of the hazard occurring or even existing – evolves, the evolution of the cost for the society of a given natural hazard shall not reflect the overall society gradual move (economical growth, demography) but shall solely reflect the changes, in either the natural hazard itself or the society specific exposure and vulnerability to the natural hazard. A proper yearly metric reaching this goal can be defined as the yearly loss normalized by annually defined *cumulative nationwide asset*. This strongly relates to the GNP (Gross National Product). As stated above, this metric, the loss per asset value, or loss per GNP provides a time-varying view of the cost incurred by the society, undistorted by its overall evolution which occurs irrespective of the hazard, but which exemplifies specific factors affecting the loss itself. These specific factors are either geophysical, either societal:

- trends in natural hazard
- specific migration towards hazard-prone regions (meaning differential in coastal population growth versus overall nationwide population growth)
- modifications in exposure or vulnerability of assets exposed to the hazard (where, how, how vulnerable are assets).
- Sensitivity of the society to disaster losses (demand surge effects, claims litigation cost surge, …) different growth rate of the hazard-prone region compared to national growth rate

It is likely that only the first four factors are significant players in long-term variations of loss per asset value.   It is interesting to note that if for example we were to address the question of future disaster losses incurred, not by the society, but for example by the US insurance industry, the metric used would be different. It should only reflect changes in natural hazards, and changes in exposure and vulnerability of the insured assets (points 1 and 3 above).

This metric is also appropriate to consider when discussing virtues of climate mitigation policy versus society adaptation for natural disaster assessment. This debate can be phrased as, for the Society (in the future), which policy should be promoted now in order to reduce the cost for the Society of future natural hazards. Clearly, what matters is the cost incurred by the Society and therefore loss per GNP is a proper measure of cost.   The debate should therefore focus on comparing the benefit of society adaptation in reducing this loss per GNP, versus the benefit of reducing greenhouse gases emission in preventing any rise in this loss per asset value (taking as a possible scenario that loss per asset value could raise either by increasing storm frequency or severity).   It is clear that taking society adaptation measures to protect against natural catastrophes should be promoted as it provides valuable benefits to the society and the people, irrespective of increasing hazard. The same argument holds however for climate mitigation: it provides benefits by reducing impacts of climate change on the environment and the society, irrespective of whether climate change is responsible for more severe extreme events. Benefits of one policy versus the other is not straightforward to assess because of the complexity of societal behaviour affecting losses. In the future, loss per asset value could be reduced if enforcement of stronger construction codes results in reduced vulnerability, reliable warnings were issued in advance to the exposed population and protection measures of homes were taken, construction was promoted further inland in less vulnerable areas than right on the coast, flood defences be erected, better awareness of people through education and media communication that ends up in a reduction of the migration flow towards exposed areas, etc …

How to measure the sensitivity of the loss per asset value to specific measures? Risk models, because they incorporate all aspects of the risk (hazard, exposure, vulnerability, cost surge and loss estimate) are very good candidates to address these issues. Sensitivity experiments can be specifically designed to quantify for example, the reduction in cost the society can expect from certain adaptation measures (as well as from mitigation measures, see for example the ABI 2005 report). The insurance industry, the scientific and the private sector modelling community, policymakers and local communities would benefit mutually from using these risk models to assess the sensitivity of the loss to varying assumptions.

References

Association of British Insurers, 2005 : Financial Risks of Climate Change, *Climate Risk Management and Metroeconomica.*

Bell, G. D. and M. Chelliah, 2006 : Leading tropical modes associated with interannual and multidecadal fluctuations in North Atlantic hurricane activity, *J. Climate*, **19**, 590-612.

Changnon, S.A., R. A. Pielke Jr., D. Changnon, R. T. Sylves, R. Pulwarty, 2000 : Human factors explain the increased losses from weather and climate extremes, *Bull. Am. Meteor. Soc.*, **81**, 437-442.

Bister, M. and K. Emanuel, 1998: Dissipative heating and hurricane intensity, *Meteor. Atmos. Phys.*, **65**, 233-240.

Emanuel, K, 1987: The development of hurricane intensity on climate, *Nature*, **326**, 483-485.

Emanuel, K., 1999: Thermodynamic control of hurricane intensity, *Nature*, **401**, 665-669.

Emanuel, K., 2005: Increasing destructiveness of tropical cyclones over the past 30 years, *Nature,* **436**, 686-688.

Goldenberg, S. B., C. W. Landsea, A. M. Mestas-Nunez and W. M. Gray, 2001: The recent increase in Atlantic hurricane activity : causes and implications, *Science,* **293,** 474-479.

Knutson, T. R. and R. E. Tuleya, 2004 : Impact of CO2-induced warming on simulated hurricane intensity and precipitation : Sensitivity to the choice of climate model and convective parameterization, *J. Climate*, **17**, 3477-3495.

Oouchi, K., J. Yoshimura, H. Yoshimura, R. Mizuta, S. Kusunoki and A. Noda, 2005: Tropical cyclone climatology in global-warming climate as simulated in a 20 km-mesh global atmospheric model : frequency and wind intensity analyses, *J. Meteor. Soc. Jap.*, accepted.

Pielke R. A. Jr., and C. Landsea, 1998 : Normalized hurricane damages in the US : 1925-1995, *Wea. Forec.* , **13**, 621-631.

Pielke, R. A. Jr., 2005: Are there trends in hurricane destruction? *Nature,* **438**, 686-688.

Pierce, D. W., T. P. Barnett, K. M. AchutaRao, and P. J. Gleckler, 2006 : Anthropogenic warming of the oceans : Observations and model results, *J. Climate*, 19, 1873-1900.

Trenberth, K., 2005: Uncertainty in hurricanes and global warming, *Science*, **308**, 1753-1745.

Webster, P.J., G.J. Holland, J.A. Curry and H.-R. Chang, 2005: Changes in tropical cyclone number, duration and intensity in a warming environment, *Science*, **309**, 1844-1846