Climate change, one decade at a time

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Climate change is happening now, and further changes during the next decades are inevitable (IPCC, 2007). During the last century, the global climate warmed by about 0.7°C. At the same time, there were distinct changes in rainfall patterns, an increase in both frequency and severity of extreme weather events, and a rise in sea levels. The impacts of these changes are already being felt, and will intensify as further changes take place. Another 2–4°C rise is projected for the current century, mostly as a result of greenhouse gases that have already been emitted. This means that, although aggressive mitigation of greenhouse gas emissions is crucial to prevent longer term, potentially catastrophic changes, most of the changes projected for the coming decades cannot be avoided.

On the one hand, index insurance is being promoted as a useful tool for climate change adaptation[1], because it helps farmers and governments (amongst others) to mitigate and better respond to climate related risks. On the other hand, climate change, by changing the frequency and occurrence of risk over time, has an important implication for the long-term affordability and profitability of index-based financial products (and hence for the willingness of the industry to invest in new markets). Indeed, a recent analysis from Hochrainer et al (2008) demonstrates that it may be worthwhile for index insurance projects to adapt as climate change unfolds. Climate science and information can potentially help to better understand and manage these concerns.

To ensure sustainability of index insurance over time, two important questions need addressing: how well does index insurance buffer against climate change, and how can we better design index insurance products given climate change. Both questions rely on understanding the future climate. Here we focus on the "near term" climate change (over one or more decades, usually involving predictions over the next 10–30 years), which lies at the intersection between year-to-year climate variability and climate change. In contrast to climate change, this timescale has immediate relevance to strategic planning, and is consequently the subject of much ongoing research.

"Near-term" climate change

In the modeling community, climatic fluctuations occurring over the next few decades are often referred to as "decadal variability," and the distinction between it and climate change is more than academic. Decadal variability implicitly refers to a set of climate *processes* that effectively differ from those of climate change as discussed in IPCC assessments. Climate changes experienced over the next few decades can in fact be thought of as a *superposition*, of the centennial-scale trends forced by increasing concentrations of greenhouse gases that mankind has added (and continues to add) to the atmosphere, and decadal variations that arise from natural processes internal to the climate system.

It is important to make a distinction between these two components of near-term climate change, because they have differing implications with respect to predictability: While the climate tendencies

[1] i.e. see for example, the Bali Action Plan, which will help frame the post-Kyoto Protocol agreement under the UNFCCC, calling for "“…Enhanced action on adaptation, including, inter alia, consideration of risk management and risk reduction strategies, including risk sharing and transfer mechanisms such as insurance" (UNFCCC, 2007).

resulting from so-called anthropogenic forcing have been extensively studied and are relatively well understood (though modeling the intermediary processes is still far from perfect), the same cannot be said about the processes underlying decadal variations. Most, if not all, such processes are lacking satisfactory theoretical explanations, limiting predictive capacity. Attempts to assess the potential of decadal forecasts, using climate models in which the climate system – most importantly the subsurface ocean - is initialized (i.e., brought to a quasi-realistic state) are just now being undertaken for the first time (Smith et al., Keenlyside et al.) Decadal variability will be a focus of the fifth (i.e., next) assessment report of the IPCC; it presently remains very much an emerging science.

Currently, GCMs generally perform poorly at reproducing decadal modes of variability. Over the next few decades, this information is particularly relevant if the decision maker is interested in acting on these variations. An example of the relative magnitude of climate variability at different time scales is shown in Figure 1. The figure was constructed by partitioning the total variability observed in annual rainfall in the Sahel for the period 1900-2006. Panel (a) shows the rainfall variability at the long-term (linear trend in the last 100 years), the scale that is usually called “climate change”. The second panel (b) shows the variations of rainfall measured at the decadal scale (after removing the linear trend), and reveals decades when rainfall tended to be above average (e.g., the 1950’s and the early 1960’s) and decades when rainfall tended to be below average (e.g., the 1970’s and 1980’s). Finally, panel (c) shows the variability of rainfall in the year-to-year time scale that remains after removing the linear and the decadal trends. The figure shows the relative magnitude of the rainfall variability at these three temporal scales as measured by the percent of the total variance explained by each temporal scale. The proportion of total variance explained by the short-term (interannual) variability is 3 times greater than the corresponding to the long-term variability (“climate change”), and 2 times greater than that of the decadal variability.

Thus, a possible approach to introduce the issue of “adaptation to climate change” into the policy and development agendas is to consider the longer-term variations (“climate change”) as part of the continuum of the total climate variability, from seasons to decades to centuries, and generate information at the temporal scale that is relevant and applicable for the particular time frames or planning horizons of the different decisions. This approach allows considering “climate change” as a problem of the present (as opposed to a problem of the future) and aims to inform the decision-making, planning and policy-making processes, in order to reduce current and potential future vulnerabilities to climate variability and change.

Implications for index insurance

Near-term climate change, including both anthropogenic and internal components, comes to bear on our expectations about climate during the next few decades, and it is these expectations, in one form or another, on which index insurance is based. But since decadal forecasts do not yet exist, how can such information be utilized in the insurance setting? A possible answer lies in attempting to *characterize* decadal fluctuations in regional historical records: Do such fluctuations exist? What is their amplitude, relative to expected climate trends over the next few decades? What can paleorecords tell us about this component in the spectrum of regional climate variability? With such information in hand it may be possible to better estimate the envelope of uncertainty surrounding climate projections based on the response to anthropogenic forcing.

Application of different temporal scale analysis to index insurance

Preliminary research is currently underway at IRI exploring how hypothetical index insurance contracts might respond to decadal changes in climate. In this study, rainfall-based drought index insurance contracts are explored under several climate change scenarios, with the resulting trends in precipitation being added to simulated inter annual climate variability to 2100. In one set of simulations, the thresholds for contract payout are fixed at values determined from the historical record, and the payout frequency proves to be quite responsive to the trend in rainfall created by the climate change scenario. In another set of simulations, the thresholds themselves evolve over time on the basis of a roughly 30 year long sliding window of time that serves as the reference point for an individual year's threshold calculation. Under this construction, the payout frequency is considerably more stable and less sensitive to the systematic shifts in climate, although some small trends in payout frequency remain. Figures 2a and 2b provide an illustration of these points under the assumption of a simulated 10% decline in rainfall for the period from 2009-2100 for Dertu, Kenya. The proposed contract has a two-tiered structure with a smaller payout for events that cross the 1/8 drought threshold and a larger payout for events that cross the 1/20 drought threshold.

Scaling up (or down)

It is axiomatic that climate projections are more reliable for larger spatial scales. This idea underlies the emphasis, in IPCC assessments, on regions of continental or subcontinental scale. If information is sought for much smaller areas – a watershed, catchment or valley – available climate projections will almost certainly have to be *downscaled* in order to infer it. Given the very large-scale nature of the forcing, probabilities of an expected impact typically will not between neighboring localities. Specific amounts and characteristics of variability may be better quantified locally; however, uncertainties will increase. So although interventions may begin at the smallest spatial (or social) scales, for climate information the situation is reversed. It is possible to conduct analyses on records from particular weather stations, e.g., but such records often have low signal-to-noise ratios, particularly for rainfall; it is for this reason that such records are often aggregated. It may also be possible to *combine* information across a range of spatial scales in order to generate some sort of optimal projection. This would be a research question deserving of investigation.

References

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Figure 1: Partition of the total observed rainfall variability in the Sahel. Rainfall is expressed as anomalies (i.e., deviations from the mean annual rainfall of 1900-2006). (a) long-term variability (linear trend), (b) decadal variability (after removing the linear trend), (c) inter-annual variability (after removing the linear and decadal trends)

(a)

(b)

(c)

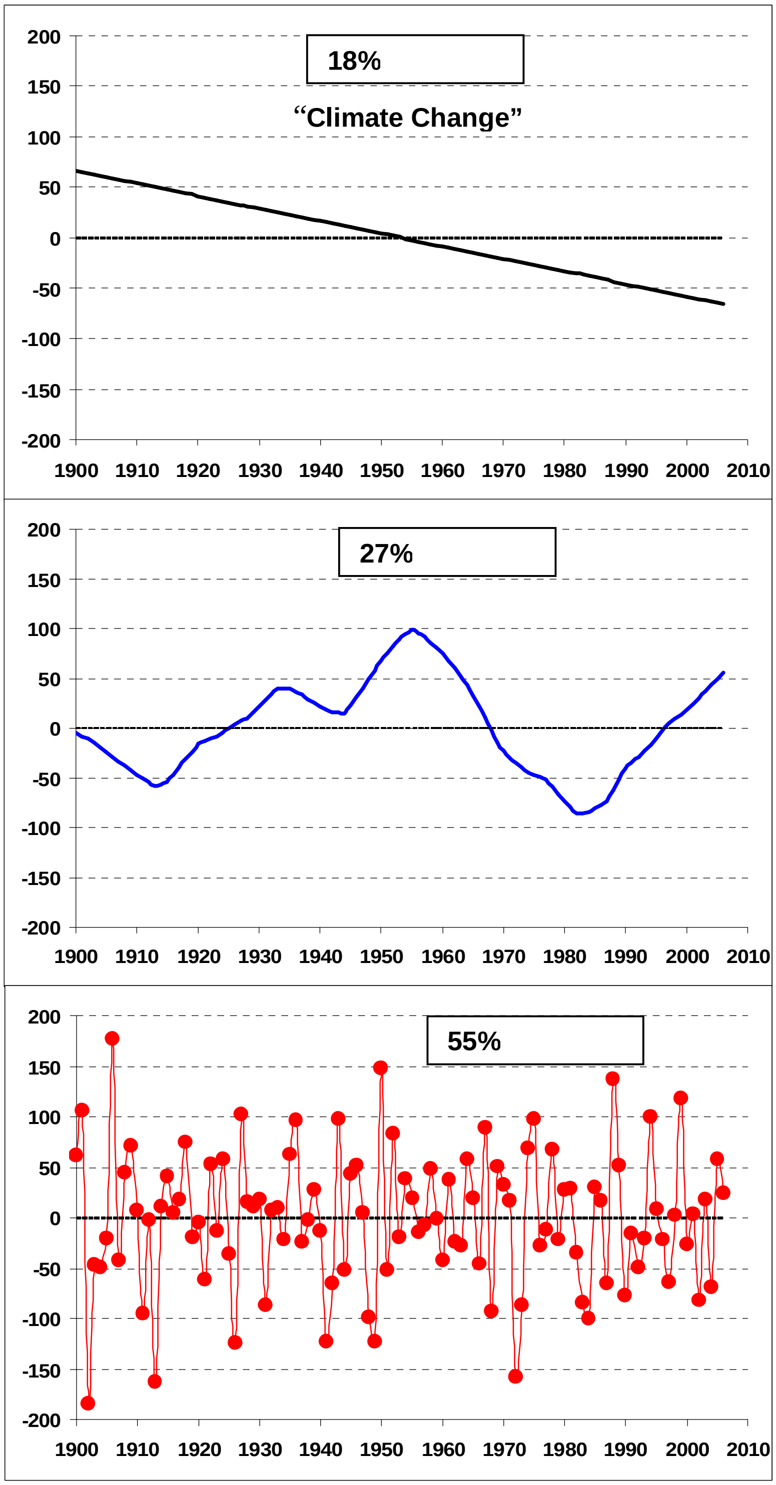

Figure 2: A steady decrease in seasonal rainfall over the 21st century would have a profound impact for livelihoods in Sub-Saharan Africa. However, ongoing research at the IRI shows that index insurance can still be a robust risk management tool even in a changing climate. The simulation below shows the effects of an anticipated 10% decrease in rainfall on an index insurance contract for a village in Eastern Kenya. If the thresholds agreed upon for a 2008 contract are held constant through 2100 (a), a 1 in 20 threshold pays out twice as frequently (1 in 10), and a 1 in 8 threshold pays out nearly twice as often (1 in 5). If thresholds are instead allowed to change with the most recent 30 years of data (b), the increase in payout frequency is not as severe.

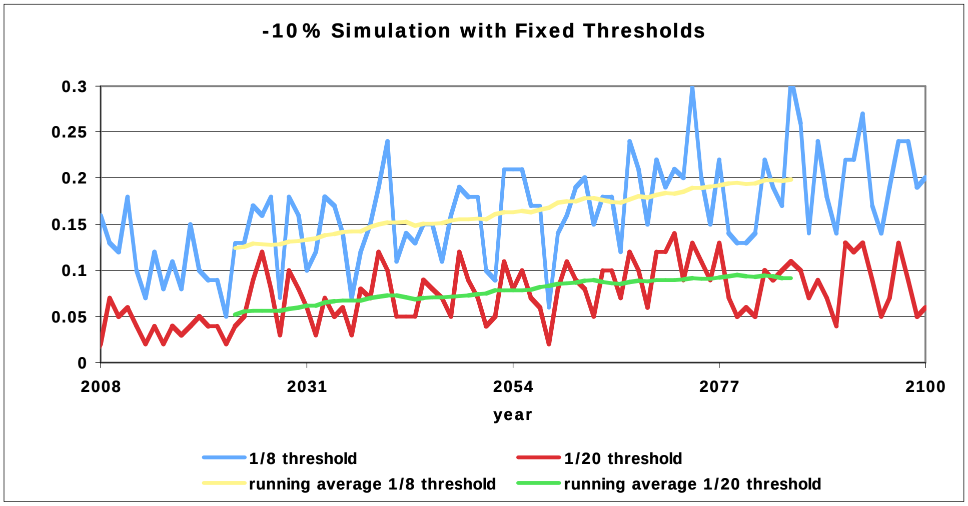

Figure 2b.