Analysis of Future Potential of Index Insurance in West Africa using CMIP5 GCM results

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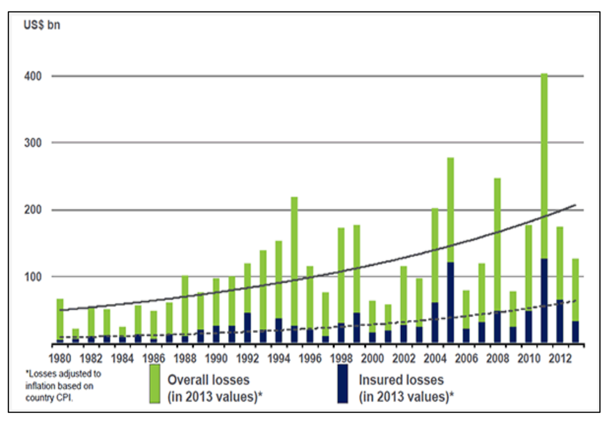
Introduction

Global and regional climate change pose a significant threat to life and livelihoods around the world, particularly in the developing world. Extreme events, in particular have a disproportionate impact on life and livelihood. Insured and uninsured losses from natural disasters have increased substantially in recent years, due in large part to changes in exposure, but also in response to evolving probabilities of hazard.

Globally, financing for adaptation is far short of estimated need, despite recent events (US/China cooperation and 3 billion USD to Green Climate Fund). There is a need for market based, scalable adaptations to serve the needs of the global poor.



Munich Re

Index Insurance

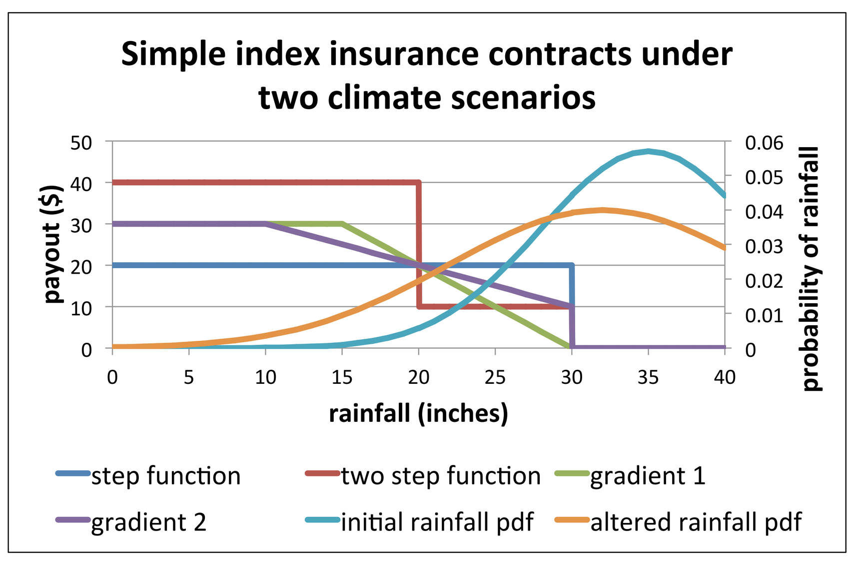
Weather based index insurance (particularly for subsistence agriculture) is perceived as a potentially attractive mechanism towards this end, as it avoids moral hazard, can pay out quickly and has lower transaction costs than loss based insurance. Index insurance is a type of insurance based simply on whether an index reaches a certain trigger or “strike” level. Weather index insurance contracts can be written on the basis of rainfall, temperature, streamflow, vegetation cover, soil moisture, etc., and can be designed to address livelihood risks associated with drought, flooding, temperature extremes, etc..

Climate science research indicates that the probabilities of extreme events are highly sensitive to changes in the background state of the climate system on multiple time scales. This will have critical implications for the payout frequency and financial viability of index insurance over time as actuarially fair index insurance premiums are based on the probability of an extreme event (p) and the payout function (y). For drought and flood index insurance contracts based on rainfall (r), these premiums are given by the equations

$$P_d = \int_0^{rstrike} p(r)y(r)\,dr$$

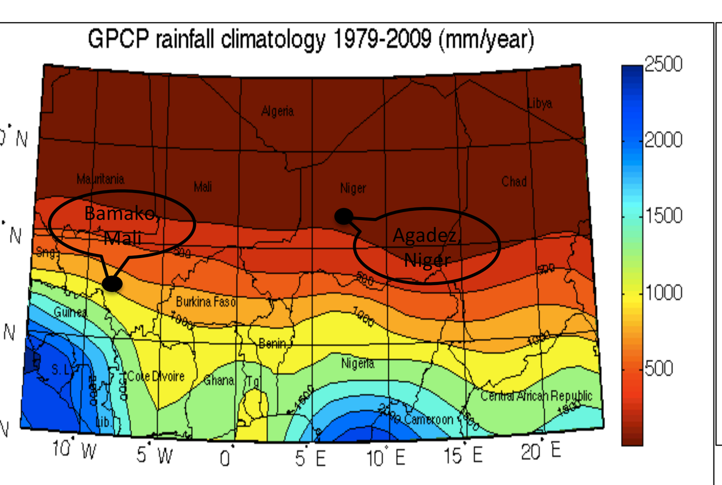
$$P_f = \int_{rstrike}^{\infty} p(r)y(r)\,dr$$

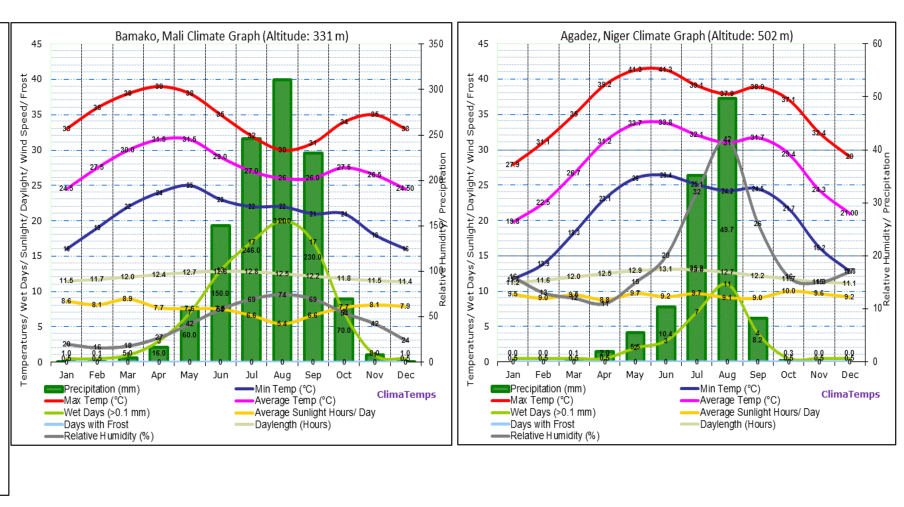
Price	Step function	2 step function	Gradient 1	Gradient 2
Initial (wetter) climate	$4.76	$2.86	$1.72	$3.24
altered (drier) climate	$8.41	$7.66	$5.40	$7.03

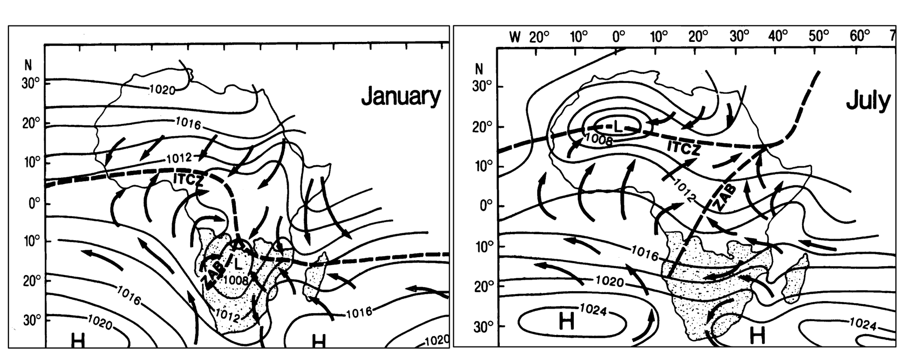


West African Climate

The climate of West Africa has a strong south-north precipitation gradient. The semi-arid region, known as the Sahel has a hot climate with a uni-modal rainy season with the boreal summer months June-October being the rainy season. The rainy season is brought about by onshore winds advecting moisture laden air from the Gulf of Guinea into the African interior. The wind direction is induced by a thermal low pressure system that sets up over the Sahara desert and northern Sahel during the boreal summer.





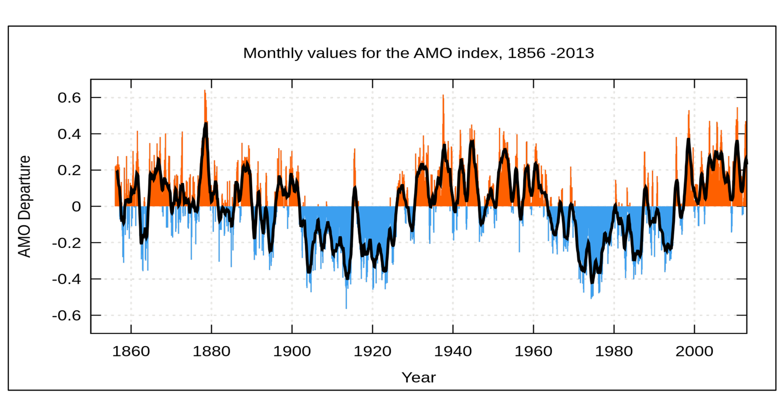


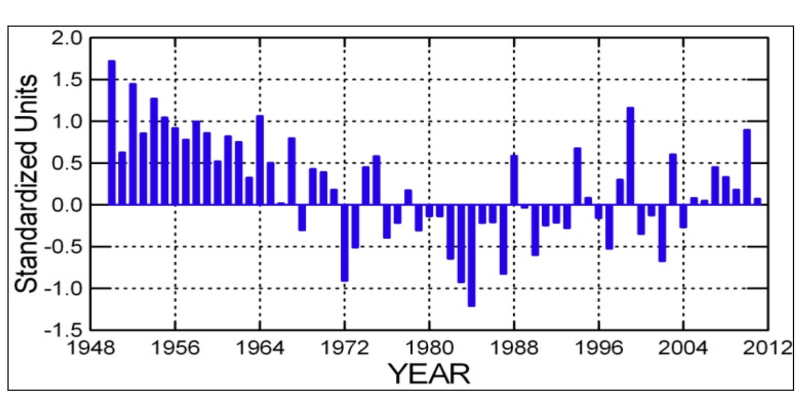
Trzaska, 2008

West African rainfall variability has several timescales, but has a particularly pronounced multi-decadal signature.

Wet period in the 1950s/1960s, dry period in the 1970s/1980s and a return to wetter conditions in the last 20 years.

This is well correlated with the Atlantic Multi-decadal Oscillation.

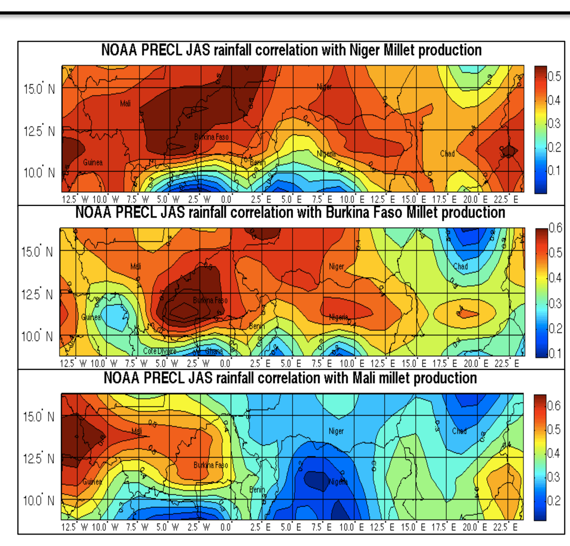




Index Selection

Regional rainfall was well correlated with national millet production in Niger, Burkina Faso and Mali, making rainfall a basis for drought insurance for the subsistence millet crop.

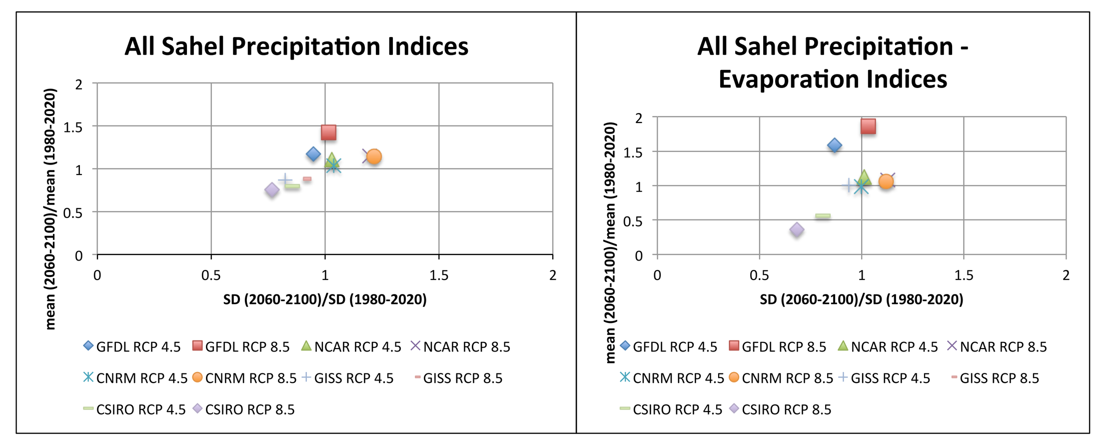
December streamflow at Niamey was well correlated (negatively) with irrigated rice production in Niger, making December streamflow a basis for flood insurance for the irrigated rice crop.



Global Climate Model Data

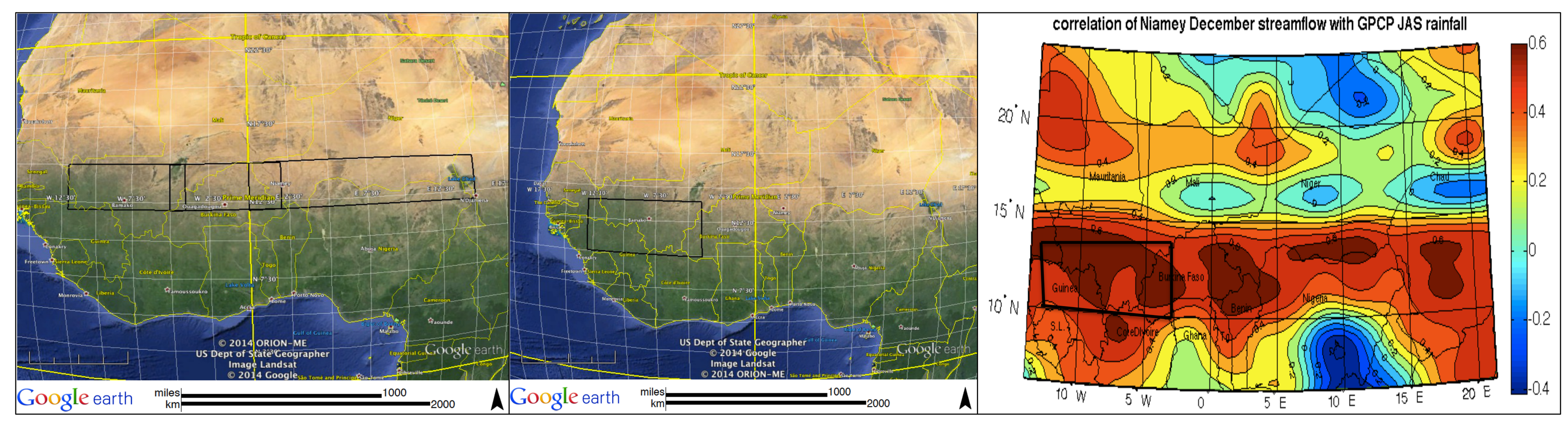
GFDL CM 3: strong wetting
NCAR CCSM4: moderate wetting
CNRM CM5: moderate wetting
GISS E2H: moderate drying
CSIRO MK 3.6: strong drying

Evaporation trends differ between models, but tend to be the same sign as precipitation trends.



Selection of sub-regions

All Sahel indices based on 10-20N, 15W to 20E. Country specific boxes for Mali (12W to 4W), Burkina Faso (5W to 2E) and Niger (0 to 15E), all boxes (12 to 15N). Upper Niger Basin box for flooding risk (10 to 14N, 4 to 13W).

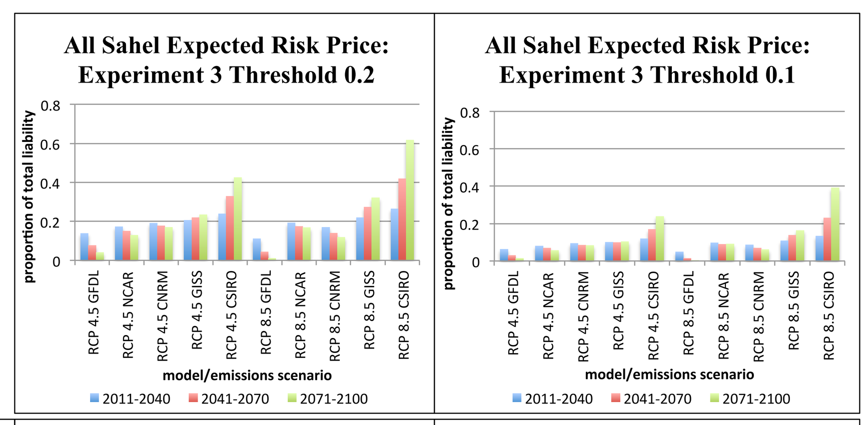


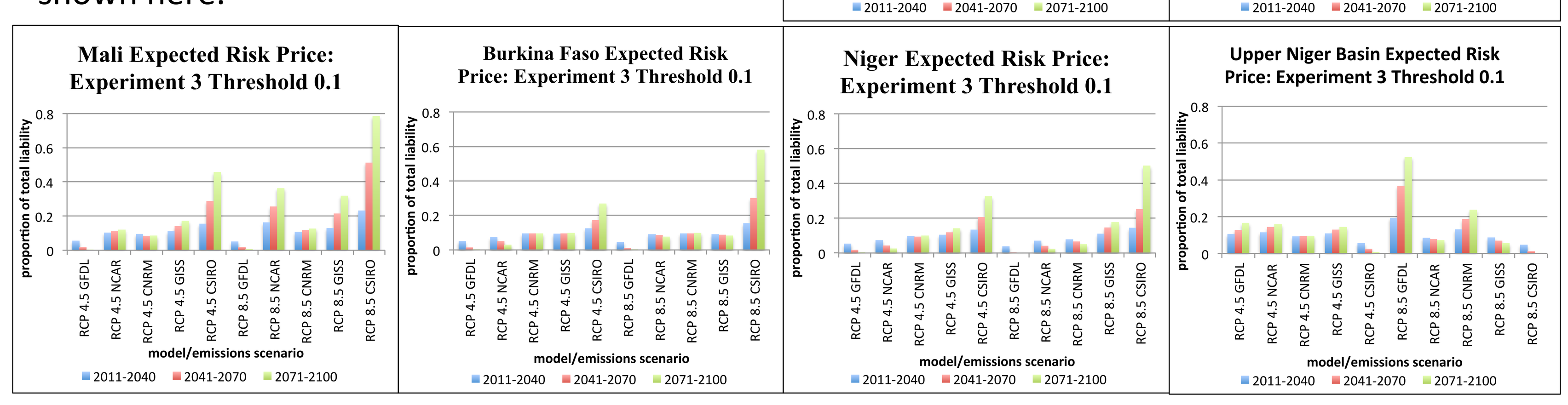
Methodology and Actuarial Price Results

Monte Carlo simulation based on GCM trends.

Experiment 1: variance change only
Experiment 2: mean change only
Experiment 3: mean and variance change

Effects of mean change dominate effects of variance change. Results of Experiment 3 shown here.

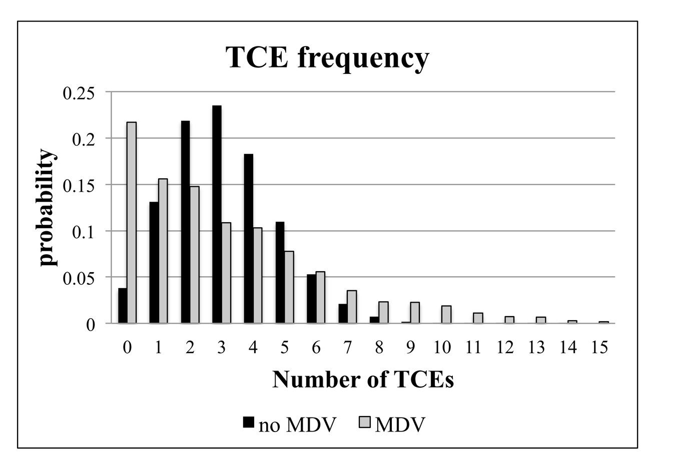


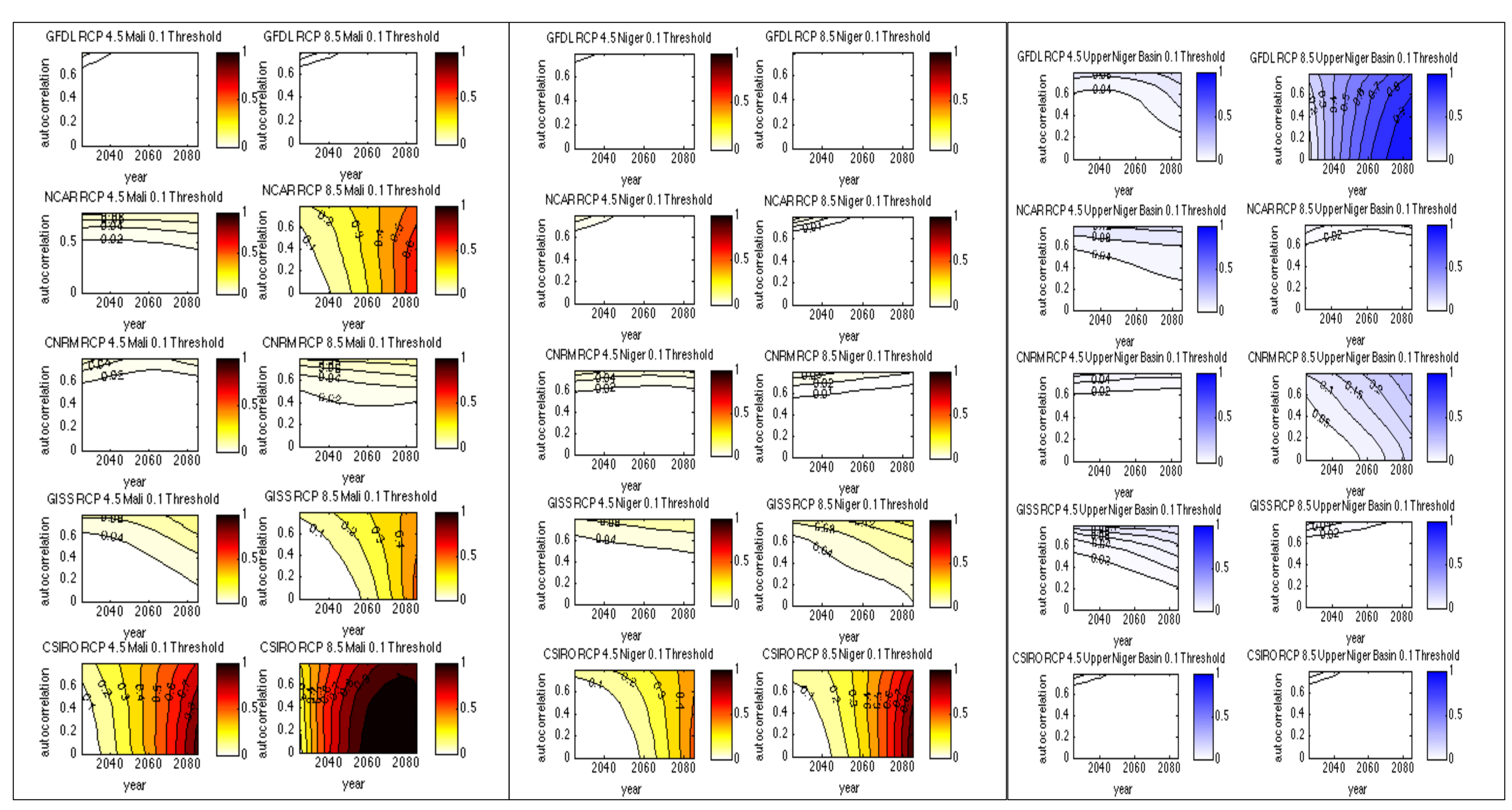


Role of Multi-decadal Variability in Default Risk

Multi-decadal variability (MDV) plays an integral role in shaping the range of extreme event outcomes. In this analysis, MDV is modeled by a lag 1 year autoregressive process with a range of different autocorrelation values to simulate different strengths of MDV.

The probability of a large number of extreme events in a short period (as modeled by Monte Carlo methods) is an indication of default risk and would factor into index insurance “loading costs”.





Probability of 10 or more extreme events in a 30 year period.
Left panel: drought risk Mali; Center panel: drought risk Niger; Right panel: flood risk Upper Niger Basin

Conclusions and Future Work

- Changes in the mean climatology tend to have a larger impact on extreme event frequency (and actuarial price) than do changes in variability.
- MDV can play a significant role in the expected default risk and loading costs.
- Trajectories of premium in an adaptive framework are highly contingent on regional climate evolution.
- **Need to model impacts of evolving higher order parameters (temporally evolving skew)**
- **Need for more refined modeling of tail behavior and degrees of extremity for more complex payout functions**
- **Need to explore more thoroughly impact of heat stress on water balance and use water balance as basis for contract**