

# From Climate Predictions to Socio-Economic Forecasts: **Steps towards a Forecast System for the Insurance Industry**

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## **Introduction**

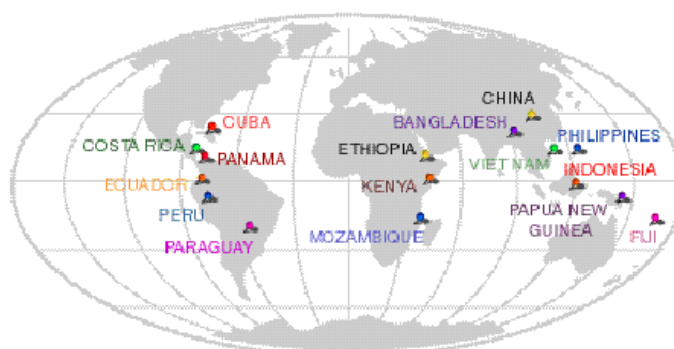
Large scale climate variability influences economics worldwide. The most prominent example in this context is the El Niño – Southern Oscillation (ENSO) phenomenon in the Central Pacific. Recognizing and understanding relationships between climate and economics may provide a valuable source of information. Combining this knowledge with nowadays available long range climate forecasts would substantially help companies operating in climate sensitive fields.

The transformation of climate forecasts into useful information, however, is far away from being straight forward. First of all, the noisy character of both, climate and economics makes it extremely difficult to identify dominant links, to understand the dynamics, and to exploit them. Furthermore, long range climate forecasts are not easy to interpret. Advanced transformation algorithms are needed. This includes the transformation of climate information into socio-economic predictions, methods to deal with imperfect forecasts in a probabilistic manner, forecasting complex dynamical systems, and comprehensive cost benefit analyses.

In this article we give a brief description of work that we did so far to develop a forecast system useful for the re-insurance industry. We combine MIKAN's climate expertise with advanced modeling methods. Climate forecasts and socio-economic variables are transformed into predictions of insured damages. Lead times range from 3 to 6 months. First results from a feasibility study show that we achieve significant predictive skill on these time scales. The system successfully predicts a proxy for potential damages in South-East-Asia over a period of 5 years.

## Teleconnections and Impacts

The ENSO phenomenon itself is not considered as a disaster. However, extreme ENSO events may change substantially the likelihood of disasters far away from its origin in the Pacific Ocean. Those changes occur through a global disruption of the large scale atmospheric circulation. Scientists refer to the process of associating a climate anomaly or its societal impact with a climate phenomenon, thousands of miles away from



**Figure 1:** Examples of developing countries that are severely affected by ENSO

the actual climate phenomenon, as one of “attribution.” The relationship is referred to as a “teleconnection.” Teleconnections can be identified by observing physical processes or by statistical studies. Teleconnections are not limited to natural hazards like droughts, storms or floods but include societal and economic disasters like infectious disease outbreak and financial damages related to natural hazards.

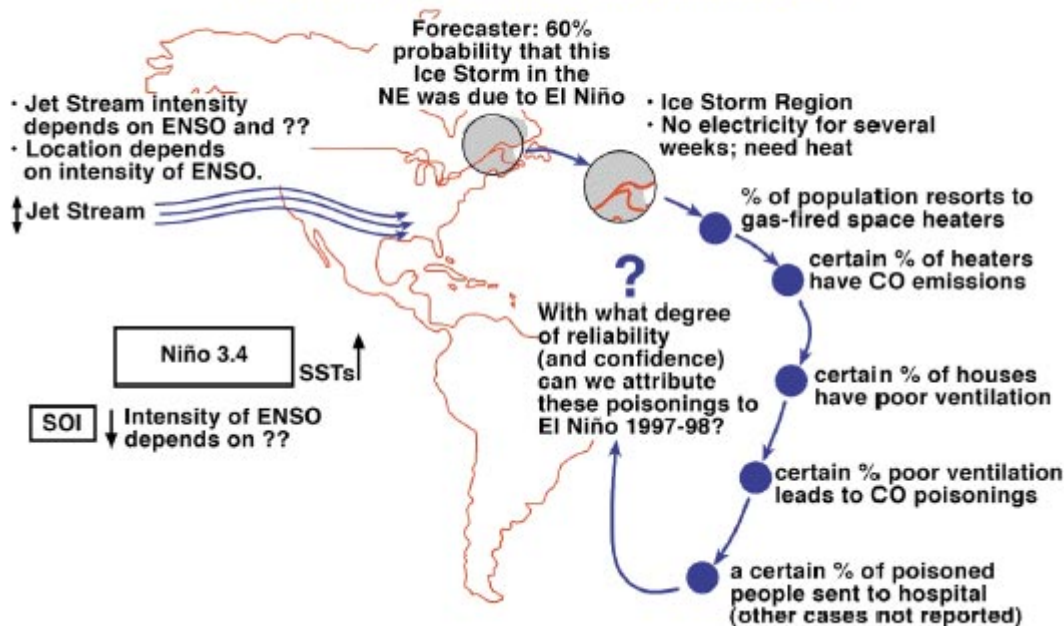
Large scale climate phenomena like ENSO may have various impacts. Most obvious are direct effects like droughts, floods, storms, frost and consequences directly related to them. Less obvious but equally important are infectious disease outbreaks, crop yield, bush fires, and in some cases even political consequences.

## The Problem with Long Causal Chains

Modeling each step of a long causal chain is often difficult if not impossible. Because several different kinds of hazards can occur in a country simultaneously, it can be difficult (but not impossible) to attribute with certainty a particular societal impact to a specific hazard. For example, the 1991–92 El Niño occurred at the same time as a major drought and the eruption of Mt. Pinatubo in the Philippines. To what extent was the drought influenced by El Niño, the eruption, or some combination of the two?

A famous January 1998 ice storm in Canada is another example of the problem of attribution. It appears (from research) that the El Niño may have been a contributing factor to this damaging ice storm. However, it is not possible to draw a general conclusion about the influence of El Niño events on the formation of major ice storms over eastern Canada. The situation becomes even more difficult, if not hopeless, if one wants, for instance, attribute the number of CO poisoned people to El Niño (see figure below).

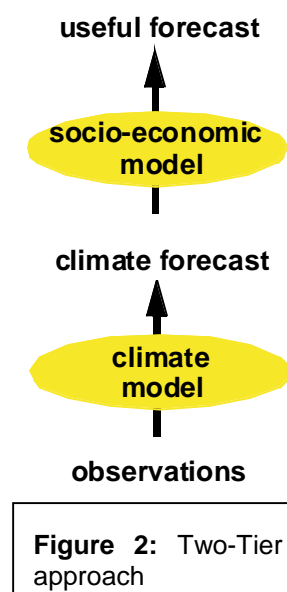
### Problem of Attribution of Impacts to ENSO (An Example: January 1998 Ice Storm)



### A Two-Tier Approach

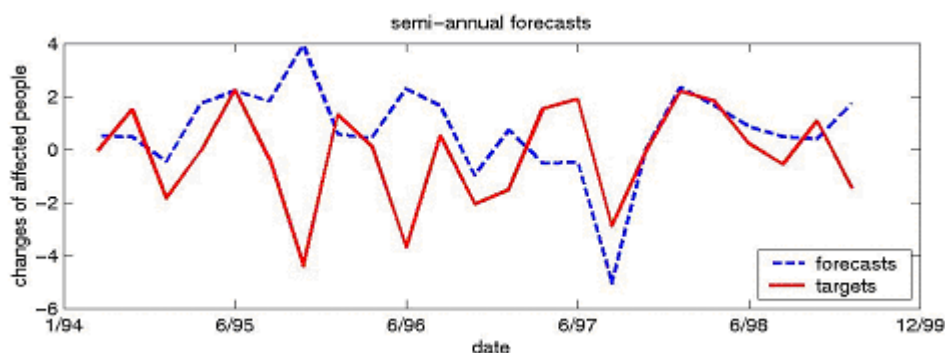
To overcome the difficulties with long causal chains we chose what we call a “Two-Tier Approach”. That means we combine preprocessed climate data and economic indices and project them directly onto the variable of interest, without attempting to model all the intermediate steps.

In the present case we used two generalized climate indices and a range of economic indices - like GDP, inflation rate, population growth amongst others. Those were projected onto the number of people in South-East Asia, affected by natural catastrophes using advanced neural networks. We chose this output variable since it can be used as a proxy for insured damages. Thus we obtain a model for the relationship between climate and economy on one side and a proxy for insured damages on the other side. Once such a model has been found it can be used to transform climate and economic forecasts into predictions of insured damages.



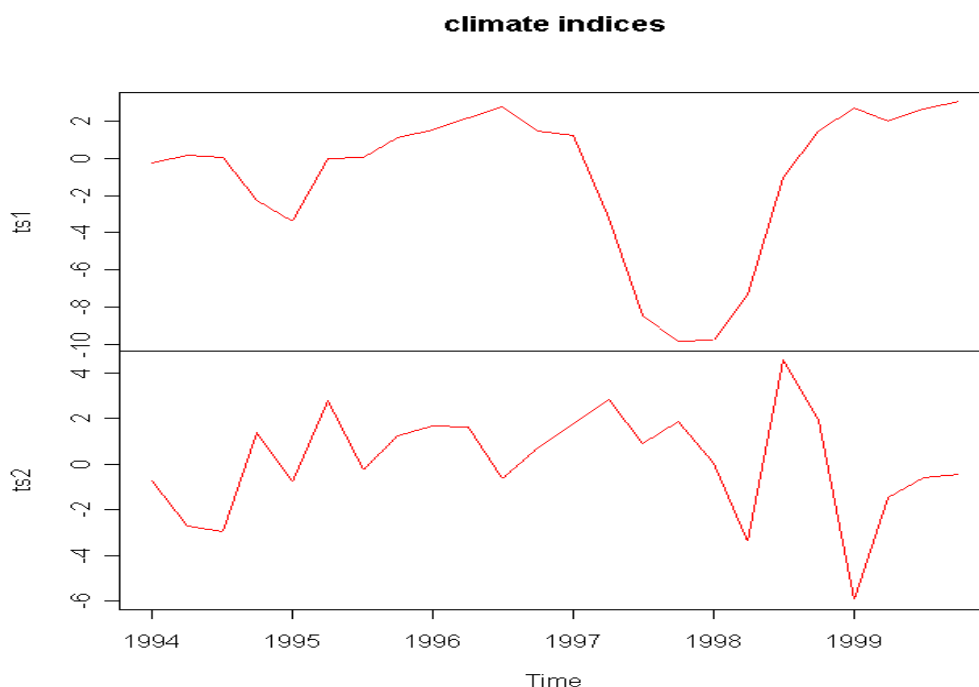
## First Results

First results obtained with an approach as described above are very promising. Data from January 1980 to December 1993 were used to train a recurrent neural network. To validate the resulting model we predicted the period January 1994 to December 1999. The results are shown in the figure below.



**Figure 3:** Semi-annual forecasts of the number of people affected by climate induced catastrophes in South East Asia (test set: 1/94 – 12/99). Especially during periods of strong climate signals (6/97 – 12/99) the model shows high predictive skills.

Especially in periods with strong climate signals (1994 to 1995 and 1997 to 1999) the model shows good predictive skill. In Figure 4 we show the climate time series for the same period.



**Figure 4:** Climate time series for the test period. The climate time series are projections of climate observations onto the first two principal components obtained from 10 different climate indices.

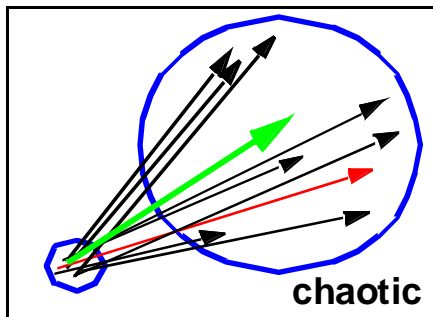
It can be seen that the relationship between climate and damage is far more complicated than a simple correlation.

It is interesting to note that the best forecast results are obtained when climate and economic indices are used as input variables. Using only climate or only economic data deteriorates the predictive skill substantially (not shown here).

### Imperfect Forecasts and Risk Evaluation

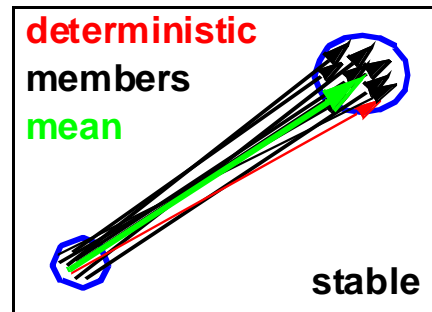
So far our forecast system is fine, but unfortunately not perfect. There are periods when the number of affected people is not predicted correctly.

In order to deal with imperfect forecast systems a probabilistic approach is needed. Instead of a single deterministic forecast an ensemble prediction is carried out. Such a system does not only predict the further evolution but provides the user with the reality (uncertainty) of the forecast.



**Figure 6:** chaotic forecast situation

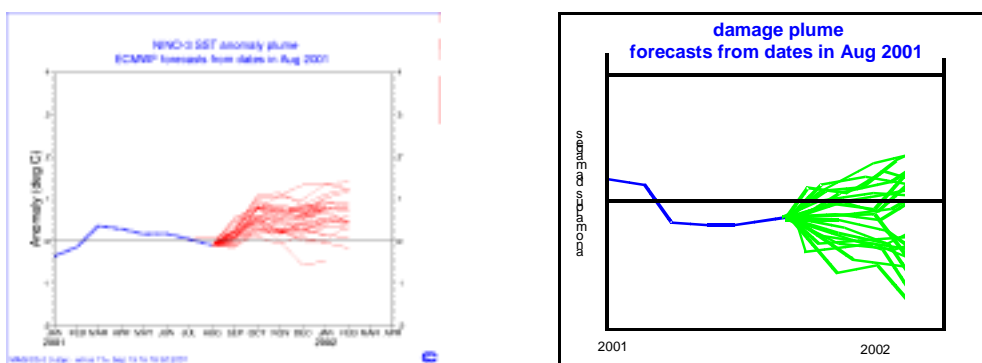
Uncertainties of the initial state are taken into account and information about the possible range of the further evolution of the system is given. Furthermore it enables the user to distinguish between stable and chaotic forecast situation, which is essential to make full use of a forecast during a decision making process.



**Figure 5:** stable forecast situation

The probabilistic approach can be applied in the following way. One takes an ensemble of climate and economic forecasts as input. A statistical model is then applied to each possible combination of those forecasts and thus yields a large ensemble of predictions of potential damages.

To make full use of such an approach it is essential to use non-linear projection models. Only in this case one may obtain a realistic probability distribution for the variable of interest. Thus climate probability distributions are transformed into damage probability distributions in a fully non-linear way (see figure below).



**Figure 7:** transformation of probability distributions

## An Integrated Forecast System

Combining the Two-Tier approach with a probabilistic prediction scheme yields a comprehensive forecast system. This system must be completed with a validation module and with a decision support model to make full use of the approach. Schematically such a system has the following structure :

- Determine a range of socio-economic models from historical data (e.g. storms, droughts, flooding, ...)
- Process the climate and economic forecasts
- Run the socio-economic model forced with the ensemble climate and economic forecasts
- Validate the ensemble prediction
- Apply decision support models
- Repeat the above steps on a permanent basis to provide high-quality predictions

## More application

The usefulness of forecast systems that transform climate information into socio-economic predictions is not limited to the insurance industry. Other branches of interest are electricity producers, food producers, commodity traders, and the tourism industry amongst others.

In this article we spoke mainly about ENSO and its impact on the economy. However, there are more large scale climate phenomena. Examples are the North Atlantic Oscillation (NAO), the Pacific North America Pattern (PNA) or the Quasi-biennale Oscillation (QBO). Some of those might be even more relevant for the US and Europe than the ENSO phenomenon.