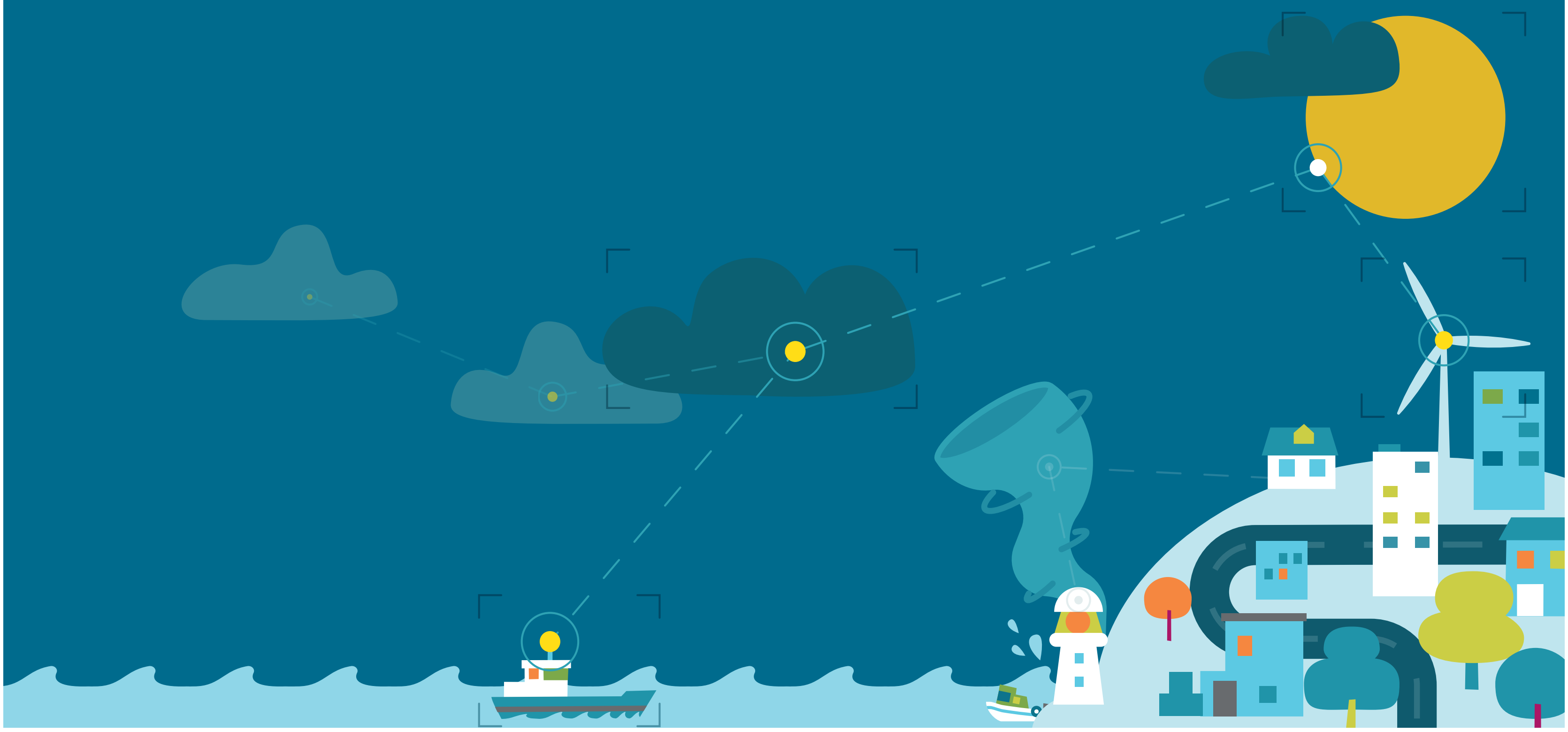
Focus

#18 - November 2015

Climate Risk Modelling

with awareness
of economic, climate
and policy related issues



SCOR Global P&C

CONTENTS

The following publication aims to provide an insight into the discussions which took place during the SCOR Foundation seminar on Climate Risks on 9-10 June 2015 in Paris.

In anticipation of COP21 which will take place in December in Paris, the seminar was organised in partnership with the Toulouse School of Economics (TSE), the Geneva Association and the SCOR Foundation. Climatologists, economists, modellers, actuaries, and (re)insurance industry professionals were brought together to this conference to reflect on climate risks and their insurability.

The SCOR Foundation seminar on Climate Risks is labelled by COP21.

EFFECTIVE INSTITUTIONS AGAINST CLIMATE CHANGE

Jean Tirole, Chairman of Toulouse School of Economics (TSE) and Nobel Prize in Economics

JEAN TIROLE
Chairman of Toulouse School of Economics (TSE)
and Nobel Prize in Economics

Jean Tirole is Chairman of the Toulouse School of Economics and of the Institute for Advanced Study in Toulouse, Scientific Director of the Industrial Economics Institute (IDEI) at the University of Toulouse Capitole, and Visiting Professor at the Massachusetts Institute of Technology (MIT). He is the laureate of numerous distinctions, including the Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2014. Jean Tirole has been collaborating with SCOR and its foundation for a number of years. Concerned about the current stage of the climate talks, he shares what he believes need to be done in order to create an effective international agreement.

Incentives & Carbon Price

Climate action is a tragedy of the commons. In the long run, all countries will benefit from lower CO2 emissions, but the current challenge is providing countries with the right incentives to participate today. Reducing CO2 emissions will be costly for many countries; therefore, **it is easier to leave the burden of reducing greenhouse gas emissions (GHG) to others**. To create an efficient agreement, rich counties must be more generous, and poor countries need to be more willing to participate since the controlling of their emissions is required in order to keep with the 2°C target. There is a need for climate policies to incorporate economic instruments, notably by setting a price on carbon. There are two main ways to do this, either through a carbon tax or through a cap and trade mechanism. In the former, countries collect a tax revenue per ton of carbon released into the atmosphere by polluters. The latter, which is more easily enforceable, fixes worldwide **the total amount of emissions permissible and allocates permits**. Parties can trade the permits among themselves, leading to a market price. If parties have enough permits to cover pollution, they sell the excess on the market, and if they have too few, then they buy some. The goal in either case is to encourage green investment with foreseeable increases in future carbon prices while discouraging the use of carbon-intensive technologies.

Monitoring & Enforcement

A very important issue is that of monitoring and enforcing a cap and trade mechanism. Independent **satellites can measure the pollution of a country every year while also encouraging good governance**. To enforce these mechanisms, J. Tirole advocates for the use of sanctions by the World Trade Organization for noncomplying countries. Likewise, when emissions surpass the amount of permits held by a country, a solution could be to add the amount to the sovereign debt of the country. As the COP21 is less than 3 months away, **agreeing on the principle of a worldwide carbon pricing (either a carbon tax or a cap-and-trade mechanism), integrating, monitoring and enforcement mechanisms, and setting a timetable for negotiations concerning transfers (Green Fund), while not ideal, would be a great and realistic stride forward**.

INTRODUCTION TO CLIMATE RISK MODELLING

Claire Souch, Head of model development & evaluation, SCOR Global P&C

DR. CLAIRE SOUCH
Head of Model Development & Evaluation,
SCOR Global P&C

Claire leads SCOR's global nat cat model development and evaluation function, responsible for establishing SCOR's view of risk across the business. She also coordinates SCOR's collaborations with academic partners, industry-science initiatives and provides input into group risk management and Solvency II compliance.

Previously, Claire spent 14 years at Risk Management Solutions, where she led RMS' global model development strategy, model releases and event-response, working closely with clients across the global (re)insurance industry to help them better understand catastrophe risk and models, uncertainties and modelling best practice.

She is a well-known speaker at industry events, and has also appeared several times on TV and radio to speak on the topic of natural catastrophes. Claire has a PhD in water resource management.

Extreme weather events are very rare by their nature. **Models are needed to help scientists, policy makers, and planners to understand events that are beyond our experience**.

Twenty three years ago, when Hurricane Andrew struck southern Florida in 1992, the insurance industry had little idea about its risk to natural catastrophes. Since then, **the scientific field of modelling has helped the insurance industry become resilient, improve planning skills and to think critically** by capturing the full landscape of what influences an event and building that into **useful models and tools**.

We use models in order to help us **understand risks from rare and catastrophic events in order to be able to manage them**. Models can help with long term planning and policy making as well as short term investment decisions. The insurance industry now has the opportunity to bring these models and techniques to academics, policy makers, and planners.

> "THE STARTING POINT TO MANAGING RISK IS TO UNDERSTAND IT; MODELLING EXPERTS HELP US BETTER UNDERSTAND AND MODEL RISK."

Understanding uncertainties

The statistical science of detection and attribution is helping us understand the degree to which extreme events are being influenced by human-driven climate change.

SCOR joins EU climate change initiative

SCOR is in the process of joining Climate-KIC, an EU-wide initiative for climate change innovation.

It is bringing together multiple stakeholders across Europe to tackle the new challenges that are being posed by a changing climate coupled with the current landscape of global development.

It is important to understand that models are not exact representations of reality and there remain many **uncertainties and limitations**. The one common feature of all major catastrophe events is that they are all unique. New uncertainties continue to arise such as the impact of increasing CO2 in our atmosphere on the frequency and severity of extreme events.

The reality is that there are many natural as well as anthropogenic-driven influences on the climate and on weather patterns and extreme events, operating on both **short term and long term** time scales.

Climate models help us understand the future range of possible outcomes of different amounts of CO2 in the atmosphere. It is also important to be clear about what time frame we are concerned with, and use the models appropriately relative to that time frame and the objective.

For example **we have more clarity and confidence in our projection for the next 5-10 years than for the next 50-100 years**.

RISK AND THE STATISTICS OF EXTREMES

Anthony Davison, Professor of Statistics, Ecole Polytechnique Fédérale de Lausanne

ANTHONY DAVISON
Professor of Statistics
at École Polytechnique Fédérale de Lausanne

Anthony Davison is Professor of Statistics at the Ecole Polytechnique Fédérale de Lausanne. His research covers a wide range of topics in statistical theory and methodology, with recent contributions mainly to the statistics of extremes. He is Editor of the leading research journal Biometrika, and in 2015 received the Guy Medal in Silver of the Royal Statistical Society.

His work on risk and the statistics of extremes has been partly funded by the Swiss National Science Foundation and has involved many collaborators from different countries.

Anthony Davison explains **the importance of forecasting future risks for fields ranging from disaster planning and public health to construction and, of course, insurance.**

In order to estimate the risks due to major extreme events, it is necessary both to understand them and to be aware that simple extrapolation from past data is unlikely to be reliable.

In dealing with extreme weather events, scientists are faced with two problems. Even in stable conditions such events may occur so rarely that they are not represented in the available climate data, so some form of extrapolation would be needed to gauge their likelihoods, even in the absence of climate change. But **the climate is changing**, and events now seen as unusual, such as droughts, wildfires or severe flooding, may become much more likely in the future. Thus a double extrapolation is needed, to estimate **the probabilities of rare events, and to forecast future conditions**.

The application of standard statistical approaches in this context can be very misleading. Extrapolating from distributions fitted to the bulk of the data may lead to poor models for the tails, perhaps because different physical laws or social mechanisms apply to rare events. For example, **the Gaussian distribution has a notoriously light tail**, and a fit of it to European summer temperature data would suggest that the heatwave of 2003 had a negligible probability of occurring.

The fit of a more appropriate model leads to a much more reasonable, though still small, probability for this event. A more subtle version of the same problem arises when dealing with several variables. Even if suitable models are fitted to individual variables, such as the annual maximum temperatures in Paris and Versailles, the probability of simultaneous rare events in both places may be underestimated if an unsuitable joint model is used.

The Gaussian copula is widely used as a simple model for joint dependence, but it would forecast that very extreme temperatures at the two places are independent, and this does not seem plausible.

> "THE CLIMATE IS CHANGING, AND EVENTS NOW SEEN AS UNUSUAL, SUCH AS DROUGHTS, WILDFIRES OR SEVERE FLOODING, MAY BECOME MUCH MORE LIKELY IN THE FUTURE."

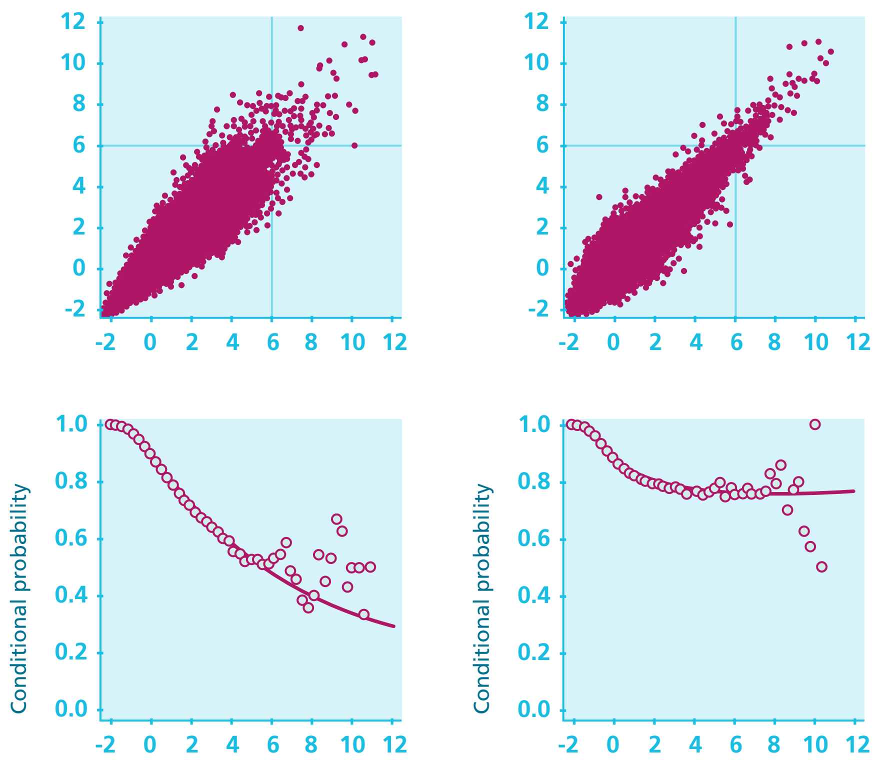


FIGURE 1:
CHANGES IN CONDITIONAL PROBABILITY

$P(Z_2>z \mid Z_1>z)$ as a function of z for a bivariate Gaussian copula with correlation 0.9 (left) and bivariate extreme value data (right). The marginal distributions in both cases are the same, but on the left the conditional probability tends towards zero, and on the right the conditional probability tends towards roughly 0.8.

In the lower panels the pink lines show the true conditional probability, and the circles show the corresponding empirical probabilities for the data in the panels above.

Figure 1 shows how the joint probabilities of tail events for two variables can differ, even when the individual variables have the same distribution. The upper panels show data simulated from two bivariate distributions. On the left, the observations seem to spread out at high levels, and this is confirmed in the lower left panel, which shows how the empirical proportion of observations above both pink lines (i.e., in the top right of the upper left panel) relative to those above only the vertical blue line changes as the blue lines increase.

The empirical proportion approaches zero at very high levels, meaning that **extreme events** on the two axes ultimately decouple. On the right, the empirical proportion tends to a limit of around 0.8, so a large event on one axis will be accompanied by an equally large event on the other axis around 80% of the time. In many cases a joint probability model like that on the right will be more suitable for events such as high temperatures at both Paris and Versailles, and even if a model like that on the left is suitable for cities further apart, such as Paris and Berlin, it may be better to over-estimate rather than under-estimate the joint probability of the event.

Thus one needs statistical tools and models that can discriminate between such situations, and ideally can encompass these different forms of dependence.

A critical problem in modelling climate-related events is dependence on both time and space.

For example, **heat waves are large-scale phenomena**: many locations in the same region may experience extreme heat or major flooding almost simultaneously, whereas summer rainfall can be very localized in space and time, even if it later leads to flooding. Thus probability models for such events need to allow for different degrees of dependence **in space and in time**.

"A CRITICAL PROBLEM IN MODELLING CLIMATE-RELATED EVENTS IS DEPENDENCE IN BOTH TIME AND SPACE."

FIGURE 2:
SIMULATION OF ANNUAL MAXIMUM DAILY RAINFALL

in the region around Zurich, based on classical statistical model with inappropriate modelling of extremes.

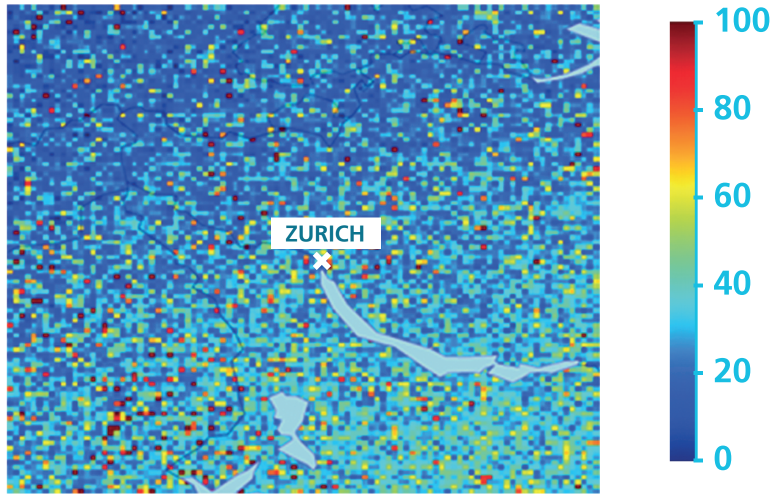


Figure 2, which shows **simulated annual maximum rainfall** from a standard statistical model, shows no spatial coherence, because the approach taken does not take dependence of extremes properly into account. Risk estimates based on such simulations would be poor, because spatial association is not taken into account.

The basis of the Gaussian distribution, the classical bell-shaped curve, is the central limit theorem, which gives approximate distributions for averages under mild conditions.

The analogous approximate distribution for maxima, the generalised extreme-value (GEV) distribution, is based on the extremal types theorem. Underlying this is the notion of max-stability: **the maximum of 100 consecutive years of data must have the same distribution as the maximum of the ten decadal maxima**.

When formally expressed in mathematical terms, this implies that only GEV distributions can emerge as **proper limits for maxima**, providing a coherent basis for extrapolation to rare events, because only certain types of tail behaviour are possible.

Generalisations of this idea to **space and space-time** events have led to major methodological advances over the past decade, resulting in the emergence of powerful approaches to the estimation of risk for complex events.

As an example, Davison considers a study of extreme flows in **rivers of the upper Danube river basin**, where spatial dependence between high flows is a key determinant of flood severity. Fifty years of daily flows are available at 31 gauging stations in the river basin, illustrated in figure 3, **whose topography varies** from the Alps to the German plain. The study considered only summer floods due to rainfall and uninfluenced by snowmelt.

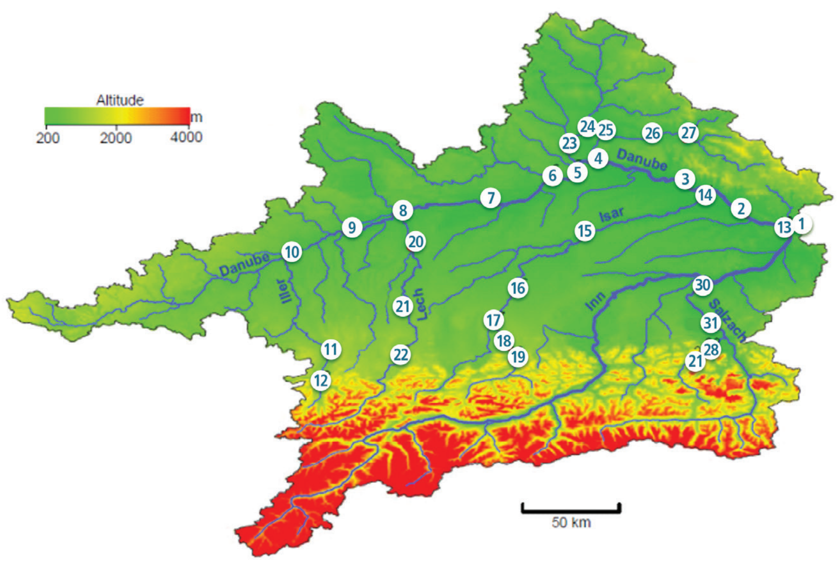
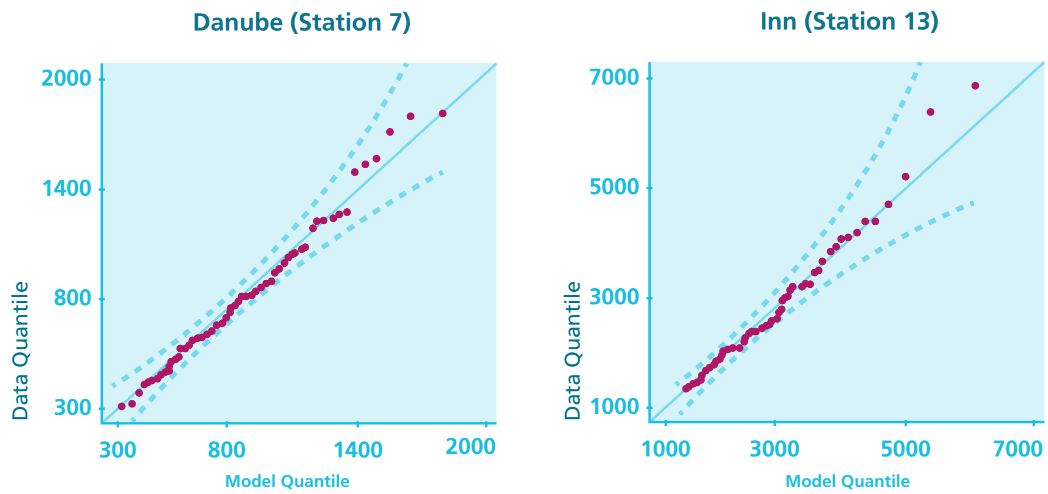


FIGURE 3:
THE UPPER DANUBE RIVER BASIN

Showing the 31 gauging stations (red disks) and altitude (green is low, red is high).

FIGURE 4:
COMPARISON OF DATA AND FITTED GEV DISTRIBUTIONS

For stations 7 and 13 of the Danube river basin flows.



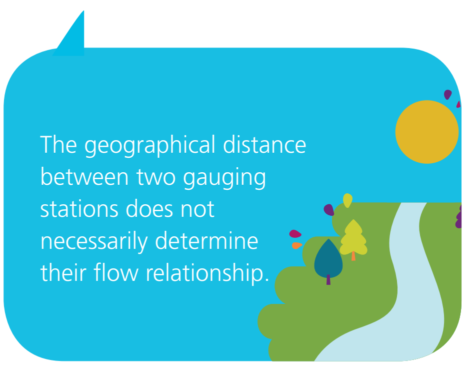
A regionalized GEV distribution was fitted to the extremes, with parameters varying with location along the river network. The near-linearity of the graphs in Figure 4 indicates **excellent fits to large flows at 2 of the 31 gauging stations**.

These fits are typical, but even a perfect fit at all 31 stations would be insufficient for risk estimation, because it might model joint extremes badly.

Dependence between extremes at different gauging stations may stem from two sources: **meteorological events** such as **major rainstorms** that influence several sub-catchments of the river basin at once, and subsequent flow events that propagate downstream through the river system, and whose joint properties depend on the structure of the river network.

As Figure 5 shows, the geographical distance between two gauging stations does not necessarily determine their flow relationship. For instance, the geographical distance between sites A and C equals that between sites B and C, but their hydrological relationship is not the same. Water that flows through C will later pass through A, but this is not true of B and C, so flow-connectedness, or lack thereof, must be taken in account when modelling dependence.

In order to relate the probabilities of simultaneous equally-extreme flows at two sites of the network, we estimate an extremal coefficient. This is analogous to the correlation coefficient, and describes the level of dependence between extremes at the different stations; an extremal coefficient value of 1 corresponds to perfect dependence, and a value of 2 corresponds to complete independence.



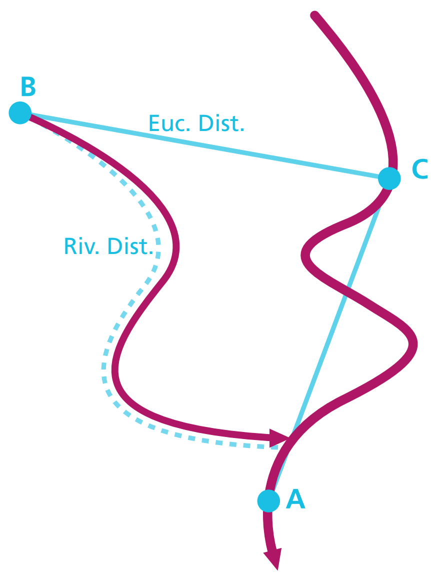


FIGURE 5:
RIVER TOPOLOGY AND FLOW-CONNECTEDNESS

The geographical distances between A and C and between B and C are equal, but B and C are not flow-connected, unlike A and C, so extreme flows at B and C will be less dependent than those at A and C.

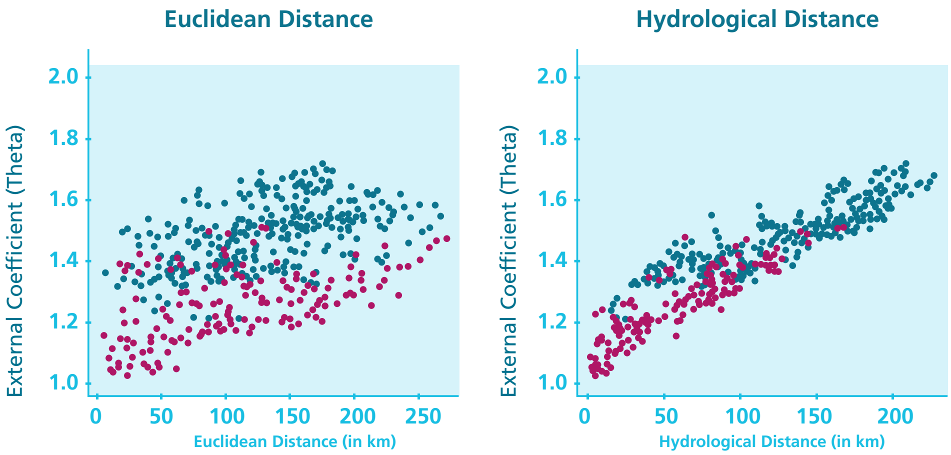


FIGURE 6:
EMPIRICAL ESTIMATES OF THE DEPENDENCE OF PAIRS OF EXTREME RIVER FLOWS

On Euclidean distance (left) and hydrological distance (right), showing how the latter provides a better explanation of the observed data.

- Flow-connected pairs
- Flow-unconnected pairs

Figure 6 shows how empirical values of these coefficients depend on geographical (Euclidean) distance and hydrological distance between the two stations. The relation is appreciably clearer with hydrological distance, which is therefore more appropriate when modelling extreme flows.

A max-stable model that uses hydrological distance can account well for extremal dependence, and so can provide accurate risk estimates for joint extremes over the river network.

Max-stable models allow appropriate estimation of risks for many other types of rare events in space and time, and have been applied to phenomena such as **heat-waves, temperature minima, extreme snow-depths, rainfall and high winds**.

"THERE'S PLENTY YET TO BE DONE. WE NEED TO KNOW IN A PRINCIPLED WAY HOW TO DO PROPER DOWNSCALING FOR EXTREMES, FITS TO VERY LARGE DATASETS AND HOW TO USE ANECDOTAL DATA"

They can be adapted to incorporate **the effects of spatial influences** such as the North Atlantic Oscillation or the El Nino-Southern Oscillation, and of temporal influences such as the multi-decadal warming, and thus can aid in space-time prediction of future rare events.

But extrapolation of any sort is dangerous, so it is crucial to recognise the large uncertainties involved and **use such models carefully and humbly**.

DEALING WITH UNCERTAINTIES WHEN DETECTING AND ATTRIBUTING CLIMATE CHANGES

Philippe Naveau, Research Scientist at the French National Research Center (CNRS)

DR. PHILIPPE NAVEAU
Research Scientist
at the French National Research Center (CNRS)

After **completing his PhD** in 1998, Dr. Philippe Naveau was a visiting Scientist at the National Center for Atmospheric Research in Boulder, Colorado for three years. From 2002 to 2004, he was an assistant professor in the Applied Math Department of Colorado University. Since 2004, he has been a research scientist at the French National Research Center and his research work has focused on environmental statistics, especially in analyzing extremes events.

Naveau discusses dealing with uncertainties in the context of climate change, largely referencing his work with Alexis Hannart within the funding of the project ANR DADA.

DR. ALEXIS HANNART
Research Scientist
at the French National Research Center (CNRS)

After graduating from Ecole Polytechnique and ENSAE in actuarial science (1999), Alexis Hannart started his career in the banking sector where he developed models for quantitative risk management. He joined the academic sector as a scientist at CNRS after obtaining his PhD under the supervision of Dr. Naveau (2010, highest honours). His research focuses on environmental statistics, especially on the causal attribution of observed climate changes and events.

Climate models, climate observations and statistics are all critical for the **Detection** and **Attribution** (D&A) of climate change. According to the IPCC Good Practice Paper on Detection and Attribution (2010), detection refers to *demonstrating that climate or a system affected by climate has changed in some defined statistical sense*[1] *without providing a reason for that change.* An example of detection is the warming of the climate system. Since the 1950s, many of the observed changes have been unprecedented over decades to millennia: the atmosphere and ocean have warmed, the amounts of snow and ice have diminished, the sea level has risen, and the concentration of greenhouse gases has increased.

Attribution on the other hand involves *evaluating the relative contributions of multiple causal factors*[2] *to a change or event with an assignment of statistical confidence.* For this, it is necessary to assess whether the observed changes are consistent with the expected responses to external forcing (volcanic eruption is an example of external forcing) and inconsistent with alternative explanations.

Detection and attribution require the following:

> **Observations of climate indicators**
  Inhomogeneity in space and time (and reconstructive via proxies)

> **An estimate of external forcing**
  How external drivers of climate change have evolved before and during the period under investigation (e.g. Greenhouse Gas and solar radiation)

> **A quantitative physically-based understanding**
  How external forcing might affect these climate indicators, normally encapsulated in a physically-based model

> **An estimate of climate variability Σ**
  Frequently derived from a physically-based model

The aforementioned factors are needed to identify a discernible **human influence on global climate** with increasing confidence, as shown by the evolution of these statements taken from F. Zwiers' work:

> In 2001 "most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations"[3]

> By 2013, we have the following evolution which states that:

"IT IS EXTREMELY LIKELY THAT HUMAN INFLUENCE HAS BEEN THE DOMINANT CAUSE OF THE OBSERVED WARMING SINCE THE MIDDLE OF THE TWENTIETH CENTURY"[4]

In order to obtain these kinds of conclusions, **statistics are necessary**. However there is a problem with the simple linear regression techniques often used under the conventional approach. Indeed, establishing a proof of causality requires comparing outcomes with and without the causal factor under scrutiny. For instance, in order to demonstrate that smoking is a cause of lung cancer, you observe people who smoke and people who don't smoke and you compare them. Similarly, in the medical area, the causal influence of a new drug is demonstrated by comparing a sample of patients that took the drug, with a sample of patients that took a placebo, all the rest being equal. But there is only one Earth, so only one observation. That is, we have a sample of **size one for Earth perturbed by CO2 emissions**. Even worse, we have no placebo sample at all: the Earth as it would have been without CO2 emissions, is not observed.

One key idea to circumvent this issue is to use climate models: we use these models as if they were numerical avatars of our planet, on which we can perform experiments and thereby produce these comparisons. Indeed, we can create **Earth simulations** with different types of forcings in order to be able to take into account the **contribution of human activity, natural forcings and internal viability**.

Of course, **numerical experiments** are not the same as real experiments because they introduce model error. This means that we need to cautiously analyze model error. This can be performed by comparing our observations of past and present climates with their numerical representations. Thereby, model error can be adequately quantified, and modelled in a statistical sense, to obtain a description of what our models are able to represent, and of what they are still not able to represent realistically at this point.

1. Statistically usually, significant beyond what can be explained by internal (natural).
2. Casual factors usually refer to external influences, which may be anthropogenic (GHGs, aerosols, ozone, precursors, land use) and/or natural (volcanic eruptions, solar cycle modulations.
3. TAR (2001).
4. AR5 (2013).

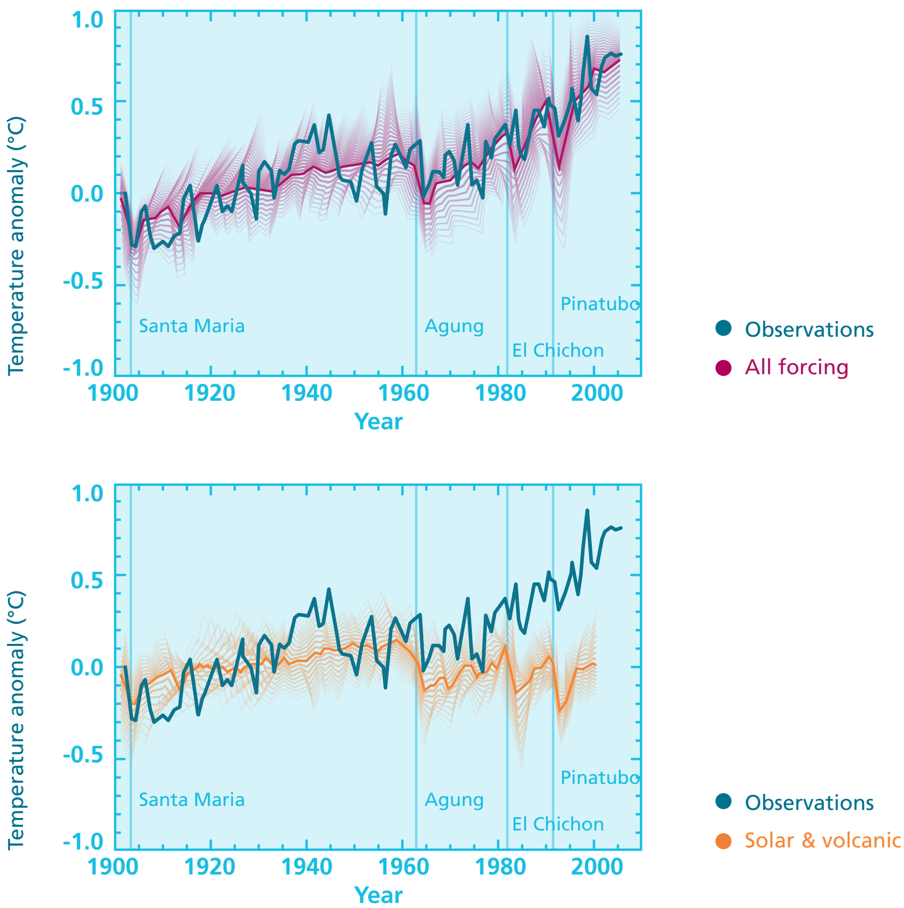


FIGURE 7:
USING CLIMATE MODELS TO GENERATE EARTH'S AVATARS

The graphs in figure 7 show two model simulations, one obtained with all forcings and one with only the solar and volcanic forcings. The blue lines show the observations, the pink lines show the results from the models which take into account all forcing and the orange looks at results from models considering only solar and volcanic forcing. In order to find out what the contribution of the anthropogenic forcing is, a linear regression is done with the observations and the anthropogenic forcing response.

Source: Claudia Tebaldi, Project Scientist at National Center for Atmospheric Research

Although this may seem like a "simple" process, there are several issues. Firstly the estimation of the internal variability, secondly dealing with **climate model errors and General Circulation Model (GCM) discrepancies** as mentioned above, thirdly dealing with observational and forcing errors, and fourthly is dealing with extreme events.

Naveau offers some possible solutions such as **regularising covariance matrices and utilizing the multivariate value theory**.

> "SO FAR HOWEVER, I DON'T THINK THERE IS A COMPLETE STATISTICAL MODEL TO DEAL WITH ALL ISSUES AND IT'S STILL A WORK IN PROGRESS."

Hannart A. and P. Naveau. Estimating high dimensional covariance matrices : a new look at the Gaussian conjugate framework. Journal of Multivariate Analysis, 2015.
Hannart, A., A. Ribes, and P. Naveau (2014), Optimal fingerprinting under multiple sources of uncertainty, Geophys. Res. Lett..

Attribution of Individual Events

A distinct question is whether or not we identify a discernible human influence on a single weather or climate-related event? For example, when considering the heat wave of 2003, the question is not "what was the trend?", but "what was the probability of having a heat wave in 2003 with and without an anthropogenic forcing?" There are less clear answers to this question than whether there is a discernable human influence on the climate and many diverse statements and lack of consensus.

The **conventional method** to answer this question is to use the Fraction of Attributable Risk (FAR) – which is the relative ratio of two probabilities, the probability (P_0) of exceeding a threshold in a "world that might have been" (no anthropogenic forcing) and the probability (P_1) of exceeding the same threshold in a "world that is."

FIGURE 8:
FAR

$$PN = FAR = \frac{p_1 - p_0}{p_1}$$

Where p_0 the probability of exceeding a threshold in a "world that might have been (no anthropogenic forcing)" and p_1 the probability of exceeding the same threshold in a "world that it is".

There are many challenges with attributing individual events to human influence, such as that we have a small probability P0 and a small probability P1: thus dividing P0 by P1 is small divided by small, which is very unstable. To answer the 2003 heatwave question, researchers ran a numerical model more than 10,000 times in order to empirically calculate the probability P0 and P1. Such large numbers of analysis is computationally very costly and can lead to long delays following events in producing analysis.

Proof of causality is also challenging. By using climate data alone, it is possible to show correlation or dependence, but it is more difficult to prove causality. As noted previously, detection is to see if there is a change and attribution is to say what is the cause of the change.

The most classical way to do that would be to show that if A does not happen, then B will not happen – a classical counterfactual definition. However, to prove causality, we need to use more concepts from causality statistics such as causal reasoning, as originally described by Judea Pearl in 2000. In addition, experimenting with climate models enables us to create "interventions", that is we can manipulate one aspect and see whether it causes a change in something else.

Stott P. A., Stone D. A., Allen M. R. (2004).
Human contribution to the European heatwave of 2003.

Adapting these concepts to climate science is a promising line of research at present. In addition, experimenting with climate models enables us to create "interventions", that is we can manipulate one aspect and see whether it causes a change in something else. When it comes to event attribution, an interesting idea proposed by the causal theory of Judea Pearl, consists in distinguishing between necessary and sufficient causation.

There is a difference between causality in terms of necessary and sufficient causation. An example of this is that clouds are a necessary cause of rain, but not a sufficient one.
On the other hand, rain is a sufficient cause for a road to be wet, but not a necessary one.

Further, the causal theory establishes that the probability of necessary causation is equal to the FAR. Therefore, existing studies inherently focus on necessary causality, not on sufficient causality. For instance, existing studies showed that CO_2 emissions are very likely to be a necessary cause, but are virtually certainly not a sufficient cause, of the 2003 heatwave.

Concretely, this means that the 2003 heatwave would have been almost impossible without CO_2 emissions, but that CO_2 emissions alone do not explain it: **many other causal factors are needed for such an event to occur**.

Such a multiple caused situation is actually rather common for rare events. For instance, plane crashes are awcknowledged to be often the consequence of multiple, independent and rare circumstances occurring simultaneously by pure chance – e.g. bad weather conditions, failure of a device, human error – where none of these factors taken alone is able to fully explain the accident, but all were necessary.

On the other hand, another important challenge is how to define a weather event, which is often an arbitrary choice that depends on the perspective adopted (e.g. policy-maker, judge, general public).

In particular, the event definition is prone to having a large effect on the amount and balance between the evidence of necessary causation and that of sufficient causation, where a restrictive definition will emphasize necessary causation whereas a loose definition will emphasize sufficient causation. In any case, having a better way to define events can help with the issue of dividing very small numbers by each other, and **improve robustness of D&A analysis in the future**.

Naveau is currently in the process of developing a different kind of FAR called a "small" FAR. Instead of fixing the return level, it is focused on the return period. The questions being considered are of the nature: if R equals 100 years, what is the probability that the last year is greater than any other years?

"IN TIMES OF UNCERTAINTY ESTIMATING NATURAL VARIABILITY IS HARD. PEOPLE USE EVENTS BUT ARE THINKING ABOUT REALISATION, WHICH IS QUITE DIFFERENT. A GOOD WAY TO BRIDGE STATISTICS, OBSERVATIONS AND NUMERICAL MODELS WOULD BE TO SET UP A VERY CLEAR EXPERIMENT TO ANSWER THE QUESTION OF CAUSALITY."

Acknowledgments: the contribution of Aurelien Ribes, an expert in D&A from Meteo-France, was paramount in helping P. Naveau in his understanding of the statistical and climatological concepts used in D&A.

CATASTROPHE AVERSION

Nicolas Treich, Research Director at the INRA and Director of Toulouse School of Economics (TSE) Thematic group in Environmental Economics

NICOLAS TREICH
Research Director
and Director at the INRA of TSE Thematic group in environmental economics

Nicolas Treich is **Research Director at INRA**, Director of TSE Thematic group in environmental economics, and co-editor-in-chief of the Geneva Review of Risk and Insurance. His research concerns risk and decision theory, environmental economics and benefit-cost analysis. He has published several scientific papers, dealing notably with risk policy issues.

Nicolas Treich talks about catastrophe aversion

Economists are increasingly interested in catastrophes and disasters. **Catastrophe modelling is essential for the management of some risks, like climate change or the financial crisis**. Sometimes, the risk is so large that it may destroy humanity, as with a large asteroid impact for instance. The lawyer Richard has argued that we should keep using benefit cost analysis and the value of life **to estimate the costs associated with reducing large, even existential, risks**.

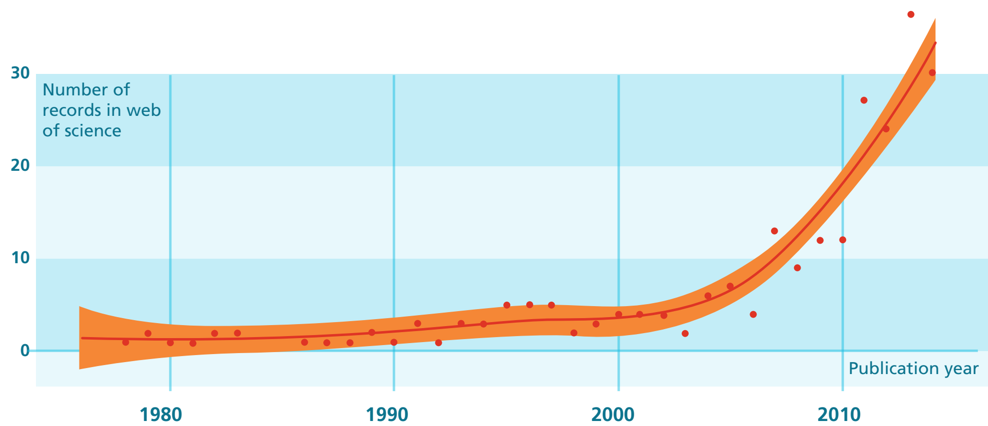


FIGURE 9:
THE GROWING INTEREST OF ECONOMISTS IN CATASTROPHES AND DISASTERS

Catastrophic risk and the notion of attitude

"AT THE END OF THE DAY, WE NEED TO FIND A WAY TO MEASURE THE CONSEQUENCES OF THE REALISATION OF THIS RISK."

Treich proposes **an approach which complements standard benefit cost analysis by integrating additional inputs from statistics or social choice in order to account for the features of catastrophic risks**.

Triech first asks: What should be our attitude toward catastrophes? Most decision makers, including the insurance industry, prefer avoiding the most catastrophic scenarios (for a given expected number of fatalities). Insurers indeed prefer to avoid correlated risks which naturally induce more catastrophic outcomes. As anecdotal evidence, the President of the United States of America and the Vice President never travel together on Air Force One in order to avoid the risk to be correlated, and thus a "decapitation strike" of the US government.

However due to social bonds and perceptions of risks, there are times where decision makers could adopt policies that prefer a more catastrophic situation (for a given number of expected fatalities). Treich cites the **example from the economist Thomas Schelling where it would be possible to persuade a family of four to fly together having a choice among two aircrafts, one known to be defective**. Splitting the family in two would reduce the spread of the distribution of fatalities, but it would increases the risk of bereavement.

In the simple example in figure 10, Treich considers a society with only two individuals, i, and two equiprobable states, s.

1 means dead and 0 means alive and there are two situations, A and B.

In situation A, agent 1 is dead in state 1, and agent 2 is dead in state 2, so we have negative correlation here. In situation B, both individuals are dead in state 1.

If we compute the distribution of fatalities in the society in situation A we know that there is one person dead in each state, so we know that **there will be exactly one death in that situation**. In situation B either everybody dies or nobody dies. Therefore, you could say that situation B is more catastrophic because **you have a possibility that everybody will die**. This definition can be used for more catastrophic situations and it's called the mean preserving spread over distribution of fatality.

"POLICY MAKERS SHOULD HAVE A SENSE OF HOW PEOPLE REACT TO RISKS. THIS IS DEPENDENT ON HOW THE RISK IS FRAMED AND HOW PEOPLE PERCEIVE THE RISK."

5. 1968

Social Choice Theory

AN EXAMPLE. A SOCIETY WITH TWO INDIVIDUALS i, AND TWO EQUIPROBABLE STATES s:

A	i=1	i=2
s=1	1	0
s=2	0	1
Pi	1/2	1/2

B	i=1	i=2
s=1	1	1
s=2	0	0
Pi	1/2	1/2

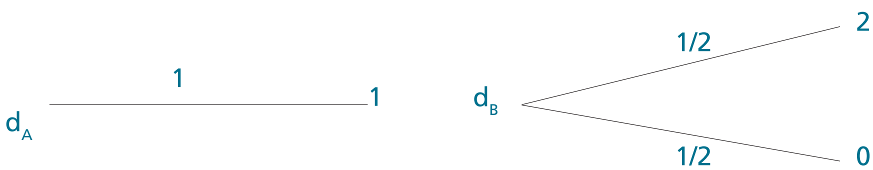
FIGURE 10:
EXAMPLE OF A MORE CATASTROPHIC RISK

Situation B is « more catastrophic » than situation A.
Remark: the expected number of fatalities is the same.

«1»: dead
«0»: alive

Pi: probability of death of individual i

DISTRIBUTION OF FATALITIES:



Studies have been done to understand the public's attitude towards catastrophe. Interestingly, they indicate that participants often prefer a more catastrophic distribution. In economics, there is a **field called Social Choice** which **uses aggregated individual preferences to rank the preference of the scenarios that are possible** to society. Social choice indicates that a more catastrophic may be preferred since it is more equitable ex post. Indeed, observe that **in situation B, there is no inequality ex post, everybody is either dead or alive!**

Risk independence, is not really realistic when talking about catastrophes. Treich is currently working on trying to integrate this type of correlation.

The conclusion is that that dealing with familiar risks is not the same as dealing with catastrophic risks. That is, a large accident killing N people is not the same as N accidents killing each one person. How do we, or should we, account for this difference in policy making? Like Treich, many researchers in economics, social choice, psychology and other fields are currently working on this question.

NATURAL CATASTROPHE MODELS

Summary of the panel discussion from the SCOR Foundation Seminar on Climate Risks

Paul Nunn, Head of Natural Catastrophe Risk Modelling, SCOR SE, moderated the panel discussion on **'The role that natural catastrophe models and the organisations that specialise in making them can play in helping both the (re) insurance industry and wider society in decision making'.** The participating speakers were: Jayanta Guin, Executive Vice President of AIR Worldwide, Dickie Whitaker, CEO of Oasis, Hemant Shah, CEO of RMS, and Lindene E. Patton, Global Head Hazard Product & Business Development, Insurance & Spatial Solutions of CoreLogic.

Nunn defines the role of catastrophe models as:

> " TOOLS THAT COMBINE DETAILED HAZARD KNOWLEDGE WITH AN ENGINEERING - BASED UNDERSTANDING OF THE FRAGILITY OF BUILDINGS UNDER STRAIN, AND CALCULATE DAMAGE AND FINANCIAL LOSS TO (RE)INSURANCE PORTFOLIOS - SUPPORTING SMARTER CATASTROPHE RISK MANAGEMENT CHOICES"

The role of cat models in climate change policy making

1. PROVIDING INCENTIVES

Hemant Shah, explains the importance of **providing modelling to (re)insurers** in order that they are able to **quantify**, and thus **monetise**, more risk. He believes that in this way, they are able to **create more incentives to manage and reduce risk within the economy**. Jay Guin adds that by converting estimates of future climate scenarios into financial dollars, despite the inevitable uncertainty which exists, it becomes easier to move policy and decision makers.

2. INFORMING

Guin talks about how **climate models** (GCMs)[6] offer an insight into understanding variability. This is because they imply an understanding of the full range of climate variability, and so if events occur that fall outside of the predictions it may be that there is an underlying shift in the climate, causing such an extraneous observation.Dickie Whitaker takes a slightly different approach, focusing on the use of **catastrophe models** in understanding the effective current weather and climate which is essential in order to make an assessment of the future climate.

He adds that once **climate models can be adapted for use in decision making**, they can have practical use at a relatively low cost, through integrating findings into cat models.

3. CREATING DEMAND

One problem, which Patton addresses, is the current lack of demand. Patton believes that this is partly due to the fact that stakeholders in the field are uncomfortable with the impact of climate change. In order to address this issue, Patton highlights the importance of presenting the data in a way which is relatable. She uses the analogy of information on asbestos in homes in the US to illustrate that as soon as people are aware that there is reliable data available, they will see that this is worth paying for and begin to ask for it more. Whitaker argued that people are already paying through public funding for research. Patton discusses the overwhelming quantities of information available in data stores and how integrating different types of data into models may render and produce different types of information relevant to consumers. The increasing availability of this information will contribute to resolving the demand problem.

6. General Circulation Models are detailed computer model representations of the Atmosphere and Oceans that reflect the physics of heat transport around the world.

Challenges in integrating evolving climate science into cat model frameworks

FLEXIBILITY

A recurring theme in the discussion is the limited accessibility of the information, which is restricted to a very small group within the reinsurance sector. Whitaker addresses **the need to better translate the work of experts into something that can be used by cities, corporations, and even individuals**. In order to achieve this goal, he argues that there needs to be more flexibility within the models, producing a set of standards and having approaches and systems that can be used by a range of academics, whose understanding of how to represent uncertainty is limited.

Guin adds that there needs to be an understanding on what is behind the models, the critical assumptions, and to stress tests the assumptions.

Patton supports the view that **information needs to be more accessible and stresses the value of a broader range of opinions** in decision making. She urges the insurance industry to follow the example of tools to make information about economics more accessible.

DATA QUALITY

Guin argues that data quality is one of the biggest challenges that exists in terms of catastrophe modelling. He explains that as there is only 30 years of recorded climate events, there is a **lack of information regarding time series of actual historical events** and scientists are consequently in a process of extrapolation. Models are therefore only as good as the amount and quality of data that is available. In addition, observations are limited especially in developing countries; this creates additional challenges in terms of data availability and quality.

TEMPORAL DISSONANCE

Shah states many do not feel the need to take a view on what the multi-year risk is, as the majority of contracts are done on a yearly basis. However, increasingly industry **leaders are developing strategies for multi-year financial contracts** that are **aligned with the temporal duration of the risk**, particularly around infrastructure and large value assets.

COLLABORATION

The main conclusion to be drawn from the discussion is the need for collaboration. D. Whitaker states that it is through **collaboration that many of the problems that exist may be solved**. H. Shah stresses the importance for the scientific community, modelling practitioners, the public policy dimension and the commercial sector, and financial services and (re)insurers to find a common vernacular and frameworks in order to solve the problems together. He suggests that a multidisciplinary forum may provide the space tackle the issue of temporal dissonance between **long-term risk and financial services products that are annual in nature**. J. Guin cites the examples of the Asia Development Bank for the pool of risks from all the South Pacific island nations and the Global Earthquake Model initiative.

CLIMATOLOGY: OBSERVATIONS, CHANGES, EXTREME PROJECTIONS AND IMPACT ON PUBLIC HEALTH

An interpretation of discussions from the SCOR Foundation Seminar on Climate Risks

What do we know so far on climate and climate risks at different timescales?

CURRENT OBSERVATIONS

Based on the new changes by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report, Valérie Masson-Delmotte, Senior Climate Scientist at the French climate research centre presented the most recent scientific findings on climate change. As of today, **the Earth has warmed, on average, by 1°C since pre-industrial levels**. Scientists are aware that changes in average global temperatures are due to several factors: changes in solar activity, injection of particles resulting from volcanic eruptions, reflection by pollution particles, and trapping of radiation by increases in Greenhouse Gas concentrations, among others. However, scientists are highly confident that human activity has been the dominant influence on warming since the 1950s, notably through the use of oil and coal.

Despite the fact that climate models are based on physical principles, they are associated with intrinsic uncertainties. Nevertheless, **scientists are able to use them in order to understand anthropogenic forcing on climate**. Despite their intrinsic uncertainties, models have demonstrated that climate change has contributed to atmospheric and ocean warming, water cycle changes, reduced snow and ice, sea level rise, and changes in extreme weather events.

PROJECTED CLIMATE CHANGES

Different scenarios emphasised by the IPCC predict the change in global average temperature in relation to the amount of CO2 emitted. The low-end scenario—which requires a peak in CO2 emissions in the next 20-30 years, a sharp decrease, and zero emissions worldwide at the end of the century—predicts that warming would continue to rise at the same rate as during the 20th century until about 2050, and that then the global mean temperature would stabalise. The high-end scenario—where emissions continue at today's current pace—would lead to 4°C warmer temperatures by the end of the century.

Not only would climate change amplify the current risks and create new ones, but Masson-Delmotte warns that these changes may surpass our ability to adapt. Of course, it is important to keep in mind that there are large uncertainties on the real change in the climate, the risks presented by the change, and the models predicting these changes.

CLIMATE VARIABILITY & EXTREME PROJECTIONS

Sonia I. Seneviratne, Associate Professor at the Institute for Atmospheric and Climate Science, demonstrates that by **observing inhabited regions and extremes, one may be able to understand how climate change may impact human populations**. While the term "global average temperature" is consistently used within climate discussions, this does not take into account the effects that may occur on a regional scale. In other words, a 2°C average does not mean that all parts of the world will evenly experience a 2°C increase in temperature. Instead, regions will change in different ways. Some regions will face much larger warming and an increase in extreme weather events like heat waves and heavy precipitation events. However, this does not mean that there will be an increase in all types of extremes. Changes are complex and there are many uncertainties. **In the high-end scenario, land temperatures could increase between 4°C to 7°C**.

However, dry regions will not necessarily become dryer, and wet regions will not necessarily become wetter. For instance, some tropical regions in Africa have actually become dryer.

Subsequently, Seneviratne adds that measures to reduce CO2 emissions and to adapt to climate change must consider the effects on a local and regional level. Some measures could ultimately enhance warming locally.

For instance, afforestation, the planting trees in areas which did not previously include them, is a measure mentioned to remove CO2 from the atmosphere. However, in snowy, high-latitude locations, **afforestation would create net warming due to a decrease in the amount of radiation reflected from the land surface**. Therefore, negotiators must consider how some measures to reduce CO2 emissions may be working the wrong direction in some specific cases.

IMPACTS: PUBLIC HEALTH

According to Professor Antoine Flahault, Director of the Institute of Global Health at the University of Geneva, these local changes could ultimately have a disastrous, direct and indirect effects on health, making it one of the most important threats to public health. Heat waves, for instance, could be clearly linked with negative health effects. Warming increases the population of insects and rodent carrying vector-borne diseases, leading to an increase in disease transmission, and the rate of respiratory disease can also increase due to a rise in air pollutants. What is not so well known is that droughts are also linked with diarrhoea incidences. Also, **changes in climate are indirectly linked with civil conflicts, food supply, and displacement**. Unfortunately, poor countries will be the most affected. Professor Flahault recalls that extreme poverty was halved in the last two decades, but climate change could reduce this achievement if governments do not take immediate action on climate change. **Climate change could exuberate or generate more poverty.** Since income is a determinant of health, actions against greenhouse gas emission are crucial to society's well-being.

ECONOMICS: LONG-DATED INVESTMENTS AND MANAGEMENT

An interpretation of discussions from the SCOR Foundation Seminar on Climate Risks

How can economic sciences help us make good decisions in a context of climate uncertainty?

There is still a lot of debate on how much the climate will change and what the consequences will be. This is the result of the high uncertainty that still exists. Scientific uncertainty includes internal variability, modelling uncertainty, and emissions (i.e. human behaviour) uncertainty. In addition, there are social and economic uncertainties—positive and normative uncertainties—that arise because the **relationship between climate and economic activity is not fully understood**.

EVALUATION OF LONG-DATED INVESTMENTS

Since climate change occurs over a long period of time, the margin and benefits of climate investment will only be known in the distant future. In order to estimate the discount rate through modelling, Christian Gollier, Director of the Toulouse School of Economics, states that extreme events and uncertainty must be taken into account in the models. He cites the work of Robert Barro, who introduced, along with others, extreme events in the standard modelling of the Consumption Capital Asset Pricing Model (CCAPM). **The Barro model predicted that there is a probability of 1.7% that there would be a macroeconomic catastrophe next year in France.** However, he does not take into account parametric uncertainties. Simon Dietz, Co-Director and founder of the Grantham Research Institute on Climate Change and Environment at the London School of Economics (LSE), asserts that estimating **the climate beta is crucial to our willingness to reduce Greenhouse Gas emissions**. These variables are, however, sensitive to different uncertainties including productivity uncertainty, rate of decarbonisation, climate sensitivity, and damages.

MANAGEMENT OF CLIMATE POLICY

Geoffrey Heal, Professor of Finance and Economics at the Columbia Business School, mentions how scientific, social, and economic uncertainties are relevant to climate decisions. **Some of the main motivations for climate policy from an economic perspective are to avoid disastrous outcomes; hence, uncertainties must be taken into account.** For example, the IPCC demonstrates the most likely outcome of temperature change to be somewhere between 2°C and 4°C. However, some models predict greater change. Since an increase in temperature above 4°C could be very dangerous for human societies as they exist at the moment, a possibility of a 5°C, from a climate policy perspective, is alarming. Heal described that there are various approaches taken to decision making in the context of uncertainty: density function, smooth ambiguity, etc.

ADAPTATION & MITIGATION DECISION-MAKING

Charles Kolstad, Environmental Economist and co-recipient of the 2007 Nobel Peace Prize, points out that a **fundamental issue is determining the best time to invest since prices in technology drop or change over time**. In order to efficiently adapt, investors need full and complete information. Economic agents want to see what the actual change is before they make those investments. Uncertainty in a firm's mitigation strategy include technological change, markets (price of oil), and government policy uncertainty. Risk management is often overlooked as a strategy for dealing with climate risk, along with mitigation adaptation. Improving availability and measures for moderating risks can be a third leg of a climate action stool where one leg is adaptation, one leg is mitigation, and one leg is risk moderation tools.

An alternative, simple approach

Since model uncertainties are so great, Robert S. Pindyck, Professor of Economics and Finance at the Massachusetts Institute of Technology, proposes instead gathering expert opinion to predict the impacts on Growth Domestic Product (GDP), and possible solutions.

POLICY MAKING AND CLIMATE RISKS INSURABILITY

An interpretation of discussions from the SCOR Foundation Seminar on Climate Risks

How can we improve the insurability of climate risks, and how can (re)insurers contribute to economic resilience in case of Nat cat events?

THE PLANTING OF TREES IN ZONES THAT DID NOT PREVIOUSLY INCLUDE THEM, HAS AN IMPACT ON BIODIVERSITY

Ottmar Edenhofer is **Co-Chair of the IPCC Working Group III and Deputy Director and Chief Economist at the Potsdam Institute for Climate Impact Research**. He shares his insight on mitigation.

First, he mentions that Greenhouse gas emissions have been rising with an increasing growth rate in the last decades. **The improvement in energy efficiency has been overcompensated by economic growth**, and Gross Domestic Product per capita has become a major driver in emissions in the last decade. As a consequence, **carbon intensity is increasing once again, notably among developing countries**. Edenhofer explains that if emissions continue at their current pace, temperatures are predicted to increase by 4°C by the end of the century, increasing severe catastrophic risks. According to expert judgement, limiting temperature change to 2°C, could avoid these severe risks. In order to reach the 2°C goal, emission reductions would have to reach between 40% (with CO2 removable technologies) and 70% (without removable technologies). **If carbon-removing technologies or bioenergy is not available, afforestation will have to play a much more important part.**

However, mitigation also has risks and costs. For instance, afforestation, **the planting of trees in zones that did not previously include them, has an impact on biodiversity and food security**. If carbon capture technologies and storage are not available, then the costs of mitigation will rise. When looking at other options, even though renewable energy has made a lot of progress, it is unlikely that there will be real incentives to stop using coal, gas, and oil in the near future, and paying off the owners of those industries to stop their use is not an economically feasible option.

A more realistic and efficient option would be to **put a price on carbon consistent with the limiting disposal space of the atmosphere**. The main limit to carbon pricing is the need to develop it on an international scale with a global price, thus requiring international consensus. According to Edenhofer while a global carbon tax is needed, there might be greater incentive if instead of a uniform carbon price, there were, initially, different carbon prices. **Revenue from carbon taxes could be used to finance infrastructure or reduce other taxes.**

(RE)INSURANCE RESPONSIBILITY IN ADAPTATION

On the adaptation side of the equation, **Erwann Michel-Kerjan**, Executive Director of the Wharton Risk Centre, is more optimistic and **believes in the power of (re)insurance to create market initiatives and signal exposure**. He encourages the (re)insurance industry to predict their future competitors and lower their exposure in order to remove the barriers of insurability.

Climate change is clearly now one of the top risks for many people outside the climate discussion. Major weather events have multiplied by 2.5 in the last 30-35 years. According to Michel-Kerjan, the (re)insurance industry has played its role and participated in economic recovery, however, what worries him is whether the industry will be allowed to continue.

He predicts that governments could be the biggest competitors of the insurance industry in the coming years. **When there are more climate events in a short period of time, governments will be forced to become involved.** For instance, after hurricane Katrina occurred, seven major hurricanes hit land within a 15-month period, something which had never happened before, so insurances began raising insurance premiums in order to increase their costs. State regulators in Florida, however, prevented premiums from increasing over a certain amount, making insurance unprofitable, and therefore, bound to leave the market in the state of Florida. Citizens Property Insurance Corporation, a state-run company, is the largest insurance provider for residential wind coverage today in Florida covering about 35% of the market.

As consumers continue asking the government for non-risk price-based insurance coverage, the relevance of the (re)insurance industry is put into question. **New private competitors can also question the relevance of the industry.** For instance, Michel-Kerjan listed the GAFA (Google Apple Facebook and Amazon) as possible future competitors for insurers. While they are not currently part of the insurance industry, customers trust them more than insurance companies. If they decide to sell insurance, which will probably happen in the future, they could access a large share of the insurance market very quickly.

The only way to move the barrier of insurability is by lowering the exposure. The insurance industry must better understand catastrophe vulnerability assessments to be able to run entire cost-benefit analysis. (Re)insurance companies (second largest investors in the world with $30 trillion in asset management) could notably use their assets to invest in resilience improving investment. The next five to ten years, trillions of euros of investment will have to be made to maintain, upgrade, and build new infrastructure. This can only happen under the condition that international regulators start unlocking some of this investment by treating long-term investment much more favourably than they are doing now.

The financial resources exists, they just need to be redirected in the right way.

(RE)INSURANCE CONTRIBUTION TO ECONOMIC RESILIENCE

Georges Dionne, Professor of Finance holding the Canada Research Chair in Risk Management at HEC Montréal, shared his observations on how the insurance industry could create better resilience. He **estimated that there have been more than 70 million people affected each year and that two million deaths have been caused by weather events since 1980**, with 95% of them in lower income countries. To save lives, the most effective policy is warning systems. Theoretically, insurance companies can increase macroeconomic resilience by reducing the variation of consumption for a given event and by giving increased coverage for instantaneous losses and consumption. Dionne observed that in practice, this is not necessarily the case and believes this is caused by several reasons. First, there is a potential overcapacity in the reinsurance industry since insurance demand is still low in many of the countries most exposed to climate risks. The population is concentrated in high risk areas which have seen an increase in the frequency of climate risk since 1970. Additionally, wealth inequality affects insurance demand and many countries are experiencing higher wealth inequality.

Secondly, there are radical fluctuations of risks, which complicates the setting of optimal capital. The third reason for low insurance penetration is the mismatch between demand, investment and prevention, and insurance contracting. **Despite the need of long-run investments for prevention, insurers only offer one-year contracts**; therefore, there should be more commitment from the insurance industry on long-term contracts for climate risks. While this may be complicated for the (re)insurance industry to cover all the extreme losses, insurance linked securities (ILS), linked to property losses due to natural catastrophes is a growing market representing 40% of extreme climate risk coverage. One important issue, however, is the long term commitment of financial markets to climate risks.

In order to fix the insurance demand and the insurance penetration problem, Dionne encourages government involvement. **Governments can reduce adverse selection and increase diversification by compulsory insurance** that could help prevent against extreme events. However, Dionne recognises that government can create a big moral problem in absence of incentive contracting as observed in many countries.

CLIMATE RISKS INSURABILITY

Summary of the panel discussion from the SCOR Foundation Seminar on Climate Risks

Industry challenges

Dr. **Maryam Golnaraghi, Director of Extreme Events and Climate Risks** at the Geneva Association, moderated the roundtable discussion with leading managers of the (re) insurance industry in hopes of providing solutions that may orient the future of the industry.

Victor Peignet, CEO of SCOR Global P&C, explains that the (re) insurance industry has a lot of capital flowing in, but the challenge is to take advantage of the opportunities, to take risks, and to convert them into real business. He mentions that the **industry must address three conditions that must be developed in climate risk insurance in order to generate demand and fill the protection gap**: legal, fiscal stability (which involves the commitment of the government to guarantee the stability of subsidies), and actuarial and modelling (a willingness to develop data to help collect statistics).

Pierre-André Chiappori, Columbia University Professor of Economics explains the problem of capacity. After big catastrophes insurance cycles show that capital is extremely productive. This means that the industry is lacking capacity. **Economic response should be to allocate a lot of capital to the industry**, but this takes time. After recent catastrophes like 9/11, Katrina, etc., the insurance cycles have been reduced, demonstrating a more efficient allocation of capital. According to Chiappori, this is the right response. There is new demand for new capital because capacity has been reduced, the return on capital is high, and capital should fly in. The type of capacity that is needed for the insurance industry is trivial vis-a-vis the potential supply; if insurers were able to tap into the potential supply, there would be no capacity problem. Alternative capital via cat bonds, ILS, mortality bonds, etc. could enable capital to flow in more efficiently and provide capacity for the industry.

Policy framework

Christian Thimann, Group Head of Strategy and Public Affairs at AXA, describes the needed changes in the regulatory and policy framework to better orient the financial system towards long-term issues, including climate change. He acknowledged that regulators have already had three major achievements. First, they have been able to render each individual sector more financially stable; second, supervision has been improved by the creation of new institutions, system risk bars, and philosophy of market prudential supervision; and lastly, markets are more transparent. However, Thimann states that not all issues are resolved.

Regulators must orient the financial sector to serve the bigger environmental, economic, and societal needs via the capital charges placed by the regulatory framework. There must not only be financially investment but also investment in hard technologies and infrastructure.

There is also an important disconnect between regulation and long-term climate needs that extend beyond finance notably caused by the tensions between the short-term needs to stabilize the financial system and the longer term needs to finance the real economy. According to Thimann, what is needed is global political impetus—conceivably provided by the G7 or G20—to preserve the major achievements while taking into account the long-term needs in the economy, society, and environment.

Partnerships

Masaaki Nagamura, Division Head of Corporate Social Responsibility and General Manager at Tokyo Marine Holdings, Inc. and Tokyo Marine & Nichido Fire Insurance Co., speaks from his own experience on **how the insurance industry can help the society become more resilient**. The 2011 earthquake and tsunami in Japan prompted the company to develop new strategies capable of predicting climate scenarios. In order to do this, **the company has partnered with universities**. Aside from generating better information to advice their customers, they have used this to **educate school children and advise local communities on enhanced evacuation methods and the risk of more frequent typhoons hitting Tokyo**.

Additionally, Tokyo Marine is encouraging a partnership with the Japanese meteorological office so as to implement a disaster preparedness program on a national or sub-national basis. Nagamura states that they are starting a subnational program that is now being proposed by the World Bank. As a result, there is a growing expectation for the insurance industry to assist the ministers with the designing of the program since the insurance industry is in the best position to offer such expertise.

According to Peter Hoeppe, Head of Geo Risk Research at Munich RE, stakeholders should also collaborate with developing countries. Hoeppe states that **there is an asymmetrical problem between the ones who are suffering the most** (developing and poor countries) **and the ones who are causing the problem** (developed countries). Unlike developed nations, developing countries do not necessarily have enough capacity to invest in adaptation. The insurance industry can support these countries after an extreme weather event by providing quick money to help the economy come back to regular business. There have been several scientific studies that demonstrate the larger the insurance penetration, the better the performance of Gross Domestic Product after a large event.

Hoeppe states that there is an asymmetrical problem between the ones who are suffering the most (developing and poor counties) and the ones who are causing the problem (developed countries).

For more information on the SCOR Foundation Seminar on Climate Risks, the speakers and the topics covered, please visit: **www.scor-climaterisks-2015.com**

Electronic distibution only

To request an electronic copy, please email : **scorglobalpc@scor.com**

Editor: SCOR Global P&C
Strategy & Developement
scorglobalpc@scor.com

No. ISSN 1638-3133
Focus #18 - November 2015

SCOR, 5 avenue Kléber
75795 Paris Cedex 16 - France
www.scor.com

Global P&C