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CLIMATE CHANGE AND INSURANCE

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ABSTRACT. *The potential for global climate change has become a major problem for the current generation. The principle of sustainability aims to assure better living and environmental conditions for future generations, and, because of this, climate change has become a major international focus. In this paper, we will analyse two aspects of climate change: changes in the average temperature and changes in the day-to-day variability of temperature. As a result of our study we find that, in Paris, the average temperature has increased by approximately 0.5 degrees Celsius over roughly the last century, while the variance of the daily temperature has slightly decreased. We then tie these results into a broader overview of the larger phenomenon of global climate change. All three major sectors of economic activity: agriculture, industry and services are influenced by climate change but in this paper, we will focus on the relationship between climate change and the insurance industry. This is especially relevant, as the insurance industry is focus risk management methods used by the manager to face phenomena such as climate change.*

KEYWORDS: climate change, mean temperature, variability of temperature, risk management, insurance industry.

JEL classification: Q54, Q56, G22.

Introduction

Global climate changes have become a major problem for the current generation, and the principle of sustainability aims to assure better living and environmental conditions for future generations. Because of this, climate change has become a major international focus.

There is currently a diversity of research being conducted at the global/regional level regarding this, with the main purpose being the determination of how nature, life itself, agriculture and industries are affected by changes in the climate.

According to NASA, climate change is a complex phenomenon which incorporates global warming and all other consequences of this (snow and ice melting, sea level rising, etc.)

Human-made climate change issues appeared due to the effects of increasing population, industrialization, and the emission of gases (Carbon dioxide (CO₂), Methane, Nitrous oxide, Chlorofluorocarbons) into the atmosphere. The recent report generated by The Intergovernmental Panel on Climate Change (IPCC) indicates in Fourth Assessment Report the fact that the climate is definitely influenced by human activities and the recent emission of CO₂ into the atmosphere is the highest in history. The report states that “there’s a more than 90 percent probability that human activities over the past 250 years have warmed our planet and the industrial activities have raised atmospheric carbon dioxide levels from 280 parts per million to 379 parts per million in the last 150 years” (IPCC, 2007a).

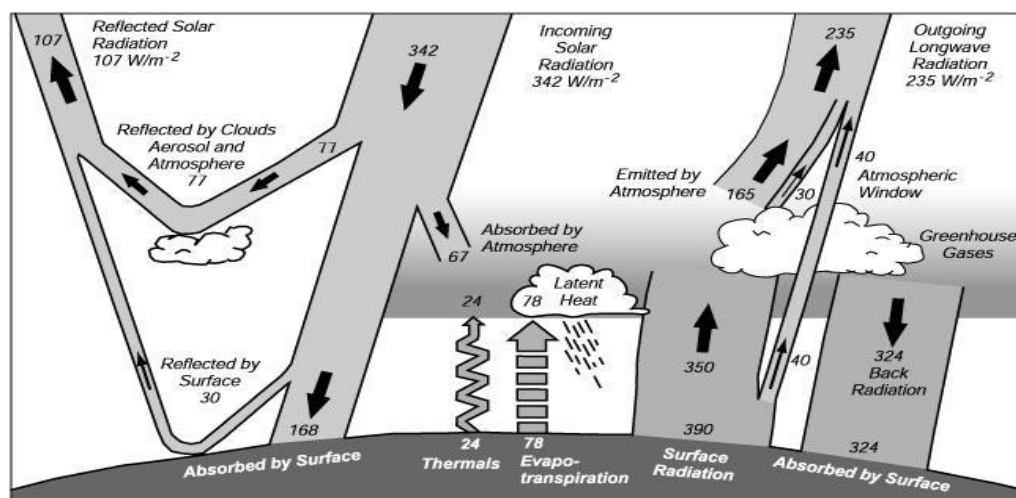
Different predictions indicate the fact that temperature recorded a significant increase and also the biodiversity is negatively affected by climate change but all these predictions depend on the chosen horizon for the model and also by emission scenario and climate model used (IPCC, 2007a; Anderegg *et al.*, 2010). These findings will be further elucidated and confirmed through the data analysis of the following section.

However, even if we take into consideration the fact that temperature fluctuates naturally, for example, data from different sources indicate the fact that in the last 10000 years it occurs with a variation of 6° C in average annual temperature, many scientists consider that “global warming is the most pressing environmental issue of the early 21 century” (Day, 1999).

To understand better the climate change phenomenon, the potential effects on the environment, economy and humans and how these effects can be counteracted we need to understand global warming process that in fact underlies the phenomenon of climate change.

Global warming phenomenon is shown briefly in *Figure 1*.

Ming *et al.* (2014) consider that: “Global warming results from the imbalance between the heat received by the Earth and, the heat reradiated back to space”. As we can observe in *Figure 1*, Shortwave radiation (ultraviolet) is emitted by Sun and is coming into the Earth’s system (342 W/m²). Part is reflected by clouds, ice, snow, Earth’s surface back into the atmosphere (77 W/m²), another part is absorbed by the atmosphere (67 W/m²) and the rest is absorbed by Earth’s surface (168W/m²). The particles from the atmosphere absorbed this radiation and warm the atmosphere.



Source: Kiehl and Trenberth (1997).

Figure 1. The Earth's Global Heat Flows (Watts per square Meter)

Longwave radiation (infrared), emitted by the Earth (390 W/m^2) and its atmosphere out to space have an undesirable impact on our lower atmosphere. From all surface radiation emitted by Earth (390 W/m^2), most returns back (324 W/m^2) due to the existence of greenhouse gases which reflect it and heat the lower atmosphere (due to the existence of greenhouse gases), which then emits infrared radiation, part of this being directed toward the Earth. According to the data provided by NASA, Global Climate Change, gases that play an important role in greenhouse effect are water vapour, Carbon dioxide (CO_2), Methane, Nitrous oxide, and Chlorofluorocarbons (CFCs).

Although globally efforts have been made to reduce greenhouse gases emissions in order to limit the average temperature increase to $+2^\circ\text{C}$ (Ming *et al.*, 2014), without the existence of an agreement between the biggest polluters, this goal cannot be achieved.

The aim of this paper is twofold. First, we conduct a unique analysis of the change in both the magnitude and variability in temperature since 1900. Next, we provide a broad overview of the nature of global climate change and its effects on the industrial sector in general, and the insurance/reinsurance industry in particular.

1. Materials and Methods

In order to fully talk about the concept of climate change, a very complex one indeed, experts need to analyse all changes in temperature, precipitation, atmospheric phenomenon, sea and ocean changing levels, etc.

Data recorded and studies made based on this data by various organizations specialized in monitoring of weather and climate, such as The National Oceanic and Atmospheric Administration (NOAA), The Intergovernmental Panel on Climate Change (IPCC), The World Meteorological Organization (WMO) indicate the fact that all these factors suffered major changes in the last years but the temperature is most affected by climate change.

The "Climate Change 2014: Synthesis Report" issued by The Intergovernmental Panel on Climate Change (IPCC, 2014b) indicates the fact that "Warming of the climate system is unequivocal and since the 1950s, many of the observed changes are unprecedented over decades to millennia". As a direct result the atmosphere becomes warmer and also the water surface recorded significant increases in temperature.

As previously noted, catastrophic climatic events have been more common in recent years as in the past. One such type of catastrophic event is extreme heat waves. An important aspect of the analysis of such heat waves involves the determination of whether such heat waves are due to (a) an increase in the mean temperature, (b) an increase in the variability of the temperature, or (c) both of the above.

In order to assess the aforementioned situation, France was chosen for the analysis. Paris was chosen because it was at the epicentre of the great heat wave of 2003 and also due to the vast amount of reliable climatic data for this location.

Although the data collected were only from Paris, it can be argued that the climate data from Paris is somewhat representative of a much larger geographic area. Giorgi (2006) notes that the severity of climate change varies by region, and he quantifies this change in both temperature and precipitation using the regional climatic change index (RCCI). The RCCI measures the susceptibility of a region to climatic changes in both temperature and precipitation. The RCCI of the region within which Paris lies is similar to the RCCI of a large swath of land running from northern Asia, extending south-southwest through nearly all of Europe, and also including most of northeastern North America as well as Mexico. Climate change will certainly not behave identically across this region but, given the similarities in RCCI across this large region, we may expect that Paris is, to a certain extent, a representative of this much larger region. Hence, our results and conclusions may, with care, be extended to much of the middle latitudes of the northern hemisphere.

Similarly, Heffernan (2007) presents a map showing the trend in temperature from 1901-2005. This map shows that the region within which Paris is located would be considered to have experienced from a moderate to a high change in temperature, relative to the average global change. Similar changes (which, should be noted, are not all necessarily induced by humans) were experienced across most of Europe, far northern Asia, northeastern North America, Greenland, and Mexico. These results support the work of Giorgi (2006) and further add credence to the assertion that temperature change within the region of Paris is similar to the change experienced across the much larger global region.

Daily high temperatures for Paris were then collected from The National Climatic Data Center for the years 1900 through 2013. These 113 years' worth of data was then subdivided into three time periods:

1. The "current period", 1975- present.
2. The "base period", 1900-1939.
3. The "intermediate period", 1940-1974.

The current time period's dates were chosen due to the rapid increase in greenhouse gas emissions that began in the 1970s (Marchal *et al.*, 2011), while the base period's dates were chosen to coincide with the pre-WWII era. Data from the intermediate period are not analysed, and it is simply used as a buffer between the two time periods of interest. The use of this buffer period makes it easier to determine whether or not changes in temperature have occurred, as the two periods of interest are no longer contiguous and, hence, a period of change has been allowed for.

First, we will test to see if there has been a change in the day-to-day variability in high temperature from the base period to the modern period. This will be done using a F-test for the difference of two variances. The current literature is equivocal regarding the effects of global climate change on daily temperature variability in recent years. Many scholars, such as Schar *et al.* (2004) argue that catastrophic events, such as the European heat wave of 2003, could only realistically occur if there had been an increase in the variability of temperature (in addition to an increase in the average temperature). Others, however, assert that, at this point

in time, global climate change may actually have produced a decrease in the variability of temperature (Karl *et al.*, 1995). Note that we are not focused on inter-annual temperature variability but, rather on intra-annual variability. Hence, we test (Savitz, 2014):

Hypothesis 1

$$H_0: \sigma_1^2 = \sigma_2^2$$

$$H_1: \sigma_1^2 \neq \sigma_2^2,$$

where σ_1^2 is the daily variance in high temperature from the current time period, and σ_2^2 is the daily variance in high temperature from the base time period. The results of this test are presented in results and discussion section.

Next, we wish to determine to what extent, if any, the mean daily high temperature has changed over the years. The current literature is overwhelmingly in support of the notion that the climate in the middle latitudes (40-70 degrees) of the northern hemisphere, within which Paris is located, has warmed since the dawn of the 20th century (Nicholls *et al.*, 1995). Furthermore, Nicholls *et al.* (1995) find that the global average temperature has increased by roughly 0.3-0.6 degrees Celsius during the majority of the 20th century. Hence, we test the following hypothesis: (Savitz, 2014)

Hypothesis 2

$$H_0: \mu_1 - \mu_2 \geq 0$$

$$H_1: \mu_1 - \mu_2 < 0$$

where μ_1 is the mean temperature, in degrees Celsius, from the current time period, and μ_2 is the mean temperature from the base time period. The results of this test are provided in Results and discussion.

After we test these hypotheses, we will analyse the implications of these findings in the economic sector and also how they affect the insurance industry. Based on data provided by different organizations (Intergovernmental Panel on Climate Change, Global Risk Information Platform, The International Disaster Database, German Institute for Economic Research, NatCatSERVICE, Swiss Re, Munich Re) we want to identify the risks associated with climate change, how they affect company activities, how companies can manage these risks, and how insurance companies can face this challenge. Since, among other things, we are assessing changes in day-to-day temperature variability; our results will provide information that speaks to the validity of short and medium-range weather forecasts.

2. Results

As we previously mentioned, we used a F-test for the difference of two variances in order to examine recent changes in both the average and variability of the temperature.

The results of this test are presented in *Table 1* and *Table 2* below.

Table 1. Change in the variance of temperature in Paris

	Variance	F-value (current/base)	p-value
Base Time Period	61.17	0.9477	0.0018
Current Time Period	57.97		

Source: Savitz (2014)

Clearly, it can be seen that there is strong statistical evidence that the variability in

daily high temperature has decreased over the last century. The variance in daily high temperature during the baseline period was 61.17 degrees Celsius squared (standard deviation of 7.82 degrees), while the variance during the current time period is slightly smaller, at 57.97 degrees squared (standard deviation of 7.61 degrees). Although the magnitude of this change is relatively small, the p-value associated with the hypothesis that no change in variability has occurred is 0.0018. This provides strong evidence that the variability in day-to-day high temperature has decreased by a non-zero amount between the time periods. Now that statistical significance has been ascertained, we will turn to the practical significance of such a decrease in variability. The effective reduction in the magnitude of temperature variability is found to be 5.23%.

The aforementioned results are in general agreement with the theory of Karl *et al.* (1995), but in contrast to the work of some others, such as Schar *et al.* (2004) who has argued that climate change should be producing an increase in temperature variability. As was previously discussed, however, the topic of temperature variability has not been studied as widely as the topic of temperature change, and the prior literature is, indeed, not uniform in consensus.

Table 2. Change in average temperature in Paris

	Mean	Difference in Means (current – base)	T-value (p-value)
Base Time Period	15.3	0.5	5.32 (p-value < 0.00001)
Current Time Period	15.8		

Source: Savitz (2014)

Regarding average temperature, above, we see conclusive evidence of an increase in the mean high temperature. We find that, from the base time period to the current time period, the mean high temperature in Paris has increased by 0.5 degrees Celsius. The p-value associated with the hypothesis test of no change in temperature is less than 0.00001, indicating that the average high temperature has nearly certainly increased between the time periods. The 95% confidence interval for the change in temperature is from 0.4 to 0.6 degrees Celsius. Additionally, the estimated increase of 0.5 degrees Celsius that we found corresponds well with the analysis of Nicholls *et al.* (1995), indicating agreement with the extant literature.

Regarding effect size, this may be looked at from two angles in this case. First, from a sheer percentage change standpoint, we find that the mean temperature has increased by 0.17%. Note that the temperatures were converted from Celsius to Kelvins prior to this calculation since only Kelvins exist on the ratio scale. At first, this effect size may seem minuscule. When compared to the typical daily variability in temperature (as measured by the standard deviation), however, the effect size is seen to be 0.065 standard deviations. This effect size is, again, small, but appears more noticeable than before.

In summary, it can be seen that, in Paris, the mean daily high temperature has increased significantly during the 20th century, while the day-to-day variability in high temperature has decreased.

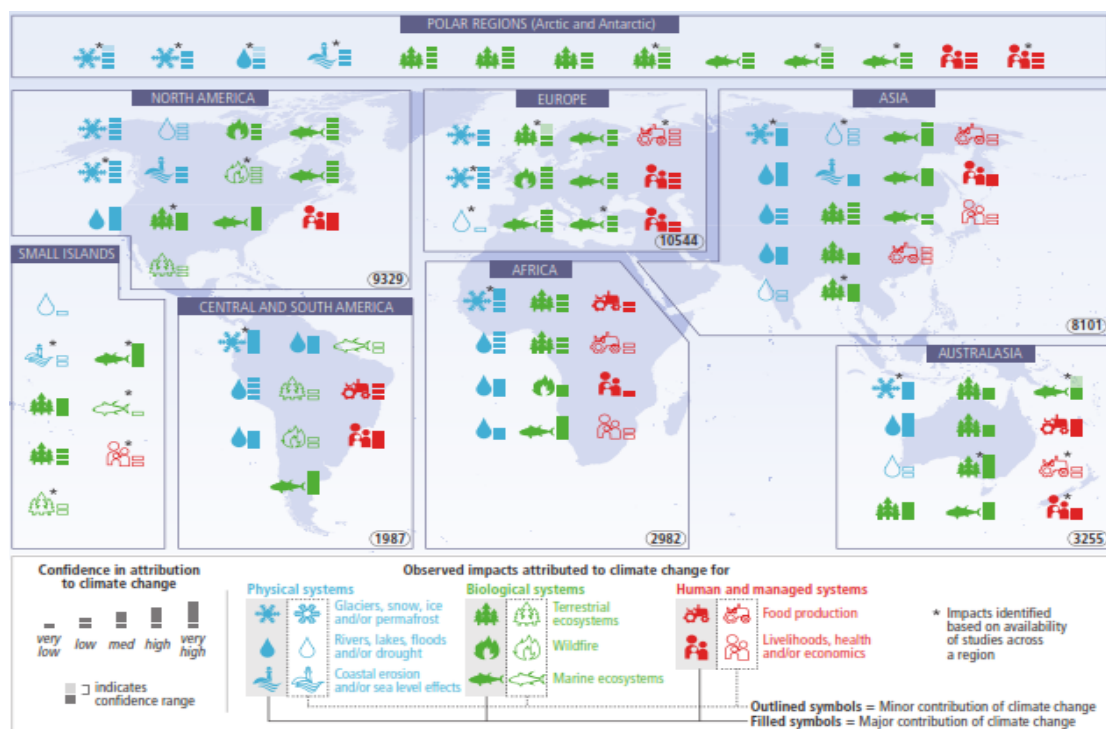
Based on our study we can say that global warming is a present phenomenon which, regarding average temperatures, is in a similar way to that posited by many scholars including Nicholls *et al.* (1995). Regarding day-to-day variability in temperature, we shed new light on the situation, given the inconclusive nature of the prior research. Indeed, our finding of a decrease in the day-to-day variation in temperature may pose a small piece of good news, as this may slightly aid in short to mid-range temperature forecasting. These phenomena

associated with climate change will certainly affect us and we need to find solutions to deal with the situation.

Next, we will consider how the risk management process is related to climate change risks and the related implications in the insurance industry. In order to fully appreciate these risks and relationships, a broader understanding of the effects of climate change in the industrial sector is necessary. Let us now turn to these issues.

The importance of the climate change phenomenon is due to the fact that it affects humanity (decrease of air quality, the risk of illness and death due to the warm atmosphere, the spread of diseases, etc). (Haines *et al.*, 2006; Shea *et al.*, 2008; Bezirtzoglou *et al.*, 2011; Sheffield *et al.*, 2011; Thomas *et al.*, 2014; Franchini, Mannucci, 2015; Houser *et al.*, 2015) natural systems (floods, storms, diminished snowpack, increased vaporization, etc) and influences all major sectors of the economy.

The Climate Change 2014 Synthesis Report (SYR) of the IPCC Fifth Assessment Report (AR5) provides us with information about the global impacts of climate change (IPCC, 2014b).



Notes: Based on the available scientific literature since the IPCC Fourth Assessment Report (AR4), there are substantially more impacts in recent decades now attributed to climate change. Attribution requires defined scientific evidence on the role of climate change. Absence from the map of additional impacts attributed to climate change does not imply that such impacts have not occurred. The publications supporting attributed impacts reflect a growing knowledge base, but publications are still limited for many regions, systems and processes, highlighting gaps in data and studies. Symbols indicate categories of attributed impacts, the relative contribution of climate change (major or minor) to the observed impact and confidence in attribution. Each symbol refers to one or more entries in WGII Table SPM.A1, grouping related regional-scale impacts. Numbers in ovals indicate regional totals of climate change publications from 2001 to 2010, based on the Scopus bibliographic database for publications in English with individual countries mentioned in title, abstract or key words (as of July 2011). These numbers provide an overall measure of the available scientific literature on climate change across regions; they do not indicate the number of publications supporting attribution of climate change impacts in each region. Studies for polar regions and small islands are grouped with neighbouring continental regions. The inclusion of publications for assessment of attribution followed IPCC scientific evidence criteria defined in WGII Chapter 18. Publications considered in the attribution analyses come from a broader range of literature assessed in the WGII AR5. See WGII Table SPM.A1 for descriptions of the attributed impacts.

Source: IPCC (2014b)

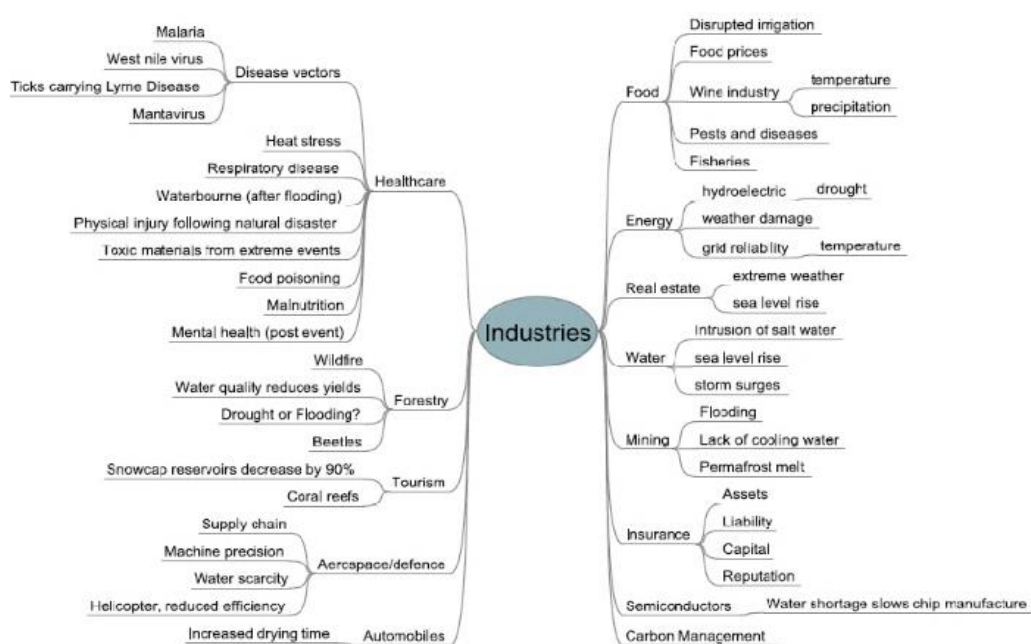
Figure 2. Global Climate Change Impacts

As we can observe, all systems (physical, biological, human and managed system) are significantly affected. A very important issue related to climate change is the fact that people are in danger and the number of victims remains at a high level (Swiss Re, 2015). Currently, several international agencies are trying to find solutions to reduce the number of victims and to protect people in these situations.

Taken into account that economic losses can be covered by a different type of insurances, severe measures are required in order to limit the life losses due to the occurrence of both natural and man-made disasters.

Besides the environmental cost of climate change, there is an economic cost determined by the cost which covers catastrophic losses and by the cost of adapting to climate change impacts.

In the following section, we will analyse the risks related to climate changes effects in economic sectors and how risk managers can face it. The impact of climate change on most of the economic sectors is highly uncertain (IPCC, 2007b) but based on the work of Tolle (2011) we can state that all major industries are facing new risks caused by climate fluctuation (Figure 3).



Source: Tolle (2011).

Figure 3. Industries Affected by Climate Change

As can be seen from the preceding discussion, all economic sectors face many risks. Risk can be considered as an event that can affect the ability of a company to achieve its objectives and to follow their strategies.

Likelihood (probability of an event) X Impact (consequences of an event) = Risk

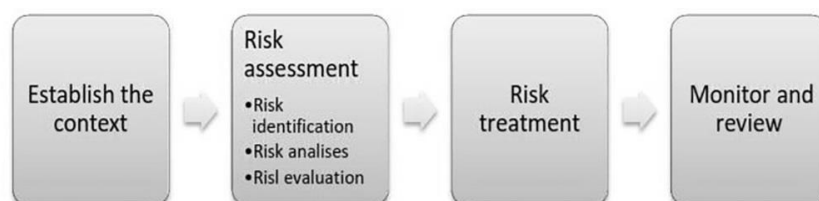
Not any risk can have a negative impact on company activity. Some of the risks can be considered to have a positive impact and can represent an opportunity for the business.

2.1 Risk Management Process

In order to manage the risk, make the right decisions, maximize opportunities, and to

reduce the negative effect of any risk related to climate change, managers need to be focused on the risk management process.

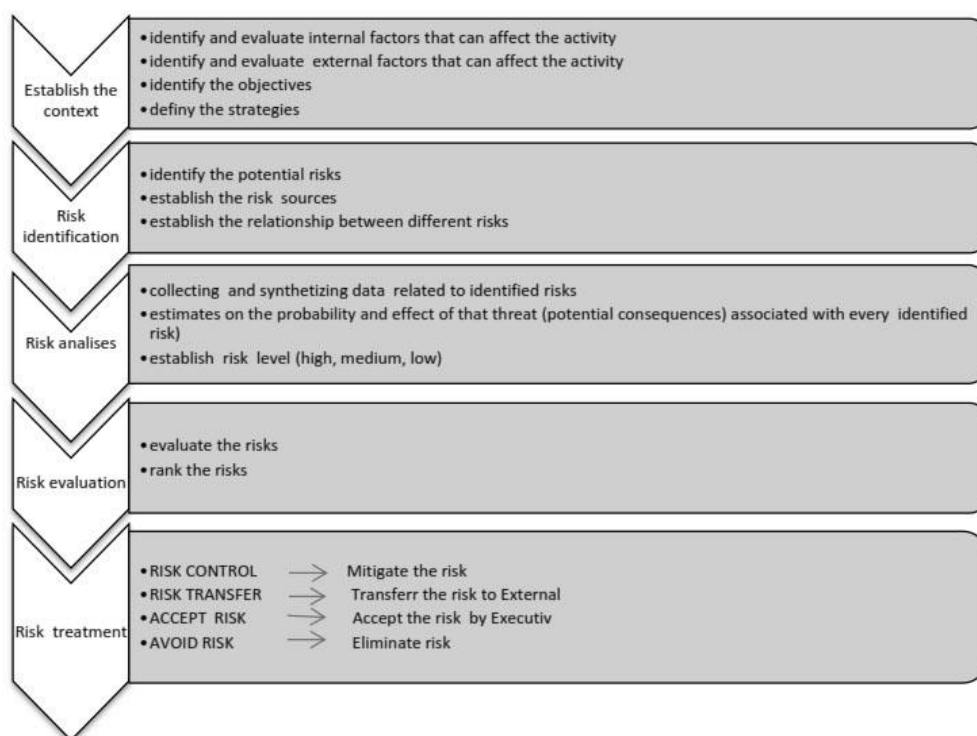
The scheme of the risk management process, which is a continuous process, is presented in *Figure 4*.



Source: authors' own configuration.

Figure 4. Risk Management Process

In order to ensure the best decisions each process requires a few steps that must be followed (*Figure 5*).



Source: authors' own configuration.

Figure 5. Risk Management Process

2.1.1 Establish the Context

This step is ampler but in this paper we will focus on the process of identification of those factors and variables that may prevent the company from achieving its goals and objectives.

According to the World Meteorological Organization (2010)), the essential climate variables related to the climate change phenomenon are presented in *Table 3*.

Table 3. Climate variables related to climate change

Domain	Essential climate variables
Atmospheric (over land, sea and ice)	Surface: [1] air temperature, wind speed and direction, water vapour, pressure, precipitation, surface radiation budget. Upper-air: [2] temperature, wind speed and direction, water vapour, cloud properties, the Earth radiation budget (including solar irradiance). Composition: carbon dioxide, methane, and other long-lived greenhouse gases [3], ozone and aerosol, supported by their precursors [4].
Oceanic	Surface: [5] sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, surface current, ocean colour, carbon dioxide partial pressure, ocean acidity, phytoplankton. Sub-surface: temperature, salinity, current, nutrients, carbon dioxide partial pressure, ocean acidity, oxygen, tracers.
Terrestrial	river discharge, water use, groundwater, lakes, snow cover, glaciers and ice caps, ice sheets, permafrost, albedo, land cover (including vegetation type), fraction of absorbed photosynthetically active radiation (FAPAR), leaf area index (LAI), above-ground biomass, soil carbon, fire disturbance, soil moisture.

Notes: [1] Including measurements at standardized, but globally varying heights in close proximity to the surface. [2] Up to the stratopause. [3] Including nitrous oxide (N₂O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF₆), and perfluorocarbons (PFCs). [4] In particular nitrogen dioxide (NO₂), sulphur dioxide (SO₂), formaldehyde (HCHO) and carbon monoxide (CO). [5] Including measurements within the surface mixed layer, usually within the upper 15m.

Source: World Meteorological Organization (2010).

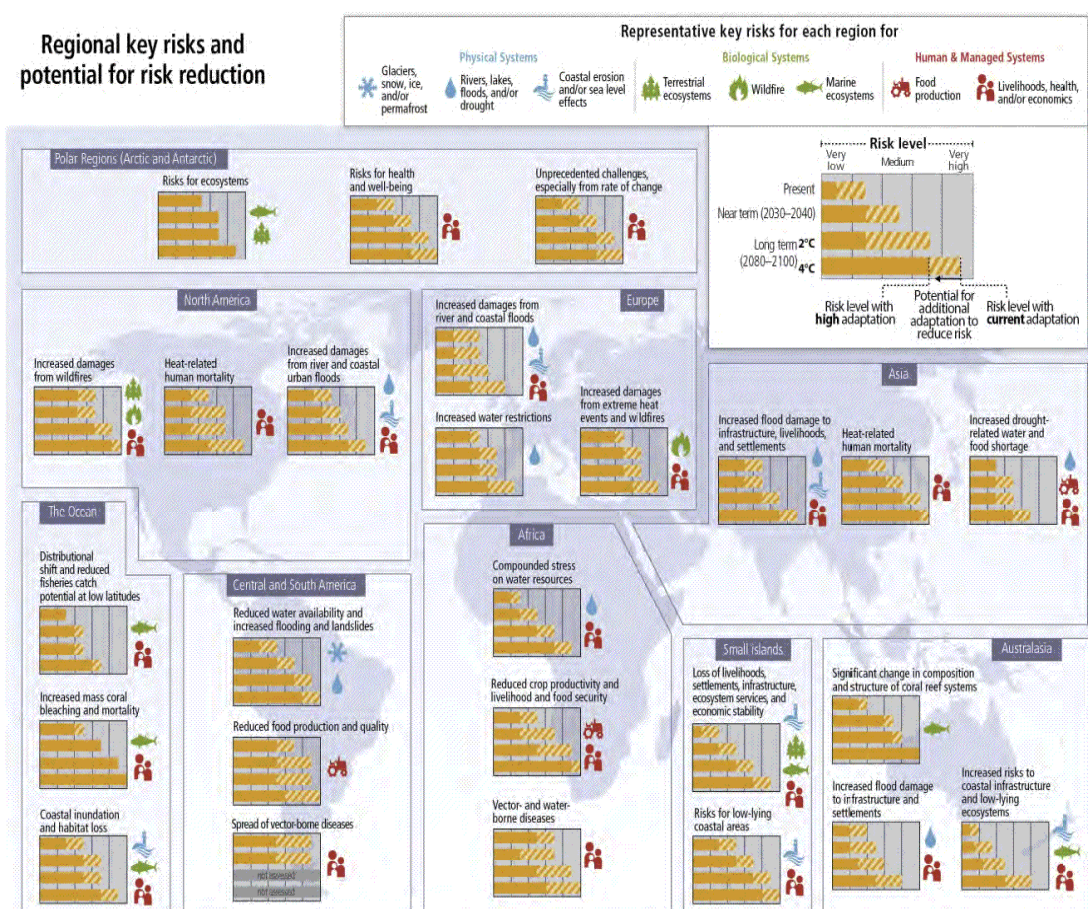
All the factors related to climate change can affect the activity of every organization. Risk managers need to identify all these factors, to establish the potential risks, to evaluate and rank the risks and to treat them according to their own policy on risk management.

2.1.2 Risk Identification

Based on variables identified in the first stage, it is necessary to identify the potential risk, to establish the relationship between different risks and to identify the probability and effects related to each risk. Potential risks that can affect economy sectors can be summarized in 5 categories:

- Risks related to resources availability (may be reduced water resources as a result of climate change or increased temperature, as verified by the previous analysis of the Paris data)
- Risks related to infrastructure (is infrastructure designed in order to resist to any disaster produced as an effect of climate change)
- Risks related to products and services demand (there will be any demand for a product/service in case that temperature will continue to increase)
- Risks related to damages produced by natural disasters to industrial capacity of companies (are industrial capacities projected and made to resist natural disasters)
- Risks related to the industrial process (is industrial process vulnerable to any climate change variable)

The risks related to climate change are presented in *Figure 6*.



Notes: Representative key risks for each region, including the potential for risk reduction through adaptation and mitigation, as well as limits to adaptation. Each key risk is assessed as very low, low, medium, high or very high. Risk levels are presented for three time frames: present, near term (here, for 2030–2040) and long term (here, for 2080–2100). In the near term, projected levels of global mean temperature increase do not diverge substantially across different emission scenarios. For the long term, risk levels are presented for two possible futures (2°C and 4°C global mean temperature increase above pre-industrial levels). For each timeframe, risk levels are indicated for a continuation of current adaptation and assuming high levels of current or future adaptation. Risk levels are not necessarily comparable, especially across regions.

Source: IPCC (2014b).

Figure 6. Representative Key Risks for Each Region

As we can observe in *Figure 6*, there is no place on the globe where climate risk is present and also we can state that multiple risks are present everywhere.

2.1.3 Risk Analysis

We can use an extended risk formula in order to analyse risks:

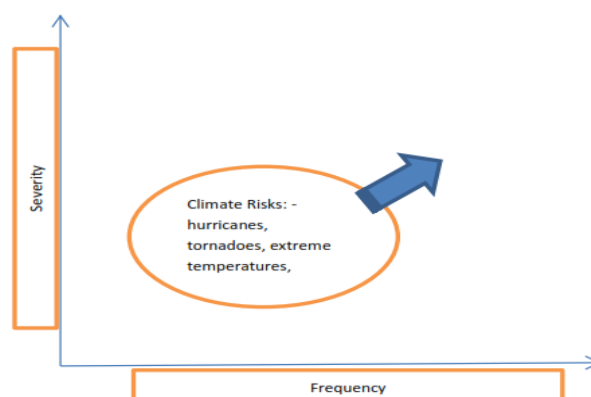
$\text{Risk} = \text{Hazard} \times \text{Vulnerability} \times \text{Exposure}$ (Van Ypersele, 2015)

We can state that risk levels cannot be always accurately quantified due to the fact that hazard is part of the equation, due to the data complexity that needs to be analysed, due to the methods used in order to evaluate and quantify a climate change related risk (IPCC, (2014b).

Based on data recorded by different agencies in recent years we can notice two major factors:

- The frequency of the risks caused by climate change is increasing (Botzen, Van Den Bergh, 2009; Repetto, Easton, 2010; Huber, Gullede, 2011).
- The severity of climate change risks is strongly connected with the level of exposure and vulnerability to these risks (IPCC, 2014b).

Until these relatively recent climatic changes, the very simple map of risks placed these risks on the level of lower frequency and medium severity. In recent years, because of these changes, the related phenomenon is placing climate risks as shown in *Figure 7* (to the part of the risk map where both frequency and also severity reach higher levels).



Source: authors' own configuration from severity/frequency perspective.

Figure 7. Evolution of Climate-Related Risks on the Map of Risks

The impact of climate change and possible disasters generated by climate change are influenced by the exposure and vulnerability of all systems (physical, biological, human and managed system) (IPCC, 2012).

2.1.4 Risk Evaluation

This risk management step is necessary in order to compare risk analysis results with risk criteria and to rank the risks using a risk matrix, based on different level or risk establish, based on this comparison,

In this stage, the risk will be evaluated and will be ranked, using a risk matrix (*Figure 8*):

	Negligible	Marginal	Critical	Catastrophic
Certain				
Likely				
Possible				
Unlikely				
Rare				

Source: Project Smart, www.projectsmart.co.uk.

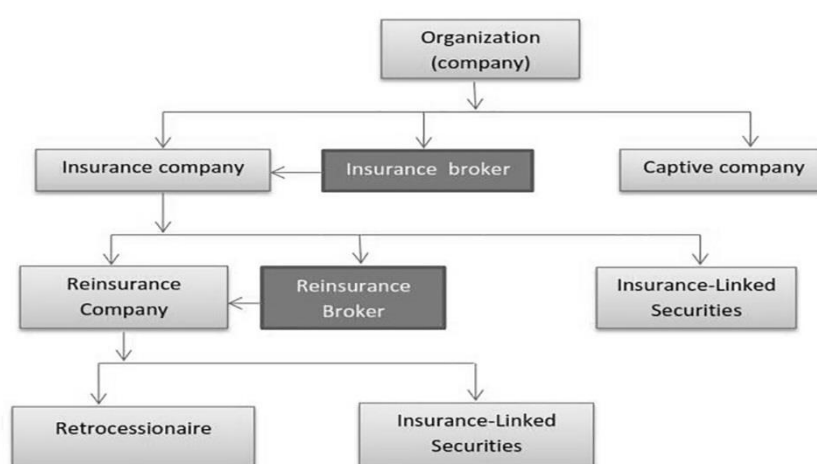
Figure 8. Risk Matrix

This step is necessary in order to compare the results of a risk analysis with the ones of risk criteria and to establish the level of risks. Risk evaluation is very dependent on people's perception of risk. Based on different elements (physical, psychological, cultural, etc.) risks

can be perceived in different ways. For this reason is very important to have different informative standards designed by specialized entities, which can be used to evaluate different risks.

2.1.5. Risk Treatment

The performance of risk management process allows risk managers to make the right decisions. As we can see in *Figure 9*, the purpose of all analysis is to decide on the risk treatment: the risk can be controlled, can be accepted or it may be more efficient to transfer it. In case the decision is to control the risk, it is necessary to develop and implement an action plan in order to eliminate the risk or to reduce it to an acceptable level.



Source: authors' own configuration.

Figure 9. Risk Transfer Process

Taking into account that all countries are facing climate change consequences, and must be prepared to prevent, protect and reduce losses from natural disasters that can affect the environment, humans and economic sectors. Hence, authorized institutions from each country/region need to develop plans in order to reduce climate change-related risks. Concrete measures will consist of developing prevention and warning systems in case of natural disasters, developing policies related disaster management, developing preventive action plans, establishing legal entities with the role of prevention and coordination of actions in case of natural disasters. In case of risk acceptance, it is very important to have a regular control of identified risk and to monitor it continuously. A very important step in the risk treatment is to transfer the risk to another part using insurance policies. A synthesis regarding the risk transfer process is presented in *Figure 10*.

2.2 Insurance and Climate Change Risks

The delicate problem related to climate change is that we must understand all involved factors in order to face these changes better. Furthermore, immediate action is important as the changes are currently at a known level. Indeed, the vast majority of prior research, as well as our original analysis, confirms the level of temperature increase long suspected. That said, future conditions may be quite different. Hence, forecasts of climate change must be taken into account by all industries, especially the insurance industry.

Potential impacts due to climate change which affect the insurance industry (insurers and brokers):

- Increasing demand for environmental insurance products;
- Increasing demand for risk transfer;
- Liquidity problems for insurance companies as a result of climate change risk;
- Increasing opportunities in GHG (greenhouse gas emissions) markets.

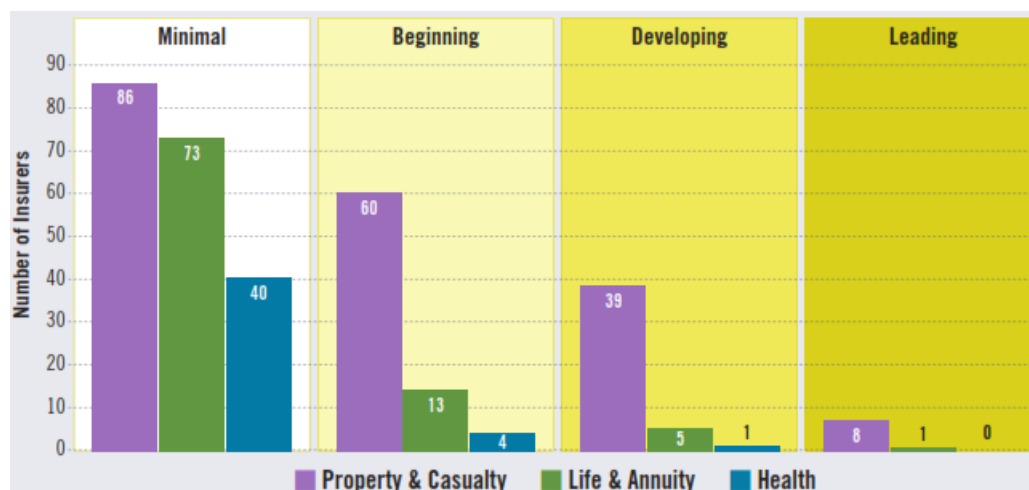
The report “Insurer Climate Risk Disclosure Survey Report & Scorecard: 2014 Findings & Recommendations” generated by Ceres (2014) analyses and ranks the largest 330 insurance companies according to five main issues:

- a) availability of insurance companies to approach climate risk;
- b) how insurers have adopted and established climate risk management programs;
- c) how insurers use in their activity computer modelling in order to manage climate risks;

d) how informed are stakeholders about climate risks issue? As a response of United Nations summit on climate change, members of The Climate Disclosure Standards Board (CDBS) have created Climate Change Reporting Framework in order to offer to shareholders more information about how their investments are affected by climate change and which is the impact of their investments upon climate change. This report is still voluntary but it is necessary that in the proximate future some information regarding climate change issues to be mandatory to disclose, in addition to mandatory financial reports.

- e) How companies are prepared to measure and reduce GHG emissions

Related to issues and using a 100 point scale, companies were divided into 4 groups: Leading, Developing, Beginning and Minimal (*Figure 10*).



Source: Ceres (2014).

Figure 10. Overall Insurer Performance – Distribution of Scores by Rating

Taking into account this information, we notice that the climate change issue is not well managed globally by insurance companies. Only 9 companies can be evaluated to be part of the Leading group, and 45 from Developing group. The majority of insurers are placed in the category *Beginning and Minimal*. Based on data from the same report it highlights a direct correlation between insurers size and insurers performance. Small companies recorded a very low average score and vice versa.

If we divide insurers companies into three categories: *Health, Property & Casualty and Life & Annuity* we can notice that all these categories confront different risks related to climate change phenomenon.

2.2.1 Insurer Type Company – Property & Casualty – Climate Risks

Infrastructure and economic sectors

Climate change phenomenon (floods, storms, rising sea level, extreme weather events, etc.) increase the frequency and severity of weather-related disasters and loss events. These changes affect not only properties but what is most important, the infrastructure (water supply, transportation, roads, power plants, etc.). People usually live in a densely populated area, so in case of an extreme event the infrastructure is affected and people who depend on it become vulnerable. Even urban systems and infrastructures seem to work separately, usually, they are very interactive and interdependent (Kirshen *et al.*, 2008). Insurers need to be aware of the costs of infrastructure in case of any event.

Economy sector

According to European Commission (2015) -Climate change consequences most affected sectors by temperature and precipitation levels are agriculture, forestry, energy and tourism.

Extreme weather events and natural disasters generate also important business interruption losses and of course company property damages. Companies need to be prepared to recover quickly in order to restore market balance and to not disrupt company activities situated in their supply chains (McCarthy *et al.*, 2001).

Properties

Water damages caused by hurricanes, tornadoes, severe downpours, hail storms, flash floods, etc. increased the number of affected properties.

According to Wüest *et al.* (2011) a combination of several factors such as higher temperatures and radiation from the sun, severe rainfall can cause soil altering and movement with disastrous consequences above properties from those areas. The phenomenon is worrying considering that in some parts of Europe the cost of damages caused by soil movement reached almost the same level as damaged cost generated by floods.

Casualty

Climate change will determine a large number of casualties (Nolt, 2015).

2.2.2 Insurer Type Company – Health – Climate Risks

Air pollution

Changes in wind patterns, the ecosystem and temperature affect air pollutant levels, especially ground-level ozone and airborne particles concentrations, which play a major role in human health level in every country (Haines *et al.*, 2006; Sheffield *et al.*, 2011).

Wildfires and biomass burning generated by high temperatures reduce air quality as a result of different gases and compounds that are spread in the atmosphere (carbon monoxide, nitrogen oxides, etc.) (Akagi *et al.*, 2011; Houser *et al.*, 2015).

In this case, the most affected are the lungs, the main organ of the respiratory system, (Houser *et al.*, 2015). Because of the major importance that these factors play in healthy population and taking into account other pollutants covered by EPA's Air Quality Index, air quality standards were developed and are calculated every day. The level of pollution is then reflected in the Air Quality Index (AQI).

Allergens

Warmer temperatures, the reduction of the numbers of cold day, and exposure to different air pollutants can increase levels of pollen concentration and pollen seasons with direct effects on allergic diseases: asthma and hay fever (Shea *et al.*, 2008; Thomas *et al.*, 2014; Franchini, Mannucci, 2015; Houser *et al.*, 2015)

Extreme temperature

Heat waves as a result of extreme temperature significantly increase the risk of death. Heat waves can affect the cardiovascular, cerebrovascular and respiratory systems, especially in older people (Houser *et al.*, 2015). These disruptions of the temperature can increase the number of patients with dehydration, nephritis, heat stroke, cardiovascular disease, respiratory disease, cerebrovascular disease, electrolyte disorders, kidney disorders, etc. (Rey *et al.*, 2007; Bezirtzoglou *et al.*, 2011; Houser *et al.*, 2015). That said, the threat of extreme heat waves at the current time may not be quite as high as it could be. This is because, at least in central Europe (and potentially extending to much of the northern hemisphere's middle latitudes), the variability in day to day temperature does not seem to have increased in recent years. Rather, there is only one factor (as opposed to two) contributing to the intensity of heat waves, and that factor is the increase in the mean temperature. It should be noted, however, that the decrease in the variability of the temperature that was found in our analysis implies the potential for a slight increase in the duration of heat waves.

Extreme weather events are floods, droughts and heavy rainfall.

Floods events can increase the risk of waterborne disease, respiratory infections (as a result of mould contamination), and can generate injuries and mortality (Penning-Rowsell *et al.*, 2005; Jonkman, Vrijling, 2008; Houser *et al.*, 2015).

According to The Center for Disease Control and Prevention, droughts can generate a decrease of water quantity and quality as a direct result of water pollution with viruses, protozoa, and bacteria that generate different infectious diseases and gastrointestinal illnesses. Also, we can notice significant effects of decreased air quality (dust storm) on the respiratory system (bronchitis and pneumonia).

Vector-borne diseases

Climate change also generates changes in the distribution and behaviour of insects and animals (Kovats *et al.*, 2001; Sutherst, 2004). Due this distribution and expansion of these vectors, there is an increased risk of vector-borne diseases like Lyme, Malaria, Chagas disease, dengue fever, West Nile virus, Onchocerciasis, yellow fever, Leishmaniasis, Chagas disease, etc. (Haines *et al.*, 2006).

Most vulnerable to all these risks are two categories of the population: children and older people. All insurers need to analyse all these factors in order to make the right decisions about the risks that they cover, about risk transfer, and about the insurance premium level.

2.2.3 Insurer Type Company – Life & Annuity – Climate Risks

Life & Annuity Insurance companies' issues regarding climate change are not as simple as it may seem at first glance. Considering that this segment of insurers is highly involved in the investment process, we can say that their decisions regarding how and where they invest their portfolios can be particularly affected by this phenomenon. A detailed analysis is necessary in order to choose right companies for every investment (where these companies are situated, can be they affected by climate change-related negative events, how protected they are, what is their policies related to climate change, etc.).

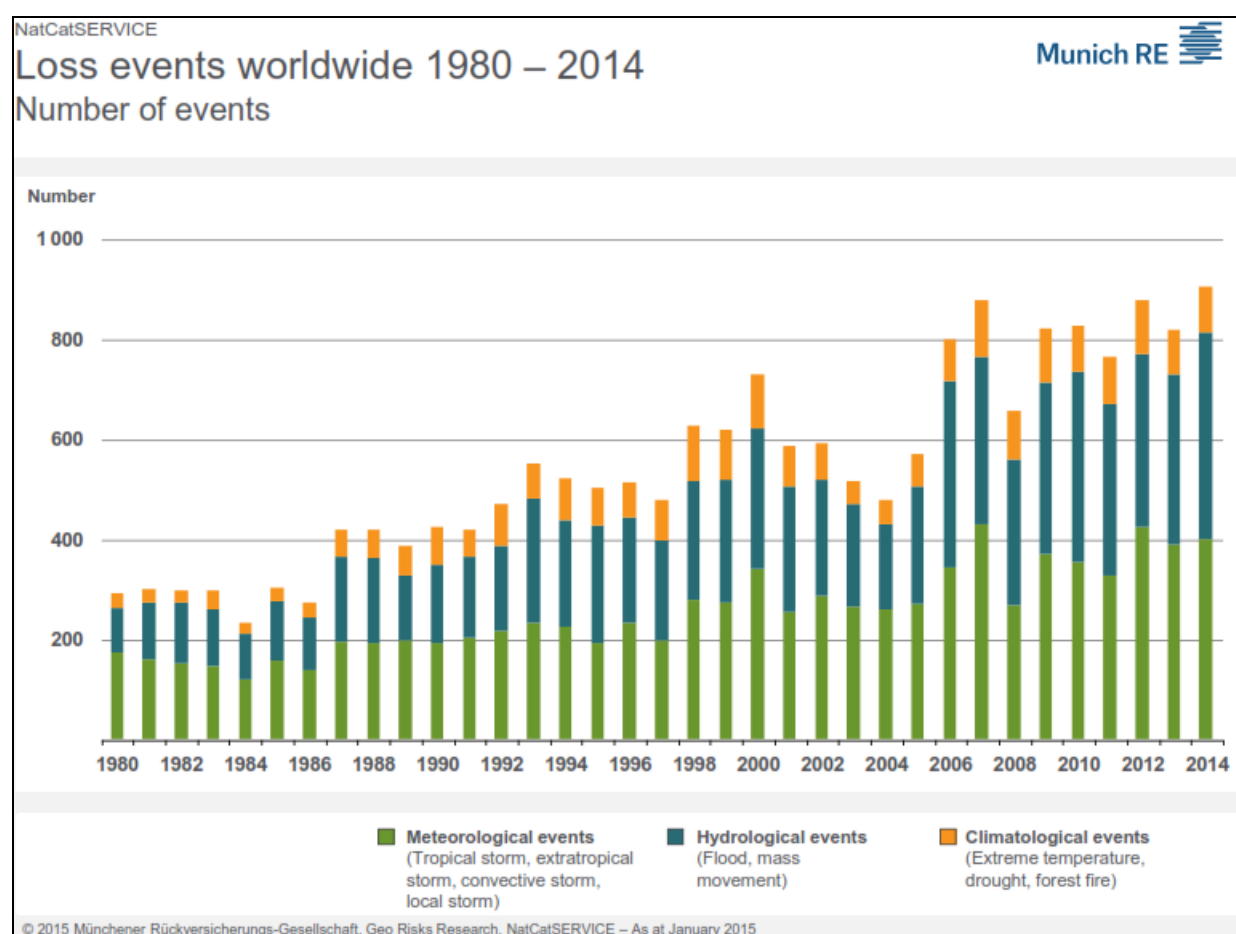
A very short analysis of how companies' activities are presented above in section Property & Casualty.

Another major issue for these categories of insurers is the fact that all climate change effects can cause injuries and mortality on very large areas (CCSP, 2008; IPCC, 2014a).

As we can notice all categories of insurers are affected by climate change. The urgent problem is to be aware of all damages that can be caused by the extreme phenomenon and to find solutions to cover all the risks related to these aspects.

As a result of Ceres analyses based on insurers responses to this survey, a conclusion was reached: all these categories confront different risks related to the climate change phenomenon.

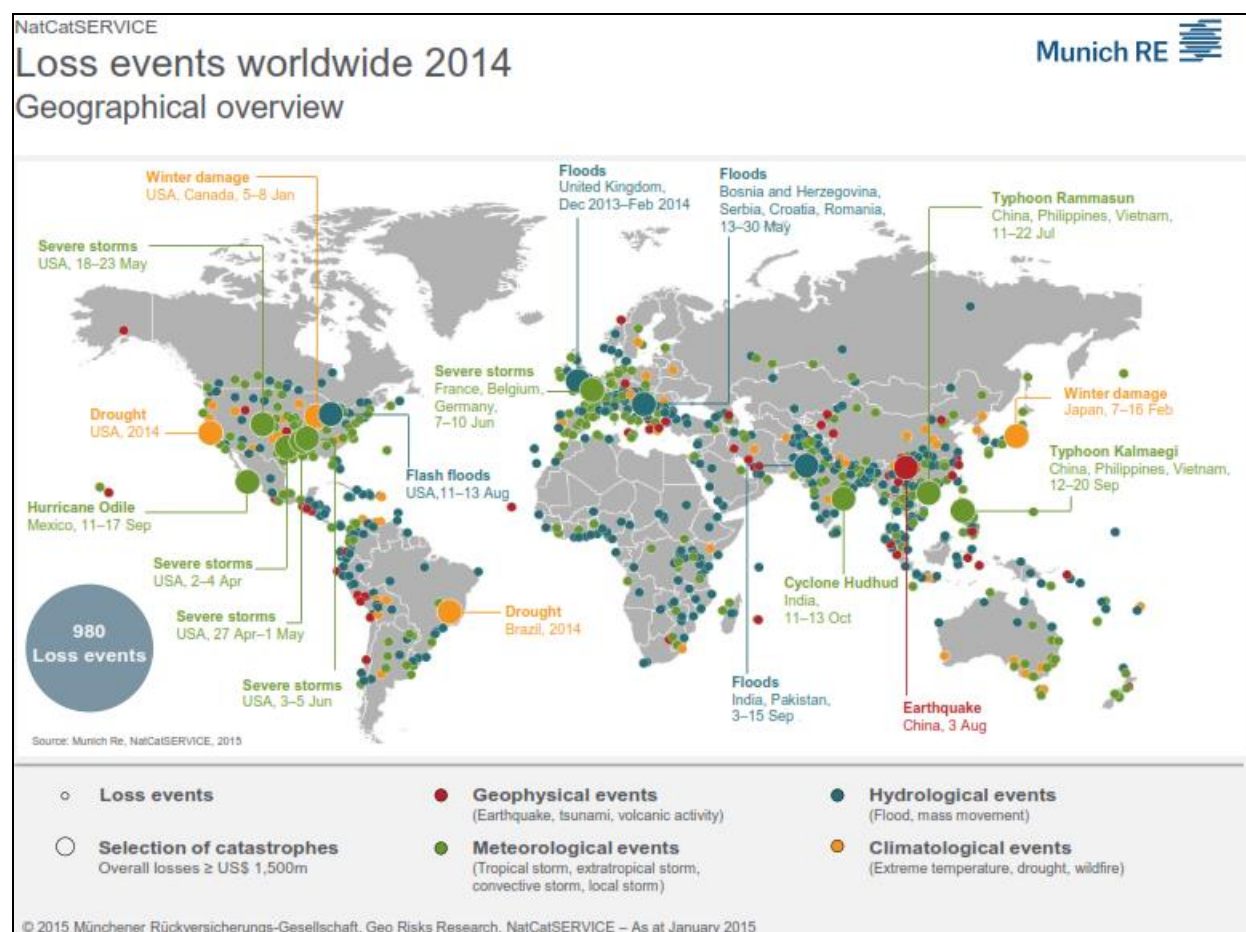
Using the statistics of Munich Re, we can see from the following table loss events, especially meteorological and hydrological events (*Figure 11*).



Source: Munich Re (2015).

Figure 11. Number of Events Worldwide, 1980-2014 (Loss events)

If we follow the data from NatCatService (the most comprehensive natural catastrophe loss database in the world established by Munich Re), we notice that in 2014 there were 980 natural catastrophes compared to 890 in 2013. Form these numbers, 900 events in 2014 are related to weather, compared to 790 in 2013. As a percentage, 91.8% of the catastrophes in 2014 are caused by weather, when in 2013 the percentage was of 88.76%. Therefore, in the last year, there was recorded an extra 3% for catastrophes caused by weather.

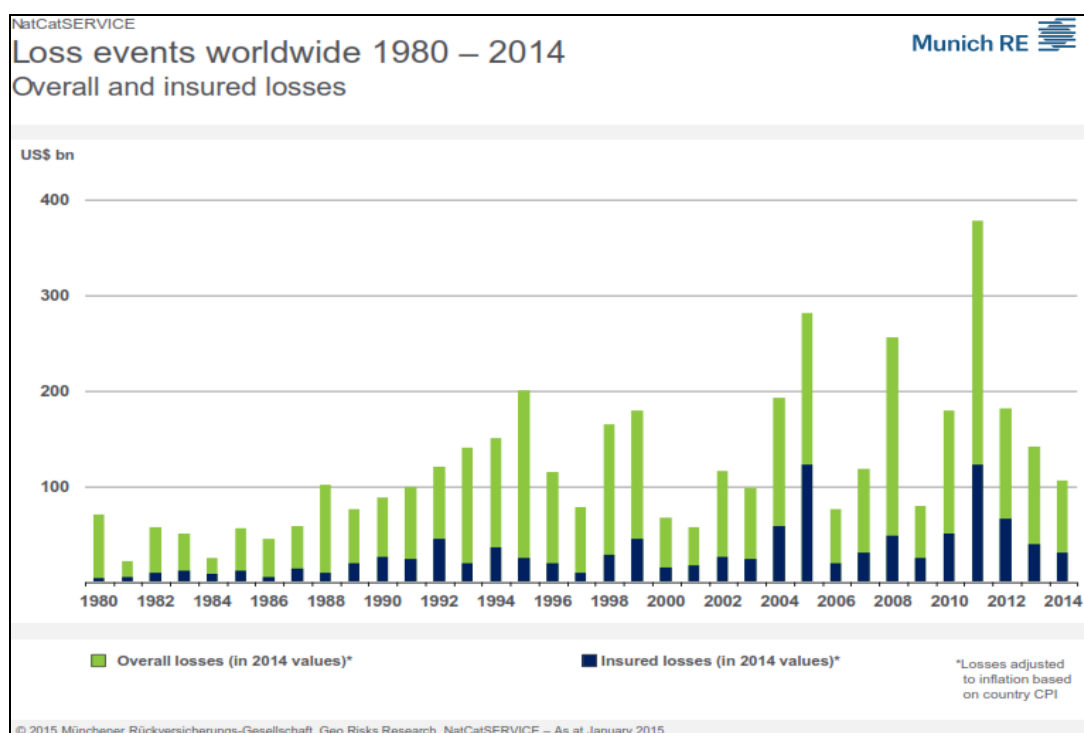


Source: Munich Re (2015).

Figure 12. Loss Events Worldwide, 2014 – Geographical overview

If we analyse the map of loss events in 2014 we notice that these events are more prevalent in certain parts of the globe so insurers need to pay high importance to these areas (Figure 12). Also, we can notice that in the last 2 years the negative impacts of natural/weather-related catastrophes are decreasing. This may be the result of some more effective/new controlling measures or maybe just a coincidence. The future will prove to us which explanation is the correct one.

The level of losses caused by natural catastrophes decreased in 2014 to a level of US\$ 110bn, compared with US\$ 135bn in 2013 (Figure 13). A very concerning fact is that even though climate change events causing high losses, only a small part from all these losses are covered by an insurance form. For example in 2014 insured losses related to weather risks were of US\$ 30bn, US\$ 5bn lower than in 2013. What is very interesting is that even though the events reached a high level in 2013, exposed parties subscribed less in 2014 than in the previous year.



Source: Munich Re (2015).

Figure 13. Overall and Insured Losses Worldwide, 1980-2014

This may lead us to some remarks:

- The Insurance/reinsurance industry is not entirely prepared to subscribe to all these risks or a higher level, to ensure this kind of risk losses.
- Exposed individuals/companies/local authorities do not have the financial power to bear the costs required by insurance companies.

In order to better face these risks, insurance/reinsurance companies should try to reduce the margin of profit as social responsibility may be more important than shareholders benefits. In this way, more individuals/companies will have access to an efficient source of financing climate change-related risks.

Conclusions

This paper contains a broad overview of the potential economic impacts of climate change and, in particular, how they relate to the insurance/reinsurance industry. In order to ascertain with better certainty the effects that are being dealt with, new climatic analyses were performed. These analyses dealt with the climate of middle latitudes in the northern hemisphere in general, and that of Paris, France, in particular. Two things were found regarding the change of climate in Paris over roughly the last century. First, the mean high temperature was found to have increased by approximately 0.5 degrees Celsius, which closely corresponds with previous work (Nicholls *et al.*, 1995). Additionally, the day-to-day variability in high temperature was found to have decreased slightly over this same time period, thus providing new insights into the specific nature of climate change.

The two aforementioned changes in climate have different implications for the insurance industry. On the one hand, the increase in temperature was found to be consistent with much prior research. This mandates that the actions of the insurance industry discussed

throughout this paper be put in place, in order to minimize the negative side effects of this increased temperature. In particular, rising sea levels and more intense heatwaves need to be prepared for.

On the other hand, the variability in temperature was found to have decreased slightly. This actually has the positive effect of making short term temperature slightly more predictable. This may allow the insurance industry, and others involved in risk management, to make decisions with less uncertainty.

All modifications in the Earth's climate as a direct result of the global warming phenomenon mandate that insurance and reinsurance companies to adopt new strategies for covering climate-related risks. Given this complex phenomenon insurance companies became more careful in their way of covering these risks. They were forced to adopt more effective risk management programs because reinsurance companies are not accepting those risks very simple.

The solution is that risks to be split between all involved parties:

- Individuals and companies will have to adopt efficient control measures against risks caused by climate changes and also measures to decrease the losses once the events occur – moreover, there will be deductibles for every insurance contract (in this way insured persons will be more aware of the importance of controlling/preventing measures)

- Insurance companies will be focused especially on the risk exposure of all possible clients, there is needed to develop new maps of exposures, based on the different risks caused by climate change. Also, they must follow if insurable principles are still standing: new risks are quantifiable and diversifiable (not to occur in the same time to all exposed elements), there must be the chance of non-occurrence and if the price for new products can be paid by insured clients. The likelihood of a catastrophe must be reanalysed and there will be important changes on the way of calculating these risks. Historical data are important, but the last decade's statistics should receive more importance and have a higher importance in establishing the transfer prices.

- Reinsurance companies received by transfer on reinsurance market the greatest part of the climate change-related risks that were initially subscribed by insurance companies. Because they will finance most of the losses, reinsurance companies will analyse the protection measures already taken by ceding companies (insurers). Also, together with other entities in the financial market, they will be very active in Cat Bonds area.

As can be seen, public authorities need to work together with insurance companies in order to identify risk exposed areas and to implement new and improved risk management measures.

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KLIMATO KAITA IR DRAUDIMAS

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SANTRAUKA

Straipsnyje pristatomas pasaulinės klimato kaitos fenomenas ir pateikiama originali Paryžiaus klimato analizė. Paryžius buvo pasirinktas todėl, kad apie jį galima gauti itin kokybiškus duomenis, jis atstovauja didelei žemyno daliai vidutinėse šiaurės pusrutulio platumose. Tyrimo metu buvo išsiaiškinta, kad daug tyrimų nurodo, jog vidutinė Paryžiaus temperatūra per pastarąjį amžių padidėjo maždaug 0,5° C. Atskleista, kad kasdienis temperatūros kintamumas per tokį patį laikotarpį sumažėjo. Šis atradimas gana unikalus ir suteikia naujų duomenų apie dar nepakankamai ištirtą klimato kaitos aspektą. Straipsnyje taip pat detalios aptariamos klimato kaitos ir draudimo sektoriaus santykis. Poveikis draudimo sektoriui yra susietas su Paryžiaus duomenų analize.

REIKŠMINIAI ŽODŽIAI: klimato kaita, vidutinė temperatūra, temperatūros kintamumas, rizikos valdymas, draudimo sektorius.