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MODELLING SEVERE HAIL RISK IN FRANCE FROM RE/INSURANCE PERSPECTIVES

Jianming Yin[1], Michael Welch[2], Yoshiaki Ogane[3], Mizuki Shinohara[4]

[1]*Tokio Marine Technologies LLC, Duluth, Georgia, USA, jianming.yin@tokiomarinetech.com*
[2]*Tokio Marine Technologies LLC, Duluth, Georgia, USA, michael.welch@tokiomarinetech.com*
[3]*Tokio Marine Technologies LLC, Duluth, Georgia, USA, yoshiaki.ogane@tokiomarinetech.com*
[4]*Tokio Marine & Nichido Risk Consulting Co., Ltd., Tokyo Japan, mizuki.shinohara@tokiorisk.co.jp*
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I. INTRODUCTION

Though infrequent in nature, hailstorms can be a significant hazard in Europe, especially in the summer months. Extreme hailstorms have caused catastrophic losses to buildings and automobiles in Munich and elsewhere in Europe (Swiss Re, 2005). There is an obvious need for property insurance industry to adequately assess hail risk in Europe. However, the very infrequent nature of catastrophic hailstorms in Europe invalidates the standard actuarial loss estimation approach. Computer models that are capable of simulating tens, even hundreds, of thousands of future likely synthetic hailstorms were developed in the past to compensate the scarcity of historical hailstorm loss data and to achieve stable loss estimates for regions where little to none historical loss data ever exist (Yin et al., 2007a and 2007b).

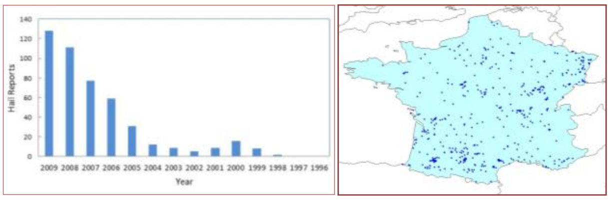
In this endeavour, a computer model is developed for severe hail risk in the contiguous France. Corsica Island was excluded in the model due to the absence of historical hail reports from the island. A severe hailstorm is defined as one containing hailstones of at least 20 mm in diameter, the minimum hail size that is considered to have the potential to inflict damage to buildings and automobiles. The hail risk model developed in this endeavour is intended not only to price individual property with hail coverage but also to allow companies to assess their needs to buy protection from reinsurance companies. Therefore, the concept of severe hail event is introduced and defined as a congregation of individual hailstorms spawned by the same convective precipitation system moving through the contiguous France in a 72-hour time frame.

This paper begins with a discussion on the availability of historical hail data for France that can be used for severe hail risk modelling. Discussion then extends to development of severe hail climatology for France and simulation of future possible hail events. The paper touches briefly upon the vulnerability functions used to estimate manufacturer automobile loss due to hail.

II. HISTORICAL HAIL REPORTS AND HAIL EVENTS FOR INSURANCE PURPOSES

There are a number of organizations in France that collect hailstorm data for various purposes. Most noticeable is the ANELFA (Association Nationale d'Etude et de Lutte contre les Fléaux Atmosphériques) of France (Dessens, 1986a and 1986b) that operates a hailpad network in regions across France including Southwestern France where hailstorms are most active. Unfortunately, ANELFA hail data could not be made available at the time this endeavour was undertaken. After reviewing the availability and quality of the hail data from various other sources, European Severe Weather Database (ESWD) severe hail reports maintained by the European Severe Storms Laboratory (ESSL) were chosen to model the severe hail risk in France. It is a pragmatic choice that balances the resource required to acquire and analyse the data and the anticipated benefits from the use of the data.

However, as shown in Figure 1, there was a sharp increase in the ESWD hail reports since 2001, the year ESSL installed a systematic approach to collect and maintain hail reports. The sharp increasing trend since 2001 was an artefact caused by the severe underreporting of hailstorms in the earlier years. Use of the ESWD hail reports as they were will result in significant underestimation of the true hail risk in France due to the missing hail reports in the ESWD data.



(a) Hail reports by year (b) Locations of hail reports

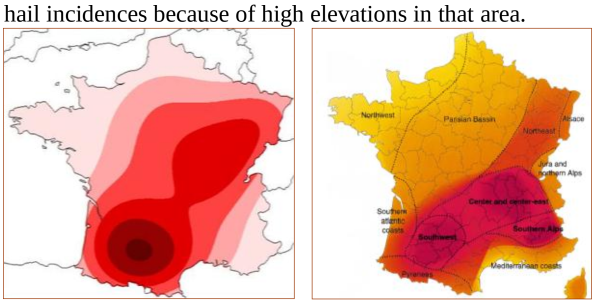
FIG. 1: ESWD hail reports from France between 580 and 2009.

The data quality of the ESWD hail reports for France prevents us from applying the hail reports augmentation techniques developed in Yin et al. (2007a). Instead, an empirical climatology for severe hail in France was derived by applying the bivariate Gaussian Kernel smoothing technique to ESWD data as discussed in Section III.

Historical severe hail events are taken from the ESWD hail reports post 2001 using the severe hail event definition. The number of severe hail events per year in France was modelled with a Poisson distribution while an exponential distribution was used to model the number of hailstorms in a severe hail event. A Monte Carlo simulation was employed to simulate up to 1 million years worth of future possible severe hail events and hailstorms in France.

III. CLIMATOLOGY OF SEVERE HAIL IN FRANCE FOR HAIL RISK ASSESSMENT

The limited number of years in the ESWD hail data with complete hail reports made it almost impossible to draw any meaningful conclusion as to the activity of severe hail in France which is needed in order to assess severe hail risks. The hail climatology map suggested by Vinet (2001) was largely based on hail measurements of all sizes and validated using hail insurance premium rate information. It was therefore considered as the climatology of all sizes of hail in France. An empirical climatology for severe hail in France is therefore derived here by applying a bivariate Gaussian Kernel smoother with the optimal bandwidth to the ESWD hail reports. This bandwidth is achieved using the out-ofsample Jackknife cross validation technique described in detail by Hall and Jewson (2007). Figure 2 shows the empirical severe hail climatology map for France. This empirical climatology map is comparable with independent studies such as those by Berthet et al. (2011) and Vinet (2001). In general, there are however, some discernable differences worth pointing out, especially in comparison with Vinet (2001). As seen in Figure 2, there is a sudden drop in hail risk in the Jura and northern Alps region defined by Vinet (2001). Relative high hail risk extends through this region in the severe hail climatology map derived in this endeavour. On the other hand, a noticeable hail risk peak appears in the Southern Alps in Vinet (2001). This peak does not exist in the severe hail climatology map, however. It is speculated that the hail risk peak appearing in Vinet (2001) was likely driven by the frequent but low severity hail incidences because of high elevations in that area.

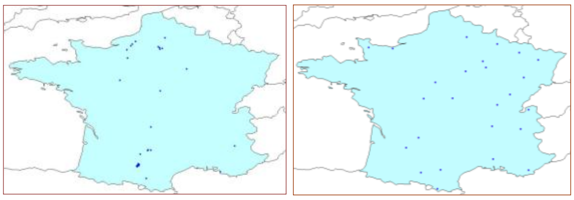


(a) (b)

FIG. 2: (a) Climatology of severe hail derived using the ESWD hail reports and (b) Hail climatology map by Vinet (2001).

IV. SIMULATION OF STOCHASTIC HAIL EVENTS AND HAIL IMPACT ENERGY

To accommodate the lack of reliable quality hail data in France, the number of hail events in a simulation year and the number of hailstorms in a simulated event are empirically derived for France based on the ESWD hail reports from France and its neighbouring countries. The number of hail events in France for a given year follows a Poisson distribution while the number of hailstorms in a hail event follows an exponential distribution. The seasonality of the simulated hail events are also achieved using historical seasonality information available in the ESWD data. To find the likely location of a simulated hailstorm, the empirical severe hail climatology is sampled as the probability of hail occurrence at a 0.01° grid resolution. This approach implies that the locations of hailstorms in a simulated hail event are independent. A simulated hail event is shown in Figure 3 with a historical ESWD hail event by its side for the purpose of visual comparison.



(a) Historical ESWD hail event (b) Simulated hail event

FIG. 3: Blue dots indicate the locations of individual hailstorms in a severe hail event.

In this endeavour, hail impact energy comprised of both gravitational and windblown components is simulated and used as hail hazard intensity to estimate hail losses to automobiles. The method used to calculate hail impact energy in this endeavour is based on the approach suggested in Matson and Huggins (1980). The physical parameters required to calculate hail impact energy and the probability distribution functions suitable to fit these parameters can be found in Yin et al. (2007a).

V. VULNERABILITY FUNCTIONS AND LOSS ESTIMATION

Innovative hail vulnerability functions for automobiles are developed in this endeavour. Three separate vulnerability functions are developed to explicitly account for the dent repair labour, parts replacement and depreciation cost, respectively. The depreciation cost is particularly applicable to manufacturer automobile coverage since an automobile can no longer sell at its original price even after it is fully repaired. These hail vulnerability functions better reflect how automobile hail loss claims are adjusted in the real world and hence provide more realistic loss estimates.

VI. CONCLUDING REMARKS

In this endeavour, an empirical climatology of severe hail is derived for France using the ESWD hail reports. An event-based hail hazard simulation model is developed to accommodate the quality and availability in the severe hail information in France. Monte Carlo simulation techniques are employed to simulate up to 1 million years worth of future possible hail events. Continuing improvements to the modelling approach are expected as more reliable hail data and new modelling technologies emerge.

VII. ACKNOWLEDGMENTS

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