



TOKIO MARINE
TECHNOLOGIES

Modeling and Quantification of Severe Hailstorm Risk in Spain from Re/Insurance Perspectives

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Tokio Marine Technologies LLC

Insurance/Reinsurance

+ Insurance

- > Transferring of the risk of a loss, from one entity to another, in exchange for a premium, to prevent a large, and possibly devastating loss

+ Reinsurance

- > Business of insuring an insurance company against suffering too great a loss from their insurance operations, and
- > Allowing an insurance company to lay off or pass on part of their liability to another insurer on a given insurance which they have accepted

Event-Based Modeling and Simulation Approach

- + Event-based models can be used to price individual sites but also to project catastrophic losses for companies to manage hail risks and to assess reinsurance needs at portfolio level.
- + Hail event definition follows Re/insurance conventions and is defined by country.

Hail Risk Modeling Definitions and Terminologies

+ Hail Event

- > Congregation of hailstorms spawned by the same hail producing system in a continuous 72-hour time period within Spain
- > Two or more events are counted when a hail producing system dwells more than 72 hours when crossing Spain.

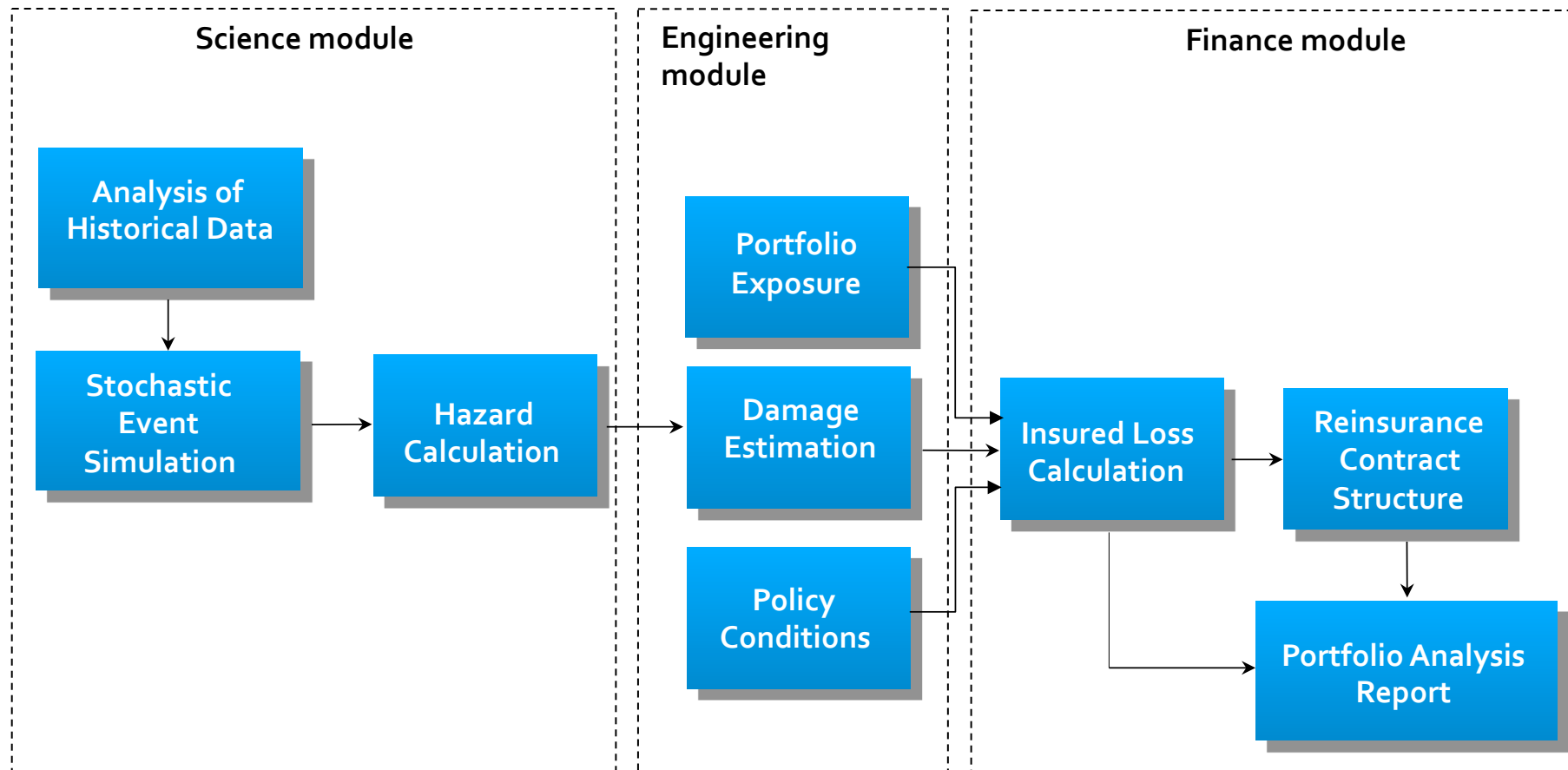
+ Hailstorm

- > Area on the ground impacted by hail with a gap in time of less than 15 minutes and a gap in space of less than 16 km (10 miles).
- > Hailstorms with hail size 20 mm or greater are termed severe hailstorms. Only severe hailstorms are modeled in this endeavor.

+ Hail Physical Parameters

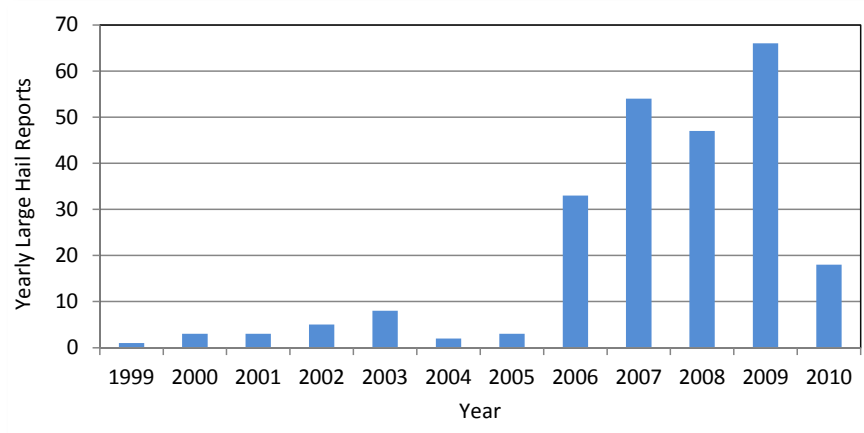
- > Characteristics of hailstorms essential for automobile loss estimation

Hail Risk Modeling Components



ESSL ESWD Hail Reports from Spain (1999-2010)

243 ESSL hail reports by year
(1999-2010)



ESSL ESWD Hail Reports from Spain (2006-2010)

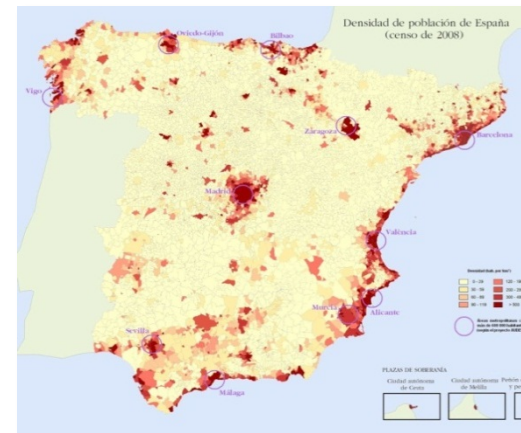
ESWD hail reports spatial distribution



Spain orography



Spain population



Causes for Spain Hail Temporal & Spatial Variability

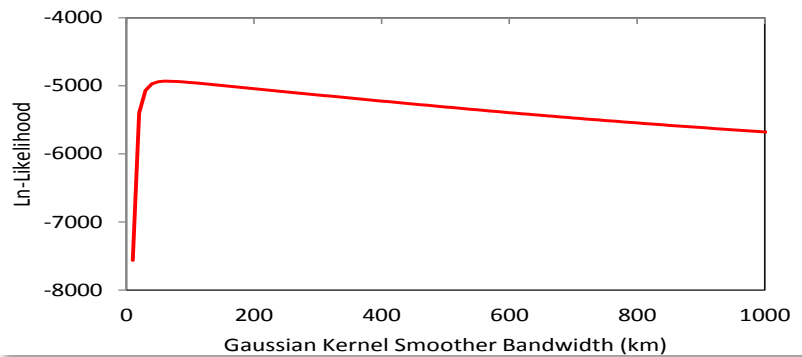
- + Sharp increase in hail reports in the recent years is likely due to
 - > Concerted efforts in reporting and maintaining ESWD by ESSL
 - > Improvement and advancement of detecting, monitoring, and reporting technologies
 - > Increased awareness and involvement of the public in severe weather
- + No climatological theory can fully explain the spatial variability in Spain hail reports
 - > Orography explains some of the regional variability.
 - > Data reveals population biases in the reports.
- + Contribution of inherent climatic fluctuations to variability

Climatology of Hail in Spain

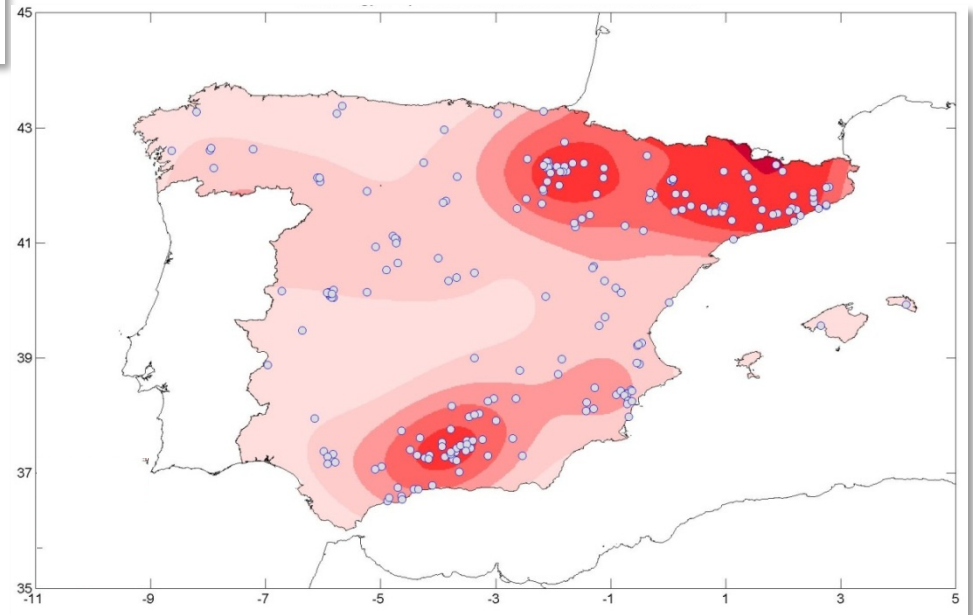
- + Hail climatology information is required to simulate the locations of future hailstorms in a stochastic hail event.
- + 218 ESWD severe hail reports since 2006 are used to derive the empirical climatology of hail in Spain.
- + A two-dimensional Gaussian Kernel smoother is applied to the ESWD reports for the continental Spain.
- + Optimal bandwidth (optimal standard deviation for the Gaussian Kernel smoother) was achieved using out-of-sample Jackknife Cross Validation technique.
- + Empirical climatology of hail in the continent Spain is derived by smoothing the ESWD using the Gaussian Kernel smoother with the optimal bandwidth.

Empirical Climatology of Hail in Spain

Optimal bandwidth = 70 km

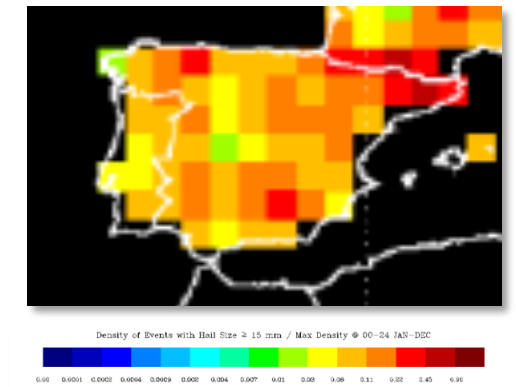


Empirical climatology of hail

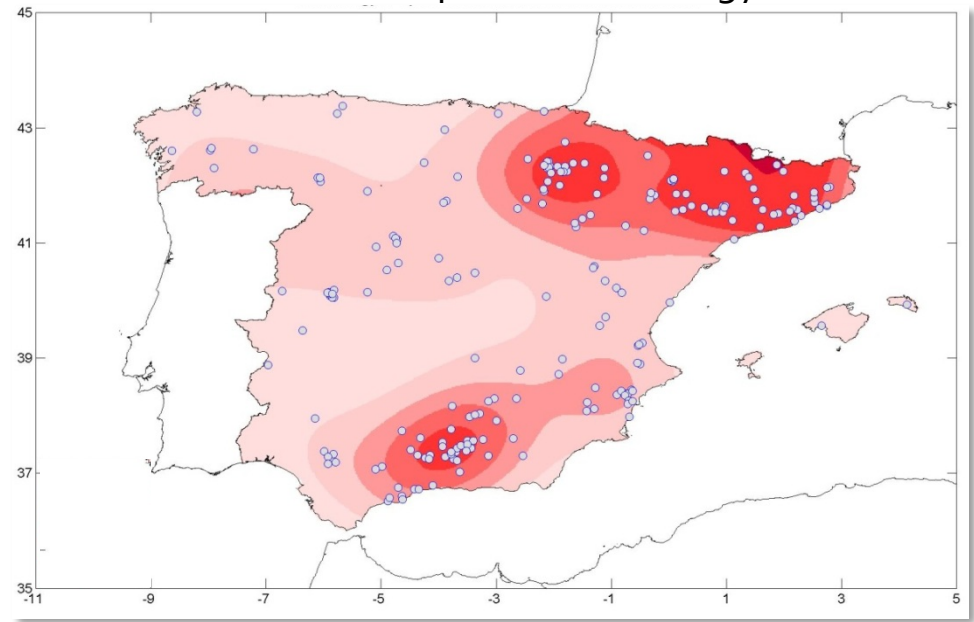


Empirical Climatology Comparison and Validation

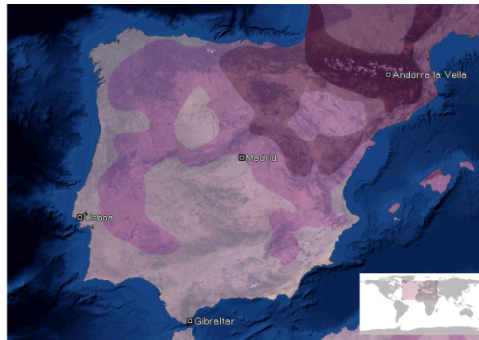
UK Met Office Climatology



TMTech empirical climatology



Munich Re NATHAN Globe of Natural Hazards

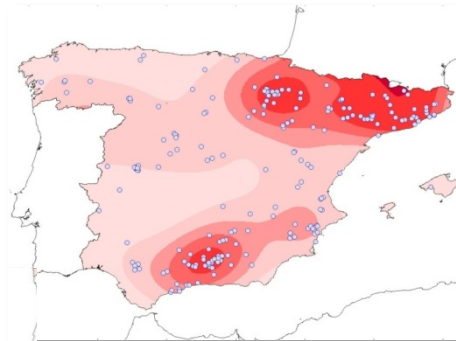
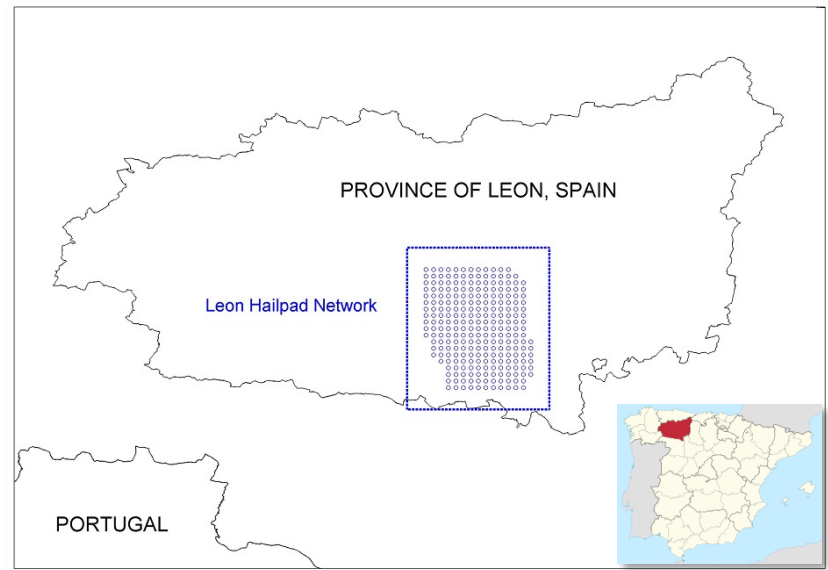


Hand and Cappelluti, 2010, A global hail climatology using the UK Met Office convection diagnosis procedure (CDP) and model analyses, Meteorological Applications.

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Estimation of Hailstorms per Year in Spain

- + Empirical hailstorm climatology provides information on the likely location of a simulated hailstorm.
- + Number of hailstorms per year is needed to assess the hail risk in Spain.
- + Hailstorm occurrences recorded by hailpad network in Leon is used together with the empirical hail climatology to estimate number of hailstorms in Spain.
- + A yearly number of 211 hailstorms is estimated for in the continental Spain.



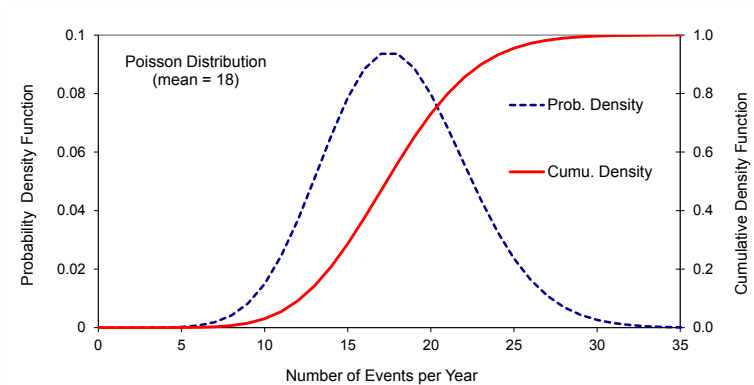
Fraile, et. al., 1999: Some results from the hailpad network in León (Spain): Noteworthy correlations among hailfall parameters, Theor Appl Climatol, 64, 105-117

Modeling of Hail Activity in Spain

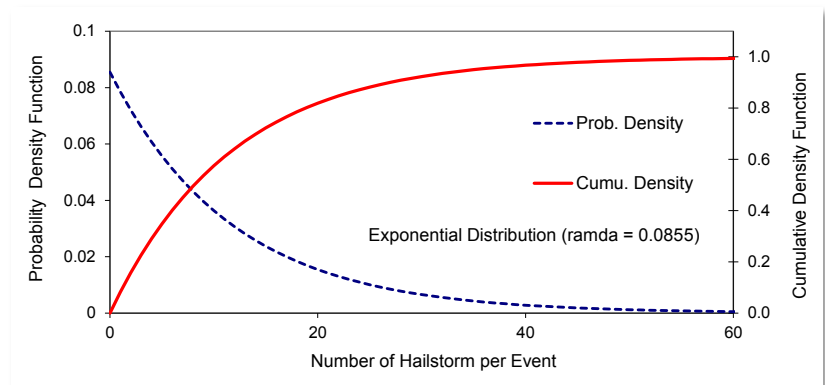
- + Hail activity in Spain is modeled first in terms of number of hail events in a year and the number of hailstorms in a hail event.
 - > Number of hail events in a year is modeled by a Poisson distribution with the mean equal to 18.
 - > Number of hailstorms in an event is modeled by an exponential distribution with the mean equal to 11.7.
- + Seasonality of hail events in Spain is modeled using a Weibull distribution.

Modeling of Hail Activity in Spain

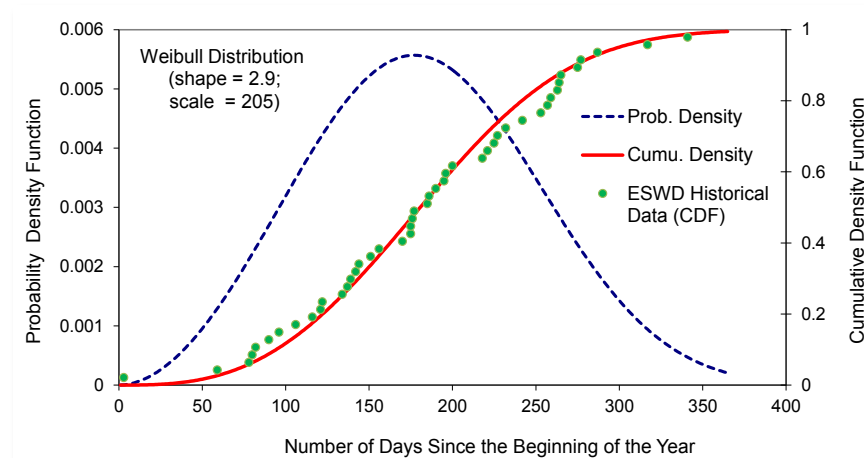
Poisson for hail events in a year



Exponential for hailstorms in an event



Weibull for hail event seasonality

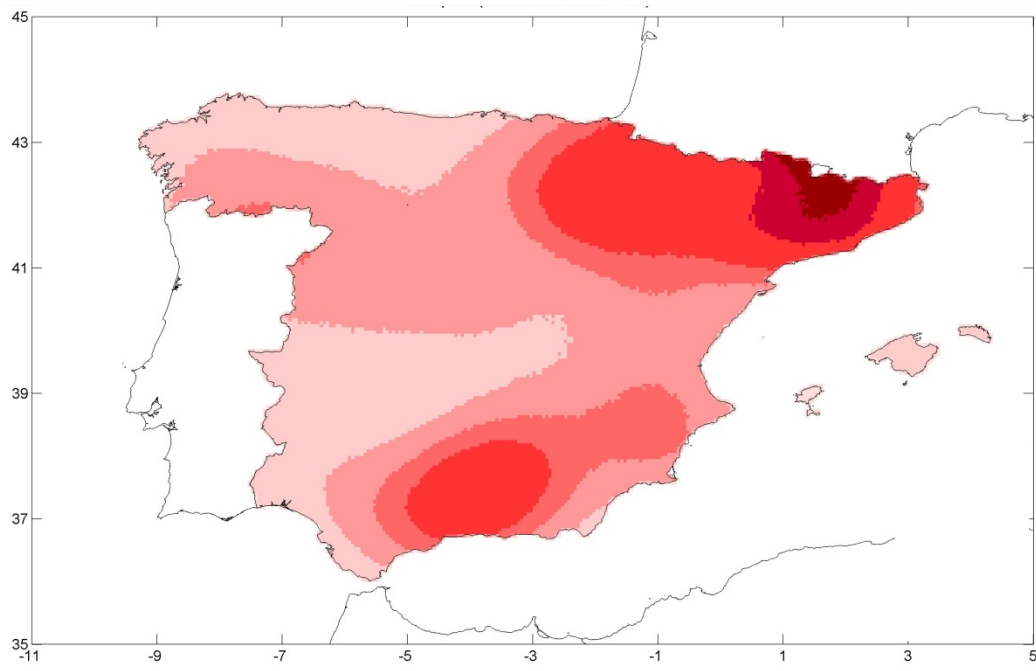


Simulation of Stochastic Hail Events

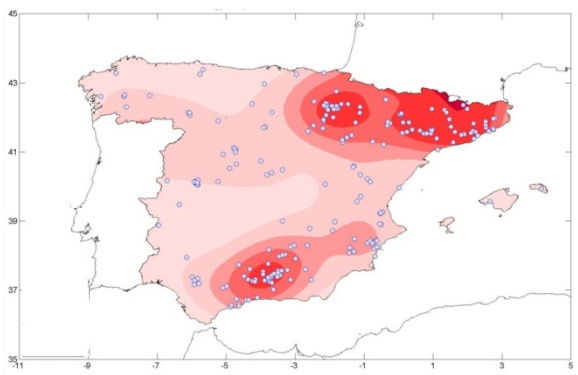
- + Monte Carlo simulation technique is employed to simulate hail activity in Spain.
- + Simulation process starts with simulating the number of hail events in a year by sampling from a Poisson distribution.
- + Number of hailstorms in a hail event is then simulated from an exponential distribution
- + Hail seasonality in Spain is defined by the starting date of a hail event and is simulated by sampling from a Weibull distribution.
- + Likely location of a hailstorm is simulated using the empirical hail climatology derived earlier in this endeavor.

Simulated Hail Activity in Spain

Simulated hail activity based on 1,000,000-years simulations



Empirical climatology



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Correlation of Hail Parameters with Hail Damage

Hail Parameter	Correlation with loss
Impact Energy (Vertical + Windblown)	0.59
Impact Energy (Vertical)	0.54
Maximum Hail Size	0.50
Modal Hail Size	0.44
Wind Speed	0.35
Percentage of Soft Stones	0.09
Onset Time	0.02

Hail Impact Energy and Hail Path Area

- + Maximum hailstone size
- + Number of hailstones falling onto a unite area
 - > Hailfall intensity – Number of hailstones falling per minute
 - > Hailfall duration
- + Hailstone sizes distribution
- + Wind speed accompanying a hailstorm
- + Path area
 - > Path width
 - > Path length
 - > Path direction

Hail Damage to Motor Vehicles



Hail Vulnerability for Auto Manufacturers

- + Three separate vulnerability functions are developed to accommodate
 - > Car-amount independent Paintless Dent Repair (PDR)
 - > Car-amount dependent repair cost such as panel beating, panel exchange, and windshield and rear glass replacement
 - > Car-amount dependent depreciation cost resulted from hail damage



Hail Loss Calculation and Aggregation

- + Hail loss estimation is estimated at 1km x 1km ($\sim 0.01^\circ \times 0.01^\circ$) grid resolution.
- + Hail loss calculation starts at location level. Locations falling into the same hailstorm are aggregated to hailstorm level.
- + Hail losses at hailstorm level are then further aggregated to hail event level.
- + Annual aggregate hail losses are calculated by aggregating the hail losses for all events in a year.

Concluding Remarks

- + Simulated hail climatology for Spain shows certain consistency in trend with the observed data and meteorological interpretation.
- + Uncertainties in modelling results remain high due to, in part, limited amount of reliable data and evolving technologies.
- + Continuing efforts are expected to improve model accuracy as more reliable data and enhanced/innovative modelling technologies become available.