Use of ESWD and OPERA Radar Data for the Rapid Estimation of Insured Losses Following Hailstorms

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1. Introduction

Impact Forecasting

Impact Forecasting is Aon's catastrophe model development team. We develop over 100 historic and probabilistic models for 12 different perils globally.

Hail in Europe

Damaging hail is contributing significantly and increasingly to insured and economic natural catastrophe losses in Europe, as shown in the figures below.

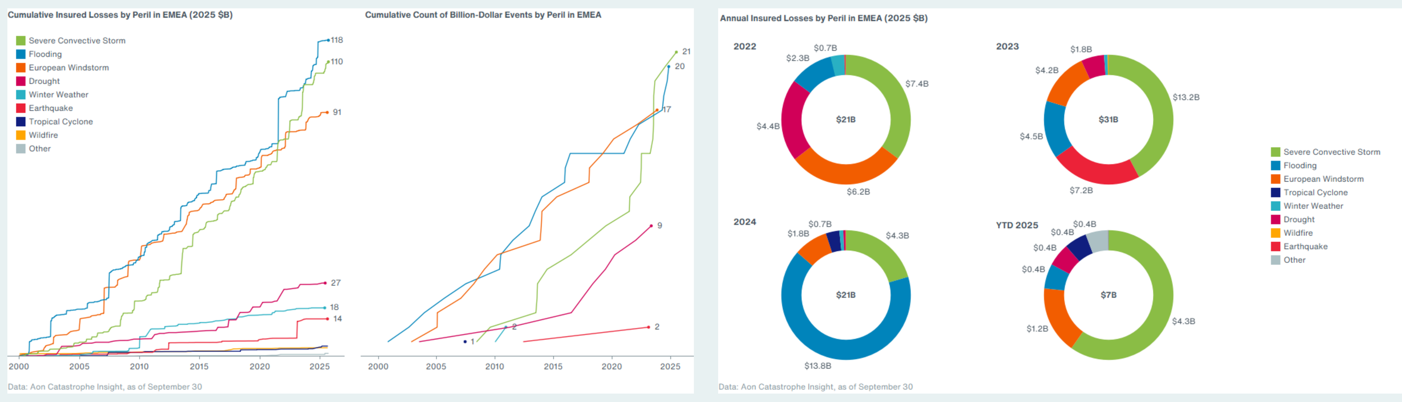
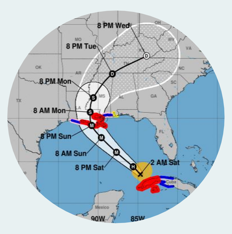


Figure1. Contributions of various perils to insured losses

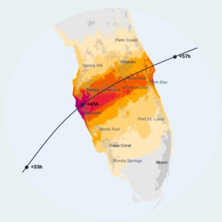
Automated Event Response

When catastrophe events hit, insurers may benefit from rapid estimation of losses. Aon Impact Forecasting provides an Automated Event Response (AER) service to give loss estimates to insurers based on forecasts preceding events and from observations immediately after events, as outlined below. We have recently expanded this service to include hail losses. While the exact location of hail is not possible to forecast accurately enough for loss modelling, it Is possible to use post-event hail reports to generate loss modelling footprints.

Client or Industry Exposure Data
Loaded on internal servers in ELEMENTS prior to the season

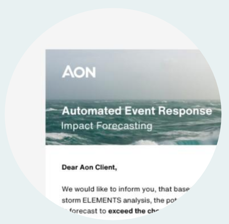


Event Monitoring
Automated check for potentially damaging events



Footprint Modelling
Computed using Impact Forecasting's catastrophe models

Loss Calculation
Using Impact Forecasting's ELEMENTS loss calculation platform



Client Reporting
Personalized report sent if loss exceeds chosen threshold

This Work: Improvement Using Radar

Following an initial operational period of two summers using only ESWD hail reports, we are now able to improve the estimation of hail footprints using radar data in combination with the ESWD reports.

2. Catastrophe Models

A: Exposure

The exposure component provides necessary information on the insured risks being modelled. The location, Total Insured Value (TIV), and some basic information on the type of risk (e.g. residential property) is required.

The exposure example below shows that for one postcode in Germany we have a residential TIV of 1,000,000 Euros.

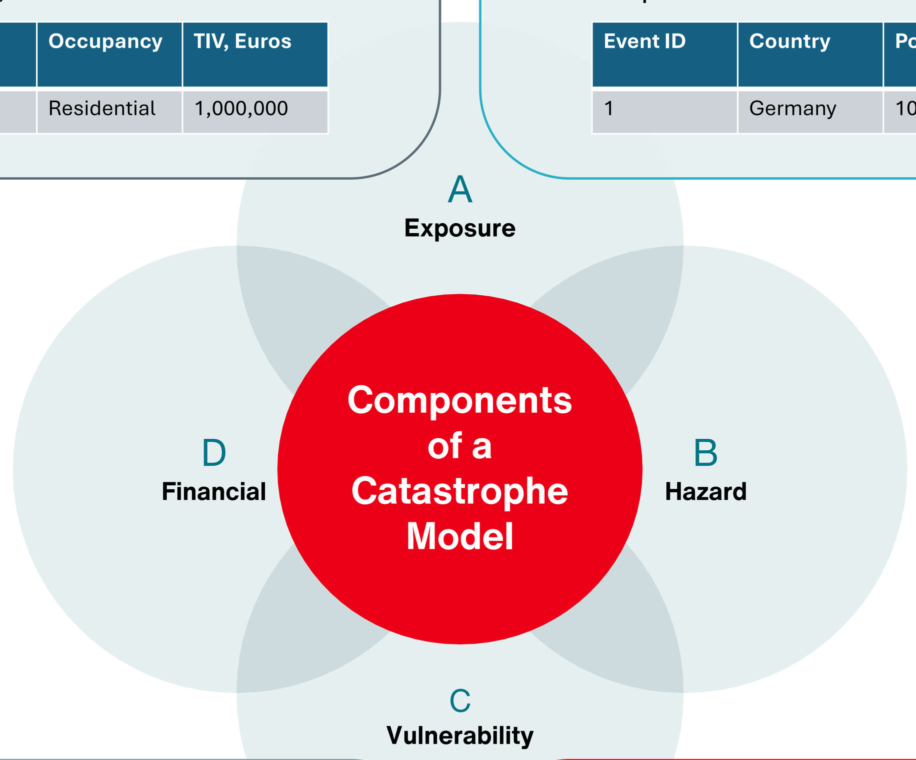
Country	Postcode	Occupancy	TIV, Euros
Germany	1000	Residential	1,000,000

B: Hazard

The hazard component describes the location and intensity of the peril being modelled. The hazard component is typically split into a historic event set, for modelling past events, and a stochastic component for probabilistic modelling.

The hazard example below shows that for one event, the postcode shown in the exposure example experiences a maximum hail size of 6cm.

Event ID	Country	Postcode	Hail Size (cm)
1	Germany	1000	6



D: Financial

The financial component sums all the losses for individual risks and applies any financial conditions, e.g. deductibles, recoveries, before creating the output,

This output may be in the form of estimated losses for individual historic events or probabilistic losses given by return period using a stochastic model.

The loss example applies the 20% damage ratio to the TIV of 1,000,000 Euros, giving a loss of 200,000 Euros.

Event ID	Country	Postcode	Loss, Euros
1	Germany	1000	200,000

C: Vulnerability

The vulnerability component connects the hazard metric to an estimate of loss. Loss estimates are in the form of a loss ratio, which is a fraction of the TIV.

The vulnerability example shows that for a maximum hail size of 6 cm, a residential risk has a damage ratio of 0.2, or 20%.

Country	Occupancy	Hail Size (cm)	Damage Ratio
Germany	Residential	6	0.2

3. The Stochastic Event Set

Event Set Generation

Identify
Academic Partners at KIT developed a method to identify days of intense convective precipitation within reanalysis. The top 720 days from 36 years of Reanalysis are selected to form a seed event set.

Placement
An ingredients-based method is used to select grid points in which hail occurrence is possible, based on atmospheric parameters which are indicative of convection such as CAPE and Humidity.

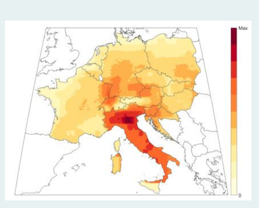


Figure 3. Frequency map of hail in Europe from the Impact Forecasting model.

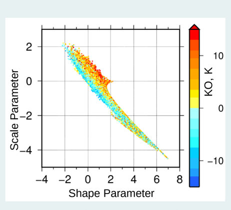


Figure 2. Shape and Scale of Weibull distributions fitted to rainfall rate distributions, against KO index.

Resample
Impact Forecasting resampled from this seed event set to fill 50,000 stochastic years with an average of 20 days per year. Days are placed in weather-type compatible clusters.

Build Events
Hail swathes are given parameters such as length and hail size from distributions fitted to observations. The hazard values are then mapped to administrative units for loss modelling.

7: Contacts and Links

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https://www.aon.com/en/capabilities/reinsurance/catastrophe-model-insight

4. Hail Footprints from ESWD and Radar Data

Radar

In this study we used OPERA radar reflectivity data, recorded every 15 minutes at a resolution of 2x2 km (improved to 1x1 km from June 2024). The data are checked for artefacts and aggregated to hourly values. The hail event on 23rd June 2021 in Germany and France is used as an example here.

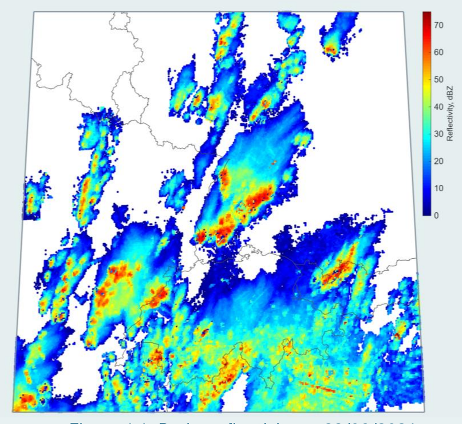
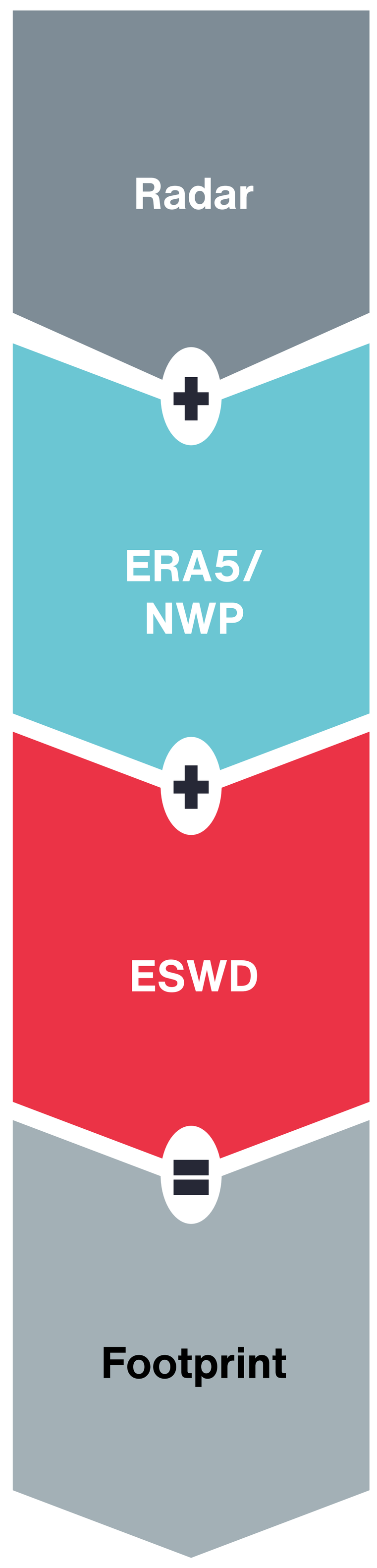


Figure 4.1. Radar reflectivity on 23/06/2021



ERA5/NWP

To estimate the freezing height and -20°C height, we used temperature and geopotential data from the ERA5 dataset across several atmospheric pressure levels. For current events a forecast model could be used instead of reanalysis. For this historic example the reanalysis data is used, as illustrated below.

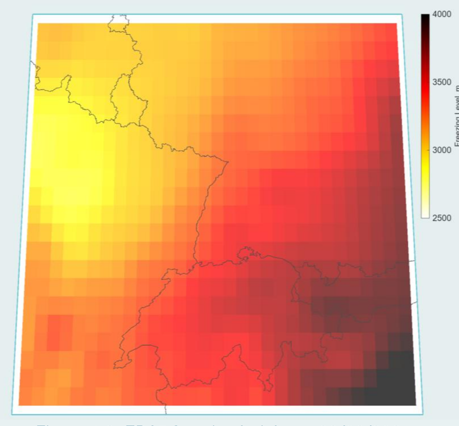


Figure 4.2. ERA5 freezing height on 23/06/2021

ESWD

Hail reports are automatically downloaded every day and used to filter radar pixels to the relevant area around the reports. A buffer of 5km is placed around the hail reports. When there are hail reports within the model domain a footprint will then be generated for the AER service. The figure below shows the hail reports for the example event.

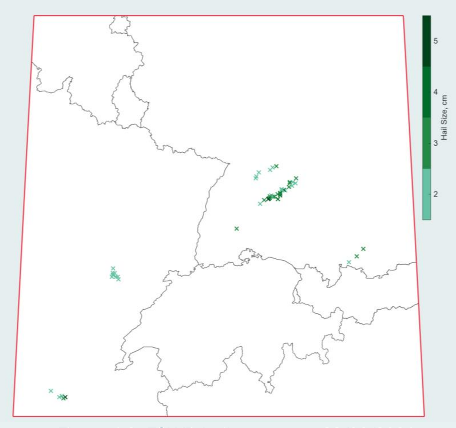


Figure 4.3. ESWD hail reports on 23/06/2021

Footprint

The MESH is calculated and then merged with observational reports for raster calculation. The raster is generated using an Inverse Distance Weighting method from the merged dataset. Then the raster is polygonised and finally converted into final model footprint. The figure below shows the smoothed hail size for the example event.

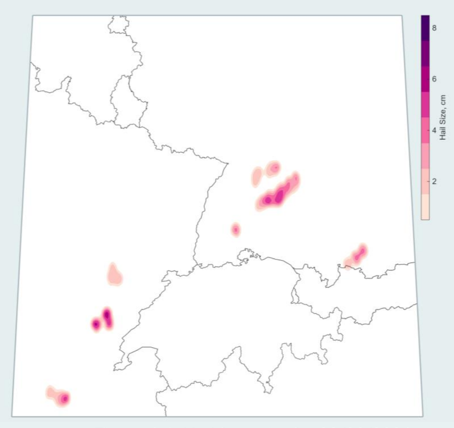


Figure 4.4. Hail footprint for 23/06/2021

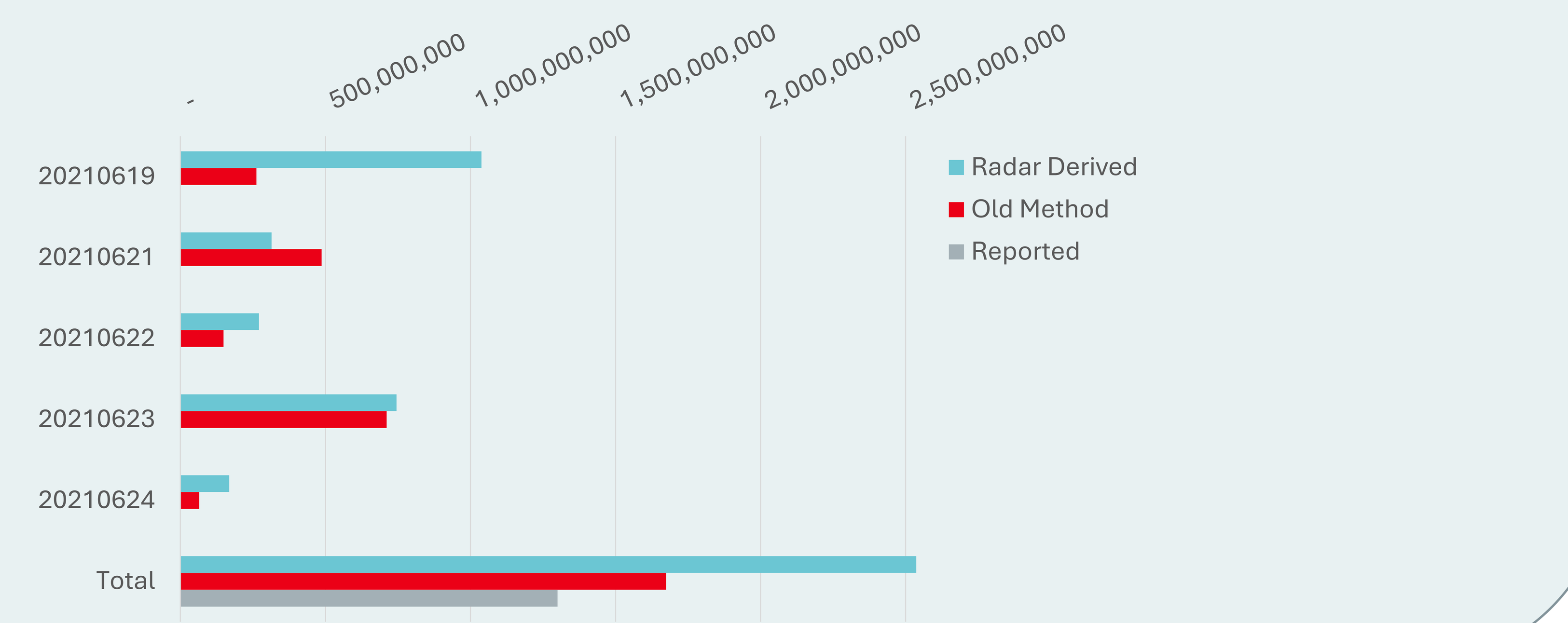
5. Results

Loss Results: Hitting and Missing

The footprints built as shown above are run through ELEMENTS, Impact Forecasting's award-winning loss calculation platform. The result shown are for the Volker hail outbreak in June 2021, including the day shown above. A market portfolio for Germany taken from Perils exposure data has been used and losses are given on a total market property gross perspective in Euros.

The radar derived footprints are compared to the old method which was based purely on drawing ellipses around ESWD reports and assigning a maximum hail size to the swathe, and to a reported total loss for the outbreak provided by Aon Catastrophe Insight.

The agreement between the two methods on the 23rd June – the example event shown above – is very good but for other days the two methods match less well, particularly for 29th June where the radar derived footprint is much higher than the previous model footprint and this drives the overall total from the radar derived method to be higher than the reported loss, whereas the old method gave a total which is closer to the reported.



6. Future Work

Updated Impact Forecasting European Hail Model

Expanded Coverage
Model coverage is expanded to cover most of Europe including UK, Scandinavia and the Balkan Countries. Using standardized Open Exposure Data risk classifications will provide a toolbox for users to reduce uncertainty by selecting specific vulnerabilities for each risk.

Historic Event Set
The radar-based method described in this work will be used to build a complete event set covering the entire domain of the Opera radar system. These footprints will become the model's historic event set.

GCM derived event set
The Stochastic Event Set is derived from GCM output with a machine learning method used to identify likely hail occurrence. This provides a continuous and consistent event set based on a physical model.

Vulnerability
Vulnerability functions are developed using a hybrid approach, combining extensive empirical studies of loss data with a simulation engine.

A Combined Model
The same GCM output is used to build event sets for European Windstorm and Flood catastrophe models. This means the dates of events are consistent across different models and enables losses to be combined across multiple perils.

An Evolving Model
This model will uphold core Impact Forecasting values of transparency and customizability. This means that as perception of hail risk evolves, the model can be adapted to keep pace through customization of both the hazard and vulnerability components.