Données & Risques Climatiques

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SoScience & Allianz

Juin 2022

June 9, 2022
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Dynamics of Natural Catastrophes (incl. Climate) [1]


Dynamics of Natural Catastrophes (incl. Climate) [2]

How are Earthquakes Located?

We can locate earthquakes using a simple fact: an earthquake creates different seismic waves (P-waves, S-waves, etc.). The different waves each travel at different speeds and therefore arrive at a seismic station at different times. P-waves travel the fastest, as they arrive first. S-waves, which travel at about half the speed of P-waves, arrive later. A seismic station closer to the earthquake receives P-waves and S-waves in quick succession. With increasing distance from the earthquake, the time difference between the arrival of the P-waves and the arrival of the S-waves increases.

Although modern techniques are more complex, we have illustrated the basic concept using an example of an earthquake near Mexico and seismic stations in North America. The following two steps show how we determine distance from the seismograms and estimate the location using three stations.

Step 1. The time between the arrival of the P-wave and the arrival of the S-wave (S-P time) is measured at each station. The S-P time indicates the distance to the earthquake similar to how the time interval between the flashes of light and the sound of thunder indicates the distance to a thunderstorm. In our example, station TEBE (with an S-P time of 1.5 minutes) is closest to the earthquake, and station ZSSN (with an S-P time of 5 minutes) is farthest away.

For observing and analyzing many earthquakes, we know the relationship between the S-P time and the distance between the station and the earthquake. We can therefore convert each measured S-P time to distance. A time interval of 1 minute corresponds to a distance of 900 kilometers, 5 minutes to 1800 kilometers, and 10 minutes to 3600 kilometers.

Step 2. Once we know the distance to the earthquake for three stations, we can determine the location of the earthquake. For each station, we draw an arc around the station with a radius equal to the distance from the earthquake. The earthquake occurred at the point where all these circles intersect.
Dynamics of Natural Catastrophes (incl. Climate) [3]

“seismic gap hypothesis” / dynamic of flood events / heat wave persistence
Flood Risk in France [1]


On fairness & solidarity

▶ **French Constitution** (1946)

12. *La Nation proclame la solidarité et l’égalité de tous les Français devant les charges qui résultent des calamités nationales.*

▶ **82-600 Law** (1982)

régime d’indemnisation des catastrophes naturelles
Flood Risk in France [3]

Two different flood perils: overflow vs. coastal PPRIs (plan de prévention du risque inondation) in Roquebrune-sur-Argens, Puget and Saint-Raphaël. The plain area (in blue) is the risky area.

Areas clearly identified as risky, from documented (historical) floods.
Flood Risk in France [6]

PPRLs (plan de prévention des risques littoraux) in Vendée. The dashed area is the risky area. Areas with possible coastal risk.

See https://github.com/freakonometrics/floods
Flood Risk in France [7]

10% of households represent 73.6% of the losses... who lives in those risky areas?


(possible bias on those 5-year notarial transactions...)

@freakonometrics  🐦  freakonometrics  📍  freakonometrics.hypotheses.org- Arthur Charpentier, UQAM, June 2022
Flood Risk in France [8]

E.g. in 4 “departements” (Loire-Atlantique, Vendée, Oise, Isère)

- sold houses / apartments,  PPRI-PPRL areas
Table 1: coastal risk areas vs. Table 2: overflow / non-costal risk areas

<table>
<thead>
<tr>
<th></th>
<th>Average Price</th>
<th>Difference (%)</th>
<th>Maximum Price</th>
<th>Number</th>
<th>Proportion (%)</th>
<th>Welch test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vendée</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non risky</td>
<td>Apartments</td>
<td>4293</td>
<td>21840</td>
<td>329</td>
<td>9%</td>
<td></td>
</tr>
<tr>
<td>Houses</td>
<td>2928</td>
<td></td>
<td>65909</td>
<td>2795</td>
<td>74%</td>
<td></td>
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<tr>
<td>Risky</td>
<td>Apartments</td>
<td>3302</td>
<td>-23%</td>
<td>9773</td>
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<td>1.0</td>
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<tr>
<td>Houses</td>
<td>10253</td>
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<td>71483</td>
<td>637</td>
<td>17%</td>
<td>-60.1</td>
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<tr>
<td>Pays-Loire</td>
<td>Apartments</td>
<td>4399</td>
<td>79913</td>
<td>8411</td>
<td>37%</td>
<td></td>
</tr>
<tr>
<td>Houses</td>
<td>3019</td>
<td></td>
<td>75472</td>
<td>12678</td>
<td>55%</td>
<td></td>
</tr>
<tr>
<td>Risky</td>
<td>Apartments</td>
<td>6784</td>
<td>+54%</td>
<td>68478</td>
<td>4%</td>
<td>-8.6</td>
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<tr>
<td>Houses</td>
<td>3245</td>
<td>+7%</td>
<td>22895</td>
<td>765</td>
<td>3%</td>
<td>-2.7</td>
</tr>
</tbody>
</table>

Table 1: Prices (€ per m²) of houses sold (2014-2018) for Vendée - Western part of France, with PPRL (coastal risk). The Difference is the relative difference between average prices (per m²) between the risky and the non-risky zones, either for apartments or houses.
## Flood Risk in France [10]

<table>
<thead>
<tr>
<th>Var</th>
<th>Non risky</th>
<th>Apartments</th>
<th>5392</th>
<th>9874</th>
<th>53%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Houses</td>
<td>5957</td>
<td></td>
<td>6913</td>
<td>37%</td>
</tr>
<tr>
<td>Risky</td>
<td>Apartments</td>
<td>4190</td>
<td>-22%</td>
<td>1471</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>4172</td>
<td>-30%</td>
<td>226</td>
<td>1%</td>
</tr>
<tr>
<td>Non risky</td>
<td>Apartments</td>
<td>2399</td>
<td></td>
<td>38333</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>1314</td>
<td></td>
<td>20625</td>
<td>69%</td>
</tr>
<tr>
<td>Risky</td>
<td>Apartments</td>
<td>2163</td>
<td>-11%</td>
<td>28125</td>
<td>2%</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>1247</td>
<td>-5%</td>
<td>7432</td>
<td>2%</td>
</tr>
<tr>
<td>Non risky</td>
<td>Apartments</td>
<td>6260</td>
<td></td>
<td>79710</td>
<td>44%</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>3356</td>
<td></td>
<td>79167</td>
<td>53%</td>
</tr>
<tr>
<td>Risky</td>
<td>Apartments</td>
<td>4333</td>
<td>-30%</td>
<td>40000</td>
<td>1%</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>2693</td>
<td>-20%</td>
<td>54096</td>
<td>1%</td>
</tr>
</tbody>
</table>

*Welch t value*
## Flood Risk in France [11]

<table>
<thead>
<tr>
<th></th>
<th>Average Price</th>
<th>Difference (%)</th>
<th>Maximum Price</th>
<th>Number</th>
<th>Proportion (%)</th>
<th>Welch t value</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Isère</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non risky</td>
<td>Apartments</td>
<td>4960</td>
<td>79800</td>
<td>27982</td>
<td>52%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>2429</td>
<td>69375</td>
<td>24600</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Risky</td>
<td>Apartments</td>
<td>3252</td>
<td>-3%</td>
<td>35714</td>
<td>2%</td>
<td>6.1</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>2543</td>
<td>+5%</td>
<td>14067</td>
<td>1%</td>
<td>-1.2</td>
</tr>
<tr>
<td><strong>Oise</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non risky</td>
<td>Apartments</td>
<td>6170</td>
<td>79963</td>
<td>24613</td>
<td>34%</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>3126</td>
<td>78214</td>
<td>44737</td>
<td>62%</td>
<td></td>
</tr>
<tr>
<td>Risky</td>
<td>Apartments</td>
<td>5725</td>
<td>-7%</td>
<td>50000</td>
<td>2%</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Houses</td>
<td>2866</td>
<td>-8%</td>
<td>62184</td>
<td>2%</td>
<td>4.6</td>
</tr>
</tbody>
</table>

**Table 2**: Prices (€ per m²) of houses sold (2000-2020) for several départements in France, with PPRI (overflow risk, or non-costal).
Subsidence Risk in France [1]


Subsidence Risk in France [2]

Joint work with Hani Ali (Willis Re) and Molly James (EURIA / ACPR).


“Subsidence is caused by the shrinkage and swelling of clay soils”

- **Geotechnical factor:** Area of municipalities at medium or high risk > 3%. (categories based on clay concentration in the soil and historical statements)

- **Meteorological factor:** Standardized soil moisture index (SSWI), if an indicator of the season is lower than a return period of 25 years, then the whole season is eligible for the commune concerned.
Subsidence Risk in France [3]

Data 1989-2018
Subsidence Risk in France [4]

Indicators 2020: ESPI (precipitation) ESSTI (soil temperature) & ESSWI (soil humidity), ERA5-Land 9 km × 9 km

(via ESDAC (European Soil Data Centre) for soil concentration)
Subsidence Risk in France [5]

Regression models for frequencies: binomial, Poisson, negative binomial & zero-inflated Poisson, zero-inflated negative binomial,
Subsidence Risk in France [6]

Random forest models for frequencies
Subsidence Risk in France [7]

2017, random forest Poisson, zero inflated, observed, Nat Cat recognition
Subsidence Risk in France [8]

2018, random forest Poisson, zero inflated, observed, Nat Cat recognition
A. Benchallal, Y. Bouroubi, and A. Charpentier. “Predicting Wildfires in Québec”. In: Remote Sensing (To be submitted) (2022).

France Info. “Canada : le ”dôme de chaleur” provoque de violents incendies à Lytton”. In: (2021).
Wildfire Canada [3]
Theoretical issues on creating a balanced from largely unbalanced data

Why do we need (more) detailed data? [1]

Central Limit Theorem

The sum of independent random variables, properly normalized, tends toward a normal distribution even if the original variables themselves are not normally distributed (with finite variance)

if $X_i$'s are i.i.d. with mean $\mu$ and variance $\sigma^2$, \[
\frac{(X_1 + \cdots + X_n)/n - \mu}{\sigma/\sqrt{n}} \approx \mathcal{N}(0, 1).
\]

Extreme Value Theory (Fisher & Tippett (1928))

there are $a_n$ and $b_n$ such that \[
\frac{\max\{X_1 + \cdots + X_n\} - a_n}{b_n} \approx \text{GEV}_\xi.
\]

where $\xi$ depends on the distributions of $X_i$'s ($\xi < 0$ Weibull domain of attraction: bounded $X_i$'s; $\xi = 0$ Gumbel domain of attraction: light tailed $X_i$'s; $\xi > 0$ Fréchet domain of attraction: heavy tailed $X_i$'s). E.g. $X_i \sim \mathcal{N}(\mu, \sigma^2)$, $\xi \leq 0$. 
Why do we need (more) detailed data? [2]

"Some light-tailed atmospheric variables like temperatures are often averaged in space, time or both. The central limit theorem makes them very close to Gaussian variables. So, don’t be surprised to find negative shape parameters for maxima of averaged values" (Philippe Naveau)
