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Géosciences pour une Terre durable

brgm

AI FOR HYDROCLIMATIC EXTREMES

Challenges in geosciences

Abel HENRIOT, a.henriot@brgm.fr

Cécile Gracianne, c.gracianne@brgm.fr, Jérémy Rohmer j.rohmer@brgm.fr
& many, many other

7th of mars 2023

AI for hydroclimatic extremes in geosciences



Abel HENRIOT

Hydrogeologist & DataScientist
10+ yrs of experience

**Understand GroundWater Ressource evolution over time
and space**

**Quantity & Quality aspects
Modeling & prediction**

AI for hydroclimatic extremes in geosciences



BRGM
French Geological Survey
60+ yrs of experience

Deliver science based knowledge to support decision maker in the field of geosciences

Geologoy, Geophysics, Mineral Resources, Natural Hazards, Groundwater Monitoring, mapping and Data Providing

Fondamental Research, Public Policy support, Transfert to Economic World

www.brgm.fr



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BRGM's Journey to face geoscientific challenges using AI in 3 chapters



GROUNDWATER



**RISK
MANAGEMENT**

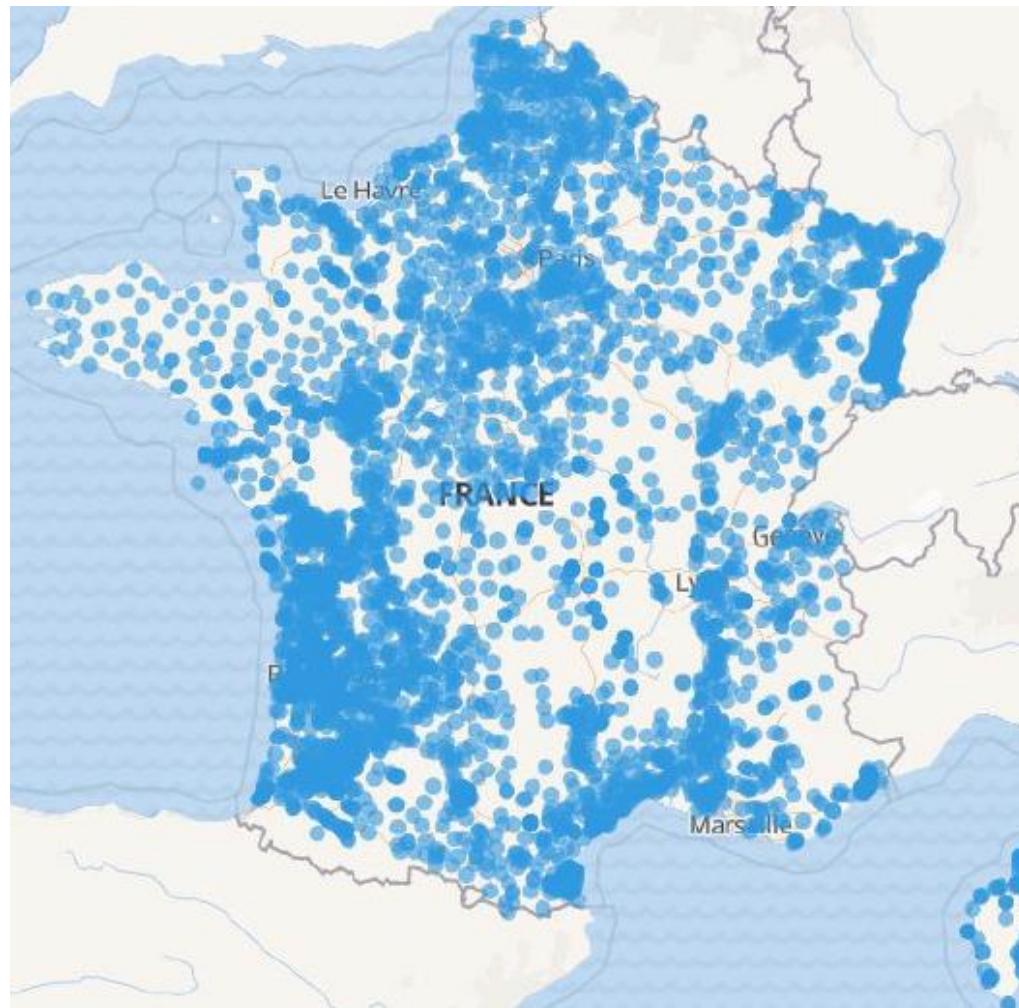


**COASTAL
HAZARDS**



GROUNDWATER

Problem set up



535 851
wells

3679
Wells with
> 1000 GWL
records

118 M
chemical
analyses

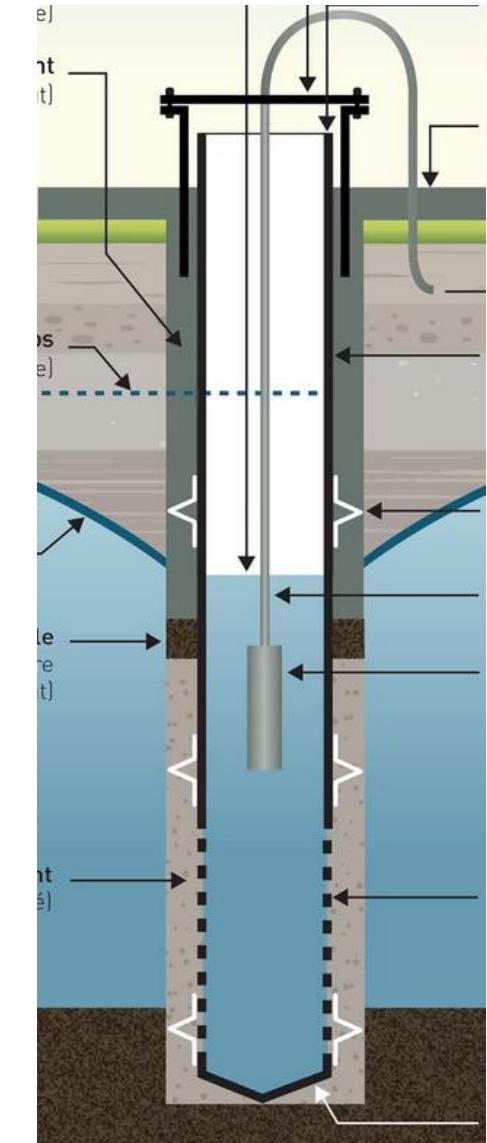
2861
chemical
components



GROUNDWATER

Challenge

- Need for **GWL prediction at scale of France**
- **Fast reliable, trustable, explainable**



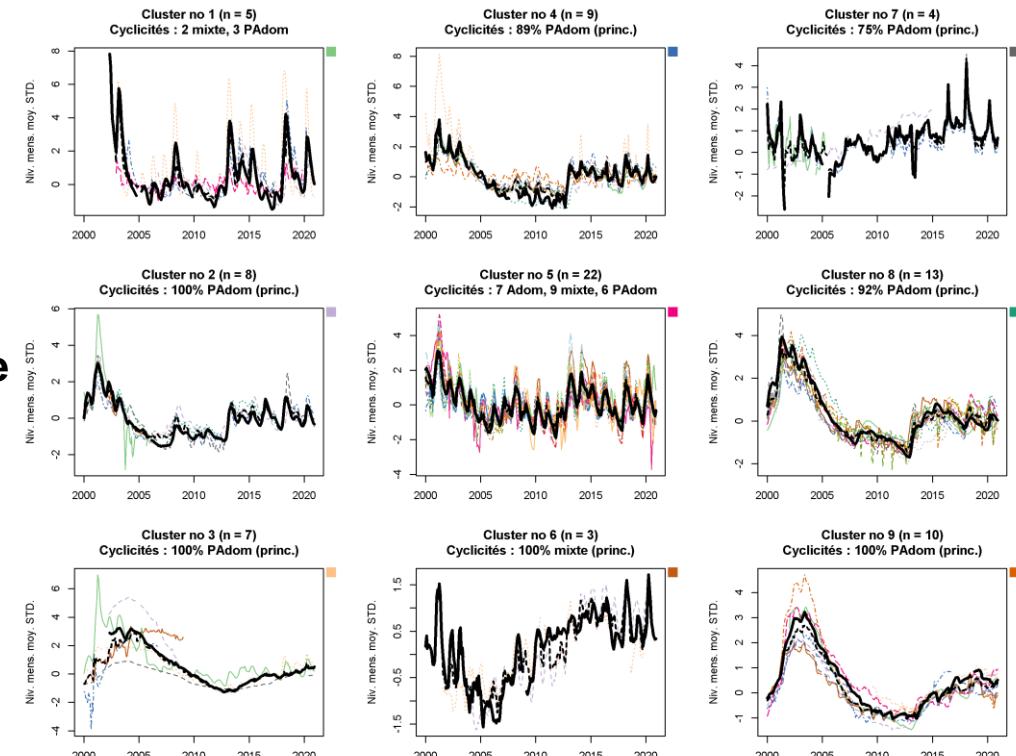


GROUNDWATER

Challenge

Deals with:

- **Inertia**
- **Effect of Climate Change**
- **Effect of Pumping**
- **Corrupted data**
- **Learn the evolution of GWL in time and space ?**

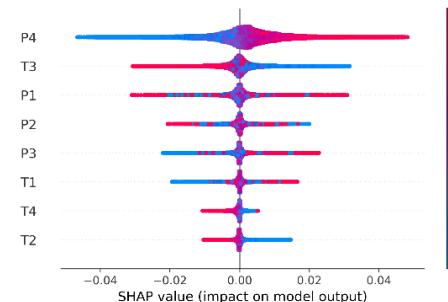
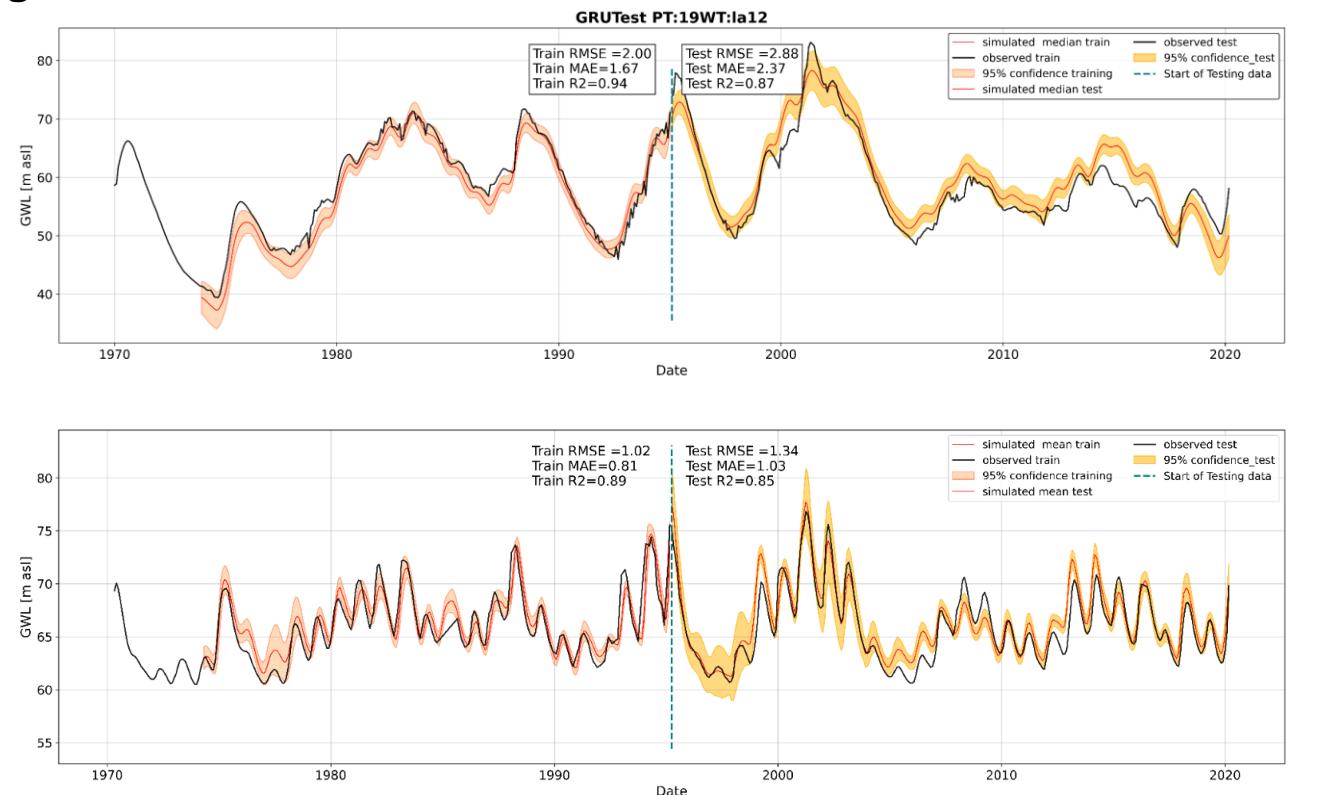




GROUNDWATER

Achievement

- **Hybrid architecture :**
 - Wavelet decomposition + GRU/LSTM/BILSTM
 - Point scale
 - Regionnal scale





NATURAL RISK MANAGEMENT

Problem set up

- Rapid assessment of crisis situation appears ‘slow’ with existing sensors networks (accelerometers, raingauges,...)
- Humans could acts as sensors
- They communicate through social network

**7M people
Affected in 2022**

Instagram | Rechercher Se connecter S'inscrire

sortirdanslesud • S'abonner Agde

sortirdanslesud #Repost @meteoexpress

Les inondations se multiplient dans le département de l'Hérault, comme ici à Agde. Orages & pluies sévissent toujours.

vidéo : Virginie Fleury / IG #météo #temps #pluie #orage #déluge #inondations #herault #agde #intempéries #alerte #vigilance

211 vues 23 OCTOBRE

Connectez-vous pour aimer ou commenter.

PROPOS DE NOUS SUPPORT PRESSE API EMPLOIS CONFIDENTIALITÉ CONDITIONS RÉPERTOIRE PROFILS

**500 M tweets
Every day**

21 M tweets
Ian hurican – 12 days



RISK MANAGEMENT

Challenges : Early warning system

- Process unstructured and heterogenous data
- Analysing text, extract geolocalisation
 - Irony, slang, abbreviation
 - W/Wo geoloc.
- Real time
- High accuracy
- Deliver usable information for ‘makers’ on the field (firefighter, rescuers,...)



The image shows a vertical stack of four tweet cards from the Twitter interface. Each card includes a user profile picture, the user's name and handle, the tweet text, and a timestamp.

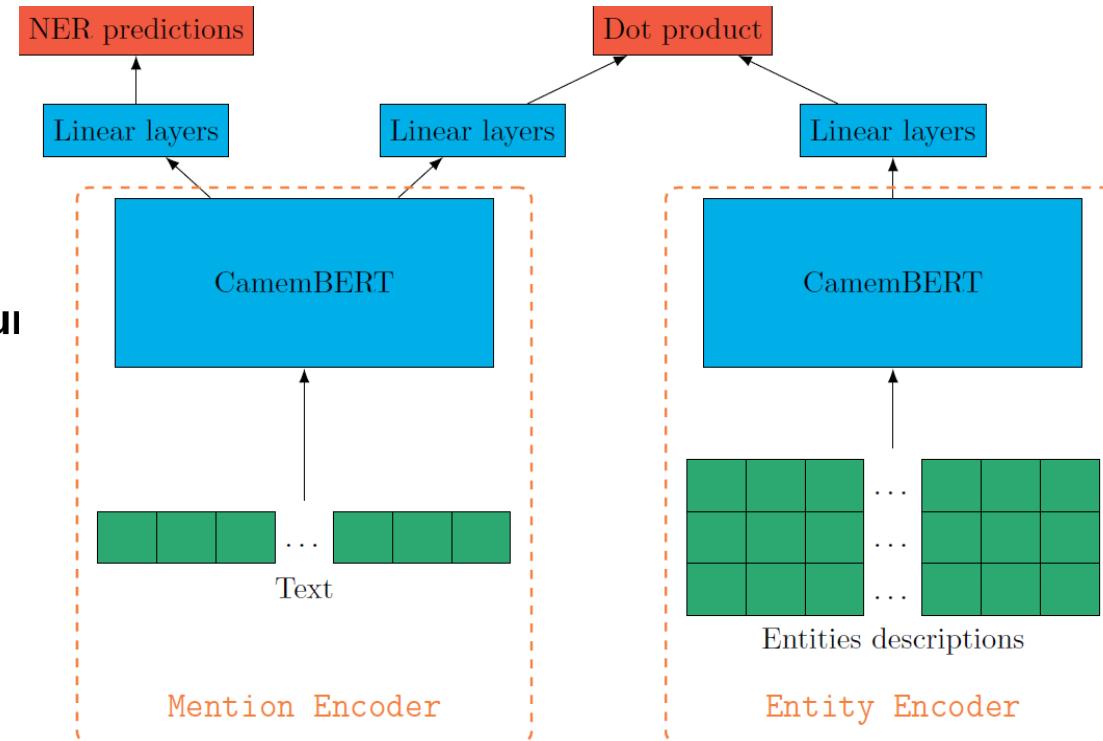
- alxousou (@alxousou)**
Je rêve ou il y a un tremblement de terre là ?
21:27 - 7 avr. 2014
- vio (@vio_Official)**
Tremblement de terre à St Raphaël à l'instant.
Pas très fort mais un mouvement de tangage impressionnant tout de même!
21:28 - 7 avr. 2014
- Or Elya (@OrelyaB)**
Oh punaise!!! LA TERRE TREMBLE méchamment en ce moment à #Nice06 !! Cc @GregLeclerc
21:28 - 7 avr. 2014
- Ced Ced (@CedCannes)**
Tremblement de terre ressenti au Cannet !
21:28 - 7 avr. 2014



NATURAL RISK MANAGEMENT

Achievements

- NLP
- Bi encoder architecture
- BERT

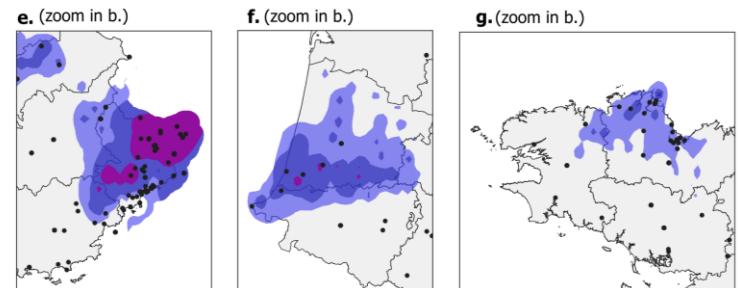
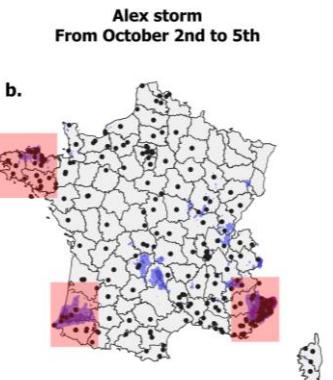
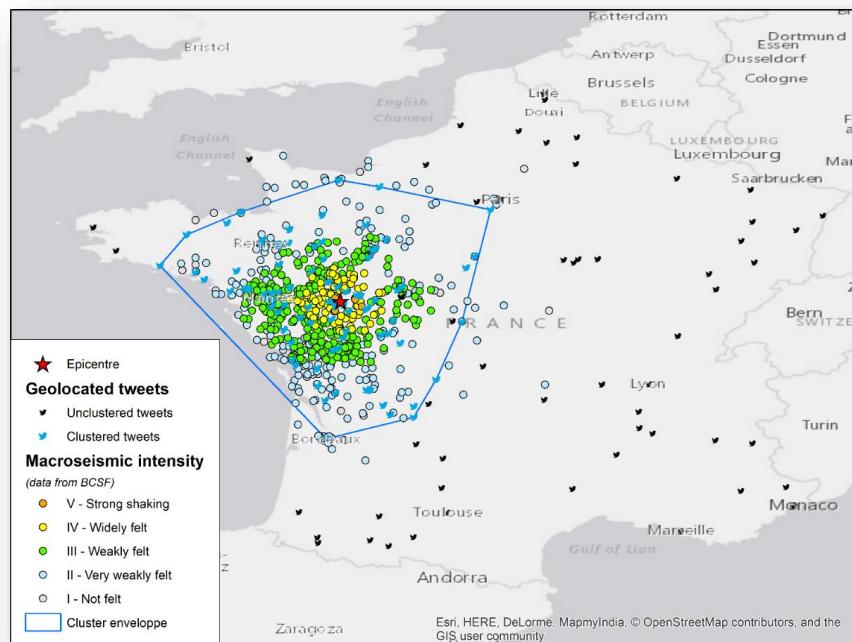




NATURAL RISK MANAGEMENT

Achievements

- Perception area :
10 min
- vs Hours with in place monitoring



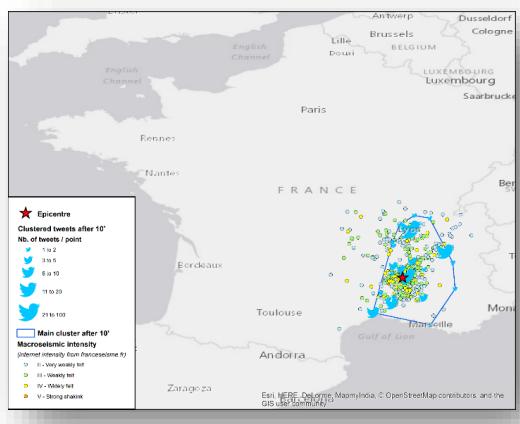
Significant flood events in the period:
- Alex storm, South-East / North-West / South-West of France



NATURAL RISK MANAGEMENT

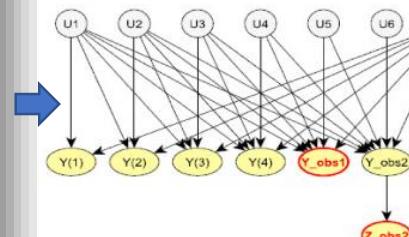
Achievements

- Treated as complementary data source
- Gain in definition

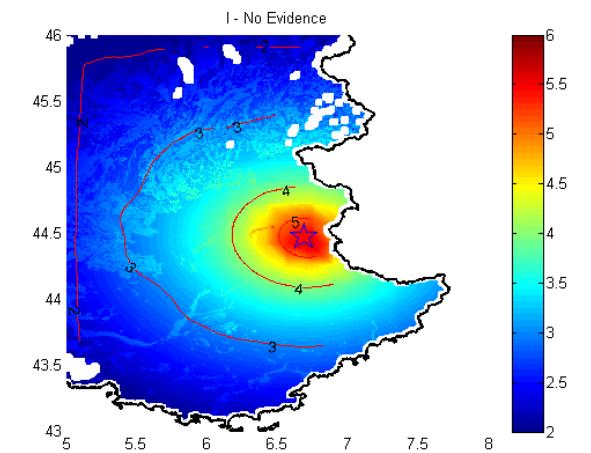


Building intensity maps from Twitter and seismic data after an earthquake

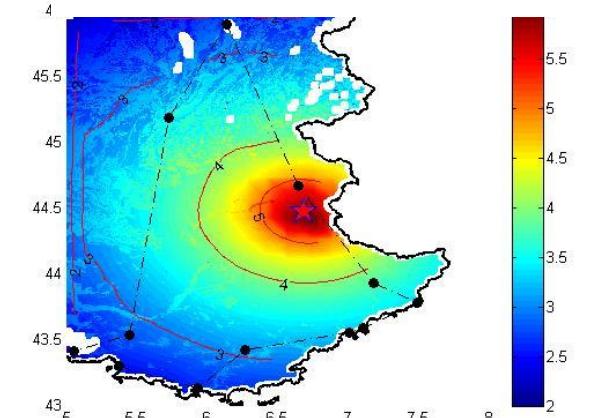
Fayjaloun et al. 2021



Soil motion intensity-sensors



Soil motion intensity: sensors + Twitter



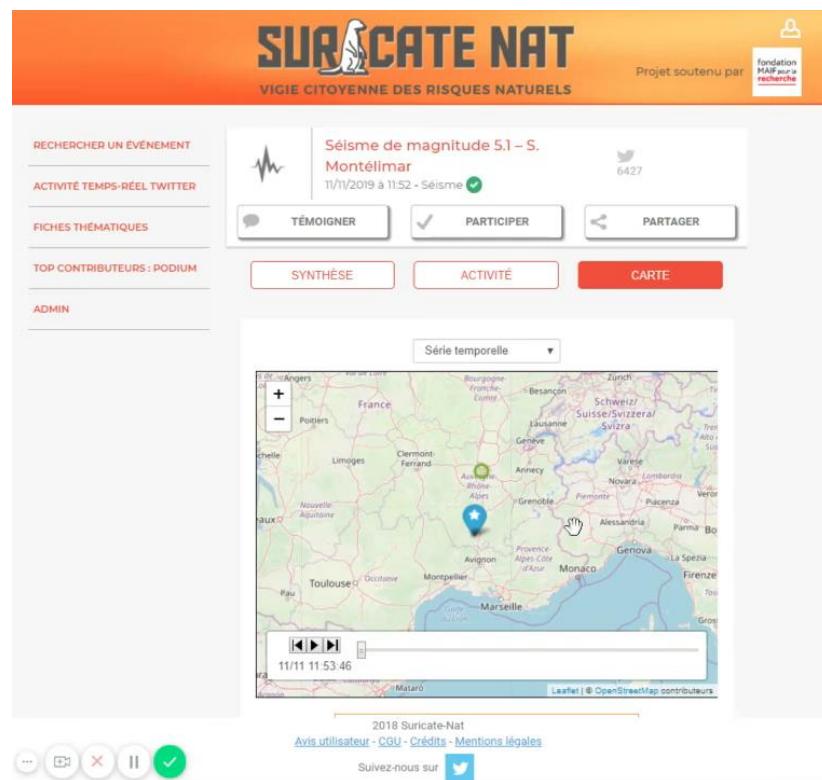


AI for hydroclimatic extremes in geosciences

NATURAL RISK MANAGEMENT

Achievements

Webportal: www.suricatenat.fr



The screenshot shows the Suricate-Nat web portal. At the top, it displays "SURICATE NAT VIGIE CITOYENNE DES RISQUES NATURELS". Below this, a banner for a seismic event in Montélimar (magnitude 5.1) is shown. The main area features a map of France and the surrounding Alpine region, with a blue marker indicating the event's location. There are tabs for "SYNTHESE", "ACTIVITE", and "CARTE". The "CARTE" tab is active, showing a heatmap of tweet concentrations. The bottom of the page includes links for "Avis utilisateur - CGU - Crédits - Mentions légales" and social media links.





COASTAL HAZARDS

Problem set up: marine flooding



2.5B €
Total cost Xynthia

700 m€
Marine
Flooding

53 deaths
Xynthia Storm- 2010



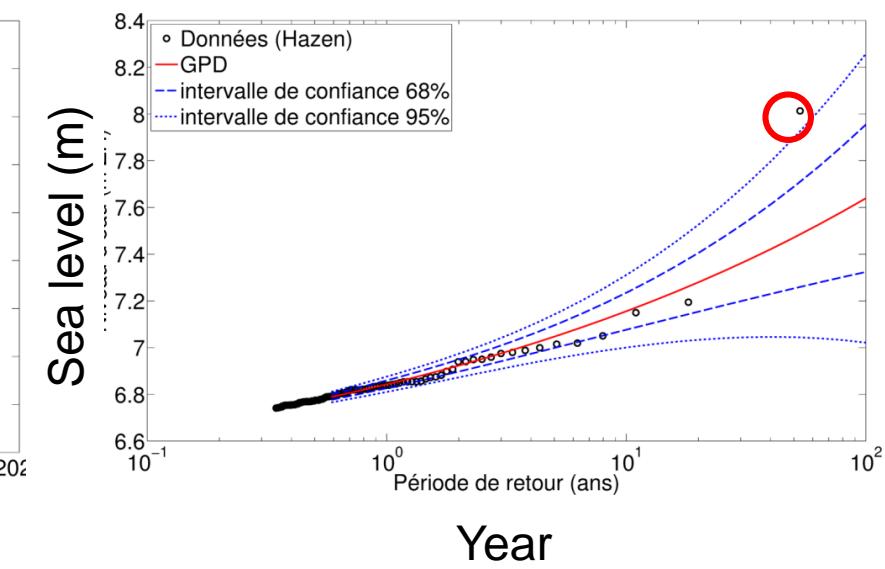
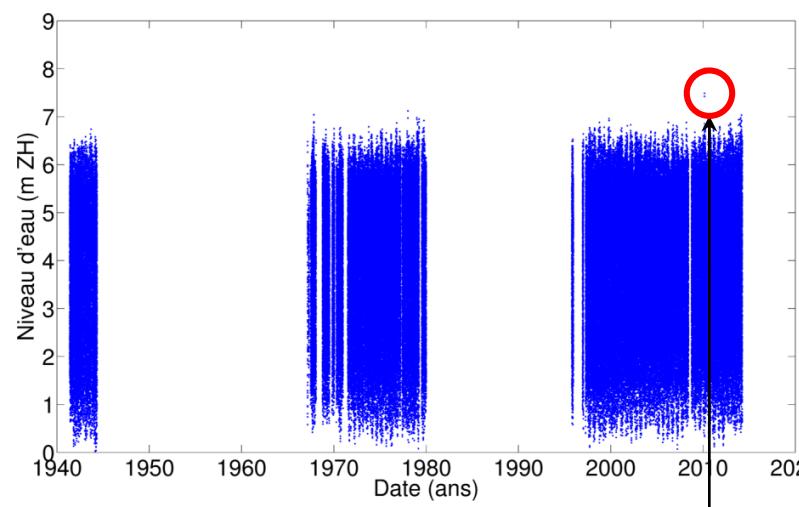
COSTAL HAZARDS

Challenge: learn the extrems ?

Deals with :

- **Extrems**
- **Too short time series**
- **Outliers / corrupted data**
- ...

Sea level at La Rochelle (France)





COSTAL HAZARDS

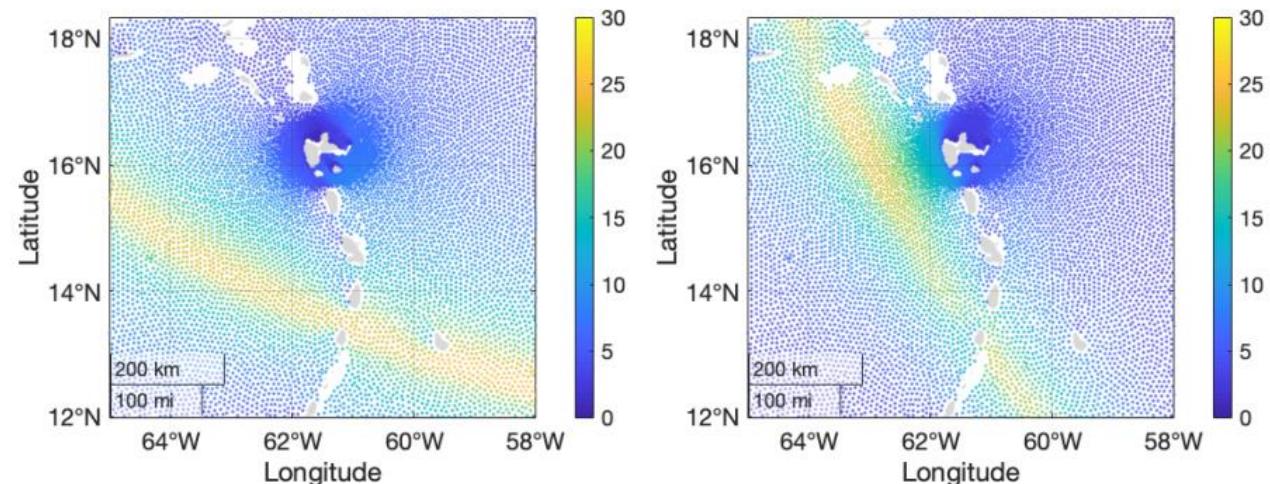
Challenge: learn the extrems ?

Deals with :

- **Extrems**
- **Too short time series**
- **Outliers / corrupted data**

Non stationarity of extrems

- **Effect of CC ?**



Spatial distribution of maximum ¹⁸wave height during two different cyclones at Guadeloupe (French West Indies)



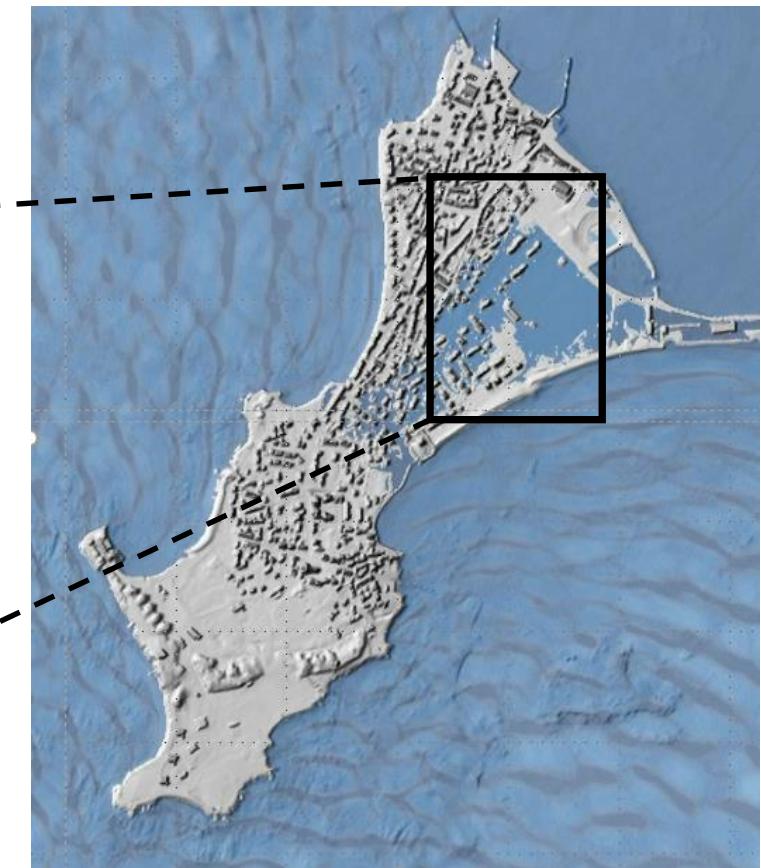
COSTAL HAZARDS

Achievements : Early warning system

- Surrogate model



Comparison with **observations** –
RISCOPE project
[Idier et al.¹⁹, Nat. Haz., 2020]



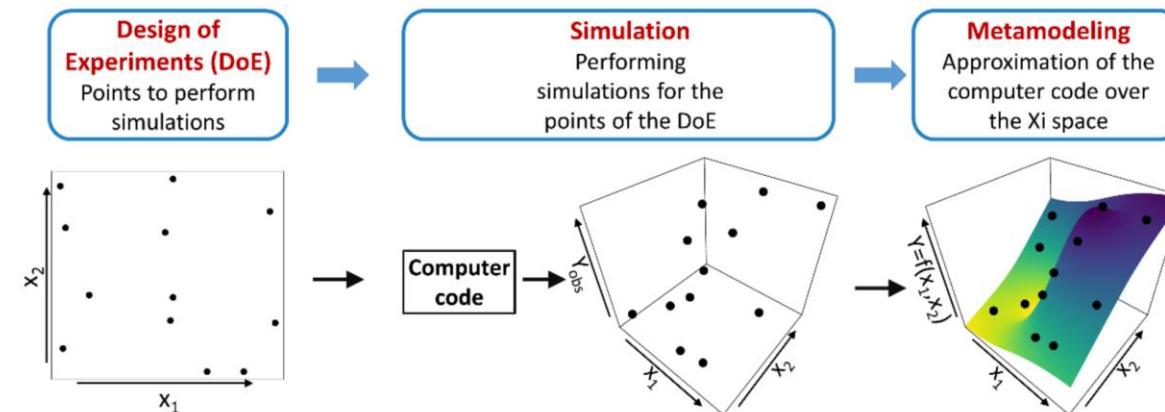


COSTAL HAZARDS

Achievements : Early warning system

Surrogate model

- Kernel methods
- 200 runs of deterministic model (2 days comput time each)
- Once trained: prediction in minutes
- Site specific: Gavres, Boucholeurs, Reunion Island



[Idier et al., JMSE, 2021], [Rohmer et al., ENVSOFT, 2018], [Lecacheux et al., Nat. Hazard, 2021] 20



GROUNDWATER

S. CHIDEPUDI, BRGM, MC2 ROUEN
N. MASSEÏ, M2C ROUEN
A. JARDANI, M2C ROUEN
B. HENRIOT, BRGM

a.henriot@brgm.fr



RISK MANAGEMENT

C. GRACIANNE,
S. AUCLAIR,
G. CAILLAUT,
F. BOULAHYA,
E. LECAUDE

c.gracianne@brgm.fr



COSTAL HAZARDS

J. ROHMER,
D. IDIER,
S. LECACHEUX,
R. PEDREROS,
G. LE COZANNET,
R. THIÉBLEMONT

j.rohmer@brgm.fr



LESSONS LEARNED

DATA is (still) often a weakness in geosciences

- good data
- Sufficient scale in space and time
- Especially when dealing with low frequency, extremes values
- Monitoring networks as patrimonial good

AI methods are not straight forward

- Data pipeline
- Combinaison of methods
- Combination of scientific expertises
- From site specifif models to generalist models

Pluridisciplinary teams is the key

Many fields remains unexplored !

- BRGM is open to collaborate



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Thank you !
a.henriot@brgm.fr

