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Placements. Assurances. Conseils.

Projection des inondations saisonnières au Canada en climat futur à l'aide de modèles statistiques et d’apprentissages automatiques.

Manuel Grenier

Scientifique de recherche principal, Climatic Hazard & Advanced Risk Modelling

CHARM

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OURANOS 2025

Information à retenir

- Le milieu de l’assurance et nos besoins.
- Les modèles statistiques et d’apprentissages machines sont des solutions viables à la modélisation de catastrophes naturelles et à inclure les changements climatiques.
- Il existe des compagnies d’assurances qui sont ouvert à la recherche et à la publication scientifique (nous existons, oui!).

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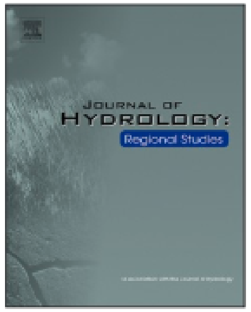

Projected seasonal flooding in Canada under climate change with statistical and machine learning

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A R T I C L E I N F O

Keywords:
Spring flooding
Summer flooding
Generalized additive model
Random forest
Gradient boosting
Regional climate models

A B S T R A C T

Study region: Canada
Study focus: Floods are among the costliest and deadliest natural hazards in the world. To date, little is known about future seasonal flooding across all Canada. In this paper, data-driven models for flood occurrence (i.e., happening of a flood) and impact (i.e., displaced population) were calibrated for spring and summer seasons in 14,000 watersheds across Canada. Generalized Additive Models (GAM), Random Forests (RF) and Gradient Boosting Machines (GBM) were

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Contexte: Pourquoi nous étudions les catastrophes naturelles?

Assurance non-vie

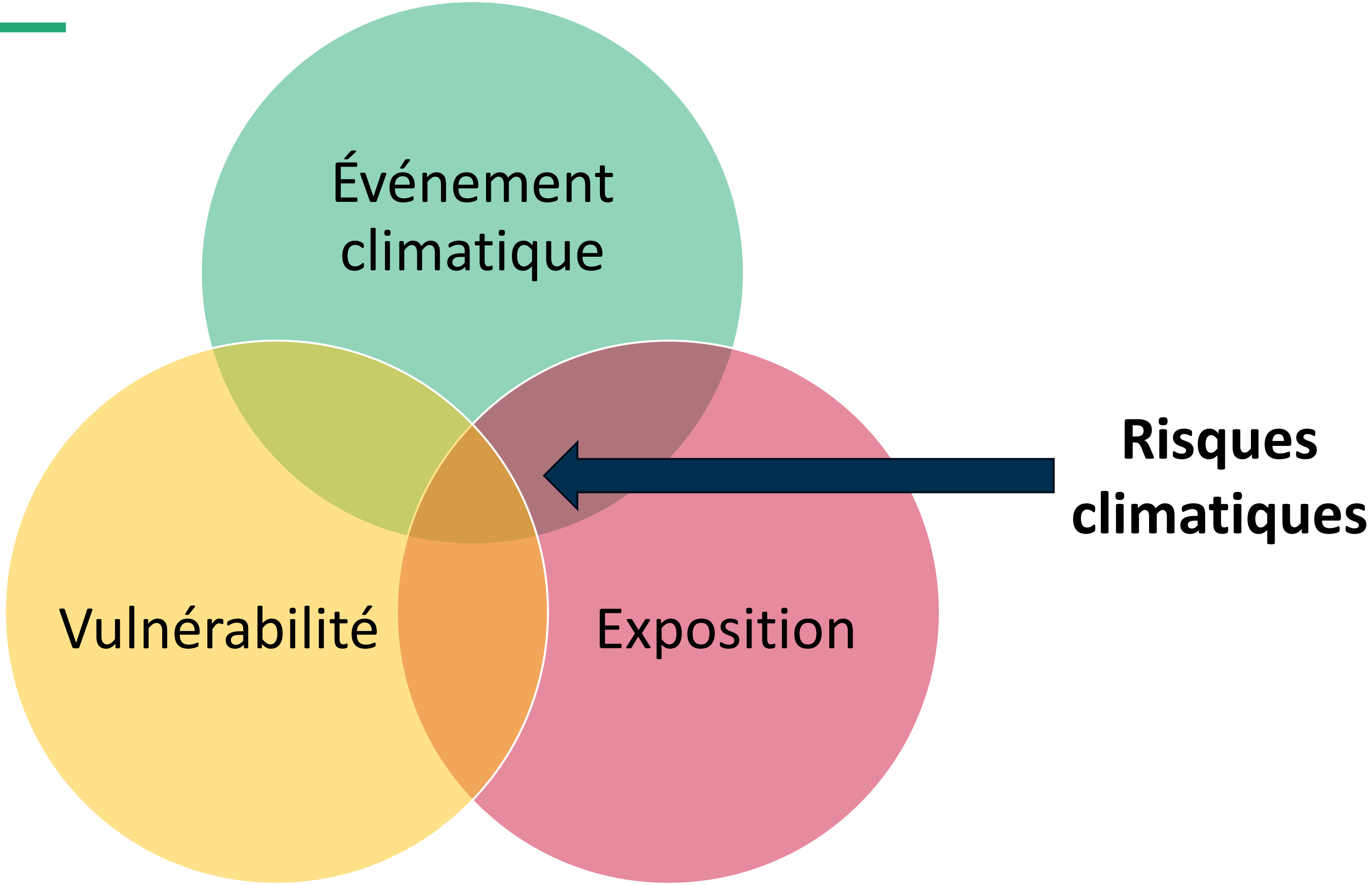
Bris de l'indépendance entre les polices

Normes des organismes de régulation financière

Réassurance dispendieuse

Changements climatiques

Contexte: Analyser nos risques climatiques



Contexte: Nos besoins

Spécifique au Canada

Transparent

Granulaire

Dépendance spatiale

Ressources computationnelles raisonnables

Proposition

AGU ADVANCING EARTH AND SPACE SCIENCE

JAMES Journal of Advances in Modeling Earth Systems

RESEARCH ARTICLE

10.1029/2020MS002221

A Global Flood Risk Modeling Framework Built With Climate Models and Machine Learning

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David A. Carozza and Mathieu Boudreault contributed equally to this work.

Key Points:

- We present a global flood model built using machine learning methods fitted with historical flood occurrences and impacts
- Forced with a climate model, the global flood model is fast, flexible and consistent with global climate
- We provide global flood hazard (occurrence) and risk (population displaced) maps over 4,734 watersheds

Supporting Information:

Supporting Information may be found in the online version of this article.

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Abstract Large scale flood risk analyses are fundamental to many applications requiring national or international overviews of flood risk. While large-scale climate patterns such as teleconnections and climate change become important at this scale, it remains a challenge to represent the local hydrological cycle over various watersheds in a manner that is physically consistent with climate. As a result, global models tend to suffer from a lack of available scenarios and flexibility that are key for planners, relief organizations, regulators, and the financial services industry to analyze the socioeconomic, demographic, and climatic factors affecting exposure. Here we introduce a data-driven, global, fast, flexible, and climate-consistent flood risk modeling framework for applications that do not necessarily require high-resolution flood mapping. We use statistical and machine learning methods to examine the relationship between historical flood occurrence and impact from the Dartmouth Flood Observatory (1985–2017), and climatic, watershed, and socioeconomic factors for 4,734 HydroSHEDS watersheds globally. Using bias-corrected output from the NCAR CESM Large Ensemble (1980–2020), and the fitted statistical relationships, we simulate 1 million years of events worldwide along with the population displaced in each event. We discuss potential applications of the model and present global flood hazard and risk maps. The main value of this global flood model lies in its ability to quickly simulate realistic flood events at a resolution that is useful for large-scale socioeconomic and financial planning, yet we expect it to be useful to climate and natural hazard scientists who are interested in socioeconomic impacts of climate.

Méthodologie

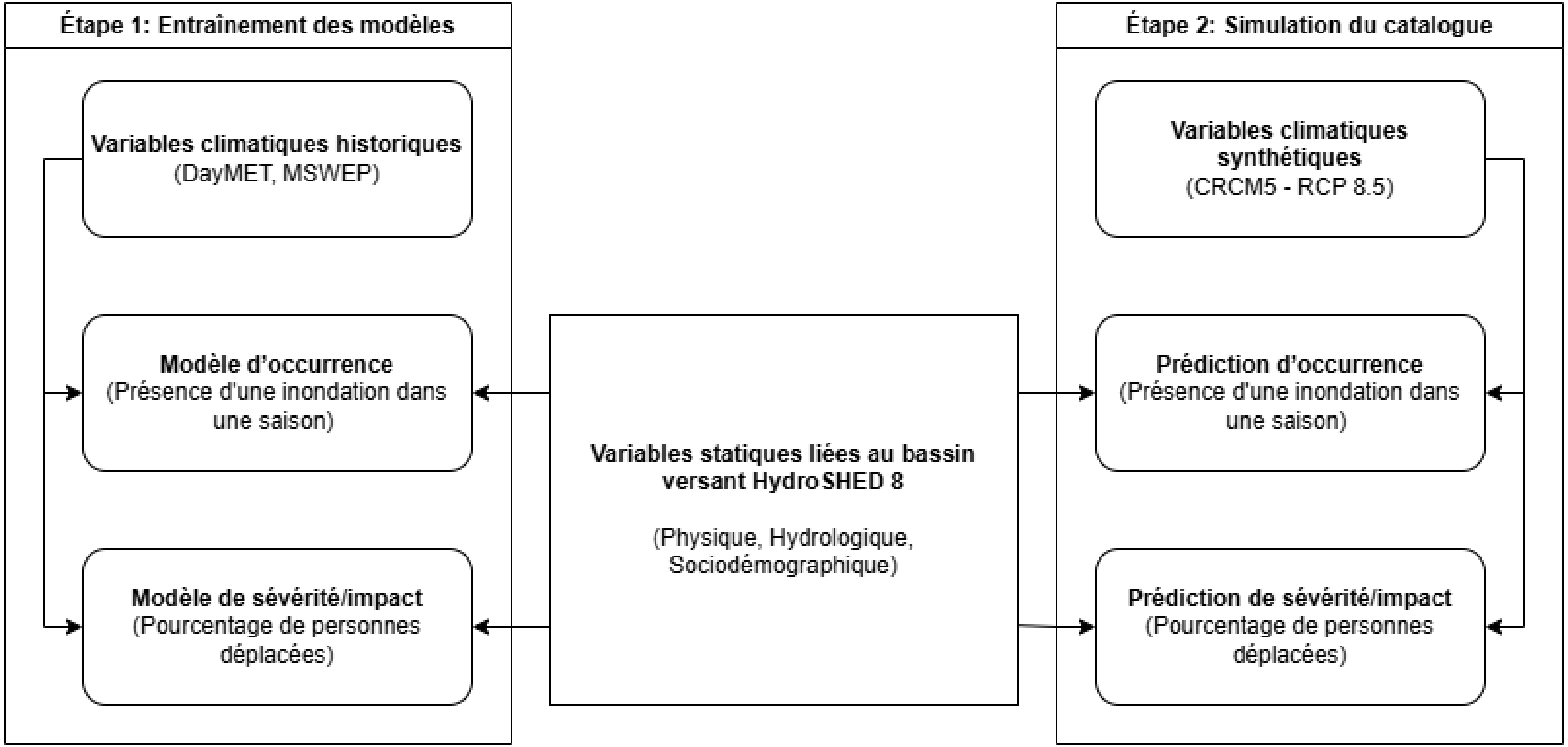
$$\hat{\mathbf{Y}} \sim \mathbf{X}_{\text{dynamique}} + \mathbf{X}_{\text{statique}}$$

- Occurrence: Présence d'au moins une inondation dans la saison.
- Sévérité/Impact: Pourcentage de personnes déplacées par l'inondation.
- Observation: Un bassin versant HydroSHED 8 pour une année hydrologique fixe.
- Modèles testés: GAM, RF, GBM.
- Entraînement: 70% [1985 - 2019]
- Test: 30% [1985 - 2019]
- Validation: 100% [2020-2021]

Méthodologie


DFO flood polygon example
Watersheds (HydroBASINS level 8)
CANADA
QUEBEC
NEW BRUNSWICK
Rimouski
Bathurst
Miramichi
Edmundston
Fredericton
Saint John
Quebec city

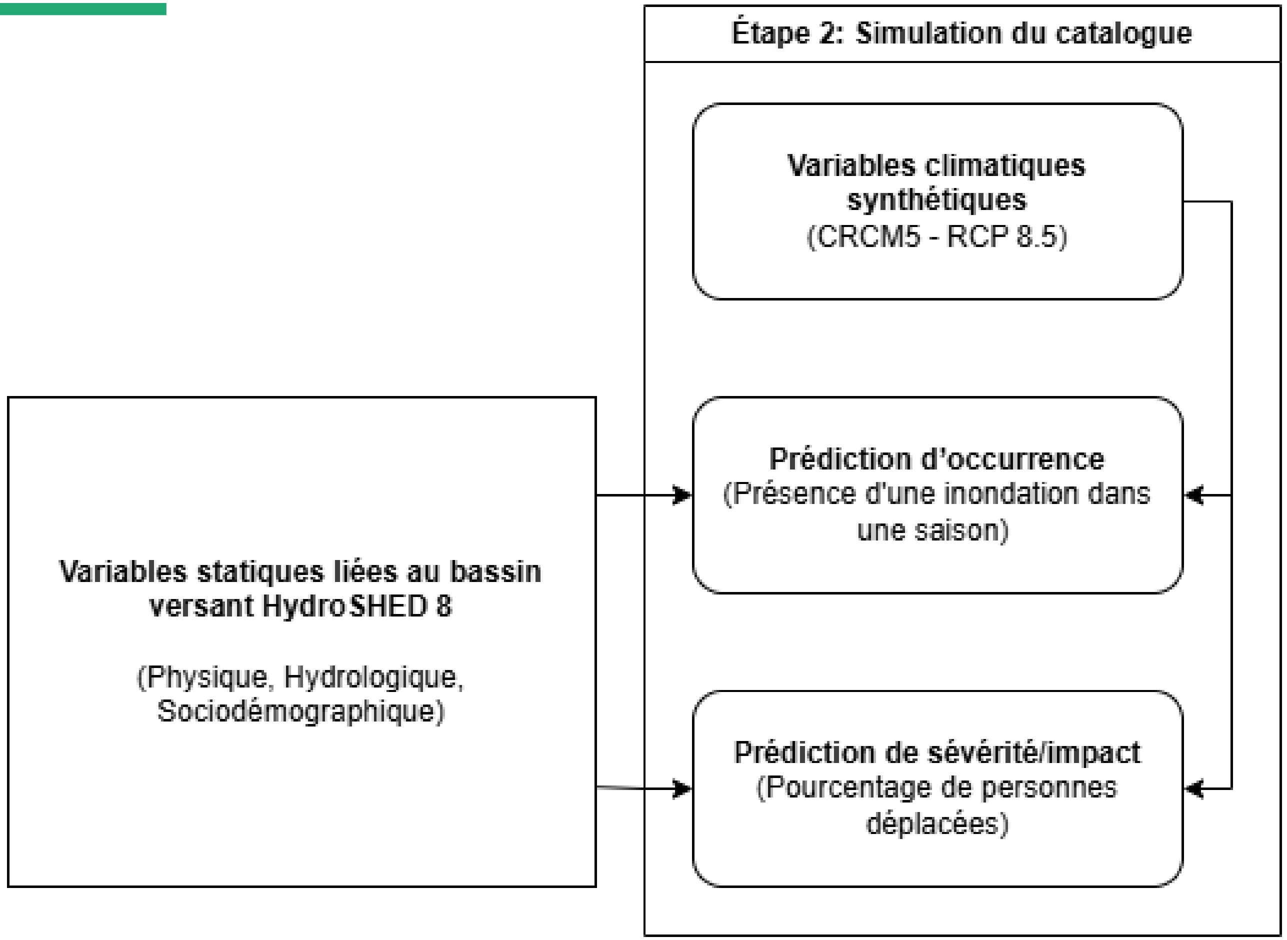
Méthodologie: Vue d'ensemble

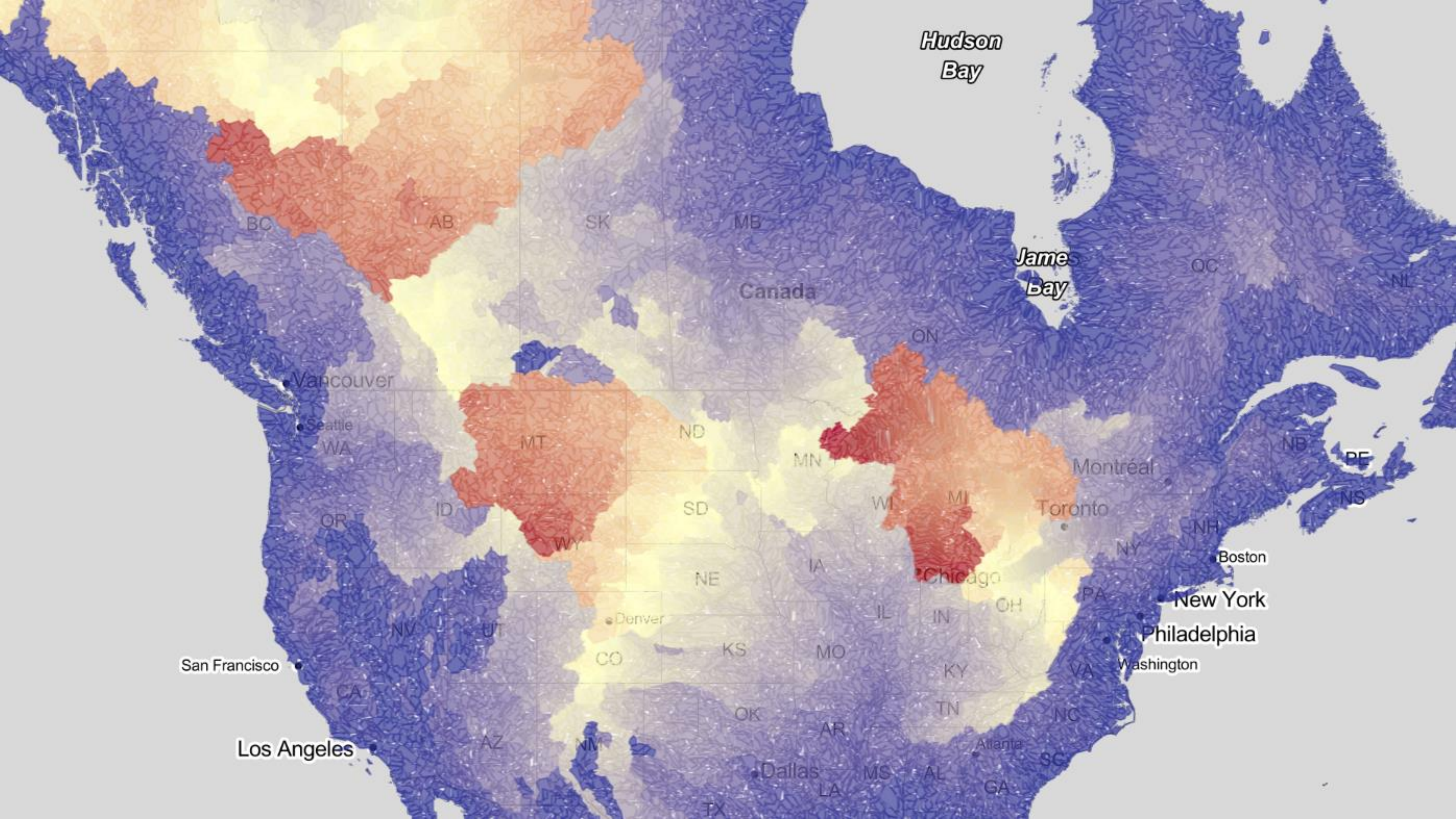


Entraînement des modèles

		Flood occurrence models				Flood impact models			
		Test		Validation		Test		Validation	
		ROC	PRE	ROC	PRE	R^2	RMSE	R^2	RMSE
Spring	**GAM**	0.936	0.665	**0.914**	**0.472**	0.584	1.690	0.399	1.840
	RF	**0.982**	**0.833**	0.878	0.454	**0.869**	**0.948**	0.392	1.851
	GBM	0.948	0.708	0.912	0.461	0.828	1.087	**0.501**	**1.678**
Summer	**GAM**	0.939	0.674	0.911	**0.470**	0.496	1.827	0.202	2.367
	RF	**0.981**	**0.835**	0.879	0.439	**0.822**	**1.073**	**0.203**	**2.367**
	GBM	0.950	0.716	**0.913**	0.458	0.807	1.115	0.109	2.517
Annual	**GAM**	0.938	0.670	**0.913**	**0.471**	0.540	1.759	0.301	2.104
	RF	**0.982**	**0.834**	0.878	0.447	**0.845**	**1.010**	0.298	2.109
	GBM	0.949	0.712	0.912	0.460	0.818	1.101	**0.305**	**2.098**

Simulation du catalogue d'événements

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Dallas
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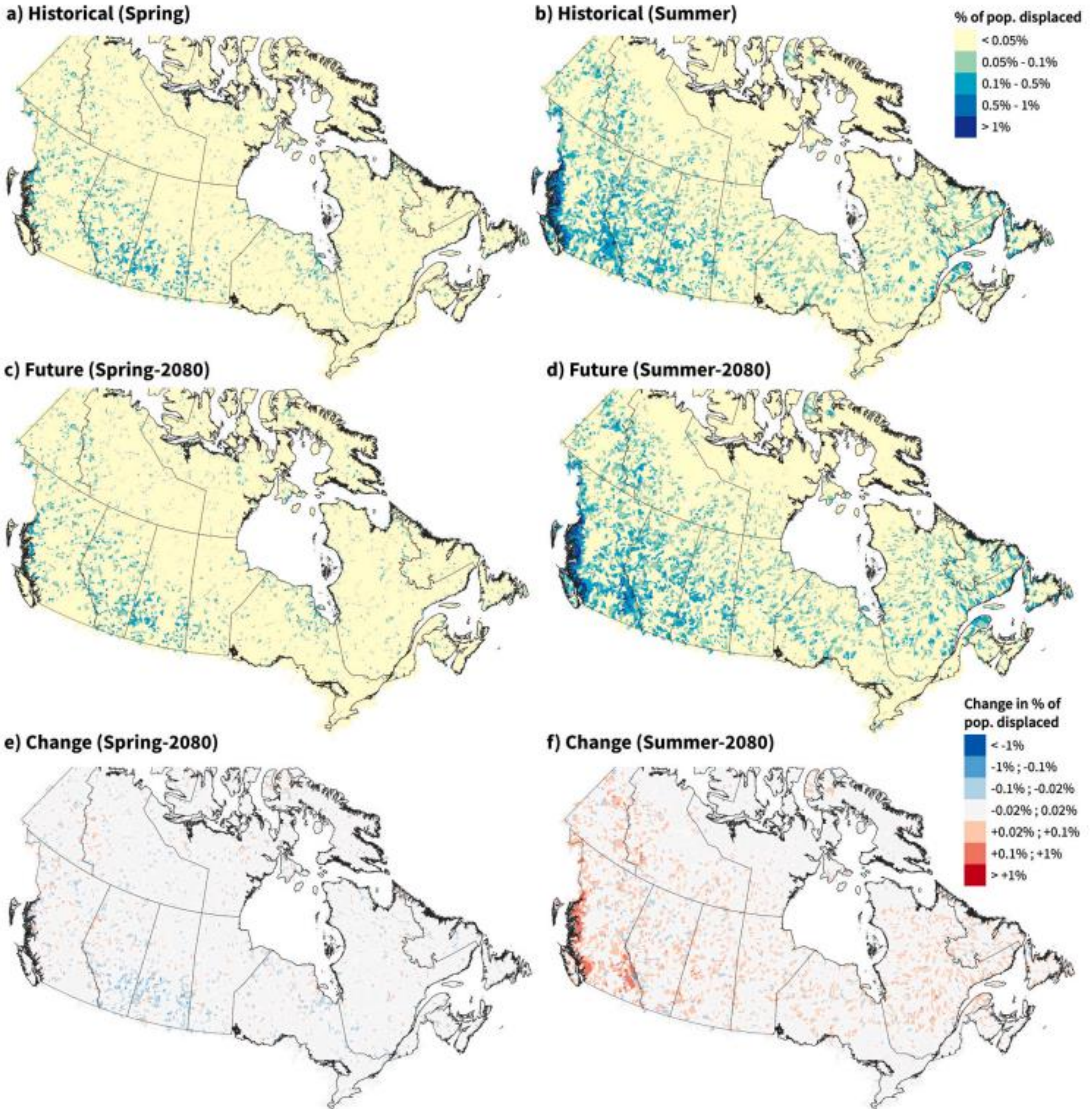
TX

Résultats

- Catalogue:
  - 200 000 années synthétiques;
  - 1980 – 2100;
  - 2 semaines.
- Analyse: Décennie historique versus décennie projetée avec les prédictions des modèles.
  - *Le climat est bien reflété dans les comportements d'occurrence et de sévérité/impact.*



En conclusion

- Les modèles statistiques et d’apprentissages machines sont viable pour les besoins de l’industrie de l’assurance.
- Cette méthodologie permet plusieurs itérations:
  - Modèles d’occurrences et de sévérité/impacts;
  - Modèles climatiques;
  - Granularité des bassins versants;
  - Variables explicatives;
  - La zone d’intérêt et la temporalité;
  - Dépendance spatiale.
- La simulation d’un catalogue d’événements est possible sans avoir recours à des énormes ressources computationnelles.

Partenariats

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Merci pour votre attention

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