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This research is supporting a CIRNAC lead Climate Risk Index tool. (providing a data layer on flood susceptibility/flood prone areas)

Prediction and classification of flood susceptibility based on historic record in a large, diverse, and data sparse country

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Objective of Research Project

- Objective:
  - Create a national dataset that maps flood susceptibility or potentially flood-prone areas based on hydro-geomorphic and meteorological data and flood history
- Why
  - To help understand areas potentially at risk of flooding
  - To identify areas that could be prioritized for high-resolution data collection and flood hazard mapping, support FHIMP
  - This research supports a CIRNAC-led climate risk index tool
- How
  - Using machine learning models of classification and regression algorithms to identify patterns in areas where flooding has historically occurred

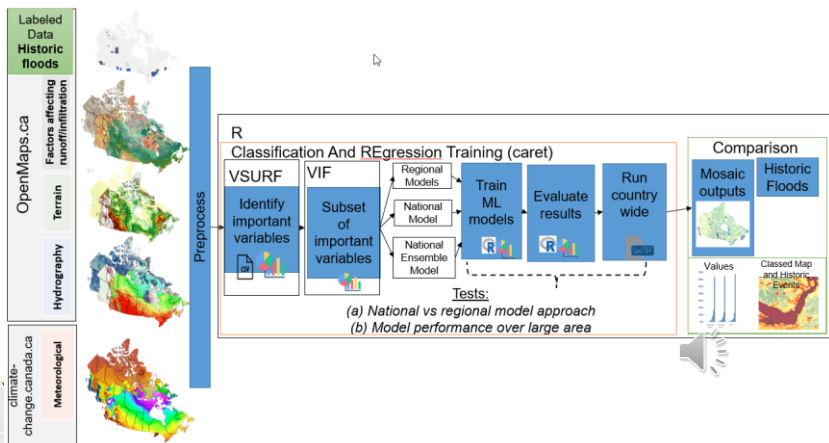Natural Resources Canada / Ressources naturelles Canada

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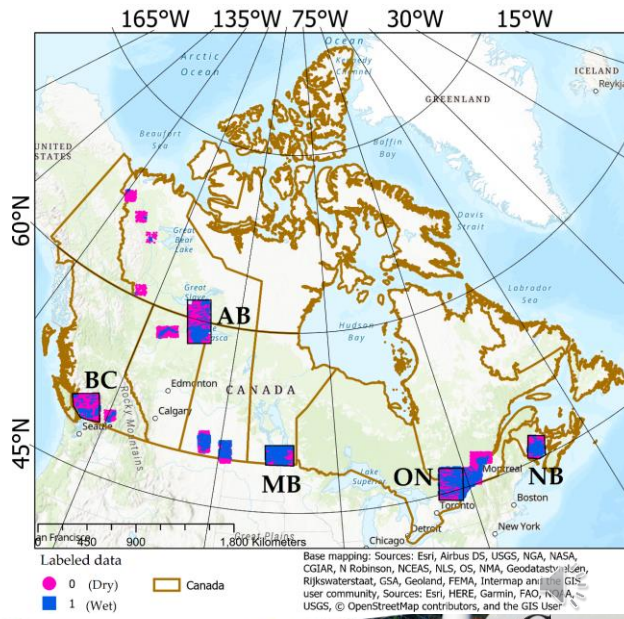
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Workflow

- Develop a method to create a national dataset that maps susceptibility to flooding (or potentially flood prone areas), based on hydro-geomorphology and meteorological data and historic record of flood events

1. Assemble Data

2. Determine 'important; datasets

3. Run several models

4. Evaluate performance

5. Select 'best' performing model

6. Apply model to the rest of the country

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Training data

- Several sites across Canada which have historic record of floods

Labeled data
- 0 (Dry)
- 1 (Wet)
- Canada

Base mapping: Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap and the GIS user community, Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User
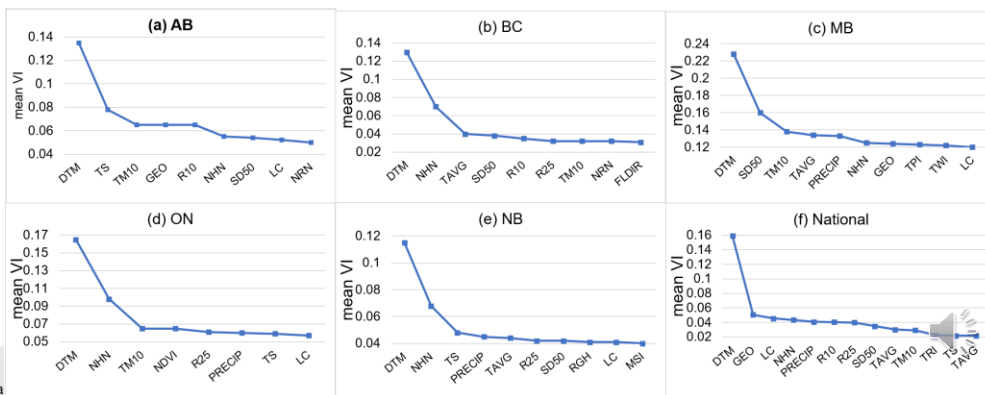
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2. Determine the Important datasets

- Through recursive feature elimination (rfe –caret) and Variable Selection using Random forest

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Single vs multi-regional models (Random Forest)

|	Regional Models (parRF) local-variables/national factors						Single Model
	BC	AB	MB	ON	NB	Average	National Model
Accuracy	0.96/0.96	0.94/0.94	0.82/0.82	0.89/0.92	0.99/0.99	0.91/0.93	0.92
Kappa	0.93/0.93	0.88/0.88	0.64/0.64	0.77/0.84	0.97/0.98	0.84/0.85	0.83
Sensitivity	0.95/0.93	0.91/0.91	0.79/0.79	0.91/0.92	0.98/0.98	0.91/0.91	0.91
Specificity	0.98/0.99	0.97/0.97	0.85/0.85	0.85/0.92	0.99/1.0	0.93/0.95	0.9
Precision	0.98/0.98	0.98/0.97	0.81/0.81	0.89/0.92	0.99/1.0	0.91/0.90	0.9
F1	0.95/0.93	0.91/0.91	0.79/0.79	0.91/0.92	0.98/0.98	0.91/0.91	0.91
AUC-ROC	0.97/0.97	0.96/0.96	0.86/0.86	0.92/0.93	0.99/0.99	0.94/0.94	0.97

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Single National Model

- RF & MARS somewhat similar
  - Though MARS higher values
- NNET model:
  - good where the training data exists
  - relatively low elsewhere
- SVM:
  - Rings north of training/test sites

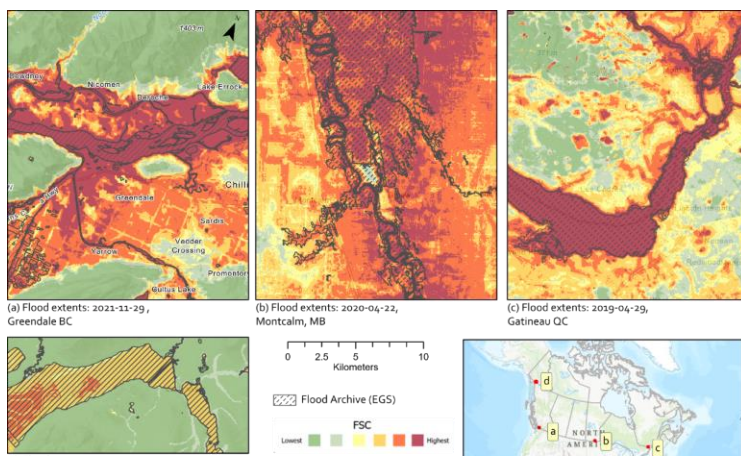Natural Resources Canada   Ressources naturelles Canada

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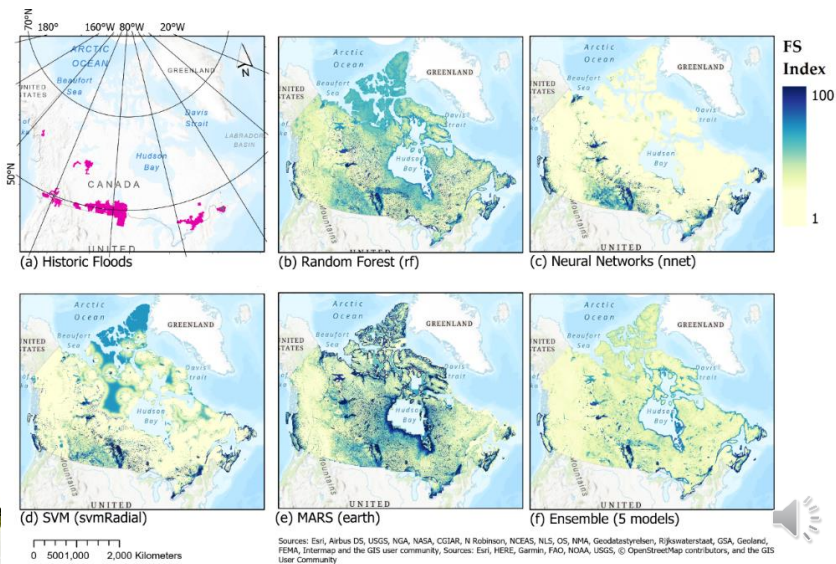
Comparison of prediction to historic events

- Using multi-regional, single national model and ensemble model approach
  - (i) Labelled points (used in training/test sets), (ii) data in the near-by surrounding sites, and (iii) All data across the country

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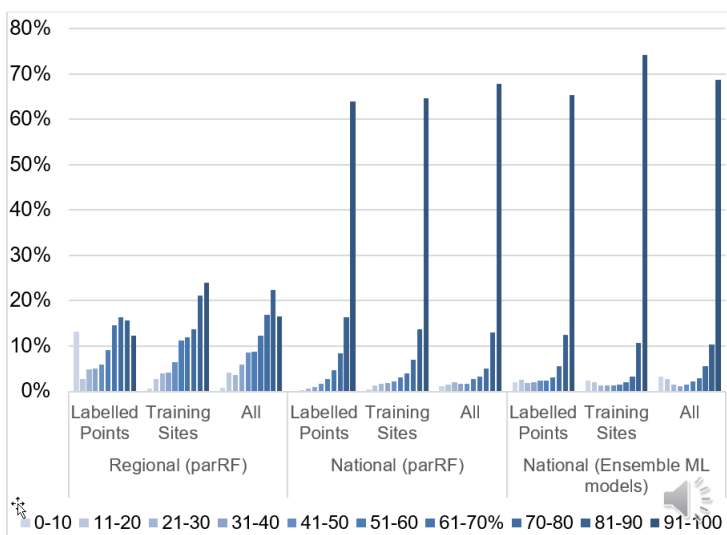
Results : Compared to historic events

- The resultant dataset provides the first continuous, national picture of flood susceptibility in Canada, with intended uses of:
  - Supporting identification and priority setting of flood hazard mapping project
  - For flood awareness communication
  - Auxiliary dataset for various climate risk indexes

(a) Flood extents: 2021-11-29, Greendale BC

(b) Flood extents: 2020-04-22, Montcalm, MB

(c) Flood extents: 2019-04-29, Gatineau QC

(d) Flood extents: 2021-07-17 Carcross, YT

Flood Archive (EGS)

FSC

Lowest — Highest

Sources: Esri, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, ... sen, Rijkswaterstaat, GSA, Geoland, FEMA, Inter ... the Sources: Esri, HERE, Garmin, FAO, NOAA, U... ... d the GIS User Community

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Conclusions

- Several challenges exist when trying to develop a flood susceptibility model for a country as large and diverse as Canada:
  - sparse training data
- Findings:
  - single national model produced better predictions than the regional, multi-region model
    - However, when a single ML model was extrapolated across the whole of Canada, there were limitations found in several models, including SVM, NN, MLP and RF.
  - An ensemble approach, which combined 5 models of different categories and combined them using a generalized linear model (GLM), ultimately produced the best flood susceptibility map, in comparison to historic flood maps

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