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G7 Transport Academic Workshop

National Research Council Canada

Building Transportation for Tomorrow:

Enhancing Resiliency Via Adoption of Emerging Technologies

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Politecnico di Milano, Bovisa Campus, Milan (Italy)

National Research Council Canada

Canada's largest R&D organization with over 100 years of experience

3 GOALS

1. Support business innovation
2. Advance scientific and technical knowledge
3. Support government policy objectives

2,500 scientists, engineers and technicians	**1,000** R&D collaborations with Canadian companies	**$1B** annual budget	**$193M** in revenue
1,030 publications	**1,700** active patents	**7,500** SME clients	**100s** of national and international partners

Ground Transportation in Canada

Canada:

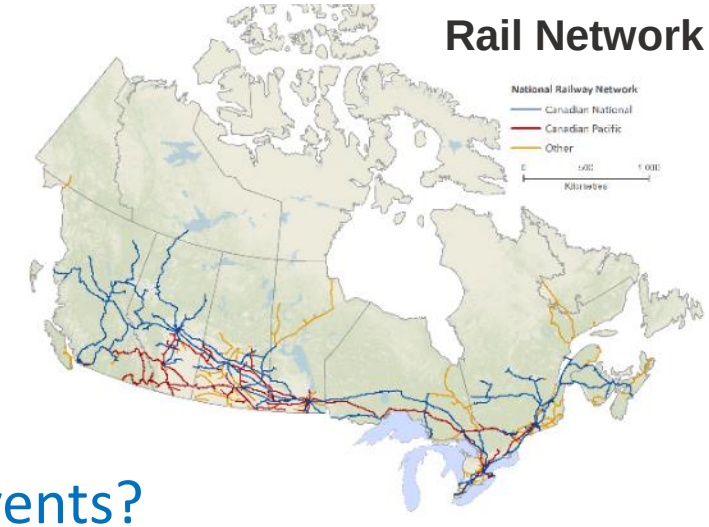
- Population: ≈ 40 million.
- Size: 9.9 million sq km.
- Stretches almost 7,560 kilometers from east to west.
- Very rich in natural resources.

Main Highway Network

Rail and Road Networks:

- 42,000+ km rail network (5th largest in the world).
- 38,000+ Highway lane-km network.
- 1.3M 2-lane equivalent lane-km road network.

Rail Network



How to ensure such vast networks can face extreme climate events?

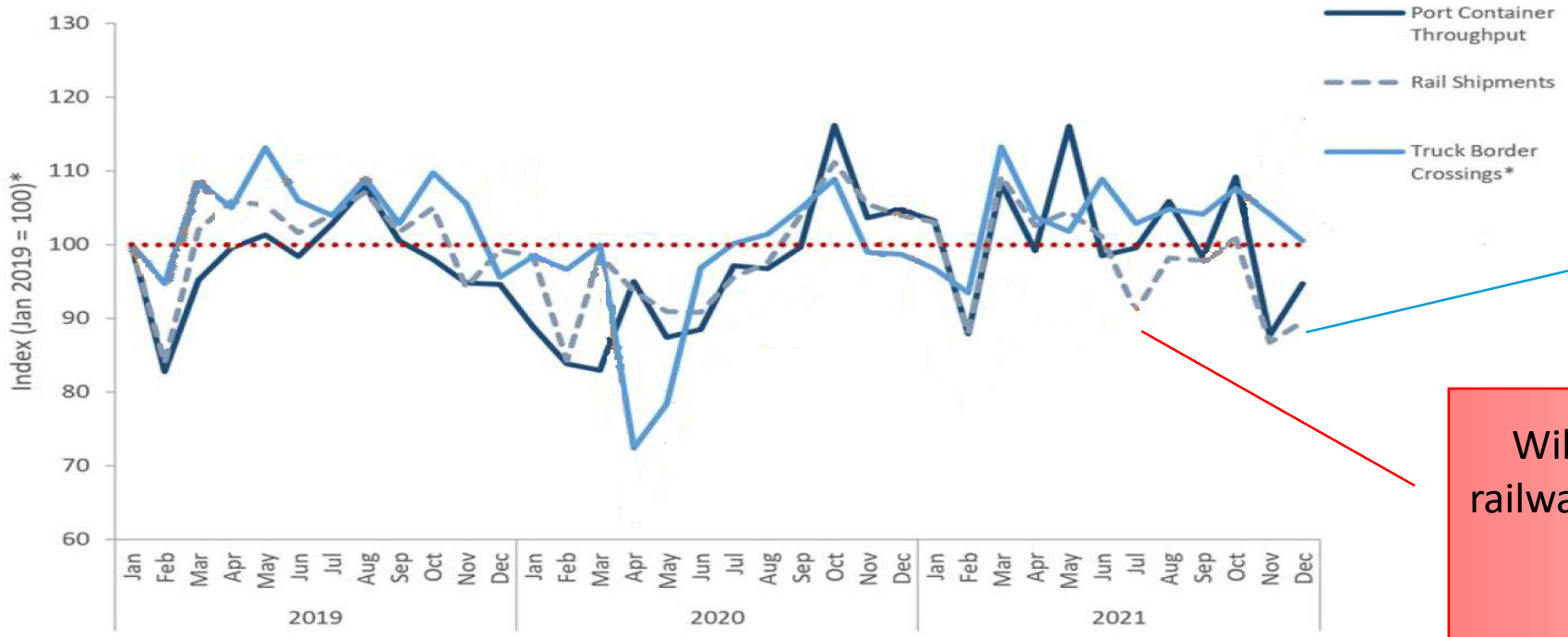
NRC Vision: Path Towards Data and Technology Driven Resilient Ground Transportation Networks

Make Better Use of Existing Datasets	Integrate past accidents, surrounding population/water ways, & weather to generate a risk picture of the National Rail and Road Networks.
Adopt Emerging Technologies	Integrating datasets extracted from new and emerging technologies; satellites, drones, onboard sensors… etc.
Develop Novel Tools for Near Real-Time Information Extraction	Use artificial intelligence, machine learning to develop tools to automate data engineering, data analytics, and information extraction.
Improve Vehicle Performance & Resilience	Use onboard sensors, ADAS, digital twinning and active controls to improve vehicles performance in facing severe climate related events.
Predictive Risk Identification Approach	Develop a technologically advanced and near real-time monitoring framework at a National level for regulators and industry to proactively conduct risk assessment and system optimization.

Rail Related Research Activities

Impact of Extreme Climate Evens on Rail Freight Flow

- Recent **extreme climate events** have led to significant disruptions in rail transportation, directly **affecting the supply chain** in Canada.
- Canada's rail network faces exposure to extreme weather events such as **severe cold, floods, wildfires, heatwaves, and frequent freeze-thaw cycles**.



Flooding in British Columbia
($163 million/day)

Wildfires blocked the main railway lines leading to the Port of Vancouver.
($170 million/day)

Source: Statistics Canada, Transport Canada, Canadian Port Authorities

Path to Resilient Rail Transportation System

Focus and Approach of NRC

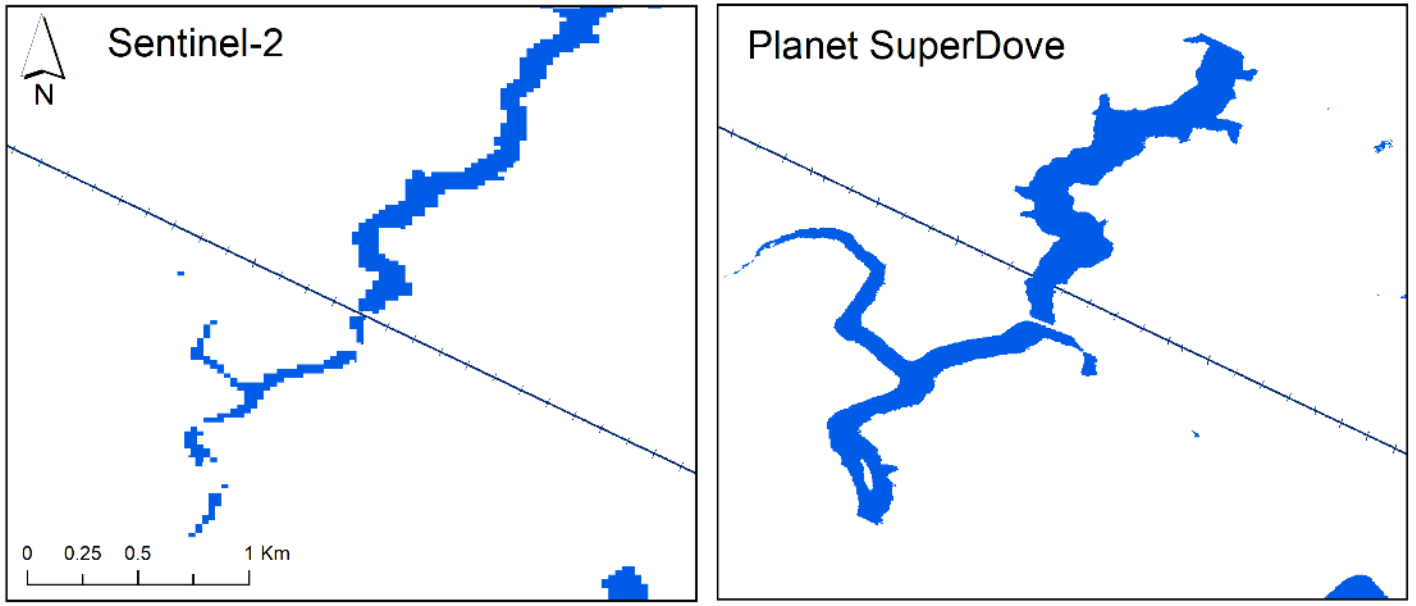
Enhancing Rail Network Resiliency:

- **Proactive Identification:** Targeting areas vulnerable to climate events for pre-emptive mitigation.
- **Prediction Models:** Developing tools to anticipate events and prepare effectively.
- **Rapid Recovery:** Ensuring quick restoration of service following extreme weather incidents.

Adoption of Emerging Technologies:

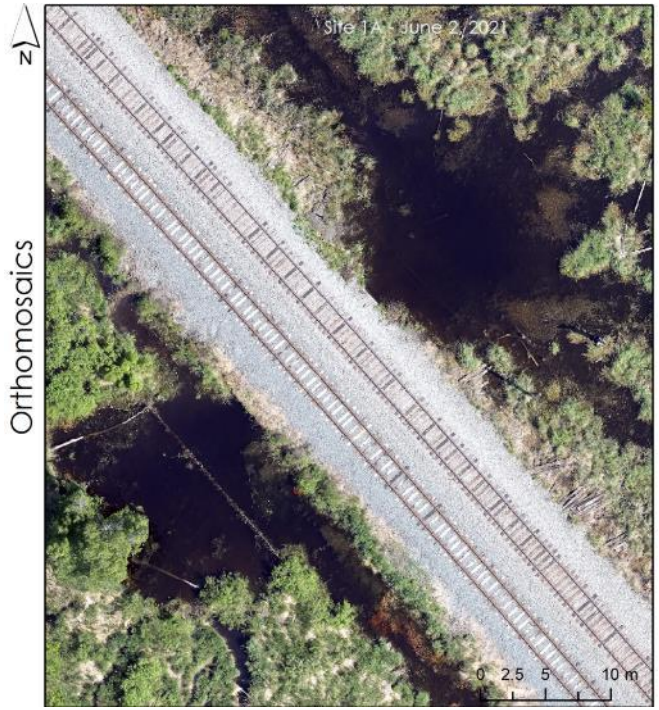
- **Satellite and RPAS Utilization:** Leveraging satellite imagery and Remotely Piloted Aerial Systems (RPAS).
- **Sensor Deployment:** Installing sensors on mobile platforms for real-time data collection.
- **Data Consolidation:** Amalgamating and analyzing large datasets from various sources for better insights.
- **AI and Machine Vision Integration:** Employing artificial intelligence and machine vision for enhanced monitoring and proactive response.

Water and Vegetation Monitoring – Satellite



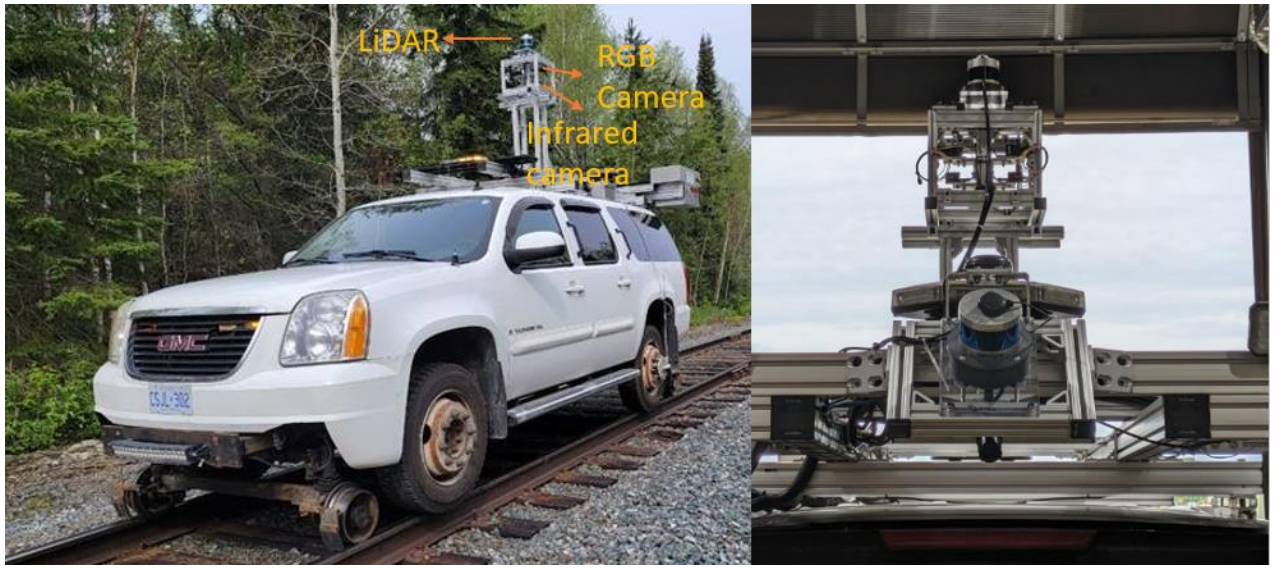
- **Satellite Data Utilization**: Ideal for detecting changes over large distances from the railway track, including water levels, vegetation growth, active fires, burned areas, and weather forecasting.
- **Broad-Scale Mapping**: Effective for comprehensive environmental monitoring relevant to railway safety and maintenance planning.

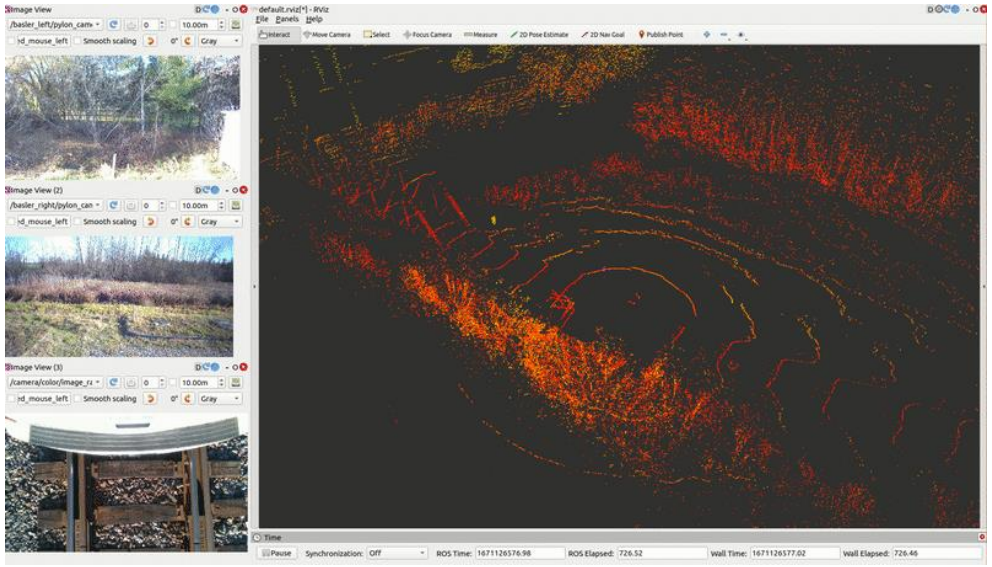
Water and Vegetation Monitoring – Remotely Piloted Aerial Systems



- **RPAS-Driven Digital Mapping:** Utilizing RPAS imagery to train algorithms that detect environmental changes affecting tracks, including water levels, water areas, and vegetation growth.
- **Proactive Network Management:** Leveraging technology for continuous and efficient monitoring of high-risk sections within the rail network.

Water and Vegetation Monitoring – Sensors Mounted on Mobile Platforms

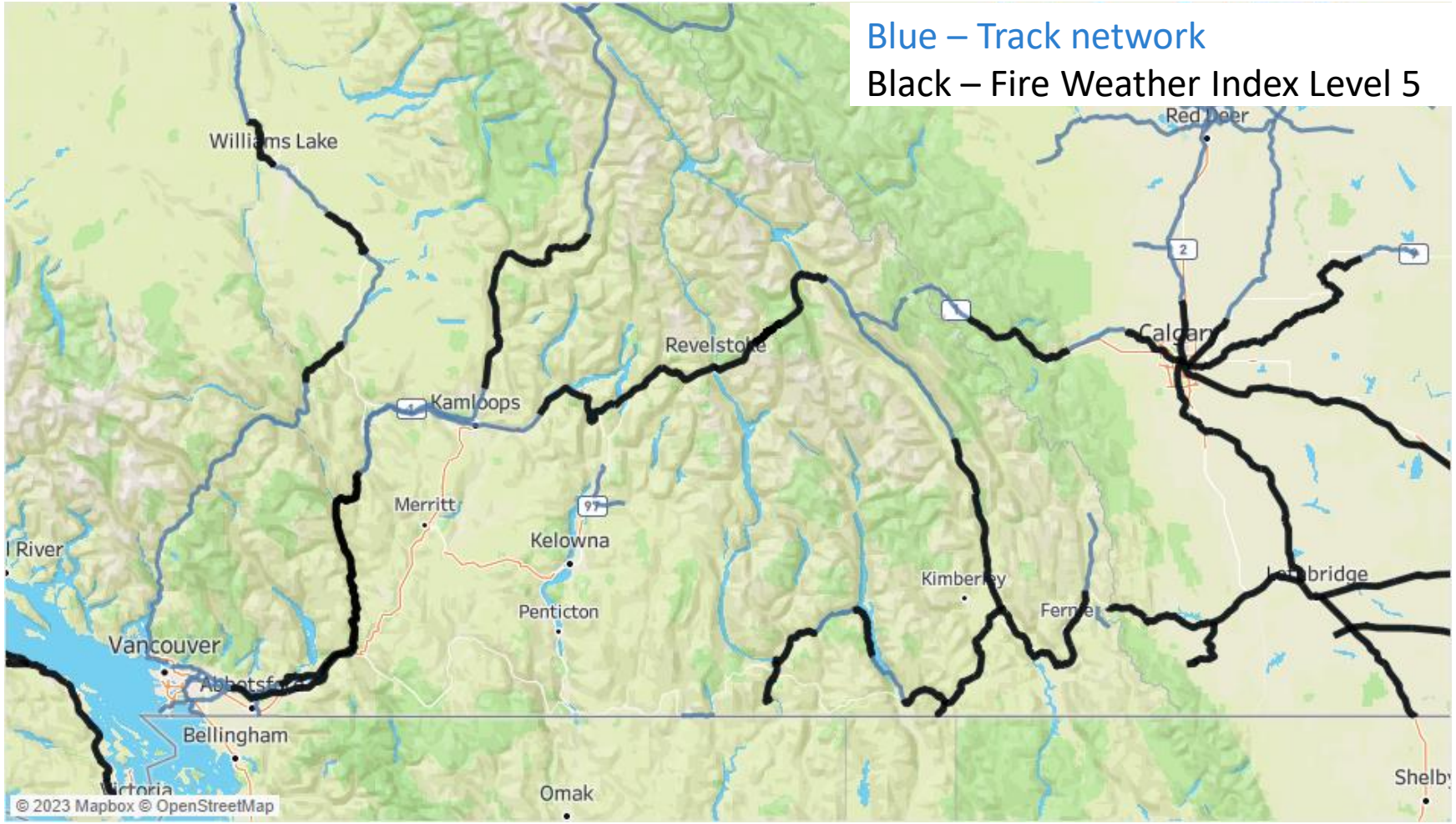




- **Sensor-Equipped Mobile Platforms**: Equipped with diverse sensors for creating digital models of tracks and surroundings, offering flexibility and suitability for long-distance monitoring despite a limited field of view.
- **Real-Time Data Analysis:** Algorithms process data on-the-go, delivering real-time or near-real-time insights on track changes and right-of-way to inspectors, enhancing safety and efficiency.

Prediction of Wildfire Risk on National Railway Network

Rail Network Wildfire Risk in a Week Starting from 2023-07-27



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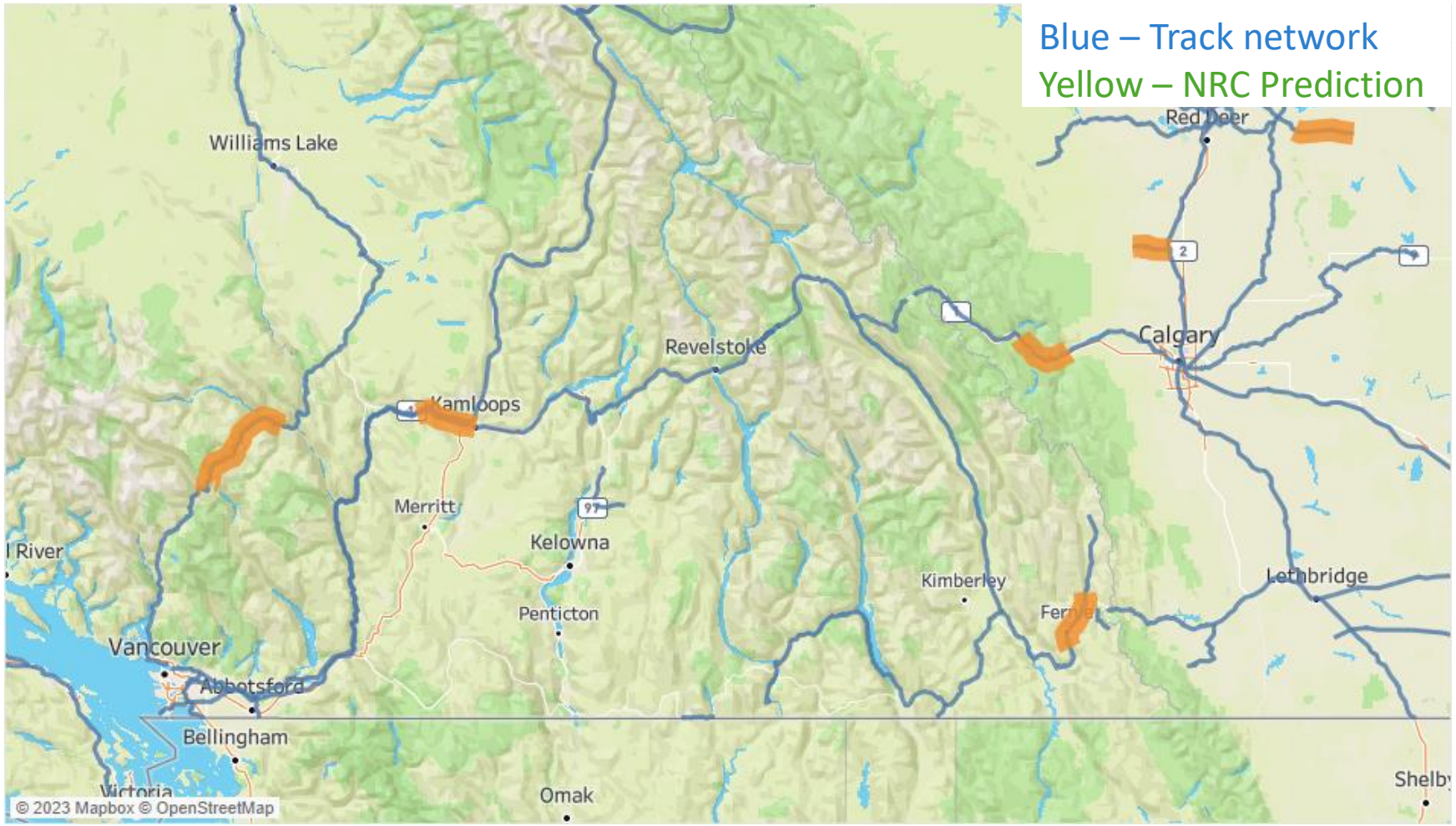
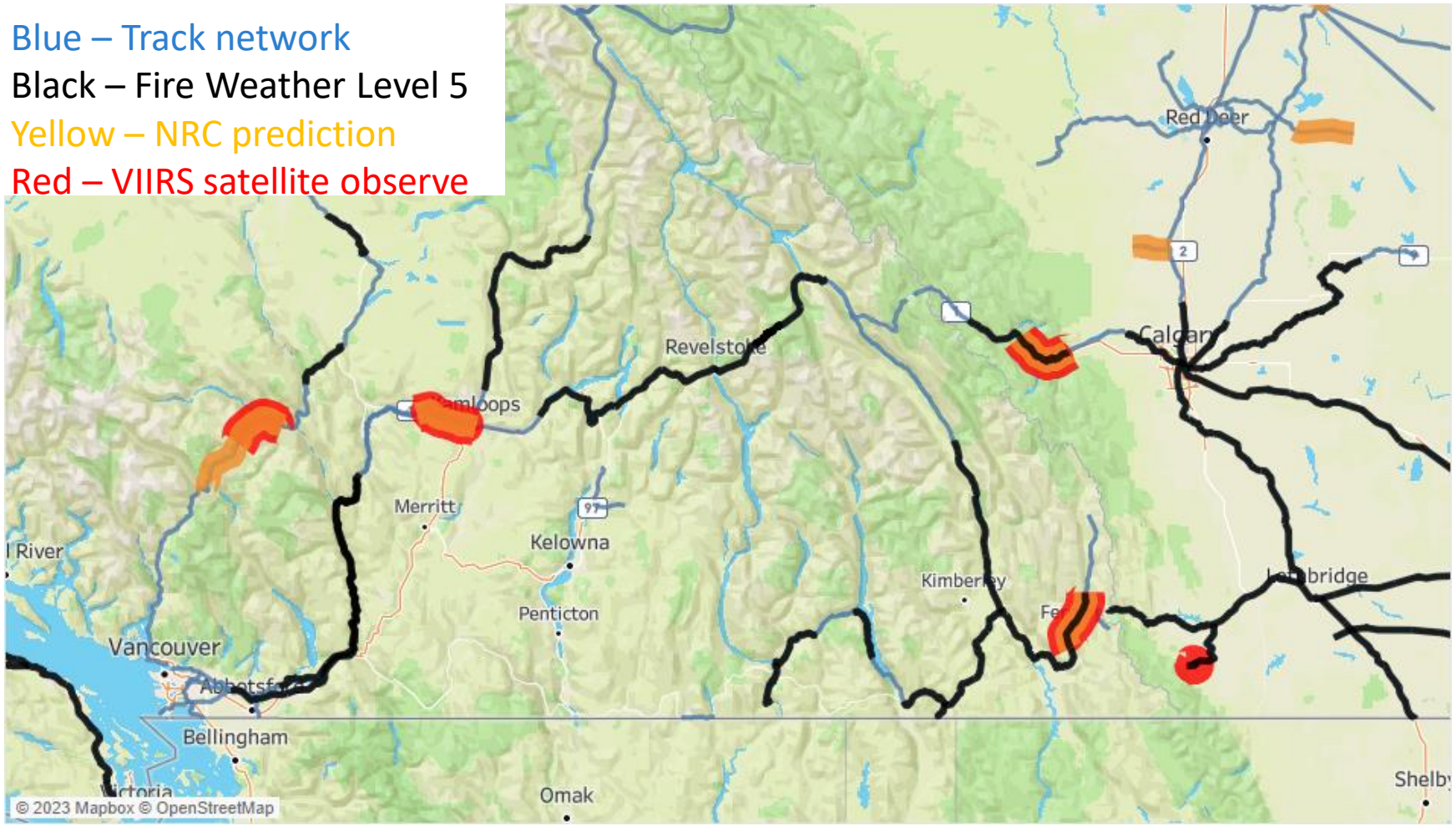


Prediction of Wildfire Risk on National Railway Network

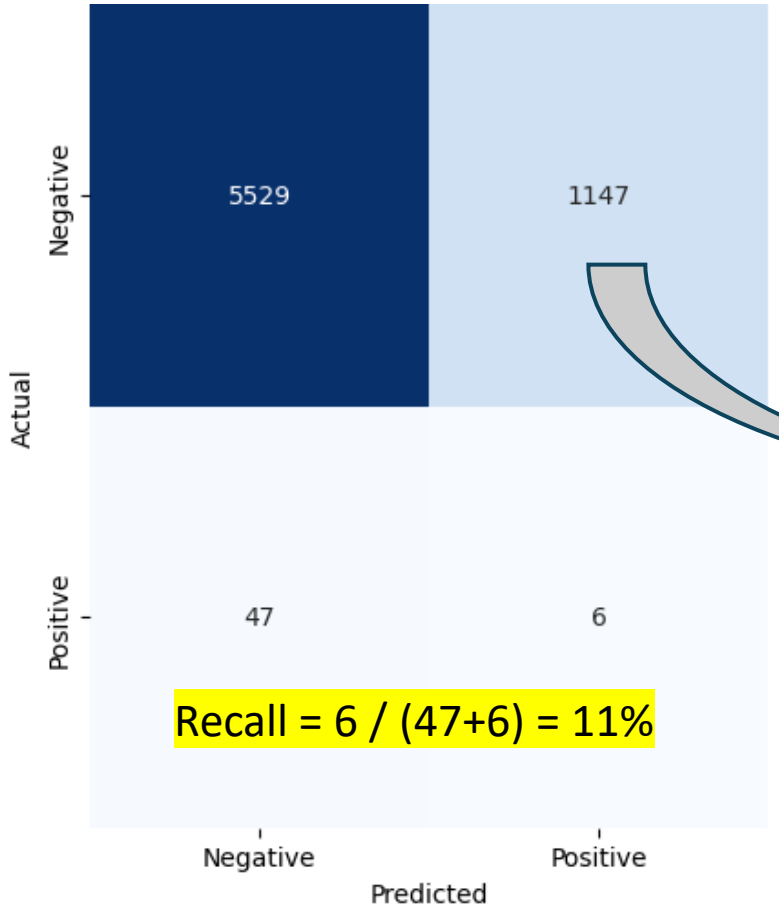
Rail Network Wildfire Risk in a Week Starting from 2023-07-27

Blue – Track network
Black – Fire Weather Level 5
Yellow – NRC prediction
Red – VIIRS satellite observe



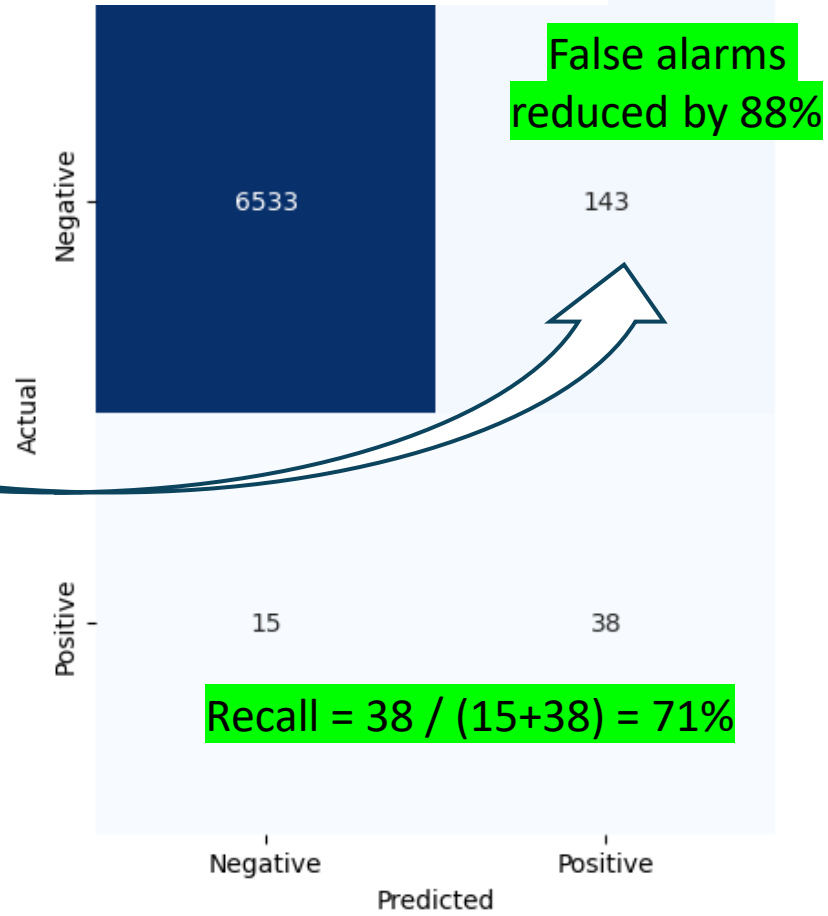
Prediction of Wildfire Risk on National Railway Network

Fire Weather Risk Index = 5 as Prediction



Recall = 6 / (47+6) = 11%

NRC Model



False alarms reduced by 88%

Recall = 38 / (15+38) = 71%

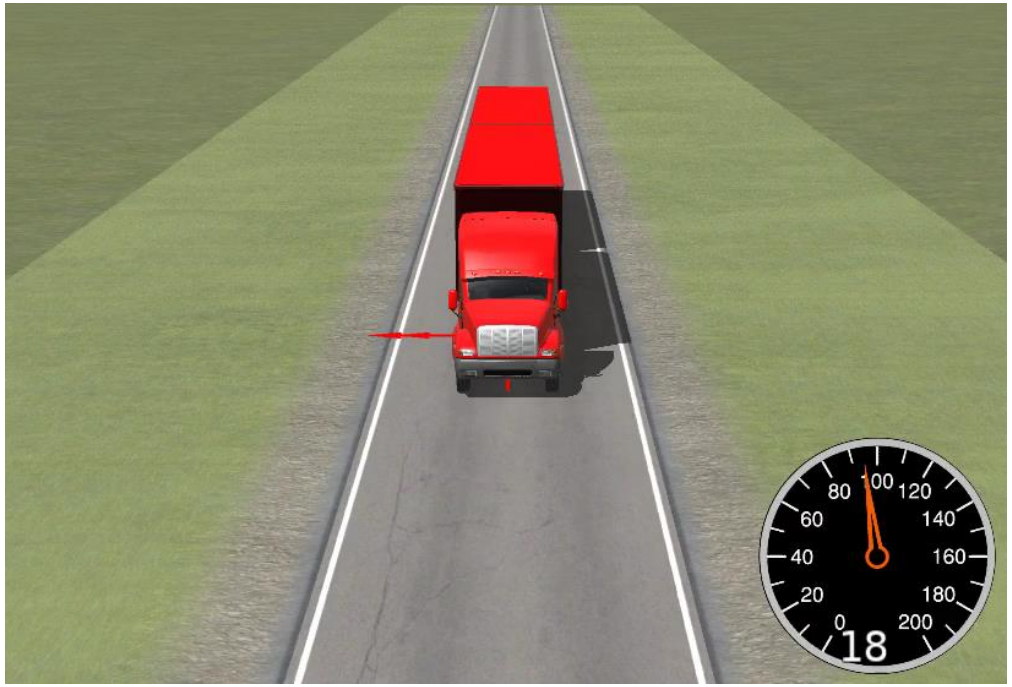
Road Related Research Activities

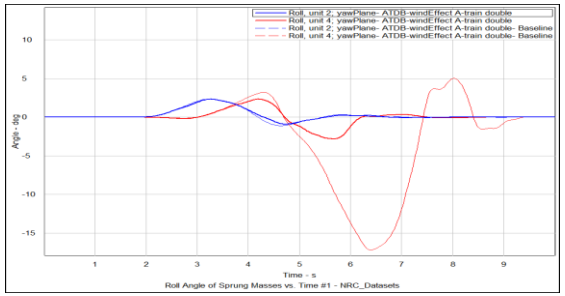
SafeTrucks – Develop Electronically-Controlled Active Trailer Steering System

3 years project, involves academia, industry and government research labs in Canada, Finland and France.

- Combine tyre-terrain knowledge, vehicle dynamics, active controls, and real-time road weather services.
- Develop articulated heavy vehicle (AHV) digital twin and predictive road safety analytic system.
- Build driver-in-the-loop simulator with controller hardware-in-the-loop, high-fidelity motion platform, haptic controls, and mixed reality visualizations to develop active control systems in a controlled, efficient and repeatable environment.
- Develop active trailer steering and active trailer differential braking systems for articulated heavy vehicles to **improve low speed maneuverability and high speed lateral stability**.

SafeTrucks – Mitigating Wind Gust Effect with Active Trailer Differential Braking System

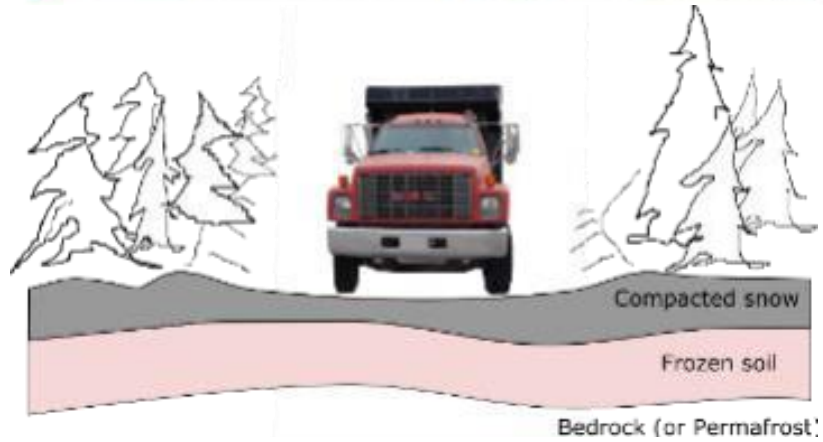




- An average of 660 truck rollover incidents in Canada/year

Winter Road: Climate Risk and Vulnerability

- Approximately 8,000 km of official winter roads in Canada.
- Winter roads are seasonally constructed, over frozen terrain and water bodies, such as lakes and rivers.
- Winter road systems are the lifelines of many northern and remote communities in Canada:
  - Only economic means for community members to get in and out of the communities, and to bring in essential supplies, such as food, medicine, fuel and building supplies.
  - Flying supplies to the mines costs four to eight times more per pound than transporting them by road."
  - The cost of replacing winter roads with all season roads was estimated to be $1.5 billion (in 2014)
- Exceptionally vulnerable to a warming climate which is reducing the operating window of these roads across northern Canada.



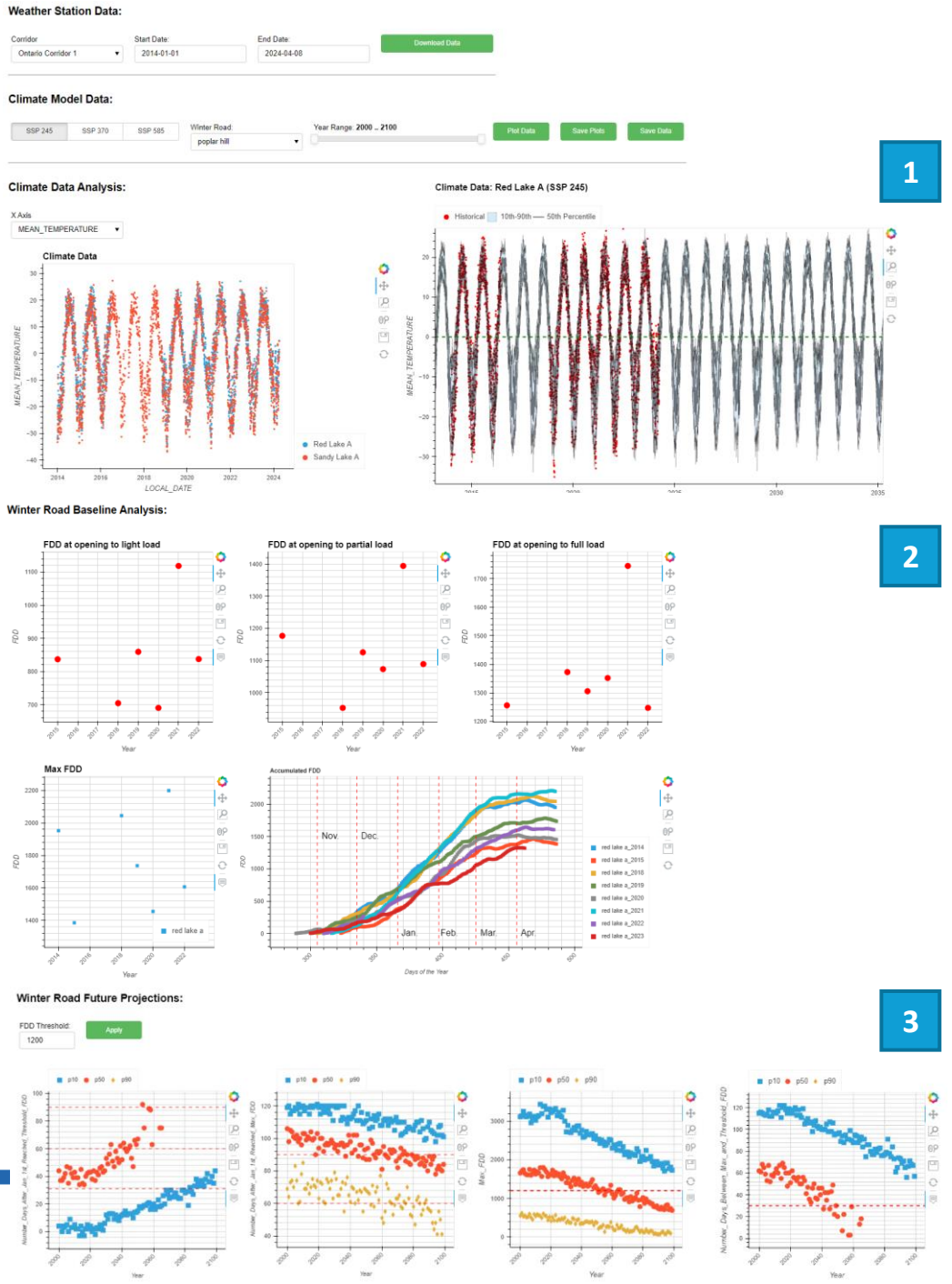
Winter Road: Climate Risk Dashboard

A framework has been developed based on published scientific methods, field data from winter road operations, and stakeholder observation, experience and concerns.

A dashboard has been created to:

1. Automate the analysis of climate data, using the latest climate models.
2. Incorporate historical data such as opening and closing dates to automate winter road season analysis and in-depth route assessments.
3. Automate winter road season forecasting.

Identifies vulnerabilities within the network, supports the prioritization of high risk segments based on key factors and evidenced-based decision-making in the context of a changing climate.



Winter Road: Future Work

- Review and assess resilient routes to identify potential best practice that can be deployed network-wide to improve climate resilience.
- Apply remote and advance sensing technologies for safety testing and monitoring.
- Develop solutions to assist vehicles to safely navigate land and ice routes.
- Develop solutions to lengthen operating seasons in a changing climate.

Conclusions

Extreme Weather events can significantly impact the safety and operational efficiency of the transportation systems → Impacting Canadian economy and wellbeing of Canadians.

Adopting and Integration of Emerging Technologies in operations and decision making can support ongoing efforts to enhance the resiliency of the ground transportation system.

Climate-resilient transportation is about adapting to, not avoiding, climate impacts to ensure operational success.

Recommendations

Continue Collaboration between government organizations, research institutes, academia and industry → enable technology development, testing, evaluation and implementation.

Funding Programs to support multi-year, multi-party, and large scale research initiatives that tackles major climate related challenges.

Thank You!

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