Innovations in Predicting Resilient Adaptations: Cascading Coupled Extremes of Wildfire, STORMs, Debris Flows, and Floods

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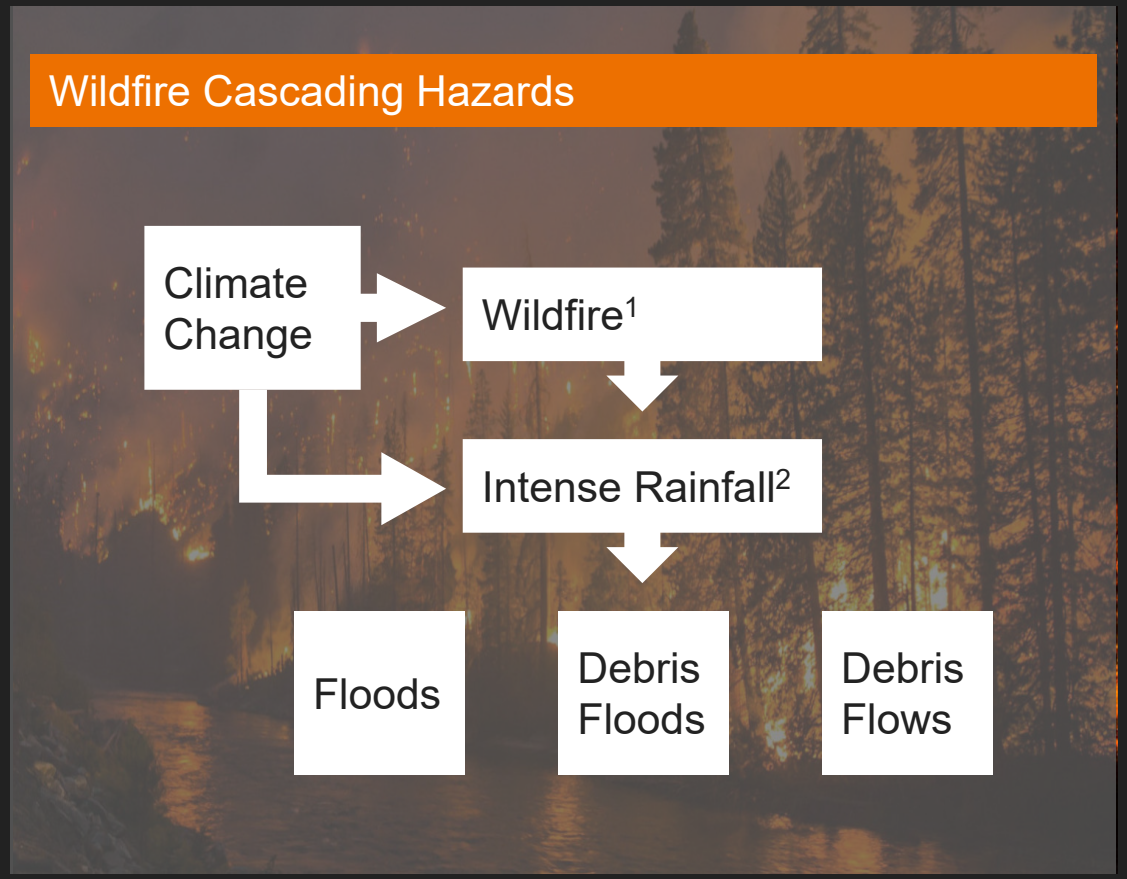
Introduction



Wildfires lead to cascading hazards

Climate change has added another dimension to these complex responses

Scientists and engineers are developing novel understandings in hazard and risk analysis that inform emergency planning and mitigation.

1. *United Nations Environment Programme, Spreading like Wildfire – The Rising Threat of Extraordinary Landscape Fires, (2022)*
2. *D. Touma, S. Stevenson, D. L. Swain, D. Singh, D. A. Kalashnikov, X. Huang, Sci. Adv., 8, p.eabm0320 (2022)*

Introduction

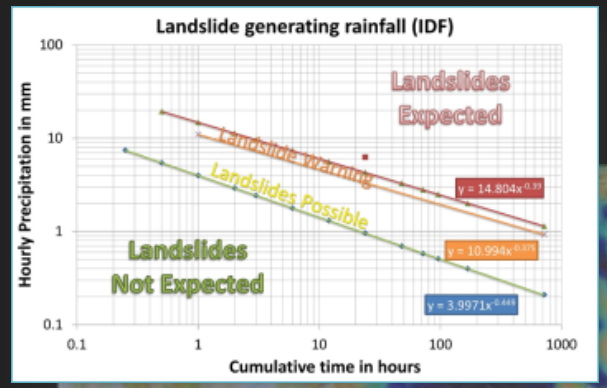
Here, we are presenting several innovative modeling and monitoring tools that:

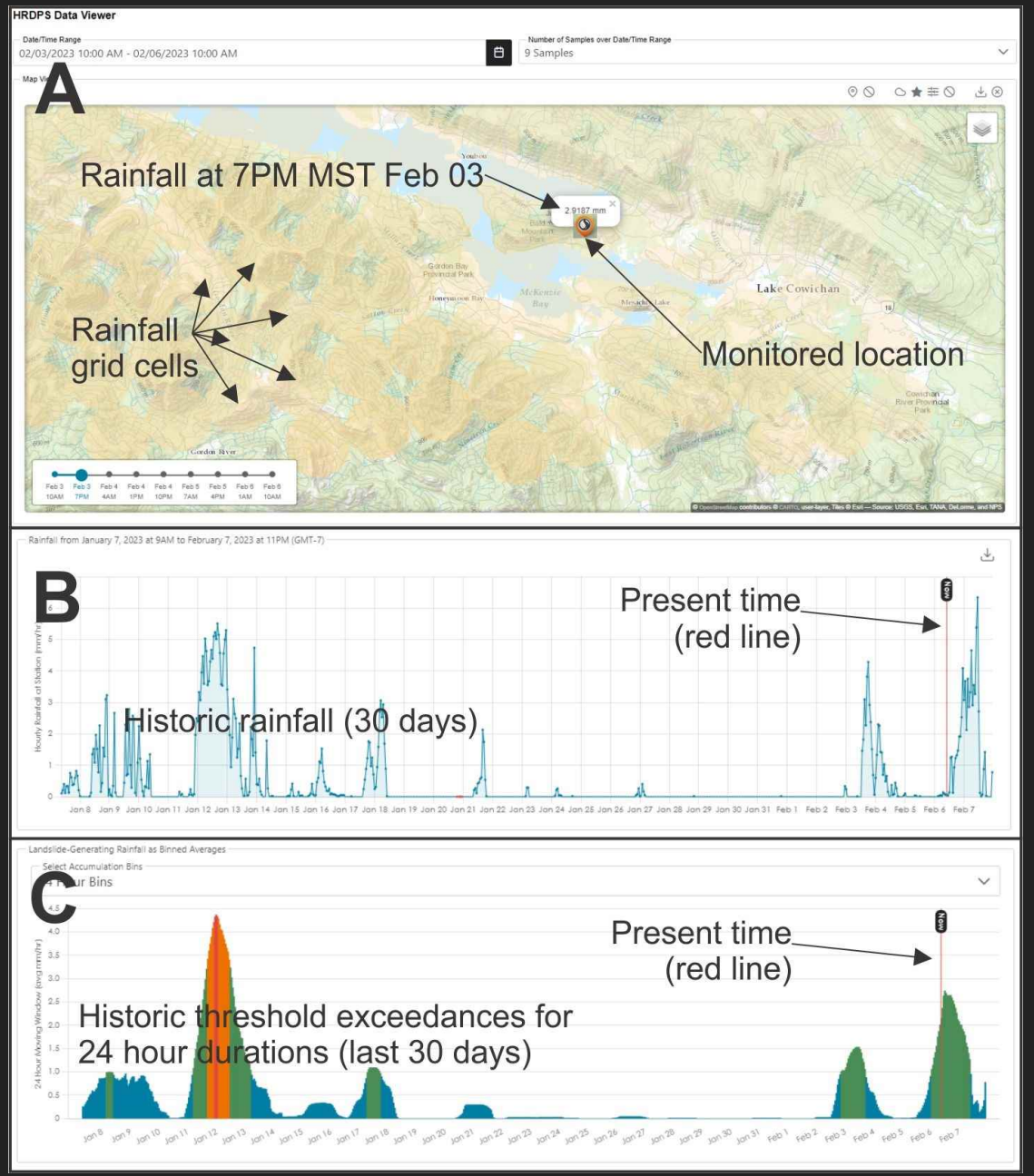
- Near-real time monitoring to show when these events have the potential to occur (will adapt to climate change over time).
- Model long-term changes associated with climate change.

Four products we are using to advance our understanding of climate change and the impacts to extreme cascading geohazards:

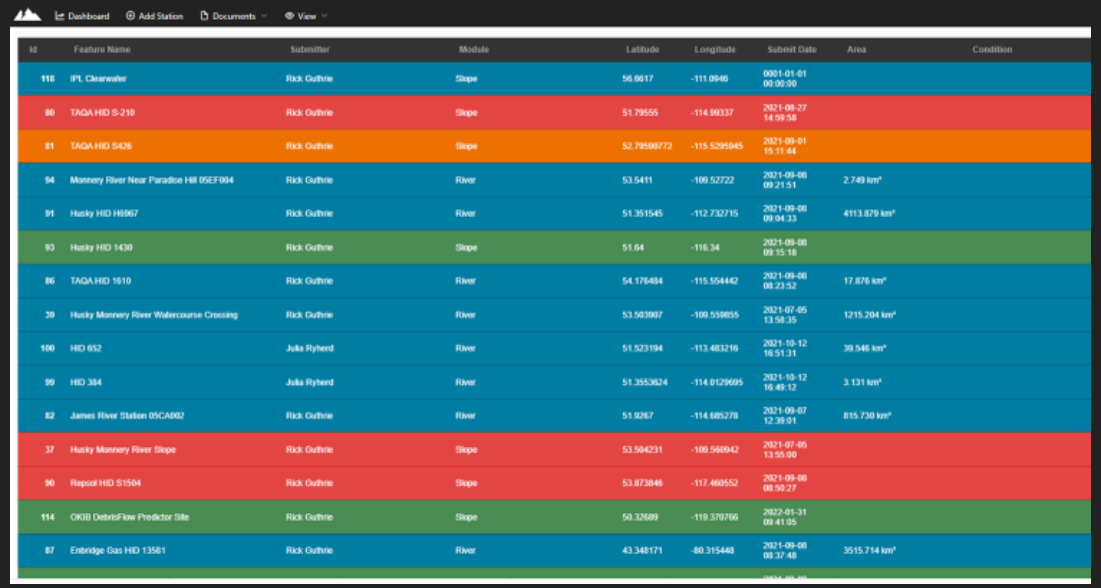
- Slope and Storm Manager
- DebrisFlow Predictor
- Flood Predictor

Slope Manager

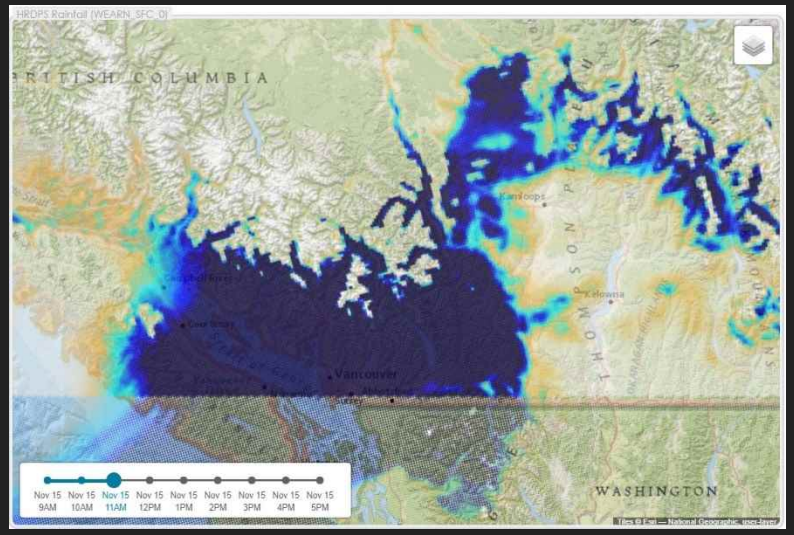


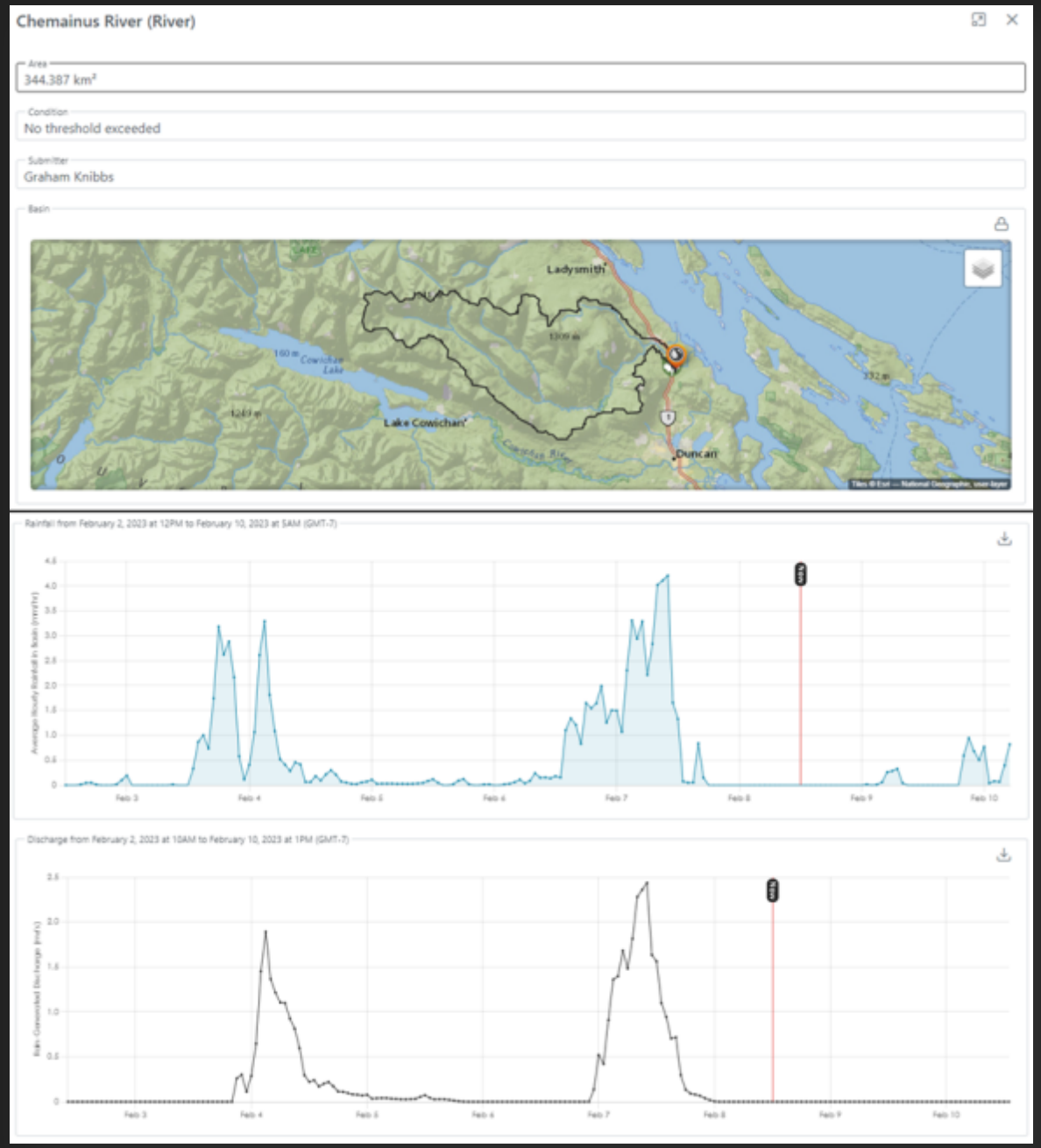


Storm Manager



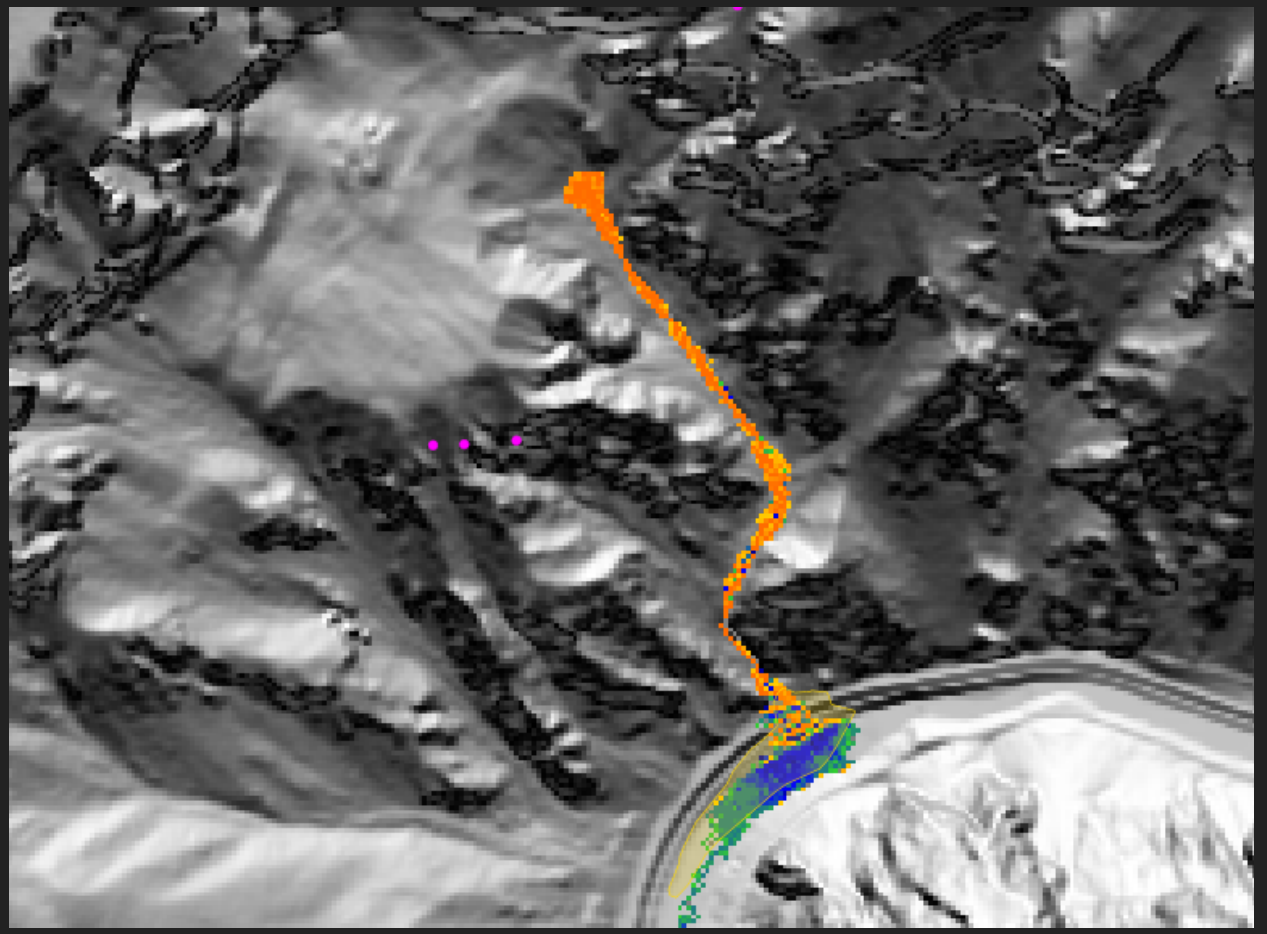
Id	Feature Name	Submitter	Module	Latitude	Longitude	Submit Date	Area	Condition
118	IPL Clearwater	Rick Guthrie	Slope	56.6617	-111.0946	0001-01-01 00:00:00		
80	TAQA HID S-210	Rick Guthrie	Slope	51.79555	-114.99337	2021-08-27 14:59:58		
81	TAQA HID S426	Rick Guthrie	Slope	52.79590772	-115.5295945	2021-09-01 15:11:44		
94	Monnery River Near Paradise Hill 05EF004	Rick Guthrie	River	53.5411	-109.52722	2021-09-08 09:21:51	2.749 km²	
91	Husky HID H6967	Rick Guthrie	River	51.351545	-112.732715	2021-09-08 09:04:33	4113.879 km²	
93	Husky HID 1430	Rick Guthrie	Slope	51.64	-116.34	2021-09-08 09:15:18		
86	TAQA HID 1610	Rick Guthrie	River	54.176484	-115.554442	2021-09-08 08:23:52	17.876 km²	
39	Husky Monnery River Watercourse Crossing	Rick Guthrie	River	53.503907	-109.559855	2021-07-05 13:58:35	1215.204 km²	
100	HID 652	Julia Ryherd	River	51.523194	-113.483216	2021-10-12 16:51:31	39.546 km²	
99	HID 384	Julia Ryherd	River	51.3553624	-114.0129695	2021-10-12 16:49:12	3.131 km²	
82	James River Station 05CA002	Rick Guthrie	River	51.9267	-114.685278	2021-09-07 12:39:01	815.730 km²	
37	Husky Monnery River Slope	Rick Guthrie	Slope	53.584231	-109.566842	2021-07-05 13:55:00		
90	Repsol HID S1504	Rick Guthrie	Slope	53.873846	-117.460552	2021-09-08 08:50:27		
114	OKIB DebrisFlow Predictor Site	Rick Guthrie	Slope	50.32689	-119.370766	2022-01-31 09:41:05		
87	Enbridge Gas HID 13581	Rick Guthrie	River	43.348171	-80.315448	2021-09-08 08:37:48	3515.714 km²	





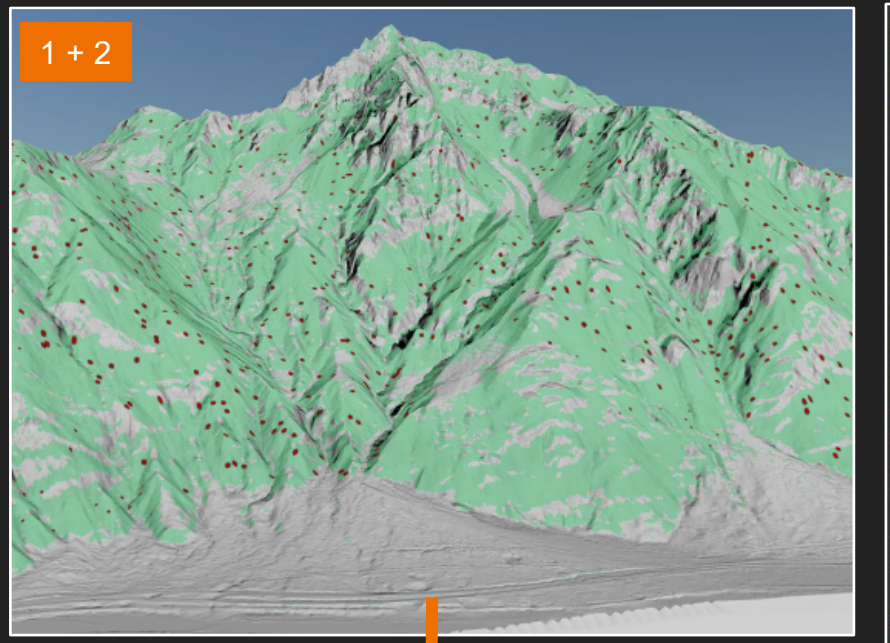
DebrisFlow Predictor

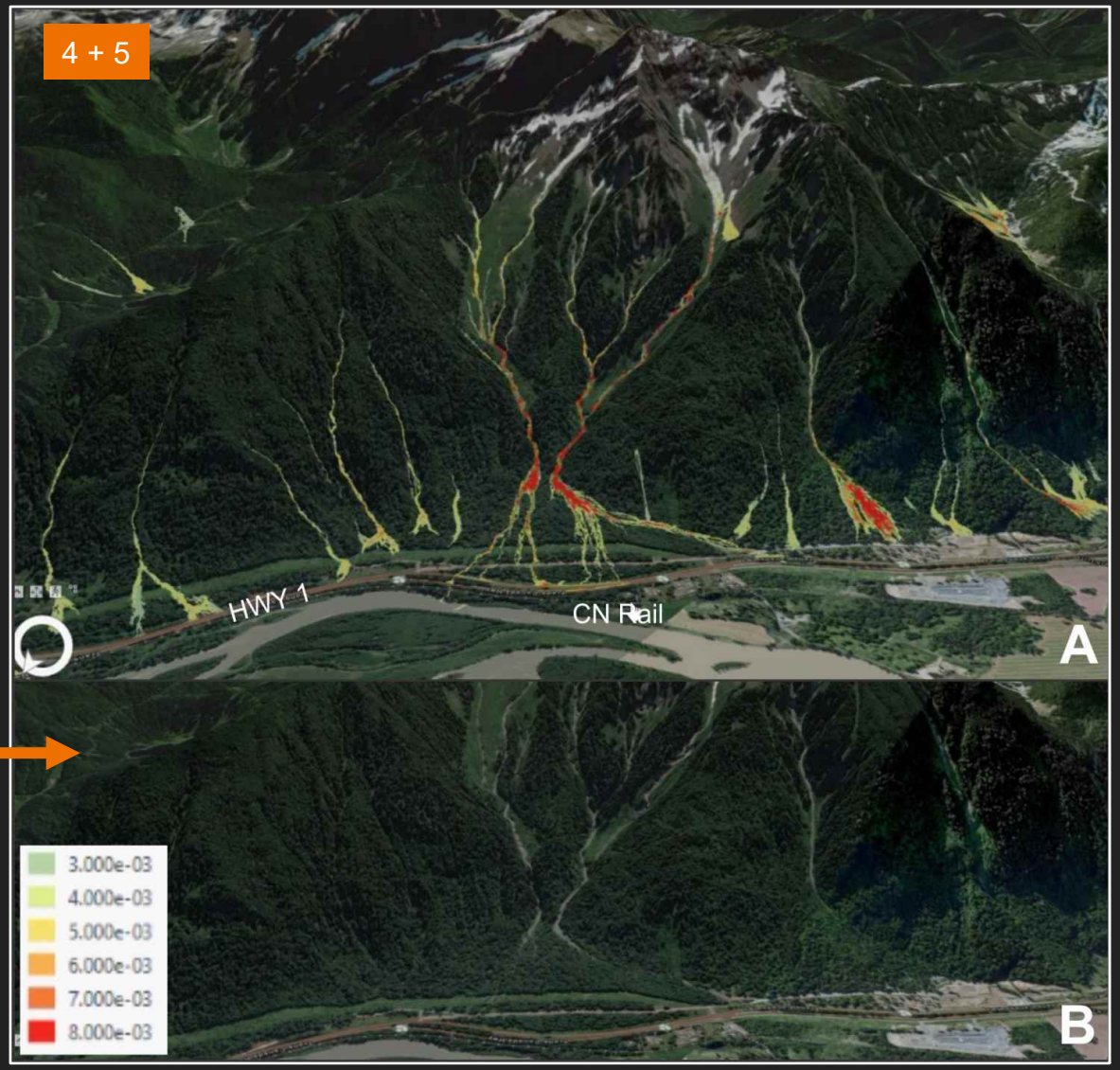
- Agent-based model
- Model debris flows from initiation to deposition
- 5 m DEM, agent interacts with slope & each other, choose paths, scour, deposit until their sediment balance is zero
- Model output = runout, inundation, deposit depth, volumes, avulsions, alluvial fan development
- Probabilistic output
- Developed over 15 peer-reviewed articles using DFP results in past 2 years.



DebrisFlow Predictor

1. Debris Flow Susceptible Terrain
2. Debris Flow Initiation
3. Debris Flow Modeling
4. Debris Flow Risk
5. DF Risk in Climate Change





Flood Predictor Potential Applications

Applications

- Pluvial and Fluvial Flood Extents
- Real-time Storm Predictions
- Mitigation and Resilience Planning
- Climate Change Forecasting
- Emergency Management/ Disaster Response

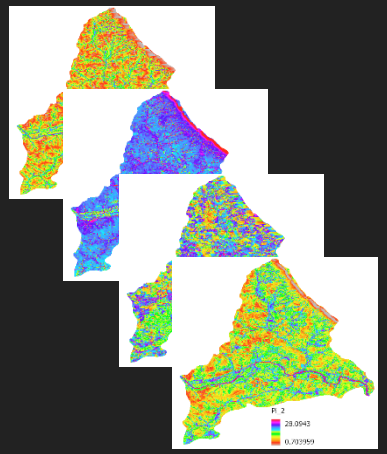
Most Beneficial When

- ☑ Unmapped or Invalid Study Areas
- ☑ Limited Data
- ☑ Limited Budget
- ☑ Limited Schedule

Flood Predictor – Prediction

User Defined Hydrologic Condition (e.g. 10%, 1%, 0.2%, Climate Change)

Dimensionless Engineering Features (Prediction Site)



Hydraulics Index 1

Hydraulics Index 2

Hydraulics Index 3

Hydrology Index

Flood Predictor Engine

Flood Prediction

Flood Probability

~10 Minutes

2-5 Minutes

Conclusions

Virtually monitor remote sites

Model to provide rapid, definitive results in rural/remote areas

Proactively assess cascading hazards in the context of climate change

Integrate the scientific and modeled results to provide evidence-based decisions for communities and along linear infrastructure.

These decisions should in turn lead to mitigation efforts that produce resilient communities and infrastructure.