SZ4D

Landscapes & Seascapes (L&S)

Image: Karen Gran

Landscapes & Seascapes Working Group

Imagining a broad, inclusive research program to study the science of geohazards acting across subduction zone land- and sea-scapes

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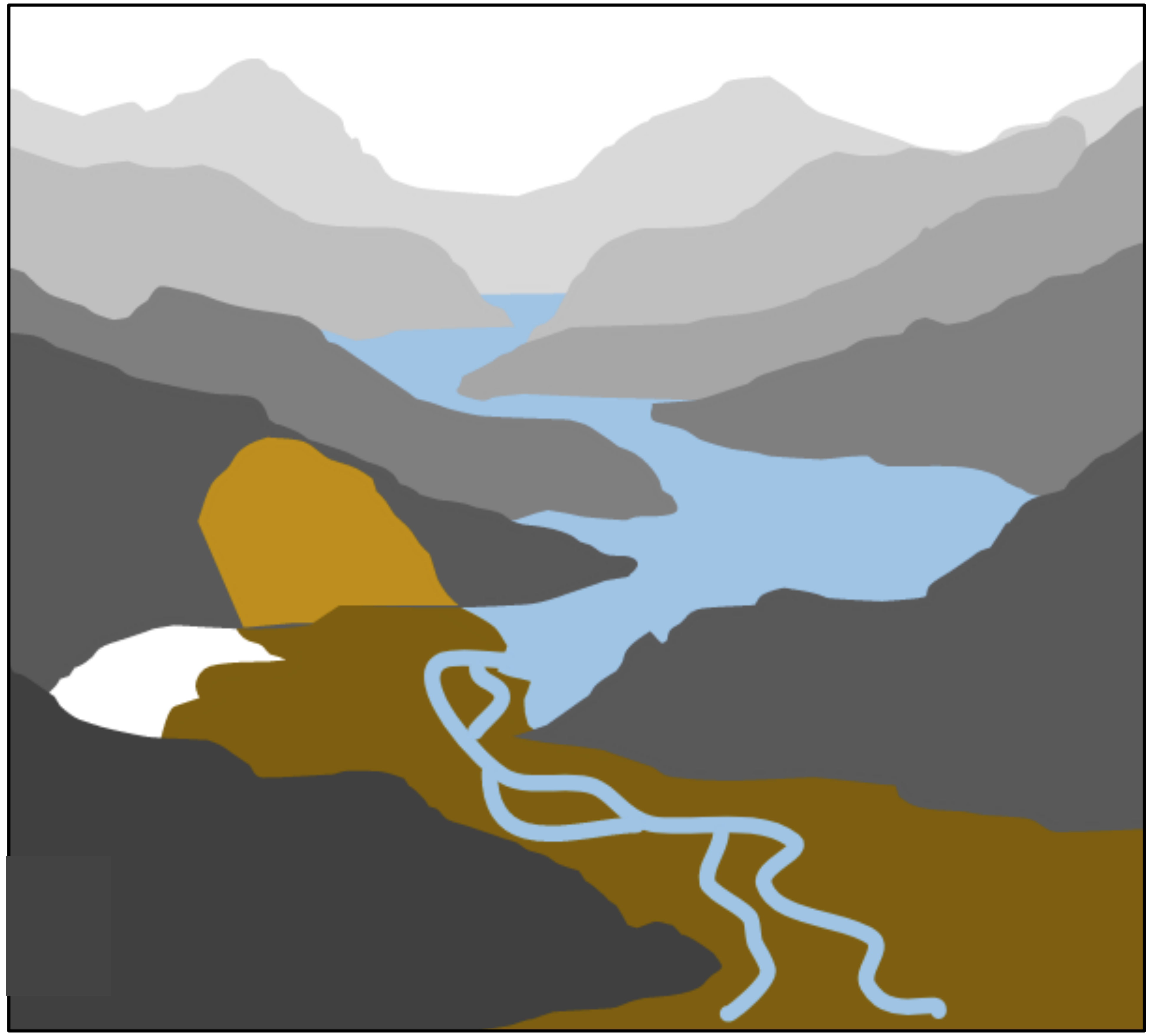
Geomorphology, tectonics, structural geology, marine seismology, marine science, and volcanology communities



~25 RCN Working Group Members

Steering Comm: Alison Duvall, U. Washington;, Sean Gallen, Colorado State U.; George Hilley, Stanford; Kristin Morell, UC Santa Barbara;
Members: Colin Amos, Western WA; Mark Behn, Boston College; Danny Brothers, USGS; Michele Cooke, UMASS Amherst; Juliet Crider, U. Washington; Stephen DeLong, USGS; Joan Gomberg, USGS; Karen Gran, U. Minn. Duluth; Jenna Hill, USGS Mong-Han Huang, U. Maryland; Eric Kirby, U. North Carolina; Leif Karlstrom, U. Oregon; Jared Kluesner, USGS; Nathan Niemi, U. Michigan; Charlie Paull, MBARI; Jon Perkins, USGS; Joann Stock, Caltech; Janet Watt, USGS; Brian Yanites, Indiana U.

L&S Primary Research Questions

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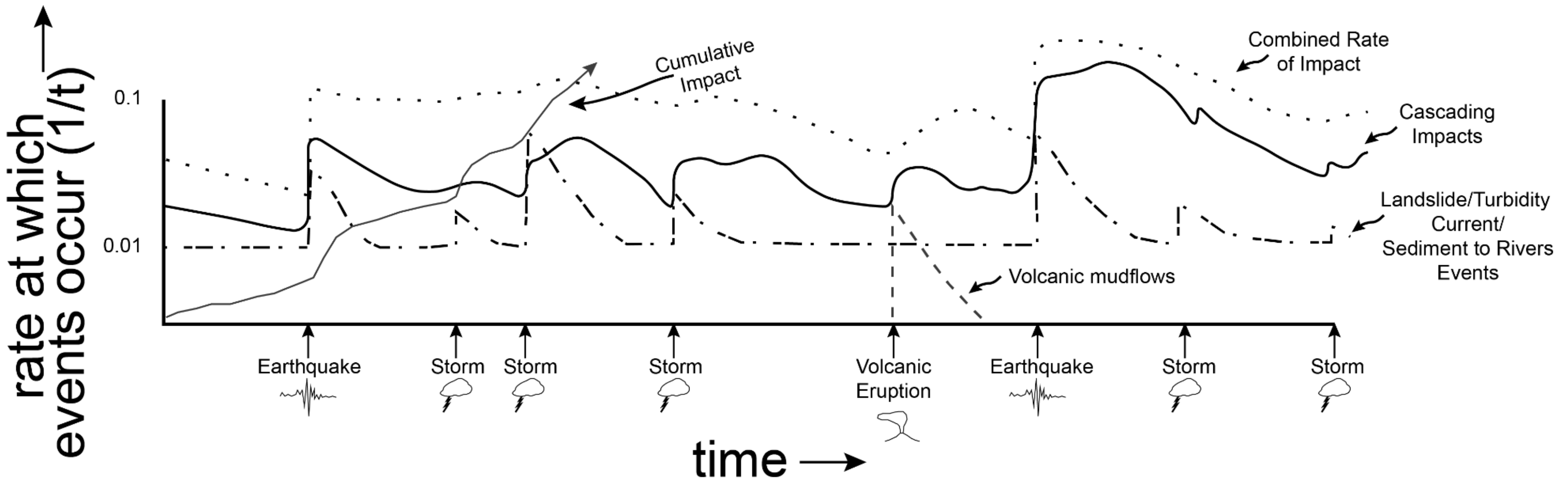
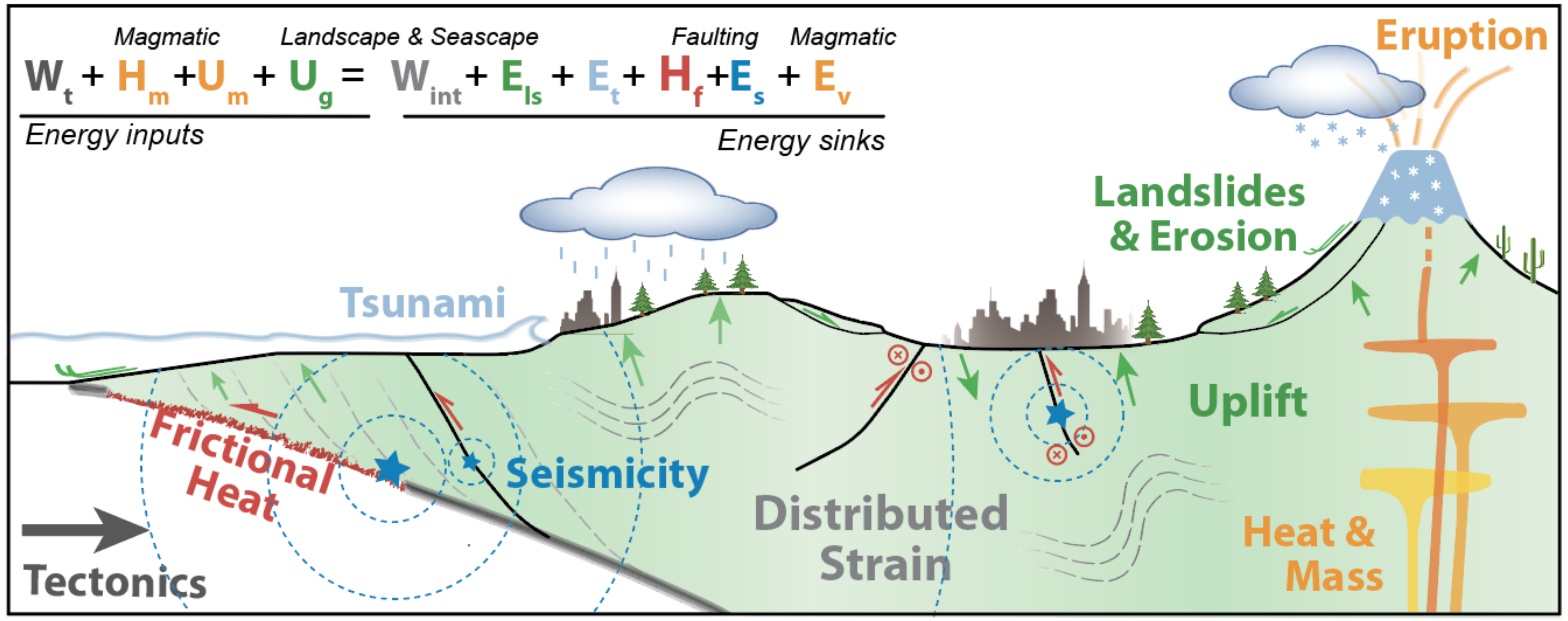
- (1) How do events within Earth's atmosphere, hydrosphere, and solid-earth generate and transport sediment across subduction-zone land- and sea-scapes?

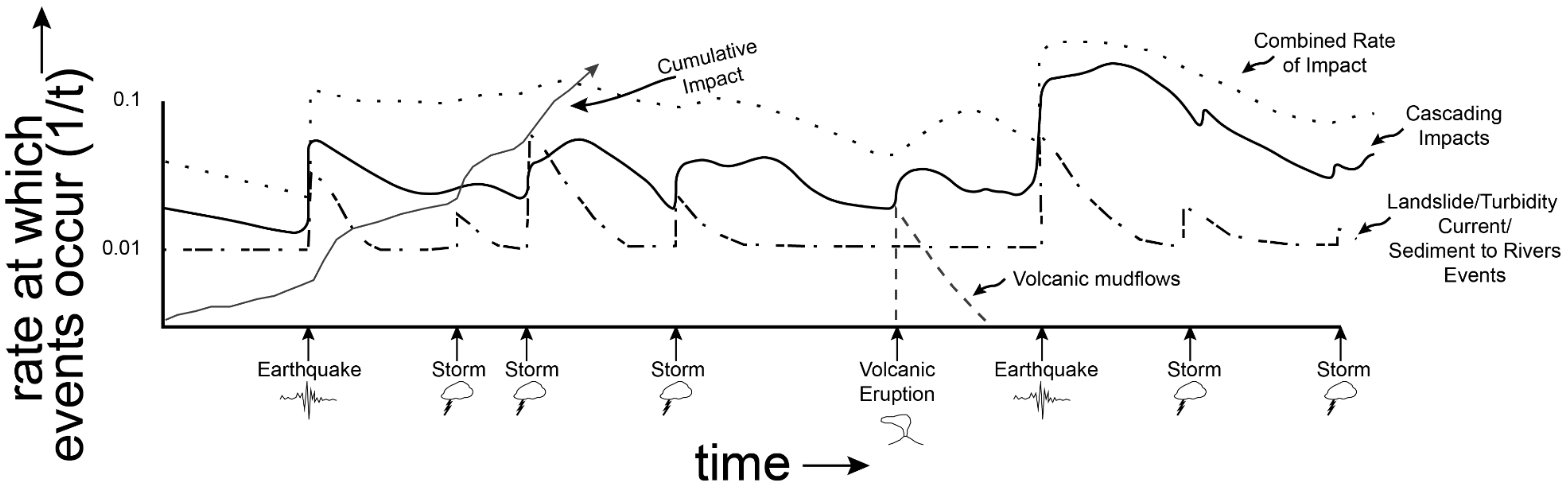


- (2) What fraction of a subduction zone's energy budget goes into building and shaping subduction zone land- and seascapes?



Example Broad Working Hypothesis for Q1

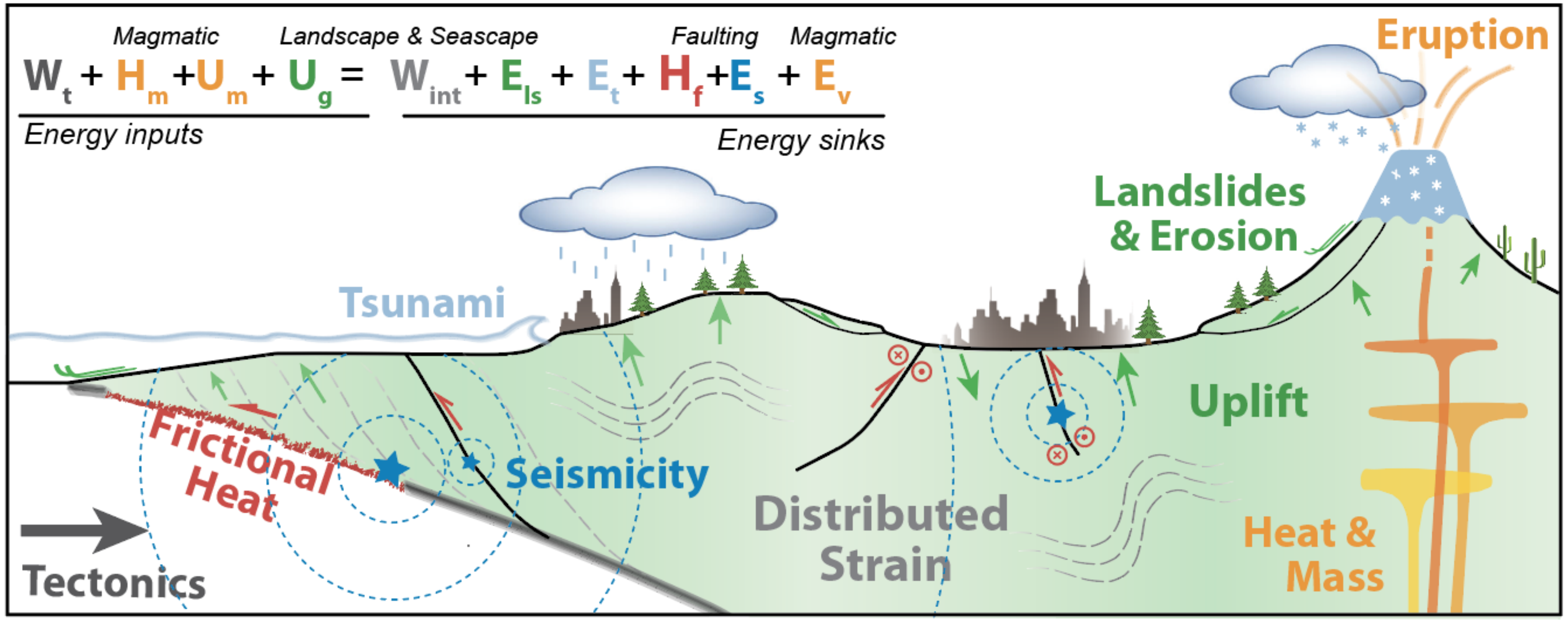
Sediment generation and transport is controlled by the frequency of drivers that initiate and mobilize sediment



When large storms occur frequently, landslide-related hillslope transport and hazards could be dominated by these atmospheric events. In areas where storms occur less frequently, earthquake shaking or intense volcanic rock weathering may play a significant role in generating landslides.

Example Broad Working Hypothesis for Q2

The subduction zone system has energetic inputs and sinks. The energy budget framework allows us to integrate these processes to investigate their interplay.



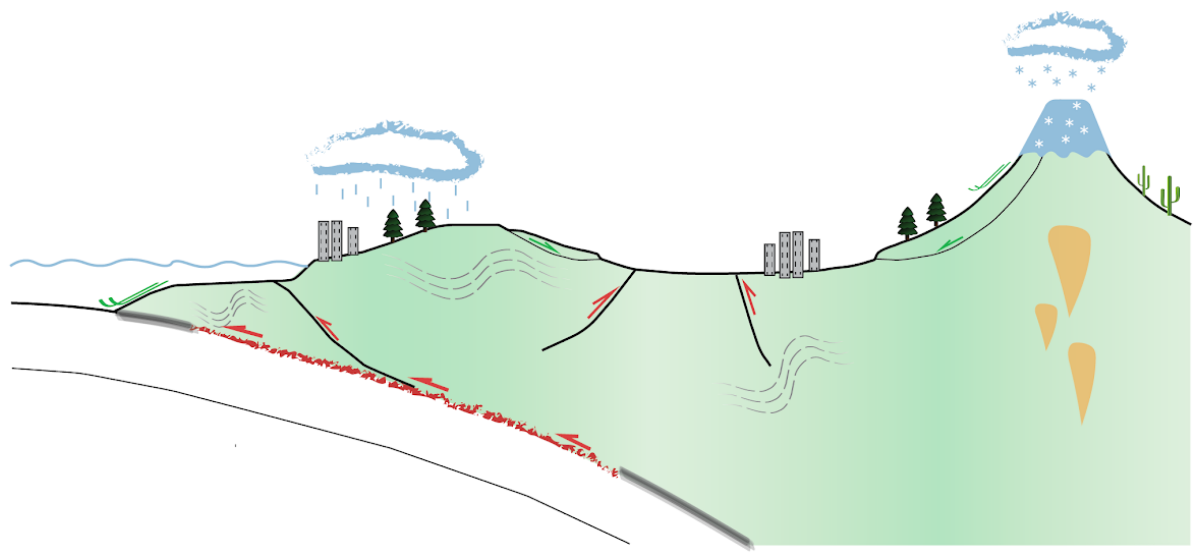
Graphic c/o: M. Cooke

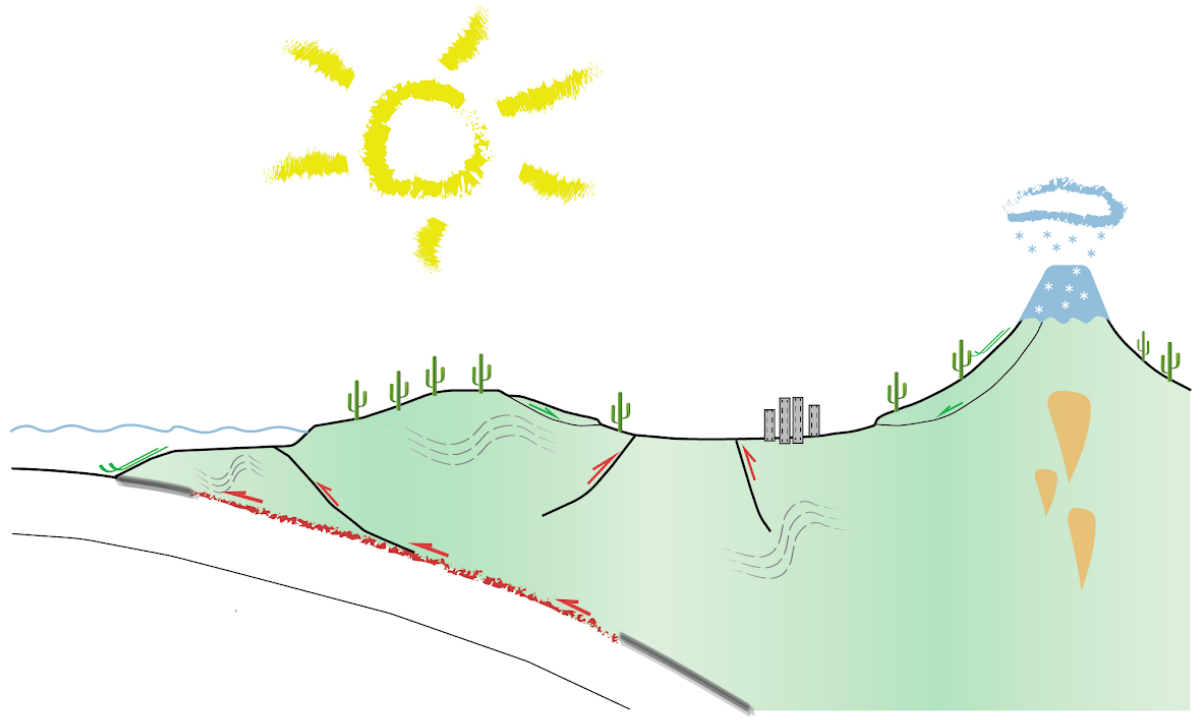
The style of upper plate deformation is regulated by plate motions and coupling along the megathrust, elastic and inelastic deformation processes in the upper plate, body forces generated by topography, and the rheological configuration of the upper plate.

Notional Experiments

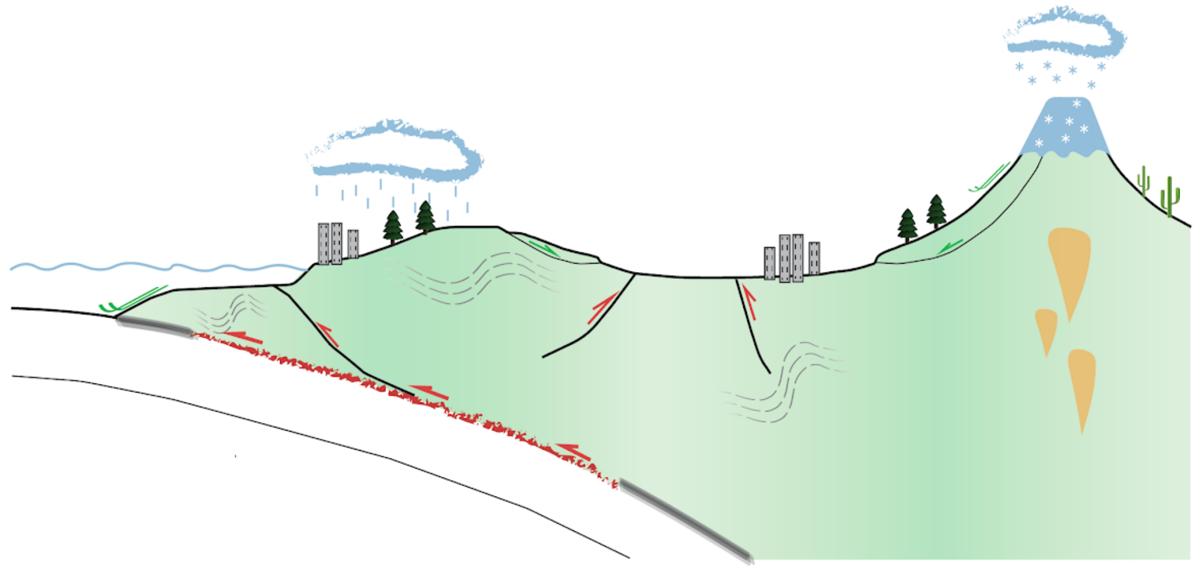
Experimental Design: Select paired subduction-zone segments that control for (as best as possible) non-targeted factor, while letting single factor vary.

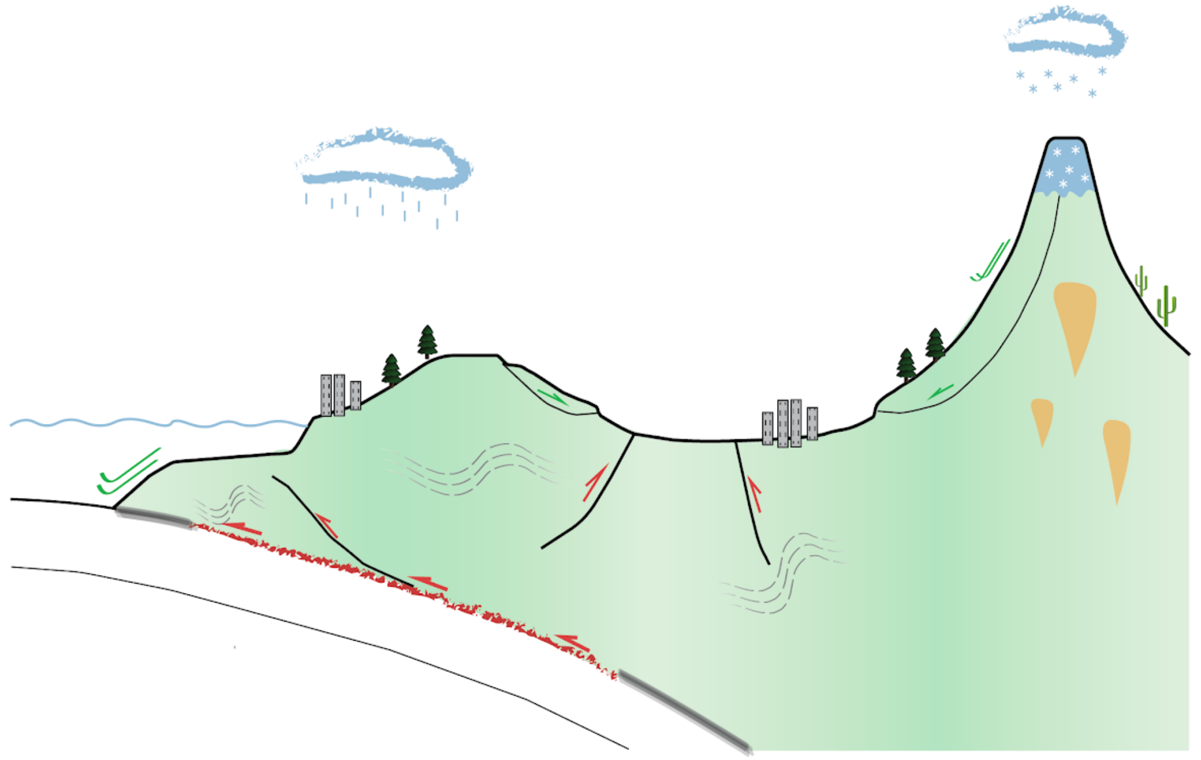
Subduction-zone segments with constant solid-earth properties, but different climates:





Subduction-zone segments with constant climate, plate-tectonic / volcanic parameters, but different mean slopes:

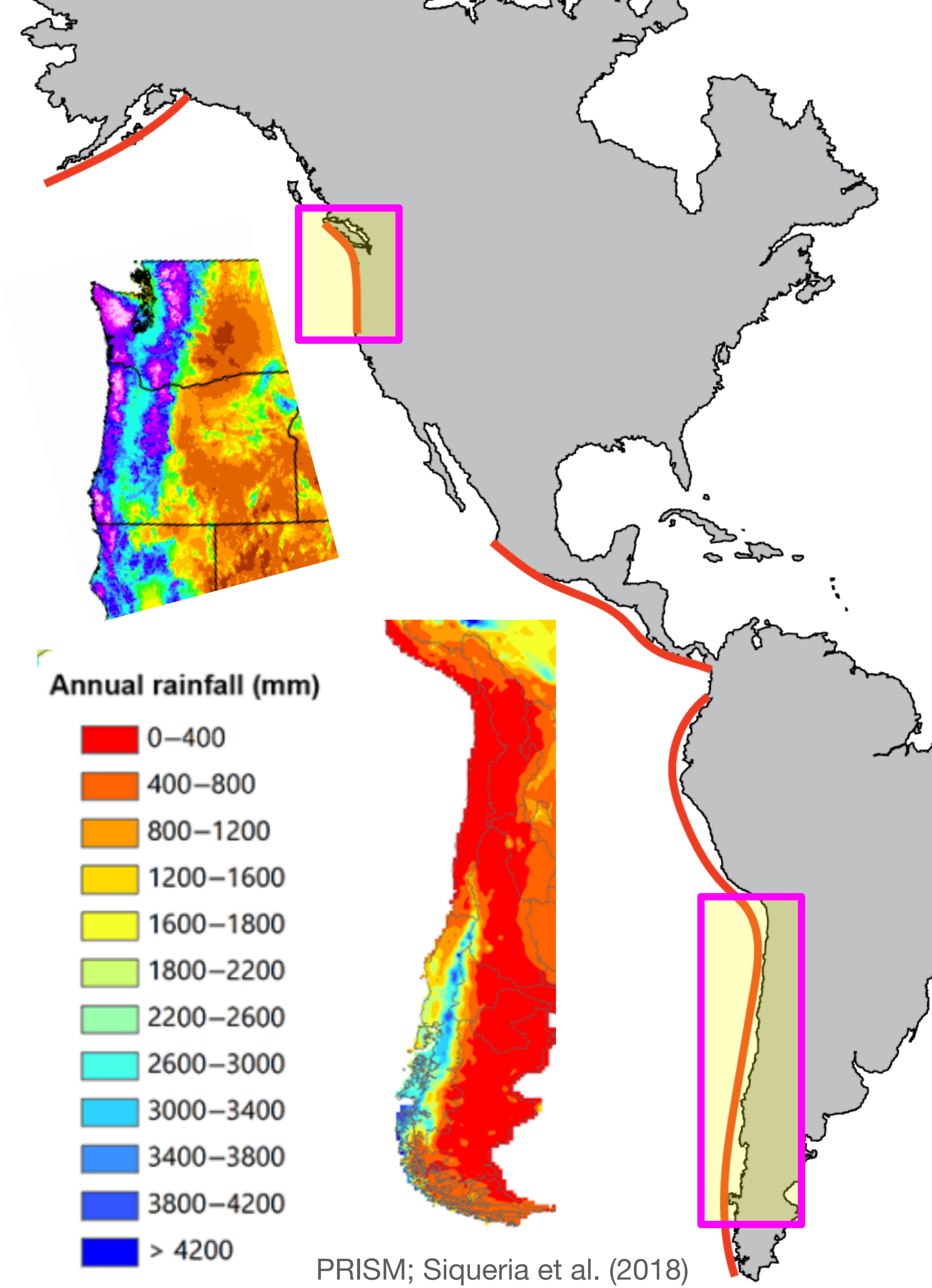




Cascadia and Chile

Ideal comparison sites to carry out L&S notional experiments

- Both margins are fluvially dominated with orographic rainfall. Chile orographic rainfall gradient at ~32°S.
- Forearc characteristics (e.g., coast range or not)
- Plate age, subduction velocity, and earthquake frequencies
- Eruptive histories and types
- End-member variations in amount of trench sediment, size of offshore accretionary prism



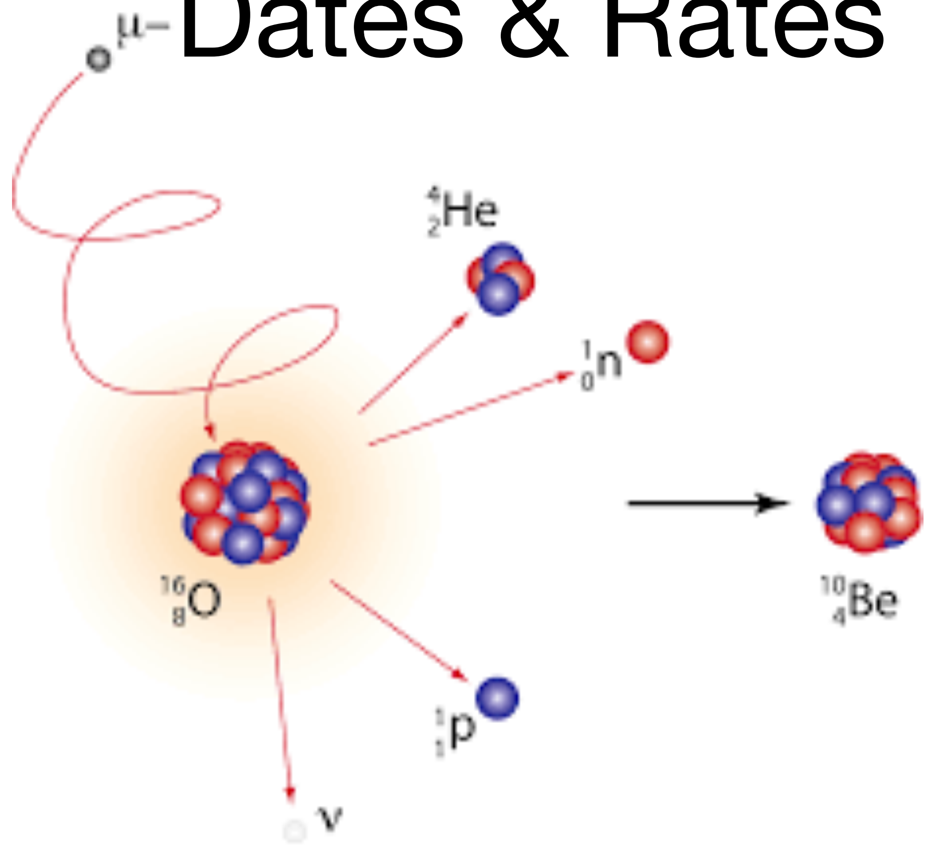
PRISM; Siqueria et al. (2018)

Traceability matrix: Data, infrastructure, & computational requirements to answer science questions, carry out notional experiments

Q1	Societal or Science Question	Quantified Objective	Observables & Measurement Requirements	Example Measurement Approaches
(1) How do events within Earth's atmosphere, hydrosphere, and solid-earth generate and transport sediment across subduction-zone land- and sea-scapes?	What are the fundamental controls on the initiation and runout of landslides, turbidity currents, and volcanic mudflows?	Measure when and where landslides, volcanic mudflows and turbidity currents initiative, how far they run out, and, when possible how fast they move	Repeat high-resolution bathymetry	AUV -based bathymetry soundings
			Terrestrial surface deformation	INSAR
			Repeat hi-res imagery	WorldView-4, Planet Labs

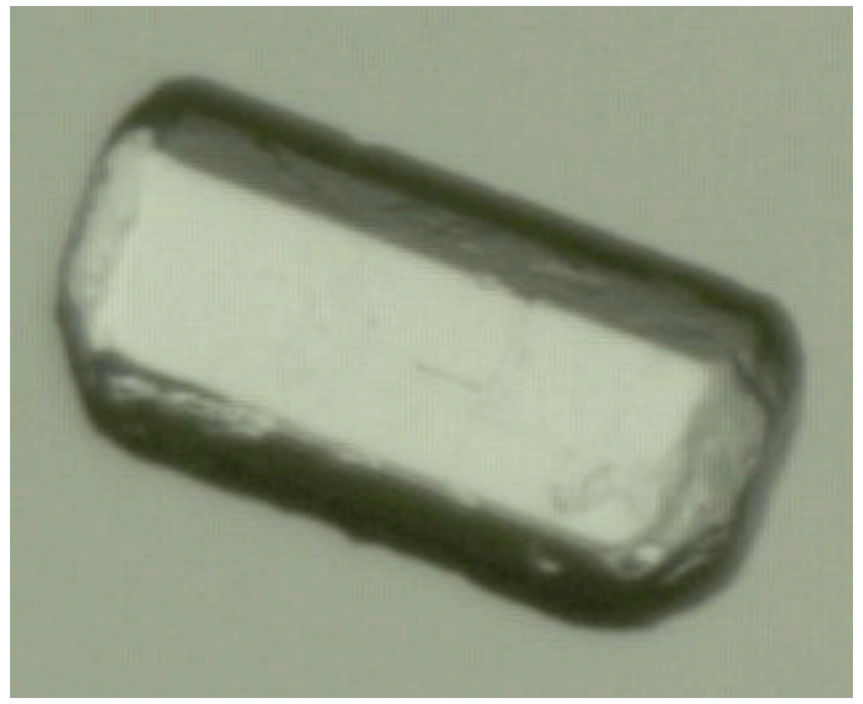
Key Basic Data Needs

Cosmogenic Dates & Rates



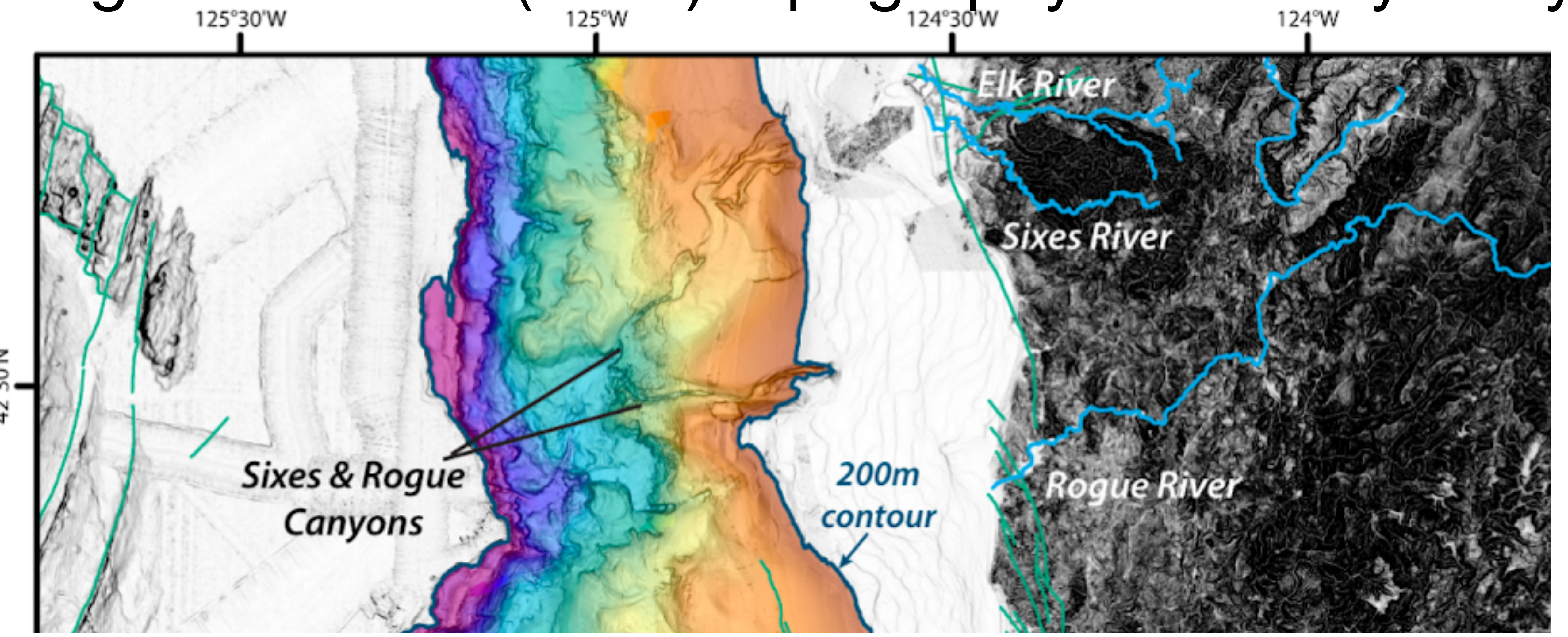
Geodesy & Paleo-geodesy

Geochronology



Repeat optical & topographic surveys

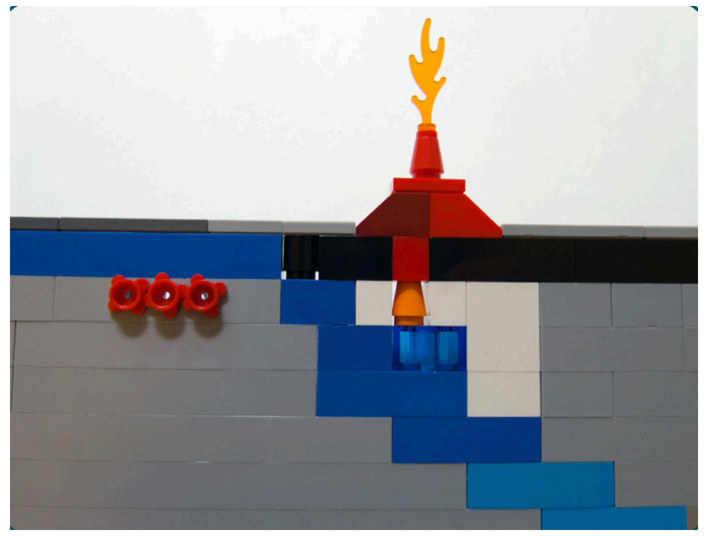
High-resolution (<1 m) topography and bathymetry



High quality geologic data

Peter Haeussler. Earth Magazine

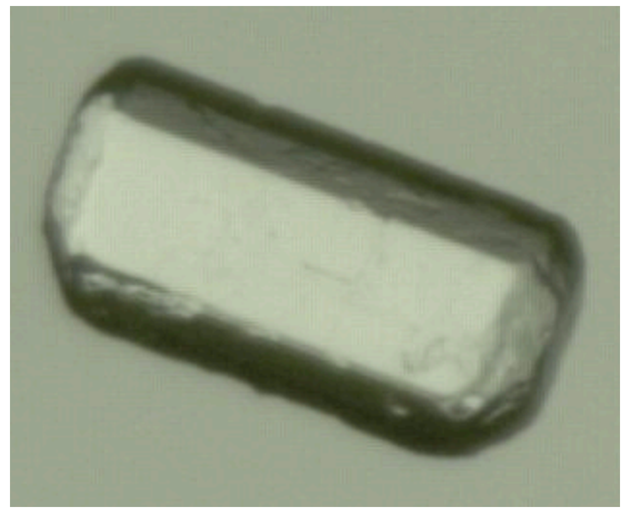
Key Infrastructural Needs



1. Robust cyberinfrastructure and numerical modeling

- Organizing, distributing, and archiving data
- Large-scale computational infrastructure. Models at scale of SZ
- Numerical model development & integration. Develop efficient, physics-based forward models

2. Development of high-throughput geochronologic facilities



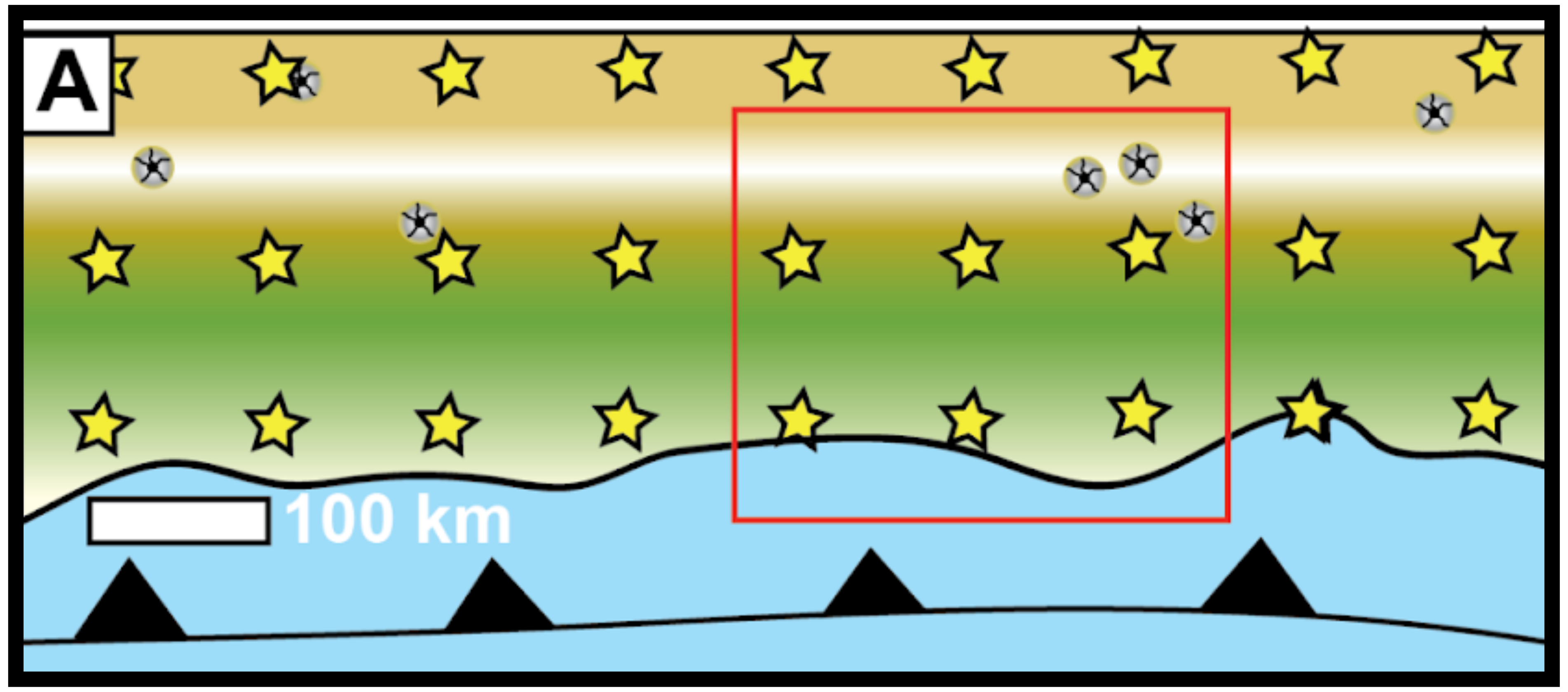
- Capable of meeting project demands while maintaining uniform quality standards

3. Integrated field-based experiments, instrumentation, and observatories

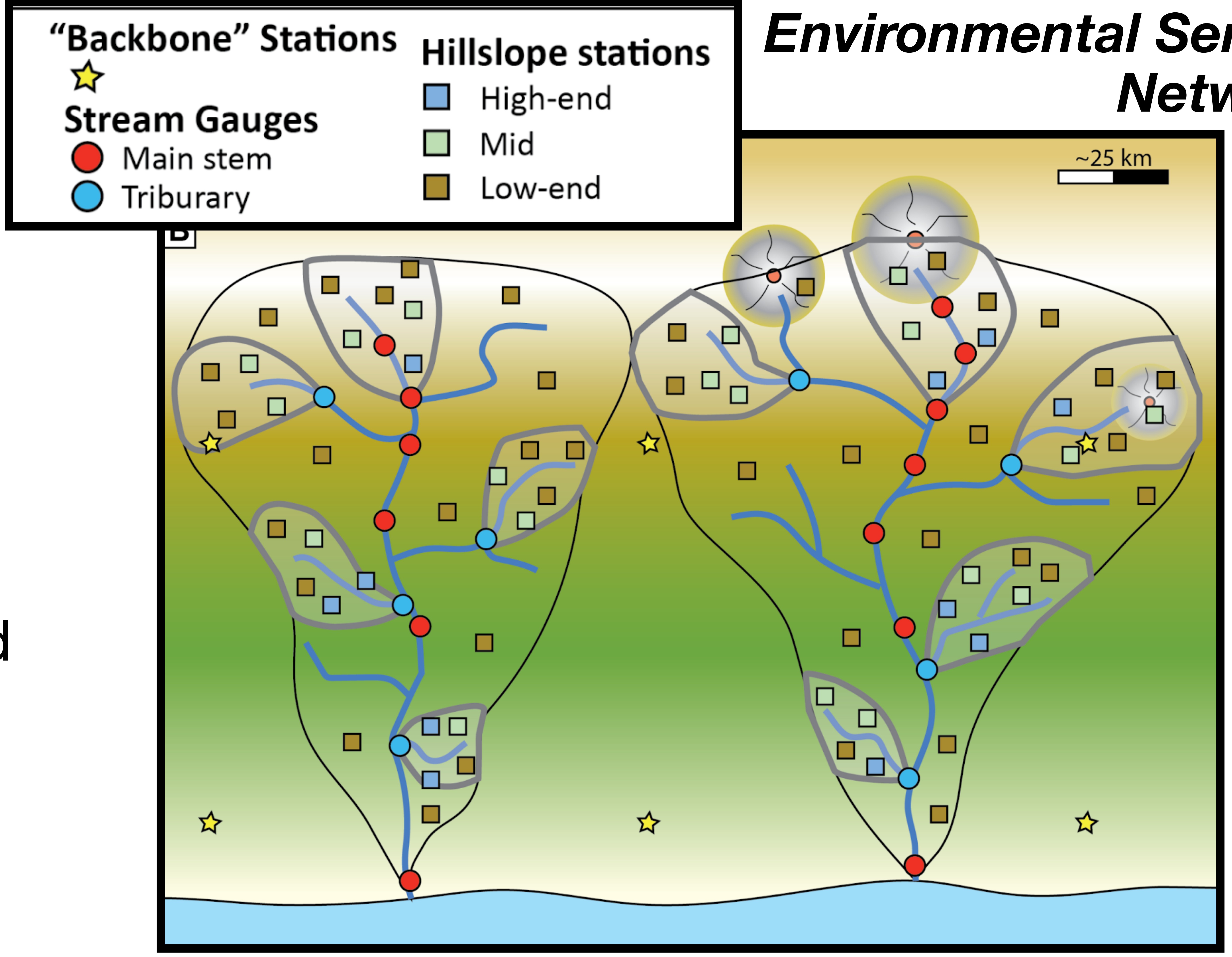
- Coordinated field-based campaigns to systematically observe transport events and coordinate measurements.
- **SurfArray**: a set of surface and environmental change detection arrays that image changes in Earth's surface, river networks, and rainfall

SurfArray

- Hillslope stations
  - Precipitation, soil moisture, temperature, microseismicity
  - Backbone array to calibrate remotely sensed data
- Stream Stations
  - Water discharge & suspended sediment gauges, freshwater chemistry, bedload transport, turbidity



Environmental Sensor Network

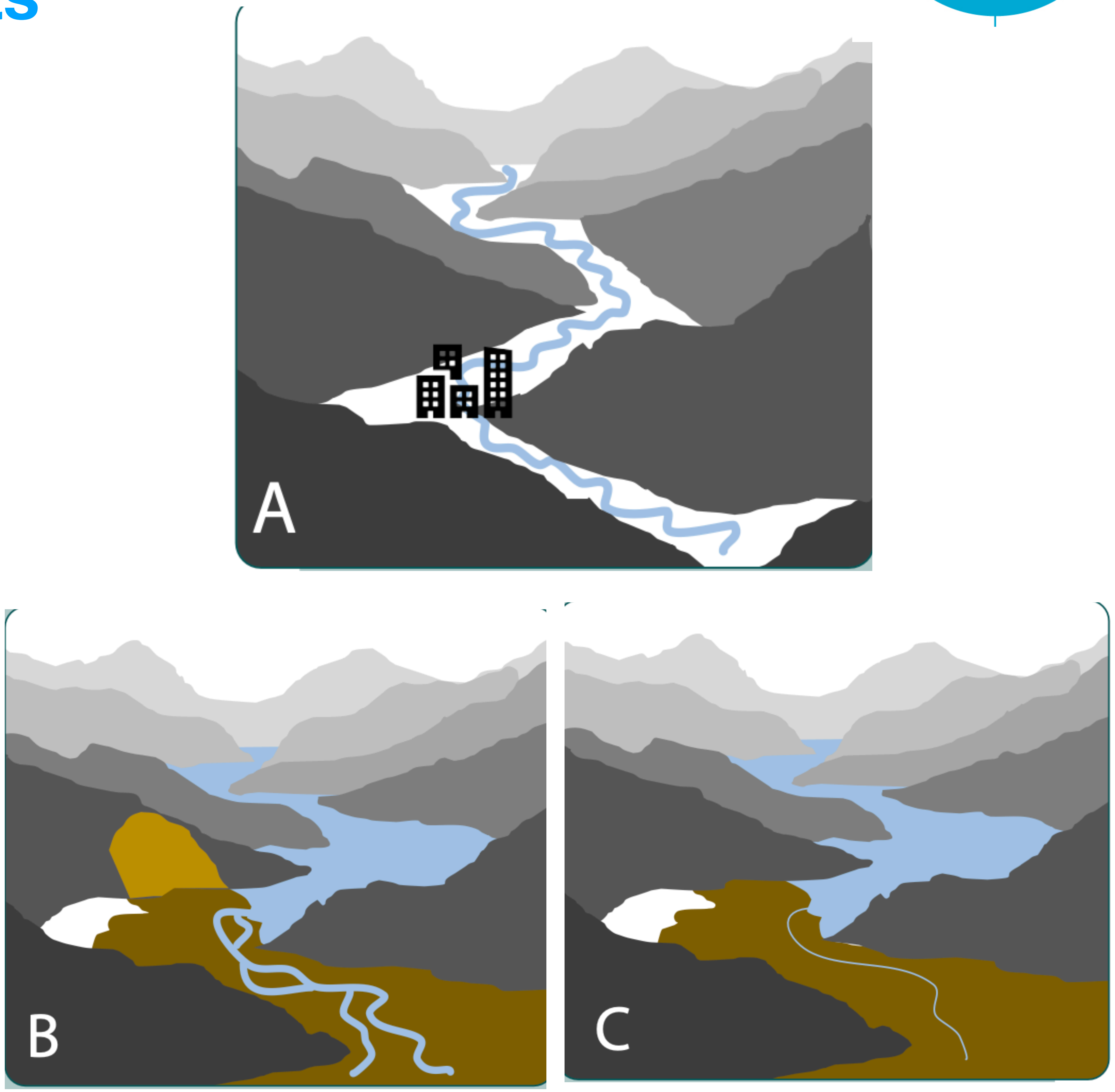


- Stationary network can be colocated with FEC and MDE array instrumentation.
- Supplemented by a moveable network for post-event rapid response.

Cross-Cutting Science

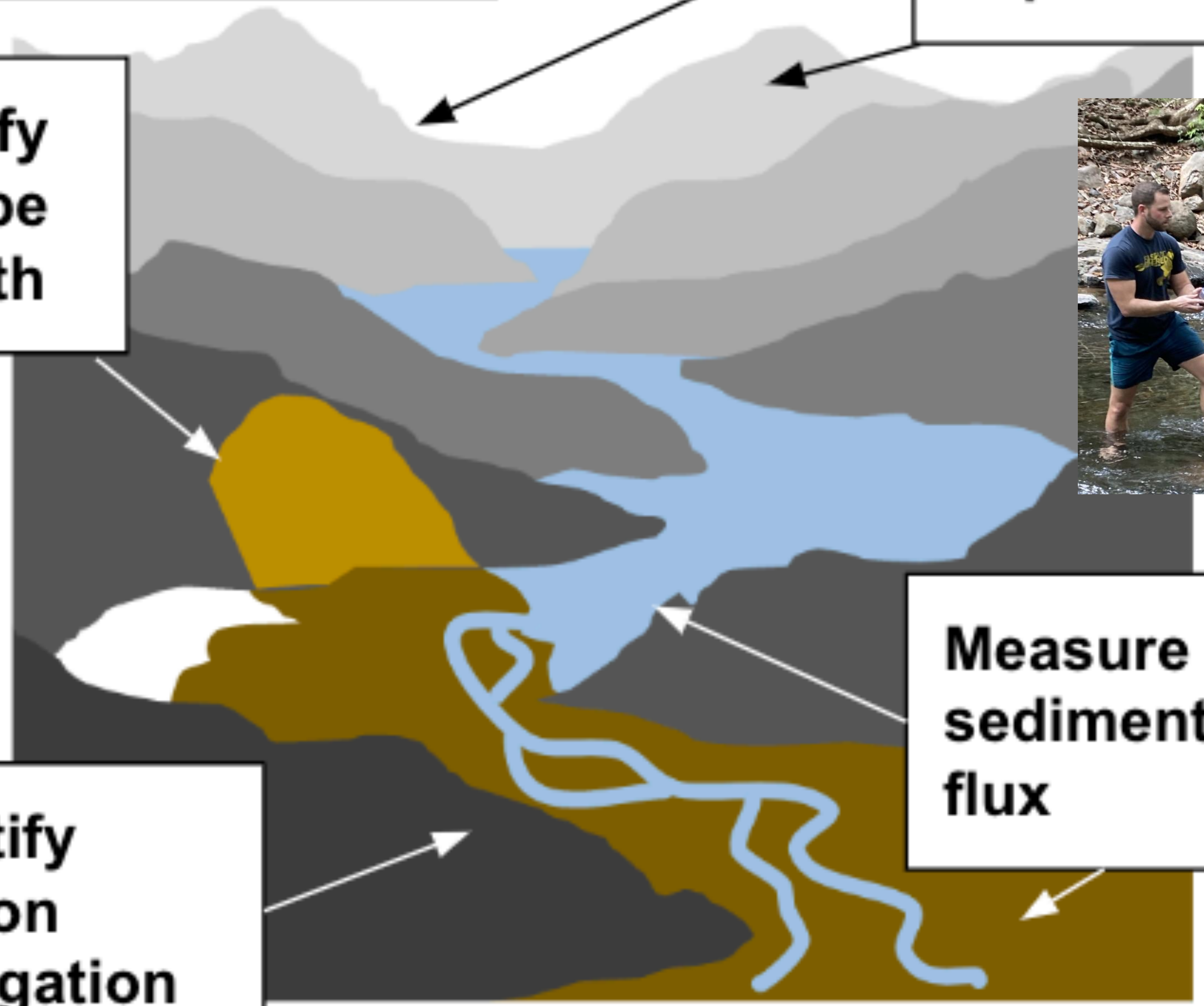
How do cascading sequences of events impact subduction zone hazards?

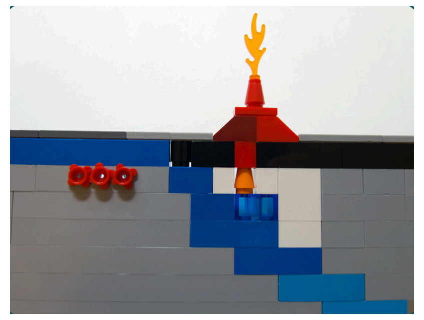
- **Eruptions** and **earthquakes** can initiate mass wasting events on and offshore.
- Single mass wasting event (e.g. **volcanic lahar** or **landslide**) can:
  - Trigger downstream effects, such as floods, aggradation or erosion
  - Disturb the landscape for >10yr.
- Long-lasting damage to communities can persist for decades, and damage (from tsunamis, landslides, and lahars) can often be greater than that from seismic shaking, and lava flows.

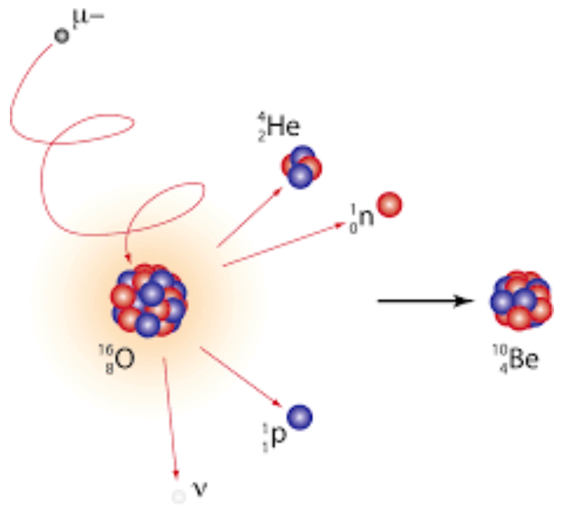


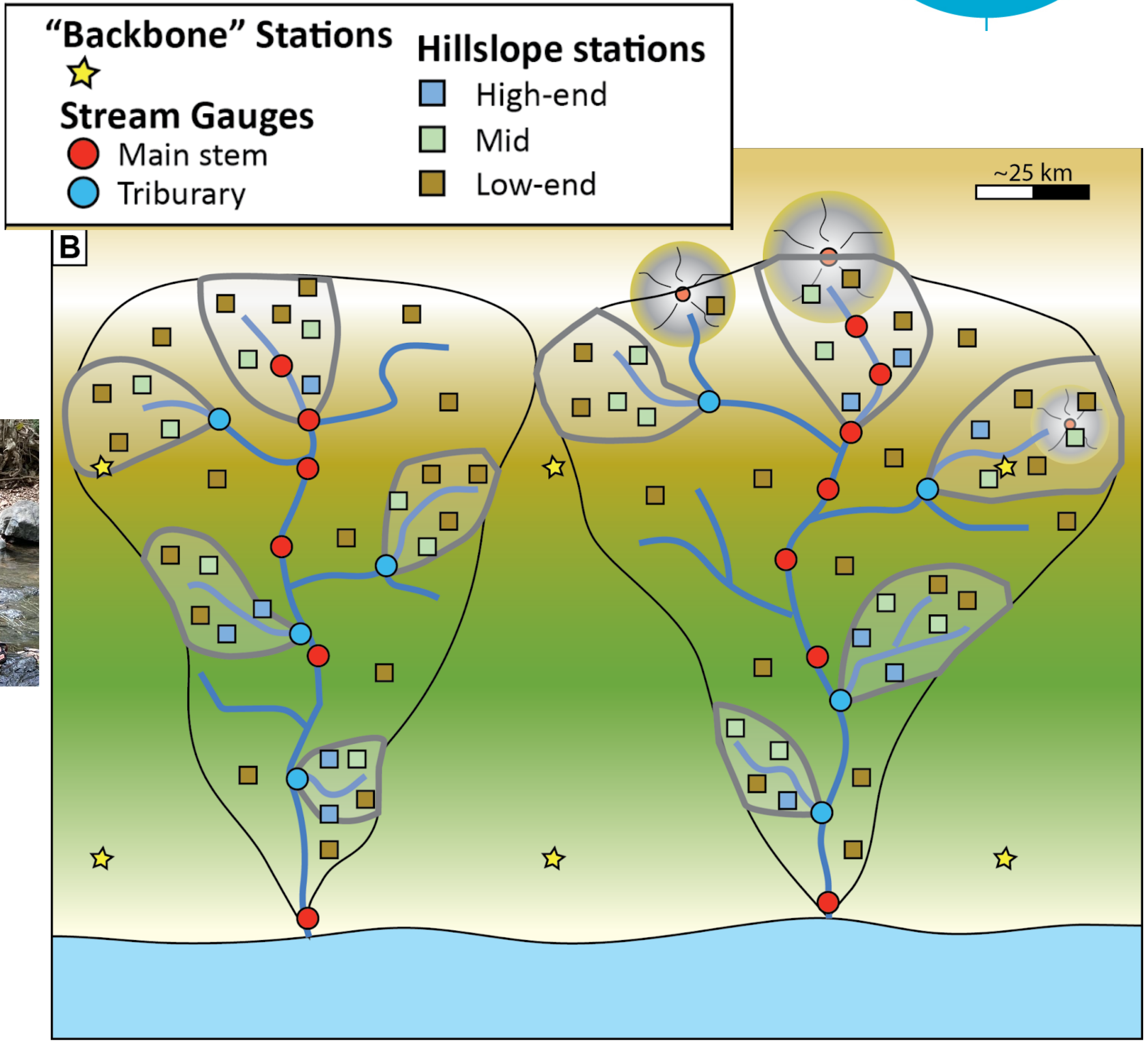
How do cascading sequences of events impact subduction zone hazards?

Integrated field-based experiments, instrumentation, and modeling



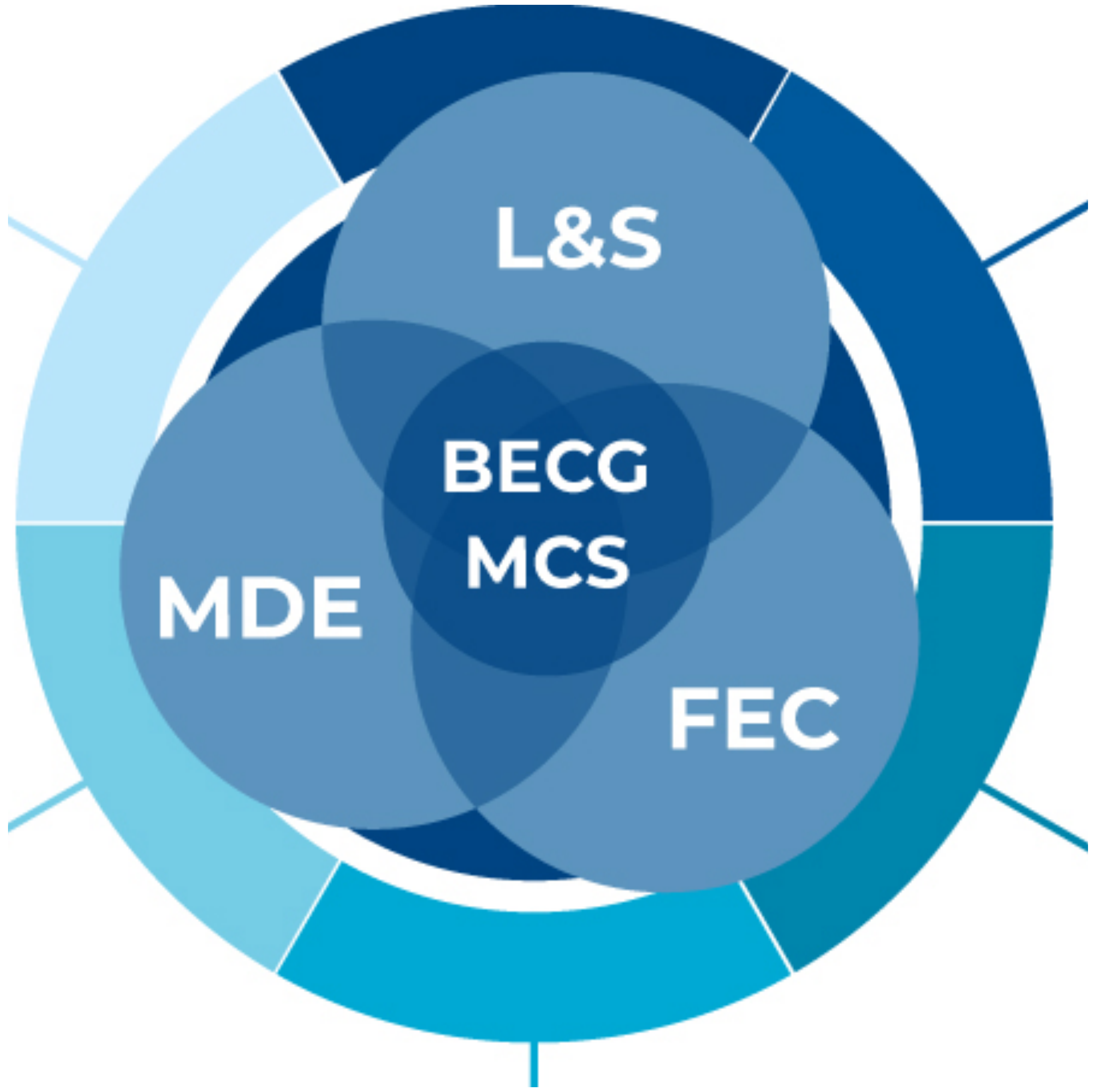


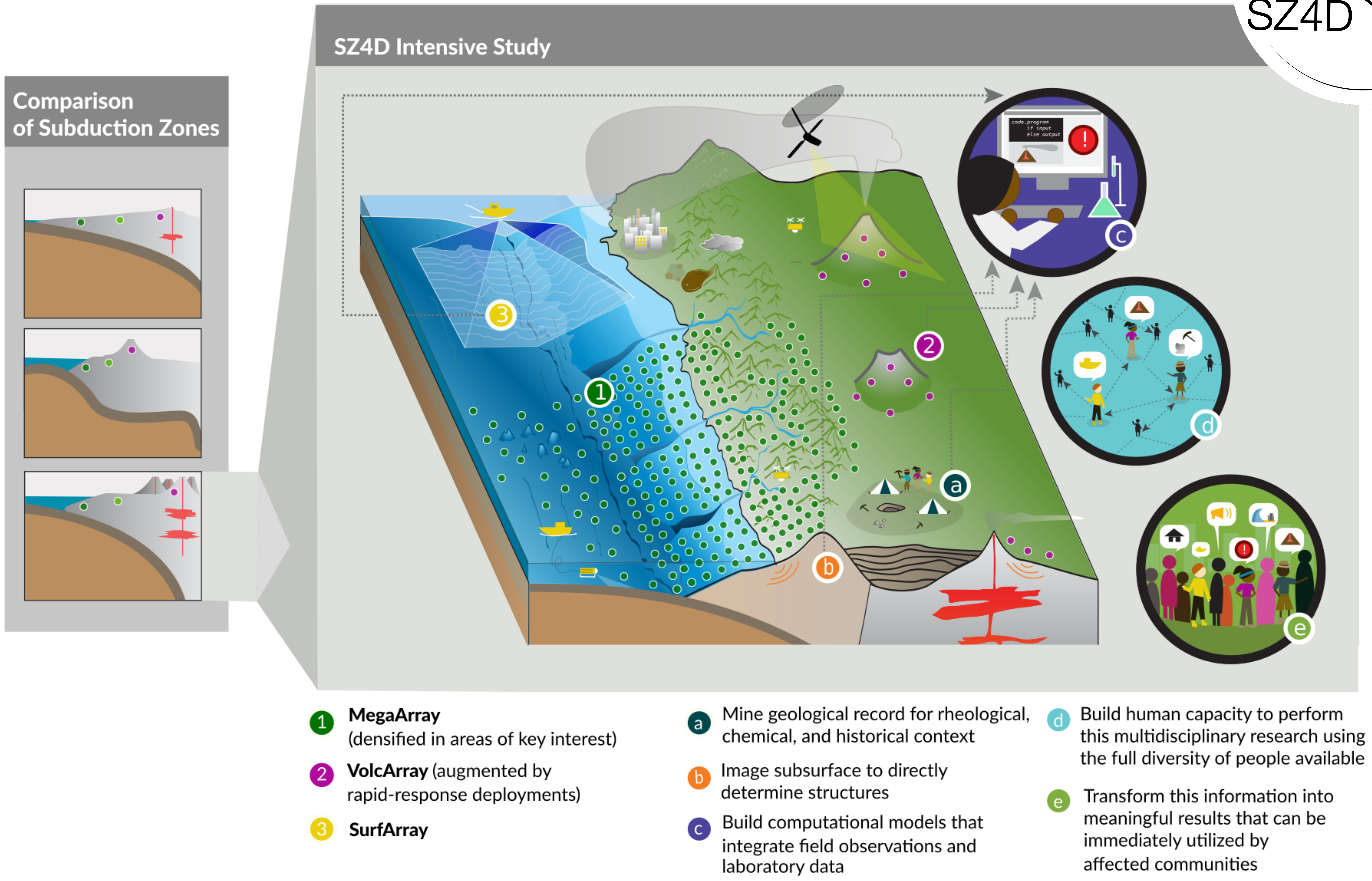




Answering the L&S science questions requires

An integrative, comprehensive, and holistic approach in a collective impact framework





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