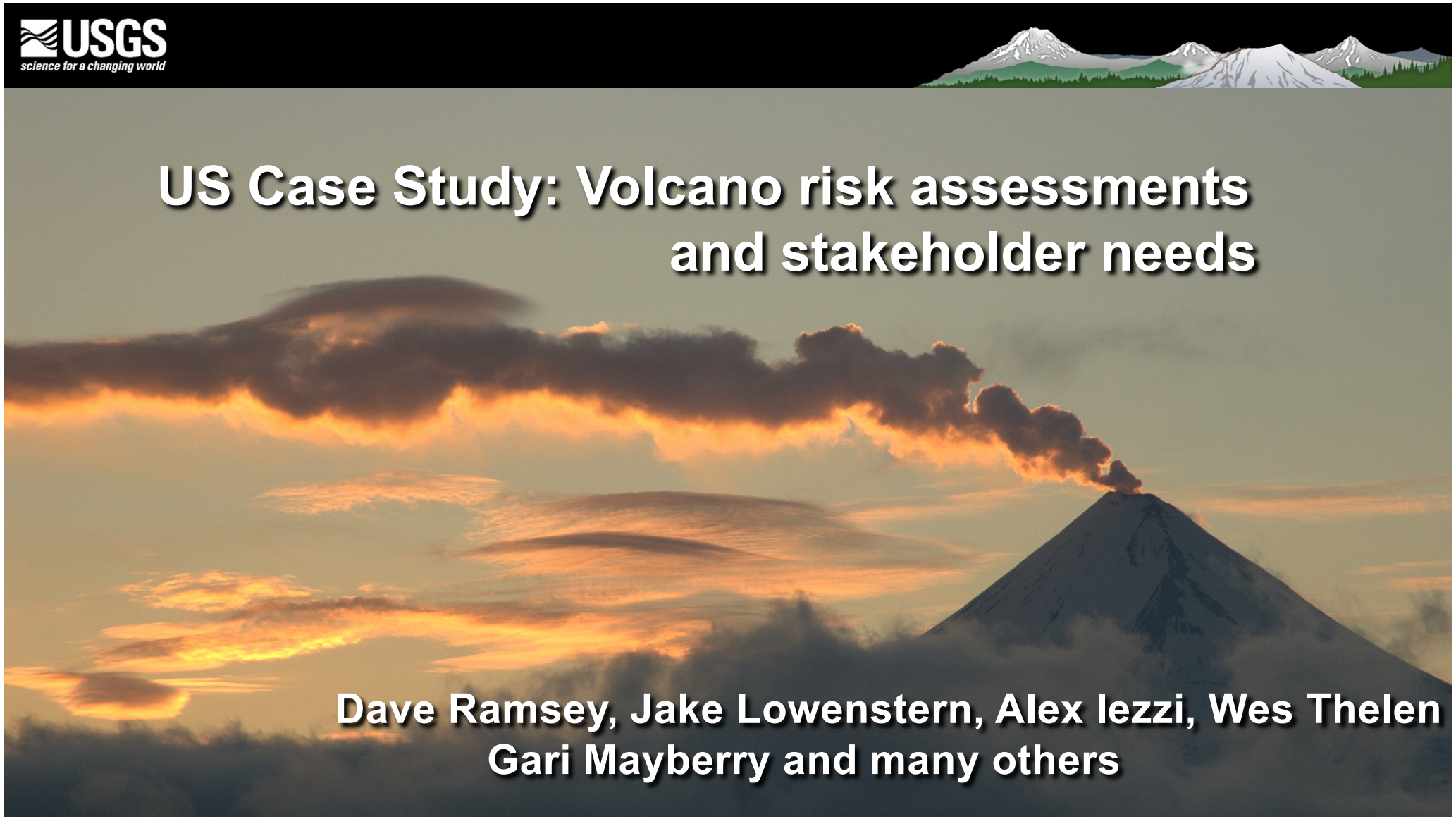
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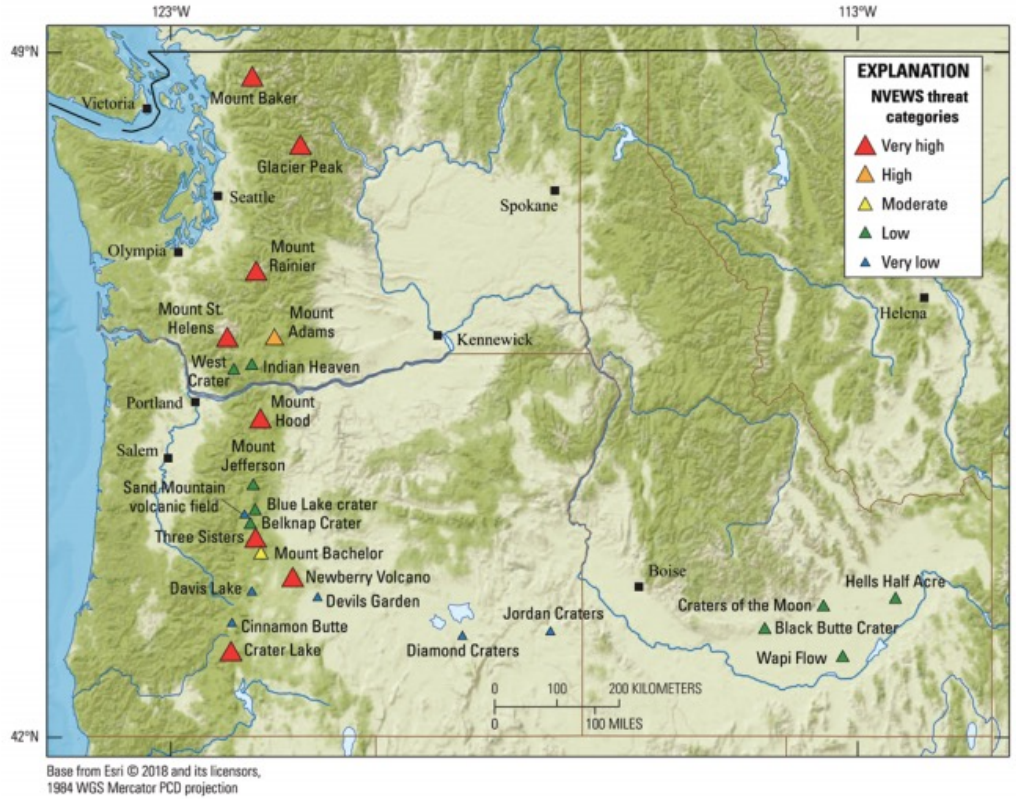
US Case Study: Volcano risk assessments and stakeholder needs
Dave Ramsey, Jake Lowenstern, Alex Iezzi, Wes Thelen
Gari Mayberry and many others

Outline of this Talk

1. Using USGS Threat Assessment as the basis for monitoring decisions
2. Developing a National-Scale Volcano Hazard Layer as the Basis for Risk Products
3. Modeling lahar impacts as the basis for warning systems and evacuation plans.



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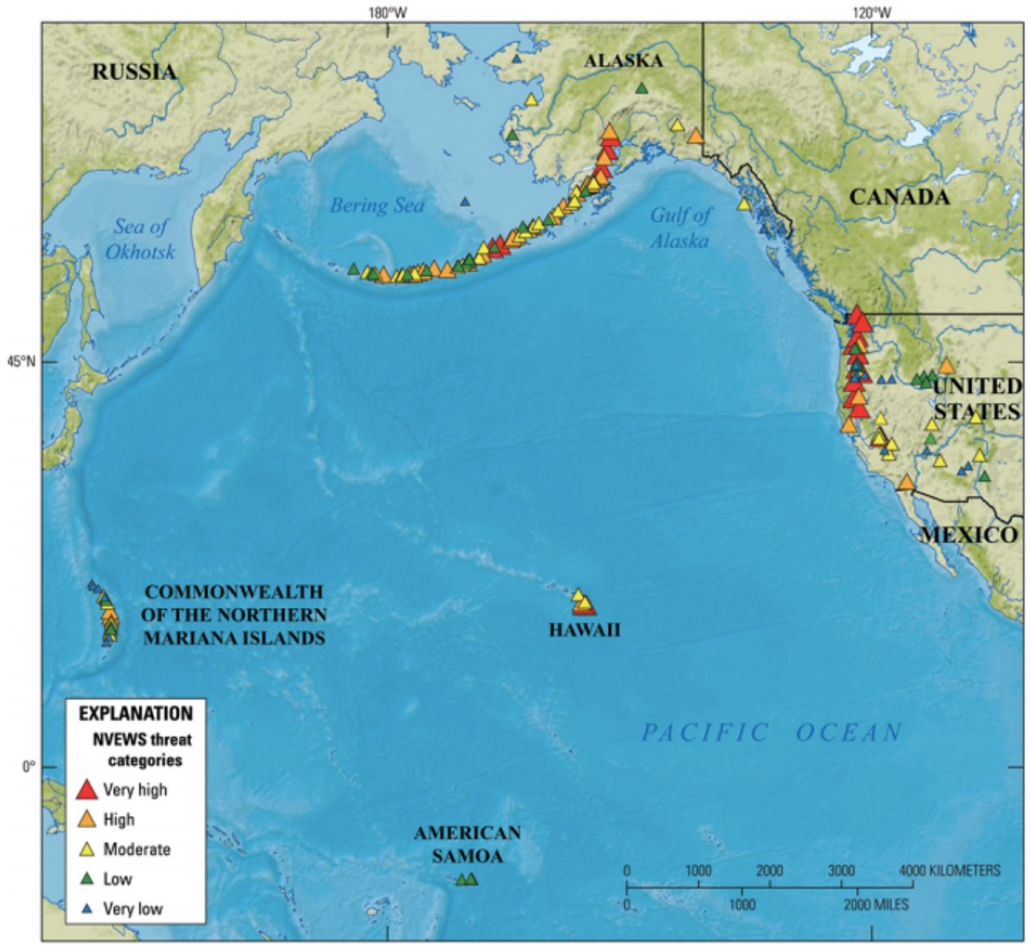
2018 Update to the U.S. Geological Survey National Volcanic Threat Assessment

Scientific Investigations Report 2018–5140

U.S. Department of the Interior
U.S. Geological Survey



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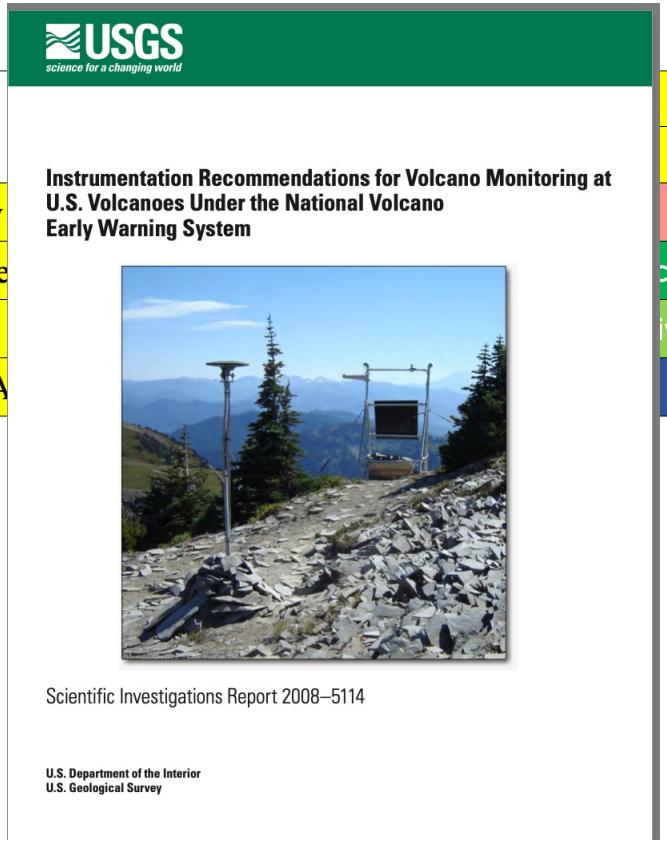
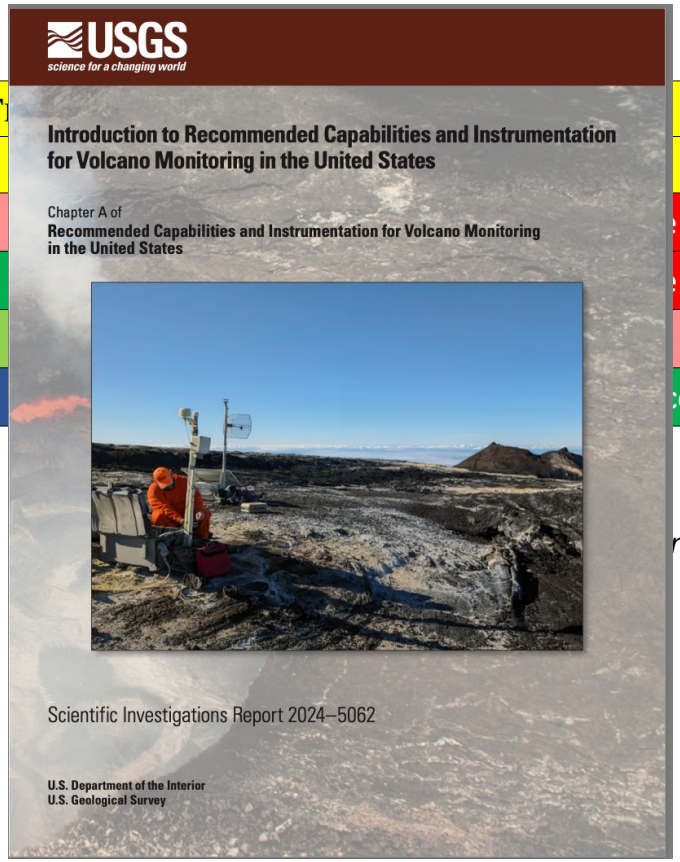
How Much Monitoring Do We Need?

Monitoring Network Density and Complexity
Elementary
Intermediate
Advanced
State-of-the-A



Moran et al. 2008



Flinders et al. 2024

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Seismology Example

Figure B1. Photograph of monitoring station September Lobe (SEP) on the 1980–86 dome at Mount St. Helens, Washington. The site has co-located seismic, geodetic, tilt, and infrasound instruments. View is to the north; Spirit Lake is visible in the near-background and Mount Rainier is on the skyline. Photograph by Ben Pauk, U.S. Geological Survey, 2018.

Summary—Recommendations for Volcano Levels 1–4 Seismic Networks

Level 1.—Five seismic stations within 200 km of the volcanic center, including two stations within 50 km.

Level 2.—Five seismic stations within 50 km of the volcanic center, including two stations within 10 km.

Level 3.—Seven or more broadband seismic stations within 20 km of the volcanic center, including at least two stations within 5 km.

Level 4.—Twelve to 25 broadband seismic stations within 20 km of the volcanic center, including at least 8 stations within 10 km and 4 or more within 5 km; at least one broadband or strong-motion station within 10 km. Small-aperture seismic array in places where logistics preclude placing stations high on the edifice.

Thelen et al., 2024, Seismic techniques and suggested instrumentation to monitor volcanoes, chap. B *of* Flinders, A.F., Lowenstern, J.B., Coombs, M.L., and Poland, M.P., eds., Recommended capabilities and instrumentation for volcano monitoring in the United States: U.S. Geological Survey Scientific Investigations Report 2024–5062–B, 9 p., https://doi.org/10.3133/sir20245062B.

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Three Sisters

Seismic Stations

Volcano	Threat Level	Threat Ranking	# Stations	Target #	% Complete
Three Sisters	Very High	7	5	12	42 (42 overall)
Fourpeaked	High	53	1	8	13 (10 overall)
Yellowstone	High	21	47	50	94 (89 overall)

Overall, we are at 55% of desired instrumentation.

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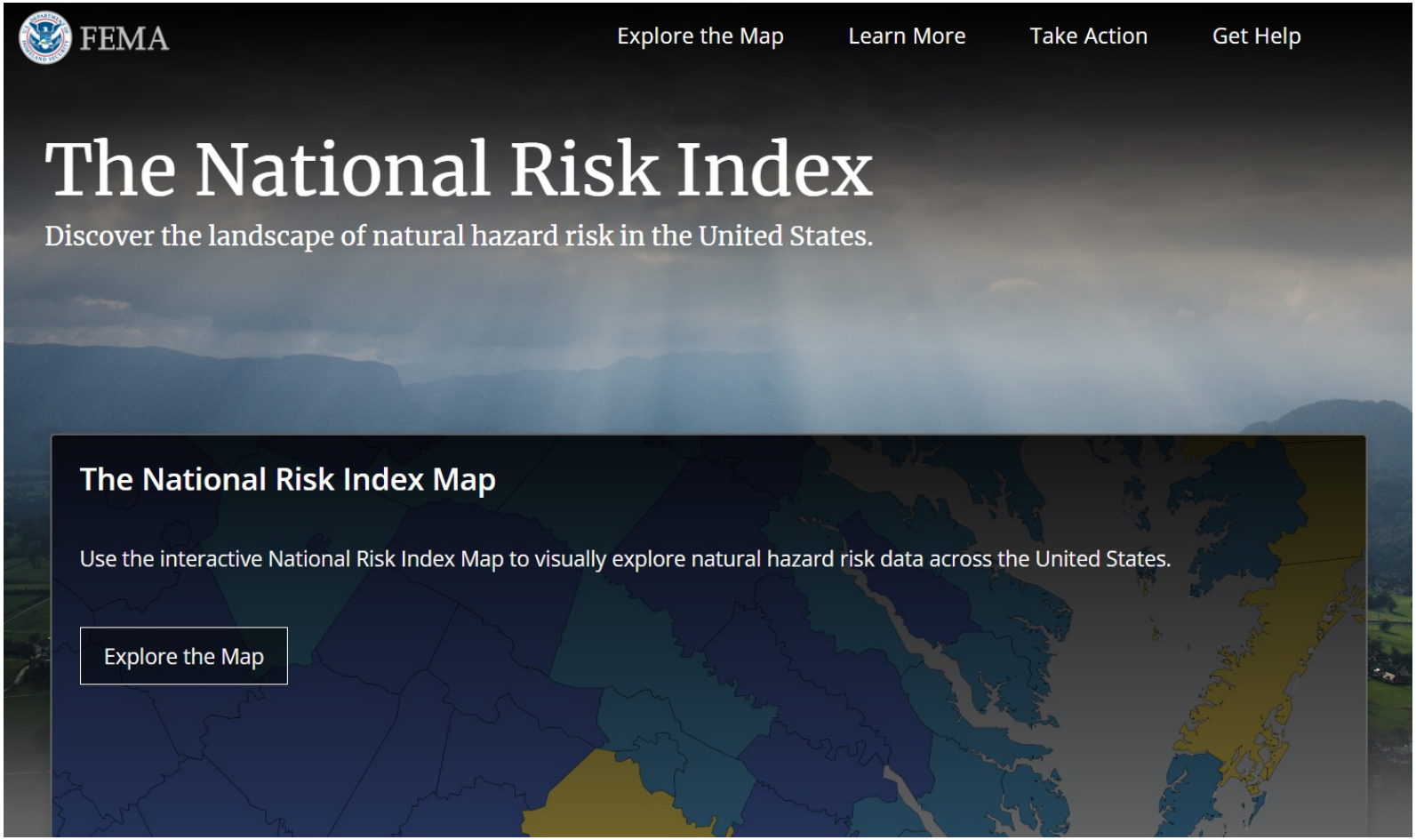

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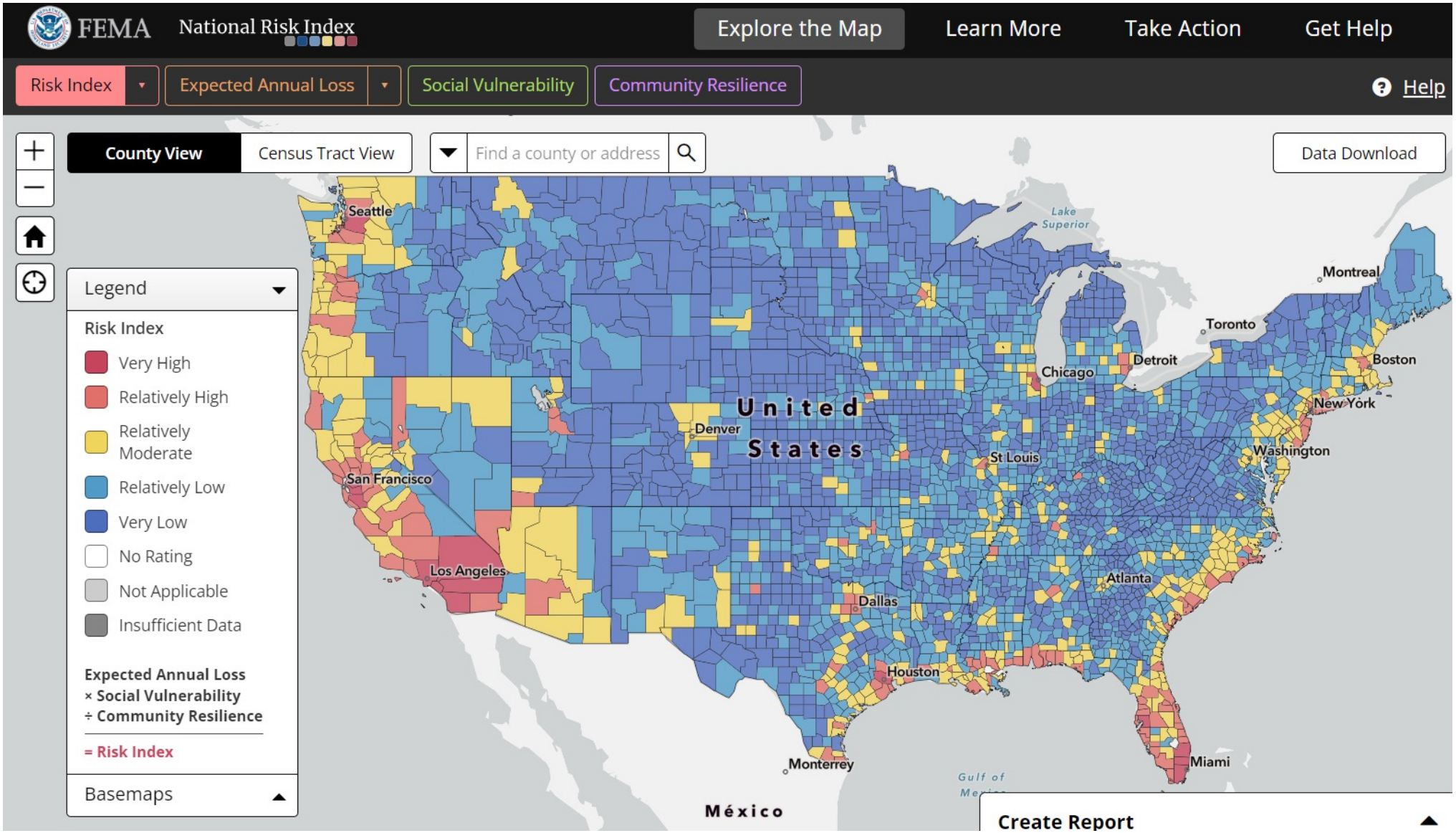
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National Risk Index
Explore the Map
Learn More
Take Action
Get Help
Risk Index
Expected Annual Loss
Social Vulnerability
Community Resilience
Help
County View
Census Tract View
Find a county or address
Data Download
Legend
Risk Index
Very High
Relatively High
Relatively Moderate
Relatively Low
Very Low
No Rating
Not Applicable
Insufficient Data
Expected Annual Loss
× Social Vulnerability
÷ Community Resilience
= Risk Index
Basemaps
Seattle
San Francisco
Los Angeles
Denver
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Chicago
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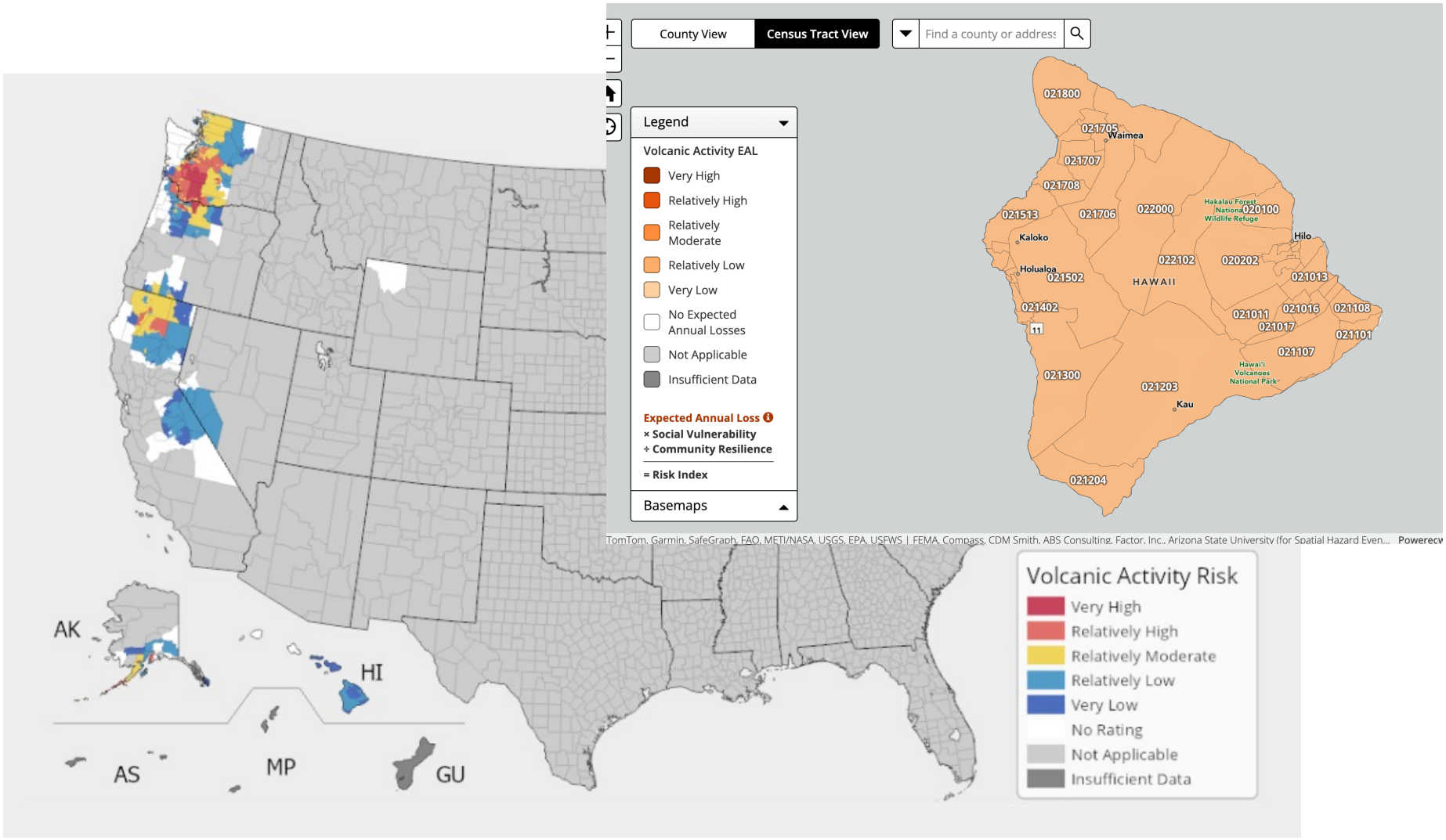
México
Create Report



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Community Disaster Resilience Zones Act

The Community Disaster Resilience Zones Act of 2022, Public Law 117–255, 136 Stat. 2363, amended title II of the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) to add a new section 206 that requires the: (1) maintenance of a natural hazard assessment program and development and maintenance of products for the public's use that show the risk of natural hazards through use of risk ratings at the census tract level; and (2) designation of, at the census tract level, community disaster resilience zones based on the natural hazard risk ratings derived from a **natural hazard risk product** maintained by the natural hazard assessment program.

Using the National Risk Index as the Natural Hazard Risk Product

Section 206 specifies the natural hazard risk product must (1) show the risk of natural hazards; and (2) include ratings and data for loss exposure, social vulnerability, community resilience, and any other element determined necessary by the President. As currently maintained, the **National Risk Index** meets the Community Disaster Resilience Zones Act requirements for a **natural hazard risk product** that can serve as the basis for community disaster resilience zone designations under section 206.

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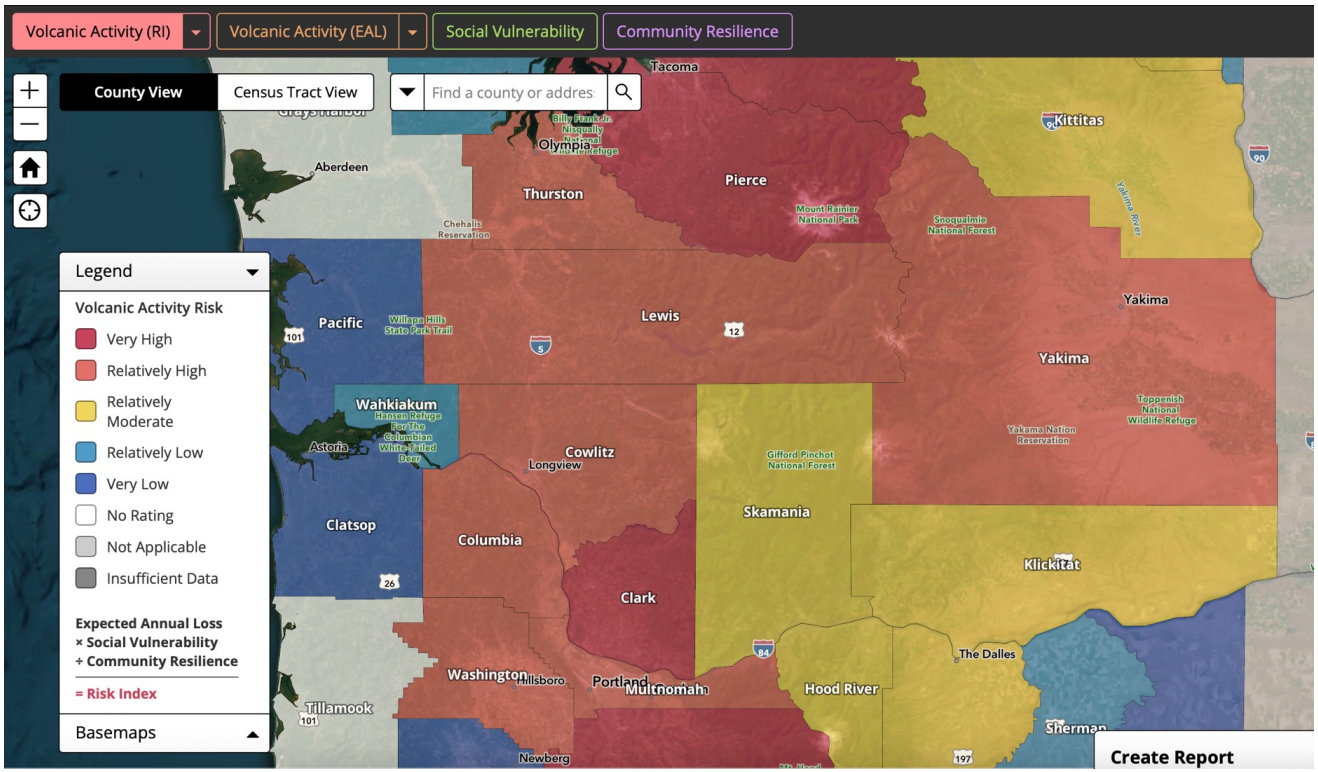
Volcanic Risk Index by County



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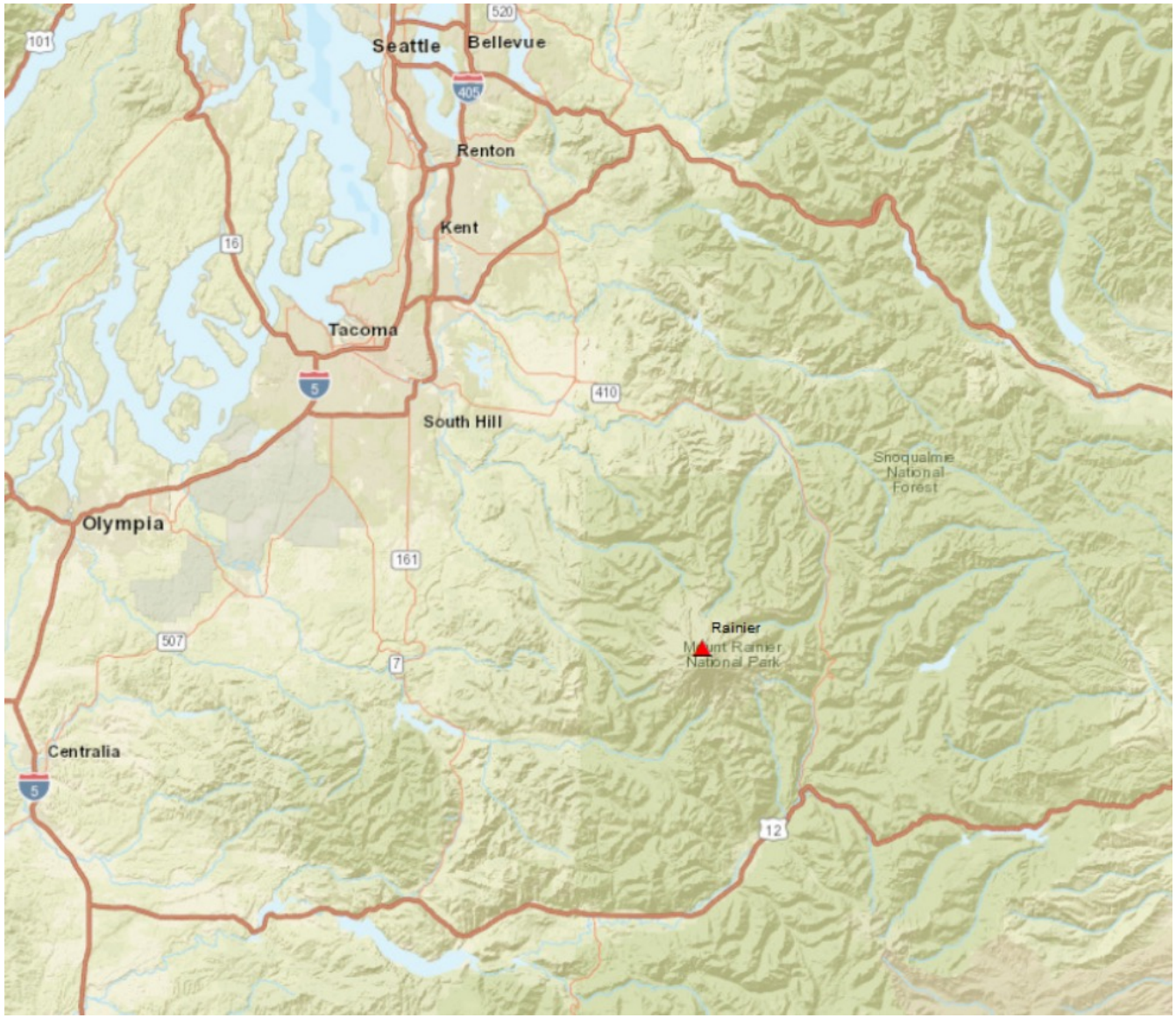

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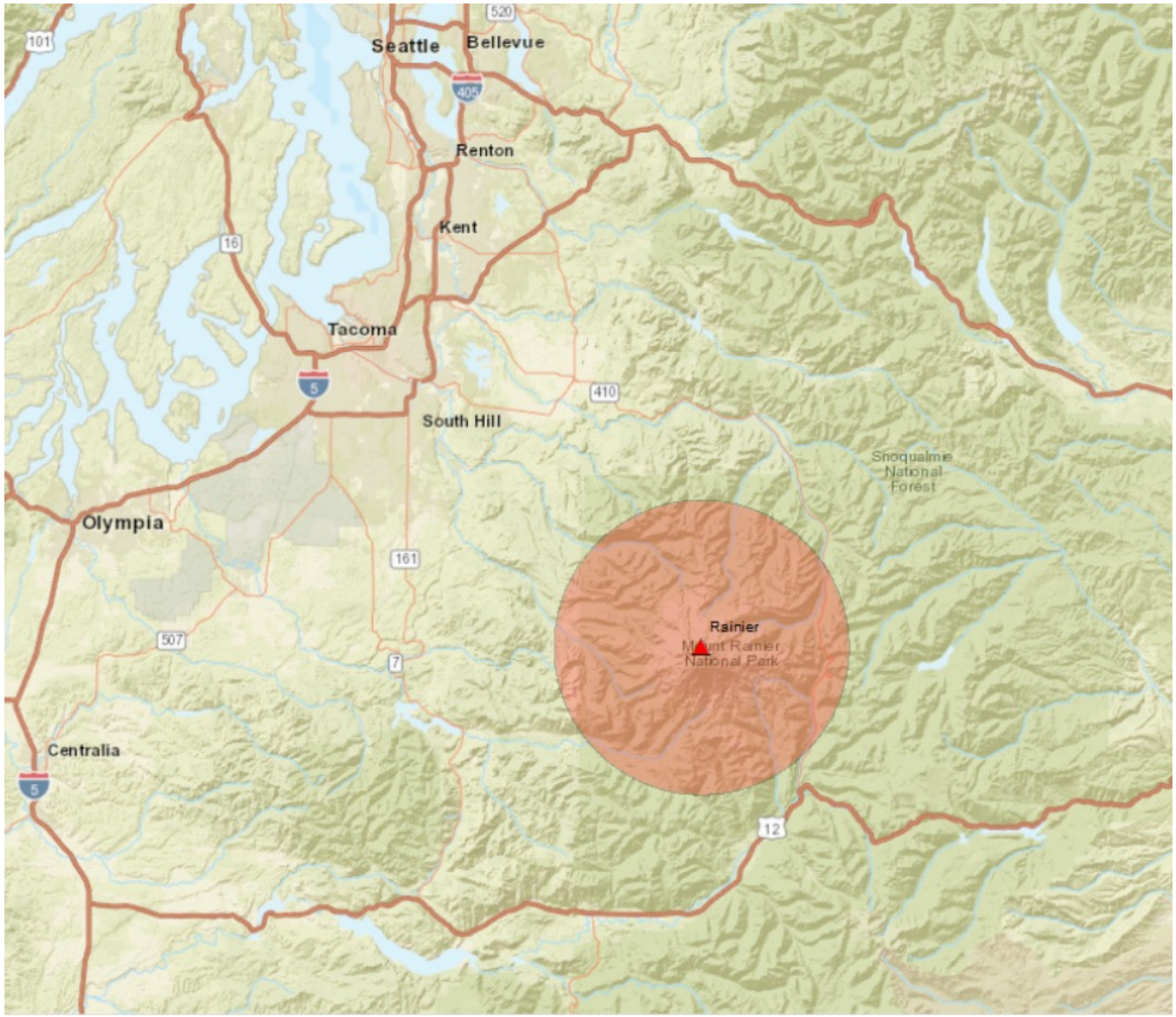

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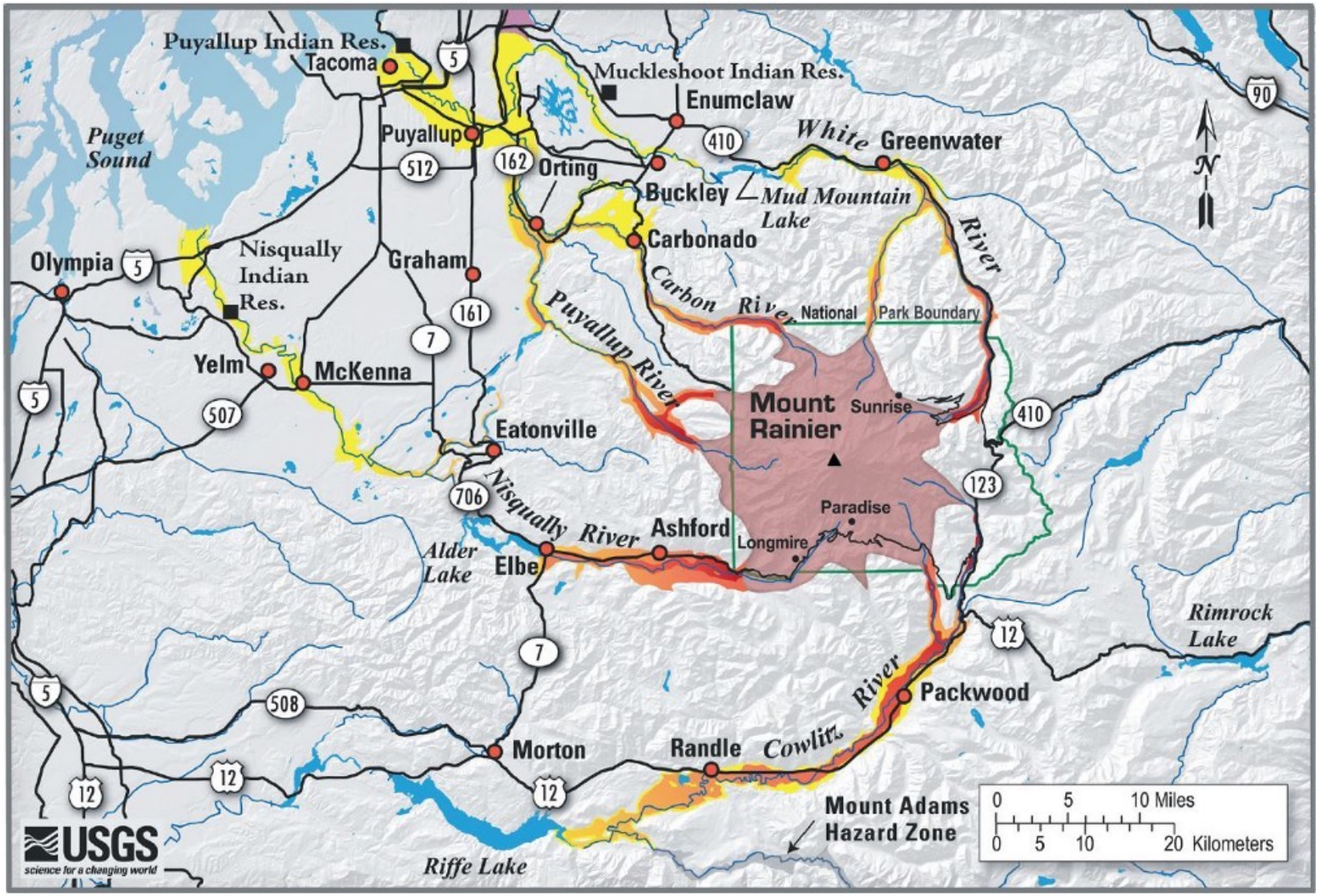
Puyallup Indian Res.
Tacoma
Muckleshoot Indian Res.
Enumclaw
Puget Sound
Puyallup
Orting
White
Greenwater
Buckley
Mud Mountain Lake
Carbonado
Olympia
Nisqually Indian Res.
Graham
Carbon River
National Park Boundary
Puyallup River
River
Yelm
McKenna
Mount Rainier
Sunrise
Eatonville
Nisqually River
Paradise
Ashford
Longmire
Alder Lake
Elbe
Rimrock Lake
Packwood
Morton
Randle
Cowlitz River
Mount Adams Hazard Zone
Riffe Lake
0 5 10 Miles
0 5 10 20 Kilometers
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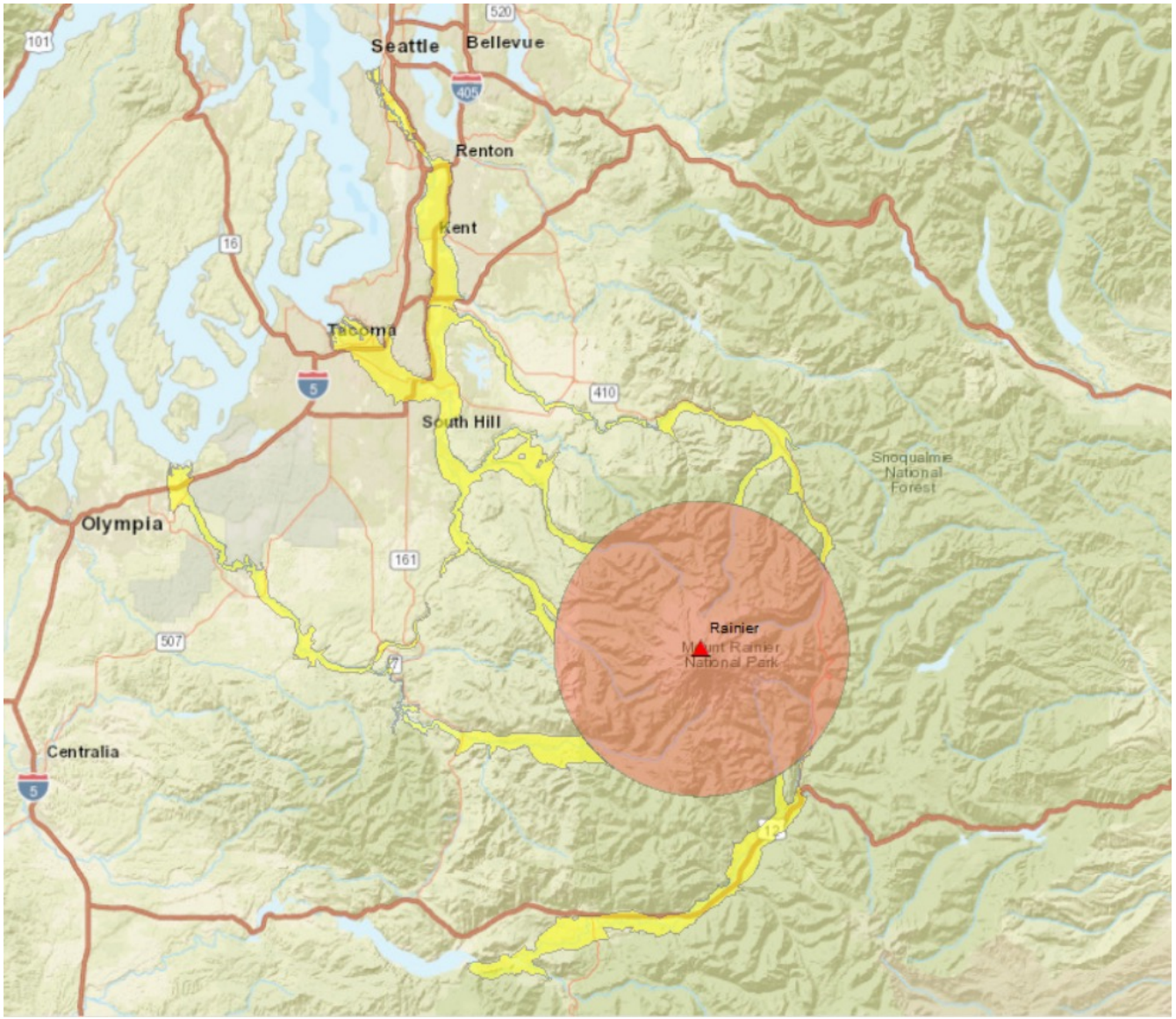

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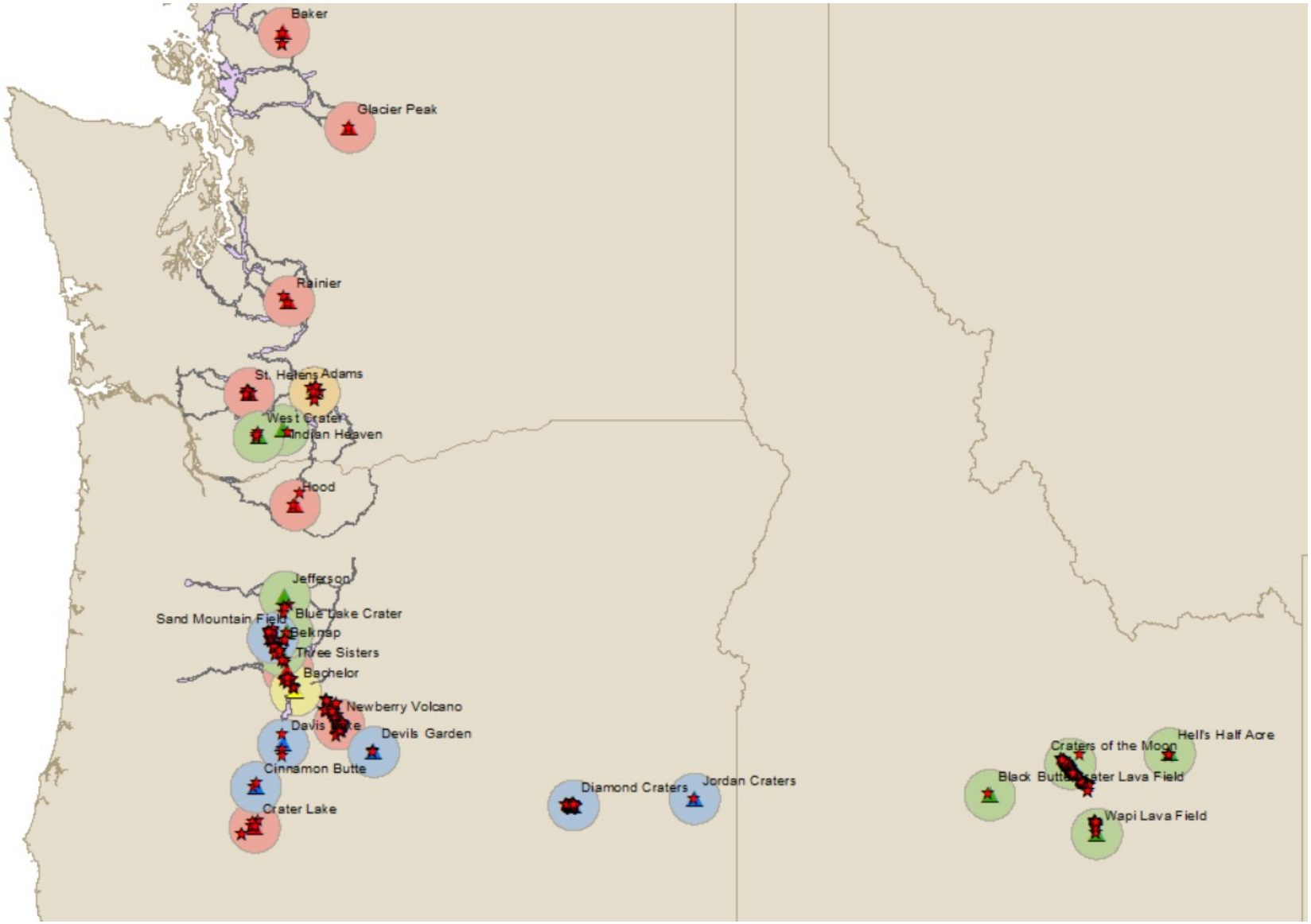

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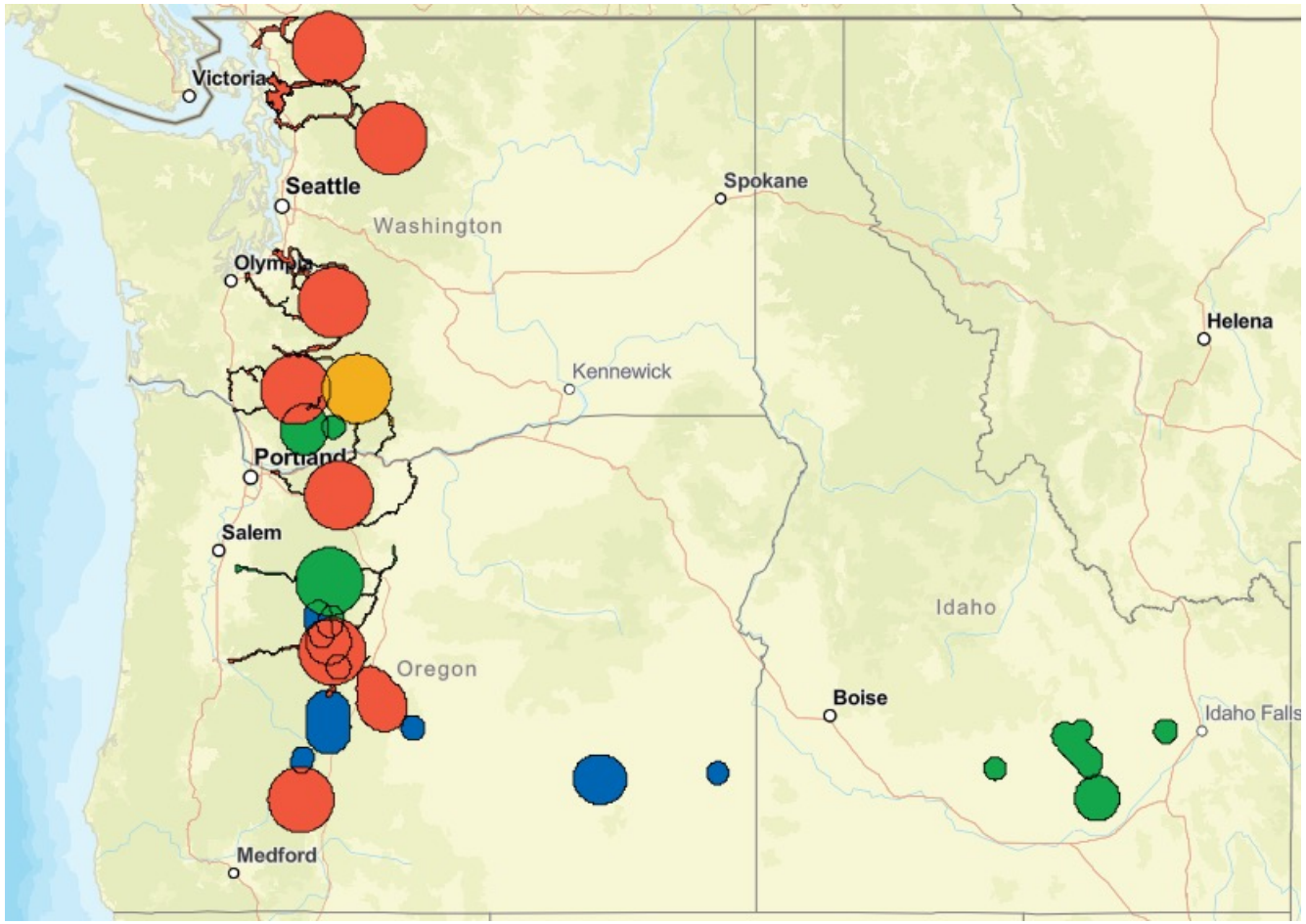
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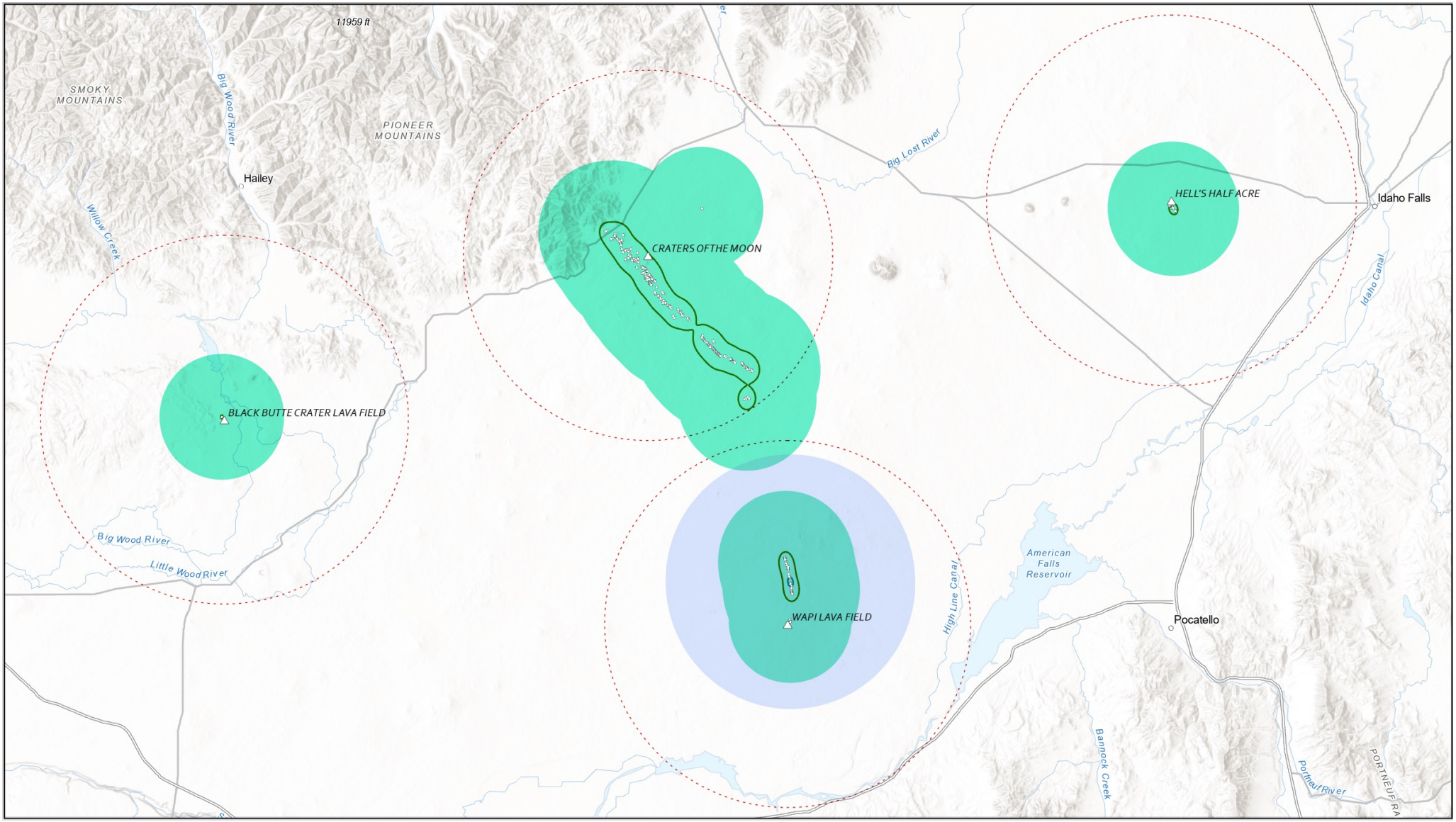
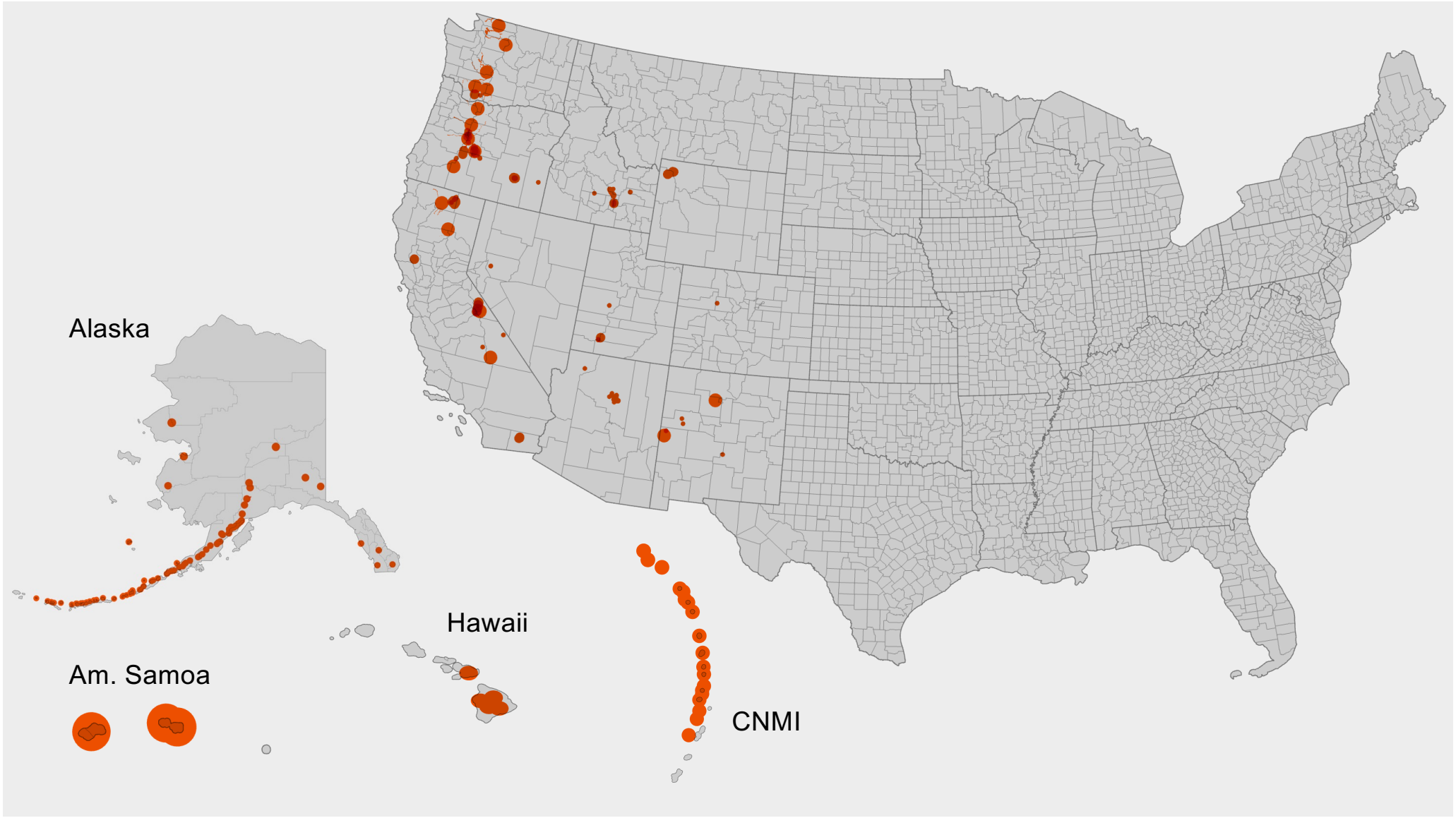
Oregon
Boise
Idaho Falls
Medford


11959 ft
SMOKY MOUNTAINS
Big Wood River
PIONEER MOUNTAINS
Hailey
Willow Creek
Big Lost River
CRATERS OF THE MOON
HELL'S HALF ACRE
Idaho Falls
Idaho Canal
BLACK BUTTE CRATER LAVA FIELD
Big Wood River
Little Wood River
WAPI LAVA FIELD
High Line Canal
American Falls Reservoir
Pocatello
Bannock Creek
Portneuf River
PORTNEUF RA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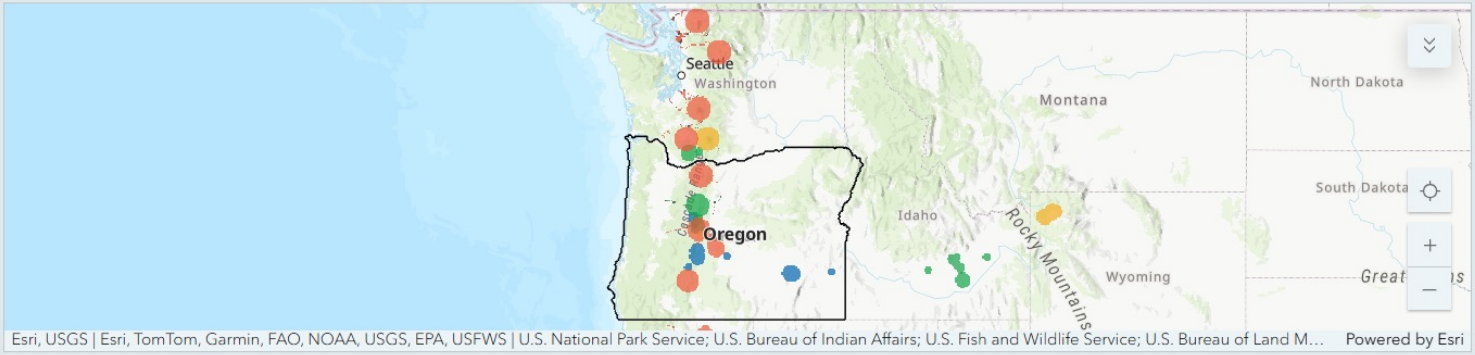
National Hazard Exposure Maps

Exposure to Near and Distal Volcanic Threats

Select a boundary type
States and U.S. Territories



Search...

- North Dakota
- Ohio
- Oklahoma
- Oregon
- Pennsylvania
- Puerto Rico
- Rhode Island

The number of **Oregon** residents in near and distal volcanic threat areas.

Volcano Threat Category	Residents in Near-volcano Ar...	Residents in Distal lahars Areas
Very High	39,296	15,650
High	0	0
Moderate	0	0
Low	821	13,036

Number of residents in near volcanic threat areas with High to Very High threat levels

39,296

Number of residents in distal volcanic threat areas with High to Very High threat levels

15,650

There are 161 active volcanoes in the U.S. and its territories, posing differing degrees of risk to people and infrastructure because of differences in their eruptive styles and geographic locations. The National Volcanic Threat Assessment categorizes each volcano into 5 categories from red (very high) to blue (very low) based on combination of 24 factors describing a volcano's hazard potential and exposure of people and property to those hazards.

The map's circles are simple buffered areas around each volcano that help visualize the extent of land that could be threatened directly by its volcanic hazards, including ballistics (airborne rocks from explosions), pyroclastic density currents,

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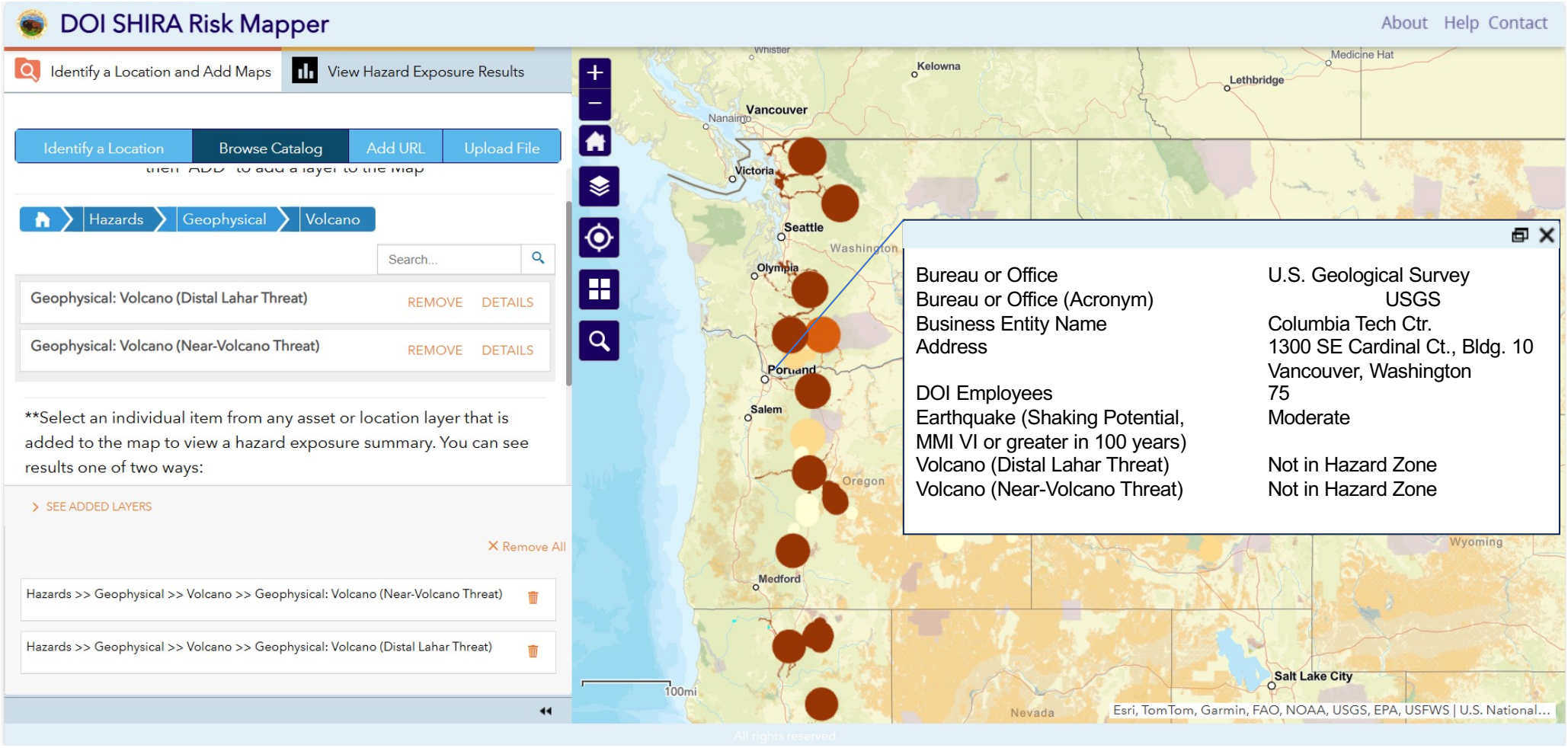


Mount Rainier: Lahars, Alarms, and Evacuations

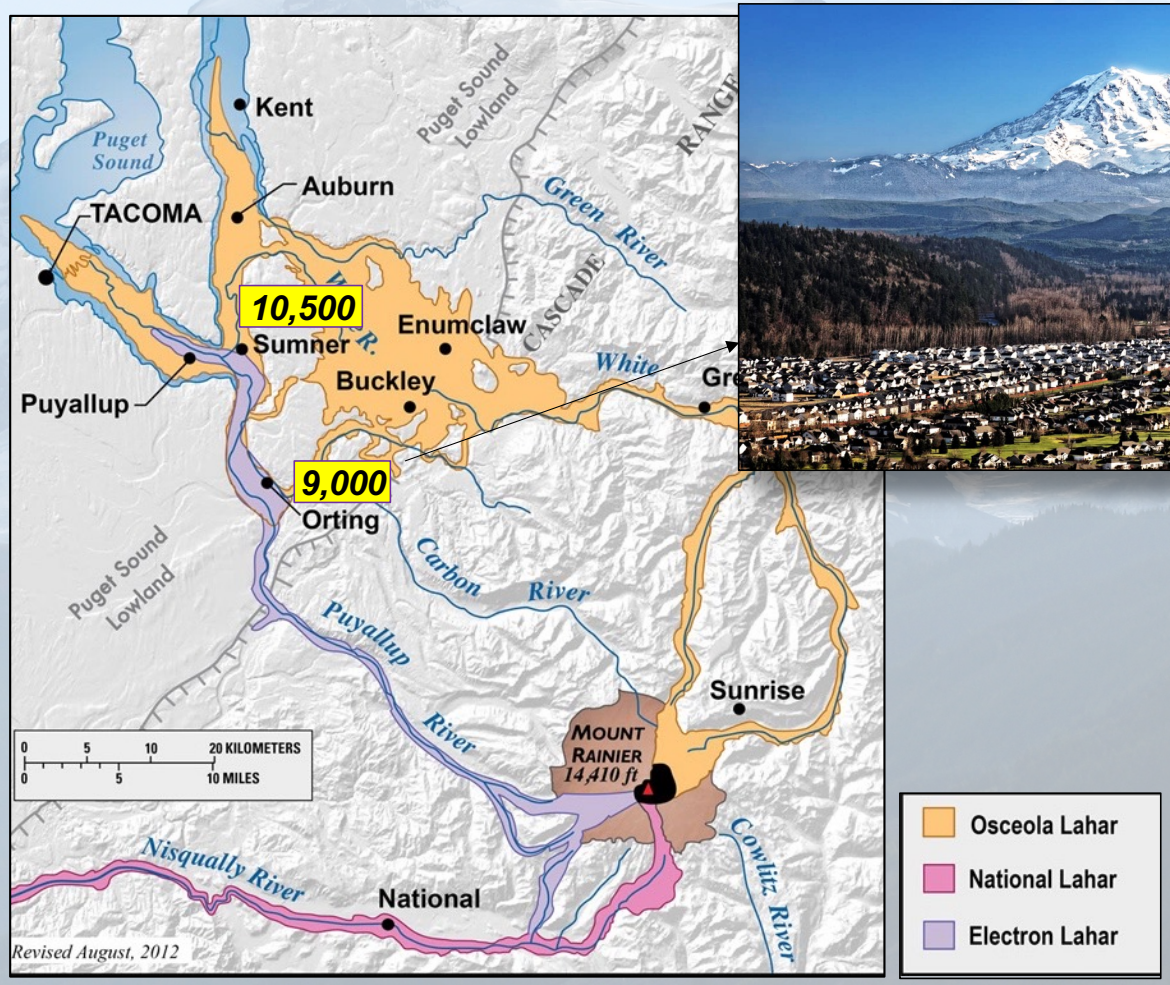
Weston Thelen (wthelen@usgs.gov)
Alex Iezzi (aiezzi@usgs.gov)

U.S. Department of Interior
U.S. Geological Survey

Photo by Seth Moran, USGS

Lahar Deposits

- Mount Rainier is prone to having **very large lahars** that can affect areas now densely populated
  - >90,000 people live in Rainier lahar hazard zones [Diefenbach et al., 2015]
  - At least 11 large lahars in the last 5,600 years
  - Most recent: **~1500 A.D. (Electron Mudflow)**
  - Most large lahars have been associated with eruptions
    - No *known* associated eruption for the Electron Mudflow

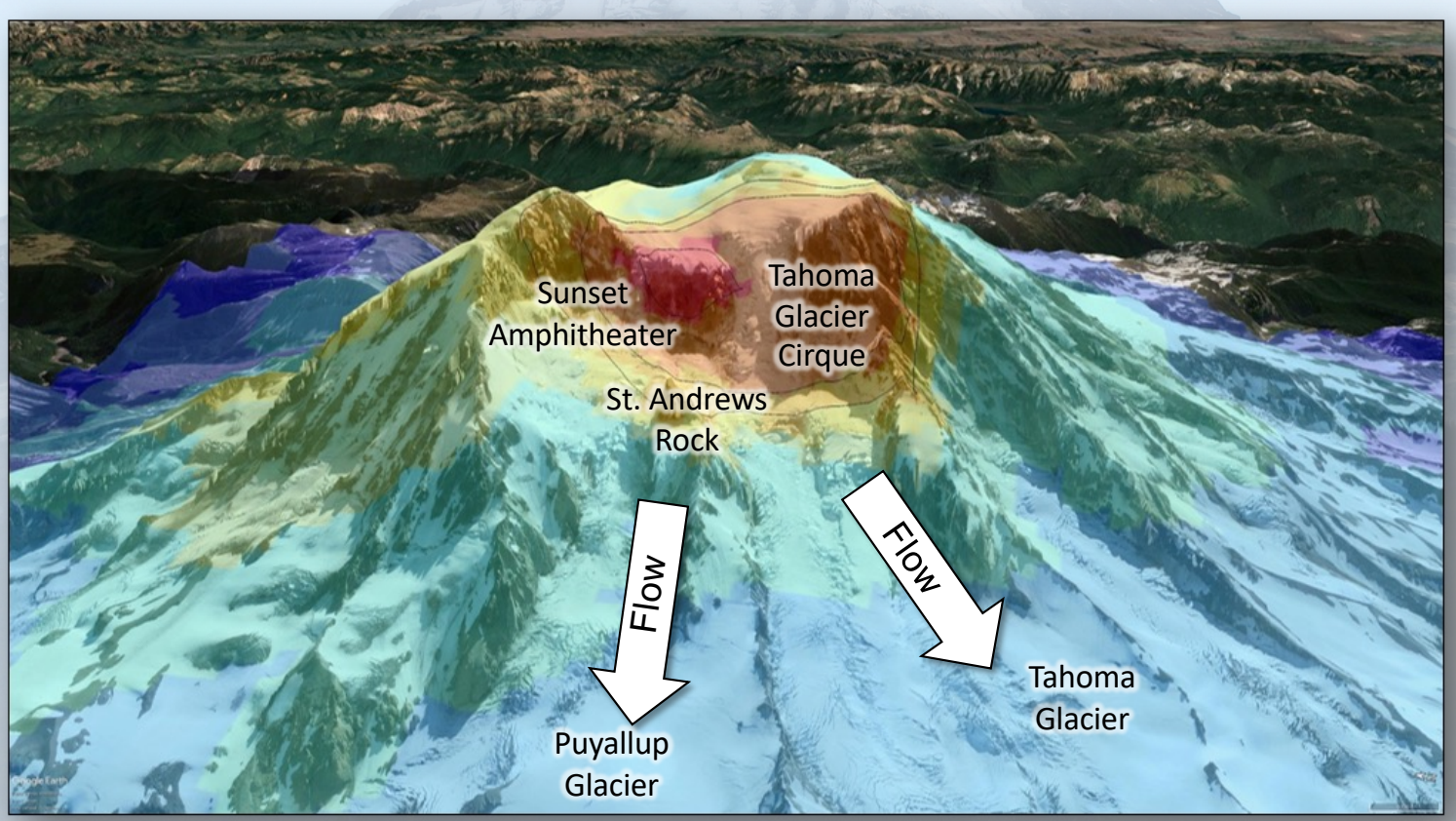


USGS photo

Driedger et al., 2014

USGS

Could another large lahar happen without an eruption?



Area of Instability on west flank from weak, hydrothermally altered rock

[Reid et al., 2001; Finn et al., 2001]

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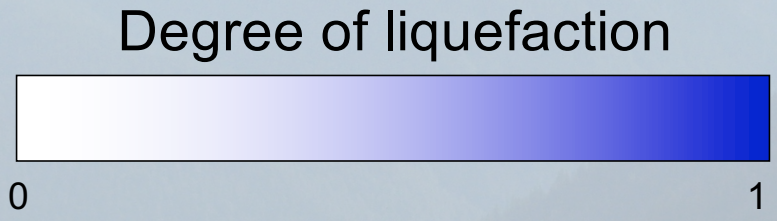
Simulating Lahar Hazards

D-Claw Model:

- Physics based flow model
- Allows to test different parameters
- Alarm system based on 8 simulations with varied:
  - Volume
  - Mobility
  - Source region



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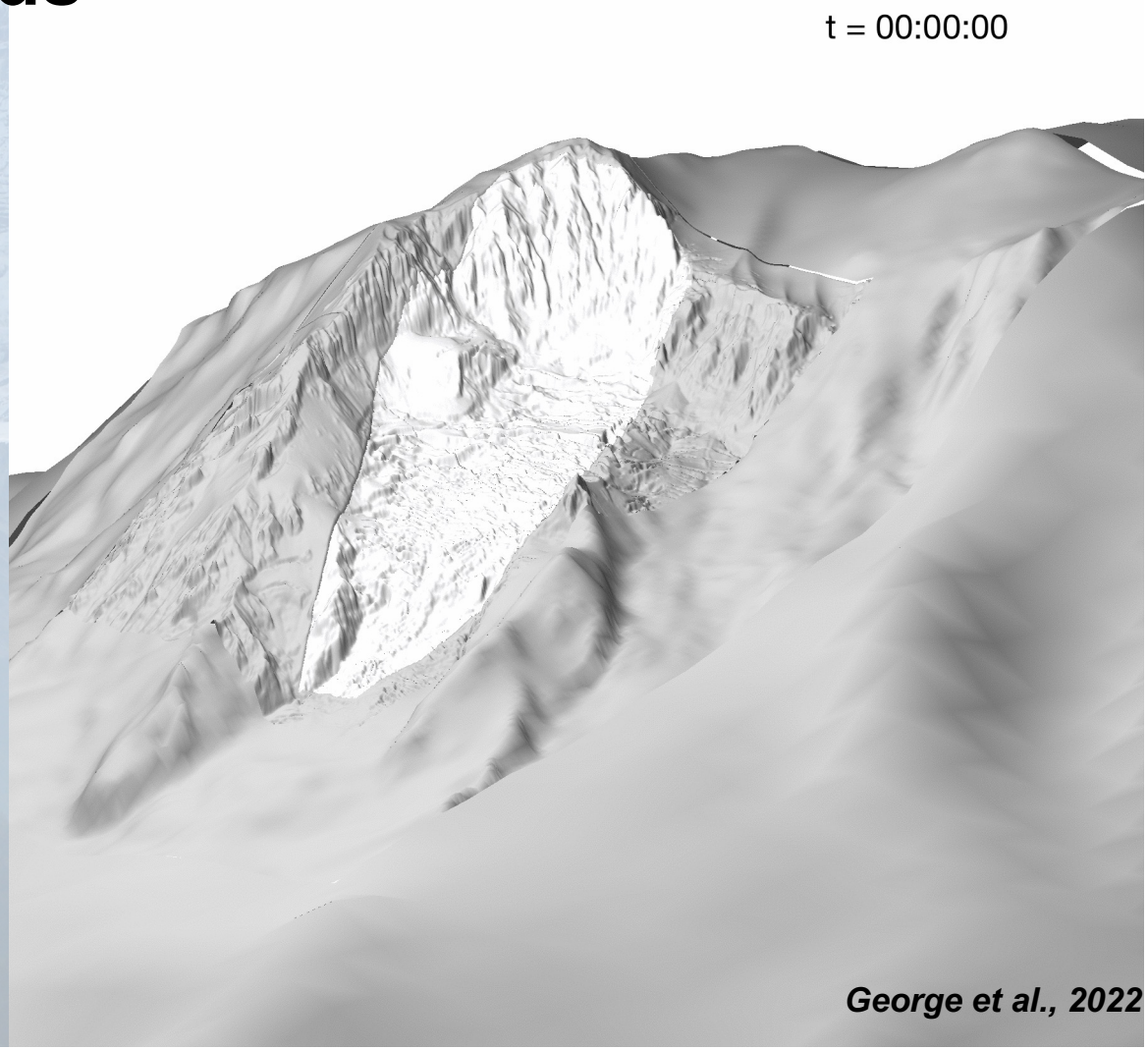
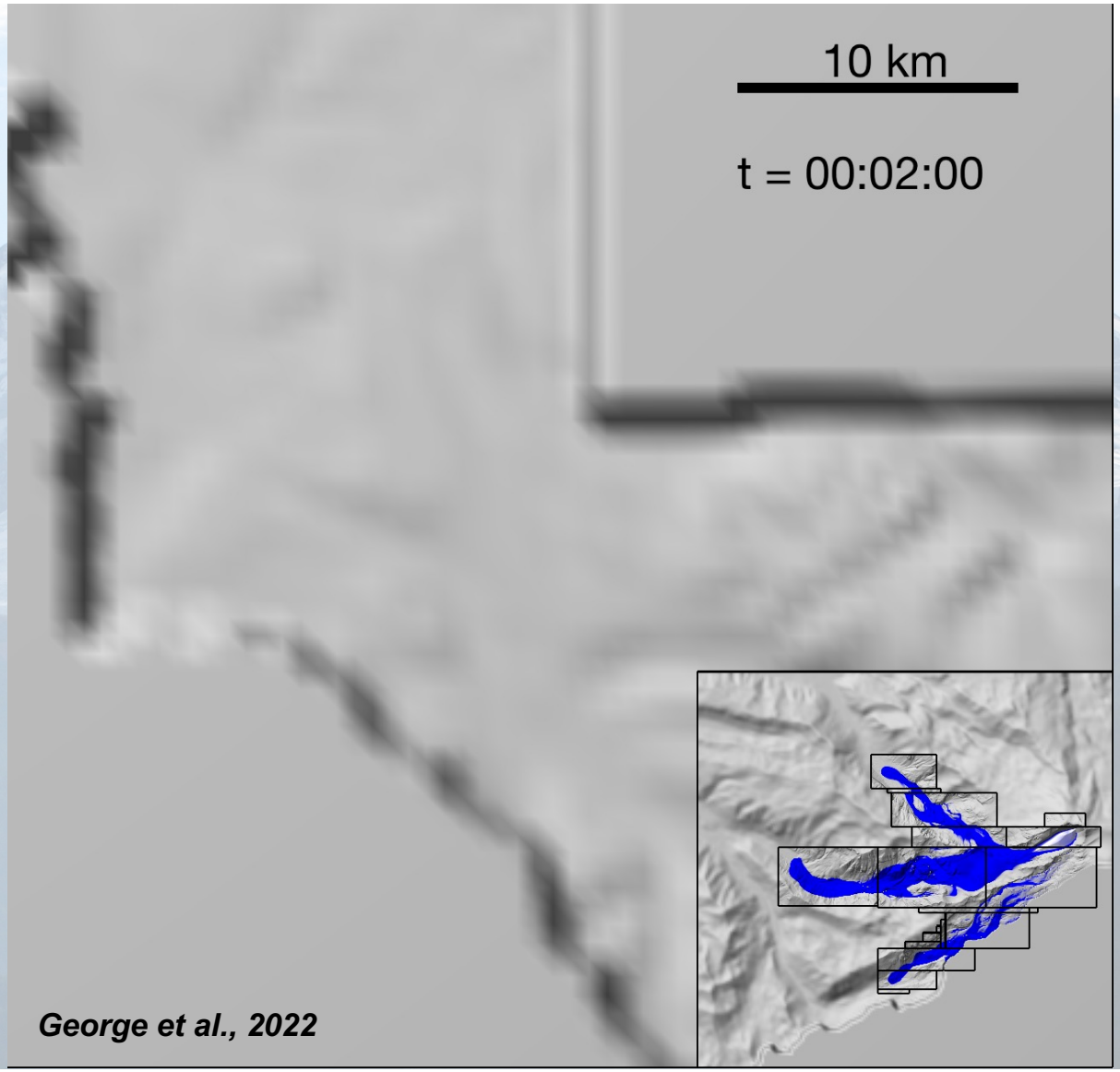


George et al., 2022

Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 2 minutes



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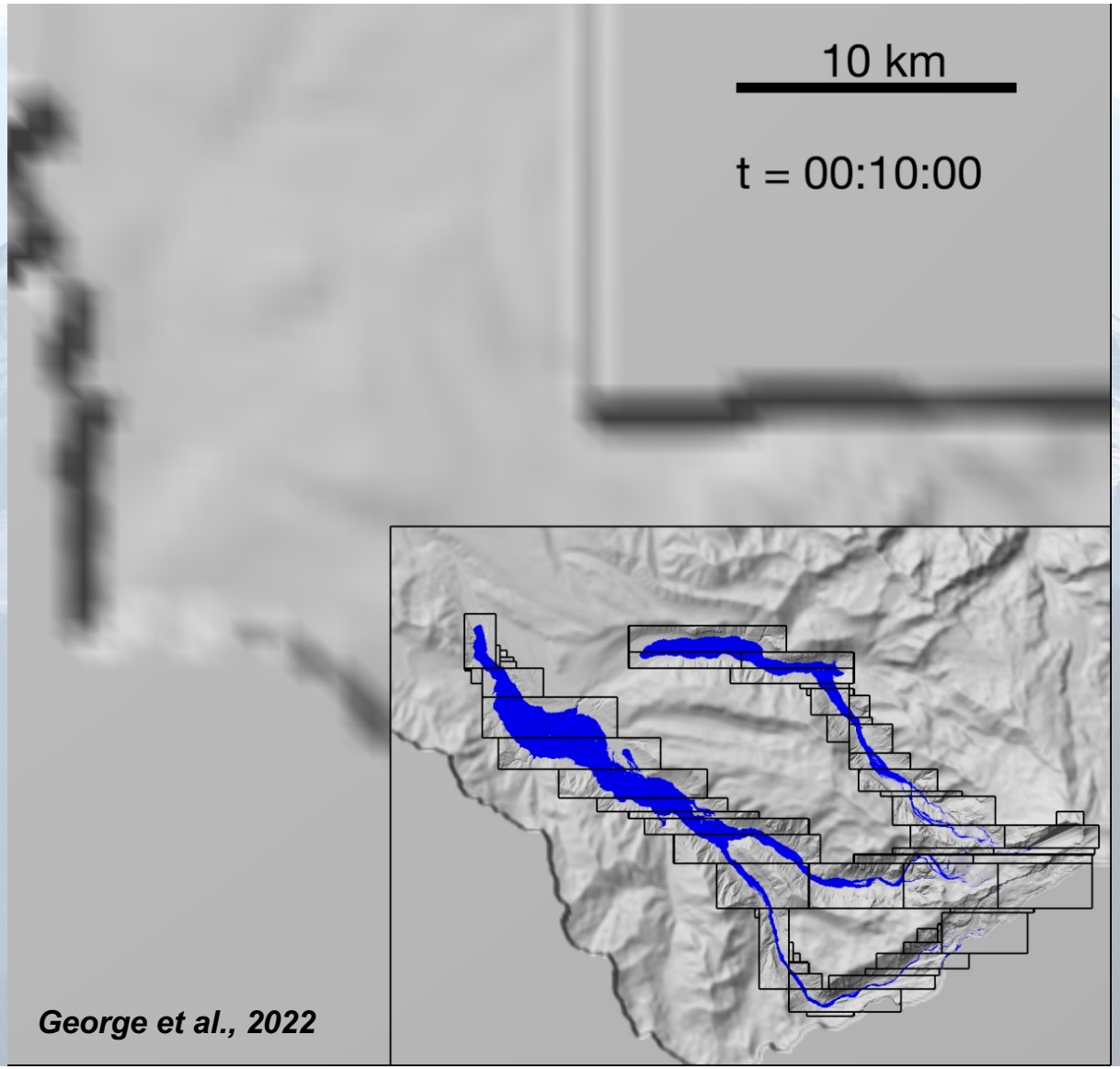
Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 10 minutes



George et al., 2022

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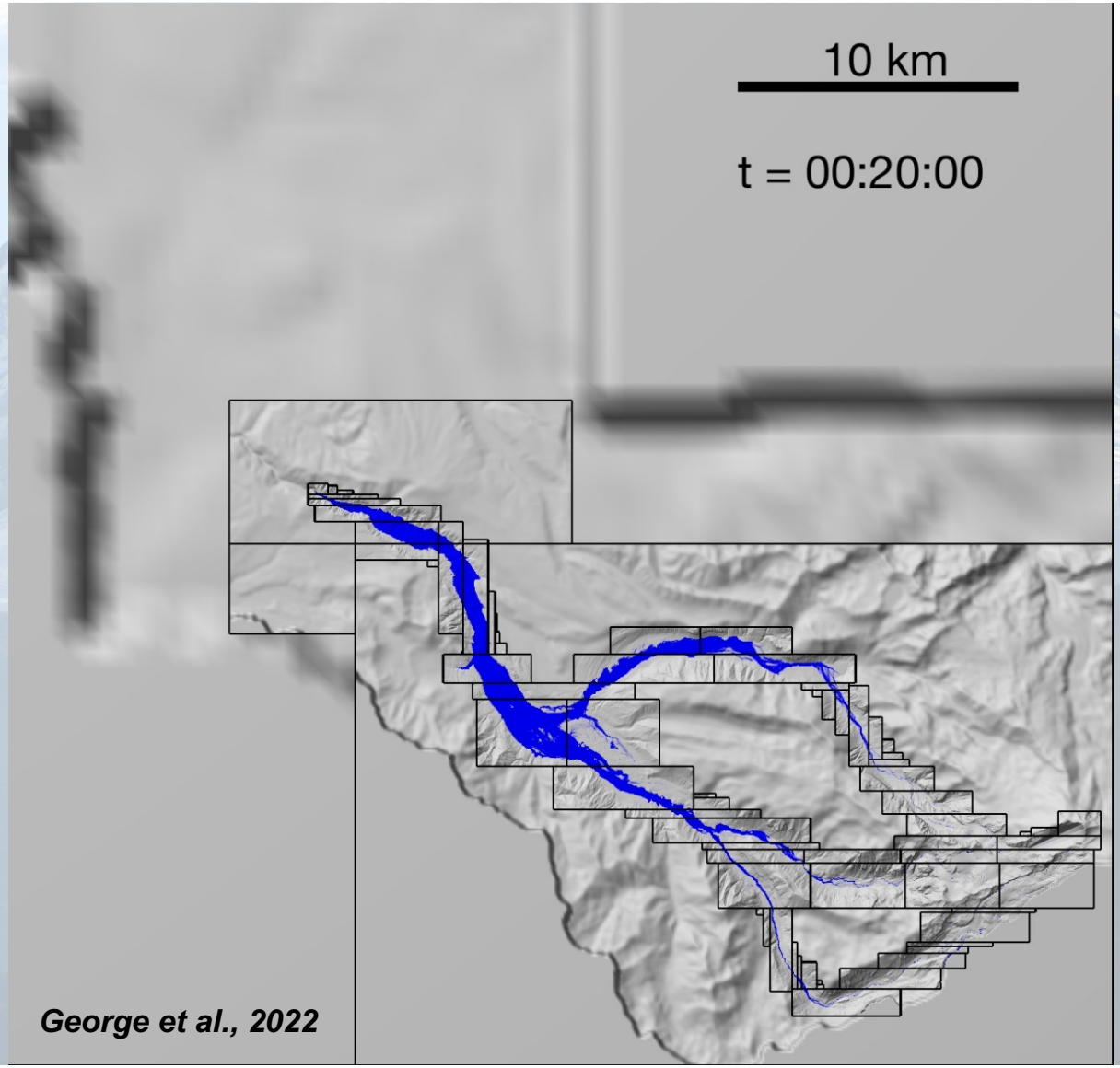
Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 20 minutes



George et al., 2022

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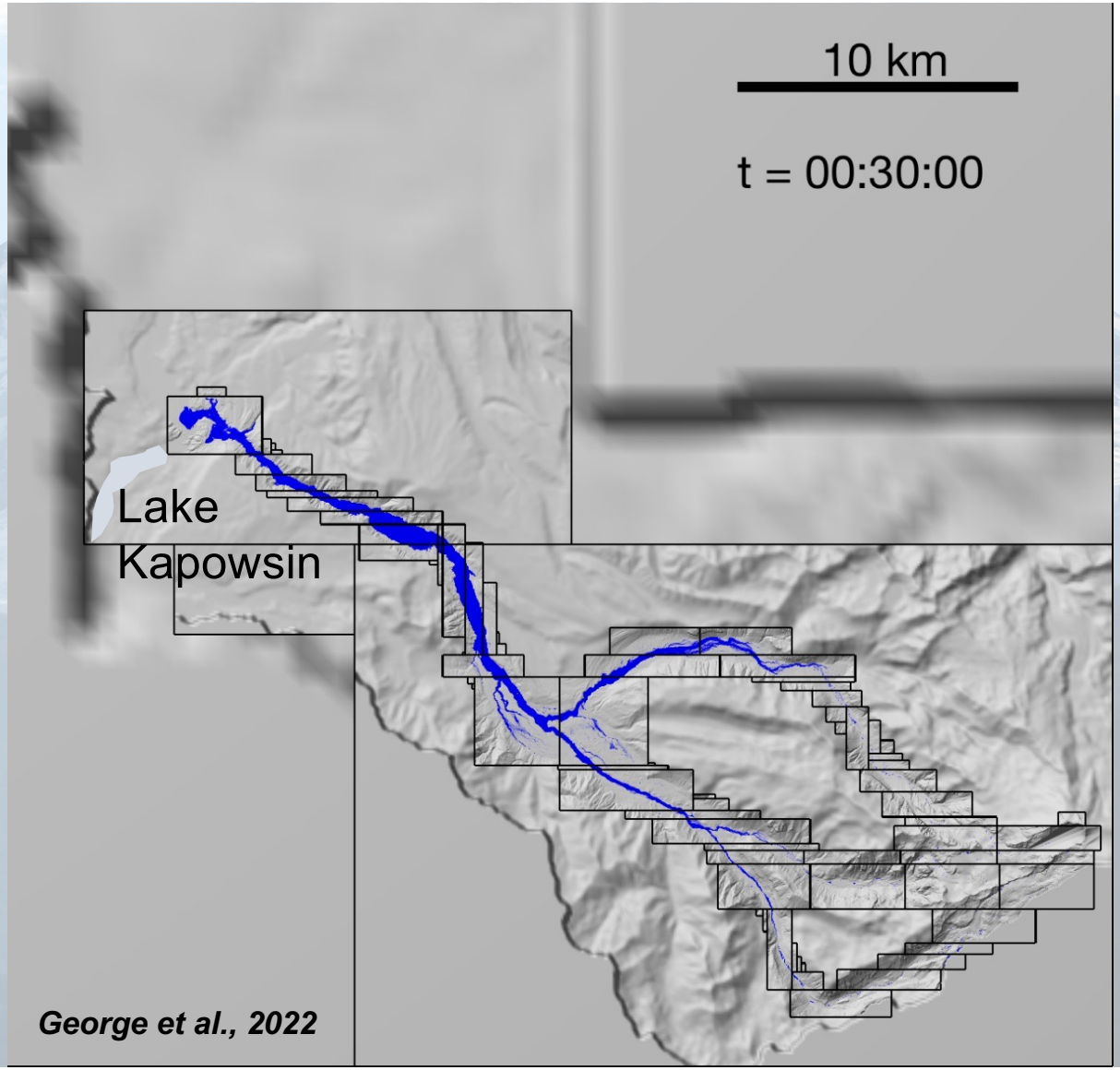
Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 30 minutes



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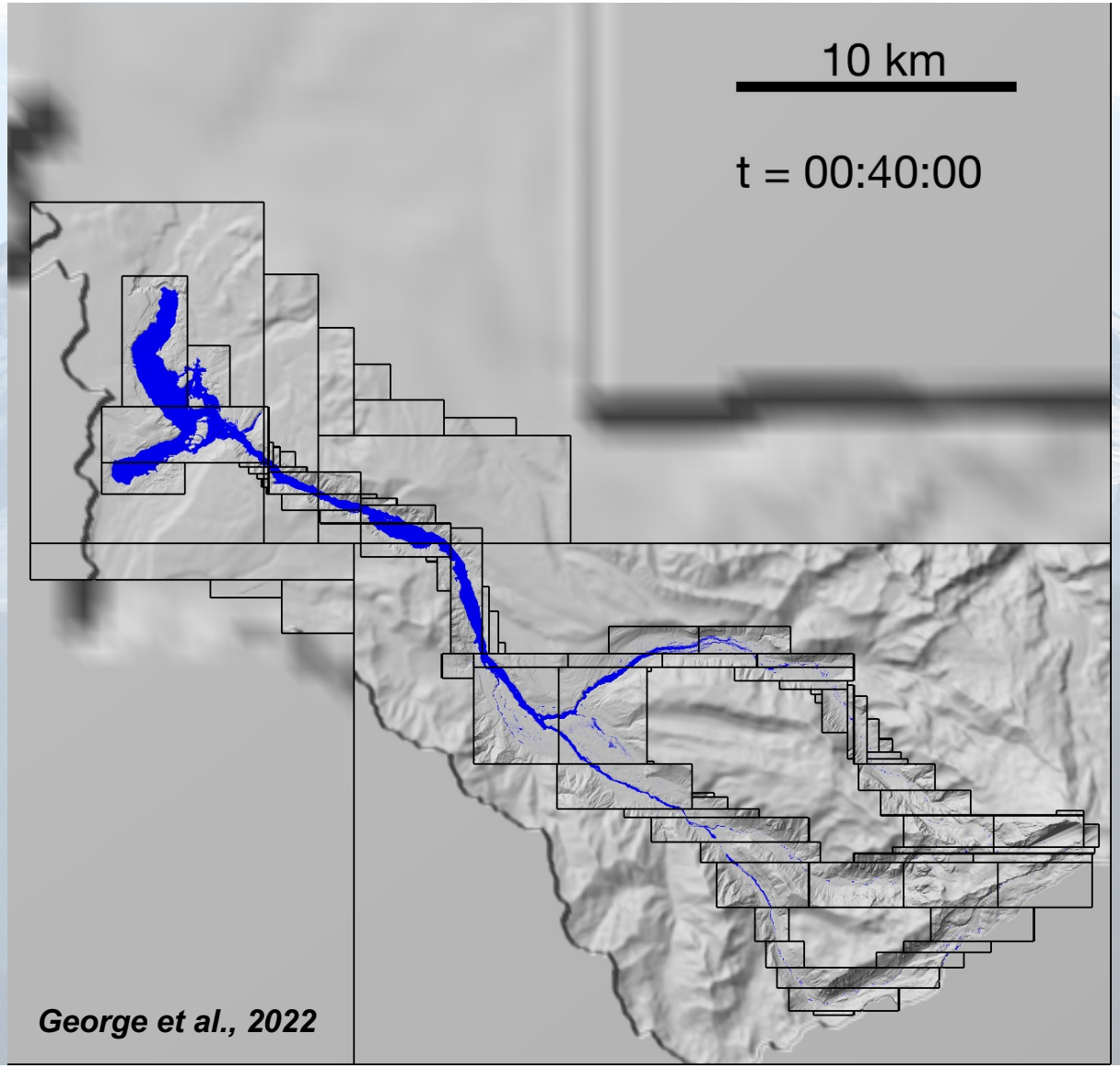
Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 40 minutes



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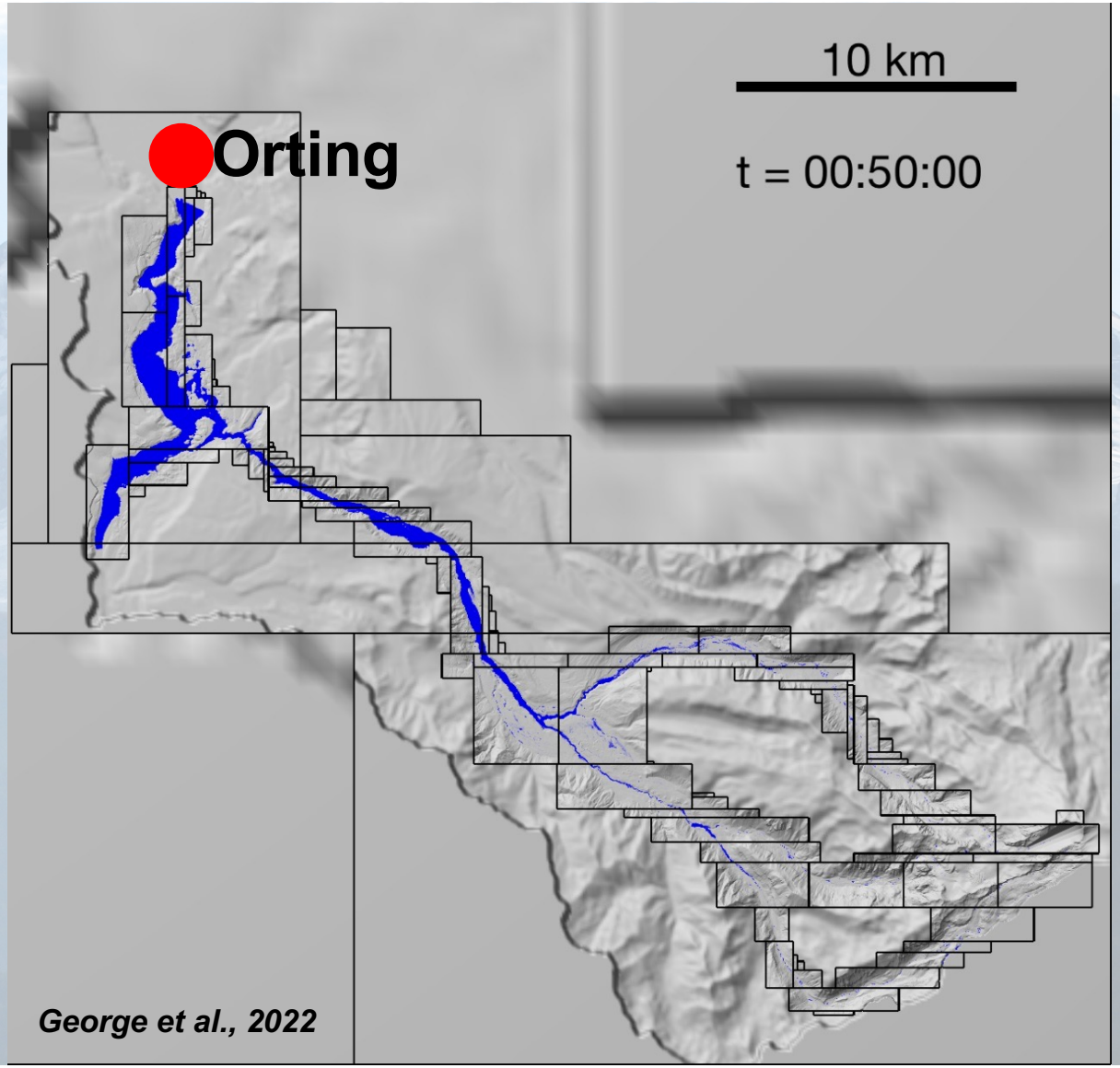
Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 50 minutes



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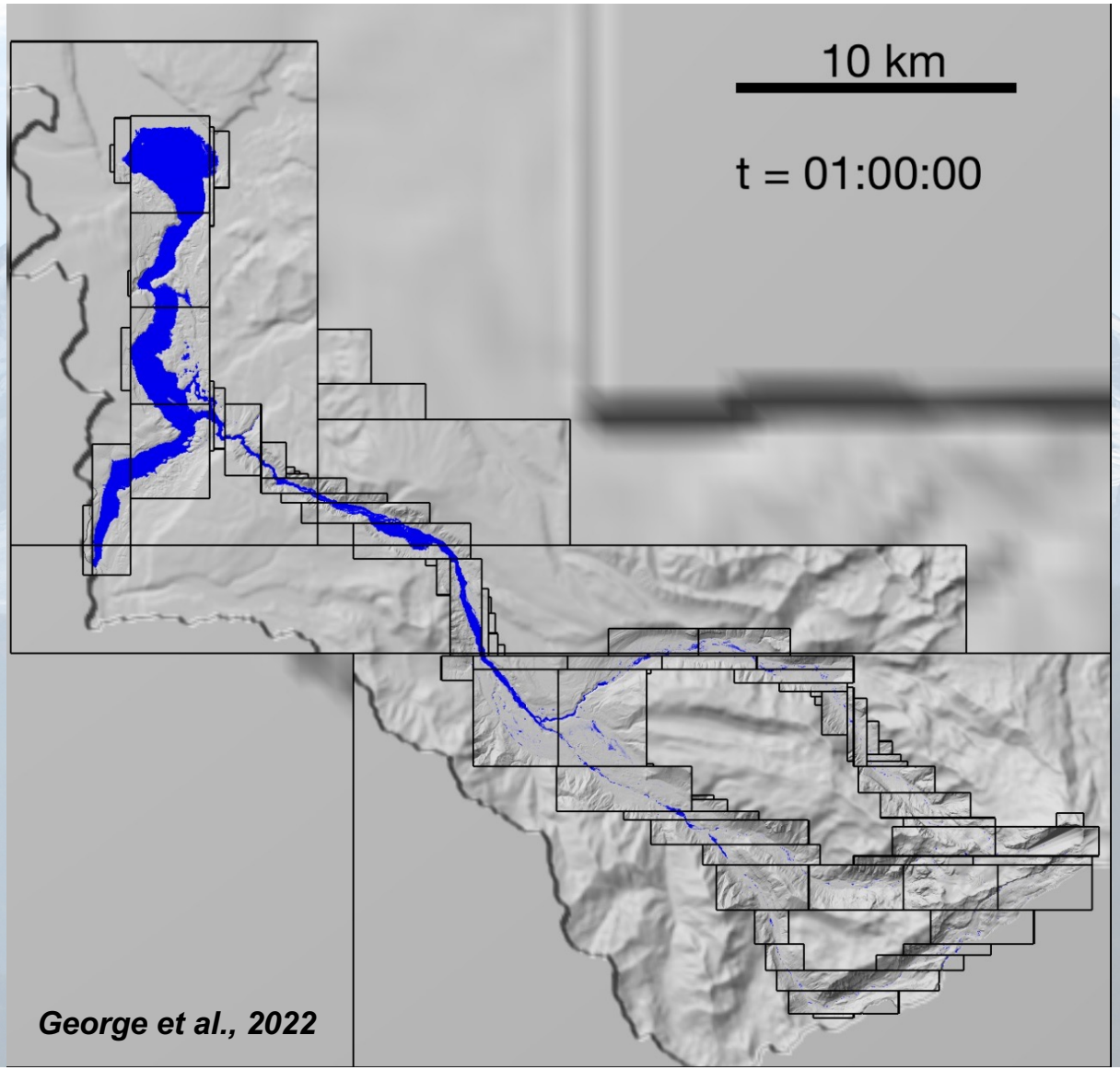
Map view D-Claw simulation of 260 million m^3 lahar originating in Sunset Amphitheater, Mount Rainier

t = 60 minutes



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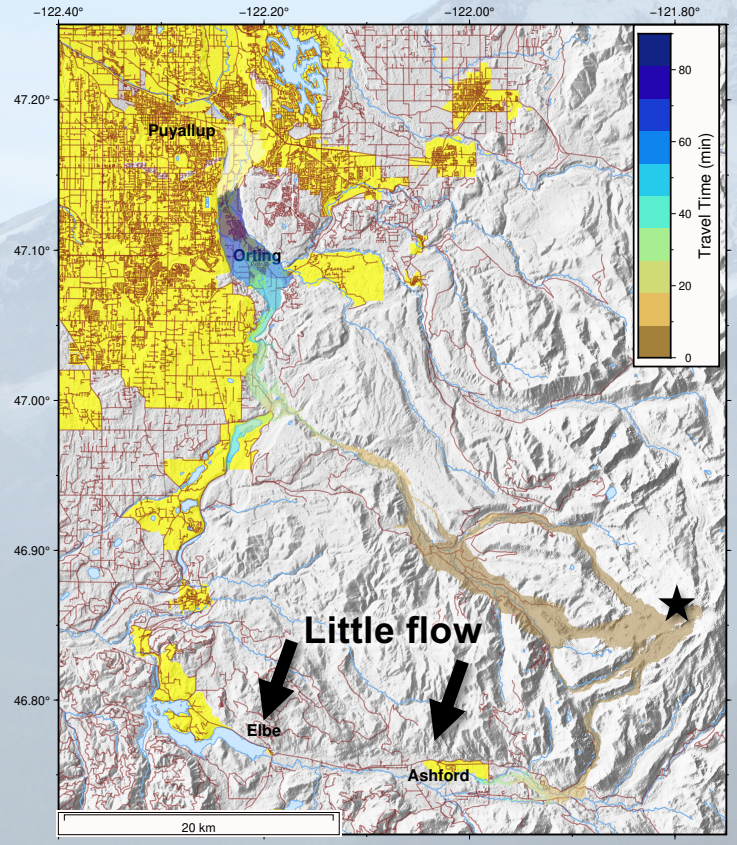
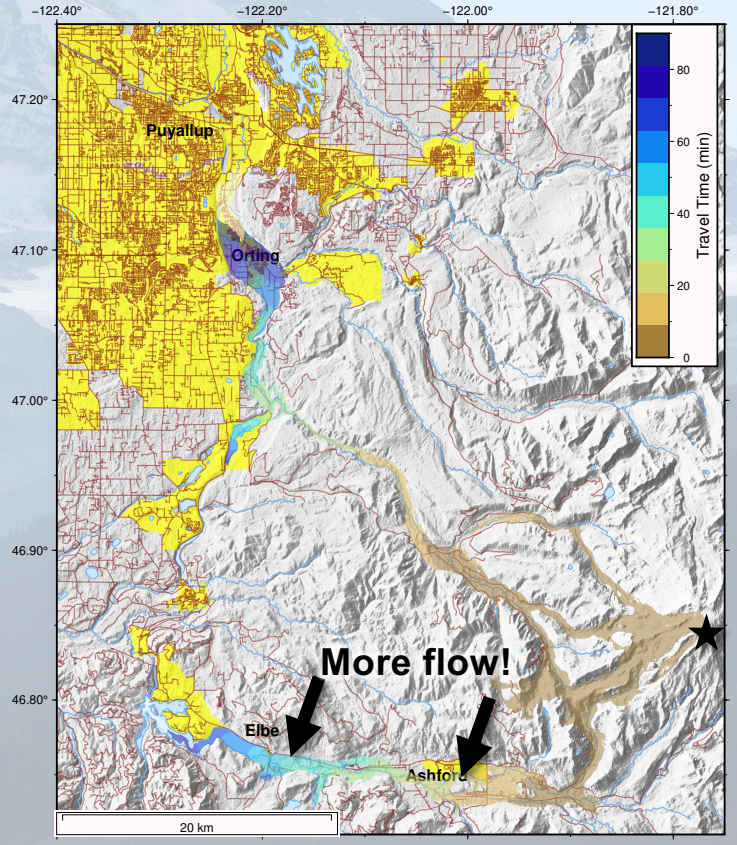
Slightly Different Source Area, Big Differences!

Western Source (similar to 500 ybp)



Based on modeling from George et al., 2022

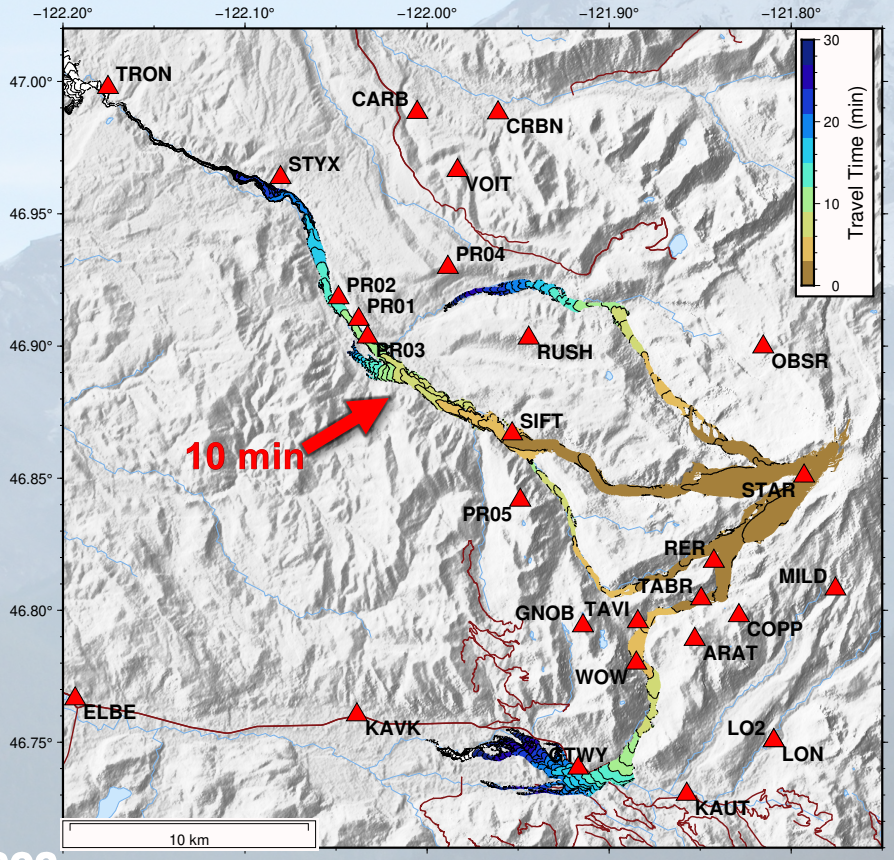
Source moved ~1 km East



Based on modeling from George et al., 2022

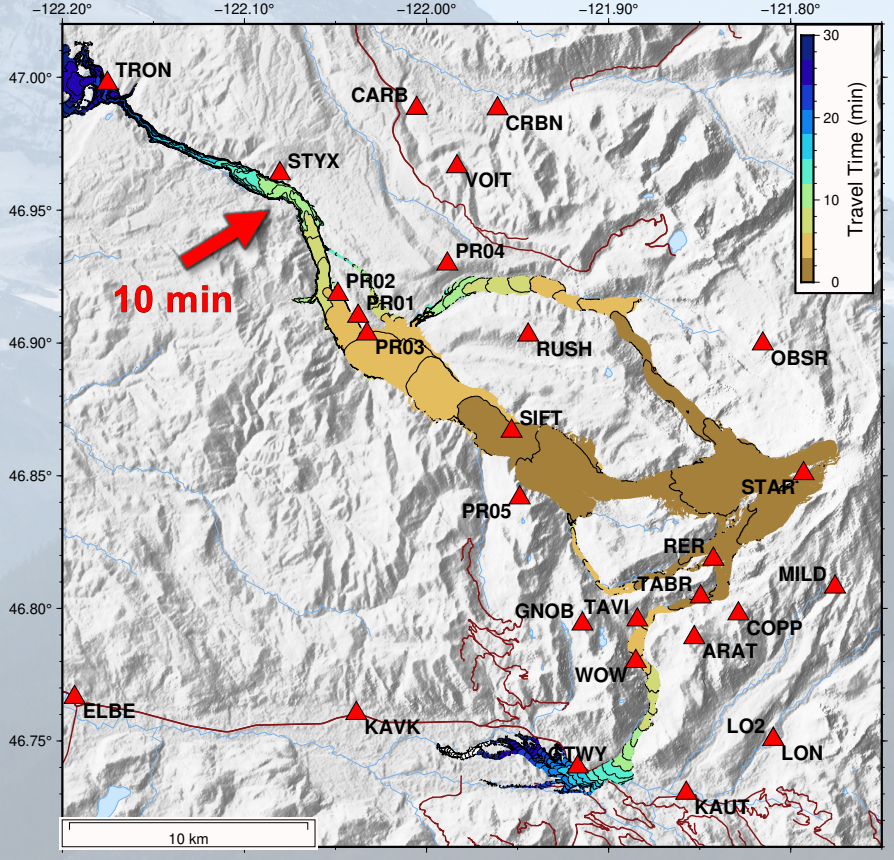
The Bigger the Flow, the Faster it Moves!

Small and highly mobile



Based on modeling from George et al., 2022

Large and highly mobile

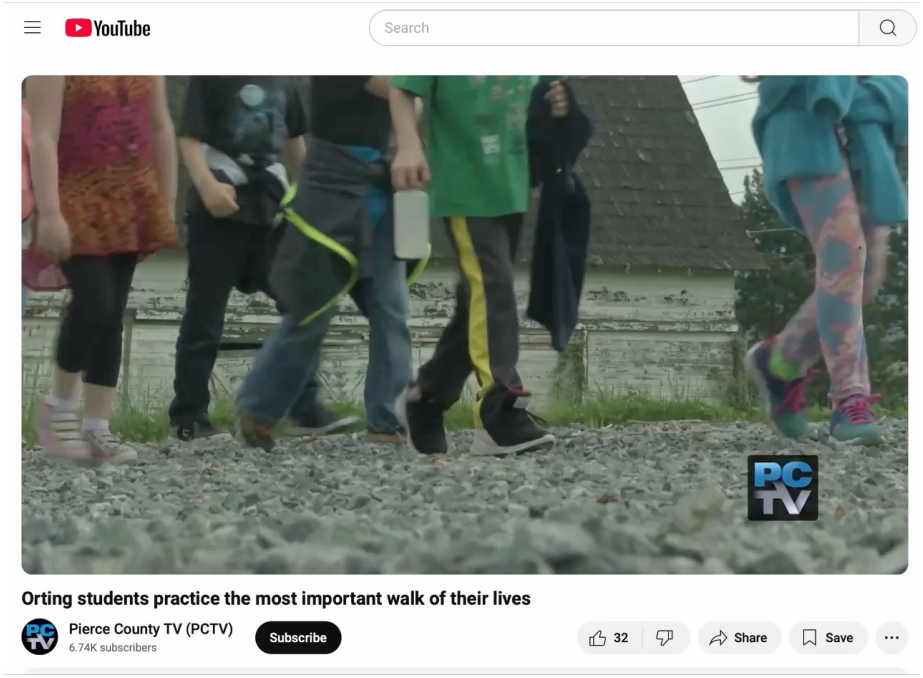


Based on modeling from George et al., 2022

School evacuation drills based on lahar scenario

- **Goal: Students reach high ground (2.2 miles) within 30-40 minutes (walking)**
- **2024 exercise: > 15,000 students walked**

2019 evacuation drill: City of Puyallup EOC



2019 evacuation drill: Students walking

Outreach and Community Engagement

2024 evacuation drill: Students walking [USGS]

Rainier Lahar Detection System

- Two-tiered system
  1. **Automated: Based on tripwires and seismometers**
     - Tripwires require physical trigger (~10 min after initiation)
     - Only on a single drainage
     - Very low false alarm rate
     - Direct to emergency managers
  2. **Scientist-Aided: Based on entire monitoring network of seismometers, infrasound, webcams**
     - Can remotely detect event on any drainage in ~1 minute
     - Higher false alarm rate
     - Must be verified by duty scientist

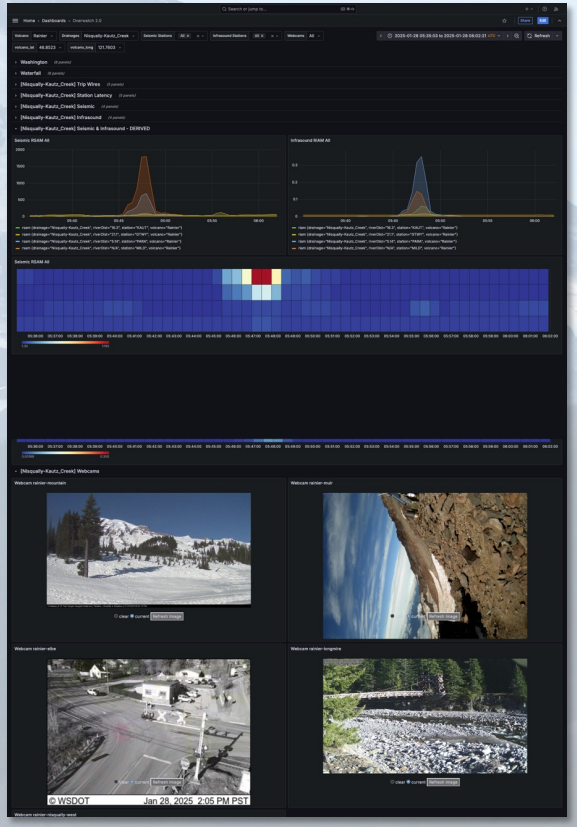


Image shows seismic data, infrasound data and webcams from the new dashboard.

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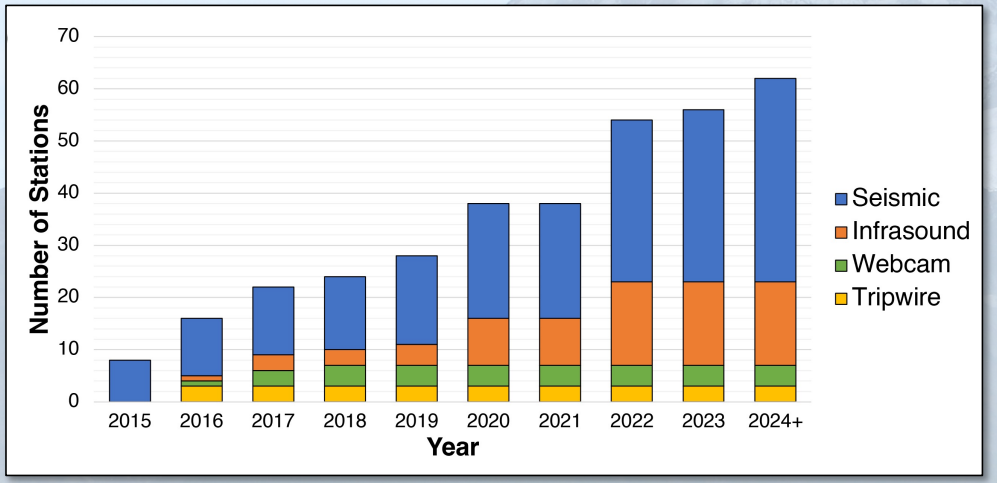
Challenges



Kramer et al., 2024

- Station maintenance
  - Equipment is hard to access (impossible in winter)
- 24/7 Staffing
  - USGS Volcano Science Center has no 24/7 capabilities
  - Requires duty scientists to be trained and on-call
- Vigilance
  - Low probability, high impact event
- Recordings of similar events on modern equipment are scare worldwide

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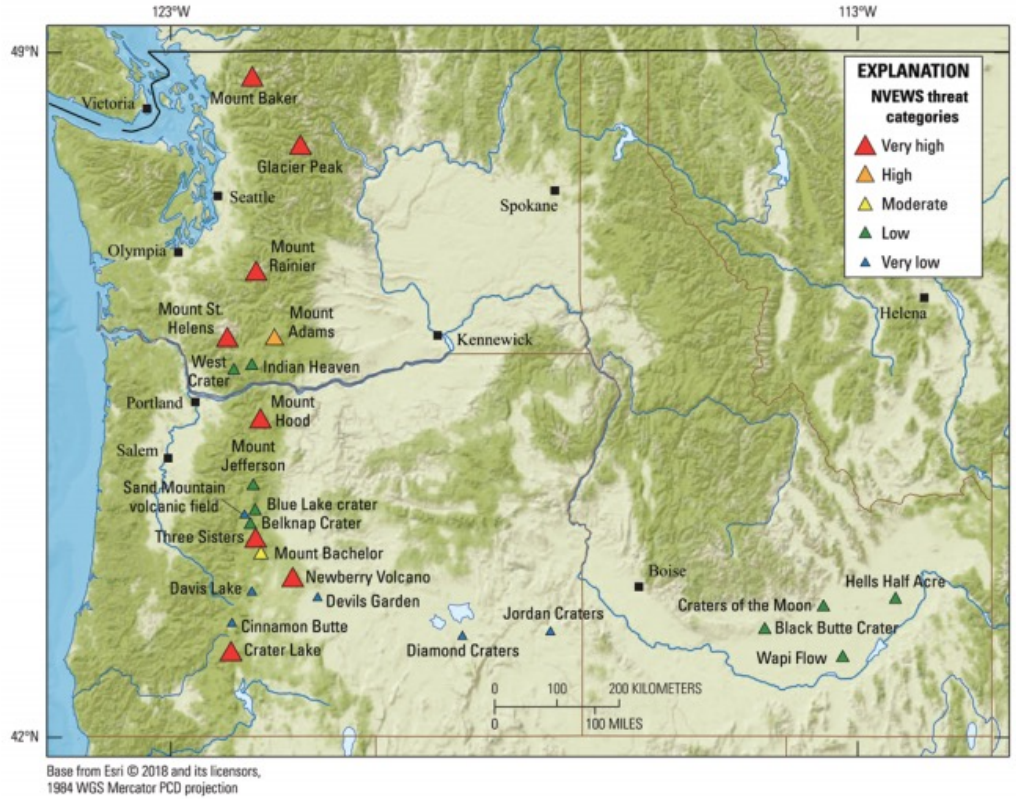
What you just learned.

1. Using USGS Threat Assessment as the basis for monitoring decisions. **Ongoing.**
2. Developing a National-Scale Volcano Hazard Layer as the Basis for Risk Products. **Nascent.**
3. Modeling lahar impacts as the basis for warning systems and evacuation plans. **Long-term, but prioritized and growing.**



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