
Alaska
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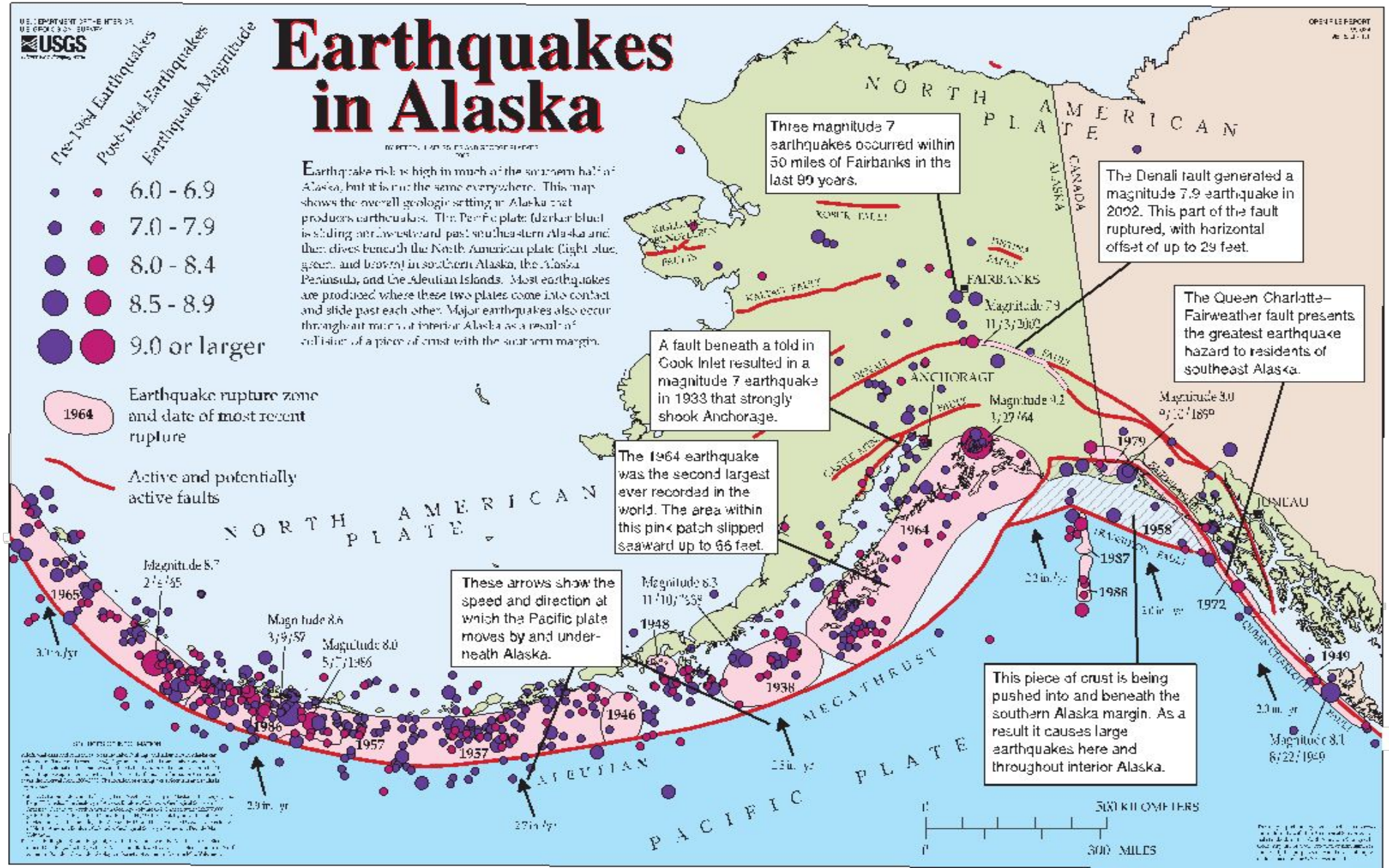
Big, Fast, Spatial Variations

- ***BIG*** earthquakes, volcanoes, glaciers, etc
- ***FAST*** rates of processes.
- ***SPATIAL VARIATIONS*** in *inputs* (subduction obliquity, sediment in trench, hydration of downgoing plate) and *outcomes* (interseismic slip deficit, seismicity in slab, creep behavior, volume flux and chemistry of magmatism)
- A high signal to noise ratio environment

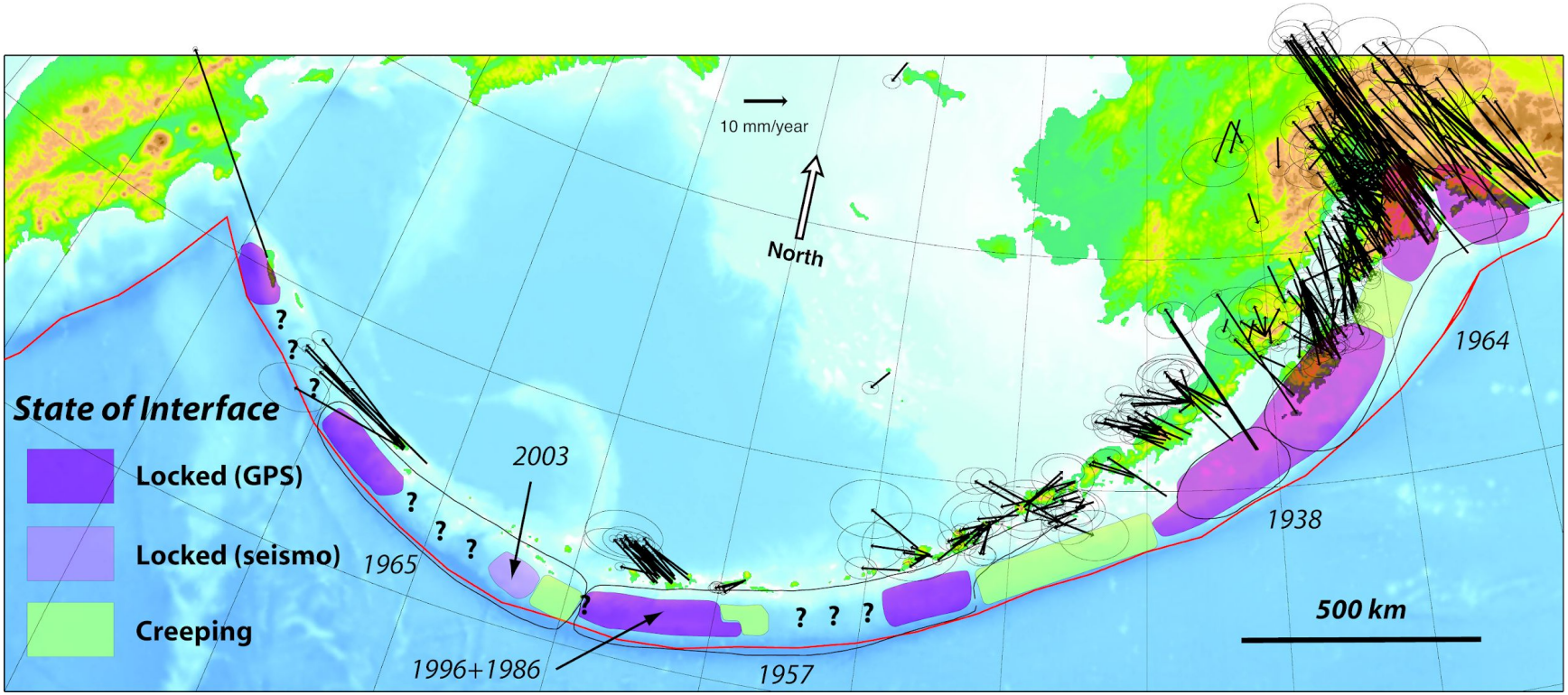
Key Advantages of Alaska

- **Faulting and Earthquake Cycles**: Large and great earthquakes within the instrumental record and likely in the future
  - We have quantitative information about patterns of coseismic and postseismic slip, interseismic creep/slip deficit, and slow slip events
- **Magmatic Drivers of Eruption**: Eruptions at a wide variety of scales, highly varied volcanic behavior
- **Landscapes & Seascapes**: Although sparsely studied, there are many landslides, rapid erosion and exhumation, large amounts of sediment mobilized.

Earthquakes and Tectonics



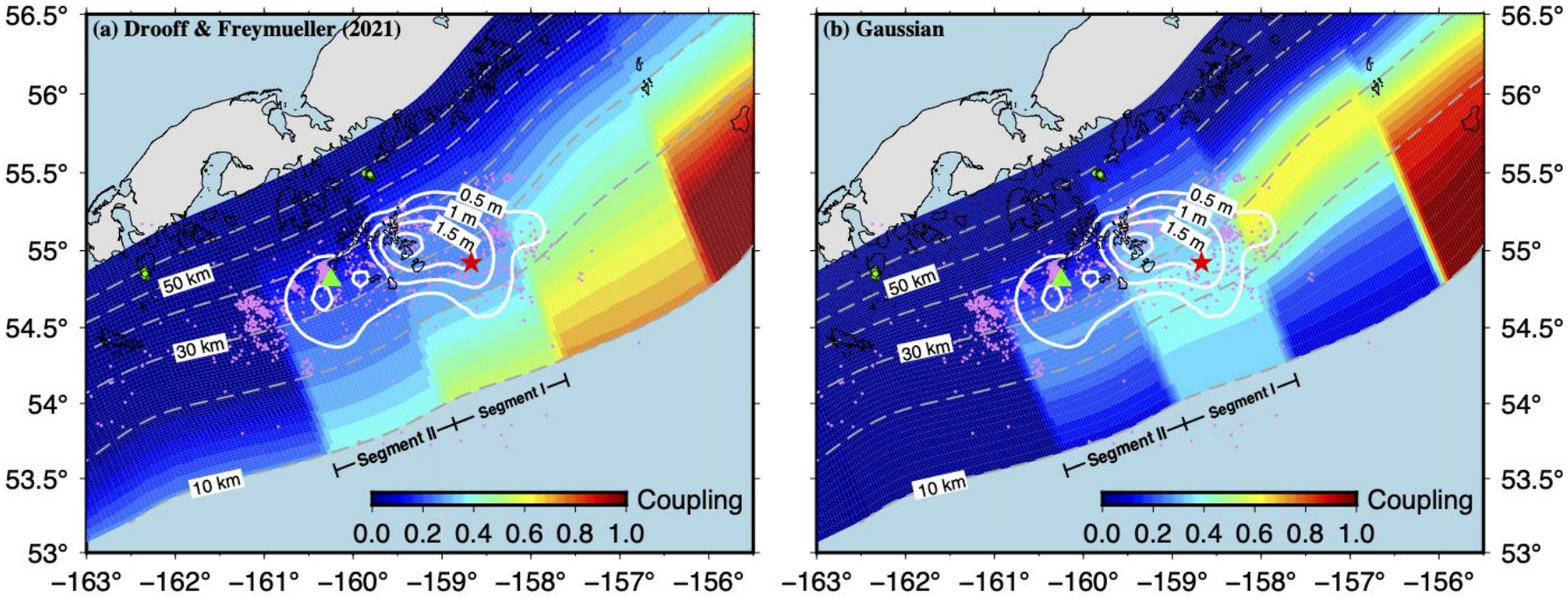
Interseismic Slip Deficit Constraints



Freymueller et al. (2008)

Simeonof Earthquake (July 2020)

M7.8 megathrust earthquake

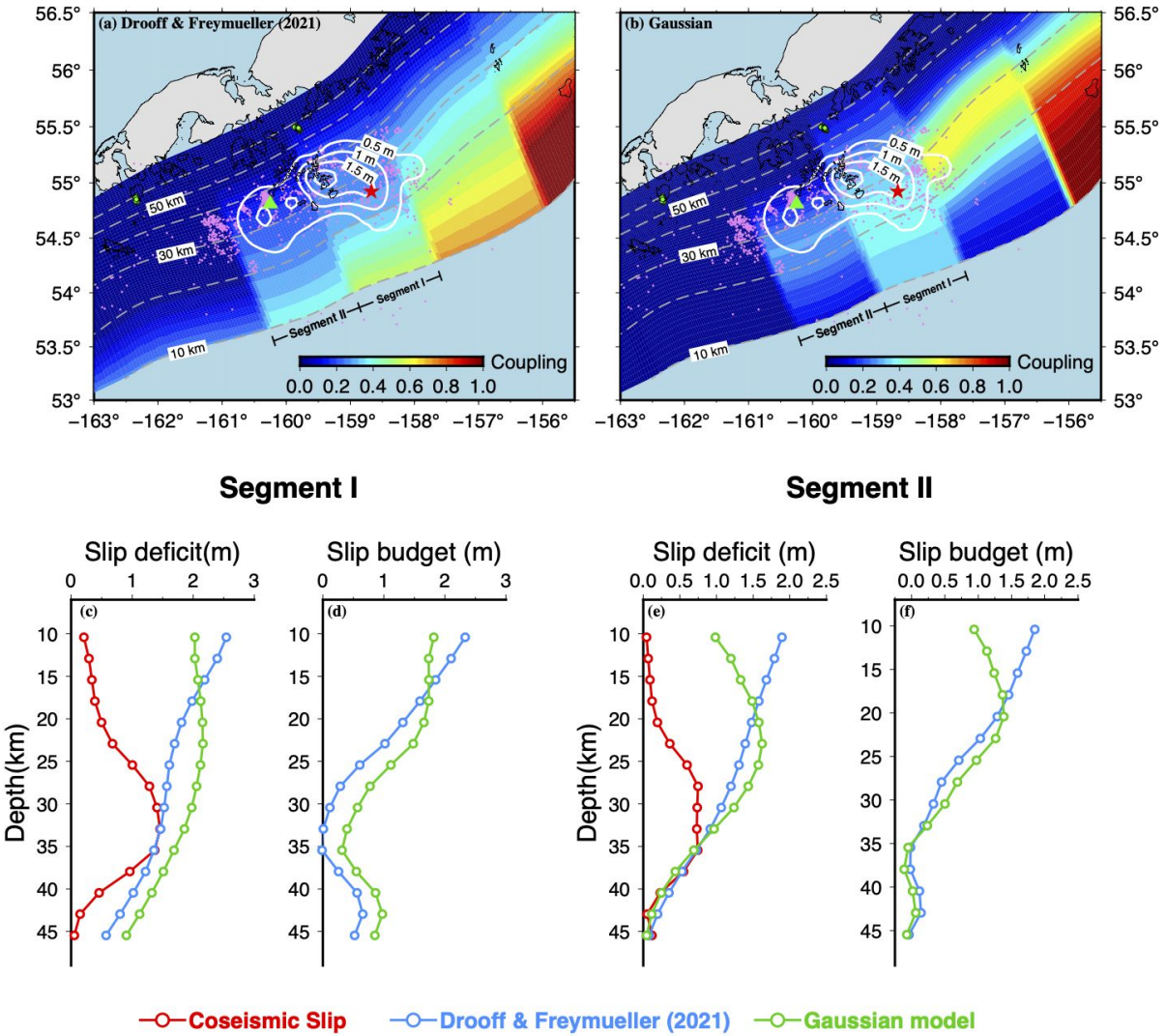


Coseismic slip did appear to change at the interseismic segment boundaries

Xiao et al. (2021)

Simeonof Earthquake (July 2020)

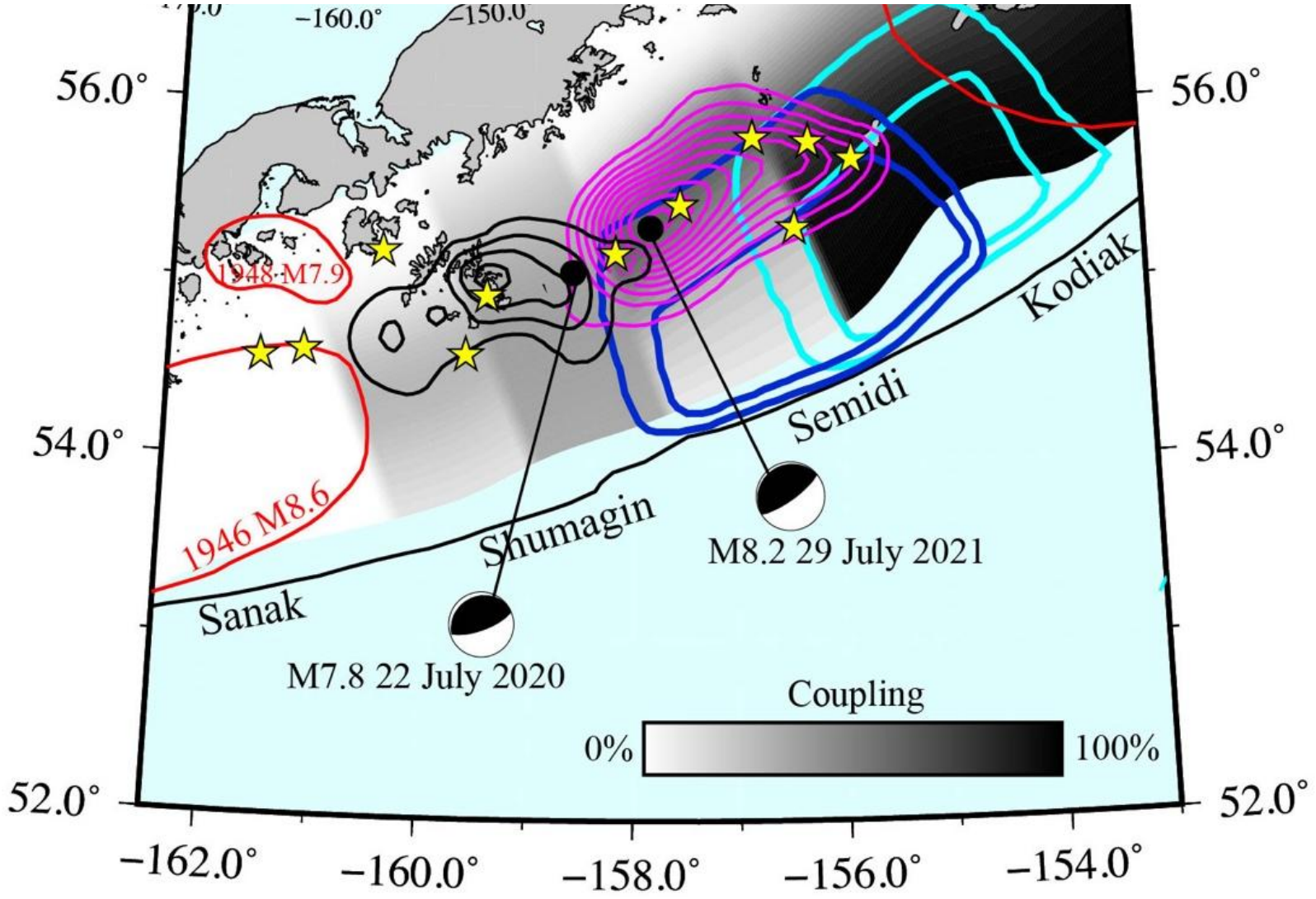
Slip Budget



- All slip deficit released below ~30 km
- Room for a similar-sized earthquake shallower

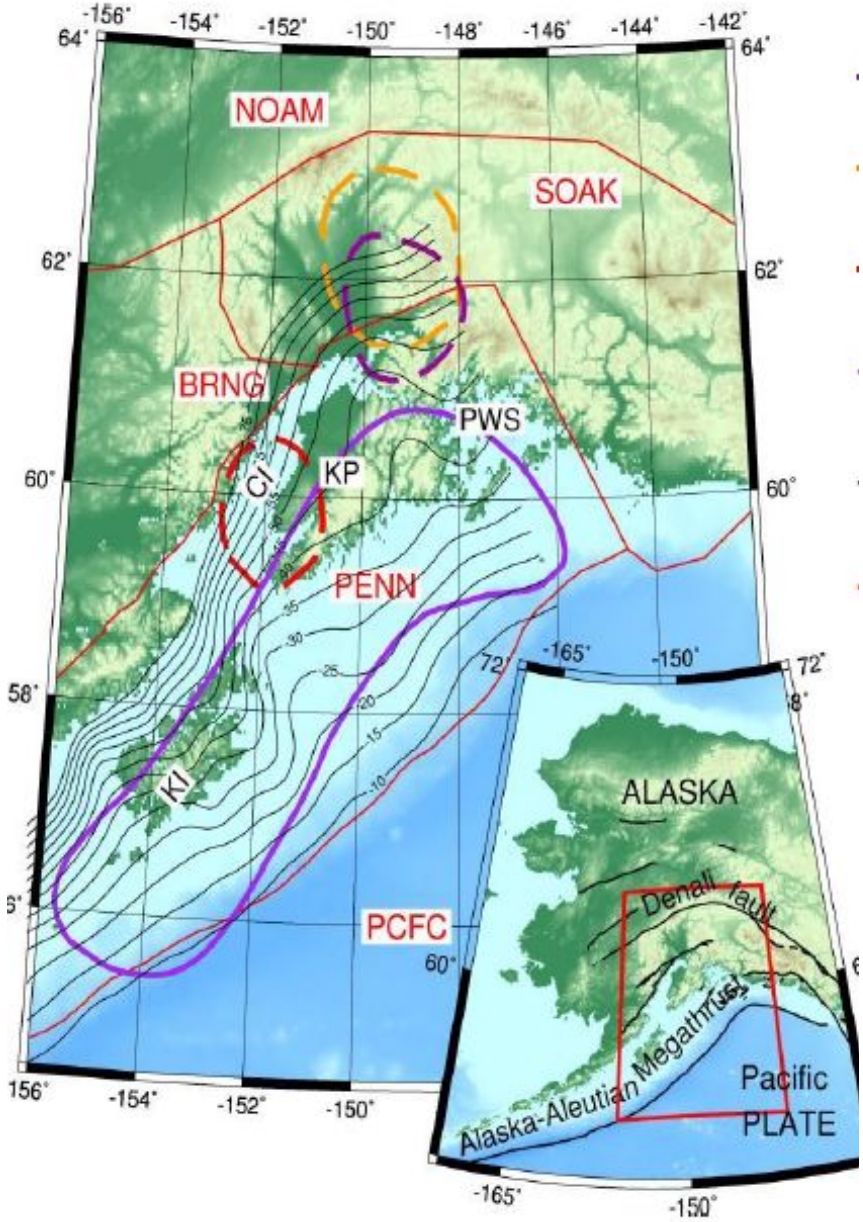
Xiao et al. (2021)

2020-2021 and 1938



Elliott et al. (2022)

Slow Slip Events



- Multiple slow slip events have been observed downdip of the 1964 earthquake (M9.3) rupture zone.
- SSE durations 2-9+ years.
- Equivalent magnitudes as large as M7.8
- Other segments appear to have a lack of SSEs

Li et al., (2016)

Eruptive Volcanism

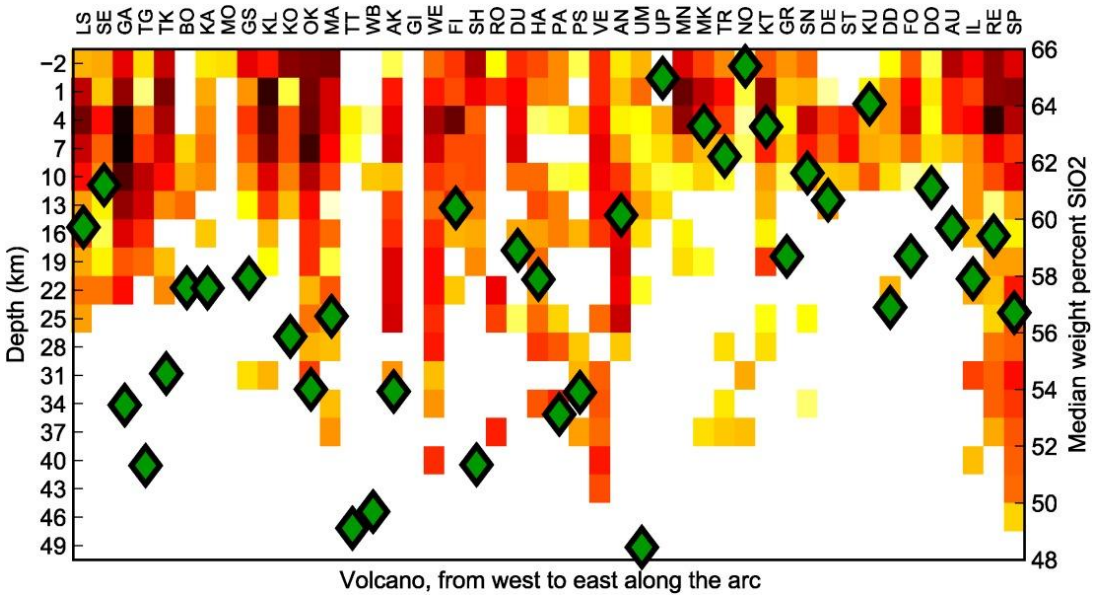
- Roughly 2 eruptions/year, plus a few per year showing unrest
- “Open system” volcanoes such as Pavlof, Cleveland
- Large calderas (e.g., Aniakchak, Fisher, Okmok), many of which were ~size of Mt. Veniaminof (~20-25 km diameter at base, ~2500 m)

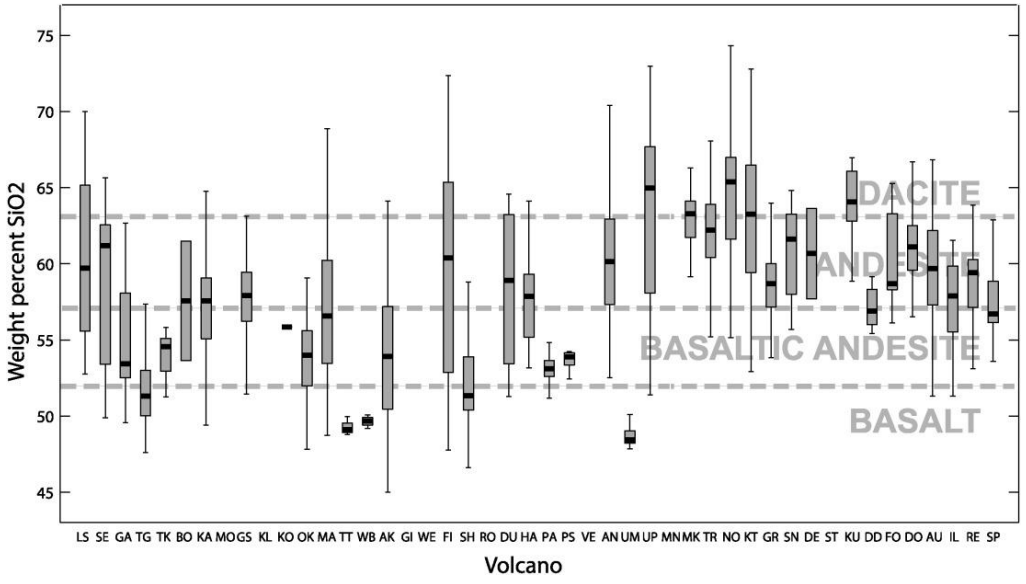
USGS Photo (Augustine)

Variation in Seismicity, Chemistry

WEST

EAST





- The depth of volcanic earthquakes varies systematically along the Aleutian arc
- Volcanic earthquake depths and SiO_2 show similar along-arc trends
- Regional subduction processes control volcanic activity

Buurman et al., (2014)

Eruptions 2005-2021

CLEVELAND

- 2005
- 2006
- 2007
- 2009
- 2009
- 2010
- 2010
- 2011
- 2013
- 2014
- 2016
- 2016
- 2017
- 2019
- 2020

VENIAMINOF

- 2005
- 2005
- 2006
- 2008
- 2009
- 2013
- 2018
- 2021

PAVLOF

- 2007
- 2013
- 2014
- 2014
- 2016
- 2021

SHISHALDIN

- 2008
- 2008
- 2009
- 2014
- 2019

GREAT SITKIN

- 2017
- 2018
- 2019
- 2021

SEMISOPOCHNOI

- 2018
- 2019
- 2021

AUGUSTINE

- 2005

ATKA VOLCANIC COMPLEX

- 2005

FOURPEAKED

- 2006

OKMOK

- 2008

KASATOCHI

- 2008

REDOUBT

- 2009

KANAGA

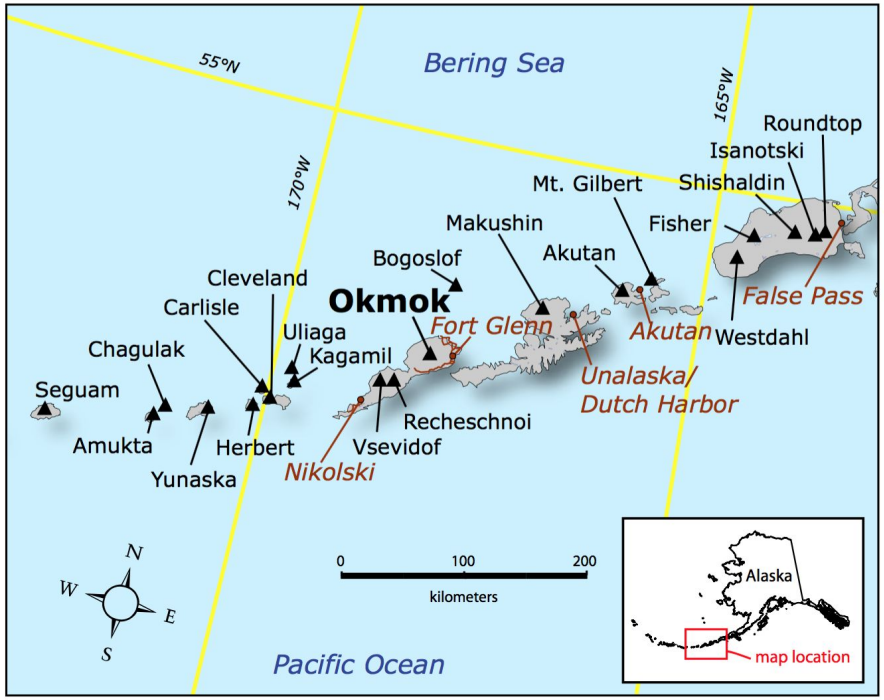
- 2012

BOGOSLOF

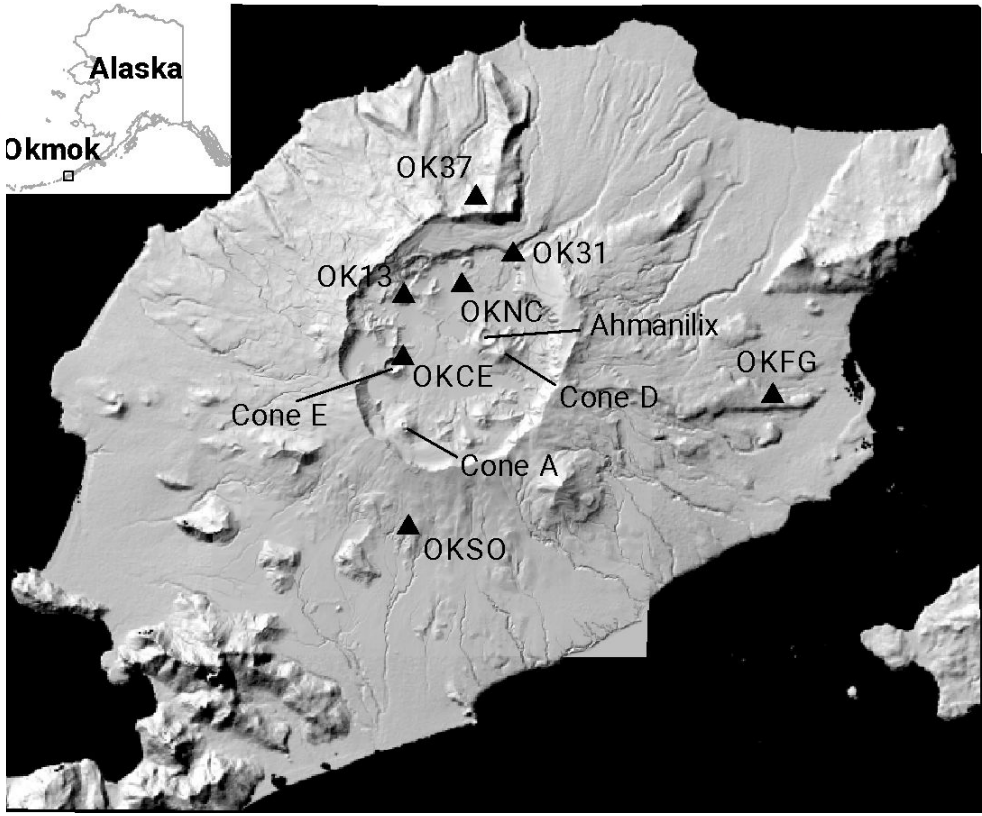
- 2016

Alaska Volcano Observatory
www.avo.Alaska.edu

Post-eruption deformation at Okmok volcano, Alaska



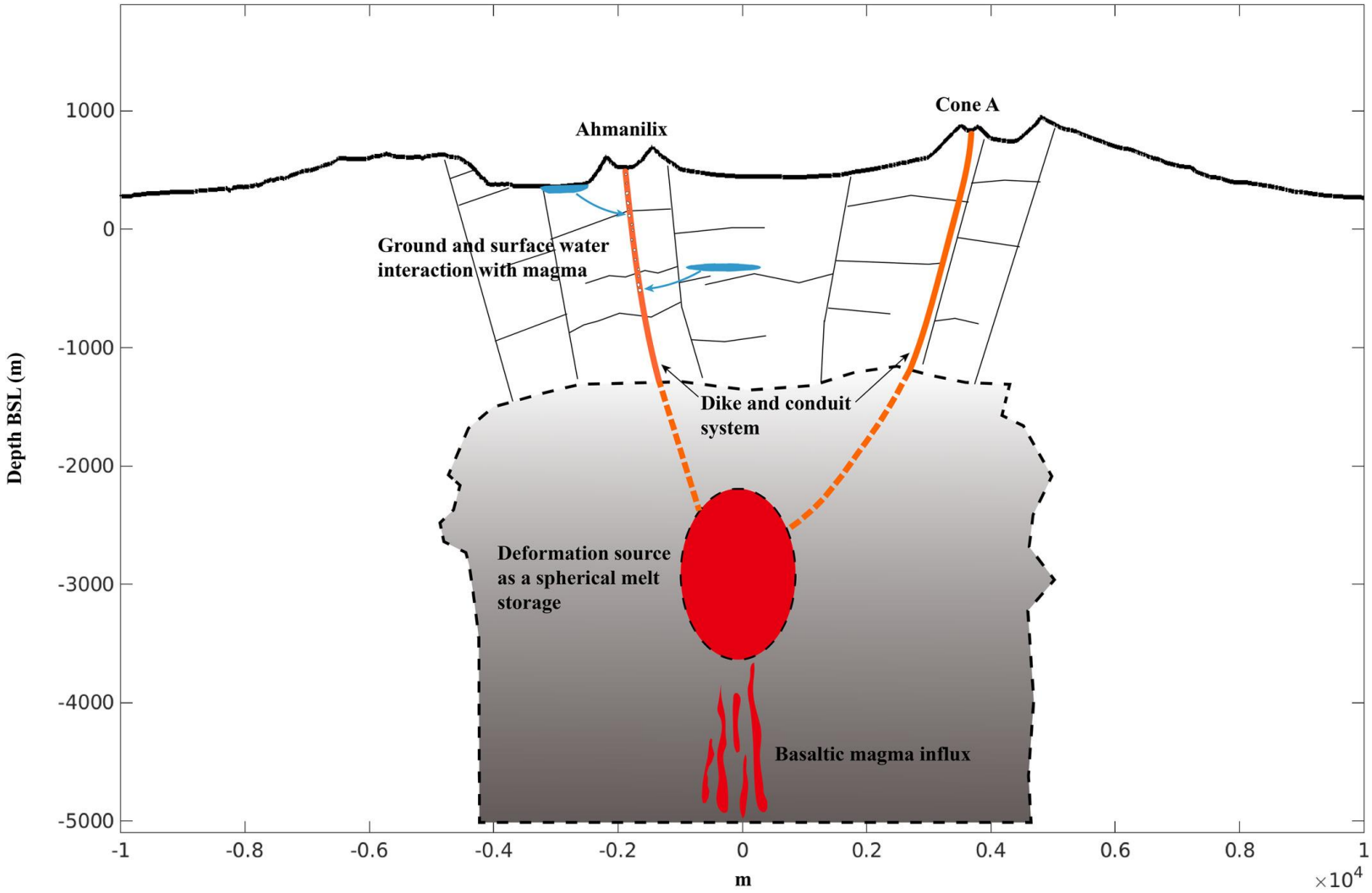
Larsen et al. 2015



10 km

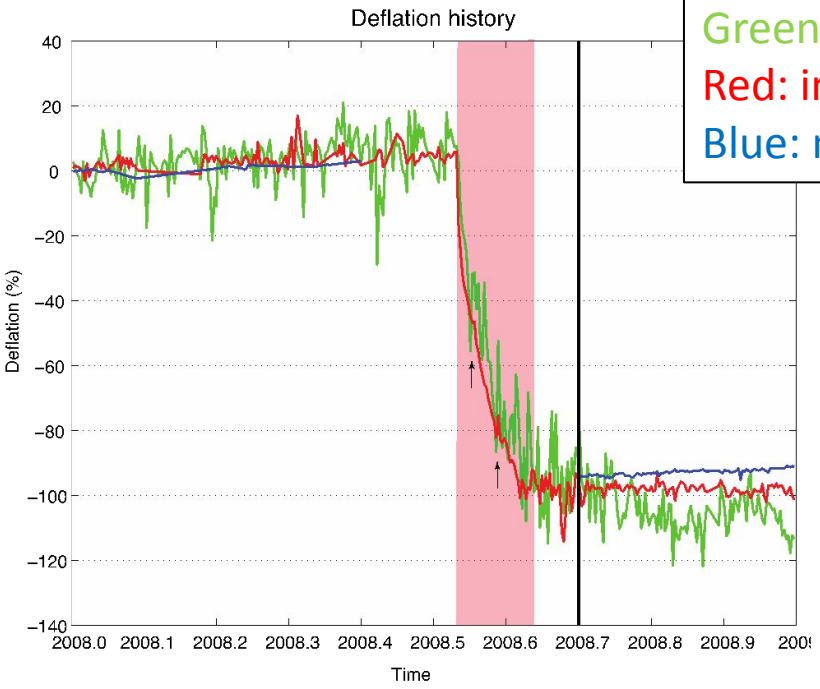
Okmok 2008 Eruption Deposits

Okmok Interpreted Structure



Wang et al. (2021)

Okmok Deflation and Inflation

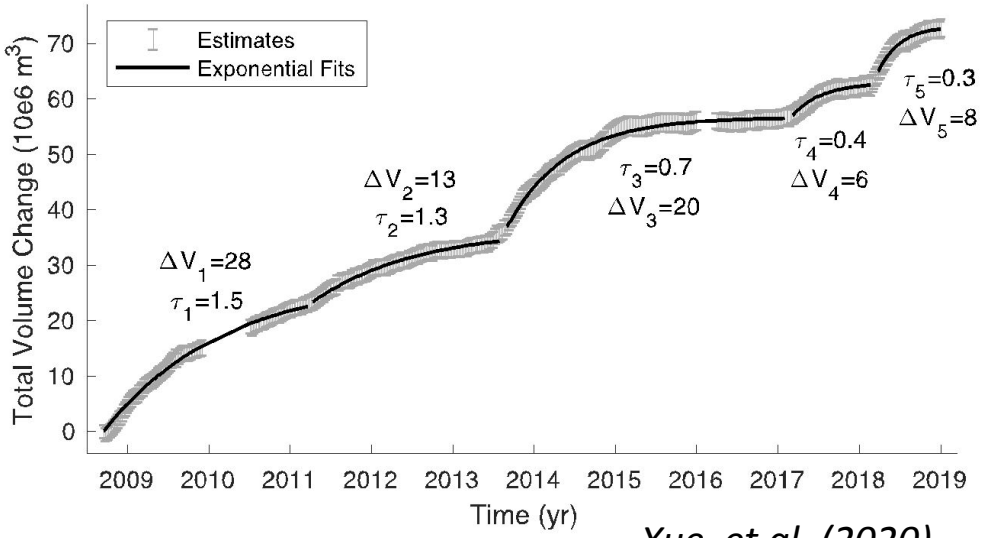


Green: far field site
Red: intermediate-field
Blue: near field (data gap)

Freymueller and Kaufman (2010)

Multiple exponential inflation episodes.

- The inflation decays exponentially, $\Delta V \cdot (1 - \exp(-t/\tau))$
- The time scale τ decreases in time

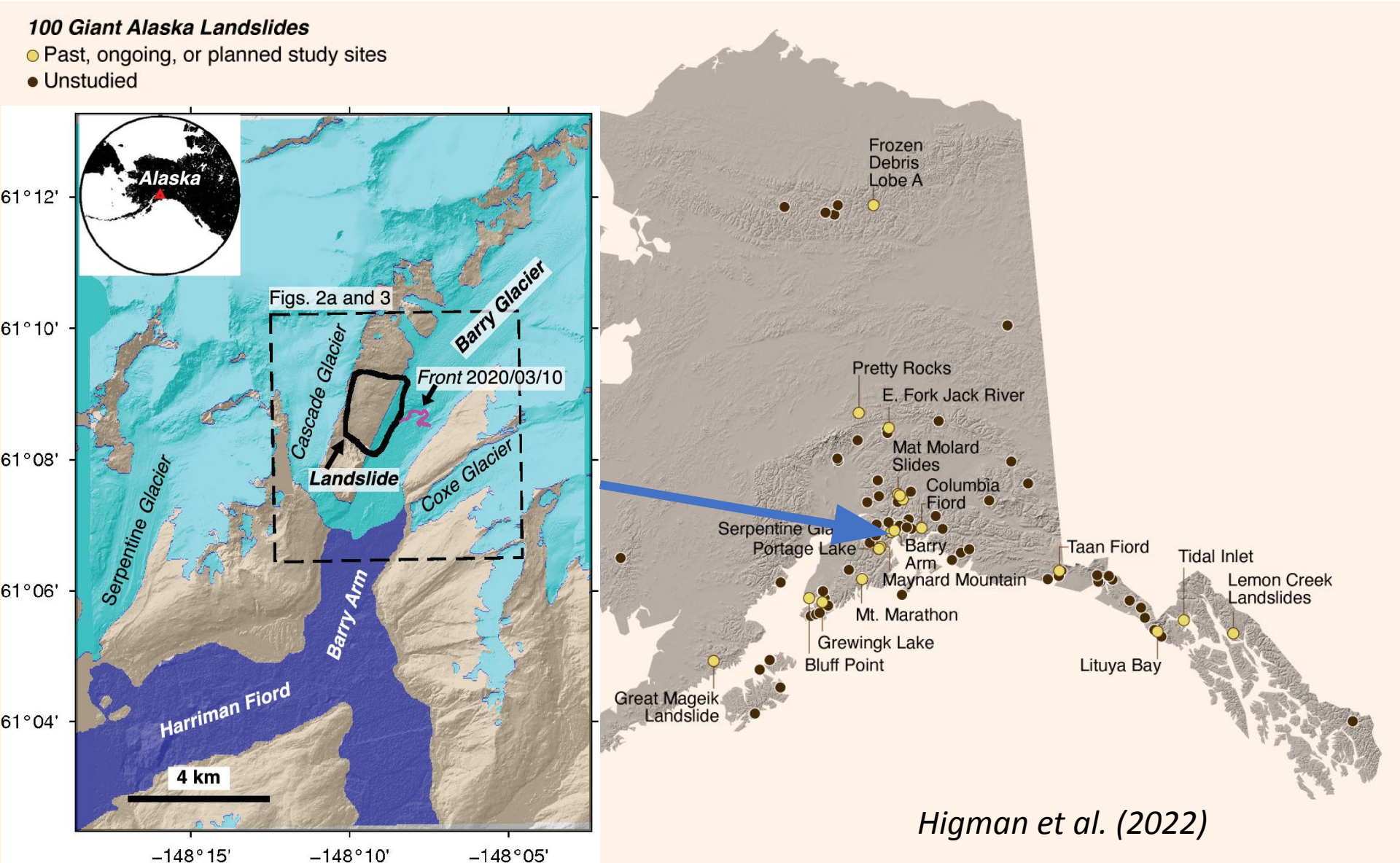


Xue et al. (2020)

Landscape Processes

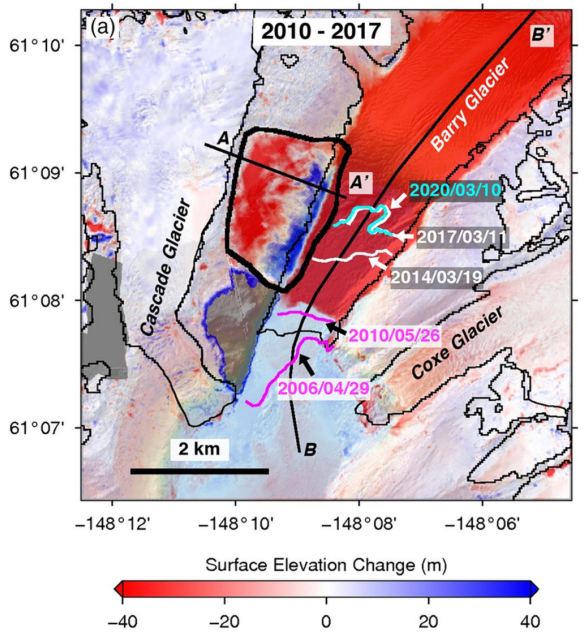
Copper River Delta (personal photo) Suspended sediment load has been measured as high as 1800 mg/liter (e.g., Phalen, 2013), annual sediment load ~70 million tons.

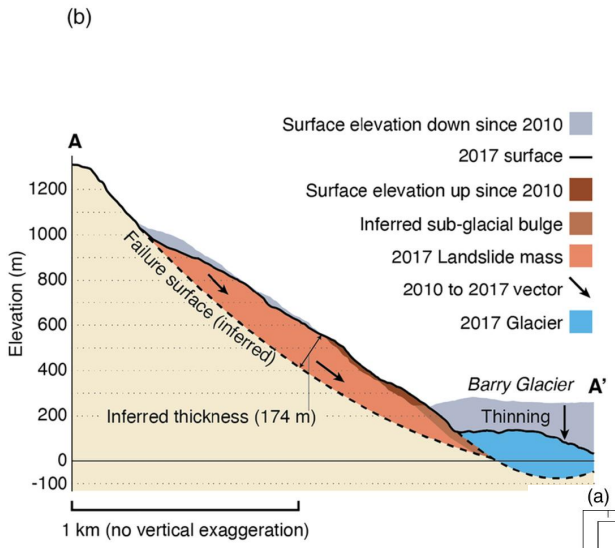
Large Landslides

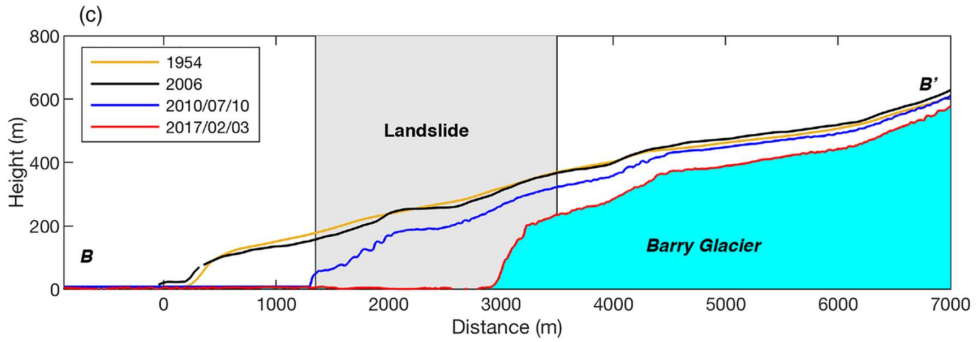


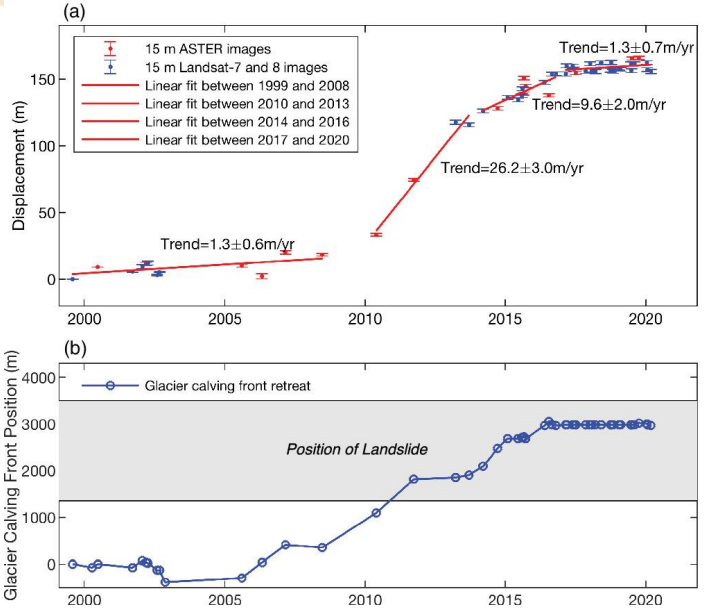
Higman et al. (2022)

Barry Arm Landslide









- Landslide rapidly accelerated immediately after glacier retreated
- Now monitored due to hazard (possible tsunami), rate has varied since 2020

Dai et al. (2020)

Volcanic Sediment

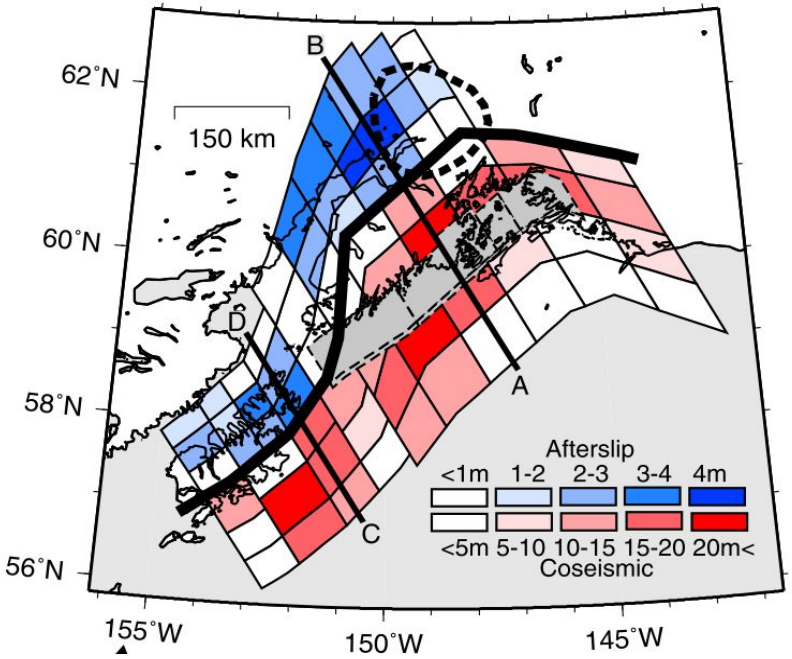
Examples near Perryville, Alaska Peninsula

- Series of beach ridges
- Large volumes of clastic volcanic sediments from Veniaminof Volcano

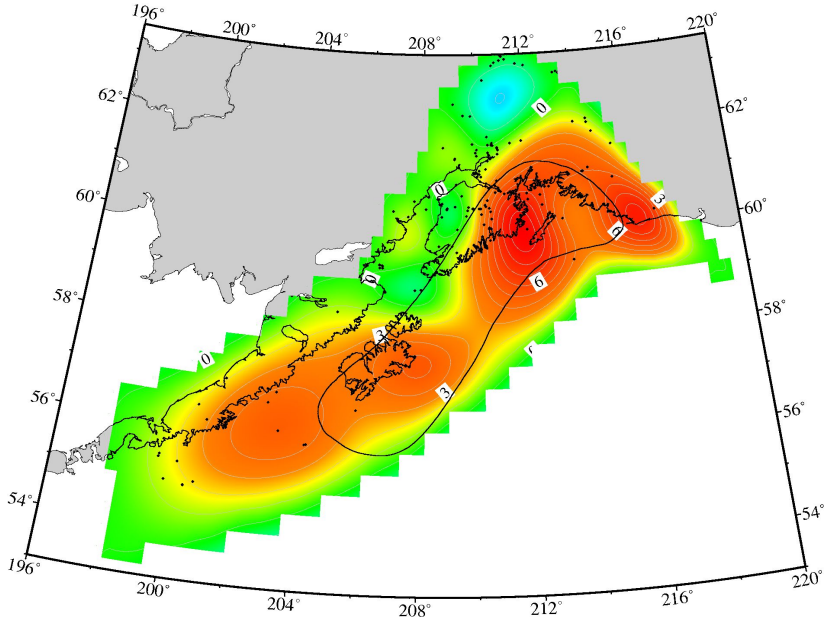
Any Time for Questions?

1964 Slip Models

Coseismic

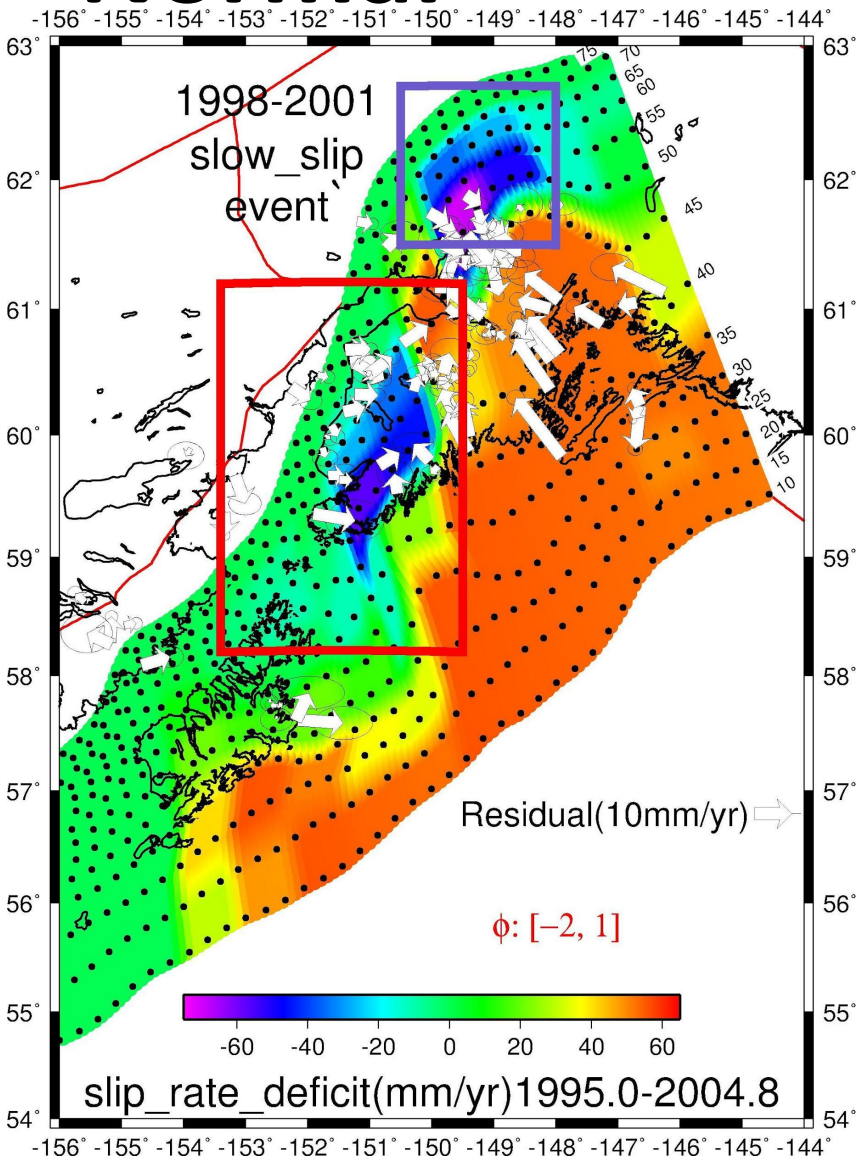


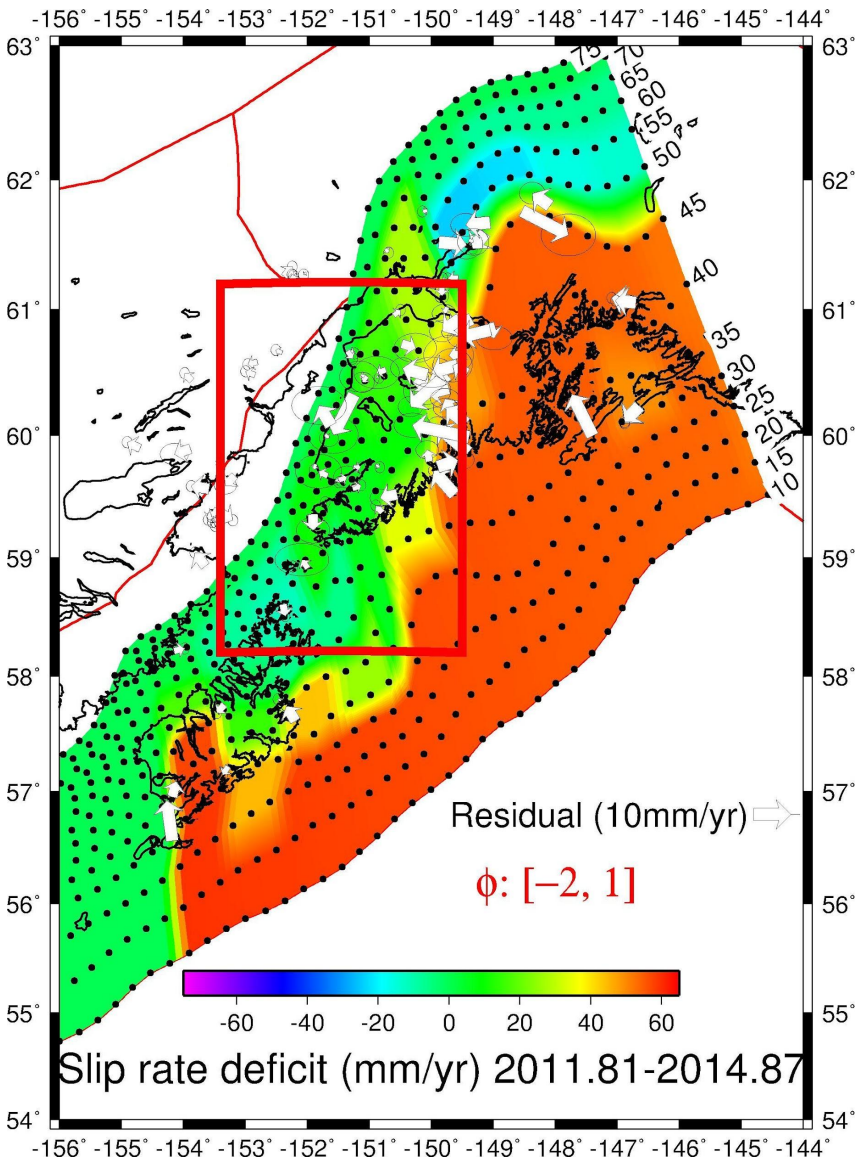
Present-day (interseismic)



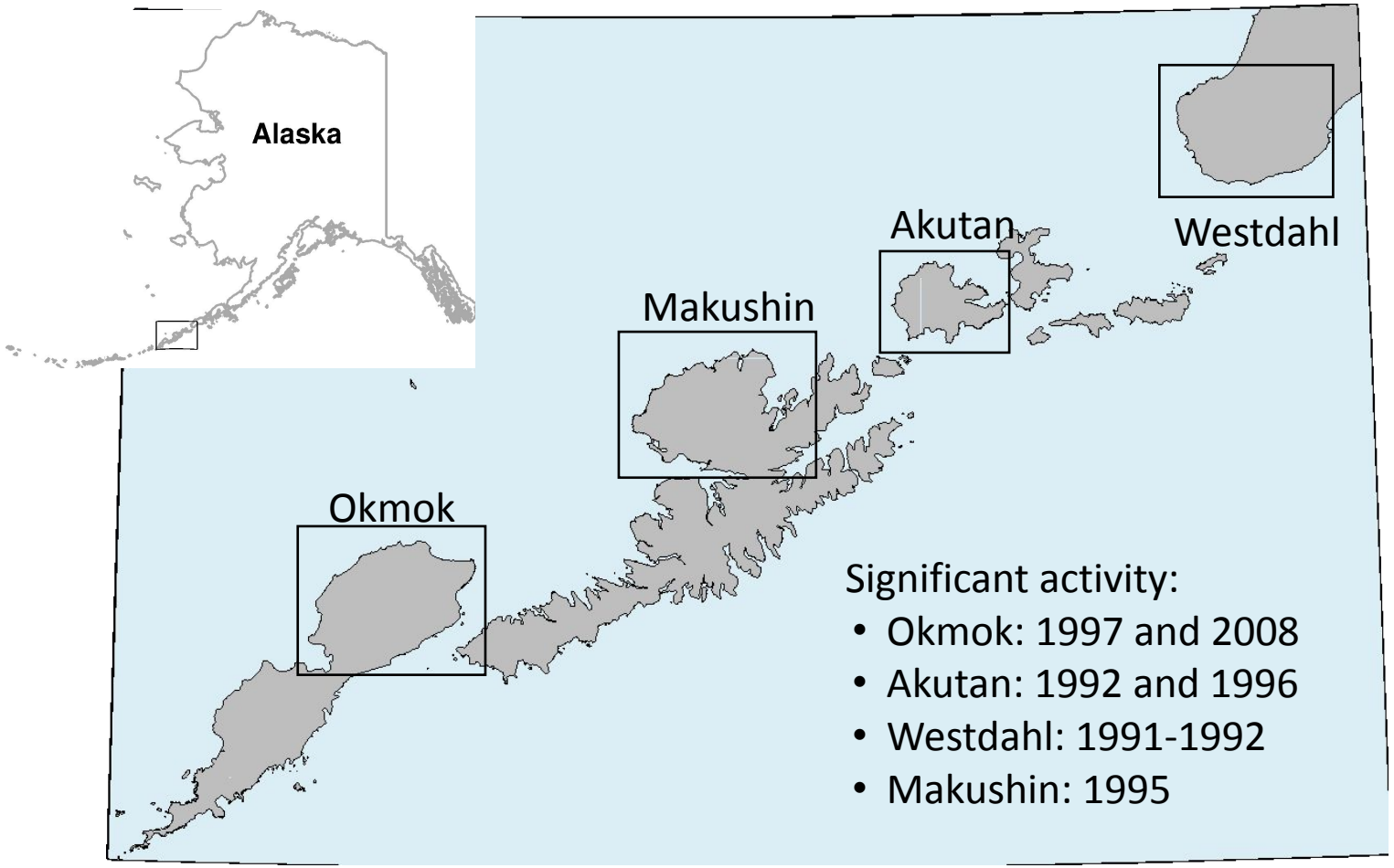
Suito and Freymueller (2009)

Slip Distribution of SSE vs Normal





Eastern Aleutian Arc



Xue et al. (2020)
Xue and Freymueller (2020)

Some Key Questions/Contradictions

- 1946 Tsunami earthquake