Sediment supply in a muddy river draining a crumbly volcano

Allison Pfeiffer, Western Washington University

SC^2 Climate Dialogue Series

June 2022

Land acknowledgement

Nooksack, Lhaq'temish (Lummi), and Sah-ku-méhu (Sauk-Suiattle)

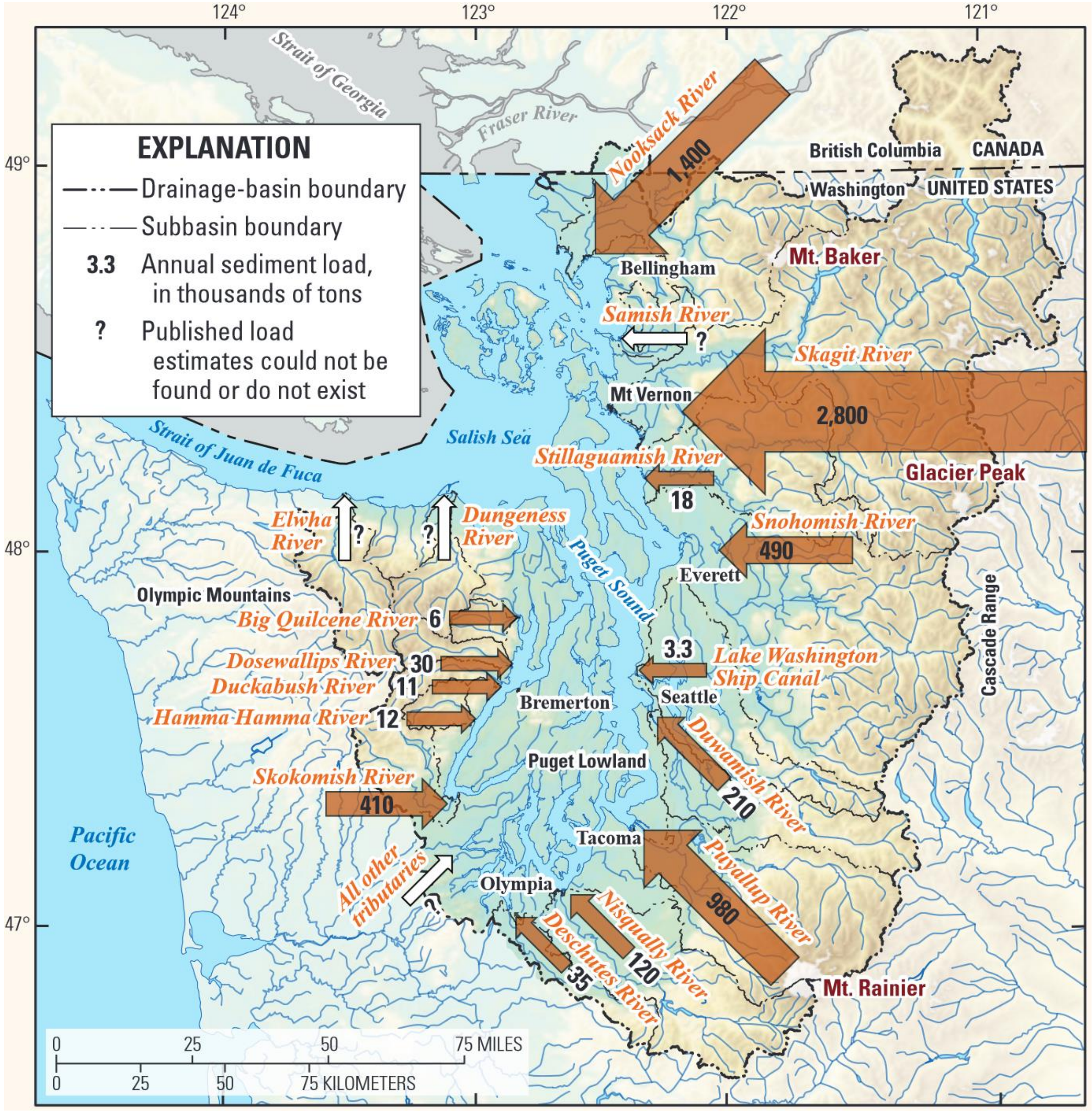
Ed Fordham, MS WWU

Andy Bunn, WWU Esci

Stephen Novak, WWU

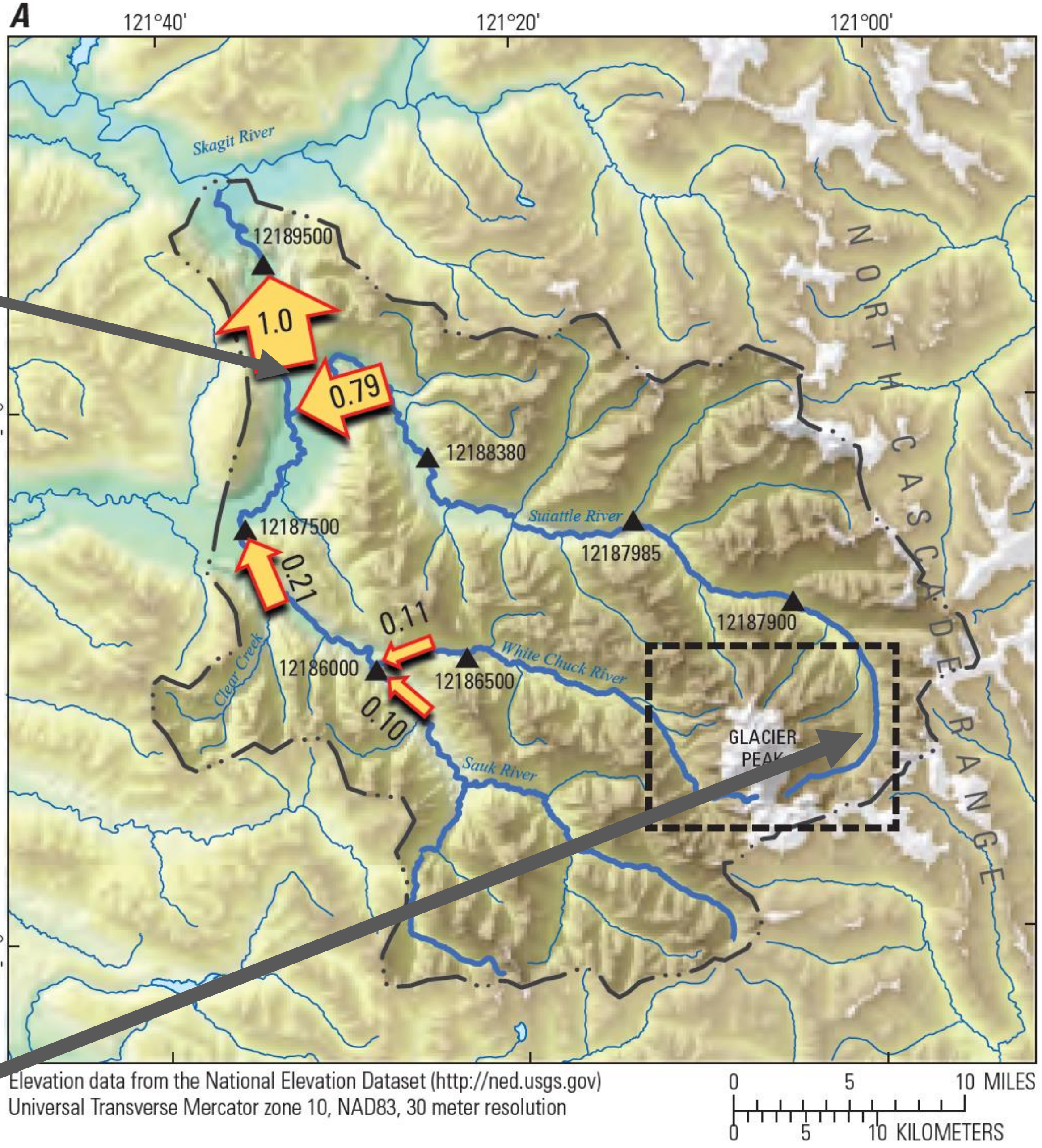
Sediment contributions to the lower Salish Sea

Skagit dominates, despite dams on all but 1 major tributary



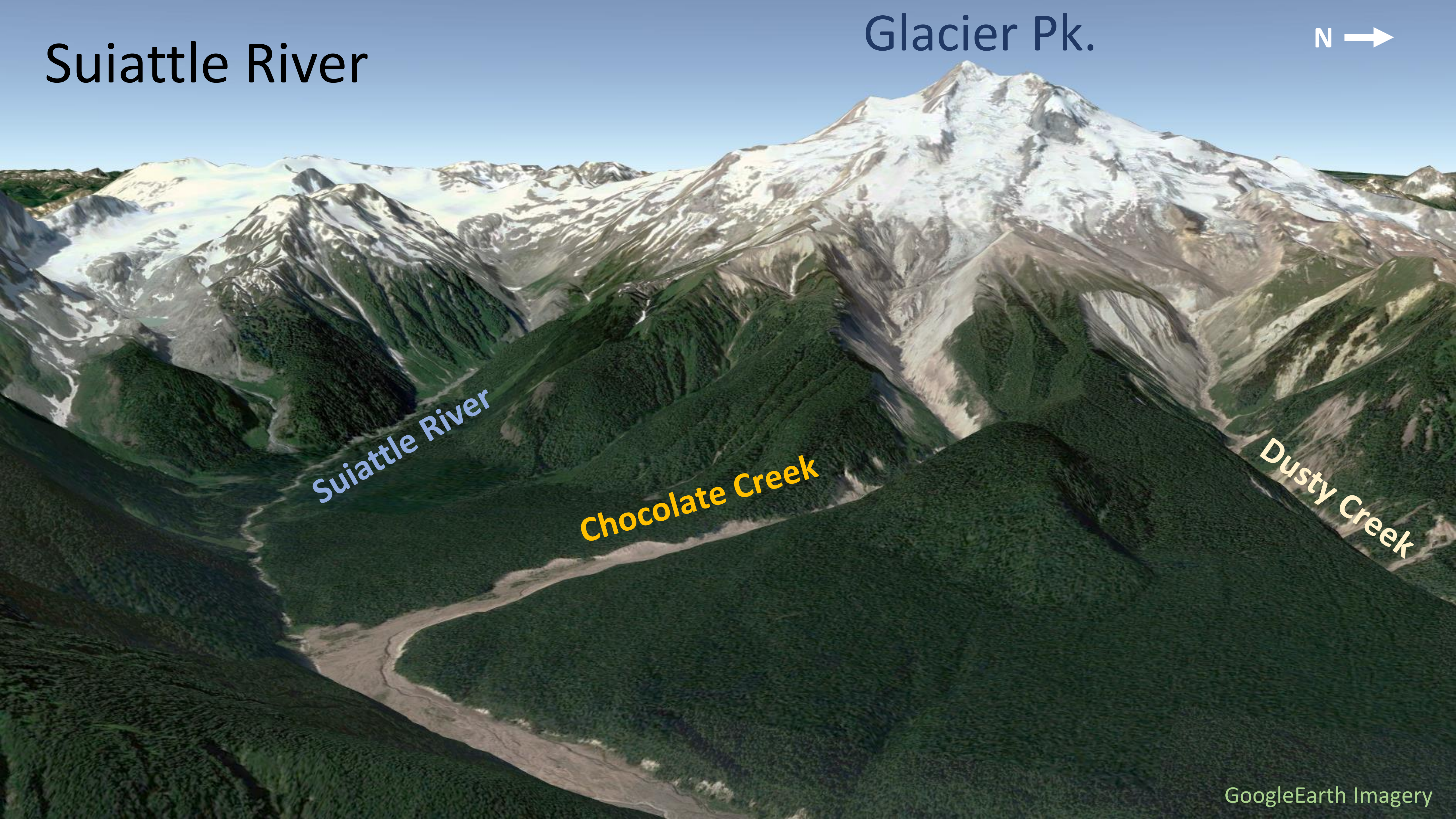
Czuba et al. (2011)

Upper Suiattle: major sed contributor to Skagit

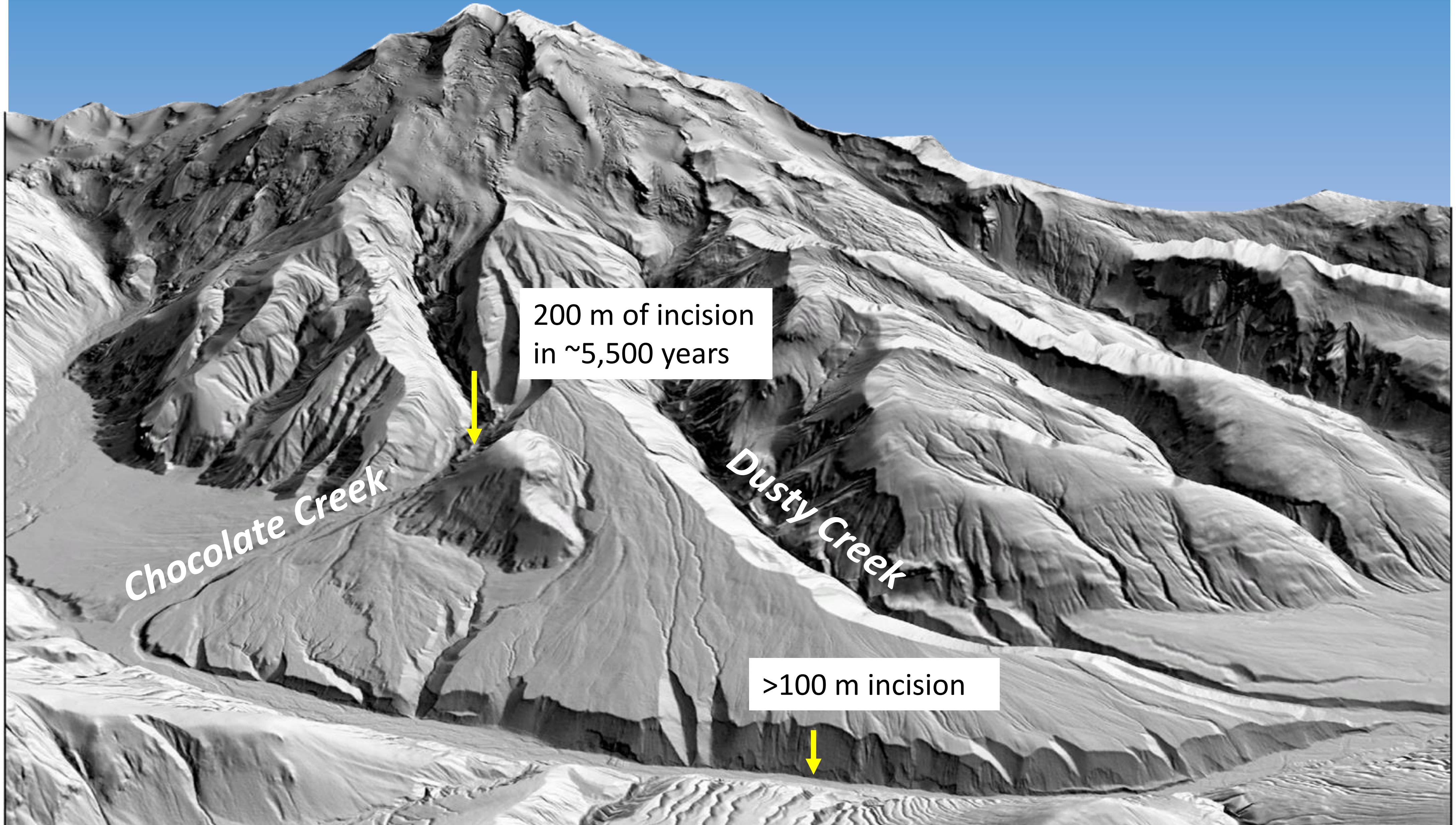


Jaeger et al. (2017)

Suiattle River



Geologic and Geomorphic Setting



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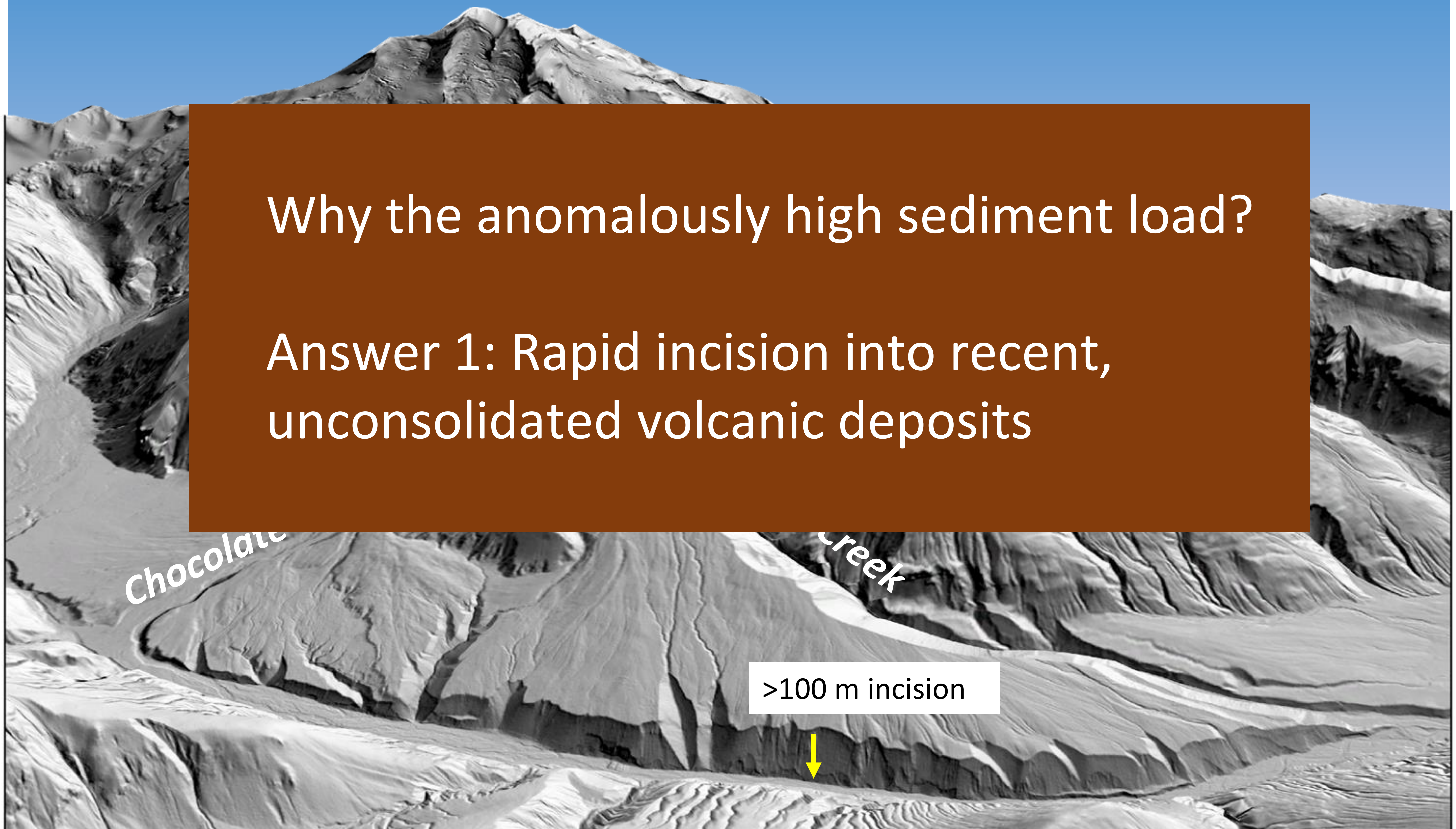
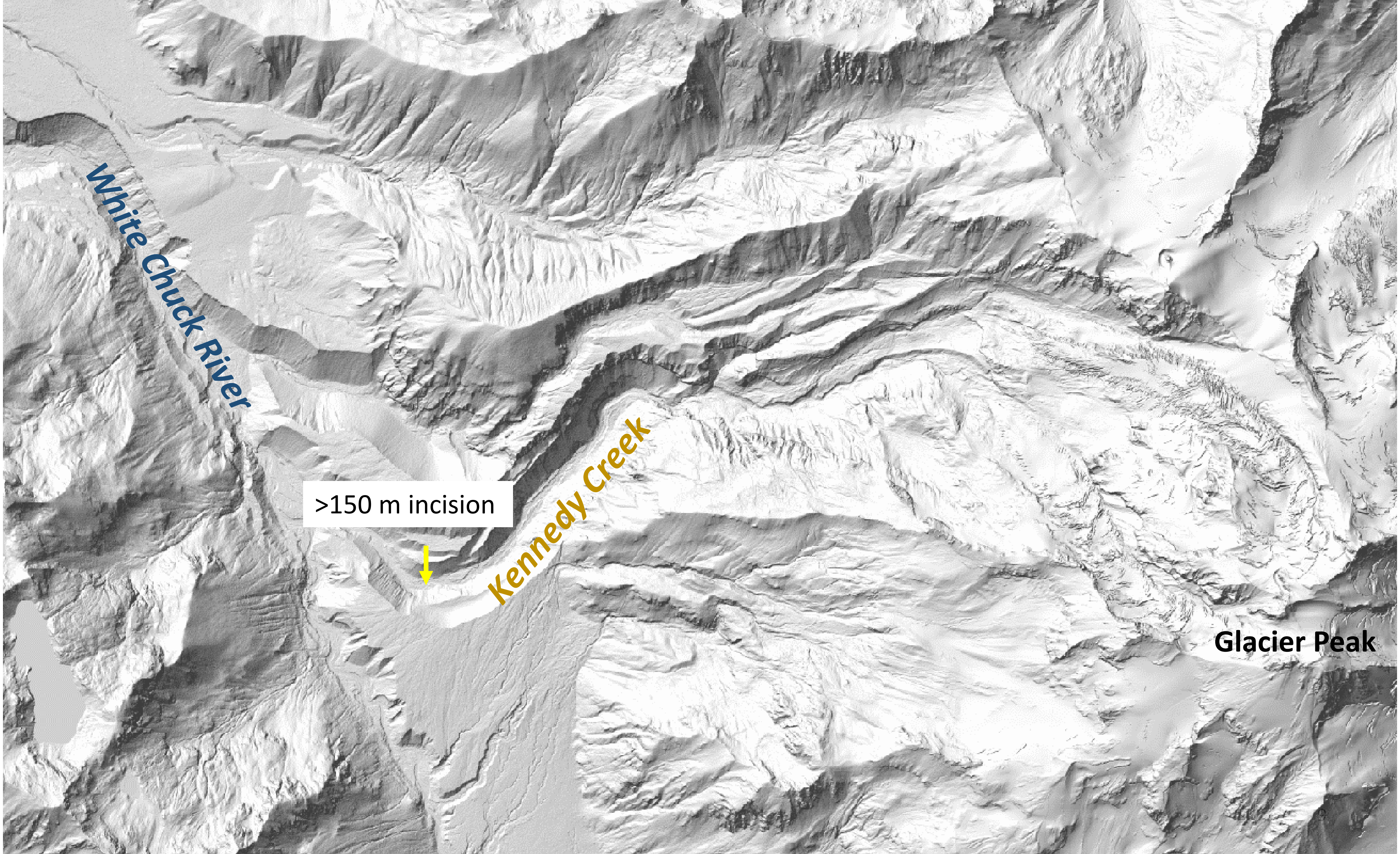
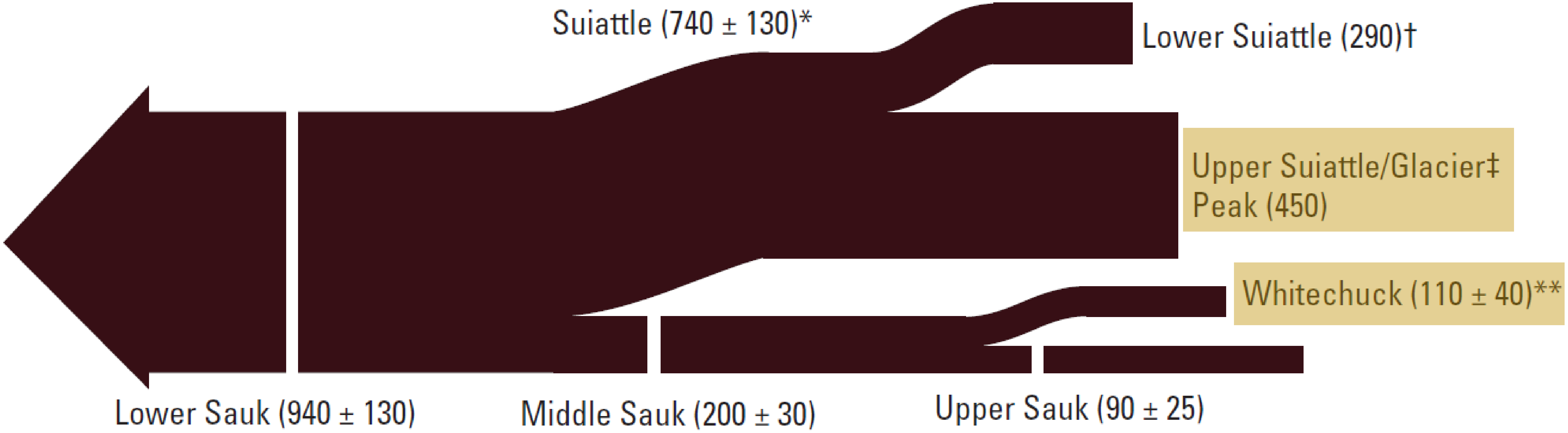


Why the anomalously high sediment load?

Answer 1: Rapid incision into recent, unconsolidated volcanic deposits

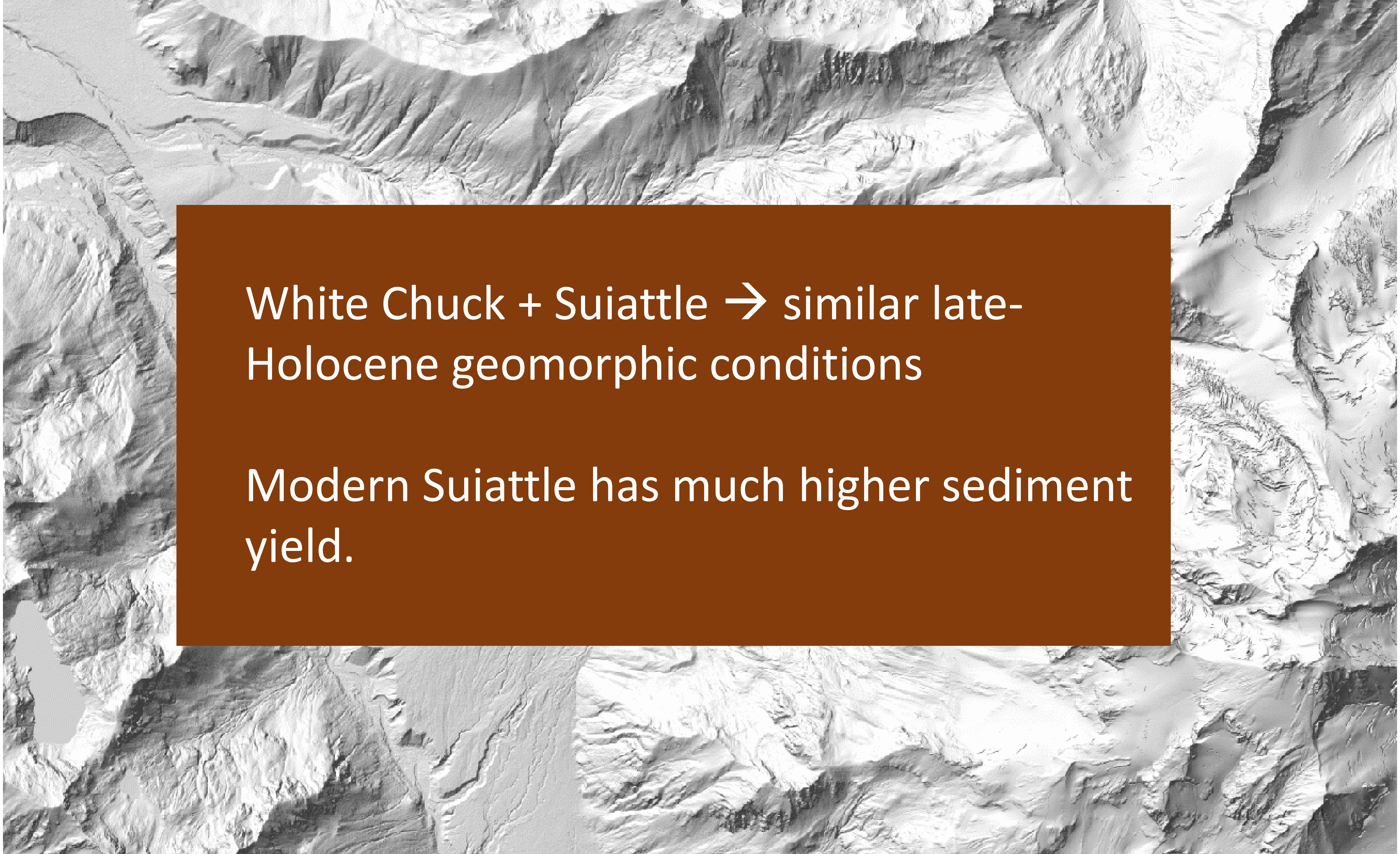

White Chuck River
>150 m incision
Kennedy Creek
Glacier Peak

Sediment budget of Sauk River (2012-2016)



Mean annual SSL, thousand metric tons

Jaeger et al. (2017)



White Chuck + Suiattle → similar late-Holocene geomorphic conditions

Modern Suiattle has much higher sediment yield.

What is known:

There are big debris flows and little ones coming out of Chocolate and Dusty Creeks.

Ford (1959), Slaughter (2004), Jaeger et al. (2017)

Remaining questions:

How often do debris flows occur? Have they always happened?

What are the triggers?

Suiattle debris flows: a recent phenomenon?

Photo: Willhiteweb.com (WA Fire Lookouts)

Suiattle debris flows: a recent phenomenon?

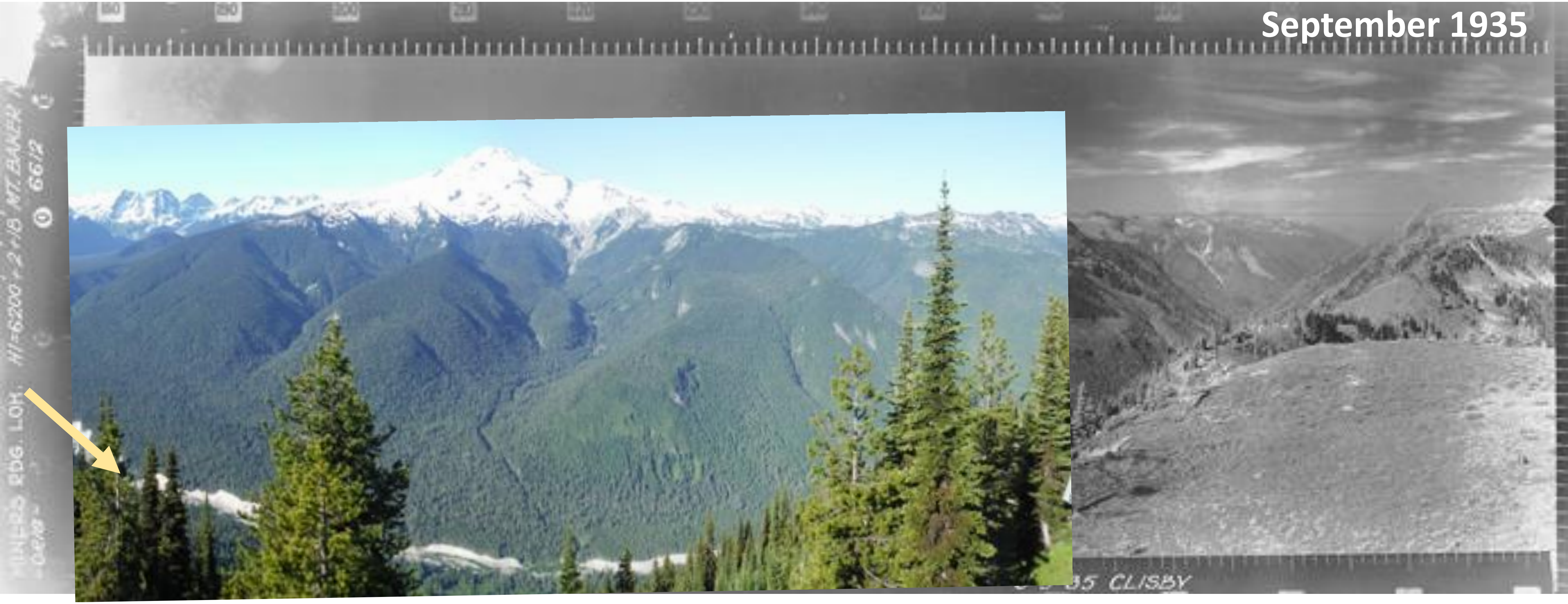
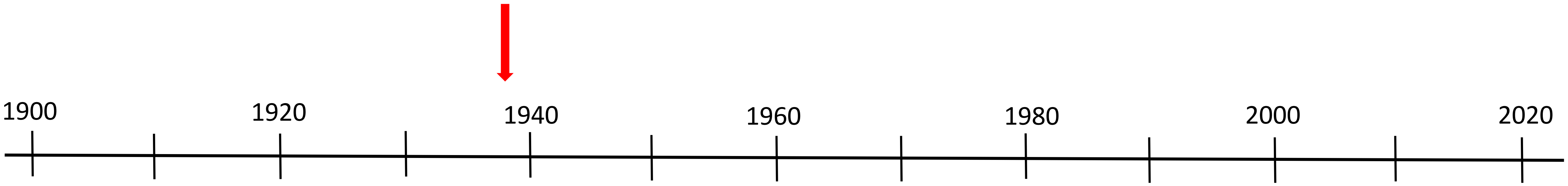
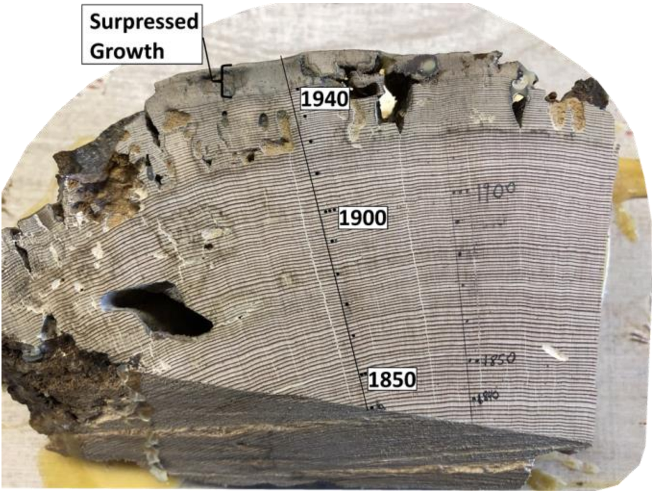


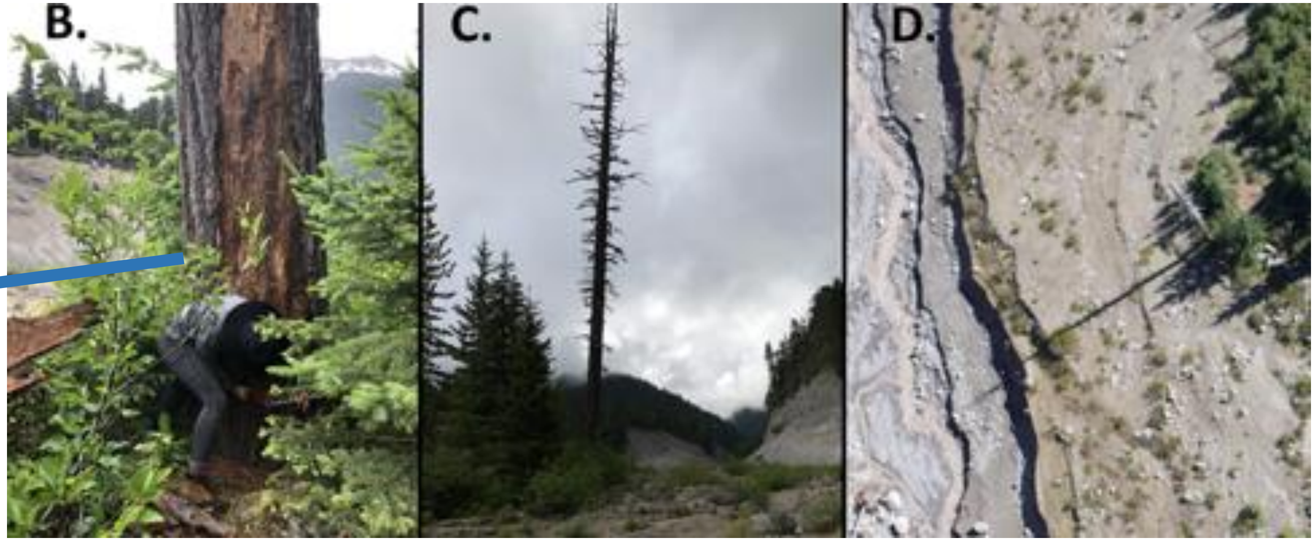
Photo: Willhiteweb.com (WA Fire Lookouts)

How many major debris flows?

Debris flows initiated in late-1930s







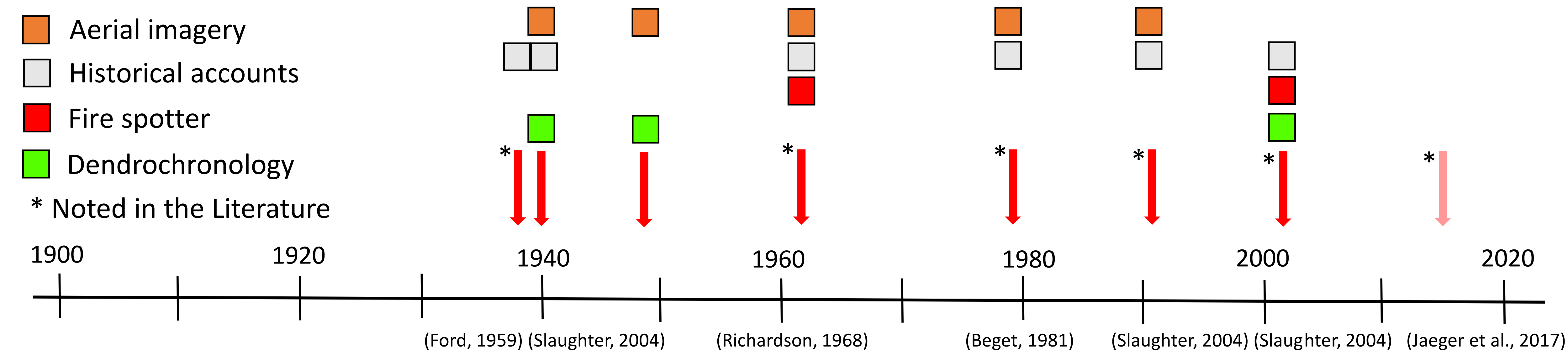
How many major debris flows?

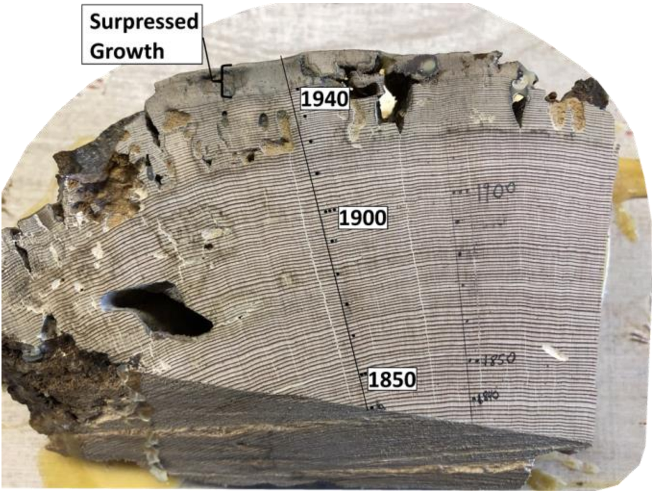
Debris flows initiated in late-1930s

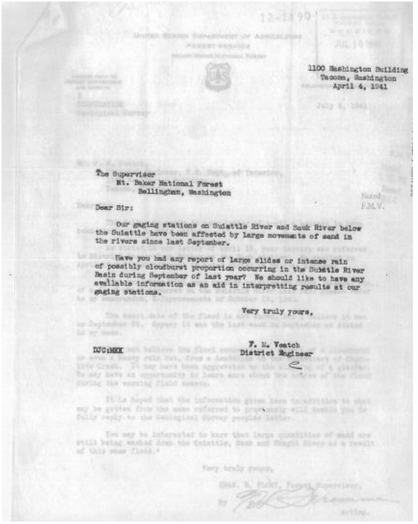
9.3 yr maximum recurrence interval

(*inter-event time range 2 to 16 yrs*)

Debris Flows **Evidenced by:**







1100 Washington Building
Tacoma, Washington
April 4, 1941

The Supervisor
Mt. Baker National Forest
Bellingham, Washington

Dear Sir:

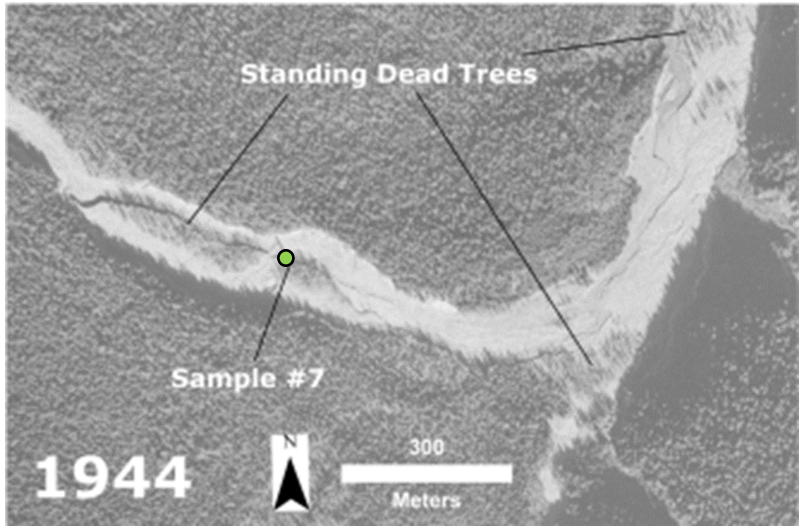
Our gaging stations on Suiattle River and Sauk River below the Suiattle have been affected by large movements of sand in the rivers since last September.

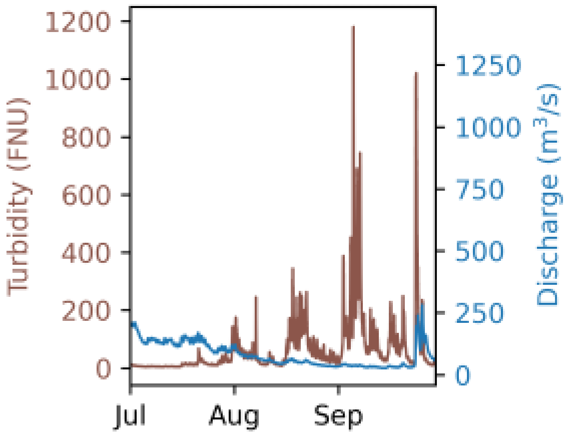
Have you had any report of large slides or intense rain of possibly cloudburst proportion occurring in the Suiattle River Basin during September of last year? We should like to have any available information as an aid in interpretting results at our gaging stations.

Very truly yours,

F. M. Veatch
District Engineer

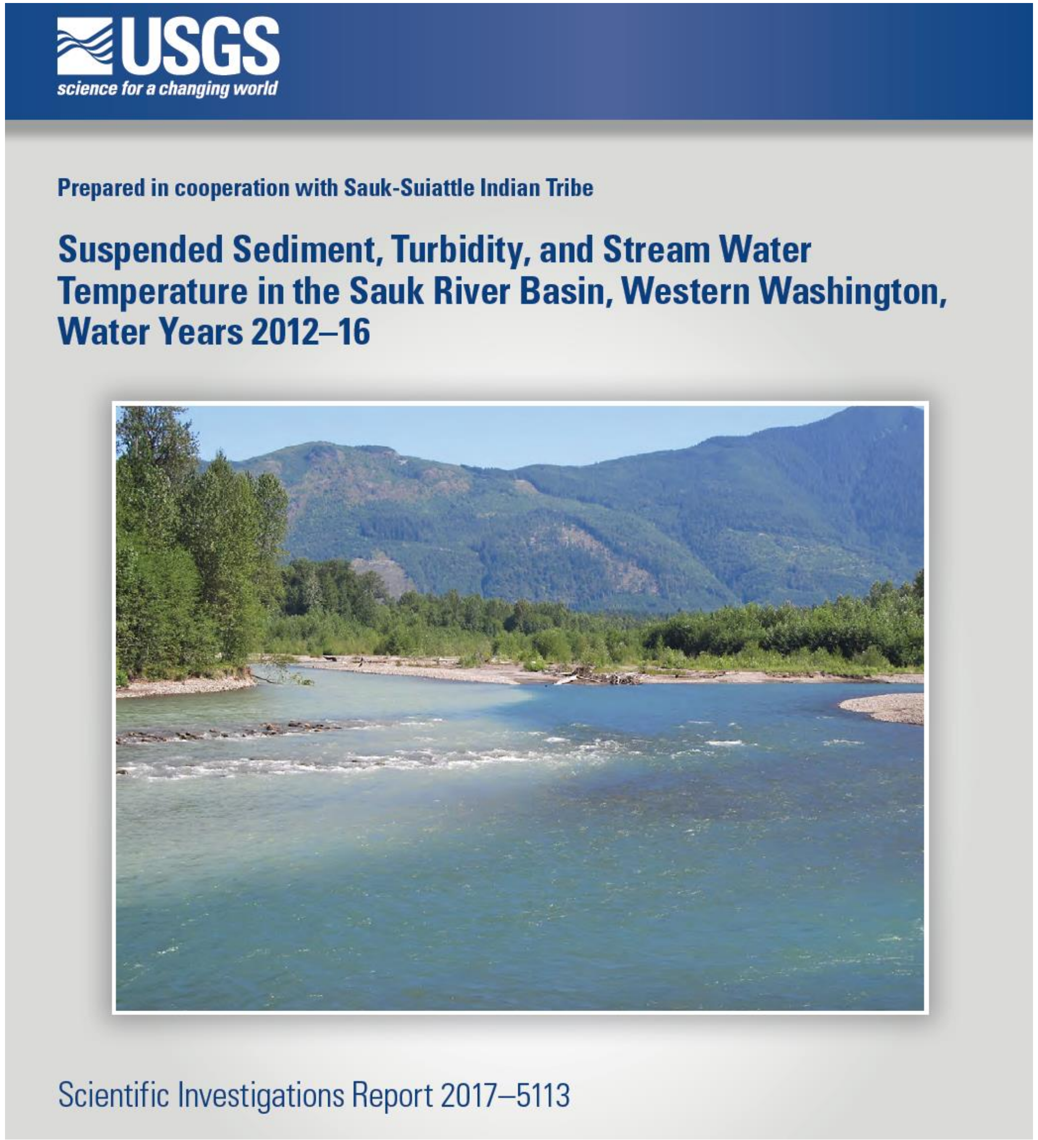
DJC:MKK





Minor debris flows?

2015 debris flow, and subsequent fall flushing noted by Jaeger (2017).


USGS
science for a changing world

Prepared in cooperation with Sauk-Suiattle Indian Tribe

Suspended Sediment, Turbidity, and Stream Water Temperature in the Sauk River Basin, Western Washington, Water Years 2012–16

Scientific Investigations Report 2017–5113

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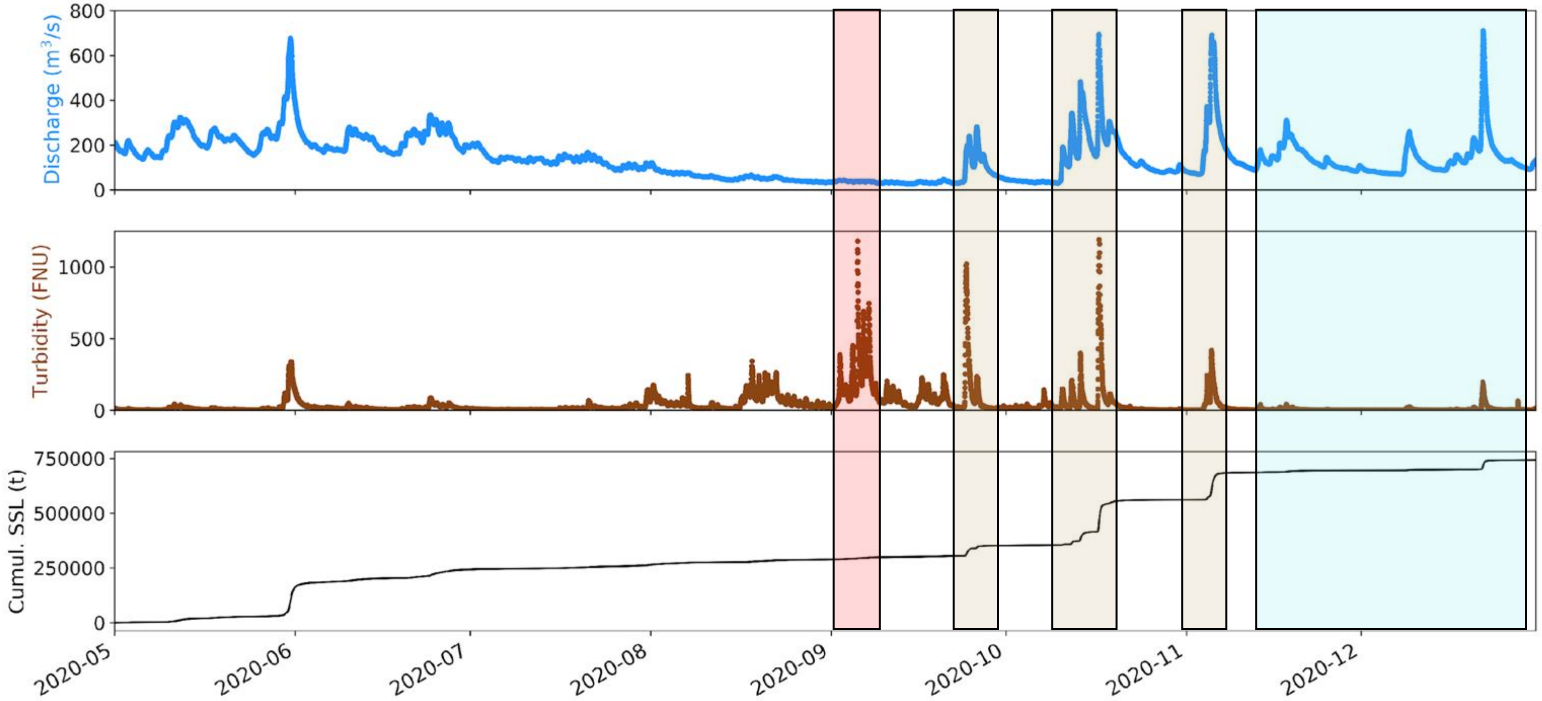


Debris Flow Signal

- Independent of precip and discharge
- SSL does not change drastically

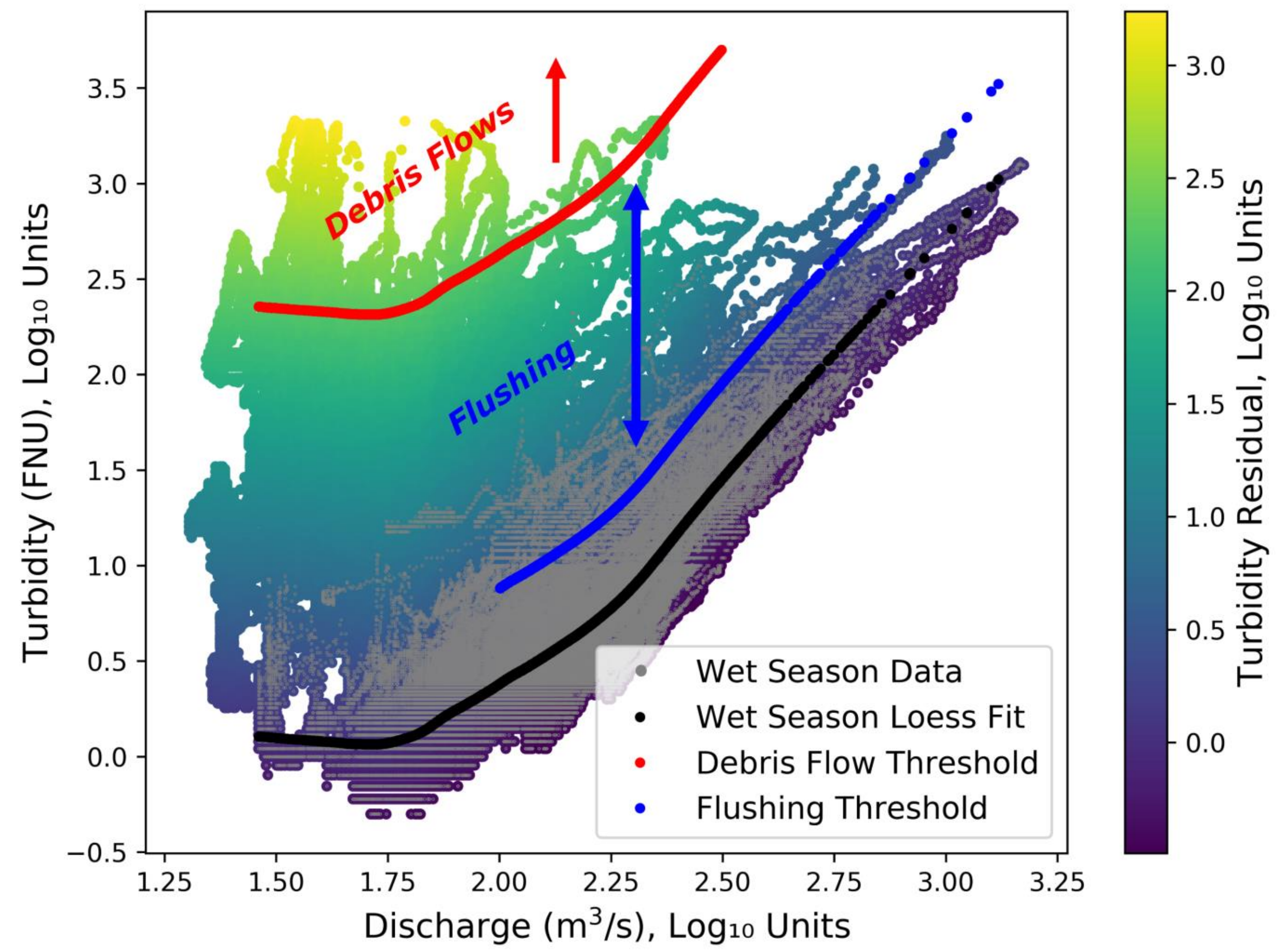
Fall Flushing

- Follows debris flow event
- Increased Q results in drastic jump in SSL
- Precip driven

Winter Rainstorms

- Discharge responds to precip events
- Minor increases in turbidity
- (Anomalous sediment load depleted)

Debris flow identification from turbidity data



USGS gauge on Sauk below Suiattle

Minor debris flows in 5 of 7 full years on record.

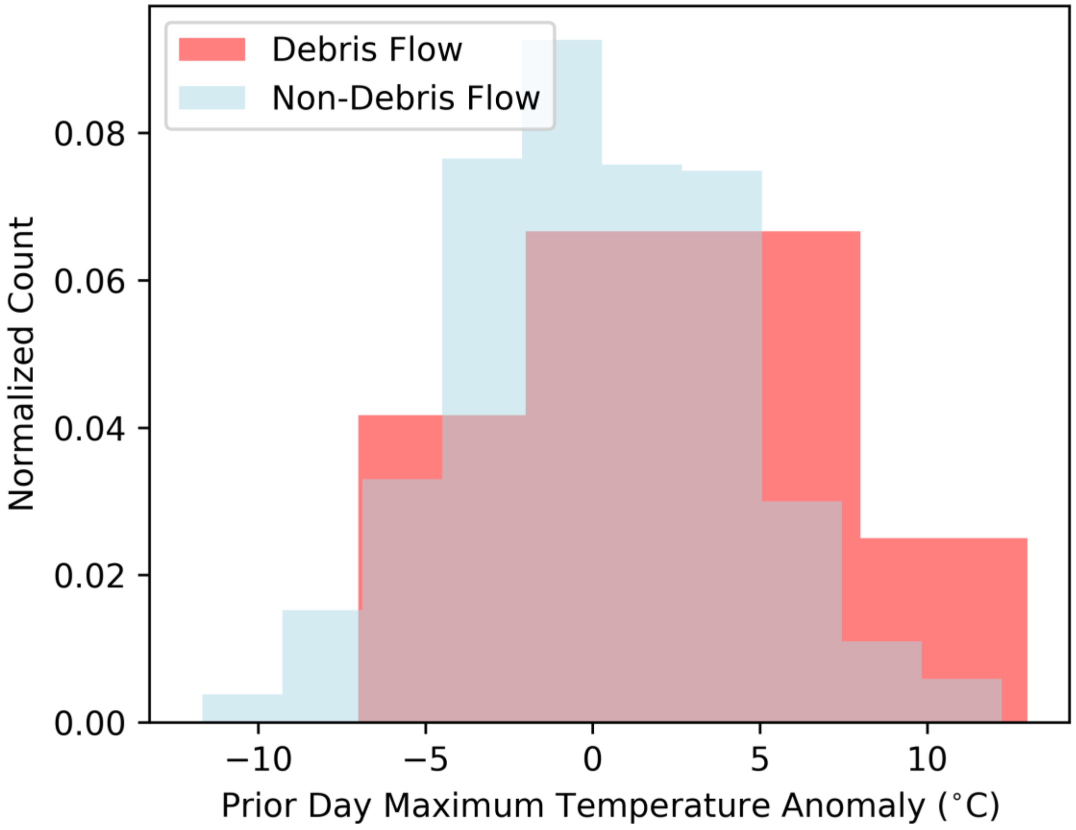
Multiple events a year.

Debris flow trigger?
Hot summer days

Minor debris flows:
hot summer days.

Historic accounts:
fire spotter plane.

Glacial outburst events.



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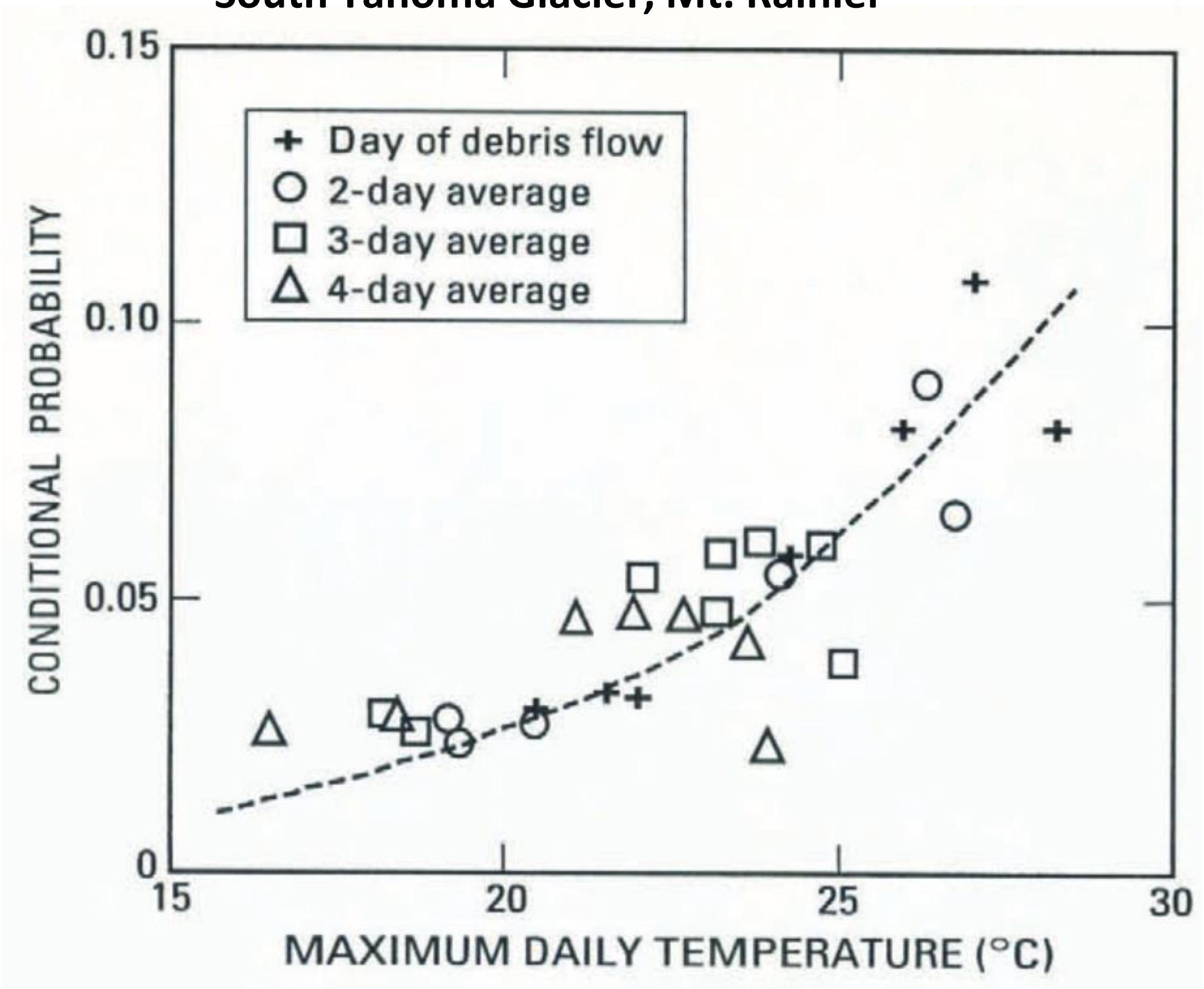
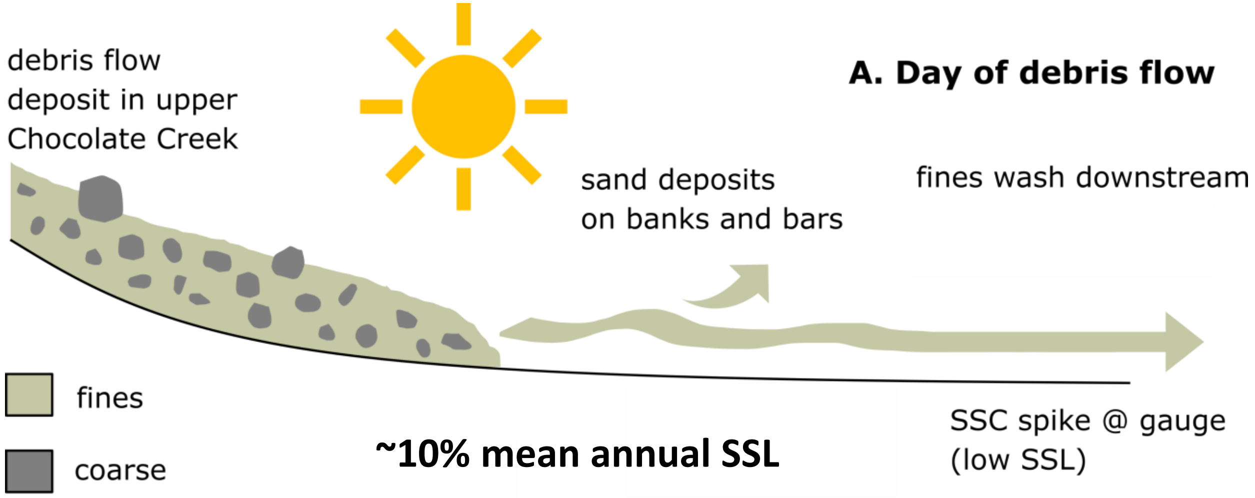
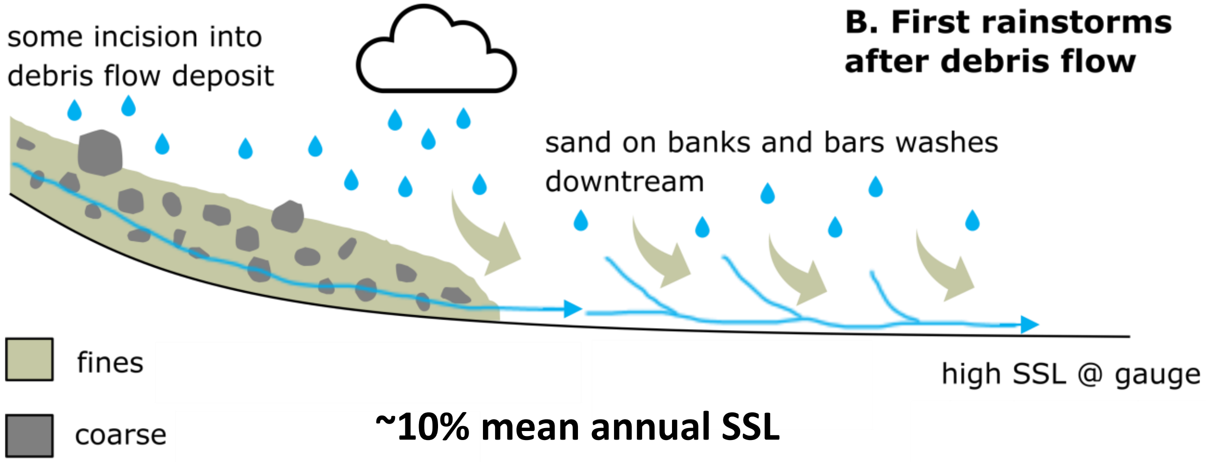
South Tahoma Glacier, Mt. Rainier

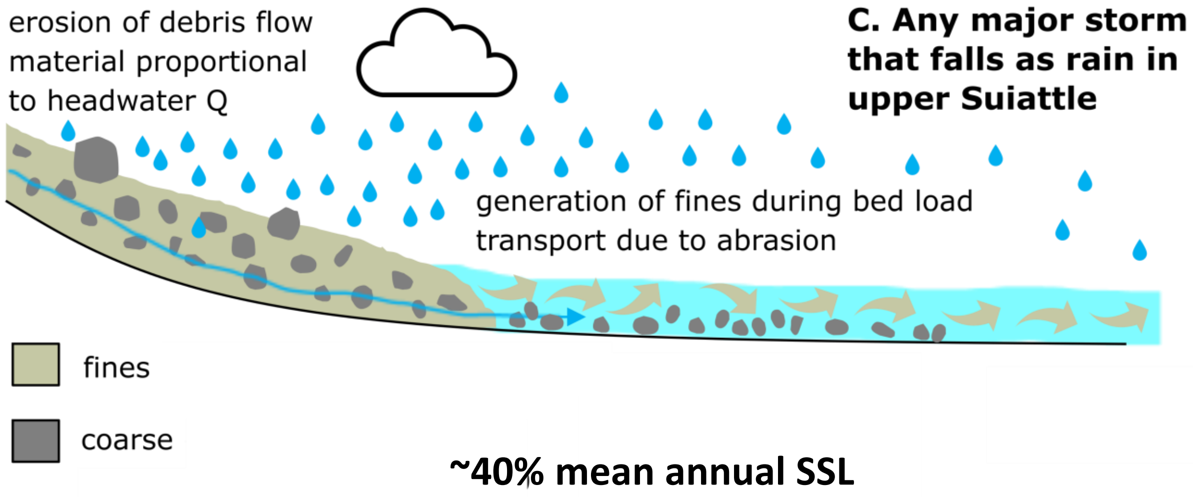


Walder and Driedger (1995)

A conceptual model for debris flow sediment delivery



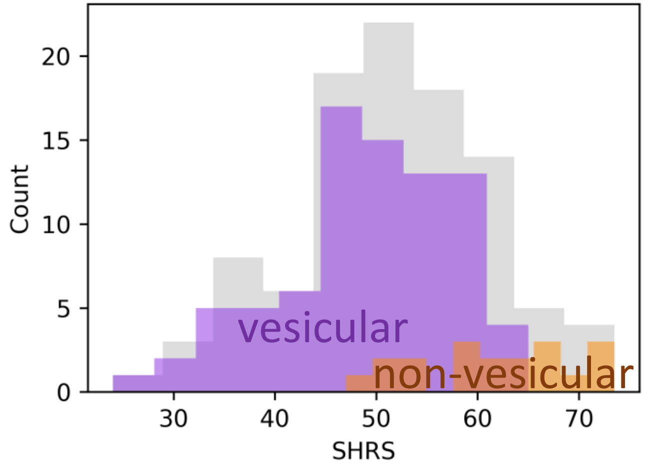




remainder of the load from downstream sources, tributaries, etc.

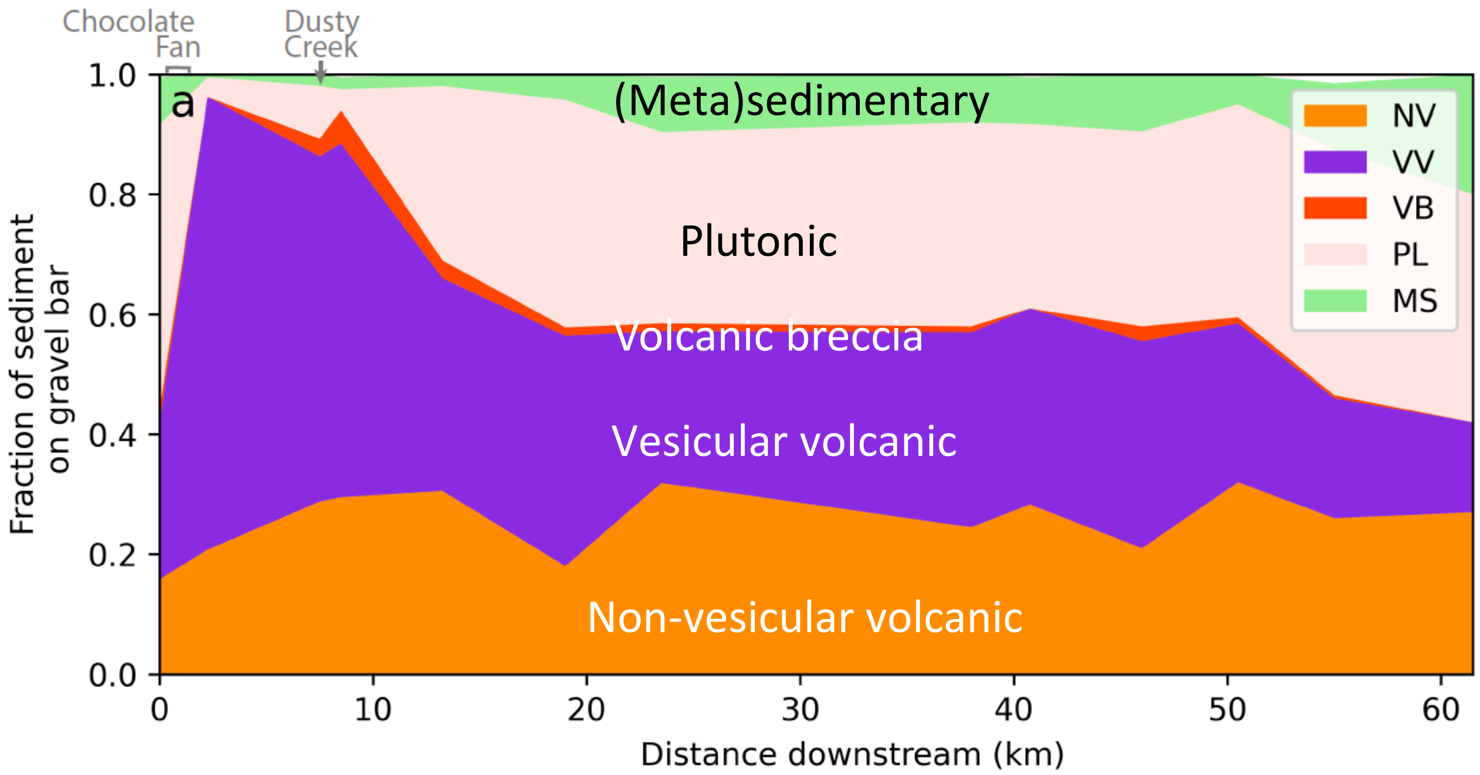
Abrasion: coarse volcanics disappear rapidly

Source material



Source material is a mix of vesicular and non-vesicular volcanics.

Vesicular are weaker.



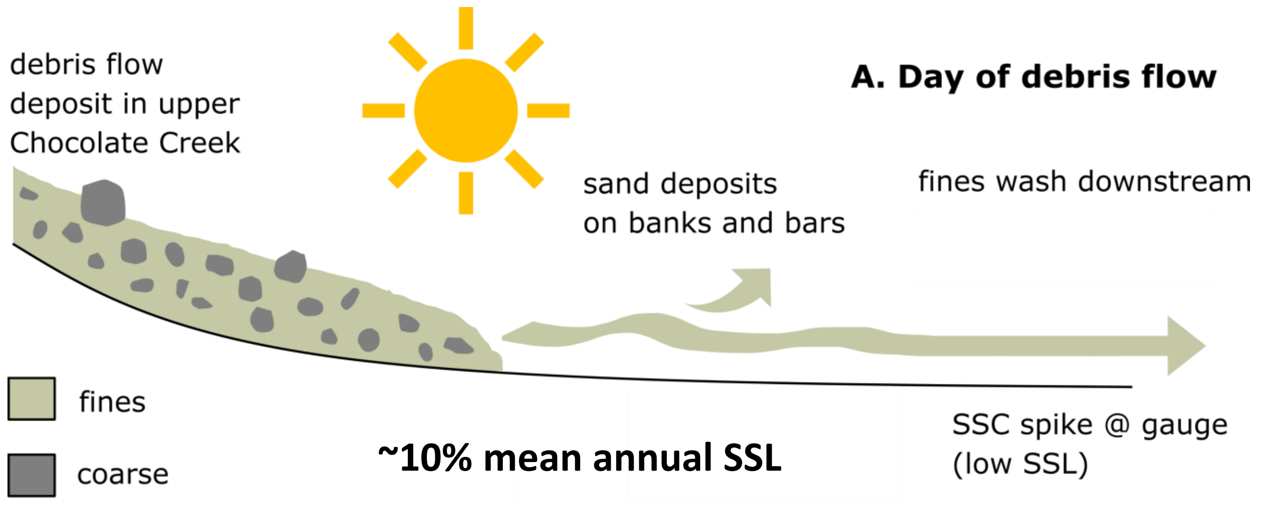
JGR Earth Surface

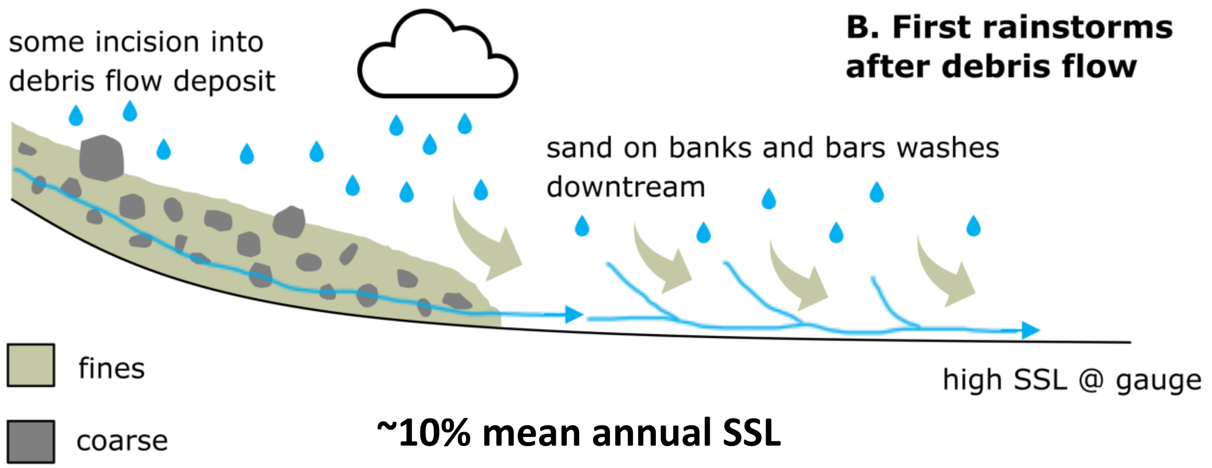
Survival of the Strong and Dense: Field Evidence for Rapid, Transport-Dependent Bed Material Abrasion of Heterogeneous Source Lithology

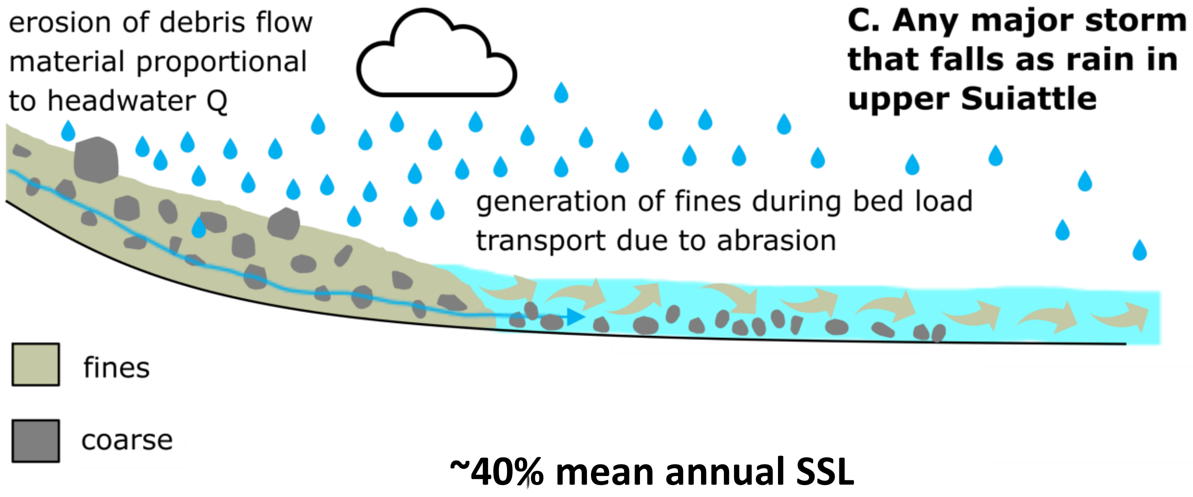
Allison M. Pfeiffer[1], Susannah Morey[2], Hannah M. Karlsson[2], Edward M. Fordham[1], and David R. Montgomery[2]

out this week!

A conceptual model for debris flow sediment delivery







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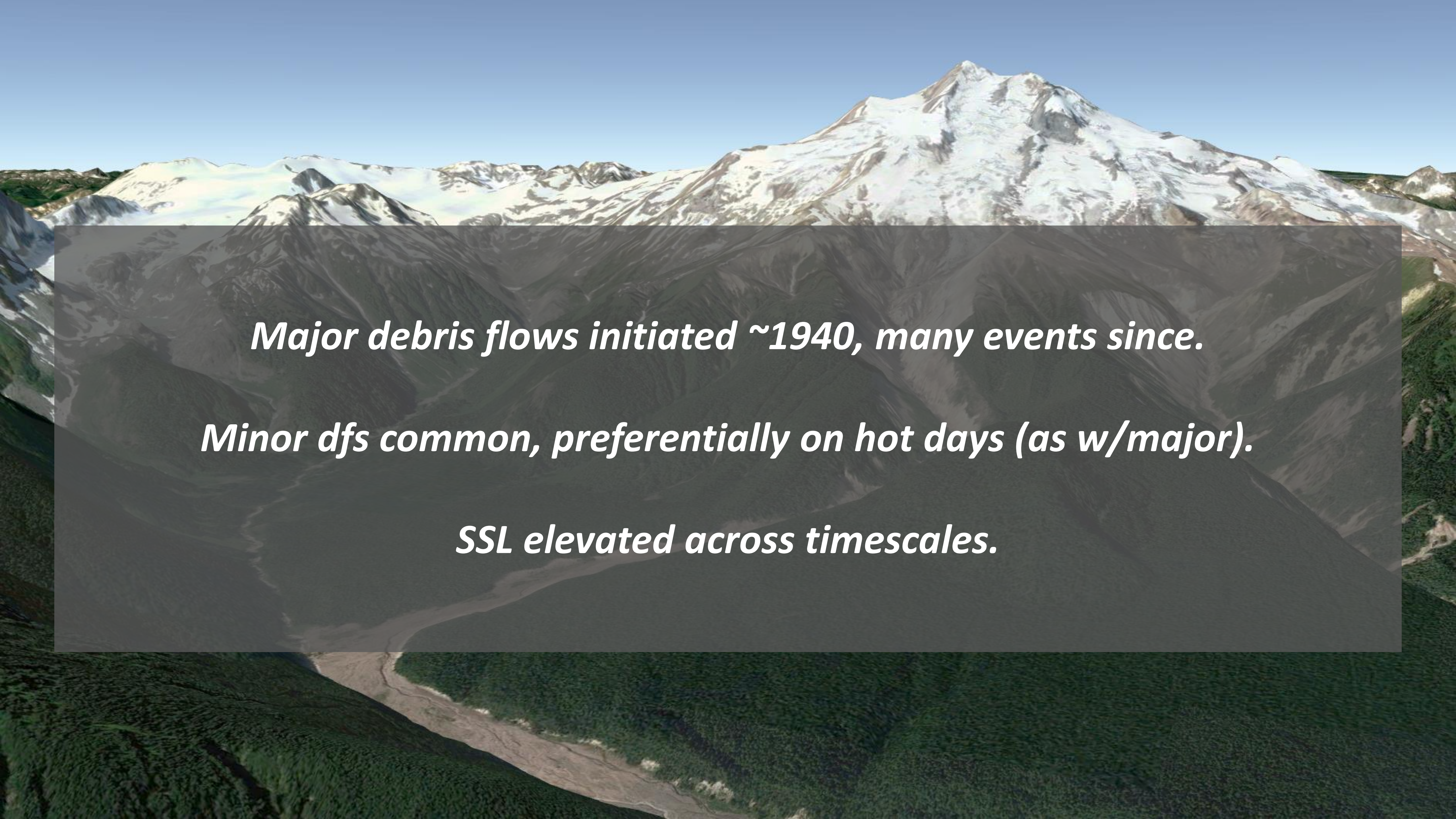

Major debris flows initiated ~1940, many events since.

Minor dfs common, preferentially on hot days (as w/major).

SSL elevated across timescales.

Questions?

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