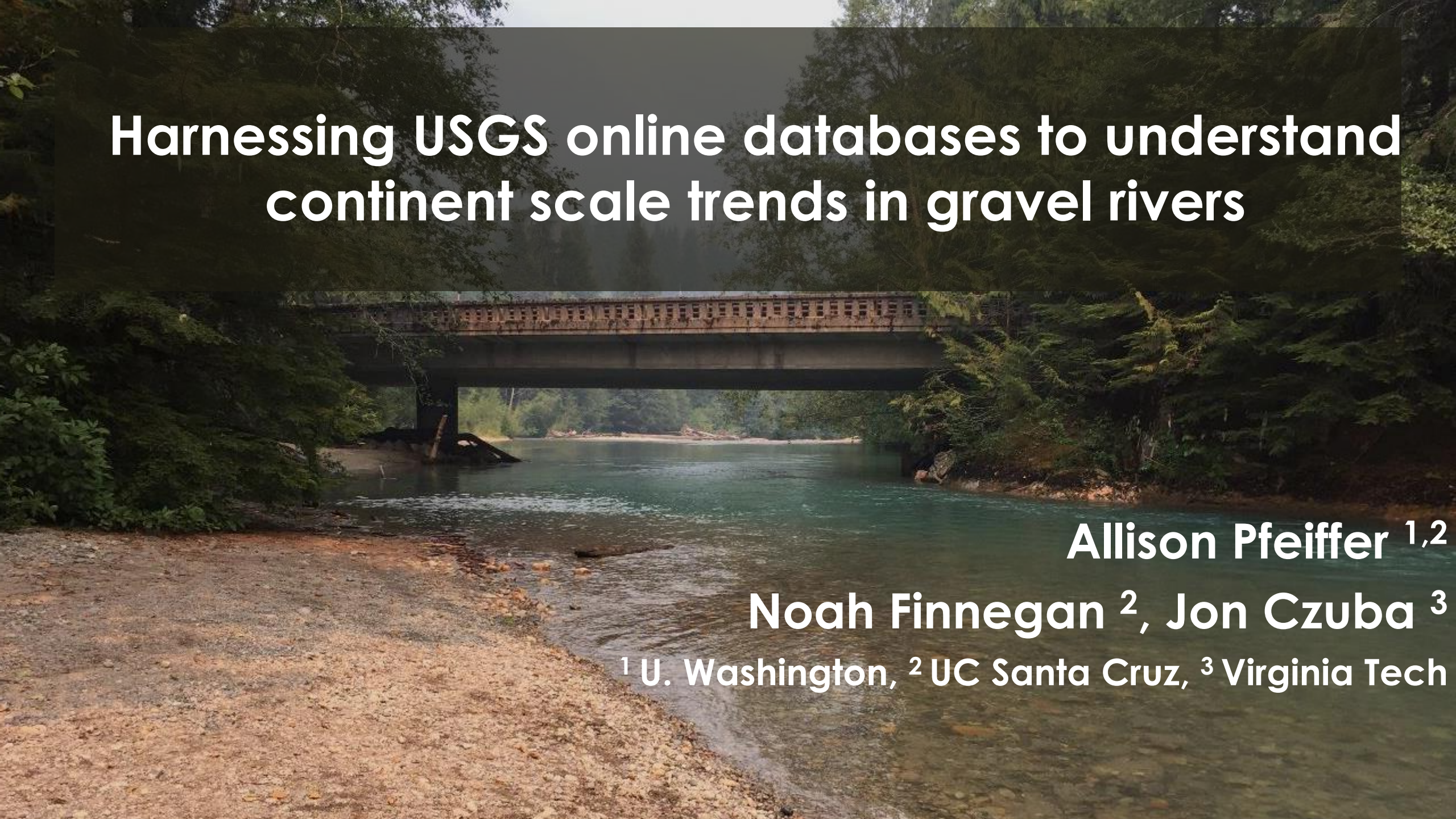


Harnessing USGS online databases to understand continent scale trends in gravel rivers

Allison Pfeiffer [1,2]

Noah Finnegan [2], Jon Czuba [3]

[1] U. Washington, [2] UC Santa Cruz, [3] Virginia Tech

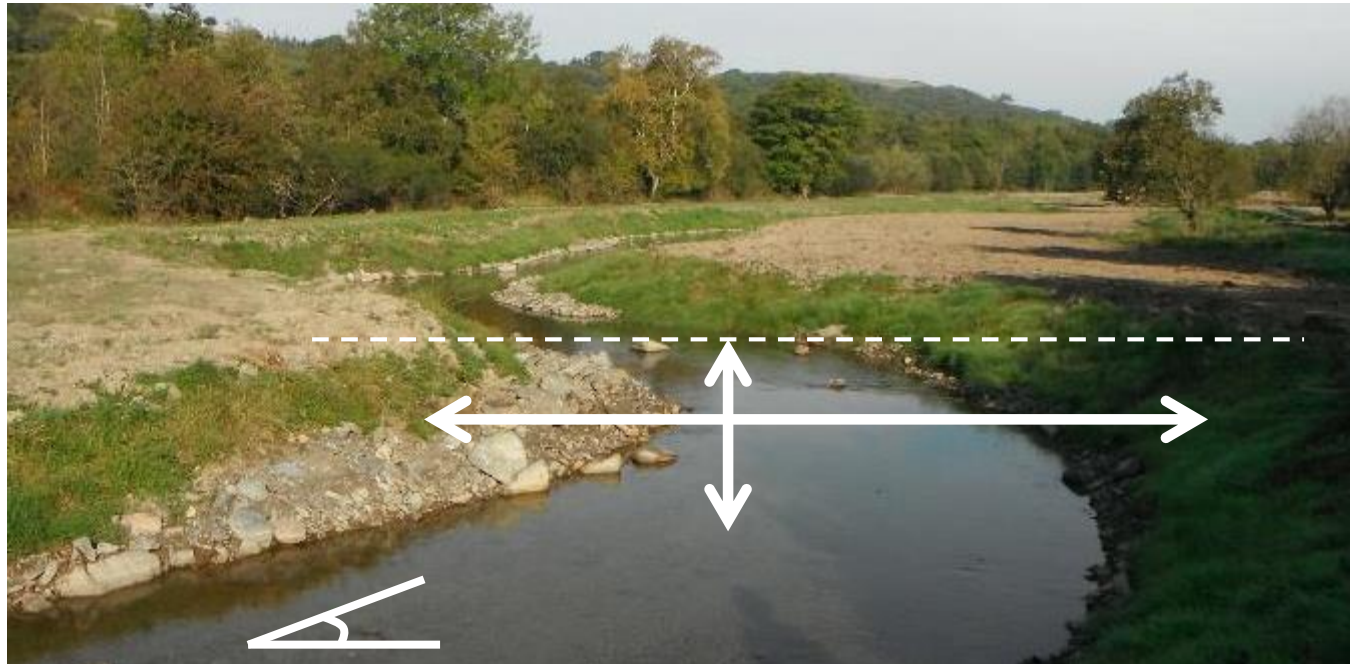
My playground: gravel bedded rivers

Self formed channels (water and sediment moving downhill)

Evolve in response to supply of sediment and water

What shape will the river be?

Width, depth, slope, grain size



My playground: gravel bedded rivers

Flood hazards and channel change

River channel restoration >$1 billion/year in US

Do all rivers obey the same rules?

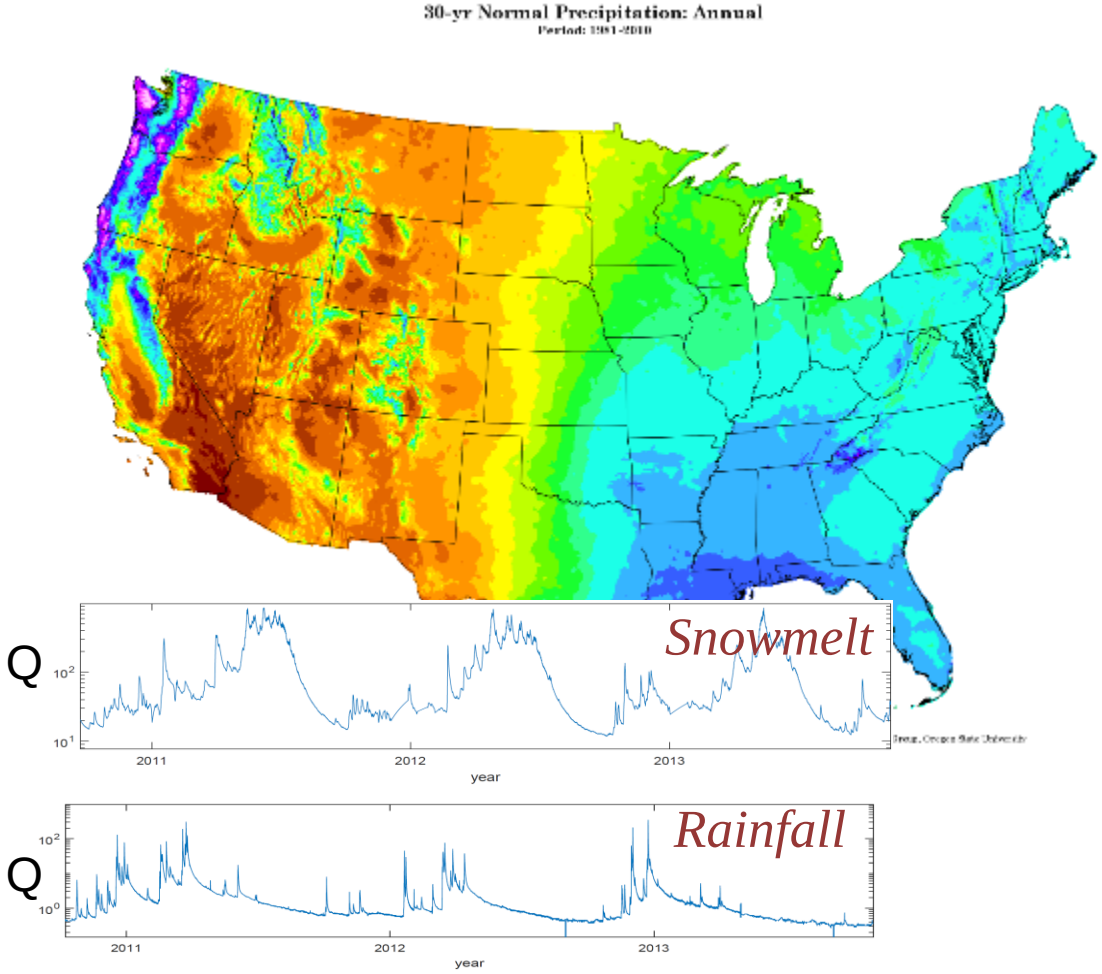
Do all rivers mobilize X sediment with Y water?

Do all gravel rivers mobilize their beds annually?
monthly?
daily?

How much does river channel forcing vary?

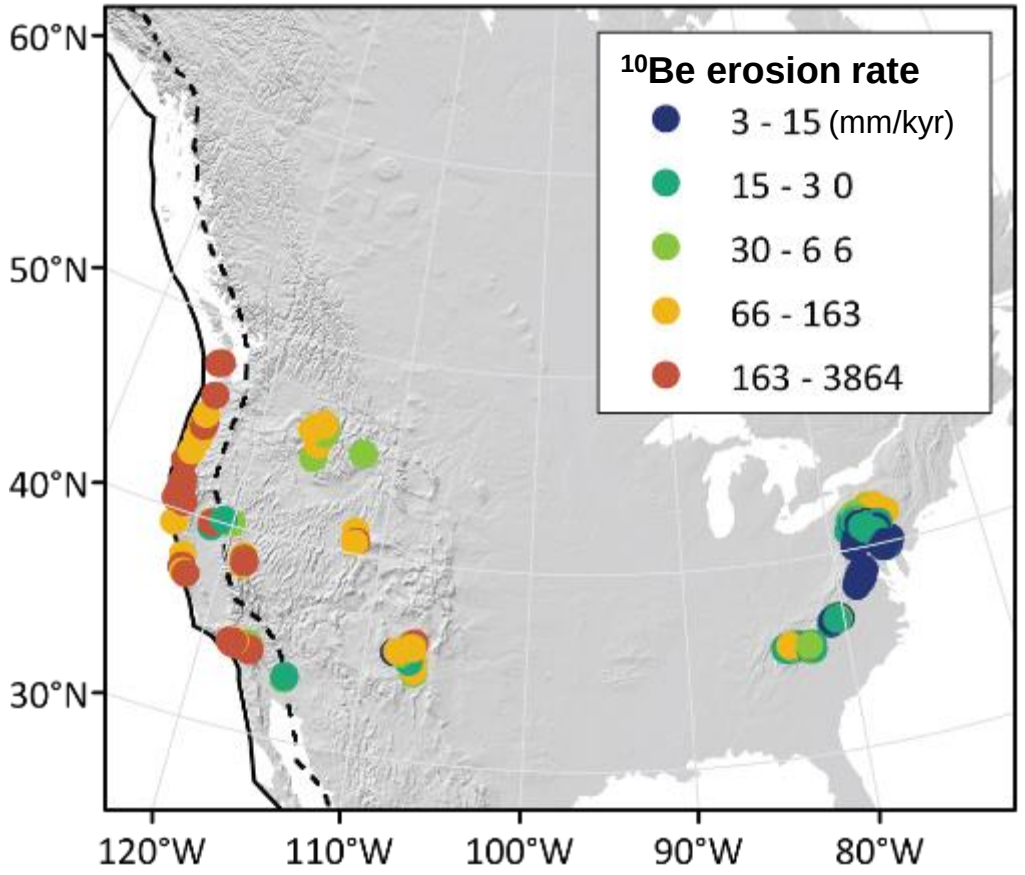
Water:

Magnitude, duration, frequency



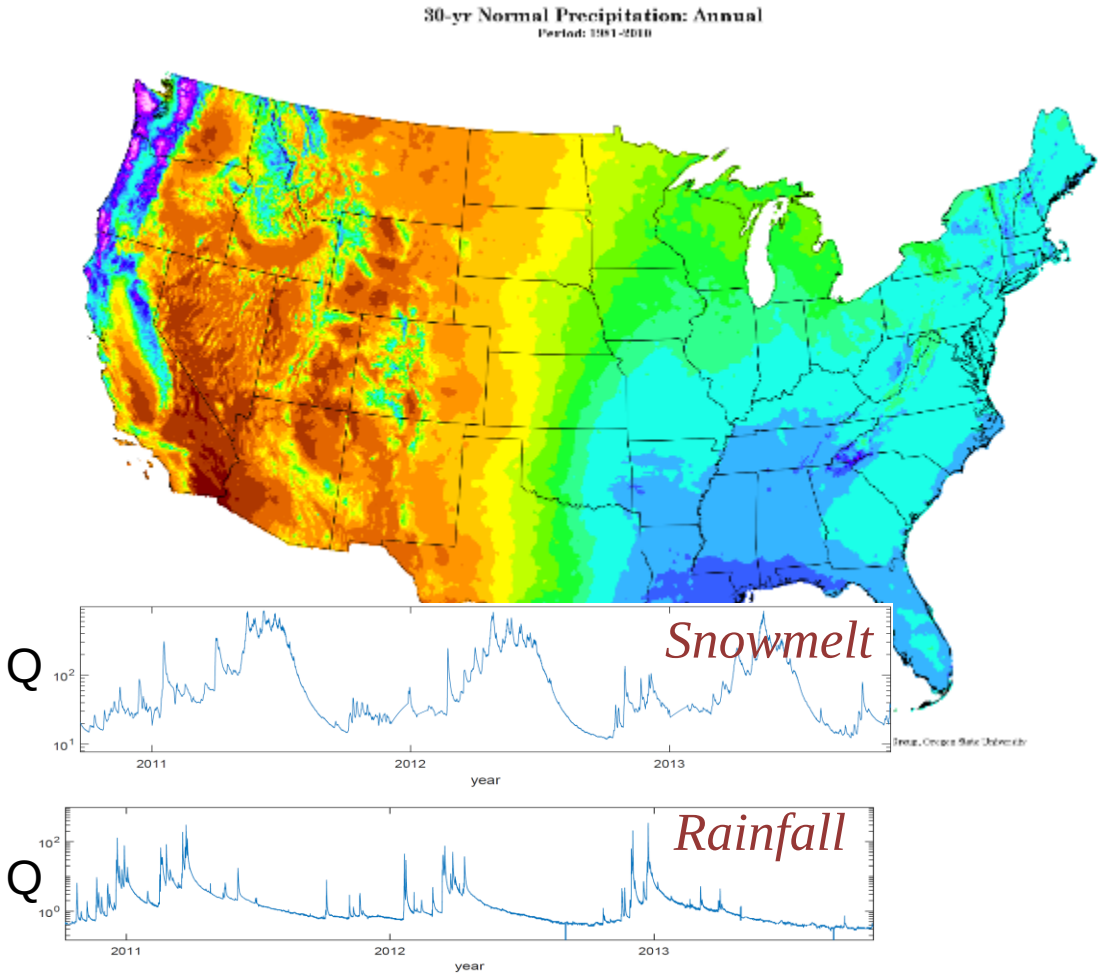
Sediment:

Orders of magnitude

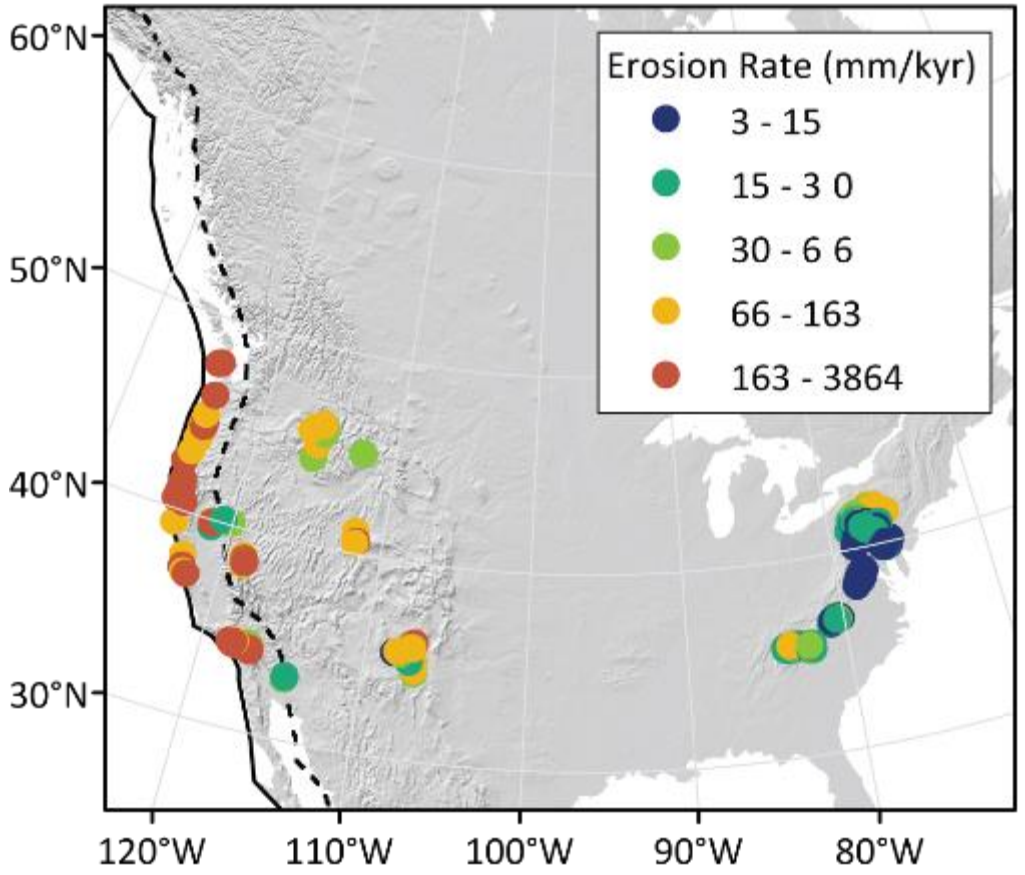


How do river channels reflect…

… differences in the flux of water?



… differences in sediment supply?



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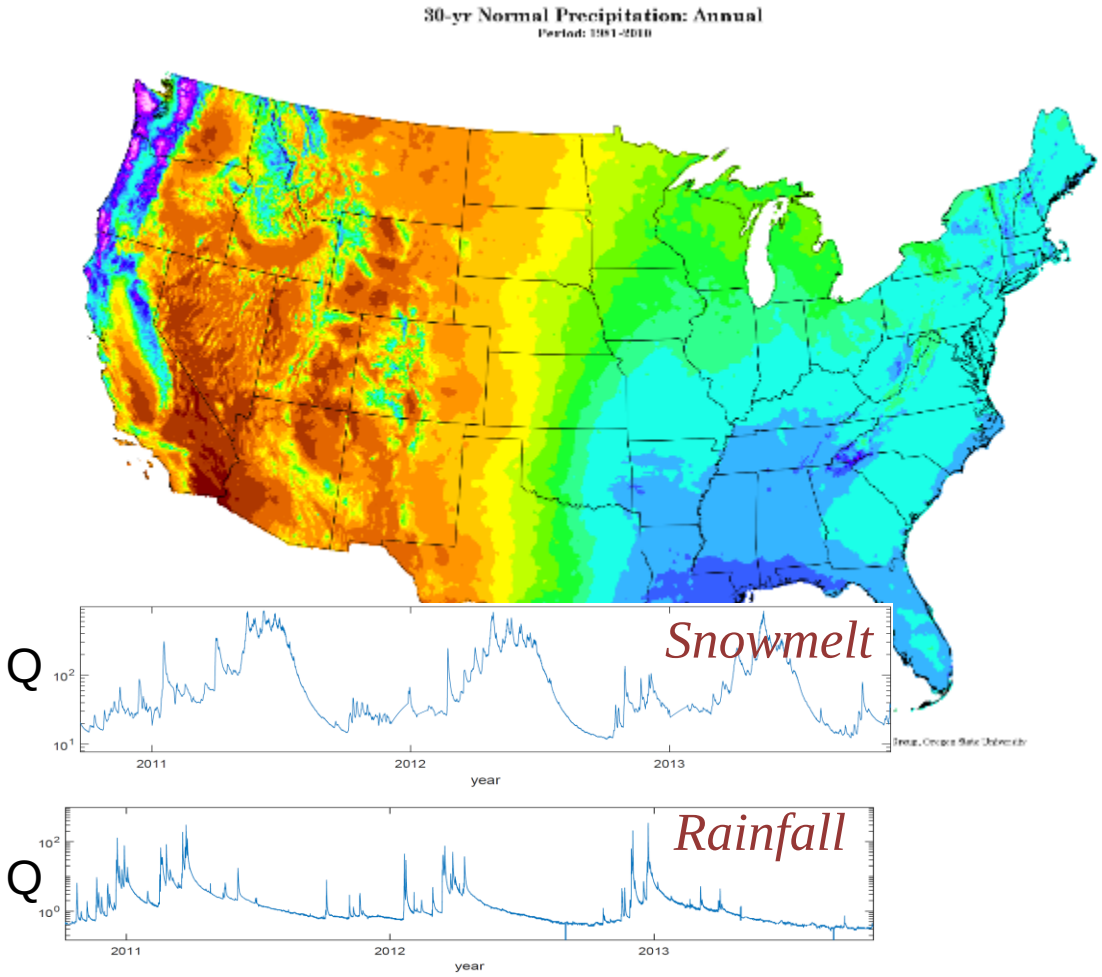
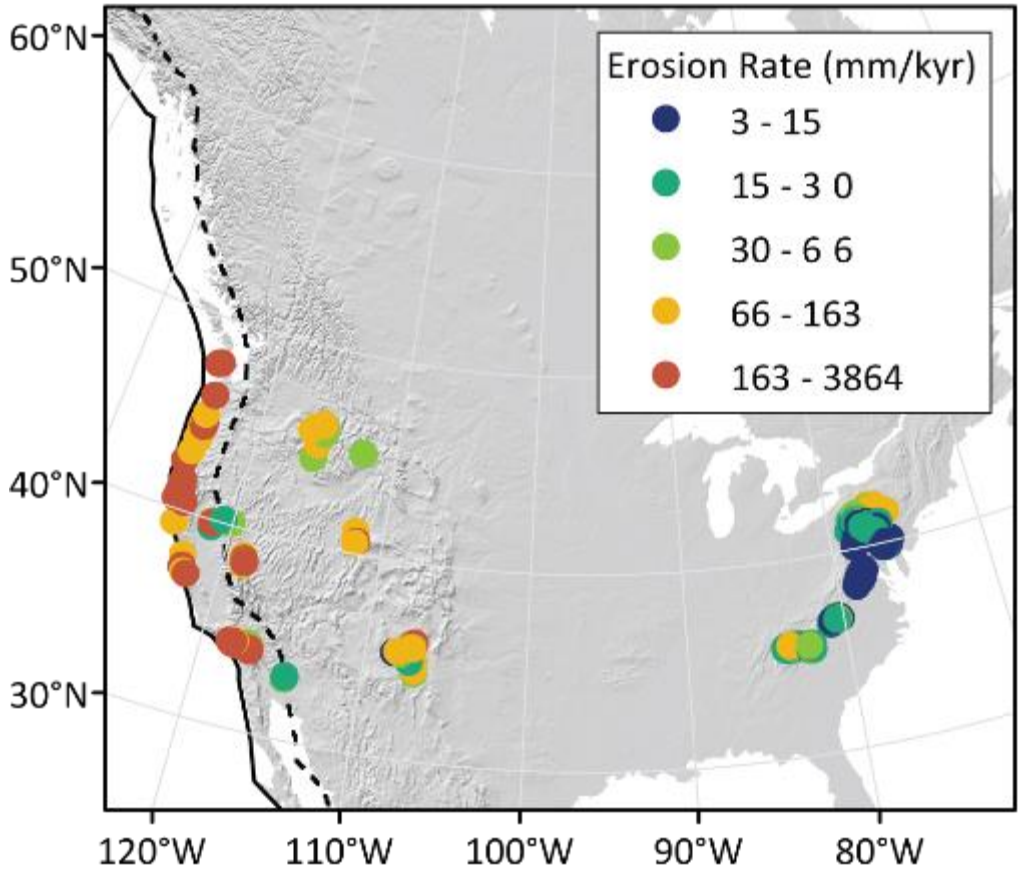
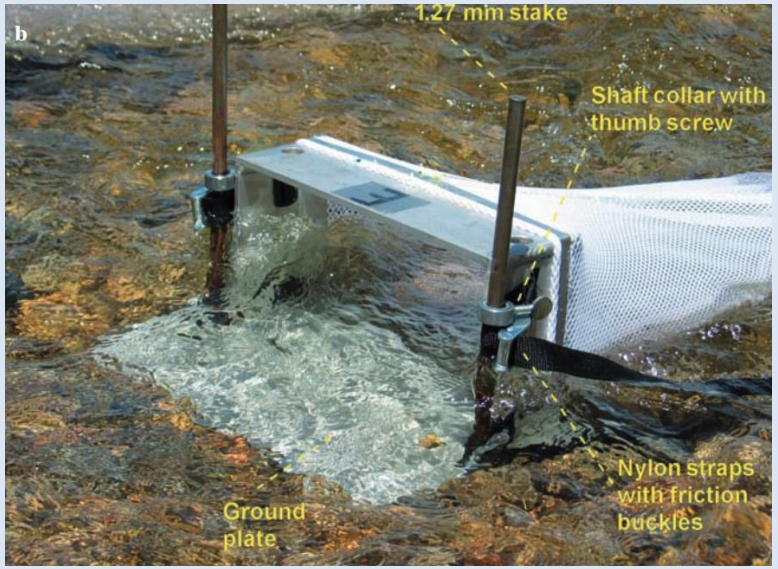


… differences in sediment supply?

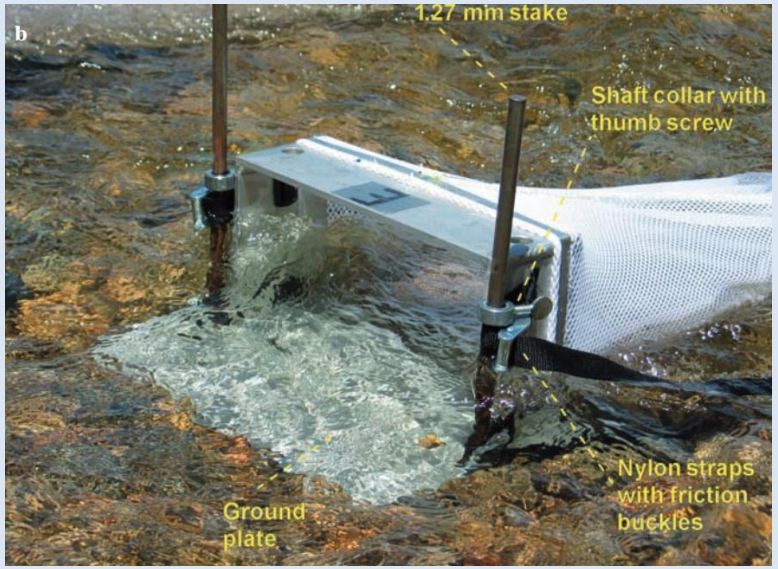


How do we usually answer these questions?



Detailed study of a single site, or small set of field sites…

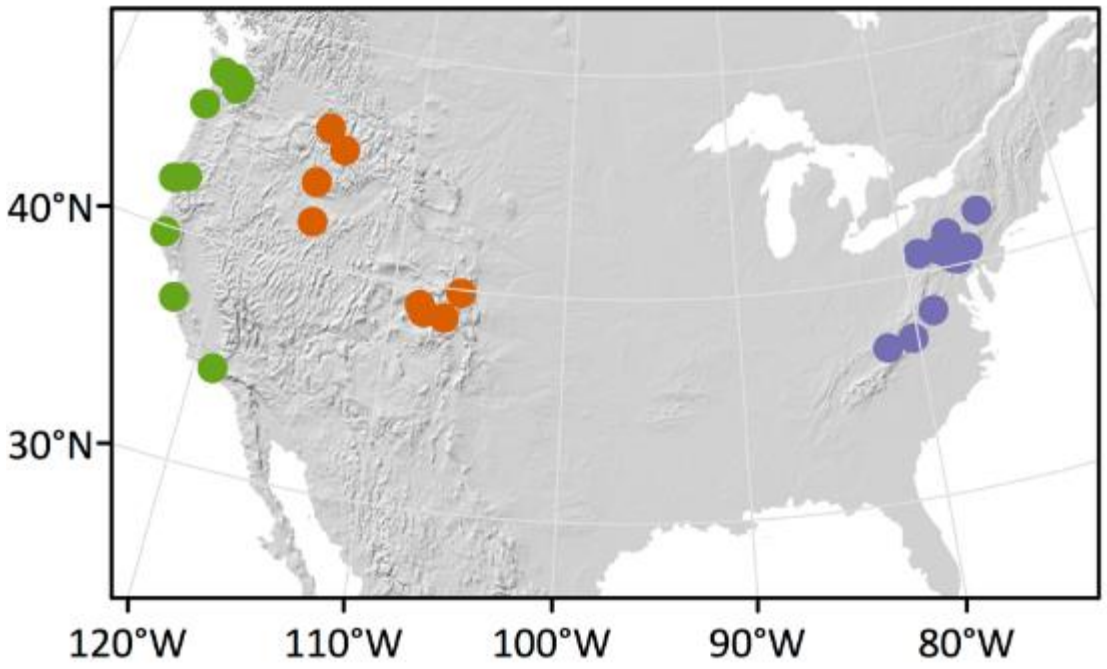
How do we usually answer these questions?



Detailed study of a single site, or small set of field sites…

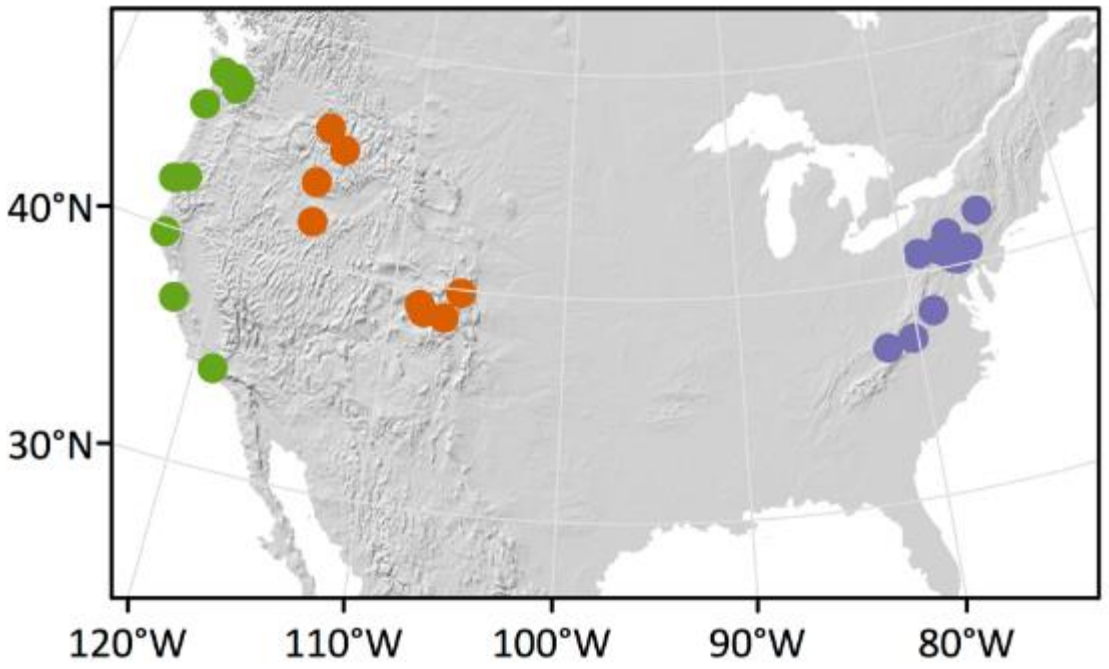
… but I'm taking the geologist's version of a 'Big Data' approach.

When does the riverbed mobilize? (hydrology + sed supply)

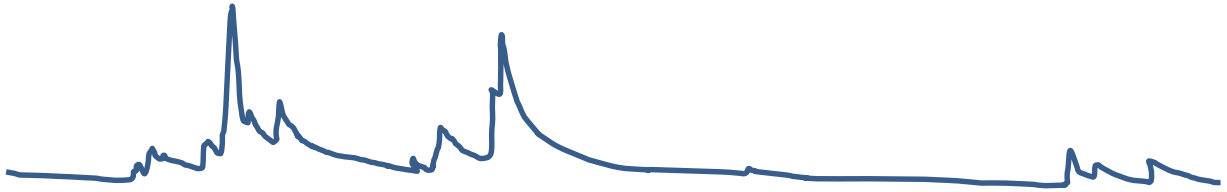


Calculate time series of bed mobility

When does the riverbed mobilize? (hydrology + sed supply)



USGS data:
multi-decadal discharge records



Modified from Phillips and Jerolmack (2016)

Calculate time series of bed mobility

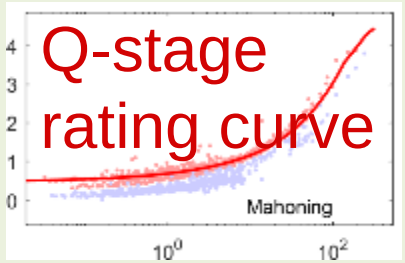
West High sed. supply, many storms
~1 day duration throughout winter

Rocky Med-low sed. supply, snowmelt dominated floods

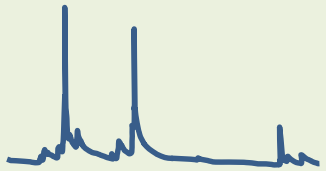
Appalach. Low sed. supply, weak seasonality to high flow events

Processing: USGS streamgage data

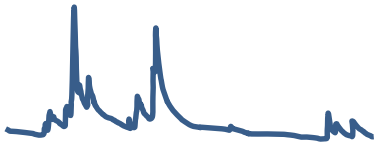
Publically available data



field data:
stage
discharge
flow depth
flow width



discharge



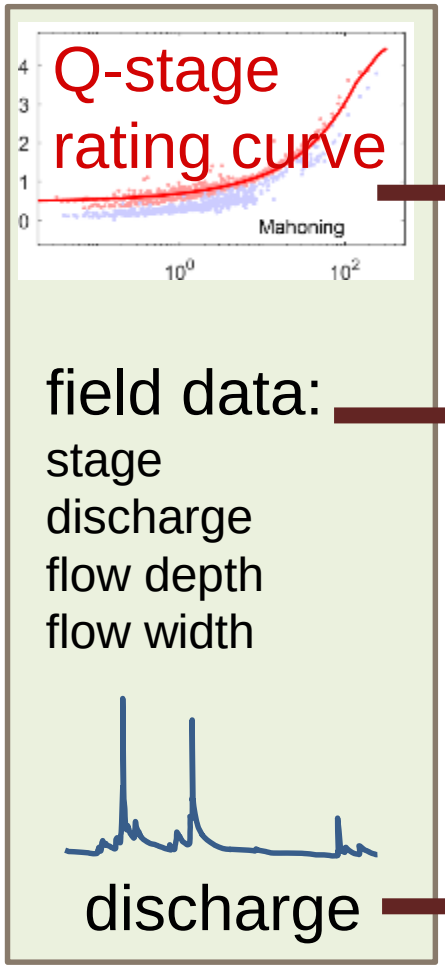
bed surface stress (τ)

A pipeline for processing publically available USGS data→ multi-decadal τ time series

modified from Phillips and Jerolmack (2016)

Processing: USGS streamgage data

Publically available data

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1,000 and 15,000 cfs. R 31 is similar to F
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# //SHIFT_NEXT BEGIN="---------------" BZO
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# //SHIFT_NEXT COMMENT=" "
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1.84     0.05     0.01
1.85     0.04     0.01
1.86     0.05     0.02
1.87     0.04     0.02
1.88     0.05     0.03     *
1.89     0.05     0.04     *
1.90     0.04     0.04
1.91     0.05     0.05
1.92     0.05     0.06
1.93     0.05     0.07
1.94     0.05     0.09
1.95     0.05     0.10
1.96     0.05     0.12
1.97     0.05     0.13
1.98     0.05     0.15
1.99     0.05     0.17
2.00     0.05     0.19
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2.02     0.05     0.24
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2.04     0.05     0.30
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# U.S. Geological Survey, National Water Informati
# Surface water measurements
#
# Retrieved: 2018-07-19 13:11:20 EDT      (caww02)
#
# Further descriptions of the columns and codes us
# https://help.waterdata.usgs.gov/output-formats#s
#
# Data for the following 1 site(s) are contained i
#  USGS 11160500 SAN LORENZO R A BIG TREES CA
# ----------------------------------------------------
#
#
agency_cd       site_no measurement_nu  measuremen
measured_rating_diff    gage_va_change  gage_va_ti
chan_discharge  chan_width      chan_area       ch
chan_loc_dist
5s      15s     6s      19d     12s     1s      12
14s     14s     4s      4s      4s      12s     9s
USGS    11160500        24      1937-12-11
WADE    unspe   unkno   2010    81.0    542     3.
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# ---------------------------------- WARNING ----------------------------------------
# Some of the data that you have obtained from this U.S. Geological Survey database
# may not have received Director's approval. Any such data values are qualified
# as provisional and are subject to revision. Provisional data are released on the
# condition that neither the USGS nor the United States Government may be held liable
# for any damages resulting from its use.
#
# Additional info: https://help.waterdata.usgs.gov/policies/provisional-data-statement
#
# File-format description:  https://help.waterdata.usgs.gov/faq/about-tab-delimited-output
# Automated-retrieval info: https://help.waterdata.usgs.gov/faq/automated-retrievals
#
# Contact:   gs-w_support_nwisweb@usgs.gov
# retrieved: 2018-07-19 13:09:05 EDT       (caww02)
#
# Data for the following 1 site(s) are contained in this file
#    USGS 11160500 SAN LORENZO R A BIG TREES CA
# ------------------------------------------------------------------------------
#
# Data provided for site 11160500
#            TS   parameter     Description
#         14696       00060     Discharge, cubic feet per second
#         14697       00065     Gage height, feet
#
# Data-value qualification codes included in this output:
#     P  Provisional data subject to revision.
#
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5s      15s     20d     6s      14n     10s     14n     10s
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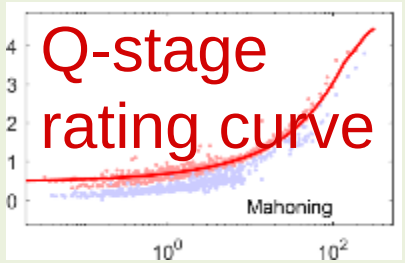
500k (+) discharge measurements

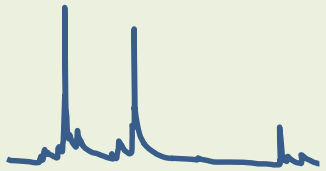
A pipeline for processing publically available USGS

Processing: USGS streamgage data

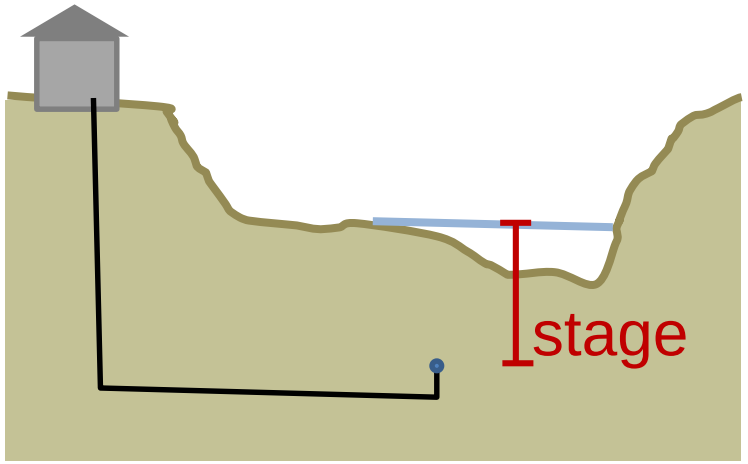
Publically available data

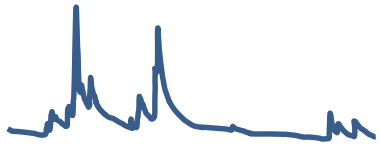


field data:
stage
discharge
flow depth
flow width



discharge





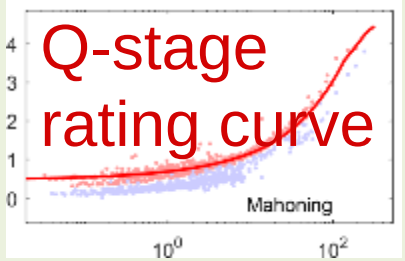
bed surface stress (τ)

A pipeline for processing publically available USGS data→ multi-decadal τ time series

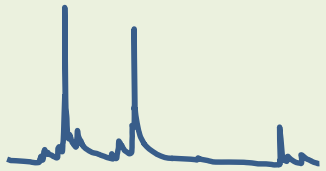
modified from Phillips and Jerolmack (2016)

Processing: USGS streamgage data

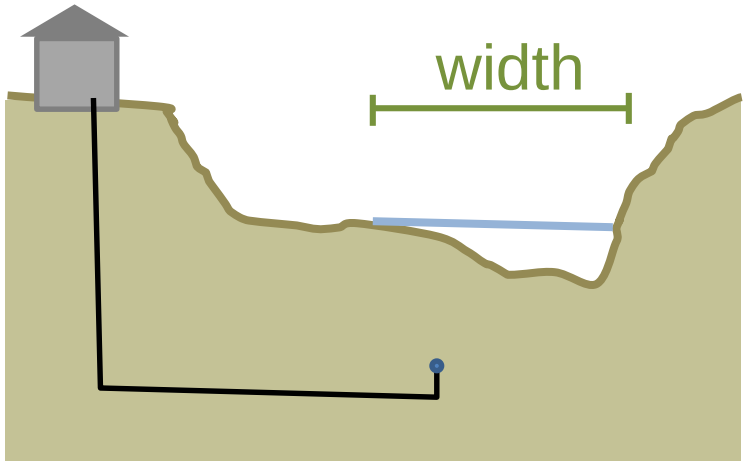
Publically available data



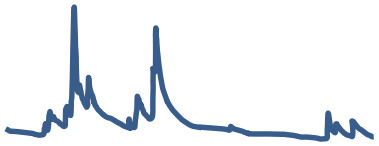
field data:
stage
discharge
flow depth
flow width



discharge



avg. flow depth



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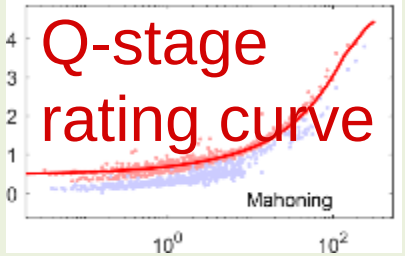
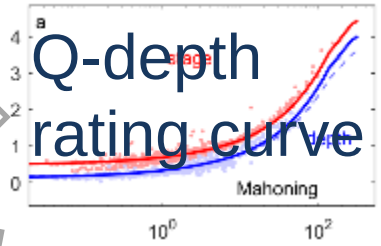
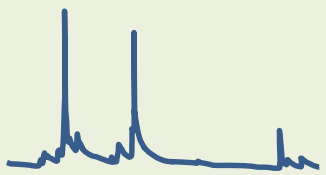
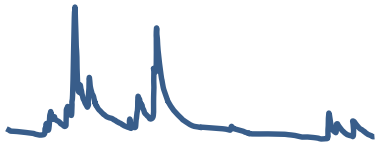


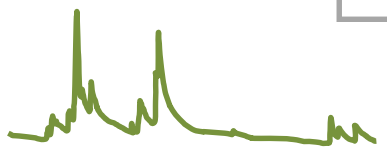
field data:
stage
discharge
flow depth
flow width

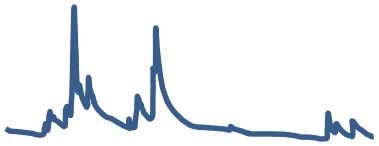


Q-width
rating curve









Channel
Slope

A pipeline for processing publically available USGS data→ multi-decadal τ time series

modified from Phillips and Jerolmack (2016)

Processing: USGS data → bed mobility estimates

depth (t)

width (t)

shear stress (τ)

channel slope

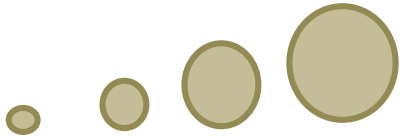
grain size distrib.

Sediment transport models

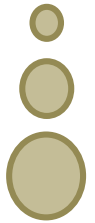
hiding effects

Variable τ^*_c

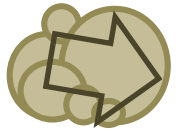
constant?
slope-dependent?
sand-dependent?



mobility



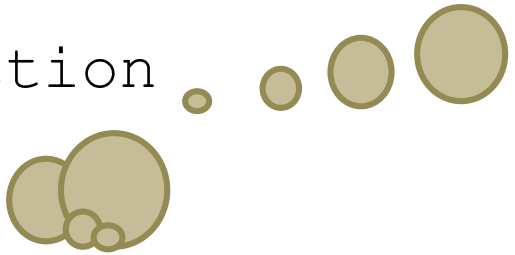
sediment flux



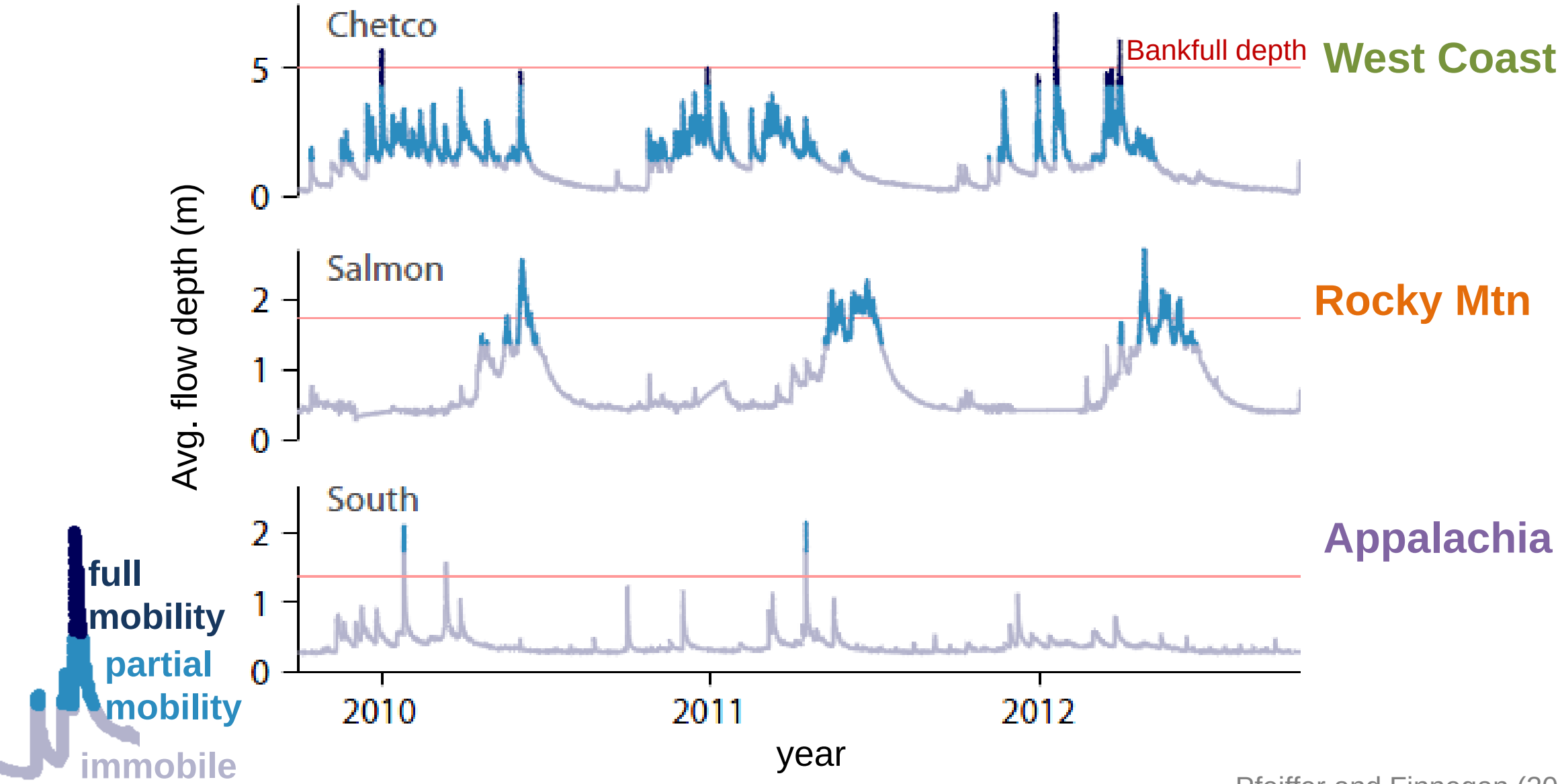
m^3/s

Processing: USGS data → bed mobility estimates

```
critical stress = f(sand? slope? constant?)
for each timestep
     stress = f(flow depth, width, slope)
     for each grain size fraction
          calculate 'hiding'
          fractional transport = f(stress, hiding, etc.)
     total transport = sum(fractional transport)
     if total transport > threshold
          mobile!
```



Time series of bed mobility



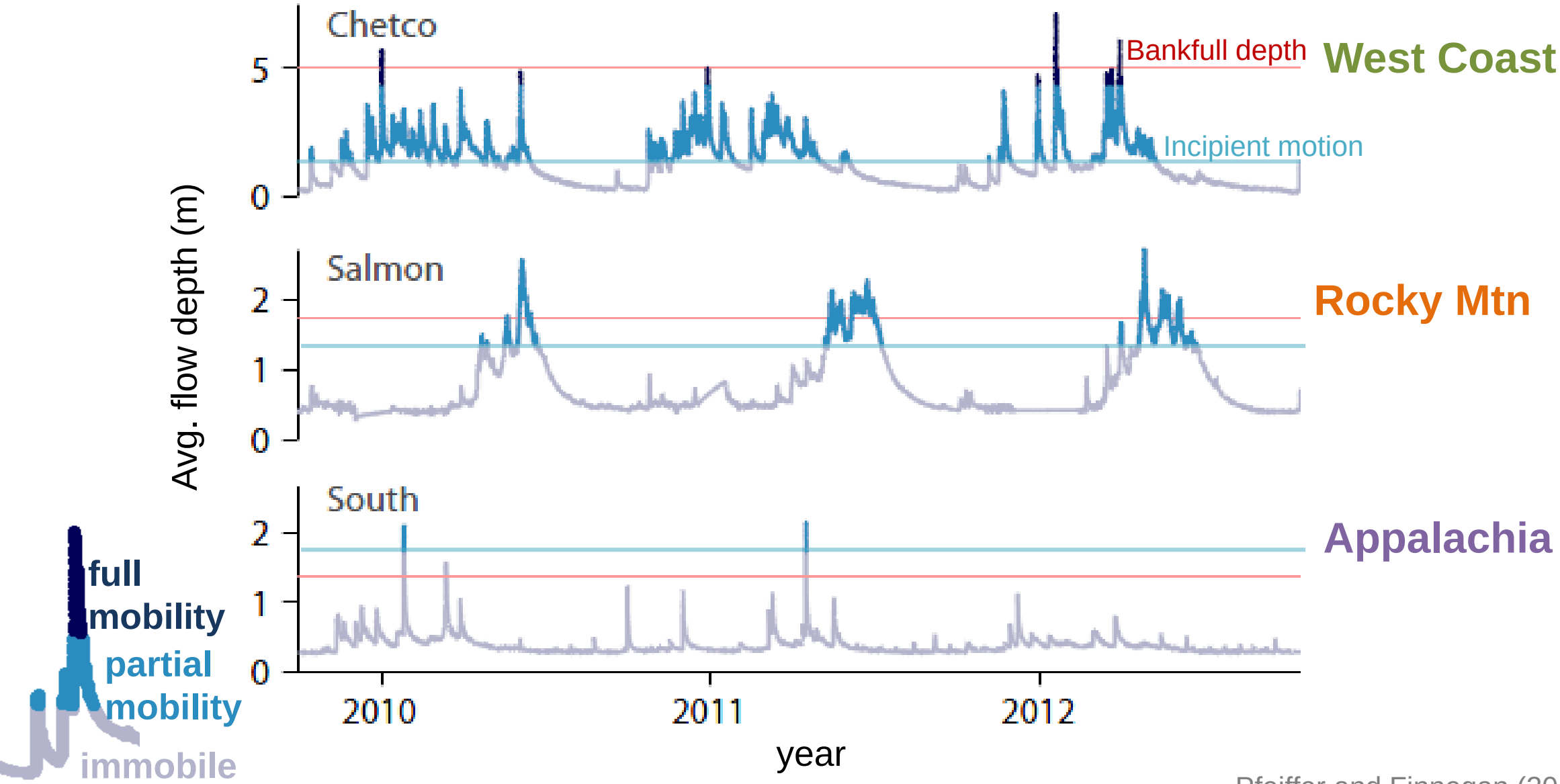
West Coast

Rocky Mtn

Appalachia

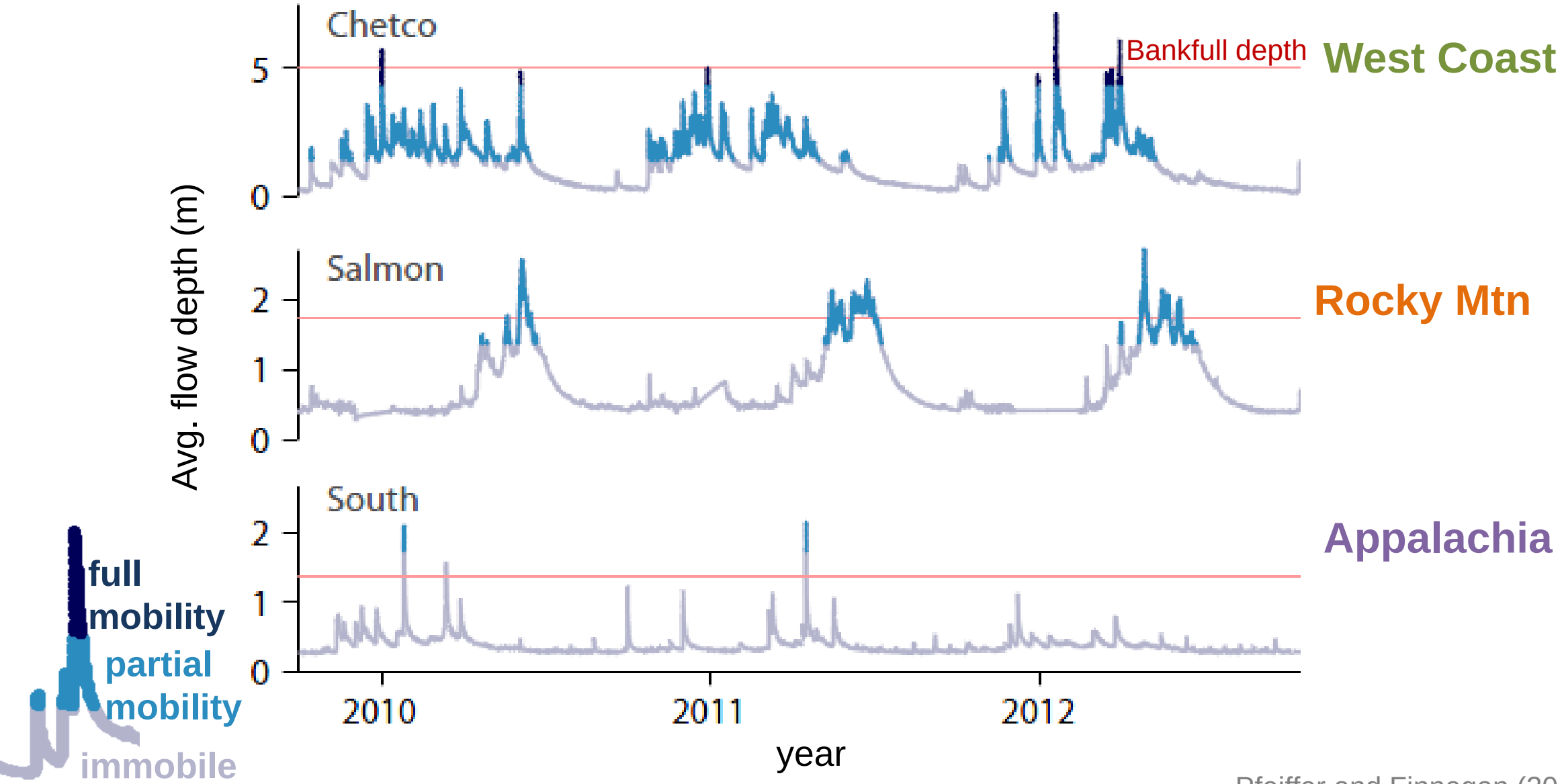
Pfeiffer and Finnegan (2018), GRL

Time series of bed mobility



Pfeiffer and Finnegan (2018), GRL

Time series of bed mobility



West Coast

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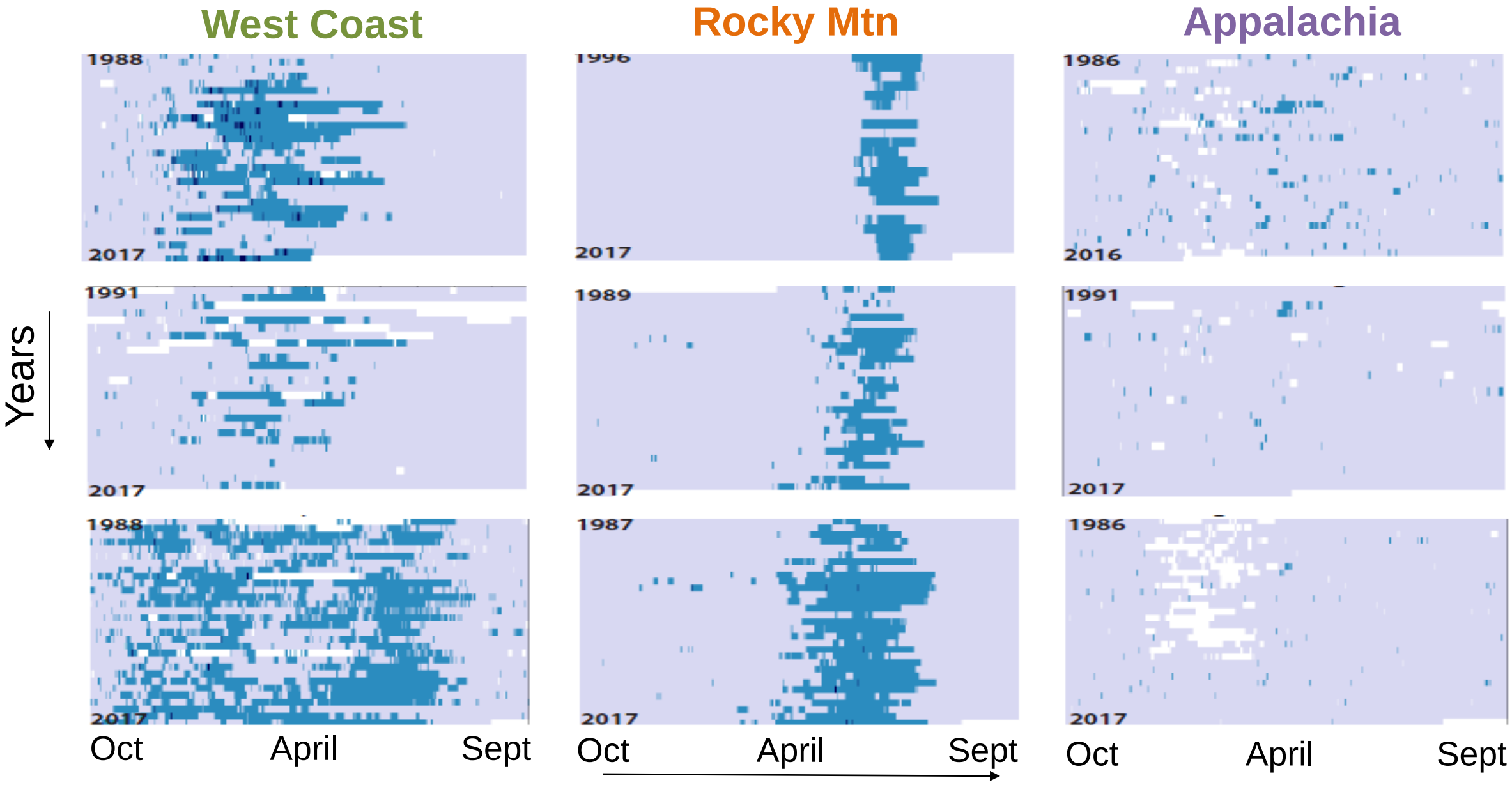
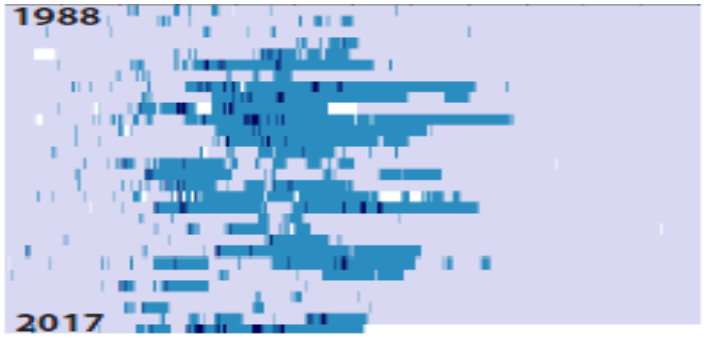
Time series of bed mobility



Regional differences in bed mobility

West Coast

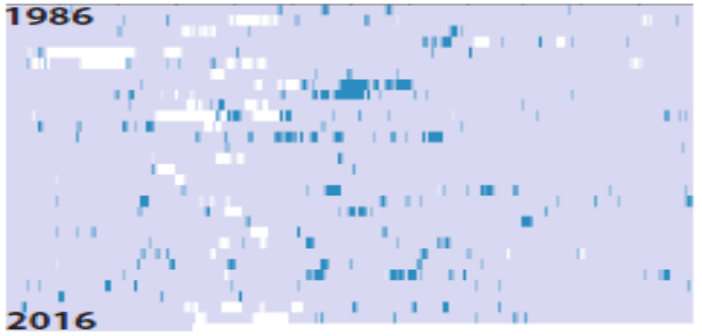


Brief peaks, full mobility is common

Rocky Mtn

Annual partial mobility assoc. w/ snowmelt

Appalachia



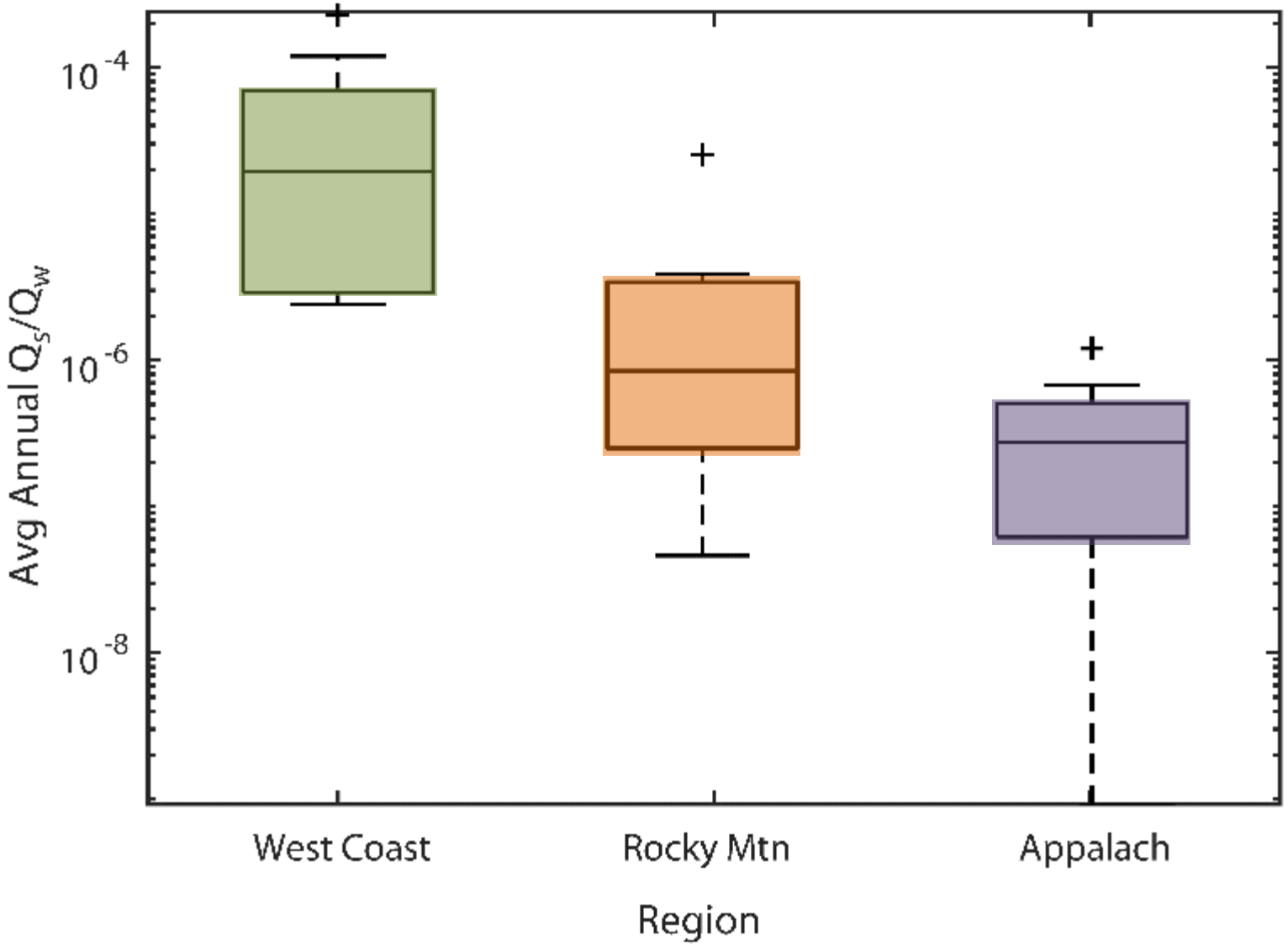
Infrequently, briefly mobile

Years

1. Differences in peak mobility and duration of mobility
2. Differences in intermittency (implications for history effects)
3. Integrate the bed mobility to get total sediment transport

Pfeiffer and Finnegan (2018), GRL

Total flux of water and sediment



West Coast > Appalach

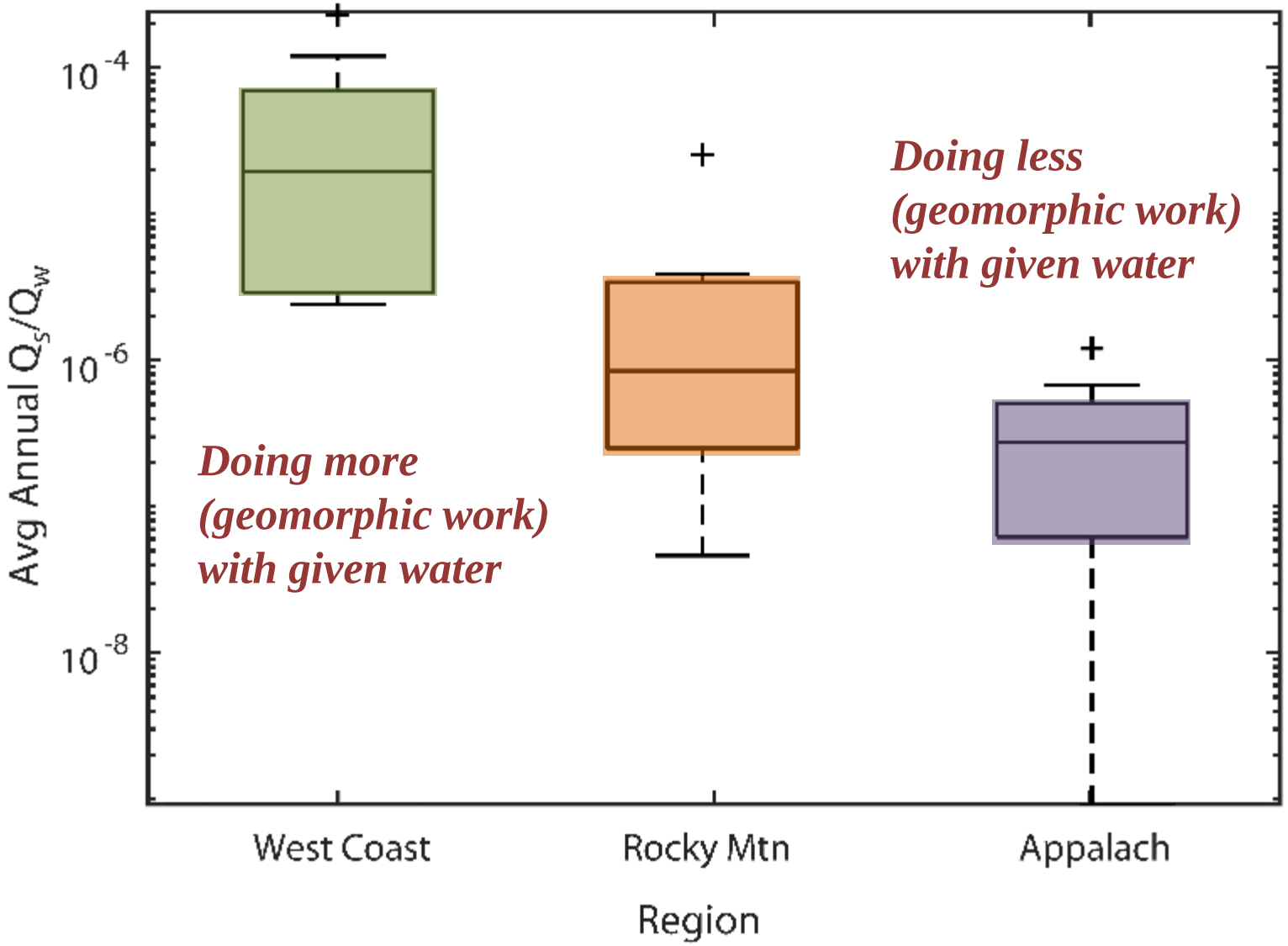
p = 0.006

West Coast > Rocky Mtn

p = 0.002

Games Howell post-hoc, $\log(Q_s/Q_w)$

Total flux of water and sediment



West Coast > Appalach

p = 0.006

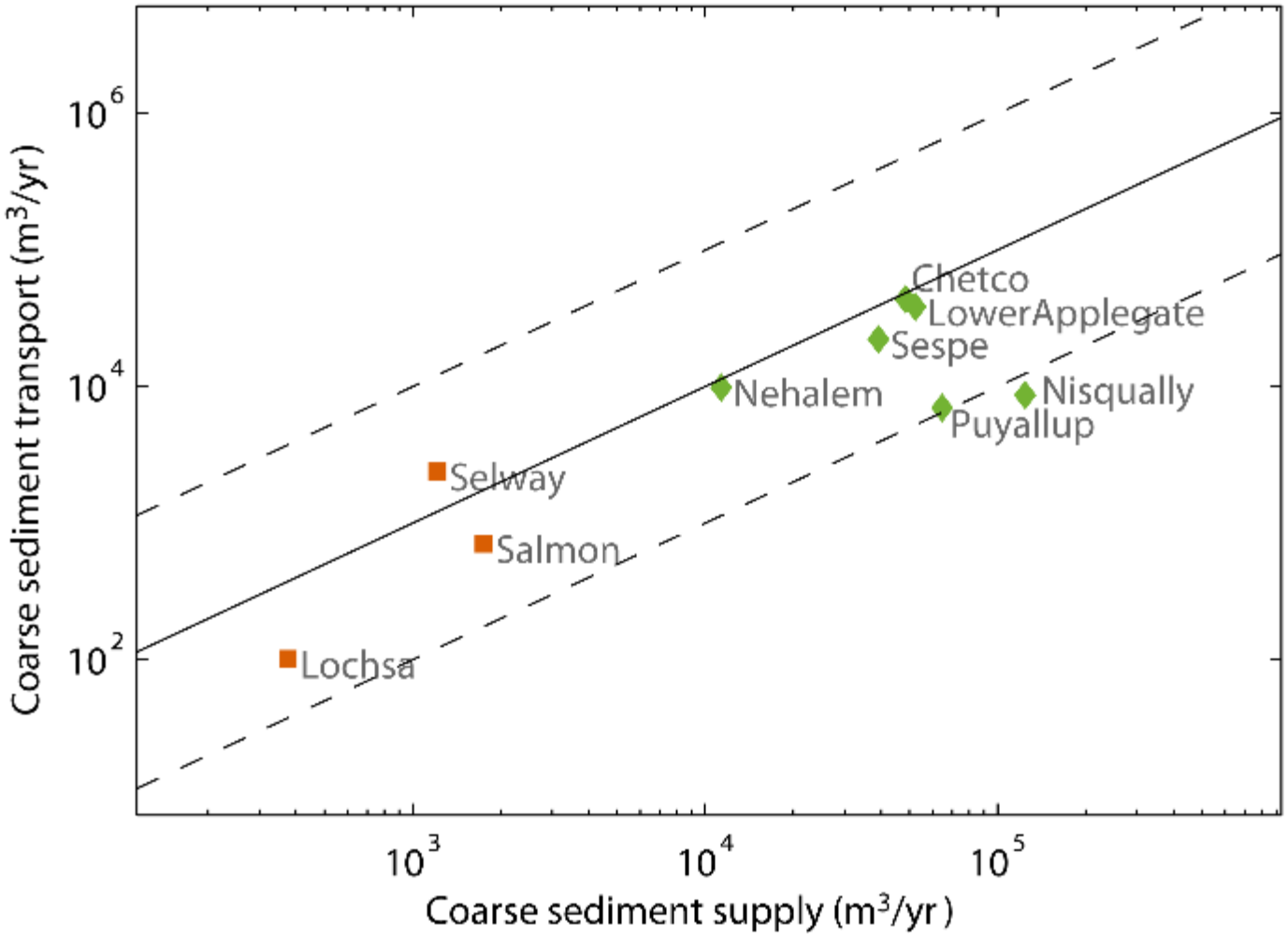
West Coast > Rocky Mtn

p = 0.002

Games Howell post-hoc, $\log(Q_s/Q_w)$

Reality check: cumulative transport v. supply

Calculated



Most from reservoir fill rates + bedload fraction

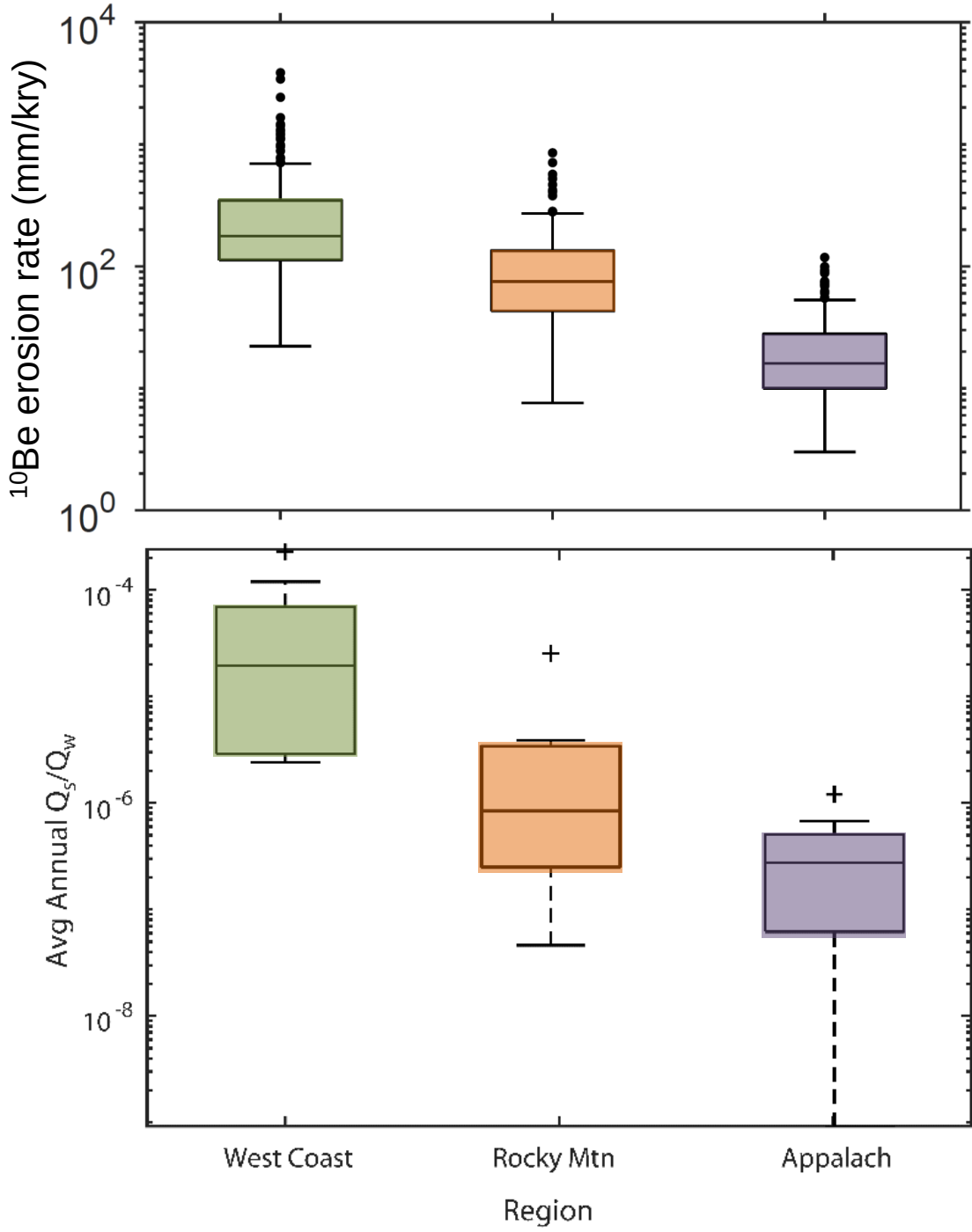
Reasonable match between supply and calculated transport

Supports our predictions of bed mobility

** Uncertainty on both axes

A hint at (quasi-) equilibrium, despite the variability

River channel geometry and grain size adjust to do more with less, or less with more, depending on the imposed climate and tectonic setting.



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Grain data: Tom Lisle, Jim O'Connor, Catalina Segura, Brian Collins, Jeff Chaplin

Questions?

Doing more (geomorphic work) with given water

Doing less (geomorphic work) with given water

West Coast | Rocky Mtn | Appalachia

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