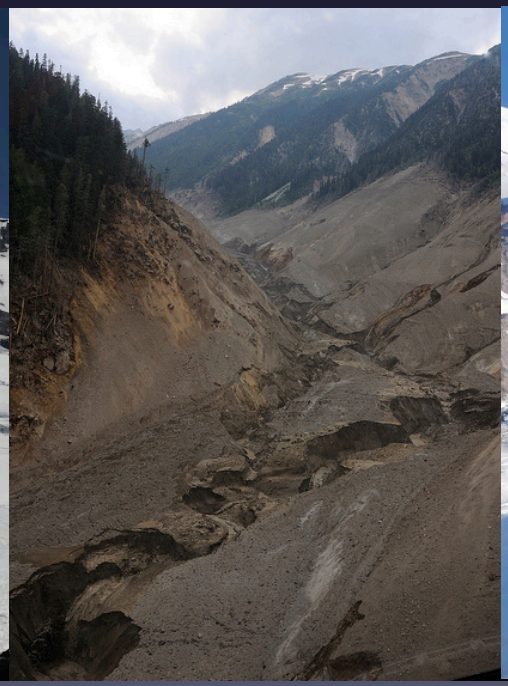
Seismology and Surficial Processes

Landslides, Glaciers, and Volcanoes

Kate Allstadt
Gazing at the Earth
June 18, 2014

EARTH & SPACE SCIENCES
UNIVERSITY of WASHINGTON
College of the Environment

Challenges with studying these processes

- Often remote, deadly
- Can happen **fast** – need good **time resolution**
- Hard to instrument or make quantitative measurements
- Don’t know where or when they will occur
- Cloud cover

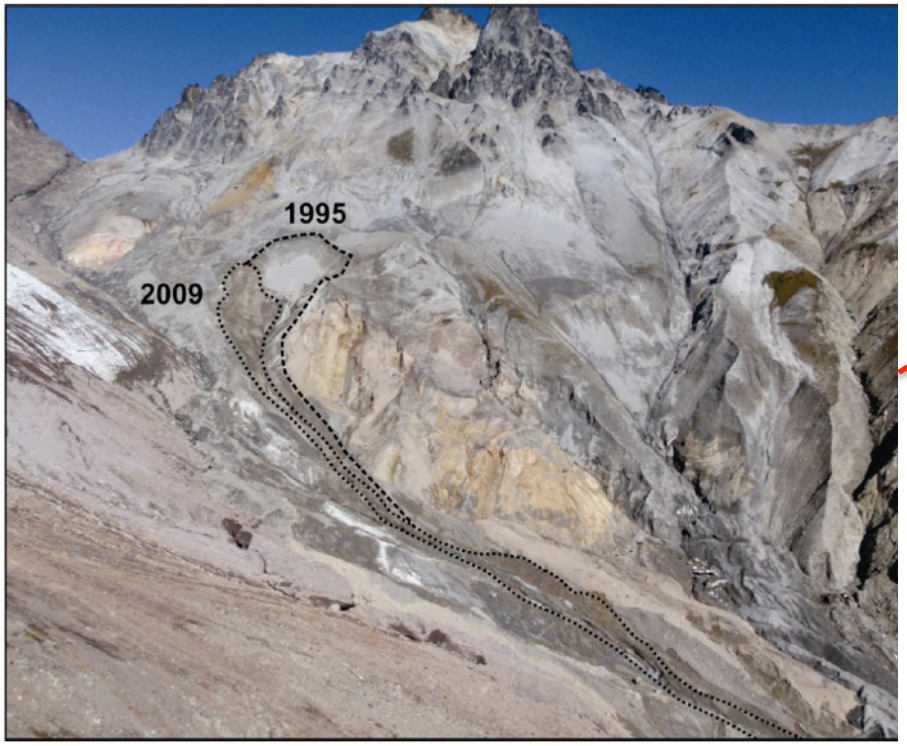
Seismology advantages

- Always watching (permanent monitoring networks worldwide)
- Can go back in time (continuous data archived)
- Can "see" 1000's of km (at long periods) – clouds don't matter
- Extremely high and precise time resolution (e.g. 100 samples per second, timing from satellites)
- Quantitative measurements
- Could be complementary to "gazing" – including help identifying targets

Landslides

Source Area – Mount Meager Rockslide – debris flow, 2010

Before

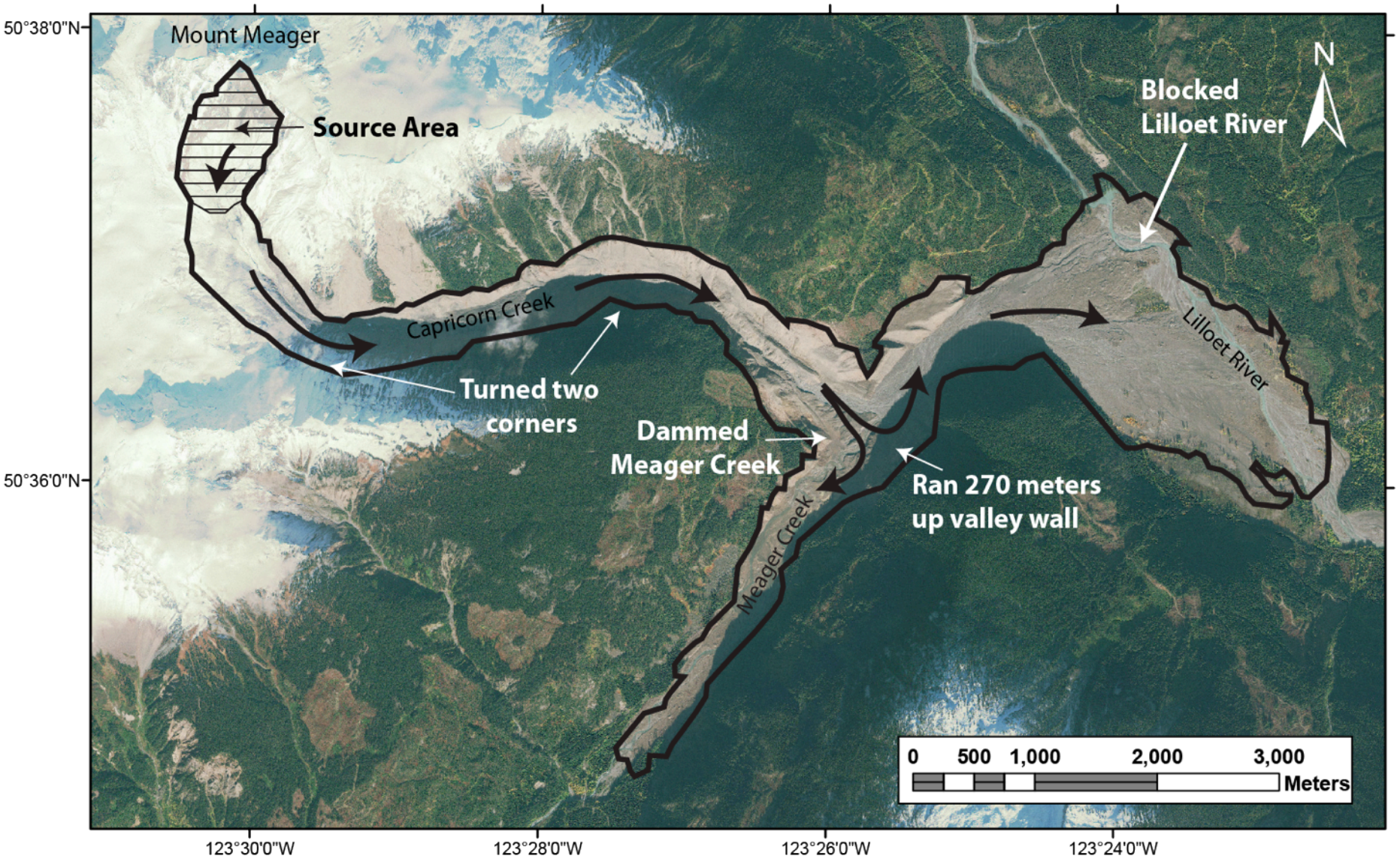


After

48 million cubic meters = ~10^{11} kg = ~5 million dump truck loads

Images from Guthrie et al., 2012

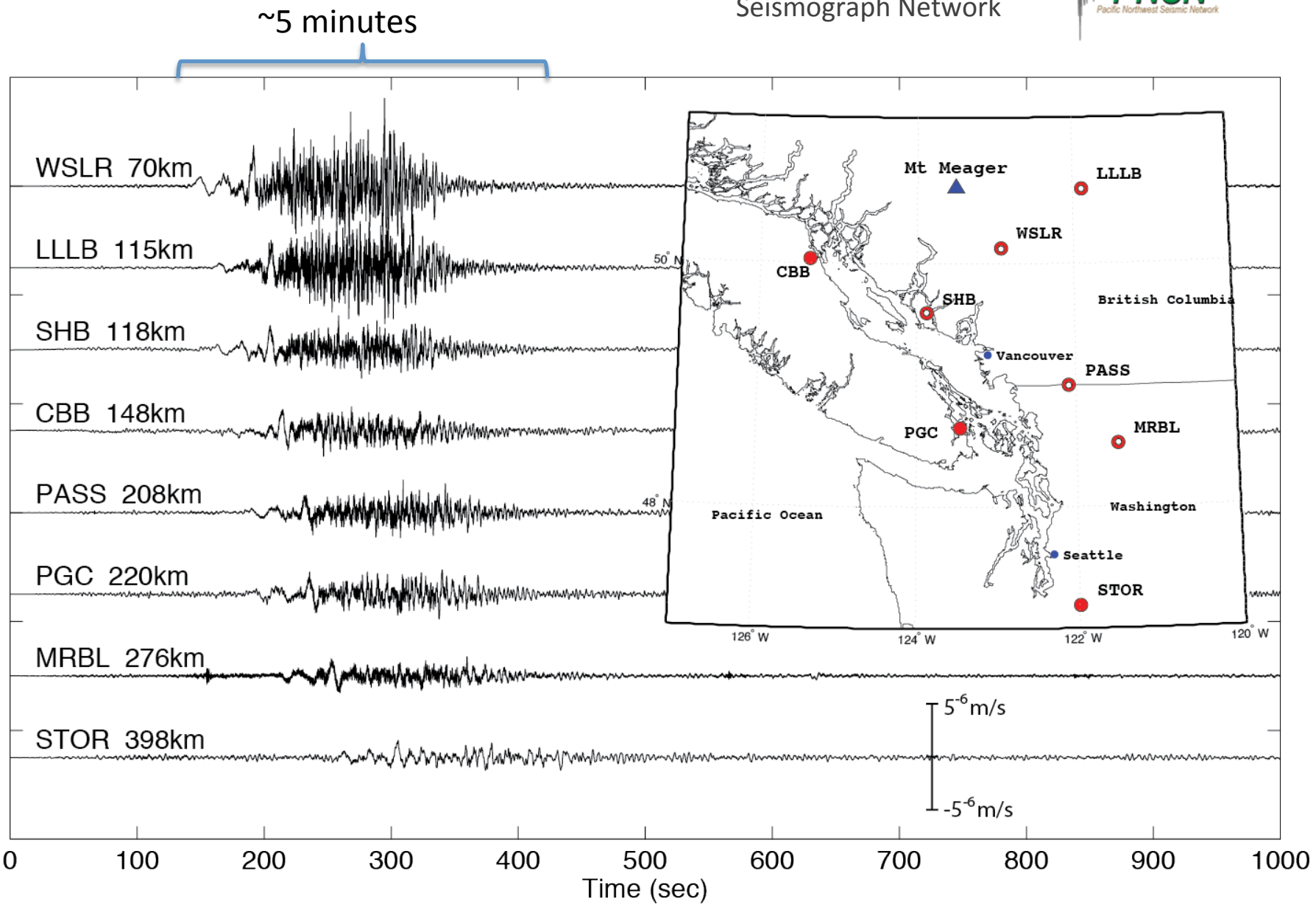
Photo by dbsteers


50°38'0"N
50°36'0"N
123°30'0"W
123°28'0"W
123°26'0"W
123°24'0"W
Mount Meager
Source Area
Capricorn Creek
Turned two corners
Dammed Meager Creek
Meager Creek
Ran 270 meters up valley wall
Blocked Lilloet River
Lilloet River
N
0 500 1,000 2,000 3,000
Meters

Seismograms

Local magnitude equivalent of 2.6

Canadian National Seismograph Network

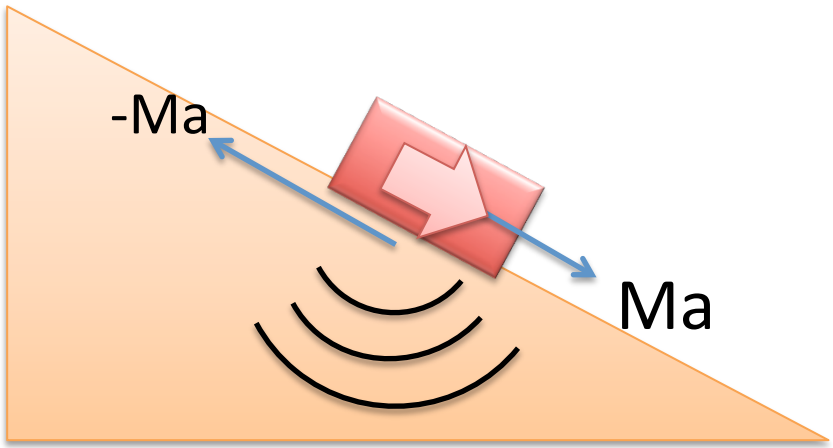


Landslide source mechanism:
~ a single force exerted on the earth in opposite direction of acceleration

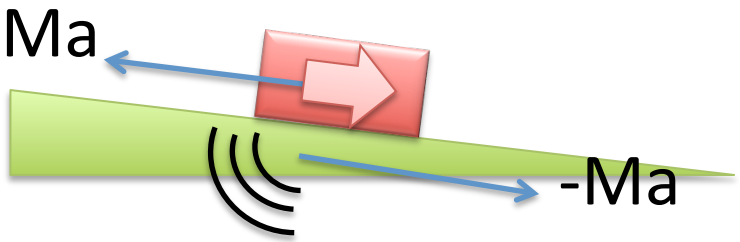
$F=Ma$

$F_{slide}=-F_{earth}$

(Newton's Second and Third Laws)



Accelerating block

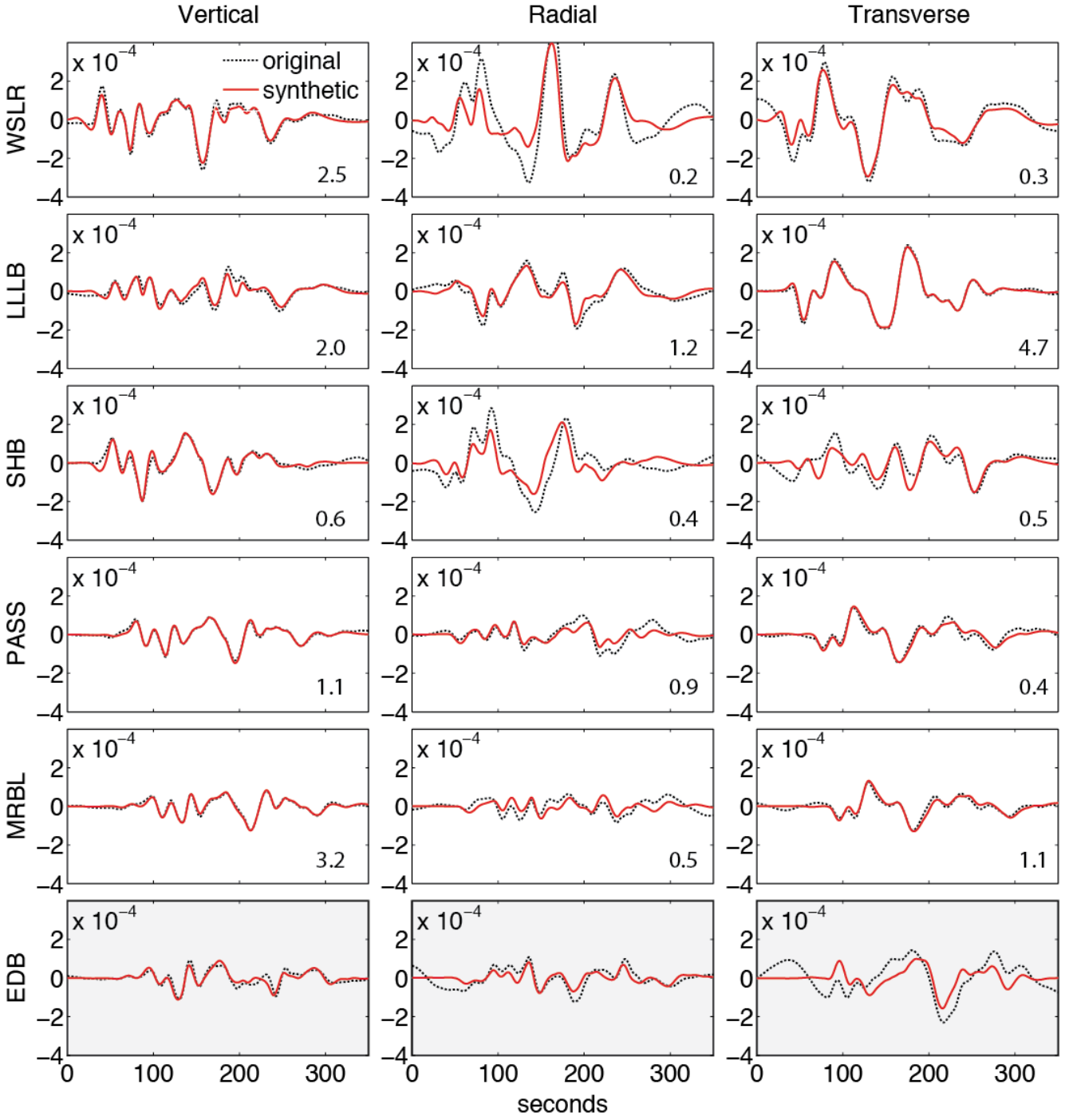


Decelerating block

Inversion of Long Periods (T=30-150s) for Force-Time Function

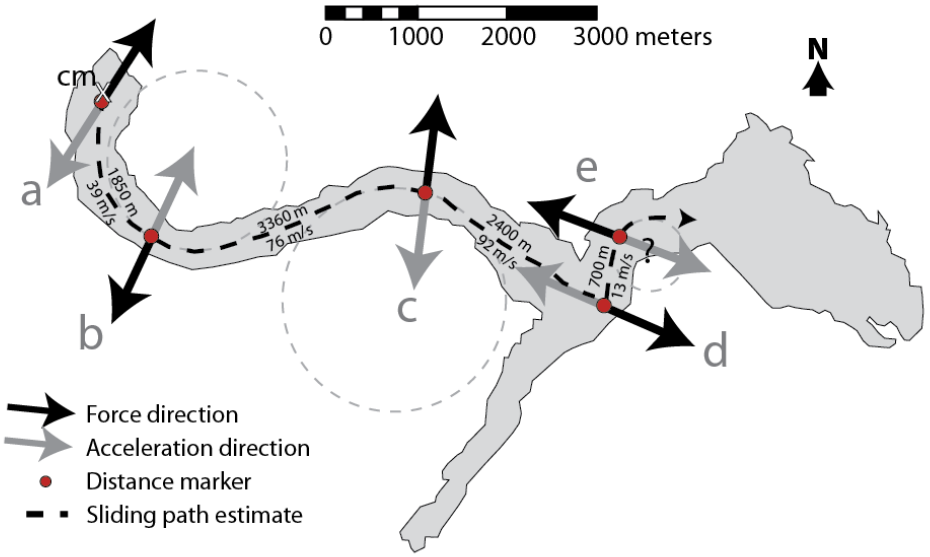
Data Fit

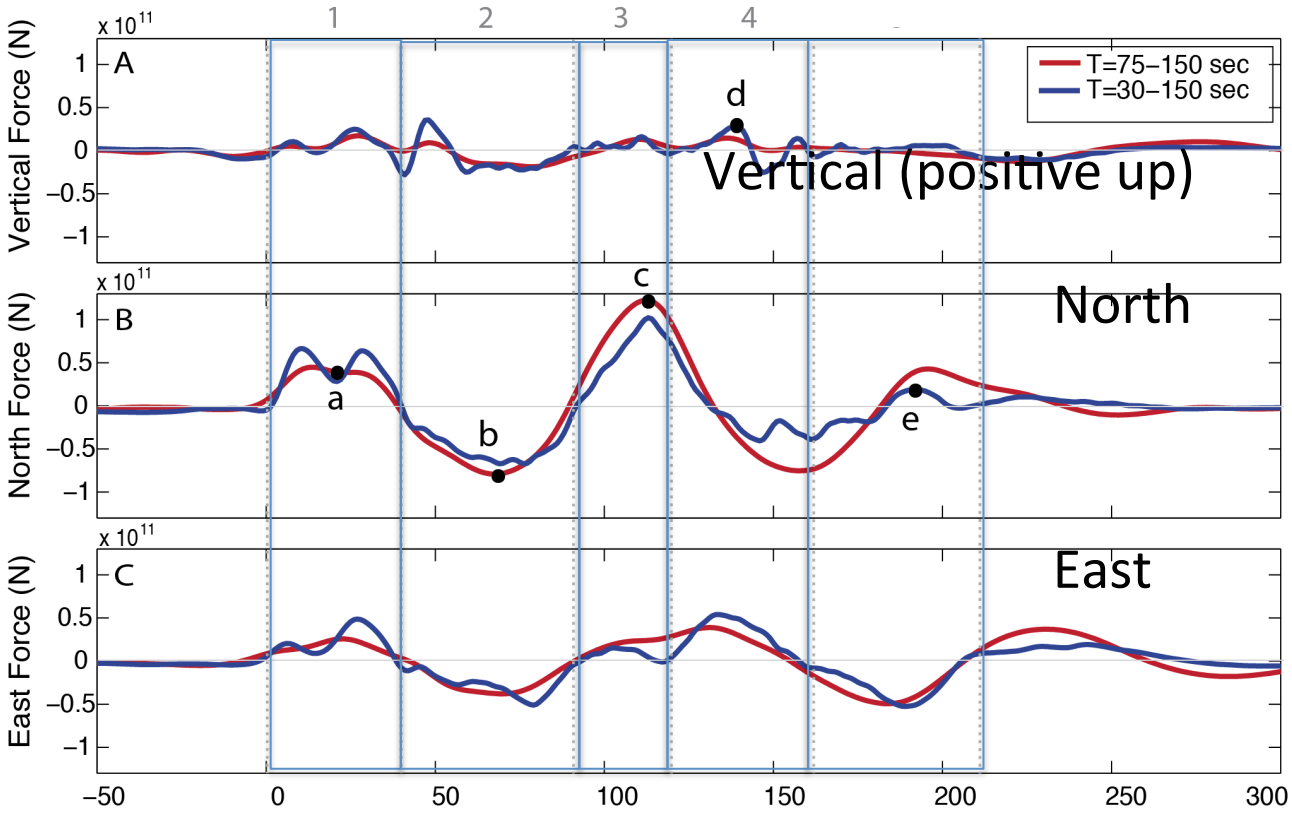
80% Variance Reduction



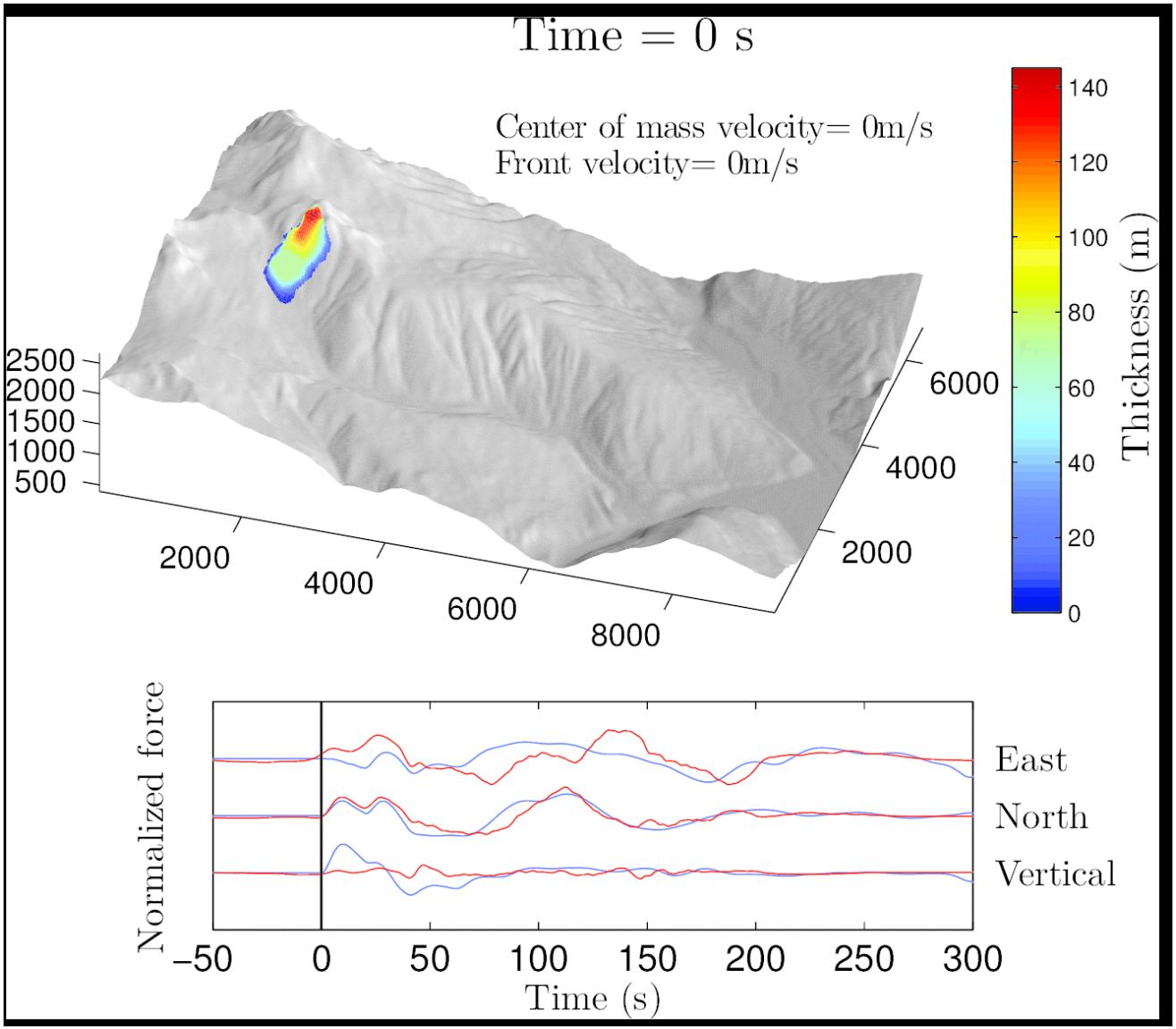
Units=cm of displacement

Interpretation of Force-Time Function





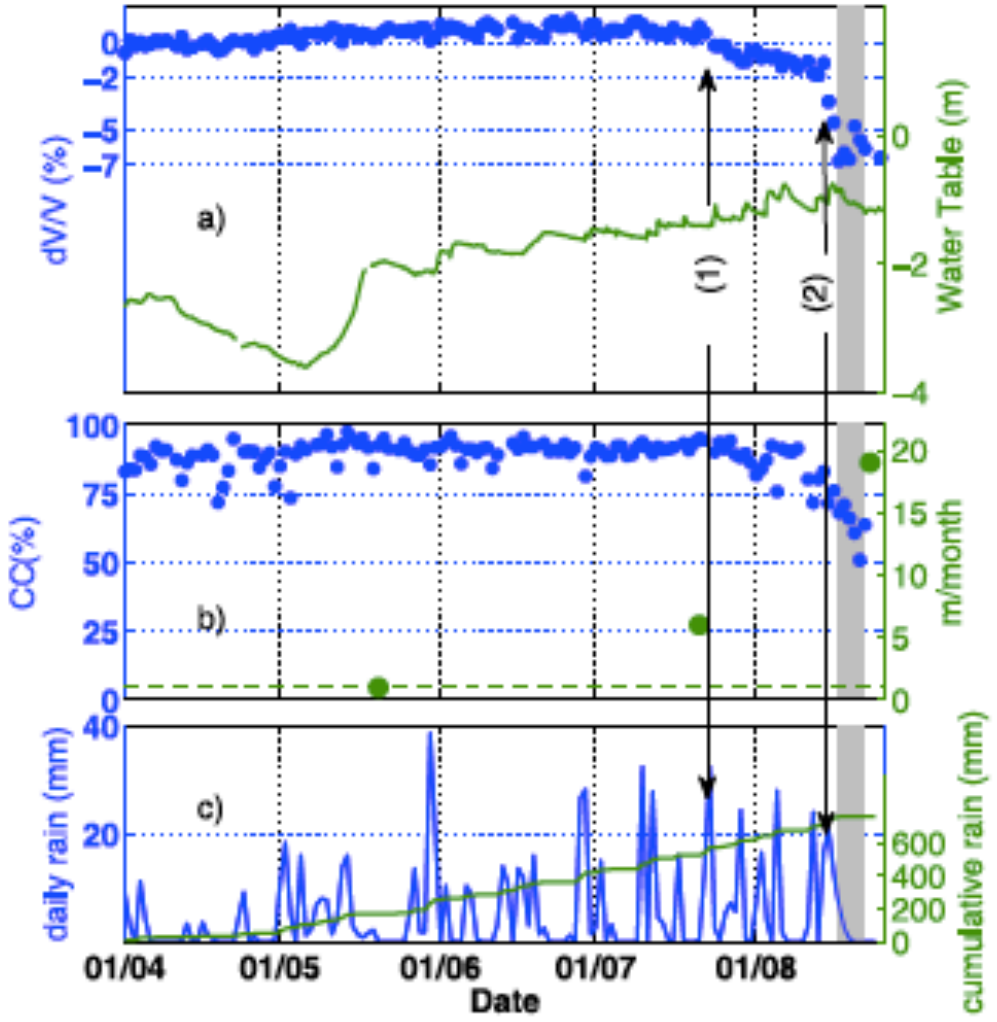
Numerical Modeling with Laurent Moretti and Anne Mangeney (IPGP)

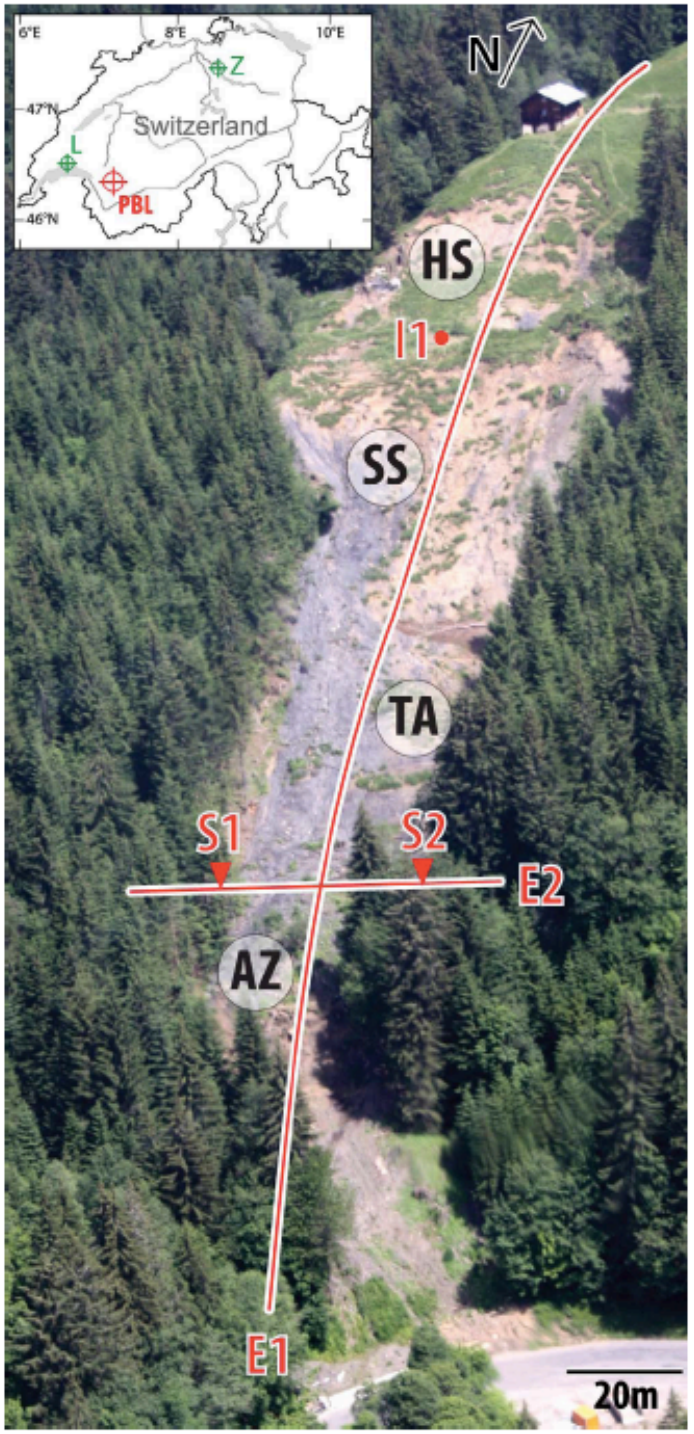



Naches/Nile Valley Landslide, Washington, 2009
Precursory activity
>2 days prior, residents hear popping, groaning
Slow deformation began >12 hrs before energetic events

Precursory changes in material properties several days before slide

Mainsaint et al. 2012





Volcanoes

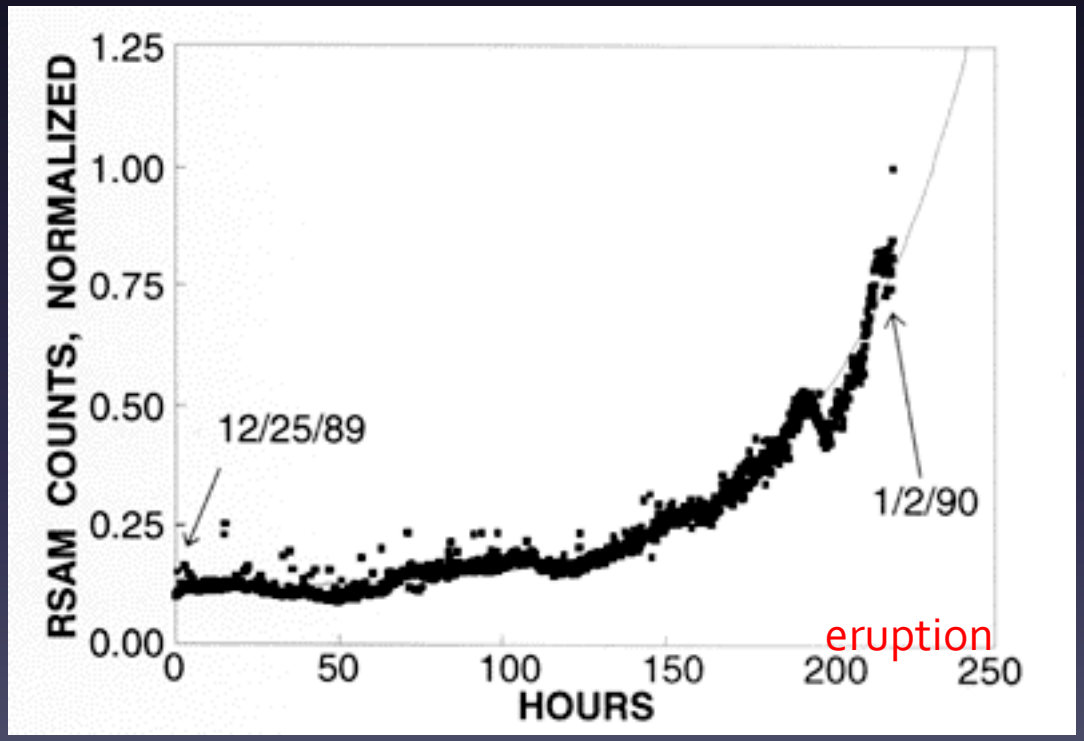
Dangerous and difficult to instrument – even when quiet

Rockfall at Mount Rainier destroying expensive GPS instrument and almost killing coworker, June 2011

https://www.youtube.com/watch?v=fzRhLs5GkYs

We can predict when volcanoes will erupt = makes targeting easier

e.g. Real-time Seismic-Amplitude Measurement



Endo et al., 1999

Pre-eruptive RSAM, Mount Redoubt 1990

http://pubs.usgs.gov/pinatubo/endo/

http://pubs.usgs.gov/fs/2005/3036/fs2005-3036.html

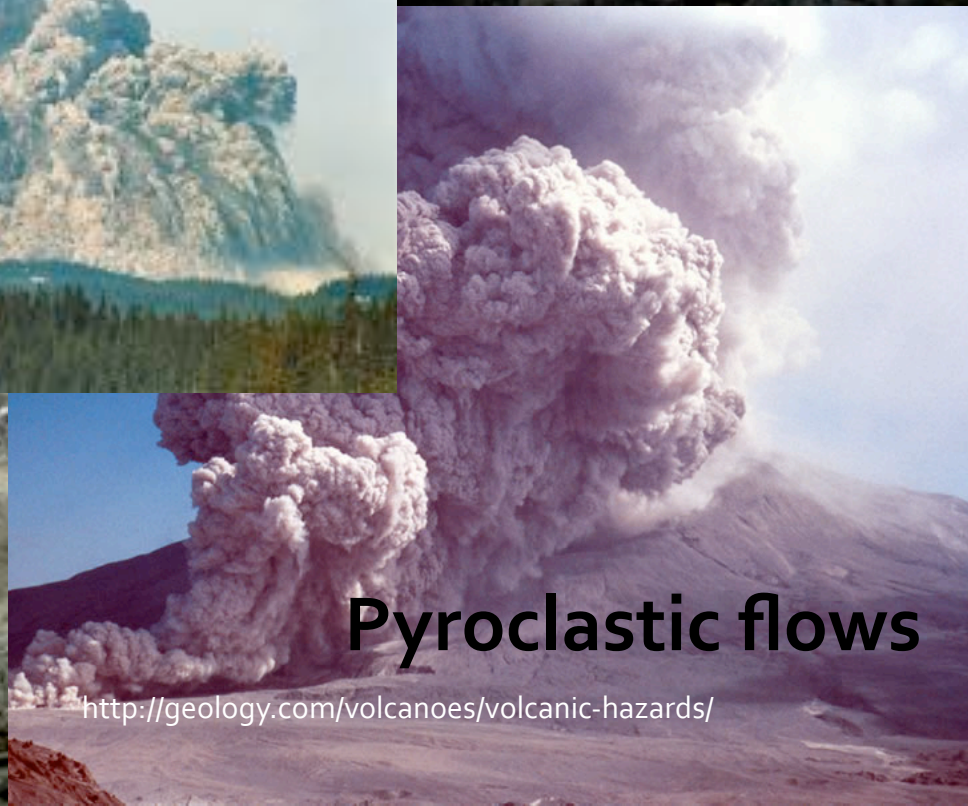
Deformation

Lava flows

Landslides/blasts

Lahars

http://www.geology.sdsu.edu/how_volcanoes_work/Thumblinks/palmarlahar_page.html

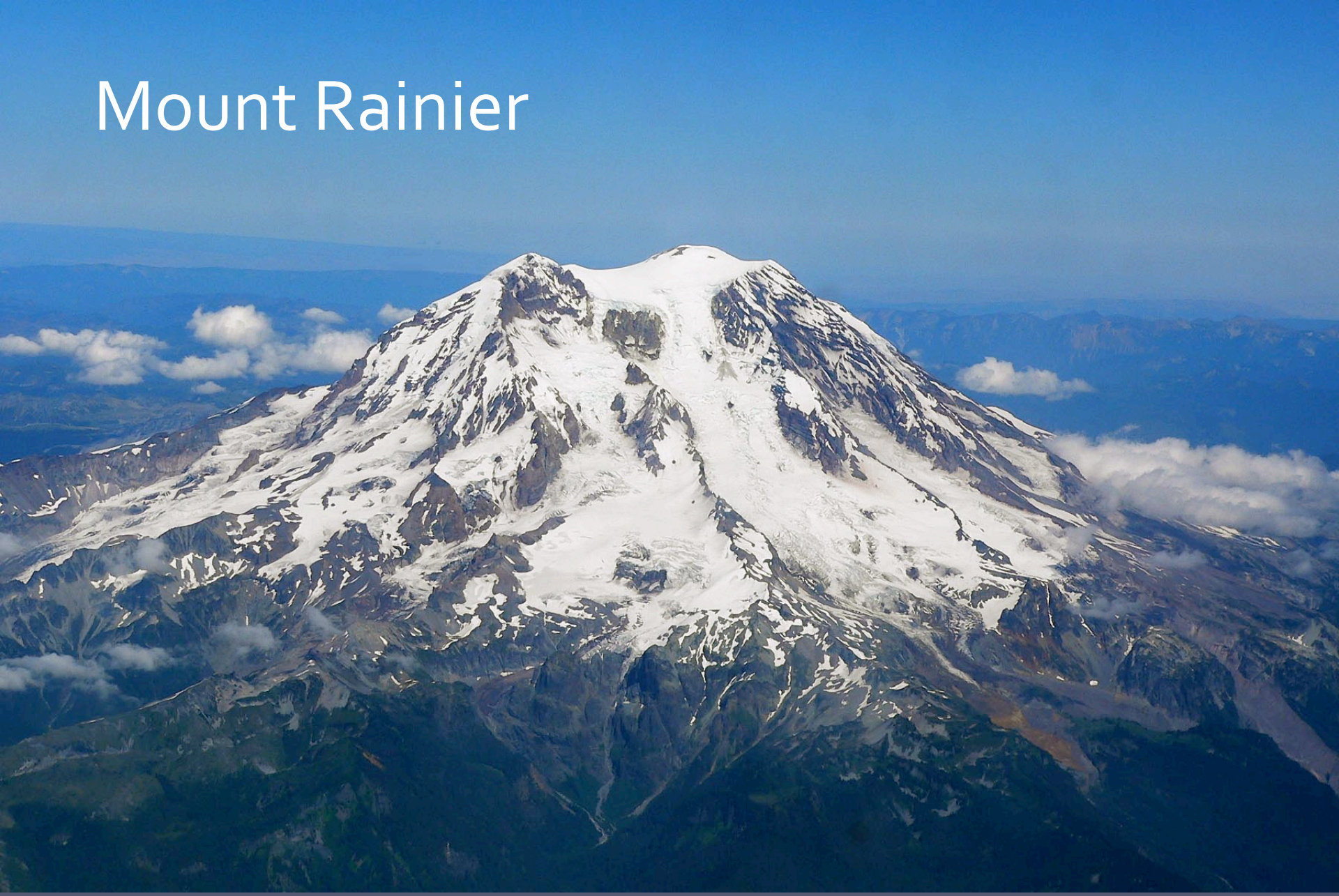


Pyroclastic flows

http://geology.com/volcanoes/volcanic-hazards/

Glaciers

Mount Rainier



http://commons.wikimedia.org/wiki/Mount_Rainier

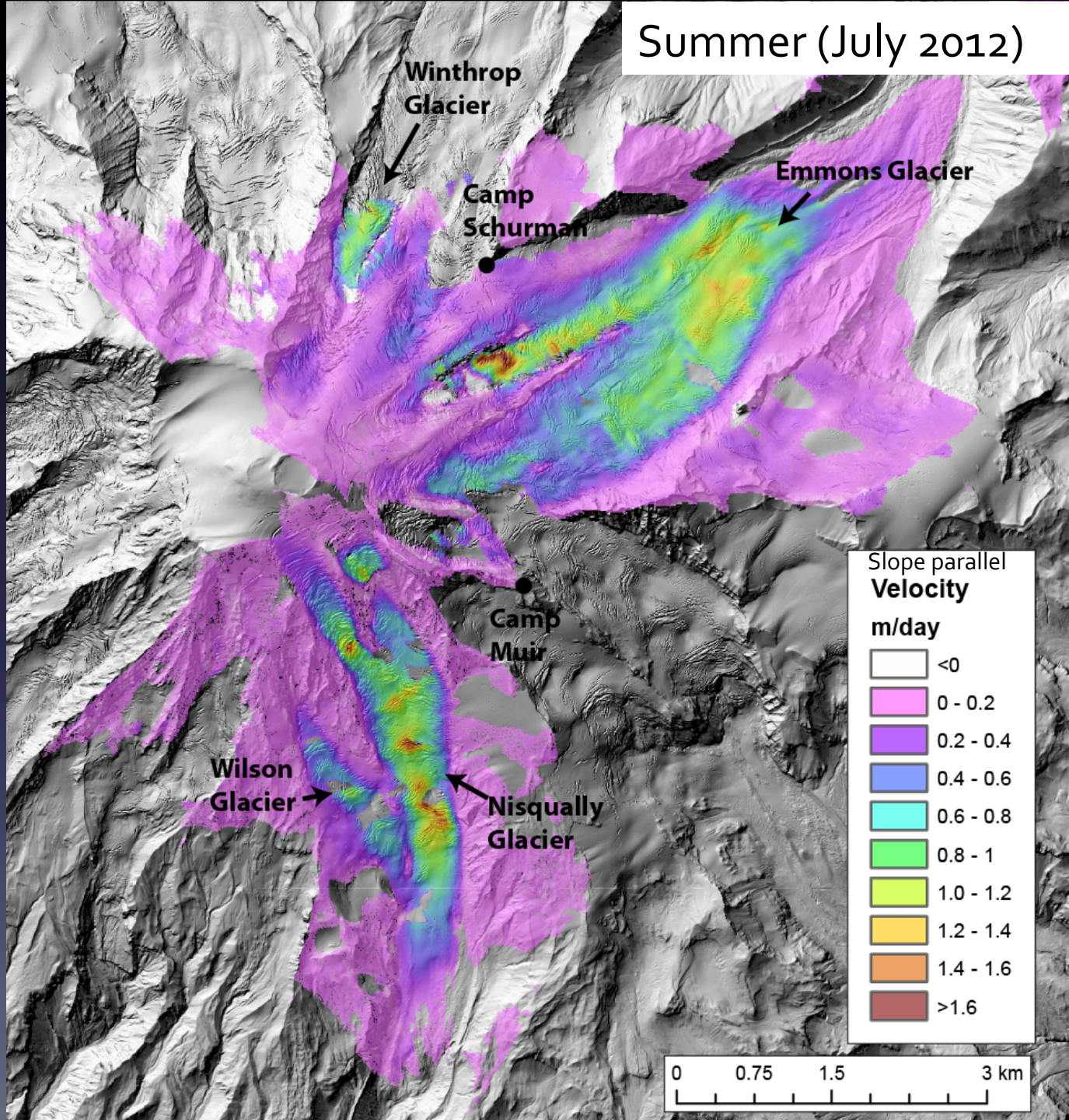
Gamma Portable Radar Interferometer

Side project with D. Shean, S. Malone and M. Fahnestock

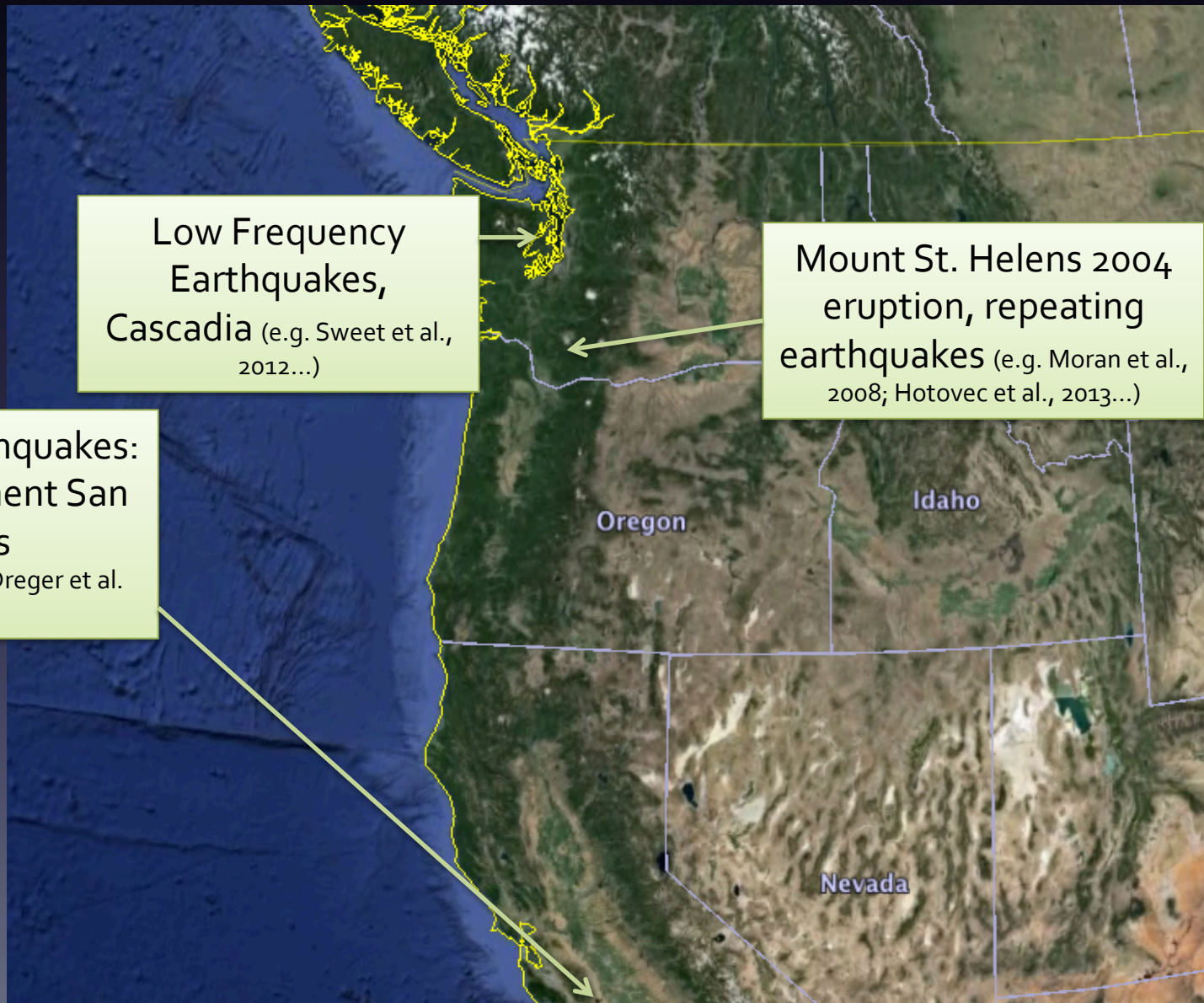
Glacier velocities at Mount Rainier from ground-based radar interferometry

3 minute sample interval + lots of stacking

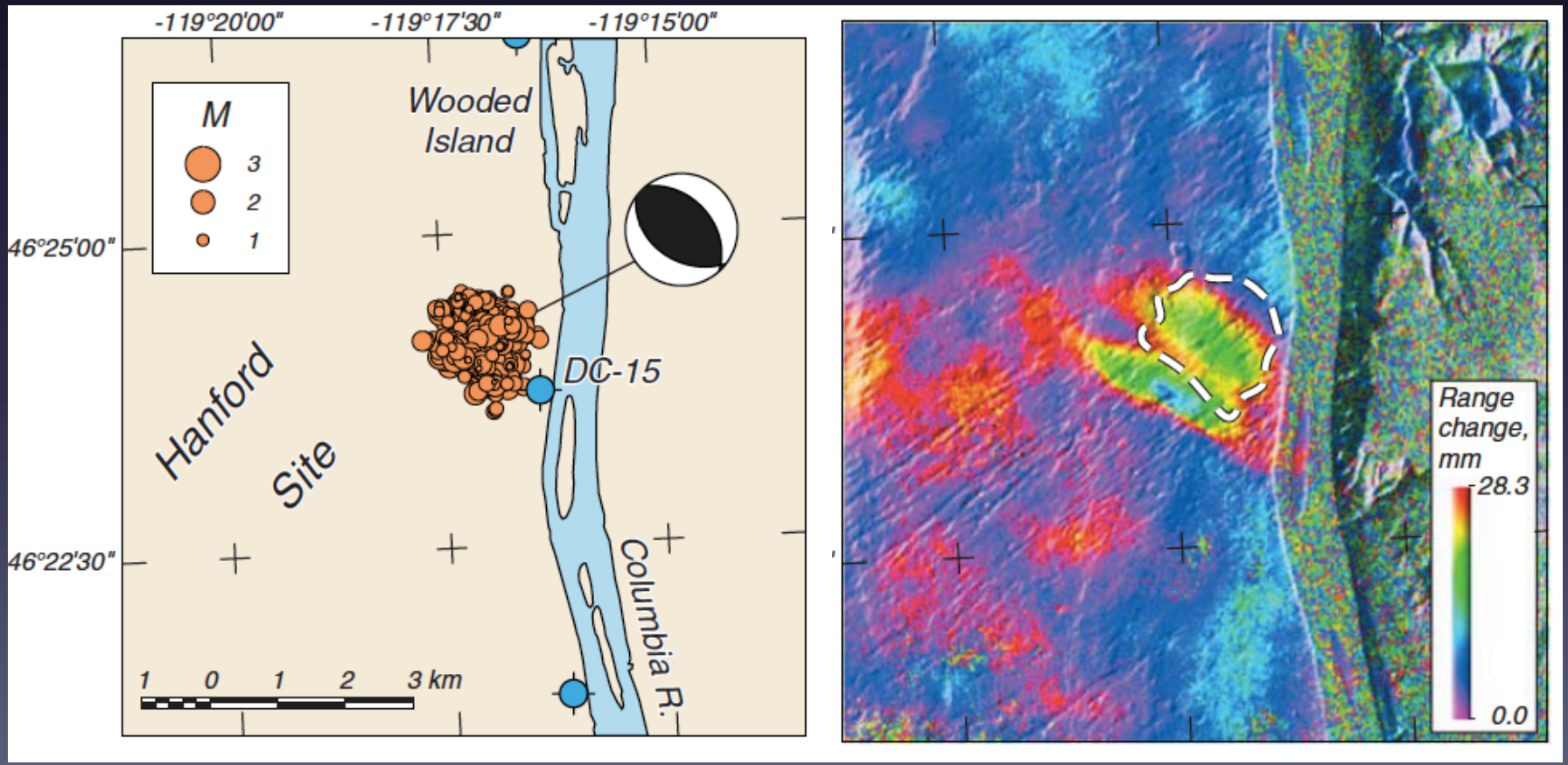
Daily Average velocities, Slope Parallel



Repeating quakes often associated with slow deformation – occur in many environments



E.g. Wooded Island swarm & deformation



Blakely et al., 2012

Episodic Tremor And Slip

Every ~14 months

www.pnsn.org