# 3D geodynamic and geomorphic modelling of the Alaska/Aleutian Margin – STEEP and GeoPRISMS


Photo: Eva Eckelmann, 2008

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# 3D geomorphic and geodynamic modelling:

- Brings together geological and geophysical data and interpretations into an overarching framework
- Used to constrain ideas and make testable predictions
- We identify 3 topics which require modelling to address key SCD science questions

1. Evolution of deformation in space and time

    Thermal advection, surface processes, metamorphism, see Ben Hooks' poster

2. Feedbacks between tectonic driven processes and surface processes

    Erosive response of large earthquakes, strain softening and erosion

3. Short term verses long term strain

    $T_{cr}$ – 10 to $10^5$ years, covers the period between recoverable and permanent strain

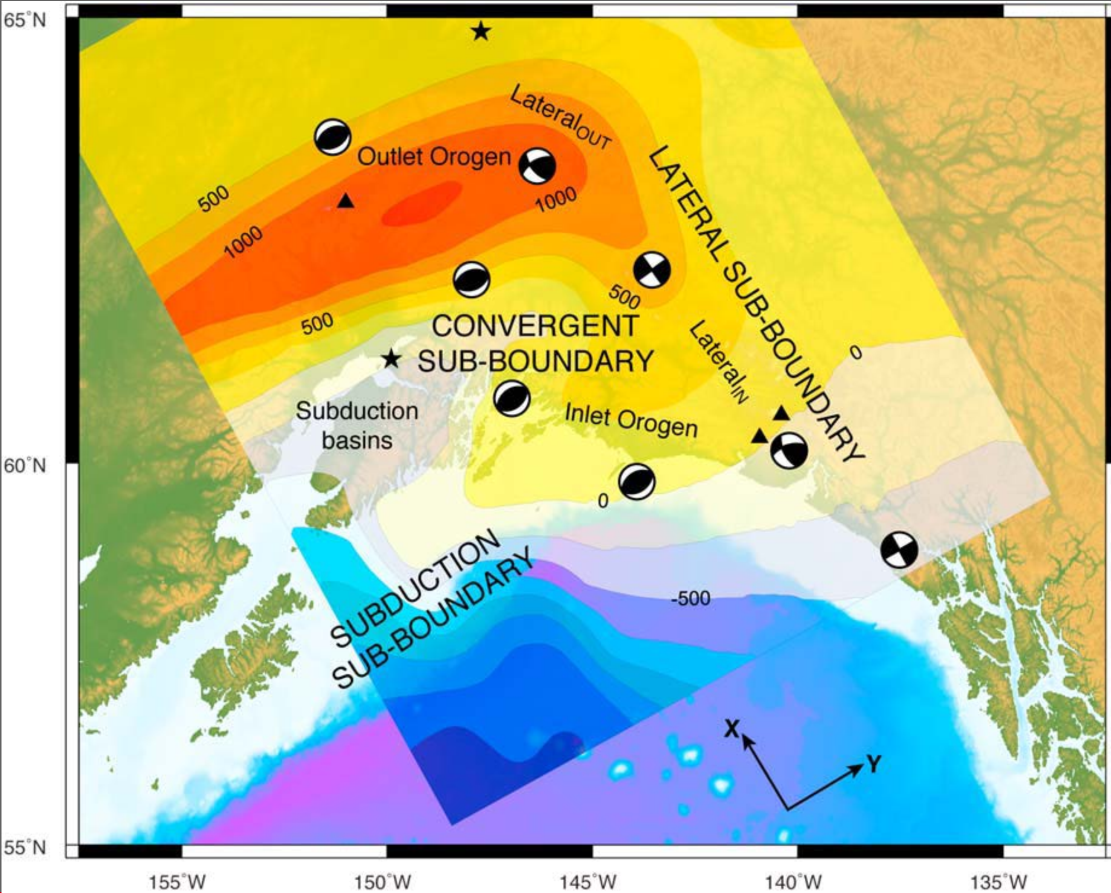
# Material strength evolution along the basal detachment:

3D macroscale models of SE Alaska identify:

Material strength evolution along the basal detachment

• Primary control on long term strain release

• Associated topographic development




Hooks (2009)

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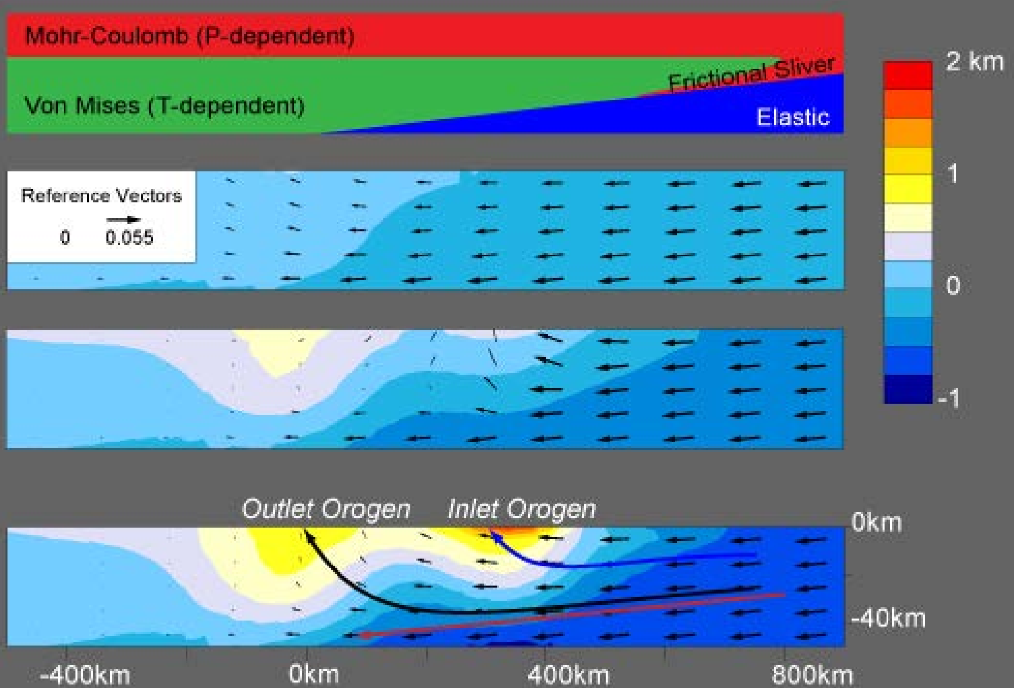
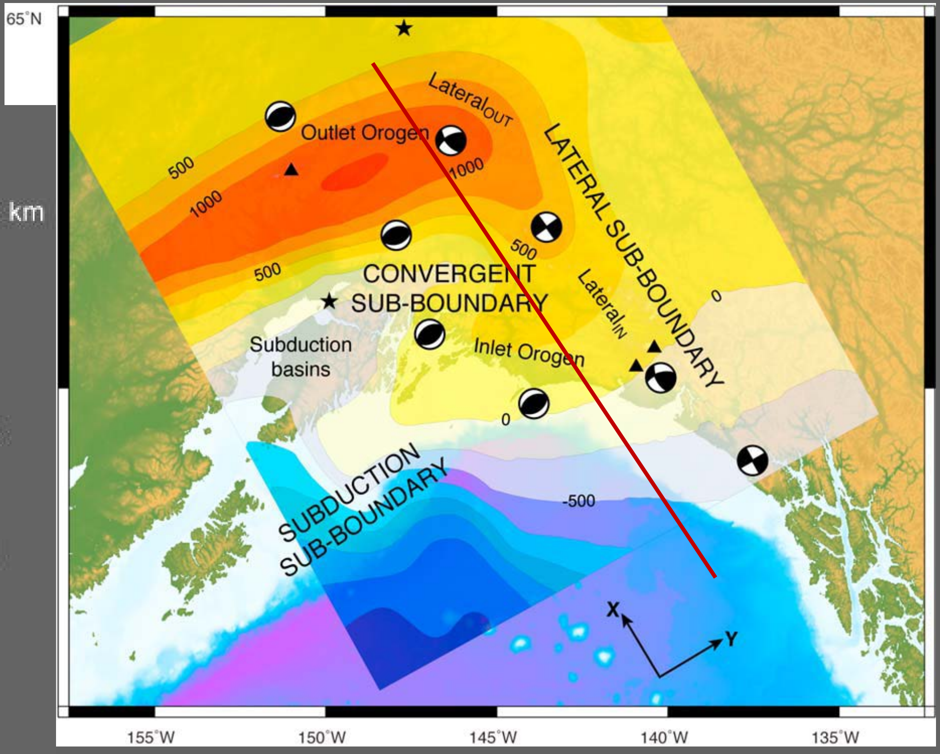


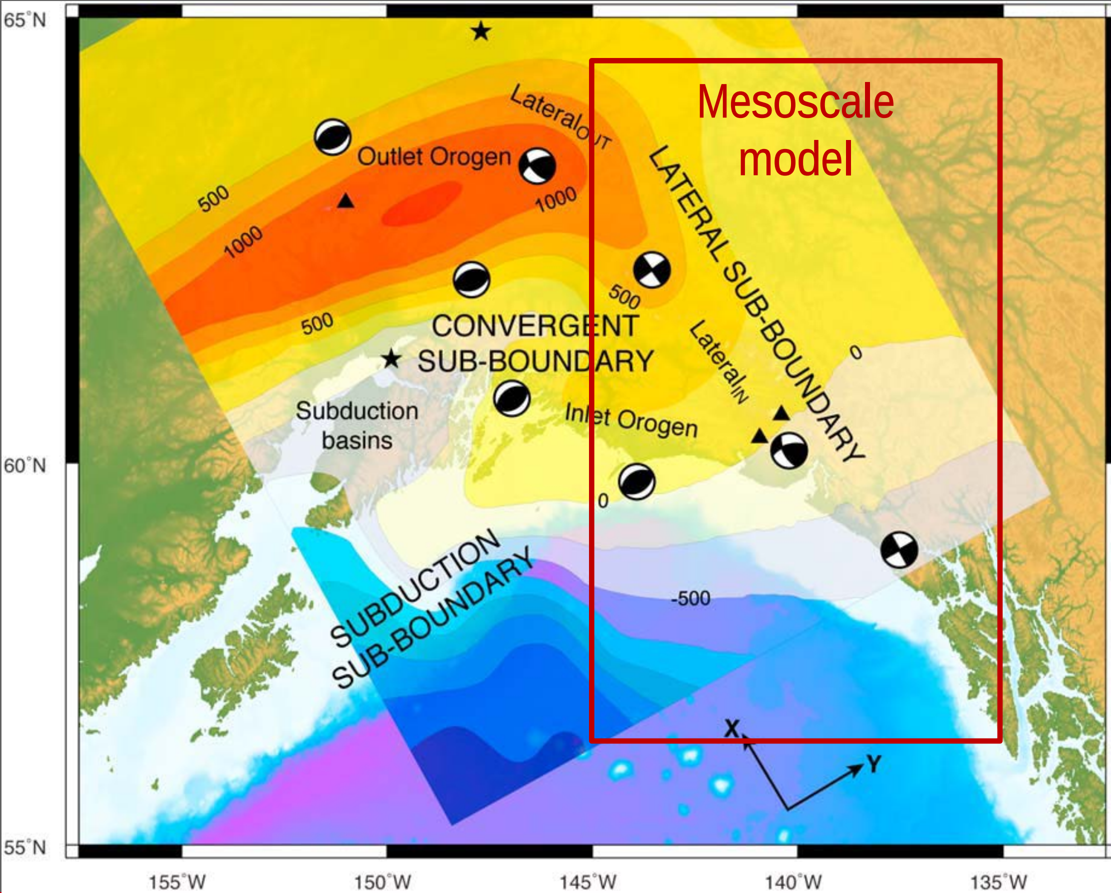

Hooks (2009)

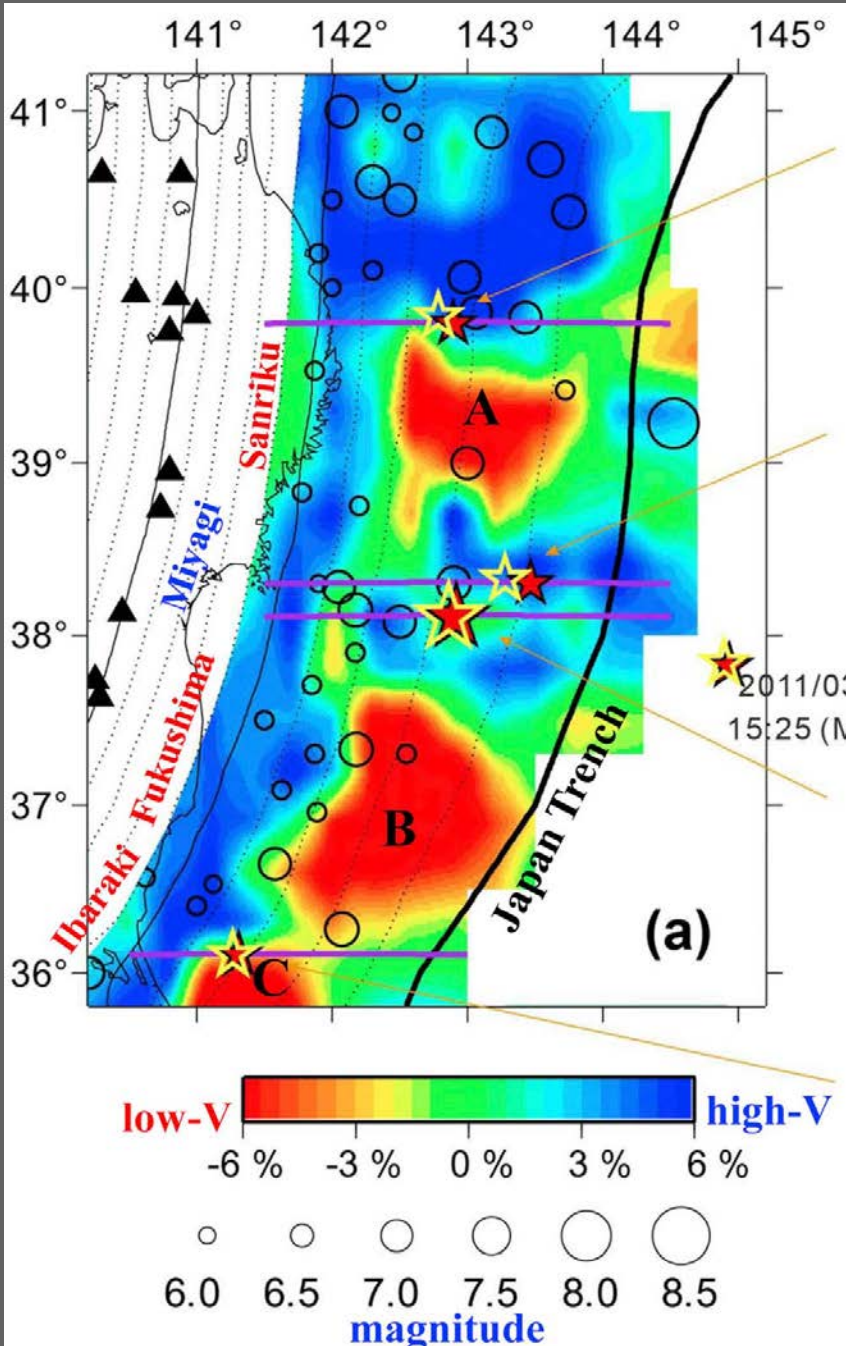
# Material strength evolution along the basal detachment:

Boundary conditions from macroscale model, incorporate sequentially the influence of:

- Erosion
- Regional observed topography
- Thermal evolution

See Ben Hooks' Poster for details






# Spatial variability of strength along the mega-thrust

With increasingly high resolution data, recent developments in modelling software and faster computers, we can expand upon existing models of the Alaska/Aleutian margin (as well as others)

Targets include:

- Rheological characteristics of the megathrust, constrained by geophysical data.
- Thermal evolution of the down going slab and overriding plate.
- Higher resolution geological, geophysical and topographic inputs to explore various system components.

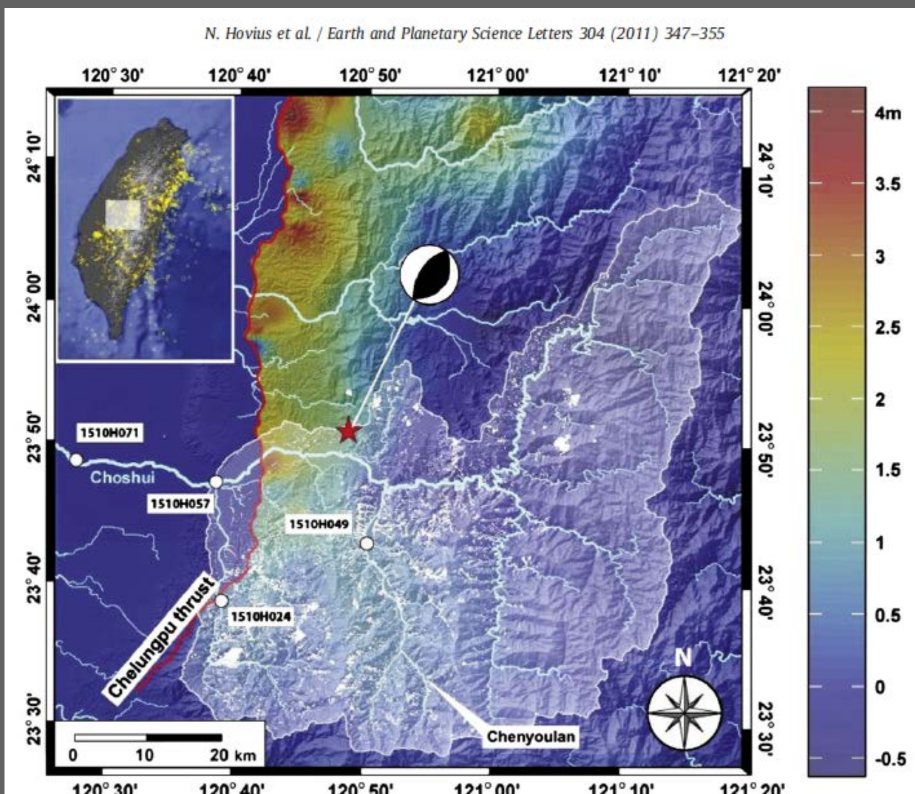
Zhao et al. GRL 2011

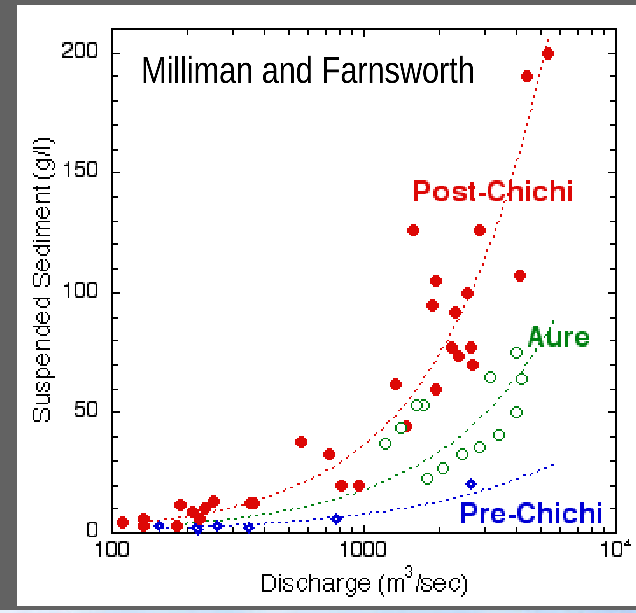
# Feedbacks between tectonic driven processes and surface processes

Chi-Chi Earthquake, $M_w$ 7.6, >20000 associated landslides

Enhanced mass wasting and sediment transport 5X background level

Returned to pre-earthquake levels in about 6 years.



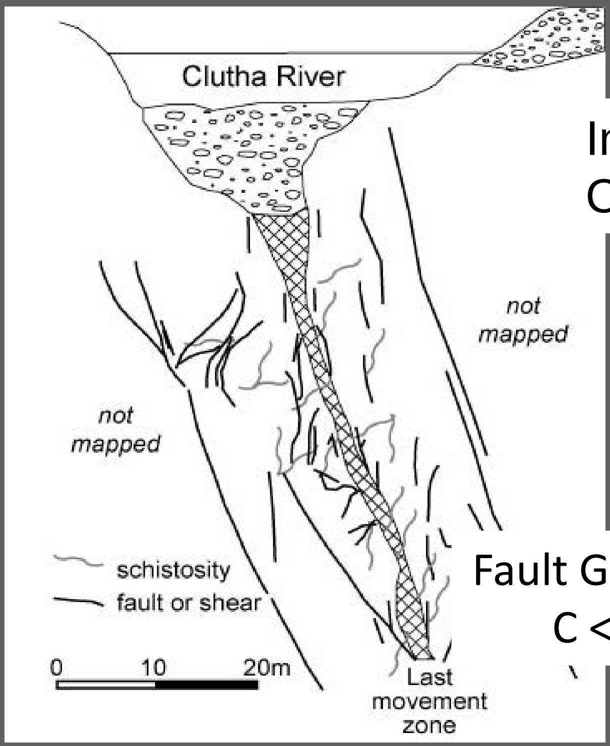

Choshui River during Typhoon Mindulle, photo Jil Chian

Discharge – 6000 $m^3/s$, suspended sediment – 50 g/l

# Strain softening

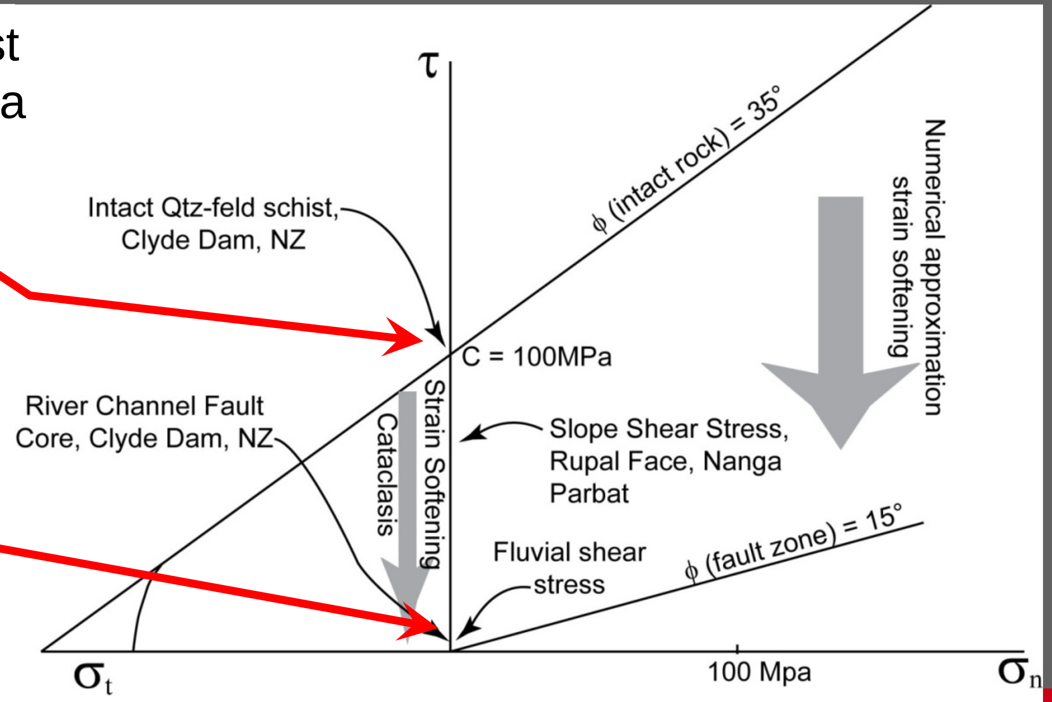
Rheology based on River Channel Fault, Otago, New Zealand

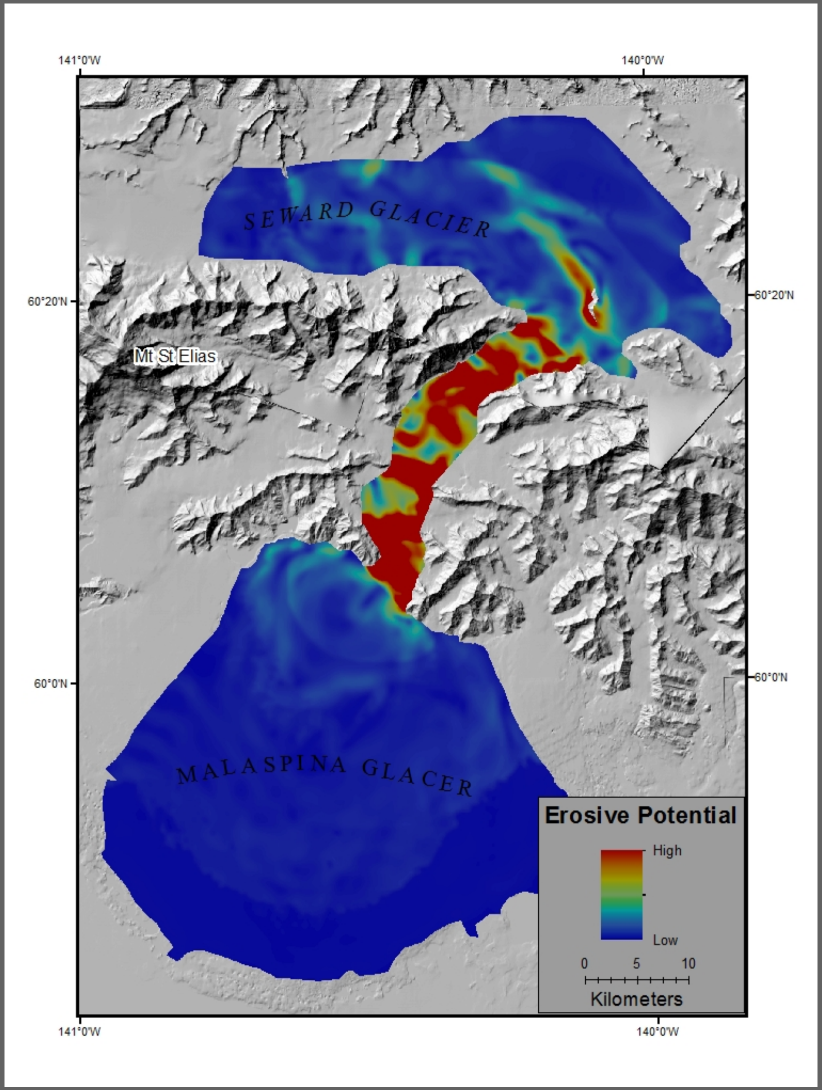
Focuses deformation → focuses erosion




Intact Schist
C ~ 100MPa

Fault Gouge Core:
C < 10kPa






Product of balance flux per unit width and the generalized surface slope

# Role of Alpine Glaciers

Extremely effective at eroding the landscape and transferring sediment

May have a significant role in the internal processes of mountain building

The Erosive Potential map of the Seward/Malaspina shows concentration of erosion and consequently rapid uplift within the narrow Seward Throat

# $T_{cr}$ – 10-$10^5$ years, Critical time period:

Encompasses:

Massive changes in normal and shear stresses due to ice sheet loading and unloading

Associated glacial:fluvial landscape development at very high observed rates

Mineralogical and thermal evolution of material strength in fault zones influencing linkages of fault zones

Strain accumulation periods of great subduction earthquakes

# Tohoku:

News and analysis, Science 332, April 2011

One lesson is that incorporating geological studies of ancient earthquakes and tsunamis into risk assessments "is essential to compensate for the limitations in the current evaluation scheme"

Over the top. The 11 March tsunami overwhelmed a coastal seawall in Miyako City designed for lesser waves.

But forecasts are generally based on studies covering the past several centuries— "not long enough for the cycle time for these big earthquakes,"

## Challenges:

- Identification of characteristic geological/topographic signals in the landscape that can be used to identify locations of great earthquakes that have occurred outside the historic record.


- Linking kinematics of the permanent strain field to high-frequency topography using the evolving geomorphic theory of tectonic:surface coupling can provide constraints on timing and location of low-frequency, great earthquakes.