USGS Earthquake Hazards Work In Alaska

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USGS work

· Non-seismic network operations
· Funding: USGS earthquake hazards program and the coastal and marine geology programs
· Work is tied to funding sources and goals
· Most of the work I’ll discuss are geologic studies, which get tied back into the National Seismic Hazard Maps
Ongoing work

- Denali fault studies
- Post earthquake studies
  - GeoEarthScope LiDAR
- Earthquake-induced submarine landslides
Seismological studies

- Installation of NetQuakes instruments
- 1 installed, 9 more permitted, and will be installed in the next month or so
- Sites will expand strong motion monitoring outside the Anchorage area to both sides of Cook Inlet to the Kenai area
Seismology studies

- Tremor studies - Justin Brown, Stephanie Prejean, Joan Gomberg, Greg Beroza
- Tremor occurs down dip of historical megathrust ruptures
- Tremor occurs on or above the subducting slab
- As deep as 100 km or so, beneath arc volcanoes
- Hot topic, but significance???
GeoEarth-Scope lidar
7.5 m
Locally generated tsunamis

- In Alaska, 106 of 122 deaths were tsunami related
- 85 of these 106 deaths were related to submarine landslide generated tsunamis
- The fjords of coastal Alaska are an ideal geologic environment for producing submarine landslides
Fjord processes

- Steep topography
- Erosion by streams
- Erosion by glaciers
- Deposition of sediment into margins of fjords
- Lies above megathrust

“the fjord has sediment and it’s got a gun!”
New bathymetry data · 2001 NOAA multibeam survey
Inferred 1964 submarine landslides

Our criteria:
- Areas where $\geq 5$ m change in depth (wanted to get out of the 2-3 m noise)
- And with multiple pre-1964 soundings
Inferred 1964 sediment transport directions

- Based on bathymetry
- Flow toward the bathtub
- Mid bay channel?
Landslides and Sediment transport to the bathtub

- Bathtub depth decreased an average of 3.5 m
- Sill at south end prevented sediment from leaving
Tsunami Modeling

- Used the 2001 bathymetry
- Put the inferred 1964 slide areas on top
- Let it run
- Model assumes slide is an incompressible viscous fluid
Tsunami Modeling

- Northward traveling wave hits Seward after about 1.5-2 minutes
- Consistent with observations
- Source from 4th of July Creek
Conclusions - Seward

- Resurrection Bay is an excellent place for landslide/tsunami studies - many factors are relatively well constrained
- We have a basic understanding of the location and size of the slides triggered in the 1964 earthquake
- There were many more slides and sediment transport was over a larger scale than previously appreciated
- The wave generated by the Fourth of July Creek slide caused the most damage at Seward
- Preliminary modeling results successfully hindcast observations of the 1964 tsunamis
Multibeam image of Port Valdez
Landslide geometry from bathymetric change

Net volume gain = 329 million m$^3$
Net volume loss = 241 million m$^3$
+ 70 million m$^3$ (source region) = 311 million m$^3$ (0.3 km$^3$)
Multibeam image of Port Valdez
What caused the tsunamis in Port Valdez?

Answer: The Blocks
New data: Were there major debris flows before 1964?
Yes! Maybe 5.
Sub-bottom profiles show previous debris flows

- Failures that emanated from the fiord-head delta contributed to all the debris lobes
- Failures at Shoup Bay moraine only occurred during the 1964 and penultimate event
- The older debris flows (3-6) are thinner and less extensive than 1 and 2
Findings Regarding Recurring Failures

- Apparently 6 major slope failure events have occurred in Port Valdez since deglaciation.
- All involved the fjord-head delta.
- The last two were the most extensive and the only ones that involved failures of the Shoup Glacier moraine.
- The increasing severity of earthquake-induced slope failures in Port Valdez likely relates to development and advancement of the fjord-head delta and retreat / advance of Shoup Glacier.
Next: Whittier

Multibeam survey 2011, probably high-res seismic too
New Direction: Southern Alaska Margin

- Moving away from interior Alaska work
- New work will focus on:
  - Paleoearthquake record
  - Paleotsunami record
  - Forearc structure and tsunami generation (offshore reflection seismic data and interpretation)
- Long term goal: understand what controls megathrust ruptures and tsunami generation in Alaska
- We may receive additional dollars in FY2011 to help get this effort on its way
All of plate boundary has ruptured in historical time
Other geologic studies

· USGS group on Chirikof
  · Paleotsunami and paleoearthquake studies
  · Identified 5 tsunami sands at 1 site, 7 at another
  · Bad weather
  · Next summer: additional work in this vicinity

· USGS external grants program
  · Kodiak paleoseismology - Ian Shennan
  · PWS high-resolution seismic - Lee Liberty
GeoEarth-Scope lidar
Source disaggregation for Los Angeles
disaggregation for peak waveheight at 475 yr return period
Earthquakes in Alaska

Earthquake risk is high in much of the southern half of Alaska, but it is not the same everywhere. This map shows the overall geologic setting in Alaska that produces earthquakes. The Pacific plate (darker blue) is sliding northwestward past southeastern Alaska and then dives beneath the North American plate (light blue, green, and brown) in southern Alaska, the Alaska Peninsula, and the Aleutian Islands. Most earthquakes are produced where these two plates come into contact and slide past each other. Major earthquakes also occur throughout much of interior Alaska as a result of collision of a piece of crust with the southern margin.

The Denali fault generated a magnitude 7.9 earthquake in 2002. This part of the fault ruptured, with horizontal offset of up to 29 feet.

The Queen Charlotte–Fairweather fault presents the greatest earthquake hazard to residents of southeast Alaska.

The 1964 earthquake was the second largest ever recorded in the world. The area within this pink patch slipped seaward up to 80 feet.

A fault beneath a fold in Cook Inlet resulted in a magnitude 7 earthquake in 1933 that strongly shook Anchorage.

The 1964 earthquake boundary has ruptured in historical time

Three arrows show the speed and direction at which the Pacific plate moves by and underneath Alaska.

This piece of crust is being pushed into and beneath the southern Alaska margin. As a result it causes large earthquakes here and throughout interior Alaska.

All of plate boundary has ruptured in historical time.