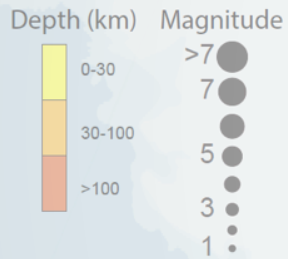


# Alaska Earthquake Center Operations and History



**Natalia Ruppert**  
**Alaska Earthquake Center**  
**Geophysical Institute - University of Alaska Fairbanks**

0 100 200 400 miles



# ALASKA EARTHQUAKE CENTER



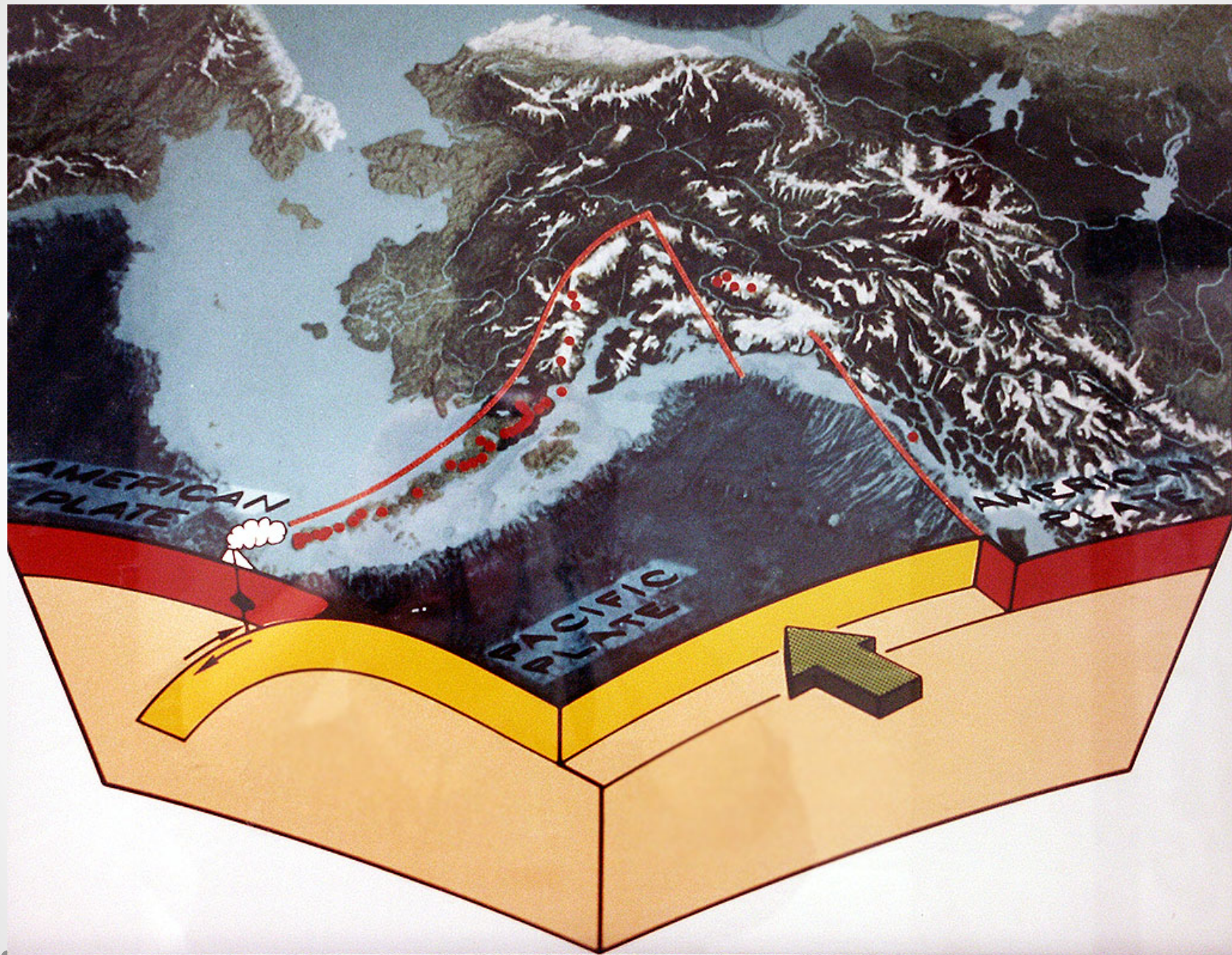
# TECTONICS



# Why is it important to monitor earthquakes in Alaska?

## Largest worldwide earthquakes

1	Chile	1960	9.5
<b>2</b>	<b>Prince William Sound, Alaska</b>	<b>1964</b>	<b>9.2</b>
3	Northern Sumatra, Indonesia	2004	9.1
4	Honshu, Japan	2011	9.0
5	Kamchatka	1952	9.0
6	Maule, Chile	2010	8.8
7	Ecuador	1906	8.8
<b>8</b>	<b>Rat Islands, Alaska</b>	<b>1965</b>	<b>8.7</b>
9-12	Northern Sumatra, Indonesia	2005	8.6
9-12	Assam, Tibet	1950	8.6
9-12	Northern Sumatra, Indonesia	2012	8.6
<b>9-12</b>	<b>Andreanof Islands, Alaska</b>	<b>1957</b>	<b>8.6</b>

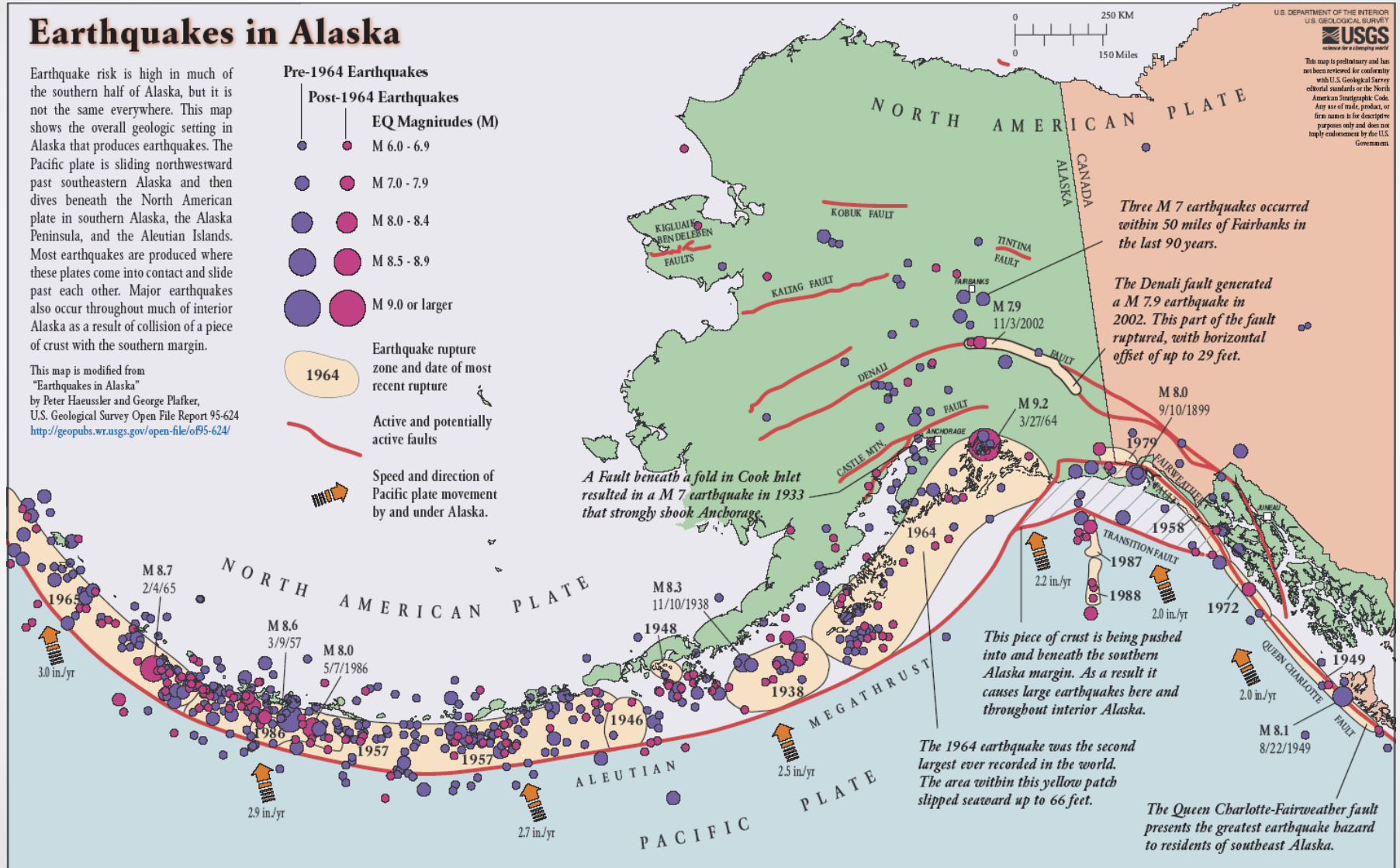
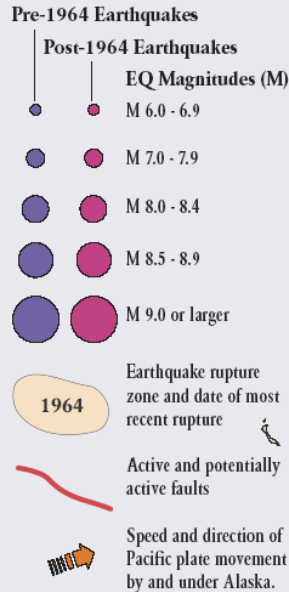


# Tectonics of Alaska

## 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 is sliding northwestward past southeastern Alaska and then dives beneath the North American plate in southern Alaska, the Alaska Peninsula, and the Aleutian Islands. Most earthquakes are produced where these 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.

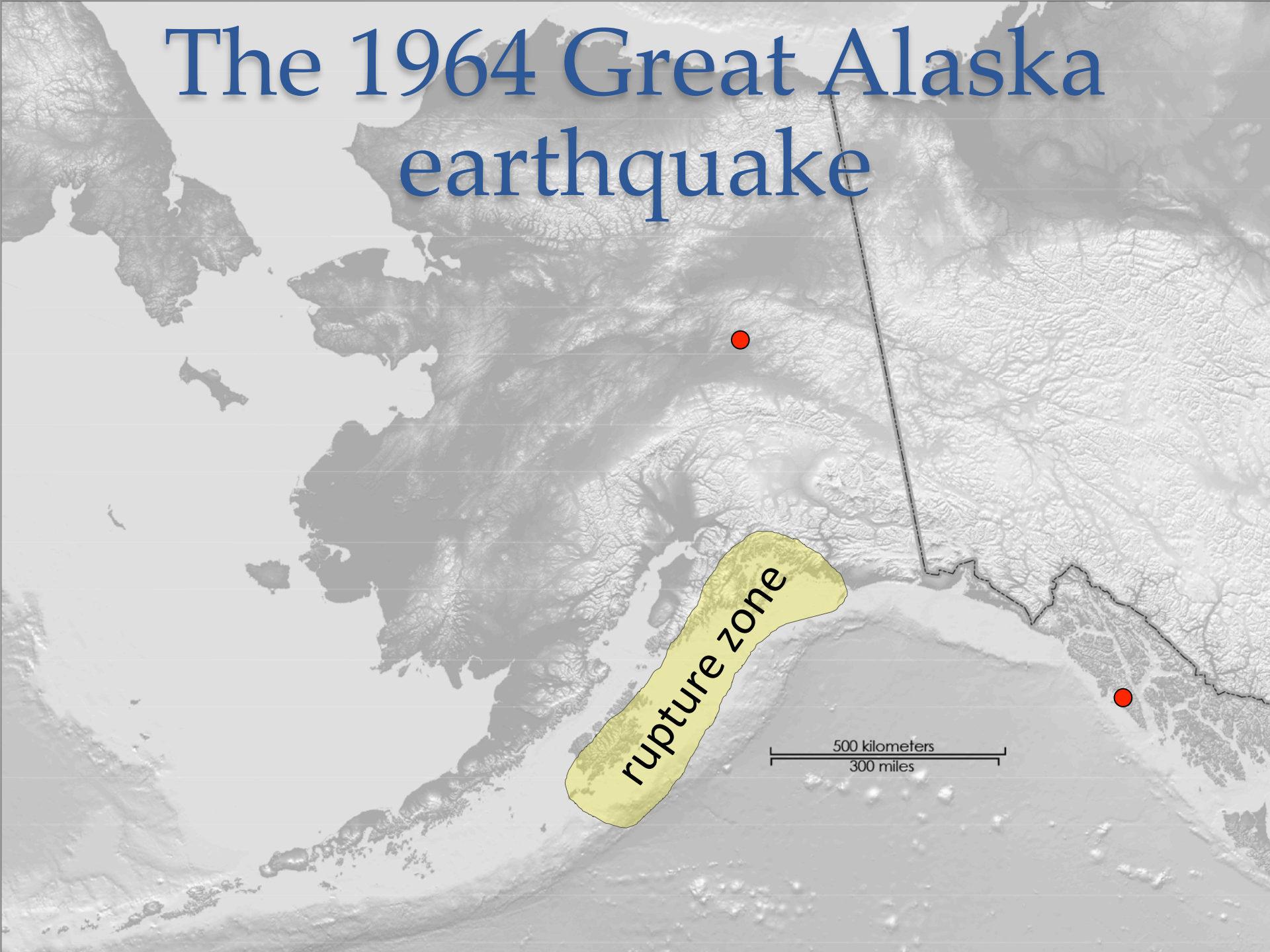
This map is modified from "Earthquakes in Alaska" by Peter Haeussler and George Pfalker, U.S. Geological Survey Open File Report 95-624 <http://geopubs.wr.usgs.gov/open-file/of95-624/>



U.S. DEPARTMENT OF THE INTERIOR  
U.S. GEOLOGICAL SURVEY  
**USGS**  
Science for a changing world

This map is preliminary and has not been reviewed for conformity with U.S. Geological Survey editorial standards or the North American Stratigraphic Code. Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

# The 1964 Great Alaska earthquake

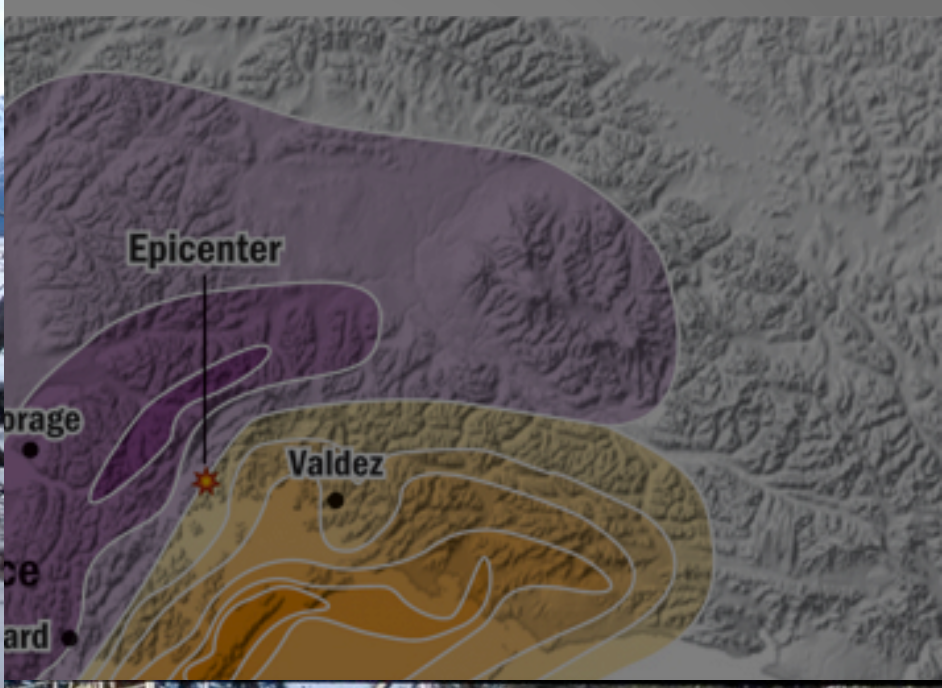


rupture zone

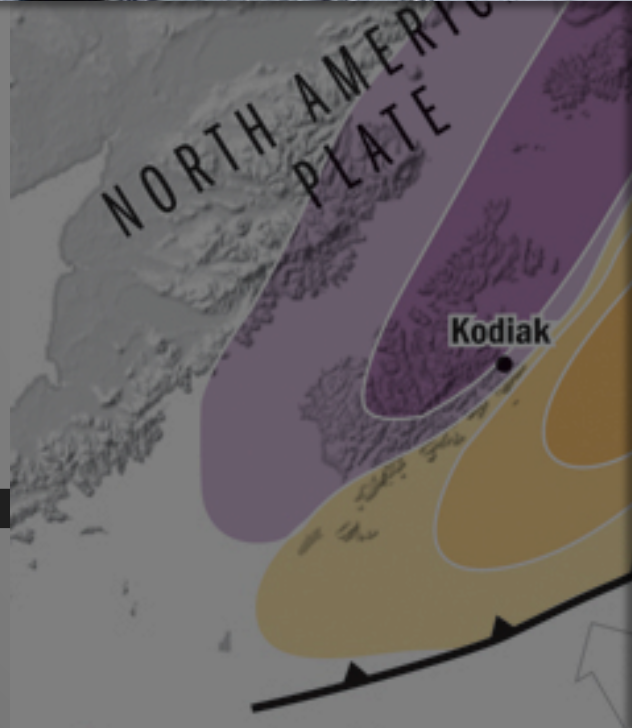
500 kilometers  
300 miles



'ghost forest'



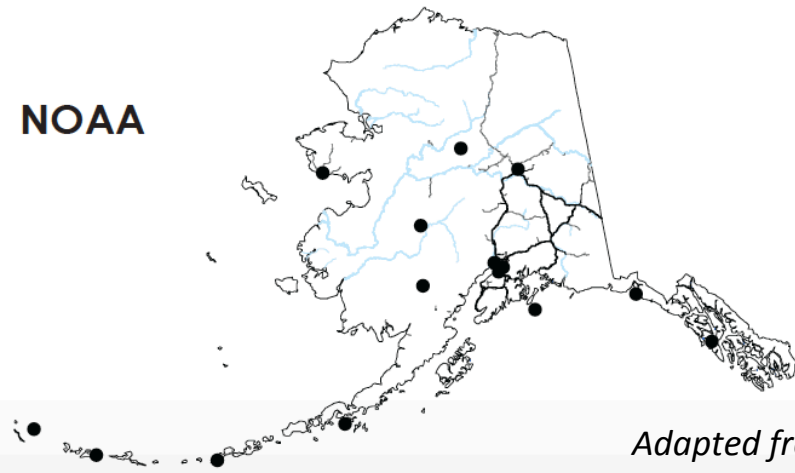
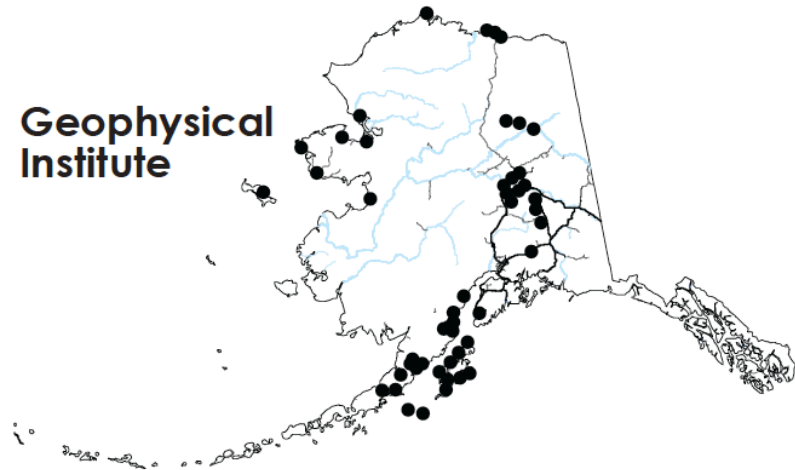
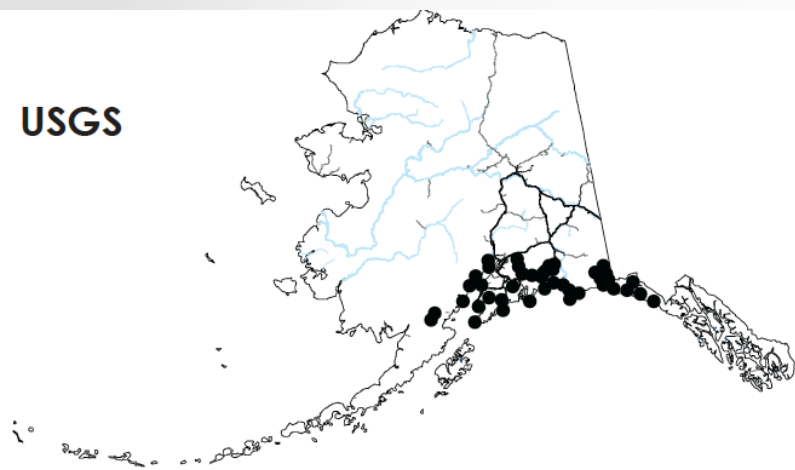
# up & dn



Uplifted dock at high tide



# Alaska regional seismic network - History



- USGS established southern Alaska network in late 1960s-yearly 1970s
- Geophysical Institute established network for volcano and earthquake monitoring in 1970s-1980s
- In late 1980s Alaska Volcano Observatory and Alaska Earthquake Center were formally established
- Alaska Tsunami Warning Center was established in 1967
- NOAA earthquake monitoring network as of 1980

# Earthquake Center mission and historical perspective

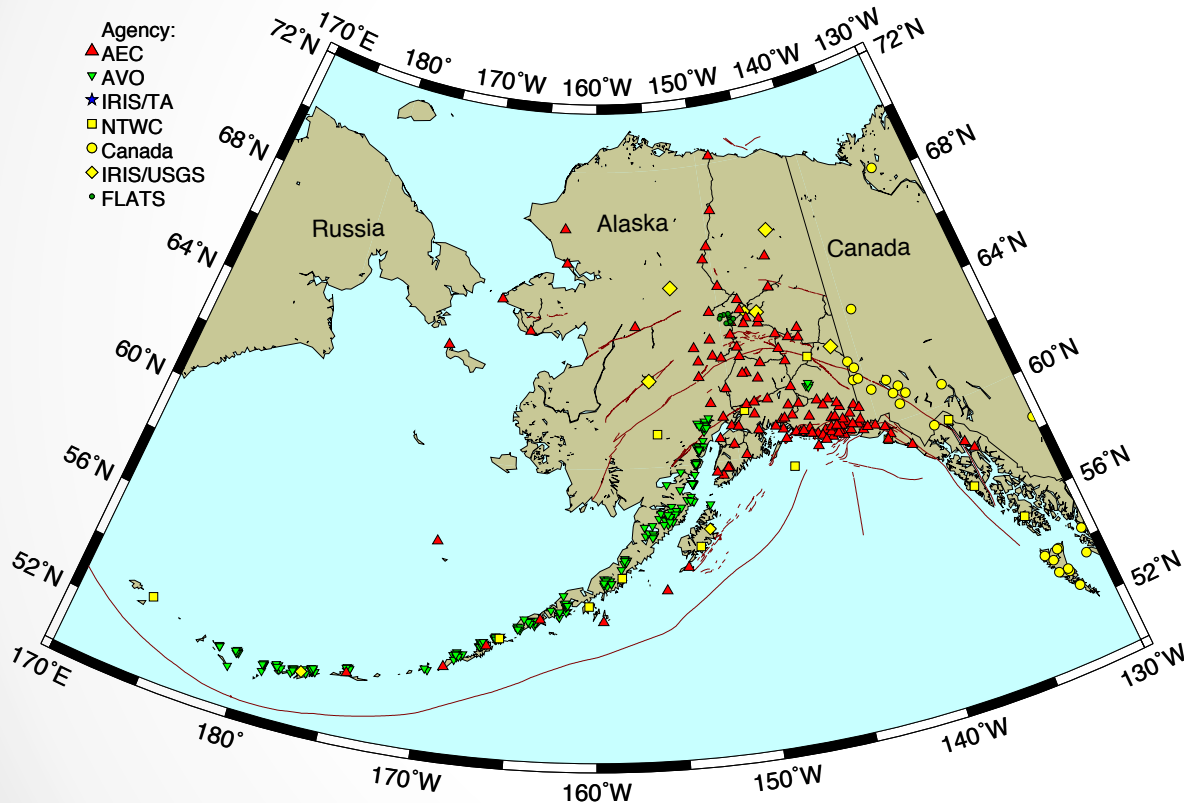
- Regional seismic network established in Alaska in late 60s- early 70s, in the wake of the 1964 M9.2 Great Alaska earthquake.
- AEC formally established in 1987 to:
  - Assess seismic hazards for Alaska;
  - Monitor earthquake activity by collecting and analyzing seismic data;
  - Provide information and assistance to State and local agencies, public and research community in planning to reduce risks to lives and property.
- We have multiple state, federal and private industry partners.



# SEISMIC NETWORK

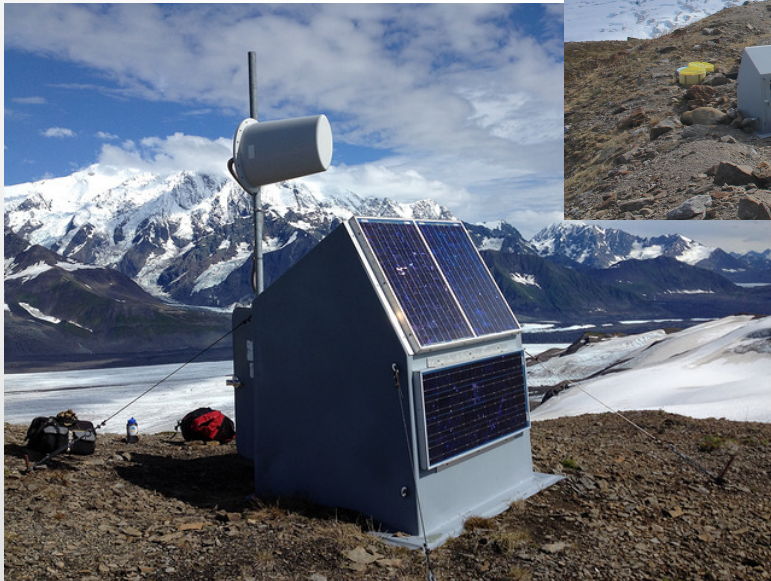
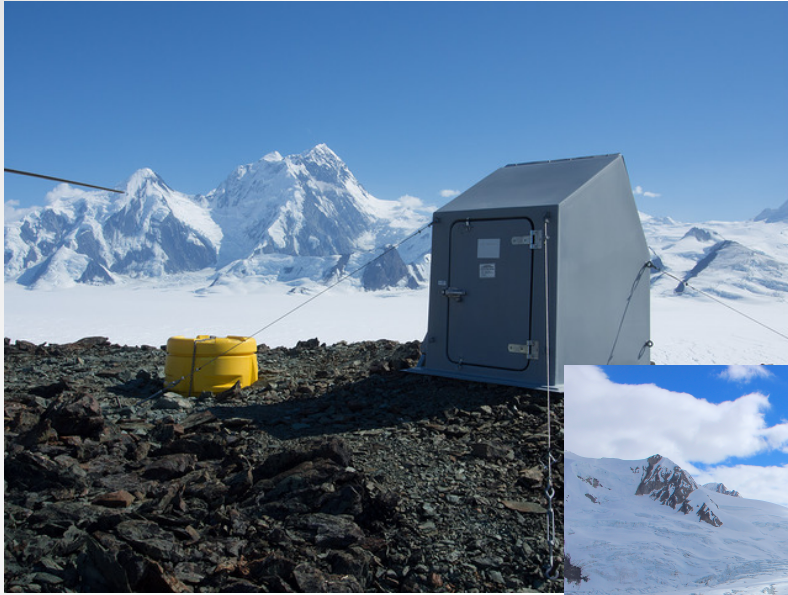
...

# Alaska seismic network - Present



- 500+ stations
- Contributors:
  - 25% is Earthquake Center (AK);
  - 40% is Volcano Observatory (AV);
  - 20% is newly installed IRIS/TA (TA);
  - Remaining 15% is Tsunami Warning Center (AT), GSN (UU/UI), USGS (US), Canadian stations (CN).

# Seismic monitoring sites



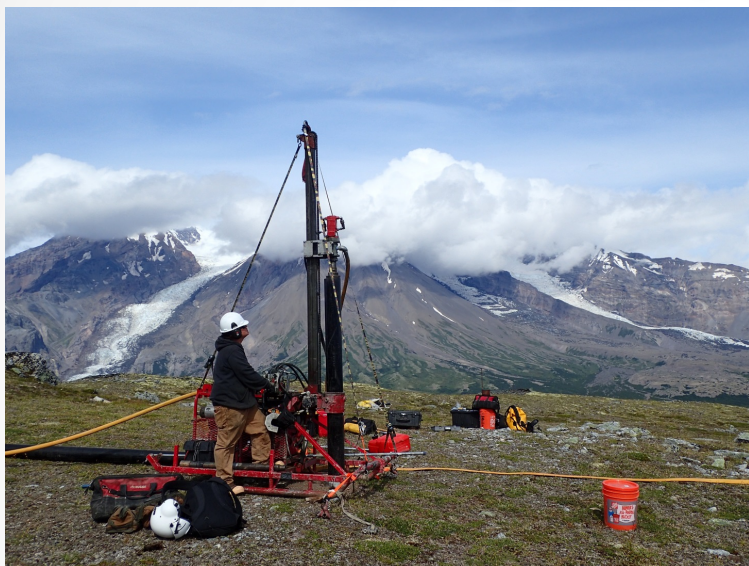
# Components of a seismic monitoring site



# Station damage: bears and snow



# State of the art seismic monitoring sites



- Posthole seismic sensors are placed in shallow boreholes (8-20 ft) augured with portable drills
- This protects sensors from surface noise thus providing high quality data
- State of art communications and power systems have been designed specifically for Alaska region



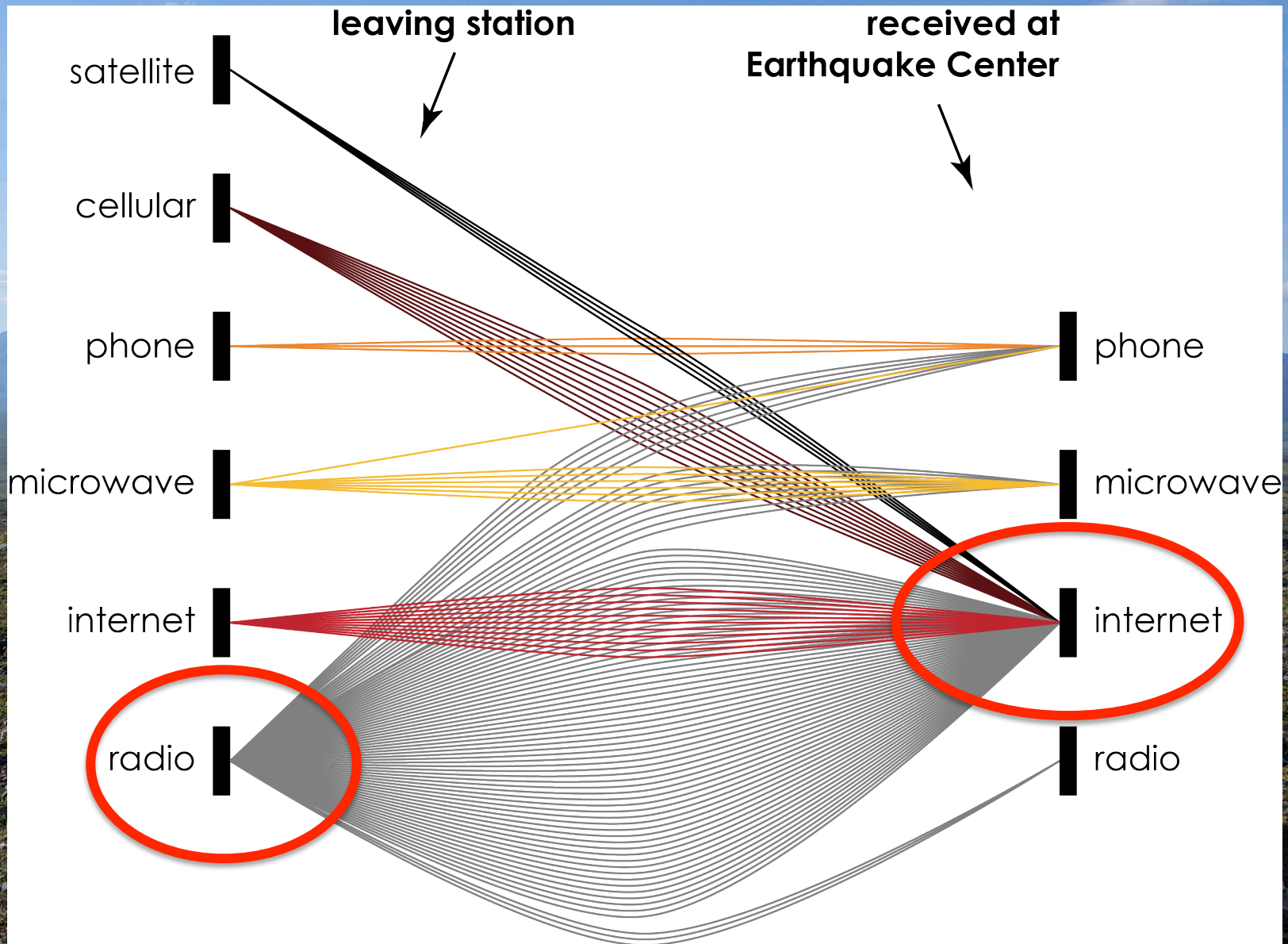
TA seismic site in southern Alaska



# Components of a seismic monitoring site

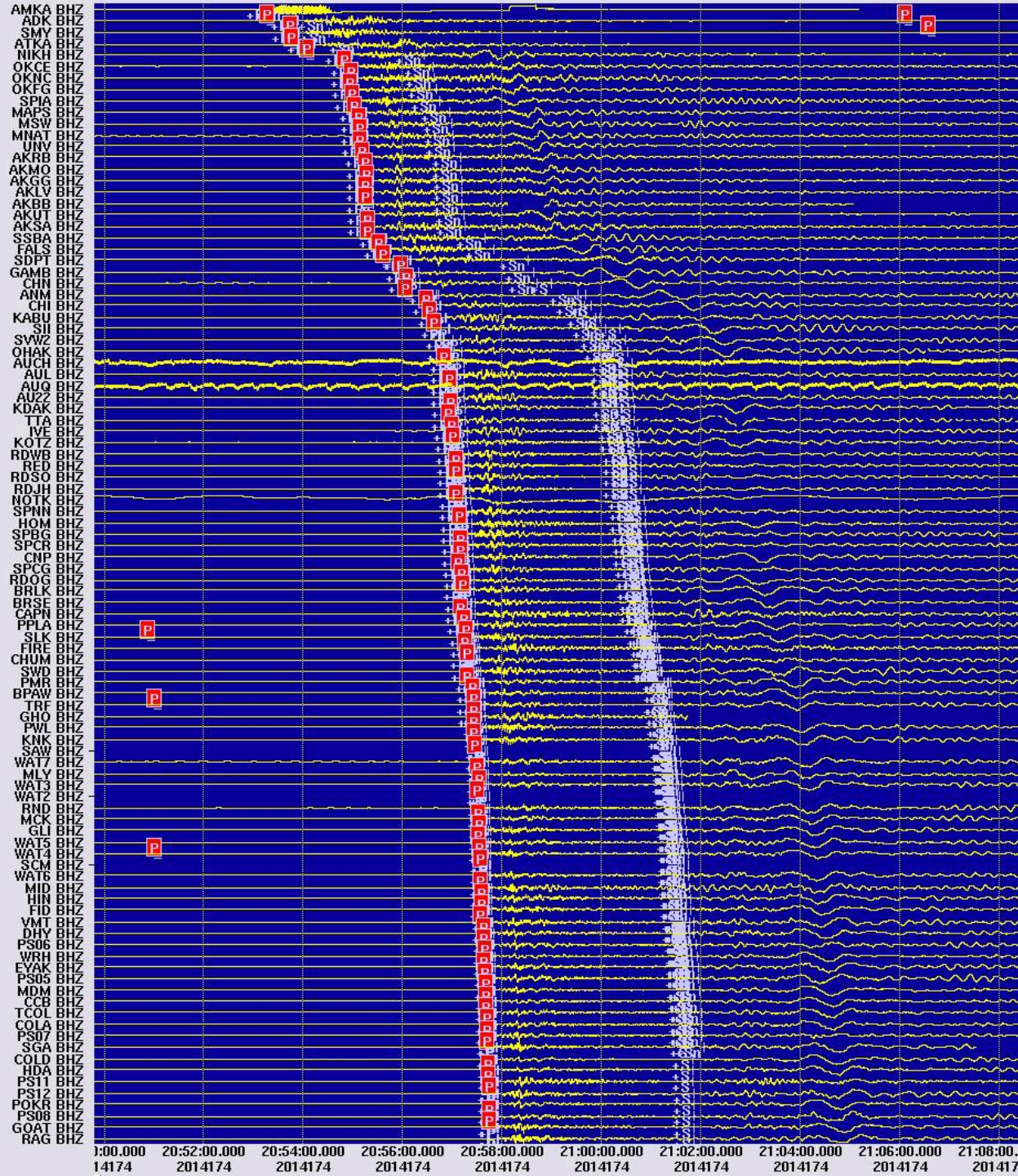
- Shallow buried vaults (up to 1 m) or shallow boreholes (2-10 m).
- A variety of seismic sensors: Kinematics, Nanometrics, Guralp.
- All remote sites equipped with Kinematics Q330 dataloggers, and some strong motion sites are Basalts or Etna2s.
- 100% digital communications (satellite, spread-spectrum radios, cell modems, dedicated phone lines, microwave, internet).
- Majority of the sites are on autonomous solar powered systems, but some are on host AC power.
- Majority of the sites are helicopter access only, with some on the road systems or commercial air routes.





# DATA PRODUCTS AND PROCESSING SYSTEMS

...



# Data

Magnitude 7.9  
 earthquake in  
 Rat Islands on  
 23 June 2014

# Server Infrastructure



UA enterprise server facility



ISO-base racks

# Hardware

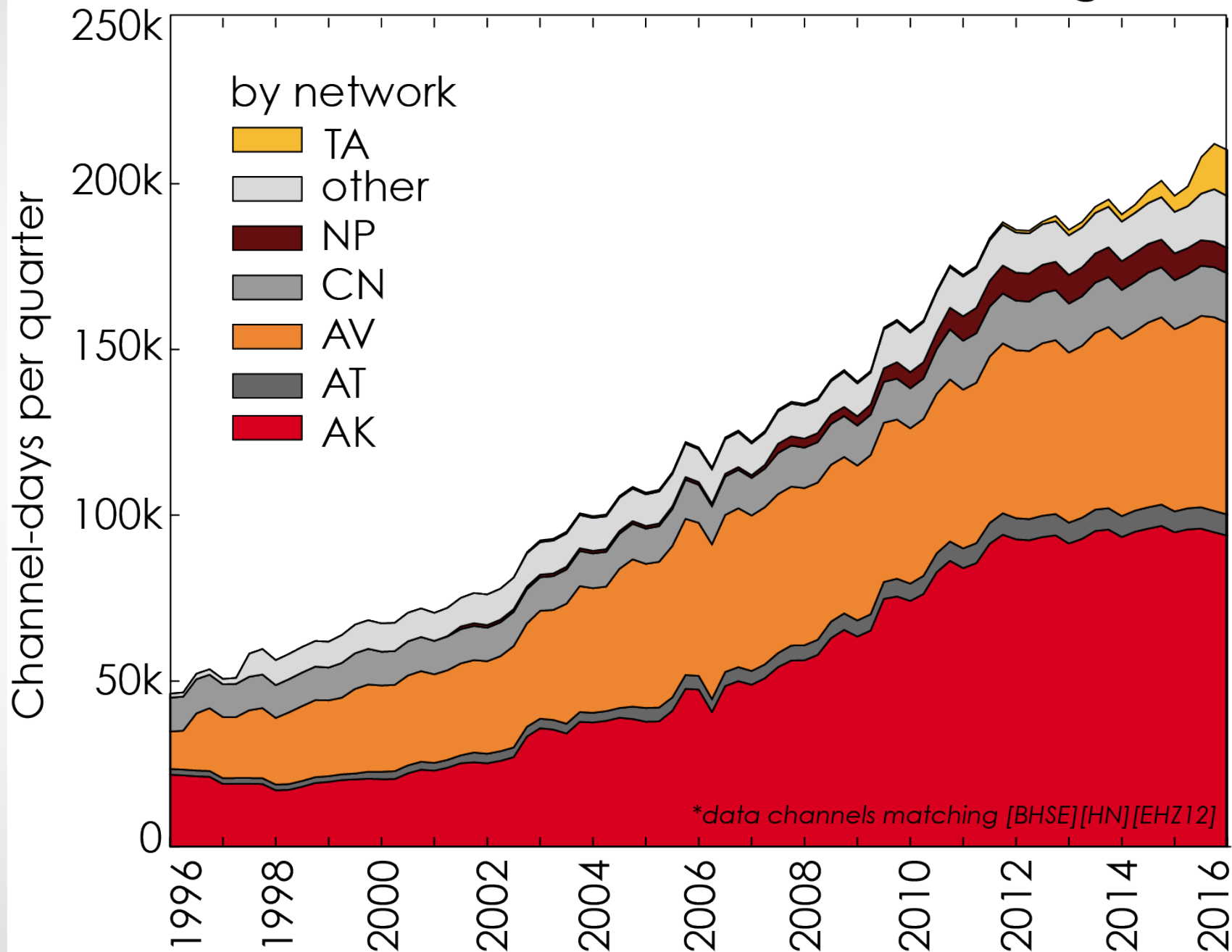
- 3x Dell R720 PowerEdge servers
  - 2x Intel Xeon E5-2620 6-core CPUs (24 logical processors)
  - 192 GB RAM
  - 4x 10 GbE ports, 4x 1000BASE-T
- 2x EqualLogic iSCSI SAN servers for VM storage / data archival
  - 1x high-performance system with 15k spinning disks, 8 TB total storage
  - 1x capacity system with 7.2k spinning disks, 96 TB total storage
  - 24 disks each in RAID 6 configuration
- 2x Dell PowerConnect 8132F network switches (24x 10 GbE ports for direct server-SAN VLANs)



# Software

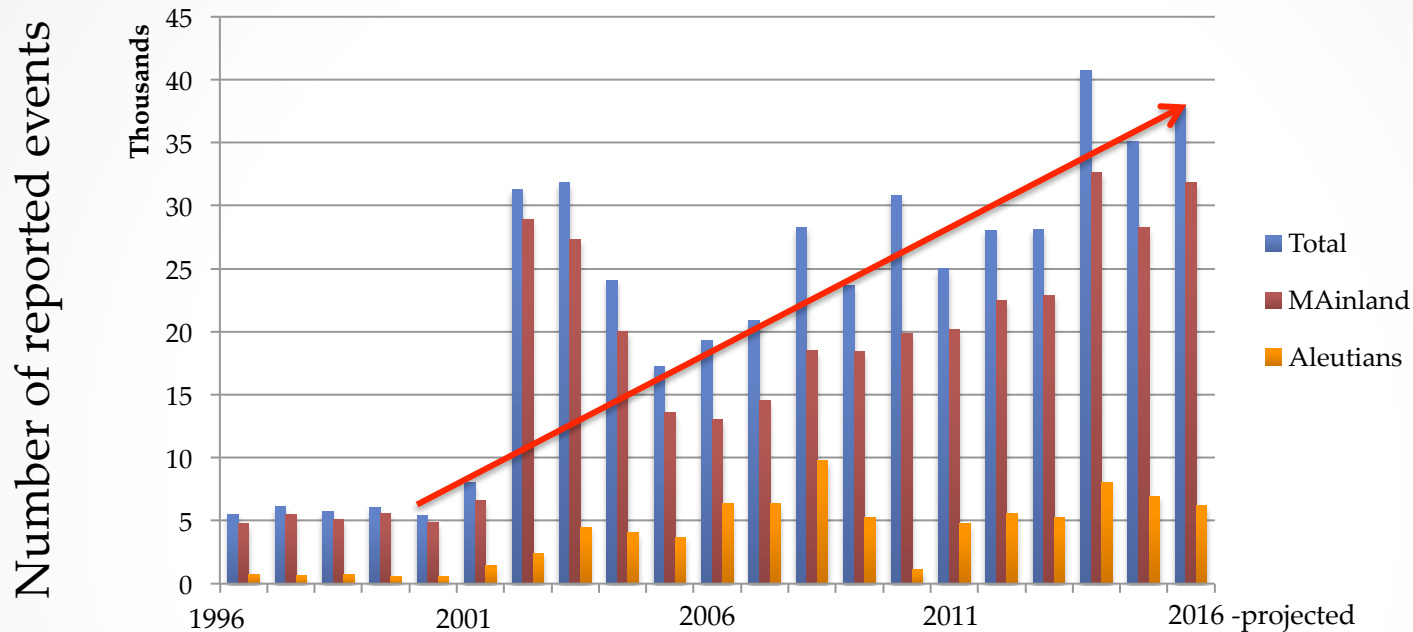
- Virtualization of cluster via VMWare vSphere Enterprise 5.5 with ESXi hypervisor
- Cluster functionality controlled using VMWare vCenter and vSphere web client
- Operations virtual machines (VMs) run CentOS 6 – preferred platform for Antelope data acquisition and processing software
- Antelope 5.5 (released May 2015)

# Continuous waveform holdings



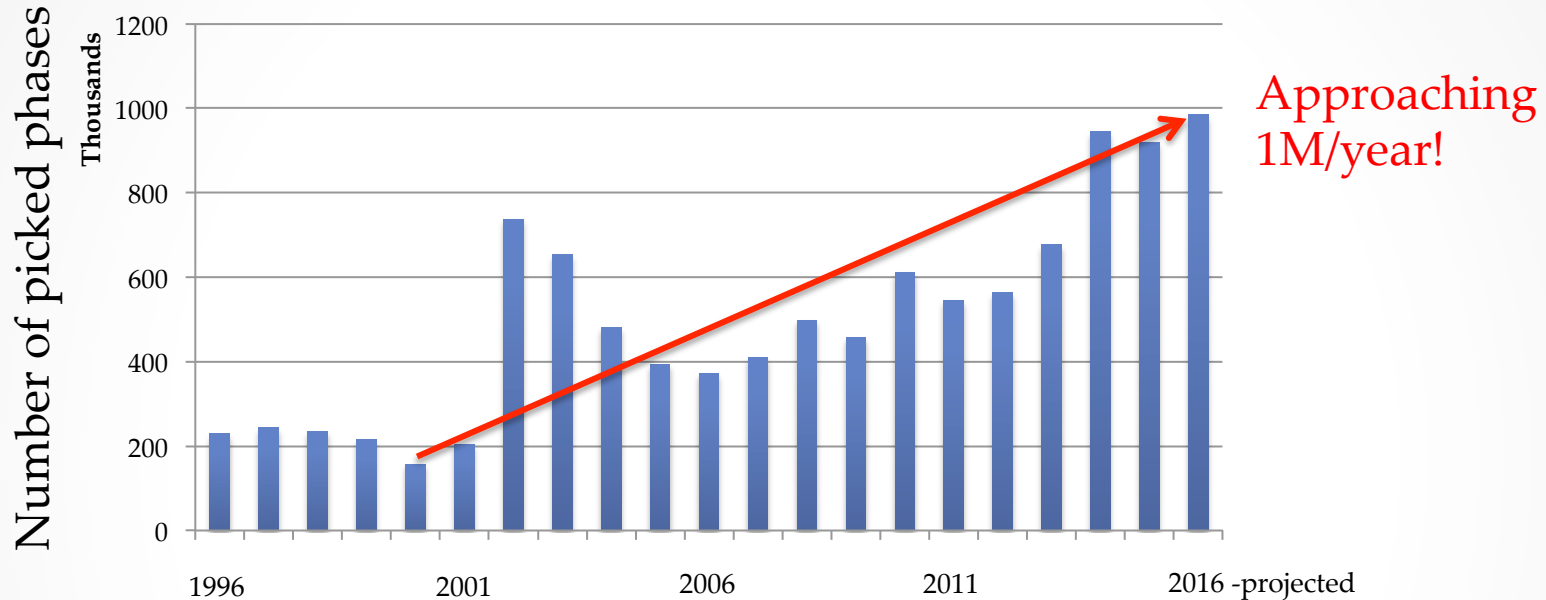


# Reported seismicity in Alaska



- End 1990s – early 2000s:
  - Alaska Earthquake Center started conversion into broadband instrumentation;
  - Alaska Volcano Observatory started expansion into the Aleutians.
- 2002 M7.9 Denali fault earthquake produced about 55K aftershocks in 5 years.
- Number of reported events has been steadily increasing with each year due to improvements in instrumentation and detection.
- Current rate of reporting is on average 100 events/day or 1 event every 15 minutes.
- 2016 increase is associated with additional TA stations.

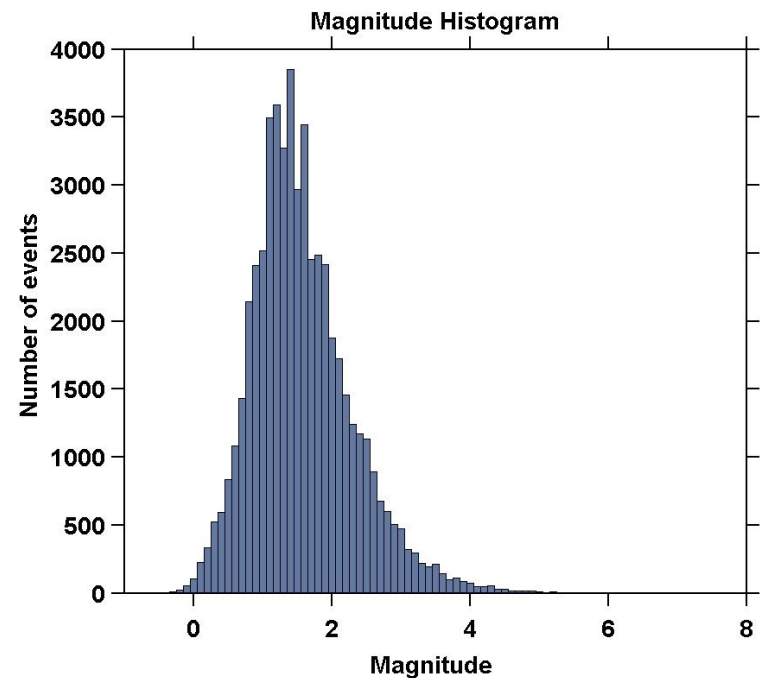
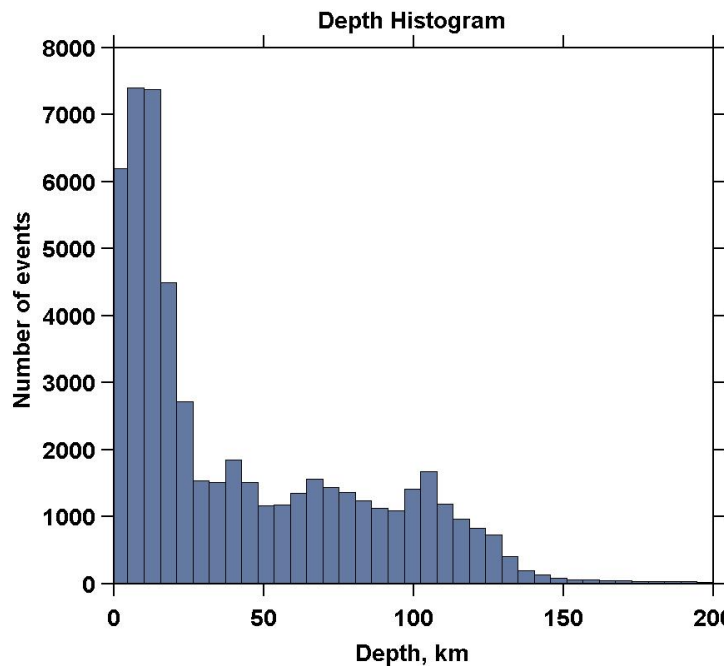
# Catalog picks

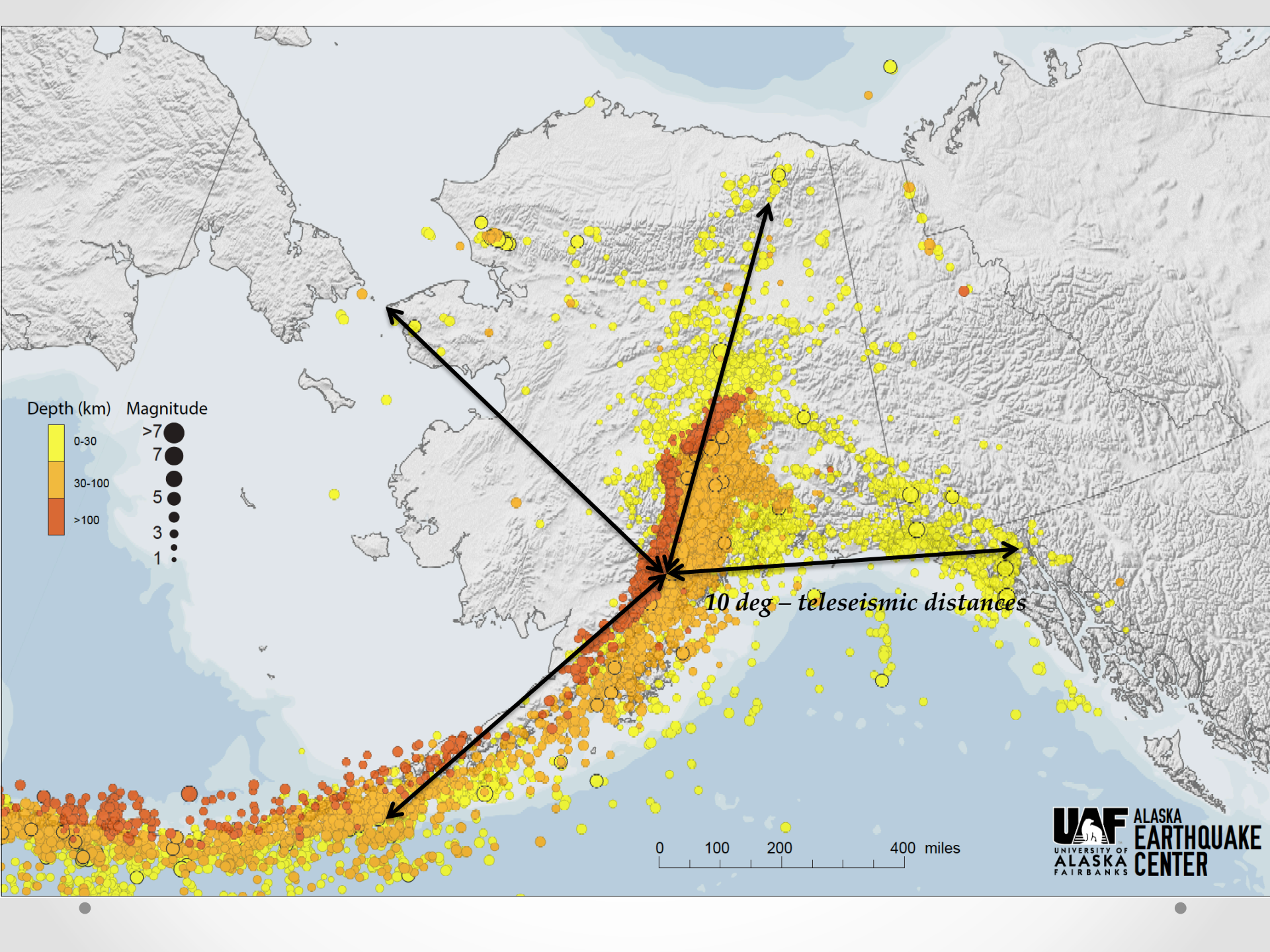


- End 1990s – early 2000s:
  - Alaska Earthquake Center started conversion into broadband instrumentation;
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- 2002 M7.9 Denali fault earthquake produced about 55K aftershocks in 5 years.
- Number of reported events has been steadily increasing with each year due to improvements in instrumentation and detection.
- 2014-2016 increases are associated with improved network performance and additional TA stations.

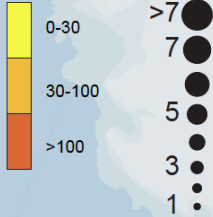
# 2015-2016 catalog

- Of the reported events half are crustal or shallow subduction interface events and half are Wadati-Benioff zone events (below 40 km).
- The magnitude of completeness varies across the region, with some areas currently being reported with  $M_c < 1$  and some no better than  $M \sim 3$ .





Depth (km) Magnitude

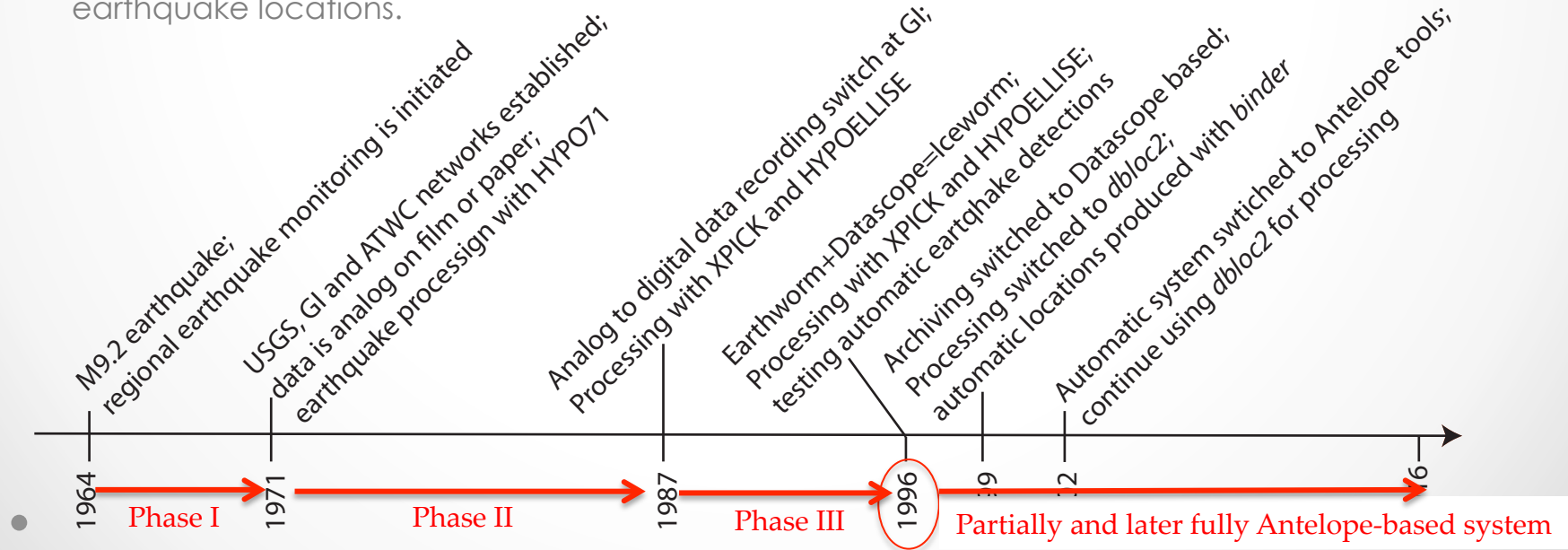


10 deg - teleseismic distances

0 100 200 400 miles

# Overview of the data recording and processing systems

- 1970s-mid1980s: Data recorded in analog form on Develocorder film and magnetic tapes, arrival times picked from scanned images, HYPO71 and later HYPOELLIPSE used for locations.
- In 1987 transition from analog to digital data recording was made at the GI UAF. XPICK program was used to pick seismic arrivals and HYPOELLIPSE program to obtain locations.
- In 1996 the Earthquake Center started experimenting with Earthworm and Datascope packages marring them into the Iceworm system (development by K.Lindquist). Earthquake data was still processed with XPICK and HYPOELLIPSE.
- In 1999 the Earthquake Center switched data archiving to Datascope-based databases and earthquake processing to dbloc2. At the same time automatic earthquake detection system was implemented on operational system.
- Since 1999, all new developments within Antelope distributions were implemented within the routine operations of the Center.
- In 2002 following the Denali Fault earthquake orbassoc replaced binder for automatic earthquake locations.



# 2016 MOST NOTABLE EARTHQUAKE

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# The 24 January, 2016 M7.1 Iniskin Earthquake



*Photo: Kenai Fire Department*

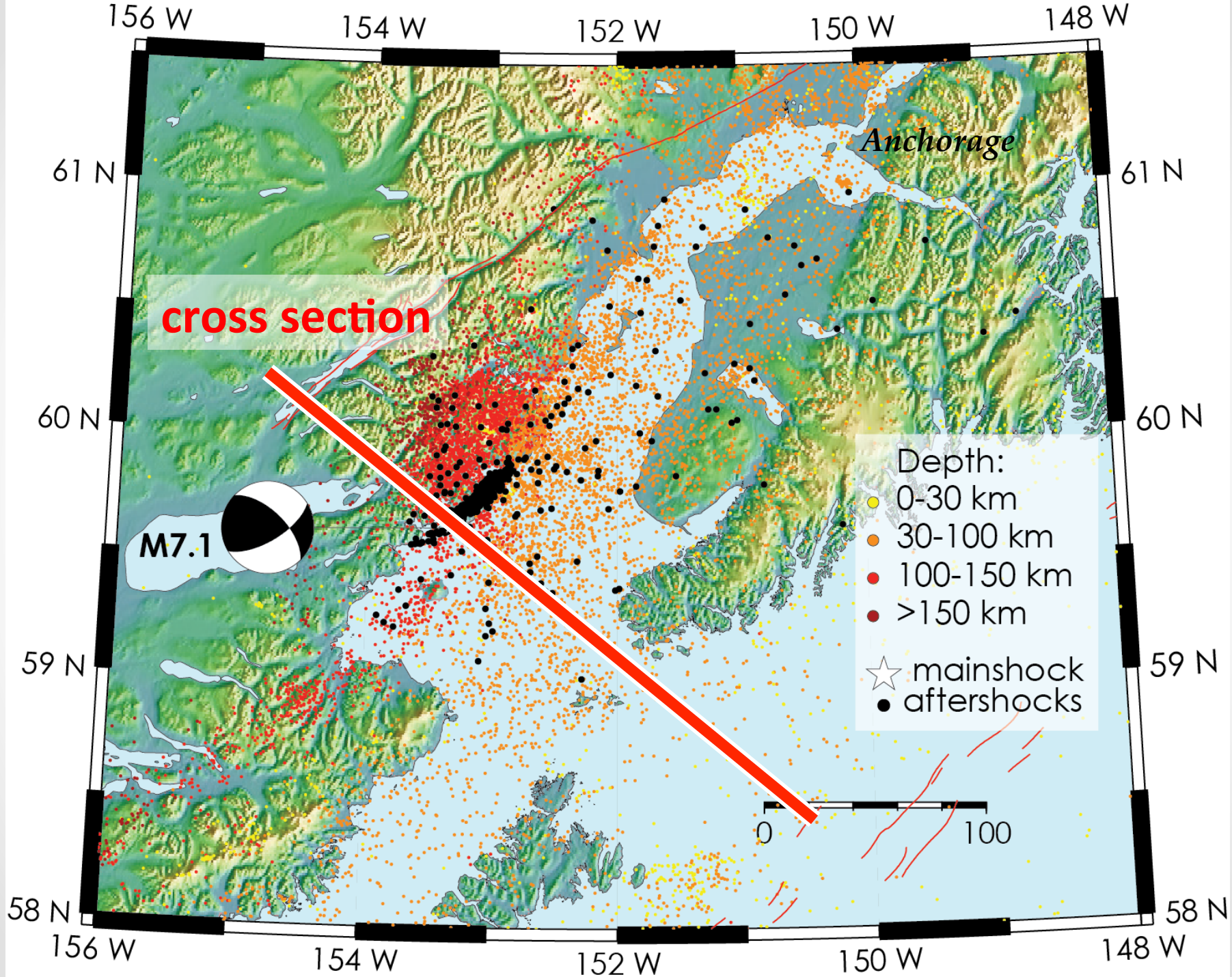


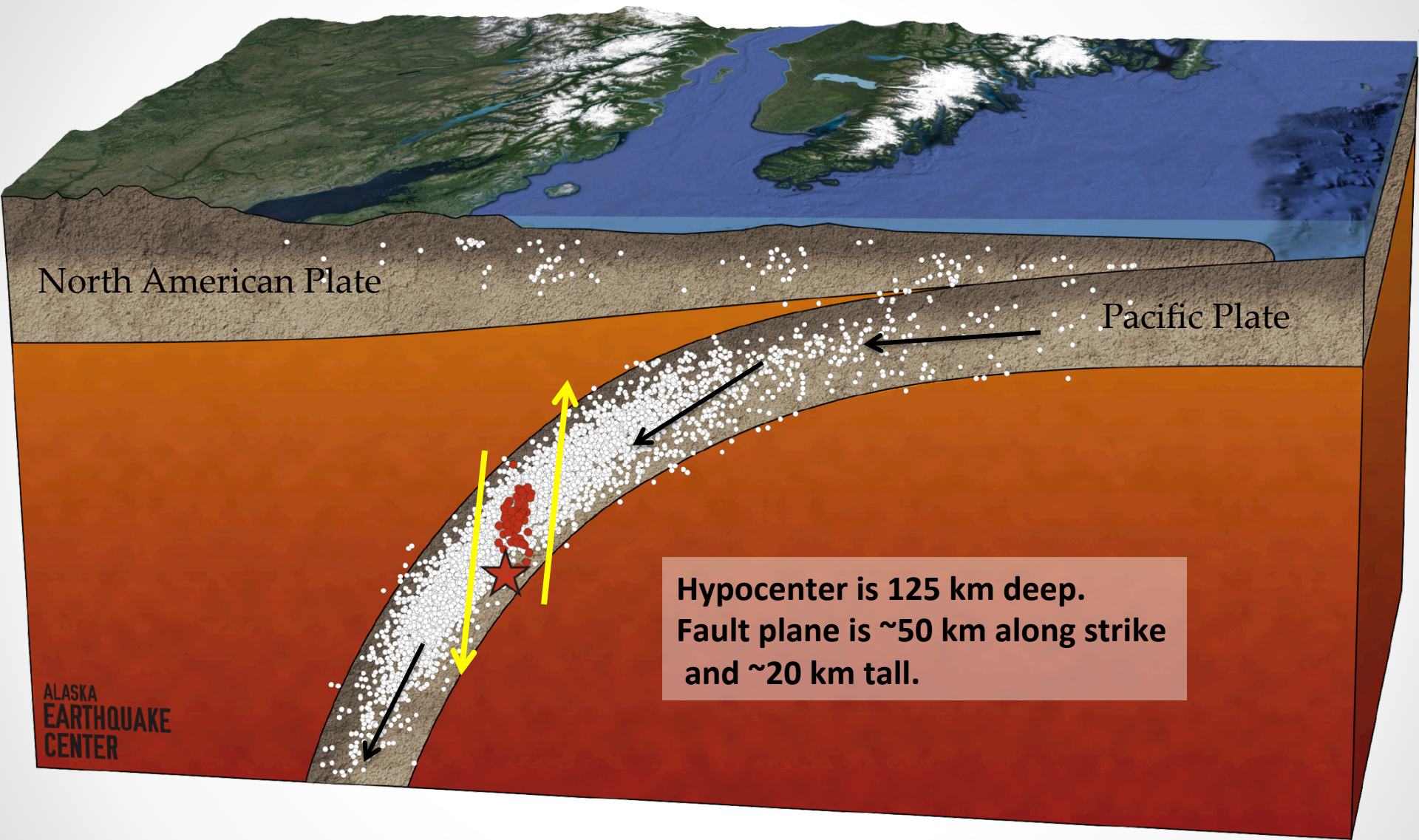
Photo: Kenai fire department







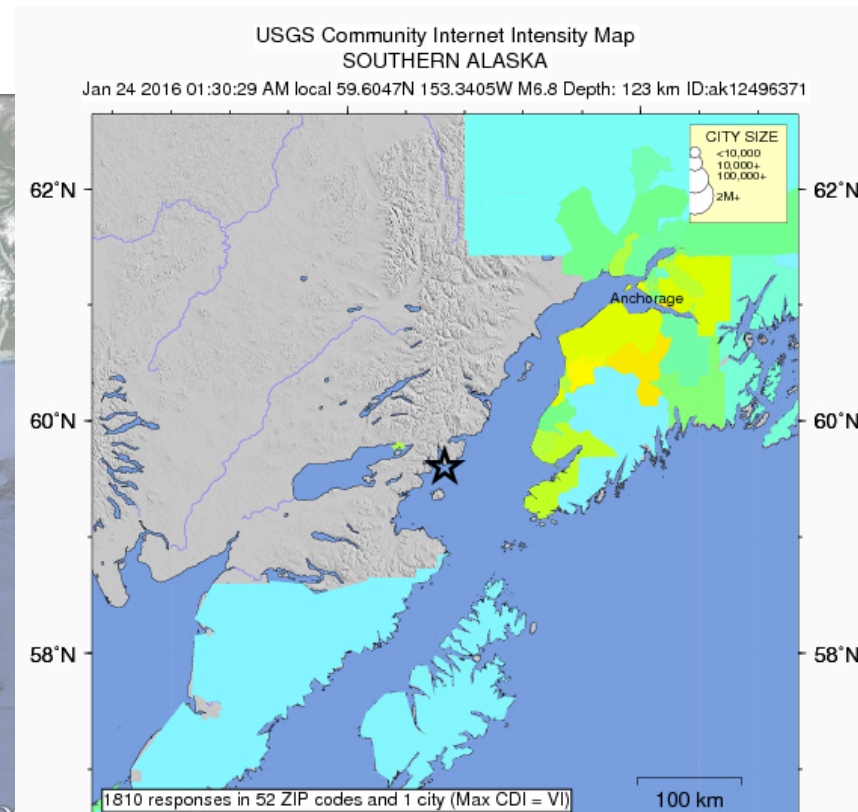
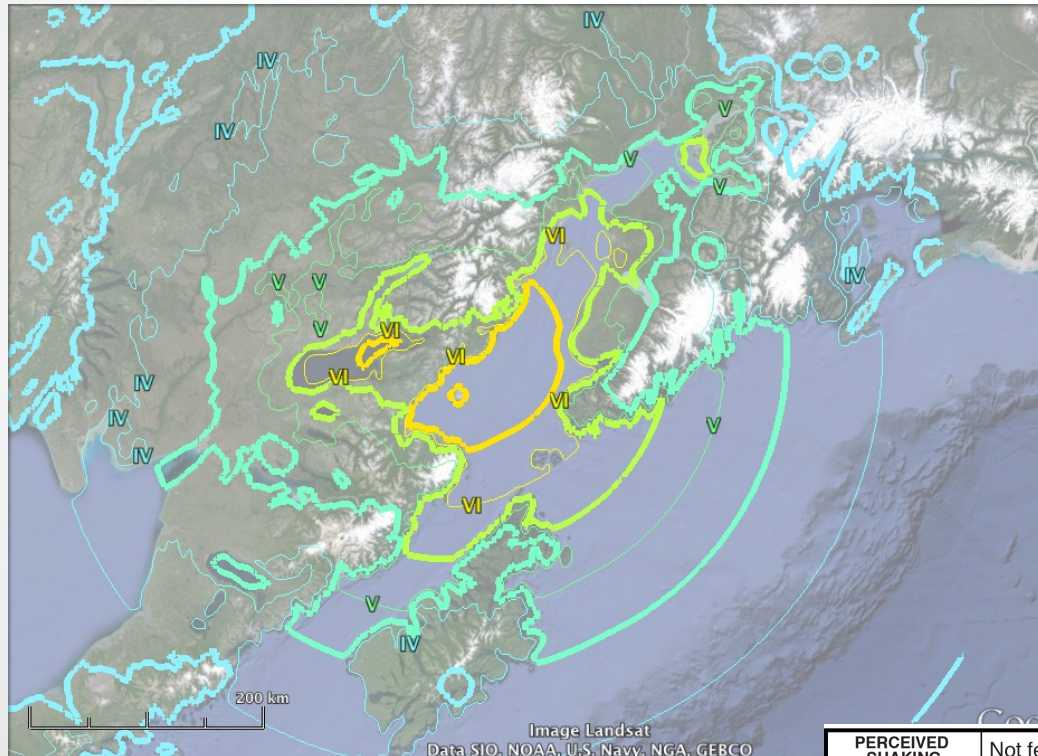




# Ground shaking intensity

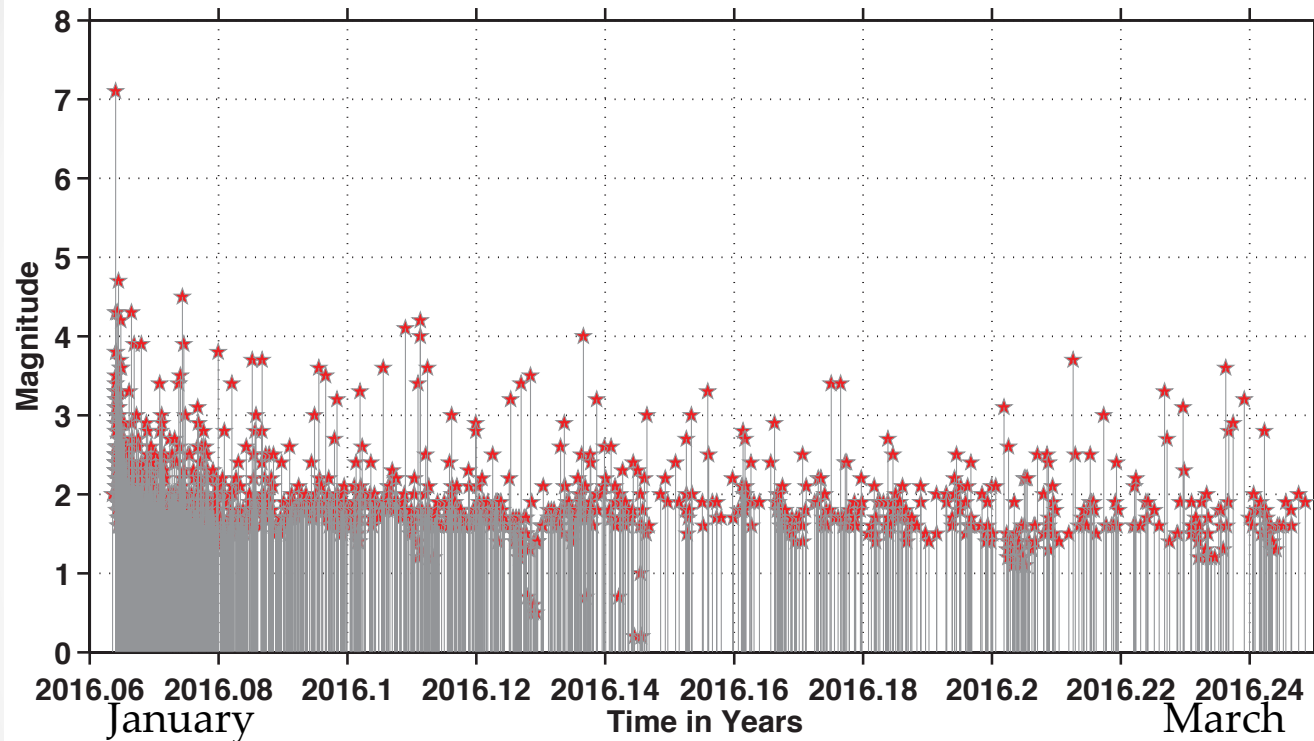
Did You Feel It (DYFI) reports

Instrumentally recorded (ShakeMap)

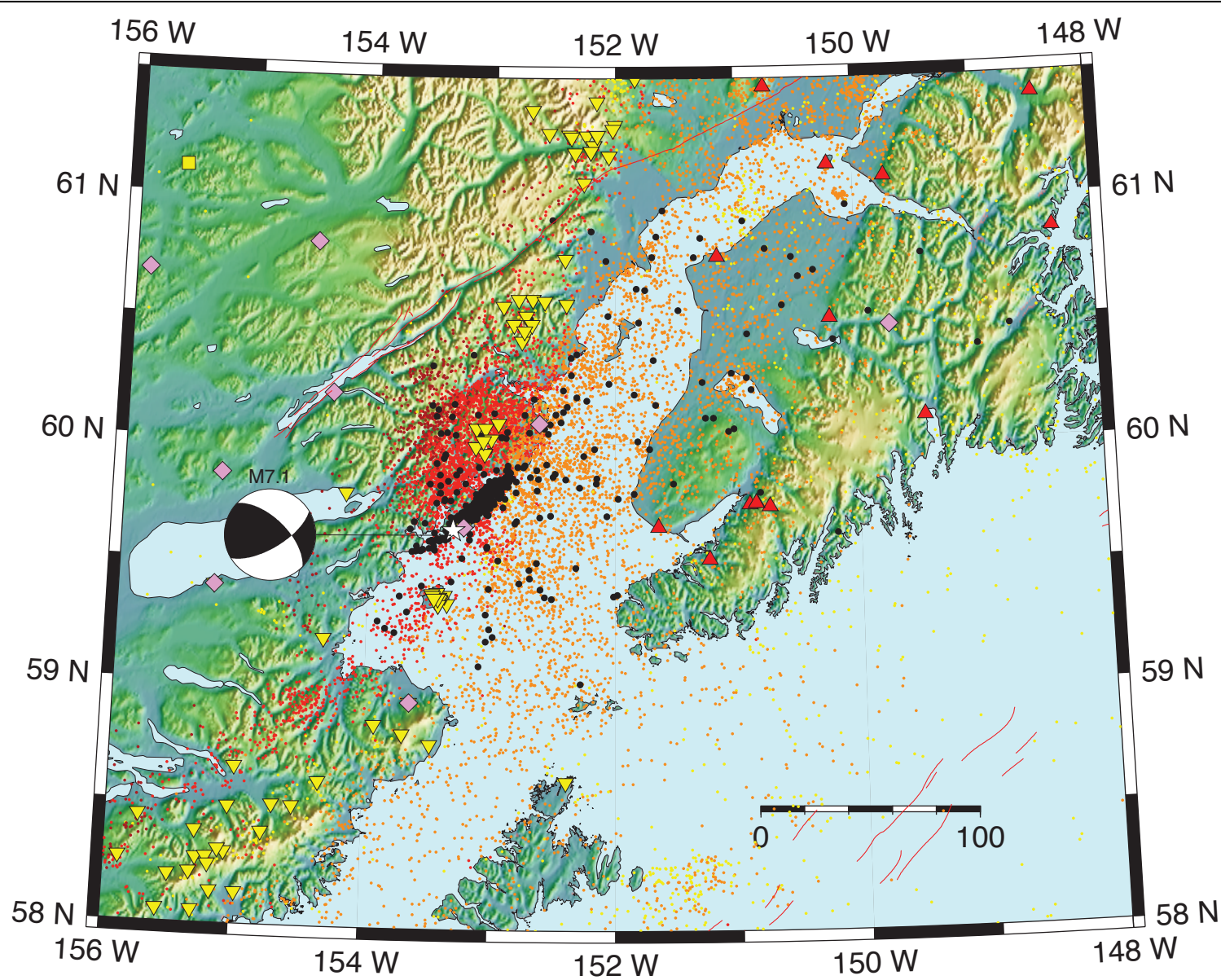


PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

# Aftershocks



- The Alaska Earthquake Center reported about 2,000 aftershocks to date.
- Magnitude of completeness of the aftershock catalog is 1.8.
- The aftershock sequence was recorded by a comprehensive network of sensors in all azimuthal directions allowing for a detailed analysis of the earthquake.



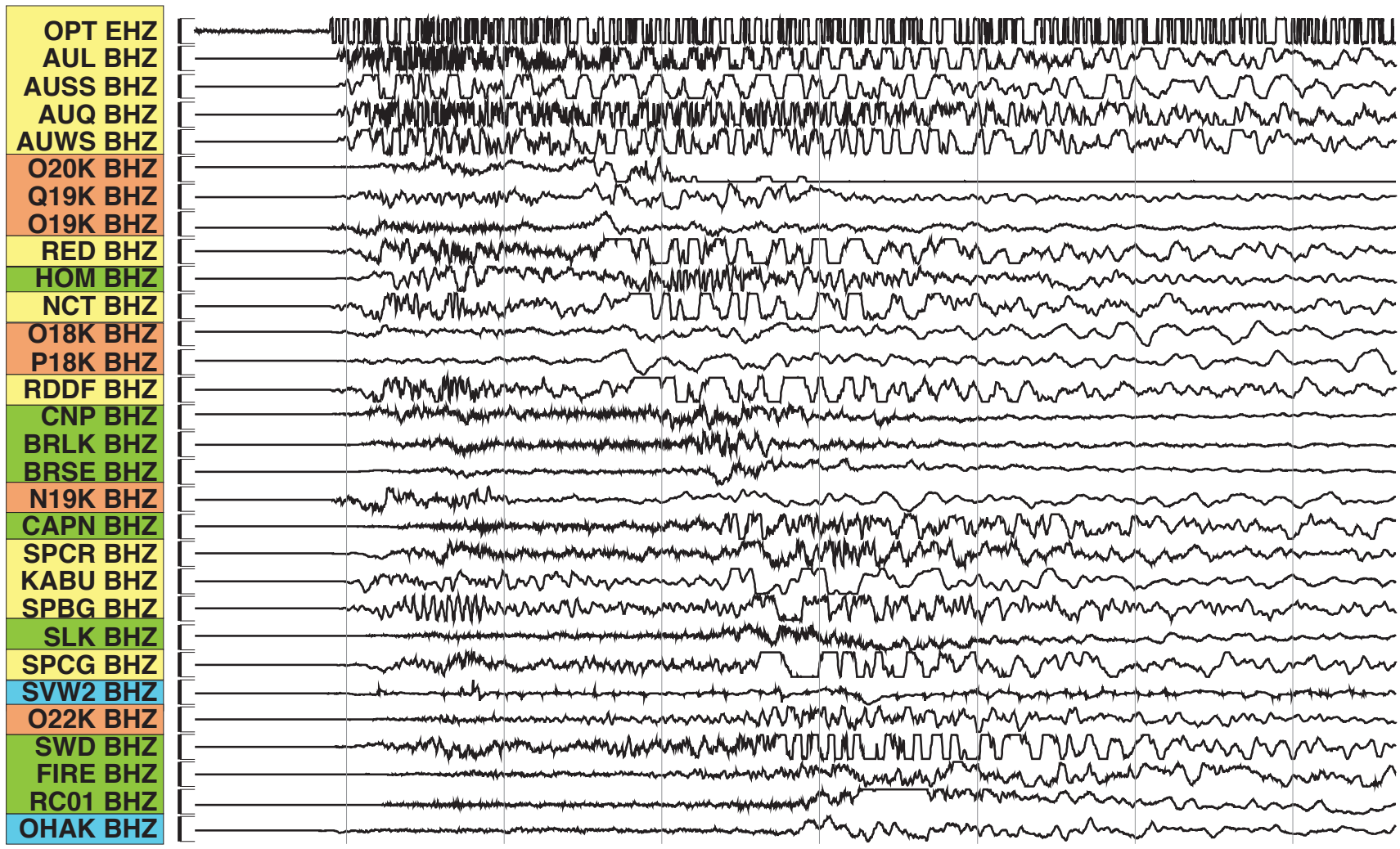
- Depth:
- 0-30 km
  - 30-100 km
  - 100-150 km
  - >150 km

- ★ M7.1 mainshock
- M7.1 aftershocks

- Seismic stations:
- ▼ AV
  - ▲ AK
  - ◆ TA
  - AT

AV AK TA AT

0.1-2.5 degrees



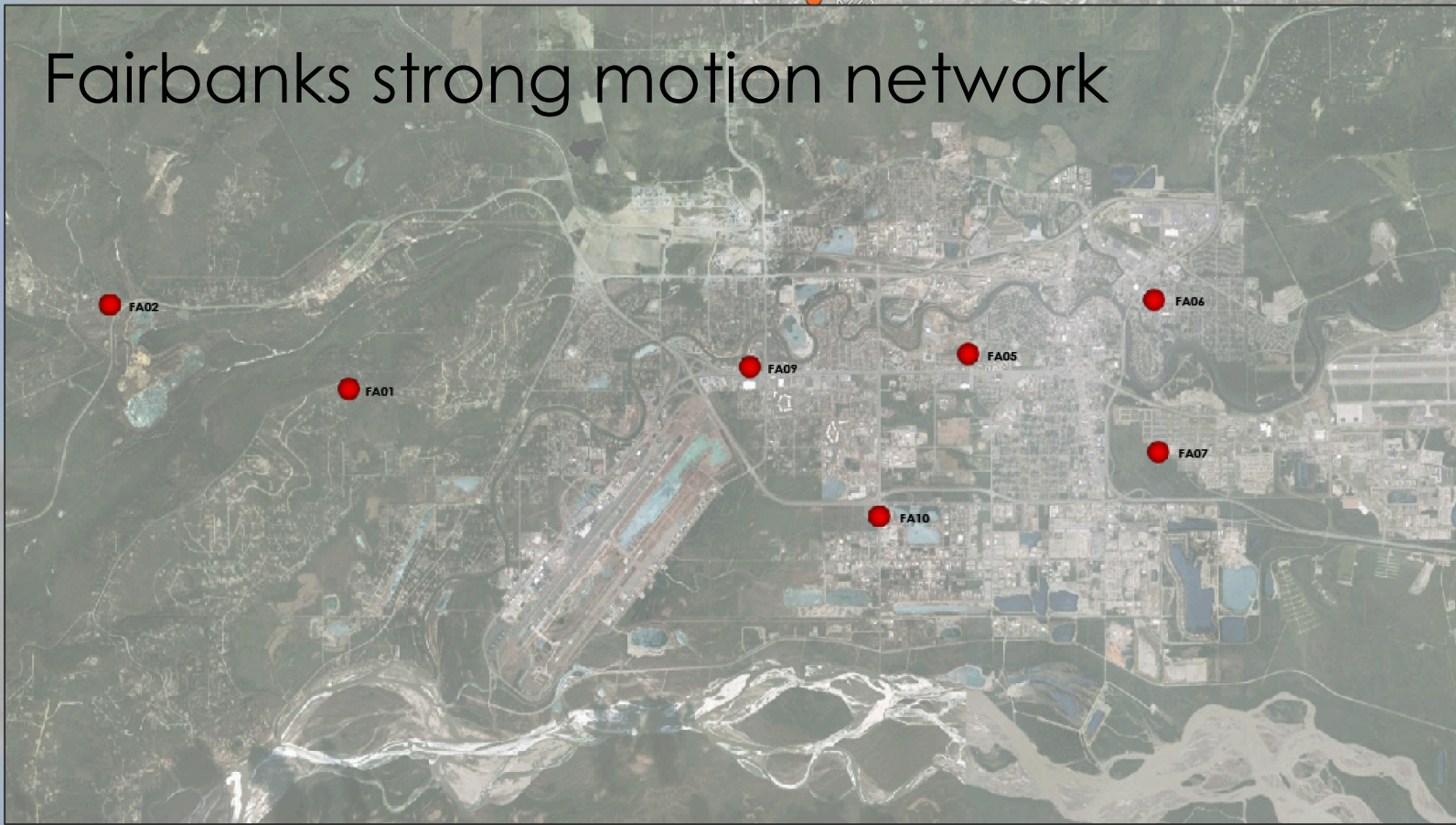
10:30:30.000 10:30:40.000 10:30:50.000 10:31:00.000 10:31:10.000 10:31:20.000 10:31:30.000  
2016024 2016024 2016024 2016024 2016024 2016024 2016024



# OTHER PROJECTS

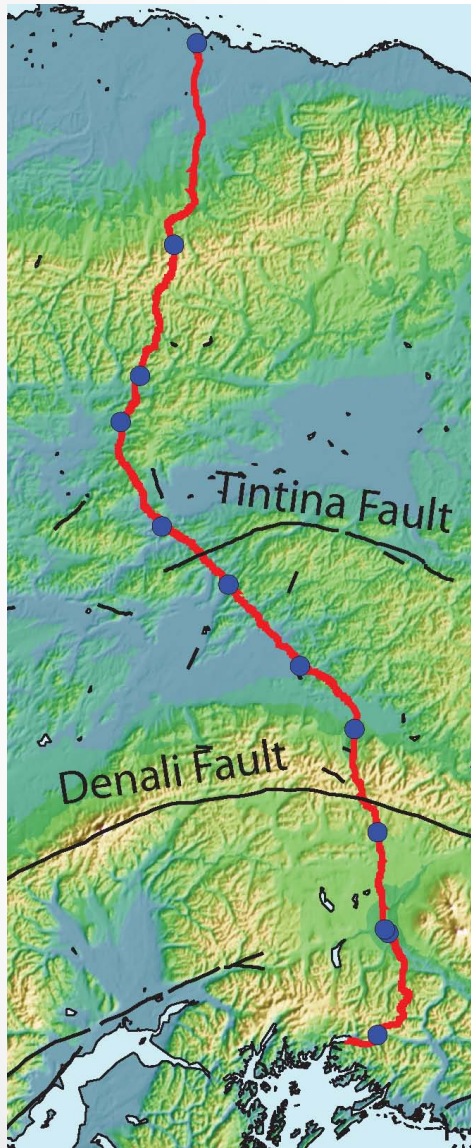
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# Fairbanks strong motion network



- DSL communications
- Host internet

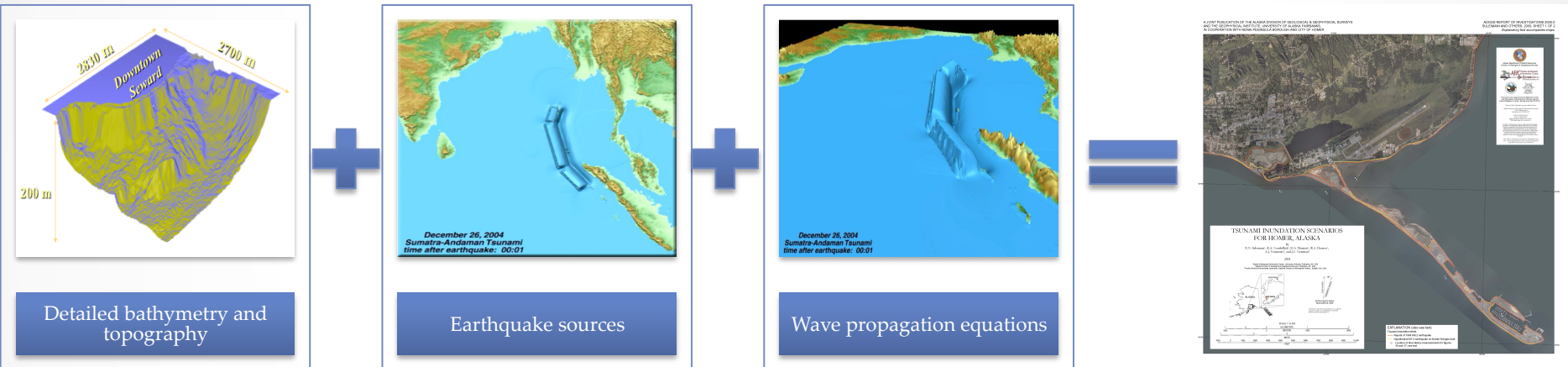
# Trans Alaska Pipeline Monitoring



- In 2008-2009 eleven new seismic monitoring sites were established along the pipeline corridor. Data is being acquired and processed at the Earthquake Center in Fairbanks.
- Custom products include: ShakeMap; ground shaking alerts, earthquake notifications.

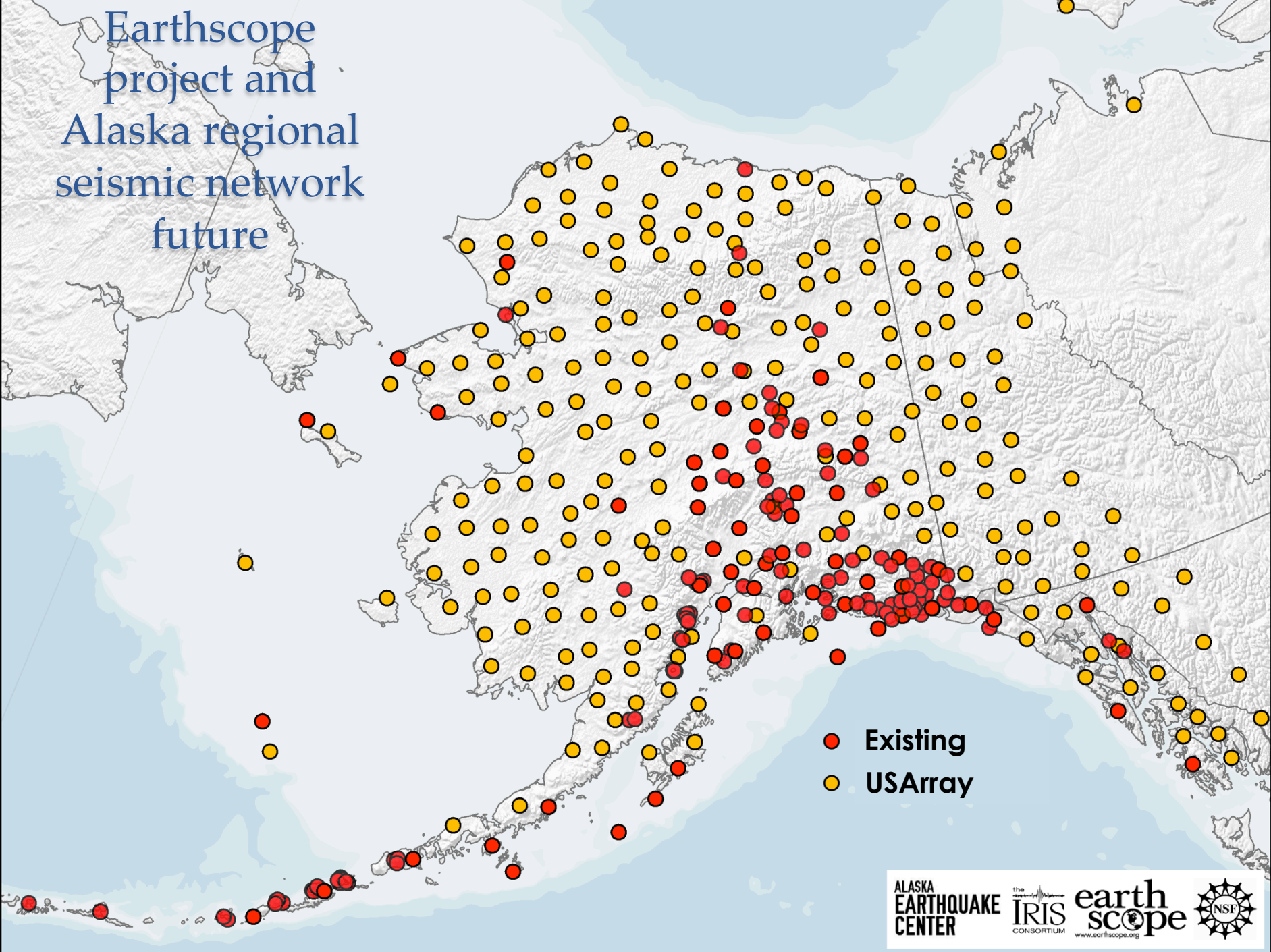


# Tsunami Inundation Mapping Program in Alaska



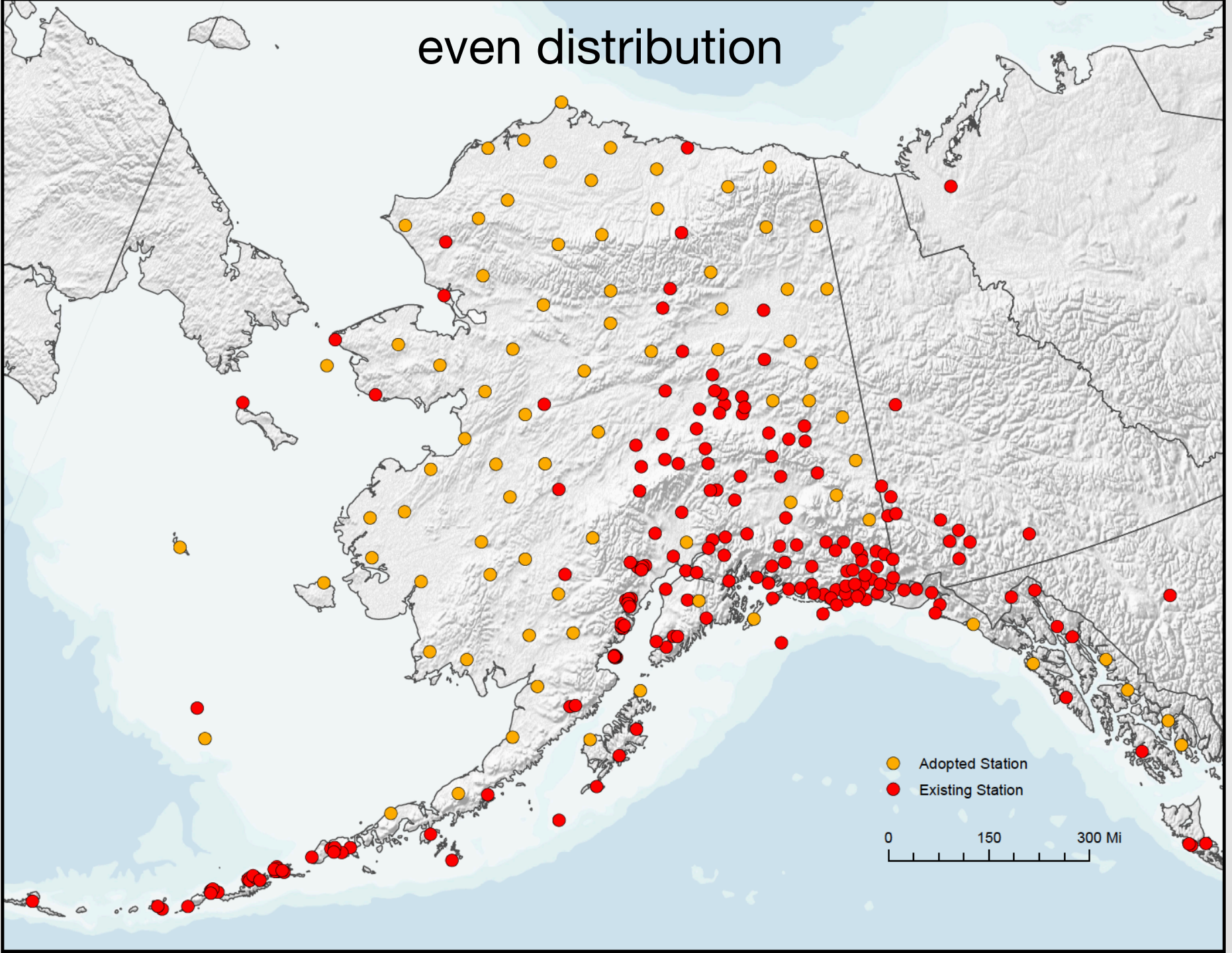
- Generating map products to assist coastal communities in tsunami prone areas with emergency planning and disaster response.

# Earthscope project and Alaska regional seismic network future



- Existing
- USArray

# even distribution

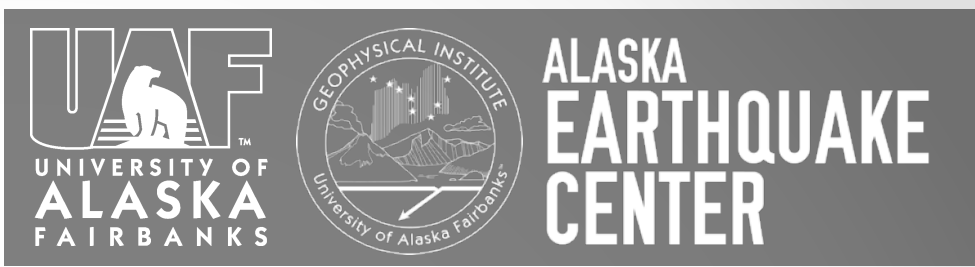


# Earthquake Center - Current state

- We are members of ANSS – Advanced National Seismic System. One of our key responsibilities is real time earthquake reporting for Alaska region.
- We collect, analyze and archive data from about 500 seismic sites in the State, and also from our neighbors Canada and Russia and Global Seismic Network.
- We report on average 35,000 local and regional earthquakes per year recently.
- We are responsible for maintenance of ~200 seismic sites.
- We provide seismic monitoring of the Trans-Alaska Oil Pipeline, and hydro-electric dams.
- We participate in the Tsunami Hazard program by producing tsunami inundation maps for coastal communities in the State.
- We have staff of about 15.



# Who We Are



Operations  
and  
Management



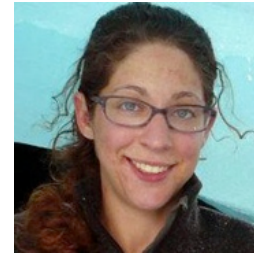
Michael West



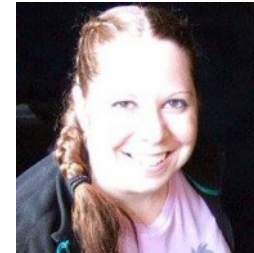
Scott Dalton



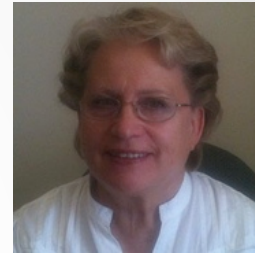
Ian Dickson



Sara Meyer



Miriam Braun



Natasha Kozyreva



Natalia Ruppert



Mitch Robinson



Dara Merz



Michelle Harrison



Helena Burman



Matt Gardine

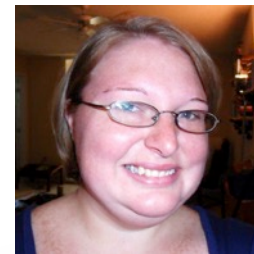
Tsunami research  
and Outreach



Elena Suleimani



Dmitry Nicolsky



Lea Gardine