Earthquakes and Seismic Networks In Alaska

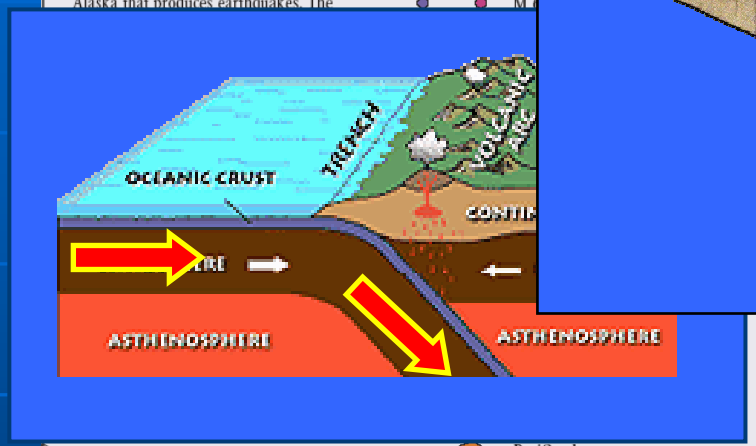
Presented by:
Roger Hansen
State Seismologist
Alaska Earthquake Information Center
Geophysical Institute, University of Alaska Fairbanks

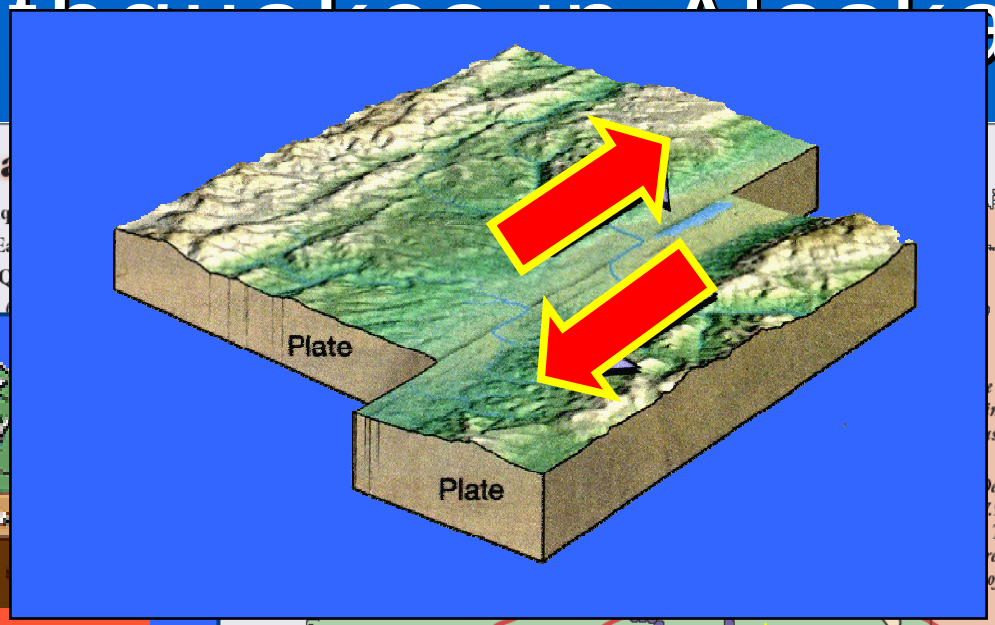
Presented to the Alaska Seismic Hazards Safety Commission December 6, 2006

The ANSS Alaska Region

- State of development in Region
- Key Partnerships
- Organizational Structure
- Capability of System
- AEIC as the Regional Center
- Issues
- Priorities for coming years

Earthquakes in 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

Pre-1964 Earthq
Post-1964 E
EQ
M

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.

PLATE

e M 7 earthquakes occurred
in 50 miles of Fairbanks in
st 90 years.

Denali fault generated
.9 earthquake in
. This part of the fault
ed, with horizontal
of up to 29 feet.

Pacific plate movement by and under Alaska.

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

M 8.0
9/10/1899

1979

9.2

7.9

7.6

6.8

8.1

June 28th
2004

M 8.7
2/4/65

M 8.6
3/9/57

M 8.0
5/7/1986

M 8.3
11/10/1938

1948

1964

1946

1957

1957

1987

1988

1959

2/1949

3.0 in./yr

2.2 in./yr

2.0 in./yr

2.5 in./yr

2.7 in./yr

8.7

8.6

NORTH AMERICAN PLATE

ALEUTIAN MEGATHRUST

PACIFIC PLATE

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

The 1964 earthquake was the second largest ever recorded in the world. The area within this yellow patch slipped seaward up to 66 feet.

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

CASTLE MTN. FAULT

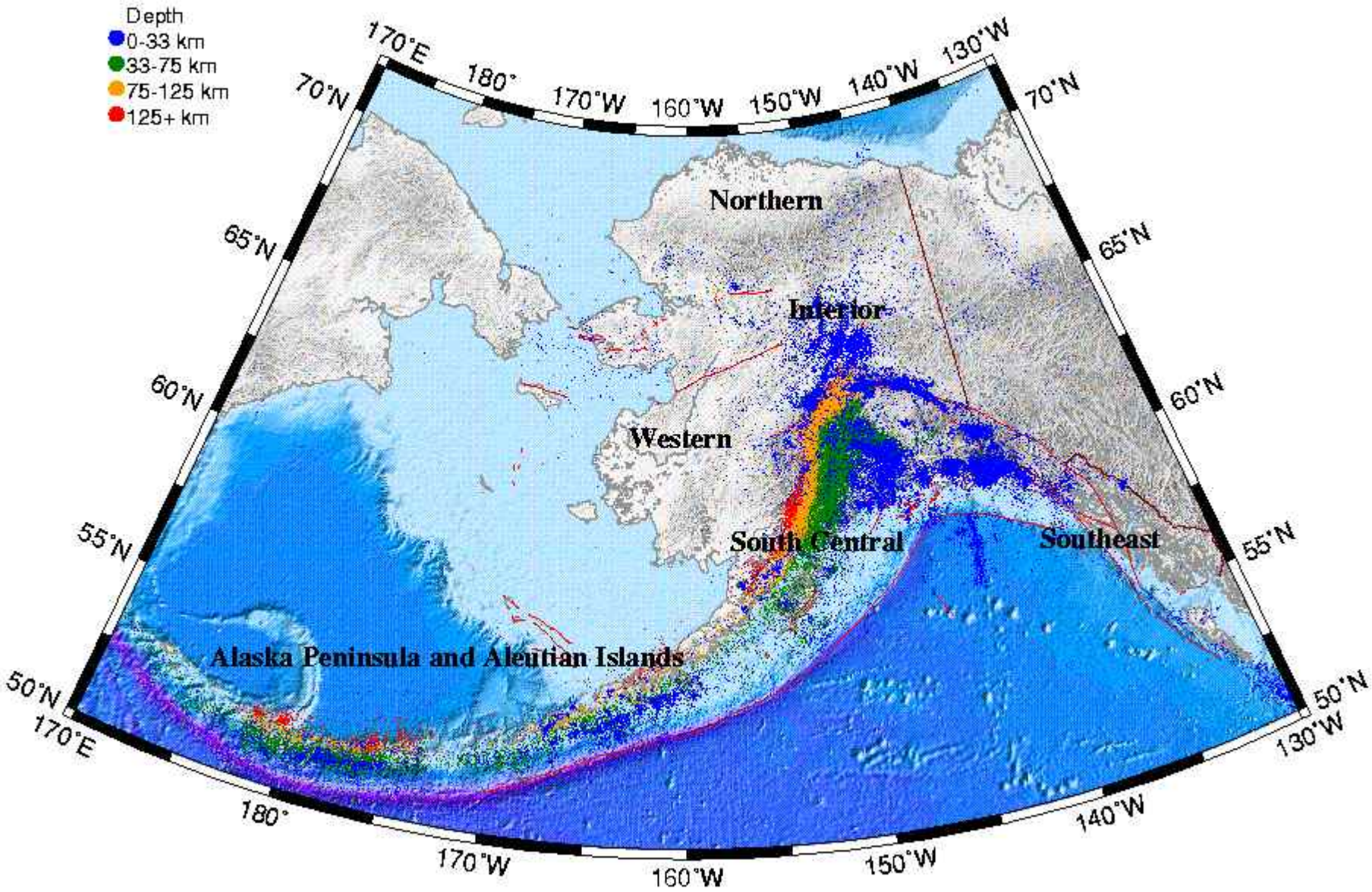
TRANSITION FAULT

JUNEAU

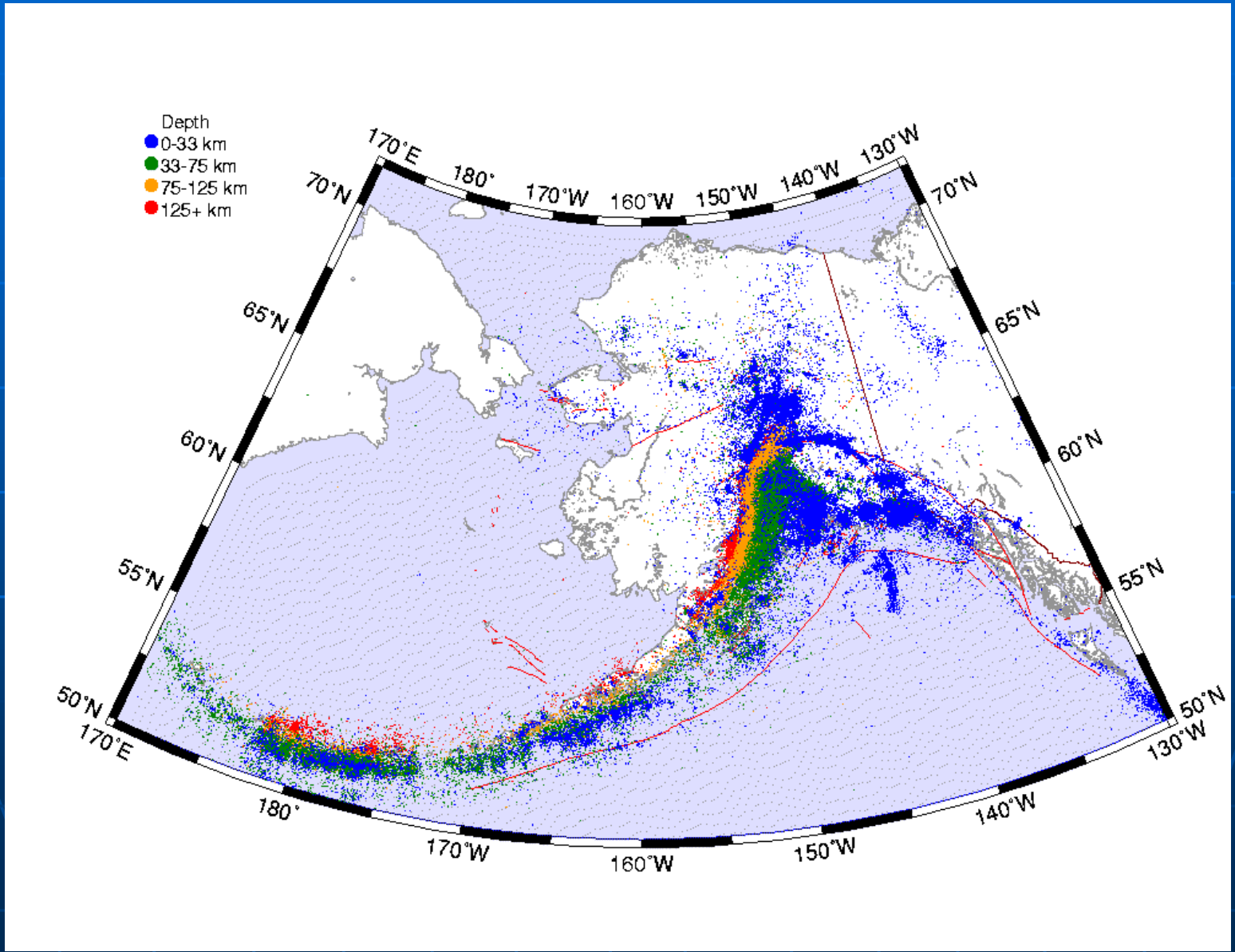
q n Alaska

0
250 KM
150 Miles
NORTH
Nover
2(
BUK FAULT
is being pushed
he southern
s a result it
uakes here and
Alaska.
second
orld.
atch
1949
QUEEN CHARLOTTE
FAULT
2.0 in./yr
M 8.1
8/22/1949
2.9 in./yr
The Queen Charlotte-Fairweather fault presents the greatest earthquake hazard to residents of southeast Alaska.

Historic Regional Seismicity

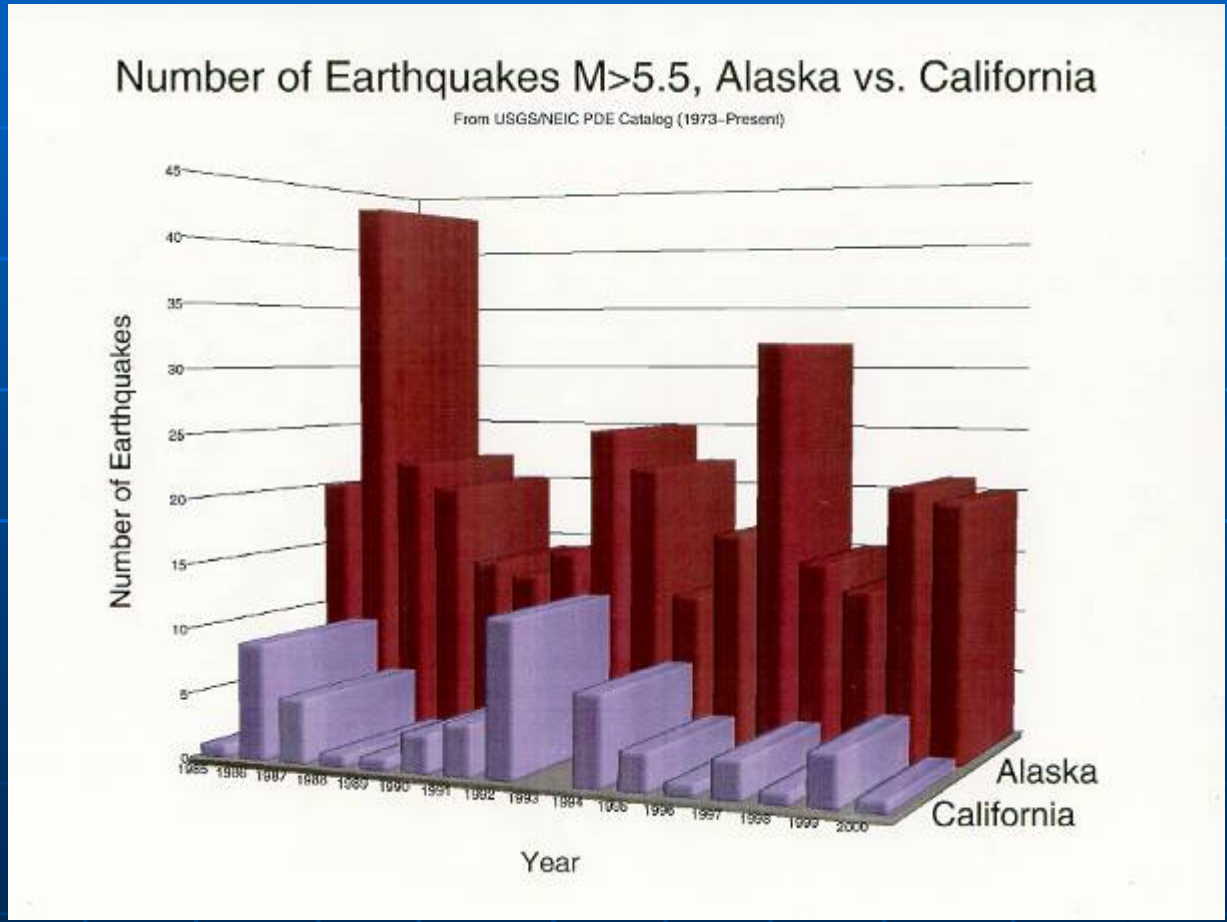


Earthquakes in Alaska: 1898 to Today

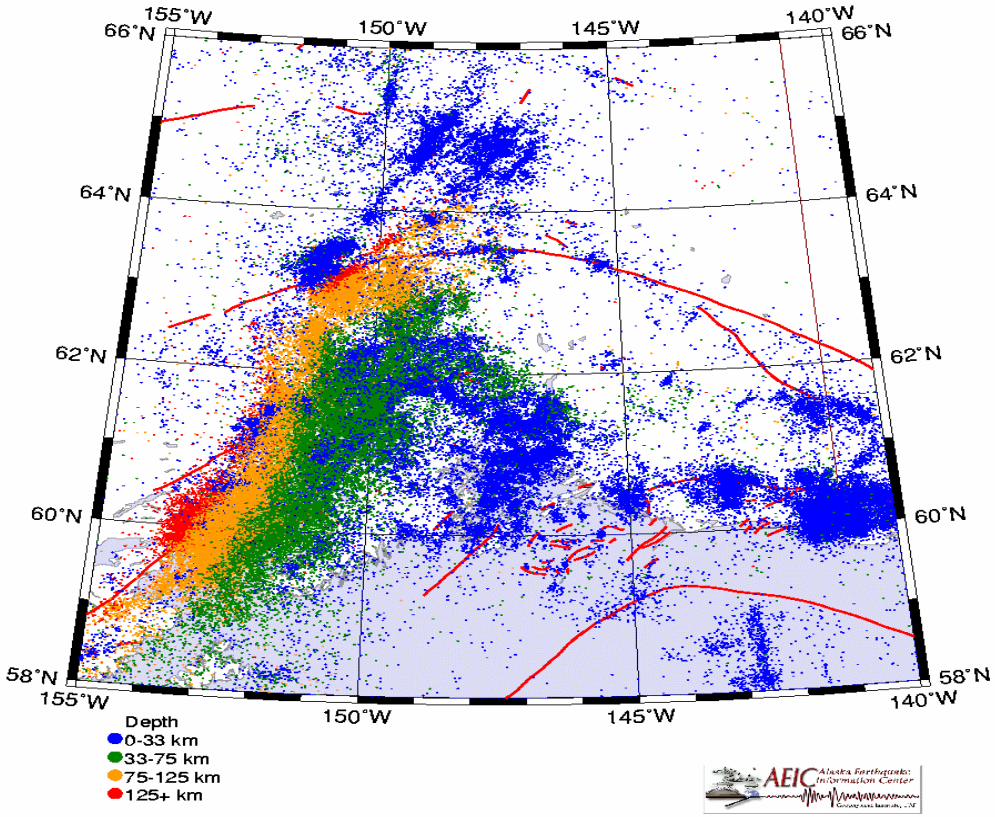


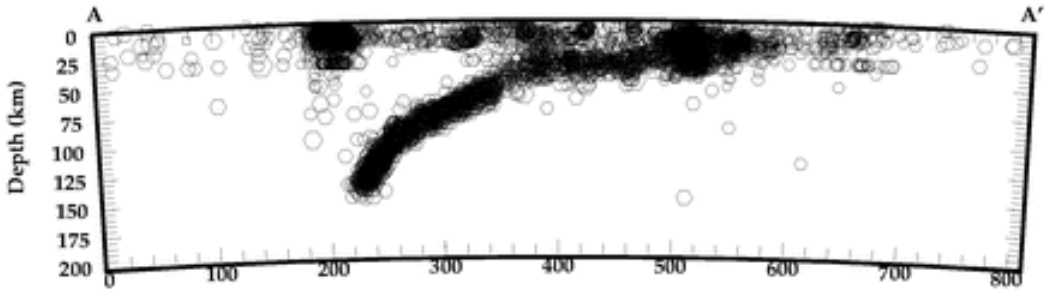
How many earthquakes do we have in Alaska?

- **215,000 in the last 107 years.**
- **20,000 – 30,000 are located every year (currently).**
- **Alaska has 55-75% of all the earthquakes in North America every year.**
- **Alaska has had 3 of the 10 largest earthquakes ever recorded.**



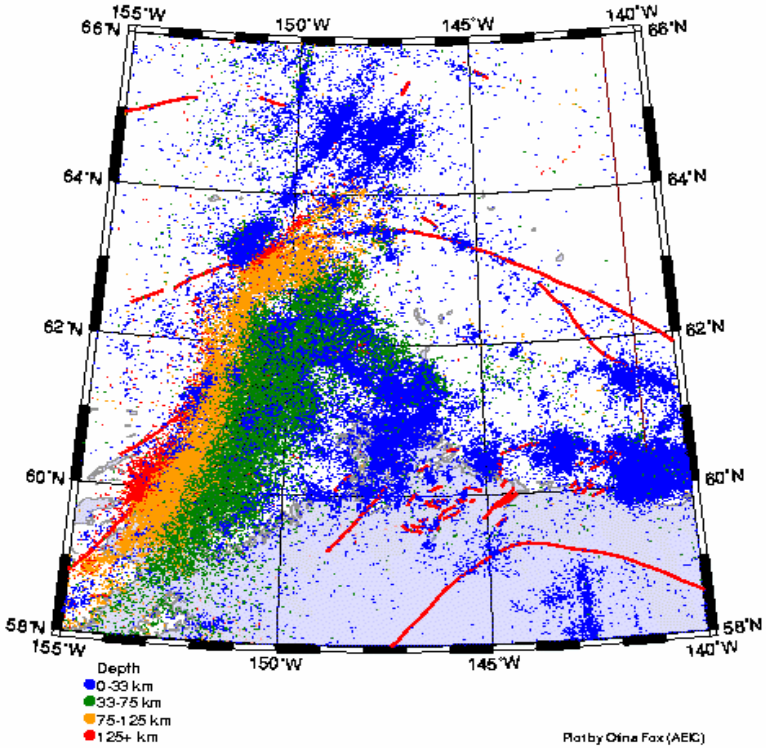
Pre Nenana & Denali Earthquakes



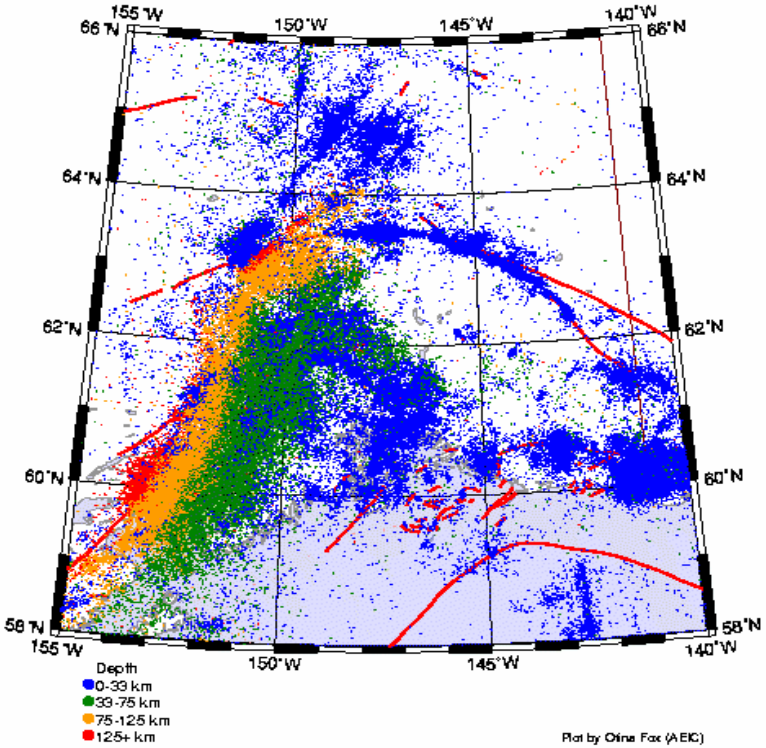


AEIC Alaska Earthquake Information Center

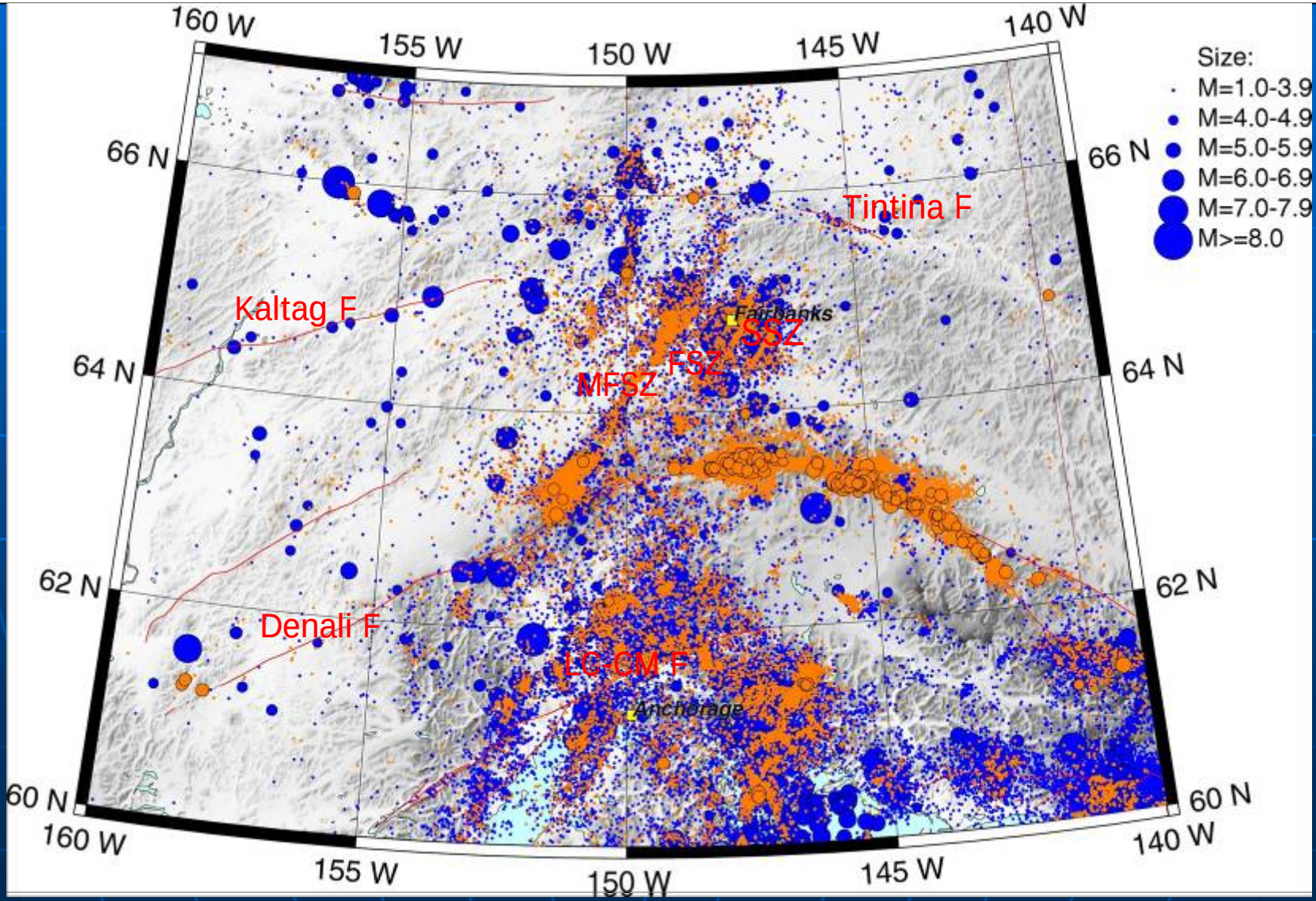
Pre Nenana & Denali Earthquakes



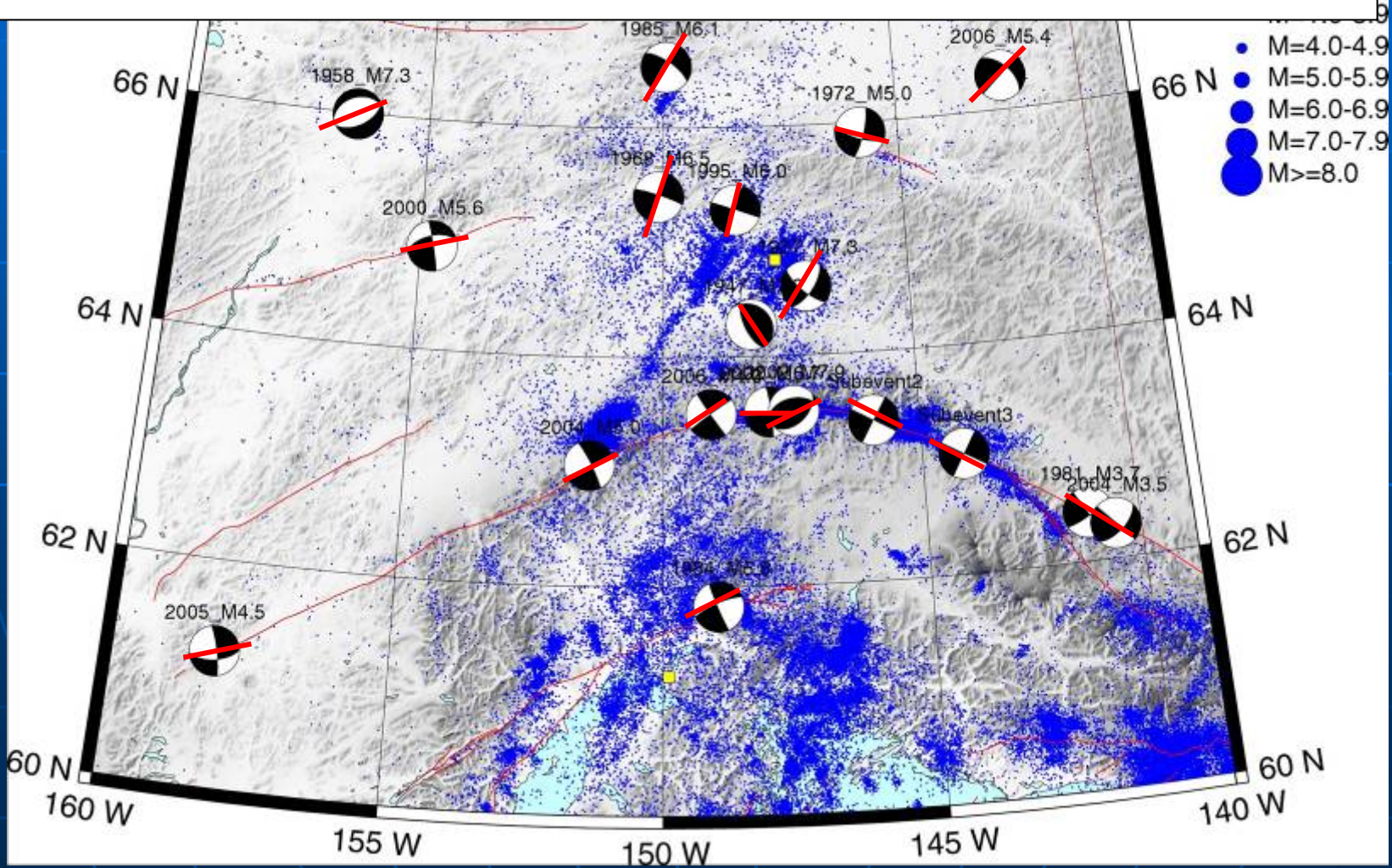
Post Nenana & Denali Earthquakes



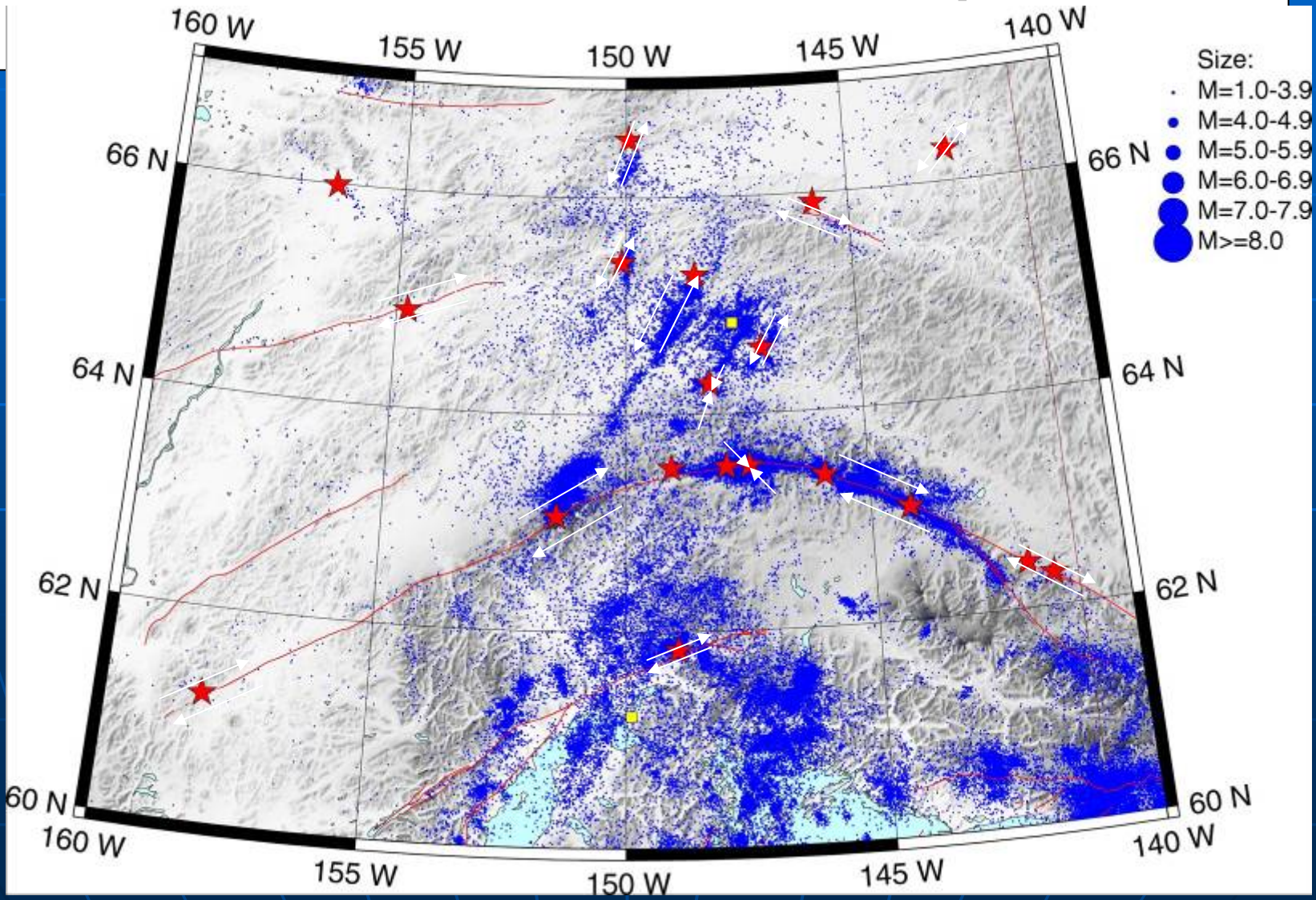
Earthquakes and Faults



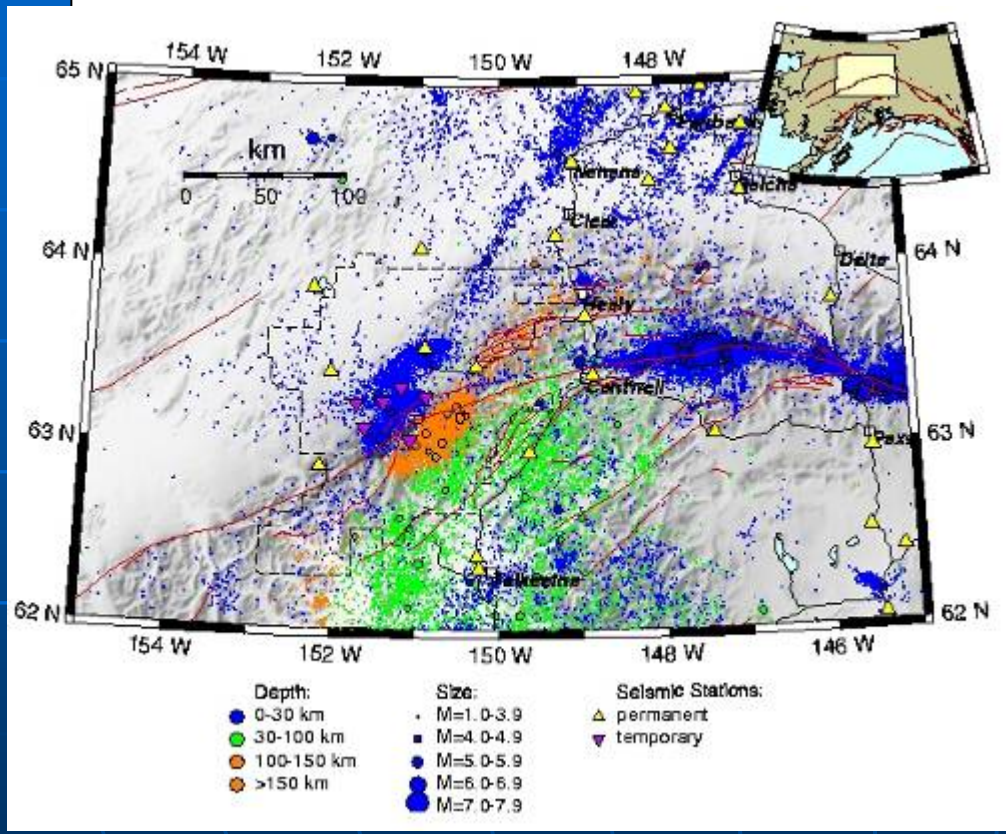
Notable Earthquakes



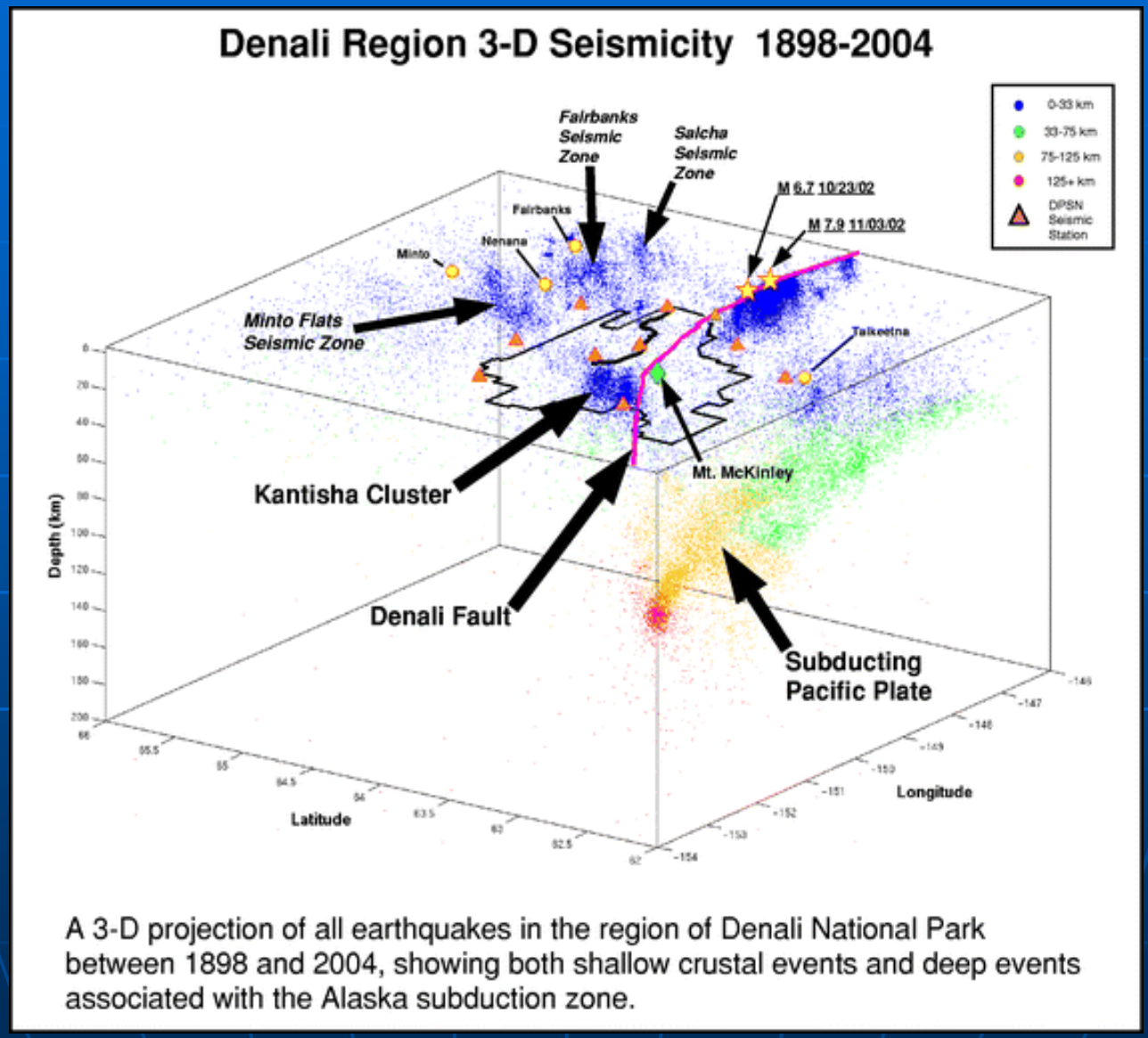
Tectonics from Earthquakes



Interior Alaska Seismicity



- Large-scale strike-slip faults: Denali, Kaltag, Tintina
- NNE-trending seismic zones north of the Denali Fault
- Earthquakes as deep as 150 km
- Largest event – M7.9 Denali fault earthquake on 11/03/2002
- Most active source of crustal seismicity – Kantishna cluster



A 3-D projection of all earthquakes in the region of Denali National Park between 1898 and 2004, showing both shallow crustal events and deep events associated with the Alaska subduction zone.

Summary

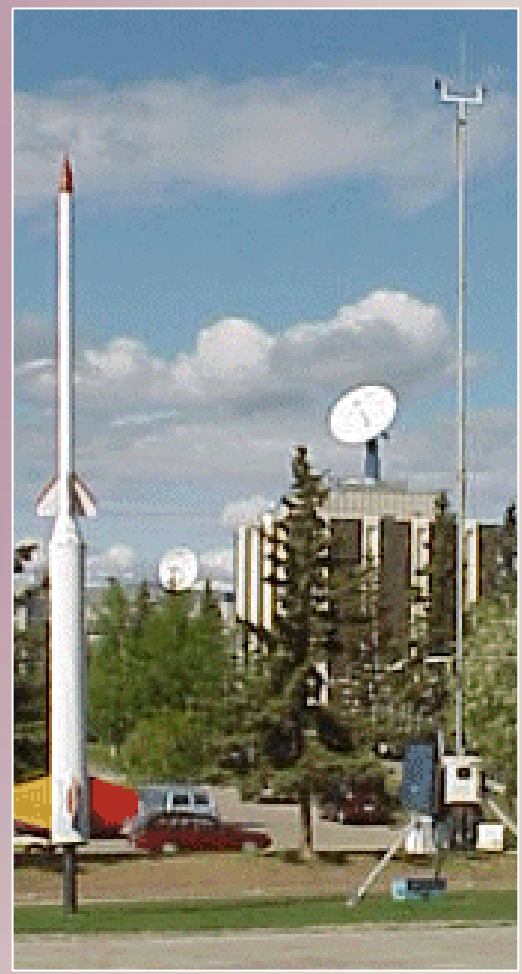
- Database of 215562 earthquakes since 1899
  - 103,645 earthquakes before 1/1/1996
  - 111,917 earthquakes since 1/1/1996
  - ~30,000 Denali Fault aftershocks
- 26,505 earthquakes in the Aleutian Islands
  - 10,409 earthquakes before 1/1/1996
  - 16,096 earthquakes since 1/1/1996

Alaska Earthquake Information Center

Research at the Geophysical Institute

~400 employees

- ~50 Professors
- Institute Service Centers:
  - Operations Office
  - Machine Shop
  - Computer Resource Center
  - Electronics Shop
  - Information/E&O
  - Business Office
  - Word Processing



UAF Geophysical Institute Seismology Laboratory

- GI Seismology Group
  - Tenure track teaching faculty
  - Research faculty
  - Professional seismologists and technicians
  - Multi-disciplinary activities
    - Frequent collaboration with other research groups
    - Strong use of Service Centers

The Alaska Earthquake Information Center

- Established by Alaska statute in 1986
- Office of the Alaska State Seismologist -
- AEIC Mandate –
  - Assess seismic hazards for Alaska
  - Collect, analyze, and archive seismic event data
  - Provide information and assistance to State and local agencies
- Partnership with U.S. Geological Survey USGS science for a changing world
- Cooperate with…
  - NOAA – West Coast/Alaska Tsunami Warning Center
  - Alaska Div. of Homeland Security & Emergency Management
  - Alaska Div. of Geological & Geophysical Surveys

Seismic Monitoring

Remote

Seismic

Monitoring Stations

Seismic Data Analysis

Archiving

and

Reporting

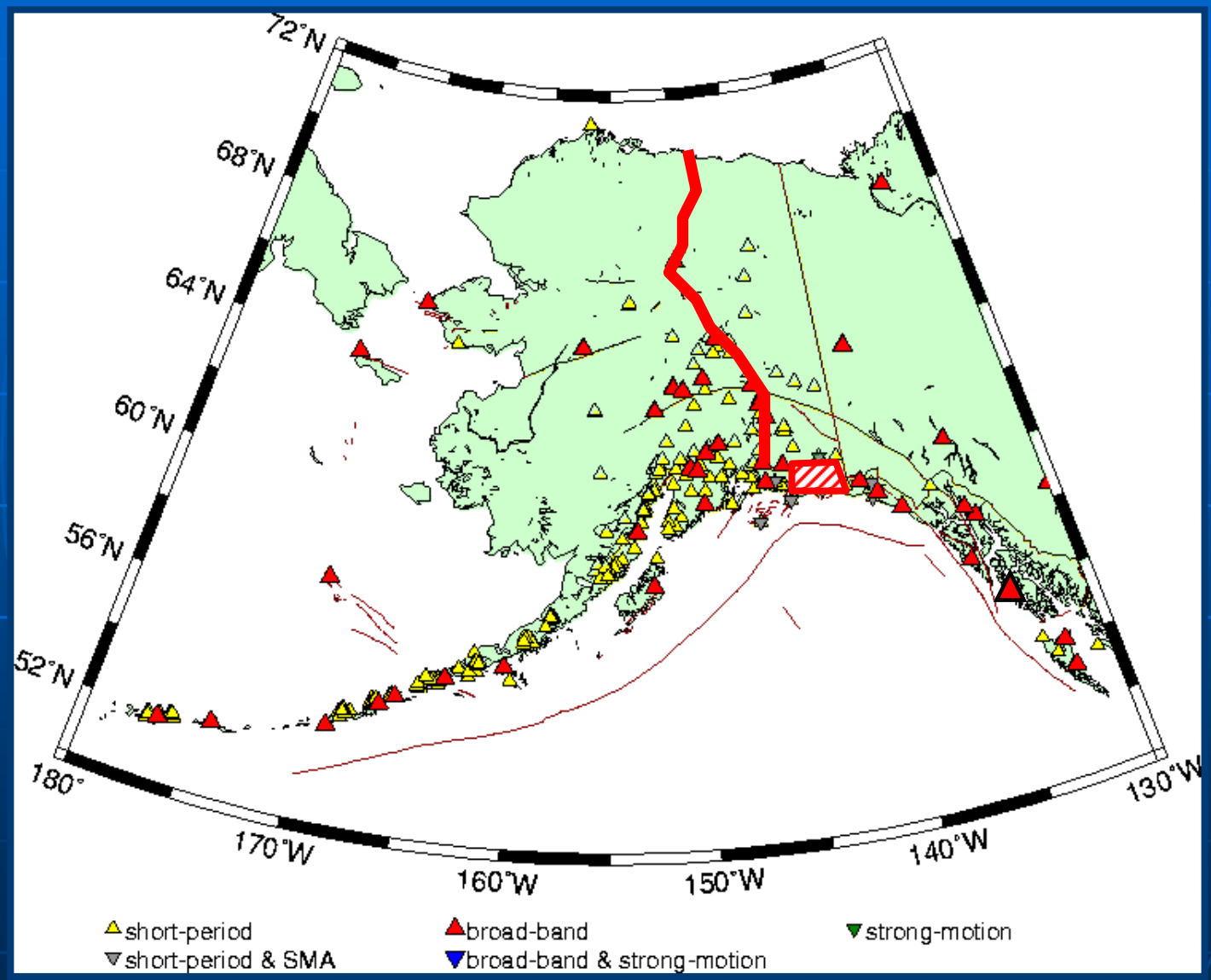
A Century of Seismic Monitoring

- First Sixty Years
  - First Station in Sitka installed in 1904
  - Second Station not until 1935 at the College Observatory at UAF
- Post 1964 Earthquake
  - Narrow Band Seismometers
  - Low dynamic range communications systems
  - Geophysical Institute
  - USGS Menlo Park
  - NOAA Tsunami Warning Center

A Century of Seismic Monitoring

- Modernization of an integrated Network
  - New instrumentation
  - Better site preparation
  - Robust digital communication through hardware and software upgrades
  - Real-time processing
  - Archiving with a Relational DataBase Management system
  - Expansion of network to tsunami specific monitoring – broadband and strong motion
  - Active volcano networks through AVO – short period
  - ANSS Regional Data Center for Alaska

Seismic Monitoring Network



400+ Stations

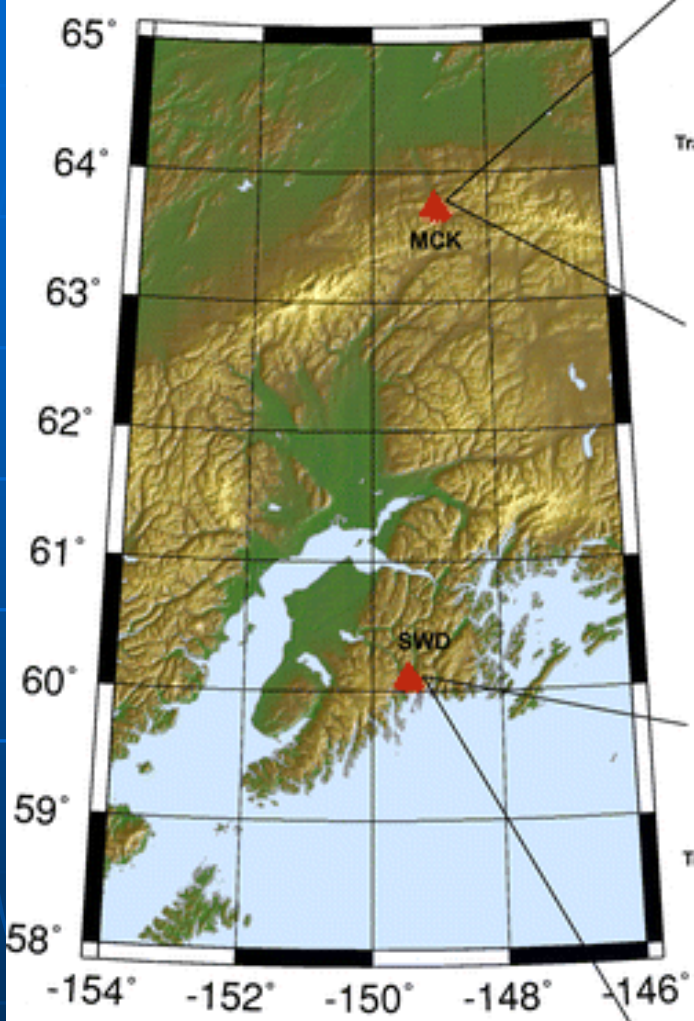
Integrated network…

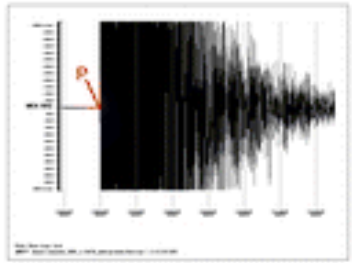
- AEIC
- AVO
- USGS
- WC/ATWC

Network expansion…

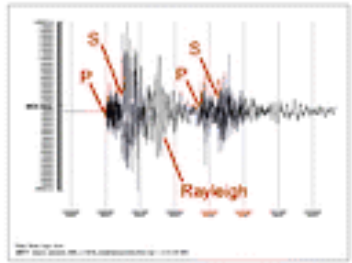
- Southeast
- Pipeline
- STEEP

The National Tsunami Hazard Mitigation Program allows the Alaska Earthquake Information Center to augment and upgrade our regional seismic network to include modern digital broadband seismograph stations. Traditional analog short-period stations lose amplitude information necessary to determine magnitude and phases later than the first arrival.

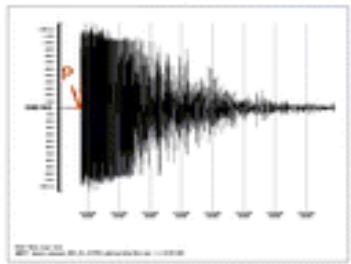




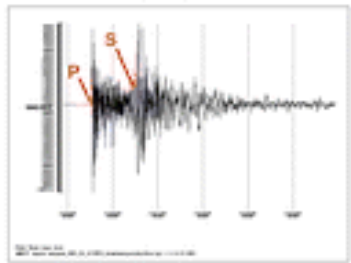
Traditional analog short-period seismogram



Modern digital broadband seismogram



Traditional analog short-period seismogram

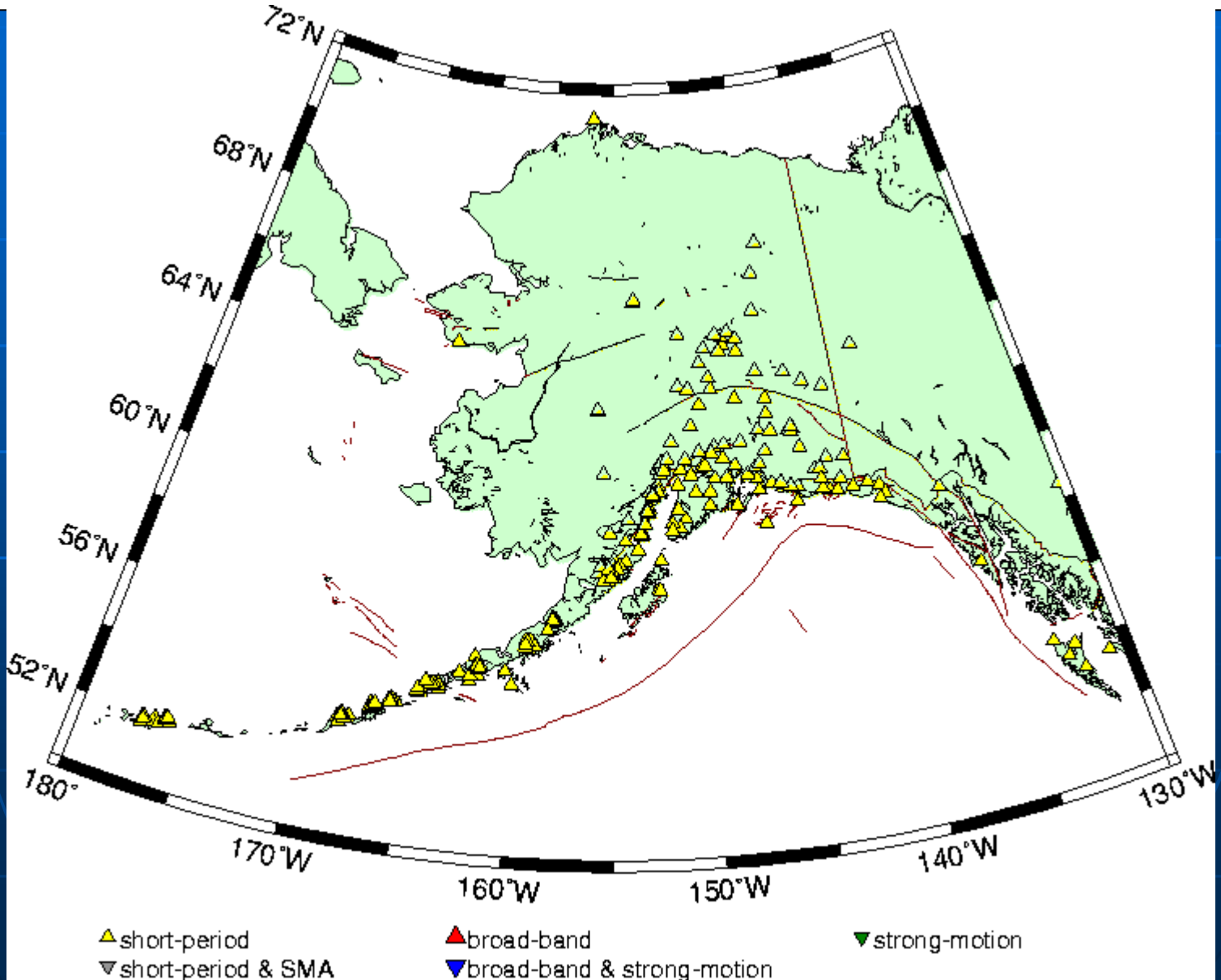


Modern digital broadband seismogram

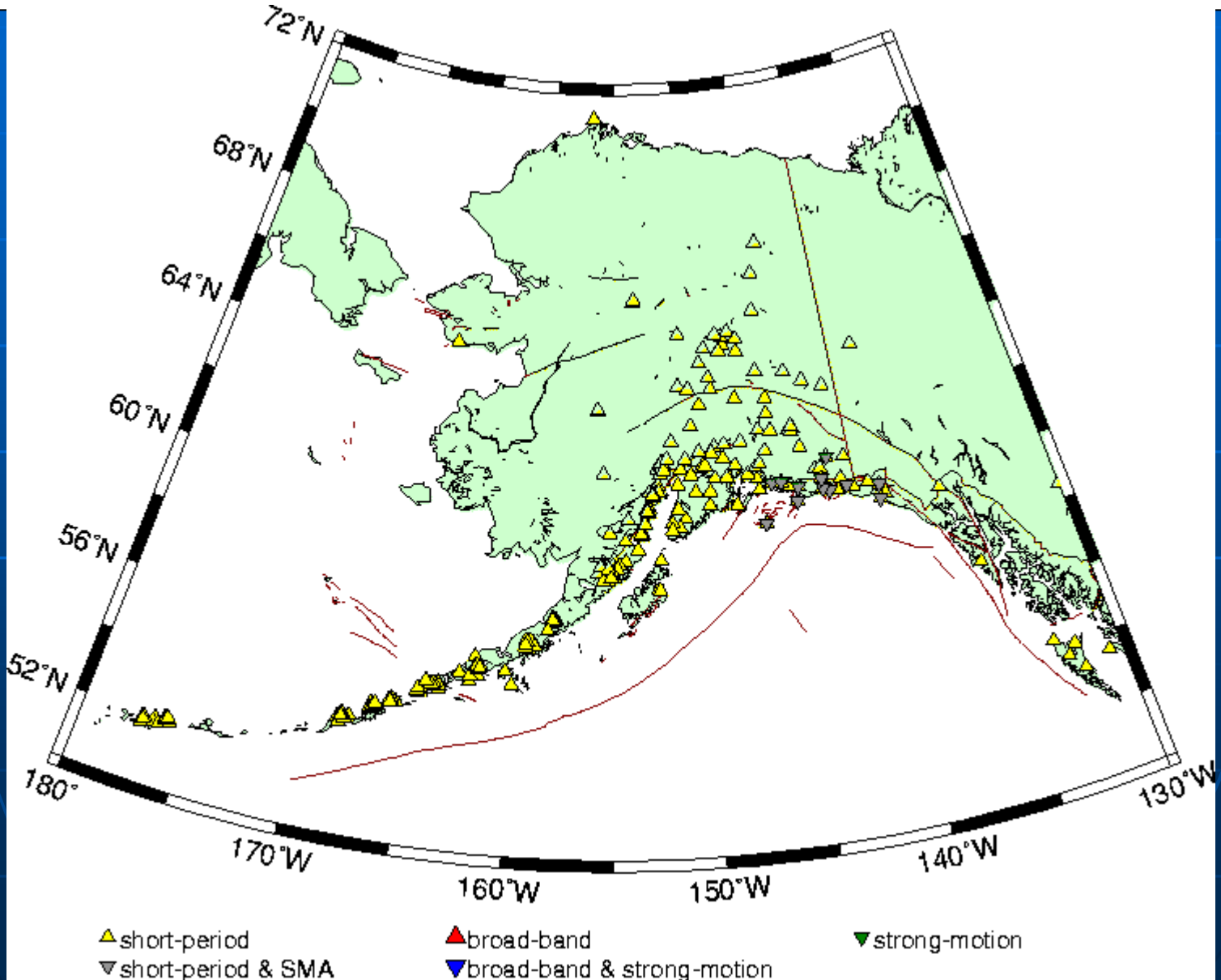
The top two seismograms show waveforms from the two November 29, 2000 Ml 5+ earthquakes located near Kantishna, Alaska. Note that the two earthquakes are only visible in the modern digital seismogram.

The bottom two seismograms show waveforms from a recent Ml 4.5 earthquake located near Seward, Alaska.

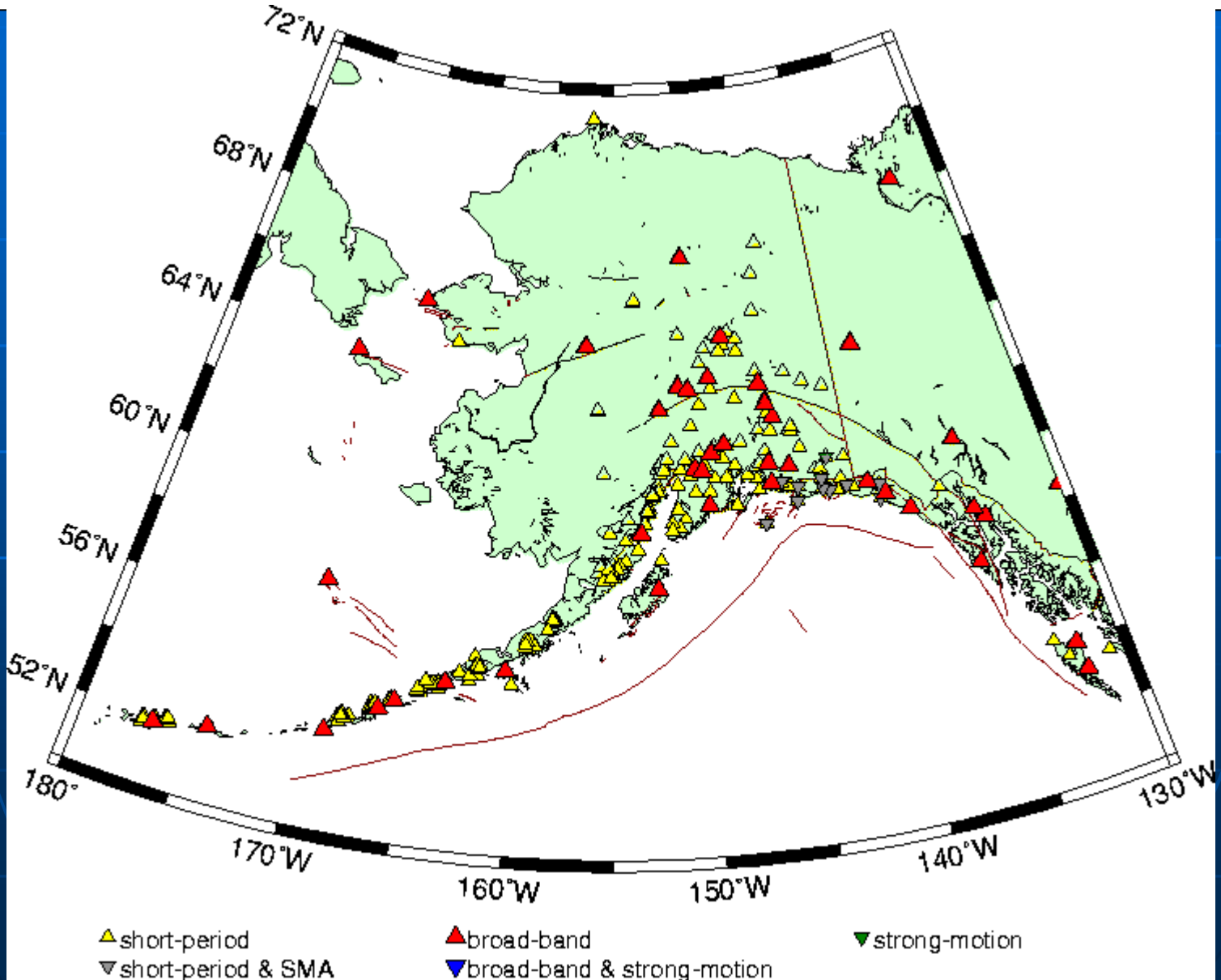
Short Period Analog Network



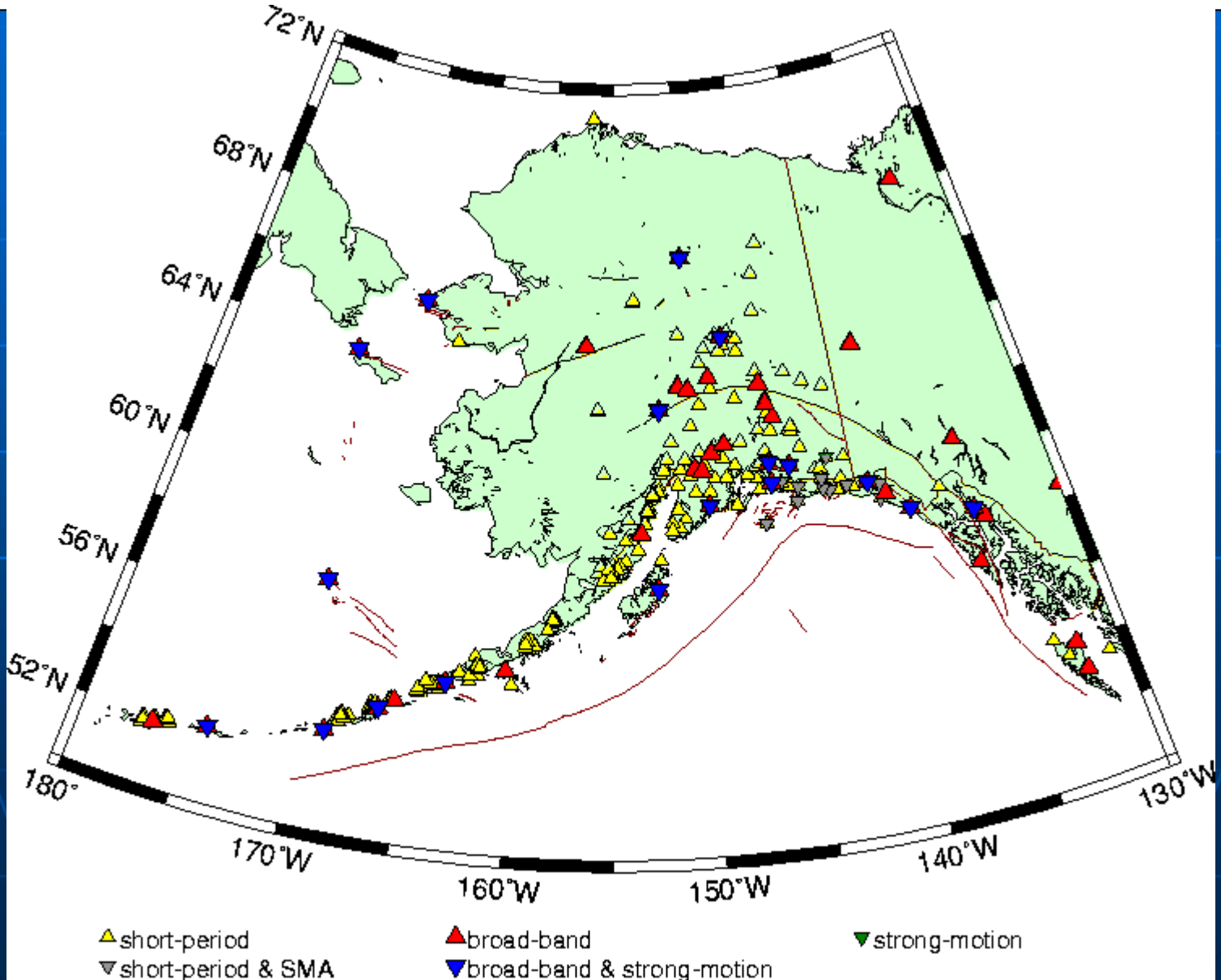
Film Recorded SMA



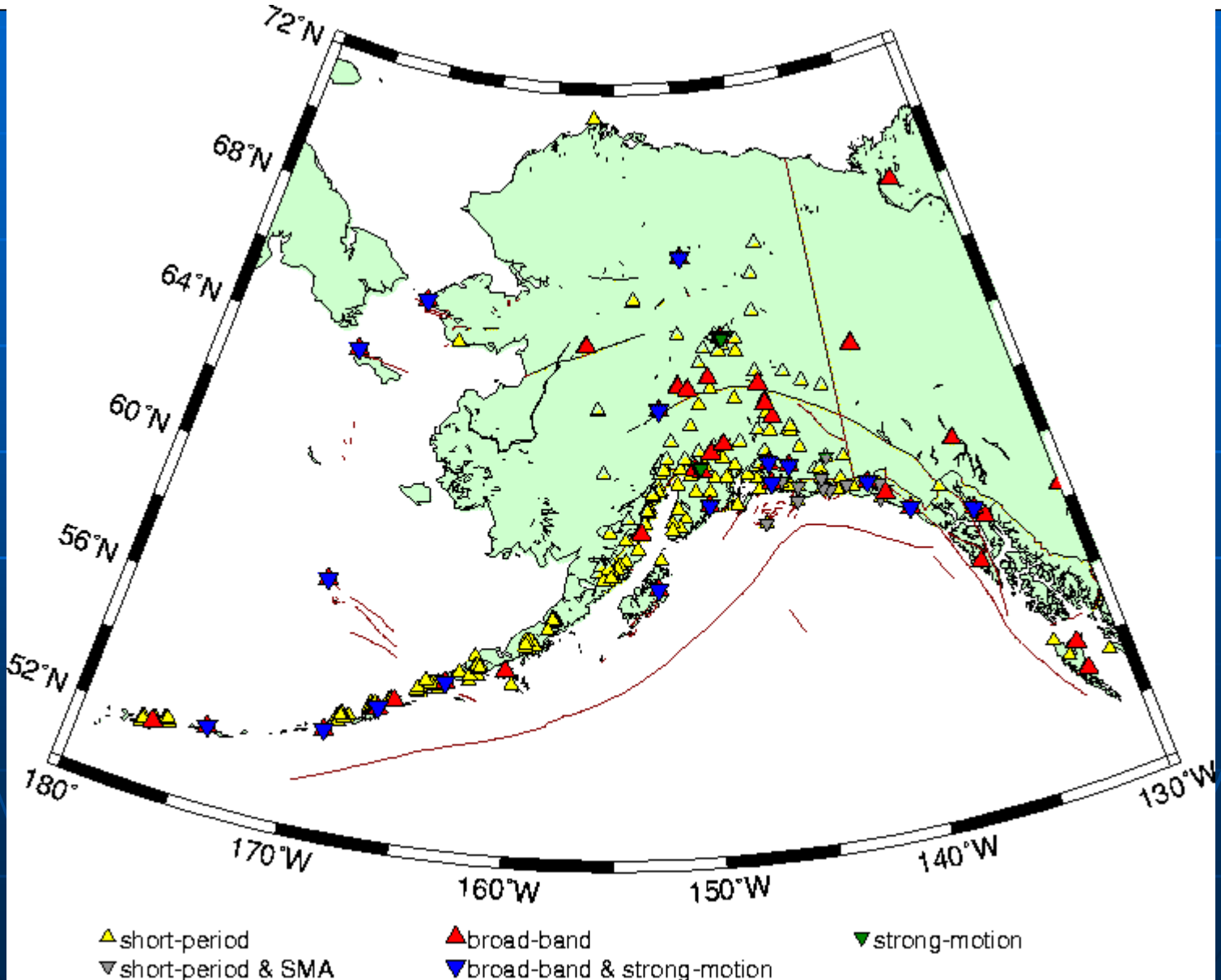
Digital Broadband Stations



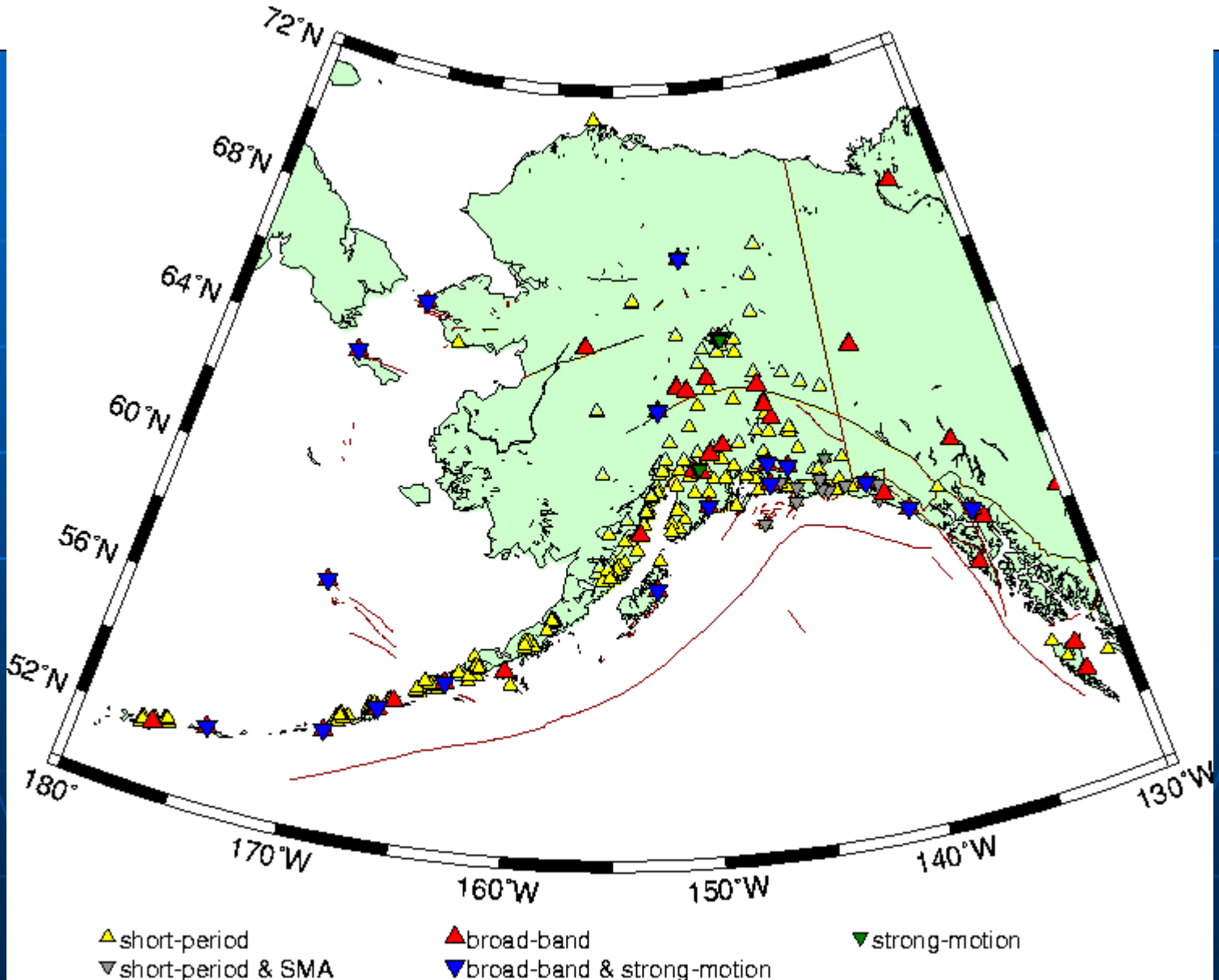
Digital Real Time SMA's



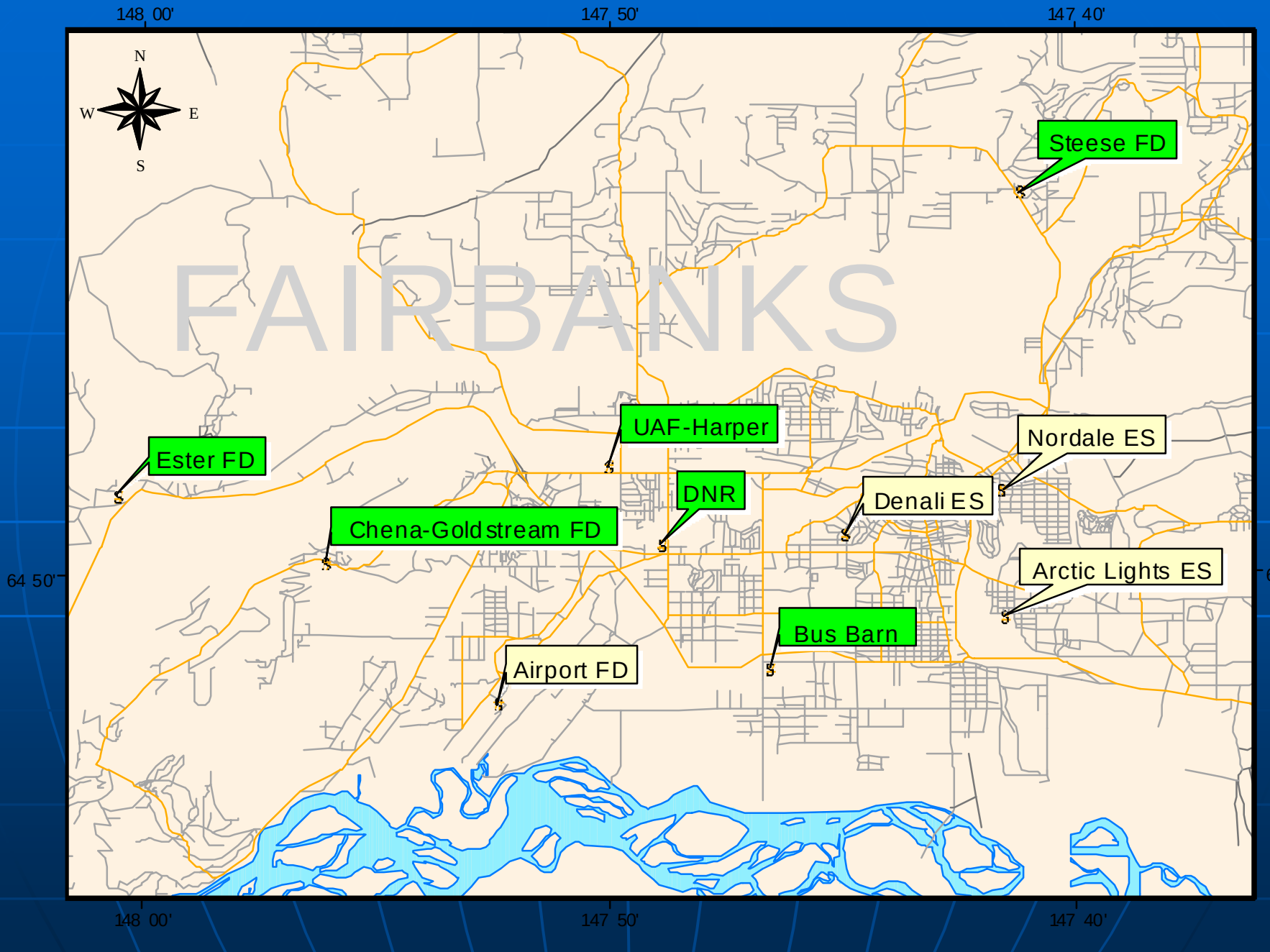
Urban Strong Motion Stations

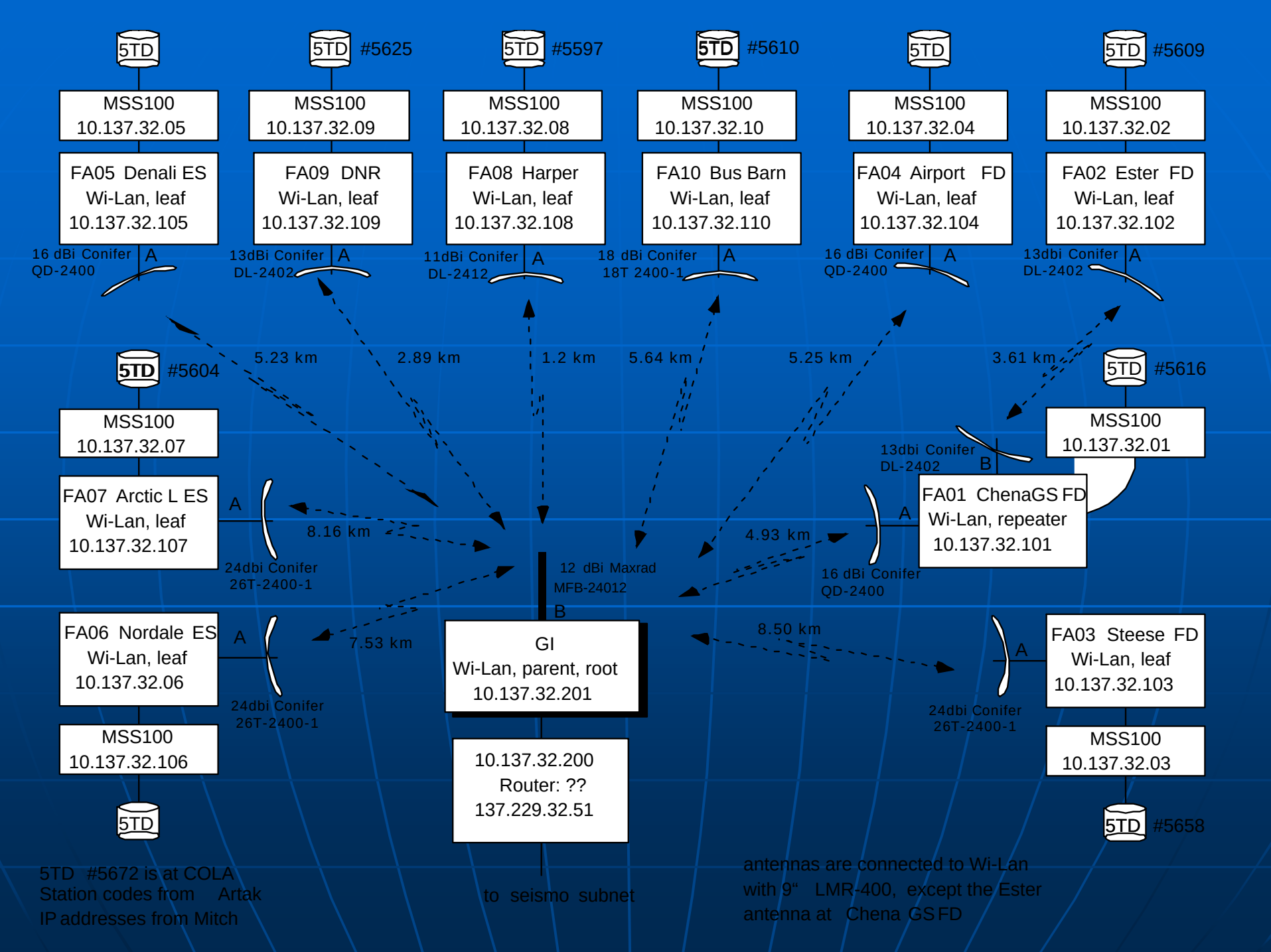


Urban Strong Motion Stations



Sling-load to Suckling Hills (SUCK)

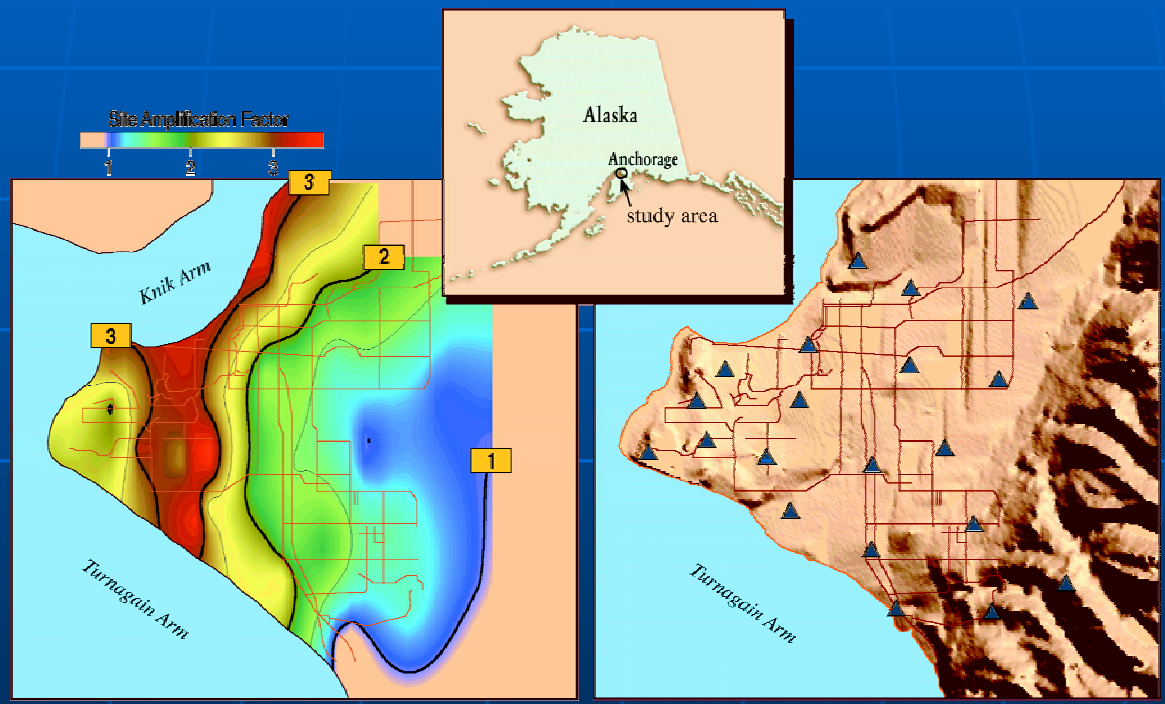

148 00'
147 50'
147 40'
64 50'
N
W
E
S
FAIRBANKS
Steese FD
UAF-Harper
Ester FD
Nordale ES
DNR
Denali ES
Chena-Goldstream FD
Arctic Lights ES
Bus Barn
Airport FD

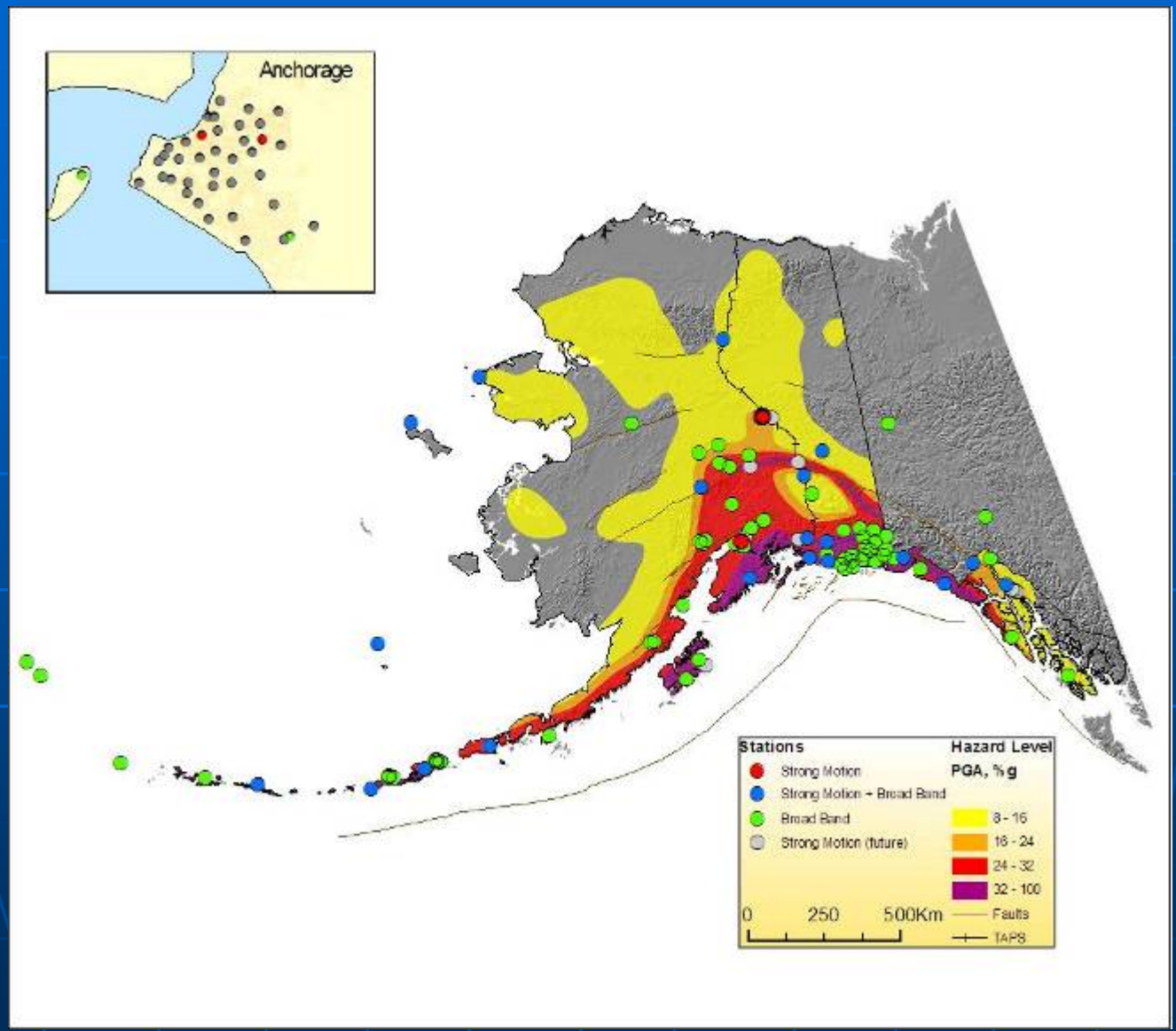

5TD
5TD #5625
5TD #5597
5TD #5610
5TD
5TD #5609
MSS100
10.137.32.05
MSS100
10.137.32.09
MSS100
10.137.32.08
MSS100
10.137.32.10
MSS100
10.137.32.04
MSS100
10.137.32.02
FA05 Denali ES
Wi-Lan, leaf
10.137.32.105
FA09 DNR
Wi-Lan, leaf
10.137.32.109
FA08 Harper
Wi-Lan, leaf
10.137.32.108
FA10 Bus Barn
Wi-Lan, leaf
10.137.32.110
FA04 Airport FD
Wi-Lan, leaf
10.137.32.104
FA02 Ester FD
Wi-Lan, leaf
10.137.32.102
16 dBi Conifer
QD-2400
A
13dBi Conifer
DL-2402
A
11dBi Conifer
DL-2412
A
18 dBi Conifer
18T 2400-1
A
16 dBi Conifer
QD-2400
A
13dbi Conifer
DL-2402
A
5.23 km
2.89 km
1.2 km
5.64 km
5.25 km
3.61 km
5TD #5604
5TD #5616
MSS100
10.137.32.07
MSS100
10.137.32.01
13dbi Conifer
DL-2402
B
FA07 Arctic L ES
Wi-Lan, leaf
10.137.32.107
A
8.16 km
FA01 ChenaGS FD
Wi-Lan, repeater
10.137.32.101
A
4.93 km
24dbi Conifer
26T-2400-1
12 dBi Maxrad
MFB-24012
B
16 dBi Conifer
QD-2400
FA06 Nordale ES
Wi-Lan, leaf
10.137.32.06
A
7.53 km
GI
Wi-Lan, parent, root
10.137.32.201
8.50 km
FA03 Steese FD
Wi-Lan, leaf
10.137.32.103
A
24dbi Conifer
26T-2400-1
24dbi Conifer
26T-2400-1
MSS100
10.137.32.106
MSS100
10.137.32.03
10.137.32.200
Router: ??
137.229.32.51
5TD
5TD #5658
5TD #5672 is at COLA
Station codes from Artak
IP addresses from Mitch
to seismo subnet
antennas are connected to Wi-Lan
with 9“ LMR-400, except the Ester
antenna at Chena GS FD

Data Concentration Hubs

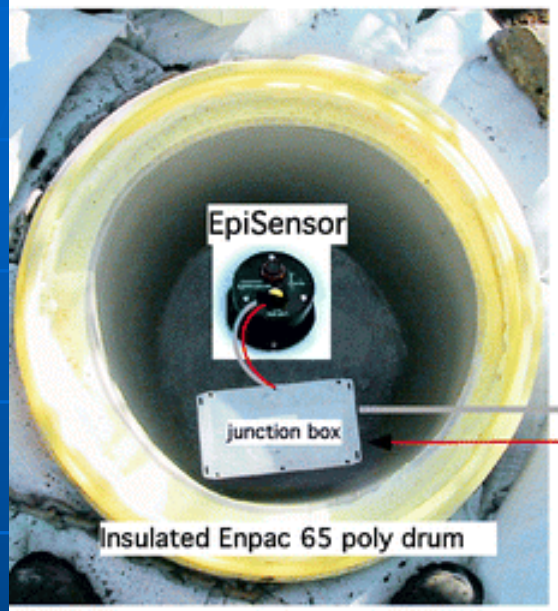
- To conserve resources, data is concentrated at various hubs for more efficient and robust telemetry to Fairbanks
  - Anchorage – DOI Intranet
  - Palmer – dedicated 56k phone line intranet
  - Homer – University internet system
  - Seward – State internet system
  - Valdez – University internet system
  - Yakatat – Dedicated 56k phone line intranet
  - Denali National Park – Dedicated phone line
  - Alaska Schools – GCI school access internet
  - Juneau, Glennallen, Cordova – in the future

Anchorage Urban Network




Anchorage
Stations
Strong Motion
Strong Motion + Broad Band
Broad Band
Strong Motion (future)
Hazard Level
PGA, %g
8 - 16
16 - 24
24 - 32
32 - 100
0
250
500Km
Faults
TAPS

TAPS Strong Motion Monitoring Station



GPS antenna

Kinemetrics Model Q330 Modular digitizer with Baler PB14
(<70 ma @ 12VDC (6W peak))

data
~100 m
power
(35ma @ 12VDC)

Communication Options

RS-232

10 base-T ethernet

Motorola V.3600 modem
(600ma @12VDC)

Cisco 1700 router
(400ma @ 12VDC)

dedicated voice grade phone line

56kB to T-1

AEIC Alaska Earthquake Information Center
Geophysical Institute, UAF

TAPS Strong Motion Monitoring System

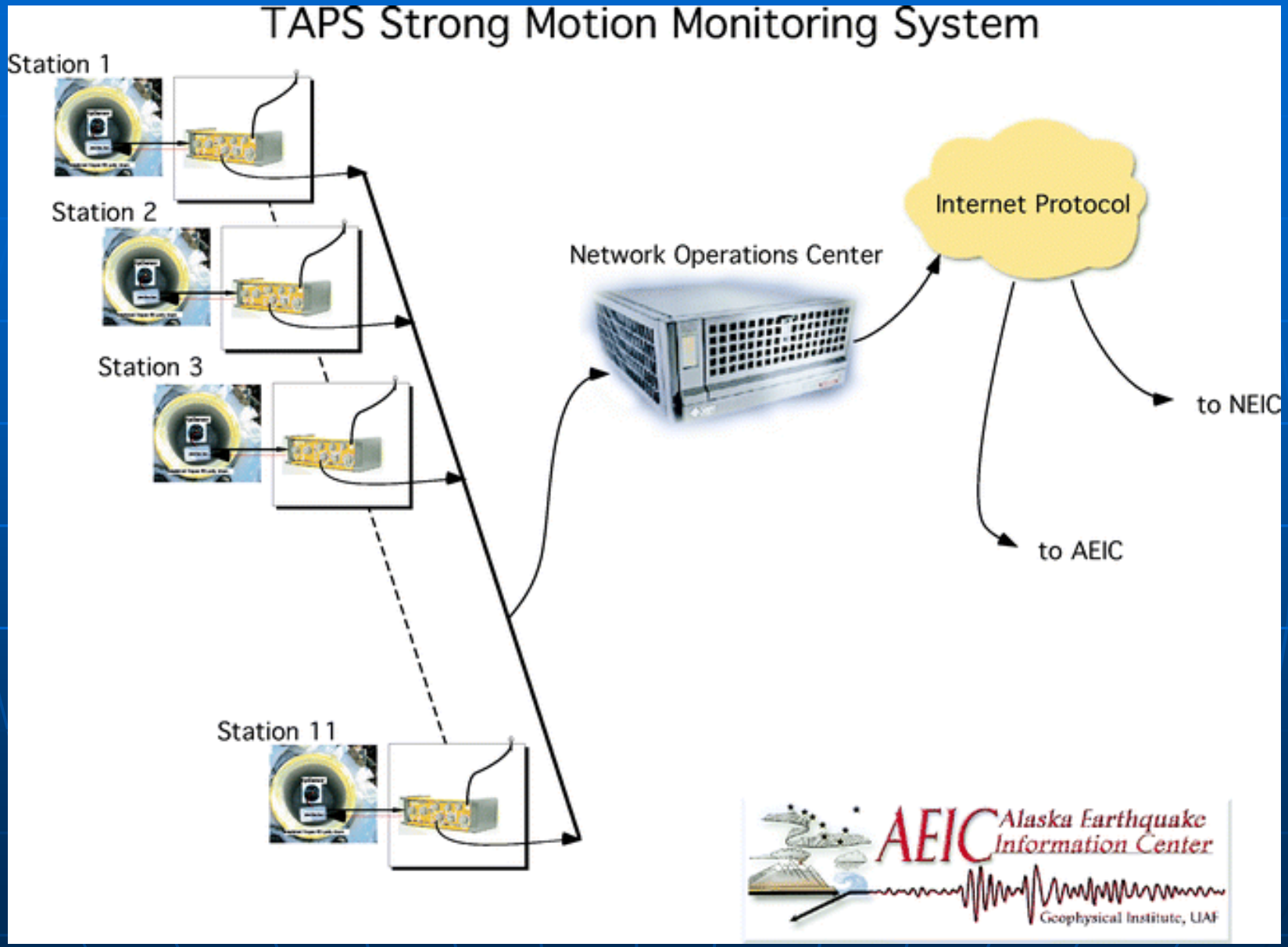


Figure 3A. Horizontal location errors - smajax <=5 km.

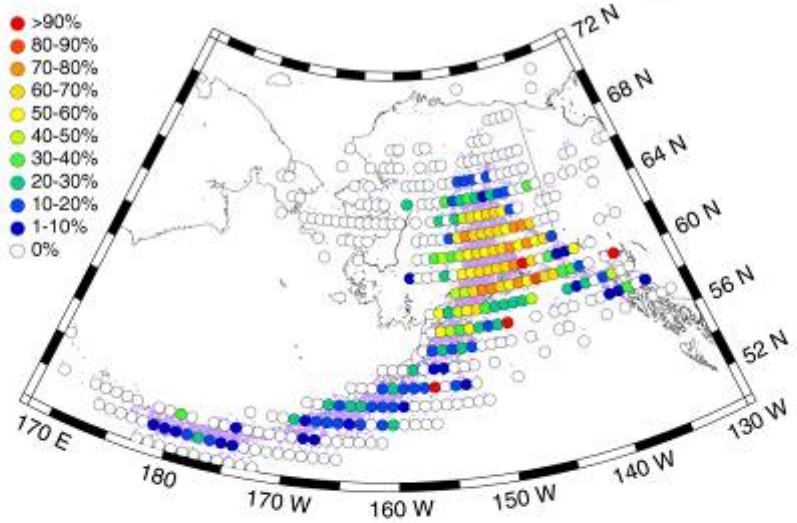
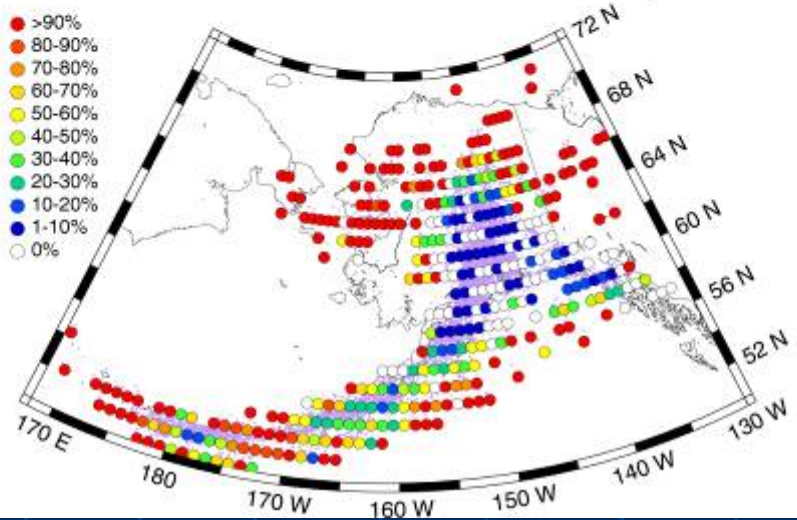
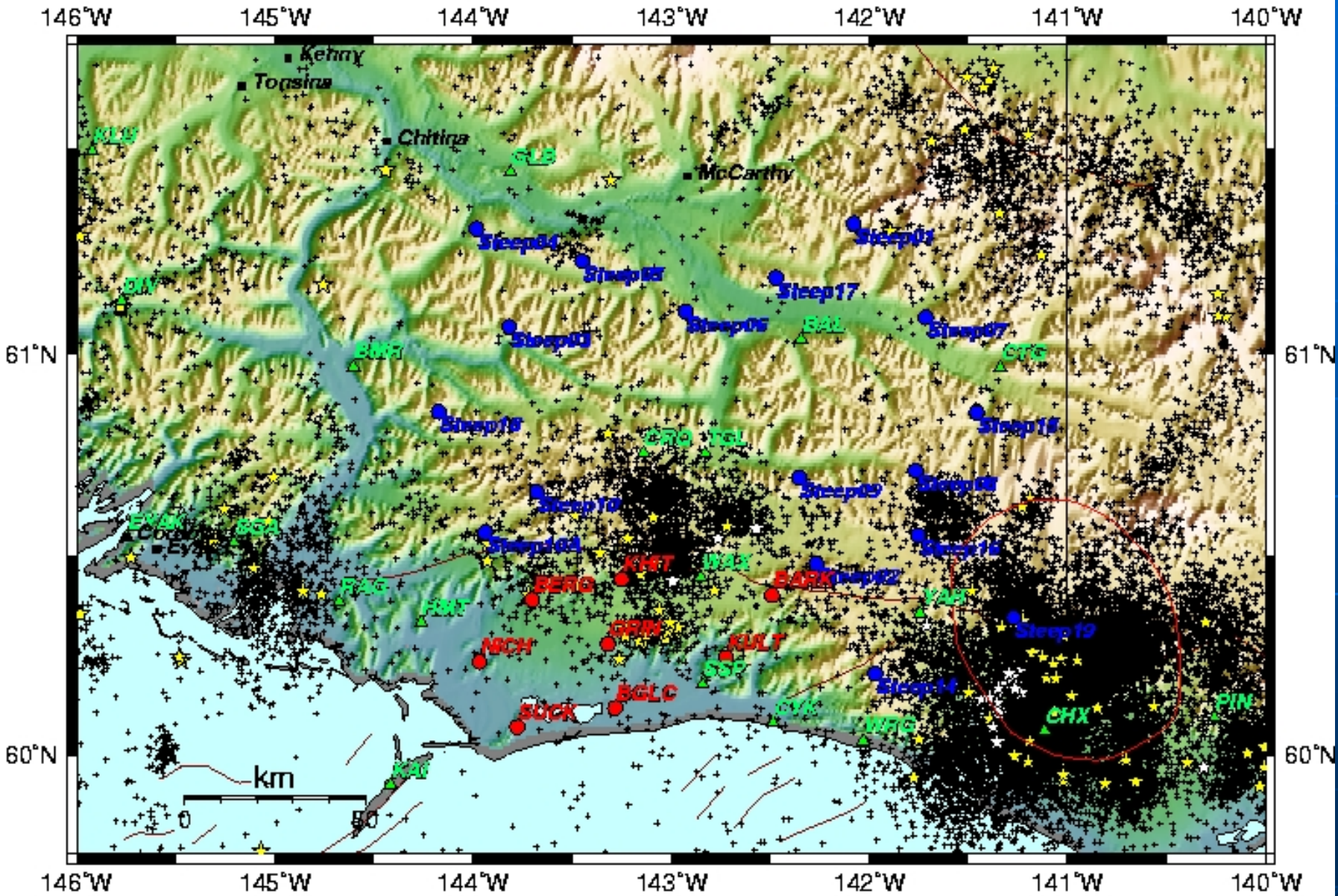
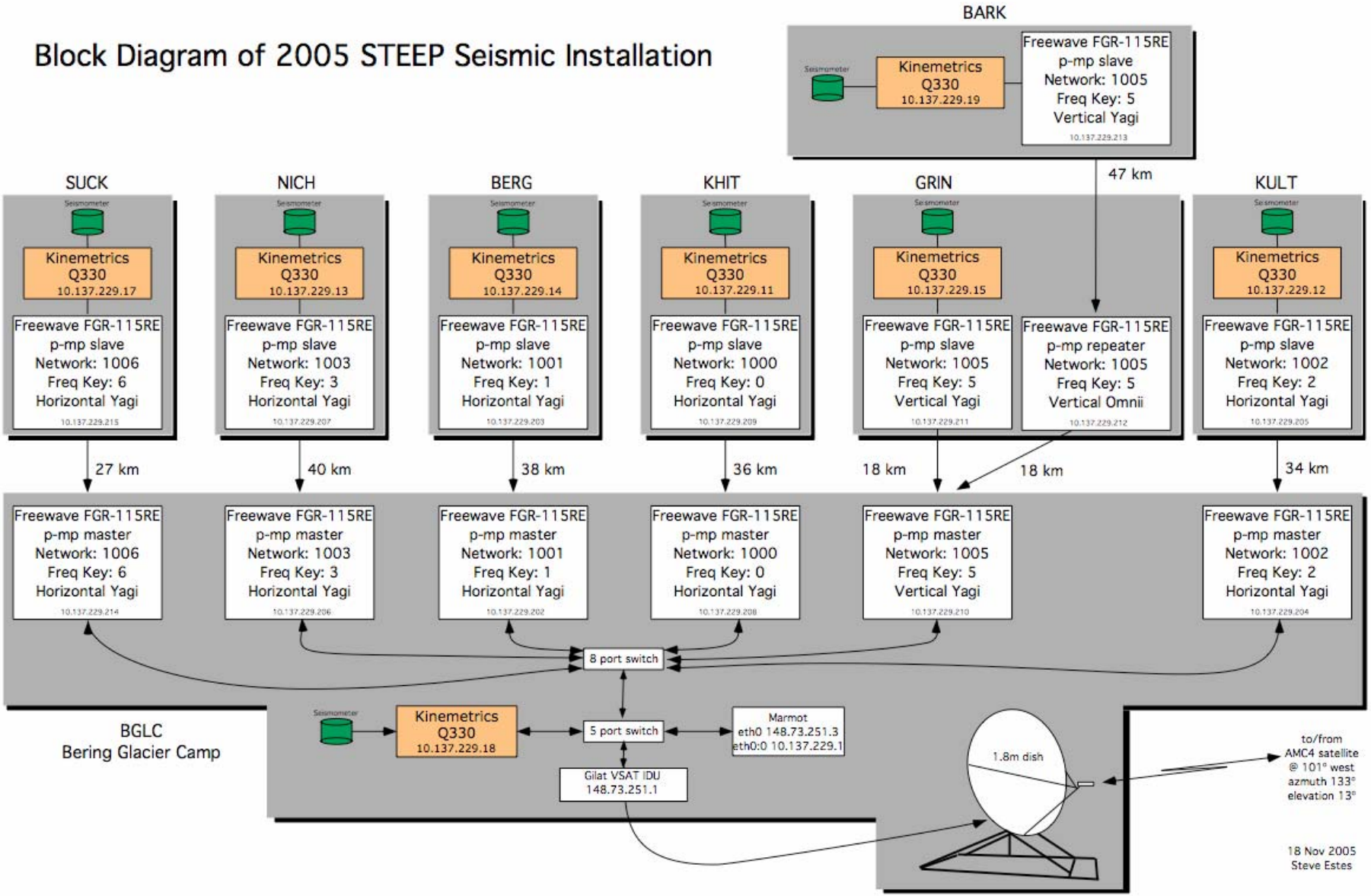


Figure 3B. Horizontal location errors - smajax >= 20km.




146°W
145°W
144°W
143°W
142°W
141°W
140°W
61°N
60°N
Kenny
Tonsina
Chitina
McCarthy
KLU
GLB
CIN
BMR
BAL
CTG
CRQ
TGL
EYAK
BGA
Ey
FAG
HMT
KHT
WAX
BERG
BARK
YAK
GRIM
NICH
KULT
SSP
BGLC
SUCK
CYK
WRG
CHX
PIN
KAL
km
0
50

Block Diagram of 2005 STEEP Seismic Installation



Khitrov in progress

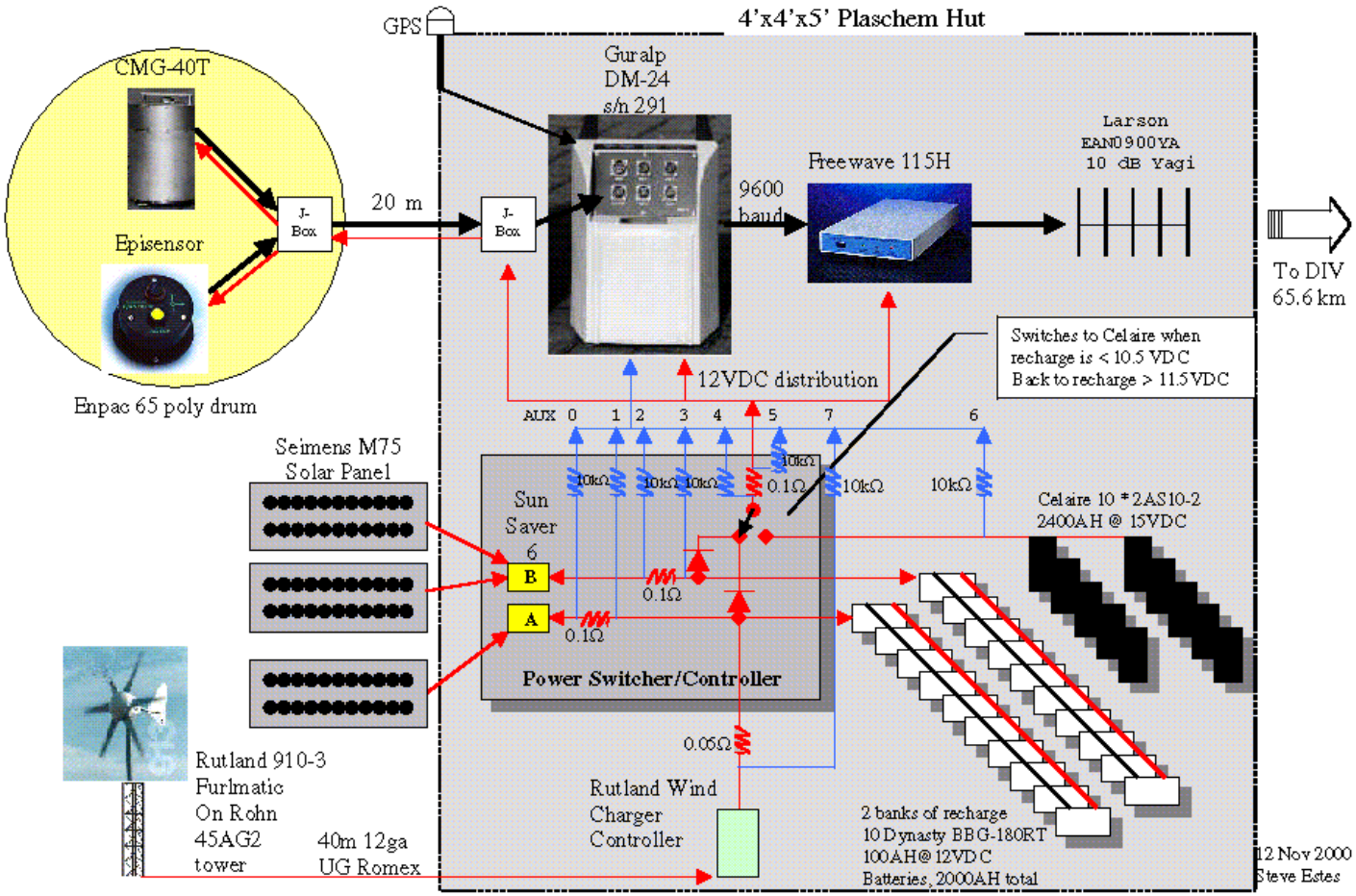

KHIT from the air

AT at Bering
cier Camp

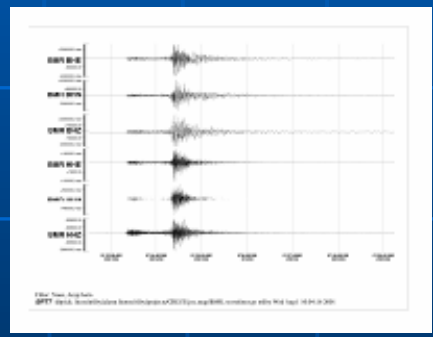

Nichawak Mountain (NICH)

BMR - Bremner River

GPS 9 July 2000: 60°58.090', -144°36.180', 842 m



BMR – Bremner River



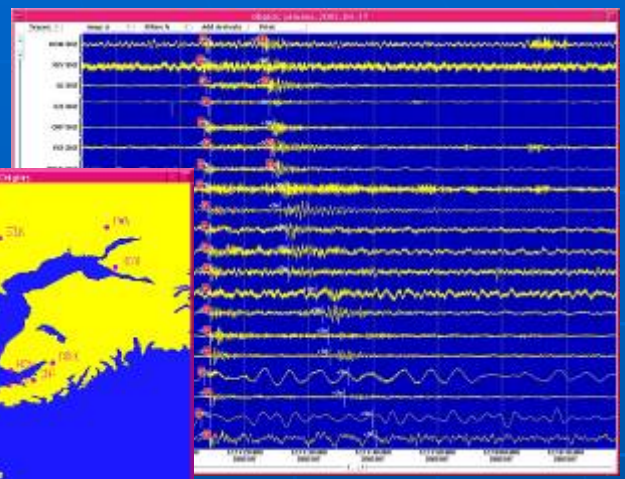
TNA – Tin City

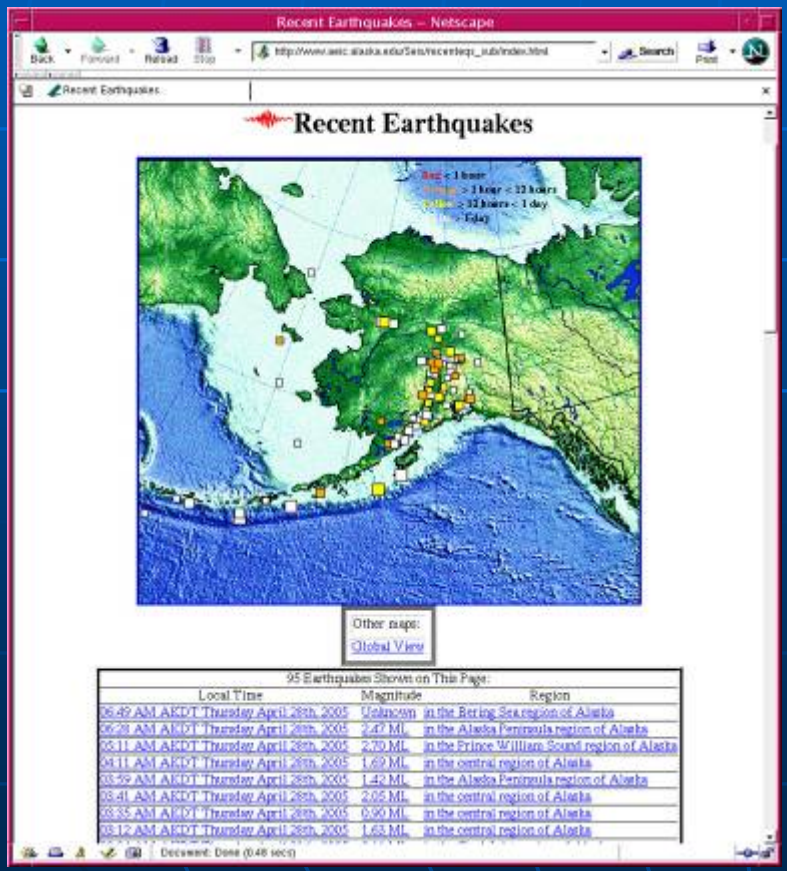
SWD - Seward

UNV – Unalaska Valley

AEIC Operations

- Detected earthquakes are automatically located within 1-2 minutes

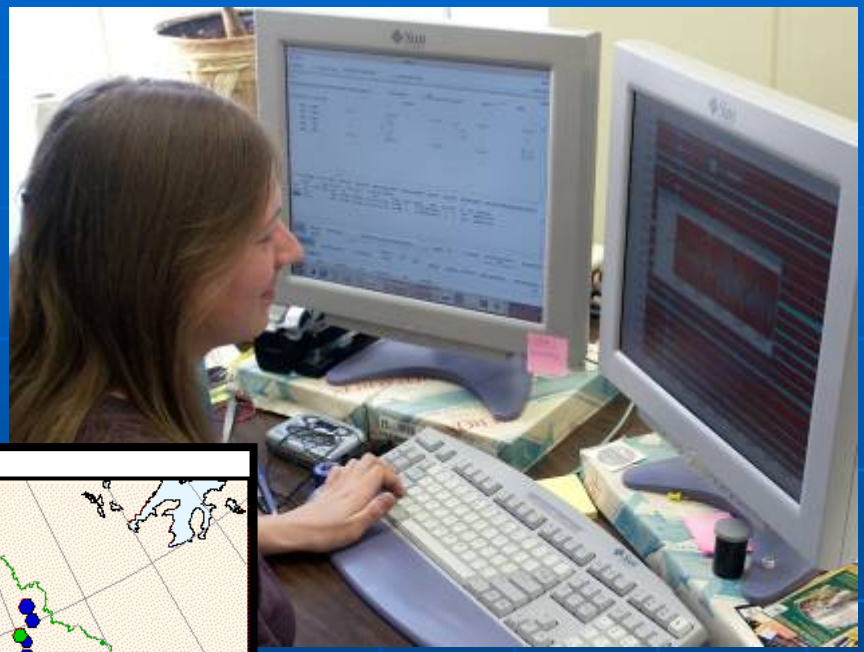


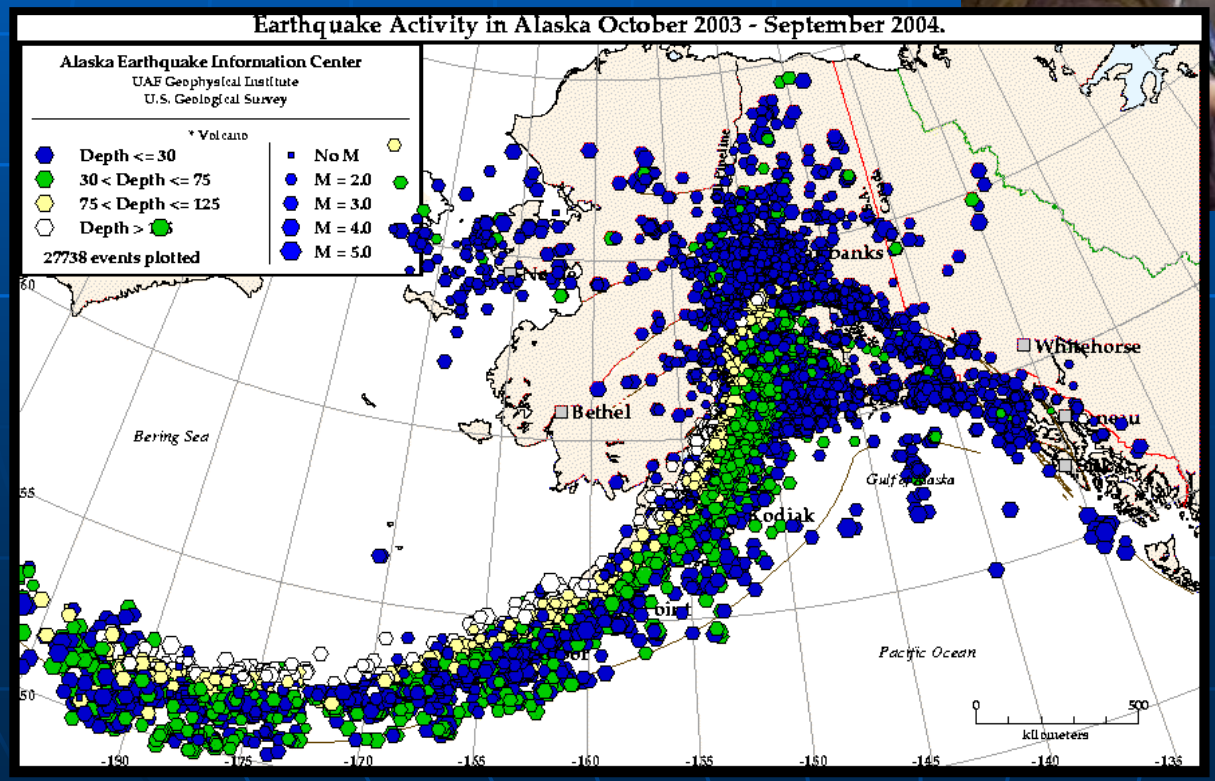


- Automatic locations are available immediately on the AEIC web page and through QDDS to USGS web pages.

AEIC Operations

•Seismic Data Analysts review every automatic location and scan stations for undetected events.





•Roughly **20,000 to 30,000** earthquakes are located in Alaska each year (50 to 80 events per day).

Earthquake Response

INFORMATION RELEASE

ALASKA EARTHQUAKE INFORMATION CENTER

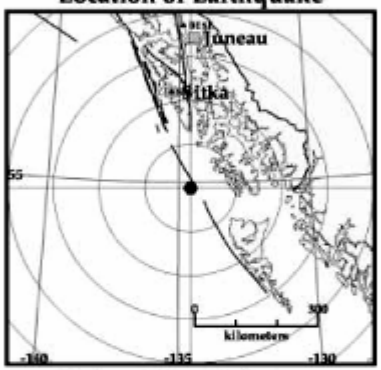
June 28, 2004
3:04 am

The Alaska Earthquake Information Center located a strong earthquake that occurred on Monday, June 28th at 1:49 AM AKDT in the Queen Charlotte Islands region. This earthquake had a preliminary magnitude of 6.6 and was located at a depth of about 19 miles (30 km). The magnitude and location may change slightly as additional data are received and processed. This earthquake was felt strongly throughout southeast Alaska. Items fell from walls in Craig, Ketchikan, and Wrangell. Strong shaking was reported as far away as Juneau.

Distance to nearby locations:

112 km (70 miles) SW of Craig
117 km (73 miles) WSW of Hydaburg
117 km (73 miles) WNW of Dixon Entrance
120 km (75 miles) SW of Klawock
153 km (96 miles) S of Port Alexander
156 km (97 miles) WSW of Kasaan
157 km (98 miles) SW of Thorne Bay
175 km (110 miles) SSW of Point Baker

Location of Earthquake



Circles are 111 km (70 miles) apart.

Preliminary earthquake parameters:

Origin Time (UT):	06/28/2004 09:49:50
Latitude:	54 N 52'
Longitude:	134 W 34'
Depth:	30 km
Magnitude:	ML 6.7 (NEIC)

The location and magnitude for this earthquake may be updated as data from additional seismic stations are received. The Alaska Earthquake Information Center will continue to gather data and may issue additional releases as appropriate. With any moderate or large earthquake, aftershocks should be expected to occur.

For more information contact:

Roger Hansen
State Seismologist
Geophysical Institute
907-474-5533
roger@giseis.alaska.edu

Natasha Ratchkovski
Seismologist
Geophysical Institute
907-474-7472
natasha@giseis.alaska.edu

The Alaska Earthquake Information Center (AEIC) monitors earthquakes in Alaska and provides earthquake information to the citizens and public officials of Alaska. The Center is a cooperative program of the Geophysical Institute of the University of Alaska and the U.S. Geological Survey and is located at the Geophysical Institute in Fairbanks with the Alaska State Seismologist's Office.

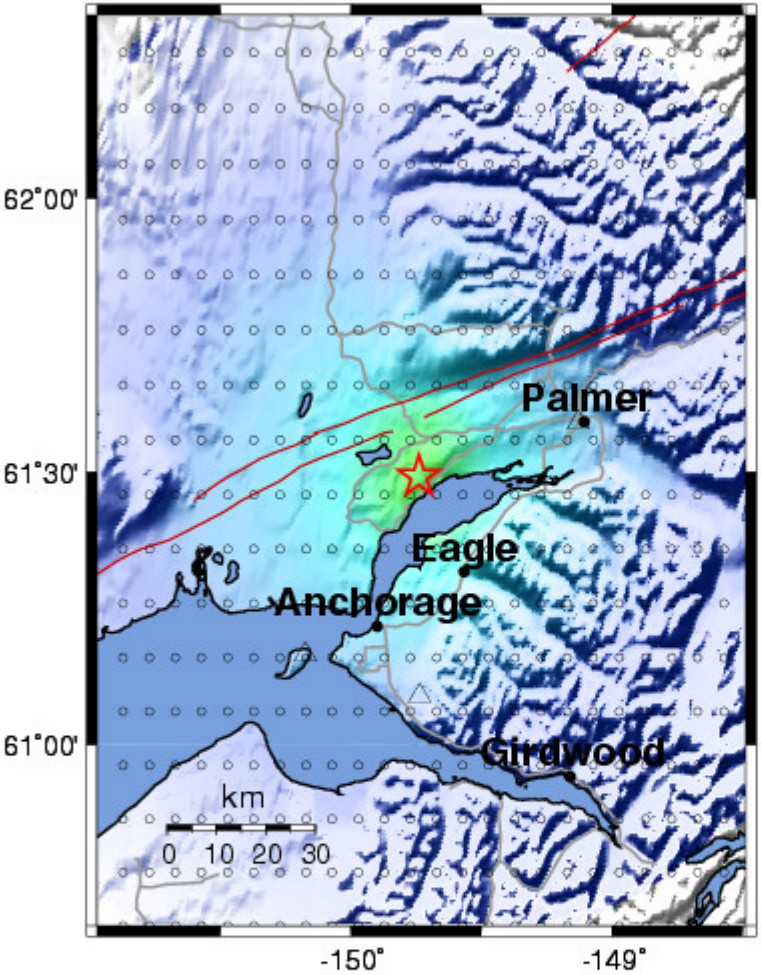
Additional information may be obtained from: AEIC, Geophysical Institute, Fairbanks, AK, 99775-7320 Ph: (907) 474-7320 FAX: (907) 474-5618 WEB: http://www.aeic.alaska.edu ; OR USGS National Earthquake Information Center, Denver, CO. Ph: (303) 273-8500 FAX: (303) 273-8450

- All earthquakes larger than M 3.5 (mainland) and M 4.0 (Aleutians) are reviewed by analysts within 30 minutes of occurrence.
- Nearby communities are contacted to determine perceived strength of shaking and any resulting damage.
- Earthquake information is rapidly released to local, state and federal agencies, statewide news media, and to the public.

www.aeic.alaska.edu

(Information releases are available online immediately after earthquakes are located.)

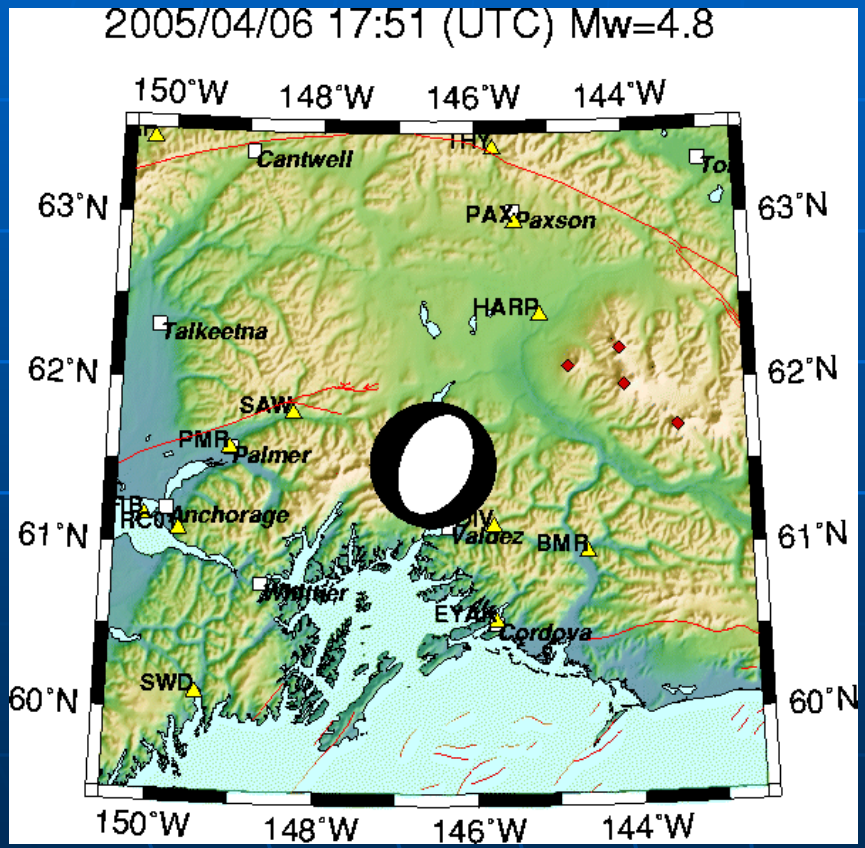
C Rapid Instrumental Intensity Map Epicenter: 19.8 miles NNE of Anchorage
ri Nov 18, 2005 04:18:39 PM YST M 4.3 N61.49 W149.74 Depth: 42.6km ID:107282

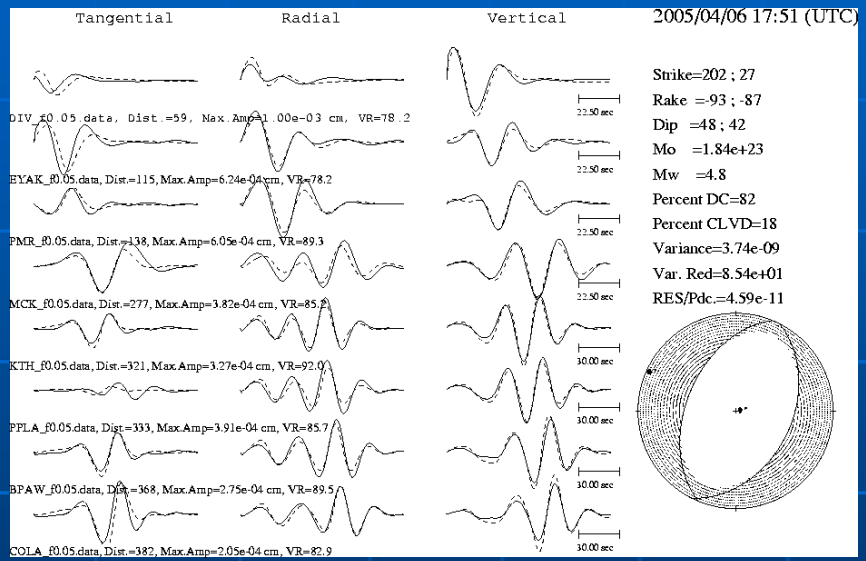


Processed: Fri Nov 18, 2005 06:25:43 PM YST, -- NOT REVIEWED BY HUMAN

PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	*<.17*	*.17-1.4*	*1.4-3.9*	*3.9-9.2*	*9.2-18*	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	*16-31*	*31-60*	*60-116*	*>116*
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Near-Real Time Moment Tensor



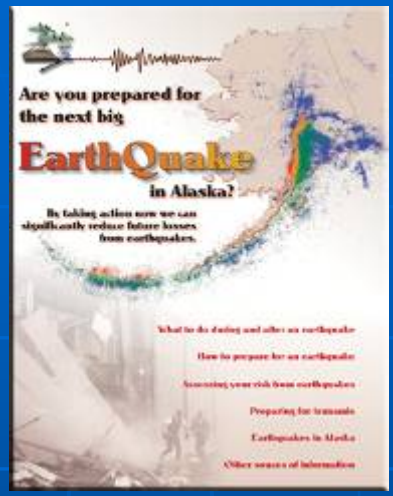


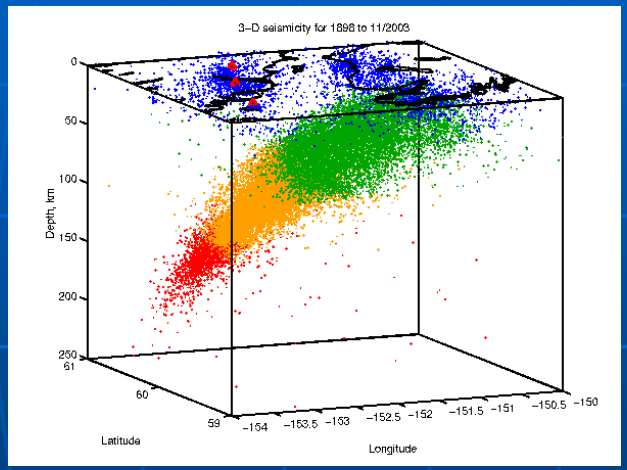
Alaska Earthquake Information Center Products

- Automatic earthquake locations and magnitudes – 1-2 minutes
  - Sent immediately over QDDS to ANSS Recent Eq
  - 24/7 alarm capability – pager/cell phone
  - Appears on GUI for rapid analyst review
  - E-mail notification for selected criteria
- Analyst reviewed information – 10-30 minutes
  - Updates sent over QDDS to ANSS Recent Eq
  - Information release sent for large and/or felt events
  - E-mail, fax, and internet delivery
- Community Internet Intensity Map: CIIM
- Daily processed data – finger utility
- Weekly reports and monthly catalogs
- Follow-up reports for large events
- Real-time faulting parameters
- Real-time locations on the internet
- Rapid distribution of shake maps – Following Reno development

AEIC Operations

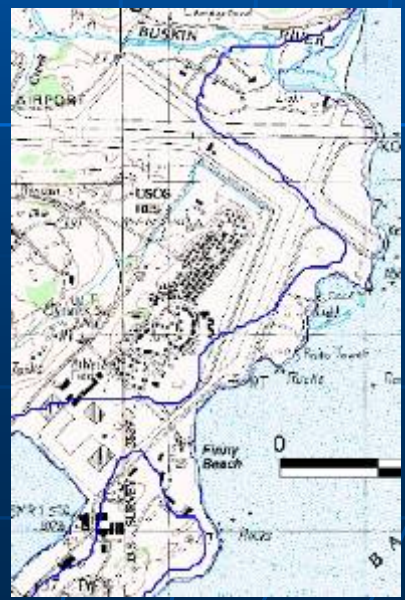
- Conduct education outreach to Alaskan communities to promote earthquake preparedness and safety.





- Support research in seismology and tectonics.

- Produce tsunami inundation maps for Alaskan coastal communities.



Issues

- Alaska is very seismically active
  - Opportunities for onscale recording of large earthquakes – Shallow, Deep, Megathrust
  - Large Area to cover
  - Difficult terrain, weather, large animals
- Exposure to Strong Shaking
  - Critical Facilities – oil terminal, fishing, Pipeline
  - Transportation Corridors
  - Fewer numbers of people
  - Still require rapid notification –State needs

Priorities

- Regional Development of Network
  - Digital Telemetry
  - Broadband and strong motion, GPS
    - Collaboration with ASL on Backbone sites
  - Regional Shakemaps
- Strong Motion and Urban Networks
  - Critical Facilities – oil terminal, fishing industry, Pipeline
  - Transportation Corridors
  - Upgrade of older SMA-1 and early K2
  - Structural Monitoring
  - Workshop for data users


JUL 15 2006


JUL 16 2006


JUL 16 2006