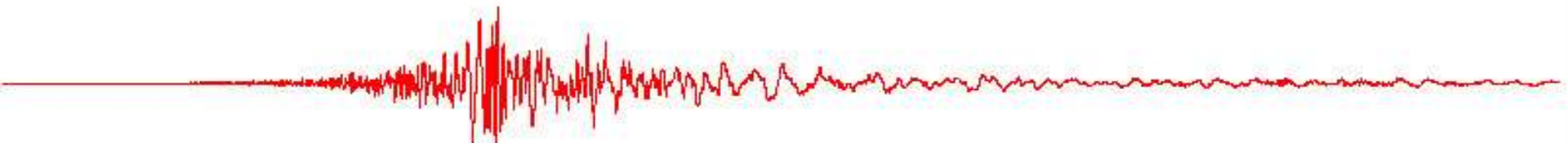


# **A Brief Introduction to the Puerto Rico and Virgin Islands GPS Network**

**Guoquan Wang  
University of Puerto Rico-Mayaguez**



Search

Reset

Stations  Campaign sites  All

Current results: 99 items



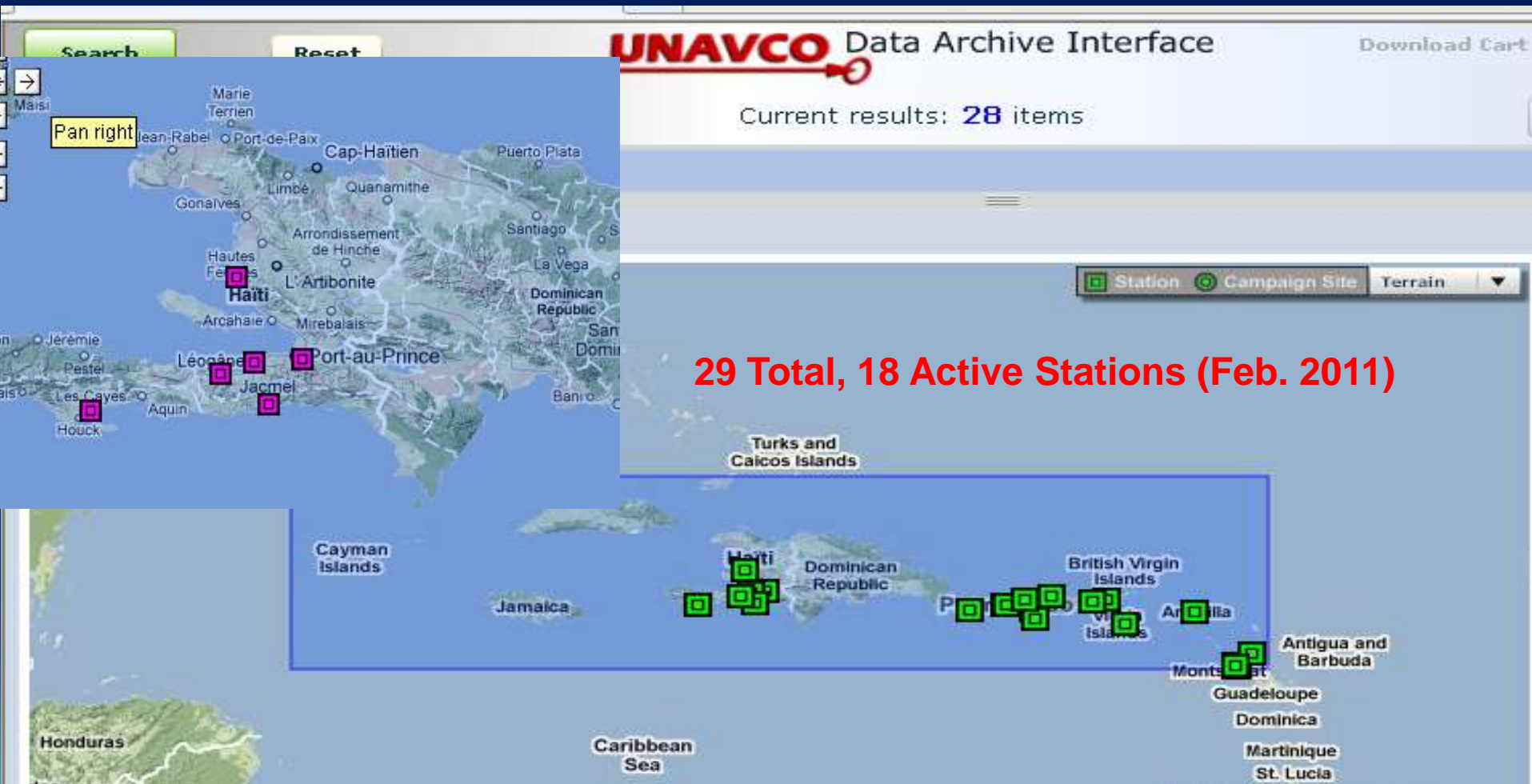
Metadata



Spatial



# Cayman Islands-Hispanola-PRVI



**29 Total, 18 Active Stations (Feb. 2011)**

- Location, Installation, Data Archiving, and Applications
- A Big Lesson Learned From the Chile EQ

# PRVI Real-Time High-Rate GPS Network

20°

18°

16°

-70°

-68°

-66°

-64°

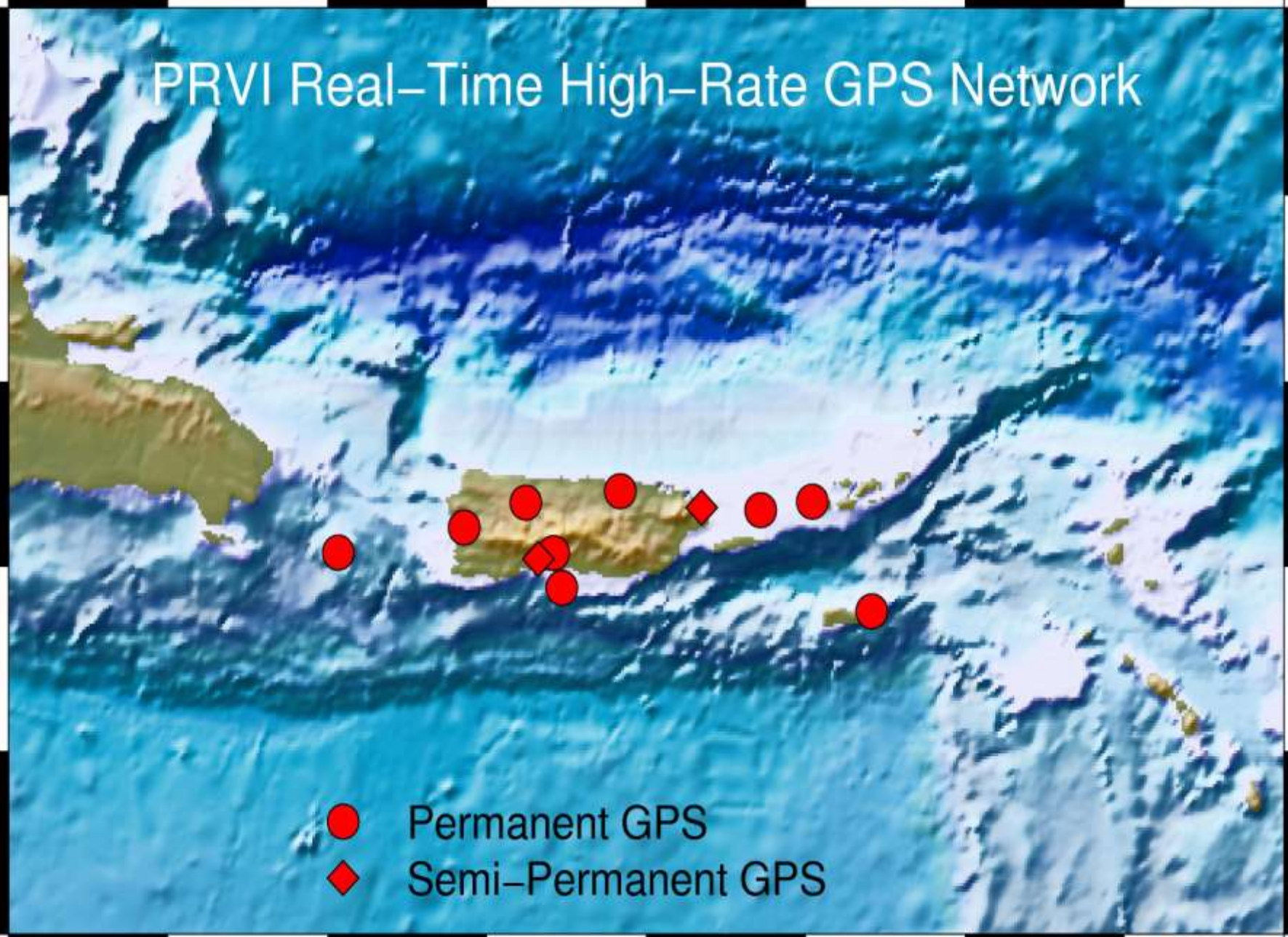
-62°



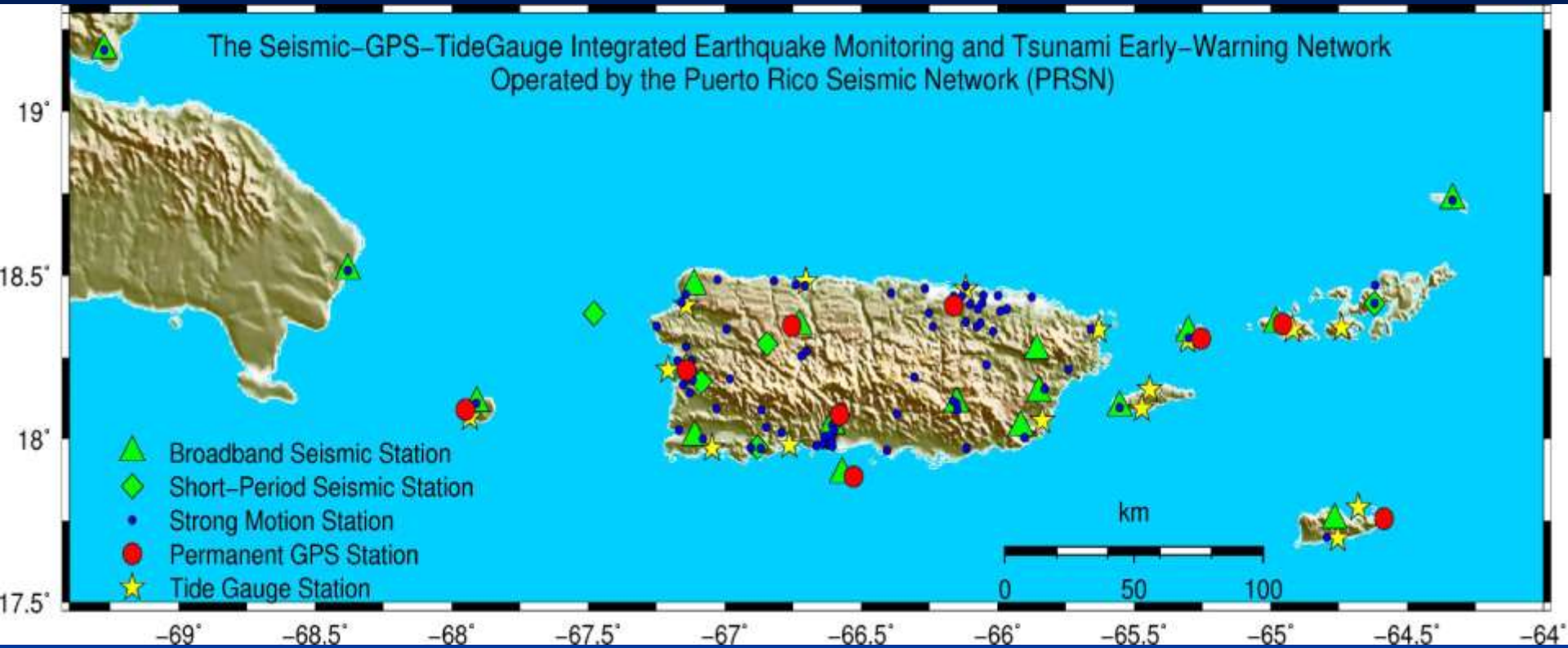
Permanent GPS



Semi-Permanent GPS



# GPS + Weather + Seismic + TideGauge



# Mona Island Seismic Observation Station

GPS+Accelerometer+Velocitymeter+TideGauge+WeatherSensor



Weather Station

Solar Panel

Strong Motion Sensor

GPS Receiver

Broadband Seismic Sensor

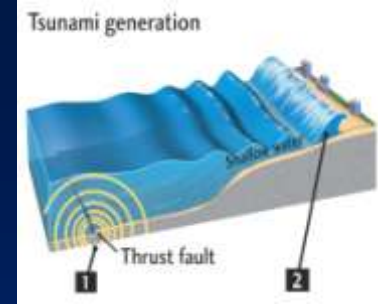
GPS Antenna

VSAT

A Real-Time Velocitymeter-Accelerometer-GPS Integrated Earthquake Observation Station  
at Mona Island, Puerto Rico

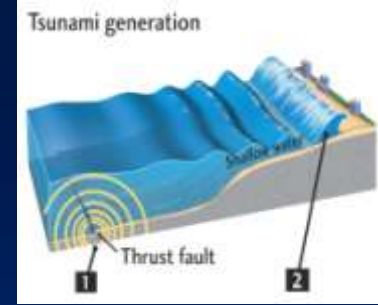
June 14, 2009

# GPS + Strong Motion Sensor



StrongMotion Accelerograph—Short and Middle Periods  
GPS Seismometer---Middle and Long Periods

# GPS + TideGauge



- ❖ Verify a Tsunami --- Absolute Sea-Level Change
- ❖ Long-term sea level monitoring



# GPS + Weather Sensors



- ❖ Weather Forecasting
- ❖ Improve “Wet-Delay Model” in the Caribbean Region

# Installation



**Short Drilled  
Braced GPS  
Monument**

- ❖ Pre-Investigation: 1-2 week
- ❖ MOU (Memorandum of Understanding ): 2 months

**A Great Challenge: Signatures Acquisition**

- ❖ Field Installation: 2-3 days



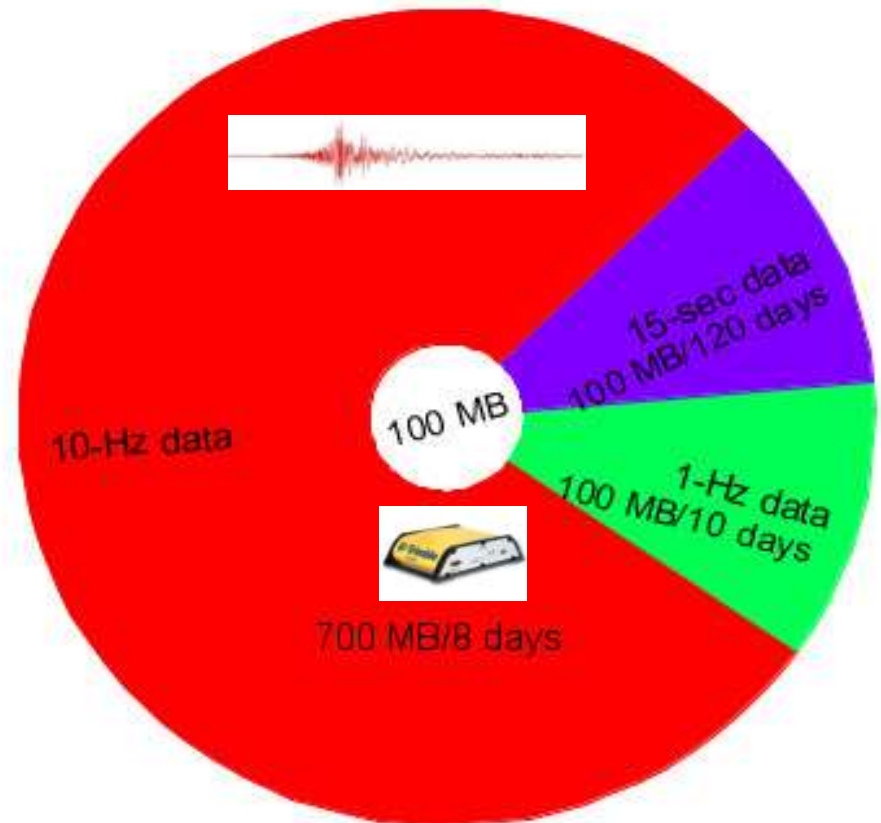
# Data and Data Archiving



1-GB Internal CompactFlash Card (Trimble NetRS)

- ❖ 15-sec  
2.5 years
- ❖ 1-Hz  
2.5 years
- ❖ 10-Hz

January 12, 2010 Haiti EQ (M7.0)  
May 16, 2010 Puerto Rico EQ (M 5.7)



# Data Archiving

**UNAVCO** Data Archive Interface Download

Search

Stations  Campaign sites  All Current results: 10 items

Metadata  Spatial

Station  Campaign Site  Terrain

POWERED BY Google 20 mi 50 km

Map data © 2011 Google - Terms of Use

Temporal

**Backup---Puerto Rico Seismic Network**

# Real Time Data Streams (RTCM3.0)

## NTRIP Server and Caster: [gps1.uprm.edu](http://gps1.uprm.edu)

- Major Users:
  - ❖ Local Land Surveying
  - ❖ Local Landslide Monitoring
  - ❖ IGS real-time GNSS data dissemination network.
  - ❖ **NASA's JPL-GPS Real Time Earthquake and Tsunami Alert Project**

```
C:\Programme\NTRIP\NtripServerCMD.exe
Port : 2101
mountpoint : MAYZ0
password : yes
attempts to connect : 0 in 52 second(s) interval(s)
protocol : yes : c:\Programme\NTRIP\LOG\MAYZ.txt
running since : Mon Aug 09 15:00:42 2010
↓ packet size : 139 average data rate : 147.739 bytes/s
average packet size : 147.627 bytes
average transmission interval : 0.99924
caster connection successful after 1 attempt(s)
ERR00 - Mount Point Taken on Localid

C:\Programme\NTRIP\NtripServerCMD.exe
Port : 2101
mountpoint : PONC0
password : yes
attempts to connect : 0 in 52 second(s) interval(s)
protocol : yes : c:\Programme\NTRIP\LOG\PONC.txt
running since : Mon Aug 09 15:00:40 2010
↑ packet size : 182 average data rate : 164.258 bytes/s
average packet size : 163.627 bytes
average transmission interval : 0.99616
caster connection successful after 1 attempt(s)

C:\Programme\NTRIP\NtripServerCMD.exe
```

# Applications

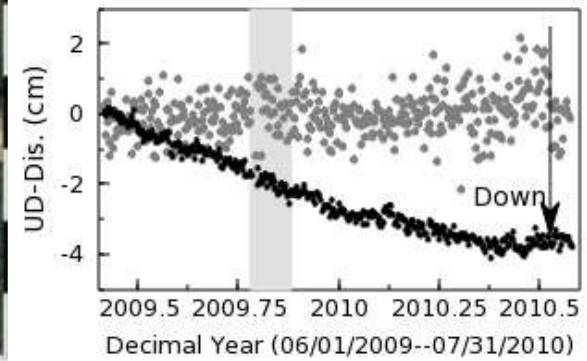
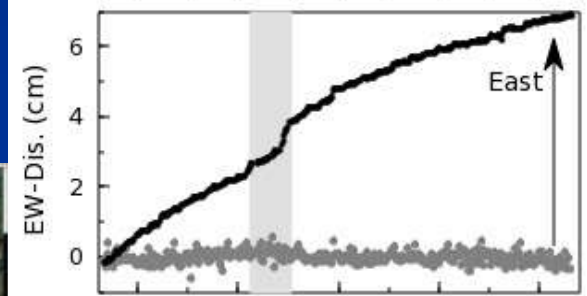
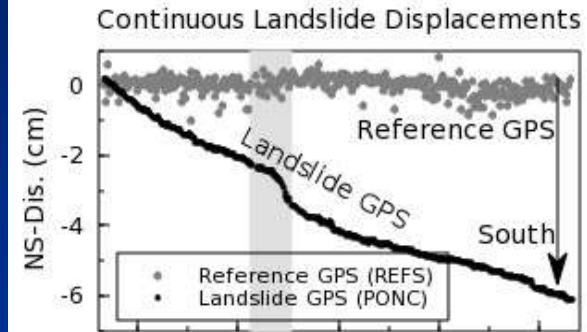
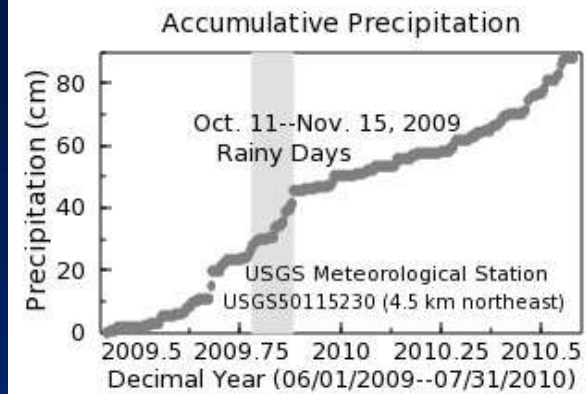
- ❖ Plate Tectonics, Micro-Plate Tectonics
- ❖ Large Earthquake Monitoring & Tsunami Early Warning (PRSN)
- ❖ Hurricane Intensity Forecasting (UCAR)
- ❖ **Landslide Monitoring**

*An Infrastructure for Multi-Hazard Minimization*



# GPS Landslide Monitoring

- Post Static Monitoring
- Real-Time Kinematic Monitoring
- Near Real-Time Rapid Static Monitoring (30 minutes)



# Real-Time Kinematic Monitoring

- ❖ TrackRT Developed at MIT
- ❖ JPL's GREAT (GPS Real Time Earthquake and Tsunami) Alert Project
- Real-Time PPP





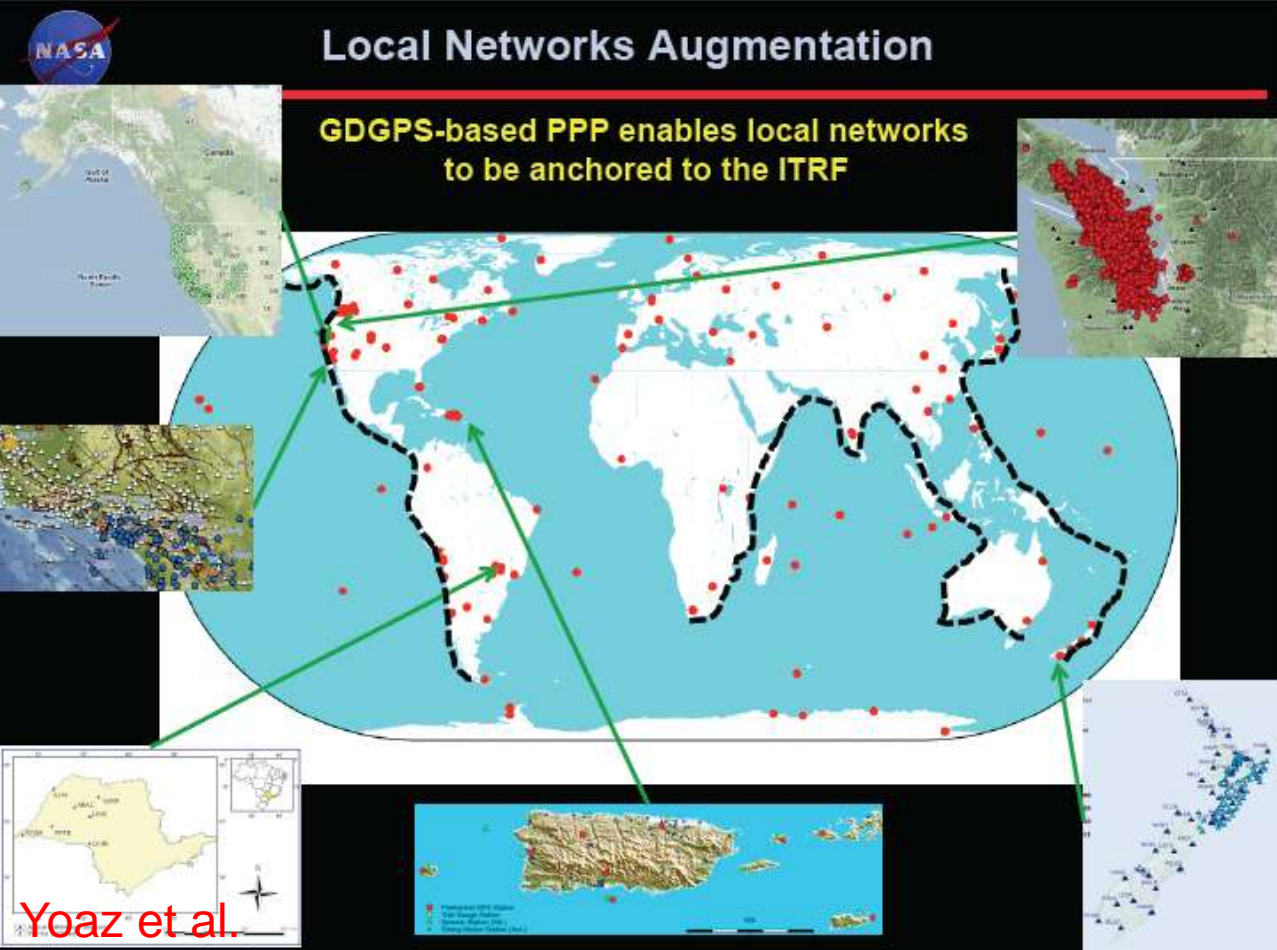
# GPS Real Time Earthquake and Tsunami Alert Project



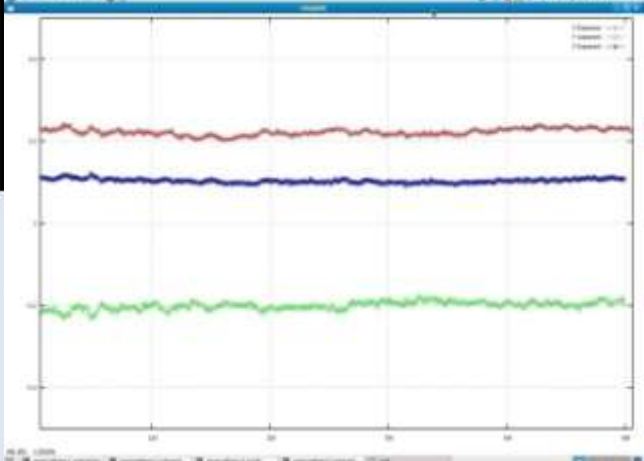
## The NASA Global Differential GPS System

### Local Networks Augmentation

GDGPS-based PPP enables local networks to be anchored to the ITRF



Station ID	Latitude	Longitude	Height	...
1	34.05	-118.24	100	...
2	34.06	-118.25	105	...
3	34.07	-118.26	110	...
4	34.08	-118.27	115	...
5	34.09	-118.28	120	...
6	34.10	-118.29	125	...
7	34.11	-118.30	130	...
8	34.12	-118.31	135	...
9	34.13	-118.32	140	...
10	34.14	-118.33	145	...
11	34.15	-118.34	150	...
12	34.16	-118.35	155	...
13	34.17	-118.36	160	...
14	34.18	-118.37	165	...
15	34.19	-118.38	170	...
16	34.20	-118.39	175	...
17	34.21	-118.40	180	...
18	34.22	-118.41	185	...
19	34.23	-118.42	190	...
20	34.24	-118.43	195	...
21	34.25	-118.44	200	...
22	34.26	-118.45	205	...
23	34.27	-118.46	210	...
24	34.28	-118.47	215	...
25	34.29	-118.48	220	...
26	34.30	-118.49	225	...
27	34.31	-118.50	230	...
28	34.32	-118.51	235	...
29	34.33	-118.52	240	...
30	34.34	-118.53	245	...
31	34.35	-118.54	250	...
32	34.36	-118.55	255	...
33	34.37	-118.56	260	...
34	34.38	-118.57	265	...
35	34.39	-118.58	270	...
36	34.40	-118.59	275	...
37	34.41	-118.60	280	...
38	34.42	-118.61	285	...
39	34.43	-118.62	290	...
40	34.44	-118.63	295	...
41	34.45	-118.64	300	...
42	34.46	-118.65	305	...
43	34.47	-118.66	310	...
44	34.48	-118.67	315	...
45	34.49	-118.68	320	...
46	34.50	-118.69	325	...
47	34.51	-118.70	330	...
48	34.52	-118.71	335	...
49	34.53	-118.72	340	...
50	34.54	-118.73	345	...
51	34.55	-118.74	350	...
52	34.56	-118.75	355	...
53	34.57	-118.76	360	...
54	34.58	-118.77	365	...
55	34.59	-118.78	370	...
56	34.60	-118.79	375	...
57	34.61	-118.80	380	...
58	34.62	-118.81	385	...
59	34.63	-118.82	390	...
60	34.64	-118.83	395	...
61	34.65	-118.84	400	...
62	34.66	-118.85	405	...
63	34.67	-118.86	410	...
64	34.68	-118.87	415	...
65	34.69	-118.88	420	...
66	34.70	-118.89	425	...
67	34.71	-118.90	430	...
68	34.72	-118.91	435	...
69	34.73	-118.92	440	...
70	34.74	-118.93	445	...
71	34.75	-118.94	450	...
72	34.76	-118.95	455	...
73	34.77	-118.96	460	...
74	34.78	-118.97	465	...
75	34.79	-118.98	470	...
76	34.80	-118.99	475	...
77	34.81	-119.00	480	...
78	34.82	-119.01	485	...
79	34.83	-119.02	490	...
80	34.84	-119.03	495	...
81	34.85	-119.04	500	...
82	34.86	-119.05	505	...
83	34.87	-119.06	510	...
84	34.88	-119.07	515	...
85	34.89	-119.08	520	...
86	34.90	-119.09	525	...
87	34.91	-119.10	530	...
88	34.92	-119.11	535	...
89	34.93	-119.12	540	...
90	34.94	-119.13	545	...
91	34.95	-119.14	550	...
92	34.96	-119.15	555	...
93	34.97	-119.16	560	...
94	34.98	-119.17	565	...
95	34.99	-119.18	570	...
96	35.00	-119.19	575	...
97	35.01	-119.20	580	...
98	35.02	-119.21	585	...
99	35.03	-119.22	590	...
100	35.04	-119.23	595	...



Yoaz et al.

# Near Real-Time Rapid Static Monitoring

- **Real Time GAMIT**

FTP—Hourly Raw Data

FTP---IGS Ultra-Rapid Orbits (updated every 6-hours)

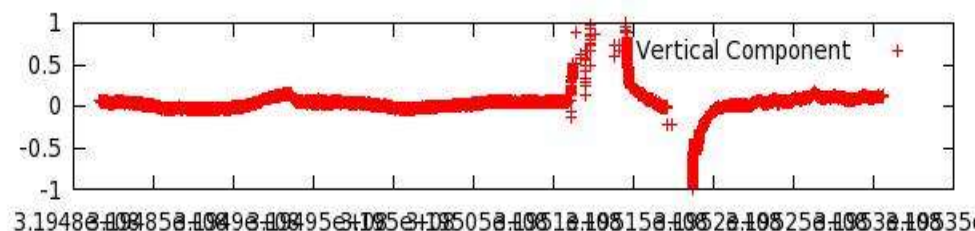
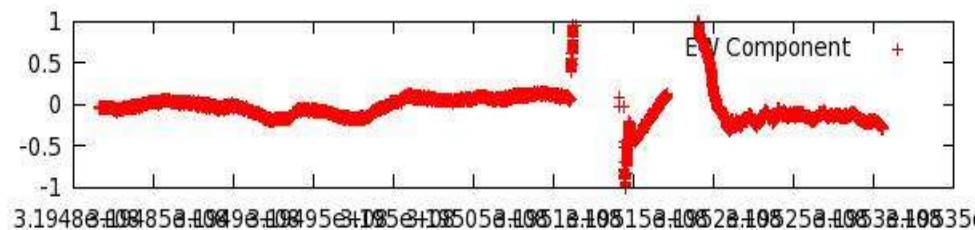
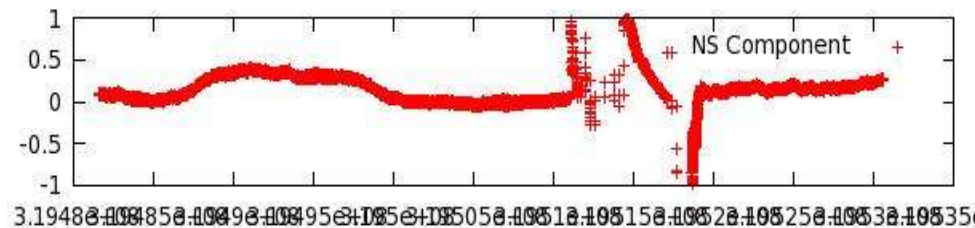
GAMIT---Hourly Position

Precision:

Single Base 1--3 cm

**Spurious Excursions**

## 24-Hour 1-Hz Real-Time PPP

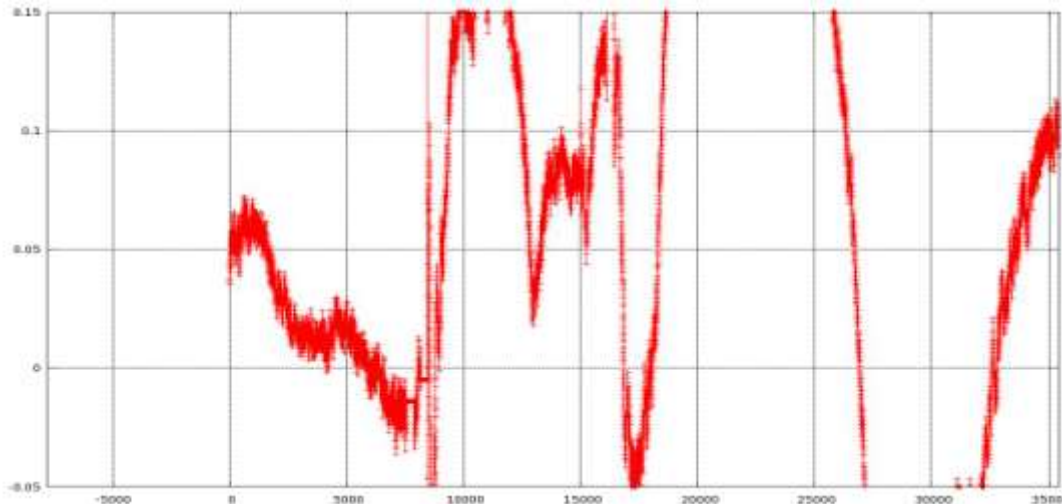


# A Challenge for GPS Landslide Monitoring!

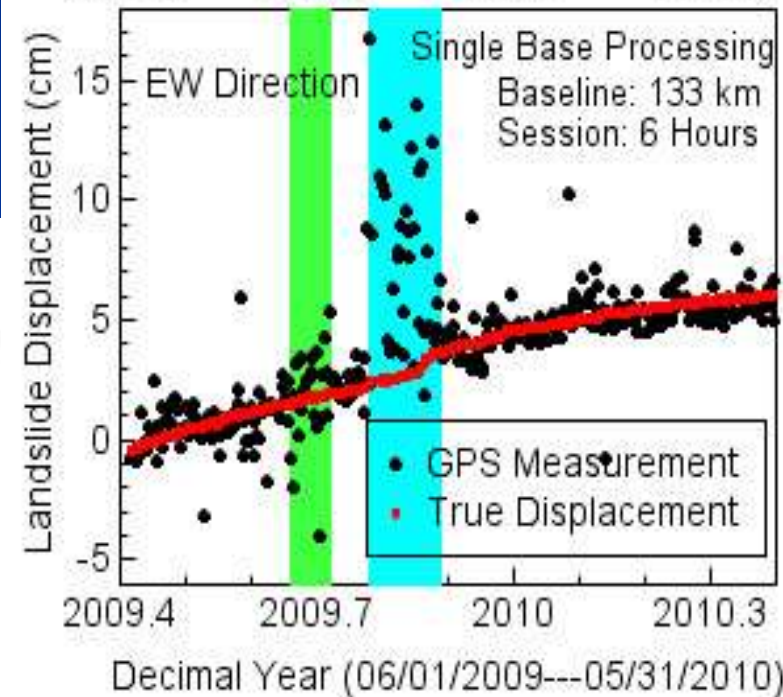
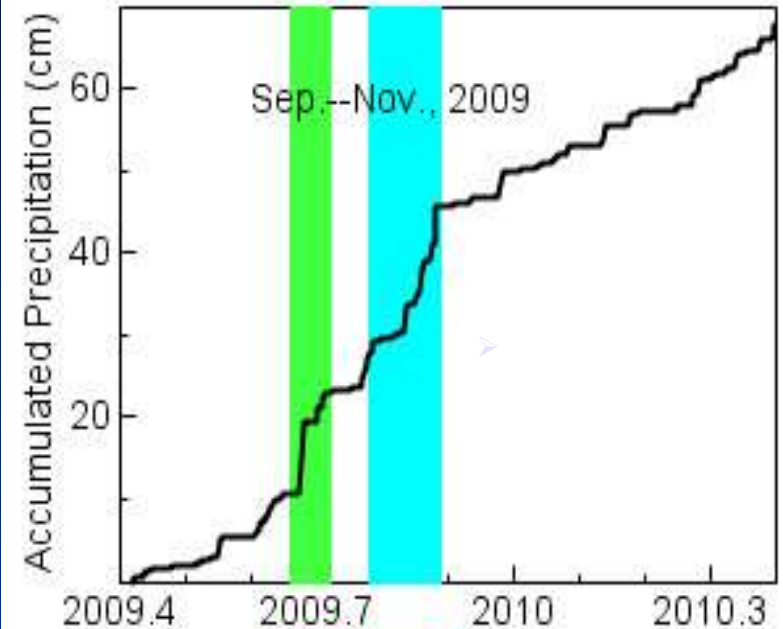
## Does GPS work in all weather conditions?

- ❖ Most catastrophic landslides happened during or after heavy rainfall events.
- ❖ Rainfall events can significantly degrade the precision of GPS measurements.

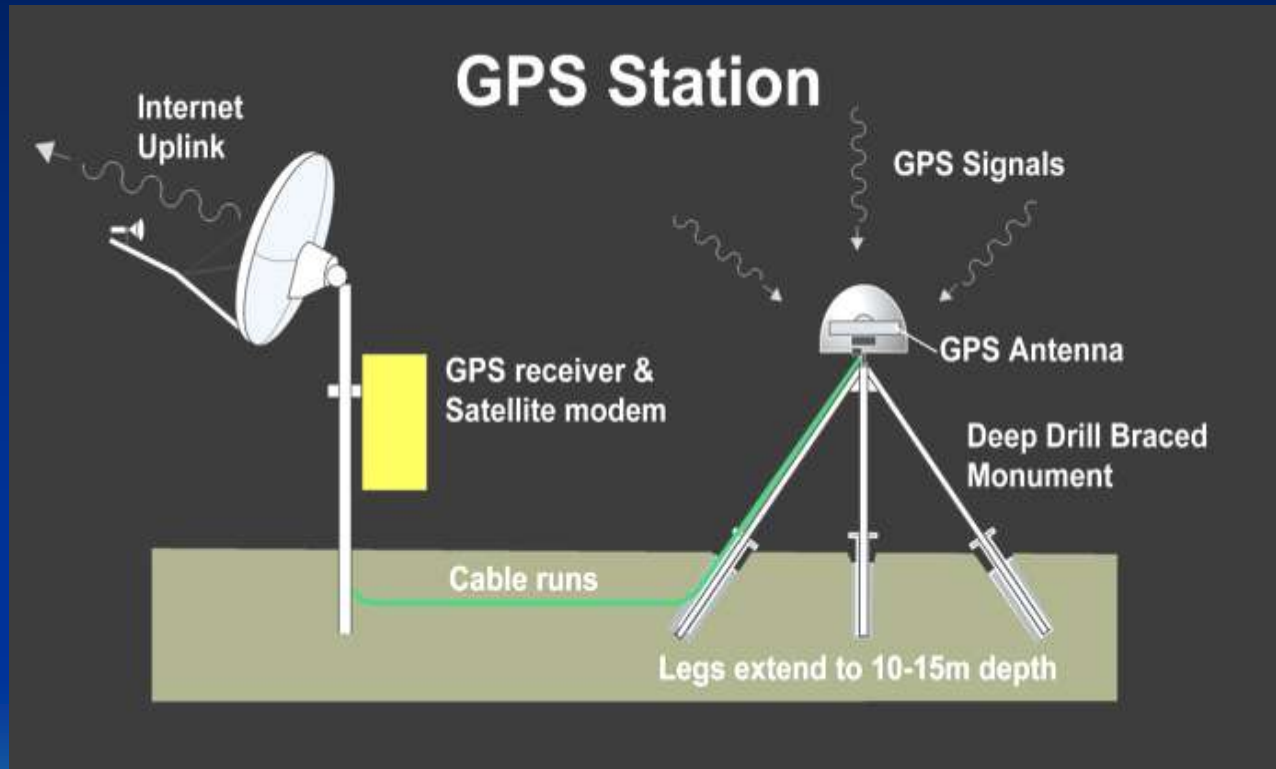
Reasons: unmodeled wet delay, multipath, liquid water



GPS Landslide Monitoring: Accuracy vs. Rainfall



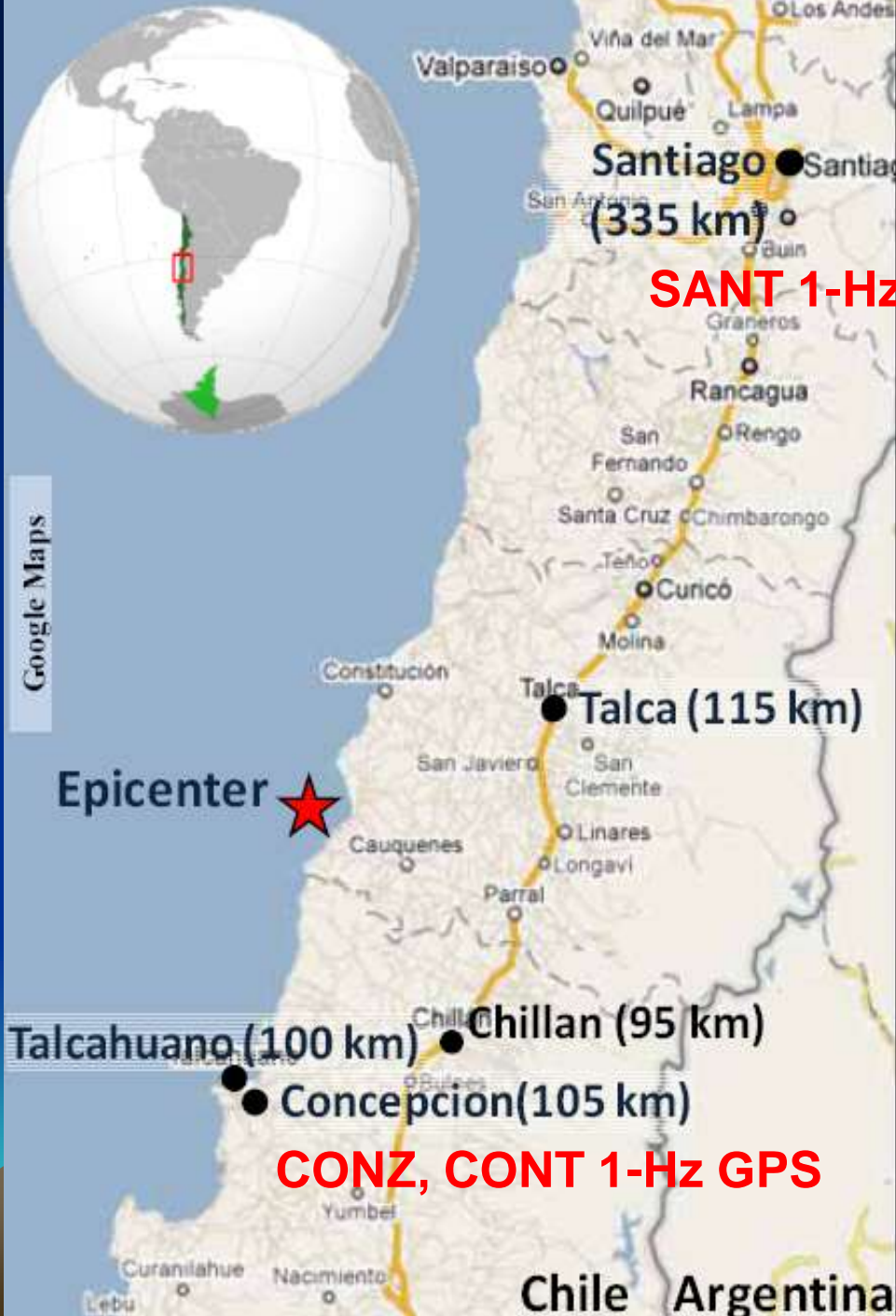
# A Big Lesson Learned from The Chile Earthquake



- Can our GPS stations resist large earthquakes?



Google Maps



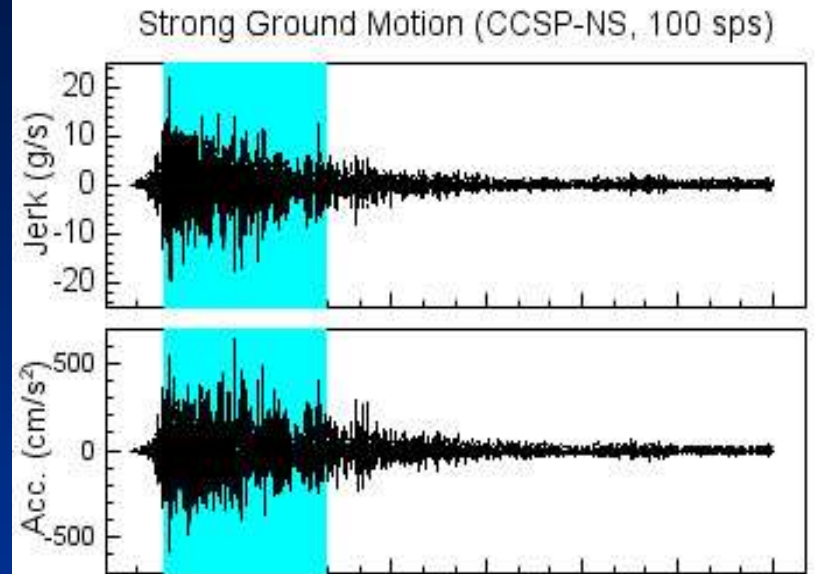
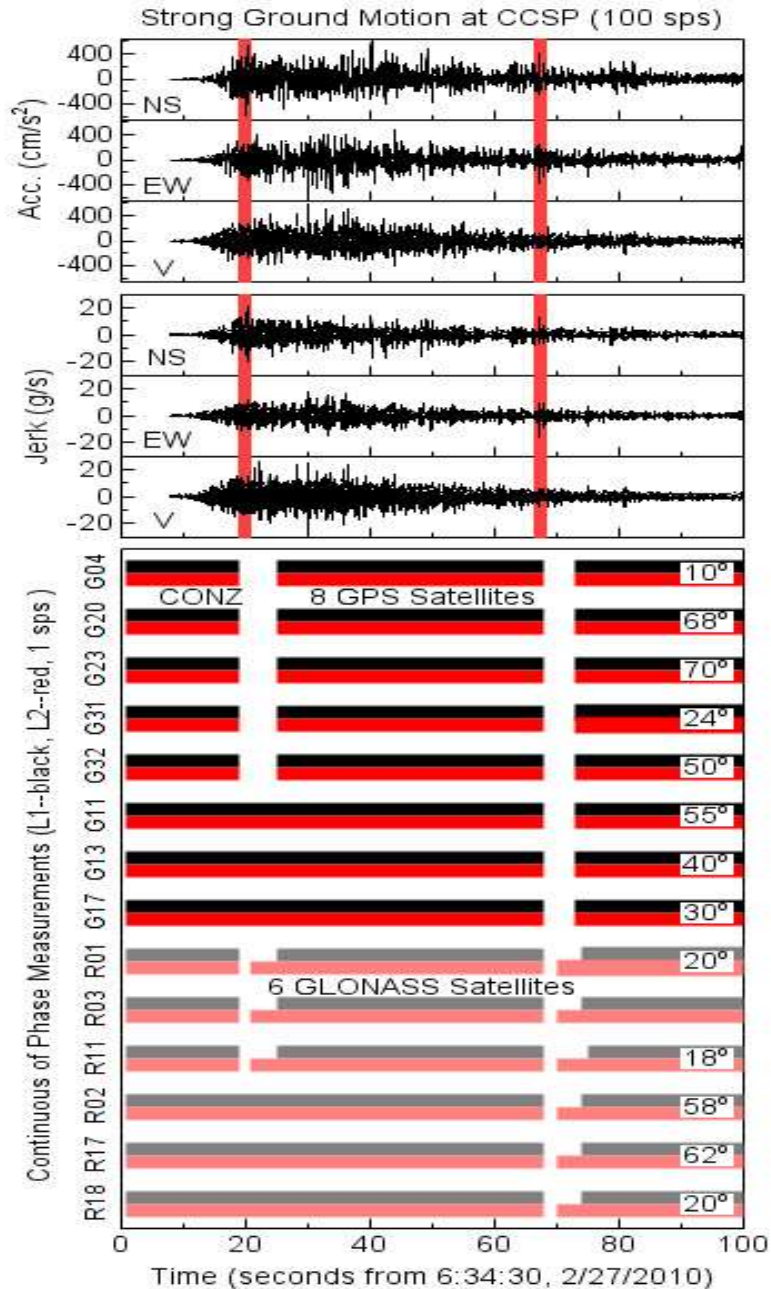
**SANT 1-Hz GPS**

**CONZ, CONT 1-Hz GPS**

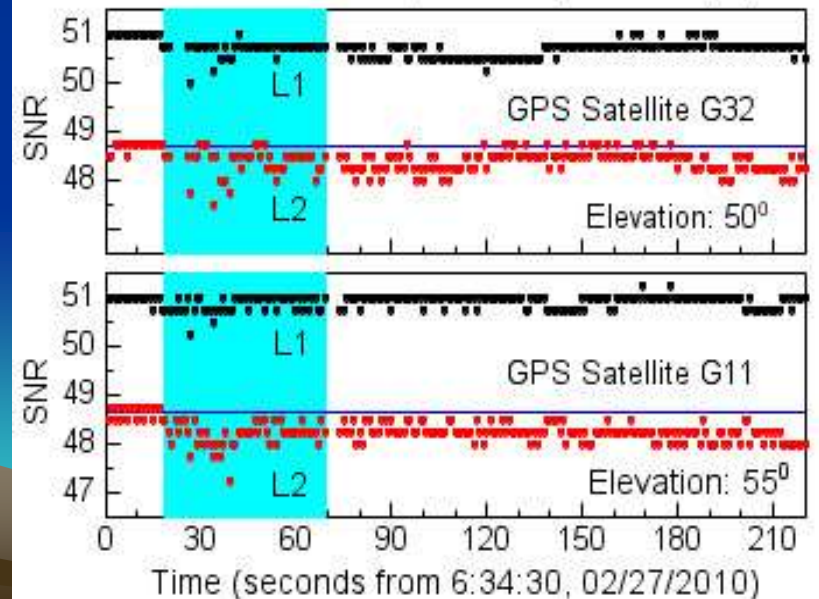


CIA The World Factbook

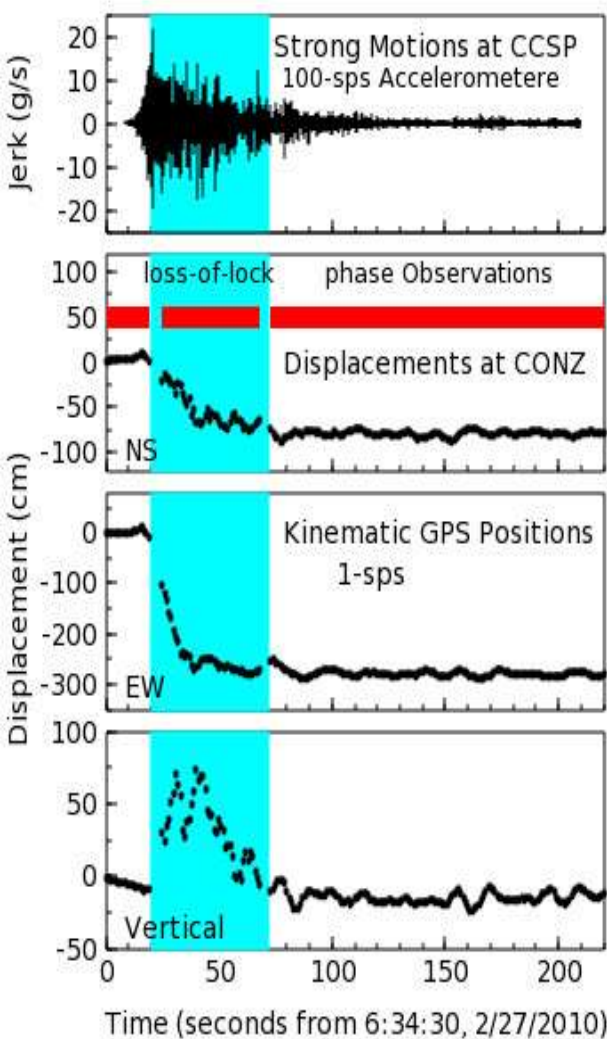
# GPS Lost Track on Satellite Signals



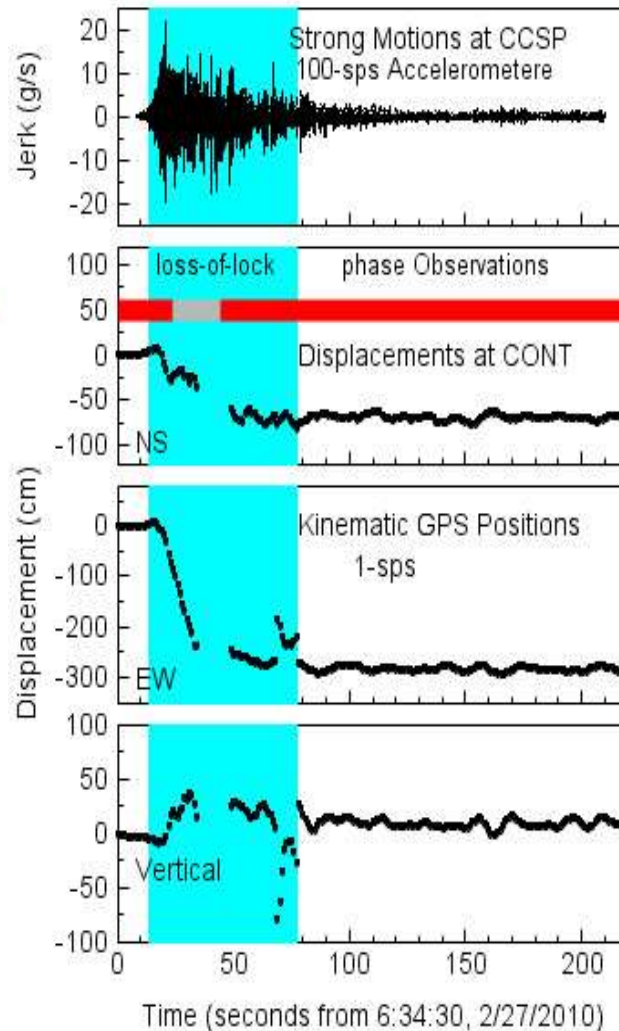
**SNR---Signal to Noise Ratio**



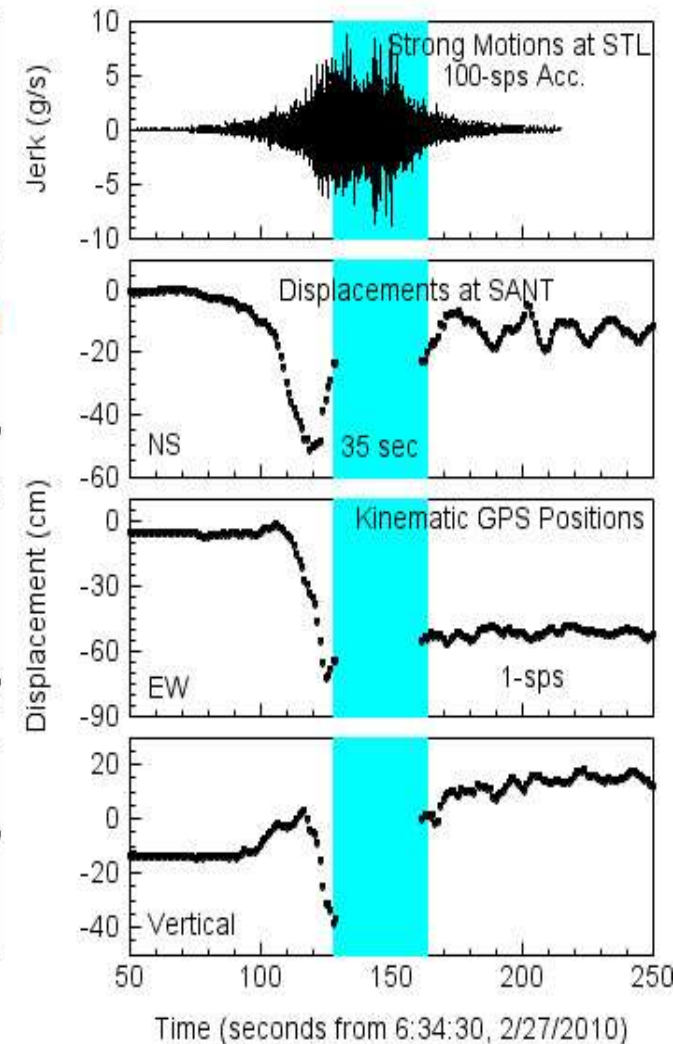
# GPS Seismograms Were Clipped!



**CONZ**  
**TPSCR3-GGD**

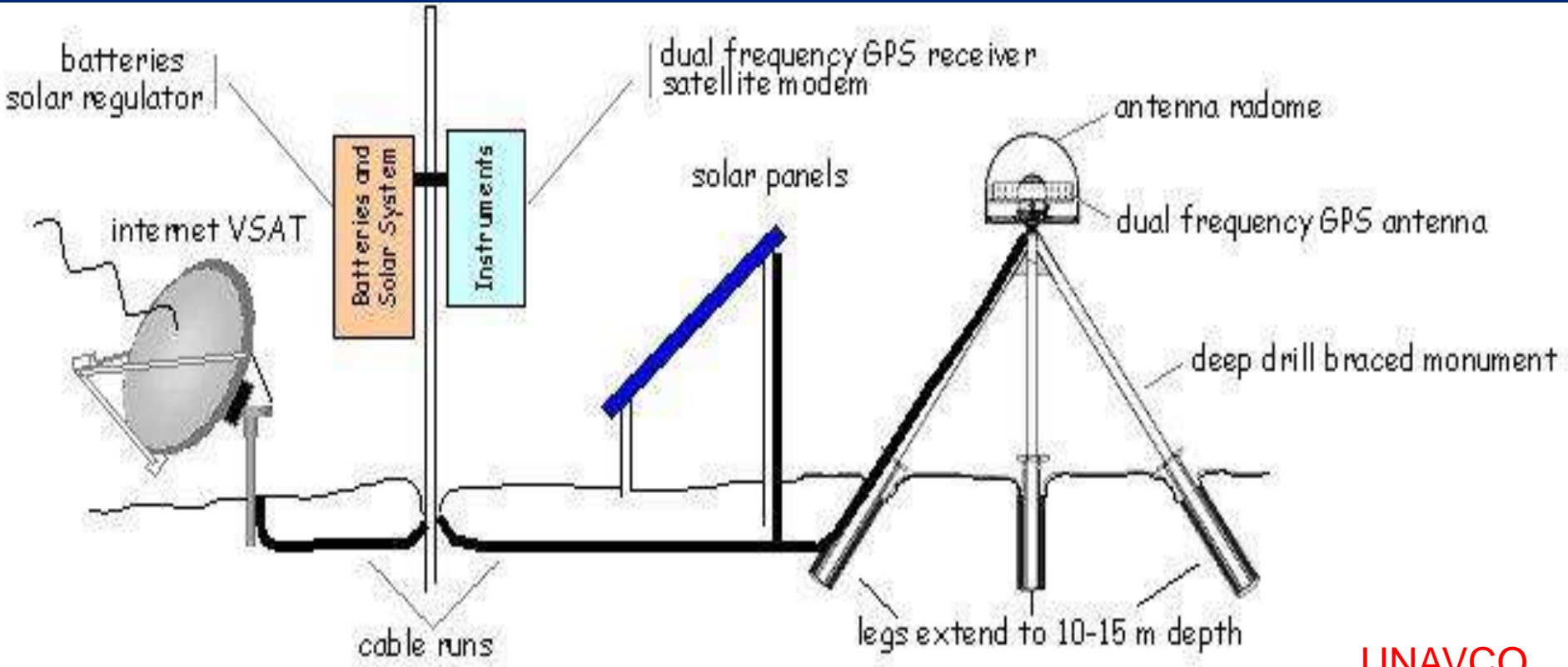


**CONT**  
**ASH700936E**

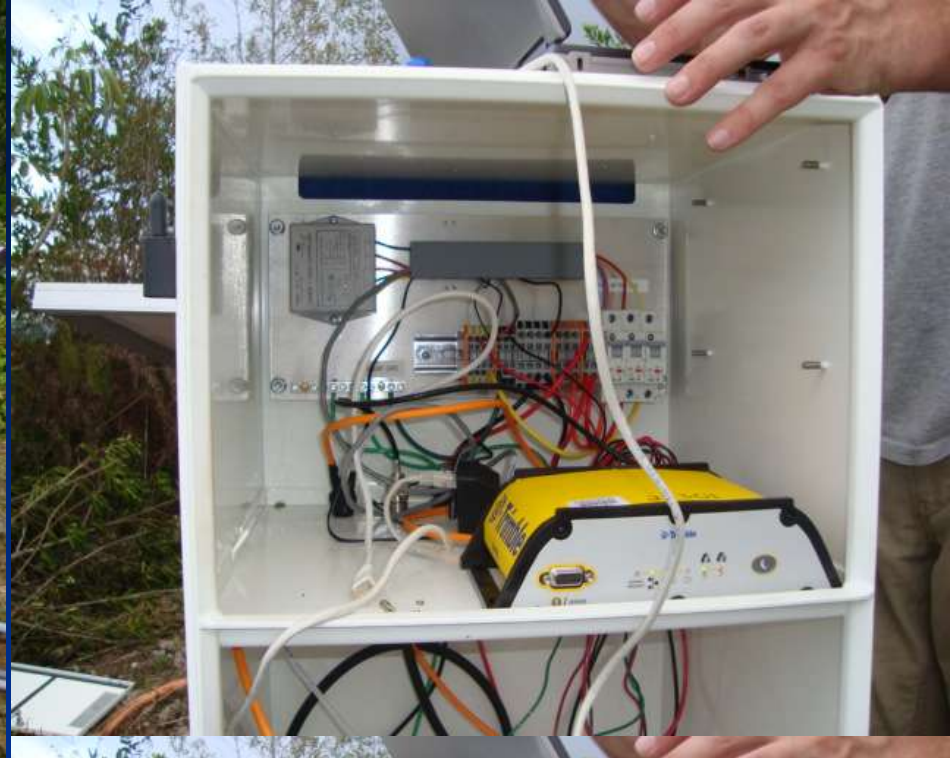


**SANT**  
**ASH700936D-M**

# Evaluation of Earthquake Resistant Ability of a Total GPS Seismic station







**Future COCONET GPS**

# The Invention of a Seismic Isolation Device for Mounting GPS Receivers

- The failure of (Loss-of-Track) was caused by
- large Acceleration or Jerk suffered by the GPS receiver and/or antenna.





Thank You!

