

# **Quartz Sensors for Improved Disaster Warning Systems and Geodetic Measurements**

**Paroscientific and Quartz Seismic Sensors**

# Quartz Sensors Solutions for Improved Disaster Warning Systems and Geodesy

- Pressure Sensors
- Triaxial Accelerometers
- Tiltmeters
- Nano-Resolution Electronics
- In-situ Calibration Methods

Measurements on the Surface of Land and Through the Atmosphere

Measurements in Boreholes on Land

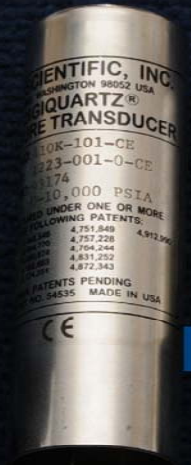
Measurements on the Sea-floor

Measurements in Boreholes Underneath the Sea-floor

# Quartz Sensors Solutions



Digiquartz Barometers



Digiquartz Pressure Transducers



Triaxial Accelerometers



Nano-Resolution Electronics



X-Y Tiltmeters

# Examples of Nano-Resolution Measurements

## Atmospheric

Measure absolute barometric pressure fluctuations to nano-bars for infrasound detection of tsunamis, extreme weather, & eruptions.

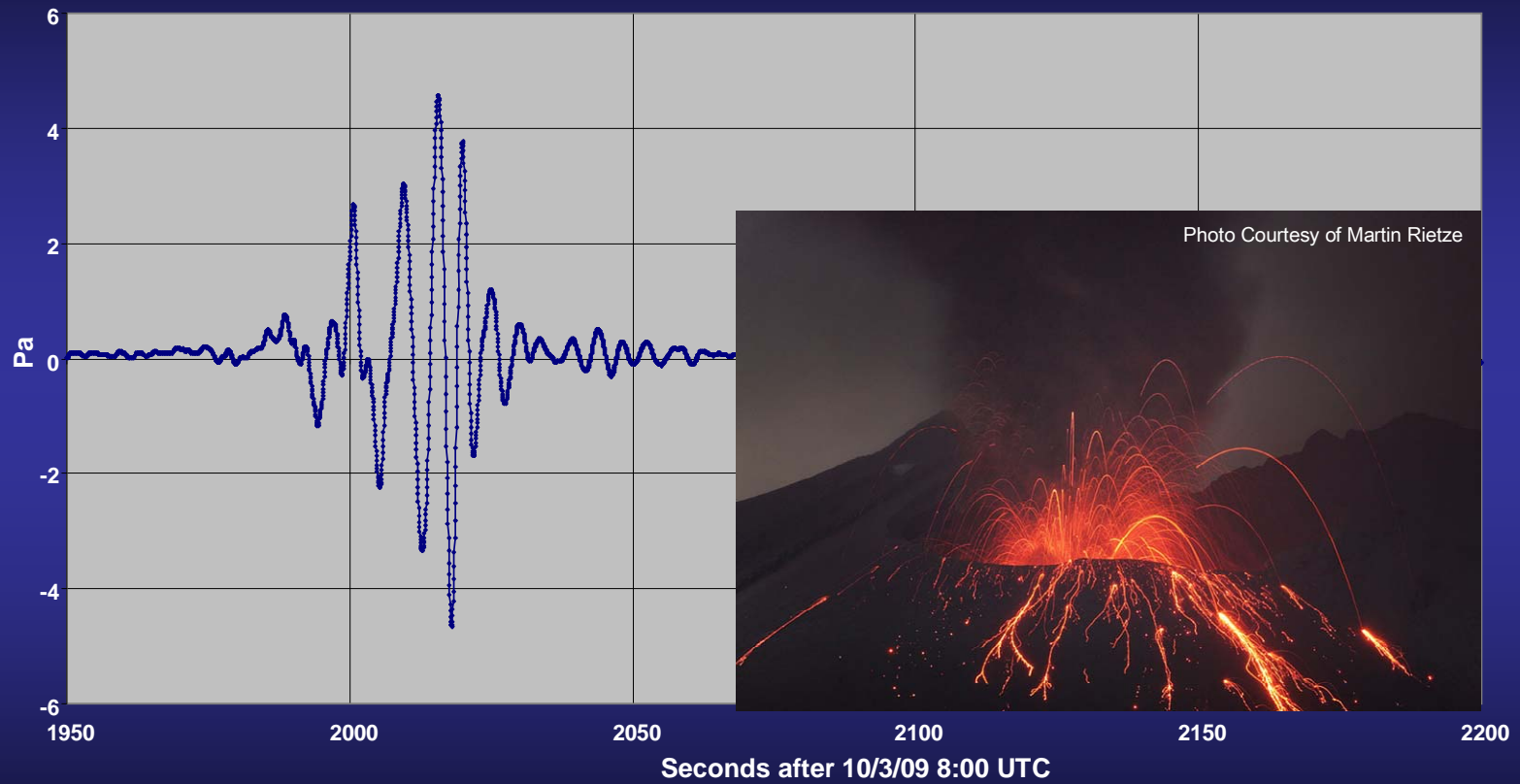
## Oceanic

Measure water level fluctuations to microns with absolute deep-sea depth sensors for detection of tsunamis and seafloor movement.

## Seismic

Measure acceleration to nano-g's with 3 g full-scale strong motion sensors and tilt to less than 1 nano-radian with +/- 9 degrees Quartz Tiltmeters.

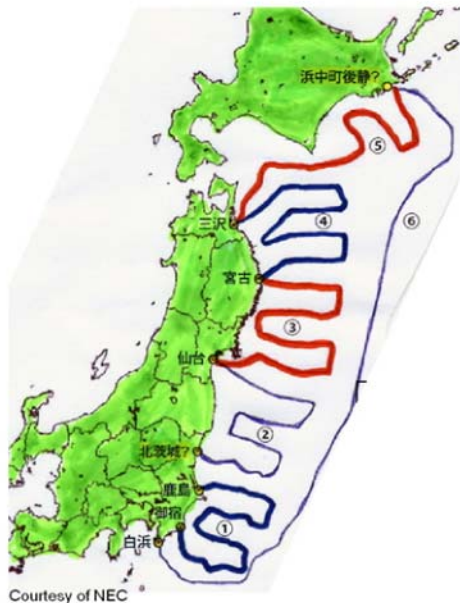
## Sakurajima Eruption Measured 1000 km Away at Nuclear Test Monitoring Site



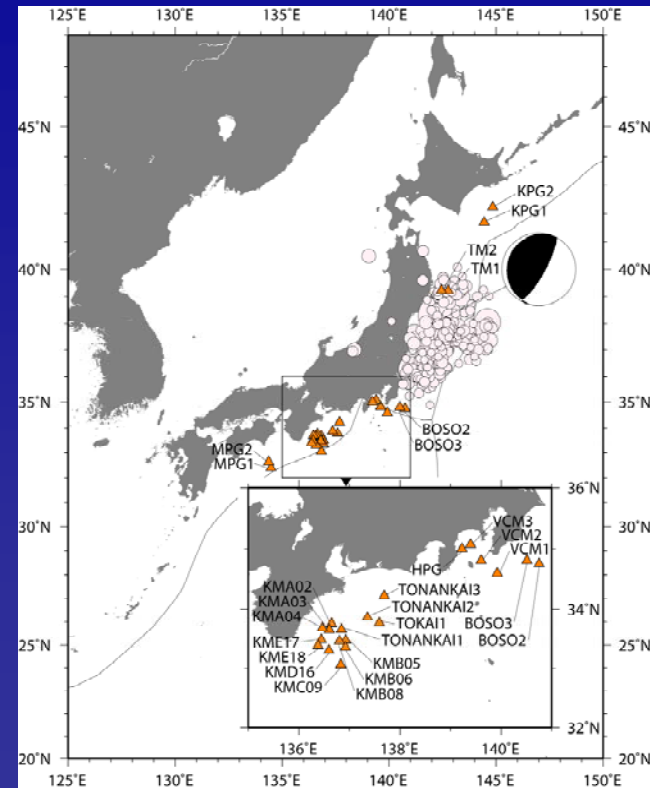
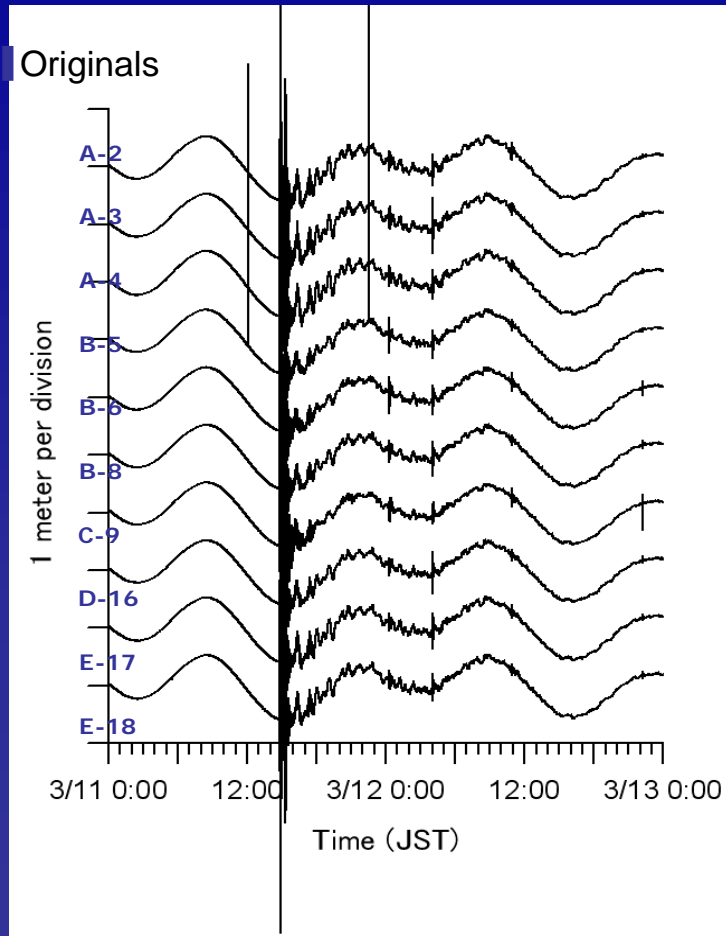
**Japan Trench Observation  
& Tsunami Warning System**  
Over 5200 km of Cable and  
154 Instrument Stations.

**Disaster Warning System for Japan**

Each cabled node contains:  
2 Nano-Resolution Depth Sensors for Tsunami Measurements &  
3 Nano-Resolution Accelerometers for Seismic & Tilt Measurements

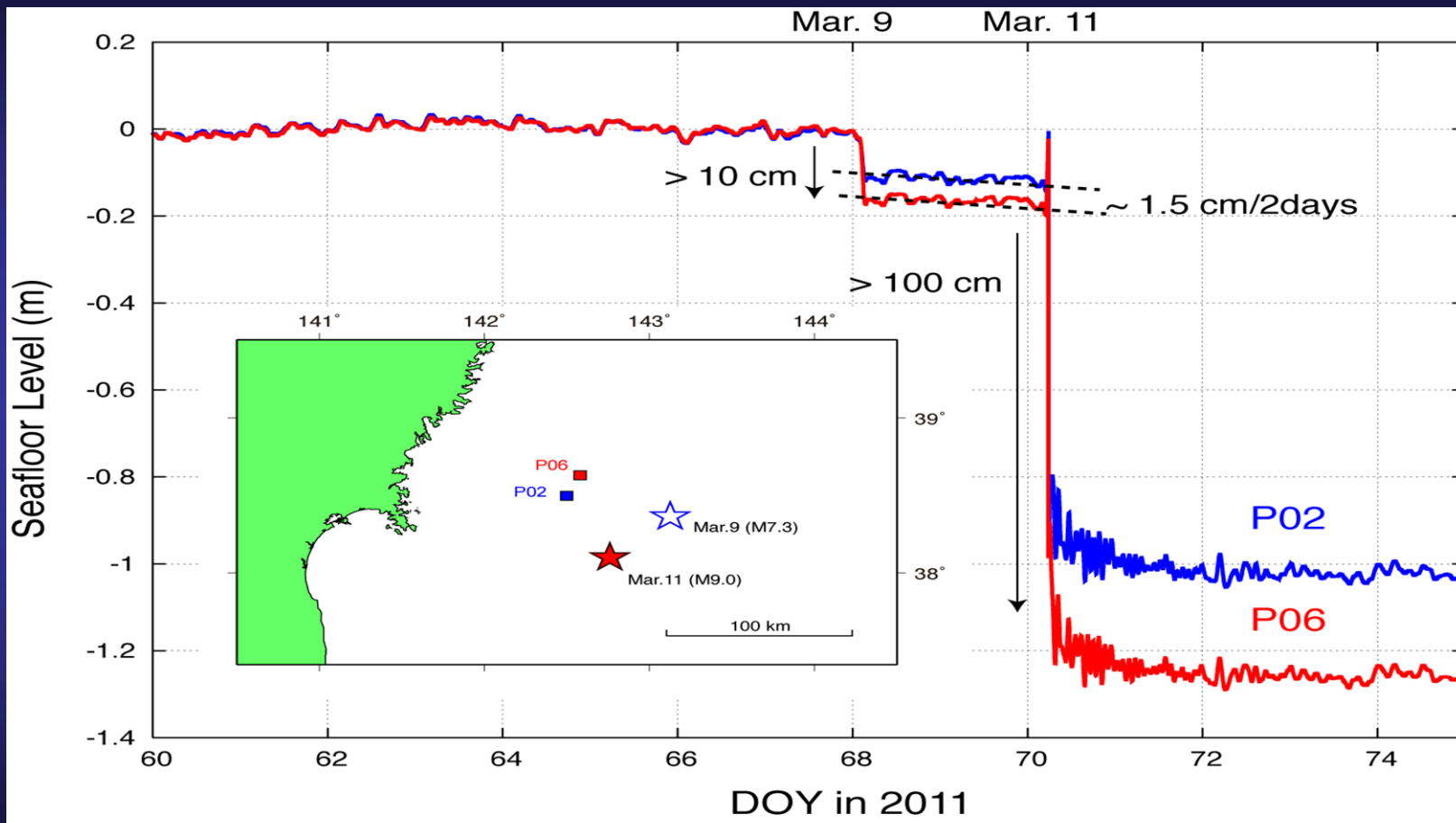


# DONET Bottom Pressure during the 2011 Tohoku Earthquake



Plot courtesy of Dr. Hiroyuki Matsumoto

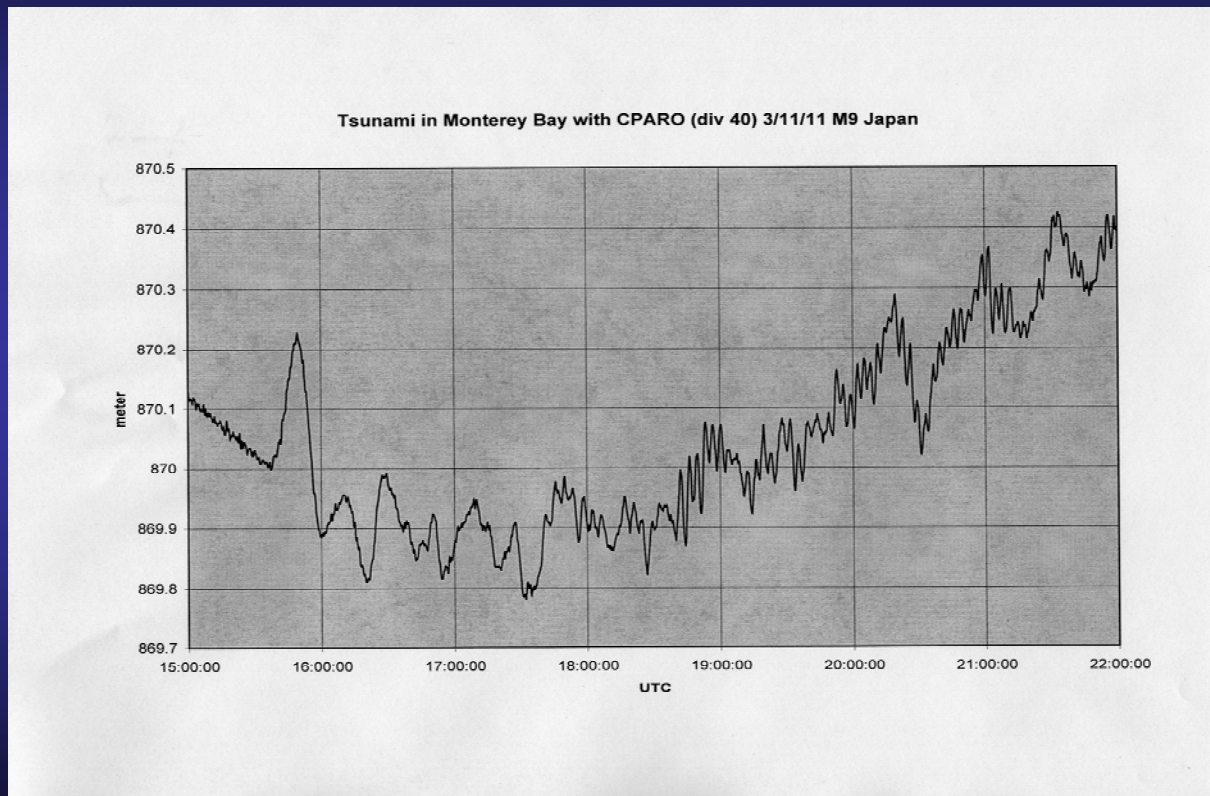
# 3-9 Precursor to 3-11 Tsunami



Plot courtesy of Dr. Ryota Hino



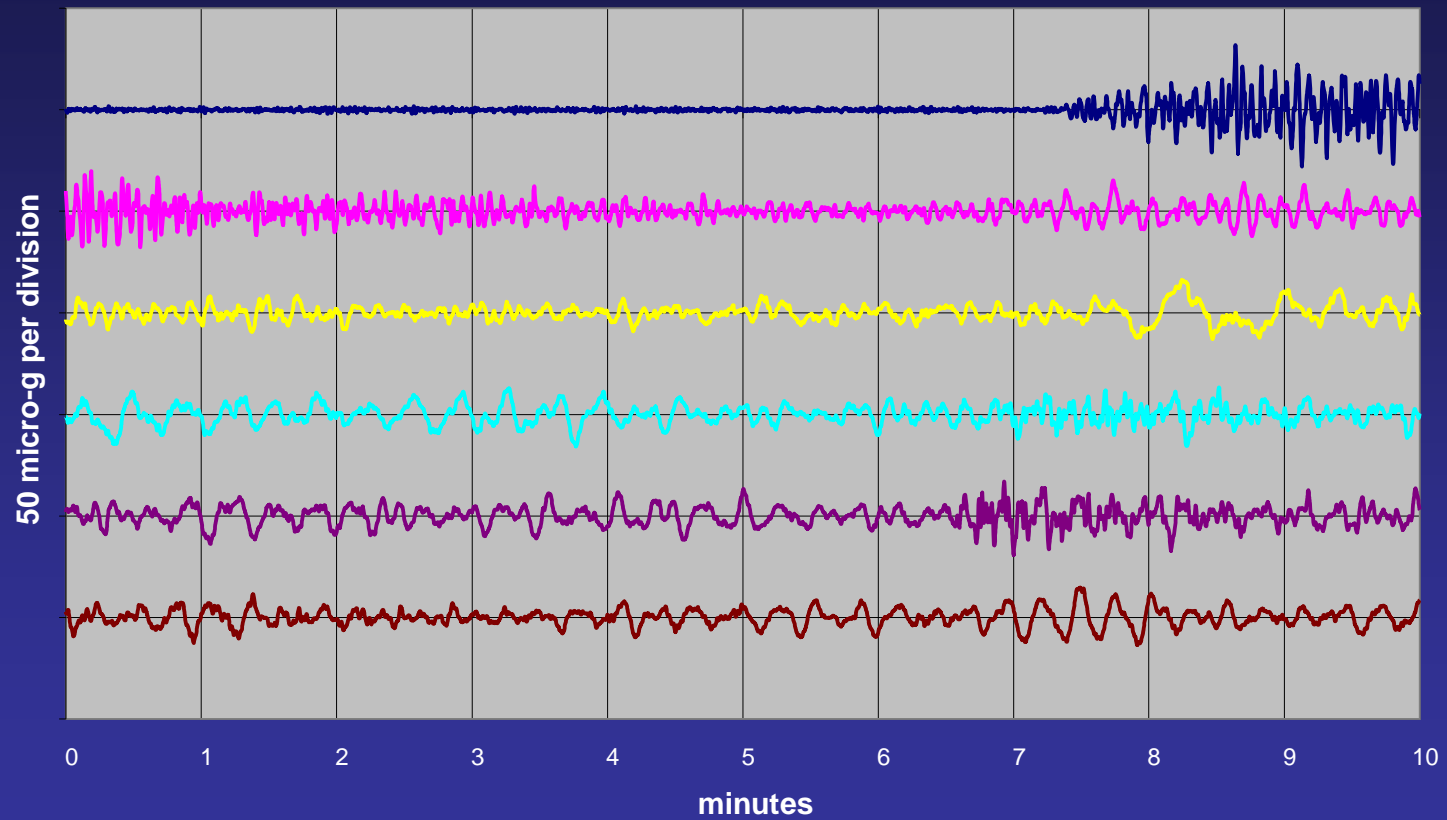
# Tohoku Tsunami Measured in Monterey California with Nano-Resolution Depth Sensor



Paroscientific, Inc.

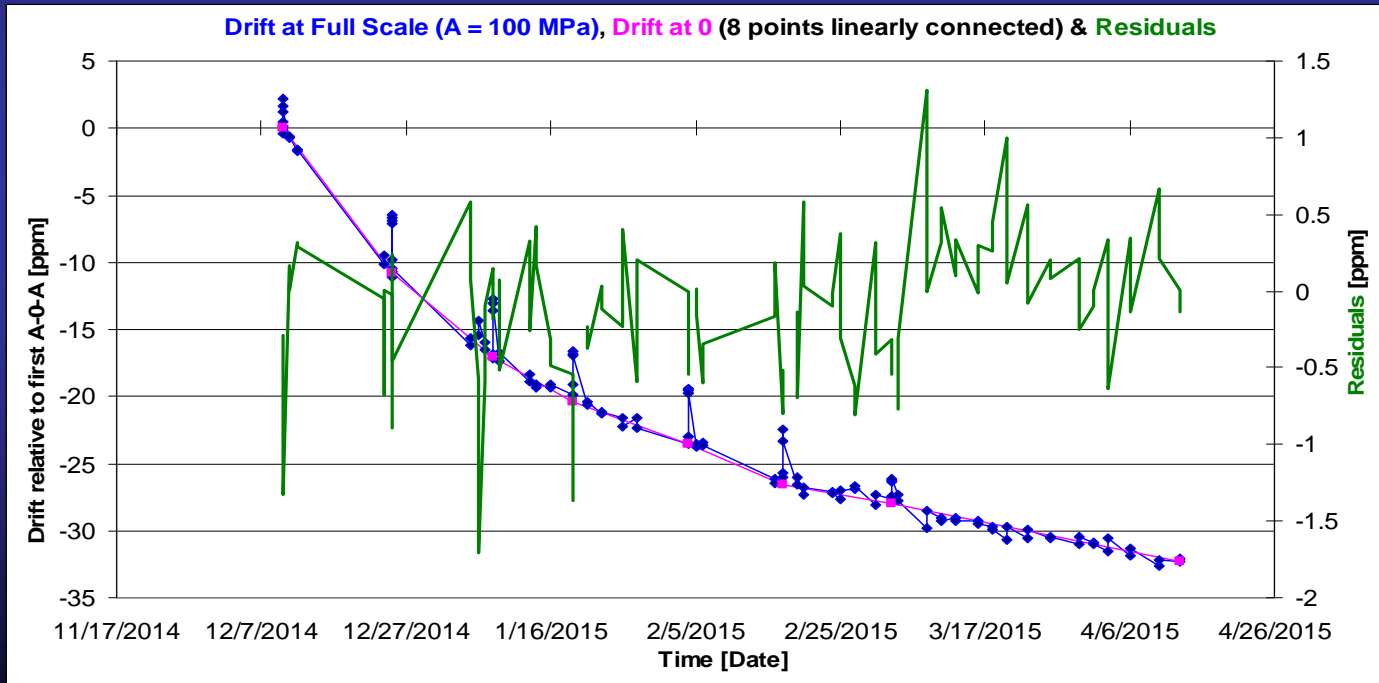


M9 Honshu Earthquake 11 Mar 2011 05:50-06:50 UTC  
Recorded with Nano-Resolution Accelerometer in Seattle, WA USA



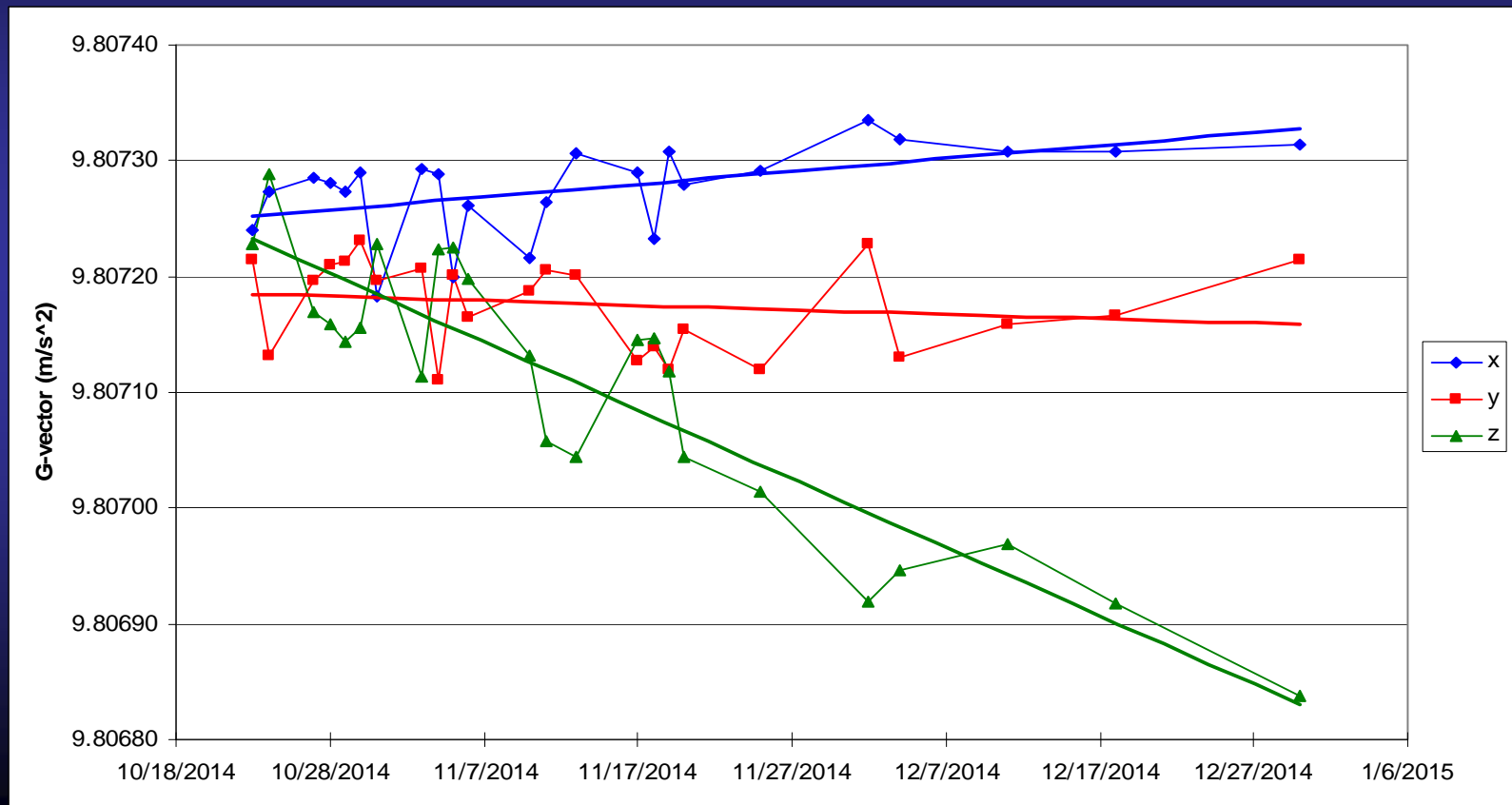
# In-situ Calibration Methods for Improved Geodetic Measurements

## Depth Sensor Stability Referenced to Internal OBS Atmospheric Pressure Using A-0-A Calibration Method



# In-situ Calibration Methods for Improved Geodetic Measurements

## Triaxial Acceleration Vector Referenced to 1 G of Earth



## **Quartz Crystal Pressure Sensors, Triaxial Accelerometers, and Tiltmeters provide:**

- ▣ Improved disaster warning times for earthquakes, tsunamis, volcanic eruptions and extreme weather events**
- ▣ Improved geodetic measurements for scientific research and predictions of natural disasters**
- ▣ Low-cost measurement solutions for new and existing cabled, remote, and mobile platforms**