

VARIATIONS OF ALTITUDE OBSERVED ON THE OCCASION OF THE TOHOKU EARTHQUAKE (M=9.0) OCCURRED ON MARCH 11, 2011

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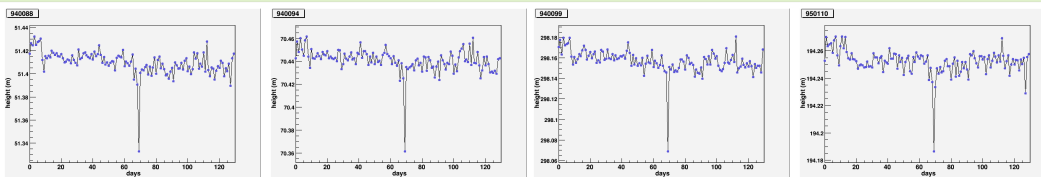
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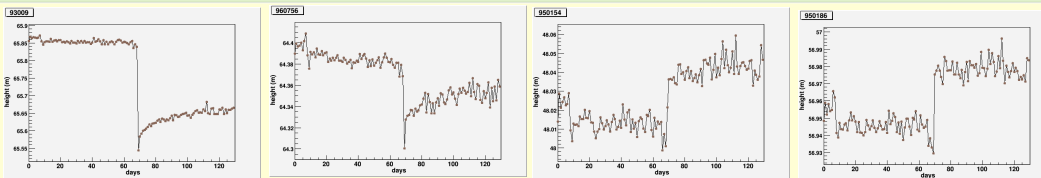
Since October 1, 2010 a GPS receiver is into operation at Tokai (Japan) in an experiment on Neutrino Physics (T2K). An evident decrease in the altitude appeared from the beginning of March 2011, so that a possible GPS precursor of the Tohoku earthquake seemed to be observed.

In order to investigate in details this possibility we have required and obtained the GPS data collected during 2011 by **GEONet (GPS Earth Observation Network)**. This is the nation wide GPS array of Japan and consists of 1240 permanent stations. The average spacing of the stations is about 20km and it is the largest GPS network of the world currently. A five meters tall pillar with the base of two meters deep is settled at each site. The pillar is made with stainless steel and equipped with a GPS antenna at the top. Choke ring antenna is used at most of the sites. A dual-frequency GPS receiver, communication devices, backup battery, tilt meter etc. are installed in the body of the pillar.

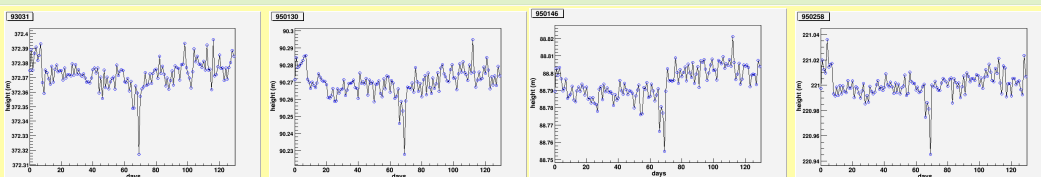
At the moment we have examined only the daily data related to the altitude. The preliminary results of the analysis are here shown. Four different behaviours stood up and they are described in panel a-d. The days are counted from January 1, 2011.



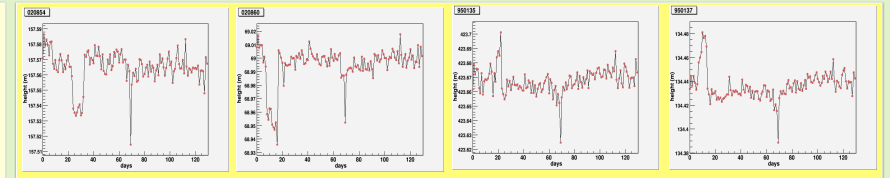
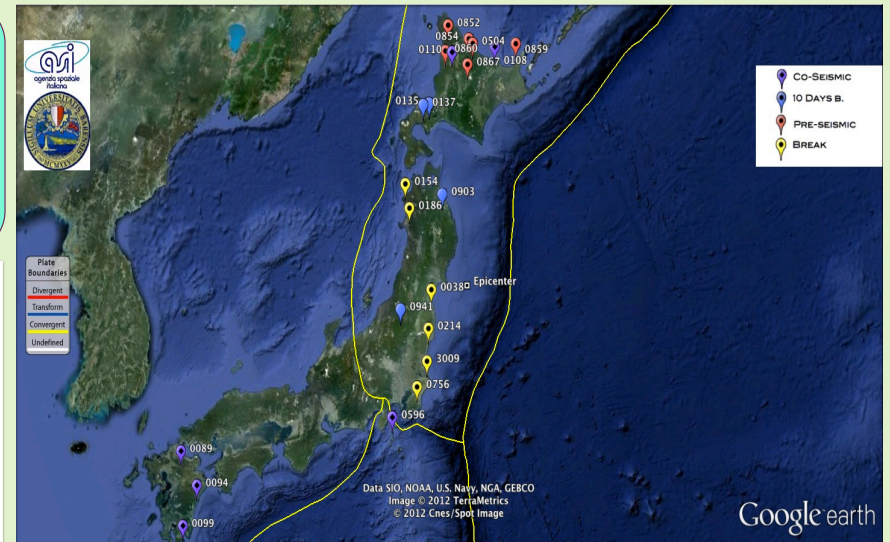
a) CO-SEISMIC EFFECT
A large decrease of altitude occurred the day of earthquake, while no other variation appeared before or after the earthquake. This behaviour was revealed in many stations of the network generally located far enough from the epicentral area. Some of these stations are reported in purple in the map.



b) POST-SEISMIC EFFECT
After the large decrease of altitude occurring the day of earthquake a permanent displacement appeared. This behaviour was revealed in many stations of the network located mainly in the direction of the coast in the epicentral area. Some of these stations are indicated in yellow in the map.



c) PRE-SEISMIC EFFECT
Before (10 days) the occurrence of earthquake some possible anomalous variation appeared. This behaviour was revealed in some stations of the network located mainly near the epicentral area. Some of these stations are indicated in blue in the map.



d) JANUARY EFFECT
During the first 10-20 days of January 2011 in many station an evident variation of altitude (increase or decrease) appeared. In some case the variation was very large and this behaviour was revealed mainly in stations located in the north of Japan. Some of these stations are indicated in red in the map.

Clear variations of altitude were revealed by the GPS data on the occasion of the Tohoku earthquake. The co-seismic and post-seismic ones [panels a) and b)] represent a very known phenomenon also taking into account the very large magnitude of the earthquake. The possible variations starting around ten days before the earthquake seem to confirm the observation in the T2K Neutrino experiment and they can represent short term precursors of the earthquake. But, in order to confirm this possibility a more detailed study must be conducted using hourly (not daily) data and some technique of data analysis as Wavelet, SD (standard deviation) or other. The variations observed in January 2011 are very singular and could represent an interesting result. According to our opinion they are related to some variation in atmosphere/ionosphere and could be produced by some planetary effect or meteorological condition, but the possibility that they are produced by some variations in the ground (producing AGW) cannot be excluded. In such a case middle term precursors of the earthquake could be claimed. In any case this phenomenon deserve a detailed study.