WATER LEVEL'S VARIATION IN BOREHOLES OF GEORGIA (2011-2013)

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Abstract:
Water level in boreholes, atmosphere pressure and temperature monitoring is performed for deep boreholes: Kobuleti, Borjomi, Akhalkalaki, Marneuli, Lagodekhi, Ajameti and Oni. We have one minute data for three years (2011-2013) and demonstrate as example measured parameters for Marneuli borehole. Water level (WL) in Marneuli borehole is related with tidal and atmosphere pressure variation. During far and strong earthquakes we observed seismic waves influence on background WL variation. Similar reaction we fixed for other deep boreholes. In MATLAB environment StationsMany, WaterAndQuakes applications have been developed at M.Nodia Institute of Geophysics. These programs allow to exclude influence of isogenic factors (tidal and atmosphere pressure variations) and create real geodynamical fields and investigate their evolution in time and space.

Introduction

Water level monitoring is made at the following deep boreholes of Georgia: Kobuleti, Borjomi, Akhalkalaki, Marneuli, Lagodekhi, Ajameti and Oni. Measuring on all stations is taken every one minute. For data recording we use datalogger XR5-SE-M and the program LogXR. Data transferring is made by GSM modules Siemens and Wavecom-type. Data processing and figures creation is realized by program StationsMany. This program is evolutionary development of programs WaterAndQuakes and RestDance. These programs are written on MatLab-language.

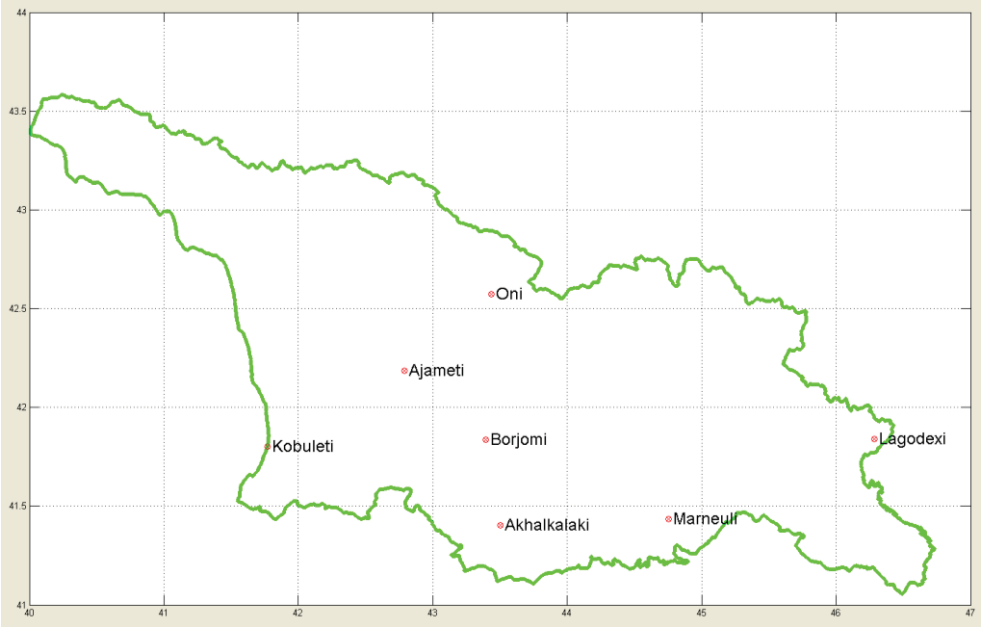

Figure 1. Location of deep boreholes in Georgia

Here is the detail description of the boreholes:

Borehole	Depth,meters	Filter interval, meters	Lithology	Geologicalintervals, meters	Waterlevel, meters
Ajameti	1330	520-740	Litostone	520-740	-6
Akhalkalaki	1400	1000	Tuff, andezit, basalt, dolomite	580-1000	-0.2
Borjomi-70	1330	1260-1300	Clay	0-12	-22
Kobuleti	2000	187-640	Tuff, andezit, bazalt	0-150 150-2000	-0.5
Lagodekhi	800	255-367	Sand+gravel	0-24	-15.8
Marneuli	3500	1235-1600	Tuff, diabases, bazalt	3100-3505	-5

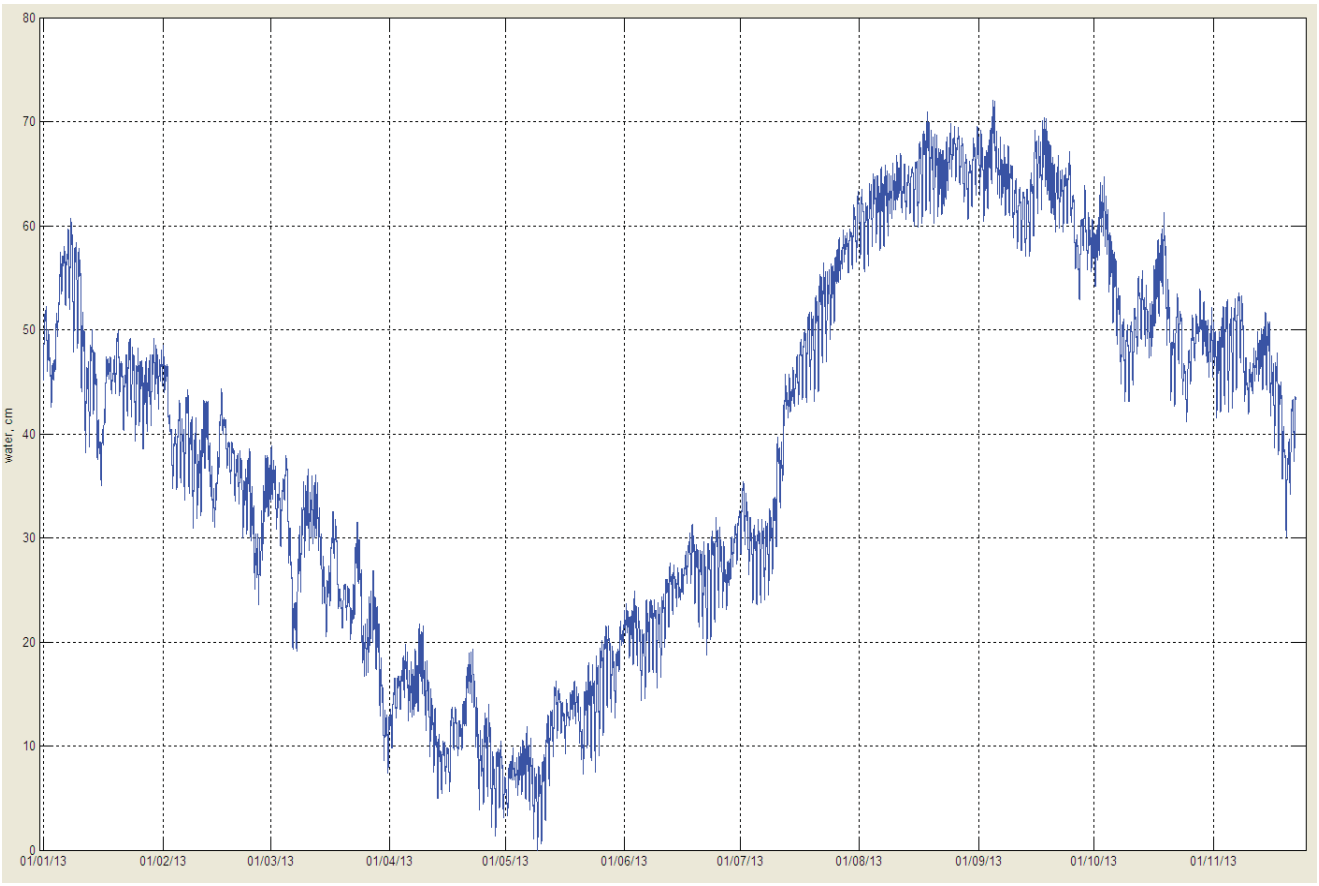

Figure 2. Marneuli water level, 2013

Here we have data of water level monitoring for Marneuli borehole during 2013 year (fig.2).

On examples (fig.2-4) we can see that water level at Marneuli borehole has season variation, have tidal (Sun & Moon) and atmosphere influence. Also it has reaction on the earthquakes.

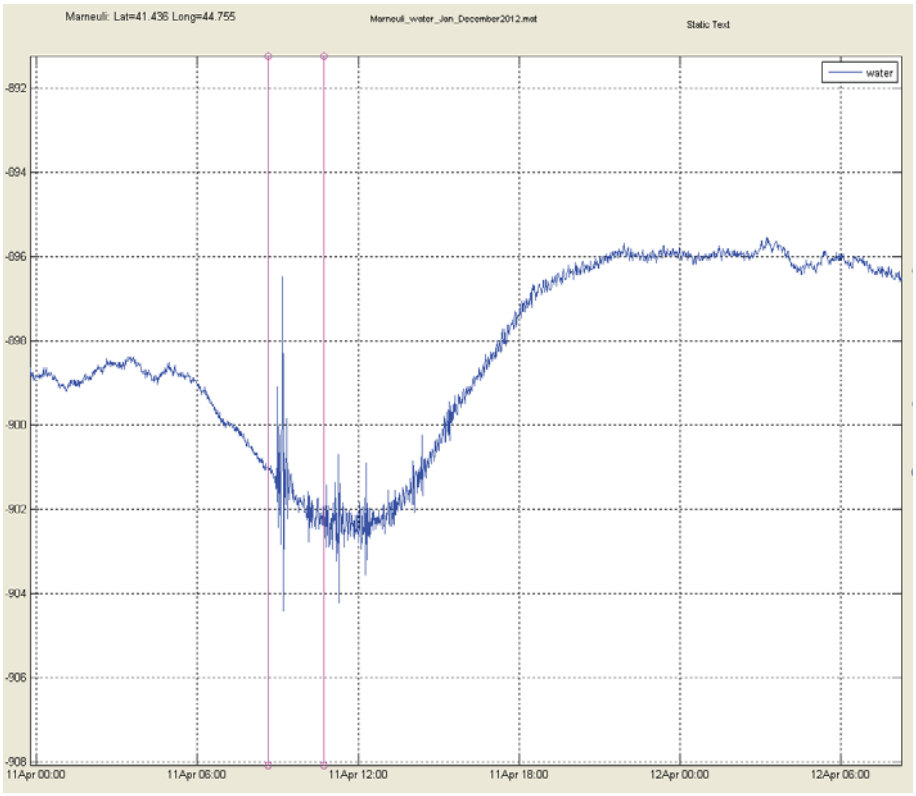

Figure 3. Marneuli, 11 April 2012, Sumatra, Mag=8.4, distance 6500 km, east direction

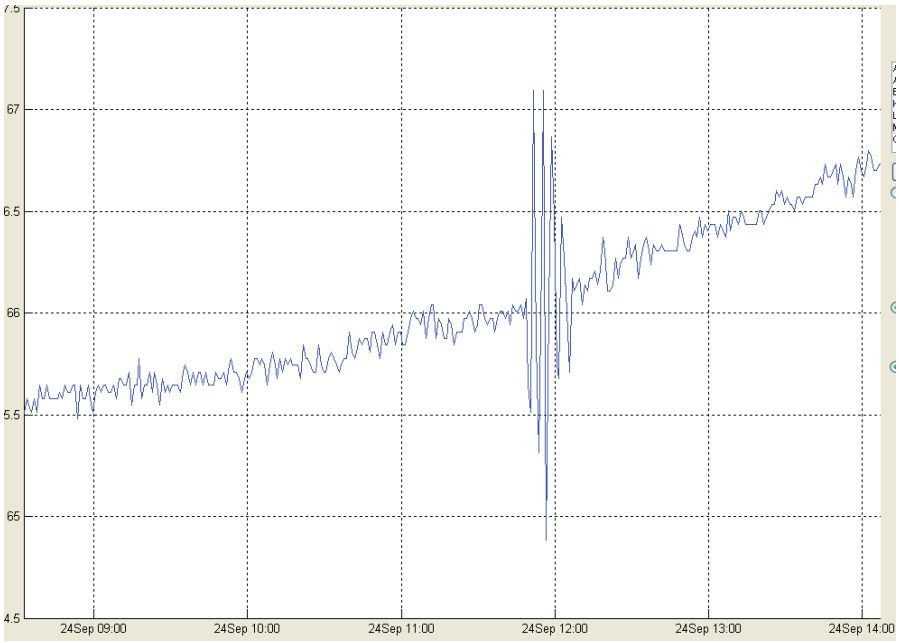

Figure 4. Marneuli, 24 September 2013, Pakistan, Mag=7.7, distance 2500 km, east direction

Our aim is studying water level behavior in the boreholes, visualization and finding methods of extraction earthquakes signals.

Visualization and simple conversions

Let us look at water level changing in various boreholes, which are made during four days before Turkey (Vani) earthquake 23 October 2011, Mag=7.2 (about 300 km on the south from Georgia). Here are water levels for Marneuli (top of picture, east), Kobuleti (west), Borjomi (center of Georgia), Ajameti and Akhalkalaki (to north and to south from Borjomi). So on the east it was small jump (Marneuli, top of picture); on the west (Kobuleti) the water was up; in the center there was jump (Borjomi); and small water down on north and south from center.

In time 19-21 October (from 4 up to 2 days before earthquake) there is water nonstandard behavior on four boreholes; than from 2 up to 0 day begin stabilization and … earthquake.

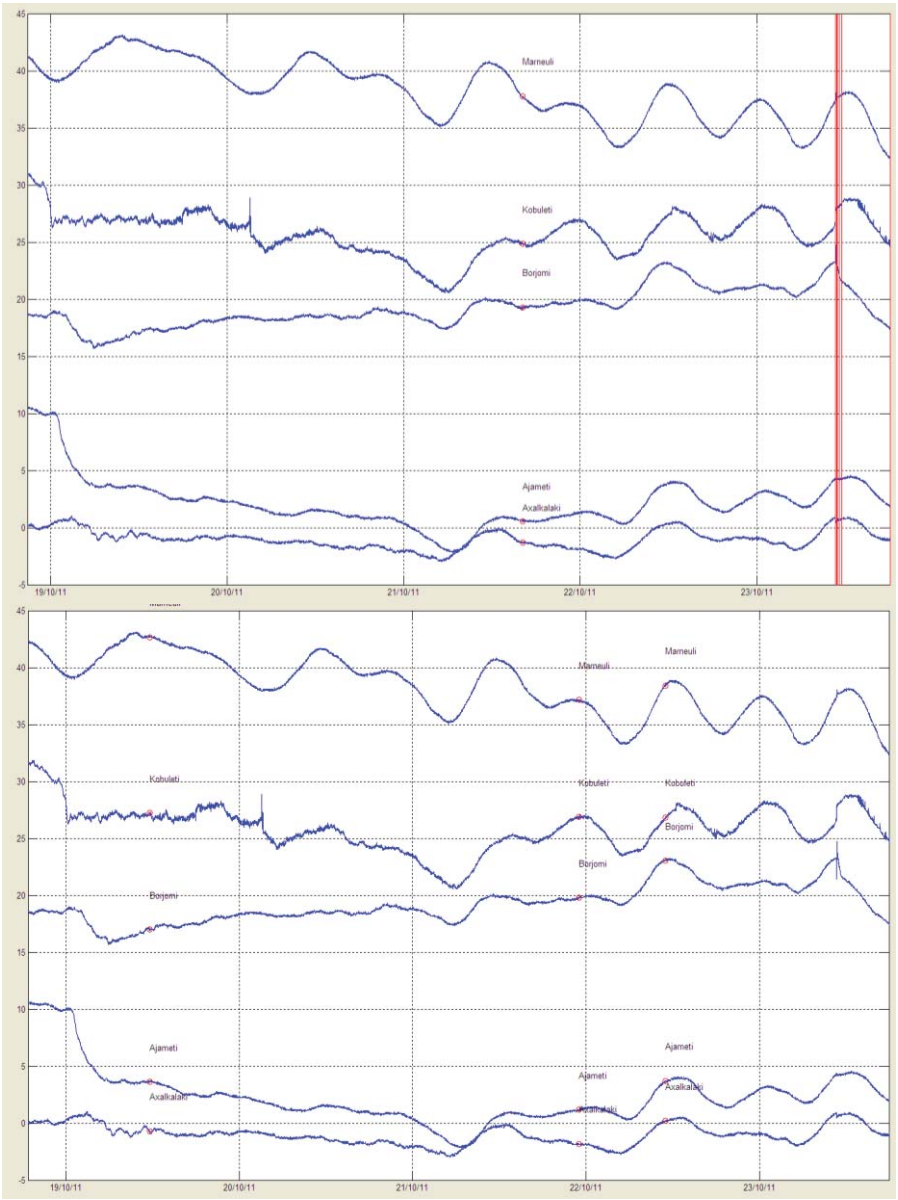

**Figure 5. Water levels in 5 boreholes (Georgia)
and earthquake in Turkey 23 October 2011, Mag= 7.2**

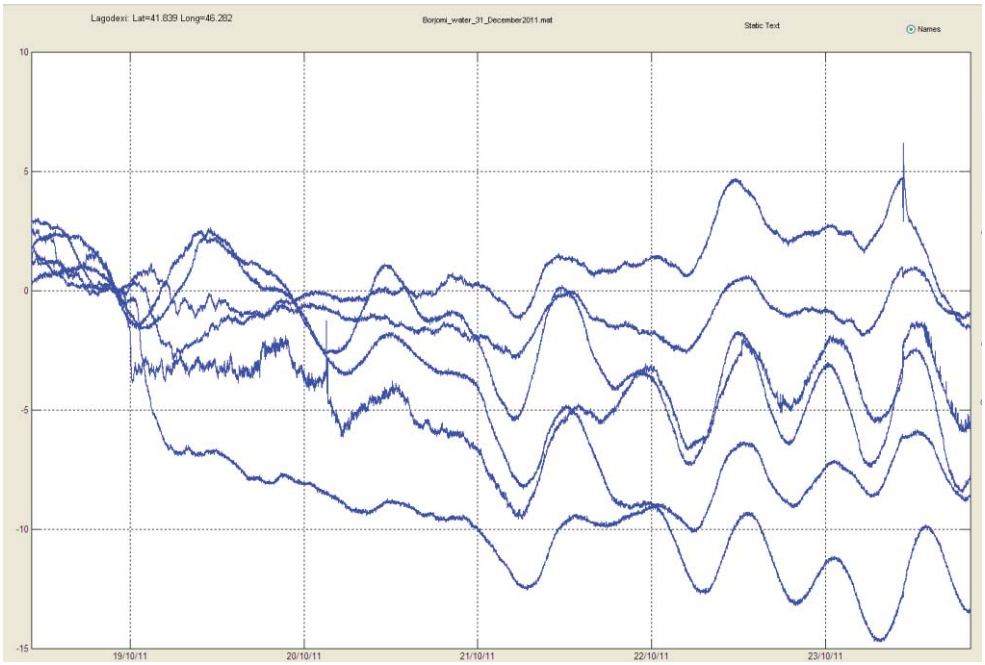

Figure 6. Conversions: Water levels are set to 0 for all stations on 19 October 2011; water moving from 19 October till 23 October and earthquakes on 23 October 2011

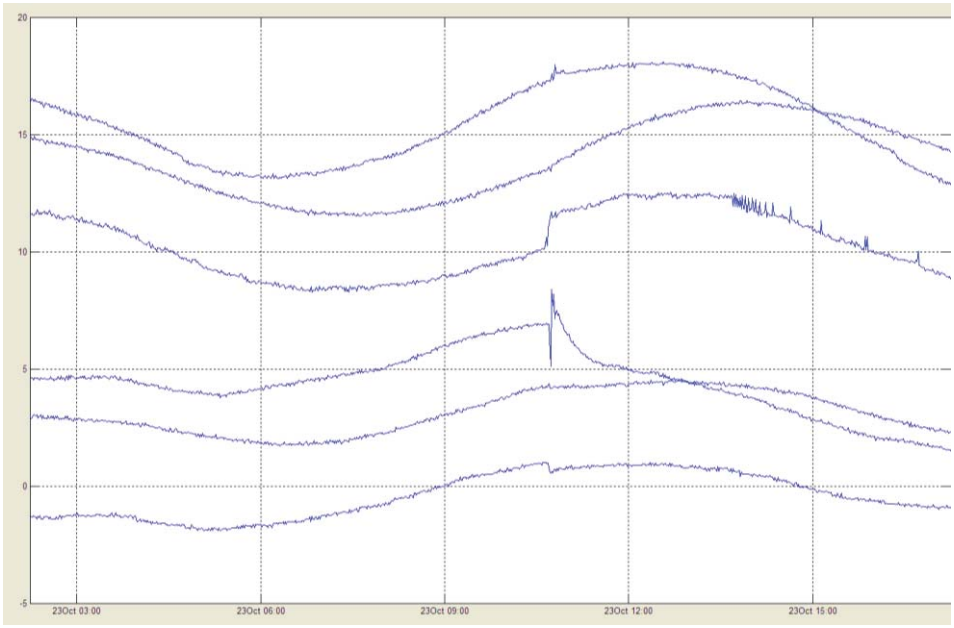

Figure 7. Water levels in Georgian boreholes, 23 October (03:00 - 15:00) and earthquake in Turkey 23 October 2011, magnitude 7.2, south direction.
From top to bottom: Marneuli, Lagodekhi, Kobuleti, Borjomi, Ajameti, Akhalkalaki

Relationship of water with atmosphere and tidal

Let us discuss more closely tidal and atmosphere influence on water level and make attempt to eliminate it from the water. Fig. 8-10 shows, these influences can be very strong.

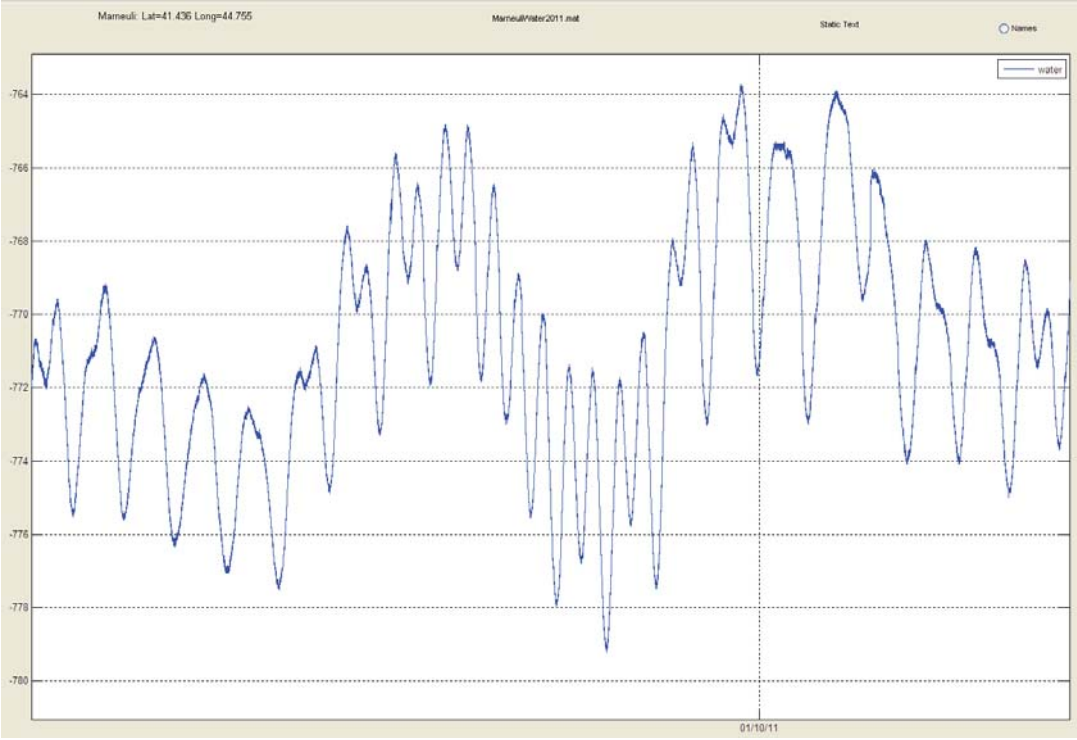

Figure 8. Water level, Marneuli

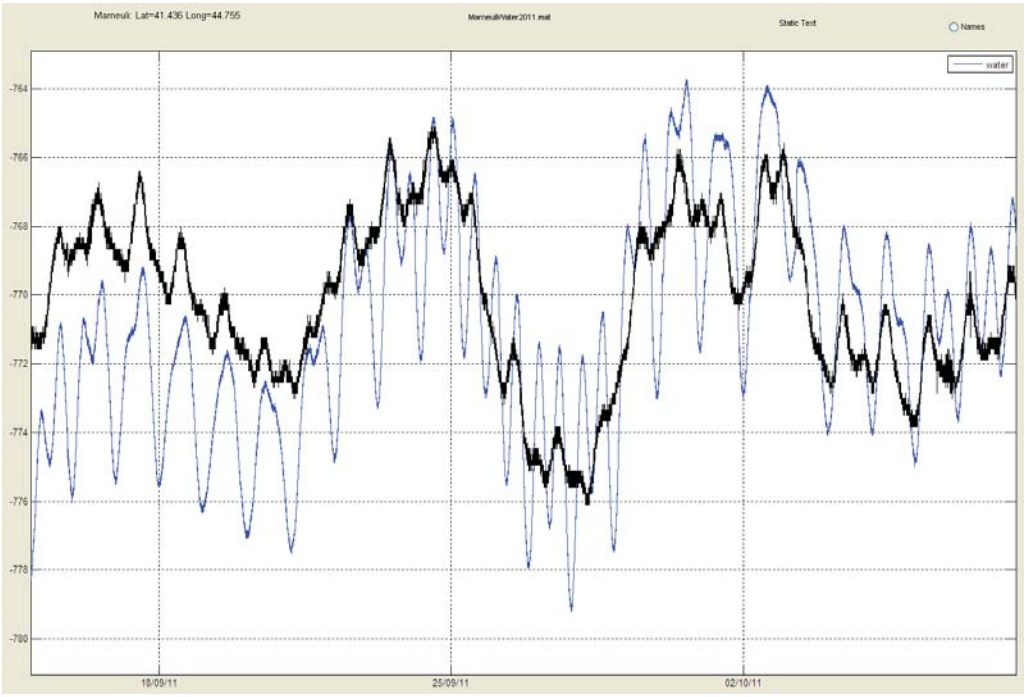

Figure 9. Influence of atmosphere on water level: water (blue) and atmos (black)

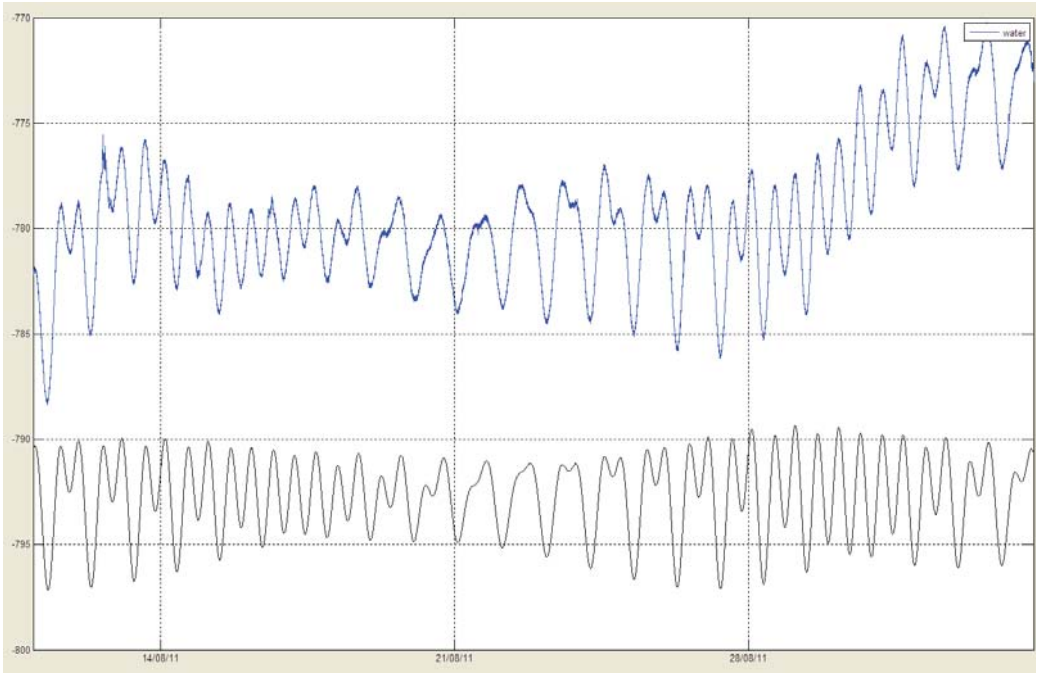

Figure 10. Water level (top, blue), tidalZ (bottom, black)

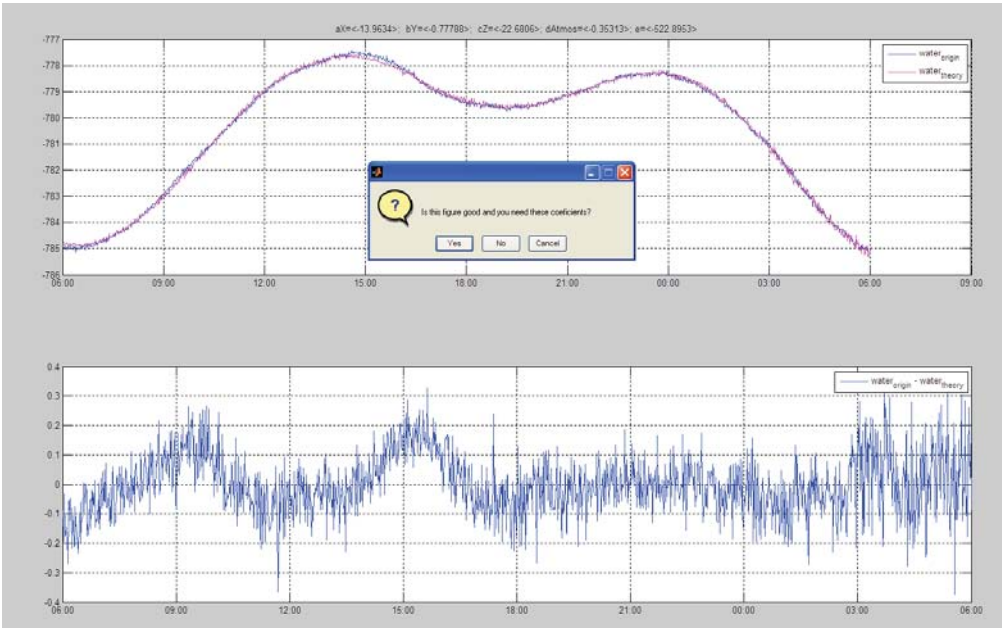

Figure 11. Water (top, blue**), water_theory** (top, magenta) and **rest=water-water_theory** (bottom)

where **water_theory=a*atmosphere+b*tidal+c**

Define **water_theory=a*atmosphere+b*tidal+c** with appropriate coefficients **a,b,c** (in fact, **tidal** has 3 components: **tidal**X, **tidal**Y, **tidal**Z and every this component has his coefficient too). On fig. 11 (top) graphs for **water** and **water_theory** almost coincide, but **rest** (fig.11, bottom) shows the difference between them.

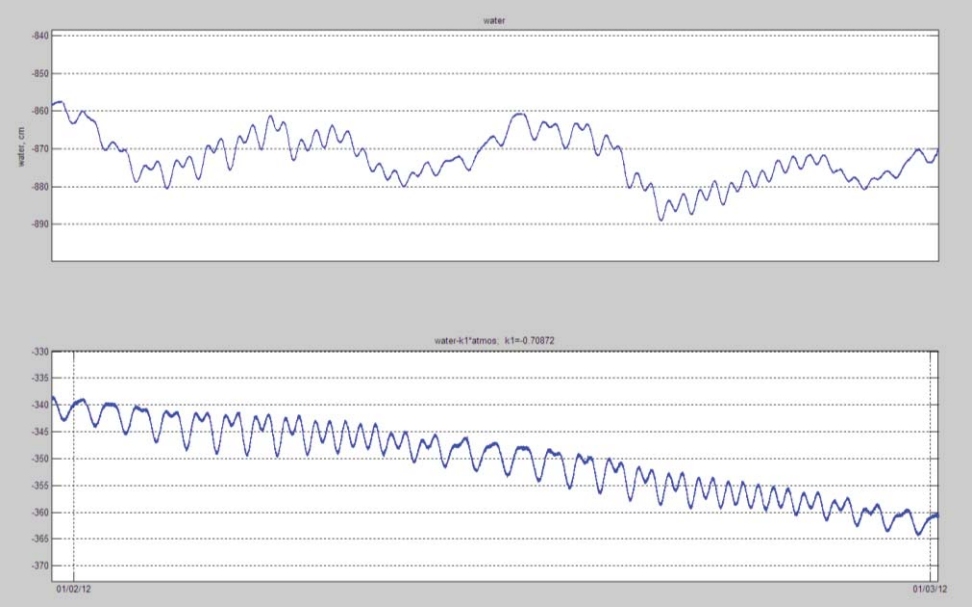

Figure 12. Marneuli 2012: water (top) and **water-a*atmos** (bottom)

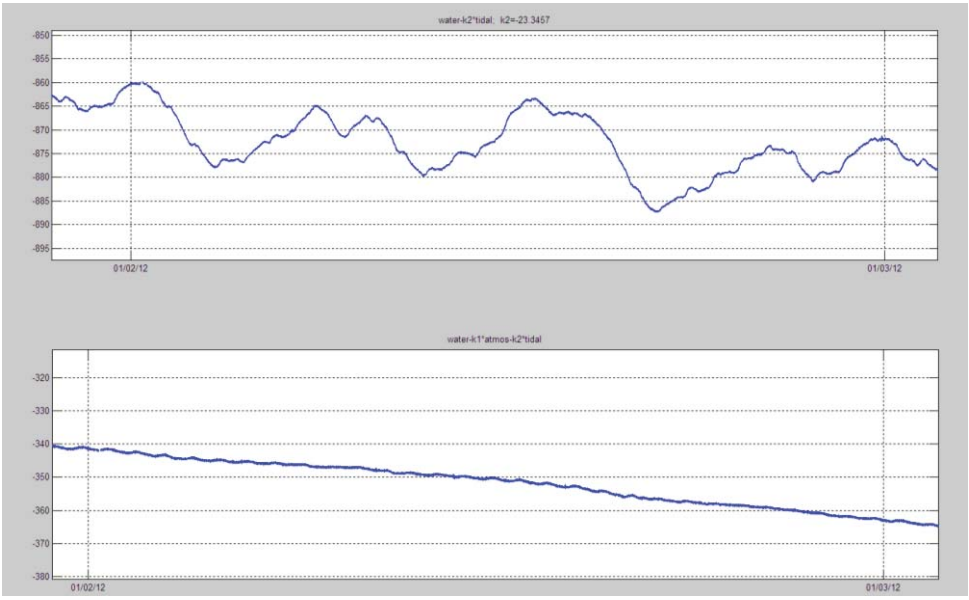

Figure 13. Marneuli 2012: water - b*tidal (top) and **water - a* atmos - b*tidal** (bottom)

On the fig.12 (top) there is original water level and result after extraction atmosphere influence (fig.12,bottom). On the fig.13(top) there is result of extraction of tidal from the water. Fig.13 (bottom) shows: after extraction atmosphere and tidal, **we can eliminate atmosphere and tidal influence on water.**

Speed for water level

Seasonal trend does not allow us to compare water levels of boreholes. Definition of speed for water level will help to manage with this problem and give to us additional information.

Definition: Speed($\boldsymbol{m}+i$)=(water($\boldsymbol{m}+i$)-water(i))/$\boldsymbol{m}$, i=1,2,3,…

where ***m*** is fixed number of minutes. For example ***m***=180 minutes.

On fig.14-15 for visualization comparability speeds-data are multiplied on some coefficients. On this pictures we see, that seasonal water trend does not exist (has small value). Also on fig.14 and 15 it can be seen anomaly in days 18-21 October, than stabilization and jumps on 23 October (earthquakes).

Speed examples

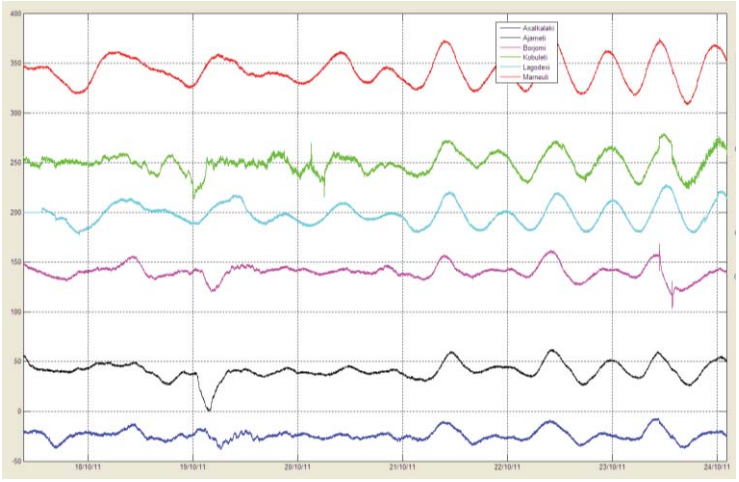

Figure 14. Speeds: *m*=180 minutes for boreholes of Georgia, 2011

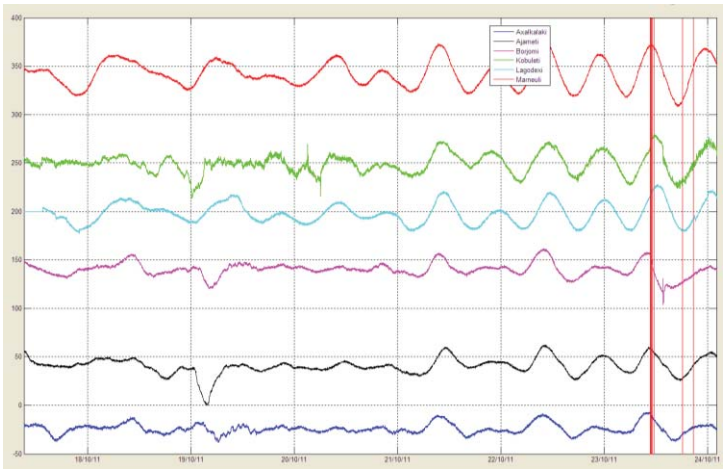

Figure 15. Speeds: *m*=180 minutes interval for boreholes of Georgia, 18-24 October and Turkey (Vani) earthquakes 23 October 2011, Mag=7.2

From top: Marneuli, Kobuleti, Lagodekhi, Borjomi, Ajameti, Akhalkalaki

Fields

By definition field is a map for the values of some parameter, measured on different points of area at the same time. For all boreholes we set the water level to zero for some days before earthquake, than construct fields and look at the water variations during 2 days up to earthquake.

Water fields, original water

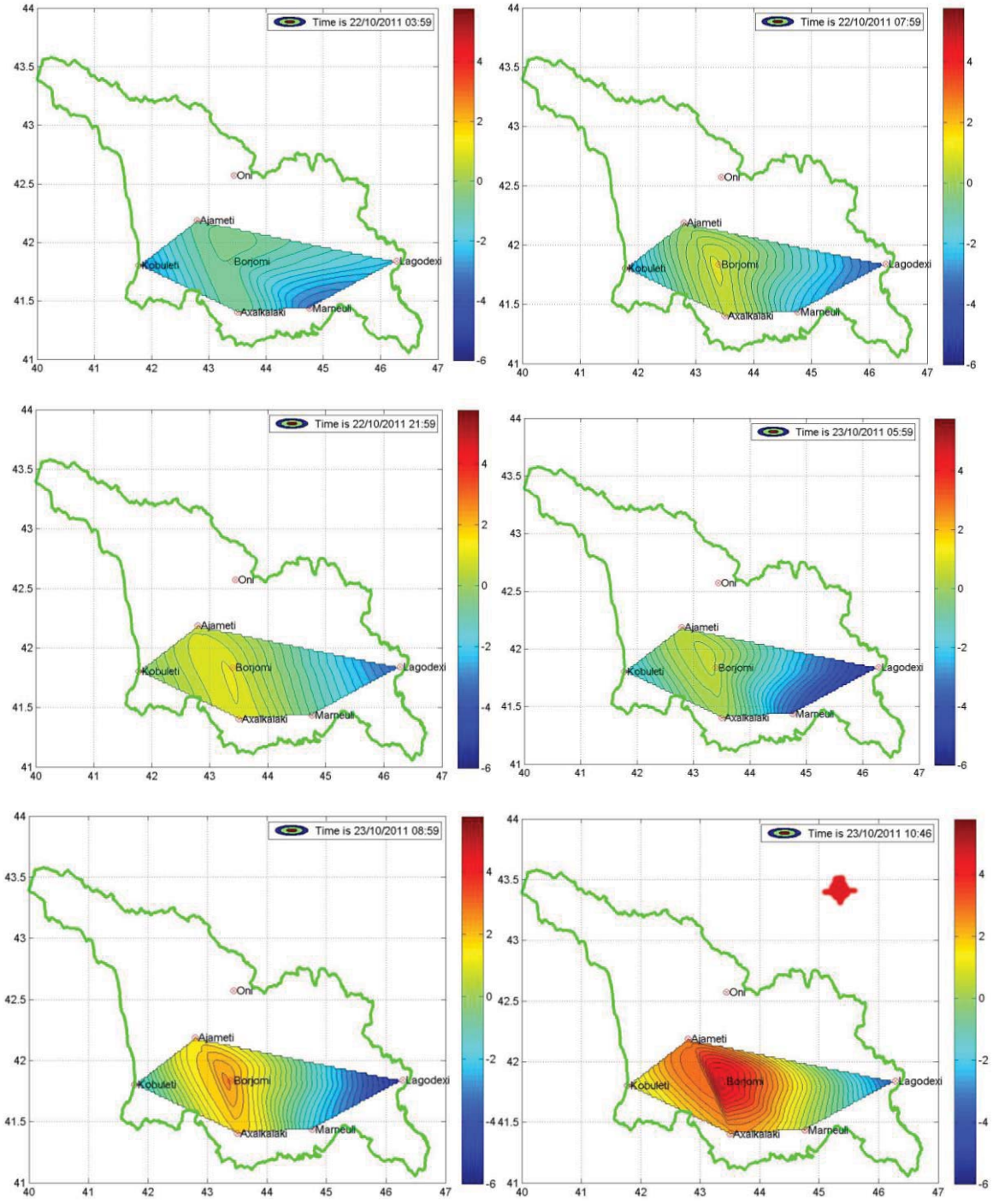

Figure 16. Field for water level in Georgia during 2 days before earthquake in Turkey 23 October 2011

Fields for water-level speed, Georgia

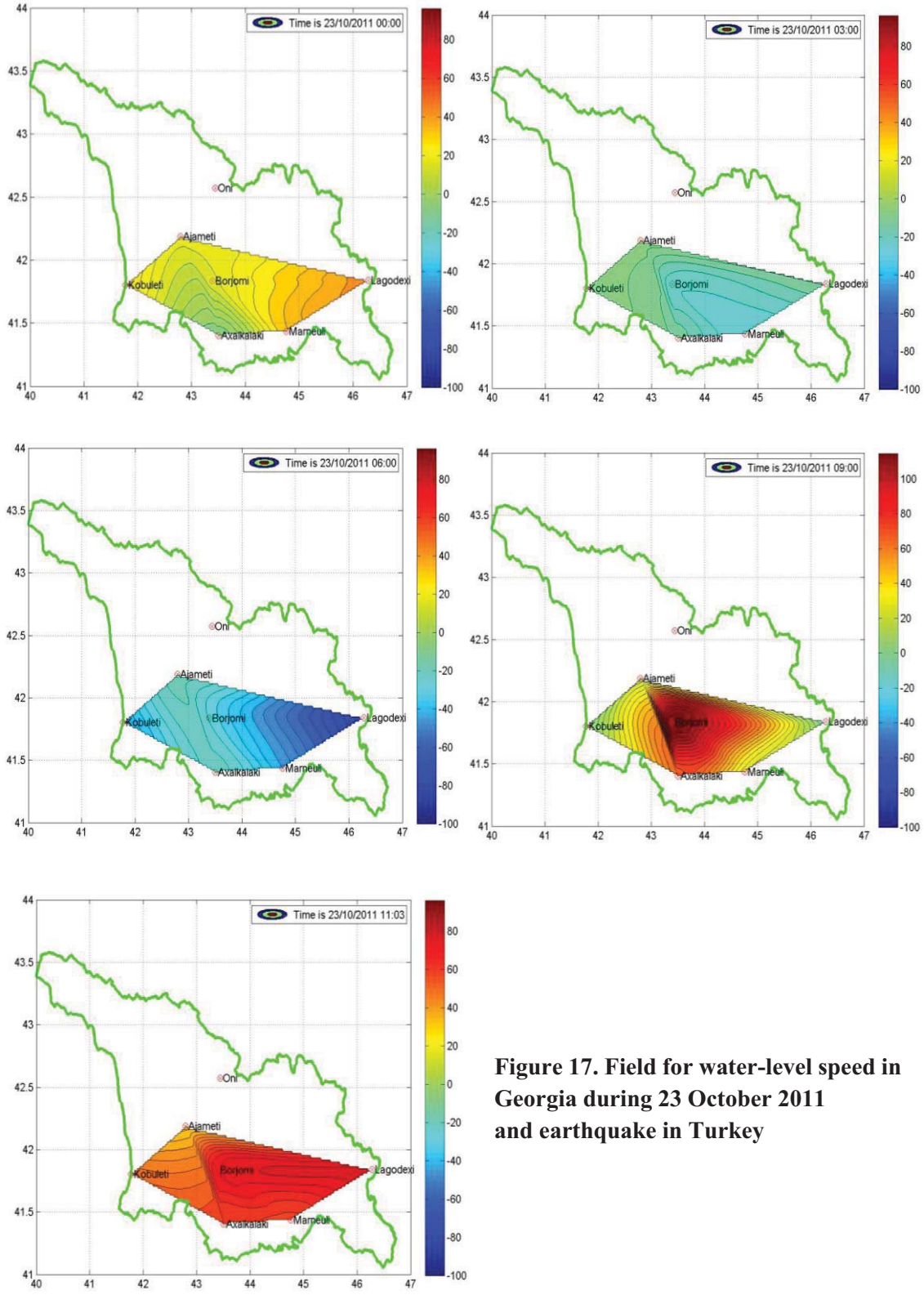

Figure 17. Field for water-level speed in Georgia during 23 October 2011 and earthquake in Turkey

Conclusion

There was shown a relation of water level variations with atmosphere and tidal behavior. The meaning of speed and field was demonstrated in this article. So in this work was shown three methods of visualization and anomaly during great earthquakes: speed, field and original behavior of water level using StationsMany-program.

References:

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