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Phase Shift Sign Changes into Boreholes of Georgia

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ABSTRACT

Using the example of a Georgian well, the possibility of regular changes in the sign of the phase shift between gravity and water level is shown.
Key words: *phase shift, water level, gravity, ellipse method.*

Introduction

In early articles on the topic of the phase shift between the water level in a well and gravity, was noted with surprise: in response to gravity, the water level should change its amplitude with a delay, but the water got ahead of it. Thus, when filtering near M2 (12.4206 h), there is an expected delay in the reaction of water, but when filtering in the region O1 (25.8193 h), water is ahead of gravity [1].

There are many articles and models that explain the phase shift in one direction or another. Various factors were taken into account: the water layer has the type confined, unconfined, leaky, etc. In particular, the presence of a negative skin effect was recognized as the reason for the advance of water [2]. By default, it is assumed that for the well the phase shift or its sign has a constant value.

Using the example of Georgian wells, we will show that the phase shift between the water level and gravity can regularly move from a state of lag to advance and vice versa. Therefore, depending on the time period for the well, both positive and negative phase shift values can be observed.

When studying the phase shift, we used the idea of an ellipse as presented in [3] and modified in [4].

To understand the issue, let's consider several comparisons. Let there be two functions: y=sin(*t*) and y1=sin(*t*-pi/6). Function y1 is obtained from the first by adding a negative number "-pi/6" to the argument and reacts "delayed" to an increase in *t*.

Example 1. If you build a motion trajectory, where X=sin(*t*); Y=sin(*t*-pi/6), then you get an ellipse, where the point with coordinate (X,Y) moves "counterclockwise" as *t* increases (Fig.1). If you specify sin(*t*+pi/6) as Y, then the point moves "clockwise".

Conclusion 1*:* by studying whether the point moves "counterclockwise" or "clockwise", you can find out whether there is a delay (phase shift <0) or advance (shift >0).

Note also: the greater the phase shift, the "thicker" the ellipse becomes. And vice versa, if the phase shift is 0, then we get a straight line on the graph.

Example 2. Let the reference function maintain its amplitude, and the function y1, maintaining the phase shift, reduces its amplitude (Fig.2). Let's depict both functions on one graph, where X=sin(*t*); Y=A*sin(*t*-pi/6), and coefficient A varies from 1 to 0.1. In this case, the ellipse graph will slope downward.

Example 3. Let the original functions simultaneously decrease their amplitude. The result is concentrically located ellipses that have changed their amplitude but retained their slope (Fig.3).

Conclusion 2: changing the slope of the ellipse allows you to determine whether the dependent function reacts consistently to a change in the reference one, or whether the proportion of their connection has changed.

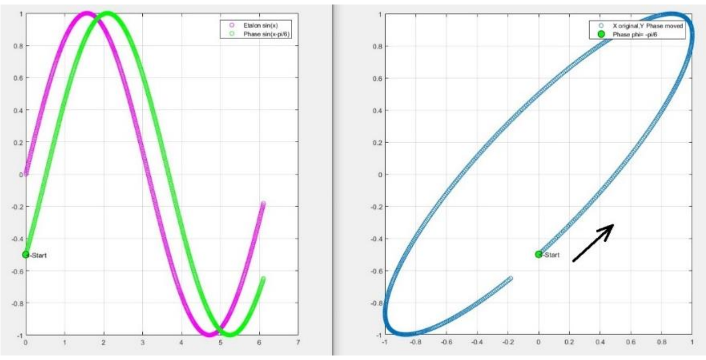

Fig.1. Red: y=sin(*t*);
green: y1=sin(*t*-pi/6)

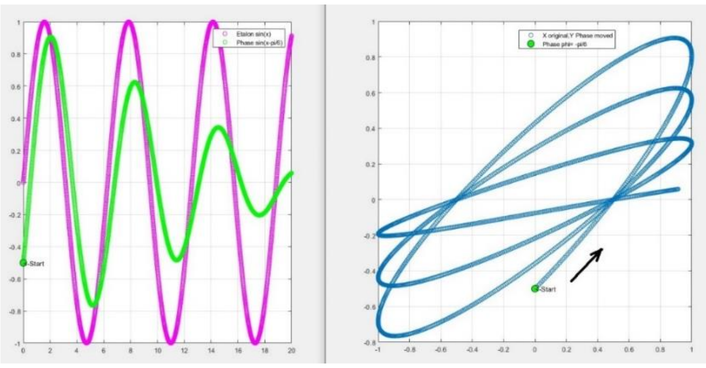

Fig.2. Red: y=sin(*t*);
green: y1=A*sin(*t*-pi/6),
A=1.0->0.1 for *t*=0:20

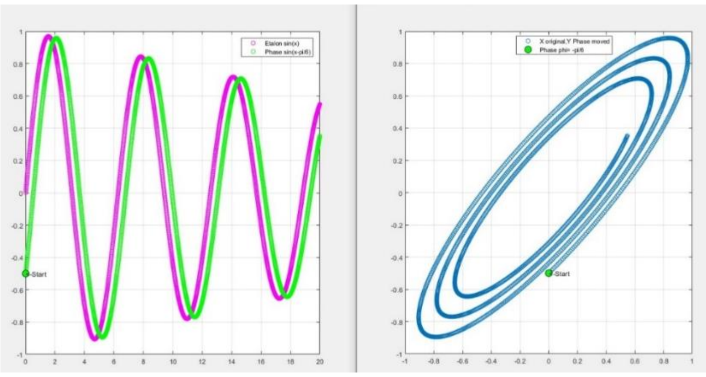

Fig.3. Red: y=A*sin(*t*);
green: y1=A*sin(*t*-pi/6),
A=1.0->0.1 for *t*=0:20

Results

A study of data from Lagodekhi and Kobuleti revealed a significant delay in the response of water levels to gravity. But for Marneuli and Nakalakevi there is both a delay and advance of gravity.

Let's consider the data obtained at the well Marneuli (January 5-February 17, 2024).

The variables are gravity y=tidalZ and water level in the form y1="-water" (in kPa). The influence of the atmosphere on water levels is removed. If the influence is retained, the results will be significantly different. Using the cwt and icwt functions (MatLab), these data are filtered in the region of M2 (12.42 h) and O1 (25.82 h). Next, we consider 2d or 3d graphs of these variables.

2d chart. We will place tidalZ on the OX axis, and "-water" along the OY axis. For clarity, in Fig.4 the influence of the atmosphere was not removed from the water level. The tilts of the ellipses are visible, therefore there are changes in the connection between the movement of water and gravity. There is also a change in the direction of movement "clockwise" or "counterclockwise", i.e. change in the sign of the phase shift.

3d graph. At X=*t* (time, minutes), Y=tidalZ, Z=-water, a 3d graph makes it possible to determine the direction of movement of a point in time and see the change in phase shift: "clockwise" or "counterclockwise" the point moves. Figures 5 and 6 show two-dimensional projections of 3D graphs, allowing you to see changes in the directions of movement over time.

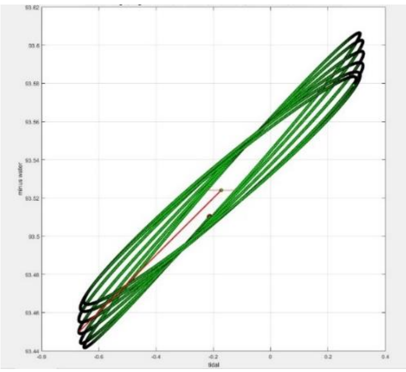

Fig.4a. Movement is only “clockwise”. M2 filtration. The influence of the atmosphere was not removed.

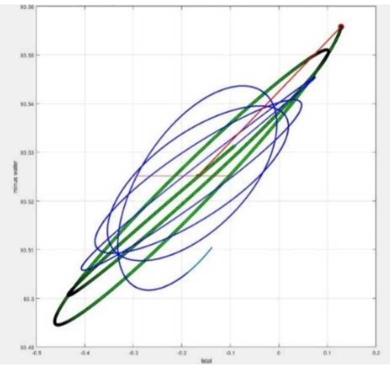

Fig.4b. Movement “clockwise” (green) and “counterclockwise” (blue). M2 filtration. The influence of the atmosphere was not removed.

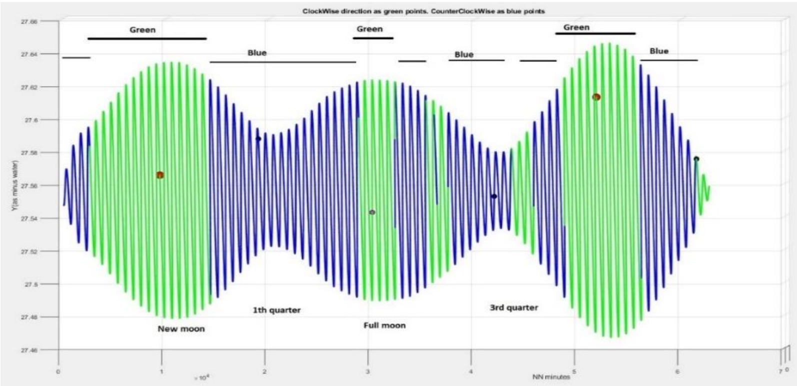

Fig.5. Marneuli 2024, M2, Y(minus water), the influence of the atmosphere is removed. Phase shift >0 (advanced, green). Phase shift <0 (delay, blue).

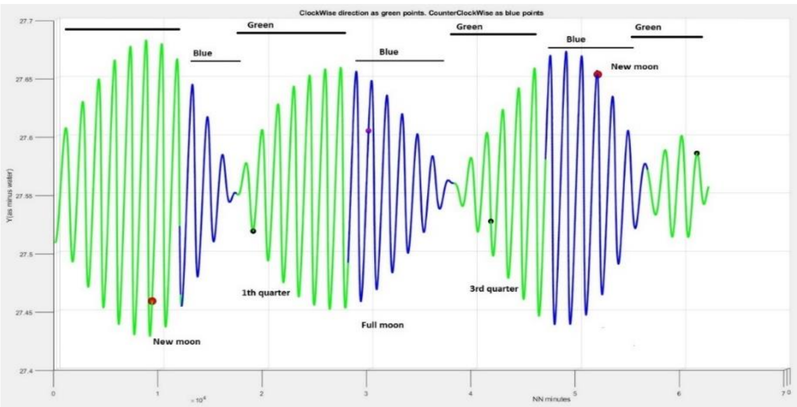

Fig.6. Marneuli 2024, O1, Y(minus water), the influence of the atmosphere is removed. Phase shift >0 (advanced, green). Phase shift <0 (delay, blue).

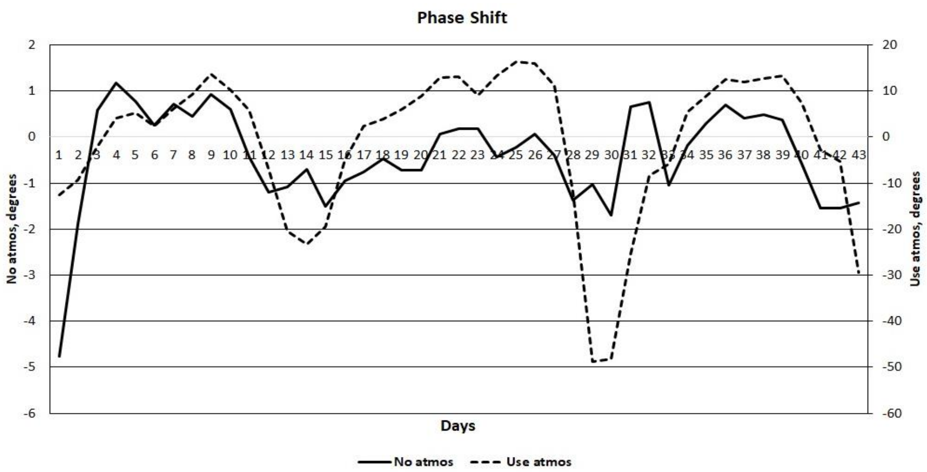

Fig.7. Phase shift, Marneuli, January 5-February 17, 2024, M2 filtration. The influence of the atmosphere is removed (no atmos, solid line) or saved (use atmos, dashed line).

Note that if the influence of the atmosphere was not removed from the water level, then the magnitude of the phase shift and the range of changes turn out to be significant. If the influence of the atmosphere is removed from the water level, then the scatter of the phase shift is an order of magnitude smaller (Fig.7).

In [1], when calculating the phase shift, time intervals of 30 days were used. From the above figures it can be seen that the choice of time interval can affect the average value of the phase shift and even its sign.

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საქართველოს ჭაბურღილებში წყლის დონის ფაზური წანაცვლების ნიშნის ცვლილება

გ. კობზევი, გ. მელიქაძე, თ. ჯიმშელაძე

რეზიუმე

საქართველოს ტერიტორიაზე განლაგებული ჭაბურღილების მაგალითზე, ნაჩვენებია გრავიტაციასა და წყლის დონეს შორის ფაზურ წანაცვლების ნიშნის რეგულარული ცვლილების შესაძლებლობა.

საკვანძო სიტყვები: ფაზური წანაცვლება, წყლის დონე, გრავიტაცია, ელიფსის მეთოდი.

Изменения знака фазового сдвига уровня воды в скважинах Грузии

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Резюме

На примере скважины Грузии показывается возможность регулярного изменения знака в фазовом сдвиге между гравитацией и уровнем воды.

Ключевые слова: фазовый сдвиг, уровень воды, гравитация, метод эллипса.