Caspian Sea Level Survey with GRACE and GRACE-FO

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Abstract

The Caspian Sea is bordered by Iran, Russia to the north, Russia and the Republic of Azerbaijan to the west, and the Republics of Turkmenistan and Kazakhstan to the east. The northern part of the Caspian Sea is very shallow. Caspian Sea Level (CSL) has been declining in recent years. In this research, gravimetric satellites have been investigated for CSL. The rate of decrease of the Caspian Sea is 3.87 cm/year. The results also show that the decrease in CSL in the north compared to the center and south is almost half, which needs further investigation.

Key Words: Caspian Sea Level, GRACE, GRACE-FO, Sea Level

Introduction

GRACE-FO's mission is to replace the GRACE satellite. GRACE-FO was launched in March 2018, which is a continuation of the GRACE mission. The GRACE and GRACE-FO tools are designed to measure the mean and time variables of gravity change variables. They can tell the difference in gravity on the planet's surface is equivalent to a 300-kilometer of water only one centimeter thick. GRACE-FO uses the same method to measure gravitational fields as the GRACE mission. The two GRACE-FO satellites are in orbit around each other, about 137 miles (220 km) apart. Small changes in the distance between two satellites, which are caused by the variable pressure of gravity each time it passes through the earth's surface, constitute the measurement. Both satellites are capable of flying forward or backward in the
atmosphere. Each GRACE-FO satellite weighs approximately 600 kg, including about 30 kg of nitrogen fuel used for orbital control maneuvers (Wen et al., 2018). Sasgen et al (2020) have identified rapid ice loss in Greenland in 2019 by GRACE-FO satellites. The reduction in ice loss stems from two unusually cold summers in western Greenland, which are accompanied by snow-rich autumn and winter conditions in the east. Velicogna et al (2020) examined the continuation of ice sheet mass loss in Greenland and Antarctica from GRACE and GRACE-FO missions. The massive 980 Gt increase in Queen Maud Land since 2009 has led to a halt in the mass loss rate of Antarctica since 2016.

In this article, Surface Mass Anomaly (SMA) in Iran with GRACE-FO satellite has been investigated.

**Results and Discussion**

The Caspian Sea has almost no tides. The water temperature of the Caspian Sea is very different in various parts of it. In the north, the average water temperature is reached -12° in winter and 25° in summer. In the south, the average temperature is 16° in winter and 28° in summer (Bruneau et al., 2016).

The water level of the Caspian Sea is constantly changing. Short-term changes last from about ten minutes to four hours and range from about three to twenty centimeters. In the Caspian Sea, barometric pressure-dependent changes are also observed. In high pressure areas, the water level goes down and in low pressure areas, the water level goes up. For one millimeter of pressure change, there is a difference of about 13.5 millimeters in the water level. Winds also affect the sea level. Land-based winds cause water levels to drop, and land-based winds cause water levels to rise. In addition, the water level of the Caspian Sea is subject to annual changes due to precipitation, the amount of water entering it from rivers, evaporation and seasonal changes (Van Baak et al., 2019).

The altitude of the Caspian Sea has fluctuated relative to the high seas in different geological periods. In the years 1900-1929, the Caspian Sea has passed a relatively calm period and has been 25.6 to 26.6 meters lower than the open sea level. In the years 1929-1977, the water level dropped sharply and from 1978-1995, the water level of the Caspian Sea increased by 2.5 meters. The average annual increase in sea
water is 14 cm, and this amount has increased up to 2.5 times in some years (Kostianoy et al., 2019).

In this paper, the steps of Ciraci et al (2020) are used to obtain SMA. Figure 1 shows the changes in the time series north, south, center of the Caspian Sea Level (CSL) with a linear trend. The results show that the CSL is generally declining and an average rate of -3.87 cm/year. The center and south of the Caspian Sea have almost the same level of decline and the north of the Caspian Sea has a reduced rate of almost half compared to the center and south. Temperature changes in the north and south of the Caspian Sea are not the same, and in the north of the Caspian Sea, cold weather prevails, which causes less decrease of level than in the south.

Figure 1: the changes in the time series north, south, center of the Caspian Sea Level

Statistical characteristics of the north, south and center of the CSL are shown in Figure 2. The minimum CSL in the north is about half that of the minimum in the south and center of CS. Also, the maximum CSL in the center and south is almost
twice that of north CS. In general, due to the elongation of CS at sea latitude, the sea level does not change uniformly and needs further research.

![Bar chart showing statistical characteristics of CSL](image)

Figure 2 Statistical characteristics of the CSL

**Conclusion**

In this study, CSL was investigated with GRACE and GRACE-FO satellites. Significant results have been achieved by applying preprocessing steps to reach sea level. So the changes in CSL in the north and south are not the same. In the north of the CSL, the changes are twice as small as in the south and center of the CSL. A closer look requires measuring in-situ observations and other sensors. However, according to research, the temperature in the north of CS is much lower than the south and center (Bruneau et al., 2016; Van Baak et al., 2019; Kostianoy et al., 2019), which can be the main cause of the difference in CSL. Also, the depth of the CS in the north is less than in the south and center, which can be another effective factor. According to research, the flow of the Volga River is also a reduction that is the main feeder of CS (Seyedvalizadeh et al., 2020). Further research to predict CSL can also be done with artificial intelligence (Memarian Sorkhabi et al., 2015).
References


