Groundwater storage changes for 35 basins over MENA domain using GRACE during the period 2003-2017

Muhammed Eltahan¹,²,³, *, Sabah Alahmadi⁴
¹ Aerospace Engineering Department, Cairo University, Cairo 12613, Egypt
² Now at Institute of Bio-Geosciences (IBG-3, Agrosphere), Forschungszentrum Juelich GmbH, 52425 Juelich, Germany
³ Now at Centre for High-Performance Scientific Computing, Geoverbund ABC/J, 52425, Juelich, Germany
⁴ National Satellite Technology Center, Space and Aeronautics Research Institute, King Abdulaziz City for Science and Technology, P.O. Box 6086, Riyadh 11442, Saudi Arabia.

*Corresponding author e-mail: m.eltahan@fz-juelich.de

Abstract. Change of water storage over Middle East and North Africa (MENA) domain is presented during the period 2003-2017 using satellite data which is provided by the space mission, Gravity Recovery and Climate Experiment (GRACE). Thirty-five basins over MENA domain are selected. Fourteen basins showed positive trend (increase) in water storage while the remaining basins showed negative trend (decrease) in the water storage. Our analysis revealed that most of the basins near the equator had positive trend (increase in storage) in groundwater changes in addition to showing periodic (increasing and decreasing) change. Volta basin highest monitored groundwater storage with 24.5cm within year 2010. On other hand, basin CHAASBasin174 has the lowest negative water storage by 20.5cm during year 2015.

1. Introduction
Water is the most important elements in our life on our earth planet. Global water resources were identified with the uncertainty over the global [1][2][3] including the groundwater [4]. Industrial, agricultural and domestic activities beside billion of people consider the groundwater as the main supplying resource for water [5][6]. Lack of wise management and challenges on the under groundwater are introduced heavily in [7]. It is estimated that around 1.7 billion of the global face high stress due to lack of groundwater storage [8].

Climate change add new challenge on the future of the global underground water resources. Some areas may face drought or flood [9][10][11]. Around of 20 % of the global population will be impacted by the decrease in the groundwater based on different numerical climate change simulations [9][12]. Based on the different future climate change scenarios, MENA domain is identified one of the most area that already face high stress water ratio and will suffer more in the near future from the decrease of the ground water [13][14].

Two more important issues are introduced and add challenges in the near future. The first issue, surface and groundwater rights are not finally formalized and agreed between the countries in this
critical region [15][16]. The second identified issue and challenge is the lack of hydrological data and inconsistent and lack of transparency on the existing rare monitored data set. However, some few studies tried to fill this gap [17][18][19]. Observed Satellite data from Gravity Recovery and Climate Experiment (GRACE) [20] mission is considered important opportunity to provide more data about the total terrestrial groundwater in this vital and important area of the planet. In this work, we present the change on the monitored groundwater storage over Middle East and North Africa MENA domain since GRACE mission started to provide its output data till end of mission (2003-2017). These trends are presented over all identified thirty-five basins that cover the whole MENA domain.

2. Data and Methods

American National Aeronautics and Space Administration (NASA) and the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt-DLR) collaborated to launch GRACE satellite gravity mission on 2002 which its mission was ended in 2017. There are three scientific centers that provided both level 1 and 2 products from GRACE measurements. The first office is GeoForschungs Zentrum (GFZ) in Potsdam, Germany. While the second and the third at USA are the Jet Propulsion Laboratory (JPL) in Pasadena, California, and the Center for Space Research (CSR) in Austin, Texas. GRACE space mission provided both unique and new information about the terrestrial water storage.

Errors in the estimated products that generated from GRACE were evaluated to be within 15 mm in polar regions and 40 mm at the Equator [21]. In this work, the presented dataset from GRACE based on the products from the Center for Space Research (CSR) in Austin, Texas [22][23][24][25][26][27][28]. In this study, change of the groundwater storage over thirty-five basins though fifteen years over MENA domain. Selected thirty-five basins over MENA domain are projected on the geograpical map of this domain as shown figure 1.

List of the basins included in this study based on the continental:

In Africa: Nile, Qattara, Araye, Thamit, Irharhar, CHAASBasin116, CHAASBasin 200, CHAASBasin 130, Senegal,Tamanrasett, CHAASBasin 122, Bode le Depression, Niger, Lake Chad, Volta, Banadama, Sanaga, Ogooue, Lake Rudoff, Jubba, CHAASBasin125.

In Asia: Muqshin, DAWASIR, CHAASBasin101, CHAASBasin158, CHAASBasin102, CHAASBasin188, Dead Sea, Kizir irmask, Shatt el Arab, Farah, shur, Jaji, Garagum, CHAASBasin174

Figure 1. MENA Domain with the selected 35 basins for this study
3. Results

The results section shows two sets of results, the first set introduces the first twenty basin that showed negative trend (decrease) in the underground storage as shown in figure 2. Most of basins in the north Africa starts to suffer from decreasing of ground water after around year 2007. basin CHAASBasin174 has the lowest negative water storage by 20.5cm during year 2015. The same behavior appeared in most basins on Asia except Kizir irmask basin in Turkey.

While the second set shows the remaining fourteen basins with positive trend (increase) in the groundwater storage as shown in figure 3. All these basins showed periodic oscillation (increase and decrease) trend for the groundwater storage. Volta basin highest monitored groundwater storage with 24.5cm within year 2010.
Figure 2. Twenty-one basins with negative trend (decreasing) water storage over MENA domain through period 2003-2017.
4. Conclusion

In this paper, the change of water storage through thirty-five basins over the MENA domain during period 2003-2017 was investigated. The trends showed that all basins around the equator have periodic and increasing trend of groundwater storage due to the increasing rate of precipitation around the equator. Most of basins in the north Africa starts to suffer from decreasing of ground water after around year 2007. The same behavior appeared in most basins on Asia.

Future work includes investigation of the rate of precipitation over all these basins and establish correlation between the precipitation and the ground water storage using advanced machine learning techniques.

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