Groundwater Storage Changes Detected from Gravity Recovery and Climate Experiment (GRACE) Data in Nile Delta Aquifer.

Ali A. El-Sagheer[1], Maher M. Amin[2], Mervat M. Refaat[3]

and Mohamed A. Freeshah[4]

1 Professor of Surveying & Geodesy, 2 Assoc.Prof. of Surveying & Geodesy, 3 Lecturer of Surveying & Goedesy & 4 Demonstrator at Surveying Department
(All authors at Faculty of Engineering – Shoubra, Benha University)

Abstract

Gravity observations can be used to monitor the groundwater storage variations, through the traditional techniques, which are very difficult due to high cost and strong labor intensity. The system Gravity Recovery and Climate Experiment (GRACE) measures gravity anomalies on the earth to estimate changes in Terrestrial Water Storage (ΔTWS) for a regional area with low cost and wide coverage. GRACE data available from 2003 to 2011 but as a result of just two piezometric maps were available, so in this study, the changes in GRACE gravity data of 2003 and 2006 were used to monitor the Ground Water Storage changes (ΔGWS) in Nile Delta aquifer, which extended from 30° to 31° N and 30° to 31° E of Egypt. (ΔGWS) are obtained by subtracting the soil moisture water obtained from the hydrological models GLDAS (Global Land Data Assimilation System) from (ΔTWS), the effective parameter for study area is soil moisture. This work has the potential to improve Nile Delta Aquifer's groundwater resource management and validate it by comparing (ΔGWS) extracted from GRACE against (ΔGWS) from two piezometric maps provided by Research Institute for Ground Water (RIGW). The results indicate that the maximum and the minimum differences between traditional techniques from piezometric maps and GRACE satellite- GLDAS model calculations are 25 and -11 mm respectively with standard deviation about 15 mm.

***Keywords*:** GRACE, Groundwater, Aquifer, Gravity field, Piezometric and GLDAS

1. Introduction

Groundwater is a necessary resource for many water users in Egypt. As the next war will be on water, especially after the problems happened between the Nile Basin countries and how much Egypt suffers from restrictions in its share of the Nile River water in addition to the urgent need for increasing the cultivated area. Ground water recharge is water that has infiltrated the ground, and moved through pores and fractures in soil and rock to the water table (the depth at which soil and rocks are fully saturated with water). The amount of water that seeps into the ground will vary widely from place to place, depending on the slope of the land, soil type, vegetation, and amount and intensity of rainfall for example, infiltration rates in sandy soil are higher than clay soil or pavement. Recharge is greatest in the spring and falls because the ground is not frozen and plants do not consume large amount of water **(Gotkowitz.M., 2010)**. Recharge maintains the supply of fresh water that flows through the groundwater system to wells, streams, springs, and wetlands. Not all precipitation becomes groundwater recharge some of it runs off the land surface to streams or storm sewers, some evaporates, and some is taken up by plants **(Johnson.S., 2012)**.

Ground water is stored in aquifers, which are water-bearing rock formations that hold water in the inter-particle pore space and cracks within rock material, to locate ground water accurately and to determine the depth, quantity and quality of the water, a target area must be thoroughly tested and studied to identify hydrologic and geologic features important to the planning and management of the resource. Rates of groundwater recharge are difficult to quantify, since other related processes, such as evaporation, transpiration and infiltration processes must first be measured or estimated to determine the balance. To improve water resources management it is critical to develop monitoring systems that provide accurate and timely information on the status of water reservoirs, including water in soil and aquifers. Satellites, in this case (GRACE), have the potential to address the observational gap of monitoring regional water storage changes. The

GRACE mission provides approximately monthly changes in (ΔTWS) on the basis of measurements of the Earth's global gravity field **(Tapley et al., 2004; Wahr et al., 2004).** ΔTWS, as inferred from the gravity measurements, represents a vertically integrated measure of water storage that includes groundwater, soil moisture, surface water and snow. Therefore, in order to infer one component from ΔTWS (e.g., groundwater storage), other components (e.g., surface water, soil moisture) need to be measured or estimated. A number of studies have validated GRACE derived ΔTWS with results from land surface models and with monitored soil moisture and groundwater storage changes. These studies showed that GRACE can be used to evaluate land surface model simulations and to estimate changes in components of the water budget (e.g., evapotranspiration, soil moisture, groundwater, snow water, and basin discharge) **(e.g., Rodell et al., 2004b; Syed et al., 2005; Yeh et al., 2006; Rodell et al., 2006; Niu and Yang, 2006; Hu et al., 2006; Swenson et al., 2008b).**

2. Study area

The Nile Delta aquifer consists of the Pleistocene graded sand and gravel, changing to fine sand and clay to the north. In the floodplain of the Nile, the aquifer is semi-confined, as it is overlain by Holocene silt, clay and fine sand. In the northwestern part of the area, a calcareous loamy layer acts as a semi-confining zone outside the floodplain. The thickness of this zone ranges between 0 and 20 m. In the desert fringes, the semi-confined layer is missing and phreatic conditions prevail. The total thickness of the aquifer increases from Cairo northward to about 1,000 m along the Mediterranean coast **(El Tahlawi .M. R. and Farrag. A. A., 2008)**. The Nile River is the mostly source for feeding supply to this aquifer. The boundary of study area (φ =30 to 31N and λ = 30 to 31E). Apart of Nile Delta aquifer which is common in RIGW piezometric maps for two years 2002 and 2006 (Figure 1).