LESSONS LEARNED FROM COMPARING GAUGE LEVELS WITH LANDSAT AND RADAR ALTIMETRY OBSERVATIONS: CASE-STUDY OF LAKE NASSER (EGYPT)

Stefano Vignudelli[1], Sohair Saad Zaghloul [2], Andrea Scozzari [3], Ron Abileah[4]

[1] Consiglio Nazionale delle Ricerche (CNR-IBF), Pisa, Italy
[2] National Water Research Center, Ministry of Water Resources and Irrigation, Cairo, Egypt
[3] Consiglio Nazionale delle Ricerche (CNR-IGG), Pisa, Italy
[4] Omegak, San Carlos CA, USA

ABSTRACT

This paper follows earlier work showing a new approach to observe water bodies from Earth orbiting satellites [1, 2, 3, 4]. The basic idea was the measurement of the water volume as first developed by Heron, a mathematician and citizen of ancient Alexandria. As the water level rises and falls, the volume of slices of the water column can be measured. Each slice is described by observations of area and level. Heron's formula gives the volume of each slice. The satellite based version of this idea uses Landsat images to measure the surface area and radar altimeters to measure the water level. The fact that both the Landsat and radar altimetry data are freely available for download makes the technique practical.

Following the previous approach, an area-level relationship can be computed and related analysis products can be made, including volume (as a function of time, or the water level, or the water area) and bathymetry (based on the shorelines outlined at various water levels). The technique was demonstrated on Lake Nasser with satellite data from 1998 to 2004, which is the best period with good Landsat imagery and overlapping radar altimetry. Analysis was presented for sections of the lake with areas in the range of 100 to 10,000 km^2, and on smaller areas of connected tributaries (including the canal connection to the Toshka Lake).

The fusion of the two data sets is a simple idea; however, there are many considerations about possible sources of errors in both Landsat imagery and radar altimetry before making the method of routine use. A preliminary analysis would show that most of the observed errors are due to altimeter-derived levels rather than the Landsat-derived surface algorithm [2].

In this paper we use ground truth data from Lake Nasser gauge level station which started collecting data in June 1972 on left bank of the Nile River on the abutment wall at the entrance of the U.S. diversion canal. The reading range is from 165.0 to 185.0 meters and the level of the zero gauge is 0 meters.

In a first step we use in situ averages of monthly min and max. A constant is subtracted from the in situ levels to match the datum of the radar altimeter data. The average is then assigned to the 15th of the month. This not as precise as using daily level readings for the exact dates of the radar altimetry data, however, the preliminary comparisons show good agreement between the two independent data sets.

In a second step, we use in situ daily data for the period 1998-2003 (approximately 60 records) recorded at Landsat dates. We replace radar altimetry with in situ data and the result is a tighter fit to the area-level curve. A close examination of radar altimetry vs in situ levels shows that there are long periods of time when the rms of radar altimetry levels is about 10 cm, and brief periods of time when the rms is very much larger (as large as 1 m).

Although conclusions cannot be drawn being the in situ levels not known for exactly altimeter dates, this has also been noted by other studies in different regions. These largest discrepancies appear to be the same as discrepancies found with using radar altimetry in synergy with Landsat. This behavior will be investigated and discussed. The possible availability of longer in situ time series would permit to better establish what caused (or may have caused) the larger discrepancies.

Lake Nasser could become an important ’test bed' for inland water radar altimetry - for both older data and newer systems - and especially important for exploitation in the Sahara region in synergy with optical imagery to derive water volume variations and bathymetry.

REFERENCE

[1] Abileah R., Vignudelli S., Bathymetry from Fusion of Multi-temporal Landsat and Radar Altimetry, In Proceedings of 6th International Workshop on the Analysis of Multi-Temporal Remote Sensing Images, Trento, Italy, 12-14 July, 2011, 189-192,doi:10.1109/Multi-Temp.2011.6005080, 2011.

[2] Abileah R., Vignudelli S., A Completely Remote Sensing Approach To Monitoring Reservoirs Water Volume, International Water Technology Journal, Alexandria, 1 (1), 63-77, 2011.

[3] Abileah R., Vignudelli S., A Completely Remote Sensing Approach To Monitoring Reservoirs Water Volume, In Proceedings of 15th International Water Technology Conference (IWTC-XV), Alexandria, Egypt, 31 March – 2 April, 2011, 1-17, 2011.

[4] Abileah R., Vignudelli S., Scozzari A., A Completely Remote Sensing Approach To Monitoring Reservoirs Water Volume, European Geosciences Union (EGU) General Assembly, Vienna, Austria, 3-6 April 2011, Vol. 13, EGU2011-10996, 2011.