Influence of large water reservoir construction and filling on dynamics of Earth crust local tilts

T. MATCHARASHVILI, T. CHELIDZE, V. ABASHIDZE, N. ZHUKOVA, E. MEPHARIDZE & T. KOBAKHIDZE
M. Nodia Institute of Geophysics, 1, Alexidze str., 0171, Tbilisi, Georgia
matcharashvili@gtu.ge

It is known that many different types of hazardous influences on the environment may be related to large hydrological structures and water reservoirs. These may be both site-specific, natural hazards as well as manmade, non site-specific hazards. Therefore we aimed to investigate the influence of Enguri High Dam construction and reservoir initial water level variation in West Georgia on the dynamics of local Earth crust tilts. A high arch dam (271.5 m high, 728 m long) was built in the canyon of the River Enguri in 1978, as part of the Enguri Hydroelectric Power Plant. The maximum capacity of reservoir is 1.1×10^9 m^3.

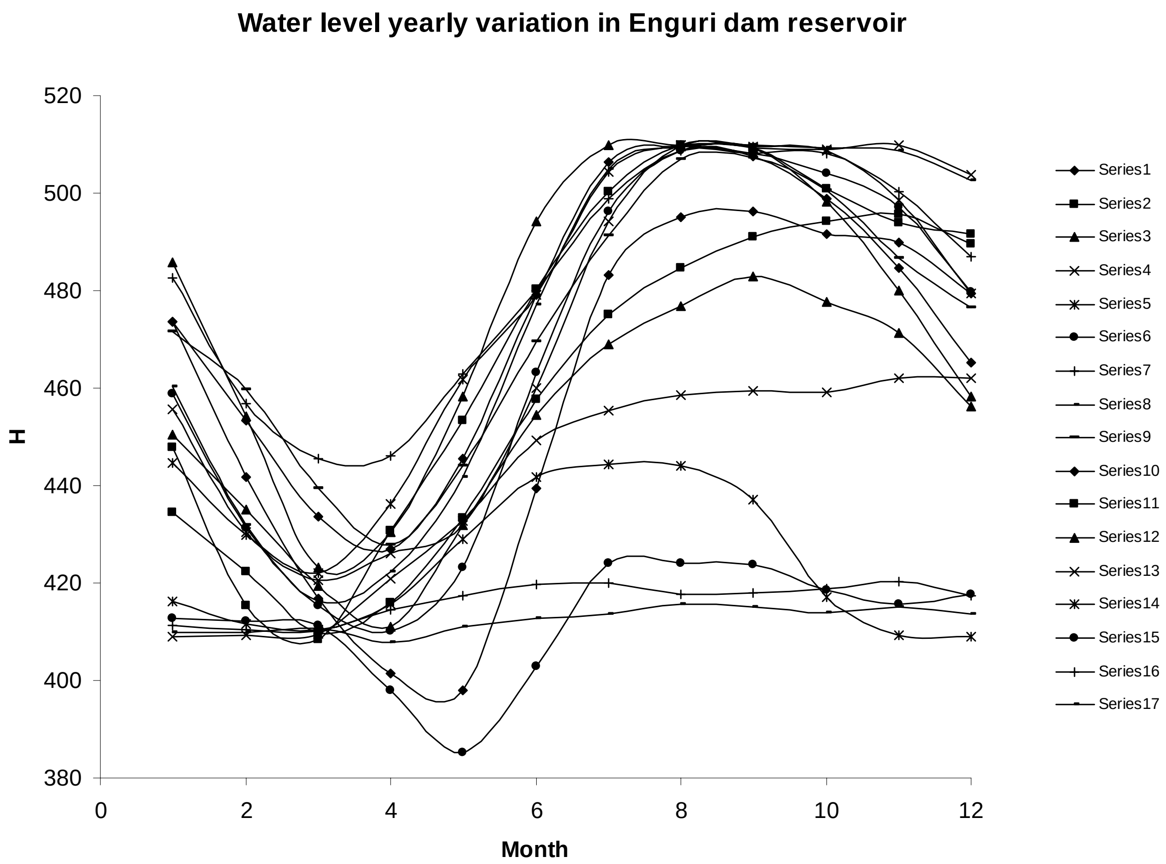

Fig. 1 Yearly variation of water level since start of reservoir filling.

In Fig. 1 the yearly changes of water level in the reservoir are depicted, since 1978 when construction of the high dam was practically accomplished. We see that since the start of water impoundment the level of water gradually increased, and after about 1985 changed periodically. In the present study a series of hourly measured tiltmeter data sequences for 13 years (1971–1983) and water level daily measurements in the reservoir, behind the dam, since the beginning of its filling with water in 1978, were investigated. Tiltmeters have been installed in the high dam foundation. In order to assess the influence of anthropogenic impact caused by dam construction, as well as the influence caused by the start of filling of the reservoir on Earth tilt generation, we considered the following time windows: long before water reservoir filling, immediately before and just after the beginning of water reservoir filling, after the second, third and fourth stage of water reservoir filling and long after completion of water reservoir filling. Thus the time period of observations considered included 8 years before and 5 years after the start of filling of the large water reservoir of Enguri Power Plant. The time series recorded for the first 8 years comprised tiltmeter measurements at the very beginning of the high dam construction process, when anthropogenic influence could be considered as practically negligible, but the last 5 years included a period when the high dam was already constructed and the tilt process of the Earth crust was influenced by an increased amount of water in the reservoir. All available water level variation and tiltmeter data sets have been handled by modern methods of time series linear and nonlinear analysis such as: spectral and time frequency characteristics calculation, testing of long-range properties of data sets by detrended fluctuation analysis, correlation dimension and maximal Lyapunov exponent calculation (according to Kantz & Schreiber, 1998; Marwan *et al.*, 2002; Sprott, 2006; Matcharashvili *et al.*, 2007, etc.).

By our analysis it was shown that, with or without manmade influence or water-level variation. The Earth tilt process is characterized by linear and nonlinear patterns, which are typical for the low-dimensional dynamics. Such low-dimensional processes, though, are much more complex than quasi-periodic processes, but are still non-random due to their internal dynamical structure. It was quite logical that the dynamics of Earth tilt behaviour, according to its (measured) recurrence properties, revealed the presence of detectable and quantifiable dynamical structure.

According to our results, the general nonlinear characteristics of dam foundation tilts have not changed qualitatively during dam construction or reservoir filling conditions, although some small quantitative differences in dynamics were detected.

This is an important conclusion, because it clearly demonstrates the absence of essential changes in the local to high dam Earth-crust dynamics and provides a basis to assume that supposedly high-dimensional hazardous changes in behaviour of the high dam body could be detected for the real-time safety monitoring purposes of the dam and water reservoir.

Acknowledgements The authors acknowledge financial support from STCU and GNSF (co-operative grant STCU-5016/GNSF 09/548) for this work.

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