AN EMPIRICALLY BASED WIND DRIVEN WAVE NOWCASTING SYSTEM: CASE STUDY OF SALTO CAXIAS RESERVOIR IN BRAZIL

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ABSTRACT

This paper summarizes the development of an empirically based wind driven nowcasting system designed to estimate the wave fields in lakes and reservoirs. The wave heights are determined by empirical models that require the wind intensity and fetch as the input parameters. Acquisition of wave data will be carried out by means of remote sensing ultrasonic measuring devices and will be used for validation of the system in the near future. A description of the study area, the wave monitoring equipment and the computational model are presented. Results obtained in terms of the wave heights for the case study of Salto Caxias reservoir in Brazil are delineated.

1. INTRODUCTION

It is noteworthy the scarcity of automated global access systems designed to simulate and forecast the wave fields generated by the wind action in lakes and reservoirs. Few examples of advanced regional systems are those administered by the National Oceanic Atmospheric Administration (NOAA) for the Great Lakes in Canada and in the United States. The difficulties in the development of such systems are usually associated to the high investments required in the acquisition and maintenance of telemetric systems in bounded water bodies and to the complexity involved in the development of numerical models capable of processing large amounts of data and mapping the results to automated platforms. With these aspects in mind, this paper presents the development of an empirically based wind driven wave nowcasting system, which consists of a high performance fully automated computational model named ONDACAD and a wave monitoring system that will be integrated to the model in the near future. Results obtained in terms of the wave heights are presented for the case study of Salto Caxias reservoir in Brazil.

2. AREA OF STUDY

The area of study comprehends the Salto Caxias reservoir located in the southwest region of the State of Paraná in Brazil. This is the fifth and most downstream reservoir of the Iguaçu River, which occupies an area of 141 km^2. The reservoir main axis is about 96 km long and it is highly dentritic and meandering.

3. WAVE MONITORING SYSTEM

Acquisition of wave data will be performed by means of a system named LOG_aLevel developed by General Acoustics, a company located in the city of Kiel, Germany. The system consists of a remote sensing, stand alone, water level gauge on the basis of ultrasonic sensors that are free of calibration or maintenance needs. The high performance ultrasonic sensors ensure reliable and precise measurements of water levels and its dynamics because they operate with very narrow sound beam that have angle of 3 degrees and perform the measurements in a frequency of 5 Hz. The wave monitoring system will be installed at the near field of the Salto Caxias Dam and will be integrated to the ONDACAD model in the near future.

4. ONDACAD MODEL

The ONDACAD is an empirically based wind driven model designed to simulate the wave heights in lakes and reservoirs. A model subroutine creates a 2-D rectangular mesh that encloses the water body. Then, the fetch is determined at each mesh cell by the method of Saville, as described in the study of Marques and Guetter [1]. The wave heights are determined by parametric equations, such as the SMB, extensively employed by the United States Department of Interior - Bureau of Reclamation [2]

$$H_{1/3} = \frac{U^2}{g} 0{,}283 \tanh\left[0{,}0125 \left(\frac{gF}{U^2} \right)^{0{,}42} \right], \quad (1)$$

where F is the fetch, U is the wind velocity, g is gravity and $H_{1/3}$ is the significant wave height. The model assumes uniformly wind distribution and does not account for the effects of (i) wave refractive or diffractive propagation, (ii) wave-wave and non-linear interactions, (iii) depth-induced wave breaking and (iv) bottom dissipation. The main advantages of the model are (i) the ability of processing large amounts of data and providing the results in form of maps to automated online platforms, (ii) the high performance in terms of computational time, (iii) the low cost of implementation and operation, and (iv) the potential of obtaining satisfactory results for applications of wave nowcasting in lakes and reservoirs.

5. RESULTS AND DISCUSSION

Wind data are measured in the State of Paraná by the Sistema Meteorológico do Paraná - Simepar. Hourly records of severe events for the period between 1997 and 2005 were processed by Gonçalvez [3] and employed in the present study. Table 1 summarizes the intensity of the wind and the corresponding returning period for the Salto Caxias reservoir region.

Table 1 Returning period and wind velocity

RP (yr)	10	20	50	100
U (m/s)	25,7	29,3	38,2	50,9

The ONDACAD model produced forty four wave maps using the described wind conditions under several directions. The highest waves reached the order of 250 cm and were generated by the most severe north and north to northwest oriented winds. Figure 1 illustrates a single map of the wave heights in cm produced by the north oriented winds of 50.9 ms-1.

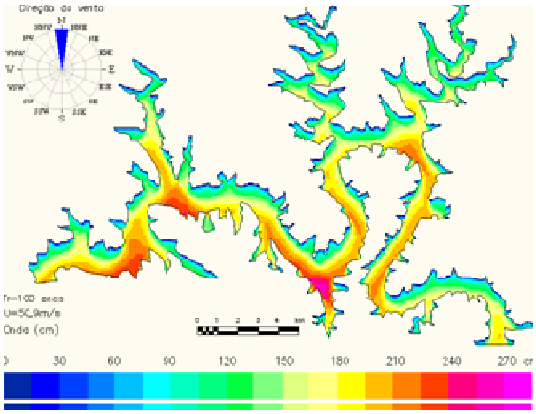

Figure 1 Wave heights for Salto Caxias

The next steps in the system development are (i) the integration of the wave monitoring system to the ONDACAD model, and (ii) validation of the results against monitored and SWAN data.

REFERENCES

[1] Marques, M. Guetter, A. K. 2011. Determinação da distribuição do Fetch no Reservatório de Itaipu. In: XIX Simpósio Brasileiro de Recursos Hídricos. Maceió/AL, Brasil, Nov/2011.

[2] Marques, M. Guetter, A. K. 2011. Estimativa com modelo paramétrico dos campos de ondas geradas por ventos severos no reservatório de Itaipu. In: XIX Simpósio Brasileiro de Recursos Hídricos. Maceió/AL, Brasil, Nov/2011.

[3] Gonçalves, R. C. 2007. Análise de freqüência regional de ventos extremos no Paraná. Dissertação de mestrado. Universidade Federal do Paraná. Curitiba, PR.

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