FIELD MEASUREMENTS AND NUMERICAL MODELING OF WIND-WAVES IN LAKE BIEL: A BASIC TOOL FOR SHORE PROTECTION PROJECTS

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Large lakes in Switzerland, as many other lakes in Europe, suffer from severe beach erosion. In order to thwart the continual regression of shores, systematic analysis of the effect of wind-waves on natural shores is undertaken. It allows a comprehensive understanding of the impact of waves on the surf zone, generated during mean as well as extreme wind events. The investigation is carried out on the basis of in situ wave measurements, and numerical modeling. It aims at providing an adequate wave prediction tool for shore protection projects. The proposed methodology (Fig. 1) is applicable, not only for the present case study, but for other confined water surfaces, where fetch limited conditions prevail.

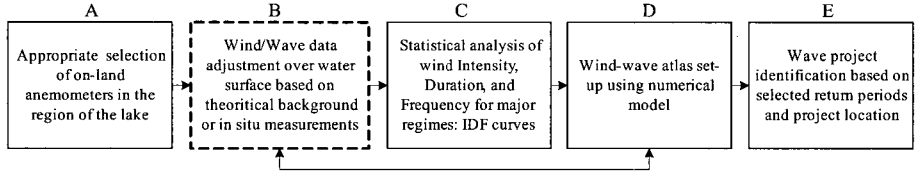
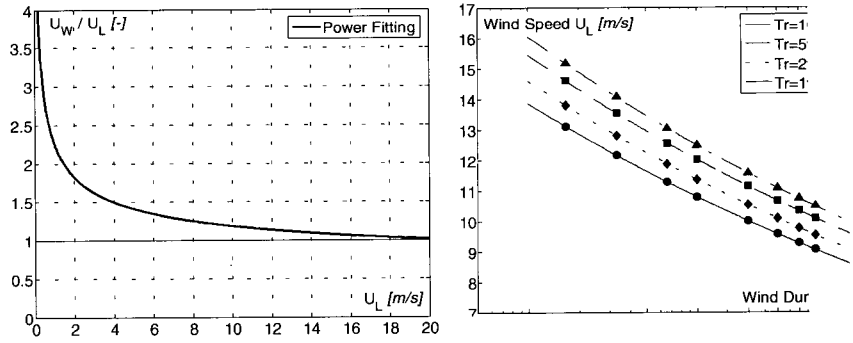


Fig. 1 The proposed methodology for the selection of the design wind-waves for shore protection measures in lakes

When using the concept of relating wind and wave statistics, focus has to be put on the determination of the over water wind statistics from over land statistics. Since the wind statistics are based on wind data measured over land, the transition ratio to wind over water is therefore to be determined. A rough correlation showed that, during mean wind conditions at Lake Biel, the over water wind speed is approximately 25 % higher than the over land wind speed (Fig. 2a). The IDF (Intensity-Duration-Frequency) curves (Fig. 2b) are based on statistical analysis of 26 years of over land wind measurements at Payerne, 30km southwest of Lake Biel. For defined wind duration and selected return period (Tr),

the curves provide a corresponding wind speed. In reality, by providing wind speed, such curves are relevant for the calculation of wind-waves in lakes for a defined return period.

The numerical wave simulations for Lake Biel are carried out using the model *Simulating Waves Nearshore* (SWAN). It incorporates the physical processes of refraction, shoaling, wave breaking, bottom friction, nonlinear wave-wave interactions and wind set-up. The comparison of modeled and measured wave data (Fig. 3) proved the applicability of SWAN for lakes (with slight changes in the default parameter set). During the "Le Vent" wind regime (south-western wind), the maximum wave heights and periods amount to 0.5m and 2.5s at the eastern nearshore region of Lake Biel. For Lüscherz, where in situ measurements are carried out, the time-series of significant wave height of both, numerical model and measurement, are given in Fig. 3a. The model results and measurements are in good agreement.



(a) (b)

Fig. 2 (a) Ratio of wind speed over water U_W at Lüscherz to wind speed over land U_L at Payerne according to U_L, for a wind sector 180° to 300°; (b) IDF curves for long term analysis of wind measurement data (year 1978 to 2003 at Payerne wind station)

The non-stationary numerical simulations reveal that wind triggers the wave conditions in Lake Biel with a comparably short response time of a few hours. Besides of long-term non stationary modeling (Fig. 3b), the wave statistics may therefore also be calculated by stationary modeling of characteristic wind conditions (3 hours).

The wave atlas proposed for Lake Biel, could be applicable thus for any shore protection project in this lake. An application of the proposed methodology for building reliable wave atlas could be similarly carried out not only for the remaining lakes in Switzerland, but for any confined water surface where wind-wave conditions prevail.

Keywords: In situ measurements; Wind and wave prediction; Numerical wave modeling

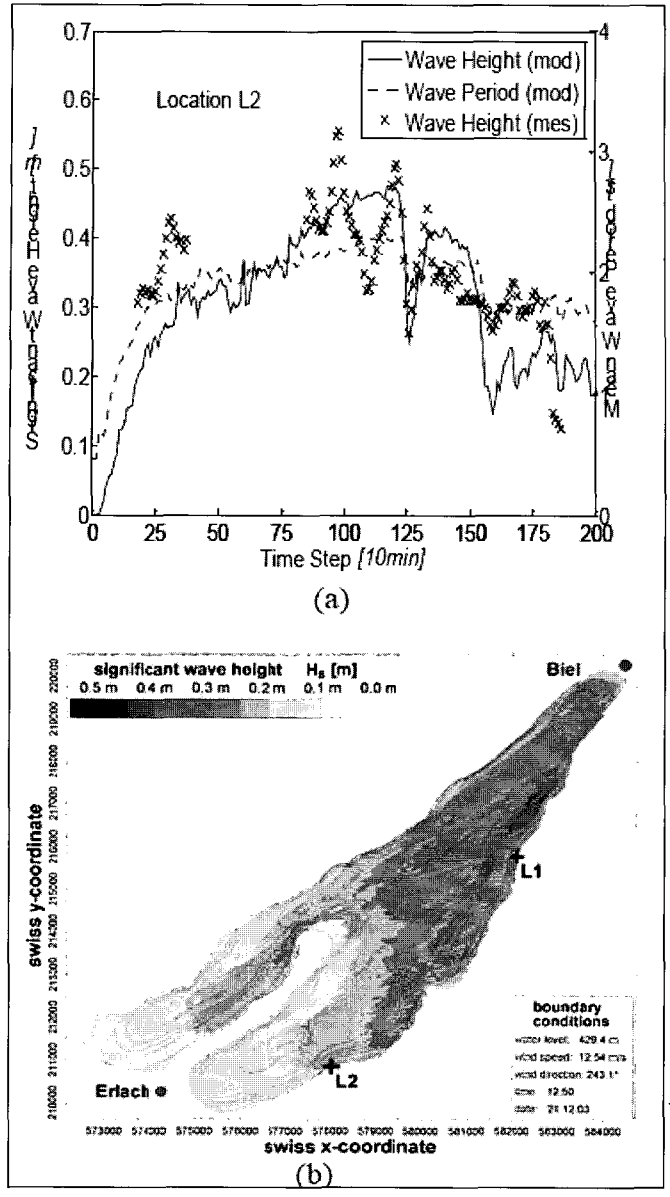


Fig. 3 (a) Time-series of significant wave height and mean wave period derived form (a-b) in-situ wind measurements and numerical modeling at Lüscherz (L2); (b) Wave field in Lake Biel during an event of "Le Vent" (Dec. 20-21.2203)