

Assessment of wave risk for Swiss lakes: Numerical simulation of waves of different return periods

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INTRODUCTION

Wind induced wave parameters are important factors for assessing the wave risk on shoreline and design of coastal structures. Determination of the extreme wave conditions is often not possible with measurements due to time limitations. The proposed methodology transfers wind statistics into wave statistics using numerical simulations. The study aims to develop a wave atlas for the principal lakes of Switzerland. The results are then published on a free-access internet platform.

METHODOLOGY

To model wind induced waves over a lake two types of data is required: the topography of the lake (bathymetric data); and the data related to the wind which blows over the lake and generates the waves (anemometric data). Once the data is collected and processed, the appropriate wind scenarios are defined. Spectral wave model SWAN is then used to simulate waves.

WIND SCENARIOS

Wind scenarios definition is based on the data collected by ANETZ weather stations located in the neighbourhood of each lake of interest. Wind roses corresponding to each station are then generated and analysed to identify the predominant winds. For each predominant wave, IDF (Intensity-Duration-Frequency) curves are calculated to get the wind speed as a function of the duration of the event for return time of 2.3, 20 and 50 years corresponding to frequent, rare and very rare events respectively.

Swiss lakes are embedded in Pre-alpine regions, where the lake is surrounded by mountains and hills. So, wind directions can strongly vary spatially due to local topography. As such, each wind scenario is implemented in the model of wave generation as a vector field. Those wind fields are derived from meteorological data (COSMO-2) which

consist of daily forecasts made with a spatial resolution of 2.2 km (see meteoswiss.ch). For each predominant wind, the dates of extreme events are extracted. Corresponding COSMO-2 wind fields for those events are then compared one to one and with the ANETZ measures and a representative wind field is chosen for each predominant wind. An example of Joran wind field over Jura lakes is shown in Figure 1.

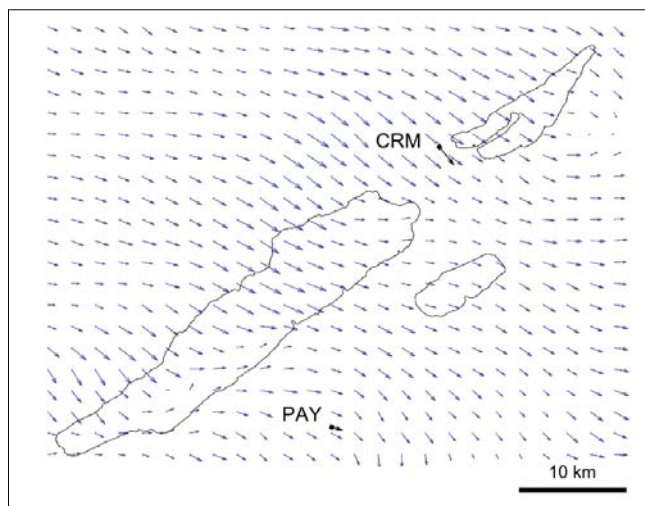


Figure 1. Wind field for the Joran wind (blowing from NW)

WAVE SIMULATIONS

For wave simulations, the geometry of each lake is generated with unstructured meshes. Simulating Waves Nearshore (SWAN) numerical model developed at Delft Technical University (see <http://swanmodel.sourceforge.net/>) is used to perform wave simulations.

Reflection, refraction and shoaling phenomena are included in the model. For each lake, each predominant wind and each return period, the waves induced by different wind duration are aggregated in order to extract the maximum envelope of the wave's significant height. The determining waves for a given predominant wind and return time can therefore be visualized on a single map although they are generated by events of different durations.

RESULTS

Results are compiled on an internet platform, www.swisslakes.net. After selecting the lake of interest, the user can visualize wave significant height (Hs) for the different wind and return time. Clicking on any point of the lake, display the corresponding wave rose (Figure 2) that summaries all the results.

CASE STUDY AND CONCLUSIONS

Knowing the wave characteristics at shoreline

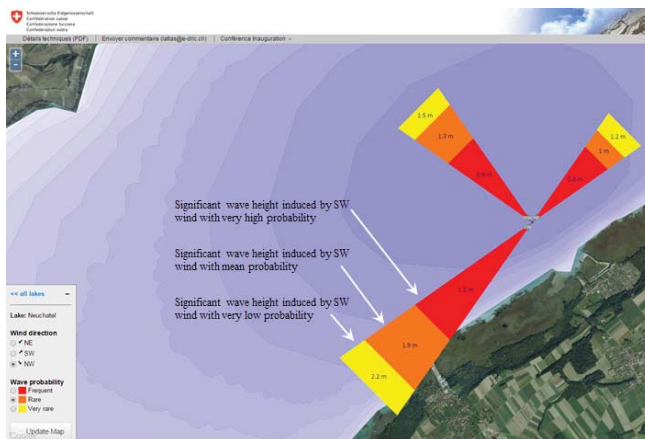


Figure 2. Example of internet platform presenting a wave rose at the selected point (www.swisslakes.net)

allows to assess the risk associated to natural wave hazard. The wave information is valuable for construction projects on shoreline or off-shore, e.g. protection dikes, harbours, or floating platforms. An example of such application is the risk assessment study of a walking trail project by the Geneva Lake in La-Tour-de-Peilz. Momentum (M_R), horizontal (F_h) and vertical (F_v) wave forces on the structure in extreme events are calculated using

KEYWORDS

Wave risk assessment, wind induced waves, significant wave height, numerical simulations, internet platform,

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wave data presented on swisslakes.net. The risk associated with extreme wind event can be calculated this way. Such risk analysis allows appropriate design of the structure and guarantees the life-security of the pedestrians in extreme wind events.

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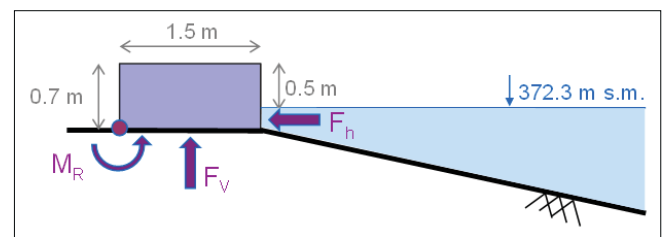


Figure 3. Wave forces (F_h , F_v , M_R) on a dyke designed for pedestrian walking trail by the Geneva Lake