

Bachelor's Project

Short-Term Prediction of Dangerous High Water Levels

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1 Introduction

The Dutch Ministry of Waterworks (Rijkswaterstaat in Dutch) has constructed storm surge barriers to protect the surrounding from a flood. The Oosterschelde storm surge barrier was built for safety by taking into consideration the effect it has on nature. Mainly, the area is a home for many aquatic animals especially for mussels and oysters. The Oosterschelde storm surge barrier is dynamic and it is supposed to be closed whenever there is an emergency that could bring damage to nature and the community. By the law the barrier should be closed only when the water is 3 metres above sea level in 10 minute average at the point of measurement RPB. When the water level is 2.75 metres above sea level, it is considered as an emergency. At this moment, emergency team should physically be there. Nevertheless, the team cannot just close even if the state of the water is in an emergency. What they do is that they keep on checking the water level and close it if they think it will exceed 3 metres above sea level and as a result it brings damage. But it is not always the case that an emergency call, when the water level is 2.75 metres is really an emergency call. It may happen that the water level goes down even after it gets to 2.99 metres. Hence, before closing the barrier, the responsible people have to make sure that the water level really exceeds 3 m above sea level. The challenge they have at this moment is when the water level gets exactly 3 metres above sea level, the 10 seconds measurement may exceed 3 m, and if no measure is taken, the barrier closes automatically. For the automatic closure the emergency team has no control. Afterwards, it may happen that the water level gets up, more than 3 metres or it immediately gets down. The ministry requires them to close the barrier only if the emergency call causes damage. Currently, they use their gut feeling to decide if the barrier should be closed or not based on internal information.

2 Project Goals

The main goal of this project is to develop a short-term prediction model that gives an advice on when to close the barrier looking into the future and taking into account factors affecting the water level. One of the factors affecting

the water level is wind; high wind speed lifts the water up as a result the water level increases. The measurement at RPBU are taken at an inner harbour. The geometry of the inner harbour causes oscillations in the water levels with a more or less known periods (the longest one being almost 10 minutes). Due to regulations, these oscillations may not be filtered away but should be taken into account in the short-term prediction model.

Currently the following model is investigated together with Dutch Ministry of Waterworks:

$$Y(t) = \alpha_0 + \alpha_1 * t + \alpha_2 * t^2 + A_1 * \sin(2 * \pi * (t - \varphi_1) / T_1) + A_2 * \sin(2 * \pi * (t - \varphi_2) / T_2) + A_3 * \sin(2 * \pi * (t - \varphi_3) / T_3) + \varepsilon$$

This model is linear in the parameters A_1 , A_2 and A_3 and non-linear in the other parameters. It can be fitted efficiently with a special algorithm (available in R). There are specific problems that need to be solved in order for this model to predict well on actual data:

1. choice of appropriate initial values for the non-linear parameters
2. choice of time window used in fitting
3. extension of this model with wind data