EFFECTS OF ESTUARY'S GEOMETRY AND BATHYMETRY ON EXTREME WATER LEVELS, STUDY CASE: MANUKAU HARBOUR, NEW ZEALAND.

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INTRODUCTION

The present work aims to understand the potential effects of bathymetry and geometry on the total water level in Manukau Harbor in the present and future projections of sea-level rise. Our study site is in the southwest region of Auckland, Figure 1. The tide is mesotidal amplitude, and the estuary has a prismatic geometry, extensive tidal zone, and depths ranging from 30m (close to the estuary entrance) to 1m in the inner channels. We analyzed the observed total water level in 2 tide gauges. The first one, located outside the Harbor, is the Anawhata tide gauge – managed by the National Institute for Water and Atmospheric Research (NIWA) –; the second, located in the inner estuary, is the Onehunga tide gauge, managed by the Auckland Council.

Figure 1. Manukau Harbor and the location of Anawhata and Onehunga tide gauges.

METHODS

Our methods can be divided into two sessions, the data and numerical analysis. The first consists of data preparation and statistical analysis between Anawhata and Onehunga water-level time series to identify the potential physical processes occurring within the Manukau Harbour. The data preparation follows Stephens *et al.* (2020). It consists in removing the effects of historical sea-level rise from the water level distribution by filtering the hourly water-level measurements using the 1-year-running-average filter. The astronomical tide is calculated year-by-year from the filtered data by performing a harmonic analysis. The non-tidal residual (NTR) is calculated by subtracting the astronomical tide from the filtered water-level data. The extreme events of water level were selected accordingly to Stephens *et al.* 2020 by using peaks over the threshold of the filtered water level and applying a declustering scheme of 3 days to ensure the independence of each extreme event. To analyze the effects of the estuary's morphology on the water level, we compared the probability density function and quantiles of Anawhata and Onehunga filtered water level (WL), non-tidal residual, and astronomic tide. We also assessed the co-occurrence of the extreme events inside and outside the harbor using a time window of +-3 hours between the peak of water level outside (inside) and inside (outside) the harbor. The second session is a numerical modelling study that aims to provide a detailed assessment of the physical processes identified by statistical analysis and understand how these physical processes will behave under future projections of sea-level rise. We set a hydrodynamical model using Delft-3D FLOW, Figure 2. The boundary conditions are the tide levels from the regional tidal model of the National Institute for Water and Atmosphere (NIWA) and the bathymetry data from Land Information New Zealand (LINZ) (e.g., LiDAR for intertidal zones), digitalized nautical charts (for shallow waters), and NIWA New Zealand bathymetry (for deep waters).

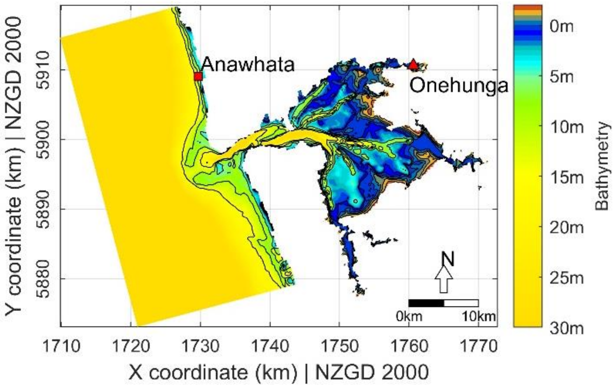

Figure 2. interpolated bathymetry in the model domain.

To identify the physical processes causing the tidal deformation and its relation to the NTR and sea-level rise, we defined the following simulation scenarios, Table 1. The scenario S1 consists of simulating an equinoctial spring tide; scenario S2, an equinoctial neap tide; scenario S3, the 99th percentile of storm surge added to the equinoctial spring tide; scenario S4, the 99th percentile of storm surge plus the equinoctial neap tide; scenario S5, equinoctial spring tide plus 5th percentile of non-tidal residual; and S6, equinoctial neap tide plus 5th percentile of non-tidal residual; and S7, equinoctial spring tide plus R.C.P. 4.5 sea-level projection. The numerical study session is under development, and any results regarding it are shown in this abstract.

Table 1. Simulation scenarios performed for the modelling study

Simulation scenario	Tide	Non-tidal residual	Sea-level rise
S1	equinoctial spring tide	-	-
S2	equinoctial neap tide	-	-
S3	equinoctial spring tide	99th percentile	-
S4	equinoctial neap tide	99th percentile	-
S5	equinoctial spring tide	5th percentile	-
S6	equinoctial neap tide	5th percentile	-
S7	equinoctial spring tide	-	R.C.P. 4.5

PRELIMINARY RESULTS

Two processes affect the WL within the estuary; the WL amplitude increases (max. of 32 cm in the quantile 99%), Figure 3, and the flood dominance intensifies, Figure 4. These effects result from the astronomic tidal amplification, with the M2 component being affected most – e.g., increases from 1.05 m (Anawhata) to 1.33 m (Onehunga) on average for the period analyzed –. The extreme events in Awhata co-occur in 69% with the extremes in Onehunga, and 63% of the extreme events in Onehunga, also occur in Anawhata within +- 2 days.

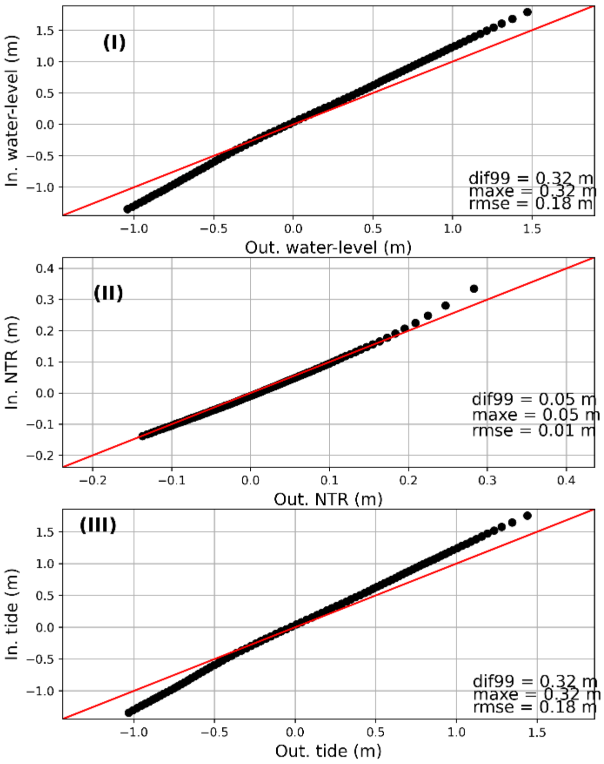

Figure 3. quantile-quantile plot highlighting the tidal amplification in water level (I) and astronomical tide (II) between Anawhata (out) and Onehunga(in).

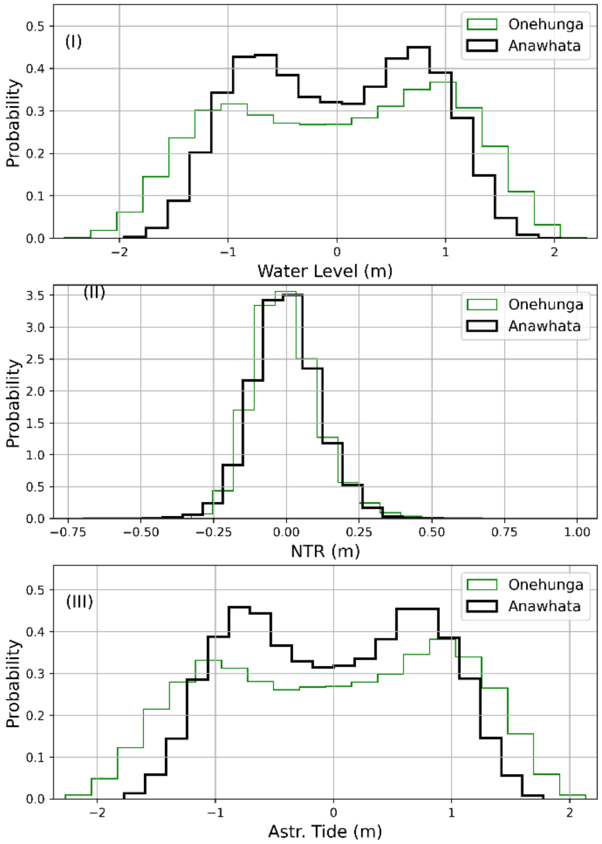

Figure 4. probability distributions of Onehunga (green) and Anawhata (black) showing the tide asymmetry due to Manukau's estuary morphology in water level (I) and astronomical tide (III).

DISCUSSION AND CONCLUSION

Our study shows that the tidal waves and their transformations, when propagated within the estuary, are the main driver for the water-level extremes in Manukau Harbor, which corroborates with the assumption that extreme water levels in NZ are driven mainly by the spring tides, made by previous studies (Stephens *et al.* (2020); Rueda *et al.* (2020)). The tide amplification is probably caused by the steep slope of the bathymetry and the estuary's entrance constriction. The numerical study will be shown at the conference and clarify the processes involved in the tide deformations highlighted by the data analysis. Our findings show the importance of monitoring the sea-level inside estuaries and studying the estuary geomorphology evolution to address the current challenges of mitigating the sea-level rise in coastal areas.

REFERENCES

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