Supplement A

The STUMPF method

The logarithm ratio band (Stumpf et al., 2003) is based on the assumption that the light attenuation increases with the water depth. This method estimates the bathymetry using the ratio of the natural logarithm between the reflectance of two different spectral bands. Assuming that these bands are affected similarly by atmosphere and bottom albedo, the method works because the attenuation rate with depth is dependent on the wavelength. The SDB using the STUMPF method is calculated as follows:

$$Z_{sat} = m1\left(\frac{\ln nR_w(\lambda_i)}{\ln nR_w(\lambda_j)}\right) + m_0$$

Where Z_{sat} is the satellite derived bathymetry, n is a constant in order to assure that the ratio remains always positive and that the ratio will produce a linear response with depth, m_1 is a tunable constant to scale the ratio to depth, and m_0 is the offset for a depth of 0m (Z=0); $R_w(\lambda_i)$ is the reflectance on the surface of the band i and $R_w(\lambda_j)$ is the reflectance on the surface of the band j. Here we used the green and blue band from Sentinel Copernicus, product type 2A images, respectively. To calculate the derived bathymetry, we used a single image dated on 2019/04/06 22:16:09 UTC for Tauranga Harbour only, when the observed tide was 0.94 m above mean sea-level at the Omokoroa tide gauge (at high tide).

The Stumpf-ratio SDB

The ratio method (Stumpf method) was applied for Tauranga Harbour separately for shallow and intertidal areas, and its results can be seen in Figure S1 and S2. The use of this approach generated a high density of estimated points because it provides a value of depth for every image pixel.

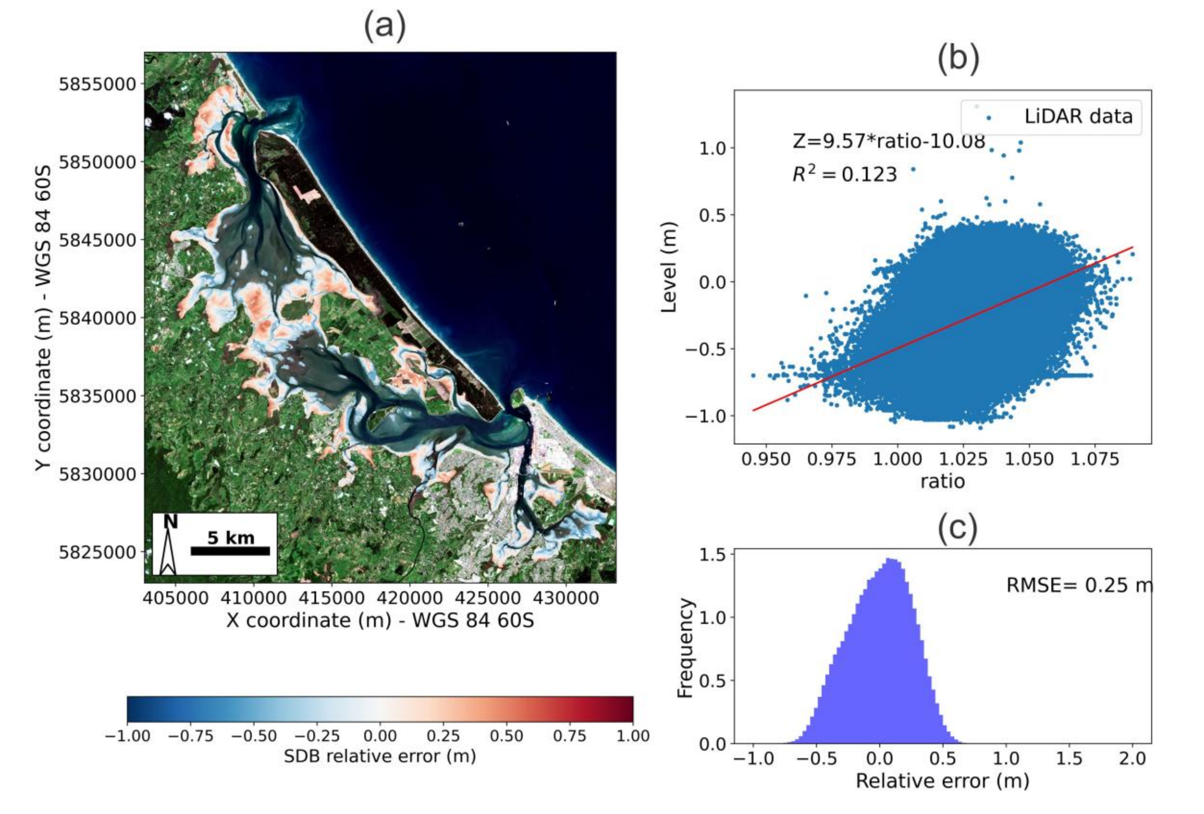
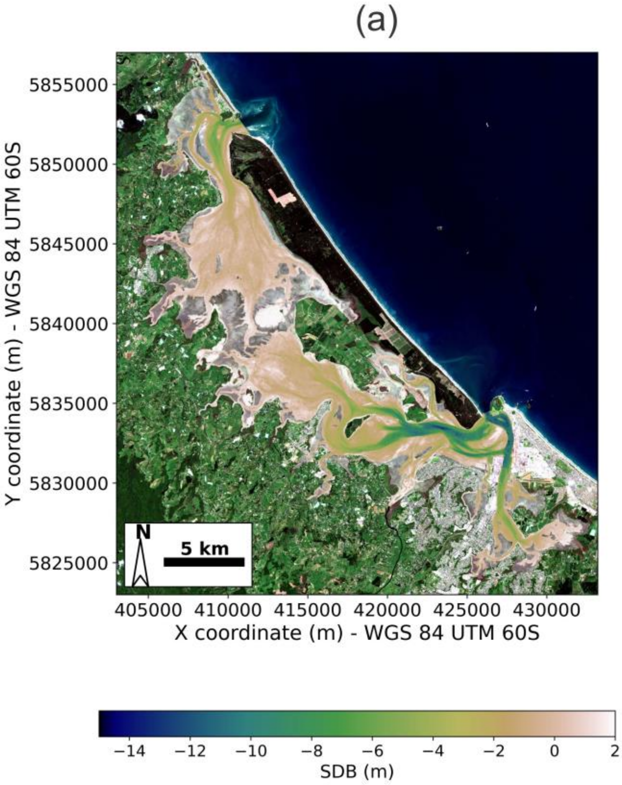


Figure S1. Satellite derived bathymetry for Tauranga Harbour using Stumpf's ratio method. (a) Map showing the estimated bathymetry samples and the spatial distribution of relative error. (b) Ratio method fitting the LiDAR data. (c) Relative error distribution of the SDB using Stumpf ratio method. Background image: ESA Sentinel 2A.



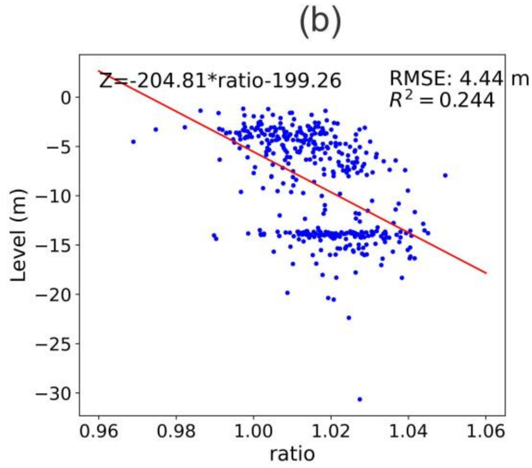


Figure S2. Satellite derived bathymetry for Tauranga Harbour, shallow and channel areas, using Stumpf's ratio method. (a) Map showing the estimated bathymetry samples. (b) Ratio method fitting the LiDAR data. Background image: ESA Sentinel 2A.

Supplement B

Hydrodynamic settings and validation

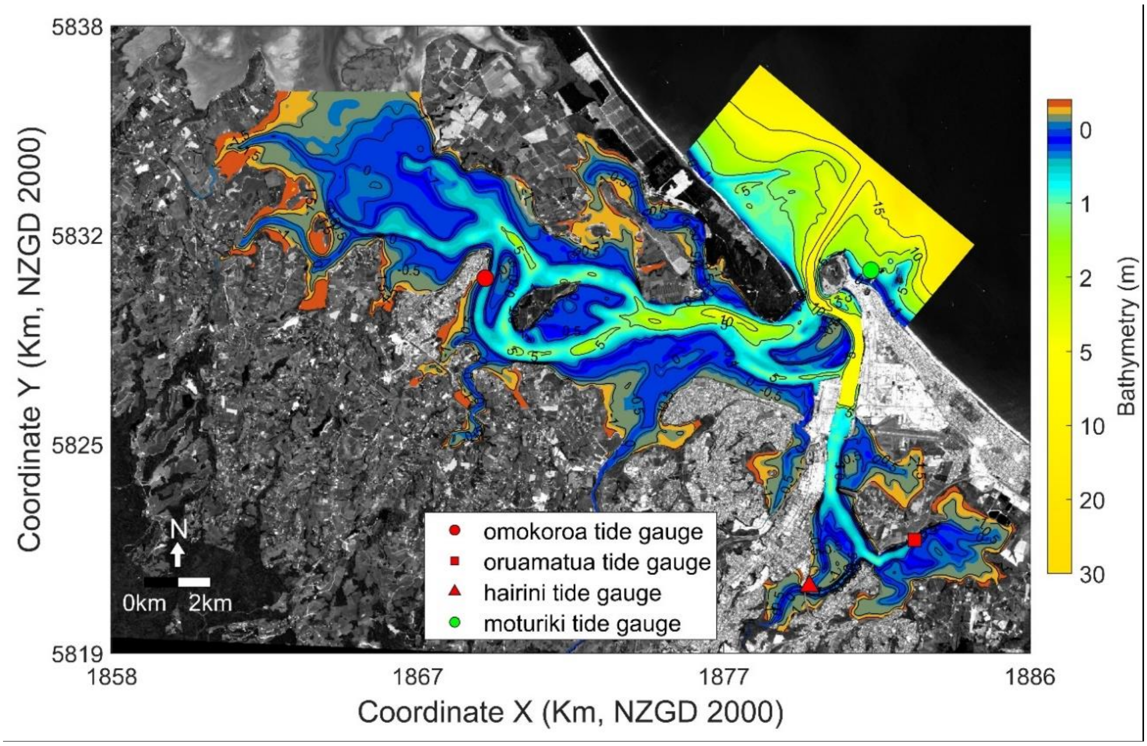


Figure S3 - Tauranga Harbour numerical model. Interpolated bathymetry in the model domain. Vertical reference level: regional mean sea level (Moturiki). Background image: ESA Sentinel 2A.

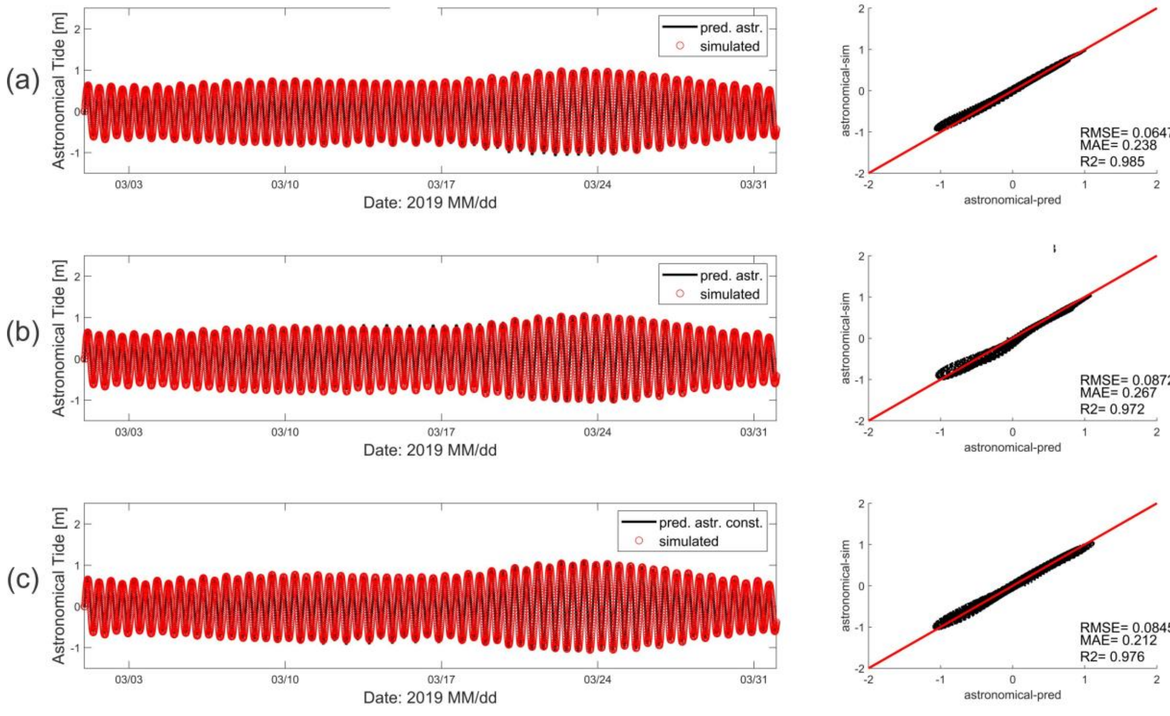


Figure S4 - Hydrodynamic model validation for Tauranga Harbour at three different observation points: the Ōmokoroa (a), Hairini (b) and Oruamatua (c) tide gauges.

Supplement C

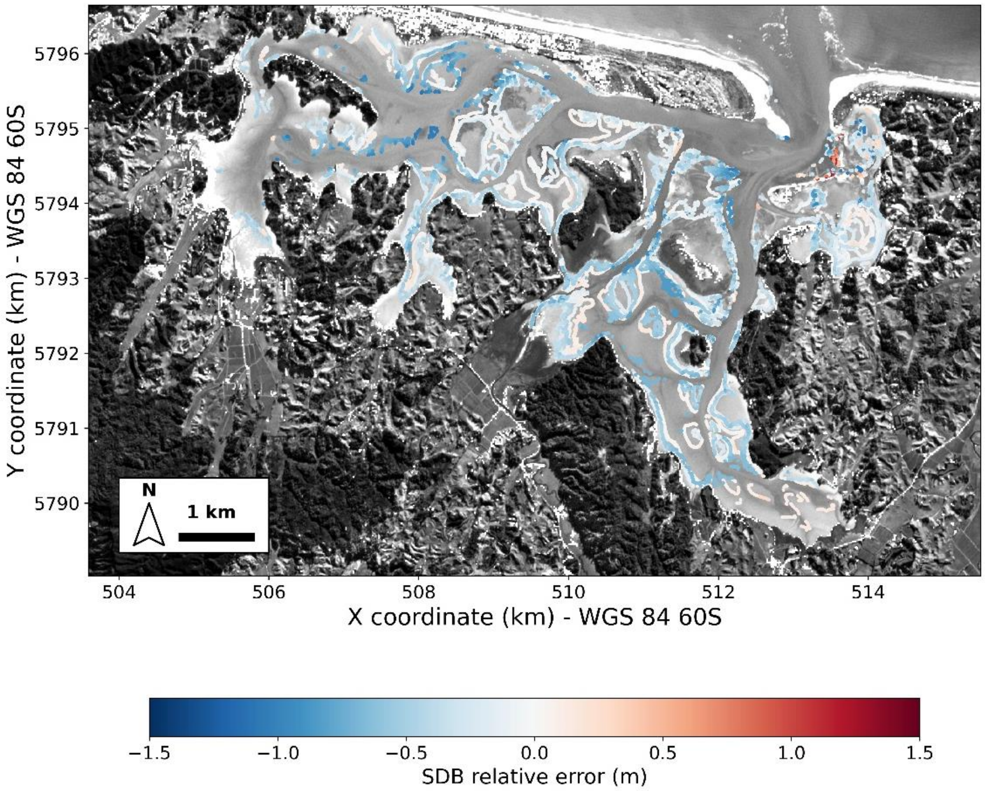


Figure S5. Satellite derived bathymetry for Ōhiwa Harbour using waterline method. Map showing the estimated bathymetry samples and the spatial distribution of relative error. Background image: ESA Sentinel 2A.

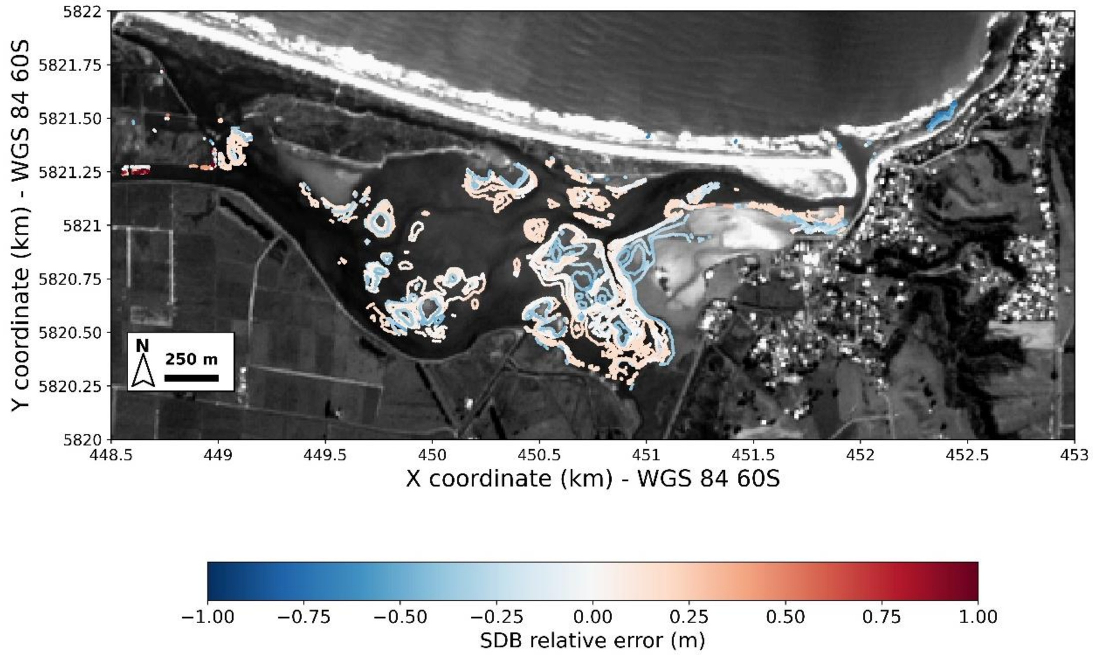


Figure S6. Satellite derived bathymetry for Maketū Harbour using waterline method. Map showing the estimated bathymetry samples and the spatial distribution of relative error. Background image: ESA Sentinel 2A.

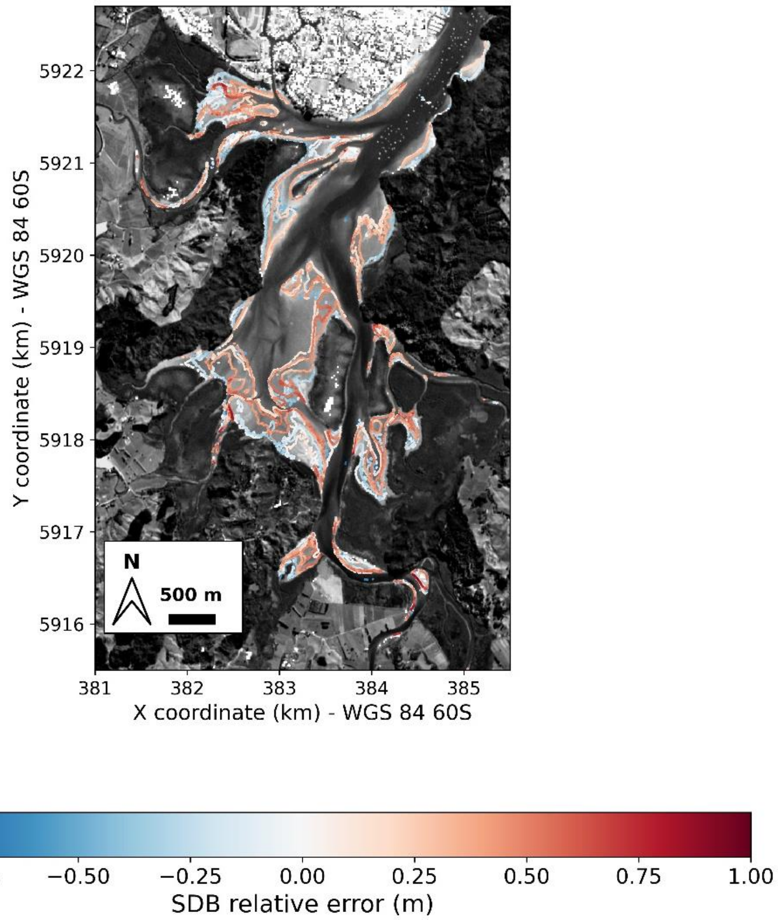


Figure S7. Satellite derived bathymetry for Whitianga Harbour using waterline method. Map showing the estimated bathymetry samples and the spatial distribution of relative error. Background image: ESA Sentinel 2A.

Supplement D

Satellite derived bathymetry use in hydrodynamic modelling assessment.

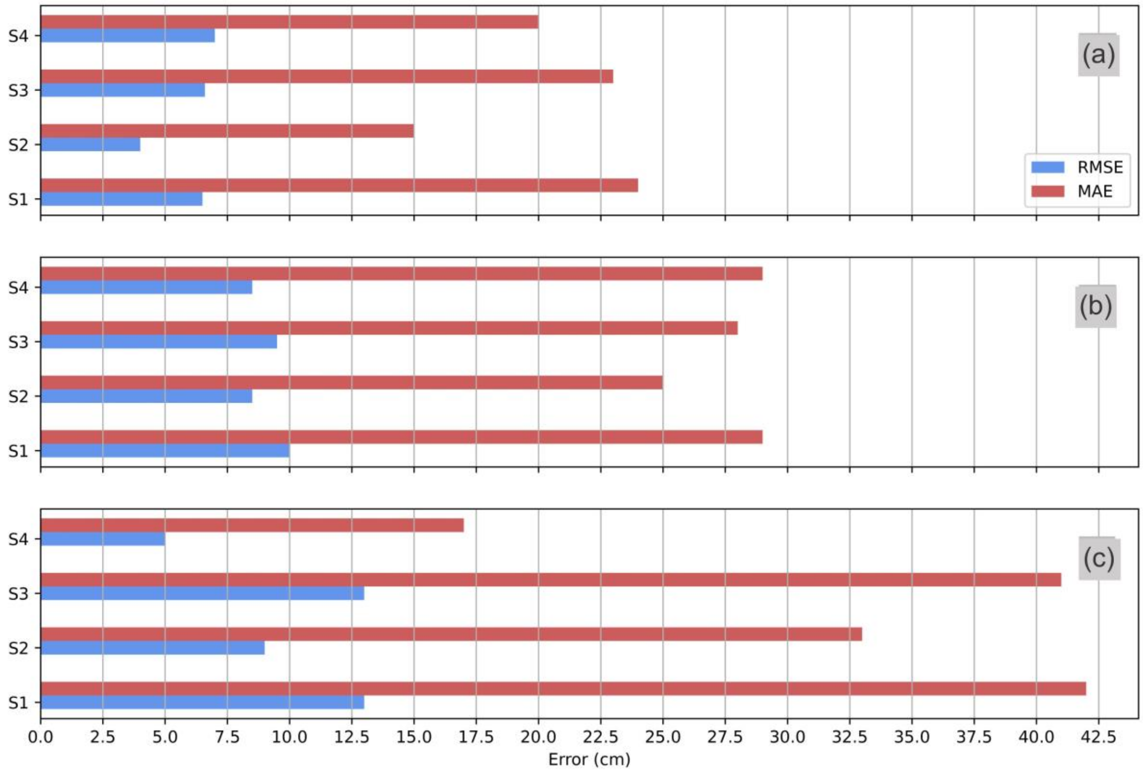


Figure S8 - The parameter errors of the four simulation scenarios (S1, S2, S3, and S4) – RMSE (blue bar), MAE (red bar) –at the 3 tide gauge locations: Ōmokoroa (a), Hairini (b), Oruamatua (c).