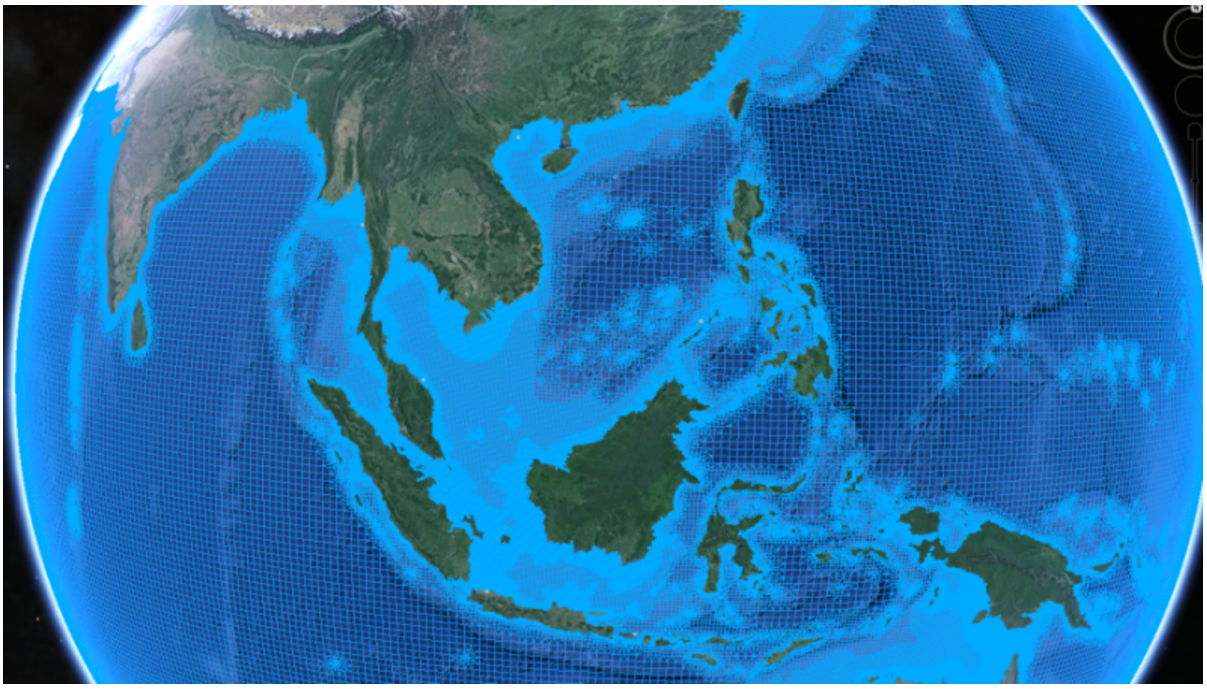
Model description and development

GTSM has a truly global coverage and therefore has no open boundaries. This makes the model very flexible to apply for different settings or for different scenarios. GTSM can be ran in tide-only, surge-only or tide/surge combined mode. One can also include sea-level rise. This way, interaction effects between tides, storm surges and mean sea level can be included.

Because of the use of an unstructured grid which allows for the local grid refinement, GTSM has a uniquely high resolution near the coasts but it is also computationally very efficient. This high coastal resolution makes GTSM very suitable to analyse extreme events. The grid is automatically generated with refinements near the coasts and in areas with a steep topography. The physical processes that are modelled are tidal forcing, bottom friction dissipation, self-attraction and loading, and internal tide friction dissipation. The internal tides are simulated with a 2D parameterization of density-driven internal waves, which is mainly relevant at steep topographies. The bathymetry consists of a combination of EMODNET (Europe), GEBCO (the rest of the globe), Bedmap2 (Antarctic), and several other local datasets.

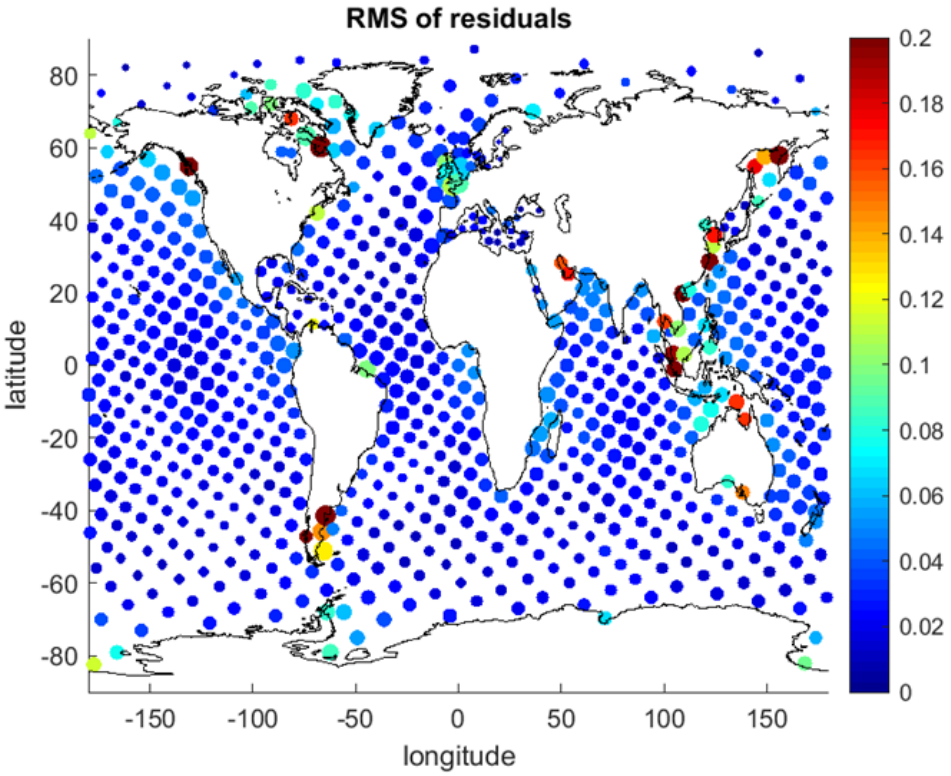


Grid of the Global Tide and Surge Model for Southeast Asia.

The development of GTSM is ongoing and a continuous effort. Version 1 of the model was developed in 2014, while currently version 4.1 is the latest released version and version 5 is in development. As summarized in the table below, the performance of GTSM is excellent for a global model and still improving with every new version of the model. Model developments include: increases in spatial resolution, better representation of physical processes, inclusion of improved input datasets, and improved calibration. The figure below shows the performance of the latest version of the model compared to the FES2014 model for tides. It clearly shows how the model performance is varying depending on the location with a very good agreement in the deep ocean and larger deviations from FES2014 in coastal areas.

Year	Version	Developments	Resolution (ocean/global coast /European coast) [km]	RMS[cm] (ocean) FES2014	RMS[cm] (European coast) CMEMS	RMS [cm] (global coast) UHSLC
2015	GTSMv2.0	Improved grid, inclusion of self-attraction and loading, improved internal tide dissipation	50/5/5	9.5	22.2	22.3
2019	GTSMv3.0	Improved grid, implementation of sea-level rise	25/2.5/1.25	6.3	14.5	17.8
2020	GTSMv4.0	Updated bathymetry, improved calibration, improved tidal potential	25/2.5/1.25	3.4	10.6	12.6
2021	GTSMv4.1	Improved internal tide dissipation, improved parametrization of bottom friction, calibration with OpenDA	25/2.5/1.25	2.6	9.2	11.3

Overview of different GTSM versions, and their spatial resolution and model performance. RMS refers to Root Mean Square of the differences between the tide time-series. Note that the mean difference is ignored because of uncertainties in the vertical reference of tide gauges and model.



Comparison of GTSMv4.1 against the FES2014 model. RMS as in table above.