Applications

GTSM is used for a wide range of applications, which include operational forecasting, reanalysis of historical extremes, and climate change projections. Many of the datasets that produced with GTSM are openly available. The table below provides an overview of the different datasets.

Dataset	Type	Description	Data availability	Reference
GLOSSIS	Forecasts	10-day forecasts of tides and storm surge with GTSMv4.1 Updated 4 times per day using GFS winds as forcing	Data is available through the Blue Earth data portal. See also GLOSSIS	Verlaan et al. (2015)
GTSR	Reanalysis, timeseries and return periods	Reanalysis based on GSTMv2.0 forced with ERA-Interim for storm surges and FES2012 for tides. Timeseries from 1979 to 2014 and return periods	Global daily maxima and return periods are openly available at: https://doi.org/10.4121/uuid:b6dd86f4-b182-4ad8-9bbd-e757bb8bd3c0	Muis et al. (2016)
CoDEC	Reanalysis and climate projections, timeseries and statistics	Reanalysis based on ERA5 and climate projections for a single CMIP5 model (CORDEX for Europe) using GTSMv3.0	European dataset is available at the C3S Climate Data Store: https://doi.org/10.24381/cds.b6473cc1 for indicators, and https://doi.org/10.24381/cds.8c59054f for timeseries. Global return periods are available at Zenodo: https://doi.org/10.5281/zenodo.3660927	Muis et al. (2020)
GTSMip	Reanalysis and climate projections, timeseries and statistics	Climate change projections based on HighResMIP using GTSMv3.0 and including annually updated sea-level rise	Global data are available at the C3S Climate Data Store. Timeseries: https://doi.org/10.24381/cds.a6d42d60. Indicators: https://doi.org/10.24381/cds.6edf04e0	Muis et al (In prep.)
COAST-RP	Reanalysis and synthetic tropical cyclones, return periods	An extension of the CoDEC dataset with return levels of total water levels based on combining the ERA5 reanalysis with the STORM dataset with synthetic tropical cyclones using GTSMv3.0	Global data are available at 4TU Data Centre: https://doi.org/10.4121/13392314.v1	Dullaart et al. (2021)
Nodal tide	Nodal 18.6 year long period tide	Analysis with GTSMv4.0 of how the nodal tide (the 18.6-year cycle) affect the mean sea level and the tidal range. For accurate assessment of the local sea-level rise trend.	Nodal tide on github and the preliminary dataset is available at https://doi.org/10.5281/zenodo.5113735	N/A

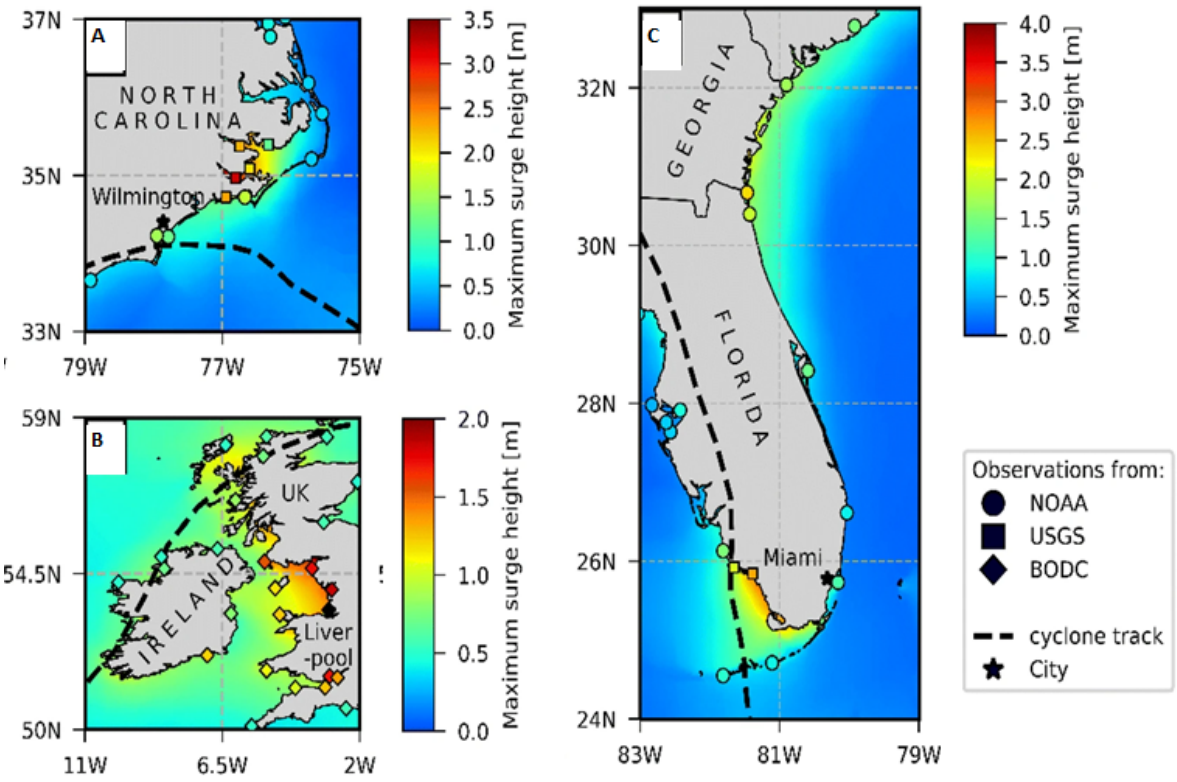
Overview of different GTSM-based datasets that are openly available.

Operational forecasting

Using GTSM as a basis, Deltares has developed an operational system called Global Storm Surge Information System (GLOSSIS). GLOSSIS provides 10-day tide and surge forecasts four times a day globally. These forecasts can be viewed and downloaded freely online at the BlueEarth data platform. We also provide dedicated data services for our clients, including near-real time estimation of flood damage for the insurance sector in Southeast Asia (SEADRIF), ocean currents forecasts that are used to optimize shipping operations and navigation for the Made Smart Group and near-surface current forecasts for the Volvo Ocean Race.

Reanalysis of historical extremes

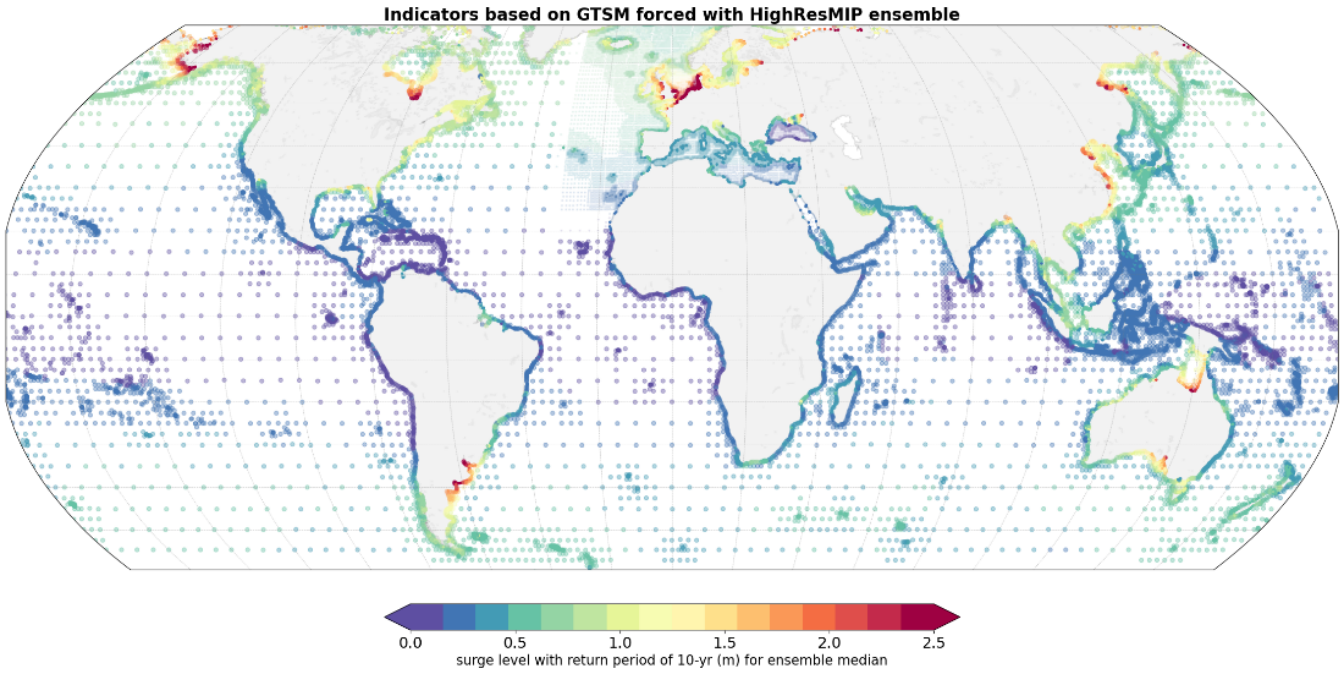
By forcing GSTM with wind and atmospheric pressure from climate reanalysis, GSTM can be used to simulate historical water levels. The first reanalysis dataset of extreme sea levels was the Global Tide and Surge Reanalysis (GTSR) dataset, which was published by Muis et al. in 2016. This dataset was based on surge simulations of GTSMv2.0 forced with ERA-Interim, combined with tide simulations of the FES2012 model. An updated reanalysis dataset was published based on GTSMv3.0 forced with ERA5 (Muis et al., 2020). The timeseries can be used to analyse individual historical events, but also to investigate trends and variability. The timeseries are also used to derive statistics on water levels, such as percentiles and return periods. The return periods form the basis of many large-scale assessments of coastal flood hazard and risk, for example, for the Aqueduct Flood Risk Analyser of the World Resources Institute. Dullaart et al. (2021) improved the return periods for tropical regions by combining the ERA5 reanalysis with thousands of synthetic tropical cyclones. The ERA5 reanalysis is also used to produce a high-resolution global flood extent maps due to coastal flooding at the Microsoft Planetary Computer, both for historical events as well as for various return periods considering sea level rise in present and future conditions.



Maximum modelled surge height for tropical cyclone Florence (panel A), extra-tropical storm Ophelia (panel B), and tropical cyclone Irma (panel C). Storm surges were generated forcing GTSMv3.0 with ERA5. Source: Dullaart et al. (2020).

Climate change projections

In the coming decades, the global coasts will be exposed to increasing risks due to climate change and sea-level rise. By forcing GTSM with output from global climate models (GCMs), we can simulate how sea levels may change under future scenarios. This was done using GTSMv2.0 in combination with a CMIP5 climate model ensemble by Vousdoukas et al. (2019). GTSMv3.0 was used to produce the called Coastal Dataset for Evaluation of Climate impact (CoDEC). This dataset contains timeseries and return periods for a single CMIP5 model with refinement for Europe (Muis et al., 2020). More recently, we used GTSMv3.0 to produce a global dataset of extreme sea level based on HighresMip (High Resolution Model Intercomparison Project) multi climate model ensemble and sea level rise under RCP8.5 scenario. Various statistics such as percentiles and return periods are computed. These indicators help to characterize water level in present-day conditions, but also assess changes under climate change. This dataset (including the time series and statistical indicators) is openly available in the Copernicus Climate Datastore (CDS). As GTSM is a self-contained model, without data assimilation and boundary conditions, the model is also very suitable to be used to study the effects of changes in tides in response to sea-level rise.



Ensemble median of surge level with return level 10-yr based on HighresMip ensemble for present-day climate conditions (1985-2014).

Other applications

GTSM has also been used for various other applications, and new applications are appearing regularly. This includes the following examples: computation of a consistent vertical reference datum in Europe based on lowest astronomical tides (EMODnet-Bathymetry portal); removing tides and surge from satellite altimetry; estimating bathymetry in the intertidal range from satellite imagery and studying the observed sea-level rise trend by correcting for the effect of the nodal cycle and the removing the meteorological-driven component of the trend.