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A new set of in-situ tidal constants based on the GESLA dataset

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Abstract

In-situ data are essential for a wide range of applications. In ocean tide models, data from bottom-pressure stations and coastal tide gauges are used for validation purposes as well as for assimilation. The Global Extreme Sea Level Analysis (GESLA) is the latest comprehensive high-frequency sea-level dataset containing 1355 harmonized records collected among 30 different international sources. The DGFI-TUM exploited the 1278 public records to derive at every station the amplitude and phase of 39 tidal constituents and the sea-level trend. A first screening was performed on all records to ensure that no large data gap occur in the timeseries and that all flagged observations are excluded. Subsequently, the sea level trend and the constants of each constituent are computed with the least-squares fit. The results are saved in user-friendly text files, and include additional information on the position of the stations, the estimated error of the fit, and a code that corresponds to the source of the record. This poster provides information on the construction of this dataset. In addition, results and tidal applications are illustrated.

The original dataset

The Global Extreme Sea Level Analysis (GESLA) dataset is a collection of high-frequency sea-level measurements retrieved by tide gauges and buoys around the world (Woodworth et al. 2017). In figure 1 the location of the publicly available data (1278 sites) is shown. The High coverage is found for North America, Europe and Japan, however sparser data are available for the coasts of the southern hemisphere.

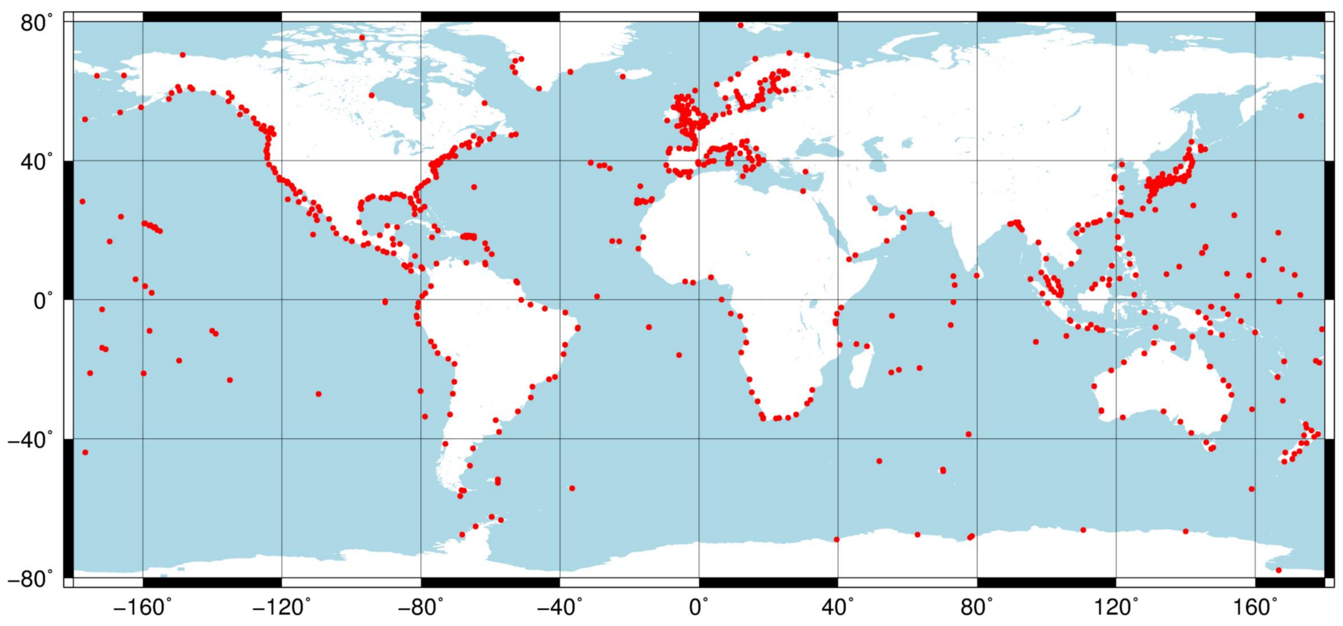


Figure 1: Location of in-situ timeseries available in GESLA.

Application examples

The GESLA dataset was already exploited in Piccioni et al. 2018 to show the impact of the ALES retracker on the performance of tidal estimation at the coast. The amplitude and phase of the major constituents were derived along-track, showing an average improvement of 4 mm for 66 tracks. Figures 2 and 3 show respectively the results obtained for the closest points to the tide gauges and one example for points along-track. The GESLA records are currently combined with data used in Stammer et al. 2014 to compare the updated Empirical Ocean Tide (EOT) model with the former version, EOT11a. Further information about this topic can be found in the poster: **An updated EOT model: first impressions from the North Sea**.

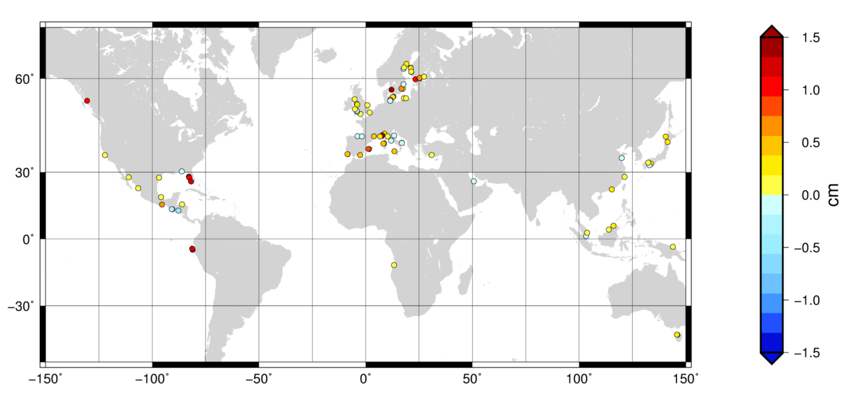


Figure 2: RSS error differences between the tidal estimation computed using two retrackers. The dots represent the tide-gauge sites. Improvements are found with the ALES retracker (positive values) .

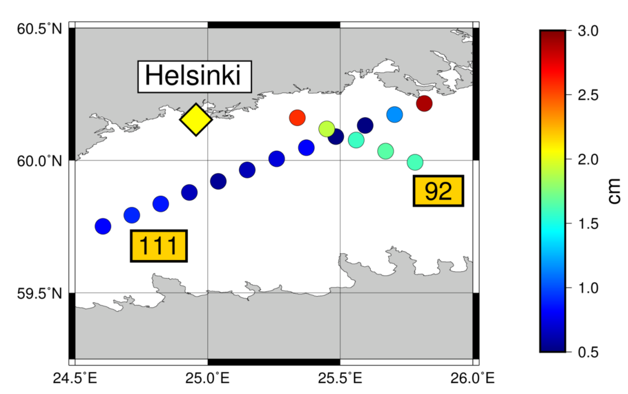


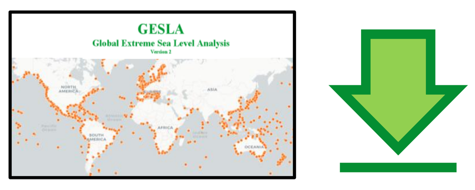
Figure 3: RMS values for M2 constituent along Jason tracks 111 and 92. The round markers are the points selected along the tracks and their color gives the value of RMS with respect to the tide gauge of Helsinki (diamond marker).

References

- Woodworth, P.L., Hunter, J.R. Marcos, M., Caldwell, P., Menendez, M. and Haigh, I. 2017. Towards a global higher-frequency sea level data set. Geoscience Data Journal, 3, 50-59, doi:10.1002/gdj3.42
- Stammer, D., Ray, R.D., Andersen, O.B., Arbic, B.K., Bosch,W., Carrère, L., Cheng, Y., Chinn, D.S., Dushaw, B.D., Egbert, G.D., et al. Accuracy assessment of global barotropic ocean tide models. Rev. Geophys. 2014, 52, 243–282, doi:10.1002/2014RG000450
- Piccioni, G., Dettmering, D., Passaro, M., Schwatke, C., Bosch, W., Seitz, F. 2018. Coastal improvements for tide models: the impact of ALES retracker. Remote Sens. 2018, 10, 700; doi:10.3390/rs10050700

Dataset Development Process

DOWNLOAD DATA FROM gesla.org



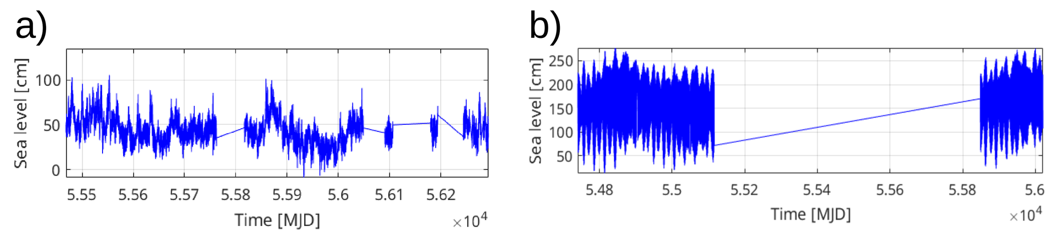
COMPUTE TIDAL CONSTANTS FROM TIMESERIES

The tidal estimation is done on a timeseries subset with a continuous time coverage of one-to-two years. This temporal selection allows to avoid large gaps and biases which were found in the original data. Outliers are removed according to the GESLA flags. The following formula is applied to obtain tidal constants from the least-squares:

$$\zeta(\boldsymbol{x},\boldsymbol{t}) = b + a\cdot \boldsymbol{t} + \sum_{k=1}^{ntides} \{A_k(\boldsymbol{x})\cdot cos[\,\theta_k(\boldsymbol{t}) + \chi_k - \phi_k(\boldsymbol{x})]\}$$

x = location vector
t = time vector
ζ = sea level measurement
b = offset
a = drift
ntides = number of constituents
A_k = amplitude
ϕ_k = phase
θ_k = astronomical argument
χ_k = Doodson-Warburg correction

a) b)



c)

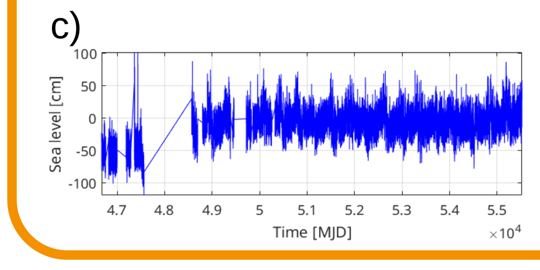


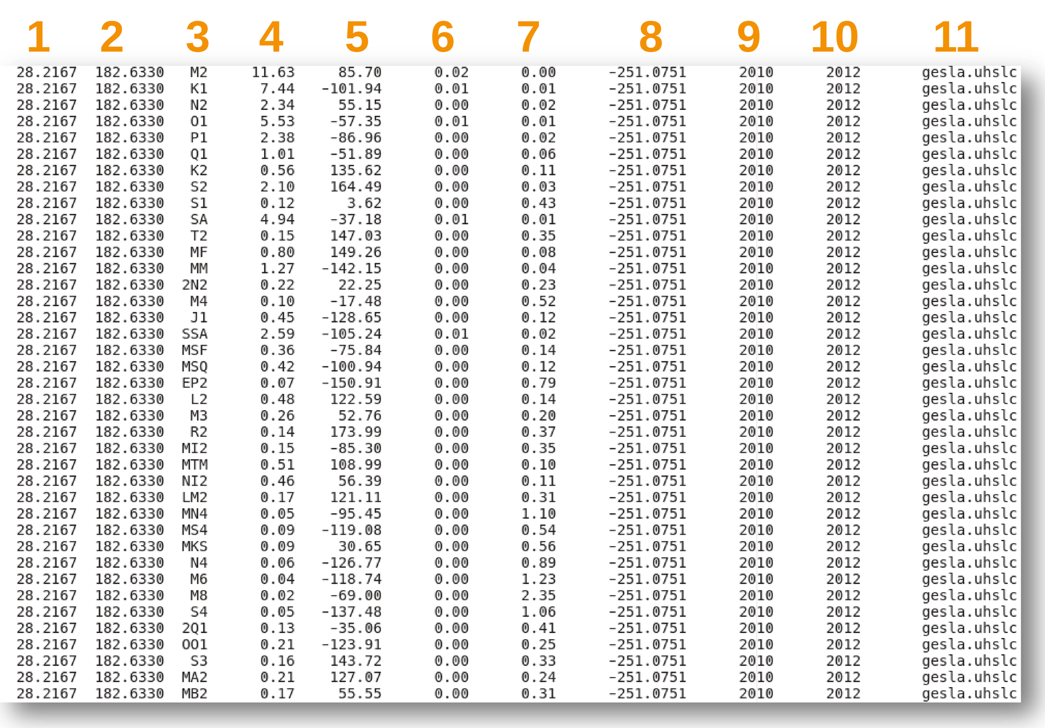
Figure 5: example of problems in the GESLA timeseries. Frequent (a) or large gaps (a), and presence of offsets (c).

MERGE RESULTS INTO ONE FILE

The results are merged to a single file so that any request can be solved with a simple command. For example, using awk information on M2 constituent for all tide gauges available in the Baltic Sea:

```
awk '$1>=15&&$1<=31&&$2>=54&&$2<=65&&$3=="M2"{print $0}' input > output
```

Information on the depth of each in-situ location is also added, so that data selection according to e.g. deep ocean, shallow water, coastal areas is also possible. The depth values are taken from the GEBCO model (see link below) through interpolation. In figure 6, a subset of the file is shown.



1 Latitude
2 Longitude
3 Tidal constituent
4 Ampltitude
5 Phase
6 Amplitude standard deviation
7 Phase standard deviation
8 Depth
9 Year of first measurement
10 Year of last measurement
11 Original dataset

Figure 6: Example for a single tide-gauge location

OUTLOOK

- Further quality checks will be performed, with focus on stations that showed problematic features.
- DGFI-TUM plans to publish the results in a peer-reviewed article and make the data publicly available and free of charge.

Links to datasets

OpenADB: https://openadb.dgfi.tum.de/en/
GESLA: http://gesla.org/
GEBCO: https://www.gebco.net/data_and_products/gridded_bathymetry_data/