# The Swedish Tide Gauge Network

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**Thomas Hammarklint**

Swedish Meteorological and Hydrological Institute, Folkborgsvägen 1, SE-60176 Norrköping, Sweden
Telephone: +46 11 4958000, Telefax: +46 11 4958001, Email: Thomas.Hammarklint@smhi.se

## Introduction

The Swedish Tide Gauge Network, operated by the Swedish Meteorological and Hydrological Institute (SMHI), records tidal elevations at 23 locations. SMHI is responsible both for the network, data and the levelling of the stations. Also, the Swedish Maritime Administration (SjöV), records tidal elevations at 30 locations, but these stations are not included in this report.

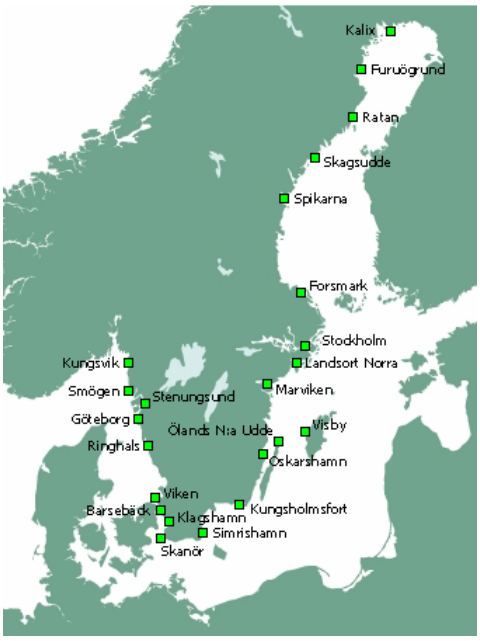


**Figure 1.** The Tide Gauge Network operated by SMHI, April 2007.

**Figure 2.** The Swedish GLOSS-station, Göteborg-Torshamnen.

| Station | Latitude | Longitude | Digital data available from | Installation of GPS | Type of GPS | Distance GPS (km) |
|---|---|---|---|---|---|---|
| Kalix | 65º 42' N | 23º 06' E | 1974 | No | - | - |
| Furuögrund | 64º 55' N | 21º 14' E | 1916 | 1993-08-01 | A | 9.5 |
| Ratan | 64º 00' N | 20º 55' E | 1891 | ? | B | 0.1 |
| Skagsudde* | 63º 12' N | 19º 01' E | 1982 | No | - | - |
| Spikarna | 62º 22' N | 17º 32' E | 1968 | No | - | - |
| Forsmark | 60º 24' N | 18º 13' E | 1975 | No | - | - |
| Stockholm-Skeppsholmen | 59º 19' N | 18º 05' E | 1889 | ? | B | 3.4 |
| Landsort Norra | 58º 46' N | 17º 52' E | 2004 | No | - | - |
| Marviken | 58º 33' N | 16º 50' E | 1964 | No | - | - |
| Visby* | 62º 22' N | 17º 32' E | 1916 | 1993-08-01 | A | 5.2 |
| Ölands norra udde* | 57º 22' N | 17º 06' E | 1851 | ? | B | 13.5 |
| Oskarshamn | 57º 16' N | 16º 34' E | 1960 | No | - | - |
| Kungsholmsfort | 56º 06' N | 15º 35' E | 1886 | ? | B | 0.1 |
| Simrishamn | 55º 33' N | 14º 21' E | 1982 | No | - | - |
| Skanör | 55º 25' N | 12º 50' E | 1992 | ? | B | 1.8 |
| Klagshamn | 55º 31' N | 12º 55' E | 1929 | No | - | - |
| Barsebäck | 55º 45' N | 12º 54' E | 1937 | ? | B | 5.9 |
| Viken | 56º 09' N | 12º 34' E | 1976 | No | - | - |
| Ringhals | 57º 15' N | 12º 07' E | 1967 | 1991-07-01 | A | 19.7 |
| Göteborg-Torshamnen | 57º 41' N | 11º 48' E | 1967 | ? | B | 12.8 |
| Stenungsund* | 58º 05' N | 11º 48' E | 1962 | No | - | - |
| Smögen | 58º 22' N | 11º 13' E | 1910 | ? | B | 0.0 |
| Kungsvik | 59º 00' N | 11º 08' E | 1976 | ? | B | 7.4 |

**Table 1.** List of stations in the Tide Gauge Network operated by SMHI. Stations marked * are non-realtime reporting stations. The columns about GPS indicates measurements of the absolute land uplift. Type of GPS: A denotes complete stations (EUREF reference stations with antennas placed on solid bedrock), B simplified stations (mounted on buildings). Distance GPS means the distance between the GPS antenna and the tide gauge. Only GPS-stations located less than 20 km from a tide gauge are included. More tide gauge data are available from discontinued stations (some located close to the continuing stations above).

## The Tide Gauge Network

The first systematic Swedish observations of the sea level started 1774 at the sluice in the harbour of Stockholm. At the end of 19$^{th}$ century the Swedish king decided to establish seven mareographs, where several are still operating or have been substituted by other stations. In 1889 the Nautical-Meteorological Bureau (a predecessor of SMHI) established a continuously recording sea level station in the bedrock (mareograph) on the island Skeppsholmen, located close to the sluice. This mareograph has since then recorded the Stockholm sea level and is now operated by SMHI. The sea level series in Stockholm constitutes the longest sea level record in the world.

During the 20$^{th}$ century more stations were established. The technique used from the beginning was the stilling well technique. The Tide Gauge Network was completely modernised during the 1980s. The traditional stilling well was still used, but the gauges were converted from analogue to digital with automatic data transfer to SMHI. Earlier the recording was only done with a chart recording apparatus. Nowadays this mechanical equipment is used as a backup for the digital recording equipment.

A new modernisation of the network was completed at the end of 2005. A new data logger (Vaisala MAWS) was installed that is more capable of delivering near real time data. The data recorded by the measurement equipment is transferred to SMHI once an hour through the telephone line and stored in a database. From there, the data can be presented in real-time on our website and in our FTP-box. Sea level data is also transmitted through the GTS-net. Quality controlled data are distributed to users via national and international exchange on a continuous basis. The software MATLAB is used for editing and correcting the data. We can delete data, fill small gaps with data from paper charts or predictions and add/subtract a constant offset to the data. The original data are stored in a separate table in the database.

At present we store data every 10 minutes and also the maximum and minimum records every hour are stored. In the future we will store all data recorded by the equipment (one minute values) in our database. In order to check the status of a station and validate real-time data an observer visits the station once a week. The tide gauges are connected to several Bench Marks. The Swedish Mapping Authority (Lantmäteriet) does the precise levelling, i.e. they are responsible for determining the distance between the Contact Point and the Bench Marks. SMHI is responsible for keeping Tide Gauge Zero (TGZ) a fixed distance below the Contact Point. Most of the gauges are installed in the bedrock, but some are located in slightly unstable areas. Levelling is done once a year. The levelling often shows no significant vertical motion on the majority of the tide gauges.

Figure 3 shows the basic structure of a typical tide gauge (mareograph). Sea level is measured in a deep well beneath the mareograph building. The well is connected to the sea through a narrow underwater pipe, to damp out short-period fluctuations of the sea level (waves).

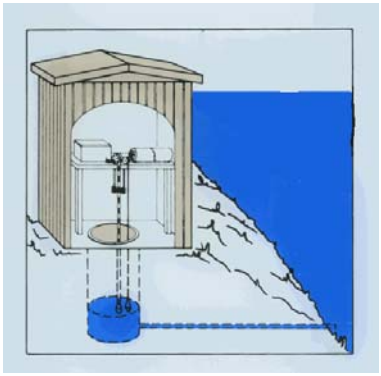

**Figure 3.** Basic structure of a typical tide gauge.

The mechanical part of the measurement equipment is constructed of a float, floating on the water surface, connected to a counterweight with a steel band. The steel band is attached on a wheel, which is connected to the digital equipment. When the sea level varies and the float follows it up and down, the equipment registers the rotation of the wheel, which is transformed into a digital reading using an encoder (Vaisala QSE 102).

## Data availability

In April 2007 the sea level database at SMHI contained about 1900 years with digital sea level observations, where 1323 years are from continued stations. Figure 4 gives an overview of the available time series from the permanent tide gauges that are operated today.

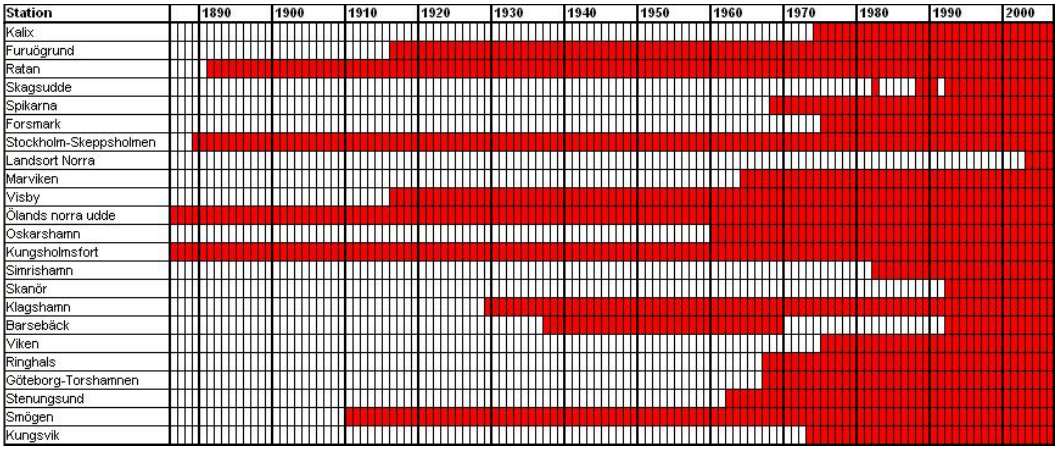


**Figure 4.** An overview of available digital time series over the years 1886-2006.

## International data exchange

Quality controlled sea level data are routinely made available through the following programmes:

**PSMSL:** Monthly and annual means once a year

**GLOSS and ESEAS:** High resolution data* every month through FTP

* 10-minutes mean values and hourly maximum and minimum values.

Real time data are also available through the BOOS and NOOS cooperation via an FTP-box.

Real time data can be obtained via:
http://www.smhi.se//weather/havsvst/sealevel.htm