Nat. Hazards Earth Syst. Sci., 9, 927–934, 2009
www.nat-hazards-earth-syst-sci.net/9/927/2009/

Natural Hazards and Earth System Sciences

A survey of European sea level infrastructure

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Received: 16 January 2009 – Revised: 20 May 2009 – Accepted: 7 June 2009 – Published: 23 June 2009

Abstract. This paper summaries findings from a survey of European sea level infrastructure (tide gauges, telemetry methods, ancillary information) conducted at the end of 2008 on behalf of the Tsunami Risk ANd Strategies For the European Region (TRANSFER), Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas (NEAMTWS), European Sea Level Service (ESEAS) and Global Sea Level Observing System (GLOSS) projects and programmes. Approximately 478 strategic tide gauges were found to be operational at this time, of which about three-quarters have near-real time data telemetry of various kinds. Around half of the gauges take part in real-time international data exchange. The NEAMTWS network can be considered to be in good shape in that most of its sites for which a gauge exists will be capable of meeting required standards in the near future. On the other hand, NEAMTWS (and the European and North African network in general) contains major gaps along the North African coastline and on European Mediterranean and Black Sea coasts which require new installations. The paper also summaries standards for the various sea level programmes, and reviews existing European infrastructure in the form of data centres and web sites.

1 Introduction

Sea levels have been measured in Europe for many hundreds of years. Early measurements tended to consist of the heights and times of high tide only (e.g. Woodworth, 1999; Wöppelmann et al., 2008). However, following the introduction of the first automatic tide gauge at Sheerness in the Thames estuary (Palmer, 1831), it became possible to record the full tidal curve. This innovation led to important developments in studies of tides, storm surges and mean and extreme sea levels, and in practical applications such as coastal surveying and harbour operations.

The Sheerness installation included a float in a stilling well, with the vertical motion of the float recorded on a paper chart fixed to a rotating drum controlled by an accurate clock (Pugh, 1987). This method was subsequently adopted at many other sites worldwide, and for well over a century this was the standard method for measuring sea levels. Even today, the technology remains a practical one, although at most sites the paper chart recorders have long been replaced by digital encoders connected to data loggers.

In the second half of the twentieth century, a number of other methods were developed for measuring sea level changes (IOC, 2004, 2006a). Tide gauges based on the measurement of sub-surface pressure, or on the time of flight of an acoustic or radar pulse between a transducer and the sea surface, proved to be both reliable and cost-effective. In particular, the new technologies did not require stilling wells, which can involve complicated installation arrangements, especially in high tidal areas. The result was that many agencies replaced their conventional float gauges with one or more of the alternative technologies, at the expense sometimes of introducing subtle systematic errors between measurements by the different techniques.

Along with the developments in tide gauge technology, corresponding progress has taken place in techniques for the transmission of the sea level data to centres, especially for the monitoring of water levels as part of flood warning systems. For example, the devastating floods in the UK and Netherlands in 1953 initiated the use of national telephone-based (dial up) transmission methods (e.g. see http://www.pol.ac.uk/ntslf/tgi/ for an example from the UK) which were eventually extended to make possible regional data exchange (e.g. see mention of NOOS and BOOS below). Nowadays, many European and other agencies routinely employ such telephonic (dial up or broadband) or

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internet telemetry, complemented in some cases by satellite techniques (e.g. Holgate et al., 2008a, b).

The availability of near real-time sea level information enables the utilisation of the data by a wide range of new users engaged in what is now called "operational oceanography", of which flood warning is only one important example (Flather, 2000). More ready access to the data has also had the benefit of allowing faults to be recognised faster than hitherto, leading eventually to improvements in the data sets available to "delayed mode" activities such as scientific research.

The result of these many years of developments is that Europe has an inhomogeneous collection of tide gauges and telemetry methods. Some of the equipment and methods are state-of-the-art, with advanced tide gauges installed and their information transmitted to centres in near real-time. However, the equipment in other countries remains little different from that of the early twentieth century and in some cases there is no real-time data transmission at all. There is inconsistency also in personal appreciation of the importance of international data exchange and the consequent necessary improvements to telemetry.

It has been evident for some time that European sea level infrastructure varies considerably between regions, and this recognition led to the initiation of a survey by the European Sea Level Service (ESEAS) of the tide gauges employed by various agencies across Europe. However, an additional factor in this discussion was introduced following the Sumatra tsunami of December 2004, the subsequent realisation that parts of Europe could be at risk from tsunamis (e.g. Kerridge, 2005), and the recognition that much of the existing European tide gauge infrastructure is inadequate (or at least not optimal) for monitoring tsunamis. That inadequacy is a consequence primarily of the unsuitable sea level sampling adopted by most tide gauges, but also inherent in the technologies themselves and in their associated telemetry methods.

In 2006, a European Commission (EC) project called Tsunami Risk ANd Strategies For the European Region (TRANSFER) was started to address many of the questions to do with regional tsunami risk. In addition, the Intergovernmental Oceanographic Commission (IOC) set up an International Coordination Group (ICG) for the Tsunami Early Warning and Mitigation System in the North-Eastern Atlantic, the Mediterranean and Connected Seas (NEAMTWS). The opportunity was taken of these new developments to undertake a new survey of existing European sea level infrastructure, the earlier survey by ESEAS anyway not having been completed.

The resulting survey, providing details of the infrastructure at each site in continental Europe together with North Africa, Greenland, Iceland and Atlantic islands, can be found in http://www.pol.ac.uk/psmsl/author_archive/european_tide_gauge_survey_2008/. It indicates which recording and communication technologies pertain to each measurement site as of December 2008 and consists of a set of tables with fields listed in Appendix A.

A first version of the survey was produced by the Proudman Oceanographic Laboratory (UK) together with Puertos del Estado (Spain), based on information obtained through our involvement in international activities such as ESEAS, Permanent Service for Mean Sea Level (PSMSL), Global Sea Level Observing System (GLOSS), or Mediterranean GLOSS (MedGLOSS). Some countries provide regular national reports to the meetings of the GLOSS Group of Experts and these proved to be most useful sources of information for the survey (http://www.gloss-sealevel.org). Important additional sources included the web sites of individual national agencies (see a list in http://www.pol.ac.uk/psmsl/programmes/).

It was necessary at the outset that the range of the survey would have to be limited to the main tide gauge stations in each country, those stations being the most useful to IOC and EC programmes such as GLOSS or TRANSFER. Many countries possess possibly 100 s of installations of what might be called "tide gauges", often simple pressure sensors for local water management, located in rivers estuaries and coastal waters, or sensors for harbour operations. It was clear that our survey could not attempt to compile a complete list of such equipment in each country, and that such lists, even if complete, would not be particularly useful for our purposes.

Our first version was sent to the many European national contacts for the above-mentioned programmes, so that it could be checked and updated. In many cases, updates were provided within a few days. We are grateful to all of our contacts who replied and contributed thereby to its overall value. Maps summarising findings are presented below.

One notes that because the survey was initiated as part of TRANSFER and NEAMTWS, it necessarily had an emphasis on the availability of real time sea level information. Nevertheless, the insight obtained into the status of the European sea level infrastructure as a whole should also provide a basis for the further development of activities such as GLOSS which also have great interest in the availability of delayed mode sea level data.

2 Summary maps from the survey

The survey suggests that approximately 478 tide gauge stations (strategic stations as emphasized above) are currently operational in Europe, North Africa, Greenland, Iceland and Atlantic islands (Fig. 1), with the greatest density of recording in NW Europe and lowest density in North Africa and parts of the Black and Baltic Seas. Many stations are located on North and Irish Sea coasts, where there are well-established requirements for continuous monitoring of water levels for flood warning.

Fig. 1. All tide gauge stations represented in the survey (some Greenland stations are outside the limits of the map).

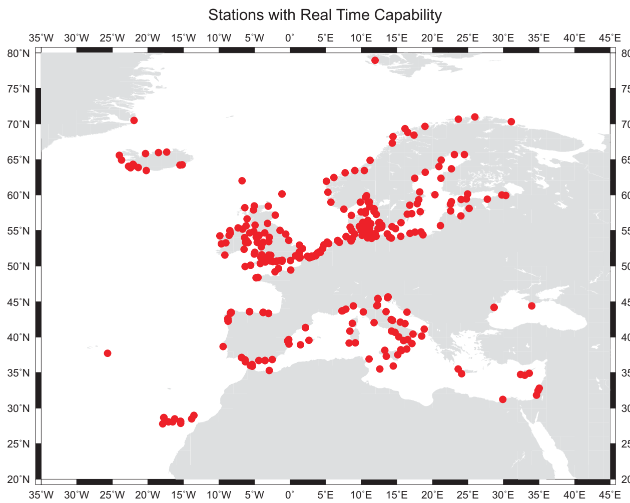

Fig. 2. Tide gauge stations capable of reporting sea level in near-real time to a national centre.

Approximately three-quarters of these stations (329) are capable of reporting sea level information to a national centre in near-real time, meaning within an hour or so, thereby providing a continuous monitor of water levels to national agencies and making the data useful for validation of operational flood forecast models (Fig. 2). A subset of these real-time stations make their data available to one or more international programmes (NOOS, BOOS, IBIROOS, MedGLOSS, SLEAC or GLOSS, see brief descriptions of these programmes below). Figure 3 shows the 179 stations in this subset. This map can be seen to be essentially the same as that of 223 real-time stations included in the EuroGOOS SEPRISE demonstrator project (Gorringe, 2007, and see below for brief description of SEPRISE), if one considers that the SEPRISE exercise included national data from more sta-

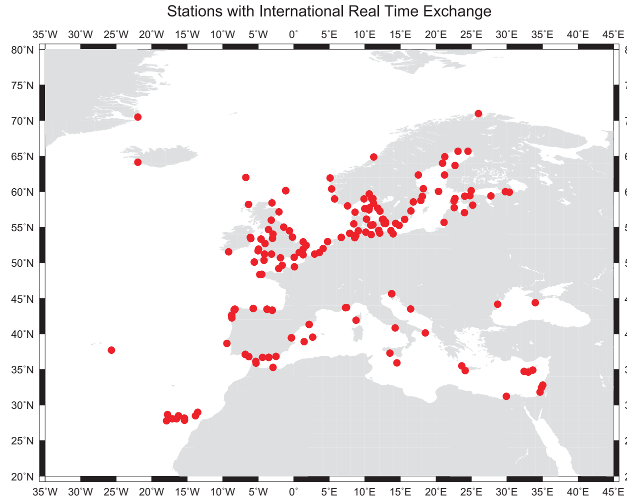

Fig. 3. Tide gauge stations which contribute near-real time sea level data to one of the international programmes.

tions in some countries (notably Norway and Netherlands) than presently contribute to the various programmes. It is clear from comparison of Fig. 3 to Figs. 1 and 2 which countries have the weakest engagement with the international programmes.

Operational flood warning originated in agencies with responsibilities for coastlines prone to high water levels due to tides and storm surges. In this application, water levels need be sampled only at sufficient temporal resolution to be able to monitor the tide and surge (e.g. every 15 min), and the associated telemetry only need be capable of transmitting data in a timescale useful for validation of the performance of operational tide-surge numerical models (e.g. 15 min or hourly transmissions). More exacting requirements for high frequency sea level recording and for data telemetry are associated with tsunami monitoring (see discussion of NEAMTWS standards below).

Figure 4 shows the NEAMTWS network required to be in place by the end of the decade (this is a slightly updated map to that shown in Figs. 2–5 of IOC, 2007). It indicates sites at which a gauge (of any type) exists and sites for which a new installation is required. Requirements include a number of new gauges in North Africa and in other parts of the Mediterranean and Black Seas. Of the existing sites, our survey has shown that many of them already meet the NEAMTWS standards or will shortly (e.g. via upgrades to MedGLOSS gauges), and of those which do not, the main factor concerns sampling frequency. In particular, all Italian, all Danish and one UK site in the NEAMTWS network employ sampling of 10–15 min which must be improved upon, while most Greek sites must also be converted to real-time.

The survey also concerned itself with whether data from gauges were being made available to the international programmes in delayed mode. For example, Fig. 5 shows the

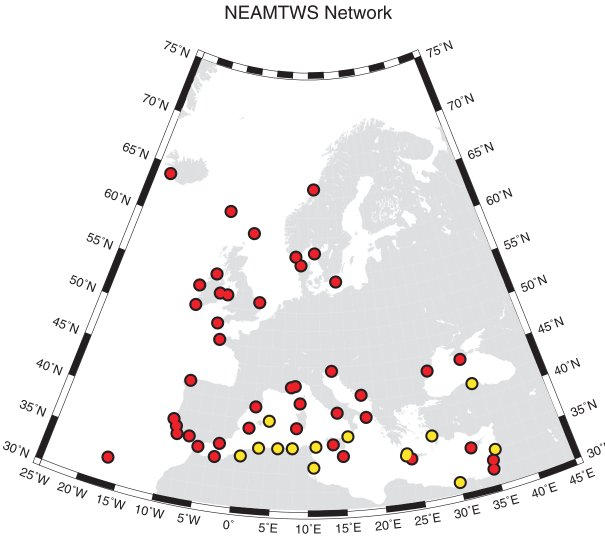

Fig. 4. The NEAMTWS tsunami network proposed to be operational in the near future. Red sites indicate stations with an existing tide gauge (of any type) while yellow sites indicate that new installations are required.

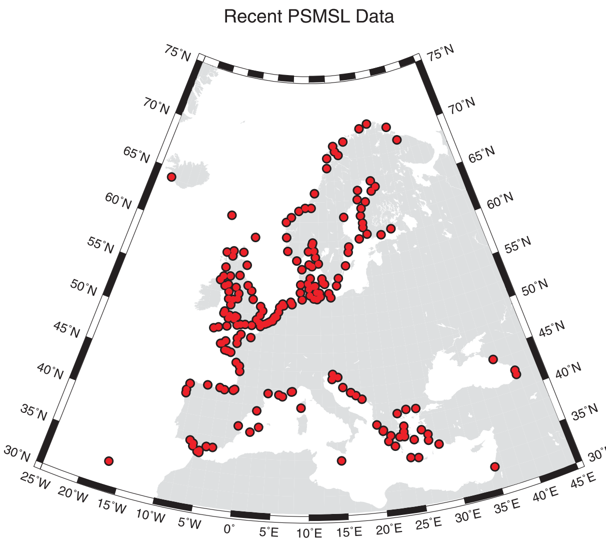

Fig. 5. Tide gauge stations which have contributed recent (2005 or more recent) mean sea level information to the PSMSL.

213 European stations for which data have been contributed to the PSMSL in recent years (since 2005). There are some similarities between this map and that of Fig. 3, in indicating which countries have (or have not) a commitment to international programmes.

The figures in this paper give only an overview of the findings of the survey, and the interested reader is invited to inspect the survey web page itself to obtain more detailed information.

3 GLOSS and tsunami (NEAMTWS) standards

Any survey is inevitably a backward-looking exercise. If it is to be useful, it should be capable of identifying deficiencies which must be addressed by future investment. In this section, we review the standards to be expected of any future European network, so that agencies can compare their existing infrastructure with future requirements.

The IOC GLOSS programme was established in the 1980s with the aim of providing worldwide sea level data primarily for oceanographic and climate studies (e.g. to increase the quantity and quality of mean sea level data to the PSMSL), and also to provide a "core network" around which densified regional networks could be established (e.g. MedGLOSS) for more local applications. GLOSS also stressed the many practical applications that could accrue from high quality sea level data.

The original GLOSS standards can be summarized as requiring a tide gauge to measure to an accuracy of 1 cm or better in all weather conditions, and with a recording frequency of 1 h or more frequent (IOC, 1997, 2006a). The latter requirement is now easily met at most sites, with recording at periods of 6, 10 or 15 min now common. However, GLOSS also calls for great attention to the geodetic control of the sea level data, with minimum requirements for local benchmarks and levelling.

During discussions following the Sumatra tsunami, it became clear that recommendations for future GLOSS stations, or upgrades to existing stations, had to take account of the need to use the same sites for tsunami applications. Therefore, most opinion in the GLOSS Group of Experts, based primarily on experience in the Pacific, became focused on providing a primary "sea level sensor" for most GLOSS-related purposes, together with a vented pressure sensor sampling at one minute or more frequently, with less rigour for geodetic datum control for the latter (e.g. Kilonsky, 2006). This approach was also followed for deployments in Africa and other locations as part of the Indian Ocean Tsunami Warning System (Woodworth et al., 2007). In these cases, the equipment employed at most sites consists of a radar tide gauge, providing sea level data of most use to tidal studies and research into sea level changes due to climate change. In addition, the station is equipped with a sub-surface pressure sensor which functions as a backup to the radar gauge and as the main "tsunami sensor". A final important component is the satellite transmission equipment which sends real-time data back to centres in Ostende (Belgium) and Hawaii (USA) and to any other centre which can access the Global Telecommunications System.

The stated requirements for NEAMTWS are similar (IOC, 2006b). They specify GLOSS type equipment capable of 1 cm accuracy and 1 min sampling or better, together with 1 min transmissions for stations within 1 h of tsunami travel and/or 100 km from the tsunami generation area.

NEAMTWS also makes recommendations on redundancy of equipment, power supplies etc.

It seems to us that at this point a tide gauge agency must consider how their sites can best be developed to meet the requirements of the several programmes. For example, a site might have a tide gauge which meets GLOSS standards, with telemetry adequate for regional storm surge applications (which tends to mean delivery of near real-time data within approximately 30 min). In this case, an enhancement to the station by means of addition of a relatively inexpensive tsunami gauge (e.g. pressure gauge, following the examples given above for the Pacific and Africa) and faster telemetry may provide a most effective option for future development. On the other hand, it is possible to purchase tide gauge systems capable of sampling adequately rapidly for tsunami applications and with the long-term stability required for GLOSS. When equipped with suitable telemetry, such single systems should, in principle, be capable of meeting all requirements. Consequently, for a new station this option, although relatively high cost, may be the most efficient.

Therefore, in our opinion, one must beware of some of the statements for tide gauges to meet "multi-hazard" applications as, for example, a simple sensor perfectly adequate for tsunamis could never be considered suitable for GLOSS. Rather, it must be the station, rather than any one particular instrument, which should be considered as providing the multi-hazard functionality.

4 Web sites and data banks

Web sites and data banks can be considered as fundamental components of the European sea level infrastructure. Web sites provide real time information, together with access to catalogues of delayed mode data. In addition, web sites can provide a wealth of other information including metadata, training information and software packages. Data banks provide the essential roles of long term storage of information and quality control of the data gathered. In this section, we review briefly some of these infrastructure assets.

Permanent Service for Mean Sea Level (http://www.pol.ac.uk/psmsl) – the PSMSL was established in 1933 and operates under the auspices of the International Council for Science (ICSU) (Woodworth and Player, 2003). It has a global responsibility to collect, analyse and distribute mean sea level data from tide gauges and presently holds over 57 000 station-years of information. For many years it was the only body engaged in international (including European) sea level data exchange.

Global Sea Level Observing System (http://www.gloss-sealevel.org/) – the PSMSL is also charged, along with the British Oceanographic Data Centre (BODC), with maintaining the data bank for delayed mode, "higher frequency" sea levels (i.e. hourly values or more frequent) from nominated GLOSS sites. There are over 30 such GLOSS sites in the wider European region.

European Sea Level Service (http://www.eseas.org) – some tide gauge agencies in Europe have regularly contributed "higher frequency" sea level data to an ftp site at the ESEAS Central Bureau maintained by the Norwegian Mapping Authority. However, at the time of writing the method used for obtained data available to ESEAS is being changed to the use of a web portal which will access data from national web sites. This should provide access to more data (and to fewer copies of the same data) and will more clearly show that ownership resides with national agencies. The portal will be operated by BODC.

National sea level agency web sites and data banks – most agencies now have such web sites, a list of which is maintained by the PSMSL (http://www.pol.ac.uk/psmsl/programmes/).

North West Shelf Operational Oceanographic System (NOOS) (http://www.noos.cc) – NOOS is the North Sea area component of the EuroGOOS programme, an association of agencies established to further the goals of the Global Ocean Observing System (GOOS). Real time data are contributed by national agencies using ftp boxes from which data can be "pulled" by the NOOS server at the Danish Meteorological Institute (DMI). The web site provides an almost complete overview of real-time sea level coverage in the area.

Baltic Operational Oceanographic System (BOOS) (http://www.boos.org) – BOOS is the Baltic area component of EuroGOOS and provides similar access to real-time data from that area. The BOOS web site is also maintained by the DMI.

Iberia-Biscay-Ireland Regional Operational Oceanographic System (IBIROOS) – IBIROOS is the European South West Atlantic Shelf component of EuroGOOS and is presently under development. The real-time data from the region will be accessible at the http://www.ibi-roos.eu web site maintained by IFREMER (l'Institut Francais de Recherche Pour l'Exploitation de La Mer). The in-situ data portal of IBIROOS, including sea level stations, will be the responsibility of Puertos del Estado, and will be developed within the MyOcean EC project.

Sea Levels of European Atlantic Coasts (SLEAC) (http://www.sleac.org) – SLEAC provides access to the Atlantic coast stations which also contribute to the individual EuroGOOS web sites. It was established by POL and the DMI in order to stimulate real time data exchange from throughout the Atlantic coastline, with a view towards the future needs of an Atlantic tsunami warning centre, rather than the focus on NOOS and BOOS which has been more appropriate for storm surge work.

MedGLOSS (http://www.medgloss.ocean.org.il/) – MedGLOSS is a joint programme of IOC and the CIESM (Commission pour l'Exploration Scientifique de la mer Méditerranée). Its web site provides real time and delayed mode data for several Mediterranean stations.

Sustained, Efficient Production of Required Information and Services within Europe (SEPRISE) (http://www.eurogoos.org/sepdemo/) – SEPRISE is a Specific Support Action funded by the EC within the 6th Framework Programme to further operational oceanographic services within EuroGOOS. It also provides access to real-time data from regional EuroGOOS activities as well as from national web sites. At present, SEPRISE has the status of a demonstrator project only.

IOC Sea Level Station Monitoring Facility (http://www.ioc-sealevelmonitoring.org) – this service developed from a collaboration between Flanders Marine Institute (VLIZ) and the ODINAfrica (Ocean Data and Information Network for Africa) programme of IOC, with the service initially focused on operational monitoring of sea level measuring stations in Africa. The service has since been expanded to a global station monitoring service for real time sea level from GLOSS stations, and for stations in the regional tsunami warning systems in the Indian Ocean, North East Atlantic and Mediterranean (NEAMTWS), Pacific and the Caribbean. Provision of low frequency and high frequency research quality sea level data is not the main aim of this service. Such data are available from the GLOSS, PSMSL and ESEAS data banks mentioned above and from the University of Hawaii Sea Level Center (http://www.soest.hawaii.edu/UHSLC/).

5 Evolution of the European infrastructure

The duty of programmes such as GLOSS, NEAMTWS etc. is to specify clearly their needs for network coverage and the technical requirements for sea level stations. There may then be a number of technical solutions to meet these requirements, which differ depending on additional national requirements, environmental conditions, and even local experience and preferences. Consequently, it seems to us that the European sea level infrastructure need not evolve in a completely uniform way. However, it will be necessary to require that the accuracy, frequency and latency of data do indeed have some uniformity, and of course that data be available from throughout the regional coastline.

It is clear from Figs. 1–3 and 5 (as it has been clear for many years e.g. Baker et al., 1997) that the main gaps in recording are from North Africa and Black Sea, although the coherence of sea level changes in the latter might obviate the need for the same density of recording as elsewhere. In North Africa, a new gauge is being installed at Alexandria under the auspices of the ODINAfrica and GLOSS programmes of IOC. That will extend an Alexandria sea level record that started in 1944. The Spanish Institute of Oceanography (IEO) operates the only other long-standing tide gauge on the North African coast, at Ceuta in Spanish North Africa (also since 1944). Puertos del Estado has recently established a tide gauge station in the Spanish North Africa harbour of Melilla to NEAMTWS and GLOSS standards. However, although tide gauges are known to exist in Tunisia, Algeria and Morocco (Woodworth et al. 2007, with that information included in our survey), there are no gauges in these countries that provide sea level data to the international scientific community, and/or provide data meeting the tsunami requirements of NEAMTWS, between Egypt and Spanish North Africa. Filling these gaps in recording must be a major priority of the various European and international programmes.

It is clear that there is also much to do in developing the collaborative regional sea level programmes (ESEAS and MedGLOSS), so that data reaches users most efficiently and that communities can be formed to make maximum use of the resulting data sets. As regards tsunami monitoring (NEAMTWS), a major need at the moment is for the identification of a European warning (or watch) centre (or centres). Without that focus, it is inevitable that most agencies will not assign priority to enhancing their existing sea level stations to meet tsunami requirements.

6 Summary

This paper has summarized the main findings of a recent survey of the European sea level infrastructure. The survey has shown that European assets vary considerably from country to country in their tide gauge hardware and telemetry methods. In particular, new investment is needed to fill gaps in the European and North African networks (especially in parts of the European Mediterranean and Black Sea coasts and the North African coastline itself) and to make data available in real time for hazard warning such as that needed for tsunami monitoring.

The availability and exchange of real-time data for operational flood warning purposes is good in most parts of North West Europe (approximately three-quarters of all gauges in the survey having real time capability). Infrastructure in tide gauges and telemetry for NEAMTWS is also good, or will be upgraded in the near future, for those stations where a gauge (of any type) already exists. Moreover, sites for which sea level sampling is at present insufficient for tsunami purposes should be capable of improvement with relatively modest investment. However, gaps in the network remain where there are no existing gauges of any type, geographically similar to those referred to above.

In spite of the gaps, Europe does already have considerable investment in tide gauge infrastructure (478 stations identified in Fig. 1). However, it is clear from other figures in this paper that the benefits of much of this investment are not being maximized by means of the fullest possible international engagement. The authors of this paper have spent many years engaged in European sea level research, and we know that this deficiency is primarily a consequence of the restricted mind-set of certain national agencies, rather than of any aspect of hardware infrastructure. Until these national agency deficiencies are addressed by recruitment of personnel who are able to engage with international programmes, then there will continue to be gaps in those programmes.

Finally, we must repeat that the information collected in the survey will inevitably be limited. As mentioned above, it is clear that many ports or coastal local authorities will operate their own tide gauge networks, which we will not know about and data from which will not be shared widely. River authorities, water companies etc. will also undertake some kinds of sea level recording which will not have been reflected in the survey. A second reservation is that the information that we have collected is bound to become out of date within a few years, suggesting that the survey should be repeated at regular intervals. Nevertheless, we are confident that the survey does provide a reasonable overview of the main sea level recording activities in Europe at the present time, and especially of those tide gauge sites most relevant to IOC and EC programmes. Consequently, the present exercise should provide a useful starting point for more extensive surveys in the future, should they be considered necessary.

Appendix A

The results of the survey can be found at:
http://www.pol.ac.uk/psmsl/author_archive/european_tide_gauge_survey_2008/.
The survey consists of tables for each sea level authority, with the columns of the tables having the following meanings:

Lon, Lat = Longitude and latitude of the station (note that coordinates taken from the PSMSL catalogue will be given to the nearest minute. Coordinates taken from other sources may be approximate only)
CCO, SCO = PSMSL country and station code(s) of that station (if in the PSMSL database)
GLO = GLOSS station code if a GLOSS station
AC = Authority code for the agency that owns and maintains the station as listed in http://www.pol.ac.uk/psmsl/pub/indexa.html.
Others should be stated explicitly.

TYP = type of tide gauge technology:
F = float and stilling well
P = ndersea pressure transducer
B = bubbler pressure gauge
A = acoustic gauge in a tube or well (and manufacturer)
AA = acoustic gauge in open air (and manufacturer)
R = radar gauge (and whether pulse or FMCW radar and manufacturer)
Others should be stated explicitly.

PUR = purpose for which the gauge was installed (more than one if necessary):
F = flood warning/coastal protection
G = national datums/geodesy
H = harbour operations/navigation
M = mean sea level/climate studies
T = tsunami studies
TI = tides
BS = bathymetric surveys
AC = altimeter calibration
Others should be stated explicitly.

FRQ = time in minutes of recording period or sampling (this is not to be confused with FRS and FRT below)

WI = when installed:
1 = more than approximately 2 years (and hence any system problems resolved)
2 = less than about a year
3 = recent installation or planned imminent installation

RT = real time data available:
N = real time data available nationally at the web site given for the authority below
I = real time data available also internationally at one of the programme web sites given under IPR (i.e. "I" also implies "N" if "N" not given explicitly).

IPR = international programmes to which real time data from the station are made available:
S = SLEAC (Sea Levels from the European Atlantic Coastline) real-time display http://www.sleac.org
NO = NOOS (North West Shelf Oceanographic Operational System) real-time display http://www.noos.cc
BO = BOOS (Baltic Oceanographic Operational System) real-time display http://www.boos.org
I = IBI-ROOS (Iberia-Biscay-Ireland Regional Operational Oceanographic System) http://www.ibi-roos.eu/
M = MedGLOSS real time web display http://www.medgloss.ocean.org.il
G = GLOSS real time web site http://www.ioc-sealevelmonitoring.org/
N = NEAMTWS tsunami network http://www.ioc-sealevelmonitoring.org
FRS = time in minutes of data resampled before transmission (i.e. averaged from the FRQ sampling). This could differ for RT = N or I and for different international programmes. If different, this should be stated explicitly.

FRT = time in minutes between transmissions. This could differ for RT = N or I and for different international programmes. If different, this should be stated explicitly.

LT = latency, the minimum time in minutes for which the real time data are available either nationally or internationally. This could differ for RT = N or I and for different international programmes. If different, this should be stated explicitly.

MET = method by which data are transmitted from the gauge to the national or international web sites. This could differ for RT = N or I and for different international programmes. If different, this should be stated explicitly.

DMF = delayed mode data availability flag. Data are freely available either:
N = nationally at the web site for the authority given below
G = GLOSS delayed mode centre (higher frequency)
E = present ESEAS archive (note, the ESEAS arrangements will change in 2009)
M = MedGLOSS focal centre
P = PSMSL (monthly means)

AD = ancillary data collected at the site including:
M = meteorological information
G = continuous GPS recording (also checked by comparison to the CGPS@TG list kept for GLOSS and TIGA in http://www.sonel.org)

Acknowledgements. We thank our correspondents in many countries who helped us to complete the survey. Their names can be found in the documents in the survey web page. Particular thanks go to V. Huess (DMI) and T. Aarup (IOC) for their advice on the international programmes, and to G. Wöppelmann (University of La Rochelle) for helping us to update the GPS fields in the survey tables. This work was funded by the EC Tsunami Risk ANd Strategies For the European Region (TRANSFER) project, which is part of the Assessment and Reduction of Tsunami Risk in Europe activity of the Sixth Framework Programme (Contract No. 037058). It was also funded by the UK Natural Environment Research Council.

Edited by: S. Tinti
Reviewed by: two anonymous referees

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