



Tide gauges network: GLOSS recommendations and on-going regional initiatives

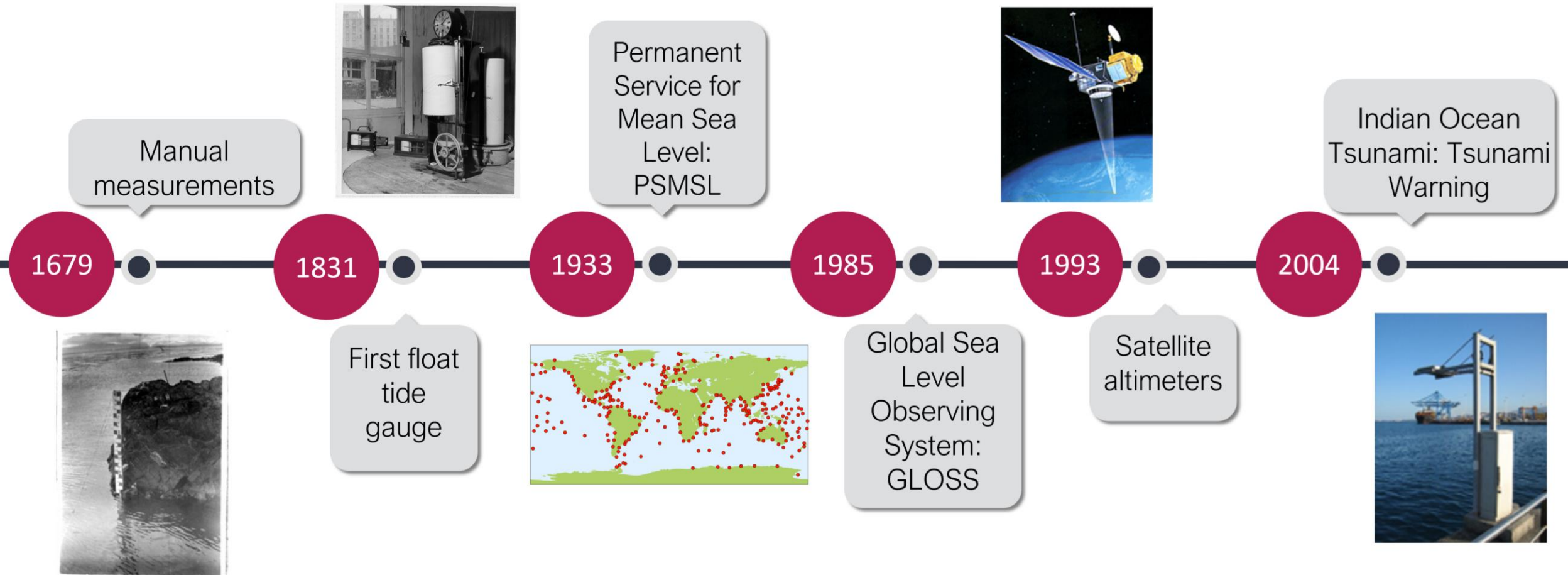
Begoña Pérez Gómez, Angela Hibbert, Elizabeth Bradshaw, Guy Westbrook, Laurent Testut, Andy Mathews, Gary Mitchum



Outline

- In-situ sea level measurements. Applications and global context
- GLOSS recommendations: instrumentation, quality control and data processing
- On-going regional initiatives:
 - EuroGOOS Tide Gauge Task Team: EuroSea project
 - MONGOOS Tide Gauge Task Team
- Take home messages

In-situ sea level measurements. Applications and global context



Manual measurements



Permanent Service for Mean Sea Level: PSMSL



Indian Ocean Tsunami: Tsunami Warning

1679

1831

1933

1985

1993

2004



First float tide gauge

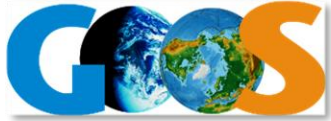


Global Sea Level Observing System:GLOSS

Satellite altimeters



In-situ sea level measurements. Applications and global context



The Global Sea Level Observing System (GLOSS), a component of the Global Ocean Observing System (GOOS), is establishing a well-designed, high-quality sea level observing network to support a broad research and operational user base.



Sea level data are vital for



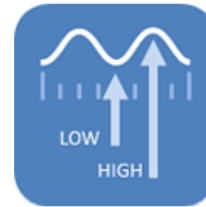
Research into sea level change and ocean circulation



Coastal protection during events such as storm surges



Providing flood warning and monitoring tsunamis



Tide tables for port operations, fishermen, and recreation

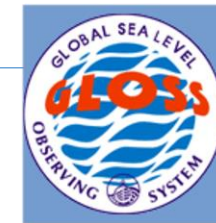


Defining datums for national or state boundaries

<https://gloss-sealevel.org/>

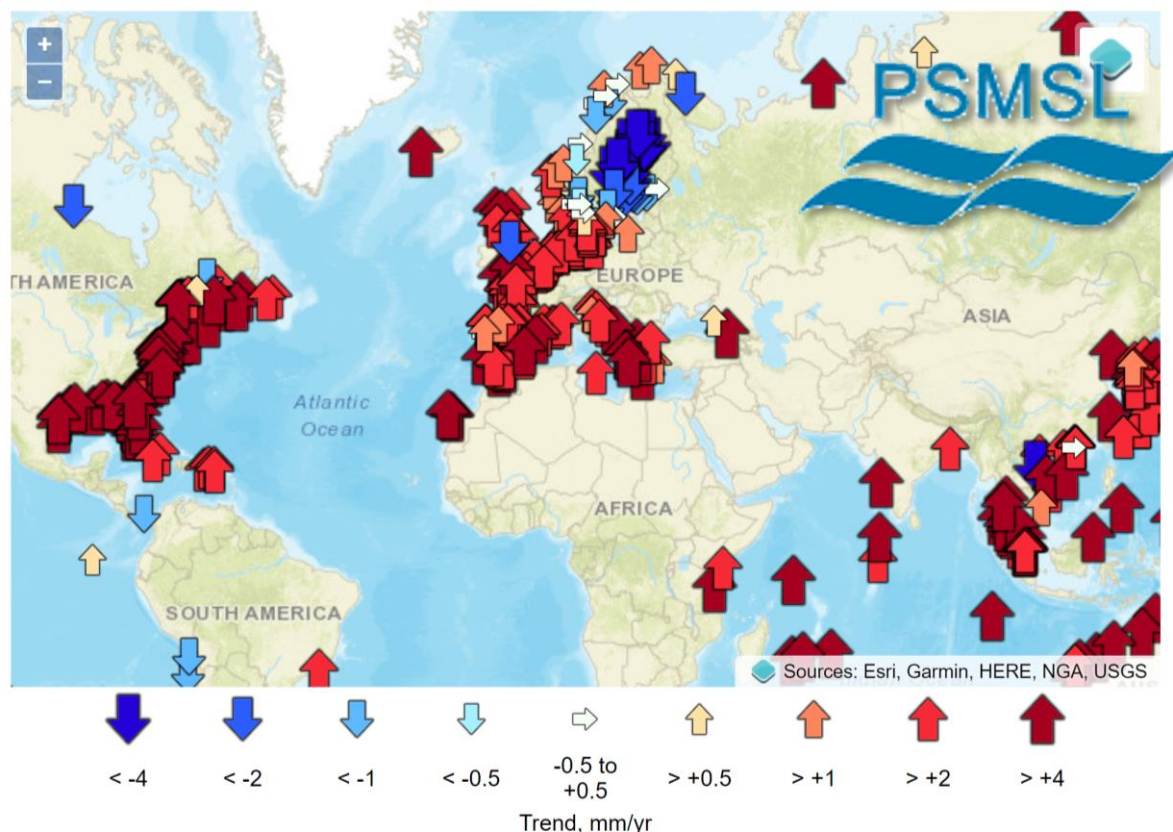
Sea level is one of the most useful oceanographic variables, used for a wide variety of scientific, economic and social purposes.

In-situ sea level measurements. Applications and global context



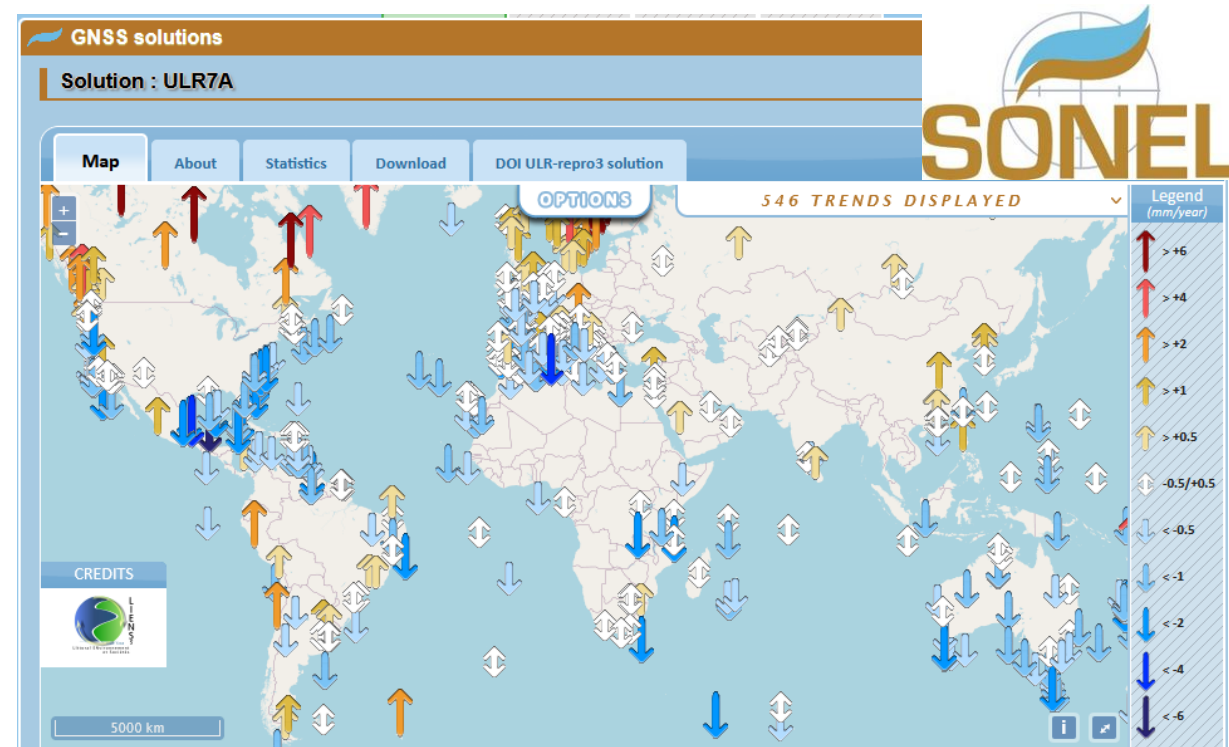
Global mean sea level

<https://psmsl.org/>



Permanent Service for Mean Sea Level: **Relative sea level trends worldwide**

<http://www.sonel.org>



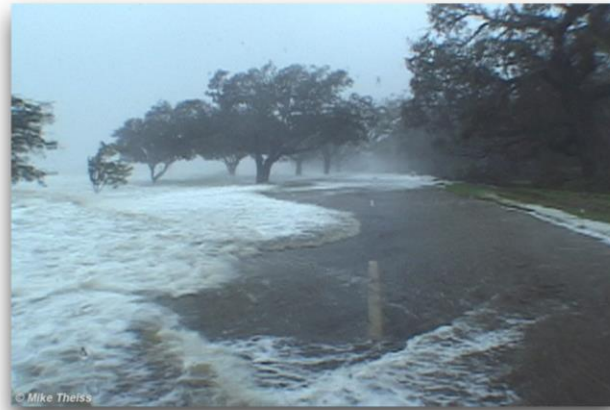
SONEL: Global Navigation Satellite System (GNSS) stations: **vertical land movement information**

In-situ sea level measurements. Applications and global context

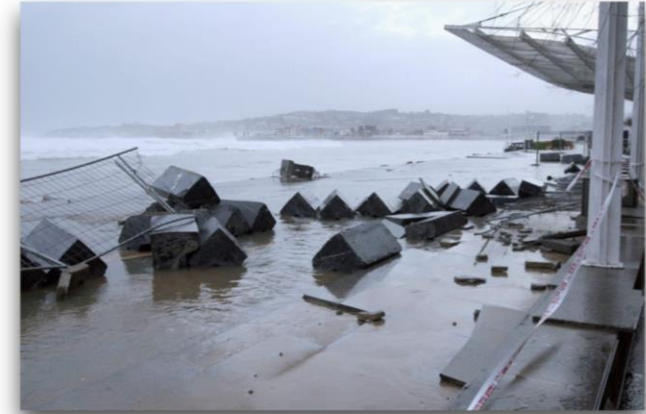
Tide gauges: critical platform for coastal sea level hazards



W. Med. (November 2001)



Katrina (2005)



North of Spain (Febr. 2014)



Japan (2011)

! Tsunamis only recorded by TG's in Europe !!

In-situ sea level measurements. Applications and global context

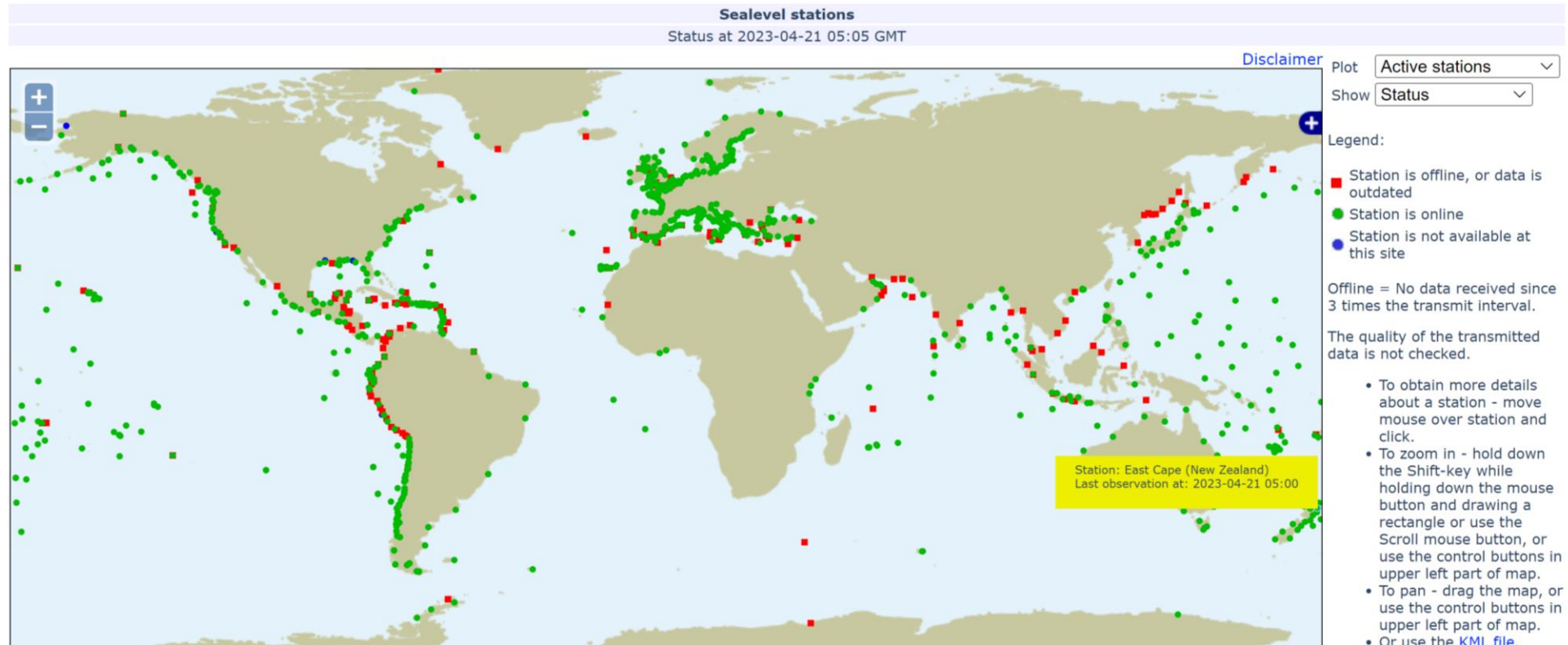


Tsunami warning, need of real time data



SEA LEVEL STATION MONITORING FACILITY

Intro **Map** Station lists Station details Services & FAQ GLOSS Catalog



<http://www.ioc-sealevelmonitoring.org/map.php>

GLOSS recommendations: instrumentation, QC and data processing

GLOSS Implementation Plan

- Reference to a permanent land position (Tide Gauge Bench Mark) and periodic levelling (**datum stability**)
- Need of **high-frequency sampling and real time data**, for assessment of extreme flooding events
- **Multiple sensors** (e.g. a radar + a pressure sensor) and ancillary measurements (e.g atmospheric pressure)
- **Co-location** of tide gauges **with permanent GNSS** receivers
- **Open data policy**: unrestricted and timely data access
- Global coverage should be complemented by **denser networks in regions** of high scientific interest.
- **Data archaeology**: recovery of historical records for climate studies

<https://unesdoc.unesco.org/ark:/48223/pf0000217832>



GLOSS recommendations: instrumentation, QC and data processing

2020: Quality Control Manual (Volume I)

- **Near-real time (Level 1 Quality Control-L1):** essential for use in operational oceanography (near-real time validation of storm surge forecasts)
- **Delayed mode (Level 2 Quality Control-L2):** essential for higher quality datasets, datum stability check and sea level trends computation
- Collection of detailed **metadata and metadata QC** essential for a best assessment of historical records

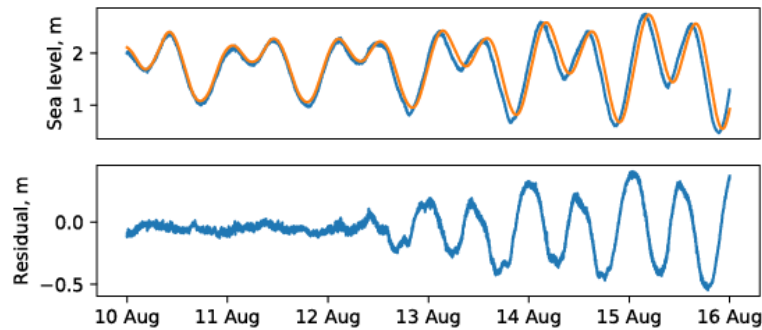
<https://unesdoc.unesco.org/ark:/48223/pf0000373566>



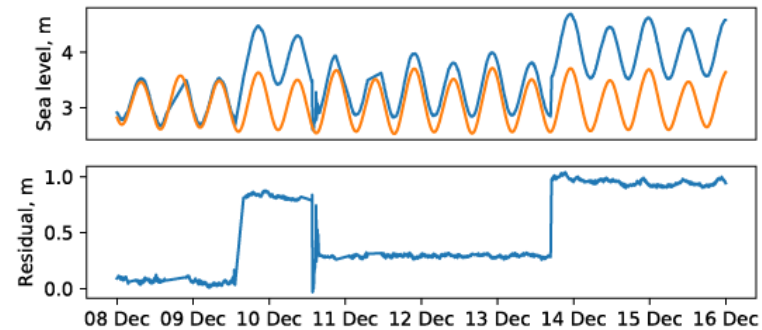
GLOSS recommendations: instrumentation, QC and data processing

2020: Quality Control Manual (Volume I)

Clock malfunction

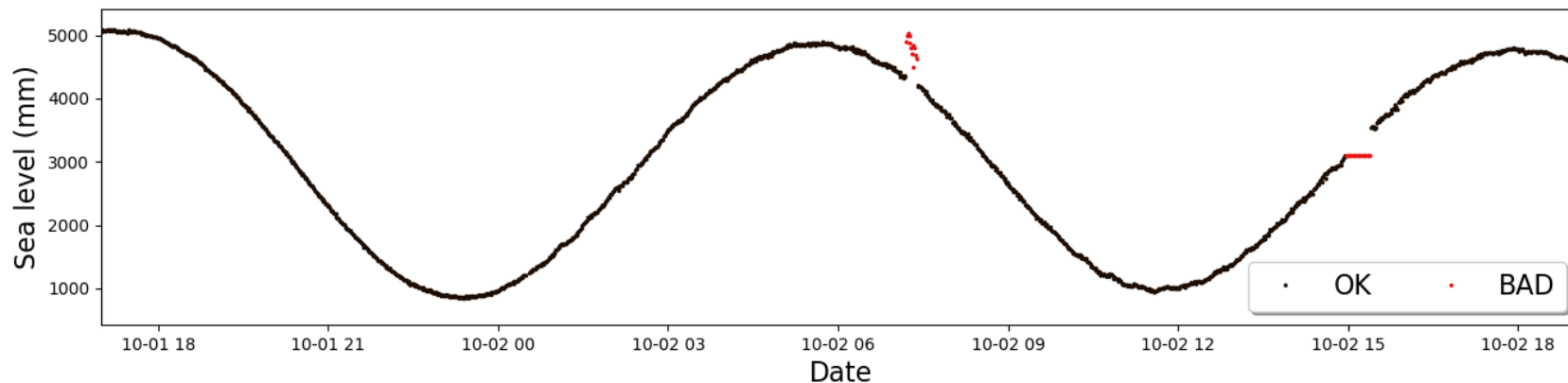


Datum changes



Spikes or constant values

Plot: Incorrect data due to an object below the radar sensor and constant values



<https://unesdoc.unesco.org/ark:/48223/pf0000373566>



Automatic algorithms **must distinguish real events (tsunamis)**

Delayed mode QC and **expert inspection always required**



On-going regional initiatives: EuroGOOS Tide Gauge Task Team



EuroSea project: Analysis of gaps/duplicity of data portals (CNRS-SONEL)

- Methodology to **cross-compare the data portals**, based on the set theory (Python package and web application)
- 5 metadata catalogues and 12 data portals were analysed and cross-compared for gaps and duplicates.
- **The IOC/UNESCO Sea Level Station Catalogue is the most complete (global) with 2450 stations referenced**
- Large variability in the content of data portals
- A “barcode” style to summarize the content of each data portal and catalogues

Tide Gauge Portals Intercomparison

Catalog(s) selection

Metadata catalogs

- GLOSS
- SSC
- PSMSL Ellipsoid
- EUTGN
- PTWC

Data catalogs

- PSMSL
- UHSLC FD
- UHSLC RQ
- SLSMF
- SONEL
- BODC
- Copernicus MS
- EMODNET
- REFMAR
- REDMAR
- GESLA-3
- NOAA
- Norwegian TGN
- Canadian TGN
- PSMSL GNSS IR
- Indonesian TGN

Loading options

Select/unselect all catalog(s)

Load selected catalog(s)

Catalog(s) statistics

#Sites	#Sites (log)	Selected sites	Selected sites (log)
psmsl			
cmems			

Sites map

Zoom selection: Select a specific region... Show catalog source:

majuro-c
Longitude: 171.373
Latitude: 7.106028

Sites table

Update selection Clear selection 2434 site(s) loaded Export table

Name	Longitude	Latitude	Original catalog	#id	#data	#link
flinten7	12.8445	55.5894	cmems	1	1	0
aarhus	10.2167	56.15	cmems	1	1	0
ahus	14.3286	55.9284	cmems	1	1	0
angelholm	12.7865	56.298	cmems	1	1	0
arko	16.9607	58.4843	cmems	1	1	0
assens	9.8833	55.2667	cmems	1	1	0

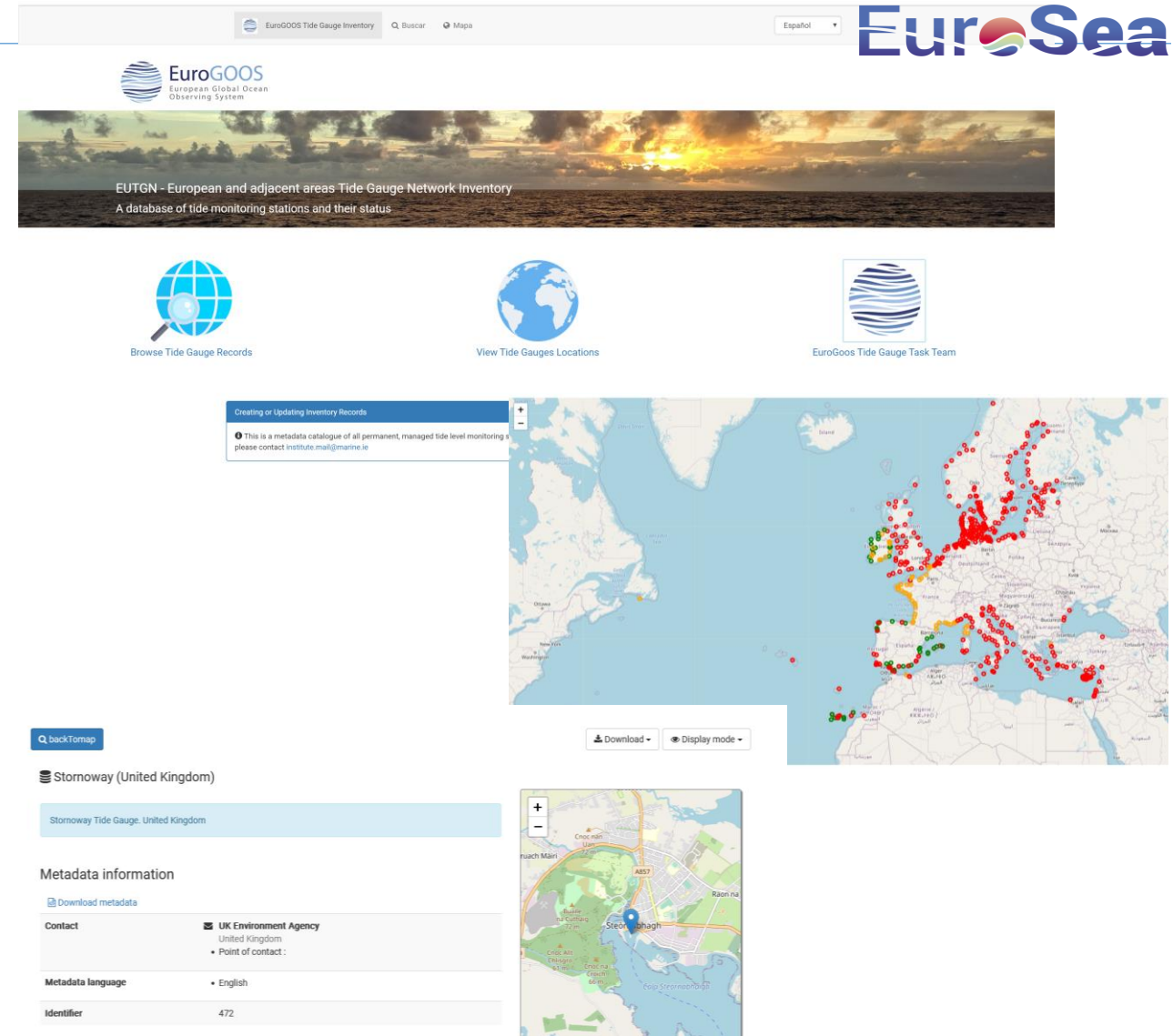
<https://www.sonel.org/tgcat/>

On-going regional initiatives: EuroGOOS Tide Gauge Task Team

EuroSea project: EUTGN: New tide gauge metadata catalogue for the EuroGOOS region.

- On-line, live, managed metadata catalogue registering all permanent tide gauges in European and adjacent coastlines
- V1.0 complete and released, **640 locations identified**, live data reduced to verified monitoring sites (528 records)
- Log in and live update options by data providers
- Version 1.0 available at the TGTT website!

Next steps: Metadata update from data providers after circular sent by the EuroGOOS TGTT chairs, with instructions, on October 28th



The screenshot displays the EuroGOOS Tide Gauge Inventory website. At the top, there is a navigation bar with the EuroGOOS logo, a search bar, and a language dropdown set to 'Español'. Below the navigation bar is a banner image of a sunset over the ocean with the text 'EUTGN - European and adjacent areas Tide Gauge Network Inventory' and 'A database of tide monitoring stations and their status'. Three main navigation icons are visible: 'Browse Tide Gauge Records', 'View Tide Gauges Locations', and 'EuroGoos Tide Gauge Task Team'. The main content area features a map of Europe with numerous red dots representing tide gauge locations. A pop-up window titled 'Creating or Updating Inventory Records' is overlaid on the map, containing a message: 'This is a metadata catalogue of all permanent, managed tide level monitoring sites. If you have any updates, please contact institute.mail@marine.ie'. Below the map, there is a 'backToMap' button and a 'Download' button. A detailed view of the Stornoway tide gauge is shown, including a map of the location and a metadata table.

Stornoway Tide Gauge, United Kingdom	
Metadata information	
Download metadata	
Contact	UK Environment Agency United Kingdom Point of contact:
Metadata language	English
Identifier	472

On-going regional initiatives: EuroGOOS Tide Gauge Task Team

EuroSea project: New GNSS-IR Data Portal at PSMSL (NOC, UK):

- Sea level data from **novel technique Global Navigation Satellite System-Interferometric Reflectometry (GNSS-IR)**: signal-to-noise ratio of conventional GNSS receivers installed to monitor land motion.
- Documentation available for the site including description and information on how site metadata can be harvested.
- PSMSL will continue to work with EuroGOOS, GLOSS, the International GNSS Service (IGS), and sites that aggregate GNSS data to improve the interoperability of the portal.

<https://psmsl.org/data/gnssir/index.php>

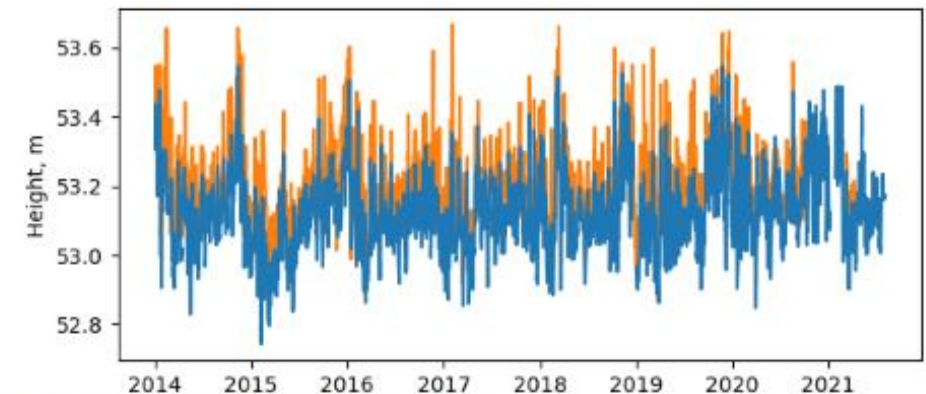
ID: 10049
IGS type code: newl
Latitude: 50.103030°
Longitude: -5.542790°
Ellipsoidal Height: 67.465 m
Reflector Height: 14.488 m
Provider: BIGF
Alternative Providers:
SONEL Link: newl
NGL Link:



Data

[Zipped data file](#)

Plot of daily data



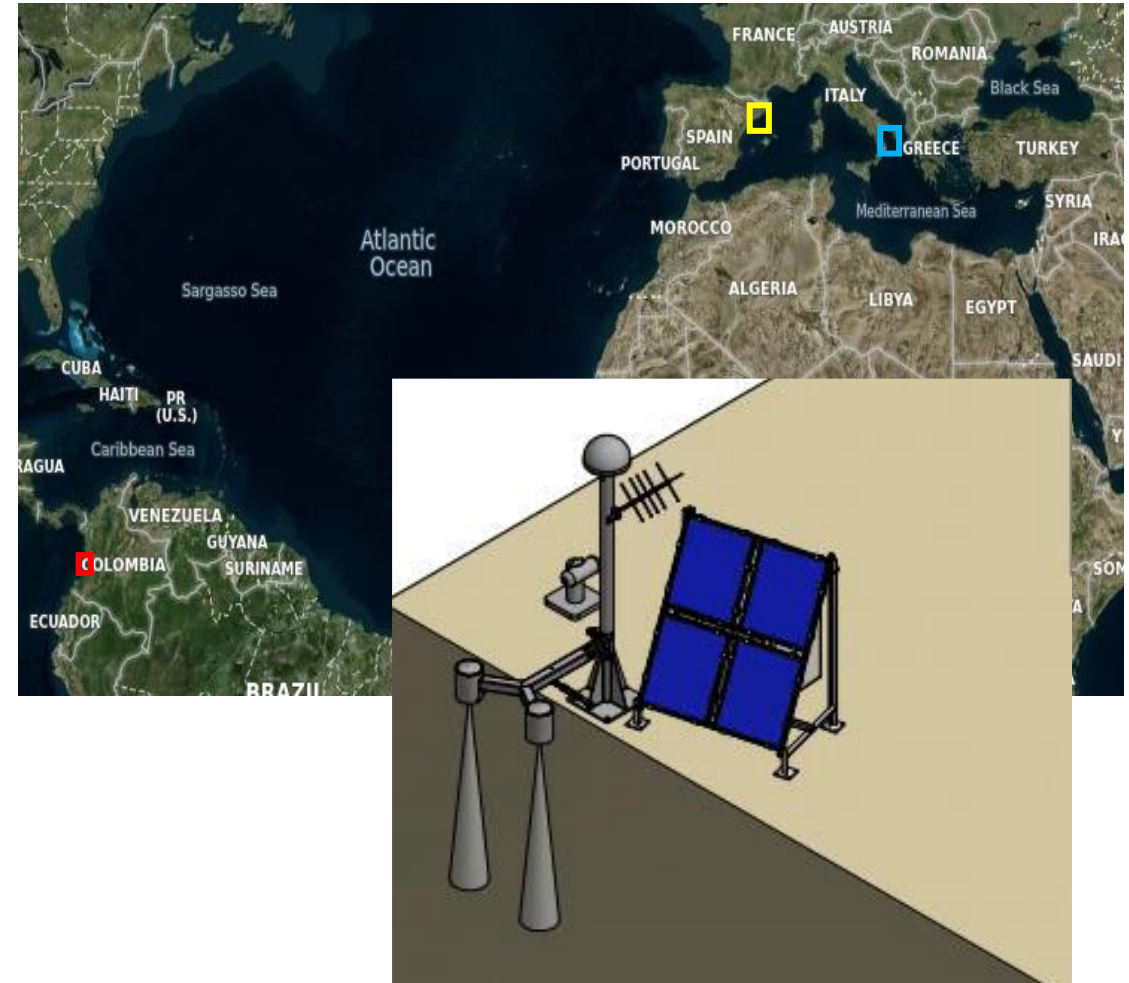
Blue: GNSS-IR Data, Orange: Nearby tide gauge data

On-going regional initiatives: EuroGOOS Tide Gauge Task Team



EuroSea project: New standard low-cost, low-maintenance sea level stations developed and installed by NOC (UK)

- Core measurements of **sea level, atmospheric pressure and land motion**
- **Innovative techniques** (e.g. Global Navigational Satellite System Interferometric Reflectometry, GNSS-IR) and **renewables** to reduce maintenance costs
- Still meet **international (GLOSS) standards** (for accuracy, sampling frequency etc)
- Allow customisation to local monitoring needs (e.g.: lightning detection and waves)



Installations at Barcelona (Spain), Taranto (Italy) and Buenaventura (Colombia)

On-going regional initiatives: EuroGOOS Tide Gauge Task Team



EuroSea project: A new method (with reduced uncertainties) of estimating sea level trends

July 5, 2022

Dataset Open Access

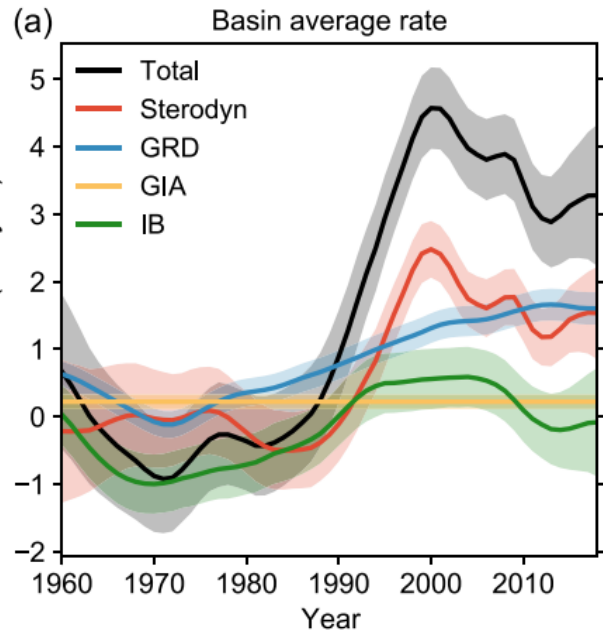
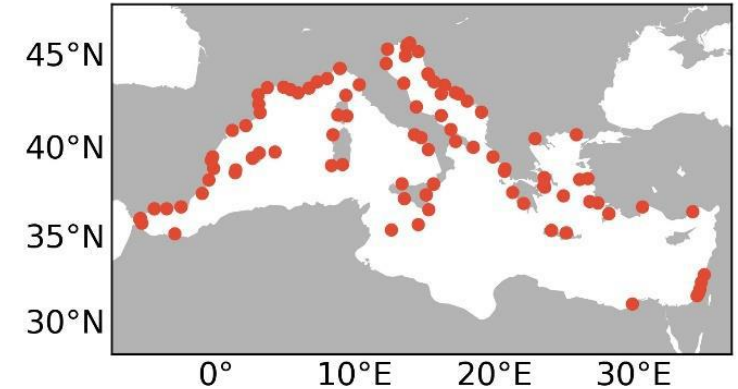
Reconstruction of Mediterranean sea-level changes and contributions for 1960-2018

Calafat, Francisco M.; Frederikse, Thomas; Horsburgh, Kevin

Data supporting the paper:

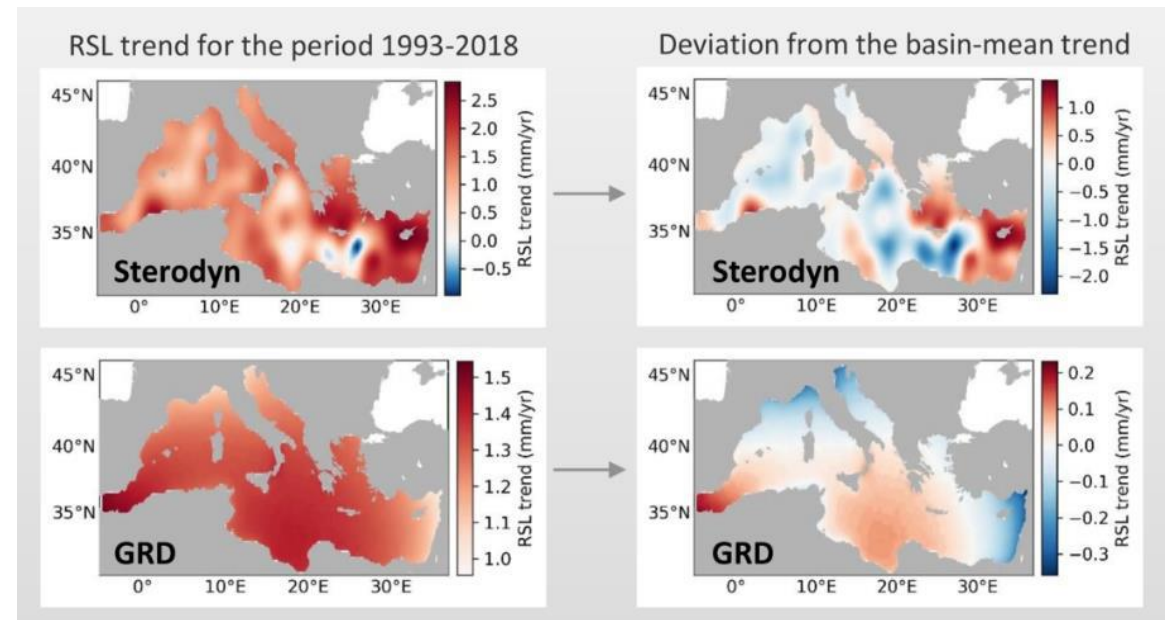
Calafat, F. M., Frederikse, T., and Horsburgh, K. (2022). The Sources of Sea-Level Changes in the Mediterranean Sea since 1960, *Journal of Geophysical Research Oceans*, under review.

In-situ (tide gauges) + satellite altimetry data



1960-1990: SLR lower than global average

Increase from 0.4 to 3.4 mm/yr in 2000-2018



On-going regional initiatives: MONGOOS Tide Gauge Task Team

Main achievement 2021 – 2022:

- Building the network: recovering the **link with tide gauge operators** in the region
- **First community paper** published:



- 44 authors from 35 institutions in the Mediterranean and Black Seas
- Accepted for publication in **Ocean Science** in **July 2022**

Objectives:

- 1) Mapping of existing coastal sea level monitoring infrastructures, basic metadata information and the respective data availability in existing data aggregators
- 2) Analysis of the fit-for-purpose status of the network

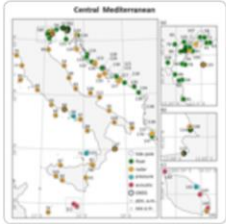
Articles / Volume 18, issue 4 / OS, 18, 997–1053, 2022 Search

Ocean Sci., 18, 997–1053, 2022
<https://doi.org/10.5194/os-18-997-2022>
© Author(s) 2022. This work is distributed under the Creative Commons Attribution 4.0 License.

Article Peer review Metrics Related articles

Review article 15 Jul 2022

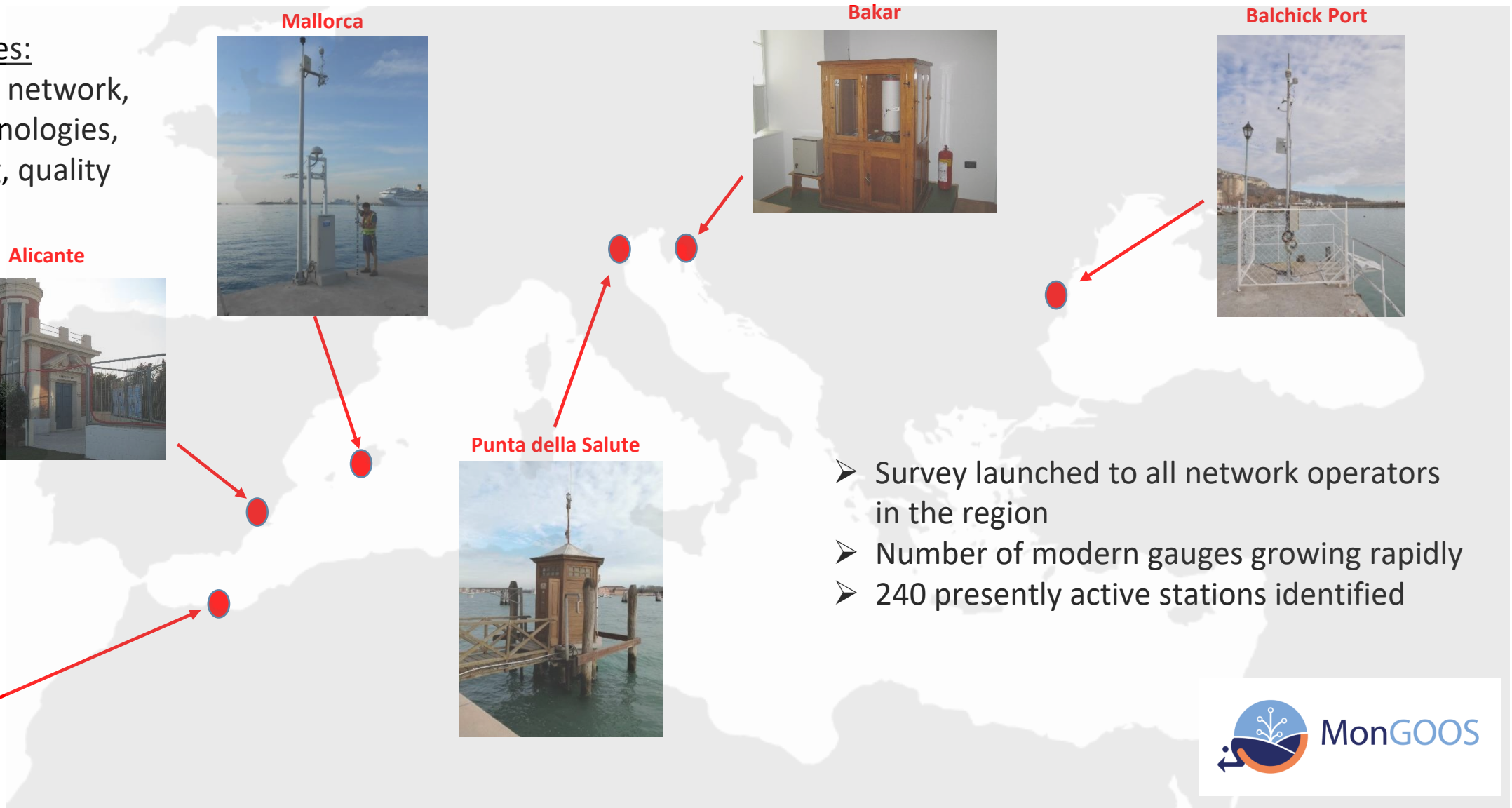
Coastal sea level monitoring in the Mediterranean and Black seas



Begoña Pérez Gómez¹, Ivica Vilibić², Jadranka Šepić³, Iva Međugorac⁴, Matjaž Ličer^{5,35}, Laurent Testut⁶, Claire Fraboul⁷, Marta Marcos⁸, Hassen Abdellaoui⁹, Enrique Álvarez Fanjul¹, Darko Barbačić¹⁰, Benjamín Casas¹¹, Antonio Castaño-Tierno¹², Srđan Čupić¹³, Aldo Drago¹⁴, María Angeles Fraile¹⁵, Daniele A. Galliano¹⁶, Adam Gauci¹⁴, Branislav Gloginja¹⁷, Víctor Martín Guijarro¹⁵, Maja Jeromeš⁵, Marcos Larrad Revuelto¹⁸, Ayah Lazar¹⁹, Ibrahim Haktan Keskin²⁰, Igor Medvedev²¹, Abdelkader Menassri⁹, Mohamed Aïssa Meslem⁹, Hrvoje Mihanović²², Sara Morucci²³, Dragos Niculescu²⁴, José Manuel Quijano de Benito¹⁸, Josep Pascual²⁵, Atanas Palazov²⁶, Marco Picone²³, Fabio Raicich²⁷, Mohamed Said²⁸, Jordi Salat²⁹, Erdinc Sezen²⁰, Mehmet Simav²⁰, Georgios Sylaios³⁰, Elena Tel¹², Joaquín Tintoré¹¹, Klodian Zaimi³¹, and George Zodiatis^{32,33,34}

On-going regional initiatives: MONGOOS Tide Gauge Task Team

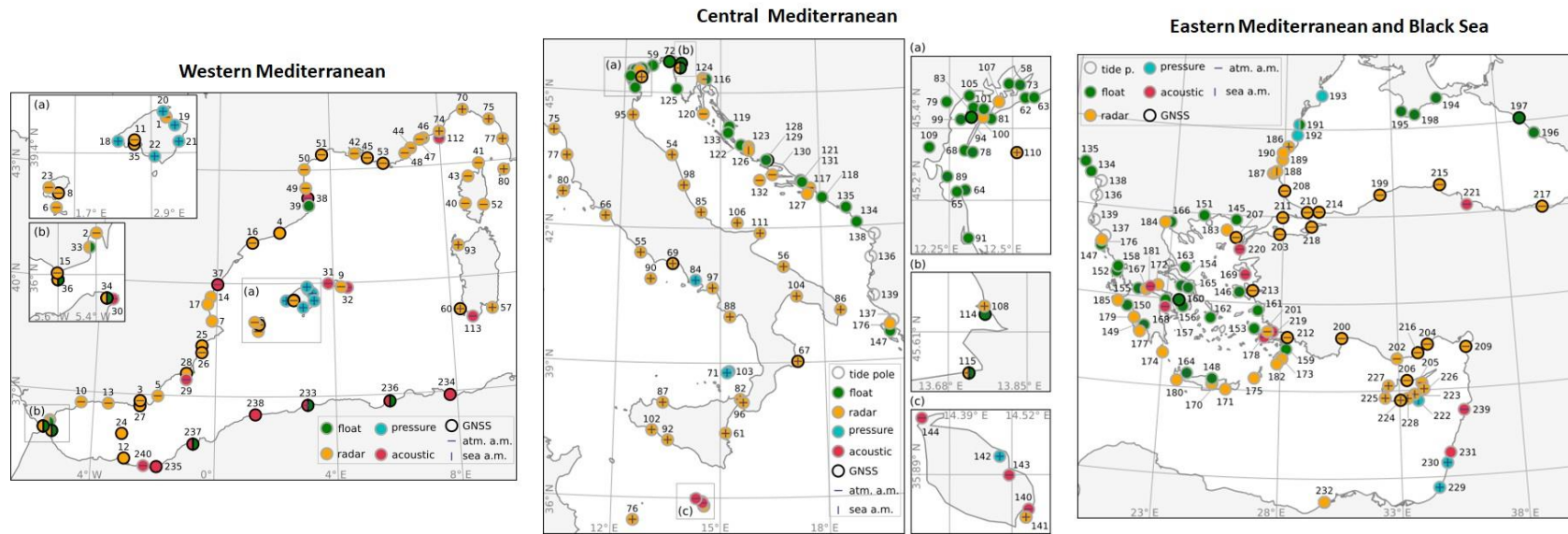
- Some examples:
heterogenous network,
different technologies,
time sampling, quality
control, etc



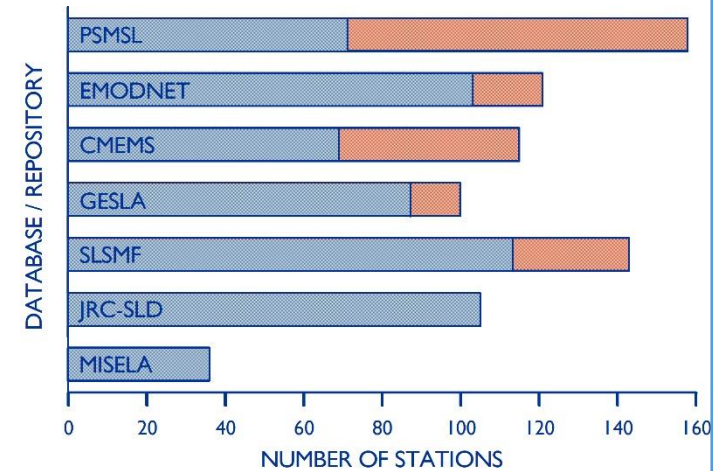
- Survey launched to all network operators in the region
- Number of modern gauges growing rapidly
- 240 presently active stations identified

On-going regional initiatives: MONGOOS Tide Gauge Task Team

Active stations and type of sensors (240)



Data Availability in different data portals



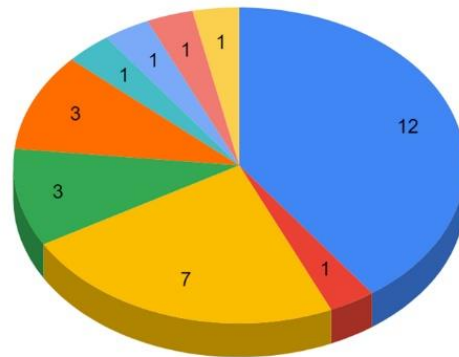
- **30 agencies**, representing most countries except Morocco, Tunisia, Libya, Bosnia and Herzegovina, Ukraine, Georgia, Lebanon and Syria
- **56% of the stations** based on radar sensors providing 1-min data with real-time data transmission
- PSMSL and SLSMF (GLOSS data portals) have the largest number of timeseries
- ISPRA (Italy) runs the largest network (62 stations), followed by the JRC (24 tsunami stations, operated jointly with other institutions)

On-going regional initiatives: MONGOOS Tide Gauge Task Team

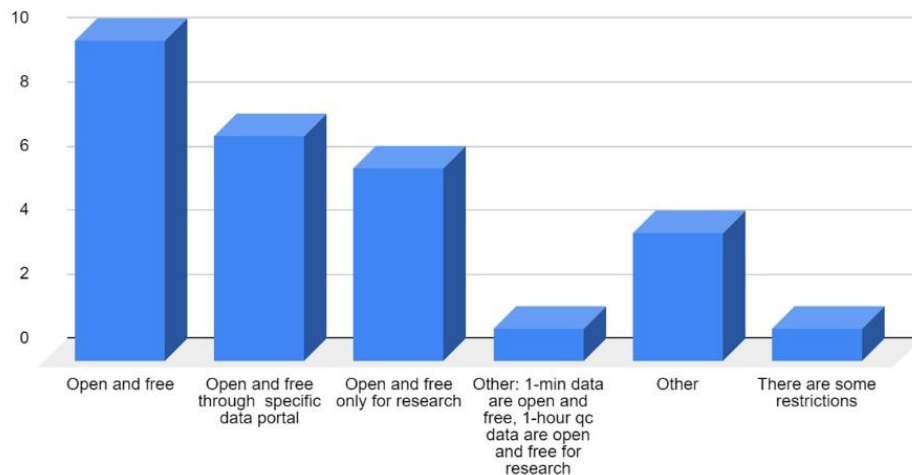
Additional info from the survey

(a) Main purpose

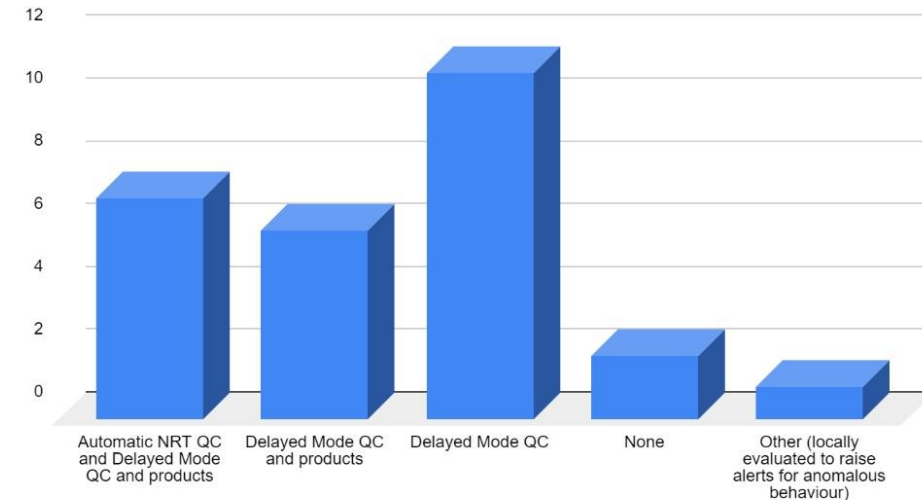
- All: multi-purpose
- Tides and long-term msl
- Tides and hydrography
- Geodesy and long-term msl
- Storm surge/ tsunami warning
- Mixed: site dependent
- Tides and geodesy and long-term msl
- Tides and hydrography and long-term msl
- Tides storm surge long term msl and geodesy



(b) Data policy



Quality Control and Data processing



- Most multi-purpose, followed by tides and hydrography
- Small data policy issues, most of the data open and free
- Need to improve QC and data processing, especially in NRT, at some stations

On-going regional initiatives: MONGOOS Tide Gauge Task Team

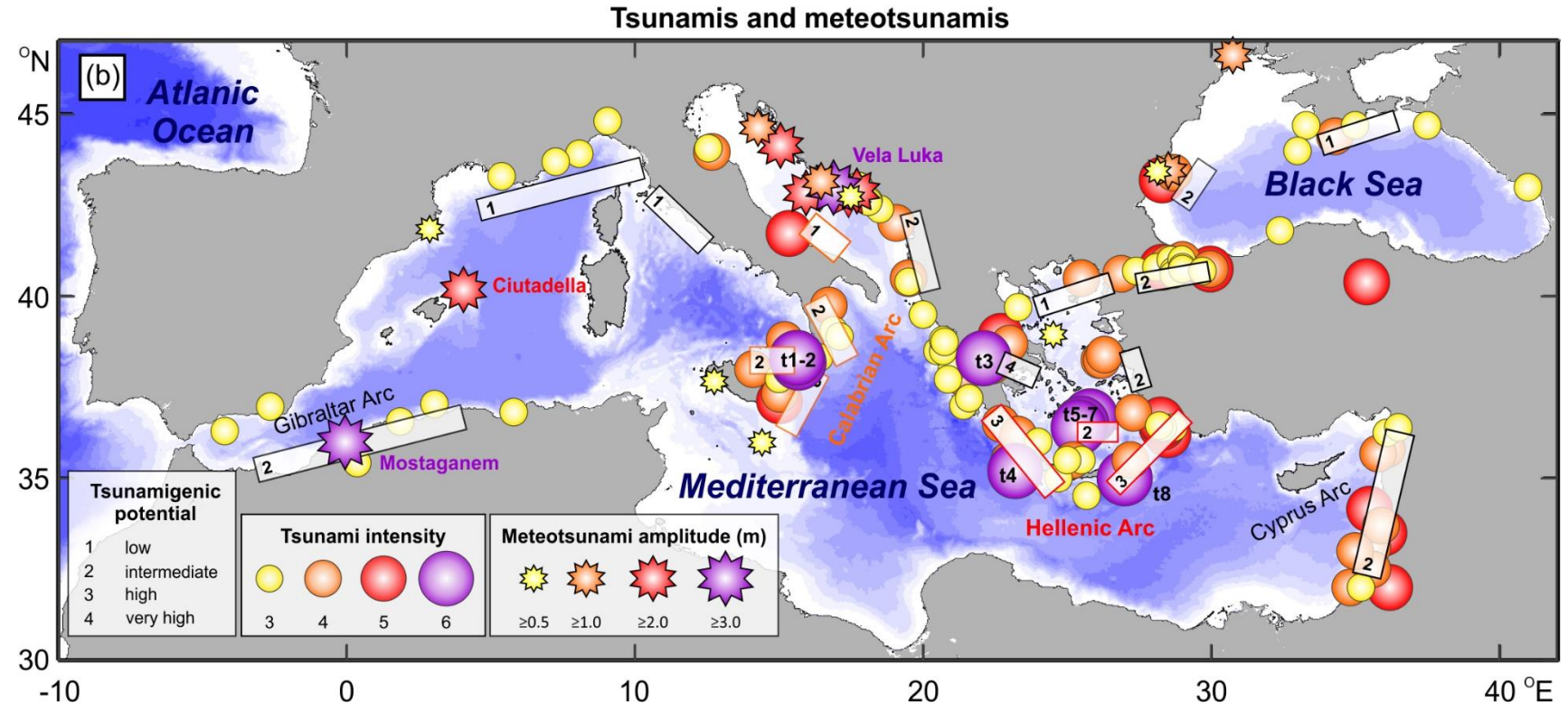
Storm Surges + Tsunamis/Meteotsunamis (timeliness and sampling intervals lowering to 1 min or less)

Tsunamis: likely hazard (convergence of the African and Eurasian plates).

Basin-wide distribution needed, with more stations closer to tsunamigenic sources:

- In 2005, most of the tide gauges in the NEAMTWS region were not suitable for tsunami warning
- At least 152 of all active stations in the M/BS are today contributing to tsunami warning systems
- Nearly 50 stations installed only for this purpose in recent years (e.g: low-cost sensors by JRC)

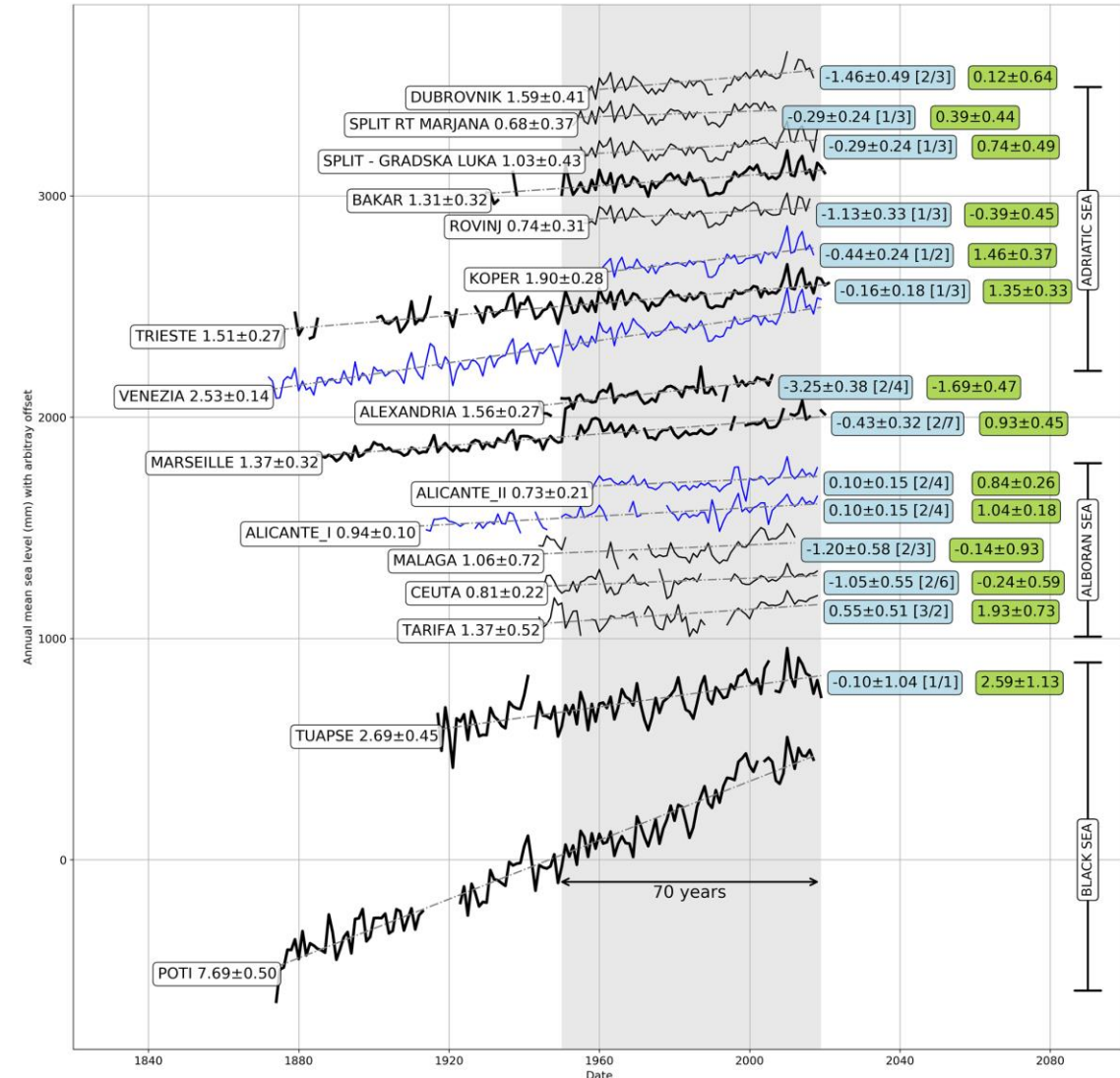
Meteotsunamis: local effects, **several hotspots**. Tsunami sensors + atmospheric pressure 1 min data useful for this application



On-going regional initiatives: MONGOOS Tide Gauge Task Team

Most challenging application: **long-term mean sea level evolution**

- Only **10 stations** cover the last 100 years of data
- **27 stations** have data for the last 30 years (**altimetry period**)
- Spatial variability of trends: positive RSL trends range from **0.68 mm/yr** in Split Rt Marjana to **7.69 mm/yr** in Poti (Black Sea)
- VLM data from GNSS (green) allow estimation of absolute SL trends (blue)



Take home messages

General tide gauge network challenges:

- Extremes and high frequency events: impact of waves
- Long-term coastal mean sea level: vertical land movement
- Remote areas and hostile conditions
- Technological evolution of sensors
- New requirements of data flow, quality control and processing
- **Harmonization** of the data and metadata in different repositories
- **Sustainability of the networks !!!**

Mediterranean and Black Seas:

- Coasts exposed to several sea level related hazards at different temporal and spatial scales
- Development of the instrumentation, remote data acquisition, processing, and archiving in the last decades has allowed the **extension of the applications** to a variety of users and coastal hazard managers
- **Lack of data/contacts in North Africa for all applications**



Thank you



Acknowledgements: tide gauge operators and data integrators

Please join us at the **2nd EuroSea Tide Gauge Network Workshop, 4-5 May 2023**
Including a **training session on sea level data quality control and processing:**

Link: <https://us02web.zoom.us/j/87678847231?pwd=d04vU04xVW1CTjBvRzQyYmNZZ2lnQT09>