Tide Gauge
EuroGOOS Task Team

MonGOOS

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

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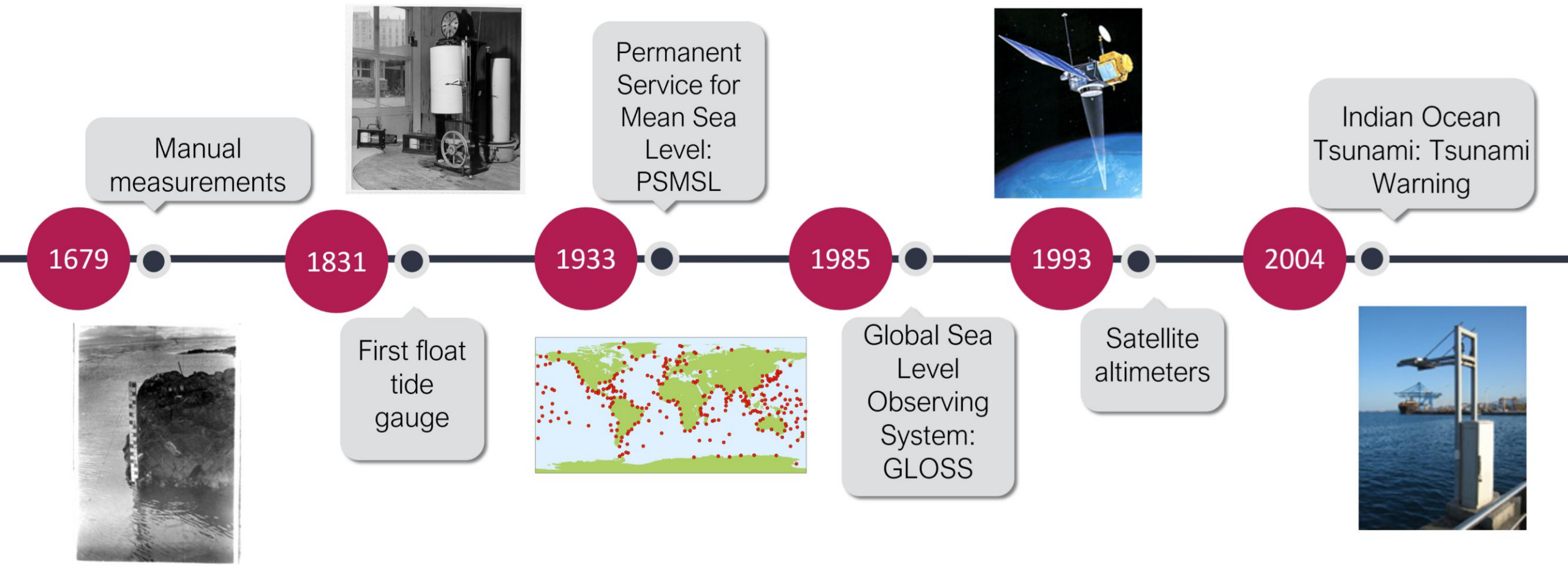
First Data Buoy Cooperation Panel – Mediterranean Training Workshop on Ocean Obervations and Data Applications

May 3 2023

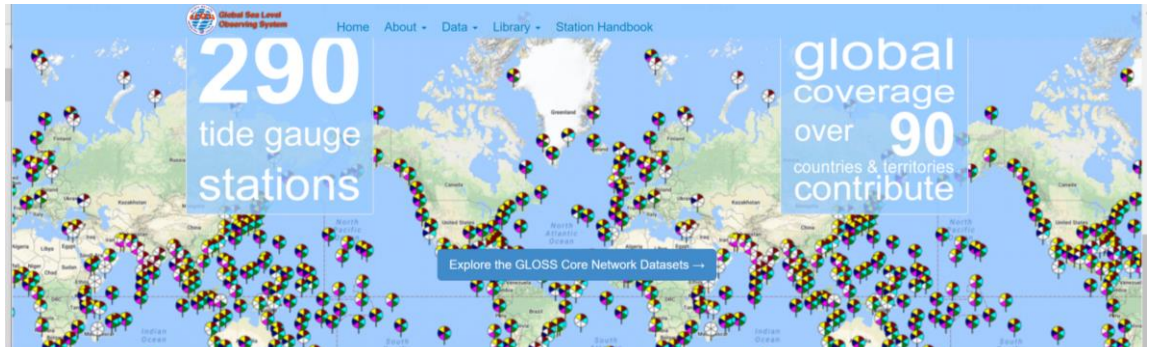
Outline

- 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



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

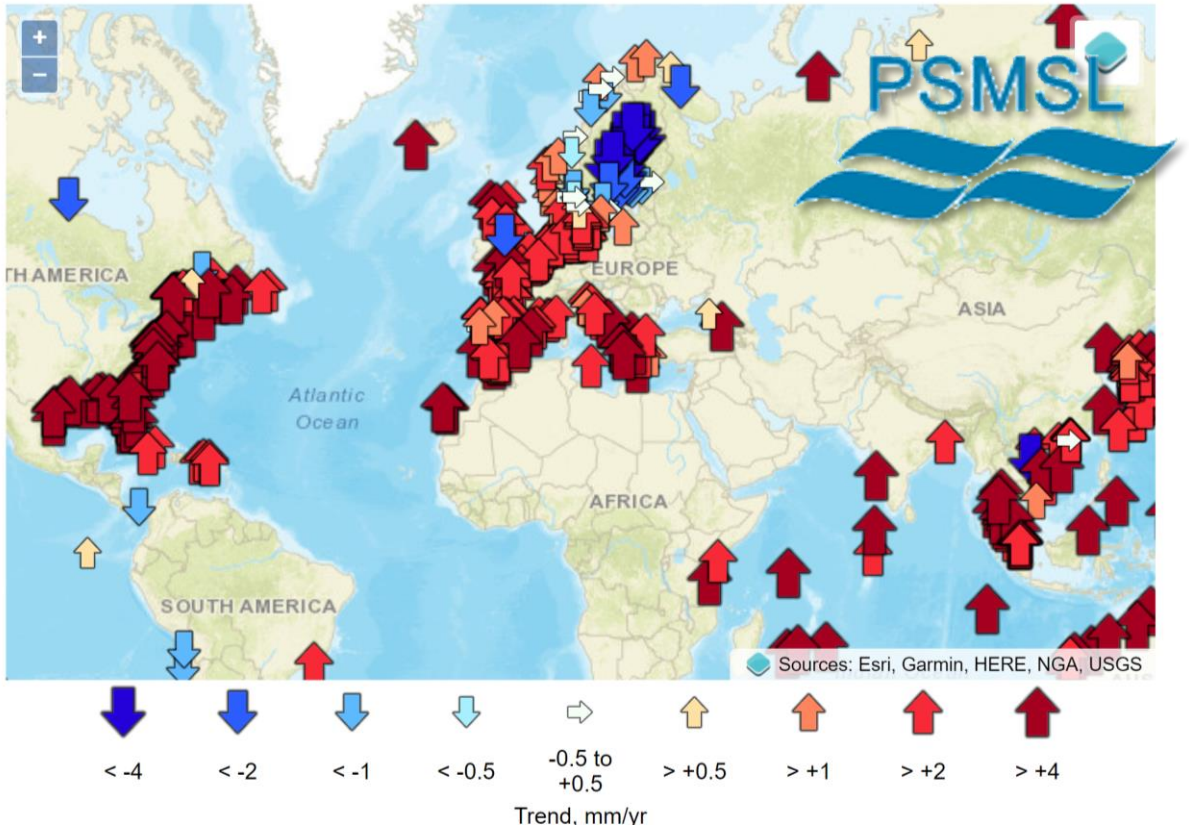
https://gloss-sealevel.org/

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

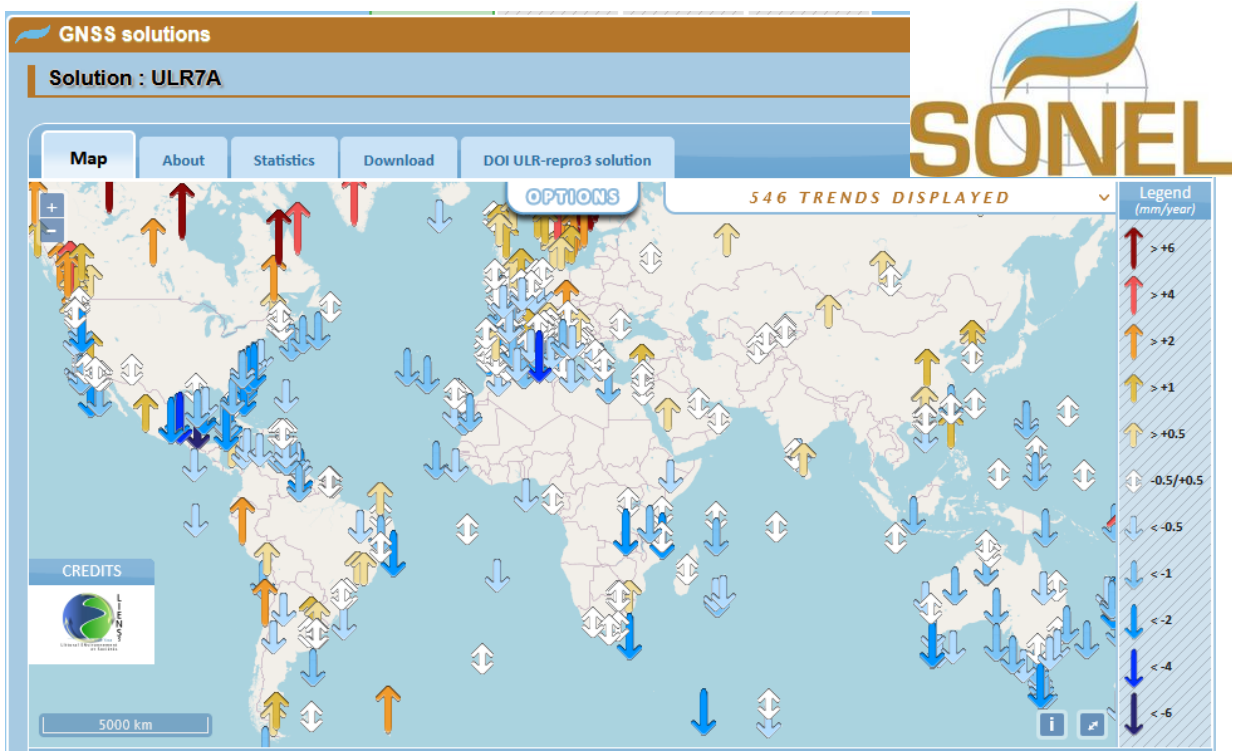
Global mean sea level

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)

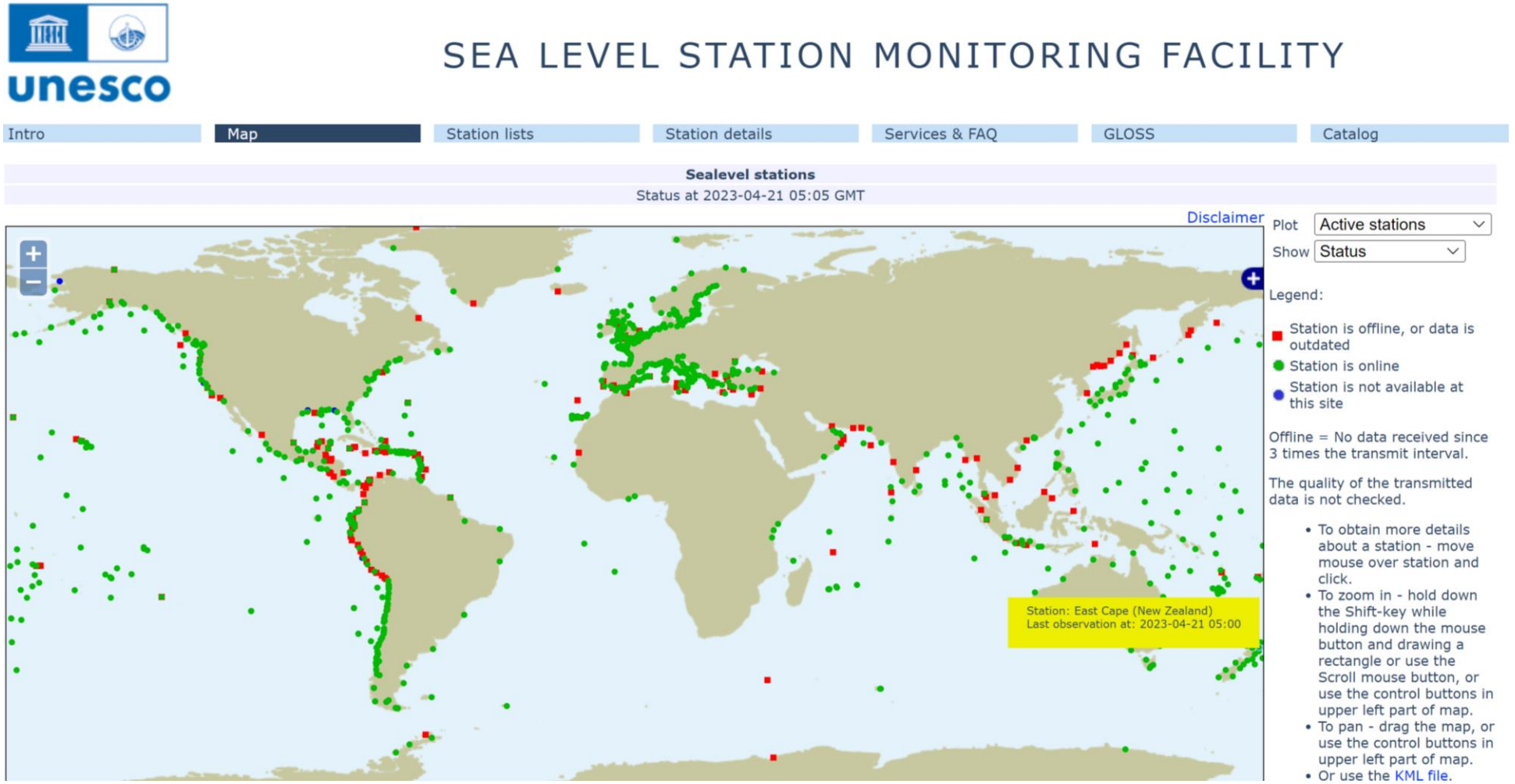
North of Spain (Febr. 2014)

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



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 archaelogy**: recovery of historical records for climate studies

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

GLOSS recommendations: instrumentation, QC and data processing

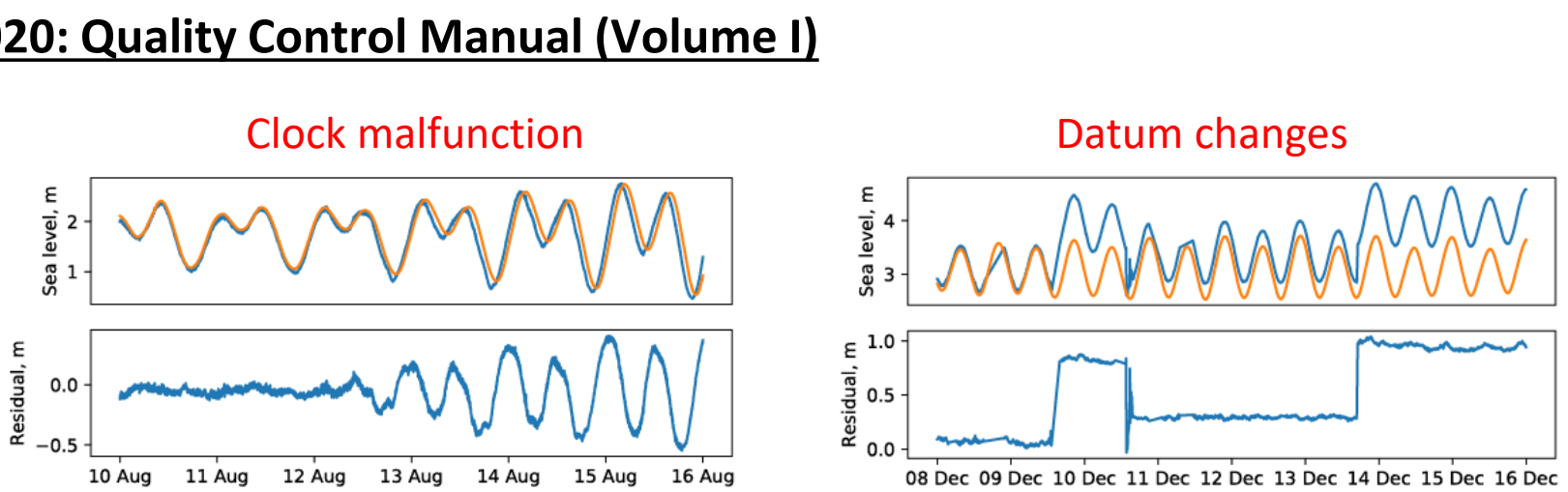
2020: Quality Control Manual (Volume I)

- **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

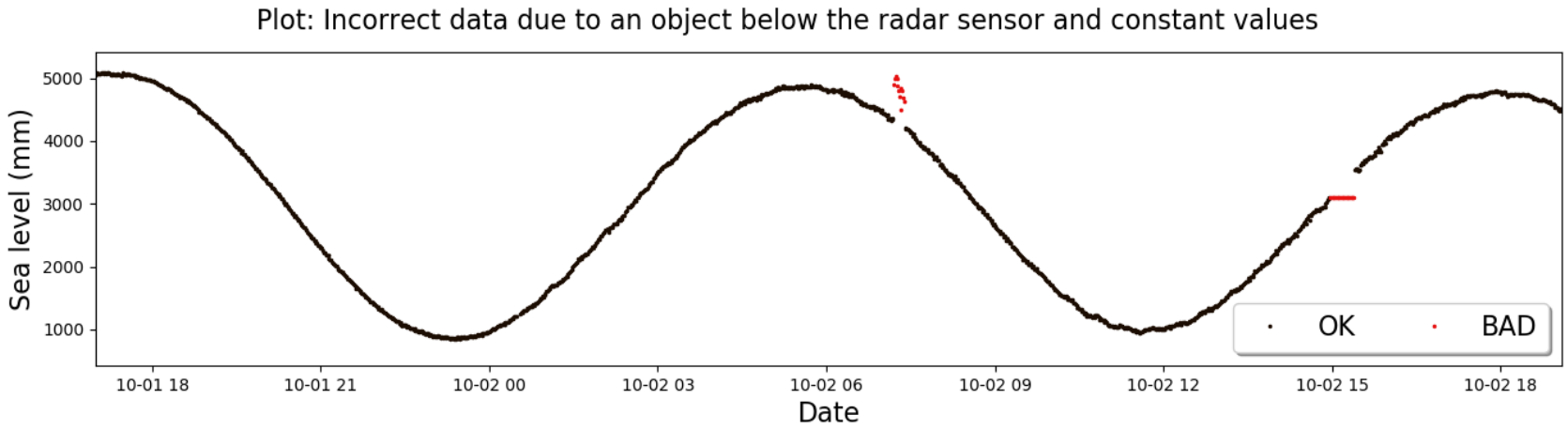
https://unesdoc.unesco.org/ark:/48223/pf0000373566

GLOSS recommendations: instrumentation, QC and data processing

2020: Quality Control Manual (Volume I)



Spikes or constant values



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

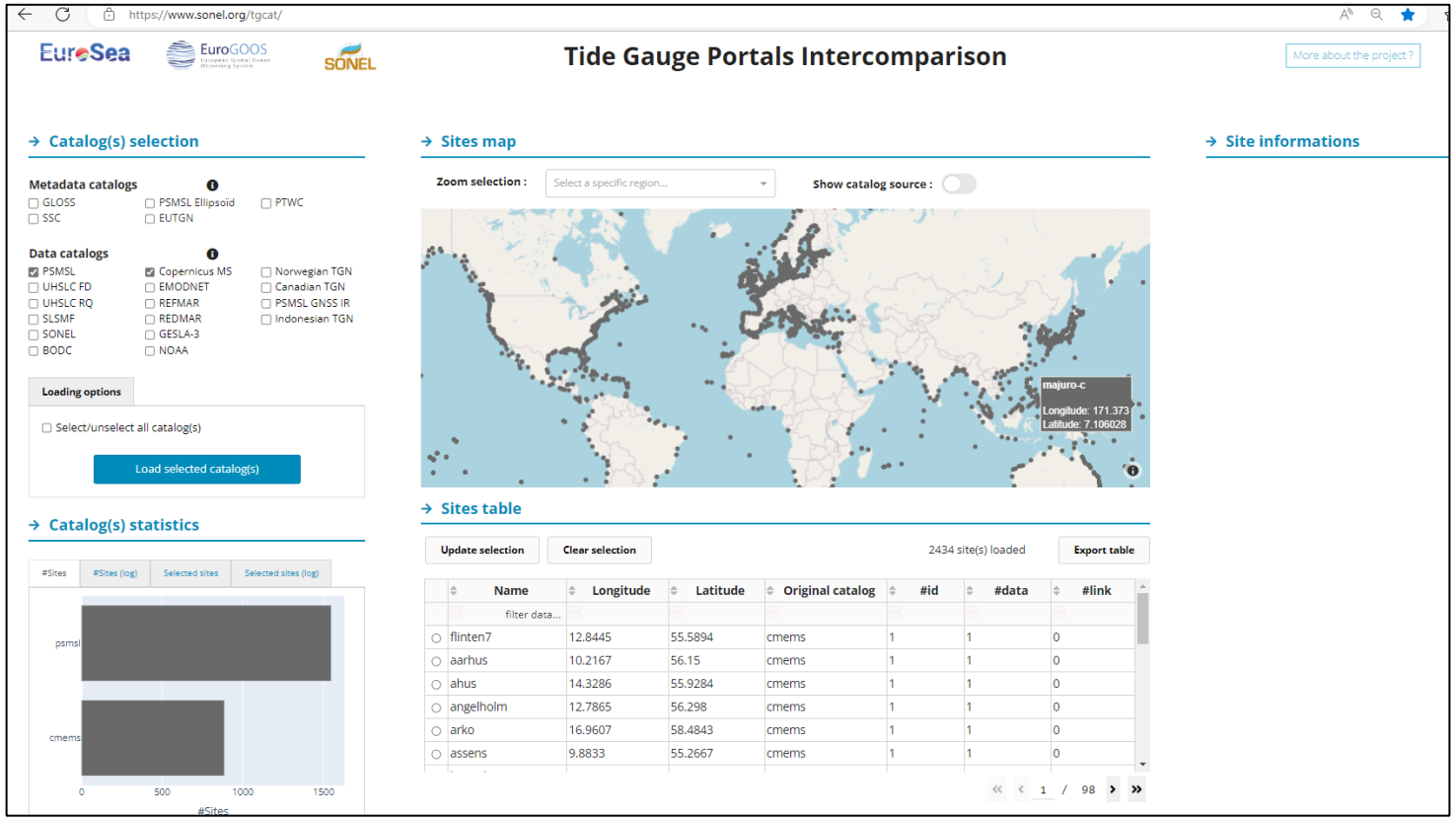
Delayed mode QC and **expert inspection always required**

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

On-going regional initiatives: EuroGOOS Tide Gauge Task Team

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

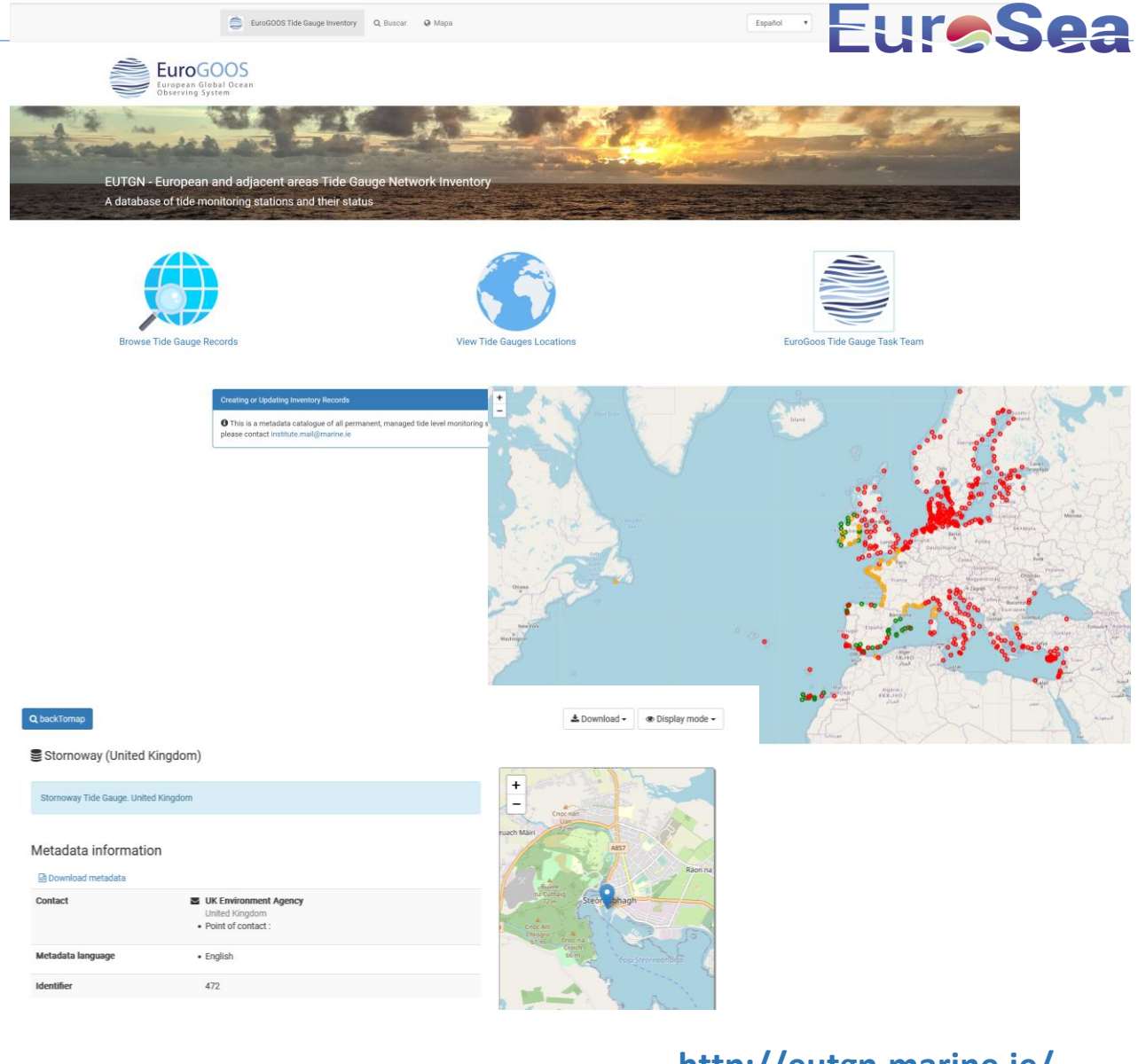
- Methodology to **cross-compare the data portals**, based on the set theory (Python package and web application)
- 5 metadata catalogues and 12 data portals were analysed and cross-compared for gaps and duplicates.
- **The IOC/UNESCO Sea Level Station Catalogue** is the most complete (global) with **2450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



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

On-going regional initiatives: EuroGOOS Tide Gauge Task Team

<u>EuroSea project: EUTGN: New tide gauge metadata catalogue for the EuroGOOS region.</u>



- 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!

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

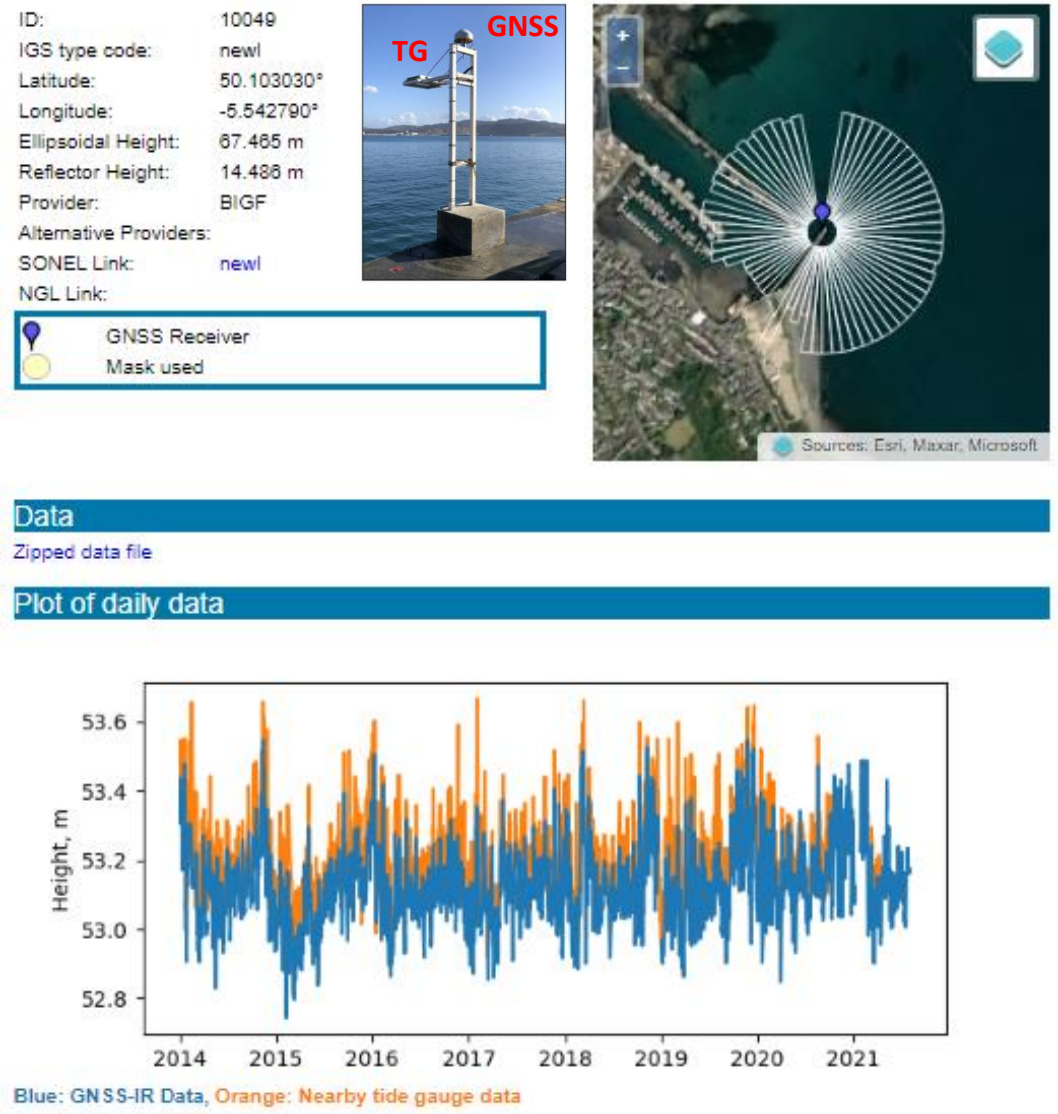
http://eutgn.marine.ie/

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.

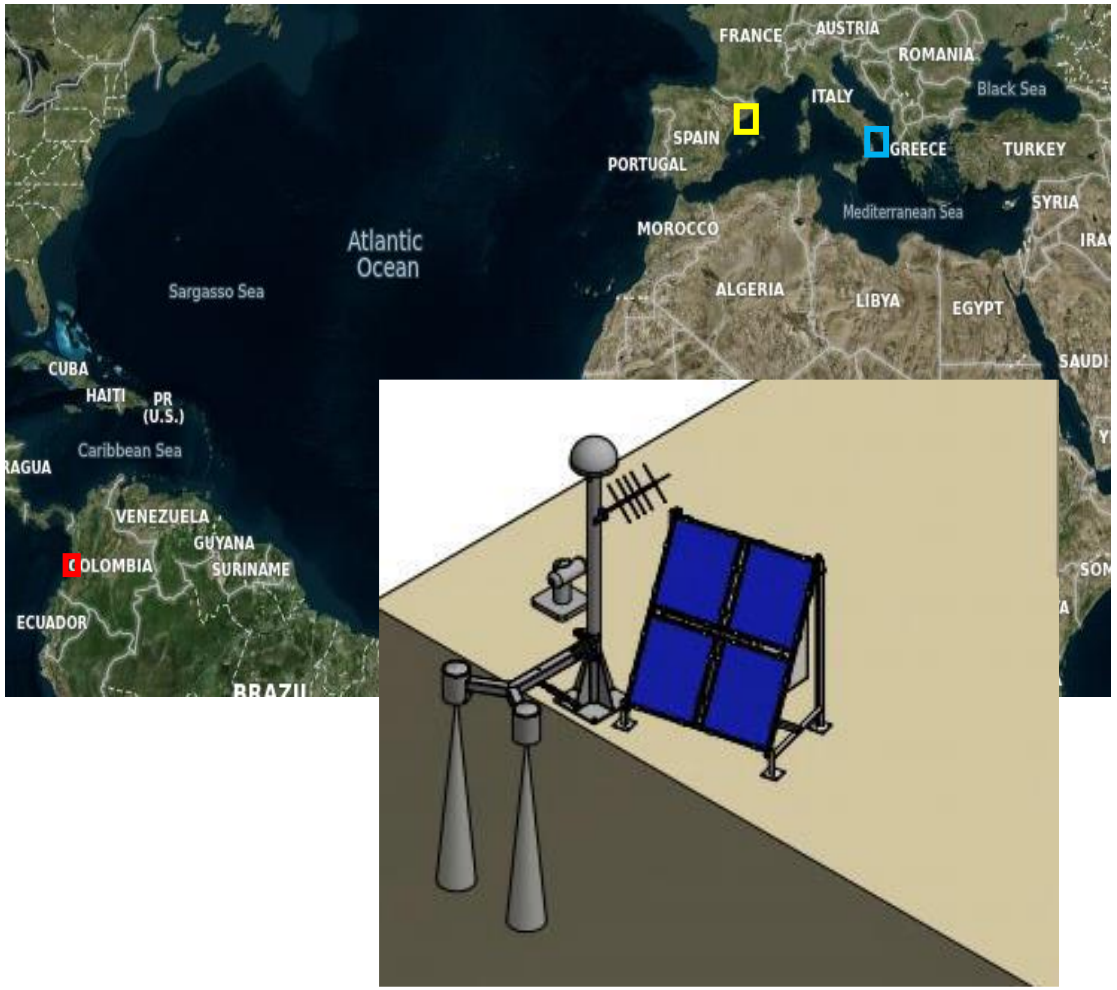
https://psmsl.org/data/gnssir/index.php



On-going regional initiatives: EuroGOOS Tide Gauge Task Team

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

- 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

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

July 5, 2022 Dataset Open Access

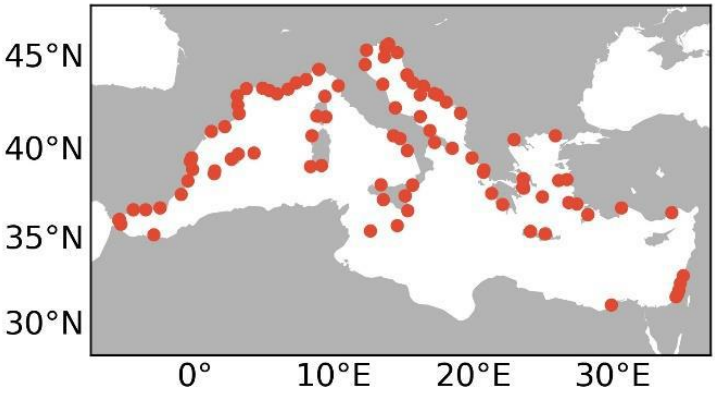
Reconstruction of Mediterranean sea-level changes and contributions for 1960-2018

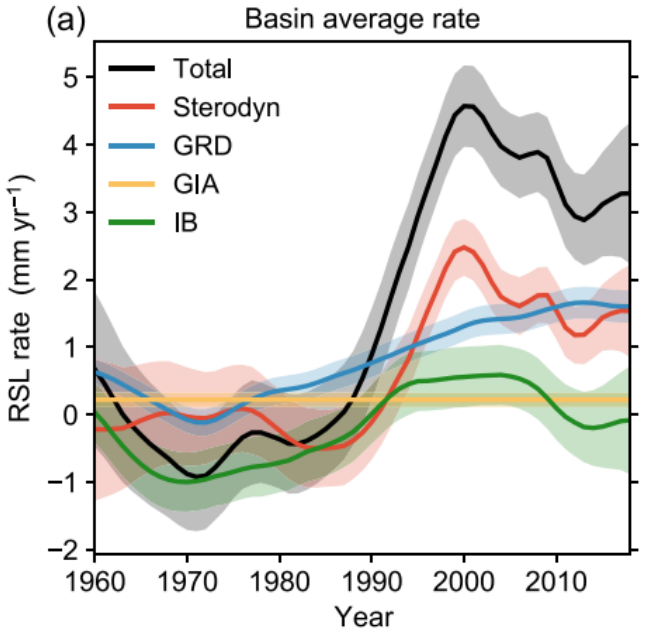
Calafat, Francisco M.; Frederikse, Thomas; Horsburgh, Kevin

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.

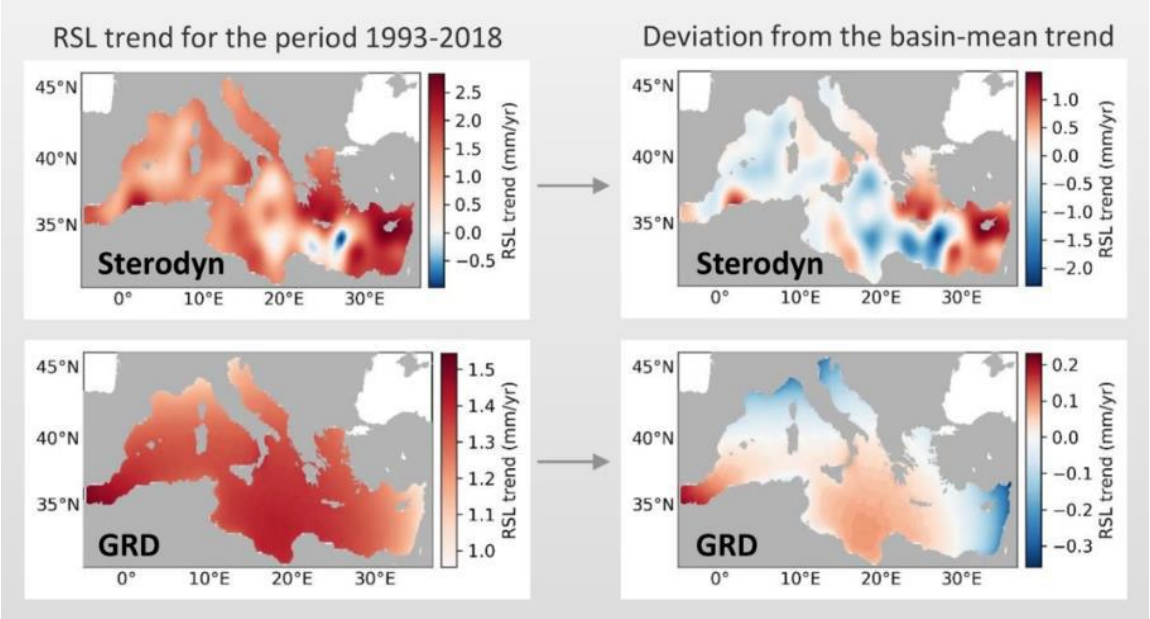
In-situ (tide gauges) + satellite altimetry data





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**:**

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

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

Article | Peer review | Metrics | Related articles

Review article

15 Jul 2022

Coastal sea level monitoring in the Mediterranean and Black seas

Begoña Pérez Gómez[1], Ivica Vilibić[2], Jadranka Šepić[3], Iva Međugorac[4], Matjaž Ličer[5,35], Laurent Testut[6], Claire Fraboul[7], Marta Marcos[8], Hassen Abdellaoui[9], Enrique Álvarez Fanjul[1], Darko Barbalić[10], Benjamín Casas[11], Antonio Castaño-Tierno[12], Srđan Čupić[13], Aldo Drago[14], María Angeles Fraile[15], Daniele A. Galliano[16], Adam Gauci[14], Branislav Gloginja[17], Víctor Martín Guijarro[15], Maja Jeromel[5], Marcos Larrad Revuelto[18], Ayah Lazar[19], Ibrahim Haktan Keskin[20], Igor Medvedev[21], Abdelkader Menassri[9], Mohamed Aïssa Meslem[9], Hrvoje Mihanović[22], Sara Morucci[23], Dragos Niculescu[24], José Manuel Quijano de Benito[18], Josep Pascual[25], Atanas Palazov[26], Marco Picone[23], Fabio Raicich[27], Mohamed Said[28], Jordi Salat[29], Erdinc Sezen[20], Mehmet Simav[20], Georgios Sylaios[30], Elena Tel[12], Joaquín Tintoré[11], Klodian Zaimi[31], and George Zodiatis[32,33,34]

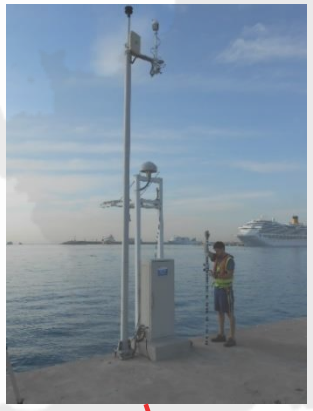
Objectives:

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

On-going regional initiatives: MONGOOS Tide Gauge Task Team

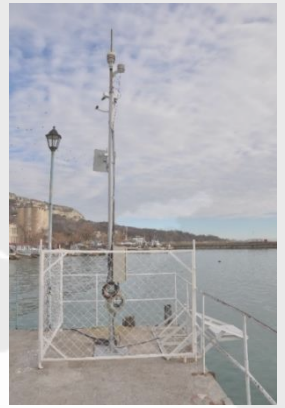
- Some examples:
  heterogenous network, different technologies, time sampling, quality control, etc

Mallorca



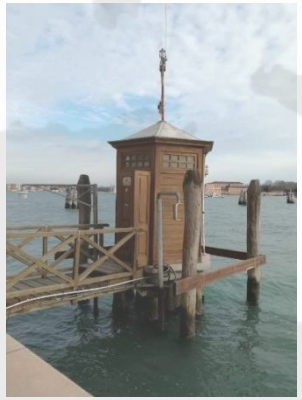
Bakar

Balchick Port



Alicante

Punta della Salute



Melilla

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

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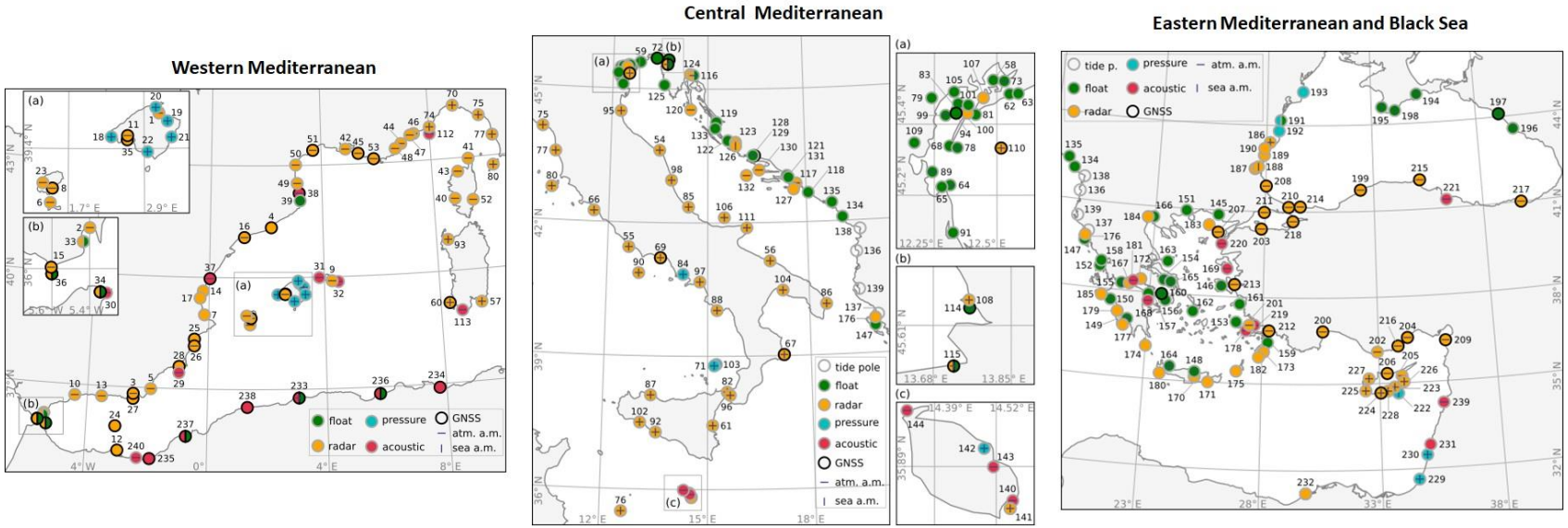
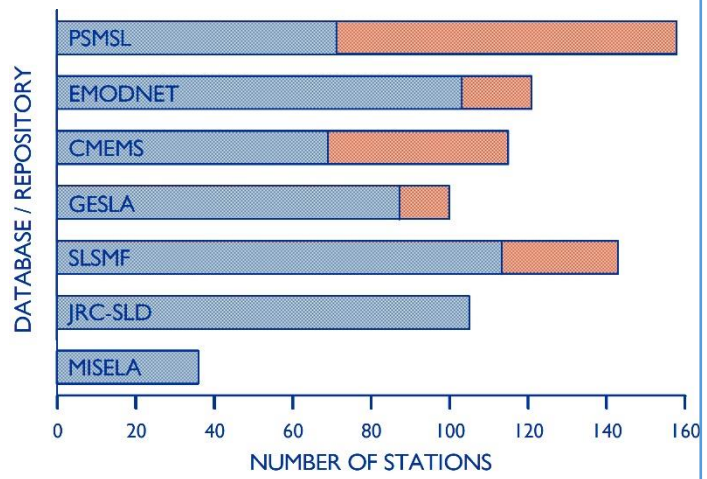
On-going regional initiatives: MONGOOS Tide Gauge Task Team

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)

Pérez Gómez et al., 2022. Coastal sea level monitoring in the Mediterranean and Black Seas. Ocean Sci., 18, 997–1053, 2022. https://doi.org/10.5194/os-18-997-2022

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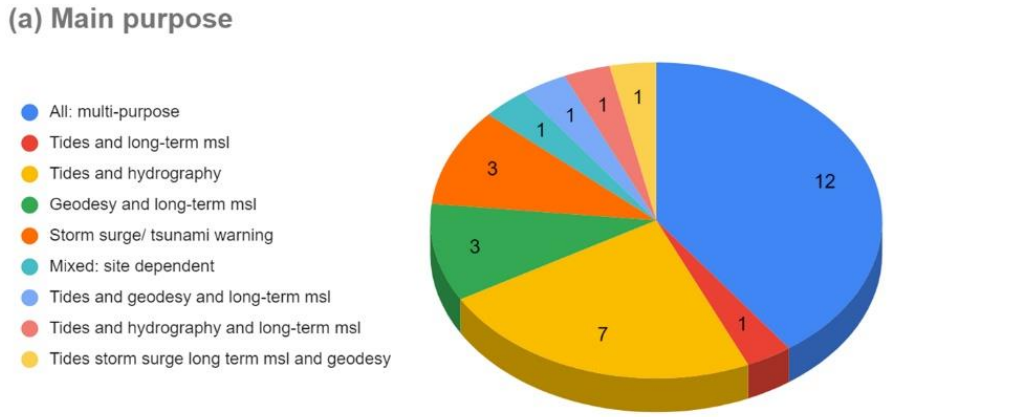
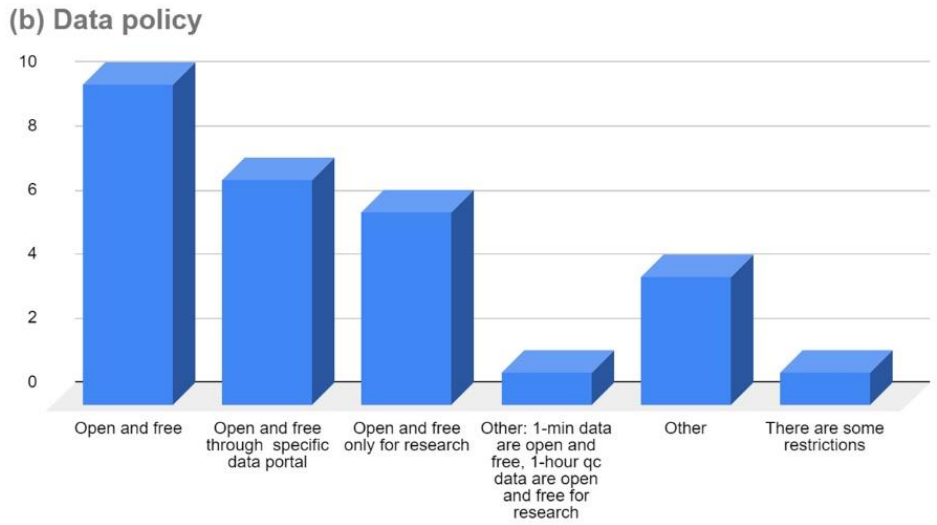
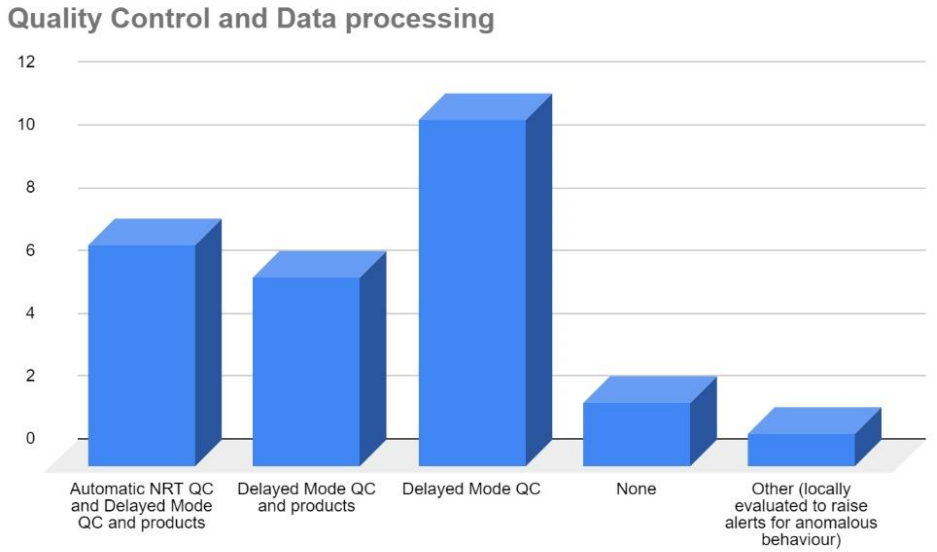
Additional info from the survey







- 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

Pérez Gómez et al., 2022. Coastal sea level monitoring in the Mediterranean and Black Seas. Ocean Sci., 18, 997–1053, 2022. https://doi.org/10.5194/os-18-997-2022

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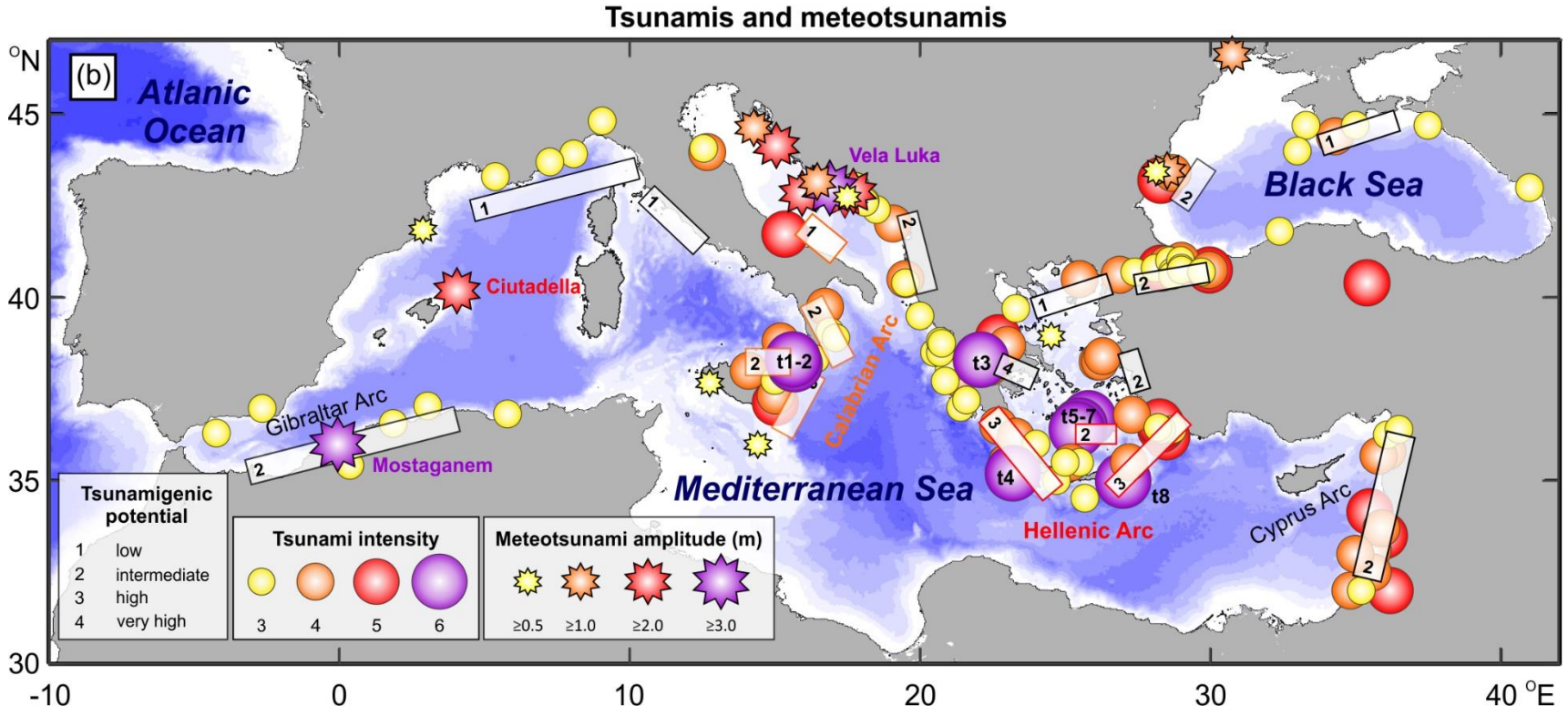
Storm Surges + Tsunamis/Meteotsunamis (timeliness and sampling intervals lowering to 1 min or less)

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



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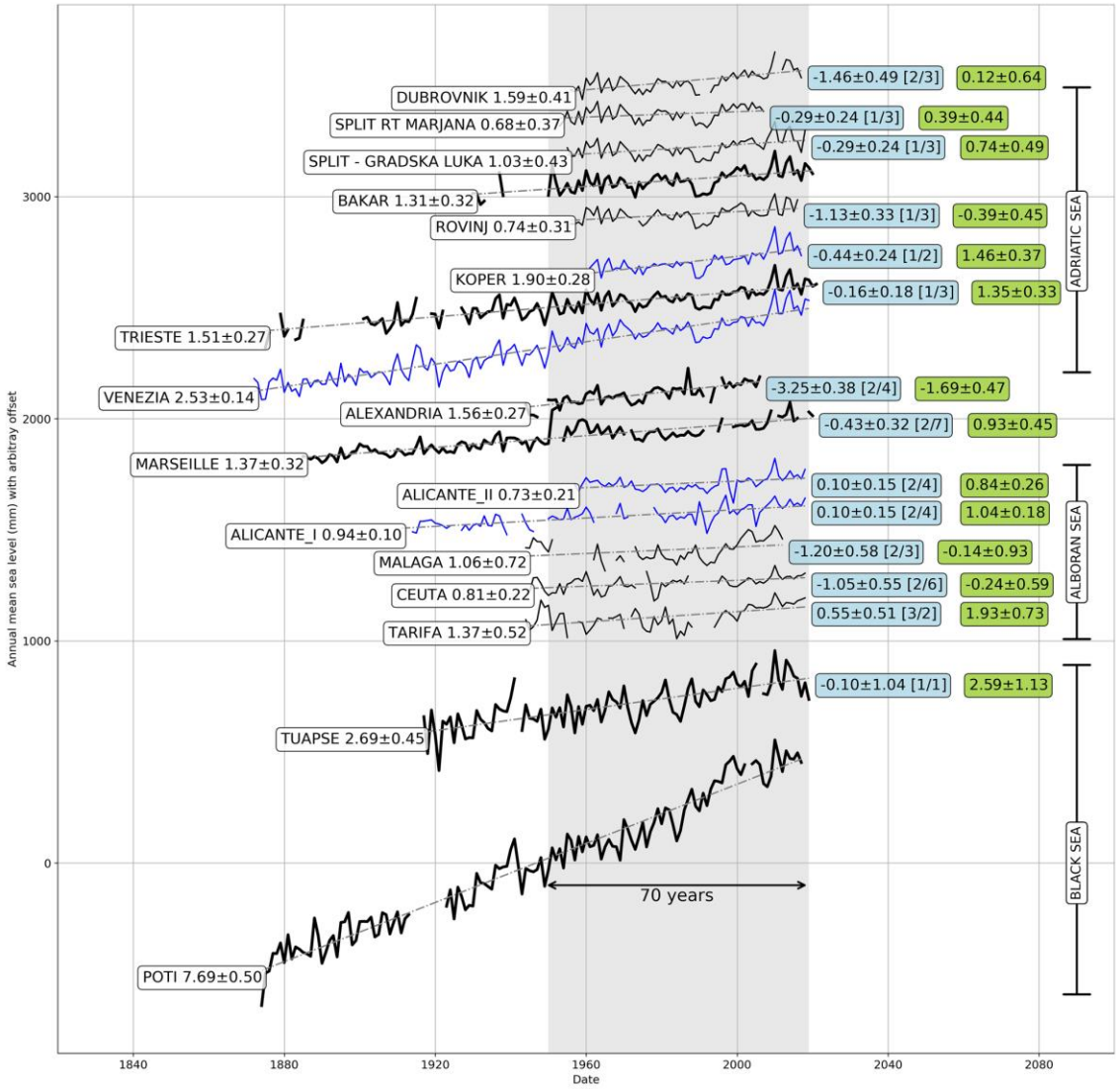
On-going regional initiatives: MONGOOS Tide Gauge Task Team

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)



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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