National Oceanography Centre

Permanent Service for Mean Sea Level

PSMSL

Sea level in the Global Geodetic Observing System

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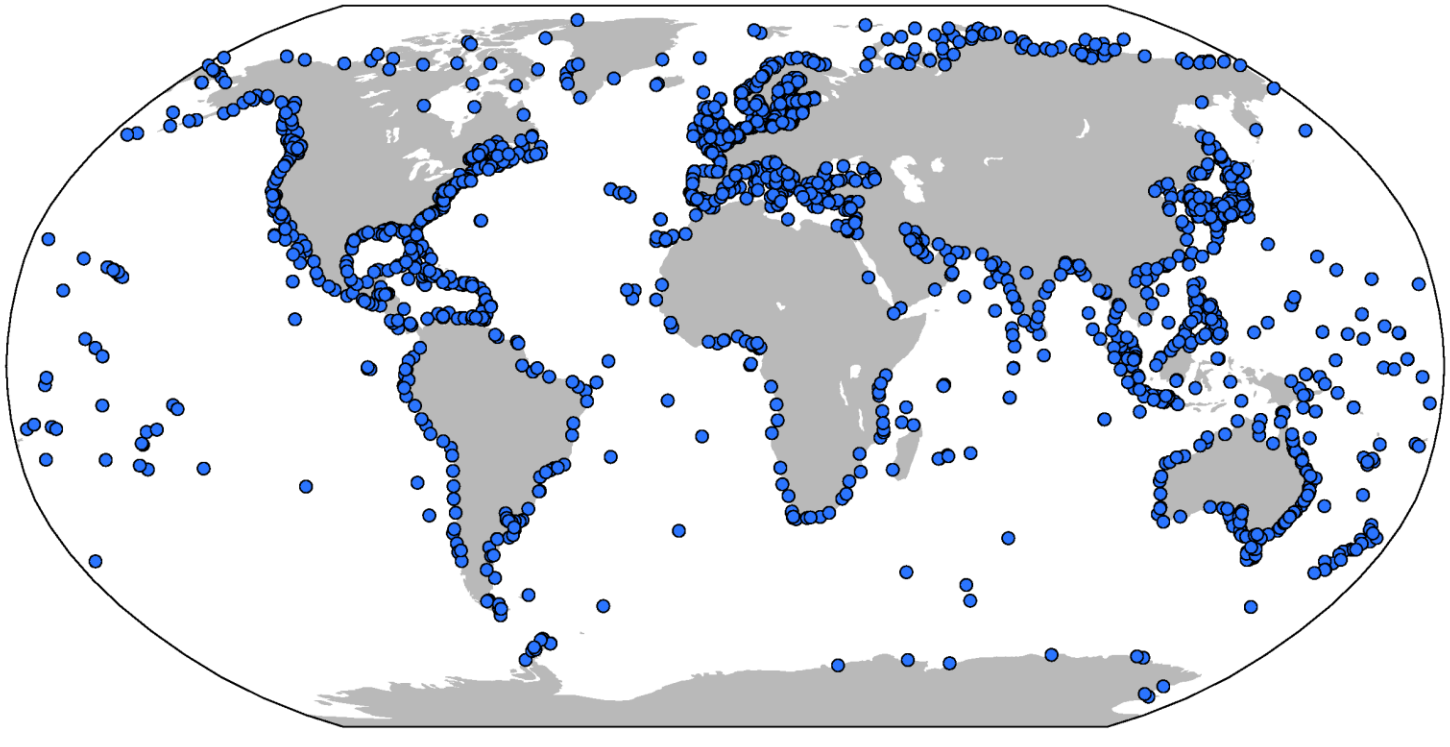
About the PSMSL

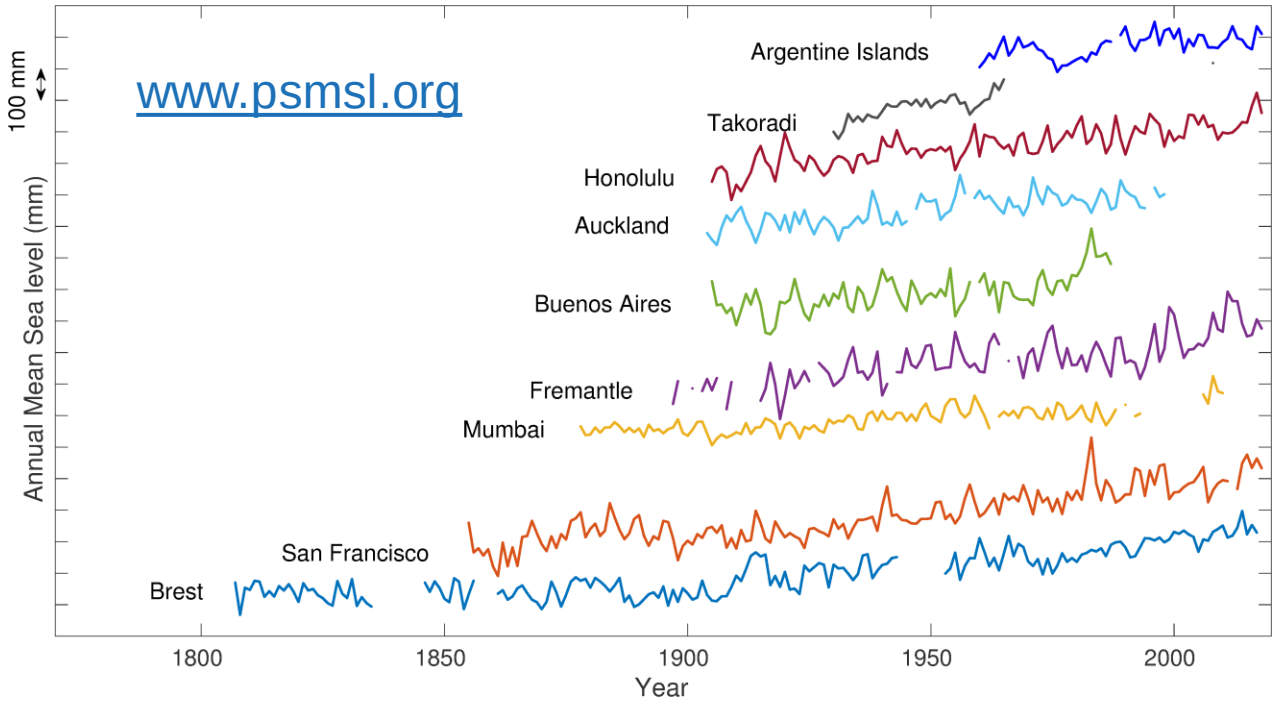
- The Permanent Service for Mean Sea Level (PSMSL) is the global databank for long-term mean sea level data and is a member of the Global Geodetic Observing System (GGOS - www.ggos.org/) Bureau of Networks and Observations



All stations
(2358)

About the PSMSL

- As well as curating long-term sea level change information from tide gauges, PSMSL is also involved in developing other products and services including the automatic quality control of near real-time sea level data, distributing Global Navigation Satellite System (GNSS) sea level data and advising on sea level metadata development.



Long records in the PSMSL dataset

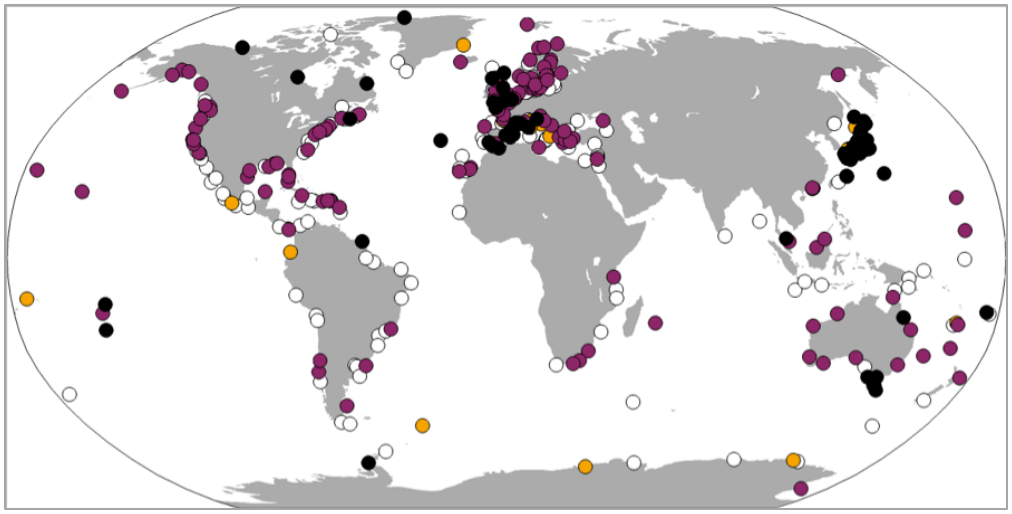
Future plans for sea level

- At the GGOS Days meeting in November 2019, the GGOS Focus Area 3 on Sea Level Change, Variability and Forecasting was wrapped up, but there is still a requirement in 2020 for GGOS to integrate and support tide gauges and we will discuss how we will interact in the future.

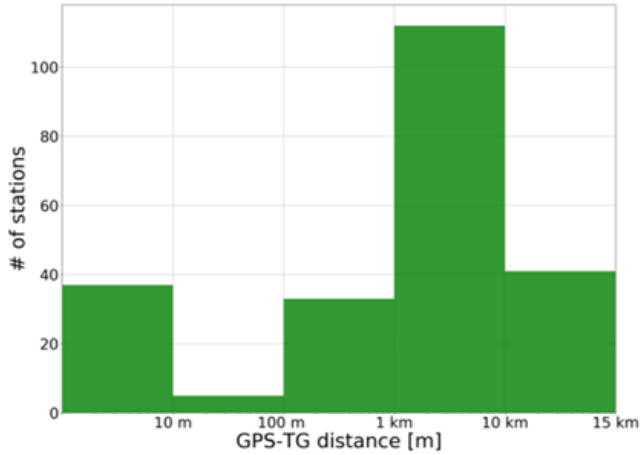
A recent paper (Ponte et al., 2019) identified that only “29% of the GLOSS [Global Sea Level Observing System] GNSS-co-located tide gauges have a geodetic tie available at SONEL [Système d'Observation du Niveau des Eaux Littorales - www.sonel.org/]” and we as a community still need to improve the ties between the GNSS sensor and tide gauges.

- Ponte, Rui M., et al. (2019) "Towards comprehensive observing and modeling systems for monitoring and predicting regional to coastal sea level." *Frontiers in Marine Science* 6(437) https://doi.org/10.3389/fmars.2019.00437

Future plans for sea level



- GNSS tied to TG (68)
- GNSS not tied (283)
- TG not datum controlled (23)
- TG inactive (184)



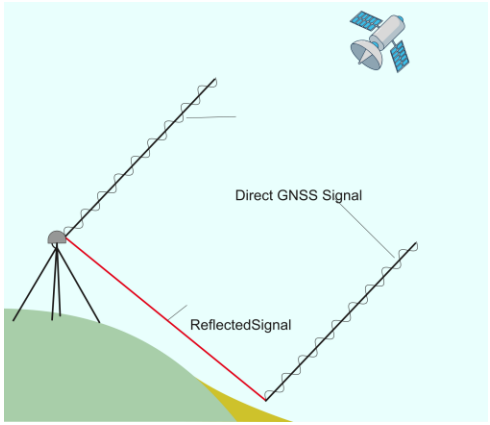
Histogram showing the distribution of the colocation distances TG-GNSS stations in Europe, from SONEL data bank. It shows that many GNSS stations are quite far from the tide gauges (>1km) and so levelling between the tide gauge and the GNSS station is difficult and expensive.

- EuroGOOS Tide Gauge Task Team and SONEL, May 2018: List of tide gauge stations co-located with a permanent GNSS station in Europe. Prepared for Mercator, CMEMS and EuroGOOS. http://eurogoos.eu/download/TG_GNSS_2018.pdf

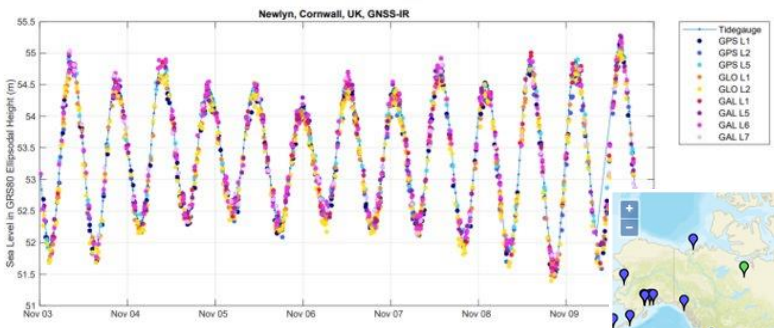
GNSS Interferometric Reflectometry Data Portal

- GNSS at tide gauges may improve as new GNSS Interferometric Reflectometry (GNSS-IR) sensors are installed to provide an alternative method to observe sea level. As well as recording the sea level, these sensors will also provide vertical land movement information from one location.

- PSMSL are currently developing an online portal of uplift/subsidence land data & GNSS-IR sea level data (in development - www.psmsl.org/gnssmr/gnssmr.php). To distribute the data, we are creating/populating controlled vocabularies and generating discovery metadata.



GNSS multipath reflections

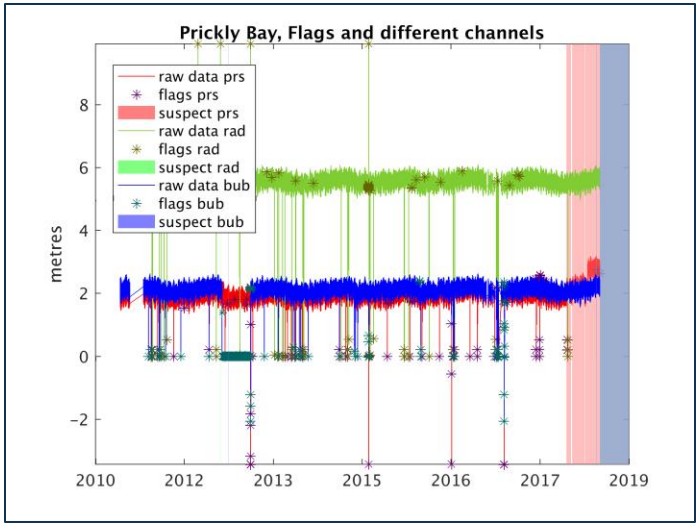


Sea level extracted from signal-to-noise ratio, Newlyn, UK

Sites suitable for GNSS-IR

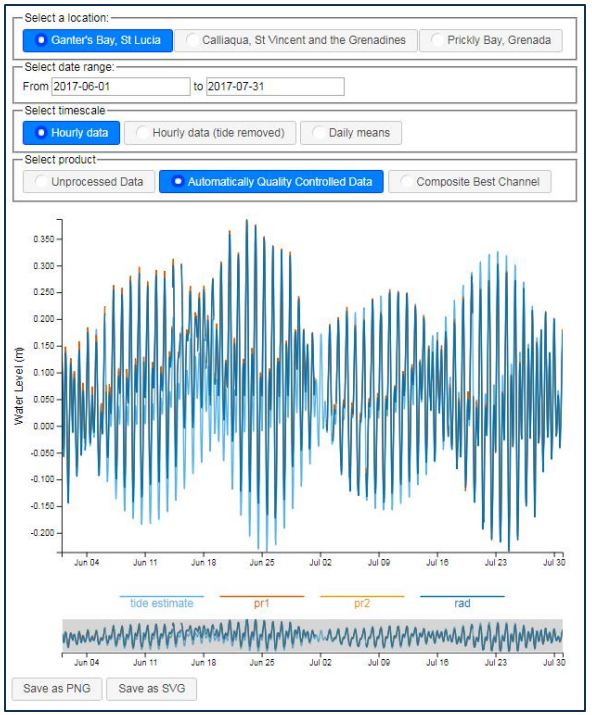
Quality control of near real-time data

- As part of the Commonwealth Marine Economies Programme, we have developed MATLAB software that performs automatic quality control of data from tide gauges, including generalised comparison of instrument channels, fitting and predicting tides using irregular high-frequency data - psmsl.org/cme/autoqc.php



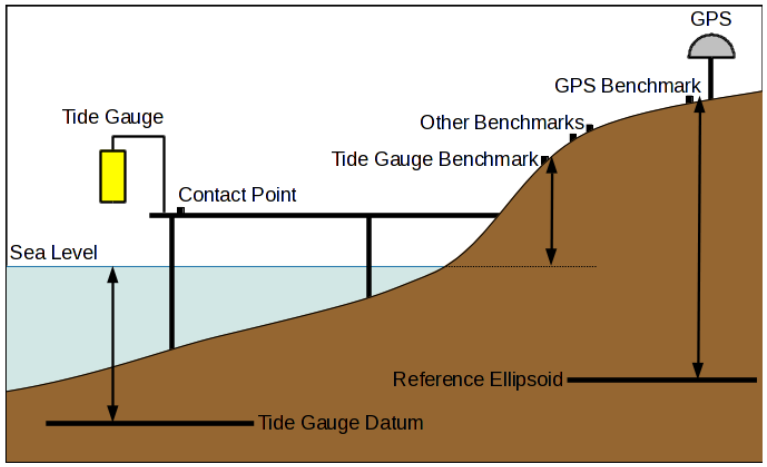
Automatic
Quality Control

Data Plotter

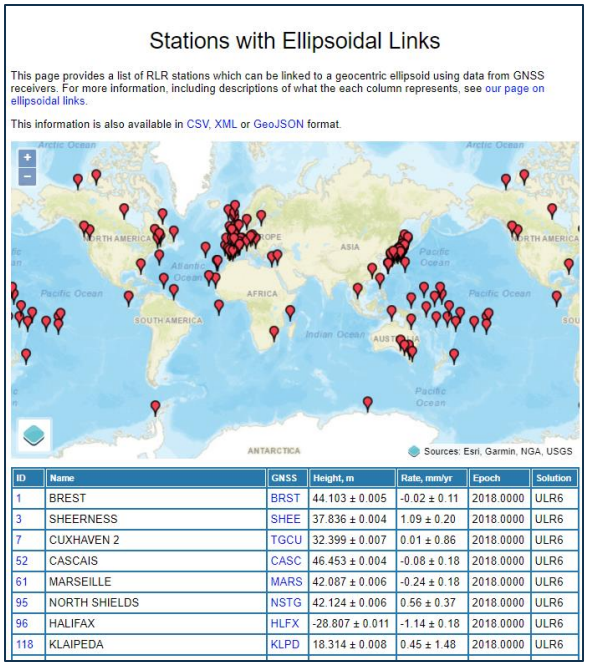


Links with GGOS

- Representatives from PSMSL will sit on the GGOS DOIs for Data Working Group and would like to contribute help with controlled vocabularies, identifying metadata standards etc. We will also contribute to the next GGOS implementation plan.
- We will display more information on the PSMSL website about links between tide gauge datums and national datums and ellipsoids



Typical tide gauge installation with GNSS



Stations with Ellipsoidal Links

This page provides a list of RLR stations which can be linked to a geocentric ellipsoid using data from GNSS receivers. For more information, including descriptions of what the each column represents, see our page on ellipsoidal links.

This information is also available in CSV, XML or GeoJSON format.

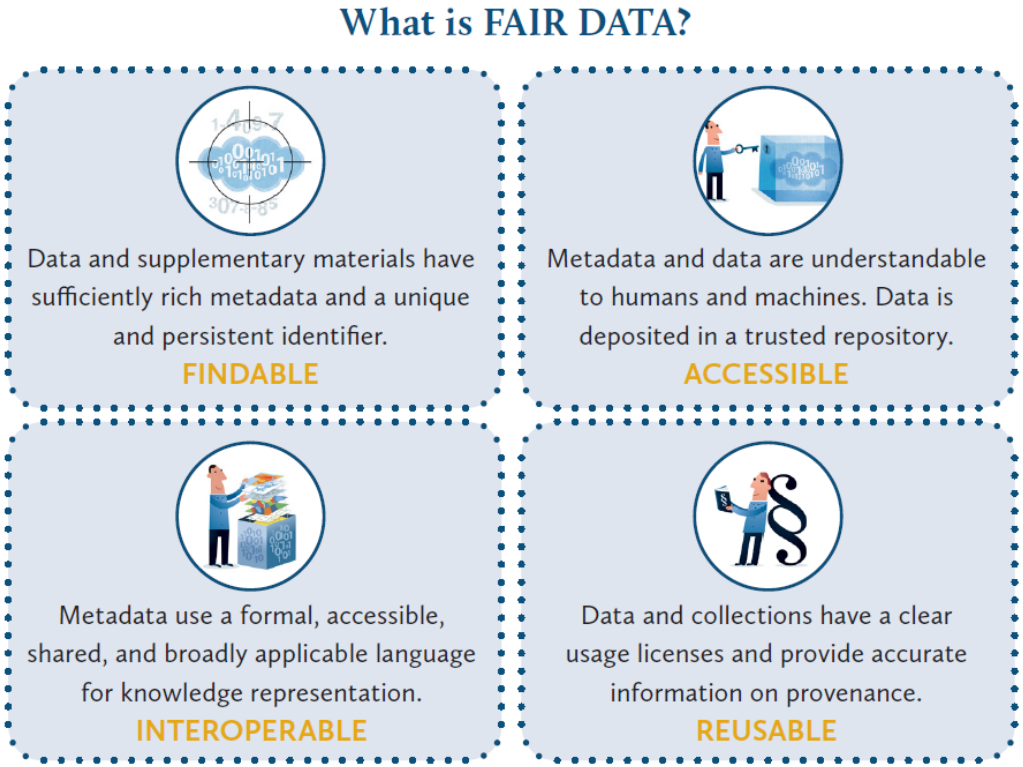
Sources: Esri, Garmin, NGA, USGS

ID	Name	GNSS	Height, m	Rate, mm/yr	Epoch	Solution
1	BREST	BRST	44.103 ± 0.005	-0.02 ± 0.11	2018.0000	ULR6
3	SHEERNESS	SHEE	37.836 ± 0.004	1.09 ± 0.20	2018.0000	ULR6
7	CUXHAVEN 2	TGCU	32.399 ± 0.007	0.01 ± 0.86	2018.0000	ULR6
52	CASCAIS	CASC	46.453 ± 0.004	-0.08 ± 0.18	2018.0000	ULR6
61	MARSEILLE	MARS	42.087 ± 0.006	-0.24 ± 0.18	2018.0000	ULR6
95	NORTH SHIELDS	NSTG	42.124 ± 0.006	0.56 ± 0.37	2018.0000	ULR6
96	HALIFAX	HLFX	-28.807 ± 0.011	-1.14 ± 0.18	2018.0000	ULR6
118	KLAIPEDA	KLPD	18.314 ± 0.008	0.45 ± 1.48	2018.0000	ULR6

www.psmsl.org/data/obtaining/ellipsoidal_links.php

Making data FAIR

- We are working towards FAIR data management principles (data are findable, accessible, interoperable and reusable) which will improve the flow of quality controlled sea level data and in 2020 we will issue the PSMSL dataset with a Digital Object Identifier.



Association of European Research Libraries - libereurope.eu/

Making data FAIR

- We will deliver our data in a NetCDF format using the Climate and Forecast (CF) standard metadata conventions commonly used in Oceanography, Meteorology and Climatology and better lineage metadata with more structure: a proper history of what happened at a site

```
netcdf uhslc_sanfrancisco_2005 {
dimensions:
        row = 8760 ;
        station_name_strlen = 17 ;
        station_country_strlen = 30 ;
        ssc_id_strlen = 4 ;
variables:
        short sea_level(row) ;
                sea_level:_FillValue = -32767s ;
                sea_level:actual_range = 1191s, 4298s ;
                sea_level:long_name = "relative sea level" ;
                sea_level:platform = "station_name, station_country, station_country_code,
uhslc_id, gloss_id, ssc_id" ;
                sea_level:source = "in situ tide gauge water level observations" ;
                sea_level:units = "millimeters" ;
        double time(row) ;
                time:_CoordinateAxisType = "Time" ;
                time:actual_range = 1104537600., 1136069999.971 ;
                time:axis = "T" ;
                time:ioos_category = "Time" ;
                time:long_name = "Time" ;
                time:standard_name = "time" ;
                time:time_origin = "01-JAN-1970 00:00:00" ;
                time:units = "seconds since 1970-01-01T00:00:00Z" ;
        float latitude(row) ;
                latitude:_CoordinateAxisType = "Lat" ;
                latitude:actual_range = 37.807f, 37.807f ;
                latitude:axis = "Y" ;
                latitude:colorBarMaximum = 90. ;
                latitude:colorBarMinimum = -90. ;
                latitude:ioos_category = "Location" ;
                latitude:long_name = "Latitude" ;
```

Example of a NetCDF format, University of Hawaii Sea Level Center (uhslc.soest.hawaii.edu/)

Making data FAIR

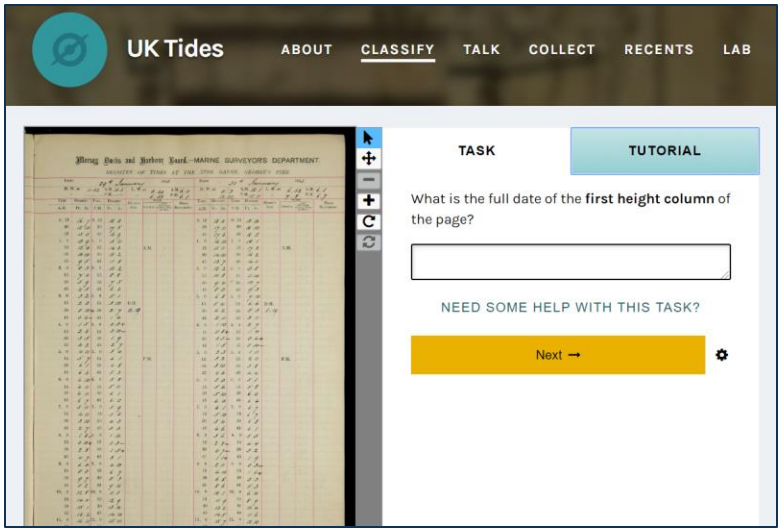
- We have been working on improving our discovery and descriptive metadata including creating a use case for the Research Data Alliance (RDA) Persistent Identification of Instruments Working Group to help improve the description of a time series where the sensor and platform may change and move many times.
  - Stocker, M., Darroch, L., Krahl, R., Habermann, T., Devaraju, A., Schwardmann, U., D'Onofrio, C. and Häggström, I., 2020. Persistent Identification Of Instruments. Data Science Journal (in press)

#	Property	Category	Occurrence	Schema
1	Persistent Identifier	Identification	10	Identifier, identifierType
2	Landing Page URL	Identification	4	LandingPage
3	Alternative Identifier		2	AlternateIdentifier, alternateIdentifierType
4	Resource Type		4	
5	Instrument Name	Instrument	10	Name
6	Instrument Description	Instrument	6	Description
7	Instrument Category	Instrument	3	
8	Instrument Type	Instrument	5	InstrumentType
9	Device URL	Instrument	1	
10	Model	Model	4	modelName
11	Sub-model	Model	2	

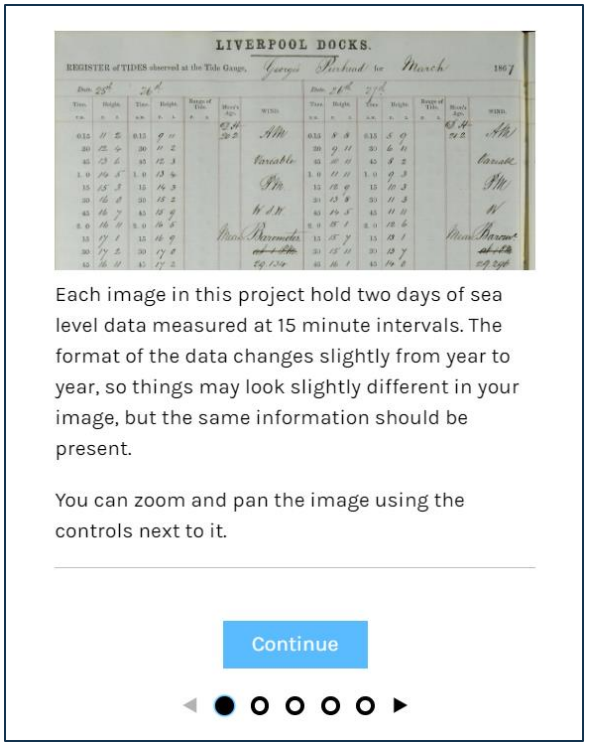
Overview of collected metadata, analysis of common metadata & mapping of properties onto PIDINST schema

Data Rescue

- Helped organise GLOSS/IHO/IUGG/IAPSO Sea Level Data Archaeology Workshop
- Developing a Citizen Science project to digitise handwritten tide gauge ledgers
- Will develop protocols concerning how sea level data recovered from historical records can be incorporated into the PSMSL dataset



Pilot Citizen Science project, using the Zooniverse project builder
www.zooniverse.org/lab



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Thank you