# A brief history of BODC sea level data

# An example tide gauge installation

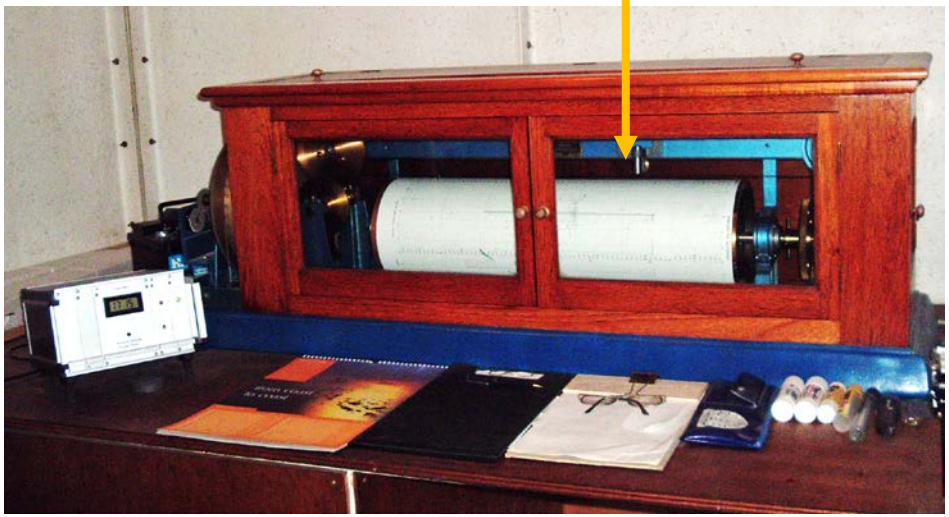
Tide gauge hut

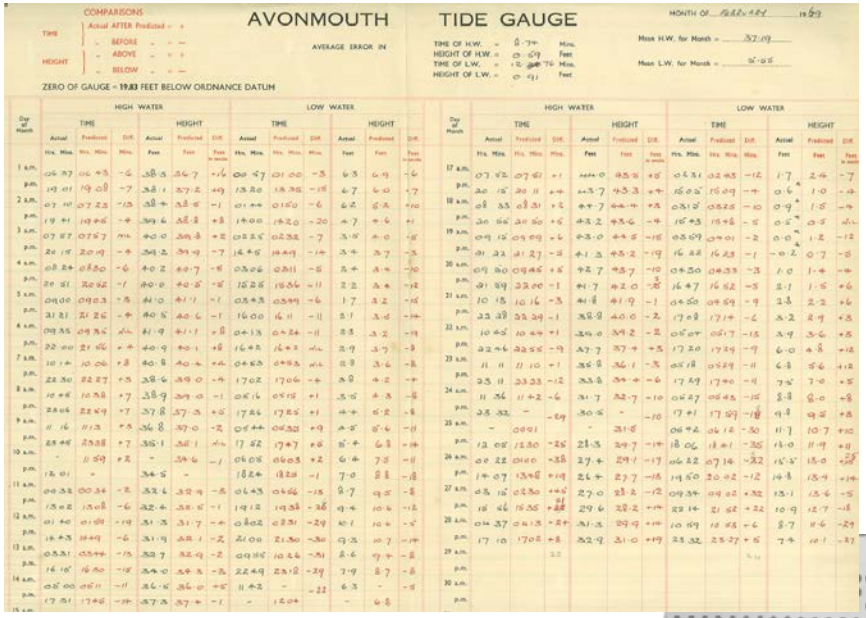
Visual tide staff

Stilling well

**Portpatrick, Scotland**

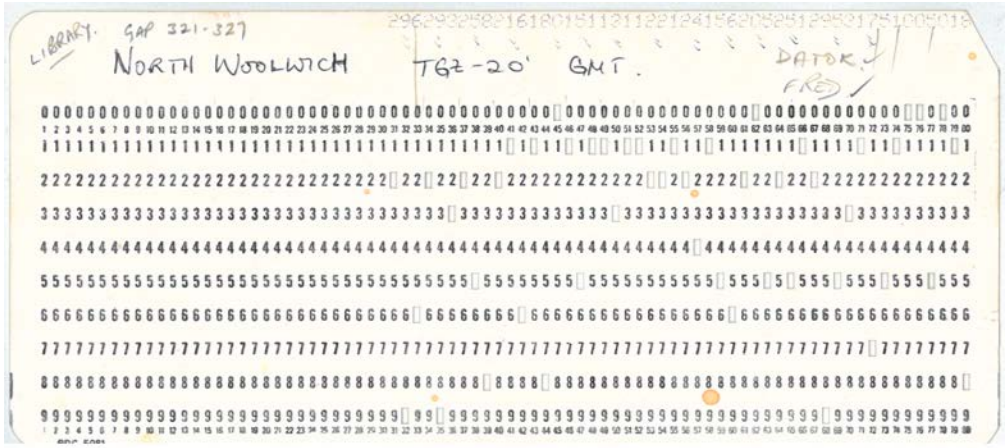
Chart recorder attached to Munro float gauge



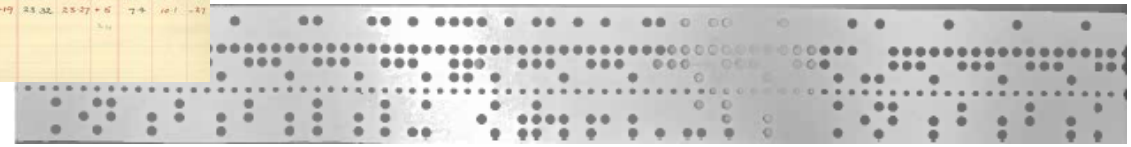


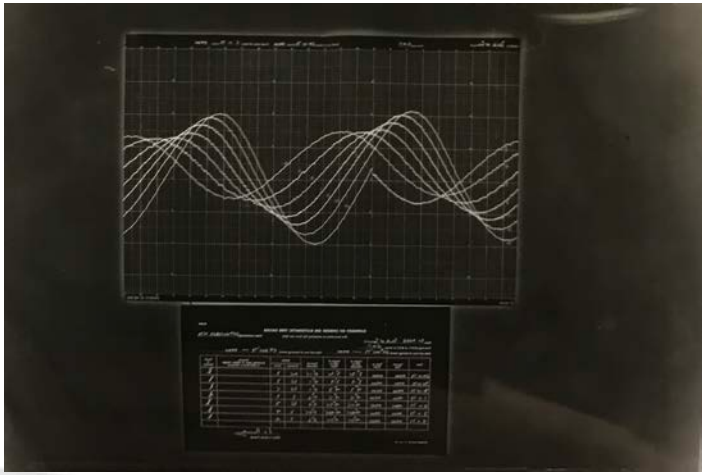
AVONMOUTH

TIDE GAUGE



NORTH WOOLWICH



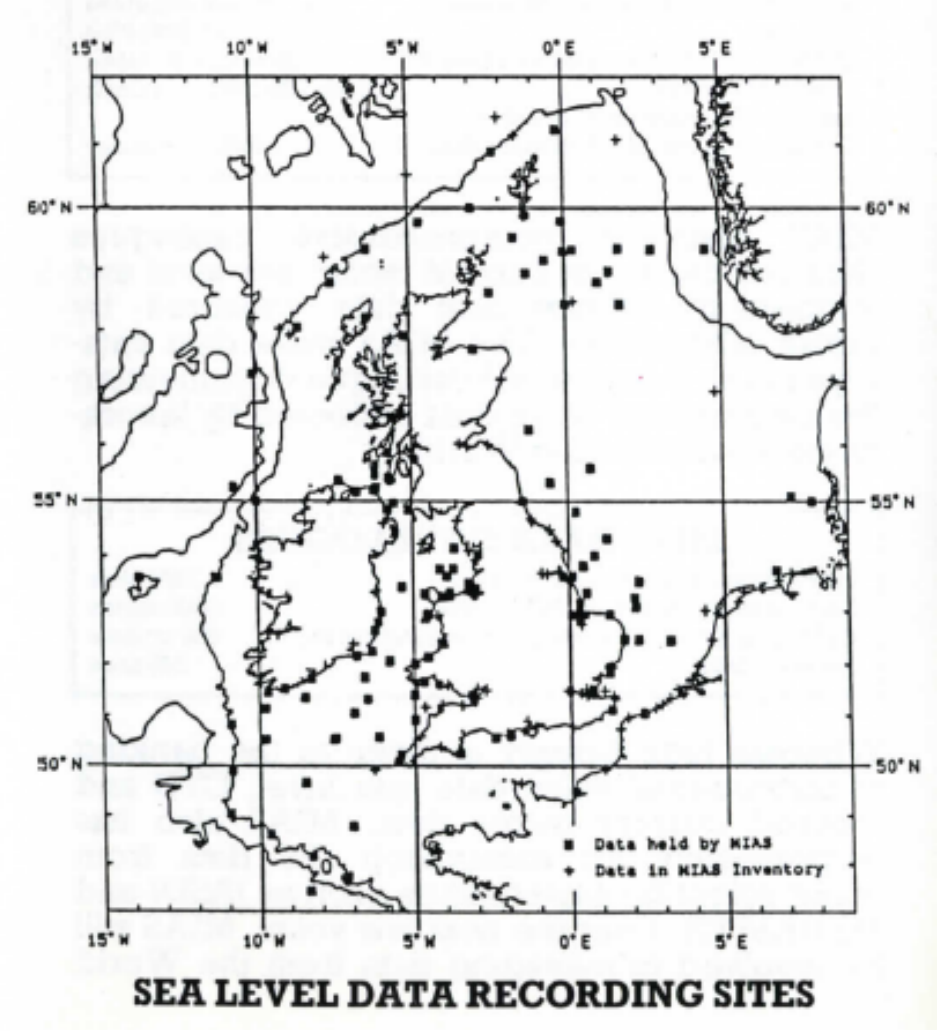


National Oceanography Centre
NATURAL ENVIRONMENT RESEARCH COUNCIL

BODC

noc.ac.uk

# Bidston tide gauge data collection, Late 1970s




SEA LEVEL DATA RECORDING SITES

First sea level data screened and banked by Lesley Rickards

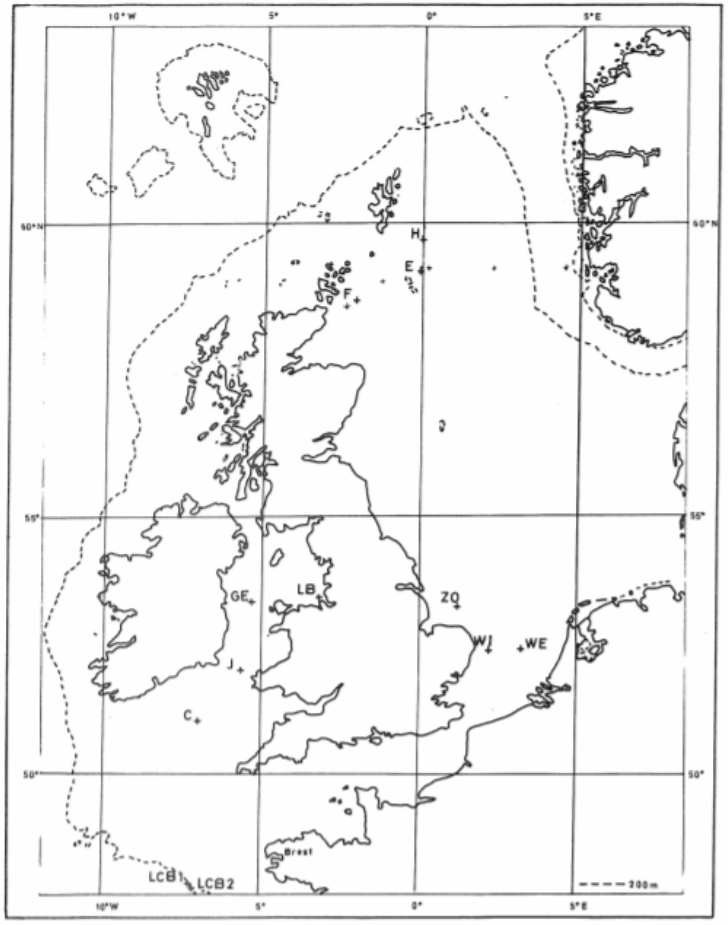



FIG 1 POSITIONS OF DEPLOYMENT STATIONS

Alcock, G. A., & Vassie, J. M. (1975). Off shore tide gauge data.

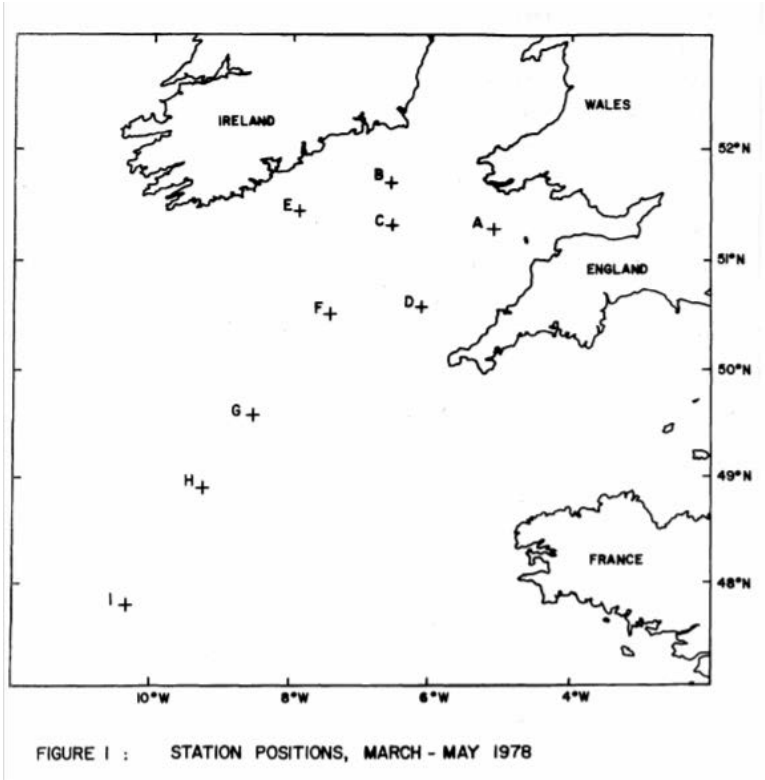



FIGURE 1 : STATION POSITIONS, MARCH - MAY 1978

Alcock, G. A., MacDonald, D. C. C., & Vassie, J. M. (1980). Offshore bottom pressure records from the Celtic Sea and south-west approaches to the UK, 1978.

# MEDALPEX, 1981-1982

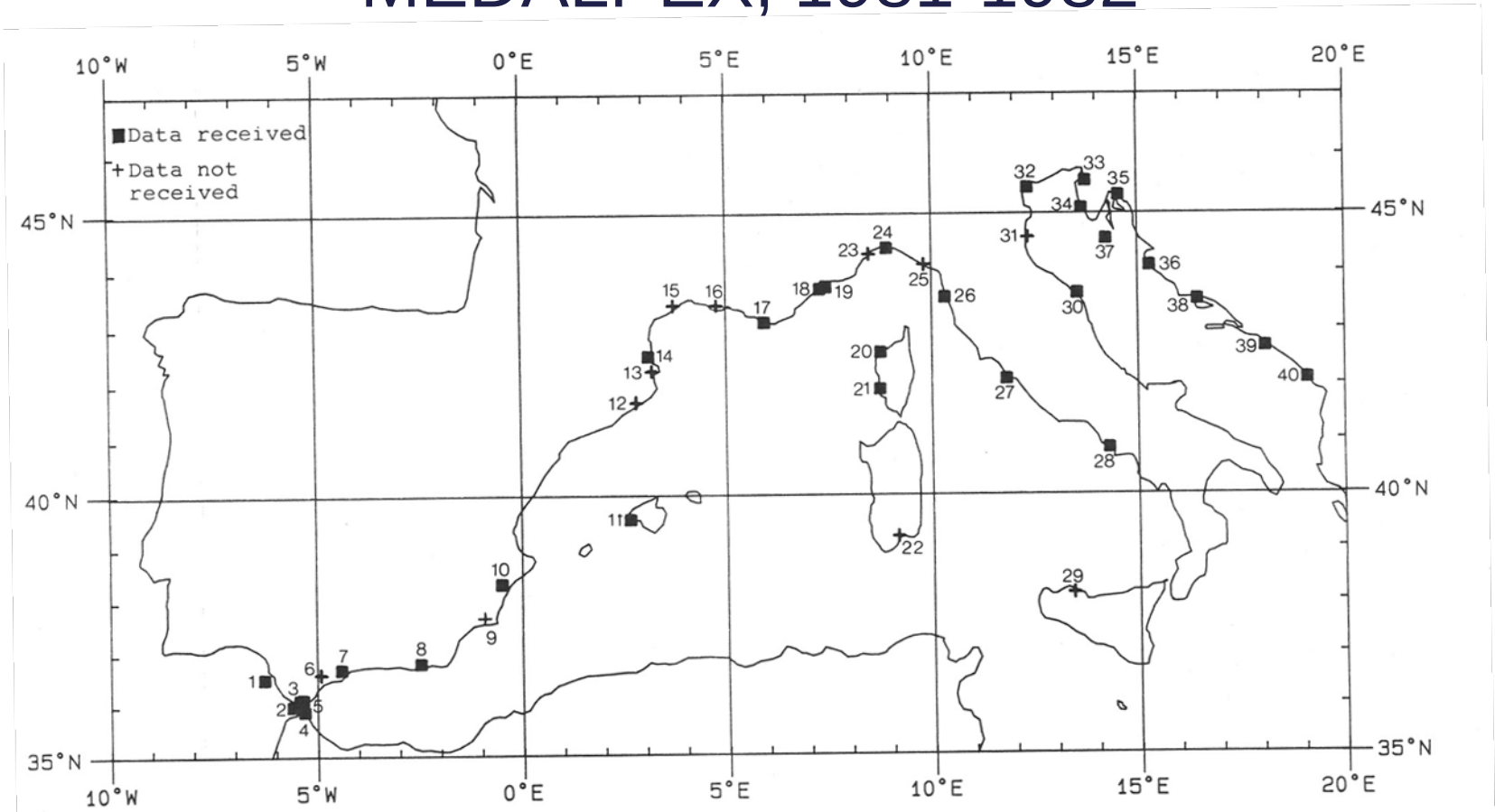



FIGURE 1 MEDALPEX SEA LEVEL SITES

The Mediterranean Alpine Experiment (MEDALPEX) was undertaken to investigate the role of atmospheric forcing on the dynamics of the Western Mediterranean. Hourly values of sea level were collected from 29 sites in the region over the period September 1981 to September 1982. The management, quality control and analysis of these data were carried out by the U.K. Marine Information and Advisory Service (MIAS) on behalf of the Permanent Service for Mean Sea Level (PSMSL).

A magnetic tape copy of the data set, including documentation, is available from PSMSL in the GF-3 format, the IOC's general format for the exchange of oceanographic data.

Rickards, L. J. (1985). Report on sea level data collected during the MEDALPEX experiment from September 1981-September 1982.

DATA MANAGEMENT, VALIDATION AND PROCESSING

At the start of the MEDALPEX year six countries had agreed to send hourly values of sea level from ports around the Mediterranean. The commitment was as follows: Belgium - 1 site (SOP only), France - 7 sites (1 for SOP only), Italy - 12 sites, Spain - 7 to 9 sites, Yugoslavia - 8 sites and U.K. - 1 site; a total of 36 to 38 sites.

In the event MIAS received data from 29 sites as shown in Figure 1 and Table 1; including data from Belgium (1), France (4), Monaco (1), Italy (6), Spain (8), Yugoslavia (8) and U.K. (1). The coastal sites were instrumented with conventional stilling wells, and at the offshore site off the coast of Corsica data were collected by an Aanderaa Water Level Recorder. A bar chart illustrating the duration of the data from each site may be found in Figure 2. This shows that 19 sites cover all or most of the whole ALPEX/MEDALPEX observation period, 2 sites cover considerably less than the whole year, and 8 sites have data for the SOP only. Tide gauges were not installed at Rosas or Blanes.

Most of the sea level data were received by MIAS on 9 track magnetic tape in the form of hourly values of sea surface elevation (in units of mm or cm) - data from Marseilles was submitted in the form of daily means. Usually local time was quoted for the data values. Some data arrived in the form of listings which were then punched onto cards, and one data set was received on a floppy disk.

The data set was translated to a common format, and the elevation values converted from centimetres and millimetres to metres. The time zone was standardised to G.M.T. The data were then plotted in the form of a time series plot for each site to enable checks to be carried out. The time series were inspected for gaps or constant values, spikes, spurious data or punching errors. Where gaps occurred, these were flagged as null data and documented. Spikes were flagged as suspect data, but no attempt was made to alter any data value unless instructed to do so by the data originator. No interpolation of gaps was carried out. The approximate tidal range of each site was compared with a tidal atlas, and data from nearby sites were compared. A check was also carried out on the periodicity to ensure that the correct interval between data values had been quoted. Time series presentations of the data are found in

Livorno, Italy

The tide gauge is situated in the south west corner of the maritime dockyard on the Calata Lucca. The instrument is a model 450 stilling well which began operating on 4 Feb 1950. No modifications have been made to the instrument. Maintenance is carried out at irregular intervals. The chart is changed weekly and the timing checked. The organisation responsible for operating the tide gauge is the Sezione del Genio Civile OO MM di Livorno. These data were supplied by the Istituto per lo Studio della Dinamica della Grande Masse as part of the Mediterranean Alpine Experiment (MEDALPEX). All times are GMT.

Tide Gauge Benchmark (TGBM) (above Italian Datum) 2.743m
Data are relative to an arbitrary zero 4.01m below the TGBM

Auxilliary benchmarks (heights given are relative to Italian datum)

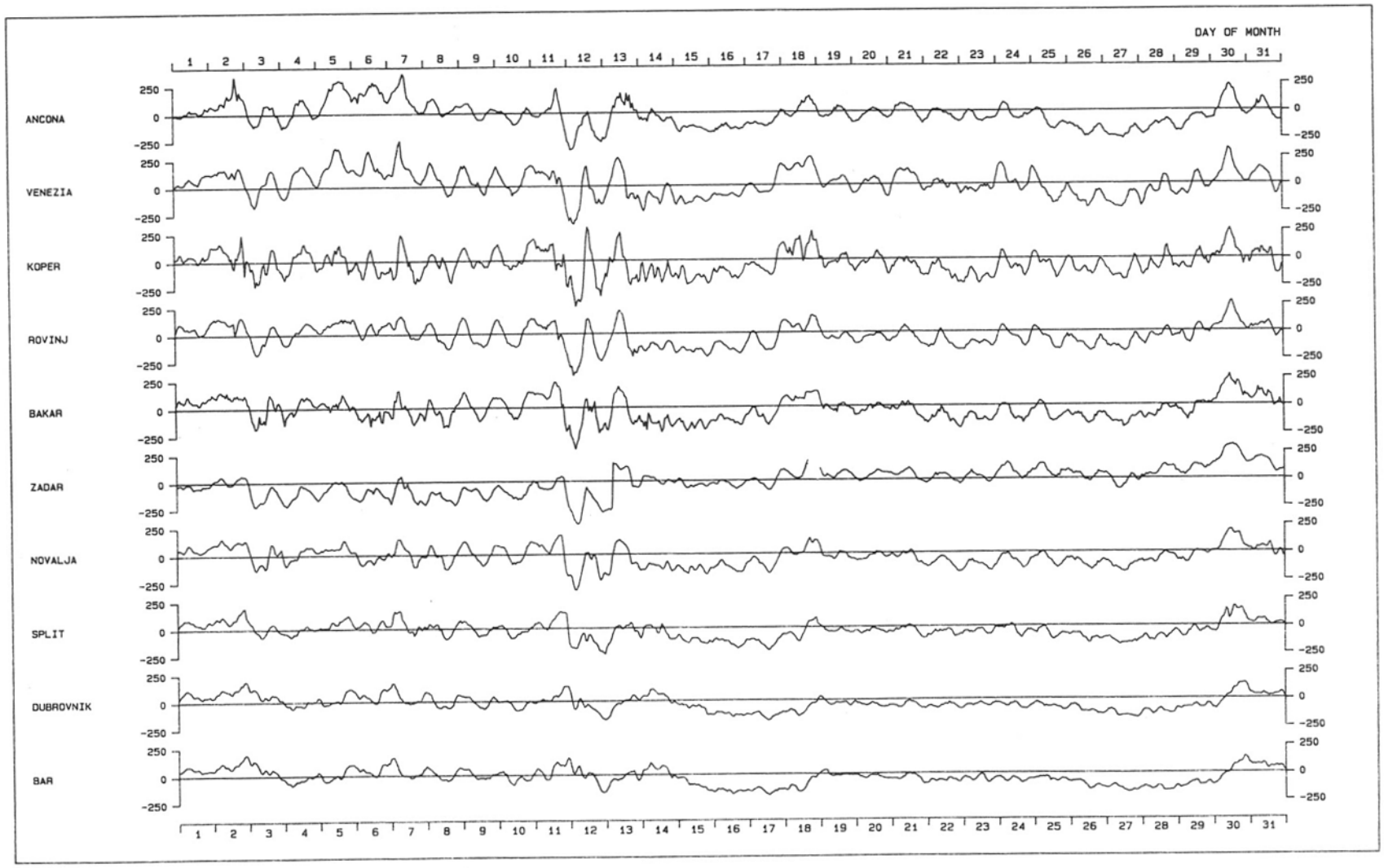
| | |
|---|---|
| CO, at the base of the wall of the canteen | 1.534m |
| | 1.779m |
| CV, on the wall of the Genio Civile offices, facing the canal | 4.365m |
| CO1, to the right of the door of the embarkation offices | 1.572m |
| | 1.815m |
| CV1, on the wall above CO1 | 4.323m |

The last precision levelling was carried out on 31 Mar 1953 by the Istituto Geografico Militare di Firenzo.

The following gaps occur in the data:

0300h 09 Oct 1981 - 1400h 15 Oct 1981
0100h 13 Nov 1981 - 1200h 19 Nov 1981
0200h 31 Dec 1981 - 1200h 12 Jan 1982
0400h 23 Mar 1982 - 1500h 23 Mar 1982
1200h 29 Mar 1982 - 1300h 30 Mar 1982

Collating metadata

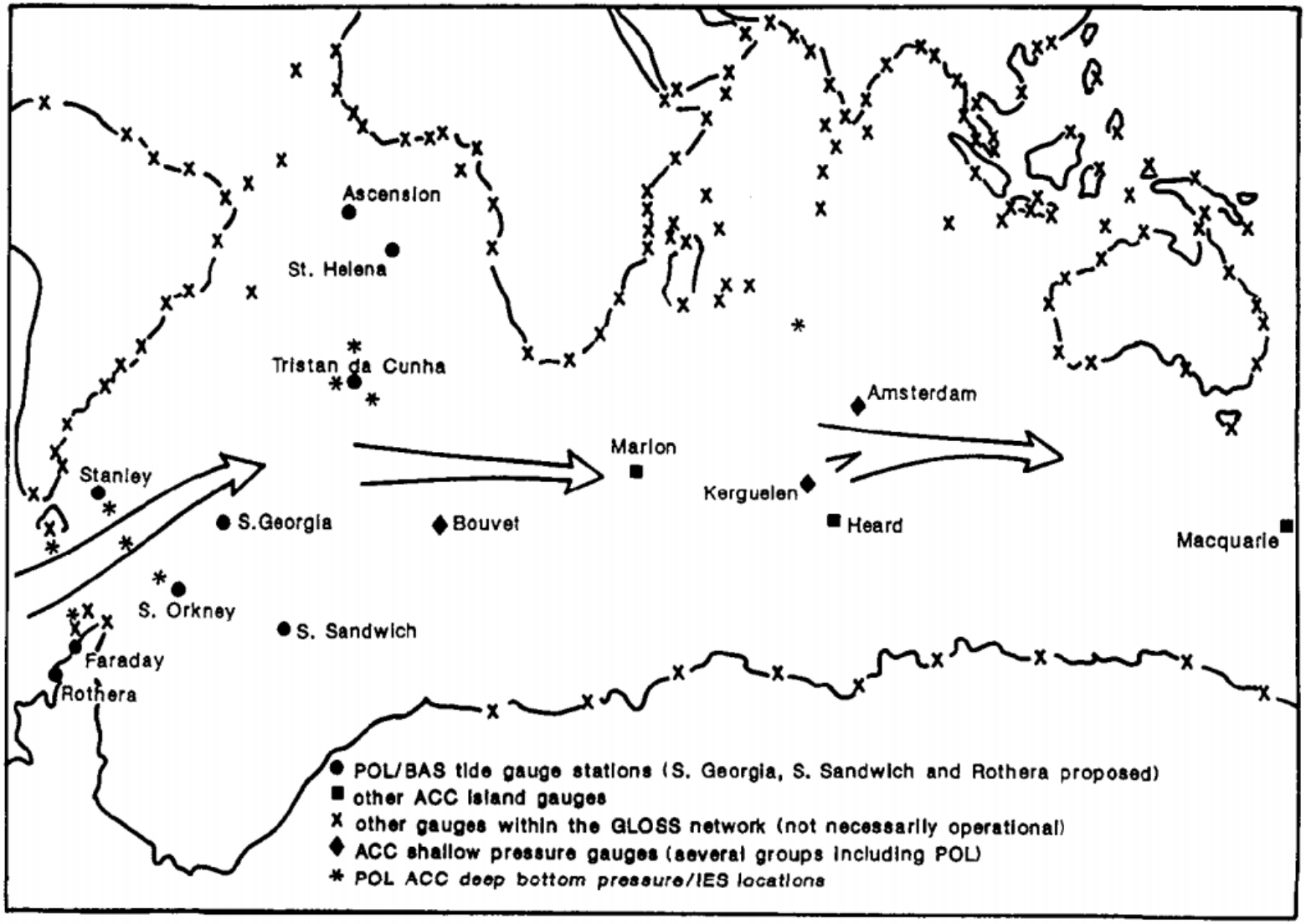



RESIDUALS (mm) FROM TIDAL ANALYSIS - MARCH 1982

# ACCLAIM, 1985 onwards

The ACCLAIM (Antarctic Circumpolar Current Levels by Altimetry & Island Measurements) network was set up to study the Antarctic Circumpolar Current (ACC), ground-truth satellite altimeters and to initiate long-term sea level measurements in the region.

The South Atlantic Tide Gauge Network (SATGN) has been managed and maintained by the National Oceanography Centre (NOC), Liverpool since 1985, under the ACCLAIM Programme.

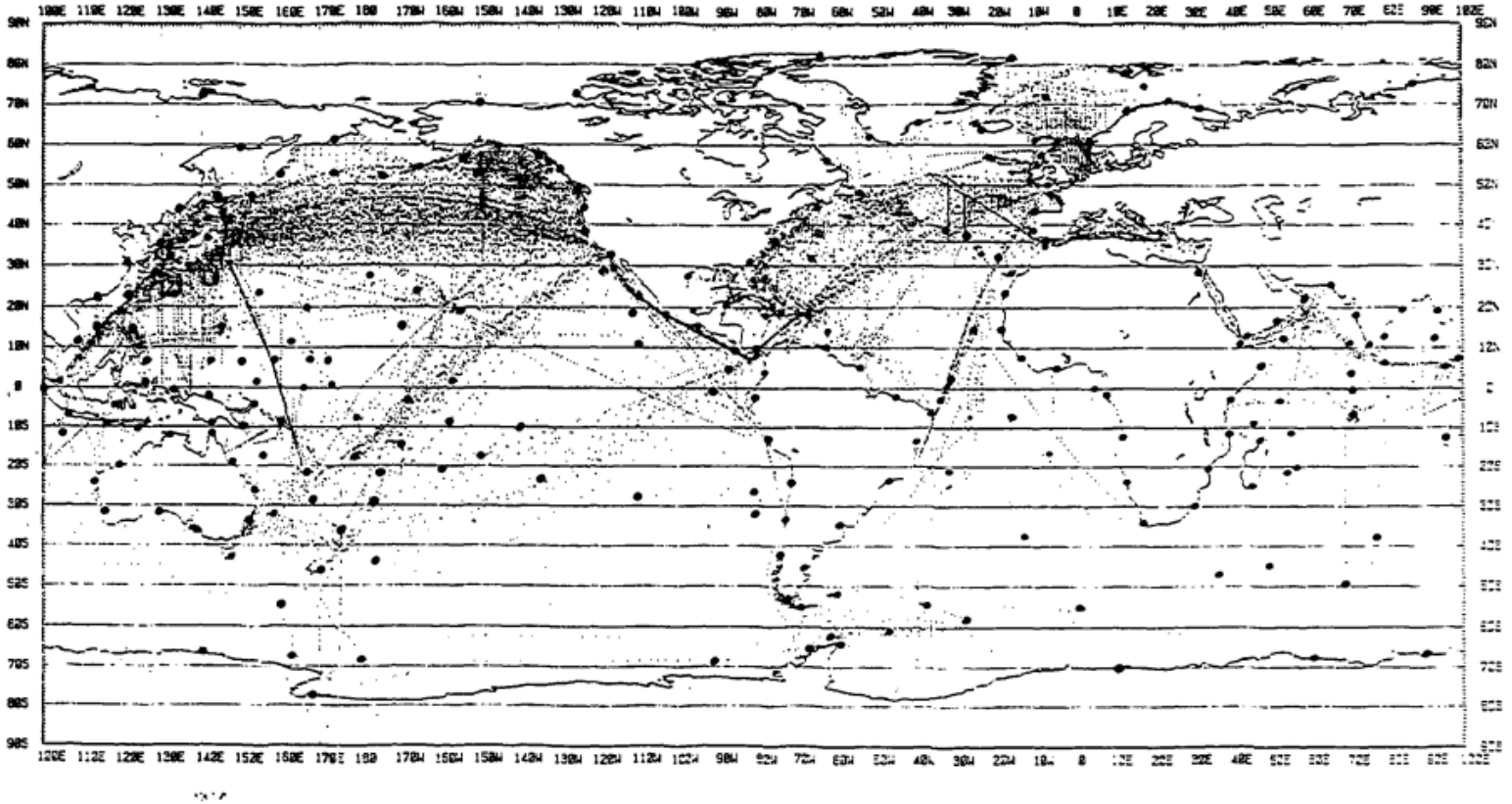



Spencer, R. et al (1993). The ACCLAIM programme in the South Atlantic and Southern oceans. *The International Hydrographic Review*, *70*(1).

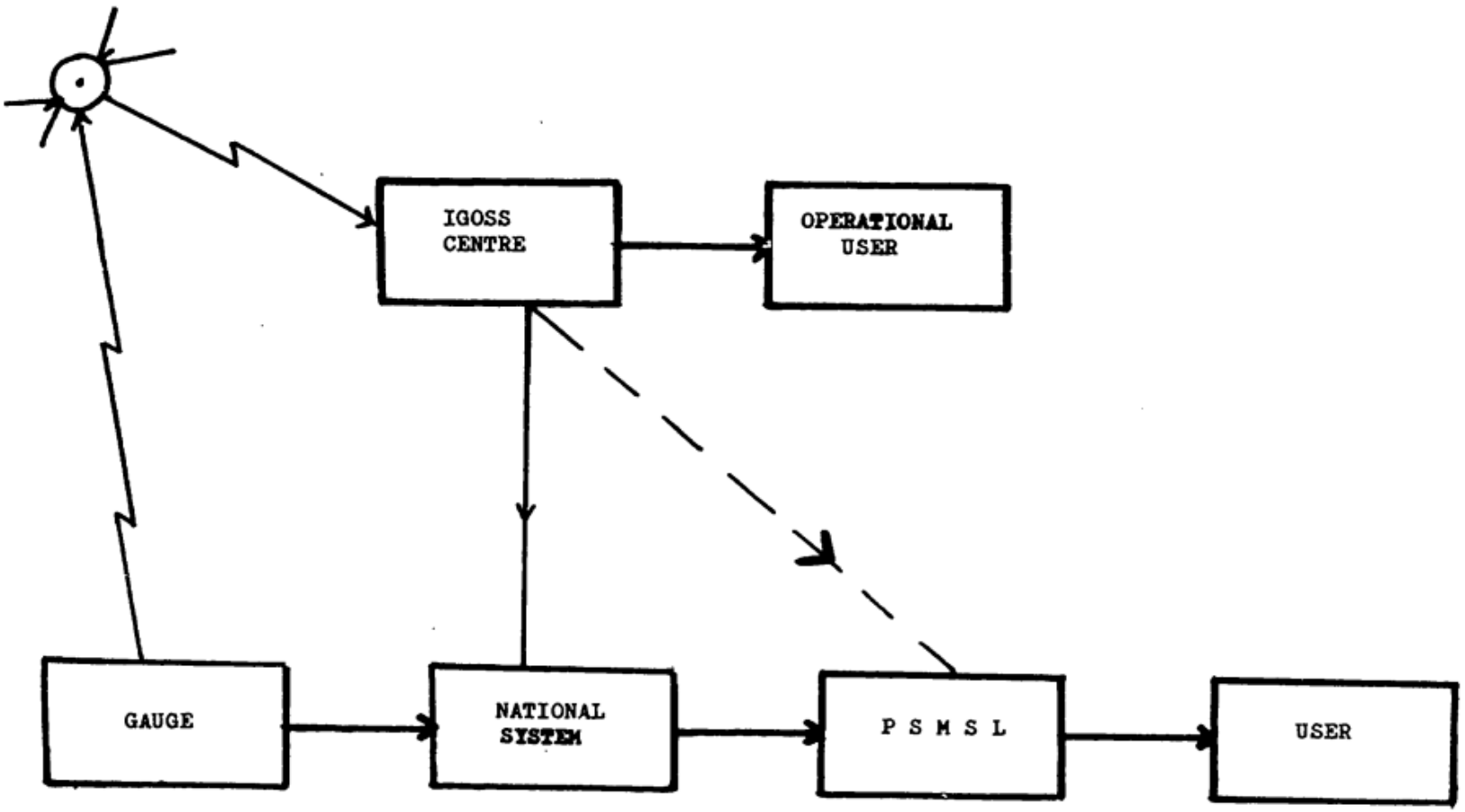
# GLOSS, 1985 onwards

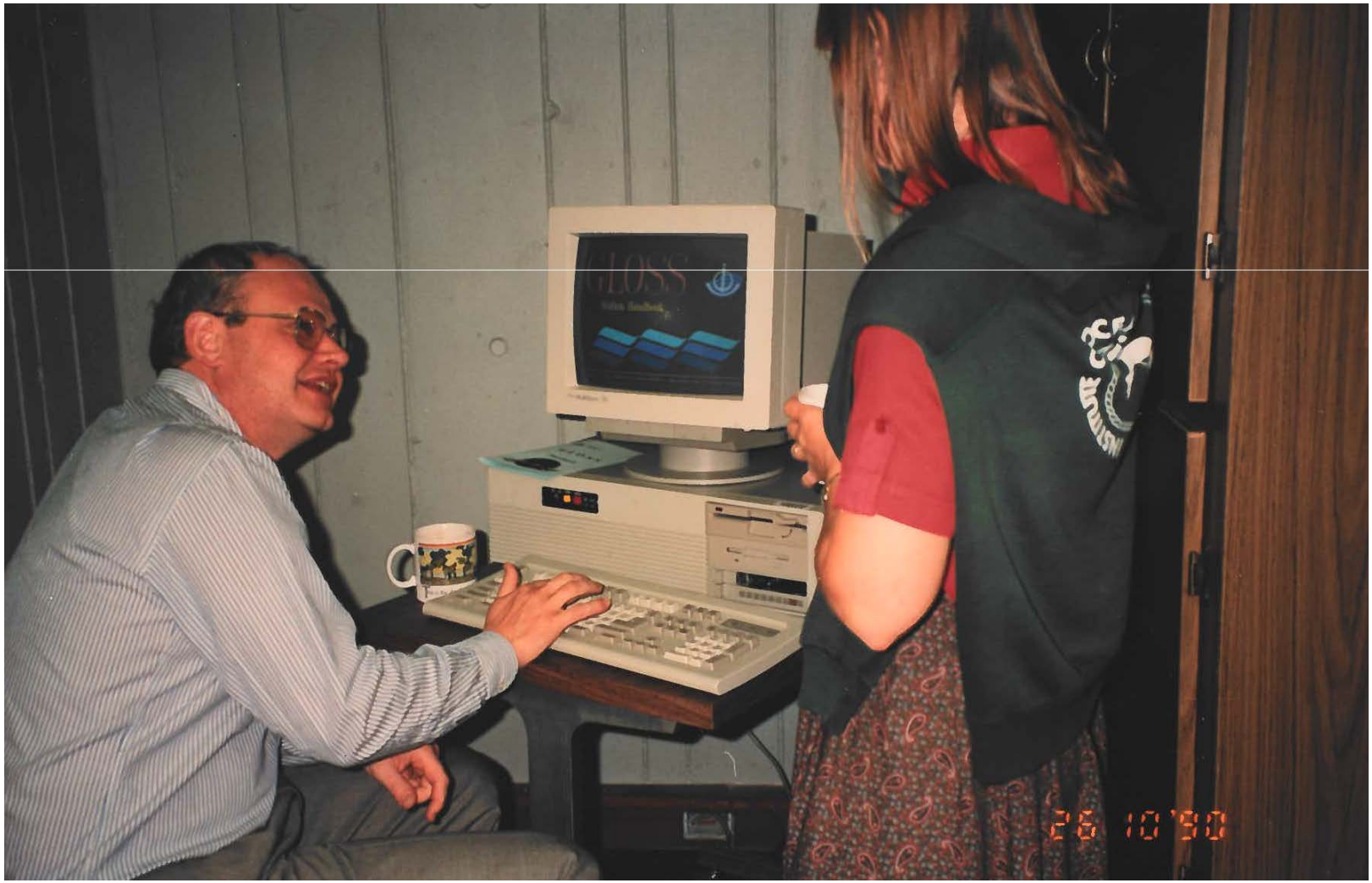
The Global Sea Level Observing System (GLOSS) is an international programme conducted under the auspices of the WMO-IOC Joint Technical Commission for Oceanography and Marine Meteorology. It was set up in 1985 to collect long-term tide gauge observations and to develop systems and standards "for ocean monitoring and flood warning purposes" and to "support the activities of the Permanent Service for Mean Sea Level" (PSMSL).

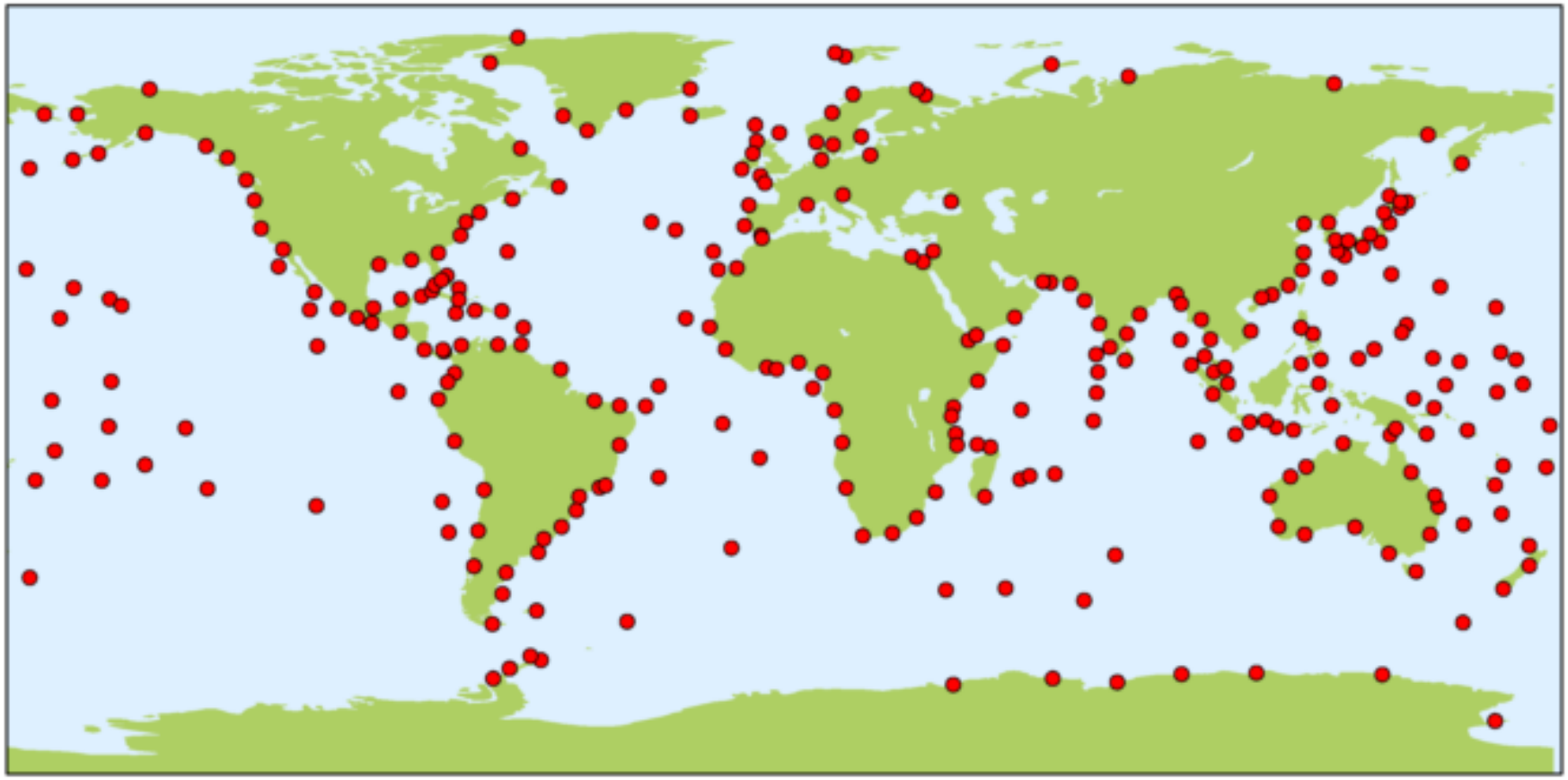
“propose a network of some 250 sea level gauges”



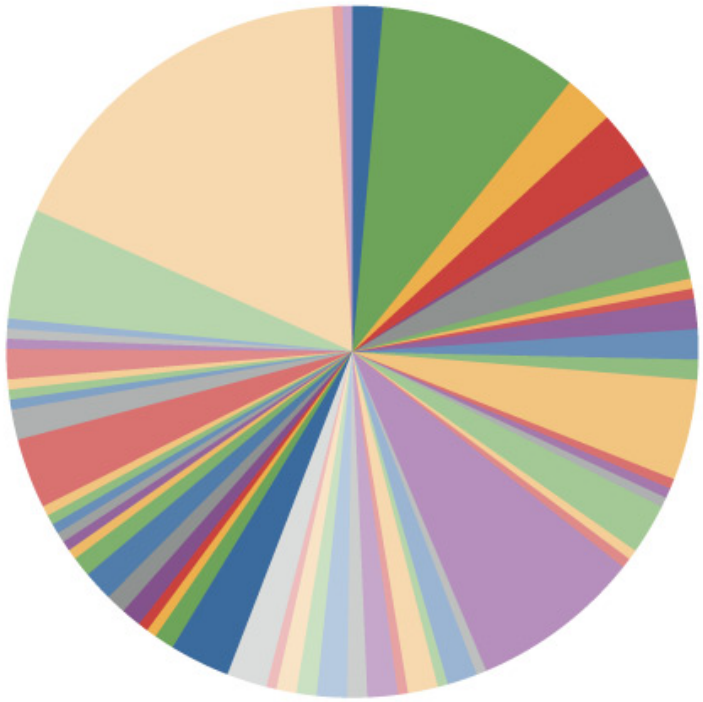
Wyrtki, K., & Pugh, D. (1984). Plan for a global sea-level network. *Prepared for the 17th Session of the Executive Council of the Intergovernmental Oceanographic Commission, Paris*, *31*.


IGOSS
CENTRE
OPERATIONAL
USER
GAUGE
NATIONAL
SYSTEM
P S M S L
USER


GLOSS
26 10'90



GLOSS Core Network 2010 (GLOSS10) – 290 tide gauge stations



**GLOSS**
tide gauges with
fast-delivery of data

ARG AUS BRA CAN CPV CHL CHN COK CRI DJI ECU EUR FSM FJI FRA DEU GHA HKG IND IDN IRL ISR
JPN KEN KIR MYS MDV MNP MHL MUS MEX MOZ MMR NRU NLD NZL NOR OMN PAK PLW PAN PNG PER PHL
PRT RUS STP SEN SYC SGP SLB ZAF KOR ESP LKA SWE TZA THA TGO TON TUV GBR USA VUT VNM

Image adapted from one by Albert Fischer,
Head of Ocean Observation and Services, IOC

# DATA CENTRES

PSMSL

Monthly means

Quality Control

Atlantic, Arctic & Southern Oceans

Delayed mode

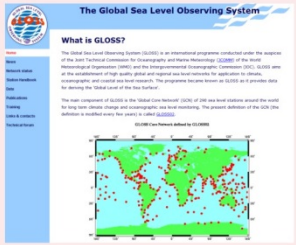
Quality Control ~1 Year

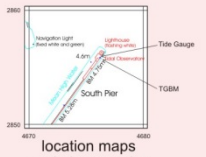
BODC

Tide gauge data

Delayed mode
Pacific & Indian Oceans

GLOSS WEBSITE




location maps and photographs

Fast delivery

UHSLC

Less than 1 month

Quality Control

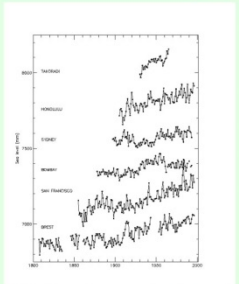
Real time
minimal automated QC

UNESCO

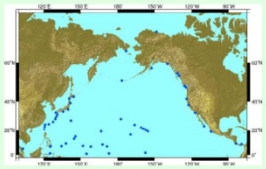
Real time

# USERS

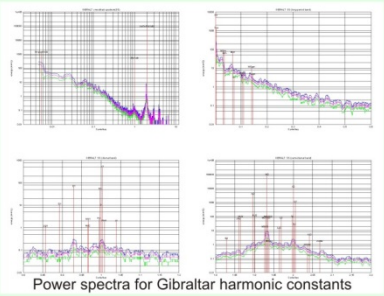
Mean sea level



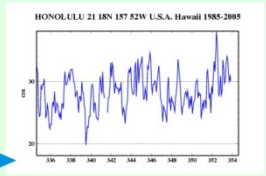
Global long term sea level records



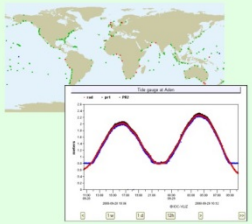
Delayed mode
High frequency data



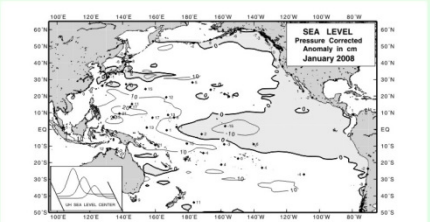
Power spectra for Gibraltar harmonic constants




Fast delivery
Hourly data



Real time
Hourly data



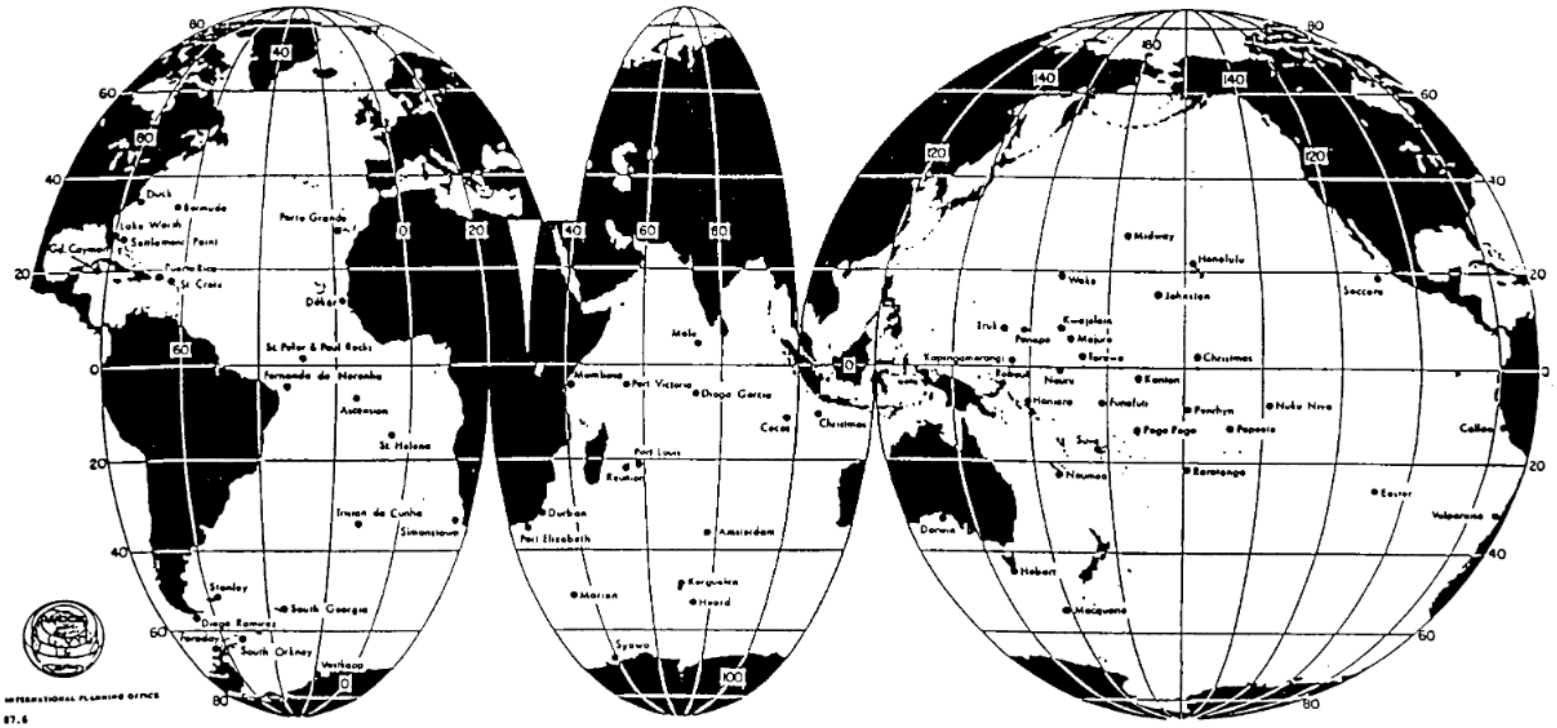

Anomaly of sea level from the 1993 to 2001 mean sea level adjusted for atmospheric pressure.

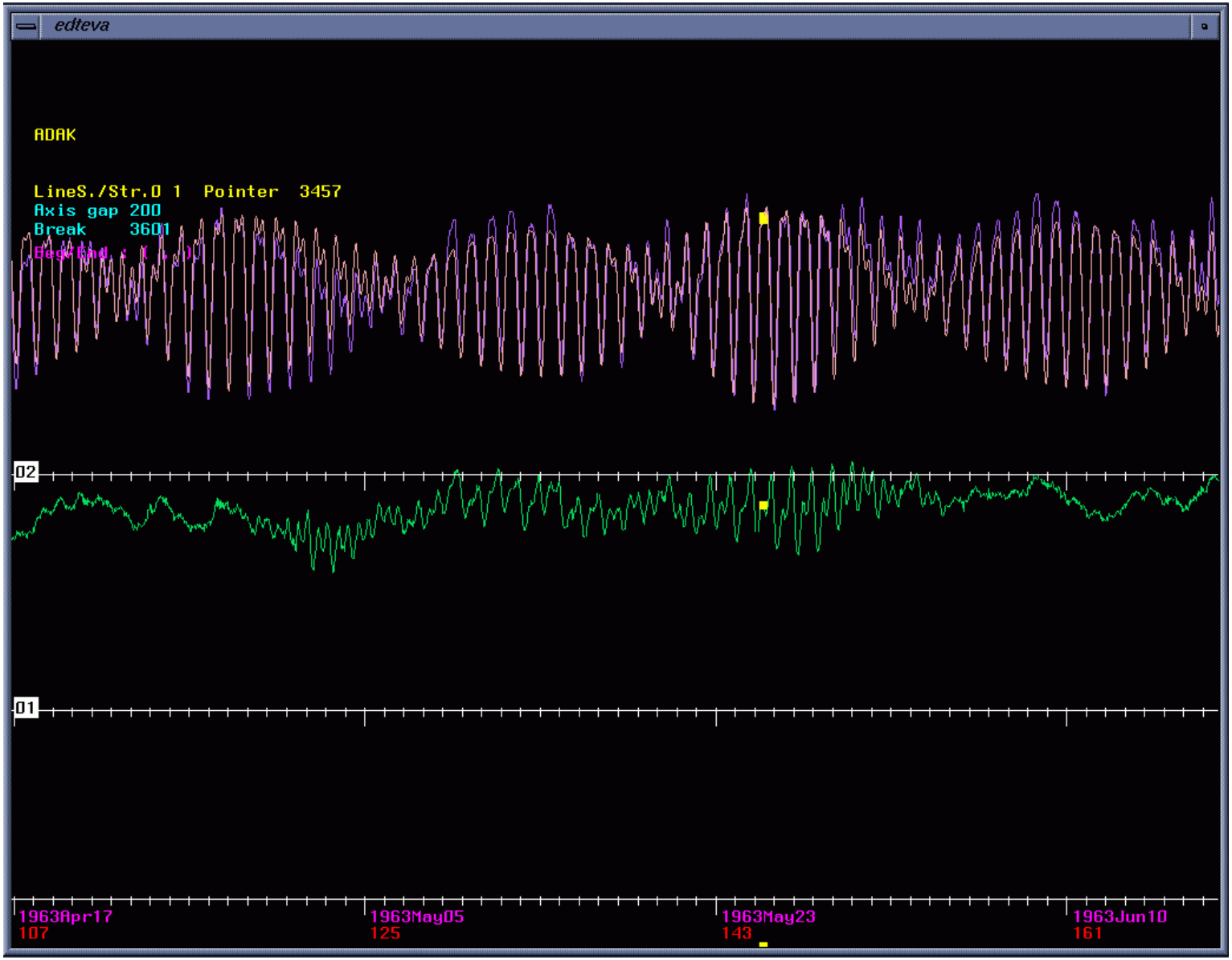
# WOCE, 1990-2002

The World Ocean Circulation Experiment (WOCE) was a major international project concerned with global scale deep ocean measurements and modelling. The aim was to improve our understanding of how ocean circulation affects the Earth's climate. The project was part of the World Climate Research Programme (WCRP).

The field phase of the project lasted from 1990-1998 and was followed by analysis, interpretation, modelling and synthesis activities (AIMS). The AIMS phase of WOCE, officially continued to the end of 2002.

# WOCE Sea-Level Network




edteva
ADAK
LineS./Str.0 1 Pointer 3457
Axis gap 200
Break 3601
02
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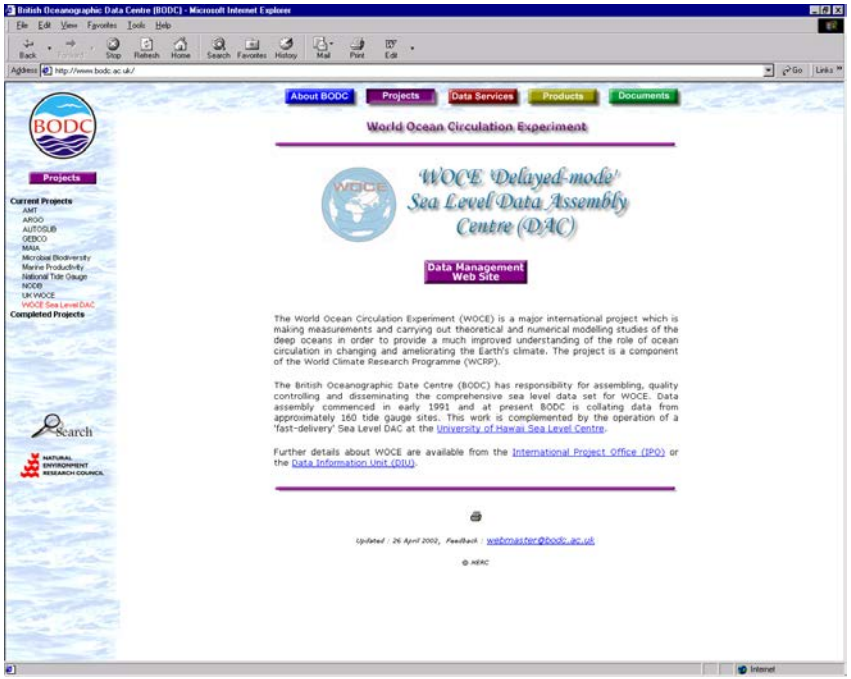
1963Apr17
107
1963May05
125
1963May23
143
1963Jun10
161



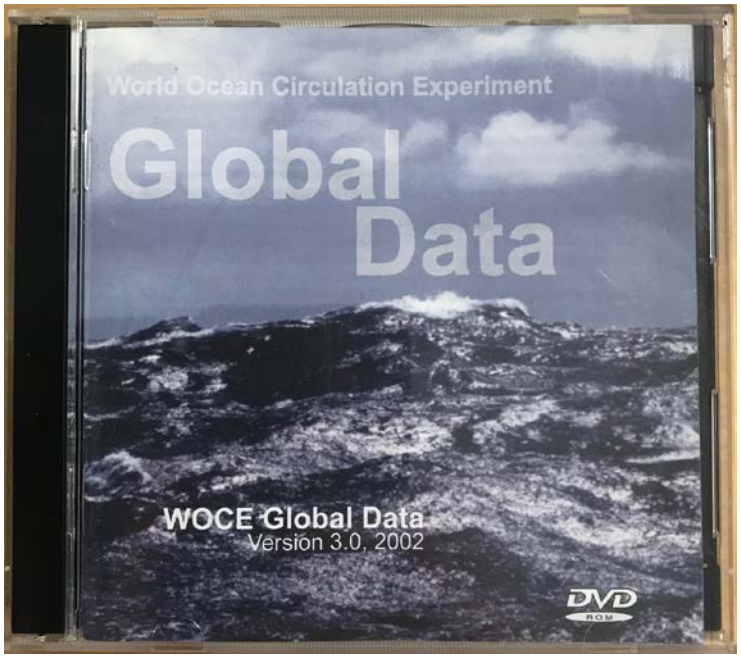

The distribution of the data set was a key requirement of BODC's role as the 'delayed-mode' centre.

The data were made available to the scientific community via the internet and in 2001/2002 there were over 2000 users actively retrieving data from the BODC web site.

A DODS server provided access to the data

The delayed-mode sea level data set was included on the WOCE Global Data Set, released at the WOCE final conference.

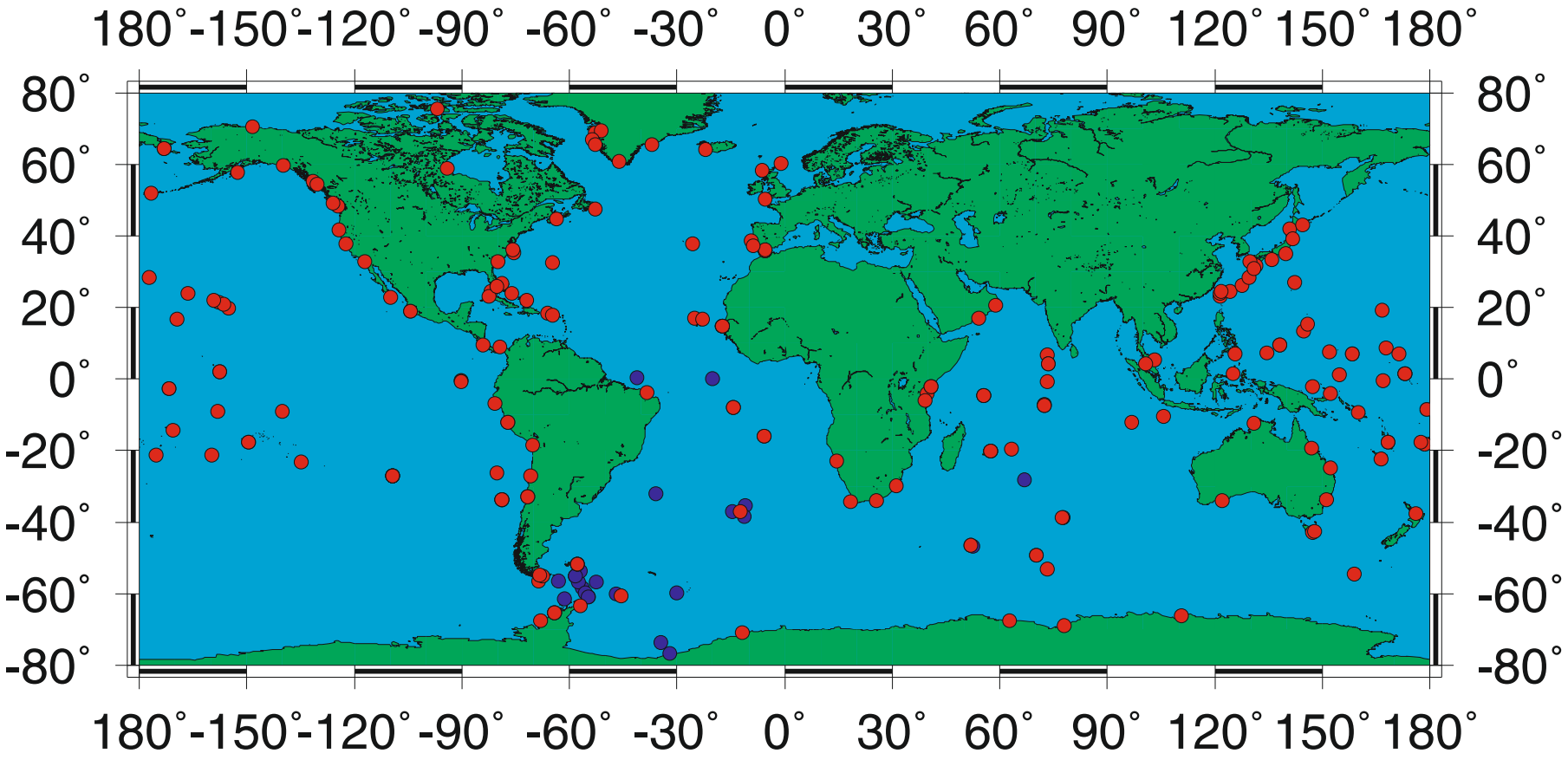
# First sea level data release on DVD




The data set consists of sea level data measured by 160 tide gauges from over 20 countries worldwide.

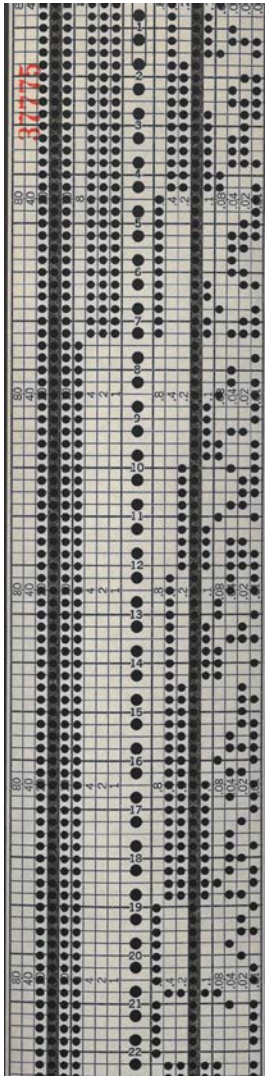
Several sites have data extending back over 80 years and the total volume of data exceeds 3550 site years.

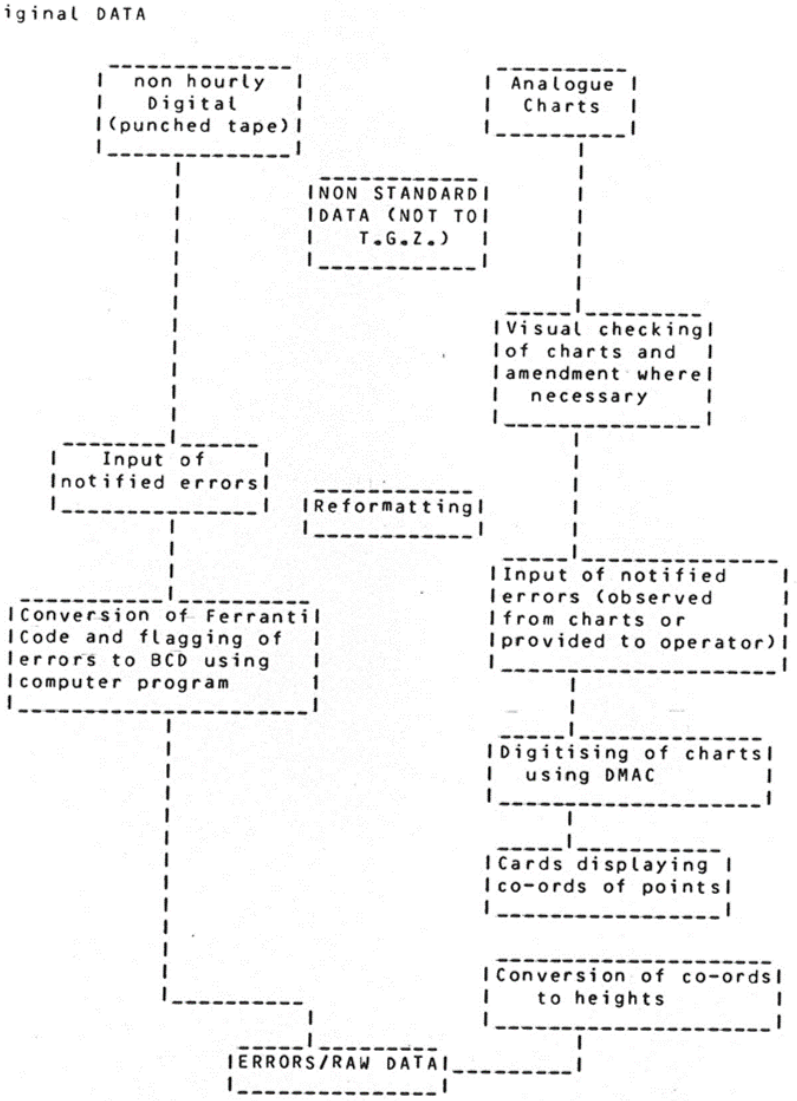
Some sites have other parameters recorded, such as atmospheric pressure, air temperature, sea temperature, wind speed, gust wind speed and wind direction.

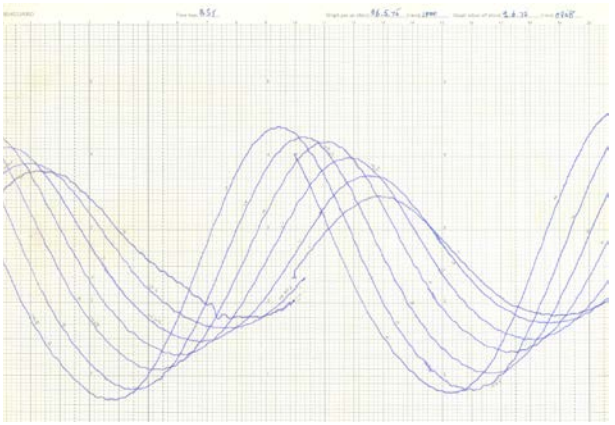

180° -150° -120° -90° -60° -30° 0° 30° 60° 90° 120° 150° 180°
80° 60° 40° 20° 0° -20° -40° -60° -80°
Tide gauge
Bottom pressure recorder

# UK Tide Gauge Network, 1993 onwards


Class A Network Dataring gauges – 1988 data processing and analysis (1989) S. M. Shaw





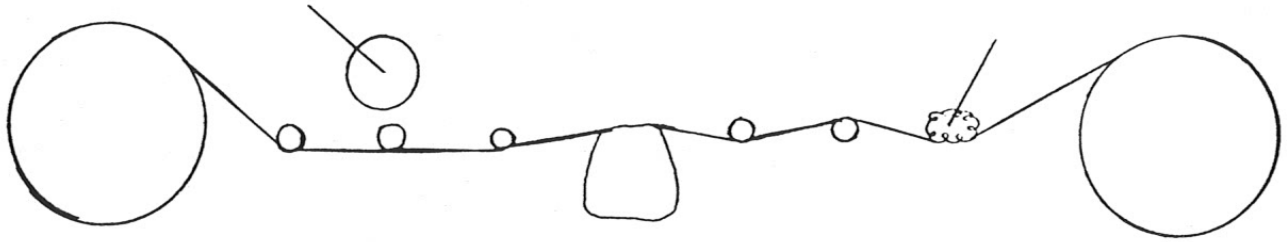



Tidal Computation Section report, 14th January 1980

Converting Aanderaa tapes to IBM files using PC AT

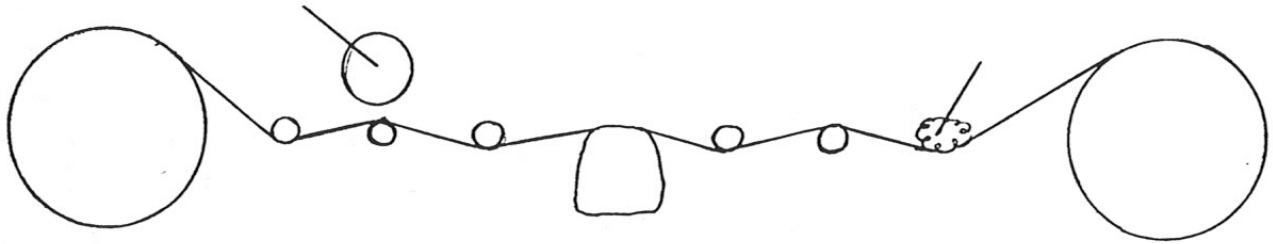
(1) Connect tape reader to PC AT via modem port, switch both on.

(2) Wind magnetic tape onto reader. (wind tape under everything except read head and middle right hand cog)



(3) Rewind tape.

(4) Put left hand side of tape between pinch roller and capstan.



DATARING User notes, R. J. Maher, 28th November 1989

## 4.0 Weekly check of gauges

Each gauge has to be regularly checked to ensure it is working satisfactorily. The LOOK program will phone each gauge in turn, record the gauge time, its flags, and the current day's data, which can then be checked at leisure. LOOK can be run on all gauges or selected ones only. There also a facility to reset the IBM PC clock, and delay the program.

To run LOOK on the IBM PC.

(1) Switch on the PC.

(2) Type cd\aztec

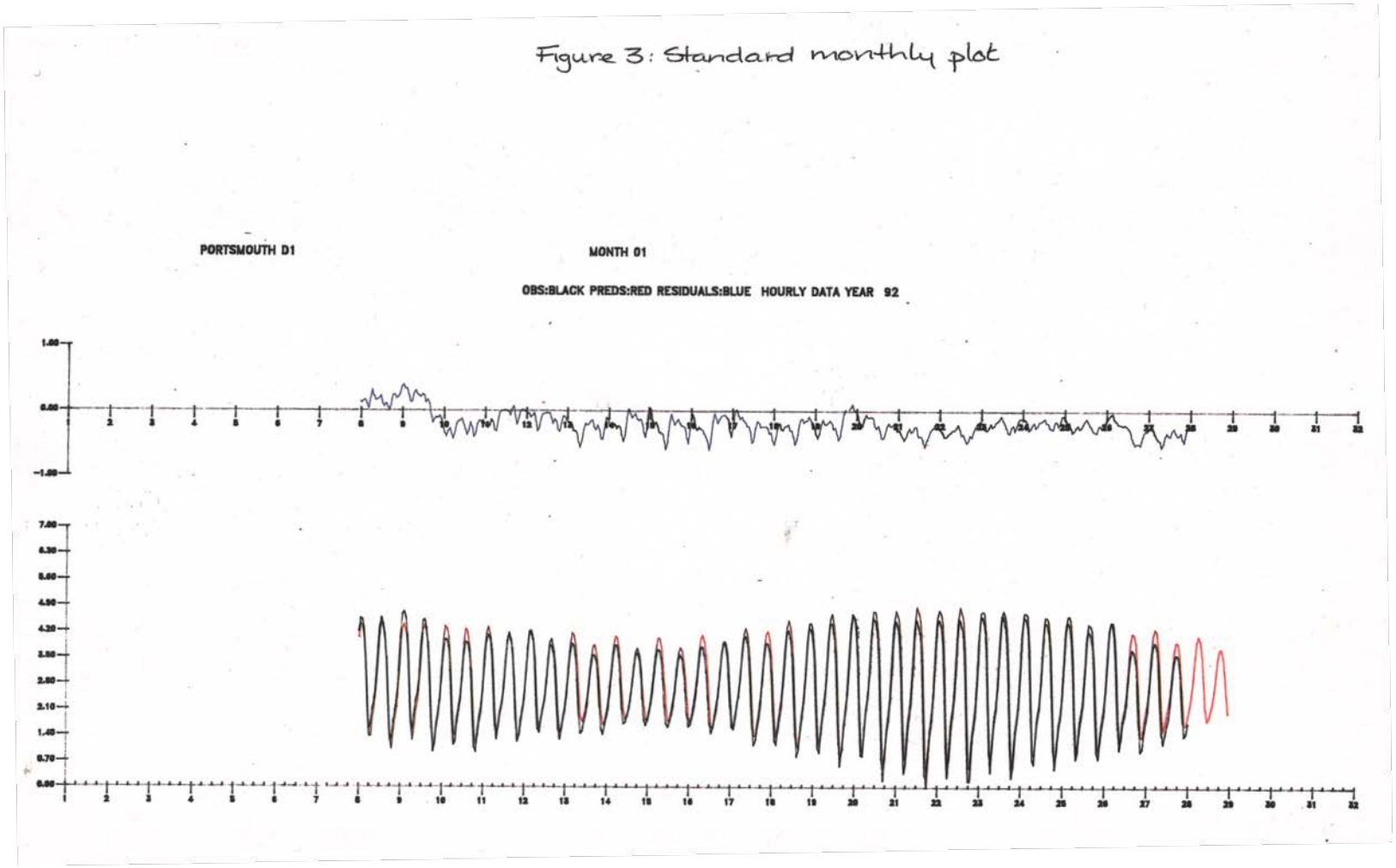
(3) Type Cntrl P to switch printer on (optional, as printer sometimes jams).

(4) Type look

(5) Answer questions as for data retrieval.

(6) Information will be recorded in \aztec\monfile.

DATARING User notes, R. J. Maher, 28th November 1989




Tidal Computation Section report, 14th January 1980

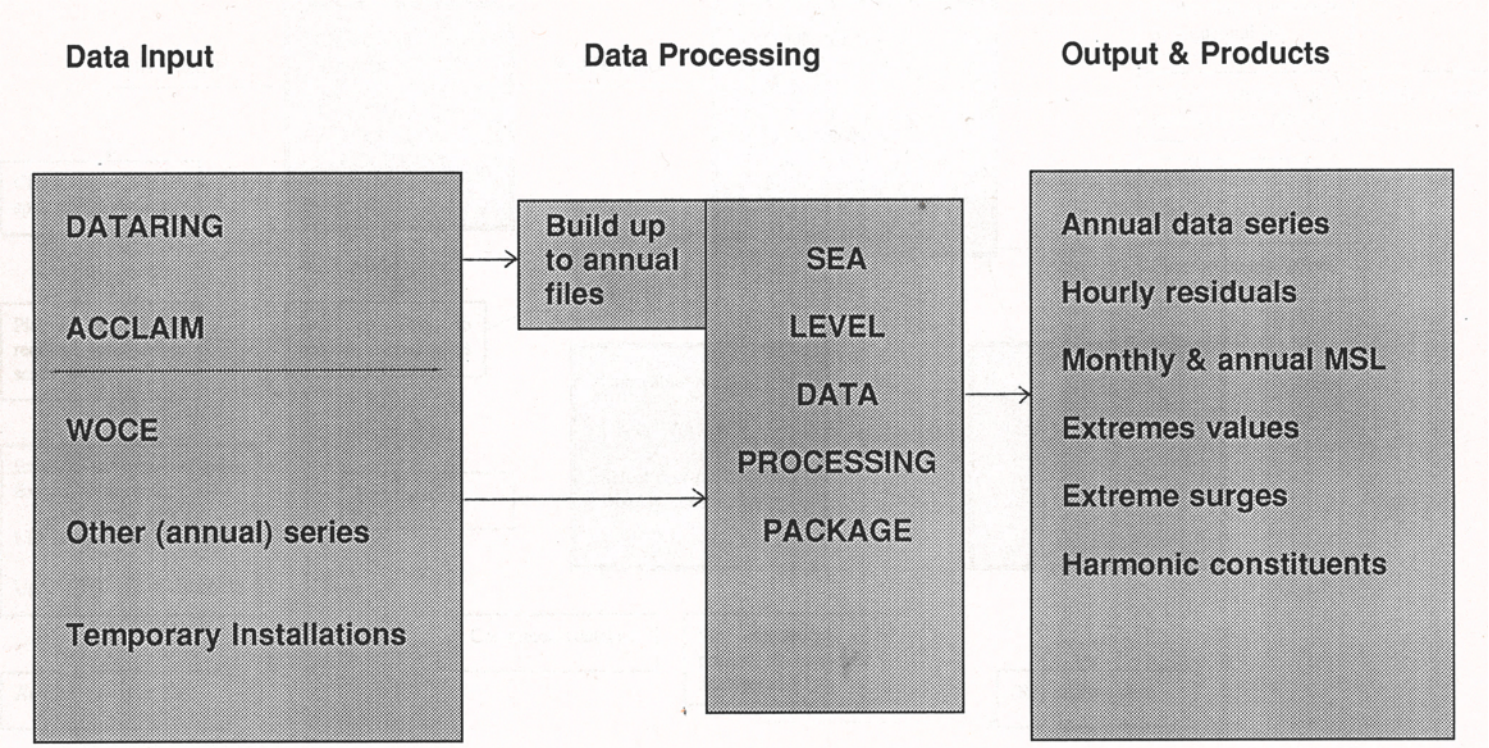



Figure 4: Overview of Sea Level Processing Package

rol,

Version 1.0, L. J. Rickards, 28th February 1992

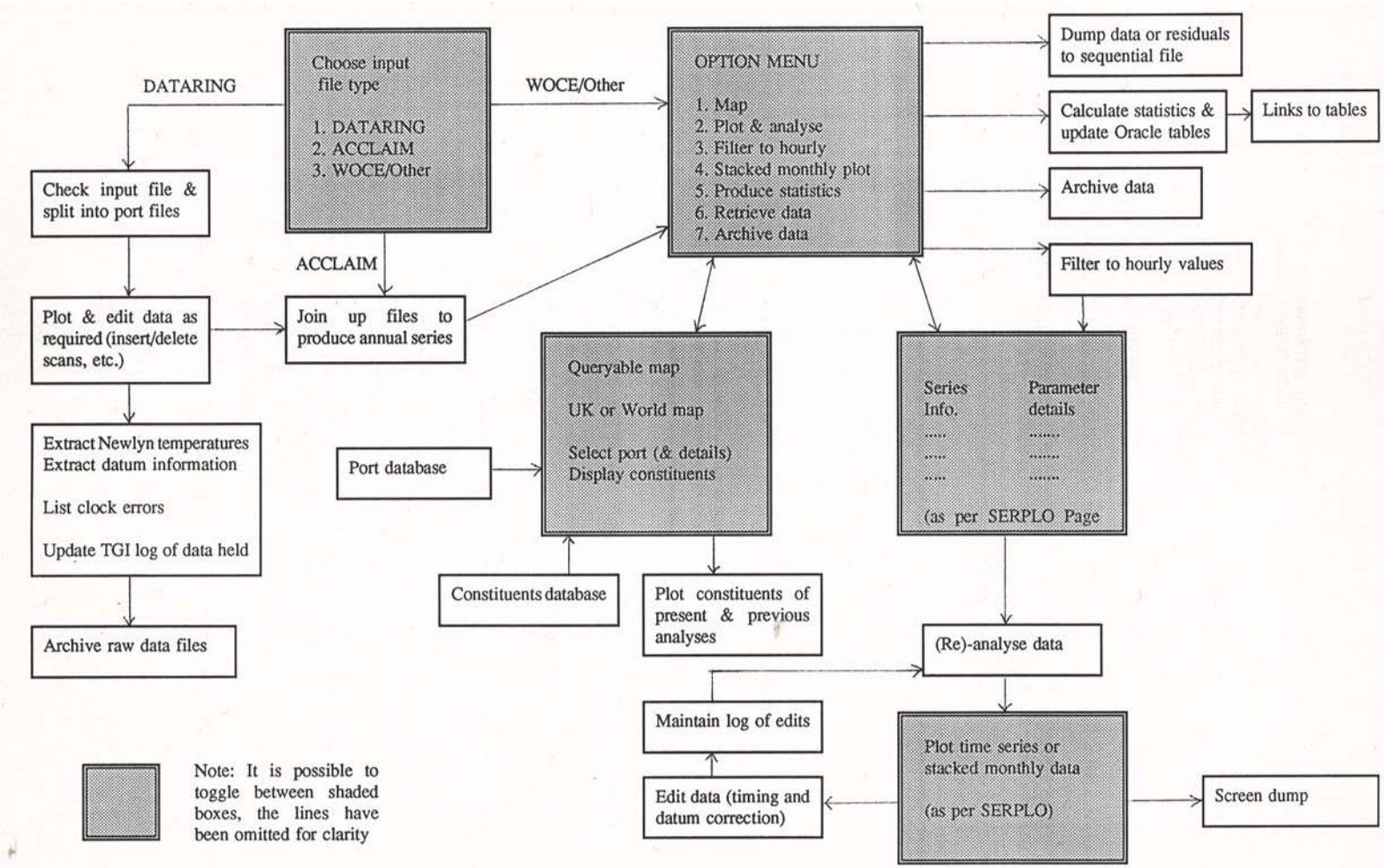
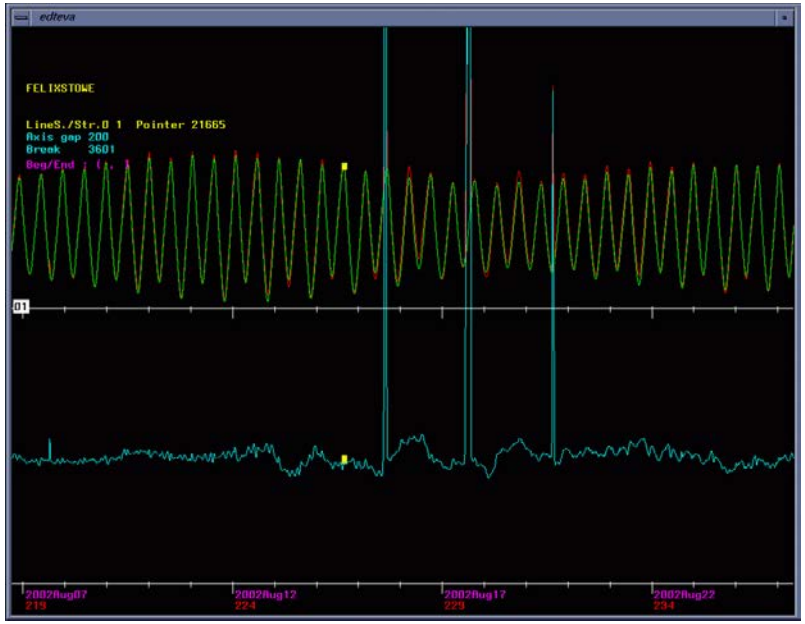
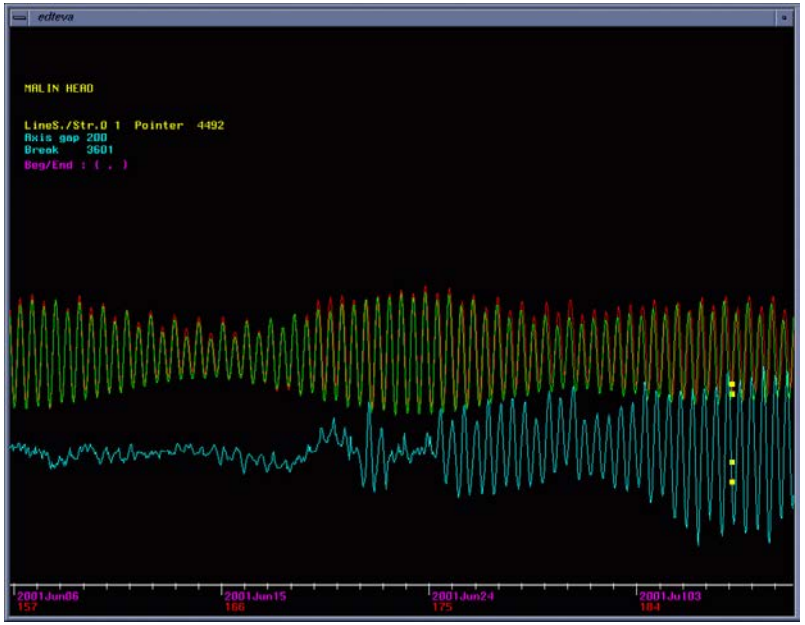
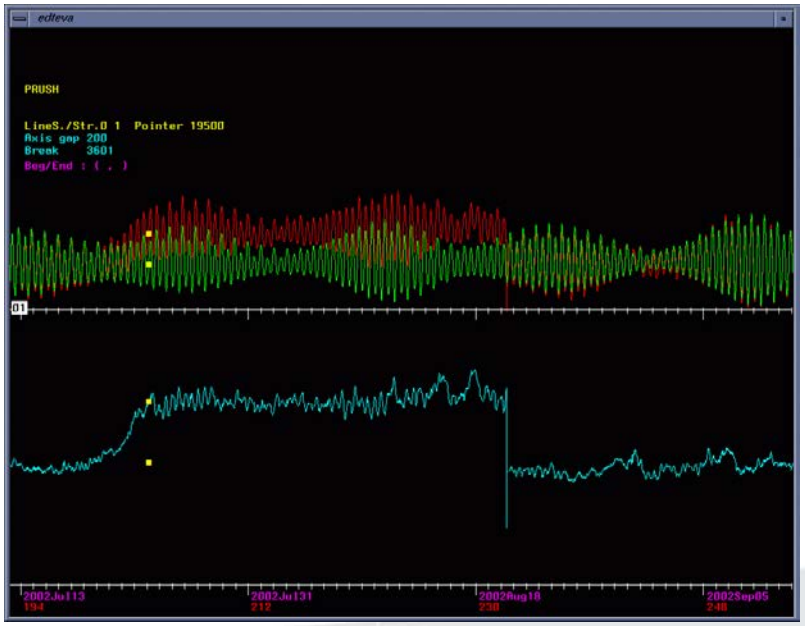



**Figure 5: Detailed view of Sea Level Processing Package**




- Spikes
- Timing errors
- Datum shifts

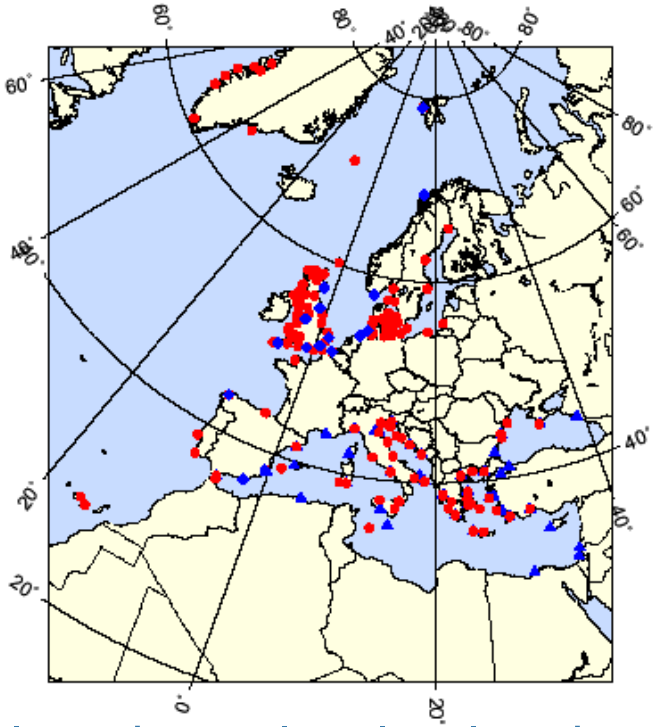


# CLIVAR Sea Level DAC, 2002-2005

CLIVAR - Climate Variability and Predictability (CLIVAR) is an international research programme investigating climate variability and predictability on different time-scales and the response of the climate system to anthropogenic forcing. CLIVAR is one of the major components of the World Climate Research Programme (WCRP). It started in 1995 and aimed to have a lifetime of 15 years.

# ESEAS, 2002-2005

The European Sea-Level Service (ESEAS) was an international collaboration of governmental and non-governmental organizations operating tide gauges along European coasts or providing related information from other sources such as satellite altimetry, GPS and absolute gravity measurements.



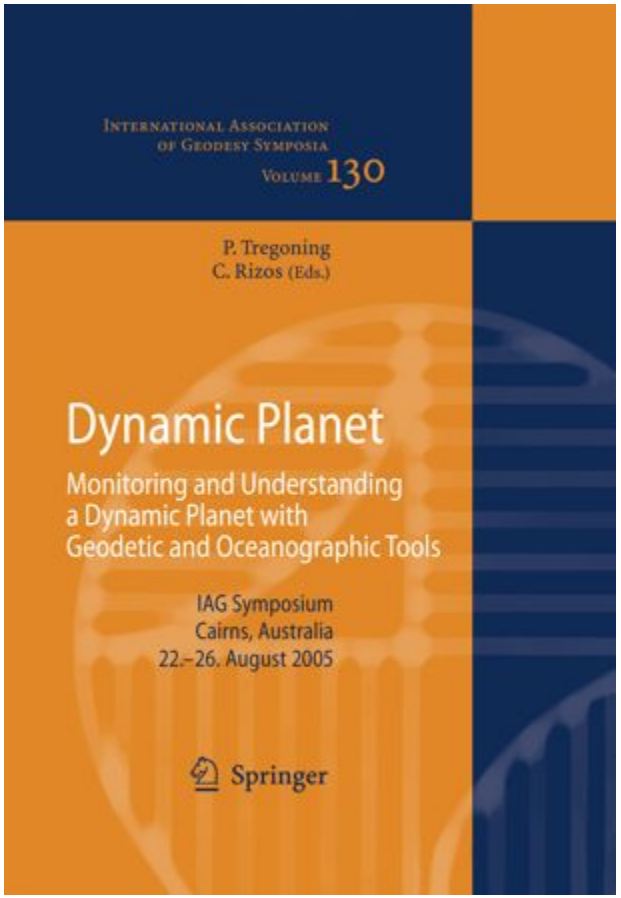
It aimed to provide quality-assured sea-level and sea-level related information for European waters to a broad range of users.

18 countries were involved, with more than 170 proposed ESEAS Observing Sites.

ESEAS

One of the objectives of ESEAS was to provide standardised access to European tide gauge data. It was recognised that a common set of procedures should be adopted for the quality control of data. This would result in data sets of sea level which have been acquired and processed to agreed standards and which have thereby obtained ESEAS quality endorsement.

Quality control also extends to other factors as well as the data. The documentation and checking of metadata is essential.




García, M. J., et al. (2007). European sea level monitoring: Implementation of ESEAS quality control. In *Dynamic Planet* (pp. 67-70). Springer, Berlin, Heidelberg.

# EA Coastal & Estuarine Extremes, 2009-2010

Provide an updated, nationally consistent dataset of extreme sea level conditions, using local gauges which are deemed to be suitable for validation. BODC were contracted to quality control tide gauge data.

- 41 sites
- > 500 site years
- Multiple formats
- Multiple suppliers
- Varying amounts of metadata

| Site | Length of Dataset | Gauge Owner | Environment Agency Region |
|---|---|---|---|
| Exmouth | 9 | Environment Agency | South West |
| Falmouth | 4 | Falmouth Harbour Commissioners | South West |
| Minehead | 9 | Environment Agency | South West |
| Padstow | 11 | Environment Agency | South West |
| Teignmouth | 4 | Environment Agency | South West |
| Uphill | 11 | Environment Agency | South West |
| Calshot | 19 | Associated British Ports | Southern |
| Cowes | 11 | Environment Agency | Southern |
| Littlehampton TL | 17 | Environment Agency | Southern |
| Lymington | 17 | Environment Agency | Southern |
| Pevensey | 17 | Environment Agency | Southern |
| Rye | 10 | Environment Agency | Southern |
| Woolston Tide | 12 | Environment Agency | Southern |
| Abersytwyth | 5 | Environment Agency | Wales |
| Cardiff | 5 | Associated British Ports | Wales |
| Llanelli | 5 | Environment Agency | Wales |
| Porthmadog | 16 | Environment Agency | Wales |
| Swansea | 5 | Associated British Ports | Wales |
| Margate | 14 | Port of London Authority | Thames |
| Silvertown/Tilbury | 19 | Environment Agency | Thames |
| Southend | 19 | Environment Agency / Port of London Authority | Thames |
| Clacton | 8 | Environment Agency | Anglian |
| Great Yarmouth | 17 | Environment Agency | Anglian |
| King's Lynn | 14 | Environment Agency | Anglian |
| Southwold | 17 | Environment Agency | Anglian |
| Wells | 17 | Environment Agency | Anglian |
| Barrow | 17 | Associated British Ports | North West |
| Burgh Sluice | 14 | Environment Agency | North West |
| Canal Foot | 15 | Environment Agency | North West |
| Fleetwood | 14 | Environment Agency | North West |
| Hilbre Island | 39 | British Oceanographic Data Centre | North West |
| Lancaster Quay | 16 | Environment Agency | North West |
| Winster Sluice | 16 | Environment Agency | North West |
| Berwick | 4 | Environment Agency | North East |
| Bridlington | 12 | Environment Agency | North East |
| Tees Dock | 17 | Environment Agency | North East |
| Buckie | 8 | SEPA | Scotland |
| Corpach | 17 | SEPA | Scotland |
| Girvan | 8 | SEPA | Scotland |
| Newport | 14 | SEPA | Scotland |
| Tarbert Harbour | 14 | SEPA | Scotland |

Environment Agency

# AtlantOS 2015-2019

AtlantOS' overarching goal was to deliver an advanced framework for the development of an integrated Atlantic Ocean Observing System that goes beyond the state-of-the-art, and leaves a legacy of sustainability after the life of the project.

Sea level is one of the GOOS Essential Ocean Variables and a key parameter as it is useful for many purposes (e.g. storms, tsunami, and long-term change).

| | |
|---|---|
| **Project** | AtlantOS – 633211 |
| **Deliverable number** | D4.1 |
| **Deliverable title** | Sea level observing site catalogue: Sys documentation of South Atlantic tide g and benchmarks. |
| **Description** | This task will develop a comprehensive sea level observing site catalogue (incl benchmarks, maps and images) [D4.1] building on the IOC GLOSS Station Ha European Sea Level Service Observing specification. |
| **Work Package number** | WP4 |
| **Work Package title** | Interfaces with coastal ocean observing |
| **Lead beneficiary** | NERC-NOC |
| **Lead authors** | Elizabeth Bradshaw |
| **Contributors** | (See list of main websites interrogated) |
| **Submission data** | 06 April 2017 |
| **Due date** | 31 March 2017 |
| **Comments** | v1 |

This project has received funding from the European Union's Horizon 2020 innovation programme under grant agreement n° 633211.

| | |
|---|---|
| **Project** | AtlantOS – 633211 |
| **Deliverable number** | 4.2 |
| **Deliverable title** | South Atlantic tide gauge data management plan |
| **Description** | Develop a harmonised data management plan [D NOC] for all South Atlantic tide gauge data buildi current international data centre activities. |
| **Work Package number** | WP4 |
| **Work Package title** | Interfaces with coastal ocean observing systems |
| **Lead beneficiary** | NERC-NOC |
| **Lead authors** | Elizabeth Bradshaw |
| **Contributors** | Lesley Rickards |
| **Submission data** | |
| **Due date** | 31 March 2018 |
| **Comments** | |

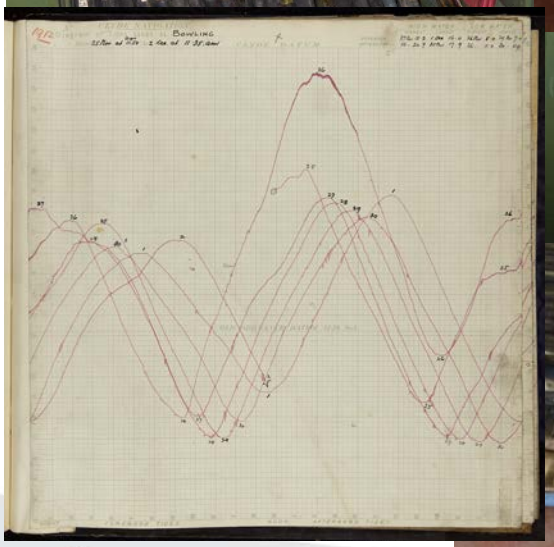
This project has received funding from the European Union's Horizon 2020 resea innovation programme under grant agreement n° 633211.

| | |
|---|---|
| **Project** | AtlantOS – 633211 |
| **Deliverable number** | D7.2 |
| **Deliverable title** | QC Report |
| **Description** | Recommendations for an automatic RT or NRT QC for selected EOVs (T&S, Current, Oxygen, CHla, Nitrate, Carbon, Sea level) |
| **Work Package number** | 7 |
| **Work Package title** | Data flow and data integration |
| **Lead beneficiary** | Ifremer |
| **Lead authors** | G. Reverdin, V. Thierry, J. Utiz, F. d'Ortenzio, E. Bradshaw, B. Pfeil |
| **Contributors** | V. Harscoat, S. Pouliquen |
| **Submission data** | 10 February 2017 |
| **Due date** | 30 September 2016 |
| **Comments** | Oxygen released mid-October 2016, Carbon and Sea Level released in January 2017 |

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 633211.

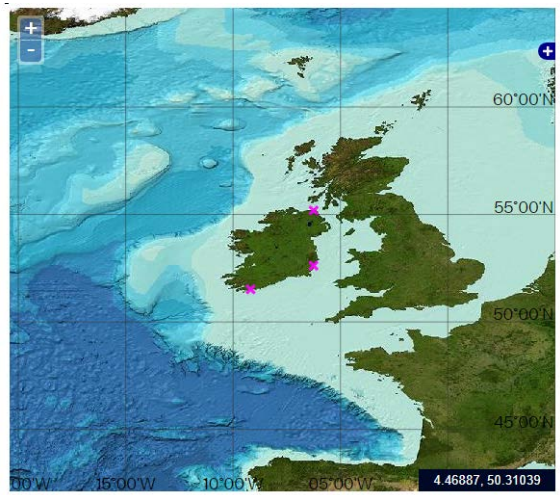
Last updated: 25 January 2017

# Clydeport, 2016



- July 2016 - Peel Group Ltd. donated tide gauge charts (345 volumes) and handwritten ledgers (91 books) from sites along the Clyde (earliest record 1841)
- Photographed data from one location, earliest date and longest record possible
- Images from Bowling Harbour, with 51 ledgers scanned (1888 to 1939). 2716 TIFF images

# Oldest (banked) record in BODC?




## Castletownshend (Eire) Site History

### 1842 Data

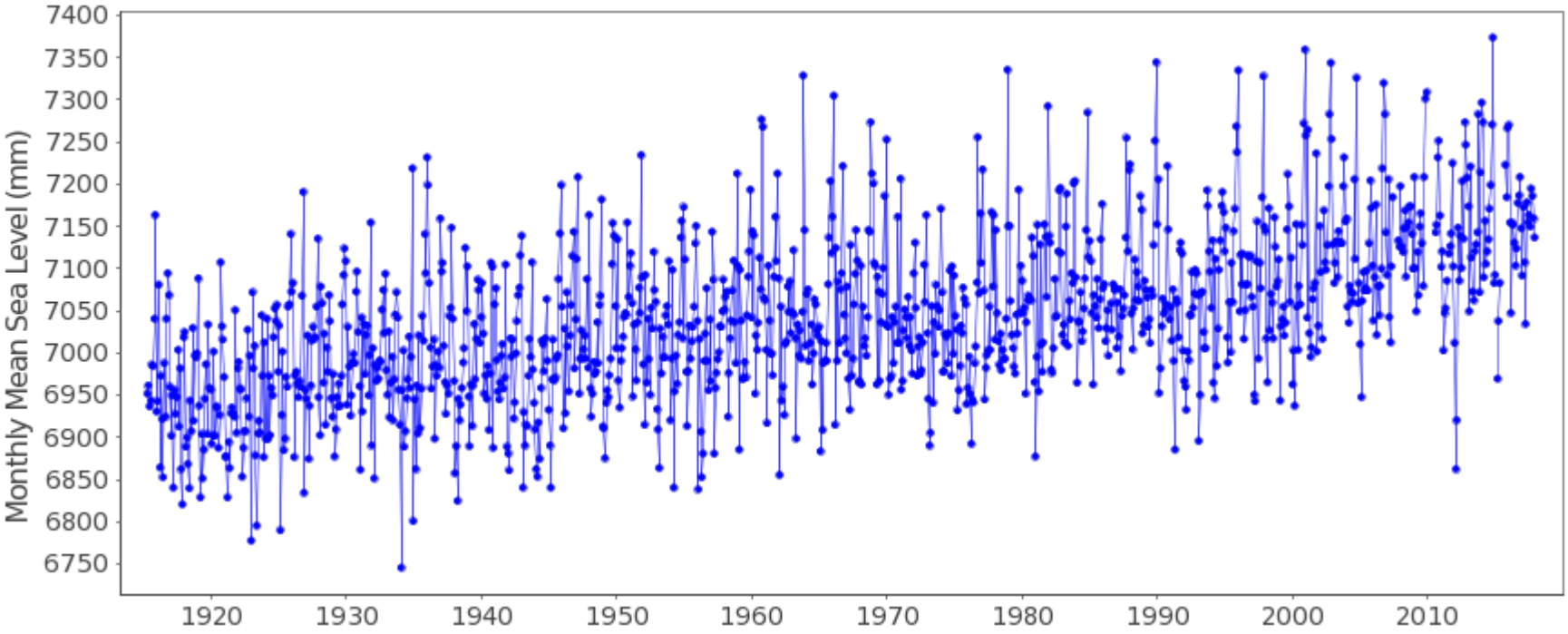
**Site**

The tide pole was situated to the north of the coast guard signal pole, near the coast guard station, opposite the slipway (Grid ref. W 109 301). Readings were taken at 5 minute intervals during the day and for a few hours at the turning points of the tide during the night. The readings were entered into a log book and times corrected to GMT. Values have been read from the log book at hourly intervals and converted to metres.

| | |
|---|---|
| **Levelling** | Benchmark used was a copper bolt driven vertically into the rock to which the coastguard signal pole is attached. |
| **Height of benchmark** | +9.951m (Ordnance Datum Ireland) |
| **Zero of pole relative to bolt** | -9.399m |
| **Zero of tide pole** | +0.552m (Ordnance Datum Ireland) |

The data were supplied by the Royal Greenwich Observatory, Herstmonceux Castle, Hailsham, East Sussex. They form part of a survey carried out by the Army in 1842. The data were reduced by Airy (G. B. Airy 1845 Phil. Trans. Roy. Soc. volume 135, pages 1 - 124) to determine mean sea level and tides around the coast of Ireland.

# Longest record in BODC?




Newlyn, 1915 onwards

MIAS BANKING OF SEA LEVEL DATA

As the UK's National Oceanographic Data Centre MIAS has undertaken to:

(1) create, develop and maintain a National Oceanographic Data Bank

(2) make oceanographic data available in a useful form to industry, research workers, and local and central government departments

(3) collaborate with other data centres in the international exchange of oceanographic data.

The Data Bank should benefit both the industrial and scientific community and, in particular, will serve to:

(1) encourage research workers to edit and document their data to a standard that enables it to be used effectively by others rather than just as input to their own studies

(2) ensure that data may be made rapidly available on demand

(3) ensure that data is available in a single format rather than a multiplicity of different formats

(4) safeguard the data both for short and long term use and so protect the considerable investment that is being made, in terms of both effort and money, in the collection of oceanographic data.

Historically, TCS has been the IOS sea level data bank, but this activity has become increasingly demanding on its resources. Initially MIAS are banking sea level data from the 'A' class network and temporary tide gauge installations, but other data sets also exist and these will be banked in due course (for example deep sea pressure gauge data). Banking the TCS sea level data may conveniently be considered as being divided into three separate but compatible stages. These are:

(1) Transfer of data and essential series header information from TCS to MIAS.

(2) Collection and collation of background information into document files on the MIAS data base.

(3) Provision of a reverse pathway by which TCS may be provided with banked data, retrieved from the MIAS data base.

Lesley Rickards
30/3/83

Reusable
Accessible
Interoperable

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