FIELD TECHNIQUES: WATER SYSTEMS (OCEANS)

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Summary

Oceanographic field techniques are mainly distinguished by the way the researcher or his instruments are brought to the water volume of interest. The traditional and still dominant tool is the research vessel, from which devices can be lowered at conducting cables below the sea surface. Instruments can be immediately recovered, or anchored to the ground, or released for floating in the water volume or at the surface. Such instruments are usually equipped with sensors to determine in-situ water properties, or with bottles to trap water for later laboratory investigations.

Still the most important technology is vertical profiling of the water column at a specific geographic position, while recording data like pressure, temperature, conductivity, dissolved gases etc. For permanent monitoring of environmental conditions, instruments mounted to moorings, platforms, masts or buoys provide the required long time data series. Sophisticated drifters are deployed at prescribed depths to keep track of large scale ocean currents and circulation.

Acoustic tomography is an in situ remote sensing method; where the devices are placed in the water volume, the measurement target, however, is the large scale and long time change of water properties in the region between emitters and receivers. Satellite remote sensing is used for continuous global scale observation of the oceans with enormous data harvest, but it is restricted to water surface properties and limited by atmospheric opacity for the electromagnetic waves in use.

1. Introduction

Oceans cover two-thirds of the Earth’s surface with an average depth of about 4000 meters. Under the influence of wind and tides, of solar heating and of water evaporation, of ice covers and permanent river inflow they form a physical system highly variable in space and time. It is practically impossible to monitor all processes occurring in this vast volume; ocean sciences evidently suffer from a lack of data and a systematic undersampling despite the high financial and material efforts of various national and international organizations and programs. It is not and will not be possible to measure everything everywhere and all the time. Therefore science is requested to specify certain key features that are affordable to be observed and yield sufficient information to understand the most important features and their impact on climate and human life.

Oceanographic field investigations arose from observations of sailors and fishermen, started systematically in the nineteenth century and became an extended research field after the Second World War. Economic and military interests of the industrially developed countries ensured ongoing support of this cost-intensive research.

Today we know almost for certain that oceans and their long-time variability play a fundamental role in climatic changes and their natural accompaniments like hurricanes, floods, or droughts. However, we are still far away from fully understanding the complex interplay of the multitude of factors influencing oceanic processes.

Continued observations with classical methods combined with very advanced techniques like satellites will be required for decades until knowledge will suffice for reliable long-term predictions of the natural conditions on Earth.

2. Measuring Platforms

Figure 1. Research vessel (r/v) *Alexander von Humboldt* of the Institute for Baltic Sea Research Warnemuende (IOW), Germany.Launching: February 1967; completion: July 1967; length: 64.23 m; gross tons: 1270.58; range: long distances; total rated power: 1750 hp; speed:12 knots; labs: 7 + CTD laboratory; crew: 15; scientists 13.

The most important instrumental platform of sea-going oceanographers is the **research vessel**. Its overall length varies between several decameters up to 90 m and more. Their displacement reaches 2000 tons while their drought can be 5 m and more. Recording room, filling room for water samples, wet and dry laboratories, several multipurpose rooms, meteorological laboratory, photographic laboratory, and a seminar room are usually available for the scientific crew of about 10–20 scientists, technicians, and engineers. Such a ship is depicted in Figure 1.

All data of navigation and environment are available continuously via an electronic data distribution system. Research vessels carry instruments for meteorological parameters (air pressure, dry and wet air temperature, wind speed and direction, etc.) and hydrographic parameters (current, optical sea water property, pressure, temperature, salinity, dissolved oxygen, etc.). In contrast, automatic recording standard instrumentation can also be installed on ships of opportunity like ferries, freighters, other commercial vessels, or even submarines.

Physical oceanographic measuring techniques have developed significantly during the last three decades. Modern sensors permit a fast and convenient data acquisition. Networks of communication systems rapidly distribute bulky data sets via satellite systems or other telemetric connections to create the base for operative decisions needed in multi-ship surveys.

Such a quickly performed transfer of data also allows quasi-online simulations of both mass fields and current fields by means of numerical circulation models to guarantee an operative dialogue between modeling and observation. Concerning success of such approaches, the risk of the proper data flow certainly lies on the measuring side.

Oceanographic instruments can be classified into one or another of a relatively small number of families:

- those that are moored to the sea floor,
- those that drift on the sea surface or at some intermediate pressure or density levels,
- those that make horizontal or vertical profiles of oceanic properties using platforms or expandable versions,
- those that strictly depend on research vessels or other moving platforms like submarines,
- those that use acoustic or electromagnetic methods to sense oceanic variations over far distances.

Altogether, they permit observations within a large range of spatial and temporal scales. All groups of devices and modern types of research vessels are permanently improved. Other instruments are recently being developed. Some of them are commercially available while special oceanographic instrumentation is constructed and manufactured directly in scientific research laboratories. From the viewpoint of sea-going oceanographers, the following key problems arise concerning access to:

- national/international ship time,
- ships equipped with modern navigation systems,

- nationally/internationally tuned cruise programs,
- availability of continuous weather forecasts,
- permission to operate with research vessels in international shelf zones and national economic regions (3–200 n.m.),
- permission to install automatically working stations along foreign coasts (automatic weather stations, recording tidal gauges, etc.),
- on-line availability of modern communication systems operating via satellites to submit remotely-sensed images for an operative cruise planning (cloudiness, sea surface roughness, infrared sea surface temperature for an identification of frontal zones, eddy-like features, ice-edges, etc.),
- sufficient memory capacity for data storing units,
- electronic data distribution system on the ship,
- powerful board computers for data handling and subsequent data transfer over far distances
- serviceable winches and probes,
- storage capacity of energy, which should be supported by the gain of both solar and wind energy, for moored buoys or other instrumental platforms,
- quickly operating microprocessors for *in-situ* instrumentation coupled with modular software tools.

The needed instrumentation underlies a number of unfavourable environmental conditions. High hydrostatic pressure prescribes compact materials to protect pressure-dependent sensor elements. Shock and vibration must be expected for all underwater instrumentation while the mechanical wear and tear influences all installed sensors. There is an enhanced electrolytic corrosion by the seawater, which requires special materials for the instrument housing of all sensors. In order to be used in oceanography, a material must possess various properties, which include high strength, light weight, corrosion resistance, easy fabrication and more. Criterions for materials are mainly given by strength-to-weight ratio, fracture strength, and resistance against any cracking by stress corrosion.

Within near-surface layers, i.e. the euphotic (= light-exposed) zone, the fouling of sensors is a great problem for moored instruments, especially in tropic/ subtropic latitudes. The fouling problem also occurs in moderate latitudes during summer months on ship hulls. It often reduces the ship speed drastically, blocks moving parts of mechanical devices or constipates inlet valves.

Ships are necessary to deploy moored strings equipped with recording current meters, bathythermosalinographs or other devices. At fixed positions, such instruments continuously record different hydrographic parameters at selected horizons. Ships are also needed to launch different kinds of surface/ subsurface drifters or floats to study thermodynamic water properties and currents along certain pathways. For this purpose, ships carry hydraulic cranes as well as different types of electromechanical winches to handle all necessary underwater instruments. In order to reduce possible effects of ship motions on lowered instrumentation, it is preferred that such winches are installed in the mid-ship area.

The propulsion of modern ships is regularly equipped with a system for the ship's fine stabilization. This is frequently required to smooth out pitching and rolling movements, which are caused by surface waves and swells.

Furthermore, one needs a suitable maneuverability of the ship to manage all instruments at wanted positions via modern satellite navigation methods like that of the global positioning system (GPS). Its target accuracy lies in the range of few decameters. This seems to be sufficient for an exact positioning above water depths of several thousand meters. Because many disciplines of geosciences participate in oceanographic research activities, there is an increasing trend for using container laboratories to make operations as flexible as possible.

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Biographical Sketches

Eberhard Hagen is a university lecturer in applied physics at Rostock University and senior scientist in physical oceanography at the Institute for Baltic Sea Research Warnemuende (IOW), Germany. He studied geophysics and meteorology at the Leipzig University. His scientific career started with experimental studies on energetic exchange processes between atmosphere and ocean in coastal zones of the Baltic Sea. During the last twenty years, his particular interest focused on both descriptive investigation and numerical modeling of circulation dynamics in coastal upwelling regions along African coasts as well as on spreading of dense water flow in deep Baltic basins. He participated several international field programs like that of the World Ocean Circulation Experiment (WOCE) and was principal oceanographer of distinct national contributions. Related field campaigns were carried out in the Indian Ocean (Channel of Mozambique), the equatorial Atlantic Ocean, along west African coasts, the North Sea, and the Baltic Sea. He was member of several working groups of the Scientific Committee on Oceanic research (SCOR) and he still is member of diverse working groups of the International Council of the Exploration of the Sea (ICES).

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