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Arvor-C: A Coastal Autonomous Profiling Float

A New Step Toward an In-Situ Virtual Mooring: a Profiling Float With Seabed Stationing Capability for Real-Time Monitoring of Coastal Seas

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Introduction

A fast growing number of users, from private individuals to professionals, needs forecasts or real time information about the coastal seas. They require information on hydrodynamic circulation, sea water temperature, sea state, biogeochemical state and primary production, in order to study ocean evolution and changes, to monitor the sea quality, …

Operational Coastal Oceanography (OCO), and particularly the Previmer program (www.previmer.org), involve forecasts in the coastal zone. They have developed numerical models to make such predictions. These models need a large volume of real time *in situ* information, from the shelf zone, over many months or even years. These data are used to validate such models and, in the near future, as input to be assimilated within these models.

OCO also involves observations in real time, to study physical and biogeochemical processes in water masses. These observations require good quality time series of real time *in situ* data.

Currently, instruments deployed in coastal zones provide data that are either limited in terms of deployment duration, or limited in terms of spatial distribution or water column sampling.

A major breakthrough in coastal observation has been made by Ifremer, the French Research Institute for Exploitation of the Sea, to make up for these drawbacks. The Arvor-C, an autonomous profiling float, was designed to make repetitive *in situ* measurements along profiles from the seafloor to the surface, providing complete three-dimensional high rate data.

This article includes detailed information about the Arvor-C architecture, its standard operation, and its fields of application.

State-of-the-art

There is a wide range of autonomous instruments capable of delivering real time *in situ* data, but their use is restricted to shores, to the first few meters depth, or to the sea bottom.

Automated 3-D measurements are currently carried out by equipment requiring complex mechanical set-ups and costly maintenance work (measurements along moored cables or using winches for example).

Gliders are state-of-the-art 3-D ocean monitoring instruments, but they require particular attention and skill, especially when navigating close to the shores. Moreover, their autonomy is limited to approximately 3 months, which is restrictive for long term observations.

Ifremer developed the Arvor-C because all these instruments fail to meet the new requirements of Operational Coastal Oceanography: provide *in situ* data, over long periods, along the whole water column, with high rate and resolution.

General description

The Arvor-C is a vertical untethered profiling float, easy to set up and ready to be deployed. It behaves like a virtual mooring, for short to long term observations. It can take measurements at the same location for each profile thanks to the optimized time of ascent and descent through the water column, the short time of transmission at the surface, and its anti-drift capability when grounded on the seabed.

The Arvor-C provides a standard set of measurements (pressure, temperature and conductivity), as well as a set of technical information. Multidisciplinary sensors can be integrated on this vertical vehicle, which is designed as an open platform. Additional sensors are being currently fitted to measure dissolved oxygen, turbidity and fluorescence.

In standard mode, the Arvor-C operates autonomously. One of the major features is its Iridium™ satellite bi-directional link: firstly, it offers a fast uplink to transfer data when surfacing after each profile, and secondly, it provides a downlink remote control to reconfigure the mission parameters during operation. For example, users can increase the number of profiles per day and the sensor sampling frequencies when a bloom is detected.

The Arvor-C can be deployed in a network for 3-D monitoring of coastal seas.

Architecture

The Arvor-C is based on the Provor and Arvor deep-sea profiling floats architecture, which are able to make profiles from 2,000 meters depth to the surface. They have proven their reliability at sea over the last 10 years, especially in the Argo program, a global array of 3,000 floats to study global ocean changes (www.argo.ucsd.edu).

The Arvor-C is an autonomous profiling float that weighs less than 20 kilograms, is 2.1 meters high and has a diameter of 11 centimeters.

The scientific payload (Seabird pumped CTD - Conductivity Temperature Depth, and in 2010 additional sensors) is located on the upper end cap, as well as a bi-band Iridium™-Global Positioning System (GPS) antenna (for data transmission, remote control and positioning), and a Bluetooth antenna (for configuration and testing).

An external bladder is fitted on the bottom end cap, to adjust the buoyancy when descending and ascending along the water column, as well as anti-drift claws, to prevent drifting when grounded on the seafloor.

The Arvor-C is a coastal profiling float, designed to withstand pressures up to 450 meters depth. It can perform up to 320 profiles when cycling at 200 meters depth. The profile repetition rate can be configured from 1 profile every hour.

Its ascending speed reaches 15 to 20 centimeters/second. For instance, a 2-second sampling period provides one single measurement every ~35 centimeters. Data are then averaged into 1-meter high slices to reduce transmission duration.

Operation description

Set up. Before its deployment, the Arvor-C is configured in the laboratory by users (scientists or technical assistants). The main parameters to be set up are the profile repetition rate and the sensor sampling frequencies.

Deployment. It can be done by untrained staff, as it only involves removing a magnet in order to power the float. The Arvor-C can then simply be launched at sea. It sends its GPS location and technical information to the data center, retrieves remote commands (if any), and then starts its profiles.

Profile, phase 1: Descent. Starting from the sea surface, the Arvor-C quickly reduces its buoyancy by pumping oil from its external ballast bladder to its internal tank, until its density becomes less than the surrounding seawater density. Then the descent starts.

Profile, phase 2: Anchoring. During the descent, pressure is monitored in order to detect the stabilization of the float which is then anchored in the seafloor sediment.

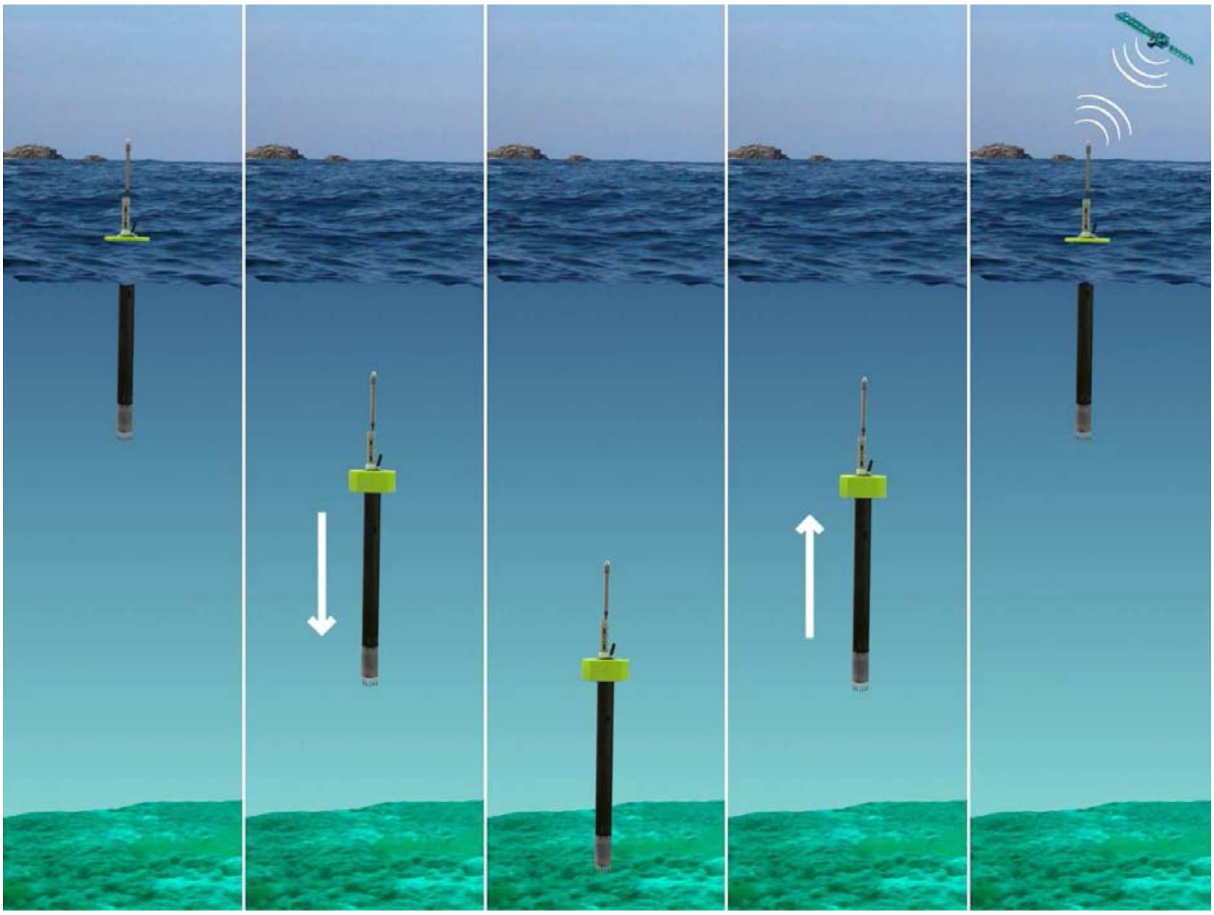
Profile, phase 3: Seabed stationing. The Arvor-C is grounded on the seafloor, until the next programmed time of ascent.

Profile, phase 4: Ascent. The Arvor-C starts pumping oil from its internal tank to its external ballast bladder, increasing its buoyancy. Data acquisition starts on the seafloor and continues all the way up to the sea surface.

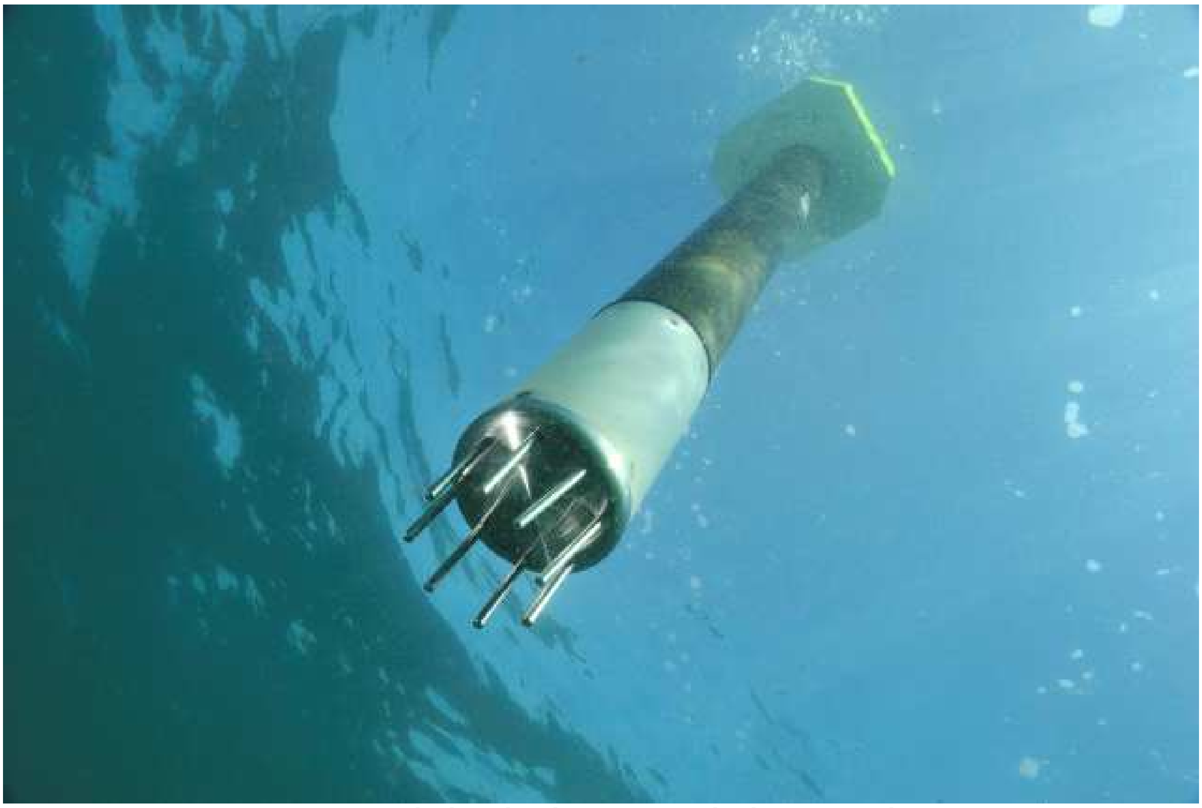
Profile, phase 5: Remote control. Each time the float reaches the surface, it retrieves the commands sent by the user via satellite and adjusts its operation according to the new requested configuration.

Profile, phase 6: Data transmission. Measurements and technical information are sent to the Coriolis data center via satellite.

Recovery. In standard operation, the Arvor-C cycles from phase 1 to phase 6 to complete its profiles. When recovery time is decided, the user sends a command to the float so that it stays at the surface. It will then regularly send its GPS position until recovery.



Typical Arvor-C cycle



**Arvor-C during the descent. On the bottom end,
its claws prevent drifting when grounded on the seafloor**

Results at sea

ASPEX scientific cruise. One Arvor-C was deployed for technical tests during the ASPEX physical oceanography cruise (Aquitaine / Armorican Shelves and Slopes Physics Experiment), led by Louis Marié (Ifremer/LPO) in July 2009. The aim of this cruise was to study the physical processes governing the hydrological structure and subtidal circulation on the Armorican and Aquitaine Shelf and Slopes over 2 years. It focuses on the vertical and temporal structures of the circulation around the “Cold Pool”, as well as the slope currents and cross-slope exchanges.

8 drifting buoys, 10 ocean bottom frames and 2 tethered moorings were deployed during this cruise, thus making it a major set up for the study of ocean circulation on the Bay of Biscay continental shelf. These instruments provide measurements on subsurface currents in real time, or record bottom hydrology and velocity profiles.

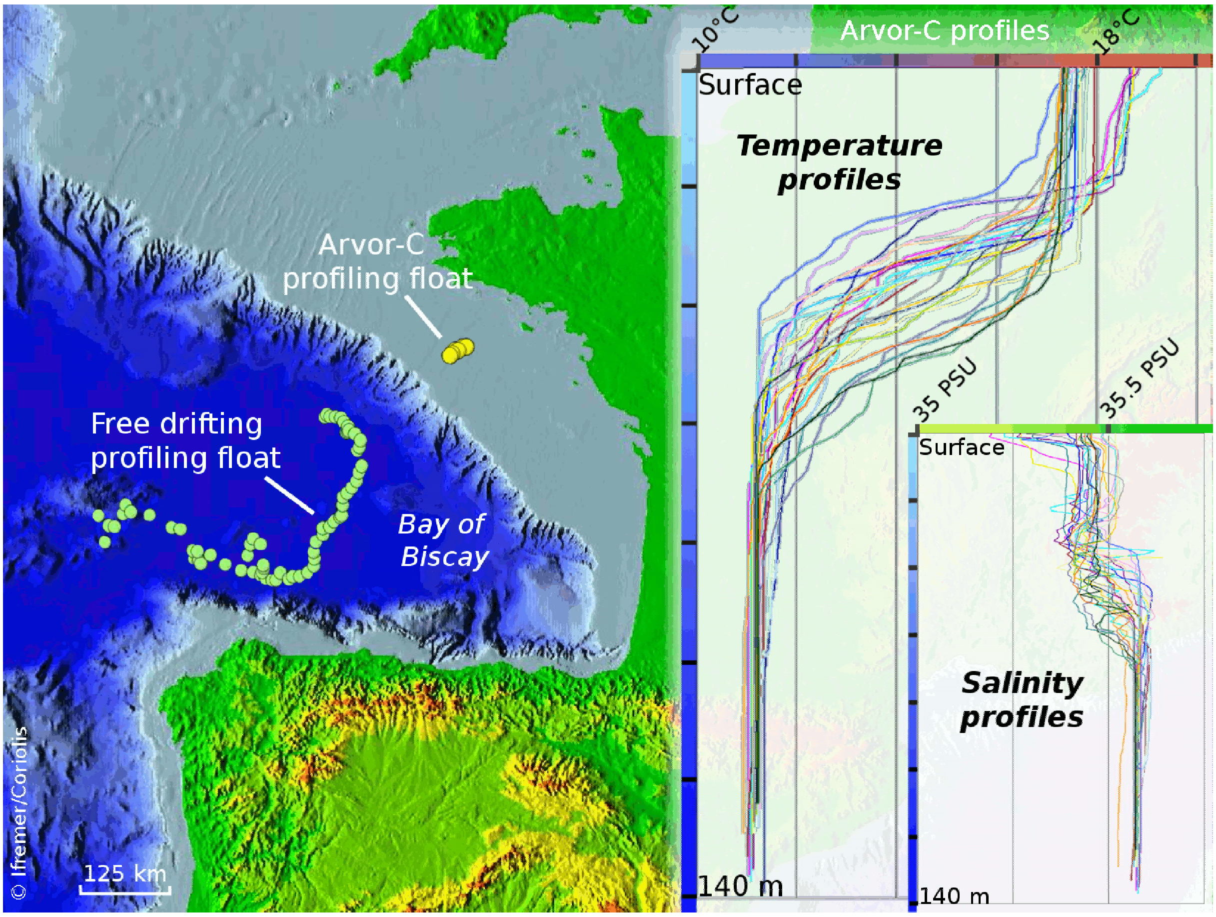
Meanwhile, 8 sections totaling 800 nautical miles were completed with a towed undulating vehicle over 10 days, collecting CTD measurements from 100 meters depth to the surface. Vessel-Mounted Acoustic Doppler Current Profilers (ADCP) collected current measurements along the way.

But all these measurements are snapshots taken either over a limited period, or spread over a whole year but limited in terms of distribution along the water column. In this way, current patterns can be observed, but a full understanding of the mechanisms driving them also requires observations with a high spatial and temporal resolution, and in the whole water column.

For these reasons, the Arvor-C is a valuable complementary tool. It was deployed on July 15th 2009, and will be recovered in Spring or Summer 2010. It provides complete CTD profiles at regular time intervals (from 1 to 3 days, depending on the seasons), from the seabed to the surface. Data are transmitted in real time to the Coriolis database, so that no data are lost in the event of instrument loss.

In the first 5 months of deployment, the Arvor-C drifted less than 200 meters per day, north of its deployment position, despite rough wave and tidal conditions. At the same time, a free-drifting profiling float (not anchored on the seabed between profiles) drifted more than 4.3 kilometers per day.

Risks. Risks during deployment include trawling, which can lead to the destruction of the instrument, or difficulties in starting the ascent when anchored in clay soils, which can lead to delay in surfacing.



Arvor-C data

Conclusions

Ifremer has developed a profiling float for coastal applications: the Arvor-C.

It can be deployed in any shallow seas, where hydrological and biogeochemical monitoring is required. It makes repetitive *in situ* profiles from the seafloor to the surface, providing information at a high rate.

It was successfully deployed during the ASPEX cruise in the Bay of Biscay, and it has provided CTD profiles since July 2009. Other deployments are planned in 2010 in the Gulf of Lion.

The Arvor-C promises to become a part of the monitoring network along the French coasts, comprising other systems such as those developed by Ifremer (Marel and Recopesca for example). For more information, please visit www.ifremer.fr/rdt or contact xavier.andre@ifremer.fr.

The Arvor-C is produced by one of Ifremer's industrial partners, NKE, which already manufactures the Provor and Arvor profiling floats. For more technical information, please visit www.nke-intrumentation.com.

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