
Ifremer
Xavier ANDRE
“Arvor-C”. *In situ* monitoring.

Ifremer

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Arvor-C : A Coastal Autonomous Profiling Float With Seabed Stationing Capability for Real-Time Monitoring of Coastal Seas

Outline

- Introduction
- Technological features
- Operation description
- Results at sea
- Conclusion

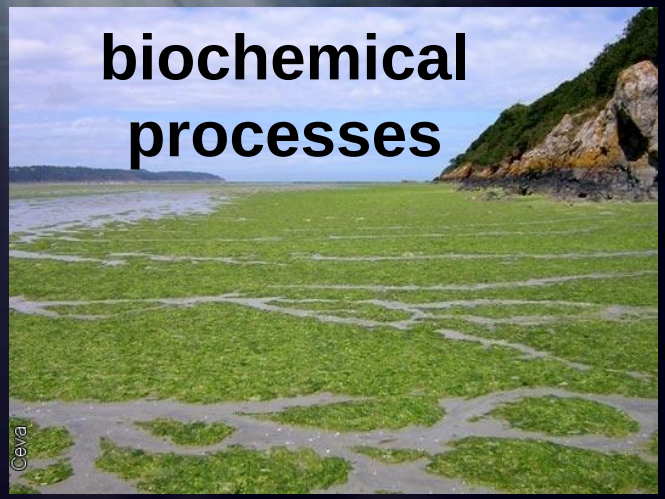
Introduction

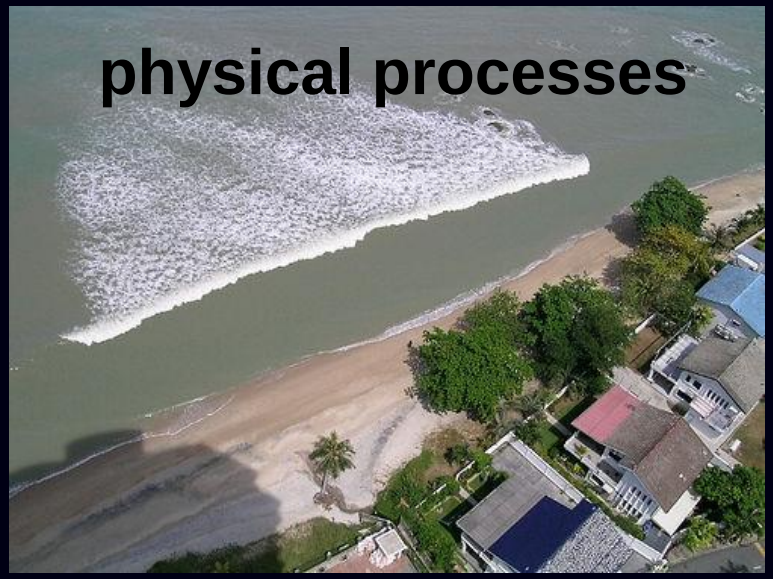
Ifremer

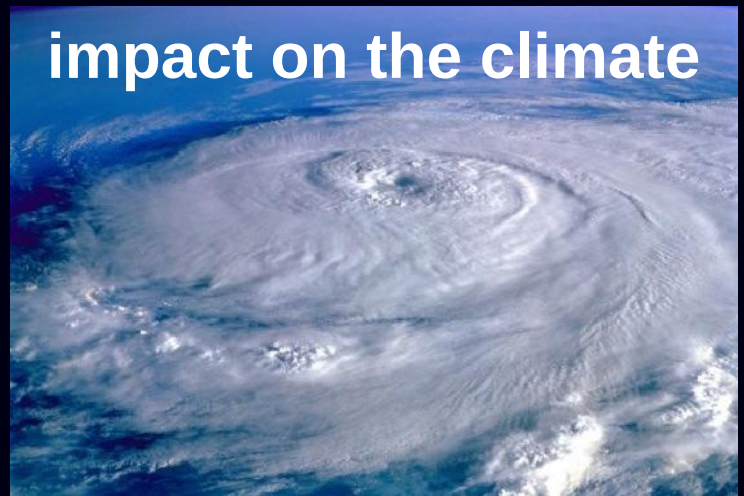
« To routinely
observe and forecast
the ocean »

Introduction

- Forecasts & real-time information





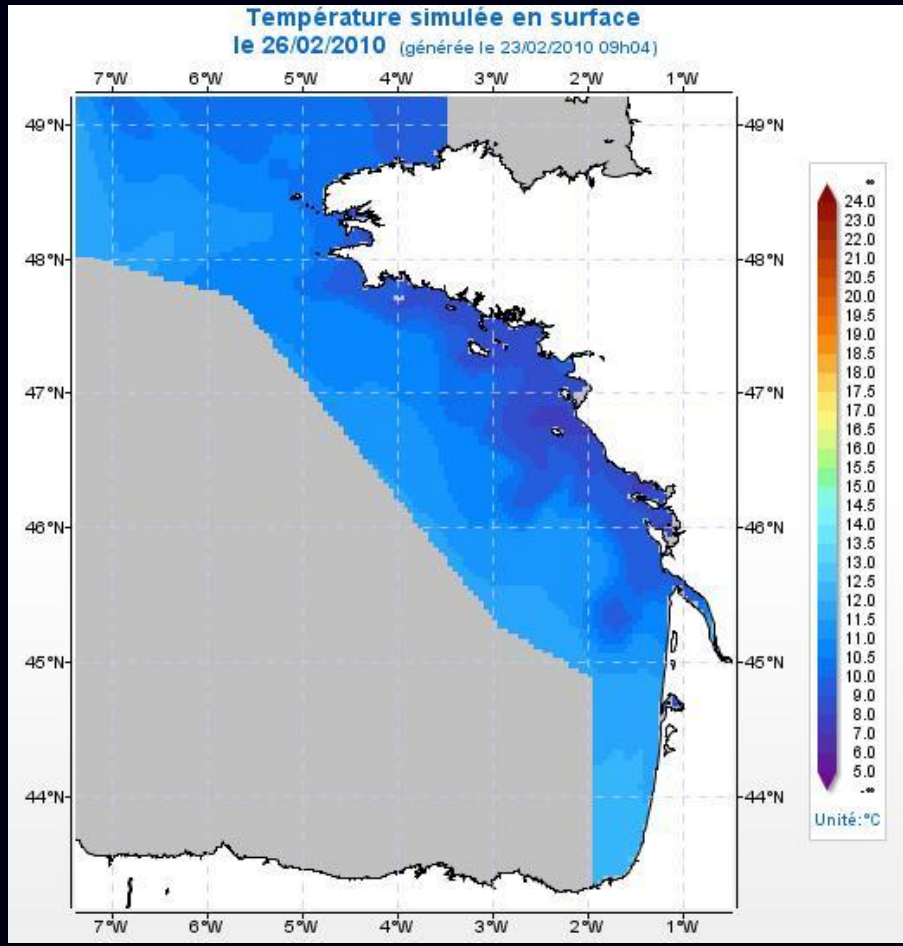


Introduction

- **Numerical models**

www.previmer.org

- Validation
- Assimilation



Introduction

- Difficulties in acquiring *in situ* data:

Complex deployment

Cost

Deployment duration

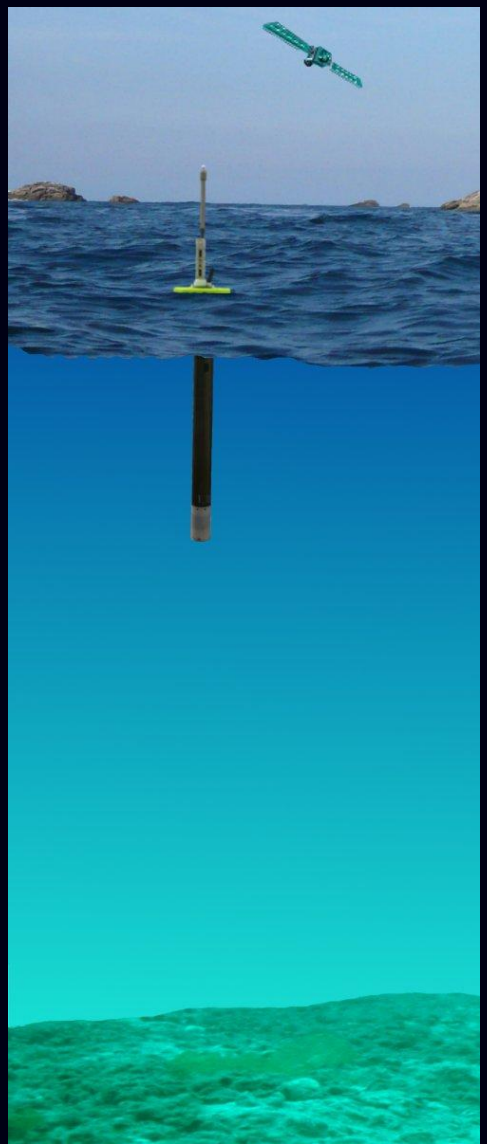
Risk of data loss

Watercolumn sampling

Spatial distribution

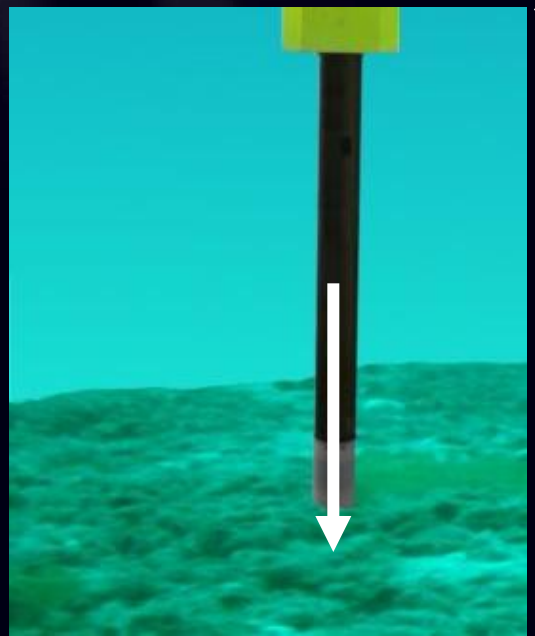
Features

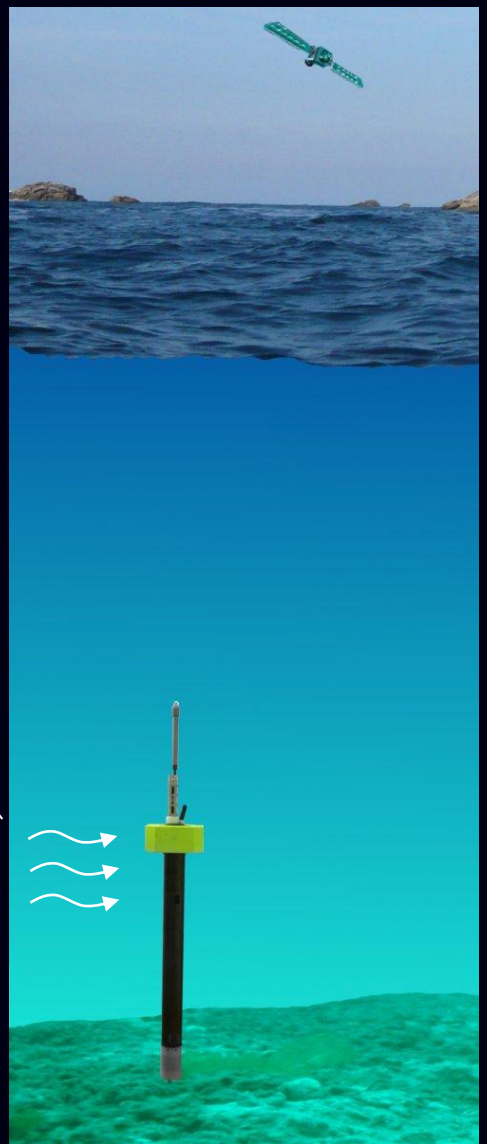
- What is Arvor-C ?
  - Autonomous profiling float
  - No mechanical set up
  - Short / long term observation
  - Can be recovered



Features

- What is Arvor-C ?
  - Seabed standby between profiles
  - Anti-drift claws

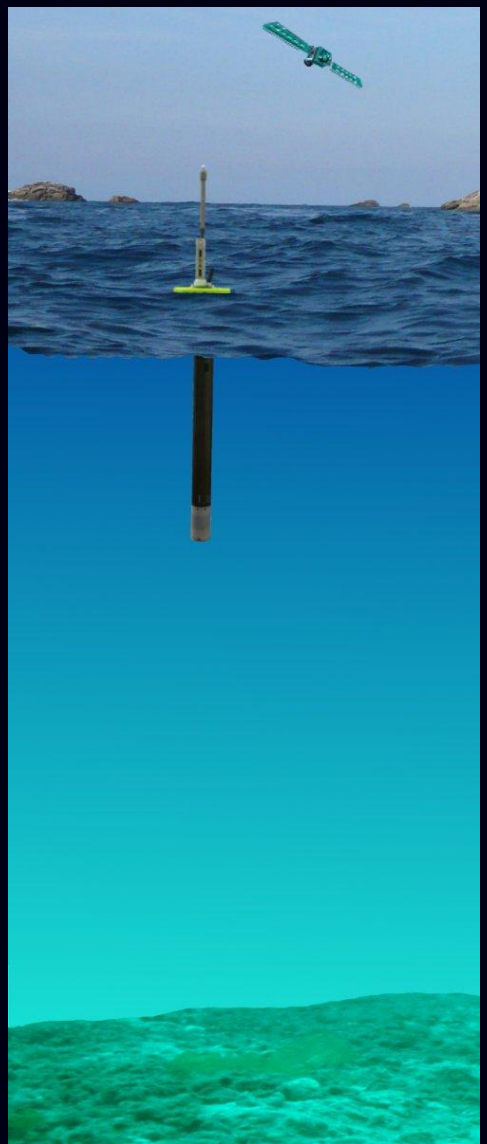




Features

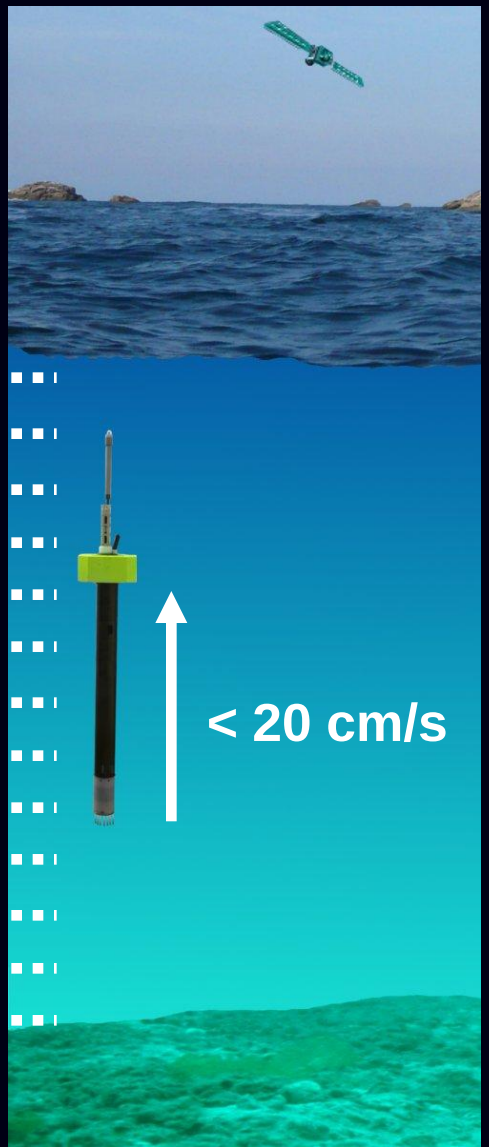
- **What is Arvor-C ?**
  - **« Virtual mooring »**
    Drift is reduced:
    - Optimized speed
    - Seabed standby
    - Short transmission duration

→ Profiles on the same location



Features

- Measurements
  - >300 profiles @ 200 m depth
  - Entire water column
  - Seabird CTD
    (Continuous pumping)



Features

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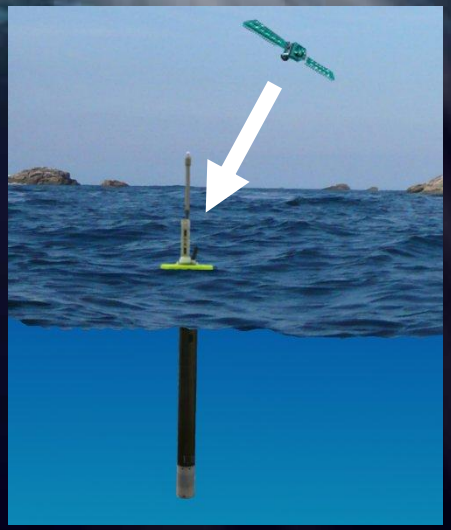
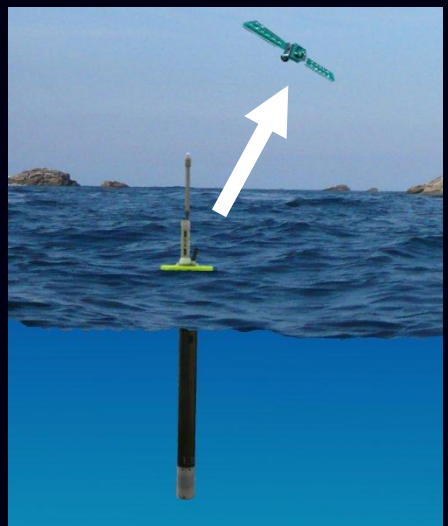
- Bi-directional Iridium transmission



remote control

data

technical information



Features

- Bi-directional Iridium transmission
  - Reduced transmission duration =
    - ↓ biofouling
    - ↓ risks of collisions and thefts
    - ↑ lifetime = ↑ number of profiles

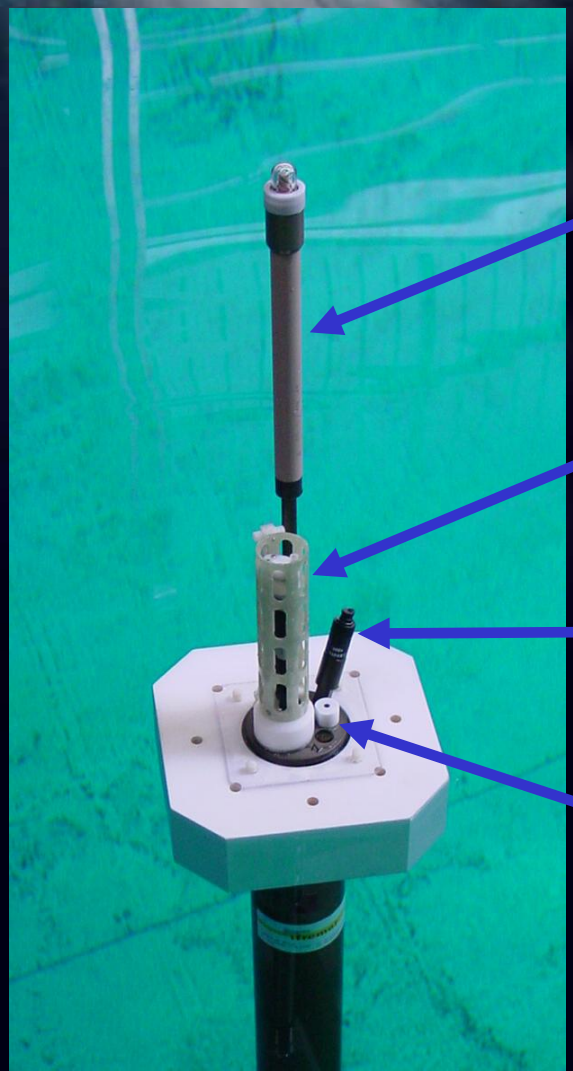
Features

- Characteristics
  - W ~ 20 kg in air
  - H 2.1 meter
  - ∅ 11 cm
  - P_{max} 450 dbars = coastal seas

Features

Ifremer

- Upper endcap



Iridium – GPS antenna

Seabird pumped CTD

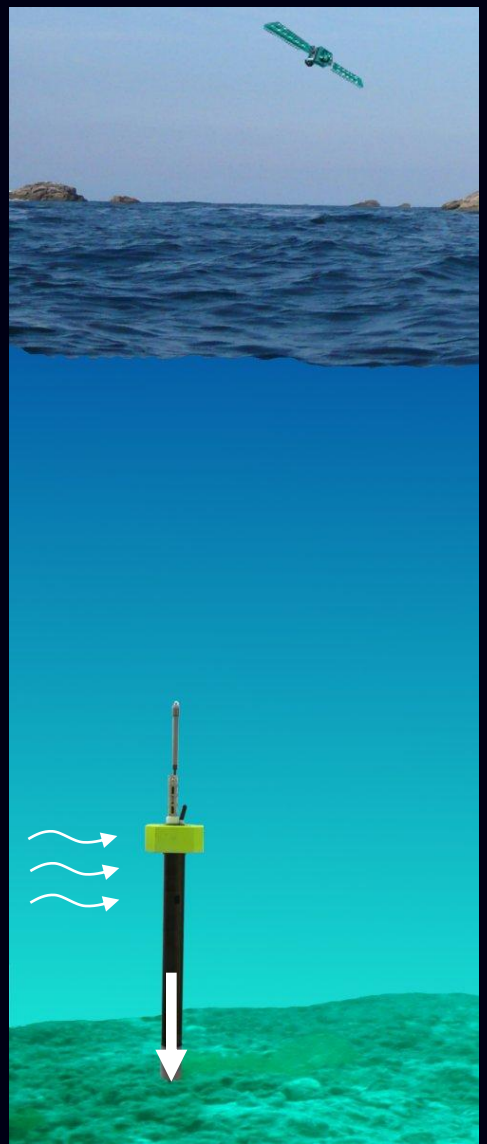
RS232 or Bluetooth

Pressure sensor

Features

Ifremer

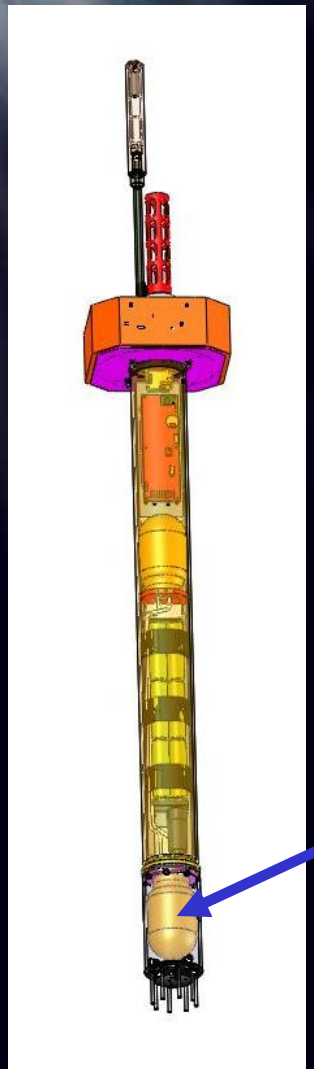
- Bottom endcap



Features

Ifremer

- Moving through the watercolumn



Hydraulic circuitry
& ballast system

External bladder

Operation

- 3 main phases
  - Set up and deployment
  - Profiling operation
  - Recovery

Operation

- **Set up and deployment**
  - **Parameters** — Ex:
    - **Sensors sampling period** — 2 s
    - **Time of profile start** — 10:00 AM
    - **Cycling period** — 1 day
  - **Can be modified during operation (Iridium downlink)**

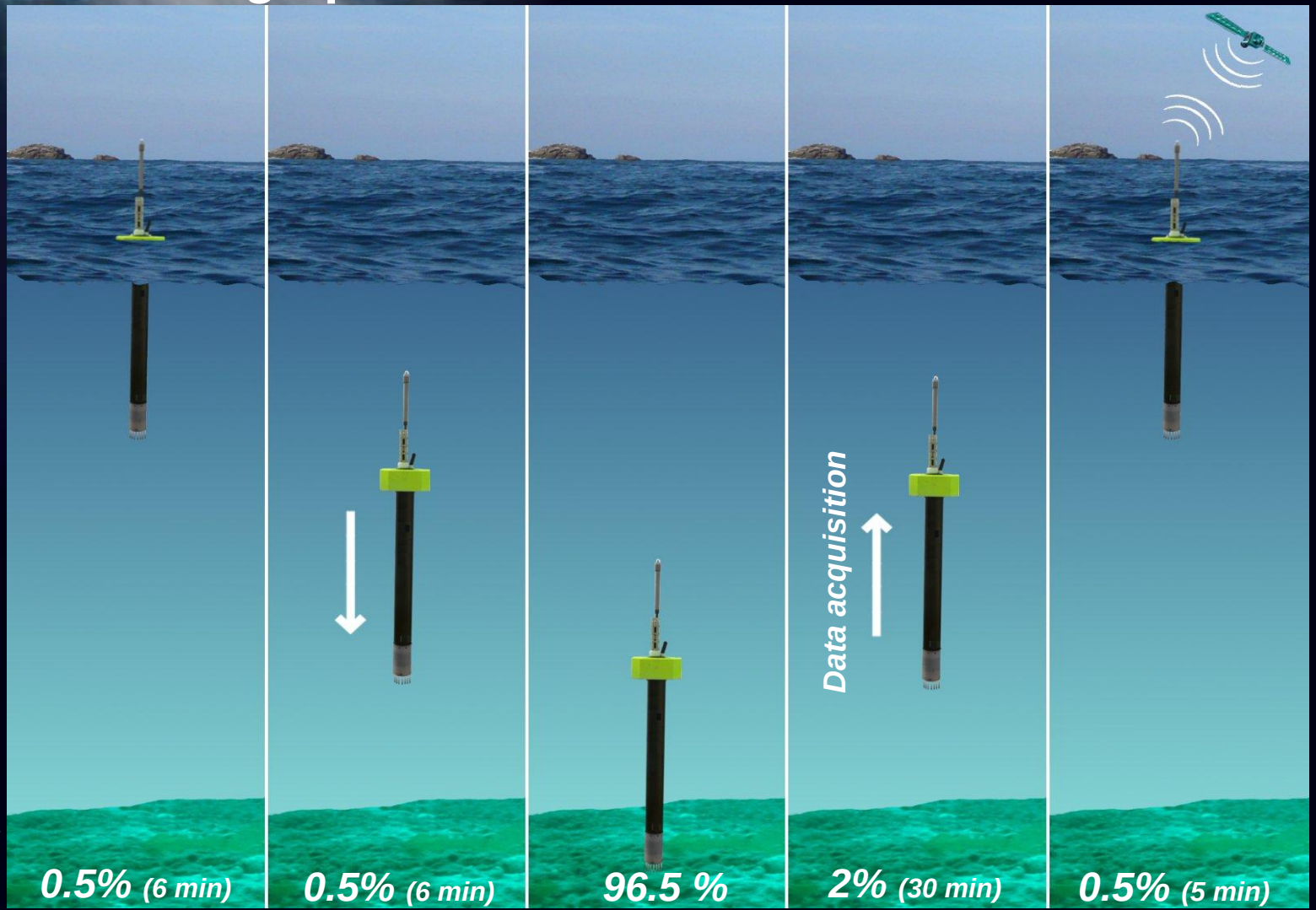
Operation

- Set up and deployment
  - Magnet removal and easy deployment

Operation

Ifremer

Profiling operation

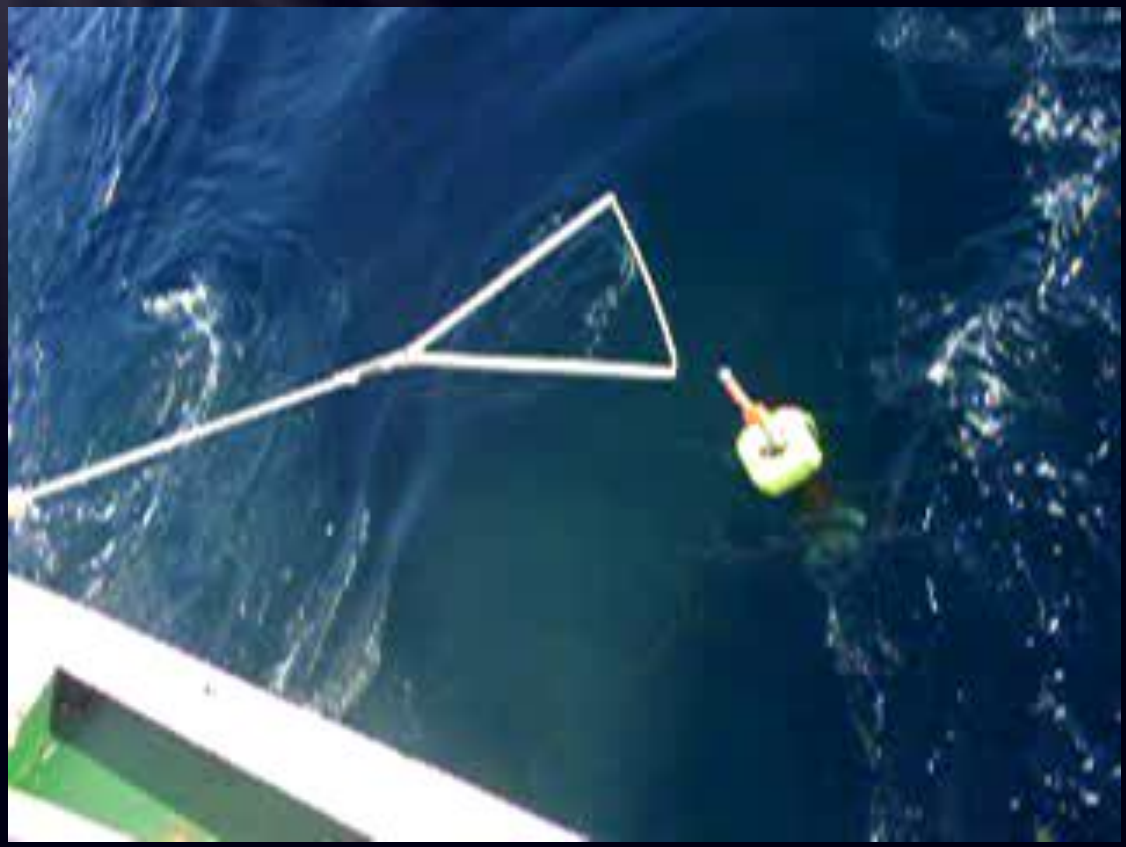


Ex :
1 profile/day
140 m

Operation

Ifremer

- Recovery
  - Just send an e-mail
  - GPS location every "N" minutes



Results at sea

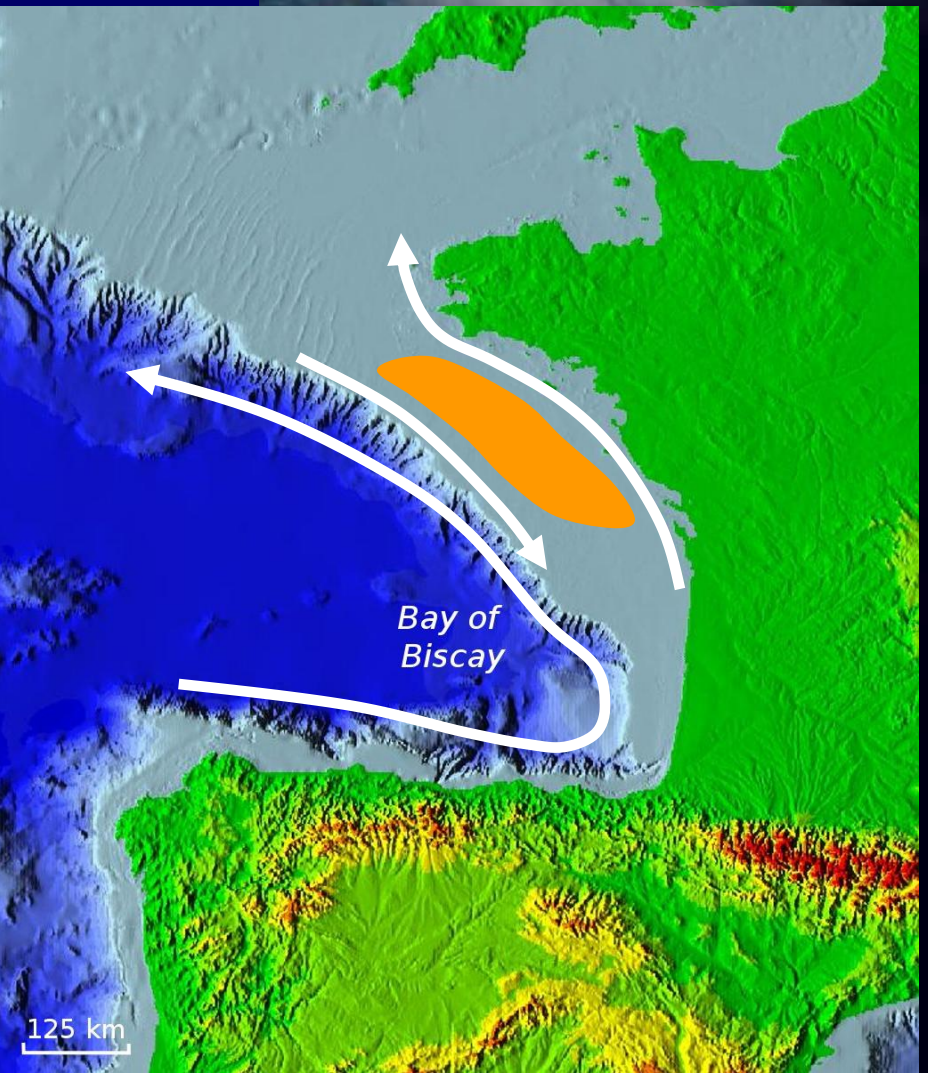
- Qualifications
  - Hyperbaric tank
  - Sea water pool at Ifremer
  - Sea trials:
    - 2007: Operation principle
    - 2008: 68 profiles
      30 m < depth < 120 m
    - 2009: ASPEX scientific cruise

Results at sea

- ASPEX scientific cruise
  - Aquitaine/Armorican Shelves and Slopes Physics Experiment: ASPEX
  - July 2009 → 2 years
  - Louis Marié, Oceanographic Physicist (Ifremer/Ocean Physics Laboratory)

Results at sea

- ASPEX scientific cruise



- Physical processes governing the hydrological structure & subtidal circulation on the shelf and slopes
- Vertical and temporal structures of the circulation around the “cold pool”

Results at sea

- **ASPEX scientific cruise**
  - **Instruments deployed**
    - **8 drifting buoys**
      - subsurface currents in real time
      - surface CTD
    - **10 ocean-bottom frames & 2 bottom moorings**
      - bottom hydrology records
      - velocity profiles records

Results at sea

- **ASPEX scientific cruise**
  - **8 sections totaling 800 nautical miles**
    - **Towed undulating vehicle**
      - CTD measurements
        0 m < depth < 100 m
    - **Vessel-mounted ADCP**
      - Currents profiles

Results at sea

- ASPEX scientific cruise
  - All these instruments
    → Observation of current patterns
  - Full understanding of the mechanisms driving current patterns
    → Hydrologic measurements with:
    - High spatial distribution
    - High temporal resolution
    - Entire water column

Results at sea

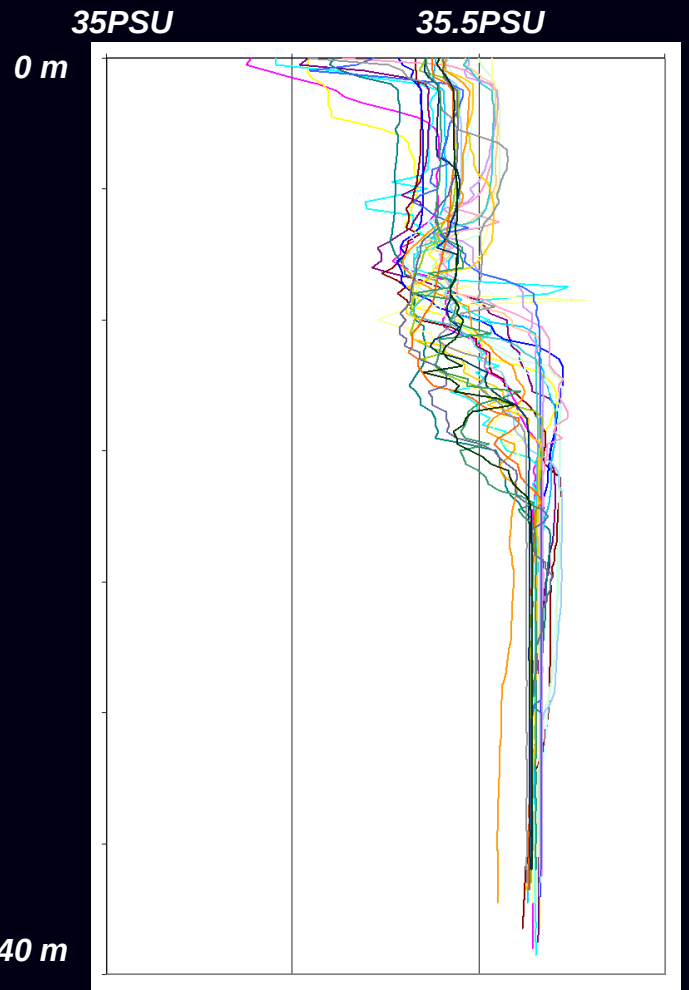
- ASPEX scientific cruise
  - Arvor-C
    - 1 profile every day / 3 days
    - 1 CTD measurement every meter
    - Entire water column
    - Data transmitted in real time to the Coriolis data center
    - It has made > 120 profiles today

Results at sea

- Arvor-C profiles

Temperature

Salinity

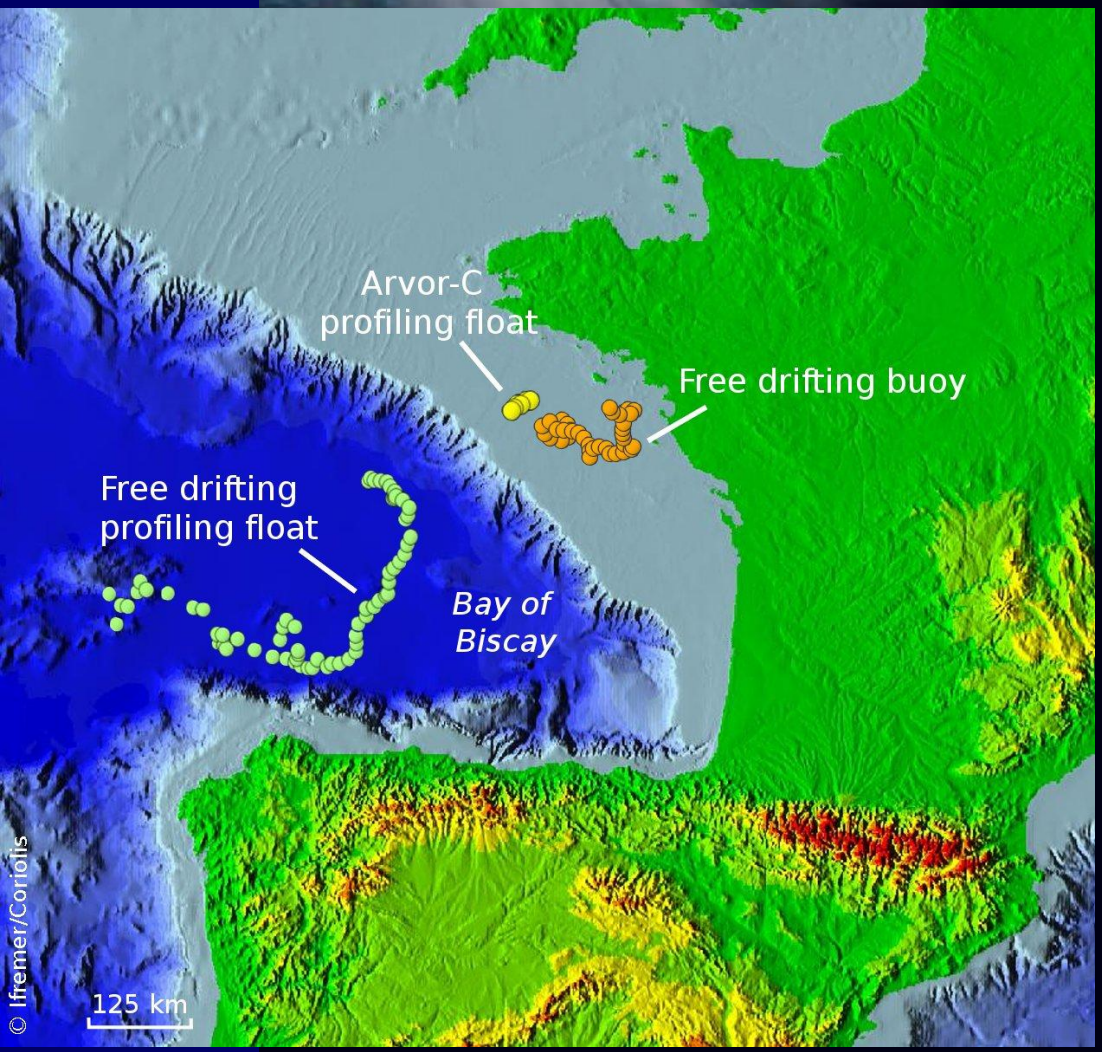


Results at sea

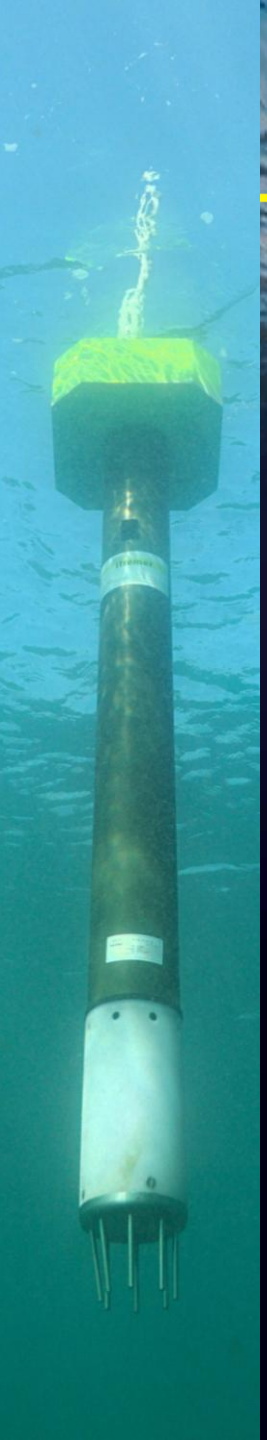
- **« Virtual mooring » = reduced drift**
  - **Arvor-C** **From 15/07/09, 4 months**
    - Standby on sea bottom between profiles
  - **Buoy** **From 15/07/09, 3 months**
    - Anchored in the water mass at 50 m depth
  - **Arvor** **From 06/04/07, 4 months**
    - Free drifting deep-sea profiling float

Results at sea

- « Virtual mooring » = reduced drift



- Arvor-C
  → 200 meters/day
- Buoy @ 50 m depth
  → 4 000 meters/day
- Arvor
  → 4 300 meters/day



Conclusion

- Arvor-C
  - Designed « to routinely observe and forecast the ocean »
  - Concept of « Virtual mooring »
    - Easy to deploy (no mechanical set up)
    - Easy to recover
    - No maintenance
    - Remotely controlled
  - Successfully deployed during the ASPEX scientific cruise

Conclusion

- In 2010…
  - Deployment in the Gulf of Lion
  - Integration of additionnal sensors:
    - Dissolved oxygen
    - Turbidity
    - Fluorimetry

Thanks to…

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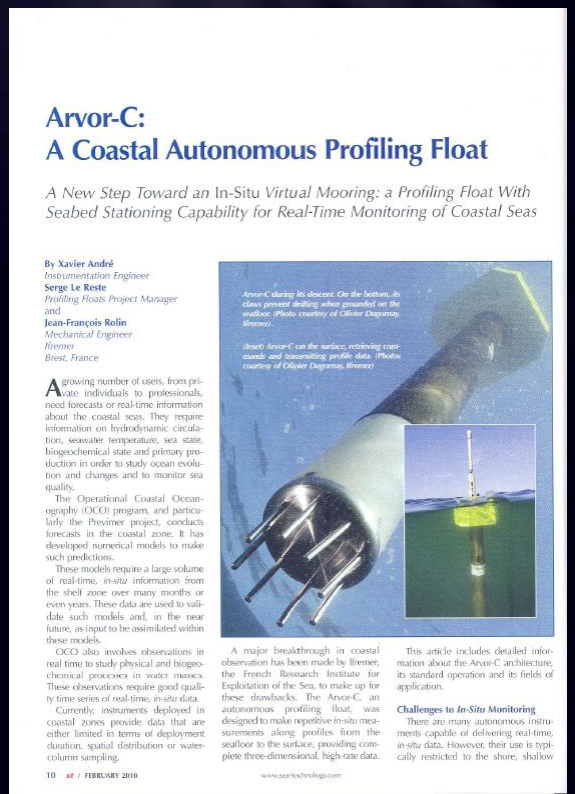

Arvor-C:
A Coastal Autonomous Profiling Float

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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Profiling Floats Project Manager
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A growing number of users, from private individuals to professionals, need forecasts or real-time information about the coastal seas. They require information on hydrodynamic circulation, seawater temperature, sea state, biogeochemical state and primary production in order to study ocean evolution and changes and to monitor sea quality.

The Operational Coastal Oceanography (OCO) program, and particularly the Previmer project, conducts forecasts in the coastal zone. It has developed numerical models to make such predictions.

These models require 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, spatial distribution or water-column sampling.

Arvor-C during its descent. On the bottom, its claws prevent drifting when grounded on the seafloor. (Photo courtesy of Olivier Dagorn, Ifremer).

(Inset) Arvor-C on the surface, retrieving commands and transmitting profile data. (Photo courtesy of Olivier Dagorn, Ifremer)

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.

Challenges to *In-Situ* Monitoring

There are many autonomous instruments capable of delivering real-time, *in-situ* data. However, their use is typically restricted to the shore, shallow

(Top) Standard Arvor-C cycle. (Photo courtesy of Xavier Caisey, Ifremer)

(Bottom) Five months of operation at sea: drift of the Arvor-C (anchored on the seabed between profiles) compared with a free-drifting profiling float (in green). CTD profiles (right).

waters of only a few meters of depth or to the sea bottom.

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

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

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

Technological Features

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

The float behaves like a virtual mooring for short to long-term observations. It can take measurements at the same location for each profile thanks to its optimized time of ascent and descent through the water column, short time of transmission at the surface, and anti-drift capability when grounded on the seabed.

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

In standard mode, the Arvor-C operates autonomously. One of the major features is its Iridium℠ (Bethesda, Maryland) satellite bidirectional link, which offers a fast uplink to transfer data when surfacing after each profile and 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.

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

Architecture

The Arvor-C is based on the Provor and Arvor deep-sea profiling floats, 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 that studies global ocean changes.

On the upper endcap, the float houses a Sea-Bird Electronics Inc. (Bellevue, Washington) pumped conductivity, temperature and depth (CTD) sensor. It

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