European Commission
European Research Area

ACOBAR

At a Glance

Title: Acoustic Technology for Observing the interior of the Arctic Ocean
Instrument: Small – medium scale focussed research project
Total Cost: ca. 3.9 Mio. €
EC Contribution: 3.0 Mio. €
Duration: 48 months
Start Date: 01/10/2008
Consortium: partners from 5 countries
Project Coordinator: Nansen Environmental and Remote Sensing Center – NERSC (Norway)
Project Web Site: http://acobar.nersc.no
Key Words: oceanography, climate, Arctic, Fram Strait, underwater acoustics, acoustic tomography, gliders, ocean observing system, data assimilation, acoustic navigation

Project Objectives

The main objective of ACOBAR is to develop a system for environmental monitoring of the interior of the Arctic Ocean by assimilation of data obtained with acoustical methods including tomography, data transmission from underwater platforms, communication and navigation of floats and gliders under the ice-cover. The project will provide 3-D observations of the properties and transport of water masses in the Fram Strait using an acoustic tomography array, consisting of source and receivers, in combination with oceanographic moorings and profiling gliders. Transmission of long-range acoustic navigation signals and commands will be tested in order to operate gliders. Data transmission by acoustic modems from underwater platforms to the surface for downloading to ships will be tested. ACOBAR offers alternative methods to the ARGO system, which cannot be used in ice-covered seas, contribute to filling gaps in the global ocean observing system and thereby support the development of GEOSS/GEO.

The Problem

The world oceans play a major role in regulating the earths climate on global and regional scale. Implementation of observing systems for the global oceans is an overarching objective of GOOS (Global Ocean Observing System) in order to provide data and information for climate research and many other applications. Ocean observing systems for the polar regions are particular challenging due to the harsh environment including sea ice. The Arctic Ocean lacks adequate observing systems because present technologies such as Argo floats are not suitable for use in ice-covered seas. The large gap in data from the Arctic Ocean introduce severe uncertainties in detection of temperature and salinity changes, understanding of ocean-ice interactions and in modelling of processes and climate. During the International Polar Year from 2007 - 2009 several new instruments and platforms for ocean observations are deployed and the collection of data is significantly enhanced. There is, however, little support and commitment to continue these observations after IPY. ACOBAR will contribute to the Arctic Ocean observing system from 2009 to 2011 by use of acoustic tomography, in combination with floats, gliders and standard oceanographical data collection. These components are envisaged to be implemented as part of a future Arctic Ocean Observing system.

Methodology

ACOBAR will implement and test two different ocean observing systems for the Arctic Ocean: acoustic tomography from stationary moorings in the Fram Strait, acoustic ice-tethered platforms (AITP) drifting on ice floes in combination with drifting gliders/floats under the ice. Acoustic modems will be used for underwater data transmission.

Acoustic tomography is based on the following principles: (A) Speed of sound is a function of water temperature and pressure, allowing temperature to be derived from travel time measurements between a source and a receiver. The distance between the source and receiver moorings in the Fram Strait is about 130 km, and sound signals travel this distance in 88 seconds. (B) Low-frequency sound signals propagate in multi-paths covering different water depths and arrive at different times at the receiver. The arrival structure is used to retrieve a mean temperature between source and receiver at several depths. (C) Ocean velocity along the propagation path can be retrieved by reciprocal transmission, since the speed of sound increases in the current direction and decreases in opposite direction.

The advantage of acoustic tomography compared to other methods is that the horizontally averaged temperature and velocity fields between a source and receiver mooring can be measured very accurately with a few hours time interval. Time series of these measurements obtained over several years are used to study the seasonal and inter-annual variability of temperature and currents. The averaged temperature and current of the water column is needed to calculate mass transport and heat fluxes.

In the ice-covered ocean north of the Fram Strait, an array of several AITPs will be deployed on ice floes. The AITPs are equipped with underwater sound source, hydrophones, modems and satellite communication via Irridium, allowing near real time data transmission via satellite. The AITPs will be used to navigate gliders and floats under the ice. Dedicated experiment to deploy AITPs and gliders will be conducted.

The first step in the project is to design and develop a conceptual acoustic system optimized to accommodate for acoustic tomography and navigation in the Arctic Ocean. The design study will estimate optimal depths, location and configuration of the source and receiver moorings, based on acoustic model simulations. Environmental impact assessment study of the acoustic system will be conducted to ensure that the acoustic signals have no harmful impact on marine mammals.

The main efforts in ACOBAR will be to plan and implement several field experiments in the Fram Strait region. The field experiments will be conducted in summer of 2009, 2010 and 2011 using the German vessel RV Polarstern, the ice-operating Norwegian Coast Guard vessel KV Svalbard and RV Håkon Mosby. The field experiments will be used to deploy and recover several acoustic source and receivers on fixed moorings, AITPs in ice-covered areas, and gliders/floats in open water as well as under ice. To serve both tomography, navigation and communication issues, three sweeping sources from WEBB Research Corporation will be deployed in a triangle in the centre of the Fram Strait. The sources will be deployed in conventional moorings and include the receiver system developed by Scripps Institution of Oceanography called STAR (Simple Tomographic Acoustic Receiver). In addition four transponders for each mooring are required for monitoring the exact position of the source/receivers in the water column.

In the middle of the triangle a long receiver array will be deployed. When the tomography system increases the number of sources from one to three, the number of acoustic tracks will increase from one to six. This configuration will allow 3 two-way transmission tracks, from which we can potentially retrieve current and temperature, and 3 one-way transmission tracks from which we will obtain temperature. This configuration will add a new dimension to the traditional monitoring in the Fram Strait. By increasing the data collection from 2D to 3D, the data becomes much more valuable.

The configuration of three sweeping sound sources will be used for underwater navigation of gliders in addition to retrieval of temperature and currents from the travel time data. Within ACOBAR, electronics in existing gliders will be adopted to process acoustic signals available from tomography sources. The operation modes, which combine tri-laterated positioning by the under-ice acoustic navigation in the ice-cover area and GPS positioning with dead reckoning in open waters, will be developed.

Data obtained form the field experiments will be assimilated into ice—ocean models in order to improve the modelling and forecasting capability in the area. Assimilation of data from the 3D tomography system, and conventional mooring arrays will be tested. Assimilation of integrated ocean parameters derived from acoustic tomography into ocean circulation models was originally recommended by Munk et al, (1995), but few such studies have been carried out. The Monte-Carlo formulation of the Ensemble Kalman Filtering (EnKF) assimilation schemes (Evensen 1994, 2003, 2006) makes it convenient for assimilation of integrated (and nonlinear) ocean parameters such as those derived from acoustic thermometry. EnKF was applied to assimilate acoustic data into an ocean circulation model using very simple ray theoretic approaches to establish the modelled observation matrix, based on direct rays (Park and Kaneko, 2000). Although a very simplified ray model was used the results were very promising, and showed a better result than using traditional acoustical inversion techniques. A first approach of assimilation of data from gliders profiling through the area will be introduced.

Capacity building activities will be done through technology transfer between USA and Europe, including workshops and exchange of PhD students, Post Docs, scientists and engineers between the partners.

Expected Results

The expected results of ACOBAR will consist of new acoustic tomography technology for ocean observation, new observational data of the deep ocean from tomography as well as from gliders, use of acoustics for underwater communication and navigation, and data transmission from underwater platforms and vehicles. Results of ACOBAR will be used to improve the ocean observing capability in the Arctic Ocean, and will thus contribute to fill gaps in the Global Ocean Observing System (GOOS).

The project will strengthen European expertise in underwater acoustic navigation, communication, data transmission and tomography. The project will promote use of underwater acoustic technology for monitoring the ocean, transferring data and navigate gliders and other underwater platforms. The technology developed in the project can potentially play an important role in building a long-term ocean monitoring system for Arctic and sub-Arctic seas. ACOBAR will contribute to building the Arctic components of GOOS. At present, observing systems for satellites and in situ platforms, are implemented under the Arctic Regional Ocean Observing System (Arctic ROOS).

Project Partners

Nansen Environmental and Remote Sensing Center , Norway	OPTIMARE, Germany
Alfred-Wegener-Institut für Polar-und Meeresforschung , Germany	Aquatec Telemetry Limited, United Kingdom
Université Pierre et Marie Curie , France	ENSIETA, France
SCRIPPS Institution of Oceanography , USA	Advanced Concepts and Systems Architecture, France
Woods Hole Oceanographic Institution, USA	