30 years of OCEANOGRAPHY WITH ARGOS

ENVIRONMENTAL MONITORING
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Born into an age of rapid technical obsolescence before the arrival of the personal computer and well before the Internet changed everything – the Argos system provided a giant leap in global communication that has not aged.

At a time when research vessels had, at best, only daily contact with their homeports, Argos allowed visionary ocean engineers to begin dreaming beyond those still-important ships to networking of independent instruments with distant laboratories.

As ocean instruments grew in sophistication and range, so the Argos system grew both in quantity of platforms and diversity of applications, while retaining the vital simple, low-power platforms.

In the 1970’s, large scale met-ocean experiments like GARP, GATE, and FGGE provided the motivation to improve in-situ observing capabilities. The observation of ocean currents by following surface buoys in the open ocean captured the imagination of oceanographers. Argos was there to provide a global, low-cost, simple, low-power satellite-based telemetry link to satisfy the needs of these new observing methods for the ocean and the atmosphere.

Observational oceanography took a major step forward when the Argo Program was conceived. The idea of autonomous platforms “patrolling” the global ocean had been proposed multiple times over the years by forward thinking oceanographers. The idea became tangible in 1999 with the implementation of Argo. Today there are more than 3,300 Argo profiling floats sampling the upper 2,000 meters over the world’s oceans and nearly all of these floats communicate their data via the Argos system.

What a ride these last three decades have been for probing the depths and revealing the ocean’s mysteries. Happy 30th Birthday, Argos!
JCOMM AND ARGOS
30 YEARS OF CLOSE COOPERATION

By
Mathieu Belbec
Hester Viola

The cooperation between the Argos system and the GOOS/JCOMM ocean observing systems has been long running and successful. CLS, the operator of the Argos satellite system, has not only provided the telecommunication system for data transmission but has also developed several operational and real-time data management services. In addition, it hosts the focal points providing international and technical coordination for oceanographic and marine meteorological observing programmes.

This close cooperation between GOOS/JCOMM and Argos/CLS has developed over the last 30 years or so, as the requirements for the ocean observing networks have changed and the Argos system has been adapted to meet the requirements of its users.

Cooperation in Argos’ early days

Originally, in the 80s, all of the data buoys deployed used the Argos system to communicate data for both research projects and directly to meteorological agencies. The Data Buoy Cooperation Panel (DBCP), through its Technical Coordinator, worked closely alongside the Argos system to ensure that marine meteorological data could be shared with a wider audience and be used globally, in the most efficient and rapid way possible. Its aim: share data on the WMO’s Global Telecommunications System, which is a telecommunication network of point to point circuits operated by National Meteorological Services and part of the World Weather Watch (WWW). At that time it was recognised that the Argos system should be naturally used as a central node to format, control and distribute data onto the GTS. Data would be used by global meteorological models to improve the quality of the weather forecasts produced.

The Technical Coordinator of the DBCP and the Argos system worked closely to ensure that data was shared in a reliable and timely fashion.

Before 1993: some network restrictions

In an effort to reliably collect and share data across the whole globe and in order to reduce the delays across the system, data processing through the Argos system has evolved, along with the advancements in satellite technology.

Before 1993, when a buoy operator wanted buoy data to be distributed on the GTS, he or she had to follow very strict standards as far as Argos message formats were concerned. Sensors had to be placed in an exact order and there was very little flexibility in the processing of the data (i.e. the types of calibration curves available were limited). In addition, it was not possible to distribute the back-hour data on the GTS, and only very limited quality control checks were done. Moreover, buoy operators could not recover the raw data of buoys reporting on the GTS, since the GTS required reports in geophysical units (whereas the standard Argos data processing system was used for that purpose).

Figure 2. Argo floats, September 2009.
Ever since, JCOMMOPS has been working very closely with Argos system personnel as well as with all other departments at CLS such as CLS oceanographers, who, being data users, can give feedback on the buoy and float data quality via JCOMMOPS. JCOMMOPS also assists platform operators in the use of the Argos system and in getting data distributed as appropriate. Consequently, the requirements of the oceanographic and meteorological communities are also relayed to CLS, which helps them improve and optimize the Argos system services, for the benefit of operational weather and marine forecasting, and oceanographic research applications.

A new era of oceanography

The Global Ocean Observing System is about to enter in a new era of oceanography with the use of multidisciplinary observing platforms (buoys, moorings, floats, gliders, marine mammals) equipped with new sensors (bio-optical/geochemical), and new telecommunication systems (Argos-3, downlink) to complete and optimize the existing networks. JCOMMOPS will continue to assist with the development of each GOOS element, with the support of its historical host CLS.

Figures 3 and 4. TOGA wind buoy and TRITON moored buoy.
From an operational perspective, sea ice features such as leads, slip lines, cracks and ridges play a crucial role in navigating polar waters and maintaining offshore structures. These discontinuities are fundamental regulators of heat, mass and momentum transfer at the air-sea interface. Hence, there is a relevant need to understand the distribution, orientation, size and duration of these discontinuous regions.

Challenging

As with many geophysical phenomena, tracking the dynamics of sea ice is very challenging. This is primarily because sea ice is one of the largest fast-moving solids on the surface of the earth with drift rates of around ten kilometers per day occurring across varying spatial (1-100 km) and temporal (hours to months) scales. The spatial coverage of this deforming field spans thousands of kilometers covering roughly 6% of the planet’s surface at any one time. It is also shrouded in darkness half the year and under variable cloud cover much of the rest of the year.

High resolution motion tracking system

The availability of high spatial resolution “all-season, all-weather” synthetic aperture radar (SAR) combined with high temporal resolution in situ buoys provide us with observing systems to evaluate the formation, dynamics and melting of sea ice. Using a cascaded framework, we are able to track sea ice drift at 400m resolution, which is an order of magnitude greater than standard motion products (3~5 km).

The use of Argos ice buoys

In the recently concluded APLIS’07 Ice Camp under the Sea-ice Experiment: Dynamic Nature of the Arctic (SEDNA) project, we have explored new ways to effectively combine high spatial (50m), low temporal (1-3 day) resolution active microwave imagery and low spatial (point), high temporal (<1 hr) resolution Argos-telemetry GPS buoys. These efforts were aimed at refining satellite motion products down to the scale of field observations to support both scientific research and logistics.

We have applied a near-real time sea ice motion tracking system as a decision-making tool for the deployment of autonomous buoys. This system helped us determine the optimal locations for deploying GPS position (for strain-rate) and stress buoys. A total of 12 real-time Argos-telemetry GPS buoys were deployed in two concentrated hexagons around our camp (Fig. 1 and 2). The inner 6 buoys were located ~10 km from the camp while the outer 6 buoys were deployed ~70 km away.

The presence of the buoys provided a Lagrangian reference to study the non-rigid dynamics while they were taking place. The Lagrangian location of the camp was tracked using continuous recording GPS devices (some connected via Argos). Using sequential images of the camp, we applied our high resolution motion algorithm to identify leads and ridges in close proximity to the camp to aid with local measurement campaigns whenever possible.

Figure 3 shows the nested array configuration including the 12 real-time Argos-telemetry buoys and 5 stress buoys, overlaid on Quicklook Radarsat-1 images. The 12 Argos-GPS buoys (6 inner + 6 outer hexagonal arrays) provided us the much needed ground truth for validating motion tracking algorithms and understanding multi-scale deformation processes.
Actively incorporated satellite-derived diagnostic motion analysis for field deployments

The satellite-derived motion tracking system shown in figure 3b is one of the new tools developed for IPY to actively incorporate diagnostic motion analysis for instrument deployment in a sea ice campaign. Successes of the system included pre-planning through post-diagnostics applications of this technology to support the deployment of autonomous buoys, manned data collection activities and synthesis of scientific findings. Pending further funding, this new motion tracking system can be used as an active component in a polar observation system. The high resolution estimate of motion from the system provides invaluable information in localizing dynamic features in the sea ice.

Remote sensing and telemetry

The combination of large land-based support infrastructure and light-weight, high powered portable equipment such as Argos ice buoys makes today’s field work more time and cost effective than ever before. We hope that our motion tracking system will aid in navigation and polar search-and-rescue operations as well as the validation, diagnosis and further development of numerical models, especially those that might help in ice model forecasting and heat flux calculations in climate modeling.

Cathleen A. Geiger
University of Delaware

Cathleen A. Geiger is a Research Associate Professor at the University of Delaware, USA. Her research focuses on sea ice motion analysis. Several of her ongoing research projects focus on research and development ideas that both support the discovery elements of science but also advance the development of operational tools necessary to facilitate scientific discovery. Long-term goals include taking advantage use of scales beyond the range of human perception to improve navigation in the polar seas, better prepare humanity for survival in these regions, and assess the interaction and impact of sea ice on our world.

The APLIS’07 research described in this article was conducted in close cooperation with: P. Clemente-Colón (NIC), M. Engram (Alaska Satellite Facility), J. Hutchings (UAF), C. Kambhamettu (UD/CIS), J. A. Richter-Menge (CRREL), and M. Thomas (UD/CIS).

Abbreviations:

NIC = National Ice Center
UAF = University of Alaska Fairbanks
UD = University of Delaware
CIS = Computer and Information Sciences
CRREL = Cold Regions Research and Engineering Laboratory

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In September 1982, at the beginning of the planning phase of the World Climate Research Programme (WCRP), the National Center for Atmospheric Research (NCAR) hosted a Lagrangian instrument workshop of physical oceanographers, ocean engineers and US government ocean funding managers.

A “Plan for the development and utilization of ocean surface drifting buoys – Drifters” resulted because a potential in WCRP science plan existed for supporting a global array of ocean surface sensors where drifters would, besides measuring SST and air pressure, also measure the horizontal water motion. The task of organizing and overseeing the development of an affordable drifter system fell to me and 23 years later in September 2005 the global array of 1250 SVP was completed.

For a scientifically defensible and affordable global drifter array to be funded with WCRP support, three technical challenges were to be overcome: i) in 1982, more than 10 drifter designs existed, but there was no field data on how well any of these followed water motion; ii) the typical drifter in cost over $10,000 (in 2009 $US), weighed over 50kg and its life time at sea with a drogue attached was less than 150 days; iii) Argos Service costs for retrieving the location and sensor data was appropriate for an experiment with 5-10 drifters, but not for a global array that would exceed 1000 units.

Incremental funding strategy
An incremental funding strategy of all ocean climate observing component was adopted by WCRP, which meant that yearly proposals would have to be written and defended for the construction of the global drifter array. In the 23 years that followed, my colleagues and I wrote over 40 proposals, and in 2005 NOAA Climate Office provided the funding for the completion and sustaining of a global array of 1250 drifters. Expansion of the drifter observations into each ocean basin was defended for 3-6 years on specific science objectives and the success of building drifters that were rugged and low cost, easy to deploy from Volunteer Observing Ships and where Service Argos would find ways to cooperate in providing affordable scientific service rates for a large arrays of transmitters and sensors.

Pan Pacific Surface Current Study
The first basin scale experiment commenced in 1987 with 200 drifters, jointly funded by the French and US science agencies. It was called the: “Pan Pacific Surface Current Study” as part of the WCRP “Tropical Ocean and Global Atmosphere” (TOGA) program. The two models shown of Figure 2 were chosen from this study for calibration of water following characteristics by fitting these with VMCM current meters on the top and bottom of the drogues and recording the relative water motion past the drogue. In 1988, engineers from US and France joined me in a 30 day ocean science expedition from Samoa to Hawaii during which time six days were spent obtaining current data, with divers over the side (Figure 1). In 1991, we published the “The WOCE-TOGA SVP Drifter Construction Manual” based on the choice of the holey sock drifter (below in Figure 2) that allowed...
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5 industrial firms and 6 ocean laboratories to build drifters to the same water following standards and comparable survivability at sea.

**DBCP Global Drifter Program**

From 1994 to 2009, sensors for air pressure, wind speed, wind direction, salinity, subsurface temperature, upwelling radiation and surface waves have been added to the SVP drifter (Figure 4). On 31 August 2009 there were 1298 drifters as sea reporting SST to the GTS system, 535 of which also reported air pressure (Figure 3). In all aspects of building the “Global Drifter Program”, that is now an official project of the “Data Buoy Cooperation Panel (of IOC/WMO)”, the academic, government, industrial and Service Argos components have shown commendable resilience, cooperation and plain hard work. I am very proud to have been part of this yet uncompleted history.

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**Figure 3. Status of the Global Drifter Array on 31 August 2009. All these data are on GDTS and are available in near real time to the global scientific and operational communities.**

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**Figure 4. Schematics of the latest models of SVP air-deployed drifters used for studies of the response of the ocean to Tropical Cyclones.**

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To learn more

ABOUT PETER NIILER'S WORK:

http://sio.ucsd.edu/Profile/pniiler
The Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has achieved the world’s first high-speed data transmission by the ARGOS-3 system, using a transmitter called PMT-HD (Platform Message Transceiver High Data Volume). The ARGOS-3 compatible transmitter, developed by KENWOOD and exclusively designed for ocean observation, was integrated into an m-TRITON buoy.

The buoy was deployed in the eastern Indian Ocean (1.5 degrees South, 90 degrees East) from the JAMSTEC research vessel KAIYO during its cruise from March 10 to 31, 2009.

The transmission system with the PMT-HD, which can provide a two-way communication and high data-rate uplink, has enabled a large transfer of data, allowing greater efficiency in data acquisition. The Argos-3 m-TRITON buoy collects 15.3 times more than a TRITON buoy equipped with an Argos-2 transmitter (27.6 kbytes per day) and energy consumption due to transmission is divided by 6 as the PMT is synchronized with the satellite and transmits only during satellite passes.

What is m-TRITON?

The TRITON (TRIangle Trans-Ocean Buoy) moored buoy network was set up for observing oceanic and atmospheric variability in the Pacific Ocean and its adjacent seas that influence worldwide climate change. The observation network’s coverage in the Indian Ocean – an area that is quite important for better understanding of the regional and global climate variability on seasonal, inter-annual and longer time scales – however, still showed some gaps compared to that of the Pacific and Atlantic covered by the TAO/TRITON/PIRATA arrays.

To enhance the observation in the Indian Ocean, particularly in the eastern tropical area, JAMSTEC has developed a new surface mooring buoy system under the Japan Earth Observation Promotion Program (JEPP) supported by the Japanese government. The design of this new m-TRITON buoy is based on the traditional TRITON buoy, but it is smaller (for easier operation) and equipped with state-of-the-art sensors, loggers and a communication system enabling energy, cost and size savings. This small buoy can be deployed and recovered by standard research vessels, and provides us with much higher temporal density data.

Future perspective

These first results are very promising for the new Argos-3 system, as the Argos-3 m-TRITON proves to be low power consumption and more efficient in data collection and transmission. Such enhancements are expected to lead to a wider and more effective use of buoy data, offering more possibilities in various fields of science, including climate variations.

The high-speed data transmission achieved by the PMT-HD can provide real-time and continuous observational data that has no missing values. This will enable the world’s scientists to perform detailed analyses on atmospheric-ocean phenomena on a shorter time scale. The increased transmission capacity will also permit observations on chemical and biological aspects of the ocean, in addition to the conventional physical observations, offering a broad spectrum of applications in multiple domains of science.

Currently, three m-Triton buoys are operating in the Indian Ocean. By equipping these buoys with the Argos-3 PMT-HD transmitter, JAMSTEC will facilitate fast and reliable retrieval of invaluable data, thus contributing to a further progress in climate research in the Indian Ocean.
EXCITING RESULTS FOR THE ARGOS-3 DBCP PILOT PROJECT

If you are interested in Argos-3, please contact Yann Bernard (ybernard@cls.fr).

Shorty after the first buoy deployment in 2009, the main objectives of the integration of Argos-3 into SVP (Surface Velocity Program) and SVP-Barometric drifters have been reached:

1. Regular, accurate sampling and accurate time stamping of sensor data;
2. Argos transmissions limited to user required sensor data (fewer messages duplicated);
3. Improvement of data quality.

Message transmissions reduced by 75%

In 2009, four manufacturers completed the implementation of the Argos-3 PMT into their drifters: Clearwater, Marlin-Yug, Metocean and Pacific Gyre. These drifting buoys use the interactive data collection mode with Argos-3 and the “pseudo-ack” mode with Argos-2 (message transmitted N times under one satellite pass) since the PMT modem calculates satellite pass predictions. Preliminary studies showed that these improvements permit to reduce message transmissions by 75% (thus increasing the buoys’ life expectancy).

Already 20 Argos-3 buoys (see the map above) have been deployed in the Pacific and Atlantic oceans and Mediterranean Sea in order to test Argos-3 capabilities all over the world. Luca Centurioni (SCRIPPS), the chairman of the Argos-3 steering team of the Data Buoy Cooperation Panel, coordinated ship opportunities for deployment of the drifters by interested users. A total of 50 drifters are scheduled for deployment for Argos-3 system evaluation.

This pilot project shows very promising first results for Argos-3, with:
• A high performance for collecting hourly sensor acquisitions (>95%);
• A large reduction (~90%) of the power consumption, reducing the size of the battery pack and/or increasing the drifter lifetime;
• Improved synoptic measurements;
• Optimization of the transmission leading to a better use of the satellite network and then better performances for users;
• Uplink transmission with an automatic checksum control;
• Remote commands via the Argos-3 downlink way to change the mission parameters.

To learn more

PLEASE VISIT OUR WEBSITE FOR MORE INFORMATION ON ARGOS-3: