Expanding NASA's mission by adding novel sensors to autonomous platforms

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Abstract

Novel sensors on novel autonomous platform can relieve some of the drawbacks of satellite technology by being able to sample under cloud, sub-surface, and in-situ. A large scale international oceanographic program (ARGO) is currently underway seeding the oceans with profiling floats which measure physical properties. The purpose of our effort is to integrate novel sensors to two such floats in an effort to showcase the benefit of having concurrent physical and biogeochemical measurements for the greater oceanographic community in general and to NASA's mission in particular.

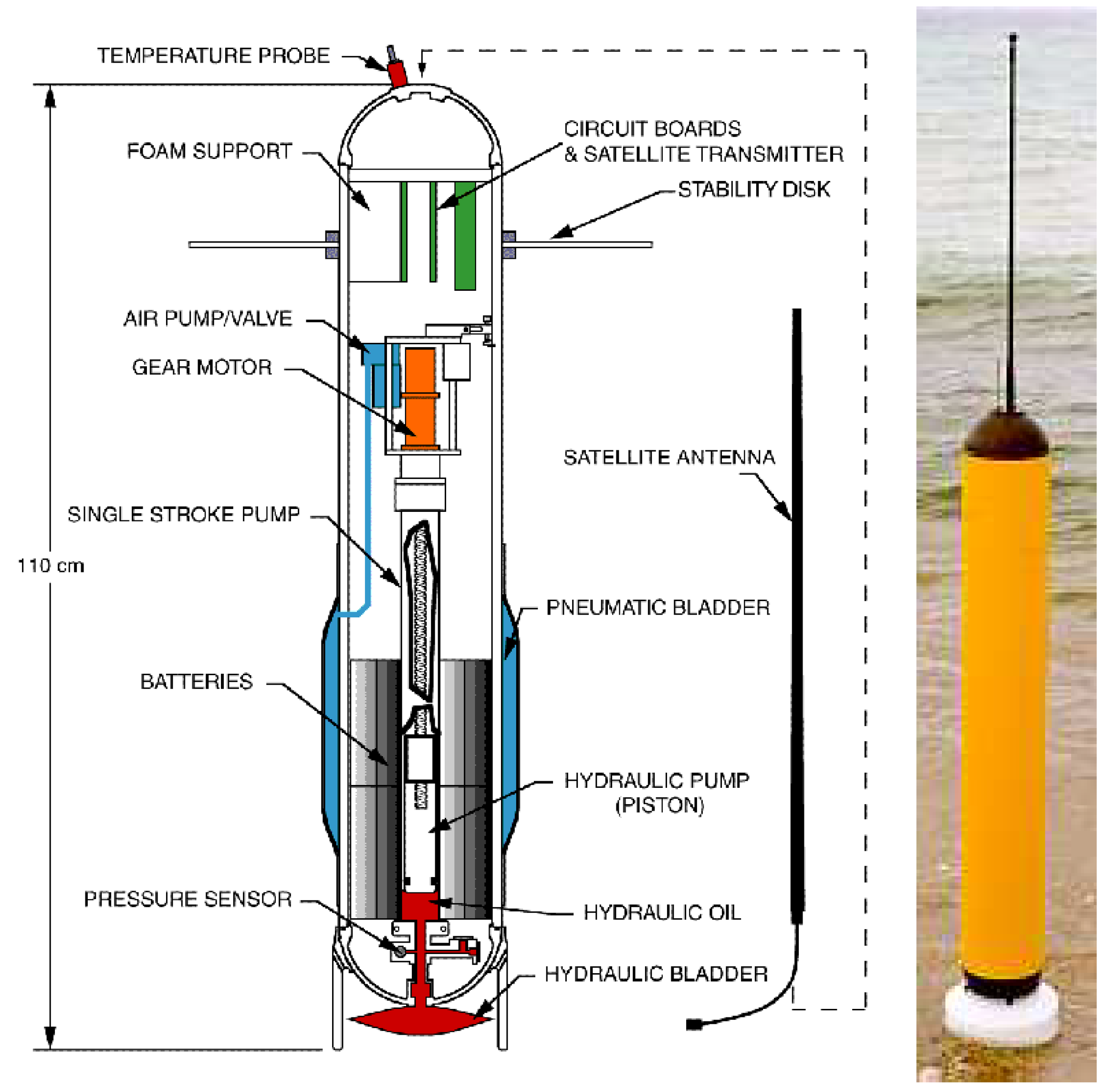

Figure 1: interior design and external view of an ARGO (APEX) profiling float. We will integrate an oxygen sensor to the head of the float (next to the CTD) while the optical sensors will be attached facing downward to the rear of the float.

ARGO

Argo is a global array of 3,000 free-drifting profiling floats that will measure the temperature and salinity of the upper 2000 m of the ocean. This will allow continuous monitoring of the climate state of the ocean, with all data being relayed and made publicly available within hours after collection.

Argo deployments began in the year 2000. The Argo array is part of the Global Climate Observing System/Global Ocean Observing System (GCOS/GOOS) and part of the Climate Variability and Predictability Experiment (CLIVAR) and the Global Ocean Data Assimilation Experiment (GODAE) (from: http://www-argo.ucsd.edu/index.html).

Instruments arrays such as ARGO are likely to continue and be deployed in the forsiable future. We believe that adding sensors to them will enhance NASA's mission.

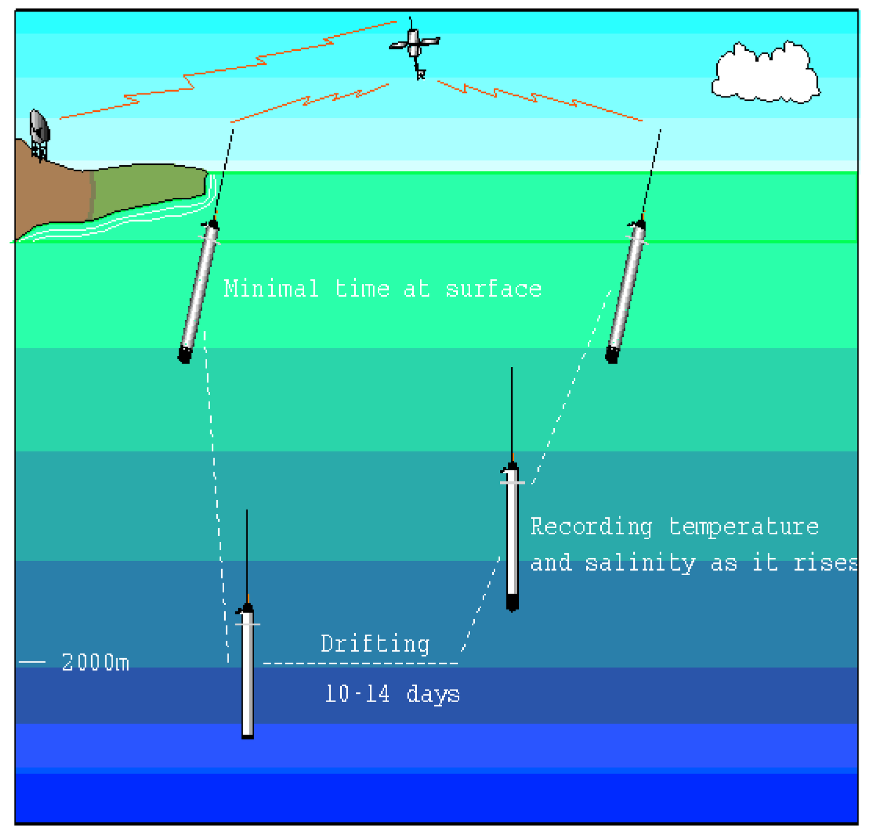

Figure 2: Typical ARGO float mission. Currently most floats do not go deeper than 1000m on most profiles.

ARGO today:

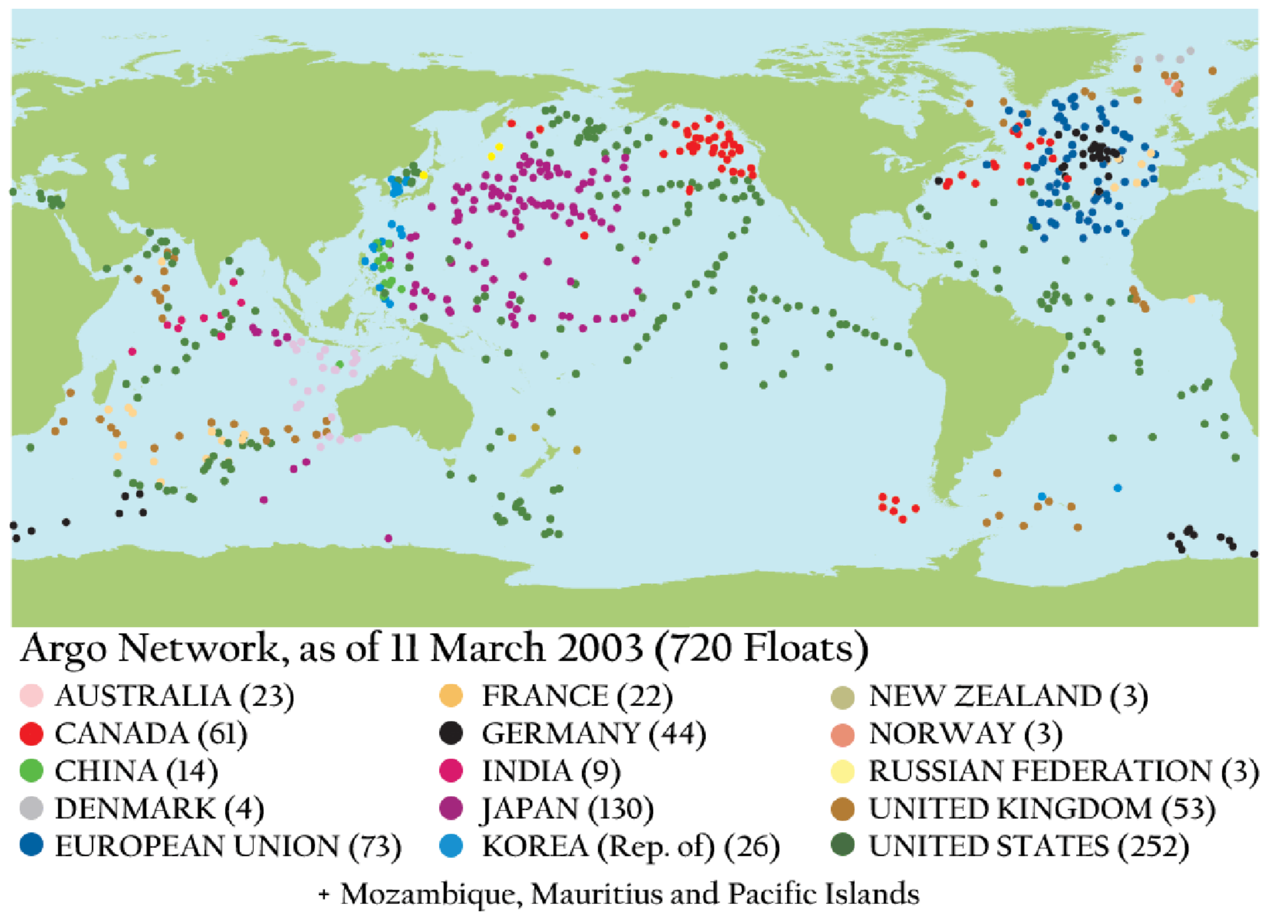

Figure 3: Distribution of ARGO floats as of 3/11/2003.

Argo floats have an average lifetime of four years. To achieve a level of 3000 operating floats, 825 floats need to be deployed per year. Current floats mission is, in general, limited to above 1000m.

At latest international ARGO science team meeting (March, 2003) the need for O2 measurement was made in particular as a tracer for circulation and for carbon science. The addition of auxilliary sensors in unlikely to happen in the present ARGO program. Future programs such as ARGO may incorporate them if their need is proven.

Our objectives

Demonstrate the utility of adding novel optical sensors to profiling floats in hope of convincing the future ARGO-like programs to adopt them (without modifying the ARGO-type mission, e.g. Fig. 2).

Demonstrate the complementary information these floats\ provide to remote sensing in:

1. sampling under clouds.
2. sampling the vertical structure.
3. sampling in-situ.

Together with ocean color (and appropriate statistics), the information from the floats can by used to better constrain biomass and primary production estimates.

Contribution to NASA's objectives

If an ARGO-like program was to adopt the use of optical sensors, NASA's mission would be enhanced by

1. Extending the surface measurement available from satellite ocean color to depth.

2. Combining in-situ measurements to remotely sensed measurement can improve sensor calibration and atmospheric correction.

3. Link surface variable linked to carbon science (chlorophyll, POC, primary production) to in-situ biogeochemical variable such as oxygen.

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Optics and ARGO floats:

To date, two short-term deployments of profiling floats with optical sensors have been performed:

1. Jim Bishop and collaborators have deployed floats with beam transmissometer near station PAPA and were able to monitor a bloom of phytoplankton following an Aeolian deposition of iron (Bishop et al., 2002).
2. Greg Mitchell and co-workers monitored the onset of the spring bloom in the Japan Sea with passive radiometers attached to floats.

Our approach:

Combine mature technologies of the APEX float (enhanced with novel oxygen sensors) and tried and true scattering+cholorophyll fluorometer sensors.
The optical sensors board were minimized and integrated to a small hockey-pack size head that is attached to the exterior of the float (Fig. 4).
An auxiliary board in-side the float handles the data input from the optical sensors and their transmission (together with the CTD-O2 data) to an ARGOS satellite (irridium in near future).
Chlorophyll fluorescence will provide a proxy for phytoplankton pigment concentration while the scattering sensor will provide a proxy for total suspended particulate or particulate organic carbon), which is dominated by phytoplankton biomass in the open ocean.

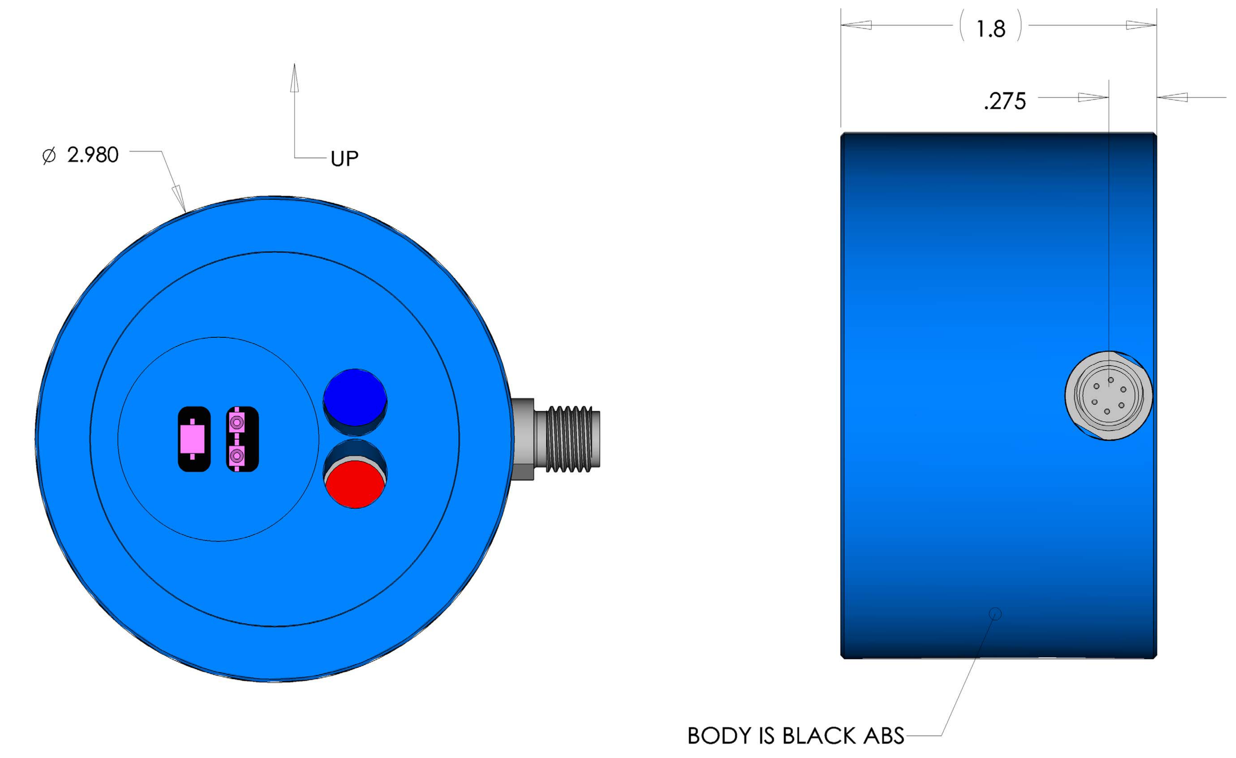

Figure 4. Front (left) and side (right) view of combined optical sensor. The left sensor is based on the Wet Labs LSS, a large angle optical scattering sensor (880nm). The right sensor is a chlorophyll fluorometer with a blue source (470nm) and red (accepting) detector.

Progress to date:

Auxiliary boards have been built by SeaBird electronics and are currently being tested. Optical sensors have been designed, assembled and tested. Testing included pressure cycling in a wet pressure tank. Optical sensors are currently being recalibrated at Wet Labs.

Deployment plan:

We are planning to deploy the floats in the summer of 2003 in the vicinity of station ALOHA. We chose this location for the following reasons:

- Low energy, floats are likely to drift slowly away.
- Regular cruises scheduled to the station providing data for validation.
- Good remote sensing coverage.
- Existence of funded studies of the biogeochemistry at ALOHA.
- Data will be available in real-time on the web (http://flux.ocean.washington.edu/).

Conclusions

We are on track to deploy biogeochemically enabled ARGO-like profiling floats this summer.
We hope this effort will help to demonstrate the advantage of adding auxiliary sensors to profiling floats participating in future ARGO-like programs.

References

Bishop J. K. B, R. E. Davis, and J. T. Sherman, 2002. Robotic observations of dust storm enhancement of carbon biomass in the North Pacific.Science, 298, 817-821.