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Ice-Tethered Profiler: Technology

Introduction

A complete description of the ITP technology is provided in WHOI Technical Report 2006-11, down-loadable to the right.

The ITP system consists of three components: a surface instrument package that sits atop an ice floe, a weighted, wire-rope tether of arbitrary length (up to 800 m) suspended from the surface package, and an instrumented underwater unit that travels up and down the wire tether. A schematic drawing of the instrument is given to the right.

Related Multimedia

The Ice Tethered Profiler System

Jack Cook, Woods Hole Oceanographic Institution

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» WHOI Technical Report 2006-11
Design and operation of automated ice-tethered profi lers for real-time seawater observations in polar oceans by R. Krishfield, K. Doherty, D. Frye, T. Hammar, J. Kemp, D. Peters, A. Proshutinsky, J. Toole, and K. von der Heydt.

» JAOT Paper, 2008
Krishfield, R., J. Toole, A. Proshutinsky & M.-L. Timmermans, 2008. Automated Ice-Tethered Profilers for seawater observations under pack ice in all seasons. J. Atmos. Ocean. Tech., 25, 2091-2095.

Surface package

The surface expression of the ITP is a cylindrical buoy that is deployed on a multiyear ice floe. The surface capsule houses a controller, inductive modem electronics, a GPS receiver and an Iridium satellite phone with associated antennae and batteries within a water tight aluminum housing capped by an ultra high molecular weight (UHMW) polyethylene dome. The electronics case sits within a cylinder of Surlyn ionomer foam designed to provide buoyancy for the plastic-jacketed wire rope tether and end weight should the ice fracture or melt (the latter designed to minimize wire angles when the supporting ice floe moves), and provide modest protection in the event of ice ridging.

The Iridium and GPS antennae are mounted internally on a chassis beneath the microwave-transparent UHMW hemispherical radome that forms the top endcap. The bottom endcap provides space for penetrators to feed the electrical signals into the compartment, and a mount for the tether. Space for an additional bulkhead connector for interfacing with other external sensors is provided, as well as extra tube length for batteries to meet additional power requirements in the future. The yellow surface package is propped on a wooden palette during deployment (an effort to minimize the ablation of ice in contact with the unit).

Individual battery slices (each nominally 1250 Wh) supply power to the surface electronics, with connectors on the SURFCON board accommodating as many as six packs. Three packs should produce at least 3300 Wh after derating for temperature. Based on a data throughput of 100 kbytes/day from the underwater profiler (2 profiles), 100 bytes/s inductive modem link, and 200 bytes/s Iridium link, the power requirements for the surface unit are less than 2 Wh/day.

Wire tether

The tether is constructed from conventional plastic-jacketed wire rope commonly used in ocean mooring applications. The upper 5-m of the wire tether is cast within a thick protective urethane jacket that also houses an electrical ground lead for the inductive modem. A custom termination is used to mechanically join the tether to the surface unit and preserve the electrical isolation of the wire tether from the sea water. Shock-absorbing spring bumpers are clamped onto the wire at the top and bottom of the programmed profiling interval to prevent the profiler from impacting the tether terminations. A 250 lb ballast weight (made of 50 lb plates to facilitate transportation) is fixed to the bottom wire termination to add tension to the wire and minimize its catenary when the supporting ice floe moves.

Profiler

A new variation of the WHOI Moored Profiler (in shape and size much like an Argo float) mounts on the tether and cycles vertically along it. But unlike a float that changes its buoyancy to profile, the ITP uses a small traction drive wheel mounted midway along its body to move up and down. Typically the drive system draws only 1 W of power as the ITP profiles at 0.25 m/s. The ITP employs the same CTD sensor package that is currently used on many of the Argo floats (the Sea Bird Electronics, Inc. model 41CP) mounted in the instrument's top hemispherical end cap. Communication between the Profiler and surface controller is supported by an inductive modem utilizing the wire tether.

The cylindrical pressure case houses the batteries, drive system, instrument controller, CTD and underwater inductive modem (UIM) as well as provides buoyancy for the unit. The underwater vehicle is ballasted to be neutrally buoyant near the midpoint of its profiling interval. The instrument controller and software are products of McLane Research Laboratories, Inc. and use the same electronic hardware and software scheme as the full-depth-capable McLane Moored Profiler. The instrument acquires profiles based on user programmable sampling depths and schedule, either at uniform spacing in time or in burst sampling mode.

The underwater vehicle has its own battery pack consisting of 24 lithium "DD" cells totaling 2500 Wh (derated for temperature): sufficient for an estimated system endurance of 1.5 million meters of profiling based on a total energy consumption rate of 1.35 W while profiling (CTD + drive motor + UIM transfer + overhead).

Data

Each ITP is expected to return 1600 or more high-vertical-resolution profiles of upper Arctic Ocean temperature and salinity in near real

time spanning all seasons over a three-year lifetime. The raw CTD and associated engineering data files are relayed from the underwater vehicle to the surface buoy at the completion of each one-way profile, which then transmits them to a logger computer at WHOI via satellite. Full-resolution CTD and engineering data are transmitted to shore.

At regular interval thoughout the day, the data files that arrived on the WHOI logger computer are accessed by a separate computer that unpacks the binary data files, performs basic edits, averages the profile data into convenient 2 -db pressure bins, produces plots of the CTD and engineering data and saves the data in ASCII and MATLAB format files. These plots and the associated data files are accessible from the ITP Data page. Additional documentation of the data processing procedures are provided there.

Since all acquired data are transmitted to shore at full resolution and the hardware is relatively low-cost (in comparison to ship time), ITP systems may be considered expendable (thus alleviating the need for expensive recovery operations to collect the data).

Hardware specifications

- Tether length: 10 up to 800 m
- Profiling range: 1,500,000 m on standard battery pack
- Duration: 2.5 to 3 years returning two 750 m profiles (one profile in each direction) per day (2000 total)
- Temperature specification: approximately -25° C (Iridium transmitter is limiting component)
- Data rate: typically 50 Kbytes per profile (totaling 100 Mbytes over 3 years)
- Telemetry: Seabird inductive link from profiler to surface unit; Iridium satellite link to shore
- Data backup: on-board storage in both underwater and surface units; data retained until successfully telemetered
- Sensors: Seabird CP-41 CTD (conductivity, temperature, pressure); optionally dissolved oxygen, chlorophyll fluorescence, optical backscatter, ocean color, photosynthetically-available radiation, velocity
- Power: lithium BCX “DD” battery packs; 3300 Wh in surface package (after derating for temperature), 2500 Wh in profiler
- Size: Profiler fits through an 11 inch hole in the ice

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Mail: Woods Hole Oceanographic Institution, 266 Woods Hole Road, Woods Hole, MA 02543, USA.
E-Contact: info@whoi.edu; press relations: media@whoi.edu, tel. (508) 457-2000
Problems or questions about the site, please contact webdev@whoi.edu