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METSPAR — a Marine Meteorological Spar Buoy

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METSPAR - A MARINE METEOROLOGICAL SPAR BUOY

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Abstract

The CSIRO Division of Oceanography is currently undertaking several instrument development programs. One of these is designed to provide a meteorological data acquisition system, including a buoy and mooring, suitable for long-term deployment in both shallow and deep water. The first configuration, detailed here, was Metspar, a spar buoy with radio beacon and Aanderaa meteorological instruments. Seven were built and deployed during the Australian Coastal Experiment (ACE) in 1983/84, which proved to be an ideal test for instruments, buoys and moorings. The experience gained with Metspars during ACE has contributed significantly to the next generation of offshore meteorological buoys, which are currently on trial off Western Australia.

Introduction

Many oceanic processes such as waves, currents, upwellings and mixed-layer formation depend on energy fed from the atmosphere. While the CSIRO Division of Oceanography has, in the past, studied these processes with sub-surface instruments, it has proved difficult to instrument the zone immediately above the ocean/atmosphere interface. This is due in large part to the difficulty of mooring and maintaining a suitable platform at sea for a useful period (from six months to a year is now common for current and sea-level observations).

The motivation for developing an instrumented buoy at the CSIRO came from the Australian Coastal Experiment (ACE) (Freeland et al., 1986), which was designed to detect the presence and propagation of coastal-trapped waves along a section of the New South Wales coast from Cape Howe to Newcastle. Since the waves are, in theory, generated by the longshore component of wind stress, it was necessary to obtain measurements of wind, atmospheric pressure, solar radiation and air and sea temperatures along and across the continental shelf (Forbes, 1987). Seven spar buoys were therefore built at the CSIRO Division of Oceanography and deployed (mid-shelf and shelf-edge) to measure and record these parameters for six months in 1983/84.

Buoy Design

Spar

There are basically two types of buoy: surface-following and surface-decoupled. The first type, if large enough (the size of a ship), is an excellent platform for wind observations, since it is only affected by low-frequency waves (i.e. swell). However, small surface-following buoys experience motions that severely contaminate wind measurements and can ultimately destroy the sensors mounted on the buoy. The second type can take several forms, the simplest of which is a vertical spar, buoyant at the top, ballasted at the bottom. The length of the spar and the distribution of buoyancy largely determine the heave response of a spar buoy (pitch, roll and yaw are negligible). In general, the longer the spar, the more stable the buoy. However, as spars must be deployed, serviced and recovered by a ship, the practical limit for the CSIRO's spar buoys (based on the length of the working deck of the RV *Sprightly*) was 15 m (9 m hull plus 6 m superstructure).

Materials considered for the CSIRO's Metspar buoys were steel, aluminium and plastic. Steel is the most robust, but also the heaviest (a large buoyancy chamber must be fitted); aluminium is light, but expensive, and must be carefully isolated from steel mooring components; plastic is light, strong, elastic, unaffected by seawater, easily machined and bonded and is relatively cheap. PVC pipe was therefore selected (200 mm diameter, 10 mm wall thickness), with additional surface buoyancy (150 kg reserve) provided by a single 200 l polyethylene drum. Both spar and drum are filled with rigid polyurethane foam. Ballast is provided by 200 kg of galvanised steel pipe, sleeved over the bottom 2 m of spar. Immediately above this is a 200 l free-flooding polyethylene water ballast tank. The general arrangement of the Metspar buoy is shown in Figure 1.

Superstructure

Bolted to the top of the spar with PVC stub flanges and galvanised steel backing rings is a 0.75 m long PVC data-logger housing. Instrument cabling penetrates the housing's PVC endcaps through heatshrink 'aperseals'. Surmounting the data-logger housing is a 1.7 MHz radio beacon (range 50 n. miles) with its own power supply and a 4.5 m long whip antenna. Mounted on the beacon are a radar reflector and a rapidly flashing white light. Parallel to the whip antenna is a main mast to support the meteorological sensors.

Three prototype masts with wire rigging were tested: two aluminium and one fibreglass. One aluminium mast broke, and one bent. The fibreglass mast, 3.5 m long, 50 mm diameter, 4 mm wall thickness, survived all sea trials. It is capable of supporting the dynamic instrument load without rigging wires, but the final version is wire-rigged (with central spreaders) to dampen any high-frequency vibrations induced by spar motion in a fully developed sea. Nylon reinforced rubber couplings between the fibreglass mast and the parallel whip antenna prevent excessive motion of the whip antenna and provide it with extra support.

Two of the six Metspar buoys used during ACE were initially equipped with Aanderaa VHF data transmitters (142 MHz) instead of the radio beacon, to serve as a data link with a shore station at Cronulla. The VHF transmitters are solar-powered and are mounted centrally on the aluminium 'T' bar at the masthead, which also supports all the meteorological sensors. As data reception from these transmitters was unreliable, they were replaced with 1.7 MHz radio beacons.

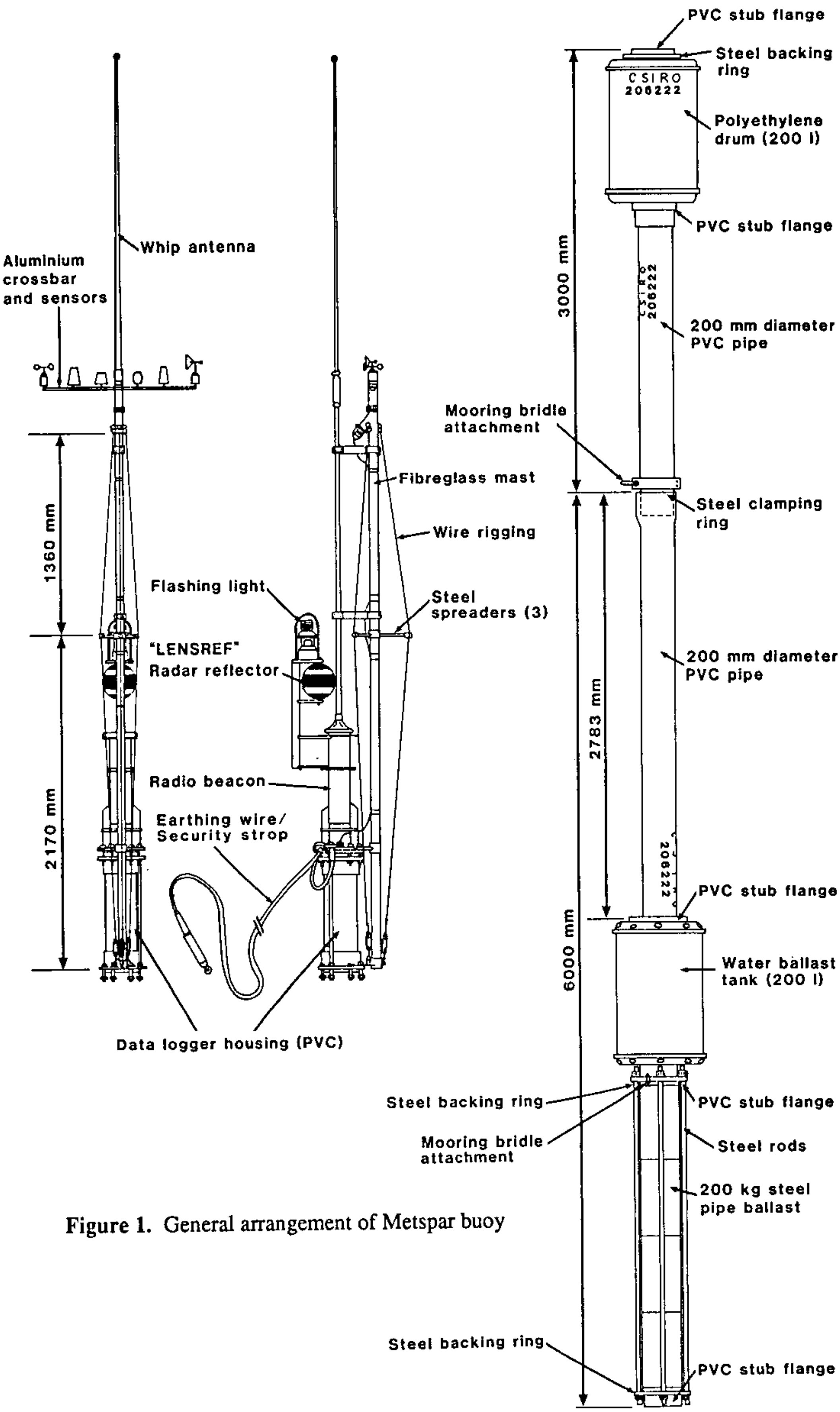

Figure 1. General arrangement of Metspar buoy

Mooring

A spar buoy is best moored from a bridle that straddles its centre of drag, with a horizontal tether to a surface or subsurface buoy, which is in turn moored to a large anchor on the sea bed. For ACE, the Metspar buoys were moored this way, as shown in Figure 2, using a chain bridle (with trawl floats), a plastic-jacketed wire tether (with line floats), a rigid polyurethane foam-filled 200 l polyethylene drum surface buoy, polyethylene rope and two railway wheels with a Danforth anchor on the sea bed. The polyethylene surface buoy and rope were later replaced with 1 m diameter O.R.E. steel buoys and plastic-jacketed wire.

This system allows the spar buoy to be serviced by detaching it at the junction of the wire tether and surface buoy and exchanging it with a spare spar, while the main mooring remains undisturbed.

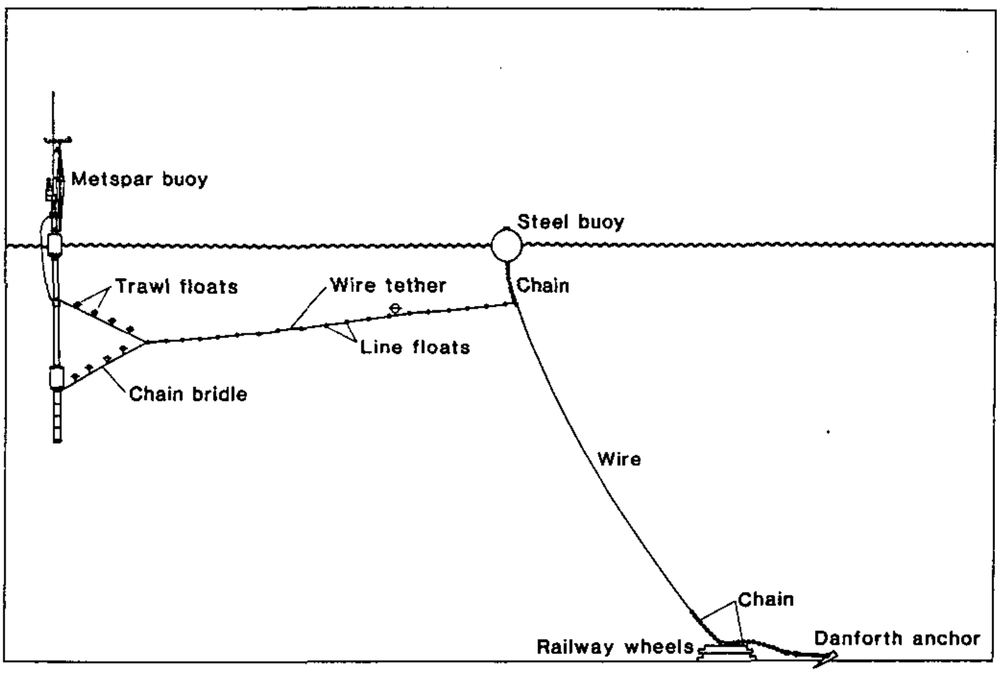

Figure 2. Mooring for the Metspar

Instruments

All meteorological sensors on the Metspar were manufactured by Aanderaa Instruments, Norway. They comprised wind speed (cup), wind direction (vane), atmospheric pressure, air temperature, solar radiation (all mounted on an aluminium 'T' bar at the masthead) and sea-surface temperature (encased in the spar 3 m below the surface). All sensors were interrogated and logged hourly by an Aanderaa data logger on 1/4" magnetic tape, which is capable of running unattended for six months. However, the radio beacon and flashing-light batteries needed replacing after three months.

Performance

Sea Trials

Following sea trials performed during the development of Metspar, the design was slightly modified to include the water ballast tank and security strop. The free-flooding 200 l water ballast tank adds 200 kg to the virtual mass of the buoy, which further damps its response to short-period waves. The wire-rope security strop ensures that if the buoy suffers severe collision damage, the radio beacon and data logger remain tethered to the mooring. The strop also acts as an earthing wire for the radio beacon. The spar has negligible pitch, roll and yaw, but heaves, as expected, with a damped period of free oscillation of 3 s. It is stable at wave periods shorter than this, passes through a resonant peak at 3 s, and begins to follow the surface wave motion at longer periods.

Towing trials simulating strong ocean currents were performed to find the exact centre of drag and thus determine the optimum bridle arrangement. At 1.5 ms^{-1}, a strain gauge in the towing line showed surges to 450 kg force as the spar met approaching heavy seas. At 1 ms^{-1}, 150 kg of drag on the spar was measured, which should correspond to 'normal' conditions across the shelf.

Survival

Seven Metspar buoys were constructed: six for deployment and one as a spare. Four were initially deployed at the shelf-break in 200 m of water and two were moored mid-shelf, in 135 m of water. During a period of severe weather and strong currents (up to 1.8 ms^{-1}) in late November 1983, all four shelf-edge buoys disappeared, probably because of insufficient buoyancy of the surface mooring-buoys. Subsequent tests showed that the polyethylene drums crushed at about 20 m depth, despite their rigid foam filling. The spare Metspar was deployed in December to replace the shelf-edge buoy off Gabo Island. At the same time, the remaining polyethylene surface-buoys were replaced with 1 m diameter steel buoys. No further buoys were lost, but failure of the wind speed sensor due to corrosion of the rotor bearing resulted in a 40-day gap in the records of two of the Metspars. A report (Forbes, 1985) gives full details of the meteorological data acquired by the Metspars during ACE.

Conclusions

As an inexpensive, easily constructed, marine meteorological buoy, Metspar proved successful. Experience has shown, however, that it is probably not a suitable design for mooring in deep water off the continental shelf, and that a much larger spar (about 45 m long) would be required to survive and record data further offshore. Such large spars are expensive to construct and difficult to deploy, so the CSIRO Marine Laboratories has developed a 3 m diameter aluminium discus buoy to fulfill this requirement. It is presently undergoing trials off the west coast of Australia.

Detailed plans of the Metspar buoy are available from the author at the CSIRO Division of Oceanography in Hobart.

References

Forbes, A.M.G., 1985. Meteorological data from the Australian Coastal Experiment; a data report, *CSIRO Marine Laboratories Report* **170**, 26pp.

Forbes, A.M.G., 1987. Wind stress in the Australian Coastal Experiment region, *Australian Journal of Marine and Freshwater Research,* (in press).

Freeland, H.J. et al,. 1986. The Australian Coastal Experiment: a search for coastal-trapped waves, *Journal of Physical Oceanography*, **16**(7): 1230-1249.

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