Woods Hole Oceanographic Institution

Upper Ocean Processes Group

Technical Note

CLIMODE Surface Buoy Mooring Design

January 2006

The first field deployments of the CLimate VARiability (CLIVAR) Mode-Water Experiment (CLIMODE; http://www.climode.org) took place in the North Atlantic during 9-27 November 2005. The R/V *Oceanus* was used to conduct a CTD section, deploy numerous floats and drifter packages, and deploy four subsurface moorings and one surface mooring. The CLIMODE observation plan included maintaining the heavily instrumented surface mooring near the Gulf Stream axis through the winter – a significant challenge due to strong currents and high seas expected in the region. This technical note will describe the design of the surface mooring and the components used in its construction.

Environmental Parameters

The surface mooring was designed for deployment in the core of the Gulf Stream. It may see currents up to 3 m/s and waves exceeding 8 m. Therefore, traditional UOP design methods were reevaluated for this mooring.

Current profiles were developed from a review of moored current meter records cited in the literature and from the ADCP data collected from the *Oleander* as it crossed the Gulf Stream by Tom Rossby (URI) and colleagues.

The current profiles for a design depth of 5000 m were:

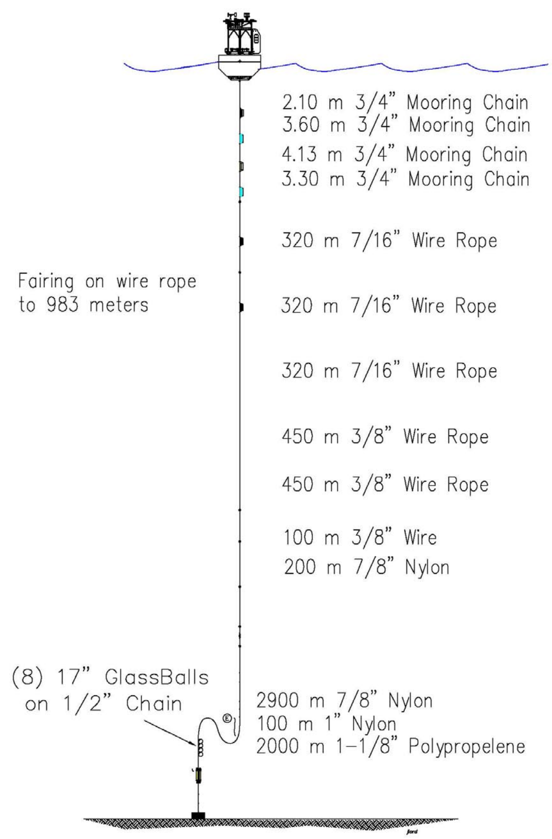
Peak Current		Extreme Current	
Depth (M)	Speed (CM/sec)	Depth (M)	Speed (CM/sec)
0	260	0	300
100	260	150	300
600	100	450	150
1000	50	750	95
1200	40	1000	70
1500	30	2000	30
5000	30	5000	30

Wave heights were estimated using historical data from NDBC buoy # 44004, located east of Cape May, NJ, at 38°28.2'N 70°33.6'W. Significant wave height averaged between 1.5-3 m over the year, with peak waves over 13 m observed.

Design Considerations

The WHOI Cable Time Domain Numerical Simulation software (Gobat et al., 1997, Tech. Report WHOI-97-15) was used to estimate static and dynamic tension. The current profiles from Table 1, and significant wave heights of 12m were used to calculate extreme loading on the mooring. The simulation indicated that near-surface components would see static tensions approaching 8,000 pounds, with potential dynamic cycling between 5,000 and 10,000 pounds at the buoy connection.

The inverse catenary design uses a combination of jacketed wire rope, plaited nylon line, and buoyant polypropylene line in the lower section of the mooring. A scope of 1.45 was used for this mooring (scope = slack length/water depth). Initial results from the traditional design indicted potential static forces on the buoy connection in excess of 12,000 pounds. Snap-on ABS plastic fairing was used with 7/16" wire rope on the first 1000 m of the mooring to reduce drag. The addition of the fairing could reduce tension on the mooring by up to 4,000 pounds in extreme conditions.

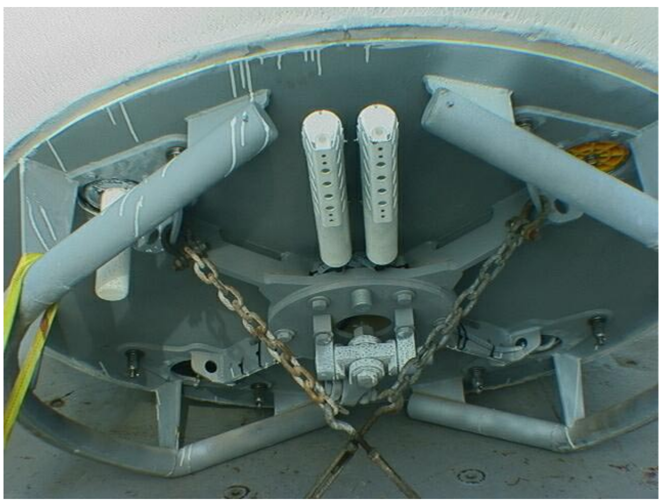


CLIMODE 1 MOORING

Component Description

Buoy: The surface element is a 2.7 m diameter Surlyn foam buoy with a water tight electronics well and aluminum instrument tower. The two-layer foam buoy is “sandwiched” between aluminum top and bottom plates, and held together with eight 3/4" tie rods. Meteorological sensors are attached to the upper section of the two-part aluminum tower at a height of approximately 3 m above the water line. The total buoy displacement is 16,000 pounds, with reserve buoyancy of approximately 11,000 lb as deployed in CLIMODE.

The lower section of the buoy was strengthened for this program. The entire bottom section was made from steel rather than aluminum. The photo below shows the buoy lower section and universal joint termination.



Chain: Segments of ¾” mooring chain are used in the first 20 m of the mooring to add some weight and stability just under the mooring. Instruments are inserted between segments of chain in the first 20 m.

Load Bars: 1” x 2.25” Grade 5 titanium bars are used to mount instruments in the upper part of the mooring, and in between shots of 7/16” wire rope further down the mooring line.

Wire Rope: Three 320-meter segments of 7/16” jacketed wire rope are used in the top section of the mooring, just under the chain. Another 1000 m of 3/8” jacketed wire rope are used below the 7/16”.

Fairing: All of the 7/16” wire rope was faired with ABS plastic snap on fairing. The airfoil shape of the fairing will reduce the drag in the section of the mooring with the highest current. The drag coefficient is reduced from a typical value of 1.5 to approximately 0.3 (0.375 was used in the model).

Hardware: All shackles in the mooring were shot peened and painted. Shot peening the shackles greatly reduces the instances of failure from cyclic fatigue.

Line: 3100 m of 7/8” and 100 m of 1” plaited nylon line are in the mooring line below the wire rope. This line offers strength and compliance to the mooring. Below the nylon is 2000 m of 1-1/8” diameter buoyant polyethylene line.

Floats: Eight 17” glass balls, mounted to ½” trawl chain are mounted below the poly line. This floatation will keep the dual acoustic releases vertical, even if the mooring goes slack.

Anchor: The anchor used for the CLIMODE mooring is a stack of three, 3100-pound, cast steel discs. The discs are held together with a 1.25” diameter steel eyebolt. In this mooring design, the anchor will move before the buoy is pulled under.

The mooring was deployed on November 13, 2005 at 38° 19.1’ N, 64° 46.9’ W at 4981 m water depth.

The CLIMODE buoy on station.

Contributed by: Jeffrey Lord

Published by the Upper Ocean Processes Group, Department of Physical Oceanography, MS 30, Woods Hole Oceanographic Institution, Woods Hole, MA 02543 USA. Contact: Jeffrey Lord.
Layout and editing, Penny Foster, Department of Physical Oceanography.