# Development of an Autonomous Direct Covariance Flux System for Use on Fixed and Mobile Assets at Sea

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## TPOS Objective

This project seeks to transition recent advances in buoy-based air-sea flux measurements to operational use in the TAO buoy array.

## Background

An autonomous Direct Covariance Flux System (DCFS) has been developed as part of and a NOAA-sponsored TPOS project with NOAA's PMEL (Meg Cronin) and ESRL (Chris Fairall). We have adapted the low-power direct-covariance flux system used in the NASA SPURS-2 and NSF OOI program for use on TAO buoys.

**Figure 1.** Surface mooring deployed during the SPURS-2 field program. A low-power DCFS was paired with an IRGA to directly measure the momentum, heat and moisture fluxes.

The present version uses a Gill 3-axis Windmaster anemometer, Lord Microstrain motion sensor and a microprocessor that collects the data and computes motion-corrected fluxes in near real-time. The fluxes and associated means are then telemetered to shores via Iridium. The ability to compute and telemeter the fluxes in real-time, along with the ever decreasing cost of the sensors, allows the current version to be considered expendable; i.e., the fluxes will be delivered without the need to recover and post-process the observations. Successful testing of the expendable version was conducted aboard the R/V Revelle during the SPURS-2 in the Eastern Tropical Pacific.

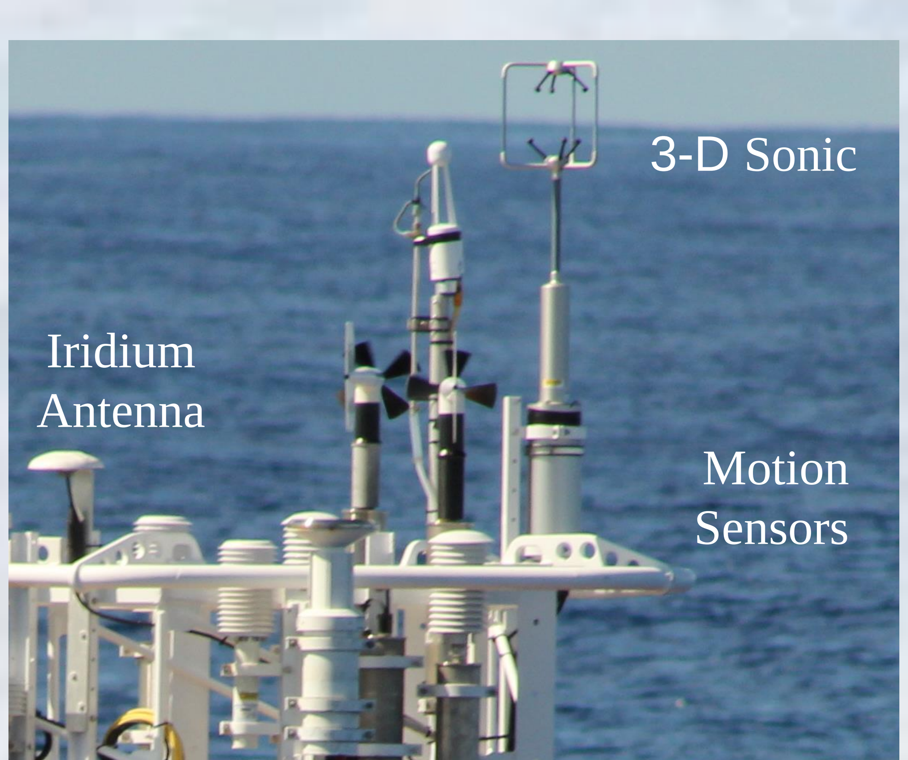


**Figure 2.** Close up of the autonomous DCFS deployed on the SPURS-2 central mooing.

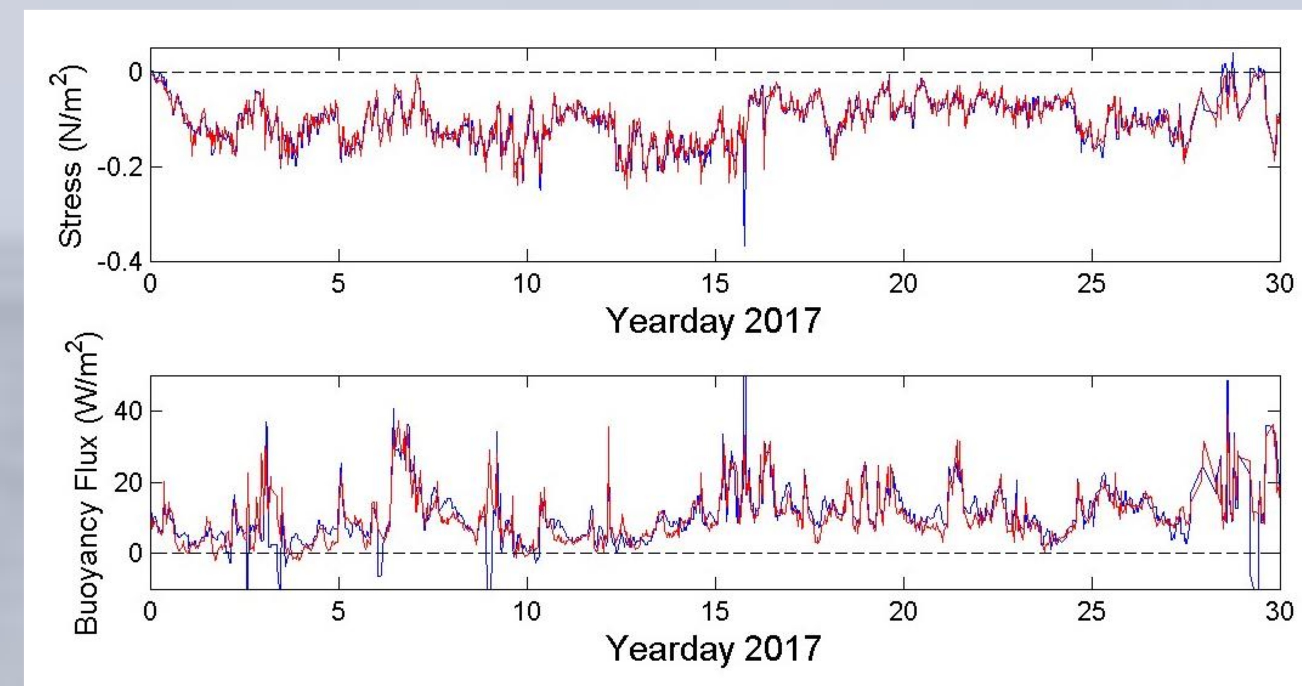


**Figure 3.** Time series of momentum (top) and buoyancy (bottom) fluxes measured with autonomous DCFS during SPURS-2. DC fluxes are shown in **blue** and bulk fluxes in **red** using COARE 3.5

## Application: X-Spar (Expendable Spar Buoy)

The autonomous DCFS will provide a number of new opportunities and deployment strategies to obtain DC fluxes over the world's oceans. As an example, WHOI is developing a drifting X-Spar as part of ONR's NISKINE program to support a variety of sensors to observe air-sea interactions processes. The X-Spar is insensitive to smaller-scale wind waves and provides a stable platform for atmospheric boundary layer sensors requiring less motion correction.

- Proposed sensor payload:
  - Autonomous DCFS with on-board flux calculations
  - Air temperature, pressure, humidity, wind speed and direction
  - Downwelling solar and longwave radiation
  - Subsurface pressure sensors to characterize the time-evolving sea state
  - Ocean temperature and salinity measurements at multiple depths
  - ADV and/or ADCP for currents
- Design specifics:
  - Data would be telemetered back and thus does not need to be recovered
  - Designed to be relatively low-cost and "expendable"
  - Minimal flow distortion - more accurate turbulent flux estimates than ships
  - Lagrangian (drifting) nature simplifies ocean heat and salinity budgets by reducing oceanic advective flux divergence
  - Meteorological sensors generally situated well above WBL and above region where additional corrections are needed
- Design Constraints:
  - Limited payload capacity (small water-plane cross sectional area)
  - Instruments powered by integral battery packs
- Measurement Objectives:
  - Accurate momentum, heat, mass and radiative fluxes
  - Measure all terms in surface heat budget to provide net heat fluxes
  - Wave statistics to quantify age of development, wave height and wave length down to short gravity waves
  - Characterization of subsurface T/S and velocity fields.

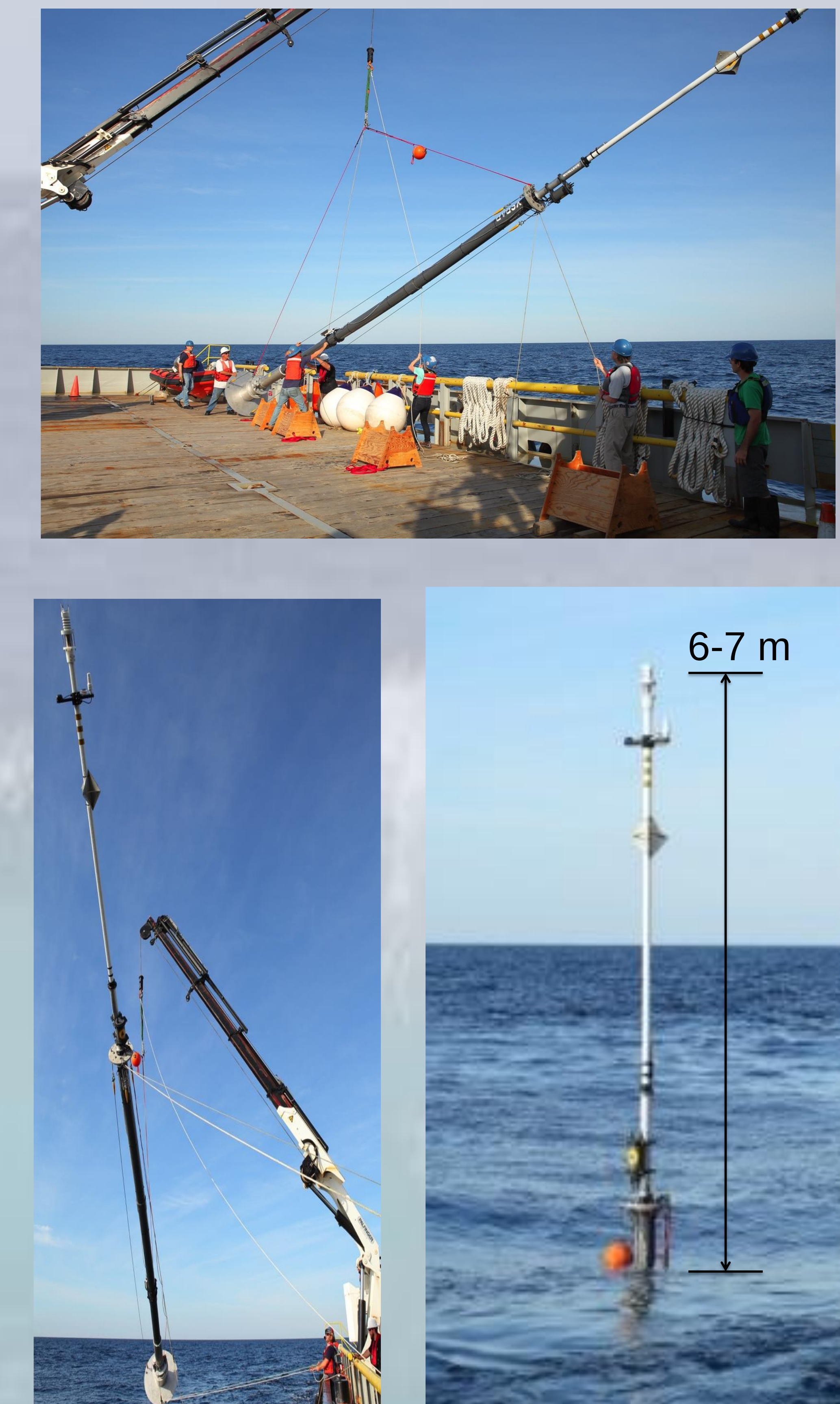


**Figure 4.** Deployment of the prototype X-Spar. The total length of the X-Spar is approximately 13 m, which will place the DCFS approximately 7 m above the ocean surface. The design greatly reduces the flow distortion that is common around ocean-going platforms and places sensors well-above the most difficult to resolve processes associated with the WBL.

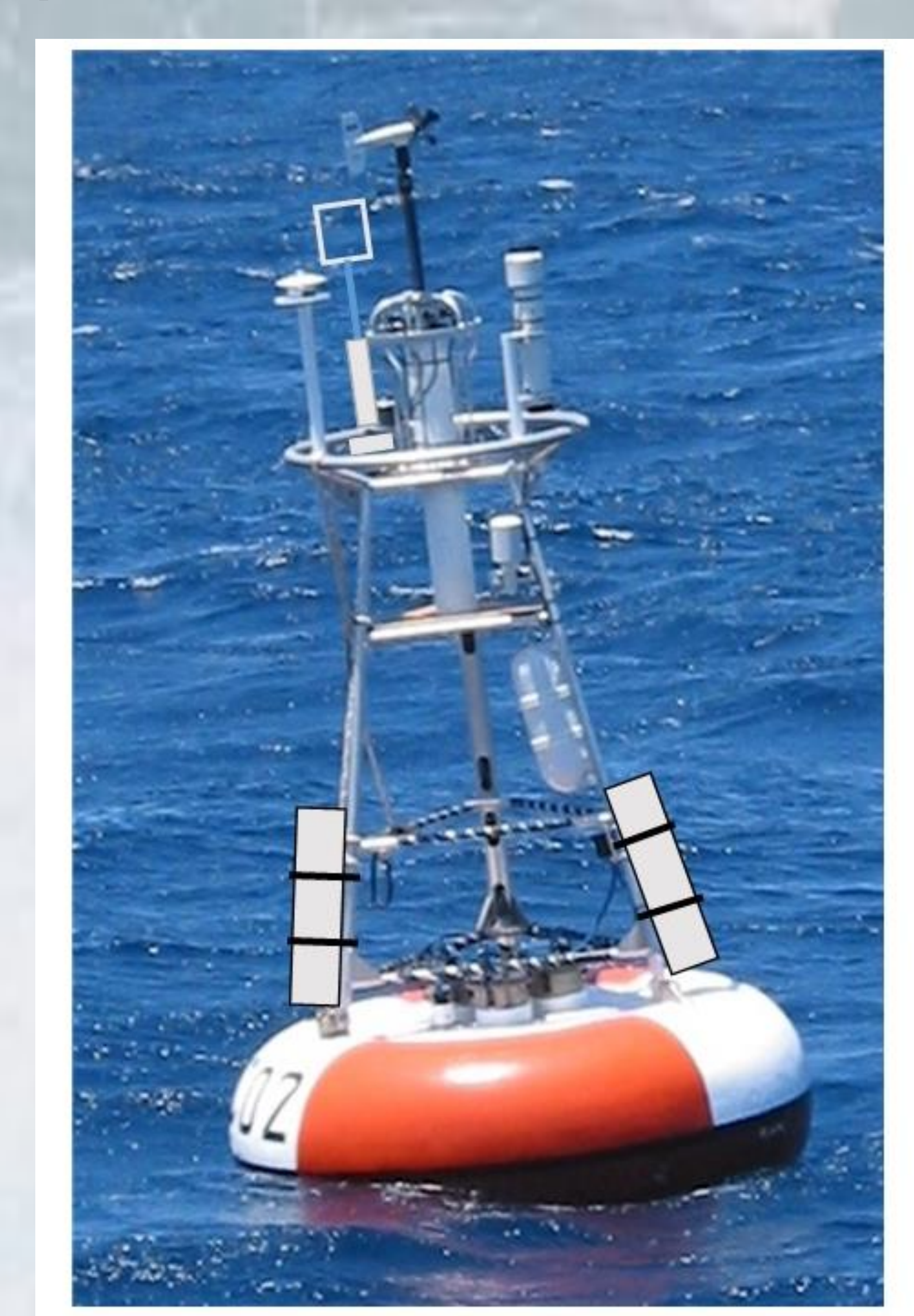

**Figure 5.** The setup envisioned for the autonomous DCFS aboard a TAO mooring. The DCFS will be placed so as not to interfere with the standard propeller-vane anemometer during initial tests. External battery packs (in well or as shown) would be used to power the DCFS