

## **An Integrated Network of *In situ* and Remote Sensors to Characterize the Somali Current**

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### **LONG-TERM GOAL**

Investigate the dynamics, structure and variability of the Somali Current, contiguous currents and other currents in western Indian Ocean, and ocean wave climate. Quantify the geostrophic and ageostrophic contributions to surface circulation, i.e. Ekman pumping resulting from the wind curl associated with local and seasonal monsoonal forcing. Use *in situ* sensors deployed in target areas over multiple seasonal monsoonal cycles to generate time-series data for analysis.

### **OBJECTIVES**

- Investigate the large scale features and the feedback mechanisms that affect the predictability of the Somali Current and western Arabian Sea Circulation
- Measure the growth of surface waves in the context of wave-current interactions during monsoonal forcing of the Somali Current
- Assess new *in situ* and remote sensor technologies and their communication protocols
- Integrate the sensor networks to facilitate data acquisition/fusion
- Develop methods to avail these data streams for assimilation into numerical models
- Introduce oceanography as an applied science to the Government of the Seychelles

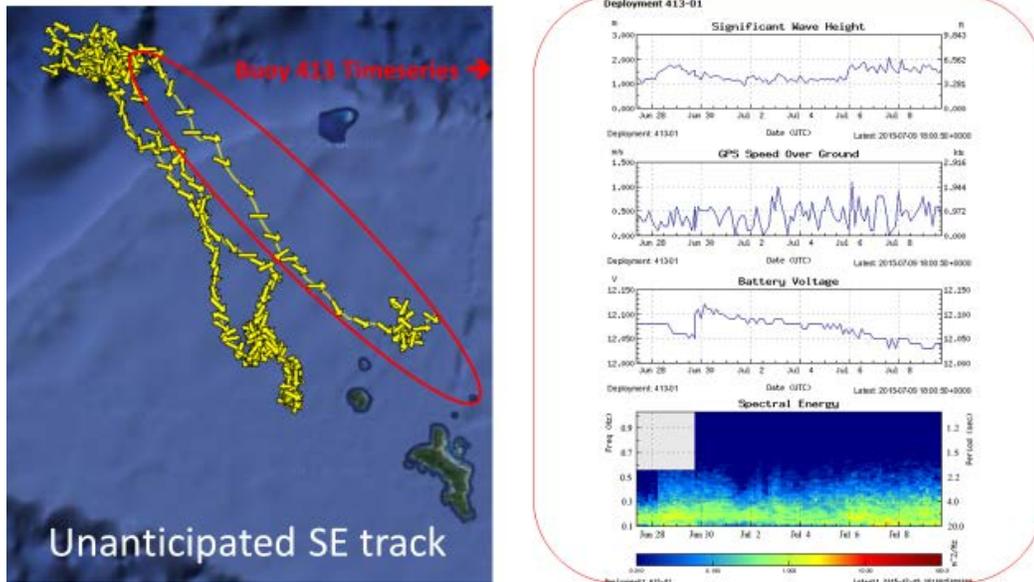
### **APPROACH**

Advances in expendable, low cost, easy to use *in situ* sensors make it possible for substantive data collection of targeted areas around the world without the expense of a traditional oceanographic investigation. Through the cooperation of host nations, navies and voluntary observing ships (VOS), a multi-year data collection plan will leverage the host nation's infrastructure and emerging sensors and communications technologies for deploying oceanographic sensors in the tropical western Indian Ocean. Collaboration with the host nations will permit routine deployment of the sensors, when and where required, using local charters for deployments when feasible.

The project will deploy Lagrangian and drifting expendable sensors that can be rapidly deployed in maritime and coastal waters at time and space scales required to better characterize the oceanography and forcing phenomena in the western Indian Ocean. Autonomous *in situ* sensors will reliably telemeter data using Iridium SATCOMS for on-scene data assessment, fusion with other data, and assimilation into numerical models. In addition to the scientific objectives of the program, these new streams of near real-time data will support Navy operational and outreach objectives, and host nation educational objectives.

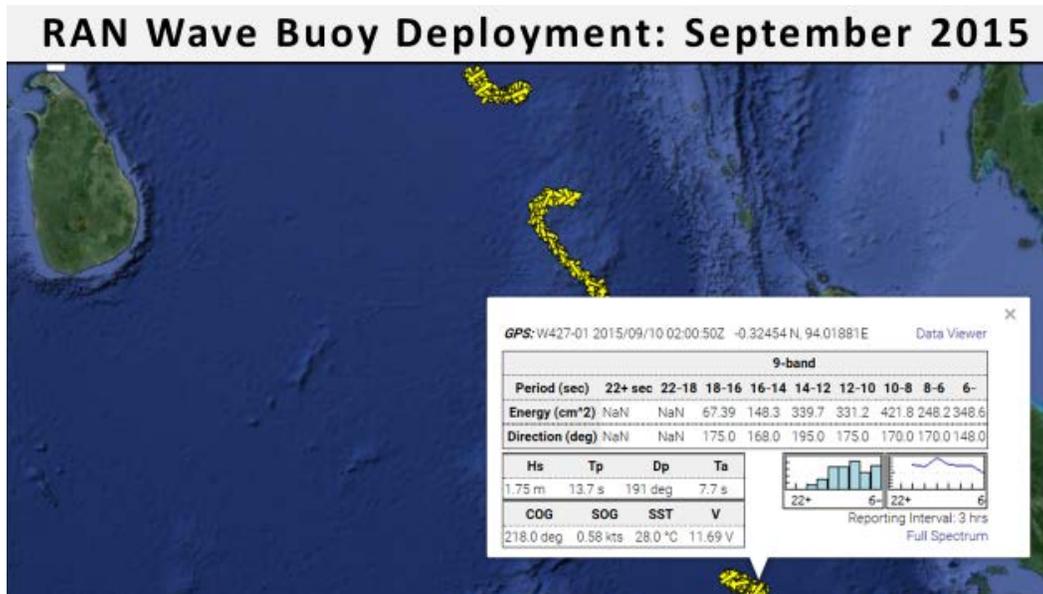
## **WORK COMPLETED**

- NASCar meetings:
  - October 2014: NASCar planning meeting, Reston, VA
  - February 2015: NASCar overview for the Royal Australian Navy and collaboration opportunity assessment, Sydney, Australia
  - June 2015: NASCar meeting planning meeting with Principal Investigators, Reston, VA
  - September 2015: NASCar overview for CNMOC/NAVO and collaboration opportunity assessment, Stennis Space Center, MS.
  
- Sensor deployments:
  - Miniature wave buoys were deployed by U.S. Navy assets, indigenous Seychelles fishing vessels and by the Royal Australian Navy (RAN) during this period of performance. Figure (1) depicts a buoy deployment evolution in June 2015 and is representative of most deployments. Miniature wave buoy deployment dates:
    - Seychelles fishing fleet:
      - January 2015
      - June 2015
    - U.S. Navy:
      - July 2014
      - April 2014
    - Royal Australian Navy:
      - September 2015



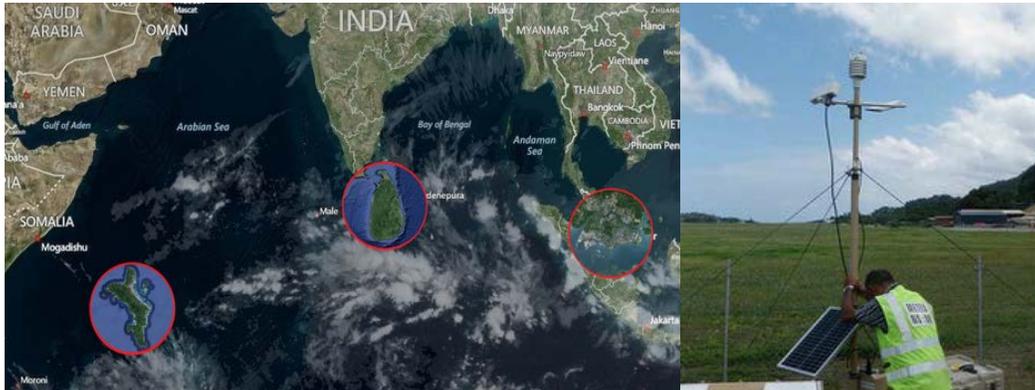
**Figure 1. Miniature wave buoy deployment in June 2015 by Seychelles fishermen.**

- The Royal Australian Navy (RAN) was the first foreign Navy to deploy sensors in support of NASCar. This burgeoning collaboration with RAN has the potential for future NASCar deployments. In addition, this milestone was highlighted by the first “remote start” of the wave buoys in the Bay of Bengal/eastern Indian Ocean (Figure 2).



**Figure 2. Three buoys were deployed by the Royal Australian Navy in September 2015. These buoys were configured with the "remote start" firmware, which permits buoys to be shipped in a "deep sleep" mode and "awakened" once per day to check whether it is in the intended deployment area.**

- XMET was deployed in support Remote Sensing of Atmospheric Waves and Instabilities (RAWI), an atmospheric subset of NASCar designed to study atmospheric intraseasonal phenomena spanning time scales from minutes to months (Figure 3). Specific dates:
  - Seychelles: January 2015
  - Singapore: December 2014

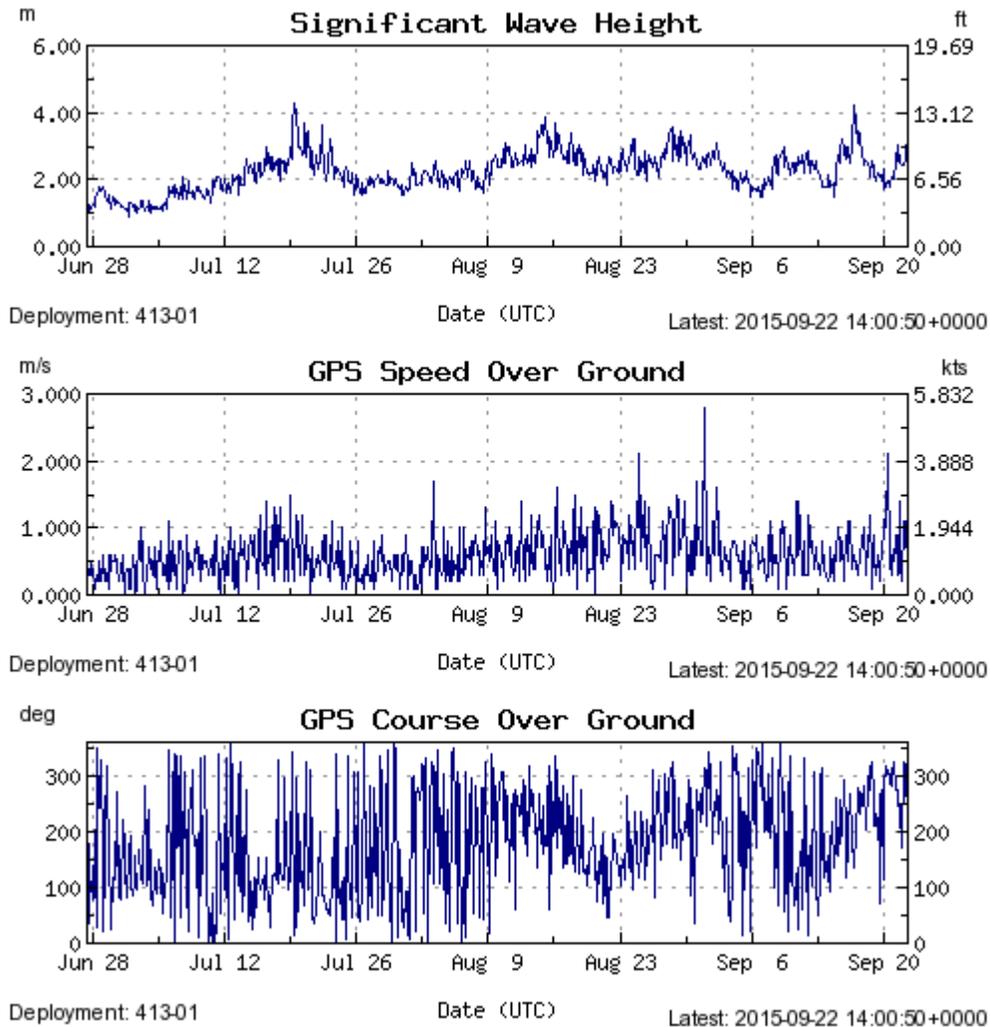


**Figure 3. Left Panel: RAWI sensor deployment sites. XMET was deployed to the Seychelles and Singapore. Right Panel: XMET being set up in the Seychelles.**

## RESULTS

- Logistics: In support of NASCar, a logistical center of gravity was established in Mahe, Seychelles. The Better Life Foundation (BLF), a Seychelles based non-governmental organization, now functions as the NASCar liaison, coordinating shore logistical support and boat charter requirements. During this reporting period, BLF supported multiple miniature wave buoys deployments and a XMET deployment. Although at a level of activity lower than anticipated, the shipping and deployment process was evaluated as viable and suitable for continued deployments based out of Mahe, Seychelles. An outcome of the deployment tests is that it might not be feasible for drifters deployed in the Seychelles to reach the full extent of the NASCar study area.
- Buoy Deployments:
  - Seychelles Deployments: Preliminary findings suggest that during the periods of deployment most of the Lagrangian/driftng sensor deployments from the Seychelles have not accessed the target areas in the western Indian Ocean and North Arabian Sea (NAS). Deployments by the Seychelles fishing fleet is restricted to a 100nm maximum distance from Mahe, Seychelles.
  - U.S. Navy Deployments: Deployment from Navy assets were in, or close to, the Somali Current and yielded exfilled data from the areas of interest.
  - Royal Australian Navy Deployments: Deployments by RAN were along vessel track and thus restricted to the eastern Indian Ocean and southern Bay of Bengal. Establishing a collaboration with RAN was a higher priority than buoy deployment location for our first engagement.

- Data: Although the number of miniature wave buoy deployments was less than anticipated, time series of surface current data highlight variability in surface currents. A representative miniature wave buoy time series of significant wave height, GPS speed over ground, and GPS course over ground are depicted in Figure (4). Preliminary comparison of miniature wave buoy speed and course with applicable archived 1/12° Global HYCOM “Arabian speed and currents” was performed. The goal was to evaluate these observations to assess the contribution and relationship to local and remote forcing and contribute to a better understanding of the surface circulation in the western Indian Ocean.



**Figure (4).** Representative time-series data from a miniature wave buoy deployed north of the Seychelles by a Seychelles chartered fishing vessel.

Expeditionary Meteorology (XMET) Sensor System: XMET was deployed to the Seychelles and Singapore to provide meteorological observations in support of a NASCar ancillary atmospheric investigation of large and small scale intraseasonal atmospheric phenomena.