Abstract
We describe a novel approach to physical oceanography by coordinating remote sensing, multiple autonomous vehicles and ship borne sensors. In contrast with conventional oceanography where ships are the single point of sampling in the middle of a big ocean or are used simply as the base of operations from where autonomous vehicles are deployed, we propose a new approach where ship and autonomous vehicles are coordinated together via satellite communications. We conclude with results and lessons learned from a real-world deployment of the R/V Falkor oceanographic ship together with multiple autonomous vehicles to study the Pacific’s Subtropical Front, 800 miles off the coast of San Diego.

Keywords – Physical Oceanography, Autonomous Vehicles, Remote Sensing.

I. INTRODUCTION
Our world is covered by a large, deep and mostly unknown ocean. A vast amount of physical oceanography uses scientific models together with remote sensing to grasp the complexity of its processes but this has several limitations. For instance, many properties of the water cannot be sensed remotely and satellites can only measure a few meters on the surface of the water. As such, in-situ sensing is still required to have a deeper understanding of processes and their manifestation under the water surface.

Oceanographic ships such as R/V Falkor from Schmidt Ocean Institute (SOI), have the capability to sample water down to hundreds of meters but only at one point at a time. Autonomous vehicles can acquire similar data at a fraction of the cost and do it at physically distributed locations simultaneously, contributing to a synoptic observation of the ocean.

Study of submesoscale ocean phenomena such as eddies, filaments and meanders requires high resolution in-situ sampling that can be addressed only with oceanographic models. The software developments were fundamental to be able to coordinate the vehicles over Iridium while maintaining good situational awareness. In the end, a very good map of the front was produced and our knowledge of the STF front has improved considerably.

III. CONCLUSIONS
The developed system was successfully used onboard R/V Falkor to detect the STF front and later map with unprecedented resolution a filament of this front. This was possible only by having the scientists on ship and in land driving the campaign with access to both real-time data coming from the vehicles over Iridium and oceanographic models. The software developments were fundamental to be able to coordinate the vehicles over Iridium while maintaining good situational awareness. In the end, a very good map of the front was produced and our knowledge of the STF front has improved considerably.

REFERENCES


Fig 1. Fleet of autonomous vehicles deployed from R/V Falkor (left) and Scientists using real-time data from vehicles and oceanographic models to decide next surveys (right)