S-MODE Field Experiment Report 2021-05-18 & 2021-05-19

Summary: The previous data collections had been too cloudy to acquire good data for MOSES, so the remainder of the campaign prioritized the validation and calibration of MOSES. On 2021-05-18 the weather was forecast to be clear at the ONR TFO site and a joint campaign with MASS and the SIO wave gliders was planned, with a collection en route over the WHOI wave glider, which was still collecting data in the line near Santa Catalina Island. To maximize the chances of clear skies, a southern flight route was taken, which limited the data collection time at the ONR TFO site. Once the flight started, clouds formed over most of the track, especially at the TFO site. MASS collected data at the TFO site after it was able to dive under the clouds and fly at 900 feet above sea level. The NASA B200 collected data over both Catalina and TFO sites, with good data collected by DopplerScatt for the entire transect, but only limited data for MOSES. The conditions over all the sites included a range of winds varying from very weak to gale-force, and wave conditions including wind driven waves and large swell. The ocean models forecast eddy activity along the flight path. This variety of conditions helped to achieve one of the goals of the campaign: collecting data with all of the instruments under a large range of environmental conditions. Since MOSES only had partial success on 2021-05-18, it was decided that a final MOSES calibration flight over Lake Tahoe, California, would be collected. This flight was conducted successfully on 2021-05-19, drawing to a conclusion the data gathering part of the campaign.

The campaign conducted from May 5 to May 19 collected data on 6 flight opportunities. Although the “May Gray” Southern California weather conditions made the campaign planning challenging, the AFRC and TOI flight crews showed flexible planning capabilities and many lessons were learned that will help in planning the logistics of the October campaigns.

The following list summarizes the campaign achievements as related to the original campaign goals:

- **Goal 1- collect simultaneous current data with DopplerScatt, MASS, and wave gliders under a variety of environmental conditions:** DopplerScatt collected simultaneous data with wave gliders on all 5 ocean flights. DopplerScatt, MASS and the wave gliders collected data on two ocean flights: May 7 and May 18. The winds ranged from completely calm to gale-force, and waves ranged from nearly flat to 5 m SWH. Both wind and swell were present. The currents varied from strong tidal currents near Santa Catalina/San Clemente to mesoscale in the off-the-shelf ONR TFO site. Current features included mesoscale and submesoscale features identified in SST and ocean color satellite imagery.
- **Goal 2- demonstrate MOSES measurement capabilities:** MOSES is a new installation on the NASA B200 with an upgraded camera from previous systems.

Clouds limited MOSES data collections, but a data collection over cloud-free Lake Tahoe should be sufficient to assess the camera health and capabilities.

- **Goal 3- demonstrate wave glider operations as they will be conducted during the forthcoming Pilot and IOP campaigns:** the wave gliders (WHOI and SIO) demonstrated piloting and NRT reporting capabilities. This included formation sailing to compute current derivatives (on May 18, Figure9 below).
- **Goal 4- demonstrate mission planning capabilities and operations and gather lessons learned for future campaigns:** Planning around the changing weather was a lesson that will be very useful in the next campaigns. The usefulness of *in situ* weather and cloud conditions, as collected by the R/V Revelle, proved invaluable for planning. On the other hand, the accuracy of state of the art weather models to forecast cloud conditions and location with the fidelity required to plan flights proved insufficient for planning data collection by the optical instruments. Models were sufficient to predict wind conditions to predict the feasibility of DopplerScatt measurements. DopplerScatt demonstrated good data collection capabilities for wind speeds above 3-4 m/s. Another lesson learned was the need for air-to-air, air-to-base, and air-to-ship communications. The MASS team used an Iridium system for texting which proved invaluable for handling changing weather conditions. On the other hand, VHF and satellite phone communications were insufficient on various occasions for air-to-air and air-to-base communications for the B200 team.
- **Goal 5- demonstrate NRT data product capabilities for mission planning:** The wave gliders had NRT products available on demand during the campaign. Only the DopplerScatt team was able to produce quick-look products among the airborne instruments, albeit at a slower rate than expected: after uploading the data to the processing computer, DopplerScatt NRT products were ready about 18-24 hours, rather than the planned 12 hours. This was partly due to having to retrain geophysical models as part of the processing, given that the data included wind speeds not previously encountered in training. However, it is also possible that a faster processor may be required during the campaign and the DopplerScatt team is assessing upgrading its capabilities. The MASS team was unable to process due to other commitments to the ONR TFO campaign, so their capability remains untested. MOSES showed that additional calibration and tuning is required before delivering useful NRT products. The MOSES team will use the Tahoe and other cloud-free data to calibrate, or fix, if required, the FLIR camera. The camera should be calibrated by the Pilot deployment.

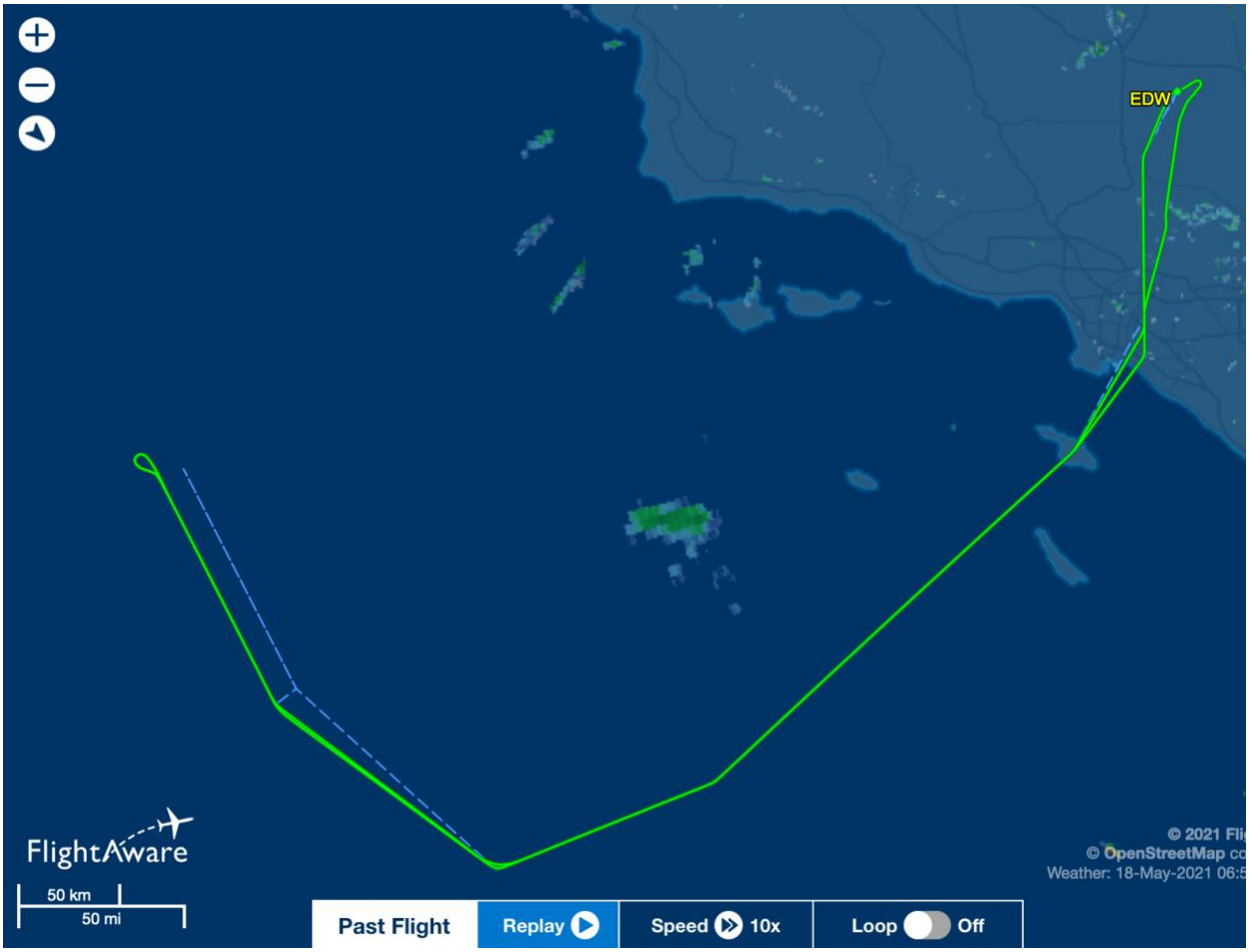

Figure 1: NASA 801 flight path for May 18.

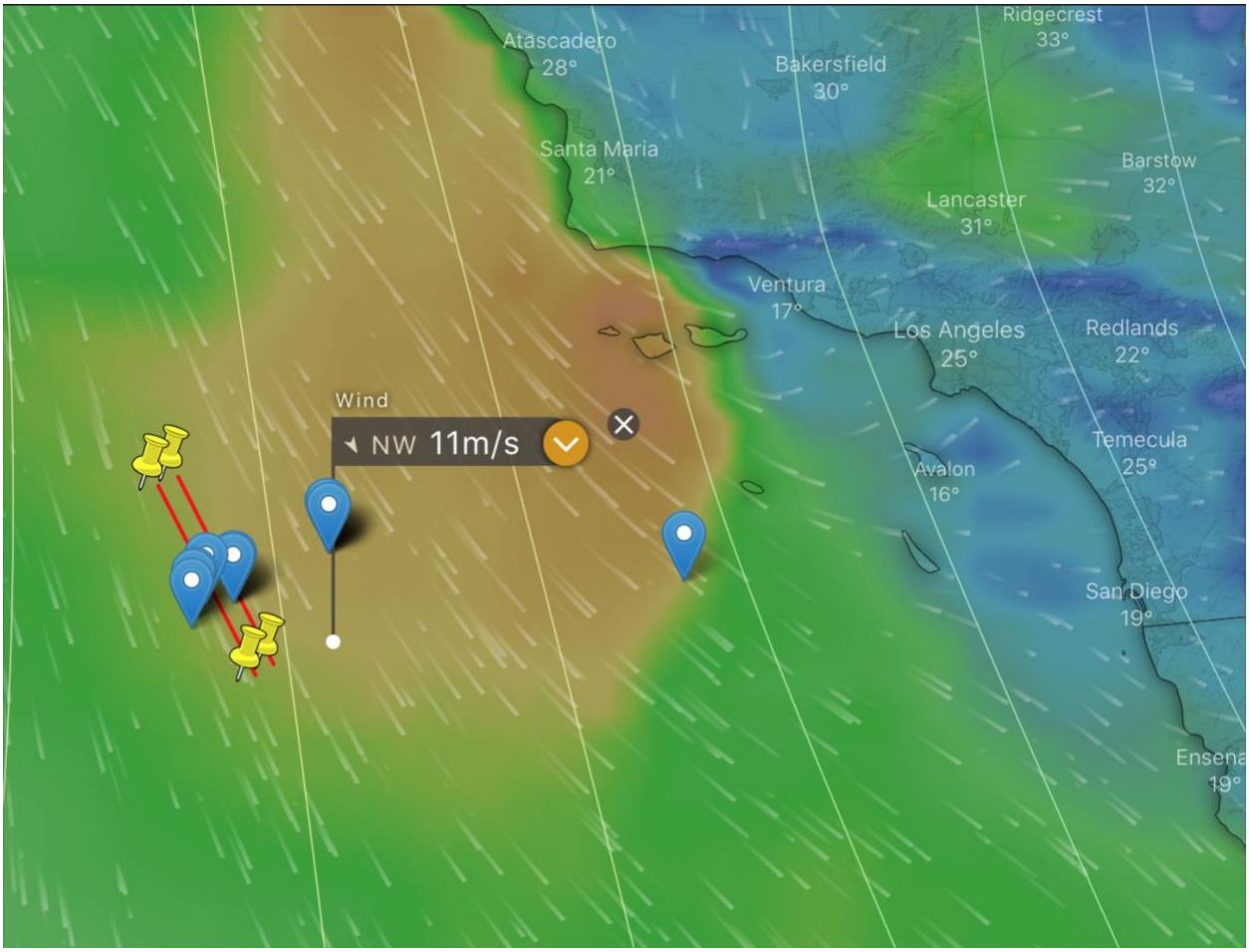

Figure 2: Wind conditions during the May 18 deployment. The B200 TFO lines are shown in red and the markers show the location of the in situ assets. The winds ranged from below 3 m/s to above 12 m/s during the flight.

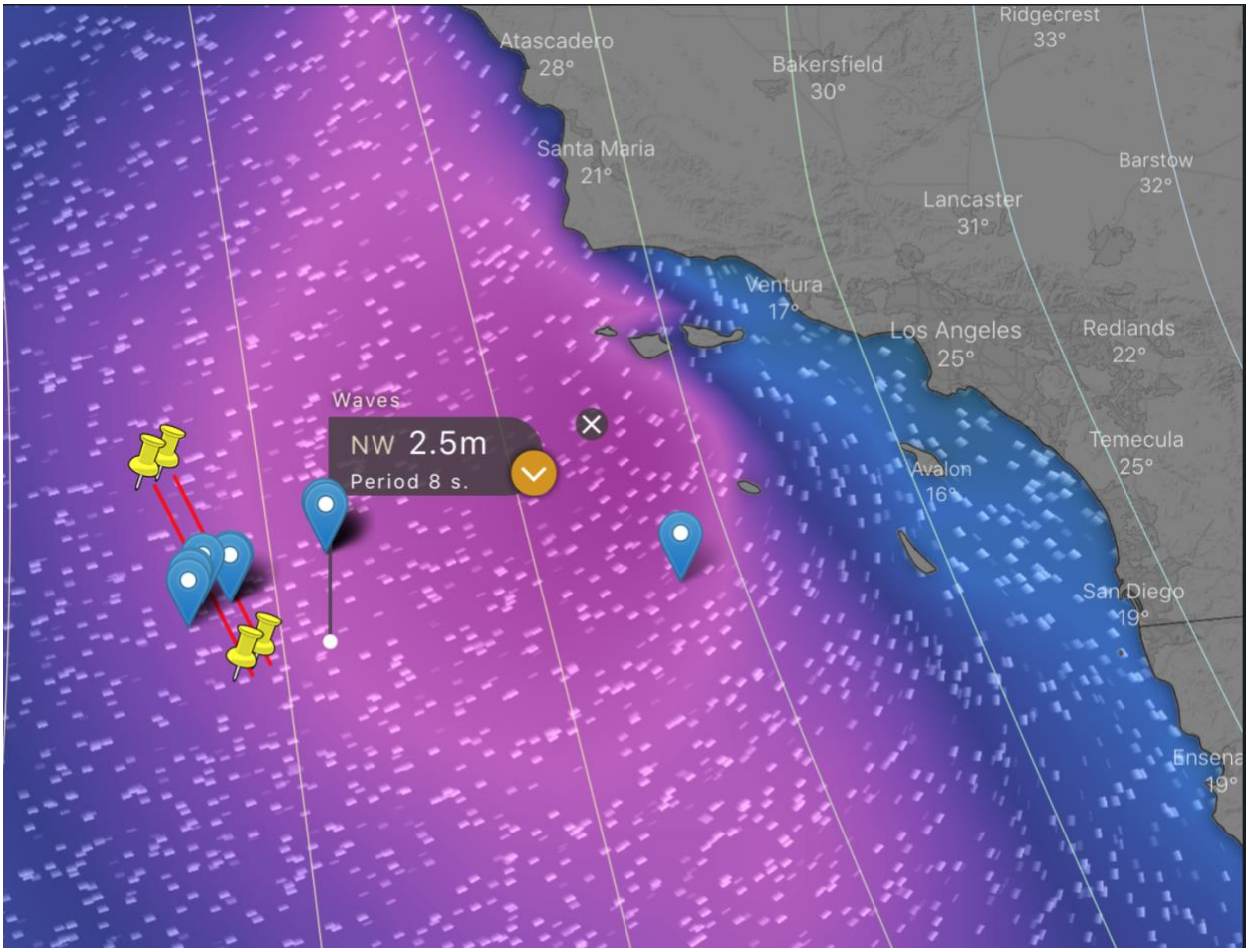

Figure 3: Surface wave conditions during May 18. The wave SWH over the flight path ranged from below 1 m to above 2.5 m. Both wind driven and perpendicular swell waves were present.

Figure 4: Pilots Hernan Posada and Jeff Borton (NASA AFRC) on May 18 NASA 801 flight.

Figure 5: Operators Delphine Hypolite (MOSES/UCLA) and Hector Torres (DopplerScatt/JPL) ready to take off.

Figure 6: Cloudy conditions over the TFO site from 28,000 ft. The MASS Twin Otter was able to penetrate below the cloud deck and fly at 900 ft.

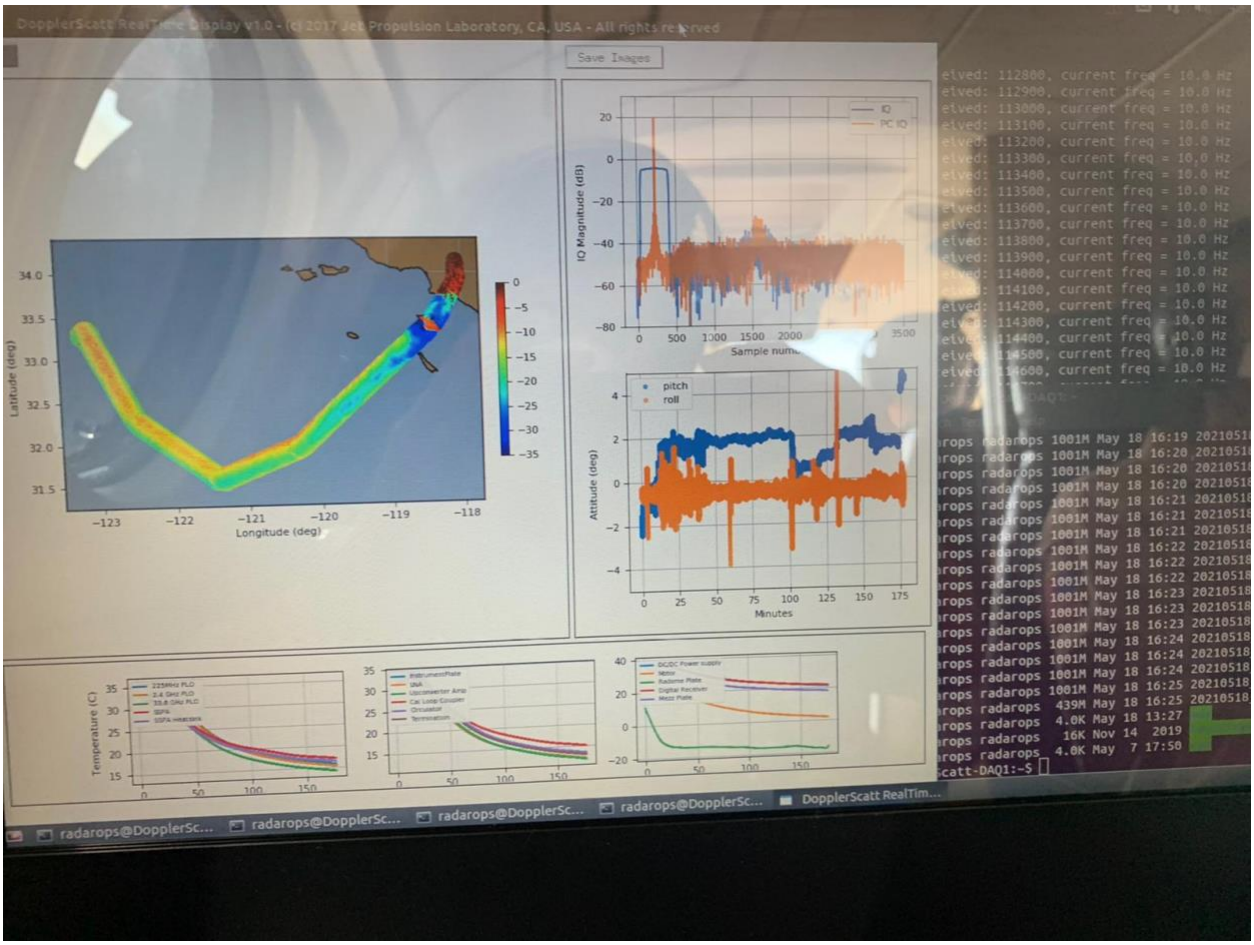

Figure 7: DopplerScatt real time display showing back scatter data collected up to the TFO site.

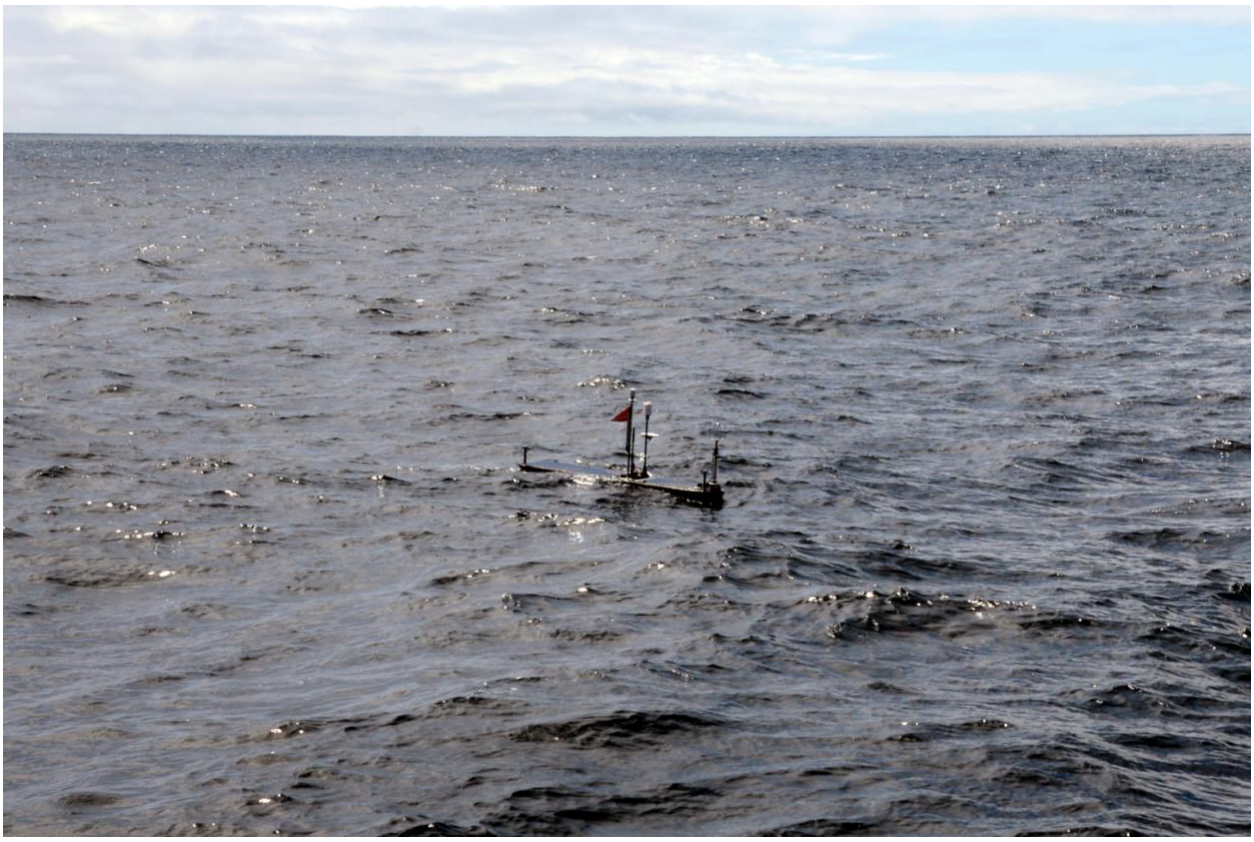

Figure 8: SIO wave glider at the TFO site as seen from the R/V Revelle.

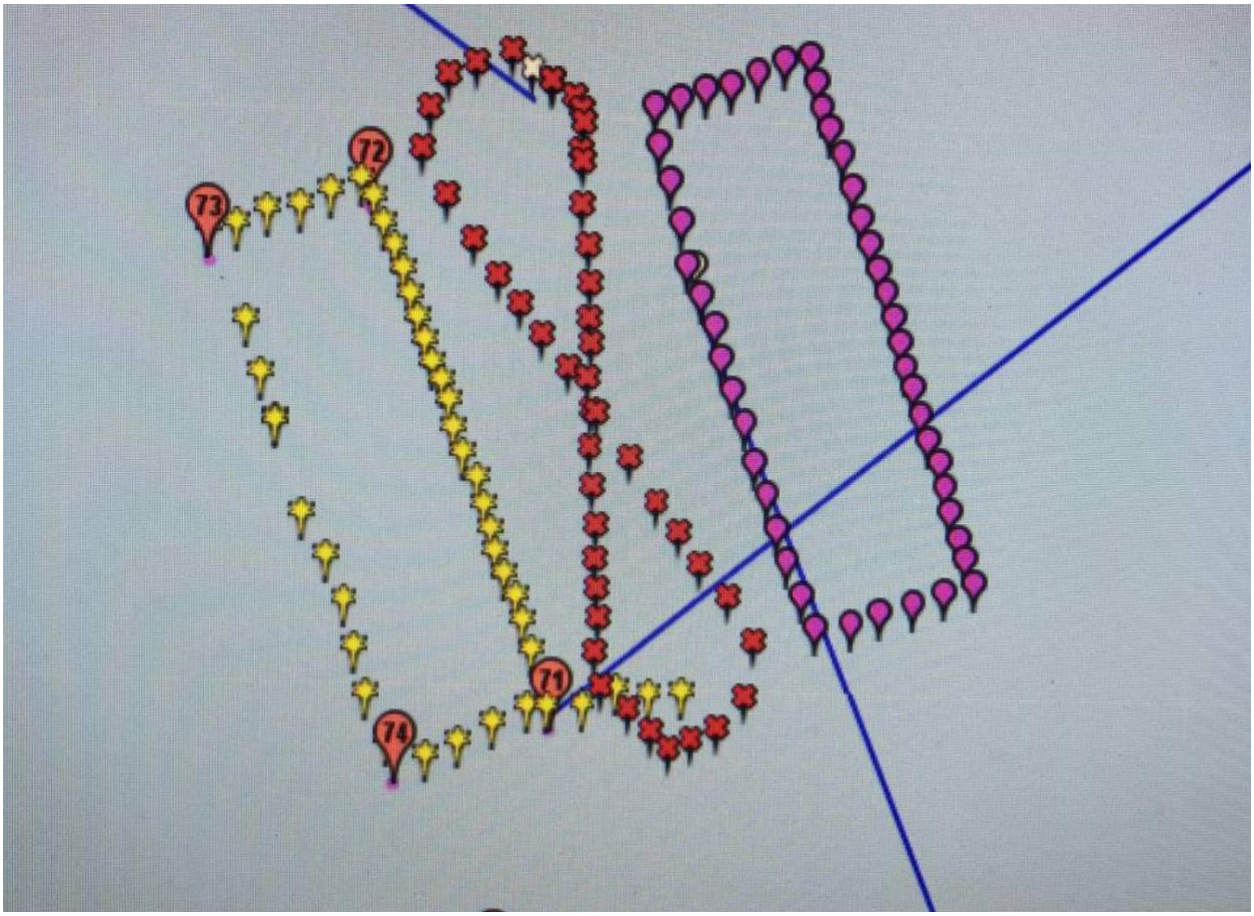

Figure 9: SIO wave glider GPS locations for 3 gliders collecting patterns that enable current derivative estimation. These actual tracks were collected on May 18 under heavy winds and wave conditions. The 'square' made up by the group of three Wave Gliders is about 2.2 km on a side.

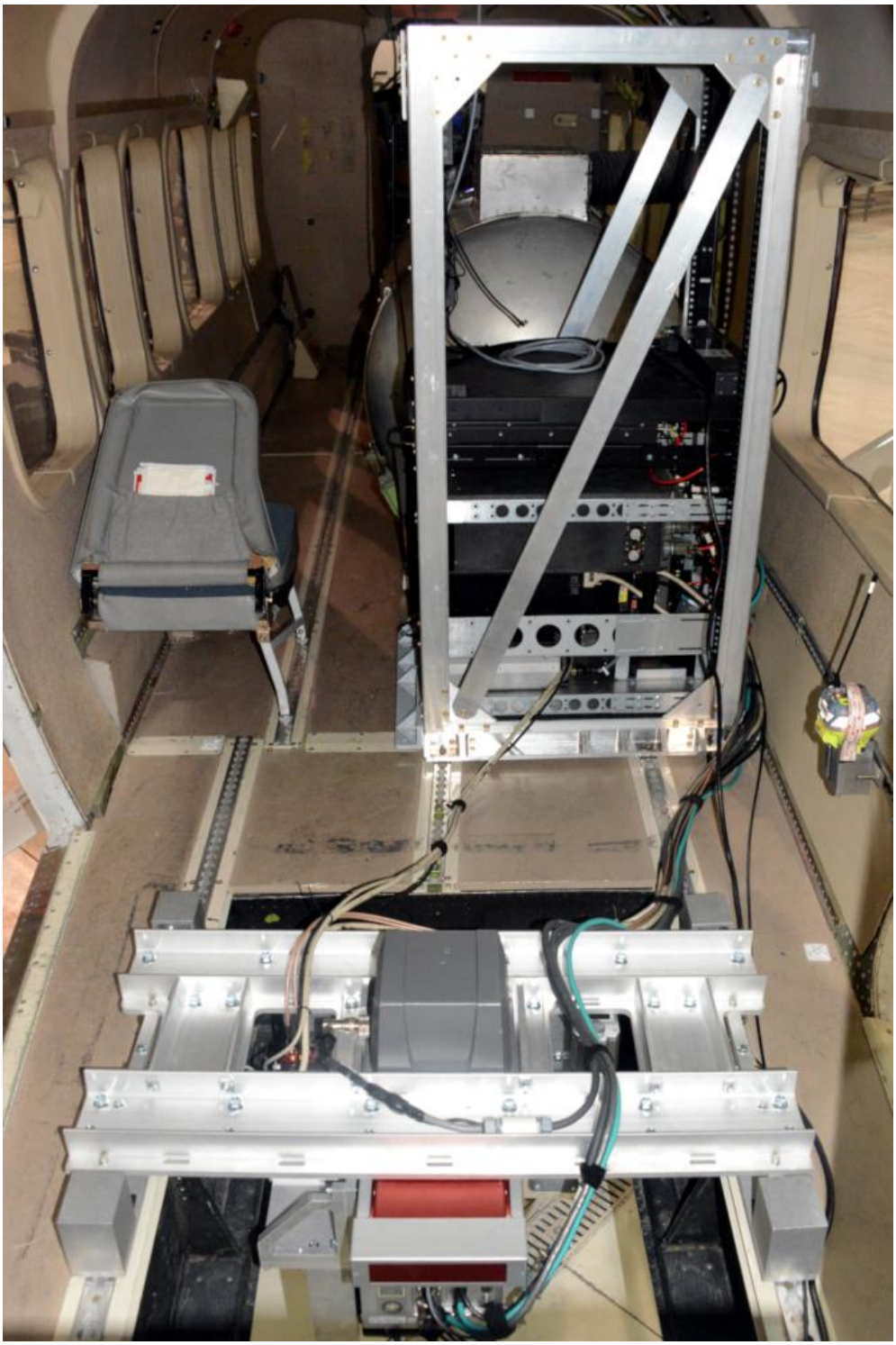

Figure 10: MASS instruments and control racks mounted on the TOI Twin Otter.

Figure 11: Strong wave breaking, wind streaking, and waves observed by the MASS team from the Twin Otter flying at 900 ft on May 18.

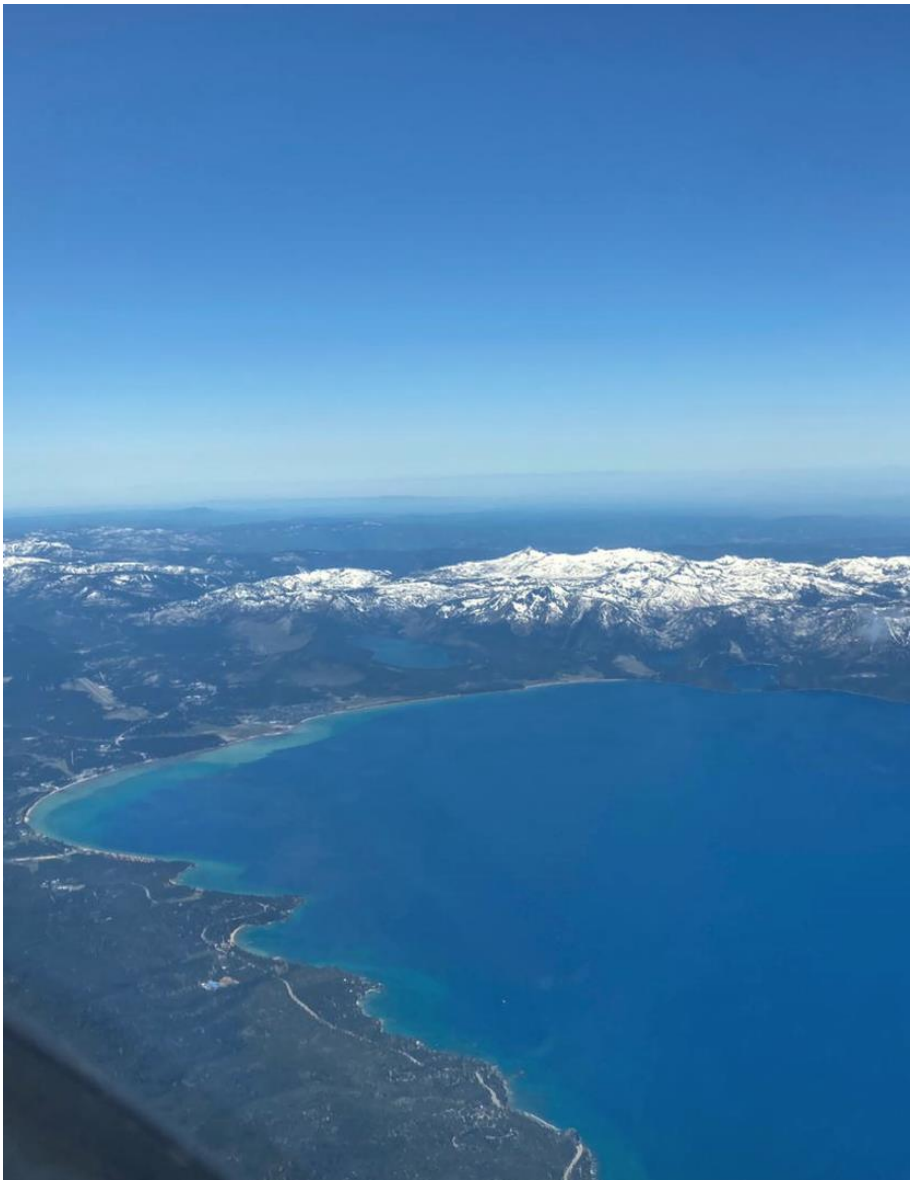

Figure 12: Lake Tahoe, California, during the May 19 MOSES calibration flights.

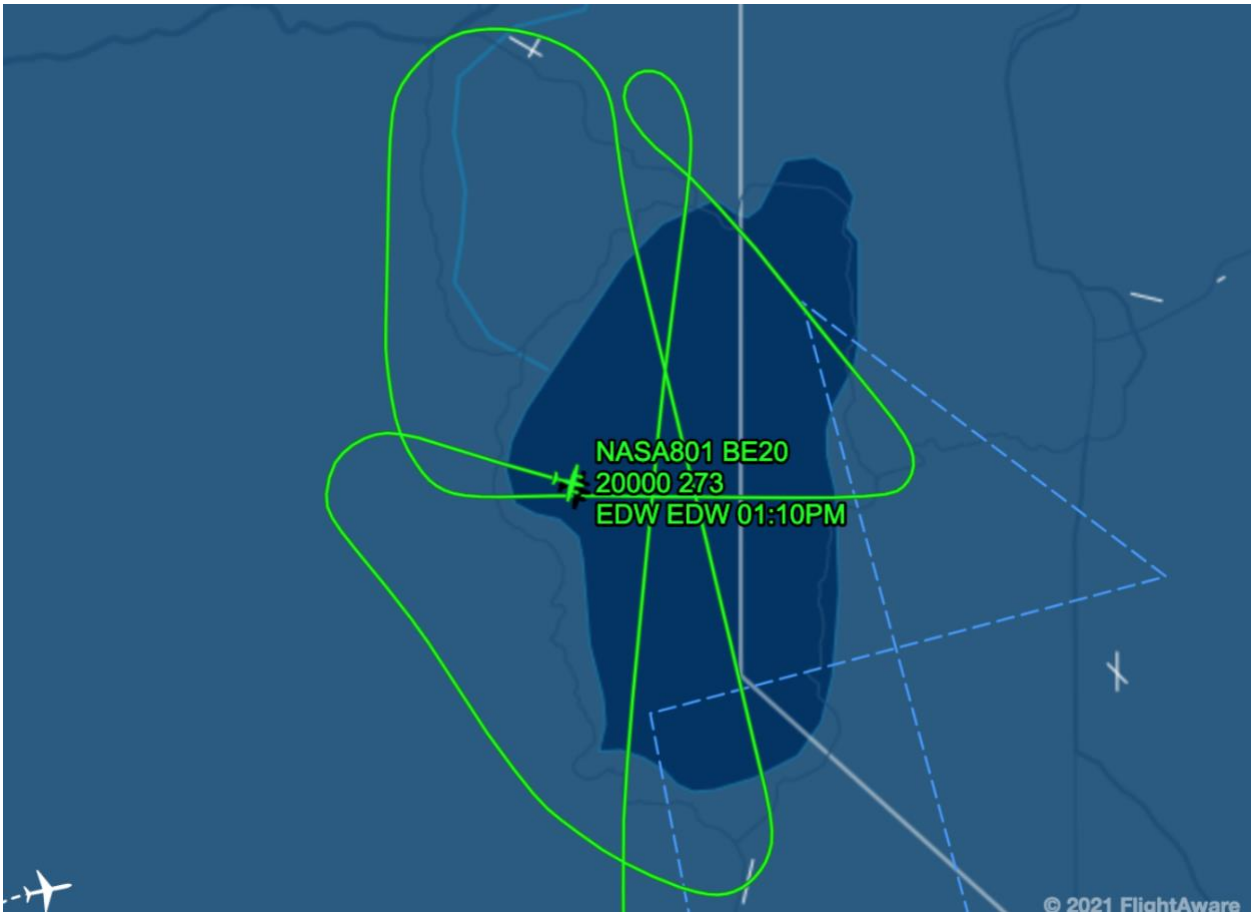

Figure 13: Flight pattern flown over Lake Tahoe by the NASA 801 on May 19 for the MOSES calibration flight.