Investigating Operational Applications of SWOT

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The US National Oceanic and Atmospheric Administration (NOAA) uses satellite radar altimetry data to supply sea surface heights, waves, and surface wind speeds and products derived from them to a wide range of operational users. Nadir altimetry is supplied to forecasters in the Ocean Prediction Center, assimilated into operational ocean models, and processed into products like upper ocean heat content (OHC) for tropical cyclone intensity forecasting. Altimetry is particularly critical for tropical cyclone intensity forecasting and safe navigation. As wide-swath altimetry matures, there will be several challenges for constructing regular two-dimensional fields of sea surface height to be suitable for use in NOAA applications, which are oriented towards safeguarding the life and property of the inhabitants of the US and its territories, promoting healthy marine ecosystems, and supporting sustainable fisheries.

NOAA's latency requirements for altimetry products range from three to five hours for marine forecasters to months for modeling reanalysis efforts. The latencies needed for OHC and operational data assimilation into ocean models are one to two days, which is potentially compatible with quick-look products from SWOT. The Laboratory for Satellite Altimetry (LSA), which is part of the Center for Satellite Applications and Research (STAR) of NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), has a mandate to research and develop operational altimetry products for NOAA and to assist in data assimilation of altimetry into ocean forecast models.

In preparation for the launch of SWOT (and future wide swath altimetry missions) and through using early SWOT mission data, we propose to answer questions about the utility of high-resolution altimetry for operational applications, including:

1) What are the optimal techniques for combining near-real time nadir and delayed SWOT data for operational products?
2) Is the sampling of sea surface heights by the altimetry constellation the most important constraint in determining OHC for tropical cyclone intensification forecasting?
3) Does the advent of swath altimetry call for new approaches for inferring OHC?

Central to this investigation will be our use of the Radar Altimeter Database System (RADS). Developed first at Delft University of Technology, and now developed and maintained jointly by LSA and EUMETSAT, RADS was established to maintain a harmonized, validated, and cross-calibrated sea level data base from all satellite altimeter data and associated corrections. Over more than twenty years RADS has grown to become a mature altimeter database and one of the most accurate and complete sources of satellite altimeter data available. RADS serves as a crucial tool for NOAA and EUMETSAT in the cal/val of the Sentinel-3 and Jason series, providing essential statistics, colinear and crossover differences. Unlike other altimetry databases, RADS includes the near-real time data streams and serves as a platform to generate NOAA's operational gridded altimetry products and homogenized L2P products provided to the National Weather Service and the National Ocean Service for data assimilation into numerical models.

Our overall objectives are i) to develop a method for incorporating wide swath altimetry into a harmonized gridded sea level anomaly (SLA) product including nadir sea altimetry within RADS, ii) to test the degree to which inclusion of SWOT data enhances the spatial and temporal accuracy of OHC estimates, and iii) to develop recommendations for the optimum configuration of an operational altimetry constellation that includes both nadir and wide-swath altimeters. An example application is detailed below.

Our Team

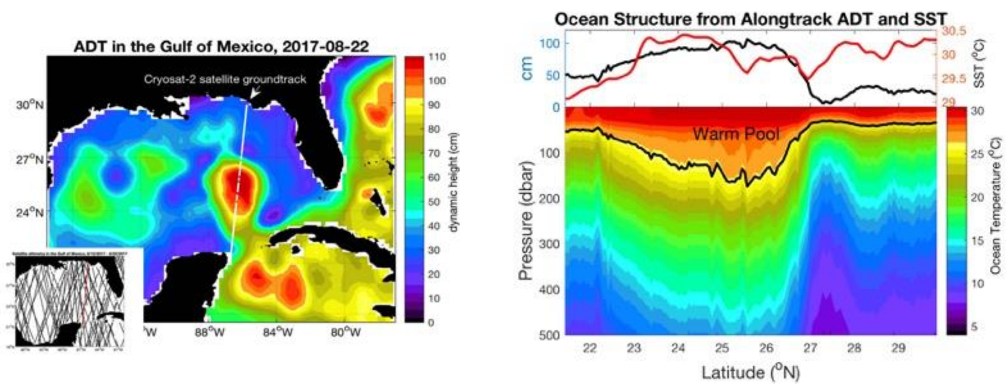

Figure 1 a (left) and b (right). a) RADS optimally interpolated, gridded near real-time absolute dynamic topography (ADT) for 2017-08-22. A map of all available groundtracks from the 10 preceding days is superimposed at the lower left. The groundtrack for CryoSat-2 has been overplotted. b) Upper panel: CryoSat-2 ADT and Geo-Polar 5 km SST, interpolated along the CryoSat-2 track. Lower panel: High resolution upper ocean heat content from NOAA's developmental OHC product, calculated directly from CryoSat -2alongtrack L3 data. The altimetry and corresponding high-resolution EDT fields depict a sharp subsurface front between 26°N - 27°N, at the edge of a Loop Current eddy. In the ¼-degree gridded data, this would be represented by only 4 - 5 grid cells, whereas in the alongtrack CryoSat-2 data, it has been sampled 14 times. New algorithms such as this may be required to leverage the information available from SWOT.

Eric Leuliette, Deirdre Byrne, Walter H.F. Smith, and Alejandro Egido all work in NOAA's Laboratory for Satellite Altimetry. Dr Leuliette is one of the co-developers and maintainers of RADS. Dr. Byrne is working on a new high-resolution algorithm for upper ocean heat content and in this work, conducting an extensive comparison of altimetry to hydrographic measurements. Dr. Smith is well known for his fundamental contributions to marine geodesy, especially applying satellite altimetry to bathymetry, physical oceanography, and oceanic tectonics. Smith has been a proponent of SAR along-track Doppler beam sharpening and cross-track interferometry for ocean measurement since 2001 and with Dr. Egido, has developed the Fully-Focused SAR (FF-SAR) algorithm, which has been shown to measure water heights with

½ meter along-track resolution. Dr. Egido is NOAA's Measurement Systems Engineer for the altimetry missions and is working to operationalize FF-SAR for NOAA.