Bathymetric extraction from ICESAT-2 Advanced Topographic Laser Altimeter System photon returns: Depth penetration in diverse geophysical contexts.

Coveney, S., Dublin City University, seamus.coveney@dcu.ie

Monteys, X., Geological Survey Ireland, xavier.monteys@gsi.ie

Kelleher, B., Dublin City University.

Hedley, J.D., Numerical Optics Ltd.

Bathymetric measurement using remotely sensed data acquired in shallow-water marine contexts generally incurs challenges regardless of acquisition method. Multibeam sonar can be challenged with respect to survey vessel access and diminishing swath width, Airborne Laser Bathymetry is often affected by nearshore wave action and turbidity, and Satellite Derived Bathymetry can be complicated by local variations in water-column backscatter and bottom reflectance.

The NASA ICESat-2 (Ice, Cloud and Land Elevation Satellite-2) acquires elevation data for the global monitoring of temporal elevation change in ice caps, glaciers, sea ice and forests. The ICESat-2 Advanced Topographic Laser Altimeter System (ATLAS) issues three along-track parallel pairs of laser beams set 3.3km apart at a Pulse Repetition Frequency of 10,000 points per second (equivalent to 0.7m ground resolution). Returning photons (approximately 10 only are required from the trillions of photons within each laser pulse) are captured as returns from 1387 orbit tracks, which repeat every 31 days. While the ATLAS instrument is not intended for bathymetric measurement, ATLAS Global Geolocated Photon data (ATL-03) acquired over water may include laser returns from the seabed. Evaluation by the ICESat-2 research team indicates the potential for bathymetric measurement to depths of 30m in sub-tropical waters. ICESat-2 bathymetric measurement errors of approximately 0.5m RMSE were highlighted using ALB reference data, with a sub-decimetre error component attributable to laser refraction beyond 30m.

The EO-Intertide project, based at Dublin City University in Ireland and funded by the Irish Geological Survey research programme, is evaluating the potential for bathymetric inference using ICESat-2 data acquired across a wide range of seabed conditions around the entire Irish coast. Initial results demonstrate the potential for bathymetric measurement from ICESAT-2 to depths of between 5 and 20 metres, depending upon seabed sediment type and exposure to ocean swell conditions. A repeatable method is applied within the EO-Intertide project to extract bathymetric ATL-03 photon returns, using ATL-03 photon confidence scores in conjunction with a 3D spatial-data selection approach and a custom local elevation filter.

The elevation accuracy of the extracted ICESat-2 bathymetric profiles are validated using combination of published Multibeam Echosounder (MBES) and airborne Laser Bathymetry (ALB) data acquired under the Integrated Mapping For the Sustainable Development of Ireland's Marine Resource (INFOMAR) project. INFOMAR is the seabed mapping programme jointly operated by Geological Survey Ireland and the Marine Institute. It is anticipated that extracted ICESAT-2

bathymetric profiles will provide a valuable input to EO-Intertide nearshore / intertidal bathymetric model generation from Sentinel-2 tidal-shoreline extractions and Satellite Derived Bathymetry (SDB). Validated bathymetric models issuing from this process will subsequently be applied as an input to the analysis of nearshore sediment dynamics within the Dublin City University PREDICT research project, to which the EO-Intertide project is allied.