

Cullen Scholarship: Novel techniques for the calibration of high precision sea level monitoring stations and development of associated Data quality control techniques (PhD Award)

Background

The increased focus on essential climate variables (ECV's) has meant that policy is beginning to implement operational environmental observation more widely.

Sea level change is considered a key ECV due to the proximity to the oceans of a significant proportion of global populations and economic centres. Changes in sea level present a threat to adjacent land areas through the impact of changes in sea level and other exacerbating factors such as increased storminess and increased average global temperatures, which feed back into greater thermal expansion of water masses.

In recent years, Ireland has benefited from global efforts to monitor the status quo and model future likely changes in sea level. There now exists a requirement to build on this through the installation of local high precision Global Sea Level Observing System (GLOSS) installations at several sites in Ireland. The objective is that the resultant data will feed into global models and data assembly centres directly, while also providing information at a local scale.

The calibration of water level (tide) gauges presents a number of complex hurdles to overcome. There are a range of traditional approaches that have proven acceptable for general purpose tidal monitoring, which in the case of the Irish National Tide Gauge Network has been determined to be within 25mm. For sea level change monitoring, however, very much greater accuracy and precision is required to achieve a level of uncertainty of 10mm. An emerging research question therefore is what is the best approach to operationally calibrating these gauges to the required accuracy?

With growing interest in this work leading to observation by Irish operational teams, it would be timely for a review to be undertaken of classic and more recent approaches to tide gauge calibration and research on new approaches which are implementable in an operational context. This work aims to complete such a review, with the focus to build on these and recent innovations to apply new technology and ideas to an age- old problem, how to best accurately and precisely measure sea level relative to a fixed quayside and to assess the current quality of such a calibration. It also proposes research into novel approaches to real-time assurance of the quality of the calibrations and expanded, user-focussed data products for sea level observation within Ireland.

Proposal

We propose a structured four-year PhD programme on a full-time basis to develop and implement a high precision calibration scheme for the Irish national tide Gauge network and associated GLOSS sea level change monitoring stations and research into novel approaches to real-time assurance of the quality of the calibrations and expanded, user-focussed data products for sea level observation within Ireland.

The project will aim to:

- Conduct a review of the state of the art in levelling and calibrating tide level sensors and stilling tube design.
- Select the most promising methods and review in detail the scope for usefully adding enhancement through novel application of technology. Identify the most promising methodology(s). This will include (but not be limited to) the novel buoy design approach being developed through a SmartBay NIAP project (NIAP/18/003) underway in collaboration between IT Sligo (D. Tormey/A. Hegarty) and the MI

(G. Westbrook). This will complete early 2021 with a tested prototype as a key deliverable. Key contacts will also be utilised through the MI membership (G Westbrook) of the EuroGOOS tide gauge task team (see <http://eurogoos.eu/tide-gauge-task-team/>).

- Implement the chosen methodology on a trial basis quantifying performance against current best practice.
- Operationalise the developed system for use across the INTGN, specifically the GLOSS stations.
- Investigate novel approaches to data analysis and assimilation, such as Machine Learning approaches, to identify drifts in calibration of tide gauges in real-time
- Through the use of co-creation and collaborative design techniques, establish new data products from sea-level observations which have a significant impact for end-users in Ireland and the wider European community
- Through the life of the program, in addition to becoming expert in the specific area of investigation, the student will be equipped with key skills in the following areas:
 1. End to end data management pathway from observation *in-situ*, through structured and operational data processing and data management to submission of datasets for inclusion in sea level change studies (submission to GLOSS)
 2. Through a strong field element, become technically up to speed with the electromechanical engineering aspects of an operational tide gauge network, specifically: scoping, design, materials, system elements, installation, operations, and maintenance.
 3. Collaborative design and co-creation of data products targeted for user needs

Outcome

The expected outcomes from the project will be:

- The issues surrounding the calibration of water level (tide) gauges will be drawn together and the relative contributions to measurement uncertainty quantified.
- A review of internationally recognised options to carrying out this work will be summarised.
- Current novel approaches using readily available new technology will have been reviewed and the most promising technology will have been assessed and possibly implemented.
- An assessment of the ability to apply emerging data analysis techniques to indicate the real-time quality of a tide gauge calibration
- New data products from the sea level data targeted at end users
- A comprehensive report (the PhD thesis) will form a working manual.
- A high impact journal will be targeted for publication of the findings.
- Findings will be disseminated and discussed via various channels including at relevant conferences; at the EuroGOOS task team which provides a tunnel into key EU member state structures.
- Project outputs should inform national climate actions and initiatives including the Climate Research Coordination Group, Climate Action Regional Offices and thus contribute to the development and implementation of the sectoral adaptation plans under the National Adaptation Framework. Results should be relevant to the UN Sustainable Development Goal 13 “Climate Action” and to Ireland’s government climate actions under the UNFCCC.

Links to MI Strategy

This proposal falls under Strategic Focus Area 3 - Research & Innovation. This research will improve the delivery of very-high quality sea level measurements and is linked with improving the understanding and observations of climate change within Ireland (SFA2). Improved data delivery and more targeted data products will also allow for improvements in the scientific advice and services available from the Institute (SFA1). Outputs from the project will enhance Ireland's capability to provide high quality tide gauge and sea level information to national and international databases.

Specific Requirements

The scholar should have a primary degree in a numerate discipline.

The training to date should include:

1. Formal study in mechanical and / or electronics
2. A practical undergraduate project based around studies undertaken in 1
3. Good communication and inter-personal skills as much team-working will be required
4. Computer literacy

Additional skills that would be beneficial would include:

1. An ability to produce computer code to tackle specific data processing and analysis tasks
2. Early signs of a self-reliant motivated working style

Financial Details

Scholarships will be up to €25,000 per annum (maximum funding of €100,000 over four years). This amount comprises a maintenance award of €16,000 (Irish Research Council rate) to the student as well as payment of fees to the host higher education institution (HEI). The maximum fees payable to the HEI will be €6,000 per annum. The scholarship award also includes a budget of up to €3,000 per annum for eligible research costs (travel & subsistence, publication costs, consumables and other costs e.g. laptop) for the sole use of the student, and are payable on a reimbursement basis direct to the host institution where the postgraduate student (scholar) is registered. There are no overheads payable on the scholarship. Publication costs are intended to cover publications on which the scholar is listed as first author and are published under Open Access.

Marine Institute Co-Supervisor(s)

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