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Assessment of the FES2014c model for tidal currents on the shelves around the North Atlantic Ocean

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Introduction

Challenges in Tidal Current Measurement

Numerical Modelling for Tidal Currents

Tidal Energy Potential and Future Outlook

Background...

Davies (1992), Luyten (1991)

Davies M. developed complex hydrodynamic equations for tide and currents and Luyten and Stommel compared M2 currents in moored current observations with the Schiwiderski model.

Robins, et. al.,(2015) Sttamer (2014)

Validated simulated tidal currents by comparing them with data from 15 tidal current meters. Utilized global tide models for analyzing tidal currents as FES2004.

Cancet (2017) and Zaron, Griffing (2021)

In the validation made with forty-eight ADCPs in the Australian continental Shelf with a data-assimilative model, Finite Element Solution (FES) in version 2014

1997, 2001, 2002 and 2010

Dushaw et al., Egbert et al., Neil, S., Lyard et. al. and Scourse, J. conducted studies comparing currents from various tidal constituents, acoustic tomography, moored current meters, and developed tidal and wave models.

Radji (2016)

Validated simulated tidal currents by comparing them with data from 20 tidal current meters. Utilized global tide models for analyzing tidal currents as FES2012, TPXO08.

Objectives

General Goal

Evaluate the accuracy of a data assimilation model and validate the tidal currents in some areas of the northern Atlantic Ocean.

Specific Goals

- Compare the model with a static field survey of eastward and northward components in the selected regions.

- Quantify differences using specific statistical metrics.
- Determine model accuracy.

Methodology Structure

Accuracy and performance of a data assimilation model and validation of the tidal currents in the northern Atlantic Ocean.

Data collection and check the requirements

Comparing those obtained from in-situ data with the model.

Comparing sample mean values of the predicted and observed data, using six statistical metrics

Phase shift and Amplitude ratio assessed

Tidal stream data collection
Barotropic models – FES2014c

Model Characteristics

- Tidal barotropic eq. (T-UGO model) in a spectral configuration
- 34 tidal constituents with 1/16 degrees spatial resolution.
- 20 years of temporal resolution: Altimeter time series
- Bathymetry
- Refined mesh in shallow water
- Tidal gauges
- Tidal currents at any location.

Fig.2.FES2014c. Tidal Stream data collection.
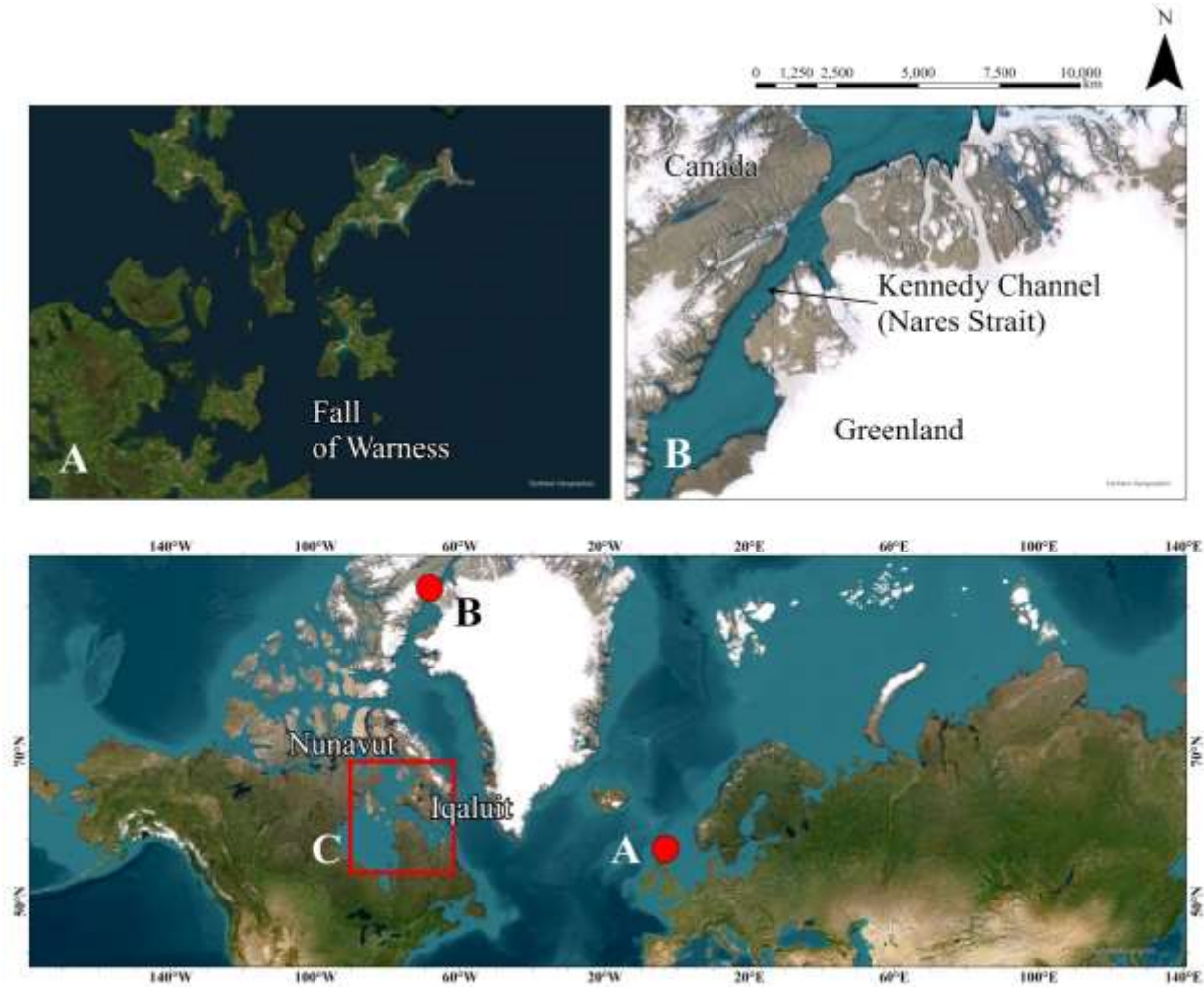
Case Study

Fig.1. Fall of Warnes, Scotland and Canadian Archipelago. Tidal Stream data collection.

- In our case, I utilised data assimilative modelling and field survey or ADCP (Acoustic Doppler Current Profiler)

- The number of harmonics, spatial resolution, and selected period are important factors to consider in this process.

Tidal stream data collection Static survey – ADCP (Fall of Warness, Scotland)

- **10 surveys** from the Reliable Data Acquisition Platform for Tidal Energy (ReDAPT) developed by the Marine Programme.

- **9 surveys** from the Dylotta project developed by the University of Strathclyde.

- Period of the surveys: 2013-2014.

- Depth-averaged tidal profiles collected in north, and east in 29 surveys in total, with 5min of frequency.
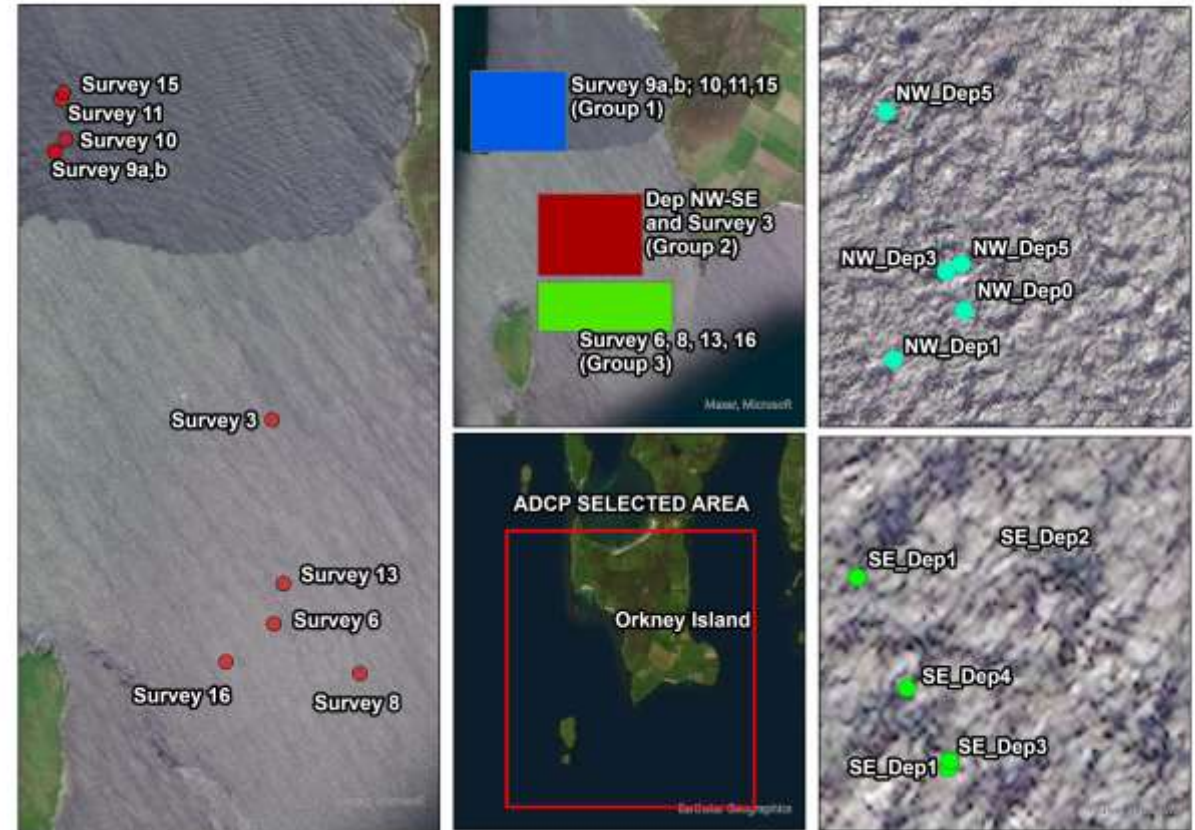
Fig.3.Location of the developments for Fall of Warness, Scotland. Tidal Stream data collection.
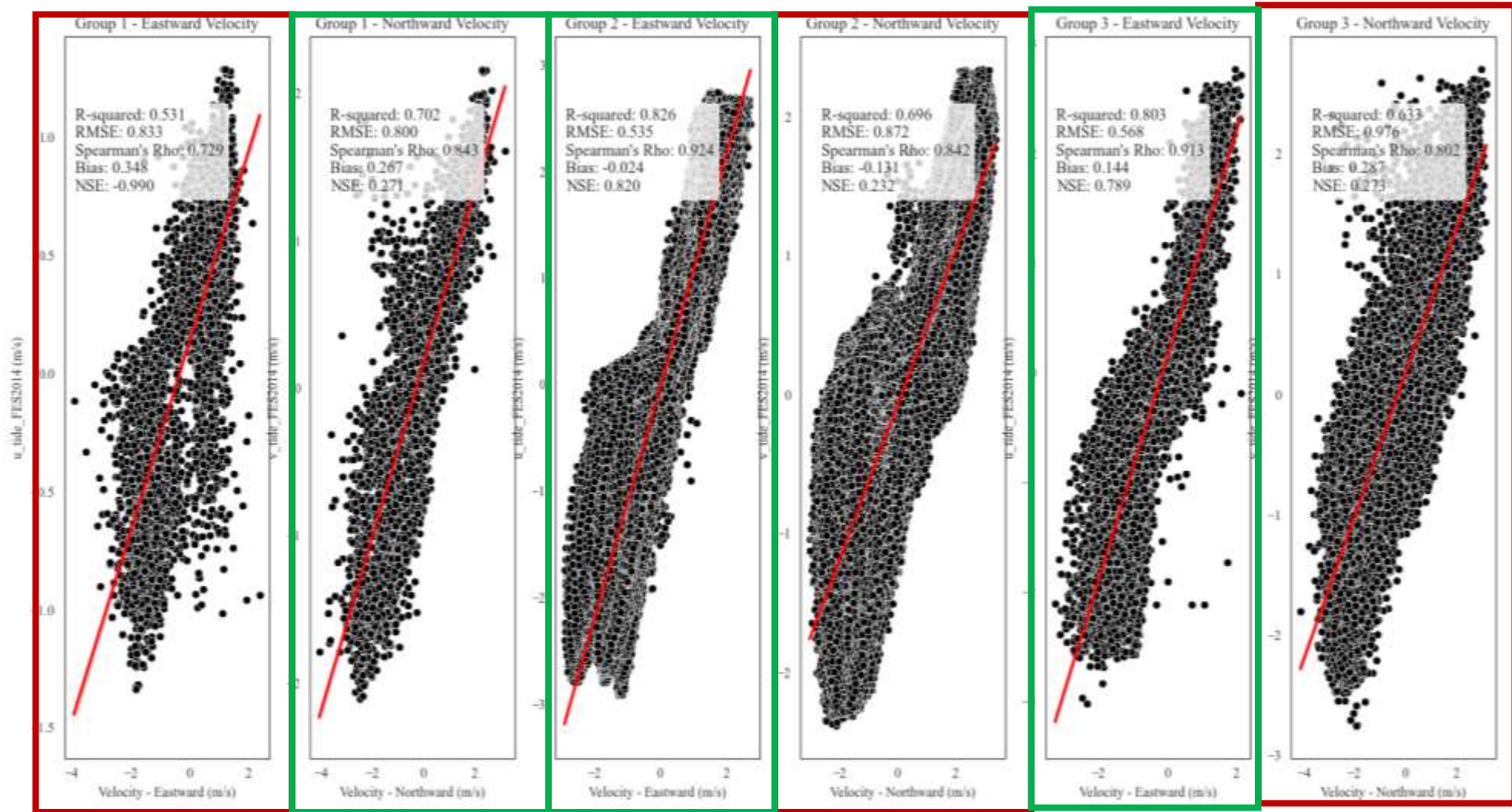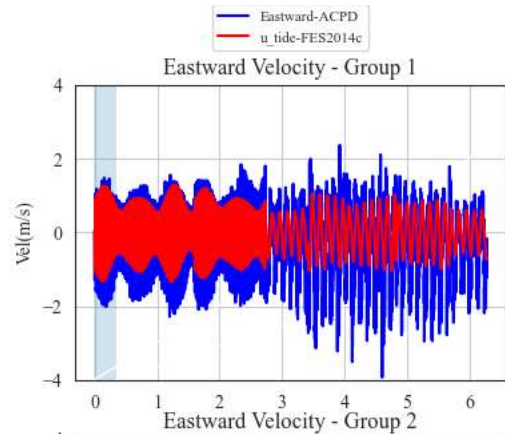
Results - Statistics

Results – Phase and Shift
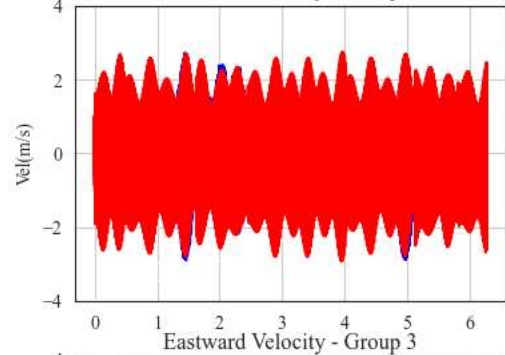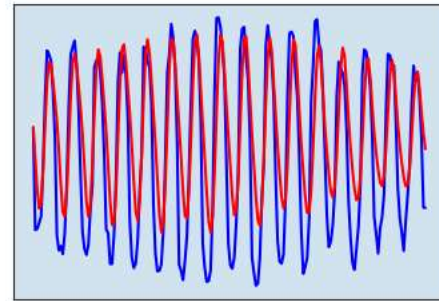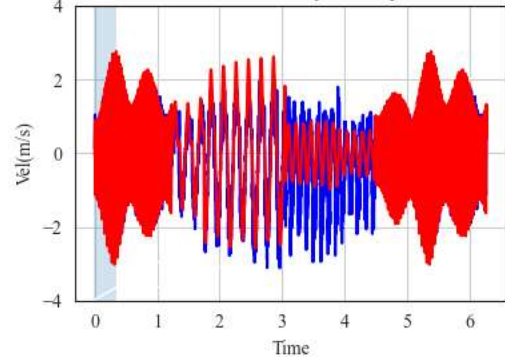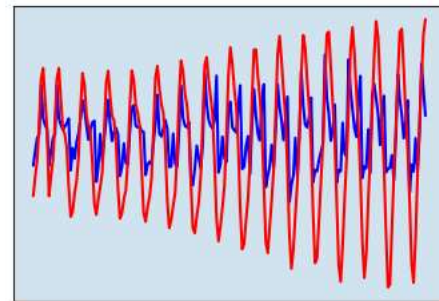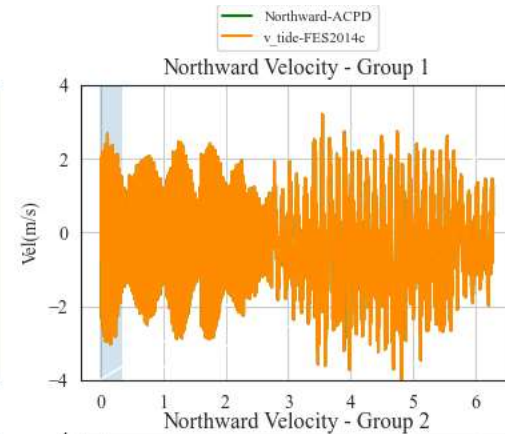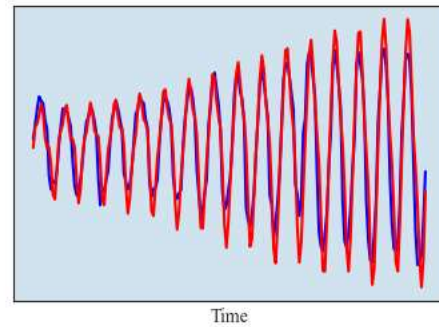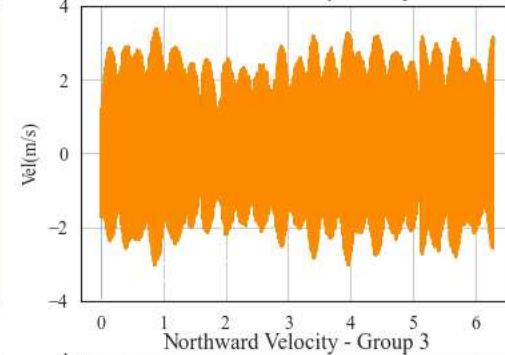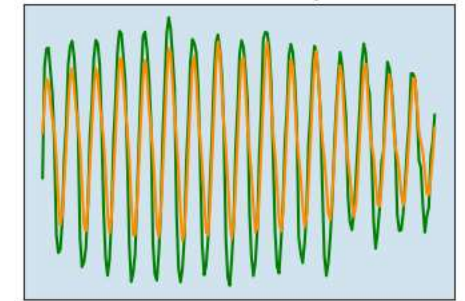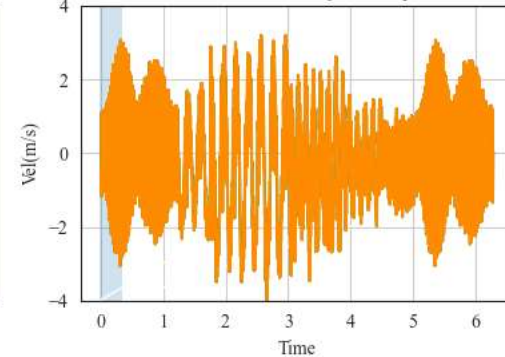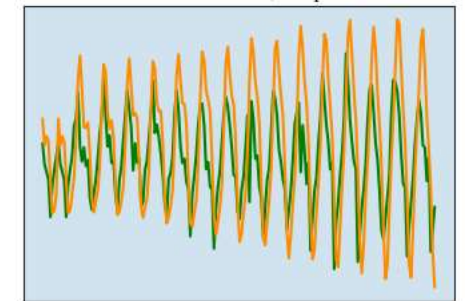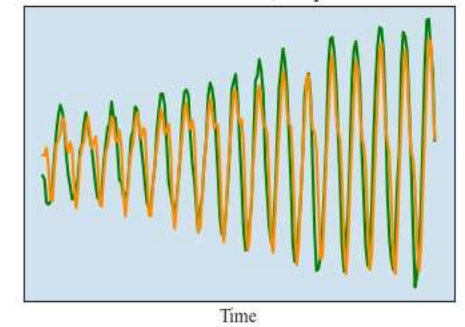
Tidal stream data collection
Static survey – ADCP
(Canadian Archipelago)

- 9 surveys from the National Science Foundation and the University of Delaware through the Artic Data Centre.

- Period of survey: 2003-2009

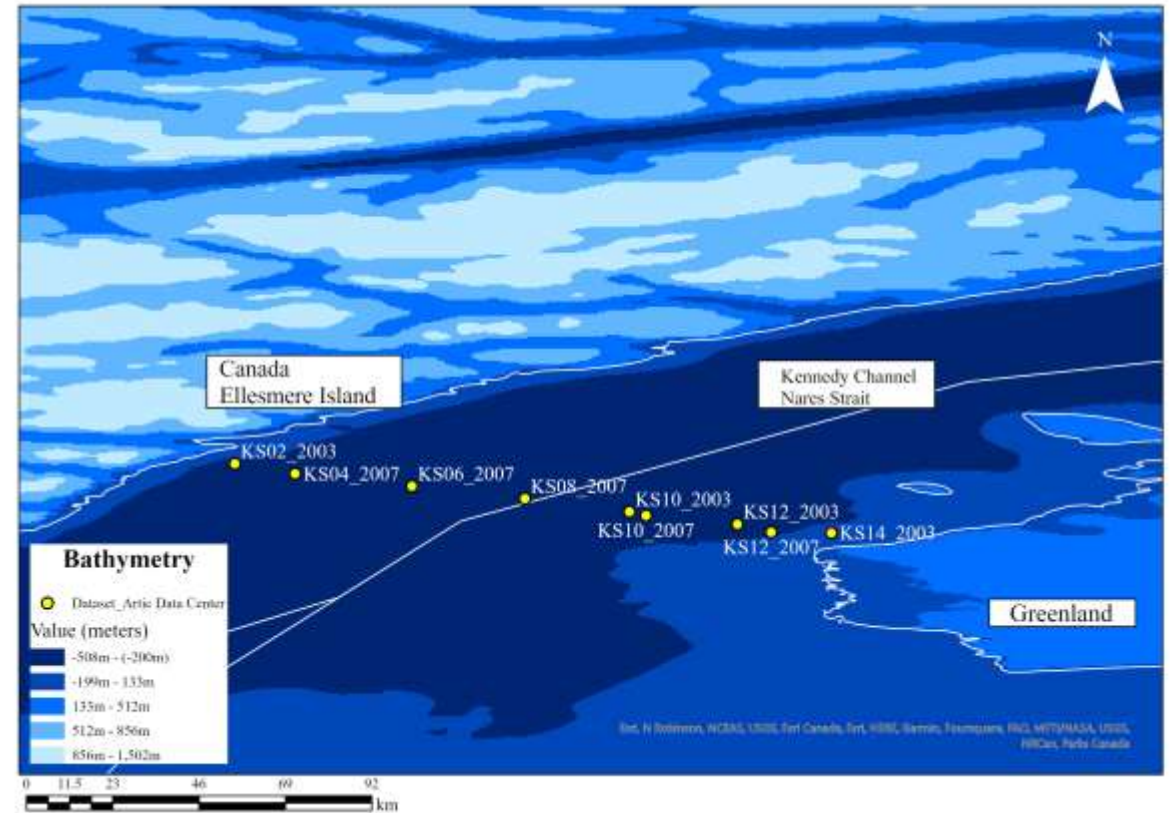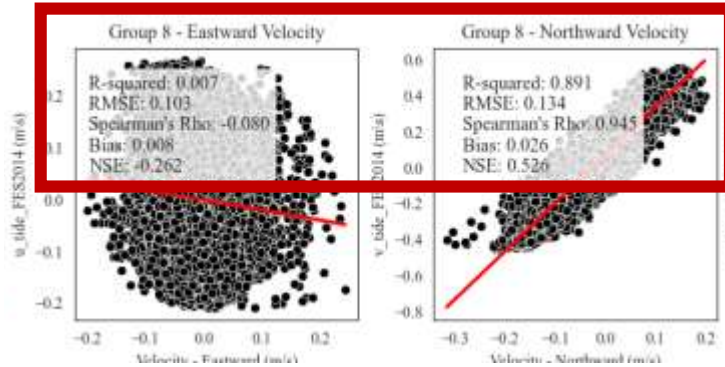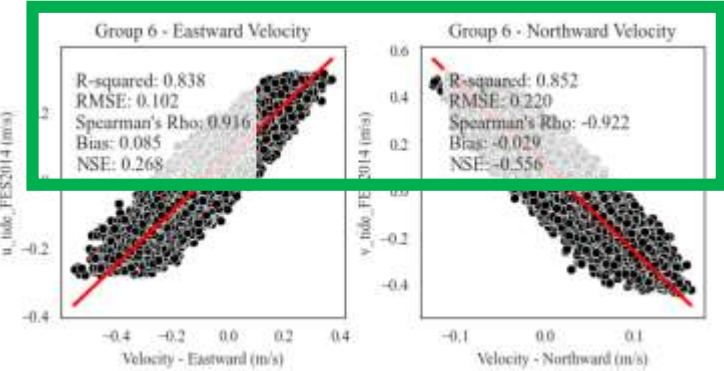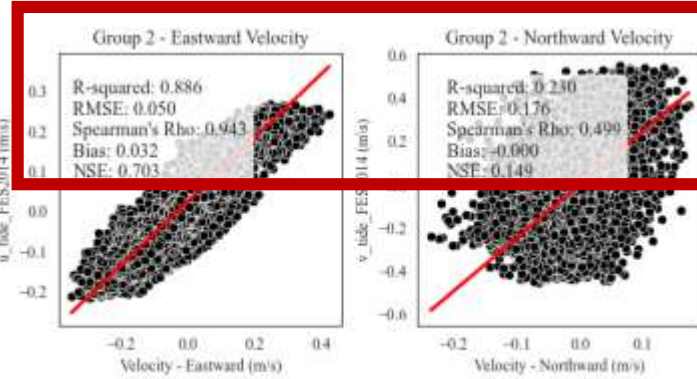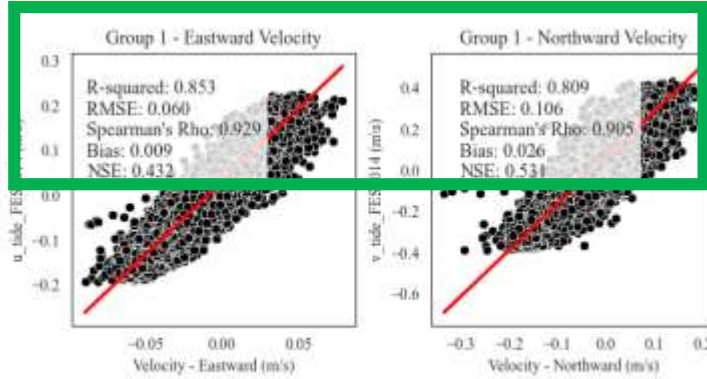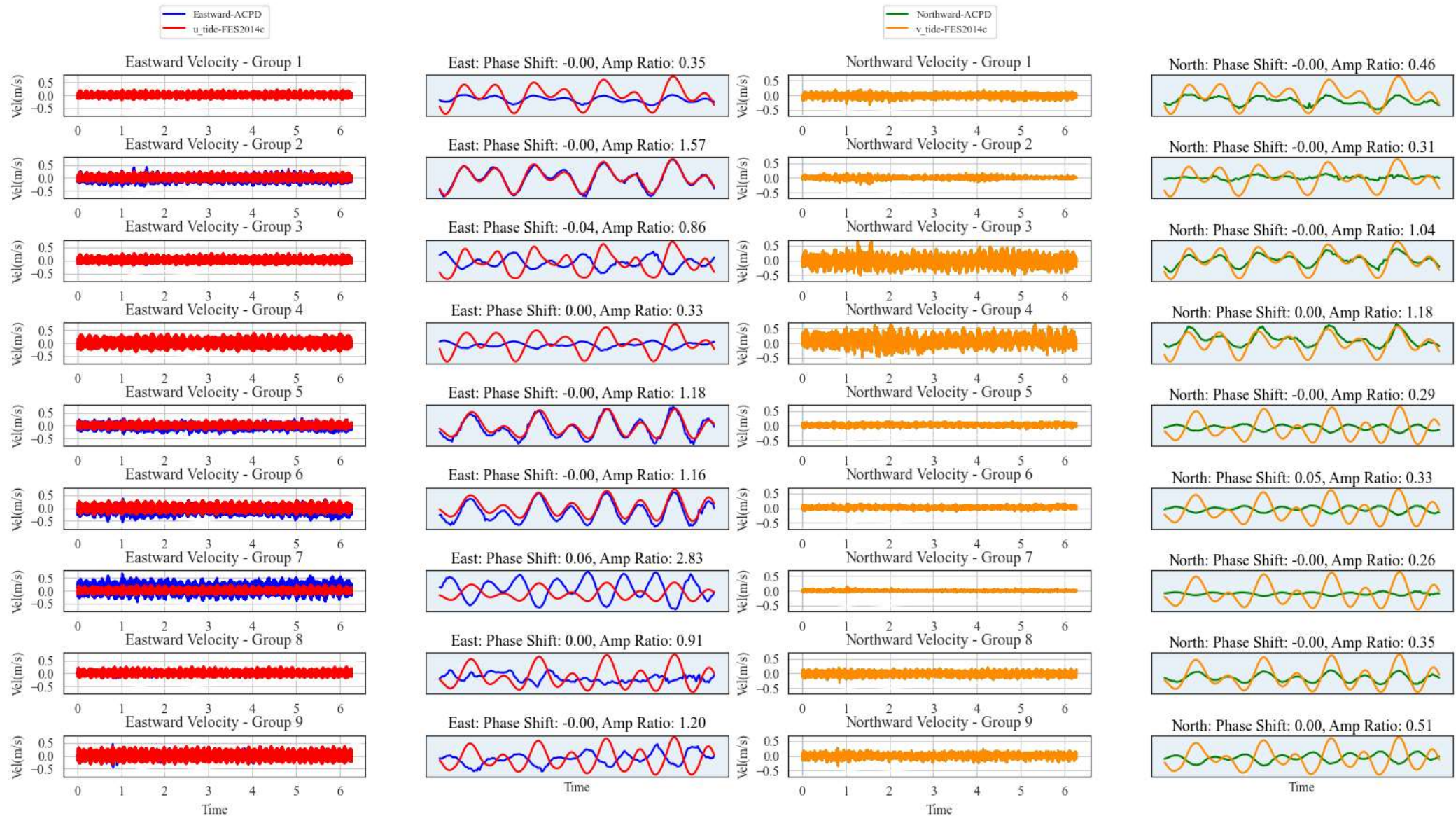- Depth-averaged tidal profiles collected in the north, and east with 30min of frequency.

Fig.4.Location of 9 developments for Canadian Archipelago. Tidal Stream data collection.

Results - Statistics

Results – Phase and Shift
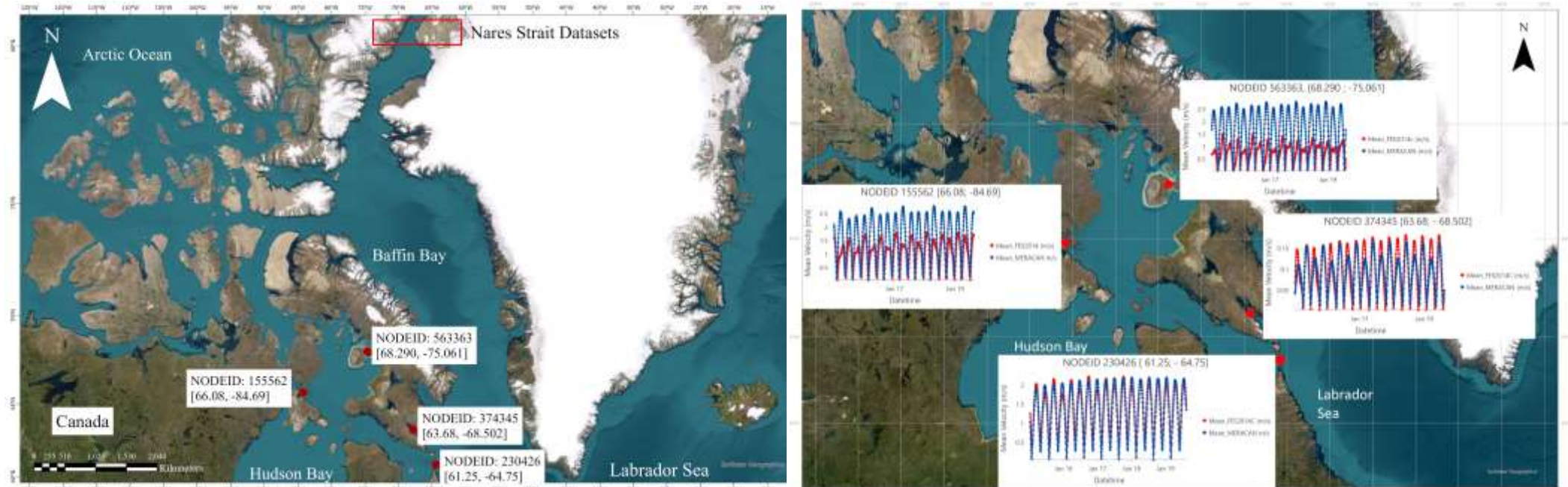
Special Case – Nunavut, Canada

Fig.5.Location of 4 Nodes for Nunavut, Canada. Tidal Stream data collection.

- The remote location facilitated the validation and utilization of alternative hydrodynamic models.

- During this phase, the FES2014 model was compared with data from the Marine Energy Resource Atlas Canada (https://arctic.meracan.ca/) to pinpoint viable sites for hydrokinetic energy extraction.
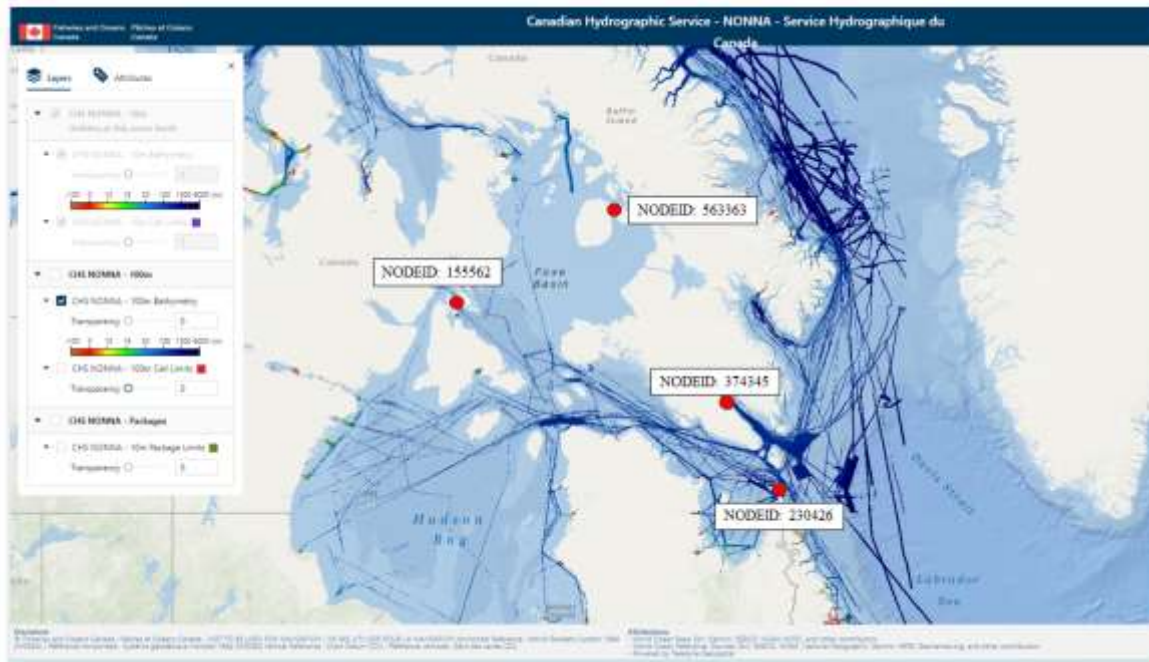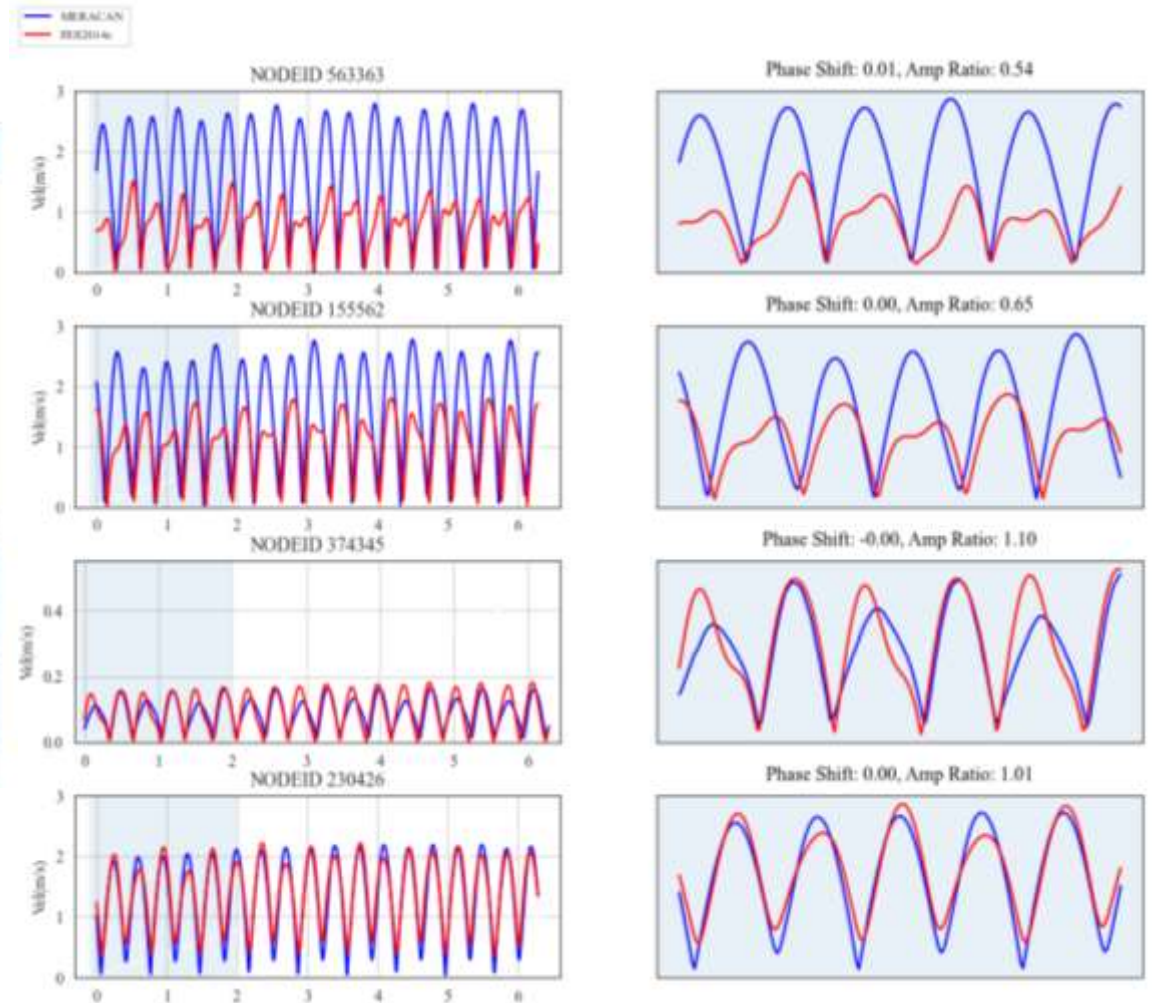
Results – Statistics
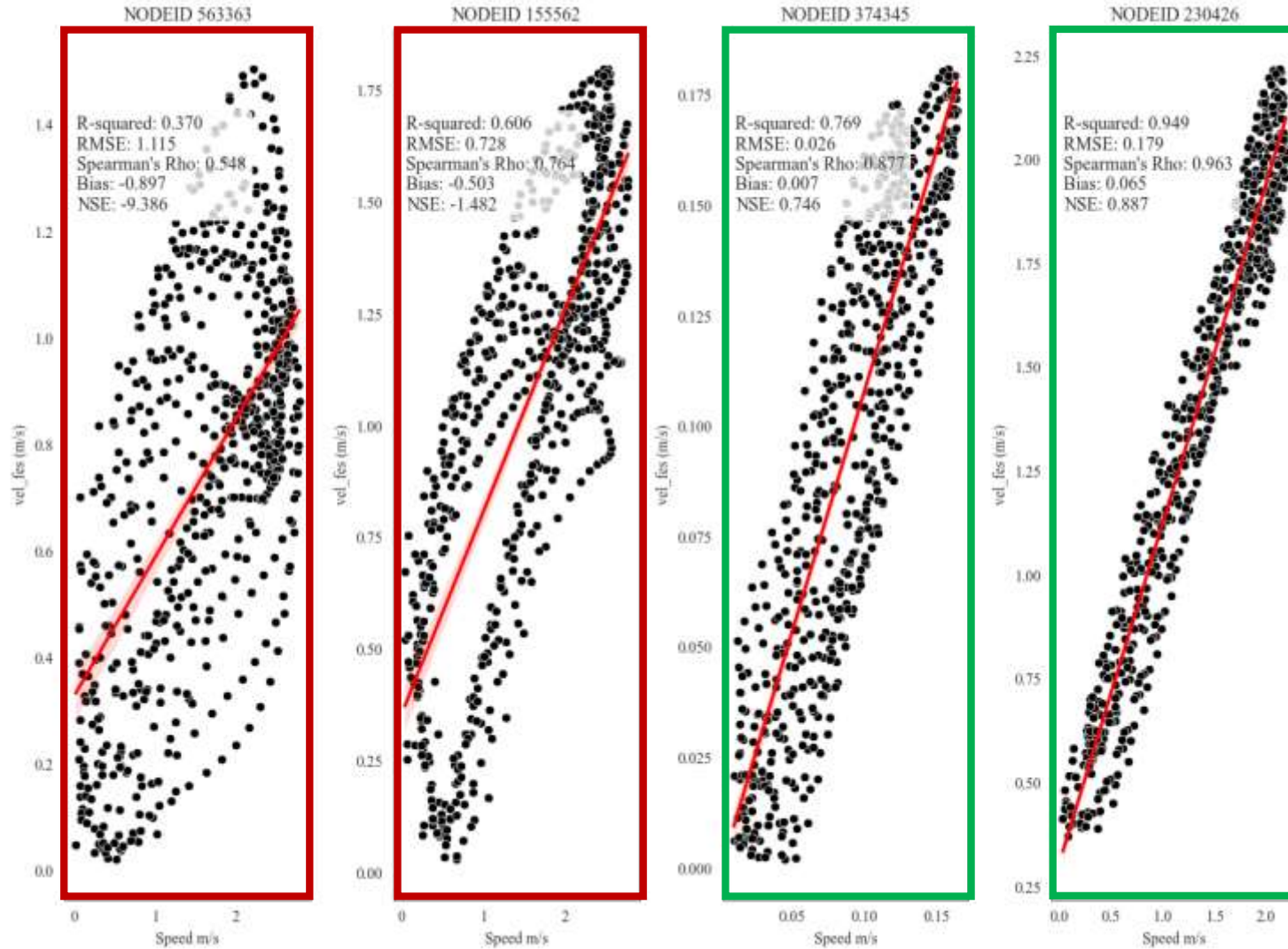
Results – Phase and Shift

Fig.5. Bathymetry of the selected sites. Tidal stream data collection.

Conclusions

- An overestimation issue is discerned in the marine environments of Canada and Scotland, highlighting the need for refinement in forecasting accuracy.

- Groups 3 and 2, situated at greater depths, demonstrate a stronger correlation with the full ensemble, and Group 1 shows the complexity of predictive performance as a shallow area.

- Conversely, Groups 5, 1, 6, 2 (east), 3 (North), 7 (East), 8 (North), and 9 (North) showcase robust correlations ranging from 76% to 89%, underscoring the model's efficacy in explaining the variability of data, albeit intermittent data due to remote locations.

- Due to the remote location in Canada, the research strategically utilises alternative hydrodynamic models and validated with the FES2014 model and data from the Marine Energy Resource Atlas Canada (MERACAN), to identify viable sites for tidal stream energy extraction.
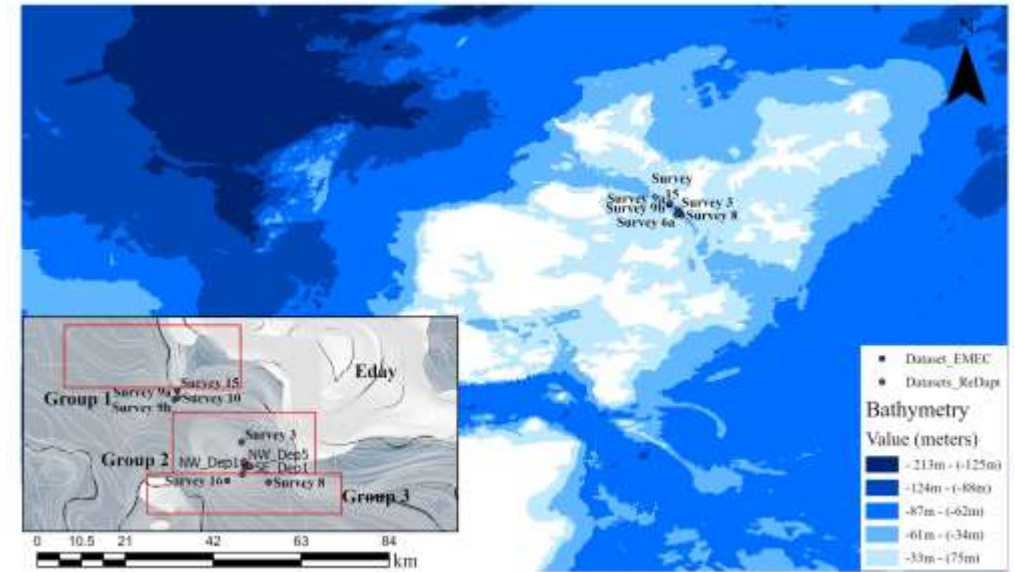
Fig.6.Bathymetry of the selected sites. Tidal stream data collection.

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