A Coupled Ocean-Wave Model for Galway Bay, Ireland

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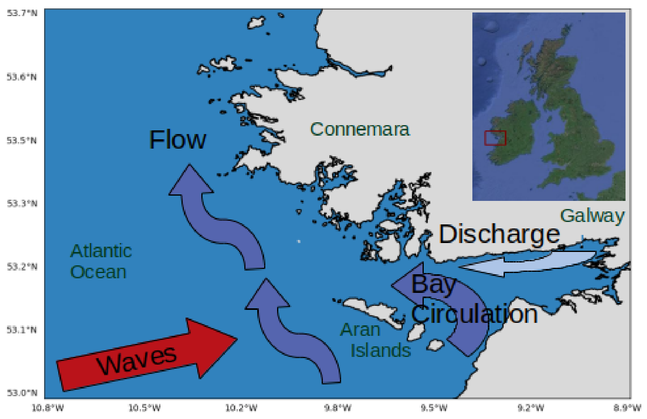
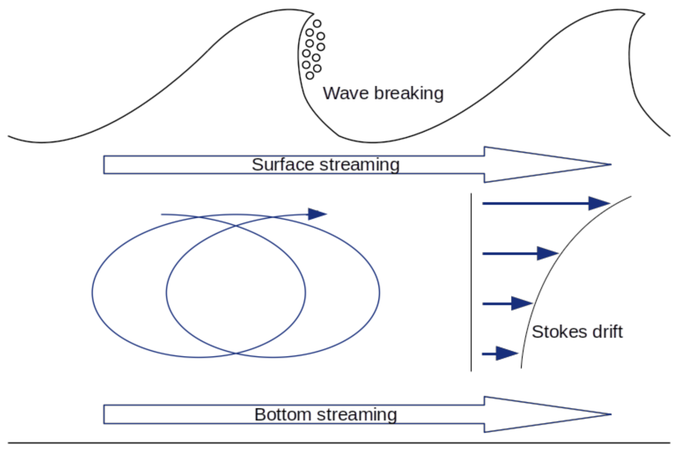
Background and Motivation

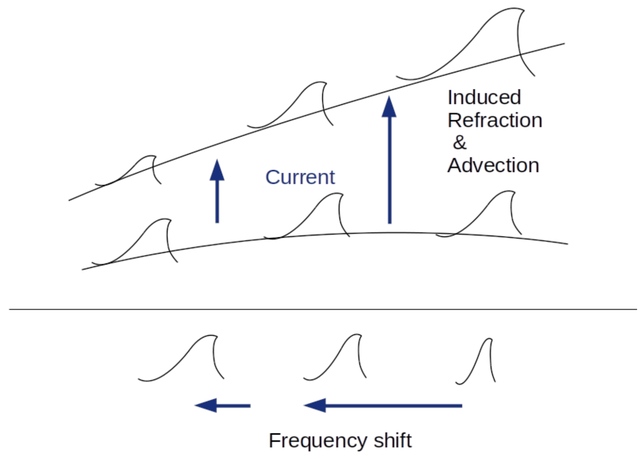
Characteristics of Galway Bay [1]:



Waves effects on current:



Current effects on waves:



Is it possible to improve the forecast capabilities using a coupled ocean-wave model [2], especially inside the Bay?

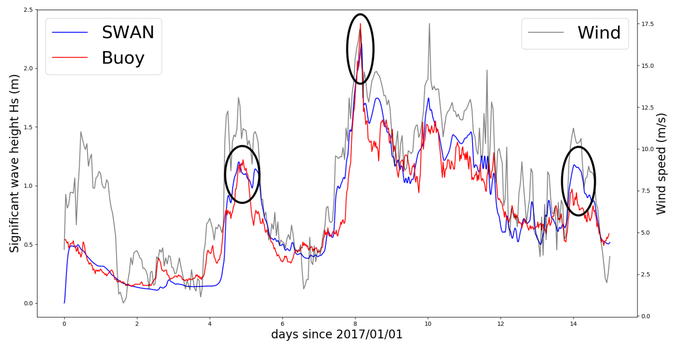
Early results

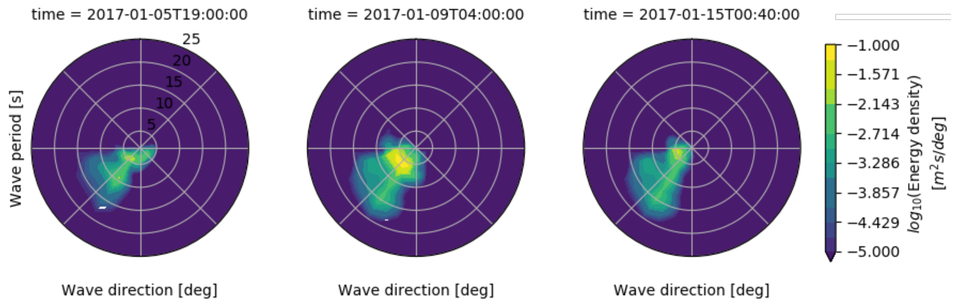
SWAN standalone

▷ Time series of Hs at the wave buoy location

▷ Wave spectra at circled times

Wind-sea waves are more important than swell inside Galway Bay.





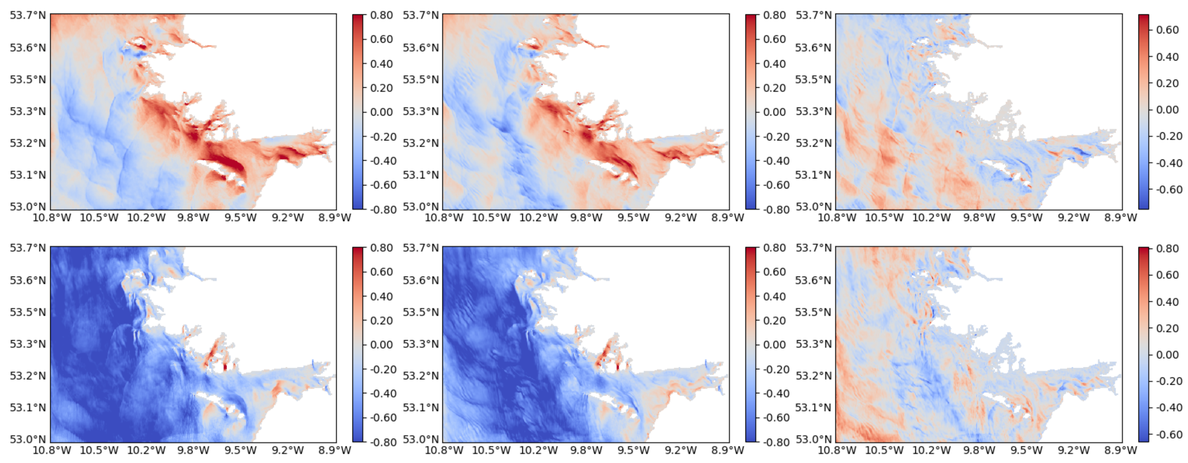
ROMS-SWAN coupled

▷ Snapshots at $t = 8$ days of eastward (top) and northward (bottom) surface current velocity (m/s)

▷ ROMS standalone (left), coupled model (middle), difference (right)

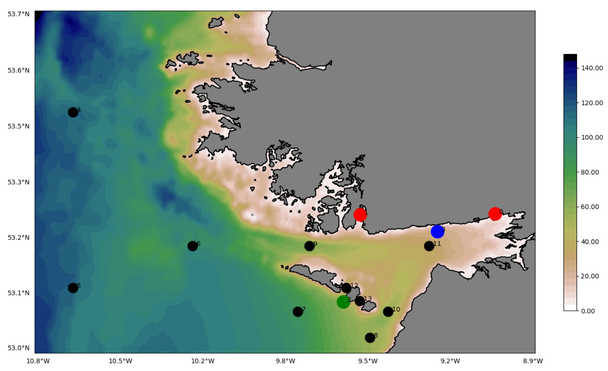
Waves can strongly interact with the current, even inside the Bay.

Future work will include the impact on floater trajectories.



Coupled model - with Coupled-Ocean-Atmosphere-Wave-Sediment Transport (COAWST)

Grid	Curvilinear grid (200mx200m) (640ptx440pt)
Bathymetry	INFOMAR and GEBCO - 20 levels
Forcing	Ocean boundary from model (Marine Institute) (10min) Wave boundary from own model (WAVEWATCH III®) (10min) Atmospheric forcing from MÉRA (Met Éireann) (1hr) River climatologies (1day)
Hindcast period	2017/01/01 to 2017/01/16 - 15s/300s time-step



Bathymetry and location of stations:

▷ Red: tidal gauges

▷ Blue: wave buoy

▷ Green: ADCP [3]

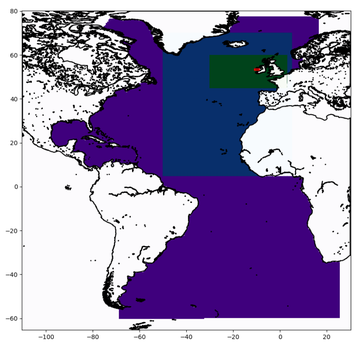
▷ Black: simple output

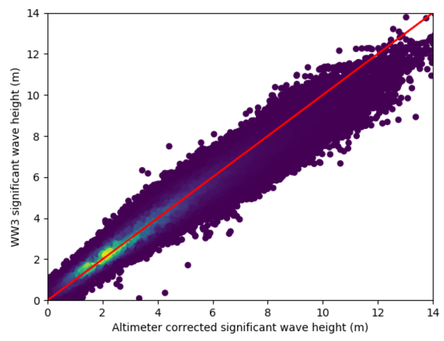
Ocean: Regional Ocean Modelling System (ROMS), computes the current u with forcing and mixing terms $\mathcal{F}, \mathcal{D}$ $\quad \partial_t u + u \cdot \nabla u = \mathcal{F} + \mathcal{F}_w + \mathcal{D} + \mathcal{D}_w \quad \rightarrow \quad U, h, \zeta$

Waves: Simulating Waves Nearshore (SWAN), computes the wave action spectrum A with source and sink term S $\quad \partial_t A + \nabla_x (U + c_g) A + \partial_\theta c_\theta A + \partial_\omega c_\omega A = S/\omega \quad \rightarrow \quad H, \omega, k$

Generation of the wave boundary conditions - Atlantic model

Regular Grids	(0.50°x0.50°) (0.10°x0.10°) (0.05°x0.05°) 34 freq from 0.0373 Hz - 32 dir bins
Bathymetry	GEBCO 2019 (0.5')
Forcing	Atmospheric forcing from ERA5 (1hr) Sea level & current from CMEMS (1day)
Hindcast period	2016/01/01 to 2018/01/01 - 300s time-step





WAVEWATCH III® model

▷ Scatter plot of Hs
Model against altimeter data

▷ Extreme waves are underestimated
A common issue with ERA5

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[1] G Nolan. *Observations of the seasonality in hydrography and current structure on the western Irish Shelf*. PhD thesis, National University of Ireland Galway, 2004.

[2] N. Kumar et al. Implementation of the vortex force formalism in the coupled ocean-atmosphere-wave-sediment transport (COAWST) modeling system for inner shelf and surf zone applications. *Ocean Modelling*, 2012.

[3] F. Fedele, J. Herterich, A. Tayfun, and F. Dias. Large nearshore storm waves off the Irish coast. *Scientific reports*, 9(1):1–19, 2019.