The Irish Atlantic CoCliME Case Study Configuration, Validation and Application of a downscaled ROMS ocean climate model off SW Ireland

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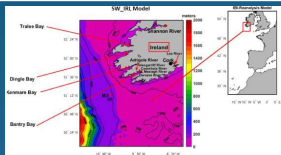[b] Met Office Hadley Centre, FitzRoy Road, Exeter, Devon, EX1 3PB, UK

Abstract

This numerical ocean modelling study focuses on shelf waters off southwest Ireland. Model results are used to provide climate change information to scientists and policymakers regarding oceanic conditions affecting harmful algal blooms (HABs) in this region. Four simulations were developed, including a 20-year hindcast simulation (1997 - 2016), a 31-year simulation (1975 - 2005), and two 30-year climate model projections (2006 - 2035) for Representative Carbon Pathways (RCPs) 4.5 and 8.5. We evaluated the capability of the hindcast model by comparing simulation results with observational data and calculating statistics such as bias and root mean square error (RMSE). The observations consisted of satellite sea surface temperatures, CTD temperatures, and salinity profiles collected in Irish waters. The pattern of sea surface temperature anomalies shows warming throughout the model domain. The maps of sea surface salinity and near-bottom salinity anomalies from the climate simulation show a general freshening on the southwestern Irish shelf. We will briefly introduce main results from the study on the relationships between oceanographic conditions and dynamics of selected harmful algae species. The authors currently develop a downscaled CMIP6 biogeochemical model for the Celtic Sea and the set-up will be presented.
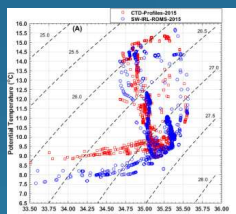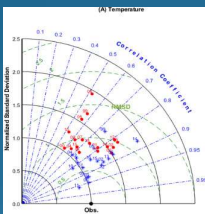
1. MODEL DETAILS

Model runs

Run	Forcing bnd	Forcing srf
Hindcast (1997-2016)	CMS IBI MY, daily, 1/12°	MÉRA, hourly, 2.5km
Historical (1975-2005)	UK Met AMM7, daily, 7km	Eur11-SMHI-MPI-ESM-LR - 3 hourly
RCP4.5 (2006-2035)	UK Met AMM7, daily, 7km	Eur11-SMHI-MPI-ESM-LR - 3 hourly
RCP8.5 (2006-2035)	UK Met AMM7, daily, 7km	Eur11-SMHI-MPI-ESM-LR - 3 hourly

Model Name: SW_IRL_ROMS
Model Code: ROMS 3.7
Model Grid: 1 km, 30 sigma

2. HINDCAST VALIDATION

Hindcast validation done for satellite SST and in-situ CTD. Here only validation vs. CTD is presented.
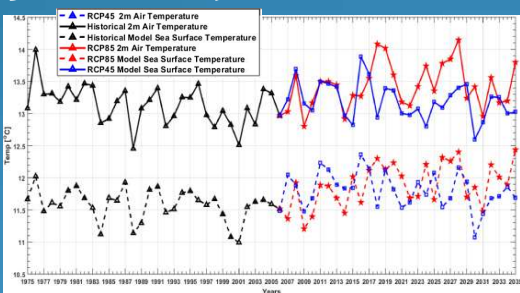

Historical run was checked if not statistically significantly different from Hindcast and found not to be, thus deemed suitable of representing oceanographic conditions and suitable for running climate projections. Some statistics are presented in the below Table.

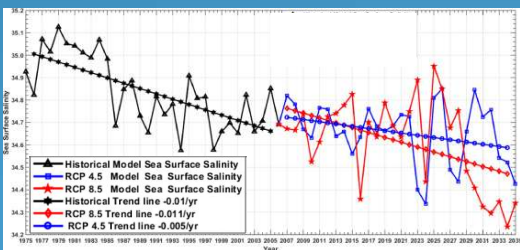| Run	Mean SST	SST ±2σ	Mean SSS	SSS ±2σ
Hist	13.16	0.33	34.70	0.39
Hind	12.46	0.28	35.26	0.35

Taylor diagrams for CTD vs modelled T & S. Numbers are years, e.g. 01 = 2001

SW_IRL_ROMS offers an improved solution vs its parent model CMS IBI

3. CLIMATE PROJECTIONS – RESULTS

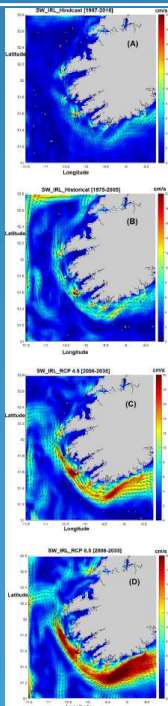SST and 2 m air T trends in historical, RCP4.5 and RCP8.5 runs

SSS trends in historical, RCP4.5 and RCP8.5 runs

Following indices were also analysed (see Hagy et al. 2021 for details)
➤ Frontal index
➤ Potential Energy Anomaly
➤ Coastal Upwelling Index

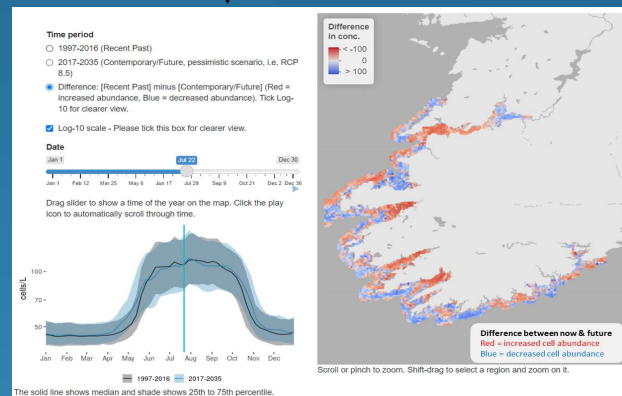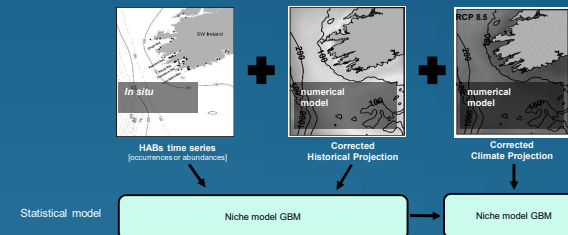Irish Coastal Current is projected to strengthen

4. DOWNSCALED STATISTICAL HAB CLIMATE MODEL

Work in progress – manuscript in prep.

Development steps:
(a) Apply cumulative distribution functions transformation to correct the historical & climate models
(b) Extract historical *In situ* HAB time series
(c) Combine *In situ* with corrected climate model
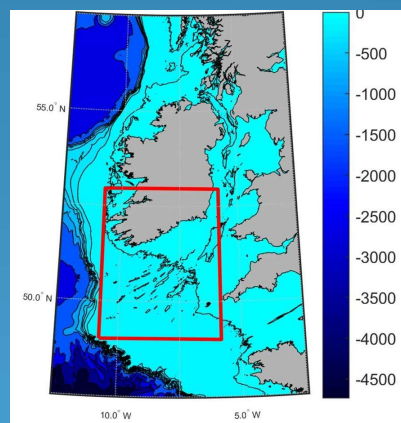(d) Develop GBM statistical models for each HAB taxon

Species investigated:
Dinophysis acuminata, Dinophysis acuta, Karenia mikimotoi, Alexandrium spp. *P. N. seriata* complex

5. CMIP6 DOWNSCALED BIOGEOCHEMICAL MODEL

Model Code: CROCO-PISCES
Model Grid: 1 km, 20 sigma

Hindcast forcing:
CROCO
➤ Daily IBI MY
➤ ERA5 1 hourly
➤ 11 Rivers
➤ Tides TPXO7.2

PISCES
➤ NORESM (Norwegian NIVA's ERSEM ESM)
➤ IBI MY BGC model
➤ NO3, PO4 and Si, DIC, TALK, DOC, DON & DOP from rivers included

For CMIP6 climate projections, atmospheric and oceanic boundary forcing will be taken initially from UKESM1-0-LL, with EC-Earth3-CC, CNRM-ESM2-1, and IPSL-CM6A-LR considered thereafter.

REFERENCE:
Nagy, H., Pereiro, D., Yamanaka, T., Cusack, C., Nolan, G., Tinker, J., Dabrowski, T., 2021. The Irish Atlantic CoCliME case study configuration, validation and application of a downscaled ROMS ocean climate model off SW Ireland. *Harmful Algae* 107, 102053, https://doi.org/10.1016/j.hal.2021.102053.

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