Projection of North Atlantic thermal anomalies onto the European Shelf Seas

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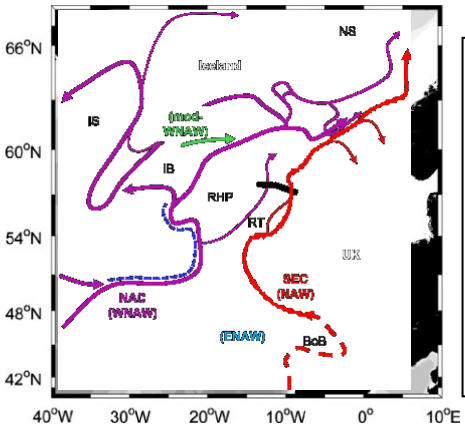
Background:

Warming of the global ocean over the past few decades has been particularly pronounced over the North Atlantic. However, in the N Atlantic variations about this trend are large, and often of opposing sign between sub-polar and sub-tropical gyres[1]. The western European shelf seas are heavily influenced by the adjacent eastern north Atlantic[2], which in turn draws source waters from both the sub-tropical and sub-polar gyres to a varying degree[3]. Basin-scale indices are often used as simple indicators of an ocean's "state", particularly when large scale oscillations between two such "states" seem to describe a major mode of variability (the Southern Oscillation Index, or SOI, is the best-known example). Two indices are often used to describe the large scale state of the Atlantic ocean, the North Atlantic Oscillation index (NAO) and the Atlantic Multi-decadal Oscillation (AMO).



Schematic of water masses and currents influencing the NE Atlantic Ocean. Major modes / indices of variability are commonly described for the deep ocean, but not so far for shelf seas.

Key
ENAW-Eastern North Atlantic Central Water(cyan); mod-WNAW-modified Western North Atlantic Central Water (green); NAC-North Atlantic Current; NAW-North Atlantic Water(red); SEC-Shelf Edge Current; WNAW-Western North Atlantic Central Water (purple).

Shelf water physical and biochemical characteristics correlate with the former index[2,4], and ecosystem changes in coastal areas show correlation with the latter index[5], though in neither case is causality well described. Shelf and coastal seas are bounded by the ocean, land and atmosphere; ocean/shelf exchange is physically complex[6], terrestrial influences are regionally variable, and atmospheric coupling is strong. At present, the only shelf index which is well described maps the competition between tidal mixing and solar heating[7]. From this view point there is view growing in acceptance that a global warming trend will lead to more highly stratified shelf seas, and reduced productivity; however this view is local, and neglects oceanic influence of the contrasting nutrient loading of the N Atlantic gyres. This project will seek to answer the question: Can well described indices be developed for shelf seas which account for inter-annual to inter-decadal modes of variability?

Rationale:

The rationale behind this project to better understand the mechanistic links between ocean modes and properties of shelf and coastal seas; whether they be predominantly causal or co-responsive to atmospheric forcing. The testable hypotheses are:

- T/S water mass relationships associated with adjacent ocean modes are imprinted on shelf seas.
- Variations in stratification (strength and/or seasonal duration) in shelf seas respond to adjacent ocean modal indices.
- Indices can be derived to describe major multi-annual modes of variation in shelf seas

Outcomes:

- Better description of inter-annual to inter-decadal variations in UK shelf seas
- Derivation of appropriate indices which capture major modes of variability
- Statistical and attributable connections between ocean and shelf modes

Methodology:

This project will draw on freely available global observational ocean property reconstructions[8],[9] and model hindcast simulations from the CMIP5 archive[10] to define oceanic and atmospheric states in the eastern north Atlantic over the last 50 to 100 years.

Geochemical proxy records (for temperature and/or salinity and $\delta^{18}O$) will be combined with instrumental records from coastal and shelf locations to describe major modes of variation in NW European shelf and coastal seas, including the strength and duration of stratification. Considerable regional variation may well be anticipated, but common patterns are also likely, as evidenced by documented ecosystem responses[5].

Multi-decadal, high resolution (1.8km) numerical model simulations of ocean / shelf exchange will be available from the FASTNEt ocean/shelf exchange programme, and will be used to explore the mechanistic/causal grounding to observationally-derived shelf sea modal states.

Training timetable:

Year 1: Literature review of previous work, focussing on in decadal trends in oceanic and atmospheric data sets indices. Training in statistical time series analysis methods. Familiarisation with geochemical proxy methodologies. Training in handling large data sets (numerical model output). Refinement of research questions and hypotheses.

Year 2: Collection of archive water property, geochemical and modelled data. Derivation of exiting index metrics. Investigation of major decadal modes of variation in shelf sea records (instrumental, proxy and modelled). Derivation of appropriate indices for shelf response. Attendance at relevant discipline-based summer training school.

Year 3: Statistical and causal investigation of existing and newly derived indices. Presentation of results at national or international meeting. Writing and submission of thesis.

References:

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