

An Earth Observation approach for monitoring and mapping the spatial distribution of bird habitats around the Irish Sea

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Introduction

The **ECHOES (Effect of climate change on bird habitats around the Irish Sea)** project seeks to address how **climate change** will impact **coastal bird habitats of the Irish Sea**, and what effect this could have on the society, economy, and shared ecosystems.

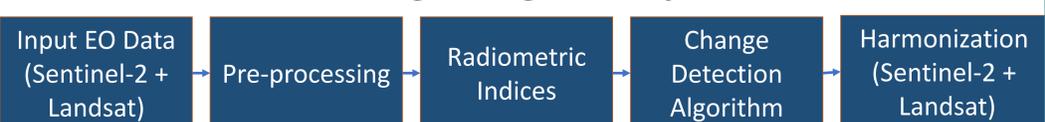
Satellite imagery are a key source of data for **monitoring and mapping** the spatial distribution of **key habitats** for the Greenland White fronted geese and Eurasian Curlew.

Mapping the current situation



Aims to generate a set of **habitat/land cover maps** from **open source Earth Observation** imagery based on a **machine learning approach**, for the areas studied in both Ireland and Wales.

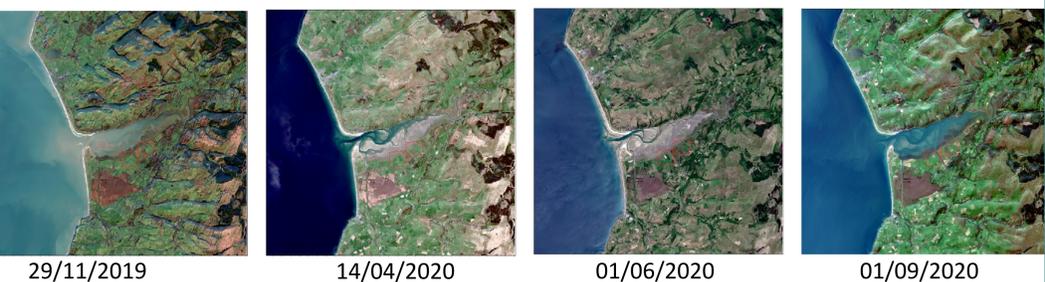
Monitoring the vegetation dynamic



And to identify the trajectory or any potential change in the habitats through the implementation of a **change detection algorithm**, based on a set of **historical satellite datasets**.

Habitat mapping process

A time series of **cloud-free Sentinel-2** images covering the **four seasons** from Autumn 2019 to Summer 2020 were identified for the study sites on the west coast of **Wales** and south east coast of **Ireland**.



Radiometric Indices

- The **Normalized Difference Vegetation Index (NDVI)** highlights the condition and the seasonal variation of the vegetation presented in the area.

$$NDVI = \frac{NIR - Red}{Red + NIR}$$

- The **Structure Insensitive Pigment Index (SIPI)** is used to identify the high variability in the vegetation structure for some particular areas.

$$SIPI = \frac{NIR - Blue}{NIR - Red}$$

- The **Normalized Difference Water Index (NDWI)** is used to identify the presence of water in the estuary areas linked to the tidal variation.

$$NDWI = \frac{Green - NIR}{Green + NIR}$$

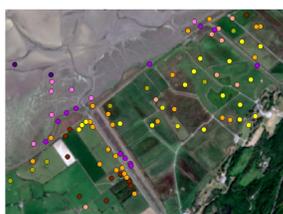
Ground Control Points

Date	Latitude N	Longitude W
26/07/2021	52.52229	-3.99213
26/07/2021	52.52177	-3.99187

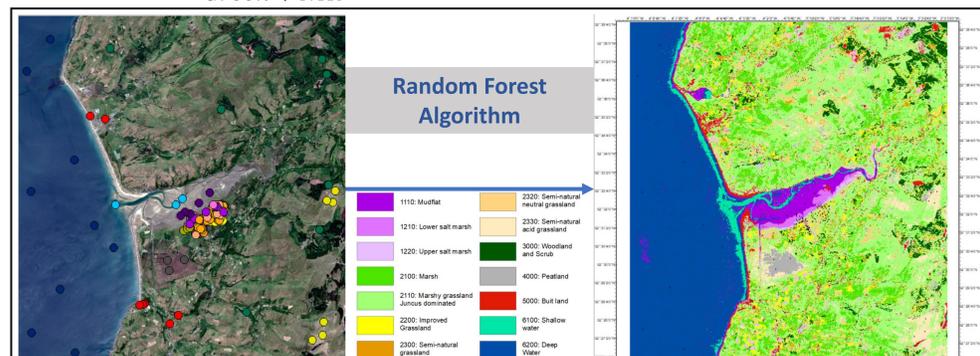
JNCC Phase One code	JNCC Phase One name
B4	Improved grassland
B4	Improved grassland

Foundation species	Note
Lolium perenne	Aftermath following silage harvest
Lolium perenne	Aftermath following silage harvest

- 1110: Skudlat
- 1120: Lower salt marsh
- 1220: Upper salt marsh
- 2100: Marsh
- 2110: Marshy grassland Junon dominated
- 2200: Improved Grassland
- 2300: Semi-natural grassland
- 2320: Semi-natural meadow grassland
- 2330: Semi-natural acid grassland
- 3000: Woodland and Scrub
- 4000: Peatland
- 5000: Bull land
- 6100: Shallow water
- 6200: Deep Water

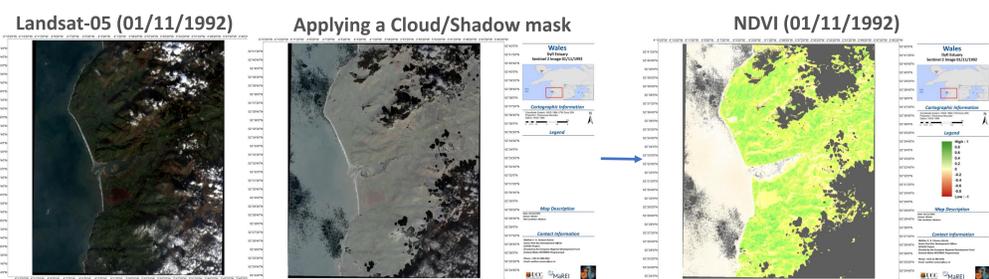
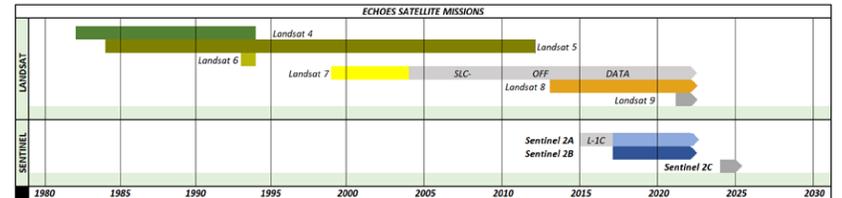


Random Forest Algorithm



Habitat monitoring process

In order to capture **change in the habitats** over the last 20 years, a time series of **Landsat and Sentinel-2** were identified using the same criteria as for the mapping process.



ECHOES Change Detection Algorithm (ECDA)

- The **ECDA** is based on the **Continuous Change Detection and Classification algorithm (CCDC)** developed by Zhu and Woodcock (2014)*. This approach uses all available Landsat data in a pixel scale.

- **Ordinary Least Squares (OLS)** based on the remaining clear Landsat Observations.

$$\rho(i, x)_{OLS} = a_{0,i} + a_{1,i} \cos\left(\frac{2\pi}{T} x\right) + b_{1,i} \sin\left(\frac{2\pi}{T} x\right) + c_{1,i} x$$

where,

x = Julian date

i = Radiometric index

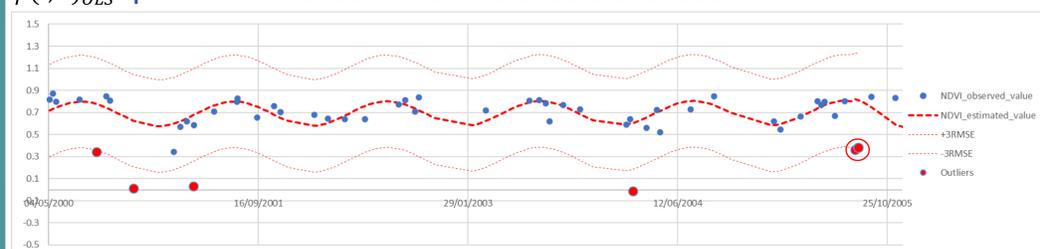
T = Number of days per year

$a_{0,i}$ = coefficient for **overall value** for the i -th radiometric index.

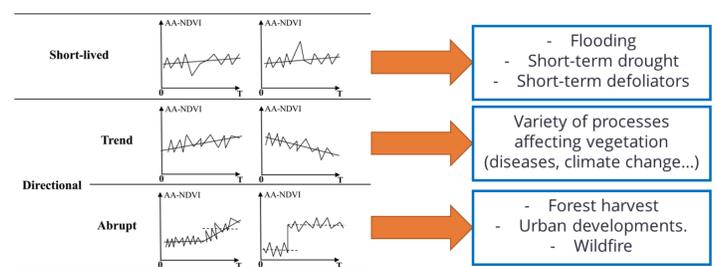
$a_{1,i}, b_{1,i}$ = coefficients for **intra-annual change** for the i -th radiometric index.

$c_{1,i}$ = coefficient for **inter-annual change** for the i -th radiometric index.

$\rho(i, x)_{OLS}$ = **predicted value** for the i -th radiometric index at Julian date x .



Any value out of a threshold equal to the **+3RMSE** or **-3RMSE** is considered as an outlier. If there's an outlier for 3 consecutive observations available this is considered as a change



Habitat Mapping and Monitoring into the ECHOES Project

- The **field vegetation information** is collected by **ornithologist** with extensive knowledge over the area.

- The outcomes coming from the mapping approaches are feeding an **Species Distribution Model (SDM)**.

- The **dynamics of change** at the field studied through the monitoring algorithms will be integrated into a **Climate Change Vulnerability Assessment**.

- All the **information generated** under the ECHOES project will be accessible through an interactive **web platform** developed in accordance to the relevant **stakeholders requirements**.



*Zhu, Z., Woodcock, C.E., 2014a. Continuous change detection and classification of land cover using all available Landsat data. Remote Sens. Environ. 144, 152-171.