# NASA Space Apps Challenge 2025

## Analysis of the Magdalen Islands (Canada) Using SAR and Visible Data: Land Loss from Coastal Erosion and Marine Submersion

**A Model Applicable to Islands Worldwide**


**TEAM EXPLORER_J1K2R1**

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# 1. Context & Problem Statement

Islands around the world are among the most vulnerable environments to the impacts of climate change. According to the Intergovernmental Panel on Climate Change (IPCC, 2022 – Sixth Assessment Report, Working Group II, Chapter 15), more than half of the population in many small island states lives within low-elevation coastal zones, making them extremely sensitive to sea-level rise (SLR), coastal erosion, and marine flooding. These phenomena are intensified by the increasing frequency and intensity of storms, changes in wave dynamics, and the reduction of natural coastal protections such as coral reefs and sea ice.

The Magdalen Islands (Îles-de-la-Madeleine) in the Gulf of St. Lawrence, Canada, represent a clear example of the challenges faced by small islands under climate change. Rising sea levels, stronger winter storms, and diminishing sea-ice cover have led to accelerating coastal erosion. Studies from the Université du Québec à Rimouski (UQAR) show that parts of the coastline erode at an average of 0.75 meters per year, reaching over 2 meters in the most exposed areas (Smithsonian Magazine, 2022). Projections suggest that by 2050, the coast could retreat by up to 38 meters, threatening homes and infrastructure (UQAR Coastal Research Group, 2021).

This phenomenon mirrors what is occurring on many islands worldwide, such as Tuvalu and Kiribati, where communities are already losing land to rising seas and are forced to relocate (UNDP, 2022). Understanding these spatial dynamics through Synthetic Aperture Radar (SAR) and satellite data is essential for developing predictive models applicable to other islands, helping to anticipate land loss and guide adaptation strategies for vulnerable coastal regions.

Photos credit: Brian Burke via Coastal Care
Source: Magdalen Islands and Shoreline Erosion, Québec – Coastal Care

# 2. PROJECT OBJECTIVES

**The main goal of this project is to allow any user to analyze coastal erosion and submersion on any island in the world (in our proof of concept: The Magdalene Islands) using Interferometry Synthetic Aperture Radar (InSAR) and Visible Satellite Data to quantify land loss over time and identify high-risk areas.**

By applying change detection and shoreline monitoring techniques, the project aims to:

- Measure variations in coastal surface between different years.
- Map zones most vulnerable to marine flooding and erosion.
- Correlate erosion patterns with environmental factors such as wave exposure and sea-level rise.
- Develop a methodological framework that can be replicated for other islands worldwide facing similar threats.

In addition, our team explored NASA's scientific resources and Earth observation missions to better understand the global significance of our topic and its alignment with NASA's objectives. We took into consideration NASA's open data and research tools, which reinforce the scientific relevance and potential applications of our project. Ultimately, the objective is to support climate resilience by providing data-driven insights that help coastal communities anticipate future changes and design adaptation strategies based on space observation.

# 3. Data & Methods

To assess the coastal evolution of the Magdalen Islands, we combined indirect measurements from Synthetic Aperture Radar (SAR) imagery with annual land surface data derived from Sentinel-2 optical imagery. This approach allows both a temporal analysis of shoreline changes using SAR and a quantitative estimation of land loss by comparing yearly shapefiles of the island's surface.

1

## Indirect Measurements – SAR Data (RADSAT, S1C & S2C)

SAR images provide consistent observations regardless of weather or light conditions. By processing multi-temporal SAR datasets, we generated 3D visualizations of coastal changes over time. The processing was conducted using the AMSTER Engine software, an open-source InSAR processing suite specifically adapted for automated time series analysis (Derauw et al., 2019; d'Oreye et al., 2022; Samsonov et al., 2020). This tool enabled the generation of radar-derived deformation maps and elevation models that highlight erosion dynamics and sediment redistribution with high precision. Additionally, we used the ZInSAR plugin, a 3D visualization tool that allows interactive exploration of ground deformation through time, providing a clear understanding of coastal subsidence and submersion-prone areas.

2

## Direct Measurements – Annual Land Surface Data (Sentinel-2)

Using Sentinel-2 optical imagery, we generated annual shapefiles representing the island's land surface. By comparing these datasets year by year, we calculated the percentage of surface lost over time. This approach provides an accurate measure of coastal retreat and land loss, enabling the identification of the most vulnerable areas.

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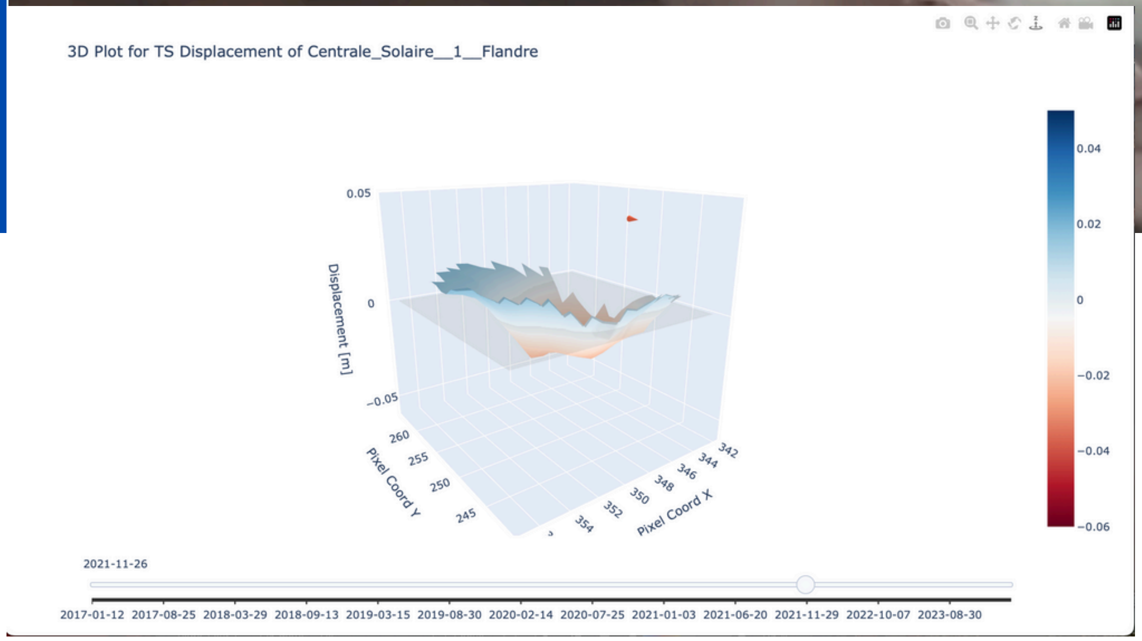
## Integration & Visualization – Interactive Dashboard

All datasets are merged into an interactive dashboard, displaying:

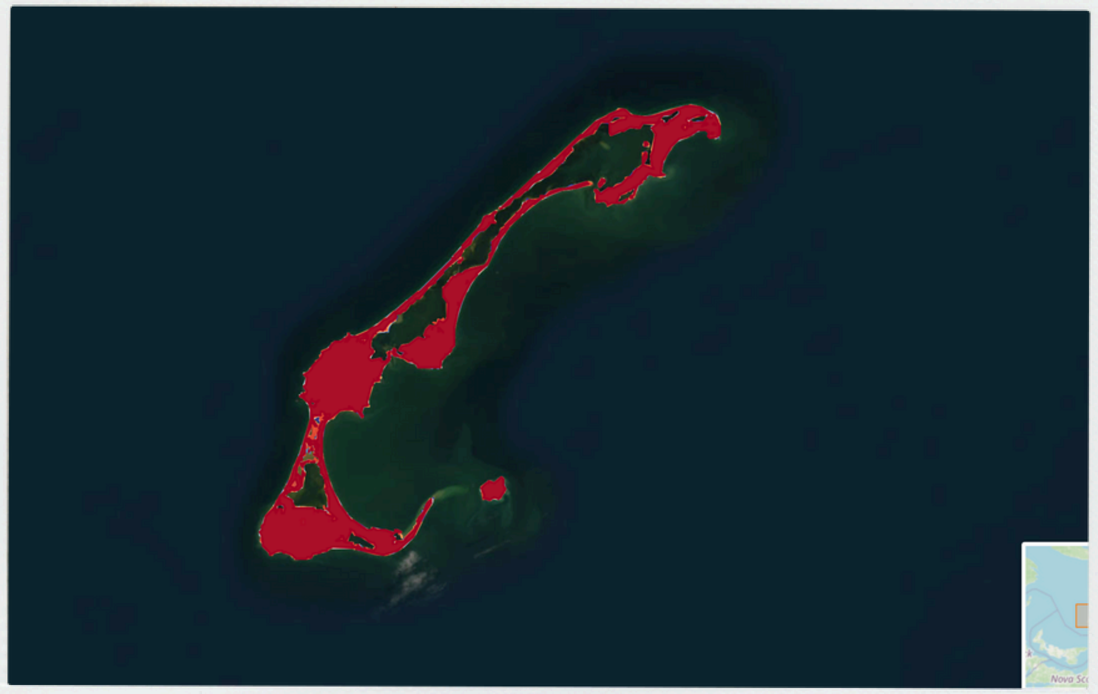
- Temporal evolution of land area and shoreline position.
- Comparative SAR and Sentinel-2 optical imagery results for each coastal segment.
- Estimated percentage of surface loss and submersion risk zones.

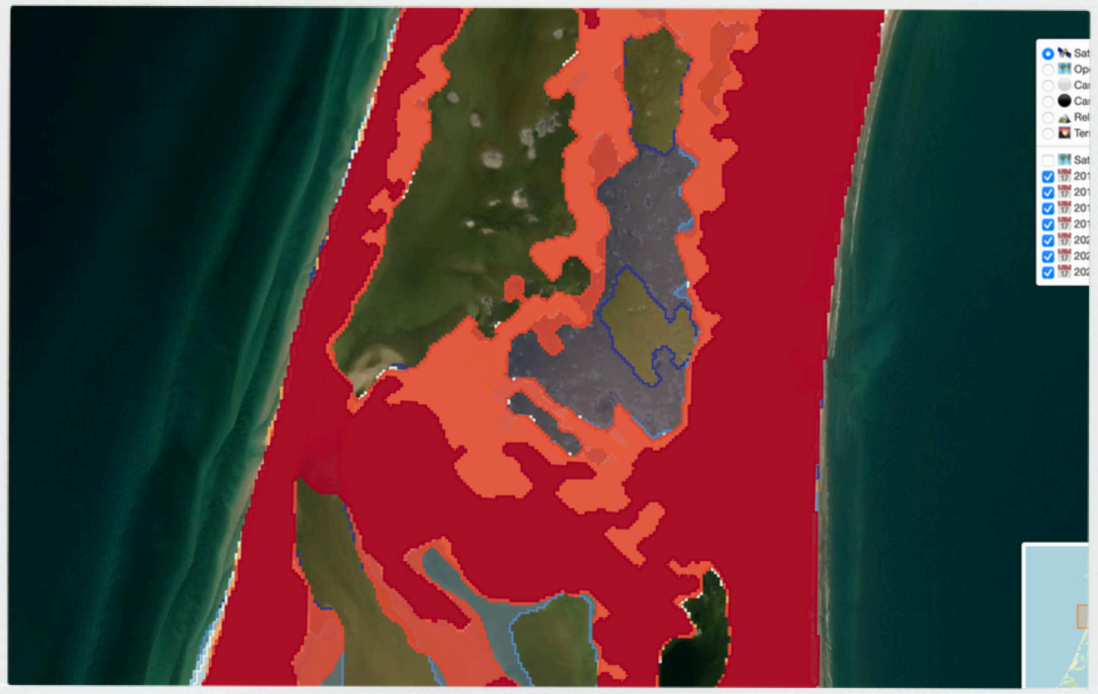
This platform not only provides an integrated view of the Magdalen Islands but is designed to be scalable, allowing future integration of other islands worldwide. The long-term objective is to create a global database for monitoring coastal vulnerability using satellite and in-situ observations. Users can modify the dates for viewing the evolution of the selected island's surface area on time series.

# 4. Results & Visualizations



Demo 3D deformation time-series visualisation





Our analysis of the Magdalen Islands revealed significant land loss and shoreline retreat over recent years.

Key Results:

- 3D SAR visualizations show the progressive erosion of cliffs and beaches over time, highlighting areas exposed to strong wave action and storm surges.
- Sentinel-2 shapefiles allowed us to calculate the percentage of surface lost annually, revealing localized hotspots where more than 5% of land disappeared in a single year.
- Combined SAR and visible data identify high-risk zones that are most vulnerable to future submersion.

Visualization Platform:

All data were integrated into an interactive dashboard, providing:

- Overlay of SAR-derived topography and visible land boundaries.
- Time-series visualisation of annual land loss.
- Charts showing surface area reduction over time for different coastal segments.

These results provide a clear, visual understanding of coastal dynamics, and the framework can be applied to other islands worldwide to monitor erosion and submersion.

Source: https://github.com/MrCreeperman147/NASASpaceApp2025

# 5. Global Application & Perspectives

**This project demonstrates how satellite-based monitoring can effectively reveal the impact of climate change on small islands such as the Magdalen Islands. By combining SAR imagery and visible optical data, we successfully quantified land loss and visualized shoreline evolution through time.**

**Key Takeaways:**

- Coastal erosion and marine submersion are accelerating due to sea-level rise and storm intensity.
- Integrating multiple satellite datasets provides a comprehensive and scalable method for monitoring island vulnerability.
- The use of an interactive dashboard makes the information accessible and actionable for researchers, policymakers, and local communities.

**Perspectives:**

- Extend the model to other islands worldwide to create a global coastal vulnerability database.
- Incorporate machine learning to improve prediction accuracy and automate shoreline detection.
- Develop real-time monitoring tools to support early warning systems for at-risk coastal populations.

By leveraging Earth observation technologies, this work contributes to a better understanding of climate impacts and supports global efforts to protect island environments and their communities.

This will give users access to a ready-to-use web map allowing them to view all the data on changes in the surface area of any island on Earth and observe any changes that may have occurred.

# 7. References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**NASA Resources & Global Relevance**

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