Interreg Caraïbes
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UNION EUROPÉENNE

SARG'COOP
Programme caribéen de coopération de lutte contre les algues sargasses

Assessing the Feasibility of Impact-Based Forecasting For Seasonal Influxes of Sargassum Seaweed on the Coastlines of Caribbean Small Island Developing States (SAR for Sargassum)

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Agenda

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- The Sargassum Threat
- Trending Sargassum Early Warning Methodologies
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- Preliminary Research Results
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Introduction

The Caribbean Institute for Meteorology and Hydrology

- WMO Regional Training Centre
- Centre for Research in Meteorology, Hydrology and Climatology
- Regional Data Centre
- Regional Instruments Centre
- Regional Centre of Excellence in Satellite Meteorology
- Advisor to regional governments

Introduction

"… to assist in improving and developing Meteorological and Hydrological Services as well as providing the awareness of the benefits of Meteorology and Hydrology for the economic well-being of the CIMH member states. This is achieved through ***training, research, investigations and the provision of related specialized services and advice***".

The Sargassum Threat

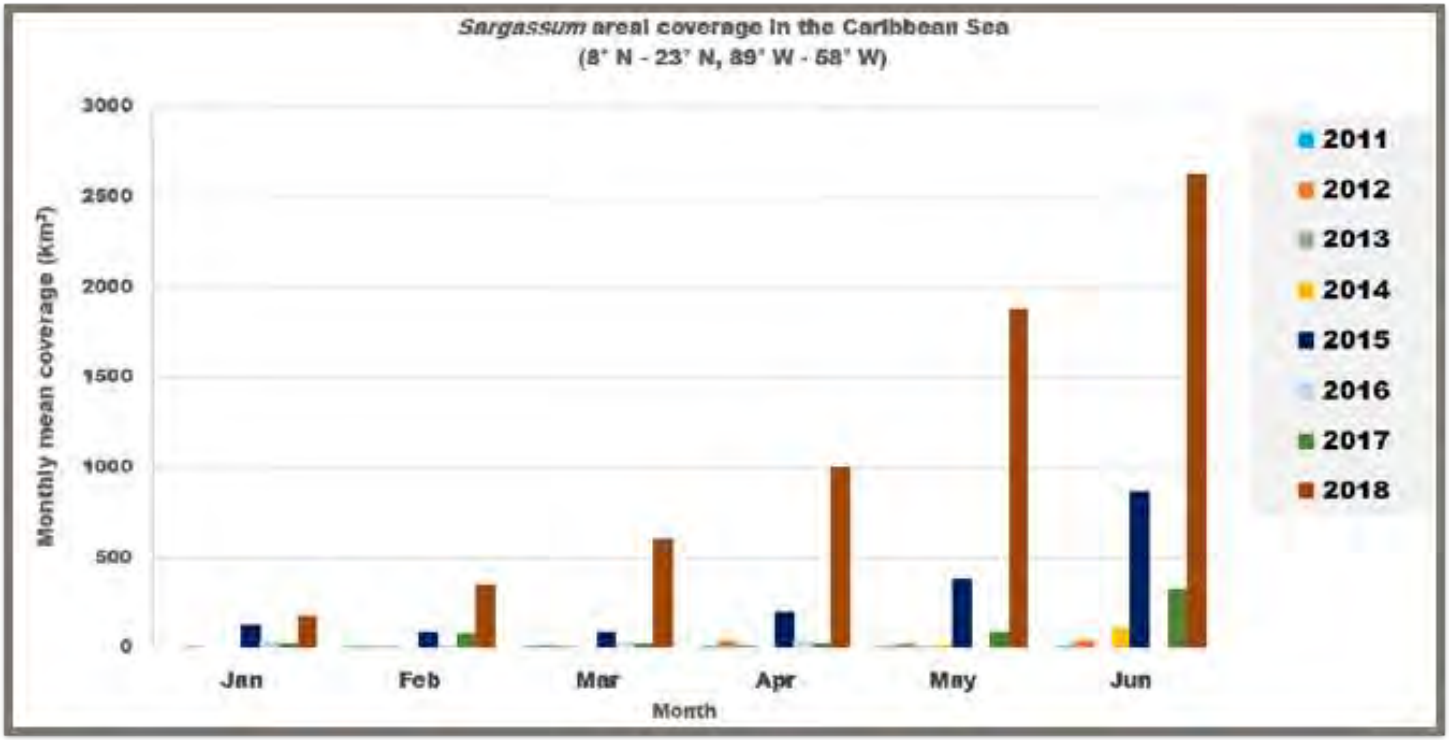
What is Sargassum?

(Image Source: WWW, 2018)[i]

- Floating masses of algae
- Term (Sargassum) originally coined by Portuguese Sailors
- Commonly associated with the Sargasso Sea where it is found in abundance

- A marine ecosystem
  - Reproduction haven and home to smaller species
  - Nursing habitat for larger fish species

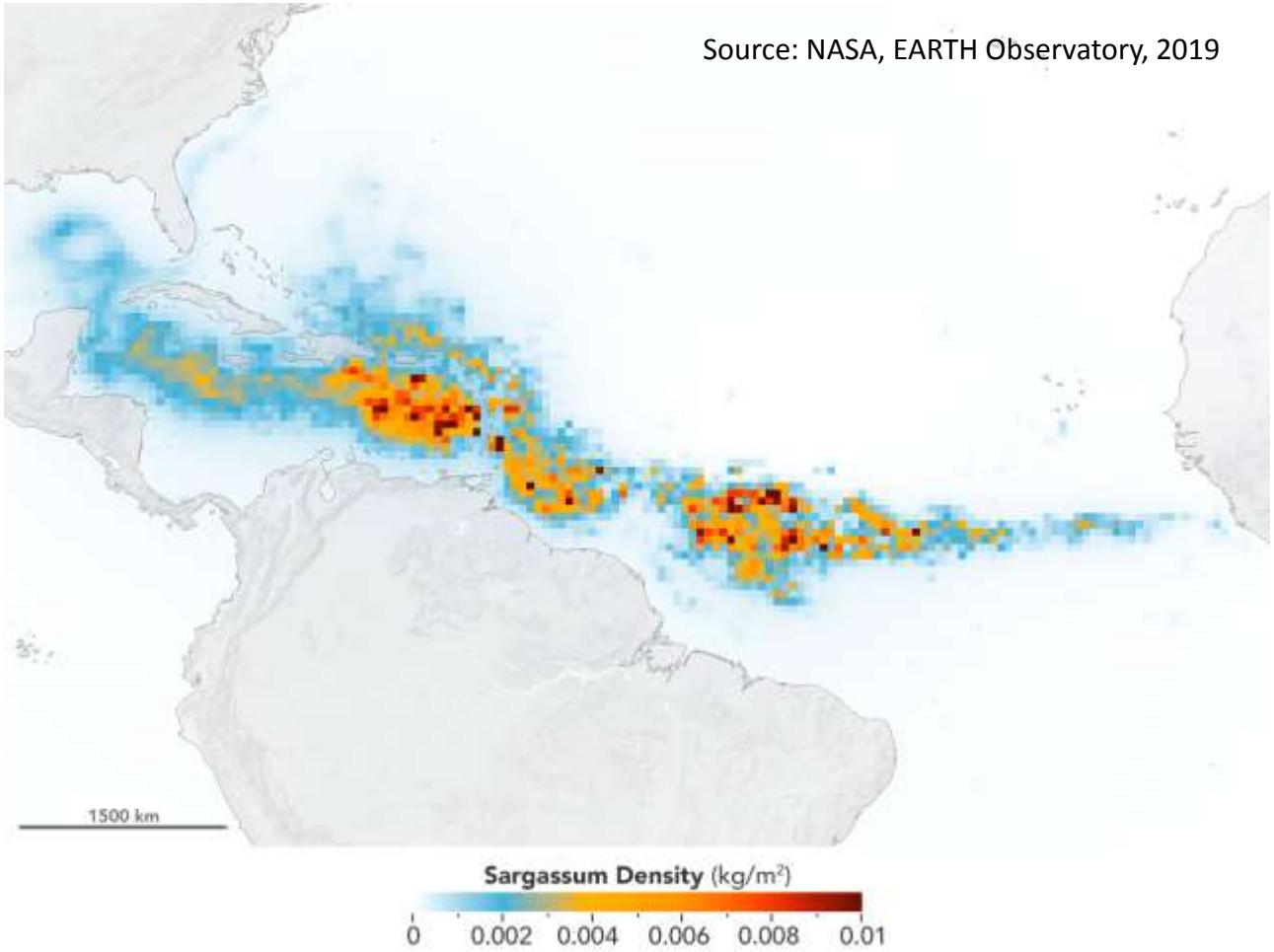
The Sargassum Threat



Source: (University of South Florida, 2019)

- Since 2011, SIDS of the Caribbean have seen an increasing abundance of Sargassum

The Sargassum Threat



- In excess of 20 million metric tonnes reported in June of 2018.

(Wang et.al., 2019)[1]

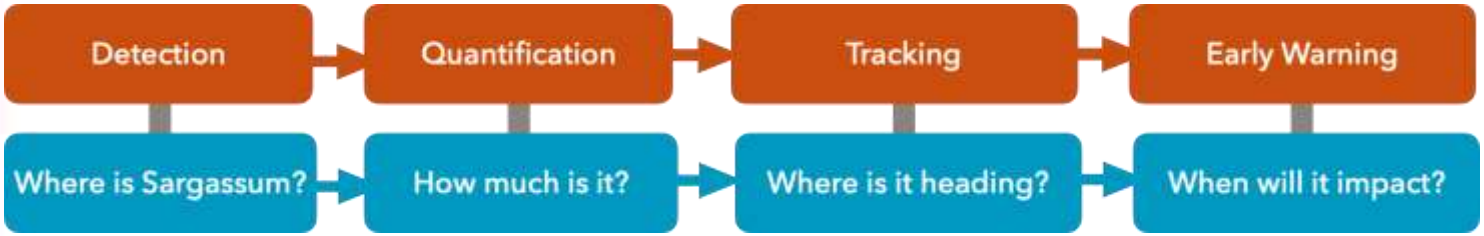
The Sargassum Threat

- In overly abundant masses, Sargassum will impact marine life:
  - Entangle (suffocate) wild-life
  - Block beach nesting sites
  - Transport invasive species
  - Damage coral reef habitats

The Sargassum Threat

- In overly abundant masses it will also:
  - Impact fisheries and tourism:
    - Damage boat motors
    - Delay/prevent fishing launches
- Impact coastal environments
- Possible respiratory ailments
  - Hydrogen Sulphide (decomposed)
- Erodes beaches in clean up effort

Trending Early Warning Methodologies



- Optical Satellite data often used for detection
  - Example – Landsat, VIIRS, MODIS
- Modelling of ocean currents (direction and speeds) for landfall prediction

Examples

- Sargassum Watch System (SaWs)
  - Developed by University of Florida (Optical Oceanography Laboratory)
  - Produces monthly Sargassum impact forecast bulletins
- Sargassum Early Advisory System (SEAS)
  - Developed by Texas A&M University Galveston

The CIMH Research Proposal

The CIMH Research Proposal

Detect Seaweed → Estimate volume/mass → Model direction and speed → Predict beaching location and timing → Quantify potential impacts?

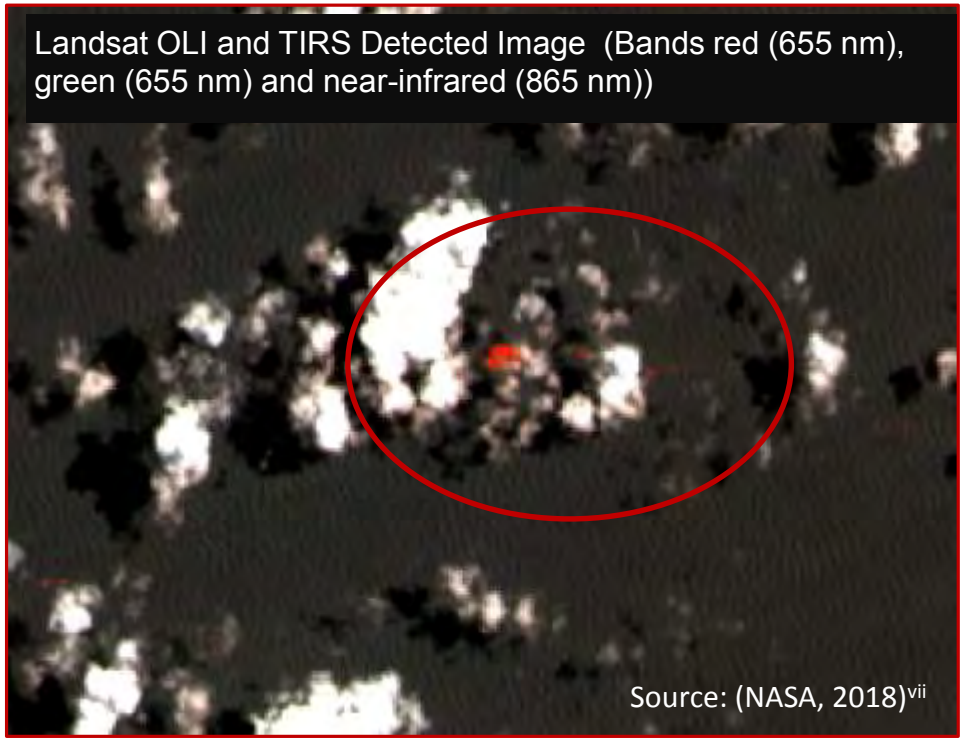
Can the chain be extended to include quantification of impacts?

The CIMH Research Proposal

Why SAR?

Optical Imagery is typically used for Sargassum Detection

- Optical sensors rely on energy in the visible to the infrared portion of the electromagnetic wave spectrum
- Clouds reflect shorter wavelengths in this range of the spectrum
- Optical sensors cannot penetrate clouds and some may rely on sunlight to detect objects



The CIMH Research Proposal

Why SAR?

SAR for Sargassum Detection and Early Warning

Sentinel 1 detected image (processed from SLC image July 16, 2018)

Source: (ESA, 2018)[viii]

- ❑ SAR pulses penetrate cloud masses
- ❑ SAR sensors are also uninhibited by darkness
- ❑ Surface wind (direction and speed) data can be derived from SAR

Preliminary Research Results

Detection Process for SAR Images

Preprocess SLC to GRD → Radiometrically Calibrate → Speckle Filtering

- Speckle is reduced
- Creates square pixels
- Loses phase info
- Retains magnitude info

(ESA, 2019)[3]

- Create Sigma Nought (σ^0) bands – Strength of backscatter energy (db) per unit ground area
- Supports quantitative analysis of SAR image
- Makes corrections for inherent variations within components of the radar equation – a form of normalization

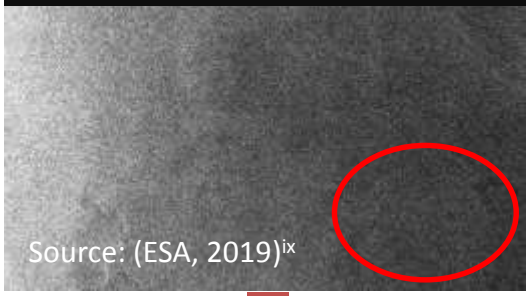
(Sarmap, 2009)[4]

- Further removal of speckle
- Easier to interpret features in the image

Preliminary Research Results

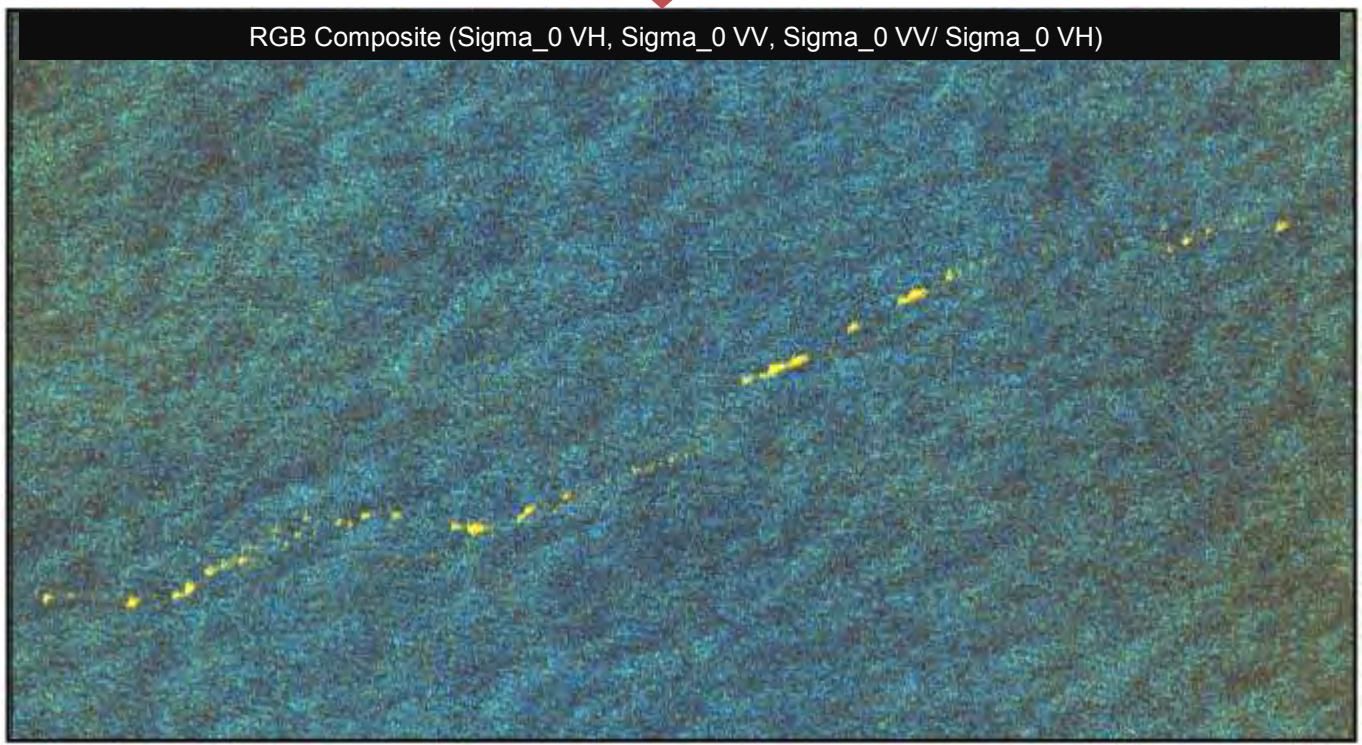
Detection Process for SAR Images

Sentinel 1 SLC image (June 4, 2018)



Source: (ESA, 2019)[ix]

RGB Composite (Sigma_0 VH, Sigma_0 VV, Sigma_0 VV/ Sigma_0 VH)



Preliminary Research Results

Classification Process

Segment Mean Shift Analysis → Generate Signature Files → Supervised Classification

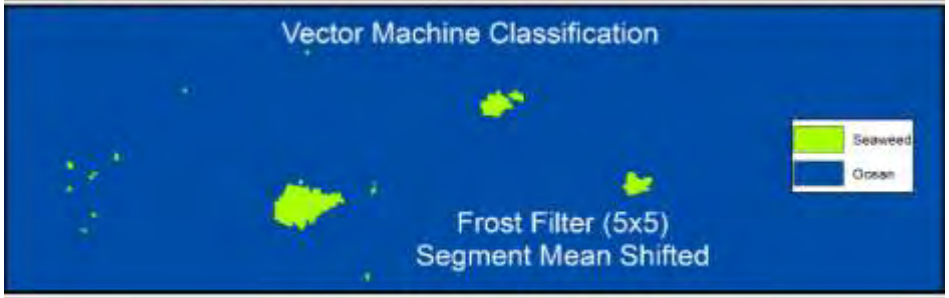
- Creates segmented regions across the pixels, thus simplifying the image
- Useful for separating pixels which represent different objects despite having similar values
- Makes classification step easier to accomplish

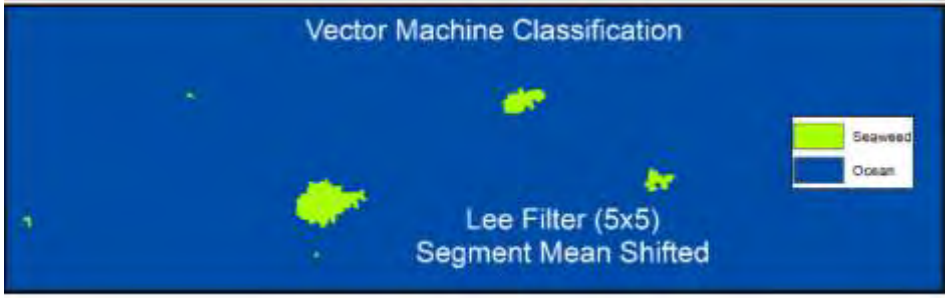
- Take training samples from segmented regions
- Statistically significant samples only!
- Use samples to train various classification algorithms and create signature files

- Use signature files to test various classification routines
- Compare results

Preliminary Research Results

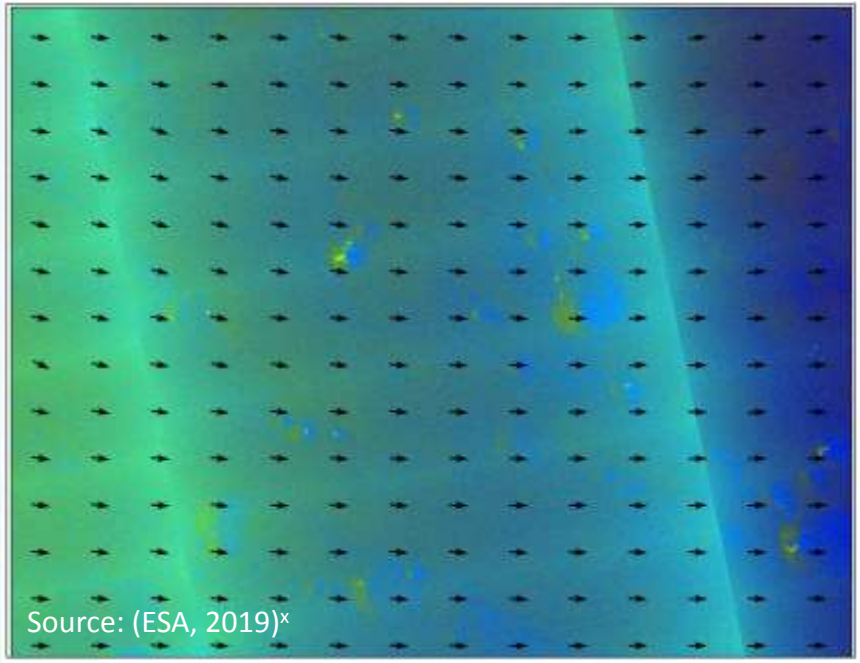
Classification Example





Next Steps

Modelling Movements



Surface wind direction as derived from Sentinel 1 OCN product

(Meteorological Convention)

- Research on techniques for surface wind (speed and direction) from SAR is underway
- These variables can serve as input to existing ocean current modelling approaches.

Next Steps

Roadmap to Operational Detection and Early Warning

Refine Classification Routine → Automate Detection Routine (Python?, R?, Machine Learning?)

↓

Integrate seaweed movement modelling (landfall prediction research is ongoing) → Develop and integrate impacts model (Quantification of impacts from landfall)

Research Challenges

- We need more data!
  - Spatially and temporally compatible optical imagery needed for positive verification
  - Alterative SAR data sources required for improved detection and tracking efforts
  - Freely available repositories are often missing images for critical location and time stamps
  - Satellite tasking services are prohibitively expensive
- Sargassum mats are sometimes difficult to detect under rough sea conditions

Summary

We don't intend to reinvent the wheel but only to see where SAR can add value:

- Detection
- Tracking and prediction of movement

- We intend to take the research question a step further by quantifying Sargassum impacts after forecasting landfall.

- More data please!!!!
  - Spatially and temporally consistent data are required for verification
  - Alternative SAR and optical data sources are required for effective detection and tracking to account for gaps in repeat cycles

Questions??

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