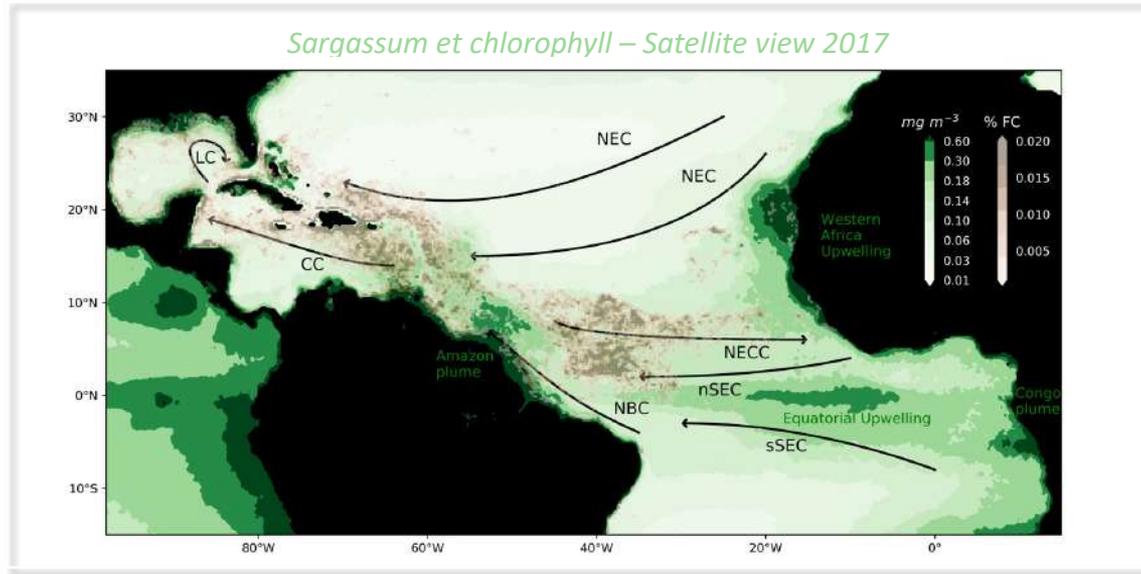


Sargassum Seasonal forecast



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FORESEA 
FOREcasting seasonal Sargassum Events in the Atlantic



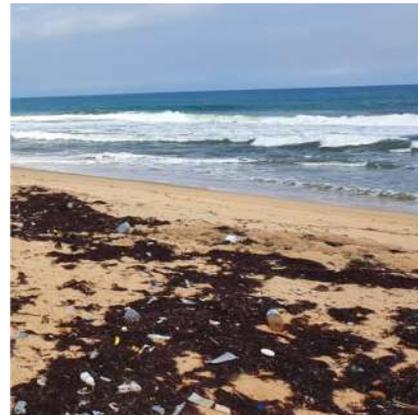
Context

Since 2011, huge sargassum mass strandings (*Sargassum fluitans* and *Sargassum natans*) have occurred in the wider Caribbean region and in West African countries

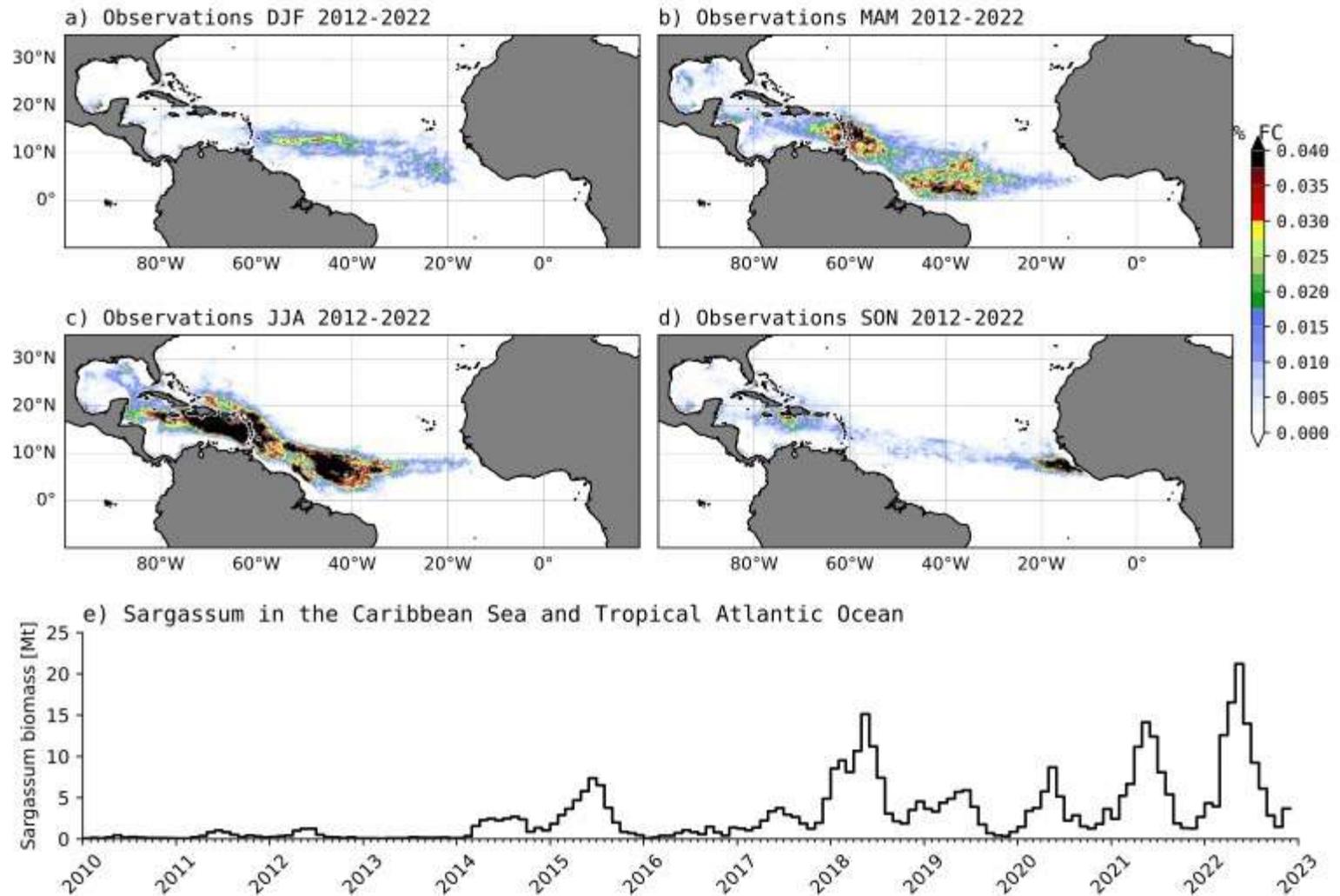


Many impacts :

- Fisheries
- Health (H2S)
- Coastal ecosystem
- Erosion
- Tourism
- ...



A large scale phenomenon / Large interannual fluctuations



ANR FORESEA (2020-2023)

Two main objectives → Understand the phenomenon (drift, growth/mortality, variability)
→ Seasonal forecasting

WP1
Remote sensing

WP2
Understanding the
phenomenon (drift,
growth, variability)

WP3 Seasonal
forecasting

WP4 Regional
downscaling around
Martinique and
Guadeloupe

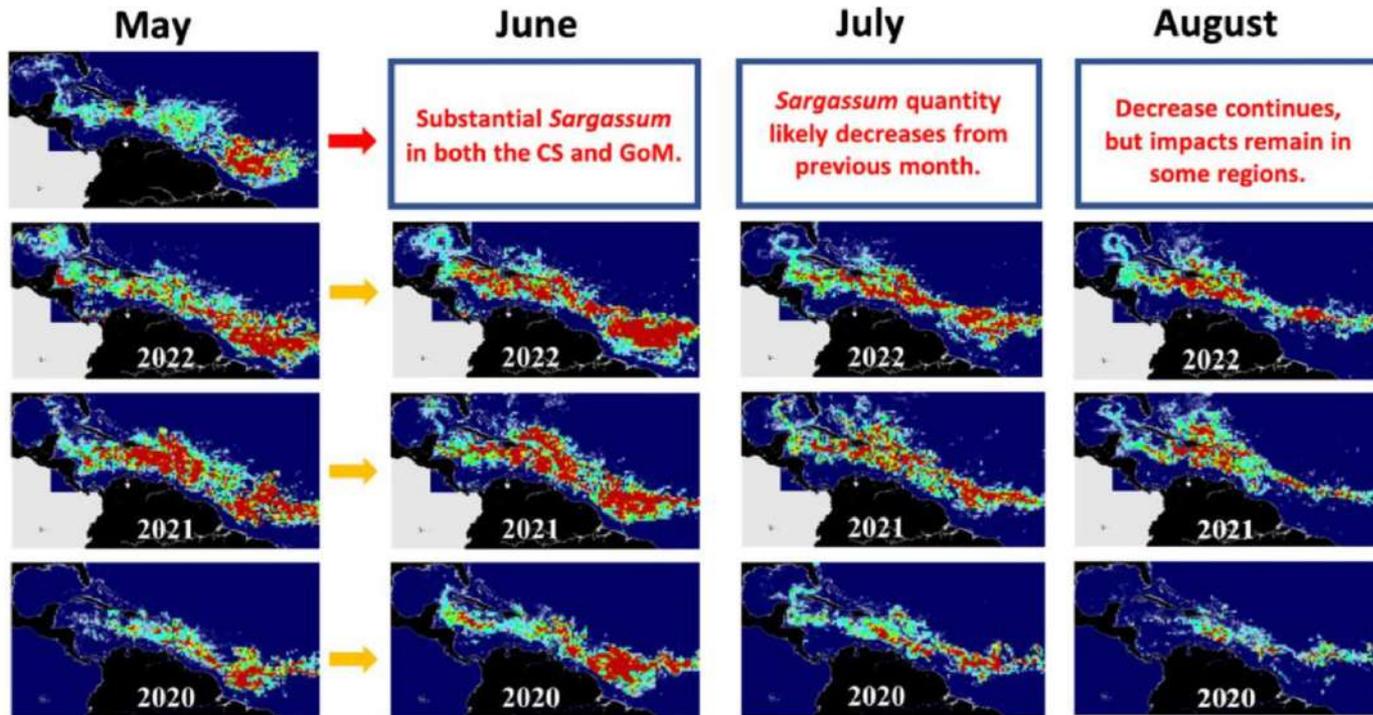
ANR
Funded from summer 2020
(part of the group received some support
IRD, Ministère de la Transition Ecologique)

CTM + RG
Not funded from
summer 2021

TOSCA SAREDA (2018-2022)

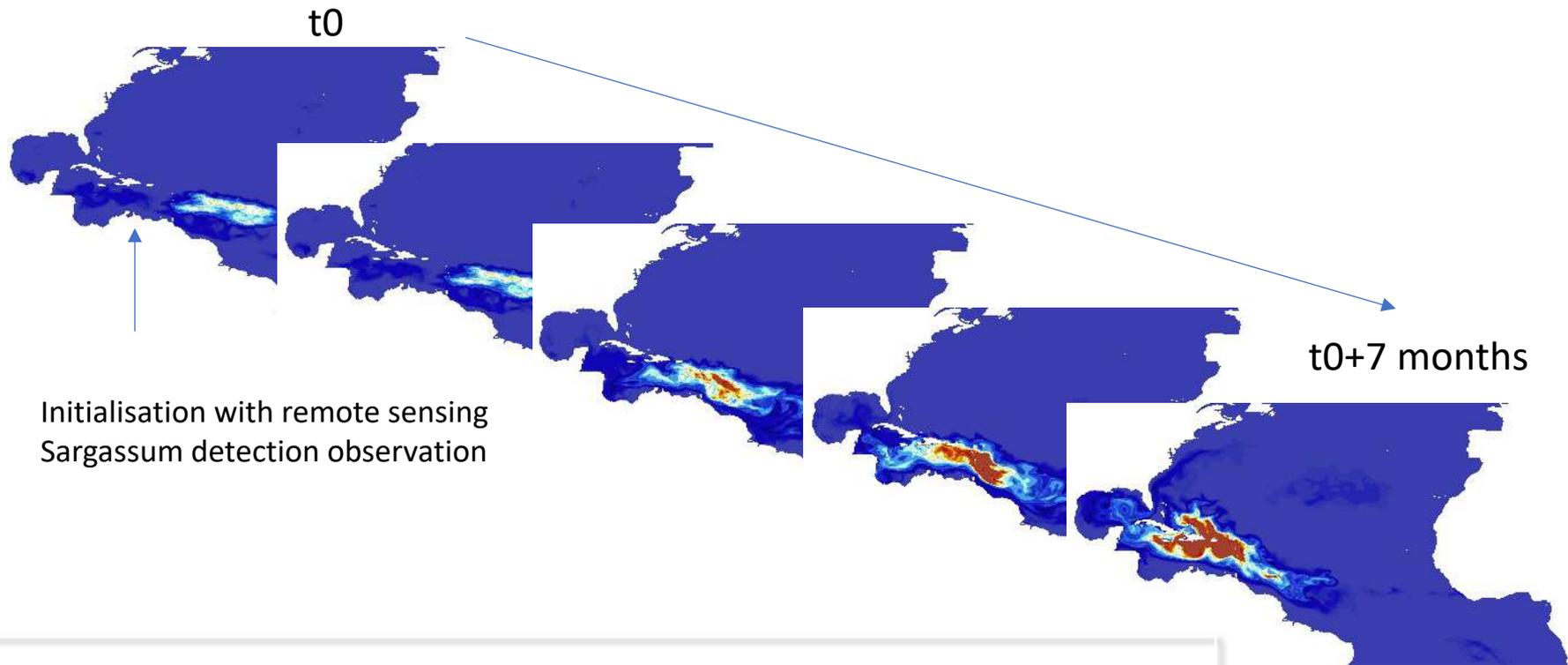
→ Detections AFAI MODIS (2002-present)

Current available forecast : USF monthly bulletin (Hu et al. 2016)



Objective : design a seasonal forecasting system

Investigate the predictability of the Sargassum seasonal events



Guidelines

- Consider uncertainties in observations and predicted ocean and atmospheric fields
- Evaluation/qualification of the forecasting performances

Sargassum model

Key ingredients identified to represent Sargassum fluctuations

Transport

currents *Wang and Hu, 2017; Brooks et al., 2018; Putman et al., 2018, 2020, Johns et al. 2021*

windage *Putman et al., 2020; Berline et al., 2020*

~~stokes drift~~ *Jouanno et al. 2021*

Growth

solar irradiance *Hanisak, 1983, Hanisak and Samuel 1987, Lapointe 1995*

temperature *Carpenter and Cox 1974, Hanisak and Samuel 1987*

salinity *Hanisak and Samuel 1987*

macronutrients (NO₃, PO₄, NH₄) *Lapointe 1986, 1995*

nutrients stored in the tissues *Lapointe et al. 1995, 2021*

Mortality/Decay

Senescence

Stranding

Some hypotheses/limitations :

- No discrimination between morphotypes (Natans/Fluitans)
- No ageing
- No inertial effect (Beron Vera 2021)
- No N₂ Fixation

Numerical model

Code NEMO-Sarg1.0 (eulerian approach)

Domain : tropical Atlantic

Vertical : surface layer only (1m depth)

Resolution : $\frac{1}{4}^\circ$

Number of prognostic variables : 3 (C, N, P)

Other : no feedback to the biogeochemical model

$$\frac{\partial C}{\partial t} = U_C - \phi_C$$

$$\frac{\partial N}{\partial t} = U_N - \phi_N$$

$$\frac{\partial P}{\partial t} = U_P - \phi_P$$

$$f(T) = e^{-\frac{1}{2} \left(\frac{T - T_{opt}}{T_x - T} \right)^2}$$

$$f(I) = \frac{I}{I_{opt}} \cdot e^{\left(1 - \frac{I}{I_{opt}}\right)}$$

$$f(Q_N) = \left(\frac{1 - Q_{Nmin}/Q_N}{1 - Q_{Nmin}/Q_{Nmax}} \right)$$

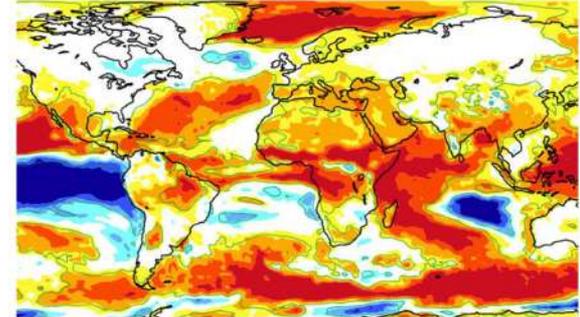
$$f(Q_P) = \left(\frac{1 - Q_{Pmin}/Q_P}{1 - Q_{Pmin}/Q_{Pmax}} \right)$$

$$\begin{aligned} \phi_{transport}(Nutrient) = \\ - U \cdot \frac{\partial Nutrient}{\partial x} - V \cdot \frac{\partial Nutrient}{\partial y} \\ K_h \cdot \nabla_h^2 Nutrient, \end{aligned}$$

Forcing

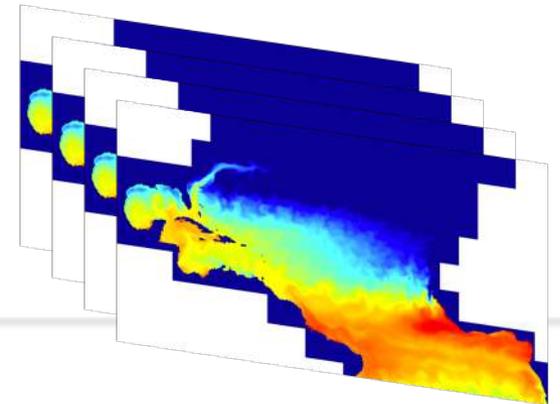
Atmosphere (irradiance, winds)

- SEAS5 - seasonal forecasting ensembles from ECMWF
- integration from t_0 to t_0+7 months
- 25 members
- available the 15th of the month



Ocean (temperature, salinity, currents)

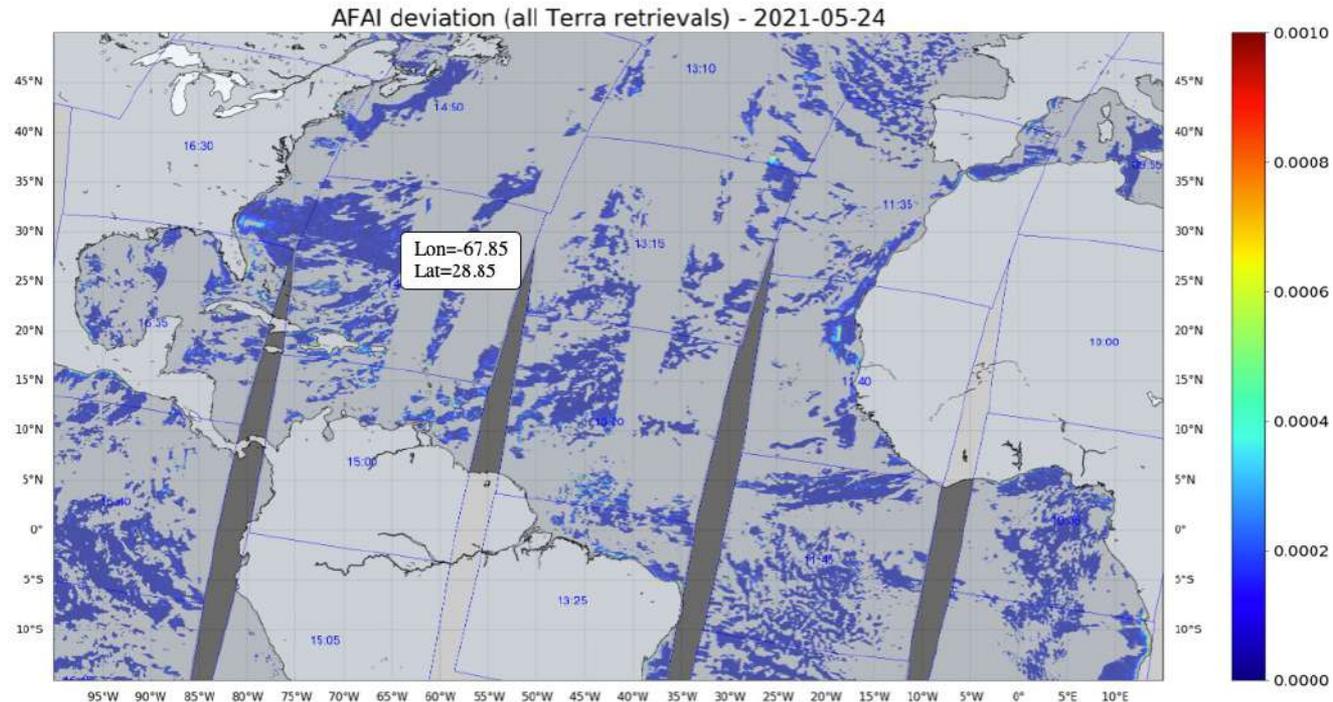
- ensembles of regional NEMO simulations at $\frac{1}{4}$ forced with SEAS5 and initialized with GLO12 - MERCATOR analysis (LEGOS)
- 25 members / monthly initialisation



Biogeochemistry (NO₃, PO₄, NH₄)

- No forecast available
- use of climatologies computed from MERCATOR-biomer4v2r1 simulations (2008-2021)

Initialisation



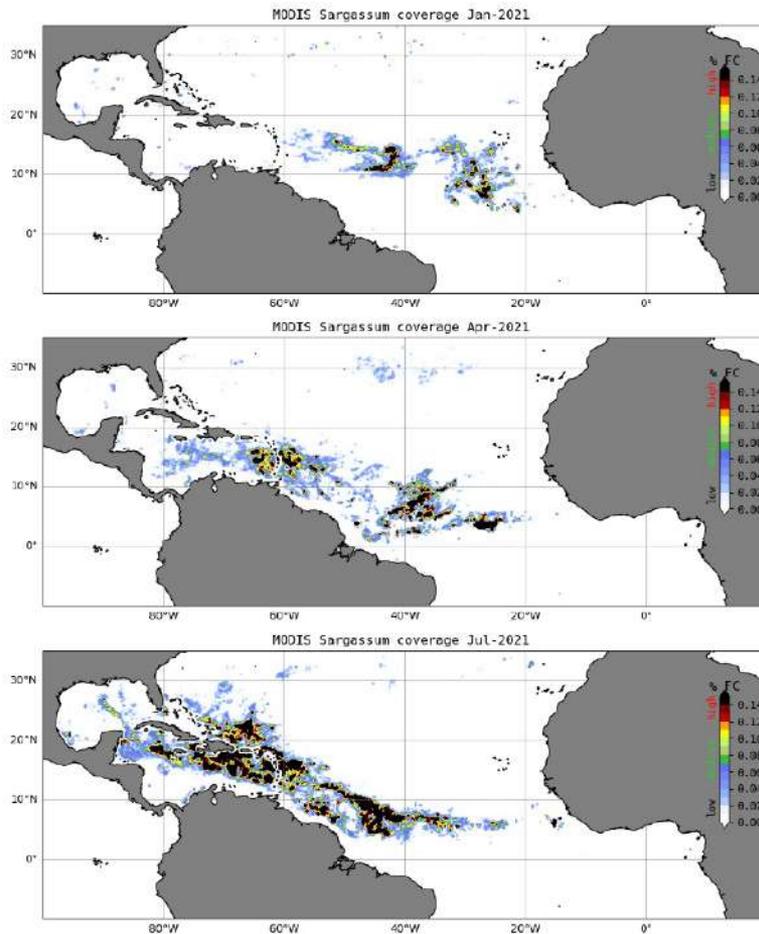
- *Sargassum* biomass obtained from MODIS AFAI index (Wang and Hu 2016)
- daily quasi near-real time production (t+2days) at ICARE (Berline and Descloitres 2021)
- False detection filtering
- monthly averages centered on the 1st of each month

Evaluation in reforecast mode

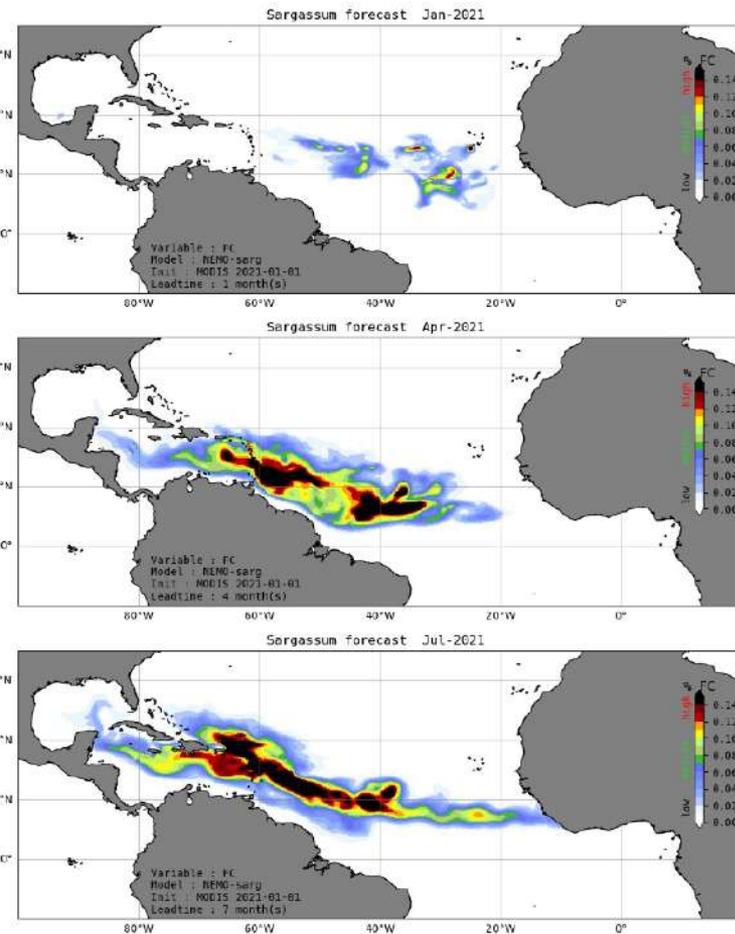
Reforecast of the period Jan 2012 to Dec 2021 :

- we place ourselves in the same conditions / constraints as for the forecast
- ensemble of Sargassum simulations (25 members), integrated 7 months forward

Modis observations

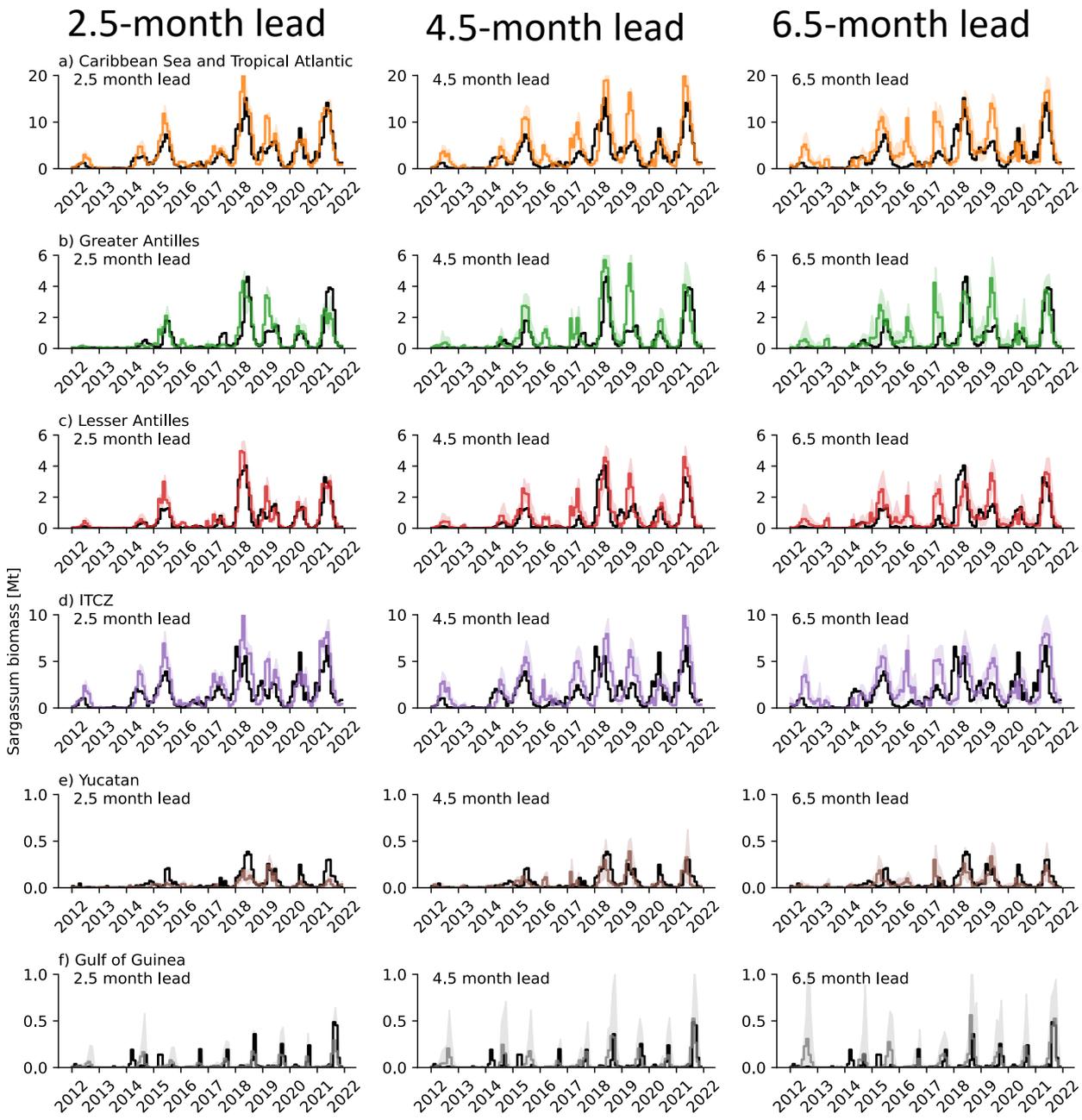


Forecast (ensemble mean)



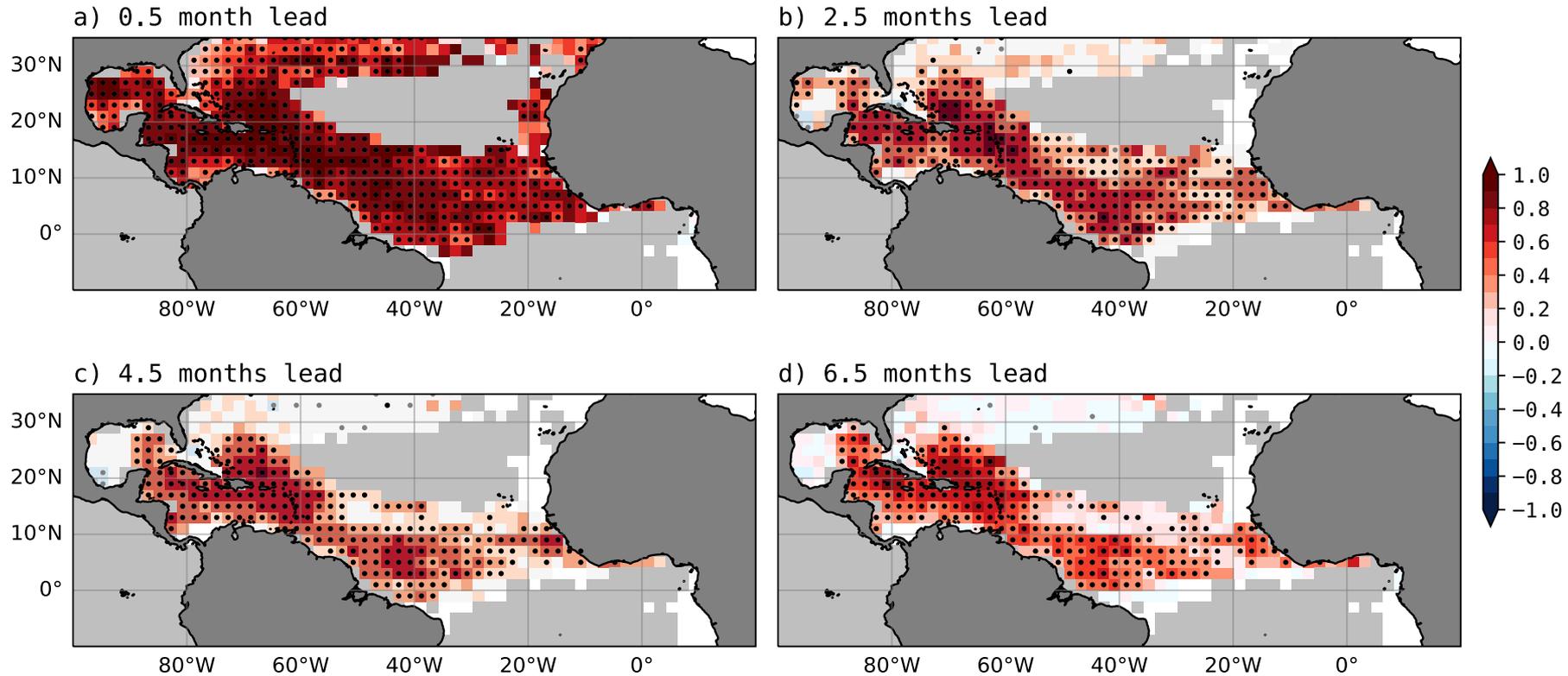
Exemple : reforecast initialized 1st of January 2021

Evaluation in reforecast mode



Evaluation in reforecast mode

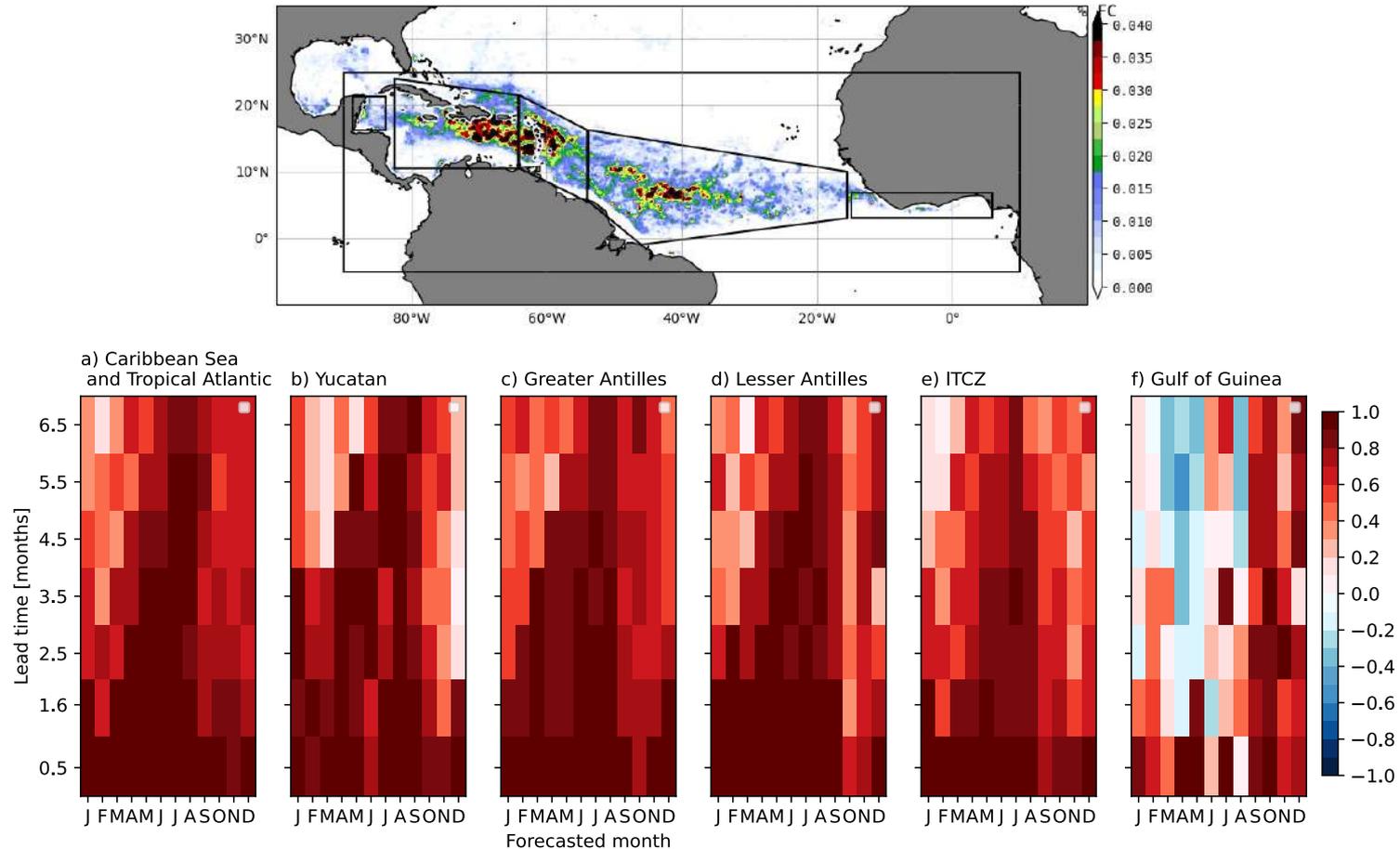
Skill of the forecast



Skill of the forecast evaluated using Anomaly Correlation Coefficient (ACC) for the period 2012-2022.

- → where the forecast performs better an observationally based climatology

Evaluation in reforecast mode



Skill depends on :

→ **target regions**

high for the Lesser Antilles / Caribbean / lower for the West African coast

→ **initialization time**

weaker predictability for initialization in Sept-Oct-Nov

Labelisation of the system by the Space Climate Observatory (SCO)

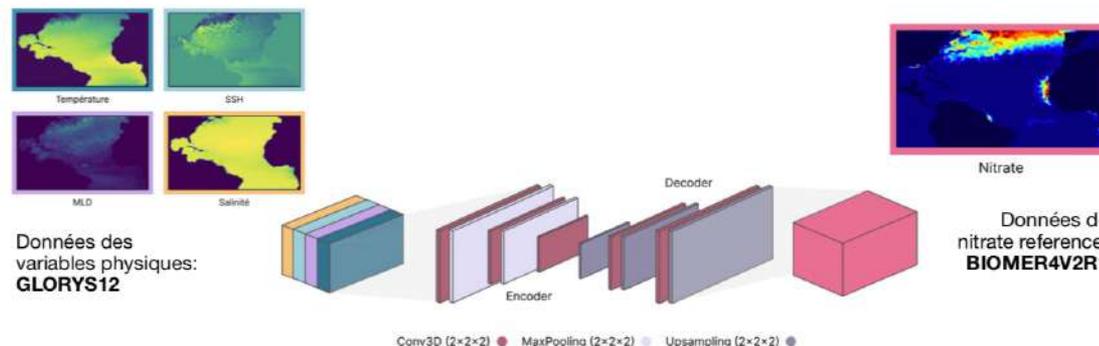
Full operationalisation of the system : SESAM project (2023-2025; IRD-MERCATOR-CLS)

- Improved initialisation using MODIS, OLCI, S2 and GOES operational detection produced at CLS
- Integration of the system at MERCATOR



Improvement of the model and forcings

- Progress on Sargassum physiology (ANR FORESEA et ANR BIOMASS)
- Data assimilation (EnKF) to account for uncertainties in observations/model (Rachid Benshila, LEGOS)
- Seasonal forecast of macronutrient concentrations

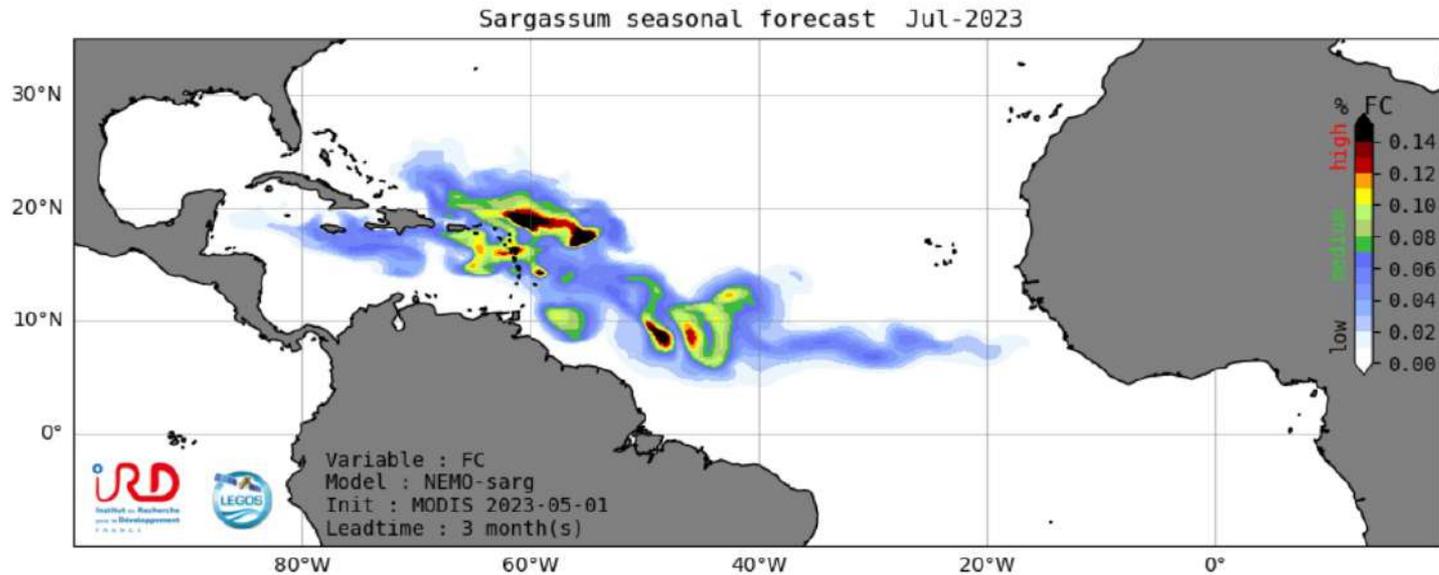


Use of CNN to reconstruct surface nutrients from EcMWF physical forecast (G. Martinez, LEGOS)

Thanks !

Seasonal Sargassum Forecast

Region	Type	Issue	Lead-time
Atlantic	Coverage	202305	3-months



<https://sargassum-foresea.cnrs.fr/sargassum-forecast/>