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Machine Learning–Based Discrimination of Coccolithophore Bloom Development Stages in Optically Complex Coastal Waters of British Columbia Using Sentinel-3 OLCI

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CSA ASC

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PACIFIC SALMON FOUNDATION

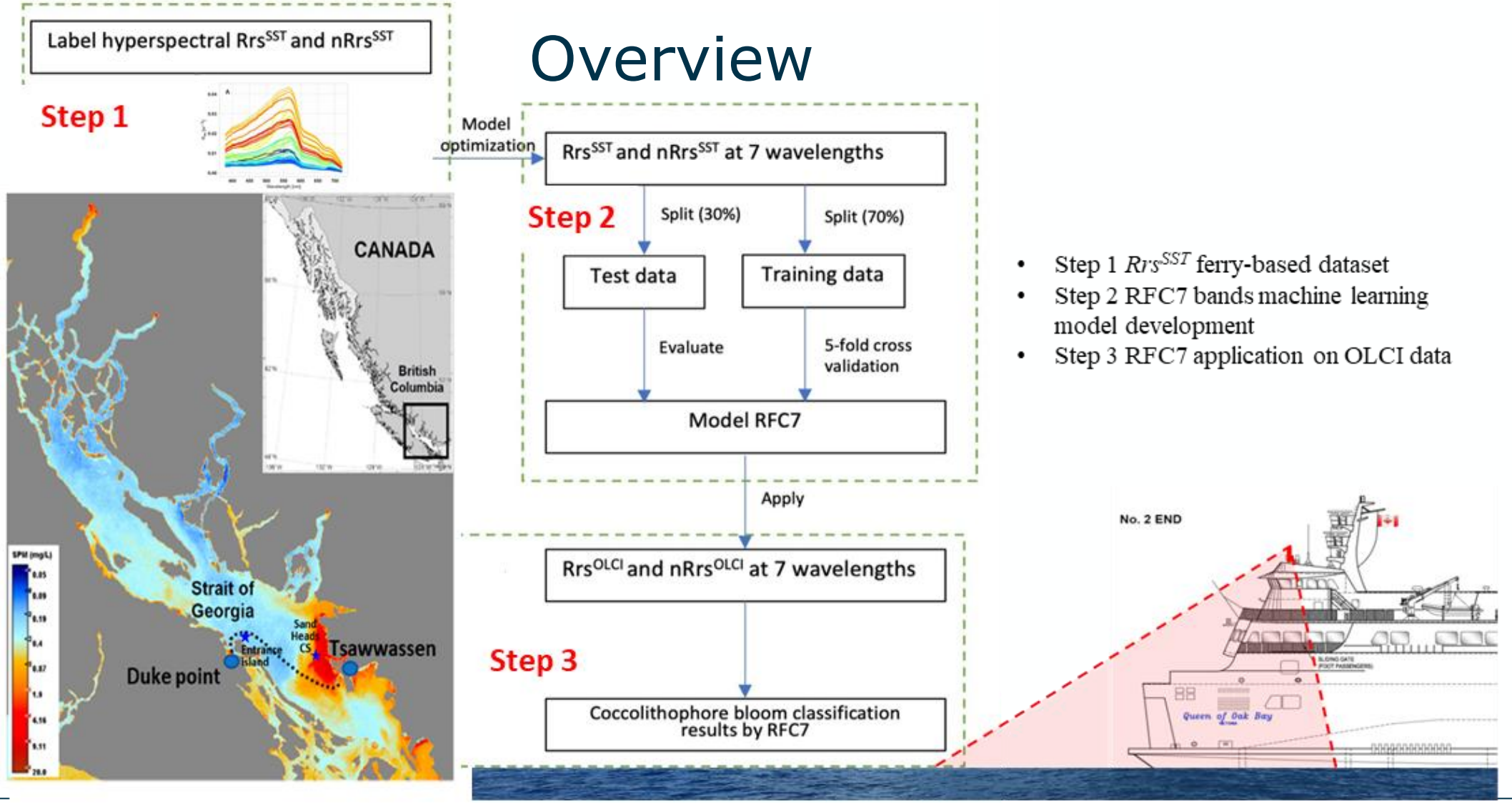
MEOPAR

BCFerries

9th Sentinel-3 Validation Team Meeting 2026

30March – 1 April| ESA-ESRIN | Frascati, Italy

Overview

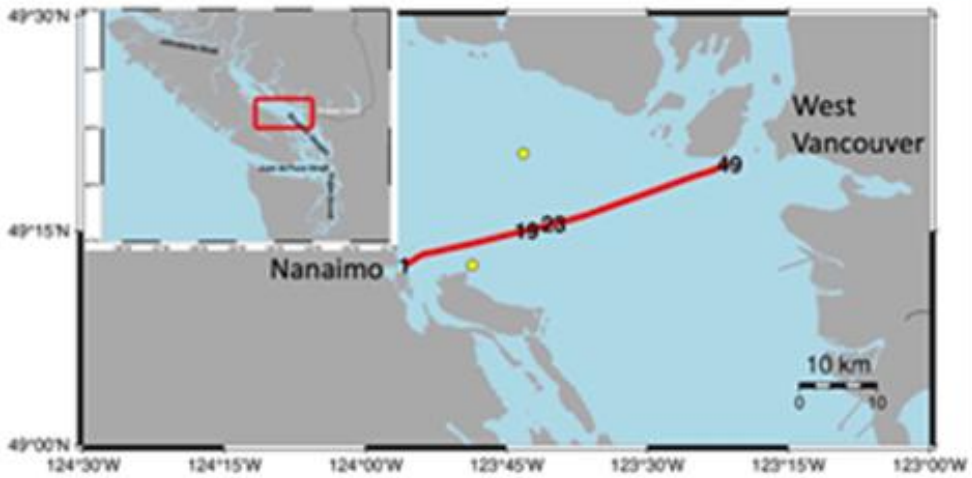


- Step 1 *Rrs^{SST}* ferry-based dataset
- Step 2 RFC7 bands machine learning model development
- Step 3 RFC7 application on OLCI data

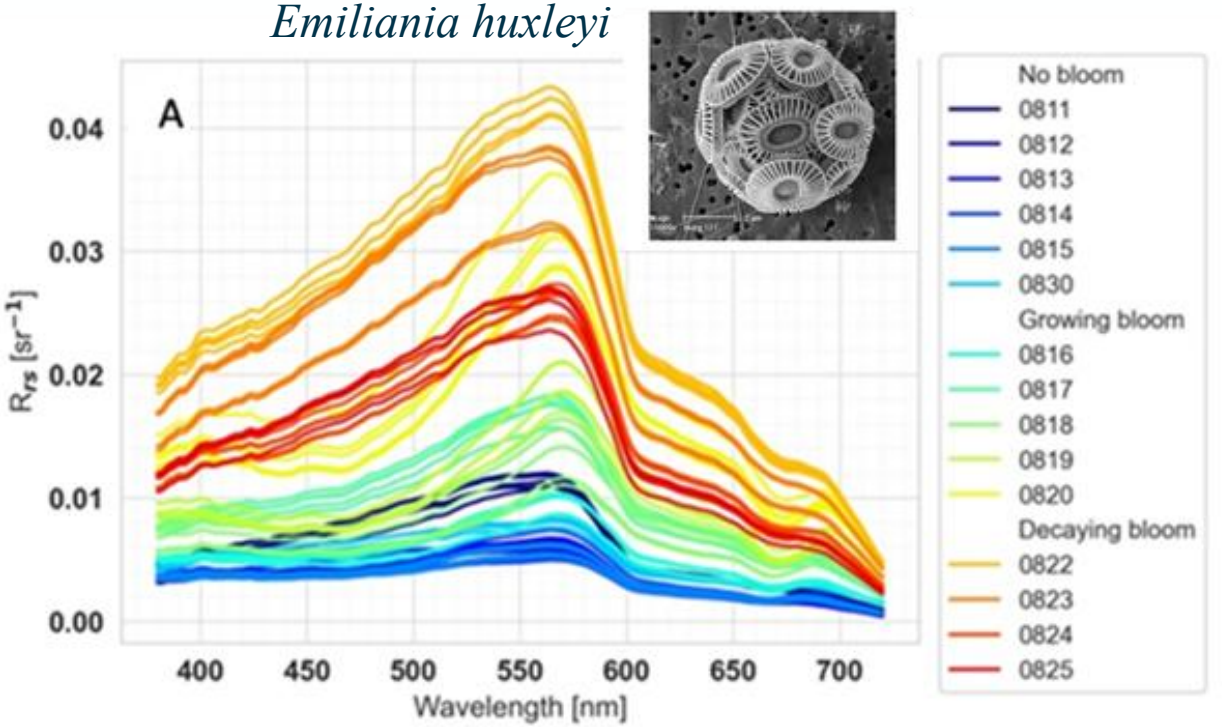
Step 1: Hyperspectral processing and quality control = labelling

- ✓ Meteorological flags: Ed
  - Meteorological flags: Ed
  - Mobley 99
  - Ship perturbation
- ✓ BRDF
  - IOP-based
- ✓ Spectral Quality
  - Quality score - global database

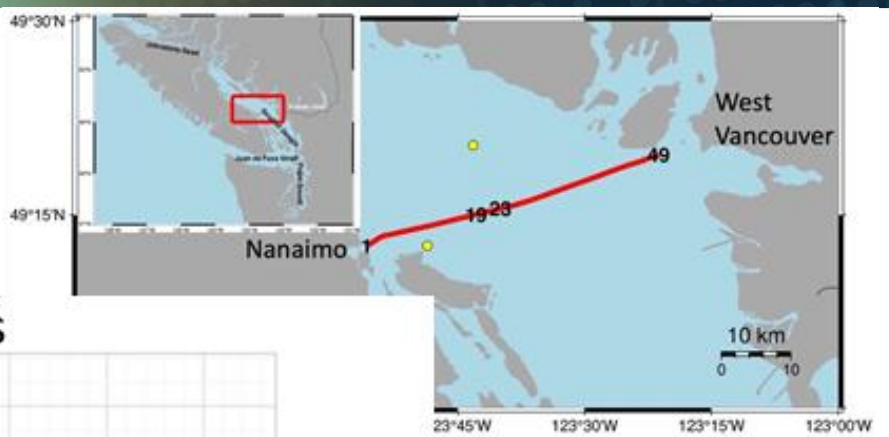
Dataset: 15 clear sky days; 46 stations per day
Total 734 measurements: 513 train, 221 test

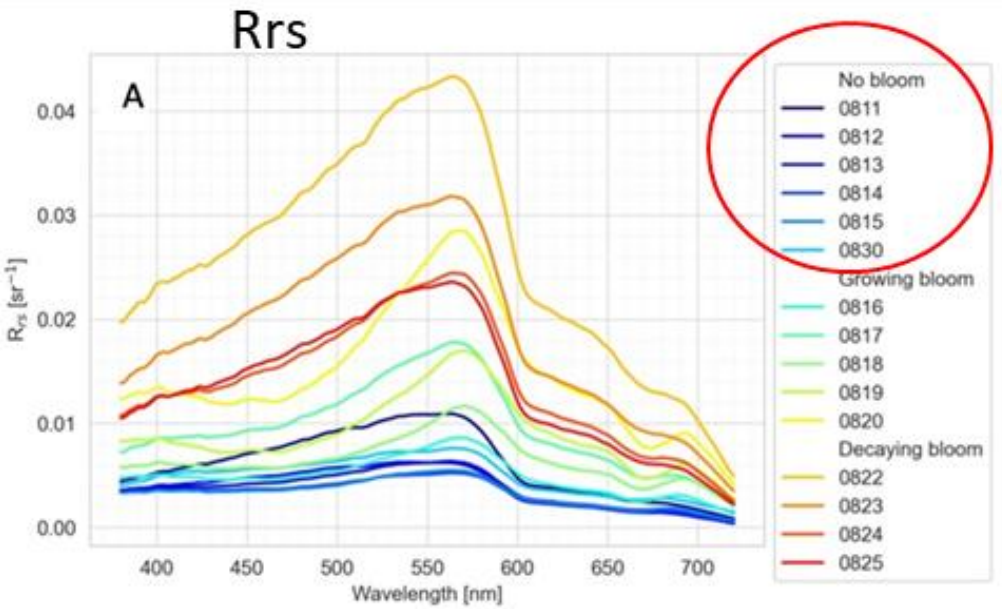


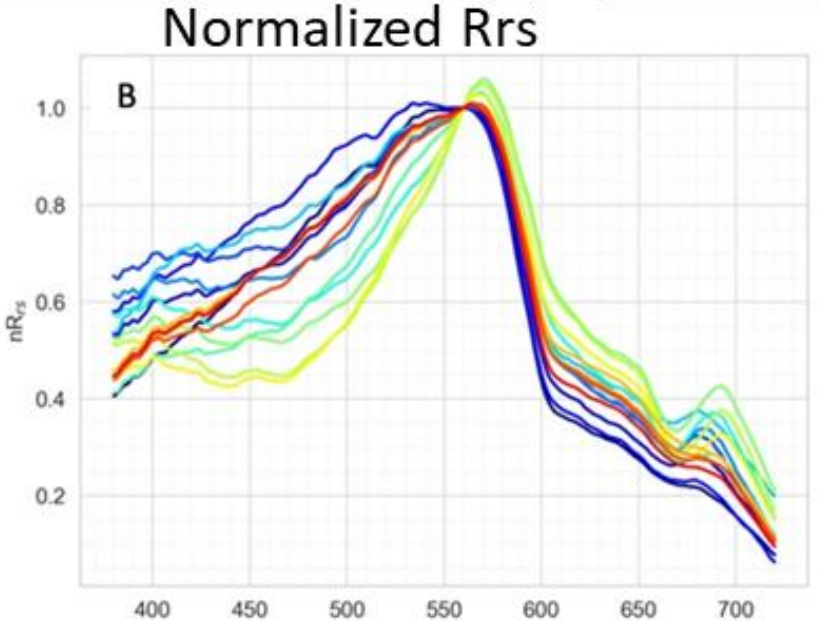
Emiliania huxleyi



Step 2: Classification of coccolithophore bloom development stages

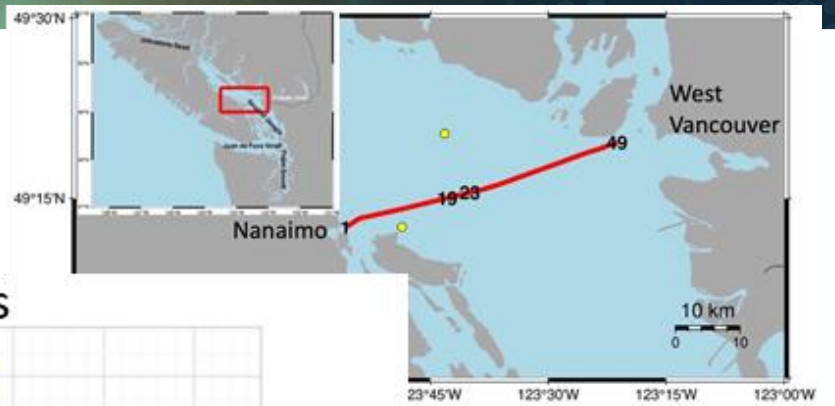


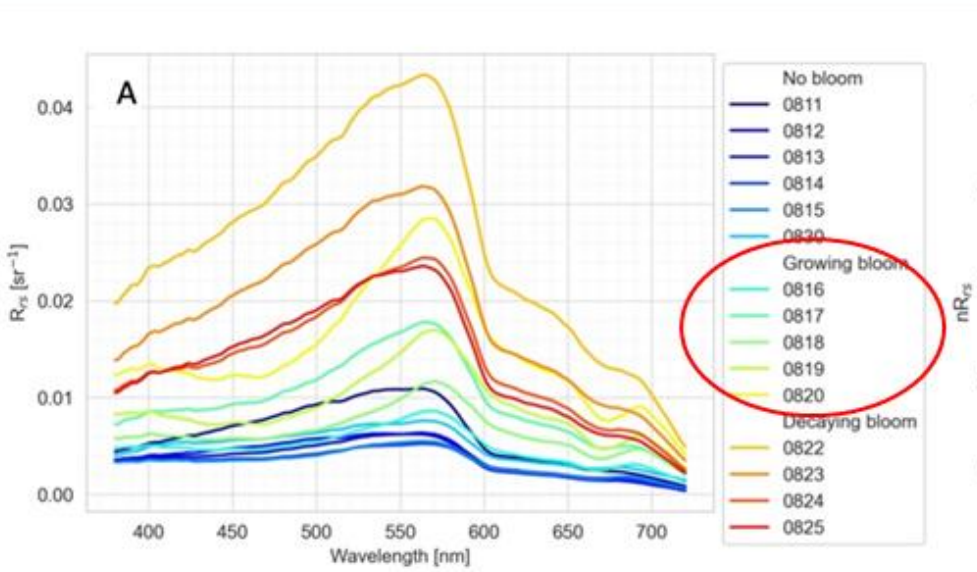


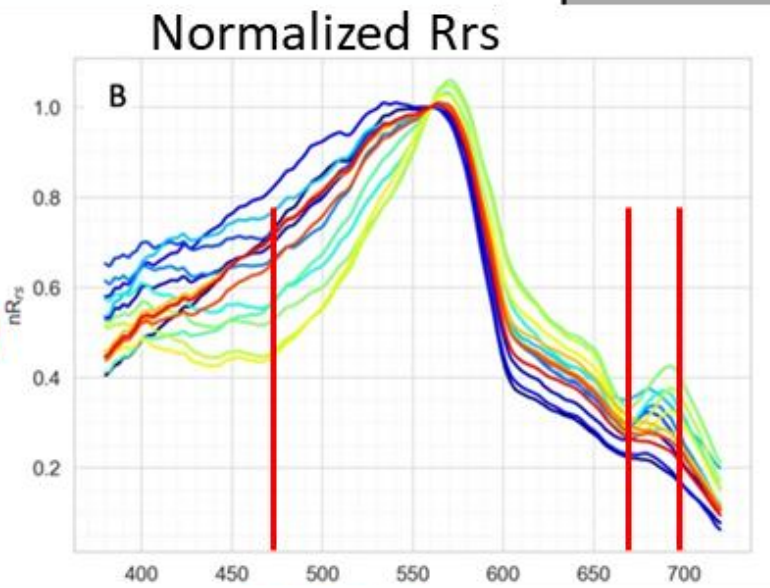


- No bloom: Relatively uniform and low values across the wavelengths

Step 2: Classification of coccolithophore bloom development stages



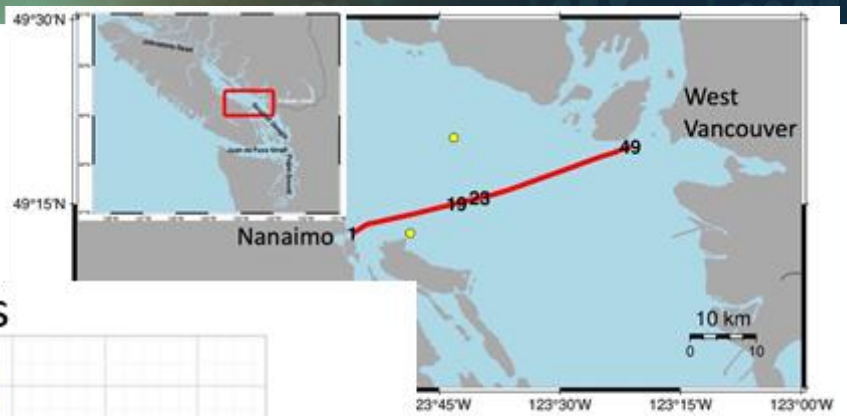


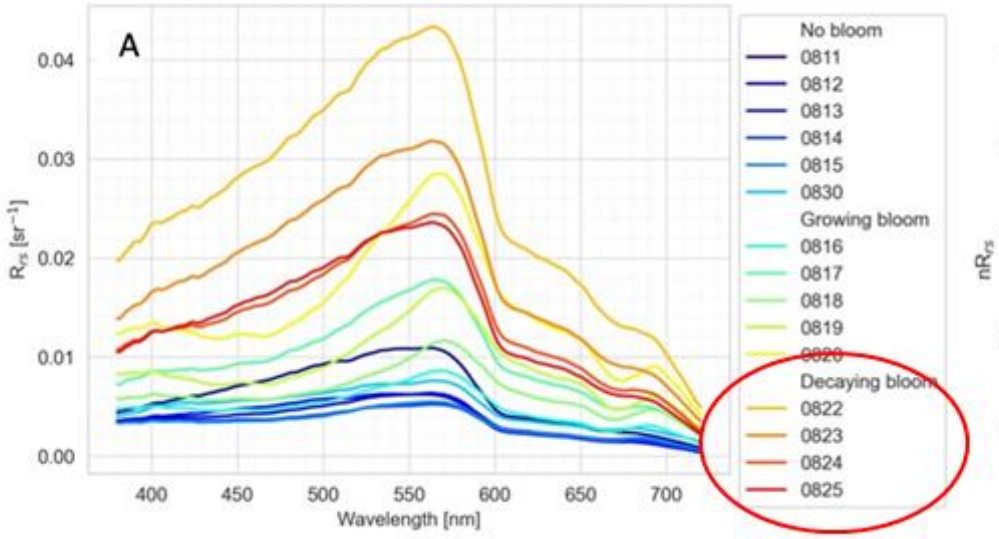


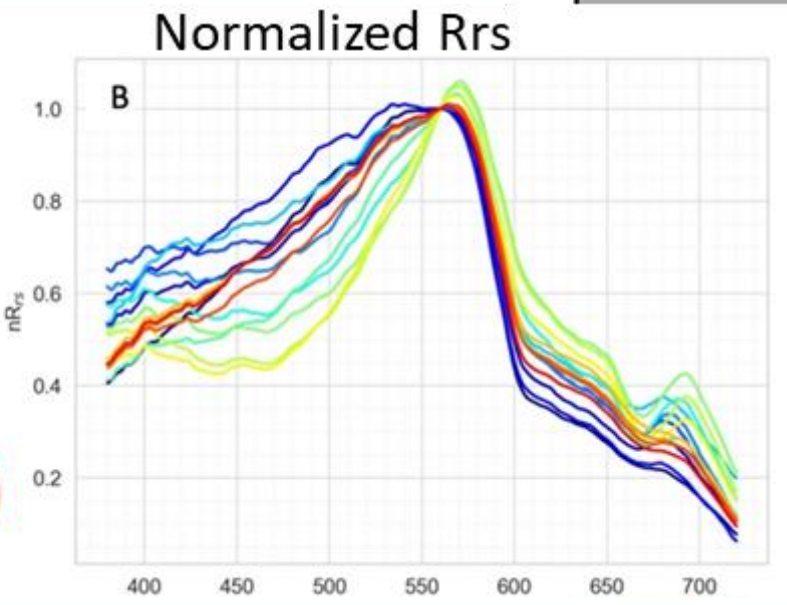
- Significant absorption 400-550 nm
- Moderate absorption around 670 nm
- Chlorophyll-a fluorescence signal around 680-685 nm

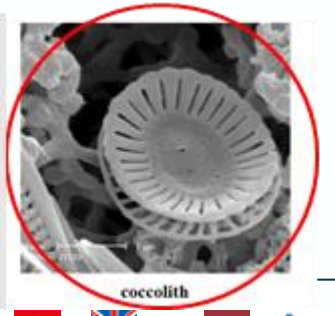
Neeley et al. (2015) and Neukermans and Fournier (2018)

Step 2: Classification of coccolithophore bloom development stages

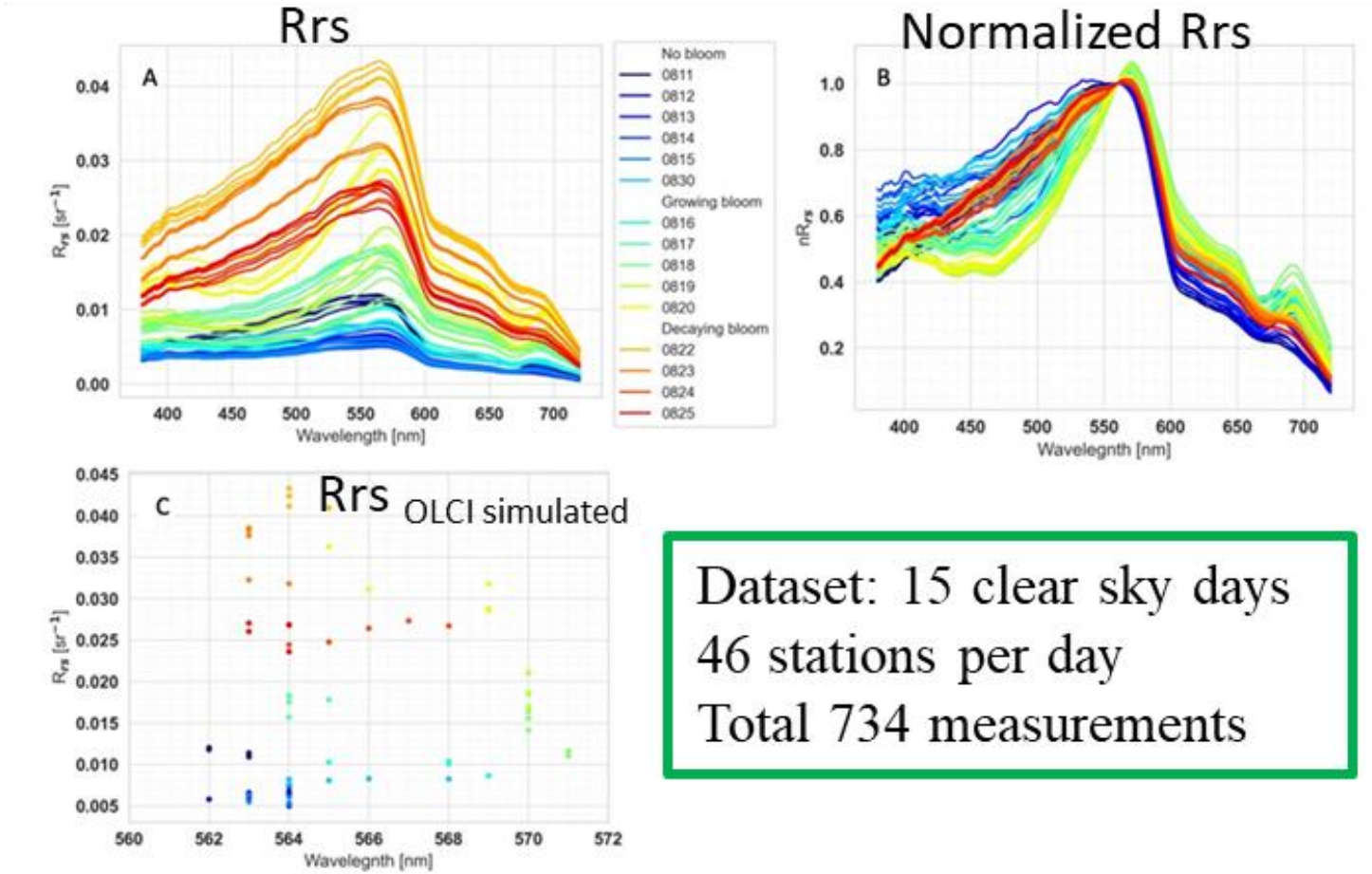






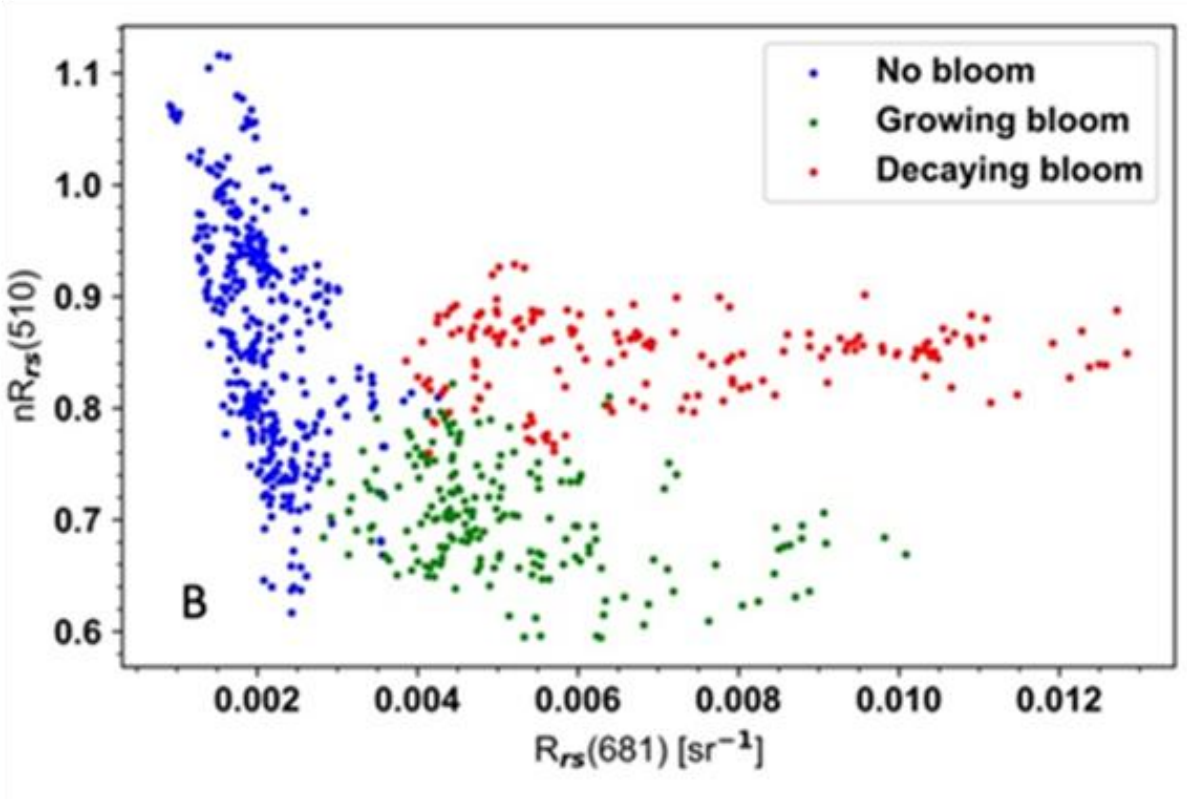


Step 2:Classification of coccolithophore bloom development stages



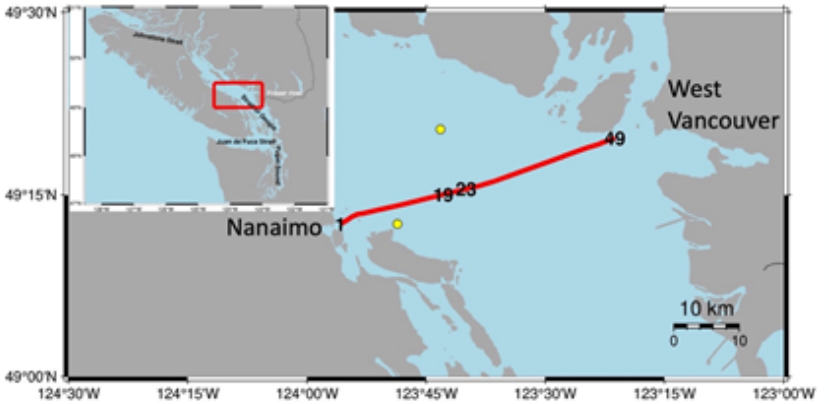
Dataset: 15 clear sky days
46 stations per day
Total 734 measurements

Step 2 Random Forest model: RFC7 – 7 Sentinel 3 OLCI bands



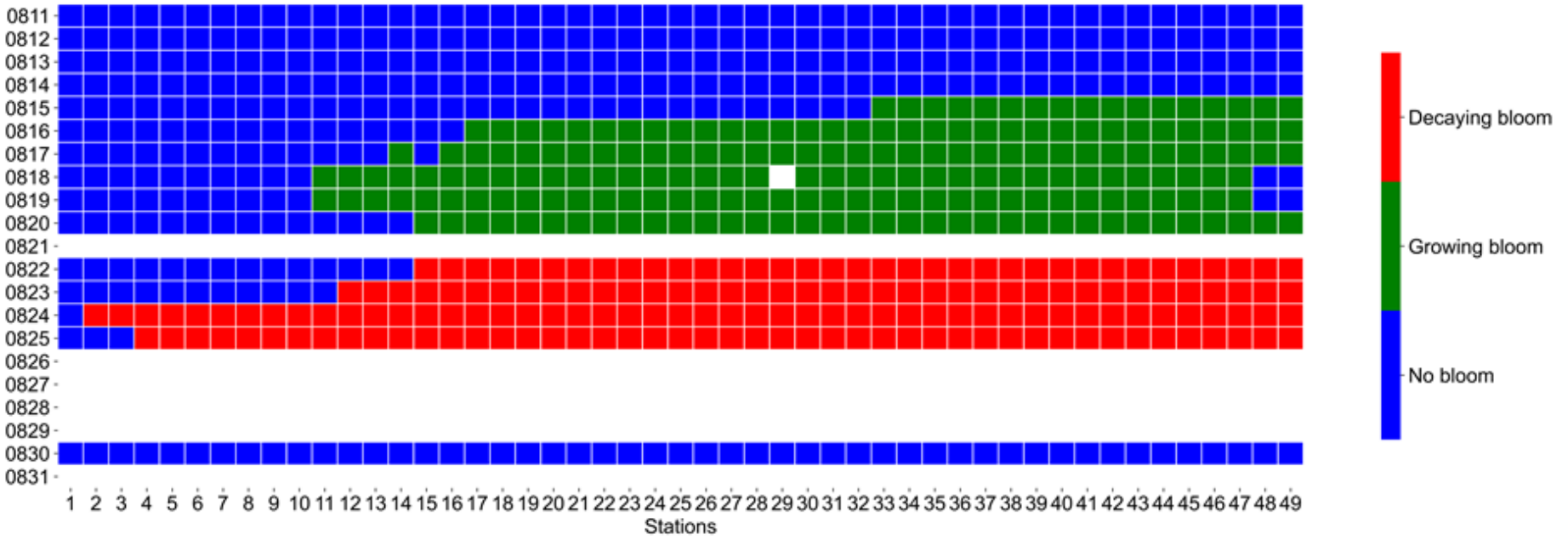
- N=734
- 70% of the samples as the training dataset and the remaining 30% as the test dataset
- Accuracy: 0.967±0.0145

Classification coccolithophore bloom development stages based on Rrs^{SST}

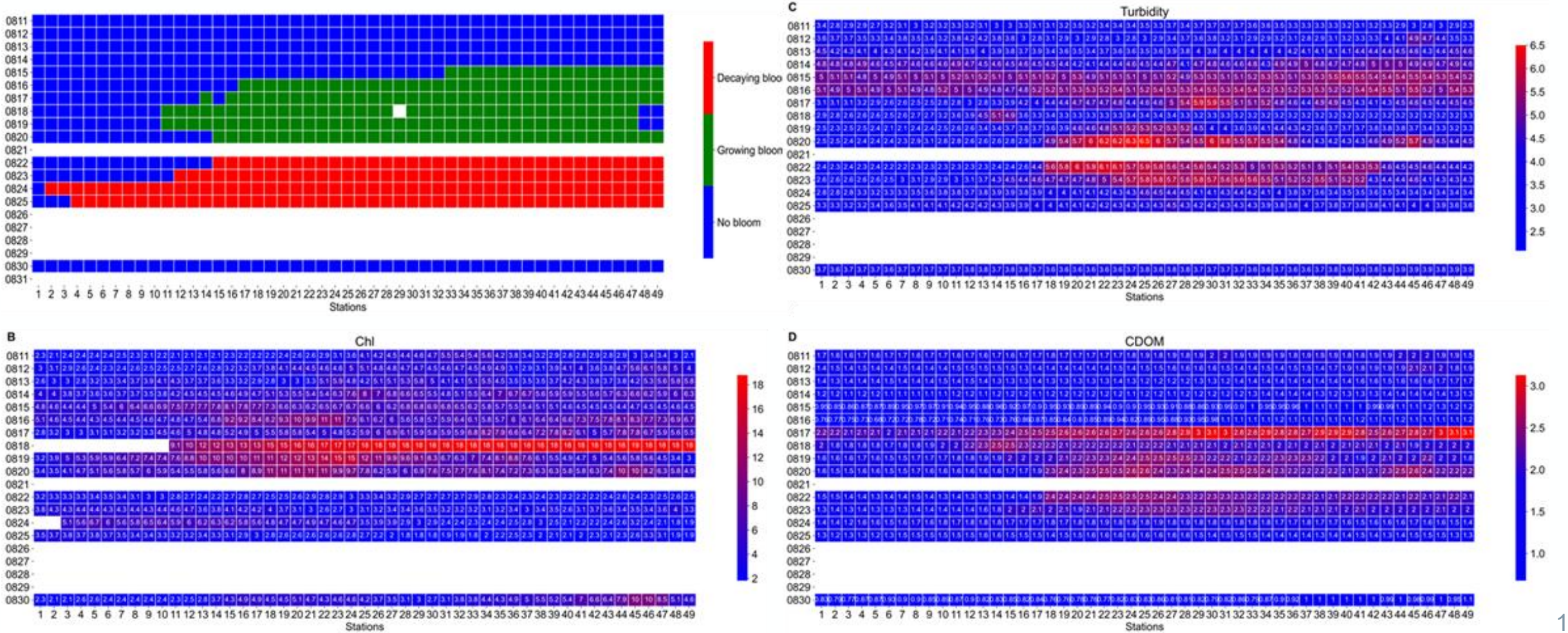


- The bloom begins in the eastern part of the ferry route and propagates westward.

- 734 samples

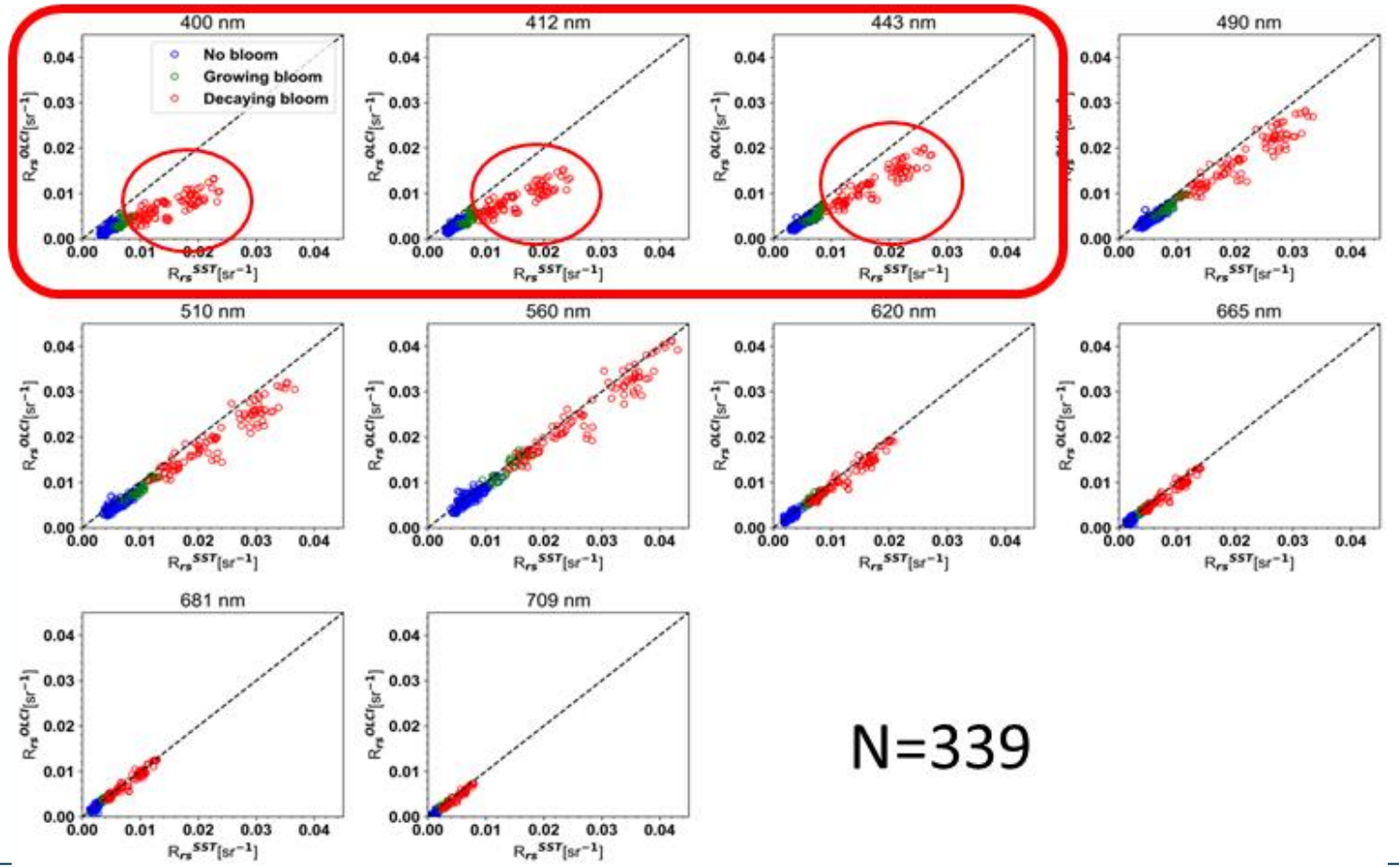


Water quality for the period



Step 3: Apply RFC7 to OLCI

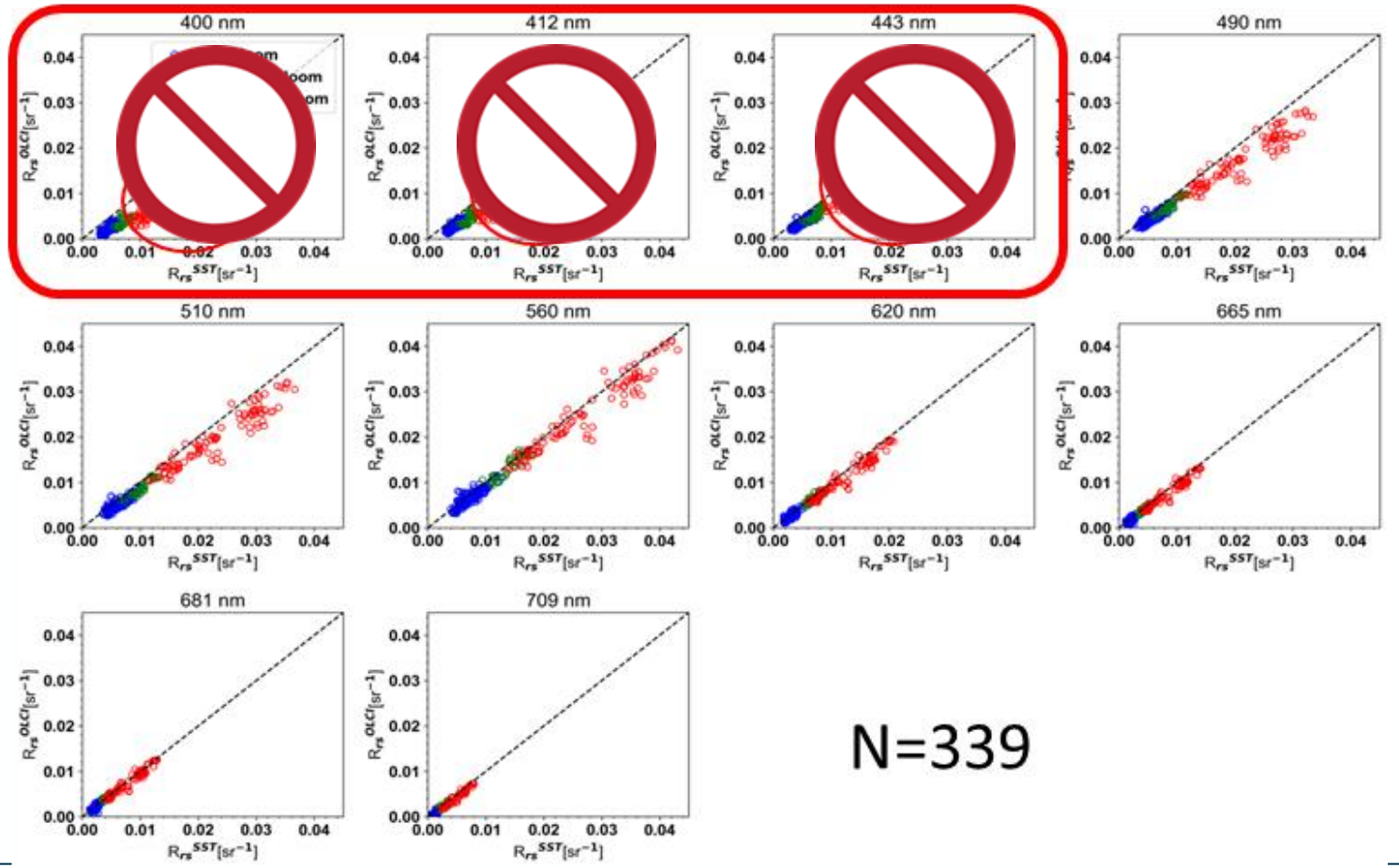
The reflectance matchups between Sentinel-3A OLCI and Hyper



N=339

Step 3: Apply RFC7 to OLCI

The reflectance matchups between Sentinel-3A OLCI and Hyper

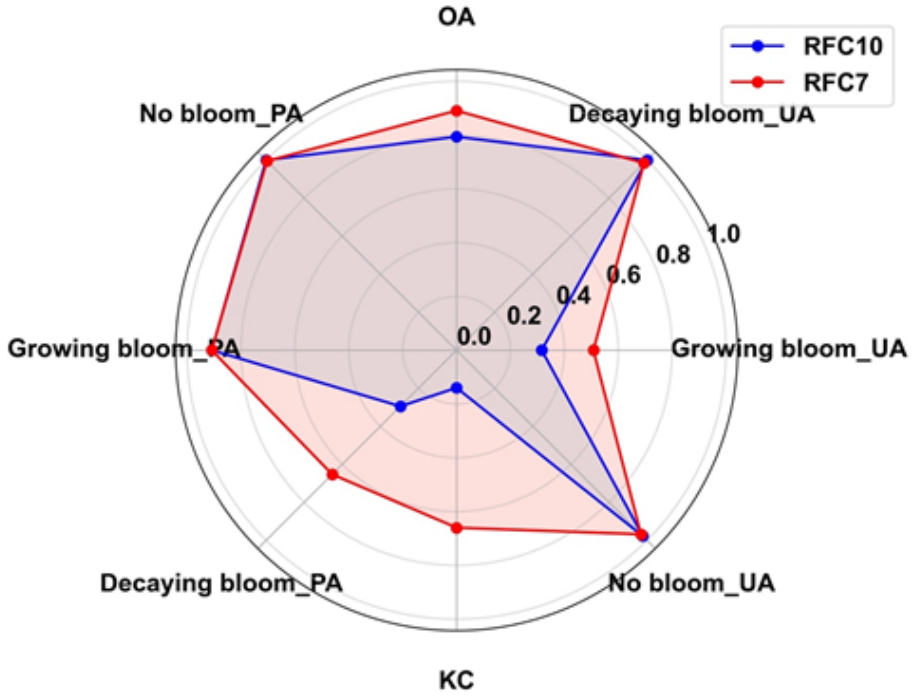


N=339

Wavelengths	Slope	Intercept		MAD	MRD	RMSE
400	0.48	0.0001		52.1	-52.1	0.0049
412	0.55	0.0003		40.4	-40.4	0.0041
443	0.69	0.0002		28.7	-28.4	0.0033
490	0.82	-0.0001		19.4	-18.7	0.0026
510	0.86	-0.0001		16.7	-15.5	0.0024
560	0.94	-0.0002		11.3	-8.2	0.0018
620	0.92	-0.0001		14.2	-12.1	0.001
665	0.92	-0.0002		17.1	-14.9	0.0007
681	0.96	0		10.8	-5.7	0.0005
709	0.93	-0.0004		31.3	-30.3	0.0006

N=339

Step 3 RFC10 (if I use10 bands) and RFC7 (if I use 7 bands) application on Rrs^{OLCI}

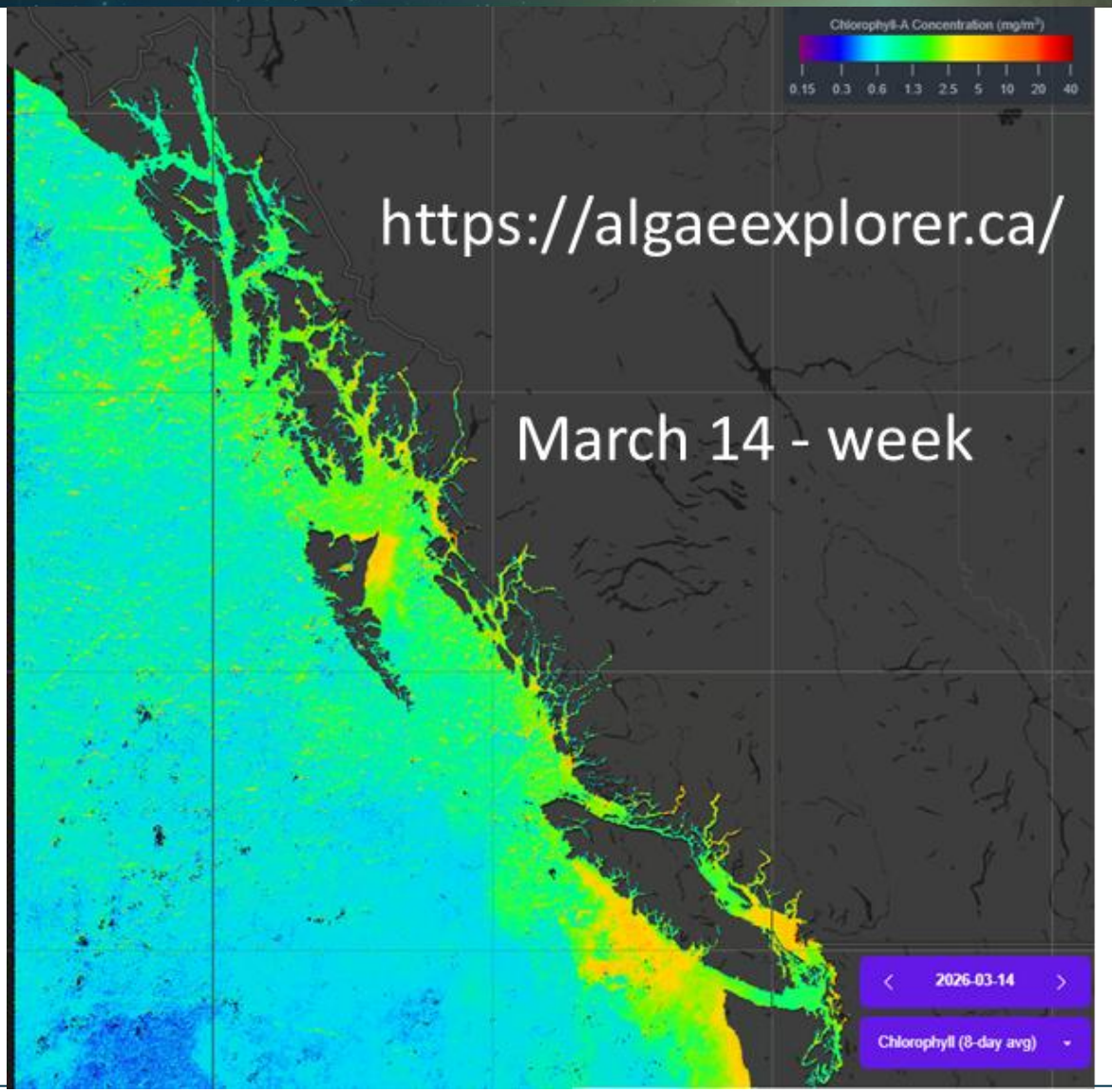


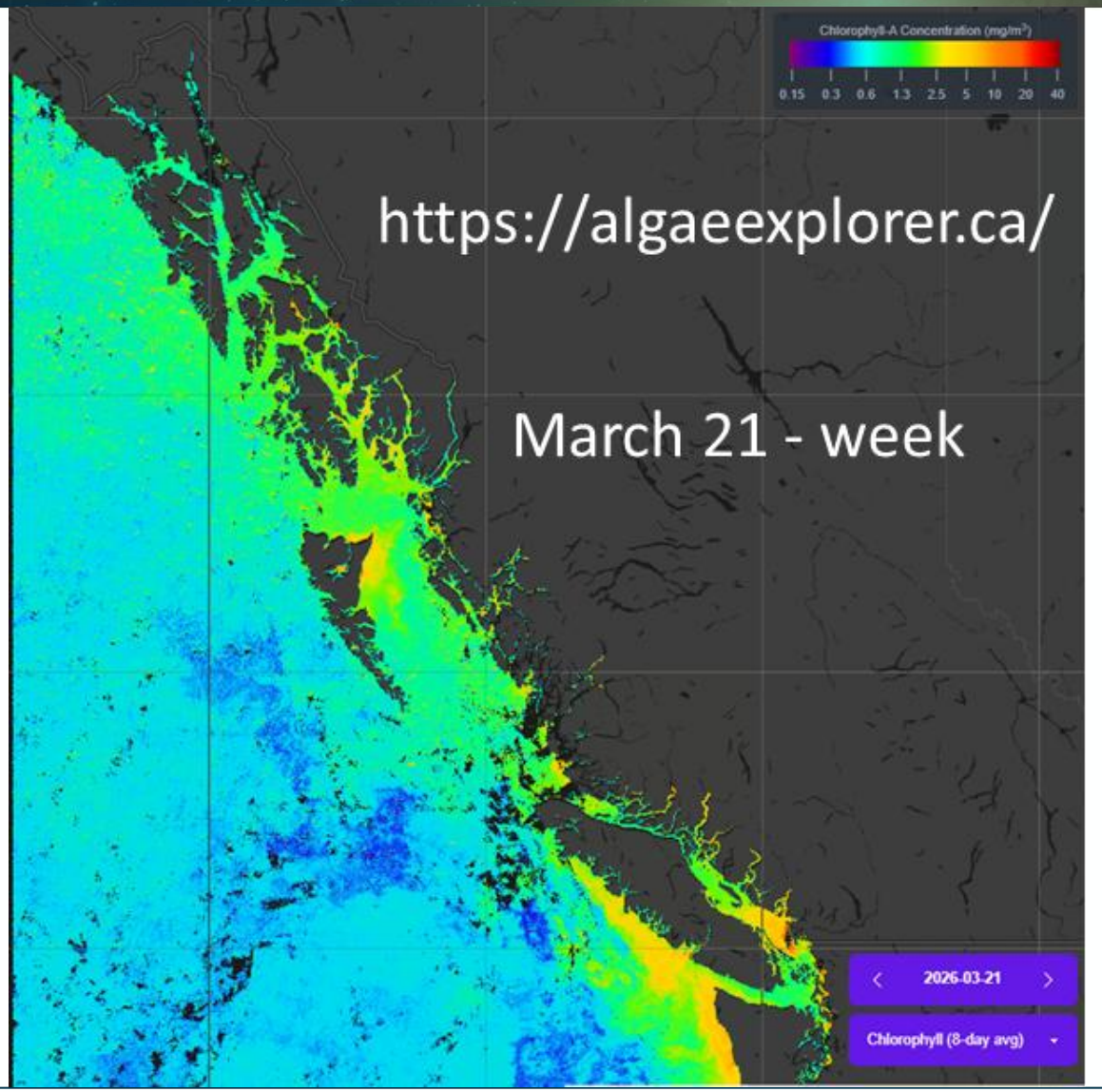
PA: Producer's accuracy
UA: User's accuracy
OA: Overall accuracy
KC: Kappa coefficient

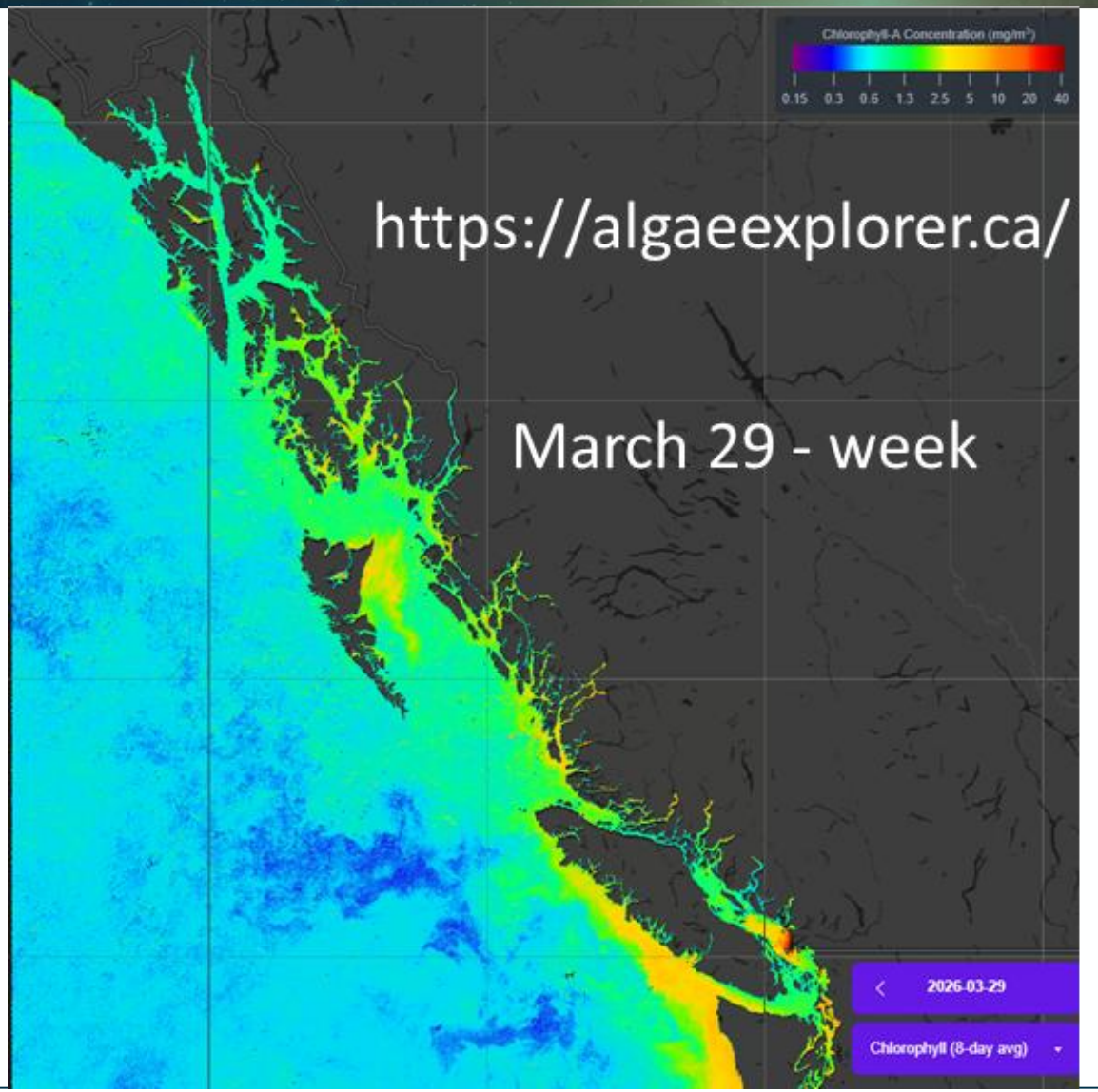
RFC10	No bloom	Growing bloom	Decaying bloom
Producer's accuracy	100%	90.9%	29.5%
Overall accuracy	79.4%	Cohen's kappa	0.14
RFC7	**No bloom**	**Growing bloom**	**Decaying bloom**
Producer's accuracy	99.5%	90.9%	65.3%
Overall accuracy	89.1%	Cohen's kappa	0.66

A machine learning algorithm for monitoring coccolithophore blooms

- The 734 samples acquired by the hyperspectral sensor were partitioned into no bloom, growing bloom, and decaying bloom development stages.
- Rrs acquired by OLCI is underestimated compared with in situ Hyperspectral values, especially in the short and blue wavelengths (400, 412, 443 nm). The decaying bloom group performs the worst in these three bands.
- By applying RFC7 to the OLCI spectra at corresponding 7 wavelengths, the total prediction accuracy was 89.1%

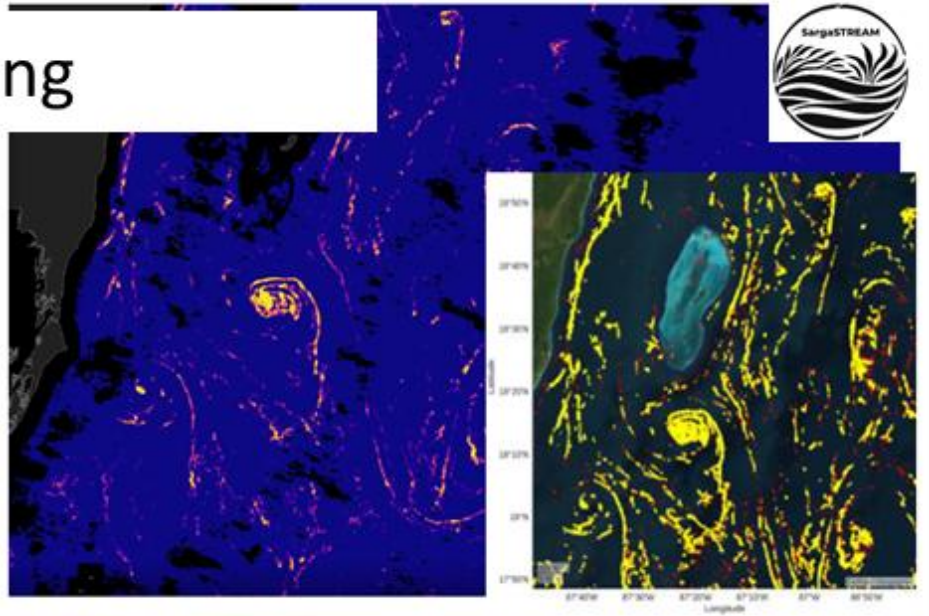

Chlorophyll-A Concentration (mg/m³)
0.15 0.3 0.6 1.3 2.5 5 10 20 40
https://algaeexplorer.ca/
March 14 - week
2026-03-14
Chlorophyll (8-day avg)


Chlorophyll-A Concentration (mg/m³)
0.15 0.3 0.6 1.3 2.5 5 10 20 40
https://algaeexplorer.ca/
March 21 - week
2026-03-21
Chlorophyll (8-day avg)

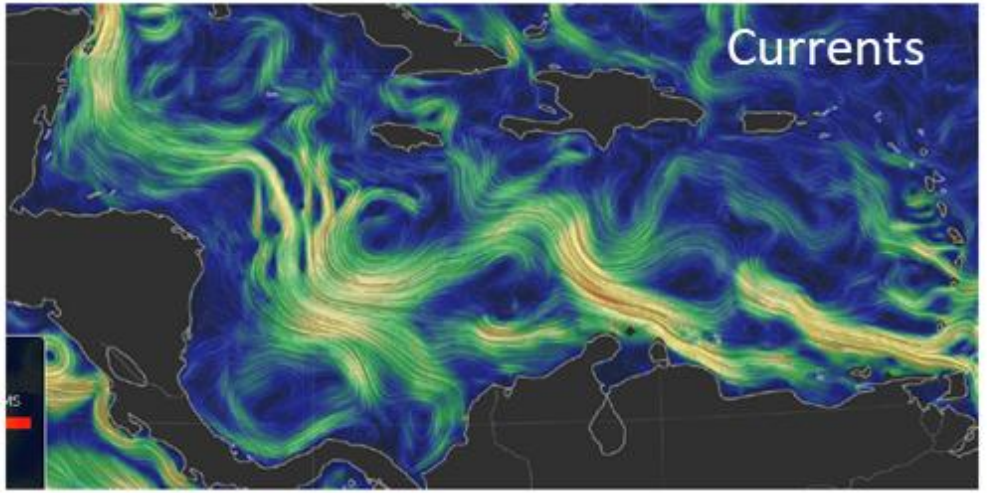

Chlorophyll-A Concentration (mg/m³)
0.15 0.3 0.6 1.3 2.5 5 10 20 40
https://algaeexplorer.ca/
March 29 - week
2026-03-29
Chlorophyll (8-day avg)

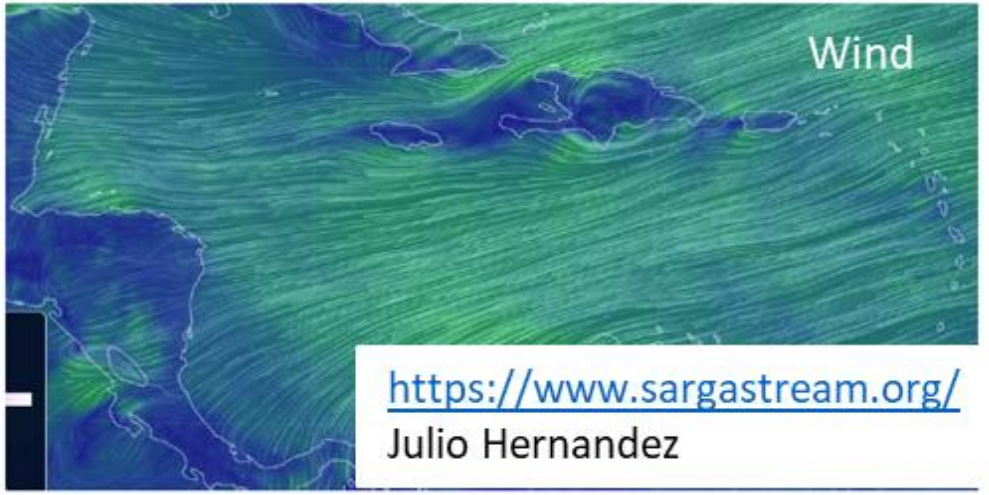
Caribbean Sea Sargassum landing

- Copernicus NFAI Product (presence = nfai > 0) Sentinel 3
  - Daily: 3-day lag



- Copernicus winds and currents
  - Global Ocean Physics Reanalysis: daily 31 Dec 1992 to 23 Feb 2026
  - Global Ocean Ensemble Physics Reanalysis: daily 01/01/1993→31/12/2024
  - Reanalysis: average circulation of last 30 days or climatology
- Projection to weeks - months





https://www.sargastream.org/
Julio Hernandez


SPECTRAL
Remote Sensing Laboratory
University of Victoria
Thank you
Maycira Costa and Ziwei Wang
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