Harmful Algal Blooms and Satellite Earth Observation

Dr Marié Smith,
Coastal Systems and Earth Observation Group, CSIR

AASA Abalone workshop 15 July 2022

CSIR
Touching lives through innovation

CSIR Marine Earth Observation

Operational Marine Industry support

Research interests

- ✓ Bio optical and radiative transfer modelling
- ✓ Satellite and model product validation
- ✓ Sensor/region specific algorithm & product development
- ✓ Phytoplankton type ID and Harmful Algal Bloom detection
- ✓ Satellite and over-flight campaign sensor validation

Project involvement

H2020 All Atlantic Ocean Sustainable, Profitable and Resilient Aquaculture

South African National Oceans and Coastal Information Management Service

GMES&Africa Marine and Coastal Operations for southern Africa

ESA 4D Atlantic PRIMary-productivity in Upwelling Systems (PRIMUS)

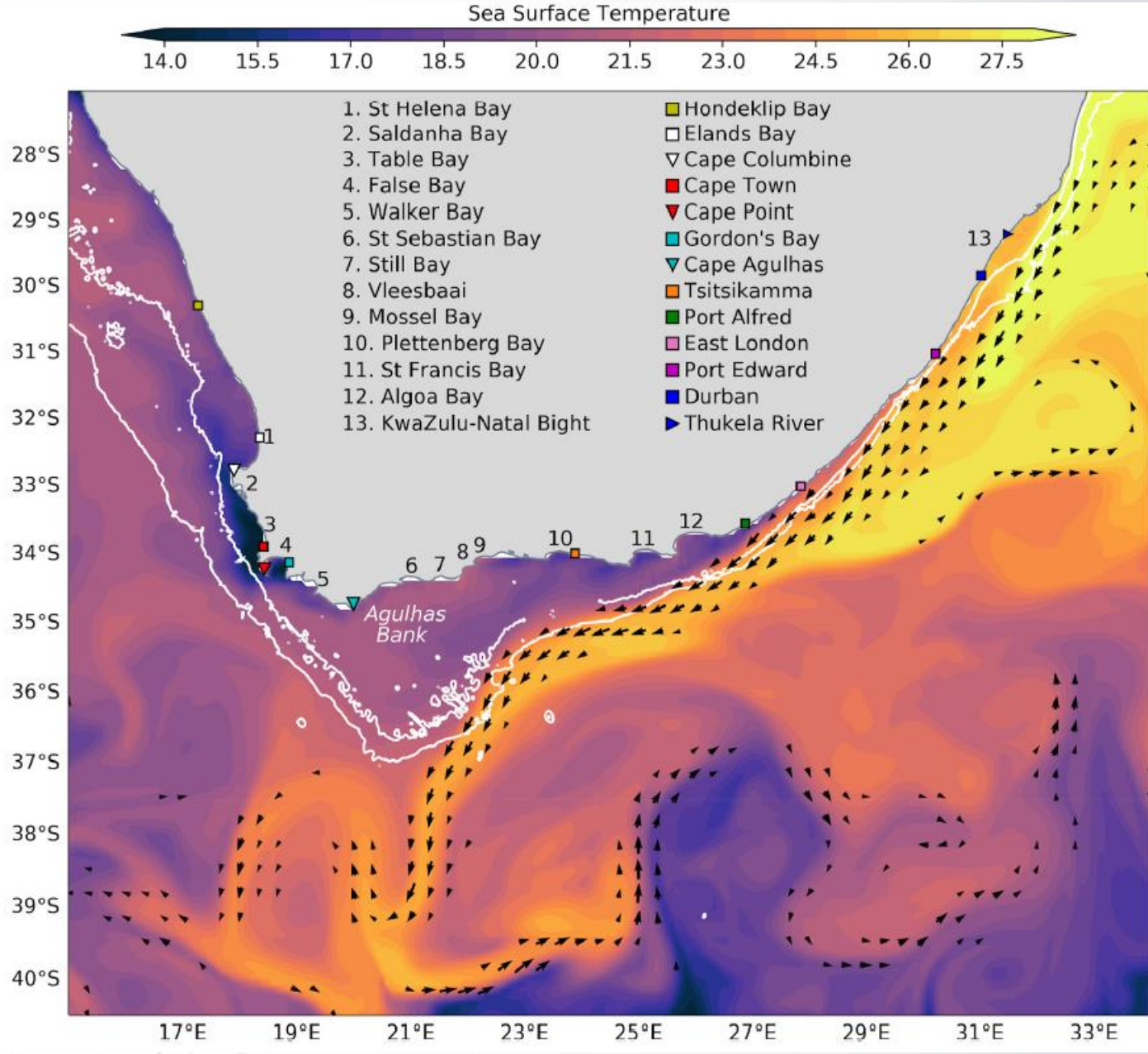
NEOFrontiers Development of new high resolution water quality observation capabilities for coastal and estuarine systems

NEOFrontiers Development of New Hyperspectral Capabilities across Aquatic, Atmospheric and Terrestrial Domains

Cyanobacteria and Surface Aquatic Vegetation of the Cape Freshwater Systems (CyanoSCape): A Hyperspectral Data Campaign and Analysis

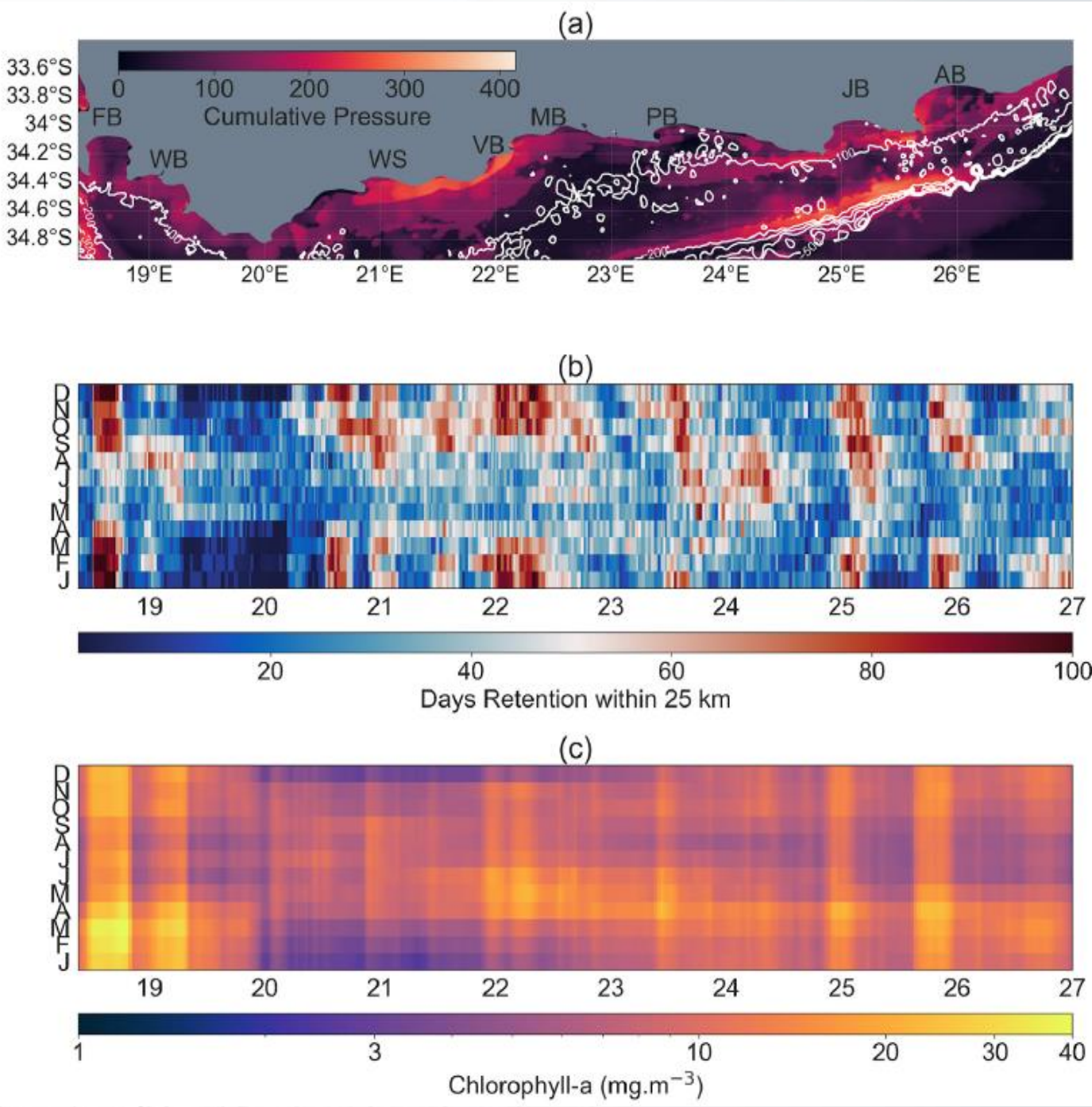
Environmental overview

- West (and Southwest) coast of South Africa is part of the highly productive Benguela Upwelling System
- Bounded in the south by the warm Agulhas current
- Southwest coast is a region of overlap between the cool-temperate upwelling system and warm-temperate Agulhas region.



Environmental overview

- The southern Benguela is in turn divided into the West Coast and the South-West Coast regions owing to a change in coastline orientation at Cape Point
- These biogeographic regions are reflected in both the make-up and frequency of phytoplankton blooms
- Generally the bays are areas of greater coastal retention and phytoplankton biomass (Pfaff et al 2022)



Harmful Algal Blooms

- Phytoplanktan can be harmful due to toxin production, mechanical damage, or high biomass (potentially leading to hypoxic events)
- Can affect both farmed and wild abalone
  - Dinoflagellate *Karenia cristata* resulted in the mortality of 40 tons of wild abalone on the southwest coast
  - Abalone have been affected by Paralytic Shellfish Poisoning (PSP) toxins (*Alexandrium catenella*),through paralysis and inability to produce viable larvae
  - Yessotoxin producing dinoflagellate species *Gonyaulax spinifera & Lingulodinium polyedrum* bloom, which affects the epithelial cells and gills

Contents lists available at ScienceDirect

Harmful Algae

journal homepage: www.elsevier.com/locate/hal

Harmful algal blooms of the Benguela eastern boundary upwelling system

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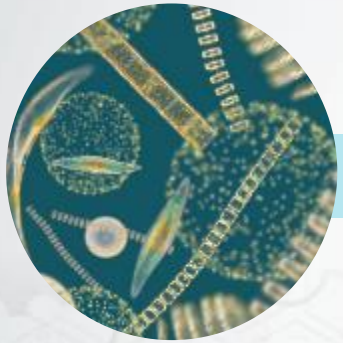
Why satellite data?

What can satellites measure?

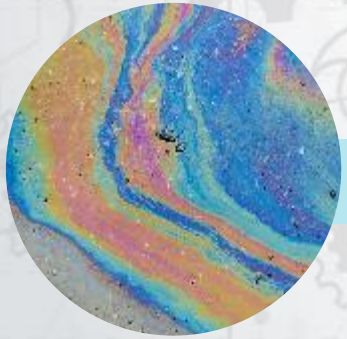


Algal blooms

Floating vegetation

Water clarity

Suspended sediments



Surface oil slicks

Sea surface temperature

What are some of the limitations?

Satellites cannot directly measure the following parameters :

- ✗ *Nutrients*
- ✗ *Dissolved oxygen*
- ✗ *Pollutants, metals, toxins*
- ✗ *Salinity (at high resolution)*

Ocean colour satellites cannot :

- ✗ *measure through clouds*
- ✗ *measure at night*
- ✗ *measure below the surface of the water*
- ✗ *detect very small features*

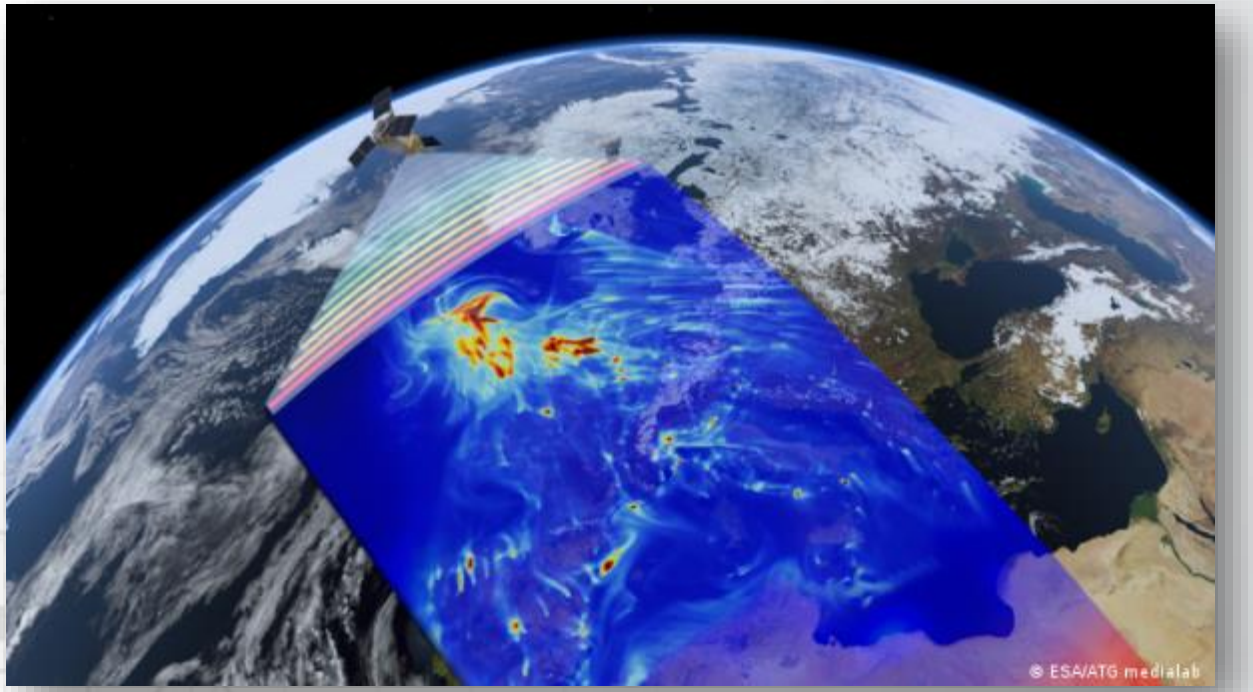
Other:

- ✗ *not "point and shoot"*
- ✗ *data not easily used by non-specialists*

Why use satellite data?

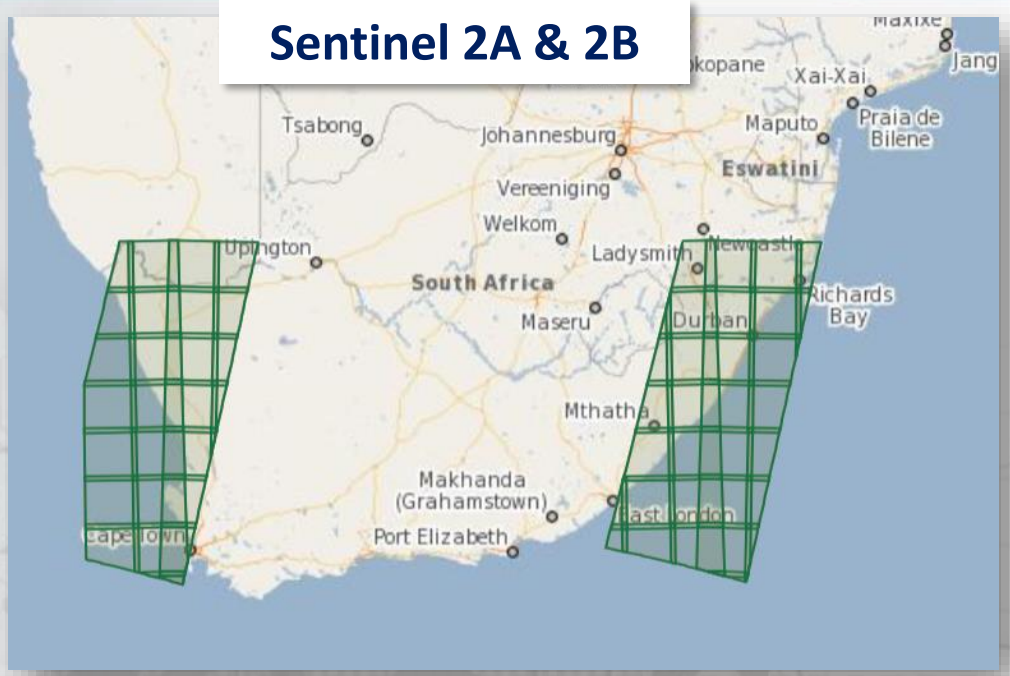
- Data are freely available
- It's a routine and reliable source of information
- It provides global coverage
- It provides historical coverage

➢ The combination of *in situ* and satellite information is often the most powerful



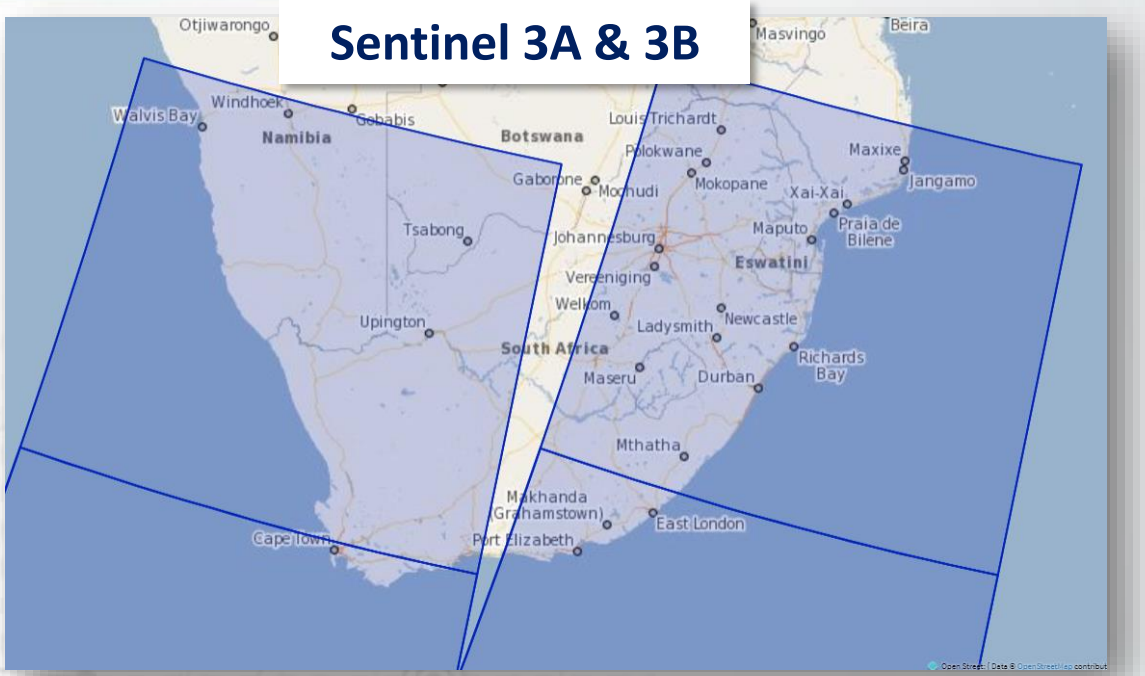
Satellite coverage & resolution

Sentinel 2A & 2B



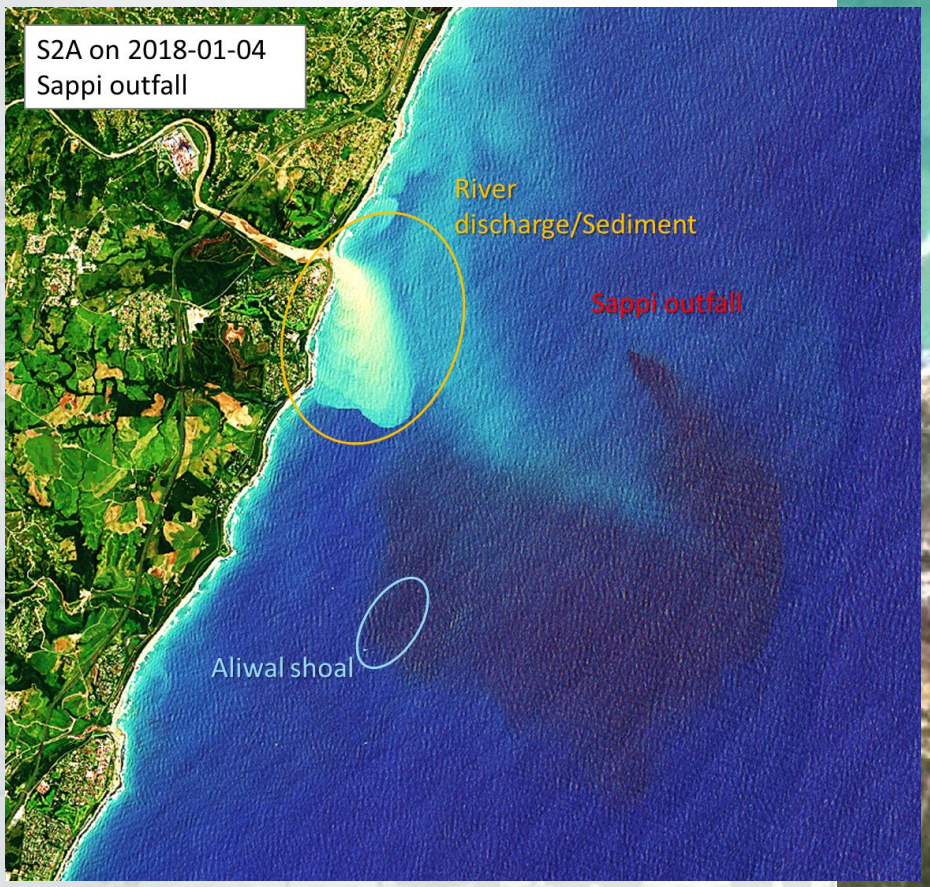
- Designed for land observation
- Narrow swath
- Higher spatial resolution (10-60m)
- 5-day revisit time

Sentinel 3A & 3B



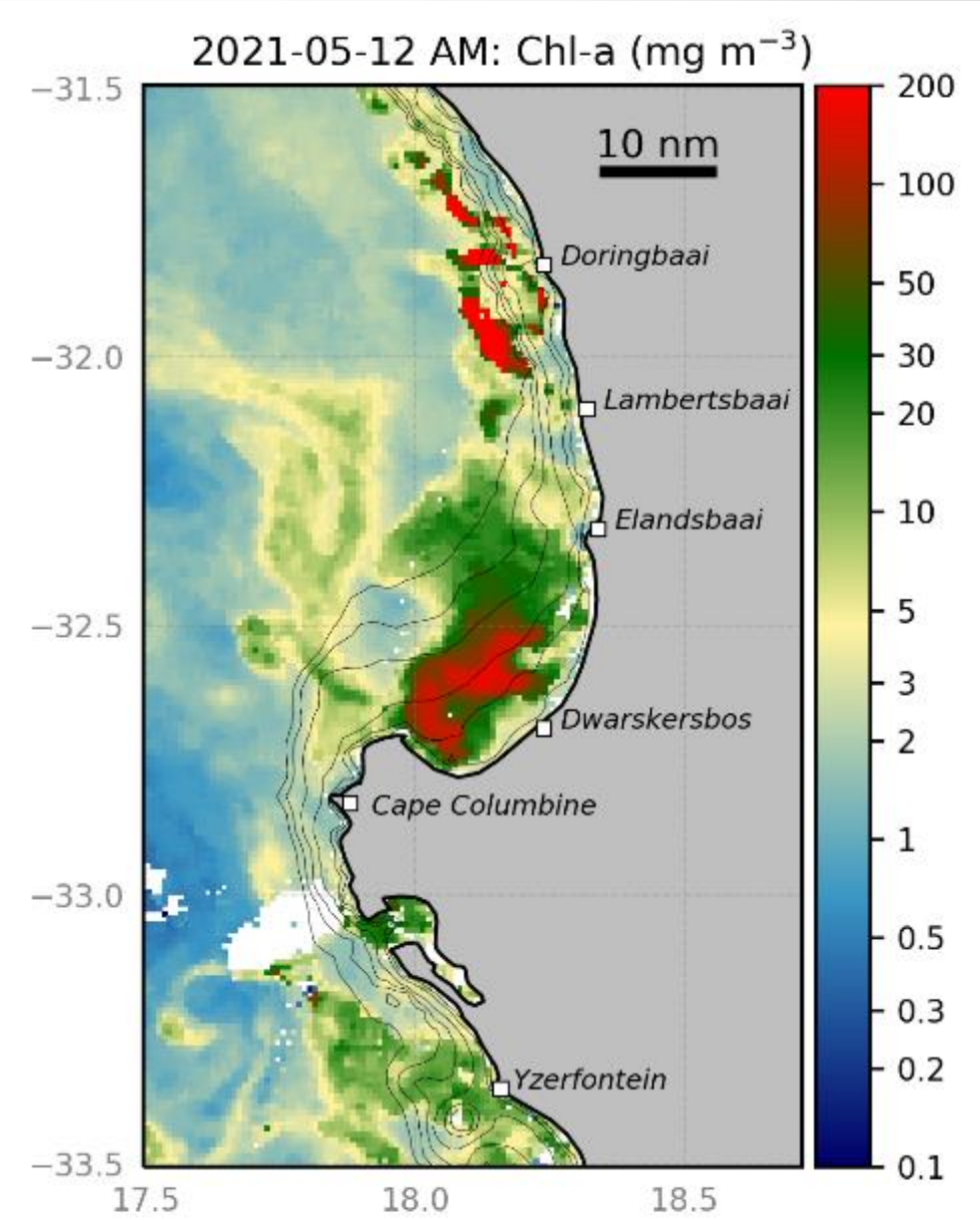
- Specifically designed for marine observation
- Wider swath
- Lower spatial resolution (300m – 1km)
- Daily revisit time

Visible impacts on ocean colour

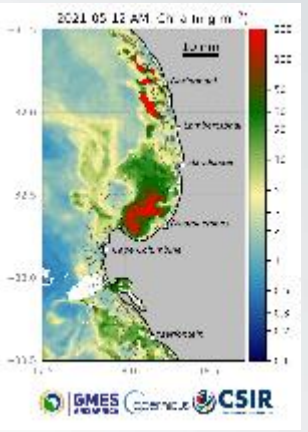


Phytoplankton monitoring

- Phytoplankton cannot be counted directly from space
- All phytoplankton contain Chlorophyll a (Chl-a) which has a measureable effect on the water leaving reflectance
- Chl-a concentration is used as a proxy for phytoplankton biomass

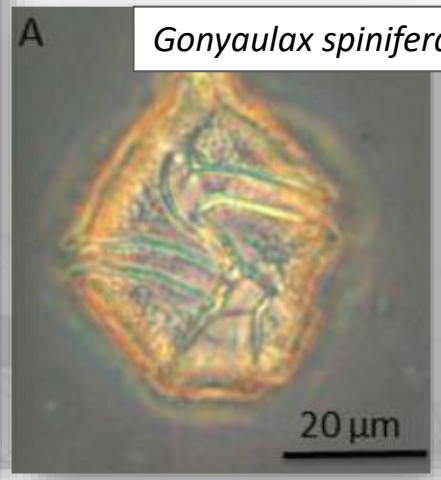


HAB detection based on spectral shape

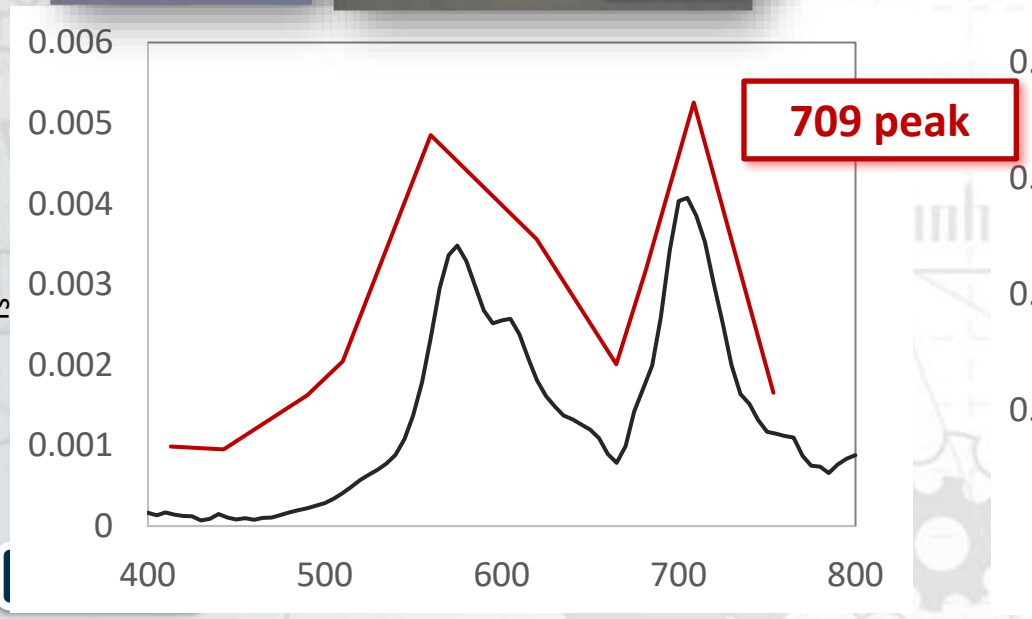


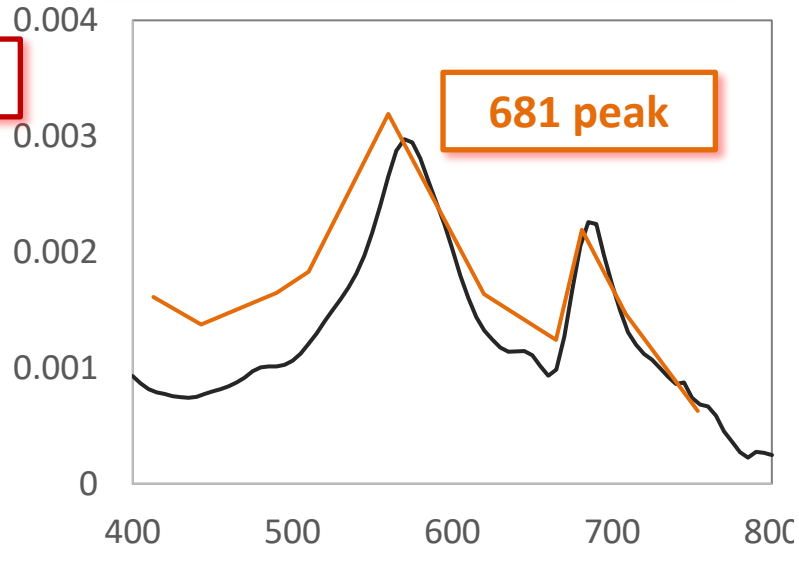
Ceratium balechii

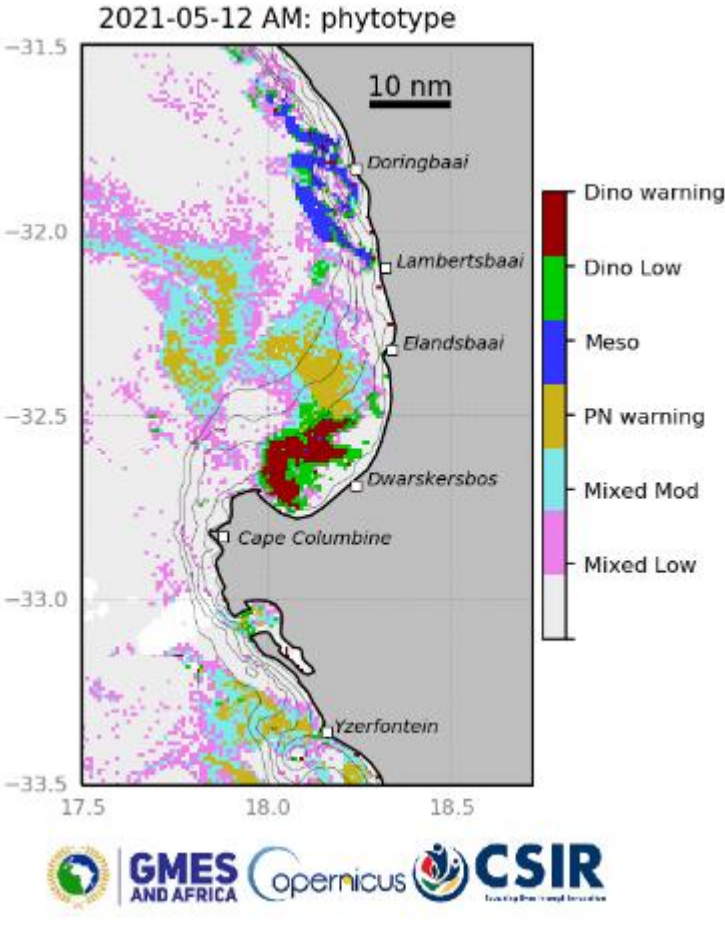
Gonyaulax spinifera



Pseudo nitzschia







The 2017 bloom

- Yessotoxin producing dinoflagellate species *Gonyaulax spinifera & Lingulodinium polyedrum bloom*
- High biomass dinoflagellate species easily detected from Ocean Colour imagery and Chl-a

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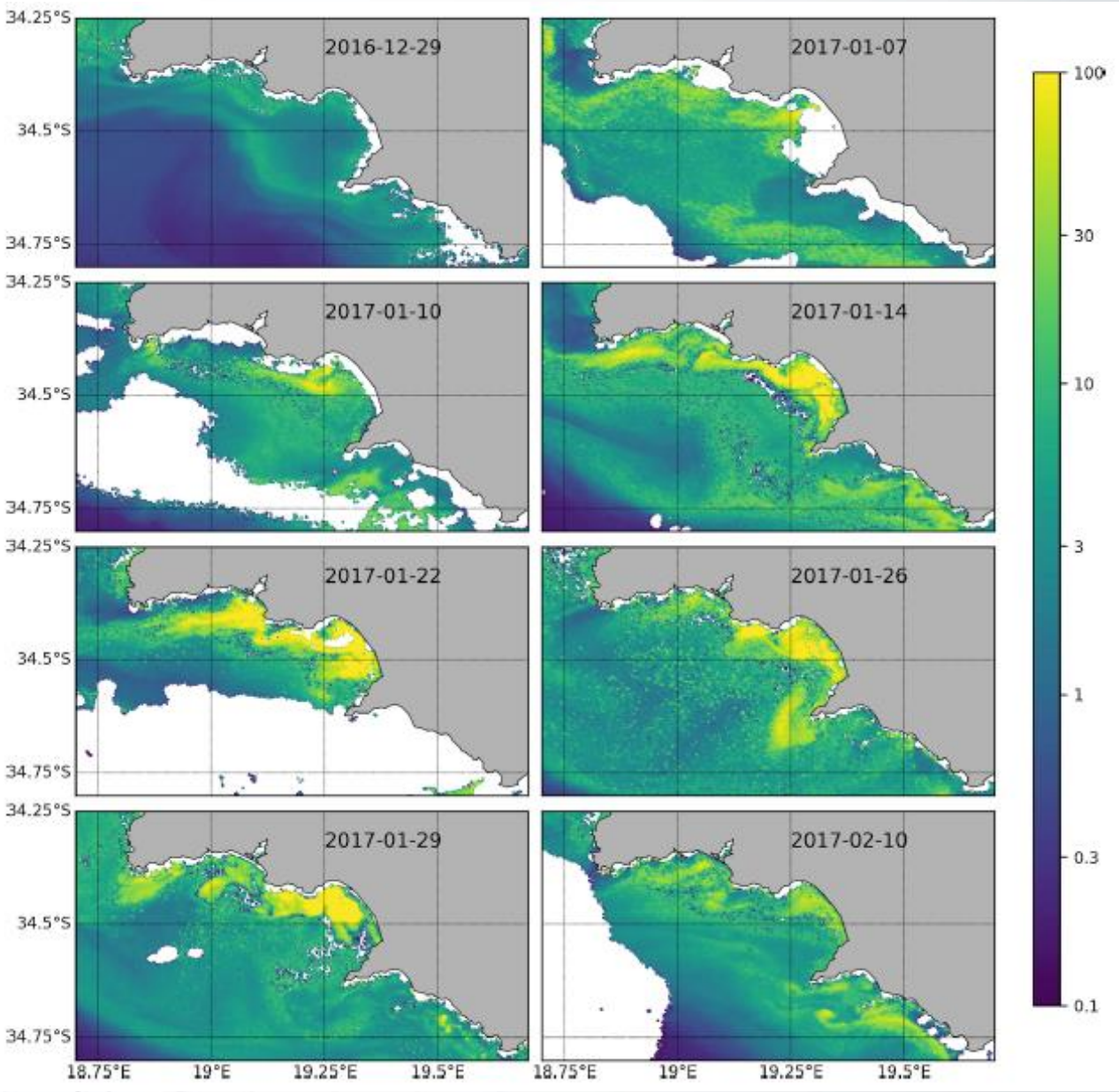
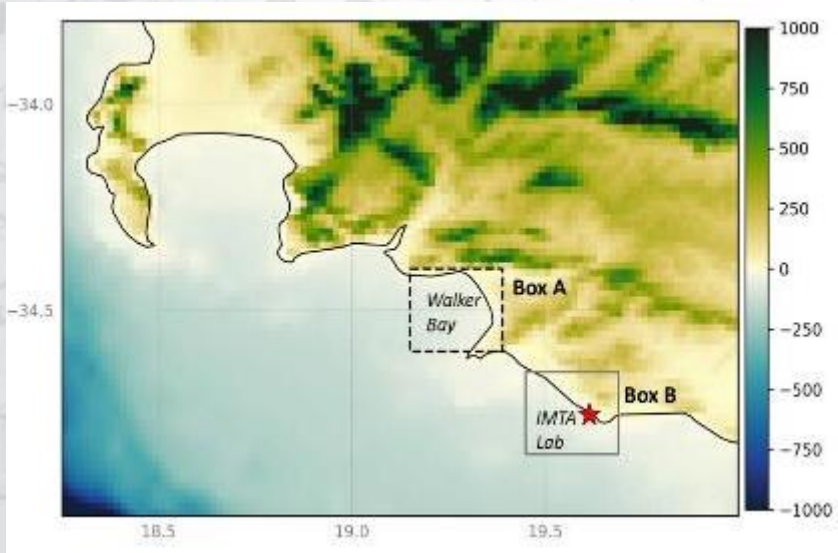
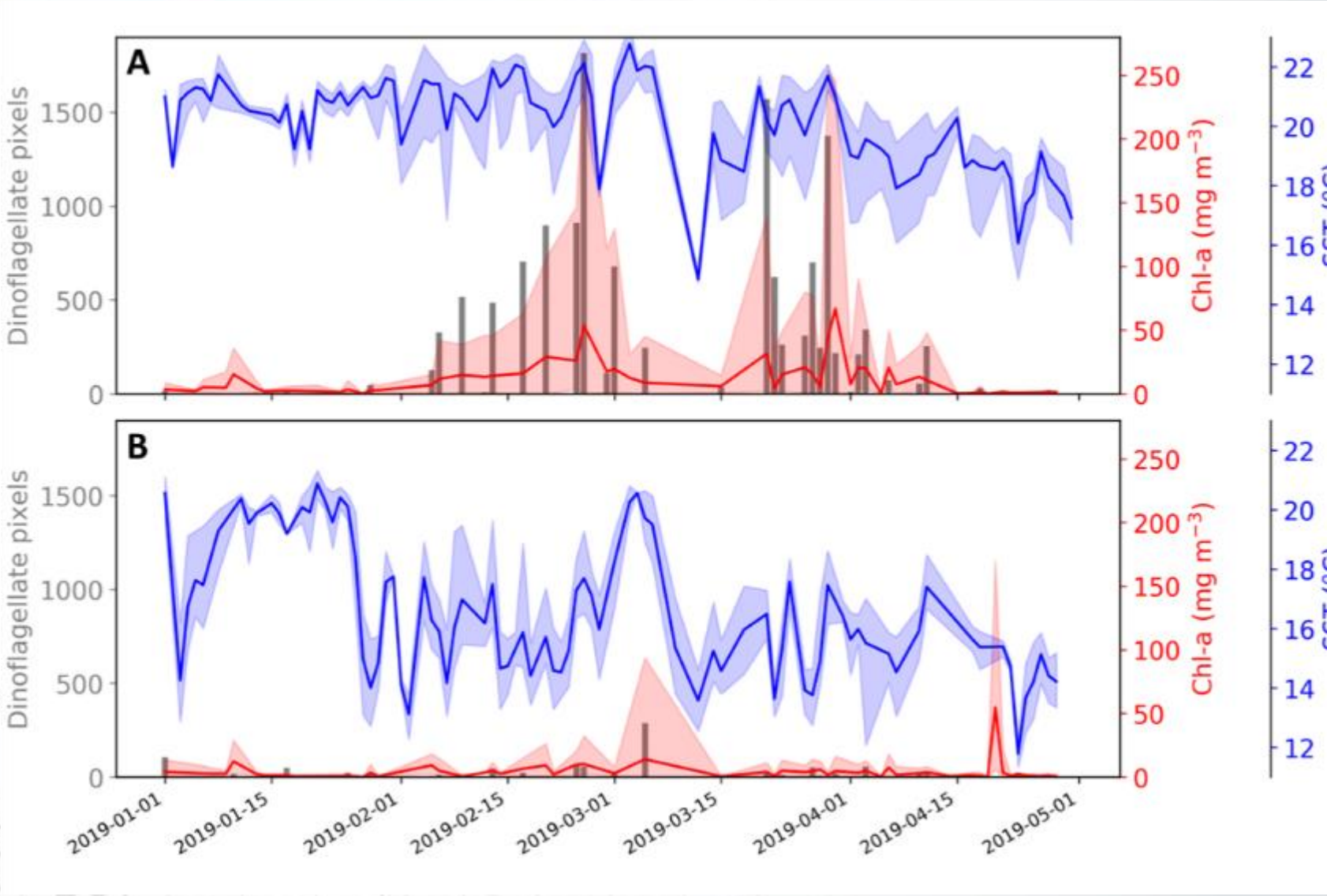


The 2019 bloom

- Using Chl-a, Temperature and phytoplankton type to inform on regional differences





Current Tools available to you

EO marine service development and delivery
National scale

National Oceans and Coastal Information Management System (OCIMS) project

Provides decision support for the effective governance of SA's oceans and coasts

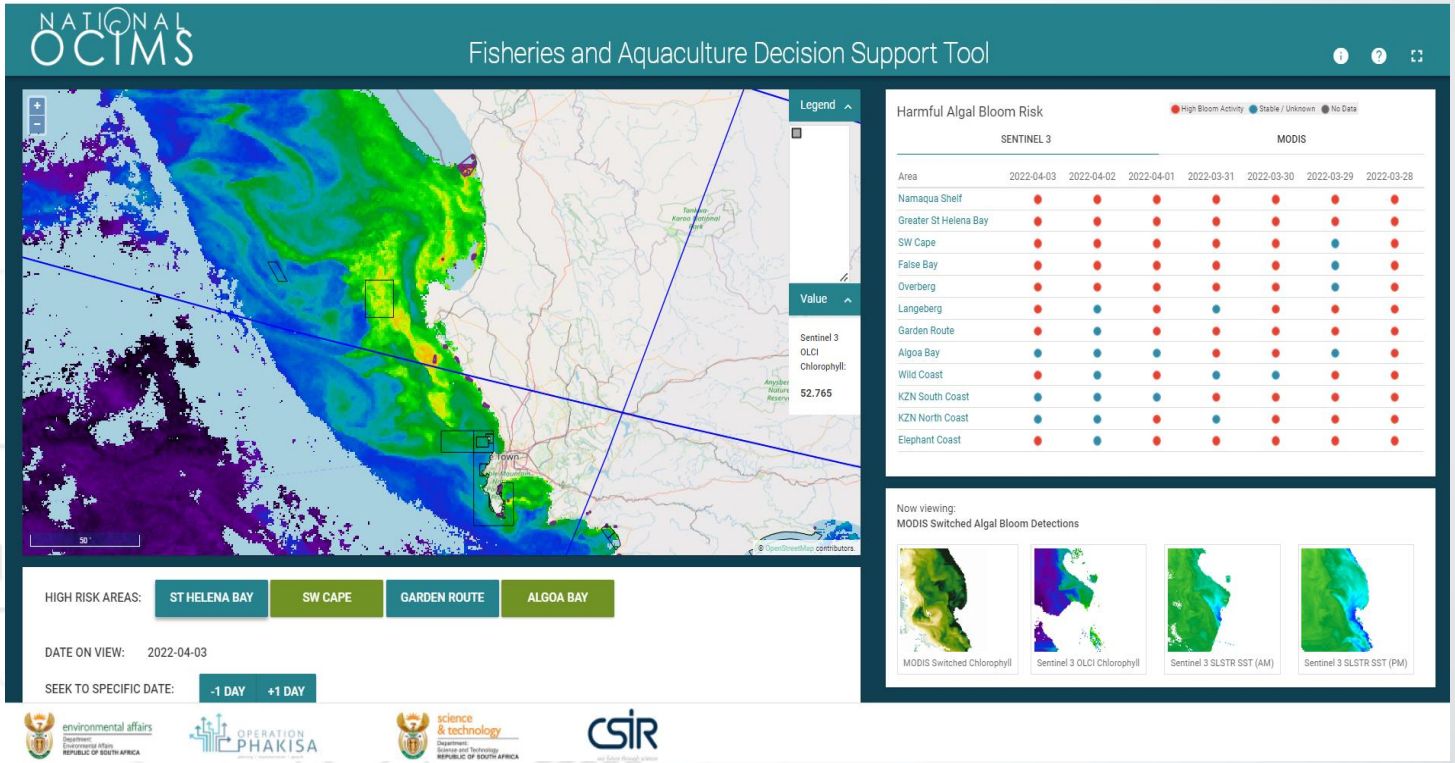
Phase2 of OCIMS runs 2022-2026

OCIMS Fisheries and Aquaculture Decision Support Tool

Current features:

- ✓ Map interface
- ✓ Sentinel3 SST [am&pm]
- ✓ Sentinel3 Chl-a [am]
- ✓ MODIS Chl-a (broken)
- ✓ HAB features (“over-alerting”)
- ✓ HAB alert panel (“over-alerting”)

https://www.ocims.gov.za/hab/app/



Several improvements planned, watch this space!

EO marine service development and delivery
Continental scale

MarCOSIO

MARINE AND COASTAL OPERATIONS
FOR SOUTHERN AFRICA AND THE INDIAN OCEAN

Used to be known as **MarCOSouth**

One of two Marine Thematic area consortia GMES & Africa programme. Represents the southern African and Indian Ocean partners.

Includes partners from Angola, Namibia, South Africa, Mozambique, Tanzania, Kenya, Madagascar, Seychelles, and Mauritius

MarCOSIO Aquaculture support service

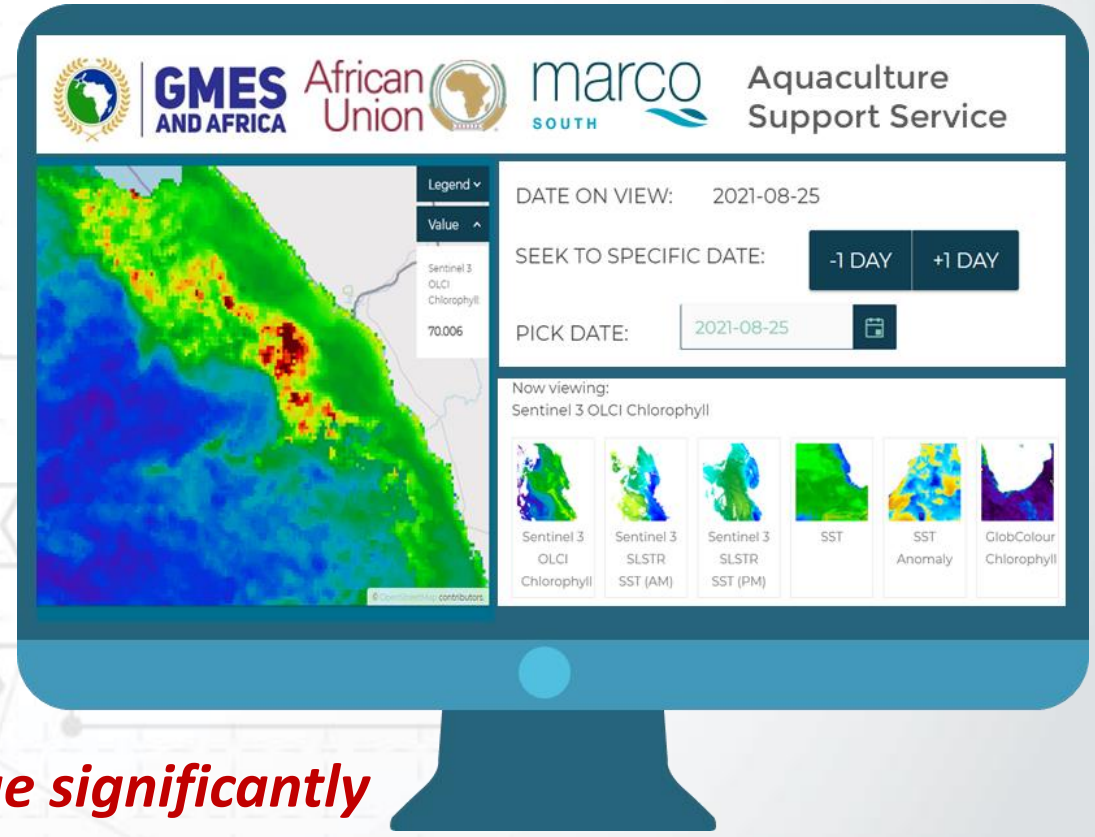
https://marcosouth.org/hab/app/#

MarCOSIO

MARINE AND COASTAL OPERATIONS
FOR SOUTHERN AFRICA AND THE INDIAN OCEAN

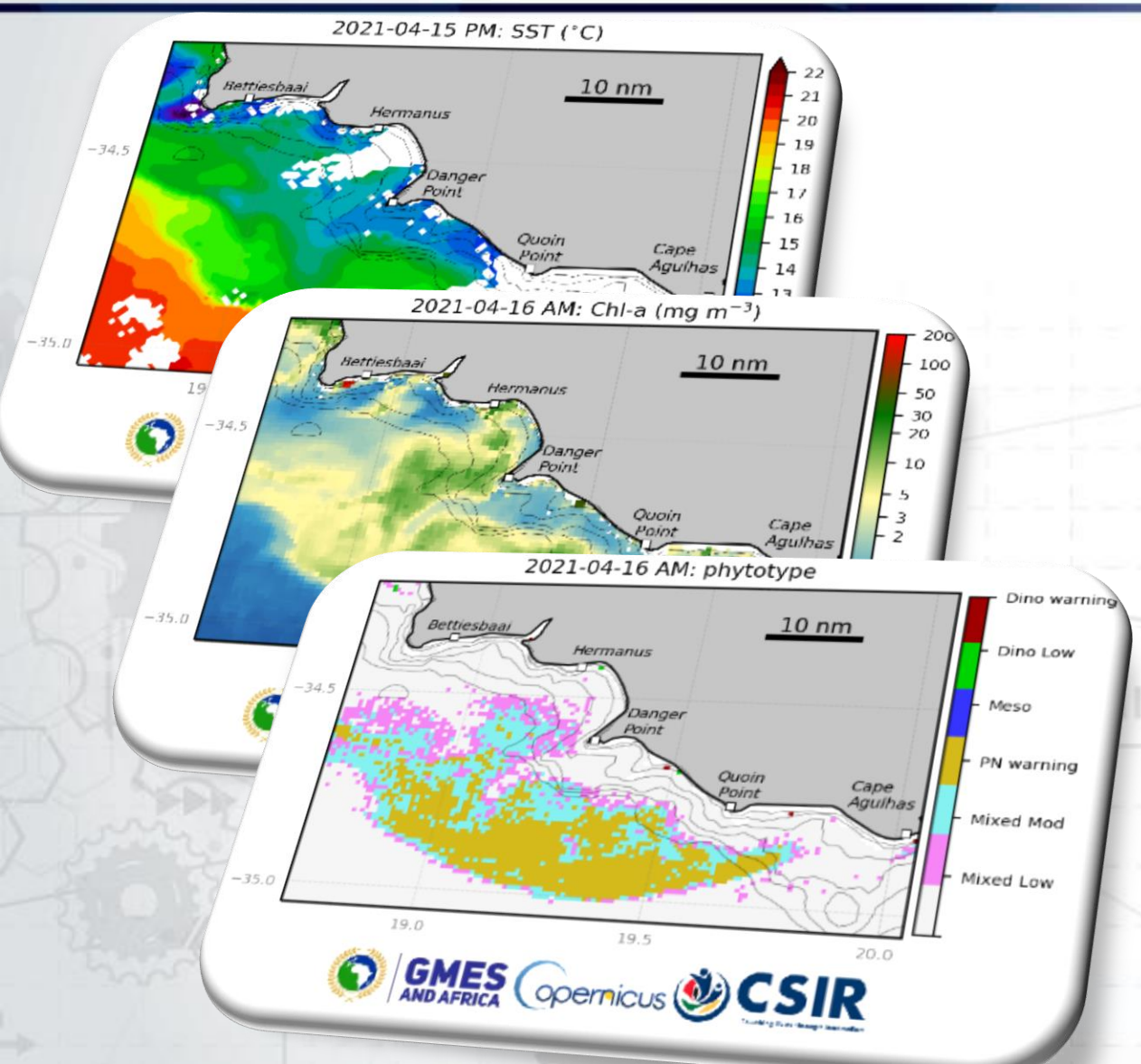
Current features:

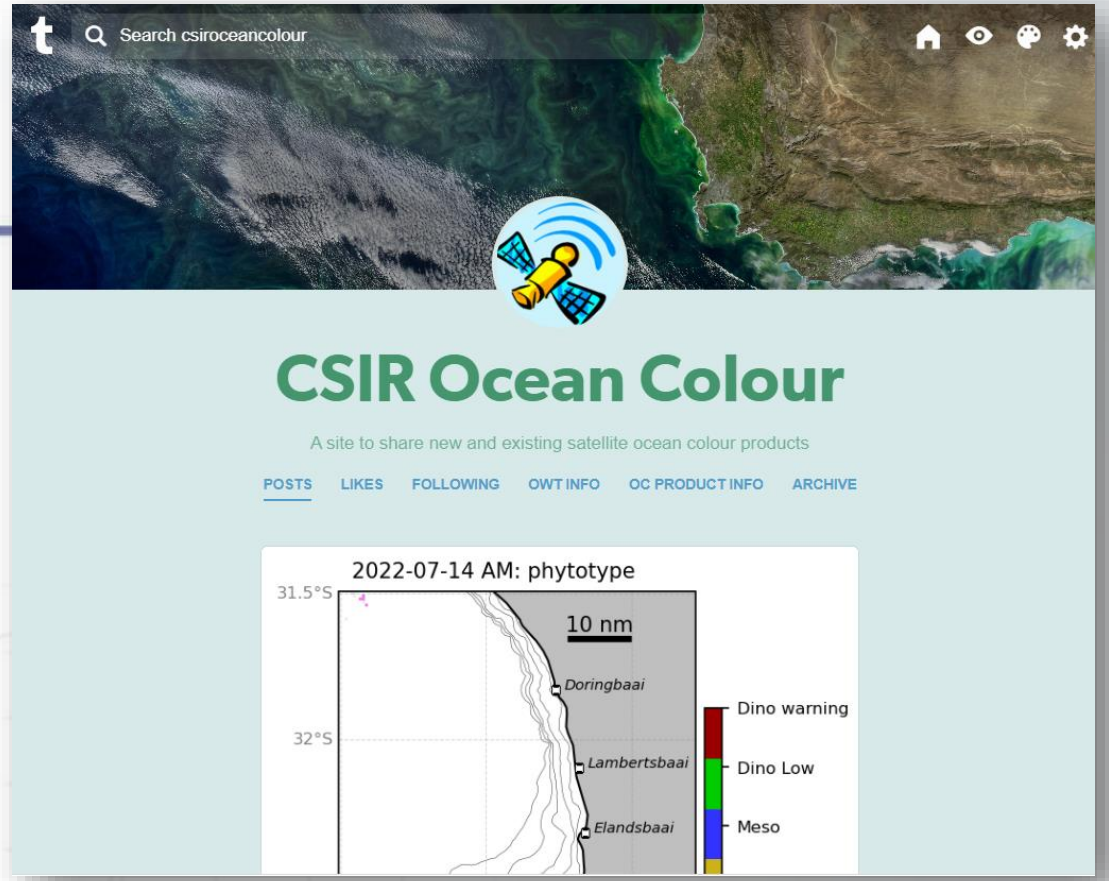
- ✓ Web tool with map interface
- ✓ Sentinel 3 SST
  - [am&pm] 1km resolution 3h latency
- ✓ Sentinel 3 Chl-a
  - [am] 1km resolution 3h latency
- ✓ OSTIA SST & anomaly
  - Gap-free 5km resolution 1day latency
- ✓ Globcolor Chl-a
  - Gap-free 4km resolution 2day latency



Services & products unlikely to change significantly

The CSIR Ocean Colour Tumblr





Regional maps in png format uploaded daily:

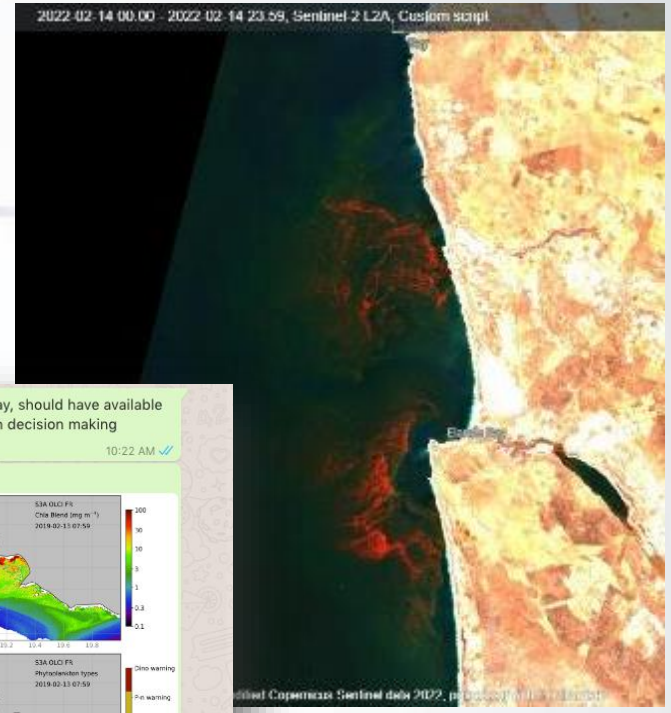
- Sea surface temperature (1km resolution, 2 times a day)
- Chlorophyll a concentration (300m)
- Phytoplankton Type (300m)

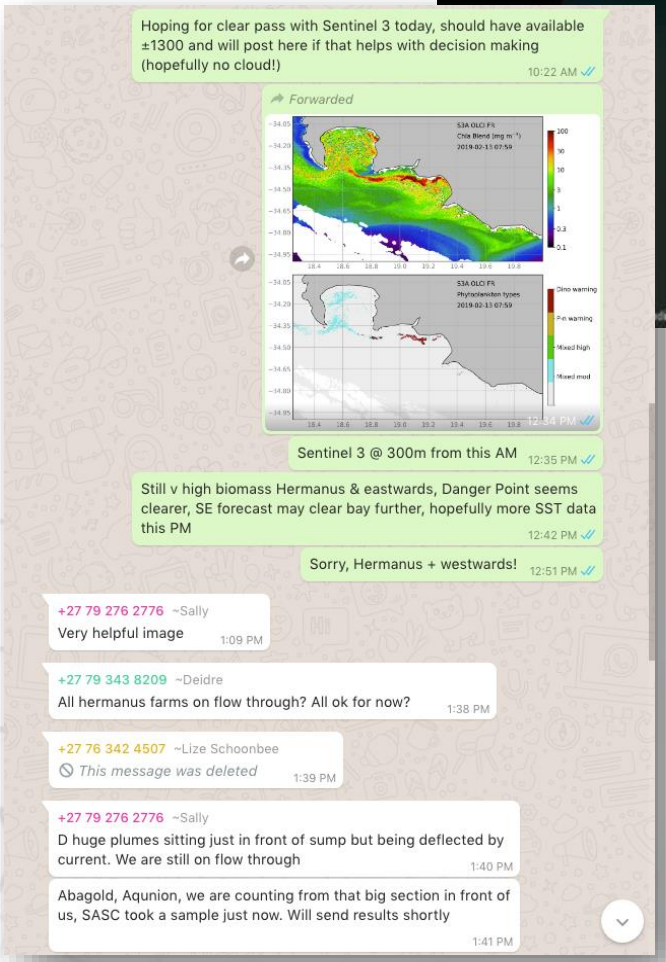
https://csiroceancolour.tumblr.com/

Me ☺ – Marie Smith (Ocean Colour Geek)

Able to provide near real-time support on regional whatsapp groups or via email

Able to resource satellite imagery not routinely provided through the online services





Current and upcoming EO projects

and how they could help you

Projects

New Earth Observation Frontiers Program

- 2 year project
- High resolution product development feeding into

NATIONAL OCIMS

- 3 year project
- In situ support for BioScape overflight campaign

Project overview

- NEOFrontiers *Development of New **Hyper**spectral **C**apabilities across **A**quatic, **A**tmospheric and **T**errestrial Domains*
- Providing in situ support for the NASA BioScape overflight campaign in end 2023
  - We will be putting the CSIR buoy in Walker Bay during late 2023
- Providing algorithm development support for upcoming hyperspectral satellite missions
  - Better ability to differential between different phytoplankton types
  - So that the satellite products are ready to be integrated into OCIMS

CSIR
Touching lives through innovation

Project overview

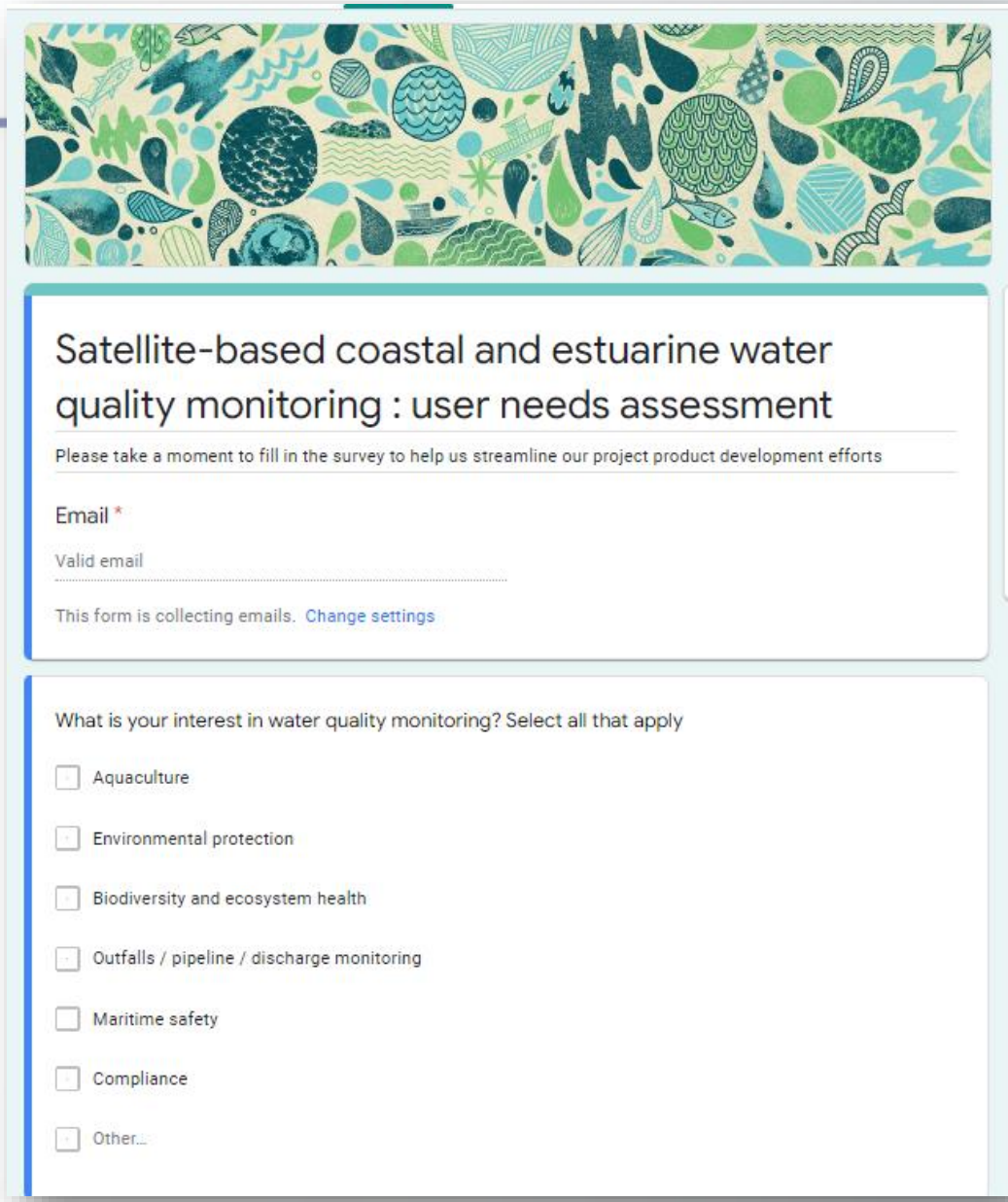
- This is a ***two year*** (2022-2023) New Earth Observation Frontiers Domain Development Action
- Focusing on developing ***high spatial resolution*** (10-300m) water quality products
- from ***freely available*** environmental satellite data
- for the ***coastal marine and estuarine*** domains of South Africa
- We want to synthesize data products into useful and ***intuitive*** information and ***indicators***, to support then needs of a diverse water quality community

We could use your input!

Come chat to me about filling out the 5minute user needs **survey**

- Specific regions needing high resolution monitoring?

Let me know if you want to join the project's **technical advisory group** for email updates on product developments and workshops



Thank you!

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