IOCS 2017 Lisbon

CNES support to OCEAN COLOUR SCIENCE

Anne Lifermann, Philippe Escudier, Bertrand Fougnie, Thierry Trémas

and the French OC science team

anne.lifermann@cnes.fr

Outline

CNES membership & support to IOCCG since creation in 1996 (1st meeting in Toulouse)

Contribution from the French community to IOCCG activities

- **3 IOCCG members (Morel, Antoine, Loisel), 8 WGs chairs**

IOCCG chair during 4 years (2010-14)

- **IOCS initiative**
- **International Summer school creation and host @ OOV Villefranche (2012-14-16) (20 students, >12 countries)**

'Advancing Ocean Colour Observations' from space

Image Quality activities

- POLDER
- Sentinel 3A
- Sentinel 2B

Phase 0 studies

- OCAPI
- Calipso > MESCAL
- Acidification

Support to Ocean Colour Science

In-situ observations

- Boussole
- BGC-Argo
- Mammals
- Campaigns
- Coastal obs
- MES

Algorithms dev

- Improved corrections
- Phytoplancton types
- Carbon
- Lidar inversion

Multi-source (OC + SST, SSH, SSS) ***science studies***

Models & assimilation

CNES Image Quality activities

POLDER 1-2-3 end of life final calibration and reprocessing

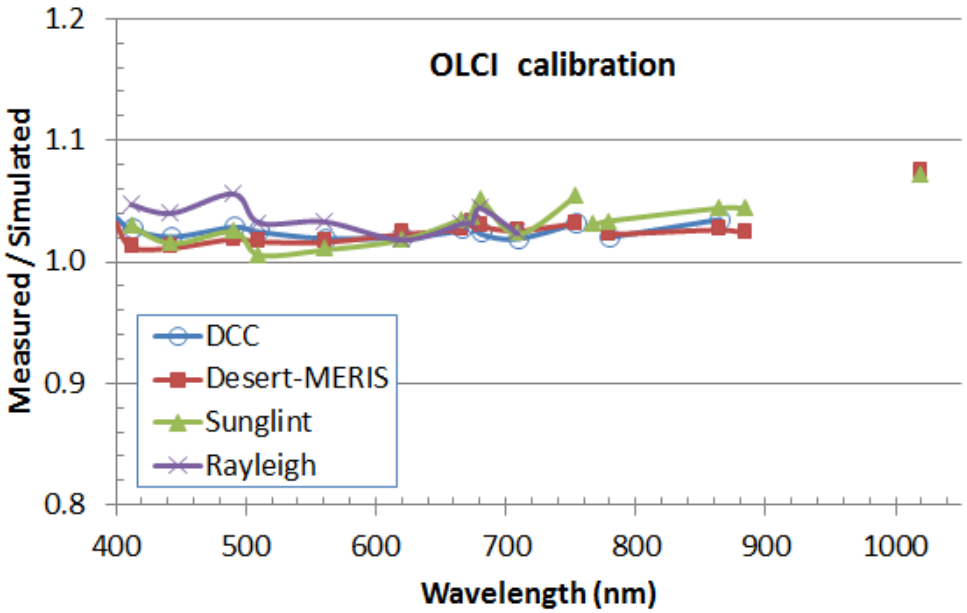
- No update on the geometrical performance (Fougnie et al., AO-2007): absol location ~2km, registrations 0.1pix
- Radiometry **:** the begin of life performance is now maintained up to the end of the A-train orbit phase (end-2010) (Fougnie et al., IEEE TGARS, 2016) **>> absolute calibration within ~2%, and interband calibration ~1%**
- Data distribution (also available in hdf format) ☞ **www.icare.univ-lille1.fr**

Sentinel-3A (… S3B) : Validation of the calibration Over Natural targets

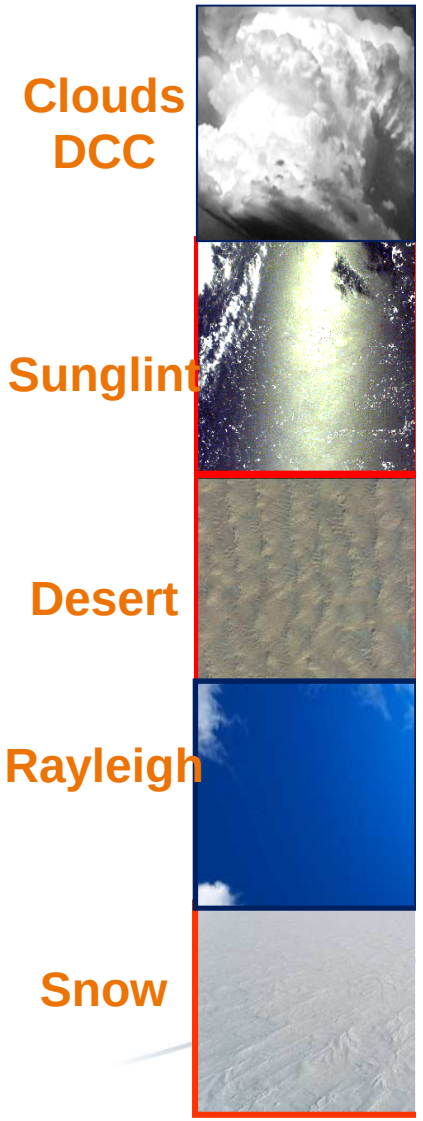
- CNES in charge of the validation of the calibration of the optical sensors (OLCI & SLSTR)

OLCI Validation of the Calibration

- **Results evidence a +2% bias for all bands**
  - **Compared to MERIS over desert sites (but also S2/MSI and MODIS)**
  - **Using Rayleigh as reference (in the red domain)**
- **Very good spectral consistency (TBC for 1020nm)**
- **On-going validation of the trending observed by the diffuser**



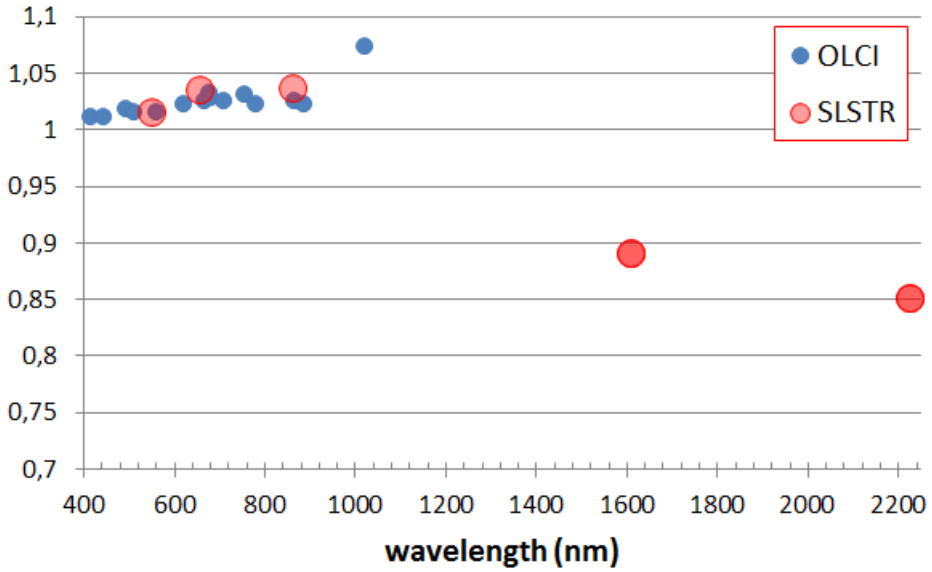
Toolbox



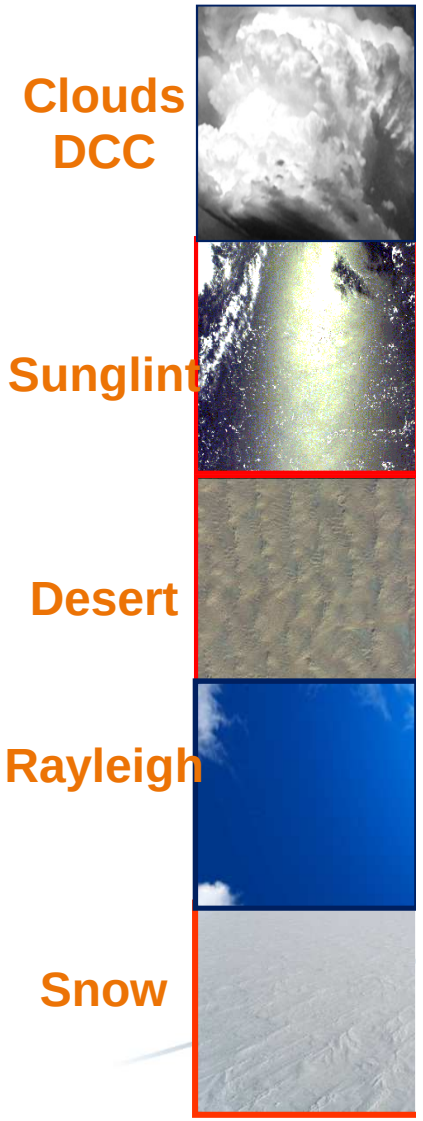
CNES : Camille Desjardins, Bertrand Fougnie
Contribution from ACRI : Véronique Bruniquel, Naceur Meskini

SLSTR Validation of the Calibration

- **Same analysis conducted for SLSTR**
  - **Issue on the calibration of SWIR bands**



Toolbox



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CNES Image Quality activities

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Sentinel-3A (… S3B) : Validation of the Calibration Over Natural targets

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➔ ***Observations with high potential for global scale applications***

Sentinel-2 (A & B)

☞ **www.peps.cnes.fr**

- Image Quality commissioning delegated by ESA to CNES
  - Most {spectral bands + methods} consistent within 3% (goal specification)
  - Other methods: <5%, but the disparity seems to be due to the method, not S2
  - Confirmation of the diffuser absolute calibration
  - Data consistency/continuity with other missions

➔ ***New high resolution observations for innovative applications***

R&T / Tools

- Release of the OSOAA (Advanced Ocean Atmosphere Successive Order) software (Chami et al, 2015)
- Accurate computation of the radiative transfer into the Ocean-Atmosphere system including polarisation, coupling terms, and the agitated surface ☞ **https://logiciels.cnes.fr/?language=en**

CNES Phase 0 activities

OCAPI STUDY/PROGRAMMATIC CONTEXT

MESCAL STUDY (NASA/CNES cooperation)

ACIDIFICATION STUDY (soon…)

- Scientific mission team under definition

OCAPI Programmatic Context

- Ocean color has demonstrated its unique capability to monitor the biological state of the ocean
- Low Earth Satellite Observation limited in term of revisit time:
  - atmospheric perturbations
  - Interest for monitoring rapid phenomenon such as algae blooms

➔ ***Geostationary orbit observation shall be a key element of ocean color monitoring system in complement to low earth observation***

- CNES Science Prospective Seminar in 2014 confirmed OCAPI as a “short term” priority for Earth Observation Program,
- French Space Consultative Committee confirmed this priority in a 2016 report
- Phase 0/A studies conducted with industry contribution to consolidate mission concept, requirements and programmatic constraints.
  - Basis for the OCAPI proposal as an hosted payload, leaded by David Antoine and submitted in June 2016 to ESA EE9 AO
  - AO declared unsuccessful
  - OCAPI considered as too mature for an Earth Explorer mission, new AO opened for missions having a science maturity between 4 and 6

  ➔ **Copernicus appears as the good framework to implement such a concept in complement to LEO observation**
    - CNES supports such an initiative, to be discussed with European partners
    - Support to science activities paving the way in that direction, taking benefit of partners initiatives such as GOCI

Lidar MESCAL phase 0

CALIPSO RESULTS OVER OCEAN (US)

- CALIPSO tilt measurements over ocean (10-14° and 30° tilt maneuvers)
- Demonstration of the potential of lidar for oceanic applications
  - Ref publications (Yu et al 2016, Lu et al 2014, 2016, Behrenfeld 1016)
- Highlights ☞ **M.Behrenfeld's presentation**

MESCAL PHASE 0 (CNES/NASA cooperation)

- Joint NASA/CNES phase 0 study (2017-18) persp 2025-26
- Clouds/Aerosols/**Ocean** profiles
- **Ocean** ☞ **see C.Hostetler's presentation "spaceborne ocean lidar"**
  - Profiles of Kd and bbp
  - 355, 532 nm
  - Fluorescence
  - Profiles every 2 meters
  - Up to 40 meters
- French OC science proposal (C.Jamet & M.Chami)

☞ ***Breakout session on Active remote sensing for OC"*** **Tuesday pm**

(cochairs C.Jamet, J. Churnside , C. Hostetler)

Support to Ocean Colour Science

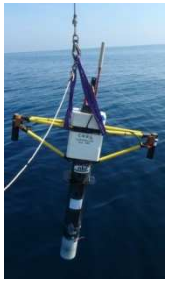
>> in-situ observations

Boussole mooring time series

LOV (D.Antoine et al)

- Continuous support since the beginning, time record [2003, 2017…], quasi operationnal
- Long term perspective discussed at European level (ESA, EUMETSAT, EU) @ workshop « FRM4SOC » Fev 2017 (frm4soc.org)

☞ **www.obs-vlfr.fr/Boussole/**



BioGeoChemical BGC-ARGO Floats

LOV (H.Claustre et al)

- Equipment of 20 floats so far, +4/5 floats /year (Chla, Bbp, Kd, radiometry)
  - Bio-Argo floats provide additional observations: O2, Chl, nitrate, pH, turbidity, Bbp Cdom …
  - Data acquisition & transmission via Iridium, QC
    - Data publically available in real-time through the CORIOLIS Global Data Assembly Center (GDAC-Coriolis)
- Proval development First data from a new Argo profiler dedicated to high quality radiometric measurements

Marine mammals

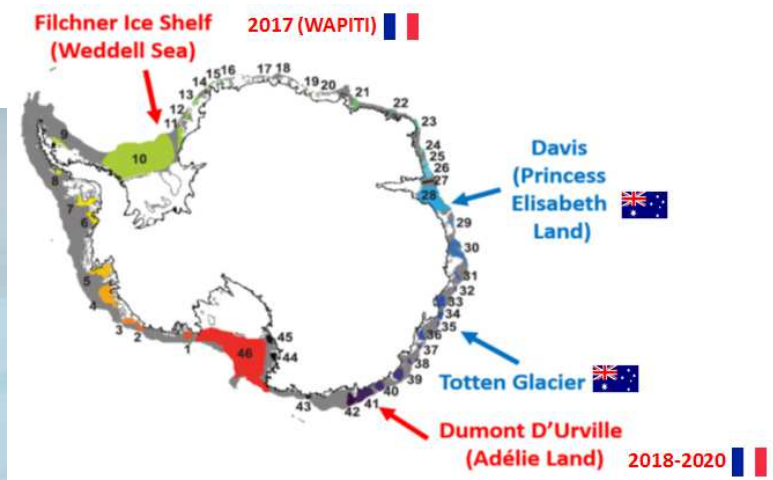
Elephants & Weddells seals : CEBC (C.Guinet), LOCEAN (B.Charrassin)

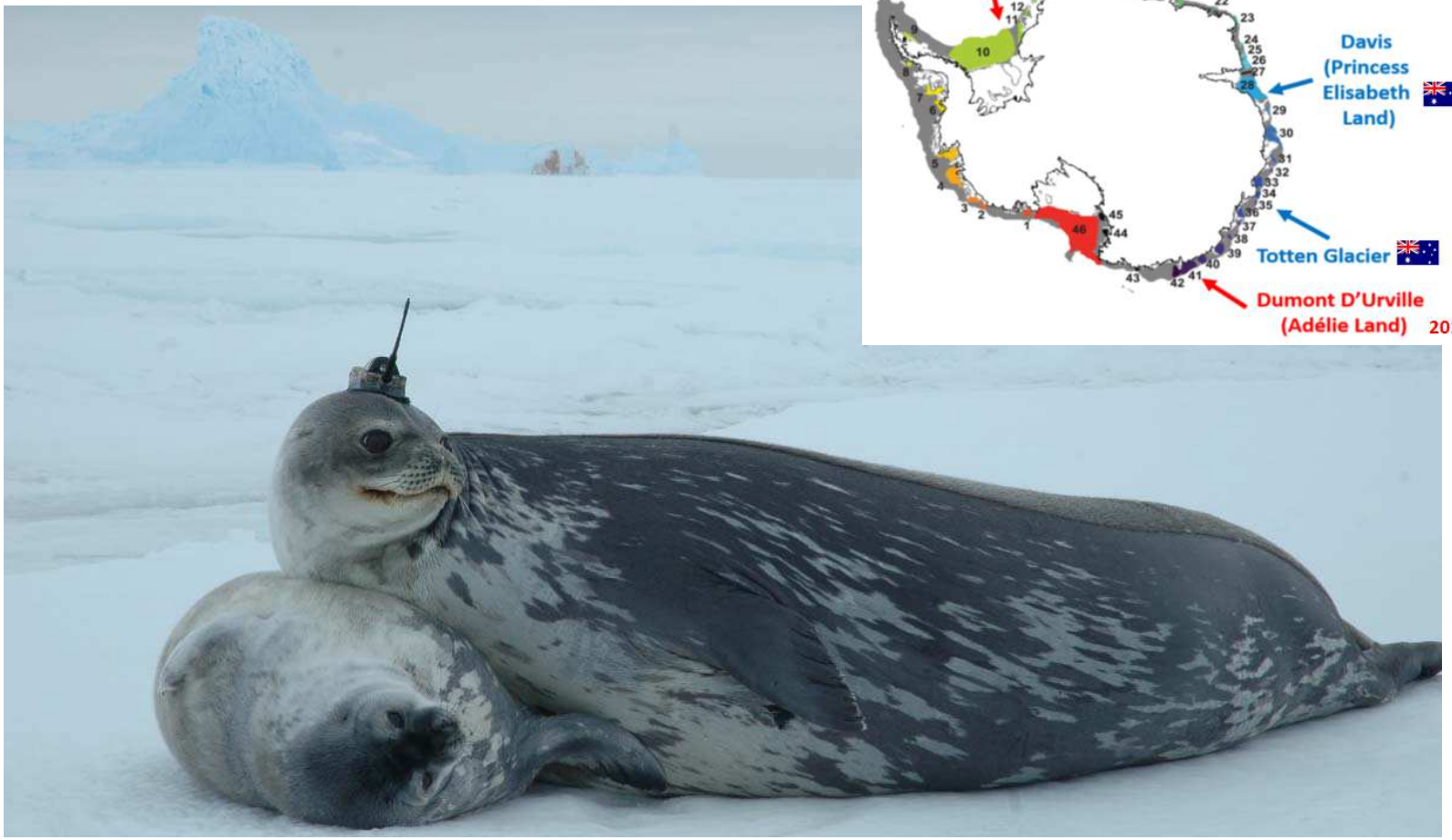
- Unique observations of ocean profiles in polar seas : physical (T/S)+ biological ressources and sea ice thickness (60 dives/day, 200-2000m, 1.4 km sampling/dive) Phytoplankton and plankton (Chla, PAR, µSonar, acceleration)

☞ **www.meop.net**

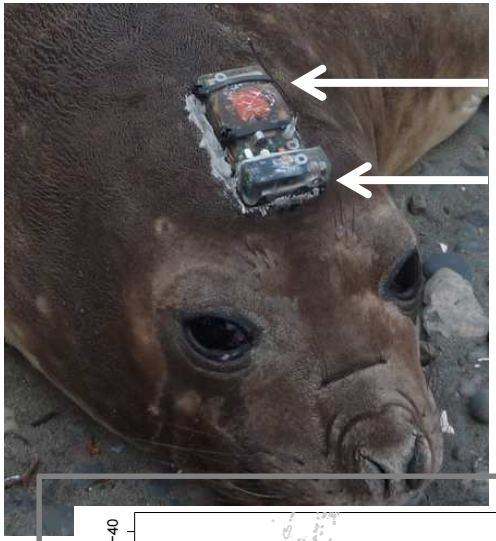
- Contribution to polar observations
- In-situ measurements for Satellite validation
- Complement surface observations with profiles
- Link physical oceanography with bio & ecology

Weddells Seals



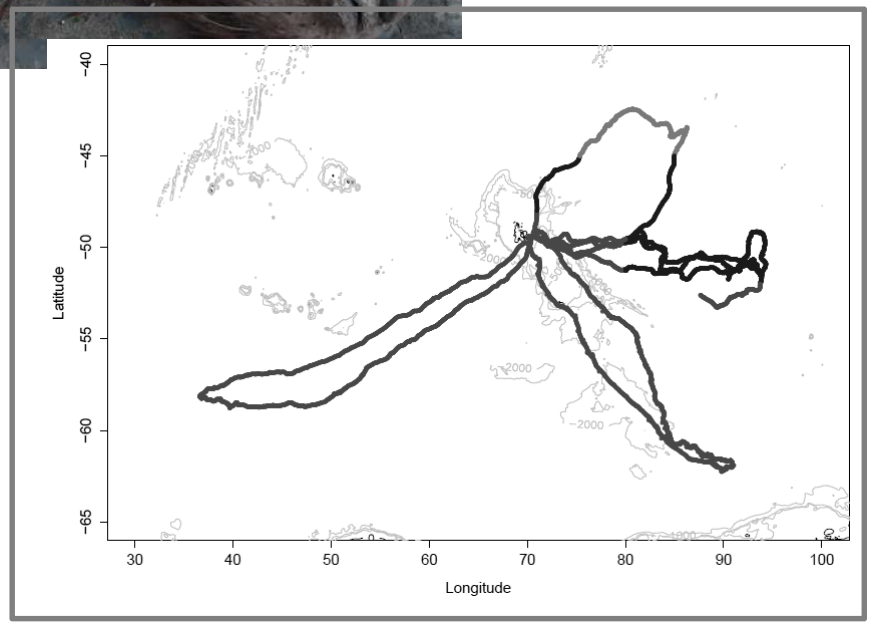


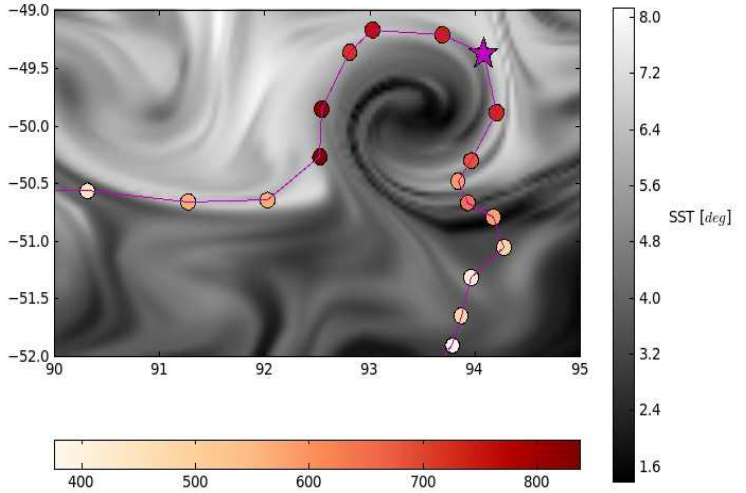
Ref : Christophe Guinet1 & Jean-Benoît Charrassin2
1. CEBC, UMR 7372 ULR-CNRS, 79360 Villiers en Bois, (guinet@cebc.cnrs.fr)
2.LOCEAN UPMC-MNHN-CNRS-IRD, Paris



Argos/GPS

Accelerometer (=indice of preys number)





Number of preys along a physical vortex dominated by diatoms (at the basis of 'lantern fish' food web)

DELLA PENNA A., DE MONTE S., GUINET C., KESTENARE E., D'OVIDIO F. (2015) Quasi-planktonic behaviour of foraging top marine predators. Scientific Reports 5:18063 | DOI: 10.1038/srep18063

>> New approaches & tools at the interface between physical oceanography, bio & ecology (CEBC/LOCEAN/LEGOS)

Support to Ocean Colour Science

>> in-situ observations

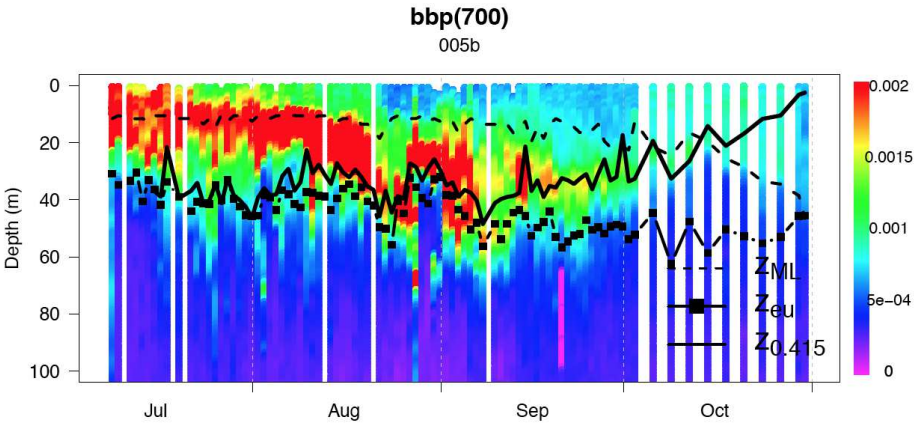
Campaigns

- **Greenedge** TAKUVIK (M.Babin)

Dynamics of the phytoplankton spring bloom in the Arctic, Baffin Bay
(Mar-Jul 2015-16
+ Jun-Jul 2016 icebreaker Amundsen)

BioArgo floats in Arctic
Baffin Bay, 4 +7 in 2017 and 6 in 2018

GREEN EDGE



- **Outpace** (SW Pacific, New Caledonia): MIO (T.Moutin, S.Bonnet, A.Doglioli)

Oligotrophy to UltraoligoTrophy PACific Exp (Feb-Apr 2015) Atalante R/V

- **Peacetime**-OC (10-05/11-06/2017) LOV (J.Uitz)

ProcEss studies at the Air-sEa I/F after dust deposition in the MEd sea
Ocean Color and bio-Optical Characterization: biooptical anomalies

PEACETIME Project

In-situ sampling measurements/matchups

LEEISA (V.Vantrepotte), LOG (H.Loisel)

- Coastal measurements (LOG): Guyana, Vietnam, English channel

cnes

Support to Ocean Colour Science

>> Algorithm development

S3VT

LOG (C. Jamet et al)

- **Contribution to OLCI/SLSTR validation team**
- **Esp. focussed in coastal waters Chl,Kd, IOPs**

☞ Evaluation and improvement of the OLCI atmospheric correction over coastal waters: Validation and improvements of OLCI OC products
Mograne M. Ah., C. Jamet, H. Loisel, X. Mériaux , A. Cauvin

Carbon pools in the ocean POC, DOC

LOG (H.Loisel et al)

- **Atmospheric correction scheme**
- **POC, DOC inversion**

☞ ***Hubert Loisel*** invited talk: c**arbon in coastal waters**
Me 17, 15h55

☞ Bio-optical algorithm for particulate organic carbon (POC) assessment in coastal waters.
Tran Trung Kien, Hubert Loisel, Lucile Duforêt-Gaurier, Xavier Meriaux

GLOBCOAST & COULCOT

LOG (H.Loisel et al)

PHYSAT

LOG (S.Alvain et al)

HARDECOT

LEEISA Guyana, (V.Vantrepotte)

- **Explore/develop OLI/Landsat8 & S2 potential for Chla, MES, CDOM inversion**
- **Guyana, Vietnam, Eastern Channel**

☞ Coastal water extraction algorithm for Landsat-8 OLI based on spectral analysis and the Hue-Saturation-Value based approach.

Dat Dinh Ngoc, H. Loisel, C. Jamet, V. Vantrepotte, L. Duforêt, Chung Doan Minh

THEIA S2/Lansdat 8 data processing

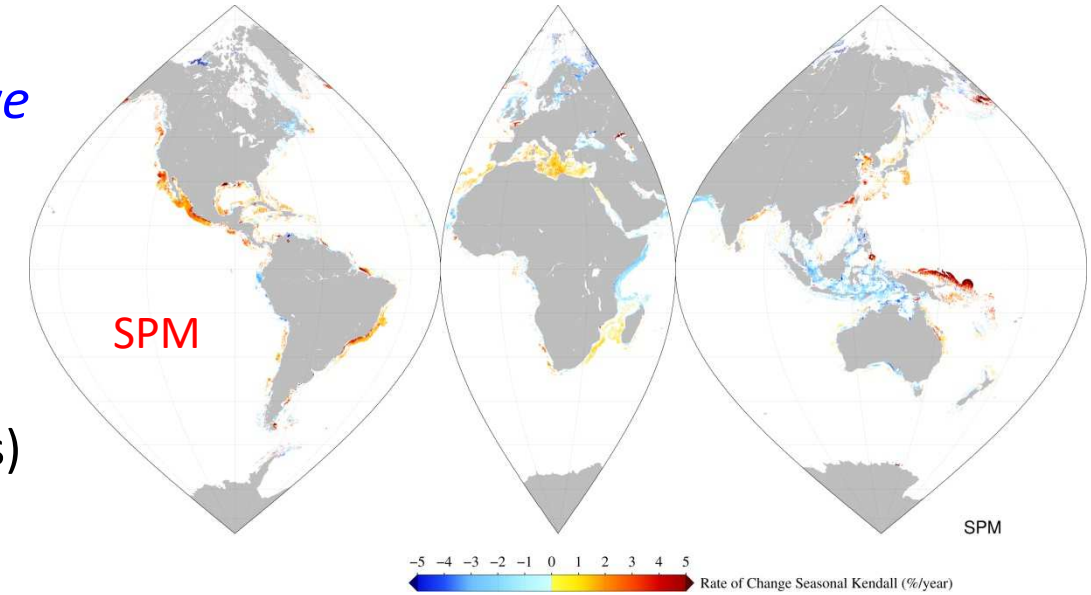
- MACCS Atmospheric correction for turbid waters (O.Hagolle et al.)
- Theia Data Center MACCS water reflectance products

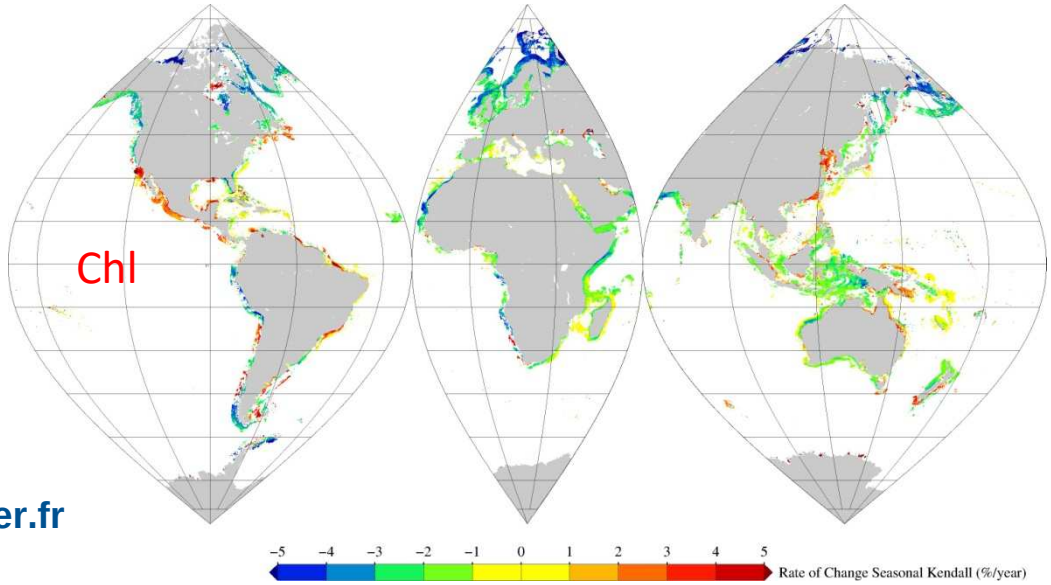
☞ www.theia.cnes.fr

GLOBCOAST & COULCOT projects >> 10 years trend of SPM and Chl

Reprocessing of the MERIS archive over the global coastal waters (can be done for OLCI)

- New atmospheric correction (Polymer adapted to coastal waters) spatial/temporal resolutions increase by a factor of 2.
- IOPs, SPM, Chl, and DOC
- Correlation maps with river and waves
- Trend over 10 years
- Identification of Hot Spots (changes by more than 4% per year)





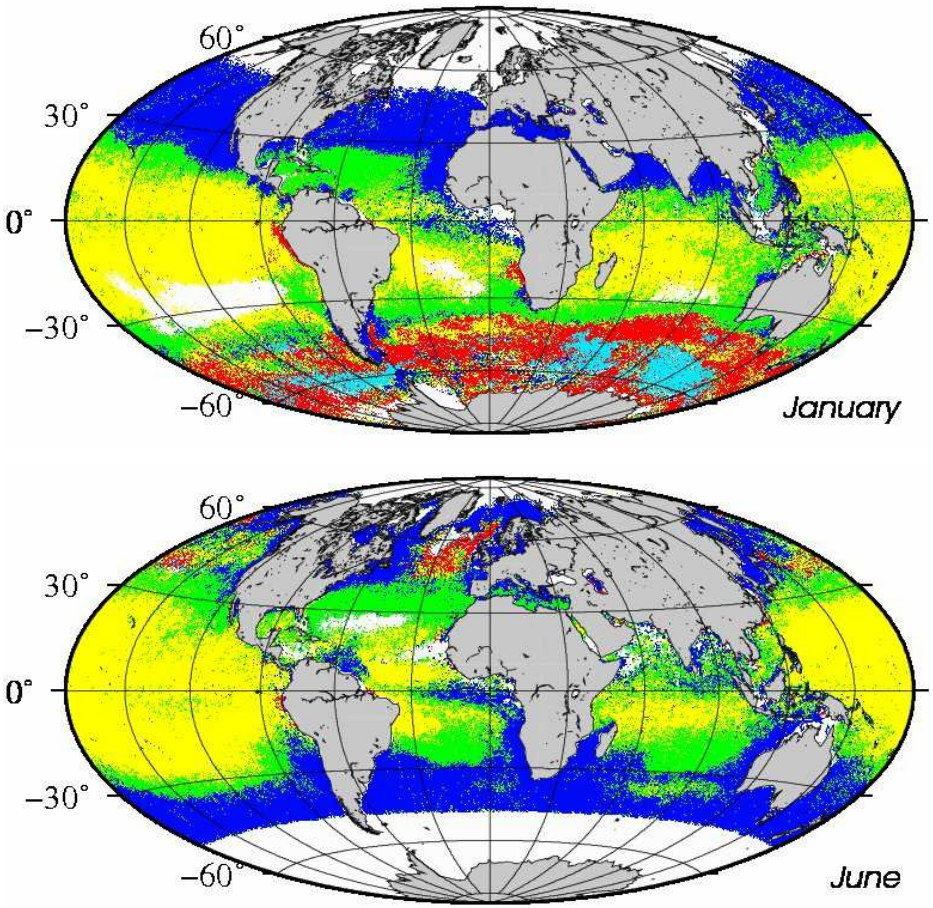
☞ **sextant.ifremer.fr**

GLOBCOAST

PHYSAT Phytoplancton Functional Types

An empirical approach based on the analysis of radiances anomalies

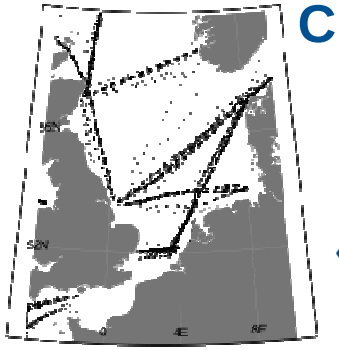
Dominance of : Haptophytes Prochlorococcus SLC Diatomées Phaeocystis_like



Maps of PFT dominance
a group is dominant when present for more than 60% of the biomass, based on biomarkers pigments

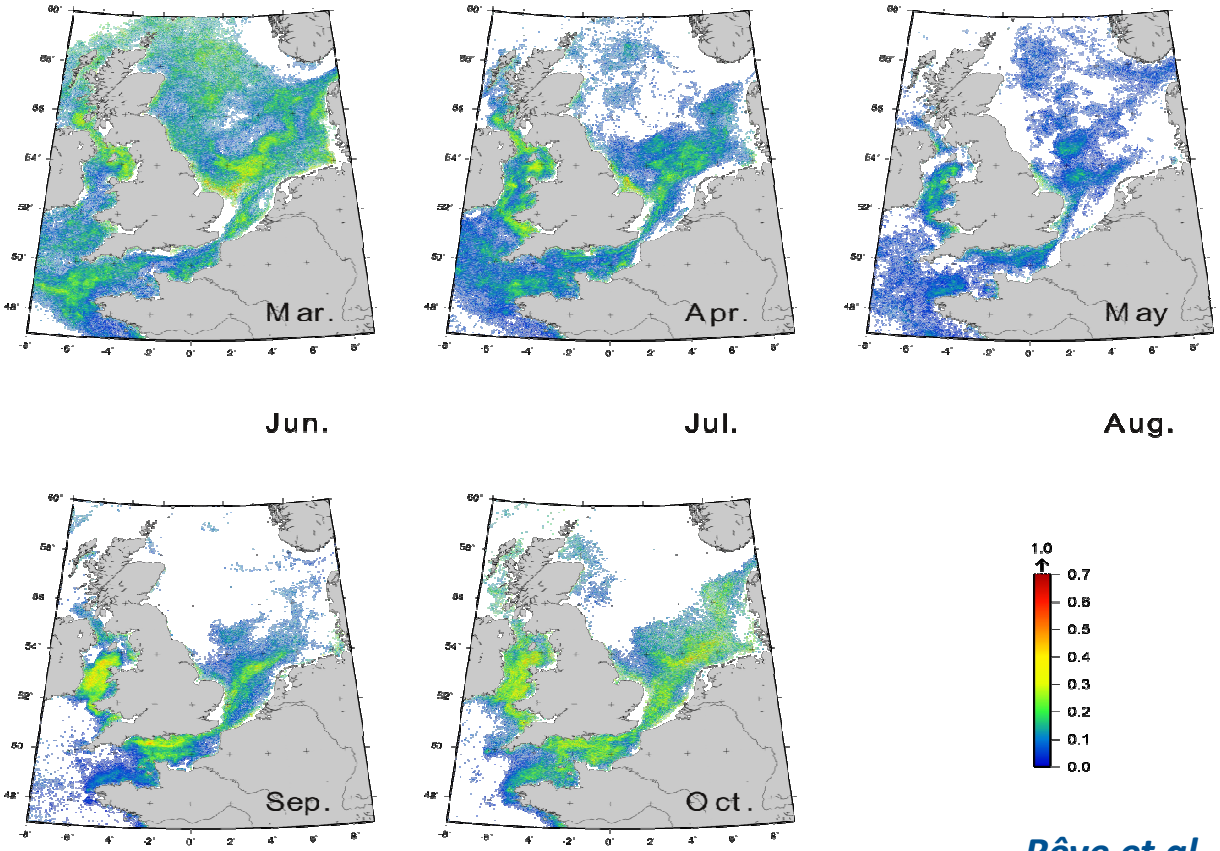
Alvain et al.
2005, 2008 and 2012 for theoretical explanation

☞ ***Data available :***
http://log.cnrs.fr/Physat-2

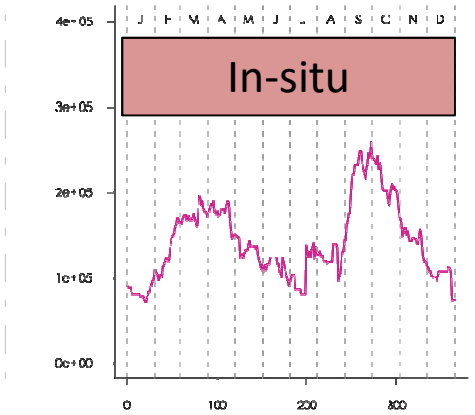


CPR OBSERVATIONS (DIATOMS COUNTS) COUPLED WITH PHYSAT SIGNALS

MONTHLY DISTRIBUTION OF RADIANCES ANOMALIES ASSOCIATED WITH « *THALASSIONEMA NITZSCHOIDES* » ASSEMBLAGE (MONTHLY FREQUENCIES DETECTION)

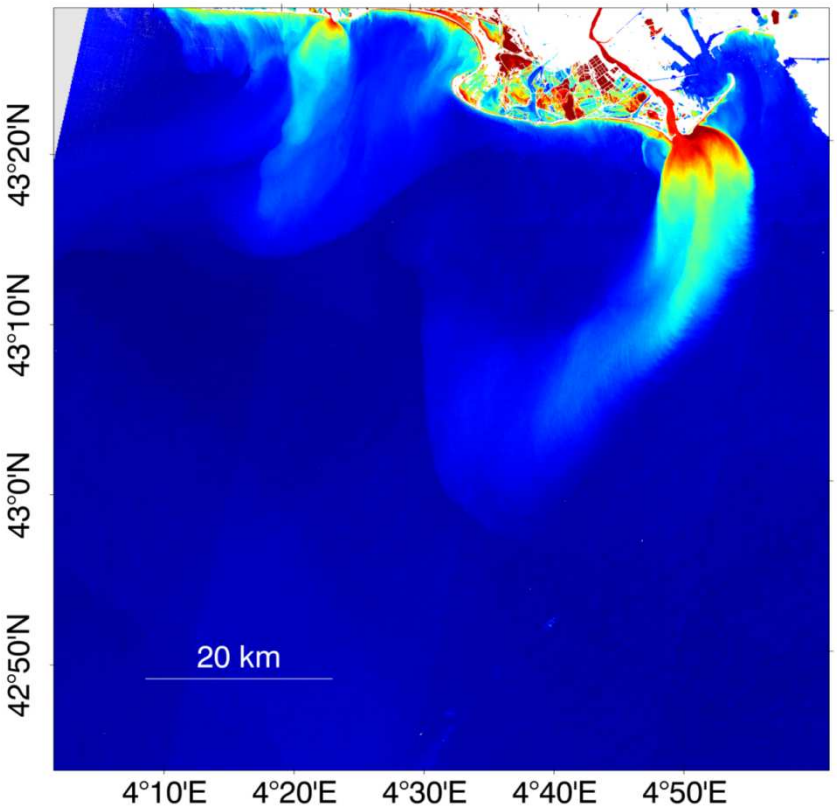


-Spring / autumn cycle
-Mixt environment
-Nutrients rich areas



Rêve et al. In revision

SPM inversion: S2 results



Monitoring of suspended matter in rivers estuaries and panache using Sentinel 2 MSI image (10m resolution) Courtesy D. Doxaran, LOV

TTC

LOV (D.Doxaran)

- **Suspended matters in river plumes**

Retrieval of Concentration, size distribution & composition

☞ ***See related posters***

☞ Constantin S. et al
Suspended particulate matter dynamics in the surface waters of the Gironde plume

☞ Di Polito C.et al
Monitoring suspended particulate matter (SPM) concentration anomalies in coastal waters: application of the Robust Satellite Techniques (RST) to MODIS-Aqua data

☞ Doxaran D. et al
Validation of ocean colour satellite products in European coastal waters as part of the EU-FP7 HIGHROC project.

☞ Morin G. et al
Exploring the capabilities of L8-OLI and S2-MSI satellite data to remote sense the size distribution and composition of suspended particles in river plumes.

☞ Ody A et al
Concentration, transport, fluxes and dynamics of suspended sediments along a continuum from rivers to river plumes using high spatial resolution ocean color satellite data.

HIGHLIGHTS

IOCCG membership & support since 1994

‘Advancing Ocean Colour Observations’ from space

Image Quality activities

- Reprocessing of POLDER dataset
- Sentinel 3A (OLCI & SLSTR) vicarious calibration
- Sentinel 2B

Phase 0 studies

- OCAPI phase 0 > EE9
- Calipso satellite tilt measurements > MESCAL
- Acidification

Support to Ocean Colour Science

In-situ observations

- Boussole
- BGC-Argo floats
- Mammals
- Greenedge
- Peacetime
- Outpace
- Coastal obs
- Cyto flux meas
- MES (Rhone, Vietnam…)

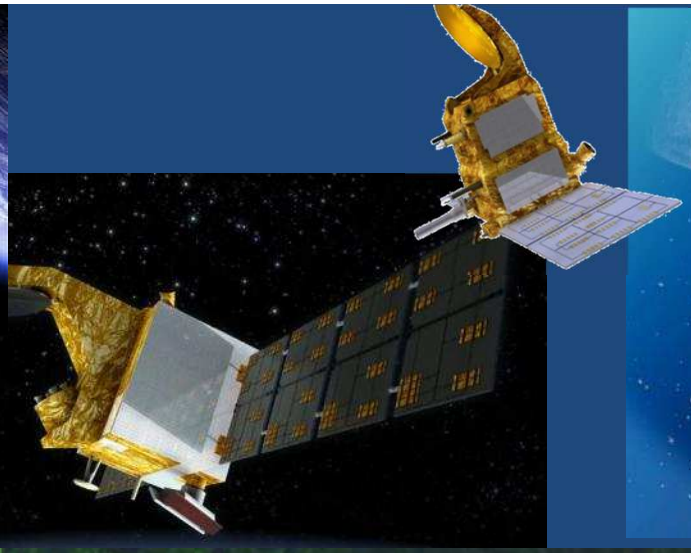
Algorithms dev

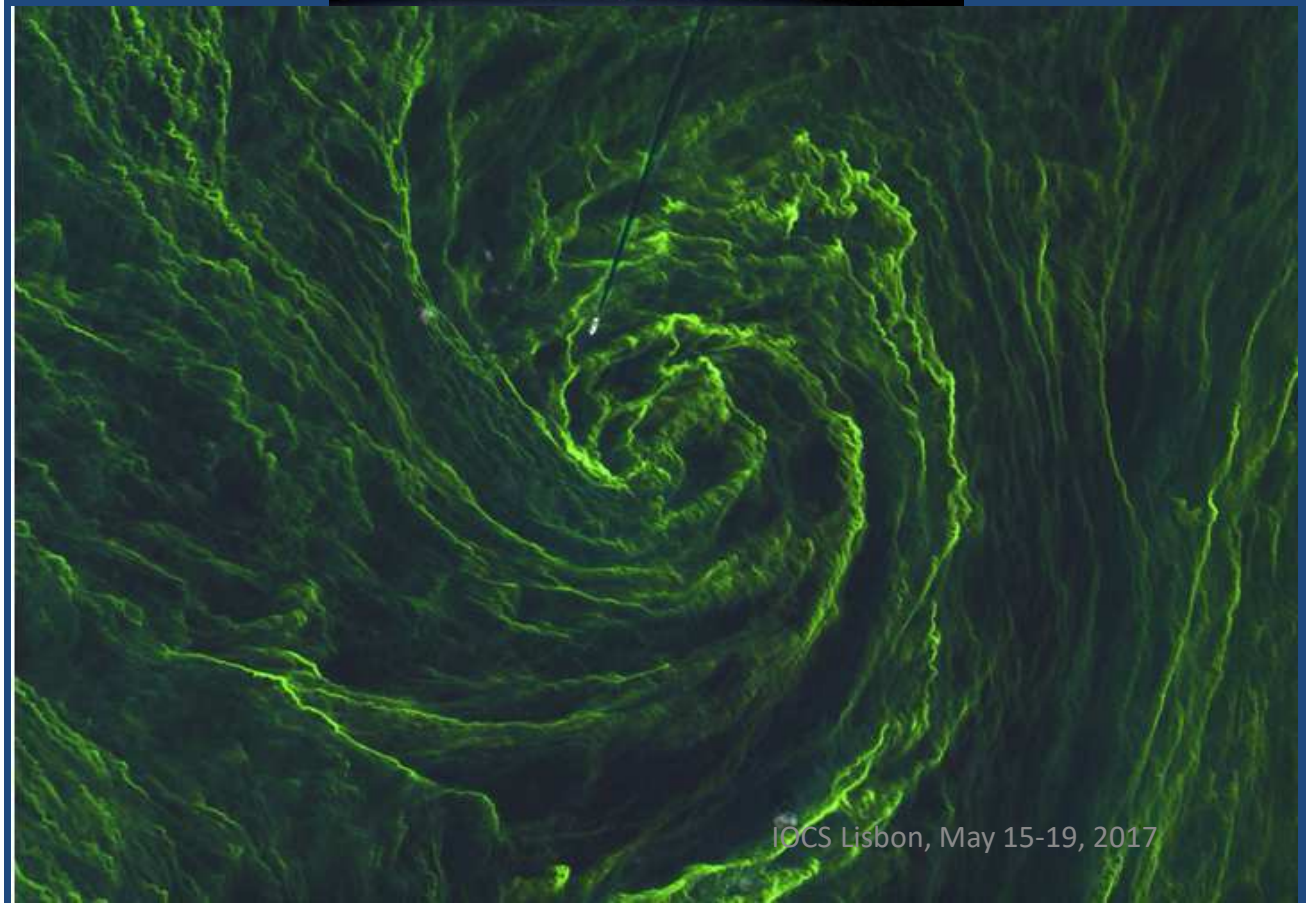
- Improved corrections
- Phytoplancton functional types
- Carbon in coastal waters POC & DOC
- Lidar inversion

Multi-source (OC + SST, SSH, SSS) *science studies*

Models & assimilation

- OCAPI





Thank you !

S2 image over the Baltic