SOLAS-FRANCE – 29 JUIN 2015

Algorithm improvement for remote sensing : method based on suspended matters, coccolithophores and phytoplankton answer to meteorological factors

(October 2013-September 2016)

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I. Context : why do we focus on coccolithophores ?





Coccospheres

A key role on carbon cycle :







Coccoliths

- The main calcified phytoplankton (CaCO3)
- **Produce** CO2 with precipitation of CaCO3.
- A sink of CO2 due to photosynthesis and sedimentation.
- Produce DMS (effect on cloud cover and albedo)
- Feedbacks on climate

(Shutler (2011), Balch (2005), Smyth (2004))

Problematic :

-What is the evolution of budget of calcite produced by coccolithophores ? -How the environmental factors impact coccolithophores blooms ?

Hypothesis:

The abundance of coccolithophores would increase by the impact of climate change or would decrease by acidification process.

CSCZ 1979-1984 (Brown and Yoder 1994)



SeaWiFs 1997-2003 (Brown NASA-USA c.p)

South-West Atlantic

Focus of study of coccolithophores dynamics on 2 areas in Atlantic.

Satellital composites of calcite for 2 periods :

Ocean color and remote-sensing





Reflectance Rrs (remote-sensing) : Lw / Ed

| Band | Wavelength | |
|------|------------|-------|
| | SEAWIFS | MODIS |
| 1 | 412 | 412 |
| 2 | 443 | 443 |
| 3 | 490 | 488 |
| 4 | 510 | 532 |
| 5 | 550 | 550 |
| 6 | 670 | 670 |

SeaWiFS

(Sea-viewing Wide Field-of-view Sensor)

 → 6 wavelengths in visible range : 412,443,490,510,550 et 670

MODIS

(Moderate Resolution Imaging Spectroradiometer)

→ 6 wavelengths in visible range :
410, 430, 480, 530, 550 et 670

Zone 1 : North-East Atlantic



Indication of blooms

Suspended matters :

large variety of different constituents (minéral clay, organic fragments, suspended sediment, etc..)

Maps of SPM (MODIS)





Seasonality of suspended matters by remote-sensing : an indication of coccolithophores bloom.

Coccolithophores and SPM dynamics



SPM map dof 23 may 2010

- Coccoliths are visible in SPM signal.

-The analysis of coccolithophores is linked to the seasonal variability of SPM signal.

- Process which impact suspended matters are important for the phenology of blooms.

coccoliths



How to discriminate these 2 components ?

II. Methods

Discrimination fuzzy-index method (Moore et al., 2009)

Fuzzy-index: distance criterion between a reflectance spectra and a caracteristic reflectance spectra linked to coccolithophores blooms.



- Index is computed for spectra from each pixel.

- Index is qualitative (0 \leftrightarrow 1) and doesn't quantify coccoliths.

Method to quantify coccoliths

Exemple of 25/05/2013 :





Quantitative result for the bloom of 2013







SPM signal allows to quantify the bloom.

Climatologies (period of 2003-2013) :





Bloom in northward direction along the shelf-break : from Bay of Biscay to Irland between April and June.

Monthly means of cocoliths for 2 years :



- Bloom in northward direction along the shelf-break between April and June for 2013.
 - Means are much lower for 2014.

Fortnight climatologies of coccoliths (2003-2013) computed with daily budgets :



Fortnight climatologies of coccoliths (2003-2013) for the 4 sub-areas :



Anomalies du nombre de pixels de coccolithes(1998-2014)

Anomalies show 2 particular years : 2001 and 2014.

Interanual variability of blooms

Fortnight variability of coccoliths (2003-2013) for the entire area :



2014, a particular year :



A weak dynamics of bloom in comparison with data of the time-serie 1998-2013.

Comparison with in-situ data

Modycot-1998 campaign (Lampert et al, 2002)



19 hexa sur GF/F 25mm

- The comparison is possible with SeaWiFS data on 27/04/1998 (with enough clear pixels on the area)

Comparison with in-situ data

Modycot-1998 campaign



<u>Comparison with in-situ data</u> In-situ data for the bloom of 1999 :

(Smyth et al, 2002, Gordon et al,)



Spectral shapes don't allow to discriminate the bloom in the area with the fuzzy-index (impact of CDOM and other components).

<u>Comparison SPM-calcite with back-scattering coefficient (Bb(546))</u> <u>Bloom of 1999 :</u>



- Bb coefficient of SPM signal on the bloom of 1999 is consistent with Bb from in-situ observations (Smyth et al, 2002)

Comparison of SPM (Ifremer) with calcite

Bloom on 25/04/2013 :



- Good correlation between SPM et la calcite.
- Quantitative difference (SPM Ifremer > Calcite Nasa) comes from algorithmic differences of coefficient Bb.

Zone 2 : Atlantic South-West



- \rightarrow Continental shelf-break.
- → Application of the method for blooms in Patagonia.

Estimation of bloom with Fuzzy-index :

9 January 2010



Method can be used for blooms between November and March between 1998 and 2015.

V. Conclusion et perspectives

-The method allows to discriminate coccolithophores blooms in the area of Atlantic North-East between 1998 and 2014.

-Good correlation between SPM signal and calcite in bloom areas.

-Extension of blooms along the shelf-break from Bay of Biscay to Ireland, with spatial differences and anomalies in the time-serie of 17 years.

PERSPECTIVES

- Explications of 2014 anomaly ?
- → Need to take account of environmental parameters (SST, irradiance, tide, waves, stratification).
- → Improvement of SPM signal :

SPM = SPMnon-algal + SPMcoccoliths

 $\rightarrow\,$ Application of the method to the Atlantic South-West area.

→ Comparison with in-situ data for the Atlantic South-West area (Argau, Tara, etc)

Argau campaign (2008) :



Thanks for you attention !

