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Spectral Variations of the Remote Sensing Reflectance during Coccolithophore Blooms in the Western Black Sea

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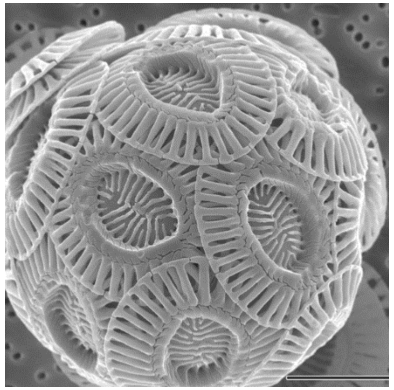
Joint Research Centre

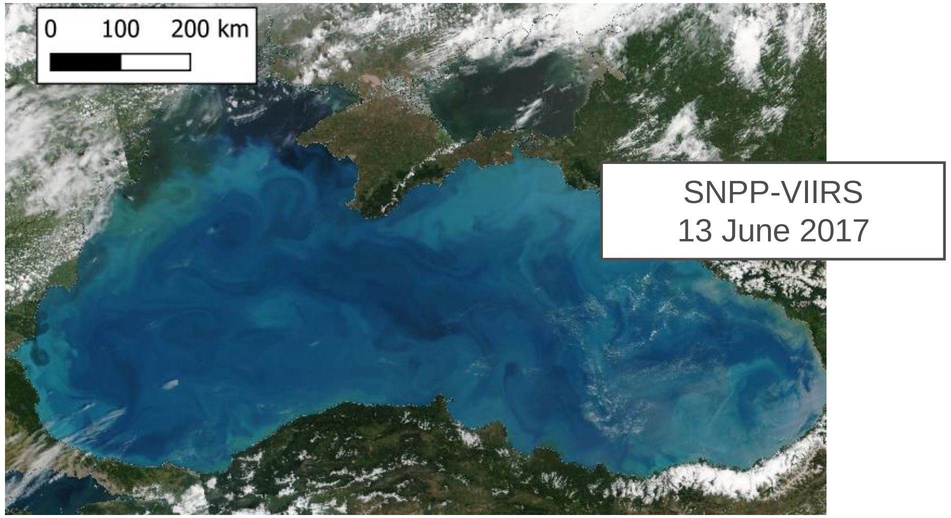
Introduction

Coccolithophores are eukaryotic phytoplankton
- covered by plates of calcium carbonate (**coccoliths**)
- major producer of particulate inorganic carbon (**PIC**)[1,2]



Source: PLoS Biology, June 2011, Cover
Author: A.R. Taylor

Coccoliths cause large **increase** of the Remote Sensing Reflectance (R_{RS}) during blooms[3-6]



Very few in situ reflectance spectra related to coccolithophore blooms are documented in the literature[7-9]

Goals

1 investigating **in situ R_{RS} spectral features** during recent blooms

2 assessing the **accuracy of satellite-derived *R_{RS}*** in the presence of coccolithophore blooms

Materials and Methods

1. Blooms identification

NASA 'COCCOLITHS' flag algorithm[3] applied to AERONET-OC data

2 AERONET-OC sites equipped with latest CE318-T (12-channel)[10]

- L_{WN} at OLCI bands
- replicate measurements (triplets) every 30 mins

2. Satellite radiometric product assessment

MODIS-Aqua/Terra, VIIRS-JPSS/SNPP
Through SEADAS (NASA's R2018)

OLCI-S3A/S3B
Collection 3 (OL_L2M.003.00)

3. *Spectral evolution of $R_{RS}(\lambda)$*

At AERONET-OC sites (in situ + satellite data)

In open Black Sea, Celtic Sea, North Sea (satellite data only)

4. Particulate inorganic carbon *PIC estimation*

Based on **CI index (Mitchell** et al., 2017)[11]

$$PIC = 0.4579\ CI - 0.0006$$

Applied to in situ and satellite data

5. Impact of satellite *$R_{RS}(\lambda)$* *accuracy on PIC estimation*

We would like to thank NASA OBPG for granting access to the MODIS and VIIRS data, EUMETSAT for providing the OLCI data and the AERONET Team for processing and distributing the data from the Ocean Color component of the Aerosol Robotic Network.

Special acknowledgments are due to Violeta Slabakova and Dragos Niculescu for their invaluable help in maintaining the Galata and Gloria/Section-7 sites, respectively.

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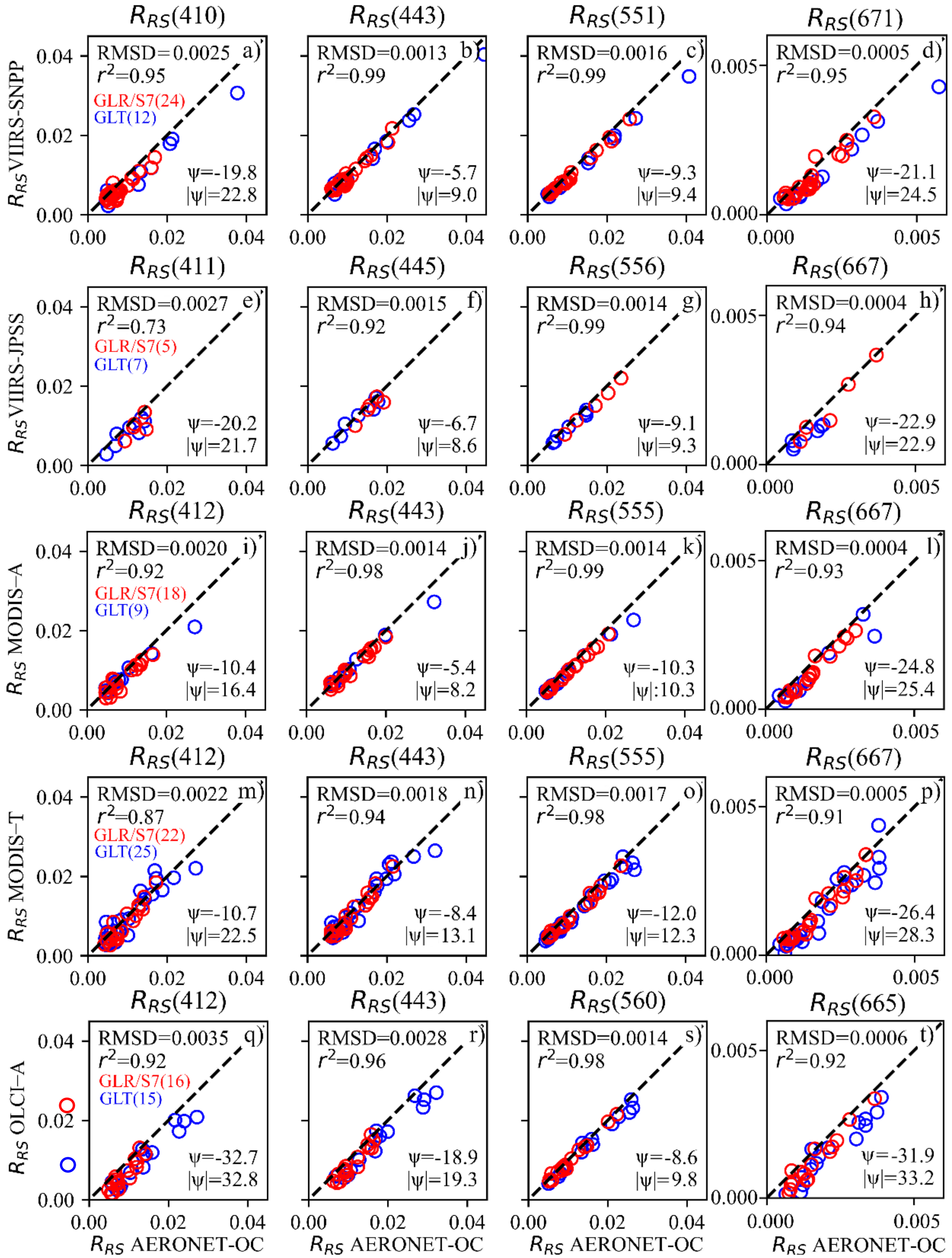
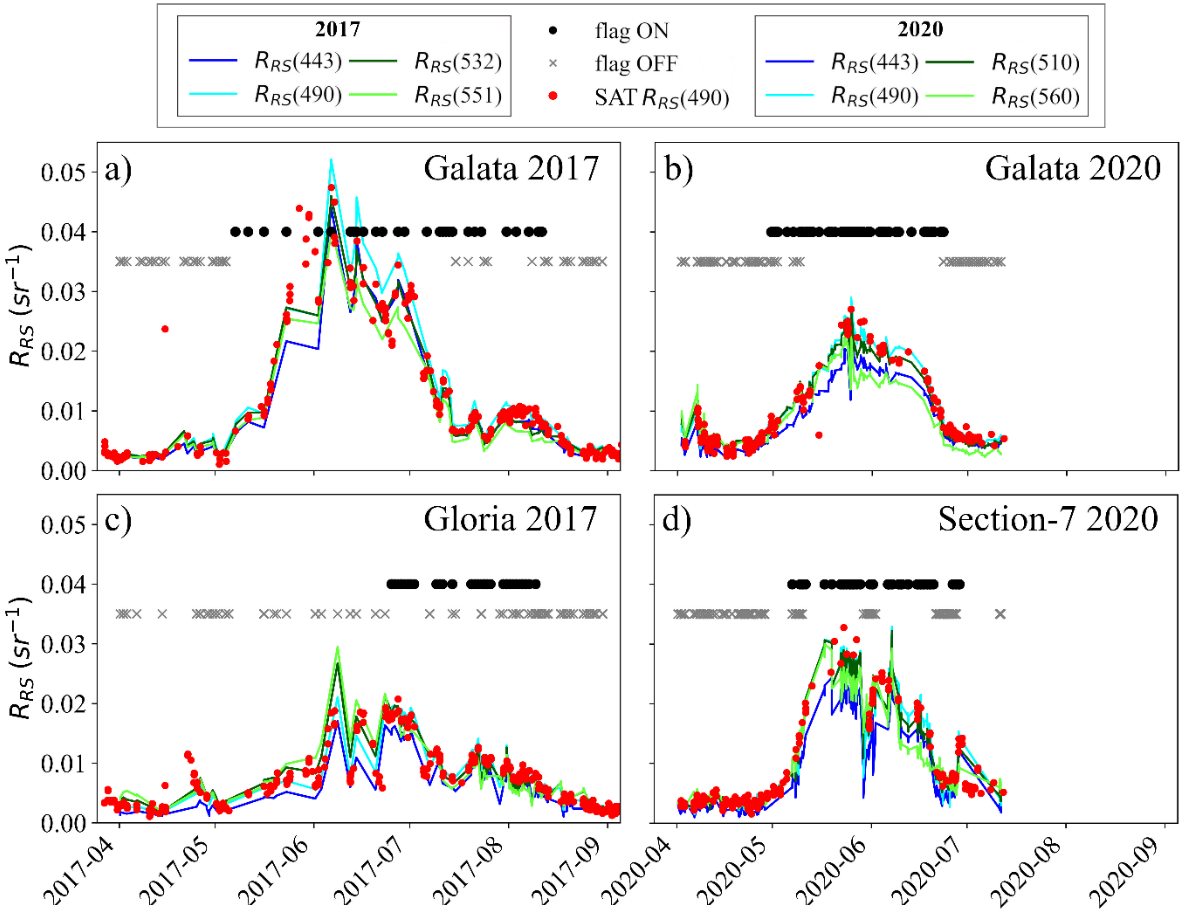
Satellite products validation



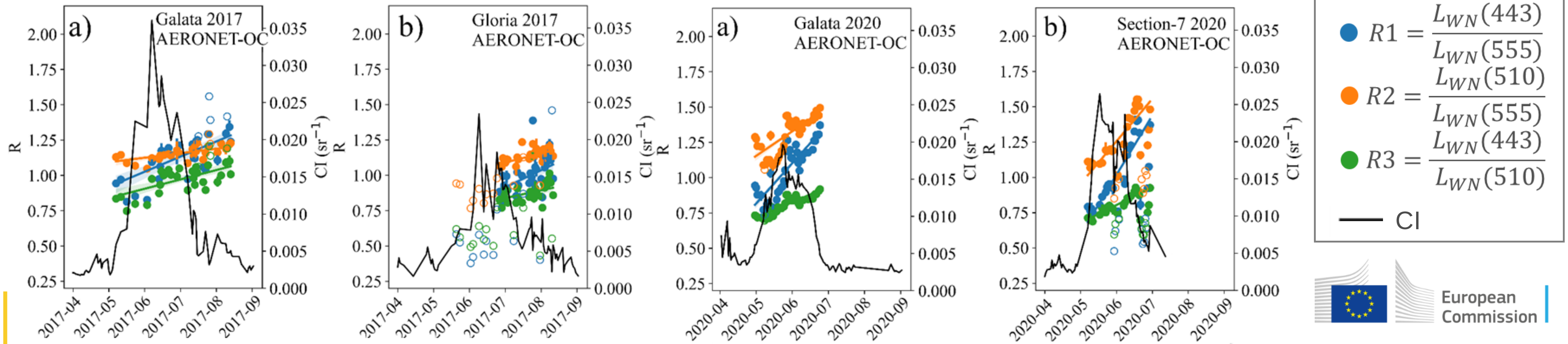
Match-ups for AERONET-OC data **with coccoliths** flag activated in 2017 and 2020

- $R_{RS}(\lambda)$ values are generally **underestimated**.
- However, product **accuracy is not degraded** in the presence of coccoliths respect to non-bloom conditions
- NASA **coccoliths flag** may sometime exhibit **false negative** cases when applied to satellite data with respect to AERONET-OC data
- **PIC underestimates** range between 5% and 12% for satellite products with respect to the values from AERONET-OC

Bloom evolution (radiometry)



- $R_{RS}(\lambda)$ **increases** since the beginning of the bloom
- $R_{RS}(\lambda)$ spectral **maximum shifts towards blue** with bloom progression and coccoliths accumulation
- Differences between coccolithophores evolution at the two sites were largely explained by the impact of the **Danube estuarine waters**



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Future developments

This study **consolidated the use of satellite** radiometric data products for the quantification of **coccoliths** concentration and **PIC**.

Spectral changes of $R_{RS}(\lambda)$ identified in this study, are relevant for the development of algorithms for the **identification of successive bloom stages**, potentially leading to different levels of **cells-to-liths ratio**[12-13].

However, there are limitations:

1. **NASA coccoliths flag**, proposed for oceanic waters, is naturally **affected** by the presence of high concentrations of colored dissolved organic matter and detritus particles
2. The presence of **other type of algae blooms** hinder coccolithophores presence identification

→

***CI* appears more** effective in identifying turquoise (most likely coccoliths) waters

Measurements of coccolithophores and coccoliths concentrations are required to consolidate the use of CI-based algorithms.

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