Ocean Predict

SYMPOSIUM OP'24

In partnership with unesco Intergovernmental Oceanographic Commission

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Retrieval of Biogeochemical Properties in Marine Waters Using a Newly Introduced Inversion of the Three-stream Irradiance Model: BOUSSOLE SITE

ECHO group of oceanography (OGS)

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$$reflectance\ R \propto \frac{L_w}{E_d} \propto \frac{b_b}{a + b_b}$$

downwelling irradiance E_d

water-leaving radiance L_w

backscattering b_b

absorption a

Inorganic

CDOM

Water

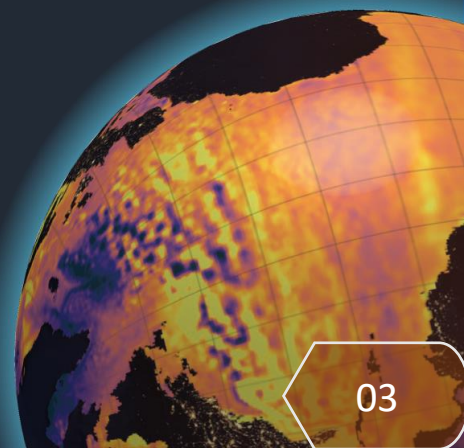
Non-phytoplankton

fluorescence

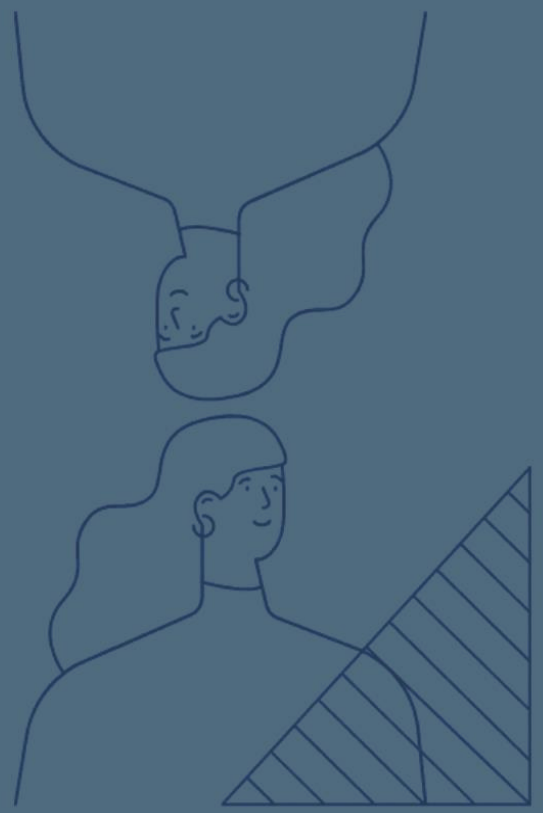
scattering b

BIOPTIMOD

“ Seas & Oceans are pools of clear waters where the light plays ”



02 Objectives

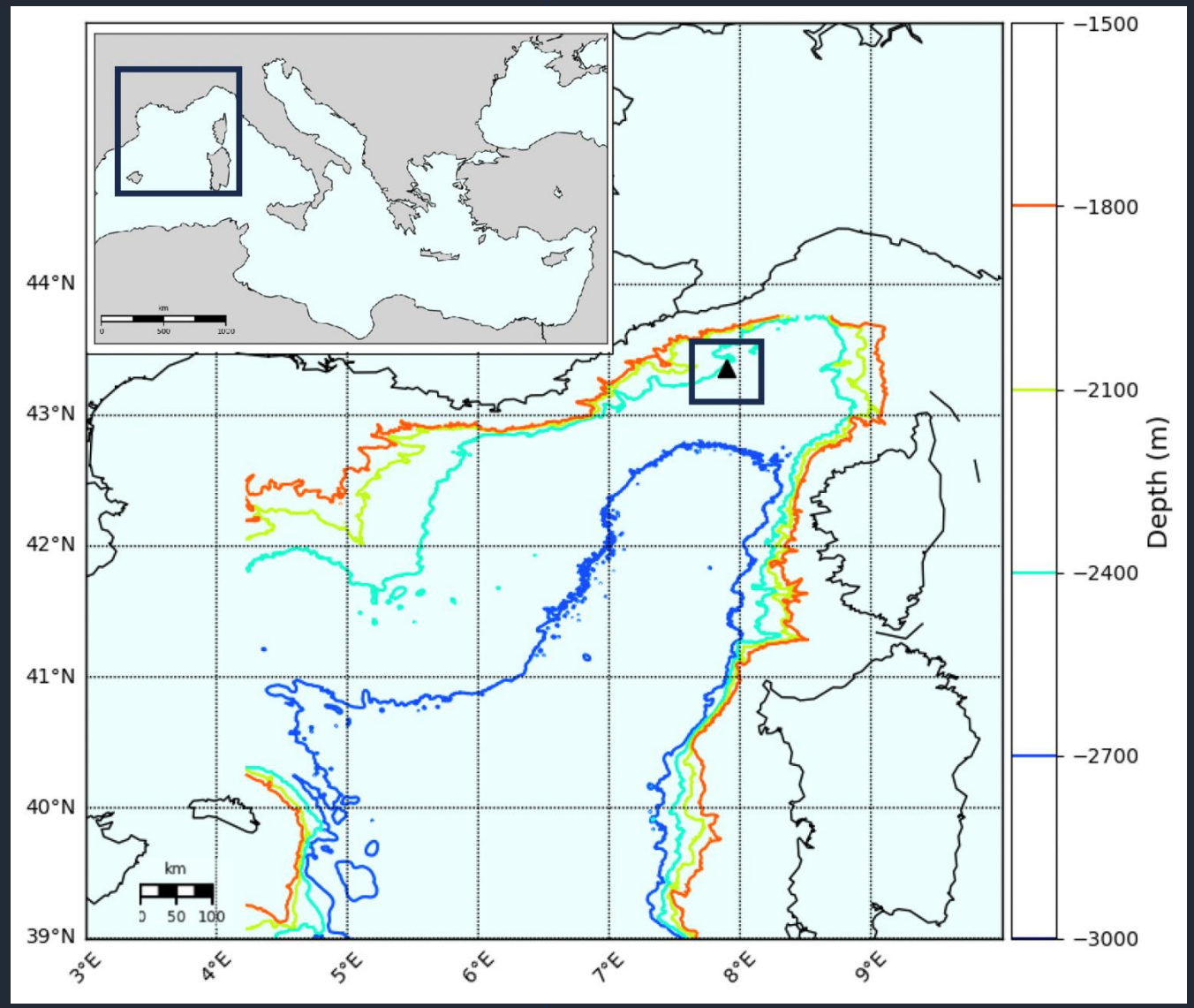


“Invert to uncover new possibilities”

- ✓ Demonstrating the feasibility of the inversion approach for identifying important physical and biological processes
- ✓ Coherently map information between optical and biogeochemical model variables.

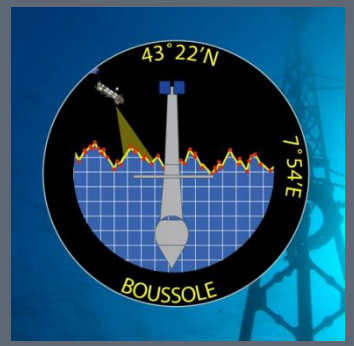
Pilot study area

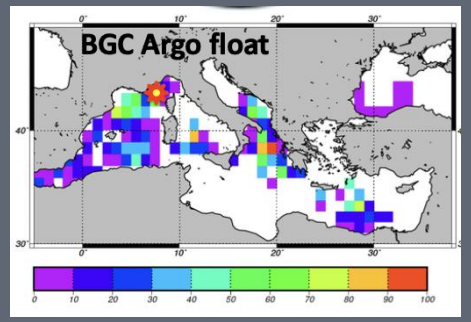
- In the Ligurian Sea (7◦54 ’E, 43◦22 ’N), one of the Northwestern Mediterranean sub-basins, at about 32 nautical miles from the French coast (water depth is 2440 m).
- High availability of bio-optical data with high frequency (every 15 min).
- Ideal for the test and skill analysis of the newly introduced inversion model.

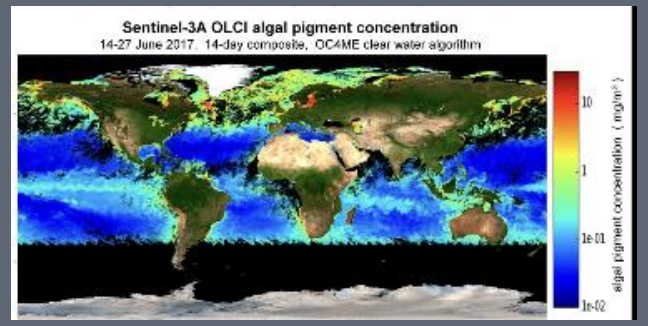


Observation tools

e.g., CMEMS data, marine optical observatory, BGC-Argo floats in the Mediterraneanen sea







Data used

OASIM data

Radiometric quantities (Spectral radiance $L(z, \vartheta, \varphi, \lambda)$, upwelling/downwelling planar and scalar irradiances) Diffuse attenuation coefficient K*d*)

(Lazzari et al., 2021)

L3 daily multi-sensor remote sensing reflectance *Rrs*)

Chl-a and Inherent Optical Properties IOPs (e.g., Total scattering, total backscattering, total absorption coefficients)

(Ras et al., 2008; Antoine et al., 2011)

Experimental data analysis

QC

- Zenith angle filter
- Data depth >2m of the nominal depth
- "Tangent" >10° filter
- Ed< 0.005 µ Wcm $^{-2}$ filter
- The *3-σ* over the average filter
- SG smoothing filter (window size=10 days)

QC

- Cloud filtering
- The *3-σ* over the quality index of Rrs
- Savitzky-Golay filtering

How?

OASIM data

Ed(λ) Es(λ) Eu(λ)

Forward model

Rrs Model

Observed IOPs & AOPs

Model validation

Rrs-satellite derived measurements (λ=412.5, 442.5, 490, 510, 555nm)

OASIM data

J=Cost function

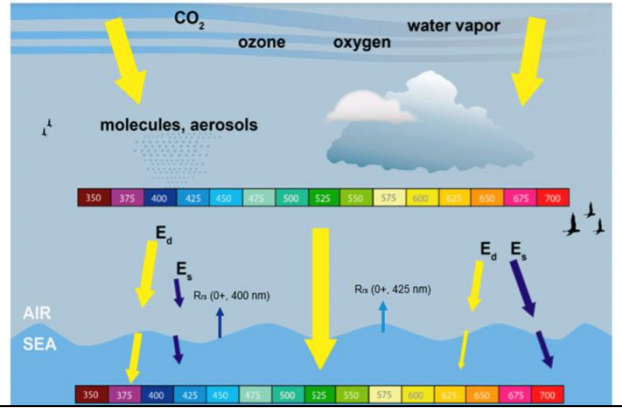
$J=\sum(Rrs_{MODEL}(\lambda,x) - Rrs_{OBS}(\lambda))^2$

Minimize

Optimization of J (L-BFGS-B, SciPy)

SEAMLESS

Data assimilation



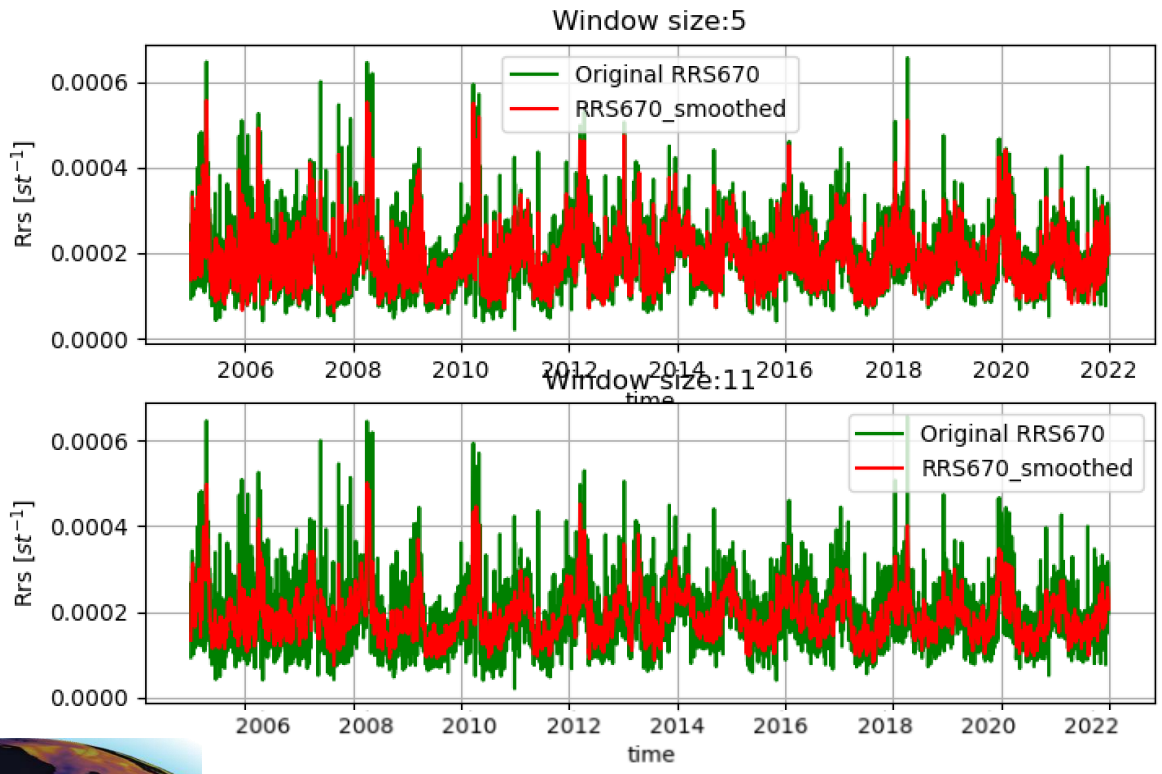
Observed IOPs & AOPs

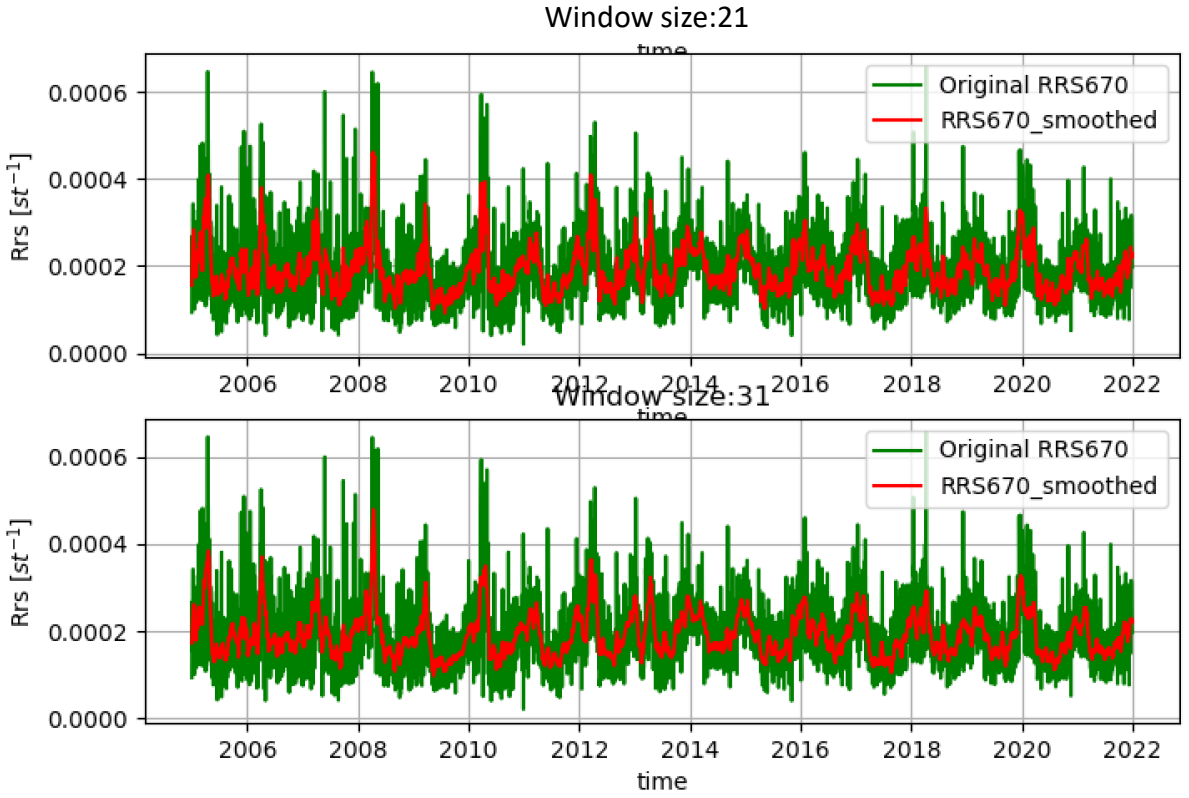
Sensisitivity analysis (Chla, bb, Kd)

Retrieved IOPs & AOPs

Lazzari, P., Gharbi Dit Kacem, M., Álvarez, E. *et al.* Determination of biogeochemical properties in sea waters using the inversion of the three-stream irradiance model. *Sci Rep* 14, 22347 (2024). https://doi.org/10.1038/s41598-024-71457-5

Signal signature analysis of Rrs (λ)



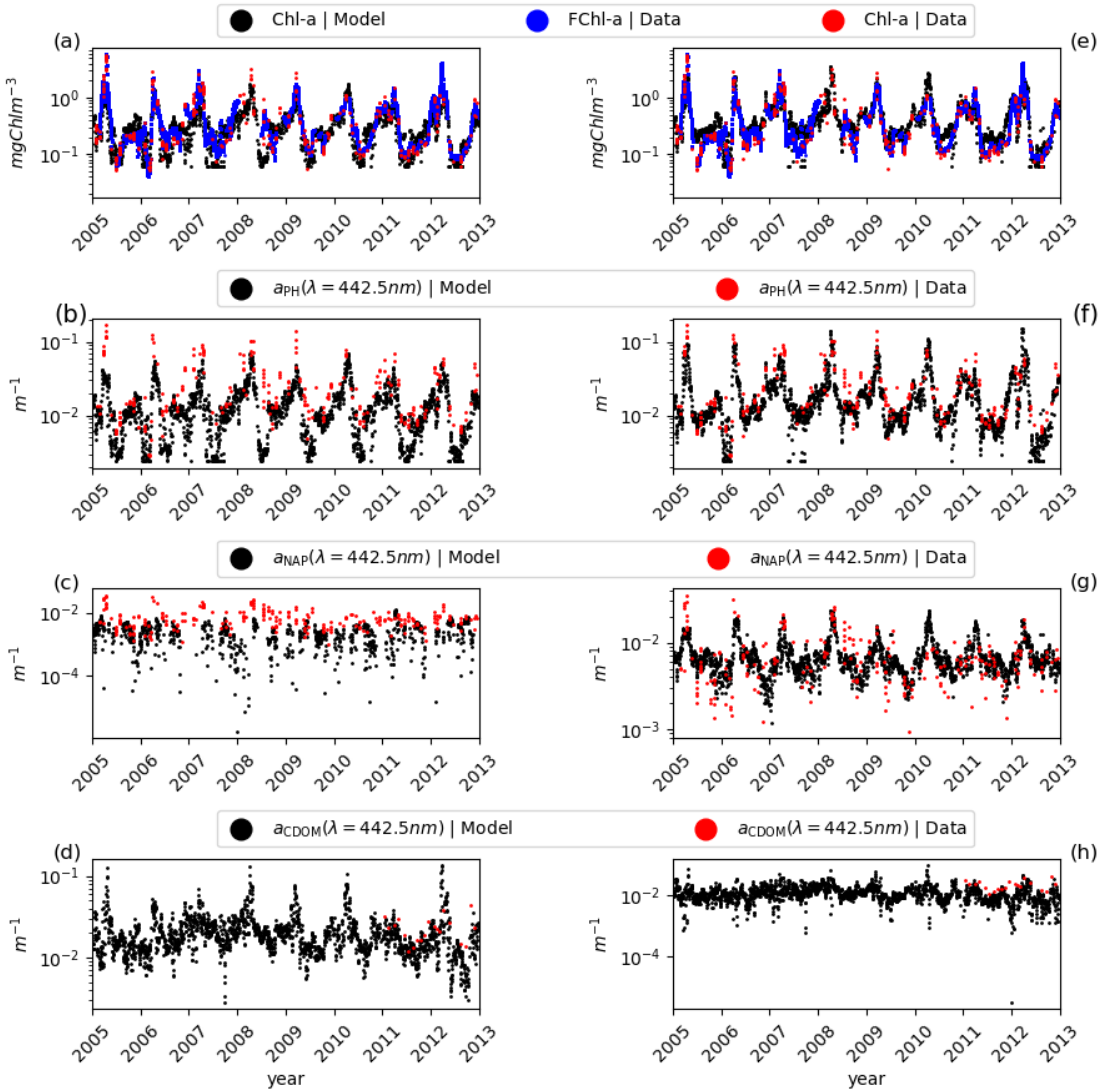


04 Inversion results

(Chla, a_{phy}, a_{NAP}, a_{CDOM} from 2005 to 2012)

REF model configuration

Chl-a best skill metrics EXP configuration



Summer [stratification] (May-Jun-Jul-Aug)

Autumn [oligotrophic condition] (Sep-Oct)

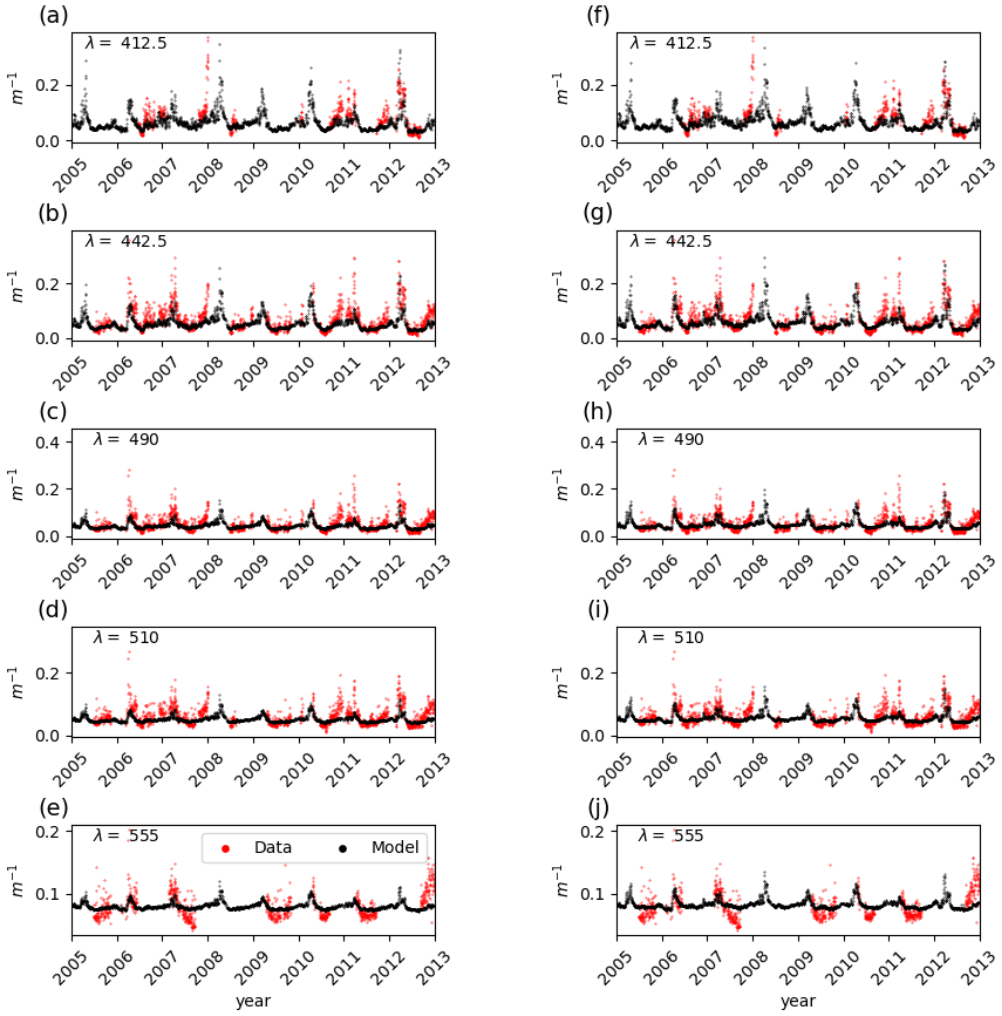
Winter [vertical mixing] (Nov-Dec-Jan)

Spring [spring bloom] (Feb-Mar-Apr)

04 Inversion results
(K_d (λ) from 2005 to 2012)

REF model configuration

Chl-a best skill metrics EXP configuration

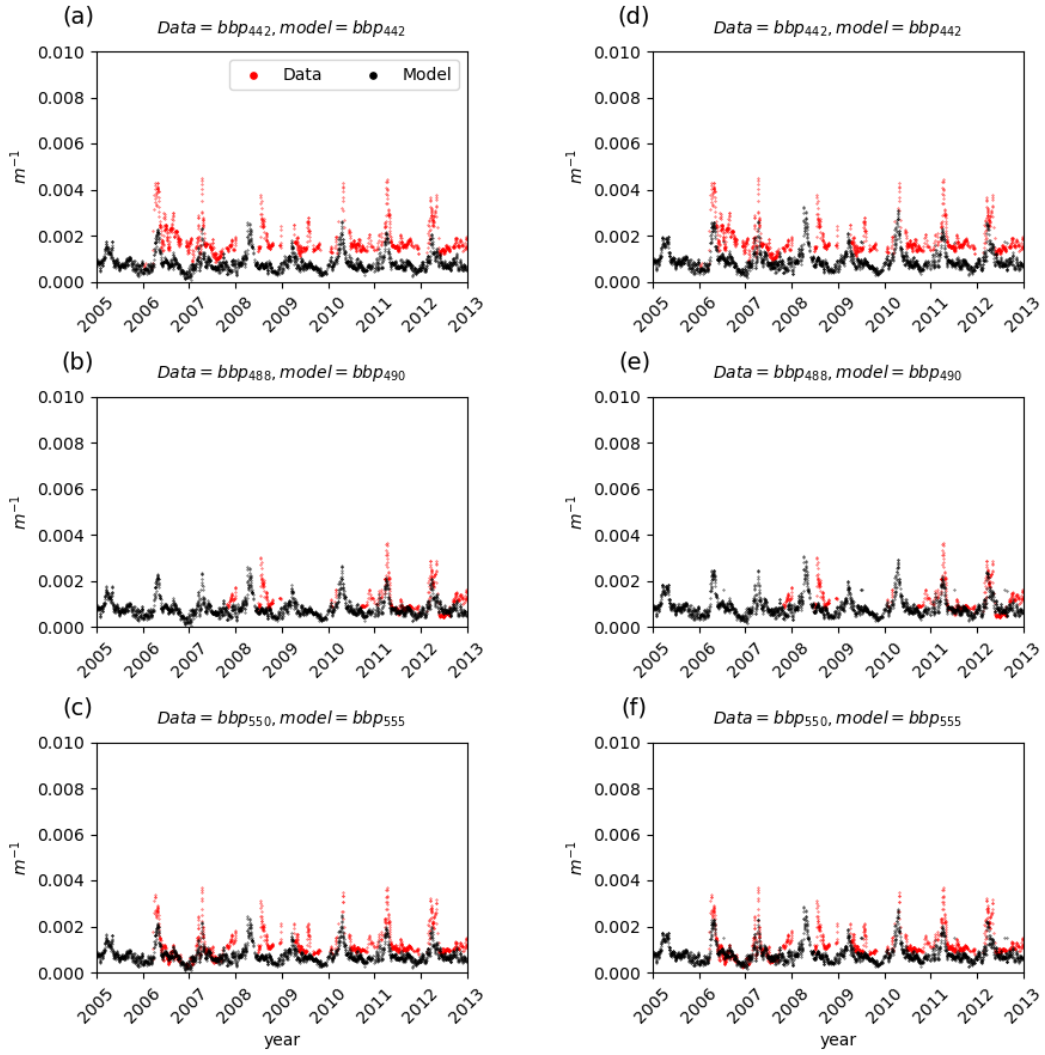


K_d at 412.5, 442.5, 490, 510 and 555 nm at daily frequency

04 Inversion results
($b_{bp}(\lambda)$ from 2005 to 2012)

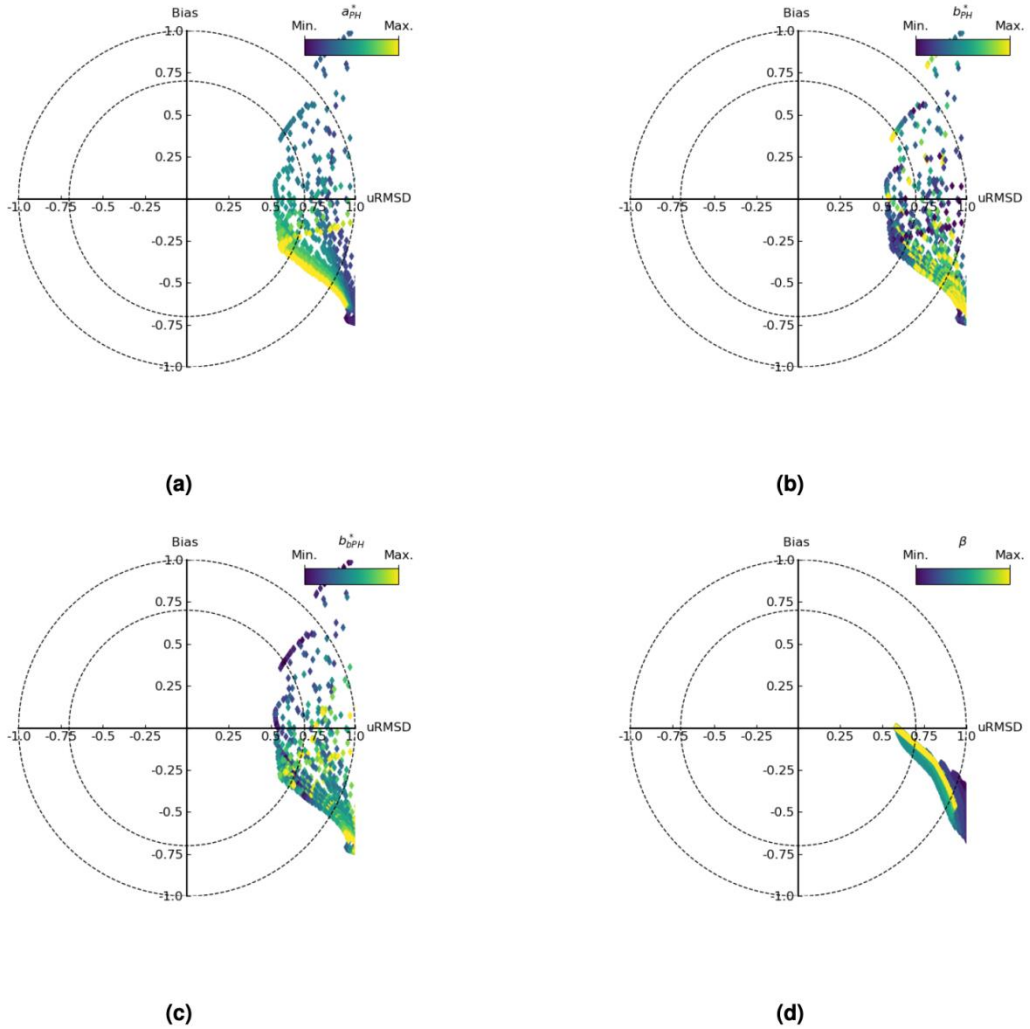
REF model configuration

Chl-a best skill metrics EXP configuration



$b_{bp}(442)$, $b_{bp}(490)$ and $b_{bp}(555)$ at daily frequency

04 Inversion results



Panel (a), (b), and (c) skill metrics for Chl-a EXP1 (Perturbation of $a^*_{PH}(\lambda)$, $b^*_{PH}(\lambda)$ and $b^*_{bPH}(\lambda)$). Panel (d) skill metrics for Chla EXP2 (Perturbation of β: one of parameters that modulates Chl-a to carbon ratio (θCHL) as a function of PAR).

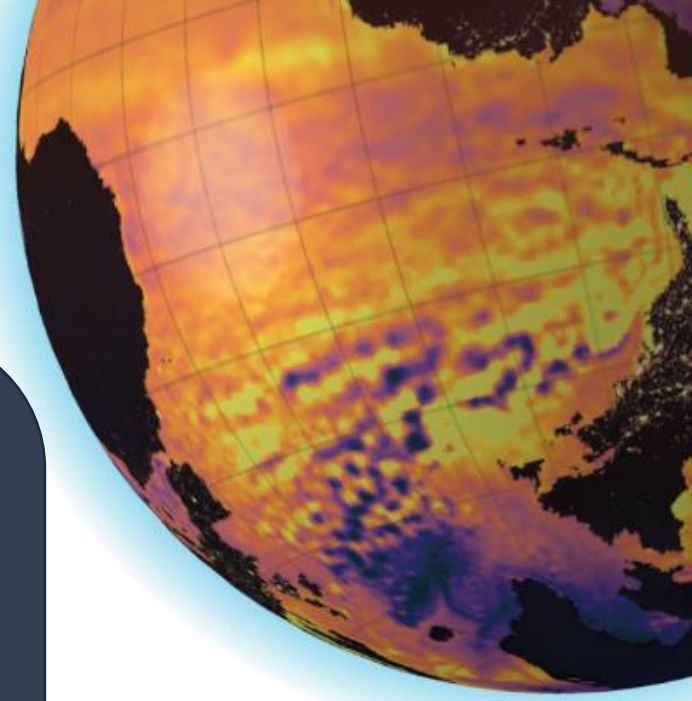
05 Main conclusions

R_{rs} QC procedure

- ✓ The procedure proposed is well suited to reduce noise in themodel output while preserving the temporal and spectral variability of the observational data
- ✓ The application with 3D operational systems, as used in CMEMS, may require development of quality control procedures to handle the Rrs data for the assimilation procedure

Inversion approach

- ✓ The IOPs analysed, such as phytoplankton absorption and particulate backscattering coefficients, proved to be important elements influencing model skill.
- ✓ Physiological processes such as phytoplankton photo-acclimation, which affect absorption and backscattering, are key elements to consider.



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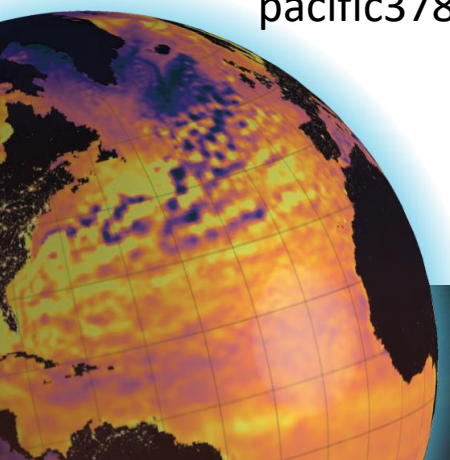

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ADVANCING OCEAN PREDICTION
SCIENCE FOR SOCIETAL BENEFITS

Thank you!

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