MERIS alternative atmospheric correction and bio-optical inversion for coastal waters

Constant Mazeran[1], Marcel Babin[2], Nicolas Lamquin[1], Stéphane Maritorena[3]

(1) ACRI-ST,Sophia Antipolis, France
(2) Université Laval, Canada and LOV, CNRS & Univ. Pierre et Marie Curie (Paris VI), France
(3) Earth Research Institute, University of California, Santa Barbara, USA

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Content

This presentation simply takes opportunity of the CoastColour framework to try contributing to some questions with already available methods

Questions on atmospheric correction :

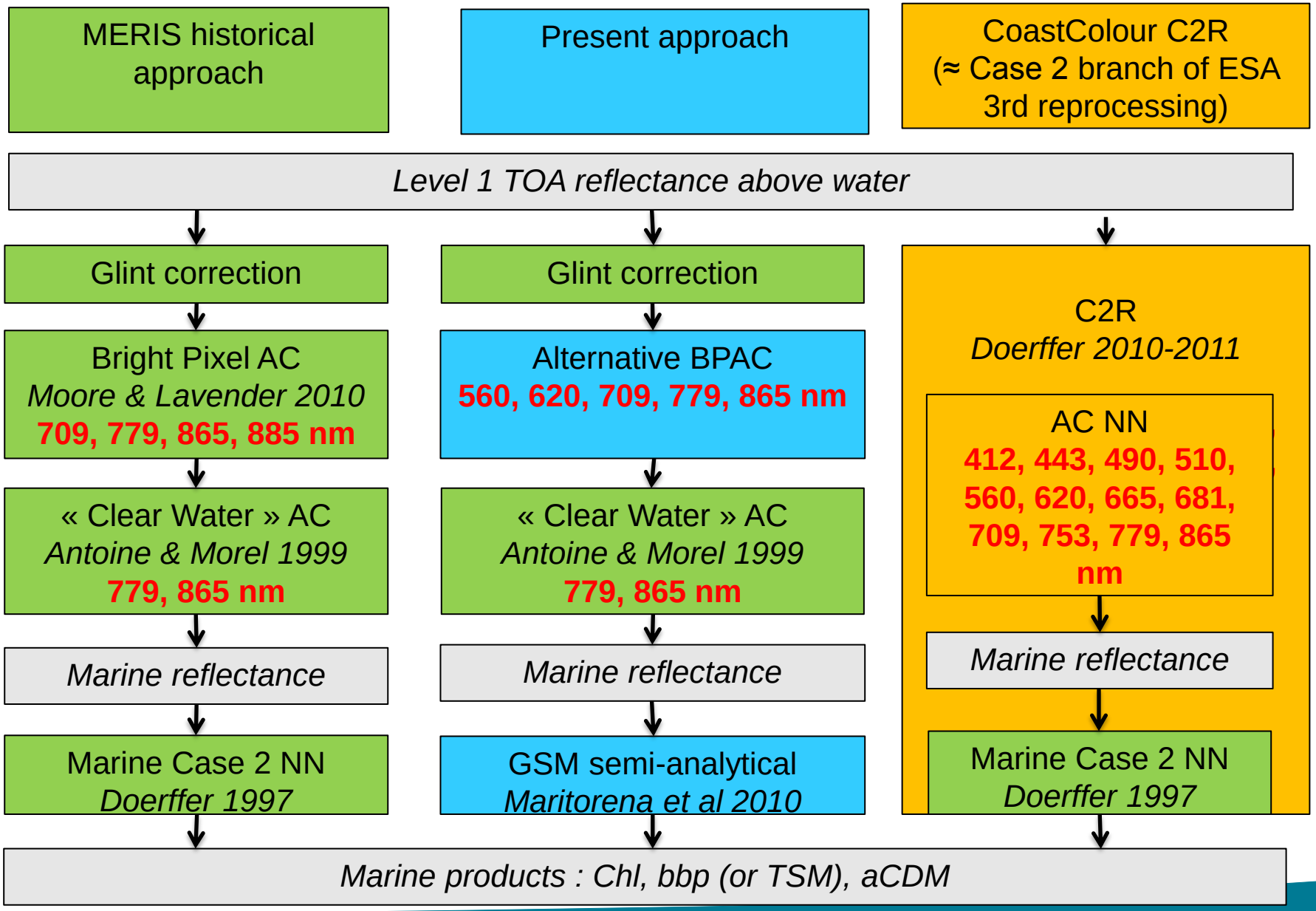
- How does an ocean-atmosphere inversion constrain the marine reflectance ?
- Is it worth working on a Bright Pixel Atmospheric Correction ?
- Quantitative validation ?

Questions on the marine signal inversion :

- How does the semi-analytical approach of GSM (Maritorena et al. 2002, Maritorena et al. 2010) compares to CC NN ?
- Playing with parametrization (number of bands, degrees of freedom…)
- What do we learn from the simulated Round Robin dataset ?
- What to be deduced from the residual of cost function ?

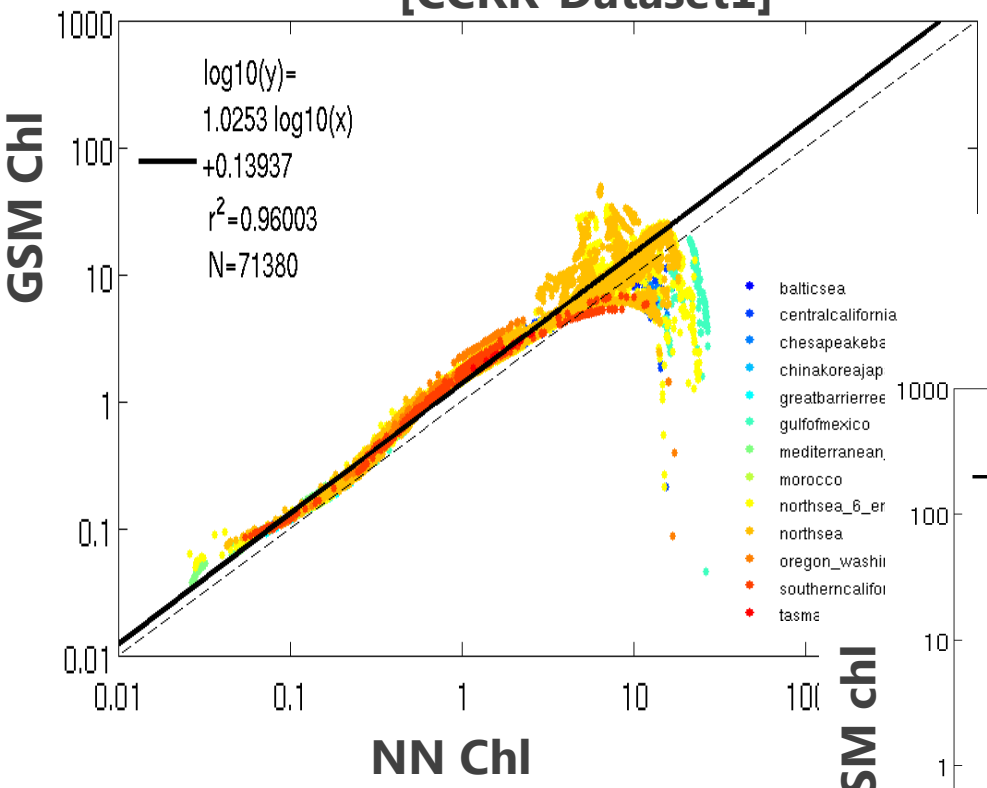
Atmospheric correction

Which bands can be considered in the AC ?

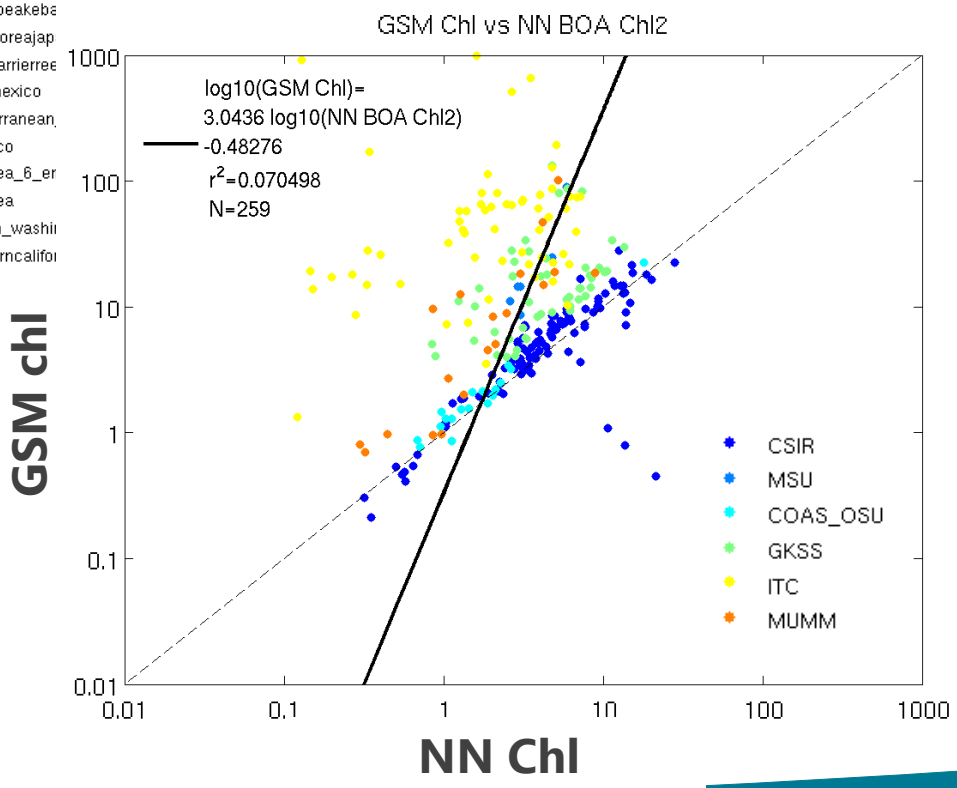


How does an ocean-atmosphere inversion constrain the marine reflectance ?

Inversion of C2R reflectance [CCRR-Dataset1]



Inversion of in situ reflectance [CCRR-Dataset2]



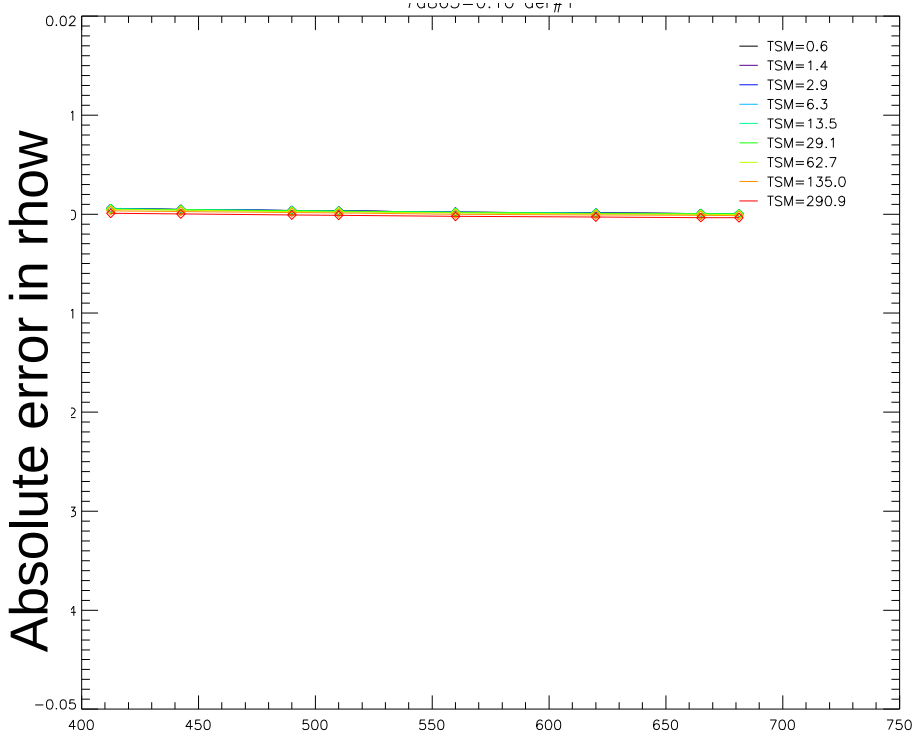
Acknowledgement to
J. Nahorniak (COAS), S. Bernard,
L. Robertson & M. Matthews (CSIR),
R. Doerrfer & W. Schoenfeld (HZG),
S. Salama (ITC), Z. Lee (MSU),
G. Neukermans & K. Ruddick (MUMM).

Why working on a NIR-precorrection (BPAC) ?

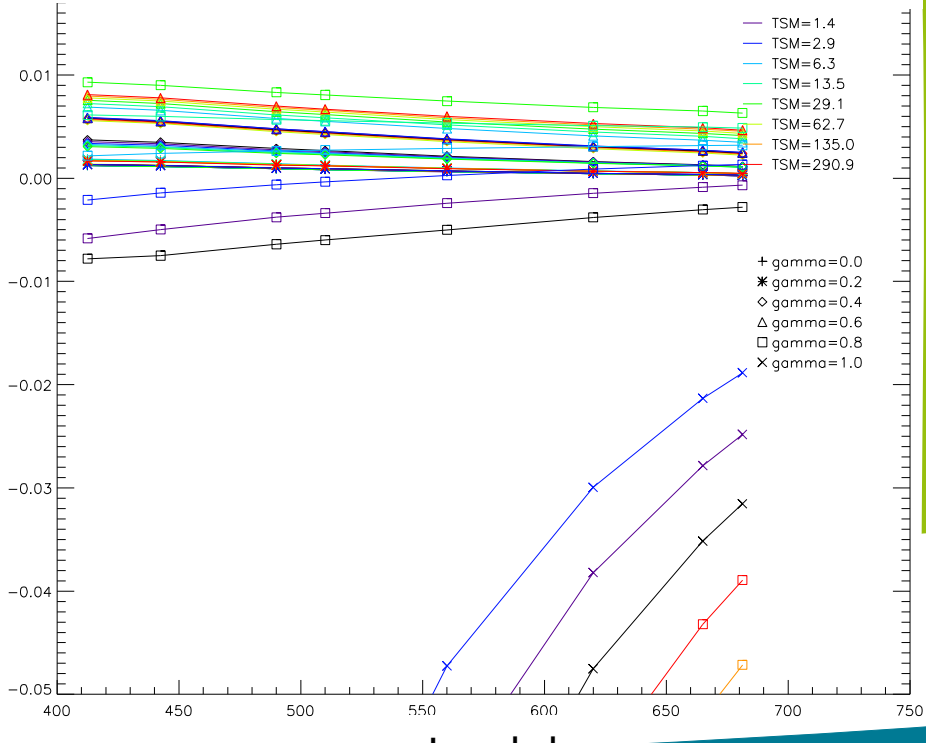
NIR-precorrection advantage: no assumption on a marine model in the VIS.
But final results remains tributary of the "Clear Water" AC.

Rhow in the VIS is highly sensitive on the marine BPAC modeling in the NIR
A lot of improvement can be hoped if we try improving the NIR modelling

Inversion when rhow(NIR) follows the BPAC model



Inversion when rhow(NIR) is more realistic



Principles of the alternative BPAC (CNES R&T project 2008, 2010)

Develop a more accurate marine reflectance model in the NIR thanks to *in situ* IOP and RT simulations. *In situ* : Coastlooc campaign (Babin *et al.* 2003)

Use some bands towards the visible: signal more difficult to model but higher in amplitude (« guardrail ») and closer to the region of interest: don't be tributary of NIR noise (straylight…). Forget 660 nm (e.g. Stumpf *et al.* 2003) where Chl absorption is high.

Band choice: 560, 620, 709, 779, 865 nm.

Inversion: compromise between robustness and accuracy. Four unknowns: magnitude and spectral shape of the aerosol signal and particulate scattering.

Take into account the model uncertainties at each bands. Choose an optimisation method on the spectral shape.

$$\chi(\rho_a^{865}, \epsilon, b_p^{560}, \gamma) = \sum_{\lambda} \omega(\lambda) \left(\frac{\overline{\rho_T}(\lambda)}{t(\lambda)} - \frac{\rho_R(\lambda) + \rho_a(\lambda, \rho_a^{865}, \epsilon)}{t(\lambda)} - \mathcal{H}(b_p^{560}, \gamma, \lambda,) \right)^2$$

~ model uncertainties

atm. model

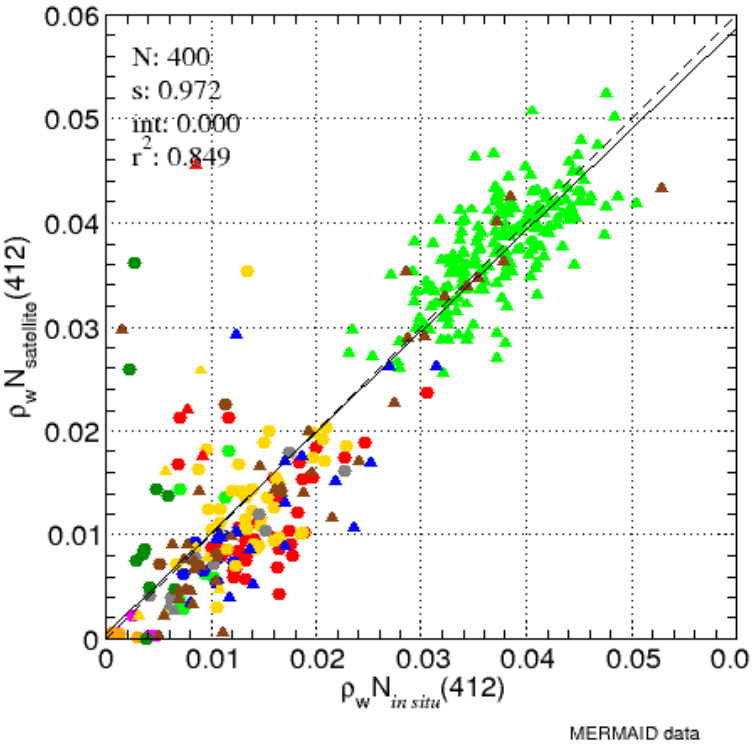
Marine model

Quantitative validation against in situ reflectance

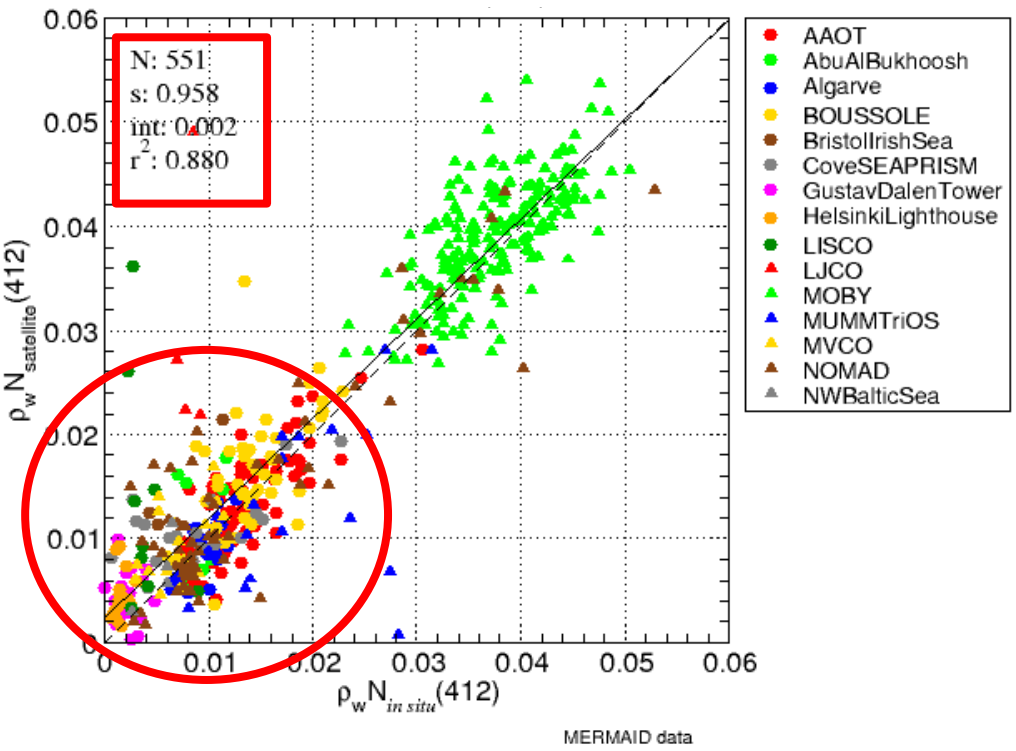
In situ spectra and matchups taken from MERMAID (http://hermes.acri.fr/mermaid)

MERIS nominal

412 nm



Alternative BPAC – keeping standard MERIS AC



Acknowledgement to G. Zibordi (AAOT, Abu Al Bukhoosh, GustavDalenTower, HelsinkiLighthouse), J. Icely (Algarve), D. Antoine (BOUSSOLE), D. McKee (BristolIrishSea), G . Schuster & B. Holben (CoveSEAPRISM), S. Ahmed & A. Gilerson (LISCO), V. Brando (LJCO), K. Voss (MOBY), K. Ruddick (MUMMTriOS), H. Feng & H. Sosik (MVCO), J. Werdell & NOMAD's PIs, S. Kratzer (NWBalticSea) for the in situ radiometric measurements and to ESA, ACRI and ARGANS for MERMAID

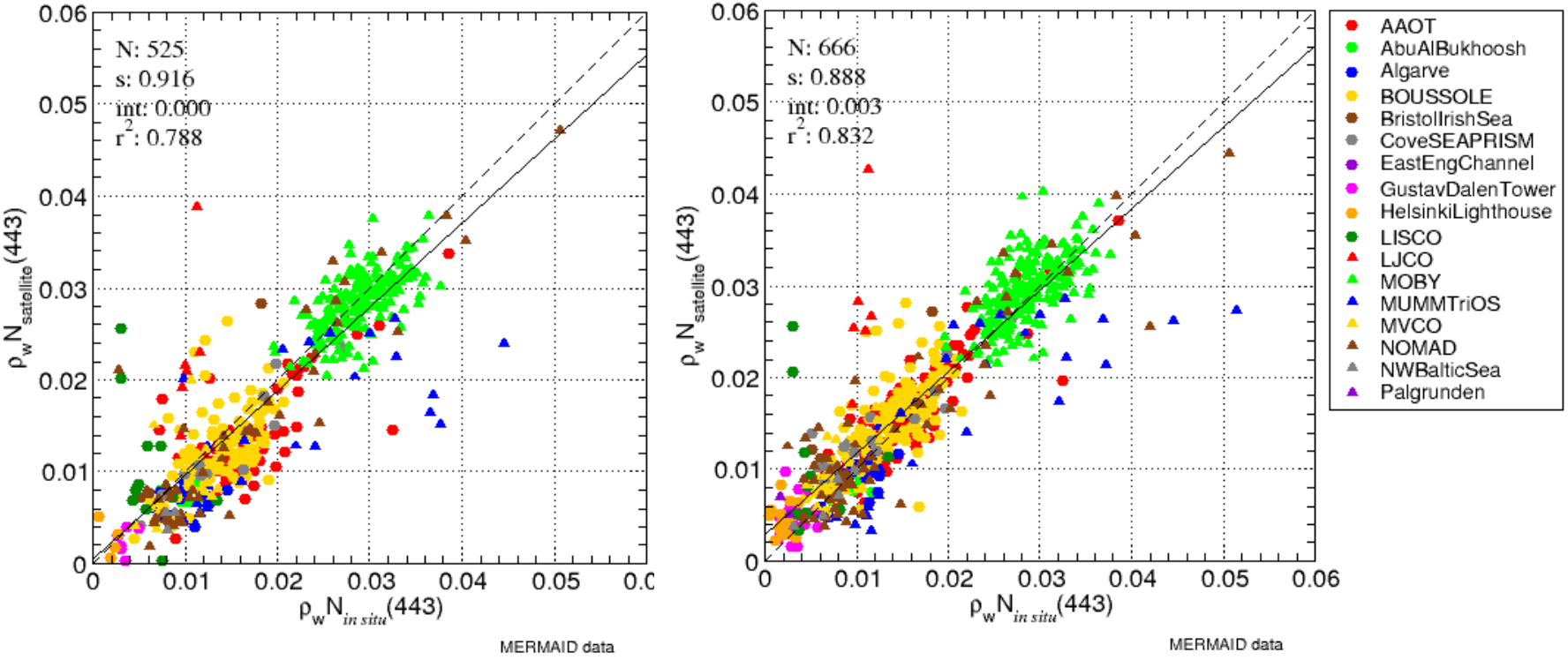
Quantitative validation against in situ reflectance

In situ spectra and matchups taken from MERMAID (http://hermes.acri.fr/mermaid)

MERIS nominal

443 nm

Alternative BPAC – keeping standard MERIS AC



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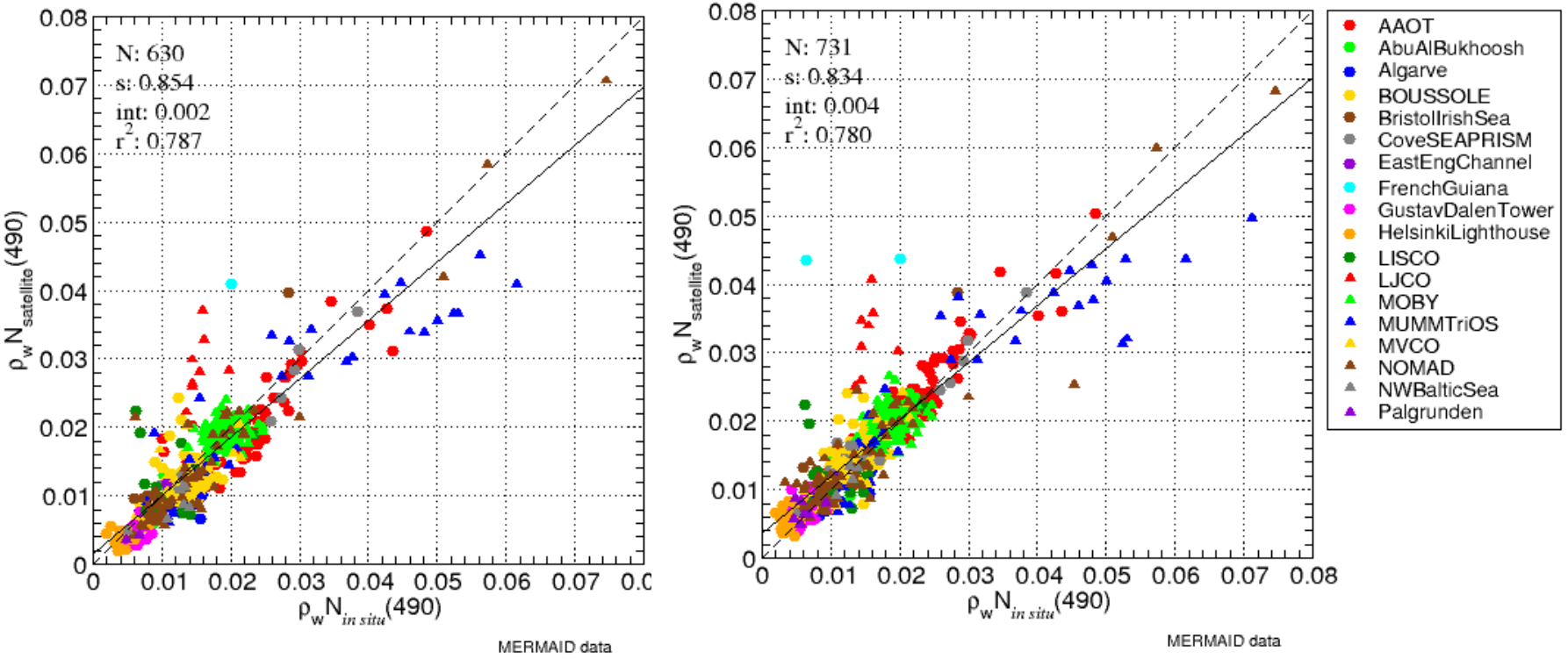
Quantitative validation against in situ reflectance

In situ spectra and matchups taken from MERMAID (http://hermes.acri.fr/mermaid)

MERIS nominal

490 nm

Alternative BPAC – keeping standard MERIS AC



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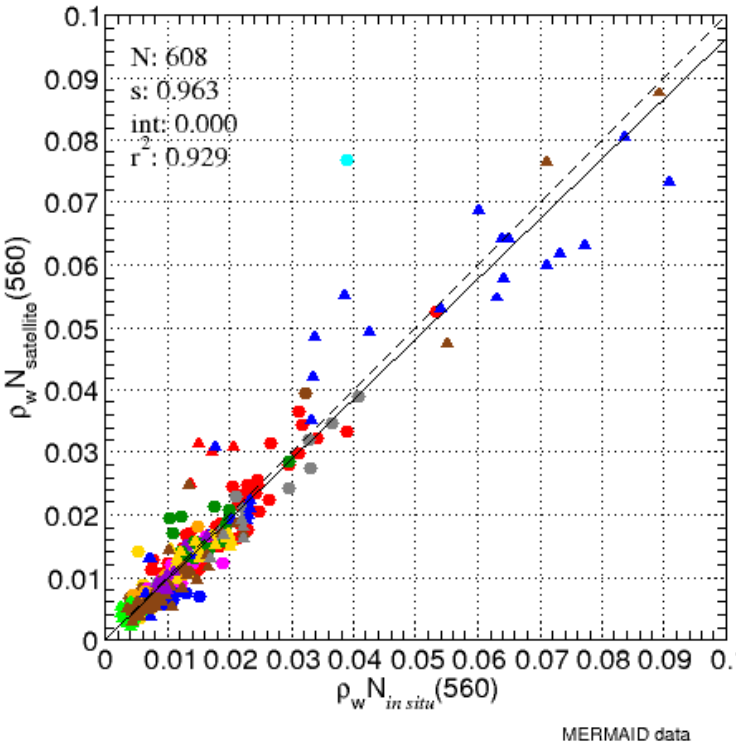
Quantitative validation against in situ reflectance

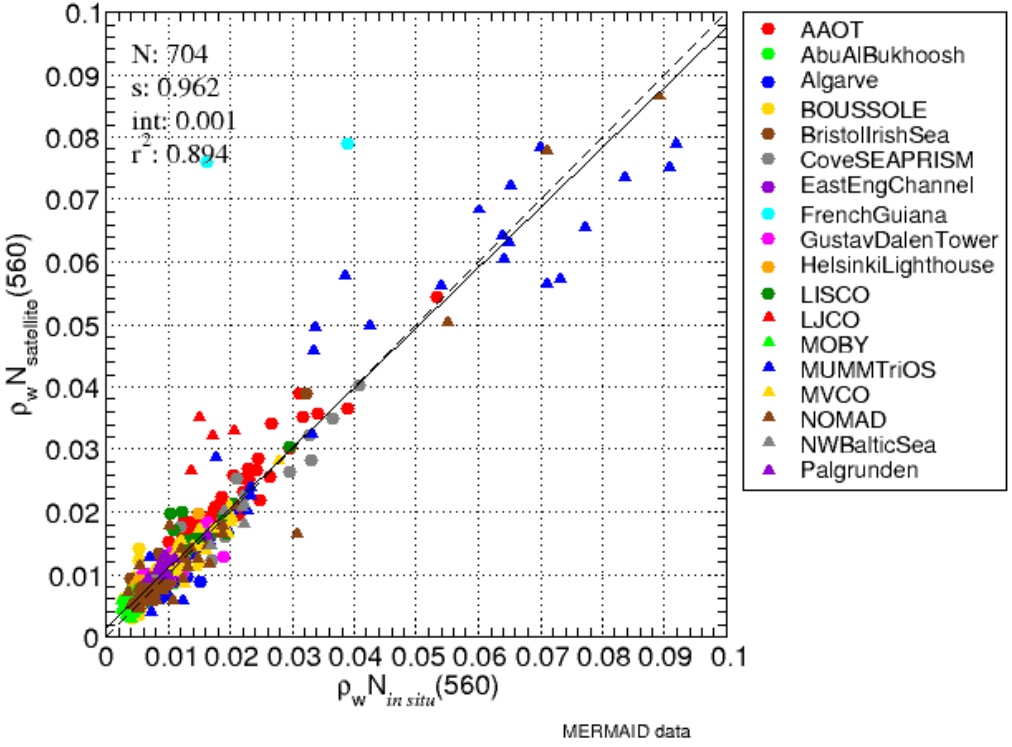
In situ spectra and matchups taken from MERMAID (http://hermes.acri.fr/mermaid)

MERIS nominal

560 nm



Alternative BPAC – keeping standard MERIS AC



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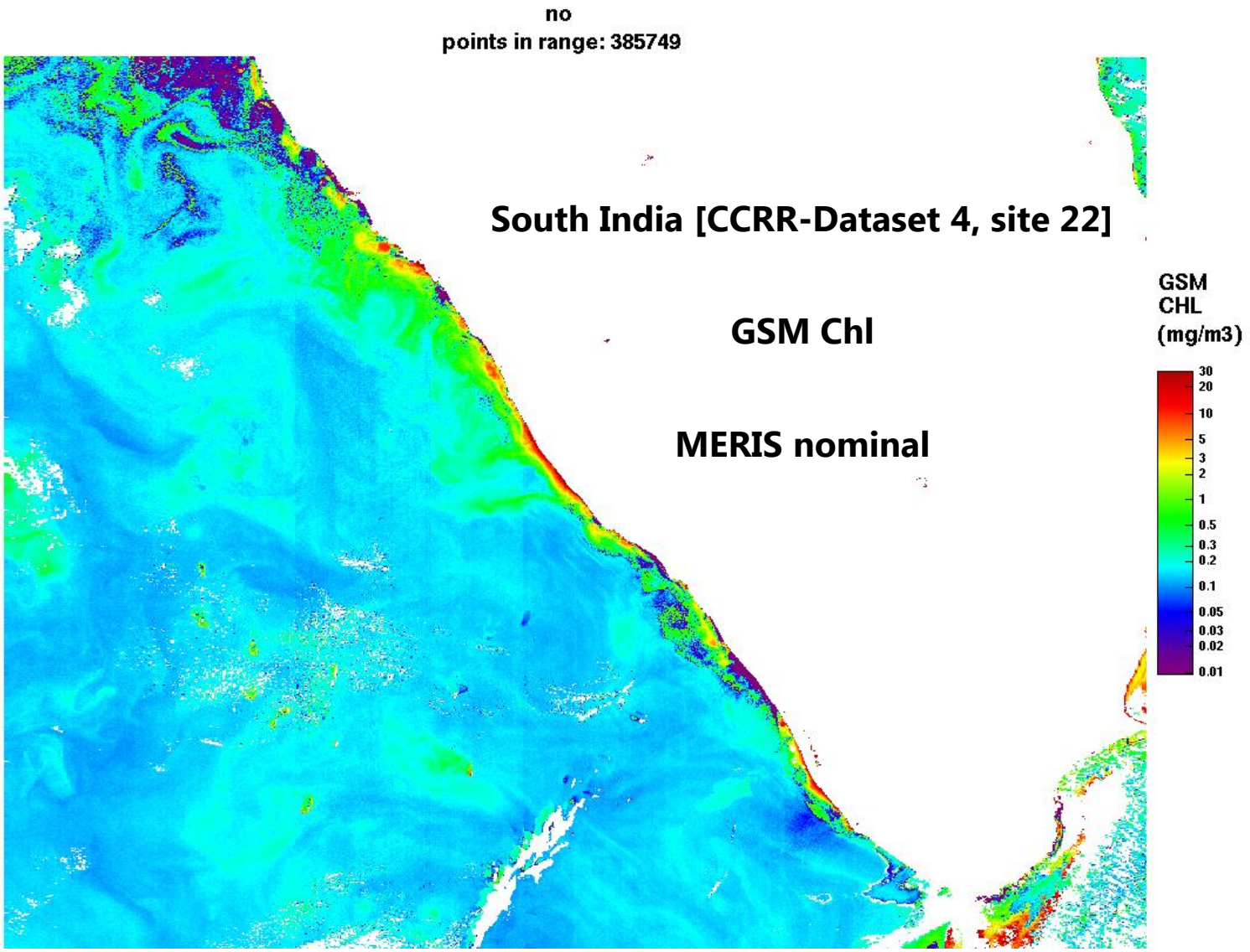
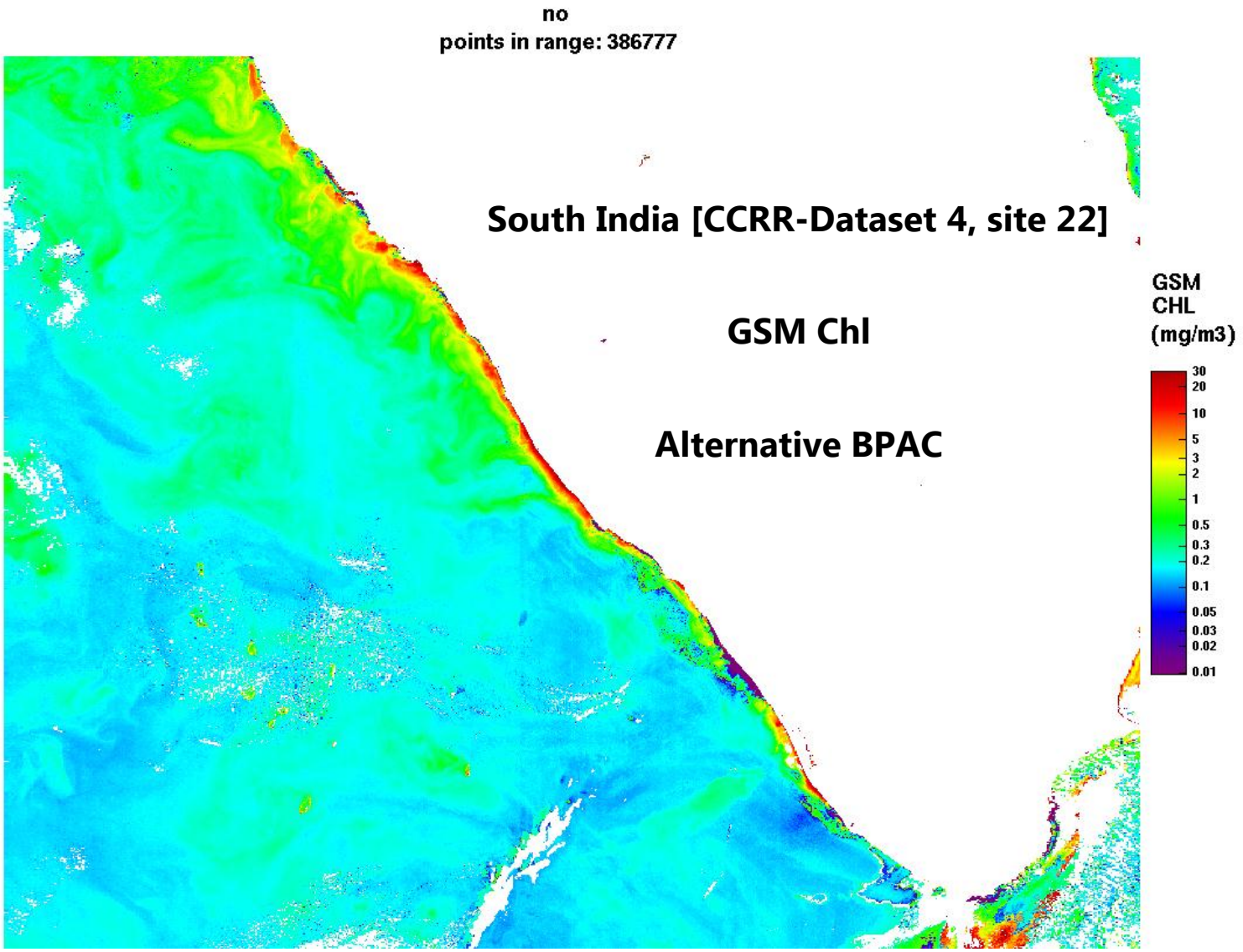
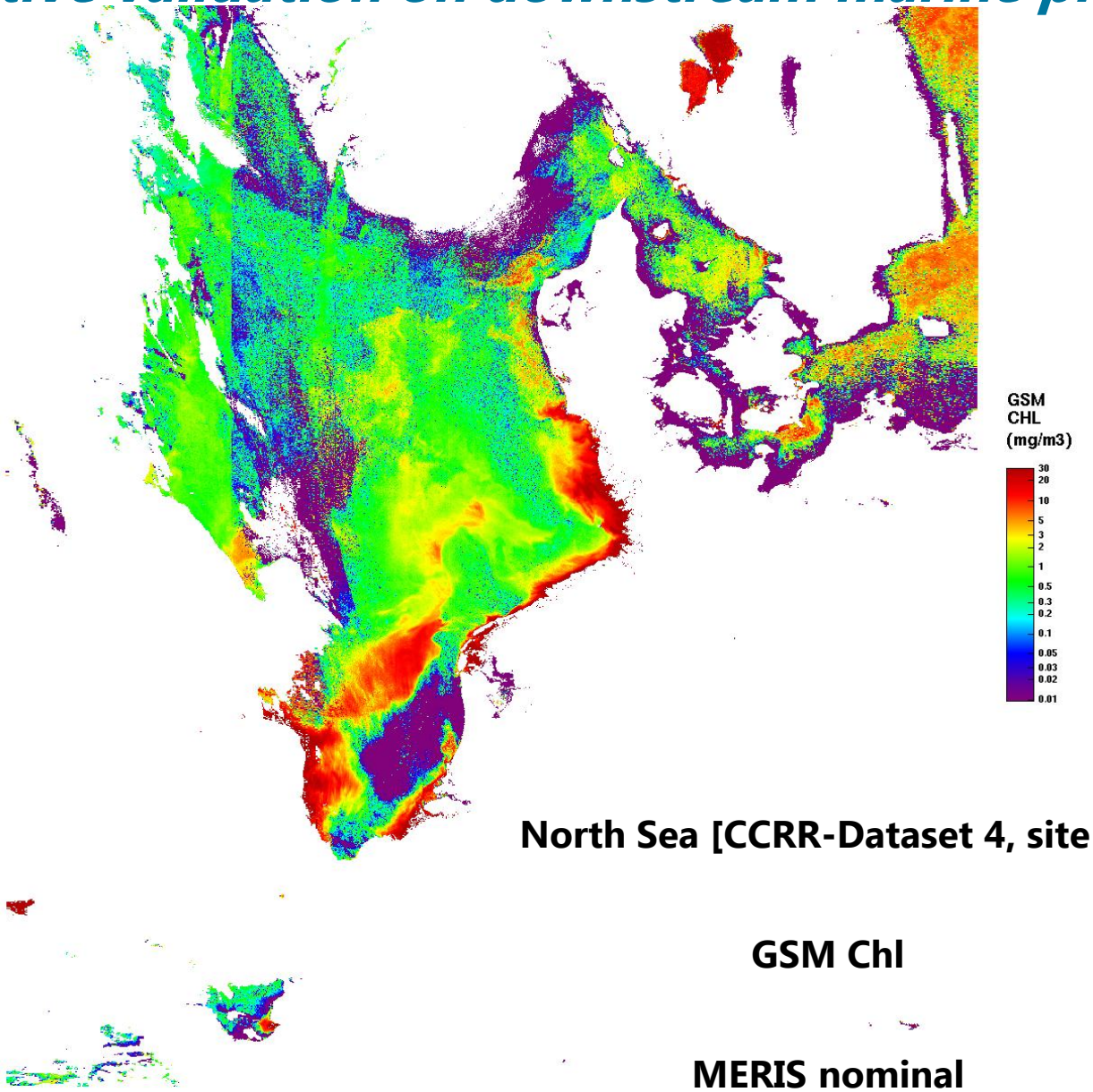
Qualitative validation on downstream marine products



Qualitative validation on downstream marine products



Qualitative validation on downstream marine products

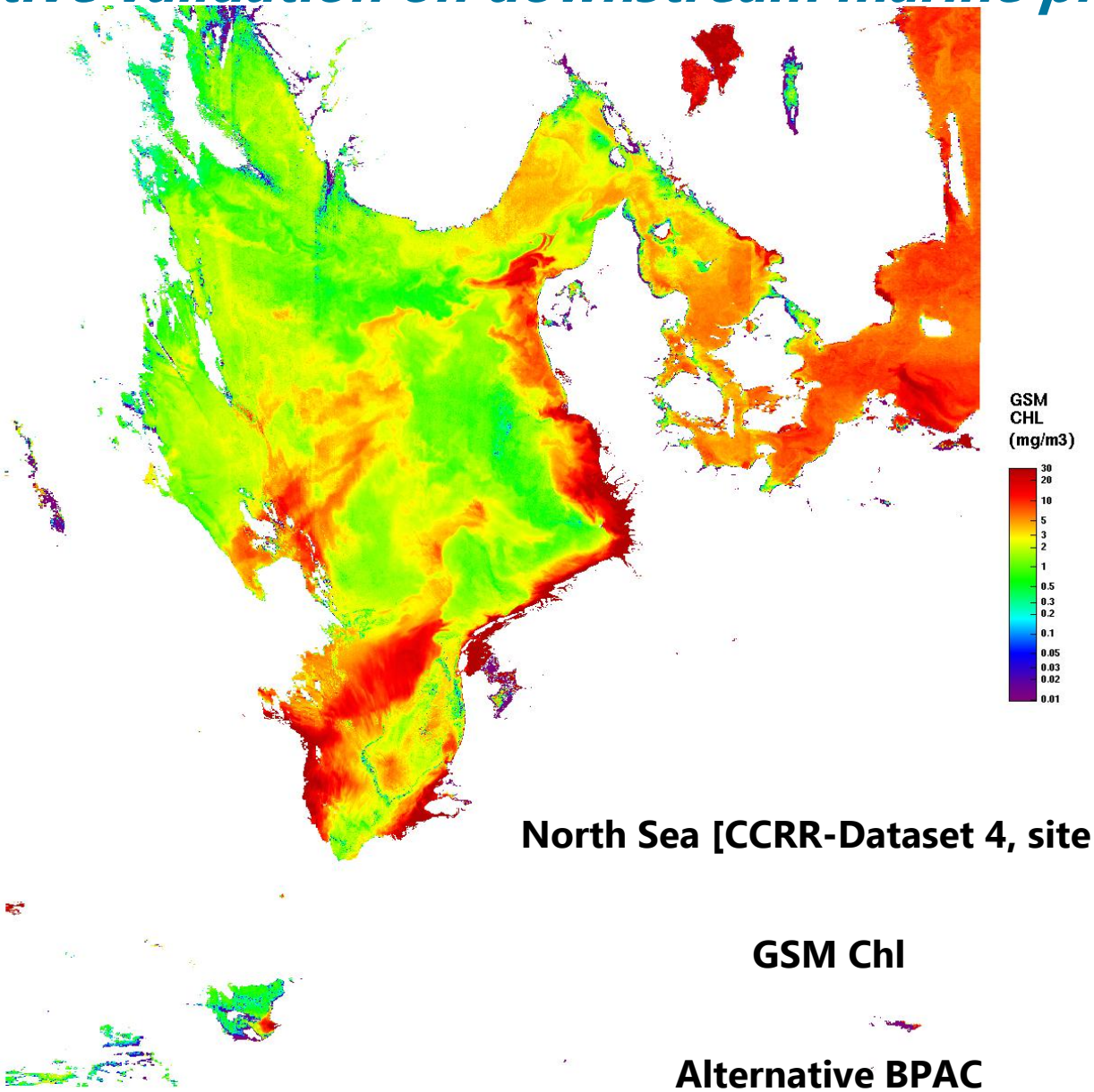


North Sea [CCRR-Dataset 4, site 1]

GSM Chl

MERIS nominal

Qualitative validation on downstream marine products

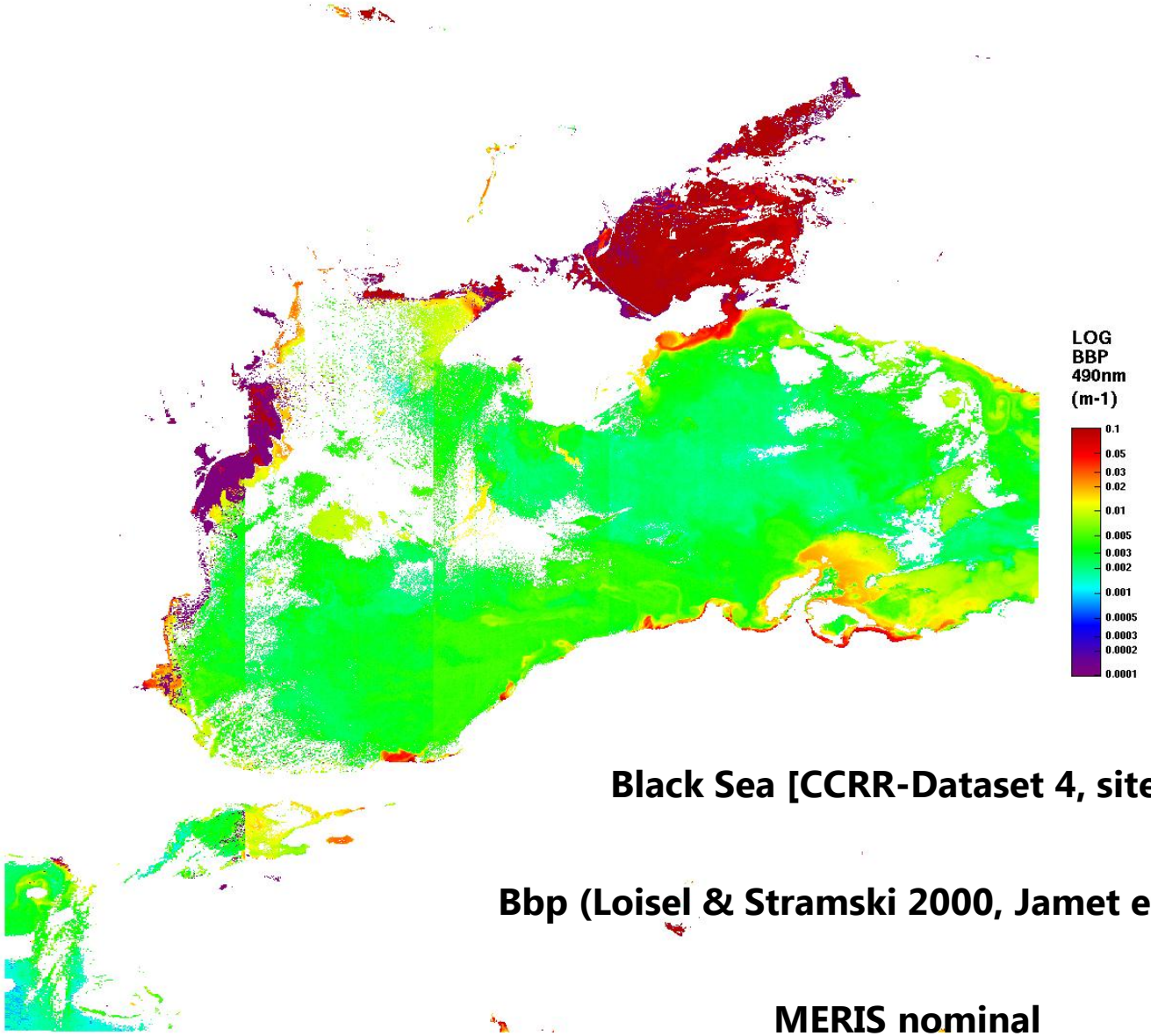


North Sea [CCRR-Dataset 4, site 1]

GSM Chl

Alternative BPAC

Qualitative validation on downstream marine products

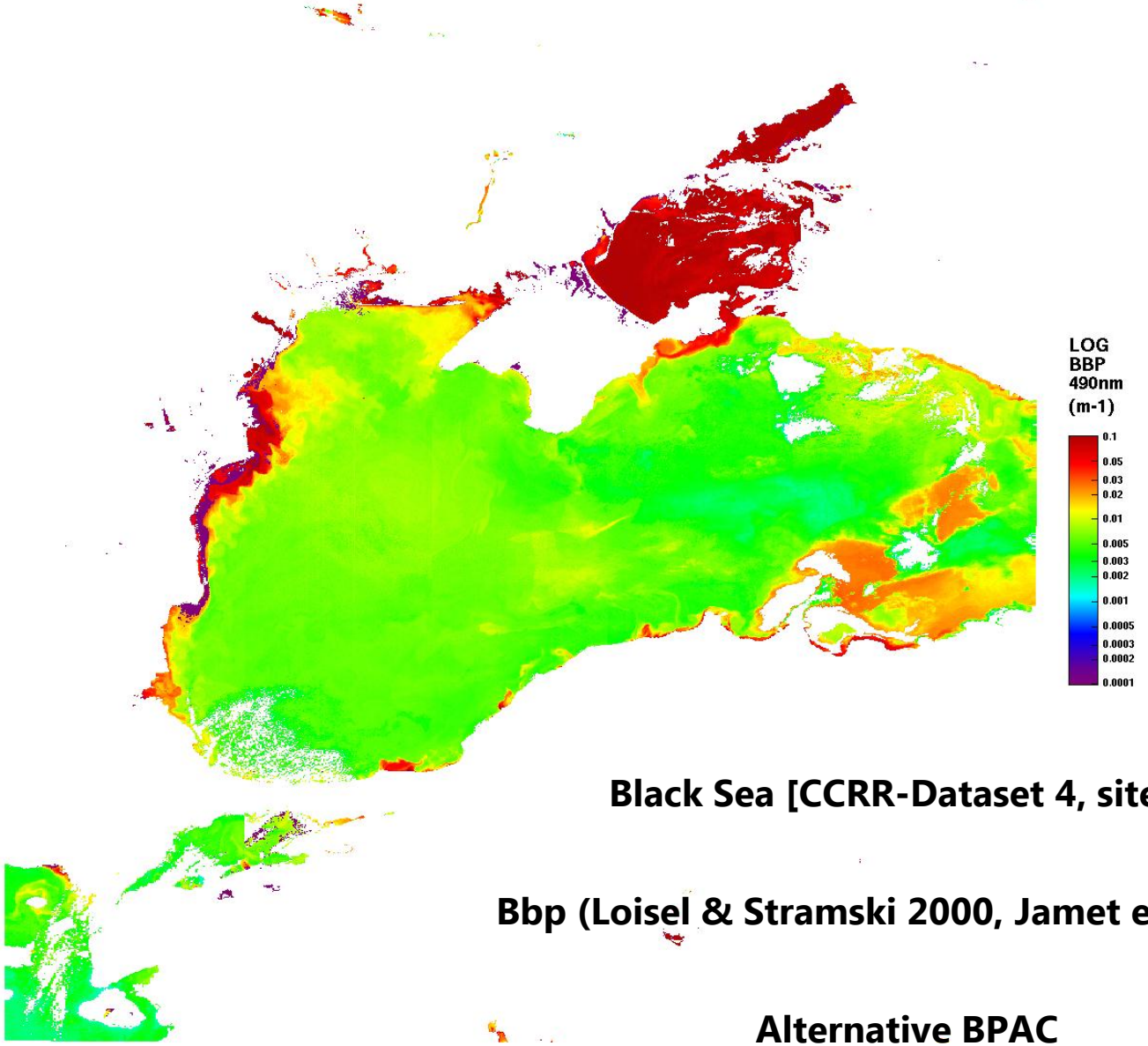


Black Sea [CCRR-Dataset 4, site 3]

Bbp (Loisel & Stramski 2000, Jamet et al 2010)

MERIS nominal

Qualitative validation on downstream marine products

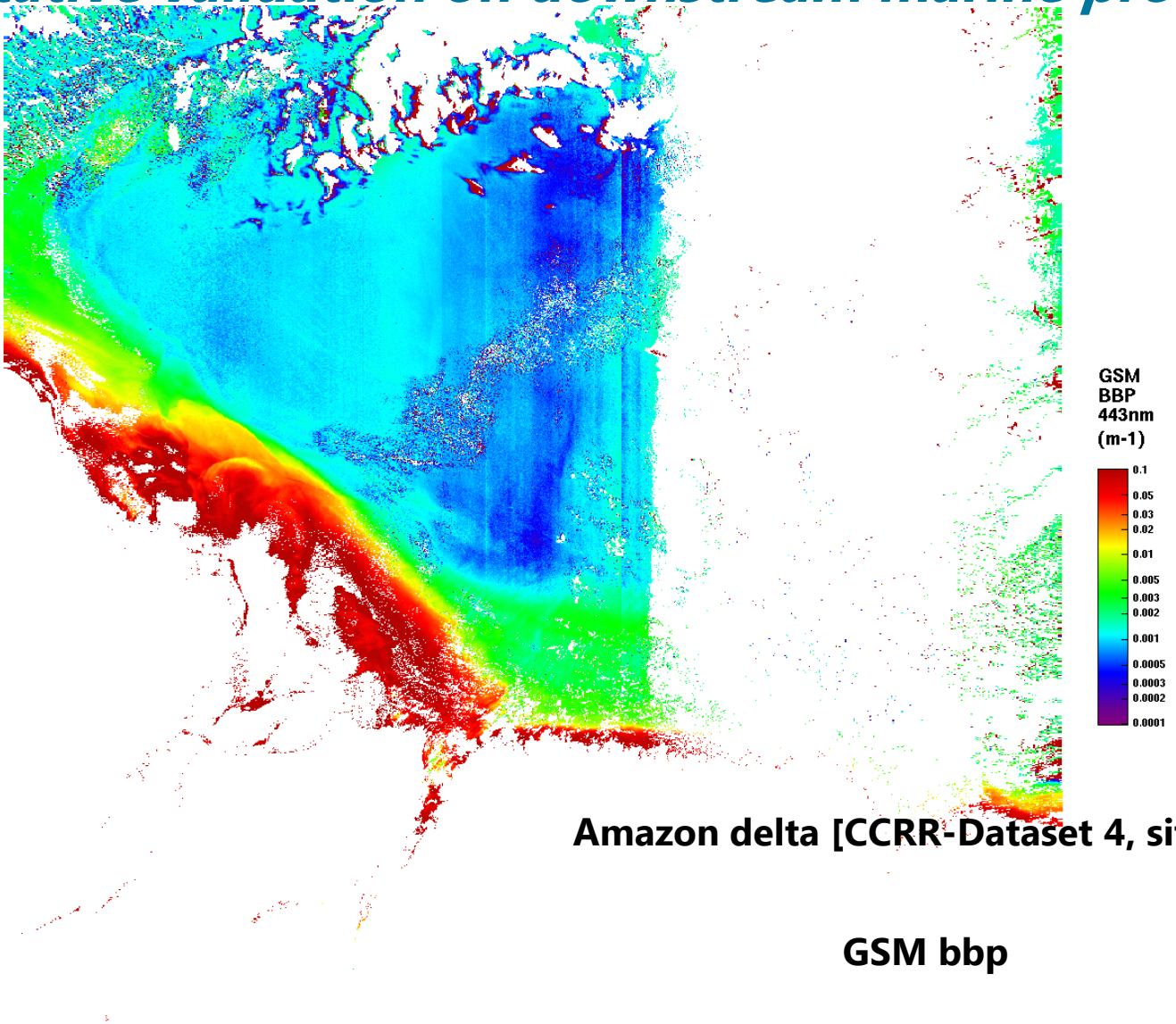


Black Sea [CCRR-Dataset 4, site 3]

Bbp (Loisel & Stramski 2000, Jamet et al 2010)

Alternative BPAC

Qualitative validation on downstream marine products

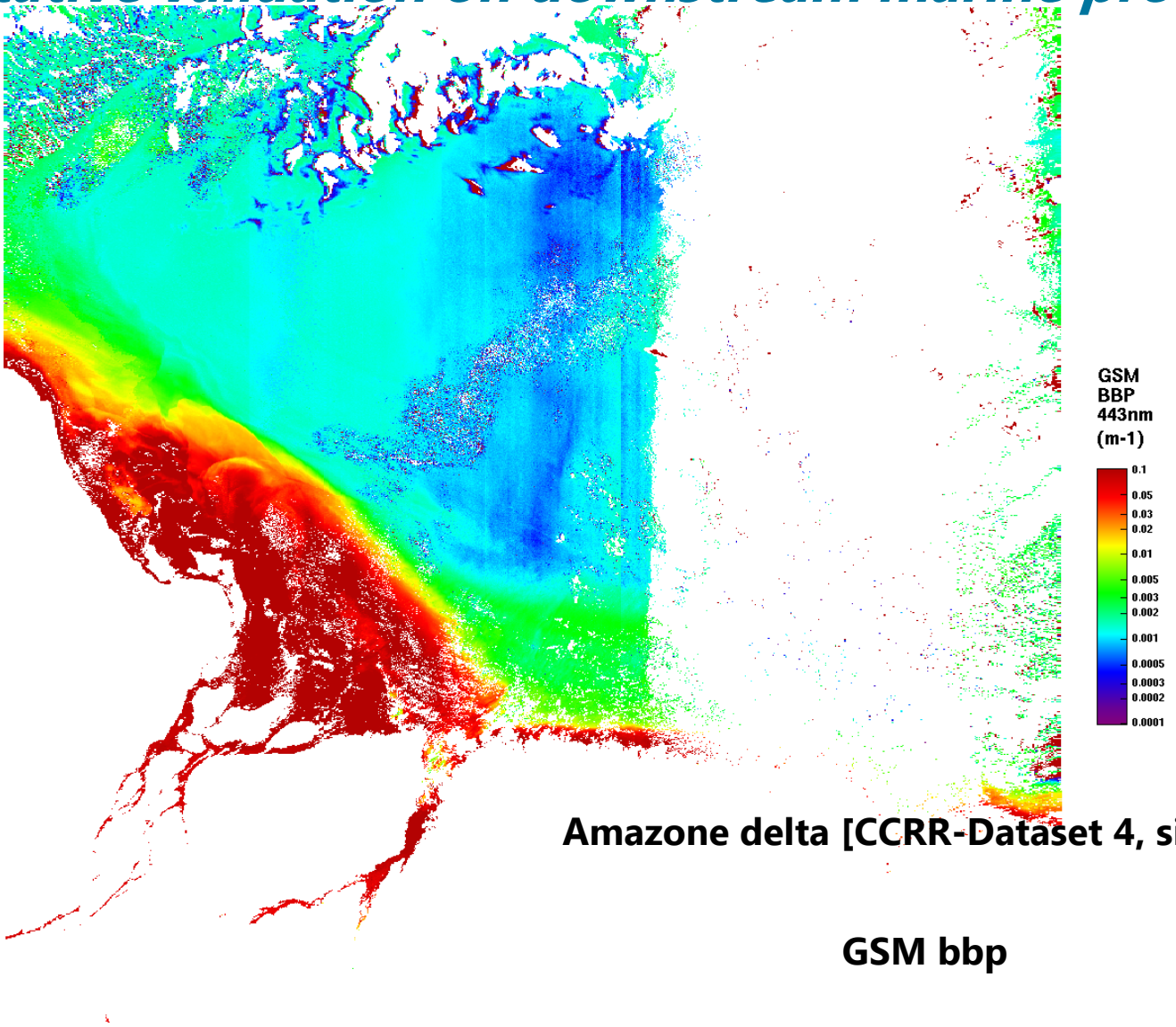


Amazon delta [CCRR-Dataset 4, site 21]

GSM bbp

MERIS nominal

Qualitative validation on downstream marine products



Amazone delta [CCRR-Dataset 4, site 21]

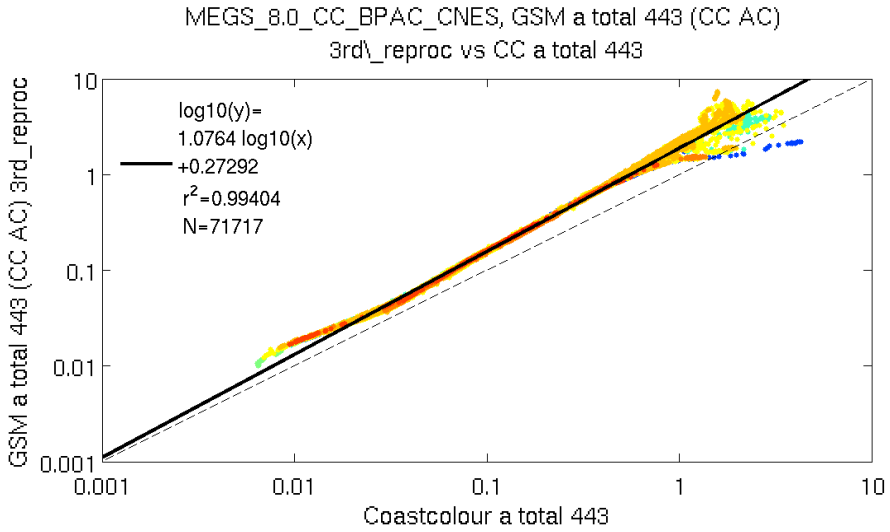
GSM bbp

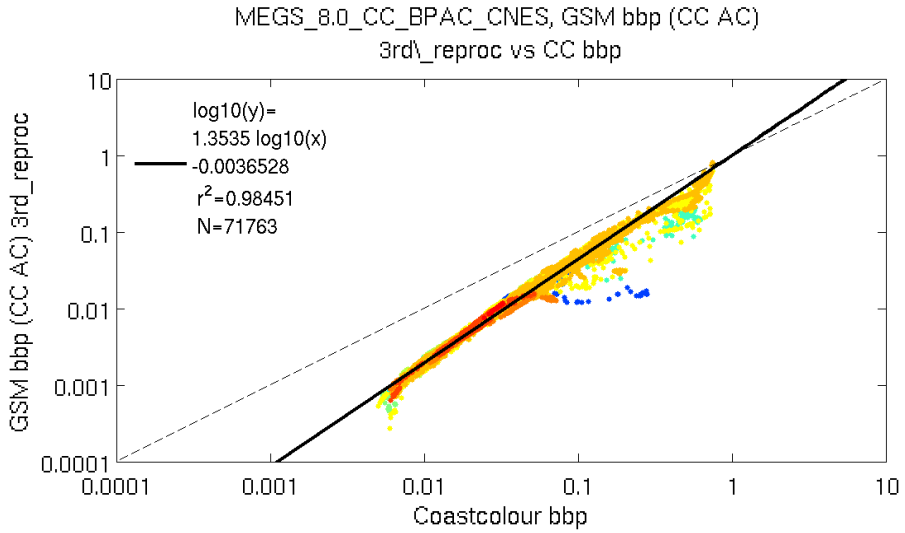
Alternative BPAC

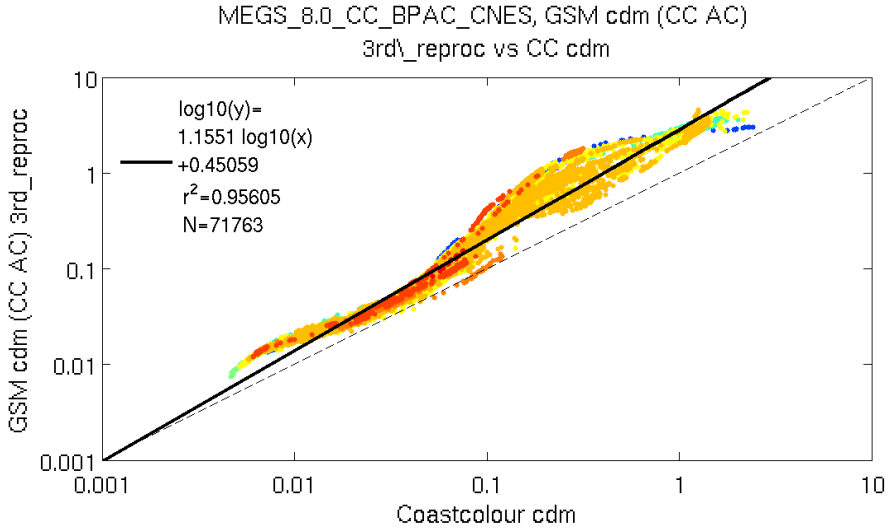
Marine inversion

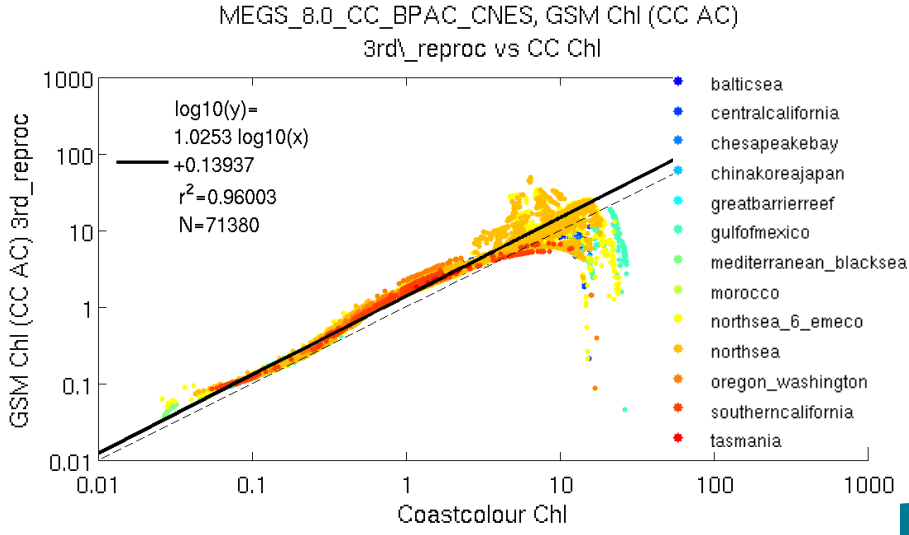
How does the semi-analytical approach of GSM compare to Case2 NN ?

Both very correlated when starting from the CC NN



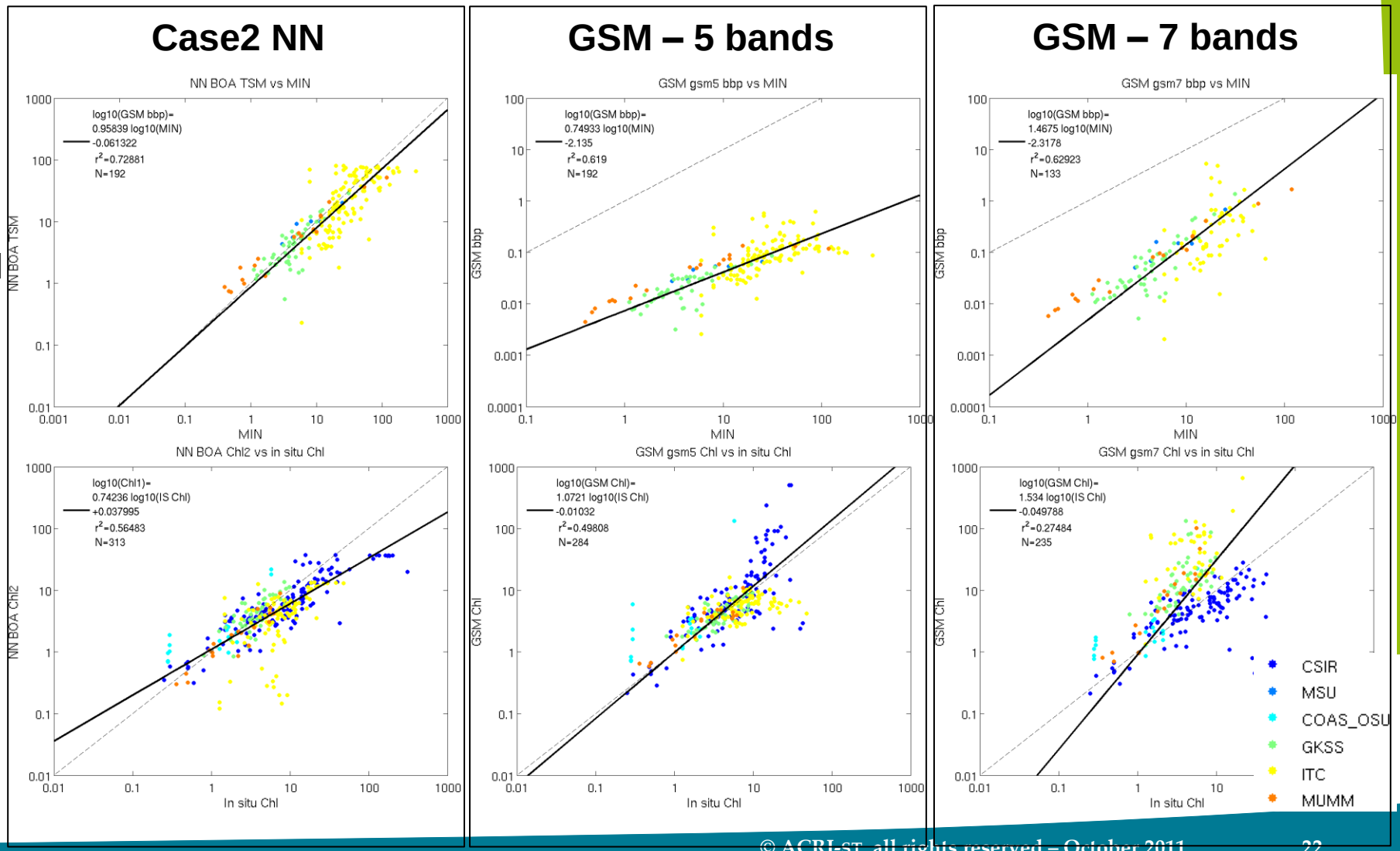






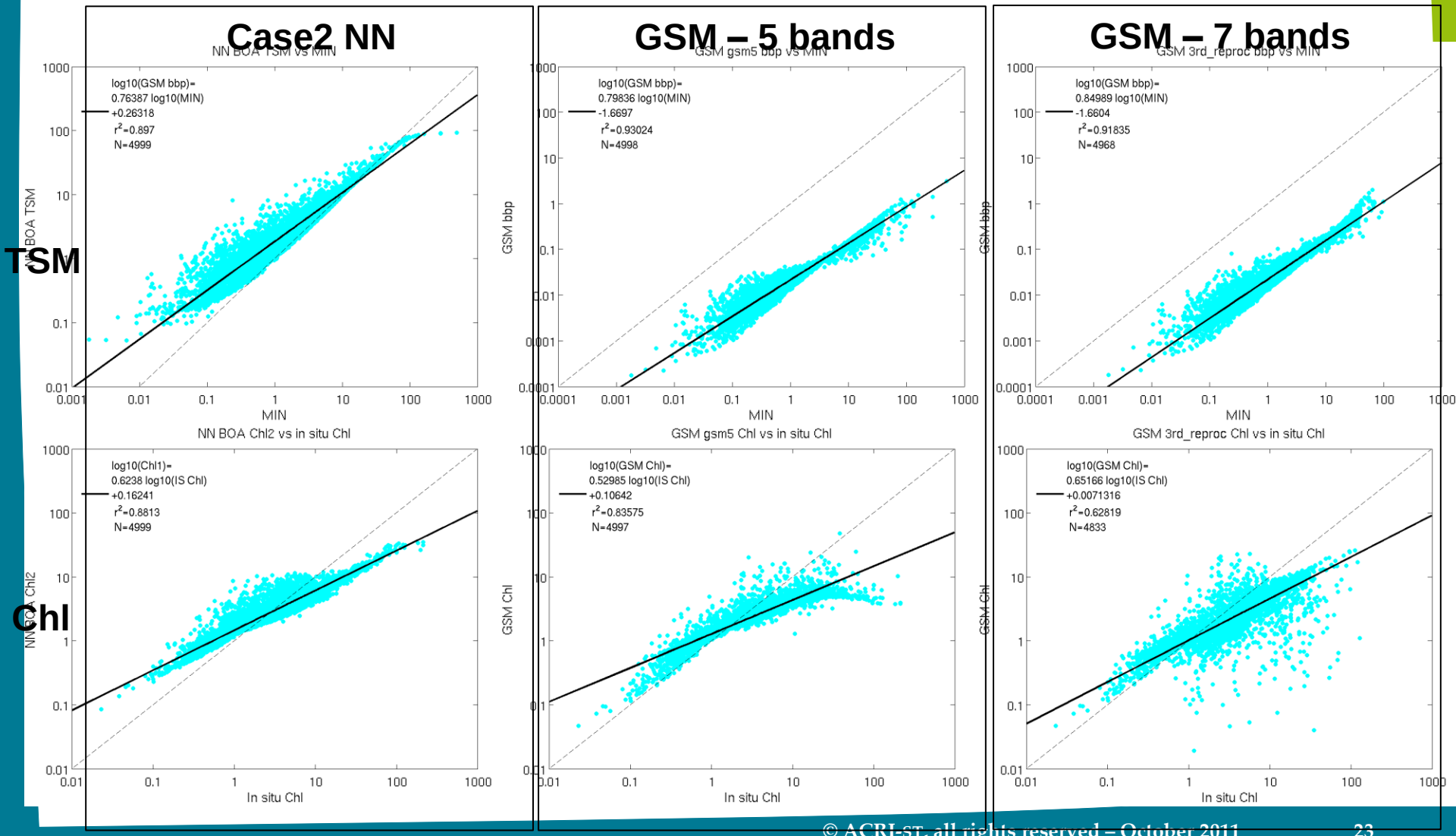
How does the semi-analytical approach of GSM compare to Case2 NN ?

Validation on TSM and Chl by inversing in situ spectra [CCRR-Dataset2]



What to be learnt from simulated datasets?

Validation on TSM and Chl by inversing simulated spectra [CCRR-Dataset3]



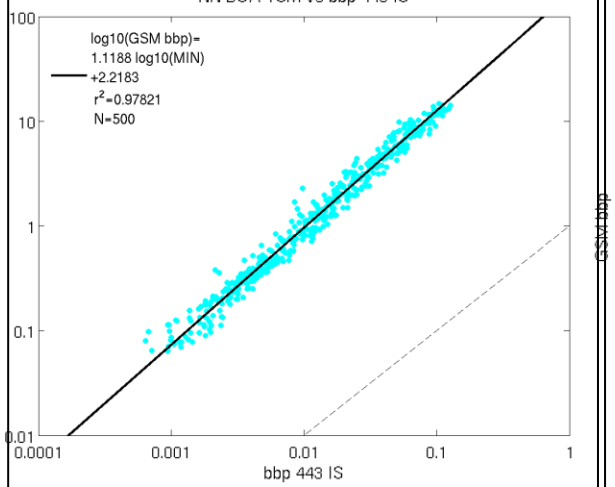
What to be learnt from simulated datasets?

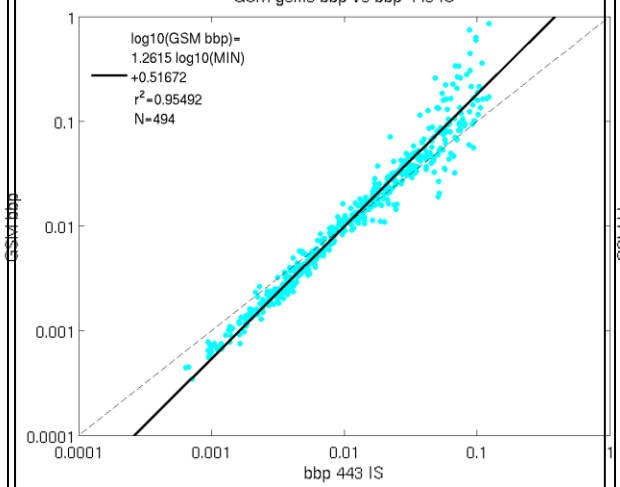
Validation on TSM and Chl by inversing simulated spectra [IOCCG 2006 dataset]

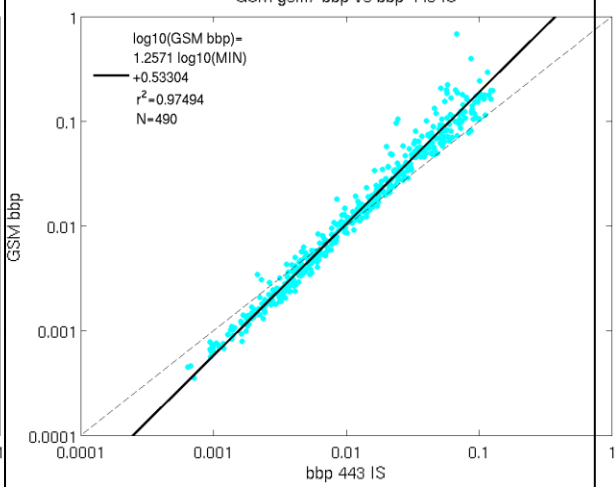
IOCCG (2006). Remote Sensing of Inherent Optical Properties: Fundamentals, Tests of Algorithms, and Applications. Lee, Z.-P. (ed.), Reports of the International Ocean-Colour Coordinating Group, No. 5, IOCCG, Dartmouth, Canada.

Case2 NN | **GSM – 5 bands** | **GSM – 7 bands**

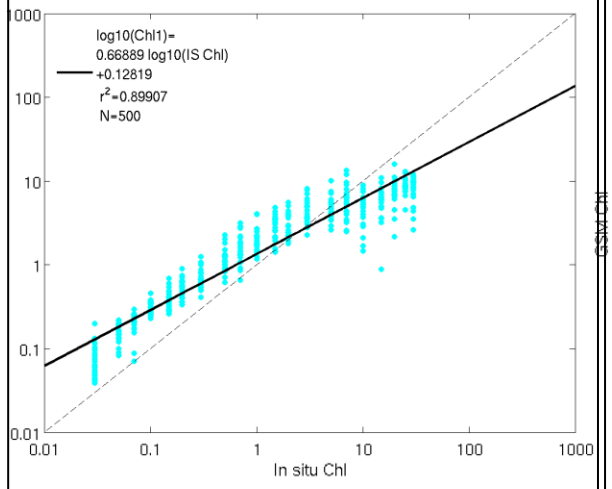
TSM

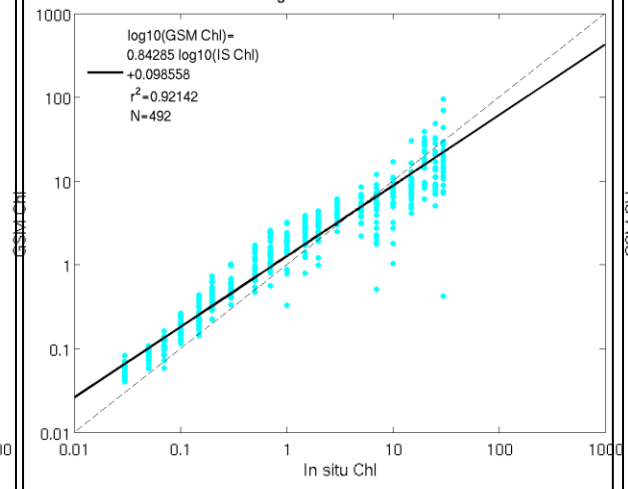


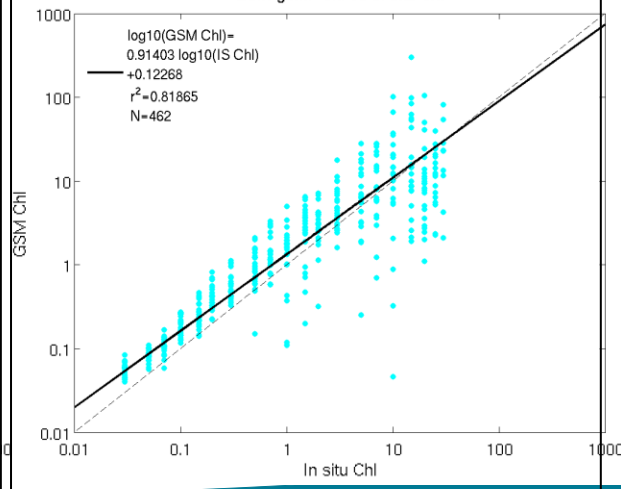




Chl





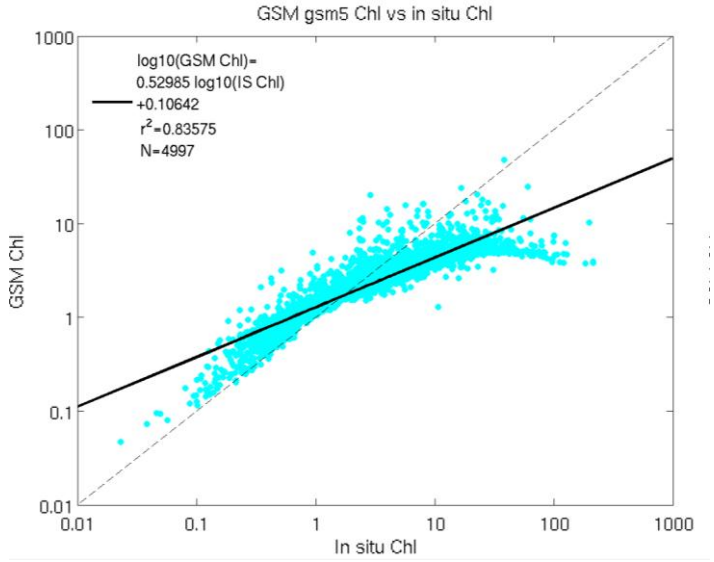


What to be learnt from simulated datasets?

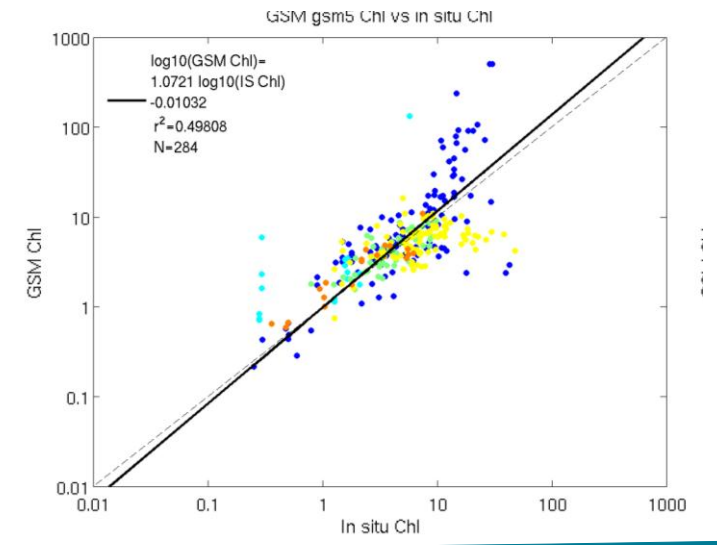
Finding an appropriate parametrization

Nominal GSM – 5 bands

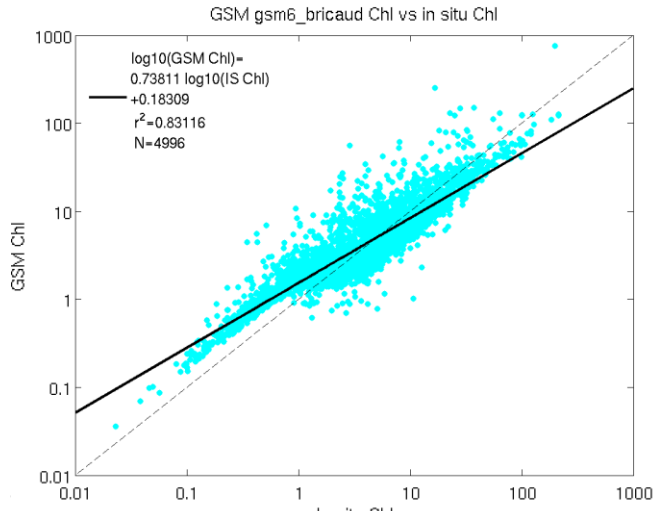
Simulated dataset

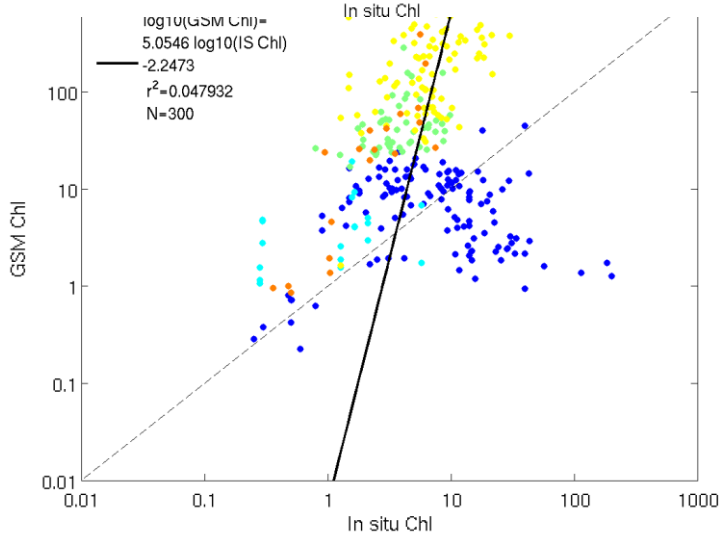


In situ dataset



GSM – 6 bands – *Bricaud et al. 95* aph*

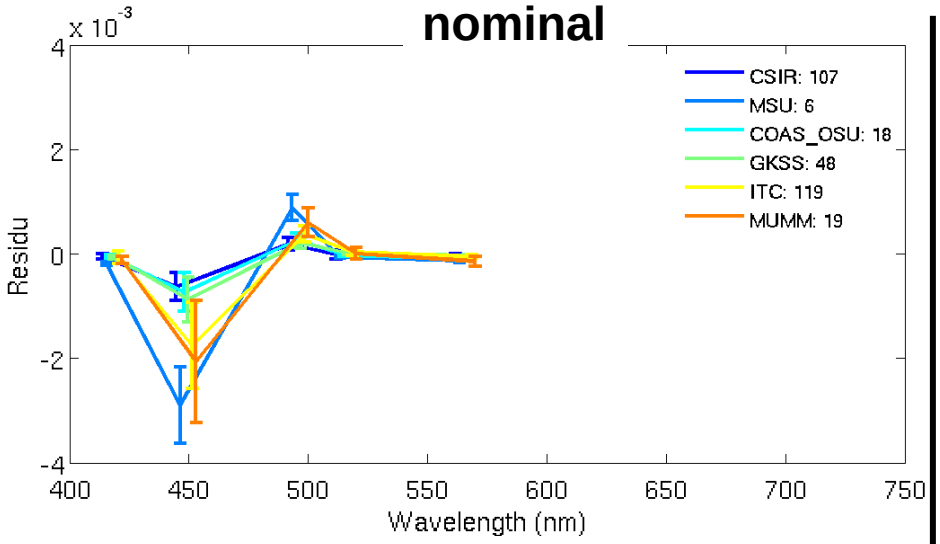


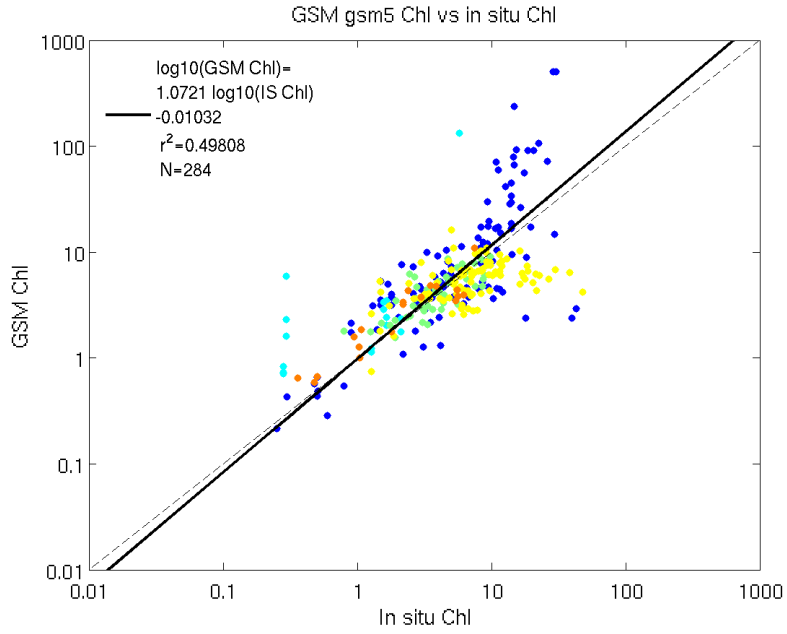


Looking at the residual of the cost function

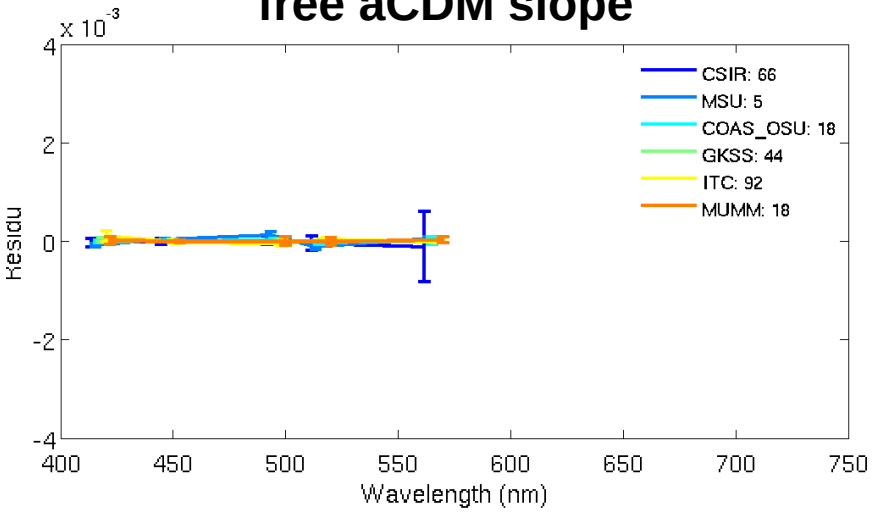
Exemple: it is worth adding the spectral slope of aCDM as new degree of freedom?

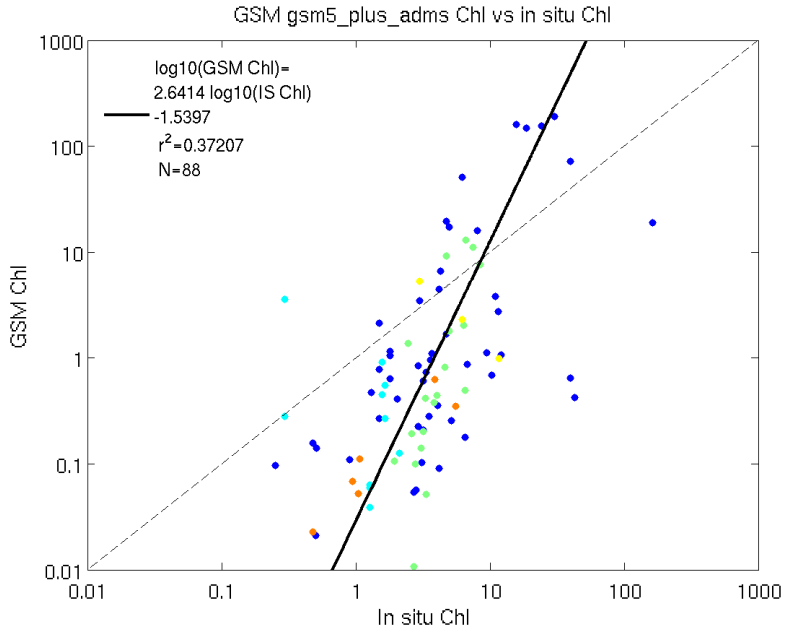
nominal



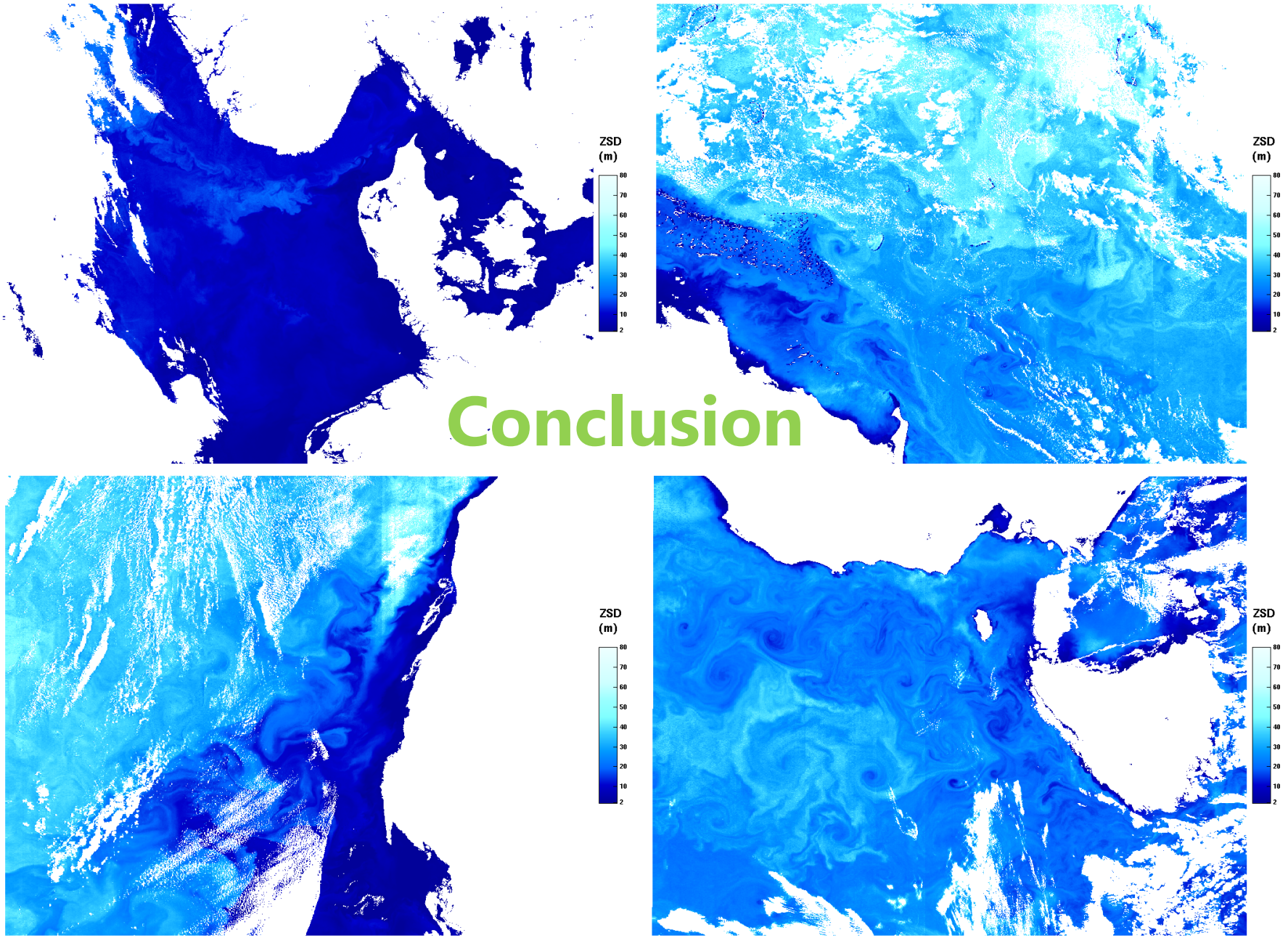


free aCDM slope





Conclusion



Secchi depth from Doron et al. 2006, Doron et al. 2011

Conclusion

ESA CoastColour is a very valuable initiative. CCRR Datasets are a good opportunity to tests algorithms. Maybe more emphasis/warning could have been put on the critical step of atmospheric correction ?

Fully coupled ocean-atmosphere atmospheric corrections are complex and might constrain the marine signal too much. Applicable at global scale ?

We do believe the historical two-step approach (BPAC+AC) to be of interest:

- Does not need a marine model on the full spectrum
- Can have great impact when working on the modeling, even when keeping the clear AC unchanged:
  - ✓ validation against in situ reflectance (MERMAID)
  - ✓ positive impact on downstream marine products, developed totally independently (GSM, bbp …)

GSM with 5 bands seems to be an interesting alternative even in coastal waters. Easy to keep an eye on the model in the code (parameter, number of bands, coefficients, degree of freedom….).

« Coastal tuning » would obviously help… Round Robin results to be analysed.

Acknowledgement

Thanks to the team at Brockmann Consult and MUMM for the CoastColour Round Robin datasets and the associated PIs:

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G. Neukermans & K. Ruddick (MUMM).

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