MEETC2: Ocean Color Atmospheric corrections in coastal complex waters using a Bayesian latent class model and potential for the incoming Sentinel 3 - OLCI mission

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Living Planet Symposium 2016

Abstract

- From top-of-atmosphere (TOA) observations, atmospheric correction aims at distinguishing atmosphere (ρ_{aer}) and water contributions (ρ_w). In coastal areas the water and aerosol spectra may show some similarities. In these areas, a priori on the variable distributions to be estimated are needed to correctly unmix the signals and **converge towards positive** & realistic estimates.

- From a methodological point of view, our algorithms MeetC2 relies on a Bayesian inference using Gaussian Mixture Model prior distributions on reference spectra of ρ_{aer} and ρ_w [1].

- Associated with the water normalised reflectance estimates, ρ_{nw}, **a total uncertainty $\sigma\rho_{nw}$**, i.e. a combination of the TOA level 1 reflectance uncertainty and the Bayesian inversion uncertainty is provided for each pixel.

MeetC2 functional Scheme

- We consider the classical multiple scattering radiative transfer equation and start from the Rayleigh corrected reflectance variable $\rho_{RC}(\lambda)$ [1]:

$$\rho_{RC}(\lambda) = \rho_{gC}(\lambda) - \rho_{Ray}(\lambda) = \rho_{aer}(\lambda) + t_d(\lambda).\rho_w(\lambda) + \rho_{coupl}(\lambda) + \varepsilon \qquad (1)$$

- Bayesian model introduces priors on the variable to be estimated and resort to maximise the a posteriori likelihood (MAP criterion):

$$P(x_a, x_w | \rho_{RC}, \varphi_a, \varphi_w) \; \alpha \; P(\rho_{RC} | x_a, x_w, \varphi_a, \varphi_w) \, . P(x_a | \varphi_a) . P(x_w | \varphi_w) \qquad (2)$$

where Xa = the polynomial coefficients of the aerosol models [1].

Xw = the coordinates of ρ_w in the reference basis [1].

φ_w={ρ_w(780),c,Θv,Θs,δψ}, observed or pre-estimated covariates (step 1, Figure 1) conditioning the a priori shape of the water reflectance spectrum to be estimated [1].

φ_w={ρ_{aer} (865),c,Θv,Θs}, observed or pre-estimated covariates (step 1, Figure 1) conditioning the a priori shape of the aerosol reflectance spectrum to be estimated [1].

- Figure 1 summarises the 4 steps involved in the atmospheric correction MEETC2 Bayesian inversion.

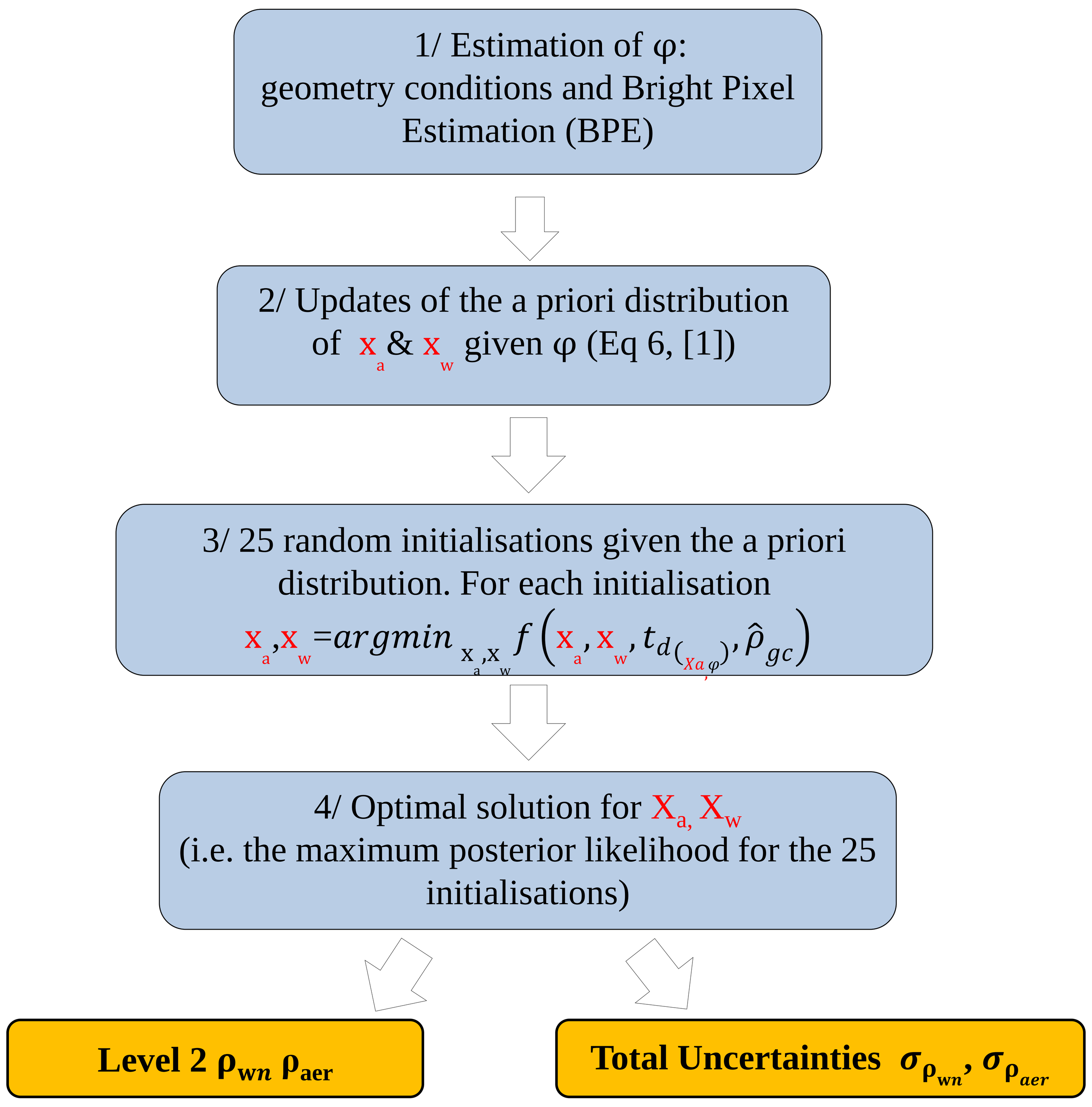

Figure 1: operational scheme for the atmospheric correction MEETC2 Bayesian inversion.

Numerical experiment

- The MERMAID (http://mermaid.acri.fr/home/home.php) in-situ matchup database is a comprehensive dataset that gathers in-situ measurements of water leaving radiances, IOPs, and MERIS TOA reflectances. To validate the proposed methodology, the radiometric in-situ profile dataset has been divided randomly in two independent datasets: a training dataset (to estimate the model parameters) and a validation dataset [1].

Validation of the inversed $\rho_w(\lambda)$ with an independent matchup dataset.

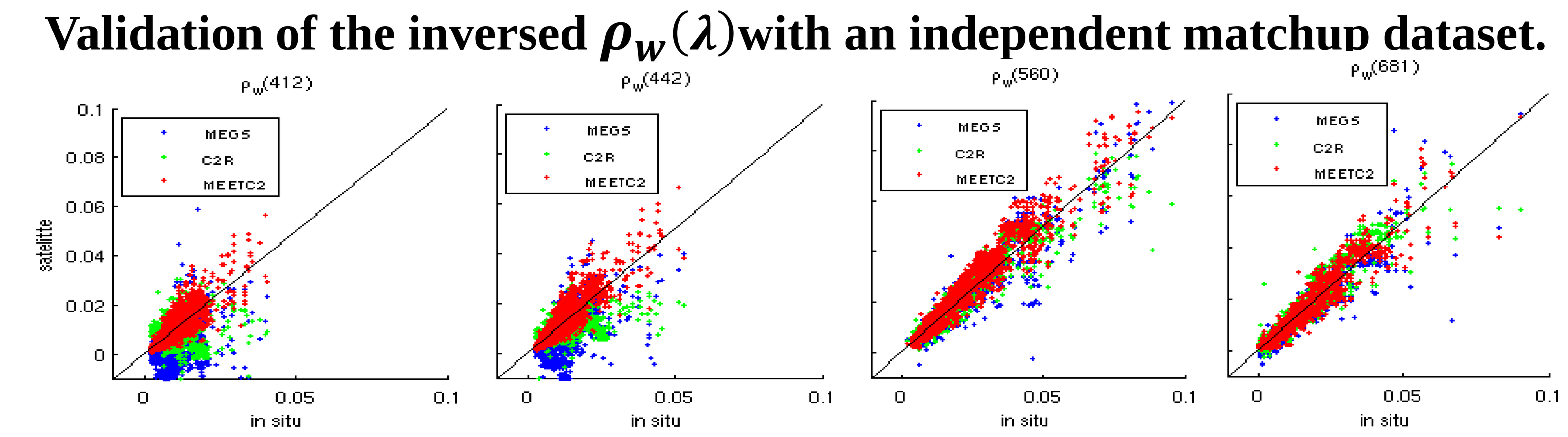

Figure 2: comparisons between the estimated ρ_w at 412, 442, 560 and 681 nm using MEETC2 vs in-situ (red), MEGS 8 vs in-situ (blue) and C2R (NN) vs in-situ (green) [1].

Comparisons of the inversed $\rho_w(\lambda)$ with state-of-the art algorithms.

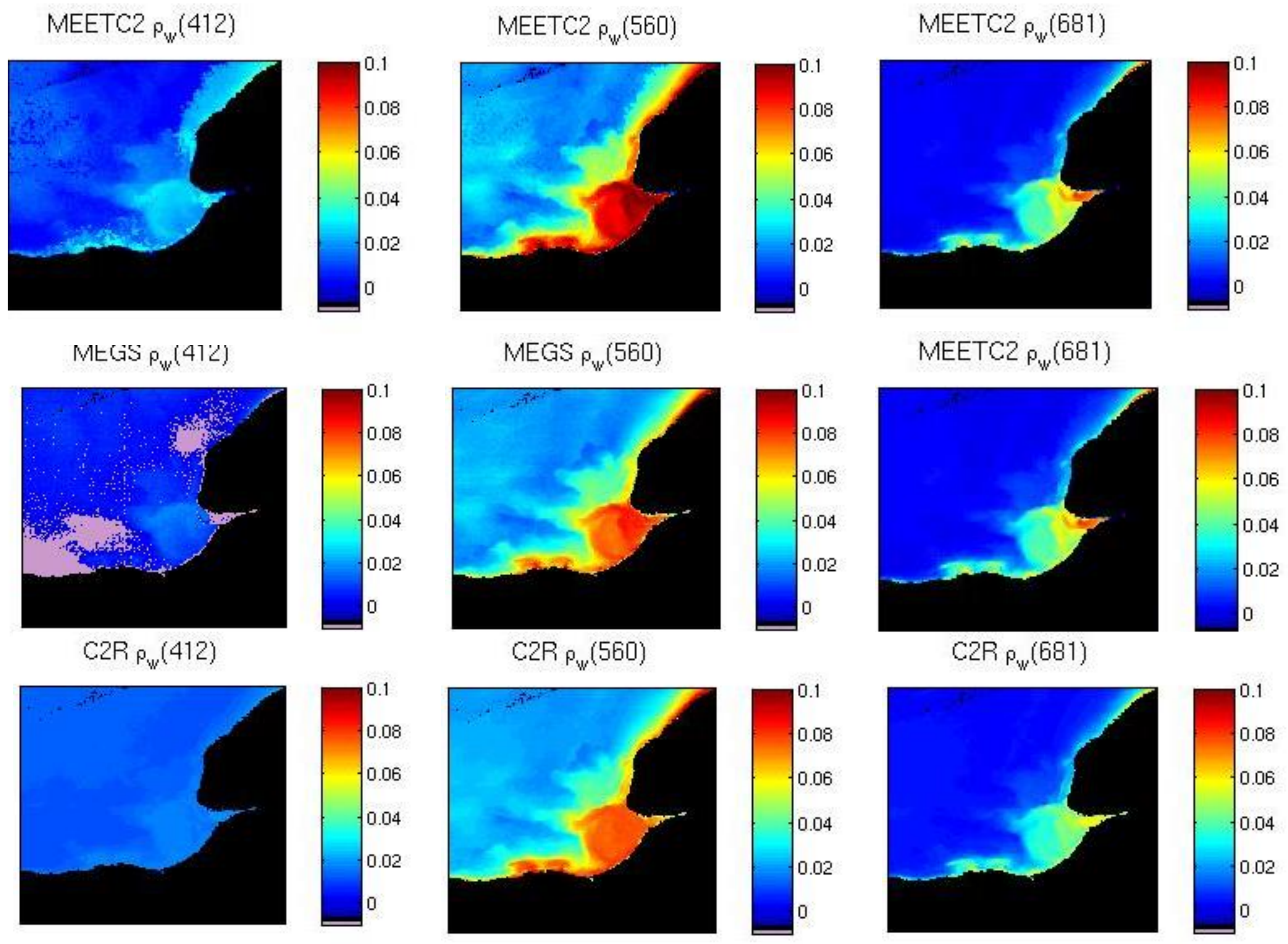

Figure 3: Estimated ρ_w(412, 560, 681) from the MERIS FR Level 1 image of the 20040209 over the French river La Seine's estuary. Top, MEETC2 retrievals, middle, MEGS v8 and bottom C2R retrievals. In pink are highlighted negative reflectances.

Towards an operational algorithm for OLCI

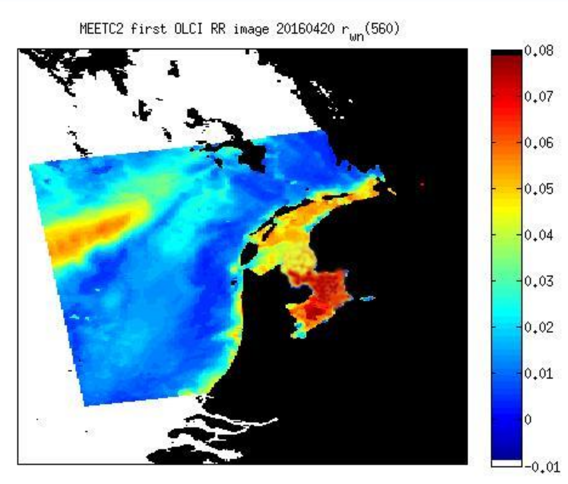

Figure 4: A first result (not verified) of the MEETC2 atmospheric correction using the OLCI RR image of the 20 April 2016 over the Baltic Sea.

- **The ambition of a Case1&2 algorithm to inverse operationally the OLCI water leaving reflectances**: the Bayesian formalism is particularly suitable to address transitions between water types and **avoid negative estimates in coastal turbid areas**.
- The natural observed variability of the aerosol (water) variables, conditioned by the geometry conditions and the concentration of aerosols (water optically active constituents), will be addressed using **radiative transfer simulations**.
- The quasi-randomised initialisations (Figure 1, step 3) involve multiple inversions for each pixel leading to high computational costs. Consequently, a parallelised implementation of MEETC2 will be developed.

[1] Saulquin, B., Fablet, R., Bourg, L., Mercier, G., & d'Andon, O. F. (2016). MEETC2: Ocean color atmospheric corrections in coastal complex waters using a Bayesian latent class model and potential for the incoming sentinel 3—OLCI mission. Remote Sensing of Environment, 172, 39-49.