Review of EUMETSAT Bright Pixel Correction study for Sentinel-3/OLCI

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1 solVo 2 HYGEOS 3 Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research

4 EUMETSAT Copernicus Europe's eyes on Earth

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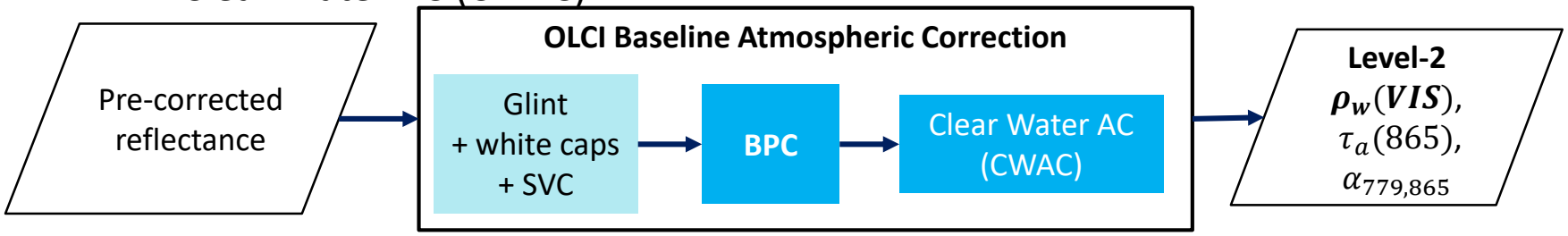
Context for S-3/OLCI

- BPC is aimed at providing ρ_w in the **NIR only**, for application of downstream Clear Water AC (CWAC)



- BPC is a key step of the Baseline AC decoupling ocean & atmosphere in the NIR

$$\rho_{gc}(\lambda) = \rho_{path}(\lambda) + t(\lambda)\rho_w(\lambda) + \varepsilon(\lambda)$$

BPC = **Case-2 NIR correction**: Legitimates Clear water AC (black pixel): Remove $t\rho_w(\lambda)$ + **Residual NIR correction**: Sun glint, white caps…: remove $\varepsilon(\lambda)$ + **Interband recalibration complementary to SVC**: Spectral alignment in the NIR $\rho_{path}(\lambda)$=$\rho_R(\lambda) + \rho_a(\lambda)$

- Note: another EUMETSAT study is starting and covers the full AC in the VIS-NIR: *Spectral matching Atmospheric Correction for Sentinel Ocean colour measurements* (SACSO, lead by Hygeos)

Revisit of the Bright Pixel problem

- BPC based on physical modelling and inversion through optimization:

Nb of bands

model

obs.

$$\chi^2(\boldsymbol{x}_a, \boldsymbol{x}_w) = \sum_{i=1}^{n} \frac{\left(\rho_{Rc}^{mod}(\lambda_i, \boldsymbol{x}_a, \boldsymbol{x}_w) - \rho_{Rc}(\lambda_i)\right)^2}{\sigma^2_{\rho_{Rc}}(\lambda_i)}$$

atm. unknowns

marine unknowns

unc. of obs.

BRDF reflectance model

IOP model and unknown

Aerosol model

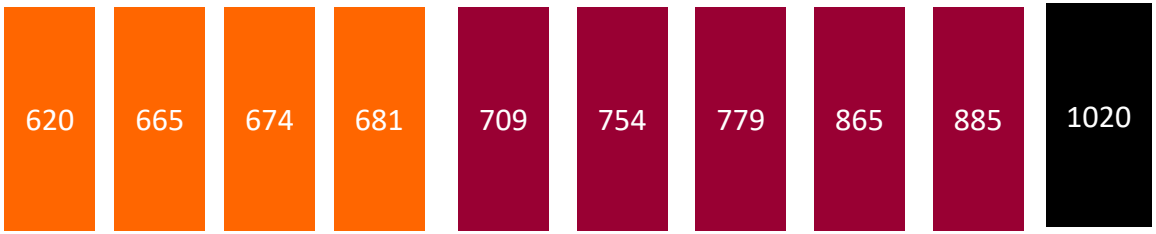
BPC bands

Input uncertainties

Numerical inversion

$$\chi^2(\boldsymbol{x}_a, \boldsymbol{x}_w) = \left(\boldsymbol{\rho}_{Rc}^{mod}(\boldsymbol{x}_a, \boldsymbol{x}_w) - \boldsymbol{\rho}_{Rc}\right)^T \left(\boldsymbol{C}_{\rho_{Rc}} + \boldsymbol{C}_{mod}\right)^{-1} \left(\boldsymbol{\rho}_{Rc}^{mod}(\boldsymbol{x}_a, \boldsymbol{x}_w) - \boldsymbol{\rho}_{Rc}\right)$$

Candidate bands of χ^2 in the red/NIR/SWIR



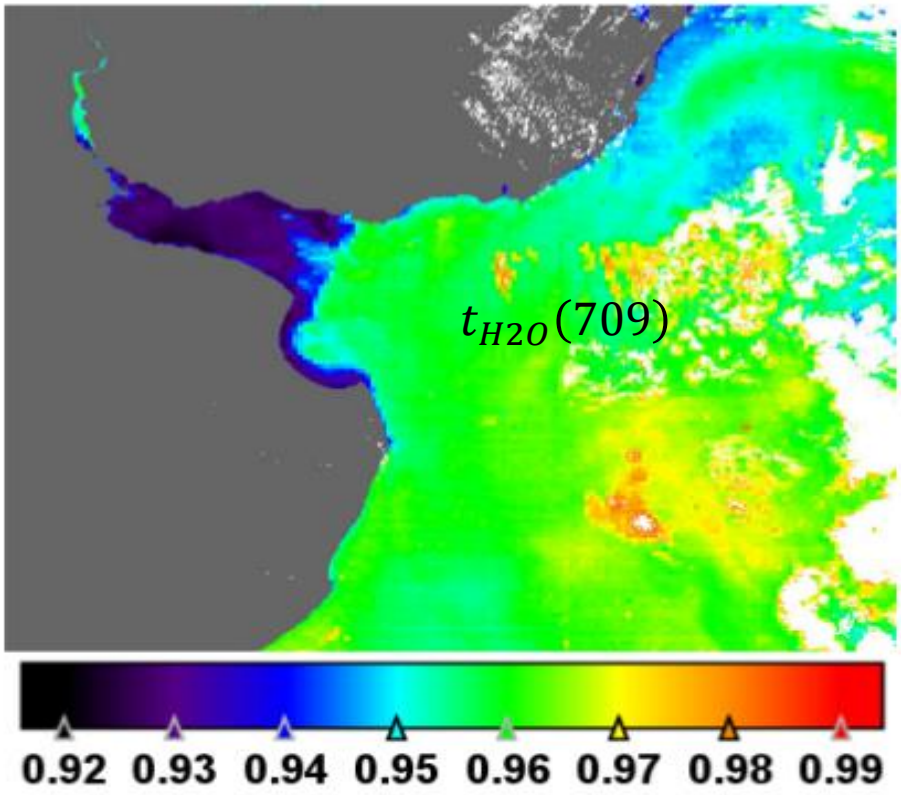
Degrees of freedom:

$\boldsymbol{x}_w = b_{bp}(\lambda_0)$

$\boldsymbol{x}_a = (\rho_a(\lambda_0), \varepsilon)$

Key findings: TOA-precorrection

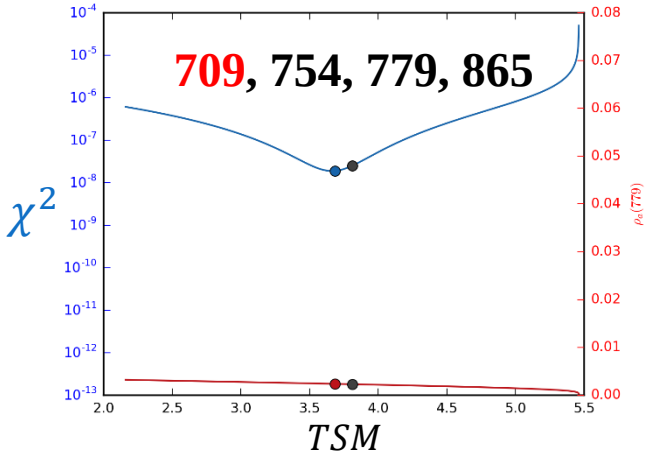
OLCI water vapour correction in the NIR is erroneous over bright waters
→ Bands 709, 865 and 1020 nm cannot be used confidently in the BPC inversion

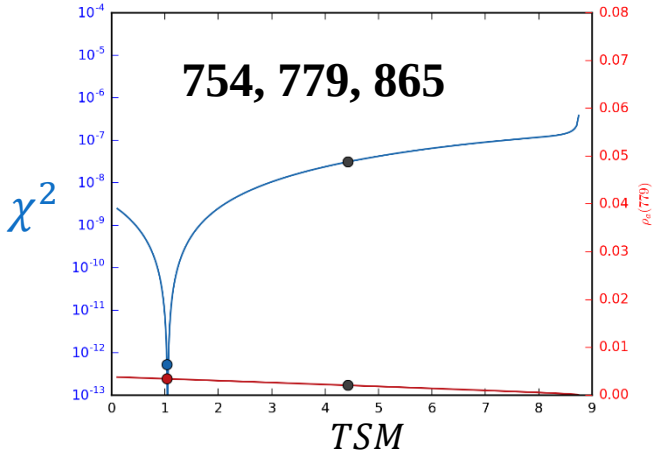


Key finding: marin/atm. decoupling

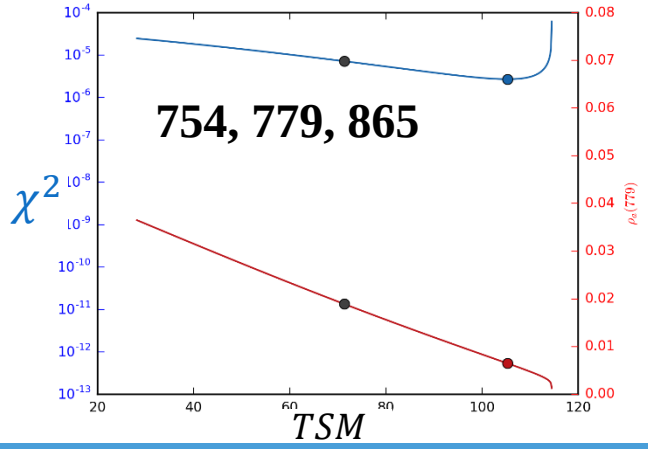
Spectral matching approach is very appropriate to understand the convergence at pixel level

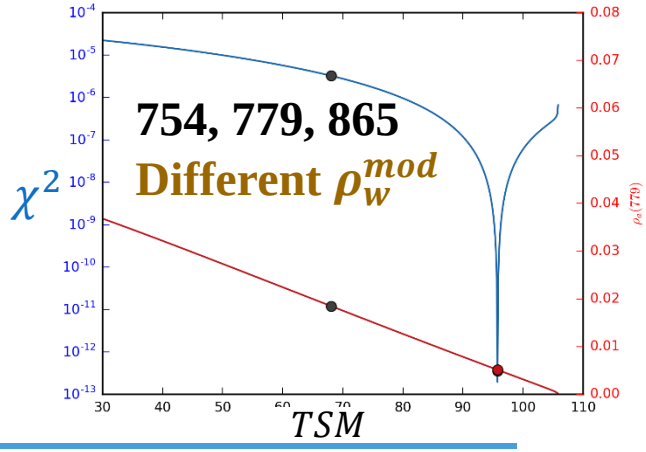
Clear waters





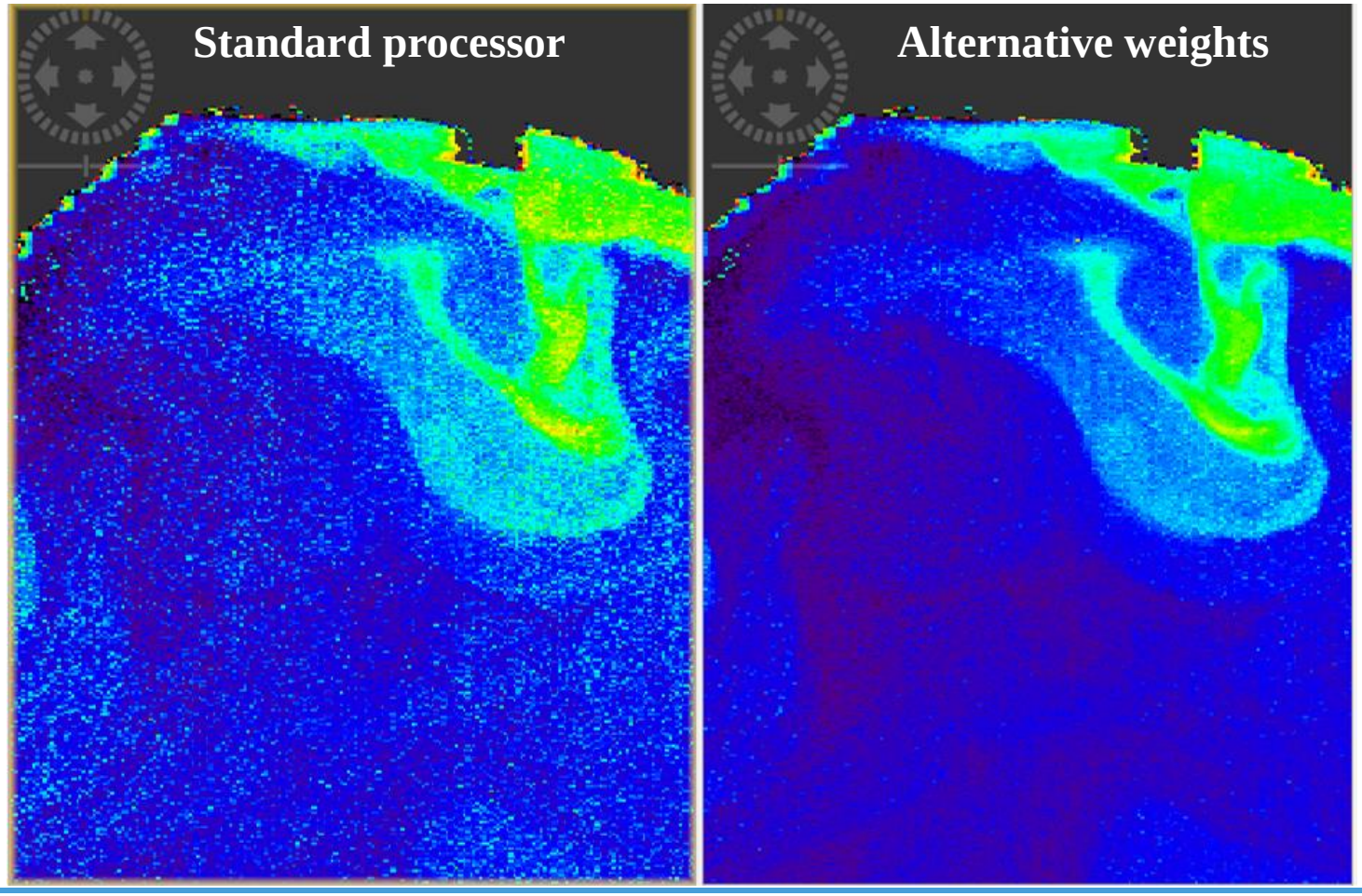
Very turbid waters





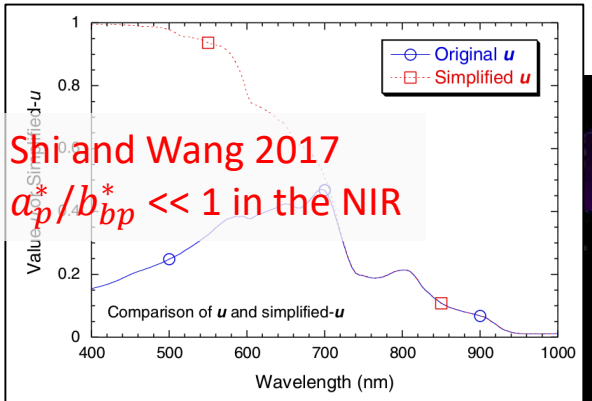
Key findings: input uncertainties

The weights used in the minimization impact robustness and may create noise or smooth data



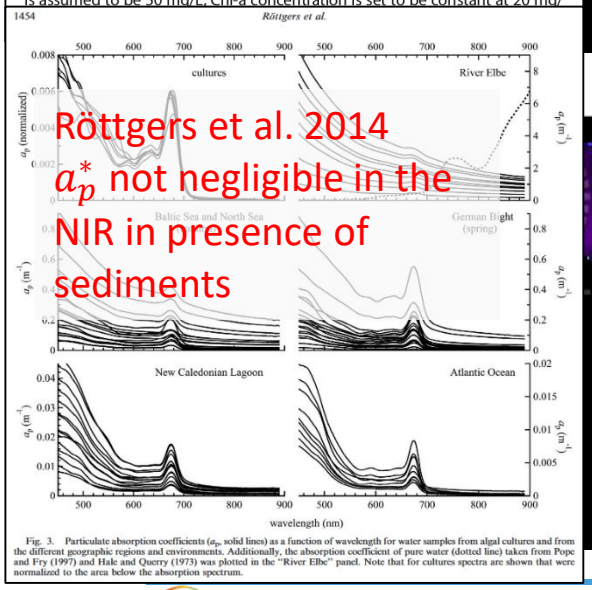
Key findings: IOPs in the NIR

BPC performance is impacted by b_{bp} slope and $a_p^*/b_{bp}^*(\lambda)$



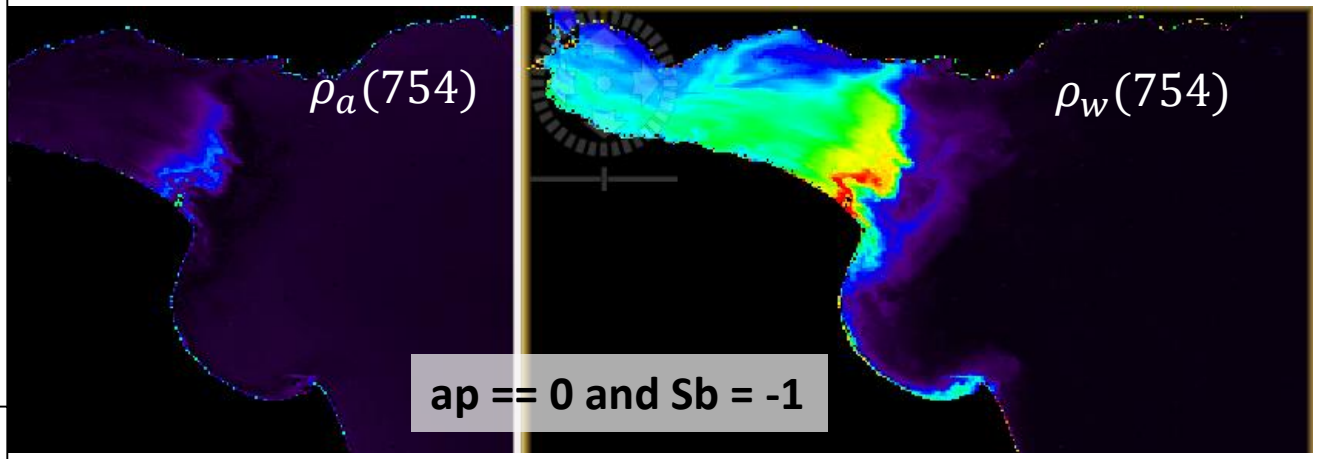
Shi and Wang 2017
a_p^*/b_{bp}^* << 1 in the NIR

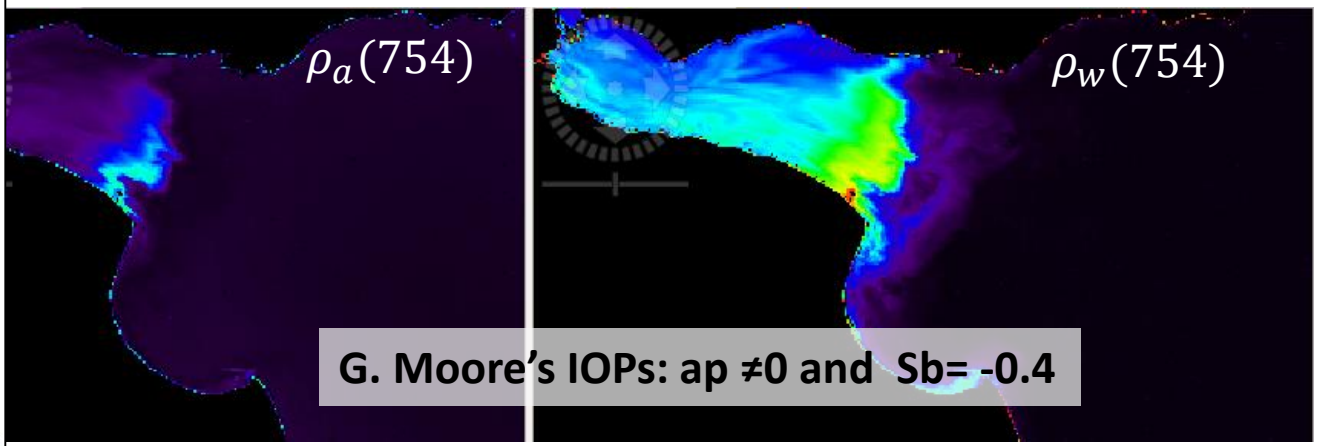
Figure 1. Comparison of $b_b(\lambda)/(a(\lambda)+b_b(\lambda))$ ($u(\lambda)$, dash line) and $b_b(\lambda)/(a_w(\lambda)+b_b(\lambda))$ (simplified-$u(\lambda)$, solid line) for a typical coastal turbid water. TSM is assumed to be 50 mg/L. Chl-a concentration is set to be constant at 20 mg/



Röttgers et al. 2014
a_p^* not negligible in the NIR in presence of sediments

Fig. 3. Particulate absorption coefficients (a_p, solid lines) as a function of wavelength for water samples from algal cultures and from the different geographic regions and environments. Additionally, the absorption coefficient of pure water (dotted line) taken from Pope and Fry (1997) and Hale and Querry (1973) was plotted in the "River Elbe" panel. Note that for cultures spectra are shown that were normalized to the area below the absorption spectrum.





Recommendations

- **Need for open source processing chain**
  - No access to OLCI Level-2 processor has made complex BPC development
- **Need to further work on the TOA pre-correction**
  - OLCI water vapour correction in the NIR is crucial
  - White-caps signal in the NIR, possibly glint residual
- **Need for more knowledge about IOPs in the NIR over turbid waters: b_{bp} slope and $a_p^*/b_{bp}^*(\lambda)$**
  - Either through in situ measurements in the NIR
  - Or from selected satellite images pre-corrected for the atmosphere
  - Alternative without a & bb: more robust modelling (through Kd)?