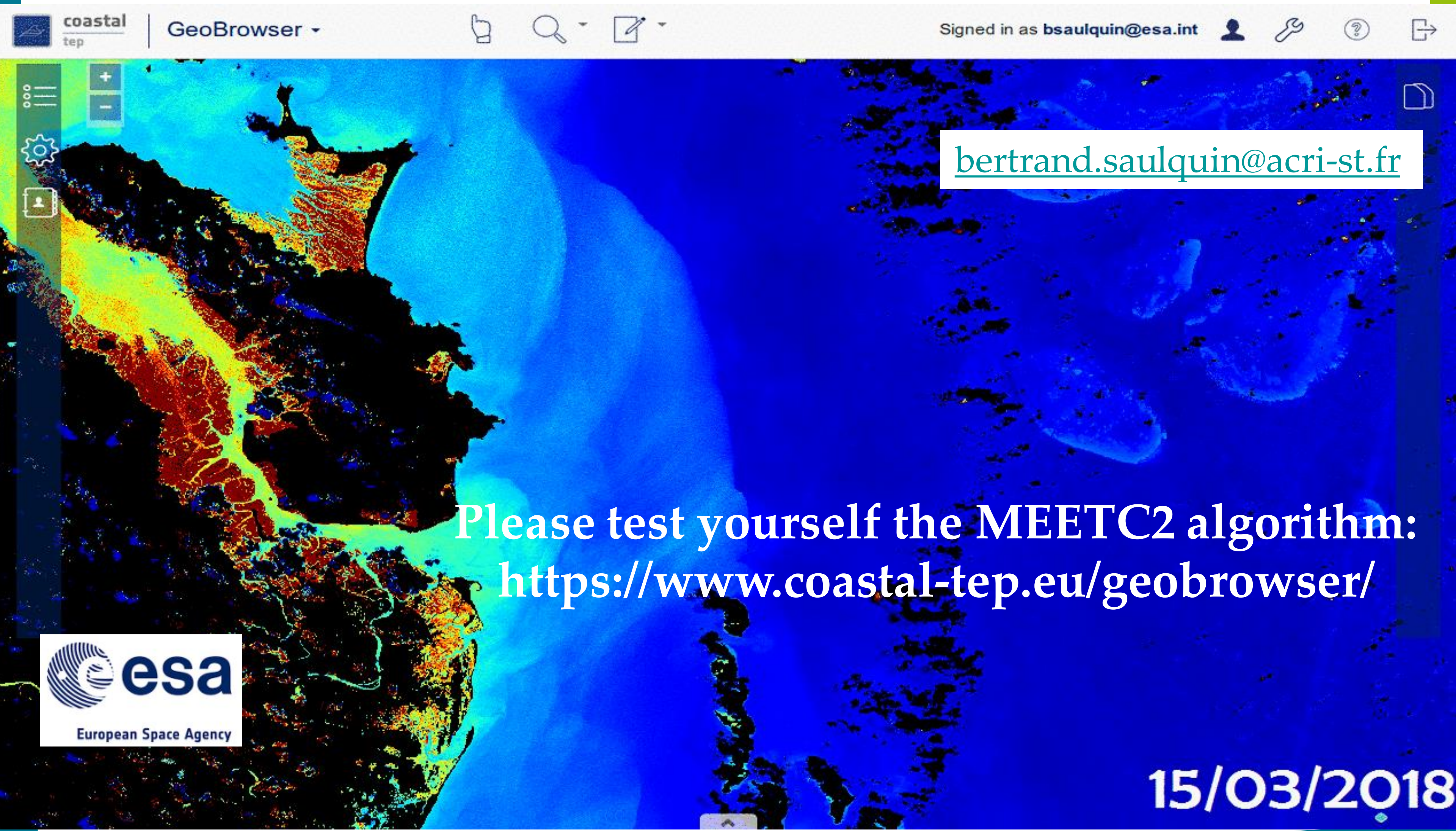
MEETC2 : Bayesian & multiscale analysis atmospheric corrections for the sentinels 2&3



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Please test yourself the MEETC2 algorithm:
https://www.coastal-tep.eu/geobrowser/

MEETC2 : a work started in 2014 …

- *Saulquin B. et al. Multi-scales atmospheric corrections for the Sentinels 2, In writing process.*
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Remote Sensing of Environment
Volume 172, January 2016, Pages 39-49

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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Opportunities: improve the atmospheric corrections with the introduction of spatial information

MeetC2 = Meet case 2 waters

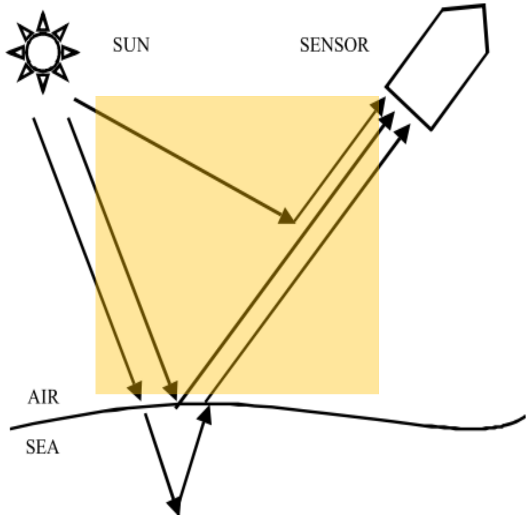
- **Targeted long term improvement**

  - Major improvements in atmospheric corrections will lead to the end of the **historical case 1 / case 2 issues in oceanography including tens of regional algorithms** and the corresponding nightmare for end users.

Opportunities: improve the atmospheric corrections with the introduction of spatial / temporal information

$$\underbrace{\rho_w(\lambda)}_{\text{HR}} = \underbrace{[\rho_{TOA}(\lambda)}_{\text{HR}} / \underbrace{T_g(\lambda) - \rho_{path}(\lambda) - t_{up}(\lambda)t_{down}(\lambda)}_{\text{LR}} \underbrace{\rho_{glint}(\lambda)}_{\text{HR}}] \,/\, \underbrace{T_{up}(\lambda)T_{down}(\lambda)}_{\text{LR}}$$

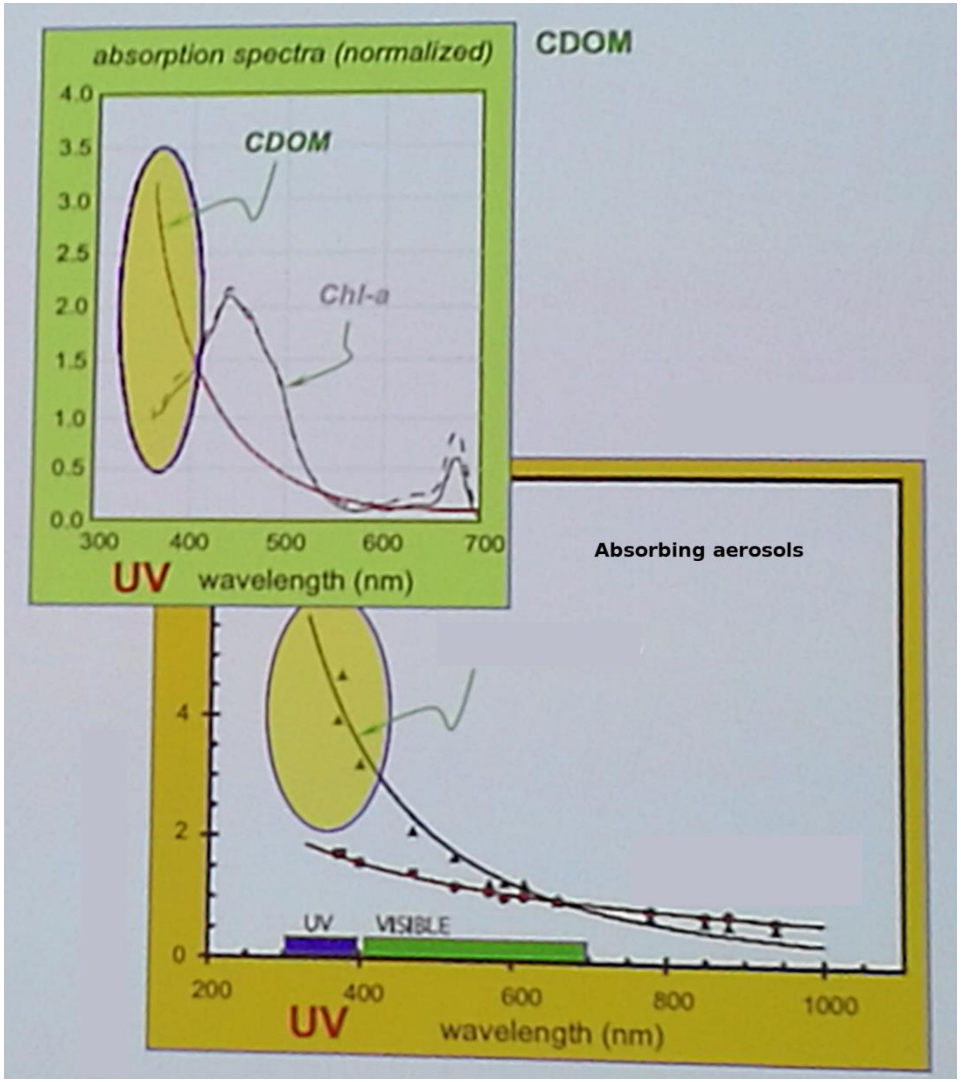
Signal	Coastal areas	Open waters
$T_g(\lambda)$	10 to 30 kms*	> 100km*
$\rho_{path}(\lambda)$	10 to 30 kms	> 100km
$T_{up}(\lambda)T_{down}(\lambda)$	10 to 30 kms	> 100km
$\rho_w(\lambda)$	Few meters	> 10km
$t_{up}(\lambda)t_{down}(\lambda)\ \rho_{glint}(\lambda)$	Few meters	Few meters



*Seinfeld, J. H., & Pandis, S. N. (2016)

The spatial continuity of the aerosols is an information as the spectral signature

The atmospheric correction issue



Spectral approach is not always deterministic

Need of:

- ➢ **External variables (assimilation…)**
- ➢ **Change your inversion scheme to include e.g temporal or spatial information**

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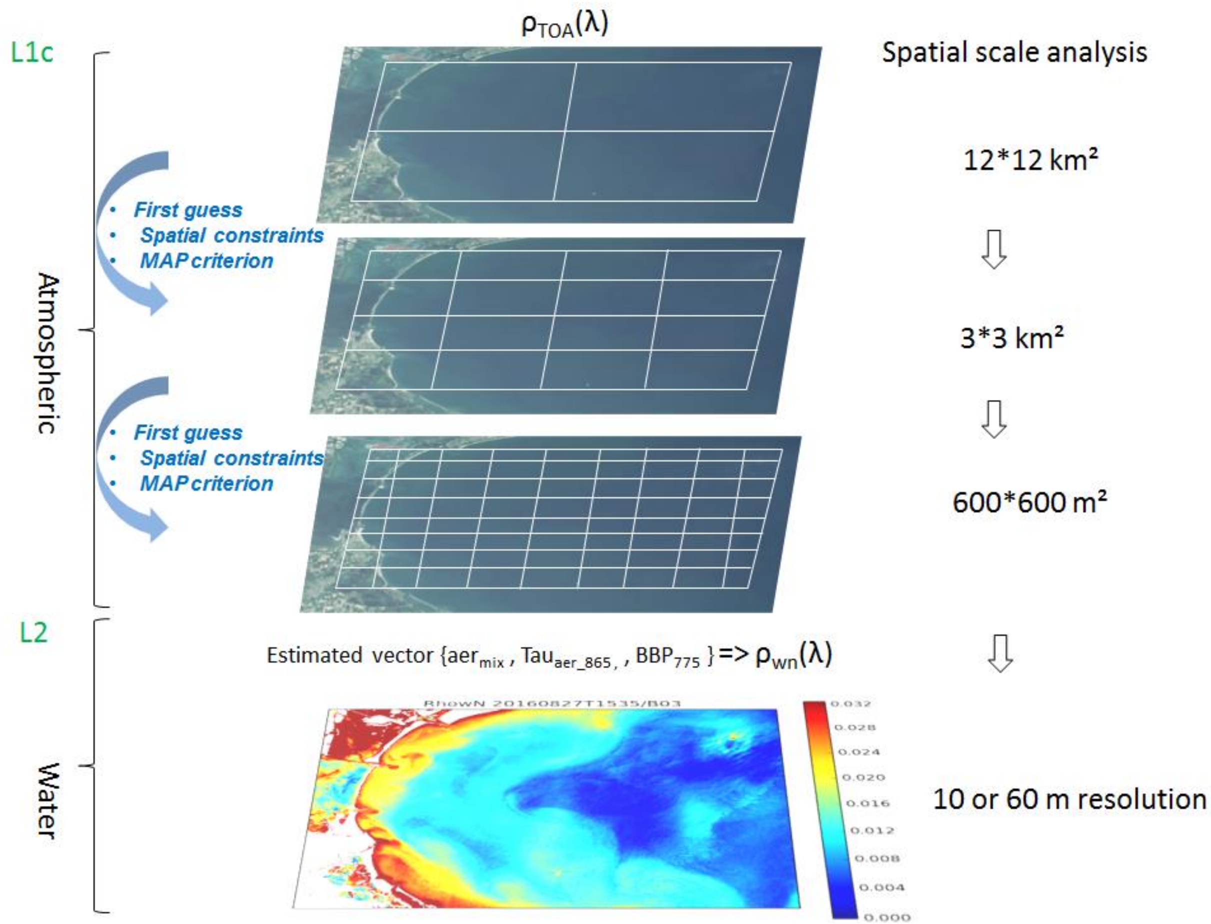
MeetC2: Bayesian & multiscale atmospheric corrections



Our cost function (expressed here using bayesian notation):

$$P(V_a, V_w | \rho_{TOA}) \propto P(\rho_{TOA} \mid V_a, V_w) \,.\, P(V_a, V_w) \, P(\nabla_{Va_{i,i+1}})$$

Spatial and/or Temporal term

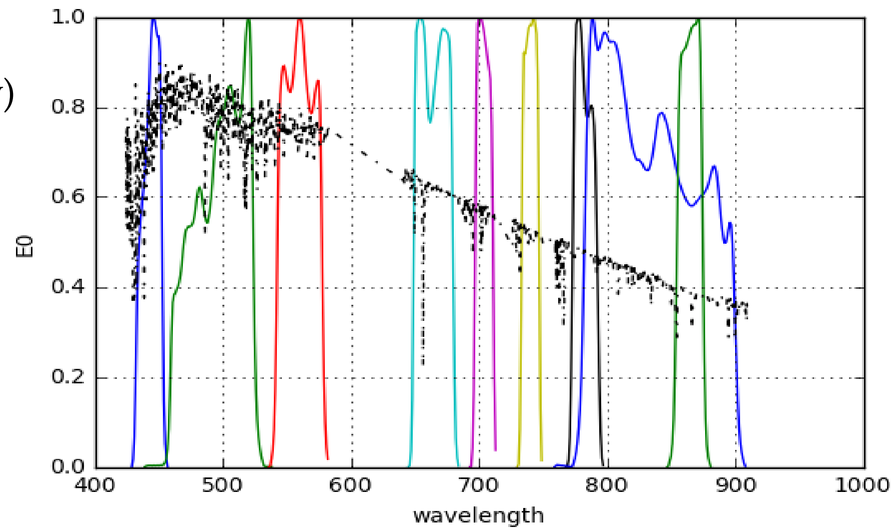
Residuals of the observation model

A priori onto parameters

MeetC2 an advanced Sentinel3-like inversion scheme

6 precomputed LUTs from **Smart-g or OSOAA** **coupled water + atmosphere RTMs** (integration using reptran & the S2 spectral response):

- **Td gaz** (λ, Θ, O3)
- **Rho_path** (λ, WV, P0, Θs, aer_type, τaer_865, Δφ, Θv)
- **Td_diff**(λ, , WV, P0, Θs, aer_type, τaer_865, Δφ, Θv)
- **TD_direct**(λ, WV, P0, Θs, aer_type, τaer_865)
- **Rho_glint**(λ, Θs, WS, Δφ, Θv)
- **Rho_water(**λ, Θs, WS,bbp_775, Δφ, Θv)



Reptran & S2A spectral response

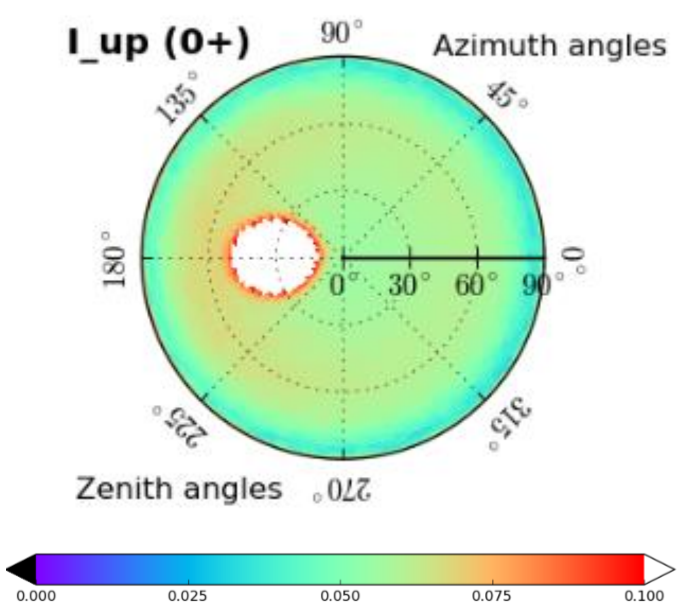


Figure: Example of Rhow simulation using **Smart-G*** (bbp_775=0.1, Θs =30°)

A dedicated water model derived from hydrolight simulations

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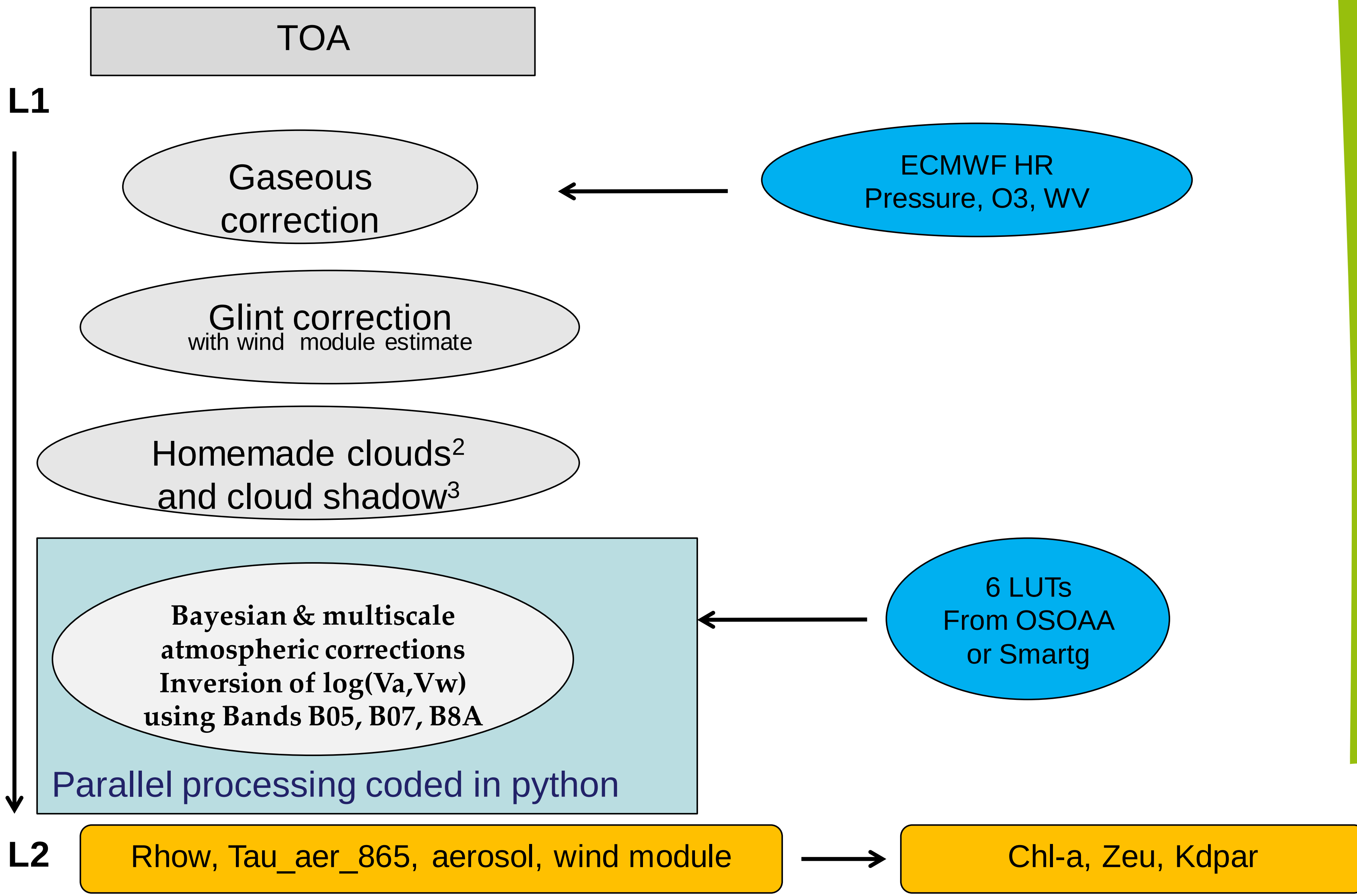
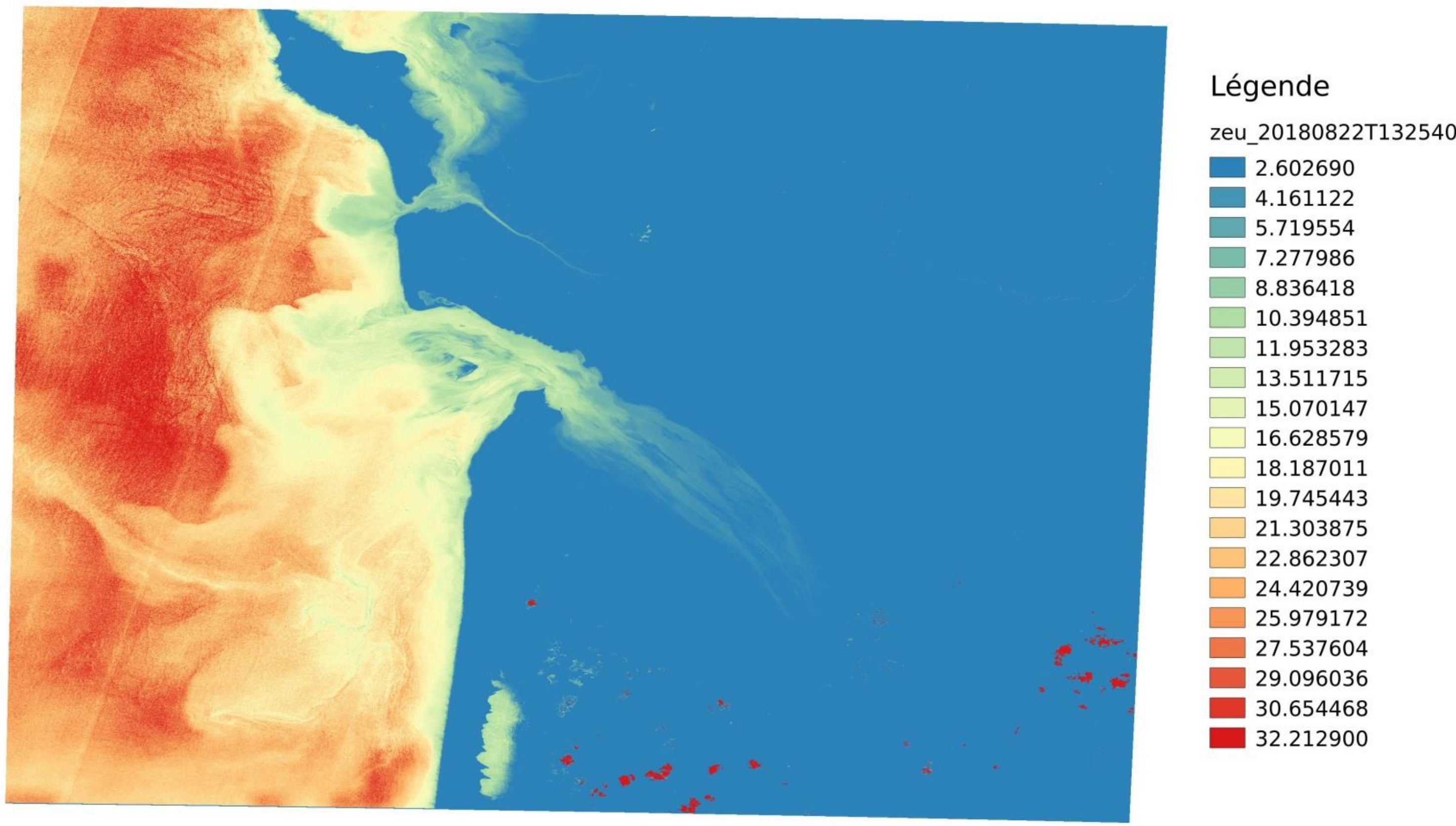
MeetC2 functional scheme



MeetC2: Current outputs

- Normalised water reflectances + **total uncertainty per pixel**
- Chl-a
- Euphotic depth
- RGB L1
- RGB L2
- Cloud mask.



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➢ Metodological improvements in the inversion lead to:

- ❖ Increase the unmixing capability of the algorithm for the atmospheric corrections:

  The shape of the aerosol and water reflectance spectra are similar in coastal areas and infrared regions leading to inversion issues. The inclusion of constraints onto the gradients of the atmospheric variables help to unmix the two contributions compared to a single pixel approach.

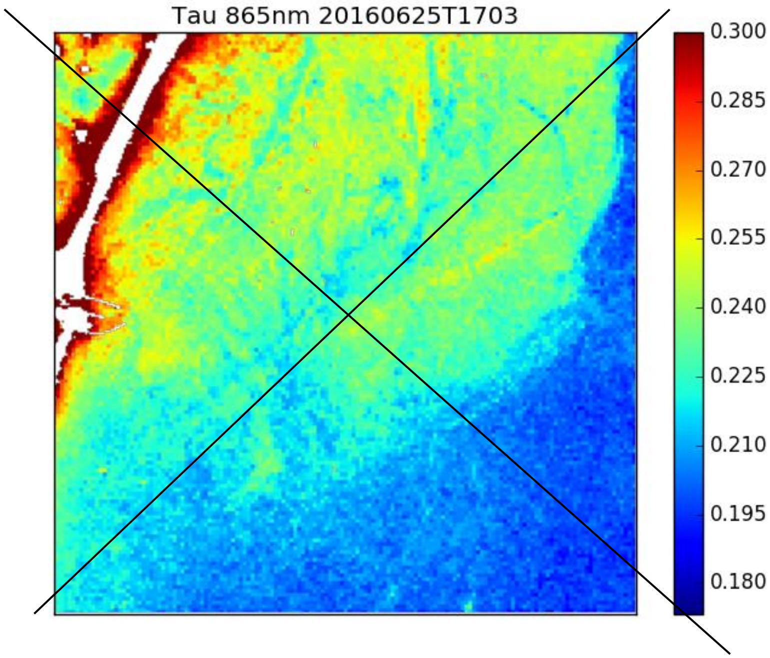
- ❖ Reduce uncertainties onto the estimates: Case of a non linear minimisation $\widehat{Va, Vw} = argmin(\widehat{\rho_{TOA}} - \rho_{TOA})$.

- ❖ Increase the speed of the processing : you do not need to do an inversion pixel by pixel

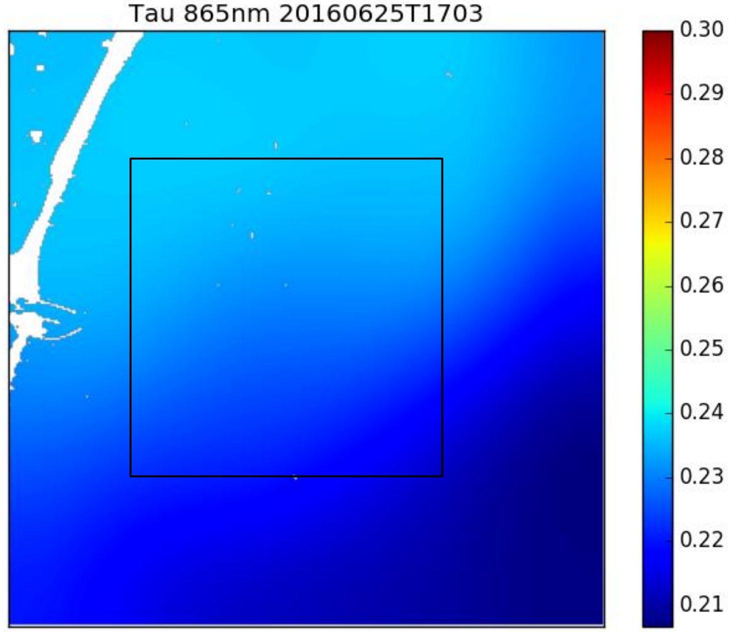
Single approach vs muti-pixels approaches

1,8 km

Tau_aer_865



Single pixel inversion



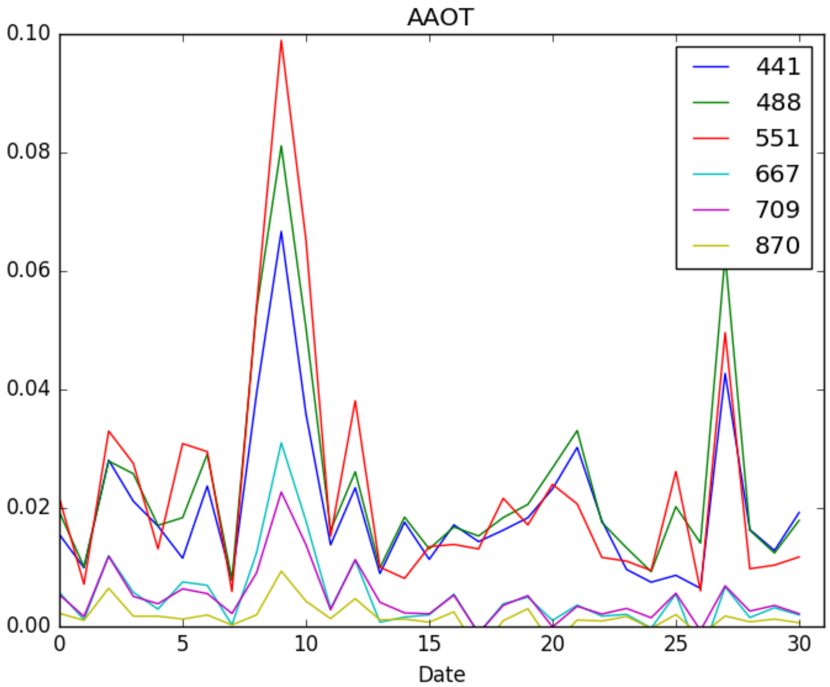
Multi-pixels inversion

Signature of sediments onto the retrieved AOT=> need to introduce spatial regularisation terms onto the atmospheric parameters

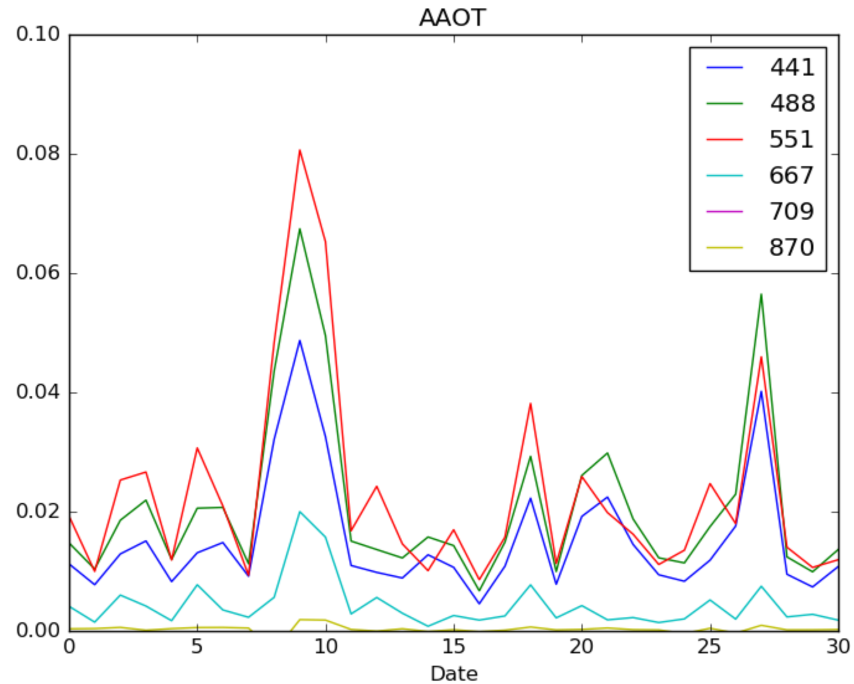
Venice laguna

Temperate Site: **Venice [Italy]**

- **A proposition to integrate the ACIX Intercomparaison exercise**

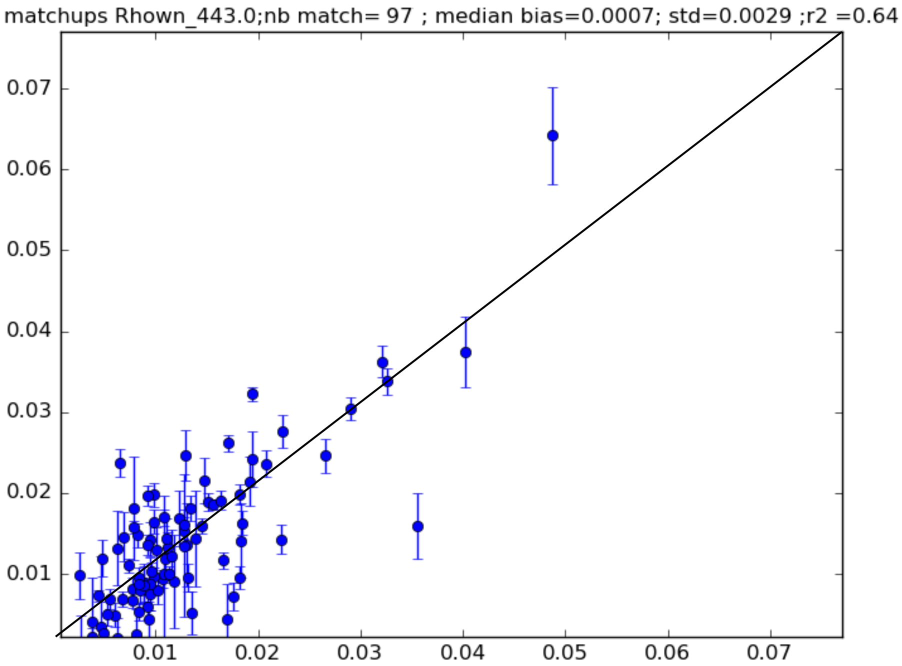


Satellite

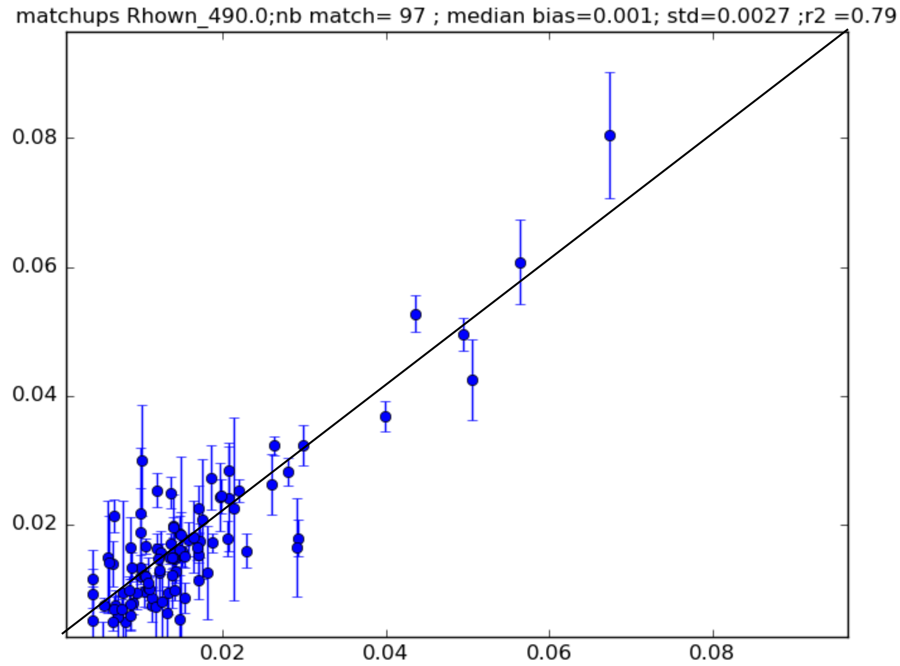


In-situ

Scatterplots, all sites: rhown estimated using S2A&B



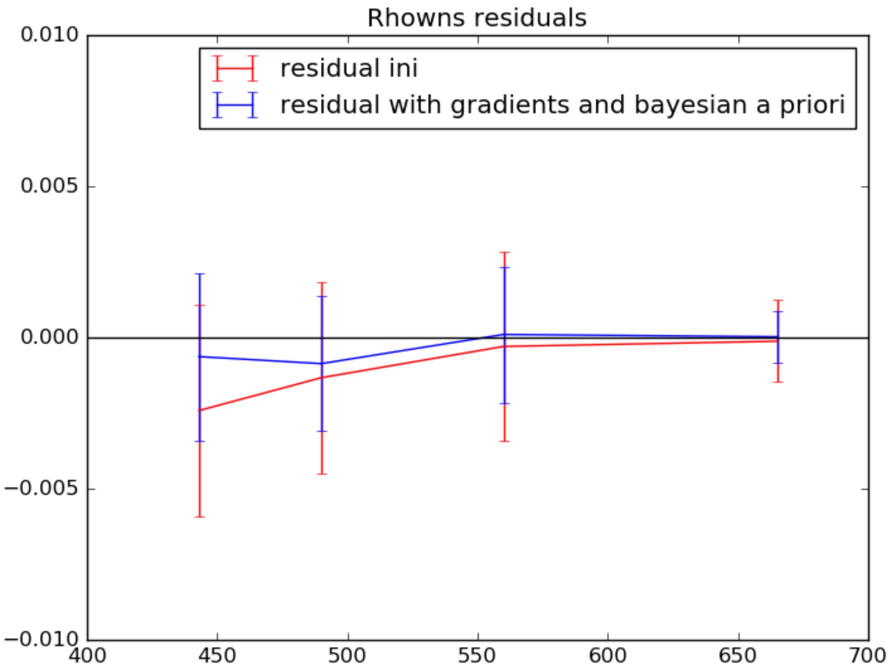
443

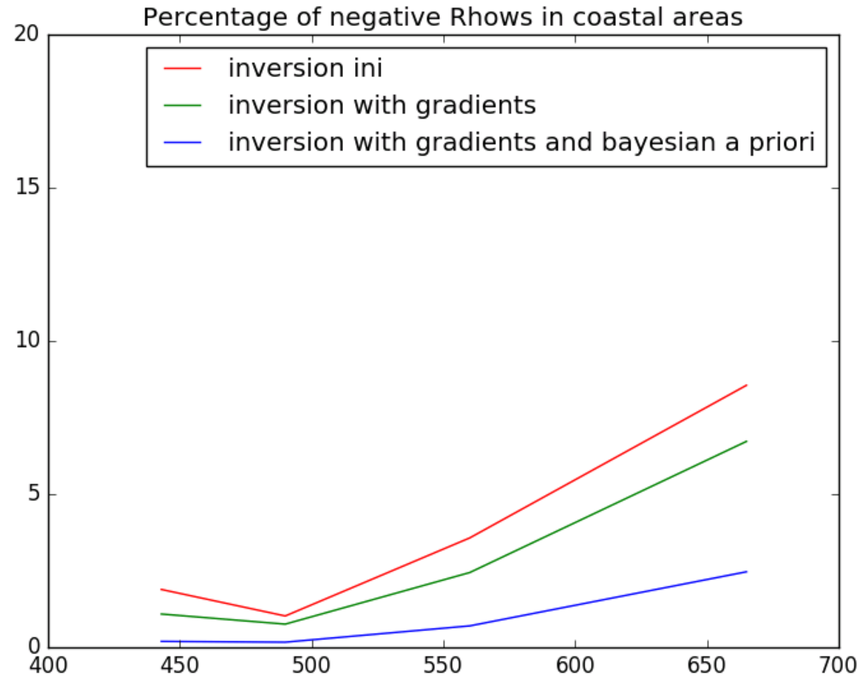


490

Level 2 validation of the Sentinels 2 A&B over waters

$$P(V_a, V_w|\rho_{gc}) \propto P(\rho_{gc} \mid V_a, V_w) \cdot P(V_a, V_w) \cdot P(\nabla_{Va_{i,i+1}})$$





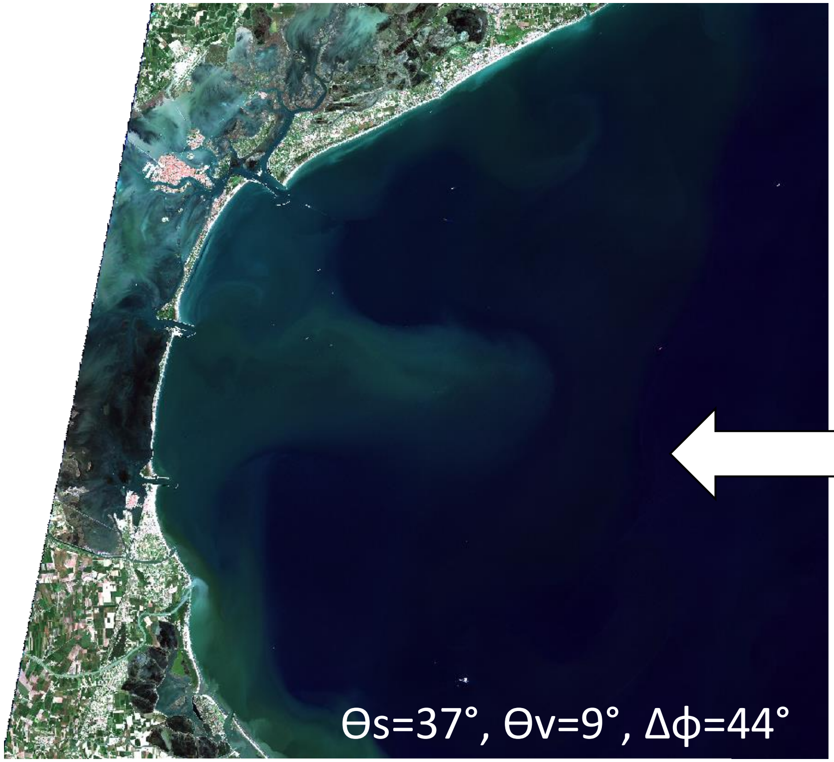
- Less bias and decrease of the uncertainties onto the Rhows

- Less negative reflectances = optimisation of the L2

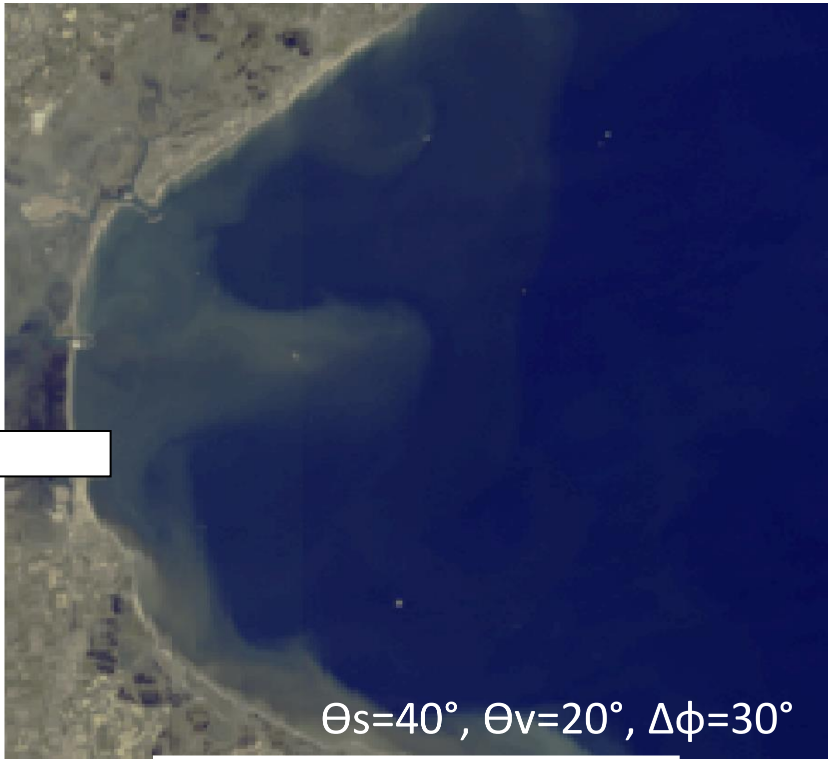
Comparisons with OLCI OL2

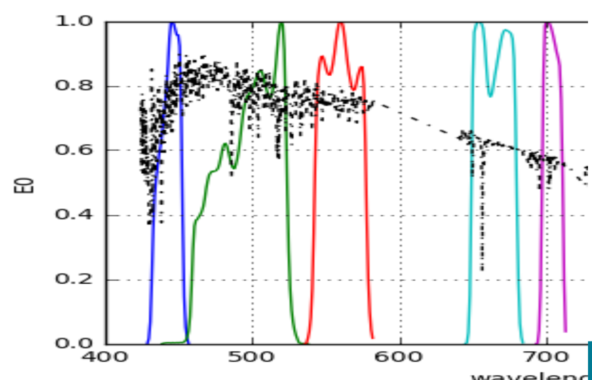
20160824 Venice Laguna (similar geometry of observation)

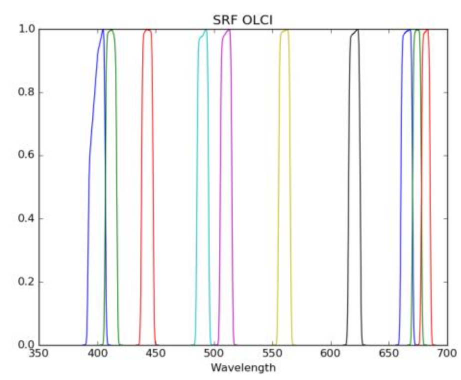
Level 1 S2 RGB



Level 1 OLCI RGB

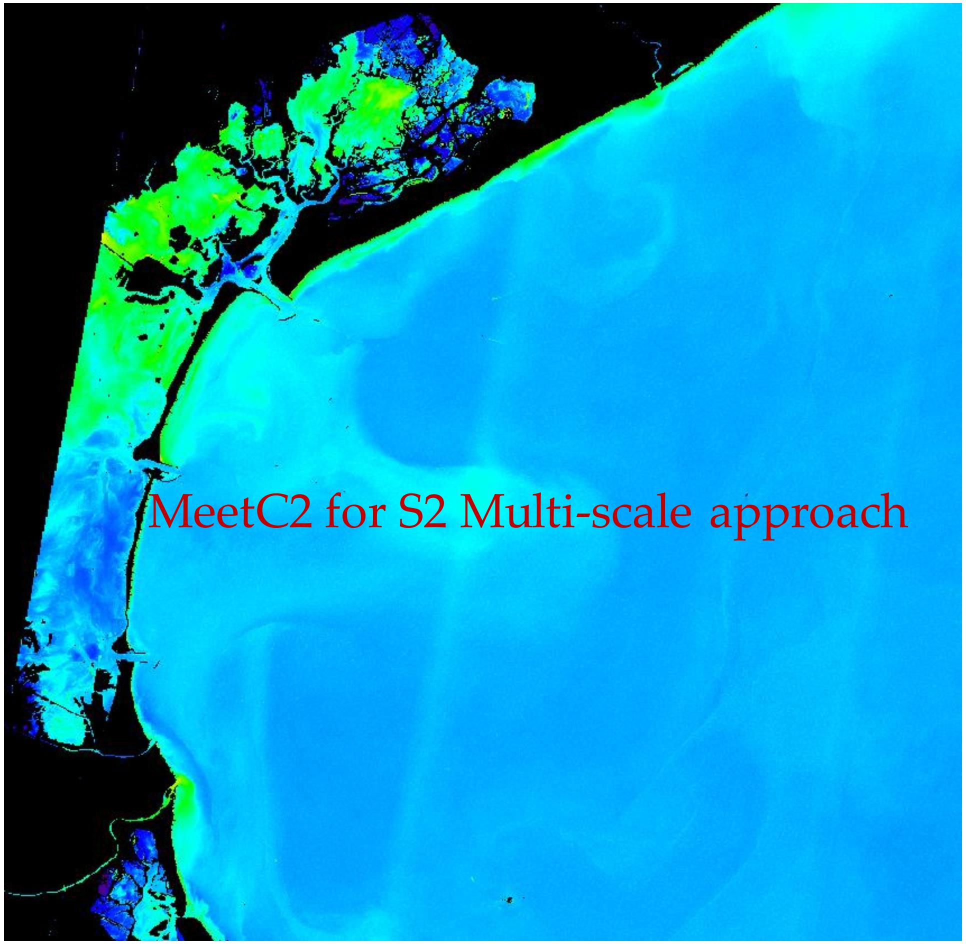


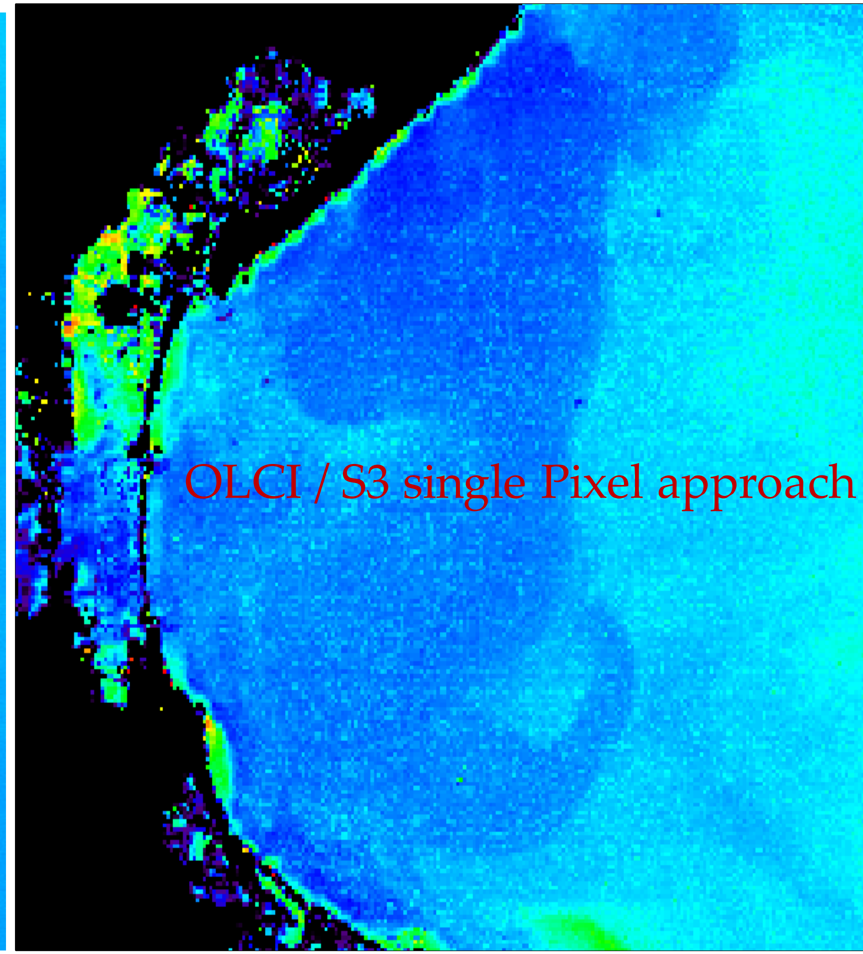




Comparisons with OLCI OL2

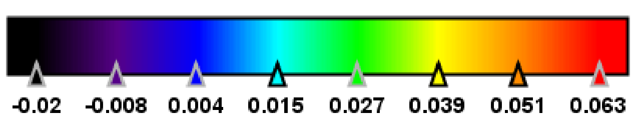
20160824 Venice Laguna





MeetC2 Level 2 S2 Rhown 443 nm

Level 2 443 nm OLCI



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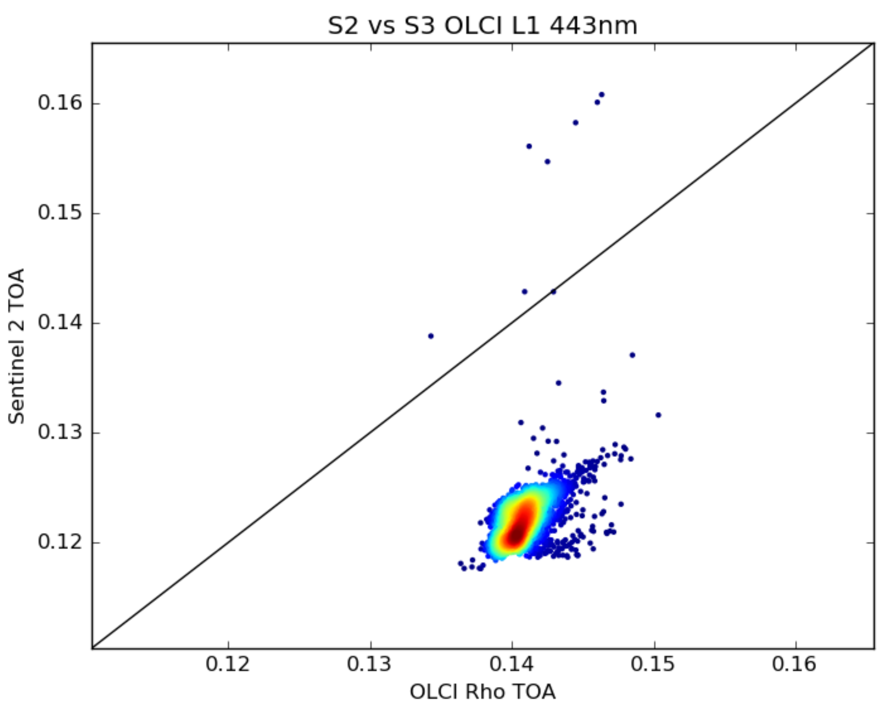
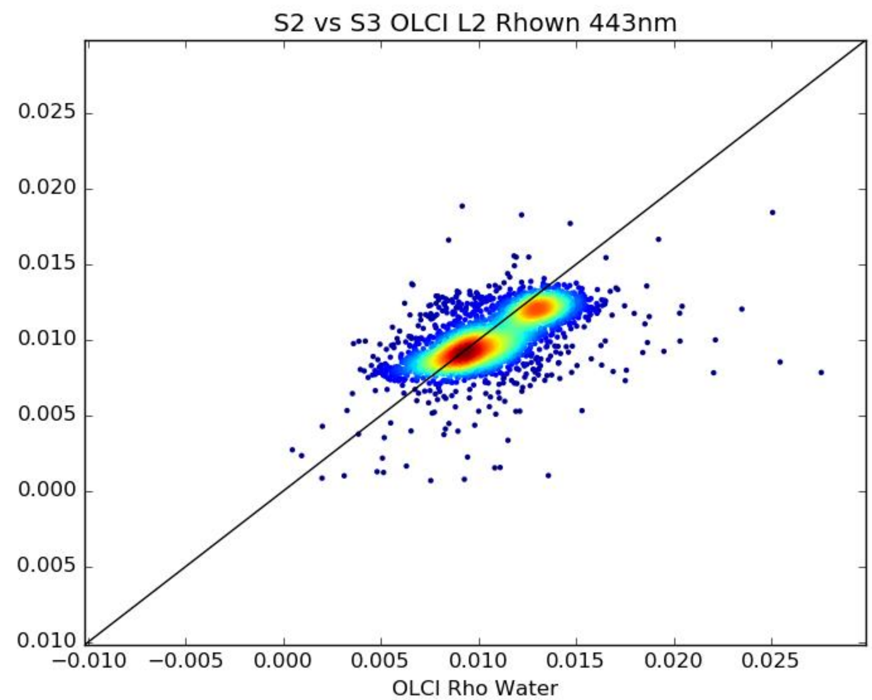
Comparisons with OLCI OL2

20160824 Venice Laguna





L1 **ρTOA** OLCI vs S2

L2 **ρw** OLCI vs S2

Without spectral adjustment

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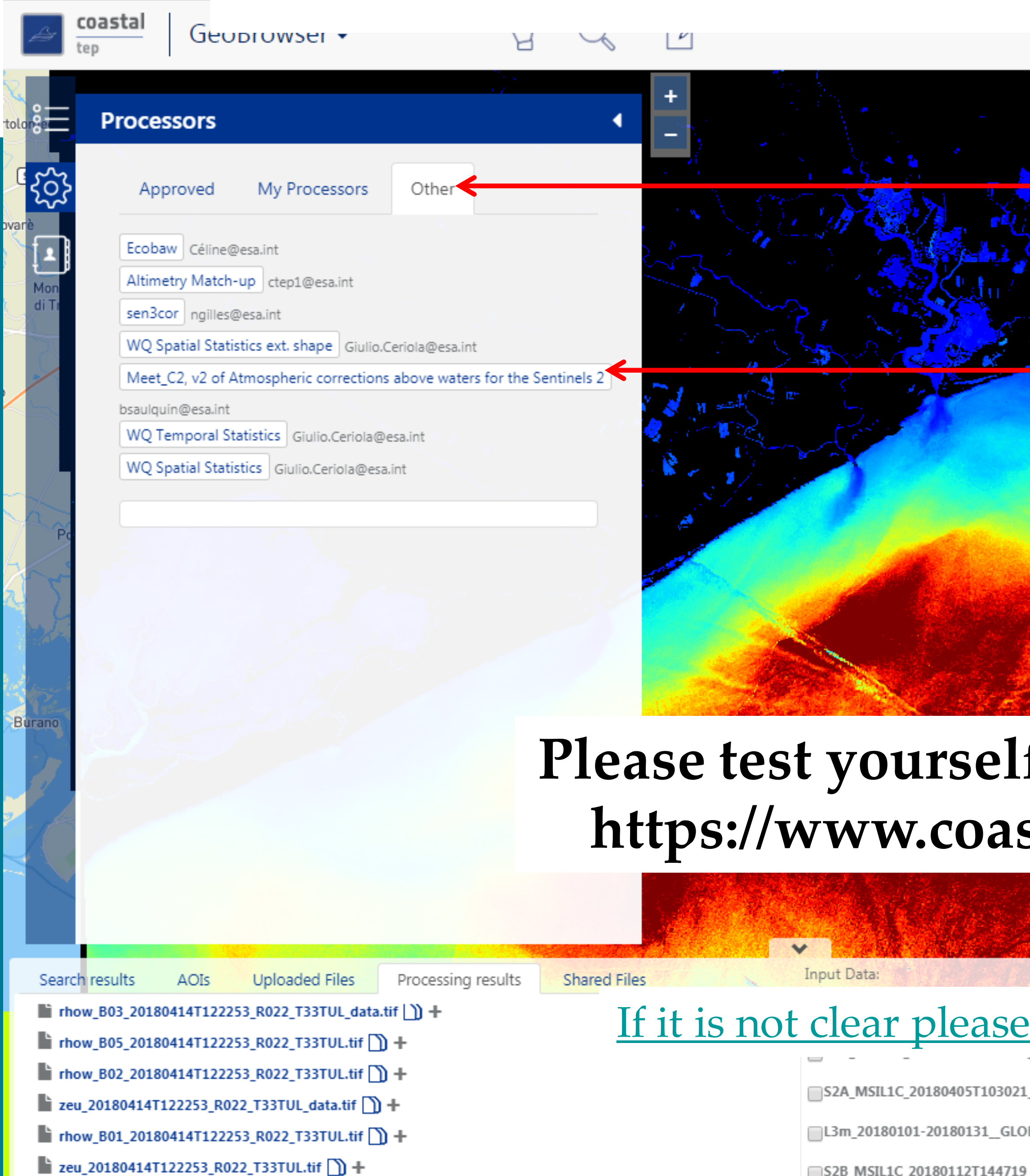
References

- ***Saulquin** B. et al. Multi-water & multi-scales atmospheric corrections for the Sentinels 2, In writing process.*
- ***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.*
- *Saulquin, B., Hamdi, A., Gohin, F., Populus, J., Mangin, A., & d'Andon, O. F. (2013). Estimation of the diffuse attenuation coefficient KdPAR using MERIS and application to seabed habitat mapping. Remote Sensing of Environment, 128, 224-233.*
- *Seinfeld, J. H., & Pandis, S. N. (2016). Atmospheric chemistry and physics: from air pollution to climate change. John Wiley & Sons.*
- *Ramon, D. et al., 2017 " Ocean-Atmosphere Polarized Radiative Transfer with the GPU-Accelerated SMART-G*
- *Monte Carlo Code", J. Quant. Spec. Rad. TransferChami, M., Lafrance, B., Fougnie, B., Chowdhary, J., Harmel, T., & Waquet, F. (2015). OSOAA: a vector radiative transfer model of coupled atmosphere-ocean system for a rough sea surface application to the estimates of the directional variations of the water leaving reflectance to better process multi-angular satellite sensors data over the ocean. Optics express, 23(21), 27829-27852.*

MeetC2 available onto the Costal TEP Web facility



1: select the good tab

2: the good processor

Please test yourself the MEETC2 algorithm: https://www.coastal-tep.eu/geobrowser/

If it is not clear please contact bertrand.saulquin@acri-st.fr