Challenges in Atmospheric Correction and Vicarious Calibration

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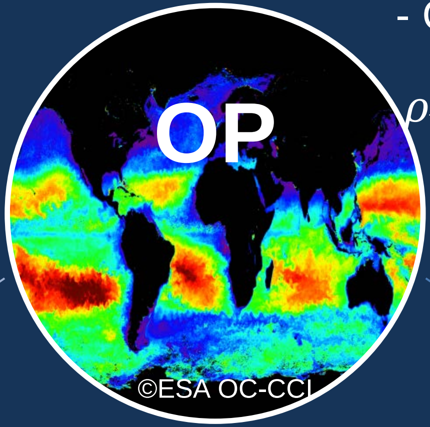
Content

- Calibration and validation of Ocean Colour Radiometry - **OCR**

- Consistency of the overall process comprising
  - Vicarious calibration - **VCAL**
  - Validation - **VAL**
  - Mission operation – **OP**

- Standard atmospheric correction: Gordon & Wang, Antoine & Morel

Integrated view on VCAL/VAL/OP



- Global maps of OCR & uncertainty

$$\rho_w(\lambda) = \frac{\bar{g}(\lambda) \cdot \rho_{gc}(\lambda) - \rho_{path}(\lambda)}{t(\lambda)}$$

- One or a few optimal site(s)
- FRM of ρ_w^t

$$g(\lambda) = \frac{t(\lambda)\rho_w^t(\lambda)\ + \rho_{path}(\lambda)}{\rho_{gc}(\lambda)}$$

$$= 1 - \frac{\Delta\rho_w}{\rho_w^t} \cdot \frac{t\rho_w^t}{\rho_{gc}}(\lambda)$$

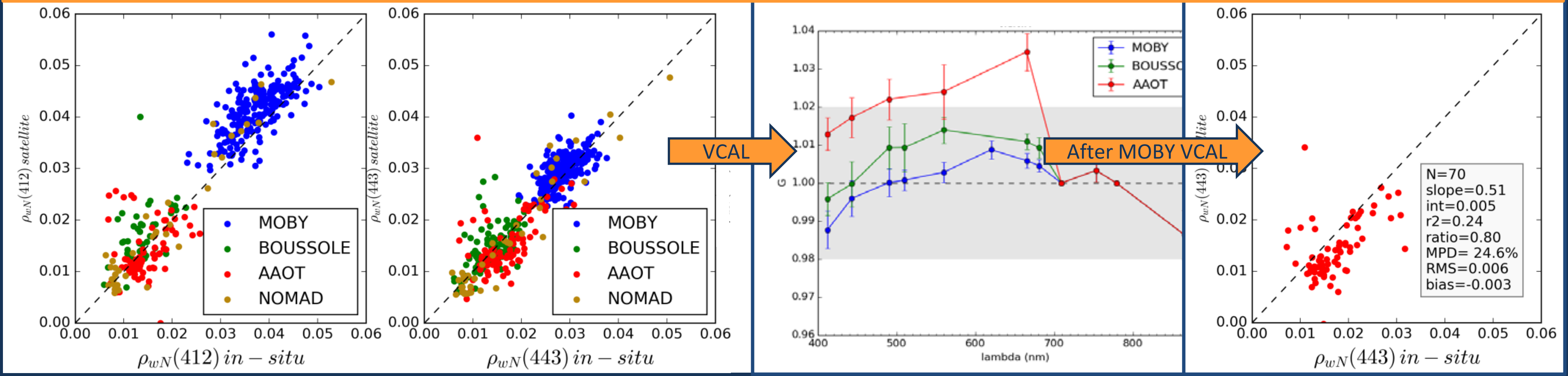
- Dataset of points over the ocean
- FRM of ρ_w^t and possibly AOT

$$\frac{\Delta\rho_w}{\rho_w^t}(\lambda) = \frac{\rho_w(\lambda) - \rho_w^t(\lambda)}{\rho_w^t(\lambda)}$$

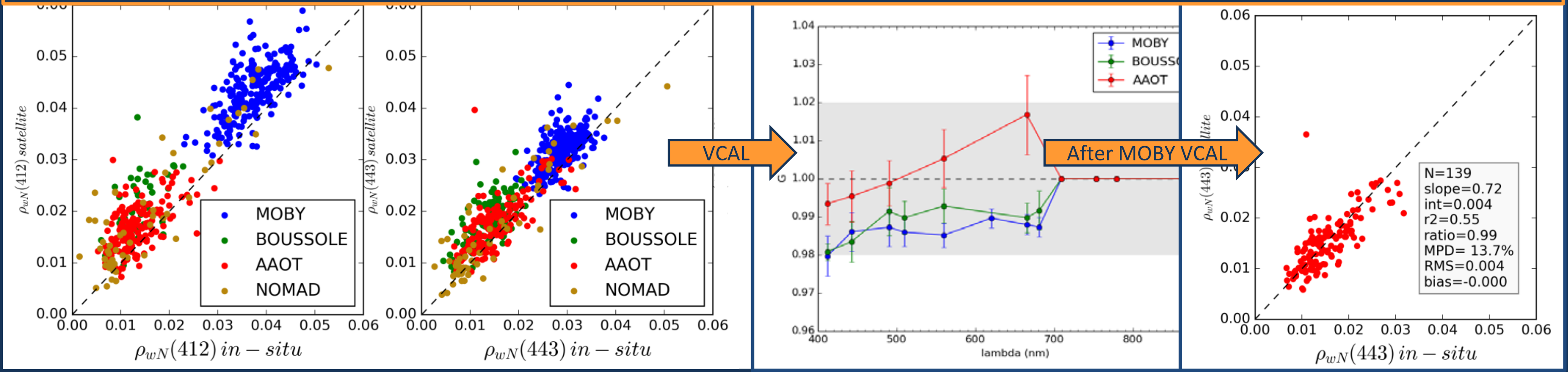
Consistency ?

Example: MERIS 3rd reprocessing

MERIS 3RP



MERIS 3RP + improved Bright Pixel Atmospheric Correction (BPAC)



G. Moore, C. Mazeran, J-P. Huot (2017). MERIS Bright Pixel Atmospheric Correction. MERIS ATBD 2.6 – *Also in use for OLCI*

Error and uncertainty in OCR

- For **VAL**, in terms of relative error on ρ_w:

$$\frac{\Delta\rho_w}{\rho_w^t} = \left(\frac{\Delta\rho_{gc}}{\rho_{gc}}\cdot\frac{\rho_{gc}}{t\rho_w^t} - \frac{\Delta\rho_{path}}{\rho_{path}^t}\cdot\frac{\rho_{path}^t}{t\rho_w^t} - \frac{\Delta t}{t^t}\right)\Big/\left(1+\frac{\Delta t}{t^t}\right)$$

calibration

AC

- For **OP**, in terms of relative uncertainty on ρ_w (cf. GUM):

$$\left(\frac{u(\rho_w)}{\rho_w}\right)^2 \approx \left(\frac{u(\rho_{gc})}{\rho_{gc}}\right)^2\cdot\left(\frac{\rho_{gc}}{t\rho_w}\right)^2 + \left(\frac{u(\rho_{path})}{\rho_{path}}\right)^2\cdot\left(\frac{\rho_{path}}{t\rho_w}\right)^2 + \left(\frac{u(t)}{t}\right)^2$$

$$+2\,\frac{u(\rho_{path},t)}{t\rho_{path}}\cdot\left(\frac{\rho_{path}}{t\rho_w}\right)^2$$

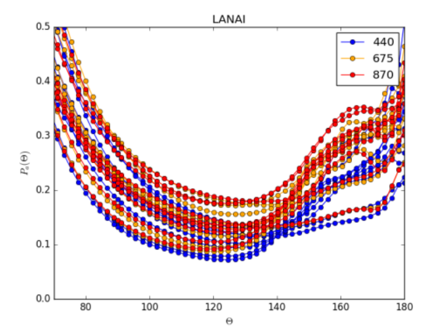
- For **VCAL**, in terms of uncertainty on gains:

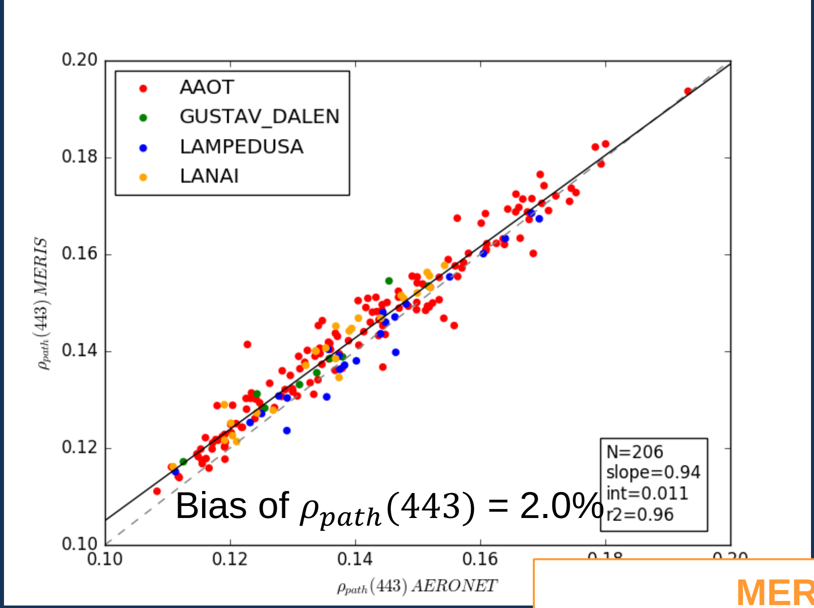
$$u(g) \approx \frac{t\rho_w^t}{\rho_{gc}}\sqrt{\left(\frac{u(\rho_w^t)}{\rho_w^t}\right)^2 + \left(\xcancel{\frac{u(\rho_{path})}{\rho_{path}}}\right)^2\cdot\left(\frac{\rho_{path}}{t\rho_w^t}\right)^2 + \left(\xcancel{\frac{u(t)}{t}}\right)^2 + 2\,\xcancel{\frac{u(\rho_{path},t)}{t\rho_{path}}}\cdot\left(\frac{\rho_{path}}{t\rho_w^t}\right)^2}$$

by principle of System Vicarious Calibration

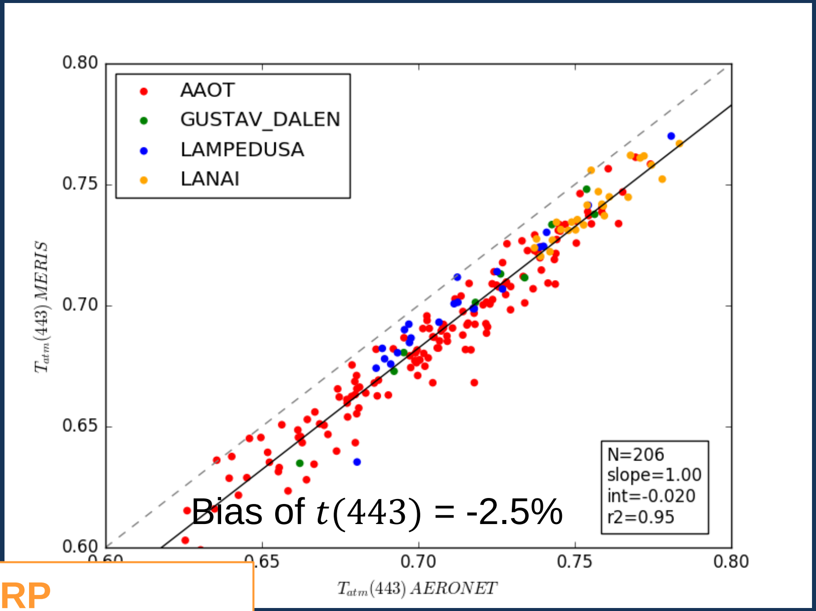
Error in atm. scattering functions

- **AERONET aerosol IOPs** (phase function, single scattering albedo, extinction coefficient) from inversion of solar extinction and sky radiance – Limited in bands.
- **Radiative transfer model** applied to MERIS acquisition matching AERONET: temporal interpolation or Δt < 3h, no glint, no cloud or ice haze, no PCD flags → $\boldsymbol{\rho^{t}_{path}}$ and $\boldsymbol{t^{t}}$





Bias of $\rho_{path}(443)$ = 2.0%



Bias of $t(443)$ = -2.5%

MERIS 3RP

Error in atm. scattering functions

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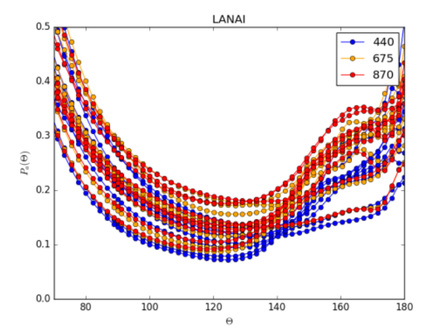
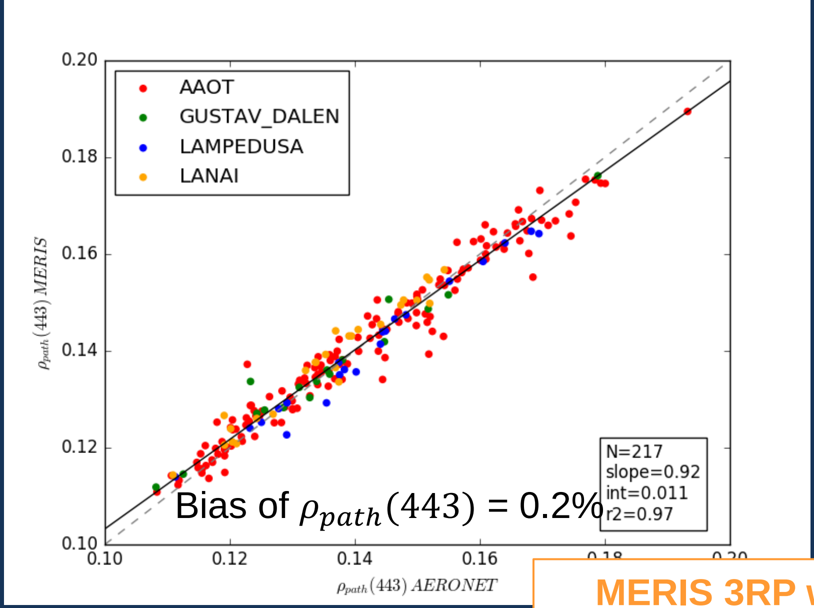
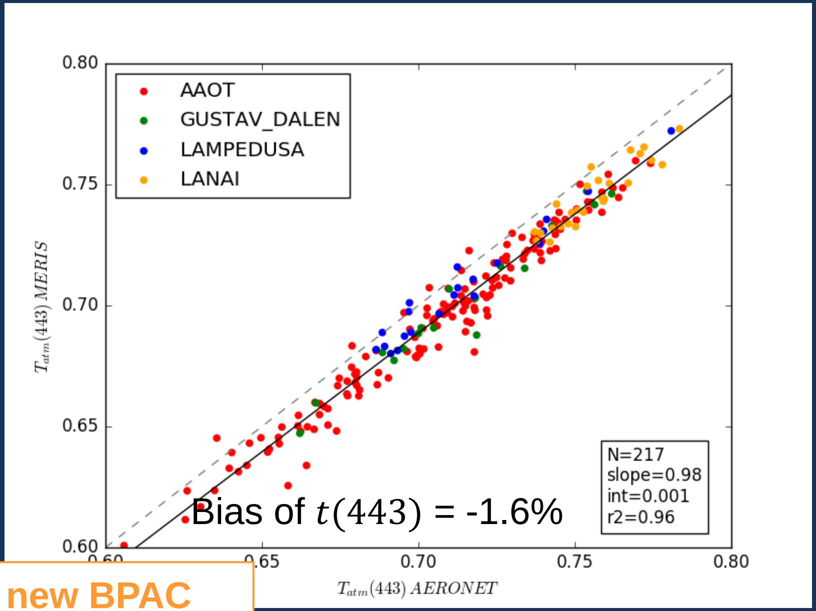




Bias of $\rho_{path}(443)$ = 0.2%



Bias of $t(443)$ = -1.6%

MERIS 3RP with new BPAC

Consistency in atm. & marine error?

- Can we achieve consistency between uncertainty provided by ρ_{path}^t, t^t (AERONET) and uncertainty provided by in situ ρ_w^t?

$$\frac{\Delta\rho_w}{\rho_w^t} = \left(\frac{\Delta\rho_{gc}}{\rho_{gc}}\cdot\frac{\rho_{gc}}{t\rho_w^t} - \frac{\Delta\rho_{path}}{\rho_{path}^t}\cdot\frac{\rho_{path}^t}{t\rho_w^t} - \frac{\Delta t}{t^t}\right)\Big/\left(1+\frac{\Delta t}{t^t}\right)$$

In situ ρ_w^t

=1-g

AERONET

LANAI – λ = 443 nm

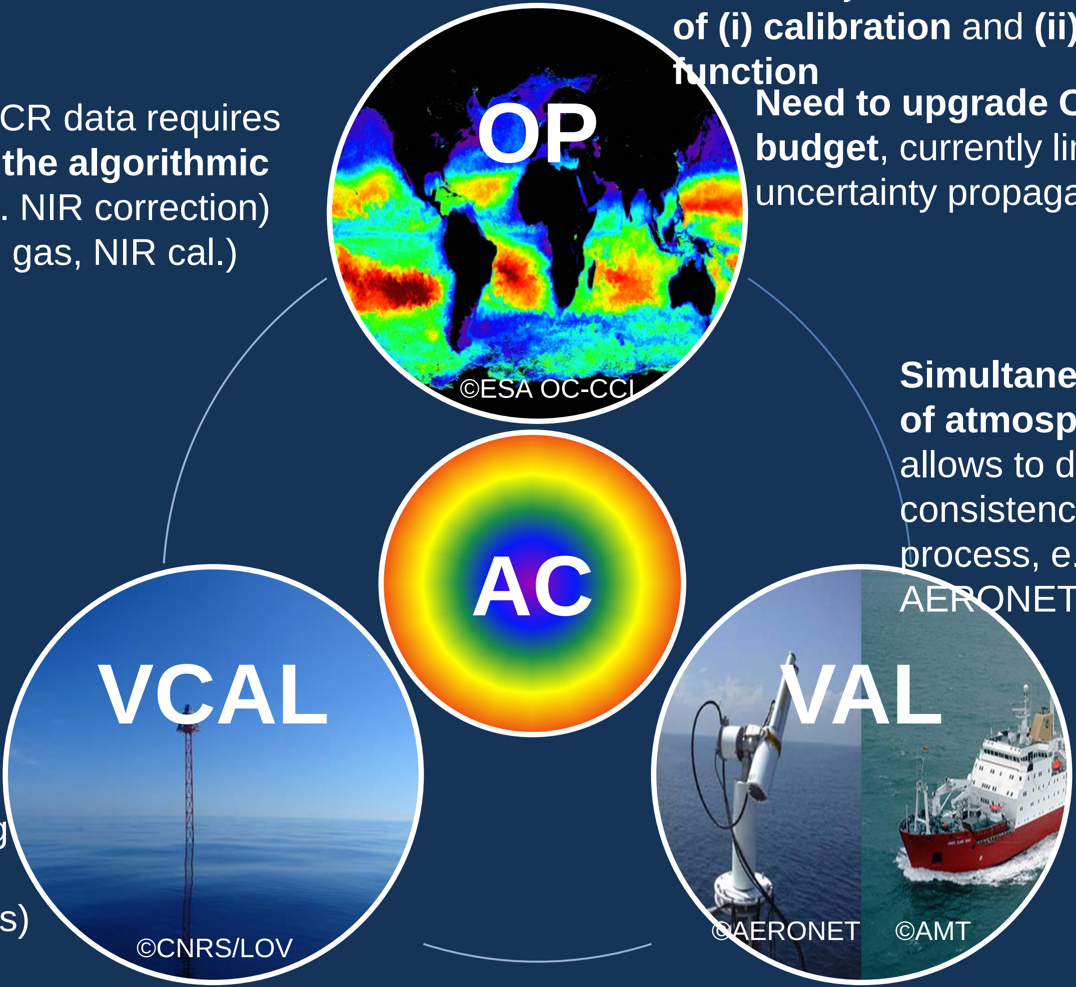
	MOBY	**AERONET and g=0.975**
Mean rel. diff.	1%	2%
Mean abs. rel. diff.	7%	9%
RMS	3.1 10^{-3}	3.5 10^{-3}

AAOT – λ = 443 nm

	AERONET-OC	**AERONET and g=0.996**
Mean rel. diff.	-13%	-12%
Mean abs. rel. diff.	16%	22%
RMS	4.8 10^{-3}	6.1 10^{-3}

MERIS 3RP

Conclusion



Uncertainty of OCR is related to **uncertainty of (i) calibration** and **(ii) atm. scattering function**

Need to upgrade OLCI uncertainty budget, currently limited to radiometric uncertainty propagation (noise)

Producing consistent OCR data requires an **integrated view on the algorithmic chain**: VCAL + AC (incl. NIR correction) + upstream steps (glint, gas, NIR cal.)

Simultaneous measurements of atmospheric IOP + OCR allows to demonstrate the consistency of the overall process, e.g. AERONET + AERONET-OC

Robustness of AC is critical to benefit globally from VCAL

Assessing atm. scattering function is valuable to select optimal VCAL site(s)

Thank you

Acknowledgment:

- **Francis Zagolski, `sol√o`:** Radiative transfer model
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- **David Antoine, LOV:** BOUSSOLE data
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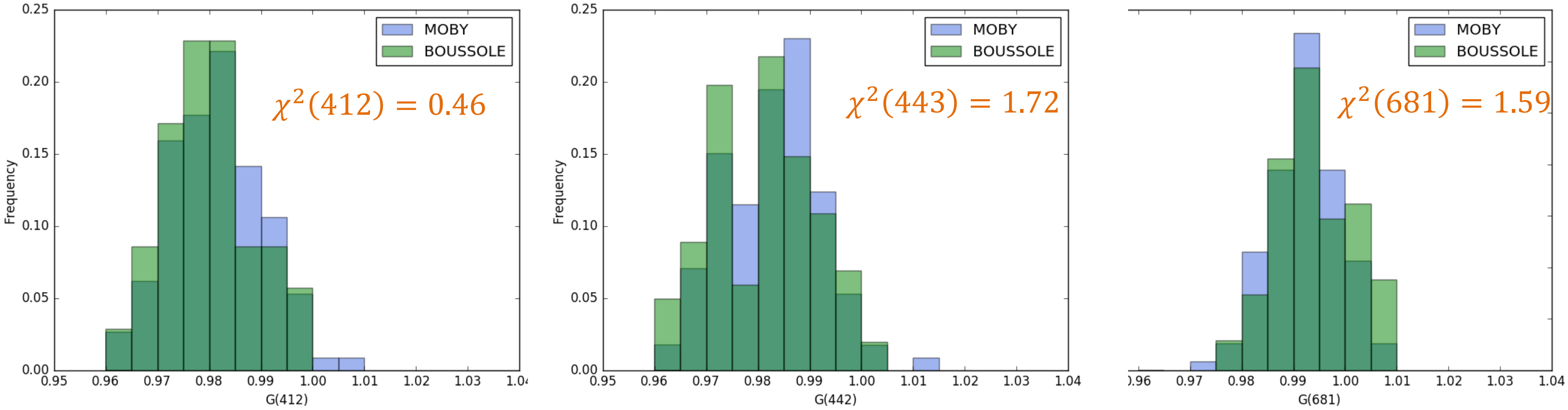
esa SPPA
Sensor Performance, Products and Algorithms

JRC
EUROPEAN COMMISSION

Consistency in MERIS 4th reproc.

- Various improvements achieved by MERIS QWG (L1b, classif, BPAC, AC …)
- MOBY and BOUSSOLE gains agreement: Chi2 test of homogeneity: if $\frac{|\bar{g}_M-\bar{g}_B|}{\sqrt{\sigma_M^2/N_M+\sigma_B^2/N_B}} < 1.96$, there is 95% probability that both sets of gains belong to the same distribution



$\chi^2(412) = 0.46$

$\chi^2(443) = 1.72$

$\chi^2(681) = 1.59$