Joint Research Centre

UNIVERSITY OF MIAMI

NIST

Spectral Resolution Requirements for Ocean Color System Vicarious Calibration

G. Zibordi[(1)], M. Talone[(1)], K. Voss[(2)] & B. C. Johnson[(3)]

[(1)] Joint Research Centre, Ispra, Italy

[(2)] University of Miami, Coral Gables, FL

[(3)] National Institute of Standards and Technology, Gaithersburg, MD

Background literature :

G.Zibordi, M. Talone K.J. Voss, B.C. Johnson. ***Impact of spectral band differences in matchups analyses of satellite and in situ ocean color radiometric data***. *Remote Sensing of Environment*, submitted, 2017.

B.C. Johnson, S. Flora, S. Brown, D. Clark, M. Yarbrough, and K, Voss (2007). ***Spectral Resolution Requirements for Vicarious Calibration of Ocean Color Satellites.*** Ocean Color Research Team Meeting, Seattle, April 11 (available at http://oceancolor.gsfc.nasa.gov/cms/DOCS/ScienceTeam/OCRT_Apr2007/Posters/).

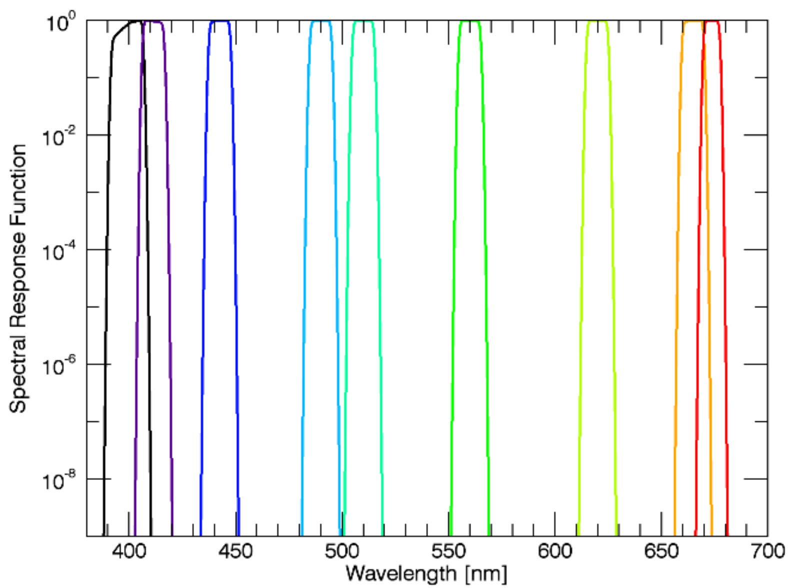
S. Flora, S. Brown and B.C. Johnson C. (2006). ***MOBY/AHAB wavelength resolution.*** White Paper presented at the MOBY/AHAB Review meeting of July 18, 2006.

Introduction

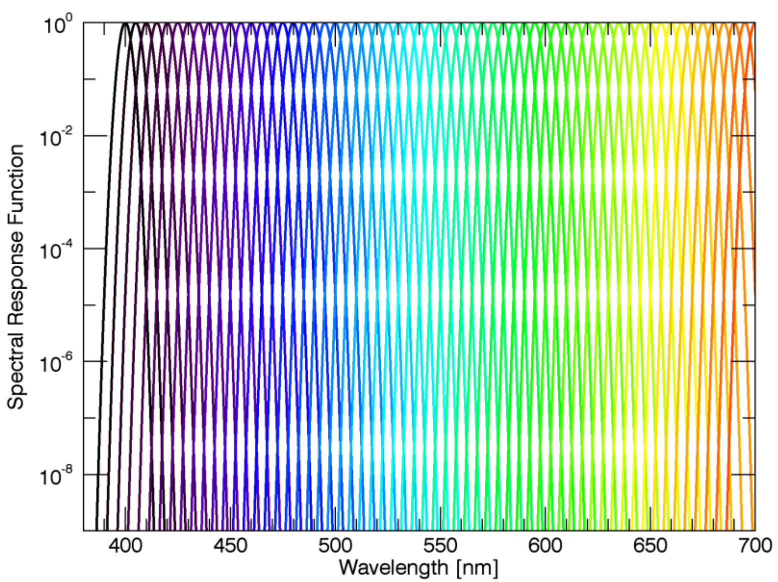
The work aims at evaluating the impact of spectral resolution of in situ radiometric data in the determination of R_{RS} at bands representative of ocean colour sensors: OLCI and PACE.

PACE-like bands have been ideally defined assuming 5 nm bandwidth, Gaussian spectral response functions, and 5 nm spectral sampling interval. This solution leads to an oversampling of R_{RS} spectra with respect to the future PACE capabilities.

The analysis is restricted to the 380–700 nm spectral region and rely on in situ reference R_{RS} from MOBY with a bandwidth $\Delta\lambda_B$ of 1 nm and a spectral sampling interval $\Delta\lambda_C$ of ~0.6 nm.

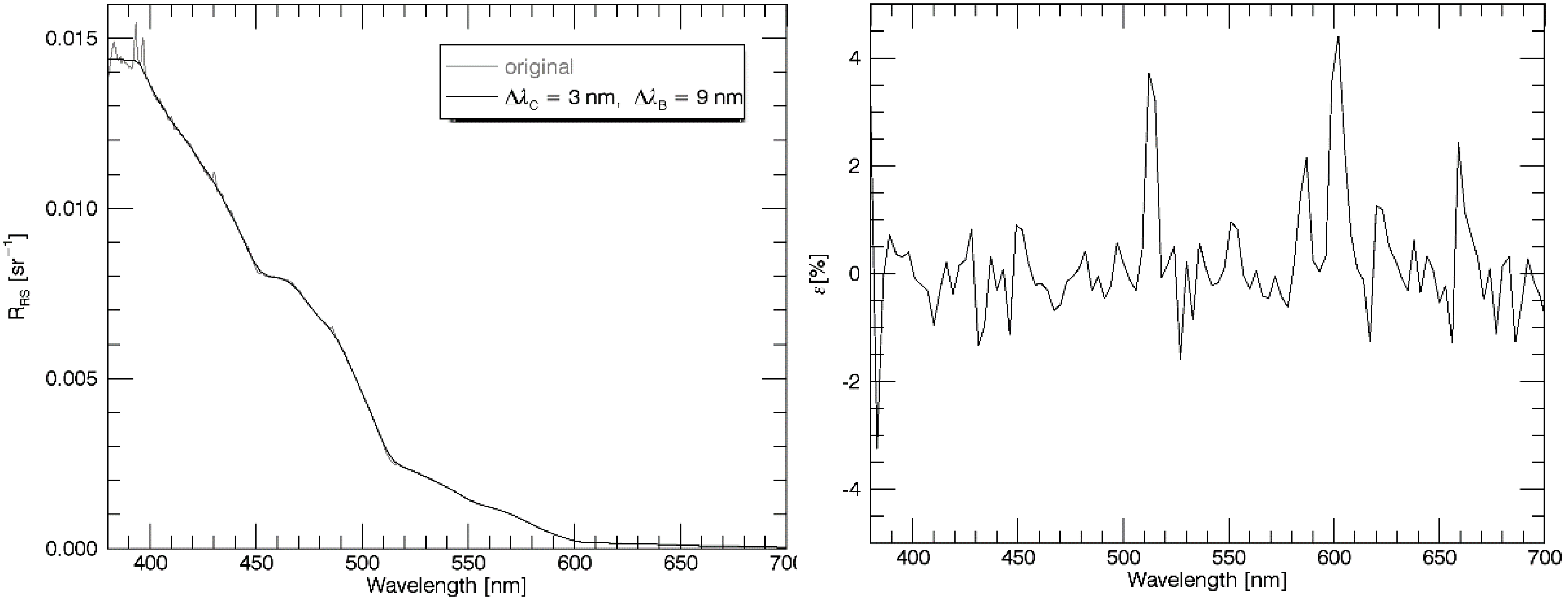


OLCI bands



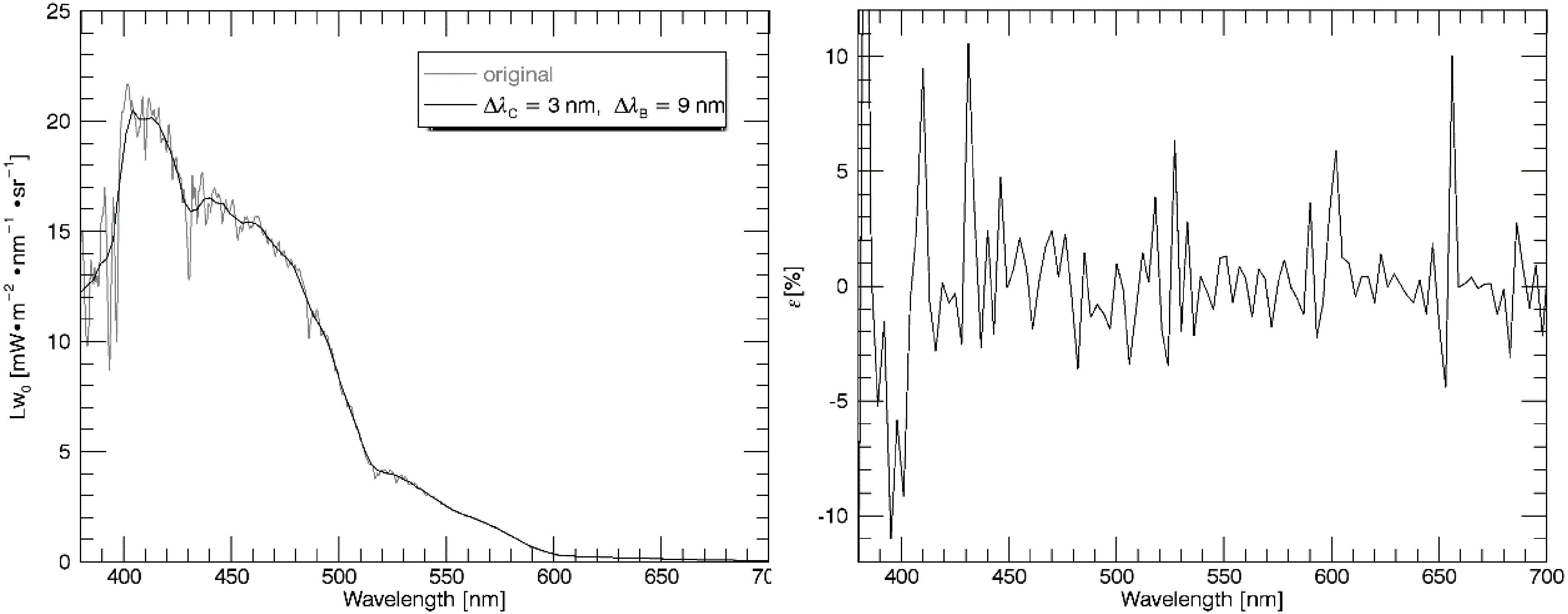
PACE-like bands

Reference R_{RS} data



MOBy original (grey line) and spectrally degraded R_{RS} data (black line) determined with $\Delta\lambda_C$ = 3 nm and $\Delta\lambda_B$ = 9 nm (*left panel*), and percent differences ε between degraded and the original high resolution spectra (*right panel*).

Reference L_W data



MOBy original (grey line) and spectrally degraded L_W data (black line) determined with $\Delta\lambda_C$ = 3 nm and $\Delta\lambda_B$ = 9 nm (*left panel*), and percent differences ε between degraded and the original high resolution spectra (*right panel*).

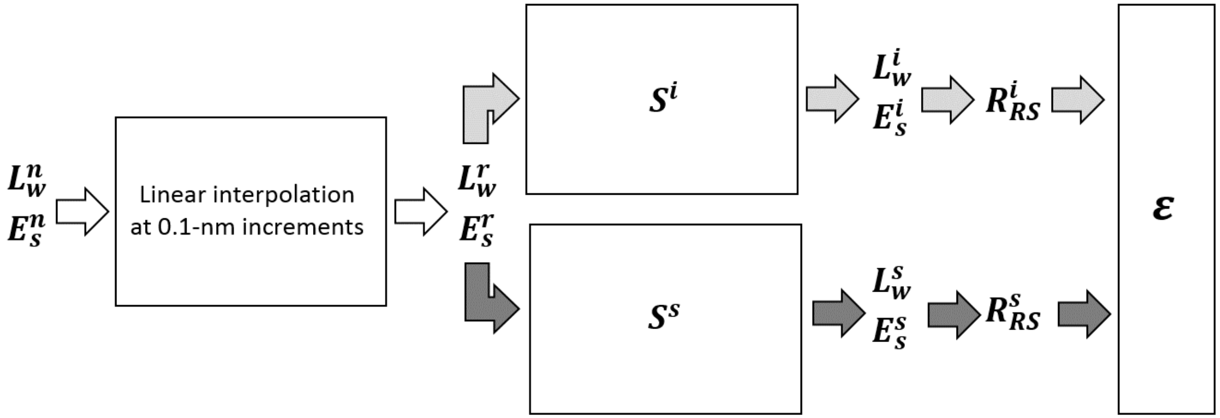
In summary

MOBy full resolution reference spectra have been applied to compute "exact" satellite R_{RS} for both OLCI and PACE-like bands, and additionally, to compute reduced resolution R_{RS} for ideal in situ multispectral and hyperspectral radiometers characterized by Gaussian spectral response, various bandwidths $\Delta\lambda_B$ and (for hyperspectral data only) different sampling intervals $\Delta\lambda_C$.

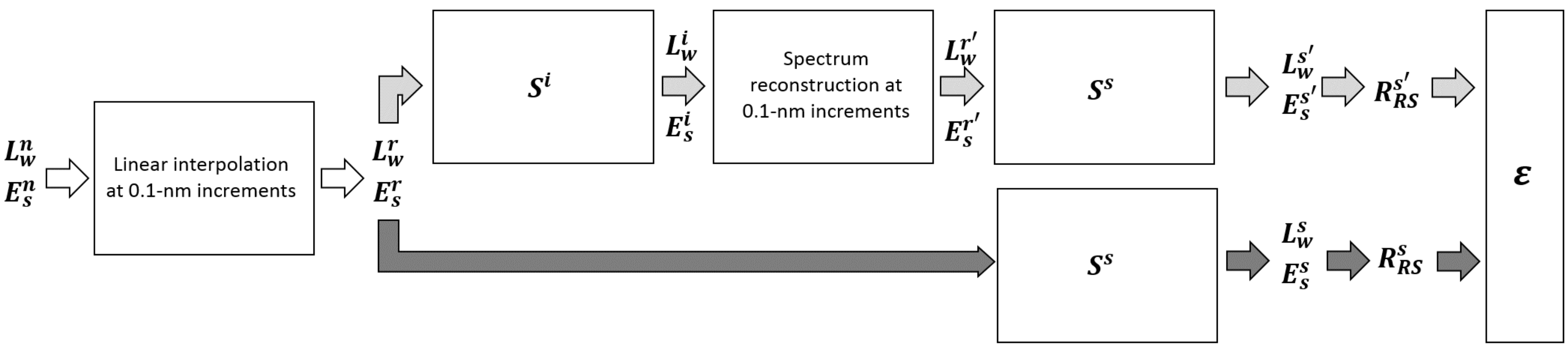
These reduced resolution spectra have then been used to determine "equivalent" satellite R_{RS}. Percent differences ε between "equivalent" and "exact" R_{RS} determined for OLCI or PACE-like bands from reduced and full resolution in situ spectra, respectively, allow drawing conclusions on spectral resolution requirements for in situ radiometry supporting SVC.

$$\epsilon(k) = 100\,\frac{R_{RS}^{Equiv}(k) - R_{RS}^{Exact}(k)}{R_{RS}^{Exact}(k)}$$

Data analysis

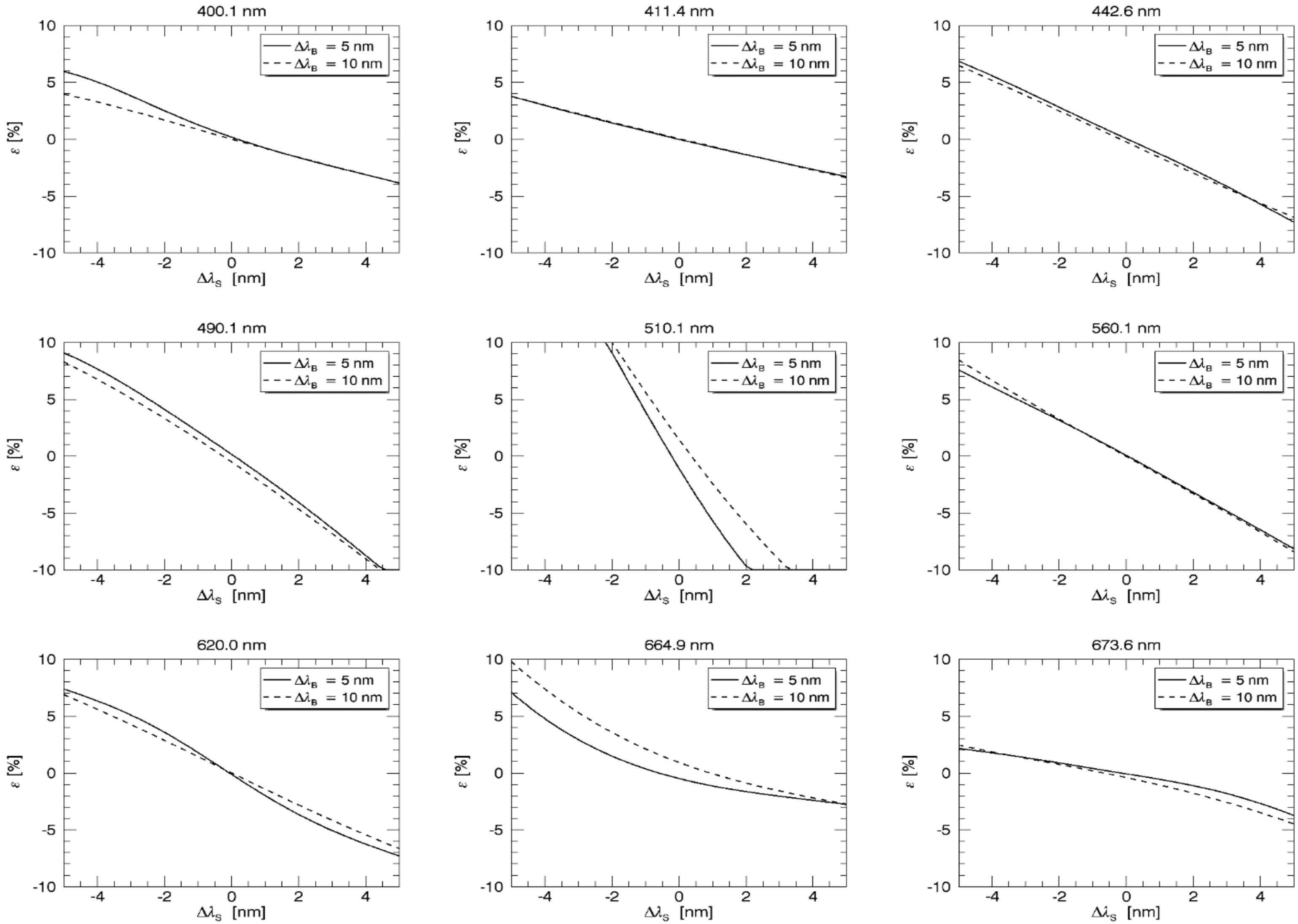


Multispectral matching scheme: in situ $R_{RS}{}^{i}$ are directly compared with satellite reference $R_{RS}{}^{s}$, both derived from $L_w{}^{r}$ and $E_s{}^{r}$ hyperspectral values accounting for the relative spectral response functions of sensors, S^i and S^s, respectively. The comparison is indicated by ε.



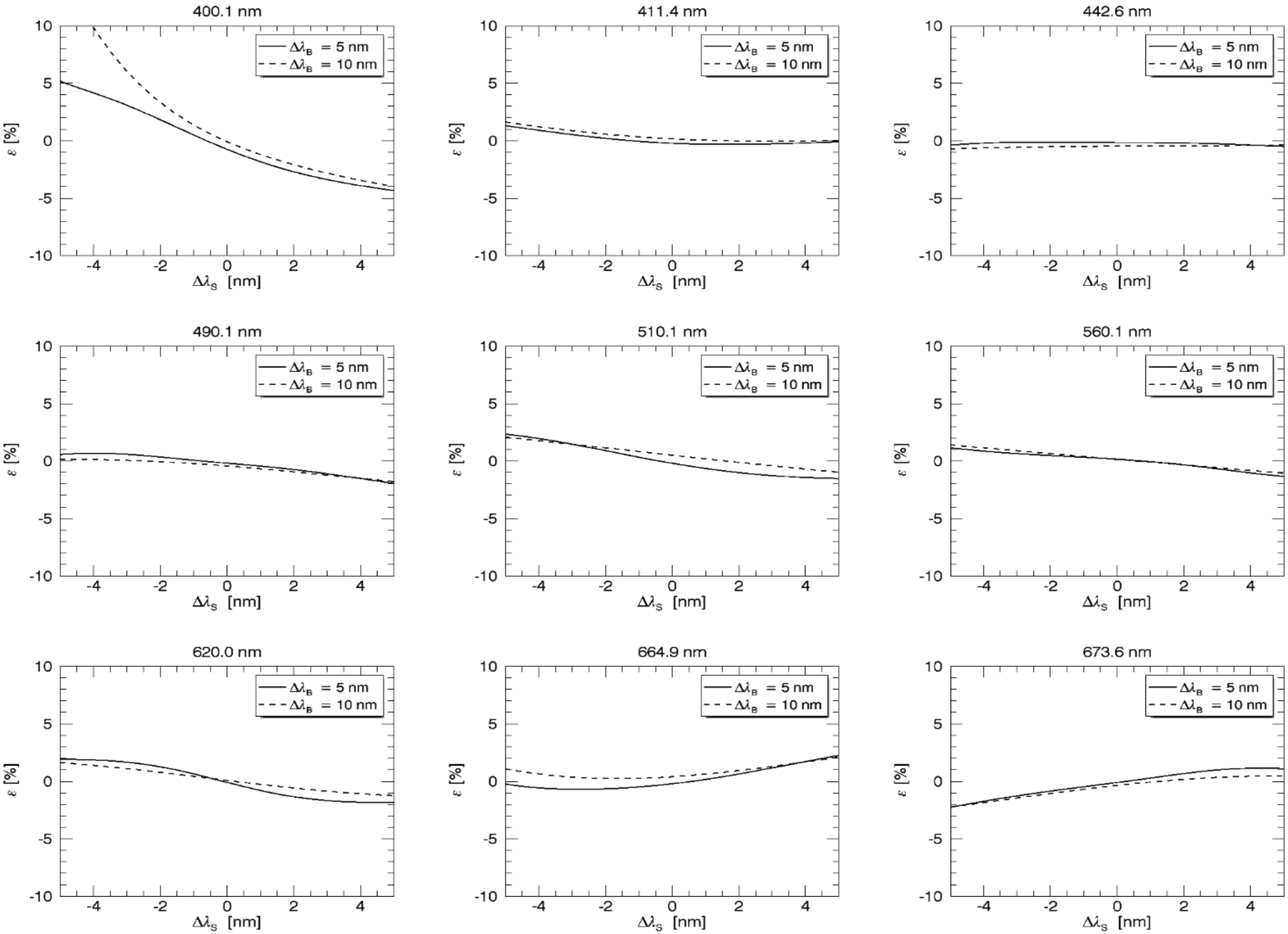
Hyperspectral matching scheme: satellite-equivalent $R_{RS}{}^{s'}$ values derived from in situ hyperspectral reconstructed $L_w{}^{r'}$ and $E_s{}^{r'}$ values accounting for the relative spectral response functions of the in situ and satellite sensors (i.e., S^i and S^s), are compared with satellite reference $R_{RS}{}^{s}$ values solely derived from $L_w{}^{r}$ and $E_s{}^{r}$ hyperspectral values accounting for S^s.

In situ multispectral



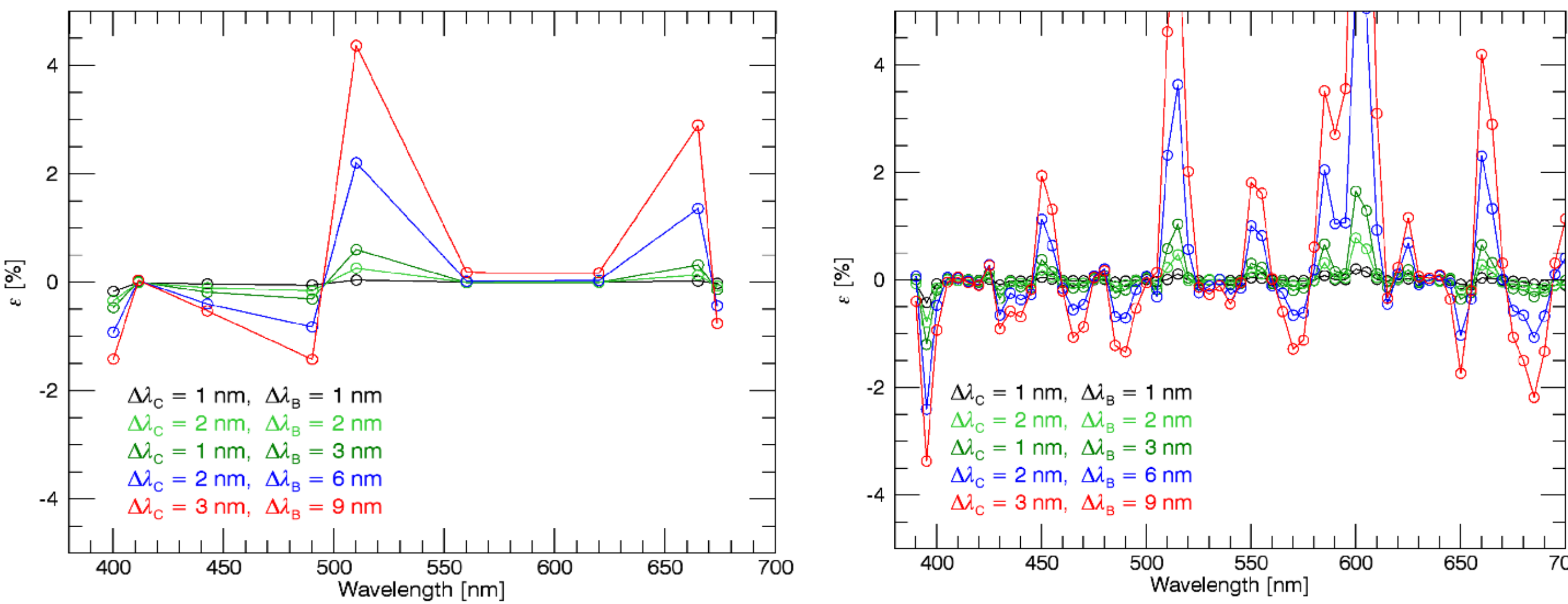
Percent differences ε between OLCI and multispectral in situ R_{RS}. The values of ε are displayed at the OLCI bands as a function of the shift in center-wavelength $\Delta\lambda_S$ between the satellite and the in situ multispectral spectral bands for two bandwidths $\Delta\lambda_B$ (i.e., 5 nm and 10 nm) of the in situ multispectral sensor.

In situ multispectral after band-shift



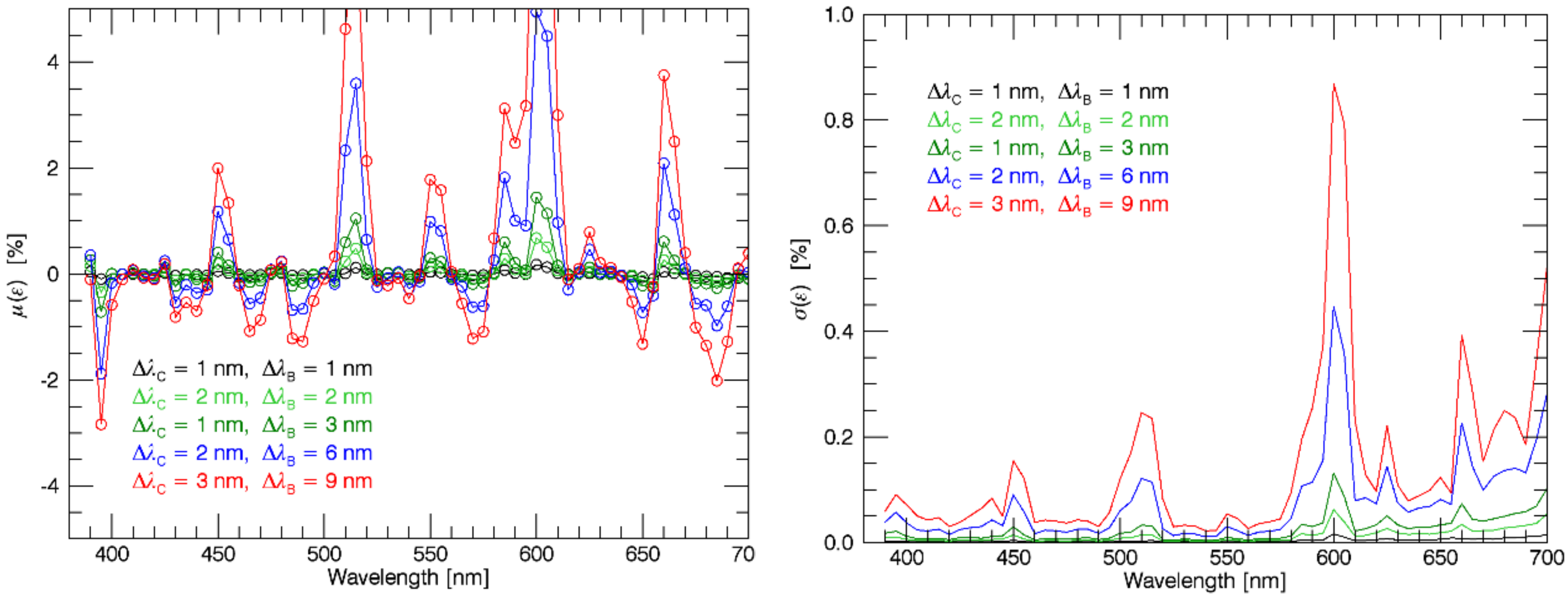
Percent differences ε between OLCI and multispectral in situ R_{RS} band-shifted. The values of ε are displayed at the OLCI bands as a function of the shift in center-wavelength $\Delta\lambda_S$ between the satellite and the in situ multispectral spectral bands for two bandwidths $\Delta\lambda_B$ (i.e., 5 nm and 10 nm) of the in situ multispectral sensor.

In situ hyper-spectral



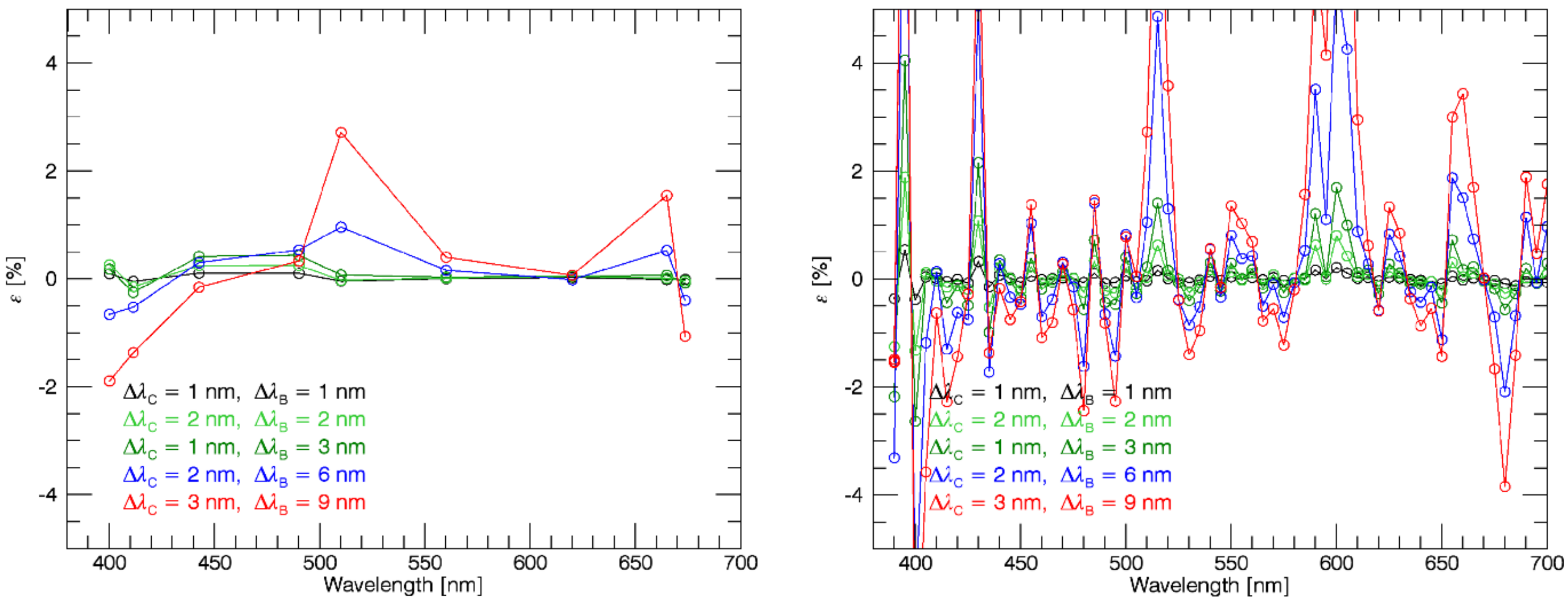
Percent differences ε between "equivalent" and "exact" R_{RS} determined for OLCI (*left panel*) or PACE-like (*right panel*) bands. Different colours refer to results for various bandwidths $\Delta\lambda_B$ and spectral sampling intervals $\Delta\lambda_C$ of the in situ hyperspectral sensor.

In situ hyper-spectral (representativity)



Mean μ and standard deviation σ values of percent differences ε *between the PACE-like and hyperspectral in situ* R_{RS}, *determined with 103 MOS spectra from May 15 to August 28, 2015.*

In situ hyper-spectral: L_W



Percent differences ε between "equivalent" and "exact" L_W determined for OLCI (*left panel*) or PACE-like (*right panel*) bands. Different colours refer to results for various bandwidths $\Delta\lambda_B$ and spectral sampling intervals $\Delta\lambda_C$ of the in situ hyperspectral sensor.

Conclusions

Assuming a percent difference ε < 0.5% in the blue-green spectral regions between "exact" and "equivalent" R_{RS} from full and reduced resolution spectra, requirements can be determined for the spectral resolution of in situ radiometric measurements satisfying uncertainty and stability needs for SVC.

The following conclusions for SVC applications are drawn relying on R_{RS} with a spectral sampling interval close or lower than half the spectral resolution (i.e., $\Delta\lambda_C \lesssim \Delta\lambda_B/2$) for in situ hyperspectral radiometers:

- *A spectral resolution better than 3 nm is required* to support *multispectral satellite sensors* (such as OLCI).
- *A spectral resolution better than 1 nm is devised* to support *hyperspectral satellite sensors* (such as PACE).

A lower ε would imply more stringent requirements on spectral resolution of the in situ hyperspectral sensors. Additionally, the use of L_W instead of R_{RS}, also increases requirements ultimately indicating the need for sub-nanometer resolutions in the blue spectral region for hyperspectral satellite sensors such as PACE.