OPERA : AN ATMOSPHERIC CORRECTION FOR LAND AND WATER

Sindy Sterckx [(1)], Els Knaeps [(1)], Stefan Adriaensen [(1)], Ils Reusen [(1)], Liesbeth De Keukelaere [(1)], Peter Hunter [(2)], Claudia Giardino [(3)], Daniel Odermatt [(4)]

[(1)]VITO, Boeretang 200, 2400 Mol, Belgium, Email: Sindy.sterckx@vito.be
[(2)]University of Stirling, Stirling, FK9 4LA, UK, Email: p.d.hunter@stir.ac.uk
[(3)]National Research Council , Department Remote Sensing, Milan, Italy, Email: giardino.c@irea.cnr.it
[(4)]Odermatt & Brockmann GmbH, CH-8005 Zurich , Switzerland, Email: daniel.odermatt@odermatt-brockmann.ch

ABSTRACT

Atmospheric correction is one of the most important part of the pre-processing of satellite remotely sensed data used to retrieve bio-geophysical paramters. In this paper we present the scene and sensor generic atmospheric correction scheme 'OPERA' allowing to correct both land and water areas in the remote sensing image.

OPERA can now be used to correct for atmospheric effects in scenes acquired by MERIS, Landsat-8, hyperspectral sensors and will be applicable to Sentinel-3 and Sentinel-2.

1. INTRODUCTION

The atmospheric correction of Sentinel-3 data over inland waters is a challenging issue. Typical ocean colour atmospheric correction algorithms are not appropriate for the correction of inland waters as 1) they neglect the (often) non-zero altitude of inland waters, 2) they assume a spatial homogenous background neglecting adjacency effects or 3) they make inadequate assumptions on the water leaving reflectance in Near-Infrared (NIR) to retrieve aerosol information. On the other hand, land atmospheric corrections usually consider a Lambertian surface and therefore don't take into account the contribution of the specular reflection at the air water interface.

The OPERA atmospheric correction scheme accounts for surface elevation variation, adjacency effects and for inland water targets also the non-Lambertian reflection of water surfaces. Through the use of a single atmospheric correction implementation discontinuities in the resulting reflectance between land and the highly dynamic water areas (such as turbid, tidal, shallow waters or macrophyte dominated waters) are reduced.

2. THE OPERA METHOD

The OPERA workflow is depicted in Fig. 1. The atmospheric correction parameters are derived from pre-calculated MODTRAN-5 Look-Up-Tables (LUTs) in function of among others sun and view geometry, aerosol optical depth, ozone, water vapour and elevation. The latter allows for an accurate Rayleigh correction over higher altitude areas.

The atmospheric correction requires information from the atmosphere such as on the aerosol and water vapor. The aerosol optical thickness (AOT) is derived from land through a TOA radiance inversion of selected end-members in the scene following the approach described in Guanter *et al.* (2007). Over water the AOT is retrieved through spatial extension of the derived values over neighbouring land pixels assuming local spatial invariability of the aerosol.

Water vapour can optionally be derived on a pixel-by-pixel basis for sensors having at least one spectral band situated within the water vapour absorption feature, and reference bands across the feature.

It is well known that the adjacency effect has to be taken into account during the retrieval of surface reflectance from satellite imagery especially for scenes with small heterogeneous irregular surfaced fields as light reflected from nearby surfaces can be forward scattered by the atmosphere into the sensor field of view. Over water the SIMEC (Sterckx et al., 2015) (SIMilarity Environment Correction) approach is used to calculate the contributing background or environment radiance assuming an invariant shape of the water leaving reflectance in the NIR. The approach was originally developed for the correction of hyperspectral airborne images acquired over inland and coastal waters (Sterckx et al., 2011). In Sterckx et al. (2015) the approach has been adapted for correction of MERIS data. Over land the background or environment radiance is determined by averaging the at-sensor radiance in an NxN window centered around the considered pixel.

The final step is the atmospheric correction following the algorithms originally given in de Haan and Kokke (1996). Over water surface an extra correction for the reflected skylight is made to retrieve the water leaving reflectance.

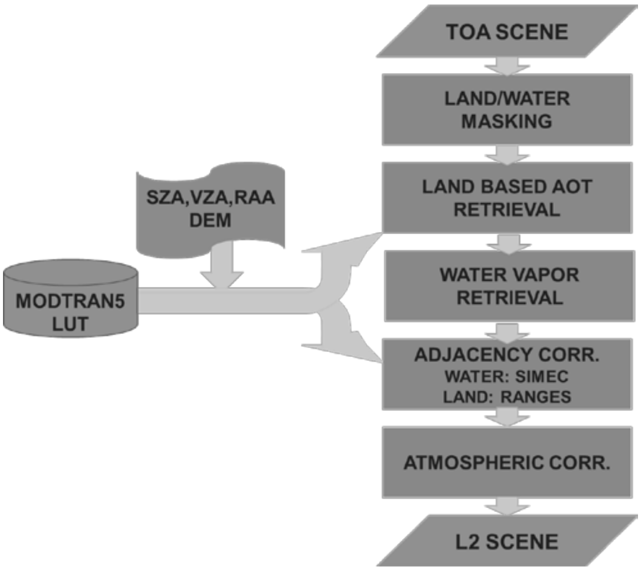

Figure 1. OPERA workflow.

3. VALIDATION RESULTS

The performance of OPERA has been evaluated on a series of scenes acquired by MERIS-ENVISAT and OLI (Operational land Imager) aboard Landsat-8 over (in-)land and coastal areas and compared to available in-situ measurements. The gain factors given in Pahlevan et al. (2014) for the enhancement of the OLI radiance data have been applied.

In Fig. 3 results of OPERA are given for a MERIS FR scene over Lake Zurich (Fig. 2). OPERA has been run with and without SIMEC adjacency correction. For comparison the neural network based Case 2 Regional (C2R) (version 1.5.1) MERIS atmospheric correction (Doerffer, 2011) is also applied with and without ICOL and compared to the proposed atmospheric correction scheme. Please note that previous C2R versions may give slightly different results (Odermatt et al., 2010)

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Figure 2. MERIS FR scene (subset) over Lake Zurich from August 15, 2007 with 3 in-situ measurement points.

In Fig. 5 we present results for an OLI scene from Lake Mantua, Italy (Fig. 4).

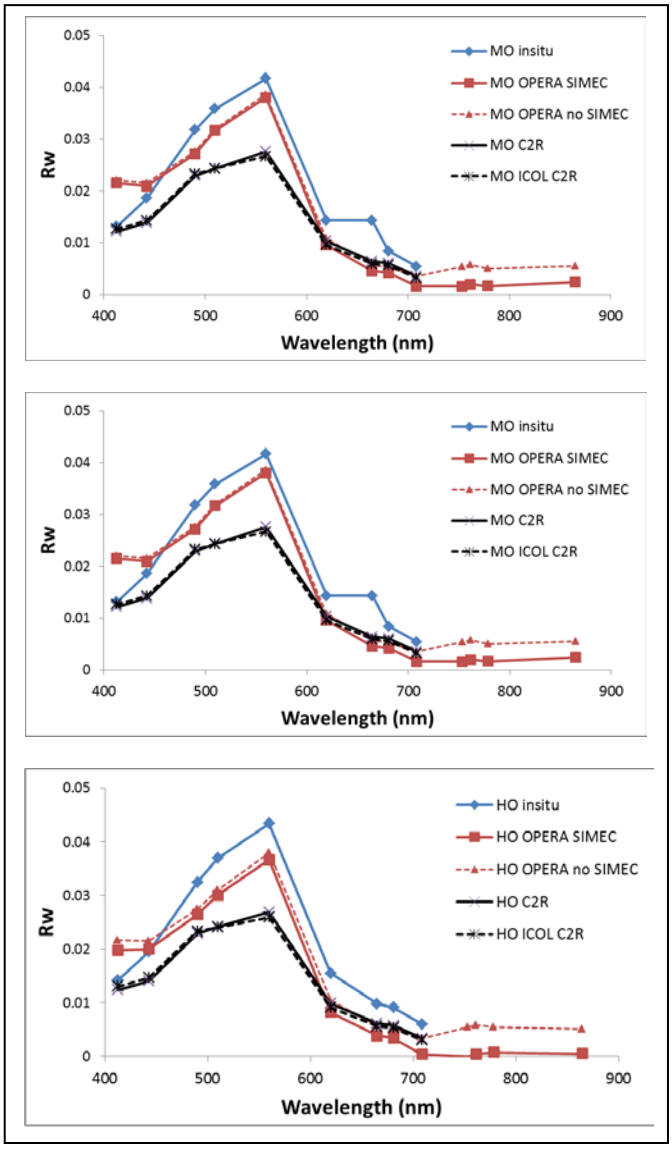
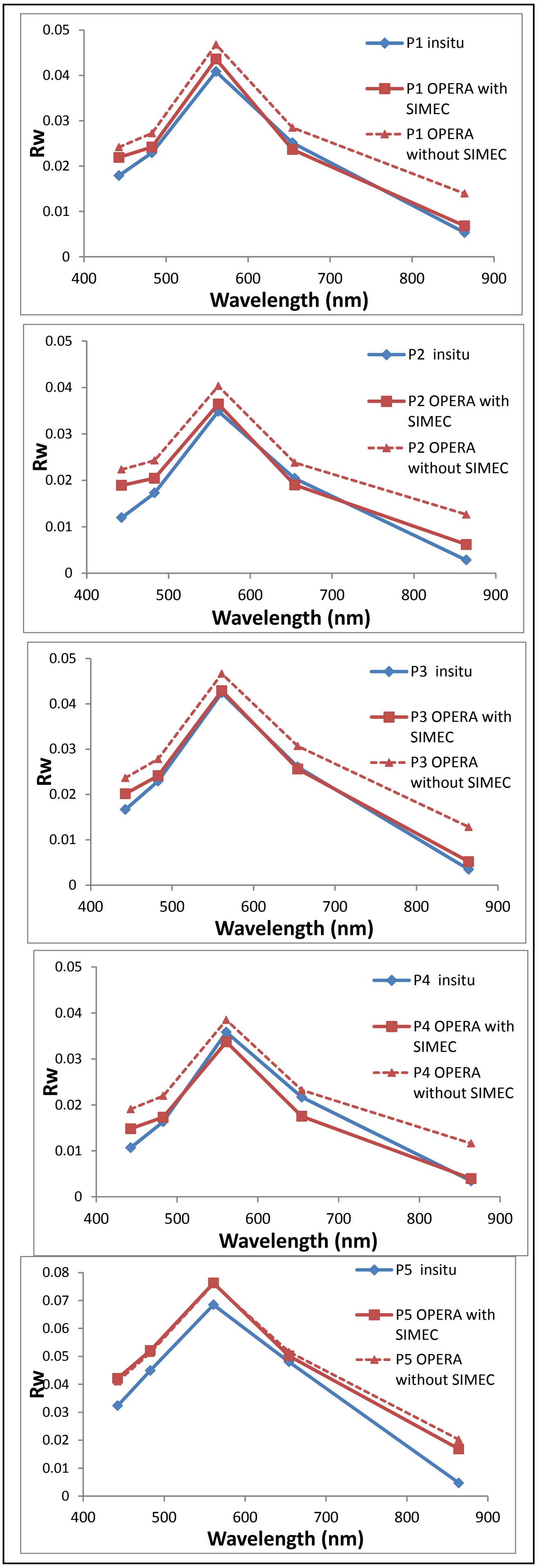


Figure 3. Comparison between in-situ and OPERA MERIS FR water leaving reflectance with and without SIMEC adjacency correction.

Figure 4. OLI scene (subset) Lake Mantua (Italy): OLI scene from September 23, 2014 with 7 in-situ measurement points.



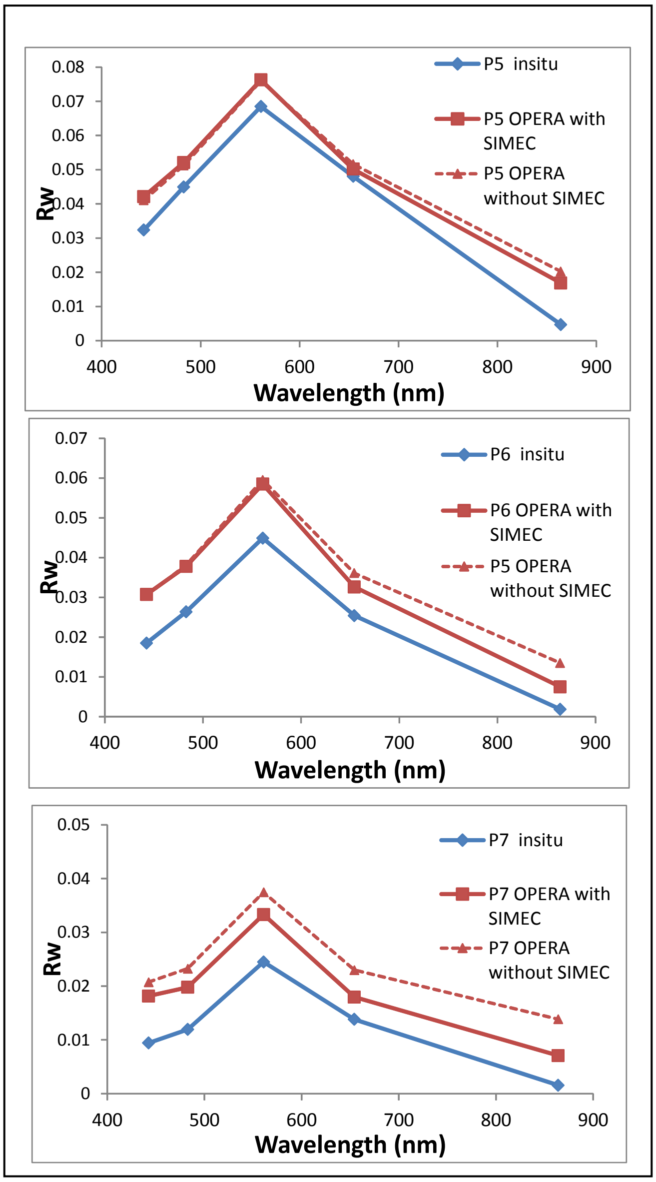


Figure 5. Comparison between in-situ and OPERA OLI water leaving reflectance with and without SIMEC adjacency correction.

4. CONCLUSIONS

OPERA is an operational scene and sensor-generic approach and can therefore directly be applied to existing and future satellite missions (such as Sentinel-3, Sentinel-2). The performance of OPERA with and without the SIMEC adjacency correction was evaluated on MERIS FR and OLI scenes. A good agreement was obtained with the available in-situ reflectance data. The application of the SIMEC adjacency correction had mainly a positive or neutral effect on the retrieved water reflectance retrieved with OPERA. As illustrated in Sterckx et al. (2015), the effect of SIMEC on the final reflectance depends on the AC algorithm applied.

5. ACKNOWLEDGMENTS

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