

Environment correction for inland and coastal water scenes: a comparison of methods

Sindy Sterckx¹, Els Knaeps¹, Richard Santer², Susanne Kratzer^{3,5}, Kevin Ruddick⁴, Carsten Brockmann⁵

¹ Flemish Institute for Technological Research, Belgium (VITO)

² Université du Littoral Côte d'Opale, France (ULCO)

³ Department of Systems Ecology, Stockholm University, Sweden

⁴ Royal Belgian Institute for Natural Sciences (RBINS), Dept VI Management of the North Sea Mathematical Models (MUMM), Belgium

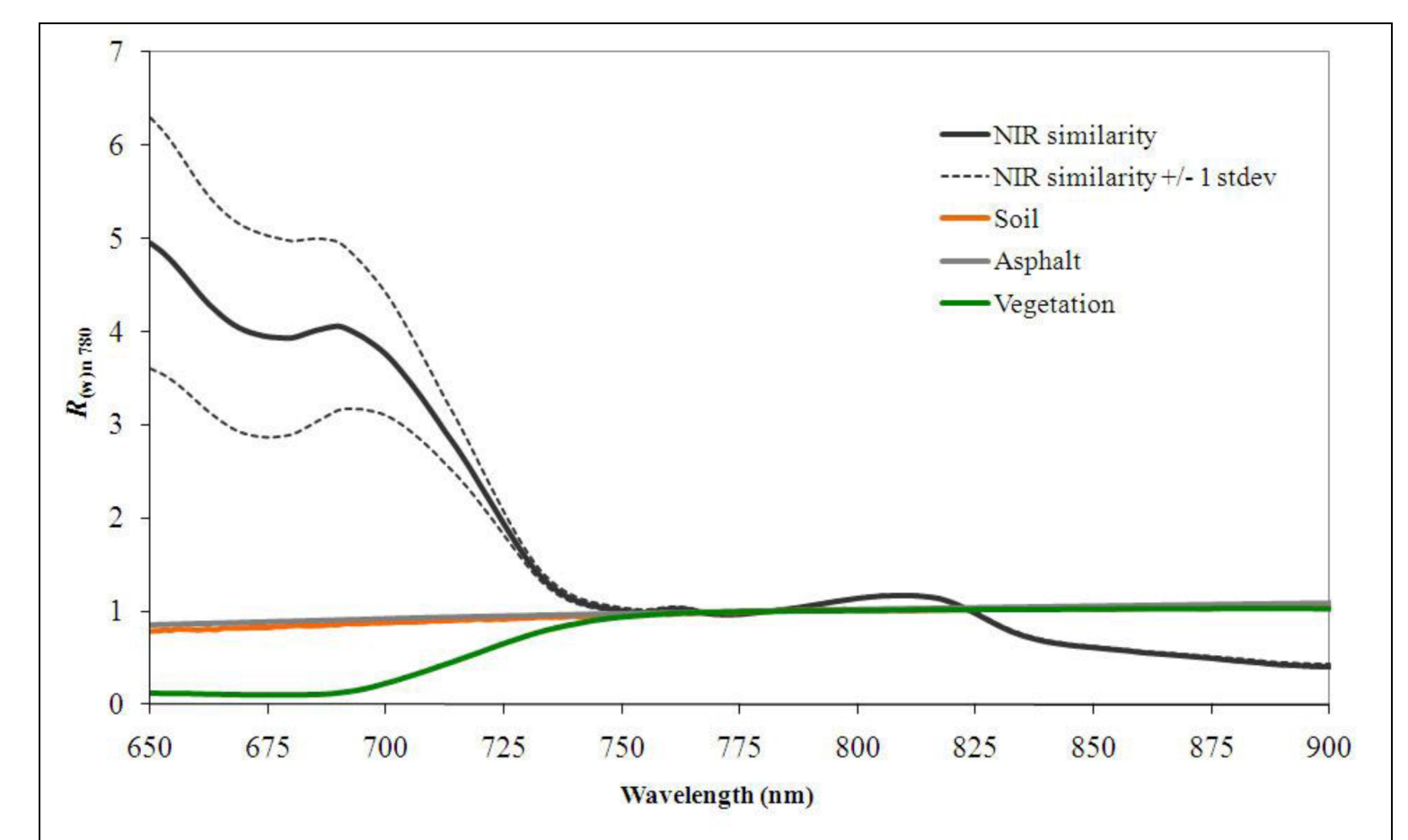
⁵ Brockmann Consult, Germany

Environment effects

With its relatively high spatial resolution coupled with a revisit time of 5 days Sentinel-2 offers the opportunity to monitor small inland water bodies, estuaries and coastal waters in order to support the European Water framework directive which forms the legislative framework for the water management undertaken by the EU Member States. In order to retrieve water quality information a proper atmospheric correction is essential. High contrasting land-water scenes (e.g. water body surrounded by vegetation) complicates this atmospheric correction. Light reflected from the nearby land can be forward scattered by the atmosphere into the sensor field of view. This causes a "blurring" of the signal and the effect is known variously as the adjacency, background or environment effect and reduces the apparent spatial resolution and modifies the spectral signature of the observed pixel.

Here, we will present the results of an ongoing comparison analysis of two environment correction approaches, ICOL and SIMEC, applied to two MERIS match-up datasets, lake Pålgrunden and the North Sea.

Figure 1 The near infrared similarity spectrum (thick black solid line) with standard deviation (stdev). Superimposed on the graph are normalized spectra typical for vegetation, soils and urban surfaces



ICOL

ICOL (Improve Contrast between Ocean and Land) includes in its formalism the classical adjacency effect (influence of the land albedo) but also (i) the reduction of the coupling between photons reflected by the sea surface and then scattered toward the sensor and (ii) a simplified formalism of the influence of bright clouds. ICOL retrieves the aerosol model over water even in turbid waters. ICOL returns an L1 radiance after correction of the adjacency effects. ICOL is available in BEAM (www.brockmann-consult.de/cms/web/beam/) to process MERIS and Thematic Mapper images.



Figure 2: Study areas indicated with red rectangle; top: lake Pålgrunden bottom: North Sea

SIMEC

SIMEC (SIMilarity Environment Correction) is based on the invariant shape of the water-leaving reflectance of the NIR (700-900 nm). This invariant shape was defined by Ruddick *et al.* (2006) by normalization at 780 nm and referred to as NIR similarity spectrum.

The main advantage of the method is that no assumptions have to be made on the absolute value of the Near Infrared reflectance, such that the correction can be applied over more turbid waters, i.e. until the similarity spectrum is valid (0.3 to 200 mg/l). The approach was originally developed for correction of high resolution airborne imaging spectroscopy data. Later some successful applications of the approach to MERIS imagery over inland waters have been demonstrated.

The AOT is currently derived from Aeronet data but will in the future be derived from nearby land targets.

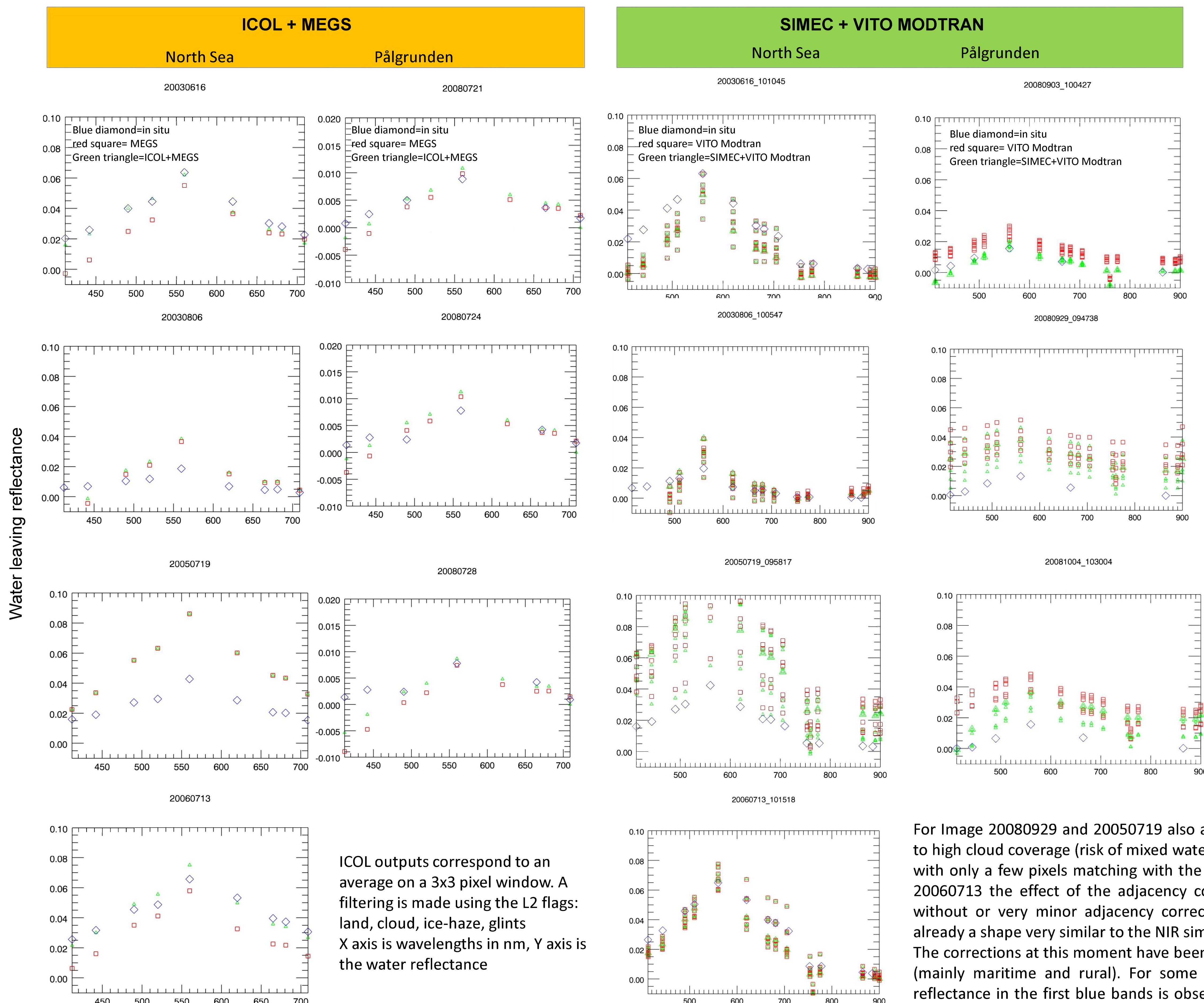
Intercomparison of methods

For the intercomparison two study areas were selected: Lake Pålgrunden (Susanne Kratzer) and the North Sea (Kevin Ruddick). For these sites match-ups are available including in-situ measured water leaving reflectance, AERONET in situ measured aerosol optical thickness (AOT) and angstrom exponent.

To retrieve the water leaving reflectance from the images different atmospheric correction procedures are used for ICOL and SIMEC (MEGS vs. VITO Modtran). Further, the Pålgrunden dataset for ICOL is different than the one for SIMEC.

Per image date the following data is shown in the plots below:

- o The in-situ measured water leaving reflectance (BLUE diamonds)
- o The atmospheric correction result without taking into account adjacency correction for the 3 x 3 pixel box surrounding the in-situ point (RED squares)
- o The atmospheric and adjacency correction result for the 3 x 3 pixel box surrounding the in-situ point (GREEN triangles)
- o For SIMEC also individual pixel results are shown to indicate the variability within the 3 x 3 pixel box



ICOL outputs correspond to an average on a 3x3 pixel window. A filtering is made using the L2 flags: land, cloud, ice-haze, glints. X axis is wavelengths in nm, Y axis is the water reflectance

Conclusions

ICOL + MEGS

For the North Sea, ICOL clearly improves the retrieval of the water reflectance. One exception is on 20050719 for which the MEGS atmospheric correction failed as indicated by the L2 flags. For Pålgrunden, as indicated by the AERONET optical thickness measurements, the days are clear. The effect on ICOL is to slightly improve the comparison between MERIS and in situ.

The comparison between ICOL and SIMEC should be also conducted at L1 or at L2 if the same atmospheric correction is applied, which is not the case here.

The MERIS atmospheric correction is the historical superposition of different algorithms of different algorithms starting from the open ocean to turbid coastal waters.

All the complexity of this last case should be included in the same algorithm as it will be presented during the Wednesday poster session by R. Santer (S2 above water: atmospheric correction including sunglint and adjacency effects)

SIMEC + VITO WATCOR

A significant effect of the SIMEC adjacency correction is seen in image 20080903 and 20081004 where a strong decrease in reflectance is observed giving a better correspondence with the in situ spectrum.

The SIMEC adjacency correction reduces the between-pixel variability (e.g. image 20080903) as a pixel-based adjacency correction is performed where pixels being larger influenced by adjacency effects are corrected more.

For image 20080929 and 20050719 also a significant adjacency correction is visible, but due to high cloud coverage (risk of mixed water-cloud pixels) the between-pixel variability is large with only a few pixels matching with the in-situ point. For image 20030616, 20030806 and 20060713 the effect of the adjacency correction is very minor due to the fact that even without or very minor adjacency correction the resulting water leaving reflectance already has a shape very similar to the NIR similarity spectrum.

The corrections at this moment have been performed using the standard MODTRAN aerosols (mainly maritime and rural). For some images an underestimation of the water leaving reflectance in the first blue bands is observed. This may be due to high absorbing aerosols, uncertainties in the sky dome correction, polarization effects....