Applying a calibrated primary production model to the Scheldt Estuary using Envisat-MERIS images

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1 Abstract

Using variations of the BPI model by Cole & Cloern (1987), primary production in the Scheldt Estuary's two contrasting regions (Oosterschelde and Westerschelde) was first modelled using in-situ values and calibrated for. Primary production was successfully modelled using in-situ values, returning r^2 values of 0.75 and 0.89 for the Oosterschelde and Westerschelde respectively using only the simple BPI model. Later, in-situ values of individual variables were compared with MERIS-derived estimates. Results show that retrieval of these variables works better for the Oosterschelde than the Westerschelde. Using the calibrated variations of the BPI model, these were applied onto the MERIS satellite imagery. Primary production was more successfully modelled in the Oosterschelde than the Westerschelde, with r^2 values of 0.816 compared to 0.2 respectively for the simple BPI model alone. Monthly composite images during March-September 2011 revealed reasonable simulation of trends in GPP values for the Westerschelde, however, there were consistently missing pixel values for K_d in the Oosterschelde, resulting in the inability to model GPP in the Oosterschelde. This error appears to only affect composite images, as the same does not occur for exact date matchups, suggesting that this might be a result of a processing issue. This pilot project into remote sensing of the Scheldt Estuary demonstrates that the possibility of using satellite imagery to rapidly model primary production in coastal systems similar to the Oosterschelde remains promising. In addition, MERIS product algorithms needs to be validated and trained against datasets of regions with high turbidity and SPM concentrations, if improvements of modelling the Westerschelde are to be made.

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2 Introduction

The Scheldt Estuary is an area in the southwestern part of the Netherlands that has experienced intensive anthropogenically-induced changes in the last century (Smaal & Nienhuis, 1992). Due to its extensive area of intertidal flats, it is also home to the largest shellfish aquaculture industry in The Netherlands, primarily growing oysters and mussels (FAO, 2007). It is also a site of ecological importance for bird species (De Vriend et al., 2011), therefore highlighting the importance of conservation for Scheldt Estuary as a productive fishery and important site for birds. In recent years, the Scheldt Estuary faces a range of eco-morphological problems, and studies have found that there is a net erosion of intertidal flats, resulting in a reduction in the bird population at the estuary (Van der Werf et al., 2015). The success of any fishery is primarily limited by an ecosystem's primary productivity (Friedland et al., 2012; Pikitch et al., 2004; Pauly & Christensen, 1995). Primary production refers to the fixing of carbon into available energy, and is most commonly achieved through photosynthesis. Photosynthesis refers to the use of light as a source of energy to convert carbon dioxide into glucose. The equation, at its simplest form, is described below:

$$CO_2 + H_2O + \textit{light} \rightarrow CH_2O + O_2$$

Knowledge on primary production is critical in quantifying the carbon cycle (Falkowski et al., 1998). It is also additionally useful for bottom-up models in the management of marine resources to estimate sustainable fishing yields (Houde & Rutherford, 1993). Capuzzo et al. (2015) hypothesized that climate change and high anthropogenic pressure on seabed structures from fishing have resulted in an increase in concentrations of Suspended Particulate Matter (SPM) in the waters, hence, affecting light availability and inhibiting photosynthesis. Furthermore, models predict that there will be an overall net decrease in primary production rates in the North Sea by the end of the century if climate change occurs under the business-as-usual scenario (Holt et al., 2015). Given that decreasing light availability poses a threat to the marine ecosystem of the North Sea, this gives rise to an increasingly urgent need for close and rapid monitoring of the situation. Although primary production models exist, one of the key requirements is the need for in-situ data to derive variables required for such models. This is not always available immediately, and can often be cost-ineffective. Remote sensing, therefore, offers an alternative for low-cost modelling and monitoring of real-time data, with increasing accessibility to high quality images (Ruddick et al., 2008).

As part of a bigger project to investigate the accuracy of satellite-derived primary production estimates in the North Sea and its adjacent basins, various primary production models were first tested in this report on part of the Dutch Delta area, the Eastern Scheldt (Oosterschelde) and Western Scheldt (Westerschelde). Both these estuaries have contrasting hydrographical conditions as well as different nutrient loadings. While not entirely representative for the whole North Sea's dynamic hydrography, the optical similarities between these areas and the coastal parts of the North Sea suggest that models developed on data from the Eastern and Western Scheldt might be applicable to the North Sea. Therefore, this project seeks to determine how accurate satellite-derived estimates of the individual parameters (chlorophyll-a, light attenuation coefficient, suspended particulate matter) are, and subsequently how accurate estimates of primary production are in these coastal and estuarine waters. Recommendations for further research in the North Sea are also provided.

2.1 Study Area

The study area comprises of the Eastern Scheldt (Oosterschelde) and the Western Scheldt (Westerschelde), and the current bathymetric data along with tidal flat locations are illustrated in Figure 1. Previously a single estuary, these two regions were separated due to anthropogenic land reclamation activities from the Middle Ages, followed by the Oosterschelde being cut off from the Scheldt river source in 1897 (Cozzoli et al., 2017). Present-day geomorphological conditions are a result of both heavy human intervention and natural processes, including the building of a storm surge barrier and dams in the Oosterschelde, dike strengthening works in both the Oosterschelde and Westerschelde, and dredging in the Westerschelde. Although both estuaries are considered tidal inlets, they have contrasting hydrographical conditions primarily due to the construction of a storm surge barrier and limited river input (due to damming) into the Oosterschelde (Nienhuis & Smaal, 1994).

The Oosterschelde is characterized by the lack of river input and retains a limited connection to the North Sea, depending on flood conditions. The Oosterschelde was initially connected to the Westerschelde, however, following the 1953 North Sea flood, dams were built as part of the Delta Project to reduce discharge during heavy precipitation. As a result, river input is now limited. The Oosterschelde retains a connection to the North Sea, except for extreme high waters, when the storm surge barrier, (also constructed as part of the Delta works after the 1953 surge), is closed. The Delta works resulted in a significant decrease in the tidal range of the Eastern Scheldt by more than half a metre, reducing it to the current tidal range of 2.5-3.5m (Eelkema et al., 2009). Tidal volume and average tidal velocity have also reduced from 1.3 to 0.9 million m^3 and 1.2 to 0.8 m/s respectively (Ten Brinke et al., 1994). The reduction of tidal range, volume and velocity from the erection of storm surge barriers has resulted in a 28% decrease in North Sea input and a drastic 64% reduction in freshwater input (Smaal & Nienhuis, 1992). Although flood protection measures have been successful, the Oosterschelde has faced a multitude of problems in the following years. The primary source of sediment is believed to be from the North Sea, and since the connection to the North Sea had been restricted with the erection of the storm surge barriers, the Oosterschelde is experiencing increasing erosion of its tidal flats (Van der Werf et al., 2015). The tidal flats have been eroding at a rate of 0.5 km^2/yr from 1987-2001, and by 2060, 35% of the intertidal area is predicted to erode (Ysebaert et al., 2016). This has severe consequences as the tidal flats in the Oosterschelde serve as important foraging grounds for birds, and residence for water bird species. As the Oosterschelde is part of the European Natura2000 network, intense research and conservation efforts are put into protecting and preserving the tidal flats in the area, as net erosion of tidal flats will result in a decline in bird population (Van der Werf et al., 2015; Smaal & Nienhuis, 1992). On the other hand, the lack of freshwater input has also contributed to an increase in water quality and a general reduction in nutrient concentrations in the Oosterschelde (Wetsteyn & Kromkamp, 1994).

The Westerschelde is part of an important shipping route to Antwerp, and has, in recent years, undergone dredging to deepen its channels for ship navigation, with approximately 6.5-7 Mm^3 of sediments being dredged annually which contributes to a 30% increase in tidal velocities (Cozzoli et al., 2017). In contrast to the Oosterschelde, the Westerschelde has the influence of fresh water input, although this contribution (105m^3/s) is small, resulting in brackish waters mainly occurring between Hansweert and Antwerp (Ysebaert et al., 2016). The Westerschelde is a turbid and well-mixed estuary (Kromkamp & Peene, 1995) that is primarily tide-dominated (Eleveld et al., 2014). Although a study by Vandenbruwaene et al. (2015) found that long-term SPM concentrations did not change from 1995-2013, they did, however, find that riverine discharge from the River Scheldt influenced the amount of SPM concentrations found in the Westerschelde. High SPM concentrations were found to have coincided with low riverine discharge, which can also be backed up by evidence from other studies (Fettweis et al., 2010). Primary production is high in the Westerschelde, primarily due to the high input of nutrients from anthropogenic runoff, causing eutrophication, and subsequently depleting oxygen levels (Ysebaert et al., 2016). The Westerschelde is a site of ecological importance as it is, like the Oosterschelde, a site for migratory, foraging and breeding bird species, and is also protected under the same directive as the Oosterschelde (De Vriend et al., 2011).

Therefore, this project seeks to address the following research questions:

1) Using in-situ data, which primary production model works best?

2) How accurate are satellite-derived estimates of the individual parameters comprising the primary production model? Is the MERIS product algorithm sufficient in estimating these variables?

3) Can primary production be successfully modelled? What recommendations can be made for future research?

Correlations were first made between in-situ and composite parameters of each model, and linear regression analysis was applied to determine model suitability. Following which, a comparison of MERIS algorithm products and in-situ variables were made to quantify sources and contribution of error. The primary production models were then applied onto exact date matchups and monthly composites to assess accuracy of primary production estimates. Satellite images are taken from Envisat-Medium Resolution Imaging Spectrometer (MERIS), which covers the period between 2005-2012. Based on the results, recommendations were made accordingly for future research reference.

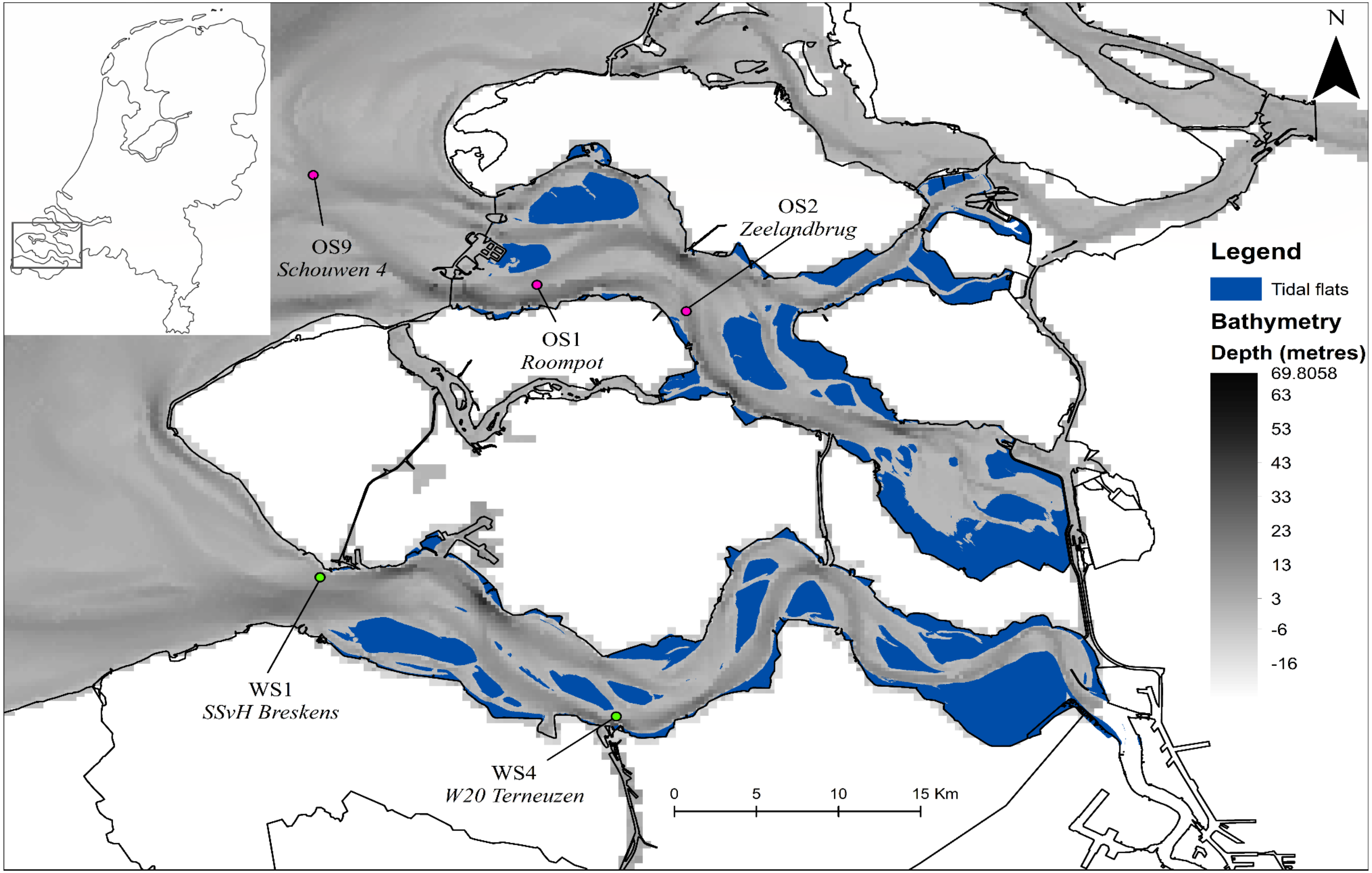

Figure 1: Map of the Scheldt Estuary area. The Oosterschelde (northern estuary) and Westerschelde (southern estuary) are labelled here, along with polygons of tidal flats in the region. An inset map of the outline of The Netherlands is also included, with the area of study highlighted (grey box)

3 Materials and Methods

3.1 In-situ data

In-situ data of the Oosterschelde and Westerschelde are used for calibration of the models prior to application onto satellite imagery. The datasets are provided by NIOZ (Kromkamp, unpublished), and data from two stations from each region are used: OS1 and OS2 for the Oosterschelde; WS1 and WS4 for the Westerschelde. The locations of these stations are illustrated in Figure 1. However, the model was calibrated on a limited part of the dataset. The methodology used to measure GPP (based on the uptake of radioactive $^{14}CO_2$ during 2h incubations at a range of light intensities) is described in Kromkamp et. al (1995) and Kromkamp and Peene (2005).

3.2 Primary Production Models

Various primary production models are used to derive an estimate of primary production in the Scheldt Estuary. First, model efficiency and suitability are tested, before deciding which of these models are to be applied onto satellite imagery. In-situ GPP data is first regressed against composite parameters of the chosen models, deriving a linear relationship for the Oosterschelde and the Westerschelde, and finally, the linear equation for each model specific to each region is applied onto satellite imagery. In-situ variables (chlorophyll-a, light attenuation and SPM) are compared with satellite-derived estimates of these variables, followed by a comparison of satellite-derived primary production estimates with the in-situ GPP values. Data from OS1, OS2, WS1 and WS4 are used in the calibration of the linear regression between model parameters and in-situ data, and the models used are described in the next section. Yet, a suitable and practical model should also be efficient in calculating primary production. One way of testing this is to use the Akaike Information Criterion (AIC), which determines a model's efficiency by assigning penalties to the number of parameters. Therefore, a model with less parameters and a reasonable correlation may instead be more efficient than a complex model that generates a high correlation. Hence, the AIC was also performed on all the models to determine which of those were suitable for use on satellite images. Furthermore, the linear regression analysis was performed to assess the distribution of samples and behaviour of the datasets. This was done using the software "R" (Version 3.3.3).

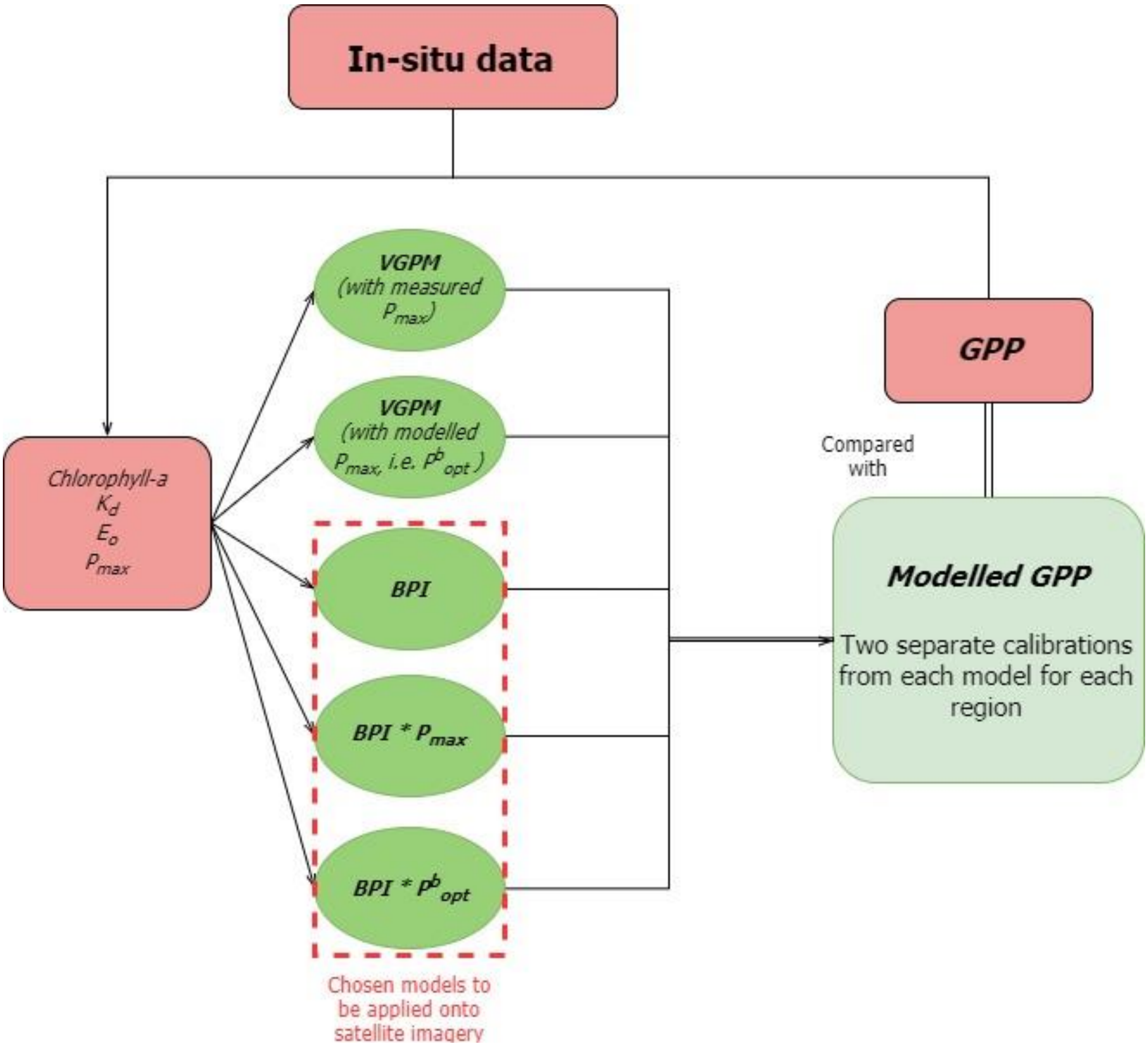

Figure 2: Flowchart of initial model calibration

3.2.1 BPI Model

Although primary production depends on several factors such as light, oxygen and nutrient availability etc., estuaries are slightly different environments than the open ocean. Light availability, especially in the case of the well-mixed and nutrient-rich Scheldt estuaries, is often the limiting factor for such systems in achieving maximum productivity rates (Kromkamp & Peene, 1995; Wetsteyn & Kromkamp, 1994). In addition, no single parameter is able to explain variations in primary productivity in a system (Heip et al., 1995), therefore, the model that Cole & Cloern (1987) used incorporates three main parameters. The model is most suited for estuaries that are limited by light availability, which makes it suitable for testing its efficiency on the Scheldt Estuaries, despite the fact that the Oosterschelde might suffer brief periods of nutrient limitation. The model is described as follows:

$$B * Z_{eu} * E_o \qquad [1]$$

The equation in [1] represents an empirical parameter derived from the product of phytoplankton biomass B (mg/m^3 chlorophyll-a), photic depth Z_{eu} (m), and surface irradiance E_o ($E/m^2/day$), i.e. BPI (Biomass * Production * Irradiance). Photic depth, taken here as the depth to which 1% of the surface light penetrates, can be obtained from the light attenuation coefficient as: $Z_{eu} = 4.6/K_d$, assuming the light attenuation coefficient is constant with depth. The value of 4.6 is a largely reasonable assumption for coastal waters, however, this value may not hold true for clearer waters and may contribute to an underestimation (Kirk, 2011). Equation [2] represents the BPI model incorporating light attenuation coefficient as a function of photic depth.

$$B * 4.6/K_d * E_o \qquad [2]$$

Although phytoplankton can contribute to light attenuation, Suspended Particulate Matter (SPM) is a much bigger contributor to the attenuation of light compared to phytoplankton biomass in turbid estuarine systems (Cole & Cloern, 1987). When this parameter is regressed against in-situ Gross Primary Production (GPP), a linear relationship is derived and can then be used to estimate GPP in a system. Thus, the general model can be described as follows:

$$GPP = a * \left[B * \frac{4.6}{K_d} * E_o\right] + b \qquad [3]$$

Hence, one of the questions to be investigated is if the a (slope of the line) and b (y-axis offset) coefficients differs significantly between the estuaries.

3.2.2 BPI model with $P^b{}_{max}$

A variation of the Cole & Cloern Model is made by adding another parameter: $P^b{}_{max}$ ($\mu mol\ O_2\ mgChl\text{-}a^{-1}\ h^{-1}$). This term describes the maximum rate of photosynthesis per mg of chlorophyll-a in a water column at a certain irradiance (Behrenfeld & Falkowski, 1997b). Incorporating this parameter into a primary production model showed a 30% increase in the model accounting for observed variability, hence the decision to incorporate $P^b{}_{max}$ into the model of Cole & Cloern (1987) and investigate its suitability. The modified model is shown below in [4]:

$$B * 4.6/K_d * E_o * P^b{}_{max} \qquad [4]$$

3.2.3 BPI model with $P^b{}_{opt}$

As $P^b{}_{max}$ data is not always available, this parameter can also be modelled using several empirical models (Behrenfeld & Falkowski, 1997a; Cox et al., 2010; Morris & Kromkamp, 2003). The modelled parameter is known as $P^b{}_{opt}$. In practice, $P^b{}_{max}$ and $P^b{}_{opt}$ are identical parameters. However, $P^b{}_{opt}$ is often used in models that account for photoinhibition, while $P^b{}_{max}$ refers to the maximum rate of photosynthesis observed at the optimum irradiance (i.e. I_{opt}). By assuming that both parameters are identical, this does not account for the potential for photoinhibition setting in at an irradiance that is less than I_{opt}, allowing the true $P^b{}_{max}$ values to be larger than the modelled $P^b{}_{opt}$ values.

3 main models are used in estimating $P^b{}_{opt.}$ The first of which refers to the temperature dependent $P^b{}_{opt}$ model by Behrenfeld & Falkowski (1997a). Figure 3 illustrates the results of the model by Behrenfeld & Falkowski (1997a), plotting the measured $P^b{}_{opt}$ values versus the modelled $P^b{}_{opt}$ values.

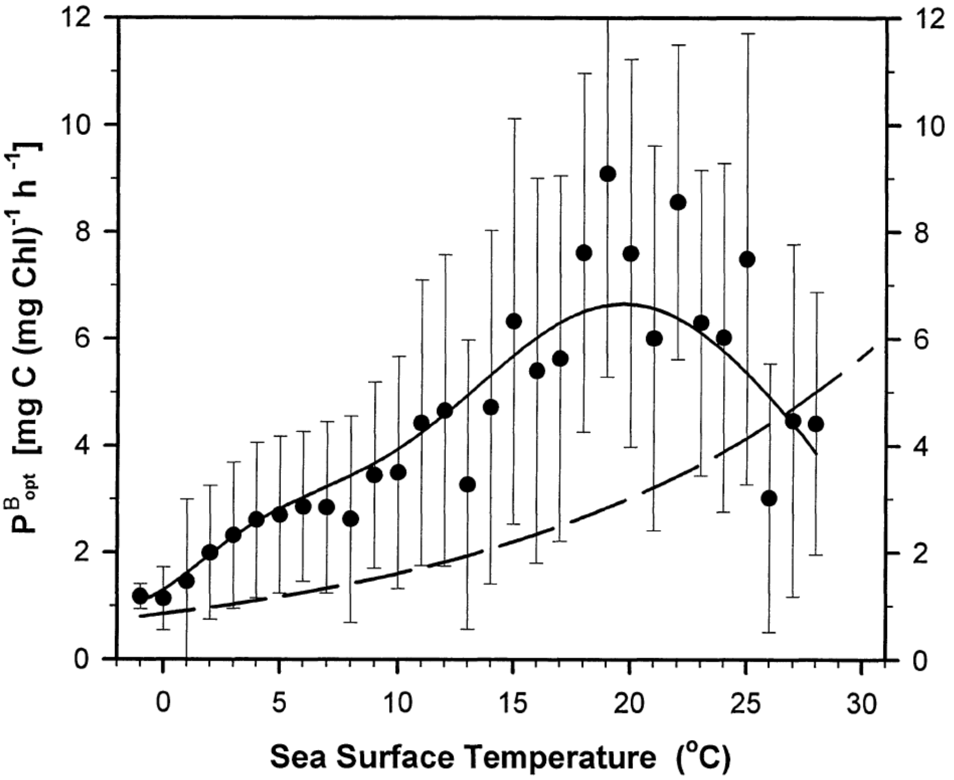

Figure 3: Measured $P^b{}_{max}$ values (black dots) versus modelled (solid line) values of $P^b{}_{max}$ (i.e. $P^b{}_{opt}$) as a function of temperature. The dashed line refers to growth rate per day. (Behrenfeld & Falkowski, 1997a).

The equation for Behrenfeld & Falkowski's model of $P^b{}_{opt}$ is described in equation [5] below:

$$P^b{}_{opt} = -3.27 * 10^{-8}T^7 + 3.4132 * 10^{-6}T^6 - 1.348 * 10^{-4}T^5 + 2.462 * 10^{-3}T^4 - 0.0205T^3 + 0.0617T^2 + 0.2749T + 1.2956 \quad [5]$$

The complex, high-order polynomial relationship between temperature and $P^b{}_{opt}$ is due to the positive relationship between -1°C to 20°C, followed by an observed decrease from >20°C onwards. The figure also illustrates the model being able to derive results well within the range of error of the measured values.

The second model by Cox et al. (2010) is described as follows:

$$P^{b}{}_{opt} = P^{b}{}_{max,10} * Q^{\frac{T-10}{10}} * \left(1 - exp\,\frac{-\alpha_{10} * E_o}{P^{b}{}_{max,10}}\right) \qquad [6]$$

$P^{b}{}_{max,10}$ refers to the maximum rate of photosynthesis at the optimum irradiance at the reference temperature of 10°C. Q_{10} refers to the multiplication factor of the rate of reaction for every 10°C increase in temperature. Lastly, α_{10} refers to the photosynthetic efficiency at the reference temperature of 10°C. Cox et al.'s model takes into account the effects of seasonal variation via a temperature dependence (i.e. Q_{10}).

The final model by Morris & Kromkamp (2003) is represented by:

$$P^{b}{}_{opt} = P_{max}\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)^{\beta} * exp\left\{-\beta\left[\left(\frac{T_{max}-T}{T_{max}-T_{opt}}\right)-1\right]\right\} \qquad [7]$$

T refers to the temperature of the water, while T_{max} and T_{opt} both refer to the maximum temperature at which no photosynthesis occurs and temperature at which the maximum value of $P^{b}{}_{max}$ is reached respectively. Lastly, β is a dimensionless parameter. For all models of $P^{b}{}_{opt}$, the individual parameters values were estimated and compared against measured $P^{b}{}_{max}$ values. Subsequently, the difference in error was used to calibrate the parameter values and derive a best fit by minimizing the error using the Solver add-in in Microsoft Excel (version Excel 2016, GRG Non-linear engine).

Following which, the adjusted primary production model would be as follows:

$$B * 4.6/K_d * E_o * P^{b}{}_{opt} \qquad [8]$$

As all models contain temperature parameters (T), this model would thus require measurements of temperature as well.

3.2.4 Vertically Generalised Production Model

The Vertically Generalised Production Model (VGPM) is a depth-integrated model that accounts for the relationship between variables measured at the surface and depth-resolved functions (Behrenfeld & Falkowski, 1997b). At its simplest form, the model considers the basic variables influencing photosynthesis, which includes sea surface chlorophyll concentrations C_{surf} (mgChl-a/m^3), photic zone depth Z_{eu} (m), irradiance E_o (E/m^2/day), photoadaptive capacity ($P^{b}{}_{opt}$ or P_{max}) and photoperiod D_{irr} (hours) to account for daily rates of photosynthesis. The model was also developed for use in both open oceans and coastal waters. The model is described in [9] below as:

$$VGPM = 0.66125 * P^{b}{}_{max} * \left[\frac{E_o}{E_o+4.1}\right] * Z_{eu} * C_{opt} * D_{irr} \qquad [9]$$

Another variation of this model is to, instead, calculate this parameter using the modelled $P^b{}_{opt}$. As mentioned earlier, $P^b{}_{max}$ and $P^b{}_{opt}$ are, in practice, identical parameters. The modified equation is illustrated in [10] below:

$$VGPM = 0.66125 * P^b{}_{opt} * \left[\frac{E_o}{E_o + 4.1}\right] * Z_{eu} * C_{opt} * D_{irr} \qquad [10]$$

The VGPM model and the modified versions of the Cole & Cloern model are therefore based on virtually identical parameters, as they both describe primary production as a function of chlorophyll-a concentrations, photic depth, daily irradiance and $P^b{}_{max}$.

3.3 Satellite imagery and processing

Satellite images are acquired and processed via CoastColour (http://www.coastcolour.org/ccprocessing/calvalus.jsp), a project of the European Space Agency (ESA) set up specifically to process images for oceanographic use. The satellite images were taken by MERIS (MEdium-spectral Resolution, Imaging Spectrometer), an instrument onboard the sun-synchronous Envisat (Environmental Satellite), with full resolution data availability from 17th May 2002 to 8th April 2012 when contact was lost with Envisat (European Space Agency, 2012). MERIS is a passive, push-broom imaging spectrometer with a spatial resolution of 290m x 260m, and has 15 spectral bands with a wavelength spectrum of 390-1040nm, covering both the visible and near infrared (NIR) range.

Table 1: Table showing the spectral bands and the corresponding wavelength and wavelength resolution (Antoine et al., 2013).

Band number	*Wavelength (nm)*	*Width (nm)*
1	412.5	10
2	442.5	10
3	490.0	10
4	510.0	10
5	560.0	10
6	620.0	10
7	665.0	10
8	681.25	7.5
9	708.75	10
10	753.75	7.5
11	761.875	3.75
12	778.75	15
13	865.0	20
14	885.0	10
15	900.0	10

Its mission was to measure ocean colour in Case 1 (open ocean) and Case 2 (coastal zones) waters, thereby measuring variables including chlorophyll concentrations, SPM, light attenuation etc. (European Space Agency, 2006). The CoastColour project was also set up to address the issue of interpreting images and wavelength data of Case 2 waters. Case 1 waters are far simpler as their optical properties are defined as a function of chlorophyll concentrations (Morel, 1997; Morel & Maritorena, 2001). The optical properties of Case 2 waters are, instead, a function of multiple variables including dissolved and suspended matter, shallow bottom reflection, floating matter i.e. algae blooms amongst others (Brockmann Consult, 2014b). By developing parameter-specific algorithms based on inter-calibration with data from Case 2 waters, the final product processed by CoastColour is therefore almost completely catered to analysis of coastal zones. CoastColour also provides three types of processing levels: Level 1, Level 2 and Level 3. Level 1 processing consists of images resampled and atmospherically corrected. Level 2 processing includes images with algorithms applied to derive various environmental parameters. Finally, Level 3 processing involves the combination of more than one MERIS product to generate a composite image. This project uses both Level 2 and Level 3 processing products, which will be elaborated in the following section.

Satellite-derived estimates of chlorophyll-a, light attenuation coefficient (K_d) and SPM were extracted from exact pixel match-ups with station points, and averaged using a 3x3 kernel, generating the mean, range and standard deviations. This was done not only to investigate the level of accuracy of the MERIS product and its algorithms used to generate these variables, but to find out if the pixel values had too much scatter and if a kernel average could minimise noise in the images. Following which, the linear equations for each model were applied onto satellite imagery for each region, generating an image of GPP values. A 3x3 averaging kernel was also applied onto the satellite images, generating the mean, range and standard deviations of each kernel into each pixel. The models were applied onto satellite images acquired from exact date matchups, and only the BPI model was applied onto monthly composites of images taken between the months of March-September in 2011, with the year being chosen due to adequate in-situ data availability. A zonal average GPP value was taken of all the pixels lying within each region. The processing steps are illustrated in a flow chart as shown in Figure 4. For the monthly composite images, the input was, instead, a Level 3 processing product of Coastcolour that involved calculating an average of each pixel value for the month, and the zonal statistics tool was used instead of focal statistics (see Supplementary information 8 for pre-processing parameters).

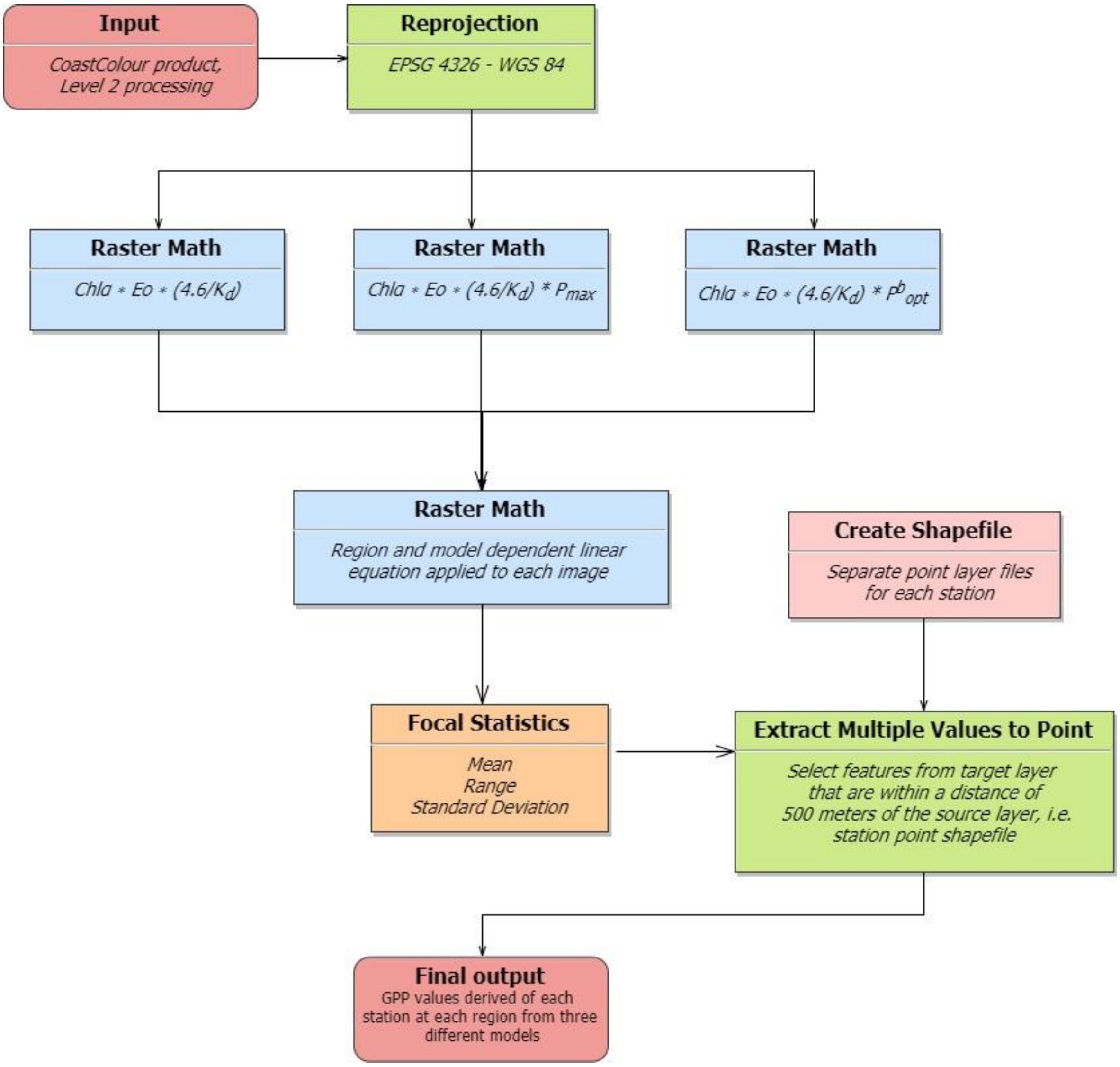

Figure 4: Flow chart of processing steps to acquire GPP values from applying the different models to satellite imagery

3.3.1 Parameters

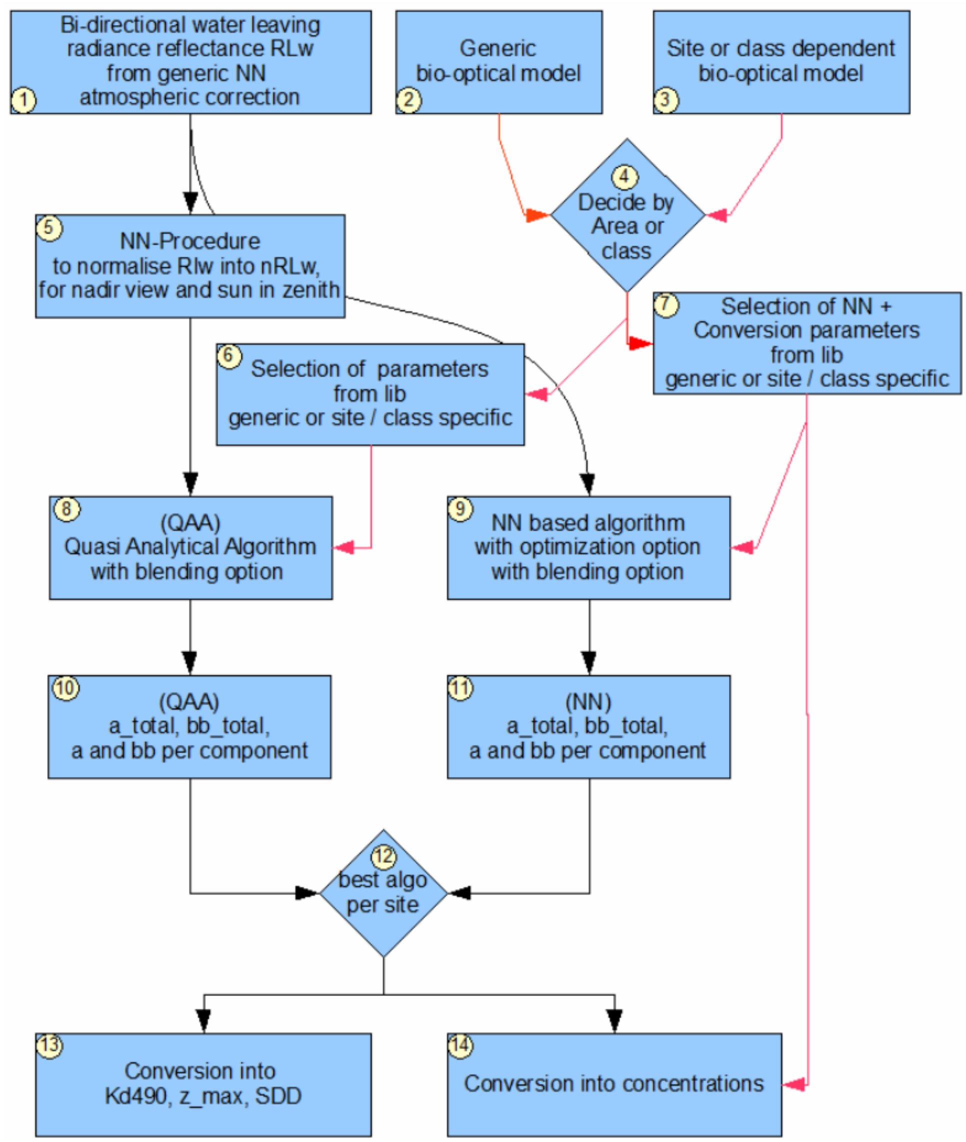

Figure 5: Flowchart of water pixel processing for the various parameters including chlorophyll-a, Kd and SPM (taken from Brockmann Consult, 2011)

The parameters used from the MERIS product were chlorophyll-a and K_d (560nm), while E_o was derived from in-situ measurements at the stations. The chlorophyll concentrations in the MERIS products were calculated using a conversion of the maximum chlorophyll absorption coefficient at 443nm ("a_pig_443"), which was derived using a neural network and Quasi Analytical Algorithm (QAA) (Brockmann Consult, 2014b). K_d is also calculated based on the neural network. The neural network uses an inverse modelling technique which operates by training with reflectance data and producing Inherent Optical Properties (IOP) of the water bodies, as opposed to the non-inversed method of training with the IOP of water bodies and generating potential reflectance data. Neural networks require datasets for "training" to be able to produce accurate results, and are optimized depending on the classification of the water body, i.e. Case 1 or Case 2 waters. The QAA derives the Inherent Optical Properties (IOP) of a water body. As the maximum chlorophyll absorption coefficient is influenced by coloured dissolved organic matter and phytoplankton pigments, the QAA decomposes the absorption and backscattering coefficient into the separate components that contribute to the absorption spectrum of the coefficients (Brockmann Consult, 2014a). By doing so, the reflectance of each component can be calculated from such optical properties. An example of the pixel processing for each of these parameters is illustrated in Figure 5.

As MERIS does not cover the thermal infrared range, temperature cannot be estimated from satellite images, and hence, in-situ temperature measurements were used to estimate $P^b{}_{opt}$ instead.

4 Results

4.1 In-situ GPP Time-series in the Scheldt Estuary

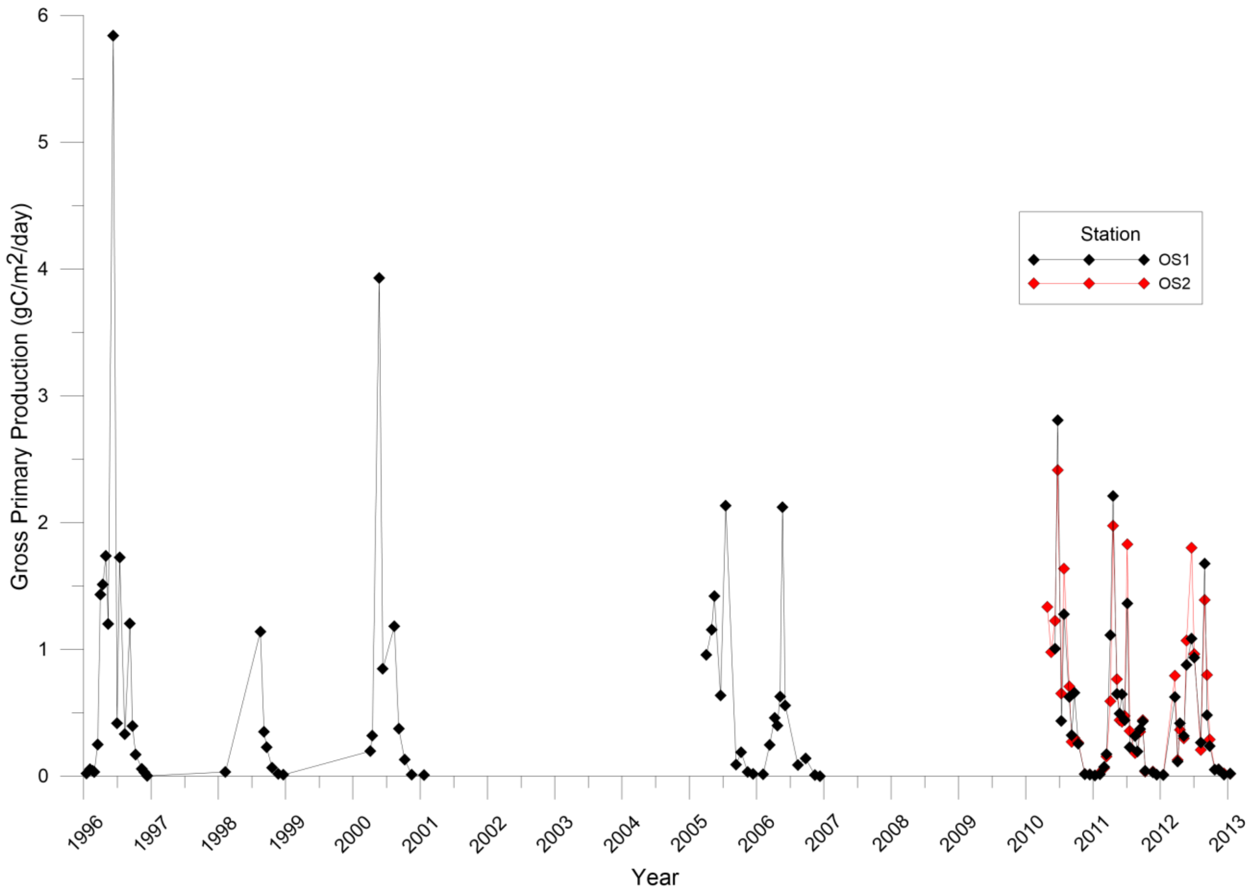

Figure 6: Gross Primary Production rates in the Oosterschelde from 1996-2013. In-situ data provided by NIOZ (Kromkamp, unpublished)

Using data from two monitoring stations in the Oosterschelde (OS1 and OS2), Figure 6 illustrates the time-series data for GPP in the Oosterschelde, with in-situ data provided by the NIOZ (Kromkamp, unpublished). Although there is data availability from 1996 to 2013, the dataset is incomplete and has several missing years due to lack of sampling. Furthermore, analysis was done on a restricted part of the dataset (see Appendix for sampling points used for this study). Given sufficient sampling points throughout the year, it can be observed that for most years, two peaks in primary production occur: the spring bloom in April/May and a summer bloom in July. There is large inter-annual variability in the magnitude of the primary production as well as in the timing of the bloom. The highest daily values were observed in the early '90s and maximal daily primary production rates show a decline at both stations.

Monthly GPP values are illustrated in Figure 7, where OS1 and OS2 both have roughly similar trends in primary production throughout the year. However, between April to July, GPP values in OS2 is consistently higher than GPP values at OS2. Interestingly, although the primary production peak each year occurs in April or May, with a second summer bloom in July or August, averaging the values over months and years leads to a single peak where highest GPP values are reached in June on average for both stations, while lowest values are between November to February i.e. winter months. The range of GPP values also increase sharply during late spring/summer months (April-July). From Figure 7, the average annual GPP appears lower for OS2 than at OS1, though the main difference in GPP values are due to the summer months (April-July), as both stations have roughly similar values for the rest of the months. Annual primary production strongly decreases between 1991-2005, but it is difficult to say if the decrease in annual GPP values after 2005 continues or stops. Longer time-series data is required in order to make this analysis.

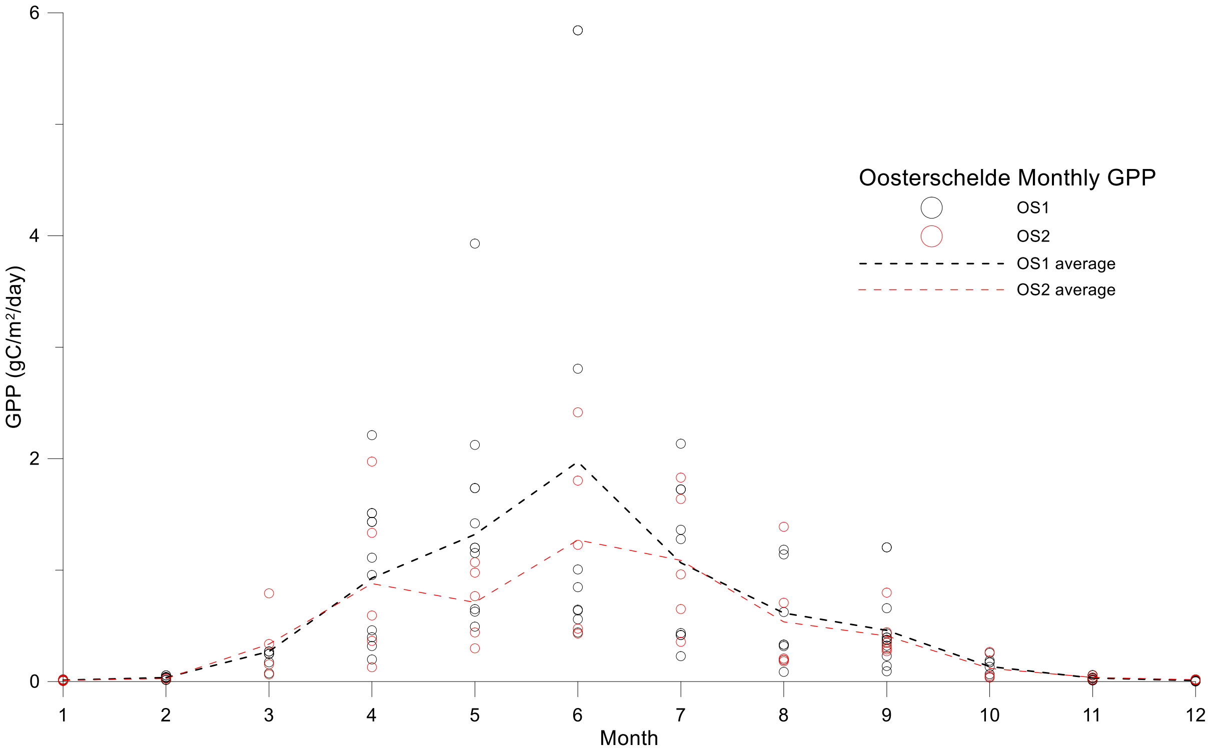

Figure 7: Average daily GPP values from each month for the Oosterschelde (circles) plotted along with the monthly average (dotted line)

In-situ GPP data from the Westerschelde spans the period between 2009-2013 and is illustrated in Figure 8. Trends in GPP values also show peaks in primary production occurring during the summer months, and are roughly split into two distinct peaks that appear to occur in spring (March/April), and late summer (July/August). The highest GPP peak is found at WS1 during July 2011, with a peak of 4.369 $gC/m^2/day$. This anomalously high peak was not observed in the in-situ GPP values for the Oosterschelde. Both WS1 and WS4 record peaks at roughly similar times, though in general, WS1 appears to have higher measurements of GPP values than WS4. The range of values appear to roughly fall between 0-2 $gC/m^2/day$. Figure 9 illustrates the monthly GPP values in the Westerschelde. The average monthly GPP values demonstrates that both WS1 and WS4 record similar GPP values for most part of the year, except for the months of July, August and September. As can be seen in the figure, GPP values at WS4 are within a narrower range than WS1 between July to August.

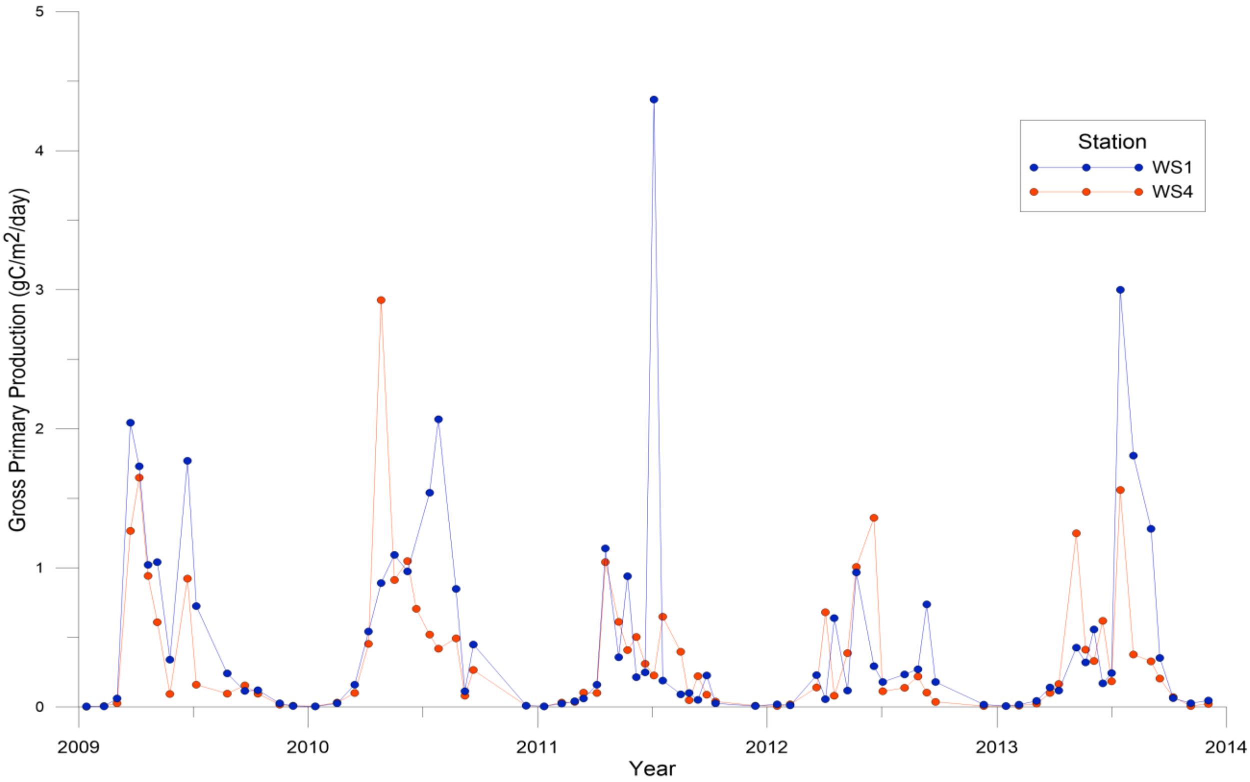

Figure 8: Gross Primary Production rates in the Westerschelde

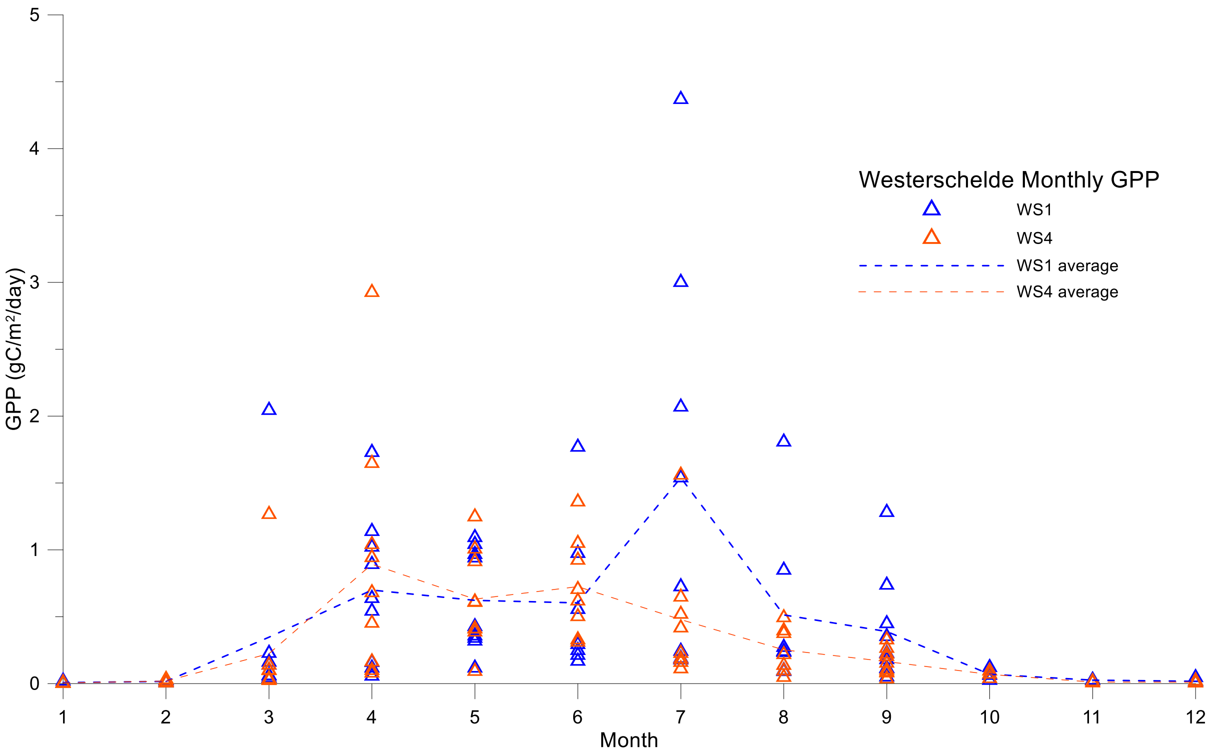

Figure 9: Annual GPP values for each month for the Westerschelde are plotted along with the monthly average (dotted line)

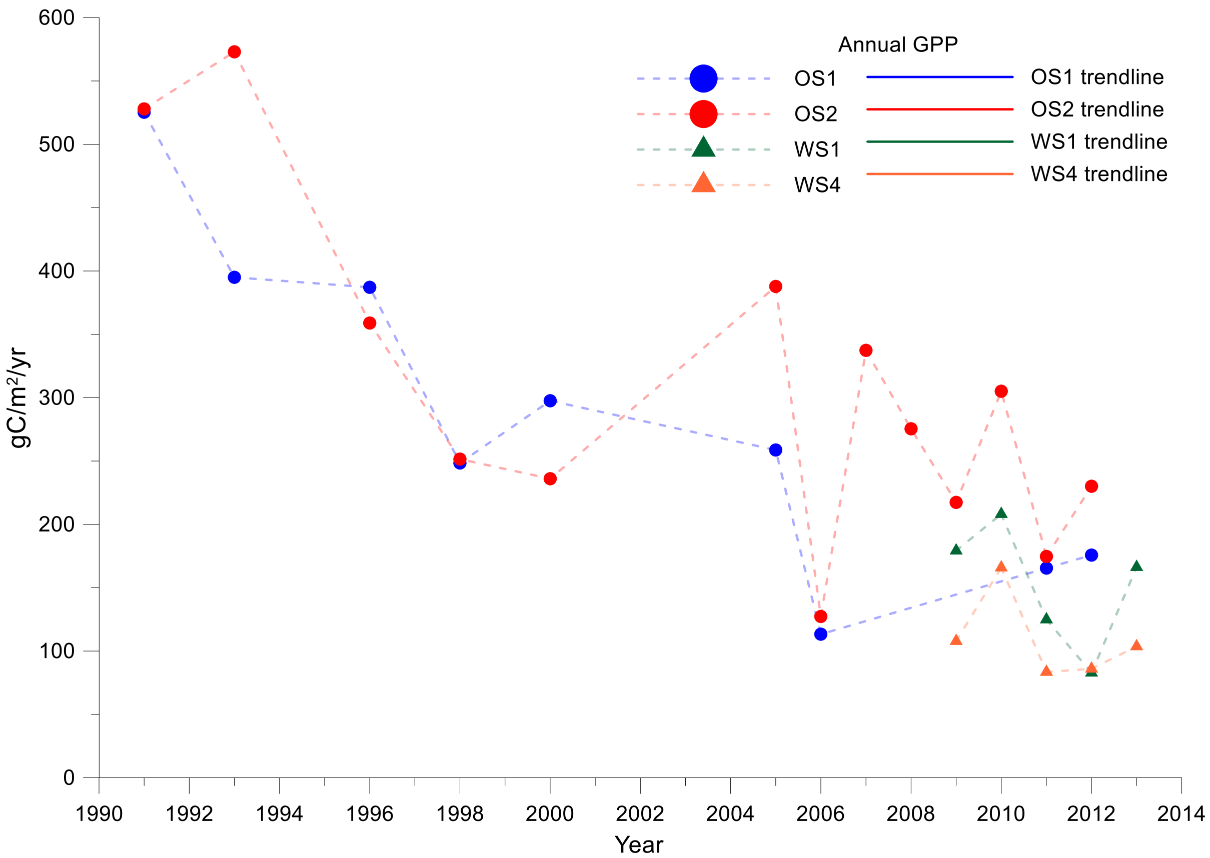

Figure 10: Annual GPP measured at the stations in the Oosterschelde (OS1 & OS2) and Westerschelde (WS1 and WS4)

Figure 10 plots the annual GPP values from each station, however, stations with data missing between April to August were excluded from the annual GPP calculations, while stations that had data missing for the winter months used the monthly average values instead as the winter months (November – February) have extremely low values of GPP. Annual GPP values are inconsistent and appear to fluctuate, however in general, the Oosterschelde has higher GPP values than the Westerschelde. There is insufficient annual GPP data to conclude which Oosterschelde stations has the highest annual GPP. The amount of data points is too little to conclude if both the Oosterschelde and Westerschelde express similarities in GPP trends, however, annual GPP values for both WS1 and WS4 in the Westerschelde show similar data trends at least.

4.2 Modelling $P^b{}_{max}$

The $P^b{}_{opt}$ models from Cox et al. and Morris & Kromkamp (mentioned in 3.2.3) were assigned default parameters and fitted using Excel's Solver (using GRG Nonlinear engine) for both Oosterschelde and Westerschelde datasets combined. New parameters were generated after attempting to achieve minimum sum of error, and the new values are detailed in Table 2 below. All three modelled $P^b{}_{opt}$ values were regressed against the measured Pbmax, and this is shown in Figure 11. Results show that despite fitting parameters, all models of $P^b{}_{opt}$ are only able to explain approximately 52-55% of the variance in the data. The $P^b{}_{opt}$ model of Behrenfeld & Falkowski has the lowest r^2 correlation values (r^2 = 0.528), however, this value basically does not differ much from the r2 values of Cox et al. and Morris & Kromkamp's model (0.562 and 0.561 respectively). One startling observation is that Behrenfeld & Falkowski's model fails to achieve $P^b{}_{opt}$ values higher than approximately 7 mgC/mgChl-a/hr. The results of modelled $P^b{}_{opt}$

Table 2: Parameters used before fitting and newly generated parameters after fitting. For the Pbopt model of Morris & Kromkamp (2003), additional constraints were used, and these are listed next to the parameters)

	Parameters	Old	New	Sum of error $(P^b{}_{opt} - P^b{}_{max})^2$
Cox et al., 2010	Q_{10}	*2*	*1.7941*	*1123.232*
	$P_{max,10}$	*4.8*	*5.6*	
	α_{10}	*0.0129* (from Cox et al., 2010)	*129.67*	
Morris & Kromkamp, 2003	$P^b{}_{max}$	*25*	*20.2*	*1125.256*
	T_{max} (≤42°C)	*42*	*41.96*	
	T_{opt} (≤T_{max})	*30*	*37.3*	
	β	*1*	*0.327*	

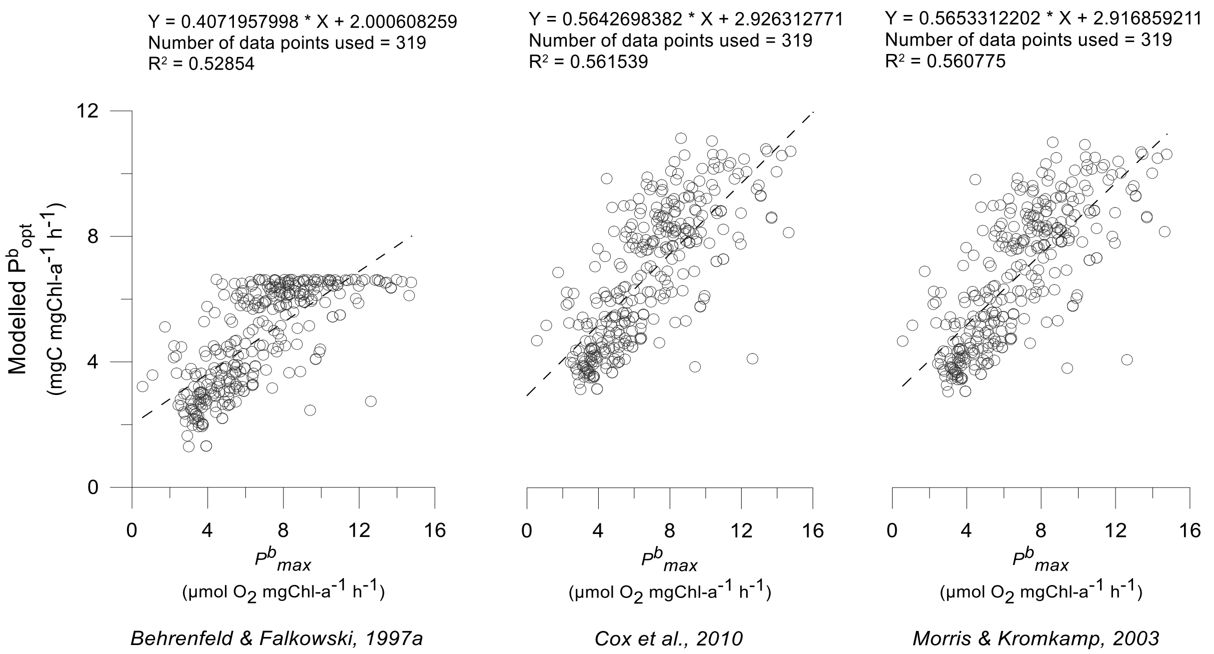

Figure 11: Plots of modelled $P^b{}_{opt}$ versus measured $P^b{}_{max}$ values.

values using Cox et al. and Morris & Kromkamp's model appears to be extremely similar, with no visible differences. However, the new fitted α_{10} parameter in Cox et al.'s model is an unrealistic value (value = 129.67). Additional constraints were attempted in order to keep values to realistic numbers, however, no desirable result was obtained thus far. Therefore, although the minimum sum of error was achieved when fitting parameters for Cox et al.'s model, the resulting new parameter for α_{10} was considered to be an unrealistic number and therefore, may not possibly be suitable for modelling P^b_{opt}.

Figure 12 illustrates the variations of BPI models incorporating the different modelled P^b_{opt} values and regressed against in-situ GPP values from both Oosterschelde and Westerschelde combined. Results show that the regression coefficients are rather high, with all BPI model variations demonstrating similar r^2 values of around 0.83. Despite the inability of Behrenfeld & Falkowski's model to predict values of P^b_{opt} higher than approximately 7mgC/mgChl-a/hr, the plateauing of values is not observed at all when incorporated into the BPI model. In view of the lack of significant differences between the results of the modelled GPP values while incorporating variations of the Pbopt modelled values and in-situ GPP values, the Behrenfeld & Falkowski (1997a) model was chosen for testing model efficiency and applying it onto satellite imagery as it depended on a single parameter i.e. Temperature.

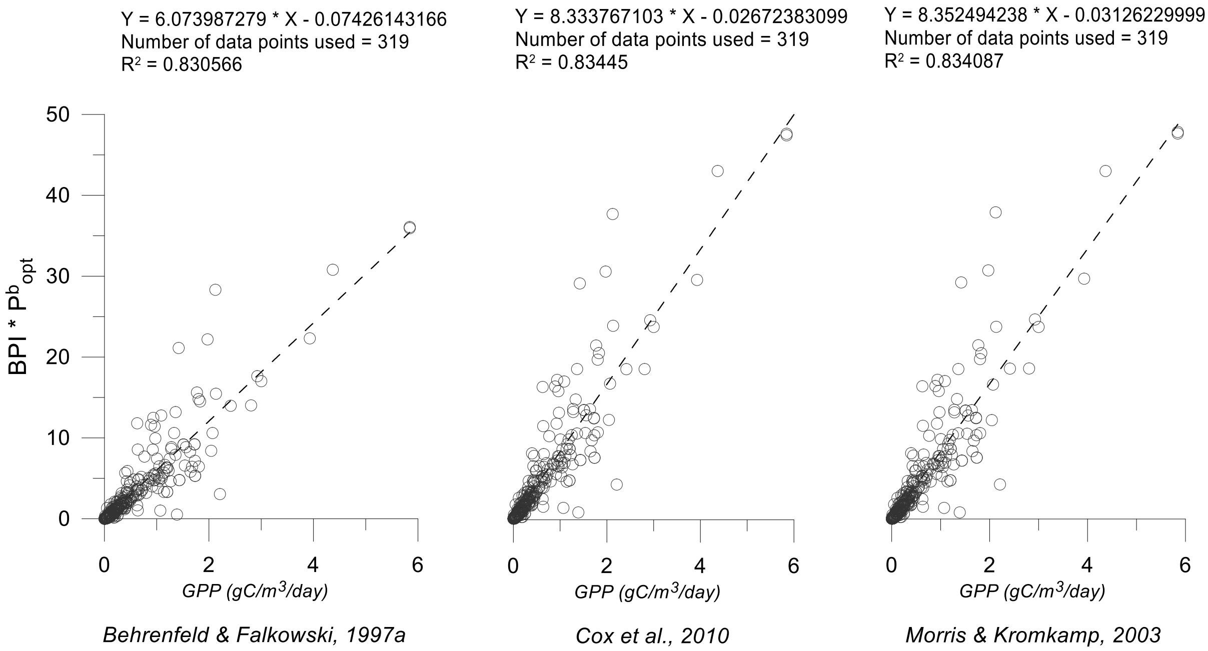

Figure 12: Comparison of in-situ GPP values versus the various BPIP^b_{opt} models*

4.3 Model efficiency

The models were applied onto the datasets of each region using in-situ variables and the results are illustrated in a time-series plot in Figure 13 and Figure 14, separated into two graphs for each station in each region. As observed, modelled data appears to closely follow trends in GPP for both regions in both stations.

For stations OS1 and OS2 (Figure 13), VGPM with P^b_{max} and VGPM with P^b_{opt} parameters seem to perform well, yet, it is unable to reproduce the exact timing in some cases, especially in 2012 and either over or underestimate the measured GPP on several occasions. In addition, VGPM with P^b_{opt} data often appears to underestimate the GPP trend in both OS1 and OS2. It can also be observed that VGPM with P^b_{max} and VGPM with P^b_{opt} misses several peaks together - April 2011 in OS1 and May & July 2012. For the BPI, BPI* P^b_{max} and BPI*P^b_{opt} models, the BPI* P^b_{max} parameters imitate GPP trends the closest out of all the models, while the BPI and BPI*P^b_{opt} models both have similar trends in data. For the most part, the BPI and BPI*P^b_{opt} models tend to miss peaks as well, like the VGPM with P^b_{max} and VGPM with P^b_{opt} models. It also tends to underestimate peaks in values especially during summer months.

For stations WS1 and WS4 (Figure 14), the VGPM with P^b_{max} and VGPM with P^b_{opt} model does predict the seasonal variability in GPP well, although the accuracy of the peaks in GPP during the phytoplankton blooms is not always reproduced exactly (i.e. March 2009, June 2009, July 2010 and July 2013). Much like the Oosterschelde, the BPI*P^b_{max} model displays the closest relation to GPP trends than all the models. Similar to the Oosterschelde, both these models also tend to underestimate the trend in values during phytoplankton bloom periods.

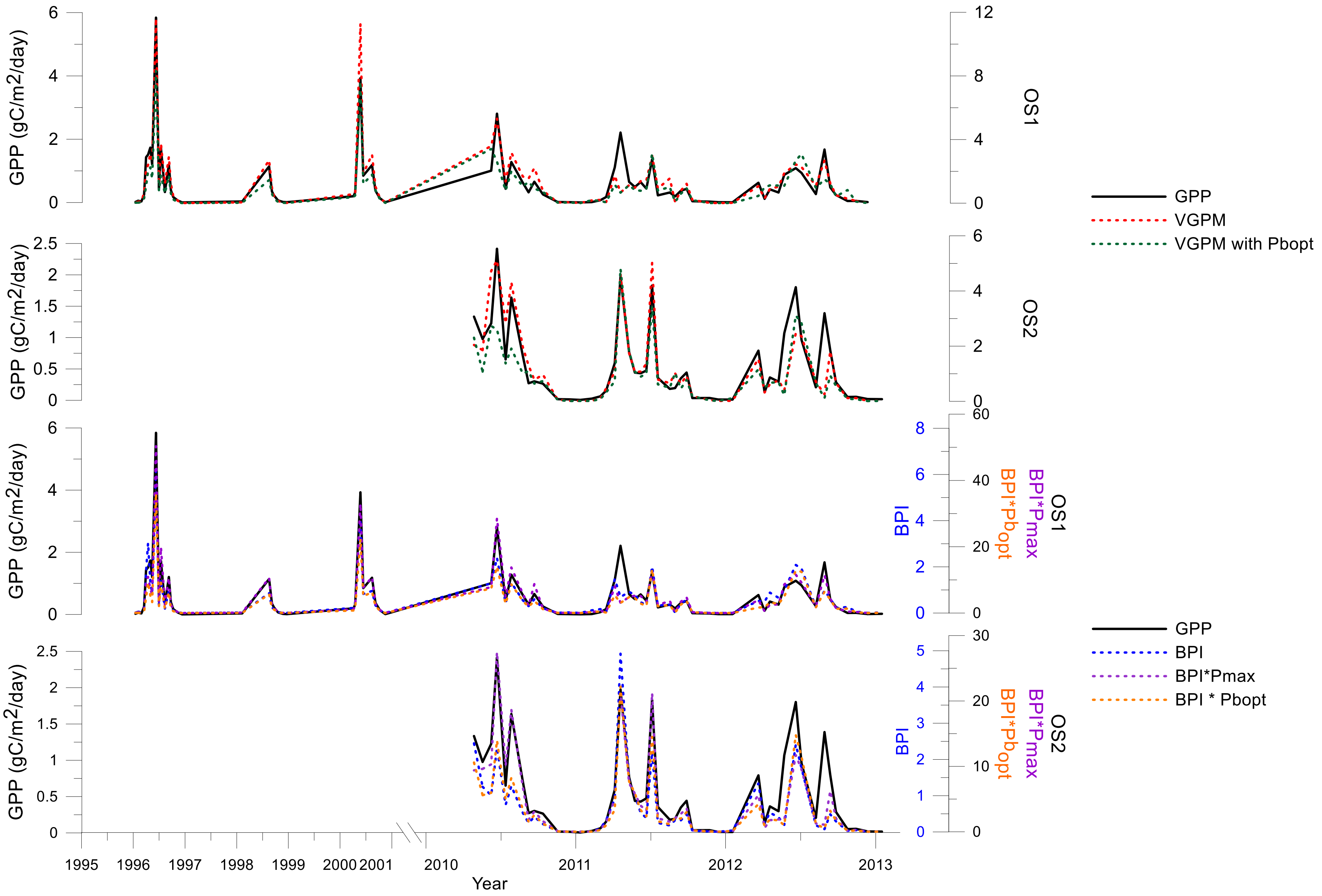

Figure 13: Time-series plot of Oosterschelde (OS1 and OS2) GPP data (black) versus modelled parameters.

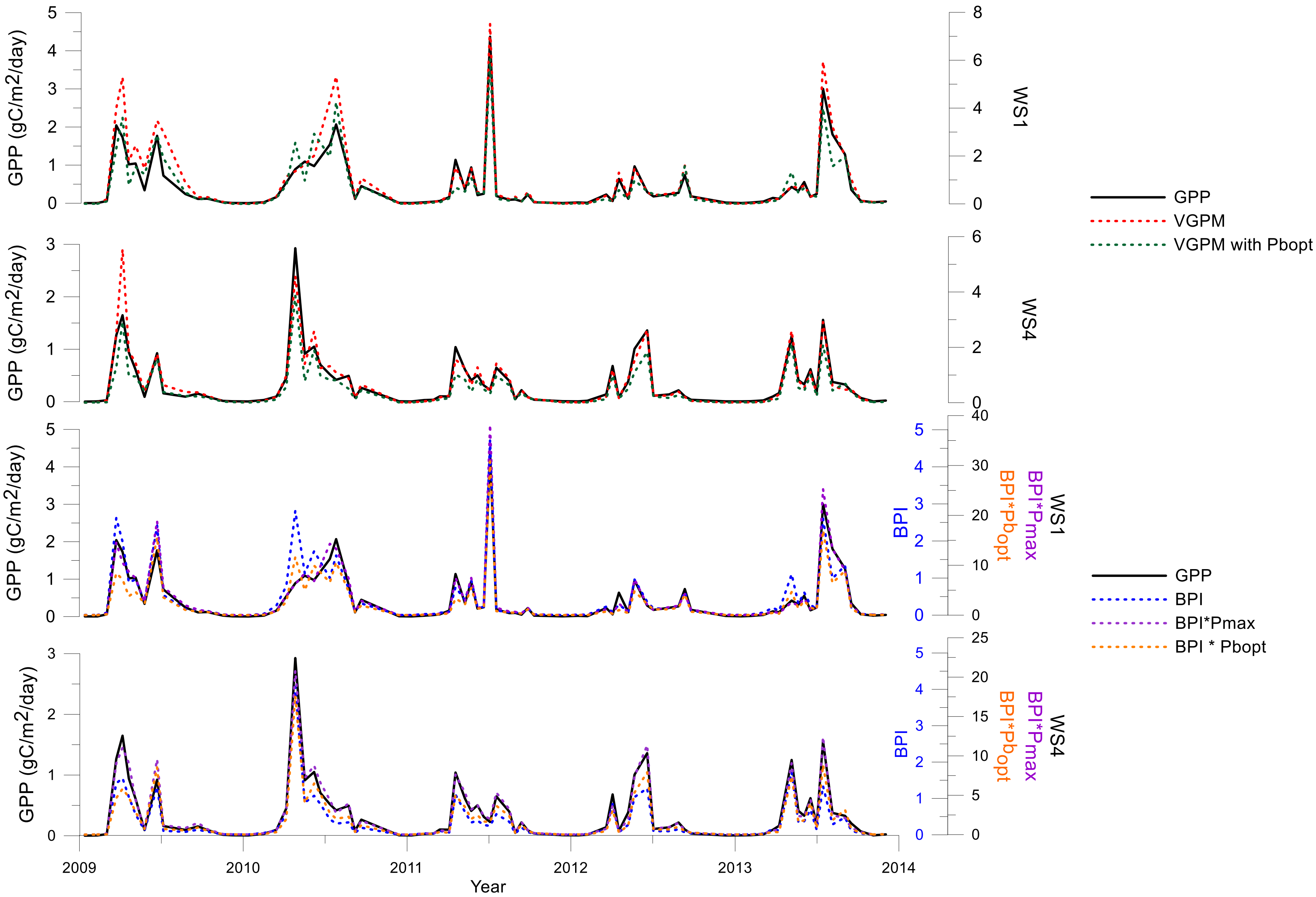

Figure 14: Time-series plot of Westerschelde (WS1 & WS4) GPP data (black) versus modelled parameter

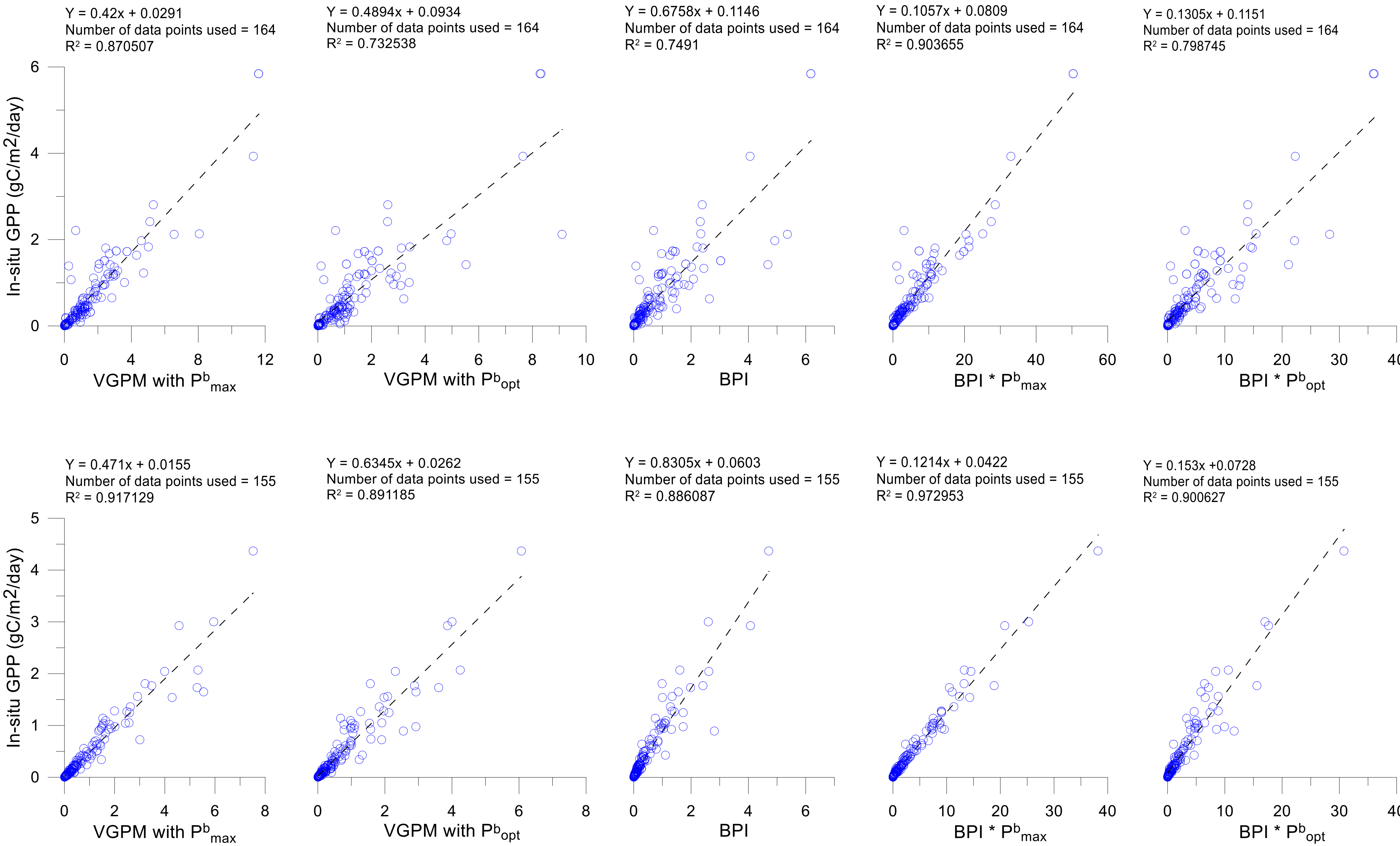

Figure 15: Comparison of the 4 primary production models. Top row: Oosterschelde; Bottom row: Westerschelde.

The 5 models (equation [2], [3], [5], [6] & [7]) were regressed against in-situ GPP values for the Oosterschelde and Westerschelde respectively. The regressions are illustrated in Figure 15, with the top row representing the modelled values versus GPP values of the Oosterschelde and the bottom row representing modelled values versus GPP values from the Westerschelde. When the model composite parameters were regressed against the GPP values from both stations in both regions, all plots displayed a linear correlation. To test this, a linear trendline was fitted and the r^2 values were calculated. All models performed reasonably well, arriving at r^2 values of more than 0.7. In general, it can also be observed that the Westerschelde displays higher r^2 values than the Oosterschelde for all four models. The model with the lowest r^2 value was the VGPM with P^b_{opt} model for the Oosterschelde and the BPI model for the Westerschelde, with r^2 values of 0.73 and 0.886 for the Oosterschelde and Westerschelde respectively, while the BPI*P^b_{max} model had the highest r^2 values for both regions, with values of 0.9 and 0.97 respectively. Moreover, the VGPM with P^b_{opt} model does not perform that much better than the BPI model in the Westerschelde, with r^2 values of 0.891 and 0.886 respectively. It can also be observed that the incorporation of the P^b_{max} parameter into the BPI model considerably constrains scatter in the linear regression between model composite parameters and in-situ data. For both regions, the BPI*P^b_{opt} model had a lower correlation to GPP data than the BPI* P^b_{max} model did, but still performed better than the BPI model.

Table 3 shows the AIC values acquired for each model in each region. As mentioned earlier, lower AIC values generally indicate better model performance compared to other models for the same dataset. At first glance, the model that has the lowest AIC values is the BPI* P^b_{max} model, while the worst performing is the VGPM with P^b_{opt} for the Oosterschelde and the BPI model for the Westerschelde. For both regions, the BPI * P^b_{opt} model performs better than the BPI model, though not by a significantly large difference.

Table 3: AIC values derived from the linear regression of in-situ GPP data from both regions against the various models.

Model	*Oosterschelde*	*Westerschelde*
VGPM with P^b_{max}	92.8	-79.8
VGPM with P^b_{opt}	211.7	-37.6
BPI	201.3	-30.5
*BPI ** P^b_{max}	44.3	-253.3
*BPI ** P^b_{opt}	165.1	-51.6

Therefore, in view of the results of the various models, the BPI, BPI*P^b_{max} and BPI*P^b_{opt} model were decidedly chosen to be applied onto satellite imagery due to the high r^2 values derived from the linear regression, and the low AIC values. Additionally, linear regression analysis was performed to better understand data distribution and investigate any potential biases. The results of the analyses are illustrated in Figure 16 and Figure 17 for the Oosterschelde and Westerschelde respectively.

Residuals versus fitted data

Whether model parameters maintain a linear relationship with in-situ data is dependent on how residuals behave in relation to the entire dataset. For a model to be considered to have a reasonable linear relationship, there should be no dependency in the models, i.e. residuals should sit in a mostly horizontal band centring near the value 0 and be evenly distributed throughout the horizontal band. For the Oosterschelde, the behaviour of the residuals seems to indicate that most models retain a reasonable linear relationship with in-situ GPP. However, residuals with higher scatter are found when GPP values are high, and this is most evident in the BPI and BPI*P^b_{opt} models. In addition, there is a notable tendency of data points to clutter around the low GPP values. The red line indicates the general trend of fitted values against residuals, and the BPI model shows that residuals are evenly distributed on both sides of the line. This may mean that the model neither over nor underestimates the predicted GPP values. Yet, the trendline in both the BPI*P^b_{max} and BPI*P^b_{opt} models show a general tendency to lean towards negative residual values at higher GPP values. This can be interpreted as the tendency for the models to underestimate higher GPP values, or in the case of the BPI*P^b_{opt} model, this may even suggest that the model is unable to predict GPP values using a linear regression.

For the Westerschelde, there appears to be a kink in the trendline between residuals and in-situ GPP after GPP values of approximately 1.2, 1.6 and 2.5 for the BPI, BPI*P^b_{max} and BPI*P^b_{opt} models. The trendline starts off horizontal, and then kinks towards the negative range. However, it cannot be concluded if the models are more biased towards higher GPP values – from the residual versus fitted data plots, it can also be observed that there are far less data points available for higher GPP values i.e. above 4 gC/m^2/day. Therefore, the results thus far appear to suggest that the model's parameters do display a good linear correlation with in-situ GPP data for both regions, however, an insufficient amount of data points for higher GPP values does not allow a conclusive decision regarding whether the linear model can also be appropriately applied for instances when GPP is high in the respective regions, and the predicted GPP could have a possibility of underestimating the actual GPP values.

Quantile-Quantile (Q-Q) plots

Q-Q plots illustrates the distribution of datasets and allow visual analysis of whether data is normally distributed or not. For data to be considered to follow a normal distribution, all points must mostly fall along a straight line. The Q-Q plots of all three models of both the Oosterschelde and Westerschelde display a distribution that falls mostly along the line shown in the plot, but curves off at both ends of the tails. This is known as "heavy-tails", which mean that the data may not be normally distributed. This may also indicate that data is exhibiting more extreme values, however, since most sample points still fall along a roughly straight line, only the end-member values appear affected.

Scale-Location plots

Scale-location plots illustrate if residuals are distributed evenly along sample data, and help supplement the preliminary observations from residual vs fitted plots. These plots are also useful in investigating the assumption that the data has homoscedasticity, which means that there is an equal distribution of variance throughout the data points. This is normally represented by a roughly horizontal straight line in the plot. However, it can be observed that for both the Oosterschelde and Westerschelde, all Scale-Location plots have non-horizontal lines, and in some cases, unevenly kinked lines in the plot. This indicates unequal variance in the dataset, and hence the assumption that the data has homoscedasticity should be rejected. However, the angle of these lines in the plots also lend argument to the previous observation that the all the models have an increasing range of error when trying to predict sample points with higher GPP values.

Residuals versus Leverage

Dashed lines indicate Cook's distance, in which data points lying beyond this line can be inferred to be an outlier that may significantly influence regression results. For the Oosterschelde, most data points lie well within the distance lines, yet two sample data points (no. 18 and 67) consistently fall along the edges of the Cook's distance line and are not consistently out of the distance lines for all three models. This may indicate that they may not be considered outliers as their position varies in all plots. For the Westerschelde, it can be observed that some data points are positioned near the Cook's distance line or slightly beyond as well. Only one data point consistently sits very near or slightly beyond the distance line i.e. no. 39. When referring to the dataset, these data points correspond to GPP peaks in values during summer months i.e. more than 4.0 $gC/m^2/day$.

Linear regression analysis summary

A combination of the reported findings in the linear regression analysis points to both the Oosterschelde and Westerschelde having tendencies to have extreme values that also correspond to potentially wider range of error when trying to predict higher GPP values. However, these extreme values may not necessarily be outliers, as none of the data points are consistently well beyond the Cook's distance line for all three models. When such data points were compared to datasets, this confirmed that all three models have difficulty predicting values for periods of high primary production.

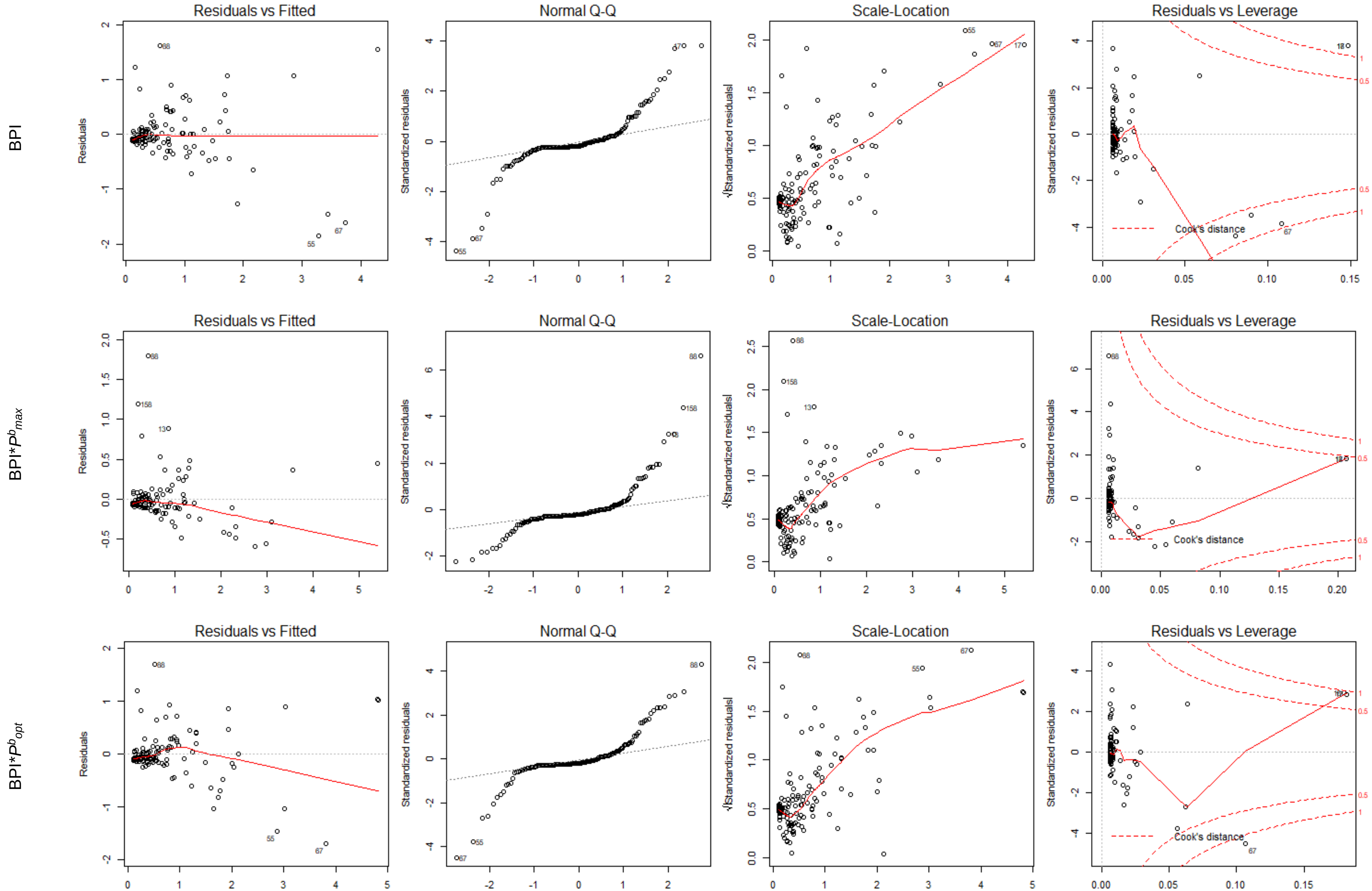

Figure 16: Diagnostic plots for linear regression analysis of in-situ GPP versus the BPI, BPIP^b_{max} and BPI*P^b_{opt} models for the Oosterschelde*

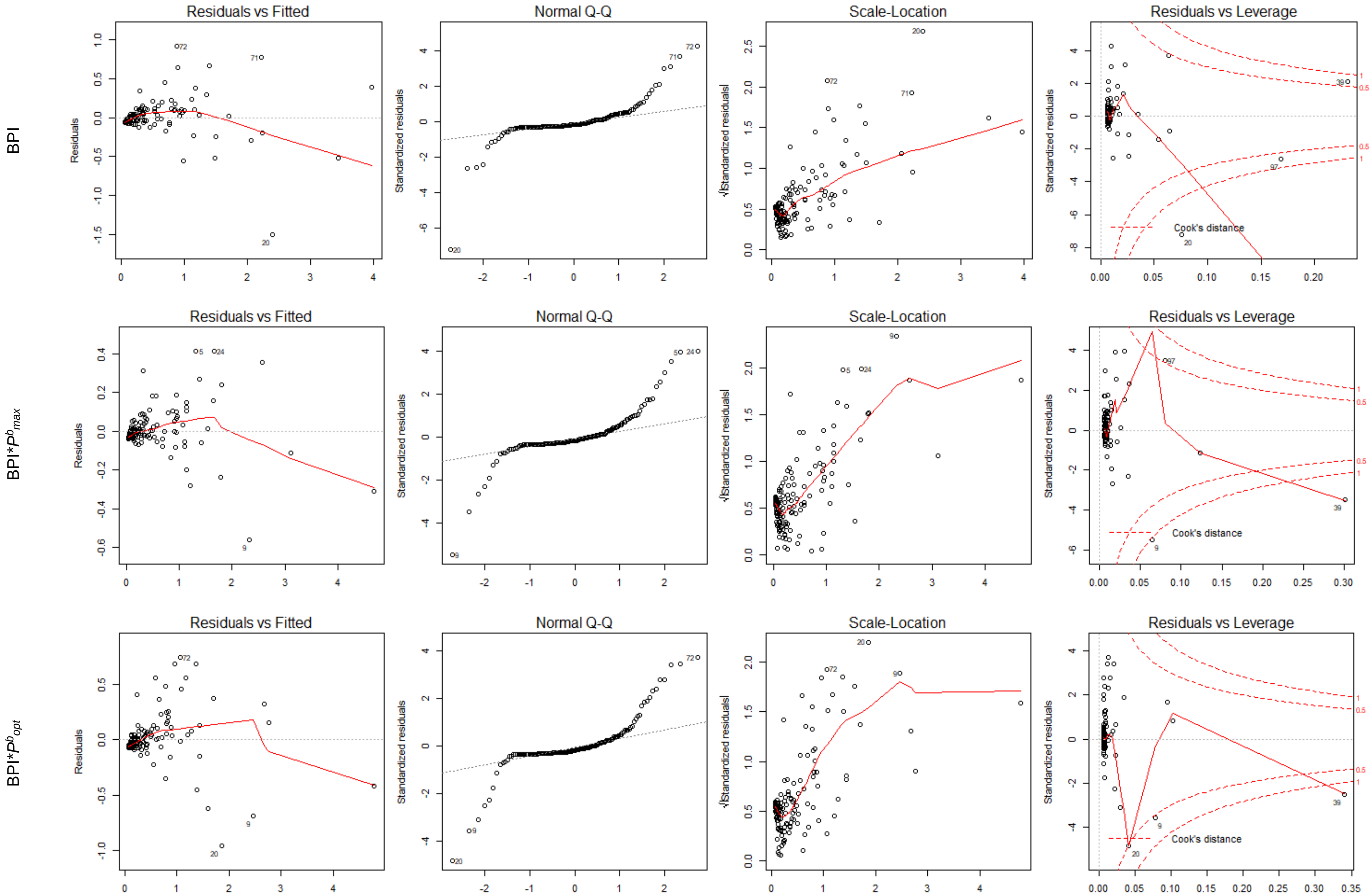

Figure 17: Diagnostic plots for linear regression analysis of in-situ GPP versus the BPI, BPIP^b_{max} and BPI*P^b_{opt} models for the Westerschelde*

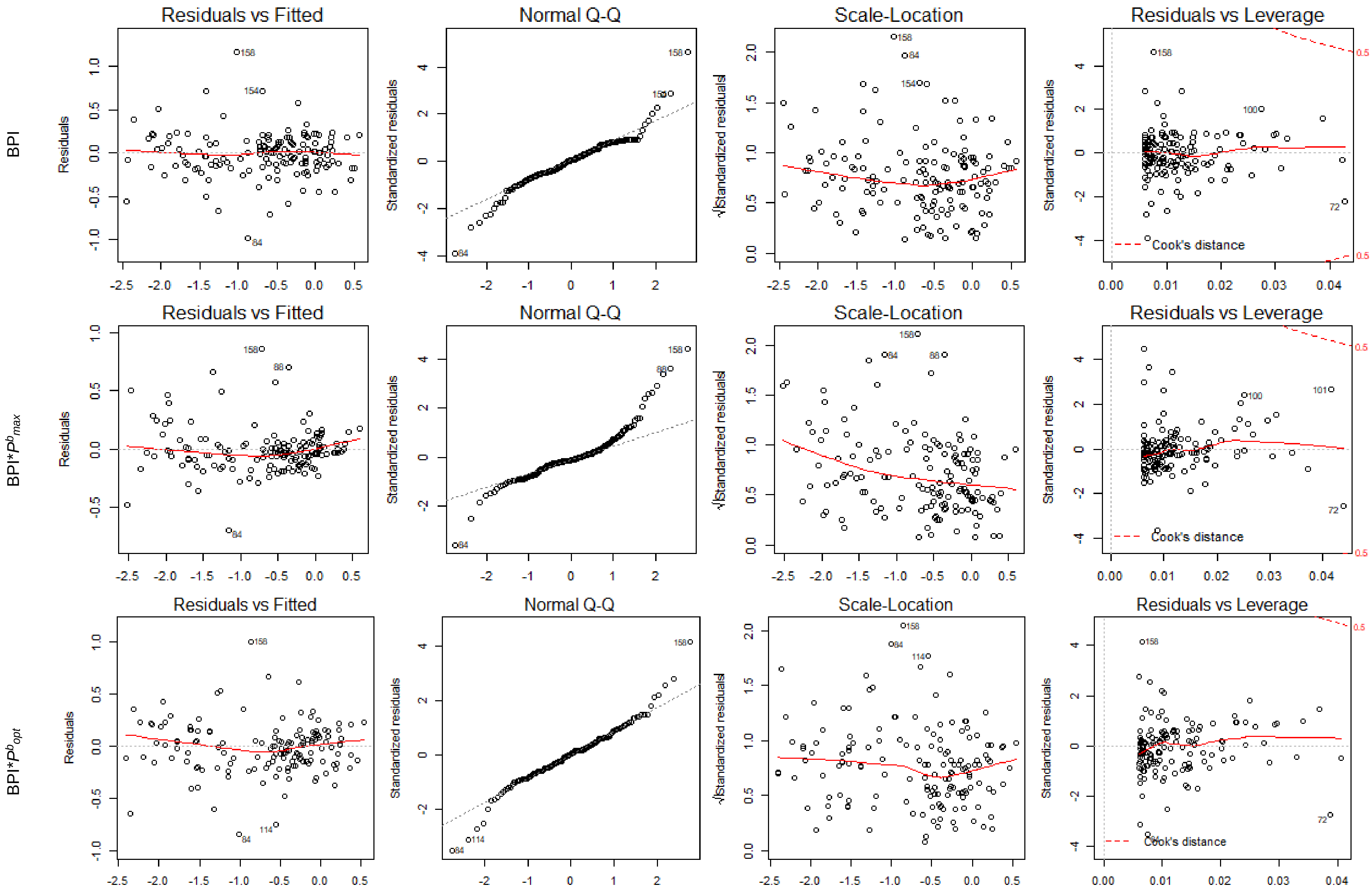

Figure 18: Diagnostic plots for linear regression analysis of the log-transformed datasets for the Oosterschelde

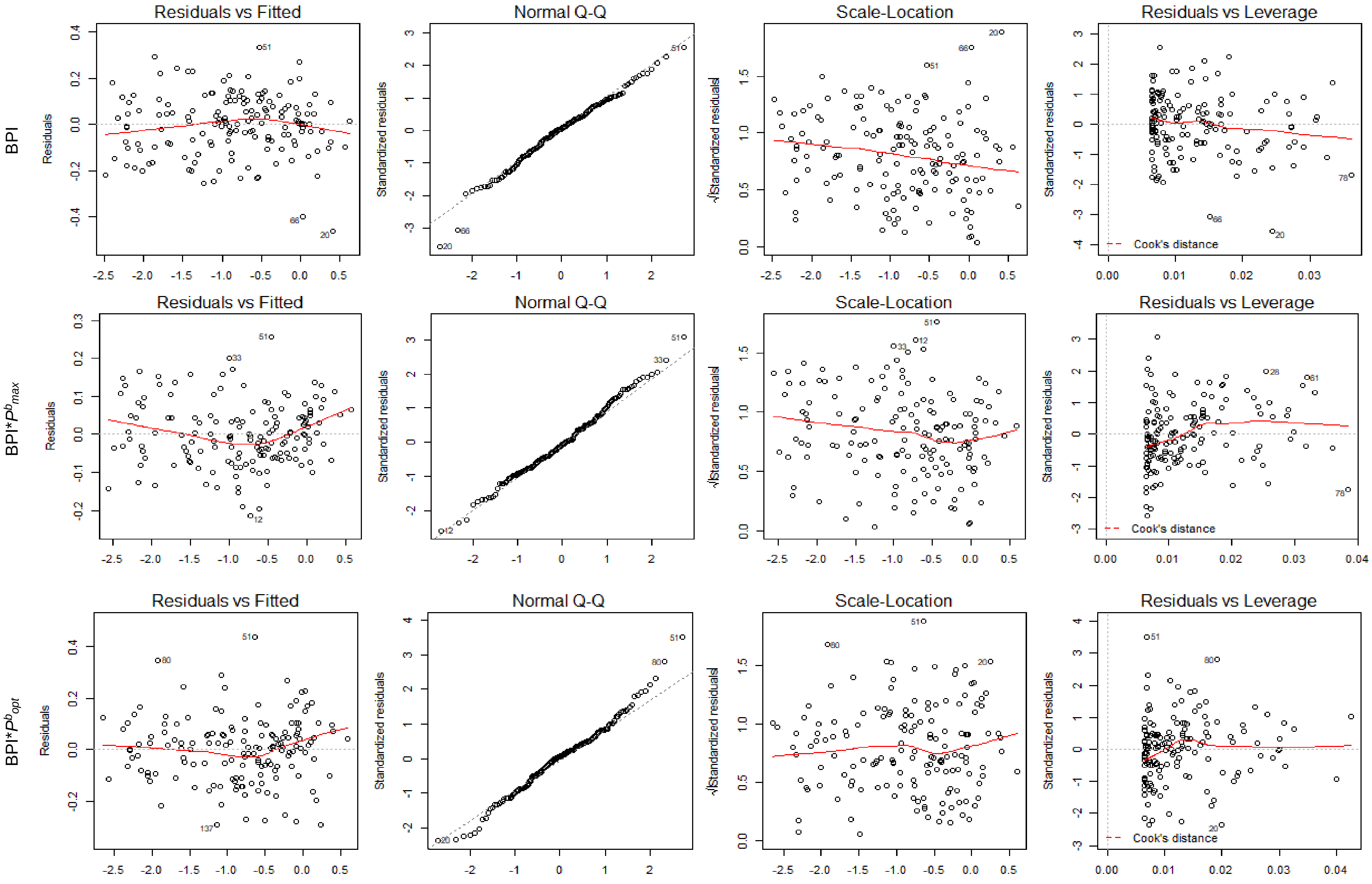

Figure 19: Diagnostic plots for linear regression analysis of the log-transformed datasets for the Westerschelde

Linear regression analysis on a log-transformed dataset

To further investigate the potential dependency in the dataset, a log transformation was performed on all modelled and in-situ values, and a linear regression analysis was performed on the datasets again. The results are illustrated in diagnostic plots shown in Figure 18 and Figure 19.

Both regions show the residuals sitting in a mostly horizontal band for all three models for the residuals versus fitted data plots. This is an improved result compared to the plots in Figure 16 and Figure 17. The Q-Q plots of the log transformed datasets also indicate an increasingly normal distribution compared to the Q-Q plots for the non-log transformed datasets. However, all models for the Oosterschelde appear to maintain the "heavy-tail" behaviour and display an 'S'-shaped curve, while all sample points fall along the straight line for the Westerschelde, except for the BPI*P^b_{opt} dataset where it displays some heavy-tailing as well. The scale-location plots in the log-transformed datasets show a straighter horizontal line than in Figure 16 and Figure 17, though the BPI*P^b_{opt} datasets in both regions show some slight kinking in the horizontal line, which may suggest some heteroscedasticity in the data remaining despite the log-transformation. Lastly, the residuals versus leverage plots illustrate all sample points remaining well within the Cook's distance lines. This is a significant improvement from the residuals versus leverage plots from the non-log transformed dataset (Figure 16 and Figure 17), as the sample points that initially fell beyond the Cook's distance lines no longer do now. This suggests that the log-transformed datasets no longer have any outliers that could significantly influence the regression coefficients.

In summary, log transforming the model values from both regions appears to create a more normal distribution of the sample points. However, the Oosterschelde still shows signs of heteroscedasticity in the data despite the transformation, evidenced by the heavy tails in the Q-Q plots. Yet, for both regions, trendlines in most of the diagnostic plots indicate some skew that remains when modelling higher GPP values. Hence, log transforming the datasets does not completely solve the issue of heteroscedasticity.

4.4 Data availability

A summary of data availability is shown in Table 4. Sampling dates from both regions were consolidated, and duplicates were removed. These dates were then considered unique dates, and were entered into Calvalus for image ordering. A total of 115 unique dates were consolidated from both regions, and 76 images were available for the dates chosen. Pixels unavailable for analysis returned an extremely low value (-9999), therefore, the total number of images available for analysis were 65% and 67.53% for the Oosterschelde and Westerschelde respectively.

Table 4: Summary of data availability for exact date satellite imagery match-ups

Number of unique dates (from both regions)		*115*
Available images on unique dates		*76 (out of 115)* *66.1%*
Total images available for analysis in each region	*Oosterschelde*	*39 (out of 60)* *65%*
	Westerschelde	*52 (out of 77)* *67.53%*
Total amount of images usable for analysis		*91 (out of 137)* *66.4%*

In addition, the reason why images available on unique dates were not always available for analysis is illustrated in Figure 20, which shows example images of cloudy (top) and clear days (bottom). This highlights the problems of remote sensing, as it is also dependent on weather conditions especially for the determination of bio-optical properties.

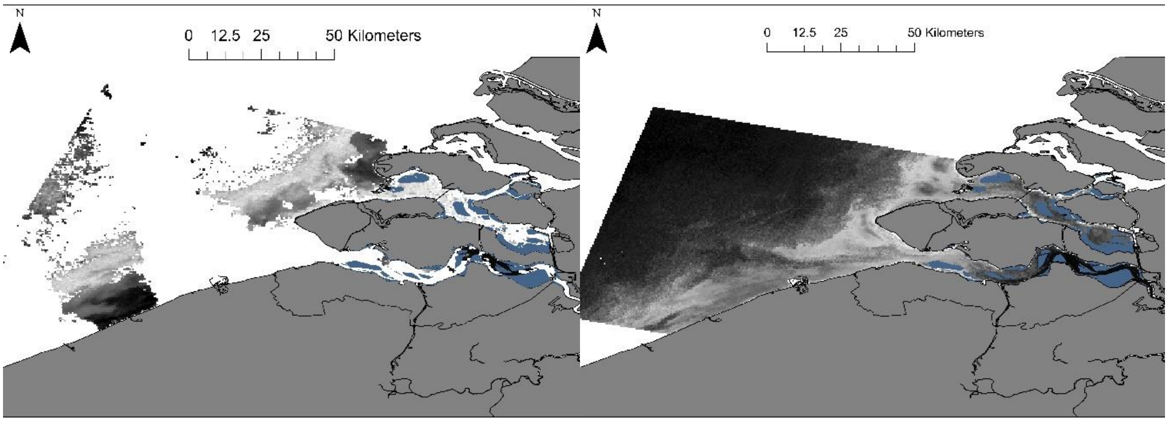

Figure 20: Example image of: [Top] A cloudy day (date of image: 24/03/2009); [Bottom] A clear day (date of image: 23/06/2010). Pixels indicate gross primary production, with darker pixels indicating lower primary productivity and vice versa.

4.5 In-situ vs satellite-derived estimates

4.5.1 Exact pixel values

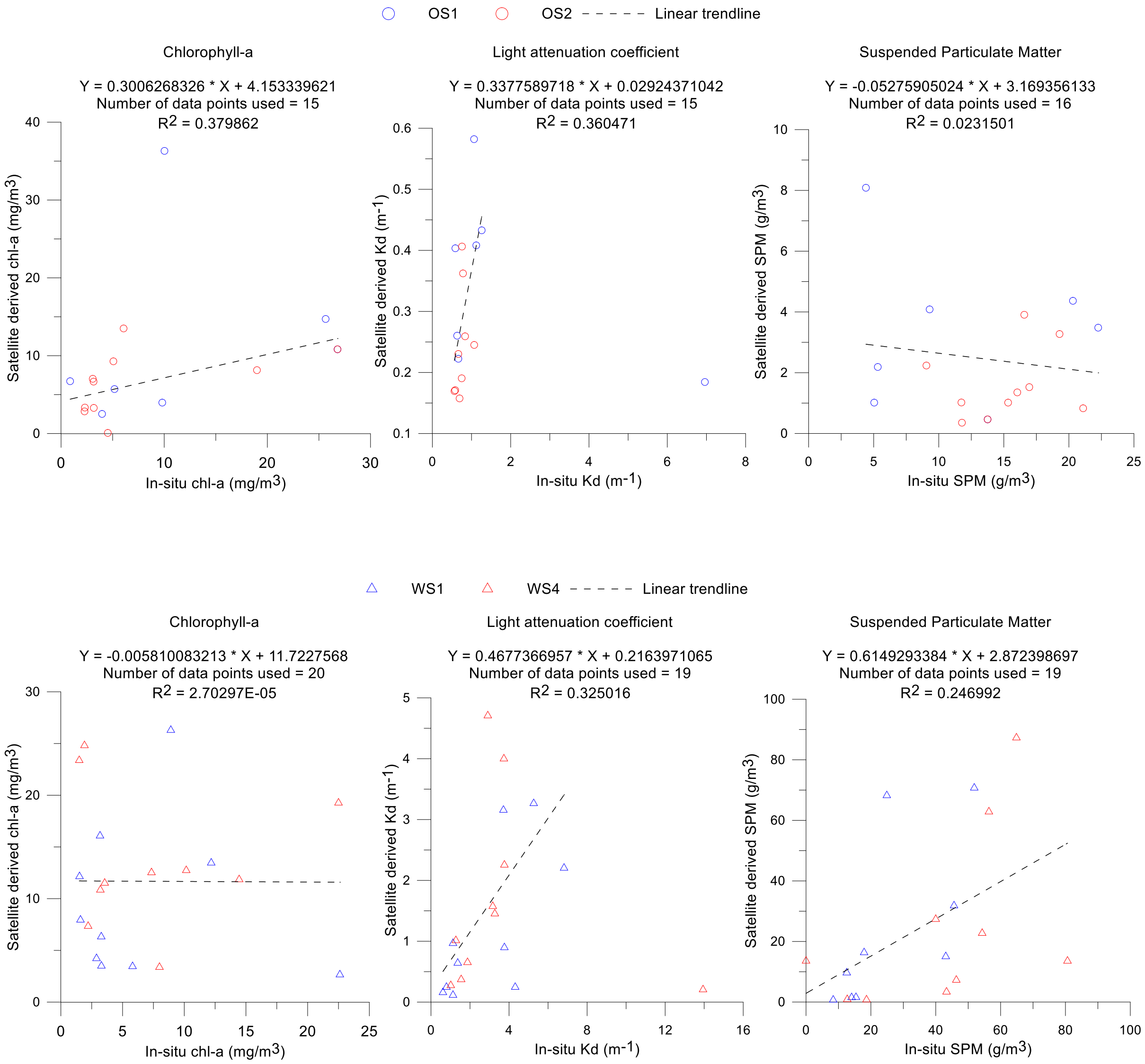

Figure 21: Exact pixel match of satellite-derived variables versus in-situ data. Top row: Oosterschelde; Bottom row: Westerschelde

Pixel values lying within the locations of the stations in each region were extracted and regressed against in-situ values. Figure 21 shows exact pixel values of chlorophyll-a, K_d and SPM of the Oosterschelde (top row) and the Westerschelde (bottom row). The range of values in the satellite-derived measurements of the Oosterschelde were generally lower than in-situ values (slope = 0.34). For the Westerschelde, the range of values were approximately similar for chlorophyll-a, K_d and SPM concentrations when comparing both satellite-derived and in-situ measurements. For chlorophyll-a in the Oosterschelde, one of the data points lies well beyond the general trend of values (in-situ: 10.022 mg/m^3; satellite-derived estimate: 36.31 mg/m^3). As most of the satellite-derived estimates of chlorophyll-a were generally underestimating in-situ values, this was considered to be an anomalous value and hence, not considered during the calculation of the regression coefficient. This gives an r^2 value of 0.38 for chlorophyll-a in the Oosterschelde, however, no relationship can be found at all for chlorophyll-a in the Westerschelde. For K_d in both regions, there is a single data point that had a very high in-situ value but low satellite-derived measurement (OS1 – 20/4/2011; WS4 – 5/7/2011). This causes the rest of the data points to seem to appear in a vertical cluster. As these are unrealistic and anomalous values for K_d, the linear regression coefficient was calculated without these points in both regions. The r^2 values for K_d in both regions are not particularly high, but have similar r^2 values in both regions and one of the best correlations amongst the other variables. In summary, no relationship can be found for SPM concentrations in the Oosterschelde, and chlorophyll-a concentrations in the Westerschelde, while K_d appears to be consistently generated similar values of correlation, although on the low end.

Figure 22 illustrates the time-series of in-situ and satellite-derived variables. For the Oosterschelde, the general pattern of satellite-derived measurements show that it does not imitate trends in in-situ data well at all. Satellite-derived chlorophyll-a measurements at OS1 do not agree with the general trend when compared to in-situ values, however, values from OS2 are able to mimic the trend in values much better. A major peak in chlorophyll-a concentrations around June 2011 appears in the satellite-derived measurements at OS1, however, this peak is not present at all in the in-situ data. K_d values for the Oosterschelde also do not show any discernible patterns that imitate the data trend in in-situ values. In some cases, the values show an opposing trend i.e. increase in in-situ values reflected as a decrease in satellite-derived values. This occurs, for example, approximately around May-April 2006 for OS1, and May-September 2011 for OS2. A very significantly large peak in K_d occurs around 2011 April at OS1 in the in-situ values, and this peak (K_d = 6.96m) does not occur at all in the satellite-derived values of K_d. Satellite-derived and in-situ measurements of SPM shared almost no similarities with each other in the time-series plot. Additionally, the obvious peak in in-situ K_d values at April 2011 also coincides with an increase in in-situ chlorophyll-a and SPM concentrations. Yet, only the satellite-derived values of chlorophyll-a show a peak in concentrations at the same time, however, SPM concentrations for this same period in both OS1 and OS2 decreased instead of reflecting an increase like the in-situ values do, and as mentioned before, satellite-derived measurements of K_d completely miss the peak in that period.

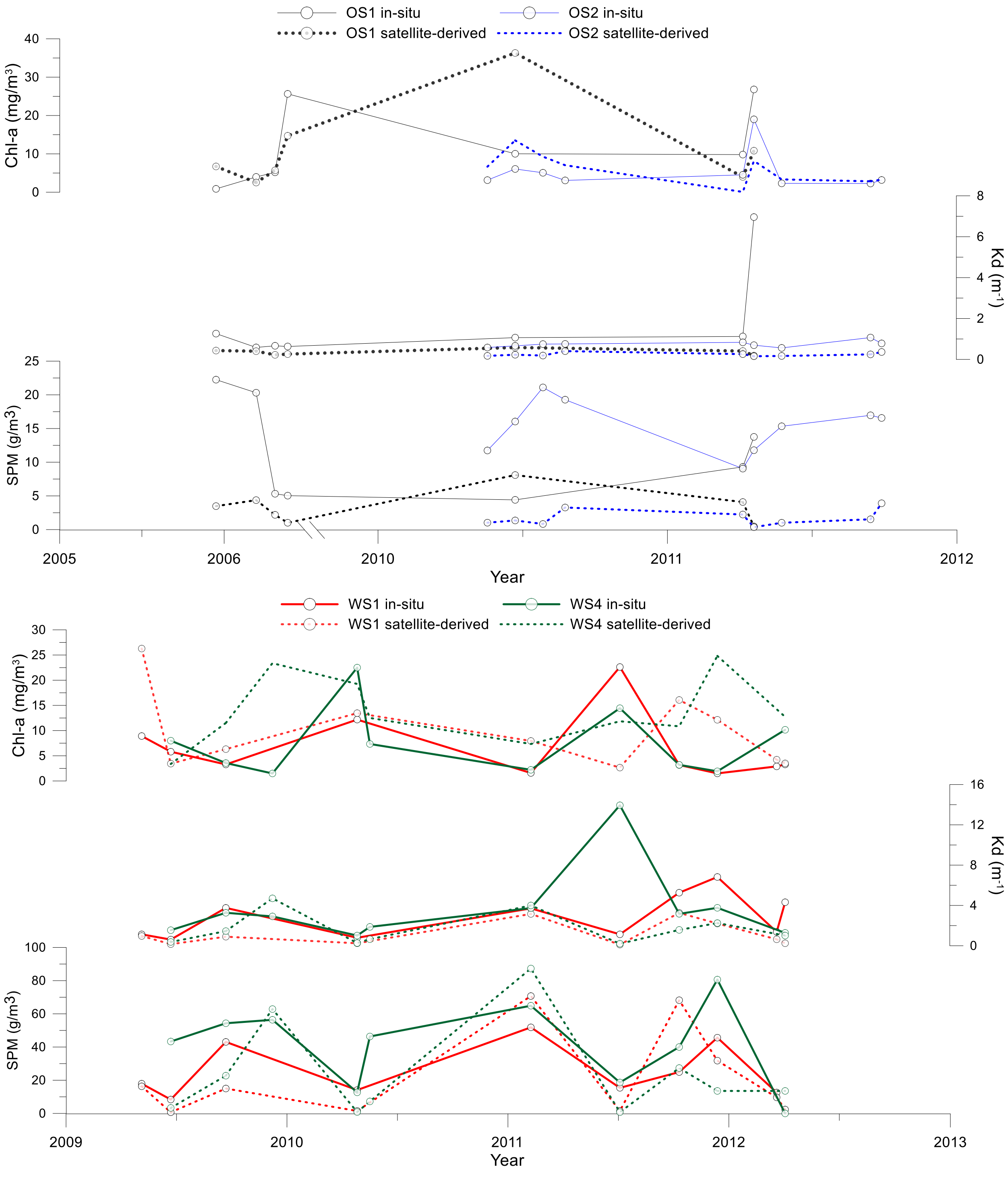

Figure 22: Time-series plot of in-situ variables (solid lines) versus satellite-derived variables. Top plot: Oosterschelde; Bottom plot: Westerschelde.

Unlike the Oosterschelde, the time-series plots of satellite-derived variables in the Westerschelde show better correlations with in-situ data trends. In general, although the satellite-derived chlorophyll-a concentrations appear to have a more erratic trend compared to in-situ data trends, the K_d and SPM concentrations have much better similarities in data trends than the Oosterschelde. Aside from a high in-situ value in K_d

that is not seen in the satellite data at around July 2011, satellite-derived K_d values show the closest, imitated trend compared to in-situ values amongst all the variables. For SPM concentrations, the general trend over the period is roughly captured by satellite-derived measurements, although the timing of the peaks differs slightly. This is apparent in the winter season between 2011-2012, where peaks in SPM concentrations were reached in October 2011 for both WS1 and WS4, while in-situ peaks in SPM concentrations were only found in the month of December 2011. When the potential outliers for K_d in both regions are ignored, the time-series illustrates the correlation in data trends better.

The pixel values of all variables from both the Oosterschelde and Westerschelde were combined to examine the correlation from a broader regional perspective. Figure 23 illustrates the combined sample points from both regions. In general, K_d and SPM values show reasonable correlations (r^2 = 0.48; r^2 = 0.39 respectively), however, chlorophyll-a appears to have completely no correlation at all (r^2 = 0.026). One prominent observation is that the Oosterschelde has visibly lower in-situ values for both K_d and SPM than the Westerschelde, which the satellite-derived estimates of these values also appear to imitate closely.

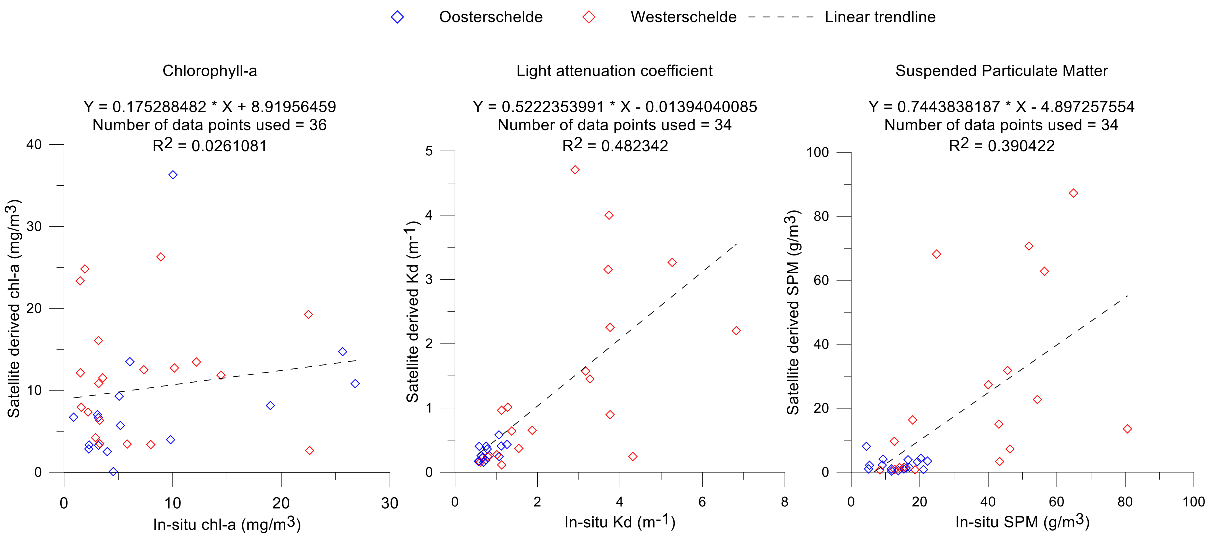

Figure 23: Exact pixel match of satellite-derived variables versus in-situ data from both regions combined.

4.5.2 3x3 Cell average comparison

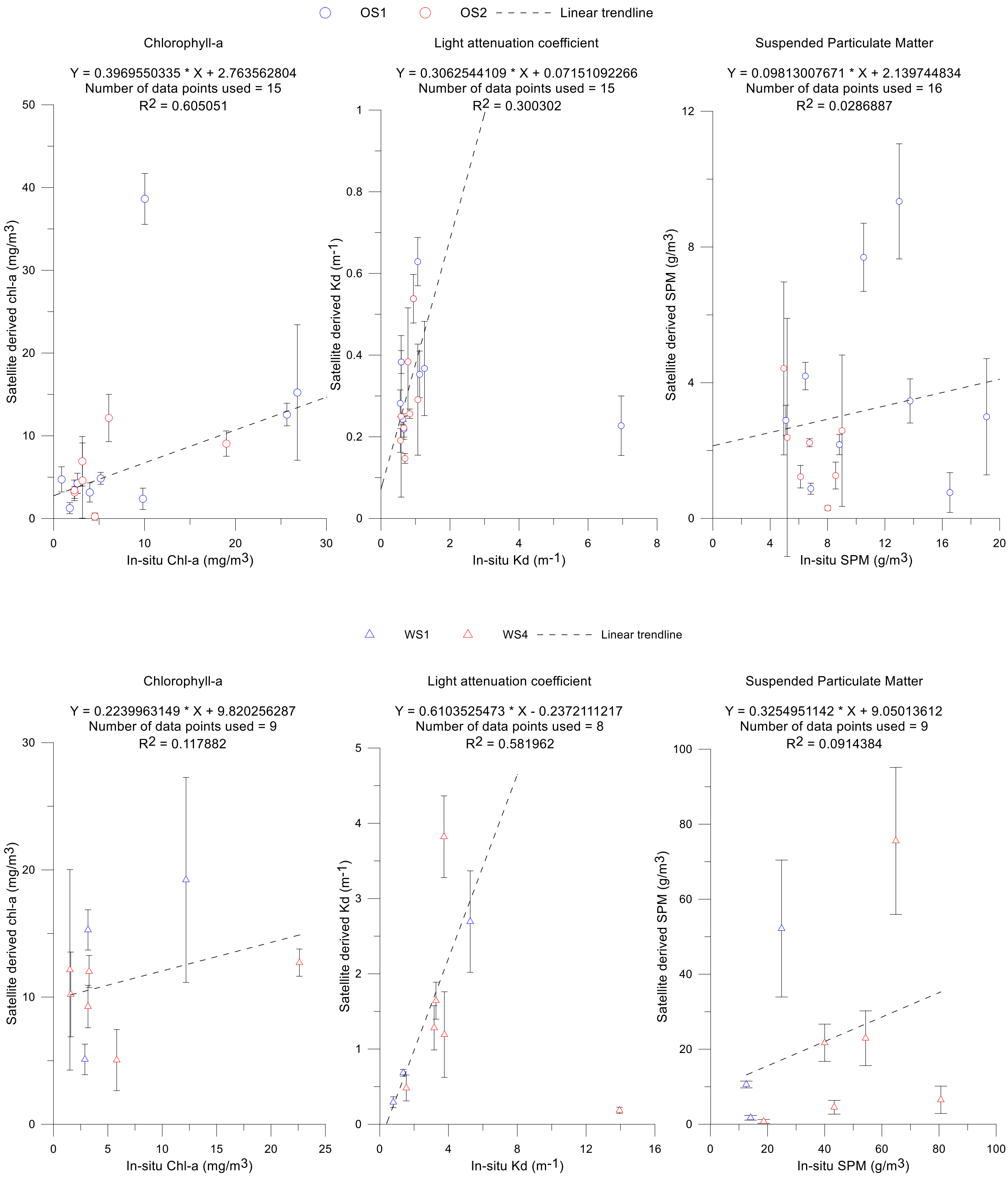

Figure 24: 3x3 cell average of satellite-derived variables compared against in-situ variables. Top row: Oosterschelde; Bottom row: Westerschelde

To investigate if an average of the area around the station points would improve the relationship between in-situ and satellite-derived measurements and reduce noise in data, a 3x3 cell kernel average of the pixel values were calculated, and the mean, range and standard deviations of the kernels were generated. The results are illustrated in

Figure 24, and in general, the r^2 values of most variables for the Oosterschelde show improvement, while for the Westerschelde, regression coefficients for chlorophyll-a and K_d values show improvement, although the improvement was the largest for K_d, from 0.32 to 0.58. in Figure 21. The regression coefficient for SPM fell from 0.25 to 0.09, Furthermore, the number of data points available for the Westerschelde fell from approximately 19 to 9. Despite the improvement in r^2 correlations for the Oosterschelde, the r^2 values are still considered low for K_d and SPM, and it is difficult to determine a definitive correlation between in-situ and satellite-derived measurements. Additionally, the range of values for all variables in both regions remains approximately similar, although the range of SPM concentrations from the 3x3 kernel average appears slightly smaller than the range derived from the exact pixel match, which could be attributed as an artefact of the averaging kernel. However, the range of values from the exact pixel matches still fall within the standard deviations of values from the kernel average of SPM. For both regions, the SPM values are estimated the poorest amongst the variables.

4.6 Satellite-derived estimates of primary production

4.6.1 3x3 cell averaged exact date matches

Primary production of the Scheldt Estuary was calculated by applying the linear equation derived from the regression between in-situ GPP values and model parameters. The results are illustrated in Figure 25 and Figure 26 for the Oosterschelde and Westerschelde respectively. In general, modelled primary production values for the Oosterschelde had much better r^2 values with in-situ GPP values than the Westerschelde for all three models. The Oosterschelde is observed to have a large overestimation of actual GPP values, ranging from 3-5 times more than in-situ values. Despite the overestimation, modelling the Oosterschelde still generates reasonable correlations. The BPI*P^b_{max} model yields the highest r^2 value of 0.51 while the lowest performing model was the BPI*P^b_{opt} model with an r^2 value of 0.41. Furthermore, the range of values for satellite-derived GPP is much larger than the range of in-situ GPP values. The BPI and BPI*P^b_{opt} model produces approximately the same range in satellite-derived values (approximately 0-12 gC/m^2/day), while the BPI*P^b_{max} model produces GPP values of up to 6 times the in-situ values, with a range of values approximately between 0-20 gC/m^2/day. A single data point from OS1, corresponding to an image dated 20/6/2005, shows that the standard deviations are more than 8 gC/m^2/day, and this data point with the abnormally large standard deviation is found in all models in Figure 25. Based on the linear equation derived from regressing the in-situ and satellite-derived GPP values together, the BPI and BPI*P^b_{opt} models both have an average overestimation of approximately 3.2-3.3 the actual values, while the BPI*P^b_{max} model has a larger average overestimation of approximately 5 times the actual values. The standard deviations of the data points also show that the variance is smaller at lower predicted versus actual GPP values, however, the variance increases when higher GPP values are modelled.

Unlike the Oosterschelde, results of the Westerschelde (Figure 26) reveal that the r^2 values of all three models fall below 0.2, i.e. only up to 20% of the variance can be explained by the data. It is unknown what causes the low r^2 values in the Westerschelde, however since chlorophyll-a had the poorest satellite-derived estimates, this may likely be the source of error. Additionally, several values stand out (n = 5) due to their large standard deviations, yet, these values are not limited to a specific data range as well, and make up 20% of the total amount of acquired images for the Westerschelde. In general, the range of values acquired from satellite-derived measurements are up to 19 $gC/m^2/day$ for all models, while the range of in-situ GPP values are up to a maximum of 4.4 $gC/m^2/day$.

Figure 27 and Figure 28 illustrates the time-series of modelled GPP and in-situ GPP values for the Oosterschelde and Westerschelde respectively, and are split into their respective stations. GPP values in both regions are generally over-estimated in both regions, although lower modelled GPP values that also corresponded to low in-situ GPP values manage to maintain a smaller difference. Summer peaks for primary production that are found in in-situ values are overestimated greatly, with the BPI model providing the lowest overestimation and the BPI*P^b_{max} model giving the largest overestimations. However, trends are better simulated in modelled GPP values for the Oosterschelde than the Westerschelde.

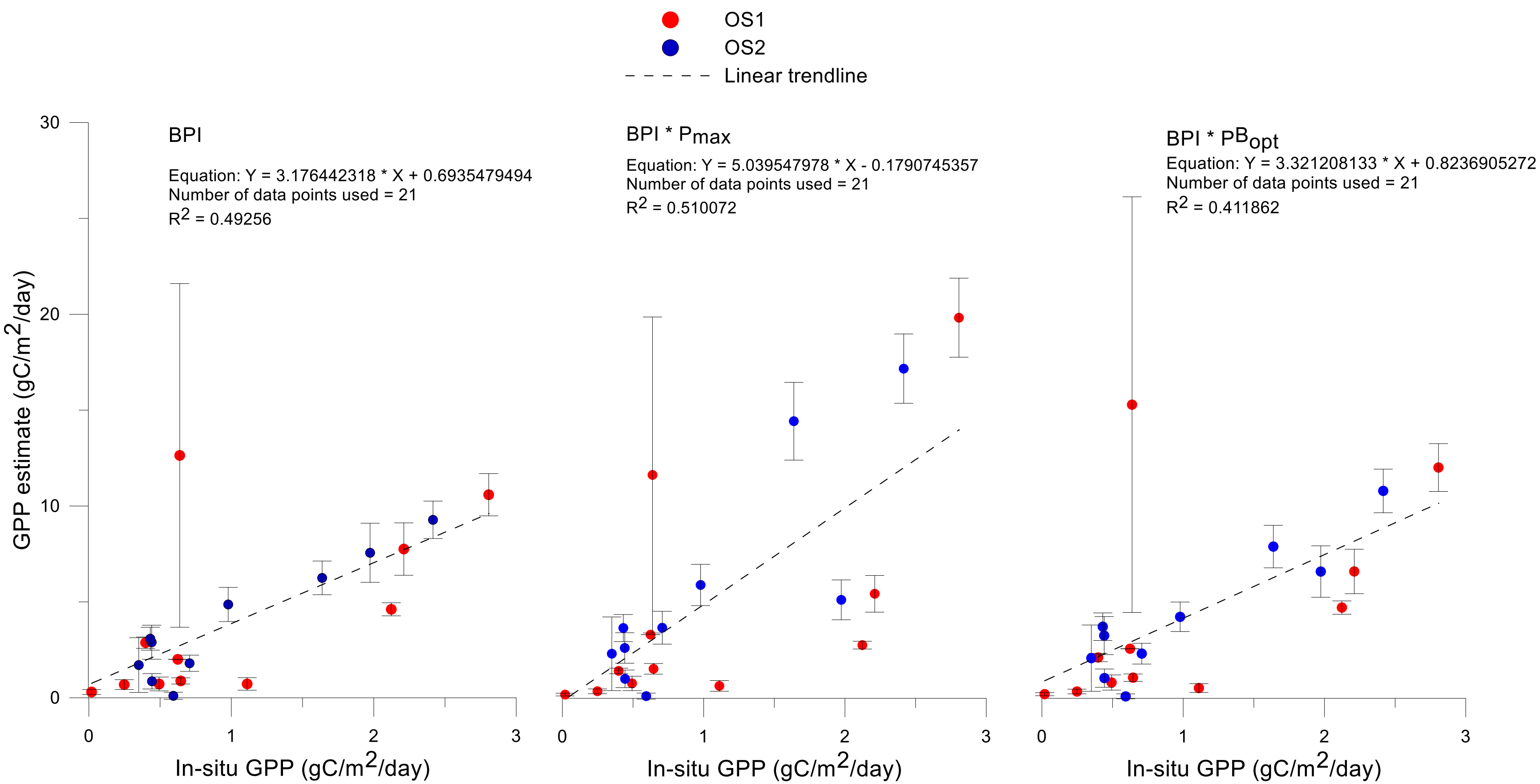

Figure 25: Plots of in-situ GPP versus satellite-derived GPP estimates for exact date matches in the Oosterschelde.

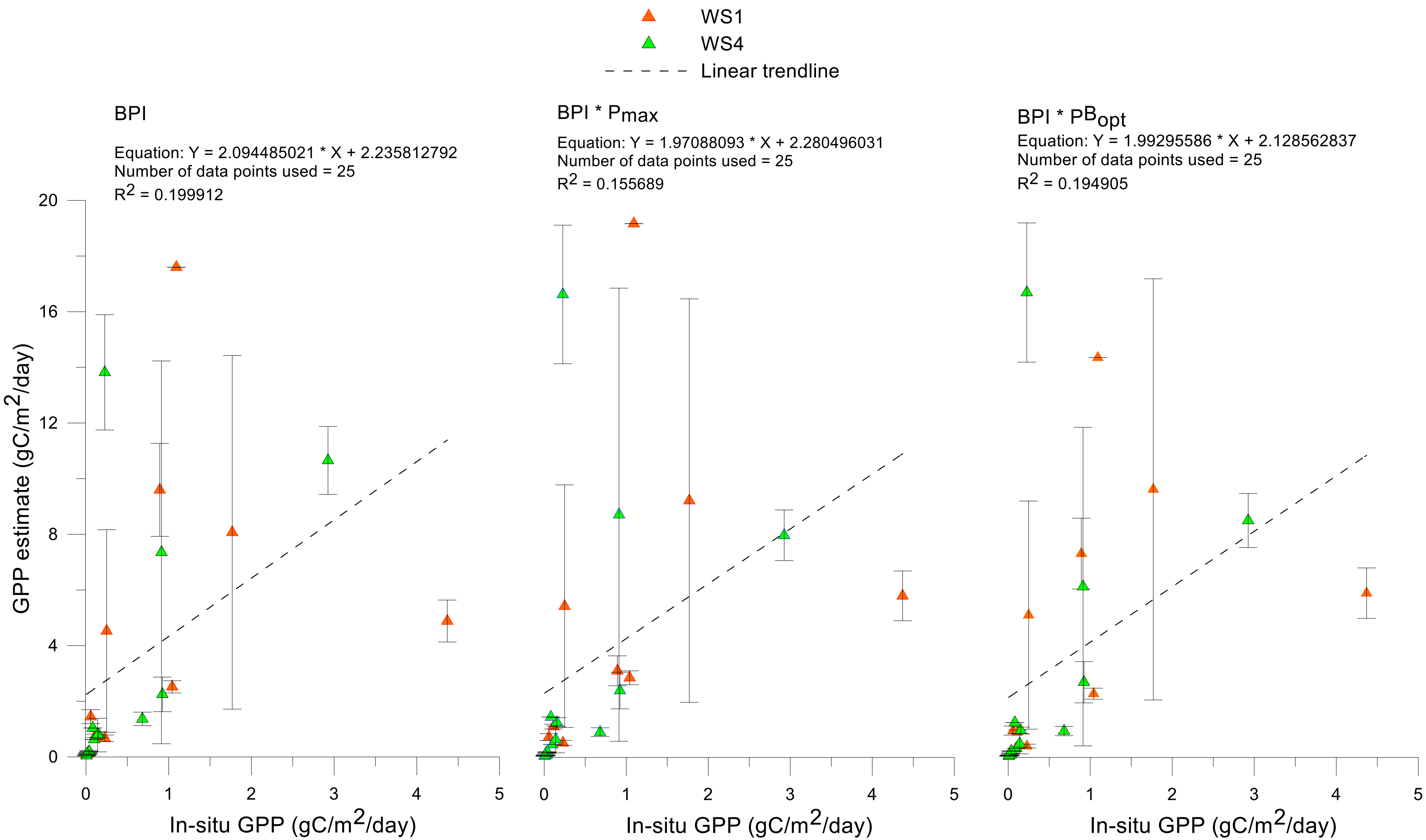

Figure 26: Plots of in-situ GPP versus satellite-derived GPP estimates for exact date matches in the Westerschelde

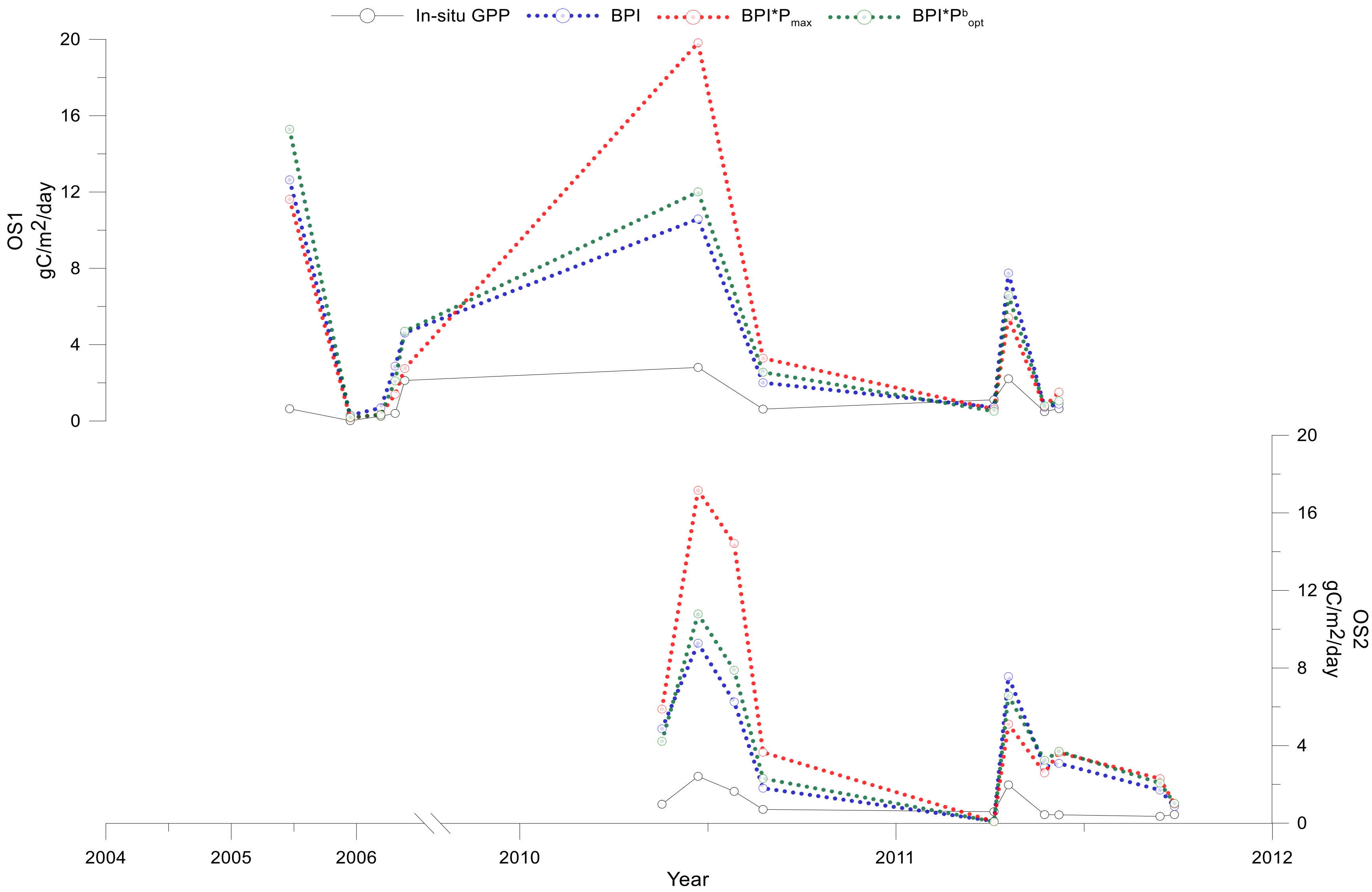

Figure 27: Time-series plot of modelled GPP in the Oosterschelde

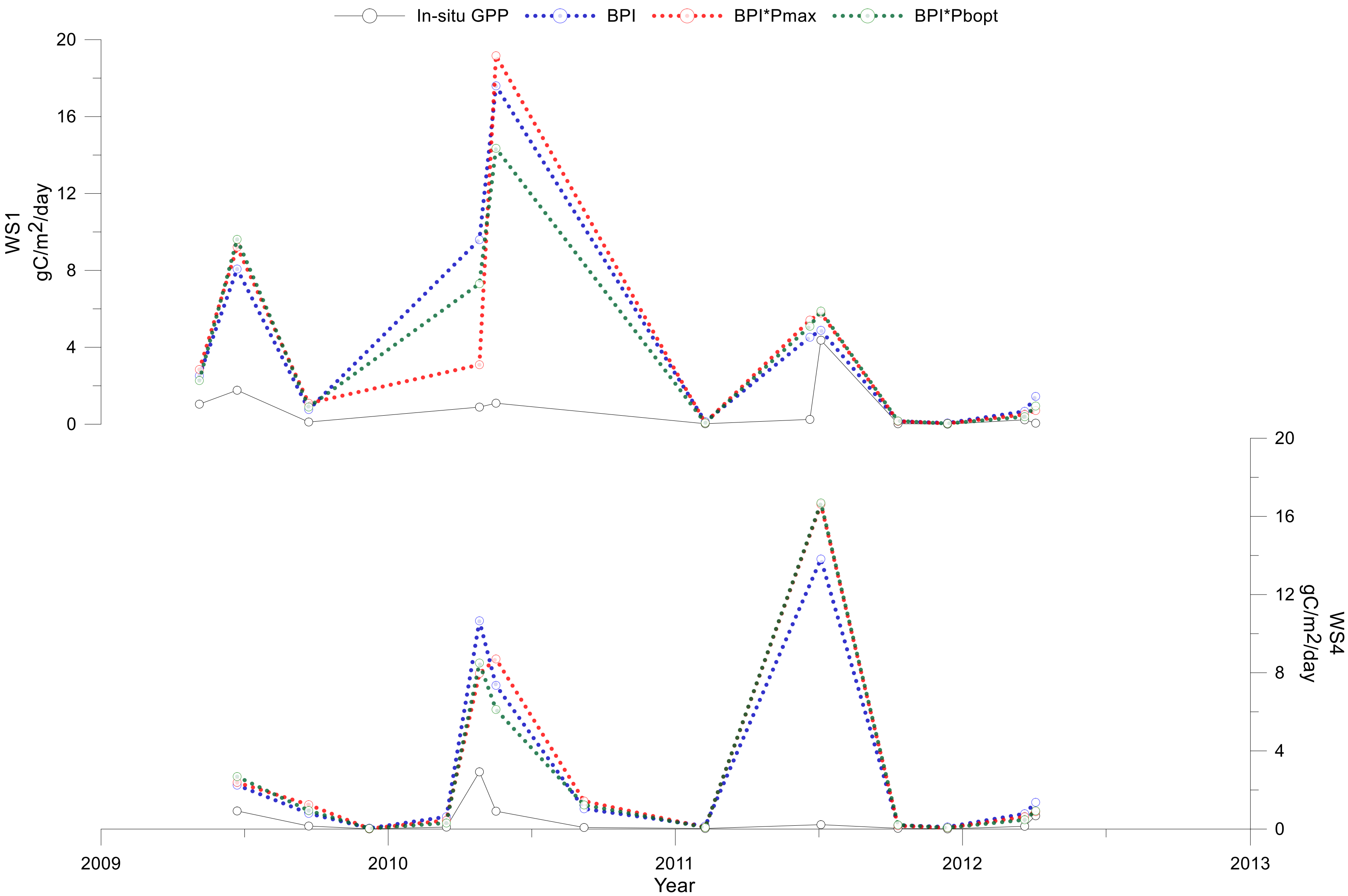

Figure 28: Time-series plot of modelled GPP in the Westerschelde

4.6.2 *Monthly composites*

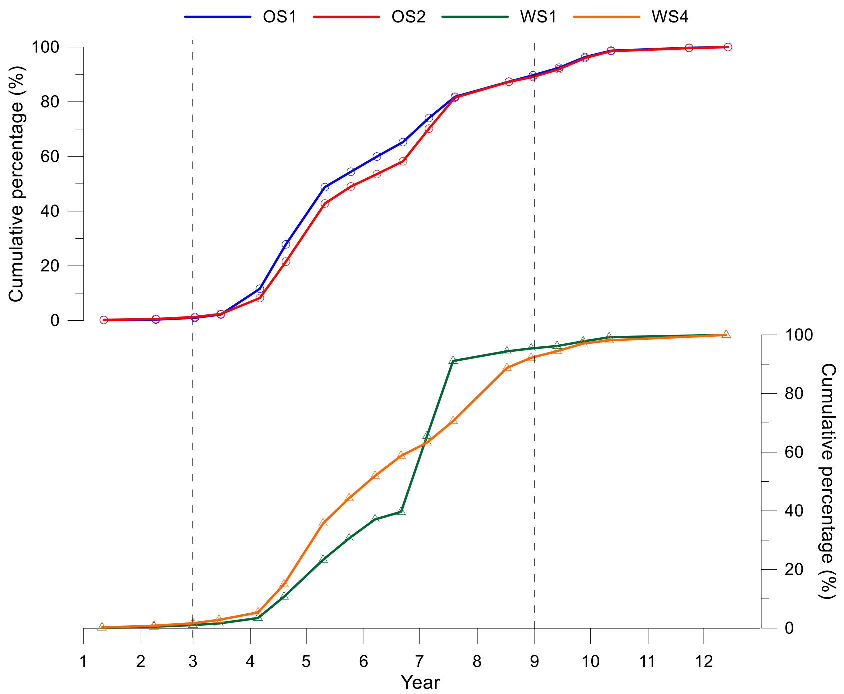

Figure 29: Cumulative plot of annual GPP for the year 2011. Top row: Oosterschelde; Bottom row: Westerschelde

Monthly composite images of the Scheldt Estuary were made for the year 2011. The period March to September was chosen as this was the period where approximately more than 95% of annual GPP occurred, and this is evidenced by the cumulative plot illustrated in Figure 29. However, it was not possible to extract satellite-derived estimates of GPP for the Oosterschelde due to missing data. This was found to have occurred in all composite images, where the processing output from Calvalus resulted in a majority number of pixels being missing for the K_d component, leading to missing data as GPP cannot be calculated. An example of this issue is illustrated in Figure 30. Data is most available for the Westerschelde, yet, there are too many missing pixel values for the Oosterschelde. It was also found that monthly composite images of K_d overlain over each other for the same period revealed an image that had missing pixels at the approximately same areas as the monthly composite images of GPP, and this is illustrated in Figure 31.

Considering that the BPI model works best for the Westerschelde, even though the relationship is poor, monthly composite images were still made to investigate the ability of the MERIS product to produce images that simulate data trends. This is illustrated in Figure 32, using the equation for the BPI model. As can be observed, the images with the most complete data for the Westerschelde, i.e. most number of pixels available, are for the months of March, April and September. The months with the least amount of data available are May, June and July. The month of August does not have a complete image, however, more pixels were available for the upstream part of the Westerschelde. From visual analysis alone, it can be observed that GPP values are relatively low for the month of March, followed by an increase in pixel values for April and May, and a slight decrease

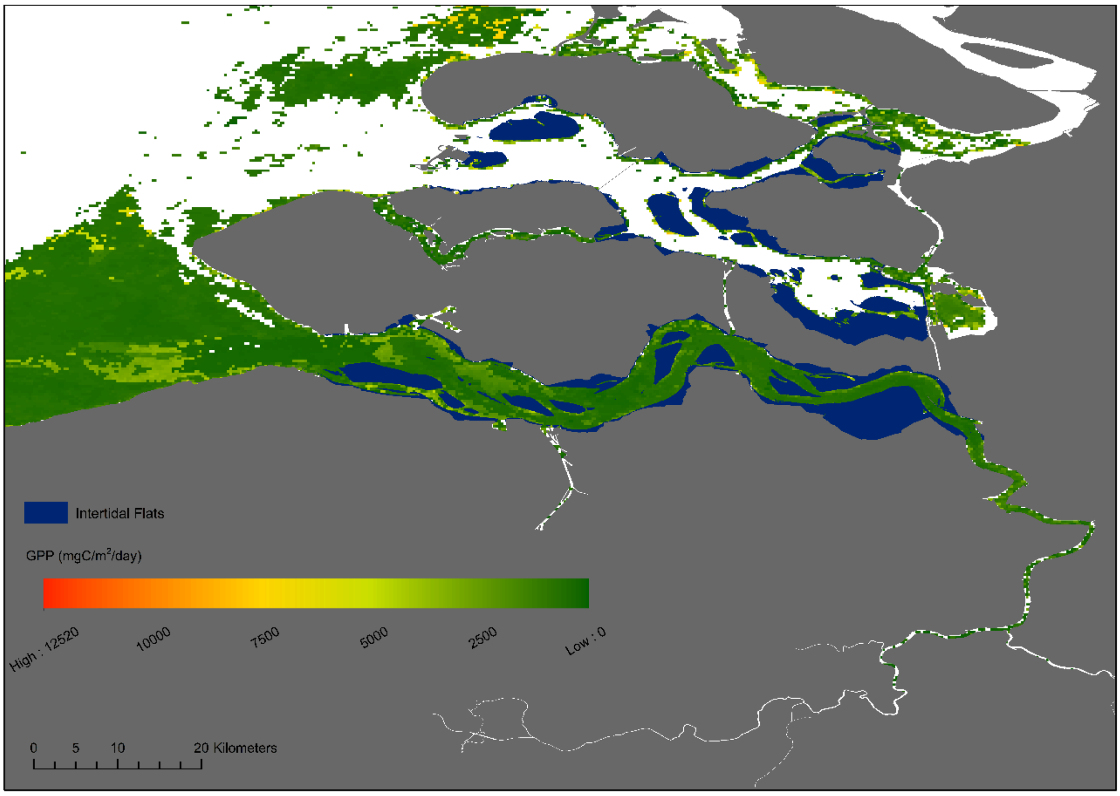

Figure 30: Monthly composite images of GPP overlain each other for the period March to September 2011 overlain over each other.

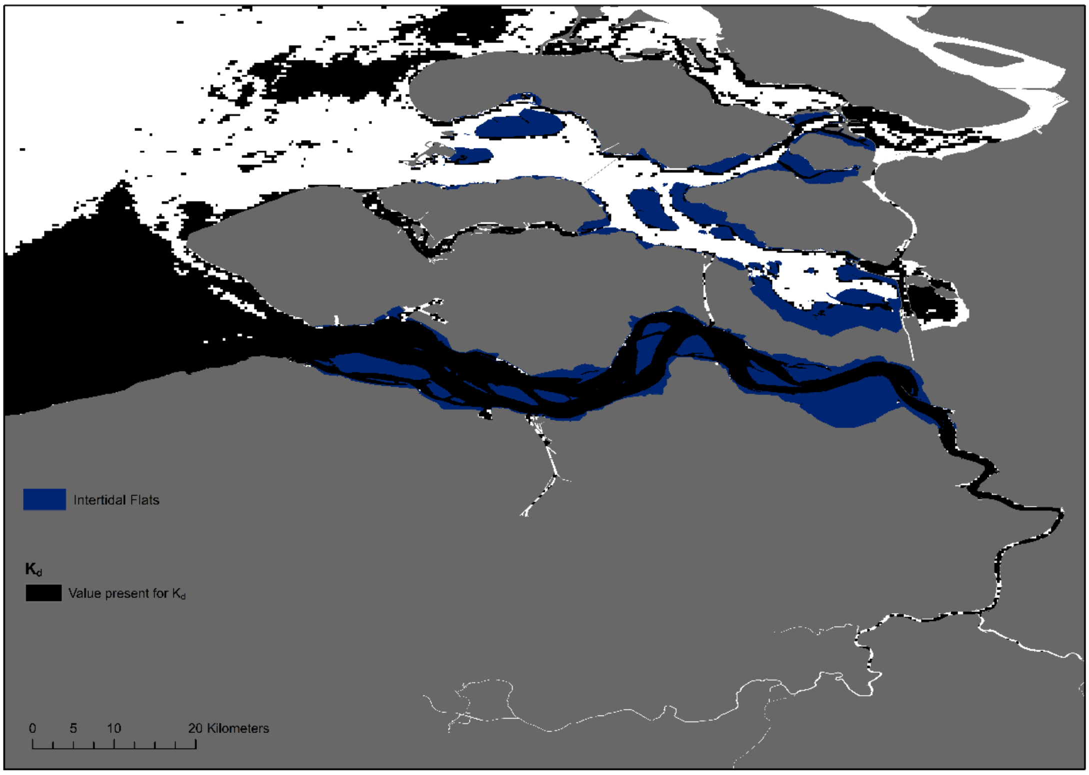

Figure 31: Monthly composite images of K_d overlain over each other for the period March to September 2011, where pixels with K_d values in black while blank pixels (white) have no data for light attenuation

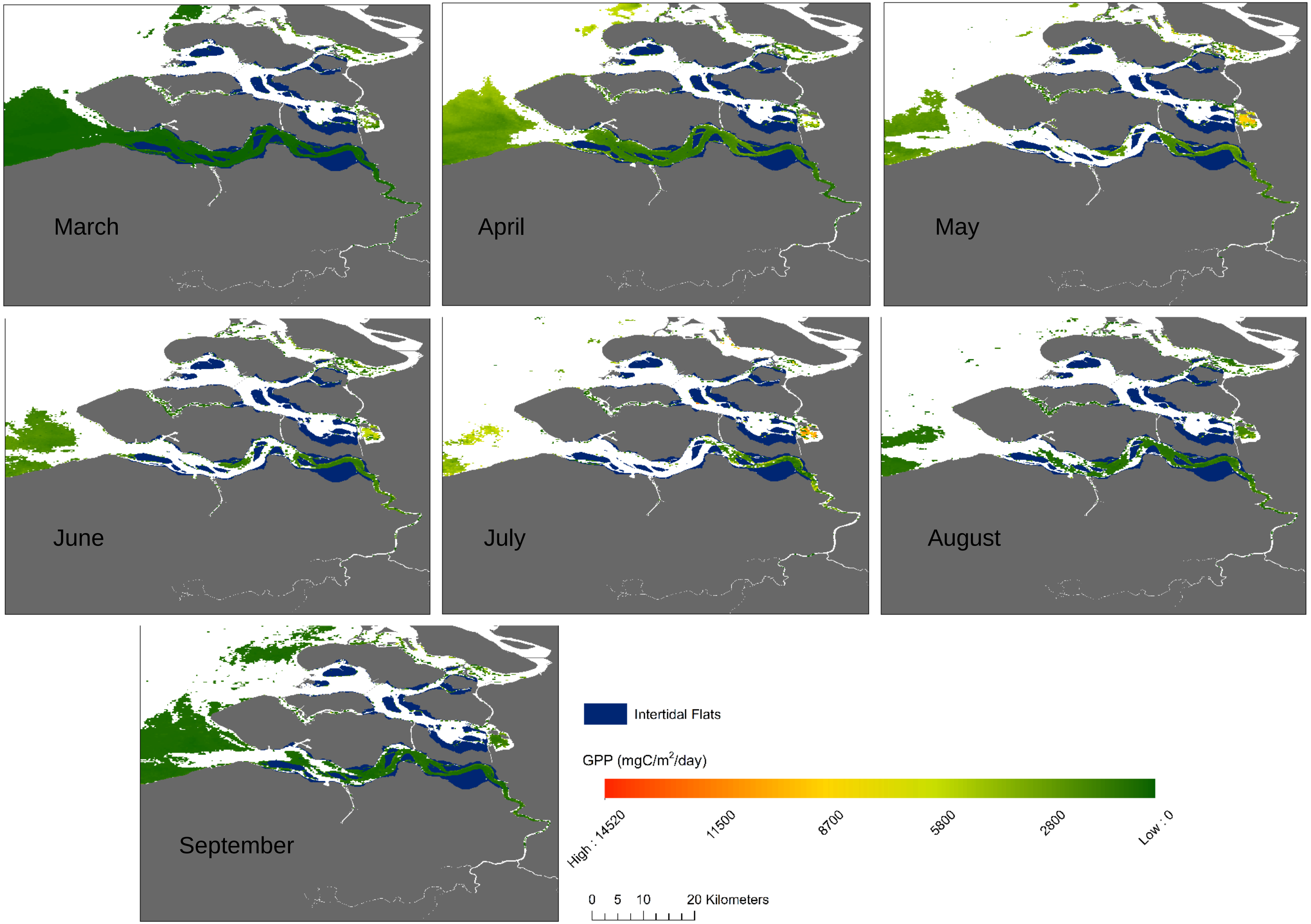

Figure 32: Monthly composite images of GPP in the Westerschelde from March to September 2011 using the BPI model

in June is also observed. July was found to have an increase in GPP values again, followed by a decrease in values for August and September. Given the limited availability of pixels, a zonal average was calculated for the Westerschelde and the resulted are illustrated in a time-series plot in Figure 33, where in-situ values from the Westerschelde stations (WS1 and WS4) are also plotted alongside. First, a polygon was made of the Westerschelde region, and zonal statistics were applied for pixels lying within this polygon to calculate the mean, range and standard deviations. The polygon limits were up until the Dutch/Belgian border in the Westerschelde, and extend up to the mouth of the estuary (see Supplementary information 9 for image of polygon). Each data point from the monthly composite images represent an average value for the entire month.

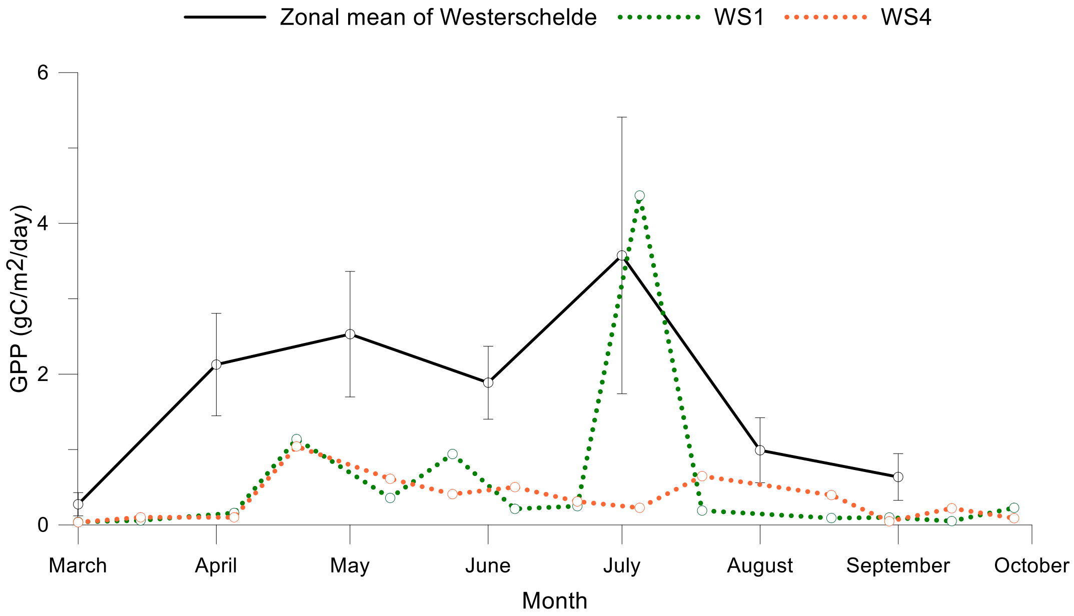

Figure 33: Time-series plot of zonal average GPP values for each month with in-situ values from stations WS1 and WS4

The lowest average GPP values are found to occur in March, August and September (below 1 gC/m^2/day). The month of July had the highest average GPP value of 4.02 gC/m^2/day. The trend in GPP starts off at a very value for March, before sharply increasing by more than 2 gC/m^2/day in April, after which, values slightly increased in May before decreasing in June by 0.7 gC/m^2/day. This was then followed by another sharp increase into July, and a steep decrease into August and September. Standard deviations are the smallest for the months of March and September, while the highest standard deviations are found for the month of July.

When compared to in-situ values, there is an overestimation of GPP throughout the period except for the month of July. In almost all cases, despite the standard deviations, none of the in-situ values lay within the potential range of error except for July. Despite the overestimation, the general trend in GPP values were quite close, except for the month of July where only WS1 had a large peak in in-situ GPP values and WS4 did not. When looking at the GPP composite image of July, many of the pixels present had generally much higher values, adding to the fact that most of the pixels for July were also missing.

5 Discussion

5.1 Modelling P^b_{opt}

As P^b_{max} values have to be measured and may not always be available, this analysis was performed to test the suitability of modelling P^b_{opt} in a system. By comparing measured *Pbmax* and modelled *Pbopt* values (from all three models), results showed that all models produced a roughly consistent regression coefficient (approximately r^2 = 0.54 on average), with no significant differences in r^2 values. An observation made included the values of the Behrenfeld & Falkowski's model plateauing at values of approximately 7mgC/mgChl-a/hr. Yet, when combined as part of the BPI model and regressed against in-situ GPP values, there is no significant difference at all in r^2 values, with only minor differences in the slope of the linear regression. Fitted parameters using Cox et al's (2010) model showed that unrealistic values of α_{10} were attained, and compared to the measured values attained in Cox et al.'s study, values were ranging between 0.01-0.05 gC(gChl/hr)/μmol photons (m^2/s) considering temporal and spatial heterogeneity. Therefore, fitted values of 129 for α_{10} are unreasonable and the model should not be used until appropriate values are found that fits against the measured values.

5.2 Model efficiency

Although the VGPM with P^b_{max} and VGPM with P^b_{opt} models were shown to generate reasonable r^2 values, the results of the AIC show that the best performing model was the BPI*P^b_{max} model. The incorporation of the P^b_{max} parameter clearly improves the linear correlation in the BPI models, however, AIC and r^2 values both indicate that even using estimations of P^b_{max} (i.e. P^b_{opt}) do not improve the result by very much. The improvement of the model appears to be much more significant if the P^b_{max} parameter is measured, rather than estimated.

Furthermore, the differences in r^2 values between the Oosterschelde and Westerschelde can be explained by the fact that the primary production in the Oosterschelde is both limited by nutrients and light availability (Wetsteyn & Kromkamp, 1994). Since the model by Cole & Cloern (1987) is most suitable for well-mixed estuaries that are limited by light availability and does not take into account nutrient limitation, this can explain the lower correlation coefficients for the Oosterschelde. On the other hand, the VGPM with P^b_{max} model was developed to model both open ocean and coastal systems (Behrenfeld & Falkowski, 1997a), which may explain why the VGPM with P^b_{max} model performs much better than the BPI model in the case of the Oosterschelde, but only a minor improvement in r^2 values for the Westerschelde.

5.2.1 *Linear Regression Analysis*

Despite high performance of the linear regressions using in-situ data, there may be several potential issues to address. The first of which is that there may be tendency for the models to underestimate higher GPP values. This is evidenced by the trendline of data points in Figure 16 and Figure 17, where it tends to lean towards negative residuals. Especially in the case of the BPI*P^b_{opt} model, this may even suggest that the model is unable to predict GPP values using a linear regression. Yet, there is possibly insufficient high in-situ GPP values that will allow for such an interpretation. The second issue is that shape of the Q-Q plots - as previously mentioned, are exhibiting heavy tails. This could mean that the data are not normally distributed, potentially generating skewed results. Since most of the data points still lie along the straight line, the tendency for more extreme values to exhibit in the dataset affects only some data points. This may however, be likely due to some of the model's inability to accurately model peaks in GPP data. Scale-Location plots in both the Oosterschelde and Westerschelde also suggest that higher values tend to generate much higher residuals than lower values, indicating the potential for increased range of error at higher GPP values corresponding to summer month primary production. This is also confirmed by the results of the Residuals versus Leverage plots, where data points close or slightly beyond the Cook's distance always responded to summer month peaks in GPP values. Hence, the results of the regression analysis reveal that a linear model is sufficient in explaining most of the data, however, the peaks in GPP values during summer months cannot always be explained by the models. This can be solved if a longer time-series were available, or if an appropriate transformation of the data could be applied to deal with the non-normal distribution of residuals.

Although linear regression analysis was performed on a log-transformed dataset and showed some improvements in the distribution of the data, the log transformed datasets were not used in the calibration and subsequent use of the model on the satellite images. Log transforming ensures that the data are normally distributed and that the dependency in the residuals disappear, but plotting the estimated and measured GPP data on a log scale causes the differences between the models to become less visible, so we continue with the results shown in Figure 15. Furthermore, the Oosterschelde dataset showed evidence of heteroscedasticity still present despite the log transformation, further lending argument to the decision of not log-transforming the datasets.

5.3 Comparison of in-situ and satellite-derived variables

Results show that SPM performs the poorest amongst the variables, while light attenuation coefficient shows a minimum of 30% variance being explained by the data in the Oosterschelde, and an even more improved r^2 value of 0.58 in the Westerschelde.

Additionally, it appears that chlorophyll-a estimates can only be made of the Oosterschelde, rather than of both regions. The fact that MERIS products for each variable derives such inconsistent and sometimes poor correlations, or even none in the case of SPM and chlorophyll-a depending on region, shows that deriving region-dependent estimates of such variables are a problem. Additionally, light can be an important factor in influencing the Scheldt estuaries (Kromkamp & Peene, 1995; Wetsteyn & Kromkamp, 1994), therefore, poor estimates of K_d may have the potential to be the greatest source of error when modelling GPP values using the BPI model and variations of it.

The fact that the EnviSAT satellite is sun-synchronous gives rise to the problem of tidal aliasing in acquired data. Tidal aliasing refers to the out-of-phase relations between tidal periods and the satellite overpass, resulting in the measurement of surface waters during opposite tide conditions every 14.8 days (Eleveld et al., 2014). Both chlorophyll-a and SPM concentrations are influenced by tidal currents (Blauw et al., 2012), which in turn influences the light attenuation coefficient. There is therefore the issue of tidal aliasing in the acquired images, and furthermore, the in-situ dataset was measured at different times, depending on the variable. Since the timing of measurement is not exactly known, it is not possible to quantify the potential error from this bias. This has implications for measuring primary productivity as the modelled GPP values may not reflect the same conditions as when the samples were taken. Lastly, there are also no prominent outliers that have consistently large standard deviations in all comparisons of variables in both regions, therefore, no data points were regarded as potential outliers.

Considering that the Westerschelde is a turbid estuary (Kromkamp & Peene, 1995), and the fact that the Oosterschelde has lower SPM values than the Westerschelde, results of the comparison between satellite-derived and in-situ variables show that MERIS products appear to be able to better model variables in the Oosterschelde than the Westerschelde. CoastColour algorithms were developed specifically to help increase the accuracy of monitoring Case 2 water systems (Brockmann Consult, 2014b). Due to the difficulties in measuring these waters, as mentioned in the early part of this report, the neural network was developed and trained specifically for Case 2 waters. Since the Oosterschelde has less of a problem with water clarity due to the erection of the storm surge barriers (Bakker et al., 1994), it was expected that the CoastColour MERIS products would be able to estimate variables better for the Westerschelde than the Oosterschelde.

When extracting values from 3x3 kernel averaged pixels, the number of data points available for the Westerschelde drastically reduced from 20 to 9. This was rather strange, considering that the number of data points for the Oosterschelde remained the same even after running the kernel average (focal statistics) on the dataset. Further investigation revealed that both stations WS1 and WS4 lie extremely close to the coastline. Focal statistics runs a 3x3 cell average of the surrounding pixels, however, kernels containing pixels with no values were not computed and therefore, an average was not calculated. Although this helped to reduce sources of error by ensuring sufficient pixels were available for running the kernel average in the images, this poses a problem for data comparison at stations that are too close to the shoreline. The resulting output from running focal statistics on the acquired images features channels narrower by one pixel on each side and larger areas of original pixels with no values.

It is difficult to conclude the exact causes of such a mismatch between satellite-derived and in-situ measurements. Several contributing sources of error include the issue of tidal aliasing, mismatch between satellite overpass and timing of in-situ sampling, different spatial scale of support of in-situ and satellite data, adjacency effects or inability of the MERIS CoastColour algorithm to accurately derive measurements of these variables. It may be possible that given the amount of in-situ data available for the period in which the satellite was operational (*Oosterschelde: n = 112; Westerschelde: n = 155*), the amount of exact date matchups is reasonably optimistic, although preliminary validation of MERIS algorithm products by CoastColour involved extremely large datasets that gave clearer correlations between algorithm-derived variables and in-situ data (Brockmann Consult, 2014a). Therefore, more exact date matchups are required to properly test the ability of the CoastColour algorithm products to produce reliable estimates of these variables.

5.4 Modelled vs in-situ comparison of GPP

Despite the high correlations observed between modelled (via in-situ variables) and in-situ GPP values of both regions, especially the Westerschelde, exact date image matchups of modelled GPP versus in-situ GPP values show that the Oosterschelde derives much better correlations than the Westerschelde. In addition, the r^2 values derived from both regions are much better than correlations derived from the regression of satellite-derived and in-situ measurements of chlorophyll-a, K_d and SPM. Considering the regression coefficients derived from comparisons between satellite-derived estimates of individual variables and in-situ values, it was expected that modelling primary production would produce roughly similar regression coefficients. Therefore, the estimates, especially in the case of the Oosterschelde, are surprising results. Furthermore, even though the BPI*P^b_{opt} model incorporates an estimate of the P^b_{max} parameter, the expectation was that the BPI*P^b_{opt} model would derive poorer estimates of primary production than the BPI*P^b_{max} due to the introduction of an additional source of error by using modelled values of P^b_{max}. This had been confirmed with the results of the AIC in Table 3, where the BPI*P^b_{max} model had the lowest AIC values and AIC analysis of the BPI*P^b_{opt} model only showed a minor improvement in AIC values from the BPI model. However, the correlations from results of the Westerschelde (Figure 26) are relatively poor based on the r^2 values, and given the larger range of values that all three models produced for the Westerschelde, it appears that the basic model by Cole and Cloern (1987) is not suitable enough to model a turbid estuary like the Westerschelde. As discussed earlier in Section 5.3, K_d has the greatest potential to be the largest source of error due to the consistently poor estimates made for both regions. As the Westerschelde is a much more turbid system and has higher SPM values than the Oosterschelde (based on in-situ data), the Westerschelde may be more light-limited than the Oosterschelde and hence, potentially influenced by the poor K_d estimates more than the Oosterschelde. It can also be observed that the all three models tend to produce larger standard deviations towards higher values for both regions. The homogeneity of pixel values within the 3x3 kernel diminishes when attempting to model higher GPP values that also correspond to higher in-situ values. This potentially supports the results of the linear regression analysis, whereby it was found that the use of the BPI-based models comes with the inability to accurately model peaks in GPP. Lastly, the time-series of modelled and in-situ GPP values (Figure 27 and Figure 28) illustrates the extent of overestimation throughout the time period. Despite the overestimation, it appears that both the Oosterschelde and Westerschelde are able to simulate trends in data quite well.

A single data point that has a rather large standard deviation in Figure 25 has approximately the same standard deviation in all three models. If it is considered as a potential outlier, Figure 34 then illustrates the GPP estimates from all three models for the Oosterschelde regressed against the in-situ values from each station excluding the potential outlier in the calculation of the regression. Results show that the correlation improves significantly, and the three models retain their level of performance when compared to each other (i.e. the BPI model remains the best performing while the BPI*$P^b{}_{max}$ is the worst performing). The BPI*$P^b{}_{opt}$ improved the most, while the least improved was the BPI*$P^b{}_{max}$ model. As all models had r^2 correlations of more than 0.6, this gives a positive outlook for the successful modelling of the Oosterschelde at least. From Figure 34, the BPI model produces a very high r^2 value of 0.816. This is considerably optimistic for a simple model, and may even suggest that such a simple BPI model without the additional $P^b{}_{max}$ parameter can successfully model an estuary with the same characteristics as the Oosterschelde.

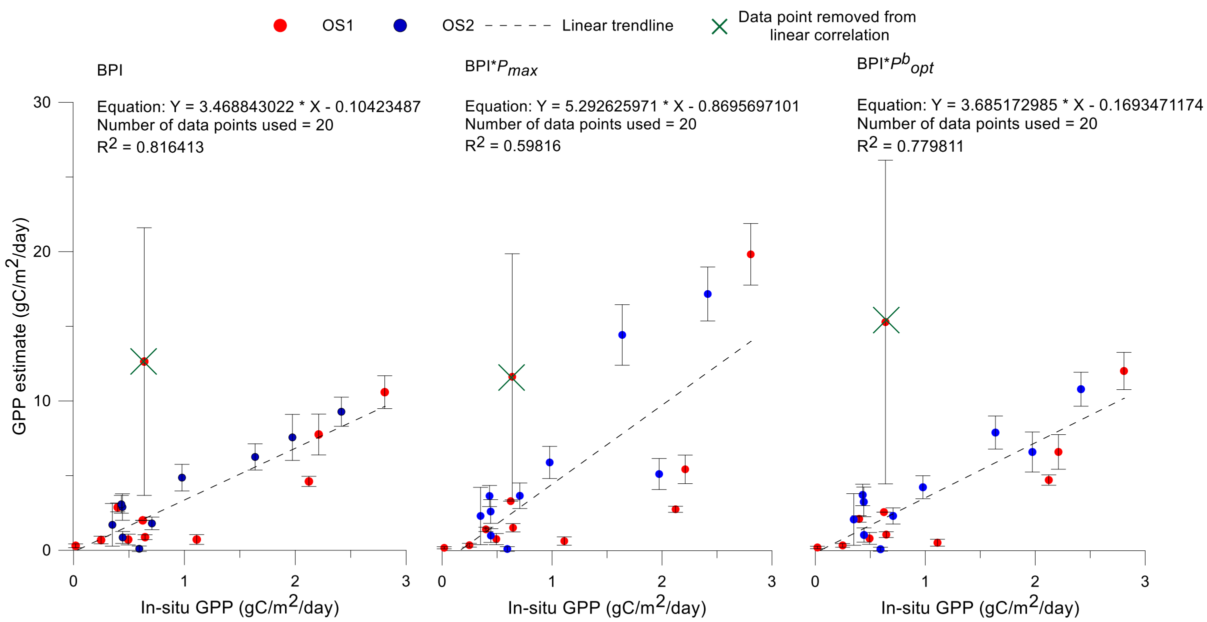

Figure 34: Modelled GPP values derived from the three models of the Oosterschelde, without the outlier

The success of modelling the Oosterschelde would have been additionally validated by images acquired on exact date matchups with OS9, a station that is located further offshore and closer to the North Sea (see Figure 1**Error! Reference source not**

found.). Unfortunately, data was only available from 2007-2008, of which there were no available images on the date of which samples were taken for measurement. Hence, this validation could not be performed. The BPI model needs to be further tested on estuaries that are similar to the Oosterschelde in biogeochemical characteristics to increase the confidence of using such a simple model on complex coastal systems.

To summarise, estimating primary production using remote sensing so far shows that it only works for the Oosterschelde. The CoastColour algorithms were specifically developed to derive better estimates of various parameters within turbid coastal systems, but, results indicate that the algorithms fail to perform for the Westerschelde. The correlation between satellite-derived and in-situ estimates for the various parameters (i.e. chlorophyll-a, K_d and SPM) leads to the expectation that the combined amount of error would potentially result in similar r^2 values produced from using the model to predict GPP values in both regions. Yet, it can be observed that the model by Cole and Cloern (1987) works very well for the Oosterschelde, and only fails to perform for the Westerschelde. As the Oosterschelde and Westerschelde have contrasting hydrographies, and that the Westerschelde is more light-limited than the Oosterschelde, improving satellite-derived estimates of K_d may be able to reduce the amount of error introduced when using the BPI model for estimating GPP. In addition, modelled GPP values from both regions are able to simulate trends in in-situ GPP values well despite the overestimation.

5.5 Monthly composites of average GPP values

3-day composites were originally made to investigate if this would provide an increased amount of data points available for investigating if the model continues to work. However, this did not work due to the same issues it faced as when generating the monthly composites of the Scheldt Estuary. Missing K_d values were found in the Oosterschelde as well, making it difficult to conduct matchups with in-situ data to further validate the models. This error appears to only affect composite images, as the same does not occur for exact date matchups, which are more affected by cloud overpass contributing to missing pixels instead. Preliminary investigations included checking the processing parameters, though basic analysis revealed that this was a systematic error caused in composite images that could not have been affected by changing processing parameters. The next potential factor that could have caused these missing pixels were cloud overpass. Figure 35 shows cloud cover data from the KNMI, with fraction of clouds obstructing skyview expressed as octants, where lower values indicate less clouds and higher values indicate cloudy. The months from May-September show higher octant values, as indicative in the daily, weekly and monthly average cloud cover data. This indicates that the skies were more overcast during this period. Cloudy skies impede remote sensing measurements due to the reflection and pixel obscuring. However, cloudy sky conditions are not able to explain the case of missing K_d pixels. These missing pixels only affect the light attenuation coefficient images produced by CoastColour, and are not found in the other variables i.e. SPM and chlorophyll-a. Furthermore, these missing pixels are too systematic – the same areas are affected in every image. It is therefore not possible that cloudy sky conditions are contributing to the lack of K_d calculations.

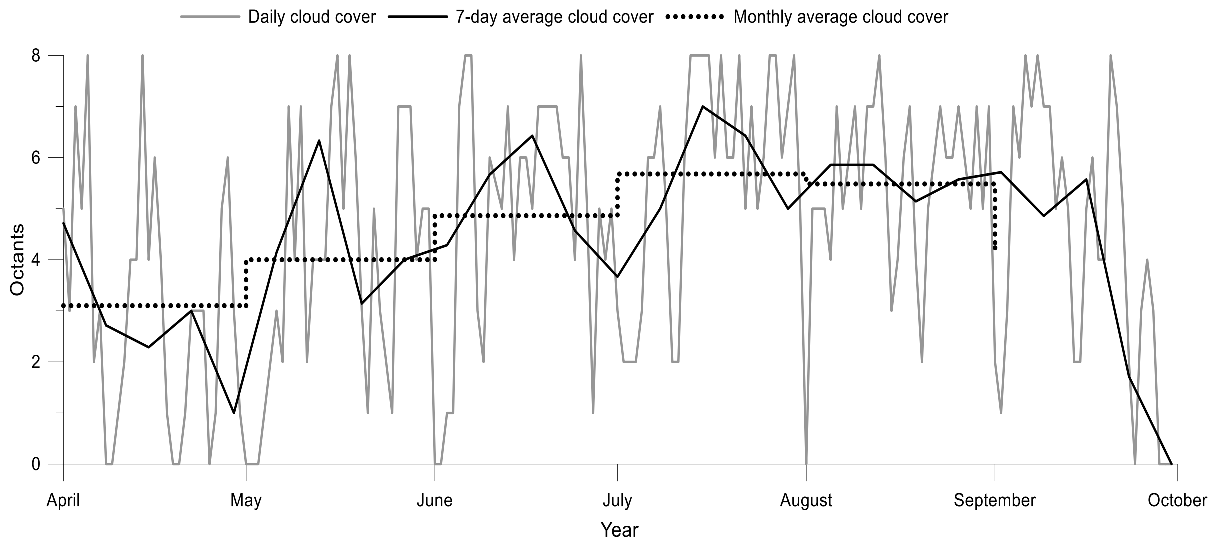

Figure 35: Cloud cover data for the period April-September 2011 showing the daily, weekly and monthly cloud cover averages (KNMI, n.d. [Accessed: 19 October 2017])

As the region most affected by these missing K_d pixels is the Oosterschelde, which has clearer waters than the Westerschelde (Hostens, 2003), a much more likely source of error could originate from the neural network used for deriving the Inherent Optical Properties of the coastal system. Since the neural network is specifically trained to better estimate the IOP of turbid systems, this could have incidentally cost the retrieval of appropriate IOPs for coastal systems that have clearer waters. Yet, intertidal areas in the Oosterschelde were found to have contained pixel values for K_d. This was a strange result, as intertidal areas are much more easily exposed during fluctuating tide conditions. If clearer waters were resulting in the inability of the neural network to acquire K_d values, one should expect that the same applies for intertidal flats. Therefore, the issue of missing pixel values specifically for light attenuation coefficient is perplexing, as potential sources of error are not able to sufficiently account for this phenomenon.

Due to the lack of K_d pixel values in the Oosterschelde, the Westerschelde became the focus of analysis for the monthly composites. An additional issue was encountered during the analysis: Exact pixel values from each station could not be acquired due to incomplete K_d images from the summer months, as observed from Figure 32. Therefore, even using 3x3 kernal averages would not have improved data retrieval. Thus, zonal averaging was used to additionally investigate if it could provide a reliable estimate of trends in GPP values at the very least. Results illustrated in Figure 33 show that using zonal averages of the Westerschelde region in monthly composites are indeed able to simulate trends in data reasonably well, with some overestimation. In addition, it can also be observed that higher modelled GPP values tend to have higher spatial variability in pixel values, as seen from the standard deviations. The difference in in-situ GPP values between WS1 and WS4 shows that there is however, also spatial variability in GPP values that may be more obvious during peaks in primary production especially during summer months.

Despite the very low correlation values between satellite-derived and in-situ GPP values for the Westerschelde, monthly composite images of the region can still be made and a simple zonal analysis of GPP can provide knowledge on data trends. However, spatial variability within the Westerschelde must be considered when applying zonal averages, yet the lack of available pixel values to conduct exact pixel matchups or kernel averages makes precise analysis more difficult.

6 Recommendations for future research

Remote sensing of primary production in the Scheldt Estuary is only successful in the Oosterschelde, even though the CoastColour algorithm was developed and intended for modelling turbid systems. The main lessons that can be taken from this project are that primary production in the Oosterschelde has promising potential to be modelled via remote sensing using the simple BPI model by Cole and Cloern (1987). Yet, the same may not be done for the Westerschelde primarily due to the large contribution of error from the satellite-derived estimates of the individual variables. Furthermore, chlorophyll-a and SPM values are still inconsistently estimated by the CoastColour algorithm with regional differences, although estimates of light attenuation coefficients may still be useful. In summary, both primary production and individual variables appear to produce better estimates using remote sensing for a coastal system similar to the Oosterschelde.

Although designed to work for most coastal areas, the Scheldt Estuary is not the only coastal region that produces such issues when attempting to model in-situ variables using the MERIS product. Zheng & DiGiacomo (2017) investigated various methods of chlorophyll-a retrieval for Chesapeake Bay, a coastal system that has large influences of Colour Dissolved Organic Matter. Their analysis of the correlation coefficient between MERIS derived estimates and in-situ values revealed an r^2 value of 0.48 ($n = 345$), although considered a reasonable estimation, falls short of the 0.9 correlation coefficient value that CoastColour acquired from subsequent validation and match-up analysis of the MERIS products against in-situ values of chlorophyll-a (Brockmann Consult, 2014c). Yet, a rather cumbersome pitfall of the validation of MERIS products is the use of the MERMAID (MEris Matchup In-situ Databse). MERMAID does not include turbid waters that have SPM concentrations of more than $15 g/m^3$. From the available Westerschelde in-situ data, 88 samples contained SPM concentrations of more than $15 g/m^3$, which is more than 50% of the in-situ data. In Figure 21, more than 50% of exact pixel matchups correspond to in-situ SPM values of more than $15\ g/m^3$ as well. If primary validation of MERIS products do not include extreme turbid systems as well, this indicates that although the algorithms were specifically developed for Case 2 coastal systems, there is an exclusion of extremely turbid systems containing high SPM concentrations. Validation needs to include a database of complex turbid systems like the Westerschelde, if such a system is to be modelled via remote sensing.

Another way of improving estimates of GPP is to consider the use alternate models i.e. the Wavelength Resolving Model (WRM). The WRM refers to the conversion of photosynthetically available radiation (PAR) and other photosynthesis-irradiance variables into primary production rates (Behrenfeld & Falkowski, 1995b). This is proposed as an alternatively viable method to the BPI model as it has been found to be more accurate than the VGPM with P^{b}_{max} model in modelling contrasting hydrographic regions in the North Atlantic (Tilstone et al., 2015). The equation is listed as follows, with a description table of the parameters:

$$\sum PP_{WRM} = 12a^{*}{}_{max}\varphi_m \int_0^D \int_0^{Z_{eu}} \int_{400}^{700} Chla(z)PAR(z,t,\lambda)f\big(x(z,t)\big)d\lambda\, dz\, dt$$

Table 5: Table of variables and description of parameters

Variables	*Description*
PP	Primary production
$a^{*}{}_{max}$	Maximum chl-a specific absorption coefficient
D	Daylength
PAR	Photosynthetically Available Radiation
φ_m	Quantum efficiency
z	(at) given depth
Z_{eu}	Euphotic depth
λ	(at) given wavelength

Therefore, instead of deriving region-dependent linear equations based on the simple BPI model, the WRM takes into account the absorption coefficients and other parameters. This alternate model for measuring primary production would not rely on the CoastColour algorithm for estimates of the individual parameters and can then be potentially compared to the results of this project in order to determine the best method for estimating the individual variables and subsequently primary production of such coastal systems.

Case studies performed by the Plymouth Marine Laboratory also indicate difficulty in acquiring match-ups, with only 35 match-ups from database of 529 sampling points between 2003-2009 (Brockmann Consult, 2014c). These matchups were made only if the time of sampling was within 45 minutes of the satellite overpass, which thus reduces the potential error in time of measurement. This further highlights the difficulty in acquiring usable images for accurate modelling data acquisition, however, also suggests that better correlations might be deduced if such a strict criterion for satellite images is used. Thus, a large database of sampling points should be a baseline requirement before deciding to model coastal systems via remote sensing. Lastly, the issue of misclassification of K_d pixel values should be further investigated. Thus far, no answers can be found as to why the MERIS algorithm produces empty pixel values for K_d in the Oosterschelde, for which chlorophyll-a and SPM pixel values were available instead.

7 Conclusion

Primary production is an essential process that dictates the success of a fishery, assuming bottom-up control. This is particularly important due to the issue of decreasing intertidal areas for important bird species, and therefore, reduction in primary production may lead to reduction in available food for these birds, further reducing the viability of the Scheldt Estuary as an area for habitat conservation. This, therefore, contributes to the increasing need for rapid, cost-effective methods of modelling primary production in such systems. Results of this project shows that the simple BPI model is able to successfully model the Oosterschelde region, but falls short for the Westerschelde. A closer investigation into the individual parameters (chlorophyll-a, SPM, K_d) reveals the MERIS algorithm's inability to attain consistent correlations in the estimates, though other contributing causes include the issue of tidal aliasing, and the timing of overpass and spatial scale of the sample measurements. Error in measurement of in-situ variables is unlikely as the results in Figure 15 show that the use of the in-situ variables in modelling primary production produces high correlations, hence, the likely source of error stems from the estimates of the individual variables from the CoastColour algorithm. However, monthly composite images made of the Westerschelde revealed relative success for being able to simulate trends in data, though spatial variability throughout the region needs to be accounted for. An additional issue that could not be resolved within the time-span of this study was the case of the missing pixel values for images of K_d in the composites, which thus contributed to the inability to model the Oosterschelde. Recommendations include the further possibility to model water bodies that have similar characteristics as the Oosterschelde, the use of the much more complicated Wavelength Resolved Model, and the need for MERMAID to include in-situ datasets of regions that have extreme turbid systems in order to improve the calibration and subsequent validation of its products.

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9 Appendix

Supplementary information 1: Table of in-situ data from the Oosterschelde including calculations of estimated Pbopt and the composite parameters

Station	*Date*	*GPP (gC/m²/day)*	*E_o (mol photons/ m²/day)*	*Chl-a (mg/m³)*	*K_d (m^{-1})*	*T°C*	*P^b_{max} (mgC/mg Chl-a /hr)*	*P^B_{opt} (mgC/mg Chl-a /hr)*	*Daylength (hours)*	*VGPM with P^b_{max}*	*VGPM*P^b_{opt}*	*BPI*	*BPI*P^b_{max}*	*BPI*P^b_{opt}*
OS1	1996-01-17	0.02	4.3876	0.68	0.709	3.74	3.1061849	2.5064	8.38972	0.039301	0.031712	0.019357	0.060127	0.048517
OS1	1996-02-05	0.056	9.224	0.85	0.663	0.07	3.9239438	1.3151	9.35749	0.099128	0.033223	0.054398	0.213455	0.071541
OS1	1996-02-05	0.056	9.224	0.85	0.663	0.09	3.9239438	1.3208	9.35749	0.099128	0.033367	0.054398	0.213455	0.071851
OS1	1996-02-20	0.042	4.8402	2.72	1.453	1.08	2.9199295	1.6418	10.2784	0.092521	0.052022	0.04168	0.121703	0.06843
OS1	1996-02-28	0.035	3.9109	1.55	1.065	2.15	3.7179384	2.0149	10.7962	0.086751	0.047013	0.026183	0.097347	0.052755
OS1	1996-02-28	0.035	3.9109	1.55	1.065	2.21	3.7179384	2.0352	10.7962	0.086751	0.047488	0.026183	0.097347	0.053288
OS1	1996-03-18	0.249	5.9336	9.62	1.501	2.72	4.7695186	2.2033	12.0539	0.662801	0.306185	0.174933	0.834348	0.385433
OS1	1996-03-18	0.249	5.9336	9.62	1.501	2.69	4.7695186	2.1937	12.0539	0.662801	0.30485	0.174933	0.834348	0.383751
OS1	1996-04-01	1.433	34.519	14.42	1.262	4.25	5.1530598	2.6403	12.9823	2.078283	1.064863	1.81435	9.349453	4.790441
OS1	1996-04-01	1.433	34.519	14.42	1.262	4.23	5.1530598	2.6353	12.9823	2.078283	1.06283	1.81435	9.349453	4.781294
OS1	1996-04-15	1.511	37.698	12.52	0.716	5.98	3.5925257	3.0268	13.893	2.394273	2.017217	3.032265	10.89349	9.17796
OS1	1996-04-15	1.511	37.698	12.52	0.716	6.01	3.5925257	3.0329	13.893	2.394273	2.021288	3.032265	10.89349	9.19648
OS1	1996-05-01	1.736	19.084	11.54	0.747	9.89	5.3824497	3.9096	14.879	3.097747	2.250071	1.356186	7.299601	5.302118
OS1	1996-05-01	1.736	19.084	11.54	0.747	9.89	5.3824497	3.9096	14.879	3.097747	2.250071	1.356186	7.299601	5.302118
OS1	1996-05-14	1.201	18.111	10.94	1.059	9.7	6.5118314	3.8568	15.5935	2.601759	1.540939	0.860643	5.604362	3.319285
OS1	1996-05-14	1.201	18.111	10.94	1.059	9.75	6.5118314	3.8705	15.5935	2.601759	1.54644	0.860643	5.604362	3.331136
OS1	1996-06-10	5.843	43.396	21.97	0.71	15.47	8.1492033	5.8402	16.5635	11.60798	8.318964	6.177081	50.33829	36.07539
OS1	1996-06-10	5.843	43.396	21.97	0.71	15.4	8.1492033	5.817	16.5635	11.60798	8.28585	6.177081	50.33829	35.93179
OS1	1996-07-01	0.417	25.474	1.81	0.599	15.66	9.0946598	5.9022	16.5686	1.192986	0.774221	0.354082	3.220258	2.089875
OS1	1996-07-01	0.417	25.474	1.81	0.599	15.65	9.0946598	5.899	16.5686	1.192986	0.773798	0.354082	3.220258	2.088733
OS1	1996-07-15	1.724	52.553	4.41	0.737	17.37	13.68405	6.3683	16.1845	3.739247	1.740169	1.446524	19.79431	9.211863
OS1	1996-07-15	1.724	52.553	4.41	0.737	17.3	13.68405	6.3531	16.1845	3.739247	1.736029	1.446524	19.79431	9.189947
OS1	1996-08-12	0.331	16.226	1.6	0.617	18.65	13.082868	6.5725	14.7965	1.218928	0.612359	0.19355	2.532193	1.272111
OS1	1996-08-12	0.331	16.226	1.6	0.617	18.69	13.082868	6.5765	14.7965	1.218928	0.612733	0.19355	2.532193	1.272888
OS1	1996-09-09	1.204	27.34	5.81	0.746	17.77	10.855591	6.4473	13.0463	2.917547	1.732775	0.979492	10.63297	6.315078
OS1	1996-09-09	1.204	27.34	5.81	0.746	17.74	10.855591	6.4418	13.0463	2.917547	1.731305	0.979492	10.63297	6.309721
OS1	1996-09-23	0.395	13.061	3.99	0.999	14.48	10.984942	5.4955	12.1322	1.232264	0.616476	0.239967	2.636021	1.318747
OS1	1996-09-23	0.395	13.061	3.99	0.999	14.48	10.984942	5.4955	12.1322	1.232264	0.616476	0.239967	2.636021	1.318747
OS1	1996-10-10	0.172	14.773	1.22	0.756	14.31	10.5976	5.4337	11.0209	0.448758	0.230091	0.109664	1.162178	0.595882
OS1	1996-10-10	0.172	14.773	1.22	0.756	14.31	10.5976	5.4337	11.0209	0.448758	0.230091	0.109664	1.162178	0.595882
OS1	1996-11-13	0.058	7.1008	0.83	1.031	10.52	9.7014558	4.0947	8.95702	0.134897	0.056935	0.026296	0.255106	0.107672
OS1	1996-11-13	0.058	7.1008	0.83	1.031	10.47	9.7014558	4.0794	8.95702	0.134897	0.056723	0.026296	0.255106	0.107271
OS1	1996-11-28	0.031	6.2051	0.78	1.131	7.21	6.351259	3.2746	8.26797	0.06633	0.034199	0.019685	0.125025	0.064462
OS1	1996-11-28	0.031	6.2051	0.78	1.131	7.09	6.351259	3.2502	8.26797	0.06633	0.033944	0.019685	0.125025	0.063981

Station	*Date*	*GPP* *($gC/m^2/day$)*	*E_o* *(mol photons/ m^2/day)*	*Chl-a* *(mg/m^3)*	*K_d* *(m^{-1})*	*T°C*	*P^b_{max}* *(mgC/mg Chl-a /hr)*	*P^B_{opt}* *(mgC/mg Chl- a /hr)*	*Daylength* *(hours)*	*VGPM with P^b_{max}*	*VGPM*P^b_{opt}*	*BPI*	*BPI*P^b_{max}*	*BPI*P^b_{opt}*
OS1	1996-12-11	0.003	0.7181	1.03	2.201	6.16	5.9034379	3.0633	7.90001	0.009894	0.005134	0.001546	0.009126	0.004735
OS1	1996-12-11	0.003	0.7181	1.03	2.201	6.19	5.9034379	3.0693	7.90001	0.009894	0.005144	0.001546	0.009126	0.004745
OS1	1998-02-09	0.033	12.999	0.8359	2.025	4.6	5.4861513	2.7259	9.62494	0.050403	0.025044	0.024682	0.135411	0.067283
OS1	1998-08-18	1.141	33.338	3.0051	0.536	20.03	12.281443	6.6215	14.4674	2.698268	1.454758	0.859788	10.55944	5.693068
OS1	1998-09-07	0.35	17.547	1.8183	0.641	17.79	10.5612	6.4509	13.2073	0.975584	0.595898	0.228967	2.418163	1.477042
OS1	1998-09-21	0.229	24.701	1.5271	0.953	15.8	8.9015056	5.9469	12.2951	0.457511	0.305651	0.18207	1.620696	1.082746
OS1	1998-10-20	0.066	11.092	0.9688	1.335	12.39	7.8706961	4.7243	10.4093	0.132041	0.079256	0.037028	0.291436	0.174931
OS1	1998-11-24	0.019	4.0045	0.7438	1.35	6.59	5.4385393	3.1496	8.44939	0.038052	0.022037	0.010149	0.055197	0.031966
OS1	1998-12-21	0.011	3.7605	0.6419	1.285	5.7	3.510713	2.9692	7.80787	0.019925	0.016852	0.008641	0.030336	0.025657
OS1	2000-04-05	0.198	13.406	2.99	0.832	8.04	5.1263041	3.4498	13.2469	0.568468	0.382552	0.221626	1.136122	0.764557
OS1	2000-04-17	0.319	27.097	4.26	1.159	8.58	4.7370701	3.5723	14.0221	0.64503	0.486428	0.458147	2.170274	1.636639
OS1	2000-05-24	3.93	26.879	24.26	0.739	14.48	8.1181421	5.4955	16.0549	11.29227	7.644255	4.059035	32.95182	22.30659
OS1	2000-06-13	0.847	41.451	3.32	0.763	16.27	9.318926	6.0893	16.6098	1.864252	1.218166	0.829668	7.731617	5.052104
OS1	2000-08-14	1.183	30.18	5.24	0.76	20.34	11.276191	6.6068	14.6769	3.05574	1.790372	0.957179	10.79333	6.323861
OS1	2000-09-07	0.375	19.112	2.76	0.72	17.71	8.2996363	6.4363	13.1741	1.049722	0.814049	0.337009	2.797052	2.169086
OS1	2000-10-09	0.132	16.761	1.57	1.06	15.36	7.7689955	5.8036	11.0841	0.311705	0.232849	0.114193	0.887164	0.662727
OS1	2000-11-16	0.012	2.7896	0.77	1.81	9.07	8.8929449	3.6913	8.80052	0.041005	0.017021	0.005459	0.048547	0.020151
OS1	2001-01-22	0.01	3.4852	0.36	1.76	3.56	9.407643	2.4564	8.64954	0.023262	0.006074	0.003279	0.03085	0.008055
OS1	2005-04-04	0.956	21.722	12.32	0.788	7.8839	4.6029984	3.4158	13.1677	2.424762	1.799354	1.562195	7.19078	5.336094
OS1	2005-05-02	1.154	18.38	11.803	0.656	11.399	4.3993394	4.3773	14.9274	2.938557	2.923831	1.52124	6.692452	6.658914
OS1	2005-05-17	1.42	35.669	19.822	0.695	11.791	2.2277951	4.5115	15.7334	2.727281	5.523012	4.679585	10.42516	21.11197
OS1	2005-06-20	0.638	53.877	2.954	0.536	16.92	5.8786898	6.2644	16.6588	1.525598	1.625682	1.365865	8.029497	8.556258
OS1	2005-07-18	2.134	28.987	4.842	0.276	20.263	10.731768	6.6113	16.0767	8.065873	4.968978	2.339212	25.10388	15.46523
OS1	2005-09-12	0.092	16.917	1.442	1.257	20.065	8.0562766	6.6203	12.8631	0.291062	0.239183	0.089271	0.719195	0.591004
OS1	2005-10-10	0.188	22.199	2.023	0.828	15.791	7.0998209	5.9439	11.0325	0.491362	0.411365	0.249488	1.771318	1.482935
OS1	2005-11-14	0.032	10.276	1.152	1.782	12.283	5.5094904	4.6858	8.91355	0.069026	0.058706	0.030557	0.168353	0.143182
OS1	2005-12-14	0.019	6.7286	0.877	1.261	6.8506	3.5300138	3.2019	7.85515	0.036449	0.033061	0.021526	0.075988	0.068925
OS1	2006-02-06	0.016	3.4228	1.015	1.189	3.3365	4.4288102	2.3922	9.44898	0.04944	0.026705	0.013441	0.059527	0.032153
OS1	2006-03-13	0.248	26.824	3.974	0.587	3.6175	3.1568195	2.4725	11.6929	0.659346	0.516418	0.835366	2.637101	2.065449
OS1	2006-04-10	0.46	32.824	8.512	1.344	7.6026	5.1870514	3.3559	13.5438	1.203098	0.77837	0.956273	4.96024	3.209134
OS1	2006-04-24	0.398	41.653	5.18	0.665	9.4433	3.1161481	3.7876	14.4324	0.970098	1.179117	1.492496	4.65084	5.652917
OS1	2006-05-08	0.627	33.064	8.05	0.464	11.687	2.6066387	4.4754	15.2544	1.86685	3.205228	2.638691	6.878114	11.80915
OS1	2006-05-22	2.123	28.703	25.65	0.632	13.901	3.8072632	5.2831	15.9521	6.560519	9.103543	5.358728	20.40209	28.31046
OS1	2006-06-06	0.559	51.86	4.13	1.063	13.811	6.6960342	5.2495	16.4712	1.20792	0.946977	0.926853	6.20624	4.865526
OS1	2006-08-14	0.087	5.4891	2.96	0.604	19.299	7.5342769	6.6187	14.7037	0.945296	0.83042	0.123741	0.932295	0.819
OS1	2006-09-25	0.14	12.88	3	0.912	18.922	7.5266752	6.5968	12.0286	0.687143	0.602249	0.194894	1.466904	1.285672
OS1	2006-11-13	0.01	2.3586	1.348	1.193	11.724	5.0149107	4.4881	8.97898	0.056517	0.050581	0.012259	0.061479	0.055021
OS1	2006-12-11	0.001	0.7576	1.291	2.975	8.8508	3.6558309	3.6371	7.90702	0.005951	0.00592	0.001512	0.005529	0.0055
OS1	2010-06-09	1.006	19.729	8.654	0.611	15.289	6.0899442	5.7797	16.538	3.592466	3.409433	1.285374	7.827855	7.429033
OS1	2010-06-23	2.807	55.093	10.022	1.064	15.567	11.966915	5.8721	16.6554	5.314952	2.608039	2.387085	28.56604	14.01731
OS1	2010-07-14	0.435	33.997	2.47	0.909	20.502	11.389344	6.5953	16.2344	1.363772	0.789731	0.424946	4.839856	2.802656

Station	*Date*	*GPP* ($gC/m^2/day$)	E_o (mol photons/ m^2/day)	*Chl- a* (mg/m^3)	K_d (m^{-1})	*T°C*	P^b_{max} (mgC/mg Chl- a /hr)	P^B_{opt} (mgC/mg Chl- a /hr)	*Daylength* (hours)	*VGPM with* P^b_{max}	*VGPM**P^b_{opt}	*BPI*	*BPI**P^b_{max}	*BPI**P^b_{opt}
OS1	2010-07-28	1.278	40.588	5.442	0.775	20.502	10.48359	6.5953	15.6351	3.17978	2.000429	1.311017	13.74416	8.646579
OS1	2010-08-25	0.624	28.148	3.162	0.738	18.99	10.498848	6.6018	14.0292	1.675517	1.053578	0.554774	5.82449	3.662485
OS1	2010-09-08	0.322	8.2531	6.564	0.833	17.33	7.3502482	6.3597	13.1359	1.546145	1.337773	0.299157	2.19888	1.90254
OS1	2010-09-22	0.658	27.881	2.269	0.488	16.36	14.640289	6.1152	12.2229	2.206371	0.921587	0.59633	8.73045	3.646654
OS1	2010-10-13	0.257	7.9572	3.204	0.568	15.01	6.3846241	5.684	10.8516	0.784529	0.698433	0.206472	1.318249	1.173581
OS1	2010-11-18	0.016	3.8781	0.919	1.336	9.46	4.9438613	3.792	8.72178	0.043855	0.033637	0.012271	0.060666	0.046531
OS1	2010-12-15	0.012	3.9315	0.983	0.683	4.33	3.525239	2.6603	7.84597	0.059273	0.04473	0.026029	0.091758	0.069245
OS1	2011-01-12	0.005	1.3546	0.771	1.336	3.62	3.2254595	2.4732	8.20959	0.011544	0.008851	0.003596	0.011599	0.008894
OS1	2011-02-09	0.014	7.1787	1.709	0.479	4.93	2.5608998	2.8026	9.61589	0.170098	0.186151	0.117817	0.301718	0.330193
OS1	2011-03-02	0.074	19.209	1.279	0.662	4.76	3.9367879	2.7636	10.9512	0.208796	0.146572	0.170716	0.672073	0.471785
OS1	2011-03-16	0.173	19.782	1.646	3.1	6.03	4.5961605	3.0369	11.8787	0.073039	0.048261	0.048316	0.222069	0.146734
OS1	2011-04-06	1.111	36.554	9.812	1.122	8.89	5.4815401	3.6466	13.2695	1.739705	1.157353	1.470479	8.060487	5.362305
OS1	2011-04-20	2.211	39.141	26.798	6.96	11.46	4.4699495	4.3978	14.1702	0.67148	0.660647	0.693246	3.098773	3.048778
OS1	2011-05-11	0.65	39.418	2.467	0.489	13.86	5.2911035	5.2679	15.4054	1.132995	1.128016	0.914762	4.840099	4.818827
OS1	2011-05-25	0.493	53.898	1.775	0.559	15.13	6.6762338	5.7255	16.0691	0.962925	0.825795	0.787256	5.255907	4.507411
OS1	2011-06-08	0.645	36.473	2.626	0.941	16.58	10.983662	6.1762	16.5119	1.383911	0.778189	0.468204	5.142591	2.89174
OS1	2011-06-22	0.441	21.76	3.265	0.941	16.37	9.7344525	6.118	16.658	1.440063	0.905064	0.347303	3.3808	2.124797
OS1	2011-07-06	1.362	41.957	7.508	0.72	18.49	6.2524548	6.555	16.4787	2.977132	3.121175	2.012572	12.58351	13.19235
OS1	2011-07-20	0.228	23.584	1.8205	0.608	17.5	7.4283418	6.3954	16.0122	0.922875	0.794544	0.324838	2.413008	2.077464
OS1	2011-08-18	0.318	18.508	2.5263	0.589	18.51	10.04046	6.5573	14.4756	1.552328	1.013805	0.365172	3.666498	2.394542
OS1	2011-08-31	0.195	14.453	3.2648	8.49	17.6	6.3157904	6.4153	13.6654	0.078644	0.079883	0.025566	0.161469	0.164014
OS1	2011-09-14	0.371	32.578	2.4774	0.896	16.75	8.2642557	6.2213	12.7617	0.787849	0.59309	0.414347	3.424273	2.57778
OS1	2011-09-28	0.432	26.154	2.918	0.603	16.64	8.0925341	6.1924	11.8455	1.219791	0.933378	0.582186	4.711357	3.605106
OS1	2011-10-12	0.041	4.2002	1.685	0.892	15.55	6.5259524	5.8665	10.932	0.207434	0.186473	0.036497	0.238179	0.214111
OS1	2011-11-23	0.03	3.6752	1.1447	4.03	9.88	5.5695354	3.9068	8.49954	0.019332	0.013561	0.004802	0.026745	0.01876
OS1	2011-12-14	0.011	1.9057	1.6032	7.1	6.89	3.2808011	3.2098	7.86219	0.005622	0.0055	0.001979	0.006494	0.006353
OS1	2012-01-18	0.01	2.2075	0.928	2.065	6.89	5.8256933	3.2098	8.43723	0.023515	0.012956	0.004563	0.026584	0.014647
OS1	2012-03-21	0.625	25.514	3.5042	0.779	6.67	7.4067714	3.1657	12.2618	1.070619	0.457583	0.527936	3.910298	1.671264
OS1	2012-04-05	0.117	11.583	3.7562	0.402	8.61	1.0810062	3.5794	13.2535	0.300744	0.995806	0.497858	0.538187	1.782013
OS1	2012-04-18	0.417	22.374	5.132	0.597	8.68	2.8852355	3.5959	14.0919	0.898482	1.119801	0.884739	2.552679	3.181468
OS1	2012-05-09	0.318	21.247	4.3613	0.645	10.82	3.9080462	4.188	15.3386	1.03346	1.107501	0.660865	2.582692	2.767726
OS1	2012-05-23	0.879	44.237	4.51	0.9308	13.33	8.7364773	5.0706	16.0177	1.887494	1.09549	0.985976	8.613961	4.999491
OS1	2012-06-20	1.086	48.275	6.201	0.661	16.41	5.5587525	6.1293	16.658	2.435468	2.685446	2.083226	11.58014	12.76873
OS1	2012-07-04	0.936	39.976	5.713	0.546	17.97	4.7679259	6.4818	16.507	2.271902	3.088555	1.924089	9.173914	12.47155
OS1	2012-08-08	0.266	13.928	2.669	0.653	19.02	7.5883266	6.6038	15.0196	1.094725	0.952694	0.261872	1.987173	1.729355
OS1	2012-08-29	1.676	34.773	4.868	0.803	19.93	11.816162	6.6242	13.7443	2.678878	1.501794	0.969688	11.45799	6.423412
OS1	2012-09-12	0.481	25.106	2.873	0.53	19.03	6.8786926	6.6045	12.8426	1.252126	1.20221	0.62602	4.306199	4.134531
OS1	2012-09-26	0.237	20.229	2.059	0.858	15.56	6.9109001	5.8698	11.927	0.500272	0.424907	0.223301	1.543212	1.310729
OS1	2012-10-24	0.05	6.5909	3.528	0.414	13.45	1.7395221	5.1153	10.1186	0.281277	0.827132	0.258362	0.449426	1.321597
OS1	2012-11-14	0.052	10.445	0.873	0.68	9.59	5.5042339	3.8268	8.89829	0.137351	0.095493	0.061686	0.339535	0.23606
OS1	2012-12-12	0.013	5.361	0.8893	5.4635	5.79	3.7854911	2.9878	7.8811	0.00837	0.006606	0.004014	0.015195	0.011993

Station	*Date*	*GPP (gC/m^2/day)*	*E_o (mol photons/ m^2/day)*	*Chl- a (mg/m^3)*	*K_d (m^{-1})*	*T°C*	*P^b_{max} (mgC/mg Chl- a /hr)*	*P^B_{opt} (mgC/mg Chl- a /hr)*	*Daylength (hours)*	*VGPM with P^b_{max}*	*VGPM*P^b_{opt}*	*BPI*	*BPI*P^b_{max}*	*BPI*P^b_{opt}*
OS1	2013-01-16	0.02	7.54	0.8548	1.04	5.13	3.7573122	2.8473	8.38478	0.05102	0.038663	0.028507	0.107112	0.08117
OS2	2010-04-28	1.334	40.51	10.983	0.837	11.265	3.8419948	4.3324	14.6765	2.043751	2.304612	2.445219	9.394517	10.59362
OS2	2010-05-19	0.978	50.144	3.153	0.584	11.74	7.7286989	4.4936	15.8157	1.855652	1.0789	1.245343	9.624878	5.596029
OS2	2010-06-09	1.227	19.729	5.818	0.523	15.639	10.209297	5.8954	16.535	4.729265	2.730955	1.009545	10.30675	5.951722
OS2	2010-06-23	2.416	55.093	6.065	0.662	16.037	11.826512	6.0201	16.6523	5.108035	2.600167	2.321817	27.45899	13.97758
OS2	2010-07-14	0.651	33.997	2.341	0.49	21.095	13.454962	6.5321	16.2317	2.832208	1.374976	0.747147	10.05283	4.880435
OS2	2010-07-28	1.638	40.588	5.073	0.749	21.095	14.749602	6.5321	15.6328	4.314504	1.910747	1.264545	18.65154	8.260132
OS2	2010-08-25	0.707	28.148	3.074	0.756	19.28	12.97866	6.6179	14.028	1.965519	1.002233	0.526493	6.833176	3.484289
OS2	2010-09-08	0.272	8.2531	4.917	0.764	17.37	7.5681301	6.3683	13.1353	1.300168	1.094039	0.244333	1.849147	1.555982
OS2	2010-09-22	0.303	27.881	1.69	0.522	16.32	7.4548772	6.1037	12.2228	0.78229	0.640505	0.41523	3.095487	2.53445
OS2	2010-10-13	0.266	7.9572	2.585	0.434	14.99	7.4369021	5.677	10.8523	0.964987	0.736627	0.218016	1.621365	1.237677
OS2	2010-11-18	0.018	3.8781	1.025	1.042	9.49	4.7597741	3.8	8.72387	0.060394	0.048215	0.017548	0.083525	0.066682
OS2	2010-12-15	0.016	3.9315	0.712	1.934	3.91	3.7106452	2.5523	7.84872	0.015965	0.010981	0.006658	0.024706	0.016993
OS2	2011-01-12	0.006	1.3546	0.675	0.732	3.16	2.7864295	2.3398	8.21206	0.015939	0.013385	0.005746	0.016011	0.013445
OS2	2011-02-09	0.027	7.1787	0.891	3.253	4.79	3.1224559	2.7705	9.61738	0.015924	0.014129	0.009045	0.028242	0.025059
OS2	2011-03-02	0.064	19.209	1.171	1.068	4.6	3.6094052	2.7259	10.9519	0.108646	0.082054	0.096883	0.34969	0.264098
OS2	2011-03-16	0.155	19.782	1.806	0.502	5.88	4.3569942	3.0063	11.8788	0.469135	0.323703	0.32737	1.42635	0.984182
OS2	2011-04-06	0.593	36.554	4.529	0.836	9.05	5.4567921	3.6863	13.2687	1.0728	0.724716	0.910941	4.970814	3.357971
OS2	2011-04-20	1.974	39.141	18.99	0.695	11.78	4.3177265	4.5076	14.169	4.602503	4.804917	4.919649	21.2417	22.17589
OS2	2011-05-11	0.766	39.418	3.768	0.477	14.13	5.1851074	5.3677	15.4033	1.738253	1.799456	1.43232	7.426735	7.688227
OS2	2011-05-25	0.441	53.898	2.312	0.564	15.33	5.7312164	5.7935	16.0665	1.06699	1.078586	1.016338	5.824855	5.888161
OS2	2011-06-08	0.431	36.473	2.806	0.887	16.79	7.5461075	6.2316	16.509	1.07762	0.889904	0.530755	4.005131	3.307461
OS2	2011-06-22	0.475	21.76	3.658	0.952	16.53	8.3385094	6.1626	16.6549	1.365814	1.009414	0.38461	3.207078	2.370212
OS2	2011-07-06	1.83	41.957	6.281	0.549	18.64	9.608376	6.5715	16.4758	5.018632	3.432407	2.208086	21.21612	14.51041
OS2	2011-07-20	0.357	23.584	1.9484	0.846	17.69	8.250009	6.4325	16.0097	0.788238	0.614591	0.249855	2.061304	1.607202
OS2	2011-08-18	0.182	18.508	1.8594	0.895	18.55	8.8030012	6.5618	14.4742	0.65917	0.49135	0.17688	1.557072	1.160654
OS2	2011-08-31	0.195	14.453	2.4308	0.495	17.9	6.3837315	6.4701	13.6645	1.015029	1.028764	0.326481	2.084167	2.112368
OS2	2011-09-14	0.35	32.578	2.2735	1.0687	16.96	8.60548	6.2742	12.7613	0.631177	0.460189	0.318798	2.74341	2.000212
OS2	2011-09-28	0.443	26.154	3.174	0.783	16.57	7.354131	6.1735	11.8457	0.928569	0.779501	0.487684	3.586493	3.010735
OS2	2011-10-12	0.036	4.2002	1.474	0.785	15.6	5.9138339	5.8828	10.9326	0.186864	0.185884	0.036279	0.214546	0.213421
OS2	2011-11-23	0.037	3.6752	0.9761	1.215	9.66	4.9362616	3.8458	8.50179	0.048473	0.037765	0.013581	0.067041	0.052231
OS2	2011-12-14	0.013	1.9057	0.7959	1.816	6.91	4.5013093	3.2139	7.86493	0.014976	0.010693	0.003842	0.017294	0.012348
OS2	2012-01-18	0.012	2.2075	7.13	1.789	6.91	0.5536306	3.2139	8.43953	0.019823	0.115076	0.04047	0.022405	0.130064
OS2	2012-03-21	0.792	25.514	7.3907	0.648	6.66	4.1950786	3.1637	12.2617	1.537466	1.159457	1.33858	5.61545	4.234808
OS2	2012-04-05	0.129	11.583	2.0095	0.437	8.86	2.3574744	3.6393	13.2528	0.322763	0.498259	0.245017	0.577621	0.891691
OS2	2012-04-18	0.365	22.374	3.7168	0.722	8.8	3.3399395	3.6247	14.0906	0.622799	0.675904	0.529826	1.769587	1.920478
OS2	2012-05-09	0.298	21.247	2.5946	0.625	10.99	4.66958	4.2424	15.3365	0.758038	0.688691	0.405742	1.894643	1.721318
OS2	2012-05-23	1.07	44.237	3.699	3.8669	13.54	9.3650607	5.1488	16.0151	0.399385	0.219579	0.194656	1.822965	1.00225
OS2	2012-06-20	1.803	48.275	8.027	0.739	16.44	4.8646077	6.1377	16.6549	2.467297	3.113012	2.412043	11.73364	14.80445
OS2	2012-07-04	0.962	39.976	5.394	0.564	18.07	5.4233542	6.4977	16.5041	2.361625	2.829474	1.758674	9.537914	11.42742
OS2	2012-08-08	0.207	13.928	2.105	0.74	19.22	7.0322079	6.6152	15.0177	0.705965	0.664106	0.182253	1.281641	1.205648

Station	*Date*	*GPP* ($gC/m^2/day$)	E_o (*mol photons/* m^2/day)	*Chl- a* (mg/m^3)	K_d (m^{-1})	*T°C*	P^b_{max} (*mgC/mg Chl- a /hr*)	P^B_{opt} (*mgC/mg Chl- a /hr*)	*Daylength* (*hours*)	*VGPM with* P^b_{max}	*VGPM**P^b_{opt}	*BPI*	*BPI**P^b_{max}	*BPI**P^b_{opt}
OS2	2012-08-29	1.389	34.773	4.26	8.7605	20.02	13.970805	6.6218	13.7434	0.254046	0.120411	0.077782	1.086673	0.515055
OS2	2012-09-12	0.798	25.106	3.018	0.717	19.05	12.85513	6.6058	12.8422	1.816953	0.933664	0.486103	6.24892	3.211087
OS2	2012-09-26	0.289	20.229	2.191	0.702	15.76	7.024049	5.9342	11.9271	0.661299	0.558694	0.29042	2.039927	1.723416
OS2	2012-10-24	0.053	6.5909	0.89	0.906	13.21	6.3721285	5.0259	10.1198	0.118788	0.093692	0.029783	0.189778	0.149685
OS2	2012-11-14	0.056	10.445	0.645	0.63	9.49	5.964919	3.8	8.90025	0.118727	0.075635	0.049193	0.293431	0.18693
OS2	2012-12-12	0.02	5.361	0.5738	2.056	5.57	4.2814075	2.942	7.88383	0.016237	0.011157	0.006883	0.029467	0.020249
OS2	2013-01-16	0.018	7.54	0.5731	1.77	4.9	3.8489669	2.7958	8.38712	0.020595	0.014959	0.01123	0.043224	0.031397

Supplementary information 2: Table of in-situ data from the Westerscheldde including calculations of estimated P^b_{opt} and the various composite parameters

Station	*Date*	*GPP (gC/m²/day)*	*E_o (mol photons/ m²/day)*	*Chl- a (mg/m³)*	*K_d (m^{-1})*	*T°C*	*P^b_{max} (mgC/mg Chl- a /hr)*	*P^B_{opt} (mgC/mg Chl- a /hr)*	*Daylength (hours)*	*VGPM with P^b_{max}*	*VGPM*P^b_{opt}*	*BPI*	*BPI*P^b_{max}*	*BPI*P^b_{opt}*
WS1	2009-01-13	*0.004*	1.868	0.933	1.75	2.4198	2.8348	2.1055	8.2933	0.011933	0.008863	0.004581	0.012987	0.009646
WS1	2009-02-10	*0.005*	3.3426	1.452	4.641	2.658	3.3228	2.1834	9.723	0.013808	0.009073	0.004811	0.015985	0.010503
WS1	2009-03-03	*0.06*	8.0471	3.407	1.951	4.6359	4.9054	2.7345	11.056	0.190846	0.106385	0.064642	0.317095	0.176761
WS1	2009-03-24	*2.044*	25.801	43.631	1.977	6.8857	5.5414	3.209	12.44	3.993123	2.312393	2.619276	14.51437	8.405178
WS1	2009-04-07	*1.73*	13.461	35.816	1.119	8.7634	5.3052	3.6159	13.357	5.288332	3.604415	1.98194	10.51459	7.16652
WS1	2009-04-21	*1.021*	41.731	11.8	2.572	11.195	9.8961	4.3094	14.247	1.791558	0.780156	0.880709	8.71556	3.795298
WS1	2009-05-06	*1.042*	26.474	8.91	1.129	12.862	7.7267	4.897	15.135	2.430846	1.540609	0.961071	7.425942	4.706377
WS1	2009-05-26	*0.34*	14.93	8.81	1.615	15.635	7.0328	5.8941	16.096	1.473679	1.235074	0.374639	2.634749	2.208154
WS1	2009-06-23	*1.769*	55.425	5.813	0.614	17.882	7.8082	6.467	16.618	3.479195	2.881612	2.413787	18.84721	15.61003
WS1	2009-07-07	*0.725*	16.213	4.94	0.684	20.171	10.443	6.6159	16.407	3.004164	1.903315	0.538635	5.624708	3.563583
WS1	2009-08-25	*0.242*	16.286	4.863	2.259	20.7	12.149	6.5779	14	0.889708	0.481737	0.16127	1.959199	1.060819
WS1	2009-09-22	*0.114*	28.262	3.274	3.7606	17.476	9.8002	6.3904	12.206	0.276646	0.180392	0.113185	1.10923	0.723293
WS1	2009-10-13	*0.121*	15.2	1.994	1.245	15.165	6.7661	5.7376	10.845	0.281529	0.238734	0.111987	0.757712	0.642533
WS1	2009-11-17	*0.025*	4.3404	1.148	1.361	10.927	6.9355	4.2222	8.7841	0.08038	0.048935	0.016841	0.116802	0.071108
WS1	2009-12-08	*0.007*	3.9733	0.919	4.153	8.8434	6.4094	3.6353	7.997	0.01698	0.00963	0.004045	0.025923	0.014703
WS1	2010-01-12	*0.003*	2.8779	1.113	4.72		2.9994	1.2956	8.248	0.007318	0.003161	0.003122	0.009363	0.004044
WS1	2010-02-16	*0.026*	12.233	1.326	2.128	2.09	3.7556	1.9944	10.077	0.053727	0.028532	0.035065	0.13169	0.069934
WS1	2010-03-16	*0.161*	17.859	3.852	1.203	4.3052	3.2333	2.6541	11.896	0.304673	0.250103	0.263052	0.850515	0.698179
WS1	2010-04-07	*0.543*	26.355	9.48	1.463	7.8084	4.9966	3.3995	13.342	1.13704	0.7736	0.78556	3.925164	2.670537
WS1	2010-04-27	*0.892*	39.906	12.186	0.795	10.643	2.2055	4.1326	14.599	1.361343	2.550859	2.813789	6.205752	11.62823
WS1	2010-05-18	*1.093*	49.056	7.557	1.514	11.543	7.449	4.4259	15.743	1.643075	0.976248	1.126353	8.390162	4.985089
WS1	2010-06-08	*0.975*	32.932	10.297	0.905	15.244	3.9685	5.7643	16.482	2.013025	2.923971	1.723613	6.840087	9.935403
WS1	2010-07-13	*1.54*	31.647	5.593	0.812	20.879	14.26	6.5589	16.236	4.294216	1.975185	1.002724	14.29846	6.576782
WS1	2010-07-27	*2.069*	21.738	14.194	0.882	20.56	8.2562	6.5906	15.656	5.323432	4.249513	1.609244	13.28624	10.60595
WS1	2010-08-24	*0.849*	37.738	4.381	1.072	19.31	10.353	6.6191	14.077	1.634142	1.044767	0.709445	7.344967	4.695906
WS1	2010-09-07	*0.113*	21.237	6.875	6.653	17.56	7.1719	6.4074	13.192	0.249273	0.222704	0.10095	0.723997	0.646829
WS1	2010-09-21	*0.449*	17.643	2.698	0.695	16.46	9.0784	6.1433	12.287	1.068764	0.723226	0.31505	2.860153	1.935447
WS1	2010-12-14	*0.01*	2.1758	1.329	2.315	4.3	3.904	2.6528	7.8919	0.018652	0.012675	0.005746	0.022431	0.015243
WS1	2011-01-11	*0.005*	1.2467	1.401	2.292	3.39	3.3003	2.4077	8.2048	0.01174	0.008565	0.003506	0.011569	0.008441
WS1	2011-02-08	*0.024*	14.289	1.589	3.713	4.92	3.5101	2.8003	9.5743	0.033993	0.02712	0.02813	0.098739	0.078773
WS1	2011-03-01	*0.04*	7.8868	1.771	2.045	5.2	5.0978	2.8627	10.894	0.096254	0.054052	0.031419	0.160166	0.089942
WS1	2011-03-15	*0.06*	18.717	1.874	2.57	6.07	4.8576	3.0451	11.814	0.104413	0.065453	0.062781	0.304964	0.191171
WS1	2011-04-05	*0.159*	8.7972	7.335	3.21	9.05	5.7283	3.6863	13.196	0.358369	0.230617	0.09247	0.529694	0.340868
WS1	2011-04-19	*1.139*	41.522	15.221	3.86	11.48	9.9466	4.4046	14.092	1.530175	0.677603	0.753165	7.491396	3.317394
WS1	2011-05-10	*0.358*	38.822	11.573	5.04	13.95	6.9117	5.3012	15.327	0.669234	0.513295	0.410066	2.834259	2.173845
WS1	2011-05-24	*0.941*	49.25	7.977	1.91	15.26	7.8715	5.7699	15.997	1.476715	1.082446	0.946167	7.447723	5.459254
WS1	2011-06-07	*0.213*	27.803	7.368	4.36	16.7	6.535	6.2082	16.454	0.481689	0.457601	0.216129	1.412415	1.341785
WS1	2011-06-21	*0.249*	33.426	6.696	4.69	16.36	8.1916	6.1152	16.621	0.526684	0.393177	0.219524	1.798251	1.342421
WS1	2011-07-05	*4.369*	51.161	22.612	1.13	18.37	8.1059	6.5403	16.466	7.521459	6.068679	4.709277	38.17305	30.79988

Station	Date	GPP ($gC/m^2/day$)	E_o (mol photons/ m^2/day)	Chl- a (mg/m^3)	K_d (m^{-1})	T°C	P^b_{max} (mgC/mg Chl- a /hr)	P^B_{opt} (mgC/mg Chl- a /hr)	Daylength (hours)	VGPM with P^b_{max}	VGPM*P^b_{opt}	BPI	BPI*P^b_{max}	BPI*P^b_{opt}
WS1	2011-07-19	*0.19*	35.851	3.848	5.111	17.62	11.978	6.4192	16.022	0.39441	0.211364	0.124161	1.487246	0.797015
WS1	2011-08-17	*0.091*	31.678	4.372	8.055	18.6	9.0894	6.5673	14.518	0.192894	0.13937	0.079091	0.71889	0.519415
WS1	2011-08-30	*0.099*	16.137	3.688	3.513	18.06	8.4968	6.4962	13.717	0.296776	0.226898	0.077927	0.662133	0.506229
WS1	2011-09-13	*0.051*	25.069	3.269	7.8	17.11	7.2695	6.3101	12.821	0.102117	0.088641	0.048329	0.35133	0.304964
WS1	2011-09-27	*0.227*	18.72	3.445	1.589	16.7	7.9184	6.2082	11.912	0.510282	0.400073	0.186692	1.47831	1.15903
WS1	2011-10-11	*0.026*	6.8589	3.175	5.265	15.87	6.6616	5.9688	11.004	0.084159	0.075407	0.019027	0.126747	0.113566
WS1	2011-12-13	*0.006*	2.9026	1.5085	6.82	7.43	4.6071	3.3199	7.9101	0.010163	0.007323	0.002953	0.013606	0.009805
WS1	2012-01-17	*0.02*	7.4264	1.5725	4.295	6.32	5.663	3.0955	8.423	0.034225	0.018708	0.012507	0.070828	0.038716
WS1	2012-02-07	*0.011*	12	0.8912	4.4613	2.51	3.5169	2.1353	9.501	0.015132	0.009188	0.011027	0.038779	0.023545
WS1	2012-03-20	*0.228*	23.748	2.8881	1.373	6.66	5.1624	3.1637	12.194	0.343483	0.210497	0.22979	1.18626	0.726977
WS1	2012-04-03	*0.057*	23.119	3.2847	4.3145	8.47	3.3727	3.5467	13.115	0.087002	0.091489	0.080964	0.27307	0.287153
WS1	2012-04-17	*0.638*	12.571	12.619	2.587	8.92	8.2963	3.654	14.014	1.300805	0.572922	0.282067	2.340115	1.030672
WS1	2012-05-08	*0.117*	19.486	11.382	10.306	11.05	5.8805	4.2618	15.26	0.24906	0.180503	0.098997	0.582153	0.421908
WS1	2012-05-22	*0.967*	47.124	6.025	1.359	13.13	7.4931	4.9962	15.945	1.482213	0.988297	0.961022	7.201059	4.801459
WS1	2012-06-19	*0.293*	43.325	3.741	2.062	16.7	5.7787	6.2082	16.619	0.484163	0.520154	0.361573	2.089412	2.244733
WS1	2012-07-03	*0.179*	27.241	9.846	6.839	18.11	5.8015	6.5039	16.492	0.364186	0.40828	0.180406	1.04662	1.17334
WS1	2012-08-07	*0.234*	34.042	8.485	7.5034	19.25	9.0706	6.6166	15.054	0.419183	0.305778	0.177078	1.606203	1.171661
WS1	2012-08-28	*0.272*	29.899	8.062	4.9431	19.92	8.4505	6.6244	13.795	0.508587	0.398687	0.224314	1.895562	1.485953
WS1	2012-09-11	*0.737*	18.452	4.149	0.557	19.33	6.6851	6.6199	12.902	1.598922	1.583316	0.632249	4.226662	4.185408
WS1	2012-09-25	*0.18*	24.734	3.68	3.6016	15.92	9.4996	5.9844	11.993	0.303739	0.191343	0.116252	1.104349	0.695694
WS1	2012-12-11	*0.017*	6.4857	2.43	5.81	6.04	3.6806	3.039	7.931	0.022753	0.018786	0.012478	0.045926	0.03792
WS1	2013-01-15	*0.006*	2.9491	2.036	5.8788	5.75	2.7402	2.9796	8.3725	0.010111	0.010995	0.004698	0.012874	0.013999
WS1	2013-02-05	*0.017*	7.2654	1.854	3.7114	4.1	2.5954	2.6021	9.4285	0.023769	0.023831	0.016695	0.04333	0.043442
WS1	2013-03-05	*0.044*	18.666	2.8118	3.54	3.36	2.7272	2.399	11.189	0.060449	0.053175	0.068201	0.186	0.163616
WS1	2013-03-26	*0.139*	27.69	4.1357	2.627	2.94	3.5113	2.2726	12.574	0.18416	0.119194	0.200524	0.704107	0.455719
WS1	2013-04-09	*0.117*	13.355	5.7617	3.097	4.2	3.6378	2.6277	13.488	0.212453	0.153458	0.114294	0.415782	0.300327
WS1	2013-05-07	*0.427*	30.986	13.31	1.7146	10.82	2.331	4.188	15.192	0.738454	1.326747	1.106462	2.579182	4.633902
WS1	2013-05-22	*0.319*	26.632	10.472	4.2443	11.25	6.3387	4.3275	15.934	0.656883	0.448463	0.302264	1.915946	1.308042
WS1	2013-06-04	*0.556*	42.783	10.066	3.227	12.23	5.4255	4.6666	16.392	0.770011	0.662312	0.613883	3.330612	2.864771
WS1	2013-06-18	*0.169*	39.98	9.1395	6.1739	14.68	4.3669	5.5675	16.615	0.29631	0.377779	0.27225	1.18888	1.515755
WS1	2013-07-02	*0.243*	34.918	4.3727	4.0317	16.28	8.852	6.0922	16.516	0.431638	0.297067	0.174208	1.542083	1.061309
WS1	2013-07-16	*3.001*	41.221	18.321	1.335	18.34	9.7164	6.5364	16.119	5.946292	4.000171	2.602236	25.28431	17.00918
WS1	2013-08-06	*1.807*	37.106	10.124	1.745	21.22	13.37	6.5145	15.122	3.213104	1.565558	0.990271	13.24012	6.451135
WS1	2013-09-03	*1.281*	35.916	7.8645	0.9725	19.73	6.7327	6.6267	13.431	1.996414	1.964974	1.336076	8.995445	8.853784
WS1	2013-09-17	*0.353*	10.948	5.1036	1.2566	17.02	9.0732	6.2888	12.529	1.021741	0.708184	0.204546	1.855889	1.286344
WS1	2013-10-08	*0.063*	11.976	5.1036	8.92	15.59	8.5599	5.8796	11.165	0.123905	0.085107	0.031519	0.269799	0.185318
WS1	2013-11-05	*0.027*	2.1464	2.249	1.699	11.99	5.9838	4.5812	9.428	0.078055	0.05976	0.01307	0.078207	0.059876
WS1	2013-12-03	*0.046*	5.4417	1.095	1.261	8.29	6.3628	3.5055	8.1316	0.077939	0.042939	0.021736	0.138304	0.076197
WS4	2009-01-13	*0.002*	1.868	1.398	4.942	2.0599	3.1992	1.9841	8.3026	0.007154	0.004437	0.002431	0.007777	0.004823
WS4	2009-02-10	*0.006*	3.3426	1.89	3.904	2.675	3.2169	2.1889	9.7285	0.020698	0.014083	0.007444	0.023946	0.016294
WS4	2009-03-03	*0.027*	8.0471	1.051	3.542	4.6699	12.619	2.7425	11.058	0.083438	0.018134	0.010984	0.138605	0.030123
WS4	2009-03-24	*1.266*	25.801	20.072	1.683	7.2285	6.3965	3.2784	12.44	2.490726	1.276586	1.415466	9.054008	4.640504

Station	Date	GPP ($gC/m^2/day$)	E_o (mol photons/ m^2/day)	Chl- a (mg/m^3)	K_d (m^{-1})	T°C	P^b_{max} (mgC/mg Chl- a /hr)	P^B_{opt} (mgC/mg Chl- a /hr)	Daylength (hours)	VGPM with P^b_{max}	VGPM*P^b_{opt}	BPI	BPI*P^b_{max}	BPI*P^b_{opt}
WS4	2009-04-07	*1.648*	13.461	35.292	1.404	9.2635	7.0864	3.7405	13.354	5.546361	2.927641	1.556513	11.03007	5.822209
WS4	2009-04-21	*0.943*	41.731	5.43	1.001	11.928	8.7142	4.5592	14.242	1.86463	0.975564	1.041327	9.074289	4.747618
WS4	2009-05-06	*0.608*	26.474	9.655	2.093	13.547	7.8527	5.1514	15.128	1.443341	0.946827	0.561765	4.411389	2.893858
WS4	2009-05-26	*0.093*	14.93	11.99	6.799	16.045	5.8723	6.0227	16.086	0.397542	0.407722	0.121111	0.711202	0.729415
WS4	2009-06-23	*0.924*	55.425	7.993	1.547	17.977	7.2619	6.4829	16.606	1.764665	1.575346	1.317306	9.566204	8.539907
WS4	2009-07-07	*0.16*	16.213	4.2	2.867	20.92	10.902	6.5542	16.396	0.635765	0.382206	0.109256	1.191153	0.71609
WS4	2009-08-25	*0.096*	16.286	6.473	5.965	20.937	10.401	6.5522	13.996	0.383841	0.241812	0.081294	0.845517	0.532659
WS4	2009-09-22	*0.154*	28.262	3.552	3.272	17.603	10.638	6.4158	12.206	0.374434	0.225823	0.141132	1.501357	0.905477
WS4	2009-10-13	*0.095*	15.2	2.213	1.786	15.179	7.794	5.7424	10.848	0.250959	0.184899	0.086639	0.675259	0.497512
WS4	2009-11-17	*0.016*	4.3404	2.135	3.137	10.841	5.6006	4.1948	8.7921	0.052421	0.039262	0.013589	0.076104	0.057001
WS4	2009-12-08	*0.008*	3.9733	1.487	2.912	8.7262	4.155	3.607	8.0073	0.025433	0.022079	0.009333	0.03878	0.033665
WS4	2010-01-12	*0.005*	2.8779	1.684	3.76	1.9282	3.6937	1.9387	8.2575	0.017137	0.008995	0.005929	0.0219	0.011495
WS4	2010-02-16	*0.032*	12.233	2.998	3.375	1.9168	3.5173	1.9348	10.082	0.071765	0.039476	0.049988	0.175823	0.096715
WS4	2010-03-16	*0.099*	17.859	5.109	3.501	4.285	4.7915	2.6491	11.896	0.205781	0.11377	0.119885	0.574433	0.317586
WS4	2010-04-07	*0.453*	26.355	8.765	1.853	7.9981	5.8768	3.4406	13.339	0.976009	0.571406	0.573445	3.370012	1.97298
WS4	2010-04-27	*2.926*	39.906	22.501	1.014	11.254	5.112	4.3287	14.593	4.566141	3.866422	4.07344	20.82354	17.63253
WS4	2010-05-18	*0.913*	49.056	7.345	1.871	11.808	8.0985	4.5175	15.733	1.404146	0.783253	0.885868	7.174246	4.001897
WS4	2010-06-08	*1.05*	32.932	6.459	0.913	16.149	8.1784	6.0538	16.47	2.577671	1.908047	1.071697	8.764748	6.487853
WS4	2010-06-22	*0.705*	53.8	3.5	1.026	16.414	7.8079	6.1304	16.609	1.250318	0.981695	0.844233	6.591645	5.175472
WS4	2010-07-13	*0.52*	31.647	7.877	2.702	21.616	10.355	6.4496	16.225	1.318954	0.821506	0.424393	4.39459	2.737154
WS4	2010-07-27	*0.418*	21.738	7.861	2.548	20.902	8.816	6.5563	15.647	1.089126	0.809964	0.308506	2.719781	2.022653
WS4	2010-08-24	*0.494*	37.738	3.746	1.902	19.63	11.618	6.6265	14.072	0.883485	0.50389	0.341899	3.972318	2.265585
WS4	2010-09-07	*0.081*	21.237	3.981	7.343	17.77	9.4451	6.4473	13.19	0.172198	0.117544	0.052963	0.500235	0.341465
WS4	2010-09-21	*0.265*	17.643	2.803	1.17	16.5	9.0229	6.1544	12.286	0.655512	0.447115	0.194428	1.754308	1.196587
WS4	2010-12-14	*0.008*	2.1758	1.348	2.753	4	4.403	2.5761	7.9025	0.017967	0.010512	0.004901	0.021578	0.012625
WS4	2011-01-11	*0.005*	1.2467	2.353	2.989	3.18	3.3703	2.3458	8.2144	0.015458	0.010759	0.004515	0.015216	0.010591
WS4	2011-02-08	*0.031*	14.289	2.21	3.736	4.98	3.6192	2.8139	9.5802	0.048478	0.037691	0.038883	0.140726	0.109411
WS4	2011-03-01	*0.036*	7.8868	2.519	2.564	5.49	4.4066	2.9251	10.897	0.094412	0.062672	0.035643	0.157062	0.10426
WS4	2011-03-15	*0.102*	18.717	2.468	1.96	6.15	5.1613	3.0613	11.815	0.191586	0.113634	0.108413	0.559545	0.331878
WS4	2011-04-05	*0.1*	8.7972	8.897	5.6	9.46	5.9463	3.792	13.193	0.258598	0.164909	0.064292	0.382301	0.243795
WS4	2011-04-19	*1.041*	41.522	18.294	3.169	11.85	6.9159	4.532	14.088	1.557039	1.02034	1.102607	7.625472	4.997034
WS4	2011-05-10	*0.612*	38.822	12.129	3.45	14.74	8.5218	5.5889	15.319	1.262664	0.828105	0.627833	5.350247	3.508904
WS4	2011-05-24	*0.409*	49.25	5.796	3.897	15.75	9.4741	5.931	15.987	0.632559	0.396	0.336945	3.192241	1.998435
WS4	2011-06-07	*0.502*	27.803	4.474	1.467	17.08	9.6109	6.3031	16.443	1.277581	0.837865	0.390047	3.748712	2.458486
WS4	2011-06-21	*0.311*	33.426	4.571	2.611	16.64	8.8776	6.1924	16.609	0.699402	0.487854	0.26918	2.389661	1.666862
WS4	2011-07-05	*0.227*	51.161	14.449	13.94	18.49	8.2272	6.555	16.455	0.395157	0.314837	0.243932	2.006887	1.598967
WS4	2011-07-19	*0.648*	35.851	6.969	2.025	17.84	9.3978	6.4598	16.012	1.413584	0.971659	0.567547	5.333668	3.666217
WS4	2011-08-17	*0.396*	31.678	4.74	1.939	18.67	9.055	6.5745	14.512	0.865134	0.628148	0.356217	3.225529	2.34196
WS4	2011-08-30	*0.048*	16.137	3.92	8.19	18.15	8.2421	6.5099	13.713	0.131214	0.103637	0.035529	0.292831	0.231286
WS4	2011-09-13	*0.221*	25.069	3.528	2.028	17.31	7.8292	6.3553	12.82	0.456453	0.370524	0.20061	1.570615	1.274939
WS4	2011-09-27	*0.089*	18.72	3.483	4.126	16.81	7.8141	6.2367	11.913	0.196074	0.156495	0.072692	0.568018	0.453359
WS4	2011-10-11	*0.039*	6.8589	3.201	3.167	15.96	6.1697	5.9967	11.007	0.130671	0.127006	0.03189	0.196751	0.191233

Station	Date	GPP (gC/m^2/day)	E_o (mol photons/ m^2/day)	Chl-a (mg/m^3)	K_d (m^{-1})	T°C	P^b_{max} (mgC/mg Chl-a /hr)	P^B_{opt} (mgC/mg Chl-a /hr)	Daylength (hours)	VGPM with P^b_{max}	VGPM*P^b_{opt}	BPI	BPI*P^b_{max}	BPI*P^b_{opt}
WS4	2011-12-13	*0.01*	2.9026	1.9148	3.761	7.24	3.9758	3.2808	7.9206	0.020214	0.01668	0.006798	0.027027	0.022302
WS4	2012-01-17	*0.007*	7.4264	1.7934	9.33	6.17	4.1691	3.0653	8.432	0.013243	0.009737	0.006566	0.027376	0.020128
WS4	2012-02-07	*0.018*	12	1.8642	5.7457	2.31	3.4854	2.0689	9.5071	0.024374	0.014468	0.01791	0.062423	0.037054
WS4	2012-03-20	*0.14*	23.748	2.1388	1.72	7.22	5.4808	3.2767	12.194	0.215573	0.12888	0.135842	0.744526	0.445112
WS4	2012-04-03	*0.681*	23.119	10.161	1.278	9.05	4.4449	3.6863	13.112	1.19722	0.992875	0.845537	3.758365	3.116876
WS4	2012-04-17	*0.08*	12.571	8.3029	6.8183	9.52	4.3439	3.808	14.01	0.169978	0.149008	0.070418	0.305885	0.268148
WS4	2012-05-08	*0.387*	19.486	12.515	4.1047	11.23	7.638	4.3209	15.252	0.892585	0.50494	0.27329	2.087386	1.180847
WS4	2012-05-22	*1.007*	47.124	11.583	2.421	13.57	7.14	5.16	15.935	1.523247	1.100834	1.037103	7.404917	5.351453
WS4	2012-06-19	*1.36*	43.325	4.593	0.716	16.62	8.8751	6.187	16.607	2.627307	1.831554	1.278439	11.34626	7.909724
WS4	2012-07-03	*0.112*	27.241	4.351	5.5585	18.26	7.832	6.5256	16.481	0.267129	0.222572	0.098088	0.768222	0.640084
WS4	2012-08-07	*0.138*	34.042	5.313	8.3495	19.51	9.6501	6.6249	15.046	0.250829	0.172198	0.099644	0.961571	0.660131
WS4	2012-08-28	*0.218*	29.899	4.997	4.5304	20.2	9.8123	6.6146	13.791	0.399263	0.269147	0.1517	1.488529	1.003433
WS4	2012-09-11	*0.102*	18.452	2.931	3.7938	19.58	8.3396	6.626	12.9	0.206849	0.164345	0.065575	0.546875	0.434502
WS4	2012-09-25	*0.037*	24.734	2.972	7.8802	16.06	5.4886	6.0272	11.993	0.064777	0.071133	0.04291	0.235517	0.258626
WS4	2012-12-11	*0.006*	6.4857	1.057	6.7832	5.89	3.6186	3.0084	7.9414	0.008345	0.006938	0.004649	0.016823	0.013986
WS4	2013-01-15	*0.007*	2.9491	3.116	6.0099	5.68	2.9046	2.965	8.3817	0.016063	0.016397	0.007034	0.02043	0.020855
WS4	2013-02-05	*0.009*	7.2654	1.655	5.3041	4.17	2.4485	2.62	9.4347	0.014016	0.014998	0.010428	0.025533	0.027322
WS4	2013-03-05	*0.024*	18.666	1.583	4.2492	3.16	3.3776	2.3398	11.191	0.03512	0.024329	0.031988	0.108043	0.074846
WS4	2013-03-26	*0.099*	27.69	3.308	2.705	2.96	3.4314	2.2788	12.573	0.139786	0.092833	0.155766	0.534498	0.354965
WS4	2013-04-09	*0.164*	13.355	5.1574	2.7019	4.12	5.074	2.6072	13.485	0.303963	0.156188	0.117267	0.595016	0.305742
WS4	2013-05-07	*1.248*	30.986	24.356	2.011	11.14	5.2536	4.2912	15.184	2.595376	2.119935	1.726306	9.069324	7.407935
WS4	2013-05-22	*0.411*	26.632	12.017	4.2241	11.82	6.7532	4.5215	15.925	0.806442	0.539945	0.348515	2.353593	1.575824
WS4	2013-06-04	*0.329*	42.783	7.477	3.9442	12.93	6.1684	4.9221	16.381	0.531685	0.424255	0.373079	2.30131	1.836318
WS4	2013-06-18	*0.619*	39.98	7.3295	1.9514	15.36	6.4738	5.8036	16.603	1.113754	0.998456	0.690769	4.471873	4.008934
WS4	2013-07-02	*0.184*	34.918	5.034	6.1036	16.46	8.3162	6.1433	16.505	0.308156	0.227638	0.132475	1.101692	0.813833
WS4	2013-07-16	*1.56*	41.221	11.639	1.648	19.14	9.2505	6.6111	16.108	2.911513	2.080802	1.339167	12.38794	8.853419
WS4	2013-08-06	*0.376*	37.106	5.276	3.1669	21.75	8.6209	6.4245	15.115	0.594625	0.443128	0.28436	2.451441	1.826873
WS4	2013-09-03	*0.328*	35.916	4.0257	1.399	19.65	4.4601	6.6266	13.428	0.470483	0.699022	0.475416	2.120397	3.150389
WS4	2013-09-17	*0.203*	10.948	4.012	1.7887	17.44	7.636	6.383	12.528	0.474849	0.396931	0.112963	0.862587	0.721045
WS4	2013-10-08	*0.072*	11.976	4.012	6.09	15.69	9.09	5.9119	11.167	0.151529	0.09855	0.036291	0.329888	0.21455
WS4	2013-11-05	*0.007*	2.1464	3.9565	8.097	11.92	5.2057	4.5565	9.4343	0.025084	0.021955	0.004825	0.025116	0.021984
WS4	2013-12-03	*0.022*	5.4417	1.5447	2.406	8.02	4.1568	3.4454	8.1415	0.037691	0.031241	0.016071	0.066803	0.05537

Supplementary information 3: Modelled GPP values of the Oosterschelde including the error

Station	Date	Modelled Gross Primary Production							
		VGPM with P^b_{max}	Error	BPI	Error	BPI*P^b_{max}	Error	BPI*P^b_{opt}	Error
OS1	1996-01-17	0.045619	0.000656	0.127702	0.0116	0.087246	0.00452198	0.12143747	0.01029
OS1	1996-02-05	0.070748	0.000218	0.151384	0.009098	0.103447	0.00225124	0.12444244	0.004684
OS1	1996-02-05	0.070748	0.000218	0.151384	0.009098	0.103447	0.00225124	0.12448282	0.00469
OS1	1996-02-20	0.067973	0.000675	0.142788	0.010158	0.093752	0.00267827	0.12403636	0.00673
OS1	1996-02-28	0.065549	0.000933	0.132315	0.00947	0.091178	0.00315602	0.12199057	0.007567
OS1	1996-02-28	0.065549	0.000933	0.132315	0.00947	0.091178	0.00315602	0.12206017	0.007579
OS1	1996-03-18	0.307507	0.003423	0.232845	0.000261	0.169054	0.00639131	0.1654096	0.006987
OS1	1996-03-18	0.307507	0.003423	0.232845	0.000261	0.169054	0.00639131	0.16519014	0.007024
OS1	1996-04-01	0.902051	0.281907	1.340813	0.008498	1.068811	0.13263389	0.74032378	0.4798
OS1	1996-04-01	0.902051	0.281907	1.340813	0.008498	1.068811	0.13263389	0.73913005	0.481456
OS1	1996-04-15	1.034776	0.226789	2.163919	0.426303	1.231963	0.07786172	1.31295546	0.039222
OS1	1996-04-15	1.034776	0.226789	2.163919	0.426303	1.231963	0.07786172	1.31537258	0.03827
OS1	1996-05-01	1.330255	0.164629	1.031172	0.496783	0.852211	0.78108258	0.80710476	0.862846
OS1	1996-05-01	1.330255	0.164629	1.031172	0.496783	0.852211	0.78108258	0.80710476	0.862846
OS1	1996-05-14	1.121926	0.006253	0.696269	0.254753	0.673082	0.27869713	0.54831779	0.425994
OS1	1996-05-14	1.121926	0.006253	0.696269	0.254753	0.673082	0.27869713	0.5498644	0.423978
OS1	1996-06-10	4.904802	0.880215	4.289282	2.414038	5.399933	0.19630822	4.82344065	1.039501
OS1	1996-06-10	4.904802	0.880215	4.289282	2.414038	5.399933	0.19630822	4.80469865	1.07807
OS1	1996-07-01	0.5302	0.012814	0.353919	0.003979	0.421164	1.7336E-05	0.38786279	0.000849
OS1	1996-07-01	0.5302	0.012814	0.353919	0.003979	0.421164	1.7336E-05	0.3877138	0.000858
OS1	1996-07-15	1.599704	0.015449	1.092225	0.399139	2.172476	0.20113044	1.31738028	0.16534
OS1	1996-07-15	1.599704	0.015449	1.092225	0.399139	2.172476	0.20113044	1.31451996	0.167674
OS1	1996-08-12	0.541097	0.044141	0.245427	0.007323	0.348459	0.00030481	0.2811334	0.002487
OS1	1996-08-12	0.541097	0.044141	0.245427	0.007323	0.348459	0.00030481	0.28123471	0.002477
OS1	1996-09-09	1.254566	0.002557	0.776591	0.182679	1.204434	1.8856E-07	0.9393099	0.070061
OS1	1996-09-09	1.254566	0.002557	0.776591	0.182679	1.204434	1.8856E-07	0.93861077	0.070431
OS1	1996-09-23	0.546698	0.023012	0.276797	0.013972	0.35943	0.00126524	0.28721996	0.011617
OS1	1996-09-23	0.546698	0.023012	0.276797	0.013972	0.35943	0.00126524	0.28721996	0.011617
OS1	1996-10-10	0.217603	0.00208	0.188734	0.00028	0.203695	0.00100456	0.19287617	0.000436
OS1	1996-10-10	0.217603	0.00208	0.188734	0.00028	0.203695	0.00100456	0.19287617	0.000436
OS1	1996-11-13	0.085772	0.000771	0.132391	0.005534	0.107848	0.00248485	0.12915797	0.005063
OS1	1996-11-13	0.085772	0.000771	0.132391	0.005534	0.107848	0.00248485	0.12910567	0.005056
OS1	1996-11-28	0.056972	0.000675	0.127923	0.009394	0.094103	0.003982	0.12351847	0.00856
OS1	1996-11-28	0.056972	0.000675	0.127923	0.009394	0.094103	0.003982	0.12345573	0.008548
OS1	1996-12-11	0.033267	0.000916	0.115664	0.012693	0.081857	0.00621835	0.11572337	0.012707
OS1	1996-12-11	0.033267	0.000916	0.115664	0.012693	0.081857	0.00621835	0.11572459	0.012707
OS1	1998-02-09	0.050282	0.000299	0.131301	0.009663	0.095201	0.0038689	0.12388663	0.00826
OS1	1998-08-18	1.162463	0.000461	0.695691	0.1983	1.196665	0.00309859	0.85812913	0.080016
OS1	1998-09-07	0.438885	0.007901	0.269362	0.006502	0.33641	0.0001847	0.30787962	0.001774
OS1	1998-09-21	0.221279	5.96E-05	0.237668	7.51E-05	0.252145	0.00053567	0.25641858	0.000752
OS1	1998-10-20	0.084572	0.000345	0.139644	0.005423	0.111687	0.00208731	0.13793623	0.005175
OS1	1998-11-24	0.045094	0.000681	0.121479	0.010502	0.086725	0.00458663	0.11927737	0.010056
OS1	1998-12-21	0.037481	0.000701	0.12046	0.011981	0.084098	0.00534328	0.11845388	0.011546
OS1	2000-04-05	0.267884	0.004884	0.264401	0.004409	0.200942	8.6527E-06	0.21489052	0.000285
OS1	2000-04-17	0.300043	0.000359	0.42425	0.011077	0.310216	7.7155E-05	0.3287093	9.43E-05
OS1	2000-05-24	4.772197	0.709296	2.857841	1.149524	3.562776	0.13485316	3.02642254	0.816452
OS1	2000-06-13	0.812151	0.001214	0.675335	0.029469	0.897861	0.0025868	0.7744745	0.00526
OS1	2000-08-14	1.312611	0.016799	0.761511	0.177653	1.221379	0.00147297	0.94045623	0.058827
OS1	2000-09-07	0.470025	0.00903	0.342381	0.001064	0.376445	2.0888E-06	0.39820086	0.000538
OS1	2000-10-09	0.160036	0.000786	0.191795	0.003575	0.174635	0.00181776	0.20160039	0.004844
OS1	2000-11-16	0.046335	0.001179	0.118309	0.011302	0.086022	0.00547926	0.11773531	0.01118
OS1	2001-01-22	0.038882	0.000834	0.116836	0.011414	0.084152	0.00549853	0.11615664	0.011269
OS1	2005-04-04	1.047582	0.008387	1.170399	0.045967	0.840713	0.0132912	0.81153901	0.020869
OS1	2005-05-02	1.263391	0.011966	1.142721	0.000127	0.788056	0.13391486	0.98418532	0.028837
OS1	2005-05-17	1.174649	0.060197	3.277228	3.449296	1.182476	0.05641774	2.87050762	2.103972
OS1	2005-06-20	0.669907	0.001018	1.037714	0.159771	0.929336	0.08487683	1.23181487	0.352616
OS1	2005-07-18	3.417014	1.646125	1.695532	0.192255	2.733516	0.35942003	2.13353143	2.2E-07
OS1	2005-09-12	0.151366	0.003524	0.174952	0.006881	0.156887	0.00421027	0.19223948	0.010048
OS1	2005-10-10	0.235498	0.002256	0.283231	0.009069	0.26806	0.00640962	0.30864872	0.014556
OS1	2005-11-14	0.058104	0.000681	0.135271	0.010665	0.098681	0.00444642	0.13379262	0.010362
OS1	2005-12-14	0.044421	0.000646	0.129168	0.012137	0.088922	0.00488902	0.12410094	0.011046
OS1	2006-02-06	0.049878	0.001148	0.123703	0.0116	0.087182	0.0050669	0.11930168	0.010671

Station	Date	Modelled Gross Primary Production							
		VGPM with P^b_{max}	Error	BPI	Error	BPI*P^b_{max}	Error	BPI*P^b_{opt}	Error
OS1	2006-03-13	0.306056	0.00337	0.679186	0.185922	0.359544	0.01244204	0.38467481	0.01868
OS1	2006-04-10	0.534448	0.005542	0.760899	0.09054	0.60502	0.02103094	0.53394155	0.005467
OS1	2006-04-24	0.436581	0.001488	1.123295	0.526053	0.572327	0.03039007	0.85288887	0.206924
OS1	2006-05-08	0.813243	0.034686	1.897929	1.61526	0.807674	0.03264322	1.65636246	1.059587
OS1	2006-05-22	2.784721	0.437875	3.736214	2.60246	2.236697	0.01292709	3.81000986	2.846002
OS1	2006-06-06	0.536473	0.000507	0.741016	0.03313	0.73668	0.03157024	0.75012347	0.036528
OS1	2006-08-14	0.426163	0.115032	0.198247	0.012376	0.179404	0.00853851	0.2219961	0.018224
OS1	2006-09-25	0.317732	0.031589	0.246335	0.011307	0.235894	0.00919566	0.28290325	0.020421
OS1	2006-11-13	0.05285	0.001836	0.122905	0.012748	0.087388	0.00598898	0.12228638	0.012608
OS1	2006-12-11	0.031611	0.000937	0.115642	0.013143	0.081476	0.00647646	0.11582322	0.013184
OS1	2010-06-09	1.538052	0.283079	0.983315	0.000515	0.90803	0.00959818	1.0846964	0.006193
OS1	2010-06-23	2.261547	0.29752	1.727886	1.164488	3.099349	0.08546797	1.94455785	0.743806
OS1	2010-07-14	0.601935	0.027867	0.401811	0.001101	0.5923	0.02474328	0.48089055	0.002106
OS1	2010-07-28	1.364712	0.007519	1.000645	0.076926	1.533181	0.06511756	1.24360298	0.001183
OS1	2010-08-25	0.732877	0.011854	0.489553	0.018076	0.696342	0.00523339	0.59311009	0.000954
OS1	2010-09-08	0.678538	0.127119	0.316799	2.7E-05	0.313239	7.6757E-05	0.36341295	0.001715
OS1	2010-09-22	0.955852	0.088716	0.517638	0.019701	1.003403	0.1193033	0.59104391	0.004483
OS1	2010-10-13	0.358637	0.01033	0.25416	8.06E-06	0.220186	0.00135526	0.26827384	0.000127
OS1	2010-11-18	0.047532	0.000994	0.122913	0.01143	0.087303	0.00508406	0.12117833	0.011062
OS1	2010-12-15	0.054008	0.001765	0.132211	0.014451	0.090588	0.00617606	0.1241427	0.012576
OS1	2011-01-12	0.03396	0.000839	0.11705	0.012555	0.082118	0.00594716	0.1162661	0.01238
OS1	2011-02-09	0.100557	0.007492	0.194244	0.032488	0.112774	0.00975622	0.15820003	0.020794
OS1	2011-03-02	0.116812	0.001833	0.229995	0.024334	0.151907	0.00606956	0.17667982	0.010543
OS1	2011-03-16	0.05979	0.012817	0.147273	0.000662	0.104357	0.00471181	0.13425609	0.001501
OS1	2011-04-06	0.759838	0.123314	1.108415	6.68E-06	0.932611	0.03182266	0.81495997	0.08764
OS1	2011-04-20	0.311153	3.60942	0.583137	2.649939	0.408327	3.24963039	0.51301279	2.883161
OS1	2011-05-11	0.505002	0.021024	0.732844	0.006863	0.592326	0.00332633	0.74402864	0.008841
OS1	2011-05-25	0.433568	0.003532	0.646672	0.023615	0.636262	0.02052413	0.70338456	0.044262
OS1	2011-06-08	0.610394	0.001198	0.431046	0.045776	0.624289	0.00042895	0.49251723	0.023251
OS1	2011-06-22	0.63398	0.037241	0.349337	0.008402	0.438128	8.2511E-06	0.39242054	0.00236
OS1	2011-07-06	1.279594	0.006791	1.474778	0.012719	1.410541	0.00235618	1.83688817	0.225519
OS1	2011-07-20	0.416746	0.035625	0.334155	0.011269	0.335865	0.01163484	0.38624304	0.025041
OS1	2011-08-18	0.681135	0.131867	0.361414	0.001885	0.468316	0.02259493	0.42762602	0.012018
OS1	2011-08-31	0.062144	0.017651	0.131898	0.003982	0.097954	0.00941792	0.1365114	0.003421
OS1	2011-09-14	0.360031	0.00012	0.394649	0.000559	0.442721	0.00514393	0.45154111	0.006487
OS1	2011-09-28	0.541459	0.011981	0.508079	0.005788	0.578722	0.02152735	0.58562131	0.0236
OS1	2011-10-12	0.11624	0.005661	0.139286	0.00966	0.10606	0.00423275	0.14304976	0.010414
OS1	2011-11-23	0.037231	5.23E-05	0.117865	0.00772	0.083718	0.00288565	0.11755379	0.007666
OS1	2011-12-14	0.031472	0.000419	0.115957	0.011016	0.081578	0.00498131	0.11593455	0.011011
OS1	2012-01-18	0.038988	0.00084	0.117704	0.0116	0.083701	0.00543188	0.11701703	0.011453
OS1	2012-03-21	0.478802	0.021374	0.471415	0.023588	0.494077	0.01714073	0.33322835	0.085131
OS1	2012-04-05	0.155433	0.001477	0.451087	0.111614	0.13776	0.00043099	0.3476826	0.053214
OS1	2012-04-18	0.4065	0.00011	0.712553	0.087352	0.350623	0.00440585	0.53033076	0.012844
OS1	2012-05-09	0.463195	0.021081	0.561253	0.059172	0.353795	0.00128126	0.47633172	0.025069
OS1	2012-05-23	0.821914	0.003259	0.780973	0.009609	0.991094	0.0125651	0.76760775	0.012408
OS1	2012-06-20	1.052079	0.001151	1.522528	0.190557	1.304518	0.04775017	1.78160066	0.48386
OS1	2012-07-04	0.983376	0.002245	1.414979	0.229421	1.050262	0.01305584	1.74281479	0.65095
OS1	2012-08-08	0.488928	0.049697	0.291601	0.000655	0.290869	0.00061845	0.34080995	0.005597
OS1	2012-08-29	1.154318	0.272152	0.769965	0.8209	1.291611	0.14775504	0.95344901	0.52208
OS1	2012-09-12	0.555041	0.005482	0.537703	0.003215	0.535911	0.00301518	0.65471862	0.030178
OS1	2012-09-26	0.23924	5.02E-06	0.265534	0.000814	0.243957	4.8401E-05	0.28617353	0.002418
OS1	2012-10-24	0.147256	0.009459	0.289229	0.05723	0.128381	0.00614362	0.28759198	0.05645
OS1	2012-11-14	0.086803	0.001211	0.156309	0.01088	0.116769	0.00419509	0.14591442	0.00882
OS1	2012-12-12	0.032627	0.000385	0.117332	0.010885	0.082498	0.00482995	0.11667058	0.010748
OS1	2013-01-16	0.050541	0.000933	0.133886	0.01297	0.09221	0.00521432	0.12569913	0.011172
OS2	2010-04-28	0.887546	0.199321	1.767174	0.18764	1.073572	0.06782255	1.49771838	0.026804
OS2	2010-05-19	0.80854	0.028717	0.956261	0.000473	1.097914	0.0143793	0.84546413	0.017566
OS2	2010-06-09	2.015541	0.621797	0.796902	0.184985	1.169964	0.00325309	0.89188695	0.112301
OS2	2010-06-23	2.174636	0.058257	1.683775	0.536153	2.982371	0.32077657	1.93937153	0.227175
OS2	2010-07-14	1.218721	0.322308	0.619565	0.000988	1.143134	0.24219572	0.75206929	0.010215
OS2	2010-07-28	1.841329	0.041343	0.969239	0.447242	2.051724	0.17116769	1.1931663	0.197877
OS2	2010-08-25	0.854687	0.021811	0.47044	0.055961	0.802926	0.0092018	0.56985306	0.018809
OS2	2010-09-08	0.57522	0.091942	0.279748	6E-05	0.276284	1.8353E-05	0.31818243	0.002133
OS2	2010-09-22	0.357696	0.002992	0.395245	0.008509	0.40798	0.01102073	0.4458859	0.020416
OS2	2010-10-13	0.434434	0.02837	0.261962	1.63E-05	0.252215	0.00019002	0.27663922	0.000113
OS2	2010-11-18	0.054478	0.001331	0.126479	0.011768	0.089718	0.00514346	0.12380821	0.011195

Station	*Date*	*Modelled Gross Primary Production*							
		VGPM with P^b_{max}	*Error*	*BPI*	*Error*	*BPI*P^b_{max}*	*Error*	*BPI*P^b_{opt}*	*Error*
OS2	2010-12-15	0.035817	0.000393	0.119119	0.010634	0.083503	0.00455662	0.11732319	0.010266
OS2	2011-01-12	0.035806	0.000888	0.118503	0.012657	0.082584	0.00586512	0.11686008	0.01229
OS2	2011-02-09	0.0358	7.74E-05	0.120732	0.008786	0.083876	0.00323493	0.11837584	0.00835
OS2	2011-03-02	0.074746	0.000115	0.180096	0.013478	0.117843	0.00289902	0.14957374	0.007323
OS2	2011-03-16	0.226162	0.005064	0.335867	0.032713	0.231609	0.00586891	0.24355468	0.007842
OS2	2011-04-06	0.479719	0.012833	0.730262	0.018841	0.606138	0.0001726	0.55336672	0.001571
OS2	2011-04-20	1.962297	0.000137	3.439471	2.147605	2.325416	0.12349298	3.00936408	1.071979
OS2	2011-05-11	0.759228	4.59E-05	1.082626	0.100252	0.865645	0.00992911	1.11852479	0.124274
OS2	2011-05-25	0.477278	0.001316	0.801493	0.129955	0.696381	0.06521939	0.88359146	0.195887
OS2	2011-06-08	0.481743	0.002575	0.47332	0.001791	0.504098	0.00534333	0.54677448	0.013404
OS2	2011-06-22	0.602793	0.016331	0.374551	0.01009	0.419771	0.00305024	0.42445064	0.002555
OS2	2011-07-06	2.137083	0.0943	1.606913	0.049768	2.322713	0.24276614	2.008913	0.03201
OS2	2011-07-20	0.360194	1.02E-05	0.283479	0.005405	0.298702	0.00339868	0.32486733	0.001033
OS2	2011-08-18	0.305982	0.015371	0.23416	0.002721	0.245422	0.00402231	0.26658668	0.007155
OS2	2011-08-31	0.455453	0.067836	0.335266	0.019674	0.301118	0.01126094	0.39079849	0.038337
OS2	2011-09-14	0.294224	0.003111	0.330073	0.000397	0.370777	0.00043169	0.3761605	0.000684
OS2	2011-09-28	0.419137	0.000569	0.444212	1.47E-06	0.459862	0.00028434	0.50804766	0.004231
OS2	2011-10-12	0.107599	0.005126	0.139138	0.010637	0.103562	0.00456468	0.1429597	0.01144
OS2	2011-11-23	0.049471	0.000156	0.123798	0.007534	0.087976	0.00259857	0.12192222	0.007212
OS2	2011-12-14	0.035402	0.000502	0.117216	0.010861	0.08272	0.00486083	0.1167169	0.010757
OS2	2012-01-18	0.037438	0.000647	0.14197	0.016892	0.08326	0.00507795	0.13208049	0.014419
OS2	2012-03-21	0.674892	0.013714	1.019274	0.051653	0.674254	0.01386415	0.66780613	0.015424
OS2	2012-04-05	0.164681	0.001273	0.28021	0.022864	0.141927	0.00016711	0.23148329	0.010503
OS2	2012-04-18	0.290705	0.00552	0.472693	0.011598	0.267877	0.00943282	0.36575418	5.69E-07
OS2	2012-05-09	0.347509	0.002451	0.388832	0.008251	0.281091	0.0002859	0.33976105	0.001744
OS2	2012-05-23	0.196865	0.762365	0.246174	0.678689	0.273517	0.63438439	0.24591277	0.67912
OS2	2012-06-20	1.065448	0.543983	1.744753	0.003393	1.320738	0.23257657	2.04728956	0.059677
OS2	2012-07-04	1.021063	0.003488	1.303186	0.116408	1.088725	0.0160591	1.60654094	0.415433
OS2	2012-08-08	0.325637	0.014075	0.237792	0.000948	0.216318	8.6825E-05	0.27245903	0.004285
OS2	2012-08-29	0.135818	1.570465	0.167187	1.492827	0.195717	1.42392537	0.18232706	1.45606
OS2	2012-09-12	0.792284	3.27E-05	0.443143	0.125923	0.74119	0.00322737	0.53419636	0.069592
OS2	2012-09-26	0.306876	0.00032	0.310895	0.000479	0.296443	5.5398E-05	0.34003485	0.002605
OS2	2012-10-24	0.079006	0.000676	0.134748	0.006683	0.100945	0.00229875	0.13464132	0.006665
OS2	2012-11-14	0.07898	0.000528	0.147866	0.008439	0.111898	0.00312457	0.13950233	0.006973
OS2	2012-12-12	0.035931	0.000254	0.119271	0.009855	0.084006	0.00409676	0.11774809	0.009555
OS2	2013-01-16	0.037762	0.000391	0.122209	0.01086	0.08546	0.0045508	0.11920305	0.010242

Supplementary information 4: Modelled GPP values of the Westerschelde including the error

Station	Date	Modelled Gross Primary Production (gC/m²/day)							
		VGPM with P^b_{max}	Error	BPI	Error	$BPI*P^b_{max}$	Error	$BPI*P^b_{opt}$	Error
WS1	2009-01-13	0.02112	0.00029	0.06412	0.00361	0.04381	0.00158	0.07428	0.00494
WS1	2009-02-10	0.022	0.00029	0.06431	0.00352	0.04417	0.00153	0.07441	0.00482
WS1	2009-03-03	0.1054	0.00206	0.114	0.00292	0.08074	0.00043	0.09984	0.00159
WS1	2009-03-24	1.8964	0.02179	2.2355	0.03667	1.80471	0.05726	1.35844	0.46999
WS1	2009-04-07	2.50649	0.60293	1.70622	0.00057	1.31901	0.16891	1.16898	0.31474
WS1	2009-04-21	0.85939	0.02612	0.7917	0.05258	1.10056	0.00633	0.65332	0.13519
WS1	2009-05-06	1.16051	0.01405	0.85844	0.03369	0.94396	0.00961	0.79268	0.06216
WS1	2009-05-26	0.70965	0.13664	0.37144	0.00099	0.36217	0.00049	0.41056	0.00498
WS1	2009-06-23	1.65432	0.01315	2.06485	0.08753	2.33084	0.31567	2.46048	0.47815
WS1	2009-07-07	1.43057	0.49782	0.50763	0.04725	0.72524	5.7E-08	0.61788	0.01147
WS1	2009-08-25	0.43458	0.03709	0.19424	0.00228	0.28014	0.00145	0.23506	4.8E-05
WS1	2009-09-22	0.14581	0.00101	0.15431	0.00163	0.17693	0.00396	0.18343	0.00482
WS1	2009-10-13	0.14811	0.00073	0.15332	0.00104	0.13424	0.00018	0.17108	0.00251
WS1	2009-11-17	0.05336	0.0008	0.0743	0.00243	0.05642	0.00099	0.08368	0.00344
WS1	2009-12-08	0.0235	0.00027	0.06368	0.00321	0.04538	0.00147	0.07505	0.00463
WS1	2010-01-12	0.01895	0.00025	0.06291	0.00359	0.04337	0.00163	0.07342	0.00496
WS1	2010-02-16	0.04081	0.00022	0.08944	0.00402	0.05822	0.00104	0.0835	0.00331
WS1	2010-03-16	0.15901	4E-06	0.27877	0.01387	0.14551	0.00024	0.17959	0.00035
WS1	2010-04-07	0.55109	6.5E-05	0.71269	0.02879	0.51886	0.00058	0.48128	0.00381
WS1	2010-04-27	0.65674	0.05535	2.39703	2.26512	0.79579	0.00926	1.85143	0.92051
WS1	2010-05-18	0.78945	0.09215	0.9957	0.00947	1.06105	0.00102	0.83531	0.0664
WS1	2010-06-08	0.96371	0.00013	1.49169	0.26697	0.87282	0.01044	1.5925	0.38131
WS1	2010-07-13	2.03823	0.24823	0.89303	0.41857	1.77849	0.05688	1.07877	0.21273
WS1	2010-07-27	2.52302	0.20614	1.39672	0.45197	1.65557	0.17092	1.69507	0.13983
WS1	2010-08-24	0.78524	0.00407	0.64948	0.03981	0.93413	0.00725	0.79108	0.00335
WS1	2010-09-07	0.13292	0.0004	0.14415	0.00097	0.13015	0.00029	0.17174	0.00345
WS1	2010-09-21	0.51893	0.00489	0.32195	0.01614	0.38954	0.00354	0.36884	0.00643
WS1	2010-12-14	0.02429	0.0002	0.06509	0.00303	0.04496	0.00122	0.07513	0.00424
WS1	2011-01-11	0.02103	0.00026	0.06323	0.00339	0.04364	0.00149	0.07409	0.00477
WS1	2011-02-08	0.03151	5.6E-05	0.08368	0.00356	0.05422	0.00091	0.08485	0.0037
WS1	2011-03-01	0.06084	0.00043	0.08641	0.00215	0.06168	0.00047	0.08656	0.00217
WS1	2011-03-15	0.06468	2.2E-05	0.11245	0.00275	0.07926	0.00037	0.10204	0.00177
WS1	2011-04-05	0.1843	0.00064	0.13711	0.00048	0.10655	0.00275	0.12494	0.00116
WS1	2011-04-19	0.73627	0.16219	0.68578	0.2054	0.95191	0.035	0.58022	0.31223
WS1	2011-05-10	0.33073	0.00074	0.40086	0.00184	0.3864	0.00081	0.40531	0.00224
WS1	2011-05-24	0.71108	0.05286	0.84606	0.00901	0.94661	3.1E-05	0.90784	0.0011
WS1	2011-06-07	0.24239	0.00086	0.2398	0.00072	0.21374	5.5E-07	0.27804	0.00423
WS1	2011-06-21	0.26359	0.00021	0.24262	4.1E-05	0.26059	0.00013	0.27814	0.00085
WS1	2011-07-05	3.55837	0.65712	3.97114	0.15829	4.67757	0.09522	4.78389	0.17214
WS1	2011-07-19	0.20128	0.00013	0.16343	0.00071	0.22283	0.00108	0.19471	2.2E-05
WS1	2011-08-17	0.10636	0.00024	0.126	0.00122	0.12953	0.00148	0.15225	0.00375
WS1	2011-08-30	0.15529	0.00317	0.12503	0.00068	0.12263	0.00056	0.15023	0.00262
WS1	2011-09-13	0.0636	0.00016	0.10045	0.00245	0.08489	0.00115	0.11945	0.00469
WS1	2011-09-27	0.25586	0.00083	0.21536	0.00014	0.22174	2.8E-05	0.25008	0.00053
WS1	2011-10-11	0.05514	0.00085	0.07612	0.00251	0.05762	0.001	0.09017	0.00412
WS1	2011-12-13	0.02029	0.0002	0.06277	0.00322	0.04388	0.00144	0.0743	0.00467
WS1	2012-01-17	0.03162	0.00014	0.0707	0.00257	0.05083	0.00095	0.07872	0.00345
WS1	2012-02-07	0.02263	0.00014	0.06947	0.00342	0.04694	0.00129	0.0764	0.00428
WS1	2012-03-20	0.17729	0.00257	0.25115	0.00054	0.18628	0.00174	0.184	0.00194
WS1	2012-04-03	0.05648	2.7E-07	0.12755	0.00498	0.07539	0.00034	0.11672	0.00357
WS1	2012-04-17	0.62822	9.6E-05	0.29456	0.11795	0.32639	0.0971	0.23045	0.1661
WS1	2012-05-08	0.13282	0.00025	0.14253	0.00065	0.11292	1.7E-05	0.13734	0.00041
WS1	2012-05-22	0.71367	0.06417	0.8584	0.01179	0.91665	0.00253	0.80722	0.02553
WS1	2012-06-19	0.24356	0.00244	0.36059	0.00457	0.29595	8.7E-06	0.41615	0.01517
WS1	2012-07-03	0.18704	6.5E-05	0.21014	0.00097	0.16932	9.4E-05	0.25227	0.00537
WS1	2012-08-07	0.21295	0.00044	0.20737	0.00071	0.23727	1.1E-05	0.25202	0.00032
WS1	2012-08-28	0.25506	0.00029	0.2466	0.00065	0.27241	1.7E-07	0.30009	0.00079
WS1	2012-09-11	0.76865	0.001	0.58537	0.02299	0.55547	0.03295	0.71299	0.00058
WS1	2012-09-25	0.15857	0.00046	0.15686	0.00054	0.17633	1.3E-05	0.17921	6.2E-07
WS1	2012-12-11	0.02622	8.5E-05	0.07068	0.00288	0.04781	0.00095	0.0786	0.00379
WS1	2013-01-15	0.02026	0.0002	0.06422	0.00339	0.0438	0.00143	0.07494	0.00475
WS1	2013-02-05	0.0267	9.4E-05	0.07418	0.00327	0.04749	0.00093	0.07945	0.0039
WS1	2013-03-05	0.04397	6.6E-10	0.11696	0.00532	0.06482	0.00043	0.09783	0.0029
WS1	2013-03-26	0.10225	0.00135	0.22684	0.00772	0.12773	0.00013	0.14251	1.2E-05

Station	Date	Modelled Gross Primary Production (gC/m²/day)							
		VGPM with P^b_{max}	Error	BPI	Error	$BPI*P^b_{max}$	Error	$BPI*P^b_{opt}$	Error
WS1	2013-04-09	0.11557	2E-06	0.15523	0.00146	0.09272	0.00059	0.11874	3E-06
WS1	2013-05-07	0.36334	0.00405	0.97918	0.3049	0.35542	0.00512	0.78159	0.12574
WS1	2013-05-22	0.32492	3.5E-05	0.31133	5.9E-05	0.27488	0.00195	0.27288	0.00213
WS1	2013-06-04	0.3782	0.03161	0.57012	0.0002	0.44667	0.01195	0.51099	0.00203
WS1	2013-06-18	0.15507	0.00019	0.28641	0.01378	0.1866	0.00031	0.30465	0.0184
WS1	2013-07-02	0.21882	0.00058	0.20499	0.00144	0.22949	0.00018	0.23514	6.2E-05
WS1	2013-07-16	2.81641	0.03407	2.22135	0.60786	3.11249	0.01243	2.67449	0.10661
WS1	2013-08-06	1.52898	0.07729	0.88269	0.85435	1.64997	0.02466	1.05955	0.55867
WS1	2013-09-03	0.95588	0.1057	1.16986	0.01235	1.13455	0.02145	1.42706	0.02133
WS1	2013-09-17	0.49678	0.02067	0.23018	0.01508	0.26759	0.00729	0.26956	0.00696
WS1	2013-10-08	0.07386	0.00012	0.08649	0.00055	0.07499	0.00014	0.10115	0.00146
WS1	2013-11-05	0.05227	0.00064	0.07117	0.00195	0.05173	0.00061	0.08196	0.00302
WS1	2013-12-03	0.05221	3.9E-05	0.07837	0.00105	0.05903	0.00017	0.08446	0.00148
WS4	2009-01-13	0.01887	0.00028	0.06234	0.00364	0.04318	0.0017	0.07354	0.00512
WS4	2009-02-10	0.02525	0.00037	0.0665	0.00366	0.04514	0.00153	0.07529	0.0048
WS4	2009-03-03	0.0548	0.00077	0.06944	0.0018	0.05906	0.00103	0.07741	0.00254
WS4	2009-03-24	1.18872	0.00597	1.23579	0.00091	1.14166	0.01546	0.7826	0.23367
WS4	2009-04-07	2.62803	0.96046	1.35292	0.08707	1.38161	0.07096	0.96336	0.46874
WS4	2009-04-21	0.89381	0.00242	0.92509	0.00032	1.14412	0.04045	0.79899	0.02074
WS4	2009-05-06	0.69536	0.00763	0.52684	0.00659	0.57791	0.00091	0.51544	0.00857
WS4	2009-05-26	0.20276	0.01205	0.16089	0.00461	0.12859	0.00127	0.18437	0.00835
WS4	2009-06-23	0.84672	0.00597	1.15427	0.05303	1.20385	0.07832	1.37905	0.20707
WS4	2009-07-07	0.31497	0.02402	0.15105	8E-05	0.18687	0.00072	0.18233	0.0005
WS4	2009-08-25	0.1963	0.01006	0.12783	0.00101	0.1449	0.00239	0.15428	0.0034
WS4	2009-09-22	0.19187	0.00143	0.17752	0.00055	0.22454	0.00498	0.2113	0.00328
WS4	2009-10-13	0.13371	0.0015	0.13227	0.00139	0.12423	0.00085	0.1489	0.00291
WS4	2009-11-17	0.04019	0.00059	0.0716	0.00309	0.05147	0.00126	0.08152	0.00429
WS4	2009-12-08	0.02748	0.00038	0.06807	0.00361	0.04694	0.00152	0.07795	0.00489
WS4	2010-01-12	0.02357	0.00034	0.06524	0.00363	0.04489	0.00159	0.07456	0.00484
WS4	2010-02-16	0.0493	0.0003	0.10183	0.00488	0.06358	0.001	0.08759	0.00309
WS4	2010-03-16	0.11243	0.00018	0.15988	0.00371	0.11199	0.00017	0.12138	0.0005
WS4	2010-04-07	0.47523	0.00049	0.53654	0.00698	0.45145	2.4E-06	0.37458	0.00615
WS4	2010-04-27	2.16631	0.57713	3.44311	0.2674	2.57083	0.12615	2.76984	0.02439
WS4	2010-05-18	0.6769	0.05574	0.79599	0.01369	0.9134	1.6E-07	0.68492	0.05202
WS4	2010-06-08	1.22967	0.03228	0.95031	0.00994	1.10653	0.0032	1.06517	0.00023
WS4	2010-06-22	0.60444	0.01011	0.76141	0.00318	0.84265	0.01895	0.86443	0.02542
WS4	2010-07-13	0.63677	0.01364	0.41275	0.0115	0.57587	0.00312	0.49147	0.00081
WS4	2010-07-27	0.52852	0.01221	0.31652	0.0103	0.37249	0.00207	0.38218	0.00128
WS4	2010-08-24	0.43165	0.00389	0.34425	0.02243	0.52459	0.00094	0.41934	0.00557
WS4	2010-09-07	0.09661	0.00024	0.1043	0.00054	0.10298	0.00048	0.12503	0.00194
WS4	2010-09-21	0.32427	0.00351	0.22178	0.00187	0.25526	9.5E-05	0.25583	8.4E-05
WS4	2010-12-14	0.02396	0.00025	0.06439	0.00318	0.04485	0.00136	0.07473	0.00445
WS4	2011-01-11	0.02278	0.00032	0.06407	0.00349	0.04408	0.00153	0.07442	0.00482
WS4	2011-02-08	0.03834	5.4E-05	0.09261	0.0038	0.05932	0.0008	0.08954	0.00343
WS4	2011-03-01	0.05997	0.00057	0.08992	0.00291	0.0613	0.00064	0.08875	0.00278
WS4	2011-03-15	0.10574	1.4E-05	0.15035	0.00234	0.11018	6.7E-05	0.12356	0.00047
WS4	2011-04-05	0.13731	0.00139	0.11371	0.00019	0.08866	0.00013	0.11009	0.0001
WS4	2011-04-19	0.74892	0.08531	0.97598	0.00423	0.96819	0.0053	0.83714	0.04156
WS4	2011-05-10	0.61026	3E-06	0.5817	0.00092	0.69191	0.00639	0.60952	6.2E-06
WS4	2011-05-24	0.31346	0.00913	0.34013	0.00474	0.42986	0.00044	0.37848	0.00093
WS4	2011-06-07	0.61729	0.01329	0.38423	0.01387	0.49744	2.1E-05	0.44885	0.00283
WS4	2011-06-21	0.34494	0.00115	0.28386	0.00074	0.33241	0.00046	0.32776	0.00028
WS4	2011-07-05	0.20163	0.00064	0.26289	0.00129	0.28593	0.00347	0.31738	0.00817
WS4	2011-07-19	0.68135	0.00111	0.53164	0.01354	0.6899	0.00176	0.63358	0.00021
WS4	2011-08-17	0.42301	0.00073	0.35614	0.00159	0.43391	0.00144	0.43102	0.00123
WS4	2011-08-30	0.07731	0.00086	0.08982	0.00175	0.07779	0.00089	0.10818	0.00362
WS4	2011-09-13	0.23051	9E-05	0.22691	3.5E-05	0.23295	0.00014	0.26781	0.00219
WS4	2011-09-27	0.10786	0.00036	0.12068	0.001	0.11121	0.00049	0.14215	0.00282
WS4	2011-10-11	0.07705	0.00145	0.0868	0.00228	0.06612	0.00074	0.10205	0.00398
WS4	2011-12-13	0.02502	0.00023	0.06596	0.00313	0.04551	0.00126	0.07621	0.00438
WS4	2012-01-17	0.02174	0.00022	0.06577	0.00345	0.04556	0.00149	0.07588	0.00474
WS4	2012-02-07	0.02698	8.1E-05	0.07519	0.00327	0.04981	0.00101	0.07847	0.00366
WS4	2012-03-20	0.11704	0.00053	0.17313	0.0011	0.13264	5.4E-05	0.14088	7.8E-07
WS4	2012-04-03	0.57943	0.01032	0.76249	0.00664	0.49861	0.03327	0.54955	0.01728
WS4	2012-04-17	0.09557	0.00024	0.1188	0.00151	0.07938	3.9E-07	0.11382	0.00114
WS4	2012-05-08	0.43594	0.0024	0.28727	0.00995	0.2957	0.00834	0.25342	0.01784

Station	Date	Modelled Gross Primary Production (gC/m²/day)							
		VGPM with P^b_{max}	Error	BPI	Error	$BPI*P^b_{max}$	Error	$BPI*P^b_{opt}$	Error
WS4	2012-05-22	0.733	0.07507	0.92158	0.0073	0.94141	0.0043	0.89135	0.01338
WS4	2012-06-19	1.25305	0.01144	1.122	0.05665	1.42	0.0036	1.28266	0.00598
WS4	2012-07-03	0.14133	0.00086	0.14177	0.00089	0.13552	0.00055	0.17071	0.00345
WS4	2012-08-07	0.13365	1.9E-05	0.14307	2.6E-05	0.159	0.00044	0.17377	0.00128
WS4	2012-08-28	0.20357	0.00021	0.1863	0.00101	0.22298	2.5E-05	0.22628	6.9E-05
WS4	2012-09-11	0.11293	0.00012	0.11477	0.00016	0.10864	4.4E-05	0.13926	0.00139
WS4	2012-09-25	0.04601	8.1E-05	0.09595	0.00348	0.07083	0.00114	0.11236	0.00568
WS4	2012-12-11	0.01943	0.00018	0.06418	0.00338	0.04428	0.00146	0.07494	0.00475
WS4	2013-01-15	0.02307	0.00026	0.06616	0.0035	0.04471	0.00142	0.07599	0.00476
WS4	2013-02-05	0.0221	0.00017	0.06898	0.0036	0.04533	0.00132	0.07698	0.00462
WS4	2013-03-05	0.03204	6.5E-05	0.08688	0.00395	0.05535	0.00098	0.08425	0.00363
WS4	2013-03-26	0.08134	0.00031	0.18967	0.00822	0.10714	6.6E-05	0.1271	0.00079
WS4	2013-04-09	0.15868	2.8E-05	0.1577	4E-05	0.11448	0.00245	0.11957	0.00197
WS4	2013-05-07	1.23801	1E-04	1.49393	0.06048	1.14352	0.01092	1.20591	0.00177
WS4	2013-05-22	0.39536	0.00024	0.34974	0.00375	0.32803	0.00688	0.31384	0.00944
WS4	2013-06-04	0.26594	0.00398	0.37014	0.00169	0.32168	5.4E-05	0.35368	0.00061
WS4	2013-06-18	0.54012	0.00622	0.63397	0.00022	0.58525	0.00114	0.686	0.00449
WS4	2013-07-02	0.16065	0.00055	0.17033	0.00019	0.17601	6.4E-05	0.19728	0.00018
WS4	2013-07-16	1.38692	0.02996	1.17243	0.15021	1.54649	0.00018	1.427	0.01769
WS4	2013-08-06	0.29559	0.00647	0.29646	0.00633	0.33991	0.0013	0.35224	0.00056
WS4	2013-09-03	0.23711	0.00826	0.45513	0.01616	0.29971	0.0008	0.55468	0.05138
WS4	2013-09-17	0.23917	0.00131	0.15413	0.00239	0.14698	0.00314	0.18309	0.0004
WS4	2013-10-08	0.08688	0.00022	0.09046	0.00034	0.08229	0.00011	0.10562	0.00113
WS4	2013-11-05	0.02732	0.00041	0.06432	0.00329	0.04528	0.00147	0.07616	0.00478
WS4	2013-12-03	0.03325	0.00013	0.07366	0.00267	0.05034	0.0008	0.08127	0.00351

Supplementary information 5: BPI model results of satellite images for all stations in both regions

Station	Image date	Filename	In-situ GPP (gC/m^2/ day)	Modelled GPP (gC/m^2/day)		
				Mean	Range	Standard Deviation
OS1	2005-04-04	MER_FSG_CCL2W_20050404_102913_000001572036_00094_16180_3944.nc.data	0.956	-9.999	-9.999	-9.999
OS1	2005-06-20	MER_FSG_CCL2W_20050620_101003_000001322038_00194_17282_7434.nc.data	0.638	12.6377	19.7841	8.96079
OS1	2005-07-18	MER_FSG_CCL2W_20050718_102445_000003882039_00094_17683_8796.nc.data	2.134	-9.999	-9.999	-9.999
OS1	2005-12-14	MER_FSG_CCL2W_20051214_104735_000004532043_00223_19816_6486.nc.data	0.019	0.301641	0.439063	0.127364
OS1	2006-02-06	MER_FSG_CCL2W_20060206_104827_000004192044_00495_20589_8724.nc.data	0.016	-9.999	-9.999	-9.999
OS1	2006-03-13	MER_FSG_CCL2W_20060313_104906_000002082045_00495_21090_3718.nc.data	0.248	0.686479	0.759232	0.255087
OS1	2006-04-24	MER_FSG_CCL2W_20060424_102919_000002332047_00094_21691_5399.nc.data	0.398	2.87232	0.982769	0.297682
OS1	2006-05-22	MER_FSG_CCL2W_20060522_104841_000002392047_00495_22092_6770.nc.data	2.123	4.6114	0.927718	0.340145
OS1	2006-08-14	MER_FSG_CCL2W_20060814_101010_000001802050_00194_23294_1294.nc.data	0.087	-9.999	-9.999	-9.999
OS1	2006-11-13	MER_FSG_CCL2W_20061113_104842_000004362052_00495_24597_4777.nc.data	0.01	-9.999	-9.999	-9.999
OS1	2010-06-23	MER_FSG_CCL2W_20100623_102423_000003262090_00323_43463_3821.nc.data	2.807	10.5901	3.28953	1.10106
OS1	2010-07-28	MER_FSG_CCL2W_20100728_102427_000003232091_00323_43964_5558.nc.data	1.278	-9.999	-9.999	-9.999
OS1	2010-08-25	MER_FSG_CCL2W_20100825_104711_000003802092_00223_44365_7013.nc.data	0.624	2.00388	0.00259778	0.00129889
OS1	2010-09-08	MER_FSG_CCL2W_20100908_100538_000002562092_00423_44565_7711.nc.data	0.322	-9.999	-9.999	-9.999
OS1	2010-10-13	MER_FSG_CCL2W_20101013_100730_000002592093_00423_45066_9235.nc.data	0.257	-9.999	-9.999	-9.999
OS1	2010-11-18	MER_FSG_CCL2W_20101118_104459_000004083096_00310_45583_0263.nc.data	0.016	-9.999	-9.999	-9.999
OS1	2010-12-15	MER_FSG_CCL2W_20101215_105506_000004533097_00267_45971_1064.nc.data	0.012	-9.999	-9.999	-9.999
OS1	2011-01-12	MER_FSG_CCL2W_20110112_102838_000004533098_00238_46373_1934.nc.data	0.005	-9.999	-9.999	-9.999
OS1	2011-02-09	MER_FSG_CCL2W_20110209_100018_000004533099_00209_46775_2986.nc.data	0.014	-9.999	-9.999	-9.999
OS1	2011-03-16	MER_FSG_CCL2W_20110316_101753_000002563100_00281_47278_4396.nc.data	0.173	-9.999	-9.999	-9.999
OS1	2011-04-06	MER_FSG_CCL2W_20110406_104928_000002593101_00152_47580_5395.nc.data	1.111	0.722378	1.10611	0.325806
OS1	2011-04-20	MER_FSG_CCL2W_20110420_103650_000002593101_00353_47781_6183.nc.data	2.211	7.75616	4.23523	1.36731
OS1	2011-05-25	MER_FSG_CCL2W_20110525_105523_000001803102_00425_48284_8145.nc.data	0.493	0.718906	0.932056	0.358637
OS1	2011-06-08	MER_FSG_CCL2W_20110608_104217_000001803103_00195_48485_8896.nc.data	0.645	0.879755	0.471559	0.162367
OS1	2011-06-22	MER_FSG_CCL2W_20110622_102737_000002563103_00396_48686_9670.nc.data	0.441	-9.999	-9.999	-9.999
OS1	2011-07-06	MER_FSG_CCL2W_20110706_101434_000002563104_00166_48887_0426.nc.data	1.362	-9.999	-9.999	-9.999
OS1	2011-07-20	MER_FSG_CCL2W_20110720_100247_000001803104_00367_49088_1240.nc.data	0.228	-9.999	-9.999	-9.999
OS1	2011-08-18	MER_FSG_CCL2W_20110818_103953_000001803105_00353_49505_2922.nc.data	0.318	-9.999	-9.999	-9.999
OS1	2011-12-14	MER_FSG_CCL2W_20111214_101335_000001093109_00324_51200_9068.nc.data	0.011	-9.999	-9.999	-9.999
OS1	2012-01-18	MER_FSG_CCL2W_20120118_102951_000002593110_00396_51703_6682.nc.data	0.01	-9.999	-9.999	-9.999
OS2	2010-05-19	MER_FSG_CCL2W_20100519_102430_000003262089_00323_42962_2066.nc.data	0.978	4.8657	3.12505	0.88957
OS2	2010-06-23	MER_FSG_CCL2W_20100623_102423_000003262090_00323_43463_3821.nc.data	2.416	9.28003	3.5805	0.977477
OS2	2010-07-14	MER_FSG_CCL2W_20100714_110623_000003912091_00123_43764_4879.nc.data	0.651	-9.999	-9.999	-9.999
OS2	2010-07-28	MER_FSG_CCL2W_20100728_102427_000003232091_00323_43964_5558.nc.data	1.638	6.2519	2.30615	0.879016
OS2	2010-08-25	MER_FSG_CCL2W_20100825_104711_000003802092_00223_44365_7013.nc.data	0.707	1.80027	1.26102	0.421797
OS2	2010-09-08	MER_FSG_CCL2W_20100908_100538_000002562092_00423_44565_7711.nc.data	0.272	-9.999	-9.999	-9.999
OS2	2010-09-22	MER_FSG_CCL2W_20100922_110655_000002022093_00123_44766_8353.nc.data	0.303	-9.999	-9.999	-9.999
OS2	2010-10-13	MER_FSG_CCL2W_20101013_100730_000002592093_00423_45066_9235.nc.data	0.266	-9.999	-9.999	-9.999
OS2	2010-11-18	MER_FSG_CCL2W_20101118_104459_000004083096_00310_45583_0263.nc.data	0.018	-9.999	-9.999	-9.999
OS2	2010-12-15	MER_FSG_CCL2W_20101215_105506_000004533097_00267_45971_1064.nc.data	0.016	-9.999	-9.999	-9.999
OS2	2011-01-12	MER_FSG_CCL2W_20110112_102838_000004533098_00238_46373_1934.nc.data	0.006	-9.999	-9.999	-9.999
OS2	2011-02-09	MER_FSG_CCL2W_20110209_100018_000004533099_00209_46775_2986.nc.data	0.027	-9.999	-9.999	-9.999
OS2	2011-03-16	MER_FSG_CCL2W_20110316_101753_000002563100_00281_47278_4396.nc.data	0.155	-9.999	-9.999	-9.999
OS2	2011-04-06	MER_FSG_CCL2W_20110406_104928_000002593101_00152_47580_5395.nc.data	0.593	0.103304	0.552721	0.183346
OS2	2011-04-20	MER_FSG_CCL2W_20110420_103650_000002593101_00353_47781_6183.nc.data	1.974	7.56173	5.06962	1.54104
OS2	2011-05-11	MER_FSG_CCL2W_20110511_110657_000001013102_00224_48083_7343.nc.data	0.766	-9.999	-9.999	-9.999
OS2	2011-05-11	MER_FSG_CCL2W_20110511_110837_000001493102_00224_48083_7347.nc.data	0.766	-9.999	-9.999	-9.999
OS2	2011-05-25	MER_FSG_CCL2W_20110525_105523_000001803102_00425_48284_8145.nc.data	0.441	2.89649	2.63815	0.887154
OS2	2011-06-08	MER_FSG_CCL2W_20110608_104217_000001803103_00195_48485_8896.nc.data	0.431	3.08051	1.92701	0.597342
OS2	2011-06-22	MER_FSG_CCL2W_20110622_102737_000002563103_00396_48686_9670.nc.data	0.475	-9.999	-9.999	-9.999
OS2	2011-07-06	MER_FSG_CCL2W_20110706_101434_000002563104_00166_48887_0426.nc.data	1.83	-9.999	-9.999	-9.999
OS2	2011-07-20	MER_FSG_CCL2W_20110720_100247_000001803104_00367_49088_1240.nc.data	0.357	-9.999	-9.999	-9.999
OS2	2011-08-18	MER_FSG_CCL2W_20110818_103953_000001803105_00353_49505_2922.nc.data	0.182	-9.999	-9.999	-9.999
OS2	2011-08-31	MER_FSG_CCL2W_20110831_110212_000002453106_00109_49692_3711.nc.data	0.195	-9.999	-9.999	-9.999
OS2	2011-09-14	MER_FSG_CCL2W_20110914_104856_000002563106_00310_49893_4569.nc.data	0.35	1.70582	4.84099	1.42744
OS2	2011-09-28	MER_FSG_CCL2W_20110928_103629_000002563107_00080_50094_5343.nc.data	0.443	0.858138	1.43505	0.40014
OS2	2011-10-12	MER_FSG_CCL2W_20111012_102341_000002563107_00281_50295_6105.nc.data	0.036	-9.999	-9.999	-9.999
OS2	2011-12-14	MER_FSG_CCL2W_20111214_101335_000001093109_00324_51200_9068.nc.data	0.013	-9.999	-9.999	-9.999
OS2	2012-01-18	MER_FSG_CCL2W_20120118_102951_000002593110_00396_51703_6682.nc.data	0.012	-9.999	-9.999	-9.999
OS2	2012-04-05	MER_FSG_CCL2W_20120405_110938_000002253113_00224_52824_0811.nc.data	0.129	-9.999	-9.999	-9.999
WS1	2009-01-13	MER_FSG_CCL2W_20090113_105813_000002022075_00309_35934_0444.nc.data	0.004	-9.999	-9.999	-9.999
WS1	2009-03-03	MER_FSG_CCL2W_20090303_101858_000001602077_00008_36635_2533.nc.data	0.06	-9.999	-9.999	-9.999
WS1	2009-03-24	MER_FSG_CCL2W_20090324_105834_000004252077_00309_36936_3548.nc.data	2.044	-9.999	-9.999	-9.999

Station	Image date	Filename	In-situ GPP (gC/m²/ day)	Modelled GPP (gC/m²/day)		
				Mean	Range	Standard Deviation
WS1	2009-04-07	MER_FSG_CCL2W_20090407_101842_000001712078_00008_37136_4238.nc.data	1.73	-9.999	-9.999	-9.999
WS1	2009-05-06	MER_FSG_CCL2W_20090506_100716_000001852078_00423_37551_5683.nc.data	1.042	2.5193	0.657658	0.220611
WS1	2009-06-23	MER_FSG_CCL2W_20090623_095622_000002502080_00108_38238_8172.nc.data	1.769	8.07037	18.9266	6.3525
WS1	2009-07-07	MER_FSG_CCL2W_20090707_105640_000004532080_00309_38439_8824.nc.data	0.725	-9.999	-9.999	-9.999
WS1	2009-08-25	MER_FSG_CCL2W_20090825_101600_000002952082_00008_39140_1044.nc.data	0.242	-9.999	-9.999	-9.999
WS1	2009-09-22	MER_FSG_CCL2W_20090922_103654_000002142082_00409_39541_2385.nc.data	0.114	0.761369	0.189367	0.0598591
WS1	2009-12-08	MER_FSG_CCL2W_20091208_101751_000001042085_00008_40643_5359.nc.data	0.007	-9.999	-9.999	-9.999
WS1	2010-01-12	MER_FSG_CCL2W_20100112_101753_000003042086_00008_41144_6433.nc.data	0.003	-9.999	-9.999	-9.999
WS1	2010-02-16	MER_FSG_CCL2W_20100216_101501_000003492087_00008_41645_7671.nc.data	0.026	-9.999	-9.999	-9.999
WS1	2010-03-16	MER_FSG_CCL2W_20100316_103552_000002142087_00409_42046_8921.nc.data	0.161	-9.999	-9.999	-9.999
WS1	2010-04-07	MER_FSG_CCL2W_20100407_104559_000001042088_00223_42361_9944.nc.data	0.543	-9.999	-9.999	-9.999
WS1	2010-04-07	MER_FSG_CCL2W_20100407_104743_000004132088_00223_42361_9946.nc.data	0.543	-9.999	-9.999	-9.999
WS1	2010-04-27	MER_FSG_CCL2W_20100427_101553_000003232089_00008_42647_0943.nc.data	0.892	9.59754	3.97546	1.66943
WS1	2010-05-18	MER_FSG_CCL2W_20100518_105800_000004112089_00309_42948_2020.nc.data	1.093	17.6003	0	0
WS1	2010-06-08	MER_FSG_CCL2W_20100608_095547_000002592090_00108_43248_3071.nc.data	0.975	-9.999	-9.999	-9.999
WS1	2010-07-13	MER_FSG_CCL2W_20100713_095550_000002562091_00108_43749_4824.nc.data	1.54	-9.999	-9.999	-9.999
WS1	2010-07-27	MER_FSG_CCL2W_20100727_105745_000003942091_00309_43950_5518.nc.data	2.069	-9.999	-9.999	-9.999
WS1	2010-09-07	MER_FSG_CCL2W_20100907_103823_000000812092_00409_44551_7665.nc.data	0.113	-9.999	-9.999	-9.999
WS1	2010-09-21	MER_FSG_CCL2W_20100921_095723_000002592093_00108_44751_8304.nc.data	0.449	-9.999	-9.999	-9.999
WS1	2010-12-14	MER_FSG_CCL2W_20101214_095141_000004533097_00252_45956_1034.nc.data	0.01	-9.999	-9.999	-9.999
WS1	2011-01-11	MER_FSG_CCL2W_20110111_110529_000000813098_00224_46359_1906.nc.data	0.005	-9.999	-9.999	-9.999
WS1	2011-02-08	MER_FSG_CCL2W_20110208_103708_000004533099_00195_46761_2952.nc.data	0.024	0.130652	0.0508206	0.0202226
WS1	2011-03-15	MER_FSG_CCL2W_20110315_105600_000001943100_00267_47264_4347.nc.data	0.06	-9.999	-9.999	-9.999
WS1	2011-06-21	MER_FSG_CCL2W_20110621_110236_000004533103_00382_48672_9615.nc.data	0.249	4.52413	7.279	3.6395
WS1	2011-07-05	MER_FSG_CCL2W_20110705_104935_000002813104_00152_48873_0370.nc.data	4.369	4.88458	2.14116	0.753567
WS1	2011-07-19	MER_FSG_CCL2W_20110719_103932_000001803104_00353_49074_1184.nc.data	0.19	-9.999	-9.999	-9.999
WS1	2011-08-30	MER_FSG_CCL2W_20110830_095840_000002593106_00094_49677_3630.nc.data	0.099	-9.999	-9.999	-9.999
WS1	2011-09-27	MER_FSG_CCL2W_20110927_111200_000001603107_00066_50080_5293.nc.data	0.227	-9.999	-9.999	-9.999
WS1	2011-10-11	MER_FSG_CCL2W_20111011_105454_000003573107_00267_50281_6051.nc.data	0.026	0.154876	0.0821404	0.024783
WS1	2011-10-11	MER_FSG_CCL2W_20111011_110052_000002503107_00267_50281_6055.nc.data	0.026	-9.999	-9.999	-9.999
WS1	2011-12-13	MER_FSG_CCL2W_20111213_105024_000004533109_00310_51186_9030.nc.data	0.006	0.0619983	0.00908649	0.00336884
WS1	2012-01-17	MER_FSG_CCL2W_20120117_110641_000004533110_00382_51689_6643.nc.data	0.02	-9.999	-9.999	-9.999
WS1	2012-02-07	MER_FSG_CCL2W_20120207_095745_000001093111_00252_51990_7614.nc.data	0.011	-9.999	-9.999	-9.999
WS1	2012-03-20	MER_FSG_CCL2W_20120320_105703_000002613112_00425_52594_9900.nc.data	0.228	0.670998	0.312391	0.118035
WS1	2012-04-03	MER_FSG_CCL2W_20120403_104238_000002563113_00195_52795_0693.nc.data	0.057	1.44641	0.716584	0.250535
WS4	2009-01-13	MER_FSG_CCL2W_20090113_105813_000002022075_00309_35934_0444.nc.data	0.002	-9.999	-9.999	-9.999
WS4	2009-03-03	MER_FSG_CCL2W_20090303_101858_000001602077_00008_36635_2533.nc.data	0.027	-9.999	-9.999	-9.999
WS4	2009-03-24	MER_FSG_CCL2W_20090324_105834_000004252077_00309_36936_3548.nc.data	1.266	-9.999	-9.999	-9.999
WS4	2009-04-07	MER_FSG_CCL2W_20090407_101842_000001712078_00008_37136_4238.nc.data	1.648	-9.999	-9.999	-9.999
WS4	2009-05-06	MER_FSG_CCL2W_20090506_100716_000001852078_00423_37551_5683.nc.data	0.608	-9.999	-9.999	-9.999
WS4	2009-06-23	MER_FSG_CCL2W_20090623_095622_000002502080_00108_38238_8172.nc.data	0.924	2.24781	2.12921	0.620128
WS4	2009-07-07	MER_FSG_CCL2W_20090707_105640_000004532080_00309_38439_8824.nc.data	0.16	-9.999	-9.999	-9.999
WS4	2009-08-25	MER_FSG_CCL2W_20090825_101600_000002952082_00008_39140_1044.nc.data	0.096	-9.999	-9.999	-9.999
WS4	2009-09-22	MER_FSG_CCL2W_20090922_103654_000002142082_00409_39541_2385.nc.data	0.154	0.801042	0.365331	0.105259
WS4	2009-12-08	MER_FSG_CCL2W_20091208_101751_000001042085_00008_40643_5359.nc.data	0.008	0.0444303	0.0455387	0.0164996
WS4	2010-01-12	MER_FSG_CCL2W_20100112_101753_000003042086_00008_41144_6433.nc.data	0.005	-9.999	-9.999	-9.999
WS4	2010-02-16	MER_FSG_CCL2W_20100216_101501_000003492087_00008_41645_7671.nc.data	0.032	-9.999	-9.999	-9.999
WS4	2010-03-16	MER_FSG_CCL2W_20100316_103552_000002142087_00409_42046_8921.nc.data	0.099	0.629742	0	0
WS4	2010-04-07	MER_FSG_CCL2W_20100407_104559_000001042088_00223_42361_9944.nc.data	0.453	-9.999	-9.999	-9.999
WS4	2010-04-07	MER_FSG_CCL2W_20100407_104743_000004132088_00223_42361_9946.nc.data	0.453	-9.999	-9.999	-9.999
WS4	2010-04-27	MER_FSG_CCL2W_20100427_101553_000003232089_00008_42647_0943.nc.data	2.926	10.6564	3.81833	1.21942
WS4	2010-05-18	MER_FSG_CCL2W_20100518_105800_000004112089_00309_42948_2020.nc.data	0.913	7.35338	21.4356	6.87831
WS4	2010-06-08	MER_FSG_CCL2W_20100608_095547_000002592090_00108_43248_3071.nc.data	1.05	-9.999	-9.999	-9.999
WS4	2010-06-22	MER_FSG_CCL2W_20100622_105545_000004532090_00309_43449_3777.nc.data	0.705	-9.999	-9.999	-9.999
WS4	2010-07-13	MER_FSG_CCL2W_20100713_095550_000002562091_00108_43749_4824.nc.data	0.52	-9.999	-9.999	-9.999
WS4	2010-07-27	MER_FSG_CCL2W_20100727_105745_000003942091_00309_43950_5518.nc.data	0.418	-9.999	-9.999	-9.999
WS4	2010-09-07	MER_FSG_CCL2W_20100907_103823_000000812092_00409_44551_7665.nc.data	0.081	1.03947	0	0
WS4	2010-09-21	MER_FSG_CCL2W_20100921_095723_000002592093_00108_44751_8304.nc.data	0.265	-9.999	-9.999	-9.999
WS4	2010-12-14	MER_FSG_CCL2W_20101214_095141_000004533097_00252_45956_1034.nc.data	0.008	-9.999	-9.999	-9.999
WS4	2011-01-11	MER_FSG_CCL2W_20110111_110529_000000813098_00224_46359_1906.nc.data	0.005	-9.999	-9.999	-9.999
WS4	2011-02-08	MER_FSG_CCL2W_20110208_103708_000004533099_00195_46761_2952.nc.data	0.031	0.155366	0.272687	0.0825341
WS4	2011-03-15	MER_FSG_CCL2W_20110315_105600_000001943100_00267_47264_4347.nc.data	0.102	-9.999	-9.999	-9.999
WS4	2011-06-21	MER_FSG_CCL2W_20110621_110236_000004533103_00382_48672_9615.nc.data	0.311	-9.999	-9.999	-9.999
WS4	2011-07-05	MER_FSG_CCL2W_20110705_104935_000002813104_00152_48873_0370.nc.data	0.227	13.8196	7.3738	2.07156
WS4	2011-07-19	MER_FSG_CCL2W_20110719_103932_000001803104_00353_49074_1184.nc.data	0.648	-9.999	-9.999	-9.999

Station	Image date	Filename	In-situ GPP (gC/m²/ day)	Modelled GPP (gC/m²/day)		
				Mean	Range	Standard Deviation
WS4	2011-08-30	MER_FSG_CCL2W_20110830_095840_000002593106_00094_49677_3630.nc.data	0.048	-9.999	-9.999	-9.999
WS4	2011-09-27	MER_FSG_CCL2W_20110927_111200_000001603107_00066_50080_5293.nc.data	0.089	-9.999	-9.999	-9.999
WS4	2011-10-11	MER_FSG_CCL2W_20111011_105454_000003573107_00267_50281_6051.nc.data	0.039	0.191855	0.038452	0.0126225
WS4	2011-10-11	MER_FSG_CCL2W_20111011_110052_000002503107_00267_50281_6055.nc.data	0.039	-9.999	-9.999	-9.999
WS4	2011-12-13	MER_FSG_CCL2W_20111213_105024_000004533109_00310_51186_9030.nc.data	0.01	0.106942	0.079831	0.020741
WS4	2012-01-17	MER_FSG_CCL2W_20120117_110641_000004533110_00382_51689_6643.nc.data	0.007	-9.999	-9.999	-9.999
WS4	2012-02-07	MER_FSG_CCL2W_20120207_095745_000001093111_00252_51990_7614.nc.data	0.018	-9.999	-9.999	-9.999
WS4	2012-03-20	MER_FSG_CCL2W_20120320_105703_000002613112_00425_52594_9900.nc.data	0.14	0.785347	1.77923	0.60342
WS4	2012-04-03	MER_FSG_CCL2W_20120403_104238_000002563113_00195_52795_0693.nc.data	0.681	1.36681	0.75216	0.244445

Supplementary information 6: BPIP^{b}_{max} model results of satellite images for all stations in both regions*

Station	Image date	Filename	In-situ GPP (gC/m²/day)	Modelled GPP (gC/m²/day) Mean	Range	Standard Deviation
OS1	2005-04-04	MER_FSG_CCL2W_20050404_102913_000001572036_00094_16180_3944.nc.data	0.956	-9.999	-9.999	-9.999
OS1	2005-06-20	MER_FSG_CCL2W_20050620_101003_000001322038_00194_17282_7434.nc.data	0.638	11.62	18.1908	8.23917
OS1	2005-07-18	MER_FSG_CCL2W_20050718_102445_000003882039_00094_17683_8796.nc.data	2.134	-9.999	-9.999	-9.999
OS1	2005-12-14	MER_FSG_CCL2W_20051214_104735_000004532043_00223_19816_6486.nc.data	0.019	0.166559	0.242415	0.07032
OS1	2006-02-06	MER_FSG_CCL2W_20060206_104827_000004192044_00495_20589_8724.nc.data	0.016	-9.999	-9.999	-9.999
OS1	2006-03-13	MER_FSG_CCL2W_20060313_104906_000002082045_00495_21090_3718.nc.data	0.248	0.338973	0.37487	0.125949
OS1	2006-04-24	MER_FSG_CCL2W_20060424_102919_000002332047_00094_21691_5399.nc.data	0.398	1.39996	0.47899	0.145087
OS1	2006-05-22	MER_FSG_CCL2W_20060522_104841_000002392047_00495_22092_6770.nc.data	2.123	2.74602	0.552441	0.202551
OS1	2006-08-14	MER_FSG_CCL2W_20060814_101010_000001802050_00194_23294_1294.nc.data	0.087	-9.999	-9.999	-9.999
OS1	2006-11-13	MER_FSG_CCL2W_20061113_104842_000004362052_00495_24597_4777.nc.data	0.01	-9.999	-9.999	-9.999
OS1	2010-06-23	MER_FSG_CCL2W_20100623_102423_000003262090_00323_43463_3821.nc.data	2.807	19.8215	6.15706	2.06087
OS1	2010-07-28	MER_FSG_CCL2W_20100728_102427_000003232091_00323_43964_5558.nc.data	1.278	-9.999	-9.999	-9.999
OS1	2010-08-25	MER_FSG_CCL2W_20100825_104711_000003802092_00223_44365_7013.nc.data	0.624	3.29046	0.004266	0.002133
OS1	2010-09-08	MER_FSG_CCL2W_20100908_100538_000002562092_00423_44565_7711.nc.data	0.322	-9.999	-9.999	-9.999
OS1	2010-10-13	MER_FSG_CCL2W_20101013_100730_000002592093_00423_45066_9235.nc.data	0.257	-9.999	-9.999	-9.999
OS1	2010-11-18	MER_FSG_CCL2W_20101118_104459_000004083096_00310_45583_0263.nc.data	0.016	-9.999	-9.999	-9.999
OS1	2010-12-15	MER_FSG_CCL2W_20101215_105506_000004533097_00267_45971_1064.nc.data	0.012	-9.999	-9.999	-9.999
OS1	2011-01-12	MER_FSG_CCL2W_20110112_102838_000004533098_00238_46373_1934.nc.data	0.005	-9.999	-9.999	-9.999
OS1	2011-02-09	MER_FSG_CCL2W_20110209_100018_000004533099_00209_46775_2986.nc.data	0.014	-9.999	-9.999	-9.999
OS1	2011-03-16	MER_FSG_CCL2W_20110316_101753_000002563100_00281_47278_4396.nc.data	0.173	-9.999	-9.999	-9.999
OS1	2011-04-06	MER_FSG_CCL2W_20110406_104928_000002593101_00152_47580_5395.nc.data	1.111	0.619315	0.948323	0.279331
OS1	2011-04-20	MER_FSG_CCL2W_20110420_103650_000002593101_00353_47781_6183.nc.data	2.211	5.42259	2.96099	0.955934
OS1	2011-05-25	MER_FSG_CCL2W_20110525_105523_000001803102_00425_48284_8145.nc.data	0.493	0.750651	0.973264	0.374492
OS1	2011-06-08	MER_FSG_CCL2W_20110608_104217_000001803103_00195_48485_8896.nc.data	0.645	1.51124	0.810103	0.278934
OS1	2011-06-22	MER_FSG_CCL2W_20110622_102737_000002563103_00396_48686_9670.nc.data	0.441	-9.999	-9.999	-9.999
OS1	2011-07-06	MER_FSG_CCL2W_20110706_101434_000002563104_00166_48887_0426.nc.data	1.362	-9.999	-9.999	-9.999
OS1	2011-07-20	MER_FSG_CCL2W_20110720_100247_000001803104_00367_49088_1240.nc.data	0.228	-9.999	-9.999	-9.999
OS1	2011-08-18	MER_FSG_CCL2W_20110818_103953_000001803105_00353_49505_2922.nc.data	0.318	-9.999	-9.999	-9.999
OS1	2011-12-14	MER_FSG_CCL2W_20111214_101335_000001093109_00324_51200_9068.nc.data	0.011	-9.999	-9.999	-9.999
OS1	2012-01-18	MER_FSG_CCL2W_20120118_102951_000002593110_00396_51703_6682.nc.data	0.01	-9.999	-9.999	-9.999
OS2	2010-05-19	MER_FSG_CCL2W_20100519_102430_000003262089_00323_42962_2066.nc.data	0.978	5.88172	3.77763	1.07533
OS2	2010-06-23	MER_FSG_CCL2W_20100623_102423_000003262090_00323_43463_3821.nc.data	2.416	17.1656	6.62303	1.80809
OS2	2010-07-14	MER_FSG_CCL2W_20100714_110623_000003912091_00123_43764_4879.nc.data	0.651	-9.999	-9.999	-9.999
OS2	2010-07-28	MER_FSG_CCL2W_20100728_102427_000003232091_00323_43964_5558.nc.data	1.638	14.4226	5.32015	2.02784
OS2	2010-08-25	MER_FSG_CCL2W_20100825_104711_000003802092_00223_44365_7013.nc.data	0.707	3.65431	2.55982	0.85623
OS2	2010-09-08	MER_FSG_CCL2W_20100908_100538_000002562092_00423_44565_7711.nc.data	0.272	-9.999	-9.999	-9.999
OS2	2010-09-22	MER_FSG_CCL2W_20100922_110655_000002022093_00123_44766_8353.nc.data	0.303	-9.999	-9.999	-9.999
OS2	2010-10-13	MER_FSG_CCL2W_20101013_100730_000002592093_00423_45066_9235.nc.data	0.266	-9.999	-9.999	-9.999
OS2	2010-11-18	MER_FSG_CCL2W_20101118_104459_000004083096_00310_45583_0263.nc.data	0.018	-9.999	-9.999	-9.999
OS2	2010-12-15	MER_FSG_CCL2W_20101215_105506_000004533097_00267_45971_1064.nc.data	0.016	-9.999	-9.999	-9.999
OS2	2011-01-12	MER_FSG_CCL2W_20110112_102838_000004533098_00238_46373_1934.nc.data	0.006	-9.999	-9.999	-9.999
OS2	2011-02-09	MER_FSG_CCL2W_20110209_100018_000004533099_00209_46775_2986.nc.data	0.027	-9.999	-9.999	-9.999
OS2	2011-03-16	MER_FSG_CCL2W_20110316_101753_000002563100_00281_47278_4396.nc.data	0.155	-9.999	-9.999	-9.999
OS2	2011-04-06	MER_FSG_CCL2W_20110406_104928_000002593101_00152_47580_5395.nc.data	0.593	0.088151	0.471737	0.156483
OS2	2011-04-20	MER_FSG_CCL2W_20110420_103650_000002593101_00353_47781_6183.nc.data	1.974	5.10662	3.42363	1.0407
OS2	2011-05-11	MER_FSG_CCL2W_20110511_110657_000001013102_00224_48083_7343.nc.data	0.766	-9.999	-9.999	-9.999
OS2	2011-05-11	MER_FSG_CCL2W_20110511_110837_000001493102_00224_48083_7347.nc.data	0.766	-9.999	-9.999	-9.999
OS2	2011-05-25	MER_FSG_CCL2W_20110525_105523_000001803102_00425_48284_8145.nc.data	0.441	2.5964	2.36485	0.795248
OS2	2011-06-08	MER_FSG_CCL2W_20110608_104217_000001803103_00195_48485_8896.nc.data	0.431	3.63576	2.27438	0.705022
OS2	2011-06-22	MER_FSG_CCL2W_20110622_102737_000002563103_00396_48686_9670.nc.data	0.475	-9.999	-9.999	-9.999
OS2	2011-07-06	MER_FSG_CCL2W_20110706_101434_000002563104_00166_48887_0426.nc.data	1.83	-9.999	-9.999	-9.999
OS2	2011-07-20	MER_FSG_CCL2W_20110720_100247_000001803104_00367_49088_1240.nc.data	0.357	-9.999	-9.999	-9.999
OS2	2011-08-18	MER_FSG_CCL2W_20110818_103953_000001803105_00353_49505_2922.nc.data	0.182	-9.999	-9.999	-9.999
OS2	2011-08-31	MER_FSG_CCL2W_20110831_110212_000002453106_00109_49692_3711.nc.data	0.195	-9.999	-9.999	-9.999
OS2	2011-09-14	MER_FSG_CCL2W_20110914_104856_000002563106_00310_49893_4569.nc.data	0.35	2.29589	6.51578	1.92127
OS2	2011-09-28	MER_FSG_CCL2W_20110928_103629_000002563107_00080_50094_5343.nc.data	0.443	0.987013	1.65066	0.460257
OS2	2011-10-12	MER_FSG_CCL2W_20111012_102341_000002563107_00281_50295_6105.nc.data	0.036	-9.999	-9.999	-9.999
OS2	2011-12-14	MER_FSG_CCL2W_20111214_101335_000001093109_00324_51200_9068.nc.data	0.013	-9.999	-9.999	-9.999
OS2	2012-01-18	MER_FSG_CCL2W_20120118_102951_000002593110_00396_51703_6682.nc.data	0.012	-9.999	-9.999	-9.999
OS2	2012-04-05	MER_FSG_CCL2W_20120405_110938_000002253113_00224_52824_0811.nc.data	0.129	-9.999	-9.999	-9.999
WS1	2009-01-13	MER_FSG_CCL2W_20090113_105813_000002022075_00309_35934_0444.nc.data	0.004	-9.999	-9.999	-9.999

Station	Image date	Filename	In-situ GPP (gC/m²/ day)	Modelled GPP (gC/m²/day)		
				Mean	Range	Standard Deviation
WS1	2009-03-03	MER_FSG_CCL2W_20090303_101858_000001602077_00008_36635_2533.nc.data	0.06	-9.999	-9.999	-9.999
WS1	2009-03-24	MER_FSG_CCL2W_20090324_105834_000004252077_00309_36936_3548.nc.data	2.044	-9.999	-9.999	-9.999
WS1	2009-04-07	MER_FSG_CCL2W_20090407_101842_000001712078_00008_37136_4238.nc.data	1.73	-9.999	-9.999	-9.999
WS1	2009-05-06	MER_FSG_CCL2W_20090506_100716_000001852078_00423_37551_5683.nc.data	1.042	2.84545	0.742806	0.249174
WS1	2009-06-23	MER_FSG_CCL2W_20090623_095622_000002502080_00108_38238_8172.nc.data	1.769	9.21127	21.6023	7.25056
WS1	2009-07-07	MER_FSG_CCL2W_20090707_105640_000004532080_00309_38439_8824.nc.data	0.725	-9.999	-9.999	-9.999
WS1	2009-08-25	MER_FSG_CCL2W_20090825_101600_000002952082_00008_39140_1044.nc.data	0.242	-9.999	-9.999	-9.999
WS1	2009-09-22	MER_FSG_CCL2W_20090922_103654_000002142082_00409_39541_2385.nc.data	0.114	1.09067	0.271281	0.085752
WS1	2009-12-08	MER_FSG_CCL2W_20091208_101751_000001042085_00008_40643_5359.nc.data	0.007	-9.999	-9.999	-9.999
WS1	2010-01-12	MER_FSG_CCL2W_20100112_101753_000003042086_00008_41144_6433.nc.data	0.003	-9.999	-9.999	-9.999
WS1	2010-02-16	MER_FSG_CCL2W_20100216_101501_000003492087_00008_41645_7671.nc.data	0.026	-9.999	-9.999	-9.999
WS1	2010-03-16	MER_FSG_CCL2W_20100316_103552_000002142087_00409_42046_8921.nc.data	0.161	-9.999	-9.999	-9.999
WS1	2010-04-07	MER_FSG_CCL2W_20100407_104559_000001042088_00223_42361_9944.nc.data	0.543	-9.999	-9.999	-9.999
WS1	2010-04-07	MER_FSG_CCL2W_20100407_104743_000004132088_00223_42361_9946.nc.data	0.543	-9.999	-9.999	-9.999
WS1	2010-04-27	MER_FSG_CCL2W_20100427_101553_000003232089_00008_42647_0943.nc.data	0.892	3.09418	1.28165	0.538209
WS1	2010-05-18	MER_FSG_CCL2W_20100518_105800_000004112089_00309_42948_2020.nc.data	1.093	19.1644	0	0
WS1	2010-06-08	MER_FSG_CCL2W_20100608_095547_000002592090_00108_43248_3071.nc.data	0.975	-9.999	-9.999	-9.999
WS1	2010-07-13	MER_FSG_CCL2W_20100713_095550_000002562091_00108_43749_4824.nc.data	1.54	-9.999	-9.999	-9.999
WS1	2010-07-27	MER_FSG_CCL2W_20100727_105745_000003942091_00309_43950_5518.nc.data	2.069	-9.999	-9.999	-9.999
WS1	2010-09-07	MER_FSG_CCL2W_20100907_103823_000000812092_00409_44551_7665.nc.data	0.113	-9.999	-9.999	-9.999
WS1	2010-09-21	MER_FSG_CCL2W_20100921_095723_000002592093_00108_44751_8304.nc.data	0.449	-9.999	-9.999	-9.999
WS1	2010-12-14	MER_FSG_CCL2W_20101214_095141_000004533097_00252_45956_1034.nc.data	0.01	-9.999	-9.999	-9.999
WS1	2011-01-11	MER_FSG_CCL2W_20110111_110529_000000813098_00224_46359_1906.nc.data	0.005	-9.999	-9.999	-9.999
WS1	2011-02-08	MER_FSG_CCL2W_20110208_103708_000004533099_00195_46761_2952.nc.data	0.024	0.067048	0.026076	0.010376
WS1	2011-03-15	MER_FSG_CCL2W_20110315_105600_000001943100_00267_47264_4347.nc.data	0.06	-9.999	-9.999	-9.999
WS1	2011-06-21	MER_FSG_CCL2W_20110621_110236_000004533103_00382_48672_9615.nc.data	0.249	5.41728	8.71605	4.35803
WS1	2011-07-05	MER_FSG_CCL2W_20110705_104935_000002813104_00152_48873_0370.nc.data	4.369	5.78771	2.53706	0.892902
WS1	2011-07-19	MER_FSG_CCL2W_20110719_103932_000001803104_00353_49074_1184.nc.data	0.19	-9.999	-9.999	-9.999
WS1	2011-08-30	MER_FSG_CCL2W_20110830_095840_000002593106_00094_49677_3630.nc.data	0.099	-9.999	-9.999	-9.999
WS1	2011-09-27	MER_FSG_CCL2W_20110927_111200_000001603107_00066_50080_5293.nc.data	0.227	-9.999	-9.999	-9.999
WS1	2011-10-11	MER_FSG_CCL2W_20111011_105454_000003573107_00267_50281_6051.nc.data	0.026	0.150797	0.079986	0.024133
WS1	2011-10-11	MER_FSG_CCL2W_20111011_110052_000002503107_00267_50281_6055.nc.data	0.026	-9.999	-9.999	-9.999
WS1	2011-12-13	MER_FSG_CCL2W_20111213_105024_000004533109_00310_51186_9030.nc.data	0.006	0.041755	0.006119	0.002269
WS1	2012-01-17	MER_FSG_CCL2W_20120117_110641_000004533110_00382_51689_6643.nc.data	0.02	-9.999	-9.999	-9.999
WS1	2012-02-07	MER_FSG_CCL2W_20120207_095745_000001093111_00252_51990_7614.nc.data	0.011	-9.999	-9.999	-9.999
WS1	2012-03-20	MER_FSG_CCL2W_20120320_105703_000002613112_00425_52594_9900.nc.data	0.228	0.506344	0.235736	0.089071
WS1	2012-04-03	MER_FSG_CCL2W_20120403_104238_000002563113_00195_52795_0693.nc.data	0.057	0.713111	0.353286	0.123517
WS4	2009-01-13	MER_FSG_CCL2W_20090113_105813_000002022075_00309_35934_0444.nc.data	0.002	-9.999	-9.999	-9.999
WS4	2009-03-03	MER_FSG_CCL2W_20090303_101858_000001602077_00008_36635_2533.nc.data	0.027	-9.999	-9.999	-9.999
WS4	2009-03-24	MER_FSG_CCL2W_20090324_105834_000004252077_00309_36936_3548.nc.data	1.266	-9.999	-9.999	-9.999
WS4	2009-04-07	MER_FSG_CCL2W_20090407_101842_000001712078_00008_37136_4238.nc.data	1.648	-9.999	-9.999	-9.999
WS4	2009-05-06	MER_FSG_CCL2W_20090506_100716_000001852078_00423_37551_5683.nc.data	0.608	-9.999	-9.999	-9.999
WS4	2009-06-23	MER_FSG_CCL2W_20090623_095622_000002502080_00108_38238_8172.nc.data	0.924	2.3861	2.26022	0.658285
WS4	2009-07-07	MER_FSG_CCL2W_20090707_105640_000004532080_00309_38439_8824.nc.data	0.16	-9.999	-9.999	-9.999
WS4	2009-08-25	MER_FSG_CCL2W_20090825_101600_000002952082_00008_39140_1044.nc.data	0.096	-9.999	-9.999	-9.999
WS4	2009-09-22	MER_FSG_CCL2W_20090922_103654_000002142082_00409_39541_2385.nc.data	0.154	1.24559	0.568099	0.16368
WS4	2009-12-08	MER_FSG_CCL2W_20091208_101751_000001042085_00008_40643_5359.nc.data	0.008	0.026991	0.027659	0.010021
WS4	2010-01-12	MER_FSG_CCL2W_20100112_101753_000003042086_00008_41144_6433.nc.data	0.005	-9.999	-9.999	-9.999
WS4	2010-02-16	MER_FSG_CCL2W_20100216_101501_000003492087_00008_41645_7671.nc.data	0.032	-9.999	-9.999	-9.999
WS4	2010-03-16	MER_FSG_CCL2W_20100316_103552_000002142087_00409_42046_8921.nc.data	0.099	0.441079	0	0
WS4	2010-04-07	MER_FSG_CCL2W_20100407_104559_000001042088_00223_42361_9944.nc.data	0.453	-9.999	-9.999	-9.999
WS4	2010-04-07	MER_FSG_CCL2W_20100407_104743_000004132088_00223_42361_9946.nc.data	0.453	-9.999	-9.999	-9.999
WS4	2010-04-27	MER_FSG_CCL2W_20100427_101553_000003232089_00008_42647_0943.nc.data	2.926	7.96313	2.85329	0.911227
WS4	2010-05-18	MER_FSG_CCL2W_20100518_105800_000004112089_00309_42948_2020.nc.data	0.913	8.70506	25.3759	8.14269
WS4	2010-06-08	MER_FSG_CCL2W_20100608_095547_000002592090_00108_43248_3071.nc.data	1.05	-9.999	-9.999	-9.999
WS4	2010-06-22	MER_FSG_CCL2W_20100622_105545_000004532090_00309_43449_3777.nc.data	0.705	-9.999	-9.999	-9.999
WS4	2010-07-13	MER_FSG_CCL2W_20100713_095550_000002562091_00108_43749_4824.nc.data	0.52	-9.999	-9.999	-9.999
WS4	2010-07-27	MER_FSG_CCL2W_20100727_105745_000003942091_00309_43950_5518.nc.data	0.418	-9.999	-9.999	-9.999
WS4	2010-09-07	MER_FSG_CCL2W_20100907_103823_000000812092_00409_44551_7665.nc.data	0.081	1.4351	0	0
WS4	2010-09-21	MER_FSG_CCL2W_20100921_095723_000002592093_00108_44751_8304.nc.data	0.265	-9.999	-9.999	-9.999
WS4	2010-12-14	MER_FSG_CCL2W_20101214_095141_000004533097_00252_45956_1034.nc.data	0.008	-9.999	-9.999	-9.999
WS4	2011-01-11	MER_FSG_CCL2W_20110111_110529_000000813098_00224_46359_1906.nc.data	0.005	-9.999	-9.999	-9.999
WS4	2011-02-08	MER_FSG_CCL2W_20110208_103708_000004533099_00195_46761_2952.nc.data	0.031	0.082207	0.144265	0.043665
WS4	2011-03-15	MER_FSG_CCL2W_20110315_105600_000001943100_00267_47264_4347.nc.data	0.102	-9.999	-9.999	-9.999
WS4	2011-06-21	MER_FSG_CCL2W_20110621_110236_000004533103_00382_48672_9615.nc.data	0.311	-9.999	-9.999	-9.999

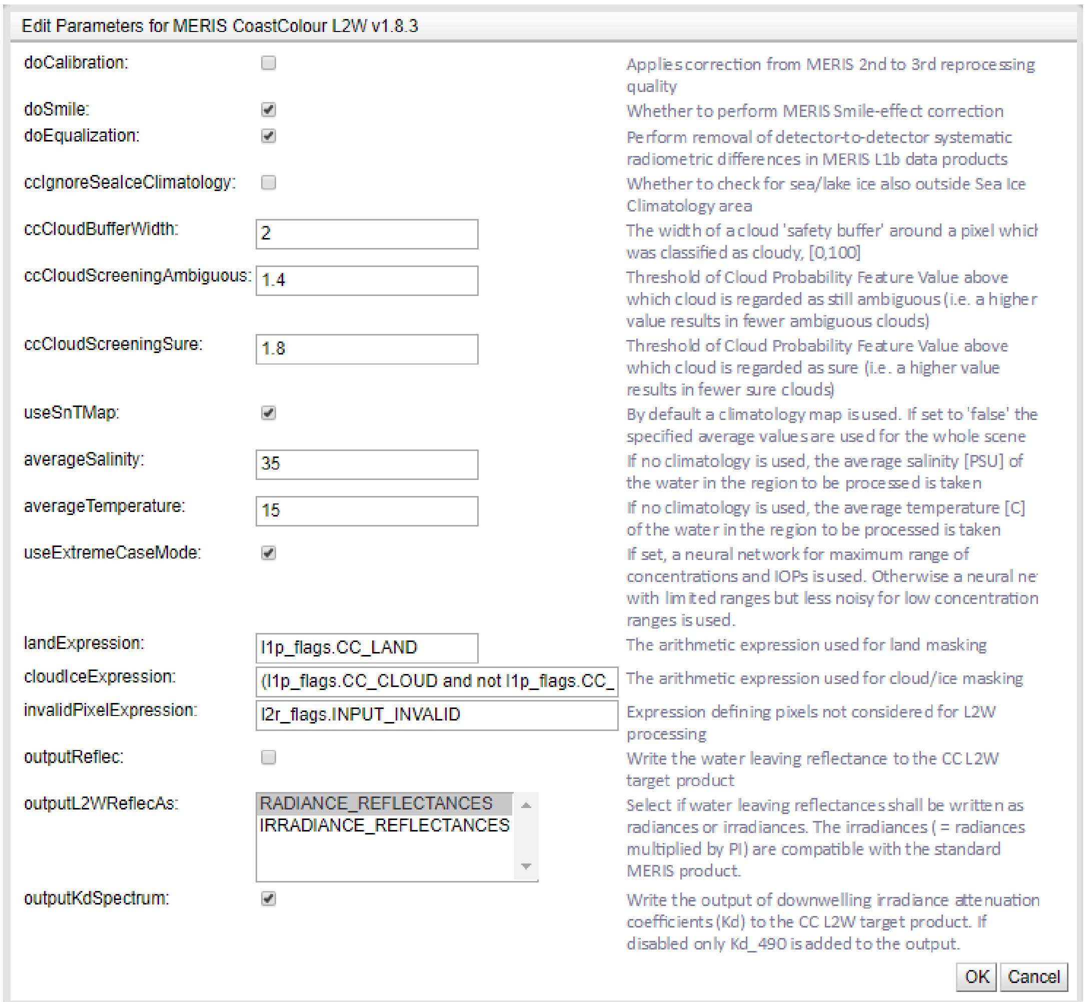
Station	Image date	Filename	In-situ GPP (gC/m²/day)	Modelled GPP (gC/m²/day)		
				Mean	Range	Standard Deviation
WS4	2011-07-05	MER_FSG_CCL2W_20110705_104935_000002813104_00152_48873_0370.nc.data	0.227	16.6198	8.86798	2.49132
WS4	2011-07-19	MER_FSG_CCL2W_20110719_103932_000001803104_00353_49074_1184.nc.data	0.648	-9.999	-9.999	-9.999
WS4	2011-08-30	MER_FSG_CCL2W_20110830_095840_000002593106_00094_49677_3630.nc.data	0.048	-9.999	-9.999	-9.999
WS4	2011-09-27	MER_FSG_CCL2W_20110927_111200_000001603107_00066_50080_5293.nc.data	0.089	-9.999	-9.999	-9.999
WS4	2011-10-11	MER_FSG_CCL2W_20111011_105454_000003573107_00267_50281_6051.nc.data	0.039	0.173017	0.034679	0.011384
WS4	2011-10-11	MER_FSG_CCL2W_20111011_110052_000002503107_00267_50281_6055.nc.data	0.039	-9.999	-9.999	-9.999
WS4	2011-12-13	MER_FSG_CCL2W_20111213_105024_000004533109_00310_51186_9030.nc.data	0.01	0.062159	0.046396	0.012054
WS4	2012-01-17	MER_FSG_CCL2W_20120117_110641_000004533110_00382_51689_6643.nc.data	0.007	-9.999	-9.999	-9.999
WS4	2012-02-07	MER_FSG_CCL2W_20120207_095745_000001093111_00252_51990_7614.nc.data	0.018	-9.999	-9.999	-9.999
WS4	2012-03-20	MER_FSG_CCL2W_20120320_105703_000002613112_00425_52594_9900.nc.data	0.14	0.62919	1.42546	0.483442
WS4	2012-04-03	MER_FSG_CCL2W_20120403_104238_000002563113_00195_52795_0693.nc.data	0.681	0.888088	0.488715	0.158828

*Supplementary information 7: BPI*P$^b_{opt}$ model results of satellite images for all stations in both regions*

Station	Image date	Filename	In-situ GPP (gC/m²/ day)	Modelled GPP (gC/m²/day)		
				Mean	Range	Standard Deviation
OS1	2005-04-04	MER_FSG_CCL2W_20050404_102913_000001572036_00094_16180_3944.nc.data	0.956	-9.999	-9.999	-9.999
OS1	2005-06-20	MER_FSG_CCL2W_20050620_101003_000001322038_00194_17282_7434.nc.data	0.638	15.2875	23.9323	10.8396
OS1	2005-07-18	MER_FSG_CCL2W_20050718_102445_000003882039_00094_17683_8796.nc.data	2.134	-9.999	-9.999	-9.999
OS1	2005-12-14	MER_FSG_CCL2W_20051214_104735_000004532043_00223_19816_6486.nc.data	0.019	0.186549	0.271473	0.078749
OS1	2006-02-06	MER_FSG_CCL2W_20060206_104827_000004192044_00495_20589_8724.nc.data	0.016	-9.999	-9.999	-9.999
OS1	2006-03-13	MER_FSG_CCL2W_20060313_104906_000002082045_00495_21090_3718.nc.data	0.248	0.327821	0.362497	0.121792
OS1	2006-04-24	MER_FSG_CCL2W_20060424_102919_000002332047_00094_21691_5399.nc.data	0.398	2.10083	0.718791	0.217723
OS1	2006-05-22	MER_FSG_CCL2W_20060522_104841_000002392047_00495_22092_6770.nc.data	2.123	4.70446	0.946441	0.34701
OS1	2006-08-14	MER_FSG_CCL2W_20060814_101010_000001802050_00194_23294_1294.nc.data	0.087	-9.999	-9.999	-9.999
OS1	2006-11-13	MER_FSG_CCL2W_20061113_104842_000004362052_00495_24597_4777.nc.data	0.01	-9.999	-9.999	-9.999
OS1	2010-06-23	MER_FSG_CCL2W_20100623_102423_000003262090_00323_43463_3821.nc.data	2.807	12.0085	3.73013	1.24854
OS1	2010-07-28	MER_FSG_CCL2W_20100728_102427_000003232091_00323_43964_5558.nc.data	1.278	-9.999	-9.999	-9.999
OS1	2010-08-25	MER_FSG_CCL2W_20100825_104711_000003802092_00223_44365_7013.nc.data	0.624	2.55458	0.003312	0.001656
OS1	2010-09-08	MER_FSG_CCL2W_20100908_100538_000002562092_00423_44565_7711.nc.data	0.322	-9.999	-9.999	-9.999
OS1	2010-10-13	MER_FSG_CCL2W_20101013_100730_000002592093_00423_45066_9235.nc.data	0.257	-9.999	-9.999	-9.999
OS1	2010-11-18	MER_FSG_CCL2W_20101118_104459_000004083096_00310_45583_0263.nc.data	0.016	-9.999	-9.999	-9.999
OS1	2010-12-15	MER_FSG_CCL2W_20101215_105506_000004533097_00267_45971_1064.nc.data	0.012	-9.999	-9.999	-9.999
OS1	2011-01-12	MER_FSG_CCL2W_20110112_102838_000004533098_00238_46373_1934.nc.data	0.005	-9.999	-9.999	-9.999
OS1	2011-02-09	MER_FSG_CCL2W_20110209_100018_000004533099_00209_46775_2986.nc.data	0.014	-9.999	-9.999	-9.999
OS1	2011-03-16	MER_FSG_CCL2W_20110316_101753_000002563100_00281_47278_4396.nc.data	0.173	-9.999	-9.999	-9.999
OS1	2011-04-06	MER_FSG_CCL2W_20110406_104928_000002593101_00152_47580_5395.nc.data	1.111	0.50872	0.778901	0.229427
OS1	2011-04-20	MER_FSG_CCL2W_20110420_103650_000002593101_00353_47781_6183.nc.data	2.211	6.58687	3.59673	1.16118
OS1	2011-05-25	MER_FSG_CCL2W_20110525_105523_000001803102_00425_48284_8145.nc.data	0.493	0.794821	1.03049	0.396513
OS1	2011-06-08	MER_FSG_CCL2W_20110608_104217_000001803103_00195_48485_8896.nc.data	0.645	1.04923	0.56241	0.193648
OS1	2011-06-22	MER_FSG_CCL2W_20110622_102737_000002563103_00396_48686_9670.nc.data	0.441	-9.999	-9.999	-9.999
OS1	2011-07-06	MER_FSG_CCL2W_20110706_101434_000002563104_00166_48887_0426.nc.data	1.362	-9.999	-9.999	-9.999
OS1	2011-07-20	MER_FSG_CCL2W_20110720_100247_000001803104_00367_49088_1240.nc.data	0.228	-9.999	-9.999	-9.999
OS1	2011-08-18	MER_FSG_CCL2W_20110818_103953_000001803105_00353_49505_2922.nc.data	0.318	-9.999	-9.999	-9.999
OS1	2011-12-14	MER_FSG_CCL2W_20111214_101335_000001093109_00324_51200_9068.nc.data	0.011	-9.999	-9.999	-9.999
OS1	2012-01-18	MER_FSG_CCL2W_20120118_102951_000002593110_00396_51703_6682.nc.data	0.01	-9.999	-9.999	-9.999
OS2	2010-05-19	MER_FSG_CCL2W_20100519_102430_000003262089_00323_42962_2066.nc.data	0.978	4.22212	2.71169	0.771904
OS2	2010-06-23	MER_FSG_CCL2W_20100623_102423_000003262090_00323_43463_3821.nc.data	2.416	10.7881	4.16236	1.13633
OS2	2010-07-14	MER_FSG_CCL2W_20100714_110623_000003912091_00123_43764_4879.nc.data	0.651	-9.999	-9.999	-9.999
OS2	2010-07-28	MER_FSG_CCL2W_20100728_102427_000003232091_00323_43964_5558.nc.data	1.638	7.88597	2.90892	1.10877
OS2	2010-08-25	MER_FSG_CCL2W_20100825_104711_000003802092_00223_44365_7013.nc.data	0.707	2.30062	1.61152	0.539036
OS2	2010-09-08	MER_FSG_CCL2W_20100908_100538_000002562092_00423_44565_7711.nc.data	0.272	-9.999	-9.999	-9.999
OS2	2010-09-22	MER_FSG_CCL2W_20100922_110655_000002022093_00123_44766_8353.nc.data	0.303	-9.999	-9.999	-9.999
OS2	2010-10-13	MER_FSG_CCL2W_20101013_100730_000002592093_00423_45066_9235.nc.data	0.266	-9.999	-9.999	-9.999
OS2	2010-11-18	MER_FSG_CCL2W_20101118_104459_000004083096_00310_45583_0263.nc.data	0.018	-9.999	-9.999	-9.999
OS2	2010-12-15	MER_FSG_CCL2W_20101215_105506_000004533097_00267_45971_1064.nc.data	0.016	-9.999	-9.999	-9.999
OS2	2011-01-12	MER_FSG_CCL2W_20110112_102838_000004533098_00238_46373_1934.nc.data	0.006	-9.999	-9.999	-9.999
OS2	2011-02-09	MER_FSG_CCL2W_20110209_100018_000004533099_00209_46775_2986.nc.data	0.027	-9.999	-9.999	-9.999
OS2	2011-03-16	MER_FSG_CCL2W_20110316_101753_000002563100_00281_47278_4396.nc.data	0.155	-9.999	-9.999	-9.999
OS2	2011-04-06	MER_FSG_CCL2W_20110406_104928_000002593101_00152_47580_5395.nc.data	0.593	0.073569	0.393446	0.130512
OS2	2011-04-20	MER_FSG_CCL2W_20110420_103650_000002593101_00353_47781_6183.nc.data	1.974	6.58205	4.4128	1.34138
OS2	2011-05-11	MER_FSG_CCL2W_20110511_110657_000001013102_00224_48083_7343.nc.data	0.766	-9.999	-9.999	-9.999
OS2	2011-05-11	MER_FSG_CCL2W_20110511_110837_000001493102_00224_48083_7347.nc.data	0.766	-9.999	-9.999	-9.999
OS2	2011-05-25	MER_FSG_CCL2W_20110525_105523_000001803102_00425_48284_8145.nc.data	0.441	3.24044	2.95144	0.992505
OS2	2011-06-08	MER_FSG_CCL2W_20110608_104217_000001803103_00195_48485_8896.nc.data	0.431	3.70692	2.31887	0.718814
OS2	2011-06-22	MER_FSG_CCL2W_20110622_102737_000002563103_00396_48686_9670.nc.data	0.475	-9.999	-9.999	-9.999
OS2	2011-07-06	MER_FSG_CCL2W_20110706_101434_000002563104_00166_48887_0426.nc.data	1.83	-9.999	-9.999	-9.999
OS2	2011-07-20	MER_FSG_CCL2W_20110720_100247_000001803104_00367_49088_1240.nc.data	0.357	-9.999	-9.999	-9.999
OS2	2011-08-18	MER_FSG_CCL2W_20110818_103953_000001803105_00353_49505_2922.nc.data	0.182	-9.999	-9.999	-9.999
OS2	2011-08-31	MER_FSG_CCL2W_20110831_110212_000002453106_00109_49692_3711.nc.data	0.195	-9.999	-9.999	-9.999
OS2	2011-09-14	MER_FSG_CCL2W_20110914_104856_000002563106_00310_49893_4569.nc.data	0.35	2.06671	5.86526	1.72946
OS2	2011-09-28	MER_FSG_CCL2W_20110928_103629_000002563107_00080_50094_5343.nc.data	0.443	1.023	1.71078	0.477022
OS2	2011-10-12	MER_FSG_CCL2W_20111012_102341_000002563107_00281_50295_6105.nc.data	0.036	-9.999	-9.999	-9.999
OS2	2011-12-14	MER_FSG_CCL2W_20111214_101335_000001093109_00324_51200_9068.nc.data	0.013	-9.999	-9.999	-9.999
OS2	2012-01-18	MER_FSG_CCL2W_20120118_102951_000002593110_00396_51703_6682.nc.data	0.012	-9.999	-9.999	-9.999
OS2	2012-04-05	MER_FSG_CCL2W_20120405_110938_000002253113_00224_52824_0811.nc.data	0.129	-9.999	-9.999	-9.999
WS1	2009-01-13	MER_FSG_CCL2W_20090113_105813_000002022075_00309_35934_0444.nc.data	0.004	-9.999	-9.999	-9.999
WS1	2009-03-03	MER_FSG_CCL2W_20090303_101858_000001602077_00008_36635_2533.nc.data	0.06	-9.999	-9.999	-9.999
WS1	2009-03-24	MER_FSG_CCL2W_20090324_105834_000004252077_00309_36936_3548.nc.data	2.044	-9.999	-9.999	-9.999

Station	Image date	Filename	In-situ GPP (gC/m^2/day)	Modelled GPP (gC/m^2/day)		
				Mean	Range	Standard Deviation
WS1	2009-04-07	MER_FSG_CCL2W_20090407_101842_000001712078_00008_37136_4238.nc.data	1.73	-9.999	-9.999	-9.999
WS1	2009-05-06	MER_FSG_CCL2W_20090506_100716_000001852078_00423_37551_5683.nc.data	1.042	2.27282	0.593313	0.199027
WS1	2009-06-23	MER_FSG_CCL2W_20090623_095622_000002502080_00108_38238_8172.nc.data	1.769	9.61502	22.5491	7.56835
WS1	2009-07-07	MER_FSG_CCL2W_20090707_105640_000004532080_00309_38439_8824.nc.data	0.725	-9.999	-9.999	-9.999
WS1	2009-08-25	MER_FSG_CCL2W_20090825_101600_000002952082_00008_39140_1044.nc.data	0.242	-9.999	-9.999	-9.999
WS1	2009-09-22	MER_FSG_CCL2W_20090922_103654_000002142082_00409_39541_2385.nc.data	0.114	0.896346	0.222938	0.070471
WS1	2009-12-08	MER_FSG_CCL2W_20091208_101751_000001042085_00008_40643_5359.nc.data	0.007	-9.999	-9.999	-9.999
WS1	2010-01-12	MER_FSG_CCL2W_20100112_101753_000003042086_00008_41144_6433.nc.data	0.003	-9.999	-9.999	-9.999
WS1	2010-02-16	MER_FSG_CCL2W_20100216_101501_000003492087_00008_41645_7671.nc.data	0.026	-9.999	-9.999	-9.999
WS1	2010-03-16	MER_FSG_CCL2W_20100316_103552_000002142087_00409_42046_8921.nc.data	0.161	-9.999	-9.999	-9.999
WS1	2010-04-07	MER_FSG_CCL2W_20100407_104559_000001042088_00223_42361_9944.nc.data	0.543	-9.999	-9.999	-9.999
WS1	2010-04-07	MER_FSG_CCL2W_20100407_104743_000004132088_00223_42361_9946.nc.data	0.543	-9.999	-9.999	-9.999
WS1	2010-04-27	MER_FSG_CCL2W_20100427_101553_000003232089_00008_42647_0943.nc.data	0.892	7.30694	3.02664	1.27099
WS1	2010-05-18	MER_FSG_CCL2W_20100518_105800_000004112089_00309_42948_2020.nc.data	1.093	14.3506	0	0
WS1	2010-06-08	MER_FSG_CCL2W_20100608_095547_000002592090_00108_43248_3071.nc.data	0.975	-9.999	-9.999	-9.999
WS1	2010-07-13	MER_FSG_CCL2W_20100713_095550_000002562091_00108_43749_4824.nc.data	1.54	-9.999	-9.999	-9.999
WS1	2010-07-27	MER_FSG_CCL2W_20100727_105745_000003942091_00309_43950_5518.nc.data	2.069	-9.999	-9.999	-9.999
WS1	2010-09-07	MER_FSG_CCL2W_20100907_103823_000000812092_00409_44551_7665.nc.data	0.113	-9.999	-9.999	-9.999
WS1	2010-09-21	MER_FSG_CCL2W_20100921_095723_000002592093_00108_44751_8304.nc.data	0.449	-9.999	-9.999	-9.999
WS1	2010-12-14	MER_FSG_CCL2W_20101214_095141_000004533097_00252_45956_1034.nc.data	0.01	-9.999	-9.999	-9.999
WS1	2011-01-11	MER_FSG_CCL2W_20110111_110529_000000813098_00224_46359_1906.nc.data	0.005	-9.999	-9.999	-9.999
WS1	2011-02-08	MER_FSG_CCL2W_20110208_103708_000004533099_00195_46761_2952.nc.data	0.024	0.067444	0.026218	0.010433
WS1	2011-03-15	MER_FSG_CCL2W_20110315_105600_000001943100_00267_47264_4347.nc.data	0.06	-9.999	-9.999	-9.999
WS1	2011-06-21	MER_FSG_CCL2W_20110621_110236_000004533103_00382_48672_9615.nc.data	0.249	5.09677	8.20033	4.10016
WS1	2011-07-05	MER_FSG_CCL2W_20110705_104935_000002813104_00152_48873_0370.nc.data	4.369	5.88537	2.57986	0.907964
WS1	2011-07-19	MER_FSG_CCL2W_20110719_103932_000001803104_00353_49074_1184.nc.data	0.19	-9.999	-9.999	-9.999
WS1	2011-08-30	MER_FSG_CCL2W_20110830_095840_000002593106_00094_49677_3630.nc.data	0.099	-9.999	-9.999	-9.999
WS1	2011-09-27	MER_FSG_CCL2W_20110927_111200_000001603107_00066_50080_5293.nc.data	0.227	-9.999	-9.999	-9.999
WS1	2011-10-11	MER_FSG_CCL2W_20111011_105454_000003573107_00267_50281_6051.nc.data	0.026	0.170311	0.090323	0.027252
WS1	2011-10-11	MER_FSG_CCL2W_20111011_110052_000002503107_00267_50281_6055.nc.data	0.026	-9.999	-9.999	-9.999
WS1	2011-12-13	MER_FSG_CCL2W_20111213_105024_000004533109_00310_51186_9030.nc.data	0.006	0.037955	0.005557	0.00206
WS1	2012-01-17	MER_FSG_CCL2W_20120117_110641_000004533110_00382_51689_6643.nc.data	0.02	-9.999	-9.999	-9.999
WS1	2012-02-07	MER_FSG_CCL2W_20120207_095745_000001093111_00252_51990_7614.nc.data	0.011	-9.999	-9.999	-9.999
WS1	2012-03-20	MER_FSG_CCL2W_20120320_105703_000002613112_00425_52594_9900.nc.data	0.228	0.391115	0.18207	0.068794
WS1	2012-04-03	MER_FSG_CCL2W_20120403_104238_000002563113_00195_52795_0693.nc.data	0.057	0.945098	0.468208	0.163697
WS4	2009-01-13	MER_FSG_CCL2W_20090113_105813_000002022075_00309_35934_0444.nc.data	0.002	-9.999	-9.999	-9.999
WS4	2009-03-03	MER_FSG_CCL2W_20090303_101858_000001602077_00008_36635_2533.nc.data	0.027	-9.999	-9.999	-9.999
WS4	2009-03-24	MER_FSG_CCL2W_20090324_105834_000004252077_00309_36936_3548.nc.data	1.266	-9.999	-9.999	-9.999
WS4	2009-04-07	MER_FSG_CCL2W_20090407_101842_000001712078_00008_37136_4238.nc.data	1.648	-9.999	-9.999	-9.999
WS4	2009-05-06	MER_FSG_CCL2W_20090506_100716_000001852078_00423_37551_5683.nc.data	0.608	-9.999	-9.999	-9.999
WS4	2009-06-23	MER_FSG_CCL2W_20090623_095622_000002502080_00108_38238_8172.nc.data	0.924	2.68459	2.54294	0.740628
WS4	2009-07-07	MER_FSG_CCL2W_20090707_105640_000004532080_00309_38439_8824.nc.data	0.16	-9.999	-9.999	-9.999
WS4	2009-08-25	MER_FSG_CCL2W_20090825_101600_000002952082_00008_39140_1044.nc.data	0.096	-9.999	-9.999	-9.999
WS4	2009-09-22	MER_FSG_CCL2W_20090922_103654_000002142082_00409_39541_2385.nc.data	0.154	0.946803	0.431808	0.124412
WS4	2009-12-08	MER_FSG_CCL2W_20091208_101751_000001042085_00008_40643_5359.nc.data	0.008	0.029557	0.03026	0.010964
WS4	2010-01-12	MER_FSG_CCL2W_20100112_101753_000003042086_00008_41144_6433.nc.data	0.005	-9.999	-9.999	-9.999
WS4	2010-02-16	MER_FSG_CCL2W_20100216_101501_000003492087_00008_41645_7671.nc.data	0.032	-9.999	-9.999	-9.999
WS4	2010-03-16	MER_FSG_CCL2W_20100316_103552_000002142087_00409_42046_8921.nc.data	0.099	0.307378	0	0
WS4	2010-04-07	MER_FSG_CCL2W_20100407_104559_000001042088_00223_42361_9944.nc.data	0.453	-9.999	-9.999	-9.999
WS4	2010-04-07	MER_FSG_CCL2W_20100407_104743_000004132088_00223_42361_9946.nc.data	0.453	-9.999	-9.999	-9.999
WS4	2010-04-27	MER_FSG_CCL2W_20100427_101553_000003232089_00008_42647_0943.nc.data	2.926	8.49802	3.04494	0.972433
WS4	2010-05-18	MER_FSG_CCL2W_20100518_105800_000004112089_00309_42948_2020.nc.data	0.913	6.1198	17.8395	5.7244
WS4	2010-06-08	MER_FSG_CCL2W_20100608_095547_000002592090_00108_43248_3071.nc.data	1.05	-9.999	-9.999	-9.999
WS4	2010-06-22	MER_FSG_CCL2W_20100622_105545_000004532090_00309_43449_3777.nc.data	0.705	-9.999	-9.999	-9.999
WS4	2010-07-13	MER_FSG_CCL2W_20100713_095550_000002562091_00108_43749_4824.nc.data	0.52	-9.999	-9.999	-9.999
WS4	2010-07-27	MER_FSG_CCL2W_20100727_105745_000003942091_00309_43950_5518.nc.data	0.418	-9.999	-9.999	-9.999
WS4	2010-09-07	MER_FSG_CCL2W_20100907_103823_000000812092_00409_44551_7665.nc.data	0.081	1.23464	0	0
WS4	2010-09-21	MER_FSG_CCL2W_20100921_095723_000002592093_00108_44751_8304.nc.data	0.265	-9.999	-9.999	-9.999
WS4	2010-12-14	MER_FSG_CCL2W_20101214_095141_000004533097_00252_45956_1034.nc.data	0.008	-9.999	-9.999	-9.999
WS4	2011-01-11	MER_FSG_CCL2W_20110111_110529_000000813098_00224_46359_1906.nc.data	0.005	-9.999	-9.999	-9.999
WS4	2011-02-08	MER_FSG_CCL2W_20110208_103708_000004533099_00195_46761_2952.nc.data	0.031	0.080582	0.141359	0.042785
WS4	2011-03-15	MER_FSG_CCL2W_20110315_105600_000001943100_00267_47264_4347.nc.data	0.102	-9.999	-9.999	-9.999
WS4	2011-06-21	MER_FSG_CCL2W_20110621_110236_000004533103_00382_48672_9615.nc.data	0.311	-9.999	-9.999	-9.999
WS4	2011-07-05	MER_FSG_CCL2W_20110705_104935_000002813104_00152_48873_0370.nc.data	0.227	16.6885	8.90459	2.50161
WS4	2011-07-19	MER_FSG_CCL2W_20110719_103932_000001803104_00353_49074_1184.nc.data	0.648	-9.999	-9.999	-9.999

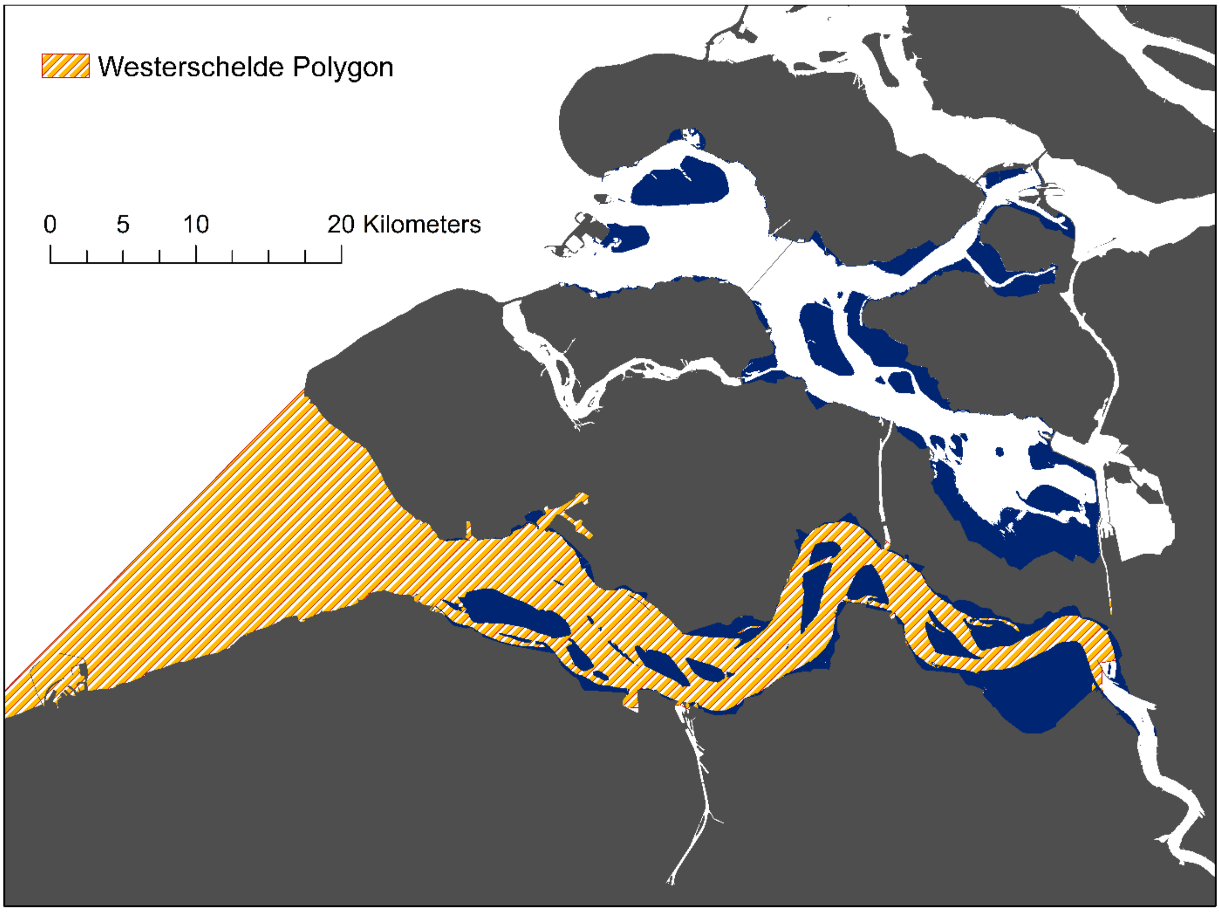
Station	Image date	Filename	In-situ GPP (gC/m²/ day)	Modelled GPP (gC/m²/day)		
				Mean	Range	Standard Deviation
WS4	2011-08-30	MER_FSG_CCL2W_20110830_095840_000002593106_00094_49677_3630.nc.data	0.048	-9.999	-9.999	-9.999
WS4	2011-09-27	MER_FSG_CCL2W_20110927_111200_000001603107_00066_50080_5293.nc.data	0.089	-9.999	-9.999	-9.999
WS4	2011-10-11	MER_FSG_CCL2W_20111011_105454_000003573107_00267_50281_6051.nc.data	0.039	0.211958	0.04248	0.013945
WS4	2011-10-11	MER_FSG_CCL2W_20111011_110052_000002503107_00267_50281_6055.nc.data	0.039	-9.999	-9.999	-9.999
WS4	2011-12-13	MER_FSG_CCL2W_20111213_105024_000004533109_00310_51186_9030.nc.data	0.01	0.064673	0.04825	0.012536
WS4	2012-01-17	MER_FSG_CCL2W_20120117_110641_000004533110_00382_51689_6643.nc.data	0.007	-9.999	-9.999	-9.999
WS4	2012-02-07	MER_FSG_CCL2W_20120207_095745_000001093111_00252_51990_7614.nc.data	0.018	-9.999	-9.999	-9.999
WS4	2012-03-20	MER_FSG_CCL2W_20120320_105703_000002613112_00425_52594_9900.nc.data	0.14	0.474113	1.07403	0.364256
WS4	2012-04-03	MER_FSG_CCL2W_20120403_104238_000002563113_00195_52795_0693.nc.data	0.681	0.928245	0.510798	0.166004


Edit Parameters for MERIS CoastColour L2W v1.8.3

doCalibration:	☐	Applies correction from MERIS 2nd to 3rd reprocessing quality
doSmile:	☑	Whether to perform MERIS Smile-effect correction
doEqualization:	☑	Perform removal of detector-to-detector systematic radiometric differences in MERIS L1b data products
ccIgnoreSeaIceClimatology:	☐	Whether to check for sea/lake ice also outside Sea Ice Climatology area
ccCloudBufferWidth:	2	The width of a cloud 'safety buffer' around a pixel which was classified as cloudy, [0,100]
ccCloudScreeningAmbiguous:	1.4	Threshold of Cloud Probability Feature Value above which cloud is regarded as still ambiguous (i.e. a higher value results in fewer ambiguous clouds)
ccCloudScreeningSure:	1.8	Threshold of Cloud Probability Feature Value above which cloud is regarded as sure (i.e. a higher value results in fewer sure clouds)
useSnTMap:	☑	By default a climatology map is used. If set to 'false' the specified average values are used for the whole scene
averageSalinity:	35	If no climatology is used, the average salinity [PSU] of the water in the region to be processed is taken
averageTemperature:	15	If no climatology is used, the average temperature [C] of the water in the region to be processed is taken
useExtremeCaseMode:	☑	If set, a neural network for maximum range of concentrations and IOPs is used. Otherwise a neural ne with limited ranges but less noisy for low concentration ranges is used.
landExpression:	l1p_flags.CC_LAND	The arithmetic expression used for land masking
cloudIceExpression:	(l1p_flags.CC_CLOUD and not l1p_flags.CC_	The arithmetic expression used for cloud/ice masking
invalidPixelExpression:	l2r_flags.INPUT_INVALID	Expression defining pixels not considered for L2W processing
outputReflec:	☐	Write the water leaving reflectance to the CC L2W target product
outputL2WReflecAs:	RADIANCE_REFLECTANCES IRRADIANCE_REFLECTANCES	Select if water leaving reflectances shall be written as radiances or irradiances. The irradiances (= radiances multiplied by PI) are compatible with the standard MERIS product.
outputKdSpectrum:	☑	Write the output of downwelling irradiance attenuation coefficients (Kd) to the CC L2W target product. If disabled only Kd_490 is added to the output.

OK Cancel

Supplementary information 8: Calvalus pre-processing parameters



Supplementary information 9: Image of the Scheldt Estuary with the Westerschelde polygon highlighted