



## Web application server

### WAS

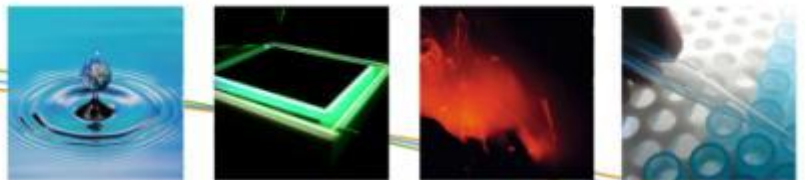
Jean-Luc De Kok and Lieve Decorte

Unit Environmental Modelling

Flemish Institute for Technological Research (VITO)

Boeretang 200

2400 Mol (Belgium)



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## 1 Introduction

The cross-border cooperation project ISECA ([www.iseca.eu](http://www.iseca.eu)), which is supported by the EU subsidized INTERREGIVa 2Seas Program ([www.interreg4a-2mers.eu](http://www.interreg4a-2mers.eu)), is a collaboration between Flemish, Dutch, French and British knowledge partners. The objective of the project is to improve the exchange of data and scientific insights related to the eutrophication of coastal waters in the English Channel and the Southern North Sea, aiming both at knowledge partners and the relevant authorities and general public. The project is coordinated by ADRINORD in France.

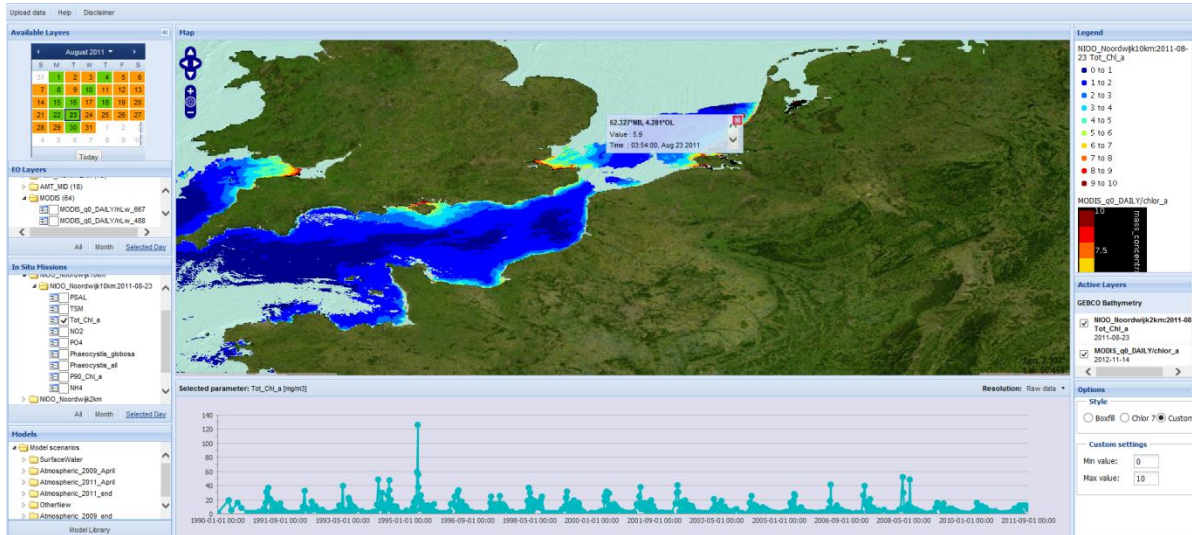
Broadly speaking eutrophication is the process of excessive enrichment of waters which can lead to algae growth and Harmful Algal Blooms (HABs) of algae such as *Phaeocystis*, and eventually fish mortality or even the production of toxic gases. Point (industrial and waste water treatment outflows and diffuse sources (mainly atmospheric deposition and agriculture) of nutrients contribute the eutrophication of estuarine and coastal waters. The potential consequences include a disturbance of the balance of marine ecosystems, and negative impacts on the coastal economy (beach recreation, fisheries and shell farming). Eutrophication of coastal waters is still considered to be an important problem and has the continued attention of the European Community ([www.ospar.org](http://www.ospar.org)). The key objective of the Web Application Server (shortly WAS) is to demonstrate the added value of combining field measurements (from buoys and vessels) and earth observation data from satellites with model results in a combined environment. Whereas the field and earth observation data can be used to monitor the current eutrophication status and record the history of change, the model simulations can be used to show the potential impact of different management strategies available to the EU member states. The model simulations are based on an empirical model for the dependency of the nutrient content and other parameters on the salinity, using sample data reported by the OSPAR workgroup in 2008 and a linear dependence on the nitrogen inflow from the main rivers.

The application area for the WAS is the 2Seas territory, for the ISECA project extended to the area between longitudes 6° W – 7° E and latitudes 48° N and 54° N. The architecture of the WAS allows for the visualization and comparison of offline, geospatial model results stored in NetCdf4 format, and comparison with Earth Observation (EO) and in-situ data. A GeoServer approach is used for the web service hosting by the Flemish Institute of Technological Research (VITO). The WAS allows for remote access to the earth observation data, which are stored at the Plymouth Marine Laboratory (PML).

The following manual briefly explains:

1. how to select and visualize an earth observation map layer for a specific date using a calendar search tool
2. how to select water quality data (in-situ observations) and visualize the data on the map locations and as a long-term trend in time
3. how to up- and download datasets of in-situ observations
4. how to select and visualize a model simulation Please note, the model simulations refer to

long-term yearly averages which means it is not meaningful to compare these directly with the earth observation data or field measurements. Below you find an example screenshot for the WAS.



*Simultaneous visualization of in-situ observations with an earth observation map layer for chlorophyll-a after selection of a calendar date (upper left). Note the peak in the long-term trend for the in-situ observations which occurred in May 1995.*

**General contact information for the ISECA project:**

Prof. dr. R. Santer

ADRINORD  
2, Rue des Cannoniers  
59000 Lille  
France

e-mail: [richard.santer@univ-littoral.fr](mailto:richard.santer@univ-littoral.fr)  
tel: + 33 (0)328 38 50 28

**Flemish contact for the Web Application Server only:**

Dr. Jean-Luc de Kok

VITO  
Boeretang 200  
2400 Mol  
Belgium

e-mail: [jeanluc.dekok@vito.be](mailto:jeanluc.dekok@vito.be)  
tel: +32 (0) 14 33 6739




## 2 WAS Tutorial

Use the Tutorial for a quick start with the application.

- [How can you select data?](#)
- [How can you view a more detailed map?](#)
- [How can you select earth observation data?](#)
- [How can you select in-situ data?](#)
- [How can you visualize model scenarios?](#)
- [Tips](#)

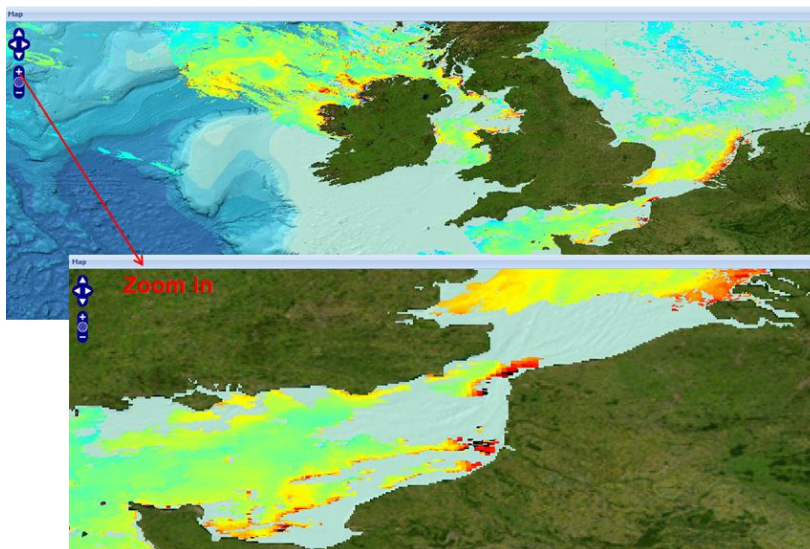
### **How can you select data?**

The calendar tool is used to select earth observation data and in-situ observations for a particular date. A colour legend is used to indicate what type of data are available for the month. See Section 3 for more details on the use of the Calendar Tool.

Color	Data available
	Earth observation data
	In-situ data
	Earth observation data and In-situ data

### **How can you view a more detailed map?**

Use the zoom functionality to zoom in on the 2Seas territory or even a smaller area.

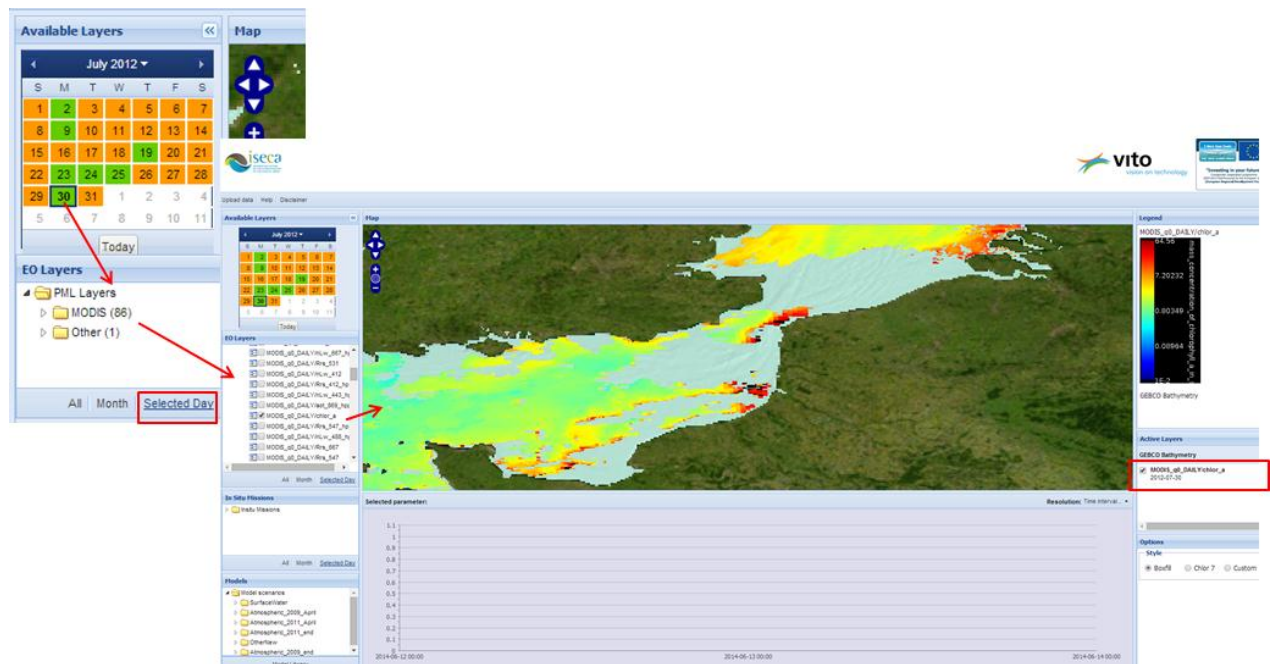


**Zoom functionality**

### **How can you select Earth Observation (EO) data?**

Example EO data: July 30<sup>th</sup>, 2012:

1. Select July 30<sup>th</sup>, 2012 in the Calendar
2. Click "Selected Day", under EO layers (left side of interface)
3. In the list choose the MODIS satellite (<http://modis.gsfc.nasa.gov/>)
4. Scroll down to the preferred indicator, for example MODIS\_qo\_Daily/chlor\_a and fill the check box to select the EO map
5. The EO data layer appears in the active layer frame



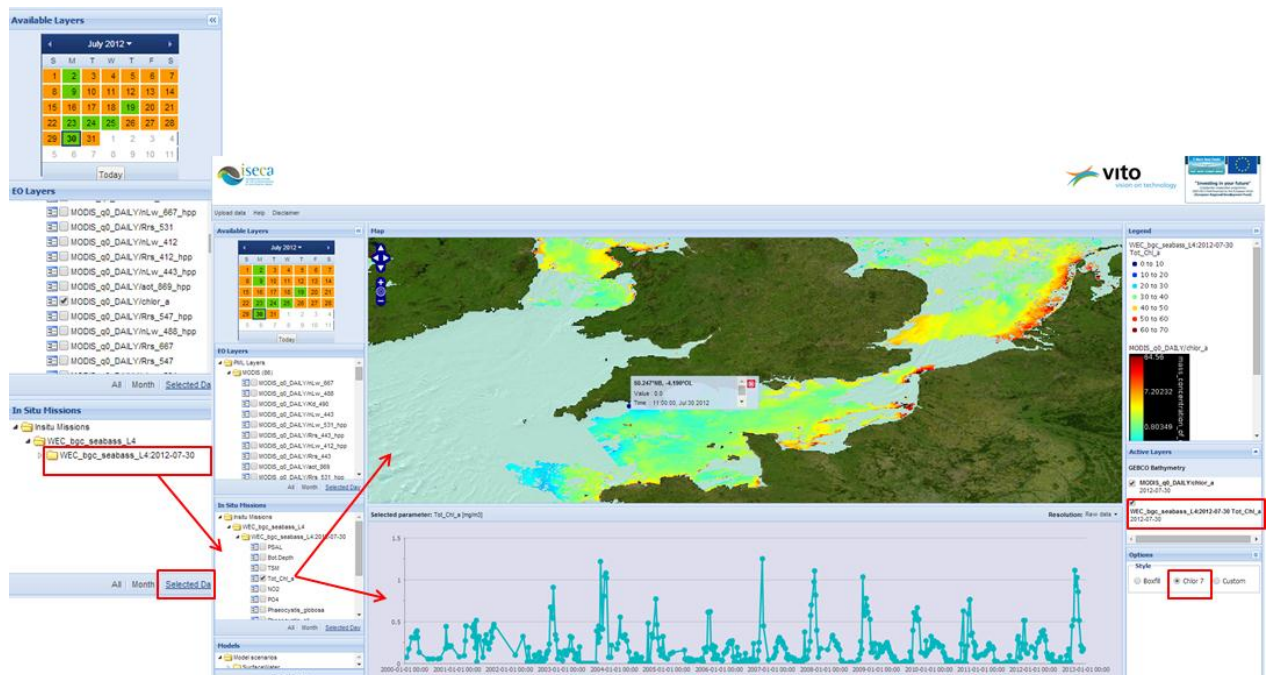
**Selecting earth observation data**

### **How can you select in-situ data?**

In-situ data example (same day) chlorophyll-a as key indicator for eutrophication:

1. In the calendar tool go to August 23, 2011 (for example)
2. Under In Situ Missions click "Selected Day"
3. In the Legend Options (right side) choose the legend style "chlor\_7" for better visualization of the markers
4. Choose the preferred Mission from the list (for example NIOO\_Noordwijk 10 km)
5. Select the preferred indicator "Tot\_Ch1\_a"
6. Clicking one of the in-situ markers gives the value and time
7. The in-situ data layer appears in the active layer frame. It includes two items: the data sampling locations and a trend line for the complete dataset.



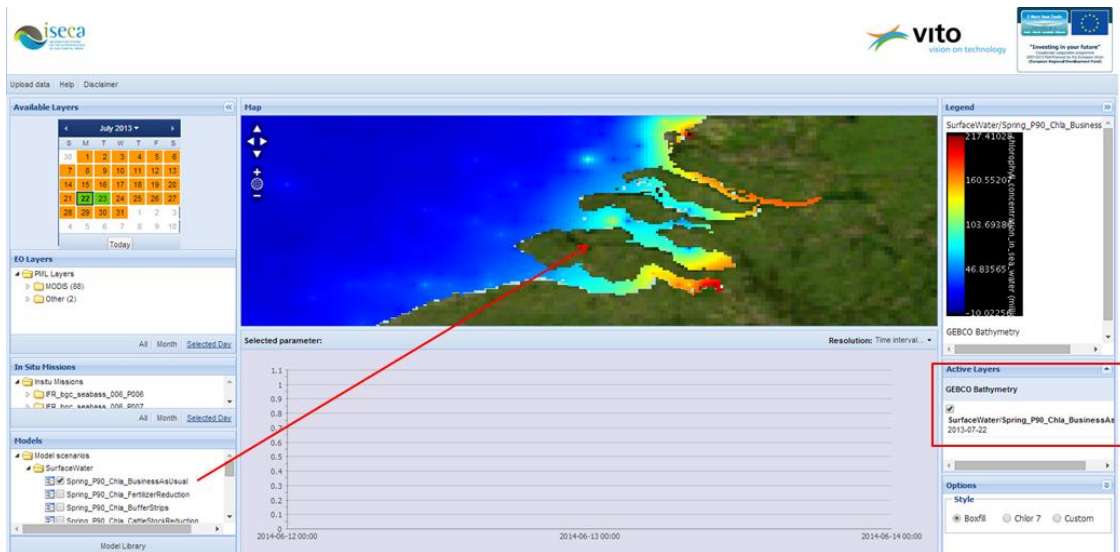


**Selecting in-situ data**

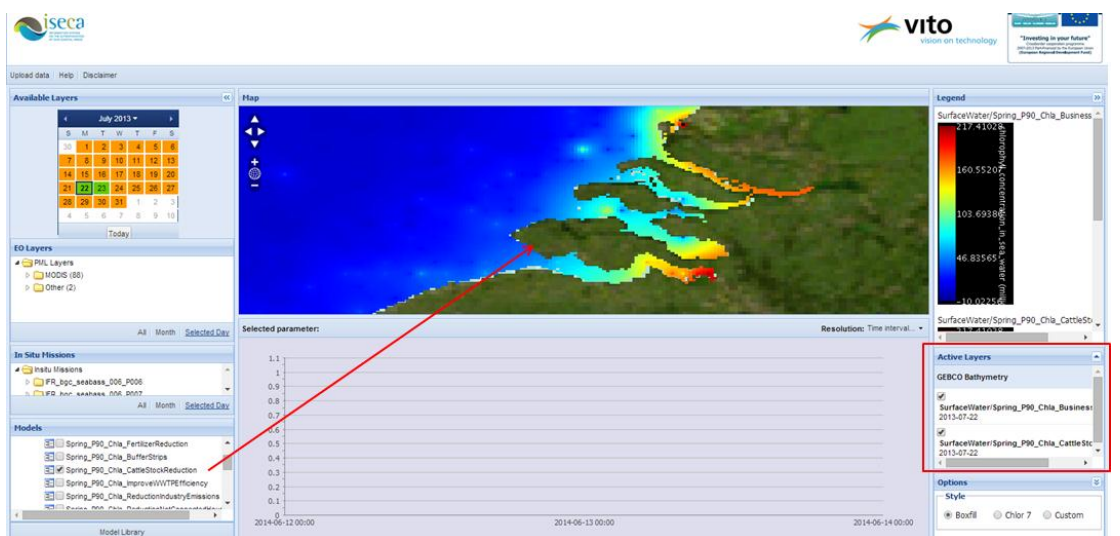
### **How can you visualize model scenarios?**

Model scenarios or simulations are not related to particular date or year but based on spring-average for period 2005-2012 using OSPAR assumptions. More details are given in Section 6 – Model Scenarios. The technical steps are:

1. The recommendation is to undo the earlier selections under “Active Layers” on the right-hand side first or press the function key F5 (refresh)
2. Zoom in on the Belgian coastal waters for a better view
3. Go to the Models menu (lower left)
4. Under “Model data” select the preferred model theme, for example 'SurfaceWater' and then the preferred scenario, for example “Spring\_P90\_Chla\_BusinessAsUsual - this is a scenario without additional management measures to reduce the five-year average nutrient load from the Scheldt basin
5. Leave the image and select (for example) the scenario “ScenariosBCZ/Spring\_Chla\_CattleStockReduction” to see the difference in water quality
6. Both model scenarios layers appear in the active layer frame and you can check or uncheck the layers to see the difference in water quality



**SurfaceWater/Spring\_P90\_Chla\_BusinessAsUsual**



**SurfaceWater/Spring\_P90\_Chla\_CattleStockReduction**

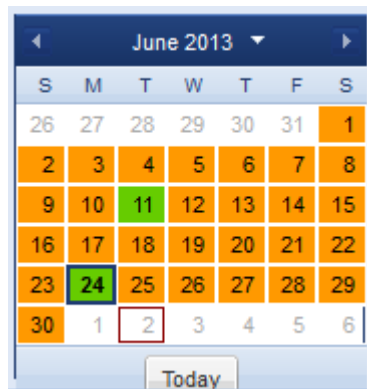
### Tips

- Every EO layer or in-situ data layer selected will be added to the Active Layers box. Here you select the layers that you want to visualize on the map.
- Always press F5 when you start with a new selection corresponding to other dates or the visualized model scenarios.
- When you selected EO data and in-situ data and you cannot see the monitoring points. Change the order of the active layers by drag and drop. (*more info: [Active layer box](#)*)
- Always select the legend style first before you select the in-situ data layer.



### 3 Calendar tool

The calendar tool is used to select earth observation data and in-situ on a particular day.



*Calendar tool*

The calendar tool uses a color legend that indicates what data is available on which day.

Next table contains the color legend:

Color	Data available
	Earth observation data
	In-situ data
	Earth observation data and In-situ data

#### ***Change the month:***

1. Click on the left arrow in the header in order to go to the previous month.
2. Click on the right arrow in the header in order to go to the next month
3. Click on the arrow next to the current month for selecting another month from the list of months



**Change from month**

**Select a particular day:**

- Click on a particular day in the selected month

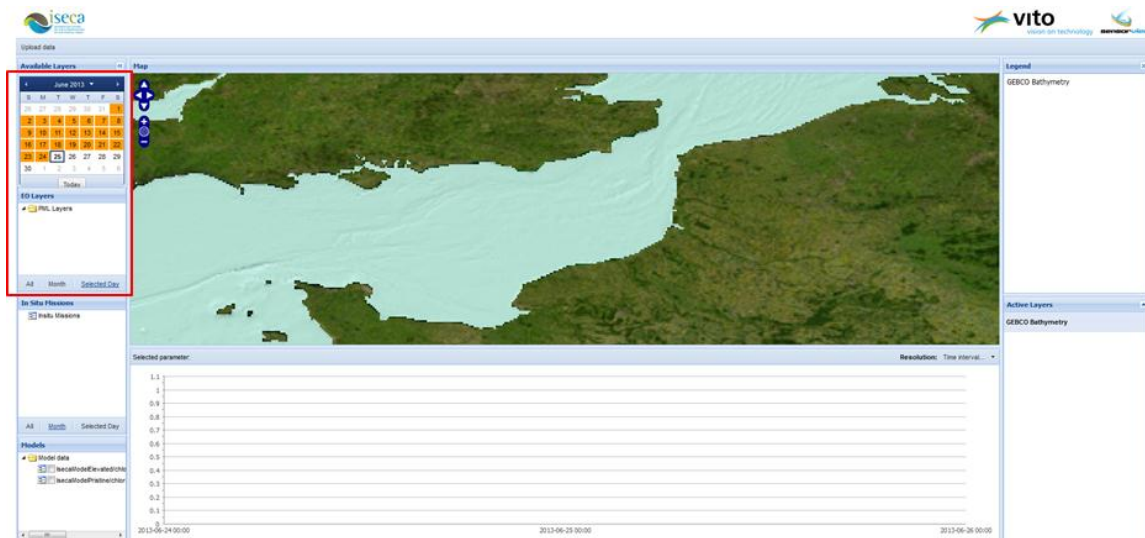
**Select current day:**

- Click on the button 'Today' and the calendar tool selects the current day. This is an in-built option. Usually the system is not yet updated for the actual date.

## 4 Earth observation data

The earth observation data are stored at the Plymouth Marine Laboratory (PML).

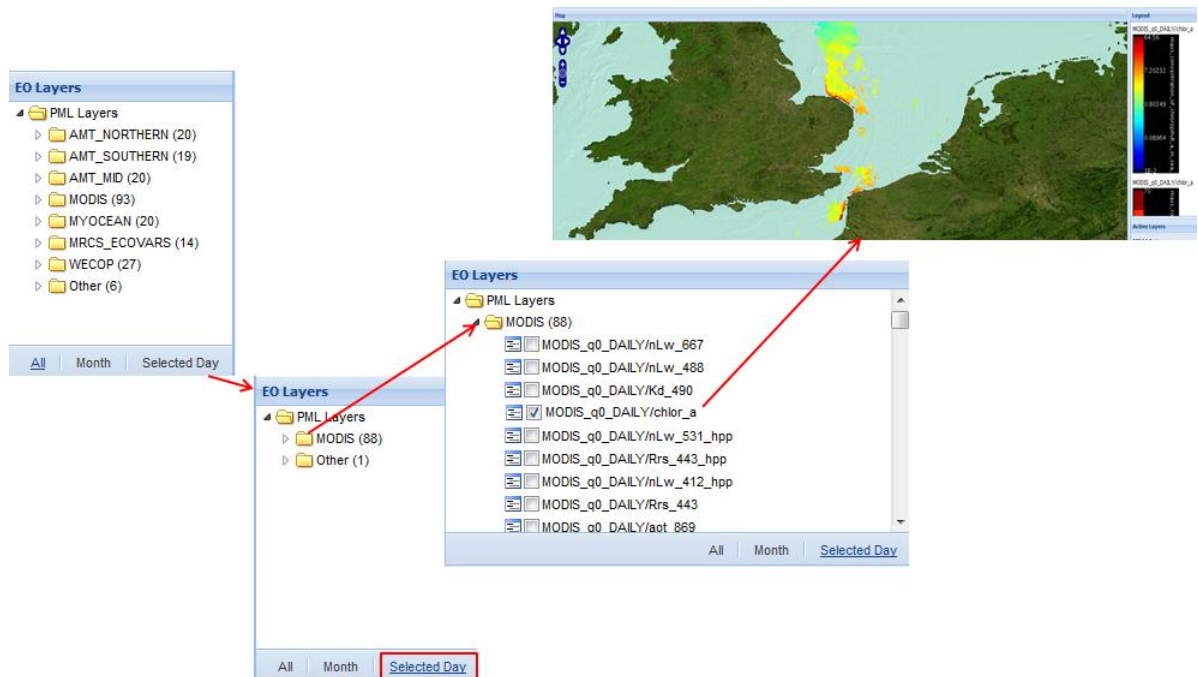
The user can select and visualize an earth observation data layer for specific dates using the calendar search tool



*Selection of EO layers starts with the calendar tool*

**Select an EO layer on a selected day:**

1. [Select a particular day in the calendar tool](#)
2. Click on 'Selected day' in the EO layer selection box and the corresponding EO layers are displayed, grouped in folders.
3. Open a folder
4. Select a particular EO layer and this map layer will be visualized on the screen



The user can select an EO layer from the same month by clicking on 'Month' or view all EO layers by clicking on 'All', at the bottom of the EO layer selection box.

## 5 In-situ data

In-situ data are field observations delivered by automated sensors mounted on buoys or vessels. The user can select and visualize field measurements on a map and on a time series showing the trend over longer periods of time.



*Selection of in-situ data in the web tool*

Related functionalities are:

- [Select in-situ data](#)
- [View in-situ data](#)
- [Colored measurement points](#)
- [Upload in-situ data](#)

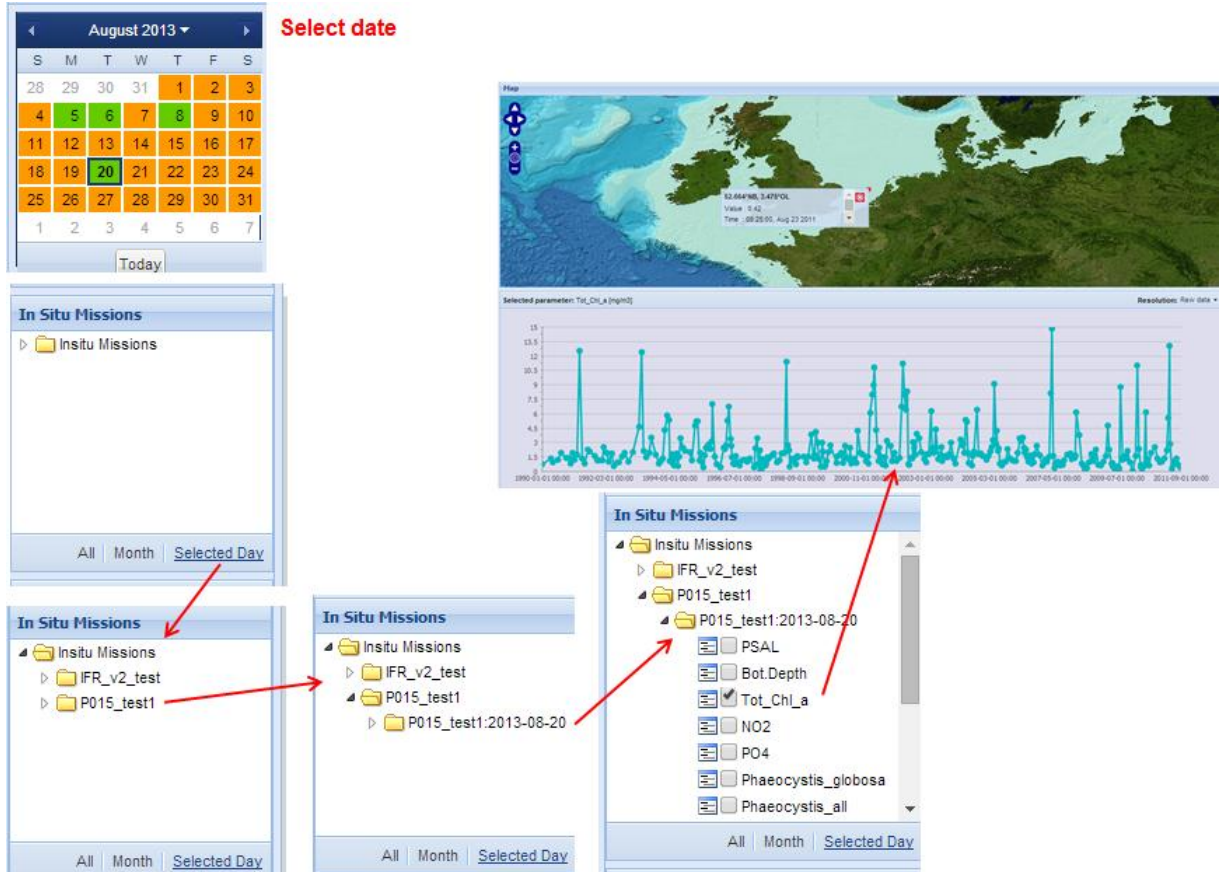
### 5.1 Select in-situ data

**Select in-situ data on a selected day:**

1. [Select a particular day in the calendar tool](#)
2. Click on 'Selected day' in the In-situ mission selection box and the corresponding in-situ data are displayed, grouped in folders.
3. Open a folder
4. Select a particular in-situ mission. A mission is a dataset which has been uploaded by other users of the WAS.
5. Select a parameter, e.g. the total chlorophyll-a value ("Tot\_Ch1\_a"). The indicator for the selected mission will be visualized on the map, and the field measurements on the



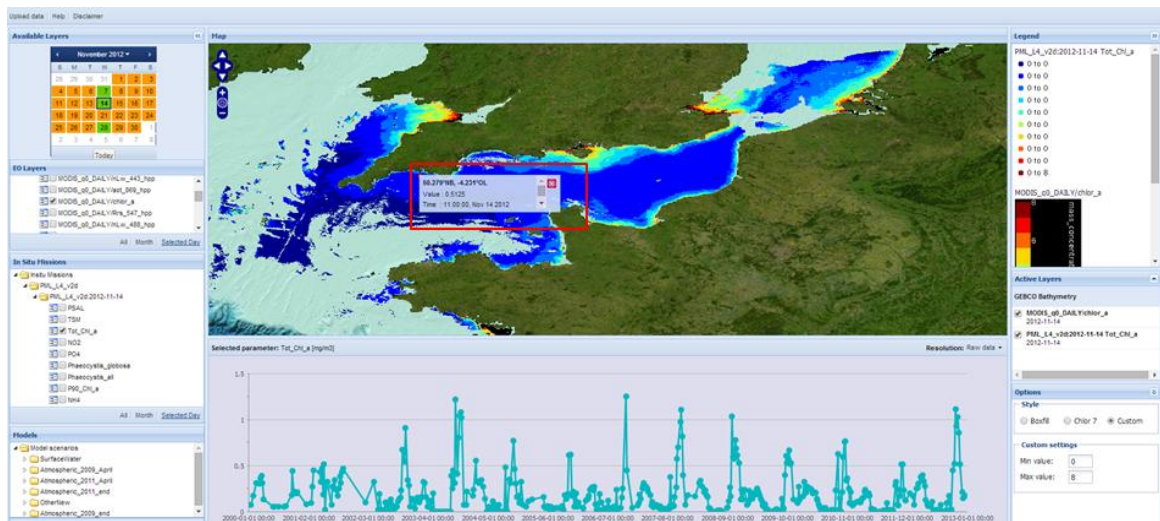
time trend line at the bottom of your screen.



The user can select in-situ data from the same month by clicking on 'Month' or he can view all in-situ data by clicking on 'All', at the bottom of the in-situ mission selection box.

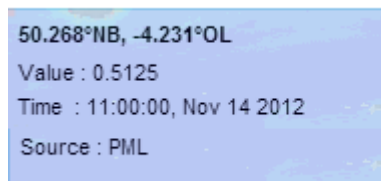
## 5.2 View in-situ data

The user can view the individual field measurements by clicking on a measurement point on the map. A popup screen appears with the coordinates of the field sampling location and the measurement value for the selected parameter.



*Popup screen with individual measurement information*

The popup screen gives the coordinates, the measurement value, the measurement time and the source.



*Detail of the pop-up information provided for the sampling location.*

### 5.3 Coloring the measurement points

The web tool provides the possibility to colour the measurement points on the map so that locations with high concentrations, hot spots, are easy to recognize.

#### **Coloring of the measurement points:**

1. Select a specific [legend style](#)
2. Select the in-situ data and the measurement points are automatically colored corresponding the measurement values.

See Section 9 for more details on the use of the Legend Tool.

## 5.4 Uploading in-situ data

The user can also upload datasets of in-situ observations (“missions”) into the WAS. The datasets are to be in comma-separated files or CSV format.

### ***Preparing the upload file.***

Before starting the upload of in-situ data, this checklist should be followed:

1. Only registered in-situ parameters <sup>1</sup>are allowed. ([see in-situ parameters](#))
2. Provide one upload file per fixed measurement location (station).  
This is important for the visualization of the trend analysis per fixed station.
3. The data must be sorted in chronological order
4. The upload file must be in accordance with the template file provided.

The upload file must contain at least the columns Cruise, Station, Type, Time, Lon, Lat and Source. The in-situ parameters must be in accordance with the registered in-situ parameters.

Cruise,Station,Type,Time,Lon,Lat,Temperature,Bot.Depth,Pres.,PSAL,SPM,Tot\_Chl\_a,NO2,NO2+NO3,NH4,SiO2,PO4,Phaeocystis\_globosa,Phaeocystis\_all,P90\_Chl\_a,Source

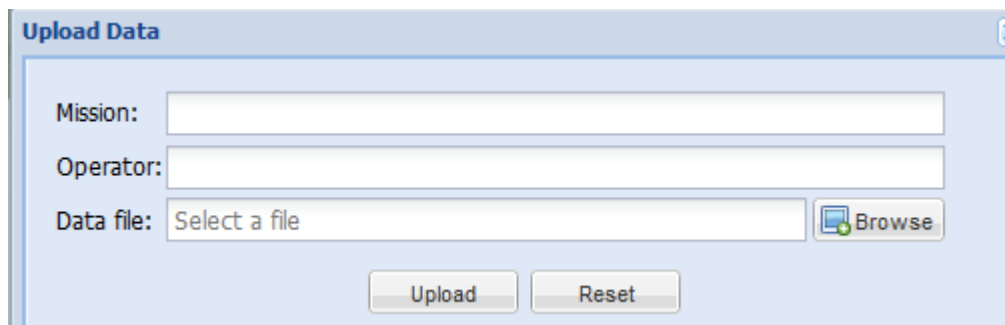
Obligated

Variable list of registered in-situ parameters

Obligated

### ***Upload in-situ data.***

1. Click on 'Upload data' and next screen appears:



2. Enter a mission name, for example “Belgian\_Coast\_Nov\_2013)
3. Enter a meaningful operator name, for example “DrMatthews\_VITO”
4. Select your data file by using the 'Browse' button

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<sup>1</sup> Registered in-situ parameters are parameters defined in the WAS application.

5. Click on 'Upload'
6. The following error messages may appear

### Errors

<b>Error</b>	<b>Explanation</b>
Err_missing_metadataend	The word 'metadata_labels_end' is missing in the file. <b>Please check the upload file.</b>
Decreasing line date at line [line number]	The data is not sorted in descending order by time. <b>Please check the upload file.</b>
Source [Source value] not length 3 in line [line number]	The source can contain max. 3 characters. <b>Please the upload file.</b>
More items in line [line number] than in header	The header is missing one or more columns compared with the data. <b>Please check the upload file.</b>
Wrong size createtimestamp for [timestamp] line [line number]	The time has a wrong format in line [line number]. <b>Please check the upload file.</b>
Err_sensor_missing_from_database[in-situ parameter]	The in-situ parameter in the error message is not registered in the WAS application. <b>Please contact VITO for registering the new in-situ parameter and mention the mission that you were loading into the WAS application.</b>

## 5.5 In-situ parameters

Currently the WAS provides the possibility to load in-situ data related to following parameters:

<b>In-situ parameter</b>	<b>Unit</b>
Tot_ChI_a	Mg/m3
TSM	g/m3
TURB_TNU	NTU
NO2	Millimole/m3
NO2+N03	Millimole/m3
PO4	Millimole/m3
NH4	Mg/m3
SiO2	Millimole/m3
P90_ChI_a	Mg/m3
Phaeocystis_globosa	Billion cells/m3
Phaeocystis_all	Billion cells/m3
Bot.Depth	decibar
PSAL	P.S.U.
Pres.	P.S.U.
Temperature	°C
SPM	g/m3

If you would like to use other in-situ parameters, please contact [jeanluc.dekok@vito.be](mailto:jeanluc.dekok@vito.be).

## 6 Model scenarios

Different model simulations can be used to show the potential impact of different management strategies available to the EU member states. The model simulations are based on an empirical model for the dependency of the nutrient content and other parameters on the salinity, using sample data reported by the OSPAR workgroup in 2008 and a linear dependence on the nitrogen inflow from the main rivers. In addition, model simulations are available for the atmospheric deposition of eutrophication-related substances such as nitrogen oxides and ammonia from different sources.

### 6.1 Water-borne inputs

Water-borne inputs of nutrients are an important cause of eutrophication. A simplified “proxy” model has been used for the WAS to demonstrate the potential of simulation modelling. The results are intended for demonstration of the comparison of different management scenarios in the WAS and have not been validated. A nitrogen balance model for the Scheldt river basin (Vermaat et al., 2012) is used to estimate the yearly nitrogen load for each scenario. The spatial distribution in coastal waters has been obtained by two-dimensional interpolation of salinity data provided by the ICES Oceanographic Database (ICES, 2012) and a “mixing diagram” for the dependency between the winter DIN levels and practical salinity for the Belgian Coastal Waters under pristine and actual conditions as reported by the Belgian OSPAR workgroup conditions (OSPAR, 2008) during 2000-2005, and another linear relationship between the winter DIN and spring chlorophyll-a content (OSPAR, 2008). The 2D interpolation is based on the inpainting algorithm by John d’Errico (2006). The critical assessment (elevated) level is assumed to be 50 % above the pristine level (OSPAR criterion). Finally, these scenarios are used for proportional rescaling of the nitrogen concentrations in the coastal waters affected by the Scheldt effluents of nutrients. The model is used to determine the impact of different measures to reduce the nitrogen outflow to coastal waters, such as reduction of the fertilizer use and cattle stock size. The following scenarios are currently available:

1. Business-as-usual scenario: no action taken, result is reduction of 2.2 % in total nitrogen load by 2050 compared to the year 2010
2. Gradual decrease of fertilizer use to 50 % of the initial value by 2040 (23 % reduction nitrogen load by 2050)
3. Buffer strips along receiving streams are considered a potentially useful means to achieve nutrient retention (Vermaat et al., 2012). Gradual increase in the use of buffer strips along river streams bordering agricultural land with a maximum width in the range of 10-50 m in the year 2040 (depending on the province). This leads to a 18.5 % reduction in the nitrogen load by 2050.
4. Gradual decrease of cattle stock size with 50 % by the year 2040 (24.6 % reduction in the nitrogen load by 2050)



5. Gradual improvement in the efficiency of waste-water treatment plants with 40 % by the year 2040 (13.6 % reduction in the nitrogen load by 2050)
6. Gradual reduction in the industrial effluents of nitrogen to 0 % by 2040 (resulting in 12.7 % reduction in the nitrogen load by 2050)
7. Gradual reduction in the effluents from households which are not connected to the waste-water treatment system to 0 % by 2040 (26.5 % reduction in nitrogen load by 2050)
8. All management alternatives B-H combined (78.3 % reduction in the nitrogen load by 2050)
9. Business-as-usual with climate change scenario G – unchanged circulation pattern with 1 degree increase in temperature. KNMI 2006 Climate Change Scenarios see [www.knmi.nl](http://www.knmi.nl). (results in 2 % reduction nitrogen load)
10. Business-as-usual with climate change scenario W+ – changed circulation pattern with 2 degree increase in temperature. KNMI 2006 Climate Change Scenarios see [www.knmi.nl](http://www.knmi.nl). (results in 5.4 % reduction nitrogen load)

In addition two other scenarios are available: one for the pristine conditions (based on the mixing diagram reported in OSPAR(2008)), and one for the critical OSPAR threshold (50 % above the pristine level).

## 6.2 Atmospheric deposition

Atmospheric deposition scenarios are also available through the WAS. The atmospheric inputs of land- and sea-based emission sources such as industry and shipping are significant for eutrophication. For the Greater North Sea the average contribution of atmospheric inputs to the atmospheric depositions for the EMEP model over the years 1990-2004 was estimated to be 33 % (OSPAR, 2007). However, more detailed information on the emission and transport of substances such as NH<sub>3</sub> and NO<sub>x</sub> is needed to understand the impact on marine eutrophication. This task is carried out by the Centre of Numerical Modelling and Process Analysis (CNMPA), of the University of Greenwich. High resolution (7x7 km) emission data were generated by VITO in October 2012 as part of an agreement to support this modelling activity. The annual emission data provided for the years 1990, 2000 and 2009 were obtained by downscaling officially reported national emissions with geospatial proxy data by means of a methodology which is also used by E-MAP (Maes et al., 2009). In addition, time profiles corresponding to the EMEP sectors were delivered to allow for temporal disaggregation at the level of months, days and hours. Three components are needed to achieve detailed modelling of the atmospheric inputs to eutrophication: (a) meteorological data, (b) emissions data and (c) modelling software for atmospheric transport and deposition. Freely downloadable meteorological data records from two different sources were considered: ECMWF Reanalysis data set ERA Interim 0.75 degree resolution (<http://www.ecmwf.int>) and NCEP (U.S.), Final Analysis, 1 degree resolution. The ECMWF data were chosen because of the slightly higher resolution, excellent compatibility with the LPD tracing software Flexpart (described below) and preference for European data. The records contain wind velocities, temperature, humidity, pressure, sunshine, precipitation and some other variables needed for the tracing model. The frequency of records is every 6 hours covering the period from 1979 until 2 months before real time.

The calculations were done with the open source, publicly available software FLEXPART

(<http://flexpart.eu>) which is based on the Lagrangian Particle Dispersion method for tracing the movement of pollutants in the atmosphere and includes also algorithms for determining the rates of their deposition onto the ground or the sea surface. The validation of the model set up was done by comparing the concentrations of nitrogen oxides calculated by FLEXPART at a number of prescribed receptor points on the ground in Kent, UK with the corresponding measurements from a publicly available dataset (<http://www.kentair.org.uk/data/data-selector>). On the WAS webpages, the results of the computer modelling are presented for the transport by air of nitrogen oxides and ammonia from their sources to the coastal waters in the 2Seas region. The examples provided are for emissions in 2000 and 2009 and historical weather data for 2009 and 2011. All four combinations between these emission and simulation years are included, so that comparisons can be made and the effect of both the emissions and the weather can be demonstrated. The atmospheric inputs of nitrogen nutrients are presented as deposition maps for the first 4 months of the studied years and for complete years. The period of the first 4 months was chosen because in the Southern North Sea, harmful algal blooms due to eutrophication usually happen in April. Total quantities of nitrogen oxides and ammonia are presented as well as specific maps of deposition resulting from road and other transport. The main conclusions are:

- Ammonia is responsible for the largest share of nitrogen deposits from the atmosphere; being more soluble, ammonia tends to get deposited not far from the source.
- Nitrogen oxides emissions are more likely to leave the region and be deposited elsewhere. (Far-away emissions which may be carried by the wind and be deposited in the 2Seas region are not part of these simulations.)
- Heavy nutrient load onto the coastal waters of Belgium and the Netherlands is observed in all model scenarios.

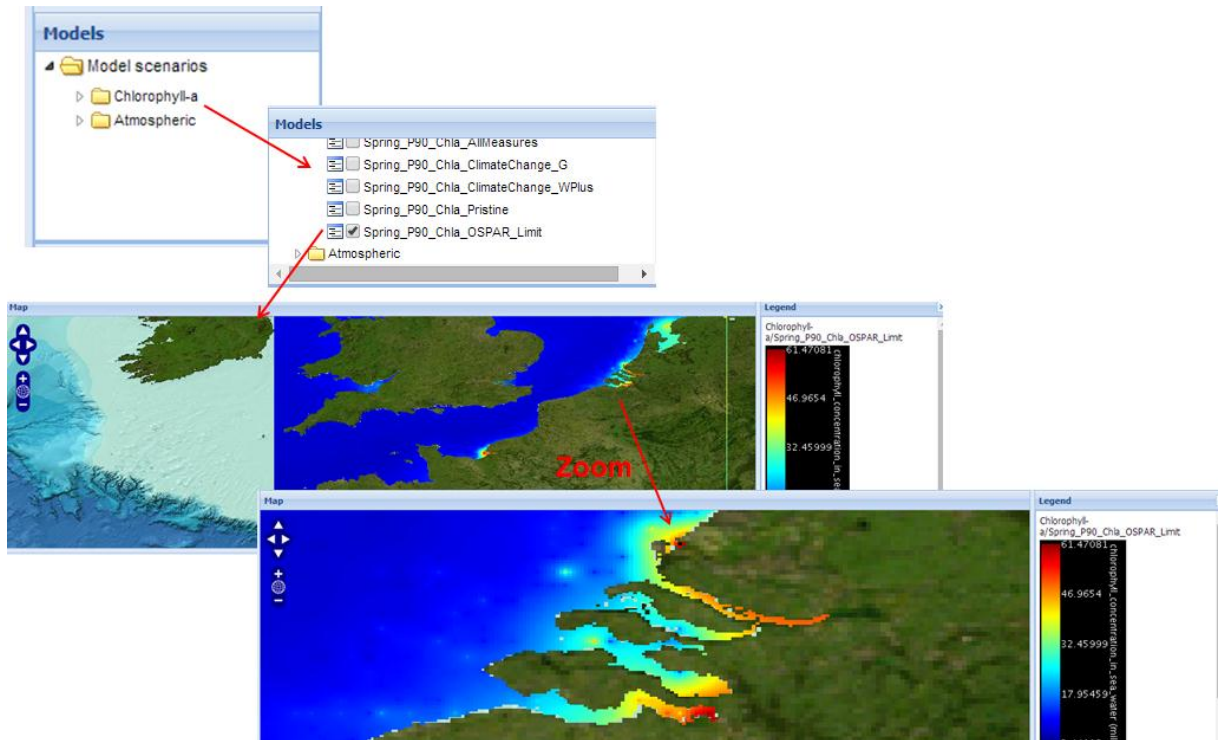
### 6.3 Selecting a model scenario



*Selection of model scenarios in the web tool*

**Select a model scenario:**

- Click on a directory: Chlorophyll-a or Atmospheric
- Select a model simulation in the model selection box and the corresponding scenario will be displayed on the map.



## 7 Model library

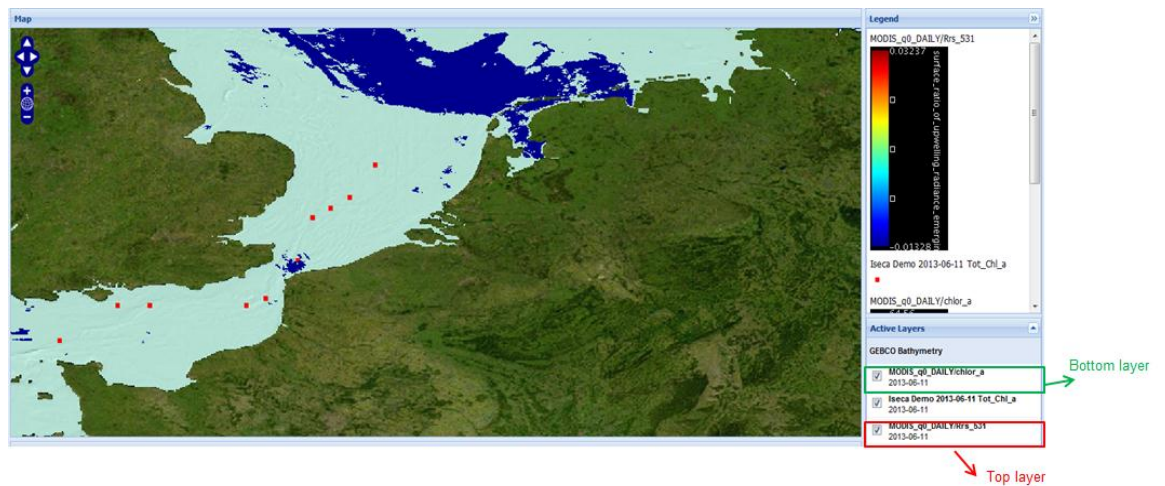
### COMPONENT-BASED MODELLING OF ENVIRONMENTAL SYSTEMS

The effort to design, implement and validate integrated models of environmental systems is often considerable. Following the practice in engineering and manufacturing, a component-based approach could facilitate the development and exchange of model constructs between researchers (De Kok et al., 2010; De Kok et al., 2013). The idea of a generic model libraries to use reusable components for integrated systems modelling (Hopkins et al., 2011) was one of the deliverables of the EU-FP6 research project SPICOSA (<http://www.spicosa.eu>). This facilitates the construction of models, exchange of model constructs between research teams, and the maintenance of models. The project used ExtendSim ([www.extendsim.com](http://www.extendsim.com)) as common simulation modelling framework. The majority of the 18 SPICOSA case studies concerned coastal eutrophication and shell species culture, making these very relevant for the ISECA project. In ISECA the case study model for nitrogen transport in the Westerscheldt Estuary (Vermaat et al., 2012) was further developed and used to estimate nitrogen concentrations in the Belgian coastal waters and use these for the “SurfaceWater” model scenarios in the WAS. . A number of case study models and demo version of ExtendSim can be downloaded and installed through the hyperlink provided here.

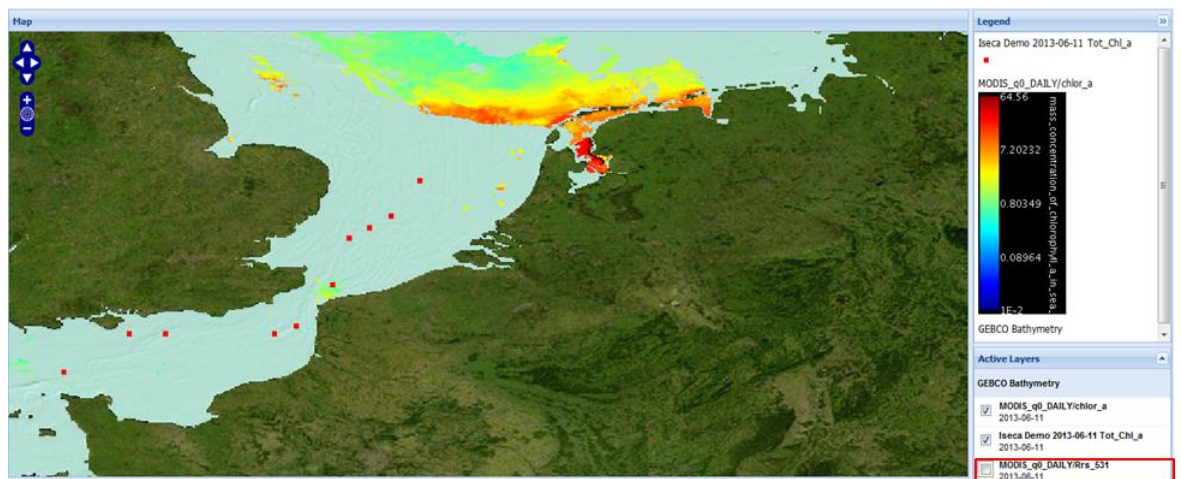
The SPICOSA model library and some example models are accessible through the “Model Library” button on the lower left of the WAS interface.

## 8 Active layer box

The active layer box allows the user to change the sequence of the layers with drag and drop, and the user can select or deselect a particular layer. The layers appears automatically in the active layer box when the user selects an EO layer, in-situ data or a model scenario. The top layer of the map corresponds with the bottom map in the active layer box.

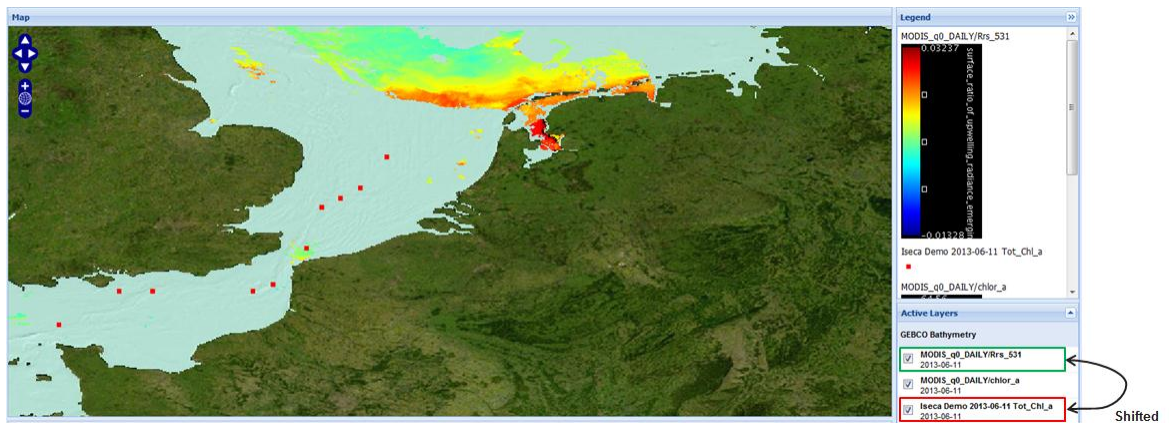


Deselect the top layer gives:



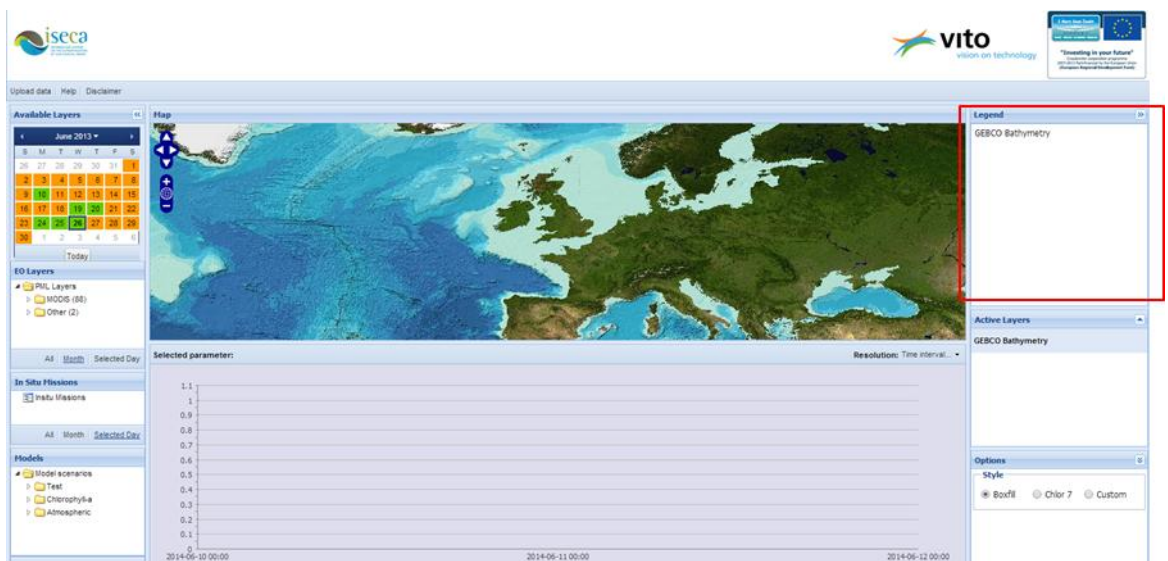
Changing the sequence of the layers gives:





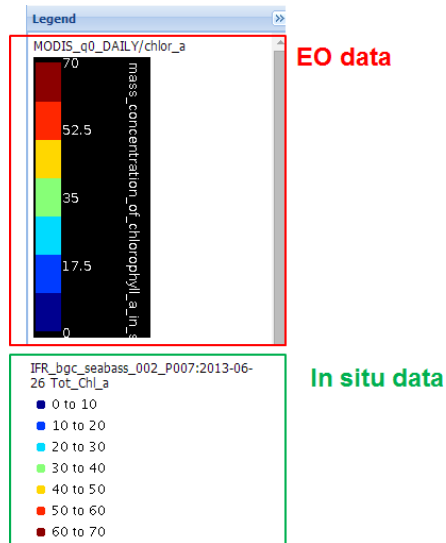
## 9 Legend

The legend box displays the legends of the different selected active layers ([Active layer box](#)).

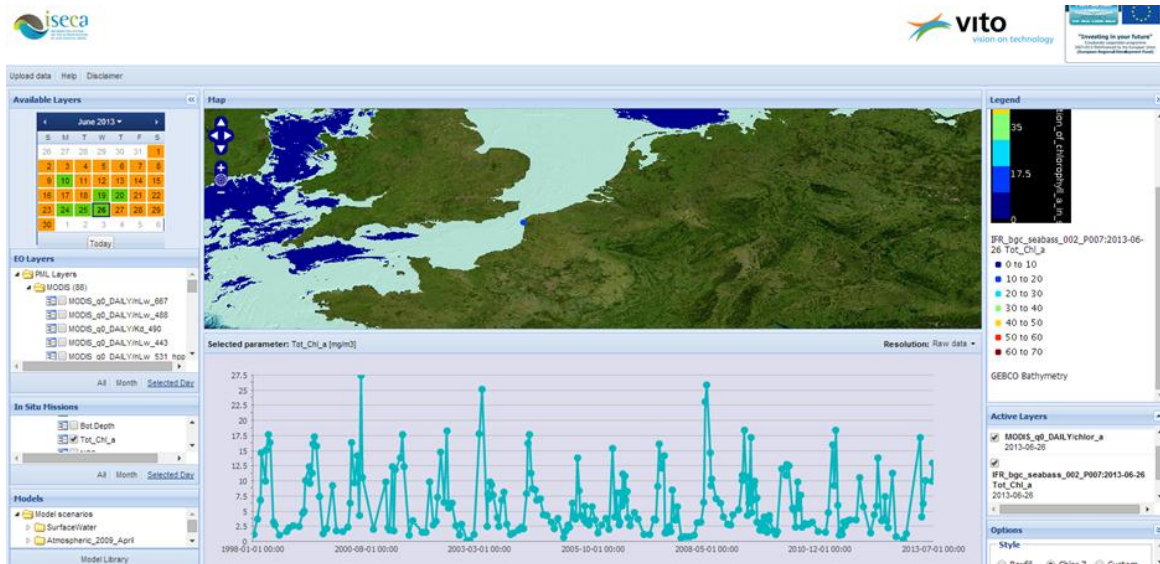


*Legend box in the web tool*

Next figure shows the legend box:



For comparing different data layers, it is important that all data layers are visualized with the same legend. ([Colored measurement points](#))  
The user can easily recognize the locations with high concentrations (*hot spots*), this can be useful to improve in-situ monitoring missions and the calibration of processed earth observation data and model simulations.

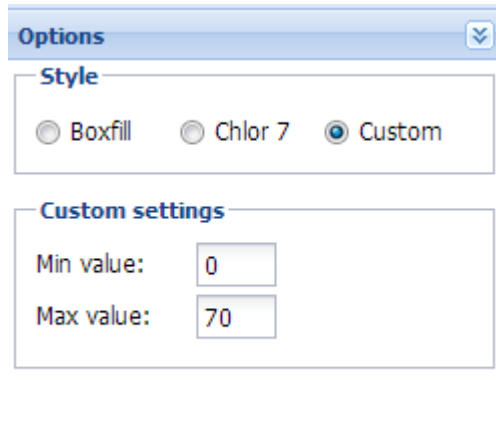


Integration of in-situ data with earth observation data with the same legend

**Remark:** It is important that all layers (EO data layer, in-situ data layer, model data layer) uses the same legend for the same parameter.

## 9.1 Legend Style

The legend Style box contains the different styles for coloring the in-situ measurement points. (see [Colored measurement points](#))



The screenshot shows a dialog box titled "Options" with a dropdown arrow in the top right corner. It is divided into two sections. The first section, "Style", contains three radio buttons: "Boxfill", "Chlor 7", and "Custom". The "Custom" radio button is selected. The second section, "Custom settings", contains two input fields: "Min value:" with the value "0" and "Max value:" with the value "70".

*Legend styles*

Three options for the legend styles are provided:

- 1. Boxfill**  
Boxfill is by default selected and is used to visualize the in-situ measurement points.
- 2. Chlor 7**  
Select Chlor 7 when you want to visualize the measurements related to the parameter Tot\_Chlor\_a
- 3. Custom**  
Select Custom when you want to visualize the measurements related to other parameters.  
Here you define the min. and the max. value for generating the legend style.

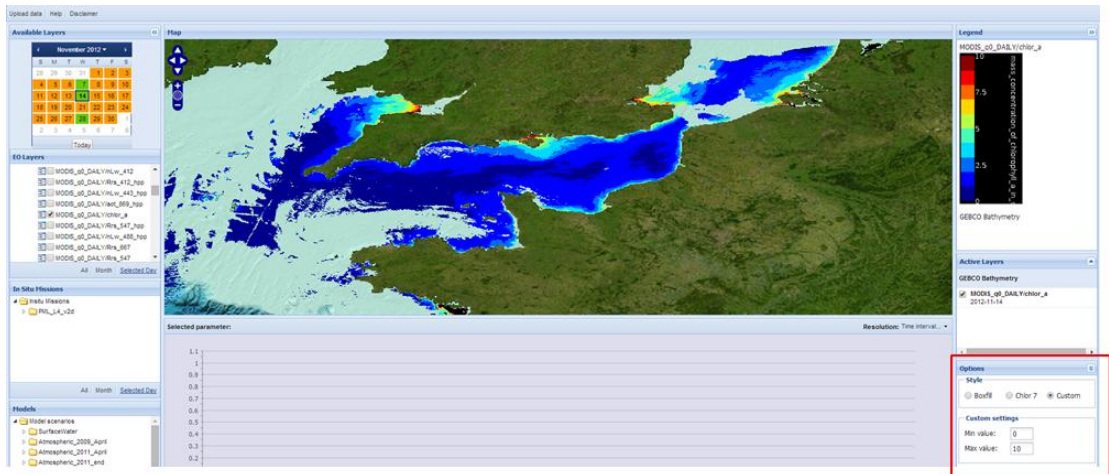
### **How to use?**

1. Select always first the legend style before you select the in-situ data layer or the EO layer, for instance select the legend style 'Custom' and an EO layer



*Legend style 'Custom' is selected before the selection of the EO layer*

2. Change the max. value from 70 to 10
3. Reselect the EO layer in the EO layers box



*The effect of a changed Legend style 'Custom'*

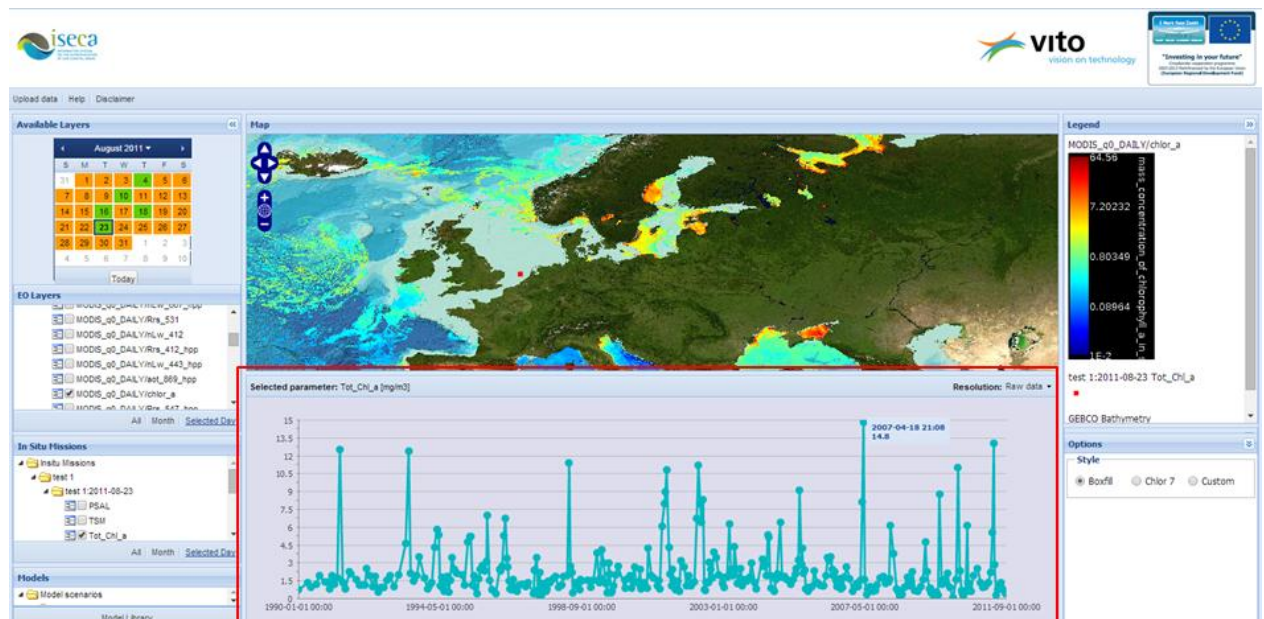


## 10 Time series

Trends are visualized as a time series, when possible.

The time series displays the measurement values of the selected parameter in a mission for the whole period. The available in-situ parameters in the WAS are described in section 5.5 In-situ parameters.

The figure shows an example of a trend for total chlorophyll-a value for the period of 1990 until 2011. The user can select a point on the graph to view the individual measurement in the time series.



**Trend analysis**



## 11 Bibliography

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