

Final report

## Information System on the Eutrophication of our Coastal Seas (ISECA)

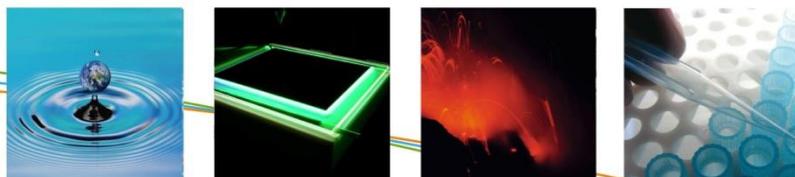
### D3.1 - The Web-based Application Server: Combining Earth Observation with In-Situ Data and Modelling.

Final Report, August 2014

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Technological Research)

2014/Unit Environmental Modelling (RMA)/R/135

9/15/2014



## ACKNOWLEDGEMENT

This work described in this report has been co-funded by the INTERREGIVa 2Seas Program (2007-2013) Contract no. 07-027-FR. [www.interreg4a-2mers.eu](http://www.interreg4a-2mers.eu)

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## SUMMARY

The cross-border cooperation project ISECA (Information System on the Eutrophication of our CoAstal Seas), which is supported by the 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 ISECA 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 (Figure 1), aiming both at knowledge partners and the relevant authorities and general public. The project is coordinated by ADRINORD in France. The ISECA project is to demonstrate the added value of combining three complementary sources of information on eutrophication: earth observation, in-situ measurements and modelling. Action 3 – Modelling - is aimed at designing a web-based platform to demonstrate the integration of model simulations with in-situ observations and earth observation data. This report discusses the currently available models in the context of the EU regulations (WFD, OSPAR, MSFD) and gives an outline of the architecture and functionalities of the prototype web service to be developed (the Web-based Application System or WAS).

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**LIST OF ACRONYMS**

ASSETS	ASSEssment of Estuarine Trophic Status
BCS/Z	Belgian Continental Shelf/Zone
CF	Climate and Forestry
COMPP	(OSPAR) COMPREhensive Procedure
DIN	Dissolved Inorganic Nitrogen
DIP	Dissolved Inorganic Phosphorus
ECOOP	European Coastal sea Operational Observing and Forecasting System
EEZ	<a href="http://www.ecoop.eu">www.ecoop.eu</a> European Exclusive Economic Zone (200 nm limit)
EMIS	Environmental Marine Information System; <a href="http://emis.jrc.ec.europa.eu/">http://emis.jrc.ec.europa.eu/</a>
EQR	Ecological Quality Ratio
ERSEM	European Regional Seas Ecosystem Model
EUTRISK	EUTrophication RISK index
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms
GES	Good Environmental Status
GOOS	Global Ocean Observing System
GSR	Global Solar Radiation (in MJm <sup>-2</sup> )
HAB	Harmful Algal Bloom
HEAT	HELCOM Eutrophication Assessment Tool
ICEP	Indicator of Coastal Eutrophication Potential
ICES	International Council for the Exploration of the Sea; <a href="http://www.ices.dk">www.ices.dk</a>
ICG-EMO	Intersessional Correspondence Group Eutrophication MOdelling
ISECA	Information System on the Eutrophication of our CoAstal seas
LME	Large Marine Ecosystem
LOICZ	Land-Ocean Interactions in the Coastal Zone; <a href="http://www.loicz.org">www.loicz.org</a>
LPD	Liquid Phase Deposition
MEDPOL	Programme for the Assessment and Control of Pollution in the Mediterranean Region
MERIS	Medium Resolution Imaging Spectrometer MODerate resolution Imaging Spectrography
M_MAP	Mapping Package for MatLab ( <a href="http://www2.ocgy.ubc.ca/~rich/map.html">http://www2.ocgy.ubc.ca/~rich/map.html</a> )
MODIS	Moderate Resolution Imaging Spectroradiometer ( <a href="http://modis.gsfc.nasa.gov/">http://modis.gsfc.nasa.gov/</a> )
MSFD	Marine Strategic Framework Directive
NAO	North Atlantic Oscillation (dimensionless weather index); <a href="http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml">http://www.cpc.ncep.noaa.gov/products/precip/CWlink/pna/nao.shtml</a> ; <a href="http://www.cgd.ucar.edu/cas/jhurrell/indices.html">http://www.cgd.ucar.edu/cas/jhurrell/indices.html</a>
NETCDF	Net Common Data Format
NEWS	Nutrient Export from WaterSheds
OSPAR	OSlo-PARis convention; <a href="http://www.ospar.org">www.ospar.org</a>
PAR	Photosynthetic Active Radiation (in $\mu\text{mol photons m}^{-2}\text{s}^{-1}$ )
RC	Reference Condition
REPHY	Réseau de Surveillance PHYtoplanktonique
STI	Statistical Trophic Status
WAS	Web-based Application Server
WFD	Water Framework Directive
WFS	Web Features Service
WMS	Web Map Service



## CHAPTER 1 INTRODUCTION

The cross-border cooperation project ISECA (Information System on the Eutrophication of our CoAstal Seas), which is supported by the 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 ISECA 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 (Figure 1), aiming both at knowledge partners and the relevant authorities and general public. The project is coordinated by ADRINORD in France.

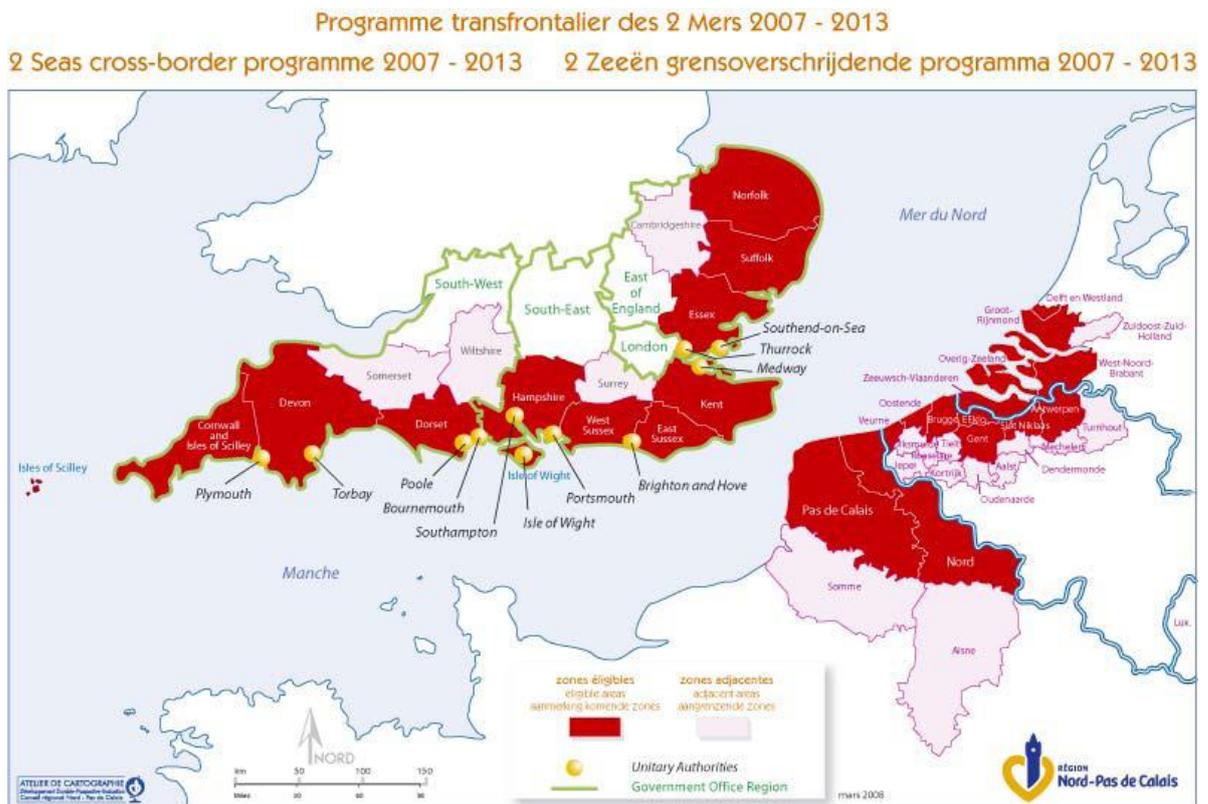


Figure 1-1 The project area for the 2Seas program ([www.interreg4a-2mers.eu](http://www.interreg4a-2mers.eu))

The general objective of the ISECA project is to demonstrate the potential value of the existing knowledge concerning *eutrophication* of the coastal waters in the 2Seas region, with both the scientific community and general public as target audience. Broadly speaking eutrophication is the process of excessive enrichment of waters with nutrients (Ferreira et al., 2010; Ferreira et al., 2011), which in turn may lead to algae growth, Harmful Algal Blooms (HABs) of algae such as *Phaeocystis*, hypoxia, and eventually fish mortality and eventually the production of toxins if the

circumstances allow this. Point (industrial and waste water treatment outflows and diffuse sources (mainly atmospheric deposition and agriculture) of nutrients contribute the eutrophication of estuarine and coastal and offshore 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).

The ISECA project is to demonstrate the added value of combining three complementary sources of information on eutrophication: earth observation, in-situ measurements and modelling. The project activities are organized around three interrelated actions (Figure 1-2). *Action 1 – Inventory* - is to identify the relevant stakeholders and determine the functional requirements for the information portal. The objective of *Action 2 – Earth Observation and in-situ data* - is to make an inventory of the available in-situ and earth observation data, as well as the methods to validate and improve these data. *Action 3 –Modelling* - is aimed at designing a web-based platform for the analysis of eutrophication, including demonstration models and a library of reusable components to model the ecological and economic impacts of eutrophication, using the outcomes of the recently concluded EU 6<sup>th</sup> Framework Program SPICOSA ([www.spicoso.eu](http://www.spicoso.eu)).

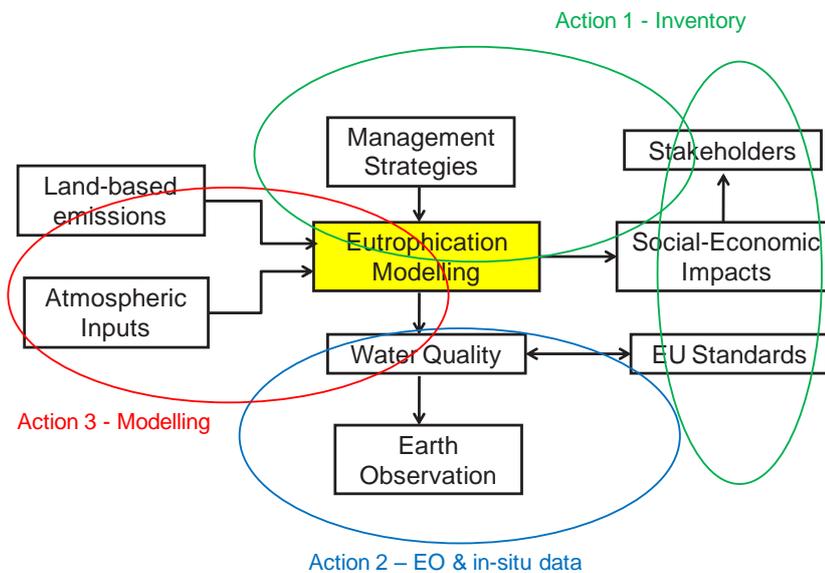


Figure 1-2 Integrated analysis of eutrophication in the ISECA project.

The main deliverable for Action 3 is the WAS, the Web Application Server. This is a demonstration version of web tool which has been developed in the ISECA project to combined earth observation data with in-situ measurements and model simulations. The earth observation data and model simulations are made available as maps, the in-situ measurements as point locations and trend lines. 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). In this report we present the architecture and functionalities of the current (August 2014) version of the WAS and the feedback and recommendations that were given

by stakeholders and potential users during the ISECA final conference held in Boulogne-sur-Mèr (F) on June 30, 2014. A detailed, step-by-step description of how to use the WAS is found in CHAPTER 3 of this report. Please note the WAS is only accessible through registration at the ISECA web site see <http://www.iseca.eu/en/>). Furthermore, the current version of the WAS only allows visualization of data and map layers, with the exception of in-situ data which can also be uploaded as files. Downloading of functionalities are not yet available.

CHAPTER 2 THE WEB APPLICATION SERVER

2.1. THE WEB-BASED APPLICATION SERVER – GENERAL ARCHITECTURE

Whereas earth observations and in-situ data can be used to visualize the historic and current eutrophication the model simulations can be used to forecast and compare the potential effectiveness of different (land-based) strategies to mitigate eutrophication. Data can also be used to calibrate and validate eutrophication models. The architecture of the WAS supports the visualization and comparison of offline, geospatial model results in NetCdf4 format, and comparison with EO and in-situ data. A GeoServer is used for the web service hosting by partner 2 (VITO). This open source software is a Java implementation and supports the sharing and editing of geospatial data by users. Data can be displayed on common mapping applications such as Google Maps, Google Earth etc. Web Map Services (WMS) for raster data and Web Feature Services (WFS) for vector data can be provided using the standard web browsers (MSiExplorer, GoogleChrome and FireFox). Different maps can be overlaid to produce composite results (provided the geocoordinates and size are identical) and transparent backgrounds are supported. The WMS maps are usually available in formats such as JPEG or GIF (i.e. not the data itself). Map operations (for example subtraction, seasonal averages etc) are not yet supported and should be made offline and beforehand. An outline for the basic functional architecture of the WAS is shown in Figure 2-1. The design is kept simple for the ISECA demonstration purpose and allow for updates of geospatial models if more sophisticated simulations become available. Web-based access to scientific models and data including functionalities for up- and download are more and more becoming a standard in environmental applications (Byrne et al., 2010). More examples of eutrophication related web services can be found in Annex A of this report.

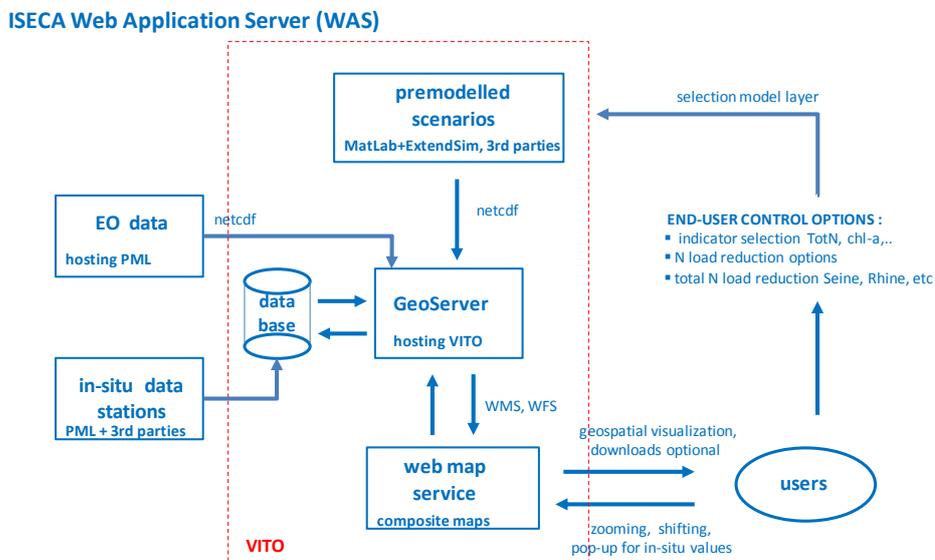


Figure 2-1. General architecture of the WAS.

A screenshot of the general WAS interface is found in Figure 2-2 below. The left-hand side of the interface provides access to three layers with EO data, in-situ data (the missions) and model results (“Models”). The background map is obtained as WMS service from GEBCO ([www.gebco.net](http://www.gebco.net)), in this case GEBCO\_08\_grid.

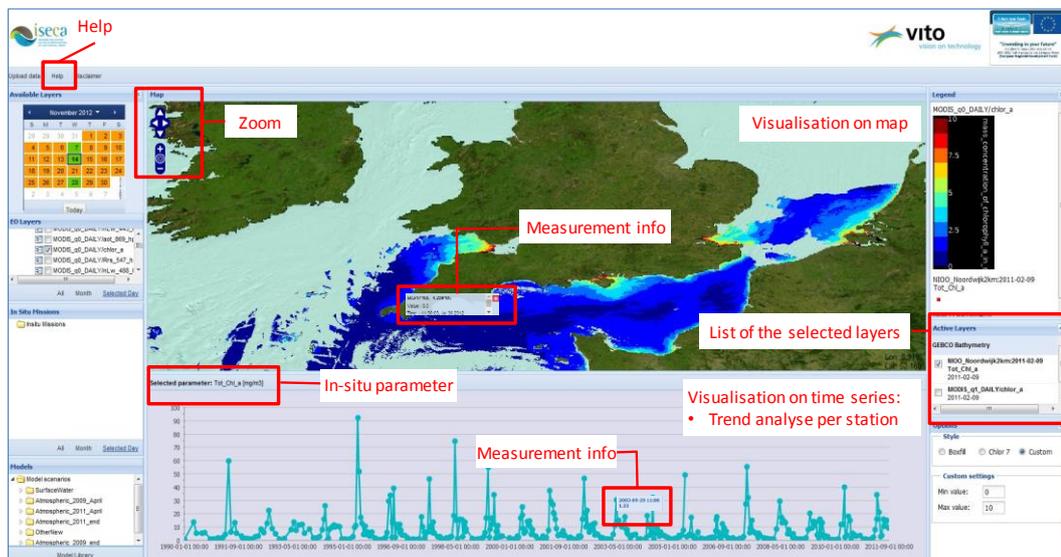


Figure 2-2. General user interface of the WAS with simultaneous visualization of earth observation and in-situ data (time series).

Detailed information on the use of the WAS is found in the online help manual. Here we summarize the functionalities. The main control panel for access of EO and in-situ data is the calendar navigation tool in the upper-left corner of the screen in Figure 2-2. With this tool users can scroll through years, months and dates. The date colors provided information on the availability of in-situ data (yellow dates), EO data (orange dates) or both EO and in-situ data (green dates). In view of the available resources and demonstration purpose of the project the modeled scenarios and earth observation data layers have been implemented offline, i.e. without direct, online communication with the different servers. Earth-observation data are stored in a database hosted by partner 3 – Plymouth Marine Laboratory. In-situ data are stored in a database hosted by partner 2 – Flemish Institute for Technological Research. All model scenarios (both water quality and atmospheric) are stored at VITO as well.

We will now first discuss the three types of information that can be accessed with the WAS: in-situ data (field measurements), earth observation data and modelled scenarios.

## 2.2. IN-SITU DATA

As far as the contents of the WAS are concerned users can only change the in-situ data by uploading files meeting the format requirements. Annex B shows an example template for in-situ data. The metadata section of the template can be used as desired, the data section uses comma-separated formatting (csv) with strict restrictions for the column labels. For example, “Tot\_Chl\_a” should be used for the data column with the total chlorophyll\_content. Currently, the in-situ

parameters shown in Table 2-1 are used. Upon request, it is possible to add, change or remove in-situ parameter types. There is no strict order for the data record attributes (latitude, longitude etc.), as long as the format instructions are respected.

<i>In-situ parameter</i>	<i>Unit</i>
Tot_Chl_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

Table 2-1 In-situ parameter labels allowed with units of measurement.

Provided the in-situ data meet the format restrictions these can be uploaded as a so-called “Mission”. A mission is a set of in-situ data, preferably restricted to a single geographical location to allow visualization of the data as a time series. The current version of the WAS does not support in-situ data downloading. Once selected the visualization of in-situ data takes places in two ways, shown in the example of Figure 2-2. On the map the in-situ data for the selected day will show as a pop-up field with information on the geographical location, parameter and units. This pop-up only shows up for a single location and data at a time because of the coupling to the calendar. On the lower end of the window the complete time series of the mission corresponding to this data record is shown as well.

### 2.3. EARTH OBSERVATION DATA

Earth observation data are always shown as map layers and can be combined with information on the in-situ data. The zooming and scrolling functionalities can be used to focus on the areas of interest. Customizing the legend range can further help improve to visualize and highlight details.

## 2.4. MODEL SCENARIOS

We refer the ISECA Final Report D3.2 (De Kok et al., 2014b) For a more detailed description of the modelling of eutrophication. Two types of model scenarios are available in the WAS to demonstrate the potential use of model forecast: water quality scenarios for the chlorophyll-a content under different nitrogen load reduction strategies in the Scheldt basin (Vermaat et al., 2012; De Kok et al., 2014b) and atmospheric deposition 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.

### 2.4.1. 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 underlying model structure is shown below:

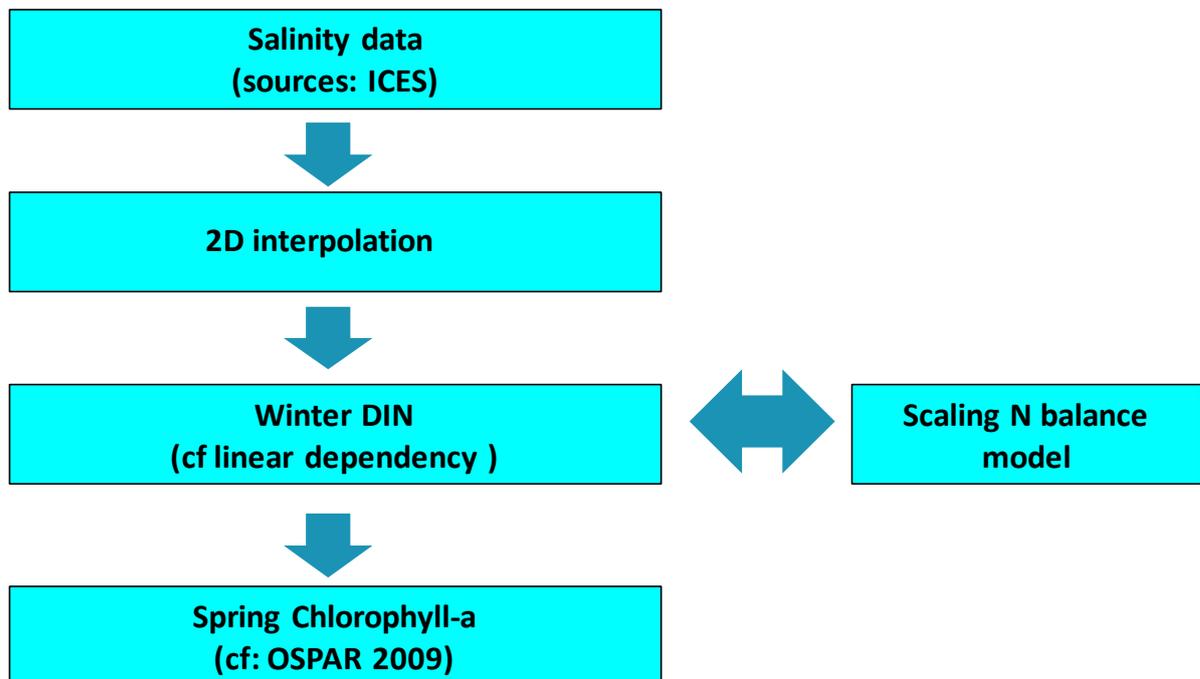


Figure 2-3 Steps in the simplified modelling process used to obtain the coastal and offshore chl-a values for different nitrogen loads for the Scheldt basin.

A more detailed description of the model architecture and functions used is found in Annex C. The model approximations include the following:

- a. linear dependency between salinity and winter DIN concentration

- b. linear dependency winter DIN and spring chl-a/Phaeocystis cell count
- c. linear dependency slope of salinity-winter DIN relationship on N load contributing rivers
- d. influence rivers (for impact load reduction) salinity dependent and not overlapping

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. Figure 2-4 shows the salinity gradient, used to translate estuarine values of the DIN level into a spatially distributed salinity pattern.

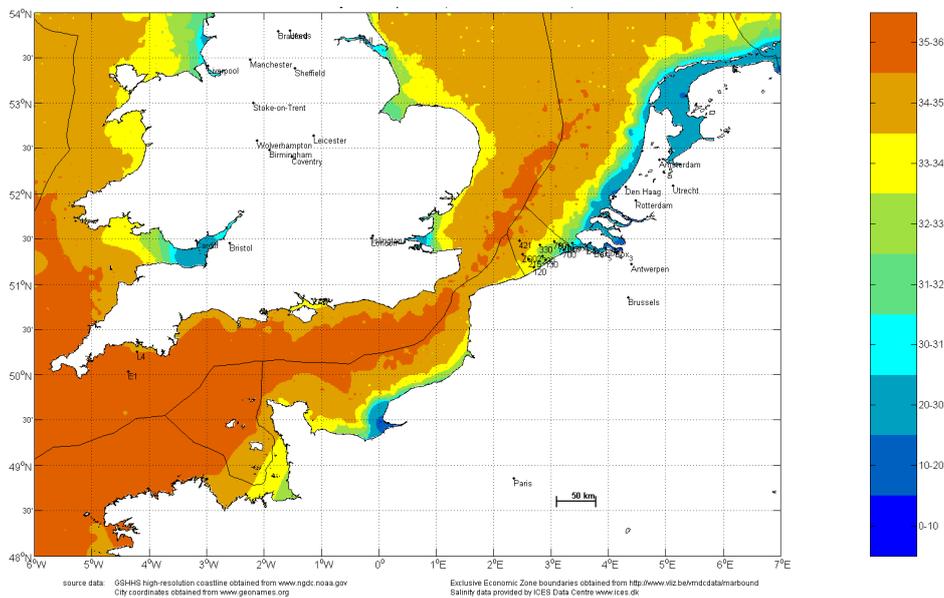


Figure 2-4 Salinity distribution for the Southern North Sea and English Channel as obtained by 2D interpolation of ICES salinity data (ICES, 2012).

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; De Kok et al., 2014b) is used to estimate the yearly nitrogen load for each scenario (see Annex D for a summary of the nitrogen balance model). Figure 2-5 shows the general interface of the model with quick access to scenarios, management options, and the model itself with the maps used. Animated bar indicators change color during the simulation to indicate changes in the nitrogen concentrations at specific measuring locations.

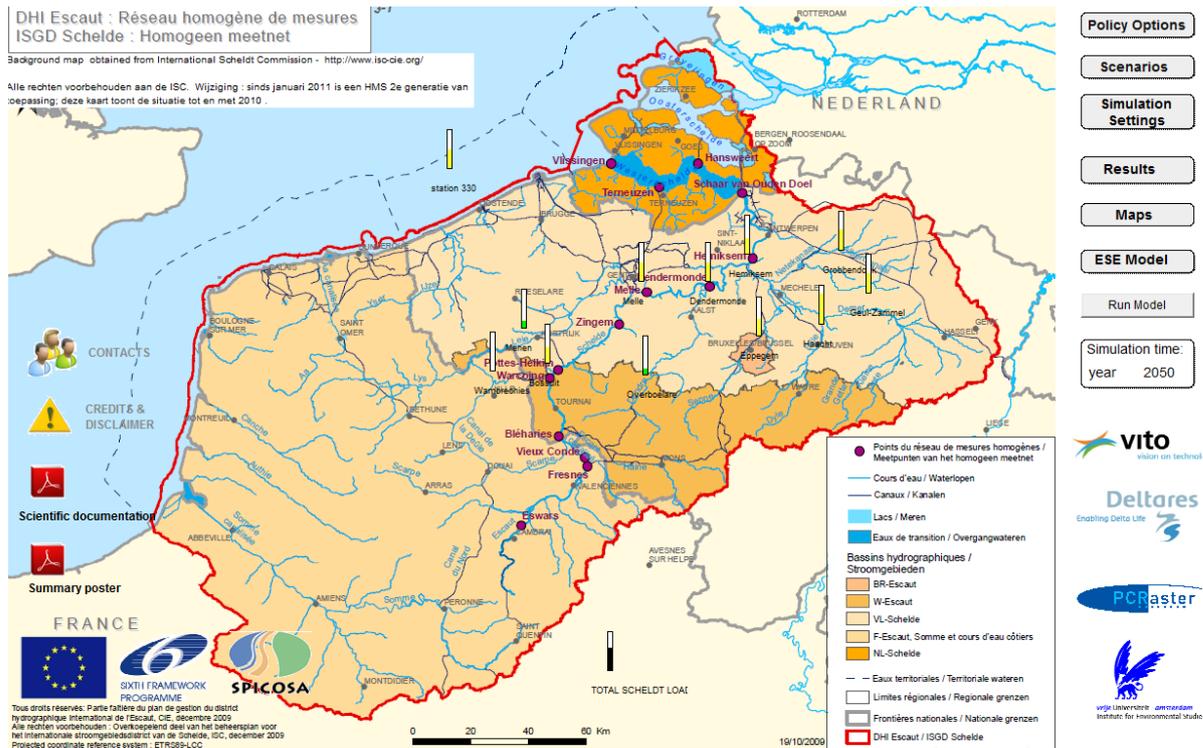


Figure 2-5 General user interface of the nitrogen source apportionment model for the Scheldt basin (Vermaat et al., 2012; De Kok et al., 2014b).

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:

- Business-as-usual scenario: no action taken, result is reduction of 2.2 % in total nitrogen load by 2050 compared to the year 2010
- Gradual decrease of fertilizer use to 50 % of the initial value by 2040 (23 % reduction nitrogen load by 2050)
- 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.
- Gradual decrease of cattle stock size with 50 % by the year 2040 (24.6 % reduction in the nitrogen load by 2050)
- 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)
- Gradual reduction in the industrial effluents of nitrogen to 0 % by 2040 (resulting in 12.7 % reduction in the nitrogen load by 2050)
- 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)
- All management alternatives B-H combined (78.3 % reduction in the nitrogen load by 2050)

- i. 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)
- j. 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)
- k. 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).

### 2.4.2. 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.

## 2.5. USER FEEDBACK AND RECOMMENDATIONS

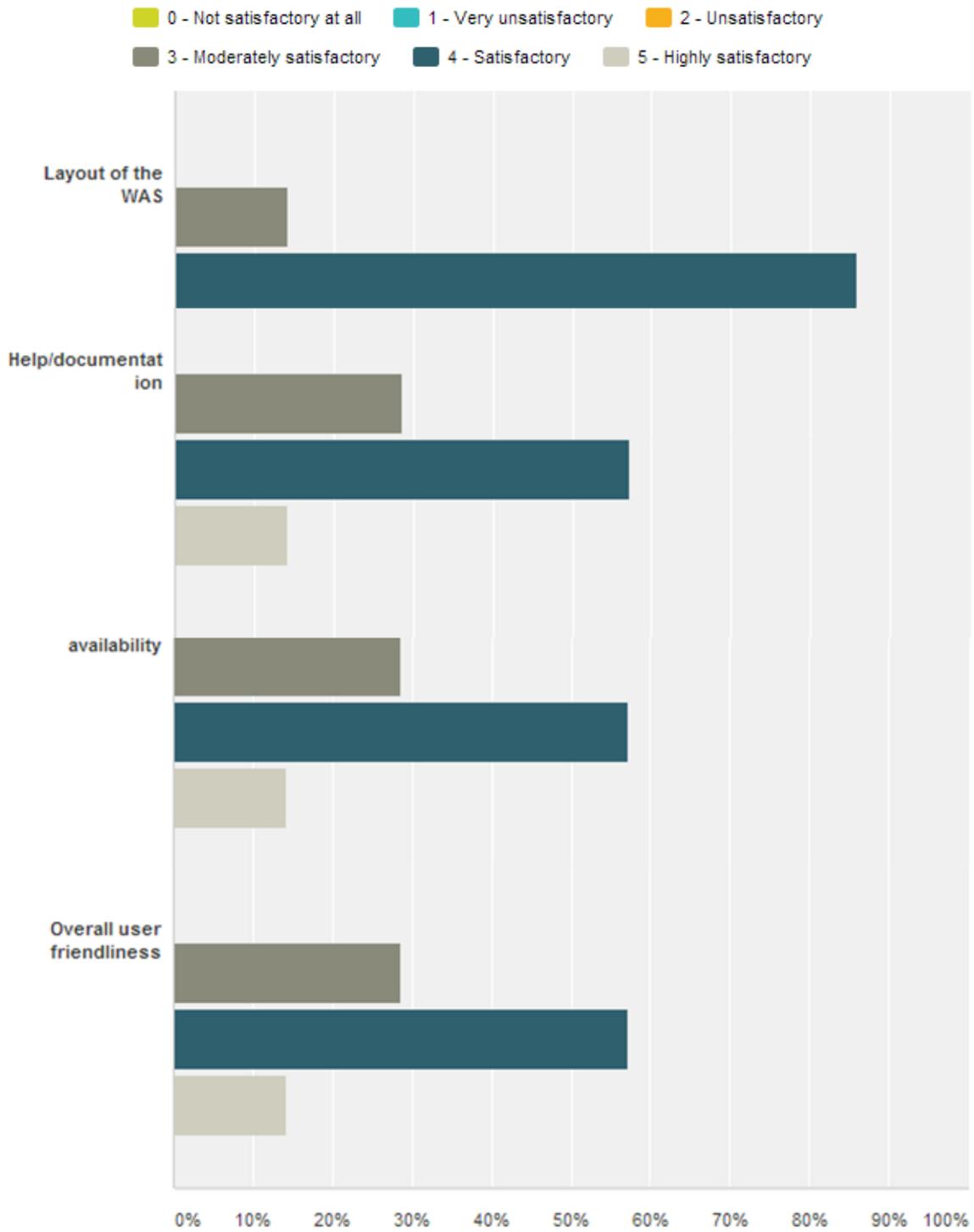
As explained the current version of the WAS is a demonstration instrument, mainly designed for the visualization of existing data. Downloading of data is not yet possible. In-situ data can be uploaded as files, and will become accessible through the calendar tool. Earth observation data layers and model simulations cannot be uploaded directly by users of the WAS.

A first user confrontation of the WAS occurred during an interactive workshop which was held during the ISECA final meeting in Boulogne-sur-Mèr (F) on July 1, 2014. The workshop participants were given a number of exercises to familiarize themselves with the WAS in a 2-hour session. As expected this also proved to be a good opportunity to obtain feedback on the functionalities and many useful suggestions for adaptation or improvement were given. The participants were of a mixed background (scientists, regional water managers, farmers and industry).

The main conclusions and recommendations were the following:

- The design of the Web Application Server is intuitive and the WAS is easy to use in general with the calendar navigation to query data
- Although the WAS could be very useful, the indicators shown are too scientific for non-experts, who would like to be given more basic information such as a problem or no problem, or an algal bloom risk map
- Depending on the screen resolution there were technical with some subwindows which could be solved with some effort. The WAS does not work on iPADS.
- The documentation should be expanded, and needs to be clearer sometimes.
- In principle there are no limitations to the uploading of in-situ data, quality control is an issue. For the time being this is solved with a Data Policy Statement on the web site. This can be considered less of a problem when the uploading facility is (temporarily) disabled.
- Who maintains the WAS? It has been decided that VITO carries out limited maintenance on the WAS for a number of years, VLIZ will do the same with the general project web site.

An online survey was held to evaluate the WAS. The first results (beginning July, 2014) are shown below.



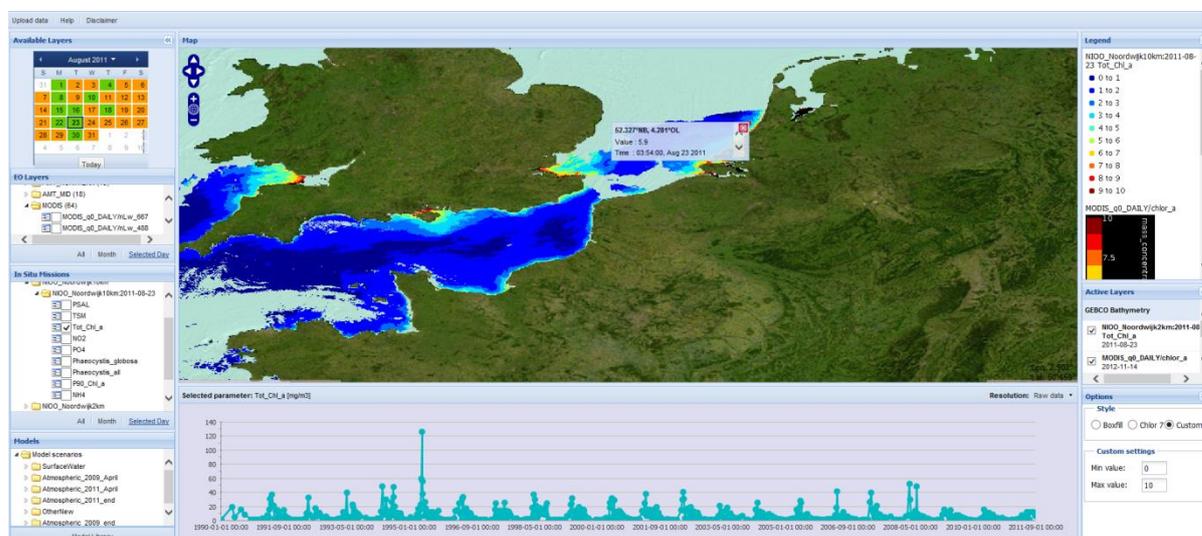
## CHAPTER 3 WEB APPLICATION SERVER FUNCTIONALITY

### 3.1. INTRODUCTION

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 explanations are given:

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.

### 3.2. VISUALIZING DATA - OVERVIEW

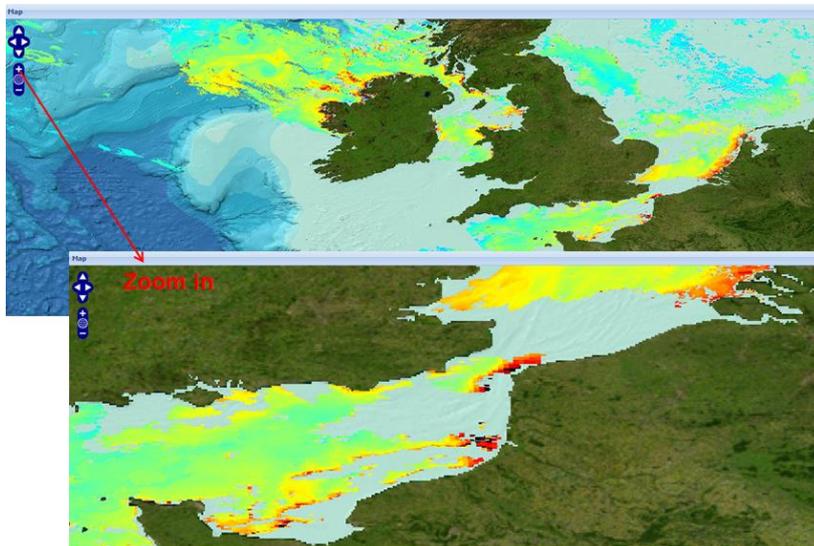
#### **How can you select data?**

The calendar tool (see Section 3.3) 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.

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.

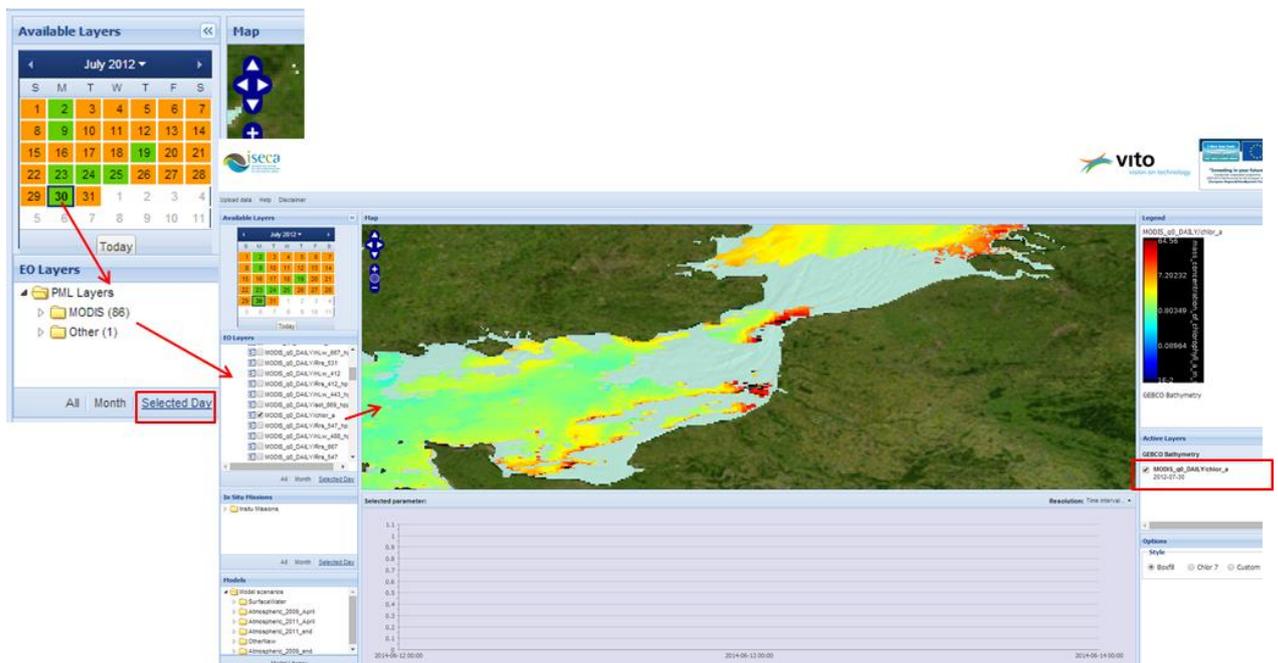


**Zoom functionality**

#### **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

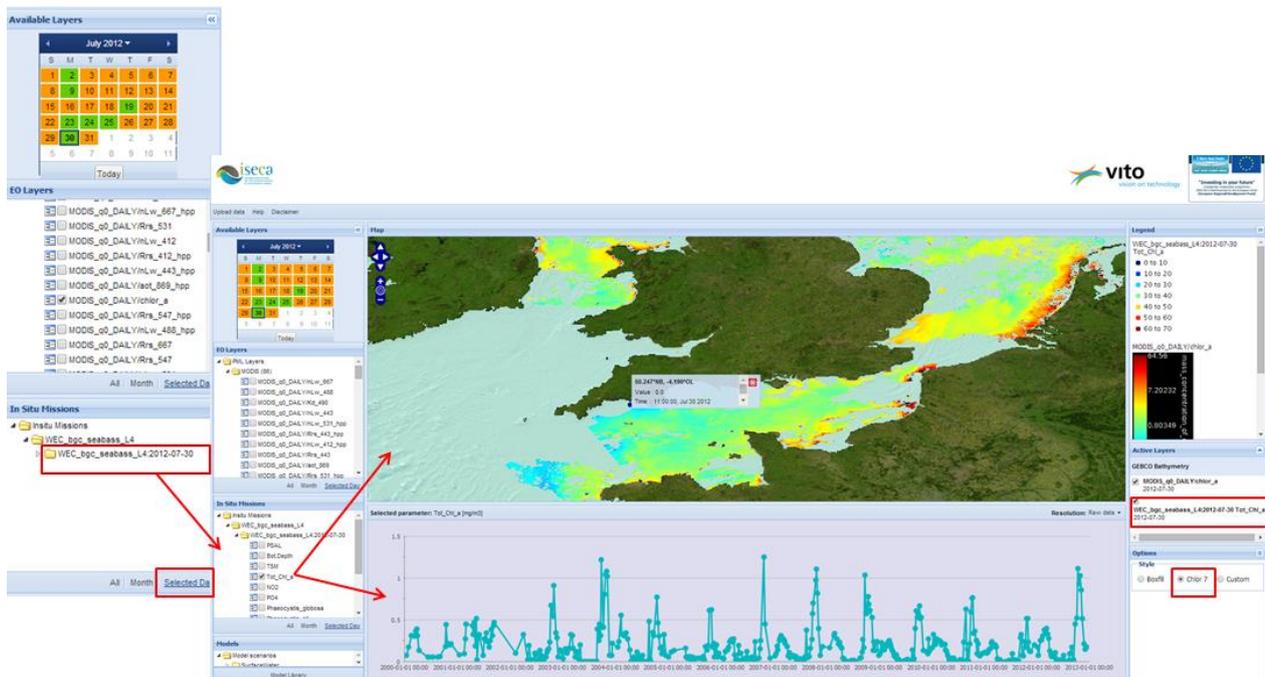


**Selecting earth observation data**

### **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\_ChI\_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.

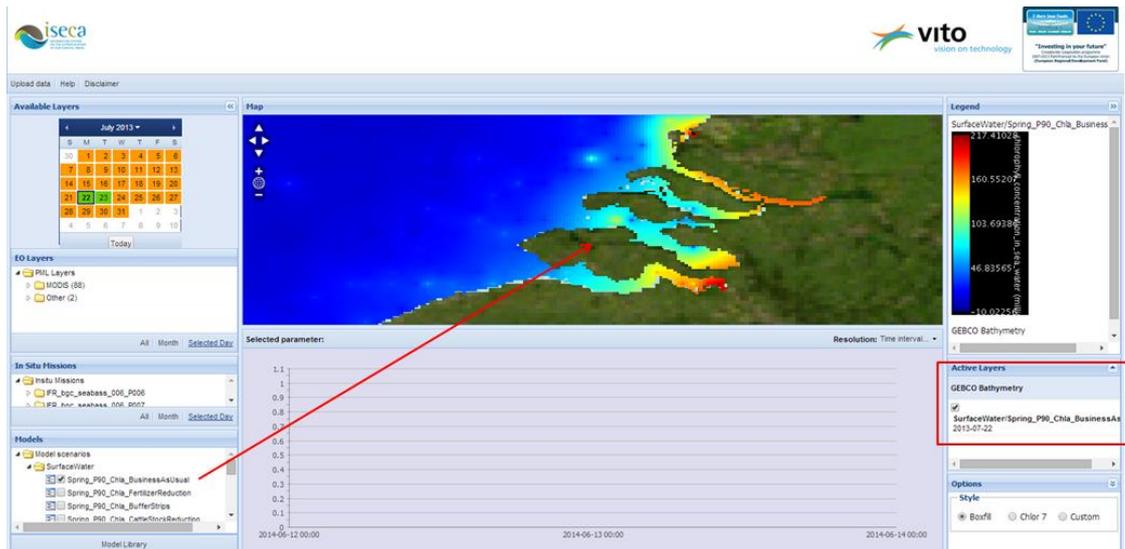


Selecting in-situ data

**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***



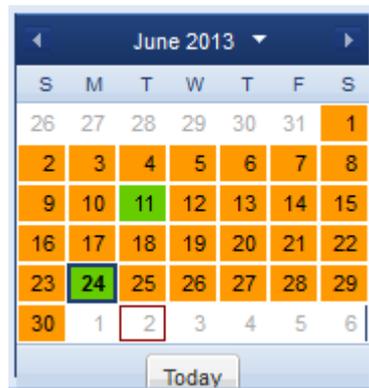
***SurfaceWater/Spring\_P90\_Chla\_CattleStockReduction***

### **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.

### 3.3. 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
Orange	Earth observation data
Yellow	In-situ data
Green	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

**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.

### 3.4. EARTH OBSERVATION DATA

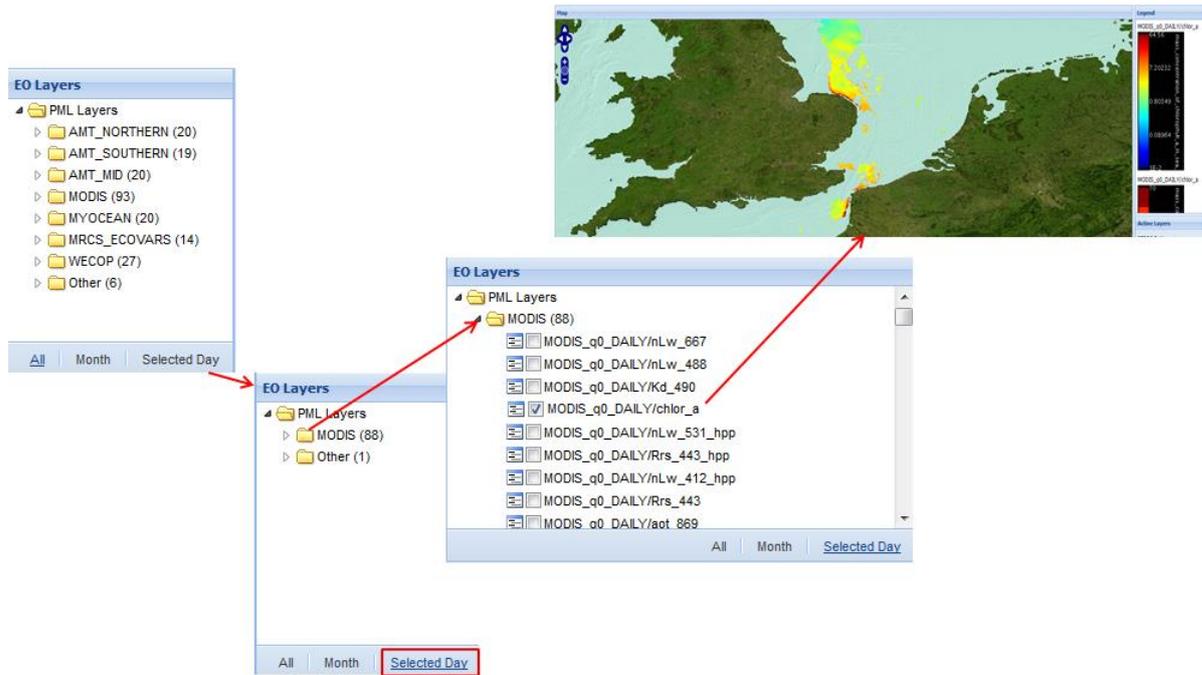
The earth observation data are stored at the Plymouth Marine Laboratory (PML). The user can select and visualize an earth observation data layer for specific dates using the calendar search tool



*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.

### 3.5. 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.



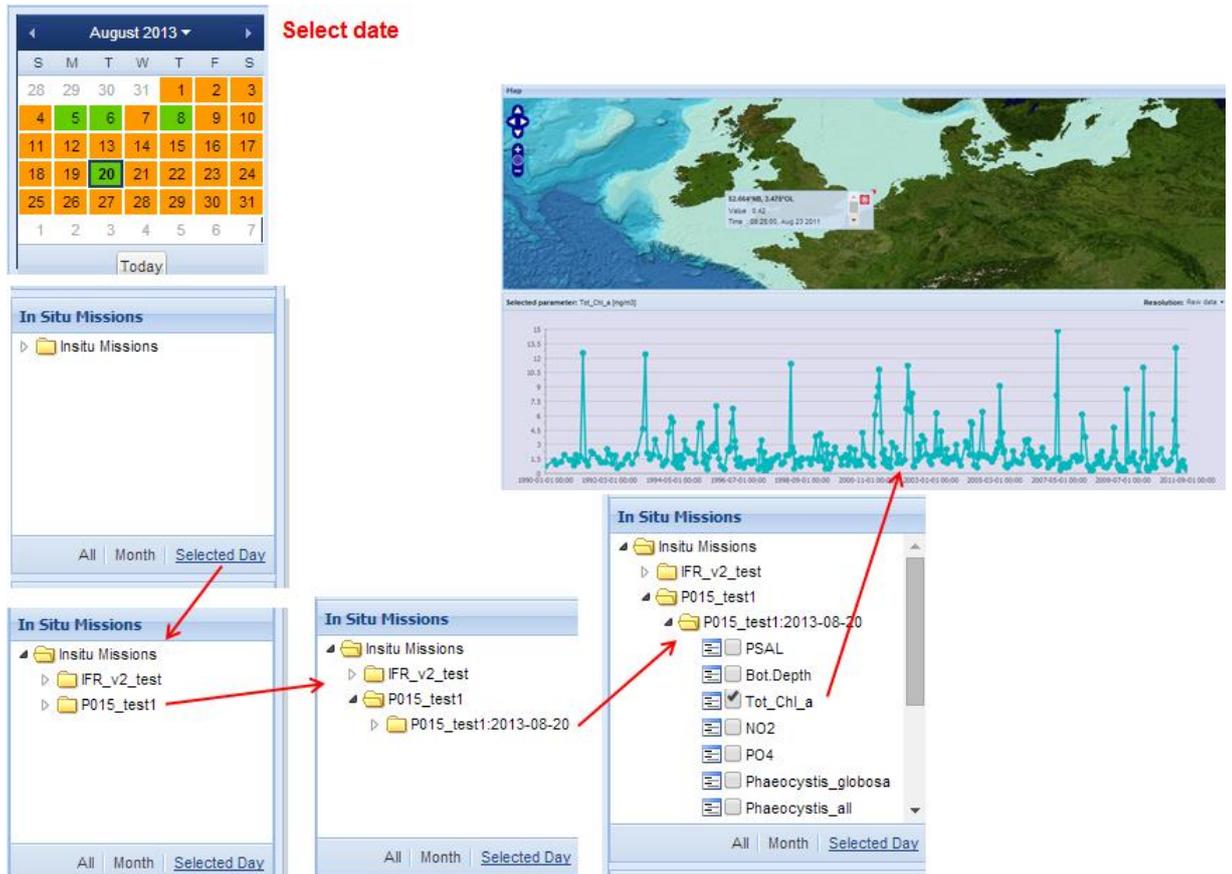
*Selection of in-situ data in the web tool*

Related functionalities are:

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

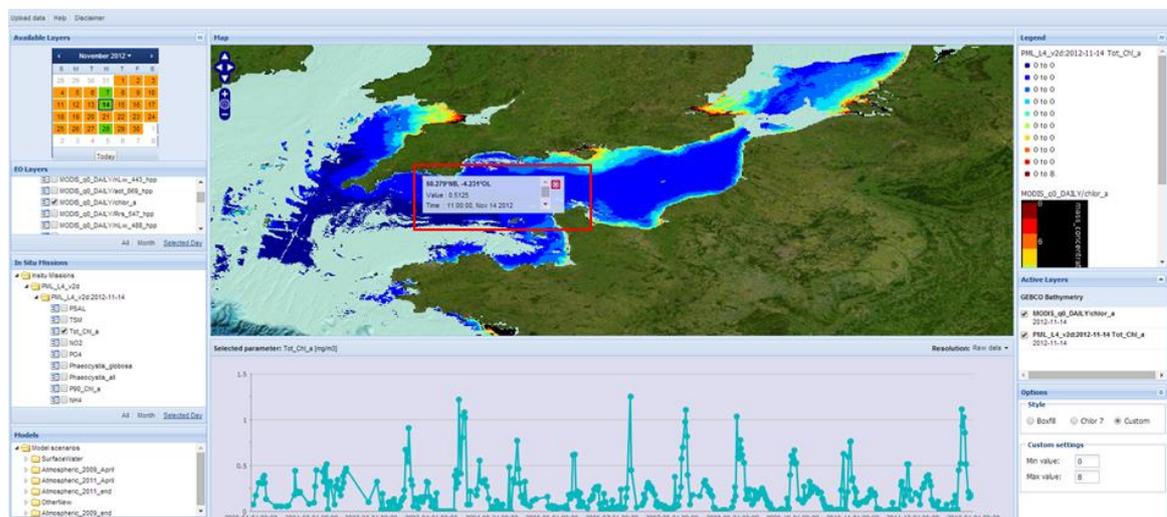
**Select in-situ data on a selected day:**

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\_ChI\_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.



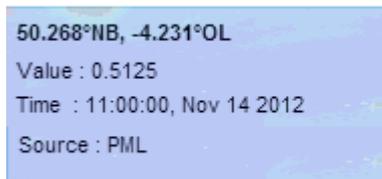
The user can select in-situ data from the same month by clicking on 'Month' or he can view all in-situ data by clicking on 'All', at the bottom of the in-situ mission selection box.

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.*

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.

### **3.6. 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.

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

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

### Errors

Error	Explanation
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><i>Please contact VITO for registering the new in-situ parameter and mention the mission that you were loading into the WAS application.</i></b>
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Currently the WAS provides the possibility to load in-situ data related to following parameters:

<b><i>In-situ parameter</i></b>	<b><i>Unit</i></b>
Tot_Chla	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_Chla	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).

### 3.7. 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.

#### 3.7.1. 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)

It is not possible for general users to add model scenarios. This should be done by the WAS host institute (i.e. VITO) and involves three steps:

1. Logon in to the samba server by entering exactly the following line in the DOS box (note the spaces!):

“net use [\\samba.rma.vito.local](http://samba.rma.vito.local) /user:username” (fill in your user name in username)

This will prompt for a password (usually root-specific and different from the network password).

2. In Win Explorer: Map network drive and enter the following path exactly:

[\\samba.rma.vito.local\iseca\ncWMS-data](http://samba.rma.vito.local\iseca\ncWMS-data)

This will open the folder with the model scenario (NetCDF) files.

3. The administrative tasks related to the management of the model scenarios can be fulfilled through the following URL: <http://iscancwms.rma.vito.local:8080/ncWMS/> . Clicking on the option “Admin Interface” will open a login screen. After login the following screen will appear for administrative tasks:

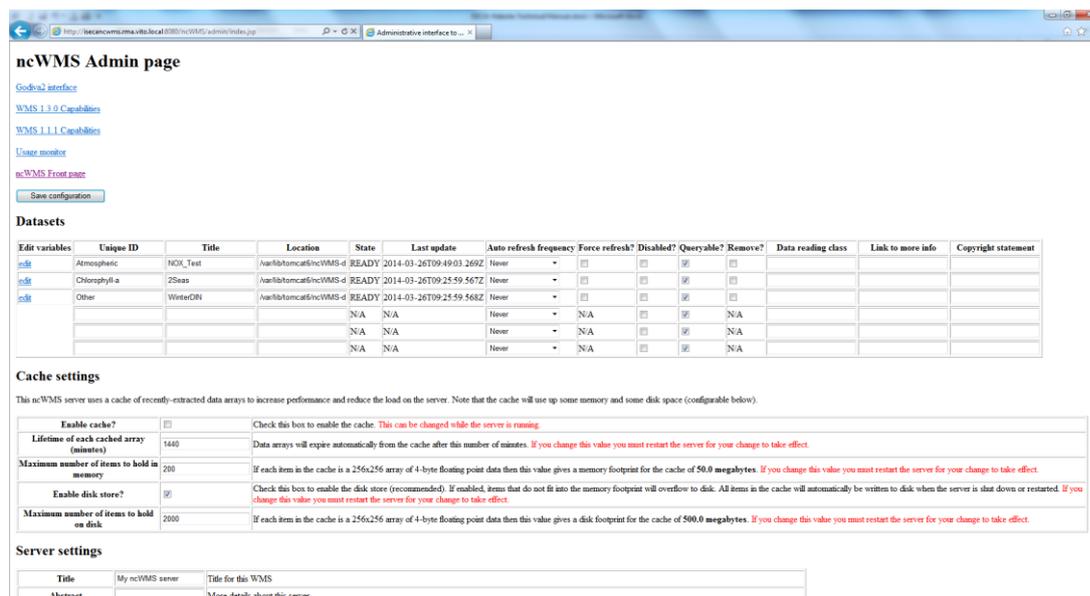


Figure 3-1. Administrative interface for definition of the model scenarios to be shown.

### 3.7.2. 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 NH3 and NOx 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.

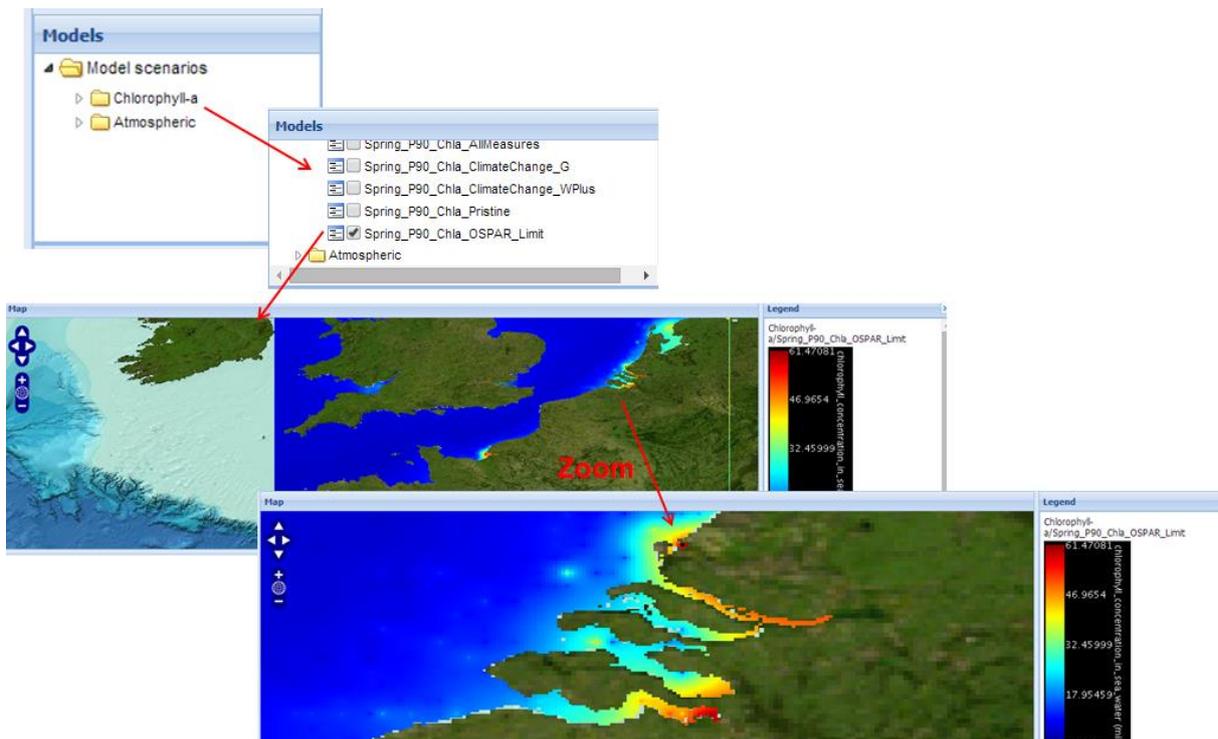
3.8. SELECTING A MODEL SCENARIO



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.



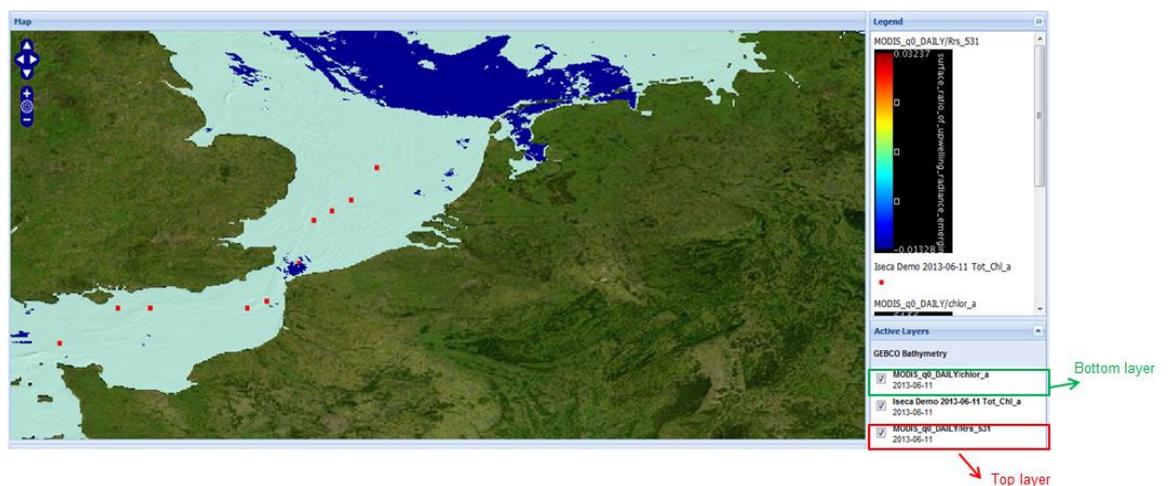
### 3.9. MODEL LIBRARY

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., 2014a; De Kok et al., 2014b). 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.

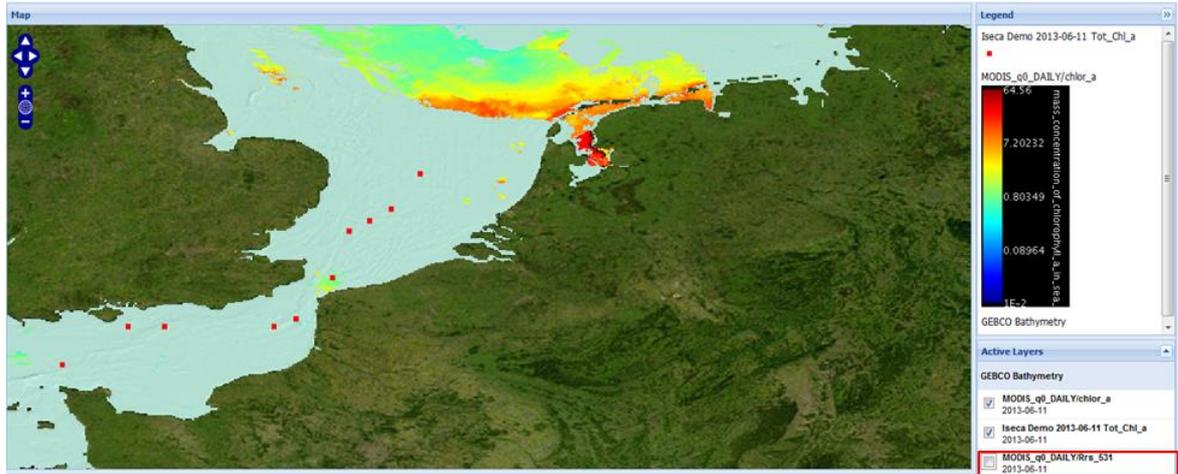
The SPICOSA model library and some example models are accessible through the “Model Library” button on the lower left of the WAS interface.

### 3.10. USE OF THE ACTIVE LAYER BOX

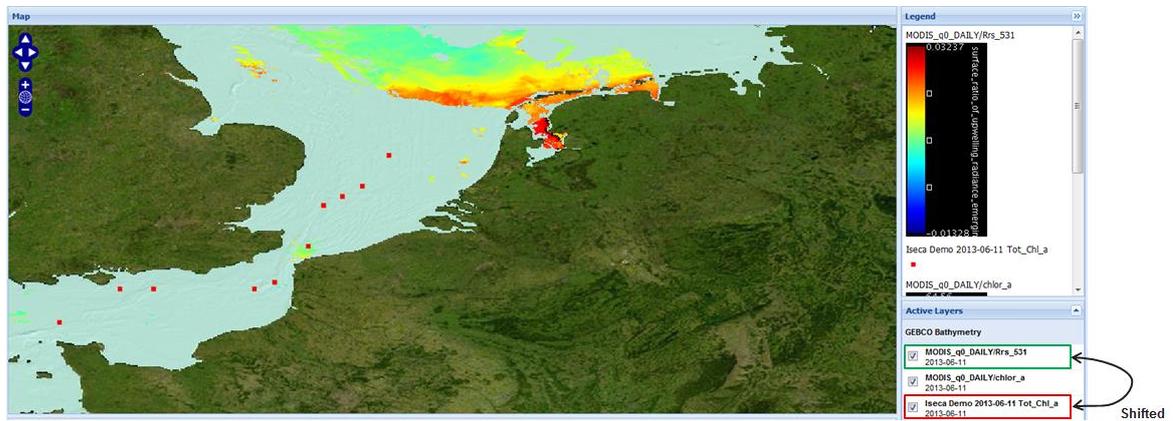
The active layer box allows the user to change the sequence of the layers with drag and drop, and the user can select or deselect a particular layer. The layers appears automatically in the active layer box when the user selects an EO layer, in-situ data or a model scenario. The top layer of the map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



Deselect the top layer gives:

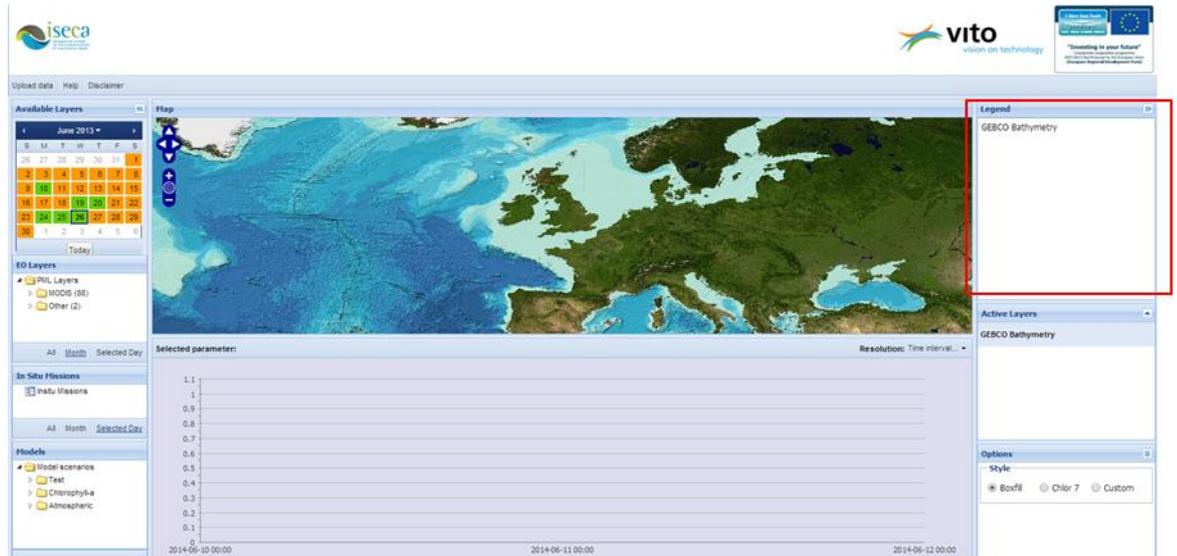


Changing the sequence of the layers gives:



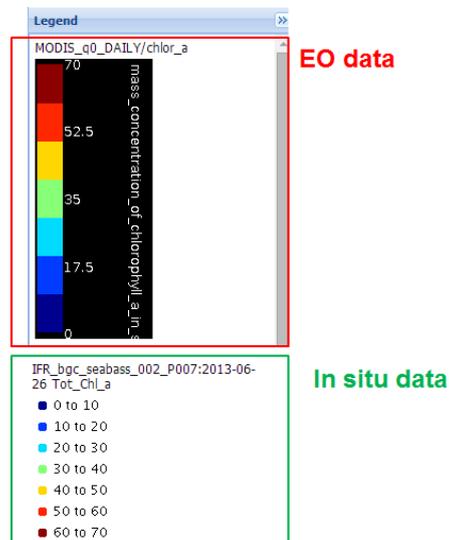
### 3.11. SETTING THE COLOR LEGEND

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



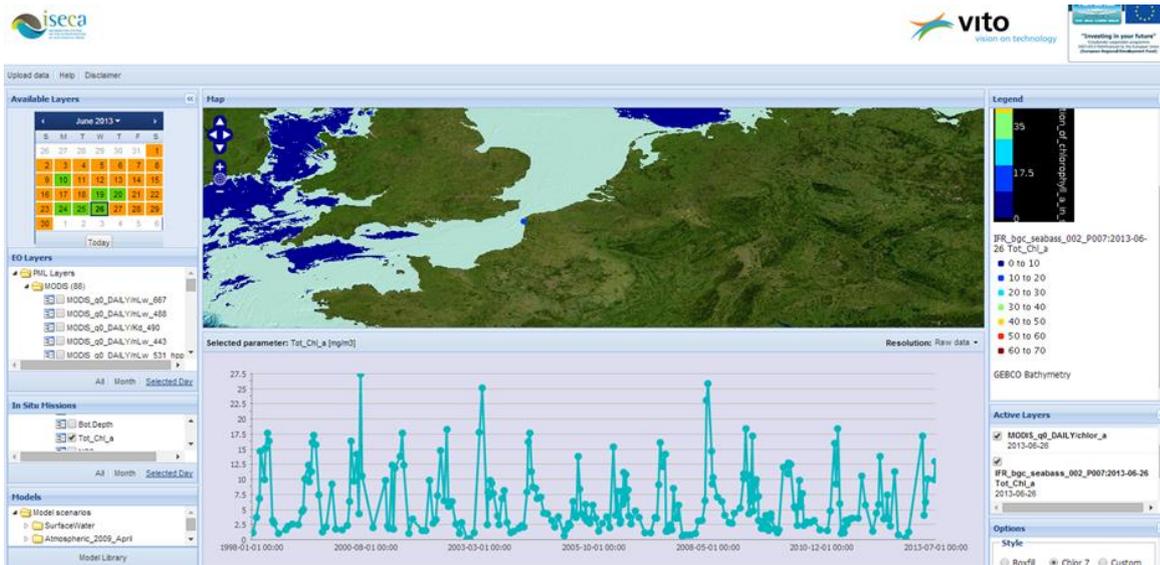
Legend box in the web tool

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](#))

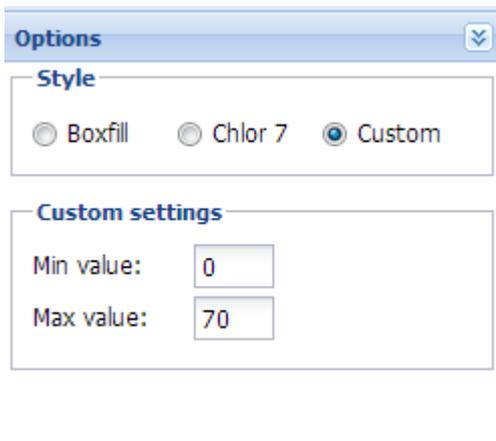
The user can easily recognize the locations with high concentrations (*hot spots*), this can be useful to improve in-situ monitoring missions and the calibration of processed earth observation data and model simulations.



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.

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



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.

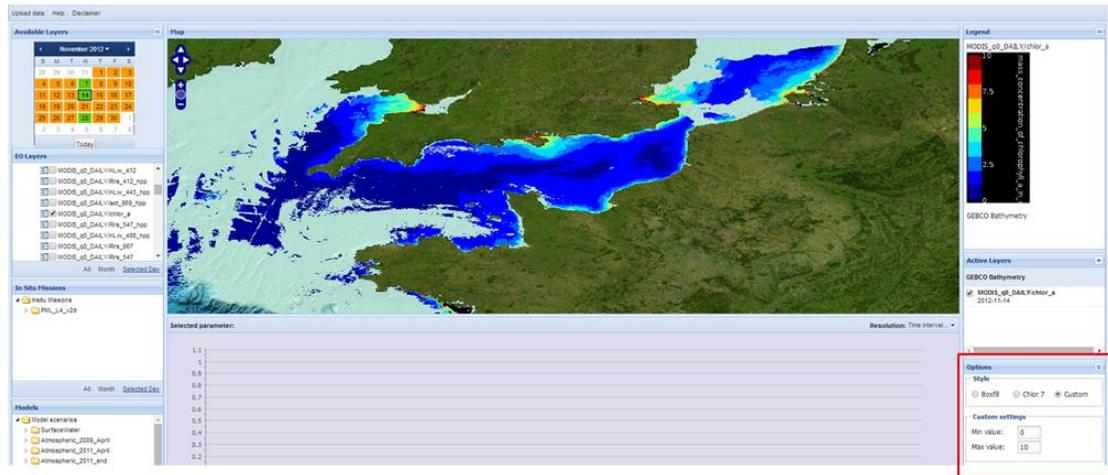
#### How to use?

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*

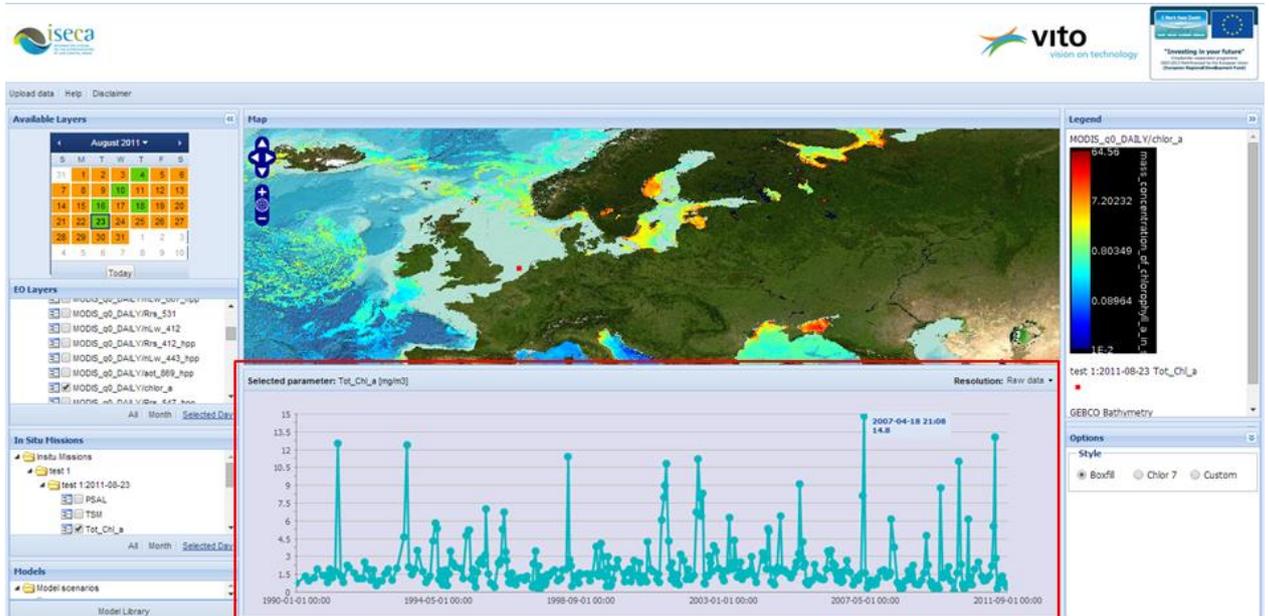
2. Change the max. value from 70 to 10
3. Reselect the EO layer in the EO layers box



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

### 3.12. TREND ANALYSIS OF IN-SITU DATA 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 figure below 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**

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## ANNEX A WEB-MAP SERVICES RELATED TO EUTROPHICATION

<http://213.122.160.71/scripts/mapserv.exe?map=D:\Websites\EUSeamap\map\ExternalEUSeamapWMS.map>

<http://map.ices.dk/geoserver/wms>

<http://rsg.pml.ac.uk/wms>

<http://openlayers.org/dev/examples/>

<http://www.mumm.ac.be/datacentre/Tools/Spatial/index.php#choice>

<http://www.mumm.ac.be/EN/Models/Development/Ecosystem/anim1.php#anim>

<http://openlayers.org/dev/examples/getfeature-wfs.html>

<http://neaforest.vgt.vito.be/>

<http://rsg.pml.ac.uk/gis/amt/client/?sessid=eba9f495ab97f34d4ac4f4a3a3b9a0a299a28e69>

## ANNEX B IN-SITU DATA TEMPLATE EXAMPLE

**metadata\_labels\_start**

```
received=20110208
investigators=Victor_Martinez-Vicente,ClaireWiddicombe,MalcolmWoodward,RuthAirs,PeterLand,DeniseCummings
affiliations=VITO
contact=jeanluc.dekok@vito.be
experiment=ISECA
cruise=WEC
station=L4
data_file_name=WEC_bgc_seabass.txt
documents=nofile.txt
calibration_files=nofile.txt
data_type=under_way
data_status=v1
start_date=19800101
end_date=20130905
start_time=00:00:00[GMT]
end_time=00:00:00[GMT]
north_latitude=50.251[DEG]
south_latitude=50.233[DEG]
east_longitude=-4.008[DEG]
west_longitude=-4.049[DEG]
cloud_percent=NA
secchi_depth=NA
water_depth=NA
wave_height=NA
wind_speed=NA
measurement_depth=NA
!
!COMMENTS
!phytoplanktoncounts:protocolsinhttp://www.westernchannelobservatory.org.uk/data.php
!phytoplanktoncounts:Zerovaluesdonotmeanabsoluteabsencefromwatersamplesandmayinsteadreflecttheuncertaintiesof
enumeratingPhaeocystis
!phytoplanktoncounts:L4Phaeocystis_4Victor.csv
!Nutrients:protocolsinhttp://www.westernchannelobservatory.org.uk/data.php
!Nutrients:valuesaremeansofvaluesfromoriginaldatafiles
!Nutrients:microm
!Nutrients:l4_nutrients_dates_corrected_0m.csv,whicharethesurfacedatafroml4_nutrients.txt
!SPM:protocolsinhttp://www.westernchannelobservatory.org.uk/data.php
!SPM:g/m3
!SPM:SPM_2001_2012.csv
!Chla-HPLC:protocolsinhttp://www.westernchannelobservatory.org.uk/data.php
!Chla-HPLC:mg/m3
!Chla-HPLC:L4_TCHLA_HPLC_2009-11removed.csv
missing=-999.0
delimiter=,
```

**metadata\_labels\_end**

```
Cruise,Station,Type,Time,Lon,Lat,Temperature,Bot.Depth,Pres.,PSAL,TSM,Tot_Chl_a,NO3,NO2,NH4,SiO2,PO4,Phaeocystis
_globosa,Phaeocystis_all,P90_Chla,Source
WCO,L4,C,1985-11-07T09:00:00.000,-4.21600,50.2500,-999.000,55,-999.000,-999.000,-999.000,1.000,-999.000,-
999.000,-999.000,-999.000,-999.000,1.000,1.000,2.500,chk
WCO,L4,C,1985-11-07T11:00:00.000,-4.21600,50.2500,-999.000,55,-999.000,-999.000,-999.000,10.000,-999.000,-
999.000,-999.000,-999.000,-999.000,1.000,1.000,23.232,chk
WCO,L4,C,1985-11-07T17:00:00.000,-4.21600,50.2500,-999.000,55,-999.000,-999.000,-999.000,25.000,-999.000,-
999.000,-999.000,-999.000,-999.000,1.000,1.000,4.675,chk
```

## ANNEX C MATLAB MODEL SCRIPT FOR GENERATING MODEL SCENARIOS

A number of scenarios have been modelled to simulate the impact of changes in the terrestrial emissions of nitrogen on the coastal and off-shore eutrophication (see Section 2.4.1). The model has been implemented as Matlab script. The main script `EutroShowIndicators35.m` asks the modeller to make the following choices:

- the subregion to model (2Seas areas as defined for the WAS, Seine mouth, Belgian coastal zone, Westerscheldt Estuary or Dutch coastal zone)
- the indicator to show (salinity, winter DIN, 90<sup>th</sup> percentile chl-a, OSPAR problem classification or Phaeocystis algae cell count)
- the general emission scenario to model (pristine without human interference, average for the years 2001-2005 or OSPAR problem limit = pristine + 50 %)
- the estuary/location for emission reduction if applicable (Scheldt, Seine, Thames or Rhine/Meuse)
- specific nutrient emission reduction scenario for Scheldt basin: single scenario or all scenarios available (see Section 2.4.1 for details)
- percentage reduction in nitrogen load (if location chosen under d differs from Scheldt)

The script runs a few minutes and then produces a map in Netcdf4 format, which is used for the WAS. A comparison for the 90<sup>th</sup> percentile chl-a value for the “business-as-usual” scenario (left) and with 70 % reduction in N load of Rhine/Meuse (right) is shown for the Dutch coastal waters here:

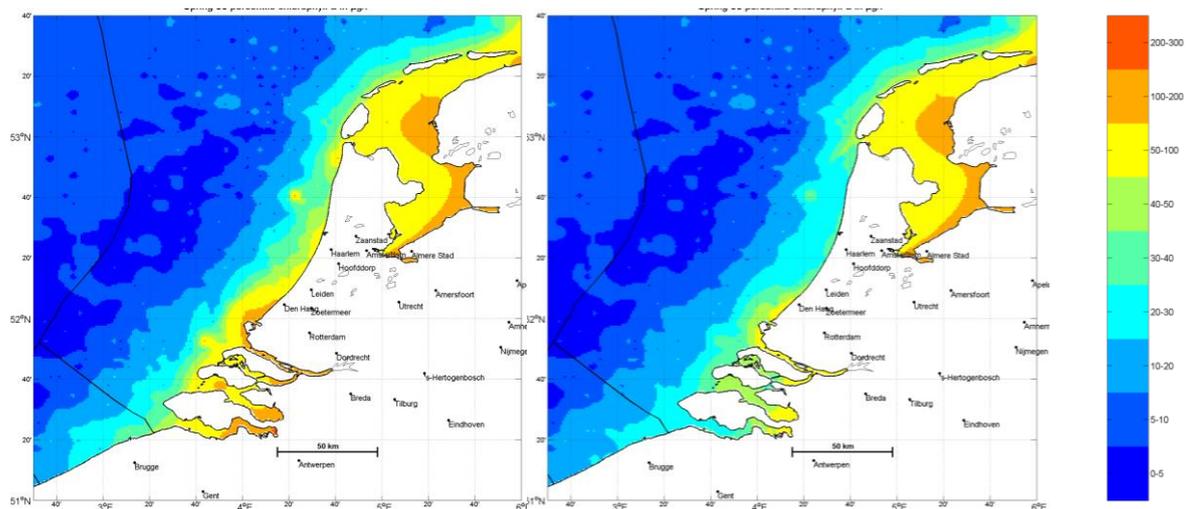


Table 3-1 lists the functions used in the script. Furthermore, the script uses the following open-source software, geodata and publications:

- `m_map` <http://www.eos.ubc.ca/~rich/map.html>
- INPAINT filling up NaN values based on algorithm by John d'Errico (2006) <http://www.mathworks.com/matlabcentral/fileexchange/4551>
- Global Self-consistent Hierarchical High-Resolution (GSHHS) Coastline data <http://www.ngdc.noaa.gov/mgg/shorelines/gshhs.html>

4. city coordinates obtained from [www.geonames.org](http://www.geonames.org)
5. Exclusive Economic Zone boundaries obtained from <http://www.vliz.be/vmdcdata/marbound>
6. Salinity data provided by the International Council for the Exploration of the Sea [www.ices.dk](http://www.ices.dk)
7. salinity-winter DIN and winter DIN-spring Chl-a relationships taken from OSPAR reporting Belgium (2008)
- 2nd application OSPAR Common Procedure obtained from [www.ospar.org](http://www.ospar.org)
8. Phaeocystis count based on Rousseau, V.; Mathot, S.; Lancelot, C. (1990). Calculating carbon biomass of Phaeocystis sp. from microscopic observations Mar. Biol. (Berl.) 107: 305-314

Note 1: the section in yellow highlight exports the array to NetCdf files. The functions such as ncread, ncwrite and ncwriteatt etc. are available in MatLab (use help netcdf in the command window to obtain an overview)

Note 2: all functions with the prefix “m\_” are available in the open source m\_map library (see <http://www.eos.ubc.ca/~rich/map.html> )

MatLab Subscript (in order of execution) <sup>1</sup>	Functionality
EutrophicationShowIndicators35.m	Main script
SetProjection.m	Set geographic projection (default equidistant cylindrical)
m_lldist.m	find range from lon lat coordinates
m_shaperead.m	Shapefile reading (not used)
meshgrid.m	Set up xy grid
m_etopo2.m	Read bathymetric map
interp2.m	2D interpolation of bath. map
GenerateLandMaps.m + ncread.m	Generate Netcdf file with land use and read the file
xlsread.m	Read salinity data
MarkCities2Seas.m	Read coordinates + names of cities with 25.000 + inhabitants
m_ll2xy.m	Lonlat to xy coordinates
FindOutliers.m	Find outliers salinity data
FindGridPoints.m	Put observations with lonlat coordinates on xy grid
inpolygon.m	Test if UK observations are in territorial waters
inpoly.m	Inside river influence zone
inpaint_nans.m	2D interpolation with sparse data
reclassify2.m	Reclassify data to correspond with integer legend categories
colormap.m	Legend color function
m_range_ring_v2.m	Set up perimeter around station
inpolygon.m	Test if inside polygon
xlswrite.m	Export station data to xls
m_pcolor.m	Set up raster plot
m_ll2xy.m	Find EEZ boundaries
m_gshhs.m + m_usercoast.m + m_grid.m	Draw coastlines
lcolorbar.m	Draw legend
m_text.m	Add text
nccreate.m	Set up netcdf file for storage
ncwriteatt.m	Add general attributes to file metadata
ncwrite.m	Add variables
fileattrib.m	Set/get file attributes
netcdf.open.m	Open netcdf file for export
netcdf.reDef.m	Set netcdf file in define modus

---

netcdf.inqVar.m	Request information about variable
netcdf.renameatt.m	Relabel attribute
netcdf.close.m	Close netcdf file
ncdisp.m	Show content summary of netcdf file in MatLab command window

Table 3-1 Overview MatLab scripts used in main script (blue = custom scripts, red = m\_map library).

Other auxiliary function are customized scripts with the following functions:

- DifMap2.m: shows the difference between two maps
- CombineNetcdf.m: combines two maps with different variables in a single map
- GenerateEEZboundaries: translates shape file with EEZ boundaries into grid points
- ShowNetcdf2: visualizes map in netcdf format
- GenerateLandMaps: uses GSHHS coastal database(<http://www.ngdc.noaa.gov/mgg/shorelines/gshhs.html>) with world coastlines to obtain lon-lat coordinates and generates land map (outside model)
- RefineAtmosphericData.m:

The script codes are available upon request.

ANNEX D NITROGEN SOURCE APPORTIONMENT MODEL FOR THE SCHELDT BASIN



The Scheldt, France-Belgium-Netherlands – SSA 9

Jean-Luc de Kok<sup>1</sup>, Hans van der Kwast<sup>1</sup>, Steven Broekx<sup>1</sup>, Guy Engelen<sup>1</sup>, Fritz Hellmann<sup>2</sup>, Jan Vermaat<sup>2</sup>, Bert van Eck<sup>3</sup>, Willem van Deursen<sup>4</sup>  
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<sup>2</sup>VU, Institute for Environmental Studies, De Boelelaan 1085, 1081 HV Amsterdam, The Netherlands;  
<sup>3</sup>Deltares, Daltonlaan 400, 3584 BK Utrecht, The Netherlands;  
<sup>4</sup>PCRaster Environmental Software, Oostzeedijk Beneden 23a 3062 VK Rotterdam, The Netherlands  
 contact : [jean-luc.dekok@vito.be](mailto:jean-luc.dekok@vito.be); [bert.vaneck@deltares.nl](mailto:bert.vaneck@deltares.nl); [jan.vermaat@ivm.vu.nl](mailto:jan.vermaat@ivm.vu.nl); [willem@pcraster.nl](mailto:willem@pcraster.nl)

Policy issue: nitrogen source apportionment for the catchment, estuary and adjacent coastal waters of the Scheldt ([www.spicosa.eu](http://www.spicosa.eu))

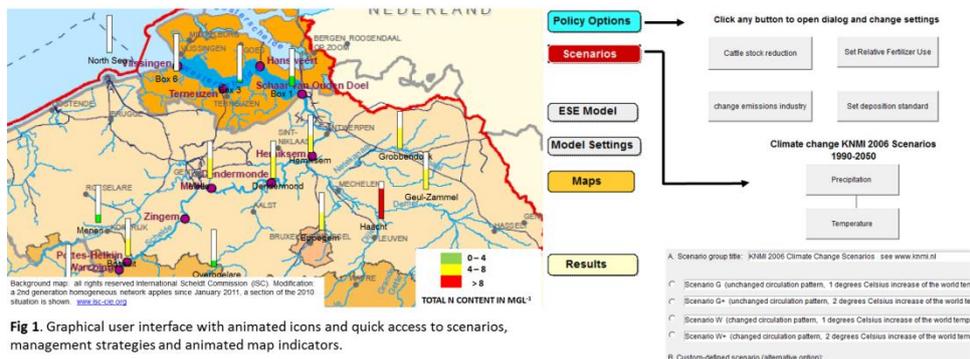


Fig 1. Graphical user interface with animated icons and quick access to scenarios, management strategies and animated map indicators.

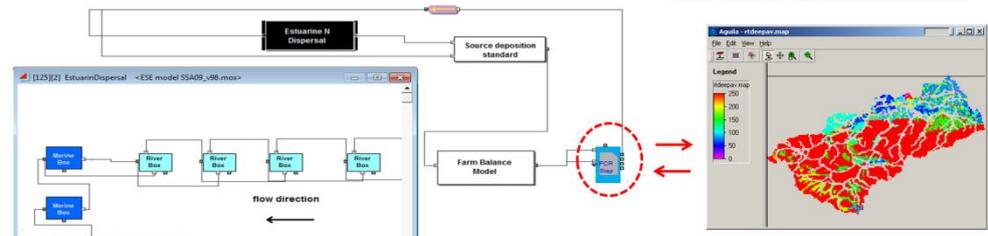


Fig 2. Hierarchical ESE system structure with feedback based on reusable model building components.

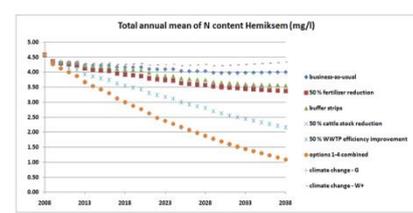


Fig 4. Example of the impact of different strategies and scenarios on the total N content at the outflow point Hemiksem near the city of Antwerp.

**Innovative and user-friendly aspects of the Scheldt ESE model**

- real-life farmers' decisions drive the economic model
- two-way spatial-dynamic model coupling
- ESE (Economic-Social-Ecologic) system model fully implemented with reusable model building components which are stored in generic model libraries
- choice from KNMI climate change scenarios which are based on the IPCC SRES scenarios for the anthropogenic driving mechanisms
- complete, 30-year simulation takes only 2-3 minutes on a standard desktop PC
- expandable set of buttons to access and parameterize management options such as fertilizer use, buffer strips, WWTP emissions, and cattle stock size reduction

**Stakeholder response**

- authorities responsible for WFD take real interest in the model and the flexibility to incorporate new policy options and scenarios
- rapidity of the simulations and model transparency highly appreciated



Poster presented at the London Littoral Forum, September 22-23, 2010. For details on the model see Vermaat et al. (2012) and De Kok et al. (2014b).