FerryScope

Summary of Annual Report 1
July 2014 – June 2015
Version 1.1
12.10.2015

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Project full title:	Bridging the divide between satellite and shipborne sensing for Baltic Sea water quality assessment
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Grant identifier:	BONUS call2012inno-38

FerryScope has received funding from BONUS - part of the European Union's Seventh Framework Programme for research, technological development and demonstration - under BONUS call2012inno-38.

1 Project FerryScope

FerryScope aims at improving water quality assessment of the Baltic Sea by the combination of satellite data, time series of shipborne Rrs measurements, and improved algorithms and models. FerryScope provides quality-assured, freely accessible NRT Rrs from ships of opportunity (SOOP). FerryScope futher develops algorithms for the retrieval of water quality parameters from satellite data for the Baltic Sea that makes use of models and the Rrs data to improve the systematic large-scale retrieval. The aim is to familiarize users, researchers and national monitoring agencies with the new service in order to develop a reliable commercial service model on top of the open-source technical model.

2 Work performed in 1st year of FerryScope

Main focus of the first year was on the in-situ data framework (WP1) and the development of the spectral library for data interpretation (WP2). Recently, a hyperspectral remote-sensing reflectance (R_{rs}) platform (Figure 2-1) was developed for automated deployment in the FP7 PROTOOL project. A first system was tested in ESA-Balmon while FerryScope now implements the system on two ferries covering long routes across the Baltic Sea (Figure 2-2). In 2015, Rflex on Finnmaid has collected 185,000 measurements. FerryScope further improves the automation aspect of data quality control and develops a set of data interfaces (Figure 2-3).

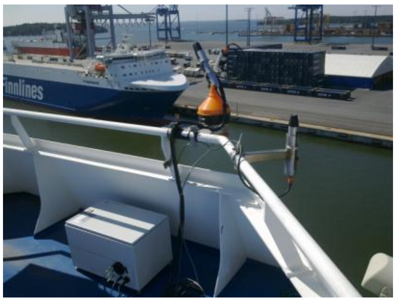

Figure 2-1: Rflex platform with hyperspectral Rrs instrument installed on M/S *Finnmaid* (Finnlines)

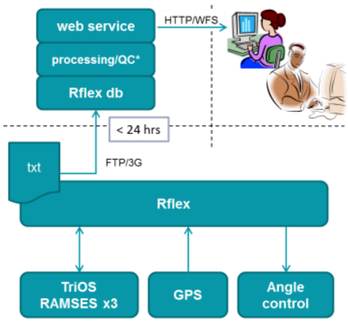

Figure 2-3: Structure of the Rflex platform on ship (bottom section) and in-situ data service (at SYKE)

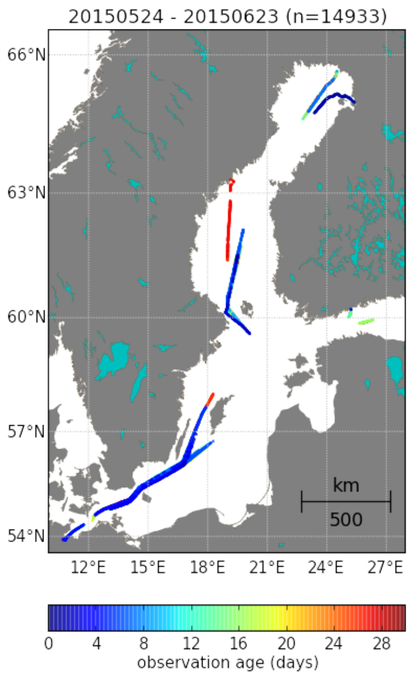

Figure 2-2: Spatial distribution and temporal coverage of the FerryScope Rrs in-situ data time series (June 2015 shown, 2014 and 2015 available)

In WP 2 the open Baltic Sea spectral library has been created based on the SIOPs and concentration distributions of field campaigns described in detail in Simis et al. (in prep). The simulations were made with Hydrolight (Sequoia Scientific Inc., version 5.2.0) separately for spring and summer conditions.

Three colour producing components, besides pure water, were assumed: phytoplankton, non-algal particles and CDOM (Table 2-2). The combinations of the concentrations and sun and viewing angles (Table 2-1) resulted in altogether 655,200 simulated Rrs spectra for spring and 561,600 for summer.

Table 2-1: Sun and viewing angles used in Hydrolight simulations

Angle	#	Range, step
SZA	5	30 - 70 deg, step 10
VZA	6	0 - 50 deg, step 10
Azimuth	13	0 - 180 deg, step 15

Table 2-2: Concentrations used in the spring simulations

Variable														
Chl (µg l^{-1})	0.10	1.0	2.0	4.0	6.0	8.0	10.0	14.0	20.0	26.0	32	42	84	250
TSM(mg l^{-1})	0.05	0.4	0.8	1.3	1.8	2.3	4.0	5.7	7.4	8.9	18	50		
a_{CDOM}412(m^{-1})	0.05	0.2	0.3	0.5	0.7	0.9	1.2	1.5	3.0	20.0				

3 First year results

FerryScope provides a continuous service of Baltic Sea in-situ Rrs measurements accessible to users. It is implemented as an OGC Web Feature Service accessible at

http://ferryscope.ymparisto.fi/Rflex/index.xhtml

The interface with data structures, query URLs and hints for programmatic data access is documented in FerryScope deliverable D1.2 Rflex WFS API Reference

http://ferryscope.org/wp-content/uploads/2014/10/FerryScope-D1.2-RflexAPIQuickStart-v1.0.4.pdf

The historical data is also available in monthly CSV files (Figure 3-1) in the Data area of the FerryScope web

http://ferryscope.org/

```
ID TIME LATITUDE LONGITUDE SHIP Sun
Elevation edpar skyrat400 Rrs Pitch Rrs
1st wl Rrs 1st wl Rrs 001 (320.0) Rrs
002 (323.3) Rrs 003 (326.6) ... Rrs 192
(950.3) Rrs 193 (953.6)

RFLEX_RRSMEASUREMENT_2320140701062720
2014-07-01T06:27:20 54.879614 13.417840
23 30 270.0805 0.09542297 3.3 320.0
953.6 nan -0.0011299575537 -
0.00103880580933 ... 0.00126361090397
nan

RFLEX_RRSMEASUREMENT_2320140701062820
2014-07-01T06:28:20  54.881690
13.428385    23 30 280.6569 0.0933562
3.3 320.0 953.6 nan -0.0028666256803 -
0.00271040635345 ...

…
```

Figure 3-1: Rflex monthly CSV files with Baltic Sea hyperspectral in-situ data

The Rflex data has been used testwise to correct for non-optimal MODIS radiometric calibration by the determination of gain settings. Figure 3-2 shows results for different seasons and different gain settings varying between 0.2% and 3.2%.

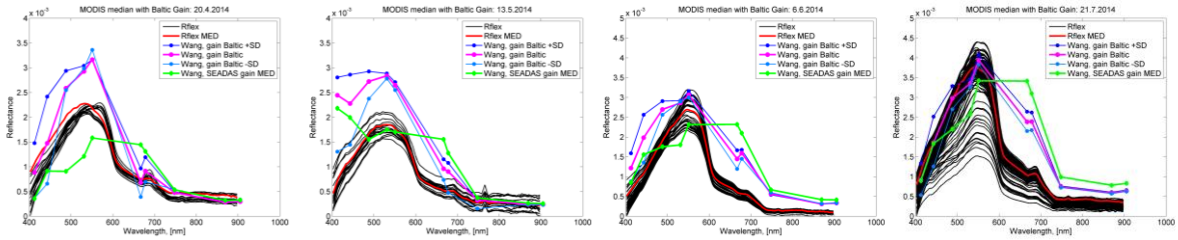

Figure 3-2: Examples of filtered Rflex spectra and different settings for gain values for MODIS data. The examples represent different seasons during the annual measurement period, two spring cases, the summer minimum and the cyanobackteria bloom period. The atmospherically corrected MODIS data with original gain provided by SEADAS is given as green line, other colors represent adjusted gains.

The second result of the first year of FerryScope is the spectral library of the open Baltic Sea. The spectral library describes the relation between modelled spectra (Figure 3-3, Figure 3-4) and inherent optical water properties (IOPs) for a large set of hyperspectral spectra. It is documented in FerryScope deliverable D2.1 Hydrolight Baltic http://ferryscope.org/wp-content/uploads/2014/10/FerryScope-D2.1-HydrolightBaltic-v1.0.pdf .

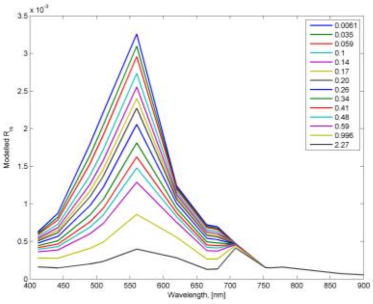

Figure 3-3: Example of modelled spectra with varying pigment absorption (from 0.0061 to 2.27), nadir viewing angle and sun angle 30°

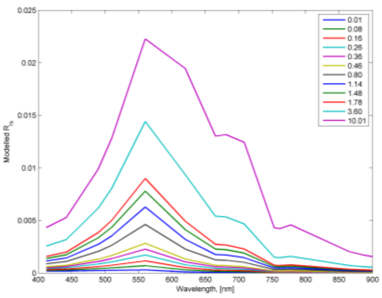

Figure 3-4: Example of modelled spectra with varying b_part (from 0.01 to 10.013), nadir viewing angle and sun angle 30°

The Sensor-Independent Ocean Colour processor SIOCS requires sensor-specific look-up tables (LUTs) to invert the spectra provided by satellite images to the water constituents. The LUTs for MERIS have been generated from the spectral library and first tests have been made.

Suitability of several empirical band-ratio algorithms for the Baltic Sea conditions have been tested using the modelled spectral library data and in situ data. There were several band ratio type chlorophyll algorithms that had very high correlation (R2>0.8 and up to 0.97) with the chlorophyll concentration used in the model. There were also several algorithms that produces good correlation with TSM and CDOM. This suggests that band ratio type algorithms may be used in retrieval of water constituents in the Baltic Sea if the atmospheric correction of satellite data is successful.