EUFAR

Report of the

EUFAR FP7

Hyperspectral water applications Expert Working Group Meeting 1 Minutes

15 April 2009 – Wageningen, Holland

Last update on 06/05/2009 by Steve Groom

1. Table of contents

2. List of attendees

- **Attendees:**

Steve Groom (SG)	Plymouth Marine Laboratory, UK	PML
Tim Malthus (TM)	The University of Edinburgh, UK	UEDIN
Els Knaeps (EK)	*Vlaamse Instelling voor Technologisch Onderzoek, Belgium*	*VITO*
Sindy Sterckx (SS)	*Vlaamse Instelling voor Technologisch Onderzoek, Belgium*	*VITO*
Dries Raymaekers (DR)	*Vlaamse Instelling voor Technologisch Onderzoek, Belgium*	*VITO*
Peter Gege (PG)	*Deutsches Zentrum für Luft-und Raumfahrt, Germany*	*DLR*
Daniel Odermatt (DO)	*Remote Sensing Laboratories, Zurich, Switzerland*	*RSL*
Hans van der Woerd (HvW)	*Institute for Environmental Studies - Instituut voor Milieuvraagstukken, The Netherlands*	*IVM*
Zhongping Lee (PL)	*Mississippi State University, USA*	*MSU*
Claudia Giardino (CG)	*Consiglio Nazionale delle Ricerche, Italy*	*CNR*
Joost Vandenabeele (JV)	*Belgian Science Policy Office, Belgium*	*BELSPO*

Names in italics are invited experts external to EUFAR

- **Excused:**

N/A

3. Introduction

SG welcomed everyone to the Kick Off Meeting of the EUFAR Expert Working Group on Hyperspectral Water Applications held jointly with the MICAS project kick off meeting. SG presented the agenda and highlighted the aim of the meeting from the EUFAR perspective:

- To foster collaboration in the field of case 2 water quality remote sensing. This meeting is an excellent example of two initiatives (MICAS and EUFAR-HYQUAPRO) working together.
- To input to the EUFAR-HYQUAPRO Task 4 research project (see below)
- To focus on hyperspectral water algorithms [or algorithms that can be operated with hyperspectral data]
- To discuss a possible intercomparison exercise between experts

TM gave a presentation on the EUFAR HYQUAPRO project (JRA2) and Task 4 which specifically focuses on water quality algorithms. The main aims of JRA2 are:

- To develop quality indicators/layers for airborne hyperspectral imagery plus higher level water quality and soil products
- To implement these in existing European airborne processing and archiving chains (PAFs)

These activities also overlap with other EUFAR activities, namely: Expert Working Groups (EWGs), N6-SP (network : standards and protocols, generic framework, JRA-2 (error propagation, quality layers), and the MICAS project.

EK gave a presentation on the MICAS project and her expectations from this meeting:

- In MICAS water quality algorithms will be developed for the APEX sensor
- A proposed methodology was outlined on the basis of wavelet transformations
- An extensive Specific IOP (SIOP) database exists for the target areas being considered by this project, These measurements were compared with ULB methodology and found to be consistent
- The proposed method is that of Albert and Mobley (2003). PG stated that this model can be used for turbid water but parameters need to be adapted to account for higher SPM ranges using Hydrolight simulations

PL questioned why it is proposed to use R(0-) instead of R_{rs} (errors associated with the latter are smaller)? He also emphasized the need to be careful when extrapolating polynomial functions (as in case of Albert and Mobley methodology) and why to focus on the optical properties (again, errors associated with these are lower than for water quality concentrations). HvW indicated that end users are largely only interested in concentration estimates.

4. Presentations on state of the art

To start the presentations TM gave a brief presentation on his interpretation of the state of the art of water quality algorithms for level 3 products from hyperspectral remotely sensed data. Arising from this he posed a number of questions as topics to focus subsequent discussions. These questions were:

- Which water quality products should be focused on (e.g. Chlorophyll, suspended matter, etc)?
- Is there such a thing as a 'global' Case 2 algorithm?
- Do we need separate algorithms for Inland waters and for Coastal waters? Is this even possible?
- Should we go for algorithms that are not perfect, but standardised, with known uncertainties (i.e. fit for purpose)?
- Do 'robust' algorithms exist? How do we define what we mean by 'robust'?
- How good can we assume atmospheric and air-water interface corrections are?
- Do bio-optical models themselves need further improvement/development?
- Just how good are inversion methods for routine use?
- To what extent do we need 'ground' calibration/validation? Has enough been done on independent validation of the different approaches? (data scarcity problem). Do we know enough about the variations of Chlorophyll, TSS, IOPs, and AOPs in Case 2 waters?
- To what extent are the algorithms we may use sensor specific?

The following experts were asked to give a short presentation on their field of expertise:

- Peter Gege, DLR: "Inverse modeling of case-2 waters: Error sources and error propagation". A simplified approach to the estimation of errors associated with the prediction of water quality parameters if other water quality parameters are poorly estimated was presented. Overall conclusions were that whilst the determination of Suspended matter backscattering is reliable if Chl and CDOM are poorly known, the determination of Chl is unreliable if errors of X, S, Y are above ~ 5 %. The determination of Gelbstoff absorption is reliable if S uncertainty is below 20 %. Errors can be reduced using a fit strategy which accounts for error propagation.
- Zhongping Lee, MSU: "Quantitative remote sensing of water clarity". The depth of the euphotic zone (Zeu) is a much more accurate and reliable predictor compared to remotely derived [Chl] for both coastal and oceanic waters. It can be objectively measured in situ and is a measure which water quality managers and water users can easily relate to. Zeu can be near-analytically derived from ocean color remote sensing.
- Hans van der Woerd, IVM: "Simple fit for purpose algorithms versus generic spectral fit algorithms for Dutch inland and coastal waters". Tests of a range of different approaches were presented for a variety of Dutch waters. More sophisticated approaches were based on the HYDROPT model developed at IVM. Whilst the simple algorithmic approach to the estimation of water quality parameters is fast, it is often only for the prediction of one WQ parameter and need to be tuned for particular water bodies. The generic HYDROLIGHT model inversion process is slow but can include the important aspect of angular dependence. The HYDROPT approach (based on polynomials and Levenberg-Marquadt NL schemes) is fast, can provide error estimates and optical closure but needs to be tuned to water bodies.

- Steve Groom, PML: “Inherent Optical Property model for coastal waters”. This talk argued that semi-analytic modeling of the underwater optical system is the preferred approach particularly where IOPs can be directly used in many applications and from which Chl and other information can be directly retrieved. It was shown that assimilating IOPs into a coupled physics-ecosystem model improves prediction.
- Claudia Giardino, CNR: “Remote sensing of Italian lakes” presented a brief overview of research in oligo/mesotrophic and eutrophic inland systems in northern Italy. Variability in IOPs were shown to be large and adjacency effects on pixel reflectances should not be overlooked. Careful consideration should be given to flight geometry and the SNR of the system being flown. Validation is also a tricky issue, where different sampling and analysis protocols, sampling depths and system dynamics all introduce errors in validation. A strong interaction with end-users to produce products relevant to their needs is also necessary
- Steve Groom, PML: “Atmospheric correction of casi data” presented the approach to sun-glint and surface effect correction developed at PML.
- Zhongping Lee, MSU: “Quantify the reliability of QAA-derived inherent optical properties”. PL introduced a quasi-analytical algorithm and used it to show that the qualities of the IOPs derived using it, in addition to the quality of R_{rs}, rely on the estimation of $a(\lambda_0)$ and Y. The quality of the estimation at each pixel, measured by projected average error and projected likelihood range, could be quantified by evaluating the error propagation in the modelling process. Higher qualities were obtainable for IOPs of oceanic waters, as both $a(\lambda_0)$ and R_{rs} possess higher reliability.

5. Discussions and Conclusions

The main issues of these discussions were:

1. Water algorithms

A lot of water algorithms are already available for different sensors, ranging from empirical to analytical models. There is always a trade-off between simple and complex algorithms on speed and generic character. The accuracy of simple models can be quite good for specific cases and it is recommended to test both simple and complex algorithms. HvW presented a fast alternative for hydrolight LUT: HYDROPT. Ping presented his stepwise Quasi analytical algorithm and another candidate approach is the Matrix Inversion Method (Brando and Dekker 2003) as used in Italian lakes by CG.

2. Error estimates on the final product:

Due to uncertainties within the algorithm or model and errors in the input R_{rs} values, it is important to estimate an error value for the derived the water quality parameters. It would be interesting to compare the resulting errors in simple and complex algorithms when operated with input R_{rs} value with known errors. However, we should ensure that this research focuses on the errors of prediction rather than on the algorithms themselves.

- PL noted that for empirical algorithms it will not be possible to quantify the error on a pixel basis. He also noticed that there is a large difference between average and maximum error, which for Chl can be as high as 500%. A more reliable water quality parameter would be water clarity, in particular Z_{eu}. The errors associated with IOP prediction are much less – the largest errors arise when converting from IOPs to concentration values since this is site specific.
- PG's research presented a list of error sources; as Chl is highly influenced by errors in the CDOM and Y concentration, these latter parameters should not be fixed.
- CG indicated that adjacency effects also have a large effect on the Chl concentration estimates.
- SG noted presented issues on atmospheric correction (incl. sun glint) which can influence the final quality estimates. The air-water interfaces should not be a problem any more but straylight/sensor calibration is seen as an important issue to solve.
- In the HYDROPT algorithm of HvW, no actual error estimates are made but pixels are flagged when fitting was not successful. This is seen as a good alternative to treat uncertainties in the final product.
- At the end, one consideration is for the end-user to define just how robust an algorithm should be. (e.g. 10 % error; 90% of the time)

3. Wider cooperation and involvement:

Currently a lot of emphasis is going into case 2 water research. Initiatives similar to those of the current meeting were reported and included:

- The GEO workshop on remote sensing of inland and coastal waters to be held in Washington in May.
- ESA workshop on coastal waters
- NASA funded project on coastal/inland water quality algorithms

It was felt that the results of the EWG should reported to these wider fora.

4. Hyperspectral research:

EK presented the specifications of the APEX sensor. A flight campaign over the Scheldt (BE) and lake Constance (CZ) is foreseen in June 2009.
PL questioned why hyperspectral sensors should be needed to investigate case 2 water. All agree that it is not clear how much 'hyper' is needed, as a lot of correlation exists between bands. Furthermore, to distinguish between pigments remote sensing S/N should increase. The APEX sensor, with S/N of 500 in the blue region, was seen as a great benefit.

5. Water products:

The recommendation from the EWG was to concentrate on the following water quality products: Chl-a, TSM, CDOM, Zeu, and IOPs. It was noted that validation error is important (i.e. errors in the in situ measurement of water quality products, surface samples and failure to match up, as partly outlined by CG above). It was also noted that end-users often ignore errors associated with in situ measurement of optical water quality parameters and that there is a role for the education of end-users on this point.

6. Experiments for testing algorithms.

Options for a community test site over which multiple sensors could be flown were discussed. The aim would be to collect data suitable to both the MICAS and EUFAR JRA Task4 research projects. The plan would be to submit a combined proposal to Eufar for Transnational Access.: Potential study sites include:

- Waddenzee (The Netherlands),
- Scheldt river (Belgium),
- Lake Constance(Switzerland),
- Lake Garda en Mantua lakes (Italy)

Funding for fieldwork associated with a TA project would be available.

7. Future meetings

It was generally felt that the meeting had been useful and the question arose as to whether future meetings could be organised:

- Tie up with Eufar meeting in Portugal September 2010?
- User oriented session in 2011 Edinburgh?

6. Action list

Action 1:	**Check on creation of EWG e-mail list**
Responsible: SG	
Deadline: 8	
Deliverable number: N/A	

Action 2:	**Provide description of potential in situ validation site**
Responsible: Anyone proposing an in situ site	
Deadline: 8	
Deliverable number: N/A	

Action 3:	**Investigate possibilities for future EWG meetings**
Responsible: SG	
Deadline: 8	
Deliverable number: N/A	