Hydrol. Earth Syst. Sci. Discuss., 6, C1029–C1038, 2009
www.hydrol-earth-syst-sci-discuss.net/6/C1029/2009/

Hydrology and Earth System Sciences Discussions

HESSD

6, C1029–C1038, 2009

Interactive Comment

Interactive comment on "Deriving inherent optical properties and associated uncertainties for the Dutch inland waters during the Eagle Campaign" *by* M. S. Salama et al.

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Received and published: 2 June 2009

1 General reply

In the revised version we validated our model with in-situ measurements from the Dutch lakes. We added to the validation a new data set from Dekker 1993 and Dekker et al 1997 measurements in the Vecht lakes. This data set is typical case 2 waters with scattering and absorption coefficients up to 20 m^{-1}.
The results are consistent and confirmed our previous findings.

The comments of the referees are in blue font and our replies are in black font. The comments are numbered to facilitate referencing.

2 Replies to the comments by referee 1: Emmanuel Boss

This paper an algorithm is introduced and used to invert remote sensing data into inherent optical properties for two bodies of water in the Netherland together with their uncertainties. I do not recommend this paper for publication at this stage due to the following reasons:

1- I find this paper to be poorly written and confusing. I have a hard time to understand the underlying philosophy, which data is used for training the algorithm and which for validation and what IOP data the author have to compare with their inversion (except for SPM and chlorophyll to biogeochemical properties that represent concentrations but are not IOP per-se

We improved the quality of the paper in the revised version. Detailed descriptions of objective, used data for validation and results are now included.

The paper is presenting a case study using measurement carried out during the Eagl-2006 campaign and data obtained from Dekker 1993. The paper holds important information:

a- it uses multi sensors: ocean color, hyperspectral airborne and ASTER images to get water quality parameters from two inland lakes. This comprehensive exploitation of EO data is unique for the Eagle project and in many studies of inland waters.

b- the inversion of remote sensing reflectance is sensitive to the spectral shape of SPM backscattering and dg absorption. Taking these two parameters into account improved the overall accuracy of derived IOPs.

c- we showed that inversion-uncertainties do not describe the total and actual uncertainty and is related to the water turbidity.

d- in the revised version, the modified GSM is validated with case 2 waters with scat-

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tering and absorption coefficients exceeding 10 m^{-1} and up to 20 m-1. This kind of validation (extreme case 2 waters) is for the first time reported for the GSM model.
We used optimization based on steepest gradient. So no training was needed to start up the optimization, i.e. only initial values and the bounds are needed. So basically IOCCG data set and the measured concentration were used to validate the modified GSM model.
We agree with the referee that this validation exercise should be separated: one with IOCCG data set and the second is with measured values. In the revised version we validated our method with in-situ measurements alone. We then used IOCCG data set to show that the modified model is consistent with, and even better than, the un-adapted version.

2- I do not understand why the authors use the IOCCG data set generated by Lee. Are these simulation applicable to the waters they investigate (these data were specifically used to look at open ocean environments where waters are deep and the atmosphere is relatively simple to deal with)? If the answer is yes please detail why it is so.

In the revised version we used the IOCCG data set just to check that the modification is meaningful. We think that any modification to a model should be first verified against the works of others. Following this philosophy we validated the modified GSM with the well known IOCCG. We argue that any modification to a model should give comparable or better results than the original model as applied to the same data sets. In this sense we used IOCCG as a baseline for our modified-model.
Indeed the values in Lee 2006 are meant for open ocean but the measured concentrations of chlorophyll-a and SPM in the Veluwe lakes (only) were in the same range at this time of the year, i.e. July little runoff, low wind speed so re-suspension is only due to ship and boat perturbations.
In the revised version we lessened the emphasis on the IOCCG data set. The major efforts of the revised version are focused on validating the method with in-situ

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measurements. The new added data set ”the Vecht lakes” is typical case 2 waters, i.e. scattering and absorption coefficient above 10 m^{-1}.

3- The uncertainties presented are not based on the full possible sources of error (e.g. atmospheric correction, adjacency effects, assumptions regarding relation of IOP and Rrs, assumptions regarding the semi analytical IOP model) and hence, I don't believe they represent the correct uncertainties (See Boss and Maritorena in the cited IOCCG report).

The presented uncertainty is based on model fit using the partial derivative matrix (the Jacobian). So the uncertainties describe a part of the total uncertainty. This was mentioned in section 5.3 where we gave very elaborative and detailed discussions about uncertainty: please see the old version pp 2084, lines 17-23. Furthermore we gave general outlines for possible improvements on error separation: pp 2084 line 23-28 and pp 2085 line1-4. A better description of inversion-uncertainty is now included in the revised version. Moreover the title of the revised manuscript is now more precise. It reads as: Deriving inherent optical properties and associated inversion-uncertainties in the Dutch Lakes.

4- In (8) you invert for 5 parameters. How can you validate them with the data you collected? At best you can check that the inversion you use is consistent in SPM and chl with your measurements in the lake. The whole IOCCG report exercise dealt with inverting this data set with different algorithms. There is no need to duplicate it here. Here you may want to simply ask the question: Given the data we collected in the lake how well to IOP algorithm perform?

Indeed we do not have data on the spectral shape of dg and SPM. The only way to check is by validating with in-situ measurements. In the new version we added a new validation exercise. The validation consisted of two data sets one in the Veluwe lakes and the other in the Vecht lakes.

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In the revised version we used the IOCCG data set just to check that the modification is meaningful. We think that our modification should first pass what other models have passed. In this sense we are not duplicating the IOCCG but showing that the modification of the GSM model is giving better results than those presented in IOCCG without modification. However, in the revised version we lessened the emphasis on the IOCCG data set. The major efforts of the revised version are focused on validating the method with in-situ measurements. There is now a small paragraph in the "Discussion" section about IOCCG data set

5- What are the uncertainties in your measurements of chl and spm? Table 1 suggests +/-0.5 for chl and +/-0.05 for spm is this correct?
We rounded the chlorophyll concentration. In the new version we put the two digits. So the sensitivity of our measurement for Chlorophyll is +/-0.05 and SPM is +/-0.005. The revised version contains the actually accuracy of the measurements.

6- Sec. 3: "The IOPs of each sampling site are computed from measured concentrations and published values of specific inherent optical properties for the Dutch lakes (Hakvoort et al., 2002)" Can you elaborate? Did you use IOPs measured in lakes? Forwhat? Earlier you specified IOPs that were not based on measurements.
In the old version we had measurements from the Veluwe lakes. This data set consists of measured concentrations of SPM and Chl-a and water leaving reflectance. No measurements of IOPs were available. We multiplied these measured concentrations by tabulated values of SIOP. The SIOP were obtained from a different lake system. So in the old version the IOPs were based on measured concentrations and tabulated SIOP values.
In the revised version we used another data set from Dekker 1993 and Dekker et al 1997. This data set (Vecht lakes) consists of measured water leaving reflectance and IOPs.

7- The ‘assumption’ that an IOP = [concentration]*concentration-specific IOP is not an assumption but a simple consequence of the Bouger-Beer-Lambert law. If that did not hold we would not be using spectrophotometers to do chemistry.
Correct, this is just inappropriate wording. We are aware of the Lambert–Beer law as we used it thought out the whole paper (e.g. see comment 6). We modified the word “assumption” in the revised version.

8- Figures 3 and 4 have too small of a text for readers to understand the content. Please enlarge.
The figure is enlarged in the revised version.

9- Only one of your dataset has radiometry and in-water properties in the same time (ASD, SPM, chl). This is the only data set for which you can test your inversion wrt lakes. You can apply and compare your inversion to the IOCCG data set, yet, in this case, you are simply repeating the IOCCG, 2006, exercise. This may be valuable to show that your algorithm is consistent or even better than the other algorithms there. But this should be done SEPARATELY from the evaluation of its success with respect to Dutch inland waters. For the Dutch in-land water case the only data you should compare your results to are those collected IN the in-land waters. Once you convince yourself and the readers that your algorithm works well relative to in-situ data then you can generalize to times where measurements are not available.
In the revised version we added a new validation exercise. The validation of our modification is now based on in-situ measurements alone.
We used two data sets for the validation. The first is in the Veluwe lakes (8 sites) and consists of water leaving reflectance and concentration. The second is in the Vecht lakes (20 sites) and consists of IOPs and water leaving reflectance. The results of the validation exercise (28 data points in total) have supported our conclusions and

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scientific findings. The validation results confirmed that the modified GSM model is appropriate to inland waters.
However we think that validation with IOCCG is not repetition but rather as you wrote in comment 9: " *valuable to show that our algorithm is consistent or even better than the other algorithms there*". Therefore we added a small paragraph about model consistency in the Discussion section.
a.

10- In short I do not believe that the results presented in this paper could be used to suggest a successful algorithm has been found for Dutch in-land waters that provide IOPs and their uncertainties. To convince me otherwise I will want to see the comparison with the in-situ data only and the uncertainties should be derived based on all sources of uncertainties, not just the inversion algorithm (that is the uncertainties in the assumptions (e.g. the IOP shape chosen) and the input data need to be taken into account as well).

Dear Authors: I am often wrong. If you feel that I misunderstood your paper please feel free to contact me (emmanuel.boss@maine.edu) and I will more than happy to change my opinion if proven wrong.
In the revised versions: 1- we validated the method with in-situ measurements In the Veluwe lakes at 8 sites. 2- we validated the method with in-situ measurements In the Vecht lakes at 20 sites. 3- we focused on model-fit uncertainty and excluded other error components. However we recognized that excluding other error components is a major limitation. We further gave suggestions for improvements.

3 Replies to the comments by referee 2

General comments:

1- From the view of applied GSM method, the paper “Deriving inherent optical properties and associated uncertainties for the Dutch inland waters during the Eagle Campaign” is meaningful for the study of regional inland waters. However, I do not think that the IOCCG datasets from other regions are convinced for the validation of the GSM algorithm you modified to adapt your case. I think that the in situ data can be reliable for the validation. So, I suggest the paper should do a revision or supply data collected in the Dutch inland waters.

Indeed the validation with in-situ measurement should be done separately. In the revised version we validated the model within-situ measurements in the Dutch lakes. We added to the validation a new data set from Dekker 1993 and Dekker et al 1997 measurements in the Vecht lakes (the Netherlands). This data set is typical case 2 waters with scattering and absorption coefficients exceed 10 m^{-1} and up to 20 m^{-1}.

We used the IOCCG data to check the consistency as a baseline such that the modified optimization should at least give comparable results to what has been published in IOCCG. We showed that this modification has improved the accuracy of the derived products, i.e. the method has passed the first test.

In the revised version we showed that the errors in the derived scattering are an order of magnitude larger for in-situ measurements than for IOCCG. So we emphasized the difference between the water bodies in IOCCG and our data and highlighted the need for improved retrievals and parameterization algorithms for inland waters.

Specific comments:

2- For the section 2 method, could you explain why you use the MERIS level-1b TOA radiance products and do not directly use MERIS level-2 water-leaving radiance reflectance products, or water-leaving reflectance from MERIS level-1b by using the MERIS Case-2 waters plug-in processor?

Off course MERIS case 2 processor is a well established method for atmospheric correction (AC) and derivation of IOP from MERIS images in case 2 waters. We

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carried out the same atmospheric correction procedure to inter compare the results from ASTER, AHS and MERIS over the Dutch Lakes This was to avoid possible bias and errors that are related to the used AC method.

3- Could you clarify where the GSM model was modified, which parameter? Which variable?

The forward-GSM model was not modified as such. However the inversion of the GSM model was modified. In this modification, we did not fix the values of the spectral shapes S and Y. We derived these values from the optimization. Our argument is that the values of these spectral shapes are related to the constituent's bio-geophysical composition and are not always known. So, any wrongly assumed spectral shape will lead to significant alteration of the derived inherent optical properties.

S: is the spectral exponent of dg absorption coefficient.

Y: is the spectral exponent of the SPM backscattering.

4- In Fig.2, 8 samples of in situ data, by compared with 500 samples of IOCCG datasets, are small events of probability space. That means the 8 samples basically did not affect on the regression (n=508). However, for the algorithm validation, the 8 samples of in situ measurements can be valid, but, IOCCG data from other regions would be uncertain although sometimes consistent.

This is correct, indeed adding 8 to 500 points will not affect the results. So in the new version we separated the in-situ form IOCCG data set. In the revised version we validated the model with two sets of in-situ measurements. The first in the Veluwe lakes "the same data set as the old version, i.e. 8 points" and contains concentrations of SPM and Chl-a and water leaving reflectance. The second in the Vecht lakes (20 points) and contains IOPs, concentrations and water leaving reflectance.

5- P2081, line 7: : : :"synthesized plus measured", what dose that mean?

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This is basically adding IOCCG (synthesized) data set to the in-situ measured data set.
In the revised version we avoided this “”mixed-up” data set, we focused our validation to in-situ measured values and lessened the emphasis on the IOCCG data set to only a small paragraph in the ”Discussion” section.

6- P2081, line 10: : : :"model II regression": : :, could you explain what the model II is?
Model I regression (Y on X) assumes that X has no measurements error. Model II regressions (Y on X) both X and Y have measurements errors.
Model II regression is the estimator. It is used when we compare estimated to measured values of the same variable. The predictor (model I) is used when we like to predict the trend of one variable to another variables. So the two variables do not need to represent the same physical variable. Please check Laws (1997). Model II regression was used in IOCCG-2006 report.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 2075, 2009.

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