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Interactive comment on "Methods comparison to retrieve the refractive index of small scatterers" *by* A.-M. Sánchez and J. Piera

Anonymous Referee #2

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This paper reviews several inverse models used to retrieve the real or complex bulk index of refraction of particle assemblages in seawater suspension, given their inherent optical properties. They use synthetic simulated data sets to compare the performance of these models. This is an important contribution to the field of bio-optics because the complexity of actual in-water suspended particles requires various assumptions to be made when modeling their optical properties (IOPs); usually the assumption is spherical homogeneous particles. The index of refraction of the particles needs to be known or assumed in order to complete the forward modeling. The author's study thus has important implications for ocean color remote sensing and its biogeochemistry applications.

I recommend the paper for publication only after the authors address the com-

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Interactive Discussion
Discussion Paper

ments and suggestions below and in the annotated PDF. Please ensure that all edits/comments and suggestions in the attached annotated PDF are addressed. They are an integral part of this review.

Overall comment: The biggest weakness of this paper is that it presents relatively complex concepts and models in a manner that needs a better organization. In particular, a summarizing flowchart or table is necessary that shows the inputs used for each model/algorithm and in each test case, the PSD, the type of particle assumed, etc., as well as the assumptions of the model, the equations used (refer to equations in this paper or elsewhere). Such a flowchart/table will greatly help the reader be able to follow how each model is applied, in a forward or inverse manner. Also, the units are sometimes not given, please give units consistently everywhere, including captions/axes labels.

I recommend the addition of a table of variables, symbols and units used.

In many cases you discuss methodology mixed with the results. You even introduce new concepts such as BFGS later in the paper. All these are better placed in methods, and/or in a table/flow-chart such as I suggest. Admittedly, sometimes text flows better if you do introduce some of these methods later where you do, so this comment does not always apply.

In the real world, given IOPs of a whole seawater sample, an average complex index of refraction would be retrieved by the presented methods. This average is weighted according to the PSD and the indices of refraction of the individual types of particles present. You should discuss this clearly somewhere and preferably also derive this weighting and state what is actually retrieved. See Eq. 8 in Boss et al. (2001) (see below), and refs. therein. This would be very useful to the ocean color research community.

You need to discuss the applicability of these models to remote sensing data. Is it feasible for them to be applied to IOPs derived from ocean color remote-sensing re-

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flectance? The problem with this may be that many operational remote-sensing inversion models for IOPs have in them an implicit or explicit assumption about the index of refraction when they were developed, so it would become a circular reasoning. Retrieving the index of refraction from space would improve our ability to distinguish sources of backscattering from each other in the ocean, so a paragraph in the discussion about that would be really important. You discuss the limitations of having limited degrees of freedom in one instance (Sect. 4.2.3). The same applies to multispectral sensors of several wavelengths only. What is the feasibility of retrieval of the bulk m value from space with the advent of hyperspectral sensors such as the planned NASA PACE mission?

More specific comments:

Title: Title needs revision of word order and, more importantly, it needs to better reflect that this paper refers to aquatic optics.

Abstract: Needs major revision. Several sentences need to be added to set the context (aquatic optics), state that complex index of refraction determines IOPs and as such is input to forward models. Refractive indices are not easy to measure, thus are often assumed or retrieved with inverse modeling, etc.

Introduction: You need to state more clearly how this test procedure works. I.e. do you start with particle(s) with known complex refractive indices, and then do a forward model (Mie, T-matrix, specify), than pass the IOPs to the inversion models and compare the results to the known inputs. Is this the scheme of your tests in this paper? It does not become very clear.

pg. 18730, line 11, eq. 14 – this needs a better explanation because it is confusing as it is presented. Do you mean that the values in Eq. 14 are already the values relative to seawater, as you use them throughout the paper? Show the actual equation to calculate the relative index, given the complex indices of the particle and the medium.

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Eq. 15 – I believe the Twardowski model retrieves just the real part of the refractive index, not something equivalent to |m|.

pg. 18731, line 2: Fig,. 1a caption in Twardowski et al. (2001) says that k was fixed at 0.005, therefore they do not ignore/neglect k in this model, which is a fit to their Fig. 1a.

pg. 18734, line 3 – you use inconsistent notation for the complex index of refraction – it is 'm' above, and 'n' here. Please use consistent notation everywhere.

Additional comments:

Sect. 4.2 Why not apply the Twardowski model to these coated particle IOPs and see how the retrieved bulk n compares to the input ones? I.e., why can't the Twardowski model be applied to the cases other than homogeneous spheres?

The Bernard (2009) reference is not given in the list of references.

In all figures with the output IOPs, consider showing spectral backscattering as well – would be very useful for remote sensing relevant applications.

Sect. 2.1: Whenever you use equations not derived by you, please give citations.

+ or – in the m = n+ik expression? Different sources list it differently. So it would be useful if you clarify this.

References:

Boss E., M.S. Twardowski, and S. Herring, 2001. Shape of the particulate beam attenuation spectrum and its relation to the size distribution of oceanic particles. Applied Optics, 40, 4885-4893

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/12/C9713/2016/bgd-12-C9713-2016-supplement.pdf

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