Estimation of positive sum-to-one constrained zooplankton grazing preferences with the DEnKF: a twin experiment.

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Answers to Referee 2

The authors wish to thank the referee for his/her helpful and constructive comments.

The section 2 has been rewritten to take into accounts the comments of the first referee. In order to make the approach less specific, the revised version of the manuscript includes the two systems to solve in order to obtain any set of prior expected values and variances for the $(\pi_i)_{i=1:N}$ and not only equal expected values. It results in a change of content of Appendix B which now describes the derivation of the system of equations required to choose the variances of the parameters $(\pi)_{i=1:N}$.

Furthermore, we discovered during the reviewing process a work of Nurmela (1995) introducing the hyperspherical coordinate system to remove constraints of sum in geometrical applications (spherical code). A reference to this work has been added in §2.3.

Main comments

- *I found the paper reasonably well written, with the exception that the level of English is slightly poor, particularly with regard to sentence formulation, which was occasionally confusing (e.g. P 1091, L 10-12).*

  The sentence mentioned by the referee has been rewritten. Language corrections have been done and we hope that the level of English has been improved.

- *On page 1097 it is suggested that for the spherical formulation, the results of the calibration are sensitive to the order in which the auxiliary/transformed parameters are assigned. If so, this is an important point which requires further discussion. For example, it would be very helpful to be able to compare results as the order is changed.*

As suggested by the referee, we performed additional experiments to assess the robustness of the results to changes in the order the parameters are assigned in the transformation. The experiments have been done with the same 20 prior ensembles and observations. In order to reduce the number of simulations, we introduced permutations in the diet of the microzooplankton only. Every four experiments, we permute the food in the correspondence to the transformed parameters. In such way, we have an overview of the performance of the method in the five configurations that were not previously investigated.

The results are quite similar to the ones obtained with our original choice assigning the transformed parameters to the preferences. For the microzooplankton, we note that the mean and standard deviation of the 20 means of preferences obtained at the final time (see Table 1) are similar to the ones obtain previously. Furthermore, we note a slight decrease of the RMS error (see Table 2) compared to previous results. This is confirmed by the ternary plot in Figure 1 for which almost all the points belong to the shaded area.

We note a slight damage of the final estimate of the mesozooplankton preferences, notably the one for the microzooplankton. However, the average values and the RMS error are relatively close to the ones of the solutions obtained with the Gelman formulation. In the ternary plot, the number of points out of the shaded area has increased from 6 to 9 which is equal to the number of points out of the shaded area obtained with the Gelman formulation.

This suggests that the spherical formulation is quite robust to changes in the assignment between the parameters, at least in this particular framework. However, we did not explore all the possible combinations (36 in total) and the amount of experiments remain relatively low (20 in total), and so more experiments would be required to strongly support this results. A comment has been added in the manuscript. However, figures and tables are not included.

[Table 1 about here.]

[Table 2 about here.]

[Figure 1 about here.]

Specific comments

- *P 1086, L 22-23: PFTs do not aim to resolve individual species, but rather larger functional groups*

  The sentence has been rewritten.

- *P 1088, L 2: What is the Gaussian anamorphosis? This is mentioned several times in the text, including in the abstract, with no clear explanation. I am not sure if this is a standard term in this field, but I had not heard it previously.*

  We call "Gaussian anamorphis" the nonlinear change of variables used to transform a non-Gaussian distributed variable into a Gaussian distributed one. This name comes from Geostatistics and has been introduced in ensemble Kalman filtering relatively recently. The term is defined in the revised version of the manuscript. Information concerning the Gaussian anamorphosis extension of the DEnKF have also been included in §3.2 "Data assimilation experiments".

- *P 1092, eqn 7: Given that the generalisation to N parameters is beyond the scope of the paper, is the Remark on the introduction of Hopf coordinates not also somewhat tangential?*

  We agree. We included this remark in order to highlight that the estimation of 4 preferences was not an issue despite the lack of solutions to the systems $(\mathcal{S}_i)_{i=1:N-1}$.The remark has been removed.

- *P 1094, L 3: Please give units of Chl:N ratio*

  Done.

- *P 1094, L 13: Z the concentration of meso- or microzooplankton feeder, would avoid confusion with MIC as food*

  Done.

- *P 1094, L 18: Are the results shown in Fig. 1 based on the true, or default values?*

  They are based on the "true" values and correspond to the evolution of the reference solution. This information has been included.

- *P 1097, L 6: Since the mesozooplankton feeds the diatoms only, suggest Since the diatoms are the only phytoplankton type fed on by the mesozooplankton. Or similar.*

  As suggested above, please elaborate on the apparent sensitivity of the spherical formulation to the choice of π_1, π_2 or π_3 for each parameter.

  The sentence has been corrected as suggested. A comment on the sensitivity of the estimation to the asymmetry of the transformation has been added.

- *P 1099, L 5: Innovations? Is this the correct word?*

  It is a standard term in optimal control and data assimilation. It corresponds to the difference between the observations and the model solution.

- *P 1102, L12-14: This estimate of performance is qualitative and subjective, as the grey shaded area seems quite arbitrary. A better estimate of shifts towards the true parameters would be given by RMS error statistics.*

  We agree that the ternary plots do not provide quantitative estimate of the performances of the approaches. However, we have included them to evaluate the number of experiments that were leading to corrections in the correct direction for the three preferences. We do not think it will be possible by only computing the RMS error because it provides information on the distance separating two variables but not on the relative positions. For that reasons, we have not removed the figure with the ternary plots. However, we ave included a table with the RMS error on the parameters (Table 2).

- *P 1102, L 27-28: On average, the spherical formulation leads to significantly better final estimates of the preferences than the Gelman formulation. Significant by what test? The spherical formulation looks marginally better, but both perform well, with all estimates within 1 s.d. of the true value.*

  We agree that the word "significantly" could not be relevant. We changed it to "slightly".

- *P 1004, L 2: Change correct estimates to improved estimates.*

Done.

List of Figures

1 Ternary plots of the final estimate (mean of the ensemble) of the grazing preferences parameters for the twenty experiments. The estimates obtained after assimilation are plotted with grey circles, triangles and squares (depending on the permutation), the true set of parameters with a black square and the mean of the background set of parameters with a black diamond. . . 7

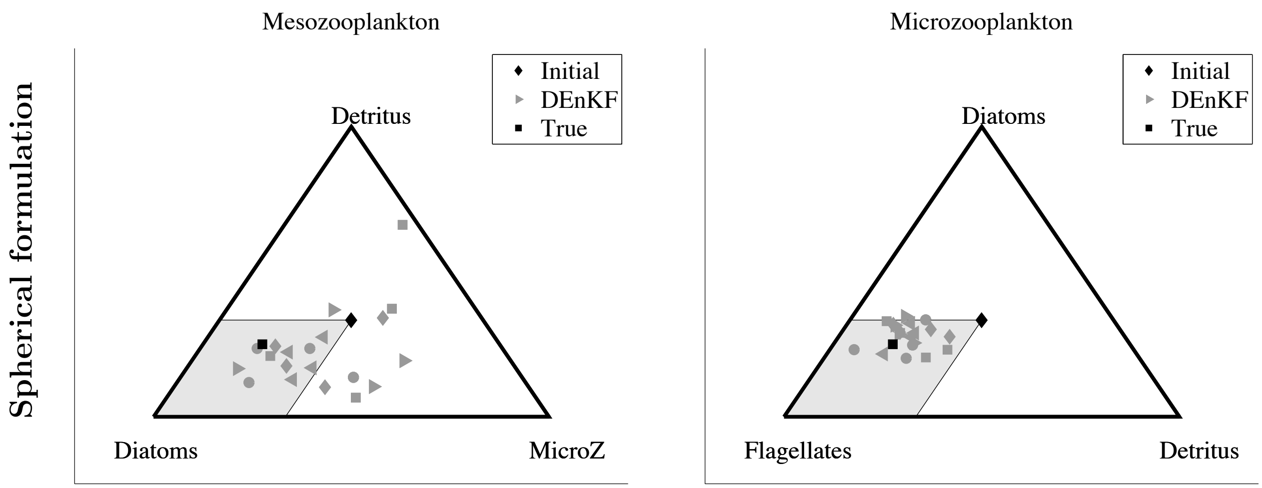

Figure 1: Ternary plots of the final estimate (mean of the ensemble) of the grazing preferences parameters for the twenty experiments. The estimates obtained after assimilation are plotted with grey circles, triangles and squares (depending on the permutation), the true set of parameters with a black square and the mean of the background set of parameters with a black diamond.

List of Tables

1 Zooplankton grazing preferences $(\pi_i)_{i=1:3}$: mean and standard deviation (computed over the twenty experiments) of the means of preferences obtained at the final time. 9
2 Zooplankton grazing preferences $(\pi_i)_{i=1:3}$: RMS error (computed over the twenty experiments) of the means of preferences obtained at the final time. 10

Table 1: Zooplankton grazing preferences $(\pi_i)_{i=1:3}$: mean and standard deviation (computed over the twenty experiments) of the means of preferences obtained at the final time.

Mesozooplankton

Diet	DIA	MIC	DET
True value	0.6	0.15	0.25
Gelman	0.50±0.19	0.31±0.16	0.19±0.09
Spherical	0.51±0.19	0.24±0.11	0.25±0.13
Spherical with permutations	0.46±0.17	0.31±0.12	0.23±0.13

Microzooplankton

Diet	DET	FLA	DIA
True value	0.15	0.6	0.25
Gelman	0.19±0.1	0.56±0.09	0.25±0.05
Spherical	0.20±0.09	0.56±0.10	0.24 ±0.05
Spherical with permutations	0.17±0.06	0.55±0.06	0.28 ±0.04

Table 2: Zooplankton grazing preferences $(\pi_i)_{i=1:3}$: RMS error (computed over the twenty experiments) of the means of preferences obtained at the final time.

Mesozooplankton

Diet	DIA	MIC	DET
Prior (%)	45	120	32
Gelman (%)	35	146.6	44
Spherical (%)	33.3	86.7	48
Spherical with permutations (%)	36.7	133.3	52

Microzooplankton

Diet	DET	FLA	DIA
Prior (%)	120	45	32
Gelman (%)	66.7	16.7	20
Spherical (%)	66.7	16.7	20
Spherical with permutations (%)	40	13.3	20