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Interactive comment on "Developing a common, flexible and efficient framework for weakly coupled ensemble data assimilation based on C-Coupler2.0" *by* Chao Sun et al.

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Dear Reviewer,

Thanks a lot for reviewing our manuscript and for the comments and suggestions.

We would like to reply some comments here, and will carefully follow all your comments and suggestions when revising the manuscript.

1. The motivation for developing your own system rather than using PDAF I found lacking.

Response: As discussed with Dr Lars Nerger, we have our motivation for developing

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DAFCC. We will rewrite the motivation part. Our motivation is as follows (also has been introduced in the reply to the first reviewer). Ensemble DA is also developed and used in China. To help the development of ensemble DA in China, especially when model resolution gets finer and DA frequencies get higher, we aim to develop a common ensemble DA framework that can enable users to make DA systems as efficient as possible. As most developers for models and DA systems in China are origin from science and do not have strong experiences in software engineering and parallel programming (many model teams even do not have any full-time software engineer), we have to make DAFCC as convenient as possible, especially for the model developers who are not proficient in parallel programming and parallel debugging with MPI. So, we try to make DAFCC handle as much work as possible. Now, the MPI communicator of whole ensemble of a component model for running an ensemble DA algorithm is generated automatically and then used intra DAFCC and the data exchanges among members, ensemble and DA algorithm are also automatically handled by DAFCC, no matter the differences regarding parallel decompositions. Moreover, we enable a DA algorithm to be enclosed in dynamic-linking library, in order to make the model code and the DA code as independent as possible.

2. There were 2 main points I could ïňĄnd in section 2, namely "PDAF [... imposes] a precondition of process layout such that each ensemble member uses the same number of processes with successive IDs in the MPI_COMM_WORLD" and "[PDAF] only makes the processor cores of the ïňĄrst ensemble member available to the DA algorithm and forces the processor cores used by other ensemble members to idle when running the DA algorithm". The second statement I think is untrue, but Dr Lars Nerger has posted a short comment on PDAF so I trust he will ensure the correctness there. The ïňĄrst point I ïňĄnd to be obscure as I cannot think of a situation where you would not have ensemble members using sequential MPI process IDs.

Response: The second point is untrue, according to the discussions with Dr Nerger. In PDAF, a DA method can use different processor cores from the first ensemble mem-

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ber, while users should be responsible for developing the data exchange functionalities among different parallel decompositions. Regarding the first point, we also have not seen a real case that ensemble members of a coupled model do not use sequential MPI process IDs. We will not highlight the support for non-sequential MPI process IDs again when revising the manuscript.

3. One overarching question which is not addressed is why would you design from the outset a "weakly coupled" data assimilation system? Why not design a strongly coupled system and then simplify it? I suppose the answer here is to still be able to piggyback on existing observation processing systems and to allow for different observation frequencies, but this should be clearly set out in the article.

Response: Thanks a lot for pointing out this important consideration. We will clearly state it when revising this manuscript.

4. I would like to see more clarity in relation to the comparisons that you make. There are a number of places where the comparison is against an system that uses I/O and reading/writing ïňĄles from/to disk rather than MPI communications. In such a case phrases like "accelerating the DA system" should be qualiïňĄed. There are other relations made where it is unclear what the comparison is with. For example in the abstract you state that the new methodology "enables the DA method to utilize more processor cores in parallel execution" but I cannot see the baseline for such a statement. Moreover would such a statement hold with a different baseline?

Response: We will rephrase "accelerating the DA system" and "enables the DA method to utilize more processor cores in parallel execution" that are incorrect.

5. Line 57. PDAF is indeed *the* standard for ensemble based DA frameworks. Others also exist. For example EMPIRE (https://pbrowne.bitbucket.io/empire) Browne, P. A., & Wilson, S. (2015). A simple method for integrating a complex model into an ensemble data assimilation system using MPI. Environmental Modelling \& Software, 68, 122–128. https://doi.org/10.1016/j.envsoft.2015.02.003. You need to discuss other parallel

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strategies such as that used by P.A. Browne, S. Wilson, 2015

Response: Thanks a lot for introducing this pioneer work. We will briefly introduce and discuss it when revising the manuscript.

6. Line 93: "How to compile the code of DA methods with the model". This is not necessary. In particular if you run (using MPI) in MPMD mode then the model and the DA could be compiled independently.

Response: It is true that the model and the DA could be compiled independently when using MPMD mode where the DA has its own executable. Regarding DAFCC, the DA does not have its own executable and shares the processor cores of the model ensemble, which means that MPMD mode is not used. The model and the DA could also be compiled independently under DAFCC, because the technique of dynamic linking is used. How to compile DA may be not a critical problem. We will not highlight it again when revising the manuscript.

7. Line 108: "Although PDAF enables a DA algorithm to run in parallel, it only makes the processor cores of the ïňĄrst ensemble member available to the DA algorithm and forces the processor cores used by other ensemble members to idle when running the DA algorithm." This is not my understanding of PDAF. I see that Dr Lars Nerger has already submitted comments in relation to PDAF, so I am assured that he will have given you the latest and correct information in relation to this.

Response: We will revise the manuscript according to the discussions with Dr Nerger.

8. Are you suggesting a coupled model which uses a different coupler, such as OASIS, would then be put into C-Coupler2.0 for the DA component?

Response: We want to offer an option of solution here. C-Coupler2 can automatically generate MPI communicator of each ensemble member of a coupled model that uses a different coupler. There can be other solutions for this functionality, while C-Coupler2 should also be called for recording the MPI communicator of each ensemble member

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for using DAFCC.

9. Line 155/Figure 3: Is a restriction that the components in each ensemble members run on the same number of MPI processes? Surely there is a restriction enforced by the DA algorithms that the component model is on the same grid for every ensemble member, or has some very exotic DA methodology been implemented? In the case they have, how do you then establish which DA algorithms are applicable given the difference in the ensemble members?

Response: We agree that there is a restriction enforced by the DA algorithms that the component model is on the same grid for every ensemble member, while a model on the same grid can be run under different numbers of cores as well as different parallel decompositions. Now we note that real cases generally use the identical core number as well as identical parallel decompositions to run ensemble members of the same model. Although we produced the support for inconsistency of core number among ensemble members, it is useless for current real cases. We will not highlight this support again when revising the manuscript.

10. Line 159/160: "execution of a DA algorithm in a component model does not force the processes of other component models to be idled". This must relate to the time stepping procedure of the coupled model. In fact here are you for the ïňĄrst time enforcing that all components of the model must have separate MPI processes? This is not the case in, for example, the ECMWF earth system model (Mogensen, K., Keeley, S. and Towers, P., 2012. Coupling of the NEMO and IFS models in a single executable. Reading, United Kingdom: ECMWF.)

Response: We correct the corresponding statement.

11. Line 188: The "weakly coupled" component of your methodology then relies on using the C-Coupler2.0 to control the coupling of the model then?

Response: C-Coupler2 and DAFCC can only handle the coupling between the model

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ensemble and the DA algorithm, while the coupling among component models in each ensemble member can also be handle by the original coupler that can be not C-Coupler2.

12. Figure 5: Why is there no red within the DA_CCPL_RUN subroutine to indicate data exchange between the model and the DA?

Response: The data from the model ensemble to the DA algorithm is transferred automatically and implicitly by DAFCC before running the DA_CCPL_RUN subroutine, while the data from the DA algorithm to the model ensemble is transferred automatically and implicitly after running the DA_CCPL_RUN subroutine. This implementation is motivated from some programming languages such as Fortran. We will briefly introduce that when revising the manuscript.

13. Line 410) "We evaluate the effectiveness of DAFCC1 in developing a weakly coupled ensemble DA system". I don't see the justiïňĄcation for this statement. I can see you have implemented the system and shown how it performs computationally with various parameters, as well as a very simplistic veriïňĄcation that the data assimilation is implemented correctly. You should state a measure for effectiveness - was it simply to have a functioning system? Compare this with Browne and Wilson, 2015, where they "propose a simple implementation strategy which does not focus on maximum efïňĄciency of the code. Instead the focus is on the speed of implementation."

Response: In this manuscript, we tried several aspects to evaluate the effectiveness of DAFCC1. First, we adapted an existing ensemble DA system, WRF GSI/EnKF, to DAFCC, where the simulation result of the DA system keeps exactly unchanged. Second, we evaluated the impact of DAFCC in terms of replacing the corresponding I/O operations in the original DA system by MPI. Third, we showed that DAFCC can serve the construction of a weakly coupled ensemble DA system. We will make clear how we evaluate the effectiveness when revising the manuscript. Moreover, considering DAFCC enables a DA algorithm to flexibly utilize a wide range of processor core num-

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ber (even from 1 to the total core number of the corresponding model ensemble), we will further evaluate the corresponding impact when revising the manuscript.

14. Line 424) Why were 3200 cores used when each node has 24 processors? mod(3200,24) != 0

Response: Although our account can use a maximum number of 3600 cores, we can only use about 3200 cores actually (there are may be some errors in the computer system).

15. Line 460/Figure 11c) Why does the ofïňĆine timing of GSI vary with different numbers of ensemble members? On line 458 you state that you run all ensemble members of the ofïňĆine system concurrently, so I would expect a constant value of time for the model run as you change the number of ensemble members. This clariïňĄcation will be essential in understanding the rest of the ïňĄgures here, as otherwise it seems like the comparison may be unfair. Could it be i/o related? With every member trying to write output ïňĄles at the same time your system slows? If this is the case it should be explicitly accounted for in the ïňĄnal paragraph of this section. Furthermore, you should detail what ïňĄle system architecture is used at BSCC in section 6.1. Is it something like lustre?

Response: We will further discuss about that when revising the manuscript.

Best regards,

Li Liu

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