Anonymous Referee #2

This study, "Realized ecological forecast through interactive Ecological Platform for Assimilating Data into model (EcoPAD)," by Huang et al. introduces a web-based platform for data-model integration framework that "can" be used for ecological forecasting. The manuscript introduces the conceptual components of the framework relatively well, albeit with too much generic details on databases, web-based workflow, metadata, data API, which are not the focus of GMDD. Even though I feel that the platform presented in the manuscript has a huge potential, I find the current state of the platform, and the example cases presented are not mature yet (with only one model, one data assimilation, one site). There is a little scientific advance from the study with results based on previous studies. The results and evidences presented, therefore, do not back the claim of 'have-it-all' platform that can be used by the scientists and 'citizens' alike. I think the manuscript should focus on specifically "what has been done" with thorough scientific discussion, and not "what can potentially be done." This would help judge if the platform is truly flexible and interactive.

Response: We apologize if our manuscript gave the reviewer an impression that EcoPAD is a "have-it-all" platform. As a matter of fact, this manuscript presents the first version of EcoPAD, starting from one model, one data assimilation and its application at one site. Please also refer to our responses to your last two comments below about why we think one model and one detailed long-term site is also important for ecological research. We agree that this version is not the final version of the platform. We add the version number v1.0. In fact, we are currently incorporating the second model into EcoPAD and implementing at two more sites. We hope the functionality of EcoPAD expands as we incorporate more models and more data assimilation techniques into it and it is applied to more sites. Section 4.4 Future developments discusses the future work.

Meanwhile, we think this platform is a significant advance in ecological forecasting and should be shared timely with the community to be a benefit from future researches. We appreciate that the Reviewer agrees that this platform has a huge potential in advancing ecological forecasting. Good ecological forecasting relies on integrative and cumulative efforts from multiple sectors of the research community. The work presented here is multi-faceted. It includes the realized near real-time ecological forecasting, the interactive model-experiment system, technical components and specific model elements (model structure, parameter and boundary condition) that affect forecasting. And it involves both modellers and experimenters. The realized near real-time ecological forecasting itself is new and a significant scientific breakthrough in ecological research. The interactive model-experiment system facilitated by EcoPAD is a new paradigm to promote the communication between modellers and experimenters. For the section related to specific model elements, there are 4 case studies, 2 from previous results and 2 from this study. We mentioned 2 cases from previous studies to keep the integrity of the manuscript. But it is not reasonable to assume these 2 cases cover the majority of what we have delivered in this manuscript.

We think it is necessary to have the description of the web-based scientific workflow. For one thing, it is relatively new in ecological literature. And on the other hand, the functionality of EcoPAD needs the support of the scientific workflow.

We did not claim that the system can be used by the scientists and the citizen alike. We hope our revised manuscript make it clearer. The functionality of EcoPAD is multifaceted. It serves to help ecological forecasting and the priority task of EcoPAD is to improve researches related to ecological forecasting. Meanwhile, the web-based modelling and visualizations help broadly disseminate results of scientific research and extend the service of ecological research to the citizen. Good ecological forecasting need to integrate merits from multiple research communities and be beneficial to the society. EcoPAD is built upon integrating advances from process-based models, observations, data assimilation, information technology and human resources. It incorporates multiple elements, but it is not a "have-it-all" platform.

The web-based workflow can be viewed as a specific technological advancement in the field of ecological forecasting, but web-based frameworks have been around for a while in the field of geoscience, e.g., PEcAn (as cited in the manuscript in line 138) and PALS. Therefore, I do not agree that it is already the first flexible framework as the manuscript claims. In fact, such claims are not always necessary, but that might just be my personal opinion.

Response: We agree that the web-based workflow itself has been applied to geoscience for a while. But a platform, such as EcoPAD, that uses the workflow to automate data transfer and processing from sensor networks to ecological forecasting through data management, model simulation, data assimilation, forecasting and visualization is, to the best of our knowledge, among the first. We claimed that the system became the first system to enable interactive model-experiment (ModEx) integration. Based on our knowledge, ModEx is a term that emerged from a workshop organized by Dr. Yiqi Luo in 2012. Although ModEx has been practised for many projects, near-time interactive ModEx was enabled for the first time by EcoPAD. It relies on timely forecasting and bidirectional feedbacks between modellers and experimenters. It works hand-in-hand between modellers and experimenters within the life-cycle of field experimentation, which is not common. Technically, EcoPAD also has its uniqueness. Nevertheless, we agree with the Reviewer that it is not always necessary to claim who is first and we removed such expressions.

The quality of the figures should be improved, and the redundant information in the schematics should be eliminated. Also, the sources of the images used in the figures are not shown in the respective figures or captions. In general, the schematics can be more technical to suit the expertise of the reader-base of the GMDD.

Response: We modify Figures 1,3,5 to reduce redundant information and deleted Figure 4. We add description of image sources to the caption of Figure 1: "Images from the SPRUCE field experiments (https://mnspruce.ornl.gov/) are used to represent data collection and the flowchart of TECO model is used to delegate ecological models". Technical details related to Figure 1 are presented through Figures 2 and 3.

The manuscript has several Grammatical errors and typos. At times, it feels like even a simple "spelling checker" has not be run through the whole manuscript once. At the same time, some paragraphs are excellently written without a blip.

Response: We go through the manuscript carefully and correct the Grammatical errors and typos.

Major comments:

- The manuscript does not clarify what the "ecological forecasting" means. In the first paragraph, there are several examples of "ecological forecasting" from previous studies. In the end, the EcoPAD seems to be simulating the carbon stocks and fluxes, which is just an aspect of ecological forecasting. The title should be revised to be more specific to the scope and capabilities of EcoPAD.

Response: We started the first paragraph with "One ambitious goal of ecology as a science discipline is to forecast states and services of ecological systems. Forecasting in ecology……". Ecological forecasting broadly refers to "Forecasting in ecology". So ecological forecasting covers multiple aspects that ecology covers. We introduced the scientific workflow of EcoPAD that wraps models, observations and data assimilation techniques. We emphasized that the scientific workflow is independent on the specific models. We took the SPRUCE project as an example to illustrate the scientific functionality of EcoPAD. Biogeochemistry is the main focus of the SPRUCE project and the model we wrapped in EcoPAD scientific workflow is a biogeochemical model that simulates carbon stocks and fluxes. No matter which aspect of ecology the model focus on, the functionality and workflow are similar as what we have illustrated through the biogeochemical example. We think the title is reasonable.

- There is no specific section on the benchmarking of the performance of the EcoPAD simulations. This is a critical step to have a reliable platform that can be used for forecasting. Therefore, evaluation of model performance should be presented in detail in this manuscript.

Response: Simulations have been evaluated in individual studies. For example, the paper by Huang et al. evaluated biophysical modelling of soil thermal dynamics, snow cover and frozen depths with observations. Jiang et al. (2018) evaluated biogeochemical modelling of carbon pools and fluxes with observations. And Ma et al. (2017) evaluated methane modelling against observation. In the future, we will evaluate accuracy of forecast results and attribute mismatches between forecasts and observations to several sources, such as forcing, model structure, parameterization, and initial values.

- The examples presented here are for SPRUCE sites. It is not clear whether EcoPAD can be used easily in other sites, even though manuscript ends with statements on how the framework can easily be implemented for different FLUXNET sites and at continental scales. If such implementations are simple as the manuscript claims, they should be the main focus of the manuscript because the results presented here have been, at least partly, used in previous studies.

Response: We remove the expression of 'easy' throughout the manuscript as it is contextual dependent and the perception differs among people with different backgrounds. Please refer to our initial response related to the main focus and the novelty of this manuscript and to your last comment about expanding this study spatially.

- Once again, the results presented here just seem like a summary and discussion of previously published manuscripts from the main author and/or co-authors of the manuscript. In fact, I found the results presented in the Appendix A2 to be far more interesting than the results presented in the main text. There should be discussion on why most of the parameters are not well-constrained (Figure A5, right panel), or why Q10 parameters for CH4 is not as well constrained as those for r and why they differ for different temperature treatments (Figure 6). I understand that there may be counter argument on this issue being out of the scope of the current paper, but, it is necessary to discuss how these potentially unconstrained parameters affect the forecast skills of EcoPAD. After all, general public, who do not understand the technical and scientific details, may easily be misinformed with the uncertain forecast of EcoPAD.

Response: We greatly appreciate reviewer's interest in issues on constraining parameters. It is surely related to the forecast skills of EcoPAD v1.0 as rightfully pointed out by the reviewer. We even more appreciate the reviewer being considerate that the detailed discussion about constraining parameters is "out of the scope of the current paper". It is difficult to balance different elements of the manuscript. For example, Reviewer 1 suggested to focus on the scientific workflow while this Reviewer suggested that the information about the scientific workflow was too much. It is a good idea to dig deep into how not well constrained parameters affect forecasting. The impact of not well constrained parameters is reflected in forecasting uncertainty, which is also an important topic we emphasized in this manuscript. Unconstrained parameters may result in high forecasting uncertainty and therefore low reliability of forecasting result. We added "Not well constrained parameters, for example, caused by lack of information from observational data, contribute to high forecasting uncertainty and low reliability of forecasting results (Lines 797-798, tracked manuscript)." to the section on implications for better forecasting, and also suggested that "….or to what extent unconstrained parameters affect forecasting uncertainty are all valuable questions (Lines 843-844, tracked manuscript)." in the part on forecasting uncertainty.

- It is not clear from the manuscript what models or assimilation methods are currently available. There are several instances of “ensembles” and “structural uncertainty” but as far as I could decipher, EcoPAD only has one model and one data assimilation method until now. This is also relevant to explaining how EcoPAD can be used to quantify uncertainty from different sources. Such quantification of uncertainty would require factorial experiments with multiple model structures, process/mechanism formulations, cost functions, optimization/assimilation schemes with multiple observational constraints, and so on. It is not clear if EcoPAD already has such functionalities or if it is yet another potential use. If so, an explanation of how “ecologists” can add such functionalities would be useful. For example, is the interested developer responsible for creating a separate docker that satisfy all the system requirements for his/her own system? I could not test “adding functionality” because it requires registration to the system.

Response: We apologize for the ambiguity. Yes. What presented in this manuscript are based on one model and one data assimilation method. We clarified this point with “Case studies presented in earlier sections are based primarily on one model (Lines 901-902, tracked manuscript)” in the revised manuscript. We also added one paragraph in the future developments section to discuss the concerns raised by the Reviewer.

“With these improvements, one goal of EcoPAD is to enable the research community to understand and reduce forecasting uncertainties from different sources and forecast various aspects of future biogeochemical and ecological changes as data become available. The example of Jiang et al. [2018] partitioned forecasting uncertainty from forcings and parameters. An exhaustive understanding of forecasting uncertainty in ecology need to also consider model structures, data assimilation schemes as well as different ecological state variables. Researchers interested in creating their own multiple model and/or multiple assimilation scheme version of EcoPAD can start from the GitHub repository (https://github.com/ou-ecolab) where the source code of the EcoPAD workflow is archived. To add a new variable that is not forecasted in the EcoPAD-SPRUCE example, it requires modellers and experimenters to work together to understand their process-based models, their observations and how messaging works in the workflow of EcoPAD following the example of EcoPAD-SPRUCE. To add a new model or a new data assimilation scheme for variables that are forecasted in EcoPAD-SPRUCE, researchers need to create additional dockers and mount them to the existing workflow with the knowledge of how information are passed within the workflow.”

Specific comments:

Line 53-55: The manuscript does not have any results or discussion on this, and thus this sentence should be removed from the abstract and the whole manuscript.

Response: We have examples (e.g., the youngster example and the TreeWatch.Net) and a short discussion (the last paragraph of section 4.4) related to this part. Nevertheless, this part is not the

main part of this manuscript and we remove it from the abstract. That being said, we think it is important to make scientific research approachable to the general public.

Line 61: one science - a science?
Response: We change "one" to "a"

Line 62: Isn't forecasting always for future?
Response: We remove "future"

Line 87-88: what are the "relevant mechanisms" that the previous systems are lacking and how does EcoPAD, and TECO therein, address these shortcomings?
Response: The context of "relevant mechanisms" is comparing the non-parametric approach vs. process-based approach in long-term ecological prediction. For example, we can derive the relationship between net primary production (NPP) and light availability based on, say, 10 years' measurement. But to predict NPP of the next 100 years, this empirical NPP-light relationship has limited capacity. The NPP-light relationship may fail to capture the impact of CO2 fertilization or water stress etc. under new conditions. In this case, physiological processes related to NPP coded in process-based models (e.g., the Farquhar photosynthetic scheme) are "relevant mechanisms".

Line 110: one-directionary – unidirectional
Response: We change one-directionary to unidirectional

Line 114-128: I think the CARDAMOM model-data fusion system (Bloom et al., 2016) deserves a mention in this paragraph (http://www.pnas.org/content/113/5/1285) and in further discussions.
Response: Thanks for suggesting this valuable reference. CARDAMOM is a specific study that applies the data assimilation method. We add it into sections when we mention Bayesian data assimilation and emergent ecological relationships. DART and CCDAS cited here are more about the software environment that makes it easier to conduct data assimilation. And we think it may not be appropriate to cite CARDAMOM here and we also remove the reference to GEMS.

Line 132, 141, 146, 147, 252: spelling errors. I am not mentioning all the places here. Please check the whole manuscript carefully.
Response: We correct typos throughout the manuscript.

Line 151-153: It's not clear what this sentence means.
Response: We rewrite this part as "Forecasting is likely to be improved unidirectionally in which either only models are updated through observations, or only data collections/field experimentations are

improved according to theoretical/model information, but not both. Ecological forecasting can also be bidirectionally improved so that both models and field experimentations are optimized hand in hand over time."

Line 176: qualitative means better quality or is it quantitative?
Response: We change "qualitative" to "quantitative".

Line 210: Should clarify what 'big data' means in this context. Diverse data?
Response: We rewrite this part as "The 'big data' ecology generates a large volume of very different datasets across various scales." So the 'big data' refers to both diverse data and the large volume of data.

Line 215: cite FLUXNET
Response: We add the reference: Baldocchi, D., E. Falge, L. H. Gu, R. Olson, D. Hollinger, S. Running, P. Anthoni, C. Bernhofer, K. Davis, R. Evans, J. Fuentes, A. Goldstein, G. Katul, B. Law, X. H. Lee, Y. Malhi, T. Meyers, W. Munger, W. Oechel, K. T. P. U, K. Pilegaard, H. P. Schmid, R. Valentini, S. Verma, T. Vesala, K. Wilson, and S. Wofsy (2001), FLUXNET: A new tool to study the temporal and spatial variability of ecosystem-scale carbon dioxide, water vapor, and energy flux densities, Bulletin of the American Meteorological Society, 82(11), 2415-2434, doi:10.1175/1520-0477(2001)082<2415:fantts>2.3.co;2

Line 305: MongDB – MongoDB
Response: We correct.

Line 338: May be better to define what IT stands for, just for the sake of completeness.
Response: We add "information technology" before "IT".

Line 345: Does docker have a website or citation?
Response: We add the docker webpage: https://www.docker.com/

Line 348-350: Isn't it redundant (unnecessary duplication) to include input data in the docker?
Response: It is necessary to have the input data in the docker. Each docker is an independent and complete unit that is capable of fulfilling a certain task requested by a user, for example, run a model simulation. This design makes the system easily portable and is not limited by the operation or filesystems, programming language or specific model requirement.

Line 381: I think the web-based platform is for job submission and not web-based simulation.

Response: The web-based platform is supported by the scientific flow, observational data, ecological models and data assimilation techniques. It receives requests from the user/command, triggers the task (model simulation, data assimilation or forecasting), carries out the task and displays the results. It is not just for job submissions.

Line 404: clarify what 'scientific values' means.

Response: By "scientific values", we refer to the biological, physical or chemical meaning associated with each parameter. We modify "scientific values" to "different biological, physical or chemical meanings".

Line 415-422: Bayesian statistics has been used in previous ecosystems studies. Please find and cite these previous studies.

Response: We add the references:

Bloom, A. A., J. F. Exbrayat, I. R. van der Velde, L. Feng, and M. Williams (2016), The decadal state of the terrestrial carbon cycle: Global retrievals of terrestrial carbon allocation, pools, and residence times, Proceedings of the National Academy of Sciences of the United States of America, 113(5), 1285-1290, doi:10.1073/pnas.1515160113

Ellison, A. M. (2004), Bayesian inference in ecology, Ecology Letters, 7(6), 509-520, doi:10.1111/j.1461-0248.2004.00603.x

Jiang, J., Y. Huang, S. Ma, M. Stacy, Z. Shi, D. M. Ricciuto, P. J. Hanson, and Y. Luo (2018), Forecasting responses of a northern peatland carbon cycle to elevated CO2 and a gradient of experimental warming, Journal of Geophysical Research: Biogeosciences, doi:10.1002/2017jg004040

Line 433-438: I wonder if experimental/observational setup can be carried out in such short notice.

Response: It depends. As methane is a routinely measured item of the project. If the person is already familiar with methane measurements, one week is enough for preparing. How it operates in practice depends on management. The example here is to show that experimenters can benefit from model information.

Line 473: Is +0 the same as control experiment?

Response: This experiment has CO2 fertilization and warming treatments. There are ambient and + 0 °C plots. The difference between ambient and +0 °C treatment plots is the open-topped and controlled-environment enclosure. Ambient plot has no enclosure. We added this explanation to the section related to SPRUCE project. We discard the expression of "control experiment" as it may refer to both.

Line 479: Is there any difference between data-model integration and data-model communication? If so, this should be clearly stated at the beginning. Both have been used frequently in the manuscript.
Response: We do not differ between data-model integration and data-model communication.

Section 3.3: Is this process done systematically or through personal communication? If systematically, how are the updates (both of models and experiments) carried out theoretically and technically?
Response: The near real time forecasting is done automatically. However, before setting up the automatic forecasting system, there are extensive non-automatic detailed communication, for example, about the unit of data from sensor vs. model. Experimenters can check forecasting results from the webpage. He or she may adjust the experimental plan, for example, change the date of measurements or make measurements of a new variable. However, the system cannot automatically incorporate measurements of a new variable without additional work of a modeller. The near real time forecasting is automated. But the loop of prediction-question-discussion-adjustment-prediction and benefits from the simultaneous updates of both models and experiments, as we showed in section 3.4.1, need interactive and non-automated communications among modellers and experimenters.

Line 548-552: In figure 6, it seems like the parameter 'r' is not well constrained for higher treatments of temperature. Discuss the reasons for this.
Response: Thank you for your comment. From Figure 6, the parameter 'r' was constrained across all treatment temperatures. We calculated the Variance-Mean-ratio (VMR, a value larger than 1 indicates the distribution is constrained) to determine the dispersion of a probability distribution. VMR values for +4.5 °C to +9 °C are 2.1, 2.1, 2.1, 1.7, 1.2, which are all significantly larger than 1.0 based on the t-test. The Reviewer might refer to why the spread or variation of the posterior distribution of the +9 °C treatment is larger than treatments with lower temperatures. The posterior distribution combines information from both the model and data. Neither the model nor the observations are perfect. We have fewer observation data points in higher temperature treatments. And variations from observations are larger in higher temperature treatments. In addition, the model may not be adequate to capture ecosystem responses to extreme temperature changes (i.e., higher temperature changes, e.g., +9 °C and +6.75 °C).

Line 580: EcoPAD only includes one model, but the sentence says that it relies on ensembles of ecosystem models. This statement is misleading.
Response: We add "will" to this sentence. And we check throughout the manuscript to correct locations where there could be confusions about what has been done and what will be done. We have a section "future developments" to clarify that multiple models are the future development plan.

Line 586-611: Summary of Jiang et al., 2018 and Huang et al., 2017. So, the results presented in current study are specific for the models and tools used in those previous studies? If there is any additional scientific advancement in EcoPAD, this should be highlighted here.

Response: This manuscript focuses on ecological forecasting. EcoPAD is the platform or the tool to help the study of ecological forecasting. We emphasize that integrative efforts are important for better ecological forecasting. The integration relies on advancements from observation, process-based models, data assimilation or parameterization techniques, cyberinfrastructures, human power from both modellers and experimenters etc. We listed 5 cases to illustrate different components that are critical for ecological forecasting and can benefit from the EcoPAD platform. For integrity, we explained studies from Jiang et al., 2018 and Huang et al., 2017. Please also refer to our response to Reviewer 1.

Line 620-630: To what extent does the parameter ranges depend on the uncertainty in the forcing? Is there a particular reason why the parameter values are randomly sampled from the posterior? Doesn't it make sense to use the posterior distributions to get the parameter ranges within certain confidence intervals?

Response: Parameter uncertainties (or parameter ranges) are obtained through assimilation observations from 2011 to 2014. In this period, the forcing is the real observed forcing. We do not have complete quantification of measurement uncertainties for each forcing and we did not account for measurement uncertainties of forcing variables. Parameter uncertainties generated in this study come from observational uncertainties of carbon variables.

The posterior integrates information from both the prior and observation. It is the best knowledge we can know about parameters. From the posterior distribution, we can get the parameter ranges within certain confidence intervals. However, whether information of parameter ranges alone can be used to derive forecasting uncertainty (or range) depends on complex interactions among parameters, model structures and boundary conditions etc. In non-linear models or there are non-linear interactions among parameters or when the posterior distribution is non-normal, it is not easy to directly propagate parameter range to forecasting uncertainties.

Line 631-642: It is not clear if GPP has an effect on carbon stocks in the TECO model.

Response: There is a link between GPP and soil carbon stocks in the TECO model. GPP affects litterfall and therefore the input into soil carbon stocks. As Figure 7 shows, when the difference between GPP is different scenarios (S1, S2, S3) is close to zero, the differences in soil carbon stocks keep growing despite under the same randomly generated forcing. That means, the alternation of soil carbon stocks, no matter it is caused by changed GPP or environmental conditions, affects soil carbon prediction in a longer time scale compared to GPP.

Line 668: It is not clear how these 'scientific' information is directly useful for general public.
Response: We remove the "general public".

Line 680-681: I am not convinced that all 7 characteristics of EcoPAD have been backed by evidences presented in this manuscript. At least, this has not been clearly presented in the manuscript.
Response: We did not elaborate on these 7 characteristics that are embedded in the system design, especially the workflow. From the previous comment, the Reviewer think it is not necessary to elaborate on the workflow. These characteristics are spread over the scientific workflow section. We do not plan to further elaborate on each characteristic and we do not have to repeat it here. So we removed this sentence.

Line 688-705: The discussion here should be divided into the users (those who run the model) and developers (those who add processes and methods to EcoPAD). Since the developers need to carry out a lot of set-up using the GitHub repository, the web-based platform seems more suited to the users. This limits the options of the users to only the ones already available in EcoPAD, which is, as of now, only one model and one data-assimilation system for one site. As such, the potential applications of the model are not applicable to the web-based system. This should be clearly mentioned in the abstract, main text, and the conclusions.
Response: EcoPAD is designed to satisfy the demand of people with different backgrounds. Users of EcoPAD range from people who want to expand and add more components to EcoPAD (developer from the Reviewer's viewpoint) to people who can only use the existing EcoPAD-SPRUCE example. The set-up of GitHub repository is not as easy as using the existing EcoPAD-SPRUCE example, but this is not to say developers do not benefit from such platform. Section 2.3 summarizes how users (including developers) can benefit from the EcoPAD framework.

Line 722: 'model structure' - In this use, does it mean different formulations of one process as in Jiang et al., 2018?
Response: Difference in model structure refers to any difference other than parameter values in formulations. It might be formulations of one process or multiple processes.

Line 744-745: What about the interactions between fluxes and pools?
Response: It is not clear what this question refers to.

Line 787-788: Assuming this statement is based on Table 1. But, it is not clear if the table is just a hypothetical example or based on the actual experience.
Response: The SPRUCE project involves more than 100 scientists with different backgrounds. The discussion started from a teleconference after the delivery of model results, unfortunately, we did not

record the teleconference. However, the discussion continued through emails. If necessary, we can show the email communications.

Line 790-791: I just wonder if it is too risky for experimenters to invest resources on carrying out experiments recommended by modellers who used one-single model?

Response: Ideally, results or recommendations would be more reliable with multiple models. As a first step, one-single model provides valuable information. We emphasize on the uncertainty of forecasting. Potential results from alternative model structures are likely to be covered, to some extent, by forecasting uncertainty resulted from parameter uncertainties. We also emphasize on the iterative model updates to rely on information from observations. We agree with the Reviewer that one-single model is not the best choice, and it is valuable to incorporate more models in future studies.

Line 804-817: I think these tasks of including several sites or using EcoPAD at continental studies should be a part of this manuscript. As I have mentioned previously, the results presented here have been published in previous studies. Using it in different ecosystems will validate the scientific soundness of EcoPAD and it will provide sufficient evidence of its potential wide-scale applications.

Response: We agree with the Reviewer that it is meaningful to expand the application of EcoPAD spatially. We argue that it is equally important to focus on one detailed long-term manipulative ecological study to comprehensively introduce EcoPAD. We chose the SPRUCE experiment as a case to apply EcoPAD partly because the valuable scientific information it provides, and also because the rare opportunities to comprehensively illustrate the functionality of EcoPAD. For example, one of the opportunities is the intensive interactions between modellers and experimenters facilitated by EcoPAD. Both modelling and field experimentation are involved through the life-cycle of the project, which creates the opportunity to illustrate the bidirectional feedback between model forecasting and field experimentation. We are applying EcoPAD to different sites (e.g., precipitation manipulation sites, ecotrons) with different versions of models. However, as a start, we think it is worthwhile to elaborate the technical support and functionality of EcoPAD through EcoPAD-SPURCE.

References:

Huang YY, Jiang J, Ma S, Ricciuto D, Hanson PJ, Luo YQ (2017) Soil thermal dynamics, snow cover, and frozen depth under five temperature treatments in an ombrotrophic bog: Constrained forecast with data assimilation. Journal of Geophysical Research-Biogeosciences, 122, 2046-2063.

Jiang J, Huang Y, Ma S *et al.* (2018) Forecasting responses of a northern peatland carbon cycle to elevated CO2 and a gradient of experimental warming. Journal of Geophysical Research: Biogeosciences.

Ma S, Jiang J, Huang YY *et al.* (2017) Data-Constrained Projections of Methane Fluxes in a Northern Minnesota Peatland in Response to Elevated CO2 and Warming. Journal of Geophysical Research-Biogeosciences, 122, 2841-2861.