

'Earth Virtualization Engines (EVE)' – Author's response to comments

January 6, 2024

The reviewers are thanked for their thoughtful and constructive comments. Adequately addressing these comments will considerably improve the articulation of EVE. Because the body of the 'Summit Statement' was negotiated over several weeks with the nearly 140 co-authors, we are inclined to leave the main text untouched as a reflection of the Summit, and propose to address the Reviewer Comments through a modification of the FAQs. We note that the FAQs are included as part of the main submission, rather than hidden supplementary material, and no comments were raised about the statement that we felt could not be adequately addressed through the FAQ section.

Summary of our understanding of the main issues raised by the reviewers

Here we first briefly summarize what we understand to be the main points raised by the two reviewers, noting the overlap on some issues. In referring to the reviewers specific comments we use the notation ¶ $n.m$ to denote the m 'th paragraph of Reviewer $n \in \{1, 2\}$.

1. More nuance and detail on the topic of AI (¶1.4)
2. Ensuring quality of service and open access to data and software (¶2.8-9)
3. More specificity on capacity development (¶1.5, ¶2.6-7)
4. More specificity on how EVE will effect the scientific culture and opportunities for scientists and scientific development (¶1.5-7, ¶2.6-7)
5. Concretization (¶1.8-9, ¶2.10-11) including meta point 'laudable statements but can we make them tangible' throughout, and how we envision a federation.

Following this itemization, ur approach to addressing the comments is elaborated on below. Before doing so we note that V. Bouchet and D. Stammer have been removed from the list of authors.

1. More Nuance and detail on AI:

Among the authors are a considerable number of world leading experts in the area of AI, both from the computational science and geoscience domain. Many of us also share the reviewer's experience of coding our first neural networks in the late 1980s and early 1990s. The change that we, and EVE, respond to is an appreciation that the new capabilities of AI, particularly generative AI, come from the size of the data sets, the size of the AI model, and the availability of computational power that enables to set the parameters of the latter given the former. This is the phase change. EVE responds by proposing to create massive amounts of data (projections)

at scale that can be linked to auxiliary (external) data to train massive models through compute resources co-proximate to the main data streams. In this respect, EVE nodes would constitute a federated landscape of what some are calling AI Research Resources.

We would address this more directly through changes to the FAQs 2, 3 and especially 6.

2. EVE's effect on the scientific culture: EVE would influence the scientific culture and practice in three ways. On the side of data provision, by greatly increasing the use of climate data (including model projections) it helps define scientific priorities that would improve data quality, either by improving the data collection, or its generation through improved modelling (also on regional scales). On the other side, by defining protocols that link the EVE nodes to lighter, distributed, data sets, enabling users to link this to their own (perhaps proprietary data), and by creating community access to the co-proximate computing and data for data that is not distributable (due to its sheer amount, i.e. km-scale projections, and some satellite data) it would create a community resource that gives scientists, and climate service providers access to data and resources that they would not otherwise have. Finally, by constituting this as a professional activity that stimulates research, EVE creates opportunities that help circumvent some of the obstacles (e.g., academic metrics of personal achievement) noted in ¶1.7.

FAQs 7 and 11 would be rephrased and their answers revised to make these points more directly.

3. More specificity on capacity development:

EVE's aspiration to strengthen capacity development, etc., is mentioned in several places (i.e., FAQs 4 and 5), but the reviewer's comments highlighted how the presentation lacked specificity. Involving communities in the information creation EVE would facilitate is not just a noble aspiration, it is materially necessary. The need for capacity development has two aspects (i) EVE needs access to local data, and only by engaging those responsible for these data can it create the social process needed to valorize local data collection and provision; and (ii) to ensure that the information that comes from EVE is trusted and actually useful and used by the communities it targets, the communities that are expected to use the data must be involved in its creation (presently in FAQ 5). This makes the capacity development organic to EVE, and further justifies the idea of EVE as a federation of regional center's of excellence.

We propose reformulating and reframing FAQ 5 which was meant to address these aspects, but did so indirectly and was ineffective. The reformulation would incorporate feedback from the presentation of EVE at the WCRP Open Science Conference in Kigali, that specifically addresses how EVE can (and must) strengthen capacity development for it to be successful. We would also modify (or delete) FAQ 12 given that in the meantime both COP and the OSC (Kigali) meeting have transpired.

4. Quality control of data and software:

EVE would address issues related to quality assurance, trust worthiness, etc, in three important (and largely novel) ways. Foremost for data quality/trustworthiness is that: (i) the data is used; (ii) that its creation is transparent; and, (iii) that its creation and provision is responsive to those that use it. EVE's novelty becomes apparent when one considers how the second and third points are addressed in our existing approaches. Meeting these goals requires an institutional framework to sustain a feedback loop that makes the data provision responsive to its use. We propose to add a bullet on this point, which also mentions the role of AI (i.e., if generative AI is used to convert data to information how do we guard against hallucination, etc.).

We propose a new FAQ, to address this point directly, making the above points and introducing the importance of EVE's Centers of Excellence to the concept as a whole.

5. Concretization:

The issue of being more specific resonates throughout the reviewer's comments. We originally tried to address this by the FAQ on what would happen without EVE. In the revisions we sharpen the presentation of how EVE differs in concrete ways from existing approaches, emphasizing the importance of regional Centers of Excellence taking the form of actual institutions federated internationally to ensure accountability, capacity development, professional opportunity, and societal acceptance.

We propose to rework the (now) final FAQ to address these issues, and update the next steps as a final FAQ to address the importance of an international framing for many of the above stated objectives (e.g., capacity development, standard development, information acceptance and distribution).