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Interactive comment on "FaIRv2.0.0: a generalised impulse-response model for climate uncertainty and future scenario exploration" *by* Nicholas J. Leach et al.

Anonymous Referee #2

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This manuscript presents a major update of the FaIR model, it clearly explains the main equations of the model, and presents parameterizations for a set of GHGs and forcings. As I understand, this manuscript has gone already through a major round of reviews and revisions, and this version is already in a very advanced stage. I do not have major comments, and I think it can be accepted after a few minor revisions.

1 Minor comments

- Sec 2.1, second line (line numbers do not add up. Very likely a misuse of LaTeX line numbers with equations). I would rather call it a '4-timescale IRF' than a '4-pool IRF'. You can think about an IRF as a coordinate transformation, that takes a four-pool carbon cycle model and maps it to a four coordinate system along four eigen directions with respective eigenvalues. Also, I assume you are talking here only about IRF_{CO_2} from Joos et al. (2013), and not the other IRFs in their Table 5. Please clarify.
- Eq. 1. The time-dependency in the adjustment factor is missing. You should write $\alpha(t)$.
- Ln 145. Isn't more appropriate to say 'carbon dioxide' than 'carbon cycle'? For CO2 n=4, and for methane n=1, so CO2 includes the full complexity of the approach, but not methane.
- Ln 177. Please check the units of the pre-industrial CH4 concentration, ppb instead of ppm?
- Section 2.4. The state-space representation of the temperature response is a very interesting an elegant way to express these equations. However, I do not think it is correct to include the forcing term F as part of the vector of states. It doesn't have the same units as the temperature variables, and it is a non-autonomous term. I suggest expressing this equation as

$$\dot{\mathbf{X}} = \mathbf{F}(t) + A\,\mathbf{X} \tag{1}$$

with

$$\mathbf{F}(t) = \begin{pmatrix} F(t)/C_1 \\ 0 \\ 0 \end{pmatrix} \tag{2}$$

and

$$A = \begin{pmatrix} -(\lambda + k_2)/C_1 & k_2/C_1 & 0 \\ k_2/C_2 & -(k_2 + \epsilon k_3)/C_2 & \epsilon k_3/C_2 \\ 0 & k_3/C_3 & -k_3/C_3 \end{pmatrix} \quad (3)$$

In this representation, you obtain a matrix A that is invertible, which would guarantee that you can perform an eigen decomposition on the entire matrix, and not just on a portion of it, as expressed in lines 323-325. Also, it better expresses the fact that in this model, temperatures respond to a time-dependent forcing according to a set of fixed timescales and heat capacities of a three-box model.

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