Response to referee comments

Referee comments are in black.
Responses are in blue. We indicate where in the text the changes can be found by L followed by a number that gives the line number.
Manuscript citations are in italic with changes in red.

Bjordal et al., 2025 have coupled an Earth System Model, NorESM2, with an Integrated Assessment Model, DIAM, to create a new coupled model, NorESM2-DIAM. The two models are coupled in a continuous fashion and exchange information bidirectionally. Information exchange between the two models occurs at an annual time scale and a regional level and includes annual carbon emissions being passed from DIAM to NorESM2 and temperature values passed from NorESM2 to DIAM. The coupled model is used to study the economic impact of climate change. The manuscript is well written, and the development of this new coupled model addresses the critical need for models that incorporate human-Earth feedbacks. The manuscript should be published after addressing the following comments.

Thank you for the clear summary and for the positive evaluation of our contribution. We appreciate the careful review and helpful comments.

1. The authors have mentioned, “To our knowledge, it is the first framework to fully couple an ESM with a high-resolution IAM”. This is incorrect. The Energy Exascale Earth System Model (E3SM) was coupled with GCAM, an Integrated Assessment Model, in a bidirectional synchronous fashion a few years ago (Thornton et al., 2017; Calvin et al., 2019), and earlier this year, a manuscript documenting a newer version of the coupled E3SM-GCAM model was published (Di Vittorio et al., 2025). These manuscripts should be cited, and comparison should be performed of the similarities and differences in the coupling framework and the impact of two-way coupling on the human and Earth system using the two different coupled models.

Thank you for pointing out these models to us. We still believe this is the first coupling with a high-resolution cost-benefit model, and have adjusted the abstract accordingly. (L9)

To our knowledge, it is the first framework to fully couple an ESM with a high-resolution cost-benefit IAM.

Additionally, as you suggest, we have added a couple of paragraphs discussing the similarities and differences between the coupling framework of our model and similar coupled models like E3SM-GCAM. (This also included some small adjustments to the previous paragraphs for better flow.) (L57-89)

… Finally, NorESM2--DIAM is a cost-benefit IAM ~~capable of evaluating~~: economic agents (consumers and firms) in the model solve explicitly-specified dynamic decision problems with well-defined objectives. It can therefore provide quantitative assessments of the welfare effects ~~across time and space~~ of a wide range of scenarios for climate policy---from laissez-faire to optimal carbon taxation---both across time and space.

~~However, t~~The primary goal of this paper, however, is to demonstrate, using a prototype version of NorESM2--DIAM, how to tackle two key methodological challenges in coupling an ESM with a dynamic, high-resolution economic model grounded in dynamic optimization. First, the two models operate on vastly different time scales. Second, the economic model incorporates forward-looking behavior: the decisions of agents ~~(consumers and firms)~~ depend on their expectations about the future behavior of the climate, which is itself influenced by those very decisions. Achieving consistency between agents' expectations and the climate trajectory thus requires solving for an interdependent equilibrium.

Successfully addressing these challenges lays the groundwork for using NorESM2–DIAM as a platform to explore the spatial and temporal dimensions of climate–economy interactions, and to assess climate policy with a degree of geophysical and economic realism that is rare in existing IAMs. This platform contributes to a small but growing literature using dynamic, forward-looking, structural economic models to study the spatial effects of climate change (see, for example, Brock et al., 2014; Desmet and Rossi-Hansberg, 2015; Fried, 2022; Krusell and Smith, 2022; Rudik et al., 2021; Bilal and Rossi-Hansberg, 2023; Cruz and Rossi-Hansberg, 2024; Kubler, 2023; Kotlikoff et al., 2024).

Our approach to coupling an ESM and an IAM, embodied in NorESM2–DIAM, contrasts with the approach taken in iESM (Collins et al., 2015; Thornton et al., 2017; Calvin and Bond-Lamberty, 2018) and E3SM–GCAM (Di Vittorio et al., 2025), two other frameworks that couple an ESM and an IAM. The main difference is that both iESM and E3SM–GCAM couple an ESM with the Global Change Assessment Model (GCAM), a process-based rather than a cost-benefit IAM. Although both DIAM and GCAM are dynamic, recursive models, in DIAM agents make decisions taking into account the entire future time horizon, whereas GCAM solves for outcomes one step at a time, considering only the current state.

The two approaches also differ in spatial resolution and sectoral detail. GCAM represents multiple sectors—including energy, industry, transport, agriculture, and land use—but divides the world into only 14 (iESM) or 32 (E3SM-GCAM)

socioeconomic regions. In contrast, NorESM2–DIAM contains only a single sector, focusing directly on gross domestic product (GDP), but at a very high degree of spatial resolution (1°×1° cells), enabling high-resolution analysis of the impacts of climate and weather on GDP and emissions.

Finally, the three models differ in how they represent climate–economy interactions. iESM and E3SM-GCAM exchange biogeochemical variables from the ESM to GCAM, whereas in our framework, temperature directly affects the economy through the productivity of labor. GCAM also explicitly represents agriculture and land use, allowing iESM and E3SM–GCAM to generate land-mediated feedbacks that are absent in NorESM–DIAM. Thus, although all three frameworks couple an IAM with an ESM, our approach employs a fundamentally different IAM, providing a complementary perspective to the two existing frameworks.

Minor comment:

2. Addition of a schematic figure that shows the coupling between NorESM2 and DIAM will enhance the readability of the manuscript.

A good suggestion. We have added such a schematic in section 2.

L101: *The two components of NorESM2–DIAM are coupled via a continuous, bidirectional flow of information as illustrated in Fig. 1.*

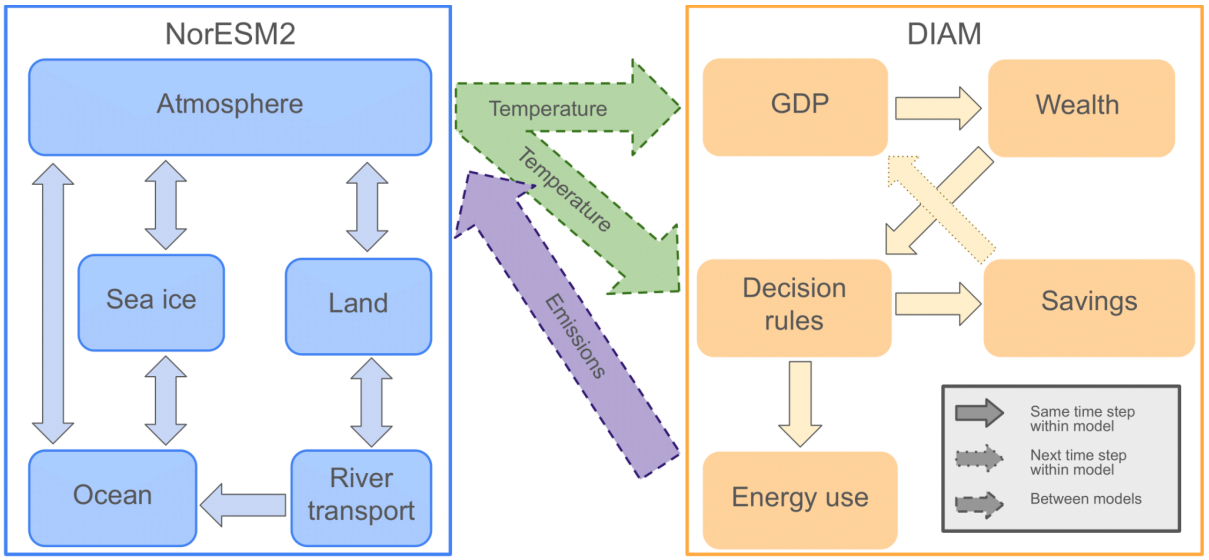

***Figure 1**. Schematic overview of the NorESM2–DIAM coupling and internal interactions. NorESM2 provides regional one-year-mean temperatures for the current model year to DIAM (dotted arrows indicate exchange between models). Regional temperature directly affects regional GDP, which in turn determines regional wealth (solid arrows indicate exchanges happening within one model for the*

current one-year time step of the coupled model). Based on regional temperature and wealth, each region then makes decisions about savings and energy use using pre-computed decision rules derived from the standalone version of DIAM. Within DIAM, savings affects GDP in the next model year (dotted arrows indicate exchanges happening within one model in the next time step of the coupled model). Energy use determines next year's emissions, which are provided to NorESM2. Finally, to complete the cycle, the different modules of NorESM2 interact to generate new regional temperatures. Note that the modules interact through a coupler, and the timing varies between modules, but they all exchange information at least once every 24 hours (Seland et al., 2020; Danabasoglu et al., 2020).