Table S1: Estimates of the confidence that tipping elements are fully represented in Earth System Model results, either by including the physics or a parameterization of the processes involved, or emerging from the simulations, for the Global Core Tipping Elements and Threshold-free Non-linear Elements.

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| --- | --- | --- | --- | --- | --- |
| ***Category*** | ***Proposed  Climate Tipping Element*** | ***Confidence that tipping element is fully represented in ESM results (authors’ evaluation based on literature)*** | | ***Evaluation by Wang et al. (2023)*** | |
| ***Current level of scientific understanding*** | ***Predictability by models*** |
| Global Core Tipping Elements | GrIS  **Greenland Ice Sheet** | incomplete | “The rapidly responding GrIS challenges the assumption of fixed ice sheets in global climate models. Instead, it reveals the need to include comprehensive process-based ice sheet models to explore ice sheet-climate interactions under climate change conditions to improve the reliability of climate change projections” (Madsen et al., 2022) | moderatea | moderatea |
| WAIS  **West Antarctic Ice Sheet** | incomplete | “While mesoscale eddies, heat transport onto the Antarctic shelves and flow under ice shelves are key to the Southern Ocean’s influence on climate, these processes are not directly represented in current global climate models.” (Hewitt et al., 2022)  “Our [Ice Sheet Model]simulations forced by raw CMIP6 climates have demonstrated that, even with the same [Ice Sheet Model], structural differences between atmosphere-ocean models can result in widely varying equilibrium states of the AIS.”(Li et al., 2023) | moderatea | moderatea |
| LABC  Labrador Sea / SPG Convection | to some extent | in several CMIP5 models under a range of forcings (Drijfhout et al.,2015)  “Recent studies suggested the need for very fine grid sizes for realistic representations of the small-scale processes governing the deep formation in the subpolar North Atlantic; however, some sensitivities to numerical choices and parameterisations remain even at 1/20°-resolution” (Böning et al., 2023) |  |  |
| EASB  East Antarctic Subglacial Basins | incomplete | “While mesoscale eddies, heat transport onto the Antarctic shelves and flow under ice shelves are key to the Southern Ocean’s influence on climate, these processes are not directly represented in current global climate models.” (Hewitt et al., 2022) | moderatea | moderatea |
| AMAZ  Amazon Rainforest | to some extent | Seven models include interactive vegetation carbon and in some cases interactive forest fires Parry et al. (2022)  Dieback was observed in a multiple CMIP5 model under RCP8.5 forcing (Drijfhout et al.,2015b) | moderate | moderate |
| PFTP  Boreal Permafrost | incomplete | “there is no consistency in model performance – no model performs well for every evaluation metric … Overall, the percentage of the models which fall within the observed range is relatively low with the majority falling outside the range of the observations” (Burke et al., 2020)  “soil carbon is still heavily underestimated in high northern latitudes (with the exception of the two CMIP6 models that represent deep soil carbon)” (Varney et al., 2022)  Collapse was observed in a single CMIP5 model under all RCP8.5 forcing (Drijfhout et al.,2015b) | moderateb | moderate to lowb |
| AMOC  Atlantic Meridional  Overturning  Circulation | incomplete | “A collapse or strong reduction of the AMOC … would be linked to … small-scale processes in the North Atlantic, which are not well-represented in current climate models.” (Hewitt et al., 2022)  “Two specific aspects can be seen as instrumental for a proper simulation of the spatio-temporal evolution of the AMOC: an adequate ocean-grid resolution and a well-balanced atmospheric forcing.” (Biastoch et al., 2021)  Collapse was observed in a single CMIP5 model under all RCP forcings (Drijfhout et al.,2015b)  “…intermodel consensus may be an artifact of common model biases that favor a stable AMOC. … By correcting the model biases, we show that the AMOC collapses 300 years after the atmospheric CO2 concentration is abruptly doubled from the 1990 level.” (Liu et al., 2017)  ““a relatively low AMOC stability during intermediate glacial states [which] is not evident in all numerical experiments performed with coupled climate models, implying that some might either overestimate the AMOC stability or have a mismatch in the required background state for the low-AMOC-stability regime.” (Menviel et al., 2020)  “Although [quasi-irreversible tipping] has been seen in simple models, it has been difficult to demonstrate in comprehensive global climate models” (Jackson et al., 2023)  “Comparing the models’ AMOC evolution to the observational data …, we find that neither the CMIP5 nor the CMIP6 ensemble mean are successful at representing the observational AMOC data." (McCarthy and Caesar, 2023) | moderate | good agreement, significant model limitations |
| AWSI  Arctic Winter Sea Ice | to some extent | Collapses in several CMIP5 models under RCP8.5 forcing (Drijfhout et al.,2015b)  “most CMIP6 models fail to simulate at the same time a plausible evolution of sea-ice area and of global mean surface temperature” (Notz and SIMIP Community, 2020) |  |  |
| EAIS  East Antarctic Ice Sheet | incomplete | “Our [Ice Sheet Model] simulations forced by raw CMIP6 climates have demonstrated that, even with the same [Ice Sheet Model], structural differences between atmosphere-ocean models can result in widely varying equilibrium states of the AIS.”(Li et al., 2023) | moderatea | moderatea |
| Threshold-free nonlinear feedbacks | PFGT  Boreal Permafrost | incomplete | “soil carbon is still heavily underestimated in high northern latitudes (with the exception of the two CMIP6 models that represent deep soil carbon)” (Varney et al., 2022) | moderateb | moderate to lowb |
| ASSI  Arctic Summer Sea Ice | incomplete | “most CMIP6 models fail to simulate at the same time a plausible evolution of sea-ice area and of global mean surface temperature” (Notz and SIMIP Community, 2020) | high | moderate to high |
| LAND  Global Land Carbon Sink | incomplete | “soil carbon is still heavily underestimated in high northern latitudes (with the exception of the two CMIP6 models that represent deep soil carbon)”  “Overall, we are not able to identify significant improvements in the simulation of the observed spatial pattern of soil carbon across the globe from the CMIP5 to  CMIP6 generation “ “…point to a need for a much greater emphasis on improving the representation of belowground soil processes in the next generation (CMIP7) of ESMs.”  (Varney et al., 2022) |  |  |
| PUMP  Ocean Biological Pump | to some extent | “These results …demonstrate that Earth system models need to incorporate ecological complexity in order to resolve non-linear climate–biosphere feedbacks.”(Armstrong McKay et al. 2021) – however, the net reduction in carbon sink observed by these authors does not seem substantial (0.7%) |  |  |
| MMHD Marine Methane Hydrates | not relevant in tis context because of time scale | Dissociation time scales are centuries to millennia (Wang et al., 2023). | moderate | low |

a *Greenland and Antarctic ice sheets jointly considered by Wang et al. (2023)*

b *Generic category* Permafrost carbon release *in Wang et al. (2023)*