https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

This is FRIDA

Cecilie Mauritzen

[1]Norwegian Meteorological Institute, 0131 Oslo, Norway

***Correspondence** to*: Cecilie Mauritzen (ceciliem@met.no)

Abstract. FRIDA is a new contribution to the portfolio of integrated **assessment** models (IAMs) that address the climate - energy - economy – and society nexus. The FRIDA acronym stands for *Feedback-based knowledge Repository for IntegrateD Assessments*. By naming it a "knowledge repository" we signal that the FRIDA model is never finished; it represents the current state of knowledge of the development team at any given time. We aim to continually integrate new scientific findings to keep the FRIDA up to date.

FRIDA comes with a learning environment that, together with the model's low computational cost, makes it a useful tool for education. It can be used in the classroom setting in interdisciplinary climate science courses and will allow students to understand how their discipline is intricately woven into the rest of the climate science disciplines. This feature set makes FRIDA accessible to a wider range of users than just researchers and scientists. Our aim is to lower the barrier to entry of using this model so that even lay people are able to use the model to build an understanding of the interconnectedness of climate and humans. Additionally, the low computational burden allows for uncertainty exploration by varying model parameters.

In this collection of papers in the Geoscientific Model Development (GMD) journal we intend to document the developments of FRIDA, from its origin in the years 2023-2026 within the European Horizon project "*WorldTrans - Transparent Assessments for Real People*" (FRIDA version 2.1 and FRIDA V3); and (hopefully) future versions that the spirited (and growing) development team will hopefully ensure. The intention of this brief introductory paper is to provide the contextual framework for the original model, and to explicitly state the original requirements.

1 Introduction

Governance of nations, businesses, international organizations and private lives alike are made difficult by the fact that the world has entered the realm of *dangerous climate change*. In 2024, global average temperature exceeded 1.5 °C above pre-industrial levels for the first time (Bevacqua et al., 2025). While an isolated year above this threshold does not yet mean the high ambition goal of the Paris Agreement - to hold global temperature increase well below 2 °C and to pursue efforts to

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

limit it to 1.5 °C on a sustained basis - has been breached, many dangerous impacts of climate change are already observed, such as extreme heat, floods, droughts and wildfires.

Many questions arise, such as: Is it even possible to combat climate change while still pursuing better lives? What strategies can ensure that mitigation efforts are inclusive and just? Is it perhaps better to focus our efforts on adaptation to the new type of climate rather than trying to prevent climate change?

For as long as the UN has engaged in climate change negotiations, these questions have been on the table, and answers have been sought using a myriad of models and expert negotiation processes. During this time, climate has continued to change, to the extent that the impacts of climate change can be felt, physically, all around the globe (IPCC, 2022)

These recognitions - that climate now affects our lives, and the failure thus far to mitigate climate change - were strong motivations for introducing a new integrated assessment model that explicitly includes diverse climate change impacts on humans. We call this new model FRIDA, with the subtitle *Feedback-based knowledge Repository for IntegrateD Assessments.* The journal *Geoscientific Model Development* has given us space to document FRIDA, including its submodules and spin-offs, in a special *GMD Collection*[1]. The first version of FRIDA (V2.1) is documented in Schoenberg et al. (2025).

FRIDA is built using the tools of system dynamics to integrate and couple the natural climate system and aspects of human life that can affect - and are affected by - climate. These include population growth, energy and food demand, investment strategies, damage to infrastructure and government budgets. FRIDA explicitly models human behavior (Rajah et al., 2025) and simulates the impact of climate change on numerous processes, such as crop yield, energy production, infrastructure, changes in livelihood in low-lying areas, uncertainties in the financial sector, and mortality due to climate extremes (Wells et al., 2025a). Human activities in turn alter climate by emitting greenhouse gases and aerosols, and by transforming land surfaces, changing albedo, managing water resources, and reshaping biogeochemical cycles, all of which modify the Earth's energy balance and the climate system.

With FRIDA we can investigate ways to minimize climate change and at the same time meet human needs within a framework that allows us to identify barriers and leverage points towards change.

FRIDA is modular, facilitating future expansions into other aspects of life on planet Earth, such as a more complete treatment of the biosphere.

FRIDA is a global model, intended to build intuition and provide insights of a general nature. As the model matures it will be possible to develop non-global versions. for instance, country-specific versions of FRIDA. One would in that case most

[1] https://gmd.copernicus.org/articles/collection12.html

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

likely link the "country"-FRIDA to a "rest of the world"-FRIDA, to allow for movement (of goods, people, policies etc.) in and out of the country in question.

This brief introductory paper is the introduction to the GMD FRIDA collection of papers. So, here is – the background for - FRIDA.

2 Original model requirements

During the framing phase of the WorldTrans project in 2022 we discussed at length how we could design a model that would produce credible and relevant results for all three working groups of the IPCC, that would be able to advice on the European Green deal (to obtain climate neutrality by 2050, leaving no one behind) and which would be useable and useful for non-expert users. We came up with the following list of requirements:

1. **Take advantage of conservation laws to constrain the model.** This involves including the full carbon, heat and water cycle.

2. **Begin with a non-regional model.** By building a global, rather than a regionally segregated model, the model output remains simpler to analyze, due to the reduced number degrees of freedom (which is large already on the global scale). The result is increased transparency and a better chance at building intuition and insights.

3. **Balanced representation of climate and humans.** This means focusing on the minimum detail necessary to capture the important interconnections between subsystems.

4. **Complete treatment of climate change forcing.** This means to include the main greenhouse gases (CO2, CH4, N2O and HFCs) and the main cooling aerosol agent (SO2), and to account for the effect of other climate forcers, such as those associated with land use change. It also means to model the sectors that create the greenhouse gas emissions (transport sector, energy production, land use and agriculture, chemical industries, cement production and waste). And it means to consider the underlying economic system and demography that creates changes in those sectors.

5. **Complete treatment of climate-driven feedback**. This implies taking into account, quantitatively, how climate affects (mostly damages) these sectors and the underlying economy and demography.

6. **Complete treatment of uncertainty.** This implies keeping the computing speed low, to allow for large ensemble runs. We obtain this by requirement no. 1 - to build a non-regional model.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

7. **Include human needs, desires and behavior.** This means that people can have an impact on the system by changing behavior, with respect to, for instance, dietary and mobility choices. It means that we can impose requirements on wealth distribution, energy consumption and so forth. Furthermore, it implies a departure from describing humans as purely theoretical economic beings maximizing profit or utility.

8. **A dynamic representation of the economy**. This means to model the economy as a system that moves forward in time and acts and reacts to its surroundings, just like we model the rest of the system.

9. **Modular organization of the model**. This is a requirement that improves the transparency of the model.

10. **Familiar external levers.** To generate change in the system we include the possibility of acting as a decision maker within the various modules of the model (for instance within government, or within the financial or energy sector)

11. **An accompanying toolbox for users of the model**. Since every model, even the simplest, is hard to interpret, we have developed a set of tools to aid the use of the model, aimed at our three user groups: 1) the *decision-maker* who would normally use IAM-based analysis to inform decisions about climate action. An important use context for the decision maker is the European Green Deal; 2) a *scientist,* say, a typical IPCC author who needs improved information flows and shared understanding of the system links and feedbacks between physical climate, the social and environmental impacts of climate change, adaptation responses, and mitigation efforts; and 3) the *engaged citizen* who is concerned about the climate challenge, but lacks the knowledge needed to engage in and catalyze a deeper societal discussion on the topic.

12. **Indices of the state of the system**. Based on variables interior to the model we include well-known indicators that describe the state of the system at every point in time during the simulations, both with respect to nature and humans.

2.1 Scope of model

The processes we have chosen to represent in FRIDA are determined by the main purposes of FRIDA: to produce numerically consistent results for IPCC Working Groups I-III and to provide advice on the European Green deal. We include the spheres we live in and interact with - land, oceans, atmosphere, cryosphere, anthroposphere. The model includes what are understood to be the largest anthropogenic forcings of climate change, and the most important impacts of climate change on humans. Fig. 1 shows, schematically, how we perceive climate change and humans to be interrelated within the model. The needs and desires highlighted in the figure are of a generic nature, but they map fairly directly into sectors of human life that each are impacted by and/or contribute to, anthropogenic climate change.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

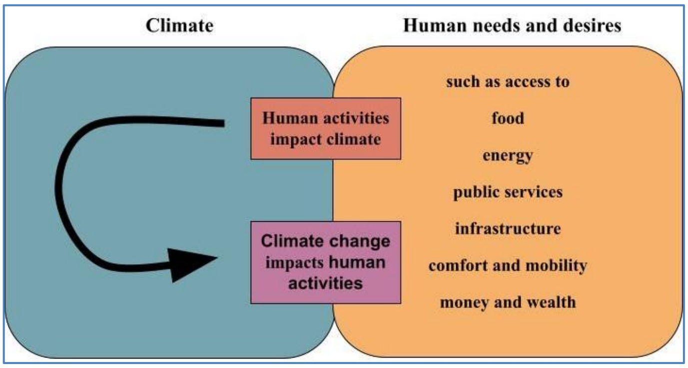

Figure 1: Schematic representation of the scope of FRIDA: The interconnectedness of climate and human needs and desires.

Though the model time resolution in FRIDA is ⅛ of a year, we do not aim to reproduce processes of shorter timescales than 5-10 years. Finally, our model simulations start in 1980 and typically end in 2150 (Fig. 2). Thus, any internal variability in the climate system on timescales longer than ca. 100 years[2] are ignored.

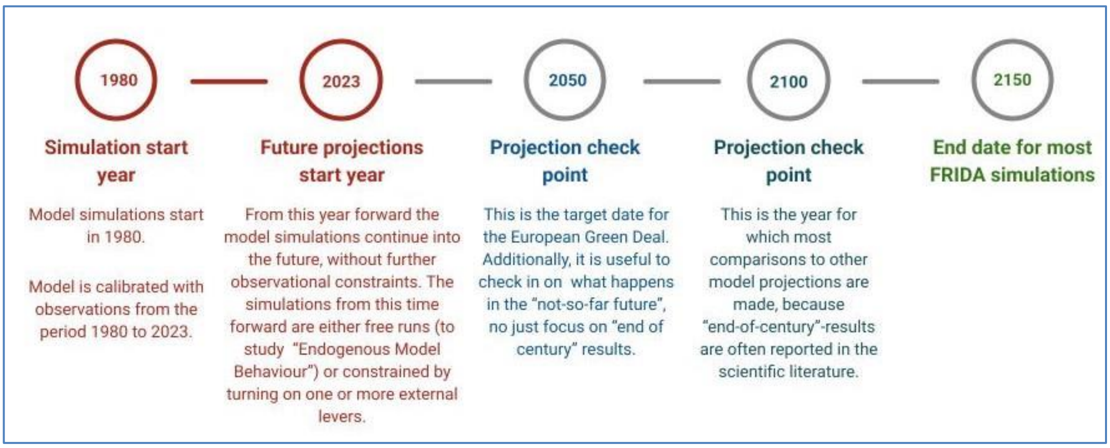

Figure 2: Schematic representation of the scope of FRIDA: The timeline for the FRIDA simulations.

3 Approach

FRIDA consists of a set of ordinary differential equations, written in the language of System Dynamics (see e.g., Forrester 1961, Sterman 2000). This approach facilitates, at relative ease, the inclusion of very different disciplines and their methods,

[2] such as slow-changing climate variations caused by astronomical or geological changes.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

ranging from the laws of nature to empirical relationships, direct observations and co-created knowledge. Central to the approach are feedback and delay perspectives, which highlight the complex and oftentimes circular interactions between system components that endogenously generate behavior.

We use the laws of nature and well-established empirical relationships to derive as many equations in the model as possible. For relationships where we have less established knowledge, we still use the best available knowledge to generate the structure, but we set wide parameter ranges so that we may report the uncertainty inherent in our projections. As a part of behavioral validation, we calibrate the model to historical observations from 1980 to the present (the "historical simulation period"; at the time of writing, this period is 1980-2023), keeping track of the uncertainty that is inherent in the model's calibration.

FRIDA's structure is validated by experts who understand how different parts of the system that are represented in the model function in reality. The calibration, validation, and uncertainty measurement procedures are described in detail in Schoenberg et al., (2025).

As mentioned, FRIDA is designed as an intuition builder, not as a source of precise future projections with fine regional granularity and sectoral detail. But there is another advantage of the relative simplicity of the model, namely the possibility of running large ensembles for uncertainty analysis. To assess the uncertainty space of a FRIDA setup, we typically run several hundred thousand simulations.

4. FRIDA's Modular Framework

FRIDA presently consists of seven modules: Climate, Human behavior, Land use and Agriculture, Energy, Economy, Resources and Demography (Fig. 3). In addition to improving the transparency of the model, the modular framework allows development of the scientific basis for each module in parallel.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

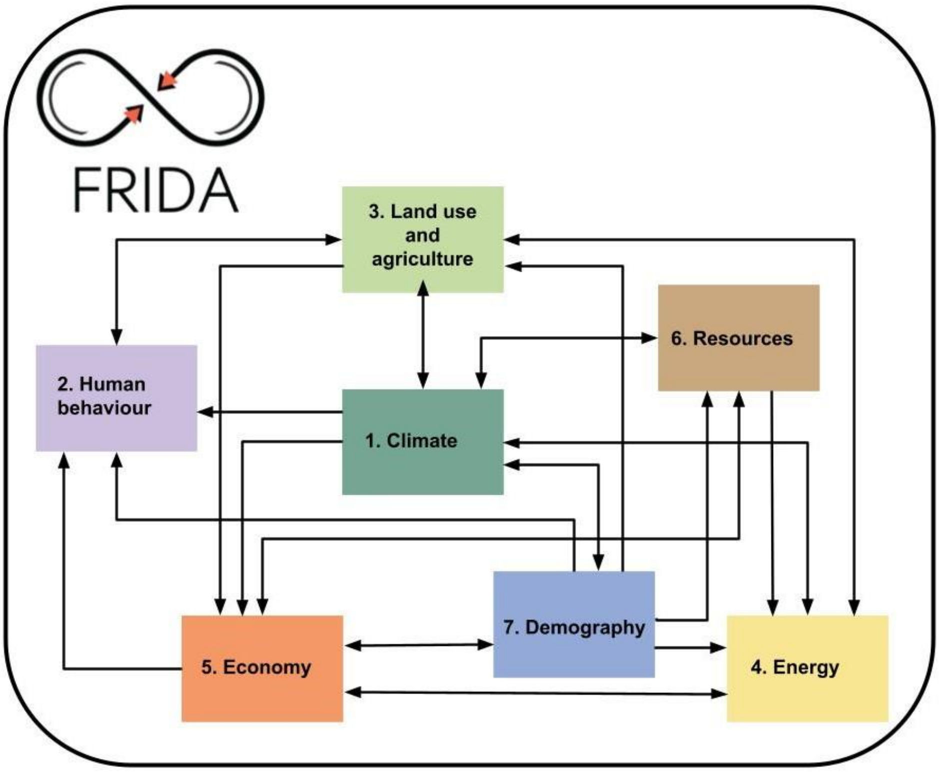

Figure 3: The modules and interlinkages in FRIDA V2.1.

We refer to all modules except the climate module as the "anthropogenic" modules of FRIDA. Note, however, that the "Land Use and Agriculture" module contains information about both nature and agriculture.

One can change or expand FRIDA, if new information is published, or if the scope of the model (Figs. 1 and 2) were to be changed. One such expansion could be to include "biosphere" as its own module, allowing FRIDA to respond to issues raised by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), complementing the present focus on IPCC. One might wish to address the sustainable development goals in the 2030 Agenda for Sustainable Development. Both these topics are partly covered in FRIDA, but not systematically. The main focus of FRIDA has from the start been to systematically and holistically address the human activities that cause anthropogenic climate change and the ways that anthropogenic climate change impact humans.

Note that there are as many linkages between the various anthropogenic modules of FRIDA as there are between the climate module and the anthropogenic modules. All these interlinkages create the complex dynamics of the system, and they are the reason it is easy to say, "everything is connected to everything", but terribly hard to understand how.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

5. Drivers of climate change

Earth's surface temperature depends on the amount of greenhouse gases in the atmosphere - in the absence of any greenhouse gases the average temperature on earth would be a freezing -19 °C, instead of the approximately + 15 °C we observe today (Ramanathan and Coakley, 1978). Any radiative change in this system results in a change in atmospheric temperature. The climate system is, however, continually trying to achieve an equilibrium state, in which the incoming solar radiation is ultimately balanced by the outgoing thermal radiation of the Earth. Minor shocks to the climate system, such as volcano outbursts, take a year or two to recover from, whereas large shocks may take millions of years. After the end of the last ice age, approximately 10,000 years ago, the Earth entered into an unusual state of quasi-equilibrium, with just minor long-term drift and temporary periods of short-term fluctuations. It was during this climatically stable period that the development of agriculture and the establishment of states took place.

But, for the past 250 years, humans have been pushing the climate system out of equilibrium. The access to cheap energy, facilitated by the invention of the steam engine and all the subsequent methods to extract energy from fossil sources, co-evolving during the industrial revolution with huge population growth, has disturbed the climate equilibrium greatly. Changes in how we use land areas have also contributed greatly to pushing the climate system out of equilibrium (Fig. 4). Details on how the climate system is modelled in FRIDA are documented in Wells et al. 2025A and Ramme et al., 2025.

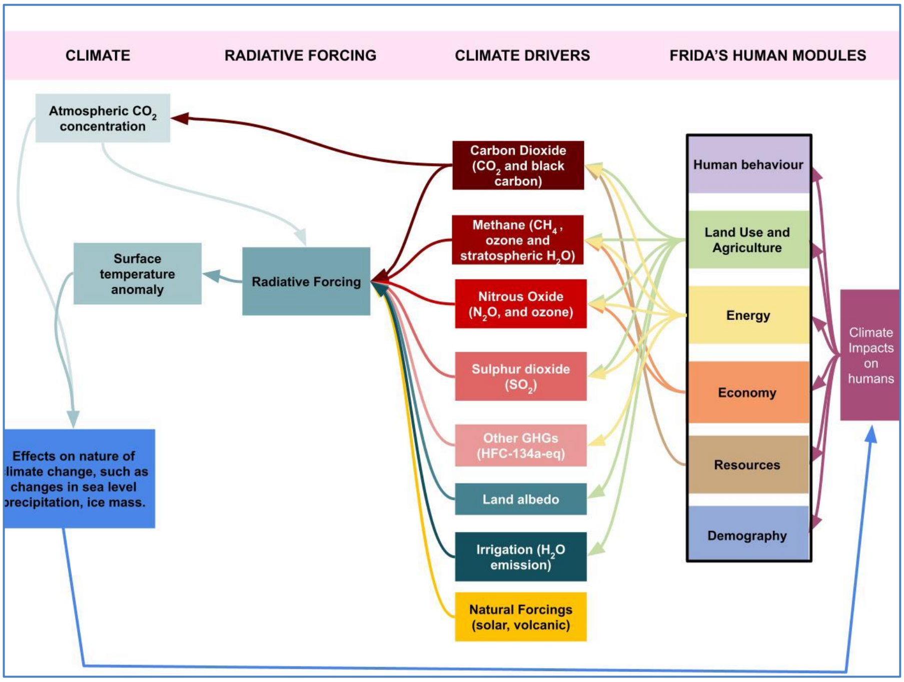

Figure 4: A schematic flow chart of climate change drivers, from the anthropogenic modules in FRIDA to the climate module.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

6. Effects and impacts of climate change

The change in atmospheric CO2 concentration and other climate forcers - and subsequent change in atmospheric temperature - have numerous effects on nature: ice melts, ocean heats up, the sea rises; there are droughts, changes in precipitation patterns, heat waves, wildfires and so forth. We refer to changes in nature caused by anthropogenic climate change as "climate effects".

We use a different nomenclature for the effects of climate change on the human side of the system, i.e. in the anthropogenic modules of FRIDA. We refer to these changes as "climate impacts".

In FRIDA we model climate impacts as recognizable processes, such as the assessment of climate risk by financial institutions; changes in demand for animal food products because of personal norms driven by climate risk perception; changes in demand for energy as a consequence of changing temperature; changes in labor productivity; changes in water use for irrigation, to name a few.

In implementing climate impacts in FRIDA v2.1, the team considered the assessment of the literature on climate impacts and risks made by IPCC WGII AR6, summarized in the Technical Summary of the report (Pörtner et al., 2022). Decisions on what impacts to include was based on three criteria: 1) applicability to the [global] scope of FRIDA; 2) the expected global magnitude of the effect as agreed upon in the extant literature; 3) when the scope and magnitude of the impact was not agreed upon in the literature, was there enough data present in the literature to reproduce at least one pre-existing global study with wide uncertainty parameters? In addition, we have added to FRIDA some climate impacts that are of relevance to the scope of FRIDA yet not included in the IPCC assessment.

To date we have implemented 16 climate impacts that directly drive the behavior of the human system plus six that drive behavior indirectly through impacts on land. This is in addition to all the feedbacks within the climate system itself. A graphical representation of the implementation of climate effects and impacts in FRIDAv2.1 is given in Fig. 5.

The climate module in FRIDA is documented in Wells et al., 2025A. Details on the treatment of sea level rise in FRIDA is documented in Ramme et al., 2025. Finally, the details on how the climate effects and impacts are implemented in FRIDA are documented in Wells et al. 2025B.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

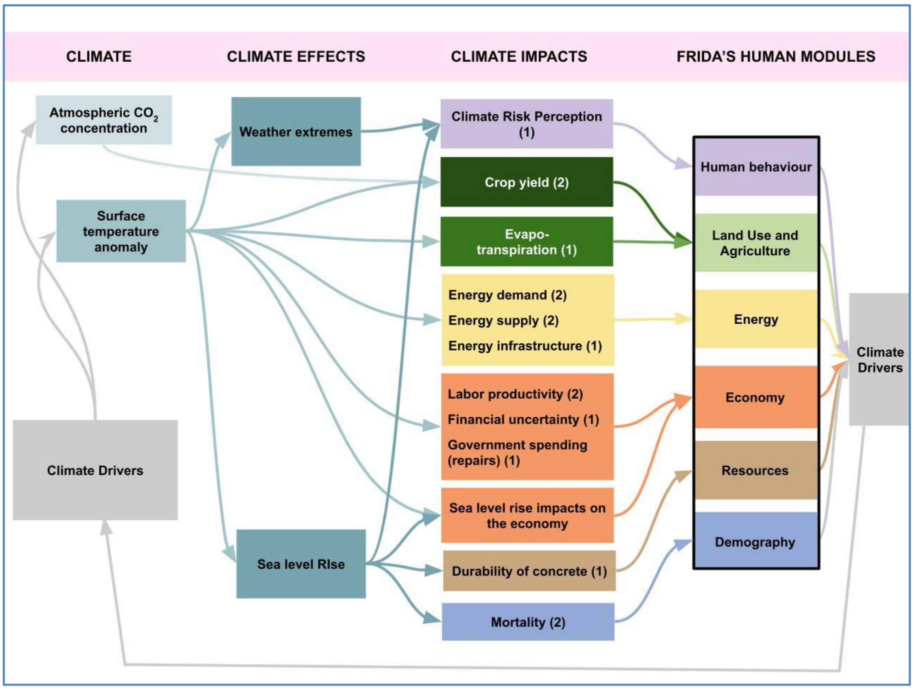

Figure 5: A schematic overview of the climate impacts in FRIDA V2.1, from climate change to the anthropogenic modules.

7. Endogenous Model Behavior

A useful feature of a (nearly)-all-inclusive model like FRIDA is that the model does not need external forcing to run into the future. The processes that are deemed important for the problem, ie. within the scope of the model, are inside the model. This is contrary to a typical Earth System Model and many process-based Integrated Assessment Models, which require external forcing to run (the former: for example, greenhouse gas emissions; the latter: for example, population growth). We call FRIDA's "free", or "unforced", or "endogenous" run the *"Endogenous Model Behavior*" (EMB) run. In the EMB run, all the change comes entirely from its internal feedback structure. The run is "free" because once you hit "play", nothing happens except what the model itself generates. It is "endogenous" because every variable that changes does so because of the model's own stocks, flows and feedback loops. And it is tied to reality in the sense that where possible, the governing equations are based on science, and the parameterizations are arrived at through calibration with observations during the historical period.

We consider the significance of the EMB run to be twofold: 1) it gives us insights into how the system would evolve into the future without further policy changes, i.e. assuming that all of the processes modelled in FRIDA operate according to the structure we've built, and all of the processes not modelled in FRIDA continue to operate as they have historically. and 2) it

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

gives us a base run to compare all forced runs to. By "forced runs" we mean experiments during which external levers are pulled, or forcings or parameters are altered.

8. Running experiments with FRIDA

Given a transparent, fast-running model like FRIDA, it is possible to dozens of experiments on one's desktop in order to build intuition. To do so one can adjust a lever or parameter at any time during the model run and see what happens.

The EMB run is a starting place for comparing all other experiments - whether we want to see the effect of implementing regulations in the future or ask "what would have happened if" this or that regulation were implemented in the past. To set up experiments with FRIDA we have developed a few guiding principles and a wide range of external levers that can be pulled to run experiments.

8.1 Best practices for running experiments: Type of research question vs type of experiment

There are many kinds of experiments one may wish to run with FRIDA. How to set up each experiment depends partly on the research questions one attempts to answer. We have identified four types of research questions that require their own type of experiments in FRIDA:

Research question type 1: *What happens to the system if we introduce this or that change (structure or policy) to the model sometime in the future?* For instance: what happens if we introduce a global carbon tax in 2030, or a new central bank target for inflation in 2040, or a moratorium on the extraction of fossil fuels in 2050? This type of experiment is easy to perform: one changes the relevant lever, or parameter, or flux in the relevant year and compares the EMB run to the experimental run. These are hypothetical "what if"- type questions.

Research question type 2: *What would have happened to the system if this or that change (to structure or policy) was introduced in past times?* For instance: what would the system have looked like if the carbon tax had been implemented in 1990. In this case the experiment is made the same way as in the previous case, except that the change is introduced to the calibration-validation period, so we compare a factual and a counterfactual system (the EMB run vs the experimental run). This can be applied both to policy changes (i.e. carbon taxes) as well as system structure, i.e. including or not including a feedback or a physical process. These are hypothetical "what if"- type questions.

Research question type 3: *How does the impact of introducing a change in FRIDA compare to a similar change in another model?* For instance: how would FRIDA and model X compare in their response to a moratorium on fossil fuels in 2050? This comparison is straightforward, one must simply make sure that the introduction is of the same magnitude and speed, and that it is initiated at the same point in time.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

Research question type 4: *What is the difference between models at various levels of maturity?* Specifically, what was the impact of including this or that process/feedback in an upgrade of FRIDA? For instance: what is the impact of using complex vs simple feedbacks from climate to the human side? Or: what are the impacts of the improvements made to FRIDA 2.1, compared to FRIDA 1.0? In this case we compare two different models, for instance FRIDA 1 and FRIDA 2, or FRIDA 2 and FRIDA2simpleClimateFeedbacks. It must be recognized that the impacts of the differences between the two models will spill over to the entire system, i.e. the impacts will be system-wide, so the interpretation of these impacts will be complex. This approach is to be used for analysis of model differences, not for hypothetical what-if questions like the ones in number 1 and 2. This approach is extremely labor intensive, because it requires full model recalibration, so it should be used sparingly.

8.2 External intervention available in FRIDA V2.1

One of the attractions of a simple model like FRIDA is that there are few computational limits to the number of research questions one might want to ask. For **research questions of type 1 and 2,** we have developed a wide range of experimental options. Based on the original purpose of FRIDA - to be of use for the European goal of climate neutrality in 2050 with no one left behind - the built-in external levers in FRIDA 2.1 revolve mainly on how to reduce emissions, decrease inequality and maintain growth in the economy without harming the planet. Fig. 6 gives an overview of the present levers, divided into demand side and supply side instruments. Do remember, though, that much information about human behavior, whether it is with respect to dietary choices, economic decisions, agricultural practices and so forth, is internal (endogenous) to the model – it entered through the building of the model and the calibration to observations (which is why the EMB run is so interesting by itself).

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

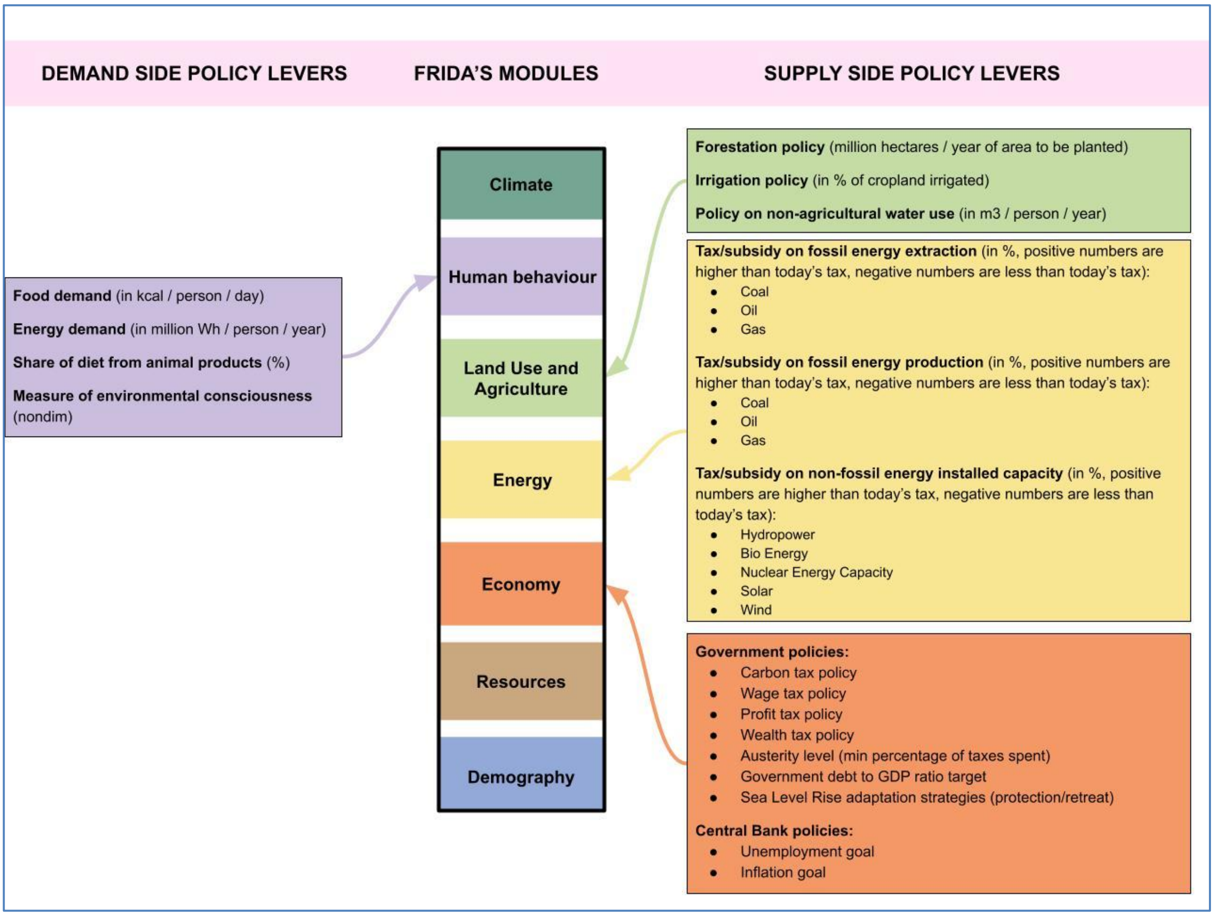

Figure 6: Overview of the external levers, or interventions, available for experiments with FRIDA 2.1.

9. Interactive Learning Environment

An important feature of FRIDA is its low computational cost, which enables real-time feedback, interactive classroom use, and systematic uncertainty exploration through parameter variation. To facilitate the learning process, the FRIDA model is accompanied by an Interactive Learning Environment (ILE) for investigating interactions between the climate system and human societies, with particular attention to feedback mechanisms. It combines guided demonstrations, scenario definition, and interactive dashboards with dynamic visualization to illustrate the consequences of decisions across time scales.

The introductory module of the FRIDA ILE presents historical and projected developments in variables such as global surface temperature, economic output, and income distribution. These examples are accompanied by simplified explanations of underlying system interactions, giving users an entry point into the logic of coupled human–climate dynamics. This stage also introduces the dashboard interface, ensuring that later experimentation is grounded in a clear understanding of how model levers translate into system responses.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

Following the demonstration, the user moves on to the dashboard (Fig. 7), where one can investigate how the model responds to interventions. Users manipulate parameters through interactive levers, observe responses across more than 225 variables, and compare results with their initial goals. The visualization framework highlights trade-offs, sensitivities, and unintended consequences, illustrating how even simple interventions can produce complex outcomes.

The idea is that by lowering technical and conceptual barriers, the platform extends beyond research applications to engage students, educators, and lay users in systems thinking and long-term decision-making. This makes the ILE well suited for interdisciplinary teaching, where students can see how their own discipline, whether economics, environmental science, or engineering, is interwoven with other domains in shaping climate futures.

Figure 7: From FRIDA's Interactive Learning Environment dashboard.

10. Concluding remarks

FRIDA was conceived as a transparent, modular, and flexible integrated assessment framework designed to connect climate dynamics with the multiple facets of human activity that both drive and are affected by climate change. By framing FRIDA as a "knowledge repository" rather than a static model, we emphasize its role as an evolving platform that can be continually updated with new scientific insights, policy needs, and empirical data.

The present version (v2.1) demonstrates that FRIDA can integrate climate forcing, human behavior, land use, energy, resources, demography, and the economy into a single, fully coupled system. This allows the model to capture cascading socioeconomic risks and systemic feedbacks, which have been identified by the IPCC as among the most urgent and uncertain aspects of the climate challenge. Because changes in one sector propagate through the entire system with realistic lags and feedbacks, FRIDA is particularly well positioned to explore risks of systemic destabilization, identify leverage points, and illuminate co-benefits and trade-offs of mitigation and adaptation strategies.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

A central advantage of FRIDA is its suitability for running a wide range of experiments. Its low computational cost enables users to explore thousands of alternative futures, whether testing hypothetical "what if" scenarios, assessing the effectiveness of different policy levers, or comparing model behavior across versions and against other frameworks. The Endogenous Model Behavior (EMB) run provides a powerful baseline for these explorations: it isolates the dynamics generated purely by the model's internal feedback structure, allowing users to distinguish between outcomes that emerge from past actions already "baked into the system" and those that result from external interventions.

Importantly, not all of our original requirements have yet been met: equity dimensions, certain social and health impacts, and systematic treatment of biodiversity remain outside the current scope of the model. Nevertheless, the framework is designed to facilitate such extensions, and the EMB run ensures that FRIDA provides a consistent reference point for evaluating model development and experimental results.

In sum, FRIDA provides a novel contribution to the family of integrated assessment approaches: it is computationally light, transparent in design, open to interdisciplinary collaboration, and accessible to both expert and non-expert users. We see FRIDA as a living platform that will grow with the scientific community, and as an instrument to help society confront the complex and cascading challenges of climate change in the decades ahead.

Code Availability

Github link for FRIDA v2.1 https://github.com/metno/WorldTransFRIDA/tree/v2.1
Github link for latest FRIDA https://github.com/metno/WorldTransFRIDA
Github link for uncertainty analysis program https://github.com/BenjaminBlanz/WorldTransFrida-Uncertainty
Zenodo link for FRIDA v2.1 https://zenodo.org/records/15310860
Zenodo link for EMD dataset https://zenodo.org/records/15396799

Author Contribution

The author is the coordinator and scientific lead of the EU project "*WorldTrans - Transparent Assessments for Real People*".

Competing Interests

The author declares that she has no conflict of interest.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

Acknowledgements

The author would like to thank the entire WorldTrans team (https://worldtrans-horizon.eu/), and in particular the FRIDA model development team: Benjamin Blanz, Axel Eriksson, Martin Grimelund, Andreas Nicolaidis Lindqvist, Jefferson Rajah, Lennart Ramme, Chris Wells and the coordinator of the model development process (the "father of FRIDA"): Billy Schoenberg. This research was supported by the Horizon Europe research and innovation programs under grant agreement no. 101081661 (WorldTrans). This work used resources of the Deutsches Klimarechenzentrum (DKRZ) granted by its Scientific Steering Committee (WLA) under project IDs 0033 and 1275.

References

Bevacqua, E., Schleussner, C.-F., and Zscheischler, J.: A year above 1.5 °C signals that Earth is most probably within the 20-year period that will reach the Paris Agreement limit, *Nat. Clim. Change*, https://doi.org/10.1038/s41558-025-02246-9, 2025.

Forrester, J. W.: Industrial dynamics, M.I.T. Press, Cambridge, Mass, 464 pp., 1961.

IPCC: Climate Change 2022: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, edited by: Pörtner, H.-O., Roberts, D. C., Tignor, M.,

Pörtner, H.-O., Roberts, D. C., Adams, H., Adelekan, I., Adler, C., Adrian, R., … and Zaiton Ibrahim, Z.: Technical summary, in: *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, 37–118, 2022.

Ramanathan, V. and Coakley, J. A.: Climate modeling through radiative-convective models, *Rev. Geophys.*, 16, 465–489, https://doi.org/10.1029/RG016i004p00465, 1978.

Rajah, J. K., Blanz, B., Kopainsky, B., and Schoenberg, W.: An endogenous modelling framework of dietary behavioural change in the fully coupled human-climate FRIDA v2.1 model. Submitted to Geosci. Model Dev. June 2 2025, https://doi.org/10.5194/egusphere-2025-2260, 2025.

Ramme, L., Blanz, B., Wells, C., Wong, T. E., Schoenberg, W., Smith, C., and Li, C.: Feedback-based sea level rise impact modelling for integrated assessment models with FRISIAv1.0. Submitted to Geosci. Model Dev. June 27 2025, https://doi.org/10.5194/egusphere-2025-1875, 2025.

Schoenberg, W., Blanz, B., Rajah, J. K., Callegari, B., Wells, C., Breier, J., Grimeland, M. B., Lindqvist, A. N., Ramme, L., Smith, C., Li, C., Mashhadi, S., Muralidhar, A., and Mauritzen, C.: Introducing FRIDA v2.1: A feedback-based, fully coupled, global integrated assessment model of climate and humans. Submitted to *Geosci. Model Dev.* June 26 2025, https://doi.org/10.5194/egusphere-2025-2599, 2025.

Sterman, J. D.: Business dynamics: Systems thinking and modeling for a complex world, McGraw-Hill, New York, NY, USA, 2000.

https://doi.org/10.5194/egusphere-2025-4881
Preprint. Discussion started: 13 January 2026

Wells, C. D., Ramme, L., Smith, C., Breier, J., Muralidhar, A., Li, C., Gjermundsen, A., Schoenberg, W. A., Blanz, B., and Mauritzen, C.: Introducing FRIDA-Clim: The standalone climate module in the FRIDAv2.1 integrated assessment model. Submitted to *Geosci. Model Dev.* Sept. 2025, 2025A.

Wells, C., Blanz, B., Ramme, L., Breier, J., Callegari, B., Muralidhar, A., Rajah, J. K., Lindqvist, A. N., Eriksson, A. E., Schoenberg, W. A., Köberle, A. C., Wang-Erlandsson, L., Mauritzen, C., and Smith, C.: The Representation of Climate Impacts in the FRIDAv2.1 Integrated Assessment Model. Submitted to *Geosci. Model Dev.* 14 July 2025, https://doi.org/10.5194/egusphere-2025-2756, 2025B.