MIT Joint Program on the Science and Policy of Global Change combines cutting-edge scientific research with independent policy analysis to provide a solid foundation for the public and private decisions needed to mitigate and adapt to unavoidable global environmental changes. Being data-driven, the Joint Program uses extensive Earth system and economic data and models to produce quantitative analysis and predictions of the risks of climate change and the challenges of limiting human influence on the environment—essential knowledge for the international dialogue toward a global response to climate change.

To this end, the Joint Program brings together an interdisciplinary group from two established MIT research centers: the Center for Global Change Science (CGCS) and the Center for Energy and Environmental Policy Research (CEEPR). These two centers—along with collaborators from the Marine Biology Laboratory (MBL) at Woods Hole and short- and long-term visitors—provide the united vision needed to solve global challenges.

At the heart of much of the program’s work lies MIT’s Integrated Global System Model. Through this integrated model, the program seeks to discover new interactions among natural and human climate system components; objectively assess uncertainty in economic and climate projections; critically and quantitatively analyze environmental management and policy proposals; understand complex connections among the many forces that will shape our future; and improve methods to model, monitor and verify greenhouse gas emissions and climatic impacts.

This report is intended to communicate research results and improve public understanding of global environment and energy challenges, thereby contributing to informed debate about climate change and the economic and social implications of policy alternatives.

—Ronald G. Prinn, Joint Program Director
Changing the Global Energy System: Temperature Implications of the Different Storylines in the 2021 Shell Energy Transformation Scenarios

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Abstract: To meet the long-term goals of the Paris Agreement, the global energy system needs to transition to a radically different fuel mix than currently in use. We analyze temperature implications of three scenarios of energy transformation developed by Shell International. The Islands and Waves scenarios explore the world development without any specific focus on a pre-determined temperature target. The Islands scenario envisions the world focused on nationalism and own security in a context of steady technological development, while the Waves scenario examines the world that focuses on development first and foremost and only changes late to address climate. The Sky 1.5 scenario explores the challenge of moving to a global economy with net-zero greenhouse gas (GHG) emissions in the second half of the century (specifically by the year of 2067). Using the MIT Integrated Global System Modeling (IGSM) framework, we simulate 400-member ensembles, reflecting uncertainty in the Earth system response, of global temperature change associated with each scenario by 2100 (mean of 2096–2100) relative to pre-industrial (mean of 1850–1900) levels. We find that for the median climate parameters, the global surface temperature increase is 2.52°C for the Islands scenario, 2.28°C for the Waves scenario, and 1.47°C for the Sky 1.5 scenario. The likely (33%-66%) range in 2100 is 2.40–2.64°C for the Islands scenario, 2.19–2.43°C for the Waves scenario, and 1.40–1.59°C for the Sky 1.5 scenario.
1. Introduction

Virtually all countries of the world participate in the Paris Agreement (UN, 2015), which has a goal of keeping the increase in the global average surface temperature to “well below” 2°C relative to preindustrial levels, and to pursue efforts to limit the temperature rise to 1.5°C. However, globally coordinated climate policy designed to achieve this goal is still not in place, and the level of pledged mitigation action varies significantly across countries. Still, with growing pressure from society, more and more government and industry actions are moving the world towards decarbonization. A growing number of administrative and business entities have declared “net-zero” emissions targets and other decarbonization actions. Societal pressures and technological trends drive a reinforcing mechanism for action: pressure to pursue low-carbon solutions results in a growing array of low-carbon options, which in turn generates more pressure to employ those options (Morris et al., 2020). These trends drive a transition in the energy system that leads to fewer emissions.

Global greenhouse gas (GHG) emissions are also affected by the Covid-19 pandemic, which has impacted all economic activity, including climate-related actions. While a declining trend for emissions is a good sign for reaching climate goals, negative impacts of the pandemic on economic growth and the ways to stimulate economies provide a complex picture for future decarbonization efforts.

In a slow growth world, emissions are lower due to less consumption, but there are also fewer resources are available for governments to support clean alternatives or for private companies to invest in new technologies. If the markets are not growing, new technologies also have a harder time competing for market share because they need to push out larger fractions of incumbent sources. Further, a prolonged slow growth would keep people in poverty and increase pressure for policies to address otherwise rising levels of inequality.

In a high growth situation, high demand and high energy prices create substantial incentives for new innovations. Growing demand and market share is a way to drive down the costs of new technologies. When demand for energy is growing, new energy sources mostly add to the mix rather than force an early and costly retirement of existing energy sources. However, without proper emission reduction policies, the growth will not be environmentally friendly.

Regardless of the pace of economic development, governments need to intervene to promote the climate sustainability agenda. The amount of resources available for such interventions is highly affected by the Covid-19 crisis. The crisis has also seen many growing negative trends related to protectionism, populism, and nationalism. For a climate problem that requires a global solution, these negative tendencies make global decarbonization pathways an even more challenging undertaking.

However, as the global average surface temperature rises and the impacts become increasingly visible, the need for energy transition will consistently return to the spotlight. This pressure has the potential to drive prolonged and sustained efforts by governments and industries to provide coherent policy support and technological leadership, especially in many sectors where solutions for decarbonization are still under development, which are required to achieve long-term temperature goals. Energy scenarios are important to assess the energy system transition required to mitigate climate challenges and to guide policy makers and industry leaders.

Numerous expert groups and individual researchers produce energy scenarios and assess their implications for climate. The Intergovernmental Panel on Climate Change (IPCC) produces periodic reports that assess the literature relevant to understanding the impacts of climate change. These reports cover scenarios of the future of the energy system, with some scenarios developed by the members of the Integrated Assessment Model Consortium (IAMC). Other well-known scenario producers include the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the U.S. Energy Information Administration (EIA), and energy companies, such as Shell, BP, and ExxonMobil.

The goal of this paper is to provide an assessment of temperature implications of the latest Shell scenarios (Shell, 2021). We apply the outcomes from the Shell World Energy Model profiles for GHG emissions to the MIT Integrated Global System Modeling (IGSM) framework, which links the Economic Projection and Policy Analysis (EPPA) model to the MIT Earth System Model (MESM). EPPA is a recursive-dynamic multi-sector, multi-region computable general equilibrium (CGE) model of the world economy (Chen et al., 2016; Paltsev et al., 2005). It is designed to develop projections of economic growth, energy transitions and anthropogenic emissions of greenhouse gas and air pollutants. MESM is an Earth system model of intermediate complexity, modeling the Earth’s physical and biological systems to project environmental conditions that result from human activity, including atmospheric concentrations of greenhouse gases, temperature, precipitation, ice and snow extent, sea level, ocean acidity and temperature, among other outcomes (Sokolov, et al., 2018).

The paper is organized in the following way. In Section 2 we describe GHG emissions in the scenarios that we consider. Section 3 discusses the resulting carbon emissions and uptakes. In Section 4 we report CO₂ and equivalent CO₂ concentrations. Section 5 discusses the temperature implications, including the results from 400-member ensembles that reflect uncertainty in the Earth system response.

2. Anthropogenic GHG Emissions

Long-term energy projections are needed to assess the climate impacts of different scenarios. In this paper, we use the
energy system projections for the Islands, Waves, and Sky 1.5 scenarios developed by Shell (see Shell (2021) for the details behind each scenario) and implement them in the IGSM model. Here we focus on GHG emissions resulting from the projected long-term changes in the energy system and their implications for the changes in global temperature. The scenarios also include the impact of the Covid-19 pandemic on emissions, which is projected to be only short-term.

The Islands scenario assumes that governments and societies decide to focus on their own security, with a new emphasis on nationalism threatening to unravel the post-war geopolitical order. Although the normal course of equipment and infrastructure replacement and the deployment of cleaner technologies bring progress and eventually net-zero emissions, the world overshoots the timeline and does not achieve the goals of the Paris agreement. Instead there is late and slow decarbonization. The resulting GHG emissions for the Islands scenario are illustrated in Figure 1. Net emissions grow from about 40 gigatonnes of CO₂-equivalent (Gt CO₂-e) in 2000 to about 60 Gt CO₂-e in 2030, then reduce slightly until 2055, with a much faster reduction afterwards to about 20 Gt CO₂-e in 2100.

In the Waves scenario, the initial response to the crises of 2020 is to repair the economy – a focus on wealth first. Other underlying societal and environmental pressures receive less attention initially until their relative neglect provokes backlash reactions. Then, moving quickly, but starting later than required to meet the goals of the Paris Agreement, global society achieves an energy system with net-zero emissions. This scenario involves late, but fast, decarbonization. Unlike the Sky 1.5 scenario, decarbonization in the Waves scenario has its primary focus on the elimination of fossil energy. The resulting GHG emissions in the Waves scenario are provided in Figure 2. In this scenario, net emissions grow even more than in the Islands scenario by 2040, to about 64 Gt CO₂-e, then GHG emissions in the Waves scenario are reduced to about 10 Gt CO₂-e in 2100.

Figure 1. Global GHG Emissions in the Islands Scenario

Figure 2. Global GHG Emissions in the Waves Scenario
In the Sky 1.5 scenario, the initial response to the crises of 2020 is to focus on responding to the pandemic and related challenges to public wellbeing – a focus on health first. Lessons learned from shared best practices, alignments of diverse interests and institutional improvements help create a pathway to health not only of people and society, but also of the environment, including meeting the stretch goal of the Paris Agreement. This is a scenario of accelerated decarbonization now. The resulting GHG emissions for the Sky 1.5 scenario are provided in Figure 3. Net emissions peak at about 59 Gt CO₂e in 2024, then they decline to zero in 2067, and stay slightly below zero until 2100.

The Waves and Islands scenarios are traditional scenarios in that they explore future possible worlds without any specific focus on creating a desired outcome. The Sky 1.5 scenario also explores a future possible world, but one that designed to achieve a certain outcome. It is aspirational as well as being rooted in today’s realities. In the spirit of the original Sky scenario published in 2018 (Shell, 2018), the revised Sky 1.5 scenario maps the difficult pathway society would need to take to meet the stretched climate goal of the Paris Agreement to limit global average warming to 1.5°C in 2100.

Appendix A compares the trajectories for energy-related CO₂, industrial process CO₂, land-use change CO₂, non-CO₂ GHG gases (CH₄, N₂O, PFC, HFC, SF₆), and SO₂ and in these scenarios. In addition to having very different energy system CO₂ profiles, the three scenarios also see differences in other sources of GHG emissions and aerosols. The Sky 1.5 scenario manages CO₂ from all sources most comprehensively, with industrial CO₂ reduced by some 75% both through process changes and the application of carbon capture and storage (CCS), building on the basis of a large-scale CCS infrastructure for energy-related CO₂. The Islands scenario also sees some CCS applied in processes such as cement manufacture, but in the Waves scenario this technology lacks support and never develops commercially and global CO₂ industrial process emissions in this scenario are not reduced below the current levels even by the end of the century. The scenarios envisage a peak in cement production (after the surges caused by large-scale infrastructure builds mature in emerging economies), and further downward pressure in process emissions arises from lower lime production as a result of increased utilization of scrap in steel production. The Islands scenario uses a lower cement growth pathway in order to use more wood in construction.

All three scenarios address land use CO₂, with the Sky 1.5 scenario giving rise to widespread forestry and land management efforts with the land sink increasing to about 13 Gt CO₂ by 2060 and reducing afterwards to about 4 Gt CO₂ by 2100. Land-use CO₂ emissions have proven difficult to eliminate. All scenarios foresee this changing, but over varying timescales. Land-use emissions reach net-zero in 2040 in the Sky 1.5 scenario, in 2048 in the Waves scenario, and in 2066 in the Islands scenario. Both the Islands and Waves scenarios deliver considerable change in the second half of the century and both see an end to deforestation on a global net basis followed by net forest cover increase.

Methane (CH₄) emissions fall in all three scenarios, with fossil methane falling with the decline in fossil fuel use. In addition, the fossil fuel industry also responds to pressure on emissions and implements much improved methane management practices, with the Sky 1.5 scenario seeing this adopted most comprehensively in the nearer term. Agricultural practices also improve methane emissions, but cannot bring them down significantly. By the end of the century, methane emissions are lowest in the Sky 1.5 scenario, but still around half peak levels.

Nitrous oxide (N₂O) emissions follow a similar path to methane, partly linked to overall fossil fuel use, but the majority of nitrous oxide emissions continue to come from agricultural soil management. By the end of the century, the Sky 1.5 scenario sees the most progress through changes in
agriculture and rapid sharing of best practices, including lowering fertilizer use. Agriculture is also addressed more comprehensively in the Islands than in the Waves scenario due to a strong focus on local problem solving.

In all three scenarios industrial gases are managed, but to differing extents. The Sky 1.5 scenario projects rapid reductions in PFCs, HFCs and SF6 as comprehensive actions are taken globally and alternative technologies are aggressively deployed. But in the Islands and Waves scenarios the transition is slower and more aligned with technology development over time as industrial concerns seek out better performing products and respond to pressure from stakeholders. However, reductions in HFC gases benefit in all three scenarios from the Kigali Amendment to the Montreal Protocol. In all scenarios for all industrial gases, emissions are down by 40% or more by 2100, with emissions in the Sky 1.5 scenario down by about 90% relative to the current levels.

Sulphur dioxide (SO2) emissions continuously decline in all three scenarios as the energy transition proceeds: renewable energy backs out fossil fuels in the power generation system, and scrubbing is employed extensively where sulphur remains in fuels. In all three scenarios there is good progress by mid-century with emissions down about 50%, but the transition for metal smelting, another large source of sulphur emissions, takes longer. The Sky 1.5 scenario is lowest for SO2 in 2100 with reduction in excess of 80% relative to the current levels.

3. Carbon Emissions and Uptake

Climate simulations with IGSM are carried out in two stages: historical simulations from 1861 to 2005 and forward climate simulations from 2006 to 2100. During the first stage, IGSM is run in a concentration-driven mode forced by observed changes in natural and anthropogenic forcing. In the second stage, IGSM is run in an emissions-driven mode and forced by anthropogenic GHG emissions from the Islands, Waves, and Sky 1.5 scenarios. Due to the large share of CO2 in total emissions and because CO2 stays in the atmosphere for a very long time, changes in radiative forcing and surface temperature are, to a large extent, defined by changes in CO2 concentrations. Atmospheric CO2 concentrations, in their turn, depend on the balance between anthropogenic carbon emissions and carbon uptake by the ocean and terrestrial ecosystems.

Figure 4 shows the total anthropogenic carbon emissions and uptakes for the duration of the simulations. CO2 concentrations simulated in the second stage of the simulations are defined not only by CO2 emissions, but also by industrial emissions of CH4 and CO (that produce CO2 with ~month to ~decade time delay). For this reason, the implied carbon emissions are shown in Figure 4. Emissions and total uptake peak at about 11.5–12.5 GtC/year and 5.5–6 GtC/year, respectively. There is a noticeable difference between changes
in emissions and uptake. Emissions peak at about 11.5–12.5 GtC/year while ensemble mean total uptakes peak at about 5.5–6 GtC/year (maximum values of total carbon uptake range from about 2 to 8 GtC/year in the individual runs). As a result, on average about 56–57% of carbon, emitted between 2006 and the time when emissions start to decrease, remains in the atmosphere, meaning that both ocean and terrestrial ecosystems are not in equilibrium with the atmospheric CO₂ level. Therefore, both ocean and land continue to take up carbon after emissions start to decrease. Total carbon uptake remains positive in the Islands and Waves simulations through 2100 and become negative in the last decade for the Sky 1.5 scenario. Carbon uptake by the ocean stays positive under all scenarios due to mixing of carbon into deep ocean. In contrast, the terrestrial ecosystem in the Sky 1.5 scenario becomes carbon source at about 2080.

**Figure 5** we re-arrange the data from Figure 4 and show the carbon fluxes of total anthropogenic carbon emissions

![a) Carbon Flux - the Islands Scenario](image)

![b) Carbon Flux - the Waves Scenario](image)

![c) Carbon Flux - The Sky 1.5 Scenario](image)

*Figure 5. Carbon flux (in Gt C/year) for the Islands scenario (panel a), the Waves scenario (panel b), the Sky 1.5 scenario (panel c)*
and uptakes for the individual scenarios. By the end of the century, net carbon to the atmosphere approaches zero in the Islands scenario and becomes negative in the Waves and Sky 1.5 scenarios.

4. CO₂ and Equivalent CO₂ Concentrations

Changes in CO₂ concentrations (see Figure 6) are determined by net emissions (emissions minus total carbon uptake), which remain positive through 2100 in the Islands scenario, but become negative in 2070 and 2050 in the Waves and Sky 1.5 scenarios, respectively. From the current CO₂ concentration of about 400 ppm, in the Islands scenario CO₂ concentrations increase to about 560 ppm in 2100. In the Waves scenario, they rise to about 535 ppm by 2070 and then decrease to about 515 ppm in 2100. In the Sky 1.5 scenario, CO₂ concentrations increase to about 480 ppm by 2050 and then decrease to about 405 ppm in 2100.

The CO₂-equivalent concentrations, shown in Figure 7, are calculated from the total radiative forcing relative to 1860. The CO₂-equivalent concentrations shown here account for radiative forcing by all GHGs and aerosols (sulfates, black carbon). It should be noted that there is no direct connection between CO₂ equivalent emissions (that use the global warming potential, GWP, approximation) shown in Figures 1–3, and the CO₂ equivalent concentrations shown in Figure 6 (see Pierrehumbert (2014) for more details). The use of CO₂-equivalent concentrations simply provides another way to compare CO₂ and non-CO₂ radiative forcing.

Figure 6. Atmospheric CO₂ concentrations (mole fractions in ppm CO₂)

Figure 7. Atmospheric CO₂-equivalent concentrations (mole fractions in ppm CO₂-eq) computed from radiative forcing by all GHGs and aerosols
In all scenarios, the CO\textsubscript{2} equivalent concentrations rise from the current level of about 480 ppm. In the Islands scenario, they increase to about 720 ppm in 2080 and then decrease to about 700 ppm in 2100. In the Waves scenario, they rise to about 700 ppm by 2070 and then decrease to about 640 ppm in 2100. In the Sky 1.5 scenario, CO\textsubscript{2} equivalent concentrations increase to about 600 ppm by 2050 and then decrease to about 460 ppm in 2100.

5. Temperature Implications

The IGSM model calculates changes in the global annual mean surface air temperature relative to a mean of 1861–1880. For the purposes of consistency with the latest IPCC reporting, we converted the results to be relative to a mean of 1850–1900. The results for temperature changes are presented in Figure 8, which also shows the observed historic temperature increase and the IGSM model realization for the historic period. For the median values of the model’s climate parameters (including a climate sensitivity of 3.2, square root of diffusion coefficient of ocean heat mixing of 1.8 cm/s\textsuperscript{1/2}, and radiative forcing due to aerosol radiation interaction of -0.24 W/m\textsuperscript{2}, see Sokolov et al (2018) for details), the Islands scenario leads to an increase in the global average surface air temperature of 2.52°C above the preindustrial level by 2100 (measured as a mean of 2096–2100 relative to a mean of 1850–1900). The corresponding increase for the Waves scenario is 2.28°C, and for the Sky 1.5 scenario is 1.47°C.

We also can estimate the year when the indicative threshold of 1.5°C will be exceeded. Using the 5-year centered mean, the global annual mean surface air temperature increase will be higher than 1.5°C in the year 2034 for the Islands scenario, in the year 2032 in the Waves scenario, and in the year 2036 in the Sky 1.5 scenario (but Sky 1.5 returns back below 1.5°C in 2092).

Figures 9–11 show the results for the global temperature change for 400 runs of the Islands, Waves and Sky 1.5 scenarios, each run with different values of climate parameters. The 400 samples are chosen from a probability distribution of climate parameters as described in Sokolov et al. (2017, 2018). The 90% probability ranges (5%-95%) for the temperature change in a mean of 2096–2100 relative to a mean of 1850–1900 are as follows: 2.01–3.07°C for the Islands scenario, 1.84–2.8°C for the Waves scenario, and 1.2–1.84°C for the Sky 1.5 scenario. The 33% probability ranges (33%-66%) are as follows: 2.40–2.64°C for the Islands scenario, 2.19–2.43°C for the Waves scenario, and 1.40–1.59°C for the Sky 1.5 scenario. The temperature results for all 400-run ensembles of these scenarios are provided in Appendix B.

Another way of illustrating the likelihood of reaching various temperature increases relative to preindustrial levels is provided in Figure 12, which shows the cumulative probability density. As seen in the figure, the Sky 1.5 scenario has a 50% probability of remaining below 1.5°C and 90% probability of remaining below 2°C in the last five years of the 21st century relative to the 1850–1900 mean. The probabilities of staying below 2°C are substantially lower for the Islands and Waves scenarios. They are 14% and 26%, correspondingly. The probabilities of staying below 3°C are 87% for the Islands scenario and 95% for the Waves scenario.

Figure 8. Global average surface air temperature change relative to the preindustrial level of 1850–1990 (°C).
Figure 9. 400-run ensemble results for the Islands scenario for global average surface air temperature change relative to the preindustrial level of 1850–1990 (°C). Darker shaded area represents 33-66% probability bound, medium shaded area represents 17-83% probability bound, and lighter shaded area represents 5-95% probability bound.

Figure 10. 400-run ensemble results for the Waves scenario for global average surface air temperature change relative to the preindustrial level of 1850–1900 (°C). Darker shaded area represents 33-66% probability bound, medium shaded area represents 17-83% probability bound, and lighter shaded area represents 5-95% probability bound.

Figure 11. 400-run ensemble results for the Sky 1.5 scenario for global average surface air temperature change relative to the preindustrial level of 1850–1990 (°C). Darker shaded area represents 33-66% probability bound, medium shaded area represents 17-83% probability bound, and lighter shaded area represents 5-95% probability bound.
6. Conclusions
Meeting the long-term goals of the Paris Agreement requires a dramatic transition in the global energy system. As such, long-term energy, emissions and climate projections are particularly important to assess consistency with the Paris goals and to guide policy makers and industry leaders. Currently, global emissions are affected by the Covid-19 pandemic, which has impacted all economic activity, including climate-related actions. However, the Covid-19 pandemic is projected to have a short-term direct impact on greenhouse gas emissions. The longer-term effect will be most pronounced if it acts as a catalyst for change in the energy transition. Ultimately, government policies and industrial technological leadership is needed for aggressive GHG mitigation.

In this paper, we have analyzed emissions and temperature implications of three scenarios of energy transition developed by Shell International. Using the MIT Integrated Global System Modeling (IGSM) framework, we simulate 400-member ensembles, reflecting uncertainty in the Earth system response of global temperature change associated with the Islands, Waves, and Sky 1.5 scenarios by 2100. We find that, for the median climate parameters, the global air surface temperature increase above the pre-industrial levels by 2100 is 2.52°C for the Islands scenario, 2.28°C for the Waves scenario, and 1.47°C for the Sky 1.5 scenario. The likely (33%-66%) range in 2100 for the Islands scenario is 2.40–2.64°C, for the Waves scenario is 2.19–2.43°C, and the Sky 1.5 scenario is 1.40–1.59°C. By presenting different potential energy futures and their resulting impacts on emissions and temperature, these scenarios can help inform government and industry decisions.

Acknowledgement
The authors gratefully acknowledge Adam Eales and Jamie Bartholomay for their valuable inputs. Shell provided financial support to the MIT Joint Program, to defray costs related to this research. Development of the IGSM framework used in the analysis is supported by an international consortium of government, industry and foundation sponsors of the MIT Joint Program on the Science and Policy of Global Change. For a complete list, see: https://globalchange.mit.edu/sponsors/current. Shell participated actively in this study, supplying the background data behind their scenarios. MIT remains responsible for all analysis and conclusions.
7. References
Appendix A. GHG emission profiles
Appendix A provides a comparison of trajectories for emissions for individual GHG gases and SO$_2$ in the Islands, Waves, and Sky 1.5 scenarios.

Figure A.1. Energy-related CO$_2$ emissions

Figure A.2. Industrial CO$_2$ emissions
Figure A.3. Land-use change CO₂ emissions

Figure A.4. CH₄ emissions
Figure A.5. \(N_2O\) emissions

Figure A.6. PFC emissions
Figure A.7. HFC emissions

Figure A.8. SF₆ emissions
Appendix B. Temperature results for 400-run ensembles

Appendix B shows the results for the surface temperature increase for 400 runs of the Islands, Waves and Sky 1.5 scenarios with different values of climate parameters. In comparison to Figures 8–10 that show probability bands, here we show the results for all 400 runs. The 400 samples are chosen from a probability distribution of climate parameters as described in Sokolov et al. (2018).

Figure B.1. 400-run ensemble results for the Islands scenario for global average surface air temperature change relative to the preindustrial level of 1850–1990 (C°). Blue line represents the mean of the ensemble.
Figure B.2. 400-run ensemble results for the Waves scenario for global average surface air temperature change relative to the preindustrial level of 1850–1900 (C°). Blue line represents the mean of the ensemble.

Figure B.3. 400-run ensemble results for the Sky 1.5 scenario for global average surface air temperature change relative to the preindustrial level of 1850–1990 (C°). Blue line represents the mean of the ensemble.
Appendix C. Carbon uptake results for 400-run ensembles

Appendix C shows the results for terrestrial, ocean, and total carbon uptake for 400 runs of the Islands, Waves and Sky 1.5 scenarios with different values of climate parameters.

Figure C.1. 400-run ensemble results for terrestrial carbon uptake
Figure C.2. 400-run ensemble results for ocean carbon uptake
Figure C.3. 400-run ensemble results for total carbon uptake

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