DISCUSSION SUMMARY

Uncertain Action, Uncertain Impacts: Selecting Climate Change Scenarios for Adaptation Planning

Online Panel Discussion, February 29, 2024

Report Date: May 14, 2025

Event Hosts:

THE COAST AND OCEAN RISK COMMUNICATION COMMUNITY OF PRACTICE, INTEGRATED WORK PROJECT 2 - FUTURE OCEAN AND COASTAL INFRASTRUCTURES: AN OFI PROJECT

Purpose

This document summarizes the online panel discussion hosted by the Coast and Ocean Risk Communication Community of Practice (CORC CoP) on Feb 29, 2024. A video of the event is available on the CORC CoP website (https://corccop.com/activities/) and the CORC CoP YouTube channel: https://youtu.be/rgxgY5fxCrU

Topic

Climate change projections provide valuable guidance for adaptation planning. However, their effective use requires consideration of uncertainty inherent in projections in the context of a user's particular vulnerabilities and tolerance for risk. Although this uncertainty has multiple sources, the primary means that relevant parties have to engage with uncertainty is by comparing climate scenarios. Deciding which scenarios warrant consideration is proving increasingly contentious; consequently, climate science communicators, service providers, and related government offices may face conflicting recommendations regarding scenario choices, shaping practices of climate risk assessment and (ultimately) adaptation action. The panelists will delve into these challenges and concerns, while considering how climate scenarios have been designed, their value and limitations, and their potential to inform adaptation planning.

Panelists

Joe Daraio, Associate Professor, P.Eng., Department of Civil Engineering, Department of Geography (Cross-appointment), Memorial University of Newfoundland
Sabine Dietz, PHD, Executive Director, CLIMAtlantic
Vanessa Schweizer, Associate Professor, Department of Knowledge Integration, University of Waterloo
Christian Seiler, Assistant Professor, School of Environmental Studies, Arts and Sciences, Queen's University

Moderator

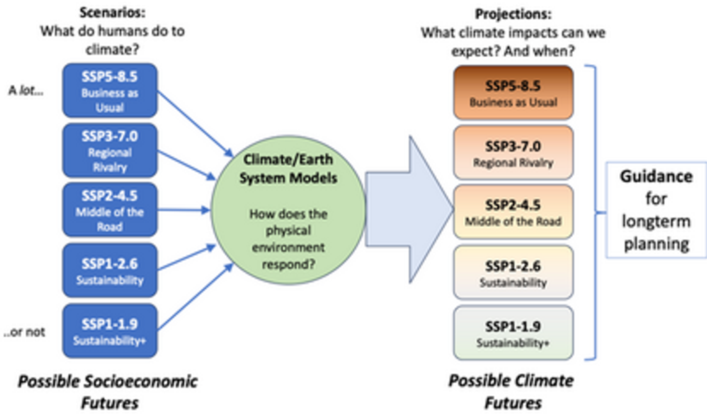
Joel Finnis, Professor, Memorial University of Newfoundland, Co-Lead CORC CoP

INTRODUCTION

Dr. Finnis

Dr. Finnis provides context and introduces the panelists at https://youtu.be/rgxgY5fxCrU (00:00:00- 00:03:34)

Stakeholders sometimes face conflicting recommendations in their attempts to make sense of what climate change will mean for them and their communities, and are left to muddle through an ocean of climate data. Inevitably, these stakeholders must contend with climate scenarios. These are potential socioeconomic futures that are fed into climate models to give us a sense of how the Earth's systems might respond, and what our climate might be like in the future.



The outcomes of these scenarios are often used as guidance for planning actions; however, it is not always clear to stakeholders which of these 'possible futures' best address their concerns. There are conflicting opinions about this in academic circles and the debate is starting to percolate through to planners and policy-makers. The choices taken may have serious consequences for climate preparedness and risk awareness.

Panelists' Expertise

Dr. Schweizer, from the University of Waterloo, is an expert on climate scenarios, sitting on the International Committee on New Integrated Climate Change Assessment Scenarios (ICONICS).

Dr. Christian Seiler is a climate scientist whose research investigates how climate change will impact the earth, focusing on temperature, surface vegetation, and extreme events.

Dr. Joe Daraio is professor in civil engineering at Memorial University of Newfoundland, with specialties in climate adaptation and making sense of climate data.

Dr. Sabine Dietz is the Executive Director of CLIMATlantic, a climate services organization serving Atlantic Canada. She is on the 'front-line', helping stakeholders in Atlantic Canada access, interpret, and apply climate data, and sees these concerns playing out in real-world decision-making.

PRESENTATIONS

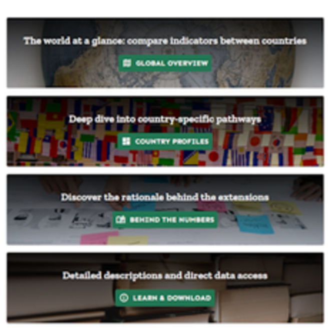
Dr. Schweizer

See Dr. Schweizer's presentation at https://youtu.be/rgxgY5fxCrU (start at 00:03:34)

Dr. Schweizer summarized the multi-step process of climate scenario development. First, possible socio-economic futures (or narratives) are envisioned by an interdisciplinary panel of experts; each describes a different approach to economic development and degree of international cooperation. The key features of each narrative are then input into economic models (Integrated Assessment Models, or IAMs) that translate them into resulting greenhouse gas (GHG) and aerosol emissions; these emissions are themselves fed into a simplified model of the climate and carbon cycle (MAGICC7) to obtain resulting atmospheric concentrations. This is the end product of scenario design: timelines of global GHG and aerosol concentrations, reflecting different economic and sustainability priorities. When fed into complex climate/earth system models, we can then examine the influence of socio-economic futures on the earth system: our 'climate change projections', telling us what impacts to expect and when to expect them.

Dr. Schweizer stressed that the process of climate scenario development is collaborative, complex, and iterative, requiring interdisciplinary collaboration. While the construction of socio-economic narratives is grounded in economics and political science, the IAM community works closely with earth system modelers to ensure that resulting scenarios make good use of available modelling resources

The interdisciplinary complexity of scenario design likely contributes to debate regarding the plausibility of a given scenario. For example, does the fact that nations have set Net Zero targets mean that a high-emission scenario (e.g. SSP5; Fossil-Fueled Development) is now less likely? Dr. Schweizer points out that most nations are not manifesting the intended emissions reductions and so questions remain whether the higher emissions scenarios, like the SSP5 trajectory, are implausible.



Check out the new database at the International Institute for Applied Systems Analysis called the SSP Extensions Explorer, that helps explain the richness and diversity of data that supports scenario development.

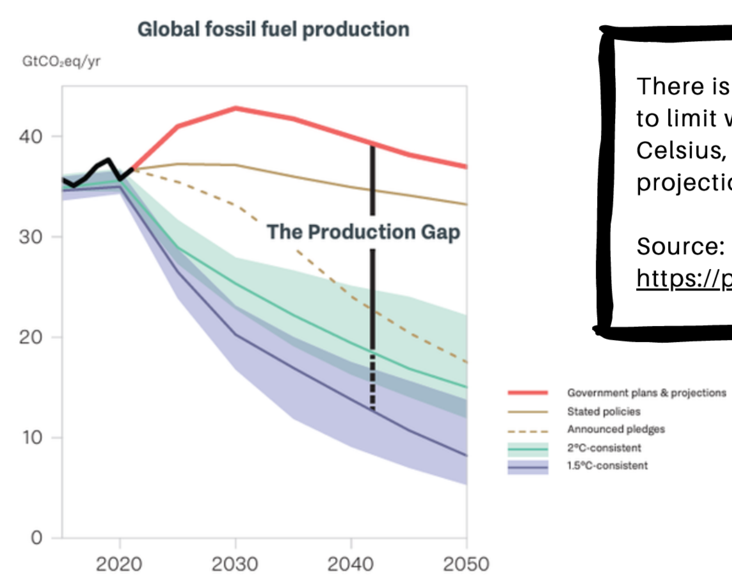
See Dr. Seiler's presentation:
https://youtu.be/rgxgY5fxCrU
(start at 00:08:55)

Dr. Seiler

Dr. Seiler began by providing a climate science perspective on scenario development, highlighting the increasing complexity of models used in each step of the process, while emphasizing the importance of capturing the interplay between human activity and the climate system in this process (e.g. accounting for where carbon emissions end up – and what portion is absorbed by the atmosphere, the ocean, or the biosphere).

Dr. Seiler's current research directly addresses this concern: he studies carbon cycle responses to both carbon emissions and shifts in climate. These are crucial considerations when anticipating climate change impacts: if the ocean and land (biosphere) do not absorb as much carbon as we expect, GHG concentrations in the atmosphere will be much higher and, consequently, we will see more warming. The carbon cycle is complex, as is its response to disturbances (responses are 'messy', and buried in a lot of noise). Consequently, Dr. Seiler must use the fossil-fuel intensive scenarios (SSP5-8.5), as these produce stronger carbon cycle responses (signals) that are easier to discern.

Although similar 'signal-to-noise' concerns drive the widespread use of high-emission/high-impact scenarios (e.g. SSP5) among climate scientists, this approach has recently attracted criticism from circles that consider the scenario to be implausibly pessimistic. Dr. Seiler instead makes a case that only the most optimistic (e.g. SSP1; Sustainability) scenarios can safely be ruled out, given existing emissions and current policies. He points out that there is a strong disconnect between the Paris 2015 agreements on emissions, and our actual measured emissions. He shared a chart from the Production Gap Report to illustrate his point (see https://productiongap.org/ or https://www.unep.org/resources/production-gap-report-2023).



There is a disconnect between policies and pledges to limit warming to 1.5 degrees Celsius or 2 degrees Celsius, and global governments' plans and projections for fossil fuel production.

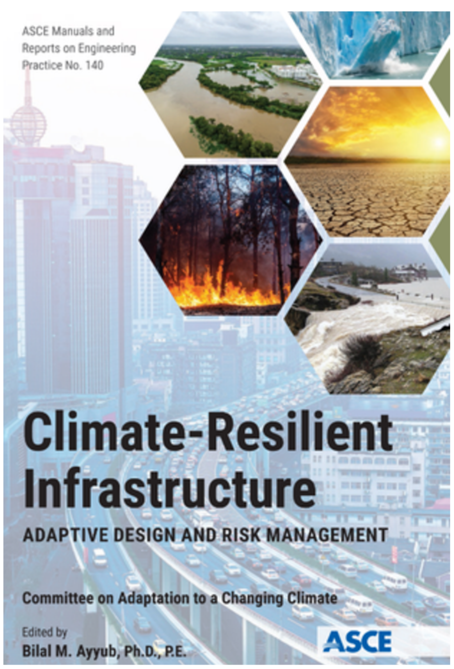
Source: 2023 Production Gap Report: https://productiongap.org/2023report

See Dr. Daraio's presentation:
https://youtu.be/rgxgY5fxCrU
(start at 00:13:37)

Dr. Daraio

Dr. Daraio stressed the need to incorporate climate change projections into engineering considerations; given that many structures are built with the expectation of lasting 50+ years, it is necessary to design *today* for the climate of the future. He outlined an approach called the Observational Method (OM) that offers a template for anticipatory climate change adaptation. This method is "a continuous, managed, integrated process of design, construction, control, monitoring, and review, that enables previously designed modifications to be incorporated during or after construction, as appropriate...the objective is to achieve greater overall economy without compromising safety." Although OM predates concerns about climate change, it provides a useful framework for considering scenarios to 'bracket' potential climate risk.

Dr. Daraio shared two examples of OM implementation, related to coastal rail design in the context of sea level rise (SLR). Here, three different level of SLR risk were inferred from climate change scenarios; intermediate risk (e.g. 1m rise over 50 years) was inferred from the *least severe* climate scenario, intermediate-high from the *most probable* scenario (1.5m) and extreme from the *most severe* scenario (2.5m). Dr. Daraio stressed the importance of considering severe outcomes during the design phase, even when moderate scenarios are more likely; while a project (e.g. rail line) might be designed for the most probably scenario, it can also be built to accommodate modifications should severe scenarios become more probable (e.g. Ayyub, 2018). However, this kind of adaptable construction typically requires assessing extreme (if hopefully improbable) risks at the design stage.



Here is a reference with more details about the Observational Method with respect to climate resilience.

Ayyub, B. M. (Ed.). (2018). *Climate-Resilient Infrastructure Adaptive Design and Risk Management*. American Society of Civil Engineers. ASCE E-books and Standards. ISBN 9780784415191

See Dr. Dietz's presentation:
https://youtu.be/rgxgY5fxCrU
(start at 00:21:45)

Dr. Dietz

CLIMAtlantic (https://climatlantic.ca/) acts as an intermediary between those producing climate information (e.g. climate model projections, based on climate scenarios) and the decision-makers who use that information. Dr. Dietz remarked that, in the past, uncertainty about climate change was interpreted as evidence that 'scientists don't know what they're doing'; in some cases, this led decision-makers to underestimate potential risk. Fortunately, the conversation is shifting. It is now more common for decision-makers to ask which scenario should be used: that is, decision-makers have accepted that climate change is a concrete concern, but are not yet confident when navigating climate uncertainty. People are muddling through, trying to find answers to often complex climate questions; in this context, making sense of scenarios can contribute to user inaction or delays in decision-making. CLIMAtlantic has begun shifting their mode of response to scenario-related questions to address these situations, in which there are no simple answers. Rather than providing a stock response, CLIMAtlantic prefers to engage users in nuanced conversations about their particular needs; climate questions; the decisions they need to make; and their risk tolerance. This helps decision-makers engage more deeply with their climate concerns, and avoids oversimplifying the issue or inadvertently miscommunicating risk (e.g. implying that using a particular scenario means avoiding risk entirely, which may not be true).

Which scenario should we use?

Will it be ok if we use SSP2?

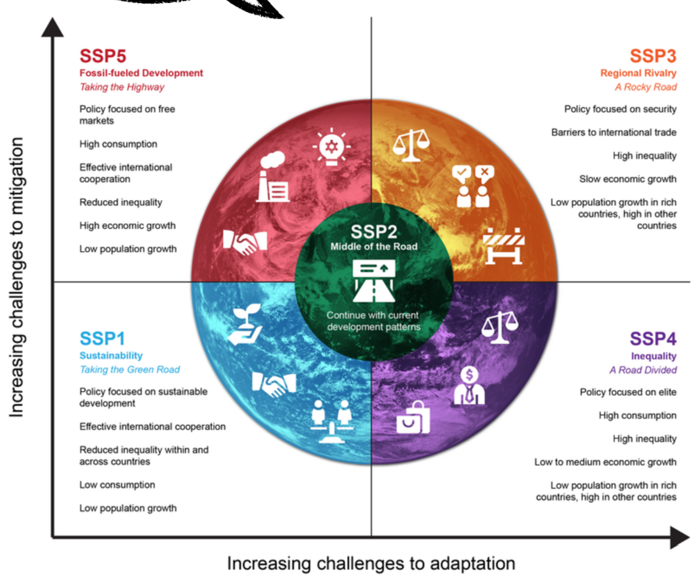
Hmmm...That depends...let's talk about risk...what are you using this for?

What questions do you need answers to?

What are the potential impacts you will see from climate hazards?

Is this the best way of looking at the future?

What decisions do you need to make?



Scenario Pathways Image Source: https://climatedata.ca/resource/understanding-shared-socio-economic-pathways-ssps/

DISCUSSION

Open Discussion:
https://youtu.be/rgxgY5fxCrU
(start at 00:26:02)

Dr. Finnis moderated a discussion among the panelists framed around three guiding questions and questions from the audience.

Is there a 'right' or 'wrong' scenario for different situations? Is this the right question to ask?

In the past 10-15 years, scenarios have been used for planning - not just for research. Are they up to this relatively new task? Are there scenarios that can be safely discounted?

What can we do to 'un-muddle' – to help practitioners find a way out of this confusion? Maybe there is no clear answer or way out? How do we work with it?

Dr. Schweizer emphasized that it was **important to consider more than one scenario**, and supported Dr. Dietz's suggestion to **shift focus to a conversation** (rather than a scenario recommendation) because it can elicit more detail about the problems or concerns to better address them and to explore the key differences in outcomes from the scenarios to understand their impacts on a decision.

Dr. Seiler pointed out that the most optimistic scenario (SSP1) aims to limit warming to 1.5 C; however, given our current rate of emissions, we expect that we will have emitted enough carbon to exceed this threshold by 2030. In 2023 we measured the highest emissions ever and atmospheric concentrations are increasing. So **while it was physically possible, not enough actions have been taken to result in the large reduction in emissions needed, in the time span available, to support the plausibility of the SSP1 scenario**.

Dr. Finnis suggested that perhaps the low emissions scenarios are useful as an indication of what could be achieved if we set our minds to it, while higher emission scenarios are useful for understanding risks we may face.

Dr. Dietz asked whether taking strong action now to manage climate change would be so bad? The outcome 50 years from now will be that we've managed climate change and achieved a lot of other benefits like more resilient communities. She also pointed out that climate action is more than infrastructure projects. **Climate adaptation is a long term process**.

She suggested that the **high emissions scenario could be a proxy for extreme events**, like flooding, hurricanes, storm surges, etc., that we can't currently model well - and 40 or 50 years from now, we don't know how bad the impacts from an extreme event like Fiona could be. How can we adapt now to be in a better position in the future from the perspective of disaster reduction or community resiliency?

Dr. Schweizer supported Dr. Dietz's comment about higher end scenarios acting as proxies for extreme events. She points out that **both SSP3 and SSP5 are high emissions scenarios but with different characteristics; with SSP3 representing a breakdown in geo-political cooperation and SSP5 representing continued growth, prosperity, but reliant on fossil fuels.**

From an engineering perspective, Dr. Daraio remarked that **most infrastructure projects are built to lifespans of 30-50 years and that, over that time span, there is reasonable understanding of possible conditions** - and, consequently, an ability to plan for/design to these conditions. This is less true over longer time periods (50-100yrs). Engineers tend not to design for catastrophic conditions because it is too expensive, or unfeasible. However, they generally want to over-design if possible, especially if life or property is at risk and so they **look at the worst case scenarios and pare down from there**. But it's important to **look at alternatives to engineered solutions, towards the non-engineering approaches** as Dr. Dietz mentioned - for example, nature-based solutions; and also, to build community resilience and to **let people know what the worst case, low probability, high impact scenarios** might involve.

Given Ukraine and Palestine, another elephant in the room is the impacts of escalating global armed conflict as a factor both setting aside existing mitigation progress (e.g. redirection of public spending) and likely damage to mitigating Earth systems, as well as adding to existing GHG production rates. (Audience Question)

Dr. Schweizer, responded that **geopolitical instability is reflected somewhat in SSP3**.

Are changes to the Atlantic Meridional Overturning Circulation factored into the scenarios? (Audience Question).

Dr. Seiler replied that the most recent climate models (CMIP6) do incorporate a weakening of the AMOC but under high emissions scenario SSP5, there was not yet a collapse projected of the AMOC. However, a recently published paper showed simulations (with the Community Earth System Model by the National Center for Atmospheric Research (NCAR) in Boulder Colorado) that included a projected collapse of the AMOC . It is something that's physically possible, but that is not yet projected by the majority of the models. **underestimated in climate scenarios.**

Extreme events, tipping points, and climate scenarios. Dr. Seiler elaborated about extreme events and pointed out that they are **not well-represented in climate scenarios**. Earth system models are very computationally expensive and so they are run with a coarse resolution (e.g., 100x100 km), often close to the equator. This means that processes that contribute to extreme events are not well represented. So if you want to understand the impact of climate change on extreme events, it is important to realize that **extreme events are possibly under-represented and underestimated in climate scenarios**. With **tipping points, many processes are also not included**. For example, wildfires are not included in the CMIP6 climate models and are in fact, still in development.

Is Artificial Intelligence (AI) used in weather forecasting or climate modeling? (Audience Question)

Dr. Seiler replied that with respect to weather forecasting, there are AI models that are competitive with physics-based models; they require very low computational resources to run although they are expensive to train. A big disadvantage is that they are not transparent and you cannot explain the outcomes of your model. The benefit of physics-based models is that they are transparent and are based on natural laws - you can explain an outcome based on these laws.

Regarding the use of AI in climate projections, one role is to estimate the right parameters to help integrate numerical simulations with global earth observations so that model outputs are more consistent with global satellite data, and thus hopefully result in more reliable projections. Another role is to replace parametrization which is needed because many processes cannot be represented physically (model scale is too coarse). AI can use global earth observations and create submodels of parametrizations that can be used in climate modeling to represent these processes or relationships.

CONCLUDING REMARKS

Dr. Dietz emphasized the importance of taking time to walk people through climate complexity - what is meant by climate change; what are the impacts; what are the risks? Communicating this complexity requires more than just an infographic or a webinar. We need to have conversations. In the end it becomes a question of risk tolerance - how much risk are you willing to tolerate? Everyone has a different degree of risk tolerance, and communities must assess their own through collaborative consultation. Many will require assistance with this process, helping to navigate climate risks as well as options.

Dr. Daraio added that we need to have available, and understand, the range of uncertainties - the best case, middle, and worst cases. If we don't know what can happen, how can we decide what we are willing to risk - we need a range of possibilities to assist with decision-making.

Dr. Schweizer pointed out that our decision-making processes can no longer operate as they might have in the past decades, when we thought we could feed information and objectives into models and expect them to output optimal choices or decisions to follow and forget about. Instead, due to conditions of high uncertainty and ongoing change, we need to continually evaluate our approaches. We need to have regular, deeper conversations - what are we trying to adapt to? What does it mean to be a more resilient community? And what are the implications of our actions (or inaction)? Climate scenarios encourage people to talk about these uncertainties and talk about the risks.

Dr. Seiler suggested that we need to think beyond 2100. Over shorter time scales (10-20 years), the differences among scenarios are small and are driven by CO2 that is already in the atmosphere. By 2100 there is a large difference between the scenarios. SSP5-8.5 means there is radiative forcing of 8.5 Watts per square meter at the top of the atmosphere and that means the global mean surface temperature will continue to warm until radiative forcing is reduced to zero - meaning centuries, rather than decades, of warming.

TAKEAWAYS

- Climate scenarios are developed around assumptions about possible socio-economic conditions and processes (Shared Socio-Economic Pathways (SSPs)) that influence carbon emissions; they are produced through multi-disciplinary collaboration.
- The most optimistic scenario (SSP1) is likely implausible, given delays in international action (e.g. Paris 2015 commitments); with a short window remaining (2030) and emissions continuing to rise, it is unlikely that we can achieve SSP1 conditions through mitigation alone.
- Most nations are not yet achieving promised emission reductions; consequently, we cannot yet rule out high impact scenarios (e.g. SSP5-8.5).
- Even high-impact scenarios may underrepresent extreme events or tipping points, due to the limitations of climate model resolution and/or physics.
- Scenarios are just a single part of a broader climate preparedness discussion. Rather than looking for a recommendation about 'which scenario' to use, users are encouraged to have conversations about risk - what impacts are anticipated? What decisions are needed? Which is the best way to look at the future? Revisit these conversations over time as conditions change.
- More than one scenario can and should be used to assist with conversations and decisions, and it is important to consider high-end scenarios in many applications (e.g. infrastructure design). Users are advised to hope for the best, but prepare (or, at least, acknowledge) the worst.
- Although the engineering of physical infrastructure is part of the climate solution, it is important to also consider alternatives. These might include nature-based solutions and non-engineered policies, programs, or social infrastructure that build community resilience.