Options and challenges for estimating the global economic impacts to a future climate

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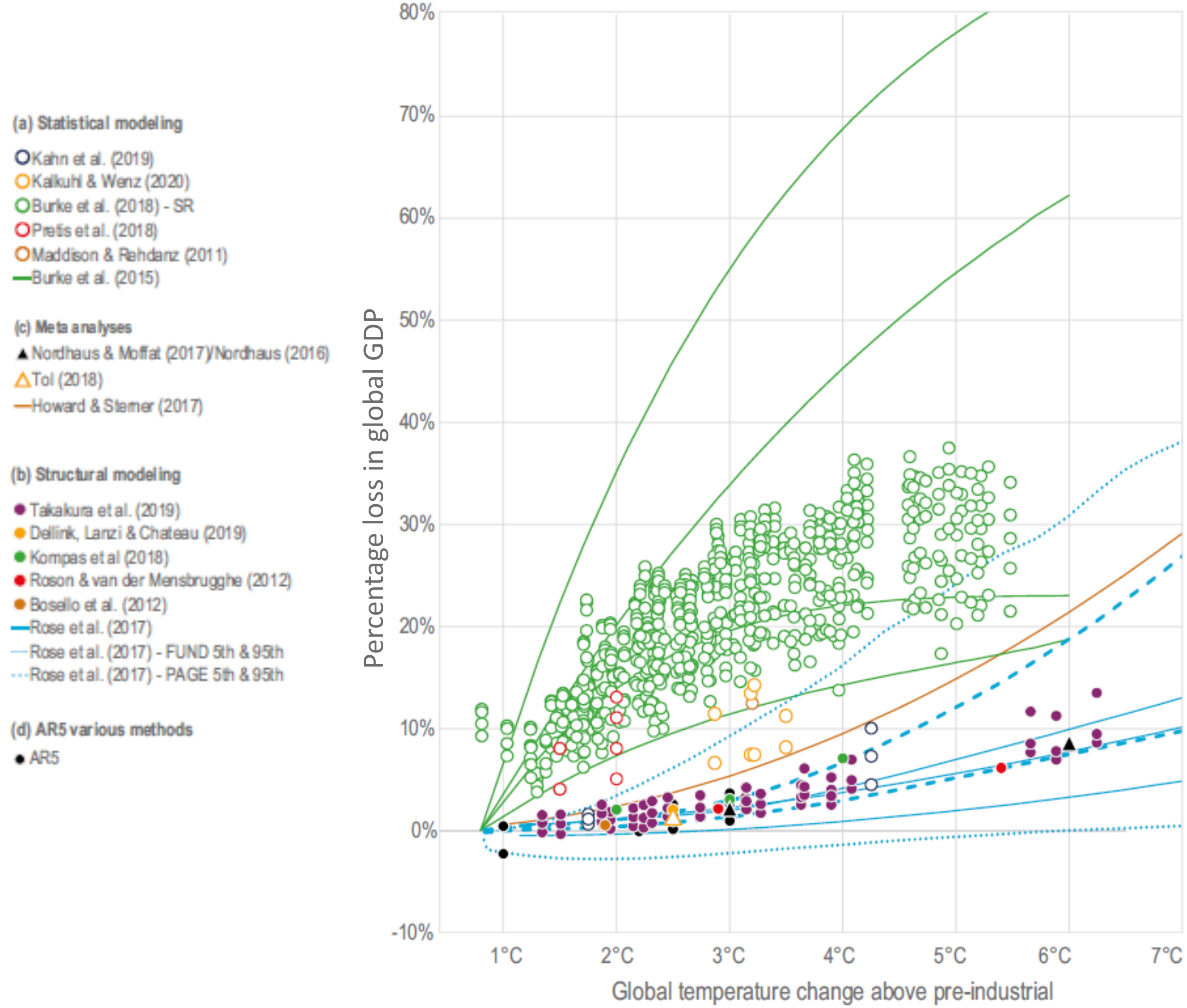
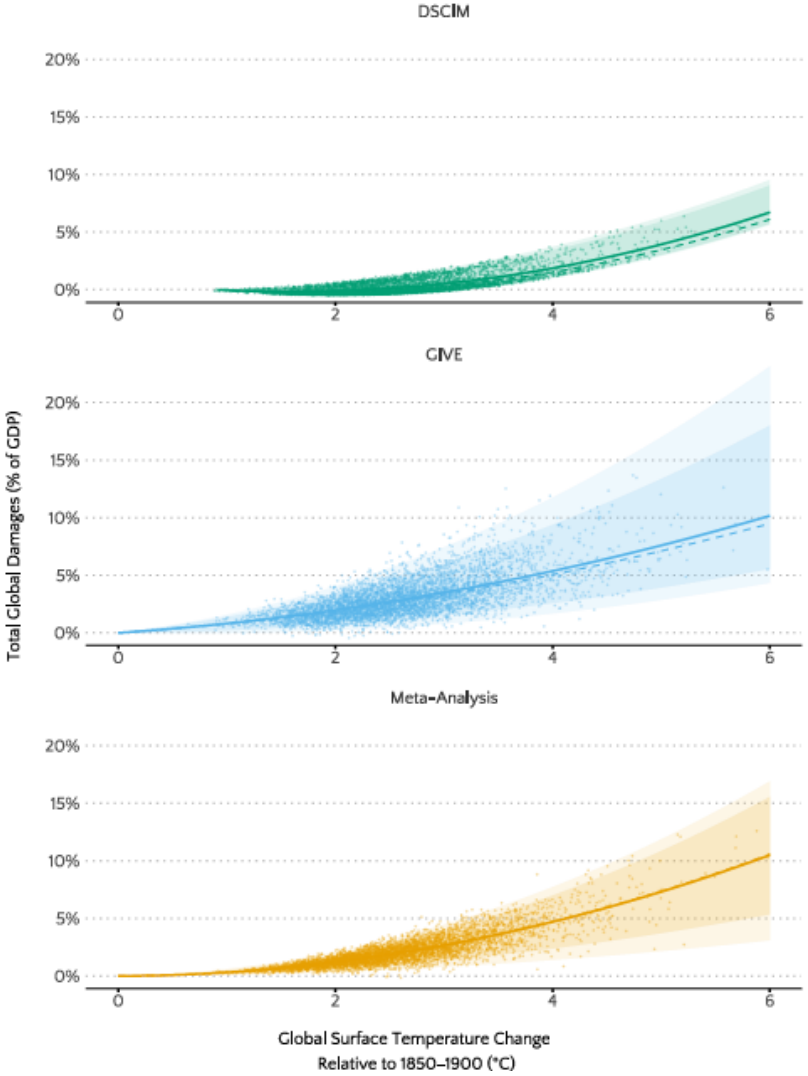
Aggregate global economic impacts estimates

IPCC WGII (2022)

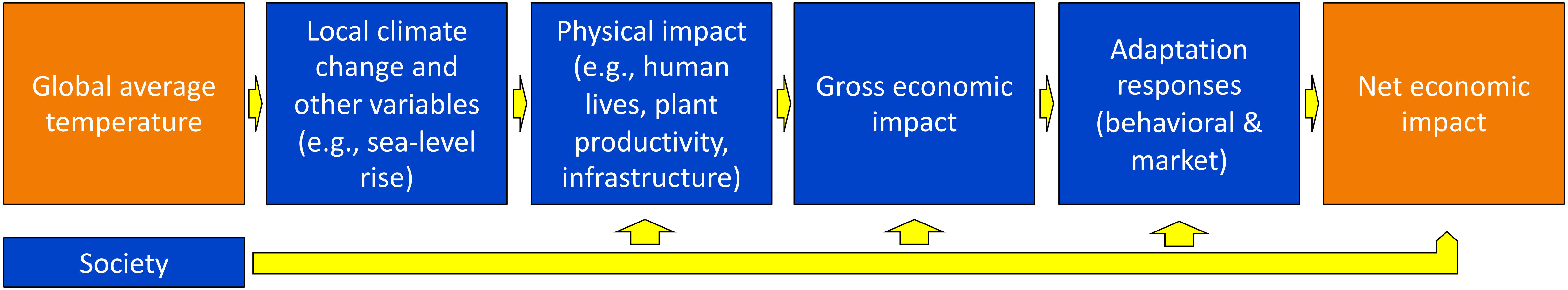


USEPA (2023)

Figure 2.3.2: Annual Consumption Loss as a Fraction of Global GDP in 2100 due to an Increase in Annual Global Mean Surface Temperature in the three Damage Modules



Estimating the economic impacts for a climate



State of the art

- Studies vary significantly in if, and how, they represent each of the pieces above, as well as in methods and scope
- Also, unique uncertainty in each step, and most studies do not account for all
- And, adaptation consideration is limited

Options

- **Methodologies**
  - **Statistical analysis** – observational relationships
  - **Structural modeling** – projecting economic structural changes (production, consumption, trade)
  - **Meta analysis** – estimating functions treating literature as data points
- **Scopes**
  - Geographic: global, regional
  - Impact: aggregate, by impact category
  - Economic: market, gridded
- **Different combinations of methodology and scope characteristics possible and in literature that inform estimation of global economic impacts**

- **Options for constructing global estimates**
  1. Sum global impact category estimates
  2. Sum regional-category estimates
  3. Sum impact category grid estimates
  4. Estimate directly statistically
  5. Estimate directly structurally – endogenous responses to input shocks within structural model
- **Options for handling methodological differences**
  - Ignore
  - Treat as structural uncertainty
  - Treat as different types of information/lines of evidence
- **Each option has strengths and weaknesses**

Scientific challenges – for policy now and science

- **Establishing the robustness of results**
- **Comparability of different methodologies** and results (IPCC WGII, 2022 and NASEM, 2017)
- **Assessment & incorporation of alternative estimates** within a category (e.g., human health, agriculture)
- **Accounting for uncertainty** separate from climate and socioeconomic uncertainty
  - Including differentiating parametric uncertainty, statistical errors, and model specification sensitivity
- **Capturing sub-global socioeconomic structural uncertainty** – see Jan. 11th Webcast #1
- **Fully accounting for potential adaptation** – behavioral and market
- **Aggregating** across categories and regions – interactions, feedbacks, consistency?
- **Transparency** – currently insufficient (e.g., equations, parameters, calibrations, uncertainty specifications, adaptation consideration, intermediate & disaggregated results, choices & results justifications)
- **Data sufficiency**
  - **For some impacts categories** – due to limitations in scientific understanding (e.g., physical system dynamics)
  - **For specifying functions** – sometimes we do not have the data needed for identifying the shape of impact functions
- **Considering justice, equity, and risk** – if and how?
- **Consistency across modules** – inconsistencies with projected climates and societies common

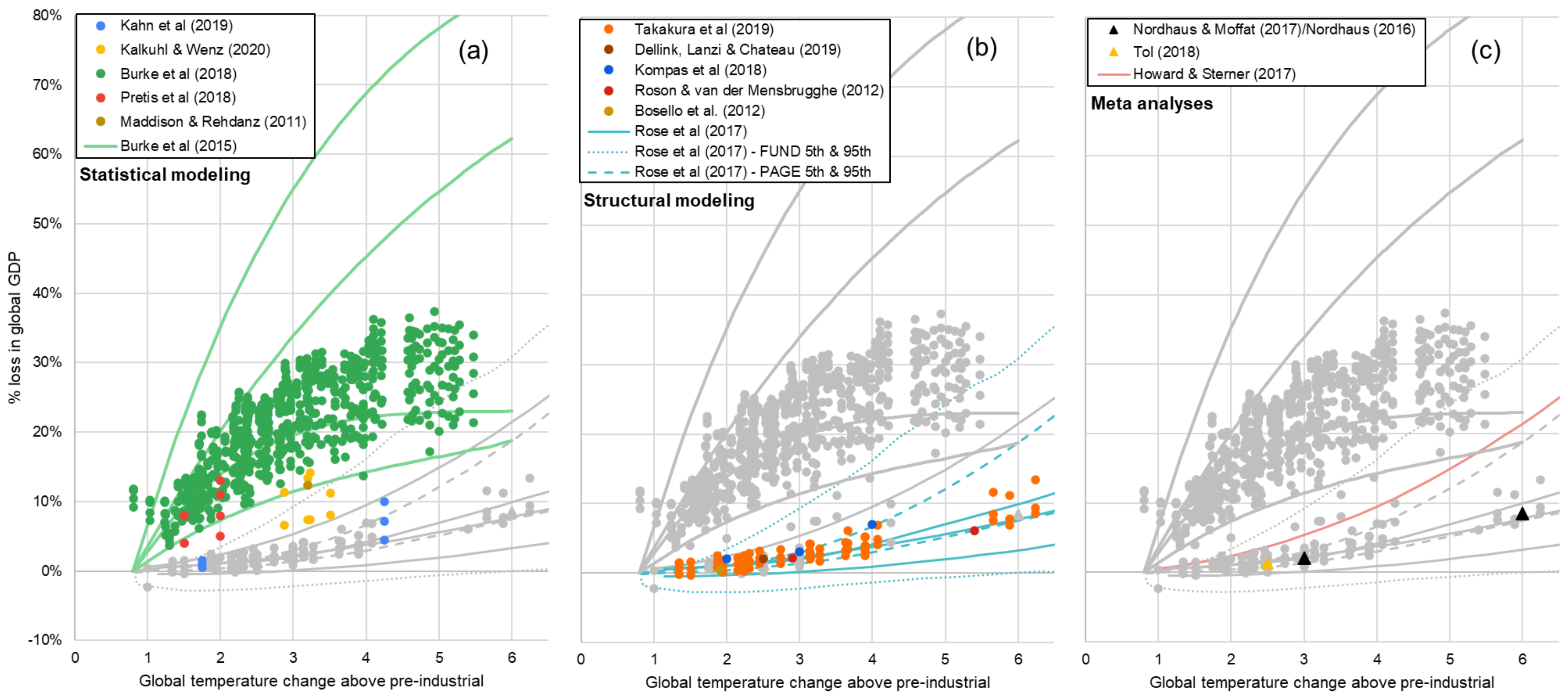
Incomparability issue: IPCC assessed global estimates and found methodological differences cannot be ignored

"The wide range, and the lack of comparability between methodologies, does not allow for identification of a robust range of estimates with confidence (high confidence)"

"Evaluating and reconciling differences in methodologies is a research priority for facilitating use of the lines of evidence (high confidence)"

NASEM (2017) also raised this comparability issue

Global aggregate economic impact estimates by global warming level
(% global GDP loss, all estimates from a paper have the same color)



Source: Rose, S, D Diaz, T Carleton, L Drouet, C Guivarch, A Méjean, F Piontek. Cross-Working Group Box ECONOMIC | Estimating Global Economic Impacts from Climate Change. In Climate Change 2022: Climate Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC, Chapter 16 (O'Neill et al, Key Risks Across Sectors and Regions), https://www.ipcc.ch/report/ar6/wg2/.

Different lines of evidence (based on IPCC WGII, 2022)

Statistical

Strengths: Based on observations, reflects net outcomes

Concerns: Responses and net results constrained by available data; making out-of-sample extrapolations (economic and climate); estimating weather (not climate) relationships; model specification sensitivity; impact and response mechanisms not explicit

e.g., Auffhammer (2018), Dell et al. (2014), Burke et al. (2015), Hsiang et al. (2017), Pretis et al. (2018), Kahn et al. (2019)

Structural

Strengths: Projects future process or economic conditions and responses; evaluates how impacts enter and transmit through processes or economies; models adaptation responses within processes, input and output markets, consumer and investment choices, and inter-regional trade; explicit and interpretable

Concerns:

Process: can be computationally intensive; can omit relevant impact channels, interactions, and market dynamics; can lack an empirical basis for calibration (Fisher-Vanden, Popp, Sue Wing, 2014)

Economic: Observational grounding

e.g., Process: Anthoff and Tol (2014); Sieg et al. (2019); Narita et al. (2020); Economic: Darwin and Tol (2001), Reilly et al. (2007), Roson and Van der Mensbrugghe (2012), Anthoff and Tol (2014), Dellink et al. (2019), Takakura et al. (2019)

Meta

Strengths: Treats estimates in literature as a data sample

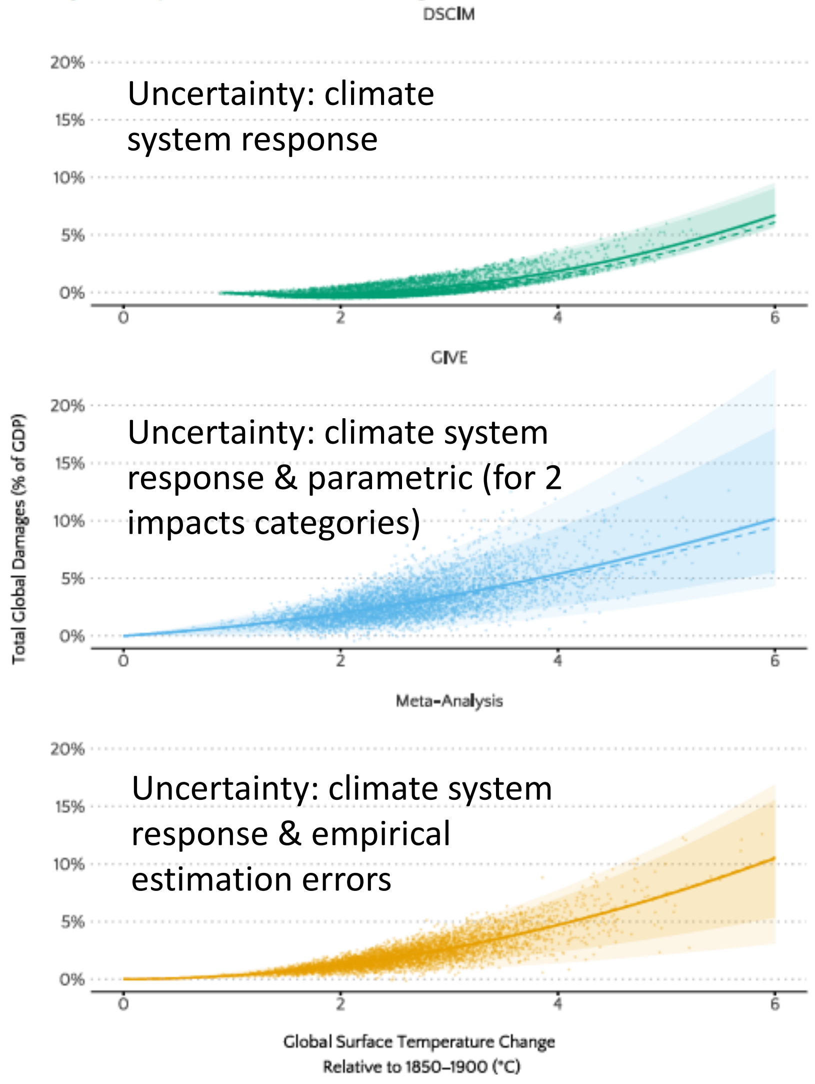
Concerns: Limited assessment of data; limited consideration of methodological differences and details

e.g., Howard and Sterner (2017), Nordhaus and Moffat (2017), Tol (2018)

USEPA (2023) SC-GHG economic impacts module

- Using three global economic impacts estimation representations (weighted equally)
  - DSCIM (Climate Impacts Lab) – sum of 5 impacts categories, primarily based on separate <u>statistical</u> modeling
  - GIVE (Resources for the Future) – sum of 4 impacts categories, each based on separate <u>structural</u> modeling
  - Howard and Sterner (2017) – <u>meta-analysis</u> of global aggregate functions in previous literature
- Scientific challenges to address here
  - Robustness
  - Methods incomparability
  - Alternative estimates (aggregate & category)
  - Aggregation (categories, regions, grids)
  - Impacts uncertainty (ad hoc, asymmetric, partial, different types)
  - Adaptation consideration (ad hoc, incomplete)
  - Transparency (e.g., equations, disaggregated projections)
  - Inconsistencies – across modules and methods
- NASEM (2017) Recommendations 2-2 & 5-1 not met

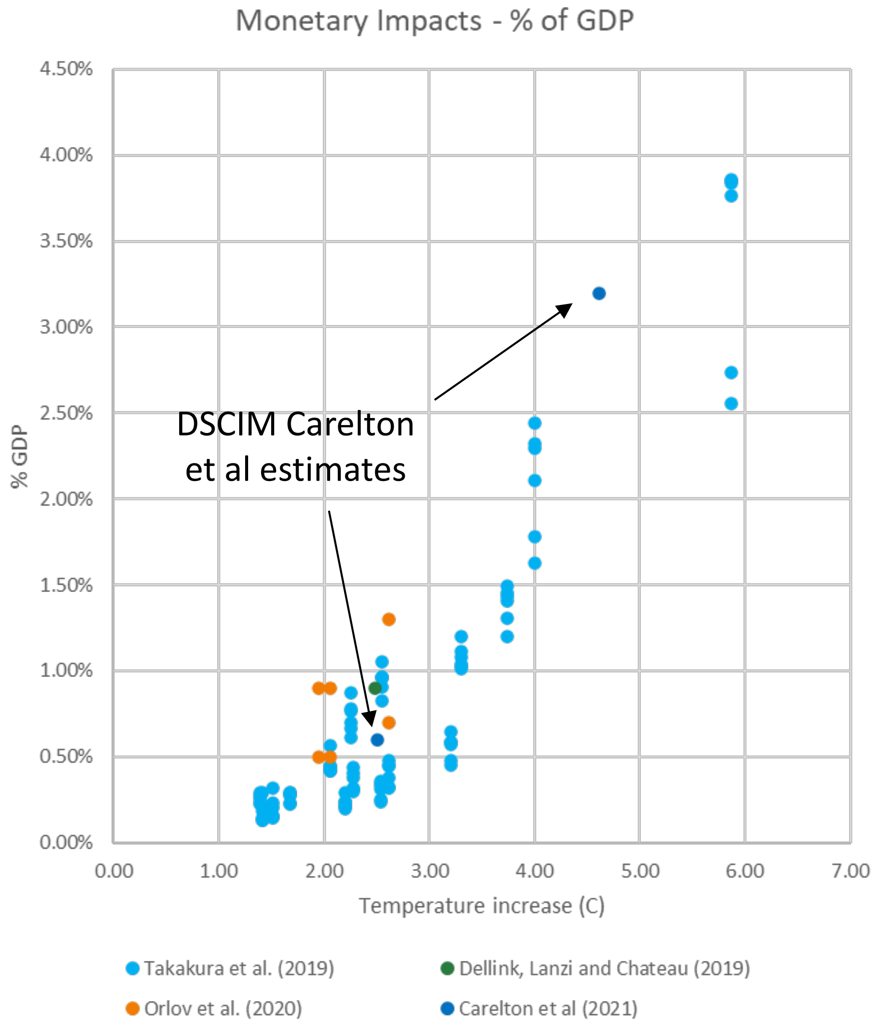
Figure 2.3.2: Annual Consumption Loss as a Fraction of Global GDP in 2100 due to an Increase in Annual Global Mean Surface Temperature in the three Damage Modules



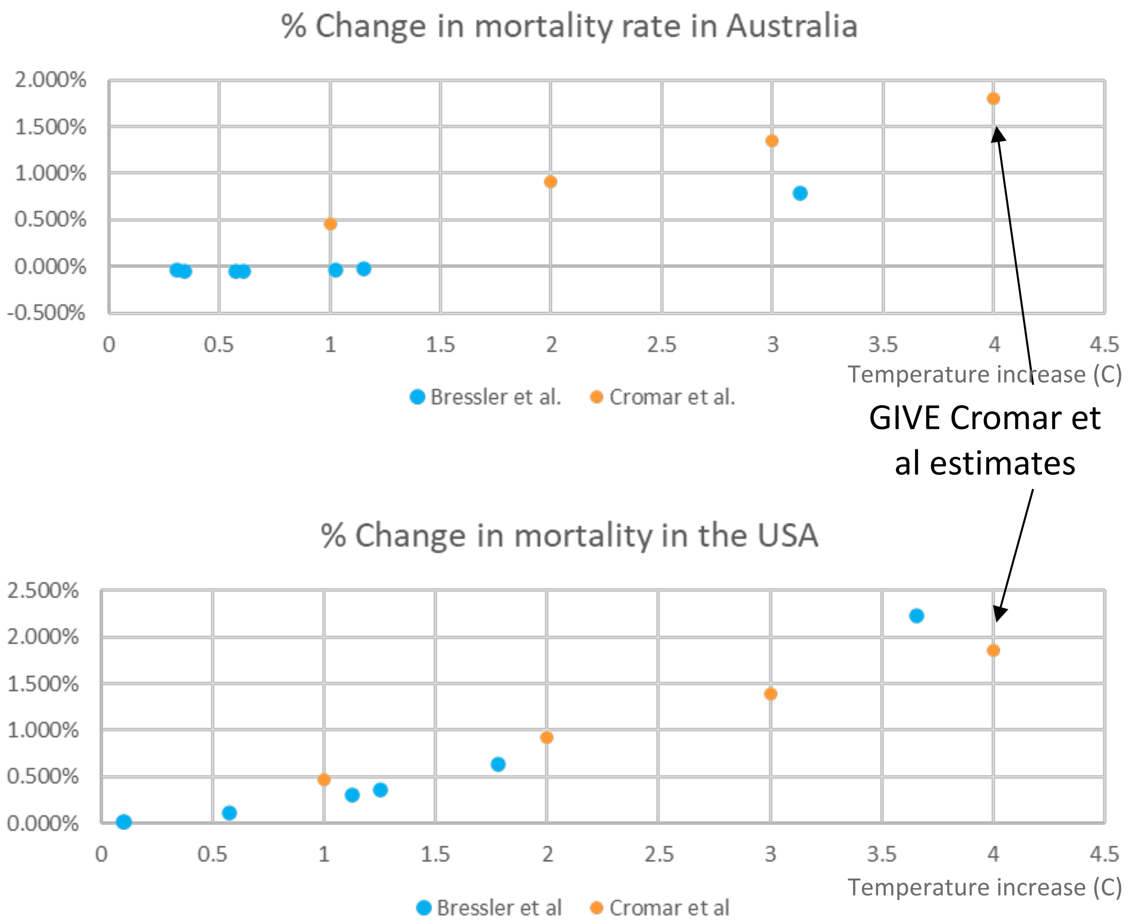
Sources: figure – USEPA (2023), text – EPRI (2023)

Need for considering, reconciling, and integrating broad literature within impact categories – e.g., human health

Examples of global monetary damage estimates



Examples of regional physical mortality estimates



Differences to assess:

1. Modeling of local climate
2. Modeling of net physical response
3. Valuing of net changes
4. Deriving aggregate metric (e.g., % GDP)

EPRI (2023)

Concluding remarks

Based on NASEM (2017), IPCC WGII (2022), EPRI (2023), and Rose (2022)

- The scientific challenges cannot be ignored and are relevant to current policy applications
- We do not yet have robust global economic impacts estimates
- Immediate priorities
  - Greater transparency (details, choices, disaggregated results) in individual methods to inform assessment, interpretation, reconciliation, use
  - Fully assessing and using the literature
  - Reconciling differences in methods – evaluating strengths, weaknesses, biases
  - Determining proper use of the different lines of evidence
  - Enhanced consideration of ALL uncertainties between global temperature & economic impacts
  - Greater evaluation of economic impacts uncertainty with respect to non-climate drivers

Thank you!

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Resources

- EPRI, 2023. *EPRI Technical Public Comments on U.S. EPA's Draft New Social Costs of Carbon and Other Greenhouse Gases Estimation Methodology and Use of Estimates in EPA's Proposed Oil and Gas Methane Rule* (#3002026256). Submitted February 13, 2023.
- IPCC WGII, 2022. Rose, S, D Diaz, T Carleton, L Drouet, C Guivarch, A Méjean, F Piontek. Cross-Working Group Box ECONOMIC | Estimating Global Economic Impacts from Climate Change. In *Climate Change 2022: Climate Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the IPCC*, Chapter 16 (O'Neill et al, Key Risks Across Sectors and Regions), https://www.ipcc.ch/report/ar6/wg2/.
- NASEM, 2017. Cropper, ML, RG Newell, M Allen, M Auffhammer, CE Forest, IY Fung, JK Hammitt, HD Jacoby, RE Kopp, W Pizer, SK Rose, R Schmalensee, JP Weyant, 2017. *Valuing Climate Damages: Updating Estimation of the Social Cost of Carbon Dioxide*. National Academies of Sciences, Engineering, and Medicine, Committee on Assessing Approaches to Updating the Social Cost of Carbon. Washington, DC: National Academies Press.
- NASEM, 2016. Cropper, ML, RG Newell, M Allen, M Auffhammer, CE Forest, IY Fung, JK Hammitt, HD Jacoby, RE Kopp, W Pizer, SK Rose, R Schmalensee, JP Weyant, 2016. *Assessment of Approaches to Updating the Social Cost of Carbon: Phase 1 Report on a Near-Term Update*. National Academies of Sciences, Engineering, and Medicine. Committee on Assessing Approaches to Updating the Social Cost of Carbon, Board on Environmental Change and Society. Washington, DC: National Academies Press.
- Rose, S, 2022. Putting science first in creating and using the social cost of carbon, *The Hill*, November 18, thehill.com.
- USEPA, 2023. EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review." https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf.

NASEM (2017) Recommendations 2-2 and 5-1
(paraphrased and emphasis added)

Recommends over-arching evaluation criteria for SC-CO_2 estimation modules and overall framework (Rec. 2-2)

- **Scientific basis:** Should be consistent with scientific knowledge in the current, peer-reviewed literature.
- **Uncertainty characterization:** Key uncertainties—including functional form, parameter assumptions, and data inputs—should be adequately represented. Uncertainties not quantified should be identified.
- **Transparency:** Documentation should allow people to understand and assess the modules, including which features are evidence-based or judgment-based. Model code should be available to researchers.

NASEM (2017) Recommendation 2-2

Future methodologies need the following:

Scientific basis: Modules, their components, their interactions, and their implementation should be consistent with the state of scientific knowledge as reflected in the body of current, peer-reviewed literature.

Uncertainty characterization: Key uncertainties and sensitivities, including functional form, parameter assumptions, and data inputs, should be adequately identified and represented in each module. Uncertainties that cannot be or have not been quantified should be identified.

Transparency: Documentation and presentation of results should be adequate for the scientific community to understand and assess the modules. Documentation should explain and justify design choices, including such features as model structure, functional form, parameter assumptions, and data inputs, as well as how multiple lines of evidence are combined. The extent to which features are evidence based or judgment-based should be explicit. Model code should be available for review, use, and modification by researchers.

Note: Module specific criteria as well. State of current methodology discussed in text and appendices.

Climate damages module: Near-term update (Rec. 5-1)

The Interagency Working Group should develop a damages module using elements from the current SC-IAM damage components and scientific literature.

- Individual sectoral damage functions should be updated as feasible.
- Damage function calibrations should be transparently and quantitatively characterized.
- If multiple damage formulations are used, they should recognize any correlations between formulations.
- A summary should be provided of disaggregated (incremental and total) damage projections underlying SC-CO_2 calculations, including how they scale with temperature, income, and population.