

BRACE: Background and Rationale

Understanding the potential consequences of climate change for ecosystems and society is necessary for an informed response to the climate issue. A wide body of literature on the impacts of climate change has developed over the past 20 years, as assessed in successive reports of IPCC's Working Group 2. Yet much remains to be done. A particularly important task is improving our understanding of how impacts differ across alternative levels of future climate change. Better understanding the consequences of a world in which the radiative forcing driving climate change increases by small, medium, or large amounts, for example, can inform policy discussions of desired long-term climate outcomes.

Costs of both mitigation and adaptation vary with future climate outcomes as well. Mitigation costs have been better studied, indicating that reducing emissions enough to limit radiative forcing to about 4.5 W/m² above pre-industrial levels is relatively inexpensive, while costs to achieve forcing below that level increase rapidly (Clarke et al., 2014). What is less well understood is what the benefits of such mitigation would be, in terms of reduced climate change impacts and adaptation costs.

This special issue on the Benefits of Reduced Anthropogenic Climate change (BRACE) is aimed at helping to fill a gap in understanding how impacts vary across different future climate outcomes. This "avoided" or "differential" impacts framing is intended to derive the costs and benefits of various long-term climate outcomes. The BRACE project contributes to this literature by assessing the differences in impacts between two specific climate futures: those associated with Representative Concentration Pathways (RCPs) 4.5 and 8.5. The latter would lead to a likely global average temperature change of 2.6-4.8 C relative to recent temperatures by the end of the century, the former to a likely range of 1.1-2.6 C degrees of warming (Collins et al., 2013).

The BRACE project is not alone in this goal. Other recent or current studies focused on avoided impacts include the US EPA study on Climate change Impacts and Risk Analysis (CIRA), the UK AVOID (and now AVOID2) project, and less directly, ongoing EU projects such as IMPRESSIONS and HELIX. Each has a particular focus: CIRA is a US-only study with wide sectoral coverage; AVOID is a global study with a substantial mitigation and emissions pathway component, focusing in particular on the benefits of stringent mitigation pathways; IMPRESSIONS and HELIX focus on Europe, with smaller case studies in other parts of the world.

The BRACE study complements these other activities and breaks new ground in several areas. It is global in scope, with a regional focus in a subset of papers on the US. It includes a substantial component on the differences in physical impacts (e.g., heat waves, tropical cyclones, drought, sea level rise) between the scenarios, drawing heavily on multi-member initial condition ensembles of the Community Earth System Model (CESM). These ensembles include a recently produced Large Ensemble (30 members) for RCP 8.5 (Kay et al., submitted) and a smaller (15 member) ensemble for RCP 4.5 newly developed as part of the BRACE project (Sanderson et al.). Societal impact studies are based on the new Shared Socioeconomic Pathways (SSPs; O'Neill et al., 2013); the study therefore contributes to a nascent literature based on the new scenario framework (van Vuuren et al., 2013) combining RCPs and SSPs. These ensembles are also used to make several methodological advances in accounting for variability even when ensemble simulations are not available. The study also includes the first application of new global scenarios of spatial population distribution, the first use

of crop models within CESM in a global agricultural impact assessment, and new high resolution (25km) global simulations of tropical cyclone activity.

BRACE authors cut across disciplines. Many are trained in economics or other social sciences and focus on societal impacts of climate change. Other authors are physical climate scientists who build and analyze fully coupled Earth System Models (ESMs), including CESM. Many of the papers have co-authors from both types of scientists.

Most of the BRACE analyses involve multiple papers approaching a specific type of impact – those related to tropical cyclones, agriculture, and heat extremes – from different perspectives, building on each other. For example, Bacmeister et al. present new high resolution simulations of future tropical cyclones; Done et al. present a new index of cyclone damage potential that is then calculated based on those simulations; and Gettelman et al. estimate actual economic damages from future cyclone activity based on a spatial model of the economic value of physical assets. Similarly, on the topic of heat extremes, Oleson et al. analyze the difference in heat wave occurrence in urban and rural areas in CESM between the two scenarios; Jones et al. combine these climate model outcomes with projected spatial distributions of the population to estimate future exposure to heat waves; Anderson et al. use these projections to estimate future heat-related mortality in US cities; and Marsha et al. focus on mortality consequences for an individual city (Houston) in which they can account for within-city spatial heterogeneity in urban form and socioeconomic conditions. For agriculture, Levis et al. use the CESM land surface model to assess the impacts on crop yields of the alternative RCPs, while Ren et al. use these yield effects to investigate their economic implications for global agriculture in the NCAR integrated assessment model. Tebaldi and Lobell address a shortcoming of the CESM yield modeling by assessing the potential direct impacts of extreme heat on crop production.

The large and medium ensembles also afford the opportunity to examine critical methodological issues in the treatment of variability and extremes in impact studies. Sanderson et al. present the RCP4.5 Medium Ensemble and examine the linearity of variability with differences in global average temperature, identifying where such linearity breaks down and suggesting physical reasons for nonlinear responses. Alexeeff et al. and Fix et al. propose and test methods of pattern scaling that go beyond the usual approaches to provide not just spatial patterns of temperature and precipitation but also estimates of their variability. This group of papers as a whole offers methods that can expand the types of avoided impacts studies that are possible to carry out in the future by extending them to situations in which ensembles of simulations are not available for all scenarios to be assessed. Further, Tebaldi and Wehner, and Fix et al., employ the ensembles to identify when differences in extreme temperature and precipitation events become apparent (and statistically significant) between them.

Overall, the BRACE study combines modeling of the physical and human systems with methodological advances in the treatment of variability and extremes to advance understanding of climate change impacts in a number of sectors at the US and global level.

References

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