
# Approaches to Modeling Impacts: Snowmass 2013

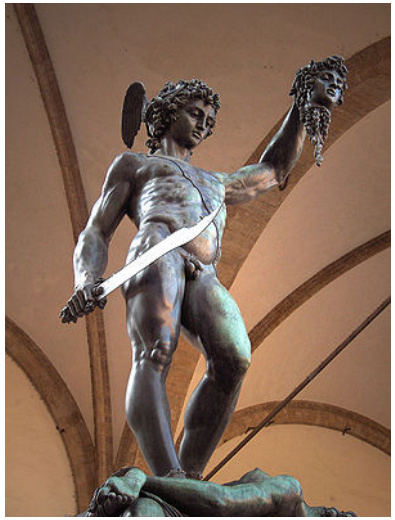
Tony Janetos
Pardee Center
Boston University

# Five Major Concerns

- What is the problem we're really trying to solve?
- Who do we think we are solving it for?
- What features of impact sectors are important to represent, and what do we already know about them?
- What are the implications of those features for different modeling approaches?
- How do we break out of the box and make some significant forward progress in research?

# Snowmass 2010

- Three years ago, Rich asked me to synthesize several days worth of discussions on uncertainties, communications with policy audiences, and so forth…
- So I did a classical interpretation of these topics



# Moving On

- But a classical interpretation, even drawing on the adventures and epic tales of pre-literate, Bronze Age Greeks doesn't seem to have done the trick.
- So in my search for analogues, I am moving on to a more technologically advanced period with international trade, some degree of globalization, international conflict, ethnic and religious warfare, and colonization, migration, and cultural assimilation – to see if this metaphor works better for thinking about modeling climate impacts in integrated models, where there is also lots going on.

# The Vikings


- Vikings were also pre-literate, war-like adventurers
- Basically, everything we know about their mythology is because of Snorri Sturleson, an Icelandic scholar who wrote these myths down in the year 1200
- You already know more about the Vikings than you think you do – names of several days of the week, lots of cognates in English stemming from persistent invasions across the North Sea

# Ragnarok, the Final Battle

- The structure of Norse mythology culminates in Ragnarok, the final battle between the gods of Asgard, led by Odin, and the frost giants of Jotunheim, led by Loki, the trickster.
- The inhabitants of Midgard, i.e. us, manage to somehow survive this catastrophe, and it is meant to be a rebirth of hope.
- This may be somewhat similar to current US policy debates over climate change

# Parallels of the Norse Myths and Climate Science and Impacts

- Lots of stories about Thor wandering around and beating up various Frost Giants
- Lots of stories about Loki tormenting the gods in Asgard
- Lots of legends and cultural references about the honor of dying in battle and going to Valhalla

- Studies of individual sectoral impacts of different climate futures
- What is the climate sensitivity anyway?
- How much should we try to quantify the economic costs of climate impacts?
- How do we discuss and communicate our findings to a variety of policy audiences?

# Approaches Depend on Goals

- Trying to assess aggregated economic costs of impacts?
- Trying to understand un-priced, but nevertheless important consequences?
- Trying to do a calculation of the physical consequences of different climate futures?
- Trying to understand the degree to which change in the climate system affects systems that we already know are imperfectly adapted to climate variability?
- Trying to understand whether impacts feed back on each other and/or on other components of the Earth system?
- Trying to understand the net effects of many different stressors on one or more impact sectors?
- Trying to assess the degree to which adaptation can counteract climate damages?

# Approaches Depend on Goals

- These are all potentially important questions
- But they are not all the same calculation
- In some cases, modeling to understand potential futures and dynamics will necessarily have spatial specificity - because the magnitude and importance of impacts depends on where and when they occur
- In other cases, policy interests “may” preclude the need for more detailed analysis
- But could that generalized information actually be derived sensibly without doing more detailed analysis?

# Approaches Also Depend on Who You Think You Are Talking To

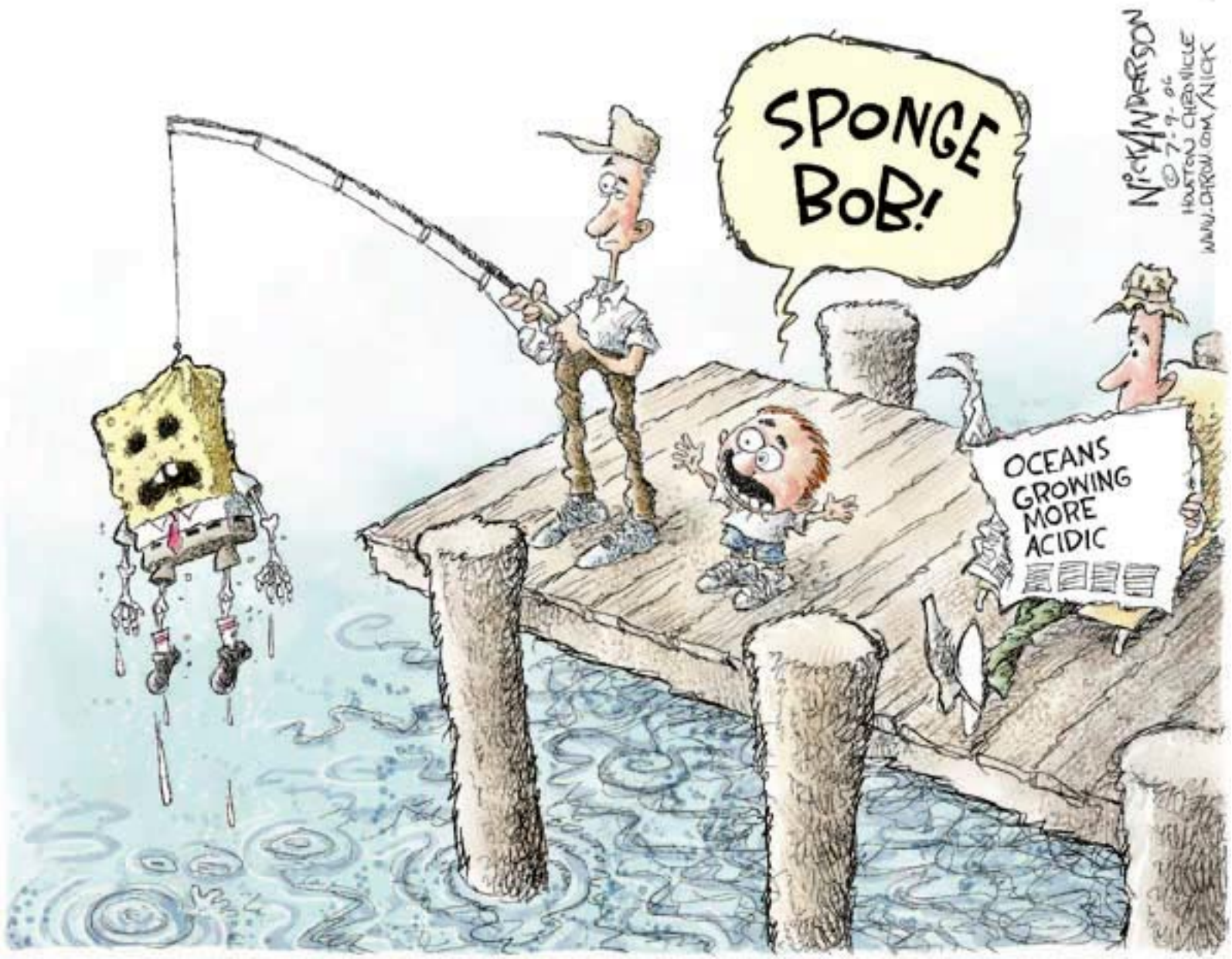
- Public policy makers who are going to make decisions about energy and emissions policies
- Public policy makers who are going to make decisions about natural resource management and planning
- Public policy makers who are going to make decisions about infrastructure, energy systems, urban expansion and sustainability…
- Private decision makers with resource management, conservation, etc. influence
- Private decision makers with assets at risk (or who are insuring assets at risk)

# Approaches Also Depend on What You Think You Are Talking About

- In general, decision makers in both public and private sectors concerned with adaptation DON'T CARE about the additional marginal impact of climate change on resources
- They care about the overall relationship between resources/sectors and variability in the climate system (even if they don't phrase it this way) and resilience
- And even if they did care, WE CAN'T MEASURE OR EVEN CALCULATE THIS MARGINAL CHANGE with any level of precision or accuracy
- But we can say a lot that's interesting about the overall relationship

# Typical Challenges for the Modelers

- Ubiquity of “bad behavior” in physical systems
- Thresholds are routine phenomena– we’ve looked at much of the literature on ecological thresholds, and in some ways the greater challenge is finding a system that does not respond in this way
- But our ability to model such changes is rudimentary – the example of the sensitivity of crop productivity to temperature thresholds, many other examples where there is an ecosystem threshold that is not necessarily related to an extreme in climate variability…
- Processes that we simply leave out – pest infestations, agricultural disease and pests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# Reinsurance and Other Players in Private Sector

- Acknowledging that there are inherent risks to infrastructure that have been undervalued
- Response clearly depends on whether one is talking about their own assets, or insuring other assets

# Public Sector Management

- Recognition that neither physical infrastructure nor ecosystems are going back the way they were
- Not necessarily because the shocks they were subjected to were due to climate change, but because the climate system is no longer stationary
- A whole series of regulatory, ethical and social issues

# Some Conclusions Persist

- The technique of inferring or developing simple, statistically-based response functions for use in reduced form IAMs faces some very difficult challenges.
- My first conclusion is that these techniques have some utility for understanding the interactions of climate impacts and economic concerns in today's world; this is important.
- But their utility for projections that are intrinsically far beyond the range in which the original parameterizations and damage functions have been developed is likely to be quite limited.
- My second conclusion is that a more process-based approach to linking concerns about impacts with their economic consequences and with the economic and technological evolution of both the impact sectors and climate policy is more likely to be helpful at the end of the day. This is likely the only way in which the consequences of extreme events and evaluating the tails of the distributions will really be able to be explored.
- We also need to be sure that the models begin to incorporate new types of decision-making about adaptation responses – including appropriate decision frameworks, responses to events and variability, and analogous policy considerations as they have done for the energy system.
- My third conclusion is that we are still in the very beginnings of being able to do this – I'm aware of experimental simulations that start to do this, but we've seen very, very few examples in the literature.

# What Would I Recommend First?

- If you are interested in a single impact sector, or in sectors that you think aren't really going to interact much, then using the IAM's seems not a wise choice – use the existing models for those sectors.
- The unique strength of the IAMs is in representing the interactions among different sectors, with economic decision-making, and potentially the interaction of mitigation and adaptation actions and the climate system.
- Impacts in the context of the IAMs still will have all the challenges of how those individual sectors/resources behave.
- I would recommend doing the modeling explorations with the most complete, process-oriented models you can, by collaborating with those communities rather than trying to reinvent them
- And only after some of this has been done, would I recommend trying to derive response surfaces, much more simplified model forms, etc.

# What Would I Recommend Second?

- We still have to recognize that in simulations of the future, in order to be credible, we need to be doing ensemble calculations, and/or use multiple climate models, as an intrinsic part of representing the climate component of the underlying scientific uncertainties.
- Single model calculations can be informative (and can be easier experimental designs), but they will need to be backed up with ensembles.
- These recommendations do put some stress on computational needs, but I just don't see a way around this…
- We continue to have a relative paucity of data about economic costs of impacts and of adaptation itself.
- And we still don't have an integrated observational system for impacts related to climate change – essentially relying on series of ad hoc studies – although we are trying to change this as part of the current NCA.

# What Would I Recommend Outside of the Box We're Currently In

- Use the scenario processes we have spent so much time on to define worlds we would like to have, e.g.
  - Meeting the MDG's
  - Acceptable levels of food security
  - Sufficient access to potable water
  - Large, liveable cities
- And then ask the question via the impact modeling:
- Does continued change in the climate system make achieving these policy goals harder or easier? Do climate mitigation or adaptation decisions change that calculation?

# A Different View of Impacts and Scenarios

- This is a very different way to think about our scenario processes, which we have structured around climate mitigation questions.
- But there is no intrinsic reason for that to be the only structuring that is reasonable.
- We've already seen examples in the past day where the climate stress on a system subjected to multiple stresses might not be the biggest issue.
- So why not think about using the IAM impacts modeling in a different format that is more explicit about climate change's and climate policies' impacts on other social goals we care about?

# Conclusions

- Thor, the favorite of the Vikings, was brave and strong, but not too bright, and depended on heroism to accomplish great tasks.
- Odin sacrificed an eye and impaled himself on Yggdrasil, the world-tree, to gain the chance to drink from the fountain of wisdom.
- I doubt we will have to go to quite these extremes.
- But we will have to be cleverer about representing processes in IAM's than we have been, and
- Face up to the fact that some of these challenges will simply require more simulation and computation than had originally been anticipated.

# Thank You