Possibility distributions of scenarios for regional climate change

Judith Curry
At time scales beyond seasons, available ensembles of climate models do not provide the basis for probabilistic predictions of regional climate change.
Scenario Thinking – Robust Decisions

- Scenarios are provocative and plausible accounts of how the future might unfold.
- The purpose is not to identify the most likely future, but to create a map of uncertainty of the forces driving us toward the unknown future.
- Scenarios help decision makers order and frame their thinking about the long-term while providing them with the tools and confidence to take action in the short-term

climate change • extreme weather events
population increase • land use changes
technology • economics
alternative policy options
Are GCMs the best tool for developing scenarios of future regional climate change?

Challenges:

• current GCMs inadequate for simulating natural internal variability on multidecadal time scales
• computational expense precludes adequate ensemble size
• GCMs currently have little skill in simulating regional climate variations
• dynamical & statistical downscaling adds little value, beyond accounting for local effects on surface variables
Scenarios of future climate

- Long range processes
- Natural internal variability
- Solar effects
- Volcanic eruptions
- Emissions
- Statistical models
- Climate models
- Regional change
- Extreme events
- Black swans

Unknows

Historical and paleo observations

Climate dynamics

20 YEARS FROM NOW...

50 YEARS, 100 YEARS
Predictability, Prediction and Scenarios

Probabilistic

MJO, ENSO

AMO, PDO

external forcing

bounded, likelihood

possibility

Days     Weeks    Seasons    Years    Decades    Century
Possibility theory is an imprecise probability theory that states that any hypothesis not known to be impossible cannot be ruled out.

A possibility distribution distinguishes what is plausible versus the normal course of things versus surprising versus impossible.
Possible/plausible(?) worst case scenarios

What scenarios would be genuinely catastrophic?
What are possible/plausible time scales for the scenarios?

Can we “falsify’ these scenarios based upon our background knowledge of natural plus anthro CC?
Modal logic classifies propositions as contingently true or false, possible, impossible, or necessary. Frames possible versus not possible worlds.

Principles for constructing future climate scenarios:

- **Modal induction**: a statement about the future is possibly true only if it is positively inferred from our relevant background knowledge (IPCC).

- **Modal falsification**: permits creatively constructed scenarios as long as they can’t be falsified by being incompatible with background knowledge.
Scenarios of future climate

Historical climate & extreme events

Paleo climate & extreme events

Creatively imagined scenarios

20 YEARS FROM NOW...

50 YEARS, 100 YEARS

Dragon Kings

Regional change
Extreme events
Black swans

Climate models
Data-driven scenarios on decadal time scales – Extreme events

The decadal scenarios are not time series, but rather frequencies of extreme events (including clusters) and worst case scenarios over the target time interval:

• Floods
• Droughts
• Heat waves
• Tropical cyclones
• Heavy snowfalls
• Etc.
Data-driven scenario generation methods

- Climatology (historical, paleoclimate)
- Extrapolation of recent trend
- Dynamic climatology empirical model (Suckling/Smith)
- **Network-based dynamic climatology** (Wyatt & Curry)
- Secular global warming as a multiplier effect
- “What if” scenarios relative to vulnerability threshold
- Sensitivity analyses
Currently:
- Warm AMO
- Cool PDO

Previous analogue:
- 1946-1964
Landfalling N. Atl Hurricanes

Atl coast: more in warm AMO, cool PDO

Fl coast: more in warm AMO
Impact of AMO, PDO on 20-yr drought frequency (1900-1999)

Warm PDO, cool AMO

Cool PDO, cool AMO

Warm PDO, warm AMO

Cool PDO, warm AMO
The ‘stadium wave’ climate signal propagates across the NH through a network of ocean, ice, and atmospheric circulation regimes that self-organize into a collective tempo.

Wyatt & Curry, 2013: Climate Dynamics
Scenarios (insights): 2015 - 2025

Stadium wave climate dynamics:
• Warm AMO (shifting towards neg), cool PDO
• More La Nina events
• Decrease/flattening of the warming trend

• more rainfall in NW, mid Atlantic states
• less rainfall in W/SW, Texas
• more hurricane landfalls along Atlantic coast, fewer in FL

“Spiking” from AGW:
• Increasing rainfall
• Increase in hurricane intensity
• Overall reduced hurricane landfall owing to eastward extension of the Atlantic warm pool
Scenarios (quantitative guidance): 2015-2025

Methodology for scenario generation using stadium wave dynamics:

• Generate a large synthetic climatology of the event using Monte Carlo resampling from the pdfs conditioned on the particular regime.

• Utilize extreme value theory to extrapolate the historical data into a far tail region so as to be able to simulate more extremes.

• Identification of ‘clustering’ of events, both intraseasonal and over periods of 3 years or less. Extreme events can arise from a single extreme storm, a correlated series of smaller events, or from antecedent conditions.
Likelihoods can be developed by:
• Weighting preference for scenario generation method
• Historical precedent
• Expert judgment
• Number of independent paths for reaching a particular scenario event
Conclusions

GCMs are not the only, or best, way to generate future scenarios of regional climate change

On decadal time scales, the greatest vulnerability is to extreme weather events: scenarios of frequency (clustering), worst case

Climate science in support of developing empirical approaches for scenario development:
• Improved regional historical and paleo records of extreme events
• Improved statistical methods for analyzing extreme events
• Improved understanding of the climate dynamics of extreme events and natural variability of regional climate
• Scenario discovering using a broader range of approaches