The large-ensemble explicit simulation approach to event attribution

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The LEES approach

- O(1,000) member ensemble simulations with BCs prescribed to simulate “actual” (blue) conditions.
- Similar magnitude ensembles to simulate possible “natural” (green) conditions with BCs modified to remove a range of estimates of the anthropogenic signal.
- Compare frequency of similar-magnitude events.

**Increasing frequency**

![Graph showing daily runoff against return time (yr) with Autumn 2000 and Non-industrial categories distinguished by color and symbols.](image-url)
Strengths

- Explicit simulation provides direct link to impact modeling (poss. via RCM)
  - No assumption $\Delta \text{hazard} = \Delta \text{risk}$

- Conclusions based on actual (simulated) extreme events
  - No GEV extrapolation
  - Relative frequencies of rare events are well characterized.

- In the limit of an accurate model, results sum to total anthropogenic impact.

- Assumptions transparent.
**Strengths**

- No limit in principle to number of causal mechanisms linking human influence to extreme events.
  - Incl. dynamics & regime-shifts
- Transparent link to other model-based activities such as seasonal forecasting.
- Event-sets are useful for insurance risk assessment.
- Prescribed SST design alleviates model biases.
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Weaknesses – in principle

- **Model-dependent**
  - For event generation.
  - For estimates of large-scale patterns of human influence.
  Both mitigated by multi-model design or attribution-based pattern-scaling.

- **Computationally intensive.**
Weaknesses – as currently implemented

- Reliant on a single model (with option of perturbing model physics)
  - Committee beware MIP-ism.
- Prescribed SSTs may lead to unrealistic A-O feedbacks, esp. in tropics.
- Hitherto reliant of observed SSTs, shifting to 1-3 month forecast SSTs to allow operationalization.
Direction of travel

- Implementing with seasonal forecast SSTs & testing near-real-time system.
- Increasing global atmospheric resolution (to N216L30) for better simulation of mid-latitude dynamics.
- Relaxation surface BCs?
- Conditional simulations to minimize computation?
- Fully coupled re-initialized seasonal forecasts?
Consider a simple chaotic system (Palmer, 2003)
Impose an external forcing
Forcing halves the risk of x-coordinate exceeding a threshold
Now consider the role of external forcing in each of these extreme events.
External forcing *increases* magnitude of individual events
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External forcing removed

Same initial conditions

External forcing present
Strengths

- No limit in principle to number of causal mechanisms (including dynamics & regime-shifts) linking human influence to extreme events.
- Transparent link to other model-based activities such as seasonal forecasting.
- Event-sets generated useful for insurance risk assessment.