A misty landscape with a forest of tall trees on a hill overlooking a body of water. The scene is hazy and atmospheric, with the water in the foreground and the forest in the middle ground. The text is overlaid on the upper portion of the image.

Event attribution: the emerging science of attributing causes to extreme events

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13IMSC, 8 June 2016

Photo: F. Zwiers (Strait of Juan de Fuca)

Introduction

- Enormous interest in event attribution
 - Event and media driven
 - Questions are mostly retrospective
- Requires “rapid response” science
 - Places high demands on process understanding, data, models, and statistical methods
 - Recently assessed by US National Academies of Science
- Critical aspect of the the WCRP Grand Challenge

Event attribution



Photo: F. Zwiers (Jordan River, gathering storm)

Event attribution

- The public asks: Did human influence on the climate system ...
 - Cause the event?
- Most studies ask: Did it ...
 - Affect its odds?
 - Alter its magnitude?
- Some think we should reframe the question ...
 - Rather than “Did human influence ...” (which requires comparison with a counterfactual world)
 - Ask “How much (eg, of a given storm’s precipitation) is due to the attributed warming (eg, in the storm’s moisture source area)” (after Trenberth et al, [2015](#))

Most studies

- Compare factual and “counterfactual” climates
 - Counterfactual → the world that might have been if we had not emitted the ~600GtC that have been emitted since preindustrial
- These studies almost always
 - Define a class of events rather than a single event
 - Use a probabilistic approach
- Shepherd ([2016](#)) defines this as “risk based”
 - Contrasts it with a “storyline” based approach
 - i.e., analysis of the specific event that occurred

“Framing” event attribution studies

- Event type
 - Class vs individual
- Analysis approach
 - “risk based” or “storyline”
- Event definition
 - What spatial scale, duration, etc
- Which risk-based question
 - Did climate change alter the odds, or the magnitude?
- What factors should be taken into account
 - “Conditioning”
 - e.g., coincident SST anomaly pattern, circulation, etc

The NAS Report ([2016](#)) struggled with these distinctions

Risk based questions

- Did human influence alter its likelihood

$$Prob(E|forcing) \text{ vs } Prob(E|\neg forcing)$$

$$Prob(E|forcing, SST) \text{ vs } Prob(E|\neg forcing, \widetilde{SST})$$

- Did human influence alter its magnitude

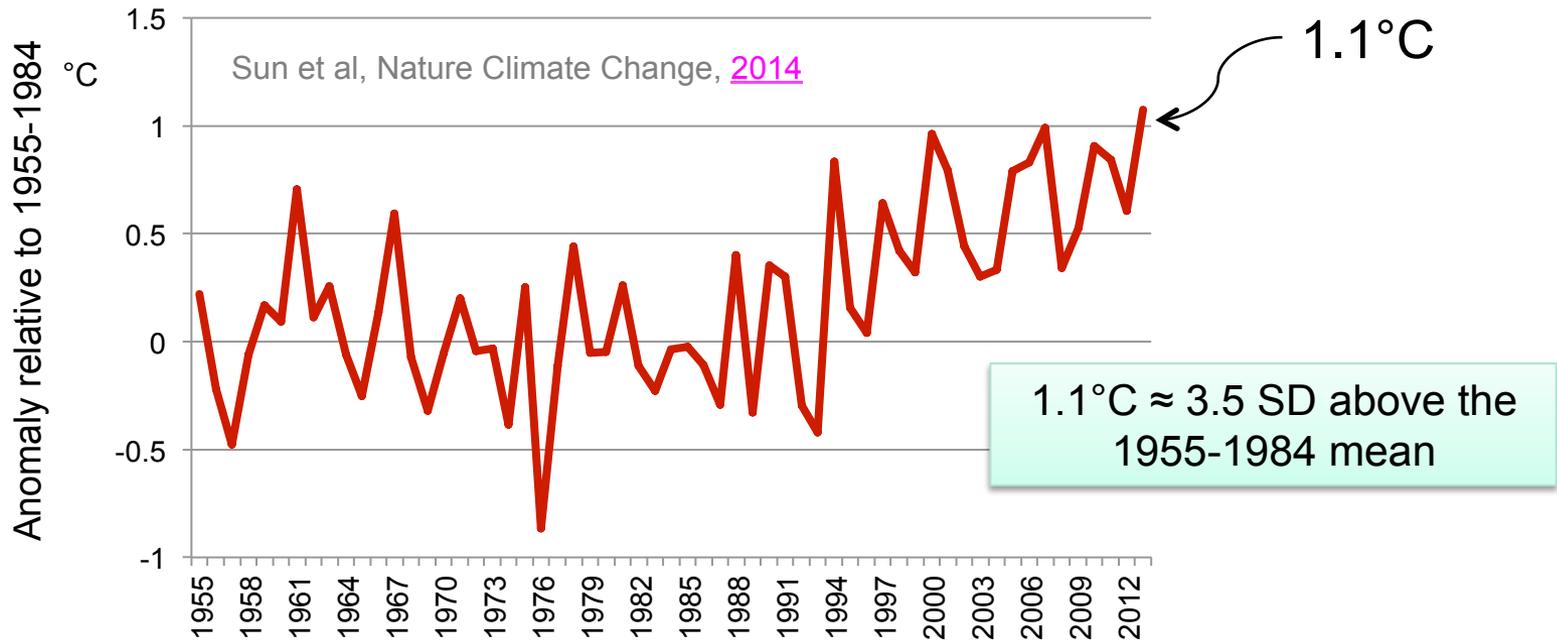
$$f(M|E, forcing) \text{ vs } f(M|E, \neg forcing)$$

$$f(M|E, forcing, SST) \text{ vs } f(M|E, \neg forcing, \widetilde{SST})$$

China's Summer of 2013



How rare was JJA of 2013?



- Estimated event frequency
 - once in 270-years in control simulations
 - once in 29-years in “reconstructed” observations
 - once in 4.3 years relative to the climate of 2013
- Fraction of Attributable Risk in 2013: $(p_1 - p_0)/p_1 \approx 0.984$
- Prob of “sufficient causation”: $PS = 1 - ((1 - p_1)/(1 - p_0)) \approx 0.23$

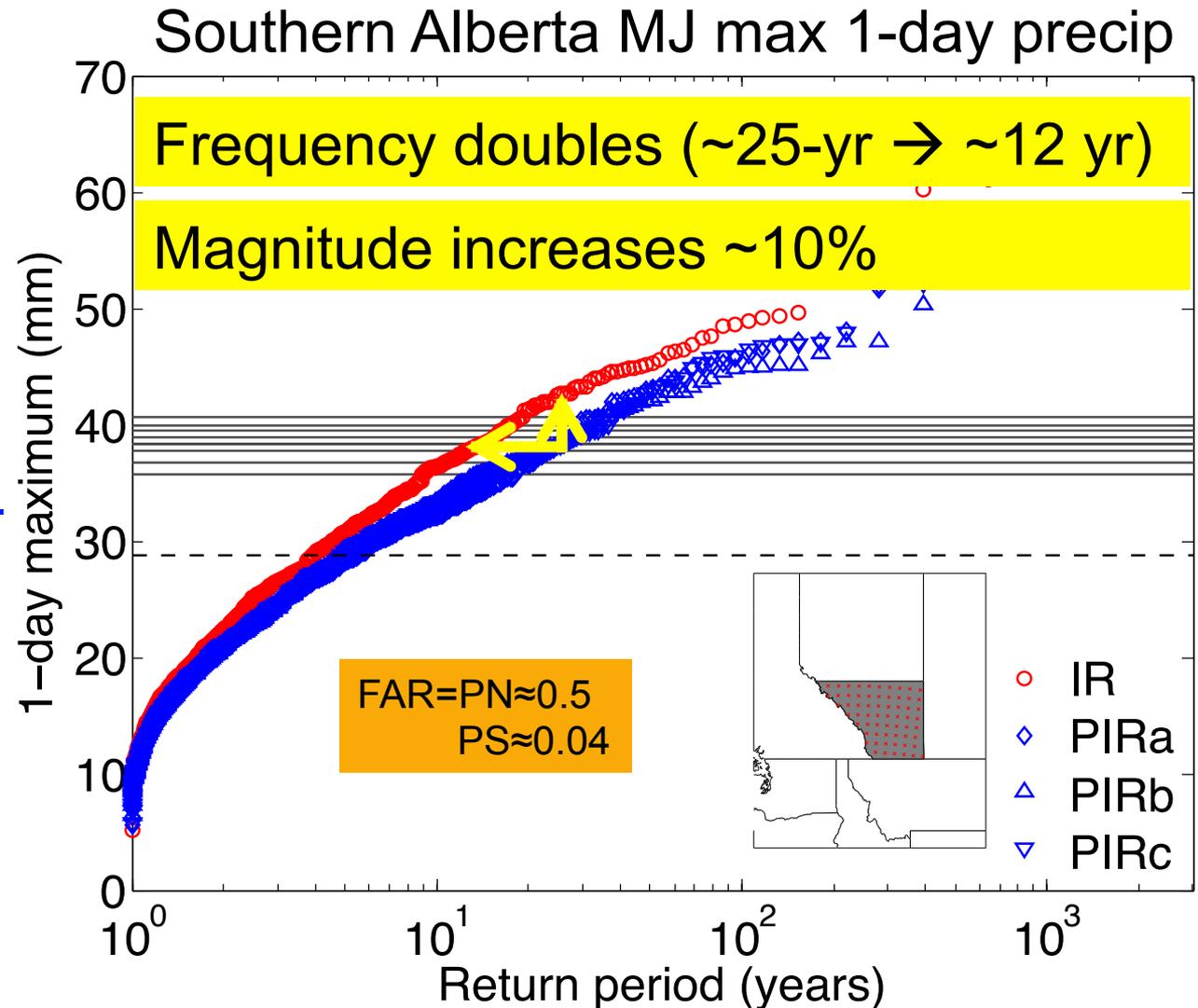
Calgary flood, 2013



Looking towards downtown Calgary from Riverfront Avenue (June 21, 2013), courtesy [Ryan L.C. Quan](#)

Calgary floods (Teufel et al, submitted)

Distribution of annual May-June maximum 1-day southern-Alberta precipitation in CRCM5 under **factual** and **counter-factual** conditions (conditional on prevailing global pattern of SST anomalies)



Some unresolved issues

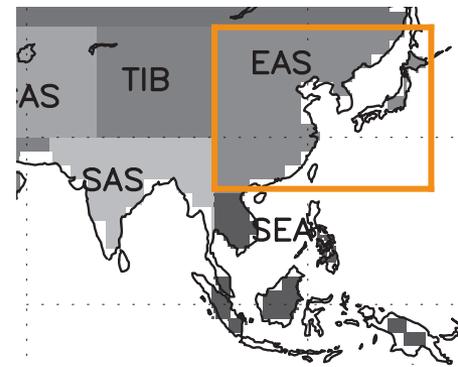


Some unresolved issues

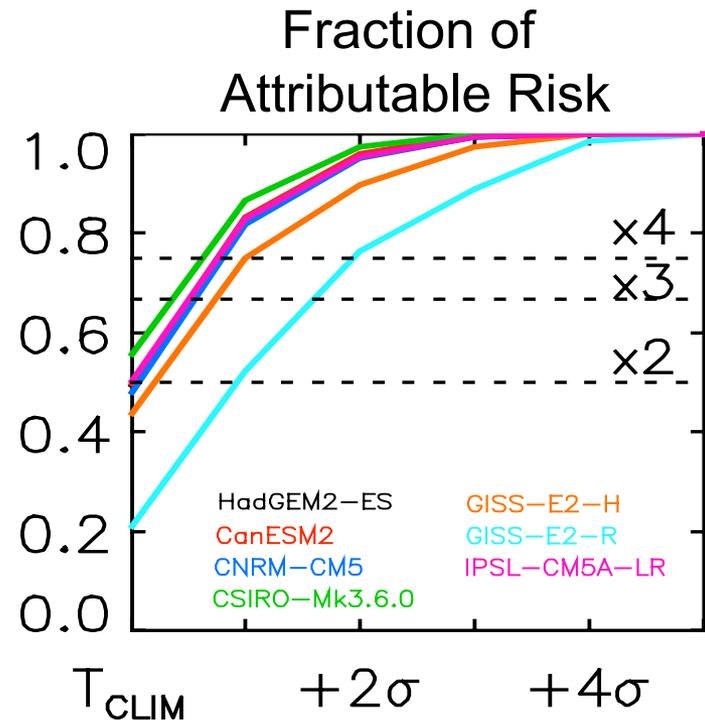
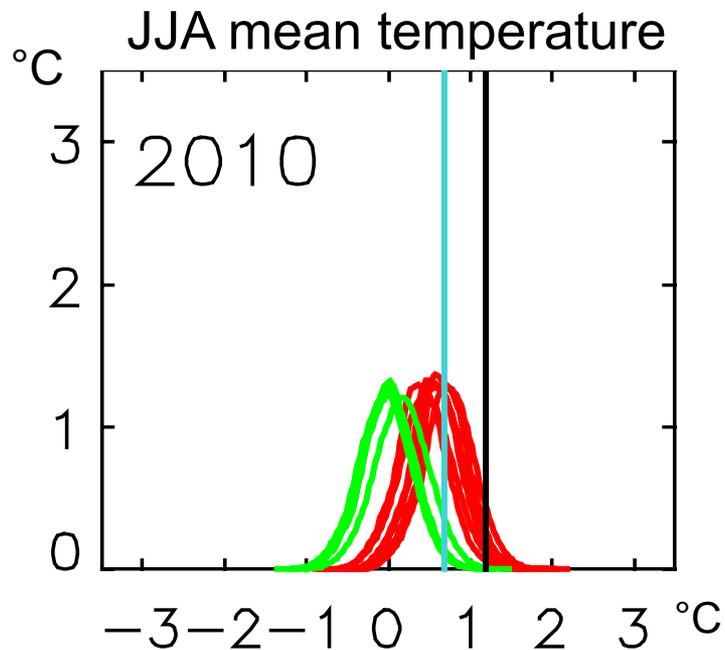
- Event characterization
 - Class vs individual, risk-based vs storyline
 - Individual is not completely synonymous with storyline
 - Data assimilation approach of Hannart et al ([2016](#))
- Event definition
- Dependence on models
- Counterfactual state specification uncertainty when conditional approach is used
- Selection bias
 - Need objective event selection criteria
- Communications
 - At each stage of the media and disaster response/recovery cycle

Retrospective vs prospective?

- Most studies are prompted by specific events
- For the risk-based approach, we could study pre-defined events



Distribution of annual JJA temperature in the 2000's relative to 1961-90 in East Asia **with** and **without** ANT forcing



Christidis et al, 2014



Questions?