Potential and limitations for using detection and attribution information

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4.1.   Start with a game:

The 20 questions game

- One player (a respondent) picks something, anything at all

- One or more players (interrogators) deduce that thing by asking up to 20 questions

- But only yes/no answers allowed!

- Good game for a long car ride

The "surprise" version of the 20 questions game

- By John Wheeler, as an analogy for quantum mechanics

- 20 respondents, each picks his/her object independently, in secret

- The interrogator asks each respondent one yes/no question in turn

- If a respondent's object is inconsistent with any of the answers provided so far, then he/she must pick a new object

- Then the respondent answers yes/no accordingly

Did you learn anything from the game?

(If not, was it at least fun?)

# What I have learned from that game

(Or what I expected to have learned before having played...)

• Was the final answer in the original secret set of answers?

• Questions can be extremely important in the production of an answer.

4.2.   A headline figure from the IPCC Fifth Assessment Report

Evidence of effects of observed climate change on other systems

IPCC (2014), from Cramer et alii 2014
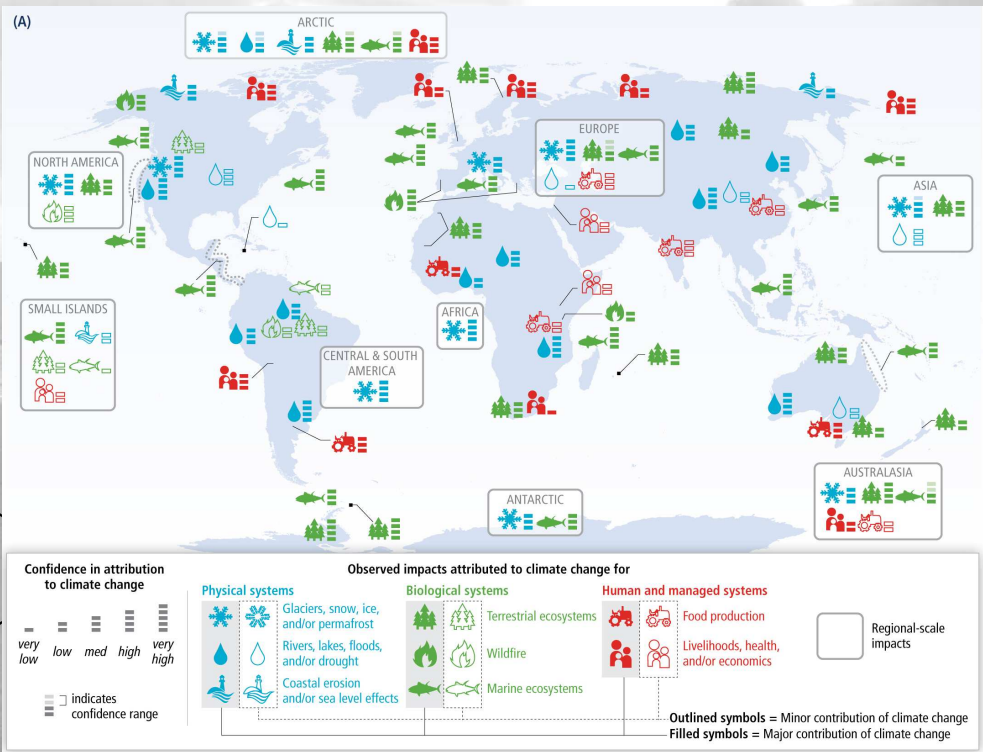
What we heard:

- "*I know* that *my* impact exists."
  - "Why is it not on *your* map?"
 - "Why do you have only *very low confidence* for it?"

Why the surprise?

18.6.5. Conclusion

Detection and attribution studies evaluate the agreement between observations of change in a system and process understanding of its causes, whether these are due to climate change or other forces. This sets a higher bar for establishing confidence in the assessment of past changes than is generally applied to the projections of future changes, because observational evidence has important gaps, while plausibility of future changes is established on the basis of process knowledge only. Despite this constraint, the body of evidence on observed impacts of

IPCC (2014) (Cramer et alii 2014)
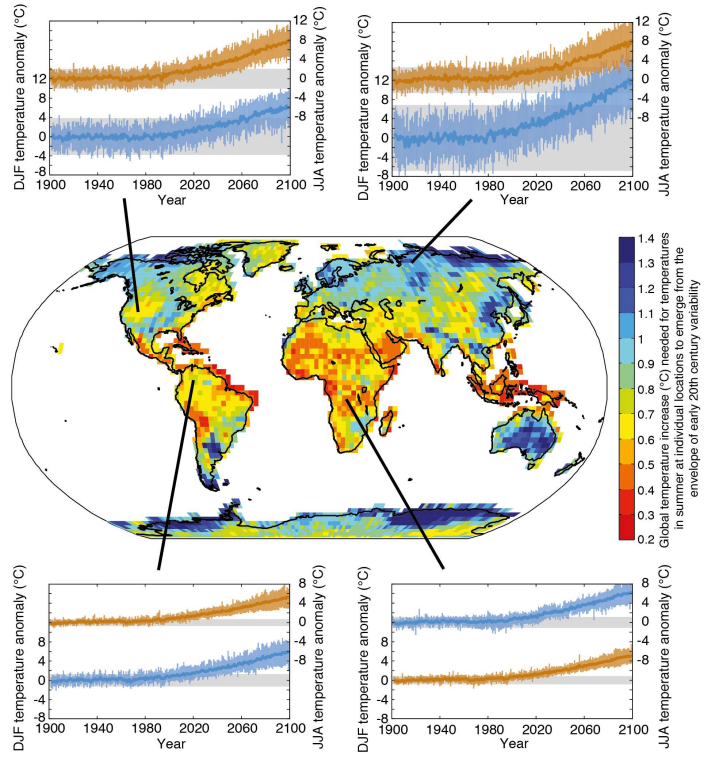
- D&A is not concerned with what we *expect* has happened and is happening (see left, signal-to-noise ratio).

- D&A is concerned with what we can say we *know* has happened and is happening (see below, confidence in detection).

IPCC (2013) (Bindoff et alii 2013)
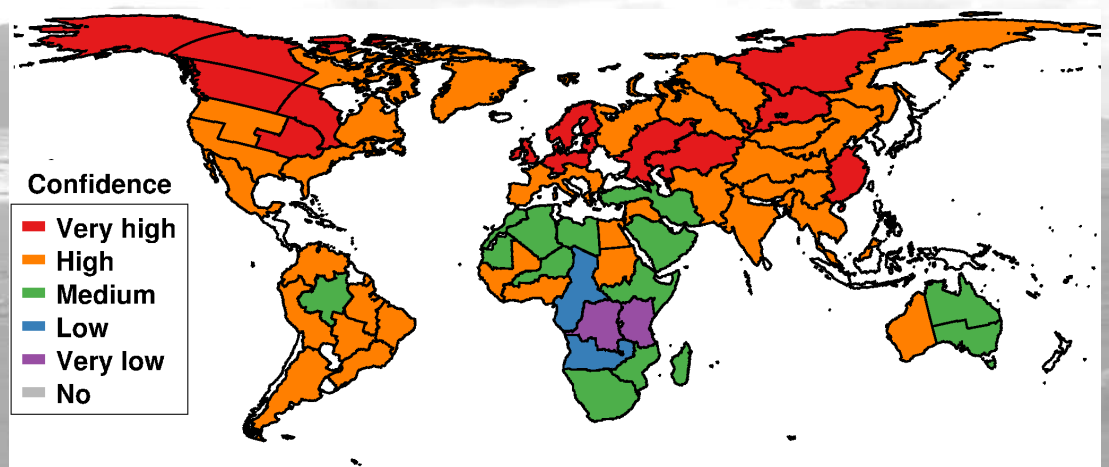
Stone and Hansen (2016)

4.3.   What is detection?

From IPCC (2013) (Bindoff et alii 2013):

minology in the IPCC guidance paper (Hegerl et al., 2010). '*Detection of change is defined as the process of demonstrating that climate or a system affected by climate has changed in some defined statistical sense without providing a reason for that change.* An identified change

From IPCC (2014) (Cramer et alii 2014):

"Detection of impacts" of climate change addresses the question of whether a natural or human system is changing beyond a specified baseline that characterizes its behavior in the absence of climate change (Stone et al., 2013). The baseline may be stationary or non-stationary (e.g., due to land use change), and needs to be clearly defined. This

4.4.   Is detection still addressing a relevant question?

- Born at a time (1970s, 1980s, early 1990s) when it was unclear whether the climate was being affected by humans

- IPCC (2013): *"It is is virtually certain that internal variability alone cannot account for the observed global warming since 1951."* (Bindoff et alii 2013)
  - *"Virtually certain"* means >99% probability

- Is this question still being asked?
  - Should it?

But detection can be more

- So far detection has been focused on refuting the null hypothesis (Lloyd and Oreskes 2018).

  – Proving observed climate trends are inconsistent with a lack of human influence

  – Proving an observed species range shift is inconsistent with a lack of climate trend influence

- Can detection be about more than that?

- How about whether a certain absolute threshold of change has been passed?

  – If/when 1.5°C warming has been reached?

  – The climate change research community did not anticipate the Paris Agreement, and had produced little useful information for it.

4.5.   What is attribution?

From IPCC (2013) (Bindoff et alii 2013):

et al., 2010). *Attribution* is defined as 'the process of evaluating the relative contributions of multiple causal factors to a change or event with an assignment of statistical confidence'. As this wording implies,

From IPCC (2014) (Cramer et alii 2014):

"Attribution" addresses the question of the magnitude of the contribution of climate change to a change in a system. In practice, an attribution statement indicates how much of the observed change is due to climate change with an associated confidence statement. Hence, attribution requires the evaluation of the contributions of all external drivers to the system change. In this chapter we simplify the assessment of this

Is attribution still addressing a relevant question?

- IPCC (2013): *"Greenhouse gases contributed a global mean surface warming likely to be between $0.5^{\circ}C$ and $1.3^{\circ}C$ over the period 1951–2010..."* (Bindoff et alii 2013)

  - *"Likely"* means $>66\%$ probability
  - Which means the contribution is also "likely" between $-1.0^{\circ}C$ and $10.0^{\circ}C$...
  - Is this an informative statement?

- IPCC (2014): *"Hydrological systems have changed in many regions because of changing precipitation or melting cryosphere, affecting water resources, water quality, and sediment transport (medium confidence)."*

  - What is a "region"? What is "many"?
  - Does that "medium confidence" apply to all statements in that sentence?
  - Is this an informative statement?

- How can these be made more informative?

# 4.6.   What question is event attribution addressing?

- From Lecture #3 concerning causative framing:

  "So the conclusion concerning the human influence on an extreme weather event may depend strongly on whether an insurer or an engineer is asking."

- Use only the change in probability approach, but for fruit fly versus tortoise

  – Fruit flies adapt quickly: should the threshold be the same in both worlds?

$P_{real}(>7.1°C)=11.9\%$
$P_{real}(>9.1°C)=5.0\%$
$P_{nat}(>7.1°C)=5.0\%$

Stone et ali (submitted)
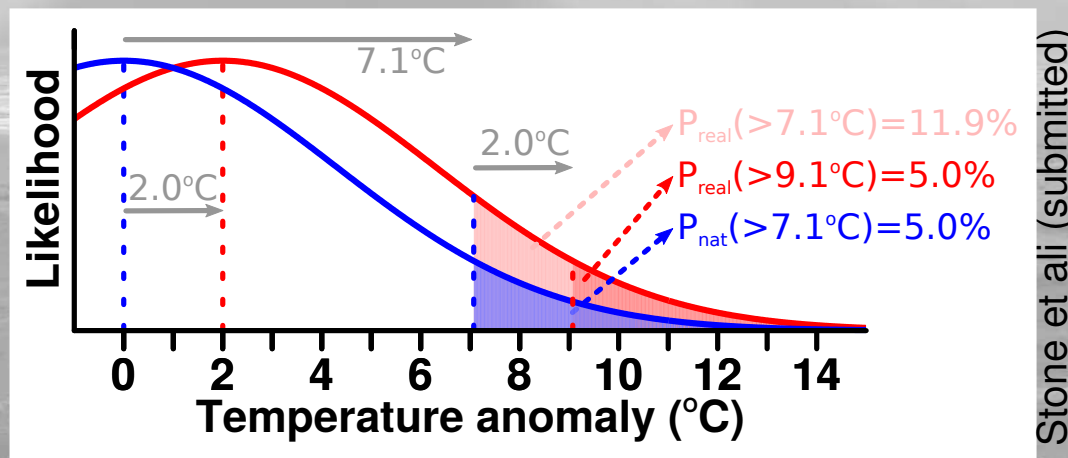
Are event attribution conclusions generally robust?

Use different framing/method/data, do you get the same conclusion?

Angélil et alii (2017)
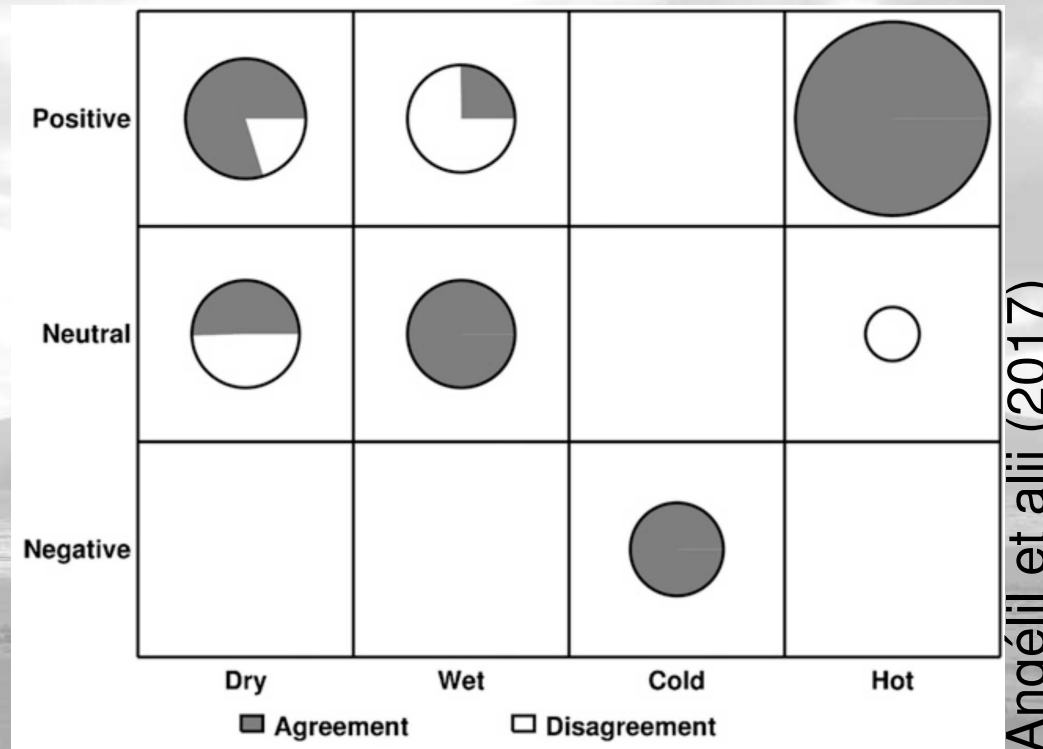
• The question matters!

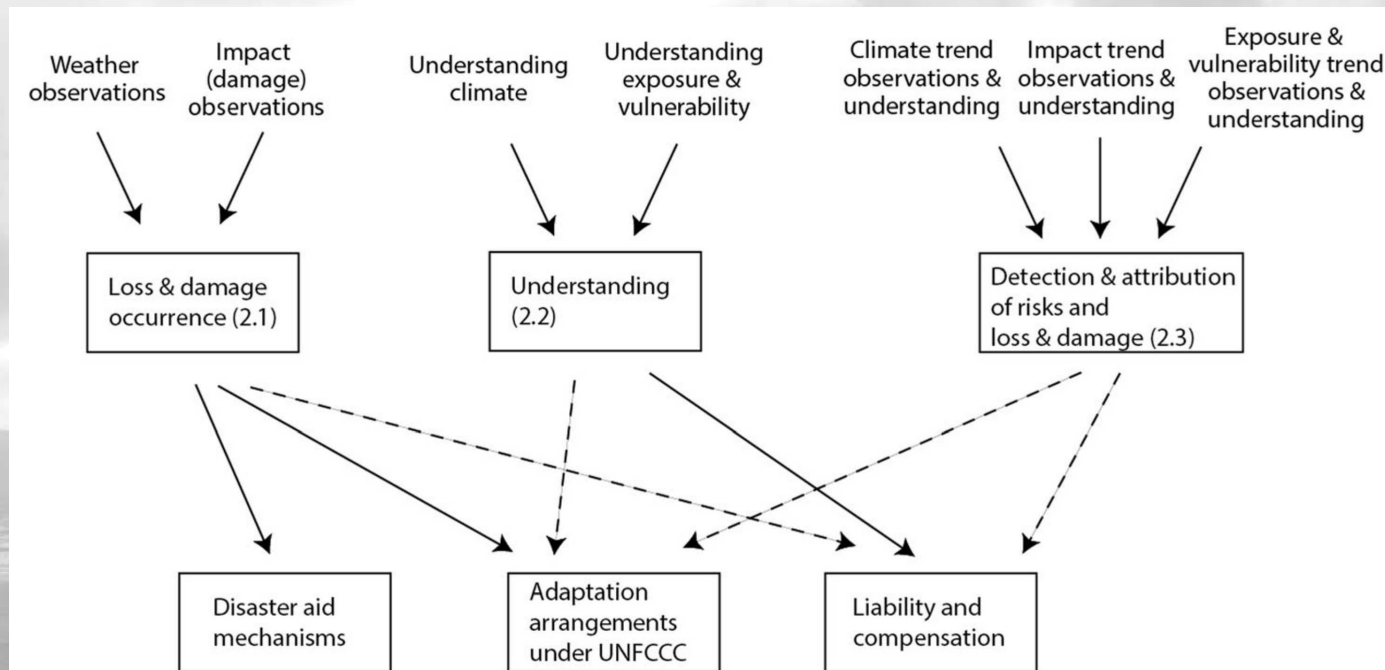# 4.7.   For what purposes might D&A be useful?

Is it necessary?

Fig. 1 Schematic illustrating how scientific evidence (*middle row*) could be linked to three potential dimensions of L&D concerning policy, law and finance mechanisms (*bottom row*). The *top row* specifies the requirements of data, observation and understanding needed for the three different types. *Solid arrow lines* indicate a (virtually) necessary requirement while *dashed arrow lines* indicate where it is currently unclear if that type of evidence is required

Huggel et alii (2015)

4.8.   Could D&A inform "Loss & Damage" mechanism under UNFCCC?

Number of AR5 impacts
Annex I
Non-Annex I   GHCN
Non-party   stations
       0   1–2 3–6 >6
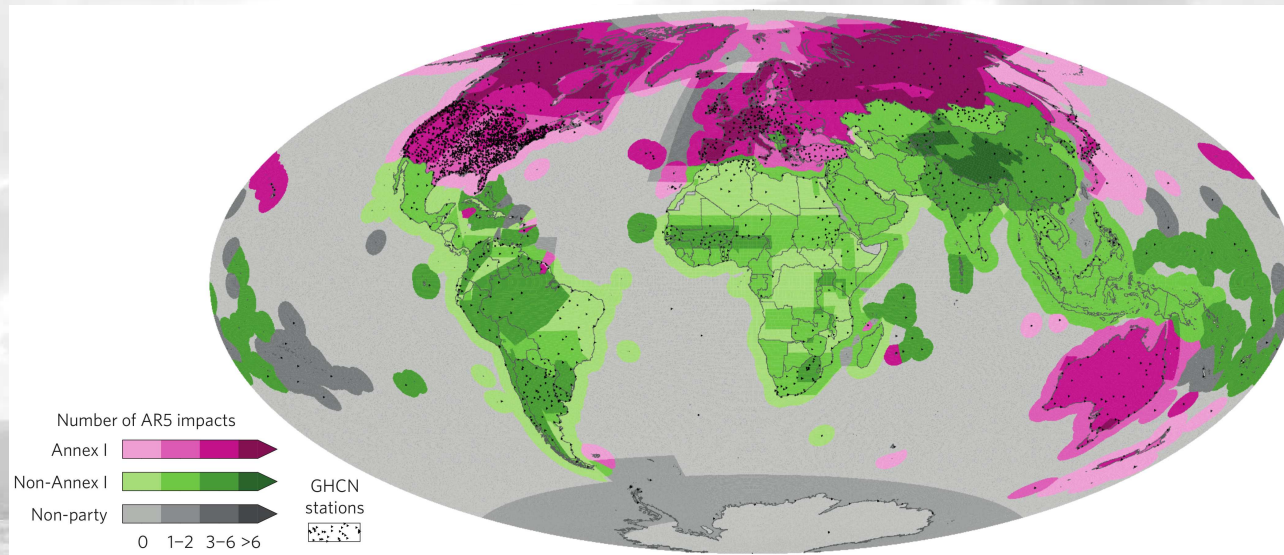
- Do we really believe there are no impacts in the ocean or in the D.R. Congo?
- Regions intended to have access to L&D mechanism have weakest D&A evidence! (Same for event attribution evidence.)
- Are we, as scientists, perpetuating an injustice?

4.9.   How we select studies

Physics: "Global warming" and its effects are easier to study in areas that are temperature-controlled: not the tropics!

Historical resources: Where do we have long-term monitoring?

Funding priorities: My country's funding agencies want a focus on my country.

Journal interests: Major journals are associated with large rich countries: do American Meteorological Society journals prefer a U.S. focus?

Personal interest: I am interested in my house.

Human capacity: Where are researchers with the skills?

Vulnerability: Did this effect someone/something?

4.10.   Spatial scale and time period

D&A conclusions depend on region and period examined.

- Are these the region and period that interest us?
- Temperature signal-to-noise ratio higher at large-scale.
  - Not necessarily the case for precipitation and impacts
- Local trends depend on marginal changes in atmospheric circulation
  - Are they monitored adequately?
  - Are they simulated adequately?
- More factors can play a larger role at local scales
  - Emitting aerosols, planting a tree, switching to a new crop (for financial impacts on farmers)
- D&A harder for exactly the sorts of questions that most entities might be concerned with.

What about climate services motivated by vulnerability?

This poses four challenges for D&A and event attribution as a climate service:

Identification: What are the relevant vulnerabilities motivating operational services?

Diversity: How should operational services proceed when multiple vulnerabilities are identified?

Omission: Should, or how should, unrepresented vulnerabilities be treated?

Transience: How should an operational service deal with a shifting focus of vulnerabilities (e.g. during an event)?

4.11.   Story of the man who lost his keys

It is nighttime. A woman is walking down a street, and comes across a man on his knees under a streetlight. She asks what he is doing. He explains that he is searching for his keys. She asks where he last remembers having them. He points to a dark area further down the street. She asks why he is not searching there. He explains that it is because the light is shining here so he can see, whereas he cannot see over there.

Main messages

- D&A is the most powerful method for diagnosing cause and effect of past and current change.
- But it is not the only way of building knowledge.
  - For instance, event attribution
- Are there ways that keep some of D&A's strengths but can address questions that D&A currently cannot?
  - Can we build our own lamps to search for keys anywhere?
- How do we express conclusions if they are sensitive to the question?
- **We need to monitor!!!**