



# Winter School 2018: Detection and Attribution

Andrew King

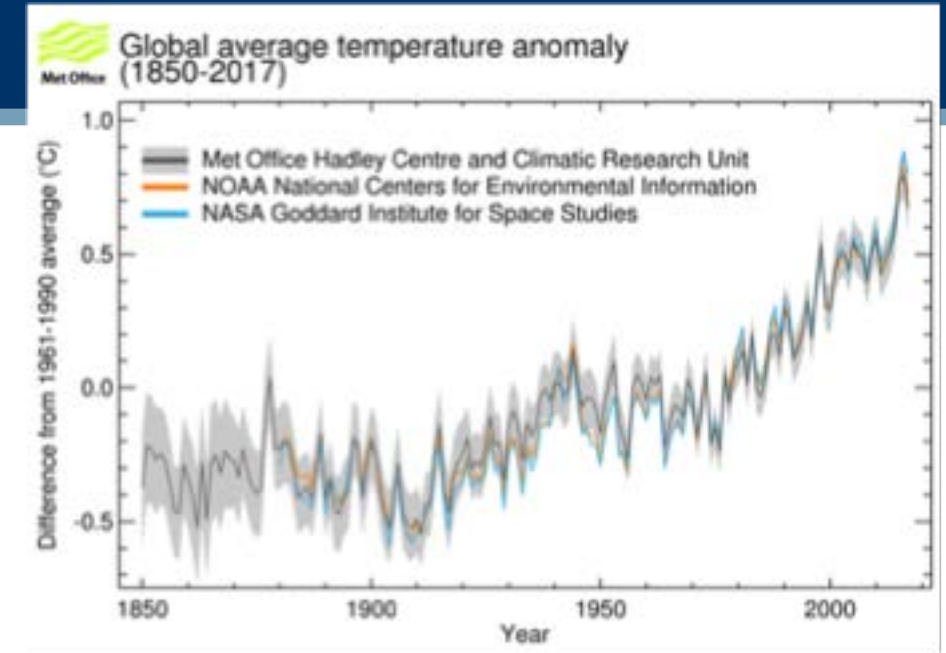
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## Outline

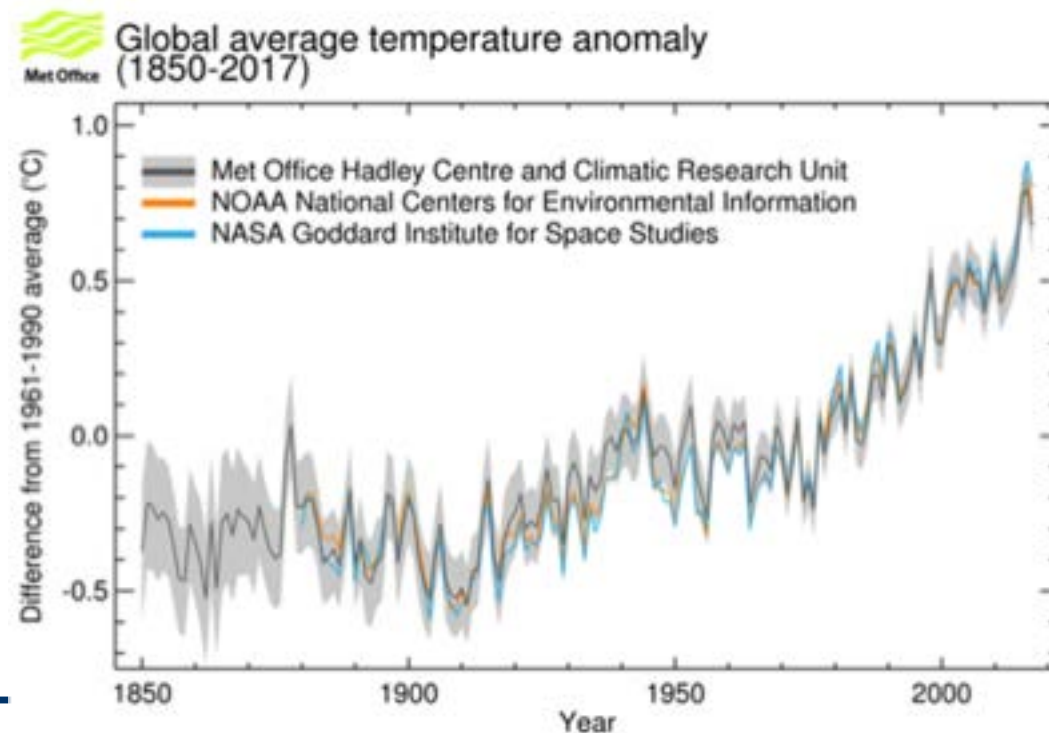
- Why are we interested in attribution?
- An introduction to *trend* attribution
- An introduction to *event* attribution
- Where next for attribution?



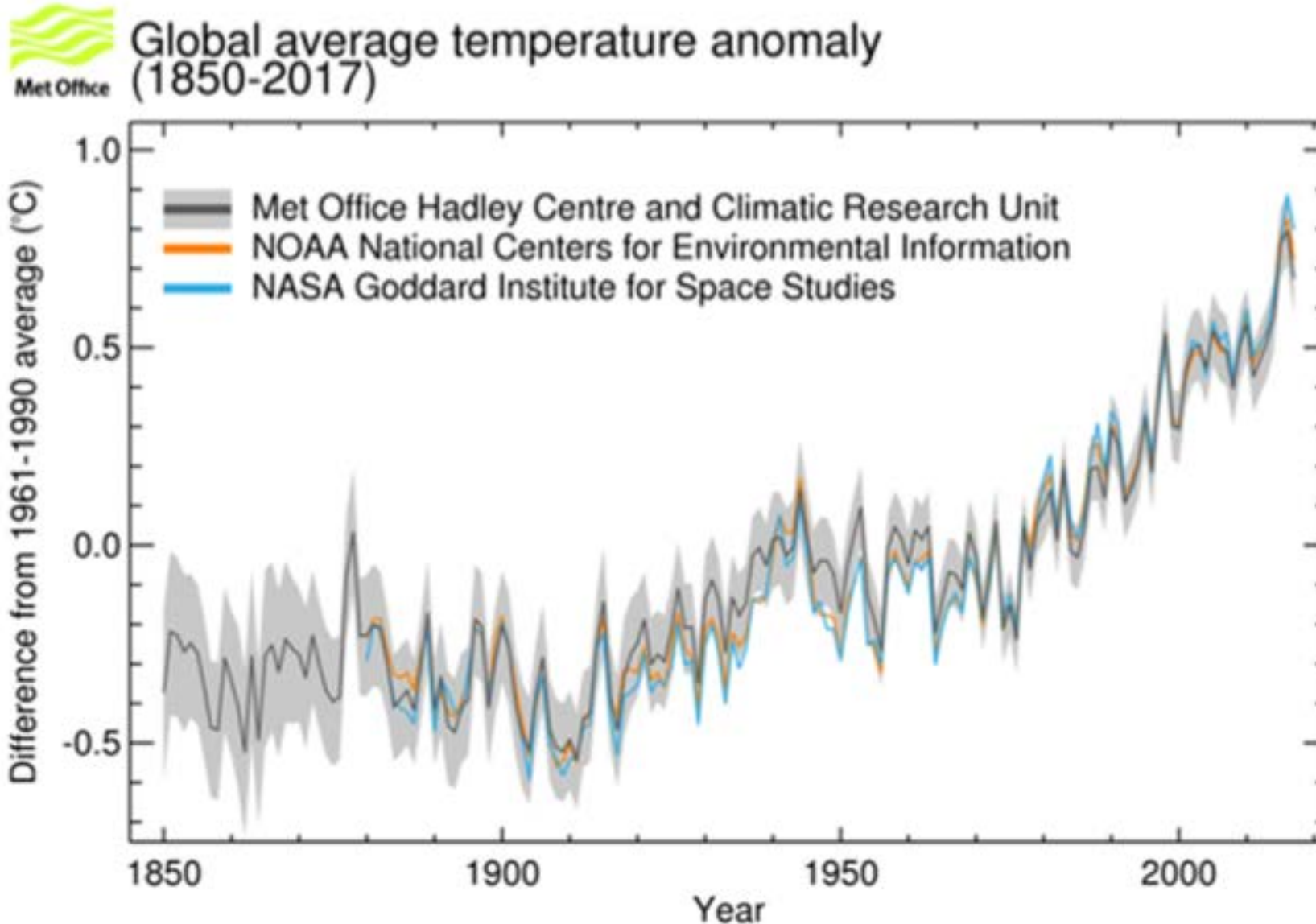
## Principal reasons

- We want to understand the causes of trends and changing extreme events and make useful statements.
  - Not just human-caused climate change but also different aspects of natural variability.
  - Can try and separate individual influences on trends and extremes.
- It's a good communication tool (most of the time!).

- Trend attribution is about understanding how much different forcings (greenhouse gasses, anthropogenic aerosols, etc.) contribute to observed trends in the climate system (e.g. global/regional temperature and precipitation).



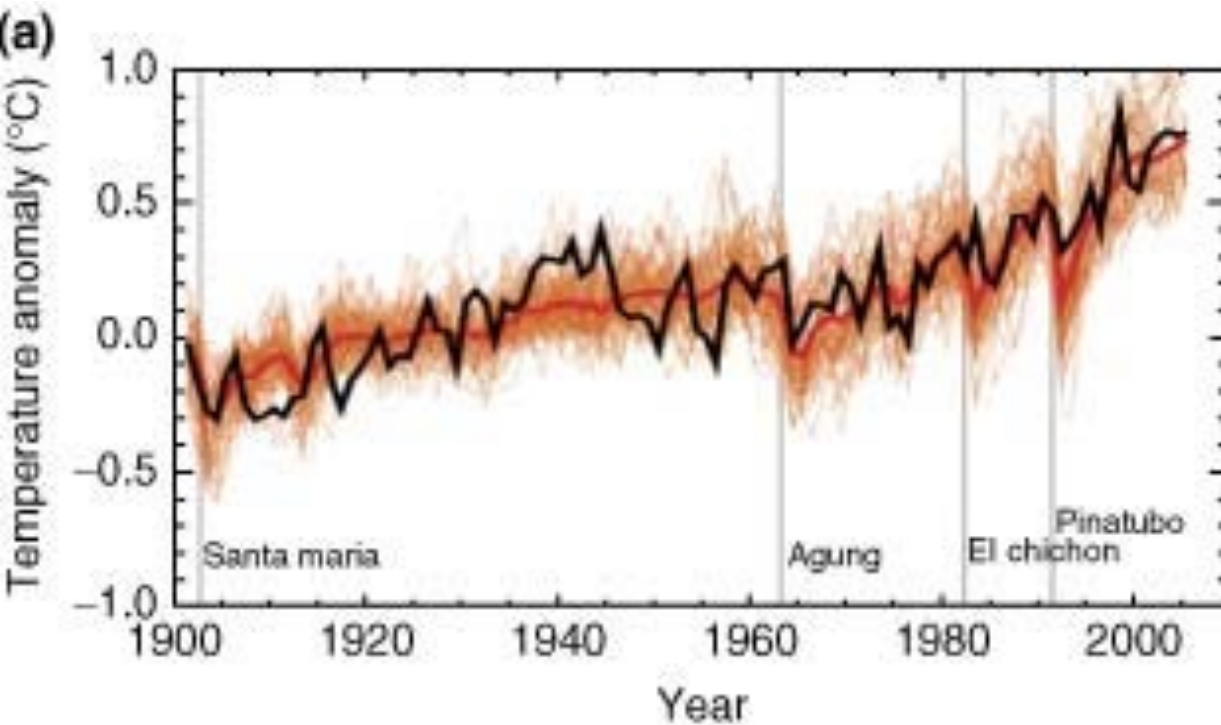
- Trend attribution is about understanding how much different forcings (greenhouse gasses, anthropogenic aerosols, etc.) contribute to observed trends in the climate system (e.g. global/regional temperature and precipitation).
- A trend in an aspect of the climate system is *detected* but detection alone doesn't explain why the change has taken place. Detection is a statistical problem.
- We then want to *attribute* the trend to a particular forcing. What's the most plausible cause for this change?



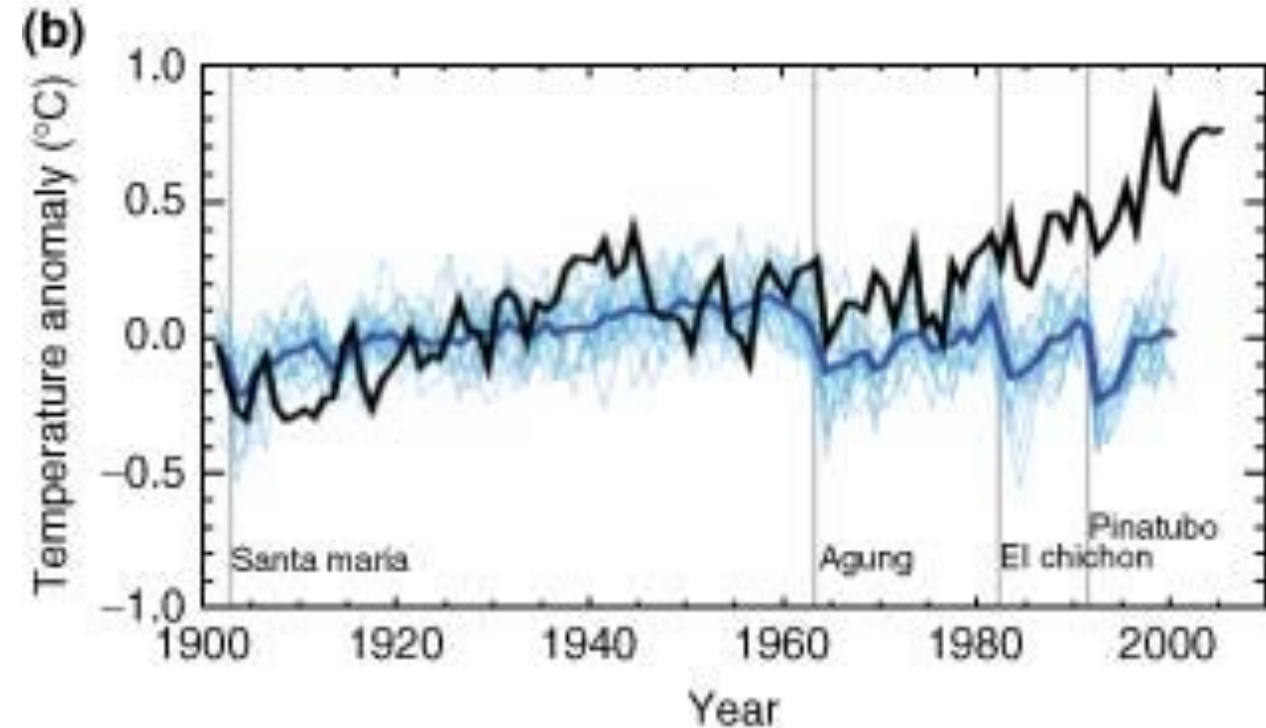
- Global temperature estimates show a change.
- We then use models to formally attribute that change to different forcings.



## NATURAL + ANTHRO

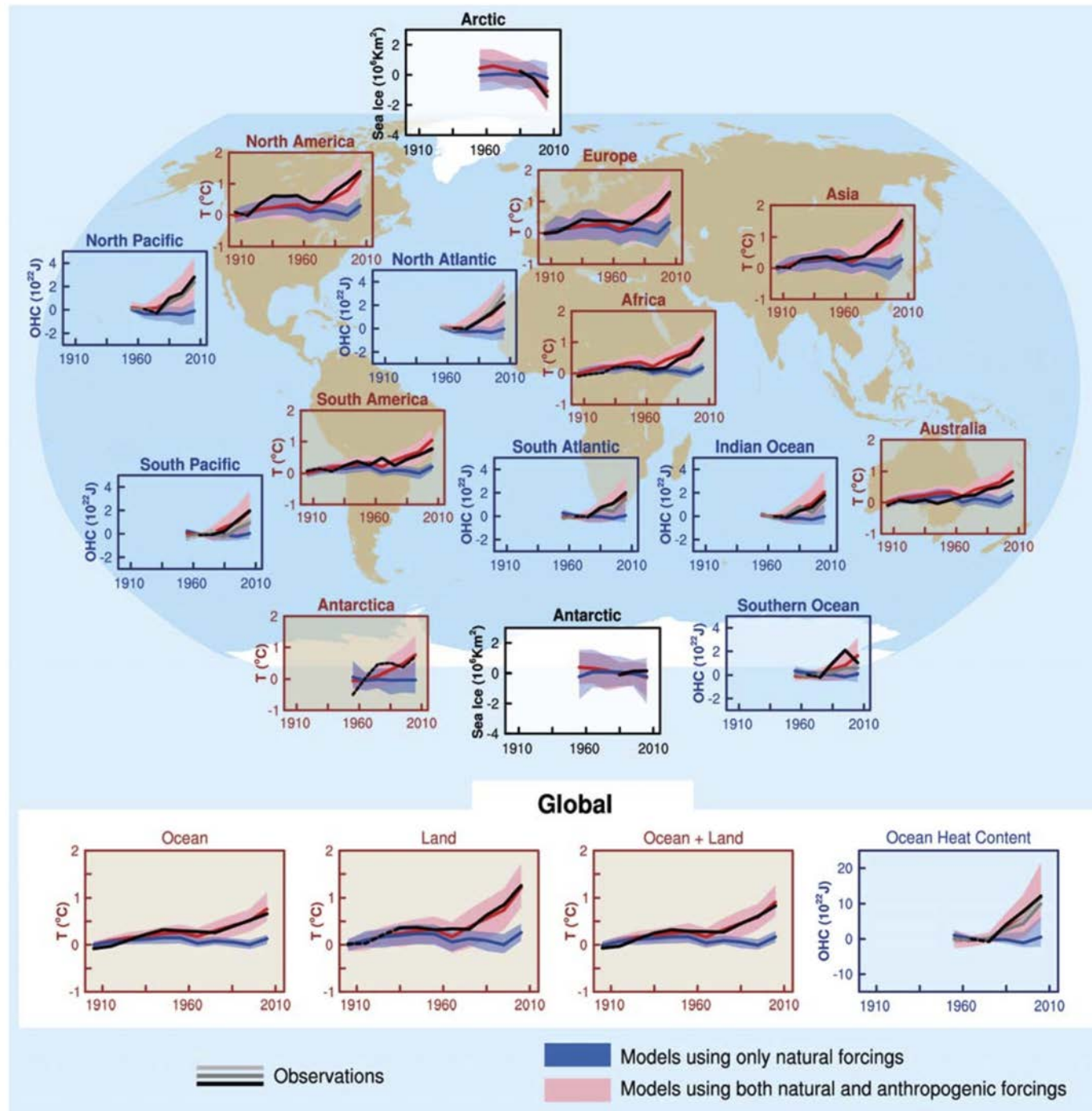


## NATURAL ONLY



Stott et al. (2010)

- Clearly models without human influences (on the right) do not capture observed trend.

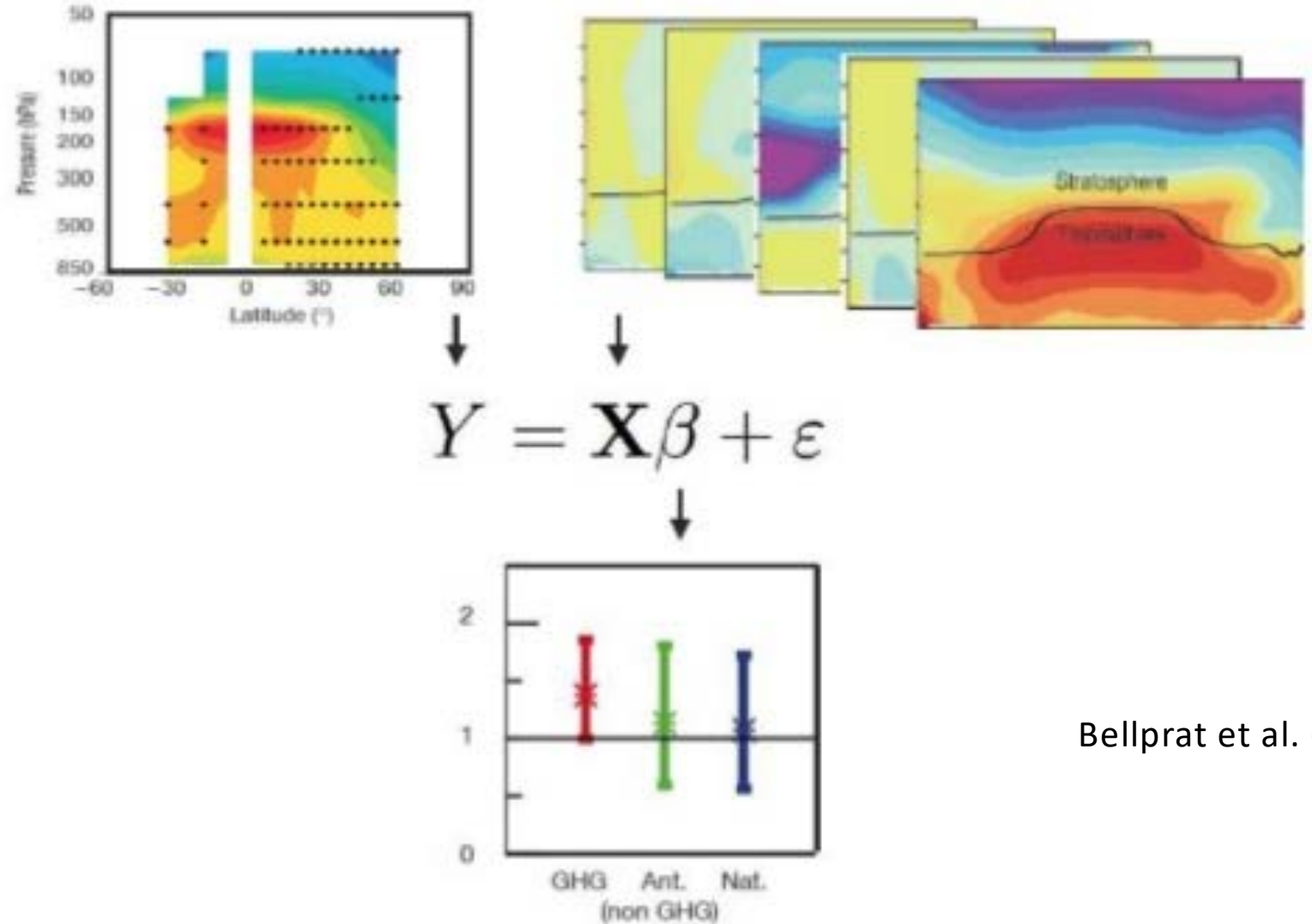


IPCC AR5 (2013)



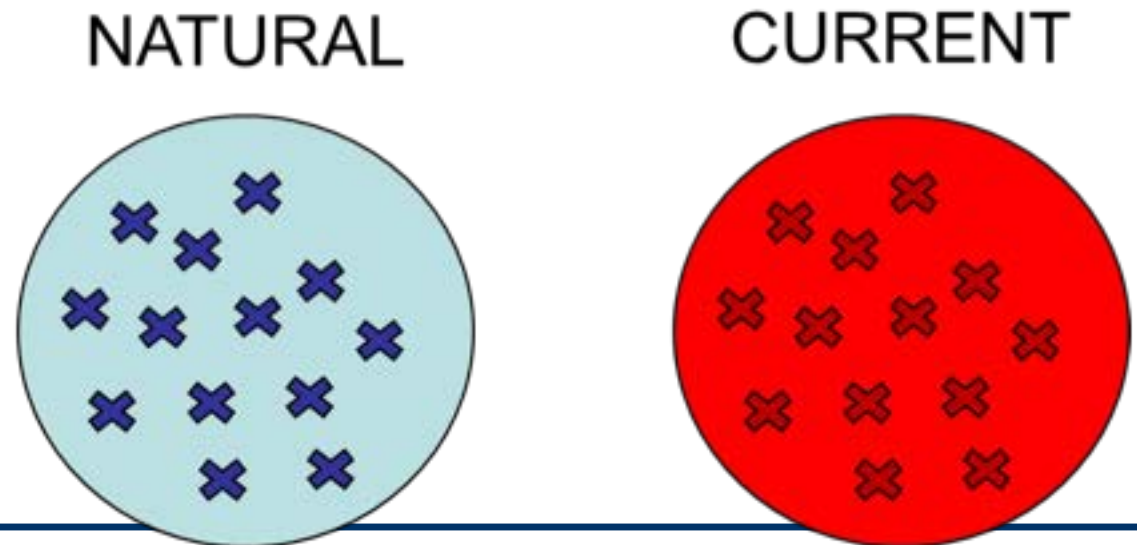
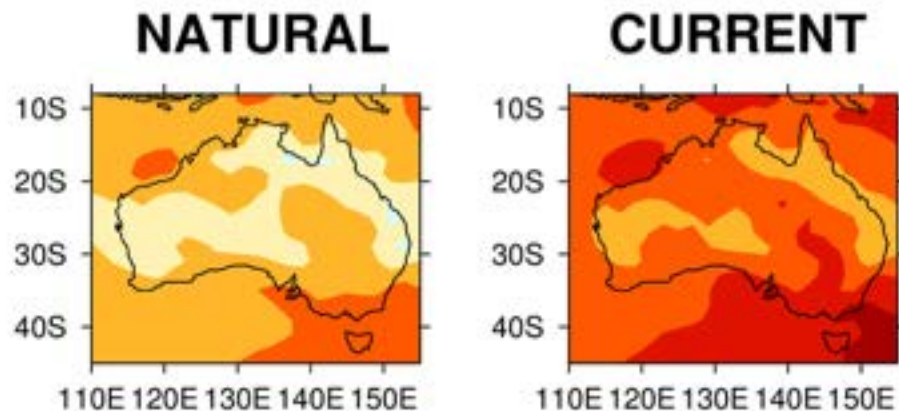
- It's trend attribution analysis that allows the IPCC to make statements like this:  
*"It is extremely likely that more than half of the observed increase in global average surface temperature from 1951 to 2010 was caused by the anthropogenic increase in greenhouse gas concentrations and other anthropogenic forcings together. The best estimate of the human-induced contribution to warming is similar to the observed warming over this period."*  
and  
*"Over every continental region except Antarctica, anthropogenic forcings have likely made a substantial contribution to surface temperature increases since the mid-20th century."*

- Different techniques can be used to formally attribute trends to anthropogenic influences. These include *optimal fingerprinting*.

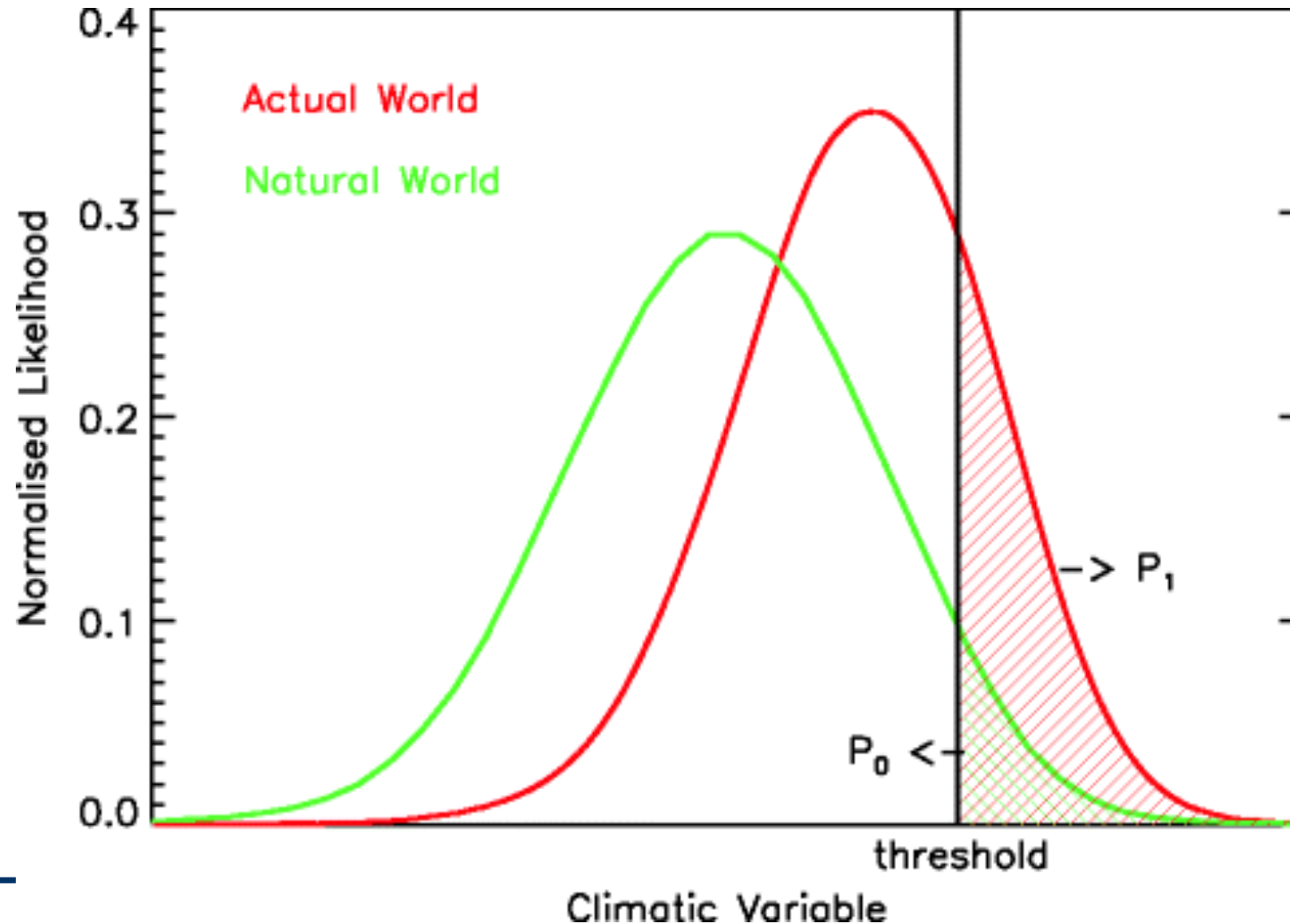


Bellprat et al. (2015)

- Event attribution uses different techniques, so we can answer “How has event X changed due to forcing Y?” and make a quantitative statement.
- Usually focussed on roles of anthropogenic climate change and major modes of natural climate variability (e.g. ENSO).
- How do these influences alter the frequency or intensity of an event.



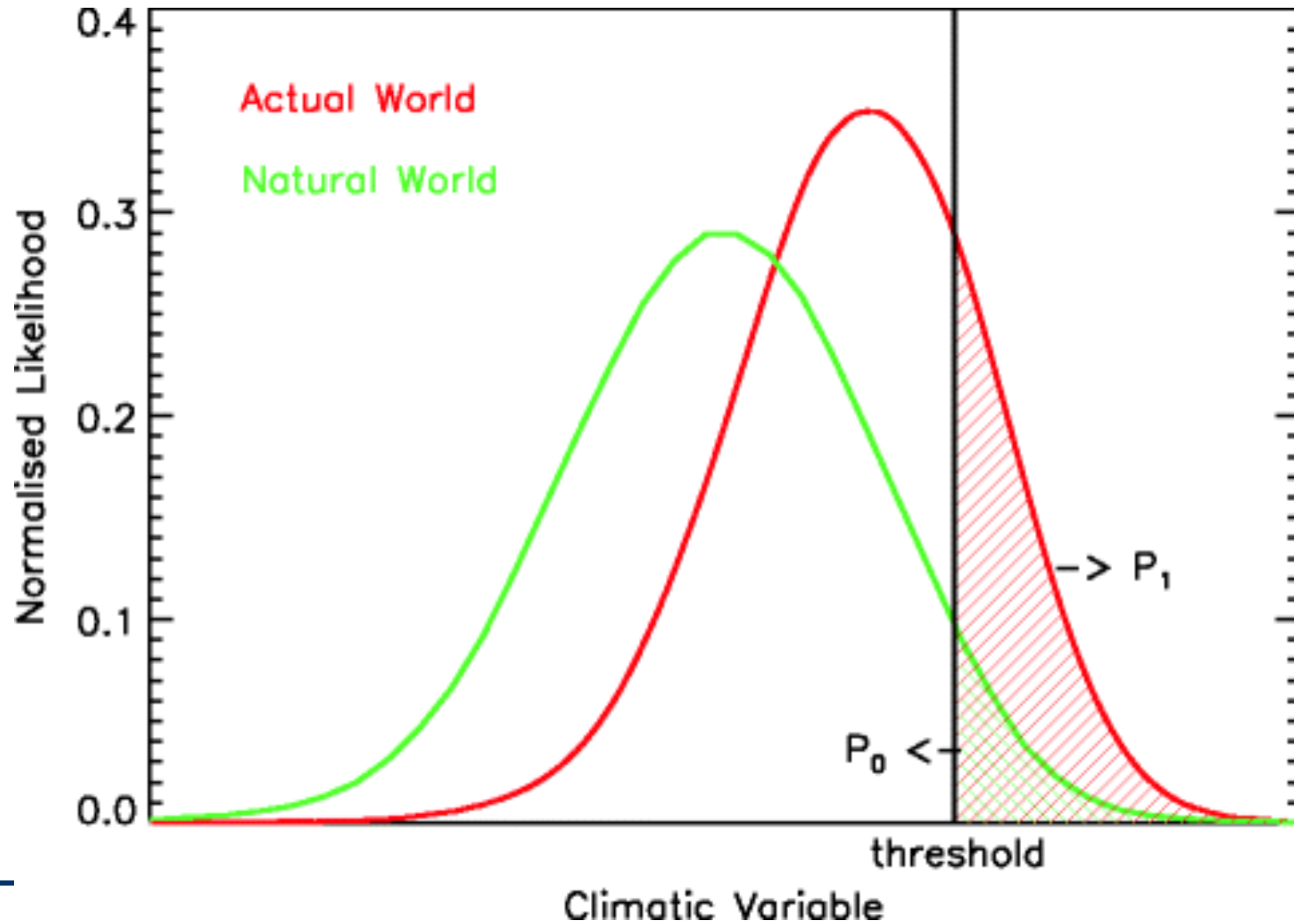
- How do these influences alter the frequency or intensity of an event.



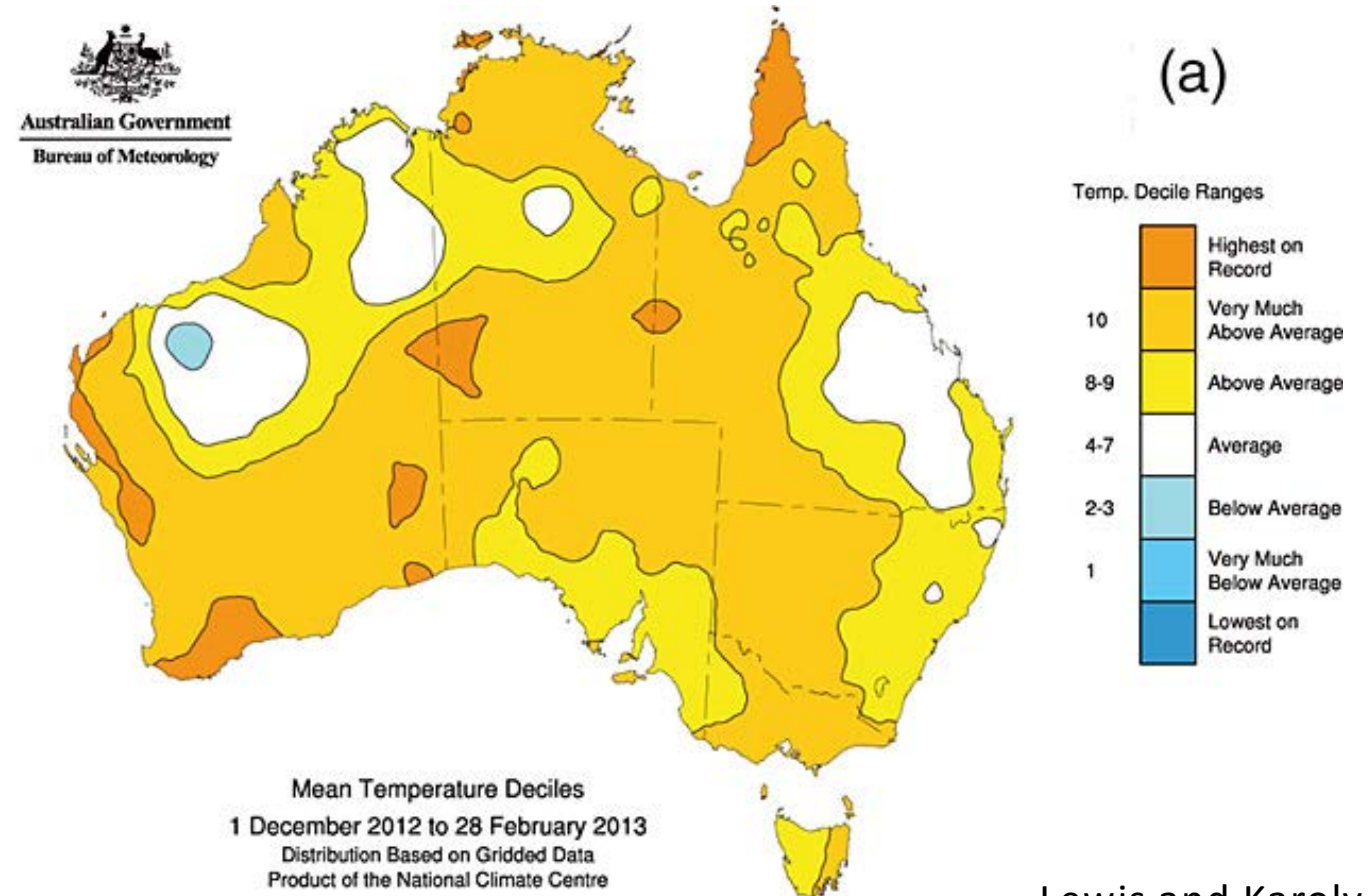
**What do we need  
before we can do an  
event attribution  
analysis?**

An extreme weather  
or climate event!





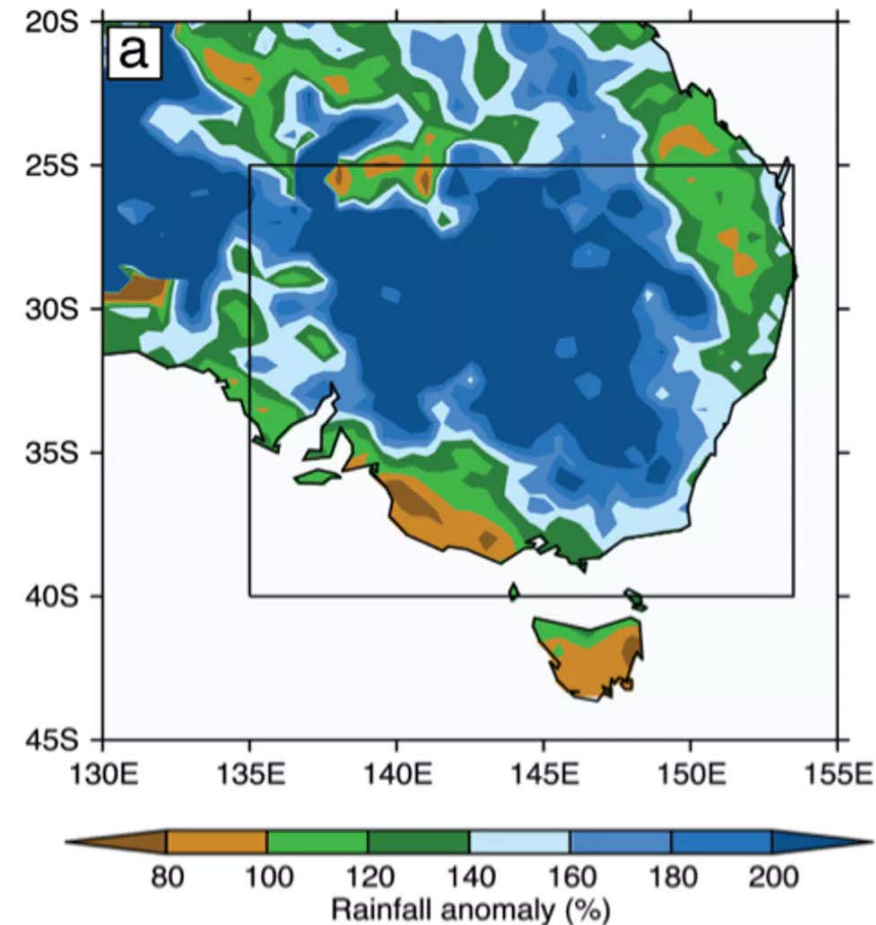
- There have been lots of event attribution studies of different types of extremes including:
  - Hot/cold seasons



Lewis and Karoly (2013)

- [illegible]

- There have been lots of event attribution studies of different types of extremes including:
  - Hot/cold seasons
  - Heatwaves and cold spells
  - Heavy rain events

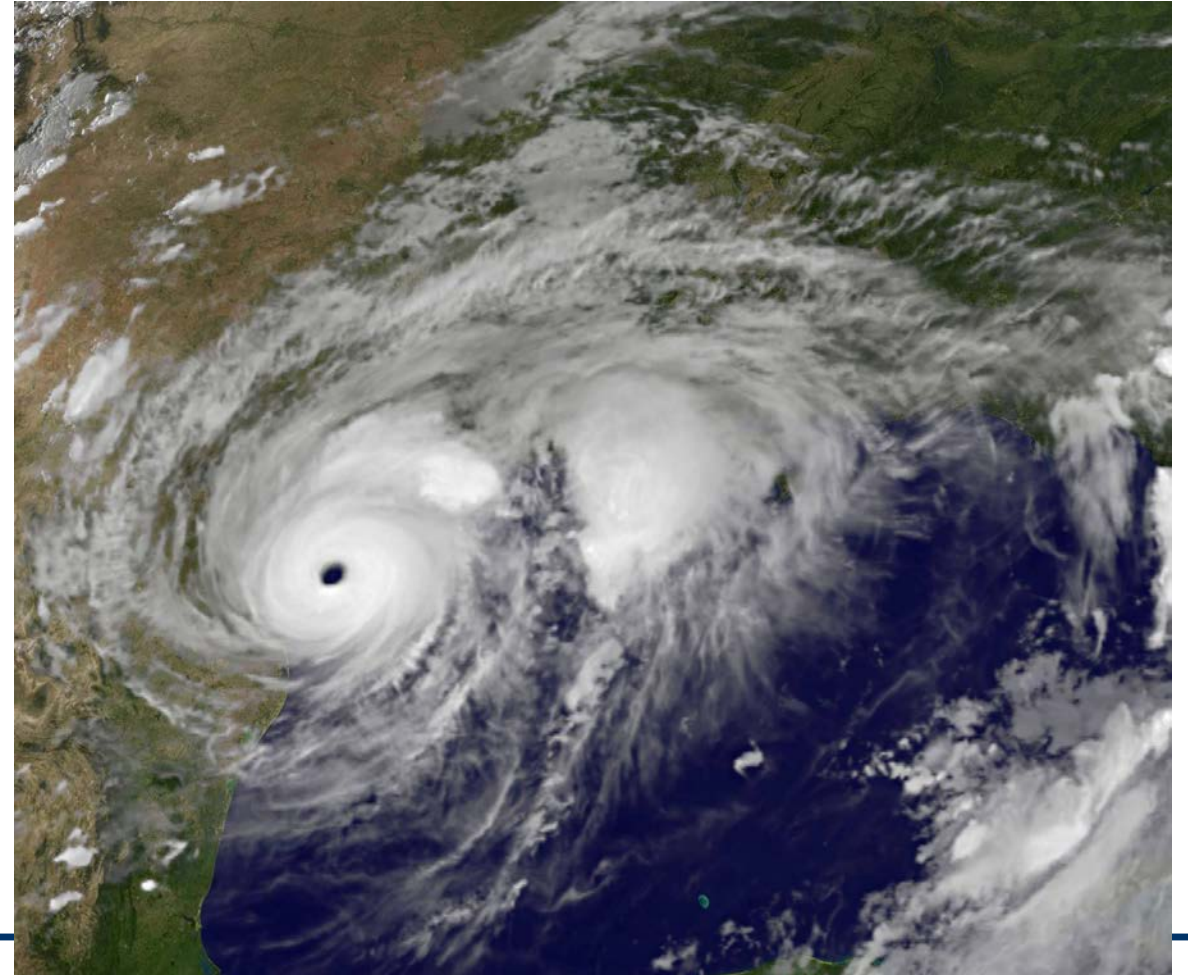


King et al. (2013)



- There have been lots of event attribution studies of different types of extremes including:
  - Hot/cold seasons
  - Heatwaves and cold spells
  - Heavy rain events
  - Variables relevant to tropical cyclones

Risser and Wehner (2017),  
Trenberth et al. (2018),  
van Oldenborgh et al. (2017)





**What do we need  
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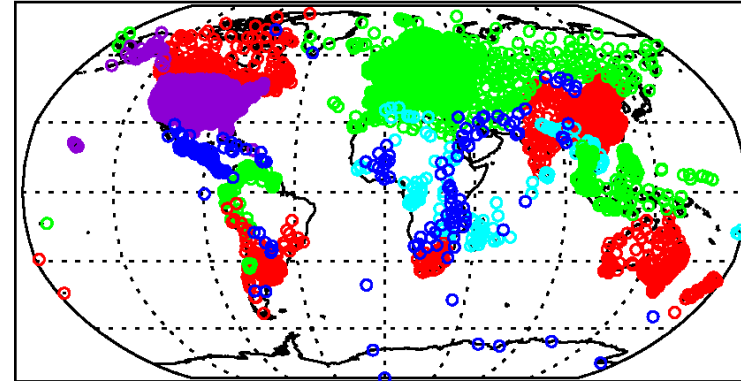
An observational  
dataset we can trust  
of a relevant variable

An extreme weather  
or climate event!

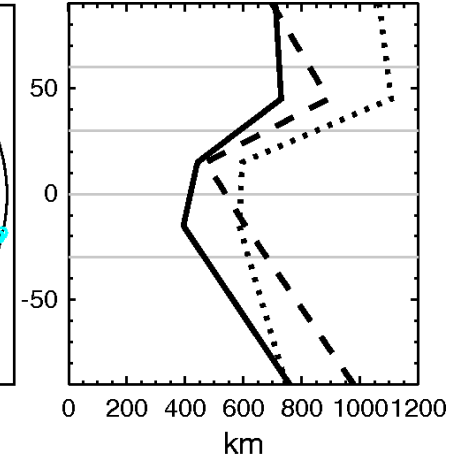
- Not as straightforward as this first sounds.
- For many regions of the world and many variables, event attribution studies aren't possible for this reason.

Donat et al. (2013)

(a) HadEX2 TXx 7381 stations

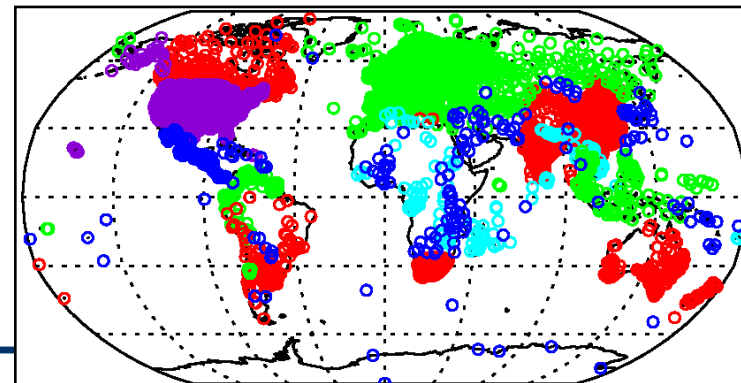


(b) DLS TXx

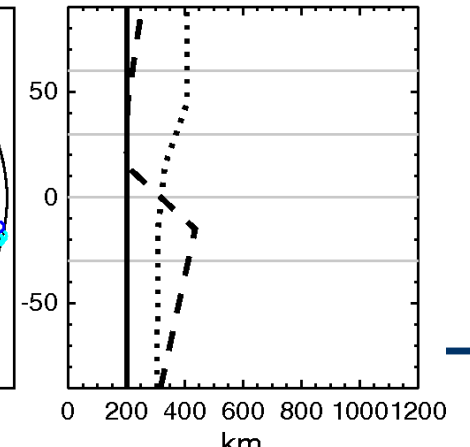


○ Authors    ○ ETCCDI workshops    ○ ECAD/LACAD/SACAD  
○ GHCN-Daily    ○ HadEX

(c) HadEX2 Rx1day 11588 stations



(d) DLS Rx1day



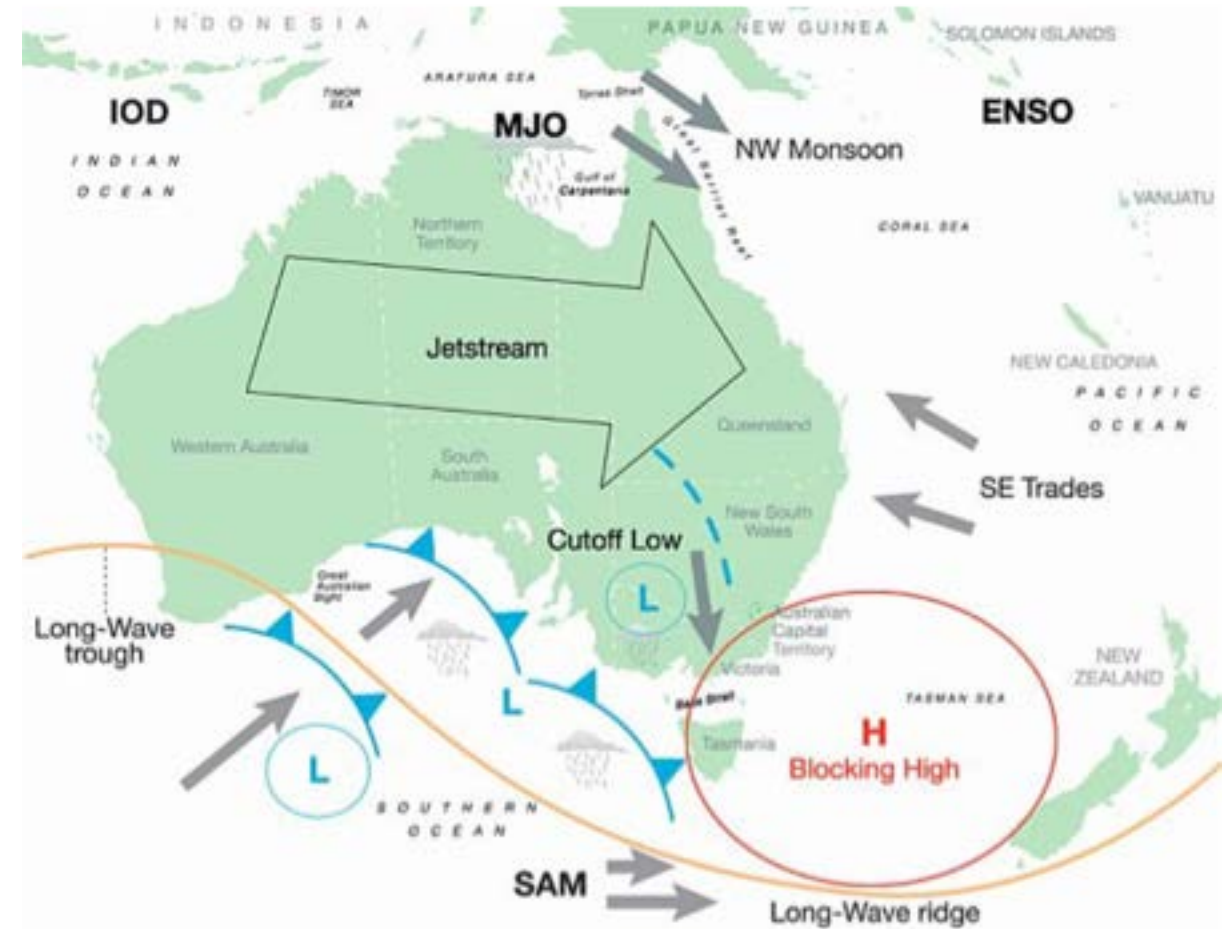
An understanding of how  
climate change and  
variability are affecting that  
variable.

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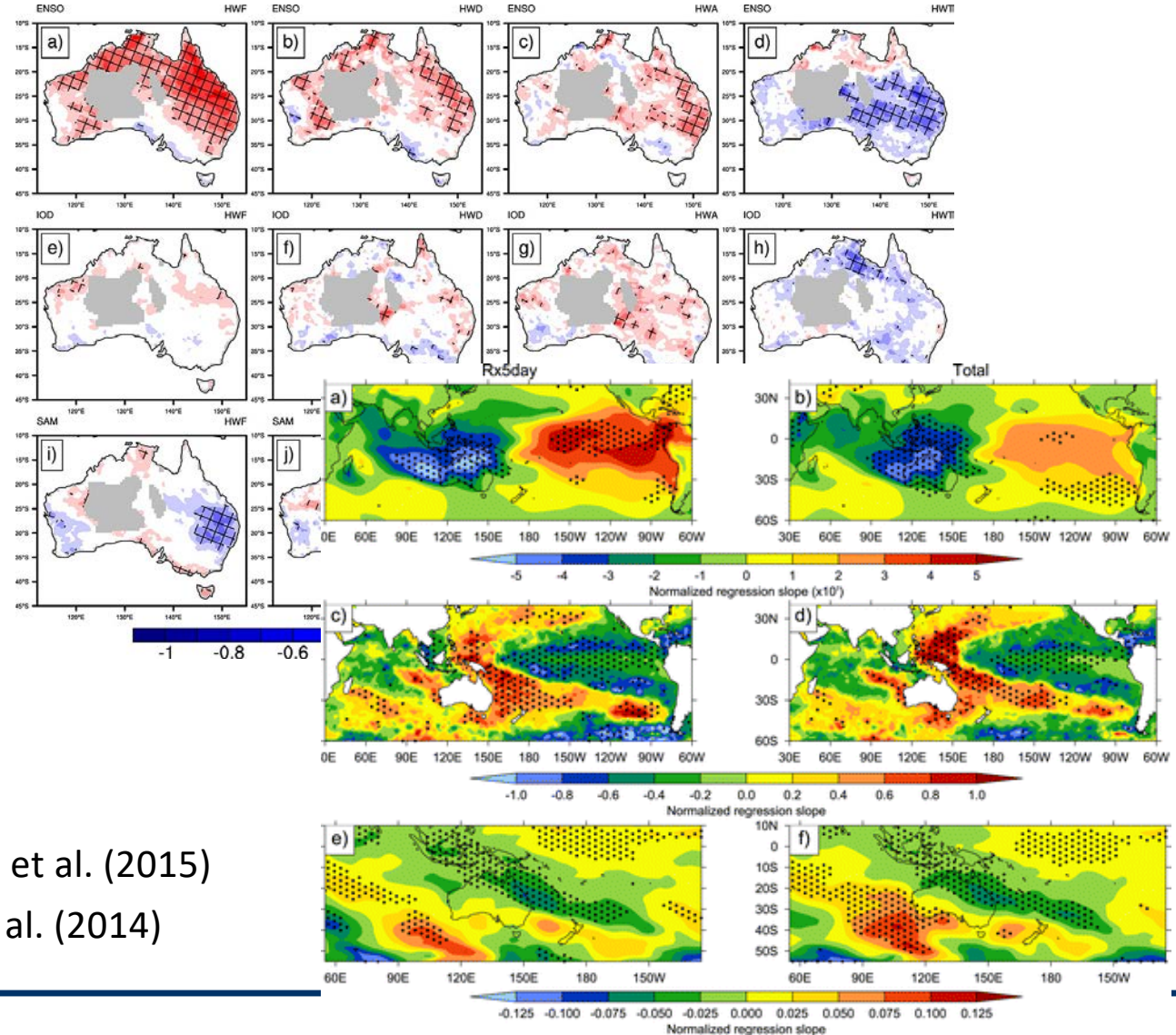
An extreme weather  
or climate event!

- If we don't already have some understanding how climate change and variability are affecting a particular type of event then we would struggle to contextualise results.



Risbey et al. (2009)

- If we don't already have some understanding how climate change and variability are affecting a particular type of event then we would struggle to contextualise results.
- Few extremes-specific analyses of influences of climate variability means this can be a challenge.



Perkins et al. (2015)

King et al. (2014)



An understanding of how  
climate change and  
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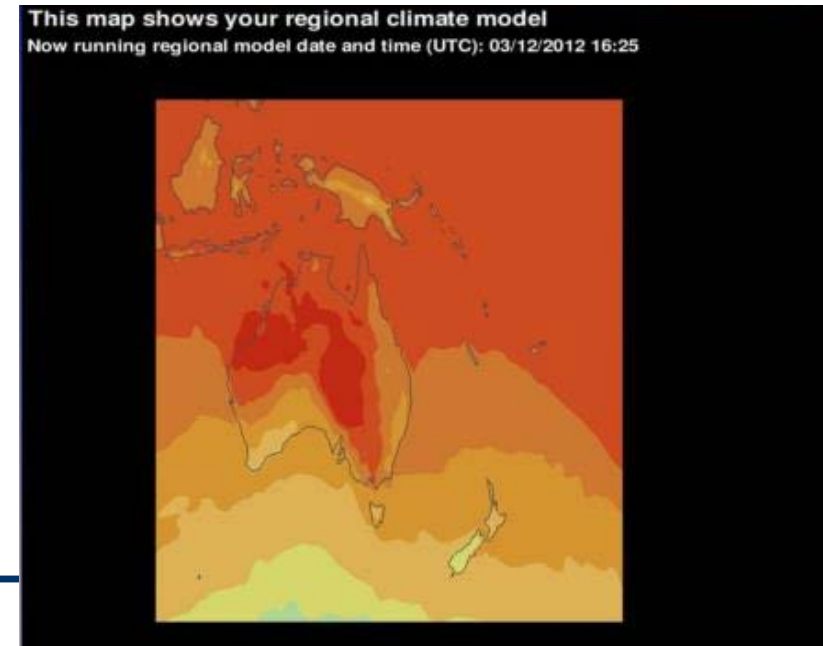
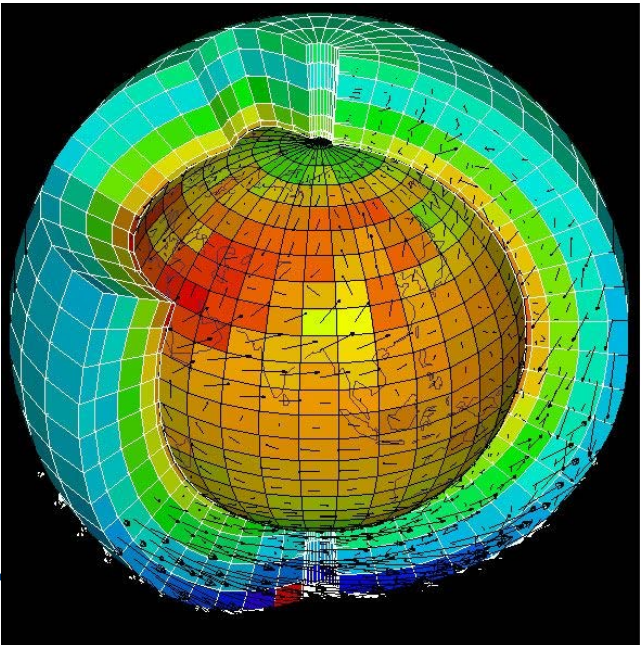
Suitable climate model  
simulations

An observational  
dataset we can trust  
of a relevant variable

**What do we need  
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An extreme weather  
or climate event!

- The climate model setup has to be right for the job.
- For an extreme weather type strongly linked to atmosphere-ocean coupling, an atmosphere-only model with prescribed SSTs wouldn't be suitable.
- For a highly localised extreme event a coarse-resolution global climate model wouldn't be useful.



An understanding of how  
climate change and  
variability are affecting that  
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Suitable climate model  
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**What do we need  
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Climate model simulations  
we can trust

An extreme weather  
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- The climate models need to be evaluated against observational datasets:
  - Do the models capture observed trends?
  - Do the models capture observed variability?
  - Do the models capture relevant teleconnections?
- If the models fail to do any of these things very well then we're going to run into problems...

An understanding of how  
climate change and  
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Suitable climate model  
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**What do we need  
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Climate model simulations  
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- If we have all these ingredients we can then do our attribution analysis



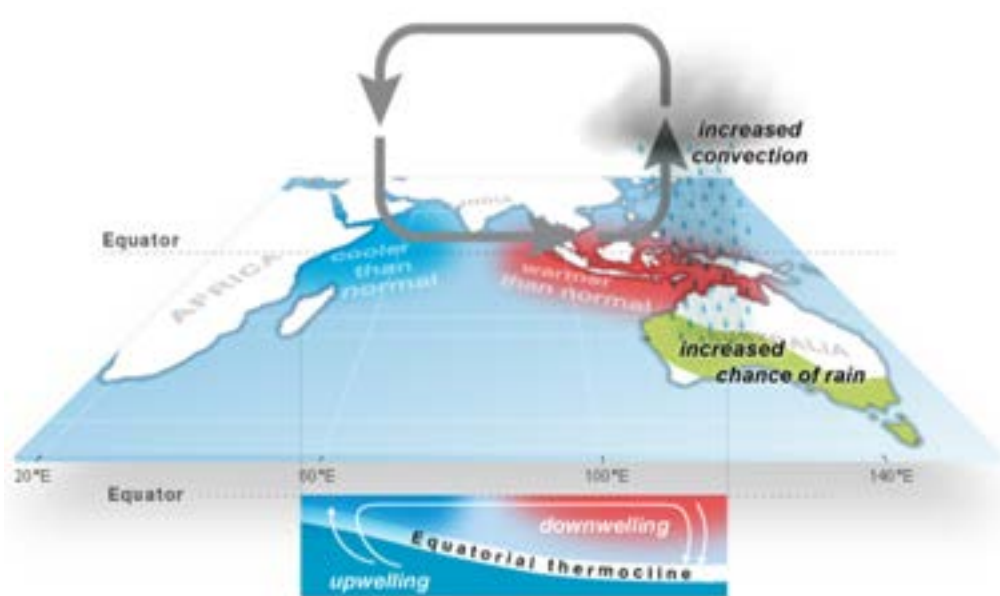
## A case study: Record wet winter in SE Australia, 2016- King (2017)

- Wettest July-September on record.
- Frequent frontal systems crossed the region.
- Culminated in Adelaide blackout storm.



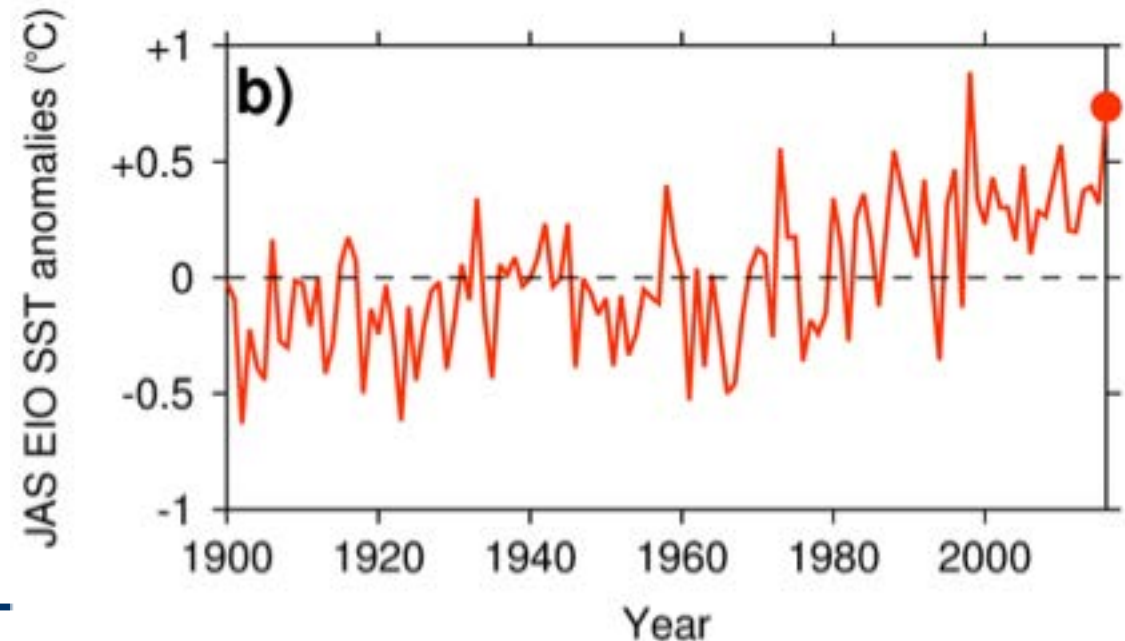
## A case study: Record wet winter in SE Australia, 2016

- Event coincided with record negative IOD. This has a known and somewhat well understood teleconnection with SE Australia.
- Not much of a trend in Jul-Sep rainfall in SE Australia.



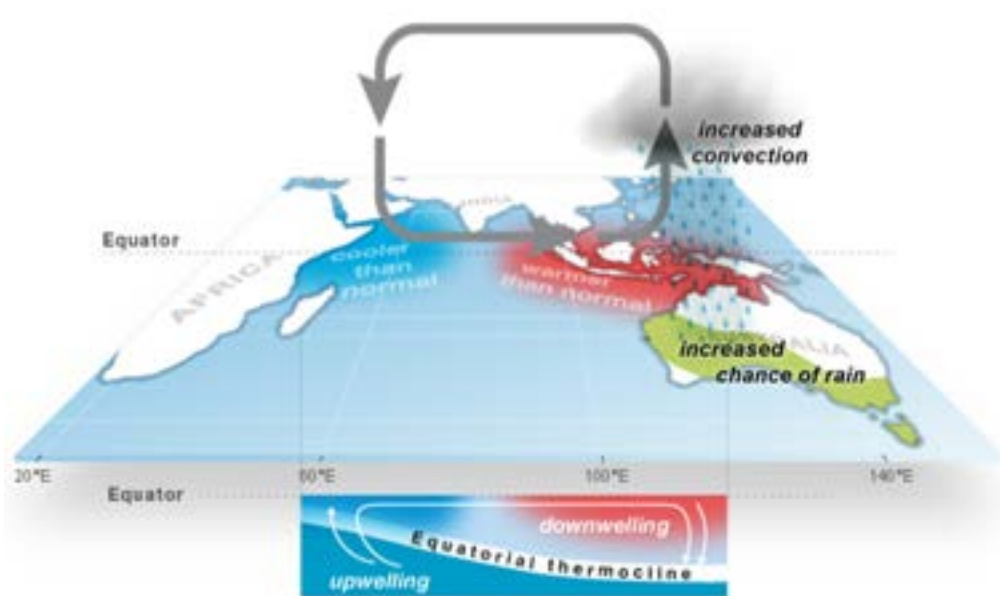
Indian Ocean Dipole (IOD): Negative phase

© Commonwealth of Australia 2013.



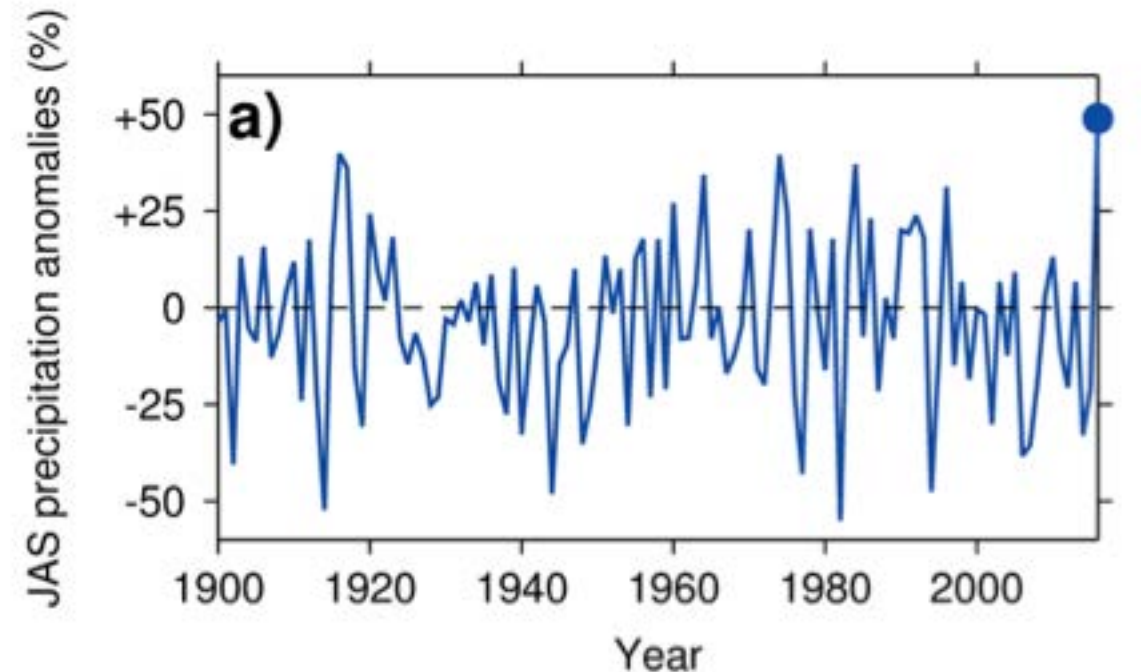
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Indian Ocean Dipole (IOD): Negative phase

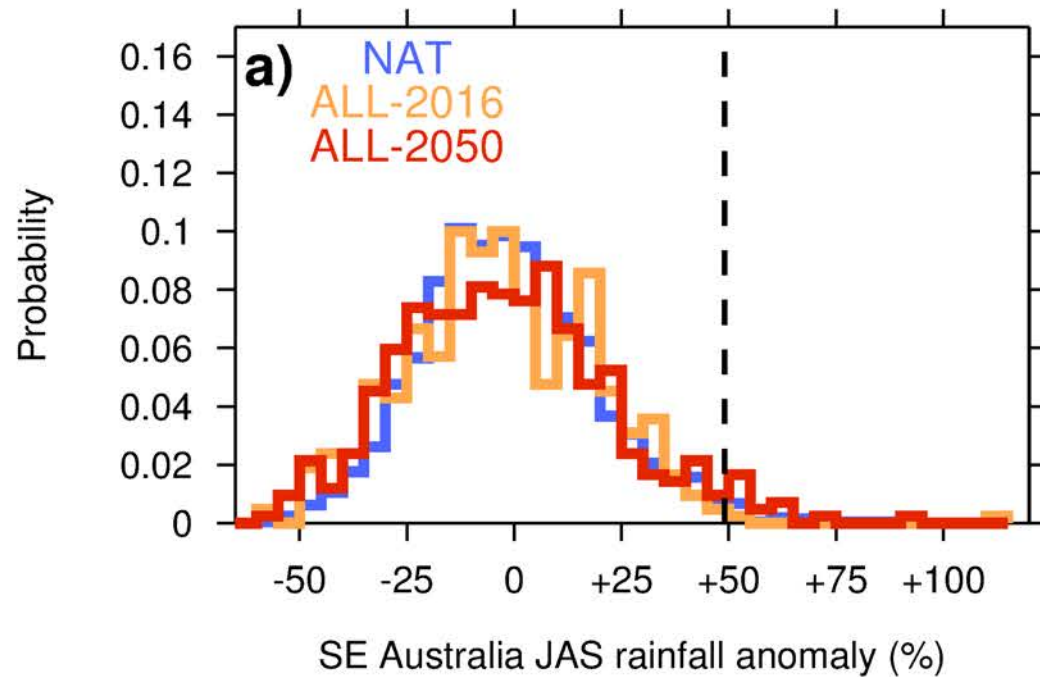
© Commonwealth of Australia 2013.



## **A case study: Record wet winter in SE Australia, 2016**

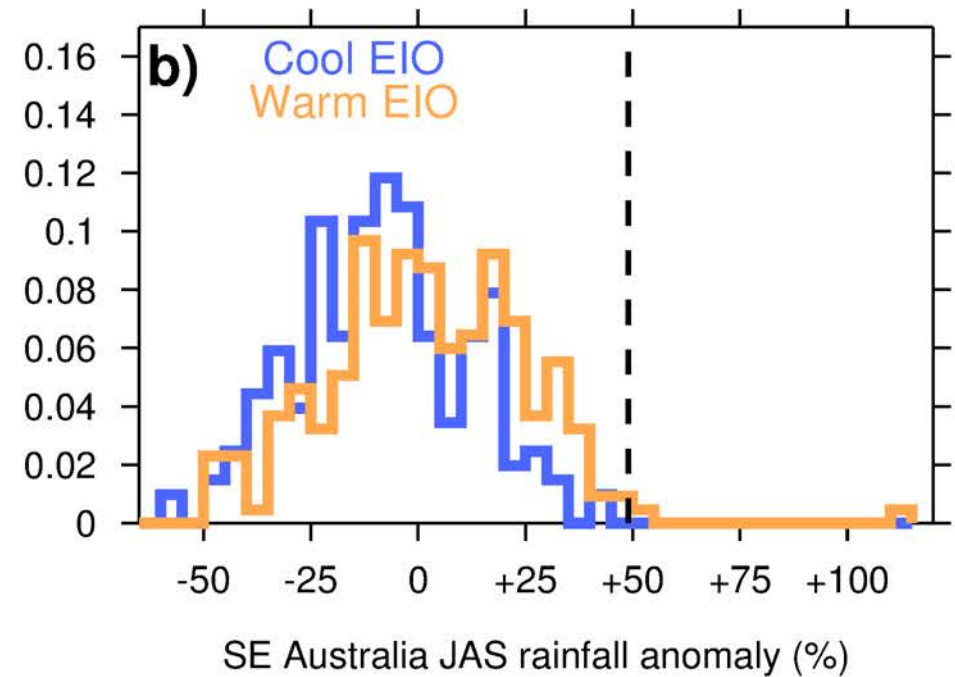
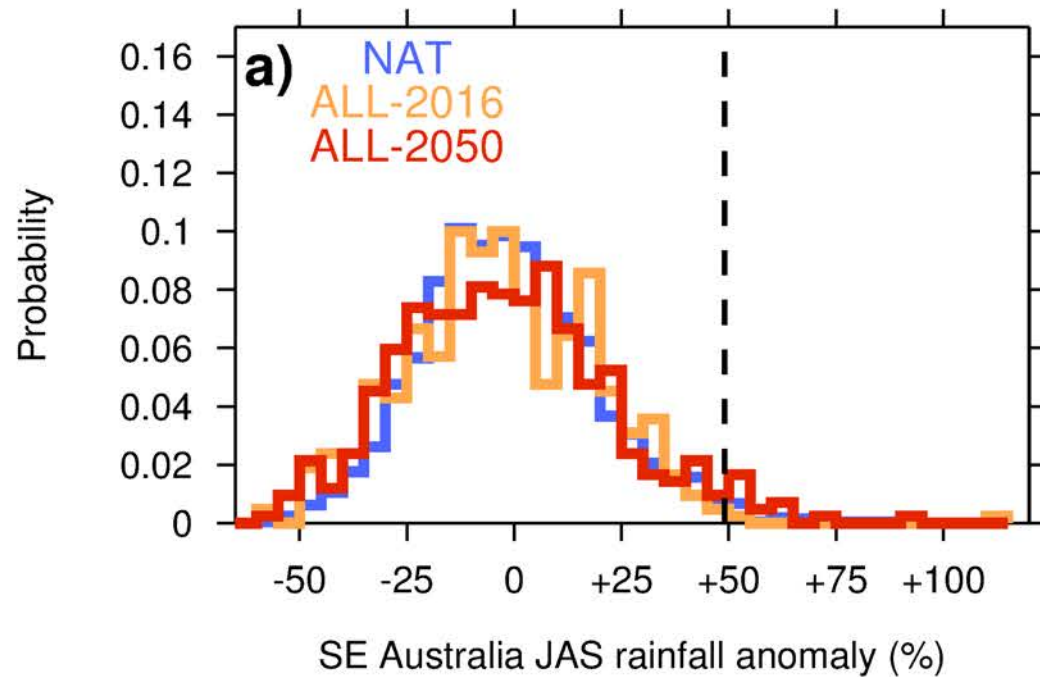
- I used CMIP5 models and evaluated them for rainfall variability and trends in SE Australia and their relationship with East Indian Ocean temperatures.
- I then used them to examine the roles of human-caused climate change and natural variability related to the warm East Indian Ocean (detrended SSTs).

## A case study: Record wet winter in SE Australia, 2016





## A case study: Record wet winter in SE Australia, 2016





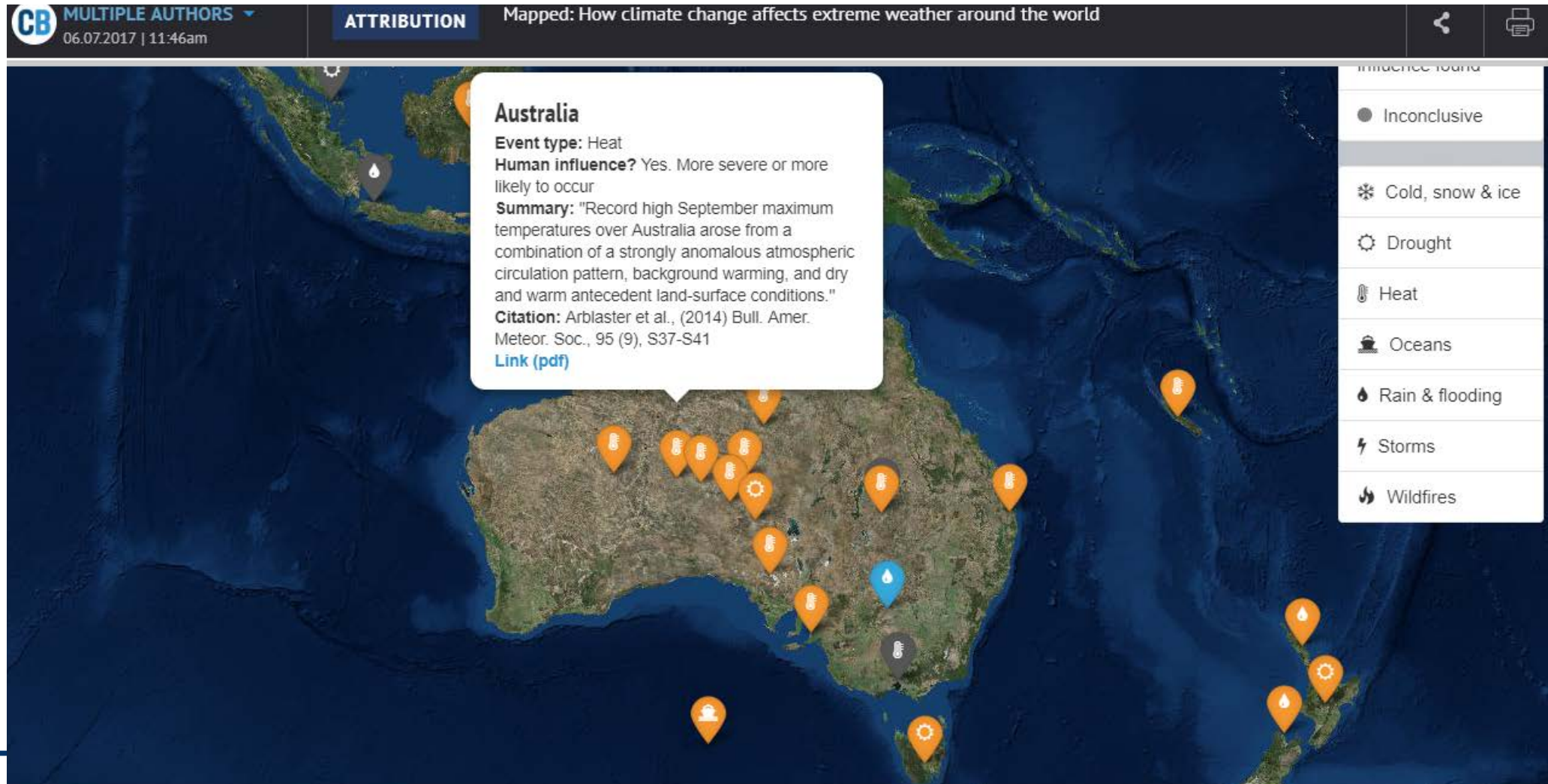
## **A case study: Record wet winter in SE Australia, 2016**

- Conclusion of study was that natural variability related to warm conditions in the East Indian Ocean more than doubled the likelihood of the wet winter occurring.
- The overall role of human-caused climate change in this event was minimal.
- Human forced climate change is increasing the moisture content of the atmosphere in this region but also reducing the incidence of circulation patterns conducive to rainfall.

There have been many attribution studies....



## There have been many attribution studies....



## There have been many attribution studies.... So what's next?

- Attribution of physical processes behind events
  - How does climate change and variability alter dynamic and thermodynamic components of events?
- Attribution of compound events
  - Events like tropical cyclones and droughts are more complex than one variable. How is climate change and variability altering specific aspects of these events?



## There have been many attribution studies.... So what's next?

- Impact-relevant attribution studies
  - Moving beyond meteorological parameters, how many extra deaths due to climate change-enhanced heatwave? How many extra homes were flooded due climate change-enhanced heavy rainfall?
- Operational event attribution
  - We're already able to do simple rapid event attribution, could this process be operationalised?

## Conclusions

- Trend and event attribution are useful in understanding the causes of trends or specific extreme events.
- Trend attribution allows us to quantify the roles of different forcings behind observed trends, such as warming global and regional temperatures.
- Event attribution allows us to estimate how much human-caused climate change or modes of natural climate variability are altering the likelihood or intensity of extreme events.
- Before conducting an event attribution study there are a few considerations to be made.
- Event attribution is advancing in several different directions.



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# Thank you

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