

The storyline approach to representing and communicating physical climate risk

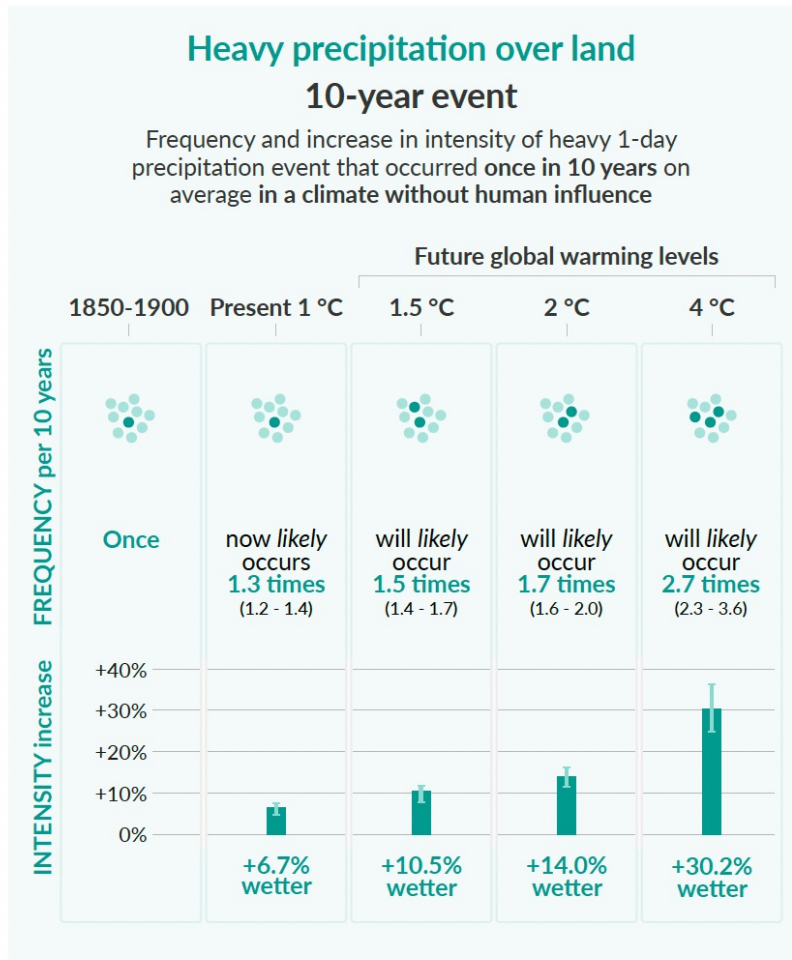


Ted Shepherd FRS, Grantham Chair of Climate Science
Department of Meteorology, University of Reading
also Jülich Supercomputing Centre, Forschungszentrum Jülich

Climate scientists tend to describe changes in extreme events probabilistically, which requires aggregation

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- In this case, the aggregation is over the entire land surface and all kinds of heavy precipitation events
 - Note that the increased intensity simply follows Clausius-Clapeyron scaling
- There are many ways to refine such calculations to be more targeted (see e.g. Naveau, Hannart & Ribes 2020 Ann. Rev. Stat. Appl.), but each choice involves a **trade-off between reliability and informativeness (or discrimination)**

IPCC AR6 WGI Summary for Policymakers (2021)

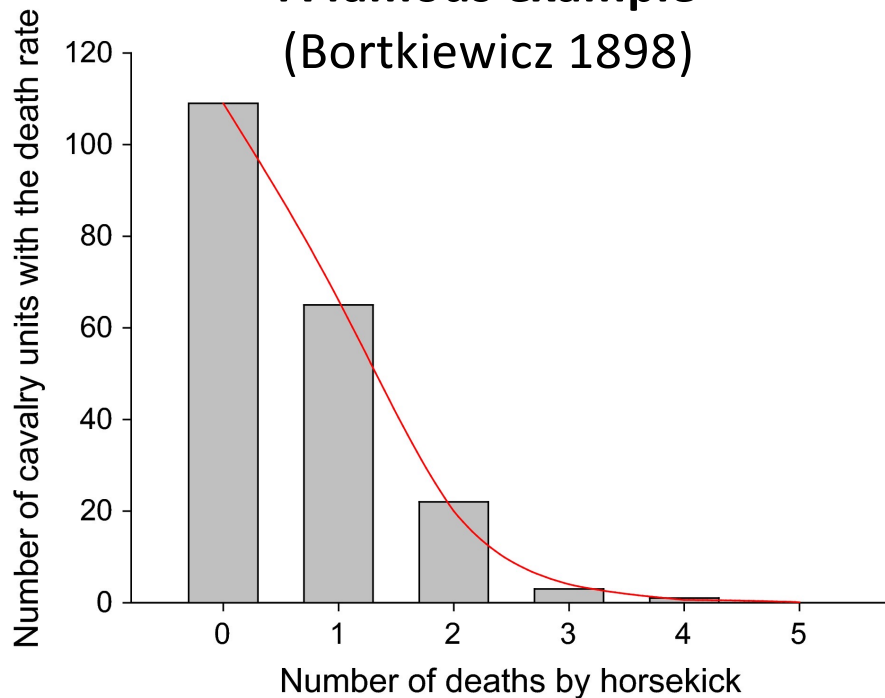
Even when aggregation is reliable, it is not informative about individual cases

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(see e.g. Bueno de Mesquita & Fowler, *Thinking Clearly with Data*, 2021 Princeton Univ. Press)

A famous example (Bortkiewicz 1898)



Pandit (2015 Anaesthesia)

- Number of Prussian cavalry units suffering a death of a soldier by horsekick in a given year (collected over a 20-year period)
 - Follows a Poisson distribution
- Shows that the deaths happened "by chance", even though **each one surely has a tragic story behind it**
- This sort of dialectic between aggregate and individual occurs across many disciplines
 - **Events in the real world are not iid** (independent and identically distributed)

“La théorie des probabilités n’est que le bon sens réduit au calcul”

Pierre-Simon Laplace (*Essai Philosophiques sur les Probabilités*, 1819)

“It is sometimes considered a paradox that the answer depends not only on the observations but on the question; it should be a platitude”

Harold Jeffreys (*Theory of Probability*, 1st edition, 1939)

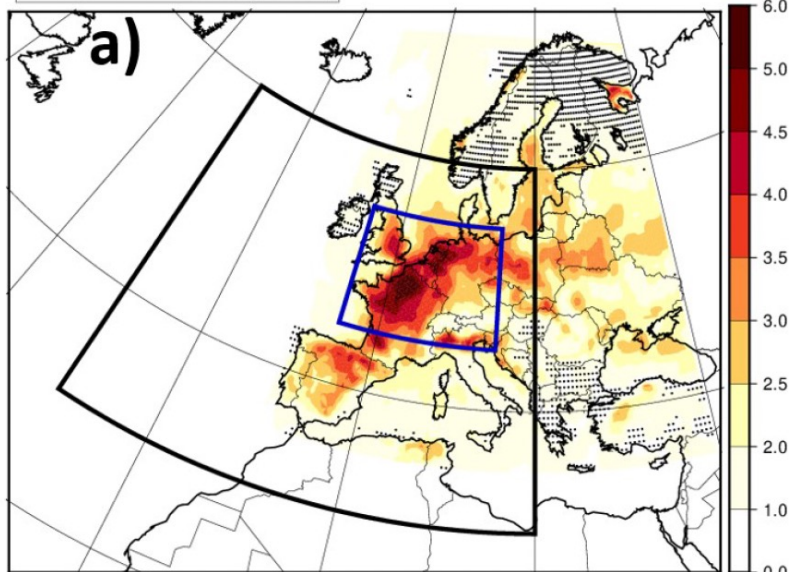
Probabilistic statements are questionable in regions where observed trends do not agree with model projections

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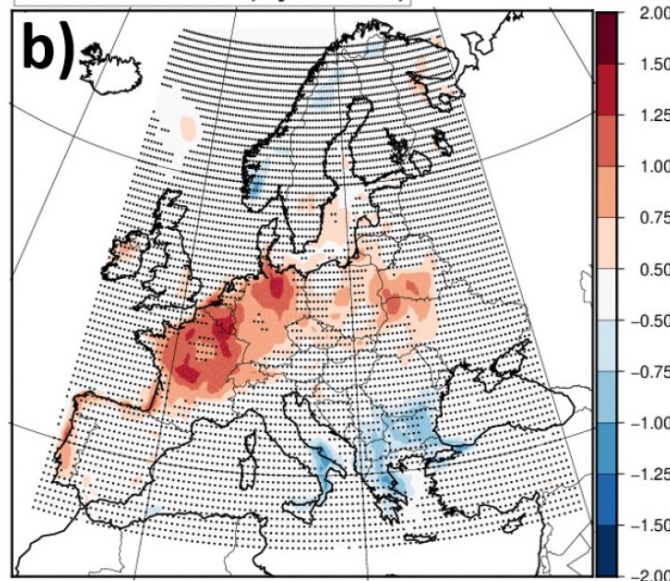
- In France, the summer maximum of daily maximum temperature has been increasing since 1950 up to five times faster than the global mean temperature
- About 1/3 of this is due to dynamical trends (i.e. having to do with atmospheric circulation) which are not present in any model

ERA5 TXx Trend (Total)



Units: °C per °C of global mean warming

ERA5 TXx Trend (Dynamical)



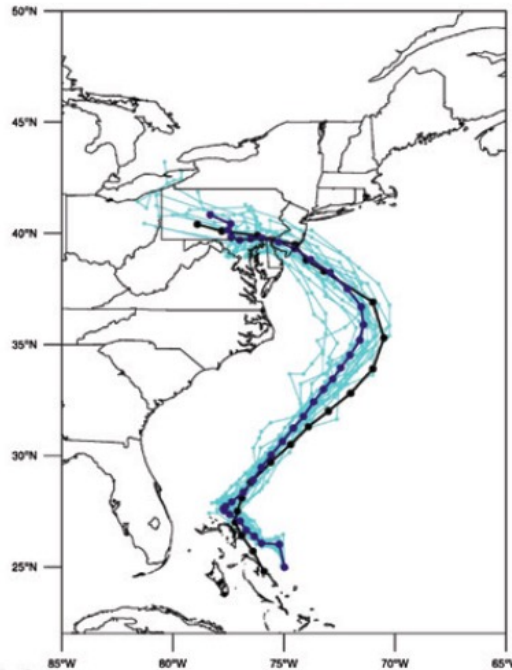
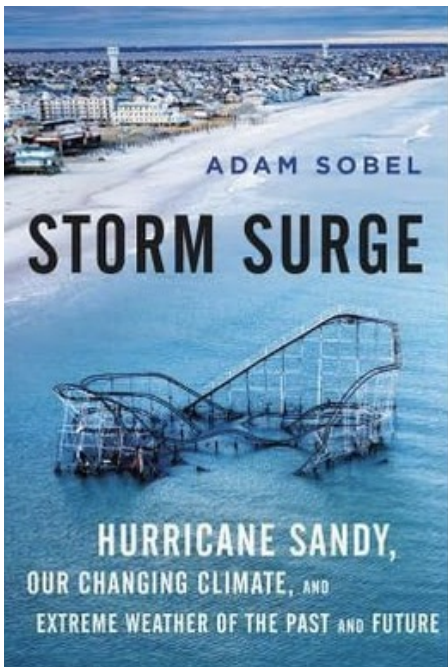
Vautard et al. (Nature Comm., in press)

- Maybe the models underestimate variability and the observed dynamical trend will reverse
- Or maybe the dynamical trend is forced and the models are missing it
- Both represent plausible causal explanations

Ultimately, every extreme event is unique,
and this uniqueness matters for impacts

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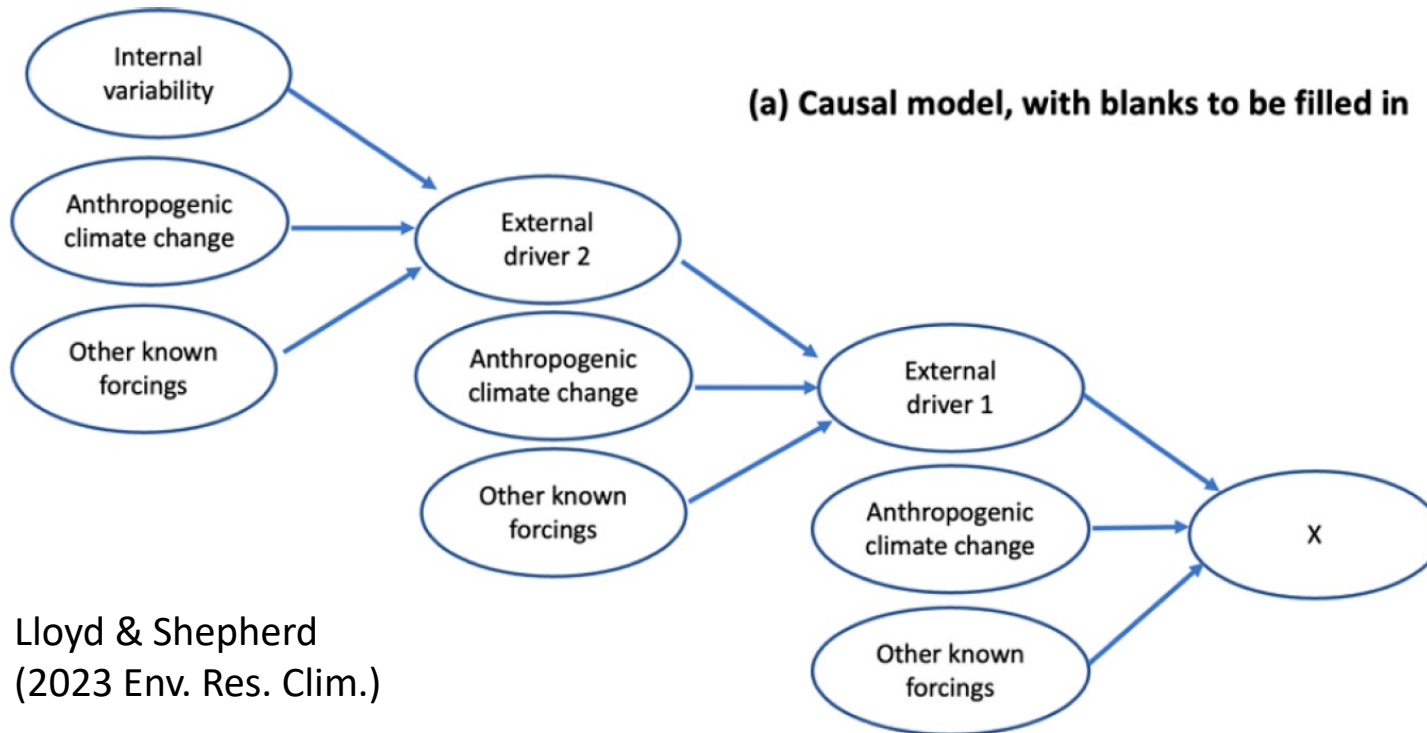


- **Hurricane Sandy (2012)** was unusual in its rapid westward steering and its merger with an extratropical storm, **both the result of a strongly deformed jet stream**
 - US weather forecasters didn't even have a protocol for handling such an event
 - It seems almost meaningless to ask if such a freak event would become more likely in the future
- But we do know that sea level will be higher, and storms will hold more moisture
 - Thus we can legitimately ask (and plausibly answer) the counter-factual questions:
 - How much were the impacts of Sandy increased by climate change?
 - How much worse might they be in the future?

In such **conditional** (i.e. "If...then") attribution, some of the causal elements are internal to the climate system and are left **contingent** (i.e. unexplained), pending further knowledge

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Lloyd & Shepherd
(2023 Env. Res. Clim.)

- Climate-change scientists have generally sought **unconditional** attribution
- Yet conditional attribution is fully consistent with the IPCC D&A Guidance Paper (2010)

- Conditional attribution is also standard practice in other aspects of climate science, e.g. seasonal prediction

We actually have a huge amount of climate information, even at the local scale, from both observations and modelling — it's just that the information is **conditional**

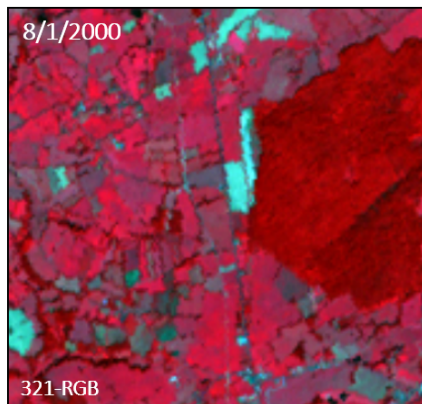
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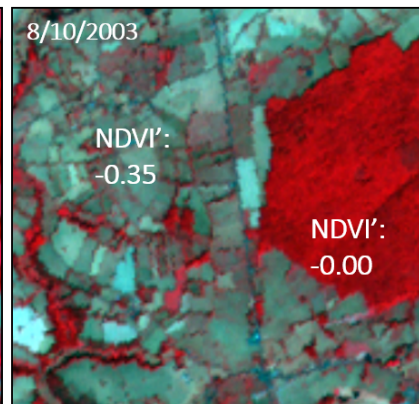
Vegetation
(red = living)



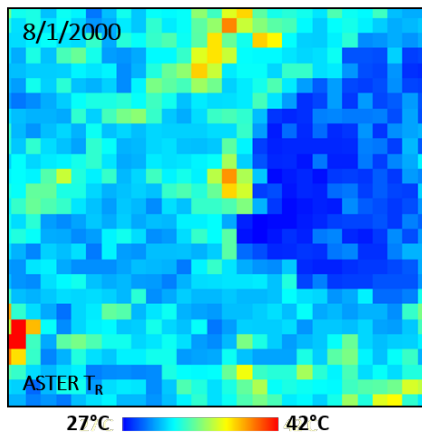
1 August 2000



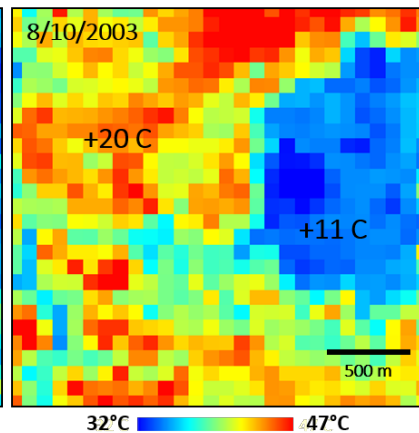
10 August 2003



Surface
Temperature



27°C 42°C



32°C 47°C

- The summer 2003 heat wave in central France
- Temperature difference between 2000 and 2003 was 11°C in forested areas, but 20°C where the vegetation died out
- We may not be able to predict the statistics of heat waves in the future, but we can predict their implications, and how to manage their impacts

Zaitchik et al. (2006 Int. J. Clim.)

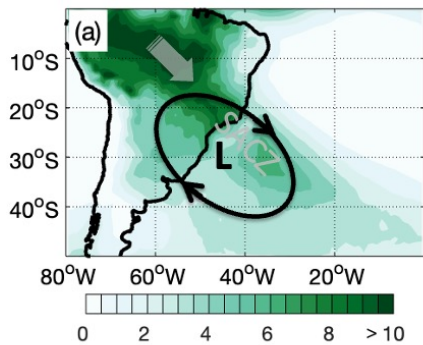
What is climate risk depends on the recipient of the information

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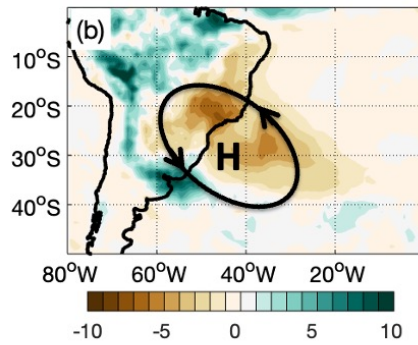
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- Anomalous anti-cyclonic circulation led to failure of 2013/14 South American monsoon
- Caused drought and heatwaves, affected food-water-energy nexus: compound risk

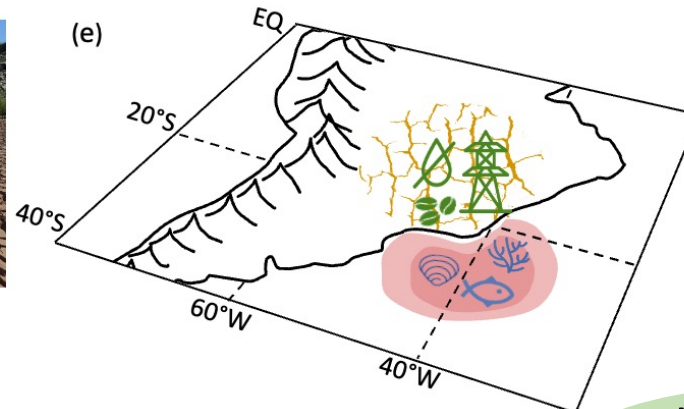
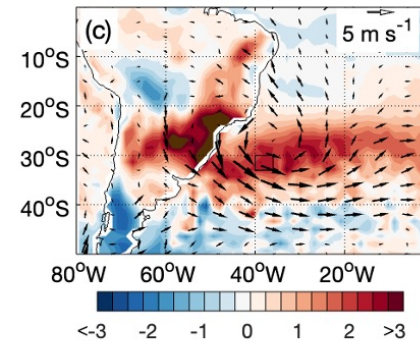
Climatological precipitation



Precipitation anomaly



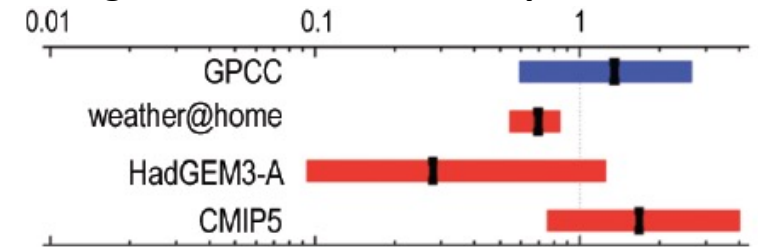
Temperature and wind anomaly



Rodrigues & Shepherd (2022 PNAS Nexus)

- A probabilistic attribution study of the event found “insufficient evidence” that climate change increased drought risk

Drought risk ratio relative to pre-industrial



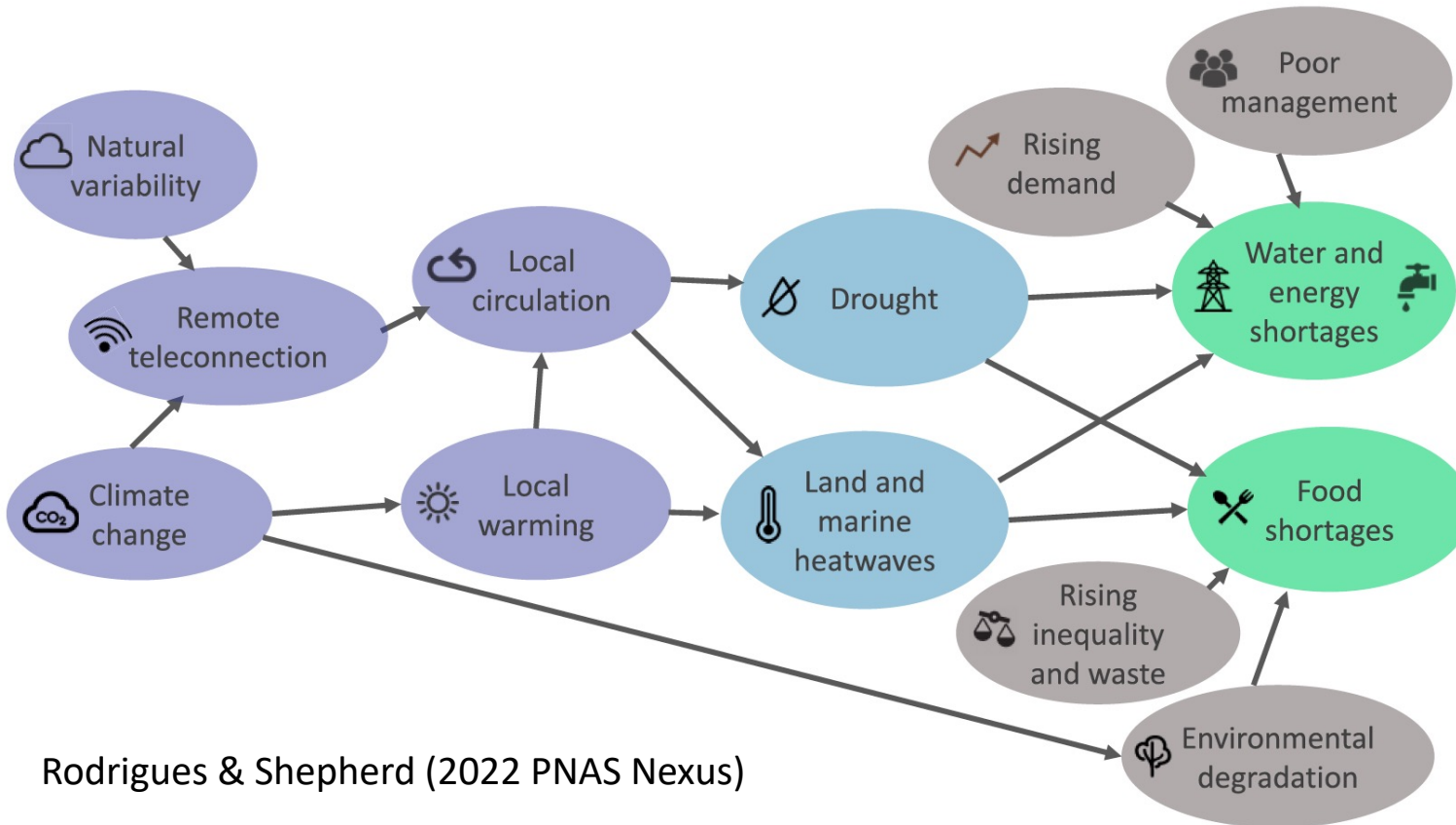
Martins et al. (2017 BAMS)

We can ask: insufficient for whom?

The relevant causal factors and their connections to impacts can be represented in a **causal network**, which can be used to define **storylines**

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Rodrigues & Shepherd (2022 PNAS Nexus)

- Non-climatic causal factors can be included
- Provides a powerful alternative to traditional (unconditional) attribution when uncertainties are high (Lloyd & Shepherd 2023 Env. Res. Clim.)

There is no such thing as a "natural" disaster

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Poverty and Famines

*An Essay
on Entitlement
and Deprivation*

AMARTYA SEN

(1981)

- Representing the socio-economic situation and the managed environment at a local scale is crucial
 - There are always multiple causal factors
 - We need a forensic approach, not a yes/no attribution to climate change

Can a narrative provide scientific evidence for decision-making?

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- An apocryphal story of a conversation on 18 March 2020.....



I'm going to see the Queen...
That's what I do every
Wednesday. Sod [coronavirus].
I'm going to go and see her.



Yeah...I
can't go

You can't go and
see the Queen.
What if you go and
give her
coronavirus?



Narrative approaches in science have a rich history

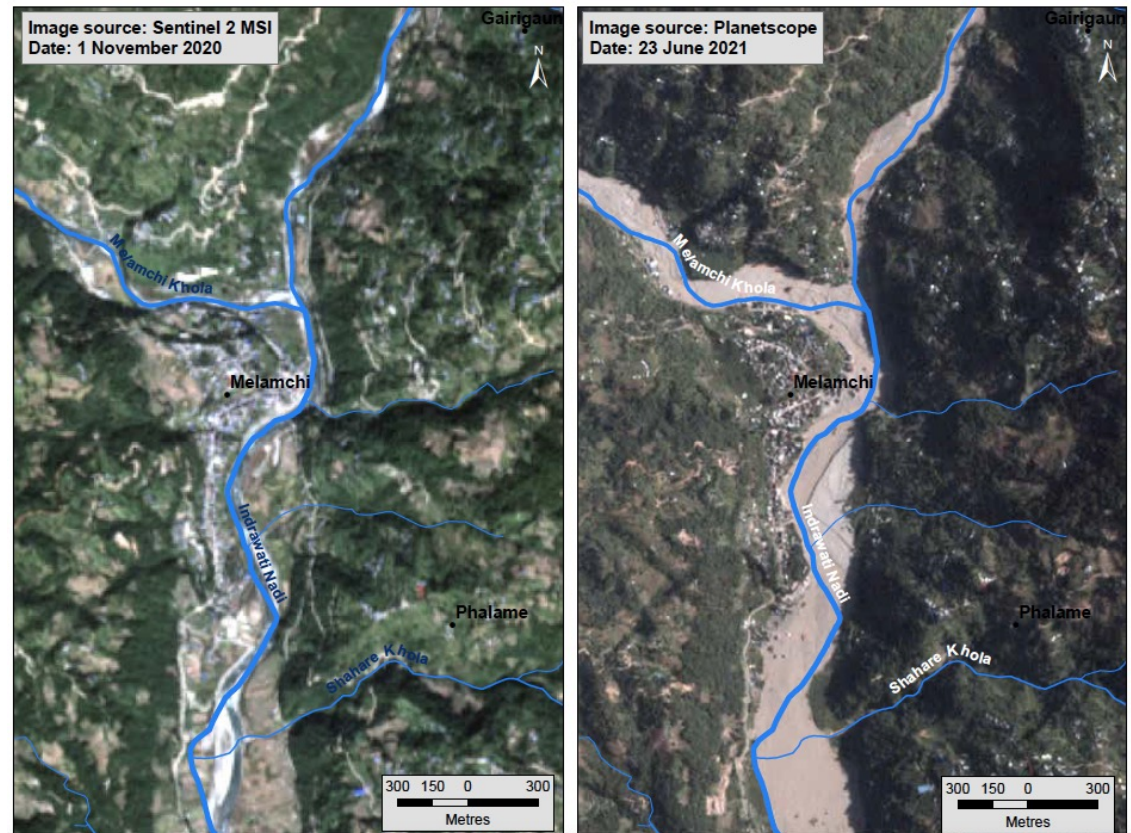
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“Natural historians have too often been apologetic, but most emphatically should not be in supporting a plurality of legitimately scientific modes, including a narrative or historical style that explicitly links the explanation of outcomes **not only to spatiotemporally invariant laws of nature, but also, if not primarily, to the specific contingencies of antecedent states**, which, if constituted differently, could not have generated the observed result.” [emphasis added]

Stephen Jay Gould, *The Structure of Evolutionary Theory* (2002)

Debris outflow from the Melamchi (Nepal)
flood disaster of 15 June 2021 (ICIMOD 2021)

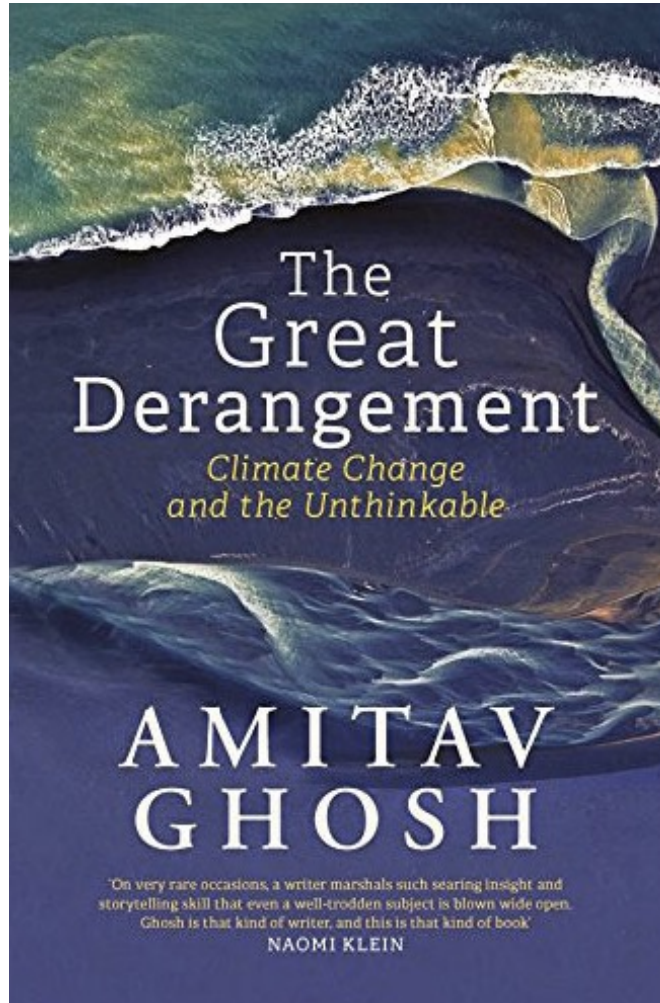


- So why not climate scientists too? (see Shepherd & Lloyd 2021 Climatic Change)

Storylines can bring meaning to climate change at the local scale

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- The novelist Amitav Ghosh asks why we find it so difficult to think about climate change
- He argues the modern mindset has promoted the primacy of human, indeed individual, agency, within a background of normalcy
- In this mindset, there is no place for the 'uncanny' – and climate change, especially at the local scale, is nothing if not uncanny
 - Storylines provide a way of talking about the uncanny

It's also a question of justice

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VINTAGE SCHUMACHER



Small is Beautiful

A Study of Economics
as if People Mattered

(E.F. Schumacher 1973)

- How would climate-change science look if it was structured “as if people mattered”? (Rodrigues & Shepherd 2022 PNAS Nexus) It would involve:
- **Grappling with complexity** of local situations....
....by expressing climate knowledge in a conditional form → *conditional probabilities*
- **The importance of simplicity** when dealing with deep uncertainty....
....through the use of *physical climate storylines*
- **Empowering local communities** to make sense of their own situation....
....by developing “intermediate technologies” that build trust and transparency → *causal networks*

Concluding Remarks

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- To address adaptation challenges, we need to navigate the '**cascade of uncertainty**' in climate predictions and projections, and connect to the decision space
 - The **societally relevant question** is not "What will happen?" but rather "What is the impact of particular actions under a situation of uncertainty?"
- We need to find a scientific language for describing the '**plural, conditional**' state of knowledge that exists at regional and local scales, and **resist aggregation**
 - By distinguishing between the thermodynamic and dynamic aspects of climate change, the **storyline approach** to regional climate information does exactly this (see Shepherd 2019 Proc. Roy. Soc. A)
- Linking to historical events, in their proper context, brings a **salience to the risk**; well understood psychologically
 - Storylines also provide a **built-in (not contrived) narrative**, hence an emotional element, which is essential for decision-making (Damasio 1994; Davies 2018)
- We need to explore storylines of climate risk, combining the best information from all sources — **interpreted not as a prediction but as representing plausible futures**