STORYLINES OF CLIMATE VARIABILITY FOR HYDROLOGICAL IMPACT STUDIES
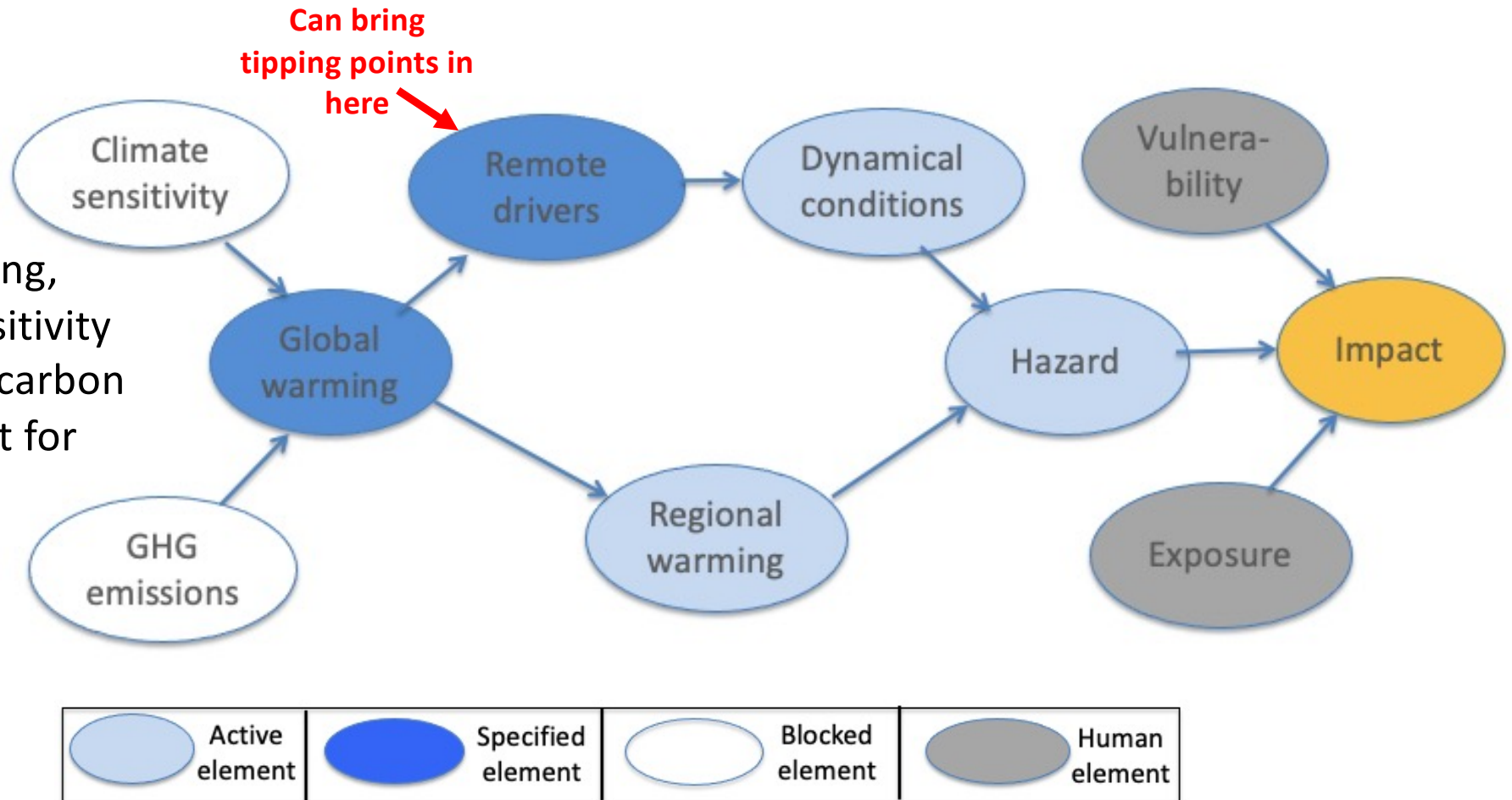
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Sharing is encouraged

A dynamical (circulation drivers) storyline of regional climate change

After Shepherd (2019 Proc. Roy. Soc. A); in IPCC AR6 WGI Chapter 10, Box 10.2, Figure 1

- **Example of dynamical storylines:** four storylines of **future cold-season Mediterranean drying** (a major climate vulnerability for southern Europe)
  - So far as we know, any one of these could be true

a) low tropical amp + strong vortex
b) high tropical amp + strong vortex
c) low tropical amp + weak vortex
d) high tropical amp + weak vortex

−0.3   −0.2   −0.1   0   0.1   0.2   0.3

mm/day/K
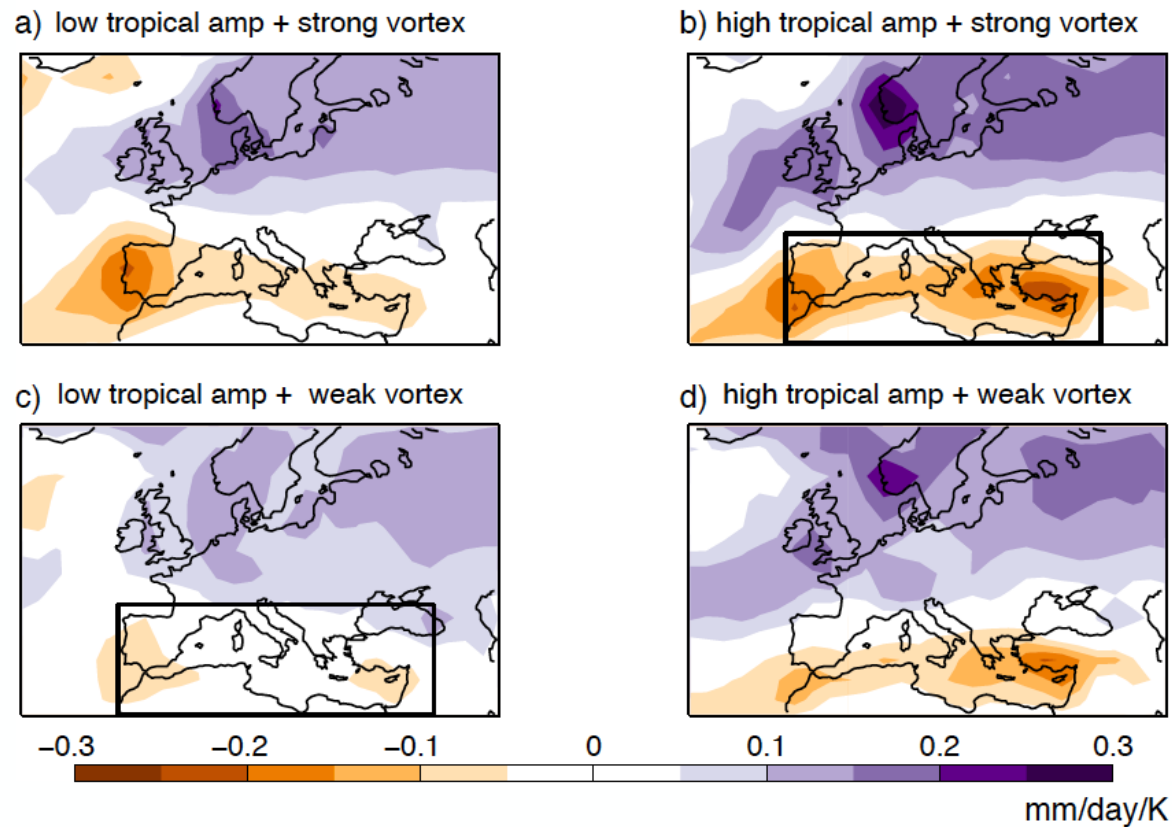
These could each be used to interpret the observed changes, to articulate multiple causal hypotheses

Zappa & Shepherd (2017 J. Clim.)

- But we can also consider storylines of **dynamical variability**, in order to construct **worst-case scenarios** beyond those seen in the observational record

  - Here, a hydrological model is driven by observed temperature and precipitation for a historical drought (2010-2012), and the input files are perturbed in various ways

- For SE England (cluster 4), even the three-dry-winter scenario would not have matched the reference 1989-93 drought, but adding 2°C of global warming would have exceeded it
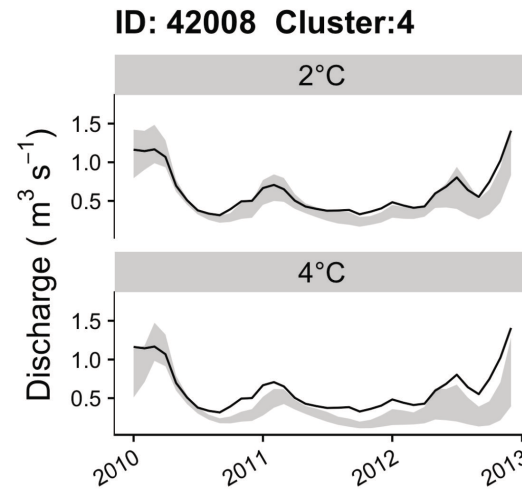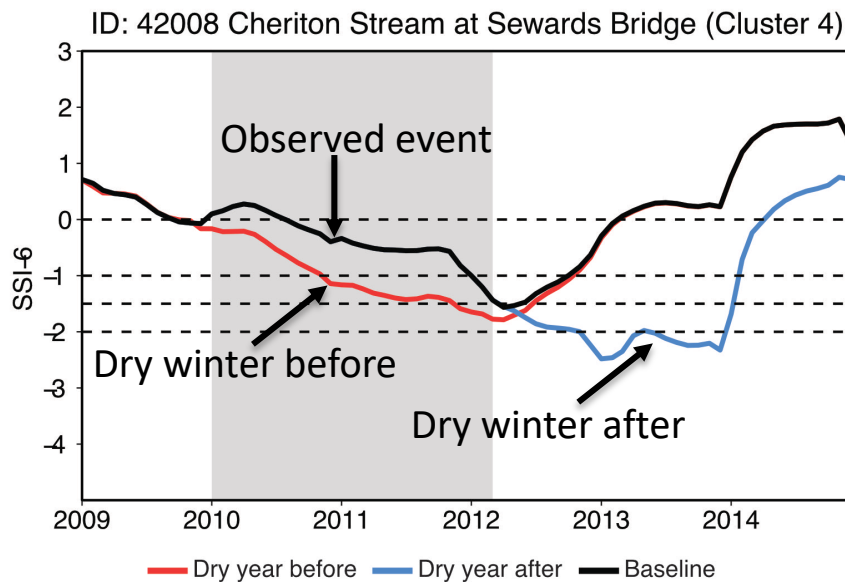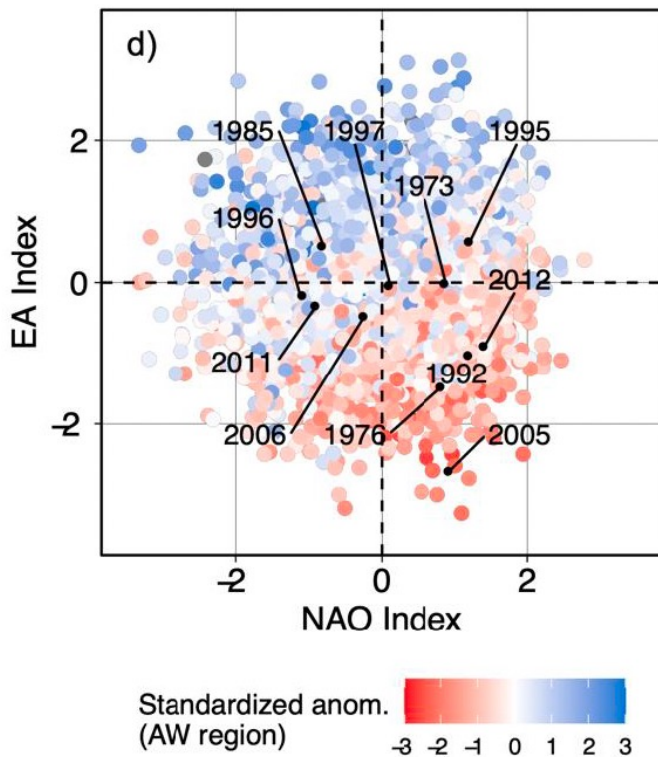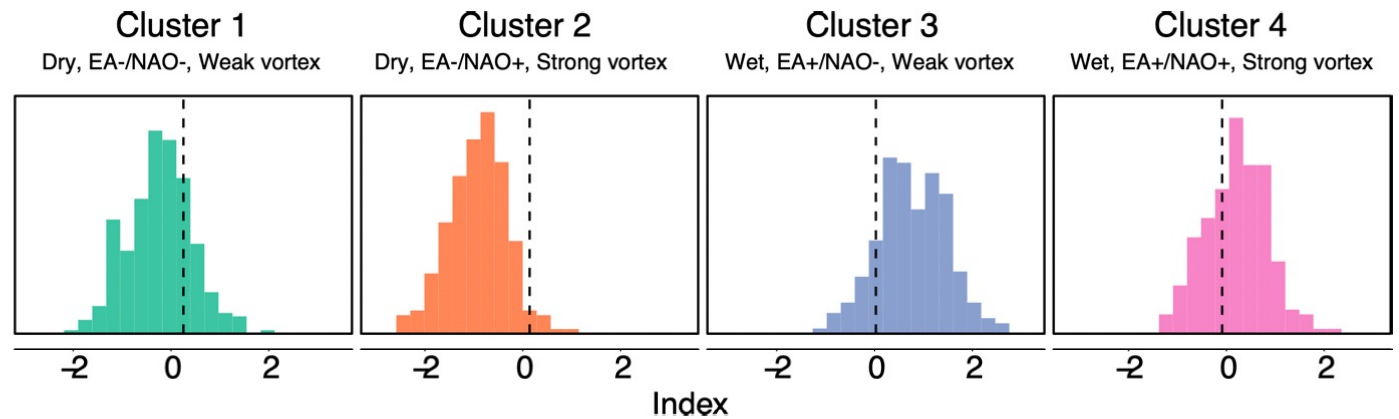

Chan et al. (2022 HESS)
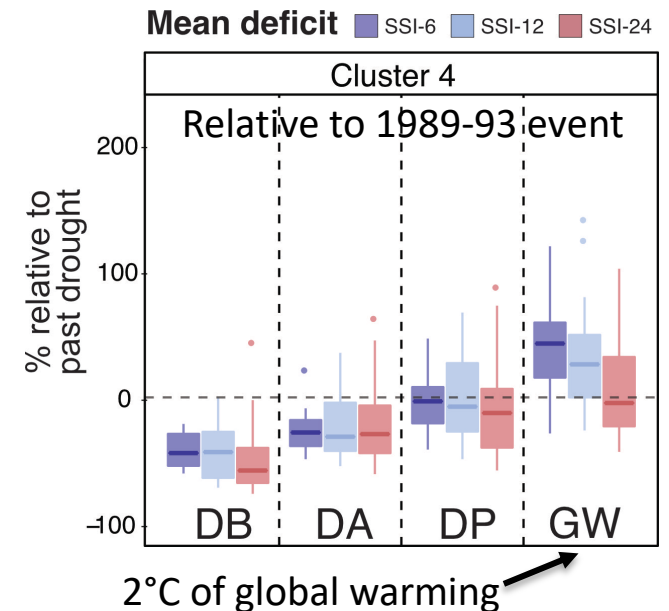
- See also Chan et al. (2022 PPG) for a historical perspective on the storyline approach

- Storylines constructed from seasonal hindcast ensembles can be used to **supplement seasonal outlooks during ongoing droughts**

Winter precipitation anomalies for East Anglia region (colour: SEAS5 hindcasts)

- In this study, which was performed in the summer of 2022 during drought conditions, storylines were constructed to examine how the drought might unfold over the coming winter, spring and summer, to inform planning by Anglian Water


Chan et al. (2024 NHESS)

- At the regional scale, the traditional probabilistic attribution of changes in extremes is challenged by **uncertainties in model projections**, and by **lack of verifying data**
  - Yet there can be a **wealth of climate information** when it is expressed **in conditional form** (see Chapter 10 of the IPCC AR6 WGI report)
  - Using IPCC regions can **obliterate important details** (Mindlin et al. 2023 J. Clim.)
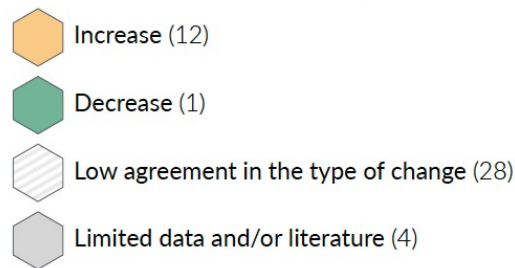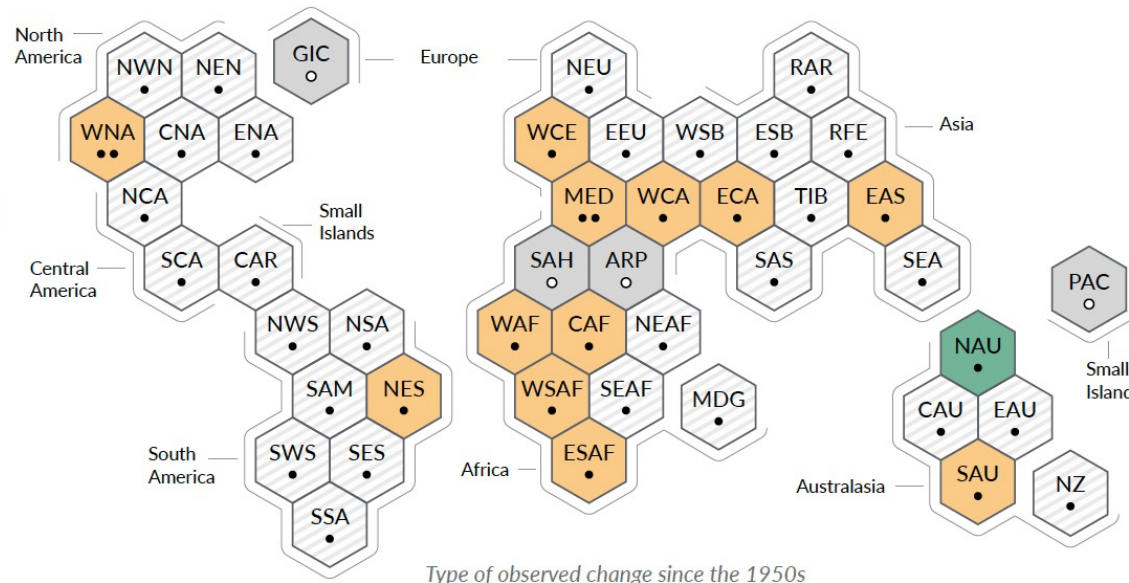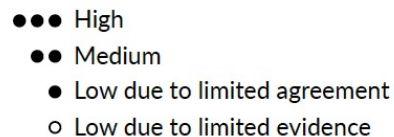
SPM of IPCC AR6 WGI report (2021)

- The storyline approach can be seen as **conditional** attribution, where some of the causal elements are internal to the climate system (known as an "external driver" of the effect in question), and their attribution to climate change is left open

- Fully consistent with the IPCC Detection & Attribution Guidance Paper (2010), but traditionally, climate-change scientists have only considered **unconditional** attribution

(a) Causal model, with blanks to be filled in

Internal variability

Anthropogenic climate change

Other known forcings

External driver 2

Anthropogenic climate change

Other known forcings

External driver 1

Anthropogenic climate change

Other known forcings

X
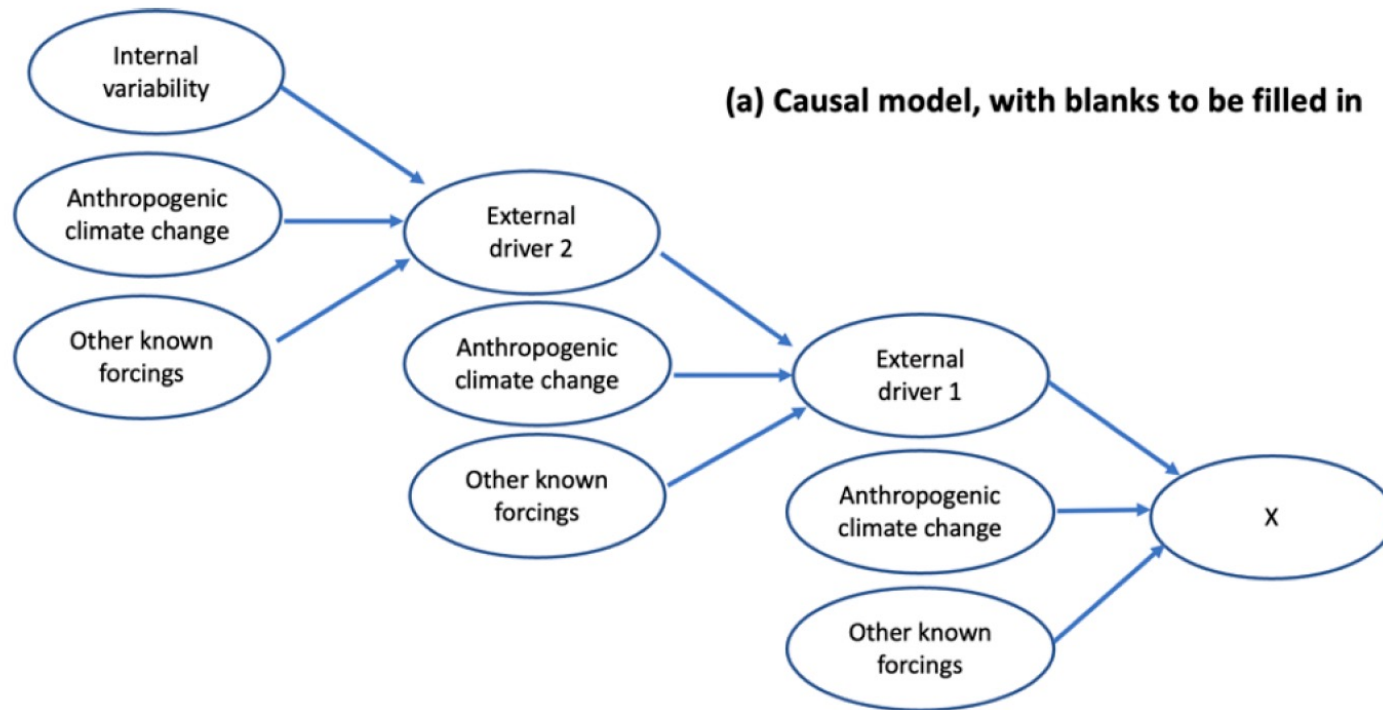
Yet conditional attribution is standard practice in other aspects of climate science, e.g. seasonal prediction

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

Frequently Asked Questions

- **What about probabilities?**
  - It's better science to acknowledge that some uncertainties are epistemic than to provide a sense of 'false precision' (Parker & Risbey 2015 Phil. Trans. A)
  - If you wish to treat CMIP multi-model ensembles as probability distributions, that is your right
  - Causal networks can provide a link between storylines and probabilities
- **Aren't storylines too subjective?**
  - If the price of 'objectivity' is to bury the subjectivity in procedural protocols, then that is not a price worth paying; it's better to be transparent
- **Aren't the number of storylines unlimited?**
  - A focus on decision relevance can narrow the possibilities dramatically
- **How do you determine what is physically plausible?**
  - This must be a process of co-development with the user

Concluding Remarks

- To address adaptation challenges, we need to navigate the **'cascade of uncertainty'** in climate 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 an uncertain regional climate change?"
- 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**
  - 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
  - The historical record can be supplemented with **storylines of extreme variability** selected from large model ensembles such as seasonal hindcasts
- 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**