

Extreme Event Attribution

Supplement lecture 9

- The chaotic nature of weather means that it is generally impossible to say, for any specific event, that it would not have occurred in the absence of human influence on climate.
- Science of **Probabilistic Event Attribution** has emerged in the last 20 years to determine the **attributable risk**: quantifying whether and how much past emissions have contributed to the probability of an extreme event occurring.
- Extreme Event Attribution studies compare how often a particular extreme weather event occurs in model experiments representing the “**world as it is**” (with human influence on climate) with how often the same type of event occurs in experiments representing the “**world that might have been**” (with the estimated impact of human influence on climate removed, allowing for uncertainty in this impact).

Factual and Counterfactual model simulations

“world as it is”

“world that might have been”
without fossil fuel emissions

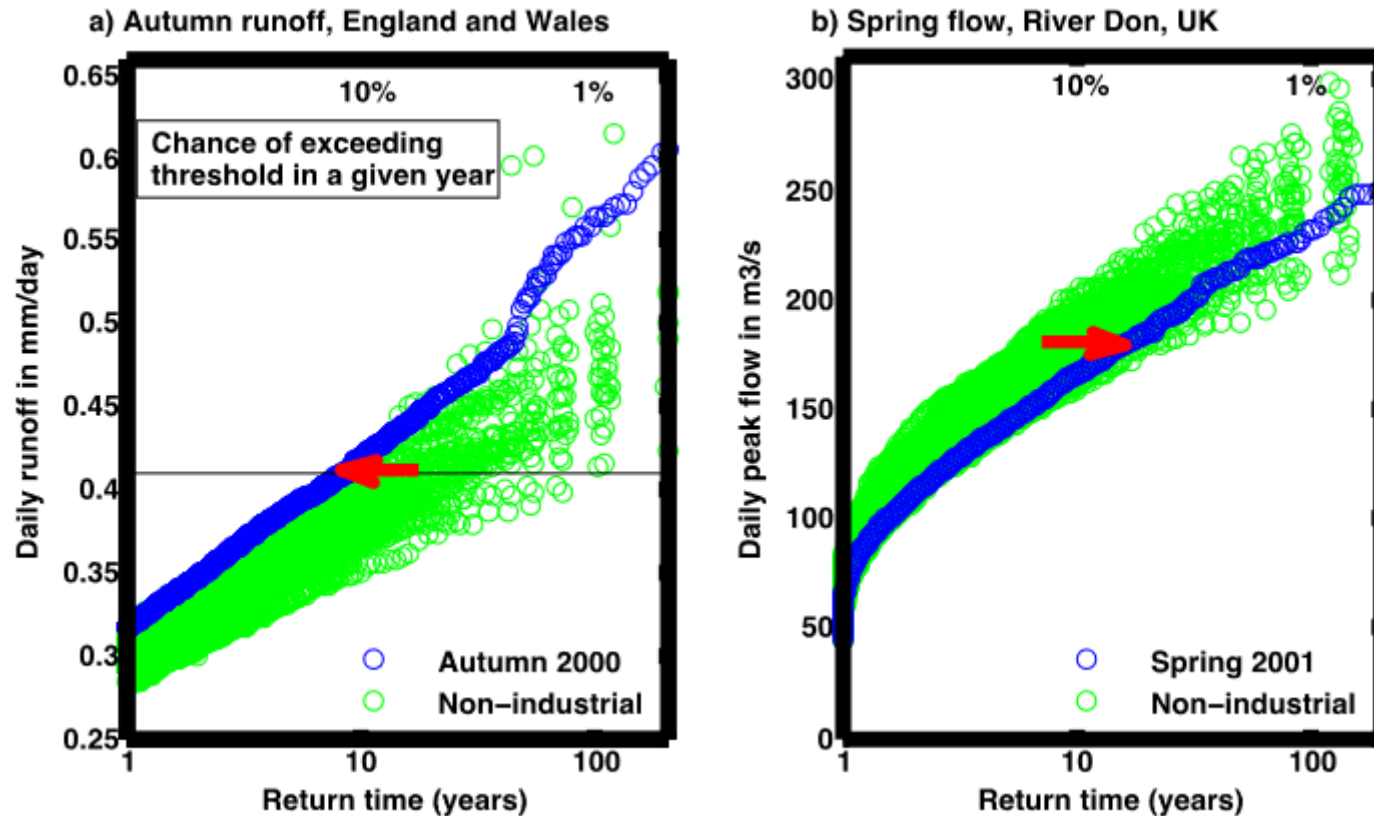


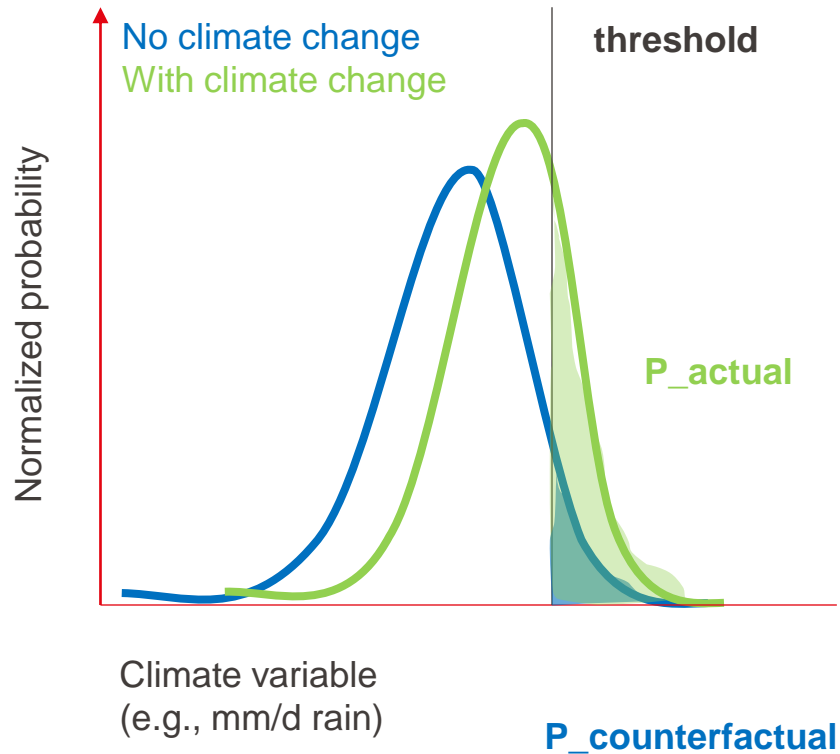
Figure 1 adapted from Figure 10.18 IPCC AR5 WG1 chapter 10.6. Return times of run-off (an indication of flooding) for simulations of the “world as it is” (blue) compared to the “world that might have been” without anthropogenic GHG emissions (green). Red arrow shows the tendency of change in the event frequency.

Panel (a) is for Autumn 2000 in England and Wales with the black line showing the threshold exceeded in observations and panel (b) is for a different season and catchment.

Worsening (roughly by a factor 2)

Alleviation:
less probability of extreme event

How do we assess the risk that the extreme event causes due to climate change?



- $P_{\text{actual}} > P_{\text{counterfactual}}$
- Probability ratio:
 $P_{\text{actual}}/P_{\text{counterfactual}} > 1$
- Fraction of attributable risk (FAR)=
 $1 - p_{\text{counterfactual}}/p_{\text{actual}}$
- Example
 - $P_{\text{actual}}/p_{\text{counterfactual}} = 2$
 - $\text{FAR} = 1 - 0.5 = 0.5$
 - \rightarrow 50 % of the event can be attributed to climate change

Steps of a scientific probability attribution study

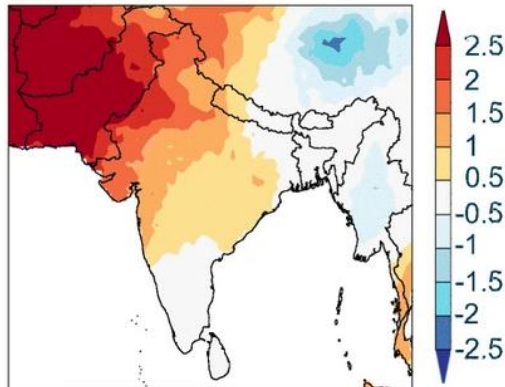
1. measuring the magnitude and frequency of a given event based on observed data,
2. running computer models that are compared to and verified with the observational data,
 1. Can the model in principle represent the extremes of interest?
 2. Are the statistics of the modeled extreme events compatible with the statistics of the observed extremes?
 3. Is the meteorology driving these extremes realistic?
→ gaining trust in the model
3. running the same validated models on the counterfactual scenario with no climate change, and
4. using statistics (see previous slide) to analyze the differences between the second and third steps, thereby measuring the direct effect of climate change on the studied event.

- Need of complete data series, too big gaps will introduce biases.
- Also gridded data from observations (interpolated between stations) can invoke biases.

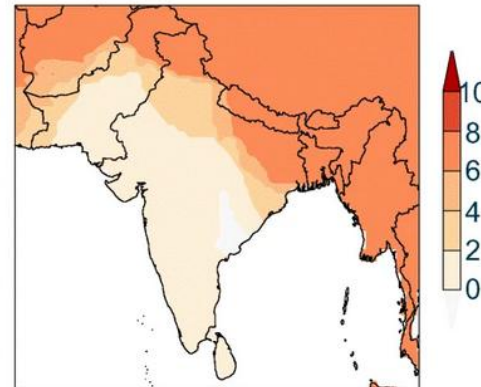
Gridded and interpolated data, based on a few stations only, or even no station data

Data set based on numerical model with observational data integrated → gives a much more realistic view of the situation

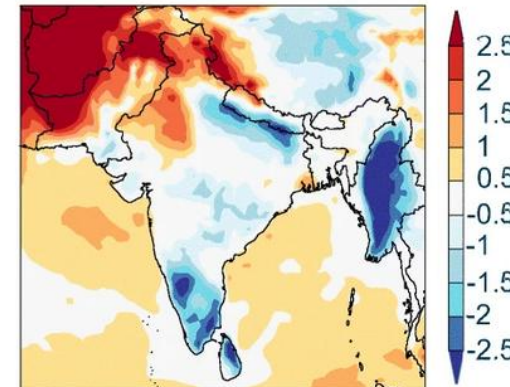
a Regression of CRU TS 4.01 Tmax on May smoothed GMST 1979:2016



b Number of stations in May CRU TS 4.01 Tmax 1979:2016



c Regression of ERA5 Tmax on May smoothed GMST 1979:2016



a Trend of May maximum temperature in South Asia 1979–2016 in the CRU TS 4.01 dataset. b Number of stations used to estimate the temperature at each grid point in CRU TS 4.01. c Trend of May maximum temperatures in the ERA5 reanalysis



Floods in India in May 2016

Current developments in extreme event attribution

- The **World Weather Attribution (WWA)** collaboration has over the last 5 years developed a methodology to answer these questions in a scientifically rigorous way in the immediate wake of the event when the information is most in demand. → 8 Step procedure (see exercises)
- Next step: **Extreme Event Impact Attribution** (as opposed to risk or probability)
 - The methods of extreme event attribution (EEA) that quantify the extent to which climate change affected specific recent extreme weather events in the past 20 years have been combined more recently with socio-economic impact data to quantify extreme weather's impacts attributable to climate change.
 - The EEIA “algorithm” can be divided into the EEA part (the climate science component) and the impact analysis (the socio-economic component, including potentially human and environmental impacts). The EEA component is used to determine the change in the probability or the intensity of a well-defined extreme weather event (e.g., the rainfall in a particular location and period) as a consequence of climate change. The impact part then links this change to the event's observed impacts (e.g., mortality associated with the event) to attribute a fraction of the total impact of the event to anthropogenic climate change causes.