

Attribution of weather and climate-related extreme events

Peter Stott, Myles Allen, Nikolaos Christidis, Martin Hoerling, Randall Dole, Chris Huntingford, Pardeep Pall, Judith Perwitz, Daithí Stone



Explaining extreme weather events in a changing climate

- What is the problem ?



Explaining extreme weather events in a changing climate

- What is the problem ?
- What do we propose ?



Explaining extreme weather events in a changing climate

- What is the problem ?
- What is the solution ?
- Is it possible ?



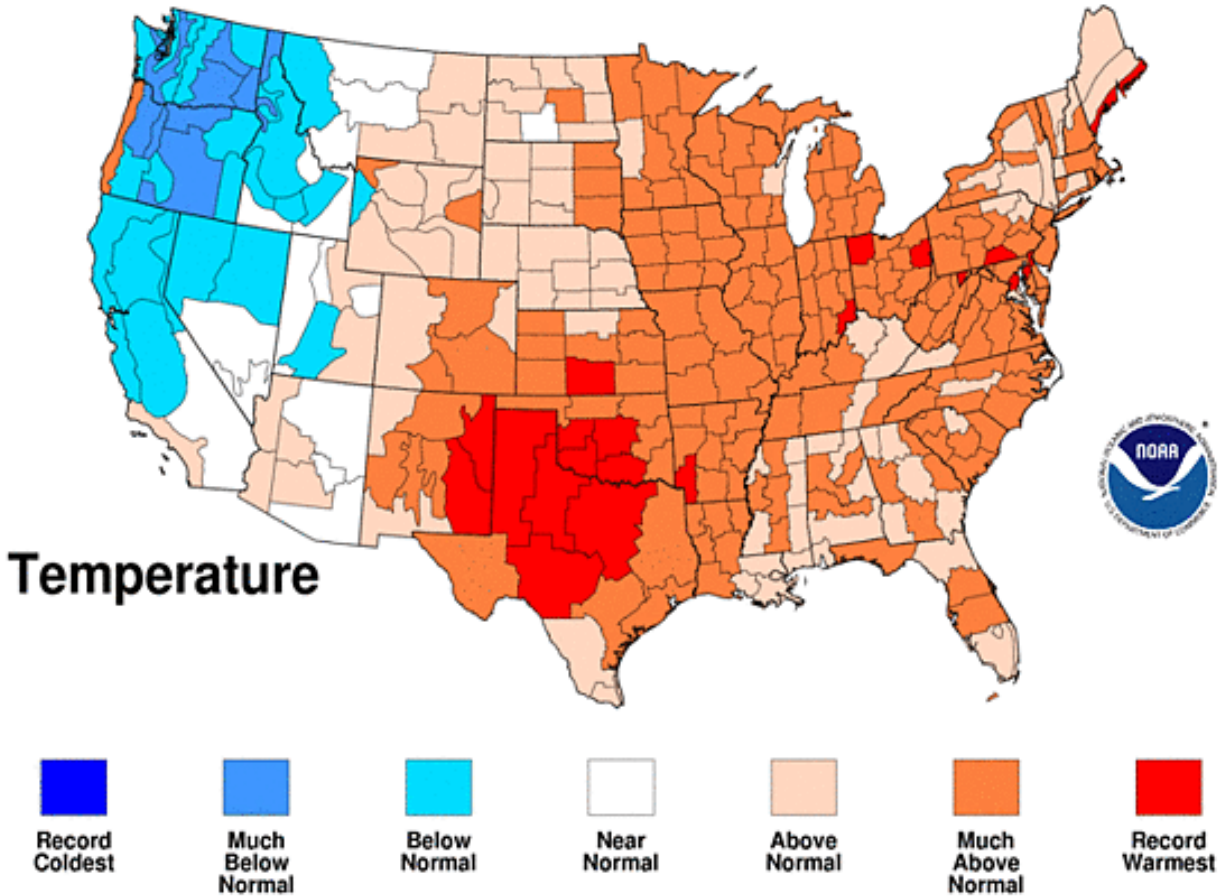
Explaining extreme weather events in a changing climate

- What is the problem ?
- What is the solution ?
- Is it possible ?
- What are the scientific challenges that need to be overcome to make this a reality ?



Jul 2011 Divisional Ranks

National Climatic Data Center/NESDIS/NOAA



Warmest months on record in Oklahoma and Texas



2010 Moscow beat previous record for July temperatures by 2.5°C

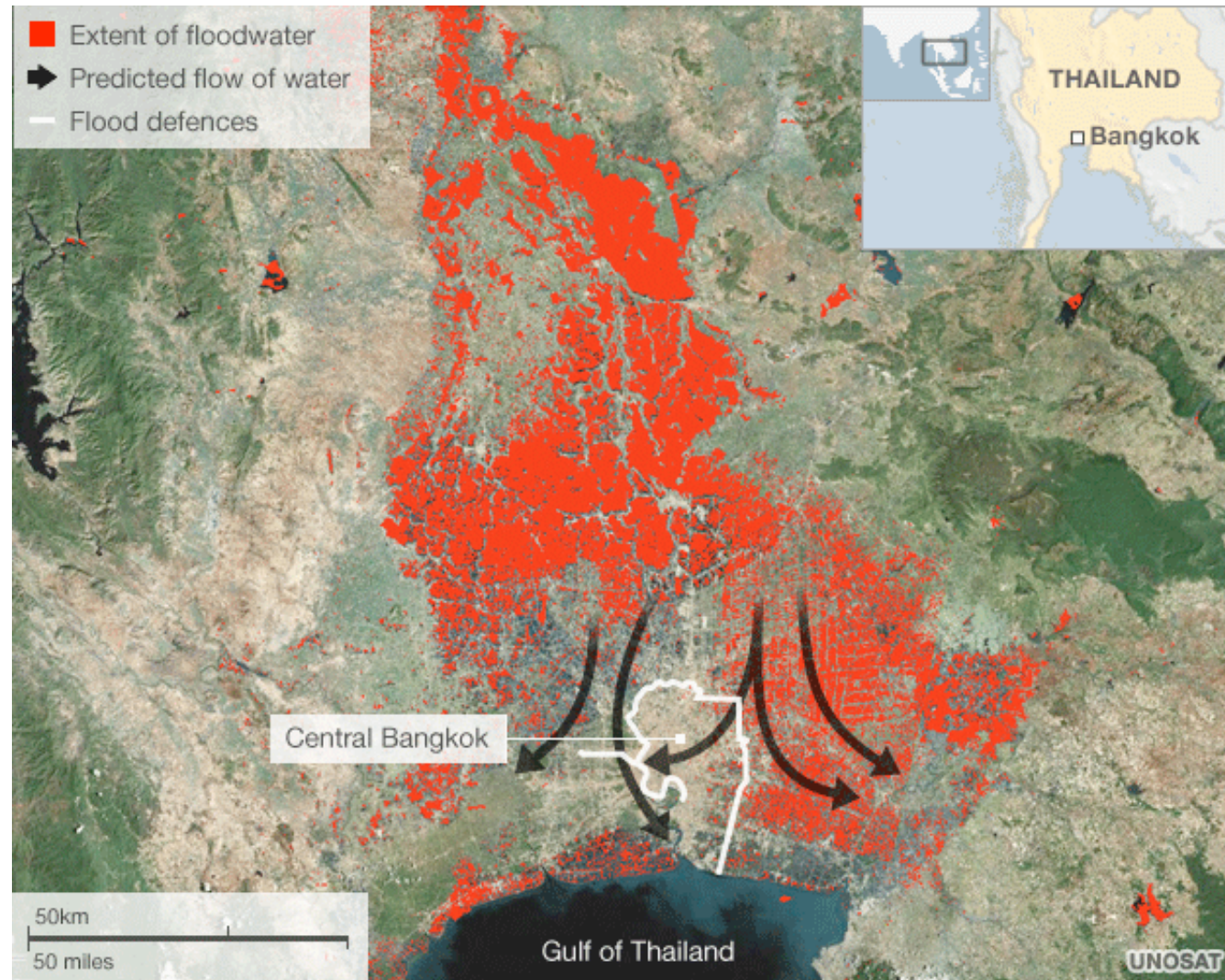




Record breaking 10.8 inches of rain fell in Peshawar, Pakistan during 24 hours in July 2010



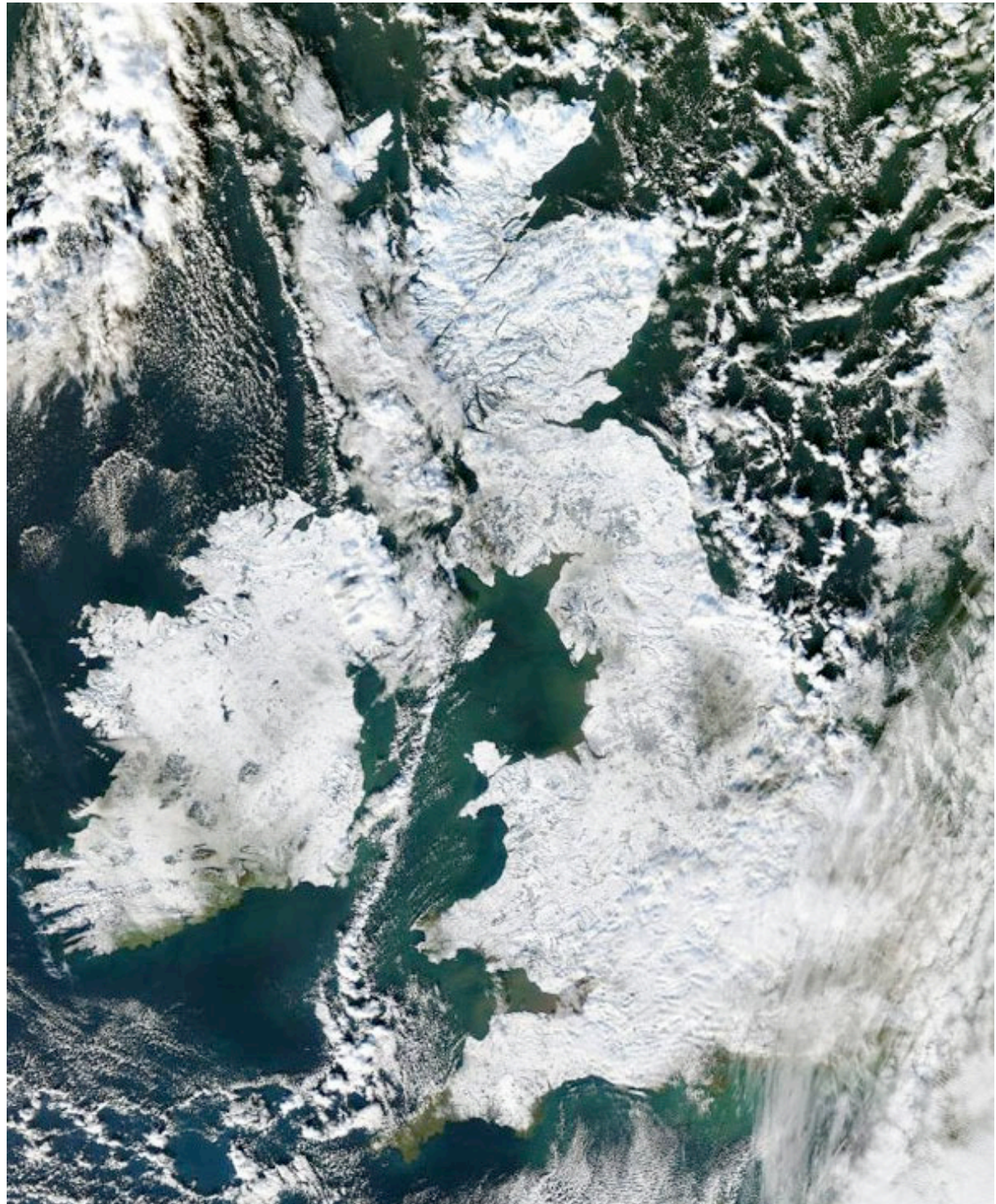
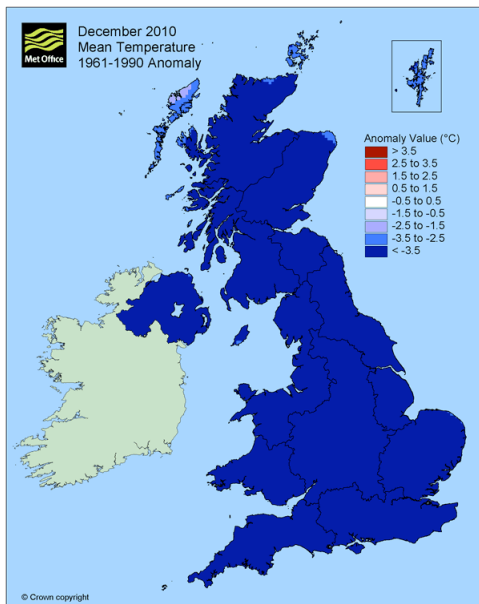
Thailand floods October 2011





British Isles
on
Christmas
Eve, 2010

December, 2010

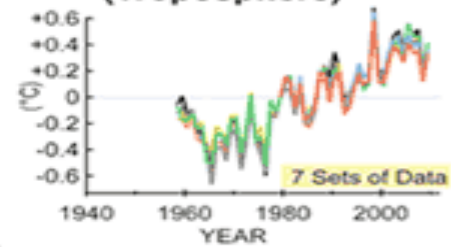




Explaining extreme weather events from a climate perspective

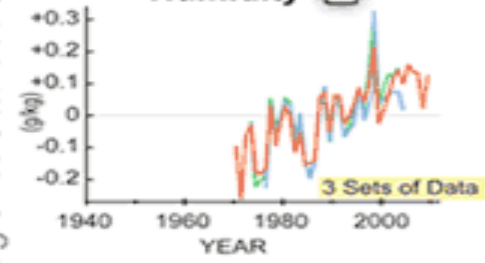


Air Temperature Near Surface (Troposphere) ↑

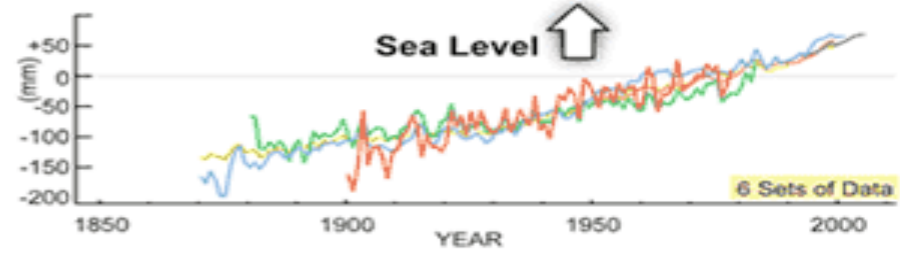
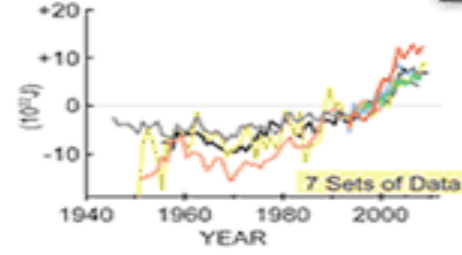


Change from Average

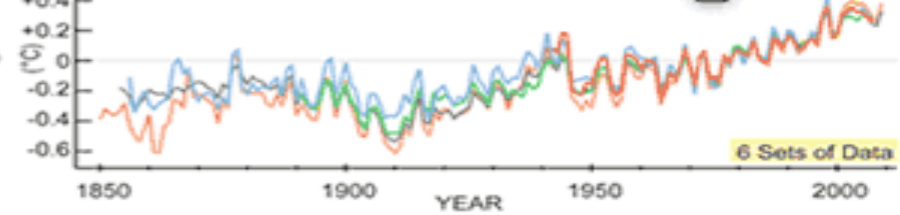
Specific Humidity ↑



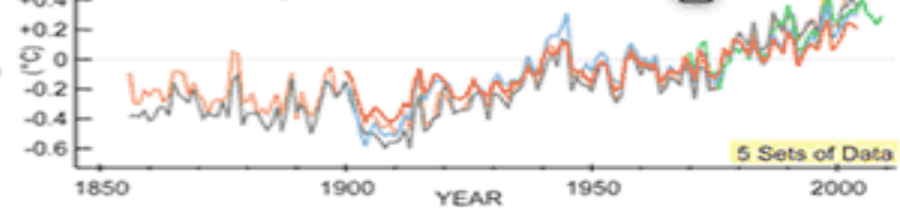
Ocean Heat Content ↑



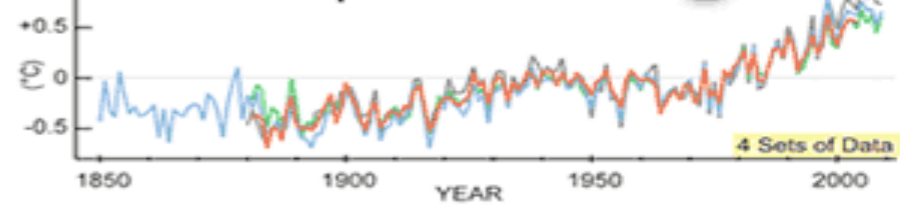
Sea-Surface Temperature ↑



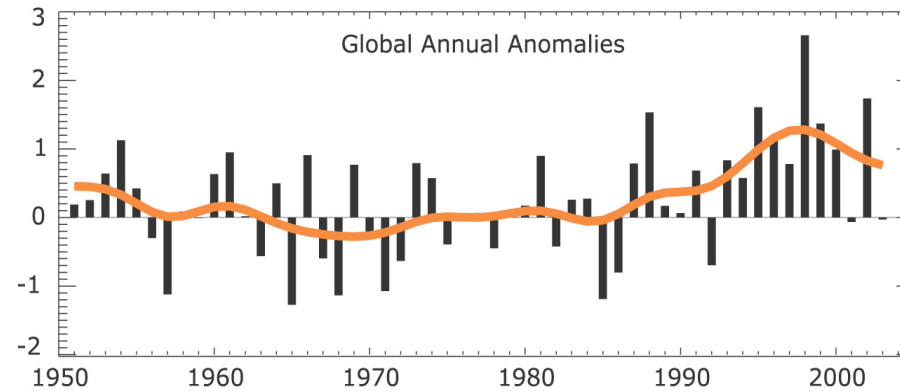
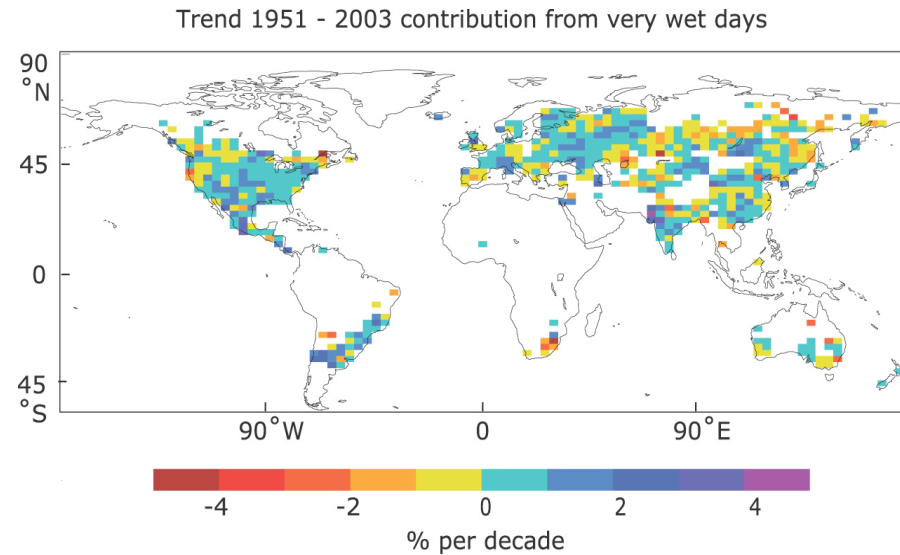
Temperature Over Oceans ↑



Land Surface Air Temperature Over Land ↑



“The frequency of heavy precipitation event has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour.” IPCC WGI AR4 SPM





But does this mean we can blame every extreme weather event on climate change ?

The risks of misattribution



Pakistan flooding, 2010



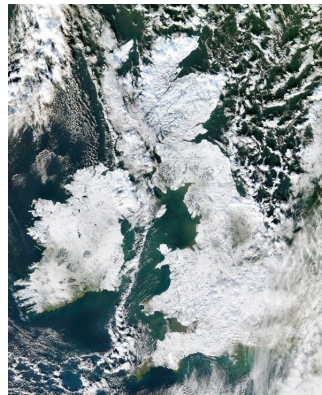
Moscow heatwave, 2010

- Consistent with the expected effects of climate change ?



UK flooding, July 2007

© Crown copyright Met Office



Cold winters, UK, 2009, 2010

The risks of misattribution



Pakistan flooding, 2010

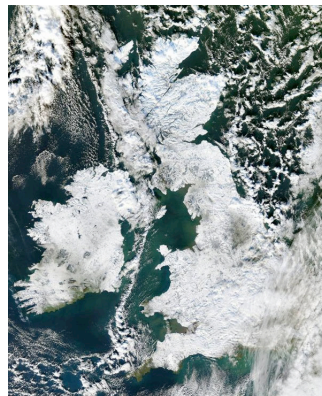


Moscow heatwave, 2010



UK flooding, July 2007

© Crown copyright Met Office



Cold winters, UK, 2009, 2010

- Consistent with the expected effects of climate change ?
- When we are uncertain whether some types of weather event could become less not more likely in future under continued climate change ?

The risks of misattribution



Pakistan flooding, 2010



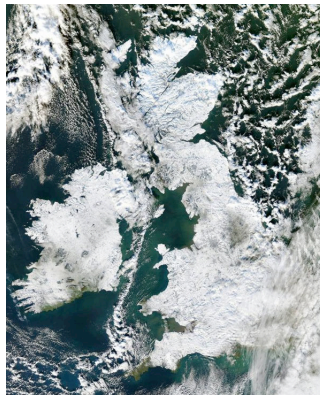
Moscow heatwave, 2010

- “It is not possible to attribute an individual weather event”



UK flooding, July 2007

© Crown copyright Met Office



Cold winters, UK, 2009, 2010

The risks of misattribution



Pakistan flooding, 2010



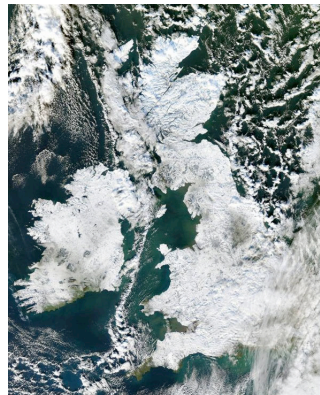
Moscow heatwave, 2010

- “It is not possible to attribute an individual weather event”
- But isn't climate change at least partially to blame for some of these events ?



UK flooding, July 2007

© Crown copyright Met Office



Cold winters, UK, 2009, 2010

The risks of misattribution



Pakistan flooding, 2010



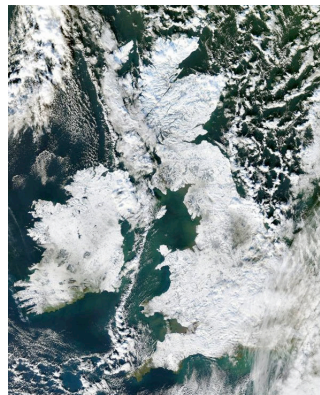
Moscow heatwave, 2010

- Mis-attribution can lead to public confusion and poor adaptation decisions



UK flooding, July 2007

© Crown copyright Met Office



Cold winters, UK, 2009, 2010



What do we propose ?



Regular attribution assessments

- Provide physically-based assessments of recent extreme weather and climate-related events



Regular attribution assessments

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- Would attribute user-relevant measures such as
 - The probability of the event (exceeding a critical threshold)
 - The magnitude of the event



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 - The magnitude of the event
- To anthropogenic and natural drivers



Regular attribution assessments

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- Would attribute user-relevant measures such as
 - The probability of the event (exceeding a critical threshold)
 - The magnitude of the event
- To anthropogenic and natural drivers
- Would need to be
 - Timely and regular
 - Scientifically robust and reliable
 - Authoritative



Is it possible to make an attribution statement about an individual weather event ?



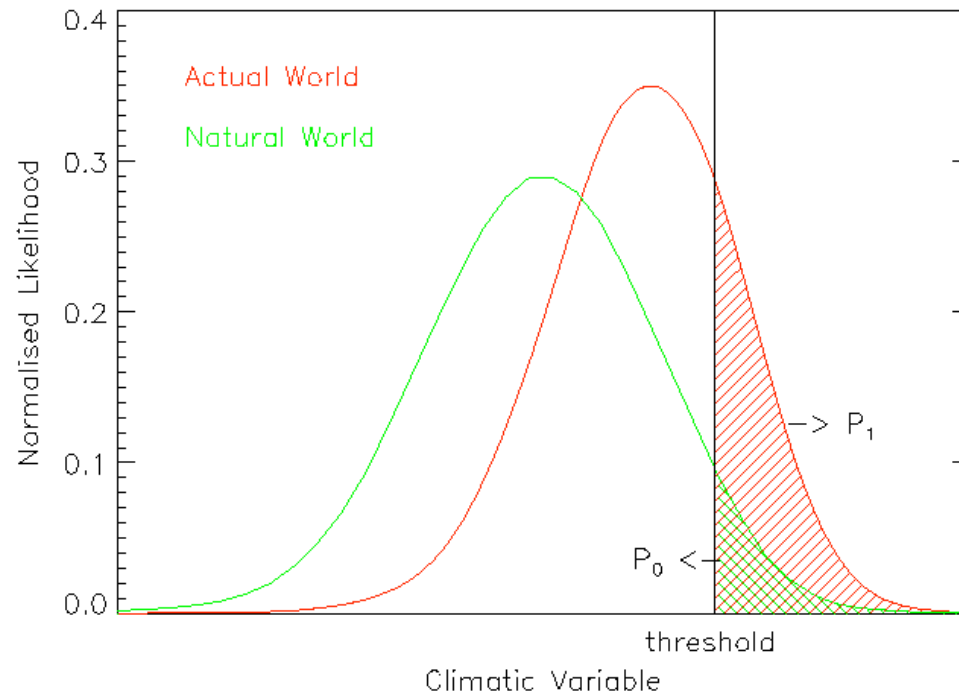
Studies in the literature show that it is :

- European heat wave of 2003
- The cold US of 2008
- Moscow heatwave of 2010
- Cold European winter 2009/2010
- UK flooding in 2000

Fraction of Attributable Risk

Fractional change in the likelihood of exceeding a temperature threshold attributable to a particular causal factor

(Allen, Nature, 2003)



P_0 : Probability of exceeding a threshold in the “world that might have been” (without that causal factor).

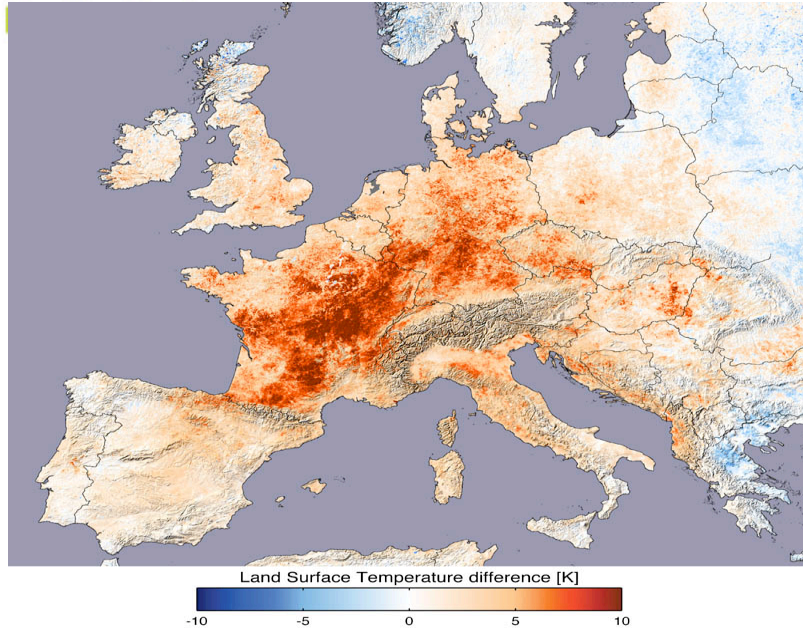
P_1 : Probability of exceeding a threshold in the actual world.

$$\text{FAR} = 1 - (P_0 / P_1)$$



Human contribution to the European heatwave of 2003

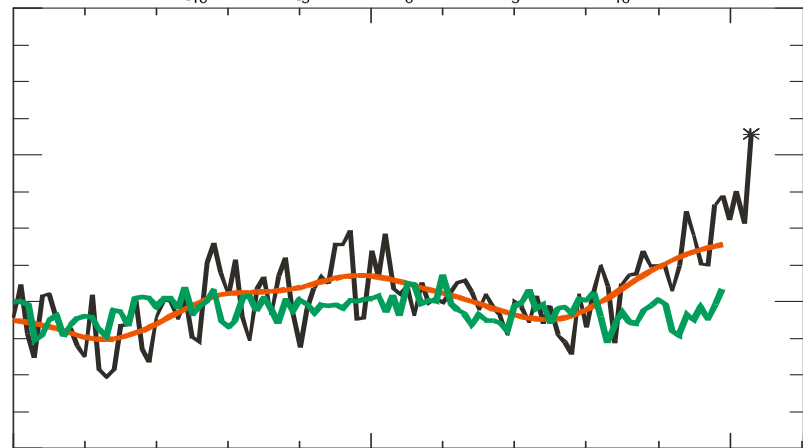
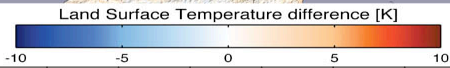
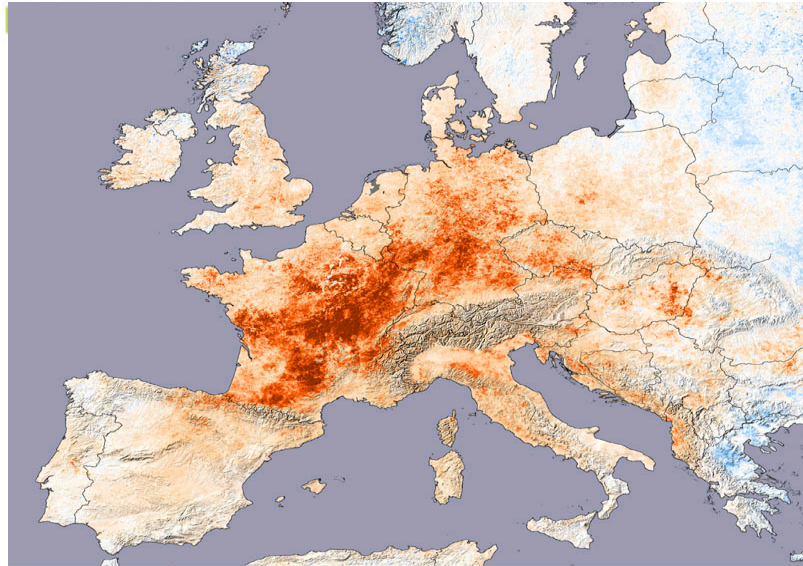
Stott et al, 2004





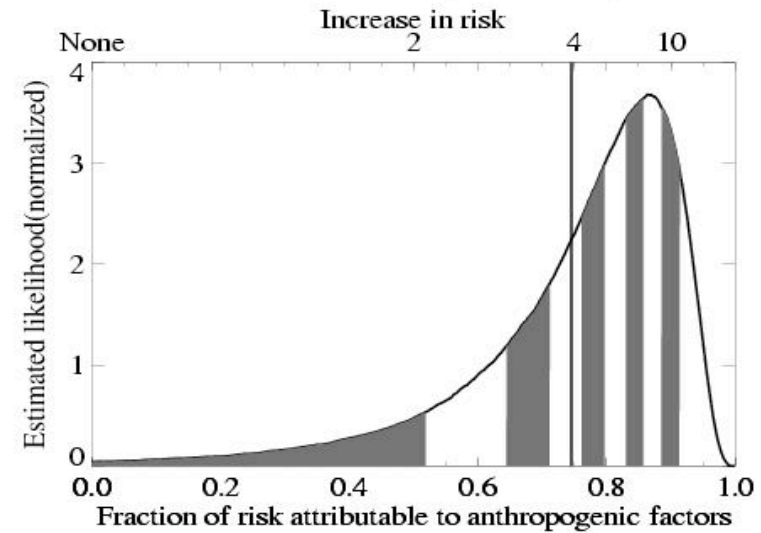
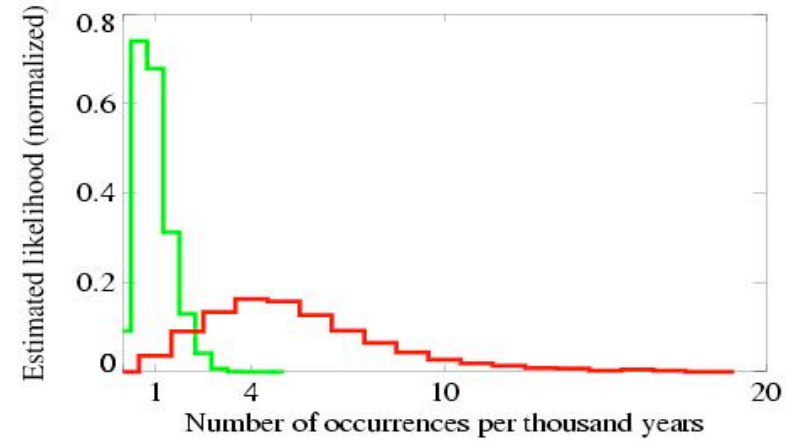
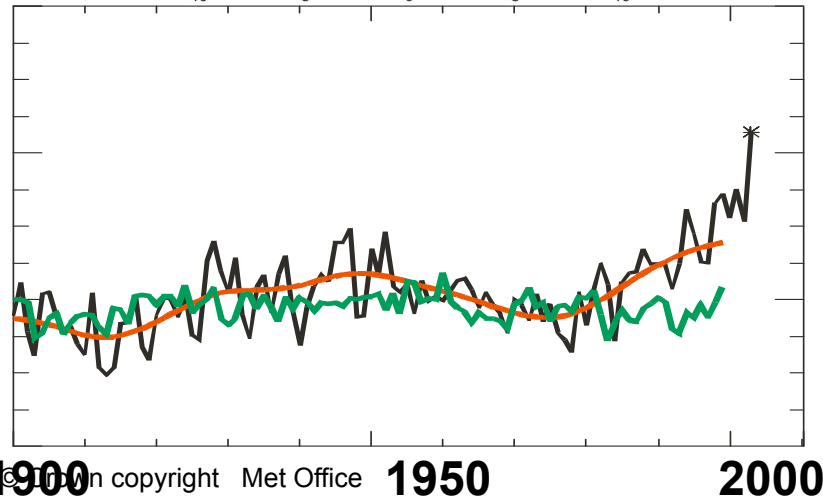
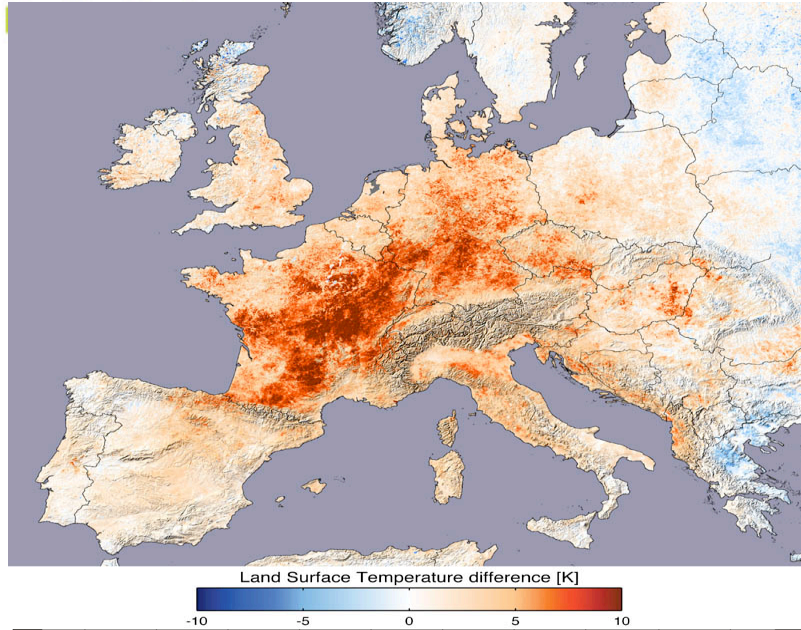
Human contribution to the European heatwave of 2003

Stott et al, 2004



© 2004 copyright Met Office 1900 1950 2000

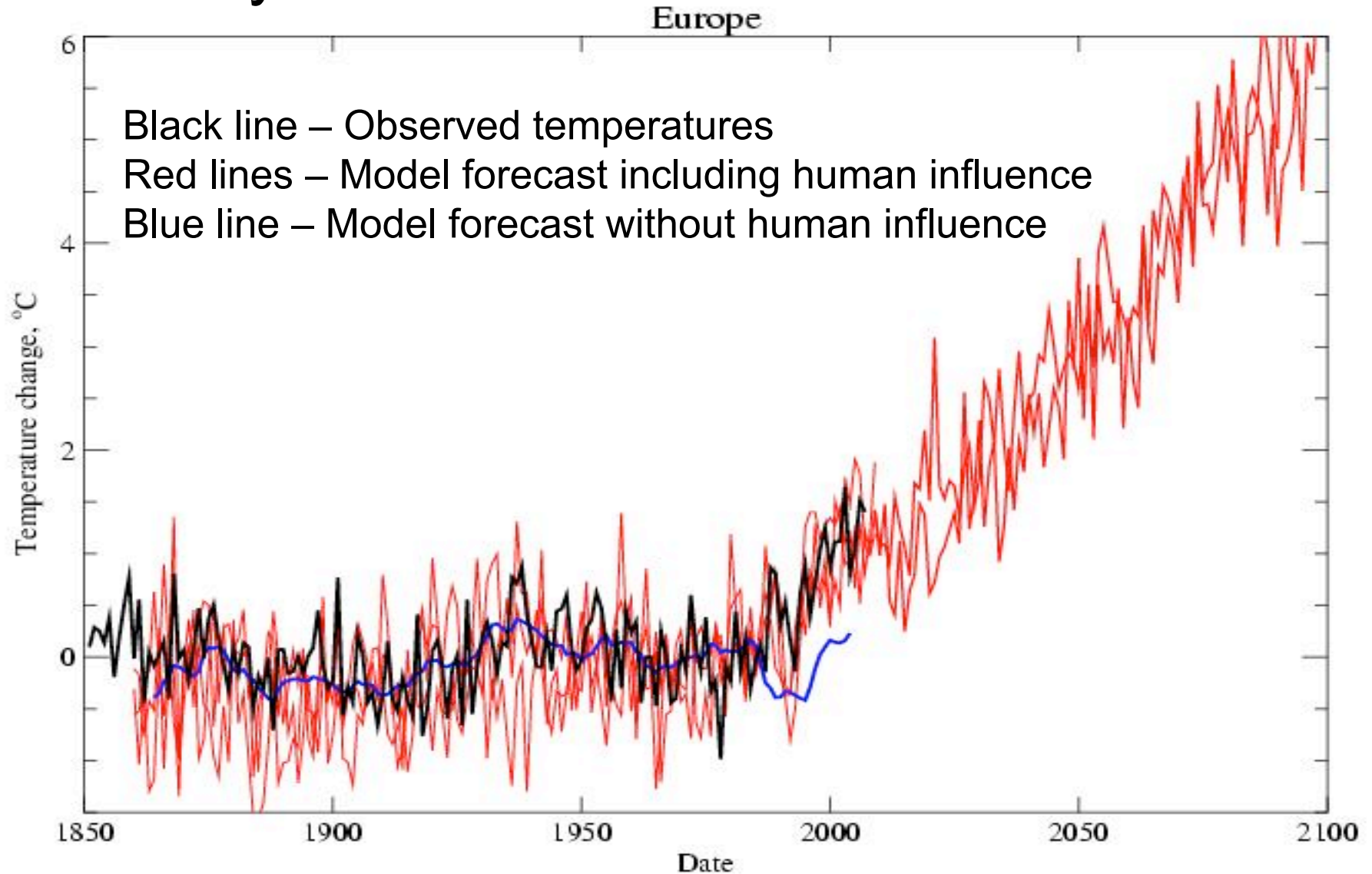
Human influence has very likely at least doubled the probability of European summer temperatures as hot as 2003



Stott, Stone, Allen, Nature 2004



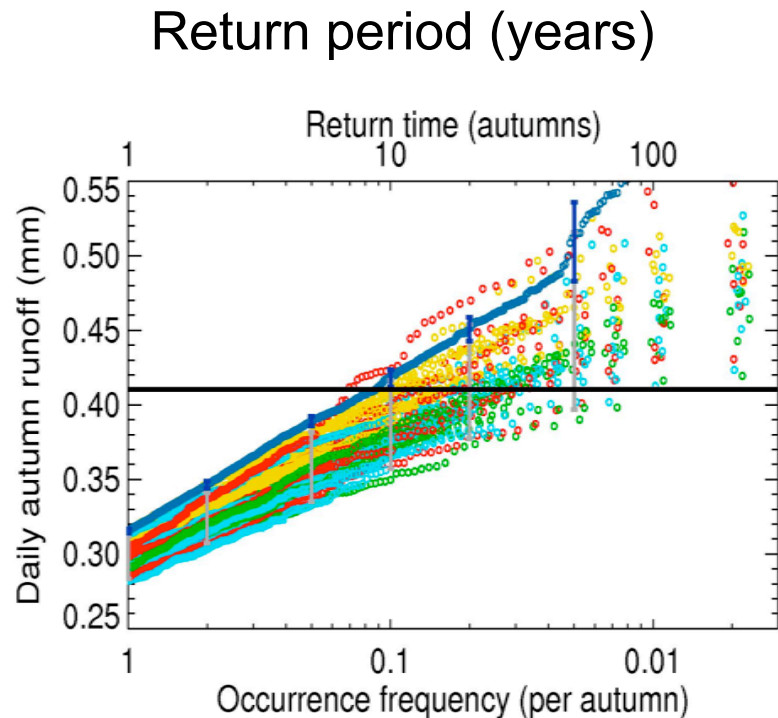
The European summers of 2003 and 2006 could be normal by 2040 and cool by 2060





Anthropogenic greenhouse gas contribution to flood risk in England and Wales in Autumn 2000

Pall et al, Nature, 2011.



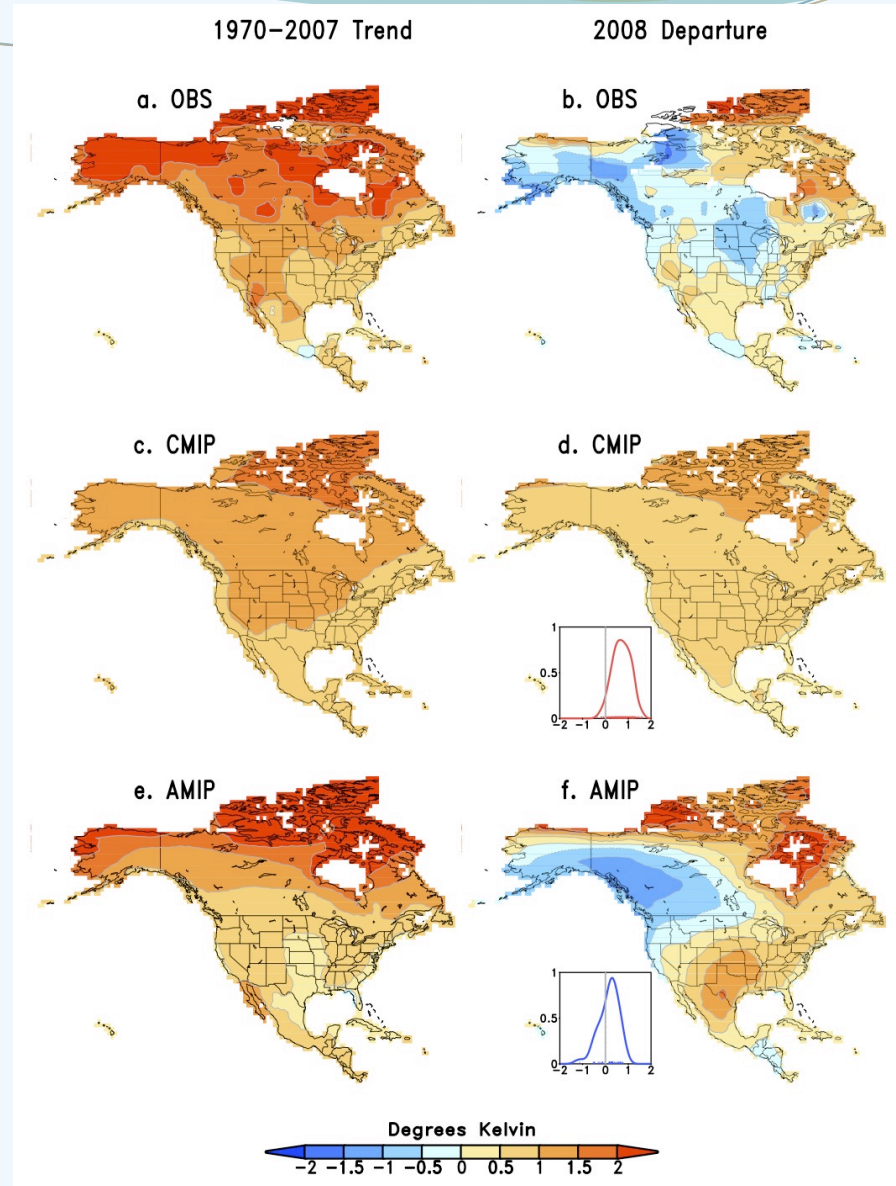
- The wettest autumn in England & Wales since records began in 1766

- In 9-out-of-10 cases our model results indicate 20th century anthropogenic greenhouse gas emissions increased England & Wales flood risk in Autumn 2000 by more than 20%, and in 2-out-of-3 cases by more than 90%.



A strong bout of natural cooling in 2008

Perlwitz et al. GRL, 2009

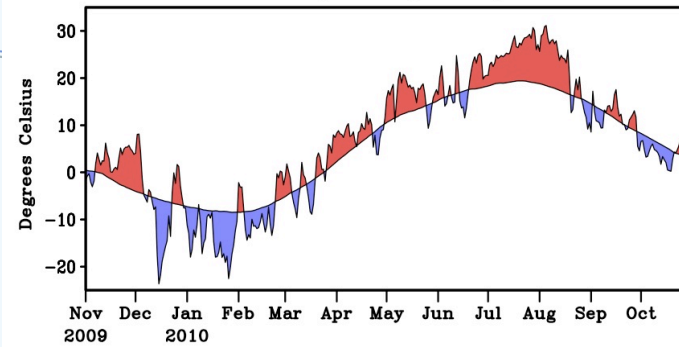




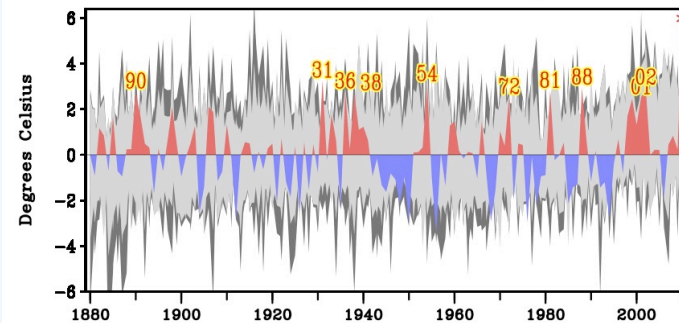
Was there a basis for anticipating the 2010 Russian heat wave?

Dole et al., GRL, 2011

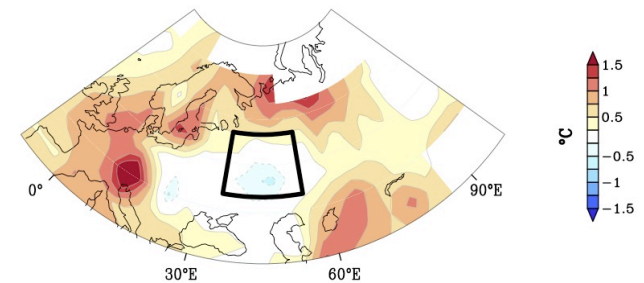
Moscow Daily Average Temperature



Western Russia July Surface Temperature

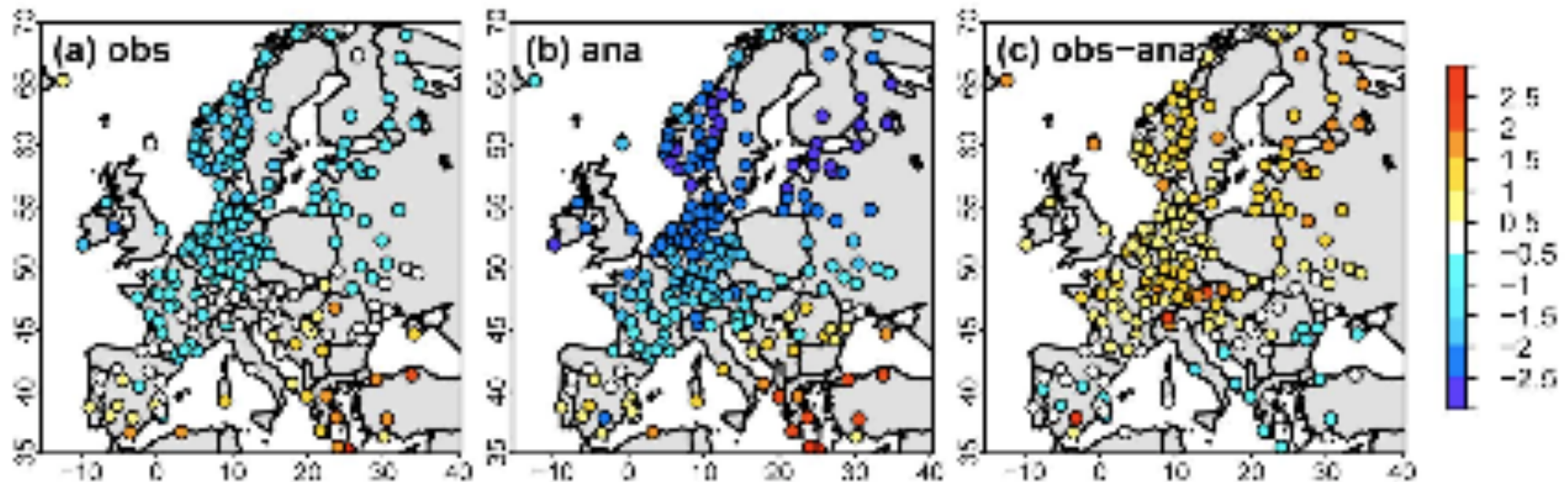


Surface Temp Trend: 1880-2009



European cold winter 2009/2010

A regional cold event mitigated by long term climate warming



Cattiaux et al, GRL, 2010



What are the challenges of providing regular, timely, and robust attribution assessments ?



Model fidelity

Attribution of Climate-related Events group (ACE)

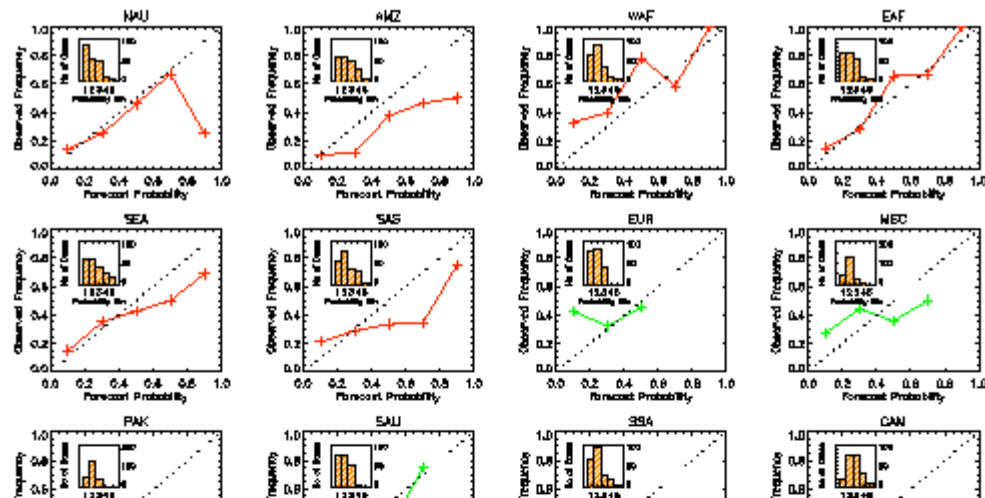
Workshop 17-18 August, 2010
Hosted by NOAA.
Supported by UKFCO.



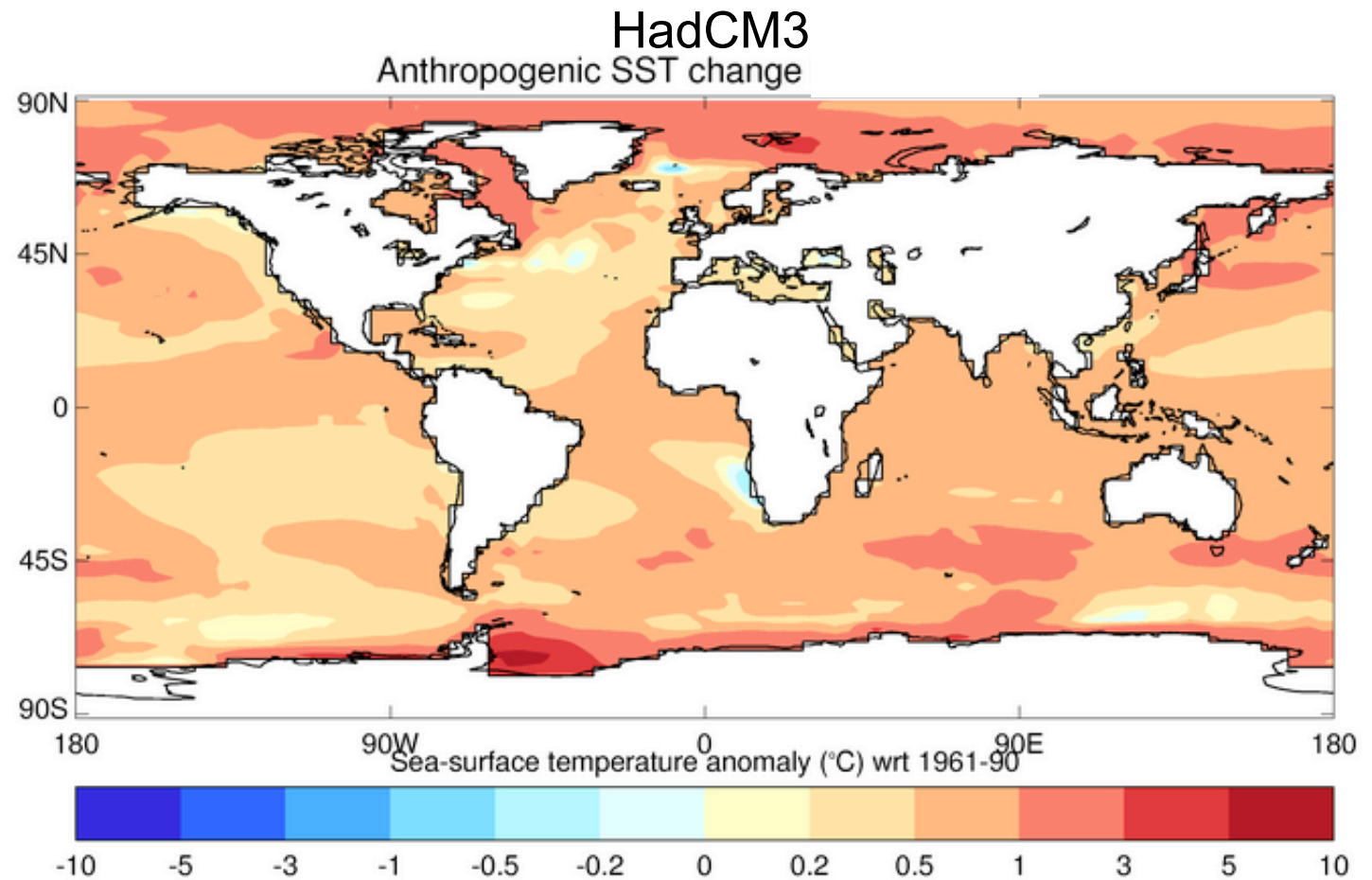
Development of a prototype Operational Attribution System

- HadGEM3-A based system
- Ensembles with observed SSTs
- Ensembles with anthropogenic component of SST change removed
- Part of ACE coordinated set of experiments also endorsed as key project by CLIVAR C20C

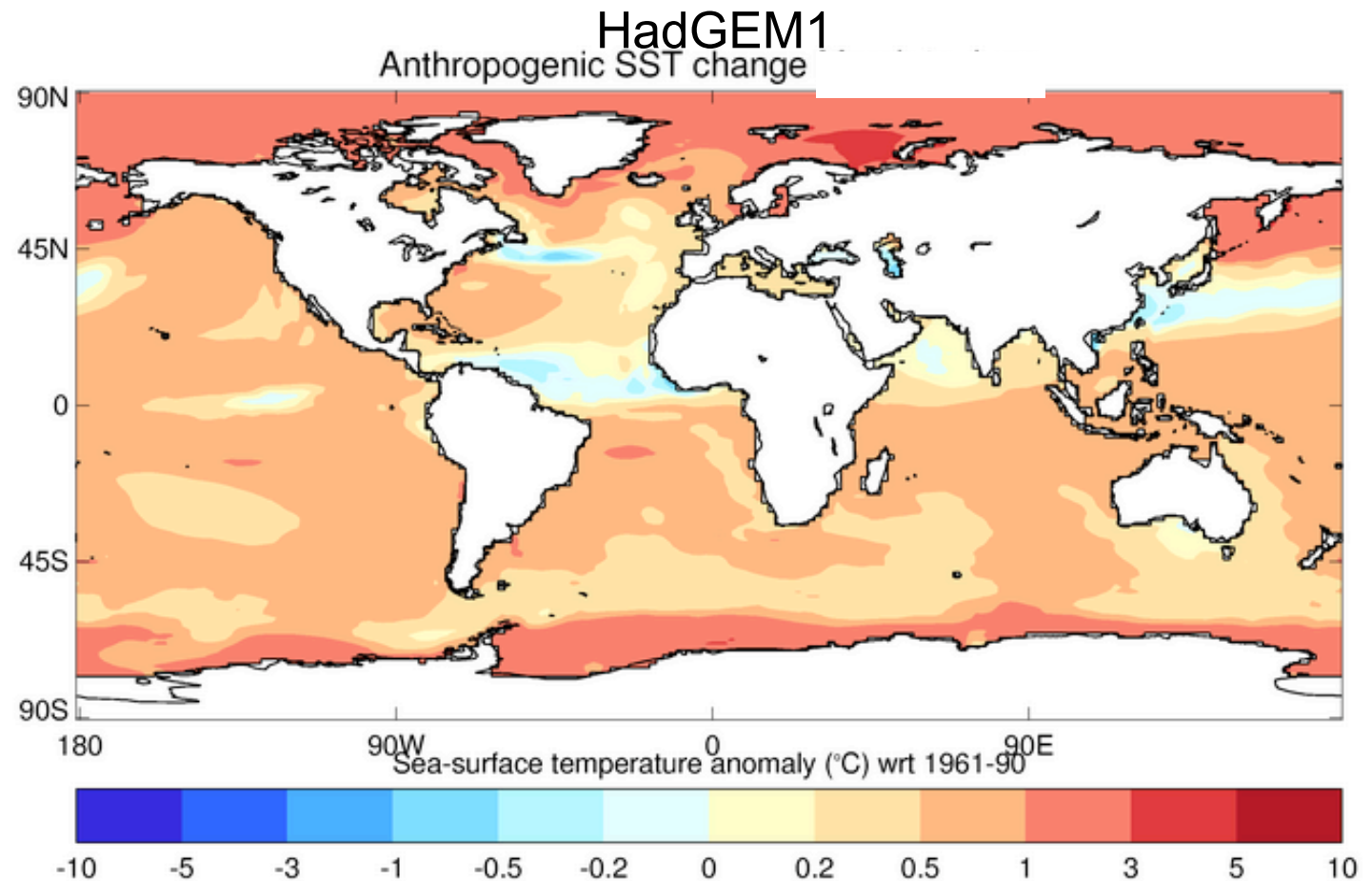
Development of reliability statistics for 1960-2010 hindcast period



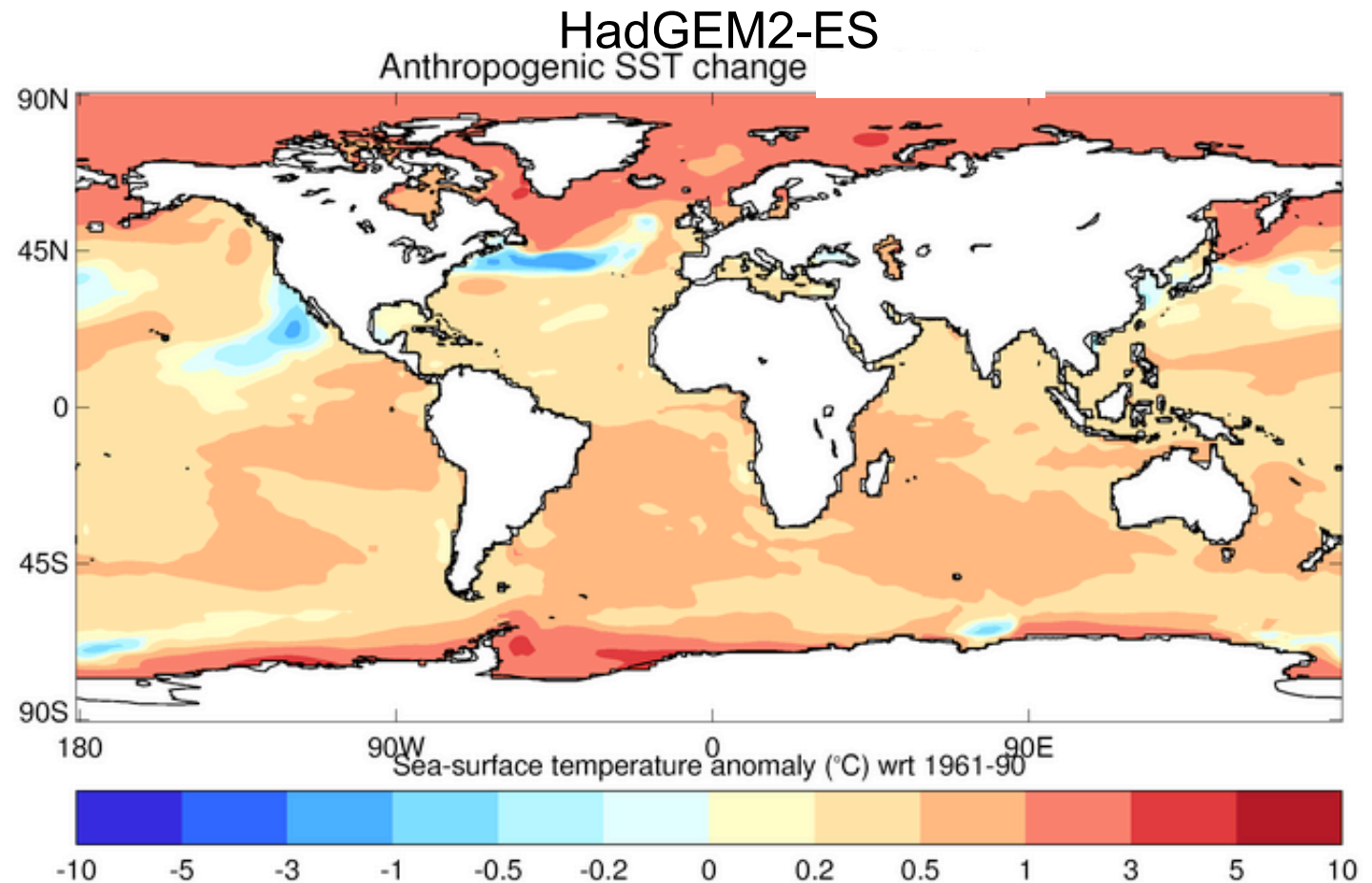
Remove anthropogenic component of sea surface temperature change



Remove anthropogenic component of sea surface temperature change



Remove anthropogenic component of sea surface temperature change





Importance of Model Reliability : Example of Pakistan Floods July 2010

Probability of getting higher rainfall than observed in 2010

P_0 : World that might have been

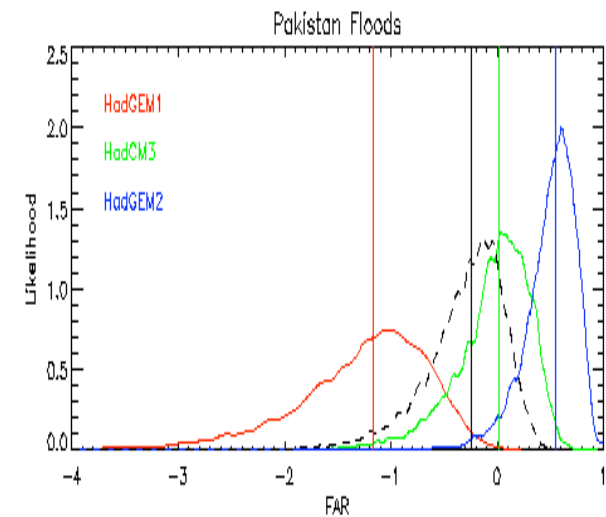
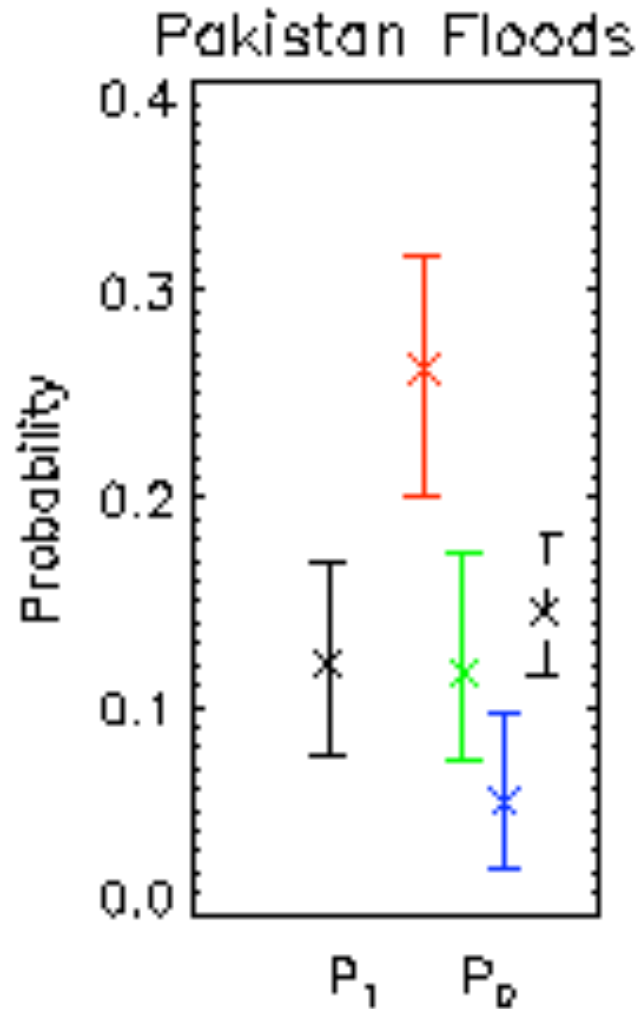
HadGEM1 SST change

HadCM3 SST change

HadGEM2 SST change

Convolution (dashed)

P_1 : Current World





Importance of Model Reliability : Example of Pakistan Floods July 2010

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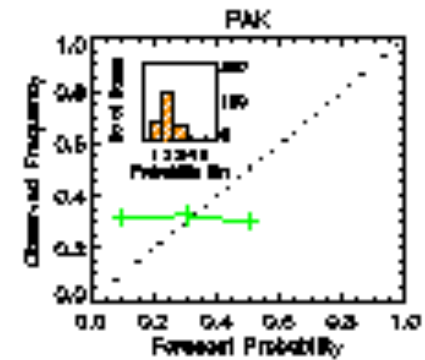
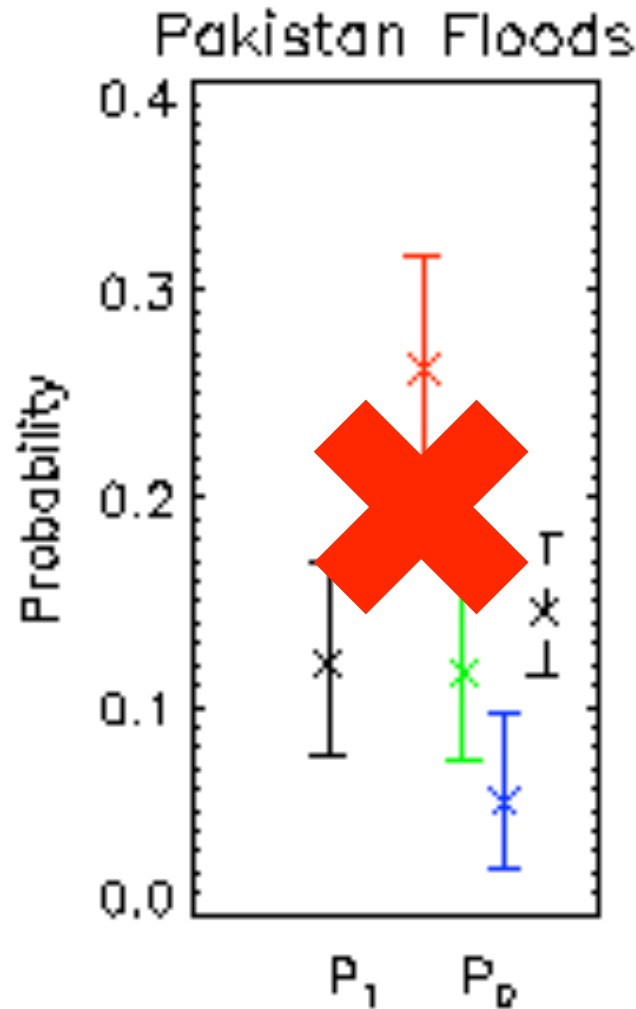
HadGEM1 SST change

HadCM3 SST change

HadGEM2 SST change

Convolution (dashed)

P_1 : Current World





Attribution of Climate-related Events (ACE)

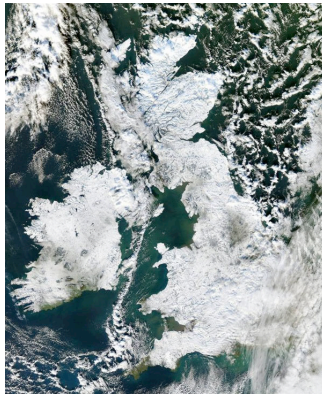
Lessons learned and future research needs to underpin an attribution service

- A clear definition of user requirements
- Clarity about question being asked
 - For example probability of exceeding a critical threshold vs magnitude of event
- Importance of timely and scientifically rigorous assessments
- Accurate and lengthy historical records
- Physical understanding to allow reliable statistical inferences
- Model verification
- Links to prediction



Relevance of attribution assessments of individual weather and climate-related events

Public interest



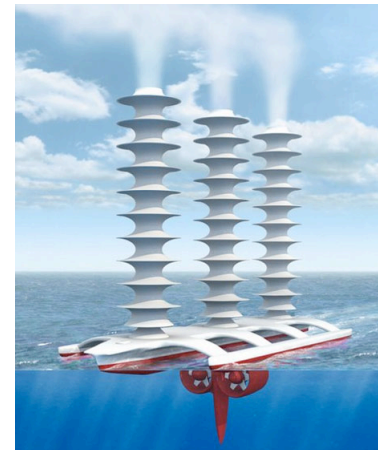
Adaptation



Litigation



Geoengineering





An attribution service providing authoritative attribution assessments of extreme weather and climate-related events

- “Climate scientists, too, have an obligation to provide answers to queries (or doubts) as to how global warming influences our weather.”
- “An attribution service with ample resources running in near real time, could prevent scientists’ answers to those questions seeming either too cautious or too speculative”.
- “The service’s broad integration into people’s daily lives .. would be a a good way to see greater acceptance of climate scientists’ actual services to society.”
- “Attribution is only as good as the models and statistics that power it” [Nature editorial, 8 September, 2011]
- There is much science to be done and a lot to gain from challenging our models and our understanding in this