Operational event attribution

Peter Stott, NCAR, 26 January, 2009
Events

August 2003

July 2007

January 2009

January 2009
Is global warming slowing down?
• Most of the observed increase in global average temperatures is very likely due to the observed increase in anthropogenic greenhouse gas concentrations.
Patterns of observed change in land precipitation attributable to anthropogenic forcing are consistent with projected changes in precipitation in future.

Detection and attribution to determine observational constraints on predictions eg Detection of human influence on zonal mean precipitation changes (Zhang et al, Nature, 2007)

Projected Patterns of Precipitation Changes

Drying of the sub-tropics and increases at high latitudes and near the equator.
Events still leave us floundering!

• A particular event such as a heatwave, a flood or a drought can prompt the response

• “It’s consistent with expected effects of climate change”

• “It is not possible to attribute an individual event”
Is it possible to make an attribution statement about an individual weather event?

\[ \text{FAR} = 1 - \frac{P_0}{P_1} \]

If the risk of a particular event has doubled as result of human influence

\[ \text{FAR} = 1 - \frac{1}{2} = 0.5 \]

Half the events can be blamed on human influence

Human influence has loaded the dice

See Allen, 2003, Nature

Stone and Allen, 2005, Climatic Change
Fraction Attributable Risk (FAR)

- Allen, 2003; Stone and Allen, 2005
Attribution of the European 2003 heatwave
Stott, Stone, Allen, 2004, Nature
Attribution of the European 2003 heatwave
Human influence has very likely at least doubled the risk of European summer temperatures as hot as 2003.

Stott, Stone, Allen, Nature 2004
Europe 2003

- France: 17 nuclear plants shut or reduced capacity
- EDF paid (€300m) 10 x normal rates to buy electricity on open market
- ...and £4.5bn missed retail sales
- estimated 900 people died in London
- 35,000 deaths overall in Europe

observation
Hadley prediction (Medium-High)
Europe 2003 and beyond

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

- Observations
- Hadley prediction (Medium-High)
"global warming ... is not at the present time happening" Nigel Lawson
Human influence, particularly emissions of greenhouse gases, has greatly increased the chance of having such warm years.

Although 2008 was slightly cooler than we would expect given current climate conditions, there is still a greater than 1 in 10 chance of a colder year than 2008. However, without any human influence on climate, we would estimate the odds of having a year as warm as observed this year to be less than 1 in 100.
Central England Temperature

2009 Anomaly so far is -1.42°C (relative to 1961-1990 mean)
1947 -2.97°C
1963 -4.37°C

A winter as cold as this year's so far is roughly a 1 in 20 year event but would have been roughly a 1 in 5 year event without human influence.
Operational event attribution

• There is a pressing requirement to improve how we put events in context of climate variability and change
  • Eg Global temperatures, Arctic sea ice
• An event attribution system needs to be regular, objective, quantitative
  • Pre-Agreed methodology, not post hoc
  • Couched in probabilistic terms
• Considerable scientific challenges remain to quantify change of risk of events
  • Eg very large uncertainties in influence of forcings at regional scales – aerosols, land use etc
  • Need to account for model biases
• Need for robust statements in face of uncertainty
  • Relative risks are likely to be easier to quantify than absolute risks
Need to better understand influence of forcings on climate response

Observations / T5max

HadGEM1 LU / T5max

T5max Timeseries
Quantifying change in risk could be easier than absolute risk
Robust statements in face of uncertainty

Using a threshold for mean summer temperature that was exceeded in 2003, but in no other year since the start of the instrumental record in 1851, we estimate it is very likely (confidence level > 90%) that human influence has at least doubled the risk of heatwaves exceeding this threshold magnitude. (Stott, Stone and Allen, 2004)
Climate services

• Monitoring : What happened ?

• Attribution : Why did it happen ?

• What is likely to happen next ?
Seasonal forecasts:
What is “normal” and how is “normal” changing?

• Winter 2008/9 (Released 22 December, 2008)

• Temperature
  • UK mean temperatures are likely to be below average in January and nearer average in February. Mean temperatures for other parts of Europe during the rest of winter are more likely to be near average, but near or above average in south-east Europe.

• Rainfall
  • Precipitation for the remainder of winter is more likely to be average, or below average over much of Europe, including the UK. However, above-average precipitation is favoured over parts of south-eastern Europe.

•Forecasts are expressed as variations from 1971-2000 averages.
BAMS proposal

- Abstract of < 250 words summarising article
- Additional paragraph of < 250 words explaining
  - Intended purpose of article
  - Set out why we need an operational attribution system
  - Set out the research needs to deliver such a capability
  - Factors making article timely/important for BAMS readers
    - Operational attribution systems urgently required to underpin expensive adaptation decisions
- Length
  - 4500 words (average length of articles)
  - 6 illustrations
Why we need a system for timely and reliable attribution service
• Core component of climate service; monitoring, attribution, prediction
• User needs – some examples meteorologically based, illustrative
• 2003 heatwave, SW drought (Milly et al, Barnett et al), 2007 Arctic sea ice, Murray Darling basin. Scale issue (Marty) to computing needs. People
• At end – strategy eg international annual assessment in state of climate. Persistent experimentation.
• EOS summary. Marty Kevin, Peter, Myles
• We need attribution service for adaptation agenda
  • Pace of system drives what we need to cope with
• Attribution of events
• Seasonal forecasting and predictability
• Understanding observed trends is complement to decadal forecasts
• MOHC glossy ?)
• Seasonal prediction angle – record tornados season 2008
• What do we mean by event by climate?
• General principles
  • Consistent use of terminology; authoritative voice
  • Regular, for set of pre-defined events specified before they occur
  • Robust
  • Quantify changes in risks (likely to be easier than quantifying absolute risk)
• Modelling strategies
  • Ensembles of simulations with and without combinations of radiative forcings, SSTs to quantify contributions of different components to observed changes
  • Coupled model (eg Stott et al, 2004), Changes in Extreme value stats
Why we need a system for timely and reliable attribution service
- Core component of climate service; monitoring, attribution, prediction
- User needs – some examples meteorologically based, illustrative
- At end – strategy eg international annual assessment in state of climate. Persistent experimentation.
- Seasonal prediction angle – record tornados season 2008
- What do we mean by event by climate?
- 2003 heatwave (Peter)
  - Coupled model
- Europe rainfall (Pall et al)
- SW drought (Milly et al, Barnett et al), Marty’s stuff
- 2007 Arctic sea ice (Clara), attribution when
- Murray Darling basin (david),
- Scale issue (Marty) to computing needs. People
- General principles
  - Consistent use of terminology; authoritative voice
  - Regular, for set of pre-defined events specified before they occur
  - Robust
  - Quantify changes in risks (likely to be easier than quantifying absolute risk)
- Strategies; experimental design
  - Obsnal reqts
  - Ensembles of simulations with and without combinations of radiative forcings, SSTs to quantify contributions of different components to observed changes

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CHull (SWU) 2004 Ghi ET AL
The European summers of 2003 and 2006 could be normal by 2040 and cool by 2060

Black line – Observed temperatures
Red lines – Model forecast including human influence
Blue line – Model forecast without human influence

HadGEM1
Change in observational methodology
Start of satellite observations

HadGEM1 is consistent with observed variability and trend; Ridley et al., Pers. Comm.
Christidis et al, 2008, J. Climate Submitted

Surface Temperature

- WNA: 0.14
- CNA: 0.016
- ENA: -0.6
- NEU: 0.05
- MED: 0.042
- SAS: 0.13
- PAC: 0.057
- ATL: 0.05
- TOTAL OBSERVATIONAL AREA: 0.075
- NAU: 0.088
- SAU: 0.14
Risk based analysis
Summer temperature changes in UK city

June / July / August temperature rise (deg C)

Relative likelihood (%)
Climate forecasts for the near future

Recent global atmospheric wind, rain, solar heating etc

Ocean observations
Including ARGO floats

Sea Surface Temperature

Seasonal forecast

Decadal forecast

Development of 2005 weak La Niña predicted

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Requirement to do more

- The Global Climate Observing System has prepared an action plan in response to a request of the Conference of the Parties to the UNFCCC “Without urgent action and clear commitment of additional resources…the Parties will lack the information necessary to effectively plan for and manage their response to Climate Change.”

- Better real-time information is required on the links between observed weather events and the effects of natural climate variability and anthropogenic climate change.
Climate services

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- Attribution: Why did it happen?
- What is likely to happen next?