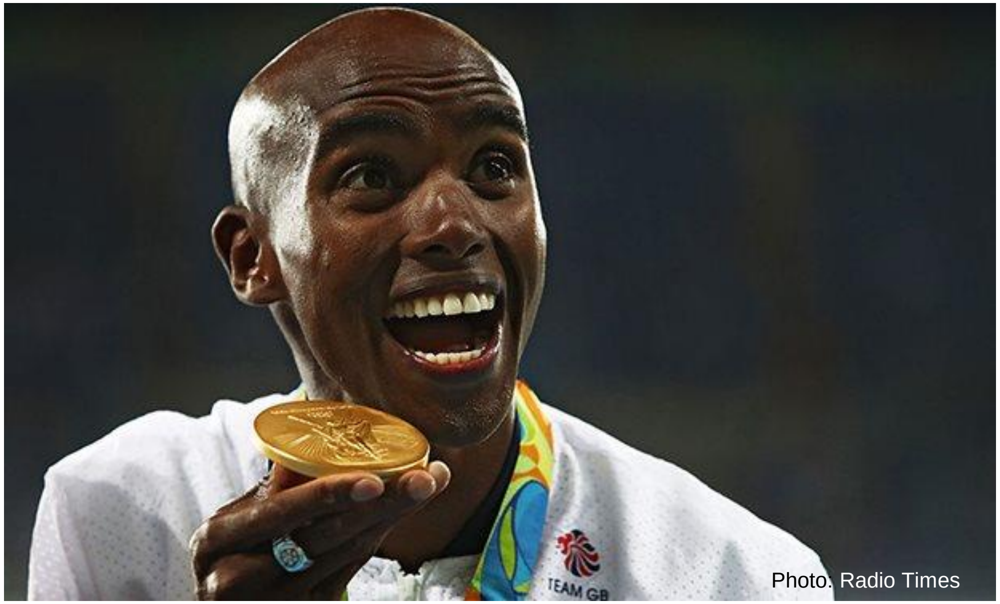
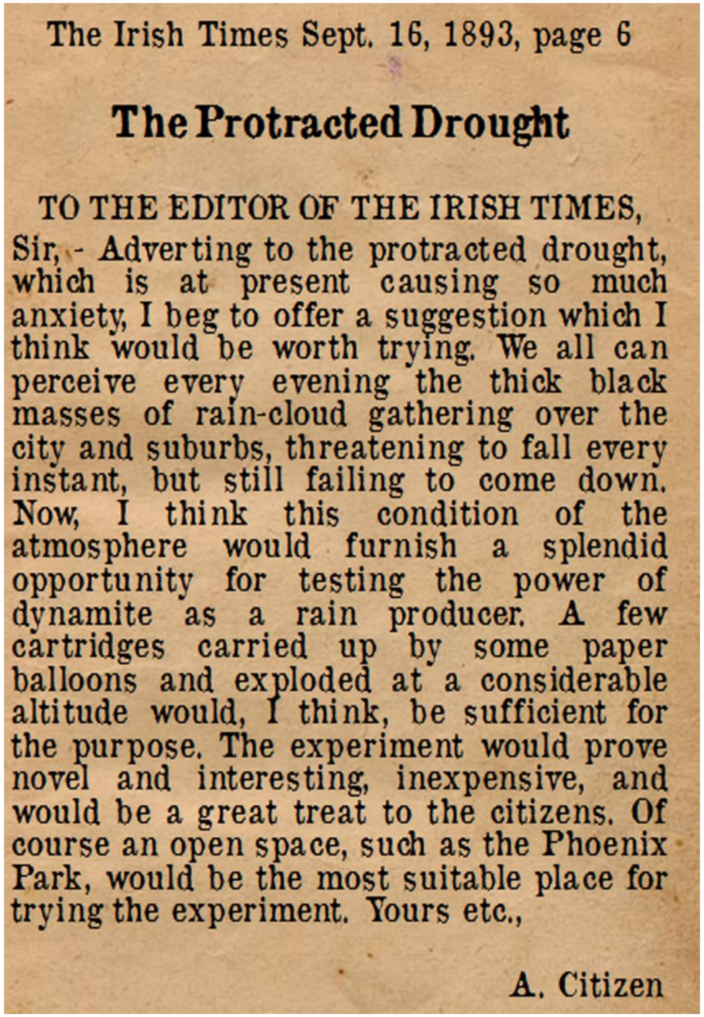
Taking a long-term view of climate and water: Understanding risk and adaptation outcomes



Rob Wilby, Department of Geography, Loughborough University, UK

Looking backwards (centuries)



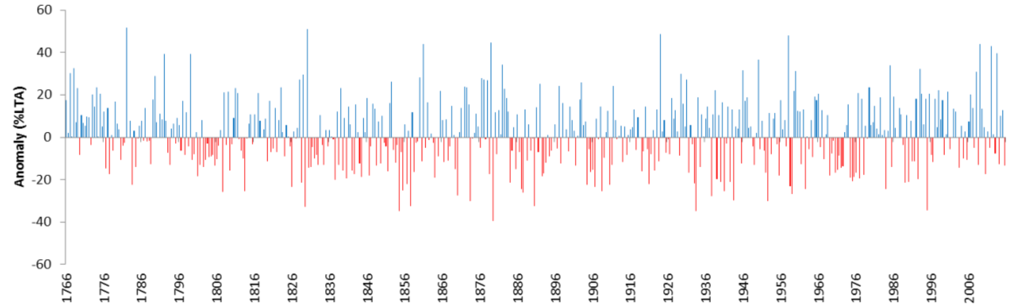
The Irish Times Sept. 16, 1893, page 6

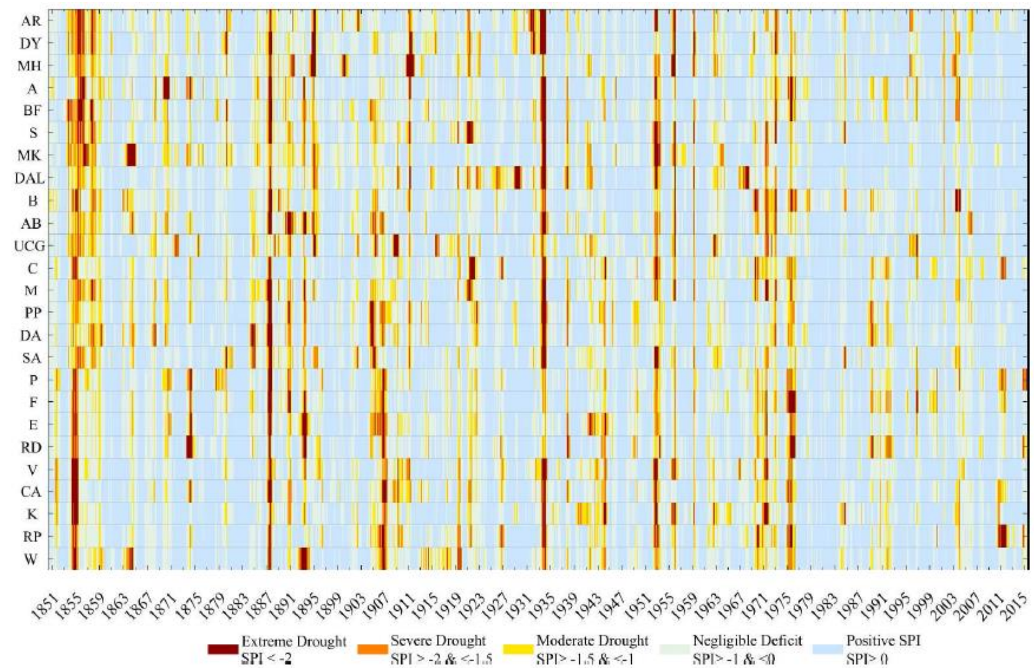
The Protracted Drought

TO THE EDITOR OF THE IRISH TIMES,

Sir, - Adverting to the protracted drought, which is at present causing so much anxiety, I beg to offer a suggestion which I think would be worth trying. We all can perceive every evening the thick black masses of rain-cloud gathering over the city and suburbs, threatening to fall every instant, but still failing to come down. Now, I think this condition of the atmosphere would furnish a splendid opportunity for testing the power of dynamite as a rain producer. A few cartridges carried up by some paper balloons and exploded at a considerable altitude would, I think, be sufficient for the purpose. The experiment would prove novel and interesting, inexpensive, and would be a great treat to the citizens. Of course an open space, such as the Phoenix Park, would be the most suitable place for trying the experiment. Yours etc.,

A. Citizen





The 'DNA' of drought in the island of Ireland 1765-2015. Source: Noone et al. (under revision)

Looking forwards (centuries)

Phase 1 : Consent, design, construction (~10 years)

Phase 2 : Operational power plant (~60 years)

Phase 3 : Decommissioning (~20 years)

Phase 4 : Storage of spent fuel (~80 years)

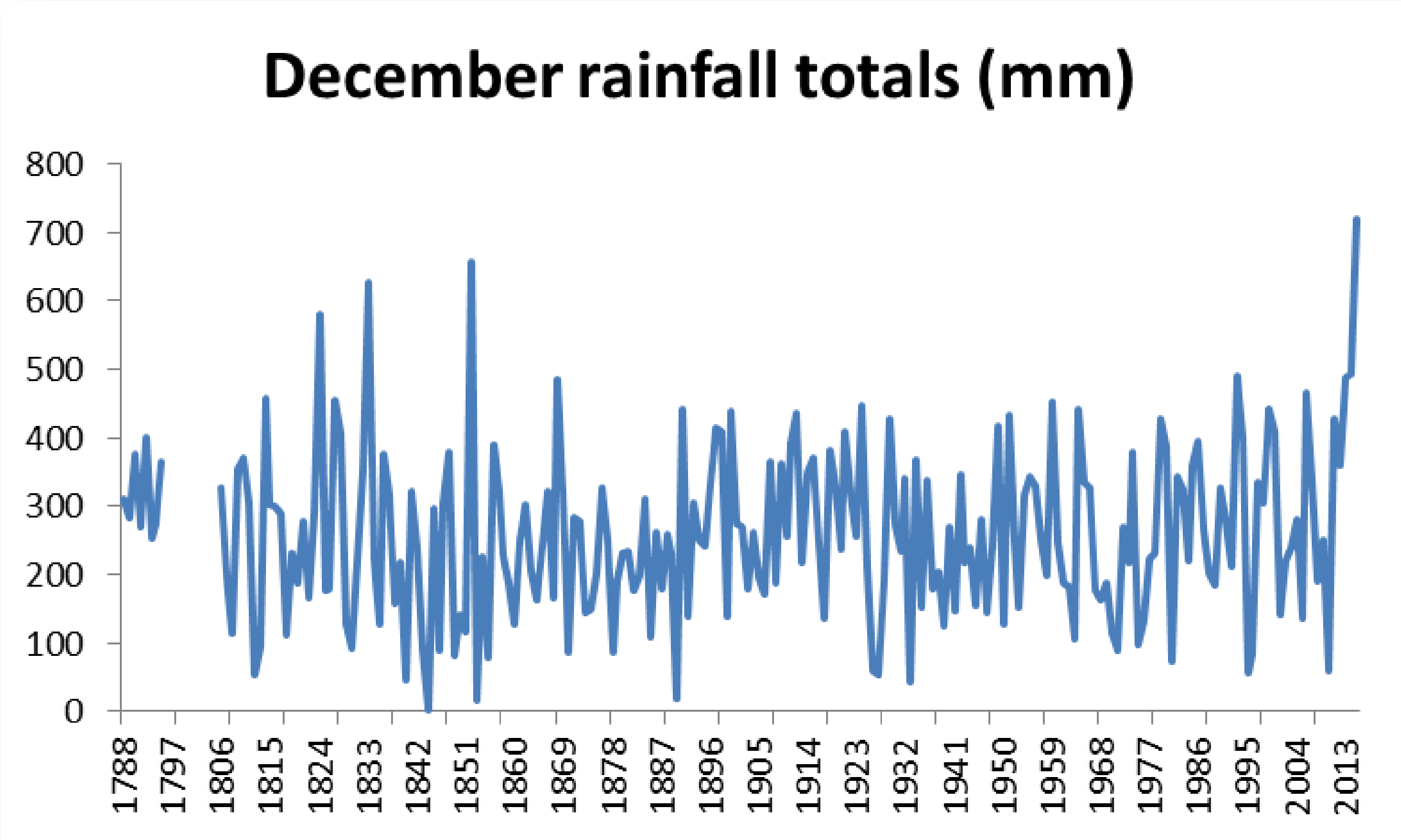
~2190s

Wilby et al. (2011) *ICE*

Part I – Understanding risks

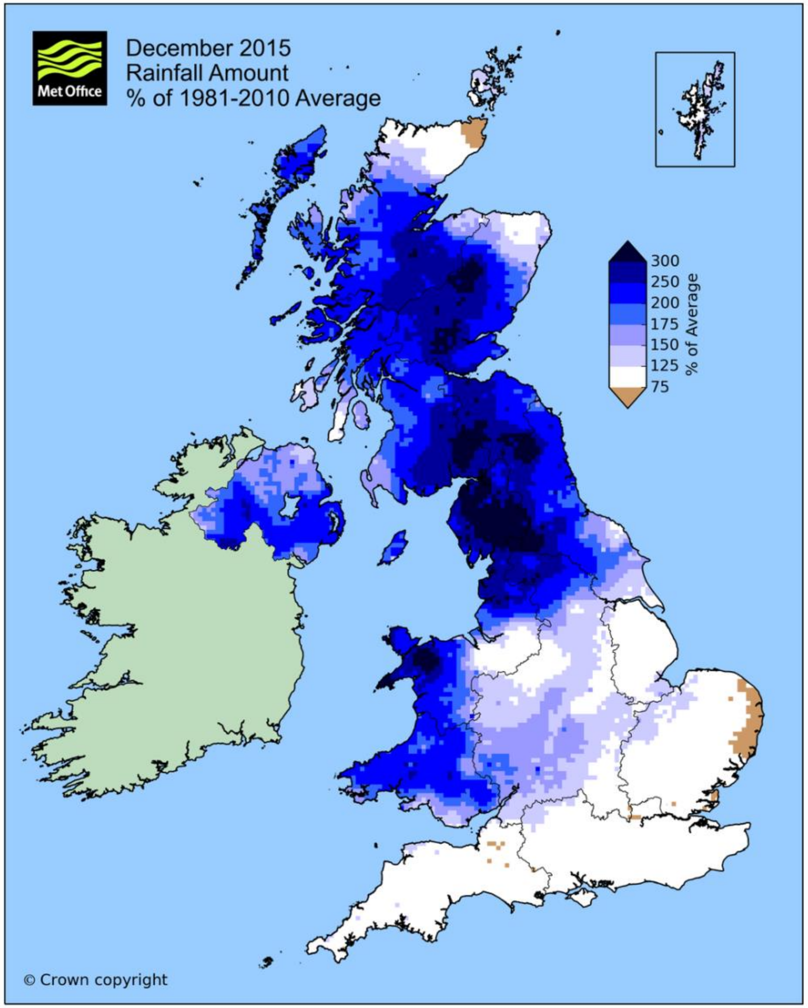
Carlisle civic centre. Photo: Rose and Trev Clough

Central English Lake District (CELD) rainfall series 1788-2016



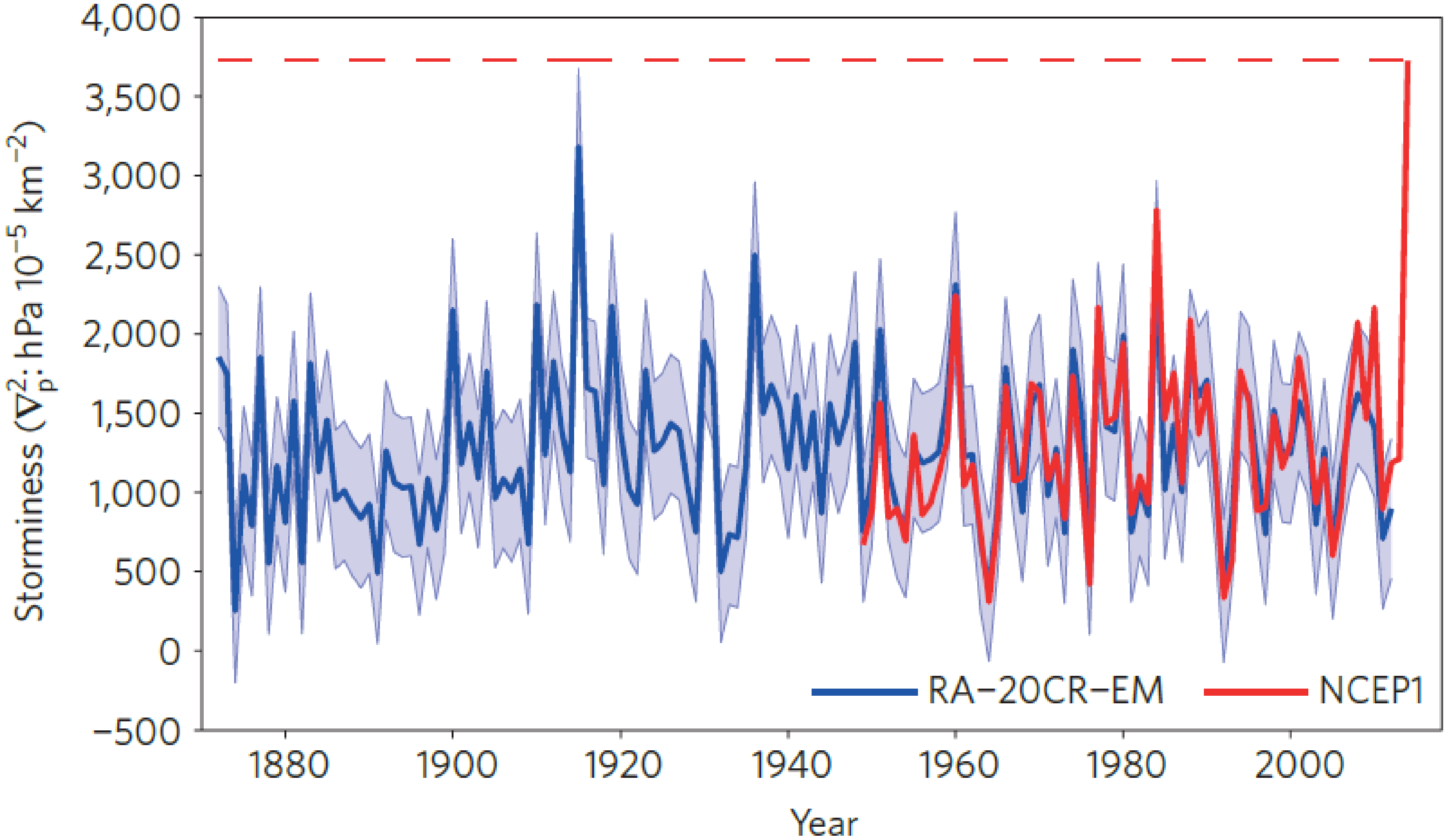
Source: Barker et al. (2004), Wilby & Barker (2016)

Winter 2015/16



Glenridding, Cumbria after Storm Frank
Photo source: Daily Mail

Winter 2013/14



An index of storminess for the British and Irish Isles showing the exceptional winter 2013–2014. Source: Matthews *et al.* (2014).

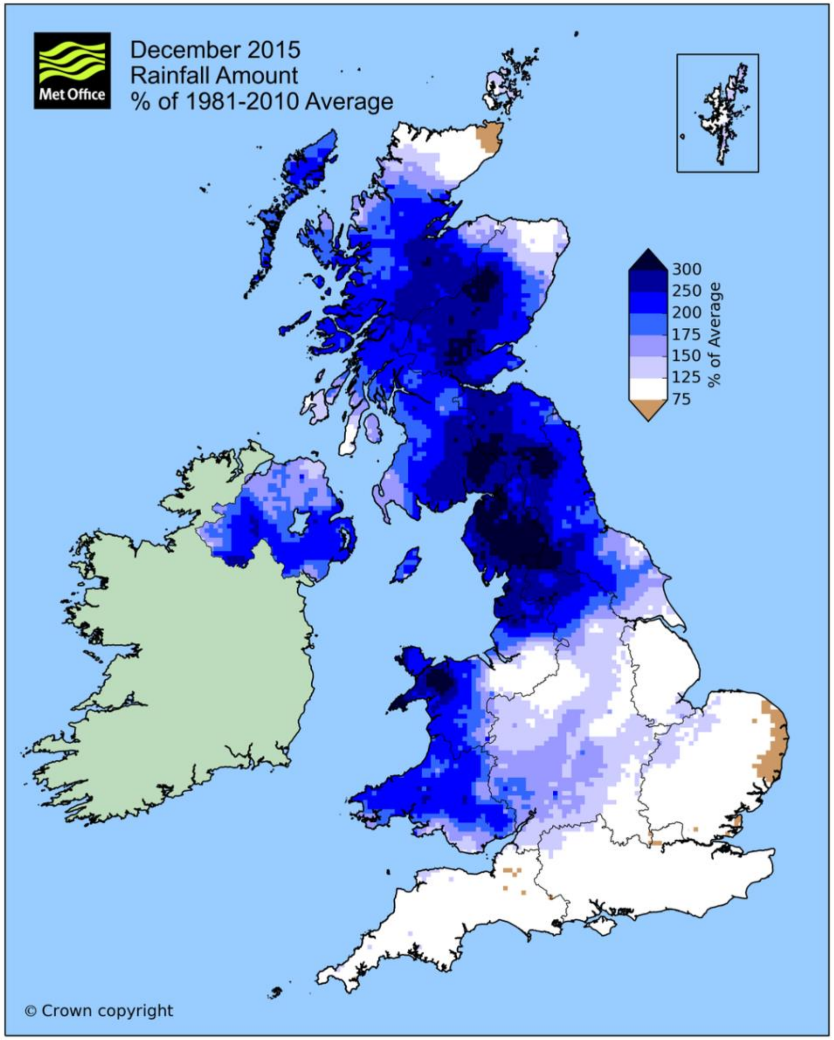
Suffolk storm surges 5-6 December 2013

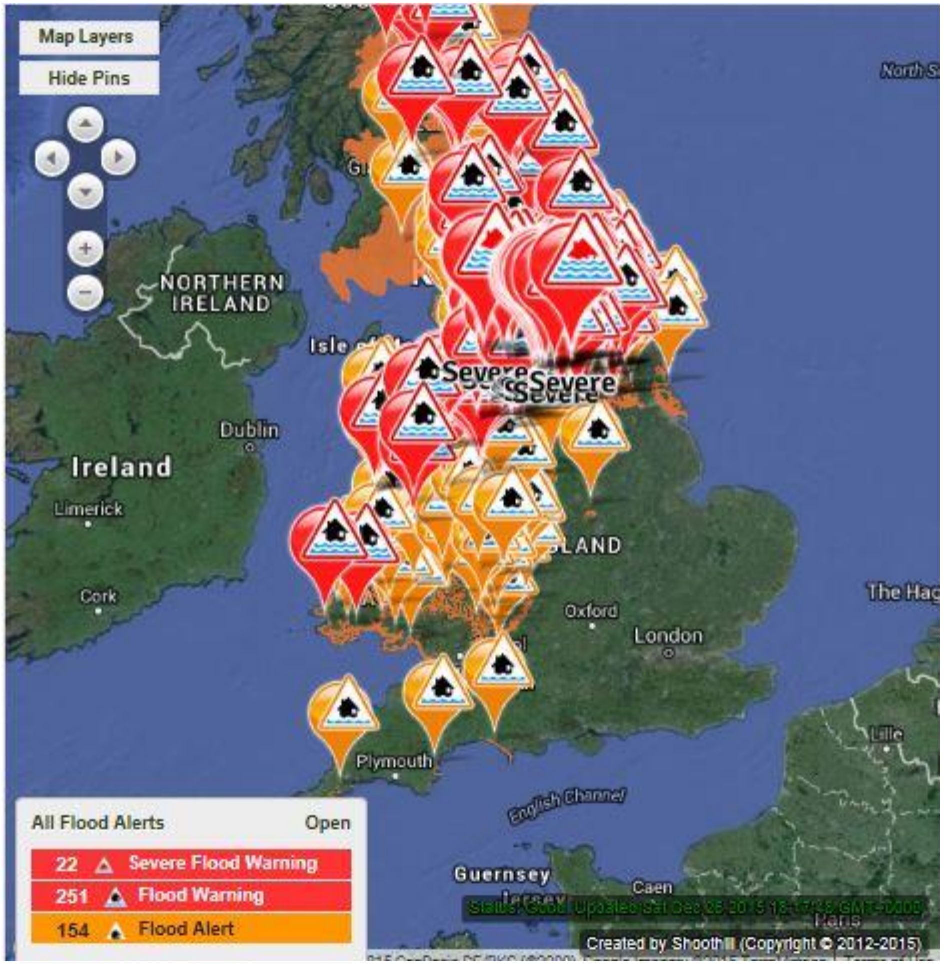
Surge damage at the RSPB Minsmere Reserve.

Source: http://www.rspb.org.uk/community/ourwork/b/martinharper/archive/2013/12/16/storm-surge.aspx

Trent Valley, UK November 2000

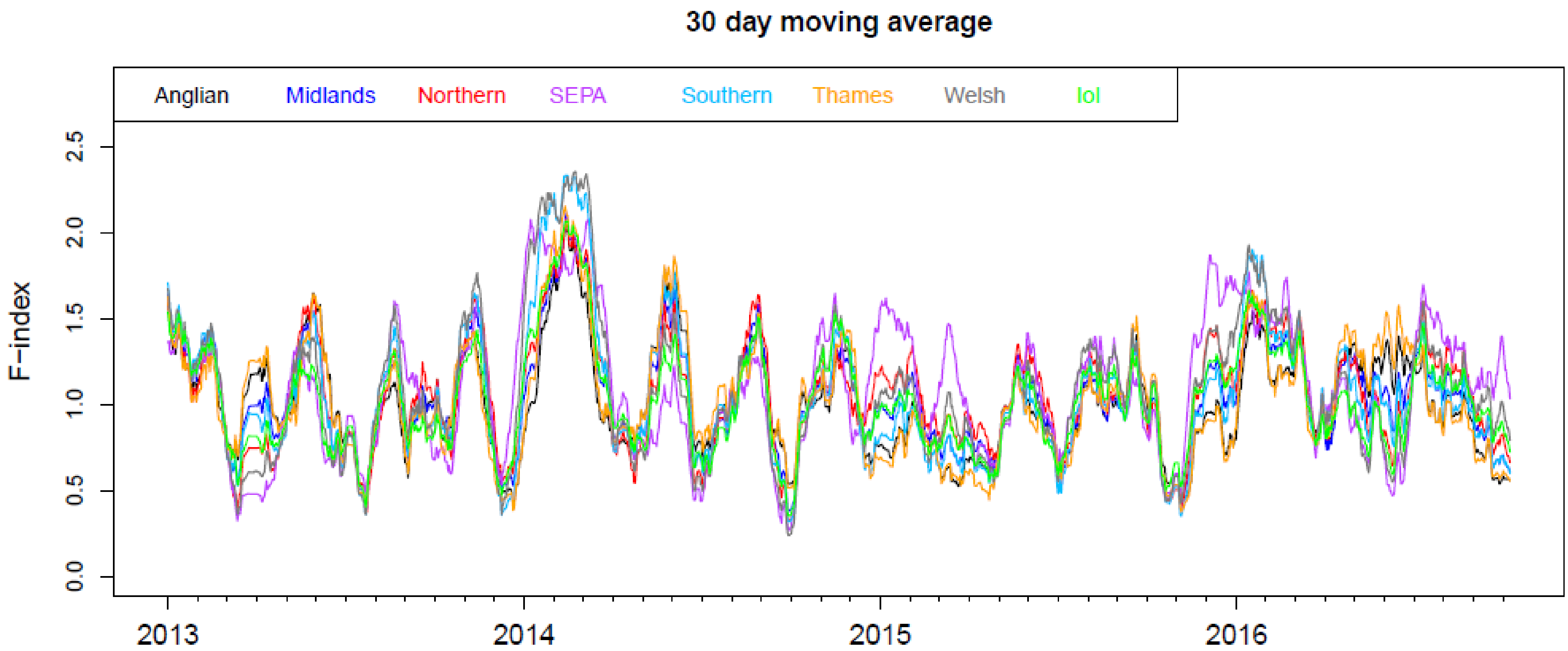
‘Super flood’ clusters in time and space





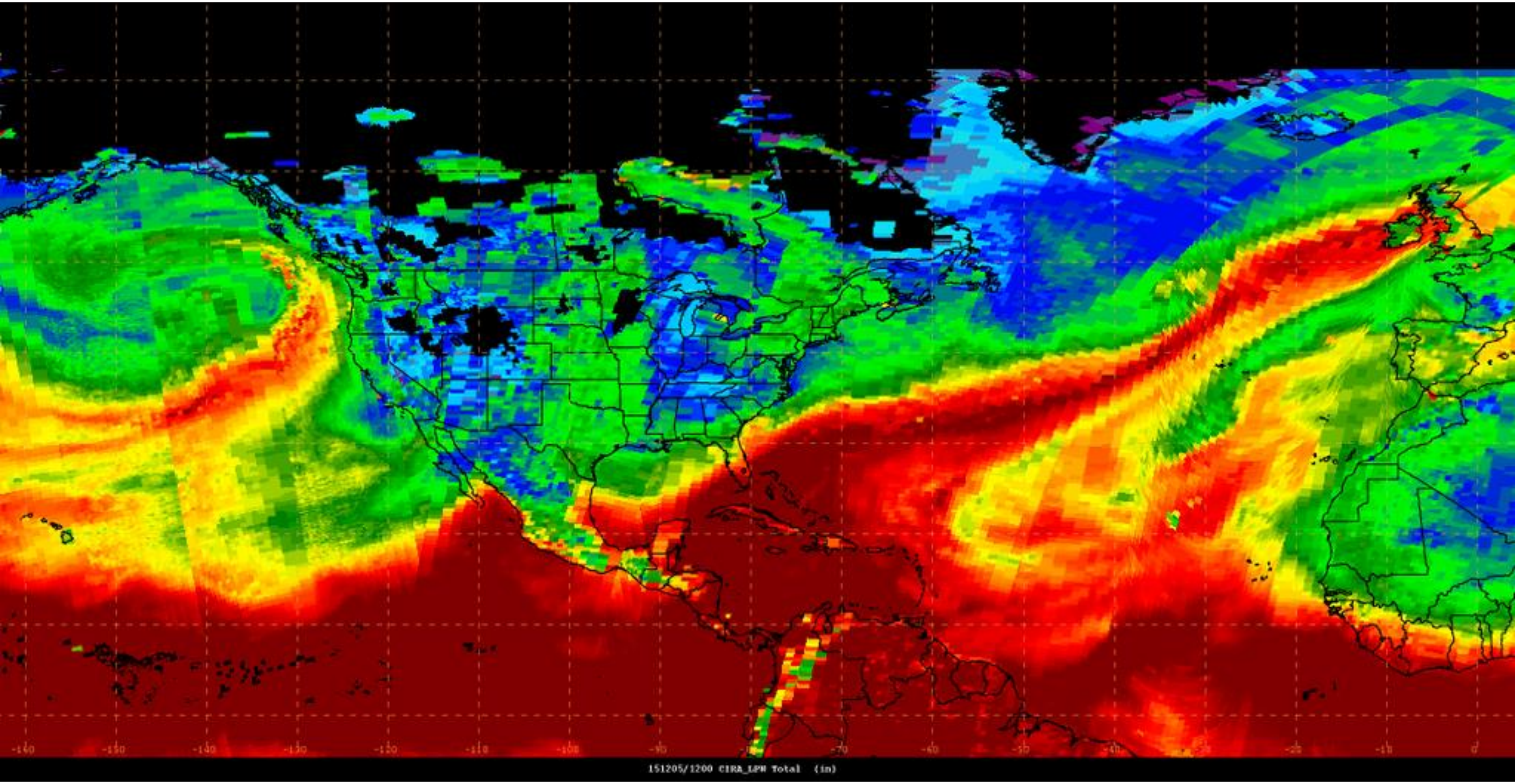
Flood alert situation on 26 December 2015

Super-flood index



Last update 8 October 2016
Source: https://crudata.uea.ac.uk/cru/data/lwt/webdocs/mov_averages.pdf

Atmospheric River (Desmond)



Source: NWS OPC - https://twitter.com/nwsopc, Public Domain, https://commons.wikimedia.org/w/index.php?curid=45444848

Summer floods of 2013 and 2016

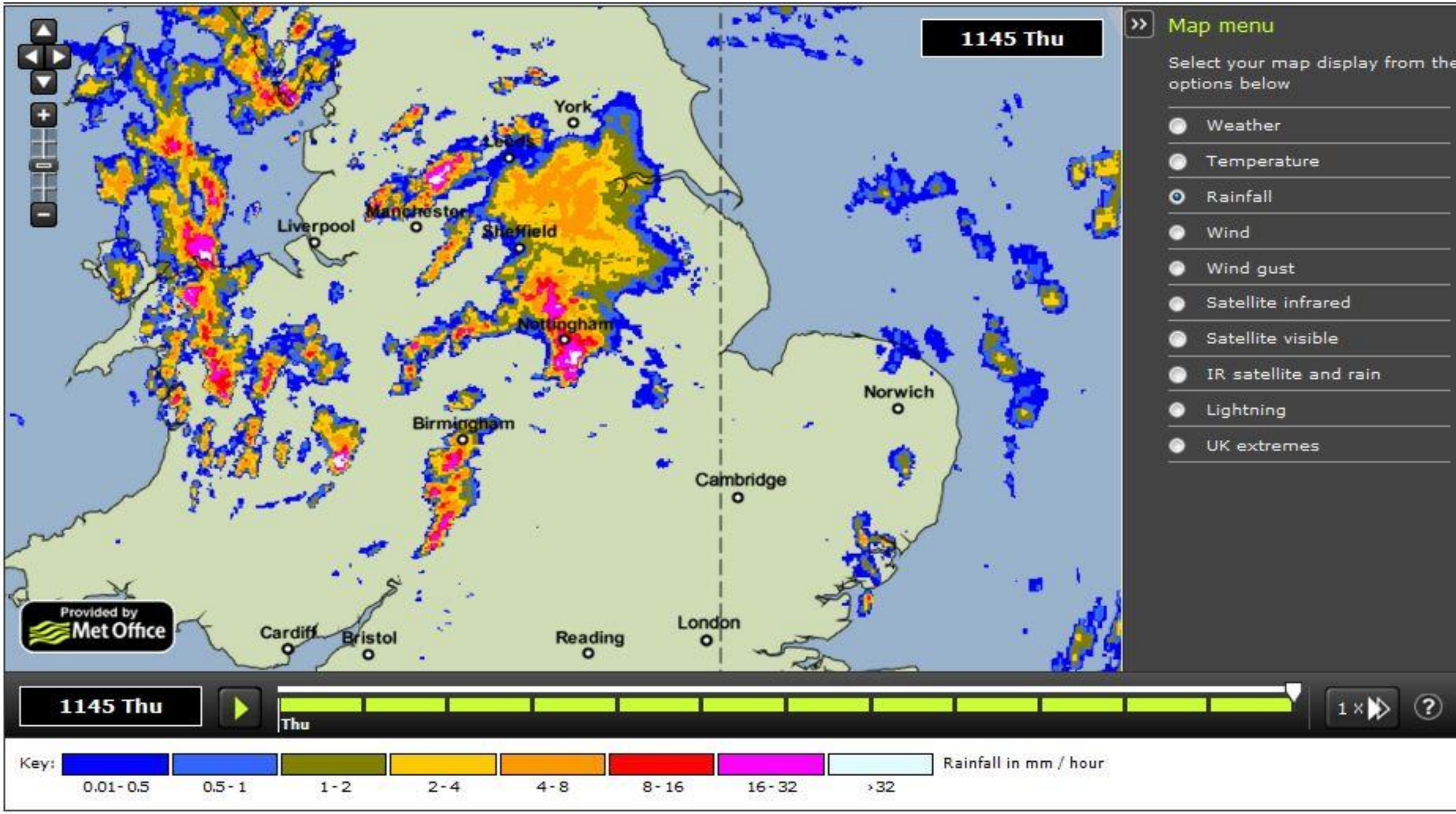
Source: http://www.dailymail.co.uk/news/article-2335696/Prague-water-floods-claim-ELEVEN-lives-Europe-threaten-German-city-Dresden.html

Campus flash flood summer 2012

Martin Hall, Loughborough University, 28 June 2012. Photo source: Emma Seddon

Storm cells* 28 June 2012

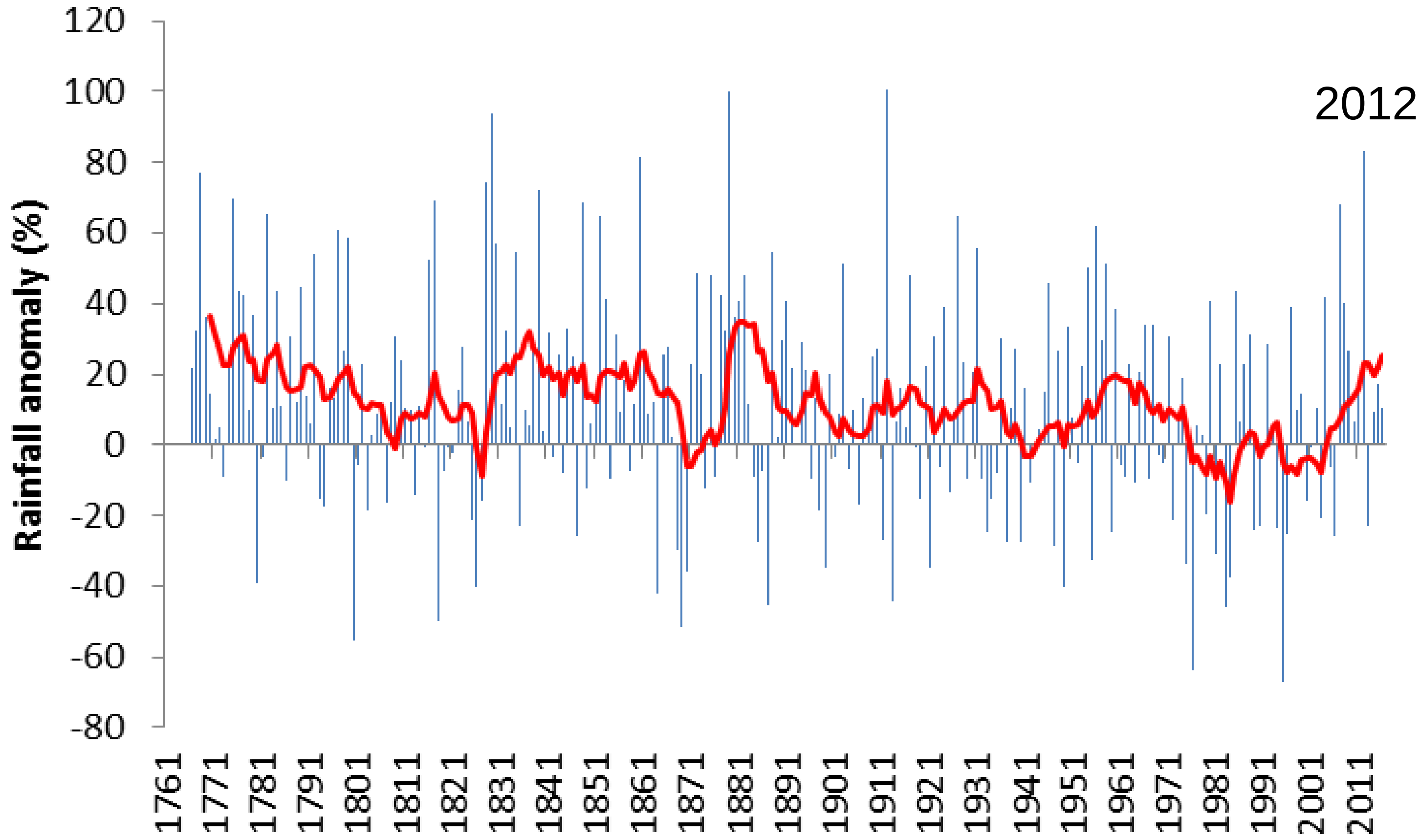
* yielding >25 mm rainfall in 15 minutes



Later that same day in Newcastle

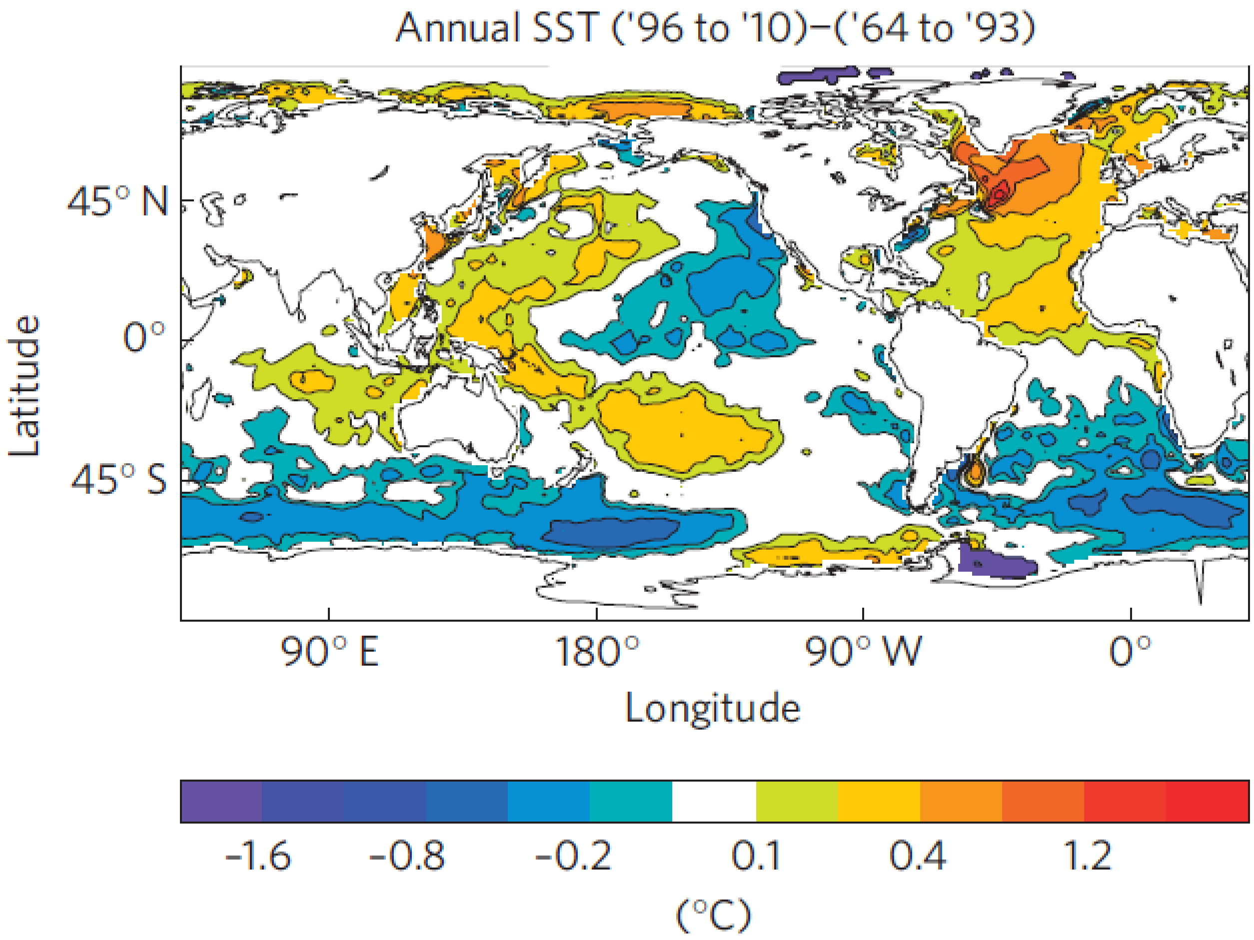
Source: http://i.dailymail.co.uk/i/pix/2012/06/28/article-2165944-13D67AD1000005DC-256_964x679.jpg

Summer rainfall 1766-2016



England and Wales Precipitation (EWP). Data source: Met Office

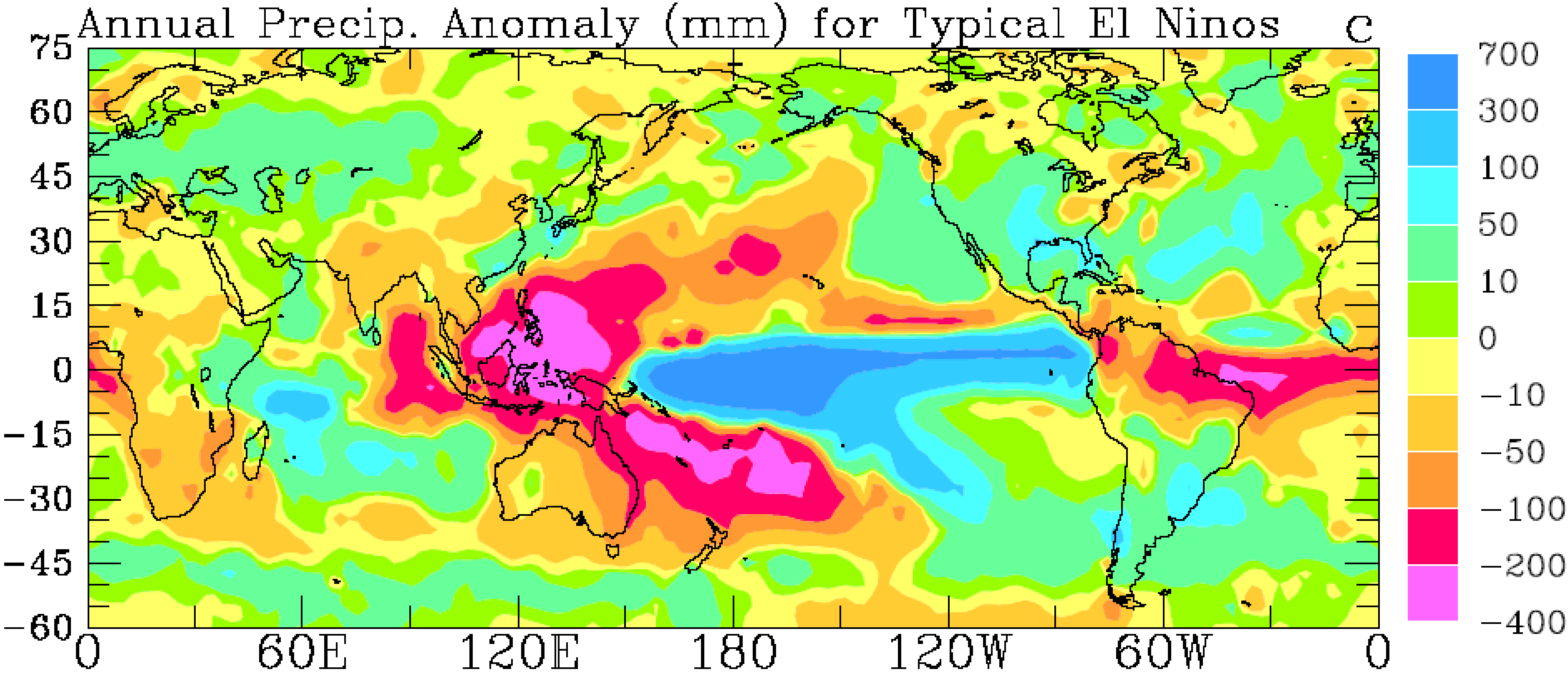
UK: Warm Atlantic ~ wet summers



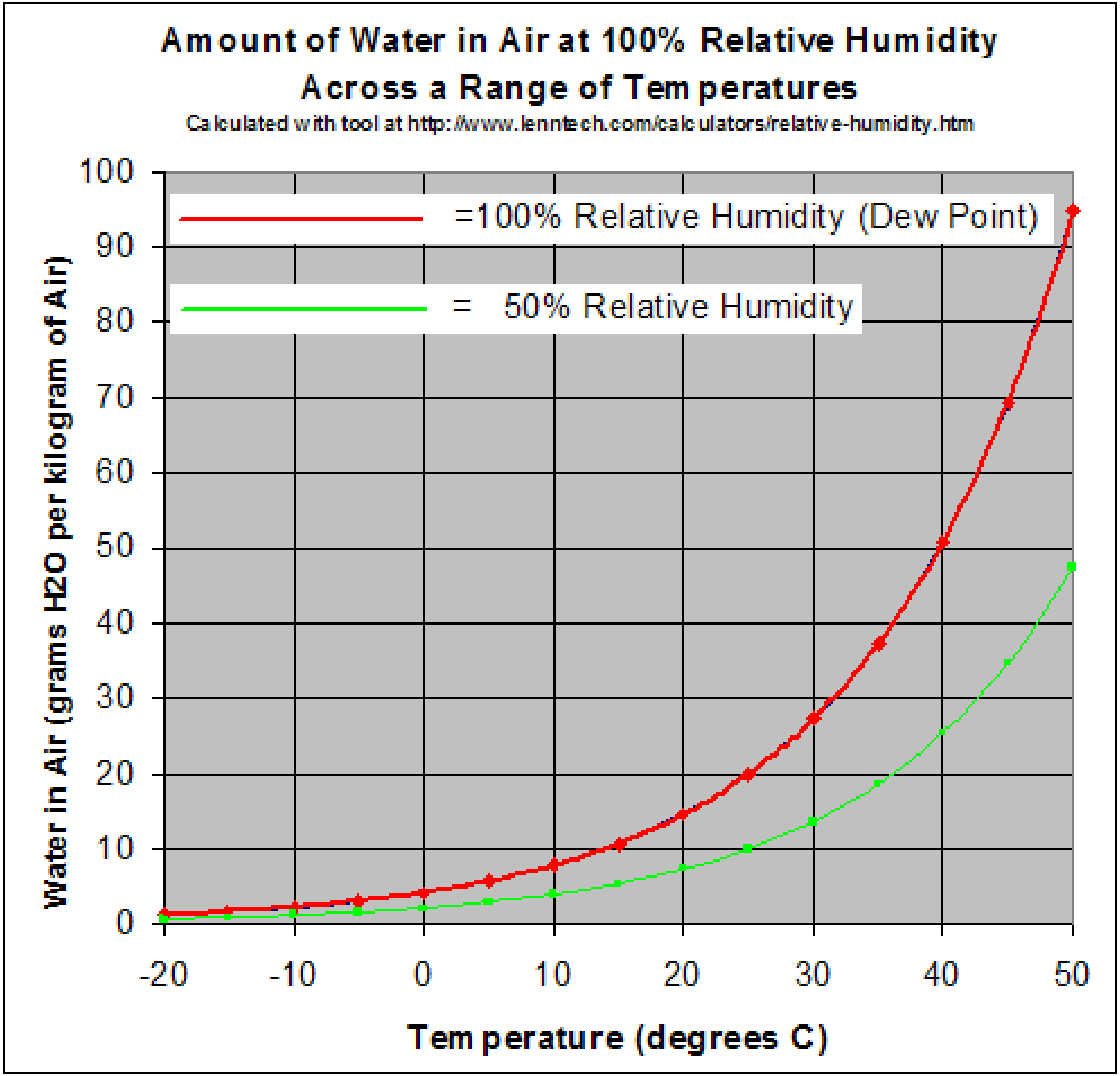
Sea surface temperature (SST) anomalies associated with a period of wet summers.

Source: Sutton & Hawkins (2012)

The El Niño "finger-print"



Annual precipitation anomalies (mm) coinciding with El Niño episodes.
Source: Dai and Wigley (2000).



Source: http://www.ctgclean.com/tech-blog/wp-content/uploads/Relative-Humidity-Graph-e1367505504127.jpg

Short-term action

HM Government

National Flood Resilience Review

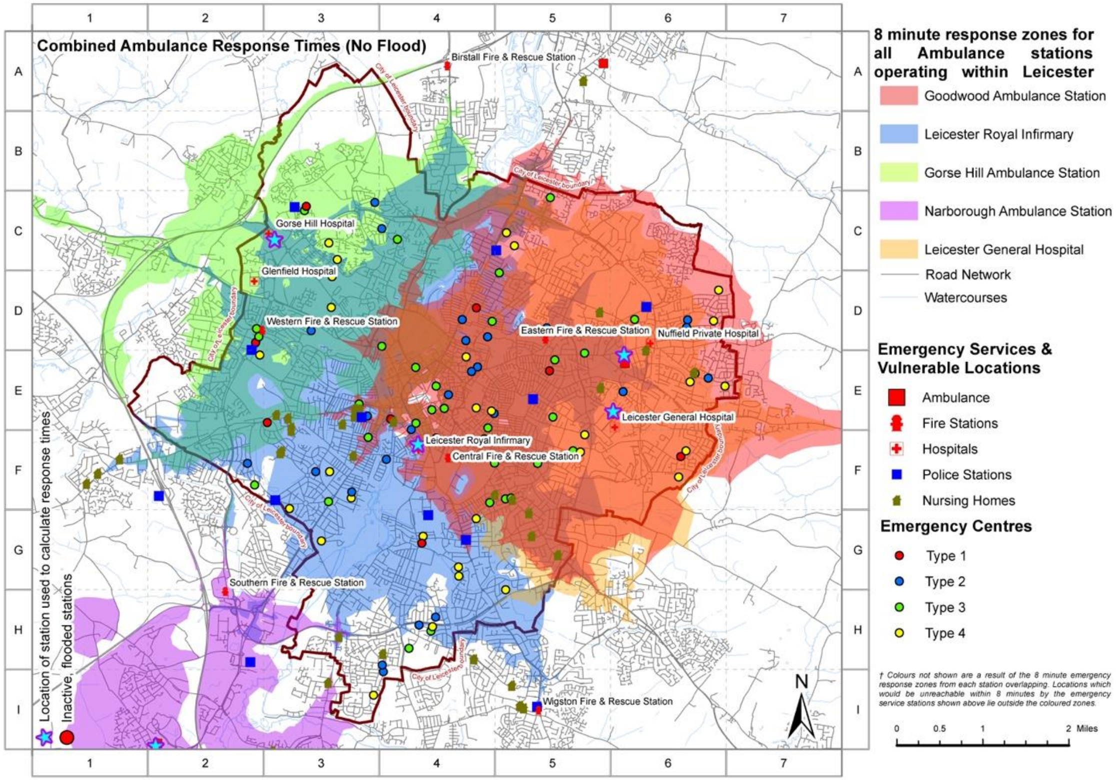
Telephone exchange at York, December 2015

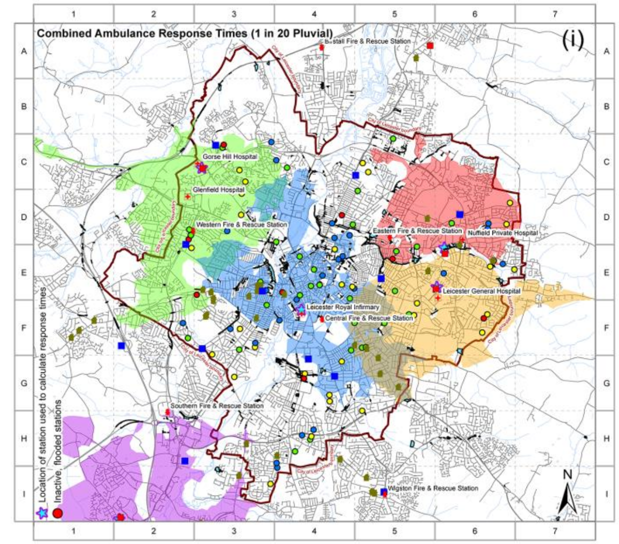
Photo source: http://www.yorkpress.co.uk/resources/images/4646167/

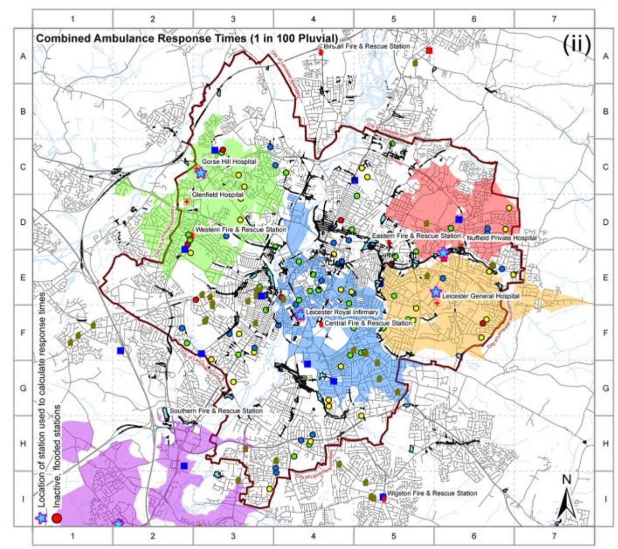
Table 2: Current levels of protection of assets against Extreme Flood Outlines (EFO) flooding (*to nearest 10).

	Total number of potentially vulnerable sites (above pop. threshold and within EFO)	Number of sites defended against flood extent in EFO	Net number vulnerable to flooding to extent identified in EFO
Sectors assessed as potentially vulnerable (clean water, electricity, telecoms, health)	820*	290*	530*

‘Hot spot’ analysis (emergency services)







Accessibility of the City of Leicester (8-minutes) for Ambulance Service stations operating under ‘normal’ (no flood conditions) [above] and [i] 20-year or [ii] 100-year pluvial flooding. Source: Green et al. (under review)

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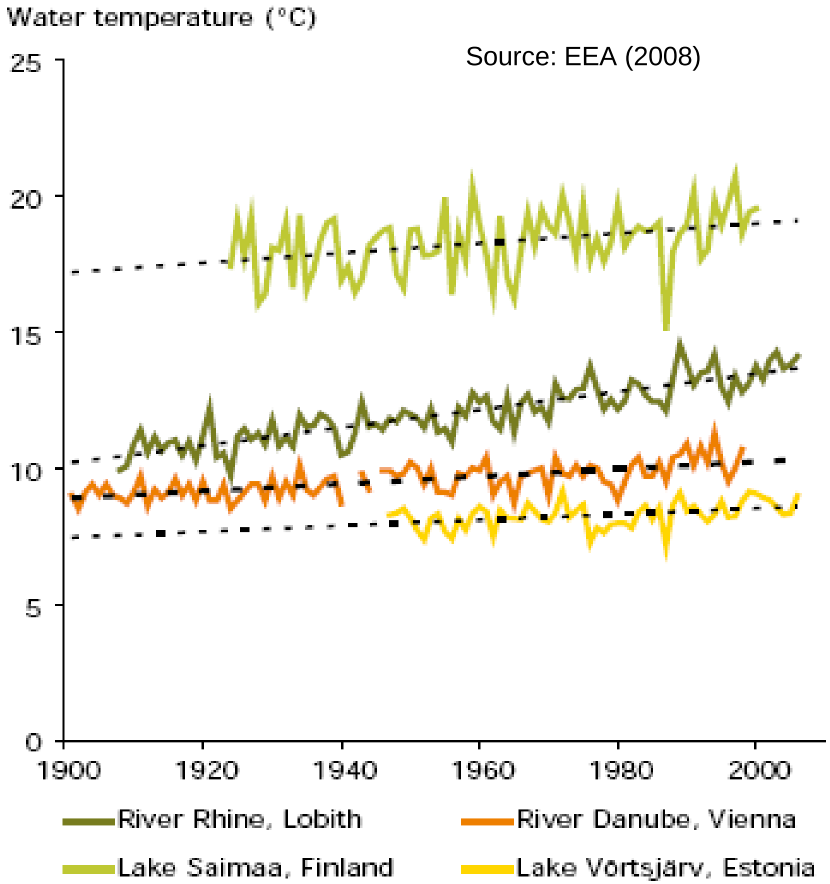
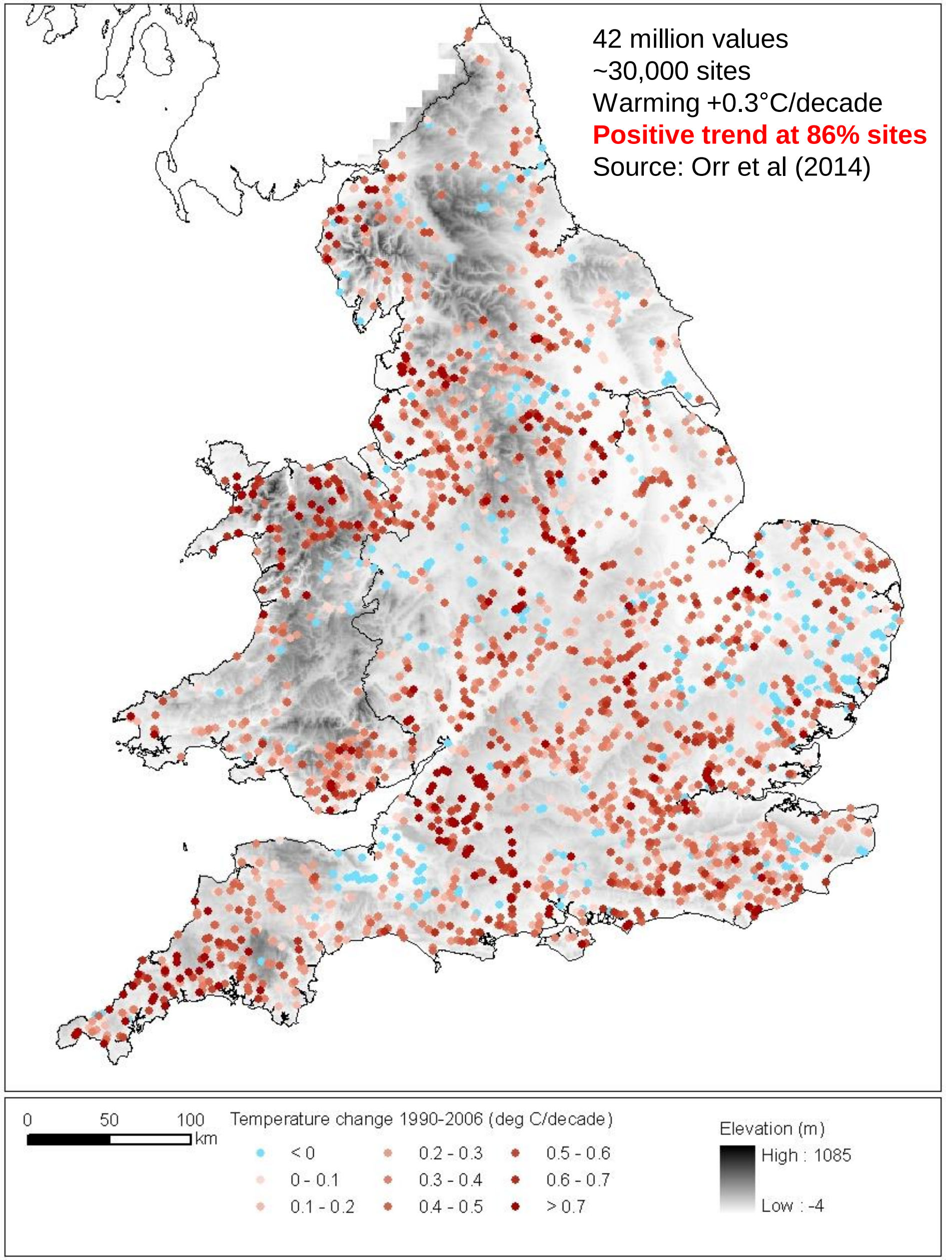
Part II – Evaluating adaptation options

Photo source: Matt Johnson

Warming rivers





Mid-Danube has warmed by ~0.5°C per decade since the 1980s.

See: Basarin et al. (2016) *Hydrological Processes*

Increase shading through tree planting to reduce water temperatures

Practical issues

Where to plant?

What species?

What buffer length?

What thermal benefit?

What ecological effects?

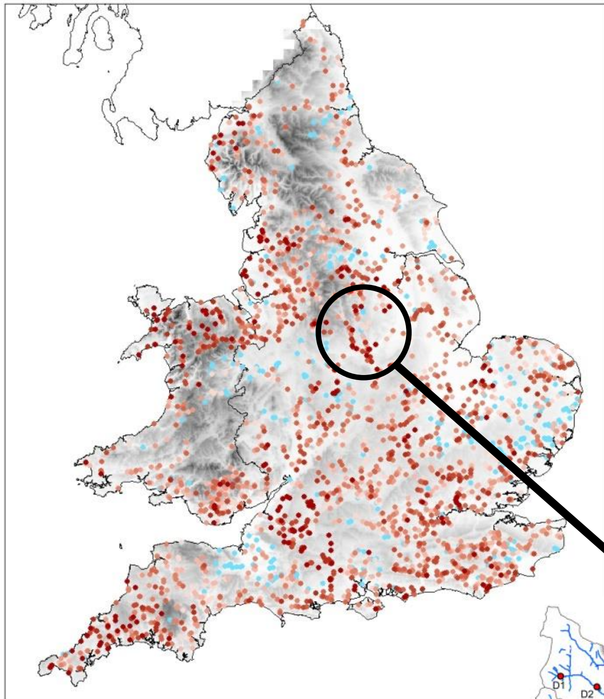
What other benefits?

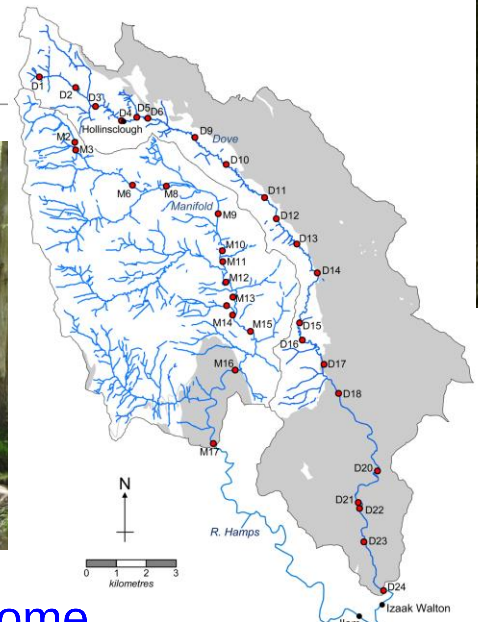
What groundwater effect?

What flood effect?

Gathering evidence: LUTEN

2011 onwards

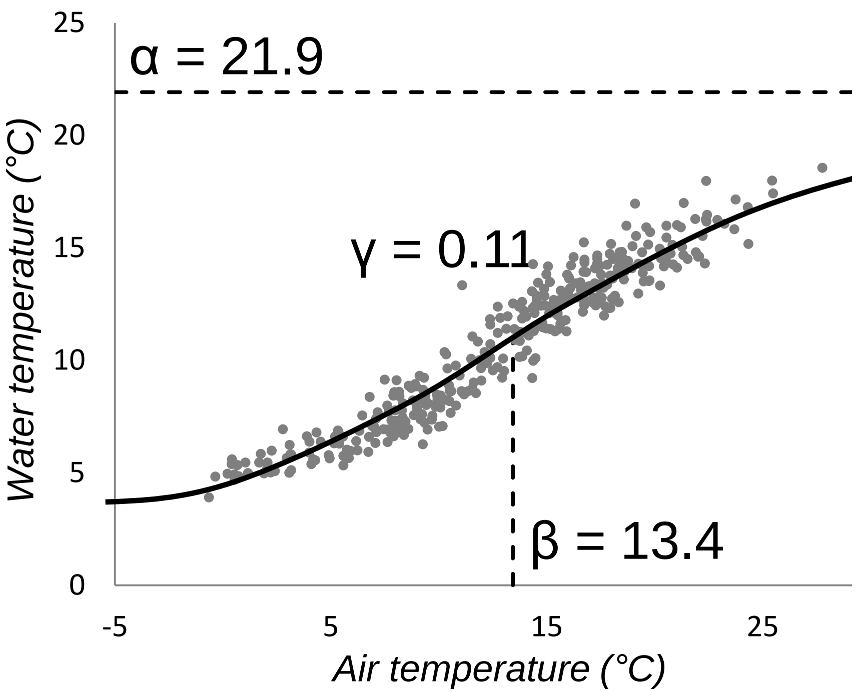




37 sites

http://www.luten.org.uk/home

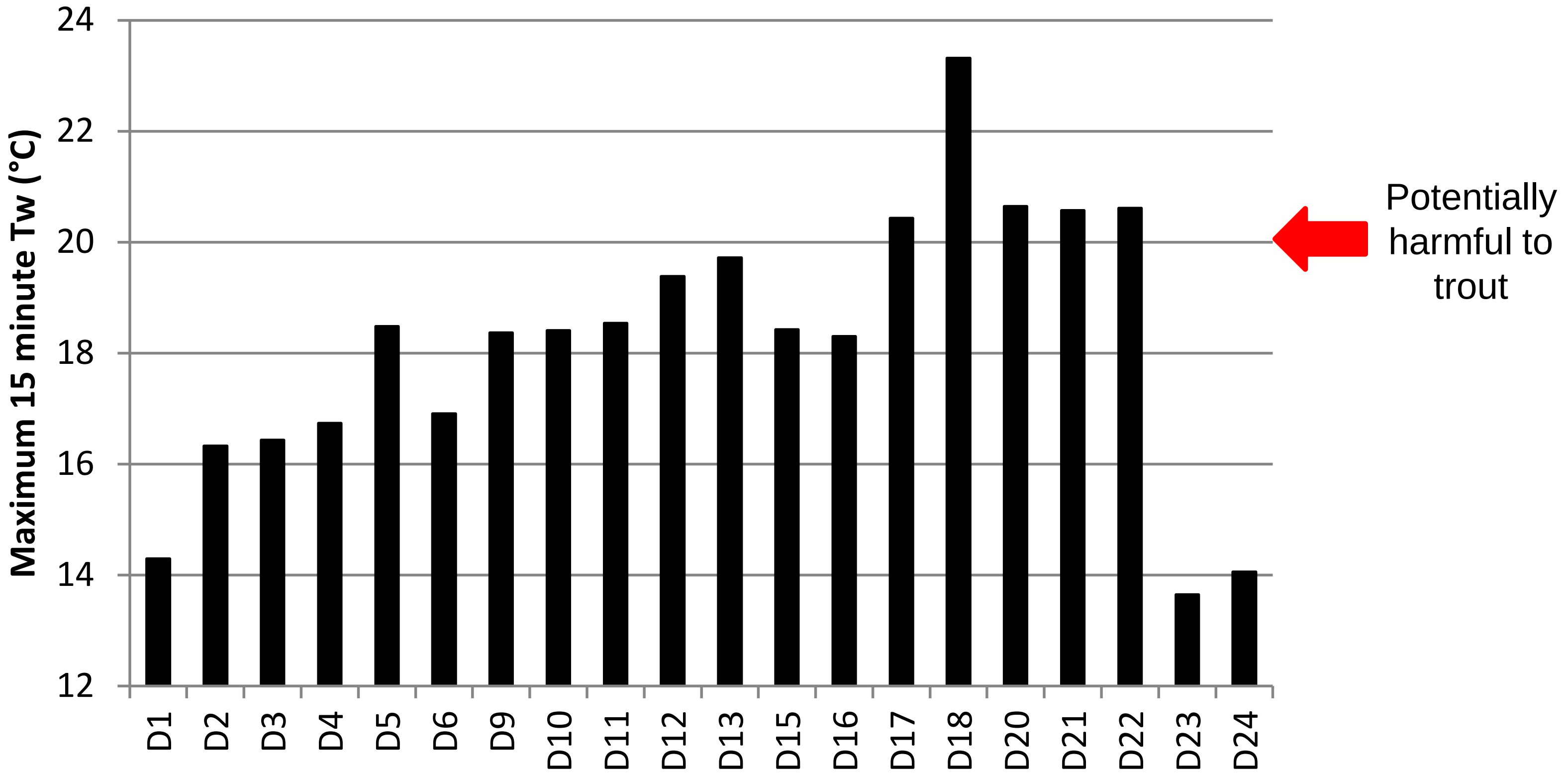
Spatial-temporal variations in Tw-Ta



Relationship between air (Ta) and water (Tw) temperatures in the Rivers Dove and Manifold. Tw > 23 °C induces fish behaviour change; Tw > 29 °C can be lethal to salmon. Source: Johnson et al. (2014)

Site	Calibration					
	α asymptote	β inflection	γ gradient	SE	R^2	*n* days
D2	16.31	10.36	0.14	1.33	0.87	329
D3	16.73	10.47	0.15	1.01	0.92	354
D4	17.66	11.07	0.14	0.99	0.94	363
D9	19.14	11.13	0.16	1.14	0.93	348
D10	19.68	12.04	0.14	1.00	0.93	348
D11	21.93	13.43	0.11	0.99	0.93	348
D12	23.57	14.52	0.11	1.29	0.92	362
D13	23.69	14.18	0.12	1.44	0.9	343
D15	24.58	15.85	0.1	1.18	0.91	321
D16	23.45	15.04	0.1	1.16	0.9	361
D17	24.97	16.39	0.1	1.45	0.87	348
D18	29.61	18.25	0.1	1.79	0.87	339
D20	25.53	15.05	0.12	1.47	0.9	329
D21	23.69	14.18	0.12	1.44	0.9	335
D22	23.87	14.33	0.12	1.75	0.9	337
D23	14.24	5.17	0.11	0.75	0.88	361
M2	18.06	11.06	0.19	1.06	0.93	333
M3	19.95	11.84	0.18	1.18	0.92	332
M6	20.88	12.18	0.17	1.15	0.93	359
M8	22.36	12.67	0.16	1.12	0.94	366
M9	19.21	10.96	0.17	0.98	0.94	332
M12	20.52	11.63	0.17	1.27	0.92	354
M14	19.79	11.2	0.18	1.38	0.9	366
M15	20.03	11.45	0.18	1.44	0.9	354
M16	21.39	12.05	0.18	1.46	0.91	356

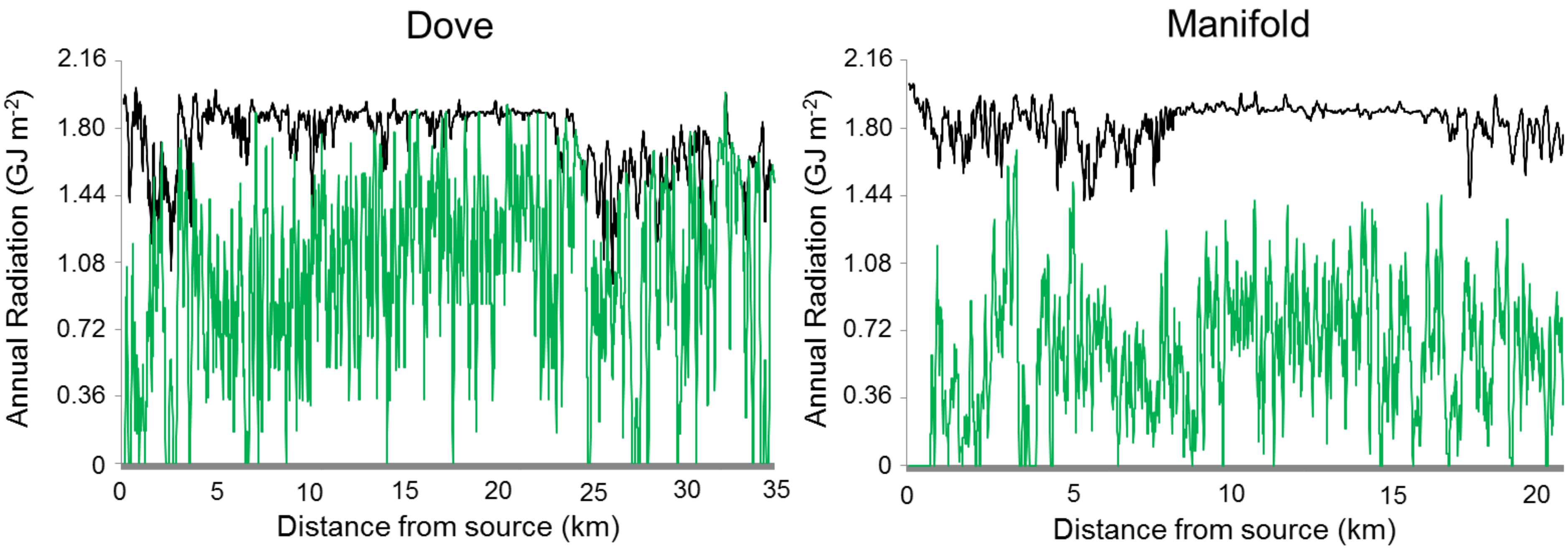
Thermal profile of the River Dove



Maximum 15 minute Tw recorded during the period March 2011 to February 2012.

Upstream of Fishpond Plantation (D20)

Where to increase riparian shade?



Downstream profiles of estimated annual direct solar radiation receipt (GJ) for a **treeless landscape (black)** and landscape with **30m high trees (green)** in the Dove (left) and Manifold (right). Source: Johnson and Wilby (2015)

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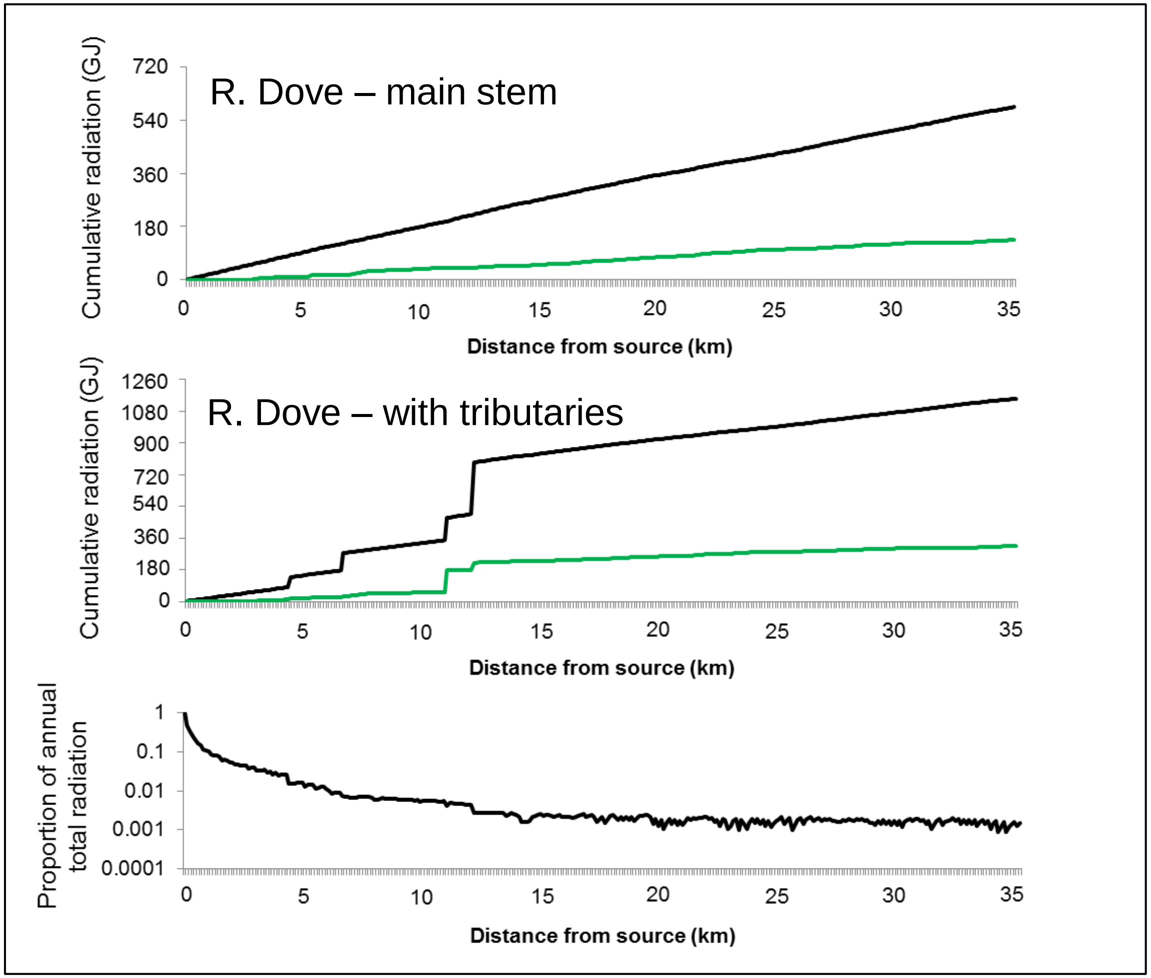
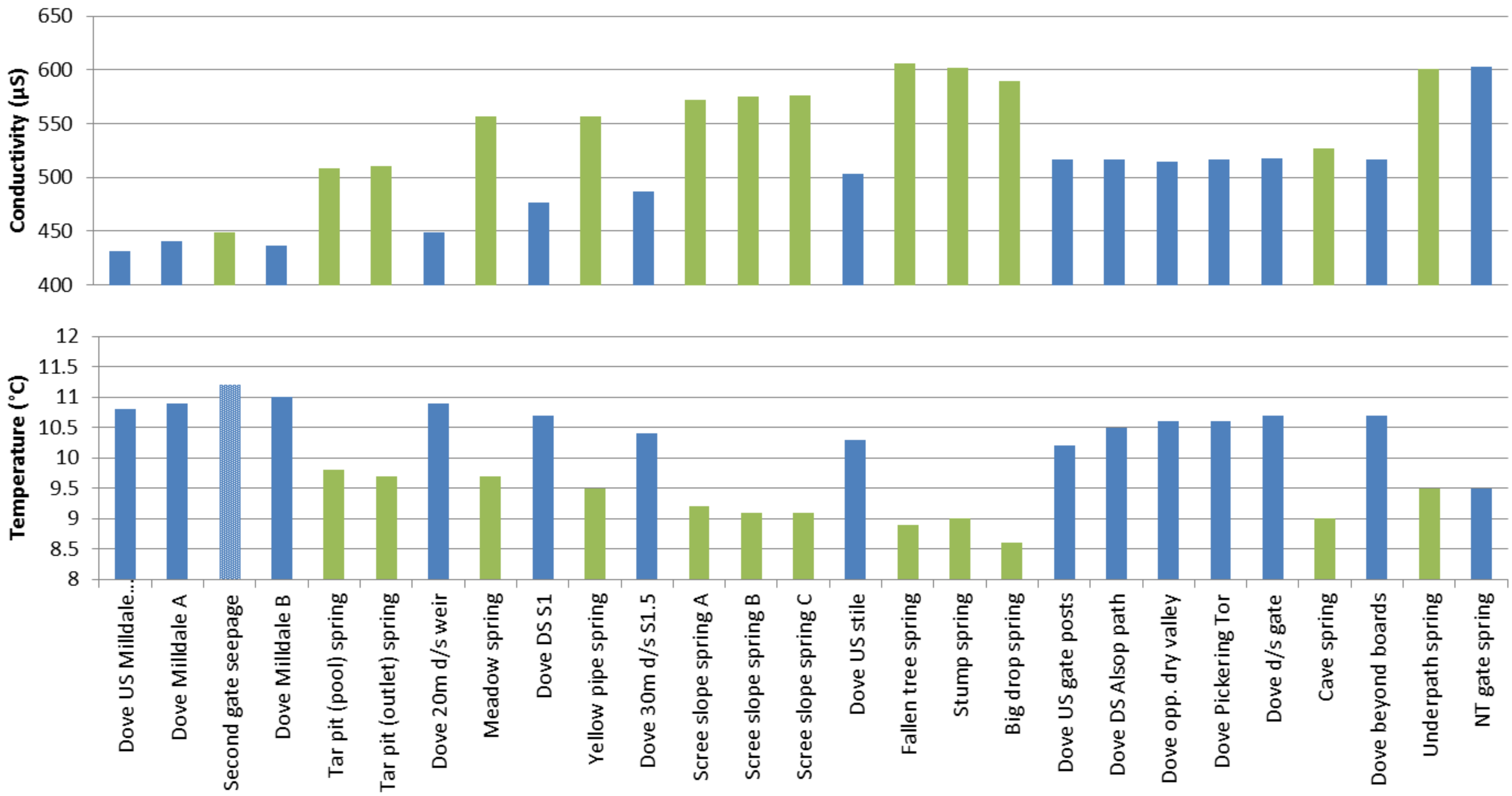
How much riparian shade is needed? (to cool the Dove by 1°C)

Site D24	Heat capacity (kg J °C)	Average velocity (m s-1)	Required shade (km)
January	2205427	0.98	15.2
February	2149313	0.94	7.6
March	2043625	0.89	4.0
April	1881096	0.81	2.4
May	1622111	0.68	1.6
June	1476224	0.61	1.3
July	1370258	0.55	1.1
August	1323391	0.52	1.1
September	1333703	0.52	1.4
October	1585399	0.66	2.9
November	1889172	0.81	8.0
December	2114340	0.93	*N/A*

Source: Johnson and Wilby (2015.)



Local effect of springs (thermal refugia)



Main stem of the Dove (**blue bars**) and spring (**green bars**) survey 23 April 2014.
Data: Alisdair Tennant

Riparian management: trees *and* fences!

Sprink, River Dove 28 May 2012

Loughborough University

Concluding remarks

- Long-term monitoring and reporting lie at the heart of adaptive management of climate risks
- A new era of field/lab/model experimentation is needed to gather evidence on the efficacy of adaptation
- Translating such science into practice is problematic even for ‘folk lore’ adaptation

Thanks for listening

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