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Using Historic Rainfall Data To Improve Forecasting

Dr Harvey J.E. Rodda

Hydro-GIS Ltd

10 Coles Lane
Chalgrove
Oxfordshire
OX44 7SY
United Kingdom

www.hydro-gis.co.uk
harvey.rodda@hydro-gis.co.uk

British Rainfall

Started by George J. Symons in 1860 with observations from 168 stations in the British Isles.

Was under the title “Symons British Rainfall” until his death in 1900

Continued until 1991 as a Met Office publication, with observations from approximately 6000 rain gauges.

British Rainfall

British Rainfall

Gave a listing of various rainfall observations:

- annual totals
- monthly totals
- days on which rain fell
- maximum falls in 24 hours
- extreme falls in short periods
- droughts
- averages over number of years

Also included special sections on methods of rainfall measurement, notable events, rules for observers, the staff of observers, evaporation and rainfall duration.

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British Rainfall Extreme Rainfalls

The chapter entitled “Heavy Rainfalls on Rainfall Days” or “Heavy Falls in 24 Hours” provided detailed information on extreme rainfall events:

- 24hr observations from 9am-9am
- Listings of all depths over a specified threshold: > 2.5 inches (63.5mm) or >7.5% of annual total 1866-1961; >50mm or >4% of annual total 1962-1968
- Descriptions of the event from observers including a summary of the weather conditions, the characteristics of the rainfall, ensuing floods and damage
- Isohyetal maps
- Photographs

The chapter was included in all editions from 1866 -1968

1.

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Table for 24th and 25th August, 1891

Division	Station	Rainfall 24th in.	Rainfall 25th in.	Total in 48 hrs in.
VIII	Hawkshead, Eastwaite Lodge	2.71	2.46	5.17
VIII	Duddon Valley, Seathwaite Vic.	2.94	2.99	5.93
VIII	Monk Coniston Park	3.25	2.7	5.95
VIII	Skelwith Fold (Ambleside)	3.04	2.88	5.92
IX	Sedbergh, Brig Flatts	3.11	2.18	5.29
X	Duddon Valley, Ulpha Vicarage	2.58	2.49	5.07
X	Seathwaite	6.14	4.10	10.24
X	Wyhtburn Vicarage	5.28	1.65	6.93
X	Borrowdale Vicarage	4.41	3.85	8.26
X	Buttermere, Hassness	4.85	4.31	9.16
X	Keswick, Barrow House	2.27	3.01	5.28
X	Kendal, Natland Park	3.61	1.77	5.38
X	Dungeon Ghyll	4.25	3.41	7.66
X	Ambleside, Nook Cottage	2.44	2.68	5.12
X	Ambleside, Lesketh Howe	2.59	2.78	5.37
X	Elterwater	3.07	3.50	6.57
X	Grasmere, High Close	2.54	3.40	5.94
X	Skelwith Bridge	2.94	3.05	5.99
X	Grasmere, Pavement End	3.53	3.43	6.96
X	Patterdale Hall	2.24	4.15	6.39

A sample of text from January 1927

"During the next few days the passage of vigorous secondaries maintained unsettled stormy weather. On the 28th a very deep depression west of Ireland caused widespread gales, which in some districts were of exceptional violence and gave gusts exceeding 100 miles an hour at Dunfanaghy in north-west Ireland, at Tiree to the west of Scotland, at Paisley and at Renfrew. Entries in the table are confined entirely to Dartmoor where the fall exceeded 3 inches on that day."

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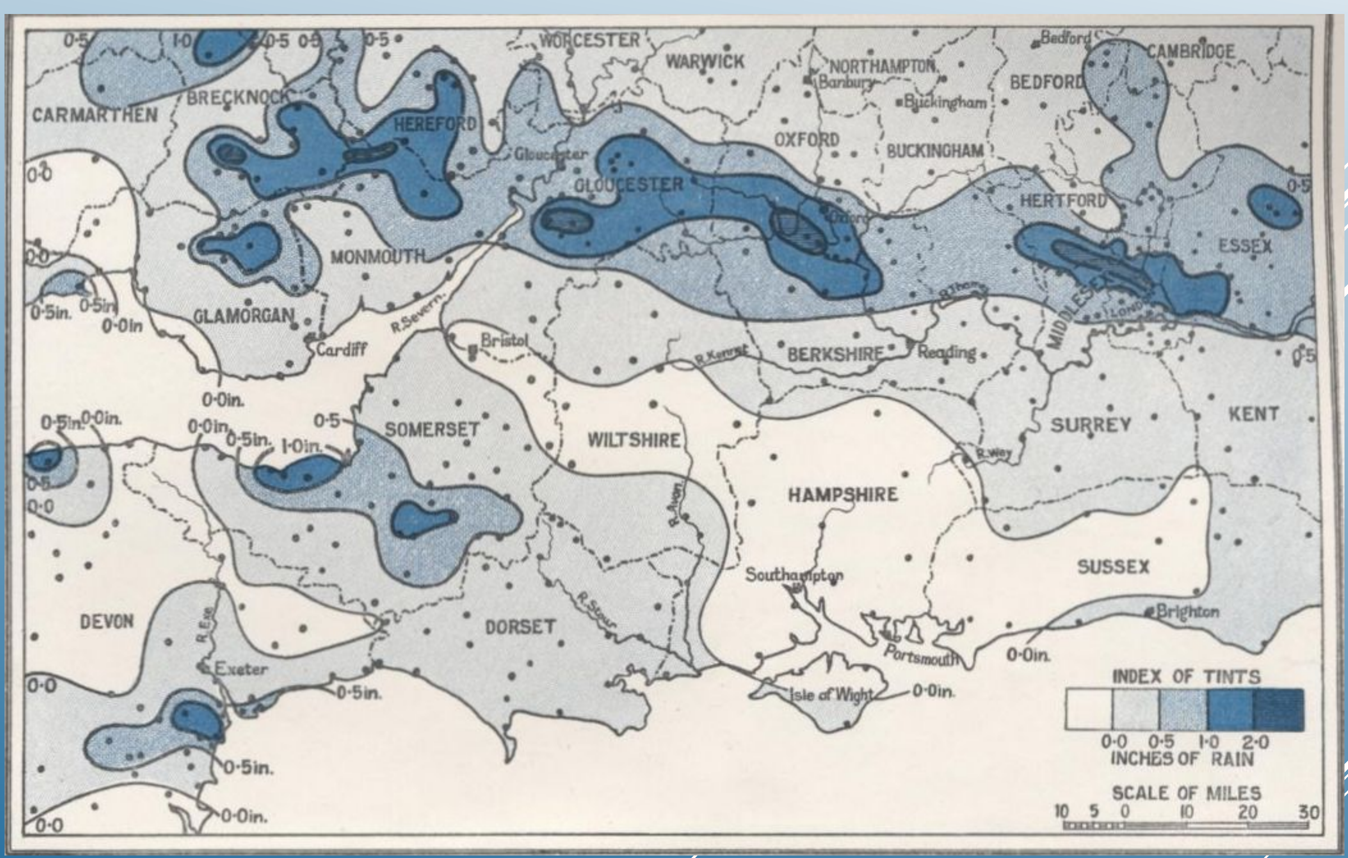
Isohyetal Map from 22nd July 1907



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Flooding in The Rhondda Valley 11th November 1929

Quality Control

Every effort was made to ensure the depths entered in British Rainfall were of good quality:

- Correspondence between BR editor and observers
- Unlikely depth observations compared with observations from nearby gauges
- Observations noted when gauges overflowed ("+" included)
- Averages taken to replace spurious values which could not be supported by other evidence

1884

"Nor does a shadow of suspicion rest upon the record; the gauge is a good one, the observations have always been carefully made, and the above figures are thoroughly supported by the surrounding stations."

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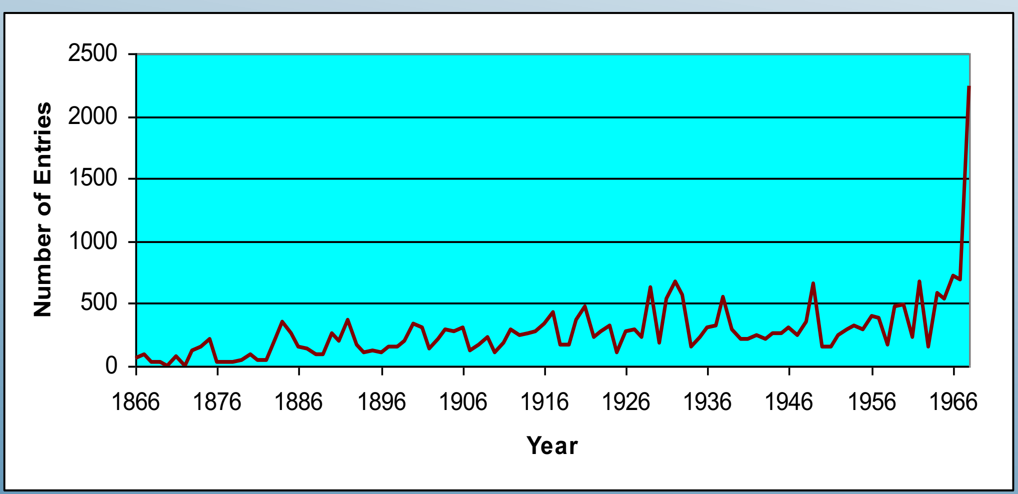
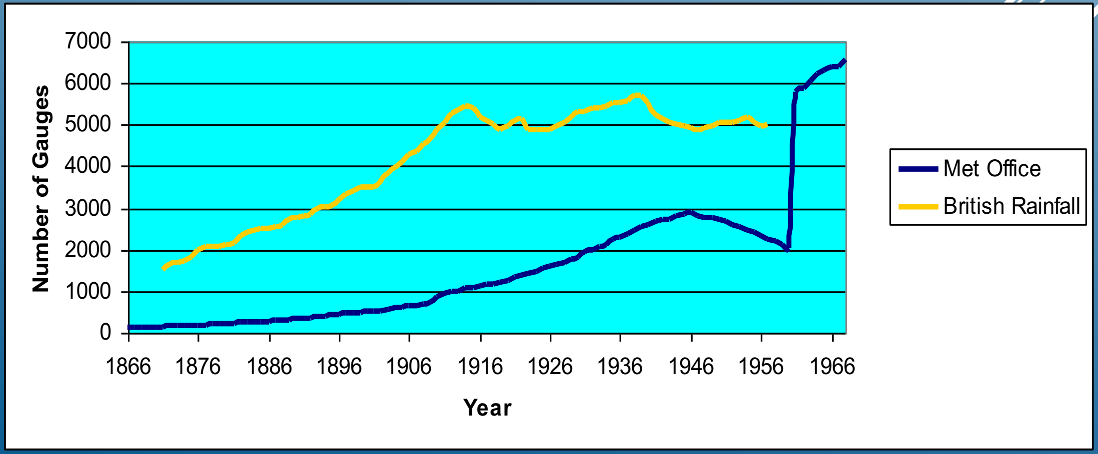
An Overview of Extreme Rainfall 1866-1968

Numbers of Observations per Year



Minimum 24 (1868, 1878)
Maximum 2237 (1968)
Average 280
Total 28,223

Numbers of rain gauges per Year



Data from significantly more gauges than the Met Office digital records

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Digitising the Archive

Part of a NERC funded joint research project between Hydro-GIS Ltd and Oxford University 2007-2009:

Quantifying Flood Risk of Extreme Events using Density Forecasts Based on a New Digital Archive and Weather Ensemble Predictions

All tables, text, maps and photos converted to digital format:

- 28,000 observations of extreme rainfall back to the year 1866;
- 1000 pages of text and eye-witness accounts describing the rainfall events and associated impacts such as flooding;
- 250 rainfall maps and photographs.

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Digitising the Archive

Digitising included scanning of maps, photos and text, converting to MS-word and XL.

Data initially used for research into extreme rainfall events, including the applications of data-based mechanistic modelling and machine learning:

Rodda, H.J.E., Little, M.A, Wood, R. G., MacDougall, N. and McSharry, P.E. 2009. A digital archive of extreme rainfalls in the British Isles from 1866 to 1968 based on *British Rainfall*. *Weather*, Vol 64, No. 3, 71-75.

Little M.A., Rodda H.J.E, McSharry P.E. (2008), Bayesian Objective Classification of Extreme UK Daily Rainfall for Flood Risk Applications, (2008), *Hydrology and Earth Systems Sciences Discussion*, 5:3033-3060

- GIS based search facility through Hydro-GIS Ltd until 2018;
- Data reformatted and currently made available through Oasis Hub.

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5km Gridded Rainfall Footprints

The original scanned isohyetal maps were converted into grid format:

- All maps georeferenced;
- Existing contours digitised as polylines;
- Interpolated surface generated at 5km resolution using the topo to raster tool from ArcGIS Spatial Analyst extension;

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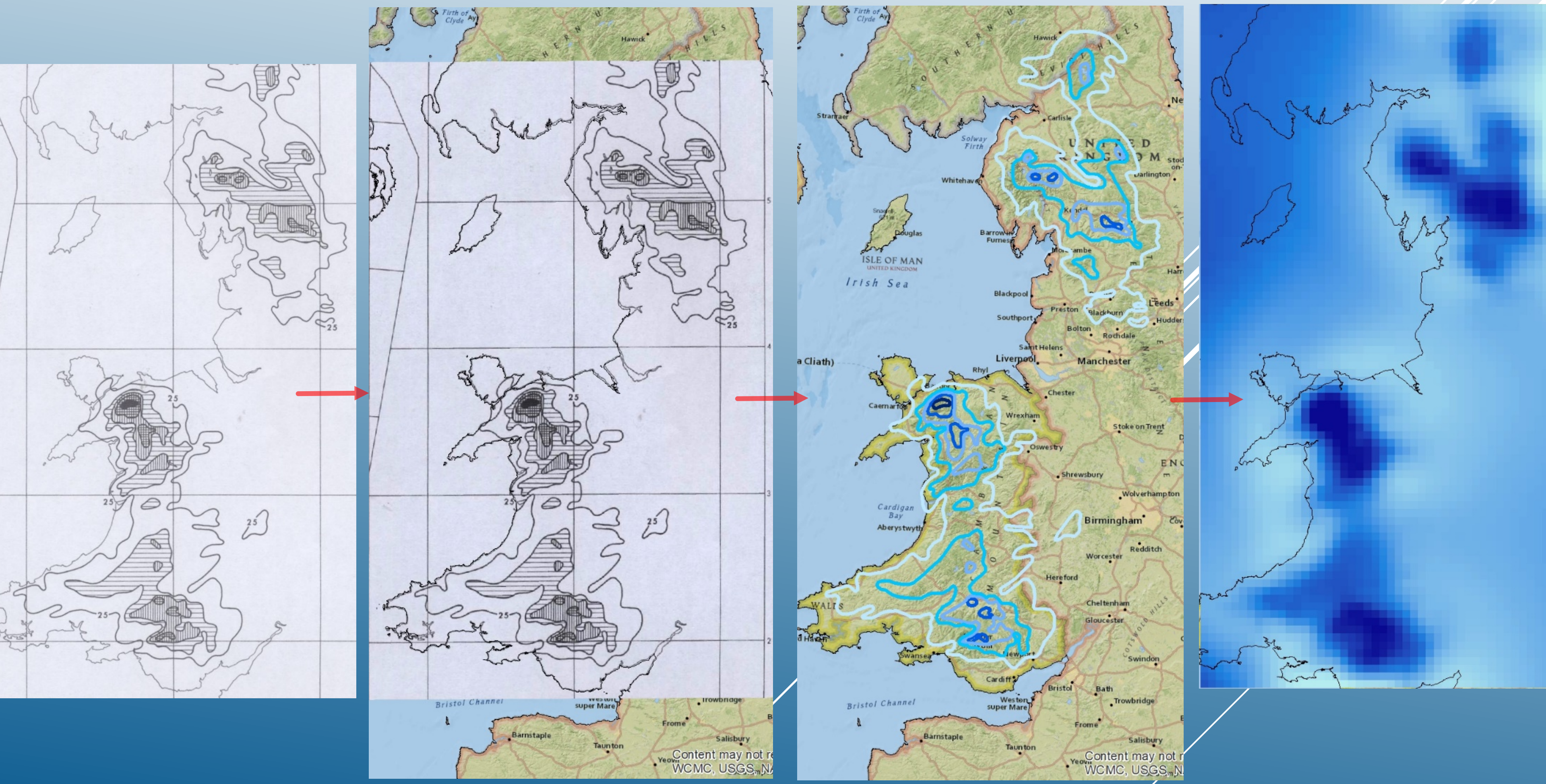
5km Gridded Rainfall Footprints



5km Gridded Rainfall Footprints

- 228 gridded footprints are available covering the British Isles;

- 26 maps were not gridded either as they were either a detail of an existing map or did not have sufficient information for accurate georeferencing

- 6 events affecting just Ireland excluded as they did not use the OSGB grid

Potential Uses of the British Rainfall Archive

There are a wide range of research applications in meteorology, climatology, hydrology and other fields:

- Studies of extreme weather
- Design rainfall estimation
- Long term climatic trends
- Flood studies
- Drainage design
- Scenarios for flood forecasting and emergency management
- Event data for catastrophe model validation

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Event Classification

Part of the original research project was to define events based on rainfall patterns, intensity and seasonality.

Mesoscale Convective Complexes (MCC) – small depressions characterised by intense precipitation from convective cells within a larger area of continuous rain. Occur in summer affect S and SW Britain, falls of over 200mm in 24 hrs can be observed. Also known as Mesoscale convective systems (MCS).

East Coast (EC) – depressions where the eastwards progression stalls over the UK bringing moist air and rainfall from the North Sea to affect areas of the east coast. Occur in summer and can bring continuous rain for up to 4 days.

Thunderstorms (T) – isolated occurrences or progressions of convective cells, occur in summer but lacking the structure of an MCC.

Orographic (O) – rainfall associated with the normal west – east movement of Atlantic depressions which is enhanced over the mountainous areas and occur throughout the year.

Depression (D) – rainfall associated with a depression but not showing the features of the other classes. Can occur throughout the year.

4.

Event Classification

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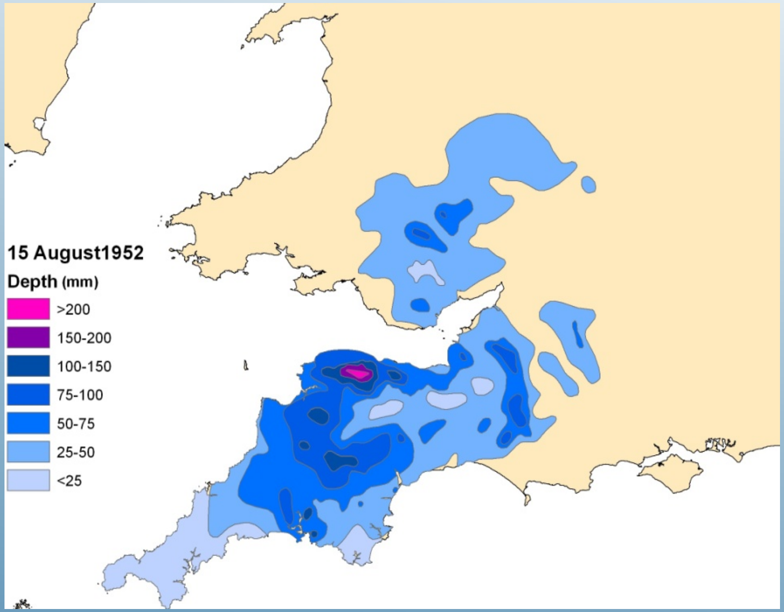

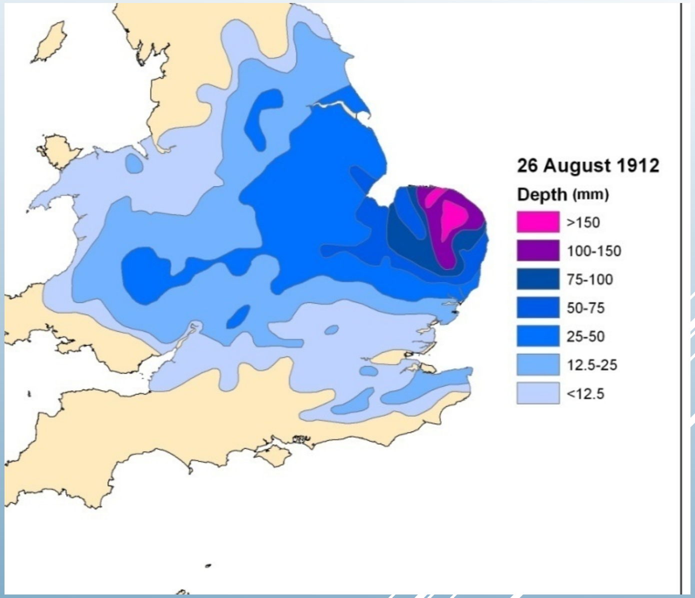

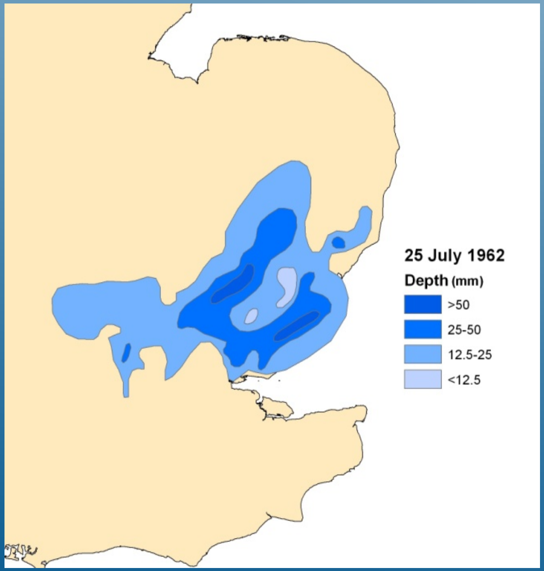

1) MCC
2) East Coast
3) Thunderstorm

4.

Event Classification

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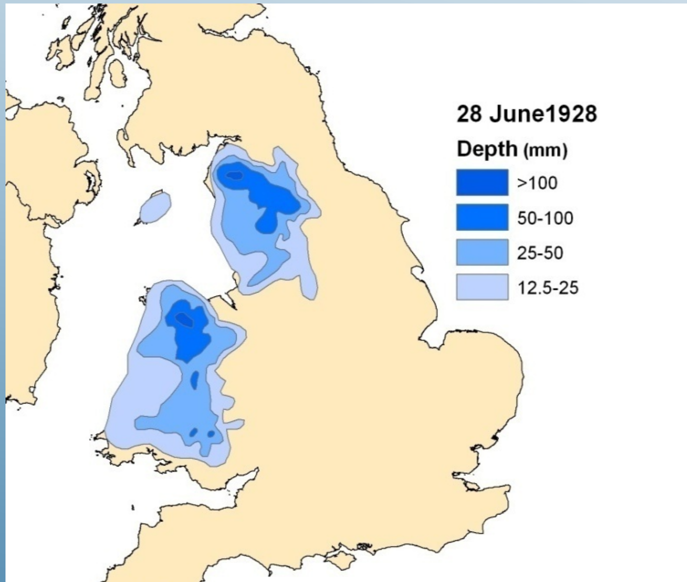

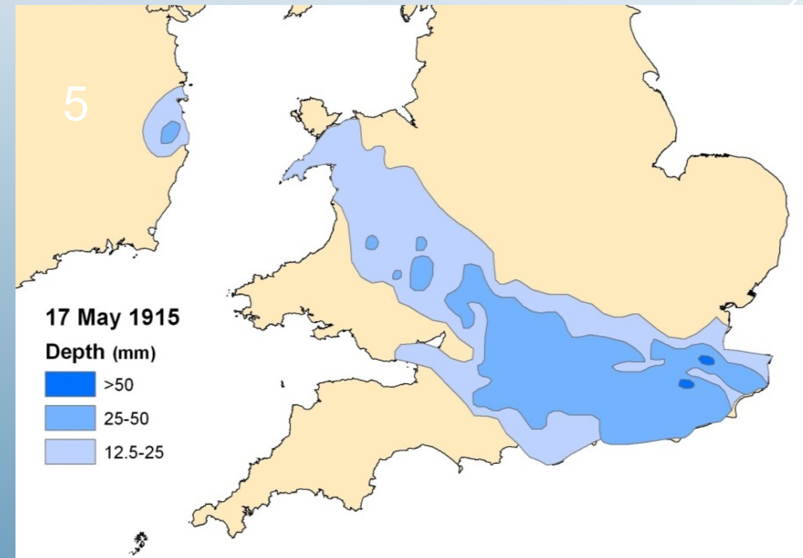

4) Orographic
5) Depression / other

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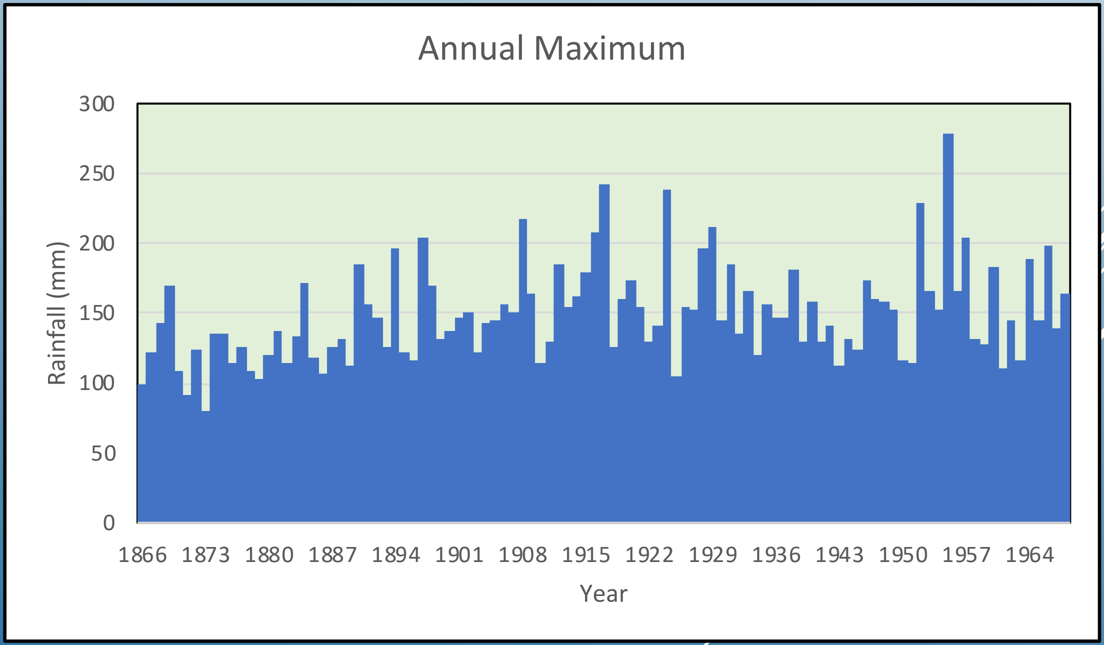
Maximum Observed 24hr Rainfalls

Maximum 279.4 (1955)
Minimum 91.9 (1871)
Average 149.8



A fall of 100mm in 24 hours is not unprecedented,
it would be expected somewhere in the British Isles every year.

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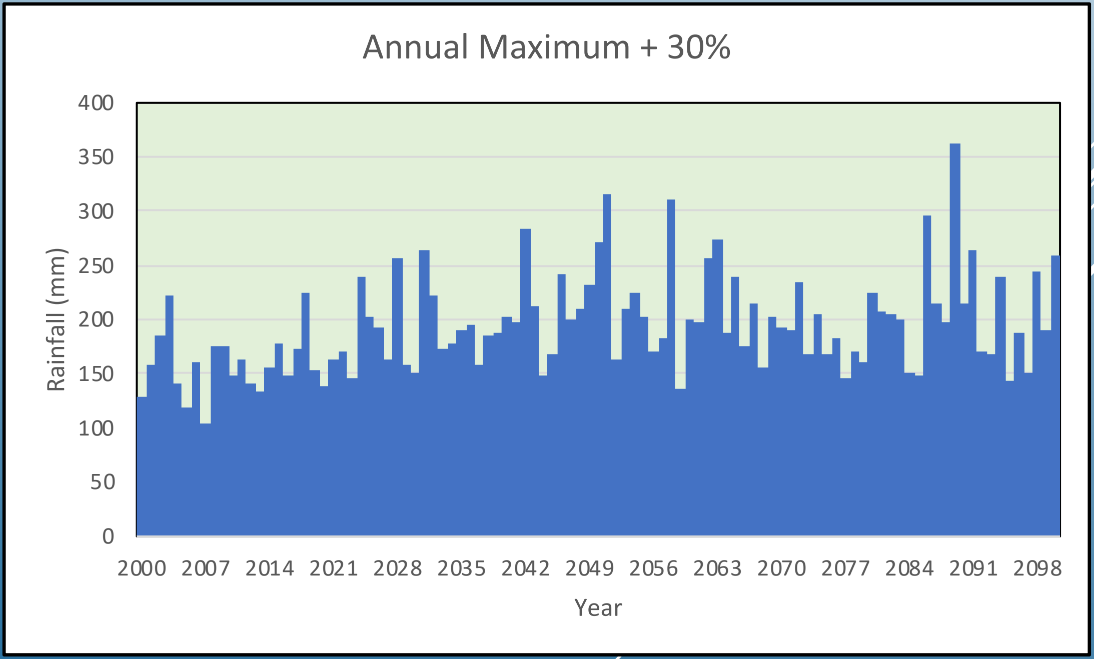
Impact of Climate Change

A warmer atmosphere will hold more moisture therefore rainfall totals will be higher.

DEFRA have used an allowance of 30% to increase extreme rainfall values by 2100



Impact of Climate Change

Recent events have seen rainfall totals over 200mm recorded in 24 hours over the standard 9:00 – 9:00 period:

20/11/2009 Seathwaite Farm, Cumbria	253mm
05/12/2015 Thirlmere, Cumbria	264mm
05/12/2015 Brothers Hall, Cumbria	244mm
05/12/2015 Dale Head, Cumbria	212mm

Seathwaite Farm (20/11/2009) and Honister (05/12/2015) exceeded 300mm over a sliding 24hr period

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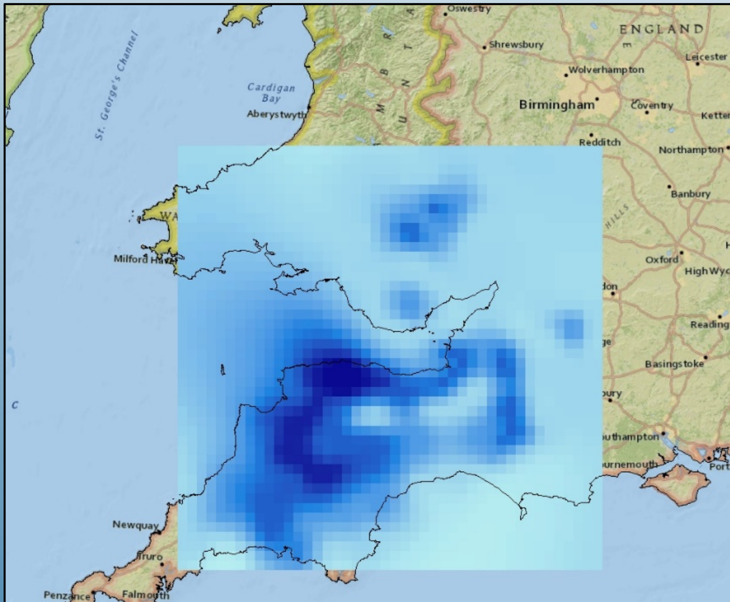
Examples of Historical Flood Events



The Lynmouth Flood 15-16/08/1952

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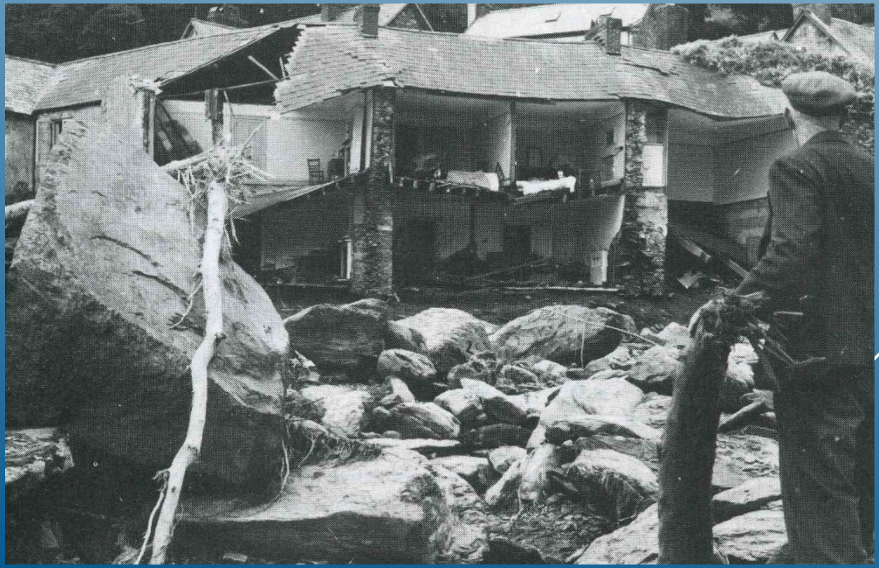
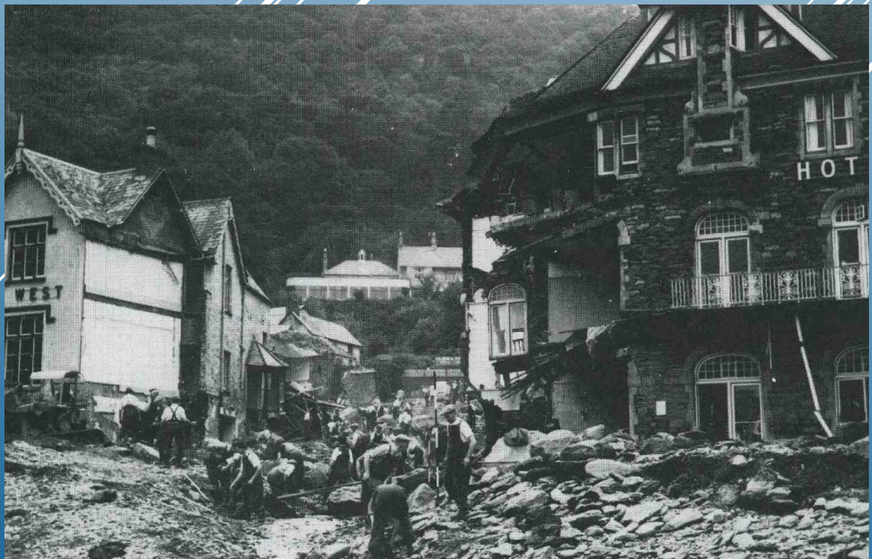
The Lynmouth Flood 15/16 August 1952

- MCC from the Bay of Biscay brought over 200mm in 24hrs to SW Britain
- Maximum observed rainfall 229mm at Longstone Barrow, Exmoor
- Sparse gauge coverage so maximum fall estimated to be higher
- Most of the rainfall within the West and East Lyn catchments which flow from the summit of Exmoor (> 500m) to sea level in about 10km.
- 34 deaths, 93 houses, 66 vehicles and 28 bridges destroyed





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Martinstown

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Martinstown 18/07/1955

Small depression (MCC) brought heavy rain to SW UK

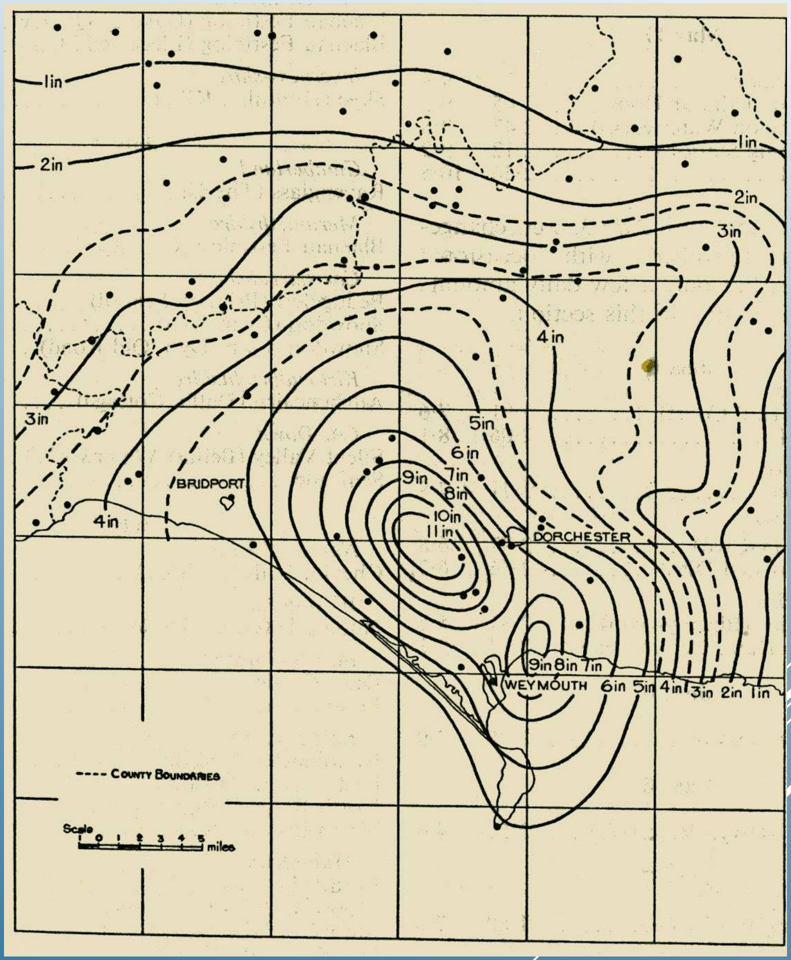
At Martinstown
279.4mm in 24 hrs
190.5mm in 5hrs

Un-official catch in a oil drum of 355mm in 24hrs on the hills above the village

Intensities of up to 50mm/hr

Daily falls >50mm in 36 rain gauges

Heavy rain (>75mm) also recorded in Devon and Glamorgan



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Martinstown

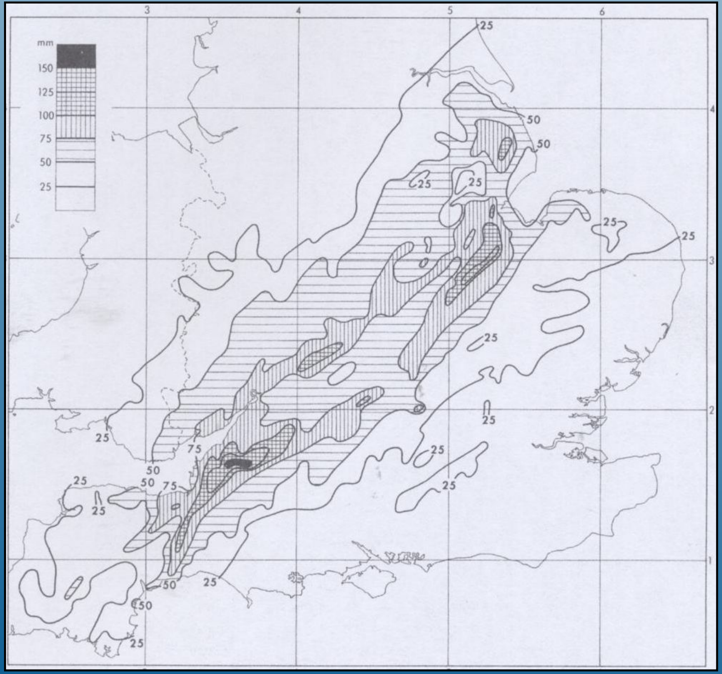
Flash flooding in centre of Weymouth, Dorchester and surrounding villages

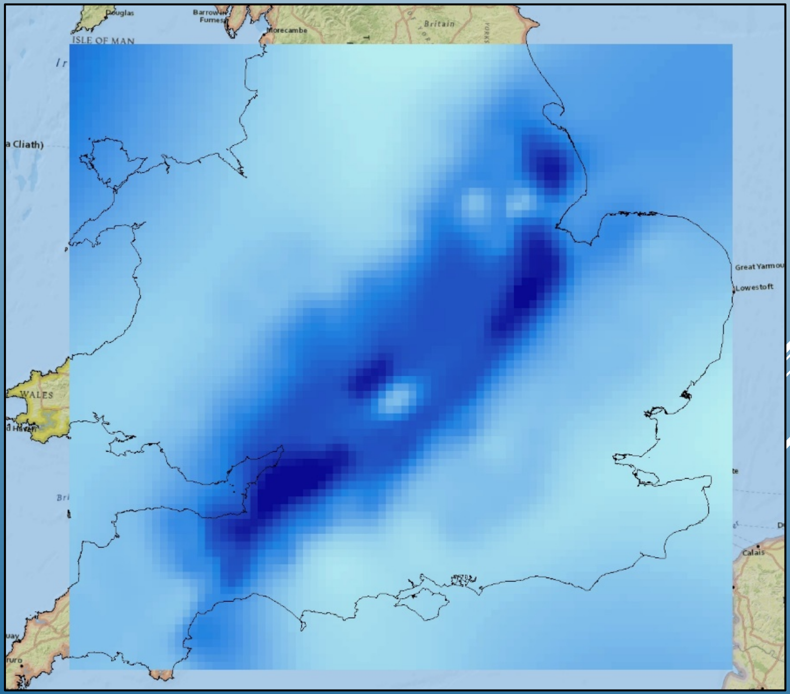
2 fatalities and 600 people evacuated from homes and caravans as the flood waters rose to 1.3m deep

10th July 1968

Extreme rainfall over a large area from the Severn Estuary to the Wash

7 deaths and an estimated 3,500 buildings damaged, numerous bridges destroyed





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10th July 1968

Bristol, Bath and SW England worst affected

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Catastrophe Model Validation

Are historical rainfall footprints and the ensuing floods adequately represented in flood catastrophe models?

RMS UK flood model based on a pan-European rainfall event set

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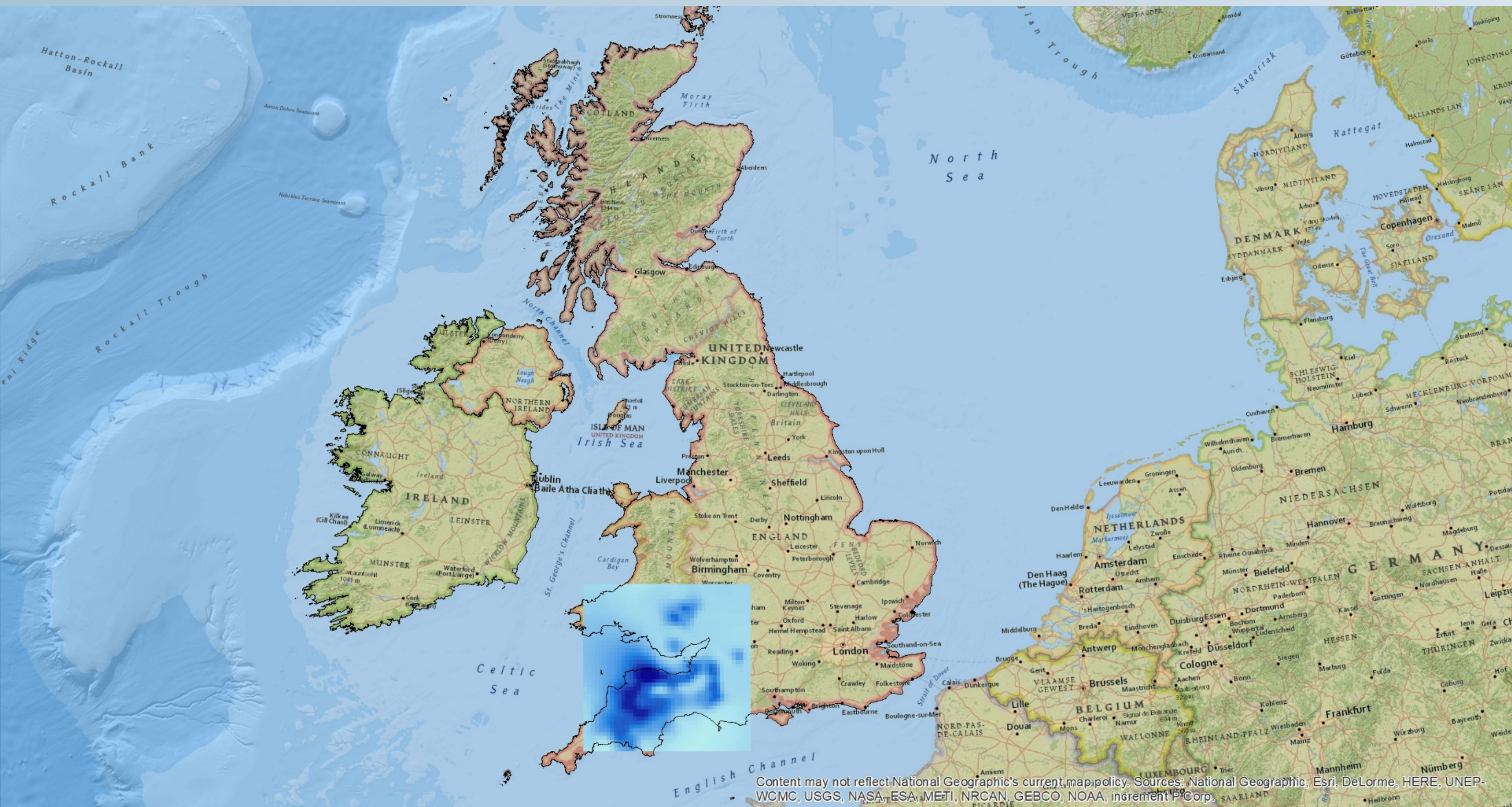

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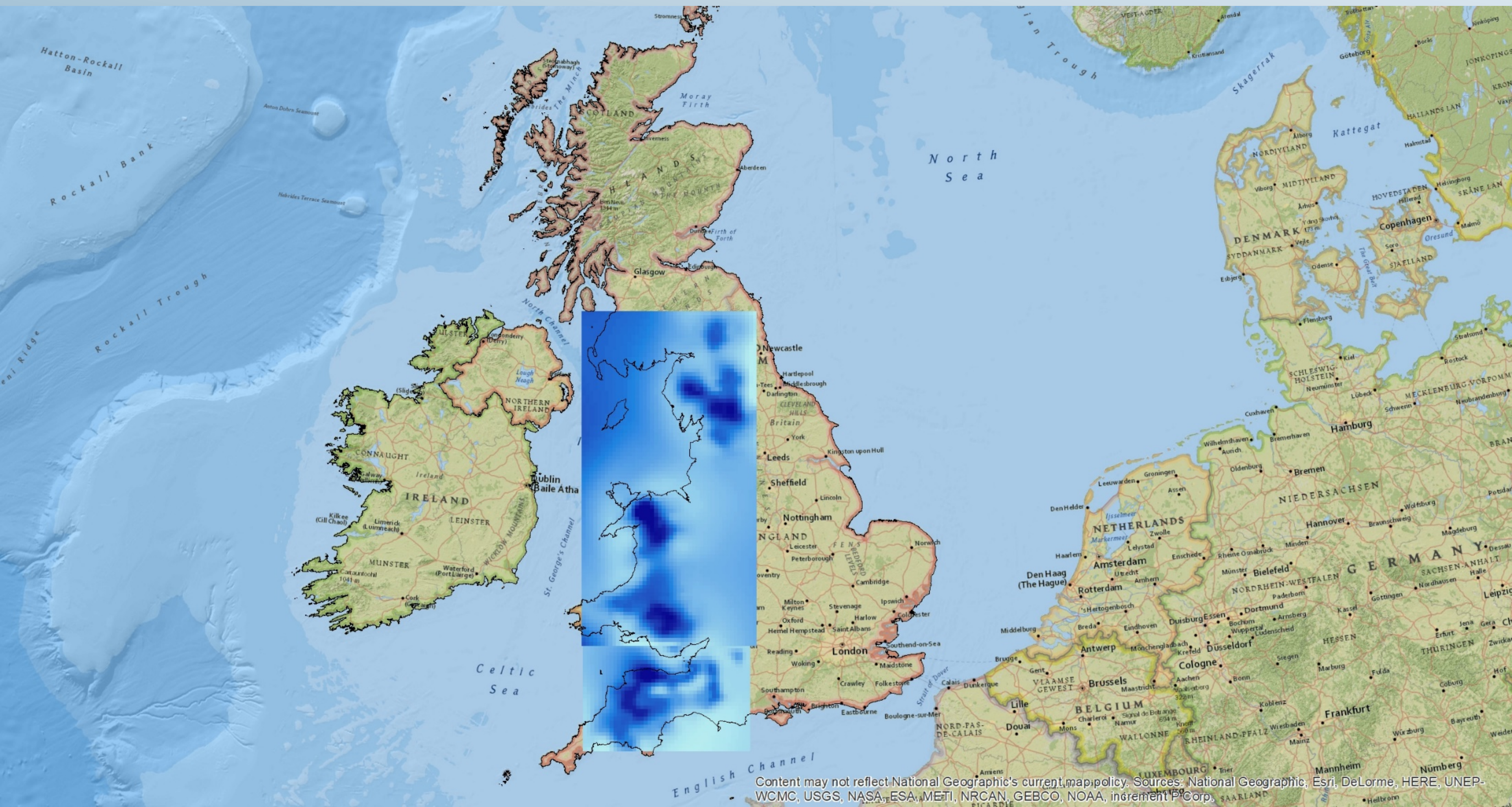

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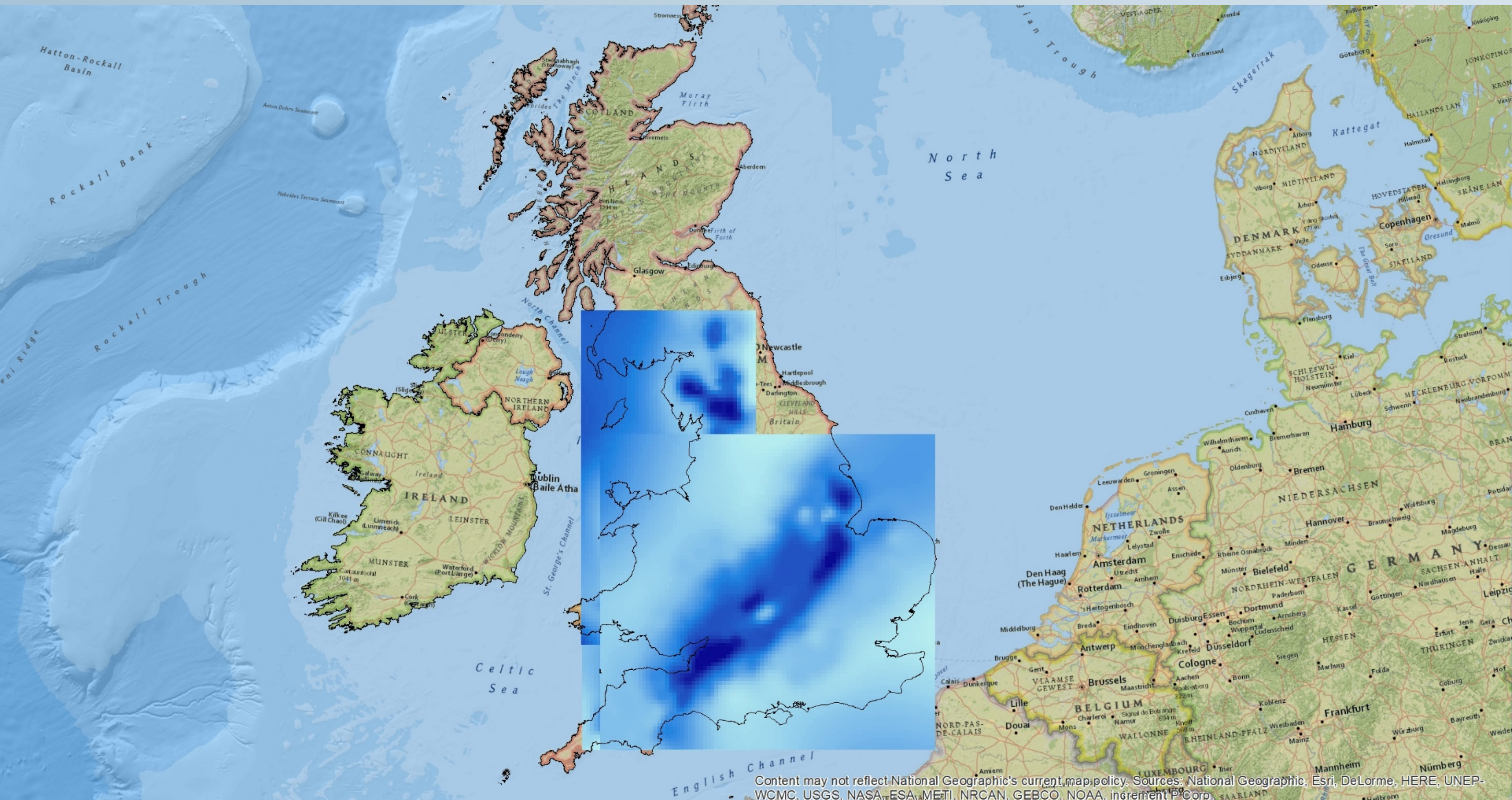

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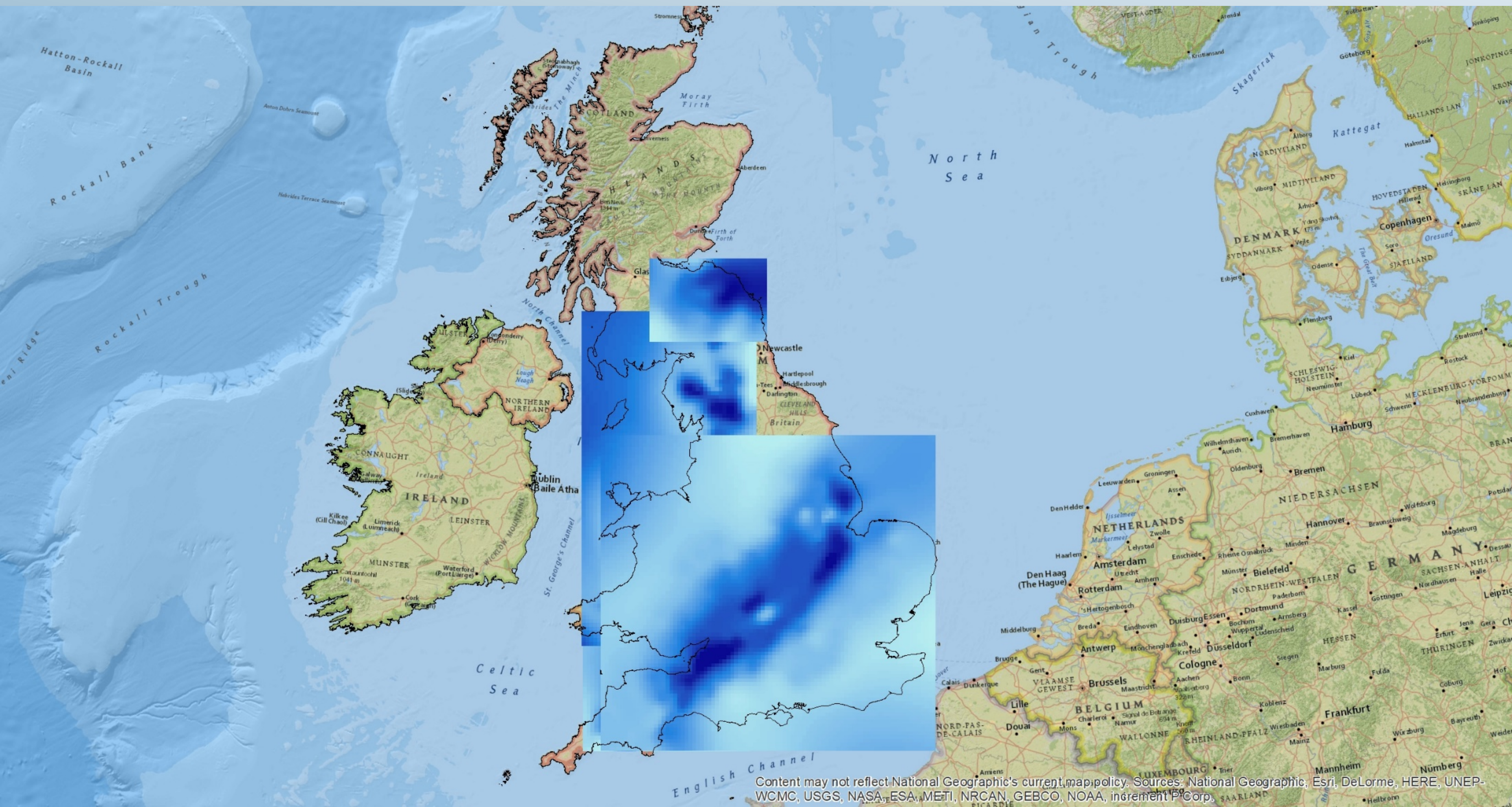

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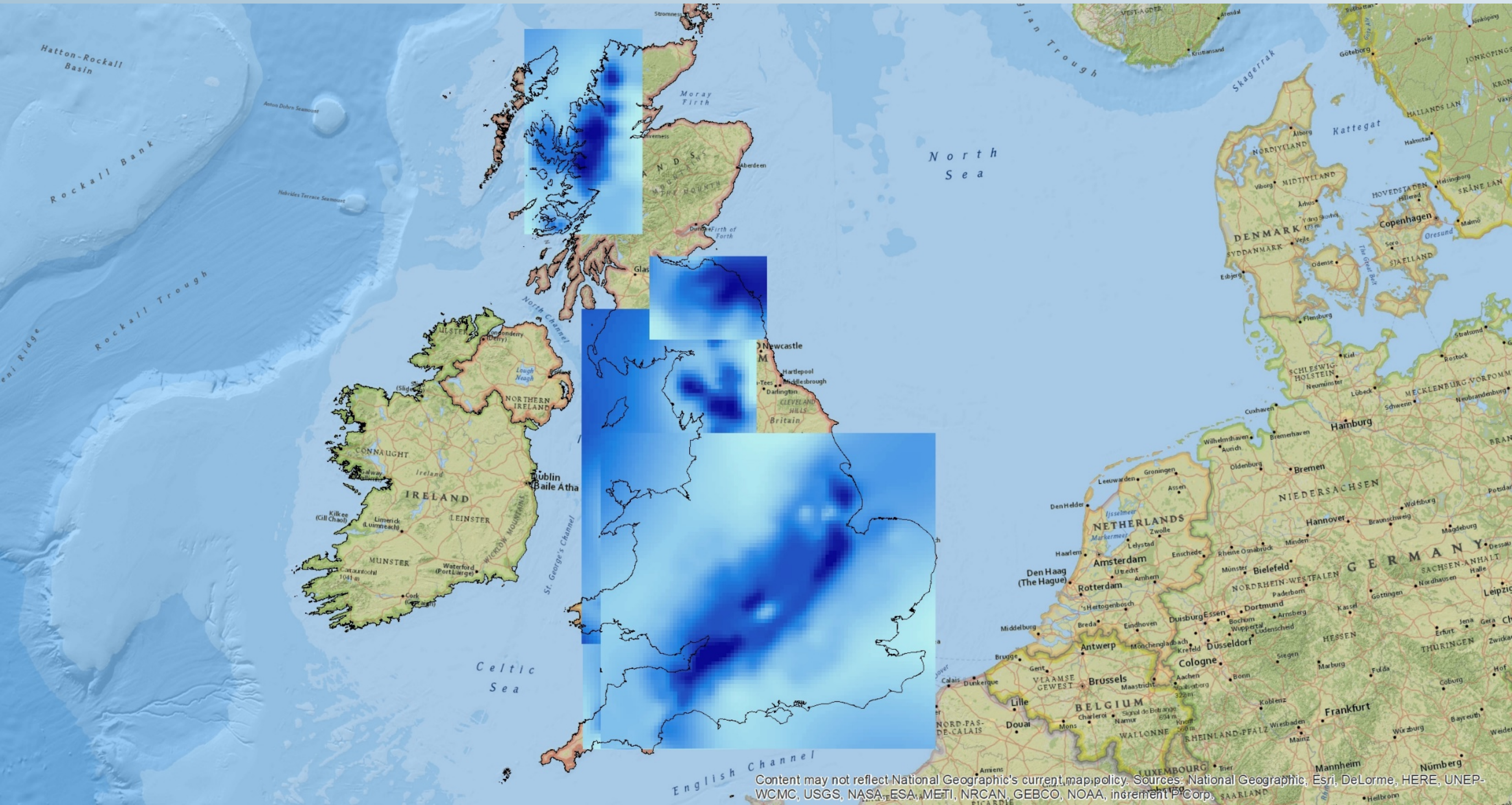

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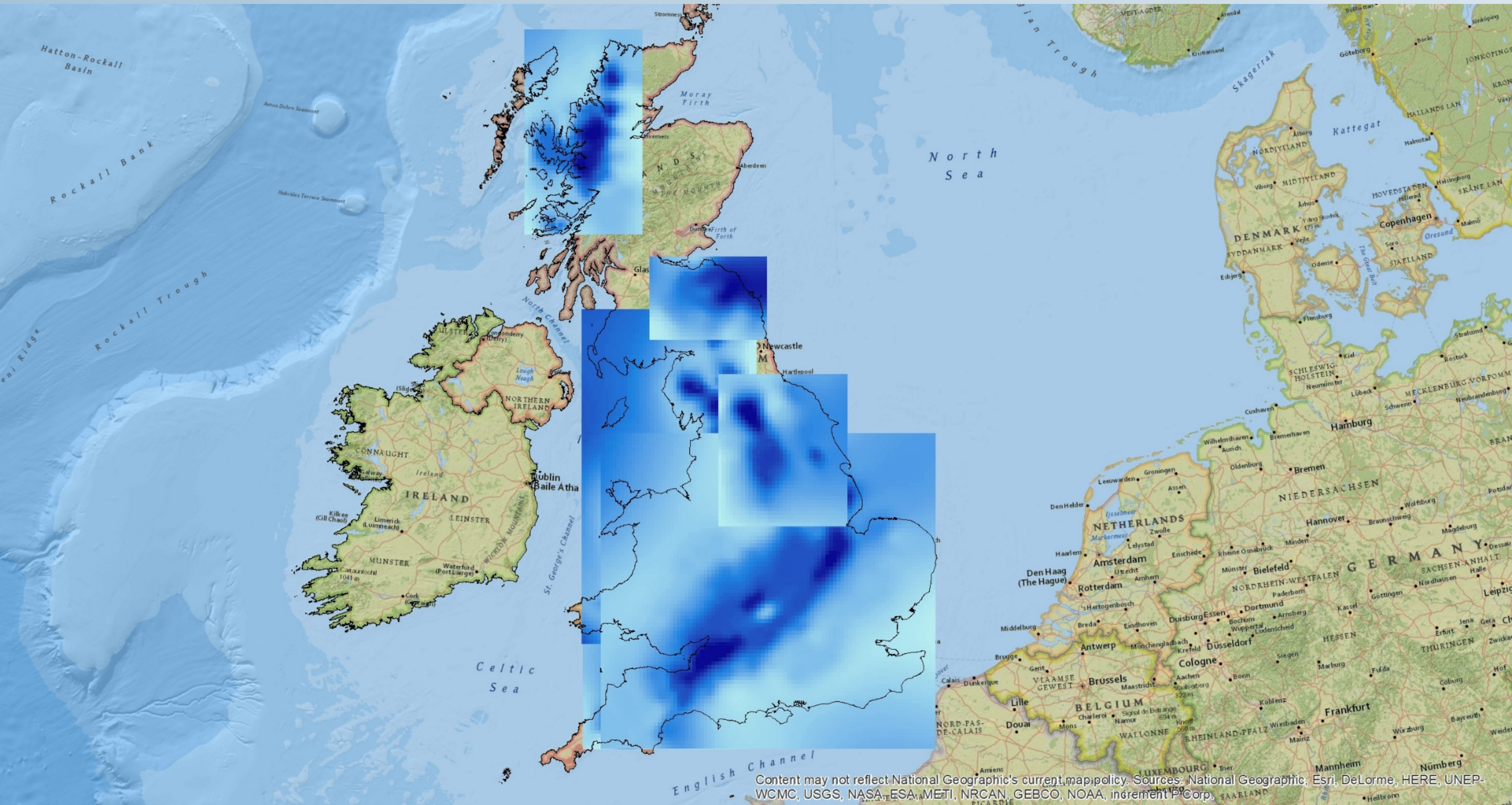

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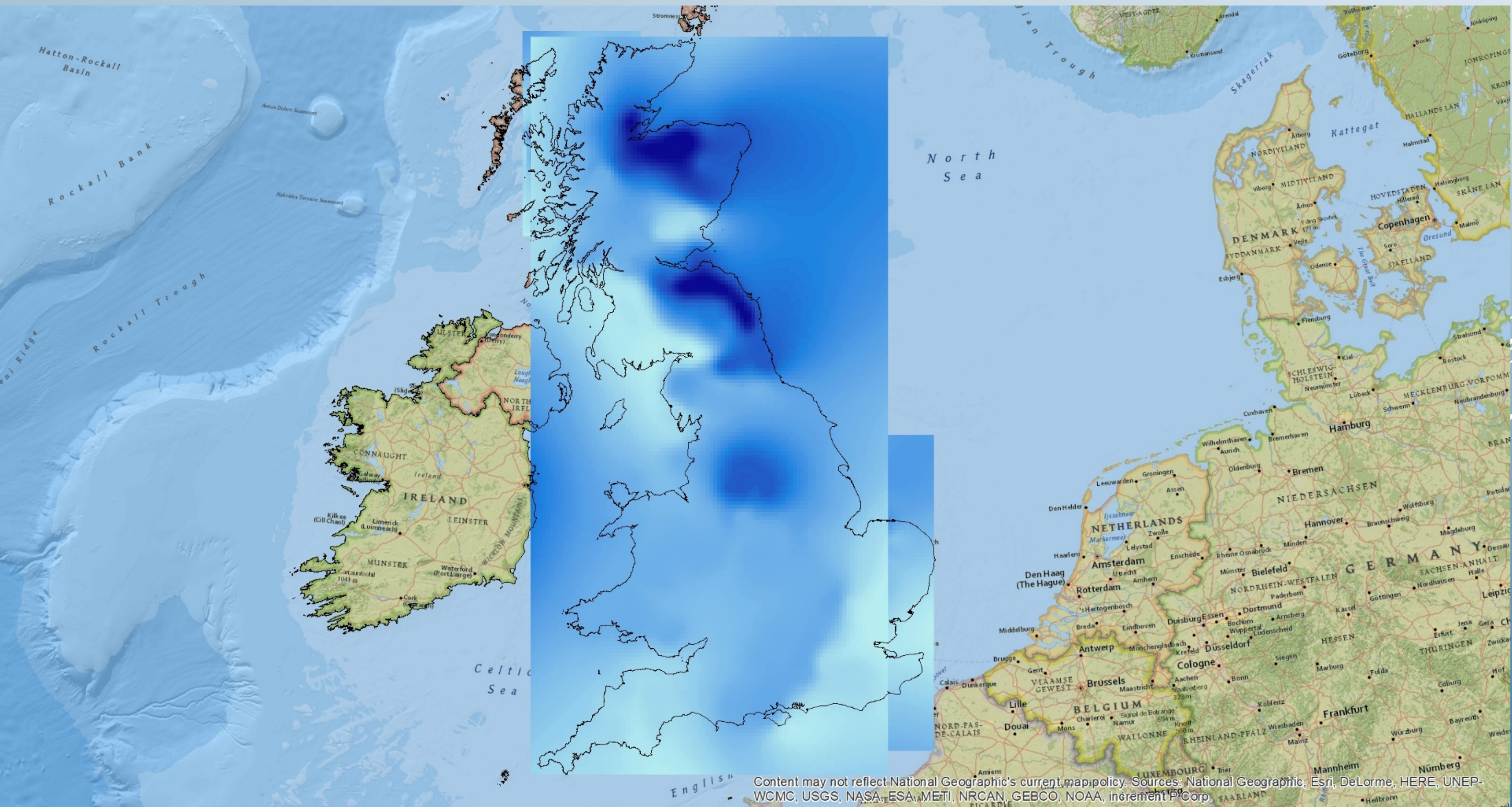

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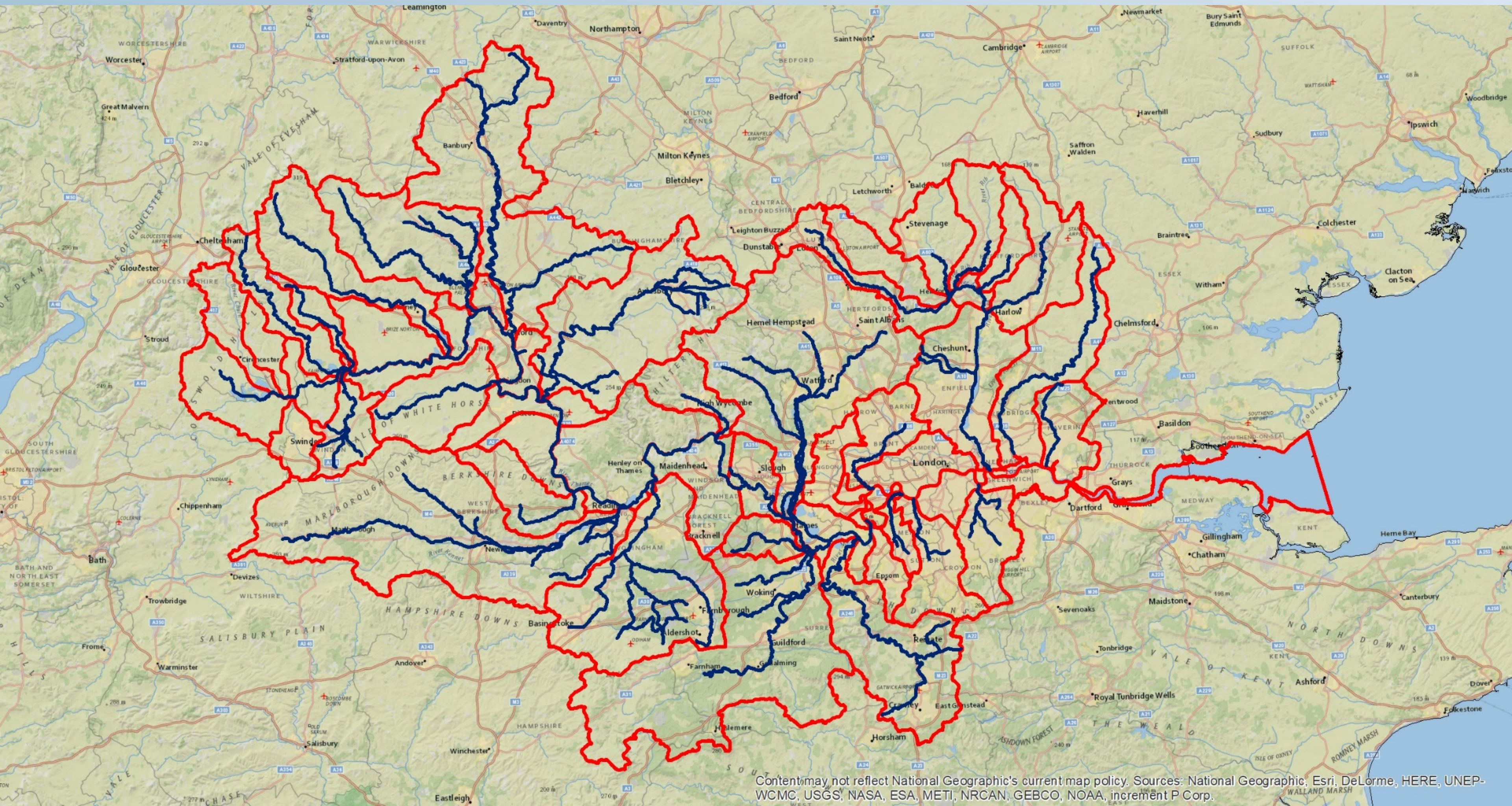
Site Specific Modelling

Are predicted rainfalls and hence flood discharges from the Flood Estimation Handbook representative of historical events?



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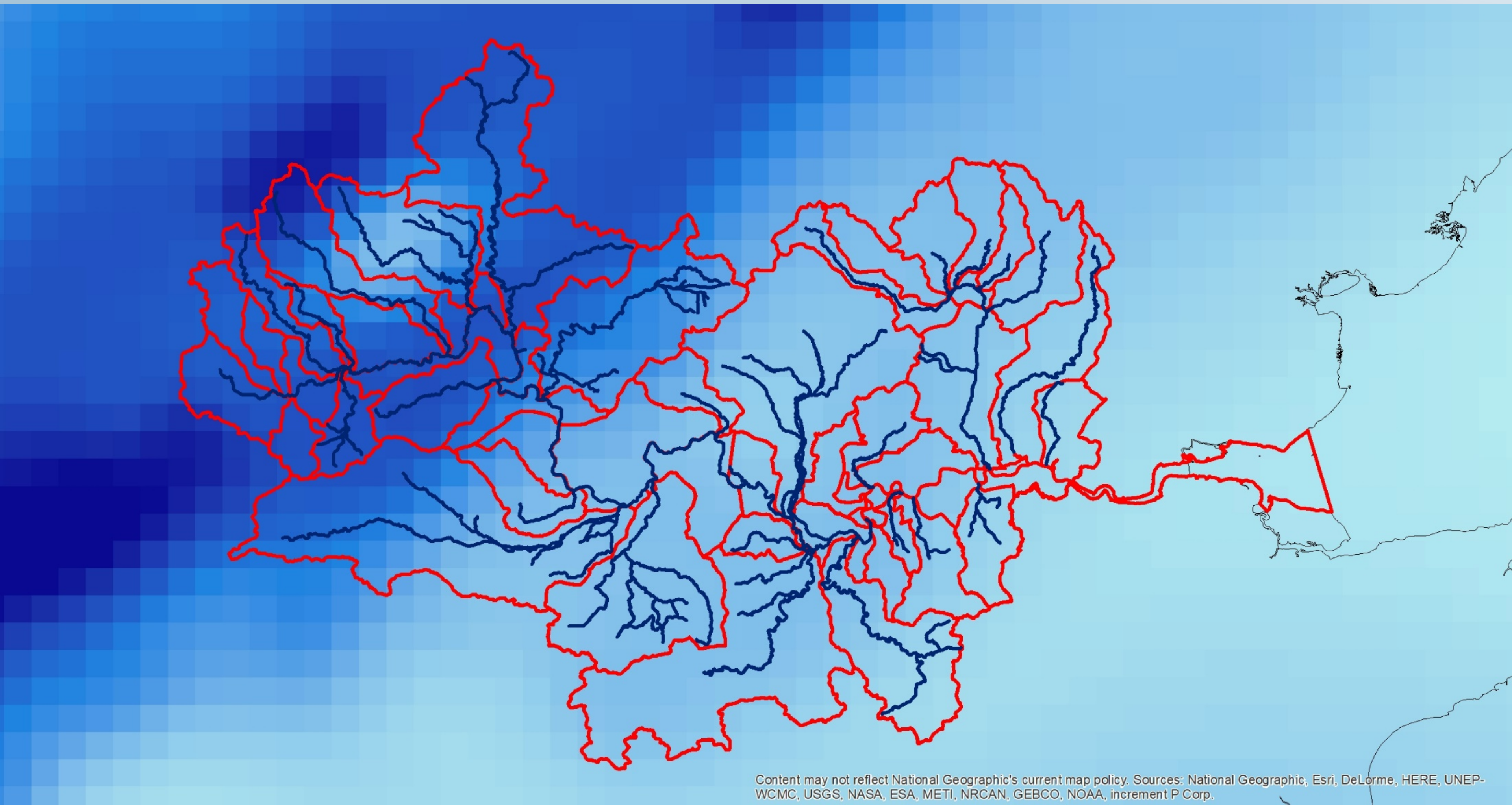

Site Specific Modelling

Are predicted rainfalls and hence flood discharges from the Flood Estimation Handbook representative of historical events?

FEH rainfalls based on met office digital data from 1961 onwards for point observations.

How does the 100-year rainfall used to generate the peak discharge for a catchment compare with that from a known historical event?

Will the 100-year rainfall be an under-estimate?

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Site Specific Modelling

16 Observations over 200mm in 24 hours

Date	Depth (mm)	Depth (in)	Location	County (pre 1974)
18/07/1955	279.4	11.0	Martinstown (The Chantry)	Dorset
28/06/1917	242.8	9.6	Bruton (Sexey's School)	Somerset
18/07/1955	241.3	9.5	Upwey (Friar Waddon)	Dorset
18/08/1924	238.8	9.4	Cannington (Brymore)	Somerset
15/08/1952	228.6	9.0	Longstone Barrow	Devonshire
18/07/1955	228.6	9.0	Upwey (Higher Well)	Dorset
22/11/1908	217.9	8.6	Snowdon (Llyn Llydaw Copper Mill)	Caernavonshire
28/06/1917	215.4	8.5	Bruton (King's School)	Somerset
28/06/1917	213.1	8.4	Aisholt (Timberscombe)	Somerset
11/11/1929	211.1	8.3	Rhondda (LluestWen Res.)	Glamorgan
18/07/1955	211.1	8.3	Upwey (Elwell)	Dorset
11/10/1916	208.3	8.2	Loch Quoich (Kinlochquoich)	Inverness-shire
12/11/1897	204.0	8.0	Seathwaite	Cumberland
08/06/1957	203.2	8.0	Camelford (Roughtor View)	Cornwall
28/06/1917	200.7	7.9	Bruton (Pitcombe Vicarage)	Somerset
18/07/1955	200.7	7.9	Wynford House	Dorset

4 observations from June 1917

FEH 100-year rainfall for Kingsdon 44.7mm

Only 20km away from where >200mm recorded

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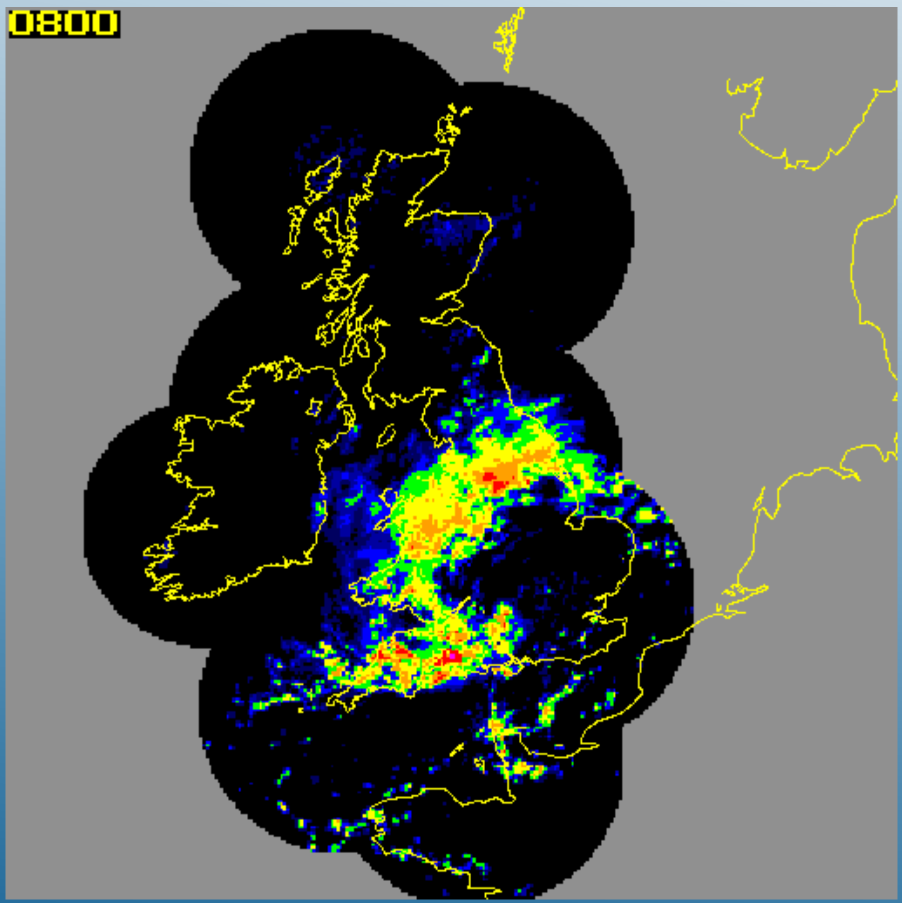
25th June 2007
103mm in 24 hours caused widespread flooding in NE England, including Hull



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25th June 2007
Widespread flooding in NE England, including Hull

- Many areas outside the EA medium and high risk flood zone maps affected;
- Flood modelling of the Forston Beck based on flow records back to 1958;
- Flood risk under-estimated, many homes in areas not identified as high risk;
- Evidence of severe historical flooding in the BRDA from 1892 not used for the EA study

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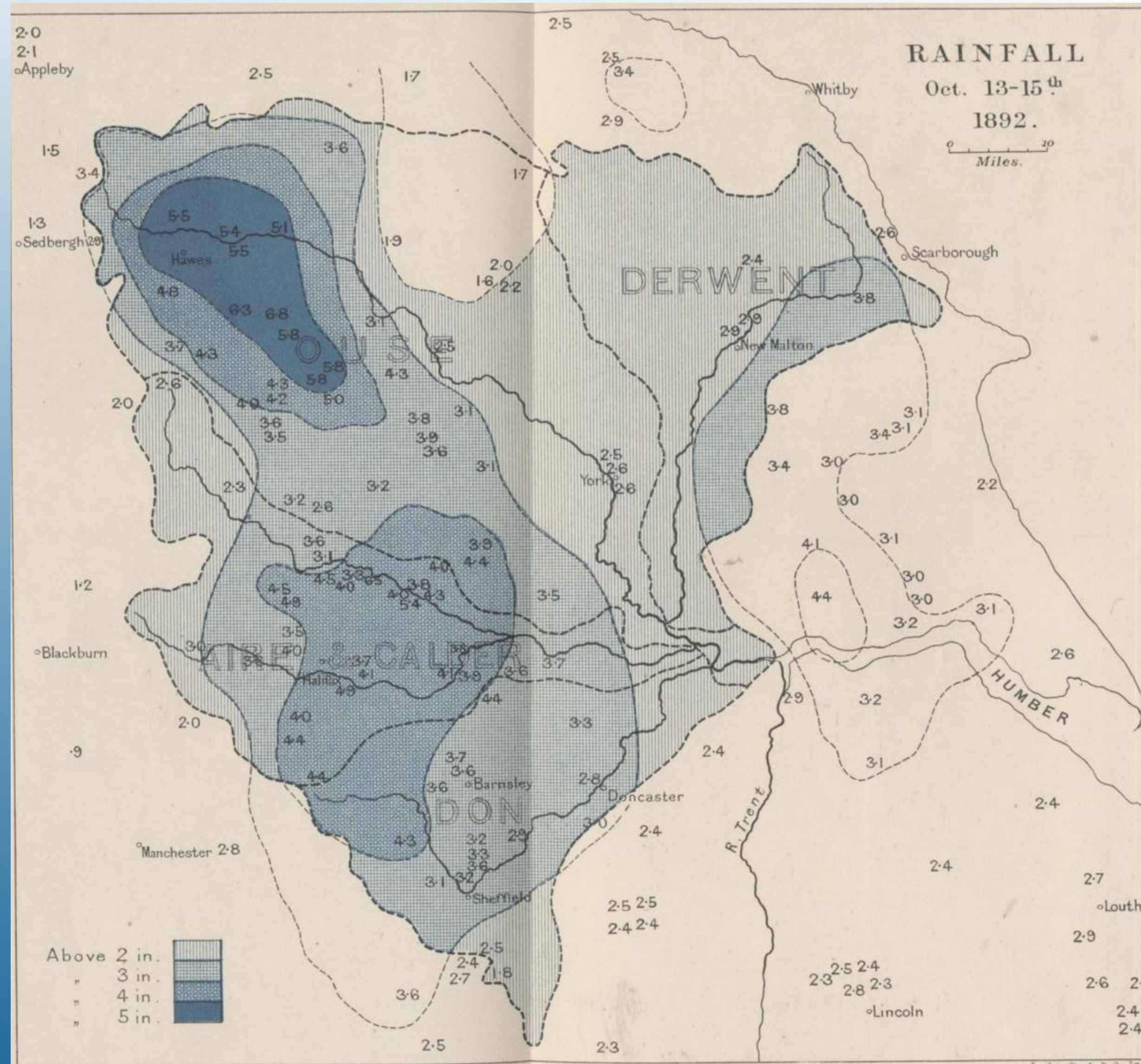
The use of information from British Rainfall could have made the authorities better prepared for the June 2007 floods in NE England



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Maximum rainfalls13-15th October 1892

Div.	Station	13th Oct (in.)	14th Oct (in.)	15th Oct (in.)	Total (in.)	Per cent
IX	Nidderdale (West Houses)	1.2	4.63	1.02	6.85	10.6
IX	Nidderdale (New Houses)	1.2	4.63	1.02	6.85	10.6
IX	Leeds (Oliver Hill, Horsforth	1.61	3.72	1.12	6.45	11
IX	Nidderdale (High Riggs)	0.5	4.45	0.84	5.79	8.9
IX	Ramsgill (Raygill House)	0.83	3.9	1.04	5.77	7.2
IX	Ramsgill	1	4.03	0.72	5.75	9.2
IX	Hawes (Hardrow Vicarage)	1.41	3.47	0.6	5.48	7.5
IX	Aysgarth (Caperby)	1.1	3.42	0.91	5.43	9
IX	Leeds (Holbeck, W.Works Department)	0.94	3.53	0.91	5.38	12.3
IX	Wakefield (Alverthorpe Hall)	0.88	3.5	0.86	5.24	11.8
IX	Bradford (Merton Road)	0.36	3.43	0.88	4.67	9.6
IX	Masham Moor (W. Somerside)	…	4.07	…	4.07	10.7
IX	Masham Moor (High Sour Mire)	…	4.03	…	4.03	11.2
IX	Blubberhouses	…	3.71	…	3.71	9.4
IX	West End (Thruscross)	…	3.67	…	3.67	8.9
IX	West End	…	3.57	…	3.57	8.1
IX	Dallow Moor (Harper Hill)	…	3.45	…	3.45	10.1

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Extract from the 1892 chronicle referring to the floods of October 1892

It is very difficult without, or even with, a series of photographs to form any idea of the mischief which this rain produced in the low lands on the side of the principal rivers. We can give only a few facts, and must leave our readers to fill in the details from their own knowledge of the necessary discomfort and danger. It is impossible to state the number of houses flooded, but the official report for York alone was more than 500, and we have dozens of photographs of, or details respecting, flooded houses in Barnsley, Batley, Bingley, Boroughbridge, Castleford, Cleckheaton, Dewsbury, Doncaster, Ferrybridge, Halifax, Kirkstall, Knottingley, Leeds, Pateley Bridge, Pickering, Selby, and Wakefield. We feel sure that the total number of houses flooded cannot have been less than 4,000.

Thank you for your attention.

Any questions?