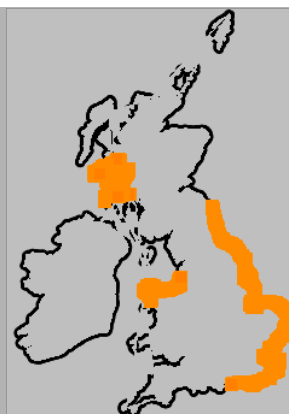


# STORM EVENT

——— 6<sup>th</sup> December 2013 ———

*The biggest event to impact the UK east coast for more than half a century. Much flooding and damage, particularly in the northeast, but a repeat of the 1953 damage levels was prevented*



## Severity Ranking



Social	<u>Loss of life</u>	*
	<u>Residential property</u>	Around 2,800 properties were flooded
	<u>Evacuation &amp; rescue</u>	Approximately 18,000 persons from around the country were evacuated
Economic	<u>Cost</u>	Estimated cost of damages to property and that incurred by the Environment Agency was under £0.5 billion
	<u>Ports</u>	The port of Immingham was closed for several days when key infrastructure was impacted by flood water
	<u>Transport</u>	160 km of rail and 190 km of roads were affected by flooding
	<u>Energy</u>	*
	<u>Public services</u>	*
	<u>Water &amp; wastewater</u>	*
	<u>Livestock</u>	Around 700,000 heads of livestock were killed
	<u>Agricultural land</u>	Approximately 68 km <sup>2</sup> was inundated
Environmental	<u>Coastal erosion</u>	There was considerable erosion, most notably along the east coast which drew comparisons to the disaster of 1953
	<u>Natural environment</u>	*
	<u>Cultural heritage</u>	*
	<u>Coastal defences</u>	There were around 50 breaches to defences around the UK

\*No known sources of information available

**Source**

Storm “Xaver” developed off the southeast Greenland coast on 3<sup>rd</sup> December 2013 and moved in an eastward direction towards the UK. On 5<sup>th</sup> December, the storm passed over north Scotland and combined with, and was enhanced by, another low-pressure system located over the Norwegian Sea. The pressure dropped rapidly to 960 mbar as the storm crossed the North Sea and passed into Scandinavia and then Eastern Europe on 6<sup>th</sup> December. Hurricane force wind gusts were recorded.

The storm generated a skew surge of over 1 m in the Irish Sea and up to 2 m in the North Sea. Skew surges in the eastern English Channel were between 0.5 and 0.75 m. Water levels exceeded the 1 in 5 year return level at 12 sites in these regions. At 9 of these sites the water level was the highest on record. The highest return period water level was at Dover and was 1 in 843 years. The highest skew surge was at Lowestoft and was 1.93 m (approximately a 1 in 200 year return period skew surge). The high water took 9 hours to travel from Aberdeen to Dover. The storm surge passing into the English Channel caused the largest water level on record at Newhaven and at Portsmouth, with a skew surge value of 0.73 m and 0.69 m, respectively. West of these gauges, the surge continued to propagate westwards through the morning of 6<sup>th</sup> December, but without causing extreme high waters beyond the Solent. In many instances, the high water levels observed in 2013 exceeded those during the notorious 1953 event, due mainly to the larger astronomical tides in 2013 (Wadey *et al.*, 2014; 2015).

Maximum significant wave heights along the east coast were highest off the North Norfolk coast (almost 4 m offshore), and lowest along the Suffolk coast (Spencer *et al.*, 2015).

**Pathway**

This was a complex event which produced at least 50 separate incidences of breached (natural and manmade) defences across the UK coastline as well as multiple incidences of overtopping.

**Receptor & Consequence**

This was reportedly the worst coastal flooding event in the UK since the disaster of 1953. A detailed description of this event is provided by Spencer *et al.*, (2014, 2015) and Wadey *et al.* (2015). There was intense media coverage of this event and it had prompted comparisons with the event of 31<sup>st</sup> January – 1<sup>st</sup> February 1953. The event coincided with the other significant news of the death of Nelson Mandela. Across Northwest Europe, by 7<sup>th</sup> December 2013, this storm had left 15 persons dead and dozens injured. There were no reported fatalities from coastal flooding (AONB, 2014). Initial estimates from the Environment Agency (EA) indicated consequences including seawater inundation to 1,400 homes, 1,000 businesses and 3,200 hectares of farmland. Over 10,000 people were evacuated along the east coast, and approximately 800,000 properties are reported to have been protected by flood defences along 2,800 km of UK coastline (Zurich, 2014). Around 2,800 properties were flooded across the UK (Wadey *et al.*, 2015). Model estimates suggest insured losses across the event were in the range of €1.4 to €1.9 billion, including wind losses and storm surge-related flooding. According to a ‘flood footprint’ map showing seawater flood depths (with a resolution of 5 m over an area of approximately 2,500 km<sup>2</sup> and covering a length of 1,500 km of coastline), locations listed as flooded from wave overtopping included: Boston, Great Yarmouth, Lowestoft, North Berwick, Jaywick, North Wales, Blackpool, Cleveleys, Walcott, Cromer, Whitstable, Portgordon and New Brighton (JBA, 2014). Numerous reports of the floods are available via major news agencies.

## **Supplemental description of impacts**

### **Wales and Northwest England**

Flooding first occurred early afternoon on 5<sup>th</sup> December 2013, on the north coast of Wales and west coast of England. Notable was Rhyl in North Wales, where 400 people were evacuated (BBC, 2013a), and between 140 (News North Wales, 2014) and 155 properties reported flooded, and a further 160 indirectly affected (e.g. loss of access, water surrounding property) (CNC/NRW, 2014). Some detail of defence failures at Rhyl is described by Parker (2014). The sand dune system at Barkby Beach and Gronant Dunes suffered damage due to wave action, with lateral losses of up to 8 m. At Kinmel Bay in Conwy, six properties were flooded and a rest centre was set up; three properties were flooded in Llandulas and one in Red Wharf Bay on Anglesey (Davies, 2013). Extensive damage was caused to the sea wall around Mostyn (a small village in Flintshire, Wales, lying on the estuary of the River Dee) and along the north Wales main line: debris carried by floodwater was left on the line, requiring clearance and repair. The Conwy Valley rail line between Llandudno and Blaenau Ffestiniog was closed due to ballast being washed away at Tal-y-cafn (Davies, 2013).

Further north, sea walls and promenades were overtopped across Liverpool Bay/Merseyside, by the combination of waves and extreme sea levels (Wirral, 2014). In the Sefton region, the sea wall and visitor car park at Crosby were damaged and the boardwalk at Formby was partly washed away (Sefton Council, 2014). The Wirral (Merseyside) experienced its worst flooding since the early 1990's with New Brighton and West Kirby particularly badly affected; cars and businesses were left partly submerged by sea water (BBC, 2013b). There were also floods across Lancashire: 14 properties were flooded in Blackpool, Fleetwood and Lytham. In Cumbria, Whitehaven harbour was damaged and the A595 (road) was obstructed. Damages totalled £300,000, although no properties were reported flooded.

### **Scotland**

In Scotland, the worst of impacts were largely wind-induced, although coastal flooding-related impacts also occurred caused by intense wave action and extreme sea levels. Most notable were floods at the Esplanade in the west coast town of Oban (Argyll and Bute) (Oban Times, 2013) and at Eyemouth (Scottish Borders) on the east coast. The total reported number of properties and businesses flooded between these two locations was 50. At Eyemouth, it was claimed by locals that this was the worst flood in 105 years (The Berwickshire News, 2013). Meanwhile, roads were flooded in Moray (10 people trapped in a bus near Buckie had to be rescued), Inverness, Aberdeen and in the harbour area of Grangemouth (SEPA, 2014).

### **Northeast England**

On the east coast, during 5<sup>th</sup> December there was flooding in Newcastle as the high water caused the Tyne to burst its banks, flooding the Quayside area of the city and requiring evacuation in Newcastle Crown Court. The National Glass Centre in Sunderland and adjacent university buildings were also evacuated amid fears the River Wear was about to burst its banks (BBC, 2013c).

East Riding (north bank of the Humber) and the city of Hull were badly hit, mostly due to the overtopping (rather than breaching) of defences: approximately 400 properties were flooded (HCC, 2014). Costs for reactive works (road closures, sweeping, gully cleaning, debris disposal, equipment hire etc.) were approximately £95,000, and permanent repair works (damaged roads and footways) £425,000 (ERYC, 2014). Further south, the promenade in Scarborough was flooded and approximately one third of sea defences around the Sands development area of North Bay were damaged whilst at Happisburgh the owner of a property at Beach Road was forced to leave after coastal erosion caused the cliff to collapse into the sea. In Whitby, up 200 properties were flooded (BBC, 2013f).

In North Lincolnshire the peak sea level event at the Port of Immingham was larger than in 1953 and associated with substantial flooding and damage to the dock facilities (ABPmer, 2014). Locations along the tidal Trent flooded, and most notably for any urban area in the whole UK the town of Boston suffered flooding of 803 residential properties (of the total of 819 in Lincolnshire), and there was £8 million damage. Notable were breach defence failures including a 40 m aperture in a flood bank at 'Slippery Gowt' (which was temporarily repaired with 2000 tonnes of stone).

### **East Anglia regions**

The low-lying regions of Norfolk, Suffolk and Essex (as well as Lincolnshire) were particularly badly hit in 1953, and a repeat of that event was feared on 5<sup>th</sup> December 2013. In Norfolk, amongst the impacts, erosion was particularly bad, three cliff-top homes collapsed into the sea at Hemsby, near Great Yarmouth, and four more were badly damaged, whilst a lifeboat station was washed away. Seawalls protecting at least three conservation sites were breached, and at Winterton at least 170 seal pups were washed away. Firefighters rescued several people from floods in King's Lynn, Bacton and Walcott (BBC, 2013d). In Cromer, part of the sea wall collapsed and the pier was closed.

In Suffolk there was extensive urban flooding at Lowestoft: 143 commercial and 90 residential properties were impacted. Of the ca. 230 properties flooded across the county, almost 170 were located in the Waveney District. Many properties were flooded and both bridges were closed, effectively cutting the town in half. There were 15 breaches across the coast and estuaries, some as large as 30 m wide. Sea defences failed at Blythburgh, which caused the closure of the A12 road, the vital link between Lowestoft and Ipswich. Rail services between Lowestoft and Norwich, and Lowestoft and Ipswich were disrupted as a consequence of flooding at Lowestoft Central and damage to the signalling network. The Lowestoft to Ipswich line was closed for eleven days after the tidal surge (SDC, 2014). Ipswich and Felixstowe escaped substantial damage but Waldringfield suffered significant flooding.

The storm surge propagated south along the English North Sea coastline, impacting areas of Essex, followed by Kent after midnight, before continuing through the Straits of Dover and reaching the English Channel. Initial forecasts for coastal Essex (which was badly hit in 1953) suggested that more than 5,000 homes could be affected (Heart, 2013) but it was only an unfortunate 38 properties which were impacted (33 commercial, 5 residential) (Johnson, 2014). Kent avoided the widespread flooding that was predicted: approx. 1,000 homes in Sandwich, Seasalter, Faversham and Medway were evacuated. Two women and two babies were rescued after being hit by a large wave walking in the Louisa Bay area of Broadstairs at 12.30pm, well before the peak of the surge hit the region around midnight. The EA's temporary flood barriers reportedly protected 219 properties in Sandwich, although "about 40 homes - in

Faversham, Sandwich and Strood - were submerged when water broke through defences in the early hours of Friday, leaving hundreds of people evacuated.” (Kent Online, 2013). Relatively minor floods were also reported in Sittingbourne, Whitstable, Dover, Rochester and Margate. Beach huts were overturned at Broadstairs, and fire crews rescuing a man from a stranded lorry at Dover’s docks.

### **South coast**

The English Channel was also affected in the early hours of 6<sup>th</sup> December, with the Sussex coast badly hit – roads were flooded in Littlehampton, Newhaven and Shoreham. Floods left railway lines out of action: and all trains were suspended from Brighton to Seaford, badly disrupting the morning commute. Shoreham airport was under water after the The River Adur burst its banks, and with a significant breach in the embankment. A number of homes on the A259 (Shoreham) were also flooded (BBC, 2013e; ITV, 2013). Minor flooding was reported on the Isle of Wight, on the north coast at Cowes and Yarmouth, and on the east coast at St Helens. Sandbags were issued at approx. 3am when the surge caused the River Medina to rise “dangerously high” (IWCP, 2013). In Southampton, properties on low-lying areas of the River Itchen came with several centimetres of flooding (Taylor, 2013).

**Table 1:** High water levels (m CD) recorded at the UK National Tide Gauge sites that reached or exceeded a 1 in 5 year return level during the event.

Tide gauge Site	Date and time (GMT)	Return period (years)	Water level (m CD)	Astronomical tide (m CD)	Skew surge (m)
Newhaven	06/12/13 01:15	39	7.79	7.06	0.73
Portsmouth	06/12/13 01:00	12	5.56	4.88	0.69
Weymouth	06/12/13 08:45	<1	2.59	2.39	0.2
Devonport	06/12/13 07:45	<1	5.79	5.71	0.08
Newlyn	06/12/13 06:45	<1	5.83	5.75	0.08
St. Mary's	06/12/13 06:45	<1	5.87	5.99	-0.12
Ilfracombe	05/12/13 07:15	<1	9.76	9.74	0.03
Hinkley Point	05/12/13 08:15	<1	12.55	12.35	0.21
Mumbles	05/12/13 07:45	<1	10	9.94	0.06
Fishguard	05/12/13 08:30	<1	5.26	5.28	-0.02
Barmouth	05/12/13 09:30	<1	5.85	5.47	0.39
Holyhead	05/12/13 11:45	4	6.55	6.03	0.52
Llandudno	05/12/13 12:00	15	8.91	8.21	0.71
Liverpool	05/12/13 12:30	43	11.15	9.98	1.17
Heysham	05/12/13 12:15	4	11.05	10.22	0.82
Workington	05/12/13 12:30	<1	8.97	8.84	0.13
Port Erin	05/12/13 12:30	<1	5.95	5.69	0.26
Portpatrick	05/12/13 13:00	<1	4.28	4.23	0.05
Millport	05/12/13 01:30	<1	3.63	3.46	0.17
Tobermory	05/12/13 07:00	4	5.6	4.98	0.62
Stornoway	05/12/13 07:30	1	5.66	5.32	0.34
Ullapool	05/12/13 07:15	9	6.25	5.64	0.61
Kinlochbervie	05/12/13 08:15	1	5.72	5.34	0.38
Lerwick	05/12/13 12:15	<1	2.52	2.47	0.05
Wick	05/12/13 12:45	1	4.15	3.75	0.4
Aberdeen	05/12/13 15:00	20	5.23	4.63	0.6
Leith	05/12/13 15:15	21	6.61	5.9	0.7
North Shields	05/12/13 16:15	405	6.58	5.5	1.08
Whitby	05/12/13 17:15	568	7.32	6.08	1.24
Immingham	05/12/13 19:15	787	9.12	7.5	1.62
Cromer	05/12/13 07:30	<1	4.85	5.12	-0.27
Lowestoft	05/12/13 22:30	188	4.76	2.83	1.93
Dover	06/12/13 00:45	843	8.45	6.81	1.64



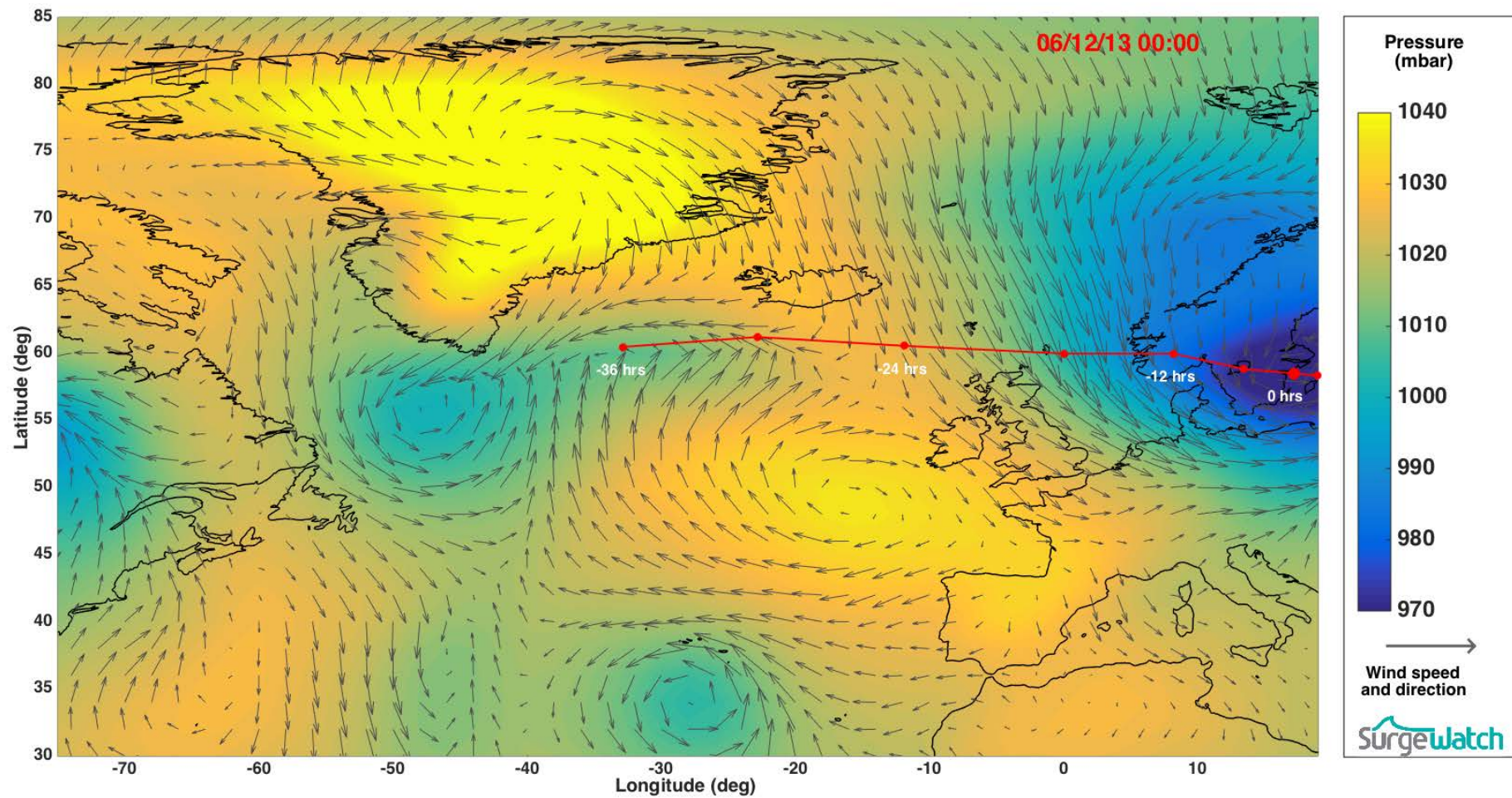


Figure 1: Meteorological conditions at time of maximum water level overlaid by the storm track



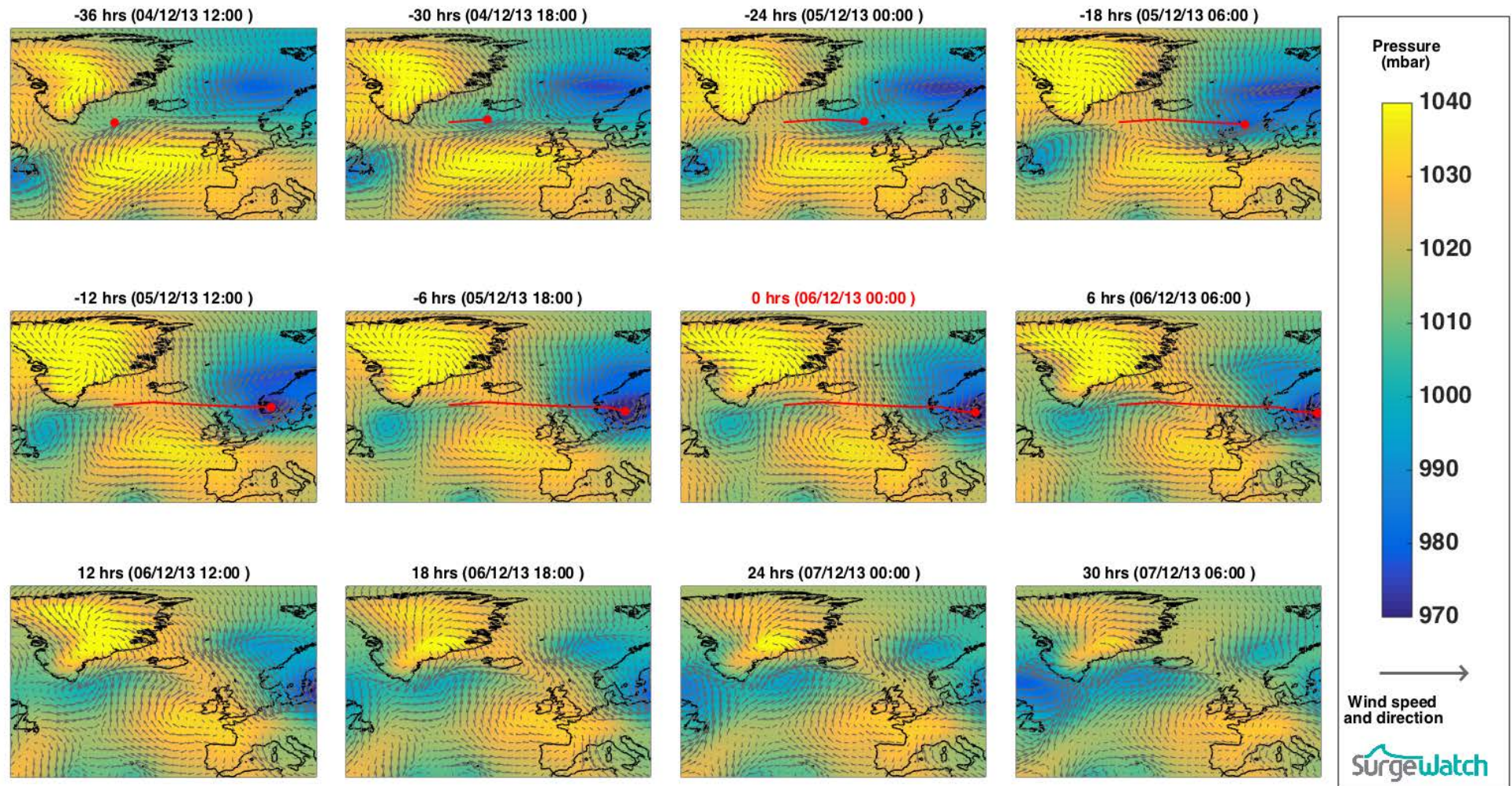


Figure 2: Meteorological conditions during event



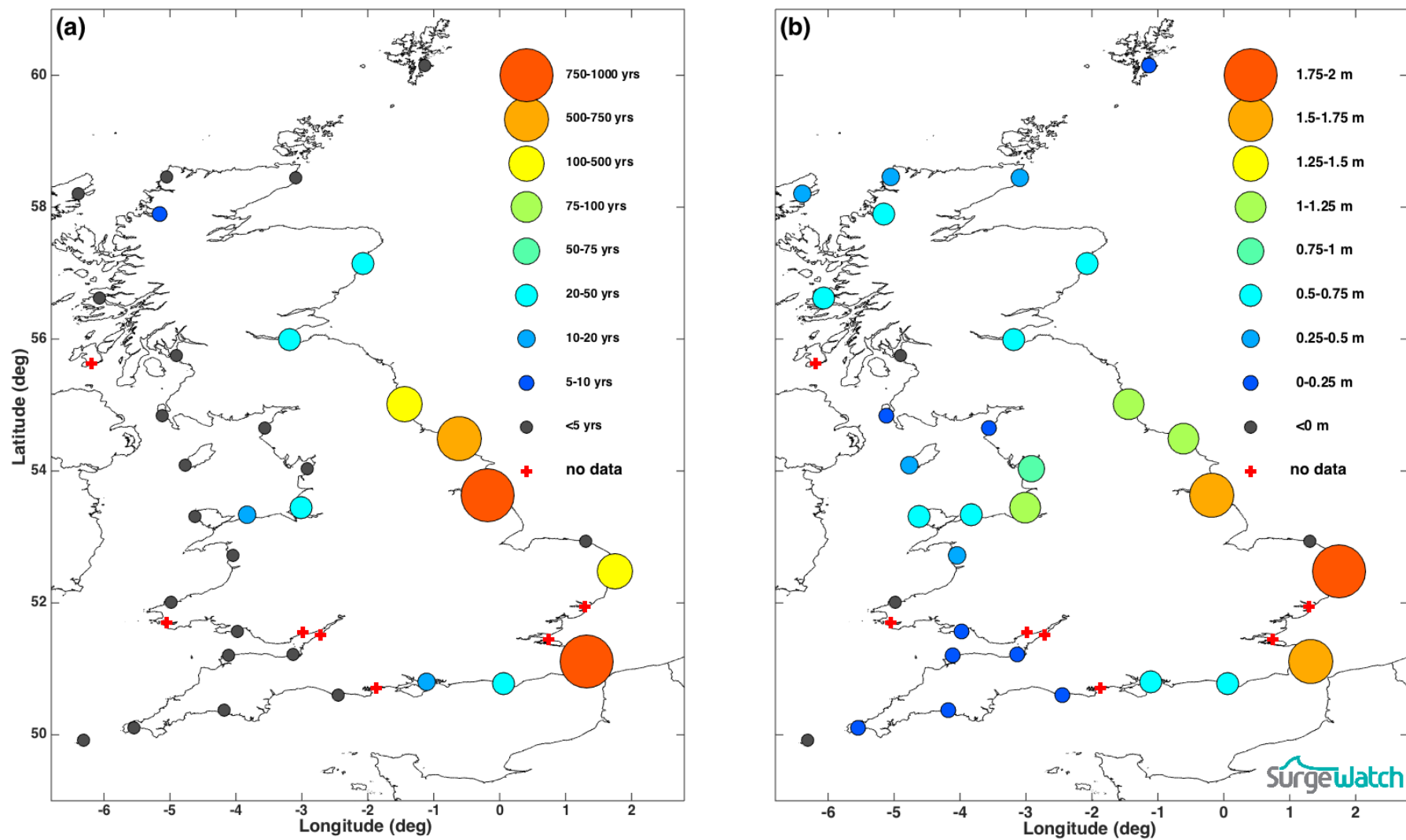


Figure 3: (a) Water level return period; (b) Skew surge levels

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