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Admiral Duncan's campaign
Thunderstorms and a gust front
World weather — October 1992

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The record-breaking rainstorm in Hong Kong on 8 May 1992

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Summary
The 109.9 mm of rain recorded at the Royal Observatory, Hong Kong between 6 a.m. and 7 a.m. Hong Kong Time on 8 May 1992 was the highest 1-hour rainfall record since observations began in 1884. Heavy rain on that day was concentrated in a small area. The synoptic background and the mesoscale aspects of the event are described.

1. Introduction

Heavy rain hit Hong Kong on 8 May 1992, giving more than 300 mm of rain to the urban areas. Rain was heaviest around daybreak and 109.9 mm of rainfall was recorded at the Royal Observatory, Hong Kong between 6 a.m. and 7 a.m. (Hong Kong Time = UTC + 8 hours; used throughout unless otherwise indicated.) This figure broke all previous records of one-hour rainfall since observations began in 1884. Flash floods caused major traffic disruptions and the normally vibrant city was virtually brought to a standstill at the climax of the rainstorm. Several lives were lost, arising from lightning, landslides and fast-flowing water down steep slopes. The insurance industry is looking forward to receiving claims totalling more than 100 million Hong Kong dollars (7–8 million pounds).

Heavy rain in Hong Kong is usually attributed to two types of weather systems, namely tropical cyclones and slow-moving troughs of low pressure. June is normally the wettest month when an east–west oriented trough crosses over Hong Kong on its seasonal march northwards into China (Tao and Chen 1987). Indeed, the worst rainstorms in recent memory occurred in June 1966 (Chen 1969) and June 1972 (Cheng and Yerg 1979). That we should have a rainstorm of such a magnitude in early May was most extraordinary. The rainfall event and its meteorological aspects are described below.

2. Rainfall

Altogether, 324.1 mm of rain was recorded at the Royal Observatory on 8 May 1992. Broadly speaking, the rain came in two spells, one around daybreak and one in the afternoon (Fig. 1). The first spell was more intense and was the one responsible for most of the havoc. The second spell, though of lesser intensity, added more water to the soil and brought further landslides. Rainfall was rather uneven over Hong Kong. Based on the information from some 60 automatic-reporting rain-gauges, it was found that the daily rainfall amount at various places in Hong Kong varied by a factor of three to four (Fig. 2). Only the northern part of Hong Kong Island and the Kowloon Peninsula, where most of the population was concentrated, got more than 300 millimetres of rain. The area involved was roughly 5 km × 15 km in dimension.

Looking further afield, the rainfall distribution in southern China over the 18-hour period 2 a.m–8 p.m. on 8 May 1992, derived from GTS data, is given in Fig. 3. The very localized nature of the heavy rain in Hong Kong is strikingly illustrated.

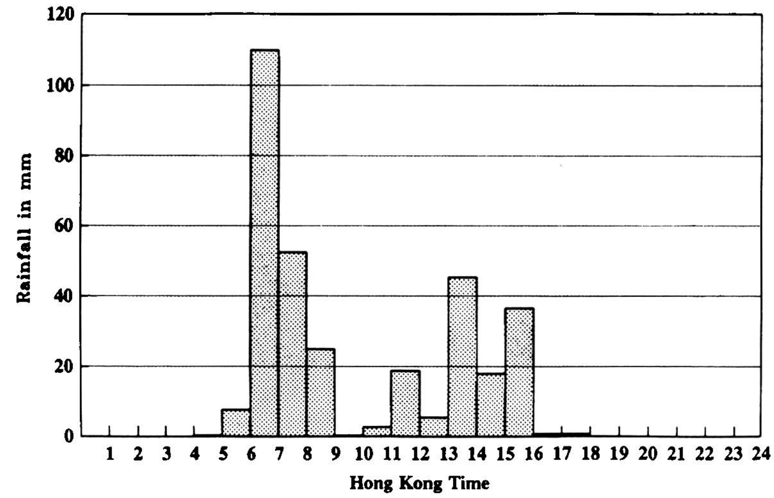

Figure 1. Hourly rainfall recorded at Royal Observatory, Hong Kong, on 8 May 1992

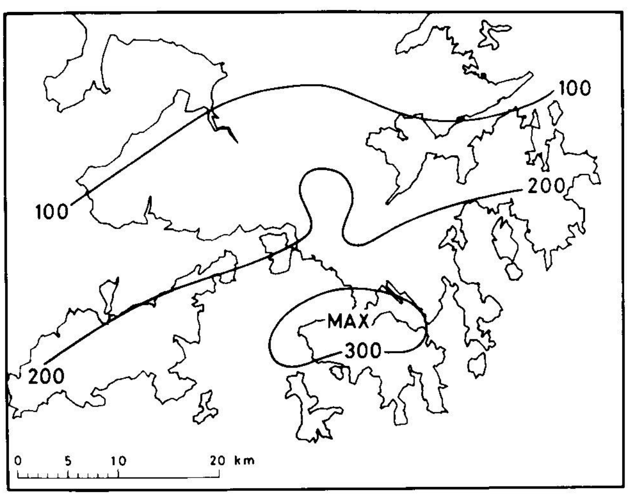

Figure 2. Rainfall (mm) in Hong Kong on 8 May 1992

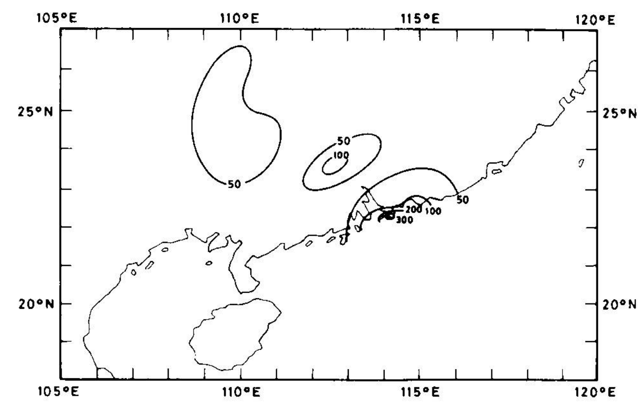

Figure 3. Rainfall (mm) in southern China, 2 a.m.–8 p.m. on 8 May 1992

3. Synoptic background

May is a transition season during which cool air intrusions reaching Hong Kong from the north become weak and infrequent. An east–west oriented trough, occasionally with frontal characteristics, is a common sight in southern China, with maritime air feeding into the trough from the south. Warm moist air, the origin of which might be traced back to the Indian Ocean, constitutes the prevailing south-westerly flow at the 850 hPa level. At higher levels, the background flow is basically westerly up to 200 hPa. In a general way, the synoptic background of the rainstorm on 8 May 1992 conforms to this pattern.

An east–west oriented trough formed over central China around 30° N on 6 May 1992. It moved southwards slowly in response to a passing mid-latitude trough in the upper-level westerlies. By 8 p.m. (12 UTC) on 7 May, the surface trough was located around 25° N, about 300 km north of Hong Kong. The upper-air conditions over Hong Kong at this time are shown in Fig. 4(a). Air in the lowest half-kilometre had wet-bulb potential temperature around 23 °C and could rise up to 250–300 hPa, provided a lifting mechanism could be found to get it above the lowest three kilometres or so. The nearly saturated layer between 400 hPa and 600 hPa and the well-mixed layer between about 600 hPa and 700 hPa are also worth noting. This profile more or less prescribed the environment for subsequent convective developments in the Hong Kong area. Fig. 4(b) shows the tephigram at 11 a.m. (03 UTC) the following day after the severe rainstorm earlier in the morning.

Reference to streamline charts (not shown) indicated that Hong Kong was then located slightly to the rear of a shallow eastward moving trough at 500/700 hPa, with appreciable amplitude confined to between approximately 20–30° N. That trough had earlier in the day brought some 60 mm of rain to Hong Kong. Cloud and rain associated with the trough were found, by 8 p.m. (12 UTC) on 7 May, off the coast of China, mostly between 120–125° E but also partly in the coastal waters north of 20° N (Fig. 5(a)).

By 2 a.m. on 8 May (18 UTC on 7 May), winds at 500/700 hPa over Hong Kong backed and became south-

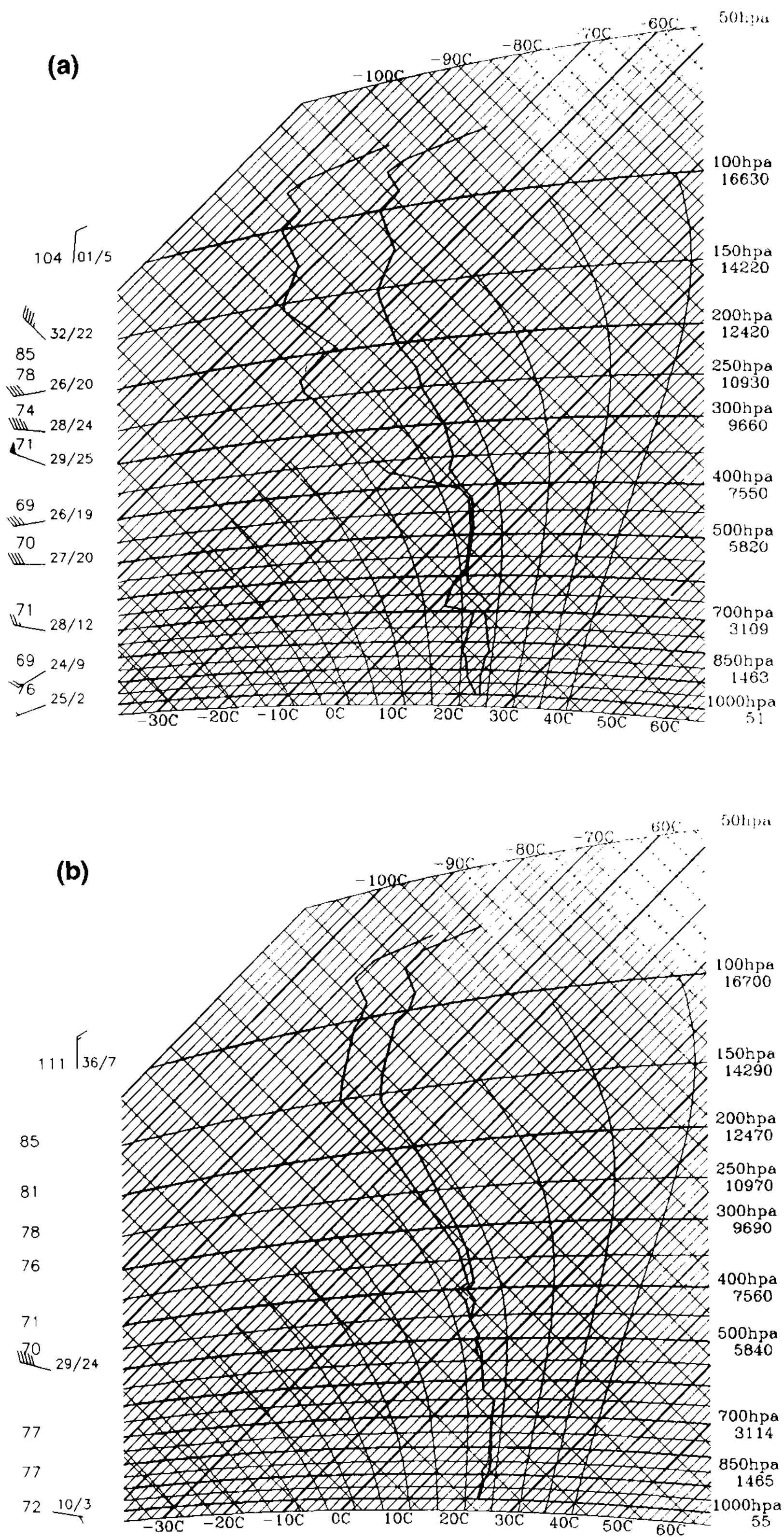

Figure 4. Upper-air conditions over Hong Kong (a) 8 p.m. (12 UTC) on 7 May 1992 and (b) 11 a.m. (03 UTC) on 8 May 1992. The equivalent potential temperature (°C) is shown to the left of the wind arrows.

westerlies (230° at 700 hPa and 250° at 500 hPa), indicating the approach of another trough at those levels. The 700 hPa streamline chart at 8 a.m. (00 UTC) on 8 May, when heavy rain was occurring in Hong Kong, confirmed the presence of a very shallow but nevertheless noticeable trough west of Hong Kong, with its axis just west of 110° E (Fig 6(b)). A similar shallow trough is found at the 500 hPa level with its axis 5° further west

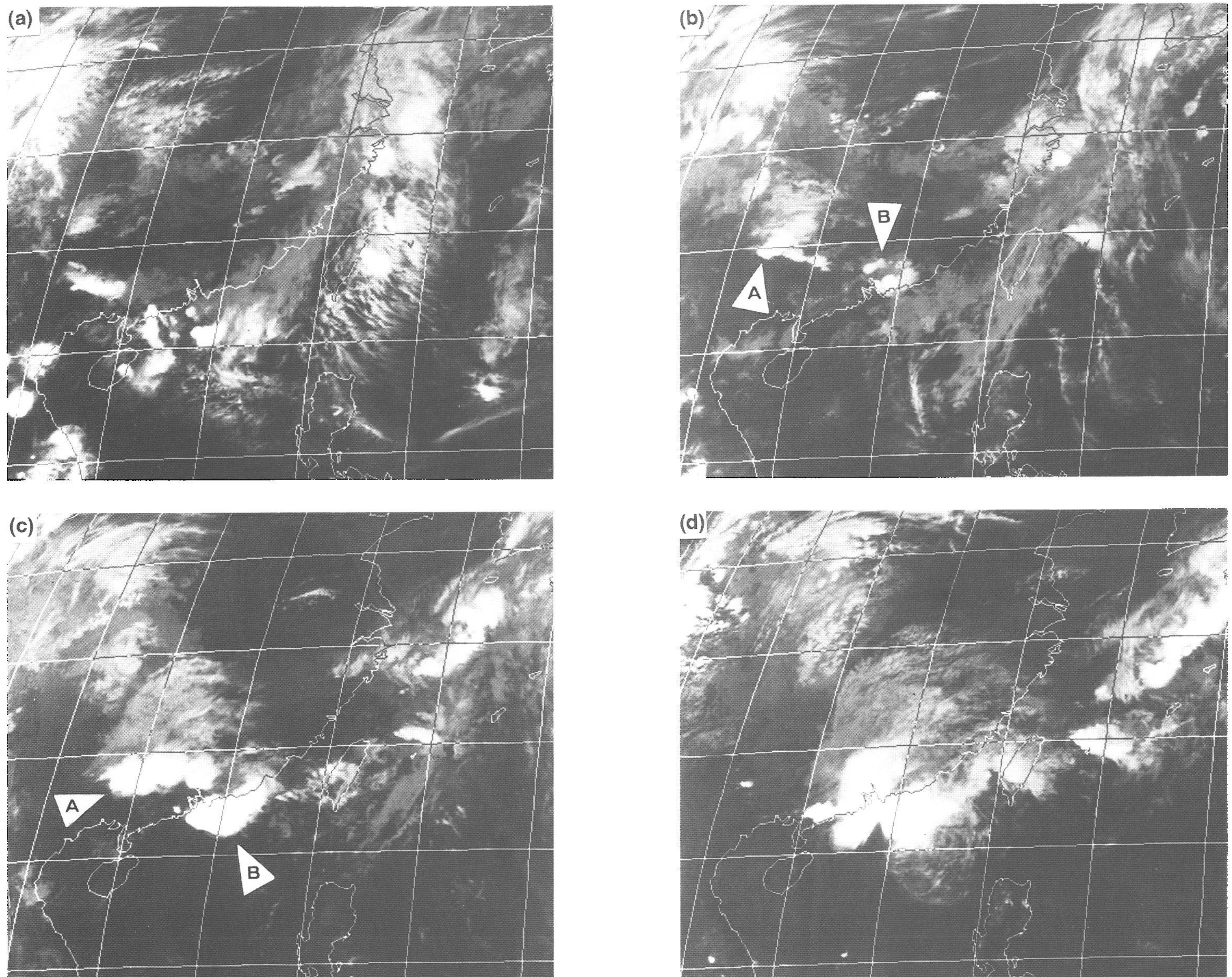

Figure 5. Infrared images from the Japanese Geostationary Meteorological Satellite for (a) 8 p.m. on 7 May, (b) 2 a.m. on 8 May, (c) 8 a.m. on 8 May, and (d) 2 p.m. on 8 May. White triangles 'A', 'B' identify cloud forms which might be associated with waves in the westerlies at the 500/700 hPa levels.

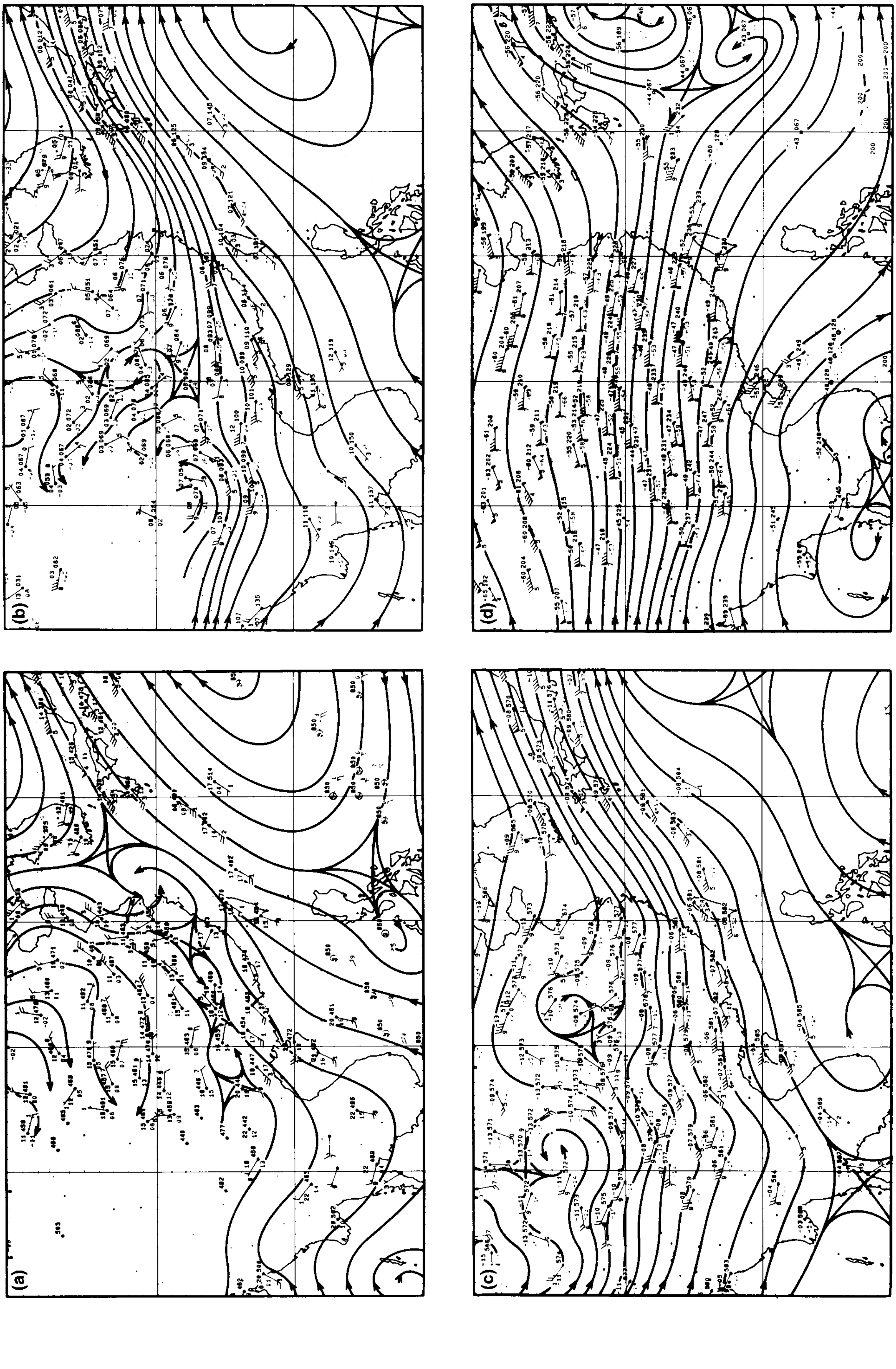

Figure 6. Upper-air streamline charts at 8 a.m. on 8 May 1992 for (a) 850 hPa, (b) 700 hPa, (c) 500 hPa, and (d) 200 hPa.

(Fig. 6(c)). By referring to satellite imageries, it would seem that this shallow trough had strong association with the intense convection near 25° N, 108° E at 2 a.m. (Fig. 5(b)) which later drifted east-south-eastward to 24° N, 112° E at 8 a.m. (Fig. 5(c)). This cloud cluster will be referred to as cluster 'A' later. It was not responsible for the record-breaking rain episode in the morning but was rather related to the second rain event in the afternoon (Fig. 5(d)). There was considerable directional divergence near Hong Kong at the 200 hPa level (Fig. 6(d)).

4. Mesoscale features

Another cloud cluster (labelled 'B' in Fig. 5) developed about 120 km to the north-north-west of Hong Kong shortly before midnight. By 2 a.m. (Fig. 5(b)), it had drifted east-south-eastward, coming to within 30 km of the northern limit of Hong Kong. If there were no new developments, the rain echoes as observed by radar would have missed Hong Kong. But a small echo was first picked up over the estuary to the west of Hong Kong around 3.30 a.m. In half an hour it grew into a significant feature with maximum estimated rainfall rates of around 20 mm h^{-1} (Fig. 7(a)). By 5 a.m. the echo took on the look of a north-east to south-west oriented band and there were higher rainfall rates (Fig. 7(b)). In a cell over the western coast of the territory, one picture element (2 km × 2 km) had an estimated rate in excess of 50 mm h^{-1}. By 6 a.m. the rain band had crossed a substantial part of the territory and was dumping rain over the urban area (Fig. 7(c)). Several picture elements had rainfall rates in the 50–100 mm h^{-1} bracket. Another cell was moving in

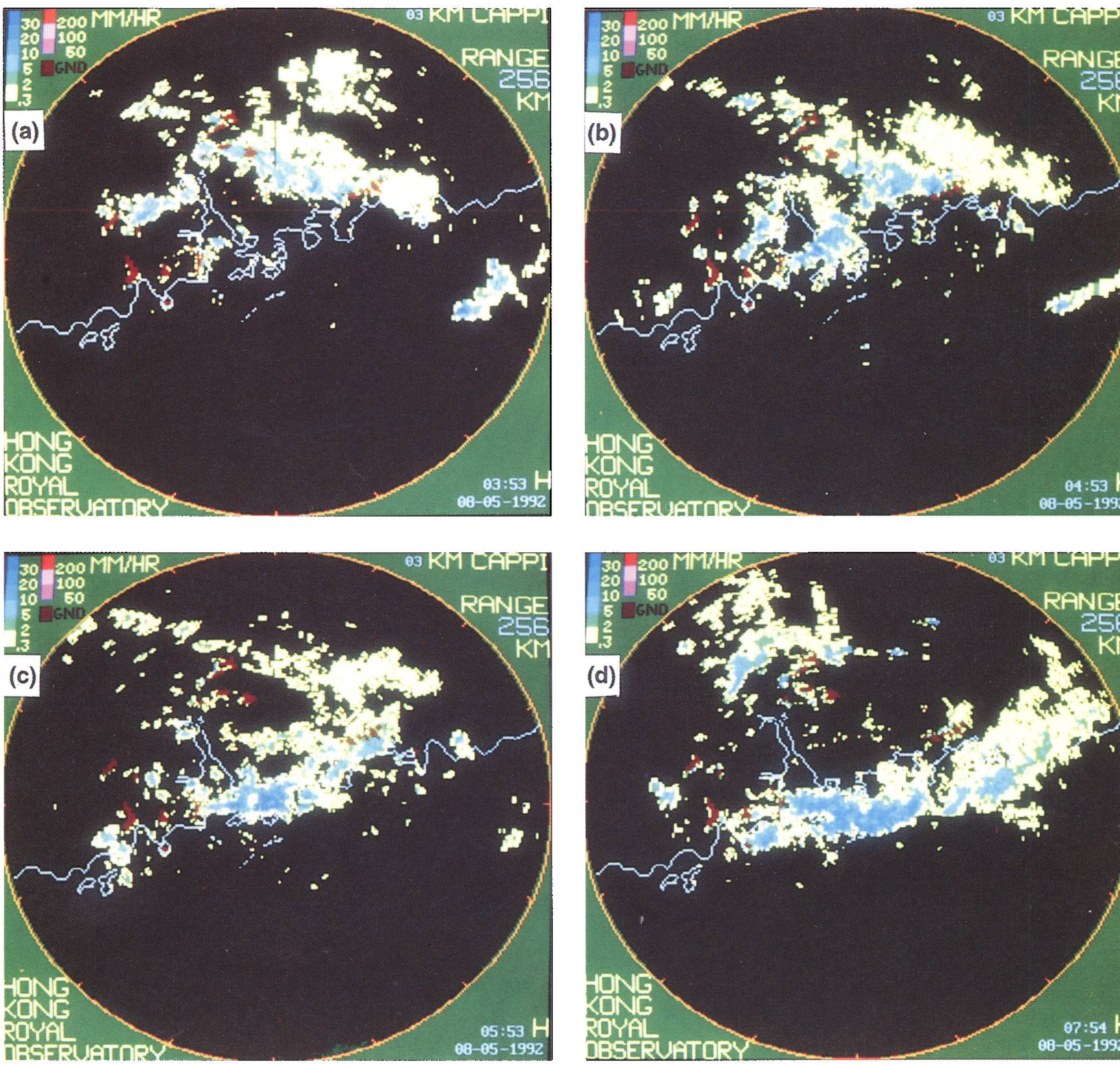

Figure 7. Three-kilometre CAPPI radar images for (a) 4 a.m., (b) 5 a.m., (c) 6 a.m., and (d) 8 a.m. on 8 May 1992. The colour-coded rainfall rate is estimated from the Z–R relationship: $Z = 200 R^{1.6}$. Brown colour represents a mask on ground returns.

from the west. The radar was inoperative at 7 a.m. By 8 a.m. the situation had evolved into one with a relatively broader east–west oriented rain band over the southern limit of Hong Kong (Fig. 7(d)). This was also the time when the rain began to subside in the urban area. The rain band eventually drifted southwards away from Hong Kong.

The existence of a number of automatic weather stations allowed us to follow the evolution of the surface flow pattern in Hong Kong during the passage of the rain band (Fig. 8). But note that it is quite hilly in Hong Kong so that some of the reports might suffer from local effects. For example, in Fig. 8(a) the anemometers at the two hill-top sites TMS and TC are respectively 969 m and 588 m in altitude. The prevailing flow before the rain band hit Hong Kong came from the south-east quadrant. A convergence line with cyclonic shear in places could be analysed over the north-western part of Hong Kong at 5 a.m. (Fig. 8(b)) when the rain band began affecting Hong Kong. No squalls, however, were reported by the stations on the passage of the shear line. C_1 marked the possible position of an incipient vortex which might be inferred from detailed examination of the time series of wind observations at the various stations. It apparently moved east-south-eastward and by 6 a.m. had moved to Hong Kong Island (Fig. 8(c)). Heavy rain commenced abruptly about five minutes later at the Royal Observatory (marked 'RO' in Fig. 8(a)). The maximum instantaneous rate of rainfall reached 312 mm h^{-1} around 6.10 a.m.

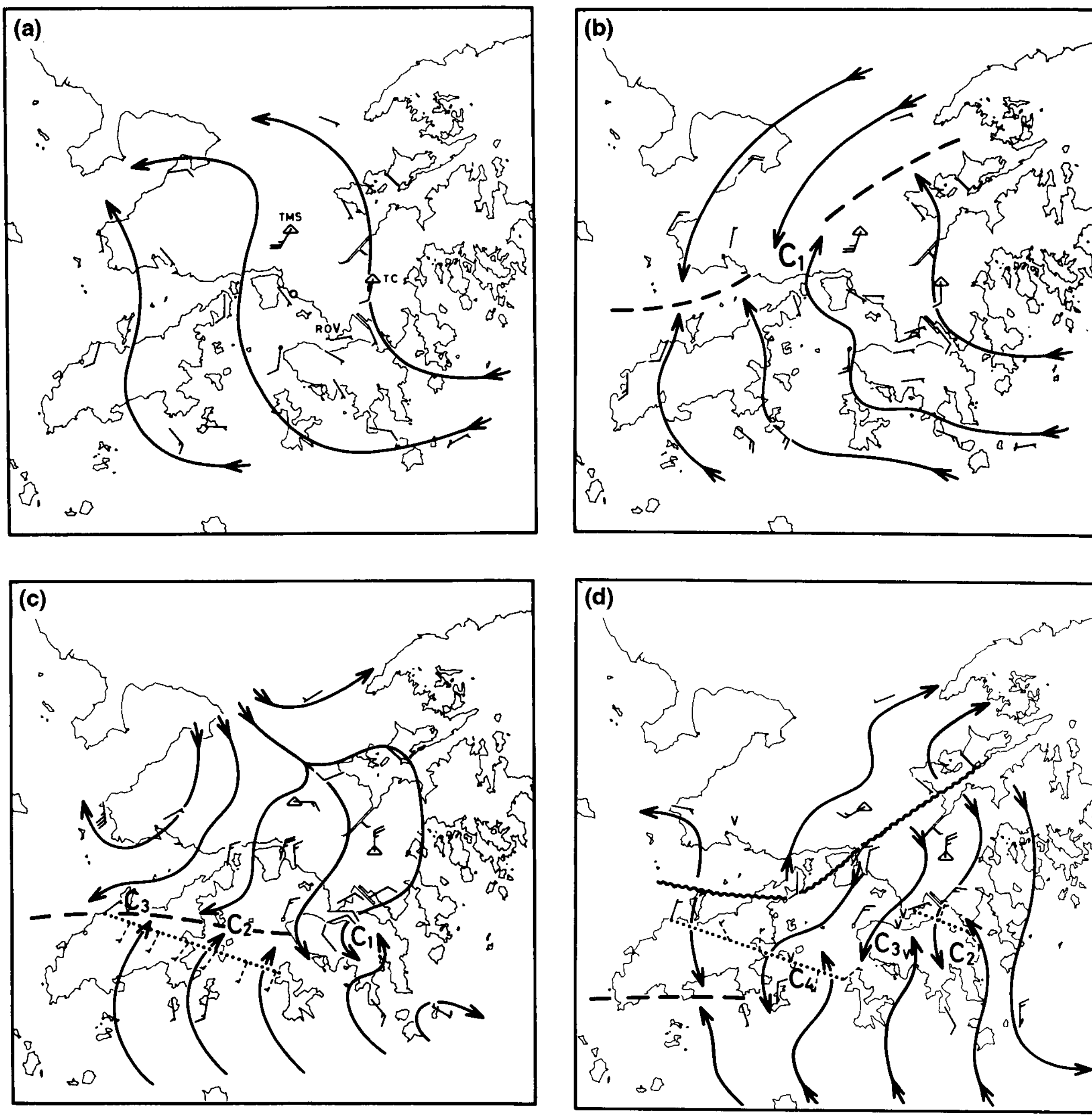

Figure 8. Surface streamline charts during the passage of the rain band over Hong Kong for (a) 4 a.m., (b) 5 a.m., (c) 6 a.m., and (d) 7 a.m. on 8 May 1992. The triangles mark two hill-top stations. Dashed wind barbs are derived from earlier fixed-point observations.

In Figs 8(c) and 8(d), some observations before the specified times have been included but displaced in the 'downstream' direction to account for propagation at a speed similar to that of the inferred vortex C_1. They are intended to help bring out certain fine details in the convergence zone between the northerlies and the south-easterlies. In both figures, inferred centres of cyclonic shear (not necessarily closed vortices) are marked. Detailed comparison of the figures with rate-of-rainfall records at the Royal Observatory (not shown) suggested that the passage of the centres C_1, C_2 and C_3 brought three separately identifiable downpours at about half-hour intervals between 6.00 a.m. and 7.30 a.m. These three downpours accounted for most of the rainfall in the morning rain spell.

The afternoon spell of rain was not so intense. Meteorologically, it was also less eventful — the surface flow over Hong Kong remained basically easterly to south-easterly throughout the period. The perturbation of the rain on the flow was much less apparent compared with the morning episode.

5. Forecasting aspects

The evolution of the synoptic situation leading to the heavy rain on 8 May 1992 was well anticipated by forecasters with the aid of prognostic charts derived from ECMWF and UK Meteorological Office data transmitted over the Global Telecommunication System. Satellite imageries also enabled forecasters to follow the development and movement of cloud and rain over southern China in response to the eastward-propagating waves in the mid troposphere. The afternoon rain spell on 8 May 1992 associated with cluster 'A' did not pose a problem to forecasters. The development of cluster 'B' was however a different matter, the only hint of a change in the synoptic situation to the forecaster being the backing of winds to south of west at 700 and 500 hPa over Hong Kong at 2 a.m. after cluster 'B' had already appeared on satellite and on radar. The explosive development from an inconspicuous radar echo over the estuary to a record-breaking rainstorm over the urban areas in Hong Kong around daybreak was virtually impossible to forecast. Indeed, even up to 5.35 a.m. the radar was forecasting only some 20–30 mm of rainfall in the next one to two hours, based on objective extrapolation. In the final stages, it was a nowcasting situation in which forecasters monitored the fast-changing situation with the help of data from automatic weather stations and rain-gauges in the territory and, in response, issued warnings of floods and landslips through the electronic media. Detailed examination of the usefulness of the various forecasting tools, such as numerical model outputs (including those of the Royal Observatory's own limited-area model) is under way and will be reported elsewhere in due course.

6. Conclusions

The rainstorm on 8 May 1992 was a very localized event, rainfall over 300 mm being confined to an area about 5 km × 15 km. It occurred in a conditionally unstable atmosphere with south-easterlies near the surface and south-westerlies at mid-tropospheric level. Rain which occurred in Hong Kong in the afternoons of 7 and 8 May could be attributed to eastward-propagating waves over southern China. However, the cluster which was responsible for the heaviest rain in the morning of 8 May had less obvious association with synoptic-scale features. The concentration of extreme rainfall in the urban areas of Hong Kong was the consequence of successive downpours coming in from the west, travelling along the convergence line between north-easterlies and south-easterlies. Had the convergence line travelled southward faster, it would have been a totally different picture. The near-stagnation of convergence lines over Hong Kong has been observed occasionally in similar situations in the month of May, such as the rainstorm of 2 May 1989 (104.8 mm in one hour at the Royal Observatory). It will be worthwhile to investigate further into this phenomenon.

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The weather during Admiral Duncan's North Sea campaign: January–October 1797

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Summary

Lawson and Rowley (1992) have shown how the tactics of modern military warfare can be partly determined by weather. If, with the formidable technology that present-day armies possess, weather can still be a factor, how much more of a consideration must it have been in more distant times? This paper looks at one, probably typical, example for its date.

1. Introduction

The battle of Camperdown was fought on 11 October 1797 between the English North Sea and the Dutch fleets, the latter then under the direction of the newly founded French Republic. The fleets were commanded by Admirals Adam Duncan and John de Winter respectively. Although comparable with Trafalgar, Camperdown has failed to exercise the same grip on the public mind. Like Trafalgar it must be viewed as the culmination of a protracted campaign during which the English fleet sought battle with a reluctant enemy (Fig. 1 shows the general area of activity). When it was finally engaged, the battle was conducted using tactics which, whether by design or accident, were strikingly similar to those used 8 years later by Nelson. That is to say, bearing down in two groups on a following wind towards an enemy fleet in traditional line ahead and not far from their own coast.

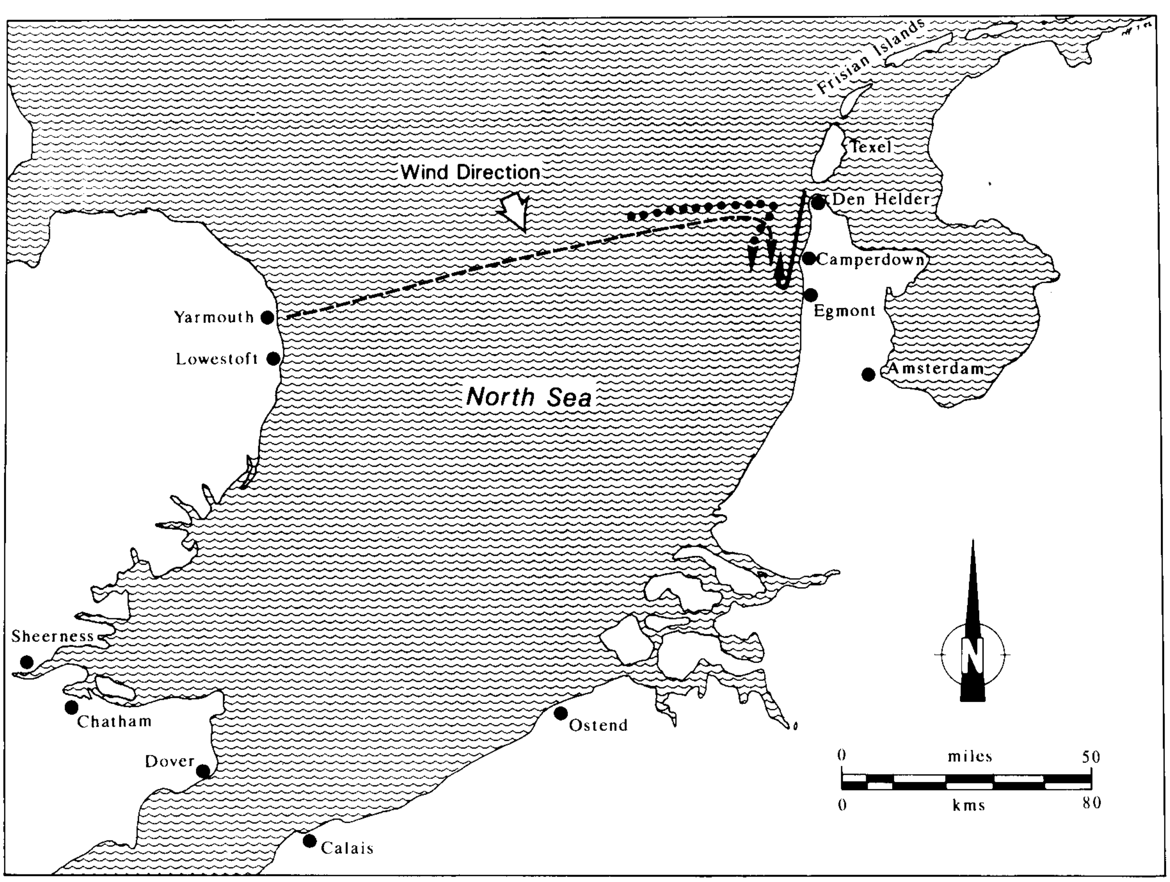


Figure 1. Map of the North Sea showing the principal locations and the routes of the fleets in the hours immediately preceding battle. The solid line denotes the Dutch fleet after having left the shelter of the Texel on 7 October 1797. The route taken by Duncan's fleet after leaving Yarmouth on the 8th is shown by the broken line. The same time-span covers the approximate route of the British observational squadron (dotted line). Battle was engaged on the 11th, offshore from the village of Camperdown.

The battleships of these times were designed to be the most powerful concentration of artillery then available. As two- or three-deck gun platforms they sacrificed the sailing qualities of speed and manoeuvrability for stability. These square-rigged leviathans could sail within only six points (about 66°) of the wind and, with a few notable exceptions, engage in battle only in light to moderate winds. Their every move and action was circumscribed by the weather.

2. The campaign

In 1795 the armies of the French Republic had subdued Holland converting it to the state of the client 'Batavian Republic', and with that action acquired a substantial, and skilfully manned, fleet. Austria and Russia had withdrawn from conflict with France and left Britain to stand alone against a powerful land-force, the potency of which was stemmed only by 21 miles of sea separating Britain from the European mainland. The fact that the distance was a mere 21 miles was immaterial, that it was sea, the successful navigation and control of which was so dependent on the weather, was crucial. As Fisher (1936) so aptly described the situation '....behind her tutelary waves and winds Britain stood impregnable. Nature was her friend.'

Adam Duncan had taken control of the North Sea fleet, based at Yarmouth, in 1795. His principal aim was to bring to battle and destroy the Dutch fleet which preferred to remain in the fastness of the Texel, protected by shallow seas and sand banks and posing a constant threat of support to an invading army launched towards the Thames Estuary and London. In the complex balance of forces the weather was critical. Westerly winds would prevent the Dutch from leaving port in any kind of order and minimized the need for anything other than an observational squadron. Easterly winds would allow the enemy to sail but would at the same time make it hard for the English fleet to break out from their base at Yarmouth Roads. In the open waters of the North Sea northerly and southerly winds offered equal advantage to ships that could make headway on port and starboard tacks. Gales, unless particularly severe, were not necessarily a danger in themselves, but they did hinder communications between vessels, hastened the general deterioration of wood, rope and canvas, and made battle all but impossible.

Of the detailed weather of those distant times there is a remarkable amount of evidence. Sources, which are described at the conclusion of the paper, are based largely on the captains' and masters' logs of Royal Navy vessels, the utility of which have been demonstrated by Oliver and Kington (1970) and Wheeler (1987, 1988). Landsmens' weather diaries were also a fruitful source of information.

3. Winter weather in 1797

By January of 1797 Duncan's fleet had established a blockade of the Texel. The general tendency to storminess, cold conditions and short hours of daylight that characterize the winter season normally combined to limit the opportunity for battle-line confrontations. As if to forewarn the French Directory of the inherent dangers of the season, the previous Christmas Eve had seen a French invasion force irretrievably scattered in Bantry Bay by a fierce storm (Lloyd 1963). Otherwise, the winter of 1796 into 1797 was unusually tranquil. The diary of William Bent, a London apothecary, indicates a mild New Year. His January entry reads:

> 'The month in general was mild; for though cold prevailed from 6th to the 16th, the thermometer was only twice so low as 29, and the medium was nearly 41.'

The February entry presents a similar picture:

> 'This month is remarkable for little rain and wind, and for the latter being scarcely ever to the northward of the east or west. Fogs and haziness prevailed very much; but whenever they cleared a while, the atmosphere appeared almost free from clouds. The barometer was high, in general.....'

A document in the care of the Institut Royal Météorologique de Belgique confirms similar weather on that side of the North Sea; '...the winter of 1796–1797 was very moderate. January was little cold, it froze for only seven days and passed without snow. Likewise February which was fine and dry.'

The impression is one of settled anticyclonic conditions with depressions being forced northwards leaving most of Britain dry, often cloud-free and spared the normal disruptions brought by winter gales. Such conditions aided Duncan's blockade of the Texel. Nevertheless, the protracted exposure to the North Sea waters took a heavy toll on the fabric of the fleet, which by March had returned to Yarmouth for repairs and revictualling. Duncan meanwhile sailed for the Nore, leaving his fleet under the command of Vice-admiral Richard Onslow.

4. Spring weather in 1797

The weather, previously so benign, was now to put Duncan at a disadvantage as a run of strong easterlies kept him in port. These easterlies continued until 16 March when a fall in wind speed and a backing to north-east allowed the fleet to put to sea. During that time the log of the *Venerable* (Duncan's flagship) records winds of force 5 and 6 rising to force 9 on the 10–12th. It is interesting to note that even headwinds of as little as force 5 were sufficient to prevent the English fleet from sailing. Duncan's sense of frustration is conveyed in his correspondence with the Admiralty. His letter of 4 March observes '.....from the wind continuing to blow strong at SE and the ebb tide done I have been under the necessity of anchoring the squadron'. On the same day his Vice-admiral, Richard Onslow, then on board HMS *Nassau*, wrote '...it now blows a gale of wind from the SE'. Duncan's letter of the following day includes '...the wind blew strong all last night and this morning from the eastward which prevented my getting under weigh...' Conditions continued bad on the 5th and deteriorated sufficiently to drive even the observational squadron away from the Dutch coast and back to port. Captain Hargood of HMS *Leopard*, a more manoeuvrable fourth-rater of 50 guns, reported '...drove off my station by a heavy Gale of Wind at SE and SSE...' by the 8th conditions had not improved and Duncan wrote '...I have used every effort in my power to get to Yarmouth, but all Saturday night and Sunday morning it blew very strong at ESE...'.

A brief spell of southerlies on the 8th and 9th allowed Duncan to excape from the Nore and rejoin his fleet but strong gales returned on the 10th to hinder further activity. On the 14th Duncan wrote again, '...from the wind continuing to the eastwards with a swell from the sea... I thought it right not to put to sea...'. But on the 18th Duncan could report that winds had moderated, veered to the west and his fleet were some 24 miles off the Dutch coast.

March's spell of dry, easterly weather was widespread. William Bent observed, '...this month has been very cold and dry for the season, which has greatly retarded the progress of vegetation... the dryness was such that the public roads, round the metropolis, were watered to lay the dust, as in summer...'. He notes winds almost continuously from the east until the 21st; thereafter becoming more south-westerly. In Edinburgh, Professor John Playfair observed '...in March the east wind began to prevail; a pretty smart frost was felt in the beginning of the month and some snow fell on the 6th and 7th; the weather was cold for the season until April.' The Belgian diary notes '...March was very cold and dry, but the weather became milder towards the end.' Although conditions in early March were favourable for an easy sailing from the Texel, the invasion forces were not prepared and the French, wishing to retain the naval forces to protect the invasion barges at a later stage, avoided any risk of engaging the English.

Information from further afield helps to recreate a picture of the wind circulations at the time. Far to the south-west, in what today is sea area Finisterre, Captain Beaufort, who a few years later was the codify his wind scale, also experienced poor weather. His log records 'heavy swell from the SW' on the 3rd, 'fresh gales' on 4 March and again on the 5th, all with winds, significantly, from between west and north-west. On the 6th more settled conditions allowed him to pursue and capture a French corsair, *L'active,* which he took back to England. Beaufort arrived off Falmouth on the 10th where he encountered easterlies.

Table I shows the relative abundance of easterlies during a month which was also one of relatively high pressure in Britain. Even as far afield as Trondheim (Birkeland 1949) the mean was 6 hPa above the average. In Britain temperatures remained cool, with sleet and snow showers, until the 23rd.

Table I. Percentage frequency of winds from the eight directions for the months March–October 1797. The data are averaged over observations from weather diaries and Royal Navy logs.

Month	N	NE	E	SE	S	SW	W	NW
March	3	31	28	10	9	11	6	2
April	14	19	23	3	12	9	15	5
May	3	14	11	5	16	30	15	7
June	19	10	10	5	7	20	18	11
July	1	2	3	3	16	29	39	7
August	0	1	2	6	30	27	24	10
September	6	8	8	3	23	16	30	6
October (to 11th)	13	29	11	0	13	11	11	12

The evidence suggests an anticyclone over northern Europe and Scandinavia extending its influence over Britain. The strength of easterly winds along its southern flanks and Beaufort's supplementary evidence of westerly weather to the far south indicates that depressions were tracking to the south of Britain, steepening the pressure gradients as they do so and bringing the occasional sleet flurries to the immediate north of their associated fronts. Fig. 2 is a reconstruction of one such situation which, though not uncommon, is more likely to occur in March than in any other month (Lamb 1950).

This particular spell of weather ended on the 23rd with a marked pressure drop noted at all English barometric stations of around 20 hPa and a simultaneous increase in temperature from an average of about 2 °C to over 6 °C; a clear indication of the arrival of milder, south-westerly weather.

Easterlies continued to be dominant, but were less persistent in April (Table I). Duncan enjoyed sufficient steerage way to remain at station off the Texel despite the frequent gales noted in the log of the *Venerable* as 'strong' (force 9) on five days between the 5th and the 11th, and fresh on two further occasions. The unsettled weather is also reflected in the low average air pressure for the month (Table II). Duncan's task was probably made easier by the easterly character of some of the gales; the short fetch off the Dutch coast at least minimizing the risk of heavy seas.

The easterlies of early April were associated with a deep depression and widespread rain and snow over England. On 10 April *Venerable*'s log recorded strong easterly gales.The mid-month period was marked by steady air pressure and variable weather with a good deal of cloud and rain over the North Sea. Winds rarely exceeded force 5 until 21 April when force 7 easterlies were noted in many ships' logs. It was, however, very cold and William Bent's April entry includes; '...the month has, in general, been rainy, and very cold for the season ...smallpox, which was becoming frequent at the beginning of the month, was checked by the cold winds...'. The frequency of easterlies suggests that a pattern established in March of high pressure to the north had not altogether disappeared.

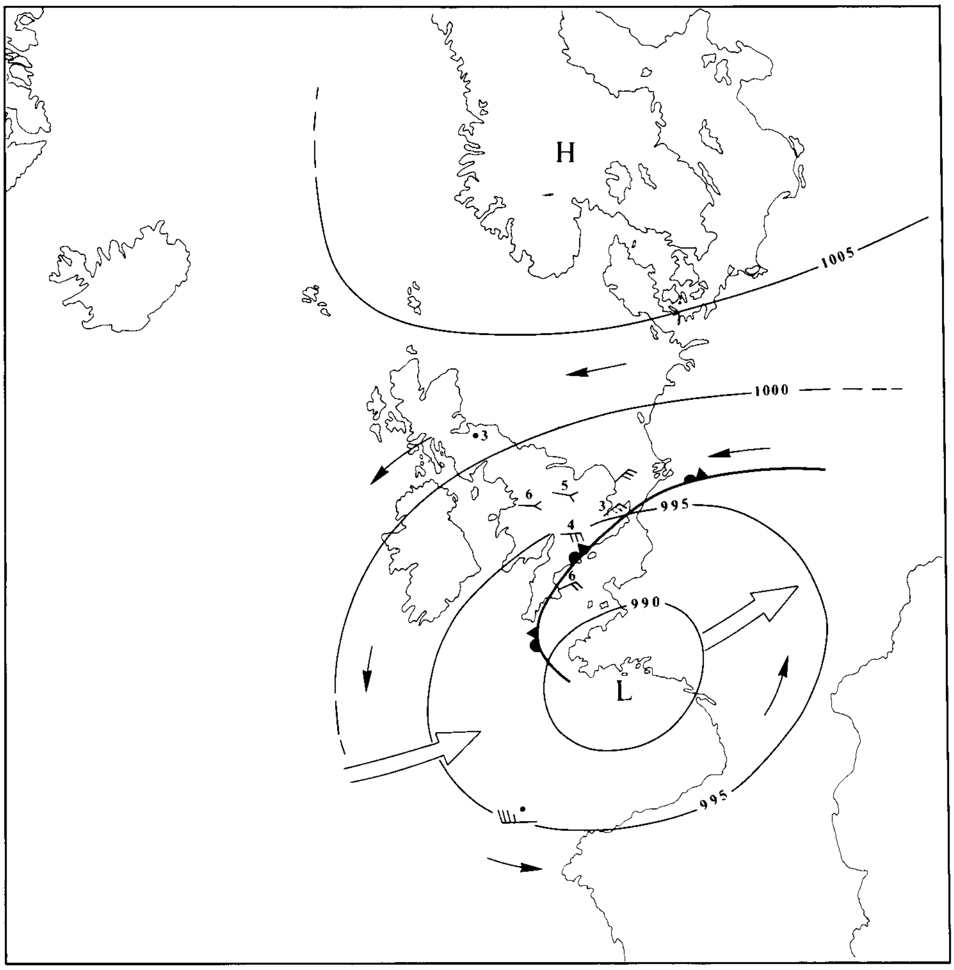


Figure 2. Generalized weather map for 4 March 1797 showing a situation which occurred commonly during the late winter and spring of that year. The symbols employed in this and the following figures are in most respects conventional. Wind arrows with 'feathers' are used where the force was known otherwise direction only is indicated by open-fork arrows. Temperatures, where known, are expressed in degrees Celsius. The isobars are interpreted from barometric readings and wind data and plotted in hectopascals. All such data were abstracted from ships' logs and other documents cited at the conclusion of the paper. To emphasize the wind circulations solid black arrows are used, while open arrows indicate the interpreted directions of movement of the principal weather systems. All such reconstructions must, of course, be regarded as approximate

Table II. Average monthly rainfall for 1797 estimated from various station records and average air pressure (from Royal Society records). For general comparison, the Central England Temperatures and their deviations from the 1784–1813 (30-year) means are also given.

	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Rainfall (mm)	28.7	47.6	61.5	90.9	64.9	89.3	114.1	69.2
Air pressure (hPa)	1016	1010	1013	1013	1016	1013	1015	1013
Central England Temperatures (°C)	4.3 −0.4	7.4 −0.5	11.3 −0.2	13.6 −0.8	17.3 +1.5	15.8 −0.1	12.5 −0.7	8.2 −1.2

The inclemency of the gale of the 21st forced Duncan's fleet to seek refuge at Yarmouth. The winds, however, were not exceptional and the motive for the fleet's return lay in its general state rather than the weather. The North Sea Fleet, it should be noted, was infamous for containing some of the oldest and least reliable vessels in the English Navy at the time. It must also be acknowledged that revictualling of the fleet by small vessels working, heavily laden, against a constant headwind would carry its own risks and delays.

May was a month of trauma for the nation, and remembered above all for the Great Mutiny by the poorly paid, often pressed, crews of the Royal Navy. Duncan's fleet 'refused orders' on 12 May, only two ships of the line remaining loyal to him; his own *Venerable* and Captain William Hotham's *Adament.* Fortunately, nature was indeed to be England's friend at this perilous moment.

Long runs of 'westerly' weather (Table I) combined, it must be recognized, with a lack of preparedness on the part of the invading forces, gave little opportunity for the Franco-Dutch fleet to leave port in order and safety. May was a wetter month than those immediately preceding it (Table II). The rain was especially heavy in western districts of England, less so in eastern areas. The log books' frequent references to westerly gales and the barometric data from land stations suggest the weather to have been determined by the passage of a number of depressions not far to the north.

If the air pressure data are averaged for each day (Fig. 3), the more important pressure variations are clearly identified with major systems on the 5th, 12th, 20th and 29th. The log of the *Venerable* notes strong south-westerly gales at Yarmouth around the first of those dates, and strong north-easterlies on the second of them. The 1st to 6th was unsettled with rain recorded widely over land and sea. Hail fell in London on the 3rd and 6th and in Edinburgh and Stroud (Glos.) on the 5th. Baker's *Record of the Seasons* quotes hailstones in London on the 6th of up to half-inch diameter and in Lewes of one inch; indicative perhaps of cold-front activity.

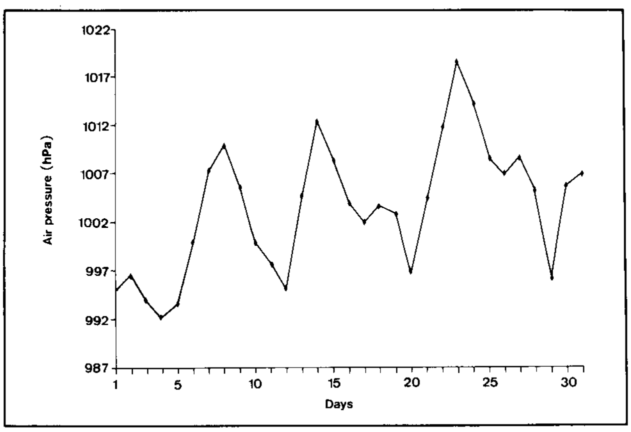


Figure 3. Trace of mean air pressure over Britain during May 1797. The daily figures are based on observations taken at various locations around Britain, all of which are listed in Fig. 5.

The latter system moved slowly eastwards and northerlies prevailed between the 7th and 11th. Snow was recorded in such disparate locations as Stroud on the 8th and Modbury and Derby on the 9th. Stormy weather continued until the 14th. Thereafter westerlies were again dominant, and while they failed to achieve gale force they would have been sufficient to deter any attempt at invasion using flat-bottomed, unstable, barges of the type then in service for the transport of infantry and cavalry.

5. Summer weather in 1797

Leaving the mutinous fleet at Yarmouth, Duncan had set out to the Dutch coast on 29 May, his flagship *Venerable* accompanied only by HMS *Adament*. He then engaged in an elaborate charade whereby his two ships, in turn, sailed within sight of the enemy, making signals to an imaginary fleet just over the horizon. The two changed stations frequently, flying various pennants and flags in order to pass as a succession of different ships. The ruse was a well-known one but appears to have served its purpose.

The weather during those weeks of frantic activity on board *Venerable* and *Adament* was, not for the last time, helpful. The barometer data indicates the passage of at least four depressions, but accompanied by little more than moderate winds. No gales were recorded until as late as 23 June when *Venerable*'s log notes them as strong. There was, however, a good deal of rain. William Bent's diary observes '...there has been only nine fair days, which for the most part were hazy and cloudy; the wind was trifling and in all points, continually varying...rain 4 inches 64 hundredths'.

Most of the month's depressions brought westerly winds, but that of the 18th was accompanied by strong easterlies, with heavy rain on the east coast. Edinburgh recorded 0.46 inches on the 19th and George Waterston's diary noted '...heavy rain and cold weather'. Thunder seems to have been widespread overland during the final week of the month. The *Gentleman's Magazine* reported a whirlwind at Chichester on the 22nd. Winds were light south-westerlies, the instability being assisted by heating over southern districts. The cooler surface of the North Sea, as it does today, minimized such activity and spared Duncan any consequent danger from this source.

July and August were dominated by westerlies (Table I). Air pressure was steady and fell away only at the close of August. Such 'lows' as were active appear to have passed well to the north, southern areas being more firmly in the grip of anticyclonic conditions. Gales were rare. They were recorded between 3 and 6 July in the logs of *Venerable* (still off the Texel) and *Director* (mutiny-bound at Yarmouth).

No log registers further gales until as late as 9 August and again on 30 August. Fig. 4 is a reconstruction using data from 20 July, but it is probably representative of much of these two months. An outbreak of peculiarly severe thunder in a southerly airstream on 16 and 17 July has already been described in the pages of this publication (Wheeler 1989).

It was during July that the invasion forces were finally prepared and embarked. However, the conclusion of the Mutiny in mid June had availed Duncan of his full complement of ships. The persistent, if light, westerlies left the Dutch fleet unable, possibly unwilling, to venture forth.

The Irish patriot Wolfe Tone was at that time seconded to the Dutch Republic as a 'political adviser'. His diary allows us to see matters from another point of view, with Tone, at one time elevated by the prospect of war, only then to be thrown into despair by the weather.

July 14th: '...the report today is that we shall get under way tomorrow... the men are in the highest spirits and singing national songs and cheering the general as they pass; it is a noble sight and I found it inexpressedly affecting.'

July 18th: '...the wind is as foul as possible this morning; it cannot be worse. Hell! Hell! Allah! Allah! I am in a most devouring rage.'

July 19th: '...it is impossible to conceive anything more irksome than waiting, as we now are, on the wind; what is still worse, the same wind that locks us up here is

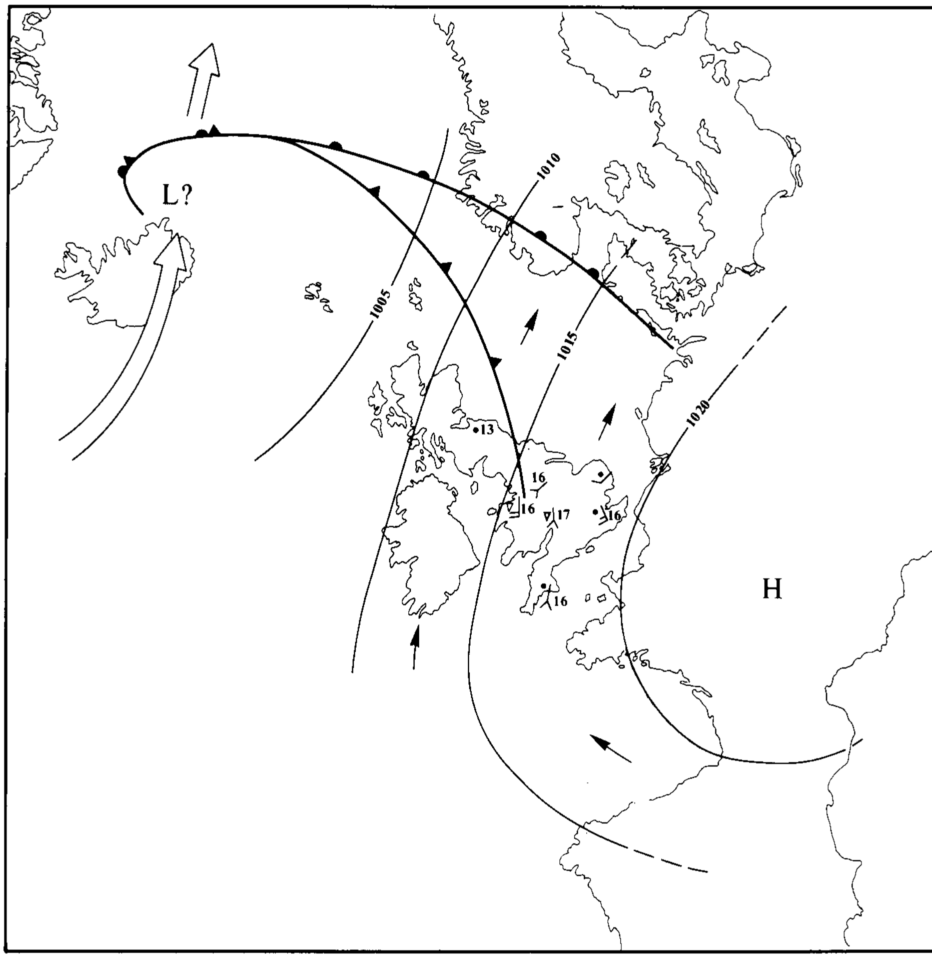


Figure 4. Generalized weather map for 20 July 1797. Unlike the situation in March (see Fig. 2 for explanation of symbols), the sequence of 'lows' and their attendant circulations are now following their more usual routes eastwards to the north of Britain. In this situation, a common one during the month, a generally mild but wet south-westerly airstream is sustained over Britain. The location of the fronts have been interpreted from the weather descriptions in diaries and logs.

exactly favourable for the arrival of reinforcements for Duncan...'

July 26th: '...I am today eighteen days on board and we have not had eighteen minutes of fair wind...'

His entry for 2 August deserves more lengthy quotation: 'Everything goes on here from bad to worse and I am tormented and unhappy more than I can express. On the 30th in the morning early the wind was fair, the signal given to prepare to get under way and everything ready, when, at the very instant we were about to weigh anchor and put to sea, the wind chopped about and left us.... there seems to be some fate in this business. Five weeks, I believe six weeks the English fleet lay paralysed by mutinies... and now that we are ready here, the wind is against us... the destiny of Europe might have been changed.'

By mid August the army had been disembarked and the invasion plan abandoned. The vigilance of Duncan and the timely intervention of the weather had confounded yet another attempt on England. But the Dutch fleet still required attention and the blockade could not be lifted.

The infrequency of gales was a welcome aid, but constant manoeuvring off a shallow lee shore took its toll on ships large and small. On 8 August Captain Henry Wray of the sloop *Seagull* observed '...we have not a rope or a sail to be depended upon. The hull is likewise much out of repair'. Even in fresh winds of force 5 or 6, keeping station for long periods was no easy task, as Duncan's letter of 7 August indicates: '...the wind has blown strong from the northward and westward for these five days past which has put the fleet to the northward and eastward. It is more moderate at present and I am endeavouring to regain my rendezvous.. '

The advance of the year was to bring its inevitable difficulties for Duncan as the weather showed signs of deterioration from what appears to have been a largely benign summer.

6. The weather of autumn 1797 and of the battle

Westerly winds continued to dominate, though less so than during the preceding summer (Table I). The approach of autumn was marked by an increase in the frequency of gales, all of which were from between south-west and north-west; they were registered by most of the fleet on 3, 6, 8–10, 12–14, 17 and 20 September. The gale of the 10th prompted the following dispatch from Duncan to the Admiralty: 'September 11 — *Venerable*, at sea. On Friday last a strong gale came on at WNW and for sixteen hours it blew a mere hurricane, during which period the *Agincourt* and *Warrior* made the signal of distress.'

And on 14 September '...Very constant and stormy since 11th from West to WSW. Yesterday *Naiad* made signal of inability...' The change in weather exposed again the fleet's vulnerability and one-by-one the ships sought the safety of Yarmouth. At the end of the month only an observational squadron, under Captain Henry Trollope in HMS *Russell*, a 74-gun two-decker, was on station off the Texel.

In October brisk westerlies gradually subsided veering within a few days of the month's start to equally moderate northerlies. Fig. 5 summarizes the situation during the first 15 days of October 1797. The air pressure traces give no indication of deep depressions and winds were generally light to moderate. Rain was recorded on a number of days but it was not prolonged. The south-westerly airflow over the period from 1st to 3rd, accompanied by a slow rise in pressure and followed by a wind veer to north-west suggests a 'low' to the north of Britain. A modest high pressure ridge with drier conditions then prevailed on the 5th but was, in turn, followed by a second 'low' on the 6th to 8th. The prevailing easterly winds point to an approach from the south-west (Fig. 5). This system may then have moved into the North Sea (possibly on the 7th) to give the variable, then north-westerly airflow that marked the following days.

The subsequent rise in pressure but persistence of north-westerlies was, most probably, due to high pressure advancing from the west against the slow-moving 'low' and consequently steepening the pressure gradient across the North Sea (Fig. 6). The prevailing north-westerlies brought unstable, typically showery, weather noted in all ships' logs. The Modbury observer noted unseasonal, by today's standards, snow showers in the highest parts of Dartmoor.

No gales were experienced before mid month and the respite gave the opportunity for the English fleet to revictual and repair. But the weather also allowed the Dutch to escape from the Texel, though why they should choose to do so, their strategic importance now nullified and no advantage to be gained by risking battle, is not clear. Such historical uncertainties notwithstanding, on 7 October Henry Trollope could write to his Admiral: '*Russell*, at sea. Sir, I have but moments of time to acquaint you I have learnt by the *Speculator* lugger the Dutch Fleet are now out and the *Circe* [the English frigate] who is hull down from us bearing NE is in sight of them — it is at present almost calm and very uncertain which way the wind may come, but whether they go north or south you may depend on seeing the *Russell* and *Adament* in sight of them...'

Duncan received this welcome news later that day and on the 9th set sail with such ships as were ready. Within 24 hours moderate westerlies had carried him to within a few miles of his target. The Dutch fleet, consisting of 15 ship-of-the-line and a screen of frigates, were on a south-westerly course having taken advantage of the light easterlies on the evening of the 7th. At daylight the winds veered to west-south-west allowing the Dutch to tack and stand to the southwards. For the next two days the sedate

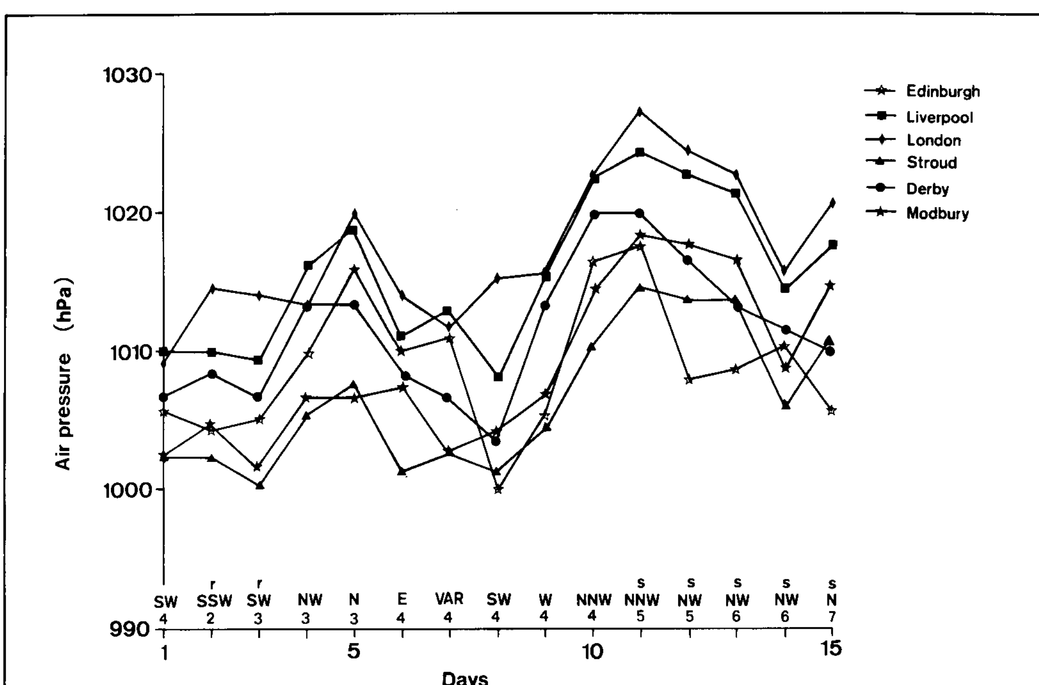


Figure 5. Composite graph showing the air pressure and associated wind and weather over Britain and the North Sea during early October 1797. Air pressure is plotted for six stations and shows the degree of agreement between them. Wind forces and direction are averages derived from the ships' logs. Where rain (r) or showers (s) are widely recorded the fact is indicated on the graph.

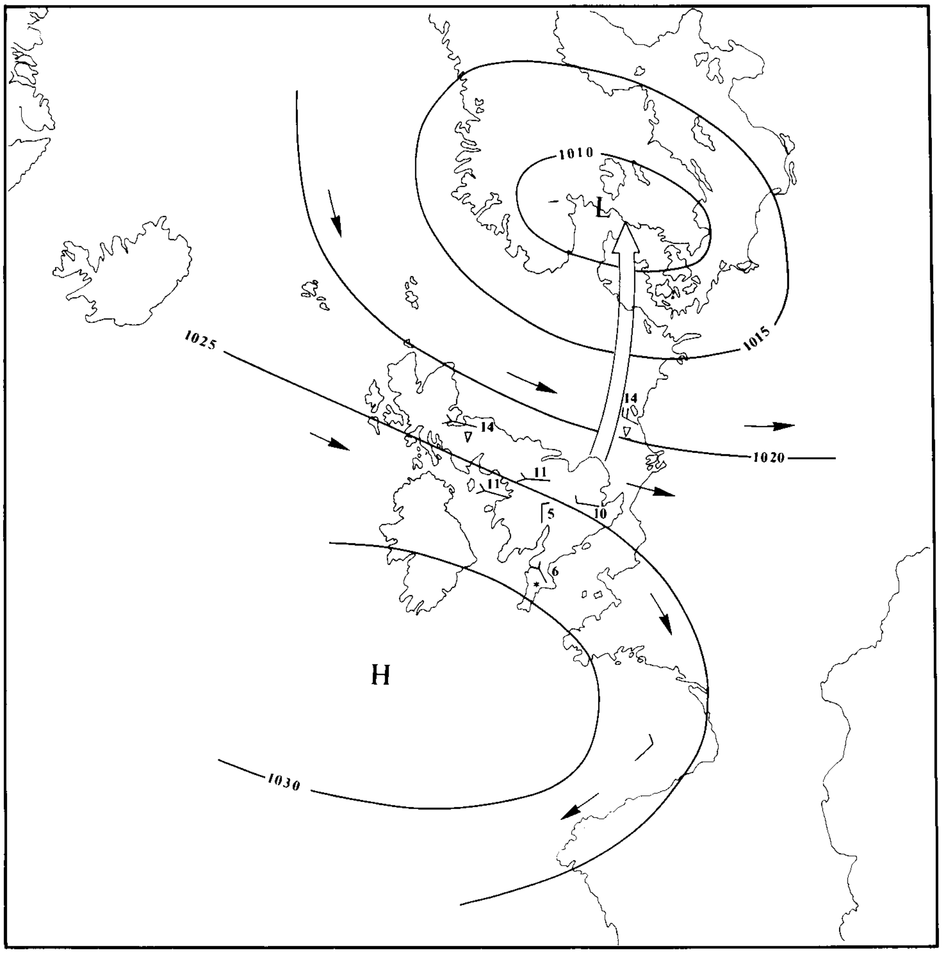


Figure 6 Reconstructed weather map for 11 October 1797 showing the disposition of pressure systems on the day of battle (see Fig. 2 for explanation of symbols). Low pressure to the north-east and high pressure to the west were responsible for the cool, showery north-westerly airstream that dominated the weather at that time. The 'low' then over Scandinavia had crossed Britain on the 8th (see Fig. 5) bringing cold showery weather in its wake.

progress of the Dutch was observed by Trollope's squadron. What appears to have been a sudden shift of wind to north-westerly on the morning of the 9th nearly drew the observational squadron on to the enemy. Lieutenant White on the cutter *Vestel* wrote in his diary: '...the *Adament* being so close from the change of wind that they might have cut her off had they made the attempt...'. During the day the wind slowly veered further to north-north-west. The north-westerly airstream now registered in all logs and land-based stations was to persist until the 12th.

Duncan sighted the Dutch coast at 11 a.m. on the 10th. The winds were moderate from the north-north-west rising to force 5 and the weather clear, but later cloudy. The English frigate *Circe* quickly found the enemy fleet 11 miles to the south-east and off shore of Dutch village of Camperdown.

Under the prevailing conditions the coast was a lee shore. The Dutch were familiar with these waters which, to their shallow-draughted vessels, represented a manageable hazard.

Matters were more critical for the deeper-draughted English ships. De Winter's tactic was to encourage the English into the shore where grounding was a serious risk. On the morning of the 11th he put his fleet about in line ahead on a port tack offering a tacit challenge to the English. Considerations of time imposed upon Duncan the need for swift action. He lay to windward of the Dutch and the following north-westerly allowed him to move quickly down upon the enemy. The principal requirement was to 'break the enemy line' to prevent them falling off with the wind and forcing Duncan to follow towards the shore. The risk was apparent to Duncan but, like Nelson at Trafalgar, he was resolved to engage and destroy the enemy. Duncan reminded his reluctant pilot to '...go on at your peril, for I am determined to fight the ships on land if I cannot by sea!' Indeed the whole battle was witnessed by a large crowd gathered on the shore.

Debate surrounds planning of the final approach which was in the manner of two loosely-knit groups, one under Duncan attacking the centre, the other, under Onslow, attacked the rear. If this tactic had been deliberate, then it represents a significant precursor to those used by Nelson at Trafalgar. But it is by no means certain that the move was not brought about by accident and under the hurried circumstances in which the engagement was approached. The battle was particularly bloody and its details are well-discussed in both Lloyd (1963) and Taylor (1937). The winds remained north-north-west at force 4 to 5 during the battle, giving enough manoeuvrability to Duncan whose close engagement prevented the enemy from escaping shorewards.

The outcome was a notable and, by the standards of the times, more than convincing victory to Duncan who captured 11 of the enemy vessels including the flagship with Admiral John de Winter on board. Hellier's representation of the battle (Fig. 7) with its choppy seas, brisk winds and cumulus clouds is probably very close to the conditions at the time.

The conclusion of battle did not signal the end of the Duncan's problems. The winds backed to north-west late on the 12th and detained his fleet, now encumbered by their valuable prizes, close to the Dutch coast. On the 15th Duncan wrote to his superiors: '...from the wind continuing to blow on the Dutch coast, the ships have had great difficulty in keeping off the shore and that we have unavoidably been separated. On Friday last [13th] the wind blew strong from WSW to WNW and continued to do so until Saturday morning, it then shifted to the north when I made the signal to wear, and fortunately anchored here [Yarmouth] last evening.'

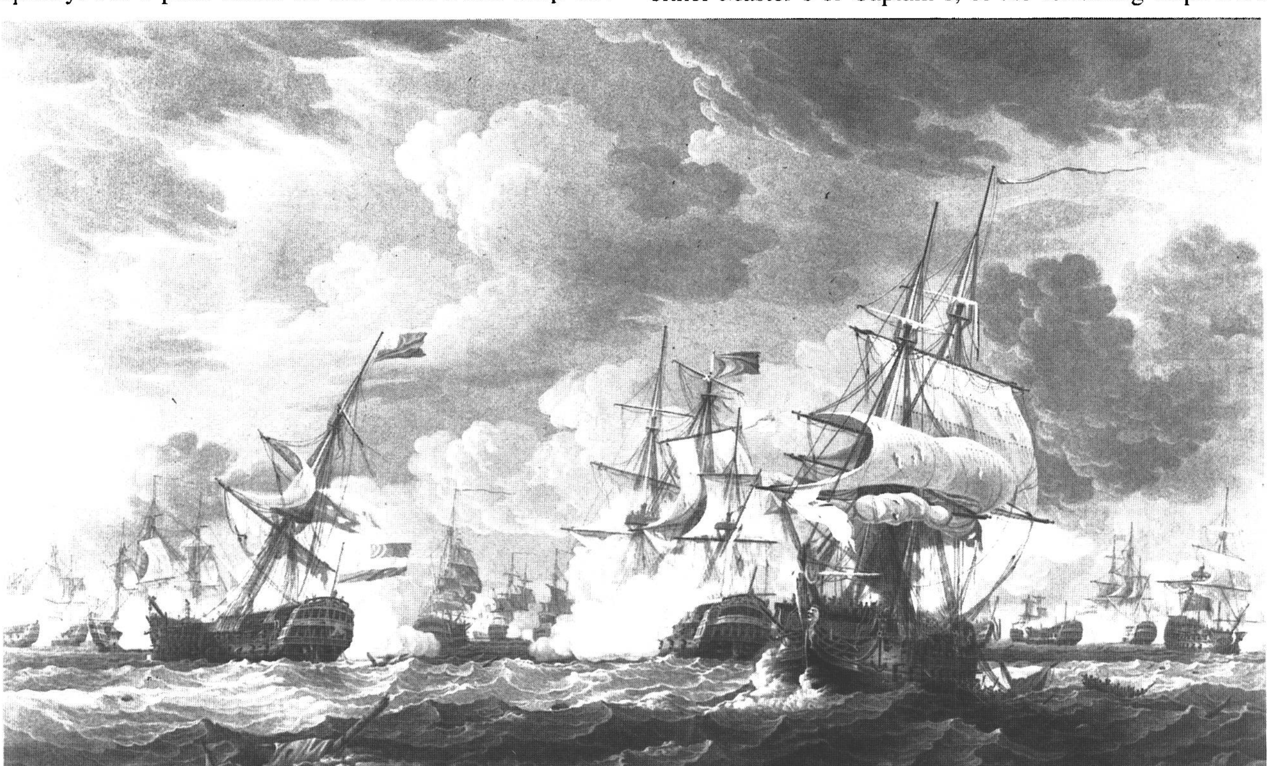
On the 14th and 15th, as the fleet struggled across the North Sea, the wind freshened to gale force and delayed yet further the safe arrival of several of its members. The master's log of HMS *Veteran* contains the following (abridged) entry for 14 October; '...strong gales and squally. At 1 p.m. came to the wind ...the ship not keeping to the wind, the prize lying like a log on our starboard quarter...Captain took counsel of all officers what was best to be done...it blowing so hard and the sea so high.'

In the event their prize, the *Delft*, had to abandoned and sank. As late as the 23rd Captain Williams of the frigate *Endymion* wrote from sea to express his hope of bringing the Dutch 74-gun *Jupiter* safely into port.

7. A supplementary note on data sources

The National Meteorological Archive of the Meteorological Office has care of the weather diaries of William Bent of London, Thomas Hughes of Stroud, Thomas Stanwick of Derby, the anonymous diary written at Modbury in Devon and the contemporary records of the Royal Society. The archives of the Royal Society of Edinburgh hold the diary of George Waterston of Edinburgh while the annual reports of city's weather prepared by Professor John Playfair of the University appear in the Society's *Transactions*. All the above mentioned items contain, or are based on, daily instrumental observations which include some or all of rainfall, air pressure and temperature. Wind direction is also commonly recorded together with brief descriptions of the weather.

Further valuable information is contained in the Captains' and Masters' logs of Royal Navy vessels. These logs, with the exception of that for Beaufort's *Pheaton* (which is kept at the National Meteorological Archive), are held at the Public Records Office, Kew. The log's, either Master's or Captain's, of the following ships were



By courtesy of the National Maritime Museum.

Figure 7. The Battle of Camperdown. This aquatint by T. Hellyer (after an original by T. Whitcombe) shows the Dutch flagship *Vrijheid* on the left and *Venerable* and the Dutch ship *Hercules* in the centre. The cumulus clouds, choppy seas and shortened sail of the vessels are all indicative of fresh, showery north-westerly winds.

examined: *Venerable*, *Director*, *Beaulieu*, *Lancaster*, *Russell*, *Veteran*, *Belliqueux* and *Powerful*. The Public Records Office also hold the Admiralty In-letters which were consulted for correspondence by Duncan and Onslow.

The Duncan Papers, in the care of the National Maritime Museum at Greenwich, were also a valuable source of incidental observations on the weather and its general influence on activities at the time. The Earl of Camperdown's (1898) biography of his grandfather also contains some illuminating correspondence. The contemporary publications *Gentleman's Magazine* and *Edinburgh Magazine* are valuable supplementary sources with monthly weather reports and tabulated daily statistics. A final useful item was Wolfe Tone's *Life and Writings*, Vol. 3 (Paris 1838).

Acknowledgements

The author acknowledges with thanks the help of Michael Wood and his staff at the National Meteorological Archive, and the staff of the Public Records Office and in the Reading Room of the National Maritime Museum.

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Thunderstorms and a gust front — 9 August 1992

The Figures relate to one of the severest thundery outbreaks to affect England during the summer of 1992. The northernmost region of activity (labelled storm area 1 on Fig. 1) originated over north Hampshire around 2100 UTC on the 8th; whilst the second area (labelled 2) developed over western France on the afternoon of the 8th. The most noteworthy features of these storms were probably the frequency of lightning, and localized sudden wind gusts. Although rainfall totals were larger they were not exceptional. One of the highest was 42 mm, recorded at Skegness in Lincolnshire in the 24 hours to 0900 on the 9th.

Synoptic background

During the night of the 8th/9th England and northern France were covered by a broad, slack area of low pressure containing very warm, moist, unstable air (850 hPa θ_w around 18 °C). The airflow above about 850 hPa was predominantly southerly, increasing with height to around 90 knots at tropopause level (about 200 hPa).

Ambient surface pressure over England fell from about 1012 hPa to 1006 hPa in the 12 hours to 0600 UTC on the 9th.

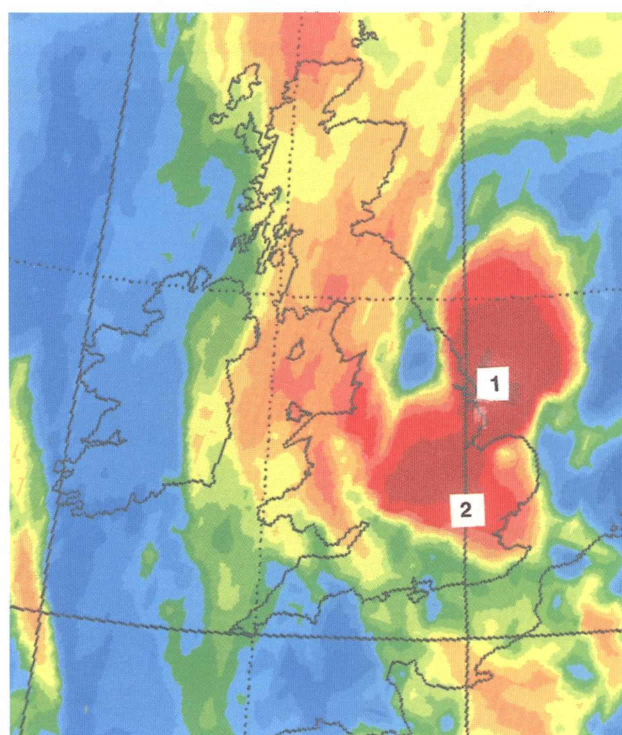


Figure 1. False-colour Meteosat infrared image for 0300 UTC on 9 August 1992. Coldest cloud tops are coloured brown (just east of the Humber). The boundary between brown and dark red corresponds to an estimated cloud-top temperature of −60 °C; each colour band covers a 6 °C temperature range. Two storm areas are labelled as indicated in the text.

Mesoscale structure

Analysis of SFERIC data for storm area 2 suggests there was intensification of one particular cell over the English Channel very early on the 9th. From observations over southern England it appears that when north-

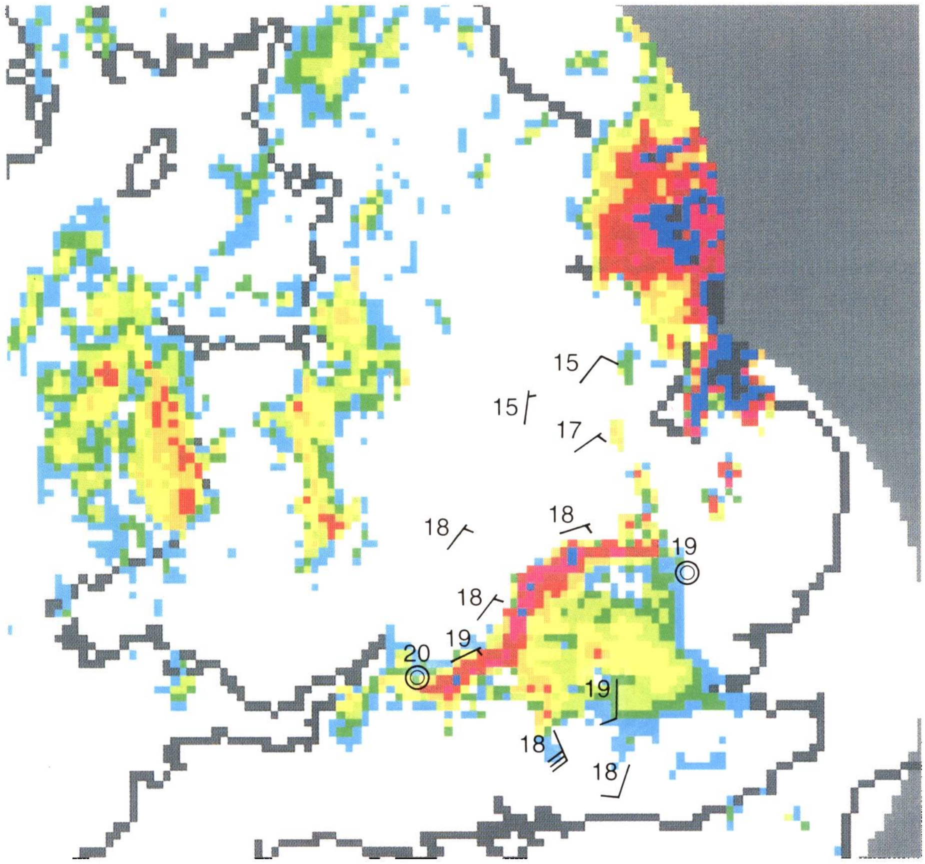


Figure 2. Raw radar data for 0230 UTC on 9 August 1992, with selected surface observations (wind and temperature) for 0200 UTC. Estimated rainfall rates, in mm h^{-1}, are as follows: cyan 0.1–0.5, dark green 0.5–1.0, light green 1–2, yellow 2–4, orange 4-8, red 8–16, dark red 16–32, pink 32–64, blue 64–128, black >128.

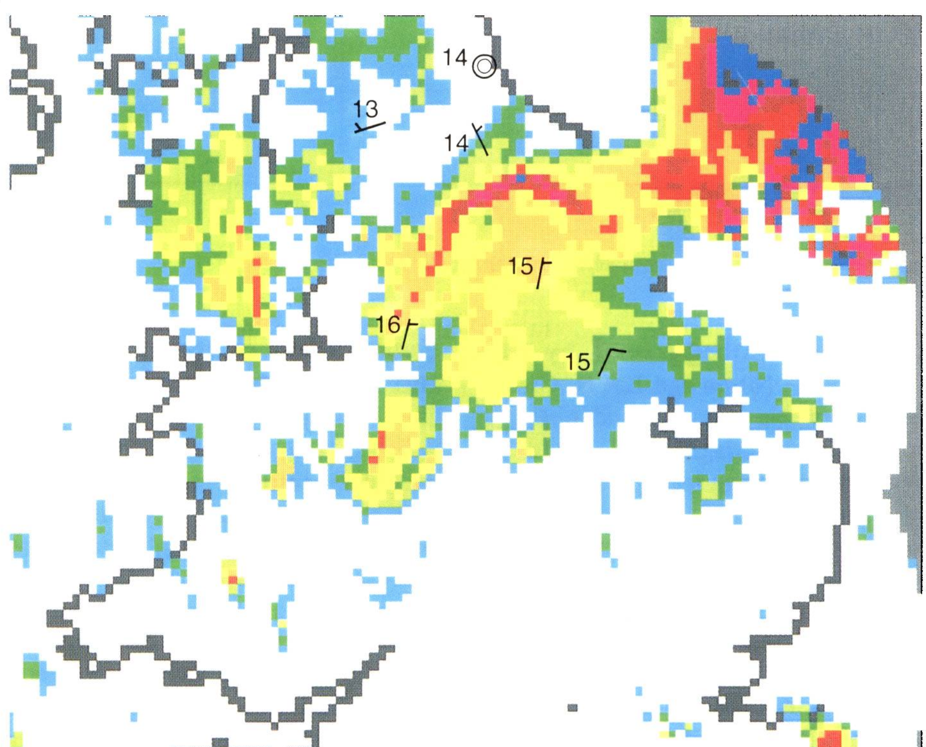


Figure 3. As Fig. 2 but for 0500 UTC on 9 August 1992; radar data and surface observations are both for this time.

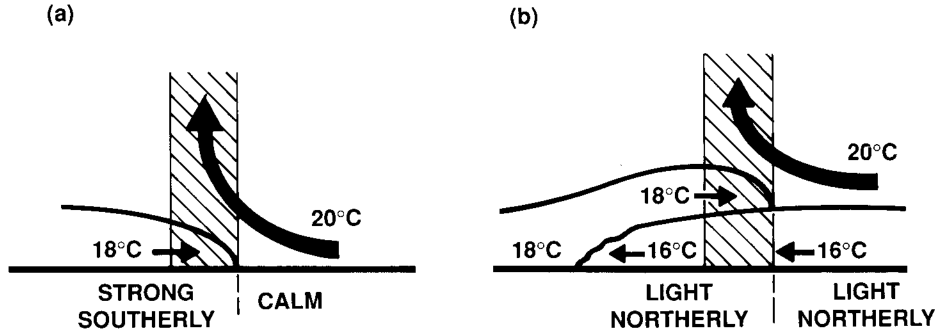


Figure 4. Schematic cross-sections of the boundary layer close to the gust front over (a) southern England at about 0200 UTC, and (b) northern England at about 0500 UTC on 9 August 1992. The cross-sections are aligned longitudinally, with north to the right. Thick solid lines show air-mass boundaries, arrows airflow, figures potential temperature, and text approximate surface winds. The gust front (dashed line) triggered rapid ascent (thick arrows), giving rise to the band of heavy precipitation (shaded). Evaporative cooling from this precipitation sustained the gust front.

ward-bound outflow from this cell (having a surface temperature 18–19 °C) came up against stagnant, warmer air (20–21 °C) over Hampshire, Dorset, Surrey and Sussex a narrow band of intense precipitation was generated. This appeared first on radar imagery at 0130 UTC. The band then moved north, as a readily identifiable feature, at a constant 55–60 knots, eventually developing into a large, intense storm over north Yorkshire around 0600 UTC. Figs 2 and 3 clearly show the arc of intense precipitation. Remnants of the cell which intensified over the English Channel are also evident on Fig. 2, as the area of yellow echoes over north London.

Many places in southern England experienced a sudden increase in wind speed as the precipitation band passed overhead, suggesting that it could be termed a 'gust front'. For example at Odiham (Hampshire) winds were reported calm at 0100 UTC, and south-easterly 29 knots, gusting 48 knots at 0200 UTC. By 0300 UTC, however, this front was moving into a region of light north to north-easterly winds (perhaps outflow from storm area 1) where surface temperatures were around 16 °C (note the surface observations on Fig. 2). In this region the surface winds appear not to have changed as the front passed overhead. This is probably because air behind the front had ridden over the now cooler surface air, instead of forcing it to rise, as illustrated on Fig. 4. Browning and Hill noted a similar effect associated with a thunderstorm system over south-west England. (Browning, K.A. and Hill, F.F.: Structure and evolution of a mesoscale convective system near the British Isles. *Q J R Meteorol Soc.*, **110**, 1984, 897–913.)

T.D. Hewson

Books received

The listing of books under this heading does not preclude a review in the Meteorological Magazine at a later date.

Advances in bioclimatology — 1, by R.L. Desjardins, R.M. Gifford, T. Nilson and E.A.N. Greenwood (Berlin, Heidelberg, New York, London, Paris, Tokyo, Hong Kong, Springer-Verlag, 1992. DM 118.00) emphasizes the mechanisms linking biological processes with their physical environments. It is the first book in a series aiming to provide a common forum for the many separate strands to be found in the vast bioclimatological field. ISBN 3 540 53843 7, 0 387 53843 7.

Advances in bioclimatology — 2: The bioclimatology of frost, by J.D. Kalma, G.P. Laughlin, J.M. Caprio and P.J.C. Hamer (Berlin, Heidelberg, New York, London, Paris, Tokyo, Hong Kong, Springer-Verlag, 1992. DM 118.00) aims to provide a comprehensive worldwide review of recent advances in frost research. It is the second in an ongoing series on bioclimatology. ISBN 3 540 53855 0, 0 387 53855 0.

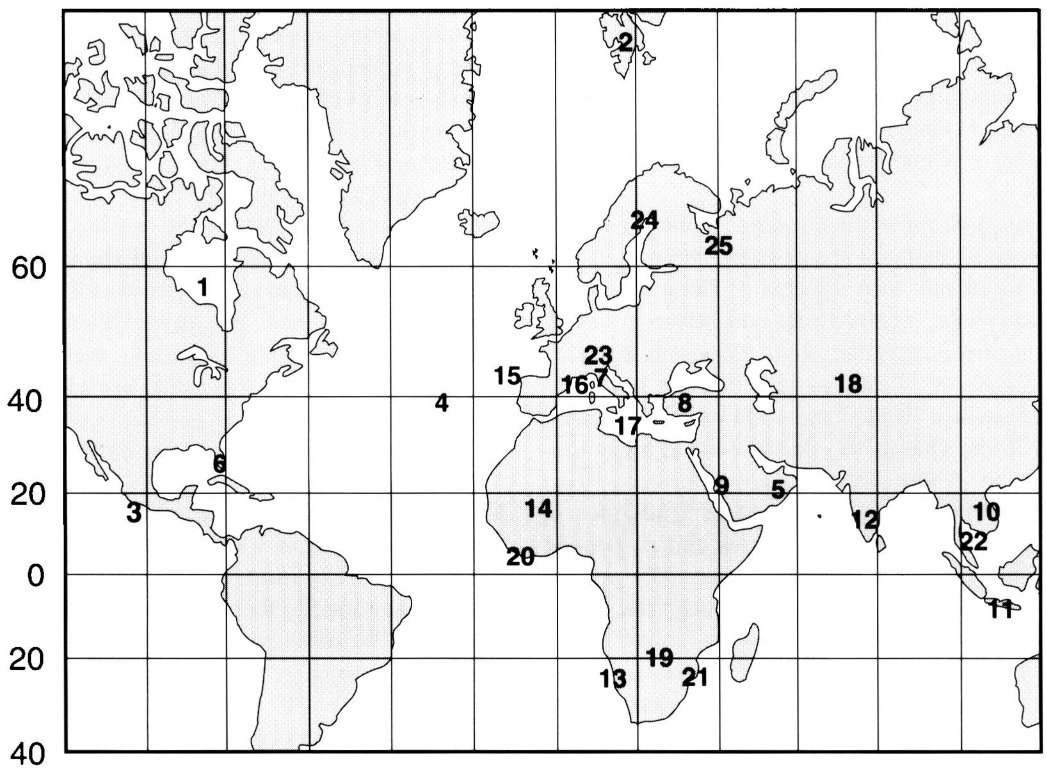
Exploration of the solar system by infrared remote sensing, by R.A. Hanel, B.J. Conrath, D.E. Jennings and R.E. Samuelson (Cambridge University Press, 1992. £75.00, $125.00) describes all aspects of the theory, instrumentation and observation concerned with the subject. The presentation should appeal to advanced students and planetary-science researchers. ISBN 0 521 32699 0.

Diffraction effects in semiclassical light scattering, by H.M. Nussenzveig (Cambridge University Press, 1992. £35.00, $59.95), based on the Elliott Montroll Lectures, considers critical effects in the subject, and presents new physical insights. The book should interest graduate students and researchers in many areas of physics. ISBN 0 521 38318 8.

World weather news — October 1992

This is the first of what I hope will be a monthly round-up of some of the more outstanding weather events each month, three preceding the cover month. If any of you, our readers, has first-hand experience of any of the events mentioned below or its like (and survived!), I am sure all the other readers would be interested in the background to the event, how it was forecast and the local population warned.

These notes are based on information provided by the International Forecast Unit in the Central Forecasting Office of the Meteorological Office, Bracknell and in the 'Casualty Reports' pages of Lloyd's List. *Naturally they are heavily biased towards areas with a good cover of reliable surface observations. It is not yet clear whether these are best compiled chronologically, by WMO Region or by phenomenon. The first method has been chosen for this month.*



Locations of places mentioned in text

1	Hudson Bay	10	Vietnam	18	Alma Ata
2	Spitzbergen	11	Jawa	19	Zimbabwe
3	Mexico	12	India	20	Ivory Coast
4	Azores	13	Walvis Bay	21	Mozambique
5	Masirah and Muscat	14	Mali	22	Gulf of Thailand
6	Florida	15	Asturias	23	Munich
7	Northern Italy	16	Gulf of Genoa	24	Gulf of Bothnia
8	Turkey	17	Crete	25	Arkhanglsk
9	Jeddah				

At the start of the month two sea-surface-temperature anomalies caught the attention. In the North Atlantic very low temperatures off north-east Canada (Hudson Bay's ice did not clear during the summer) were balanced by a warm surge near Spitzbergen. Off the Pacific coast of Mexico sea temperatures were around 29 °C providing the energy for many tropical storms.

On the 1st Tropical Storm 'Bonnie' passed through the Azores; although there was little rain, the wind reached 60 kn at times causing considerable disruption. Next day Hurricane 'Virgil' began rapid development to the west of Mexico. Meanwhile an Arabian Sea Cyclone, romantically named '06A', passed close to Masirah Island and gave Sur, in Muscat, 33 mm (previous maximum in a day, 1.6 mm in a 10-year record).

On the 3rd a trough crossed Florida and the resulting severe thunderstorms and tornadoes dropped 202 mm on Jacksonville, killed four people and did $100m worth of damage. Next day 'Virgil' crossed the Mexican coast 90 miles east-south-east of Manzanillo with winds of up to 90 kn: rainfall at Acapulco reached 125 mm (there was a *forecast* of up to 425 mm in the mountains). Despite the flooding there were no reported fatalities.

Low pressure over the western Mediterranean brought massive amounts of rain to northern Italy and a heatwave to Turkey. By the 7th twelve were reported dead in the north of Italy from the flooding chaos after three days of heavy rain with more than 100 mm in many places (156 mm in Naples on the 4th) and the Po broke its banks. The southerly winds brought föhn conditions to Turkey; 33.2 °C on the 6th set an all-time record at Bandirma on the Straits of Marmara. But the next day the 25 kn winds helped the temperature up to 37.0 °C! It was hotter in Saudi Arabia where Jeddah's October record was beaten by a whole degree when the temperature reached 43.0 °C.

It always seems worse in the Far East! In the period 5th to 7th, Da Nang in Vietnam accumulated 295 mm. If this looks like a lot of rain then the port of Dong Hoi about 100 miles north-west received 680 mm between the 5th and 9th. Not surprisingly the worst floods in 40 years resulted and at least 37 deaths with half the homes in Quang Binh Province flooded and 1000 vehicles stranded on National Route One as the floods washed away sections of the road. A few days later Jawa (formerly Java) had torrential downpours causing huge landslides in Barat Province burying 50 unfortunates and destroying vast areas of rice fields. On the 9th Cyclone '07B' moved across India killing more than 70 in flash floods and landslides in Kerala and Tamil Nadu.

Acapulco had 20 mm overnight on the 7th followed rapidly by a further 187 mm! Two days later, on the 10th, Hurricane 'Winifred' made landfall in Mexico near Manzanillo where 75 kn winds gusted to 110 kn and created 13 ft waves in the harbour (temporarily closed). The storm decayed amongst the mountains of Jalisco state without any immediate reports of casualties. Rain made an impact at Walvis Bay on the coastal fringe of the Namib Desert whose 4 mm was about 20% of the annual total. Elsewhere in Africa it was hot; Gao in Mali had a day maximum temperature of 42 °C followed by a cloudy night minimum of 31 °C.

The western Mediterranean low continued to cause disruption when on the 11th Madrid reported 70 mm, Valencia 44 mm and in Asturias Province in the north of Spain a high tide combined with the rainfall to cause flooding. Late the next day a thunderstorm moved south down the Rhône Valley into the Gulf of Genoa and dumped 70 mm on Le Luc in three hours. On the eastern flank, a scirocco raised the temperature at Souda, on the north coast of Crete, to 33.5 °C, 0.7° above the record.

During the 15th Alma Ata, in Kazakhstan, the temperature reached 25 °C under sunny skies: next day the maximum was only 3 °C with wet snow!

Over the period from 17th to 21st it continued very wet in and around the Alps with 25 mm of rain at low levels and good deal of snow over the mountains, while to the south, Italy had more flooding in its northern Regions with extensive damage in Tuscany with all the bridges in central Pisa closed for a while and at least three incautious motorists were drowned. Over in Mexico at Atizapan de Zaragoza storms damaged 200 homes, drowned two more motorists and killed one with lightning. (Climate tables suggest that the rainy season here is from June to September; this year it started in April and was clearly not over by this day.) About this time reports coming out of the worst drought-ridden areas of Zimbabwe spoke of heavy rains doing 'colossal' damage. In west Africa, Abidjan in the Ivory Coast collected 151 mm in the 24 hours up to 0600 UTC on the 23rd (about the average monthly total). To point the other extreme of African weather, it was reported that at Beira, Mozambique, the rivers have run dry so there is no drinking water for ships bringing supplies — there is also so little fuel for bunkering that some ships are having difficulty in reaching the next port.

Typhoon 'Angela' brought yet more torrential rain to Vietnam, 247 mm in 24 hours to Qui Nhon being the largest readily available total: earlier the 200 000-ton ore-carrier *Daeyang Honey* vanished with its crew of 28 near the eye of the storm. Although the storm decayed over land it was correctly forecast to rejuvenate in the Gulf of Thailand. The close proximity of 'Coleen' complicated matters for the forecasters but they got the heavy rain warnings right — 297 mm at the Thai island resort of Ko Samui in three days of downpours before she dissipated on the 29th. The Germans managed some storms of their own when on the 26th there were reports of violent storms around Munich uprooting trees, damaging buildings and blocking some higher-level roads with snow. Meanwhile the remains of 'Frances' provided the wet air to bring a lot of heavy rain to the north-west of Spain on the 27th with totals of 60–100 mm in many coastal gauges.

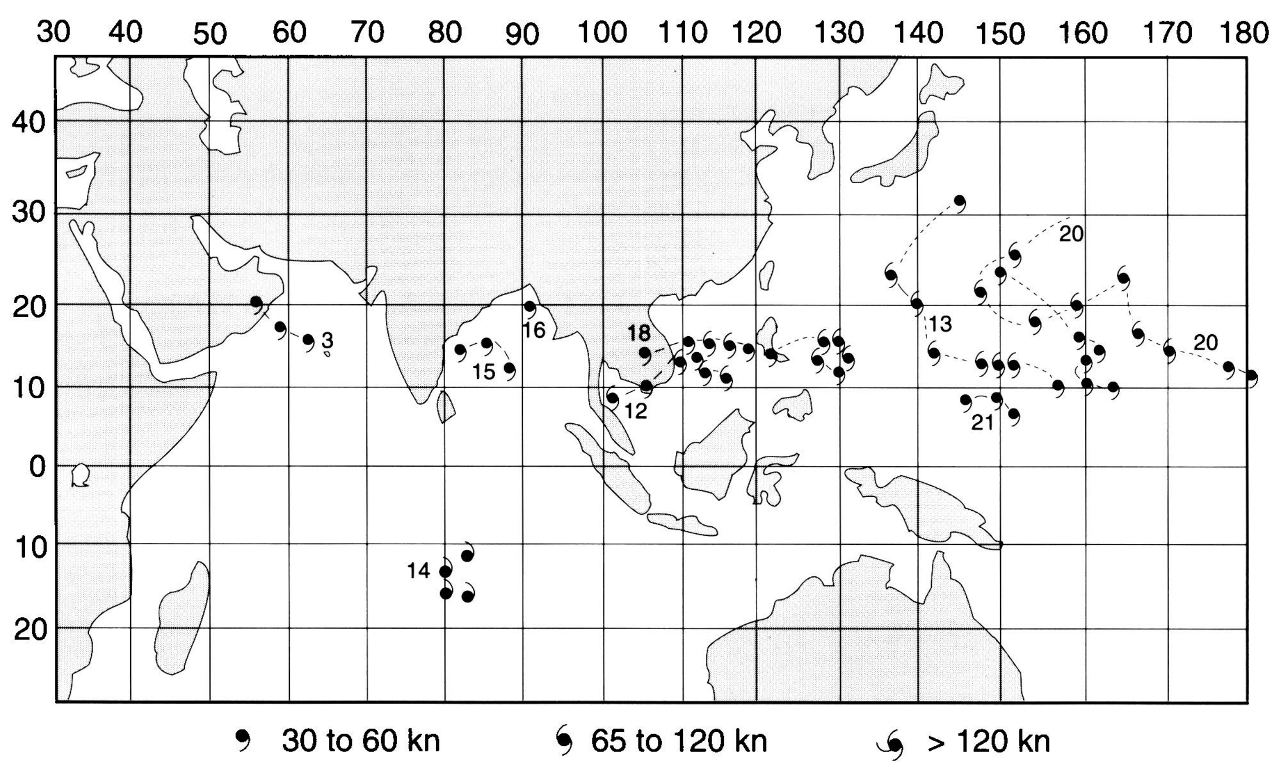
To end on a seasonal note: recent cold weather over Scandinavia has resulted in the formation of sea-ice 4 weeks earlier than usual at the northern end of the Gulf of Bothnia. Further north on the Kola peninsula near Murmansk snow had accumulated to a depth of 79 cm by the 26th. The cold weather had reduced the flow in the river Dvina at Arkhanglsk to the extent that navigation was becoming difficult.

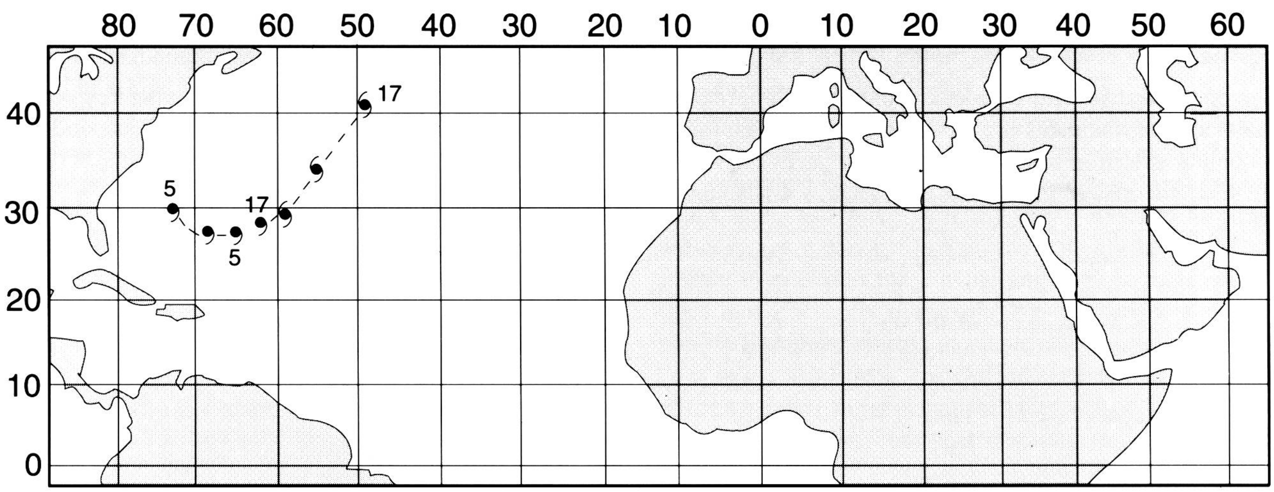
October tropical storms

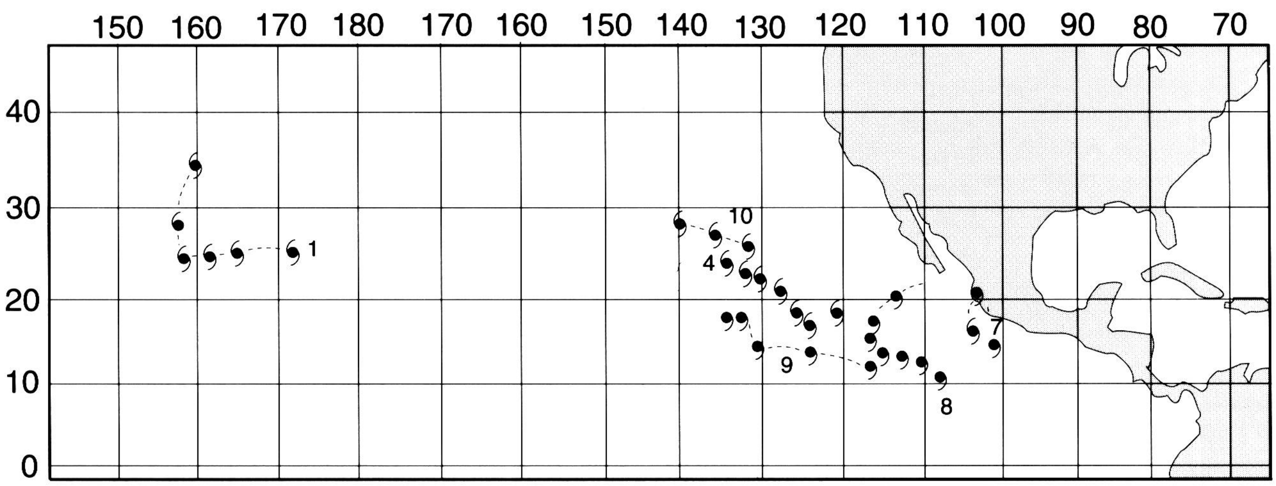
List of tropical storms, cyclones, typhoons and hurricanes active during October 1992. The number is the key on the charts shown, the dates are those of the first detection and date of falling out of the category through dissipation or becoming extratropical. The last column gives the maximum sustained wind in the storm during its lifetime. 'Tina', the strongest eastern Pacific storm in 1992, was also the longest lived on record.

No.	Name	Basin	Start	End	Max.
1	Ward	NWP	26 Sept.	6 Oct.	100
2	Aviona	SWI	27 Sept.	1 Oct.	65
3	06A	NI	1 Oct.	3 Oct.	55
4	Tina	NEP	24 Sept.	10 Oct.	130
5	Earl	NA	26 Sept.	3 Oct.	50
6	Virgil	NEP	1 Oct.	5 Oct.	115
7	Winifred	NEP	7 Oct.	10 Oct.	95
8	Xavier	NEP	13 Oct.	15 Oct.	45
9	Yolanda	NEP	16 Oct.	22 Oct.	50
10	Yvette	NWP	8 Oct.	17 Oct.	155
11	Zack	NWP	7 Oct.	15 Oct.	35
12	Angela	NWP	16 Oct.	29 Oct.	90
13	Brian	NWP	17 Oct.	25 Oct.	100
14	Babie	SWI	18 Oct.	21 Oct.	50
15	07B	NI	7 Oct.	9 Oct.	65
16	08B	NI	21 Oct.	21 Oct.	30
17	Francis	NA	23 Oct.	27 Oct.	75
18	Colleen	NWP	18 Oct.	28 Oct.	80
19	Zeke	NEP	25 Oct.	30 Oct.	45
20	Dan	NWP	24 Oct.	3 Nov.	115
21	Elsie	NWP	29 Oct.	7 Nov.	150

Basin code: N — northern hemisphere; S — southern hemisphere; A — Atlantic; EP — east Pacific; WP — west Pacific; I — Indian Ocean; WI — west Indian Ocean.







A new Moon?

A report in *Space News* for January 4–10 1993 tells of a Russian plan to unfurl a 20 m diameter sail at their Mir space station in early February 1993. The sail will reflect sunlight onto an area about 4 km in diameter with light equivalent to the brightness of five full moons. However, the beam will be moving so fast that any point in its path will only be illuminated for one second. The visual effect will be a single brilliant flash, visible by day as well as at night.

I believe there are distant plans for a series of large reflectors to provide illumination for high-latitude parts of the CIS during their long winter nights. The current test is of material and principle and might give rise to reports of UFOs or other unlikely phenomena.

R.M.B.

GUIDE TO AUTHORS

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Articles on all aspects of meteorology are welcomed, particularly those which describe results of research in applied meteorology or the development of practical forecasting techniques.

Preparation and submission of articles

Articles, which must be in English, should be typed, double-spaced with wide margins, on one side only of A4-size paper. Tables, references and figure captions should be typed separately. Spelling should conform to the preferred spelling in the *Concise Oxford Dictionary* (latest edition). Articles prepared on floppy disk (IBM-compatible or Apple Macintosh) can be labour-saving, but only a print-out should be submitted in the first instance.

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