Right for the Wrong Reason?

A New Look at the 6 June 1944 D-Day Forecast by a Neutral Swede

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ABSTRACT: There are at least three popular perceptions surrounding the weather forecast for the D-day landing in Normandy, 6 June 1944: 1) that the Allied weather forecasters predicted a crucial break or “window of opportunity” in the unsettled weather prevailing at the time; 2) that the German meteorologists, lacking observations from the North Atlantic, failed to see this break coming and thus the invasion took the Wehrmacht by surprise; and 3) that the American forecasters, guided by a skillful analog system, predicted the favorable conditions several days ahead but got no support from their pessimistic British colleagues. This article will present evidence taken mostly from hitherto rather neglected sources of information, transcripts of the telephone discussions between the Allied forecasters and archived German weather analyses. They show that 1) the synoptic development for the invasion was not particularly well predicted and, if there was a break in the weather, it occurred for reasons other than those predicted; 2) the German forecasters were fairly well informed about the large-scale synoptic situation over most of the North Atlantic, probably thanks to decoded American analyses; and 3) from the viewpoint of a “neutral Swede,” the impression is that the American analog method might not have performed as splendidly as its adherents have claimed, but also not as badly as its critics have alleged. Finally, the D-day forecast, the discussions among the forecasters, and their briefings with the Allied command are interesting not only from a historical perspective, but also as an early and well-documented example of decision-making under meteorological uncertainty.

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In meteorology, the greatest story ever told must be about the weather forecasts for the planned D-day, the Allied invasion of Normandy in early June 1944. The broad outlines are well known: how the weather in the English Channel from late May gradually worsened as the suitable time for the invasion, with respect to light and tides, came nearer in early June. The commander in chief, Dwight G. Eisenhower, had to postpone a planned landing on 5 June after his team of meteorologists had warned about low clouds, poor visibility, and strong winds. The operation was launched the following day, 6 June, under marginal conditions during a lull in a stormy and unsettled spell. In this article, it will be argued that this forecast is surrounded by at least three popular perceptions.

The first builds upon the notion that the invasion succeeded thanks to a forecast break in the bad weather which gave the forces a “window of opportunity” (Beevor 2009, p. 21; Stagg 1971, p. 107). The second holds that the Wehrmacht had been taken by complete surprise because the German forecasters, due to their lack of observations from the North Atlantic, had not spotted the alleged break (Beevor 2009, p. 42). Finally, it has been claimed that an American analog system forecast the favorable conditions days in advance (Krick and Fleming 1954, 180–81).

It will be shown that the D-day forecast for 6 June was synoptically not particularly well predicted, and any break in the weather occurred for reasons other than those predicted. It can therefore be said that the D-day forecast was “right for the wrong reason” (Gordon 1996a,b). Moreover, the German meteorologists knew more about the weather conditions over the North Atlantic than has been assumed, probably because they had managed to decode American forecast information. Finally, the pros and cons of the American analog method will be discussed

The different forecast groups

The Allies had set up three independent forecast groups, two British and one American, quartered in separate locations around London. By doing so they hoped to prevent a single German bomb from wiping them out. As coordinator and rapporteur to Eisenhower were James M. Stagg, a Scottish geophysicist, and his deputy, Don Yates, an American meteorological colonel. They were stationed in Bushy Park, just southwest of London, within walking distance of Eisenhower’s personal headquarters. This was also the HQ for the newly formed U.S. Strategic Air Forces in Europe. Its codename, Widewing, also became the name of the American meteorological group led by Lt. Col. (Dr.) Irving P. Krick from the California Institute of Technology (Caltech), with Lt. Col. Ben Holzman as his deputy. They were supported from Washington, D.C., by a Joint Weather Centre (JWC) that the U.S. Army Air Force had organized in the Pentagon, Room 4D260. JWC made twice daily forecasts 3 days ahead and experimental forecasts 6 days ahead using synoptic extrapolation and advanced statistical methods (Bundgaard 1986, p. 15). The JWC has not figured prominently in the literature, although such statistical techniques provided the basis for further developments, for example, the model output statistics (MOS) technique of the 1950s and 1960s.

One of the British groups, Dunstable, under the Air Ministry, was stationed at the Meteorological Office at Dunstable just north of London. It was headed by the Norwegian meteorologist Sverre Petterssen, and his deputy was the legendary British forecaster Charles K. M. Douglas. The second British group, Admiralty, under the Royal Navy, was housed in downtown London with Lt. Comdr. Geoffrey M. Wolfe, and his deputy was the New Zealander Inst. Lt. George L. Hogben.

The historical accounts

Among the participants, the first to publish an account after the war was Douglas (1952a,b). A couple of years later Krick gave his version in the semiautobiographical *Sun, Sea and Sky* (Krick and Fleming 1954). It was later supplemented by the more controversial *Storm: Irving Krick vs. the U.S. Weather Bureaucracy* (Boesen 1978). In the early 1970s, Stagg's version of the events, *Forecast for Overlord* (Stagg 1971), and Sverre Petterssen's autobiographical *Kuling fra Nord* (Petterssen 1974) were published. The latter was later republished in its original English as *Weathering the Storm* (Petterssen 2001).

In 1984, on the fortieth anniversary of D-day, the American Meteorological Society organized a symposium in Fort Ord, east of Monterey, California (Fig. 1).

The proceedings included a wealth of eyewitness reports and important documents (Shaw and Innes 1986). At the fiftieth anniversary the U.K. Meteorological Office published a well-documented account with an emphasis on the British contributions (Cornford 1994). At the seventy-fifth anniversary the Royal Meteorological Society organized a meeting in London where, among others, Brian J. Booth presented a critical examination of Stagg's book *A Cold Front Has Appeared from Somewhere* (B. Booth 2014, personal communication).

Transcripts of telephone discussions

Three declassified wartime documents serve as important complements to the personal memoirs. They contain detailed transcriptions of the daily (scrambled) telephone discussions between Stagg and the three forecasting groups, and Stagg's final briefing to Eisenhower and his staff.

Stagg wrote "Report on the meteorological implications in the selection of the day for the Allied invasion of France" just after the event, with the help of his aide George D. Robinson (Robinson 1986a,b). It is reprinted in Shaw and Innes (1986, 133–170) and Cornford (1994) and will, in line with Fuller (1990, p. 89), be referenced here as the Overlord Meteorological Report (henceforth OMR).

A similar document, "Report by the Allied Naval Commander in Chief Expeditionary Force on Operation Neptune," was finalized in November 1944, and its Appendix 16 covers the meteorological problems (Neptune Meteorological Report 1944, Appendix 16, 156–65). It also contains detailed transcriptions from the telephone discussions, which are similar, but not identical to, the ones in OMR. Here it will be referenced as the Neptune Meteorological Report (henceforth NMR).

Krick's, Petterssen's, and, in particular, Stagg's recollections, apart from being written long after the events, have a personal and polemic character that makes it difficult to see the forest for the trees. Stagg seemed to have had access to OMR, whereas Petterssen had not—for the chronology Petterssen had relied on Stagg's book. But the transcripts of the telephone

Fig. 1. The 1984 Fort Ord meeting about the D-day forecast got coverage in the local Monterey newspapers. The invasion was said to have occurred in a "break" or a period of a "brief lull" in the weather.

discussions, especially in OMR, give a fairly objective, condensed, and, therefore, clearer picture of what was discussed.

Stagg's briefings to the commander in chief were also published as Appendix 10 to "*The Second World War, 1939–1945*" by the historical branch of the British Air Ministry (Air Ministry 1954, 139–46). It also contains post-invasion analyses not found in OMR, but it does not have the discussions leading up to the invasion.

There do not appear to be any similar documents from the Widewing side, although we know that both Krick and Holzman kept diaries (Shaw and Innes 1986, p. 107) and that the telephone discussions were partly recorded on a captured German Telefunken wire recorder (Bundgaard 1986, p. 21).

The weather discussions up to 4 June

The telephone transcripts show that, from late May until midday Sunday, 4 June, there was a strong difference of opinion between Widewing and the two British groups. Widewing, relying on the analog forecast system (see below), discussed the possibilities of the Azores ridge extending onto the Channel about 4 times more often than it discussed the possibility of unsettled conditions due to westerly flow and frontal influences. In contrast, Dunstable and Admiralty focused on conditions that could disturb the weather. Cyclonic activity and westerly flow figure about 3 times more often than the possibility of anticyclonic conditions. Only late on Saturday, 3 June, and early Sunday, 4 June, was there any concurrence, when Widewing acknowledged the arrival of a cold front and the British paid attention to a ridge from the Azores high, albeit in a weakened condition.

The synoptic forecast maps

In all narratives of the D-day forecast, the only maps presented have been surface analyses (mean sea level pressure and fronts). The absence of forecast charts makes it hard to relate forecast discussions to the synoptic situation. From the telephone transcripts, it is not too difficult for an operationally trained meteorologist to reconstruct, in a schematic way, the synoptic forecast maps that would have been available at the time. For an example of such a reconstructed forecast map (valid midnight, 4 June), see Fig. 2.

Early on Sunday, 4 June, the consensus, as reflected in Stagg's briefings to Eisenhower, was that a west-southwest flow of warm moist air would dominate the Channel during the following days. A cold front somewhere west of Ireland would move onto the northern British Isles but would not make it beyond the Channel. In his briefing, Stagg instead focused on

Fig. 2. (top left) Synoptic analysis at 0100 UTC 4 June 1944. (top right) Tentative sketch of the predicted development of the synoptic pattern at 0100 UTC 5 June 1944. (bottom left), (bottom right) As in the top-right panel, but for 6 and 7 June, respectively. The forecast maps are based on the transcripts of telephone discussions and a briefing Sunday morning, 4 June. Notations of cyclones L_5 and L_6 are as given in OMR.

another cold front associated with a depression near Nova Scotia—this front was expected to cross the Channel during the first part of Wednesday, 7 June (Shaw and Innes 1986, 142–143, 160; Stagg 1971, 101–102). No improvement in the weather was expected until then.¹ With low clouds and poor visibility expected on 5 June, the invasion had to be postponed for that day. The evening briefing on Sunday, 4 June, was probably the most important of all because it seemed to offer Eisenhower the possibility of launching the assault two days later, on Tuesday morning, 6 June.

The first popular conception: The break in the bad weather

What happened later on Sunday, 4 June, appears to have been overdramatized in the memoirs. According to Petterssen (2001, p. 243) “a major reorganisation of the atmosphere threw the forecasters into confusion,” but in the end the three teams “reached a state of harmony that hadn’t been attained since February when the conference discussions began.” Stagg was alerted to “a cold front [which] has appeared from somewhere... it is already across Ireland and is moving eastward quickly” (Stagg 1971, p. 105). This does not tally with the notes Stagg made at the time (B. Booth 2014, personal communication). Nor did the cold front appear from “somewhere”; it had been on the charts but was not expected to penetrate the Channel area until Wednesday, 7 June.

Now it had “moved much further south than was expected” and was in the evening traversing the Channel. It was agreed that a fair interval after the cold front would start at midnight and end in the morning of Tuesday, 6 June, due to increasing clouds from the approaching warm front in the west coupled to cyclone L₆. On subsequent days the weather would continue to be unsettled and disturbed (see Fig. 3) (Shaw and Innes 1986, p. 143; Neptune Meteorological Report 1944, p. 162; Stagg 1971, 112–113).

There was a general feeling of relief in the evening. “Most of the uncertainties that had plagued us had now been removed” (Petterssen 2001, p. 244). But the consensus made the groups overconfident. It was taken for granted that L₅, the low over the British Isles, would move toward Norway, followed by L₆, the low approaching from the Atlantic. A transient ridge in between that was expected to bring good weather over the Channel on 6 June. *This was the basis for the prediction of a break or “window of opportunity.”*

For the outlook beyond 6 June, most of the discussion seemed to have focused on the approaching cyclone L₆, which was mentioned twice as much as L₅ (see OMR and NMR transcripts in the sidebars).

¹ According to Stagg (1971, 108–109; Shaw and Innes 1986, p. 155), a weather ship far west of Ireland caused confusion by reporting erratic changes in surface pressure. Neither in the Daily Weather Report published at the time, nor in the archived observations, can any such inconsistencies be seen (B. Booth 2014, personal communication).

Fig. 3. (top left) Synoptic analysis at 1200 UTC 4 June 1944. (top right) Tentative sketch of the predicted development of the synoptic pattern at 1200 UTC 5 June 1944. (bottom left), (bottom right) As in the top-right panel, but for 6 and 7 June, respectively. The forecast maps are based on the transcripts of telephone discussions on Sunday evening, 4 June.

The transcripts in OMR of 4 June evening discussions

L_5 is the cyclone just west of Scotland and L_6 is an approaching cyclone in the North Atlantic.

Dunstable: L_5 not expected to have passed Shetland on the 5 June, therefore still expect L_6 to move east, not NE. Ridge between L_5 and L_6 weakening. L_5 moving northeast to Norway coast on 6 June, and filling. L_6 south of Iceland Tuesday morning, with wave on cold front. Disturbed conditions after 6 June.

Widewing: L_6 expected to move NE so that by midday 5 June its center will be about $59^\circ\text{N } 35^\circ\text{W}$ with 980 mb center, and by midday 6 June at $64^\circ\text{N } 25^\circ\text{W}$ with 990 mb center.

Admiralty: Cold front of L_5 through area early 5 June, linking back through flat wedge to warm from of L_6 . L_6 expected to move into Iceland area and fill. Warm front of L_6 near Scillies by 1300 6 June, moving east slowly. Cold front of L_6 through Channel area on 8 June or 9 June.

The transcripts in NMR of 4 June evening discussions

Some of the notations of synoptic features have been changed to correspond with the OMR transcript.

Dunstable now anticipated that L_6 would at $54^\circ\text{N } 38^\circ\text{W}$ by 0700 5 June with a pressure of 980 mb or less, and $60^\circ\text{N } 22^\circ\text{W}$ by 0700 6 June. L_5 would move slowly up to the west of Norway as previously indicated. At 0700 on 6 June [fronts from L_5] would run from the center southward over the Baltic to West Germany, then westward across the Western Channel and finally become [warm front] running up to L_6 in $60^\circ\text{N } 22^\circ\text{W}$. Wave developments on [cold front from L_6] was considered probable.

Widewing's main modifications to this were in the probable track of L_6 which they still maintained would move into Denmark Strait. Its position at 1300 5 June would be $59^\circ\text{N } 35^\circ\text{W}$ with a depth of 980 mb and at 1300 on 6 June $64^\circ\text{N } 25^\circ\text{W}$ with a pressure of 990 mb. Wave development on [cold front from L_6] was also considered likely but it was thought [warm front from L_6] would be rather inactive.

Admiralty agreed with the Dunstable forecast of the movement of L_5 and wave development on [cold front from L_6]. Their prognosis of L_6 was as follows: 1300 5 June $57^\circ\text{N } 38^\circ\text{W}$ depth of 980 mb, 1300 6 June $61^\circ\text{N } 30^\circ\text{W}$ depth 980 mb and 1300 7 June $64^\circ\text{N } 24^\circ\text{W}$ depth 990 mb. It was maintained that L_6 was deepening so rapidly now that it must soon undergo marked retardation; continued intensification of the ridge between L_5 and L_6 was therefore likely. Position of [fronts from L_5] at 1300 on 6 June was from $61^\circ\text{N } 30^\circ\text{W}$ across the south of Ireland and thence southward to Blacksod Point, from here [a warm front from L_6] ran south to the west of Brest.

The "let's go" forecast

The agreed forecast that Stagg presented to Eisenhower in the evening of 4 June stated that "there will be an interval of fair conditions, which should last until at least dawn on Tuesday [6 June]." Winds would decrease to force 3–4 on the French Channel coast and clouds would become mainly less than 5-tenths of the sky, with base 2,000–3,000 feet (~600–900 m), later to increase to 8–10-tenths. It was assumed that, after that, the weak transient ridge would give way to a warm front (coupled to L_6) that would cross on Wednesday, 7 June.

Following this briefing, provisional instructions were issued for launching the invasion early on 6 June. This forecast was repeated the next morning (5 June) when the final go-ahead was given.²

² Normally Stagg and his group left Eisenhower's room after their briefing. But Stagg (1971, p. 114) claims that after the evening briefing on 4 June they remained and were privy to the discussions. His account, however, seems to be an edited extract from page 224 of Chester Wilmot's 1952 best seller *The Struggle for Europe* (B. Booth 2014, personal communication).

An authentic D-day forecast chart

The schematic reconstruction of the Allied meteorologists' understanding of the synoptic development (Figs. 2 and 3), in particular the expected transient ridge over the Channel, is verified by an authentic forecast. It was produced on Monday, 5 June, for an American pilot, a Sergeant Mentz, who was to carry out a weather reconnaissance flight southwest of Ireland early on 6 June. It was saved for the future by C. M. K. Douglas in his archive at the National Meteorological Archive in Exeter (Fig. 4) (Douglas 1947).

This forecast map gives the impression that cyclone L_5 , initially over the British Isles, had moved away northeastward to Norway. It was the transient ridge over the Channel that was expected to provide good operational weather during the morning of 6 June. It would, in line with the official D-day forecast, soon be followed by cyclonic conditions, increasing westerly or southwesterly winds, lowering cloud ceiling, and worsening visibility.

An unexpected turn

But cyclone L_5 never did move away to Norway. Instead, it made an unexpected southeast turn onto the North Sea (Douglas 1952a, p. 23; Douglas 1952b, p. 168; Gordon 1996a; Simon 1986, p. 10; Cornford 1994, footnote 23). Cyclone L_6 stayed over the Atlantic, delaying the arrival of its warm front. The ridge never arrived, and the flow stayed cyclonic (see analyzed charts in Fig. 5).

Thus, on the invasion day of 6 June, the winds did not weaken, nor did they back toward the southwest. They remained between west and northwest along the Normandy beaches and reached force 3 to 5, stronger than forecast (Air Ministry 1954; Shaw and Innes 1986, 146–47).

Many soldiers suffered dreadfully from sea sickness during the 18-h journey in flat-bottomed boats (Fuller 1990, p. 93). The damp sea sickness bags rapidly filled, and some soldiers resorted to vomiting into their helmets. They were thoroughly exhausted by the time they reached the beaches.

The strong onshore wind piled up the water, which meant the advantage of invading at low tide was lost. Tanks that were supposed to land 5–8 km from the shore were put in water much closer in. Many of them sank in the choppy 1–3 m seas (Beevor 2009, p. 85, 90, 104). On invasion day, there had been a marginal break in the clouds and visibility, but there was no respite with the wind.

Right for the wrong reason?

The British–Australian meteorologist Adrian Gordon, who followed the events from his wartime position in Reykjavik,

Fig. 4. Forecast map from 5 June valid at 0100 UTC 6 June given to an American pilot, probably copied from the official forecast map, which has been lost (Douglas 1947). System L_5 is predicted to have reached southern Norway while system L_6 is approaching the British Isles, threatening to increase the clouds and worsen the visibility later on 6 June.

Iceland, noted later: “It is somewhat ironic that the forecast upon which Eisenhower made his ‘to go’ decision, a forecast which the meteorologists concerned claim as a success and largely responsible for the success of the invasion and subsequent victory was, in effect, right for the wrong reason” (Gordon 1996a, p. 73; Gordon 1996b, p. 256).

In 1984, in a letter to the Fort Ord meeting, Gordon quoted a letter from Douglas: “A point I could enlarge upon was the element of luck.... Everyone thought that [the depression which moved quickly northeast to North Scotland] would go on moving NE even if more slowly, but it suddenly became stationary and then moved slowly SE while filling rapidly” (Gordon 1986, p. 104; Gordon 1996a, p. 73; Gordon 1996b, p. 178).

The element of luck and the role of uncertainty were explicitly recognized at the time. Indeed, when Air Marshall Tedder received a forecast from Stagg, he asked about the confidence: “Do all the meteorological centers agree on the forecast?” (Shaw and Innes 1986, 143–144; Stagg 1971, p. 99, 113; Fuller 1990, p. 91). Roberts (1986, p. 97) relates a similar experience with his commander.

Although the D-day forecast was not quite correct, Eisenhower, as we now know, still made the right decision to launch the invasion. It remains a matter of speculation what he might have decided if he had received a 100% correct forecast. Intriguingly, the German High Command seems to have made the wrong decision from a reasonably accurate forecast!

The second popular perception: The Germans had been ill informed of the weather

It is sometimes stated that it was a lack of upstream observations over the British Isles and the North Atlantic, which hampered the German meteorologists’ possibilities to forecast the weather (Beevor 2009, p. 42). It is, however, well documented that the Germans conducted weather reconnaissance flights west of Ireland (Kington and Selinger 2008), received observations from the German embassy in Dublin, and listened in to the exchange of weather information between the Royal Air Force controls and arriving planes (Cornford 1994, footnote 7). This information would have been sufficient for a 1-day forecast for the Channel, and we know that the German short-range forecasts were fairly correct (Gordon 1986; Bates and Fuller 1986, 259–260; Kington and Selinger 2008, 223–224). Still, the Germans appeared quite capable of issuing skillful forecasts for more than 1 day ahead.

On 3 June, at his headquarters halfway between Paris and Rouen, Field Marshal Rommel started to plan his departure for Germany to see his family and visit Hitler. On 4 June, the chief meteorologist of the 3rd Air Fleet reported that weather in the Channel would be so poor that there could be no landing attempts until 10 June (Beevor 2009, p. 42). How could the German meteorologists have any opinions, right or wrong, about the weather almost a

Fig. 5. Synoptic analyses at 0000 UTC from 5 to 8 June 1944. The low that was supposed to move northeast to southern Norway remained over the North Sea for some days. On 6 and 8 June the observed winds in the Channel were force 4 and occasionally force 5.

week ahead? The explanation is that they knew much more about the synoptic situation than they have been credited for.

German North Atlantic analyses

Wartime German Tägliche Wetterbericht (Daily Weather Reports) are available at the National Meteorological Library and Archive in Exeter, United Kingdom, and the Swedish Meteorological and Hydrological Institute, Norrköping, Sweden. The 3 June 1944 edition (Fig. 6) has a 0000 UTC analysis (bottom left) which covers most of the North Atlantic as far west as Labrador and Hudson Bay (Fig. 6).

The text at the bottom right describes the synoptic situation, but also indicates what the German meteorologists thought about the future development (translated from German): “On the north side of this high-pressure ridge, which reaches from the Azores to France, the Atlantic cyclones, or at least parts of them, will continue to advance into northern Central Europe in the next few days” (Shaw and Innes 1986, p. 117). This is consistent with the long-range outlook given to Rommel on 4 June.³

Westward extent of the German analyses

For months leading up to May 1944, the westward extent of the German analyses in their Daily Weather Reports had been

³ These forecasts are lost, but it would be possible to infer from the German military archives what kind of information the meteorologists gave them.

Fig. 6. The German routine Daily Weather Report from 3 June 1944. (top left) Maps valid at 1200 and 1800 UTC the day before. (bottom left) The European–Atlantic map at 0000 UTC, where the analysis over the North Atlantic appears not to be based on observations but intercepted American coded analyses. (right) Map at 0600 UTC (courtesy Gunnar Larsson, chief archivist at SMHI, Norrköping, Sweden).

longitude 40°W. In early May there was a sudden extension westward to 80°W. This date does not coincide with any significant change in the Allied observational network. Additional Allied weather ships were placed in the eastern Atlantic only 10–15 days later. During the rest of May the westernmost extent of the German analyses alternated between 40° and 80°W, then remained at 80°W for most of June (Fig. 7).

Fig. 7. Westward extent of the MSLP analyses on the German Daily Weather Reports at 0000 UTC during spring 1944. Around 10 May 1944 most of the analyses were extended from 40°W (the longitude from Iceland to the Azores) to 80°W (the eastern shores of Hudson Bay).

From where did the Germans get this extra synoptic information? There were too few German submarines to supply enough observations for their North Atlantic analyses, and even fewer for the extensions into mainland Canada. A detail in the German surface pressure analyses—the small kinks in the isobars—might reveal their origin (Fig. 8). In synoptic weather maps, kinks in the isobars indicate where fronts intersect. There were no facsimile transmissions of isobaric maps (Simon 1986, p. 9; Robinson 1986a, p. 88), which leaves as the only possibility that the information came from coded mean sea level pressure (MSLP) analyses. Would it have been possible for the Germans to decode these messages?

Did the Germans use U.S. analyses?

At least twice a day, JWC provided coded surface and upper-air analyses for North America and the west Atlantic to not only Widewing and U.S. meteorological units in the outfields, but also the British and Russian forces (Allan 1986, p. 5; Bundgaard 1986, p. 15; Fuller 1990, p. 38ff.). The forecasters used them to supplement their own local analyses in preparing 1–2-day forecasts.

Fig. 8. The 0000 UTC analyses in the German Daily Weather Report for (left) 4 and (right) 6 June. Note the kinks in some of the isobars. Also, the analyses over the Soviet Union might be based on decoded MSLP analyses.

The Americans generally used less strong encryption than their British allies. An over-complicated coding–decoding procedure would cause delays and misinterpretations of the meteorological information. These drawbacks could outweigh the advantage of secrecy (B. Booth 2014, personal communication; Ratcliff 2006, 47–48).

The change on 10 May 1944 (in Fig. 7) might be coupled with a change in the JWC’s coding of the disseminated analyses, perhaps on Sunday, 7 May. This would explain why the westward extension of the German analyses temporarily declined on 7–9 May from the normal 35°–45°W to around 25°W. It probably took the Germans some days to break the new code.

Thus, from early March 1944, the Germans might, twice daily, have intercepted state-of-the-art surface and upper-air analyses covering a large part of the Northern Hemisphere. This would have enabled them to make fairly realistic forecasts for the Channel several days ahead.

The third popular perception: The role of the American analog system

The idea behind analog systems was that, by finding a similar meteorological situation in past surface maps (1899–1940), the current situation was likely to follow a similar sequence to that of the past. This method was used most when forecasting beyond a few days ahead. The third perception is that Widewing’s analog system was the main factor behind the success of the D-day forecast.

The performance of the analog system

According to the transcripts, the analogs beginning on Sunday, 28 May 1944 (8 days ahead) called for an extension of the Azores high northeastward toward Ireland by 5 June. This extension would push approaching cyclones toward the north and protect the Channel (Cornford 1994; Bundgaard 1986, p. 17). Even if the details were quantitatively not correct, for example, in the exact position of the ridge, the analog system nevertheless qualitatively indicated a change in the weather regime, from a generally zonal flow to meridional. It should be noted that on the evening of 3 June, both Widewing and Admiralty suggested that L_5 would not move northeastward to Norway, but southeastward onto the North Sea. In the case of Widewing, this idea might have been inspired by the analog system.

Applying a modern trough–ridge diagram or Hovmöller diagram to the days around D-day shows that the synoptic development on 6 June was part of a *downstream development*. It originated with a deep cyclogenesis over the North Pacific on 3 June (outside the diagram). Energy propagated rapidly eastward, leading to deep cyclogenesis over the western Atlantic (50°W) on 5 June, with the downstream narrow ridge of high pressure (20°W) on 5–6 June being a consequence of this cyclogenesis (Fig. 9).

Fig. 9. Time–longitude or Hovmöller diagram for the 1,000-mb (1 mb = 1 hPa) geopotential height, averaged over 35°–58°N and between 90°W and 30°E, for the period 4–8 June 1944. Blue indicates low pressure areas, brown and yellow are high pressure areas. The thin black line shows the speed of downstream development as 30° day^{−1}. Image courtesy NOAA/ESRL/Physical Sciences Division (www.esrl.noaa.gov/psd/). The “finger of high pressure” formed 5–6 June west of the British Isles downstream from a deepening low at 45°W in the North Atlantic.

At this time (1944) the use of Hovmöller diagrams lay some years in the future. Yet, synopticians before the war already had an intuitive feeling that weather systems affected each other downstream (Persson 2017, p. 951). Such downstream development events are quite common and have most likely figured in the selected analogs.

Opinions about the analog system

In the 1940s, the analog method developed by Krick at Caltech was not particularly controversial, for the simple reason that it was one of the few long-range methods available (Petterssen 2001, p. 194). It only became controversial after the war. In his 1954 semiautobiographical *Sun, Sea and Sky*, Krick claimed that “the British, using short-range methods, could see no weather coming up in the unstable atmospheric conditions of those touch-and-go days of the first week in June 1944.” He further noted that “[h]ad not the skilled meteorologists using modern methods [i.e. analog techniques] correctly foreseen tiny chinks opening in the [weather of 1944 in Western Europe] all the mighty preparations for D-day might have gone for nought, and the war in Europe might have gone on for years” (Krick and Fleming 1954, 180–181).

Krick’s book was reviewed in the *Quarterly Journal of the Royal Meteorological Society* by none other than James Stagg: “[Krick’s account], to speak mildly, is hardly likely to be an acceptable statement of what took place: it is not even worthy of Dr Krick as a professional meteorologist, and as one who contributed honourably to the D-day forecast” (Stagg 1955, p. 116).

As noted by Fleming (2004a,b), Krick’s account was given quasi-official status in the celebratory volume *A Century of Weather Service* (Hughes 1970, p. 89). By then the appreciation of the analog method had become influenced by other issues such as the controversy about Krick’s work and the role of statistical forecasting in relation to dynamic numerical forecasting. Although the NWP eventually won the contest in the 1960’s, the rivalry with the statistical methods continued.

Summary and a look ahead: What can be learned from the D-day forecast?

Much of the perception of the D-day forecast centers on an alleged break in the bad weather. It was supposed to occur in a ridge between two low-pressure systems, one leaving the area and the other approaching. In reality the first low stayed in the area for longer than expected, and it was within this system there was a lull, an improvement in the visibility and cloud ceiling, but not the winds, which kept the sea very choppy.

The forecasts issued by the German meteorologists have not been as well documented as those of their Allied counterparts. It has been taken as almost self-evident that the German forecast had to be worse than the Allied’s because of a lack of observations. But judging from the available material, in particular to their synoptic mapping over the North Atlantic, it is not surprising that the Germans managed to give fairly correct advice to their High Command, both in the short and longer term. Their forecasts might even have been more realistic, or at least less optimistic, with no speculations about any break in the weather. In the 1930s the German meteorologists were regarded as the leading experts in extended forecasting (Namias 1986, p. 10).

The role of Irving Krick’s analog system has come to dominate the historical debate on the D-day forecast. Although claims by Krick that the system forecast favorable weather conditions several days ahead cannot be vindicated, its virtue was to indicate the crucial transition from mainly zonal to more meridional flow.

Finally, is there something to be learned from the D-day forecast? It was 75 years ago and the observational coverage has improved tremendously since then, both qualitatively and quantitatively. Our understanding of the atmosphere is much better, and the forecast

methods have reached a standard that could hardly have been dreamt of in 1944. However, there is one element that has a familiar ring to it and is of great interest today. That is when Air Marshall Tedder asks about *an assessment of the confidence in the forecast he has just heard from Stagg*. This illustrates that the D-day forecast is a significant early example of decision-making under meteorological uncertainty. The details of the discussions and the deliberations in OMR and NMR offer, more than the autobiographical narratives, unique material for further studies.

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