Chapter 7
Forecasting and World War II

The influence of weather on warfare is indeed very strong. The original Kamikaze (Divine Wind) was a typhoon which in 1281 destroyed the Mongol fleet that was attempting to invade Japan. In Elizabethan times attempts by the Spanish Armada to land forces in Ireland were thwarted by bad weather. Something similar happened just over two hundred years later. John Tyrell in the inappropriately titled Weather and Warfare gives a fascinating account of the way in which the weather during 1798 thwarted the activities of the Irish rebels and their French supporters. Weather can also be used to military advantage and Napoleon's strategy at the battle of Austerlitz in 1805 is a classic example of this (even if the Russian winter eventually started his downfall).

As mentioned in Chapter 5 the Germans, in setting up a meteorological institute at the University of Leipzig in 1912 were aware of the importance that weather would be likely to have in the forthcoming war. Lessons were learnt, and this point was certainly not lost on the authorities in Britain as it prepared for World War II. The Battle of Britain or the Battle of the Atlantic may be acknowledged as pivotal events in this conflict, but, as will be shown in this chapter, the 'Weather War' was probably of equivalent importance, even if this is not generally recognised outside military circles. In order to support this opinion, I will start with the British preparations for a commitment to having a meteorological monopoly over the major theatre of war, namely the Atlantic. With hindsight it can be seen that there was much sense in this approach. A British bombing raid over Europe would be assisted by knowing what weather to expect on the way to and at the target. Conversely, if Germany were denied access to information on the largely prevailing weather conditions, then their bombing raids on Britain would be all the more difficult for them. In the absence of other sources U-boats would have to be used to obtain weather data, but a U-boat that was doing this was being diverted from hunting down convoys. It can be asserted with some confidence that this tactic was very successful, although how the Germans responded is a fascinating history, and they are deserving of much credit for their initiative.

Any discussion on forecasting during the second world war must also cover the close link between weather and the cracking of enemy ciphers, particularly Enigma. Certainly the breaking of the German weather ciphers meant that by late 1942 much of the weather across Europe was an open book to the Allies. The final part of this chapter covers the work of the forecasting teams prior to the D-Day landings and the controversy that followed their success.

Anglo-Irish Agreement

Just before the outbreak of war several countries were asked if they would be willing to provide Britain with exclusive access to Atlantic weather data. Amongst these was Ireland and Iceland. Ireland responded positively, Iceland did not. When war became imminent, the continued receipt of meteorological observations from Ireland became a matter of great concern to the British Meteorological Office. In August 1939, the Irish government agreed in principle with a British proposal that existing arrangements for the exchange of information should be continued. Details were worked out on 1 September 1939 and, on the outbreak of war, the approved arrangements came into force.

*2. In August 1939 the United Kingdom authorities received through the Eire High Commissioner a Memorandum prepared in the Department of Industry and Commerce. This stated in part that -
The Irish Government are prepared in the event of a war to continue the existing arrangements under which observations made at their weather reporting stations are furnished to the British Meteorological Office on the understanding that meteorological reports and forecasts will continue to be furnished by the British Meteorological Office to the Irish Meteorological Service.

3. The arrangements brought into force during the early stages of the late War may be summarised for convenience as follows:-

(a) Data received from the then Eire Government
(i) Surface reports from 5 synoptic stations and 1 auxiliary station.
(ii) Upper wind reports from 2 stations.
(iii) Some additional data for used in connection with the United Kingdom flying-boat flights to and from Eire.

(b) Data supplied by United Kingdom Government
(i) Surface reports from 18 stations in the United Kingdom, 6 stations in France and 1 Belgian station.
(ii) Upper wind reports from 5 United Kingdom stations.
(iii) Upper air temperature reports twice daily from Aldergrove (Northern Ireland).

4. In addition the Eire Meteorological Service undertook to assure that no information was transmitted in clear from Foynes to aircraft in flight. Further, messages containing Irish reports and meteorological advice were sent by secret cypher from Shannon Airport to Botwood (Newfoundland) for the information of the Meteorological Service at that base and of the Meteorological Service of Canada. In return Botwood base transmitted to Shannon Airport meteorological reports from Newfoundland and Eastern Canada for later transmission to the Central Forecasting Office in the United Kingdom.

5. During and after 1941 arrangements for the exchange of data were made direct between the technical services of the two countries and there was a large expansion of the supply of information from both sides."

The fine detail of the technical arrangements came about as a result of a meeting of the Irish Meteorological Service and the Irish army Air Corps at 11a.m. on 13 October 1939, where it was decided that daily flight forecasts would be relayed by priority telephone and telegram from the meteorological office at Foynes to Baldonnel and Rineanna (current site of Shannon Airport). For its part, the Air Corps agreed to make daily weather flights at 1200 GMT at Baldonnel (also at Rineanna from January 1942) to record upper-air values of pressure, temperature, humidity and wind, similar to the THUM ascents being made by the RAF. It was also decided that a Meteorological Officer would visit Baldonnel to give lectures and arrange examinations in meteorology for pilots of the Air Corps. Regardless of what it says above it would appear that weather reports were provided by stations at Belmullet, Birr**, Dublin, Foynes, Malin Head, Markree, Roche's Point and Valentia. Together with Aldergrove in Northern Ireland, reports from these sites would have provided a well-balanced synoptic coverage over the country.

It is firmly believed that it was this agreement which accounted for the fact that Britain did not occupy the Irish Free State during the second world war. Given that they had evacuated in 1922 and they were probably aware that the Irish Army had two command structures: A

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* The name of the townland in which Shannon Airport is situated
** Birr boasts the oldest regular meteorological records in Ireland

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brigade structure based on the very successful tactics used by the IRA in the period between 1916 and 1922. This was to be used in the event of a British invasion of the Free State. The other, more public structure was the conventional battalion format, so that in the event of a German invasion, the Irish Army would form part of a British defence of the island. An occupation of Ireland against the wishes of the people would have been more trouble than it was worth, unless the dictates of war directed otherwise as it did in the case of Iceland.

The invasion of Iceland
It is reported that the in-clear weather reports from Iceland were transmitted in the Greenlandic language, but with the German onslaught and occupation of Denmark on 9 April 1940 Britain moved quickly, if somewhat haphazardly*. A plan was approved to land a force at Reykjavik. There, they would overcome any resistance and take care of local Germans. To guard against a German counterattack by sea, they would secure the harbour and send troops by land to nearby anchorages. The British were also worried that the Germans might airlift troops, as they had done with great success in their Norwegian Campaign. To guard against this, troops would drive east to the possible landing grounds. Troops would also be sent by land to harbours and the landing strips in the north of the country.

On 3 May the men of the 2nd Royal Marine Battalion were informed to prepare for a mission. On 4 May, they received some modest additional equipment in the form of Bren light machine guns, anti-tank guns and 2-inch mortars. Supporting arms provided to the force consisted of two 3.7 inch Mountain Howitzers, four QF 2 pounder naval guns and two 4 inch coastal defence guns. The guns were manned by troops from the artillery divisions of the Navy and the Marines, none of whom had ever fired them. They lacked searchlights, communication equipment and gun directors.

The force 746 marines under the command of Col R. Sturges was accompanied by a small intelligence detachment and a diplomatic mission, although no one in the expedition was fully fluent in the Icelandic language.

On 7 May, the force was boarded the cruisers HMS Berwick and HMS Glasgow in Grenock harbour. At 4 o'clock in the morning on 8 May, the cruisers departed for Iceland. They were accompanied by an anti-submarine escort consisting of the destroyers HMS Fearless and HMS Fortune.

At 1:47 a.m., Icelandic time, 10 May, HMS Berwick used its catapult to launch a Walrus reconnaissance plane. The objective was to scout for enemy submarines, but against orders it ventured too close to Reykjavik, thereby alerting people that something was up. Amongst those who came down to the harbour was the German Consul, Werner Gerlach. Now certain what was going to happen he returned home and started to burn sensitive papers.

Approximately 400 marines were trans-shipped to HMS Fearless and taken ashore, where they met with grumbles, but no resistance.

A guard was immediately placed on the Post Office. The telegraph office, the radio station and the meteorological office were quickly occupied and attention then transferred to the

* Much of the information presented here is derived from (http://en.wikipedia.org/wiki/Invasion_of_Iceland)

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capture of the German consul, Gerlach's fire was soon extinguished and documents were salvaged.

John Coulson* member of the Marine Expeditionary Force later related his experiences to his students at Bristol University:

"Notwithstanding their failure to get to Iceland first, German naval planners evidently entertained hopes of making use of sympathetic Icelanders and any German agents who remained at large in the country. One of the most important tasks faced by British occupying forces after settling the administration of the capital was to locate those in communication with U-boat crews, or other German vessels, and render them ineffective. Many of the operatives engaged in such activity were based in the hill country, many miles from Reykjavik. Consequently this task took six months to accomplish."

The Faeroe island were occupied on 12 April and the marines in Iceland were relieved on 17 May when 4,000 troops arrived.

Britain needed their troops elsewhere, and in July 1941, passed responsibility for Iceland to the United States (five months before Pearl Harbour) under a U.S.-Icelandic defence agreement. Britain had persuaded the Icelandic Parliament to approve an American occupation force.

**The defence of Greenland**

Greenland was a Danish possession and in 1940 the Norwegian whaler *Furenak* was used by the Germans to land a four man weather observation team on Eastern Greenland but they were quickly captured.

On 9 April 1941 the Danish Ambassador in Washington, on behalf of his government (de jure neutral) concluded an agreement where the United States agreed to take care of Greenland on behalf of Denmark (the ambassador, although subsequently sacked by Copenhagen continued to be recognised as such by the US). Almost immediately, surveying expeditions were sent to Greenland to plan for possible naval bases and air bases. Soon after this, the US Coast Guard instituted a naval patrol. In May 1941 they captured two weather parties en-route to Greenland. and in September of 1941, they seized a Norwegian trawler sent to establish a German weather station on the East Coast of Greenland. The local Government in Greenland created an army, comprising 26 men, known as North-East Greenland Sledge Patrol. Their task was to patrol the coast line to look for any evidence of German landings. The sledge patrol was at the same time an effort to show the Allies the willingness of the Danes to fight against the Axis.

The Germans managed to land two parties on eastern Greenland in August 1942. Codenamed "Operaton Holzauge" 27 men over-wintered and remained unlocated until March 1943, when they had an encounter with a Greenland army patrol. They killed its leader and captured two others, but one patrol member escaped and travelled 600 miles to report the location. In late May the Allies launched a bombing raid using B-24 which completely destroyed the station. The surviving Germans scuttled their supply ship (*Sachsen*) and were evacuated by sea-plane in Mid-June.

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In September, 1943 the trawler Cobura landed a party, under the codename "Bassgeiger," in northern Greenland. This group included four ski-troops to provide defence and they avoided detection until mid June 1944 when they moved out and the U.S. Coast Guard intercepted their replacements. Nevertheless, they were able to hide an automated station before departing**.

Weather stations in the far north

The Germans had much more success in the far north of the Atlantic and in fact this had a significant influence at various times during the war, even if their actions lacked the type of co-ordination that one might have expected from a mighty military machine. Initially, Germany’s occupation of Norway had little consequences for the Spitzbergen Archipelago. However, following the invasion of the Soviet Union the Barents Sea gained special significance for Arctic convoys. The Germans landed a He-111 weather aircraft on Spitzbergen on what appears to have been a 'scout-the-terrain' mission. Realising the likely implications the British launched Operation Gauntlet in August 1941. The passenger liner Empress of Canada was escorted by five ship task-force including HMS Nigeria (under Adm Sir Phillip Vian) and HMS Aurora. They evacuated the entire population of 3200 which included Norwegians and approximately 1000 Russians (mostly connected with the coal mines). The Norwegians manning the weather station were happy to surrender. False reports were transmitted implying that there was low cloud cover and fog (to prevent German reconnaissance flights). Following the evacuation it took five days to destroy everything.

The Russians were then ferried to Archangel. This was followed by a bombardment of Bear Island, where two Norwegians were taken off and the wireless transmitter destroyed. The Germans did not realise that much of this had taken place until about 5 September. A ten man Luftwaffe met. team was landed. They were then able to fly in tons of supplies and by 11 November they had two remote stations and a primary site. These and reports from the
Weather ship *Sachsen* provided the necessary information for the 'Channel Dash' (discussed below).

It seems strange that different branches of the German military each had their own installations there. For example, in 1941-42, the station 'Bansö' wintered in Adventdalen near Longyearbyen and 'Knospe' in Signehamna in the Krossfjord.

A company of Free Norwegian ski troops was landed on Spitzbergen in May 1942, but as they were unloading they were bombed by four FW-200 Condors. Their transport ship, the *Ishjørn* was sunk and the *Selis* caught fire. A total of fourteen people including their commander (Capt. Einar Sverdrup, brother of the great meteorologist and oceanographer, Harald Sverdrup) was killed and their radio destroyed. The surviving force established a garrison with about 80 soldiers in Barentsburg. They hunted the German weather men as the Luftwaffe hunted them. The German weather station 'Knospe' in the Krossfjord was discovered, and a German soldier was shot there. A German submarine, which came to pick up the crew of the weather station, attacked the Norwegian camp in the Krossfjord. This attack also cost the life of one Norwegian. The Allies landed more supplies in June but could not locate the German weather party. On 15 July they returned in battalion strength with two cruisers and four destroyers. The Germans spotted them and were evacuated, leaving an automated weather station behind them. Later that year, the Germans again established a weather station in the Krossfjord on the same site (station 'Nussbaum').

![Map of Spitzbergen](http://www.spitzbergen.de/HTML-Dateien/Spitsbergen_E/E_Svalbard_Karte.htm#Svalbard) for a map of Spitzbergen which is clickable for further detail

In September 1943 the Germans used their otherwise inactive capital ships to spearhead 'Operation Zitronella' (also known as Operation Sizilien) an amphibious raid on Spitzbergen. (7 September 1943) *Tirpitz*, *Scharnhorst* and 9 destroyers (five Narvik class destroyers: Z27, Z29, Z30, Z31, Z33, and *Erich Steinbrinck, Karl Galster, Theodor Riedel, Hans Lody*). Barentsburg and Longyearbyen were shelled. Resistance was quickly overcome and the entire operation was completed in four hours. 608 men of the 349th Infantry Regiment were landed. A total of 9 Norwegian soldiers were killed and 41 were captured including the garrison commander with most of his files intact, but all facilities had been destroyed.

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In spite of this success the Germans had to withdraw again almost immediately. Admiral Donitz knew that the island could not be held in the face of overall Allied maritime supremacy. The task force returned to Norway on 8 September, and the Allies were back on Spitzbergen, with a new weather station and garrison (now in Longyearbyen), one month after that. The Luftwaffe used Zitronella as cover, allowing them to land a team unseen on nearby Hope Island. The trawler Kehdingen also delivered a team to Franz Josef Land on 15 September. The Allies remained ignorant of the German weather station on Hope Island until winter had set in and could not remove them until spring 1944. Just as in Greenland, the meteorologists evacuating Franz Josef Land left a concealed automatic weather station behind them.

Spring eventually comes even in the arctic, and by mid-June 1944, the Allies had again forced the Germans out of Greenland and the U.S. Coast Guard intercepted their replacements. But the "Bassgeiger" group was able to hide an automated station on Greenland before departing, and the meteorologists on Franz Josef Land did the same there. In 1944-45 the Germans had no less than four staffed weather stations in Svalbard. The last German military unit operating anywhere in the world was the station 'Haudegen' on Nordaustland, which was evacuated by the Norwegians in September 1945, very much so to the relief of the Germans”.

Jan Mayen island, half way between Iceland and Spitzbergen was another strategically important place. The first meteorological station was opened in 1921 by the Norwegian Meteorological Institute, who annexed the island in 1922 for Norway. Following the German invasion of Norway the meteorologists evacuated the island, destroying the station as they left.

A British weather station was established on Jan Mayen island in 1940, but a sudden storm destroyed their ship and left them stranded without supplies and they had to be evacuated. Another attempt was made in October, but was foiled by bad weather. They returned with military support in March 1941 and rebuilt the station. It was attacked in April but not damaged. There is no explicit evidence that the Germans had a weather station there but on 7 August 1942 a German Focke-Wulf Fw 200 "Condor", probably on a mission to bomb the station, smashed into the nearby mountainside of Danielsenkrateret in fog, killing all 9 crew members (in 1950, the wreck of another German plane with 4 crew members was discovered on the southwest side of the island). In 1943, the Americans established a radio direction finding station on the island. They also had ships equipped with RDF for triangulation so that they could locate German radio transmissions from Greenland”.

As the Allies continued to neutralise the manned stations the Germans had to put more reliance on the automated stations. These were deficient in that they couldn't report "ballistic" (high altitude) winds - a vital kind of data for air strike (and air defence) planners. Moreover, Germany's weather planes could not reach Greenland's northeastern corner. Berlin therefore exercised its only remaining option, and dispatched a weather ship into those waters. The icebreaker Wuppertal was chosen, and she left Tromsø in August 1944, with a 12-man weather party on board. The ship moved west of Spitzbergen in September, sending twice-daily reports as it passed by. A U-boat then landed yet another party on northeastern


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Spitzbergen, giving Germany its best observations from the region since 1940, and probably contributed to the reports which warned of severe Arctic weather about to envelop northern Europe, the cover for the Ardennes Offensive (16/12/1944 - 30/1/1945).

The operation ended in tragedy for the Wuppertal and her crew; they were operating too far north too late in the year. The ship became ice bound 120 nautical miles south of the North Pole during the first week of October. Its weather reports ceased a month later, and neither the ship or the crew have ever been found.

The loss of the Wuppertal left Germany with only one manned weather station active - Group Haudegen (another naval unit) on Spitzbergen's northeast coast. This forced Berlin to rely more and more on the inadequate remote stations. The last version consisted of submerged buoys laid by U-boats. The buoys surfaced twice each day to record data and transmit for about an hour before re-submerging again. Advertised to have a nine-month life, those buoys were testimony to the technological prowess of the Germans; several were still operating in 1946.


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Foynes returns to prominence
From 1940 onwards the air routes back to Britain were fairly limited. Although a long-distance flight over Europe in a fast aircraft might have been possible, the transport of dignitaries, politicians and top-brass from Egypt and further east would not have taken this option. Nor could they have chanced it over Vichy France with a wing and a prayer over German occupied France. Genl. Franco was not going to permit over-stopping in a Spain which was sympathetic to the Nazi cause. Before the war Imperial Airways were operating a fleet of flying-boats and the obvious first stop in Europe was Gibraltar, which was firmly in British hands. From there it was a short hop to Lisbon, but an inspection of the map below shows that even if the Spanish coast was skirted as far as Vigo a direct onward flight to UK would have been fraught with danger. It would have been picked up on German radar and long-distance interceptors scrambled.

So the only possibility was to take the maximum broad arc into the Atlantic that fuel limitations and weather conditions would permit. Of course if you were Churchill you might have Jack Kelly-Rogers fly you on your own and land at Castle Archdale on Lough Erne. It was not politically expedient for him to land at Foynes, although many others including Anthony Eden did. Once landed that did not prevent Churchill crossing the border incognito. His first cousins, the Leslies lived at Glasslough in Co. Monaghan and Monaghan town itself was pretty much aware every time he was there. For everybody else it was an evening take-off from Lisbon with a dawn landing for refuelling (and Irish coffee) at Foynes before continuing to Poole near Southampton. For trans-Atlantic flights which assumed an even
greater importance after the United States entered the war, Botwood in Newfoundland was only available in the summer when the Bay of Exploits was not frozen over. At other times the east-bound route from New York was via Bermuda, and Lisbon, while the westbound journey (taking advantage of the north-east trade wind belt) went via Lisbon, Bathurst and the West Indies. So important was Foynes to the Allies and so great the threat from German ships such as the Bismarck, Scharnhorst, Tirpitz etc that the Irish Free-State Government was persuaded to have a defensive position constructed at Ardmore Point on the lower reaches of the Shannon in late 1942. This had a commanding view of the narrow channel between the Co. Limerick coast and Scattery Island which straddles the estuary. Churchill donated two six-inch guns and a large quantity of ammunition for each. Fort Shannon, as the installation was called was sufficiently complex that it is unlikely that it could have planned without expert design assistance from the Royal Engineers, but direct evidence of this co-operation has yet to be found.

In 1985, I had my discussions with Con. Gillman concerning his time at Foynes during the war. My line of questioning arose out of interviews I had had with retired telegraph staff during a Royal Society funded visit to Newfoundland and mainland Canada earlier that year. Most of these people had been on the Azores before and during the war. I happened to mention to Con. about an Imperial Communications Co. telegraph operator named Quintrell who I was told had returned to UK in 1939 and had subsequently operated as a communications security officer in Ireland using the rank of Major. It turned out that Con. had known the man and explained that he and a Col. Knaggs travelled through Ireland monitoring the security of key communication installations on behalf of the British government. He went on to explain that Foynes transmitted meteorological information just before any scheduled take-off from Lisbon. This was output as numbers and enciphered before transmission. Initially it was a fairly crude matter, but this practice was significantly strengthened after the United States entered the war in 1941. From that point on a new cipher key was used every day. Although, according to Con, the cipher-room was under military guard by the Irish army, with a lieutenant in charge, it was subject to British inspection. The coding staff were hand-picked and had to pass through both civilian and military checks on entry. The civilian coding clerks were locked in and although they had an alarm bell close at hand, there was much concern about what might happen in the event of fire. There was also a military guard inside who had an alarm with which he could call for assistance in the event of any trouble. Con. recounted a visit by Major Quintrell to the cipher room at Foynes. The soldier in the ante-room was quizzed on the procedures which were to be used in the event of an unauthorised incursion. There was a bell-push.

"Have you ever used it?" asked Quintrell.
"Yes sir, once sir" replied the guard.
"By Jove, when?" asked Quintrell, suspecting a cover-up.
"It was a test sir" was the response

I was particularly curious, as this level of provision did not seem to be consistent with the actions of a neutral state. My father, as a retired Irish Army officer was able to arrange a meeting with Lieut. Genl. Michael J. Costello, who had been OC Southern Command during that period and therefore would have been responsible for such a detail. Costello adamantly disputed the contention that there had been any military involvement inside the base at Foynes. His final words on the subject were "The (Irish Army) guard at Foynes was at Mount Trenchard House (i.e. outside the base). In this he may have been strictly correct, but to him this had nothing to do with any infringement of Irish neutrality. Subsequent

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inspection of Irish Army Archives reveal that there was a sizeable detachment at Foynes and the order for the guarding of the base had in fact been signed by Costello himself! He was obviously fully aware of the extent to which the Free State was not neutral, but was prepared to carry this knowledge to the grave.

The Germans landed many spies in Ireland during the war and without exception they were captured and interned, but that is another story. At least two of those landed were set up to provide weather reports. One of these was an Irishman named Lenihan who crossed the border into Northern Ireland, contacted the police there and explained that he had been instructed to establish a weather station in Sligo, which is not too far from Belmullet, a place that was to feature prominently in 1944.

The Irish Government itself operated a very strict censorship regime covering both press and radio broadcasts. Sports commentators were prohibited from making any remarks about the state of the football pitch, race course or otherwise in case such information might be of use to the Germans.

Hubert Lamb, who was by then in charge at Foynes, obtained in-flight experience when he flew to America in 1942 to attend meetings in Toronto and New York on the trans-Atlantic air service. The westbound flight from Foynes to Botwood took about fifteen hours, as was normal at that time. He was impressed by the well-appointed accommodation on board . . . "Each passenger also had a bunk aft to sleep in." Lamb, however, did not sleep as he took the opportunity to observe, from the air, cloud formations and their development over the sea, the sort of experience that would serve him well in a later career.

**Two meteorological views of the 'Channel Dash'**

The November 1978 issue of the *Meteorological Magazine* (pp 321 - 338) contains a remarkable account of a remarkable event which clearly demonstrates the effects which the Weather War had on both sides. The two battleships *Scharnhorst* and *Gniesenau* as well as the large cruiser *Prinz Eugen* had been holed up in French harbours since 1941. Since November 1941 the RAF had mounted no less than 25 bombing raids on these targets and getting these ships back to Germany became a priority. However, the question was, which way to go? The long-way round would leave them exposed to the Royal Navy which had already destroyed *Bismarck*. The short route involved a passage through the Straits of Dover where they would be a target for UK shore-based guns. The British knew that something was being planned and redoubled their efforts to mine the waters of the southern North Sea. The Germans meanwhile were planning a massive air defence and Luftwaffe units were recalled from the east to support *Operation DonnerKeil*. The article in the Meteorological Magazine is a translation and transcription of the notes of Dr. Walther Stöbe, Chief Meteorological Officer of Air Fleet 3 who was based in Paris. He was charged with making the critical go-no go forecast for the operation. A Luftwaffe meteorologist was making the critical forecast because air cover by the Luftwaffe was considered vital to the success of the operation. To maintain air superiority meant being able to get sufficient aircraft into the air for the required period of the passage. While the Luftwaffe planned to have bombers, to attack British surface ships, it was the fighter cover to ward off RAF fighters that was deemed crucial. The Luftwaffe requirements were that the weather over southeast England should be such as to prevent or hinder British air operations (e.g. low cloud, overcast or fog), but the same weather should provide ideal takeoff and landing conditions over German airfields in France,
Belgium and the Netherlands. However under no circumstances would it be acceptable to have the reverse and allow British aircraft to operate unhindered against the ships.

The Navy also had its own requirements - no fog so that the ships could use their maximum speeds, low sea state so that the German torpedo boats could operate effectively in protecting the ships' flanks, a following wind would help, and finally the sortie would have to take place under maximum duration of darkness which meant in conjunction with a new moon. This would occur during 11 - 17 February. After February, nights would be too short.

Stöbe received his task on 4 February 1942 and started a series of forecasts beginning 5 February through 14 February. At first he refused to make the forecasts citing the "scientific impossibility." Only after the Chief of Staff reassured him that they were not "nailing the Weather Service down" did he reluctantly commence his series of forecasts. Stöbe eschewed climatology noting "What good was it to know, for instance, that in February the frequency of weather type 7 . . . was 54 per cent . . . The actual weather can never be approached through such statistical means and frequencies . . . "

Strict security requirements hindered Stöbe's task, he noted that "..few discerning military officers realized during the course of the war that the meteorologist, who in all the important decisions in a modern war may be able to turn the scales, can never correctly prepare his forecast if he is not informed of the tactical plan in time." Because of the strict security requirements, he was unable to use the long-range forecasting expertise of the Central Weather Group at Luftwaffe Headquarters in Berlin. This did not greatly disturb him in that he found their routine monthly forecast too general for his exacting task. Because of the joint nature of the operation, he coordinated his forecasts with Dr. Süssenberger, Chief Meteorologist of Naval Group (West) describing the relationship as "..exemplary in very way, which, from the military viewpoint could not always be said of the Air Force and Navy."

On 6 February, based on the current situation, Stöbe predicted that after the 10th a zone of bad-weather would be expected in southern England, but he acknowledged that critical observations would be needed to confirm that the synoptic situation remained in place. Few observations, mainly signal intercepts, were available from the British Isles. The Navy also realized the criticality of the weather forecasts and placed meteorologists aboard the Gneisenau and assigned three of Germany's strategic U-boat assets near Iceland as weather observing stations. Based on the U-boat observations of 9 February, Stöbe identified a developing disturbance which moved unhindered to Jutland. This indicated to Stöbe that small disturbances would continue to move through the area of operations bringing with them the changeable weather situations needed, but more importantly in a predictable sequence ("..expected to show certain constant elements of development and sequence."). The Luftwaffe undertook weather reconnaissance in the North Sea to augment the U-boats' reports.

There were four regular daily flights
   (1) From Stavanger westward to longitude 12ºW
   (2) From Wilhelmshaven almost to the Shetland islands
   (3) From Paris into St George's Channel and the Irish Sea

* these comments have a particular resonance, when viewed in the context of the 'forecasting for D-Day controversy' which will be discussed later

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(4) From Brest north-westwards to central Ireland
On 10 February Stöbe briefed the impending favourable weather conditions to Admiral Saalwachter, Commander, Naval Group (West); Vice-Admiral Ciliax, commander of the operation for the navy (and a former commanding officer of Scharnhorst); and Fieldmarshall Sperre, Commander, Air Fleet 3 and his subordinate Colonel Adolph Galland who commanded the all-important fighters. Galland wryly observed: "Now the weather god had to be consulted, for he played an important if not decisive part." Admiral Saalwachter scheduled the go-no/go brief for mid-day on the 11th. Early on the 11th, the U-boats reported westerly gales and falling pressures indicating the development of another disturbance. Based on the scenario of the previous disturbance noted on the 9th, Stöbe provided his forecast for 12 February:

"A low pressure disturbance has formed in the region south of Iceland. Strong winds and falling pressure in the area north of Scotland suggest that in all probability this depression will move south with a speed of 50 km/h and on 12 February between 0800 and 1000 hours will lie in the region of the eastern exit from the Channel and then will move further south."

In the first hours of the forenoon the weather would deteriorate quickly, while the battle area would again clear up. Conditions over the bases would deteriorate as they improved over the battle area. In the afternoon the bases would again have favourable weather. Based upon Stöbe's forecast, Admiral Saalwachter gave the order for the operation to proceed.

abstracted from http://www.datasync.com/~bouchard/rich/channel_dash.htm#N_8_

Suffice to say that the operation was an outstanding success and a tribute to the efforts of Stöbe and his colleagues. However, the other fascinating aspect of the article in the Meteorological Magazine is the fact that the editors included side-by-side copies of British and German synoptic charts for each day from 5 to 14 February 1942. Those for 12 and 13 February are shown above and indicate quite clearly the blind-spots in the data on both sides. Sadly Dr Stöbe did not live to see the publication of this article; he died in 1971.
Weather ships and the Enigma cipher
The writer Simon Sebag-Montefiore ("Enigma: the Battle for the Code", Weidenfeld & Nicholson, London, 2000) added to the growing knowledge on this subject by revealing that Harry Hinsley, the great historian of British Intelligence during the second world war had in fact identified the German weather ships as the 'Achilles heel' of the German communications system. He hypothesised that although weather information was transmitted by them in Meteo cipher they must receive their instructions via naval Enigma machines. They were unarmed and with luck they could be taken by surprise with their encryption machine intact. On 7 May 1941 the Navy dispatched a not insignificant fleet to intercept the München which was operating north west of Iceland. The keys for May and the machine itself was thrown overboard but they managed to get a complete set of keys for June as well as the 'short-weather cipher' (Wetterkurzschlüssel). This allowed weather reports from U-boats to be deciphered. U-110 was forced to surface in a depth-charge attack off the west coast of Ireland on May 9, 1941 and was boarded by a crew of the destroyer HMS Bulldog; the booty included besides another ENIGMA machine a golden treasury of rules for its operation. The result was exactly as expected. The machine together with the instructions for its settings were available to the experts at Bletchley Park. It was deemed necessary for the construction of decrypt tables to mount an identical operation in order to determine how the setting changed at the turn of the month. On 28 June the Lauenburg, operating north of Iceland was captured, its vital contents (a complete set of keys for July) were removed and it was then sunk. In August 1941 U-570 was captured almost intact off the coast of Iceland. The box for the ENIGMA machine was empty, but there was a slot for a fourth rotor. That was confirmation of what they already suspected from references to the 4-rotor ENIGMA in manuals that had been captured, that the introduction of this version was imminent. The seizing of U-559 on October 30, 1942 meant that subsequent weather reports compromised the security of the new 4-rotor ENIGMA machines so that the intelligence blackout which was caused by this new rotor was completely overcome during the next two months.

All the while the Germans remained ignorant of the true purpose of these operations on the München and Lauenburg, but there was a price to be paid. Up to this point there seems to have been a sort of 'gentleman's agreement' as the British also operated two unarmed weather ships in the Atlantic under the codename 'The Panthers'. Although the Arakaka and Toronto City were ideal U-boat targets, they had been unmolested up to this point. However, on 22 June Arakaka was torpedoed by U77 in position 47° 00' N, 41°40' W and following the attack on the Lauenburg, Toronto City was sunk in approximate position 46°N, 30°26' W on 1 July. There were no survivors and amongst those lost was Stanley Proud who had been one of the original seconded staff at Foynes. The Panthers were not replaced, but maybe by that time the Allies were already winning the Weather War
The cracking of weather ciphers
There is an extraordinary amount of information about this subject on the World Wide Web, but much of it is scattered and un-correlated. In the presentation below it is proposed to present three virtual transcriptions which give separate views of these events, often covering the same subjects, but from different sides. In the case of the British and American documents which are cited here we have personal recollections, while the German viewpoint is presented with the benefit of hindsight. The cited sections are given in sans-serif font.

American view*
Paul Pfeiffer worked for a firm of real estate lawyers and was approached by a client who had been a WWI Signals Corps Officer who invited him to join the Signals Corps Cryptological School. He joined up in February '42. He was assigned to the weather section who were readily solving Italian and Vichy ciphers but were having difficulty with German ciphers. Earlier in '42 they had had a visit from "George Cunliffe McVittie, (known as Mac), professor of astronomy and mathematics at Kings College, London. who was founder and Head of the Meteorological Centre at Bletchley Park and was generally concerned with obtaining continuous information about weather conditions over enemy-held territory through broken cipher codes of enemy weather forecasts. He had informed Capt. Edward Wrigley, head of the US section that the Germans were enciphering Spanish/Portuguese clear text weather reports into three separate ciphers (one for their army, one for their navy and one for their air force).

The Germans were also enciphering a few weather reports from occupied France. Bletchley was intercepting both the German enciphered transmissions from DDX Berlin and the Spanish/Portuguese clear text from DAN. The British were using the clear text to crib into the German enciphered weather broadcasts four times daily at 6-hour intervals, usually intercepted about one hour after the clear text transmissions. Wrigley had wisely persuaded McVittie to arrange for radio transmission of both the clear text and German enciphered British intercepts to the Pentagon for pick-up by his section. The British enciphered their transmissions with onetime pads so that the total process from interception to receipt, decipherment and transportation to Arlington Hall consumed an average of three days, much too long to be of operational value. Captain Wrigley's group was using the material primarily for training purposes, operating in three shifts of 8 hours each. Sergeants Richard Friendlich, Edwin Marton and George Northern were the enlisted men most advanced in solving the German ciphers.

The solution of the German weather ciphers depended heavily upon an understanding of the International Meteorological Code (I. M. C.) clear text utilized by all nations prior to World War II. The I. M. C. consisted of 25 digits arranged in 5 equal groups of 5 numbers each.

The first group commenced with a three digit station indicator. The fourth digit represented C1, the form of low cloud, ranging from 0 (no low clouds) to 9 (heavy or swelling cumulus or cumulonimbus and low ragged clouds of bad weather). The fifth digit represented Cm, the form of middle clouds ranging from 0 (no middle clouds) to 9 (alto cumulus in several sheets at different levels, generally associated with thick fibrous cloud veils and a chaotic appearance of the sky).

The second five number group started with two digits, called WW, for present weather, ranging from 00 (cloudless), 01 (partly cloudy), 02 (cloudy), 03 (overcast), to 19 (signs of tropical storm or hurricane). The third digit, V, represented horizontal visibility in miles and ranged from 0 (visible at 55 yards) to 9 (30 miles). The fourth digit, H, height of lower clouds, ranged from 0 (0 to 163 feet) to 9 (above 8,202 feet). The fifth digit, N, represented the total amount of sky covered with clouds and ranged from 0 (absolutely no clouds) to 9 (sky obscured by fog, dust storm, or other phenomena).

* "Breaking the German weather ciphers in the Mediterranean detachment G, 849th signal intelligence service"
Paul N. Pfeiffer Cryptologia Oct 1998

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In the third group, the first two digits, DD, represented surface wind direction: 00 (no wind direction), 02 (north/northeast), 06 (east/northeast), 08 (east), 10 (east/southeast), 12 (southeast), 14 (south/southeast), 16 (south), 24 (west), 32 (north). The third digit, F, represented the force of wind on the Beaufort Scale, 0 (calm) to 9 (hurricane), 7 representing high wind, 8 gale. The fourth digit, W, represented weather during the six hours preceding the observation, again ranging from 0 (clear or scattered clouds) to 9 (thunderstorms). The fifth digit, N, represented the total amount of sky covered with clouds at the time of observation measured in tenths. 0 represented no clouds, 5 equaled 7 or 8 tenths coverage, 8 completely overcast, and 9 overcast with fog, dust storm or other phenomena. The fourth group began with PPP (atmospheric pressure reduced to sea level) and continued with TT (temperature). This group was of minor significance in forecasting for the selection of desirable bombing targets.

The final five-digit group was occasionally used to report upper air wind observations at 5,000 foot increments called PIBALS (Pilot Balloon Observations). This group was extremely important in forecasting wind direction and force over targets at altitudes not subject to accurate enemy flak fire. Thus, wind force F could vary from 4 (moderate breeze) at 5,000 feet to 7 (high wind) at 20,000 feet. Wind force and direction data were also vital to the scheduling of rendezvous locations for the fighter escort and bombing groups converging on the targets.

The internal structure of the I. M. C. was a factor in facilitating cryptanalysis. The methodical German code clerks listed their station observations almost invariably in the same sequence so that the first three digits in the first group of each synoptic report could be identified fairly speedily. The height of the PIBALS in the fifth group in standard 5,000 foot increments (5,000, 10,000, 15,000, 20,000, 25,000) provided an additional breakthrough into the German ciphers. Moreover, if WW in the second group proved to be 00 (clear), then V, the third digit, would likely be 6 or higher and the form of the low and middle clouds (Cl, Cm) reported in the fourth and fifth digits of the first group would likely be 00. The height of lower and middle clouds reported in the fourth and fifth digits of the second group would likely also be 00.

The German method of encipherment comprised two separate steps. First, the five digit I. M. C. groups were each stretched to six digits to accommodate two trigrams. Thus, for example, station indicator, present weather, 44000, could become either 441900, 442800, 443700, 444600, or 445500. Second, trigrams from the German enciphering tables were then substituted for the clear text equivalents.

Timely cryptanalysis of the broadcasts for operational purposes would have been extremely difficult had it not been for the fact that the Germans were utilizing separate trigram tables for their Army, Air Force and Navy weather transmissions every six hours. Moreover, usually after 30 days usage, the cipher tables of only one service were changed, leaving the other two cipher systems, which the Detachment had solved, still in effect. This practice facilitated cribbing the decodes of the unchanged tables into the new tables.

*************

I was detailed to Casablanca, ultimately to join the 849th Signal Intelligence Service encamped at Haman Melouane, about 15 miles south of Algiers.

Wrigley was on leave so there was no opportunity to confer with him regarding what, if anything, he wanted me to accomplish in North Africa for the benefit of the Section. We had recently become aware that some US radio intelligence company in North Africa was intercepting the German weather traffic for relay to the Pentagon, supplanting the previous service from Bletchley Park. Consequently, the day before I was scheduled to begin the process of overseas deployment, I visited the Section and suggested to the lieutenant in charge that I might copy the critical keys to the German cipher decryption for possible use in the Mediterranean Theater of Operations. He replied, "We never had this conversation," and left the room. I approached the Top Secret file cabinet and made copious notes of the pertinent methodology, put them in my breast pocket and departed, praying that I wouldn't be captured by a German submarine crew en route to Casablanca.

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In early May, together with nine other officers with no weather cryptanalysis experience, I shipped out of Hoboken, New Jersey, in style aboard the Santa Rosa, a converted Grace Line passenger ship, as part of a large convoy of Liberty ships escorted by destroyers. One night, as we were approaching the Azores, a Spanish merchant ship, lights ablaze, sailed through the middle of the convoy. The next evening near sunset we were attacked by German subs. Our escorts dropped their depth charges, the subs disappeared, and my Top Secret notes remained unharmed and unseen.

Upon arrival at Haman Melouane the ten officer group reported to Major Richard J. Doney, chief of the Intelligence Branch of the 849th Signal Intelligence Service. We were informed that no assignments were awaiting for us and there would be an indefinite delay while Doney and the commanding officer, Lieutenant Colonel Millard E. Rada, decided what use could be made of each of us.

With the information copied from the Arlington Hall weather section, I endeavored to persuade Doney that if we could arrange the transfer of Sergeants Friendlich, Northern and Marton from Wrigley's section, the nucleus of a unit could be organized to break the German weather codes on the spot utilizing the 122nd Signal Radio Intelligence Company then located in Constantine, east of Haman Melouane. Two radio sets of the 122nd were concentrating on German stations DAN and DDX, Berlin, which were regularly broadcasting the weather traffic. It was clear to me that we had the potential of providing a useful service to the Allied Air Forces in the Mediterranean Theater of Operations and I did my best to persuade Doney to begin the process of forming such a unit.

He decided that the matter needed to be cleared with the chief signal officer, Colonel Harold G. Hayes at Allied Forces headquarters in Algiers, so I began preparing a memorandum setting forth the method of decryption. When Doney and I reported to Hayes, he proposed to contact the Chief Weather Officer of the United States Air Forces in North Africa, Lieutenant Colonel Joseph A. Miller, Jr., also stationed in Algiers, to determine if the Mediterranean Allied Air Forces could use such a service. We heard nothing for three weeks. Finally, Doney and I met with Miller, who explained vehemently that he was totally dependent upon McCuttie's decodes radioed in British cipher from Bletchley. The service was unreliable because the British frequently failed to provide the one-time pads necessary to break their transmissions in time for operational forecasting. "They are treating us like colonies!" exclaimed Miller. He was obviously delighted at the possibility of having a comparable U. S. unit at his service.

******************************

Detachment G offices were established in the 12th Air Force headquarters building in the city below, next to the weather station charged with forecasting for the selection of bombing targets in northern Italy and southern Germany. The station was under the command of Major Lauren, who together with his first assistant, Captain Swanson, plotted the synoptic reports on the four daily maps, drew the connecting isobars and prepared the written forecasts for distribution to the lower echelon weather stations. They were delighted to have Detachment G on hand to furnish solved weather reports from all of German-occupied Europe on a regular basis, which they had lacked while totally dependent on the unreliable British transmissions from Bletchley Park.

The unit quickly discovered that the Germans had ceased enciphering weather reports from Occupied France and that the Italian encipherments, also studied at Arlington Hall, were gradually disappearing with the retreat of the Italian army. Fortunately, intercepts from the German station XBU at midnight were found to include Rumanian and Hungarian enciphered synoptic reports that were easily decoded by sliding cellophane strips of International Meteorological Code clear text alongside the transmissions. These decodes furnished additional crib material for breaking the DDX and DAN enciphered German broadcasts covering synoptic reports from Norway to southeast Europe.

Progress in breaking the German transmissions was slow at first. It was obvious that we needed some IBM equipment to speed up trigram frequency counting. Also, considerably more manpower was required in order to furnish the number of synoptic reports needed to fill the four daily weather maps used for forecasting. Consequently, a request was made through channels for IBM machinery and additional cryptographic enlisted men trained in cryptanalysis techniques. At my request, Lauren temporarily assigned one of his staff, Sergeant Tom Burrage, to Detachment G to regularly construct weather maps in-house from the decodes as they became available so that their accuracy could be readily checked before sending them on to the forecasters. The results were encouraging. Moreover,
as we observed the progress of the weather patterns from northwest to southeast Europe on successive maps, we were able to predict the flow of the frontal systems to some degree, substantially assisting the decryption process. As the volume of decryptions began to increase, it was decided to transmit them by teleprinter (TWX) to all the Allied weather stations operating in the Mediterranean Theater of Operations, using the 12th and 15th Air Force land lines. Personnel from the 122nd Signal Radio Intelligence Company were assigned to perform the transmissions using scrambler tapes to guard against possible interception by electronic induction by the German or Vichy French spies then believed to be operating in North Africa.

After arriving in Foggia, the scrambling of the TWX transmission of the solutions ceased. The Air Force weather station operators had experienced some difficulty in setting the scrambler tapes so that many transmissions had been unduly delayed. Security was no longer considered a serious problem. Continuing interrogation of POWs who had worked in the German weather service revealed no compromise of Detachment G activities. It was reported that one POW, interrogated in Naples, confidently asserted that his commander had emphatically stated that the system of trigram tables was impossible to break. Consequently, it was decided to transmit the deciphered synoptic reports over the TWX lines in clear. Reliability was improved and no security problems resulted.

In January 1945, Detachment G transmitted 14,813 lines of deciphered German weather reports to Mediterranean Allied Air Force weather stations. In February 1945, the decodes totaled 11,325. Also in January 1945, Sergeant Frank Onstine, who in civilian life had been an actuary with the Metropolitan Life Insurance Company, reported his belief that intercepts from German station DAN indicated that the Germans were repeating trigram tables previously used and solved by Detachment G. Onstine theorized that the Germans had been unable to regularly produce new trigram tables randomly so that the latest intercepts had to be based upon tables previously used. Onstine developed a highly sophisticated system involving “parent” and “grandparent” trigram tables that enabled him to identify used tables when repeated. Upon verifying his conclusion, the unit changed over to a simple decoding procedure utilizing the trigram tables previously broken. This operation continued for about three to four weeks during which much needed leave was granted. Onstine was subsequently awarded the Legion of Merit by the 849th C. O., Lieutenant Colonel Millard E. Rada, in a combined ceremomial formation of Detachment G and the 122nd. The results of Onstine’s valuable insight and indefatigable efforts in matching the current with the used tables were shared with McVittie at Bletchley Park on a visit by Lieutenant Lester Block. According to Block, McVittie was astonished to learn of this phenomenon and quickly took advantage of it in the Bletchley operations.
British view
One of the appendices in Audric's article gives a summary of the IMC referred to above

Before World War II, an International Conference had designed a code for the exchange of weather reports between all countries. The information was contained in groups of five figures and could be sent by radio or telegraph . . . . In peacetime, weather information was available to every country, but upon the outbreak of World War II the belligerents immediately enciphered their WT reports. Whilst several neutral countries continued to send en clair, others such as Sweden and Switzerland did not. Those countries that could send their reports internally by telex, such as the United Kingdom, did so without enciphering them, but Russia, covering such a vast area, had to use WT, and as it was at war with Finland and had a non-aggression pact with Germany it encoded all its observations.

International Meteorological Code for Synoptic Observations

The meaning of the letters are as follows:-

<table>
<thead>
<tr>
<th>III</th>
<th>identification number of station</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>form of low cloud</td>
</tr>
<tr>
<td>CM</td>
<td>form of medium cloud</td>
</tr>
<tr>
<td>ww</td>
<td>weather at time of observation</td>
</tr>
<tr>
<td>V</td>
<td>Visibility</td>
</tr>
<tr>
<td>h</td>
<td>height of base of cloud</td>
</tr>
<tr>
<td>Nh</td>
<td>amount of cloud of which the height is reported by h</td>
</tr>
<tr>
<td>DD</td>
<td>wind direction</td>
</tr>
<tr>
<td>F</td>
<td>force of wind</td>
</tr>
<tr>
<td>W</td>
<td>past weather</td>
</tr>
<tr>
<td>PPP</td>
<td>total amount of cloud</td>
</tr>
<tr>
<td>TT</td>
<td>pressure in millibars and tenths, initial 9 or 10 omitted</td>
</tr>
<tr>
<td>T</td>
<td>temperature in degrees Fahrenheit (UK) Celsius (Europe)</td>
</tr>
<tr>
<td>U</td>
<td>relative humidity</td>
</tr>
<tr>
<td>Ch</td>
<td>form of high cloud</td>
</tr>
<tr>
<td>a</td>
<td>Characteristic of pressure change in last three hours</td>
</tr>
<tr>
<td>pp</td>
<td>amount of tendency in fifths of millibars</td>
</tr>
<tr>
<td>RR</td>
<td>rainfall in millimetres at 0700 for preceding 13 hours and at 1800 for preceding11 hours</td>
</tr>
<tr>
<td>TTx</td>
<td>maximum temperature at 1800</td>
</tr>
<tr>
<td>TnTn</td>
<td>minimum temperature at 0700 given in place of TTx</td>
</tr>
<tr>
<td>E</td>
<td>state of ground</td>
</tr>
</tbody>
</table>

Synoptic observations were made at the same time all over the world and the times of major observations were at 0100, 0700, 1300 and 1800. The times of minor observations were 0400, 1000, 1600 and 2200.

Every observation comprised the first five groups of the six shown above; the sixth group was reported only at 0700 and 1800. All times were GMT.

* "The Meteorological Office Dunstable and the IDA Unit In World War II" Brian Audric
(www.rmets.org/pdf/hist02.pdf)

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Audric's memories of the time are as follows:

**The IDA unit**
I arrived at the Central Forecast Office, Dunstable, on 1 April 1940.

At 0900 on 2 April, I was introduced to Philip Howse from Bletchley Park. Howse explained that we were to be members of a new unit called IDA and we were to decode Russian weather reports which would be intercepted by the WT section.

In April 1940, the British forecaster's European weather chart had blank areas over Germany, Austria, Finland, Russia and the eastern Baltic. As shipping in the Western Approaches now kept radio silence, the only reports available were from the Azores, Iceland and Greenland. Although many weather systems move from west to east over the British Isles, not enough accurate information was available over Germany to prepare good forecasts for Bomber Command operations. By mid-summer 1940, after most of Europe had been overrun by Germany and Italy, the European chart contained only Portugal and Spain.

From the outbreak of War, Station X at Bletchley Park had been at work breaking the German and Russian weather codes and had achieved considerable success. Their decoded material was sent to Dunstable by telex and re-issued to a restricted clientele (such as RAF Commands and selected RAF stations) under the heading MANX. Instructions were given to all meteorological stations that any MANX information arriving accidentally at unauthorised stations must be immediately destroyed by burning.

Having been shown by Howse how to decode the Russian transmissions, we practised the art for the next three days. On Friday 5 April, we went on to a 24-hour roster of three shifts, 0800-1500, 1500-2200 and 2200-0800. It required four bodies to cover the shifts and rest days; the fifth one did a normal day 0900-1700 or covered for those on leave or sick.

The reports from the European area of Russia were the most useful to our forecasters. However, there was another section of the broadcasts which we could not decode and this was sent immediately to Station X by telex. Headed KWADRAT, this portion was in a more sophisticated cipher which changed every six hours and contained a selection of Russian station reports intended for Germany. An hour or so later, the Germans sent a similar message to Russia in the same code which contained a selection of German station reports. Thus, our Russian decodes were used to break KWADRAT and provided us with a useful selection of German stations to be sent out on MANX.

The IDA Unit took over all the routine decoding, whilst the staff at Station X, under Dr McVittie, continued to provide the keys to decoding and keep them up to date. As the work increased, so did the staff.

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When the day-to-day decoding was transferred from Station X to the IDA Unit, a new and much more interesting phase of our work commenced and we became responsible for supplying weather information for most of Europe to our forecasters and the MANX recipients. The main source was the German collective transmission broadcast on the call sign DDX, which included a comprehensive collection of German weather stations followed by a good selection of reports from the conquered countries and the Eastern European states that had allied with Germany. The interchange of information between Russia and Germany via Kwadrat (see above) continued until the German invasion of Russia. I was on night shift when the invasion started and the Russian Kwadrat arrived. This was decoded as usual by Station X, but when the German Kwadrat was decoded it was found to be rubbish.

**The Russian code**
The Russian code was quite simple. One figure in each group of five was replaced by another, and a second figure dependent on the first one was subtracted from the remaining four figures in the group. This sounds complicated, but, as the example will show, it was an easy system to learn and we could decode almost as quickly as reading the numbers. Here is an example: -

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The key

<table>
<thead>
<tr>
<th>(a)</th>
<th>(b)</th>
<th>(c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td>7</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

The coded message as received: 99369 21553 09895 39875 56167. Replace each underlined figure as shown in column (a) by the corresponding figure in column (b), thus (we have): 99365 01553 39895 19875 86167. Now take the figure in column (c) corresponding to the original figure in column (a) and subtract it from each of the remaining four figures in each group: The decode is 88255 02664 32128 14320 80501.

The German code

Station X supplied us with printed code sheets on thin cards. The cards had ten vertical columns, each of 100 groups. The first read downwards 000, 001, 002 etc. to 098, 099, while the second column read 100, 101, 102 etc. to 199 and so on until the last which read 900; 901, 902 etc. to 999. Against each of these numbers was written a random three figure group. This was sheet A, and sheet B was the reverse of A. Thus, if 921 printed on sheet A read 436, then 436 printed on sheet B read 921. The sheets that we received were by no means complete, but Station X sent us additions to the sheets daily and the amount of information steadily increased.

An example of a DDX decode: 92120 43326 95449 70762 39042. Message as received, coded on sheet A: 921/20 4/332/6 95/449/ 707/62 3/904/2. Divided into 3-figure groups. Exchange each 3-figure group above by its replacement from sheet B. The single figure at the end of the fifth group was exchanged for another taken from a single figure replacement code (similar to the (a) and (b) columns in the Russian Code shown above). A single-figure exchange code was included in each DDX sheet. This single figure exchange was not needed when the rainfall groups were sent at 0700 and 1800.

The decoded weather report: 43650 05628 24328 17620 80103.

There were five or six sets of such sheets in operation at any one time and the set lasted for some weeks. The code sheet was changed at each synoptic hour (see Appendix). After some time, the set of sheets (HEFT) was replaced by another set and usually it was brought back into service at a later date. The codes which ceased to be used on DDX altogether were then used on a similar broadcast, call sign DAN, which I believe was transmitted for the German Navy. By the time the codes reached DAN, they were the most complete versions that we had.

Later on, there was a change in the method of coding and we found that the 5-figure groups had become 6-figure groups. Station X must have had knowledge of a change as they had warned Knighting in advance. The day that the change occurred, the same Heft continued in use and gave the following decode: -

432450 051528 244928 178820 800103

but it did not take long to see that by adding the two centre figures in each group without carrying tens we got: - 43650 05628 24328 17620 80103.

For instance, in 56167 the first digit ‘5’ is underlined. A 5 in column (a) corresponds to 8 in column (b), so we now have 86167. A 5 in column (a) also corresponds to 6 in column (c). So we subtract 6 from 6167, ignoring carries and negative signs. The final result is 80501

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The object of the change was to vary the trigrams which carried the station number (436) and the trigram in the fifth group which often read OxO and which provided a speedy method of finding which code was in use after a change at the synoptic hour. This intention to improve the security of the code made little difference to Station X’s ability to break it and indeed it probably improved their chances. Strangely, DAN still retained the old method using 5-figure groups. The reports sent out by DAN contained many of the reports that had already been sent out on DDX and these were excellent cribs for updating the codes and kindly supplied by the Germans themselves. The Germans looked after their codes, as I never heard that any of them fell into Allied hands.

I never saw any signs that the enemy had any of our UK reports, but there was an occasional report from the London area (station 151-Croydon) which may have come from one of the few spies that are known to have operated in the UK. I did see reports from Greenland on DDX a few times, and I learned after the war that they were probably authentic. There was a small German force which spent some time in NE Greenland operating a weather station until they were captured. Early in the war, some German fishing boats operated in Icelandic and Greenland waters, sending weather reports, but we did not see these on the broadcasts that we decoded. I do not know whether the Germans ever sent encoded weather analyses or forecasts.

The Vichy French code
The Vichy Government transmitted weather reports in its own code for the area that it controlled in France and French North Africa. The code comprised a horizontal and a vertical key, each of 25 figures. The received message was subtracted from the horizontal line 25 figures at a time and then by the vertical figure appropriate to each of the horizontal lines. The keys were changed every six hours. Once we knew the system, it became a diverting form of crossword puzzle to decode the reports (the subtractions were made on the base eleven which added to the fun). The French reports arrived first and we could generally solve the riddle of the keys using them only, but sometimes we would need the North African reports for confirmation. Since we could decode these reports perfectly, they were valuable cribs for breaking DDX.

Just prior to the TORCH landings in North Africa in 1942, there were some negotiations between the Allies and Admiral Darian, the representative of Vichy in North Africa, and copies of the future Vichy codes were sent to England, where they were received by Colonel Gold, the Deputy Director. Gold rang Dunstable to enquire whether the codes were accurate. As some applied to that day, he was pleased to hear from me that they were, but a little miffed when I said that we had no trouble in breaking them. After the TORCH landings, the Germans took over Vichy France, the reports stopped and that particular diversion was over for us.

The Italian codes
When the Italians entered the war in 1940, they commenced sending coded broadcast weather reports. Although I must have deciphered them, I cannot remember anything about them. We received a printed code book from Station X which had been issued to the Italian Navy for coding weather reports from their ships. The Italians never missed the book but we used it rarely as there was very little traffic.

The Hungarian, Romanian and Bulgarian codes
These three countries used the same type of code, which consisted of a string of random numbers from which the incoming data were subtracted. As the number of figures used considerably exceeded the number of figures expected in any one transmission, the starting place had to be found, which did not present much difficulty to us. If the message ‘ran off the end’, we carried on again at the beginning. Each country used a different set of figures and the codes were changed from time to time, though not frequently. Once the code had been established by Station X, the reports were valuable cribs for the German ciphers.

Luftwaffe weather reconnaissance
From the start of World War II, radio messages from Luftwaffe planes were intercepted at RAF Cheadle and at first deciphered at Bletchley. Later, staff were sent from Bletchley to Cheadle and took over the translation of Luftwaffe messages. German long-range reconnaissance aircraft operated at first over the North Sea. Later on, after the occupation of Europe, several routes were flown from

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Norway and France, covering the Western Approaches and North Sea, the North Atlantic towards Iceland and off North Cape, Norway, to Spitzbergen. Weather reports and reconnaissance of shipping movements were sent back.

The weather reports were not based upon any of the International weather codes, and deciphering these messages was not possible until the body of a German airman was washed up on the East Coast of England. In his pocket was a hand-written card which was the airman’s personal copy of the code for enciphering his weather information before transmission to his base. When we received the card at Dunstable, it was quite undamaged and fully legible (a compliment to the makers of the ink). From this time, decoded copies of the reconnaissance reports were sent to us from Cheadle and we could use the weather information. Included in these messages were the shipping reports, and these very often contained depressingly bad news about losses from Allied, especially the Russian, convoys. We had the shipping reports stopped and received only weather reports thereafter.

We received a surprising amount of information from the various flight reports and we had one girl who specialized in the collation and issue of them, as the planes mostly flew by daylight. Miss Fraser worked a permanent day shift.

Later, additional information appeared in the messages which we could not decode. Station X eventually sent us an enlarged code and we discovered that some LuftWaffe flights were making landings at particular places, recording temperature and pressure at increasing heights starting from 50 metres above ground. The RAF had made similar flights in England for several years and continued to do so for years after the War. One of these locations for upper air measurements was over Spitzbergen, and a Focke-Wulfe 200 crashed there. A Norwegian trapper investigated the wreck and sent some of the documents that he found to the authorities in England via the Norwegian resistance and Commando Units from Shetland. Amongst the loot was the key that we needed, and the Upper-Air Unit made good use of the information. It was said that the trapper had fired his hunting rifle at the plane when it was at its lowest point and brought it down by a very lucky shot.

One-Time pads
The Met. Office teleprinter network was connected to all the weather forecasting stations in the United Kingdom and with a direct line to ONM Paris for the exchange of reports between the UK and France. The French connection ceased in 1940 and was not restored until 1944, when France was liberated. It was unnecessary to encipher any of the teleprinter traffic, but some collections of UK reports had to be sent abroad by radio, and the staff in the Communications Room encoded this traffic. They used code books containing numbered pages, each page having five-figure groups of randomly-generated numbers arranged in horizontal lines. The signal, already in the International Code, was subtracted from the page lines and then transmitted. A starting group indicated the page and line to be used by the decoder. Some of these pads may have been used more than once, but for real secrecy no part of such a book was ever used twice. This was the One-Time Pad. IDA sent collections of Manx reports daily to Meteor Almaza, Cairo, using such a One-Time Pad.

Other reports received by the IDA unit
The British Embassies in neutral Sweden and Switzerland sent daily weather reports to the Foreign Office in a diplomatic code, whereupon the Foreign Office sent us the decode and these were issued on MANX.

*****************
Some weather reports came from the Royal Navy via Portishead Radio under the code name PICE.*****************

From the autumn of 1940 until mid-summer 1941, we received weather reports codenamed PANTHER from two ships cruising the North Atlantic, the SS Arakaka and the SS Toronto City. These were the first Weather Ships and we issued their reports on MANX. Tragically, the messages ceased from both ships within ten days of each other and we presumed that they had been sunk as we never heard anything more of them. Recently, their history has been researched and published. The ships were torpedoed by U-boats and lost with all hands.

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General
The amount of information decoded by the IDA Unit varied according to the completeness of the codes that we used. When a new HEFT of DDX codes was introduced we could do nothing with DDX until Station X provided new key sheets. Generally, this took only a few days. During this time, we could still supply some information from other sources. Rarely did all the codes from all the countries involved change at the same time.

Routinely, we decoded everything that we could, then collected all the information for each synoptic hour and sent it to Station X. It was carried by Motor Cycle Dispatch Riders on four regular runs each day, the first at 0800, the last at 2200. Station X used all this material to upgrade the codes, and their updates were sent back to us by each return delivery. On one occasion, when no rider was available, I took the bag myself by taxi. This was my only visit to Bletchley Park and I got no further than the guard lodge.

When the IDA Unit first operated, we plotted our decodes onto a weather chart which was shown to the forecasters. As the amount of information increased, the forecasters’ assistants took over the plotting and all the UK, neutral and enemy reports were plotted on the same charts.

There does not appear to be any published recognition of the work done by Station X on the breaking of the enemy weather codes. The group under Dr McVittie worked tirelessly to provide all the initial code information and subsequently maintaining and improving the codes. We occasionally met some of the Station X staff, but apart from very guarded telephone calls we had little actual contact with each other.

In the first sentence of the final paragraph above Audric comments on the lack of published recognition of the work done by Station X on the breaking of enemy weather codes, However, it must be remembered that his contribution would have been written in relative isolation, because people were only just beginning to open up on the entire subject. In a more recent contribution’ Mavis Batey (née Lever), whose major contribution led to the naval victory at Matapan noted

"Both these methods exploited German errors. The first relied on the observation that short meteorological telegrams transmitted at midnight by German airfield radio stations were first encoded and then enciphered in a substitution cipher that used the letters in the Enigma plug connections for the given day."

She continues "An example might be as discovered by Dilly

Gale Approaching From West Force 8

<table>
<thead>
<tr>
<th>Code book</th>
<th>CFI</th>
<th>LPJ</th>
<th>KTO</th>
<th>AYJ</th>
<th>SXB</th>
<th>DEO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitution</td>
<td>CFP</td>
<td>LIT</td>
<td>KJB</td>
<td>MXT</td>
<td>SYO</td>
<td>DQB</td>
</tr>
</tbody>
</table>

Dilly would have noted the unusual reciprocal substitution as a possible stecker key
Self Steckers CC FF LL KK SS DD Steckered letters I=P J=T O=B A=MY=X E=Q."

So, we see that weather intercepts themselves made a major contribution to the routing settings of rotors and plugs that were essential for rapid decryption of Enigma traffic.

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* Mavis Batey ’Dilly Knox—A Reminiscence of this Pioneer Enigma Cryptanalyst’ Cryptologia,32:2,104—130 Online Publication Date: 01/042008 (see p. 120)

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German view*
This is a textbook on the subject, written by a specialist who was in a position to illustrate key points with details of German performance during the second world war. In the Introduction the author states "It has become customary among cryptologists to explain how they became acquainted with the field. In my case, this was independent of the Second World War. In fact, I was never a member of any official service—and I consider this my greatest advantage, since I am not bound by any pledge of secrecy. On the other hand, keeping eyes and ears open and reading between the lines, I learned a lot from conversations (where my scientific metier was a good starting point), although I never know exactly whether I am allowed to know what I happen to know." He measures much of what he has to say against the views of Hans Rohrbach (1903 - 1993), a colleague at Mainz University in 1959, who, as a mathematician had been to Germany what Turing had been to Britain. Because of the lack of cryptographic discipline on the part of Robert Murphy, Roosevelt's representative in the Mediterranean Rohrbach's group at the German Ausw rtiges Amt were able to break the American cipher M-138-A. Bauer makes much use of Rohrbach's seminal work *Mathematische und maschinelles Methoden beim Chiffrieren und Dechiffrieren* **.

Bauer says of German weather ciphers At the other extreme, the Germans encrypted in the Second World War weather reports in the International Meteorological Code; as the prevailing wind is westerly in Europe, that often provided the 'probable word' and lead to compromises with U-boat messages. It would have been better to transmit such low-priority messages in *Klartext*. Rohrbach recommended including vulnerability to errors when assessing the security of a method, on the principle that humans error. Rules of intelligence security and counter-intelligence also play an important role.

He says of the short-weather cipher used by the German Navy. Batey here???
The *Wetterkurzschrüssel* (short weather cipher) of the *Kriegsmarine* coded air temperatures by a polyphonic single letter code (X was missing!):

<table>
<thead>
<tr>
<th>A ≅ +28</th>
<th>B ≅ +27</th>
<th>C ≅ +26</th>
<th>D ≅ +25</th>
<th>. . .</th>
<th>W ≅ +6</th>
<th>Y ≅ +5</th>
<th>Z ≅ +4</th>
</tr>
</thead>
<tbody>
<tr>
<td>A ≅ +3</td>
<td>B ≅ +2</td>
<td>C ≅ +1</td>
<td>D ≅ 0</td>
<td>E ≅ -1</td>
<td>F ≅ -2</td>
<td>. . .</td>
<td>Z ≅ -21</td>
</tr>
</tbody>
</table>

In a similar way, water temperature, atmospheric pressure, humidity, wind direction, wind velocity, visibility, degree of cloudiness, geographic latitude, and geographic longitude had to be coded in a prescribed order; a weather report consisted of a single short word. This seemed to be very economical and also made direction-finding reconnaissance difficult, but it was cryptologically utterly stupid: the superencrypted weather reports the U-boats were ordered to broadcast regularly were for the enemy's cryptanalysis of the superencipherment almost as good as plaintext.

Under the heading "Battlefield attack" he says It is a truisum that war can bring rich booty. That applies particularly to cryptological material. For example, the German submarine *U-33* was captured by the Royal Navy in the Firth of Clyde on February 12, 1940. The otherwise reliable radio operator Kumpf forgot to throw the ENIGMA rotors overboard. The Poles had already worked out the wiring of the first five, but rotors VI and VII were new to the British. In August 1940 rotor VIII was captured, too. On April 26, 1940 the German Q-boat *Polares* (*Vorpostenboot* 26) was seized off Ålesund. The British found matching plaintext and cryptotext for the previous four days, although this was not enough to allow the decryption of the naval ENIGMA to be fully broken. The operating instructions captured from the submarine *U-13* in June were also of little help. The breakthrough came the next year: on March 4, 1941 the capture of the trawler *Krebs* in the Norwegian Vestfjord produced not only two familiar rotors but also the complete keys for the previous month. This allowed BP (Bletchley Park) to read in March 1941 all of

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* "Decrypted Secrets: Methods and Maxims of Cryptology" (4th, Revised and Extended Ed.) Friedrich L. Bauer, Springer-Verlag Berlin Heidelberg 2007
the February Kriegsmarine signals. As a consequence, the reconstruction of the bigram tables used was possible.

He presents his 'Maxims of Cryptology' and measures German performance against these. In many cases the Germans were wanting and had they abided by these maxims then the Enigma machine had the potential to be perfectly secure. He also points out the failures of the British and Americans. The case of Murphy is mentioned above, but he says In late 1940, the German auxiliary cruiser Komet (‘Schiff 45’) under Capt. Eyssen captured bigram ciphers and code books from several ships of the Merchant Navy. The Allies did not find out about it until they studied the German archives after the war.

He considers the security of German ciphers and the concerns of Admiral Dönitz
The introduction of the 4-rotor ENIGMA on February 1, 1942 caused a blackout, but by December 1942 the signals could again be decrypted on a regular basis, and the Allies gained the upper hand in the U-boat war. This was again achieved by capture, which brought to light an incredible stupidity on the part of Eberhard Maertens, Head, and of Ludwig Stummel, Chief of Staff, of the Marine-Nachrichtendienst. The seizing of the U-559 off Port Said on October 30, 1942 by HMS Petard provided a new edition of the Kurzsignalheft and a second impression of the Wetterkurzschlüssel, which would have been a fair prize in itself. In addition, Philip E. Archer managed on December 13 to decrypt a message that showed that when the 4-rotor ENIGMA was communicating with coastal stations that had only a 3-rotor machine, the fourth rotor (the Griechenwalze) was simply placed in the neutral position. That was a convention which made communication possible. The stupidity was that the three-letter ring setting of the 3-rotor ENIGMA was always the same as the first three letters of the ring setting for the 4-rotor machine. That was not necessary, but was done purely for convenience in producing the monthly orders. It meant that if the enemy knew the ring setting for the 3-rotor machine, then only 26 attempts were needed to find the setting for the 'Greek' rotor. Thus, starting with December 13, 1942 the British finally cracked the 4-rotor ENIGMA for the entire TRITON key net of the submarines (introduced in 1941); even the introduction of a second Greek rotor on July 1, 1943 did little to alter their complete mastery of ENIGMA traffic until the end of the war.

He gives further details under his maxim "One should not underrate the adversary"
Perhaps nothing, as a particularly crass case of the permanent underrating of the British by Rear Admiral Eberhard Maertens and Captain Ludwig Stummel shows. In fact, in March 1942, two German auxiliary cruisers were sunk. Admiral Fricke requested an investigation—but no hints were found. Then, it happened in mid-1943: Decrypts of signals from Allied convoys showed that the Americans supposed there were twenty German submarines in a narrow map square. Indeed, the wolfpack Meise with its 18 boats was in the square. The Befehlshaber der Untersee-Boote, Großadmiral Karl Dönitz (1891–1980), ordered Maertens to investigate, as he had done in 1941 when U-570 was seized. “Again Maertens exculpated ENIGMA. The British U-boat situation reports themselves stated that the Allies’ information on submarine locations was coming from direction-finding ...” (Kahn). Maertens also saved his head by explaining falsely that they had been located by the H2S (German code name Rotterdam-Ger’at), a radar bombing aid working on a wavelength of 9.7 centimeters, found February 2, 1943 in a British bomber shot down over Rotterdam. Dönitz had to comply, but remained suspicious and finally fired Maertens after an accident around the convoy SC 127 on March 12, 1944 was again explained by either treason or lack of cipher security. It is known today that poor Maertens was the victim of tricky British disinformation.

Nothing perhaps demonstrates so clearly the extent of Allied achievement during this period as the two of the several synoptic charts which appeared in R.P.W. Lewis's article "The use by the Meteorological Office of deciphered German meteorological data during the second world war" which appeared in the Meteorological Magazine vol. 114, (1985) 113 - 118. The first is a surface chart for most of Europe for 1800 GMT on 4 July 1942, where each data-point is clearly marked. We can see large gaps in the information.
If we move forward a year to 1300 GMT on 18 July 1943 we get an idea of the extraordinary increase in the information density. One of the things to note here is the data-points in what we now call sea areas *FitzRoy, Sole* and *Shannon*. This is clearly the result of data collected by aircraft flying from Lisbon to Foynes.
Several of the memoirs make reference to the weather decrypt achievements of George McVittie who was awarded an OBE for this work in 1946. He returned to King's College London. In 1948, he became Professor and Head of the Department of Mathematics at Queen Mary College and was there for four years. In 1952 he was invited to take over the chairmanship of the Department of Astronomy at the University of Illinois where he remained until 1970. A sabbatical at the University of Kent at Canterbury led to his retirement there in 1972, where he became an Honorary Professor. He died in 1987.
Prequel to the Normandy landings

Donald MacIntyre in his book *U-boat Killer* (ISBN 0-304035235-7), p.142 says that "It was the German practice to maintain in mid-Atlantic one or more U-boats for the sole purpose of transmitting, twice a day, a weather report. These reports, of course were vital to their long-range forecasts of the weather in and around Europe."

He then goes on to describe how in early May 1944 his escort group used high frequency direction finding to locate and destroy such a weather-reporting U-boat, U-765 at 52°30'N, 28°28'W. When viewed in the light of the bigger picture it is clear that this was yet another part of the "Weather War" and an action intended to blind the Germans to Atlantic weather in the run up to D-day.

According to http://ibiblio.org/hyperwar/ETO/Ultra/SRH-008/SRH008-11.html#fn2
"During the period from 1 January to 18 May, 1944, 29 U-boats worked as weather stations. Of this number only two were sunk The urgency attached to these U-boat weather transmissions was shown many times in Command's instructions and reprimands to the boats. On 4 May weather boats were told: 'Reports are of the utmost importance for the entire conduct of the war - judgment as to air situation, invasion, etc.' Again on 10 May: 'Omission of weather reports is of great disadvantage to whole waging of the war.' Among the first messages sent after the invasion began was an order to four U-boats in the mid-Atlantic, not regular weather reporters, to 'send a supplementary weather report today. Urgently needed.'

Wikipedia contains records of some other weather reporting U-boats (U-534, U853, U-488 and U-490). U-488 was sunk on 26 April 1944 and U-853 on 6 May 1944.

Forecasting for D-Day

This is a well worn subject, so the treatment here will be somewhat tangential. However before starting it is well worth re-visiting something which Paul Pfeiffer mentioned in his (American) account.

"When Doney and I reported to Hayes, he proposed to contact the Chief Weather Officer of the United States Air Forces in North Africa, Lieutenant Colonel Joseph A. Miller, Jr., also stationed in Algiers, to determine if the Mediterranean Allied Air Forces could use such a service. We heard nothing for three weeks. Finally, Doney and I met with Miller, who explained vehemently that he was totally dependent upon McVittie's decodes radioed in British cipher from Bletchley. The service was unreliable because the British frequently failed to provide the one-time pads necessary to break their transmissions in time for operational forecasting. "They are treating us like colonies!" exclaimed Miller. He was obviously delighted at the possibility of having a comparable US unit at his service."

It is known that Churchill was particularly careful about his 'Ultra' disclosures and given the actions of people like Robert Murphy, his concerns may have been justified. However the resentment of Britain acting as a conduit was more widely felt. The Italian trans-Atlantic telegraph was cut by a UK Post Office cableship just as Italy joined the war and remained idle until the start of American operations in North Africa. The landing fleet for *Operation Torch* included a cable ship which brought the western end of the cable ashore "... so that Eisenhower could have a line of communications (to the US) that would not be eavesdropped on by the British."

So where did the Americans stand in the matter of weather forecasting for D-Day? The answer should have been very well. Indeed one could conjecture that by 1944 they were in a position to be better equipped than Britain in terms of expertly trained staff. This state of

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affairs had come about by some long-term investment and by the vision of one or two key people. One of these was Harald Sverdrup who noted that the Bergen School was supported by an annual grant that Vilhelm Bjerknes received from the Carnegie Institution of Washington almost from the first days of its establishment after his visit to Washington in 1905. Bjerknes received this grant continuously to the end of his career. Sverdrup notes the vital role that the Carnegie Institution played in developing the earth sciences in those early years, and he himself received support from the Institution throughout his career. He also notes that the Bergen School produced some very bright guys including Jacob Bjerknes, Tor Bergeron, Olaf Devik, Theodore Hesselberg, Carl-Gustaf Rossby, and Halvor Solberg. Sverdrup was appointed director of the Scripps Institution of Oceanography in 1936. This was one of several extraordinary insightful appointments by Robert G. Sproul, the long-time President of the University of California. The other was Jacob Bjerknes

In July 1939, Jacob Bjerknes embarked on an extended tour of meteorological institutions in North America. Bjerknes was thousands of kilometers away when Germany invaded Poland on 1 September. During this trip, the University of California’s entrepreneurial president, Robert G. Sproul, and two stalwarts of the Bergen School already in the U.S., Rossby and Harald Sverdrup, worked furiously to convince Bjerknes to stay in California. They wanted him to become the cornerstone of a new center for atmospheric research, the Pacific Coast’s answer to Sverre Petterssen’s program at MIT. The invasion of Norway by German forces on 9 April 1940 and Sverdrup’s proximity at the Scripps Institution of Oceanography (SIO) near San Diego led Bjerknes to agree to a high-paid position at UCLA, though not without first negotiating the hire of his compatriot, Jørgen Holmboe, from MIT.

The vicissitudes of a war had led to the formation of the original Bergen Geophysics Institute in 1917. In 1940, they led to its partial reformation in Southern California. Bjerknes’s decision served several interests. It furthered Sproul’s project to turn his home state into a scientific research center—and servant—for the U.S. military and Los Angeles’s flourishing aeronautics industry. Bjerknes’s decision advanced Rossby’s longstanding plan to bolster meteorological research and instruction in the United States according to the Bergen model. Both Rossby and Sverdrup hoped Bjerknes would use his acumen to advance Pacific maritime meteorology from its backwater status. Most importantly, the U.S. Weather Bureau and Army Air Corp had immediate plans to convert UCLA into a centerpiece of their emergency defense training program, as the United States prepared for going to war. Bjerknes embraced these interests, many of which had been integral to the formation of the original Bergen School. From 1940-1945, UCLA and SIO together trained some 1,400 military forecasters.

The details and the distortions
Notwithstanding what has been said in the previous paragraphs, the aftermath of the D-Day forecasts was an unedifying affair where the best showmen rushed to gain acclaim irrespective of whether the credit was theirs to claim. Collectively it was creditable even if there was serious divergence of opinion. Much of this is given in an excellent account by James R. Fleming**

His hero Sverre Petterssen† (1898 - 1974)

joined the Norwegian army and studied in Bergen where he met Tor Bergeron during a lecture, and was so impressed by his analysis of a 1922 storm that he joined the Bergen School of Meteorology in 1923. He remained a weather officer in the Norwegian Air Force until 1939. He

* from Extended Abstract of paper to be presented at the International Commission on History of Meteorology Meeting, Polling Monastery, Weilheim, Germany, 5-9 July 2004. "Bergen South: The Americanization of the Meteorology Profession in Latin America during World War II" by Gregory T. Cushman


† http://en.wikipedia.org/wiki/Sverre_Petterssen

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went to the US in 1935, lecturing on Norwegian meteorological theories to the US Navy and Caltech. In 1939, he was hired by MIT as head of the meteorology department.

With war in Europe and the Nazis occupying Norway, Petterssen decided to leave MIT to serve in Meteorological Office of the British Air Ministry as an advisor on loan from the Norwegian Air Forces. Sir Nelson Johnson, head of the British Met Office, appointed Petterssen head of the Upper Air Branch at Dunstable with primary responsibility for preparing forecasts for bombing raids over Germany. (Fleming op. cit.)

Brian Audric++ recalls Petterssen at Dunstable
When the new enlarged WT Room was occupied, we took over the old one, which put us next to the Forecast Room with which we communicated via a hatch. This was the home of the IDA Unit for the rest of its existence. The space vacated by IDA in the Forecast Room was later taken up by the Upper-Air Unit, an Anglo-Norwegian group led by Professor Sverre Pettersen, which did very valuable forecasting work, especially before the D-Day landings.

The picture below, taken from the last page of Audric's work shows a picture of the Special Long Range Forecast Unit who were responsible for the Dunstable contribution to Overlord. Petterssen is seated on the left of the picture and Charles Douglas on the right.

According to Fleming (op. cit.)
During this period Petterssen identified strong upper level winds later known as the jet stream and investigated linkages between upper level and surface conditions. In addition to many other duties, he prepared the long-range forecasts for the Anzio landings in Italy and was the only Norwegian-trained meteorologist involved in the contentious forecasts for D-Day.
At first sight I was inclined to disagree with this contention, since the Bergen School had been widely accepted throughout the US. But maybe events were to show otherwise.

Although Petterssen argued for a team of meteorologists working in the same place and cultivating personal contacts, it was decided to have a system of three independent forecasts drawn up by three different groups feeding the information to SHAEF through Group Capt. James Stagg and Donald N. Yates of the USAA. The American Group was led by American


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group led by Irving Crick and Ben Holzman. The Admiralty group of forecasters was led by Lawrence Hogben and Geoffrey Wolfe. The final was led by Petterssen and Charles Douglas. Although many accounts refer to them as civilians, it must not be forgotten that Petterssen was a Norwegian air force officer and that the Met. Office was part of the Air Ministry.

The *Daily Telegraph* for 5 Jun 2004 takes up the story

. . . . Stagg, he merely reported to Eisenhower the analyses of three two-man teams of forecasters from the Met Office, the United States military and the Royal Navy. Only the Navy men, Lawrence Hogben and Geoffrey Wolfe, survive. Dr Hogben said: "We six never agreed about anything except that Stagg was not a good meteorologist and that he was a bit of a glory hound." The six worked for months before D-Day, perfecting forecasting techniques many of which are still in use. "I don't think people realise how close run it was," Dr Hogben said. "Not much would have to have changed for D-Day to have been a failure, and a failure caused by the weather." Mr Wolfe, 92, agreed: "It was bad enough when they landed on June 6, but it could have been a disaster." Each team produced forecasts and Stagg tried to achieve consensus before reporting to Eisenhower. On June 3, after a settled period, the British teams predicted sudden and serious decline. Storms would rule out air support of the invasion and make landing extremely treacherous. "But the Americans produced a false forecast, not deliberately, but still false and stuck by it," Dr Hogben said. "[Irving] Crick and [Ben] Holtzman, [the American team] even telephoned C K M Douglas and Sverre Petterssen at the Met Office to persuade them to change their unfavourable forecast to agree with them. "Then Eisenhower would have a two-to-one majority in favour, the attack would have been June 5 as Eisenhower wanted. The weather was terrible that morning, with Force Six winds and high seas." But a telephone call from the two naval officers stiffened the resolve of the civilian forecasters to resist the Americans. The Met Office forecasters refused to change their opinion of June 5 and Stagg was forced to tell Eisenhower that the weather did not meet the criteria laid down by the Overlord planners. "The outcome of D-Day, perhaps the whole future of the western world rested on those forecasts, so I think you could say there was some pressure," Dr Hogben said. "Things looked very bleak. We knew that, without a change, the invasion would have to be postponed until June 19, the next time the tides would be right. Luckily, the next day there was a wholly unexpected break and we were able to change our forecast to favourable. The Americans, of course, had never shifted. They were 70 per cent confident of their forecast." Dr Hogben added: "If we had been a little less certain and said no again, it would have had to shift to the 19th. As it happened, on the 17th, all six of us produced a forecast for the 19th for almost perfect conditions, so they would definitely have gone ahead." And if in that parallel universe, D-Day had taken place on June 19, what would have happened? "Utter catastrophe. Complete failure. On June 19 the biggest storm of the 20th century came up. "If they had landed that day, I doubt many landing craft would have even made it to the beaches. It does not bear thinking about.

According to Fleming

About a week after D-Day, Petterssen received a copy of a letter from Stagg to Sir Nelson Johnson (the Head of the Met Office) praising the efforts of the Dunstable forecasters and panning the other forecast centers for either actively opposing or only half-heartedly accepting the "best advice" given by Petterssen and Douglas. Petterssen immediately wrote to Johnson suggesting that it might not be wise to mention contributions by individuals, as Stagg had done. Rather, he thought it satisfactory for all concerned just to have it said that the meteorological profession had stood up to the test and rendered a signal service in the liberation of Europe.

However that was not to be. Irving Krick was in quick to claim credit*

. . . eleven years after *Overlord*, he wrote a popular account that emphasized the reticence of the British and the bravado of the Americans: "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, that would justify the risk of committing the great expedition to the stormy

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Channel crossing*. As Krick reminds us, “Had not the skilled meteorologists using modern methods correctly foreseen tiny chinks opening in the. . . weather of 1944 in western Europe, almost as fleeting as glimpses of blue sky between storm clouds (and had not the military commanders taken their word), all the mighty preparations for D-Day might have gone for naught, and the war in Europe might have gone on for years”.

The author reminds us that the Americans were using 'analogue techniques'. With hindsight one might think that they were attempting to solve the famous equations of Vilhelm Bjerkness using analogue computers. After all he had received his B.S. degree in Physics from the University of California, and his M.S. and Ph.D. in meteorology from the California Institute of Technology. He had been steeped in the tradition of the Bergen School, but when it came to the crunch did he use this background? No, because he had his hobby idea, something which harked right back to the pre-Bjerkness ideas of collecting a very large amount of weather data and comparing the developing pattern of weather, forty years in his case, as a means of predicting what the weather was about to do. He was prepared to trust the lives of Allied troops to a technique that even the German forecaster Dr Stöbe had eschewed two years earlier when, in connection with the Channel Dash he asked "What good was it to know, for instance, that in February the frequency of weather type 7 . . . was 54 per cent. . . . The actual weather can never be approached through such statistical means and frequencies . . . " Yet Crick persisted and his views might even have prevailed were it not for the sensible intransigence of Dr Petterssen and although Crick's techniques are now more or less forgotten, it did not stop him from claiming the credit in the face of British meteorological pessimism. There may have been Col. Blimp reasons for this. In spite of the importance for US submarines of much of Sverdrup's oceanographic work, and in spite of the death of his brother fighting with the Free Norwegian Forces in Spitsbergen, he had serious security clearance problems in the US during the war. The situation concerning Jacob Bjerknes is less clear, but there may have been a suspicion of all things Norwegian amongst the US military hierarchy, so that Fleming's contention that Petterssen was the only protégé of the Bergen School working on Overlord may indeed be correct. Anyway, in 1970 the American account was codified and given quasi-official status by Patrick Hughes in A Century of Weather Service a celebratory volume produced by the U.S. Department of Commerce. It has always been recognized that victors get to write the histories, but if the man in the New York street car were to be made aware of how the facts have been distorted in his name by this 'official history', then he too might think it a duplicity unworthy of American integrity.

Fleming continues

Although Petterssen was annoyed by the claims, distortions, and suppressions that appeared in print over the years in newspapers, magazines, and books, he felt that his 'noname' policy was sound as long as no one descended to the level of personal derogations and unfavorable reflections on the profession of forecasters. What caused him eventually to discard his policy was not the proverbial last straw: it was Dr. Stagg's book, (J.M. Stagg, Forecast for Overlord, June 6, 1944, London, Ian Allan, 1971) a book that led Petterssen to compose his own historical memoir. (Weathering the Storm: Sverre Petterssen, the D-Day Forecast and the Rise of Modern Meteorology, James Rodger Fleming, ed., Boston, American Meteorological Society, 2001) where 5 chapters are devoted to the preparations for D-day. Referring to Stagg, Petterssen wrote in his book : . . .when someone, however skilled in the arts and maneuvers of management, does not know the theories to be adapted, nor has experience that could be called upon for this purpose, had he possessed knowledge of the theories that might be applied, and when he, amongst other things, uses a popular book to question the scientific competence and professional skills of his helpers, then one arrives at the conclusion that the no-name policy has outlived its usefulness.

* It is not unusual within the UK defence related establishments to give a 'senior' man access to what might be restricted information, so that he can write the history. Fleming's description of the work: "a standard bureaucratic account" is probably well founded
Petterssen say of Hugh's account

"In reading Hughes' story one is led to wonder whether there exists in the worthy science of topology a theorem that defines an upper limit to the amount of distortion at which identity is completely lost. The moral of Hughes' story might well be this: if you wish a rumor or a fantasy to be shrunk, don't take it anywhere near Washington, D.C."

Fleming draws his extended abstract to a conclusion with " Victor Boesen's account, _Storm: Irving Krick vs. the U. S. Weather Bureaucracy_, published in 1978 and now available on the Web takes the distortions to a new level." Having consulted the on-line document I am forced to agree, but wonder whether there might not have been other (perhaps age-related) factors, as Boesen appears to have seriously confused many factual details such as individuals and names.

A personal view

Whatever the truths and falsities, whatever the rights and wrongs, Stagg's book, contains what is for this author a particularly poignant sentence:

"a report from Blacksod (Belmullet) was crucial in deciding which team of forecasters had the right analysis".

When I related the details of the D-Day forecasts and particularly the locations in Ireland that feature on wartime weather maps to my father (then 89) he recalled:

I joined the army on 8 August 1940 and immediately before that I had been on holiday with my cousin who had just got a new car. We travelled through the West of Ireland and stopped off at Belmullet. There was a shop/post office there and I have a clear memory of the lady (post mistress) excusing herself, going out to take readings of weather instruments in her back garden and keying them by telegraph before she finished serving us. 'It was important', she said, 'that the measurements were taken and transmitted at precise times'

The late Brendan Mc Williams, a meteorologist who wrote a column for the Irish Times under the name "Weather Eye" recorded on Tue 4 Apr 2001

"Weather Eye was saddened to hear that Ted Sweeney of Belmullet passed away some days ago. For many years before 1956, when the Meteorological Service opened an official weather station at Belmullet, Ted Sweeney and his mother, in addition to running the local post office, also provided regular weather observations of excellent quality for use in weather forecasting. One of these weather reports, in June 1944, was destined to influence the course of history. . . ."

Of such things is history made."
Loose ends and Climate Research
And while we are back in Ireland it is time to close another chapter in the development of a meteorological career. As stated earlier when talking about the flying boat base at Foynes, when Marian Doporto was transferred to the Met. Service HQ in Dublin Hubert Lamb became officer-in-charge. However, in late 1943 or early 1944, the Head of the Irish Met Service, Austen Nagle instructed the meteorological office at Foynes to take on an increasing load of public service work, without allowing any new staff to be employed or trained. Lamb objected to this proposal as it would have jeopardised the time and resources required for ensuring air safety on the trans-Atlantic operations. It is worth noting that during his time there no aircraft was ever lost as a result of an inaccurate forecast. Nevertheless matters came to a head in November 1944 with the result that Lamb resigned but was promptly reinstated in the UK Met. Office in a post of comparable seniority. It was from here that his career took off. After the War a posting as a meteorologist on a Norwegian whaling ship improved his proficiency at Norwegian as well as giving him first experiences of the interplay between ocean currents and long-term weather changes. Back at the Met. Office he compiled a scheme of classification known as 'Lamb Weather Types'. During a time when he thought that he had been forgotten by the establishment in the Climatological Section of the Meteorological Office and without the aid of computers he set about utilizing the old data that had been collected and stored (back to 1750 over Europe). Just as the possibility of retirement loomed he left the Met Office in 1972 to take up the post of Founding Director of the Climatic Research Unit (CRU) at the University of East Anglia in Norwich. "He felt that, at a time when the Meteorological Office was putting total faith in new high-speed computers (everything was predictable from basic physics) and there was no need to look at past events, it was also necessary to look in detail at past climates and for this he would use the vast archive of data that had been collected over the centuries by people who were convinced that this was the true function of meteorology. He became the father of modern 'hindcasting'. His great work "Climate: Present, Past and Future" was published as two volumes in 1972 and 1977". He died on 28 June 1997.

* And weather can always have the last laugh. It is reported from the University of East Anglia that the degree ceremony at which Lamb was awarded an Emeritus Professorship was interrupted when the Congregation Hall was flooded during a freak torrential downpour!
From a prefabricated catalogue with $27^2 262 = 1352$ entries of all $U_{ij} (j2, 3)$ the position and order of the two rotors II and III serving for $RM$ and $RL$ can be determined. With such an indicator setting the decryption can be carried through on an ENIGMA replica. The method is characterized as meet in the middle. Switzerland, like other small nations, used ENIGMAs without a plugboard (of course with changed rotor wiring) during (and partly after) the Second World War (US codename INDIGO). With the help of prefabricated catalogues, the Germans thus read all their news. On the British side, Mavis Lever was an expert in rodding, she used it in 1940 and 1941 against the Italian Navy and was instrumental in helping the British fleet win the battle of Matapán.

The British in Bletchley Park had champions in preparing the confrontations of plaintext fragments and cryptotext, the cribs (Sect. 19.7.1); only a few of them can be mentioned here. As well as the linguist Hilary Hinsley née Brett-Smith and the linguistically versed mathematician Shaun Wylie, there were also people with a kind of abstract ability for pattern finding in Bletchley Park: the chess champion Hugh Alexander and the formally gifted Germanic philologist Mavis Batey née Lever. Her abilities can be illustrated by the fact that she noticed one day the absence of the letter L in a long fragment of ENIGMA cryptotext. To notice this was already unheard of. But she also concluded that this was caused by a long filling with plaintext /l/. This successful assumption led to the determination of the setting, to a lasting break, and finally to the victory of the British fleet over the Italian on March 28, 1941 near Cape Matapán on the Greek coast.