

## **6 Ship's Meteorological Station**

### **6.1 Meteorological conditions during leg M39/1 (K. Flechsenhar)**

RV METEOR left Las Palmas harbor on April 18th 1997 and sailed to her first working area in the Gulf of Cadiz, where they arrived in the evening of April 20th. During this track the weather was influenced by a low centered west of Portugal, which caused northwesterly winds of 6 to 7 Bft on April 20th and 21st, and swells of about 3.5 m height. On April 22nd wind and seas decreased and from April 23rd to May 1st the scientific program was carried out under optimum conditions. On April 30th however RV METEOR for a while got into dense fog at 36.0°N8°20'W. On May 1st the ship passed Cabo de São Vicente with Westsouth-west Gale 7 to 8 Bft, and wave heights of about 3 m. This wind was primarily caused by a low approaching from the west, but its intensity was strengthened by the orographic effect of the steep cape. On May 2nd and 3rd the station works continued under fair weather off SW Portugal, but a westerly 3 m high swell caused some rolling and pitching of the ship. On May 4th, RV METEOR proceeded to the North and passed Cape Roca, height of swell now about 4 m. From May 5th on the weather was dominated by a low pressure system with center near Scotland and became rather bad. A strong southwesterly to northwesterly wind (6 to 7 Bft) made the sea very rough. During passages of cold fronts even Northwest gale 8 with gusts up to 10 occurred and the scientific was carried out under difficult conditions.

In the evening of May 7th RV METEOR passed Cape Finisterre with northwesterly winds of 5 to 6 Bft and swells of about 5 m. Until May 10th off Cape Finisterre, the Wind decreased to Bft 5, but a 5 m high swell, rolling on continuously from the North Atlantic Ocean, hampered station works. On May 10th all research operations were terminated and the ship headed towards Brest across the Bay of Biscay, wind Southwest to West 4 to 6 Bft, swell about 4 m. In the morning of May 12th RV METEOR moored in Brest.

Twice a day a weather report was compiled and published in the morning and in the evening. Additional comments were regularly given to the ship's command, the chief scientist and upon request. The necessary data and weather maps were received from the wireless stations Bracknell and Pinneberg, as satellite pictures (satellites METEOSAT and NOAA), and by fax (forecast charts from Bracknell or Offenbach). The forecasts of weather conditions and height of sea and swell were based essentially on surface analysis charts of the North Atlantic Ocean of 00.00 and 12.00 UTC every day. Surface observations of land stations and voluntary observing merchant ships were compiled by hand and analyzed by hand.

Meteorological parameters have been measured and recorded continuously and were transferred to the ship's data collecting system. Sensors and meteorological equipment were maintained regularly, some repairs were done. Every day at 0 and 12 UTC a rawin sonde was launched with the ASAP-System, determining a vertical profile of pressure, temperature, moisture and horizontal wind up to an altitude of 20 to 25 km. The evaluated data (temps) were transmitted into the GTS

of the WMO. Every hour a World Meteorological Organization (WMO) standard weather observation was practiced. 8 of them were transmitted into the WMO Global Telecommunicating System (GTS) including eye observations done by meteorological staff.

## **6.2 Meteorological conditions during leg M39/2 (B. Brandt )**

METEOR left Brest on May 15, 1997. After intense discussion of the weather development over the next five days it was decided to go Northwest and to travel the course of METEOR cruise M39/2 in the originally intended counterclockwise direction.

The weather during the first week of the cruise was determined by high pressure over the Norwegian Sea and depressions moving from Newfoundland to the Bay of Biscay. Mostly moderate easterly winds were prevailing, bringing favourable conditions for the first cross section across the Iceland Basin to the Mid Atlantic Ridge. Only on May 20 easterly gales prevented an intended mooring which had to be postponed for one day.

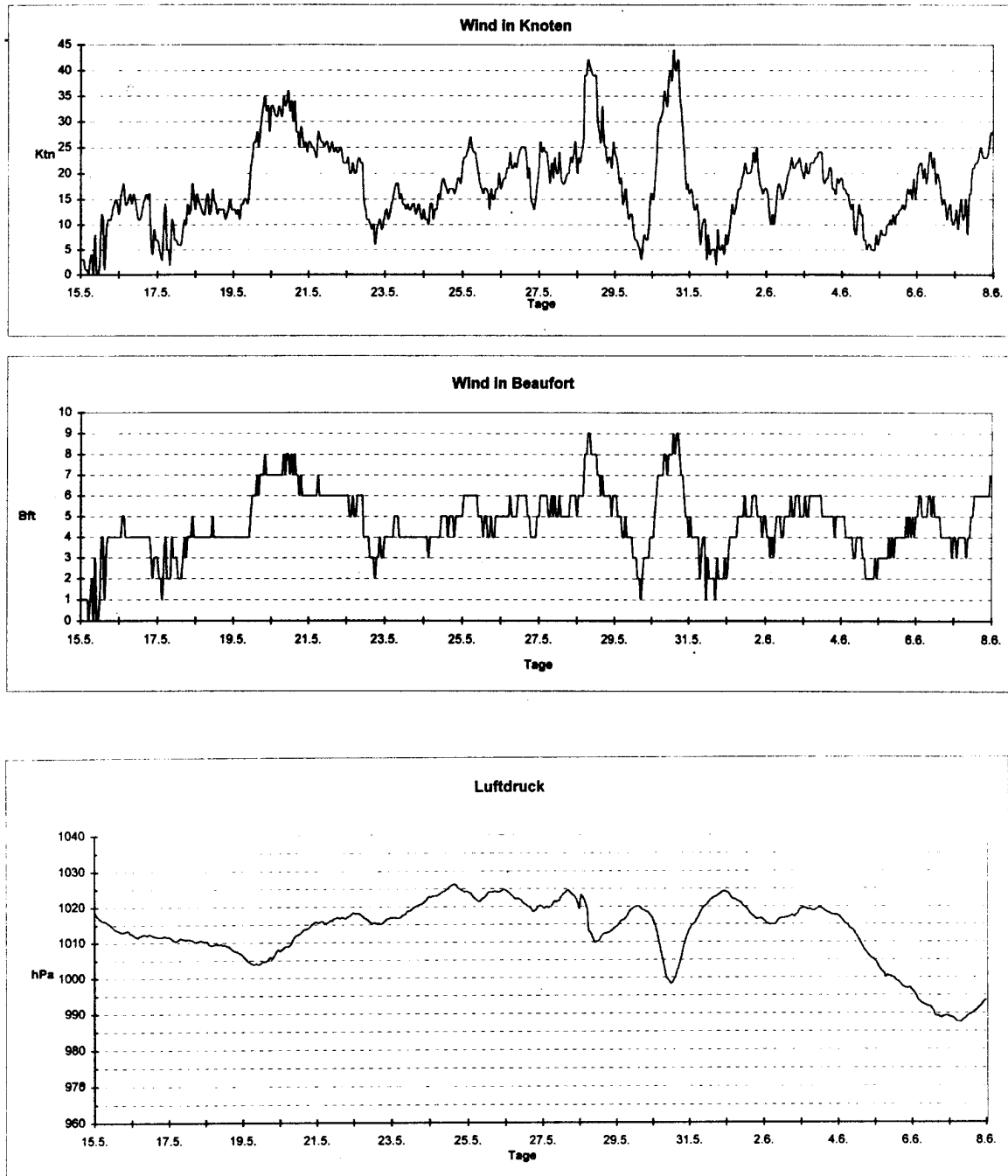
On May 23 the high pressure centre began to move southward to the British Isles, and depressions now moving northwards from Newfoundland to Greenland caused prevailing winds to veer from East to South. This southerly air current was frequently accompanied by fog. On May 28 and 30 two fast moving storm depressions caused southerly gales and consequently a mooring had to be delayed until May 31 (Figure 59).

The first days of June were determined by moderate to strong northerly and later easterly winds between high pressure near Iceland and a stationary low north of the Azores. On June 5 METEOR got under the influence of a depression originating from Labrador, intensifying east of Newfoundland, and later moving east. But due to the rapid disappearance of the Icelandic anticyclone winds were only light to moderate from northeasterly directions. During the last two days of the final leg of the cruise the ship was lucky to stay near the centre of the depression with mostly moderate northeasterly winds. METEOR put in at Cork on June 8, 1997.

## **6.3 Meteorological conditions during leg M39/3 (B. Brandt )**

After leaving Cork harbour on June 11, 1997, RV METEOR passed the rear side of a depression moving northeast across the Irish Sea with northwesterly winds up to 7 Bft. Between June 13 and 16 two weakening depressions moving from the Labrador Sea to the Bay of Biscay brought winds of 6 Bft at the most from different directions, but heavy shower activity.

On June 17 a steady westerly air stream with sometimes high swell built up between the intensifying Azores anticyclone and a storm depression moving from Cape Farewell to the Hebrides. Westerly to northwesterly winds were mostly moderate to strong, only reaching 8 Bft on June 19. Thus conditions for the first mooring station on June 21 were rather favourable.



**Fig. 59:** Observations of wind and air pressure during Leg M39/2.

After passing  $30^{\circ}$  W METEOR reached the western slope of the Azores anticyclone with winds backing southwest and the air becoming warm and moist. With winds being southwesterly to southerly 6 Bft conditions were again favourable for the second mooring on June 23. On June 24 and 25 southerly winds were increasing to 7 Bft due to depressions connected with a 500mb trough stretching South from Newfoundland. Fog or drizzle were almost continuous.

With METEOR proceeding West and passing the trough line the air became clear on June 26 with light northwesterly winds increasing to 7 Bft on June 27. The final days of the cruise were determined by an almost stationary and weakening depression South of Newfoundland in the centre of which METEOR experienced light to moderate winds from variable and later north-

easterly directions, accompanied by fog patches and later by widespread fog. METEOR docked in St. John's on July 2, 1997.

#### **6.4 Meteorological conditions during leg M39/4 (G.Kahl)**

When METEOR sailed from Saint John's, Nfld, on July 6, 1997, a trough trailing behind an occluded front had passed that city in the early morning hours. Moderate to strong westerly winds were blowing as the low of 1000 hPa slowly drifted southeast-wards from the Labrador coast and the ship went northward. Meanwhile, a high of 1020 hPa had formed over North Quebec, extending into the Labrador Sea by July 9, so that winds were light. However, a new low 1010 hPa had slowly formed over the New England States and moved northeast, reaching North Quebec with a central pressure of 1005 hPa on July 11. During these days the research vessel still enjoyed the presence of a wedge of high pressure 1020 hPa that extended northward from the high now 1030 hPa centered midway between Newfoundland and the Azores. The low, now of 1000 hPa moved to the south of Greenland on July 13 while moderate winds from easterly directions veering to westerlies later were experienced by METEOR returning from the vicinity of Southwestern Greenland by then. In the meantime, an area of low pressure west of Hudson Bay had elongated to the Gulf of St. Lawrence and had formed a low of 1000 hPa over the Strait of Belle Isle. Upon reaching open waters this low intensified to a complex gale 990 hPa east of Belle Isle and southeast of Cape Race. The METEOR approached her stopover destination St. Anthony from the north to northeast, thereby experiencing strong northeasterly winds but avoiding gales. During stopover time the following wedge of high pressure closed in to eliminate what little amount of clouds had been left over St. Anthony by the passage of the gale center. When METEOR put out to the Labrador Sea again another gale center had developed west of Hudson Bay and had moved to North Quebec, minimum central pressure being 990 hPa on July 17. Whereas central pressure filled somewhat, the area of strong southeasterlies extended out to the ships working area, easterly and southeasterly winds of 6 and 7 Bft being observed from July 18 to 20. Cyclonic activity on Canada's Eastern Seaboard did not cease after that date, but the ship was lucky to be in the center of the low of 1000 hPa during July 21 to 22 when the low eventually filled and moved away northeastward. Light northwesterly winds gave way to light and variable conditions, and when METEOR visited Cape Farvel on July 25, it was calm for a few hours. The research vessel then headed south while a developing gale center made its way from the Grand Banks to the Irminger Sea, intensifying to 990 hPa while on its way. Another gale center was following closely, reaching a central pressure of under 990 hPa on July 28, too, on a position midway between Iceland and the Azores. METEOR was influenced only by moderate to strong northwesterly winds up to July 28. The gale center south of Iceland further developed into a storm center 975 hPa on July 29, the ship benefitting but shortly from the area of high pressure building to the southwest of the storm center which slowly filled thereafter. The research ship was influenced by a gale center that had developed over the region of the Great Lakes during July 26, being hardly discernible by that date but having reached a central pressure of under 990 hPa over North Quebec by July 28. The gale center then moved on to Southwestern Greenland, making its landfall with a central pressure of 980 hPa on July 30 just when METEOR visited the northern part of Flemish Cap. Southwesterly gales of 8 Bft were observed for several

hours. These abated to moderate Southwesterlies when the ship headed east to reach 35 West by August 2. Another gale center 995 hPa had reached the Labrador coast and had moved quickly to southeastern Greenland, meanwhile further deepening by 5 hPa. The METEOR then headed north, Southwesterlies becoming strong almost immediately, lows crossing the North Atlantic quickly, developing into strong gale centers by the time they reached the vicinity of either Greenland or Iceland. After all, the Greenlandic Inland Ice Sheet and the East Greenland Current are a principal source of cold air masses in summer. West of Baffin Bay, a gale center 990 with a large diameter had developed. While it deepened further to 985 hPa, a secondary gale center 995 hPa developed over the northern part of Hudson Bay. This gale center, having intensified to 985 hPa, passed Hudson Strait during August 7 and moved east to southeast later to be centered west of Ireland when METEOR finished her cruise. The ship had made her way to Southeastern Greenland through strong westerlies caused by a low 1000 hPa there during August 6 and 7, then winds were light while they backed to east during the afternoon of August 8, and during the last days of her cruise the ship had to make her way to Reykjavik against strong easterlies.

### **6.5 Meteorological conditions during leg M39/5 (G. Kahl)**

When METEOR left Reykjavik on schedule in the morning of 14.08.97, there were light southeasterly winds accompanying her out to sea. These resulted from a central low 1000 centered at 56 North 28 West. The Azores High 1027 was to be found just east of that archipelago. A secondary low 1005 which had originated somewhere along the U.S. east coast a few days earlier had made its way to the region east of Cape Race. However, winds backed to the northeast and were up to 6 Bft by 16.08. because the secondary low had become the major low of the northeastern North Atlantic by intensifying to 990 and moving up to the south coast of Iceland, the former central low now being relegated to a mere extension of the new gale center. A new low 1005 had passed Cape Race to lie northwest of the Azores, and another development was taking place over Nova Scotia.

Still another development had taken place during these few days. A low at the Labrador coast had moved up to the central part of the west Greenland coast and then it had been veering at the Polar Circle, eventually going southeast over the ice clad interior. A secondary low 1000 formed over The Irminger Sea, and this kept the METEOR from experiencing more than 5 Bft up to the 20.08. By then, the gale center south of Iceland had moved on to the Norwegian Sea and eventually to the Fram Strait, and the next low waiting in line had moved up from Newfoundland to 60 North 25 West, thereby deepening to 985.

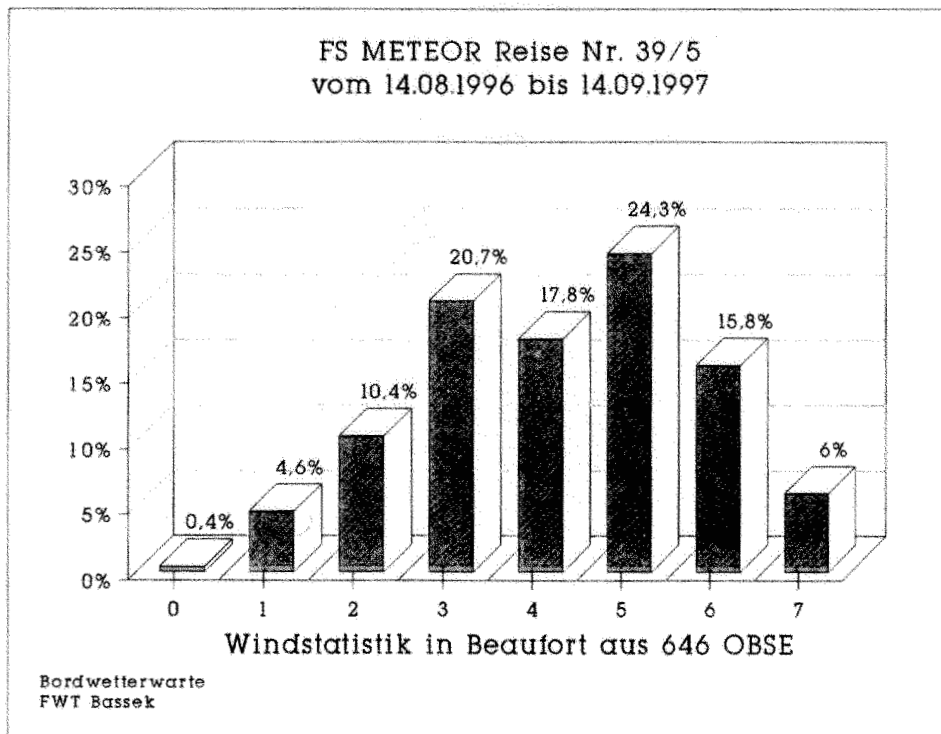
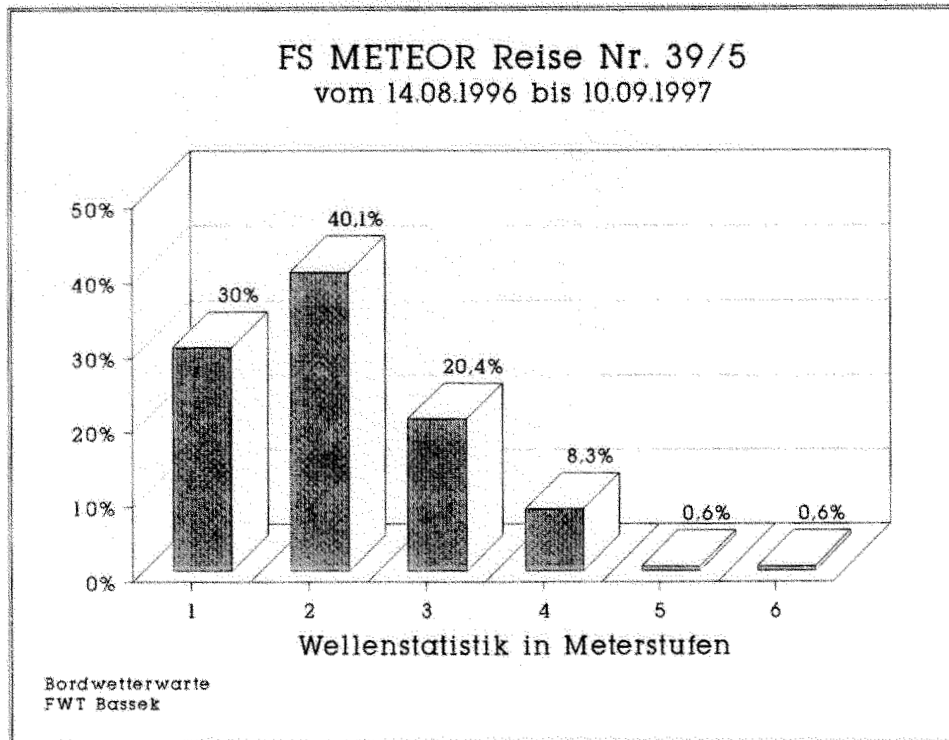
Conditions deteriorated somewhat on 21.08. when central pressure in the gale center fell below 980 before it crossed Iceland on its way northward and began to fill. Northwesterly winds of 7 Bft were experienced for a few hours now but when the vessel approached the Greenland coast winds abated again to light northerly winds. For some time even the state of "light and variable" was reached, this being appreciated by scientific as well as ship's crew. At nightfall on 25.08. when Greenland was left behind winds were still light and visibility was of an order that is seldom observed in more southerly latitudes.

While the research vessel was on her way to the southeast, one of the lows migrating over the Atlantic at 40 to 45 North had slowed and intensified to a gale center 975 at northwestern Ireland on 27.08. This, too, moved on the Norwegian Sea and the Fram Strait so that METEOR was not bothered, the observed winds being northwesterlies about 4. During 31.08. a flat low that had moved from Labrador to our working area had seen some intensification to a central pressure of 1000 because of the cold air flowing out of the gale center passing Jan Mayen by then passed north of our position so that westerly winds of 6 Bft were observed, veering northwest and abating 4 Bft by the next day. Winds were up West 7 Bft by 03.09. to 04.09. because of a cold front originating from the last mentioned low having deepened to a gale center of 980.

On the whole, the General Circulation over the North Atlantic was weak as it should be according to the time of year, but some prominent features of the synoptic charts may be figured out:

1. Lows moving along the U.S. coast, passing the Azores and then going up to the Norwegian Sea,
2. Lows originating west of Hudson Bay, intensifying over North-Quebec to gale center strength and then moving east,
3. A few special developments like the low going up the western Grennland coast and then not continuing to Baffin Bay but choosing to go over the Inland Ice,
4. A quasi-permanent high over the region of the Great Lakes and Hudson Bay, and
5. The Azores High becoming a major feature of the synoptic Chart only during the latter part of the voyage.

Intensity of all Developments has risen during the time the voyage took. During the 03.09. the Azores High once again introduced itself to the synoptic chart at 48 North 40 West with a strength of 1025. By 07.09. this was up to 1040 at 50 North 22 West. Thereafter, it weakened but slowly and moved northeast, swinging east by 10.09. and visiting Germany one day later. The METEOR was near the core of the anticyclone, so that winds were light and variable during the last few days of probing the ocean. In other regions, however, intense gale centers reigned, the Norwegian Sea being especially hard hit by a low that became almost a storm center 975 during 09.09., our research vessel being lucky to be left unmolested at least as far as the English Channel. Hamburg was reached by 14.09.1997. Some weather statistics of this leg are shown in Fig. 60.



**Fig. 60:** Weather statistics during M39/5 for a) Wave statistics in meter steps and b) Wind statistics in Beaufort scale.