GEORG VON NEUMAYER: HIS INFLUENCE ON MARINE METEOROLOGY IN THE GERMAN METEOROLOGICAL SERVICE

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Georg von Neumayer achieved outstanding scientific results and created the organisational framework for the successful completion of scientific tasks. Returning from Australia, Neumayer aimed to set up in Germany a state-owned centre for marine meteorology, hydrography, navigation, marine instruments and geomagnetism, with an emphasis on scientific research with practical application of the findings. Since 1868, a successfully operating private institute, Norddeutsche Seewarte, had existed in Hamburg. This institute provided instructions for sailing routes and the optimal use of favourable winds and currents. In 1875, the institute was transformed into an imperial institution, the 'Deutsche Seewarte' (German Marine Observatory), with a broad spectrum of marine responsibilities including meteorological forecasts and warnings, data acquisition and management, and climatology. Its first director was Georg von Neumayer, who led it to worldwide recognition. In 1903, he retired but the Deutsche Seewarte continued in his spirit. At the end of World War II, the institute was destroyed by bombs and ceased to exist. Today, the tasks are shared between Marine Meteorological Office of the Deutscher Wetterdienst specialising in the marine meteorological and related topics and the Federal Maritime and Hydrographic Agency.

Keywords: marine meteorology, Deutsche Seewarte, Deutscher Wetterdienst

THANKS to his creativity, his negotiating skills and persuasiveness—combined with a remarkable organisational talent—Georg von Neumayer did not only achieve recognised scientific results but he also managed to create the institutional preconditions for successful and productive scientific and related practical work in the field of meteorology.

His name is associated with quite a number of outstanding achievements in different disciplines, for instance polar research, which is the subject of a separate presentation during this symposium. In honour of all those accomplishments, the German Antarctic Observatory bears his name: 'Neumayer Station'.

This paper focuses on von Neumayer's merits in the area of marine meteorology. When Georg von Neumayer started his professional career, marine meteorological knowledge was still getting started.

In the first half of the 19th century, the US Navy Officer and Hydrographer Matthew Fontaine Maury had begun to equip sailing ships with meteorological logbooks, asking the masters to make weather observations at sea and to document them in the standardised tables of those journals. When the vessels had returned, he collected the books, evaluated the meteorological data, compiled the 'Wind and Current Charts', and provided the masters with advice on meteorological and sea conditions in order to make their voyages safer and faster.

A similar method to collect marine meteorological and oceanographic data was used by Georg von Neumayer in Australia, where in 1857 he had established the Flagstaff Observatory, whose director he was until 1863.

Later, in 1879, von Neumayer mentions this in his report to the Second International Meteorological Congress in Rome.

Having returned from Australia in 1864, his aim was to set up in Germany a state-owned centre for marine meteorology, hydrography, navigation, marine instruments and geomagnetism, with an emphasis on scientific research as well as on practical application of the findings.

In 1865, at the German Geographical Congress in Frankfurt, he proposed the establishment of such an institute, named Deutsche Seewarte (German Marine Observatory). But the time was not yet right.

In 1868, the private institute, Norddeutsche Seewarte, was founded by Wilhelm von Freeden, former director of the naval college of Elsfleth, in Hamburg. This institute worked with great success on Maury's principles, aiming at 'the safety and shortening of sea routes'. It provided the sailing ships operating worldwide with instructions suggesting favourable routes and how to use winds and currents optimally. These instructions were based on weather observations made by the ship officers at sea.

Von Neumayer, who was very much in favour of setting up a central marine institution on the German coast, had a broader point of view. He was convinced that such an institute had to be entrusted with an extended spectrum of responsibilities, namely with nautical, hydrographical, meteorological, instrumental and geomagnetic tasks.

Finally in 1875 (Germany had become united in the meantime) von Neumayer's proposal, which he had persistently pursued over the years, could be put into practice. The Deutsche Seewarte (German Marine Observatory) was established in Hamburg as an imperial institute financed by public funds. As such, it provided the organisational basis for the fruitful and successful evolution of related scientific research and effective and efficient operational application of the results.

Georg von Neumayer, who had been one of the driving forces, became the first director of the Deutsche Seewarte and led the institute to worldwide recognition.

The combination of science and application was a guiding principle for von Neumayer. It was always kept in view at the Deutsche Seewarte and is still valid for marine meteorological work at the Deutscher Wetterdienst (DWD).

Right from its beginning, the Deutsche Seewarte had two very important areas of responsibility: the promotion and support of shipping in general, and the issuing of storm warnings to protect shipping and the German coasts.

The marine meteorological tasks were distributed mainly between three departments:

i. Marine Meteorology
ii. Marine Instruments
iii. Operational Forecasts and Warnings

Von Neumayer employed first-rate professionals and set clear goals. He retired in 1903, but the Seewarte continued in his spirit. At the end of World War II, the institute was destroyed by bombs and ceased to exist.

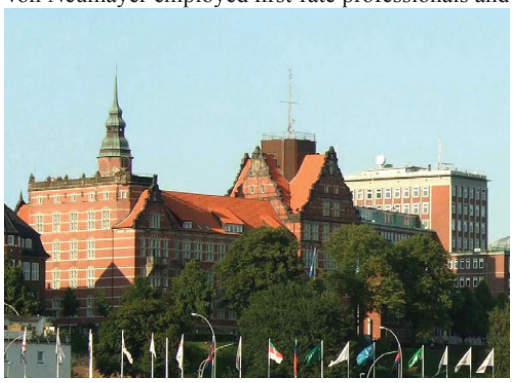

Fig. 1. Marine Meteorological Office of DWD and German Maritime and Hydrographic Agency.

Today, the tasks are shared between the Federal Maritime and Hydrographic Agency and the Marine Meteorological Office of the DWD, with the latter specialising on the marine meteorological and related topics. Figure 1 shows a picture of the two institutions.

Thus, the DWD, especially its Marine Meteorological Office, follows the tradition of the Deutsche Seewarte and of von Neumayer's principles, goals and initiatives.

Marine meteorology, of course, is under continuous development, always taking account of state-of-the-art science and technology. New areas of responsibility and new methods have evolved, all with the influence of Georg von Neumayer and the Deutsche Seewarte on marine meteorology in the DWD still in evidence. This will be shown by a number of typical examples.

MARINE METEOROLOGICAL TOPICS AND THEIR DEVELOPMENT, FROM THE DEUTSCHE SEEWARTE TO THE MARINE METEOROLOGICAL OFFICE OF THE DEUTSCHER WETTERDIENST

Marine data acquisition and management

As the availability of observational data is the primary precondition for marine meteorological and climatological work, data acquisition had been one of the main tasks of the marine meteorological department of the Deutsche Seewarte.

Ships plying the oceans were equipped by the Seewarte with precision instruments. As its director, von Neumayer had promoted the development, maintenance and calibration of such equipment. Personnel of the institute instructed the masters on the use of these instruments and how to make and document weather observations at sea.

For this purpose, standardised meteorological logbooks were given to the ships, developed by the institute according to Maury's and von Freeden's ideas.

Upon returning from a voyage, the masters handed the meteorological journals over to the Seewarte. There, they reported on special meteorological events encountered en route, asked questions and received sailing instructions for the next voyage free of charge.

This was a fruitful 'giving and taking' on a voluntary basis, for mutual benefit—a principle, which governs the marine data acquisition still today.

The voluntary meteorological observations at sea still constitute one of the primary and essential sources of in-situ data from the oceans. In return, the various Services provide shipping with marine forecasts and warnings.

The stock of meteorological logbooks gathered by the Seewarte has increased remarkably over the decades and contains millions of weather observations. Gradually, it became clear that in order to efficiently utilise this huge amount of data for climatological purposes, automated data processing had to be applied.

But as the data were available on paper only, they first had to be transferred to appropriate media. This work began in the 1940s and is continued at the Marine Office of DWD in Hamburg, where almost 40 000 historical marine meteorological journals of the Seewarte have so far been stored in the archive. These journals contain roughly 20 million historical data sets, about half of which have been transferred to electronic media already, and are made available by DWD as an important contribution to international climate research and application. The remaining part of the data will be digitised in the framework of the DWD project HISTOR.

The meteorological logbooks being used today still resemble rather closely those used in the days of the Seewarte. But an advanced method for documenting the observations at sea has begun to replace the old meteorological paper logbooks: Most of the German observing ships already use 'electronic logbooks', where the observers key in and temporarily store the data. Special software performs some quality checks on the spot and, if necessary, informs the observer on possible errors. This makes subsequent data processing and quality control much easier.

In the days of the Seewarte, just as today, quite a number of parameters were observed and recorded every four hours (today every six hours), including among others sea and air temperature, humidity, air pressure, wind direction and force, visibility and weather, clouds, waves and ice. Figure 2 shows parts of the observational records in a historical meteorological journal.

As in von Neumayer's days, the Services nowadays supply the ships with standardised sets of calibrated precision instruments for the measurement of such parameters. Further, they foster progress in the development and application of new sensors and systems. In addition to those ships making 'manual' observations, an increasing number of vessels are being equipped with automatic weather stations, with the advantage of shorter observation intervals and saving of personnel. On the other hand, unfortunately, so called 'eye observations', such as waves, visibility or cloud formation, are no longer possible with these automatic stations, which is a huge disadvantage!

The Marine Meteorological Office of DWD has established a system of Port Meteorological Officers, PMOs, who are stationed in the ports of Hamburg, Bremen, Bremerhaven and Rostock. The PMOs support more than 800 so called Voluntary Observing Ships (VOS) within the German merchant fleet. This system of distributed agencies had already been developed by the Seewarte and has proven to be very efficient.

Besides providing support for the observing fleet, an especially important task of the PMOs is the recruitment of new VOS as well as the motivation of crew members. This had already been one of von Neumayer's concerns, who in his above-mentioned report states that only really reliable observations are valuable, so that particular emphasis is placed on finding conscientious observers through the personal contact of the institute's officers with ship masters. In this context, it is worth noting that von Neumayer and the Seewarte had already set up an award system to encourage voluntary observers to increase the number and quality of their weather observations. The awards consisted in atlases, books etc. A similar system is very successfully applied today by the PMOs of DWD, thus enhancing the effectiveness of their work and contributing to the fact that the German observing fleet is the second largest in the world.

The marine data required by forecast centres, climate research and monitoring cannot be provided by one country alone. International co-operation and division of labour is necessary. Therefore, in the framework of the World Meteorological Organization (WMO), the DWD and many other National Meteorological Services take part in the international VOS program for the worldwide exchange and distribution of observed data.

Today, two different data flow schemes are used for marine observations: the non-real time and the real-time branch (see fig. 3).

In the first decades of the Seewarte, wireless telegraphy was not yet available for the transmission of the marine observations. So the observations were recorded in the meteorological journals on board the ships and arrived at the institute after the return of the vessels. This non-real time data flow scheme has been

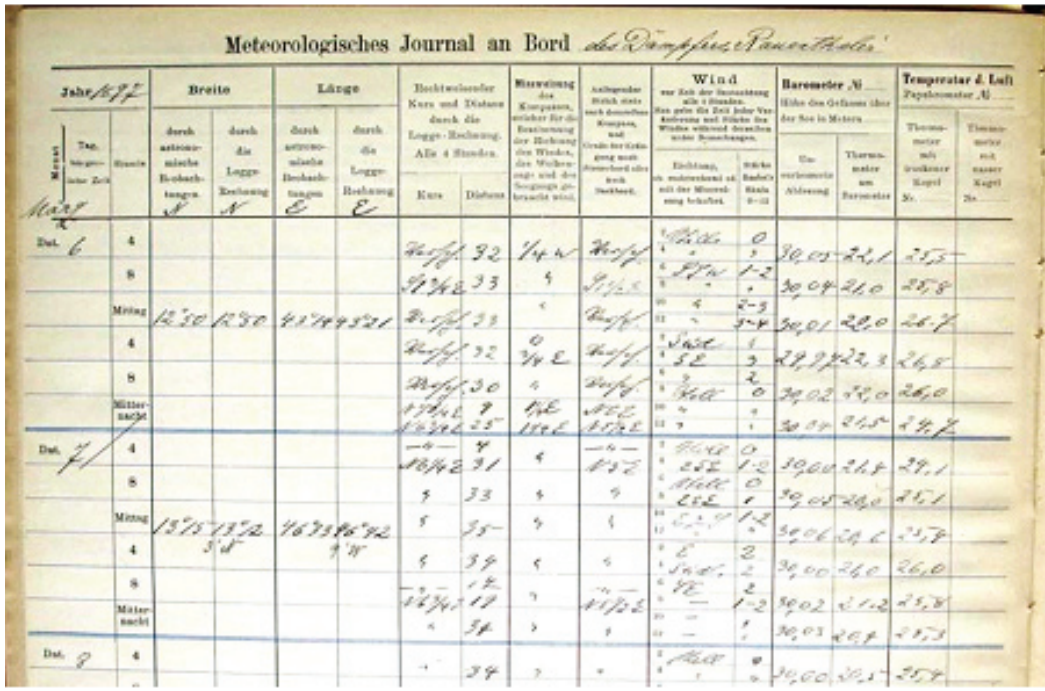

Fig. 2. Records in a historical meteorological journal.

developed further: today, both the meteorological paper logbooks and the electronic media, are collected by the PMOs and handed over to the data processing section of the Marine Meteorological Office. Internationally, the non-real time data flow is ruled by the WMO Marine Climatological Summaries Scheme (MCSS). Within this scheme, the DWD is responsible for running one of the two Global Collecting Centres, receiving and distributing the worldwide ship observations as delayed mode data stream.

The other data flow scheme for the management of marine meteorological observations is the real-time transmission.

At the beginning of the 20th century, radio telegraphy was already used for exchanging meteorological data from land stations. The Deutsche Seewarte assumed the task of radio centre for the distribution of weather data for central, western and northern Europe. Later, marine observations were also transmitted. In this context, the coastal radio stations were of great importance. Today, real-time transmission of marine meteorological observations takes place via satellite and the Global Telecommunication System (GTS) of WMO, through which they are available to the National Meteorological Services for their real-time applications, such as marine weather forecast, warnings and ship routeing.

The international data exchange and distribution mechanisms, including those for marine meteorological data, are continuously developed further: currently, a new WMO Information System, WIS, is in the planning stage. The DWD will substantially be involved in this ambitious project.

In order to gain more insight into the physical and meteorological processes governing the marine atmosphere, it was necessary to collect appropriate aerological data. For the gathering of such data, the Seewarte used kites, balloons, radiosondes and aircraft. Here especially, the evolution of transatlantic aviation in the 1930s gave impetus.

The Marine Meteorological Office of DWD continues these activities. Numerous test voyages resulted in a program for semi-automatic aerological ascents from merchant vessels. Today, it is integrated in the Automated Shipboard Aerological Programme (ASAP) of the WMO as well as in a complementary European program, E-ASAP, in which the DWD plays a leading role and contributes with four containerised radiosonde systems.

All marine meteorological in-situ, ship or buoy data, historical as well as contemporary, which the

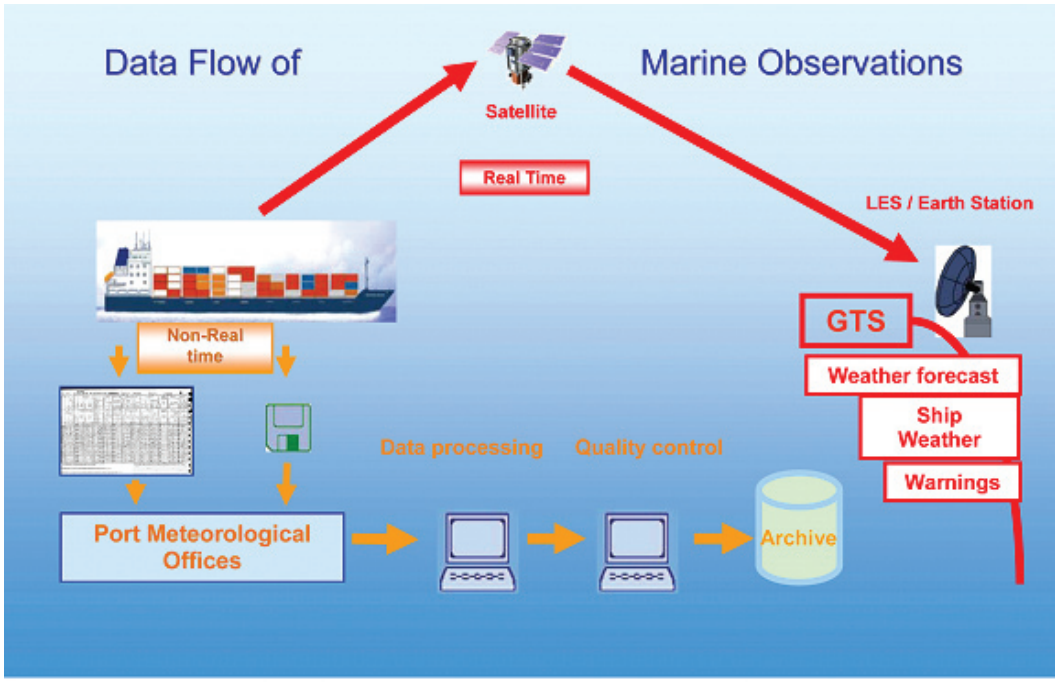

Fig. 3. Marine Data Flow.

DWD receives either in real time or within the delayed mode scheme, are processed, subjected to quality control and stored in the marine archive. Currently, this archive comprises more than 180 million data sets, increasing by at least another million every year. It is continuously being updated and forms the marine reference data base of the DWD. Figure 4 shows the amount of data stored in the ship observation archive.

Since von Neumayer's days, not only the amount of data has increased enormously. The possibilities of data processing, too, have evolved rapidly, especially thanks to the introduction of electronic data processing.

Application of marine meteorological data

Sailing instructions, ship weather routeing. Promotion and support for shipping in general was one of the main tasks of the Seewarte from the outset, as shown before. The institute advised ship masters on optimum routes for their voyages. The sailing instructions were elaborated using the marine weather observations that had been provided to the institute by the voluntary observers. Improvement of navigational safety, shorter transition times and increased economy were the main objectives. It is reported that by the aid of such instructions the gain in time during transatlantic journeys amounted to several days on average. A good example of a recommended route is the voyage from the Channel to Zanzibar and back.

Over the years, the routing service improved continuously. What must be mentioned, though, is that these instructions of the Seewarte were based solely on the climatological knowledge derived from the meteorological logbooks.

Later in the 20th century, the sailing instructions were complemented by meteorological forecasts. But medium range weather forecasts, as they are available nowadays, did not yet exist. The situation changed fundamentally with the advent of numerical weather prediction in the 1960s.

Since that time, ship weather routeing - as it is called today - has been based on numerical forecasts of winds, and later also waves, and a special routeing software, which is applied and continuously further developed by experts at the Marine Meteorological Office of DWD. This led to remarkable improvements. Calculations have revealed that meteorological ship routeing for westbound voyages saves about 2 to 3 per cent of the travel time on average, plus the further advantages of fuel saving and improved reli-

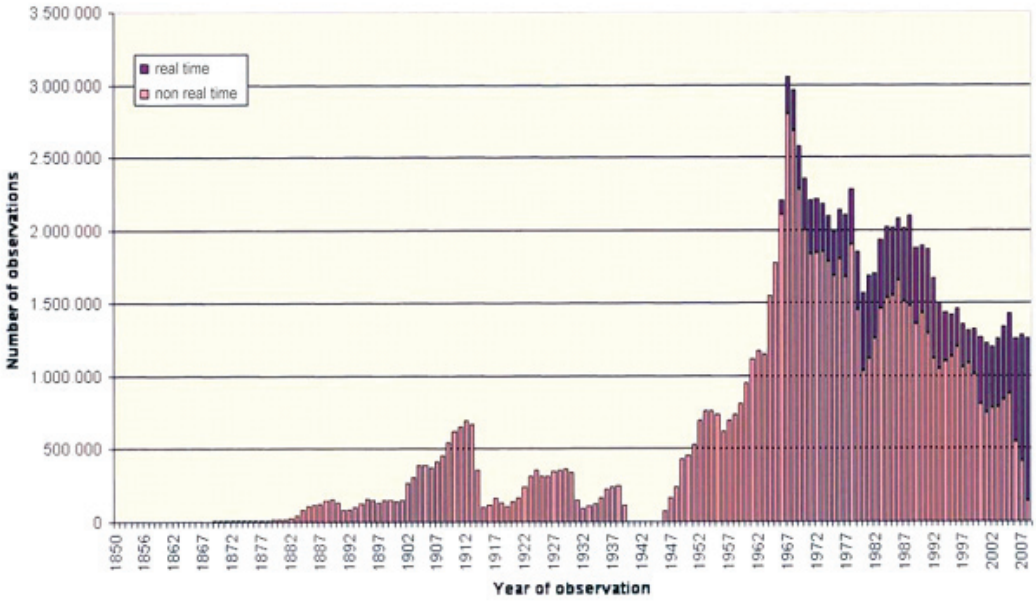

Fig. 4. Marine Meteorological Archive (Ship Observations, Dec. 2008).

ability of the time schedule. Ship routeing - although it is no longer free of charge as in the early days - is a good example of how deeply Georg von Neumayer and the Seewarte have influenced the evolution of these important and successful fields of work of the DWD's Marine Meteorological Office.

Sailing handbooks, climatological atlases and other marine climatological publications. Apart from individual sailing instructions, the Deutsche Seewarte, as part of its tasks, also prepared a number of marine climatological publications to support the German merchant fleet and shipping in general.

Of particular importance were the 'Sailing Handbooks'. They contained a combination of scientific evaluation of the observations, presentation of the results and practical ship routeing information. Presented in a clear and easily understandable way, they represented a great help to the bridge crews, explaining to captains that the observed weather phenomena were caused by air pressure systems and how they could conclude the appropriate course.

The first of these books was issued in 1885: the *Sailing Handbook for the Atlantic Ocean*. Eight years later, in 1893, it was followed by the *Handbook for the Indian Ocean* and, in 1897, by that for the Pacific. As an illustration, Figure 5 shows the 1899 edition of the Handbook for the Atlantic Ocean.

In addition to the sailing handbooks, the Deutsche Seewarte also issued monthly climatological charts for the oceans.

Later, when the era of sailing ships was superseded by that of the steam ships, the handbooks still kept their importance. They were renamed 'Sea Books' or 'Sea Handbooks'. Even today, it still is required by law that sea-going vessels must have such literature on board. The handbooks are published by the Federal Maritime and Hydrographic Agency, with the marine climatological parts being prepared by the Marine Meteorological Office of DWD in Hamburg.

With the amount of marine climatological data having increased considerably over the decades, the data processing tools, too, have improved rapidly and thus make the preparation of marine meteorological and climatological products by the DWD very efficient.

In this context, the Deutscher Wetterdienst offers quite a number of publications and periodicals for shipping purposes, global climatology and for the co-operation in the field of international marine climatology. A large part of these products are published on the DWD website at www.dwd.de.

Marine meteorological forecasts and storm warnings
As mentioned earlier, coastal meteorology and storm warnings for the German North Sea and Baltic Sea

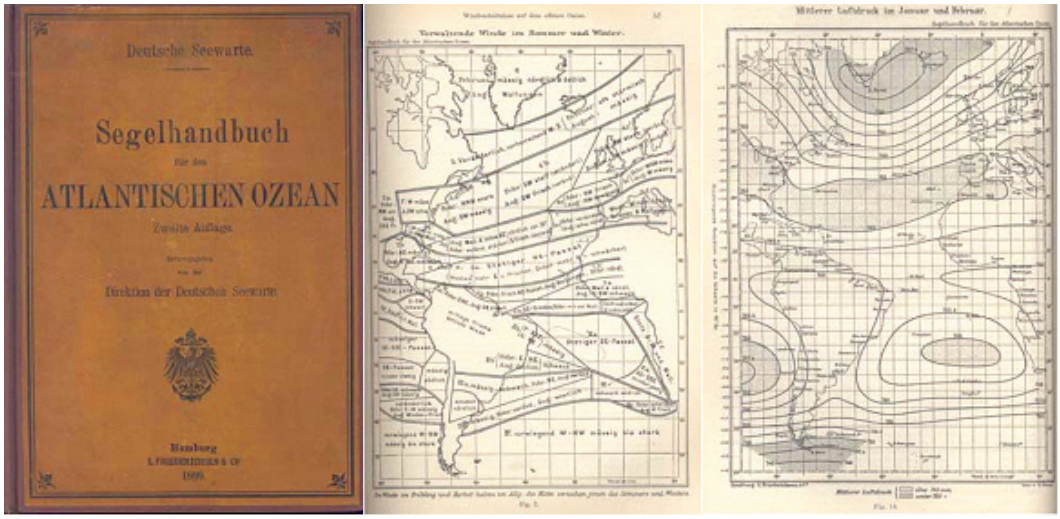

Fig. 5. Sailing Handbook for the Atlantic Ocean.

coasts belonged to the initial main tasks of the Deutsche Seewarte. Very soon, it became clear that reliable storm warnings could be achieved only on the basis of synoptic analyses and forecasts.

So the Seewarte performed pioneering work—and on the 1st of September 1876 it published its first official daily synoptic weather chart, including a forecast for the following day. An example of such a chart is given in Figure 6.

The required observational data from the European region were collected via telegraphy, a very modern method at that time.

In the following years, the Seewarte established a network of warning stations along the German coast from the island of Borkum in the west to the mouth of river Memel in the east. This network proved to be very successful. Class 2 signal stations gave qualitative information only by hoisting a ball, whereas class 1 stations provided detailed information on wind force and direction by setting a combination of ton, cone and flag.

Although weather information and gale warnings have been transmitted regularly by the coastal radio stations since 1907, the optical signal system had kept its importance for the coastal shipping for many decades, because not all of the sea-going ships were obliged to be equipped with RT units. In principle, this warning system stayed in operation until 1982. Today, the gale and storm warnings are transmitted by public broadcast stations as well as by the DWD transmitter Pinneberg near Hamburg. Furthermore, the information is also accessible via the internet (www.dwd.de).

The impetus which von Neumayer and the Seewarte have given in the field of coastal storm and severe weather warning was taken up by the Marine Meteorological Office of DWD: in 2005, it took on responsibility for NAVTEX (Navigational Warnings by Telex) in the North and Baltic Seas and acts as National NAVTEX Coordinator. Based on the 'International Convention for the Safety of Life at Sea' (SOLAS), the international NAVTEX Service was established as an important element of the 'Global Maritime Distress and Safety System' (GMDSS). NAVTEX transmits its information via RTTY on medium wave. Merchant shipping and pleasure boating are the main users. In Germany, NAVTEX is operated in co-operation with the Federal Maritime and Hydrographic Agency. The information is disseminated via the DWD transmitter Pinneberg.

Another important field of co-operation with the Federal Maritime and Hydrographic Agency concerns storm surge prediction for the German coastal areas. In order to elaborate reliable warnings this institute receives precise wind forecasts from the Marine Meteorological Office of DWD.

Marine meteorological and climatological research. Georg von Neumayer was always convinced that the work in an institute like the Deutsche Seewarte had to be based on sound scientific foundations. This can, for instance, be seen by the fact that he had established the post of a scientific meteorologist 'Meteorologe der Deutschen Seewarte', who had the rank of a head of department. Later, von Neumayer set up a special research department.

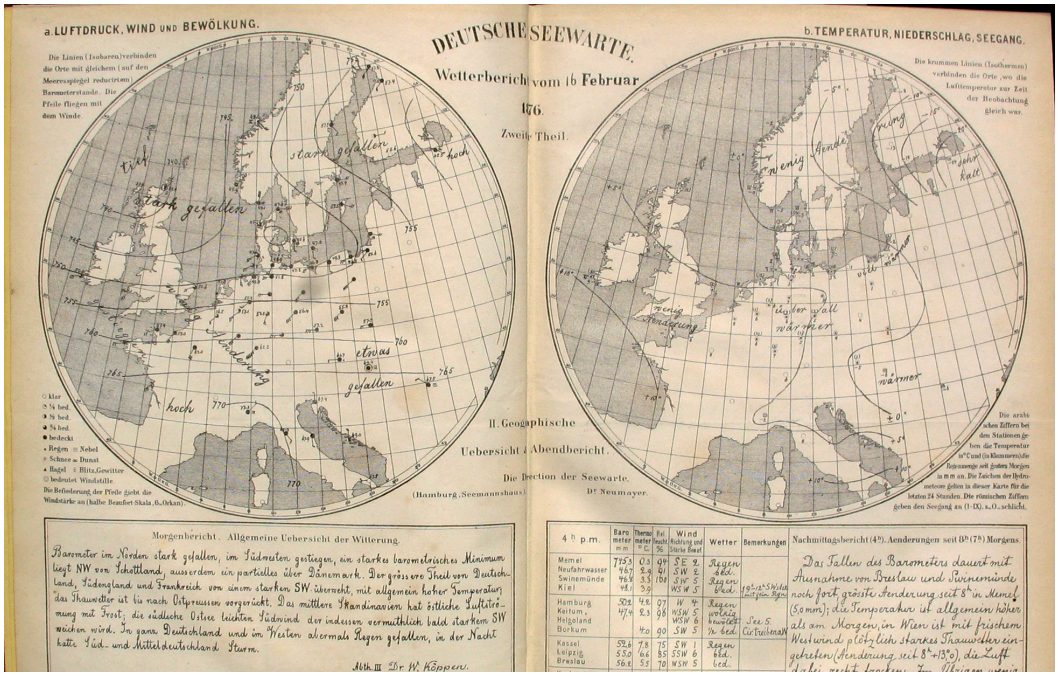

Fig. 6. First weather chart of 16 February 1876 with outlook for the next day issued by the Deutsche Seewarte (Source: Meteorological Institute, Munich).

It was this favourable 'research climate' which led to the remarkable scientific output of the institute. Also in this sense, the Marine Meteorological Office of DWD is in the tradition of the Seewarte and carries out scientific investigations, for instance on storms and waves, or research projects on coastal climatology. An important topic in the area of marine meteorological and climatological research currently is 'coastal protection'.

The potential impacts of climate change on the German shores, harbours, shipping and waterways in view, the DWD, together with the Federal Maritime and Hydrographic Agency, therefore plays a leading role in a comprehensive research project of the German Federal Ministry of Transport, Building and Urban Affairs.

CONCLUDING REMARKS

Georg von Neumayer undoubtedly is one of the most respected and distinguished scientists of his time. His achievements in the area of marine meteorological science and management are well recognised all over the world.

At a time when many things still had to be developed and agreed both on the national and international level, von Neumayer set up important organisational structures. He paved the way for meteorology to be placed in a governmental framework. With the establishment of the Deutsche Seewarte as an imperial institution, he laid the foundations for the future development of the German National Meteorological Service as a public institution.

According to his opinion, marine meteorological performance, development and progress had to be based on international co-operation, a requirement which is also reflected in the law of the Deutscher Wetterdienst. As stated earlier in this paper, division of labour in the worldwide community of National Meteorological Services is a fundamental prerequisite to solve the extensive and challenging tasks. Therefore, the Deutscher Wetterdienst contributes actively to international programs and projects. In the field of marine meteorology, many of these activities are coordinated by the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) in which the DWD is a reliable partner.

To conclude it can be said that in many respects Georg von Neumayer can be seen as a pioneer of our modern, efficient and effective structures of marine meteorology at the DWD. There is no doubt that these influences will continue to be of great benefit to the Deutscher Wetterdienst and also to the related Services in the future.