Meteorology as Nationalism on the German Atlantic Expedition, 1925-1927

Penelope K. Hardy
hardyp1@xavier.edu
Xavier University

> "*. . .* it is possible not only to give a powerful impetus to our own research activity, but at the same time to give thought to the views of our rivals and offer the world a new, permanent impression of the irrepressible German potential and scientific proficiency. . . . Our rivals may very well drive the German flag from the ocean by forcing us to give up our naval and merchant fleet, but they cannot stop us from rehabilitating it again and earning recognition for it through a great cultural act. An oceanographic expedition is thus equally in the interests of Germany and German science*."*
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> -- *Fritz Spiess*[1]

Introduction

In 1925, the naval research and survey ship *Meteor* left Germany on a two-year mission. Though owned by the German navy, led by naval captain Fritz Spiess, and crewed by naval personnel, *Meteor* was not a traditional warship, and its mission was not in line with traditional naval strategy. Instead of weapons, *Meteor* carried the tools of a team of scientists who would, with their naval colleagues, spend the next two years crisscrossing the Atlantic Ocean in the name of atmospheric and oceanographic science. At the same time, it served other purposes—individual, institutional, and political. Chief among these was a dedication to German nationalism in the wake of the country's devastating Great War loss.

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[1] Spiess, *The Meteor Expedition: Scientific Results of the German Atlantic Expedition, 1925-1927*, trans. ed. William J. Emery (New Delhi: Amerind Publishing Co., 1985), 10-11.

The popular tendency is often to portray scientists—and for scientists to portray themselves—as either naively surprised by their work's geopolitical ramifications or uneasily forced to compromise to gain patronage, even if scholars recognize these tropes as rationalizations.[2] In the usual chronology, the emergence of this relationship in the earth sciences is sited in the twentieth century's middle decades, when, as Matthew Henry has noted, "Cold War funding meant the emergence of new roles for scientists as agents of foreign policy, and the framing of their science as a symbol of a politically loaded technological superiority." In the case of New Zealand, Henry instead sites that shift earlier, at the interwar intersection of meteorology and political power.[3]

An examination of the *Meteor* expedition supports this earlier placement.[4] The expedition was a joint project of the Reichsmarine—the Weimar-era Germany navy—and a coalition of scientists and their supporters. Planners from both these groups embraced nationalist goals from the expedition's very conception. By cooperating to do science on, under, and above the Atlantic, they cooperated to regain prestige both for their constituent organizations and individuals, and for their nation on the world stage, goals that were reflected in every facet of the expedition—its science, its logistics, and its public relations. Their meteorological and oceanographic endeavors would lay symbolic claim to the Atlantic Ocean and the airspace above it, while participating in neocolonial efforts to replace the empire denied them after the war. As Sheila Jasanoff and other scholars have noted, "science and technology can be fruitfully studied as social practices geared to the establishment of varied kinds of structure and authority."[5] The *Meteor* expedition's outcome thus represent a co-production of scientific knowledge of the ocean and the atmosphere and of a data-based German power over them, a metaphorical seizure of territory that would position German scientists as inheritors of a tradition of expeditionary science and place Germany back amongst the Great Powers scientifically. At the same time, this scientific

[2] Chandra Mukerji has examined this murky compromise between patronage and control over research in the case of oceanographers and the United States government in *A Fragile Power: Scientists and the State* (Princeton, N.J. : Princeton University Press, 1989).

[3] Henry, "Australasian Airspace: Meteorology, and the practical Geopolitics, of Australasian Airspace, 1935-1940," ch 12 in *Climate, Science, and Colonization: Histories from Australia and New Zealand*, ed. James Beattie, Emily O'Gorman, and Matthew Henry, 233-250 (New York: Palgrave McMillan, 2014), 236.

[4] Arguably scientists had always been agents of foreign policy, at least in the expeditionary sciences. In his meteorological and oceanographic projects in the 1840s and 1850s, US Navy lieutenant Matthew Fontaine Maury certainly pursued linked scientific and political goals, though in a period where "scientist" was a less well-defined category. The British Challenger Expedition in the 1870s, jointly sponsored by the Royal Society of London and the Royal Navy, was clearly an imperial project. Penelope K. Hardy, "Every Ship a Floating Observatory: Matthew Fontaine Maury and the Acquisition of Knowledge at Sea," ch 1 in *Soundings and Crossings: Doing Science at Sea 1800-1970*, ed. Katharine Anderson and Helen M. Rozwadowski, 17-48 (Sagamore Beach, MA: Science History Publications/Watson Publishing International) and Hardy, "Where Science Meets the Sea: Research Vessels and the Construction of Knowledge in the Nineteenth and Twentieth Centuries," (PhD diss., Johns Hopkins University, 2017).

[5] Jasanoff, "Ordering Knowledge, Ordering Society," Ch 2 in *States of Knowledge: The Co-production of Science and Social Order*, ed. Jasanoff, 13-45 (London: Routledge, 2004), 17.

knowledge would lay the groundwork for the German military resurgence that would soon follow.

Background

Opportunities for scientists—and especially Europeans—to do science at sea were greatly curtailed during the Great War. This limitation was caused both by the problem of safety in an environment of unrestricted submarine warfare and by the massive redirection of resources—both materiel and personnel—required by the participating countries' war efforts. In Germany, following a model which would become standard for many nations later in the century, the navy enlisted the help of scientists to study conditions German warships and submarines were likely to encounter.[6] Among these was Alfred Merz.

Before the war, Merz had been a rising star in limnology, oceanography, and climatology, particularly interested in large-scale, ocean-atmosphere systems. He did graduate work in the Adriatic, then rose through the ranks at the Institut für Meereskunde (IfM)—the Institute for Oceanography—in Berlin, leading his students on field trips to local lakes and eventually the North Sea and Baltic, where he spent time developing instruments to measure temperature and current and dynamical methods to process the data. By 1915, he had developed a theoretical conception of tidal dynamics in the North Sea that allowed him to turn the few known statistics on tidal heights into precise tidal charts for the area at the Imperial Navy's behest, a task that occupied him until 1918. While this work remained useful to science, in that his results proved the validity of his methods, its benefit to the war effort was obvious and immediate. At the same time, he continued thermometrical work close to shore in an effort to better understand the surface interface between air and water. The relationship thus developed with the navy led to the post-war establishment of a working group involving the IfM, of which Merz became director in 1921, and the Deutsche Seewarte—the German Hydrographic Office, sometimes called the Naval Observatory—in Hamburg, to continue North Sea tidal research.[7]

The navy's own resources and personnel had obviously been thoroughly enmeshed in the war effort. In its aftermath the service suffered both the actual losses of combat and those imposed by the punitive restrictions of the Treaty of Versailles. These losses stung, and they were aggravated in the early 1920s by Germany's ongoing economic woes and by the loss of

[6] For the relationship between the US navy and oceanographers, see Gary E. Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment* (College Station: Texas A & M University Press, 2001). See also Mukerji, *Fragile Power.*

[7] Norbert Krebs, "Alfred Merz [Obituary]," *Geographische Zeitschrift*, 32. Jahrg. 1. H. (1926): 1-6; Reinhard Hoheisel-Huxmann, *Die Deutsche Atlantische Expedition 1925-1927: Planung und Verlauf* (Hamburg: Convent Verlag, 2007), 38. On the Deutsche Seewarte, see Heinrich Walle, though he ignores the shifts between military and civilian control during the World Wars, "Die Deutsche Seewarte," *Marine-Forum: Ausgabe A: offizielles Organ der Marine-Offizier-Vereinigung* 10 (2004): 26-28.

political prestige under the new, republican government for a service whose officers had been solidly monarchist.[8] Thanks in part to the large role naval troops had played in and the reactions of naval leadership to both the 1918 revolution that brought the Weimar government to power and the 1920 Kapp Putsch which attempted to overthrow it, public and government confidence in the navy remained low.[9] Because the German Peace Delegation had considered renouncing all warships before the navy took things into its own hands and scuttled most of them at Skapa Flow, historian Keith Bird has argued that the Versailles Treaty's severe restrictions may have paradoxically "saved the German navy from extinction."[10] By 1920, "[i]n government and civilian circles, a pronounced lack of faith in the navy's ability to perform even the simplest task was quite widespread."[11]

The treaty restrictions severely limited the numbers and classes of ships the navy could operate, which orphaned some unfinished new construction in the slips. Such was the fate of new construction gunboat "C", begun during the war but left unfinished, and now, because of the Versailles quotas, unfinishable as a warship. A quick-thinking naval hydrographer suggested commissioning it instead as a survey and research vessel, and the hull—moved hastily from the forfeited port of Gdańsk to Kiel—was finished accordingly, though much interior work was left to complete.[12] At heart, though, the navy was still working strategically to counter the various indignities of Versailles. Though publically they appeared only to be shuffling survey ships—they would complete and keep the new vessel in place of an older one allowed under Versailles—they consciously kept open the possibility of arming it in future. Many within the navy were also suggesting a large-scale trip abroad, to show the flag in as many ports as possible and thus project the image of a navy—and nation—that still mattered on the world stage.

The Deutsche Pazifische Expedition

With this desire in mind, oceanographer Gerhard Schott at the Deutsche Seewarte drafted a proposal for an expedition to the Pacific, aimed mainly at the navy's flag-showing requirement. Science was a secondary concern; the proposed trip would fill gaps left in the observational record by earlier voyages. In its broad, observational approach and imperial ambitions, the planned voyage would thus have resembled that of the British HMS *Challenger* fifty years earlier. The navy asked Albrecht Penck, Merz's mentor and his superior at the IfM, to comment on Schott's proposal and perhaps suggest an alternative. Penck delegated the task to Merz.

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[8] Keith W. Bird, *Weimar, the German Naval Officer Corps and the Rise of National Socialism* (Amsterdam: B. R. Grüner, 1977), especially 141.
[9] Bird, *Weimar*, 9-10; 67-70.
[10] Bird, *Weimar*, 65.
[11] Bird, *Weimar,* 112.
[12] "Die Deutsche Atlantische Expedition auf dem Vermessungs- und Forschungsschiff "Meteor": I. Bericht," *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 5/6 (1926): 1.

Merz agreed with the navy's concern for German visibility on the world stage, though he framed the problem through his own experience as a scientist.[13] Without funding, limited in their access to field sites thanks to the loss of colonies, and shunned from participation in international scientific endeavors, Merz warned that German scientists would appear to be out of touch with first-rate science, an image he feared would increasingly become reality as the lack of research opportunities took its toll.[14] Addressing a major, interdisciplinary scientific problem on a global scale would prove Germans' ability to do good science and do so in a very public way. The global ocean provided just such a problem, and was itself a field site from which Germany could not be excluded. Merz suggested a three-year program of observations organized around a series of inter-related questions which grew from his own scientific interests, including the origin of oceans and continents, the general circulation of water in the oceans and of air in the atmosphere, a better understanding of ocean tides, a clearer picture of the ocean's bottom contours and of benthic tectonic activity, and a better understanding of the makeup of seawater.

The navy liked Merz's plan—though this preference may have laid the seeds for later contention between the IfM and Seewarte—and commenced planning. Of primary concern was the vast distances involved; the ship would need to be able to cruise between eight and nine thousand nautical miles before refueling. As currently configured, the former gunship "C"—now the research and survey ship *Meteor*—could not carry enough coal to fire its boilers over such distances. Pacific coaling stations were few and far between, so a naval shipyard was tasked with considering *Meteor*'s conversion to oil-fired boilers to handle the great distances involved. Unfortunately, such a change—exchanging boilers for diesel engine, tightening the coal bunkers to instead hold oil, and changing the rig on the auxiliary sails—would increase the still-ongoing construction costs by twenty percent, or three million extra marks. The hard-pressed post-war navy simply could not manage the sum, and the Weimar government did not share Merz's and the navy's sense of urgency for the task, given everything else left to rebuild in the war's wake. The plan for a grand "Deutsche Pazifische Expedition" was dropped.

The Notgemeinschaft Der Deutschen Wissenschaft

In January 1924, Merz attended a meeting of the Notgemeinschaft der Deutschen Wissenschaft—the Emergency Committee for German Science—chaired by Prussian minister of culture Friedrich Schmidt-Ott. The Notgemeinschaft was a non-governmental organization with

[13] This account of Pacific expedition plan relies on Hoheisel-Huxmann, *Deutsche Atlantische Expedition,* 7-13.
[14] On the postwar exclusion of German scientists from international scientific efforts, see Daniel Kevles, "'Into Hostile Political Camps': The Reorganisation of International Science in World War I," *Isis* 62 (1971): 47-60. On the impact of the loss of colonial field sites for German climatology, see Philipp Lehmann's contribution to this issue: "Losing the Field: Franz Thorbecke and (Post)Colonial Climatology in Germany," *History of Meteorology* 8 (2017): 145–158.

a commitment to fund German science, formed in the war's immediate aftermath by leading scientists of the Prussian Academy of Scientists who shared Merz's fear that Germany was in danger of falling from the ranks of first-rate scientific powers. Schmidt-Ott echoed that fear, complaining that while he received many requests for support, they did not include any "really visionary ones." Merz, no doubt disheartened by the failure of the proposed Pacific expedition, insisted such ideas existed, but scientists held no hope of getting them financed. When Schmidt-Ott assured him funds could be found for the proper project, Merz pitched a version of the proposal he had offered to the navy.[15]

Since the original project had foundered on the immense distances of the Pacific, the new proposal stayed in the Atlantic, a region better known but more easily reachable. A thorough study with a close network of stations could build on the long-term studies already accomplished and on Merz's own work on large-scale atmospheric and oceanic circulation. The voyage could incorporate the work of other leading scientists, such as Alfred Wegener's meteorology and Fritz Haber's chemistry, and these three areas would contribute to understanding the biology of the Atlantic. The navy would no doubt be interested in pursuing hydrographical investigations, since they still wanted an excuse to send their new survey ship abroad, making the proposed expedition a broad effort to renew German relevance on almost every scientific front. Indeed, Merz's proposal used the language of conquest. The Atlantic, he said, was "a free field for exploration" to which Germany "must set about laying claim."[16]

Schmidt-Ott was hooked, and asked Merz to write a formal proposal.[17] Merz, worried after the earlier failure of earning a reputation with the navy as a "maker of empty projects," first approached personal contacts in the navy seeking details of the ship's capabilities and a frank appraisal of the plan's likelihood to gain the support of naval leadership. With their encouragement, Merz worked up a preliminary proposal.[18]

The prospect of sharing costs made the proposal more palatable to both navy and Notgemeinschaft. Over the next several months, they discussed expedition logistics, focusing largely on whether to make one long voyage or several short ones, with time at home in between. Advocates for the latter hoped time in between would allow not only processing of results but also refinement of methods and a redirection of efforts and focus based on those results. (They also feared participants' performance would decline on a long duration mission.) Merz, though,

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[15] "Abschrift der Aufzeichnungen von Prof.Dr. A. Merz über die Verhandlungen bei der Planlegung der Deutschen Atlantischen Expedition," N167-19, Auftrag Nr. 729, Bundesarchiv-Militärarchiv, Freiburg im Breisgau, Germany (hereafter BMF).

[16] Spiess, *Meteor Expedition*, 7. German planning was co-incident with French meteorological voyages on the training ship *Jacques Cartier* and a British effort to establish a global network of ship-based meteorological observations. These no doubt influenced the German perception of a scramble for the Atlantic. Katharine Anderson, "Marine Meteorology: Observing Regimes and Global Visions, 1918-1939," *Soundings and Crossings*, 213-244.

[17] "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF.

[18] "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF.

pressed consistently for one, unbroken trip, fearing—probably rightly—that if they once returned home, the funds for future legs would evaporate.[19] He was eventually successful.

Staffing the voyage required extensive discussion, tied obviously to the planning of the research agenda but also to jockeying between the institutions contributing plans and expertise to the voyage. In addition to the Notgemeinschaft, Merz's IfM, the participating scientists' universities, and the navy, this included the Deutsche Seewarte, which following the war had been removed from navy control and assigned to the Ministry of Transportation. Erich von Drygalski, the scientist who had led the German South Polar expedition on the *Gauss* in the late 1880s and was now associated with the Academy of Science and the Geographical Society, was also invited to participate. Hugo Hergesell, who had developed methods for ocean-going meteorology aboard Prince Albert of Monaco's yachts twenty years earlier, joined to plan the expedition's meteorology.[20]

As the *Meteor*'s overhaul already included seven cabins for scientists, Merz proposed a lead scientist, two hydrographers, two chemists, and two meteorologists. The ship's doctor could double as an expedition biologist. The scientists would assist with sample collection, rather than restricting themselves to laboratory work, and naval personnel would train as lab assistants. Merz pushed for the selection of young, up-and-coming scientists who could be future leaders in their fields. Though the group debated inclusion of various sub-specialities, and these were tied to the coordination of specific scientific measurements and sampling in the work plan, the discussion was for the most part congenial. [21] Merz was eventually confirmed as expedition leader and given final authority to choose personnel, though he sought the input of the others on the suitability of men in their respective fields.[22] In addition to Merz, four oceanographers, a biologist, a geologist, a chemist, and two meteorologists eventually embarked.[23]

Making the *Meteor*

The *Meteor* was 75 meters long, 4 meters in draft, and displaced 1200 tons. As originally planned, its middle deck would have bristled with side guns between superstructure and stern. Their absence left room to accommodate the scientific staff. The new "residential deck" contained nine scientific staterooms, a laboratory, and a drafting room.[24] The ship was furnished with "beautiful functional interior decor done in the most beautiful wood." It was decorated with

[19] "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF.
[20] Hardy, "Where Science Meets the Sea."
[21] "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF.
[22] "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF.
[23] "Die Deutsche Atlantische Expedition auf dem Vermessungs- und Forschungsschiff "Meteor": I. Bericht," *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 5/6 (1926): 4.
[24] "Die Deutsche Atlantische Expedition . . . I. Bericht," 6-7.

"[a]ttractive items," including a piano and gramophone. Shipbuilders generally avoid wood on modern warships for fire safety reasons, but it was included here not just for the comfort of the scientists or to make the space esthetically pleasing over the cruise's long duration, but also because of the ship's ulterior mission, to show German pride abroad. The tastefully appointed interior allowed them to "exhibit this decor to the outside world" when officials and scientists of recently adversarial nations as well as German expatriates toured the ship in foreign ports. The efficacy of keeping up such appearances was later clear when "[i]n the foreign press our laboratory was termed 'a wonder of a floating laboratory.'"[25]

That wondrous laboratory, which had been "furnished according to the wishes of the individual scientists" provided chemical, biological, and geological workstations, as well as accommodations for two laboratory technicians. Each workstation was provided with fresh and salt water and electrical power, and the lab was well equipped with a chemical stove with fume extraction, three electrical centrifuges, microscopes—including a polarizing microscope, gas analysis equipment, geological elutriation apparatus, and a plethora of storage cabinets, racks, and containers. The nearby drafting room provided work stations for two oceanographers equipped for titration, room for the meteorological equipment, and a drafting and calculating table for cartographic and calculating work. This room also housed read-outs for the remote measuring anemometer, air thermometer, and water thermometer. A comprehensive map file, scientific expedition library, and a card file of known oceanographic data completed the equipment.[26] On the lower deck, a dark room was equipped to handle both still and cinematographic film, which would be used to study the flight of sea birds in slow motion, and also contained a recording apparatus for stereographic wave studies.[27]

As presented later in Spiess's official account, the expedition was a curious mix of rigor and resourcefulness. The participating institutions collaborated to procure instruments. Much of the naval equipment had come from an old cruiser, but this was largely obsolete and required supplementation or modernization. The navy procured the necessary ropes and cables, while oceanographic gear was arranged through the IfM. The Seewarte and the observatory in Lindenberg provided or procured meteorological equipment, the Kaiser-Wilhelm Institute chemical equipment, and the State Zoological Museum in Hamburg biological equipment. Instruments developed for previous expeditions were improved, and the expedition members often developed instruments in their areas of expertise, a task no doubt helped by the long lead time and relatively early identification of team members.[28] The larger equipment was manufactured ashore, typically by corporate—when possible German—makers. But the captain stressed their ability to improvise and make do. On a mission of such length and duration, and with resupply and repair limited by the financial resources of their sponsors, the *Meteor*

[25] Spiess, *Meteor Expedition*, 31-32.
[26] "Die Deutsche Atlantische Expedition . . . I. Bericht," 6-7.
[27] "Die Deutsche Atlantische Expedition . . . I. Bericht," 6-7.
[28] Spiess, *Meteor Expedition, 28.*

personnel had to necessarily be self-sufficient. The ship carried its own machine shop for major repairs; a precision mechanical workshop for instrument crafting and repair was added for the expedition.[29] A "well-trained precision mechanic" accompanied the expedition and was "responsible for maintenance of all scientific equipment and instruments."[30] A glassblowing lamp allowed repair of glass apparatus and the manufacture of new instruments, such as a special inspection tube for measuring water visibility depth from a small boat.[31]

The upper deck held three motor lifeboats, four sounding machines of various types, a meteorological kite winch, and special anchoring equipment designed to hold the ship fast in deeper water than ever attempted. In addition to the kites, the ship could launch balloons, filled from hydrogen cylinders carried aboard, which could in turn be refilled with hydrogen electrolyzed from seawater.[32] While no longer a gunboat, the ship carried a "wind gun," designed to shoot smoke cartridges as high as 7500 m altitude, allowing observation of wind speed and direction when clouds made tracking pilot balloons impossible. The ship also carried small arms and harpoons, which were later used from a small boat in an attempt to catch a whale; at this the unpracticed crewmembers had no success.[33]

If *Meteor*'s outfitting reflected the balancing act the navy was playing with the requirements of Versailles, it demonstrated as well the commercialization and corporatization of science in the first decades of the twentieth century. Where the earlier expeditions' instruments had borne the names of individual designers, *Meteor*'s instruments often came from commercial makers and bore company names. These were, whenever possible, Germany companies. The photographic instruments and film were donated by the Aktiengesellschaft für Anilinfabrikation, better known as Agfa.[34] *Meteor* carried two new echo-sounding devices. One was of completely German origin, developed by the Kiel-based Signalgesellschaft and thus named the Signal sounder. The other was a product of the Submarine Signal Corporation in Boston, Massachusetts, sold to the Atlaswerke in Bremen and renamed the Atlas sounder.[35]

To back up and verify the echo sounders, *Meteor* carried two line sounders: a Thomson sounding machine, originally developed by Lord Kelvin in the 1870s, and a Lucas machine, designed in the 1880s. *Meteor*'s sampling lines used reversing thermometers and messenger-operated sampling gear that would not have appeared unfamiliar to earlier expeditions. Merz's home-grown tidal current meters, developed during his North Sea work, were deployed

[29] "Die Deutsche Atlantische Expedition . . . I. Bericht," 6-7.
[30] Spiess, *Meteor Expedition,* 23.
[31] Spiess, *Meteor Expedition,* 169; "Die Deutsche Atlantische Expedition auf dem Vermessungs- und Forschungsschiff "Meteor": II. Bericht." *Zeitschrift der Gesellschaft für Erdkunde zu Berlin*, 5/6 (1926): 211.
[32] "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF; Spiess, *Meteor Expedition*, 67.
[33] Spiess, *Meteor Expedition*, 67, 155.
[34] Spiess, *Meteor Expedition*, 393.
[35] Sabine Höhler, "Depth Records and Ocean Volumes: Ocean Profiling by Sounding Technology, 1850-1930," *History and Technology* 18, no. 2 (2002): 140.

alongside their commercially-developed cousins.[36] Thus for both technological and budgetary reasons, they had, as Spiess put it, "a strange combination of old and new on our ship. While on one side [it] had sailing arrangements and old model drive, on the other hand [it] had the most modern equipment on board: gyrocompass, radio direction finder, echo sounder—a mixture of the oldest and the latest."[37]

Assembling the expedition

Meteor was finally placed in commission in November 1924, officially the first new German naval vessel completed since the war, but ten years and nine months after construction had begun.[38] This long-delayed completion allowed many physical changes to the ship as it was adapted and readapted for its evolving mission. Alongside changes to the working and living accommodations, the propulsion systems evolved significantly. With the planned diesel conversion abandoned, the ship retained a coal-fired steam system supplemented by sail. In order to increase range, two of the four original boilers were removed, allowing enlarged coal bunkering capacity.[39] A smaller, auxiliary boiler for in-port use would reduce coal consumption and allow downtime for main boiler maintenance. A diesel generator powered shipboard electrical systems to further reduce coal consumption. Two meters added smokestack height improved exhaust gas flow as well as conditions on deck, where ash and flue gases sometimes interfered with the scientists' work. Propeller efficiency was improved. At the same time, the ship's sailing rig was modified to a full-rigged forward mast with three square sails. When cruising range still fell short of requirements, a petty officer's cabin was converted into an additional coal bunker, and storage space was found on deck for another 50 tons. *Meteor* now carried 440 tons of coal, providing a theoretical steaming range of 6800 nm.[40]

The long lead time caused by the expedition's shaky financial start allowed thorough preparation by scientists and naval personnel. Merz and his students had assembled every previous hydrographic observation they could find into a comprehensive card file, as well as preparing current maps and salinity and temperature sections from known data. Meanwhile, naval personnel received special training to allow them to undertake or assist with their own scientific assignments. Ship's officers were responsible for astronomical and geomagnetic work, photography and cinematography, and the measurement of electrical potential. Ship's personnel also operated the sonar equipment, rapidly becoming experts in the new technology. Senior non-commissioned officers served as assistants and draftsmen for oceanographic work, chemistry,

[36] Krebs, "Alfred Merz," 1-6.
[37] Spiess, *Meteor Expedition*, 63.
[38] Hoheisel-Huxmann, *Deutsche Atlantische Expedition,* 20.
[39] "Die Deutsche Atlantische Expedition . . . I. Bericht," 9.
[40] "Die Deutsche Atlantische Expedition . . . I. Bericht," 25-26.

and meteorological kite and balloon handling.[41] Six non-scientist civilian employees also embarked, though their identities and roles are poorly recorded. They likely filled roles as assistants, mechanics, and "invisible technicians."[42]

Spiess reported consistent professional behavior and no strain between the various groups of personnel beyond that expected among any large number of human beings constrained to close quarters over an extended period. However, very little exists with which to check this claim. The Meteor Commission kept tight control on publications, reserving ownership of all output except the hydrographic products belonging to the navy.[43] This was not unprecedented, but it meant this expedition did not spawn the flurry of unofficial accounts that followed the *Challenger* Expedition.

The expedition suffered a major leadership challenge when, after the first leg of the journey, Merz fell ill. He tried to remain on board to supervise the oceanographic work from his sickbed, but was soon returned to Rio de Janeiro, the nearest port, for treatment at the German hospital. The expedition proceeded with Spiess in nominal command of both ship and science, until a telegram six weeks later informed them of Merz's death. The scientists apparently asked Spiess to retain scientific leadership, a decision with which their backers in Germany eventually concurred.[44] It is unclear if this arrangement had been discussed in advance. Despite Merz's history of illness, the commission had let him evaluate his own fitness for the long voyage; perhaps, whether because of this history or simply because travel at sea and to foreign ports involved certain risks even for the healthy, they had established a continuity plan for the mission.[45] It is also possible that the scientists could come to no consensus allowing one of them to step into a superior position, so the naval officer who already commanded the ship seemed a compromise. Either way, Spiess appears to have been a good choice. Though not a trained scientist, he had been involved in the planning from the beginning, and he understood the work and its goals. He conscientiously continued the scientific plan to the best of the ship's ability, expressly considering Merz's original instructions whenever modifications had to be made.

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[41] "Die Deutsche Atlantische Expedition . . . I. Bericht," 7.

[42] "Die Deutsche Atlantische Expedition . . . I. Bericht," 7. For invisible technicians, see Steven Shapin, "The Invisible Technician," *American Scientist* 77, no. 6 (1989): 554-563.

[43] This policy is discussed in numerous places, among them Albrecht Penck to Spiess, 9 October 1925, N167-16, Auftrag Nr. 729, BMF. A four-page document outlining the principles under which the expedition results would be published was drafted after discussion amongst the principals; "Grundsätze für die Aufbau und Umfang des wissenschaftlichen Expeditions-Werkes der Deutschen Atlantischen Expedition," N167-19, Auftrag Nr. 729, BMF.

[44] Spiess reports being approached by Hentschel and Reger, the "two oldest scientists," Spiess, *Meteor Expedition*, 130. The committee's endorsement was conveyed by letter; Penck to Spiess, 9 October 1925, N167-16, Auftrag Nr. 729, BMF. Penck also made sure the navy endorsed the plan; Penck to Spiess, 13 October 1925, N167-16, Auftrag Nr. 729, BMF.

[45] On Merz making the fitness decision, "Abschrift der Aufzeichnungen," N167-19, Auftrag Nr. 729, BMF.

Doing science at sea

Much of the scientific work of the expedition was organized around stations, as had become the standard for oceanographic work. These 300 sampling points were arranged along fourteen latitudinal cross-sections of the Atlantic, called "profiles," ranging from about 20ºN to below 60ºS. At the end of each profile, the ship would visit ports along the South American and African coasts, allowing time for replenishment and repair, but also crew leave, scientific expeditions ashore, visits with local scientific and political connections, and other activities. The profiles had been planned according to expected climatic conditions over the course of the two-year expedition, visiting the furthest southern latitudes, for instance, during the southern hemispheric summer, and accounting for seasonal variations in the trade winds elsewhere. Echo sounding and some surface and meteorological work continued at and between stations.

A typical station involved lowering numerous thermometers and sample bottles via a large winch on the aft deck; another winch forward was available as backup. Each carried 8000 m of aluminum-bronze stranded wire rope, with a high tensile strength and an 830-kg breaking strength. The aluminum-bronze alloy meant the line required no grease to prevent corrosion. Sample bottles were spaced along the line at intervals, their number determined by the depth, and each could be triggered in sequence by a falling weight to capture seawater.[46] Once preliminary contamination checks were done, the samples were secured for further analysis in port, where chlorine titration—conducted by one of the scientists or a crew member trained for the task—allowed the calculation of salinity. The lines carried reversing thermometers, both pressure-protected and unprotected, at the same points as the water samples. Once the line reached the desired depth, it would be left for twenty minutes for the thermometers to register accurately. A messenger weight sent down the line would then trigger both water sample capture and the thermometers' reversal, locking the temperature reading at depth. The resulting temperature and salinity data together provided useful information about the movement of water throughout the ocean. Comparison of the protected thermometer with the unprotected, which was thus affected by pressure, provided a calculated depth based on the known effect of pressure on temperature and the regular increase of pressure with depth, which could double-check the sounding line. Thermometers could be calibrated in port with a bucket of ice water. To check that the water samplers closed at the desired depth, the resulting samples were analyzed for hydrogen ion concentration, which also varies regularly with depth.[47]

[46] Spiess, *Meteor Expedition*, 94-5.
[47] Spiess, *Meteor Expedition*, 96, 99.

A four-liter bottle at the bottom of the line was rigged to sample seawater with no contact with metal.[48] These samples—1,282 in total—were intended to allow very precise measurement of the precious metal content of seawater, a pursuit which was central to Haber's chemical program. He hoped gold could be distilled from seawater to erase the massive war reparations imposed by the victors at Versailles, which were wreaking havoc with the German economy.[49] Onboard analysis proved inconclusive, so the samples were shipped back to the Kaiser-Wilhelm Institute in Berlin, where further analysis proved Haber's dream elusive. Sampling found the gold content of seawater to be about 10^{-9}g/kg, or, as Spiess noted, "one hundred-thousandth part of a milligram" per kilogram of seawater. Distilling it would thus cost far more than it gained.[50] Seawater would not be the answer to Germany's financial woes.

To study the ocean bottom, a cylindrical steel tube containing a glass tube was attached to the 10-km piano wire of the Lukas sounder, and dropped into the sea with a sink weight sufficient to ram it into the bottom. A spring sensed contact and stopped the drum paying out the sounding line. The depth could then be read before retrieval. Unlike some earlier samplers, the weight was raised with the tube, allowing its reuse and obviating the need to haul disposable weights; Spiess calculated that over the course of the trip this saved the need to carry 12,000 kg of weights. The tube was closed on the bottom to prevent loss or contamination of the sample, thus retrieving not only bottom material but also the water in contact with it. When it reached the surface, the glass tube was removed from the steel one and sealed with rubber corks at each end. Bottom core samples averaged greater than 50 cm in length, with some exceeding 90 cm. The glass tube allowed observation of the sample's stratification before it was removed and cut in half lengthwise, with half retained for analysis onboard and the other half secured in paraffin for analysis in Germany. In bottoms too sandy to successfully secure a core, a grab sampler enclosed a four-liter bottom sample in two bowl-like scoops. Color, oxidation, calcium content, and particle size analysis allowed the scientists to compare with surface plankton sampling and to integrate geology into their study of currents.[51]

Because of the need for multiple water and temperature samples over great depths, a station usually involved the taking of three series of samples, in shallow, intermediate, and deep water. Merz had estimated each station would take ten to twelve hours, but with practice they averaged eight to nine, and as few as six when the weather was fine. Meanwhile the biologists performed net catches on the surface and in shallow water.[52]

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[48] Spiess, *Meteor Expedition*, 94-5.

[49] Ralf Hahn, *Gold aus dem Meer: Die Forschungen des Nobelpreisträgers Fritz Haber in den Jahren 1922-1927* (Berlin: Verlag für Geschichte der Naturwissenschaften und der Technik, 1999), 33.

[50] Spiess, *Meteor Expedition*, 353-354. As Haber put it, "Die Aussicht auf eine Nutzbarmachung des Meerwassers zur Goldgewinnung ist geschwunden." Quoted in Hahn, *Gold aus dem Meer*, 80.

[51] Spiess, *Meteor Expedition*, 153.

[52] Spiess, *Meteor Expedition*, 99.

The bulk of biology work on the voyage consisted of plankton studies. Plankton counts were performed on the water samples gathered during the sounding series. Nanoplankton, especially, were too small to catch with even a fine silk net and thus had to be centrifuged from water samples and then counted and examined under a microscope. Over 1200 such samples were examined while at sea, demonstrating that plankton lived even at depths of 4000 or 5000 meters, and their numbers were greatest where cold Antarctic water mixed with warm.[53]

Larger plankton were captured from using one of two pumps which pulled from between 50 and 100 meters depth. The water was discharged into a barrel, then filtered through a net of fine plankton gauze. Actual net catches were also made with the Lucas sounding machine and either an Apstein or Nansen net. The former filtered water through its funnel shape towards a measuring cylinder where plankton accumulated on a piece of parchment paper. The latter directed water towards a bottle; the apparatus was sent down open to a predetermined depth, then hauled up until a messenger closed it at a second predetermined depth. In both cases, the collected plankton were sent to the State Zoological Museum in Hamburg.[54] This work, in concert with chemical and current studies, was intended to help explain the distribution of nutrients and of plant and animal life in the oceans and their relationship with oceanic currents.[55] In fact, the results showed from the paucity of nutrients in tropical surface waters compared to relatively high values below the thermocline that vertical mixing did not take place, helping to explain the lack of plankton in these nutrient-poor areas.[56] Later, these results would contribute to the explanation of spring plankton blooms during seasonal upwelling near the poles.

The biologists observed larger animals as well, though less thoroughly. Twice a day, they conducted a quantitative bird count in the ship's aft quadrant. They also counted floating and moving organisms, such as jellyfish and weeds. Lookouts were trained to call the biologist immediately if any unusual plant or animal was sighted. Occasionally, the biologists also examined larger animals. For instance, while at anchor on the western side of the Mid-Atlantic Ridge during the second profile across the Atlantic, a 90-kg blue shark was caught and dissected.[57] And as has been mentioned, slow-motion film studies were made of albatross in order to study their flight.

Meteorology at sea

Meteorology formed a major area of research both in its own right and in concert with the oceanographic studies, to elucidate the role of winds in the development of surface currents. The

[53] Spiess, *Meteor Expedition*, 124-5.
[54] Spiess, *Meteor Expedition*, 124-7.
[55] Spiess, *Meteor Expedition*, 124.
[56] Eric Mills, *Biological Oceanography: An Early History, 1870-1960* (Toronto: University of Toronto Press, 2012), 160.
[57] Spiess, *Meteor Expedition*, 123.

crew's normal observations of meteorological conditions were recorded hourly in the ship's logbooks and daily observation books. The embarked meteorologists made similar but more extensive observations of surface air pressure and temperature, atmospheric humidity, surface water temperature, cloud forms and coverage, surface wind direction and strength, evaporation rate, and visibility. These were taken regularly three times a day, at 7 AM, 6 PM, and 9 PM. Spiess noted the ship was equipped to observe as well as "the first class meteorological observation station on land." Observations were radioed home as well as recorded. On the preliminary run, crewmen discovered the thermometer on the bridge read falsely high because of proximity to the metal bulkheads. A series of remote thermometers were set up for comparison, located on the bow, stern, and atop the foremast in order to be as far from heat sources as possible. All four were read in the drawing room.[58]

The meteorologists also measured solar radiation with a pair of actinometers, though the deck of a ship proved less than ideal for instruments that must remain focused on the sun during a reading. The actinometers were also difficult to keep smoke-free on the coal-burning ship. One of the meteorologists constructed a recorder for measuring total radiation, which was placed on the aft deck.[59]

Twice a day, unless cloud cover obscured visibility, the crew released and tracked pilot balloons to observe winds aloft. The large, rubber balloons, perhaps 1.5 meters in diameter, reached heights of up to 21,000 m before bursting. On cloudy days, the wind gun provided an alternative tool for visualizing and tracking the winds until its use was stopped because the vibrations it induced affected the ships thermometers.[60]

For more detailed information, both kites and balloons could carry instruments aloft. Large box kites were launched from the aft deck using an electric motor and 10 km of piano wire, though the crew had to learn how to handle them in the small space available. The main kite carried a "meteorograph," an instrument package which recorded temperature, air pressure, moisture, and wind velocity. As the main kite rose into the air, up to five or six auxiliary kites were attached to the line to provide additional lift, allowing the heavy package to ascend as high as 4 km. Kites were launched "in even slightly favorable conditions," including on brightly moonlit nights, when they were tracked by searchlight. A smaller, hand-operated winch controlled them in the air and retrieved them to the deck. The kites were highly stable aloft, but difficult to retrieve in a strong wind, and they might sometimes dive into the sea at the last moment and be lost.[61]

Paired balloons allowed study of meteorological conditions at higher altitudes. A fully inflated main balloon carried the meteorograph basket, while a secondary balloon filled with less

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[58] Spiess, *Meteor Expedition*, 64-65. Quote on p. 64.
[59] Spiess, *Meteor Expedition*, 66.
[60] Spiess, *Meteor Expedition*, 66-7.
[61] Spiess, *Meteor Expedition*, 67-9, 287. Quote on pg. 69.

hydrogen tagged along for the ride. The gas within the balloons expanded with decreasing atmospheric pressure until the fuller balloon burst at about 20 km altitude. The second balloon, unable to keep the instruments aloft by itself, acted as a parachute to slow their descent and then as a beacon so the ship could retrieve the instruments.[62] These flights were carried out less often than kite ascents, in part because tethered kites could safely ascend into clouds, whereas a heavy cloud cover that obscured tracking of the free-floating balloons could result in the loss of the instrument package.

Sounding the ocean

The most revolutionary of the investigatory technologies aboard *Meteor* was sonar, in the form of an echo sounder or fathometer. A navigational device to find depth using a sound pulse had been patented in Germany as early as 1912, and in the wake of the *Titanic* disaster inventors and maritime officials experimented with the same concept to measure distances horizontally or find objects (such as icebergs) in the water surrounding a vessel. The Great War's interference in civilian shipping had retarded the spread of the navigational technology and obscured other experimentation beneath the cloak of military secrecy. By the 1920s, though, the US, France, and Britain all experienced some success in developing these tools and were deploying them in limited fashion aboard moving ships. An American warship had sounded a continuous profile across the Atlantic, and while the single resulting depth cross-section demonstrated such a feat could be accomplished, it hardly cast much new light on the topography of the Atlantic basin. In 1923 the US hydrographic office published a bathymetric chart of the California coastline incorporating 5000 sonar measurements conducted by two warships over thirty-eight days, but while this represented a vast improvement both in area covered and in time and labor spent, it barely touched the rim of the vast Pacific.[63]

With their two new, state-of-the-art sounders, the Germans hoped to provide the first comprehensive survey of the Atlantic. Both operated by emitting a 1050-Hz pulse, which reflected off the bottom and returned to the ship after a delay which depended on the depth beneath the ship's keel. A receiving membrane on the hull detected the reflected signal. The sounding apparatus calculated the depth based on the delay, using a preset approximation of the speed of sound in seawater.[64] Soundings could thus be conducted in any depth, in all weather,

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[62] Spiess, *Meteor Expedition*, 53-54.

[63] Höhler, "Depth Records," 136. "Echo Sounding: Test carried out by the U.S.S. 'Stewart' 20th to 29th June 1922'', *Hydrographic Review* 1 (1923): 71 – 72. Gerhard Schott, "Tiefseelotungen mittelst Echolot," *Annalen der Hydrographie und Maritimen Meteorologie: Organ des Hydrographischen Bureaus und der Deutschen Seewarte* 51 (August 1923): 192-195.

[64] This was 1470 m/s for the Signal sounder, or 1490 m/s for the Atlas. Hoheisel-Huxmann, *Deutsche Atlantische Expedition,* 58.

while the ship maintained speed. At every oceanographic station, an old-fashioned line sounding verified the echo sounding results.[65]

In addition to the receiving membrane on the hull, a microphone also picked up the returning echo and conveyed it to listening naval personnel. Schott, at the Seewarte, believed automation that allowed the calculation of depth without human intervention, and thus elimination of the human ear from the process, rendered the method more objective and thus its results more accurate and trustworthy.[66] The technicians doing the listening, though, found that with practice they could distinguish bottom type and topography based on differences in the reflected sound. They could also hear the reverberating echoes. Technicians soon learned to recognize the different sounds and patterns of reverberation returned from different bottom morphologies. On a flat bottom, the echo might repeat up to five times at regular intervals. But when the bottom was broken and irregular, the intervals were irregular and the repeated echoes might even overlap. [67] Retaining the human ear in the process thus led to results that might arguably be less precise in terms solely of depth measurement, but which provided additional layers of information granted solely through the employment of this expert sensory knowledge.

The results were as good as could have been hoped. The two modern echo sounders performed flawlessly; they remained in continuous use during the thirty-month expedition with no technical difficulties, usually taking individual measurements every twenty minutes, and thus at two or three mile intervals.[68] When the bottom topography seemed particularly interesting, the interval was shortened. The morphology thus charted often determined the location or interval of oceanographic stations, as it suggested the contours of ocean basins which could, when augmented with the thermal and chemical results gained by sampling, elucidate the movement of deep currents. The resulting charts of Atlantic topography represent a significant legacy of the expedition, and formed the basis for a three-dimensional, bottom relief model of the South Atlantic displayed in the Berlin Museum of Oceanography.[69]

In addition, as historian Sabine Höhler has pointed out, the use of a sound moving through water to calculate distance rendered the water itself the medium of measurement, instead of the lines and weights of the previous generations of sounders. The properties of sea water that affected the behavior of sound within it thus became important objects of study for the purposes of their participation in this technology, rather than just as an end in itself.[70] This would prove immensely important to the future direction of physical oceanography as a field, both rendering

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[65] Spiess, *Meteor Expedition*, 151.
[66] Höhler, "Depth Records," 134. Schott, "Messung der Meerestiefen durch Echolot," *Verhandlungen der Deutsche Geographentages* 21 (1926).
[67] Spiess, *Meteor Expedition*, 83.
[68] Spiess, *Meteor Expedition*, 83.
[69] Höhler, "Profilgewinn. Karten der Atlantischen Expedition (1925–1927) der Notgemeinschaft der Deutschen Wissenschaft," *NTM International Journal of History & Ethics of Natural Sciences, Technology & Medicine* 10, no. 4 (December 2002): 234-246.
[70] Höhler, "Depth Records," 122.

the world's blue water navies important patrons of oceanography and simultaneously guiding the direction of study as the field developed over the course of the next several decades.

Nationalism at sea and ashore

Historians have noted a push in the first few decades of the twentieth century towards internationalism in science, especially in European science. The ocean and atmospheric sciences in particular seemed highly suited for transnational work, as the winds and currents and their flora and fauna respected no national boundaries.[71] Katharine Anderson points to marine meteorology in particular for its ability to "tell us much about global science in the first decades of the century," both in terms of its organizational history and "as a conceptual ideal."[72] Post-Great War, the formation of the League of Nations suggested a new internationalism on the political front, one which scientists might have been forgiven for imagining would be reflected in their own situation.

However, just as the war had wrought major changes in European politics, the case for international science had also been complicated by the conflict, especially when it came to Germany. Along with their compatriots in other occupations, German scientists were dealing with a swirl of both concrete and emotional repercussions from the war. This included actual privation and hardship, amplified by the hyperinflation of the 1920s; in the case of scientists this meant a lack of funding opportunities, especially outside Germany, where German currency was not accepted because of its illiquidity. It also included censure and blame, or at least the perception of blame, from international peers and scientific bodies, who as a result did not invite German participation in international efforts.[73]

Neither were German scientists above the emotional fallout of the war. Many of them had invested themselves fully in the war effort, in keeping with Haber's claim that "[i]n wartime, the scholar belongs to his nation, in peacetime to mankind."[74] They suffered a wounded nationalist pride at the same rate as their peers in other professions. As a nation, Germans had lost a war, and they suffered now from restrictions on what had been favorite nationalist projects, such as

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[71] Elisabeth Crawford, "The Universe of International Science, 1880-1939," in *Solomon's House Revisited: The Organisation and Institutionalization of Science*, ed. Tore Frängsmyr (Canton, MA : Science History Publications, U.S.A., 1990), 251-269; Rozwadowski, "Internationalism, Environmental Necessity and National Interest in the Marine Sciences and Other Sciences," *Minerva* 42 (2004): 127-149; Jacob Darwin Hamblin, "Visions of International Scientific Cooperation: The Case of Oceanic Science 1920-1955," *Minerva* 38 (2000): 393-423; Rozwadowski, *The Sea Knows No Boundaries: A Century of Marine Science under ICES* (Seattle: University of Washington Press, 2002.)

[72] Anderson, "Marine Meteorology," 213.

[73] Daniel Kevles, "'Into Hostile Political Camps'," 47-60; Elisabeth Crawford, "Internationalism in Science as a Casualty of the First World War: Relations between German and Allied Scientists as Reflected in Nominations for the Nobel Prizes in Physics and Chemistry," *Social Science Information* 27, no. 2 (June 1988): 163-201.

[74] Quoted in Crawford, "The Universe of International Science," 252.

the fleet Germany had worked so hard to maintain at the level of a world power, or the colonies they had scrambled to build abroad. Germany had been at the forefront of science, a leader in any number of fields. The lack of money, of colonial sites to accommodate their fieldwork, and of international goodwill meant they now risked falling behind in science, just when they had been so decisively removed from world power status politically. These concerns were reflected in every detail of the planning and execution of the Deutsche Atlantische Expedition, from the practical to the symbolic.

From a practical standpoint, the ongoing devaluation of Germany's currency was a constant backdrop to their work. This can be seen in Merz's fears that a multi-stage expedition would be cancelled after the first leg, as he imagined returning home to find funding for the next sections had evaporated. During the expedition itself, supplies—from instruments to foodstuffs and even coal—were often shipped via German cargo line to their expected ports of call so they could be paid for in home currency, rather than spending scarce foreign currency or gold for these expenses abroad.

From the more emotional standpoint, the planners and participants positioned themselves as inheritors and continuers of a great scientific tradition, and when possible, a specifically German tradition. This was not wholly without precedent. Certainly previous expeditions made similar nods to the footsteps in which they travelled, as Spiess did when he reported making a mid-ocean station on 10 August 1925 in the same location as *Challenger* had, or when they made another at the spot where over seventy years earlier the American USS *Dolphin* had recorded the deepest point ever sounded in the Atlantic.[75] Neither was he out of line to do so; the use of sonar sounding to check *Dolphin*'s notoriously deep line sounding, thus reconfirming with new technology the inaccuracy of the original depth, was completely scientifically appropriate. That in doing so he claimed for German science some greater mastery over the hitherto imprecisely known depth was, however, symptomatic of an entire attitude of the expedition. When Spiess cited previous expeditions, he noted that (by his calculation) seven of the ten major expeditions preceding his had been German, including those of *Gazelle*, *Möwe*, and *Planet*, and he noted every time *Meteor*'s track or data intercepted these forerunners.[76] When *Meteor* reached South Georgia Island in February 1926, ship's personnel visited the site of the German 1882/3 International Polar Year investigations, a visit Spiess described as a kind of pilgrimage. Appropriately to that purpose, they found many remains, though the station had mostly been destroyed.[77]

This is not to say the Germans distanced themselves from the scientific work of non-Germans. Spiess invoked the names of *Challenger* and *Dolphin* as tokens of power, proving *Meteor*'s worthiness for inclusion in the list of major expeditions and great ocean-going science.

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[75] Hoheisel-Huxmann, *Deutsche Atlantische Expedition*, 36; 89.
[76] "Die Deutsche Atlantische Expedition . . . I. Bericht," [XVII] – 77.
[77] Hoheisel-Huxmann, *Deutsche Atlantische Expedition*, 47.

Similarly, Merz visited Scandinavian researchers before the expedition, seeking their blessings for the plan, and the researchers welcomed already famous Swedish oceanographer Walfrid Ekman as a guest on the preliminary expedition, ostensibly to supervise the initial use of their water samplers and current meters, which were based on his designs, but clearly also seeking in his presence approbation for their efforts.[78] If Germans did science that put them in the company of great expeditions and met with the approval of internationally known scholars, then they were a Great Power once more, in a way Versailles could not deny them.

The displays of nationalist pride were not confined to the performance of science, however, though it is difficult to tell how much of its frank display is because of the hybrid nature of the expedition's leadership, which left a career naval officer to write the official expedition account, or because that account was intended for the public rather than a scientific audience. Port calls for replenishment and refueling were intentionally scheduled for former German colonies or major German expatriate communities whenever possible. This practice places *Meteor*'s scientific efforts within the neocolonial framework described by Gregory Cushman, allowing a Germany officially stripped of its colonies to maintain an informal empire.[79] These visits were celebrated with speeches commemorating Germany's past and predicting its future greatness, and with patriotic songs, such as when they concluded a celebration in Windhoek with a rousing rendition of "Siegreich woll'n wir England schlagen!" ("We want to defeat England!") in the presence of British officials. Spiess followed with a speech, telling the crowd, "Germany has always risen again. What it needs is the right man and he will come!"[80]

While it is perhaps unsurprising for logistics and public relations, which so clearly encompassed the swirl of both concrete and emotional repercussions from the war, to express a nationalist agenda, the expedition's scientific activities were not exempt, as Merz's initial promise to lay claim to the Atlantic suggests. Sabine Höhler has argued the gathering of oceanographic and sounding data—and their publication by German scientists in charts of the ocean's basin which were labelled as products of German science—constituted a symbolic claiming of territory.[81] If Germans could no longer claim colonies ashore, they could, in the act of mapping, claim the bottom of the ocean.

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[78] Spiess, "Bericht des Expeditionsleiters," 9.

[79] Cushman, "The Struggle over Airways in the Americas, 1919-1945: Atmospheric Science, Aviation Technology, and Neocolonialism," ch 7 in *Intimate Universality: Local and Global Themes in the History of Weather and Climate*, ed. James Rodger Fleming, Vladimir Jankovic, and Deborah R. Coen (Sagamore Beach, MA: Science History Publications/USA, 2006), 175-222.

[80] Spiess, *Meteor Expedition*, 271.

[81] Höhler, "Profilgewinn," 234-246. In this article and elsewhere, Höhler's argument follows Bruno Latour's depiction of the collection of data into charts as a rendition of time and space into stable but portable form; Höhler, "Depth Records and Ocean Volumes: Ocean Profiling by Sounding Technology, 1850-1930," *History and Technology* 18, no. 2 (2002): 119-154.

Their meteorological efforts similarly laid claim to the currents of the air over the Atlantic. While the meteorologists onboard both wrote their own reports and sent data home for further analysis, much of their results volume consists of hundreds of pages of tabulated data, an assertion of German data dominance to support the symbolic seizure of aerial territory. Spiess also noted, "The total aerological data [from the voyage] will be of great practical value for aviation over the Atlantic Ocean, which cannot be long in coming."[82] Charles Lindbergh's transatlantic flight, just two weeks before *Meteor* at last returned home to Wilhelmshaven in early June 1927, drove this message home. Although Spiess did not explicitly tie this prediction to military purposes, the statement—and the studies it represents—must be considered alongside other forms of German pushback against mandated disarmament. Just as the encouragement of soaring in gliders allowed the nation to train a cadre of pilots without building powered aircraft, so too would the scientific study of the atmosphere over the Atlantic have great usefulness for a revived military machine.[83] Indeed, as Cushman has related, the Deutsche Seewarte was involved in other projects that let them "appropriat[e] the weather in the Atlantic Basin" and, more concretely, furthered the efforts of the German aviation industry in Latin America, where it found a refuge during the post-Versailles restrictions on military airpower.[84]

The German Atlantic Expedition, then, demonstrates the not-uncommon trope of science as a tool of politics. But these scientists were neither naïve pawns of savvy politicians nor cynically trading their support for naval goals in exchange for access to resources for their work. They were instead willing wielders of politics, as eager to use their skills to forward German pride and to defend their perceived place in the first rank of a worldwide hierarchy as were their naval colleagues. This model of the relationship between science and the state is a useful one to keep in mind. It is likely also a more common one than many might prefer to imagine.

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[82] Spiess, *Meteor Expedition*, 391.
[83] See Peter Fritzsche, *A Nation of Fliers: German Aviation and the Popular Imagination* (Cambridge, MA: Harvard University Press, 1992), especially ch. 3, "Gliding and the Revival of Nationalism," 103-131.
[84] In addition to its support of the *Meteor* Expedition, the Seewarte conducted between 1922 and 1930 a number of meteorological expeditions towards this end, including ten to Latin America, five to West Africa, and others in the North Atlantic, while expanding a network of shipborne observers in the Atlantic. Cushman, "Struggle over Airways," 188.