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Finding a Point of Observation in the Global South: The C. L. Gerling and J.M. Gilliss Correspondence (1847–1856)

Carlos Sanhueza-Cerda
Universidad de Chile, Chile

Lorena B. Valderrama
University Alberto Hurtado, Chile

Abstract

Historians of science have amply demonstrated the transnational character of science; however, they have not sufficiently attended to how several scientific projects were coordinated as part of global initiatives. Our research – based on the unpublished, written correspondence between Christian Ludwig Gerling in Germany and James M. Gilliss in the United States, from 1847 to 1856 – examines the issues that were being discussed in the search for an observation point in Chile that could be linked to the various astronomical research projects happening in the global north. This article shows that the building of this network had to navigate communicational and language barriers, financial uncertainty, lack of adequate scientific instruments, and the influence of intermediaries. In fact, the intermediaries involved affected the formulation of questions and objectives, as well as the choice of methods and instruments to be used (such as Alexander von Humboldt and Friedrich Gauss), and directly impacted on how these things were brought to bear (for example, instrument manufacturers, diplomats, and translators).

Keywords

Astronomy in the nineteenth century, Christian Ludwig Gerling, James M. Gilliss, Chile, astronomical networks

Corresponding author:
Carlos Sanhueza-Cerda, Department of History, Universidad de Chile, Ignacio Carrera, 1025 Santiago, Chile.
Email: carlos.sanhueza@uchile.cl

Introduction

The history of science has been discussing the global dimension since the end of the twentieth century. Accordingly, studies have been conducted on the multiple facets of exchanges between Europe and the rest of the world, regarding the representation of nature,[1] trade and art,[2] and the development of the Spanish, Portuguese, and British empires.[3] Attention has recently been paid to the role of knowledge in the process of globalization,[4] as well as to intermediaries that have acted as liaisons between the local and the global.[5] In 2010, the journal *Isis* dedicated a special issue to the global histories of science, attending "to the connections and disconnections of science on the global stage."[6] For those studying the history of science, its global dimension is quite evident. Yet the extent to which science, as an activity, constitutes an international phenomenon has not yet been adequately addressed. How were these global networks of exchange formed? What implications did this have? What dynamics shaped this process?

Lissa Roberts, who has discussed some of these issues, calls for greater integration in the history of science, in which science is seen as a "mutually constructive element of global history."[7] This is because science, according to Roberts, is "a historical phenomenon, one that is simultaneously a constructive element and a product of more general history on a global scale."[8] In this sense, there is a need for dialogue among historians of science and other historians interested in broad developments, integrations, and interactions around the globe. Turchetti, Herran, and Boudia have inquired as to whether science can actually be transnational. Although the question may seem trivial, it proves quite relevant when considering that it has been virtually absent from debates on transnational, world and new global history, as well as on the history of science. These authors believe that the history of science can open "new spaces of collaboration which could propel the discipline beyond its current reach," which is why they call for there to be debate on the "transnational history of sciences."[9]

In effect, the issue is not whether science can constitute a global or translational activity,[10] but rather on what scale and in what conditions this dimension can be understood. Sujit Sivasundaram has shed light on the complex nature of writing about the history of science from a global perspective.[11] Again Roberts, in her comments on the Chemical Heritage Foundation's "Chemistry and Global History" conference in 2014, shared her thoughts on how to understand global history, stating that ". . . it is preferable to speak of global histories, especially since this allows for the coexistence (whether parallel, collaborative, or competitive) of multiple, spatio-temporal regimes, imaginaries, expectations, and so forth." Furthermore, Roberts affirms that some prefer to consider the notion of global "as referring to a method or approach rather than a geographical frame. Speaking of 'global histories' in this sense affords exploration of productive tensions within and between levels of scale (local/regional/national/world), in dialogue with other tensions." In other words, speaking of global histories "helps us to recognize material agency as 'essentially' local."[12] Therefore, this perspective allows for the linking of different scales without necessarily having to favour one over the other.

One fundamental element for understanding global exchanges is the correspondence between different actors that took part in these networks. It has been argued that, since the scientific revolution, collaboration, and the exchange of information (especially in

terms of observations and experiments) arose through the letters scientists sent each other. The analysis of these documents allows us to study, from the wings, the epistemologies at play during observations, the relationship between communication and observation and discussions on the effects of the scientific revolution.[13] In one sense, these letters by scientists and academics include some aspects that allowed them to reinforce their authority, whether in terms of the handling of instruments or in making the best observations possible. In another sense, this communication created what has been called a "social environment" that allowed for global scientific projects. The correspondence between scientists allowed them to find sponsors, consolidate friendships, and establish reliable channels of communication.[14]

In the case of astronomy, it has been mentioned that the first modern astronomers whose ability to find data on the phenomena they studied largely depended on their colleagues. Through these exchanges, they wove "webs of learned correspondence in which details of instrumentation, observational protocols, data in various forms, and procedures for their reduction were highly prized matters of both jealous and generous exchange."[15] These communications were a mechanism for the dissemination of news on heavenly phenomena over long distances "for discussion on their nature."[16] This did not strictly deal with information on research that was underway. In effect, as will be seen in this case study, the correspondence between astronomers identified an "uncertainness associated with the other components of the discipline: the quality of the instrument used (or not used) to record the observation, the optical interpretation of the phenomena observed," as well as including discussions on the mathematical techniques used to deduce positions or the physical principles involved.[17] Many of the discussions and debates that occurred through this correspondence not only involved the authors or readers of these letters, but also other actors (such as telescope manufacturers) who were mentioned within. At the same time, as shall be seen later on, the letters themselves were cited in scientific articles and science journalism.

Another important point of interest in the relationship between science and a globalized world has to do with the scientific projects that, in order to successfully meet their goals, had to coordinate an array of different tasks. These ranged from calibrating and producing the instruments needed to carry out measurements and observations, to the transporting of people and economic resources to make the research possible. To that end, scholarship has been produced on the study of the Earth's magnetic field during the 1830s – a period also known as the "magnetic crusade,"[18] – the late nineteenth-century French effort to map the night sky from different parts of the globe in what was called the *Carte du ciel*.[19] The case of the Astronomical Expedition to the Southern Hemisphere is one example of these nineteenth century global projects.

Nineteenth century astronomy as a global project: the case of the astronomical expedition to the Southern Hemisphere

Astronomy in the nineteenth century constitutes an ideal setting for the analysis of global projects, insofar as they required observations to be made across the planet for their findings to be considered valid. In effect, astronomy, at the time, was facing the

challenge of coordinating different points of observation in the aim of determining the distance between stars and building a system of measurement that would make it possible to locate the positions, distances, and orbits of celestial bodies. For centuries, different methods were put forth so that predictable astronomical events could be used for these purposes; one such method was that of Edmund Halley in 1716. These events could be studied by calculating the solar 'parallax', that is, the difference in the angle of the apparent position of an object observed from two different vantage points. Halley proposed that the "transit of Venus" – which takes place when the planet travels directly between the Sun and the Earth – could shed light on the matter if two observers located at approximately the same longitude, but with a significant difference in latitude between them, could observe Venus's path across the Sun at slightly different transects.

Christian Ludwig Gerling (1788–1864) from the Philipps-Universität Marburg, Germany, refloated Halley's idea by suggesting that the solar parallax could be determined by measuring the position of Venus and Mars close to their inferior conjunction, especially at stationary points, from observatories located near the planet's meridian, but with a fair amount of latitudinal distance between them.[20]

Christian Ludwig Gerling was educated alongside Johann Franz Encke. After finishing school, Gerling attended the University of Helmstedt, but in 1810, he continued his academic education in the fields of mathematics, astronomy, physics, and chemistry under Carl Friedrich Gauß and Karl Ludwig Harding at the University of Göttingen. After receiving his doctorate, Gerling got a job in the city of Kassel, Hesse. There, he continued looking for a university position, and was finally named professor of mathematics, physics and astronomy and director of the Mathematisch- Physikalisches Institut at the Philipps-Universität Marburg in 1817.[21]

In 1847, Gerling published an article in the *Astronomische Nachrichten*, "On the use of the stationary points of Venus in determining the solar parallax." According to Schrimpf, Gerling suggested taking measurements of Venus rather than Mars as it is much closer to Earth during its inferior conjunction than Mars is when in opposition. Nevertheless, there is a disadvantage in observing Venus: during its conjunction, it is only visible during the day, and there are only a few stars bright enough to serve as a comparison for differential measurements. These conditions mean that the success of the project would require the cooperation of observatories located in different hemispheres. According to Schrimpf, Gerling suggested observatories in Königsberg, the Cape of Good Hope, the District of Columbia, the Antilles and Greenwich. Gerling sought out information on the state of astronomy in different parts of the world and, in the process, contacted Johann Flügel, the US consul in Leipzig, Germany. Given that the development of astronomy in the nineteenth century was centred in Europe, most of the world's observatories were located in the Northern Hemisphere. Without observations taken in the Southern Hemisphere, the solar parallax could not be studied. Consequently, in the subsequent issue of *Astronomische Nachrichten* (the journal in which he had previously explained his vision of the solar parallax in 1847), Gerling put forward a proposal for a global astronomy project that would connect different observatories on opposite sides of the world.[22] If there was a country that could make observations in the Southern Hemisphere, it was the United States.

M. Gilliss (1811–1865), an astronomer at the United States Naval Observatory, agreed to explore Gerling's idea in order to carry out a set of observations that would later be compared to those done by his colleagues in the United States. Since the meridian on the east coast of the United States also passes through Chile, Gilliss was considering building an observation point as far south as possible.[23]

Gilliss' approach to astronomy began when he was working as an assistant at the US Navy's Depot of Charts and Instruments under Lieutenant Charles Wilkes (1798–1877). As part of his job, Gilliss had to make astronomical observations in order to determine the precision of chronometers, and he became quite good at it. The precision and worth of his observations and measurements were recognized by his peers, as well as the astronomers that came after him.[24]

When Wilkes was made the leader of the US expedition to the south seas in 1837, Gilliss was put in charge of the unit, assisting Wilkes with coordinated magnetic and meteorological observations at different locations around the world in order to determine "differences of longitude by means of moon-culminations, occupations, and eclipses."[25] During those years, Gilliss also took up the idea of founding a proper observatory, which had been unsuccessfully proposed in Congress in 1825.[26]

In 1842, he convinced the US Congress to invest 25,000 dollars in a new instrument depot and an observatory, which he supplied with astronomical instruments, primarily purchased in Germany. It was in this journey to Berlin, Hamburg, Leipzig, Munich and Altona where he met the astronomical and optical instrument manufacturers Georg Merz (1793–1867) and Adolf Repsold (1806–1871), as well as Heinrich Schumacher (1780–1850), the founder of the journal *Astronomische Nachrichten* and director of the Altona Observatory, among other German astronomers.[27] Despite his efforts to found the Naval Observatory, he was not named its director and he ended up at the US Coast Survey, which centred on hydrographic work.

While at the US Coast Survey, Gilliss published a series of astronomical observations in 1846, which constituted the first star catalogue published in the United States.[28] He also continued working on the simultaneous measurements for the Wilkes expedition.[29] This scientific work allowed him to gradually gain entry to many scientific associations in the United States and Europe.[30]

Gillis' scientific interests in the Southern Hemisphere were in line with the geopolitical interests of the US government in this same region. The South American expedition that was then being prepared would be the third. These expeditions had geographical, political, commercial, and military objectives in the newly independent nations of South America. The three expeditions were led by the Navy and financed by Congress. Although they had geopolitical objectives, they were valuable to the scientists of the time: they allowed measurements and observations to be made in a variety of fields, data to be obtained and collections in US museums to be inaugurated on the natural history of the countries of the south.[31]

The first exploration of this type was carried out from 1817 to 1818. The Commission to Investigate the Spanish Provinces of South America, as it was called, was led by the diplomat and former senator Caesar Augustus Rodney (1772–1824) and centred on Argentina and Chile.[32] The second, the United States South Seas Exploring Expedition, was carried out from 1838 to 1842 and followed the Atlantic and Pacific coasts of South

America, as well as Antarctica and Oceania. It was led by Wilkes, who had participated in the first expedition.[33]

The Gillis expedition was approved by Congress, from which it also received its primary financing, and was "supported by the country's leading scientific societies of the day, such as the American Philosophical Society (1743), the American Academy of Arts and Sciences (1780) and the Smithsonian Institution (1846)."[34] The official, transnational character of this expedition was due to the diverse interests of its financiers and collaborators. For example, Gillis was advised by the committees of the American Philosophical Society and the Academy of Arts and Sciences, which wanted to get the most out of the money they have given the expedition (see Note 17). Its military and political objectives also led him to go beyond astronomical observations "applied to navigation and cartography in order to fulfil the task of covering different fields of study of the nature of Chile."[35]

During more than 6 years (before and after the expedition), Gilliss and Gerling exchanged letters in which they discussed the significance of the astronomical expedition to Chile and deliberated issues such as how they would ensure its success, get funding and build the necessary instruments of measurement and observation, as well as the scientific matters that could be explored.[36] This correspondence shows that the Astronomical Expedition to the Southern Hemisphere did not only respond to US interests, but rather early on it was informed by a combination of diverse interests stemming from a network of German scholars, including the astronomers Heinrich Schumacher, Johann von Lamont, and the aforementioned Christian Gerling; scientists such as Friedrich Gauss and Alexander von Humboldt; as well as telescope and astronomical instrument manufacturers such as Georg Merz, Adolf Repsold, Carl Pistor, and Carl Martins.

Gilliss and Gerling's scientific agenda

The interest these two scientists shared in turning their astronomical activities into an international effort can be seen from the time they began to write to each other. As stated by Gilliss, their transnational exchange started with a letter sent by Gerling dated 17 April 1847, in which he explained his method for calculating the solar parallax from both hemispheres, before publishing it less than a month later in the German journal *Astronomical Nachrichten*, 25, Nº 599. Gilliss cited this letter, both in his expedition to Chile, as well as in the press. From the outset, this cooperation made its way into public opinion in the United States, insofar as the expedition needed the approval of the citizenry and the politicians who would be financing the endeavour.[37] On 24 July 1847, Gilliss published the English translation of Gerling's letter in the *National Intelligencer* of Washington D.C., which made it clear that Gerling "invites the cooperation of Americans in a great astronomical enterprise, having for its object to effect a new and more precise determination of our distance from the sun [. . .]."[38] Gerling thanked Gilliss for speaking about their cooperation to the US media, as well as "the friendly manner in which you published my ideas of the observations of Venus in the *National Intelligencer*."[39] In that sense, this clearly shows how a scientific endeavour based on international cooperation did not only require discussion on its main ideas and competency in the use of

astronomical instruments, but above all a scientific agenda whose impact could be felt beyond the observation of the stars. Unveiling the mysteries of the universe had to be a matter of public interest, just as much as the applicability of the results to cartography, meteorology, or seismology had to be of interest to the government. Much like with the *Magnetic crusade* and the *Carte du ciel*, the parameters of the scientific problems they sought to resolve were defined in the intersection of the interests of those who financed their efforts and the matters alluded to by relevant figures in scientific communities (such as Friedrich Gauss and Alexander von Humboldt, in this case) through publications and personal correspondence with expedition organizers.

At the heart of the Astronomical Expedition to the Southern Hemisphere was the problem of how to measure the distance of celestial bodies from different points of the globe, and do so in a coordinated fashion.[40] This not only required deciding in which locations to make measurements, but also laying out the framework for the mission's success, which entailed unified reference points and methods. On 11 July 1847, Gilliss mentioned a concern he had prior to his trip to Chile: how to determine the longitude of Washington D.C. In the letter, he also spoke about the work that had been done by the *United States Exploring Expedition* in 1838, stating that

> When the U.S government was about to send out a Squadron of Ships under Capt. Wilkes in 1838; it was deemed important that moon-culminations and occultations should be observed at Washington which would serve as comparisons of those made by the Officers of the Exploring Expedition in determining their Longitudes.[41]

Gilliss recounted that he had already made some progress, in that he himself made observations "in a little house that had been put up some time before by Capt. Wilkes."[42] Gilliss went on to state that, with these measurements, he was hoping to determine the longitude of Washington "from comparison of all the moon-culminations and occultations with those of the European observatories during the same period [. . .]."[43]

It was essential, once they determined the coordinates of the locations that would be used in the expedition to Chile, that they come to an agreement on the methodology needed to obtain the best measurements possible of the inner planets, such as Venus and Mars. Gerling suggested early on to Gilliss how important the meridian observation and the prior selection of the stars that would serve as reference points were, stating "I believe that the little stars for micrometrical observations should be early selected [. . .]."[44] In the same letter, Gerling also suggested a way of framing the relationship between these reference points:

> If micrometrical observations shall prove of real importance it will be necessary that the point "A" of the heaven [or celestial body] to which they refer, be determined of near as possible in the same manner, and on the same elements, as the point "C" determined by Meridian observations. This only may be performed if your little stars, in each period undergo a new accurate Meridian-comparison with Fundamental-Stars, and particularly with the same Fundamental-Stars to which refer the simultaneous Meridian-observations of the planet.[45]

One particularly relevant letter was the one sent to Gilliss on 10 November 1848, in which Gerling shared "some small observations"[46] regarding the plans for the upcoming

expedition, indicating what instruments were needed and explaining what types of observations were of interest to German scientists. These comments had a lasting effect on the scientific agenda of the trip to Chile.

The first observation detailed the methodology that had to be employed in Chile in the measurements to be taken of Mars and Venus. Gerling affirmed that he agreed entirely with Gillis's goal of carrying out simultaneous measurements of both planets from different observatories and comparing the different distances between the same stars to obtain the angle needed in order to establish a basis off of which to measure. Gerling further elaborated that it was of utmost importance that he uses a meridian circle, stating that "This acquisition is really the cornerstone of your project." Moreover, Gerling even maintained that this measurement alone would determine the extent to which more observation power would increase the accuracy of our knowledge of parallaxes."[47] Here, it becomes abundantly clear how important the Expedition to the southern hemisphere actually was, and how, in Europe, they saw an opportunity to begin and/or continue certain experiments (as we will later see), as well as put some of their tried-and-true instruments to the test. In this transatlantic dialogue, the initial aim of studying the solar parallax was one of the many goals that started to take shape.

For example, Gerling's second observation had to do with a matter that repeatedly comes up in these transnational dialogues: the dilemma of Earth's magnetic field. From the outset, Gilliss mentioned that he had carried out "magnetical observations" in Washington using the recommendations laid out by the Royal Society, as well as those of the German Magnetic Association. In a letter to Gerling in 1847, he mentions that he was planning on continuing these measurements in the southern hemisphere, as was demonstrated in the conclusions of the expedition to Chile.[48] In 1848, Gerling wrote to Gillis alluding to the importance of coordinating their research:

> In terms of your planned magnetic observations, I think it's highly important to schedule and announce the observation times beforehand. For my part, due to a lack of equipment and assistants, I can only keep to the Gaussian times with regard to the variations of the declination, however, if you were able to schedule the observations beforehand, I would do my very best to adhere to the same times.[49]

In a letter the following month, Gerling once again brought up the matter in the context of the general importance of his expedition, since, once data from the other side of the world was obtained they would be able to study to what extent "the texture of the Earth's crust depends on its magnetic field." On the other hand, Gerling also points out that the expedition would also help shed light on Gilliss's query as to whether or not magnetism diminishes with increasing altitude. Accordingly, Gerling mentions that his own observations were made "at 7000 feet, as well as in the valley below."[50] The idea of a network for the observation of magnetism had already been proposed in 1836 by Alexander von Humboldt (1769–1859), thus giving rise to what became known as the "magnetic crusade."[51] However, a vast majority of the measurements had been taken in the northern hemisphere, which made Gilliss's journey to the south especially interesting to European scientists. In fact, following his response to Gilliss in November, 1848, Gerling wrote a letter to Friedrich Gauss (1777–1855), in which he told him about the expedition to Chile

and about his US colleague's interest in receiving comments and advice from Gauss himself, as well as from other German scientists.[52] Gauss, in response to Gerling, showed a great deal of interest, saying "the US expedition to Chile will provide us with some results."[53] A year later, Gerling told Gilliss that he had mentioned his plans in Chile to Johann von Lamont (1805–1879), who was also involved in magnetic observations. Gerling explained that Lamont had suggested that Gillis should carry out the observations comprehensively, that is, by integrating declination, inclination and intensity. According to Gerling, Lamont was convinced that incomplete observations were only usable when complemented with readings from nearby locations.[54]

The third observation of Gilliss's expedition was in regard to seismic activity. In the aforementioned letter from 10 November 1848, one of the major obstacles was obtaining an instrument that was "especially outfitted" (*besonders eingerichtet*) for the task. To that end, Gerling suggested the use of a spring pendulum (*Feder-Pendel*). Moreover, as can be seen in Gilliss's research once in Chile, this was a particularly bedevilling problem for the scientific expedition. Finally Gillis acquired a seismometer manufactured by the Scottish physicist James D. Forbes (1809–1868), but this did not work in Chile and was, instead, replaced by a homemade pendulum that recorded its results by making marks in the sand.[55]

Intermediaries

Intermediaries are a vital component of exchanges, also playing a fundamental role in the dynamics of global networks.[56] From the outset, Gilliss urged Gerling to make his German colleagues aware of the itinerary of his upcoming trip to Chile, stating, "I should have little fear of success if Gauss, Schumacher, Encke and others of you [. . .] write me of its utility and importance."[57] In that sense, Gerling himself acted as an intermediary between German scholars, such as Humboldt and those mentioned by Gilliss.

Upon hearing about the expedition to Chile, in December of 1851, Humboldt wrote to Gerling expressing his interest in the longitudinal measurements of Valparaiso and Callao, since he himself had taken measurements of the latter during his trip to Peru, explaining that

> It is to be [my] wish that Lient. Gilliss should tell us something about the longitude of Valparaiso [. . .]. I am myself [. . .] interested in the matters as my determination of the longitude of Callao de Lima by means of a transit of Mercury has been entirely confirmed by observations of a more recent time [. . .] as the difference of the meridians of Callao and Valparaiso appears to be well fixed.[58]

He also expressed to Gerling his desire for Gilliss to examine the elevation of the permanent snow line and temperatures in Chile "during different seasons on the ocean's surface."[59] Following his trip to Chile, and having already arrived at some of the results from his research, Gilliss sent Humboldt the coordinates for Valparaiso and the elevation of the highest peaks of mountains such as Tupungato and Aconcagua. Gilliss – in a gesture ostensibly intending to bolster the binational network that he and Gerling created – wrote to Humboldt informing him that "my observations faully [sic] corroborate the value of the solar parallax deduced by Professor Encke from the transit of Venus."[60]

Friedrich Gauss was also part of this United States-German network. In a letter sent to Gauss, in November 1848, Gerling mentions the Astronomical Expedition to the Southern Hemisphere, stating "I've finally gotten news from Gillis's overseas expedition and think you ought to know the basic details."[61] In many ways, Gerling knew that part of the science the expedition sought to do involved his own work, as was made clear in the type of geomagnetic research done by Gilliss in Chile. Later on, in the same letter, Gerling mentions that Gilliss brought a device with him for meteorological and magnetic observations for which "he may need something else, or may ask for some insights or advice."[62] To that end, Gauss responded to Gerling, saying that "Mr. Gilliss has already described so many things he wants to probe that I have nothing to add."[63]

The manufacturers of scientific instruments in Munich, Berlin, and Hamburg were very relevant players in this global network. This connection is made clear by the correspondence that Gilliss received in Washington, currently available in the archive of the US Library of Congress. From early on in this scientific endeavour, the Berlin-based manufacturers Carl Philipp Heinrich Pistor (1778–1845) and Carl Otto Albrecht Martins (1816–1871), of the Pistor & Martins firm, got in touch with Gilliss through the president of the Astronomical Society of Leipzig, Gustav Adolf Hahn (1804–1857), who offered to be a liaison between the two parties in a letter from 6 September 1848.[64] Already in October of that year, the firm contacted the diplomatic mission to coordinate the shipment of the meridian circle that Gilliss had ordered.[65] Months earlier, Johann von Lamont had written to Gillis in regard to that very instrument, explaining that "[. . .] it [is] so impossible to find [. . .] already made for sale."[66]

In order to have certain instruments built it was essential to make arrangements so that the process did not take an excessive amount of time, or that they were made to the specifications required of the expedition. It was not always possible to have an instrument ready on demand; and once again, here, the involvement of Gerling and his knowledge of how things worked in Germany were paramount. In the case of the micrometre, the Munich-based firm of Georg Merz (1793–1867) wrote to Gilliss on 5 November 1848, saying that they were aware that he was looking for one and that "An instrument of 84," 66" aperture with clockwork and filarmicrometer is ready."[67] On 20 November, Gerling wrote to Gilliss that the instrument was ready to be shipped to the United States. In that same letter, Gerling mentioned the role that Johann von Lamont had played in convincing the Merz company that the US expedition had funding and was ready and able to make payment.[68]

The linchpin in the relationship between Gilliss and Gerling, however, was undeniably Johann Gottfried Flügel (1788–1855) – both the US Consulate and the Smithsonian Institute's representative in Leipzig, Germany. This intermediary acted as a liaison between the New World and the Old. From the project's inception, Flügel offered himself up as a bridge between the two scientists. Already in a letter from 8 February 1847, Flügel introduced Gilliss's project to Gerling[69] and on 7 June he offered to act as intermediary between the two.[70] On 30 August of that same year, Flügel sent a newspaper clipping to Gerling of the aforementioned article published in the *National Intelligencer* containing the English translation of the letter he had sent to Gillis.[71] Flügel's work as a go-between was even more crucial in his coordinated effort to make Gerling and other German scientists aware of Gillis's Expedition to the Southern Hemisphere, as can be seen in the copy sent to Gerling of a letter originally addressed to Gillis:

> I sent him [Gerling] through Mr. Fay, a copy of the Intelligencer with his letter of Sept. 2º and when I tell you that since its receipt on Saturday I have made a translation of its 7 pages: made three copies of our letters referring to the Expedition in all 54 pages, besides some 10 quite long letters to scientific men and societies [. . .].[72]

Clearly, the question of what language to communicate in was partially resolved by Flügel's mediation, since he himself could quickly channel requests to Gerling. On 31 October 1847, Flügel delivered a message to Gerling from Gilliss that read

> When you write Dr. Gerling, pray say that I have taken so much interest in his Geodelical investigations that I should be glad to have an opportunity to examine his *Ausgleichungs, Rechnungen der praktischen Geometrie*, but can not find one either in New York or Philadelphia.[73]

A month later, Flügel delivered another one of Gilliss's requests; as we will later see, language was becoming an obstacle in this global network, about which Gilliss inquired, "I greatly wish that all the German astronomers who honour me with a letter would, like him, write their language in English letter, for I am invariably completed to have recourse to a translator for the German text."[74]

Even Humboldt was part of Flügel's web of correspondence. On 22 December 1849, Humboldt wrote to Flügel thanking him

> for [. . .] Gillis's letter on the findings of the parallax in Chile and the astronomical longitude of Washington. [. . .] [It's] Encouraging [. . .] to continue scientific-based development in the United States and to see how much the government gets involved with a three-year expedition to Chile, because when a professor from Marburg wants the same thing, no one in Europe listens to him.[75]

Two years later, Humboldt again mentioned the expedition in a letter to Flügel, stating "The interesting expedition to Chile led by the admirable lieutenant Gilliss shows its true purpose [. . .]. The resurgence of the west coast [. . .] will prove to be a great world event."[76] Undoubtedly, Flügel, as Gillis's agent in Germany, was important even in relationship Humboldt maintained with his North American colleague.

Facing difficulty and uncertainty

The correspondence circulating throughout this United States-German network shows a series of risk factors that were not only being discussed in writing, but also put to the test as they ventured into unknown conditions. They wondered what could go wrong, what to expect from such an expedition, and what were the particular challenges and advantages to doing this work in the southern end of the world. But, most of all, the question remained as to whether their astronomical observations would be considered valid in the global north.

Transatlantic communication

The dialogue between Gilliss and Gerling also exposed some of the issues with the way the transatlantic network functioned. At the outset of their correspondence, Gilliss brought

up the subject of translation between German and English, expressing that this work had to be done by individuals for which both he and Gerling could vouch, but within their limited resources. Johann Gottfried Flügel, as previously mentioned, became the mediator between both men; however, there were other translators, a fact alluded to in the letters, for example: "I placed it in the hands of a Friend of Dr. Flügel, who rendered it into tolerably good German-English for me, and from this, with the aid of the original."[77]

However, in November of the same year, Gilliss explained the linguistic problems he was having to Flügel regarding the correspondence with his German colleagues. He did not have the resources to get the German letters translated and, therefore, requested that they write to him exclusively in English, either by having Flügel translate them or by having Gerling attach an English summary.[78] The Gerling Archive in Marburg contains rough drafts of letters written to Gilliss in German, along with their corresponding extracts translated to English. On the US side, in the National Archive in Washington D.C., the original German letters are included with their English translations – translations which also include notes in the margins made by different hands (thus indicating that they were subsequently revised).

Here, one can conclude that these translations were an integral part of the network itself (in that many words were left in the original German). Correspondingly, as can be clearly seen in Figure 1, some words are explained rather than translated; as such "*Declinationbestimungen*" is left in German and later explained in English as "Differences from same stars." In other instances, entire phrases are left in German next to their translation; for example, in Figure 2, with the expression "Ende Gut, alles gut," translated as "End well, all well." On more than one occasion, as previously mentioned, Gilliss wrote to Flügel so that he would translate the gist of what his colleague from Marburg had written. Moreover, the very circulation of the letters made this endeavour all the more complex; several letters are explicit in that their writers were not sure as to whether they should expect a response, or whether they got lost on their journey across the Atlantic, forcing them to try to pick the discussion back up where they had left off.[79] In this sense, the participation of mediators (such as the translators in Washington and Flügel himself) was vital for the comprehension of communication in a network that always allowed participants to work in their native tongue.

Instrument manufacturing and functionality

Aside from the communicational difficulties experienced on both sides, the coordination of measurements was, undoubtedly, a never-ending issue. In the aforementioned letter from 10 November 1848, Gerling affirmed to Gilliss, after reflecting on the scope of the Astronomical Expedition to the Southern Hemisphere, that the measurements of Mars and Venus from different locations could lead to a map for the astronomical community if, and only if, astronomers took the time to send their measurements to their peers so that the data could be compared.[80] Moreover, continued Gerling, the very possibility of success depended on whether other observatories would agree to help collect data in a simultaneous fashion – an indispensable condition of the task. This was precisely the problem that beset Gilliss, vis-à-vis his colleagues in Washington, and impeded the expedition from achieving the success that was expected.

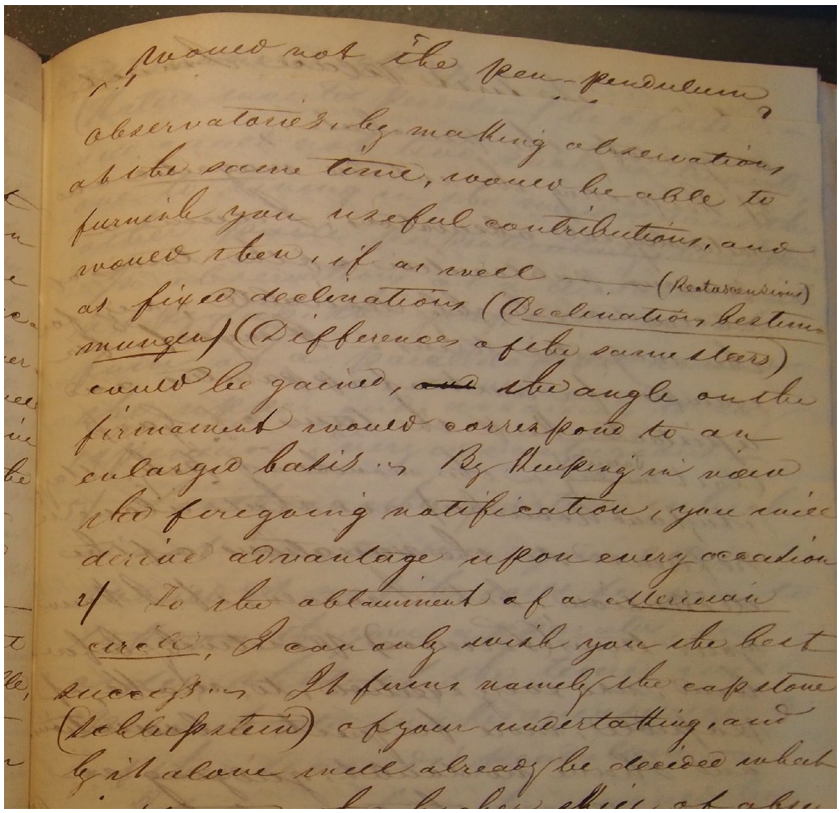

Figure 1. English translation of Gerling's letter to Gilliss.

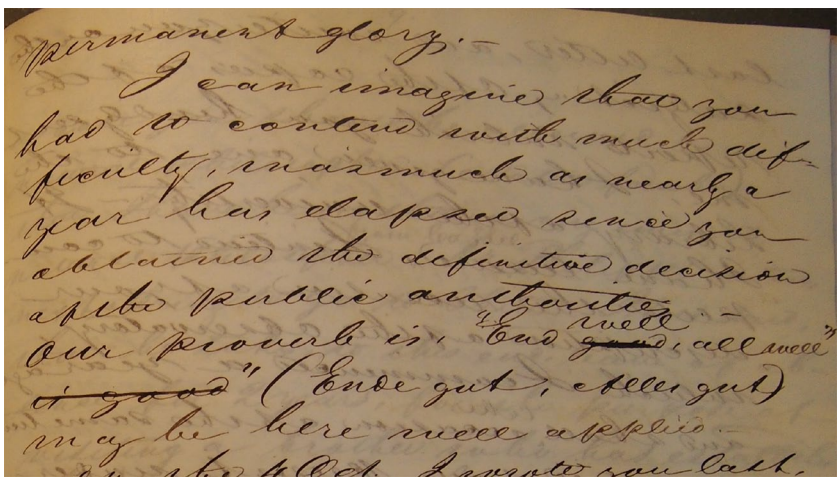

Figure 2. English translation of Gerling's letter to Gilliss.

The expedition did not always have the instruments needed to take some of the measurements that were crucial for the effort's success. The issue surrounding the instruments did not only consist of modifying them to be able to take specific measurements, but rather the challenge of manufacturing and shipping them, due to time constraints and the socio-political realities of the areas where the manufacturing would take place. In that sense, in a letter to Gilliss, Gerling wrote that there was a shortage of meteorological and magnetic observation equipment, which made it difficult to obtain the data with which to compare.[81] In a letter sent on 24 November 1848, from the city of Altona, Heinrich Christian Schumacher (1780–1850) explained to Gilliss the situation of the telescope he had ordered from the Martins workshop in Berlin. The issue was that the manufacturer needed more time, as the 9 months stipulated in the order would not be enough for them to finish. In parallel, he had made the same request to another manufacturer in Hamburg, Adolf Repsold, who stated that it was not at all possible to make the instrument, regardless of the timeframe. Schumacher explained to Gilliss that

> I fear you will think me very ungrateful. [. . .] I hope you will excuse the delay when you consider in what times of agitation and trouble we live here, of which happily for you, you have no idea. Perhaps I [would] have something different to write about, was is not, that the instrument you have ordered at Berlin, on account of which Mr. Martins has written me, requires perhaps some remarks [. . .] The term of 9 months you have fixed to Mr. Martins is too short. I have consulted Mr. Repsold and he declared it impossible to make the instrument, even if he had nothing else to do [. . .]. Is it not enough when the instrument before the end of 1849 is embarked.[82]

Schumacher went on to explain that even other less complex instruments, like the Kiffels chronometer, could not be made because of the political conflicts in Europe at the time. The situation that would later be called the 1848–1849 *March Revolution* had the German Confederation on a war footing and, thus, made it impossible to manufacture and ship instruments ordered from the United States.[83]

On several occasions, the only solution to the problem of manufacturing times that did not coincide with the expedition's itinerary was to modify instruments that already existed. The manufacturer Georg Merz wrote to Gilliss from Munich about his order and request for quality control testing so that the instrument could be used at a higher latitude, saying

> We are working on the instrument with the strongest application, and are yet as far as to finish it until we receive your answer. The varying latitude between twenty degrees we have applied also [to this] instrument with other improvements, so that it should be of the greatest value for such an expedition.[84]

In fact, already in a previous letter Merz had mentioned that "For the southern hemisphere now we must chiefly change the screw of the clockwork."[85]

Aside from manufacturing, another frequent uncertainty in the correspondence with regard to instruments had to do with whether they would work properly in the southern hemisphere.[86] Gerling commented to Gilliss in a letter from 20 November 1848, that he

had not considered that a clockwork device (*Uhrwerk*) should have a different configuration (*Einrichtung*) for the southern hemisphere. Moreover, the high latitude could potentially alter the readings. The problem consisted of finding out whether the polar gradient (*Polhöhe*) of the southern hemisphere could have an effect on the instruments. To that end, Gerling stated, "all of these types of instruments (with which I have no experience) will have a margin of maneuverability that so that they won't go over by more than a few degrees."[87]

Location

Another aspect under discussion was related to where exactly they were going to carry out the observations. Gilliss had considered installing a point of observation on the island of Chiloé located in southern Chile, due to its geography as well as its inhabitants. In the lead up to the Astronomical Expedition to the Southern Hemisphere, Gilliss commented to Gerling that

> Clearly at the same meridian as Washington, but in latitude 43ºS, is the island of Chiloe, a place of the same trade which is, I think occasionally visited by American whales ships for supplies, but [in any] event possessing sufficient intercourse with the coast of South America to render it accessible without much trouble and to avoid the necessity of a special ship. I think, inhabited too, by civilized people.[88]

However, the original idea to reach higher latitudes clashed with their lack of knowledge on the location; the rainy climate of that area made astronomical observation a difficult task. Gilliss had not considered that the climatic conditions at these latitudes (even in South America) were similar to countries in the northern hemisphere located near the North Pole. Moreover, it was impossible to install the equipment they needed without urban infrastructure (roads, accommodations, etc.) that would enable them to transport equipment and ensure the safety of the research team. In the end, Gilliss had to accept the installation of the observatory in Santiago, the Chilean capital.

Another issue discussed in the letters was the possibility of contracting diseases or getting into misunderstandings with local authorities that could ruin their work. In fact, the very possibility of making it to Chile aroused interest among scholars in Marburg: "One of them told me he wants to ask you some of questions in the near future on diseases in Chile."[89] In terms of liaising with Chilean authorities, Gilliss recounted to Gerling that he had been in contact with Manuel Carvallo Gómez (1808–1867), the *chargé d'affaires* of Chile's diplomatic mission in Washington. The idea was to obtain the proper permits as well as the general consent of local authorities, about which Carvallo Gómez touched upon in a letter to Gilliss:

> Chile has been represented as possessing peculiar advantages of these observations and the Government of the United States will be glad to avail, itself of that locality, if it's agreeable to the Government of Chile. [. . .] I do not doubt it has its interests in the promotion of knowledge. I trust such facilities may be afforded to Lieut. Gilliss as will best enable him to attain the desired objects.

Conclusion

As has likely become clear, a crucial aspect of the global history of science is directly related to the scale with which one approaches it.

On the one hand, there is the aspect of historical records; that is, the documents with which one can reconstruct this type of history. As has been recently suggested, scientific archives should been seen as "third nature," insofar as they constitute the "repository of what a discipline considers worth knowing and preserving; [. . .] their practices are the precondition for (and often the essence) of research."[90] In this case, our precondition was the correspondence that two institutions, one on each side of the Atlantic, decided to archive, which, in turn, depended on what they considered to be worthy of safekeeping in the nineteenth century. Therefore, the image of this network is filtered through the lens of Gilliss and Gerling, which is why they seem somewhat over represented vis-à-vis other – perhaps even more important – actors. For example, on the Chilean side, we have only one letter sent to Gilliss from the *chargé d'affaires*, which leaves several questions unanswered, such as whether or not there were discussions on where the observation point would be established, or if they received any recommendations from Chilean intellectuals on the matter. Gilliss and Gerling's letters only reveal how things unfolded in the northern hemisphere.[91]

In addition, this article has shed light on the micro-dimension of global networks. On the one hand, it was not only important to coordinate between scientists on each of the Atlantic, but also to come to consensus on what research would be the most relevant for the astronomical endeavour to be considered a success (The transit of the inner planets or Earth. This consensus building also took place around what the best methodology of observation would be (identifying fixed stars off of which to compare or basing observation off of the Fundamental Stars used in the northern hemisphere), as well as around how to obtain instruments that were adequate for the observations at hand (where to have instruments built that were calibrated to the southern hemisphere).

On the other hand, this micro-dimension exposes the difficulties of coordinating over long distances. In this case, the problem was not only the time it took for correspondence to arrive from one side of the ocean to the other, but also the language barriers entailed in not having established a lingua franca. Effectively, the network functioned in both native languages. To face these challenges, they had letters translated (as Gilliss did with the letters from German colleagues), attached translated excerpts (as Gerling did) and used intermediaries as translators (like in the case of Flügel in Leipzig). At the same time, the manufacturing of instruments for the expedition was not only a matter of identifying the most adequate instrumentation for their intended research, but also of finding manufacturers that could build them. A considerable amount of the correspondence between Gilliss and Gerling had to do with German manufacturers: how to gain their trust, how to compel them to have the instruments ready on time for the expedition, how to calibrate for a part of the world in which, at the time, practically no testing had been done.

A vital aspect of this global network was undoubtedly the role of intermediaries. The literature has unpacked the role of these "go-betweens" by "exploring how such agents, [. . .], made and changed the contents and the paths of knowledge."[92] This is a crucial

point in understanding precisely how Gilliss and Gerling were able to coordinate an astronomical undertaking on the other side of the world. Much has been said here about the role of Johann Gottfried Flügel, but Gerling himself was also a liaison between German astronomers and scientists (such as Humboldt, Gauss, Lemont, Schumacher) and between manufacturers of lenses and measuring instruments in Hamburg (Repsold), Berlin (Pistor & Martins), and Munich (Merz). Another important point, albeit not very explicit in the correspondence, is the role these very instruments played in the global network. This begs several questions regarding the extent to which their research depended on the timely manufacturing of instruments, the expedition's limitations in terms of what the instruments could or could not measure in the southern hemisphere, and the extent to which technical aspects influenced potential outcomes of the expedition. On 25 April 1850, after arriving in Chile, Gilliss wrote the following to his colleague in Marburg:

> On arrival in Chile there was little difficulty in obtaining information respecting its climate so far as individual experience could afford evidence; or of learning the peculiar advantages each locality afforded for repairs to our instruments in case of necessity, or of facilities for our personal requirements as connected with an observatory.[93]

From here on in, the leading figure vying for the success of this astronomical endeavour would be speaking from a local perspective in this network of knowledge.

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Notes on Contributors

Carlos Sanhueza-Cerda is a Professor at the Universidad de Chile. Educated in history and geography, he obtained a PhD in History at the University of Hamburg, Germany. His research interests include the History of Science during the nineteenth and twentieth centuries, namely the circulation of travellers, scientific instruments and knowledge between Latin America, Europe, and North America.

Lorena B. Valderrama is a Professor at the University Alberto Hurtado, Chile, in the Department of Journalism, and co-researcher of the FONDECYT Regular 1170625 "Looking at the stars from the South of the World: the National Astronomical Observatory of Chile (1852-1927)." Her research concentrates on the history and popularization of science and technology during the nineteenth and twentieth centuries.

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11. S. Sivasundaram, "Focus: Global Histories of Science. Introduction," pp. 95–7. According to this author, the diffusionist perspective of George Basalla has been, until now, the most frequent approach (in spite of the fact that the studies cited in the previous footnote differ significantly from this perspective). The diffusionist point of view sustains that science took on a global dimension as a result of its dissemination from Europe to the rest of the world. See G. Basalla, "The Spread of Western Science," *Science*, 156, 1967, pp. 611–22. For a critique of the diffusionist perspective, see K. Raj, *Relocation Modern Sciences* (London: Plagrave, 2007) and K. Raj, "Beyond Postcolonialism . . . and Postpositivism. Circulation and the Global History of Science," *Isis*, 104, 2013, pp. 337–47.

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13. D. van Miert (ed.), *Communicating Observations in Early Modern Letters (1500–1675). Epistolography and Epistemology in the Age of the Scientific Revolution* (London; Turin: The Warburg Institute-Nino Aragno Editore, 2013), p. 7, 244.
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21. The biographical information on Gerling is based on Schrimpf, "An International Campaign of the 19th Century to Determine the Solar Parallax," p. 3.
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23. J.M. Gilliss, *The United States Astronomical Expedition to the Southern Hemispheres in 1849-'52*, 2 vols., (Washington, DC: Nicholson Printer, 1855–1856).
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33. Dick, *Sky and Ocean Joined. The U.S. Naval Observatory 1830-2000*.
34. Valdes *et al.*, "Alcances naturalistas de una expedición astronómica," p. 552.
35. Valdes *et al.*, "Alcances naturalistas de una expedición astronómica," p. 553.
36. The correspondence amounts to a total of 62 letters, stored in two separate archives, one in Washington and the other in Marburg.
37. J.M. Gilliss, *The United States Astronomical Expedition to the Southern Hemispheres in 1849-'52*, vol. I, p. IV. In fact, these articles, both US and German, can be found in the archives at the University of Marburg, along with Chilean newspapers that announce Gilliss's expedition to Chile.
38. Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg). That same newspaper later mentioned the letter from Gerling to Gilliss on four separate occasions, as well as the far-reaching potential of the upcoming astronomical expedition (October 30, 1847; December 4, 1847; April 22, 1848; June 10, 1848). See *Archive of C.L. Gerling*, Library of the Philipps-Universität Marburg.
39. Gerling to Gilliss, September 22, 1847. Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
40. Huffman, "The United States Astronomical Expedition (1849-52) for the Solar Parallax."
41. Gilliss to Gerling, July 11, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
42. Gilliss to Gerling, July 11, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
43. Gerling to Gilliss, July 1, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
44. Gerling to Gilliss, September 22, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg). Emphasis in original.
45. Gerling to Gillis, September 22, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg). Emphasis in original).
46. Gerling to Gilliss, July 7, 1848, National Archives, Washington D.C. The original German reads: "Eine wenige Bemerkungen." This translation and the following were made by the authors.
47. Gerling to Gilliss, July 7, 1848, National Archives, Washington D.C. The original German reads: "Diese Anschaffung bildet eigentlich den Schlussstein in ihre Unternehmung. [. . .] allein wird sich entscheiden inwieweit die erhöhte Beobachtungskunst auf die Genauigkeit unserer Kenntnis der Parallaxen von Einfluss ist [. . .]."
48. See Gilliss, *The United States Astronomical Expedition to the Southern Hemispheres in 1849-'52* and letter Gilliss to Gerling, July 11, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
49. Gerling to Gilliss, 10 November, 1848, National Archives, Washington D.C. The original German reads: "Was die beabsichtigen magnetischen Beobachtungen betrifft, so halte ich auch hier eine vorgängige genaue Vorausbestimung und Bekanntmachung der Beobachtungszeiten für höchst wünschwert. Ich selbst halte zum Beispiel, aus Mangel auf Apparat und Gehülfen nur die Gaussichen Termine mit und zwar allein in Beziehung auf die Variationen der Deklination, würde aber, wenn ihre Termine zum voraus wusste, gerne alle Bemühungen anwenden um wo möglich äfter zu beobachten."
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54. Gerling to Gilliss, 6 Februar 1849, National Archives, Washington, DC. The original German reads: "unvollständige Beobachtungen nur da brauchbar sein können, wo an anderen nahen liegenden Orten das fehlenden ergänzt wird."
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57. Gilliss to Gerling, July 25, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
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59. ". . . *in verschiedenen Jahreszeiten des Meeres an der Oberfläche*." Rough draft of a letter in German, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).346-a-1.
60. See I. Schwarz, *Alexander von Humboldt und die Vereinigten Staaten von Amerika: Briefwechsel* (Berlin: Akademie Verlag, 2004), pp. 411–3. We would like to thank Sandra Rebok for providing us with information on the correspondence between Gilliss and Humboldt.
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62. Gauss to Gerling, 30 November, 1848 in *Carl Friedrich Gauß Briefwechsel*. The original German reads: "[. . .] kann er vielleicht noch eins und anderes dazu nehmen und *bittet deshalb um Bemerkungen und Ratschläge*."
63. Gauss to Gerling, 15 december 1848 in *Carl Friedrich Gauß Briefwechsel*. The original German reads: "Herr Gilliss hat schon so viel Gegenständen bezeichnet, mit denen er sich beschäftigen will, dass ich nichts hinzuzusetsen habe."
64. G. A. Hahn to Gilliss, 6 September 1848, National Archives, Washington, DC.
65. Pistor & Martins to Gilliss, 11 october 1848, National Archives, Washington, DC.
66. J. v.Lamont to Gilliss, July 9 1848, National Archives, Washington, DC.
67. G. Merz to Gilliss, November 5 1848, National Archives, Washington, DC.
68. Gerling to Gilliss, 20 November 1848, National Archives, Washington, DC.
69. Flügel to Gerling, February 8 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
70. Flügel to Gerling, June 7 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
71. Flügel to Gerling, August 30, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
72. Flügel to Gerling, Februar 7, 1848, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
73. Flügel to Gerling October 31, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
74. Flügel to Gerling, 25 November 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).

75. Schwarz, *Alexander von Humboldt und die Vereinigten Staaten von Amerika*, p. 262. The original German reads: für die [. . .] Notizen von Gilliss über die Parallaxenbestimmungen in Chili und die astronomische Länge von Washington auszudrücken. [. . .] ist es aufrichtend [. . .] der Entwickelung wissenschatlichen Sinnes in der Vereinigten Staaten zu folgen und zu erkennen wie sehr die Regierung – eine dreijährige Expedition nach Chile, weil ein Professor in Marburg sie wünscht und in Europa niemand hört¡¡- selbst daran Theil nimmt." Marburg's professor is Gerling.
76. Schwarz, Ingo, *Alexander von Humboldt und die Vereinigten Staaten von Amerika*, p. 268. The original German reads: "Die Interessante Expedition der verdienstvollen Lieut. Gilliss nach Chili zeigt ihrem eigentlichen Zwecke nach [. . .]. Die Belebung der westlichen Küste [. . .] wird in ihren Folgen eine grosse Weltbegebenheit."
77. Gilliss to Gerling July 25, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
78. Gilliss to Gerling October 31, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
79. G. Merz to Gilliss, 1 December 1848, National Archives, Washington, DC.
80. Gerling to Gilliss, November 10, 1848, National Archives, Washington, DC.
81. Gerling to Gilliss, November 10, 1848, National Archives, Washington, DC.
82. Heinrich Christian Schumacher to Gilliss, November 24, 1848, National Archives, Washington, DC.
83. Heinrich Christian Schumacher to Gilliss, November 24, 1848, National Archives, Washington, DC.
84. G. Merz to Gilliss, February 10, 1849, National Archives, Washington, DC.
85. G. Merz to Gilliss, November 16, 1848, National Archives, Washington, DC.
86. Gerling to Gilliss, 10 November, 1848, National Archives, Washington, DC.
87. Gerling to Gilliss, 20 November 1848, National Archives, Washington, DC. The original German reads: So wird ja wohl jedes Instrument das Art (Ich habe keine Erfahrung damit) so viel Spielraum haben, dass es aug einen oder einige Grade nicht ankommt.
88. Gilliss to Gerling July, 25, 1847, Archive of C.L. Gerling, Library of the Philipps-Universität Marburg, (Marburg).
89. Gerling to Gilliss, November 6, 1848, National Archives, Washington, DC. The original German reads: Eine von Ihnen hat mir gesagt, dass er einige Fragen über Krankheiten in Chile demnächst an Sie zu richten, beabsichtige."
90. L. Daston (ed.), *Science in the Archives: Pasts, Presents, Futures* (Chicago: University of Chicago Press, 2017), p. 2.
91. In Chilean archives, such as the National Archive and that of the University of Chile, the only records of the Expedition to the Southern Hemisphere are from when Gilliss left the country in 1852.
92. Schaffer *et al., The Brokered World*, p. X.
93. Gilliss, *Astronomische Nachrichten* Nº 740, p. 145.