An Enduring Vision: Qingdao Observatory and the Transnational Meteorology in Modern China, 1898–1937

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Introduction

In 1898, German geologist Ferdinand von Richthofen (1833–1905), on behalf of the German Empire (1871–1918), proposed a blueprint for the northern Chinese coastal city of Qingdao, emphasizing the need for an observatory dedicated to meteorological, geomagnetic, and astronomical observations. Based on his fieldwork in China, Richthofen envisioned this observatory as a scientific hub, working in collaboration with scientific stations from other states to establish observational networks across Shandong Province and throughout China. With submarine communication cables around Qingdao, it could also emerge as the "Central Meteorological Observatory of the Chinese-Japanese Sea" (centralen Wetterwarte für die chinesisch-japanischen Meere).[1] Although Richthofen's vision was rooted in German colonial ambitions, it was Imperial Japan (1905–1945), the Republic of China (ROC, 1912–1949), and later the People's Republic of China (PRC, 1949–) that realized and expanded upon his plan.

[1] Ferdinand von Richthofen, *Shantung und seine Eingangspforte Kiautschou* (D. Reimer, 1898), 270-271. Although the primary focus of Qingdao Observatory was meteorology (broadly encompassing weather, climate, and other atmospheric sciences), as Richthofen noted, it also undertook observations in other scientific fields. Therefore, this article primarily addresses meteorology, while also discussing the Observatory's work in astronomy, geomagnetism, and oceanography.

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No other meteorological observatory in East Asia underwent as turbulent a history of sovereignty transitions as Qingdao Observatory (Fig.1, in German, Kiautschou Observatorium; in Japanese, 青島測候所; in Chinese, 青島觀象台; hereafter referred to as "the Observatory"). It was also one of the most important observatories in modern East Asia.[2] From 1898 to 1914, the German government, military, and scientists invested significant efforts into its construction. Following Germany's defeat by Japan during the Siege of Qingdao (1914), the Japanese took control of the Observatory. Notably, when World War I (1914–1918) ended and the Chinese government in Beijing requested the return of sovereignty over the Observatory from Japan, Japan refused and forcibly retained Japanese technicians in Qingdao. This resulted in thirteen years of diplomatic negotiations and joint observations between the two states. During the Second Sino-Japanese War (1937–1945), the Observatory was seized again by the Japanese military until 1945, when the Chinese Nationalist government regained control of Qingdao. Five years later, the Chinese Communist Party (CCP) took over the Observatory.

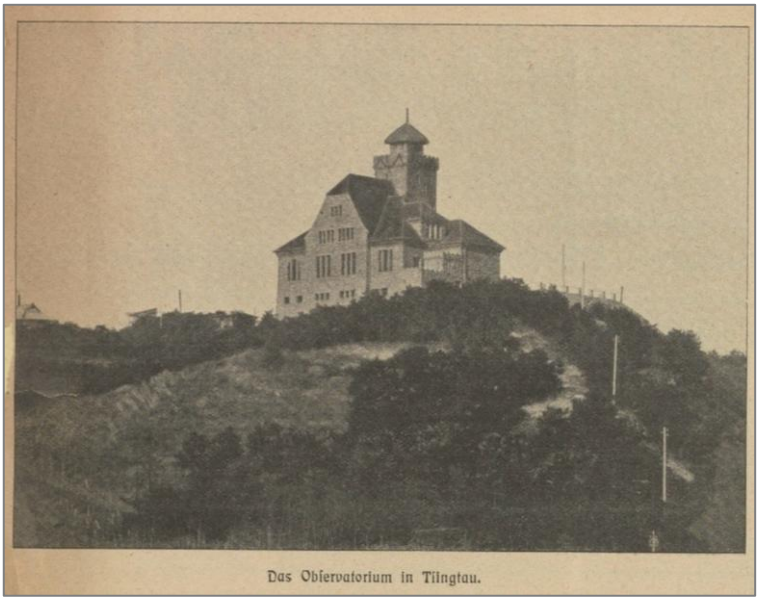

Fig. 1. "Das Observatorium in Tsingtau" [The Observatory in Qingdao], photograph published in 1912. Courtesy of the German Federal Archives (Bundesarchiv).

Although the history of Qingdao Observatory reflects the shifting political regimes and power discourses of imperialism, colonialism, and nationalism from 1898 to 1937, this paper does not adopt the framework of imperial or colonial science of specific states, which focuses on science's contributions to state enterprises.[3] Nor does it align with the previous debates

[2] Shen Bingbing, Zhang Jing, Yan Huiling, and Zhang Min, "Qingdao Guanxiangtai de Lishi Yange yu Gongxian Yanjiu, 1898-1949 [Qingdao Observatory's Historical Development and Contribution, 1898-1949]," *Qixiang Keji Jinzhan*, no.4 (2016): 44-50, CNKI.

[3] This kind of research often focuses on cases involving meteorological observatories and meteorologists. On the history of observatories established by Britain, France, and Germany in Asia, see P. Kevin Mackeown, *Early China Coast Meteorology: The Role of Hong Kong* (Hong Kong University Press, 2011). Wu Yan, *Science, Interest and Expansion of Europe: Zi-Ka-Wei Observatory (1873–1950) in the Context of the Territorial Expansion of European Modern Science* (China Social Sciences Press, 2013). Gerhard Kortum, "The Naval Observatory in Tsingtau (Qingdao), 1897-1914, German background and influence," in *Ocean Science Bridging the Millennia: A Spectrum of Historical Accounts*, Selim Morcos et al. (UNESCO, 2004), 257-261. Iwo Amelung, "Das Observatorium in Qingdao—Koloniale Meteorologie in Ostasien [Qingdao Observatory—Colonial Meteorology in East Asia]," in *Deutschland: Globalgeschichte einer Nation* [Germany: A Global History of a Nation], ed. Andreas Fahrmeir (C.H. Beck, 2020), 435-440. On meteorologists and technicians, see Masumi Zaiki and Togo Tsukahara, "Meteorology on the Southern Frontier of Japan's Empire: Ogasawara Kazuo at Taihoku Imperial University," *East Asian Science, Technology and Society: An International Journal* 1 (2007): 183-203, https://doi.org/10.1215/s12280-007-9010-9. Fiona Williamson, "Just doing their job: the hidden meteorologists of colonial

surrounding Scientific Sovereignty,[4] which emphasize exclusivity and nationalism. Instead, it critically employs a transnational perspective and integrates Actor Network Theory (ANT) to examine how meteorological materials, scientists, and various local practices, such as observational techniques and data exchange, manifested and evolved across both spatial and temporal dimensions.[5]

The transnational meteorology of Qingdao engages with the regional context of China's national formation, highlighting the co-contributions of multiple states, such as China, Japan, and Korea.[6] Furthermore, to move beyond the limitations of the transnational perspective that "see nation-states – homogeneous, simple, and rigid – as the only actors,"[7] and to address the unexpected moments of internal power inconsistencies during the Sino-Japanese co-management of Qingdao Observatory, as well as the sustained scientific collaborations across three regimes, this paper applies network as an alternative approach.[8] By foregrounding the agency of local scientists and scientific practices, this study responds to the calls by historians of science to relocate meteorology.[9] Building on scholarly reflections on network theories,[10] it also brings back discourses and unequal power relations into the analysis while focusing on the role of shifting peripheries and centers in shaping multiple scientific networks.[11]

Importantly, writing this connected story does not imply that science is independent of imperialism, colonialism, or nationalism. Rather, these seemingly exclusive and opposing power dynamics and ideological expressions converge along the path of transnational science

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Hong Kong, c. 1883-1914," *The British Journal for the History of Science* 54 (2021): 341-359, https ://doi.org/10.1017/S0007087421000182. Most recently research, see Mark E. Frank, "National Climate: Zhu Kezhen and the Framing of the Atmosphere in Modern China," *History of Science* (2023): 1-29, https://doi.org/10.1177/00732753231157453.

[4] Wang Zuoyue, "Saving China through Science: The Science Society of China, Scientific Nationalism, and Civil Society in Republican China," *Osiris* 17 (2002): 291-322, https://doi.org/10.1086/649367. Hiromi Mizuno, *Science for the Empire: Scientific Nationalism in Modern Japan* (Stanford University Press, 2008). To the extent that the history of Qingdao Observatory is acknowledged, attention has been almost exclusively directed toward the diplomatic negotiations and differing significance of the Observatory's scientific sovereignty for Japan and China after 1922, see Liu Xiao, "Understanding sovereignty through meteorology: China, Japan, and the dispute over Qingdao Observatory, 1918-1931," *Annals of Science* (2023), https://doi.org/10.1080/00033790.2023.2231465. Ren Haojie, "Research on the Modern Qingdao Observatory (1922-1937)" (M.A. Thesis, Qingdao University, 2023).

[5] On Actor Network Theory, see Bruno Latour, *Reassembling the Social: An Introduction to Actor-Network-Theory* (Oxford University Press, 2005); Michel Callon, "Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay," in *Power, Action, and Belief: A New Sociology of Knowledge?*, ed. John Law (Routledge, 1986), 196–233; John Law and John Hassard, eds., *Actor Network Theory and After* (Blackwell, 1999).

[6] Prasenjit Duara, *The Global and Regional in China's Nation-Formation* (Routledge, 2009).

[7] Song Nianshen, *Making Borders in Modern East Asia: The Tumen River Demarcation, 1881–1919* (University Press of Cambridge, 2018).

[8] The most relevant is Bruno Latour, *The Pasteurization of France* (Harvard University Press, 1988).

[9] Roy Malcolm MacLeod, "On Visiting the 'Moving Metropolis': Reflections on the Architecture of Imperial Science," *Historical Records of Australian Science* 5 (1982): 1-16, https://doi.org/10.1071/HR9820530001. David N. Livingstone, *Putting Science in Its Place: Geographies of Scientific Knowledge* (University of Chicago Press, 2003). Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650-1900* (Palgrave Macmillan, 2007). Martin Mahony and Angelo Matteo Cagliotti, "Relocating meteorology," *History of Meteorology* 8 (2017): 1-14, http://meteohistory.org/scholarship/history-of-meteorology/history-of-meteorology-volume-8-2017/.

[10] For example, see David Bloor, "Anti-Latour," *Studies in History and Philosophy of Science* 30 (1999): 81-112, https://doi.org/10.1016/S0039-3681(98)00038-7. Martin Müller, "Assemblages and Actor-networks: Rethinking Socio-material Power, Politics and Space," *Geography Compass* 9 (2015): 27-41, https://doi.org/10.1111/gec3.12192.

[11] My thinking here has been inspired by Kenneth Pomeranz's research on the economic history of Shandong. I argue that, beyond canals and maritime trade, science offers another possibility for transforming and constructing new center-periphery orders. See Pomeranz, *The Making of a Hinterland: State, Society, and Economy in Inland North China, 1853–1937* (University of California Press, 1993). Moreover, Fiona Williamson's research points out that meteorology in British Malaya was not a case of knowledge flowing from the center to the periphery. On the contrary, meteorology operated as a series of widespread nodes. See Williamson, "An Ocean Apart: Meteorology and the Elusive Observatories of British Malaya," *Isis*, 114 (2023): 687-899, https://doi.org/10.1086/727680.

and multiple modernities. It was the demand for overseas expansion by colonial empires that drove German scientists to distant East Asian frontiers to establish and manage Qingdao Observatory. Yet, the call of the civilizing mission also encouraged them to assist in the development of China's meteorological enterprise. Subsequently, Japanese scientists, with a Pan-Asianist interpretation of science, justified Japan's colonial interests in China and asserted Japan's aspiration to lead Asia in the international scientific arena, seeking equality with Europe. These two distinct forms—imperialism and colonial modernity—fuelled the anti-colonial nationalism of later Chinese scientists in the latter half of the Republican period. At the same time, Germany and Japan each integrated Qingdao into their colonial scientific networks, which continued to overlap, aligning with maritime communication networks between China and Japan, as well as with China's local and national scientific networks. More broadly, these scientific networks were also global, connected individuals, institutions, and nations, and facilitated flows and interactions of scientific knowledge, personnel, equipment, and practices. In turn, they intervened in and shaped the global scientific system. The Observatory also served as China's maritime frontier and the colonial periphery of German and Japanese empires, while also being the centre of the "Chinese-Japanese Sea" and a hub within multiple scientific networks, frequently shifting its identity within a complex spatial order. This fluid positioning nurtured a unique path to scientific modernization in modern China and East Asia.

These layered and overlapping networks at local, national, regional, and global levels are also synchronic, highlighting temporal continuity in Qingdao's multiple scientific networks. Since the 1990s, an increasing number of modern Chinese historians have transcended the 1949 divide, demonstrating how the early PRC inherited political and economic legacies from both Japan and the Nationalist government, involving substantial scientific and technological specifics.[12] Recent studies in the history of meteorology have also recognized the institutional, organizational, and personnel continuities in meteorology before and after the Second Sino-Japanese War.[13] This research provides a more detailed local case study of meteorology, further enriching this growing academic focus. Notably, the story of Qingdao is connected not only to the times of science and technology, but also to the science and technology of time. In addition to meteorology, Qingdao Observatory was the first scientific institution in China to conduct independent time measurement and provide time signaling services. It maintained these measurement activities and continually improved their accuracy under different regimes.

Additionally, my research is also inspired by recent attention to verticality in the political geography and the history of science. This vertical turn aligns with ANT's emphasis on the agency of no-human actor, shifting focus beyond the static land territories of modern states to include the agency of no-human materialities, particularly the environmental forces of oceans, atmospheric phenomena, and planetary systems, thereby expanding our

[12] For instance, see William C. Kirby, "Continuity and Change in Modern China: Economic Planning on the Mainland and on Taiwan, 1943-1958," *Australian Journal of Chinese Affairs* 24 (1990): 121-141, https://doi.org/10.2307/2158891. Joseph W. Esherick, "War and Revolution: Chinese Society during the 1940s," *Twentieth-Century China*, no.1 (2001): 1-37, https://doi.org/10.1353/tcc.2001.0007. Koji Hirata, "Made in Manchuria: The Transnational Origins of Socialist Industrialization in Maoist China," *The American Historical Review* 126 (2021): 1072-1110, https://doi.org/10.1093/ahr/rhab351. Victor Seow, *Carbon Technocracy: Energy Regimes in Modern East Asia* (University of Chicago Press, 2021).

[13] Fang-yu Liu, *Weather and Warfare: Chinese Meteorology during the Second Sino-Japanese War* (Republic of China History and Culture Society Co., Ltd., 2023), 237-253.

understanding of territorial governance in modern nation-states.[14] The verticality is closely tied to the multi-scalar nature of atmospheric science.[15] The visibility of such global environmental objects, which span specific geographic and environmental scales, more clearly reflects the interventions of human political order and technological infrastructure. In the case of Qingdao Observatory, its production and dissemination of atmospheric knowledge, research on the sea between China and Japan, and observations of longitude and celestial movements, all contributed to the exploration of this dynamic, vertical environment and revealed the governing powers employed scientific understanding of the natural environment. Through its continuous knowledge production, meteorological reporting, and timekeeping services, the Observatory not only contributed to the formation of multiple scientific networks but also profoundly influenced daily life and socio-economic structures centered around Qingdao, shaping new communities.[16]

Drawing on a diverse range of multilingual historical sources, including administrative documents, local archives, scientific reports, personal memoirs, and newspapers from China, Germany, and Japan, this article bridges the temporal divides across the German, Japanese, and Chinese periods of rule to explore their transnational, multi-dimensional history in Qingdao. This narrative transcends the binary framework of Western versus non-Western perspectives, or colonialism versus anti-colonial nationalism. Rather, I argue that it was the competing state powers—advancing Qingdao's and modern China's meteorological modernization amid political fractures and diplomatic confrontations—that collectively wove multiple networks and jointly created new communities. This process serves as a microcosm of how, in modern East Asia, diverse regimes were integrated through local scientific practices and subsequently contributed to the global scientific enterprise.

Germans Greet the World in East Asia, 1898–1914

Today, Qingdao is the largest city in Shandong and the third-largest city in northern China, just behind Beijing and Tianjin. In stark contrast, as late as the 19th century, this seaside city was geographically peripheral, and also played a marginal role in other respects: it lacked favorable agricultural conditions, and the empire did not appreciate its commercial potential as a seaport, let alone its capacity for advanced education and science. The canal that connected Qingdao to the Shandong hinterland had become unnavigable. Qingdao's advantage in maritime trade was further undermined by the newly opened treaty port Chefoo (present-day Yantai), located nearby.[17] Nevertheless, France, Russia, and Germany began to take notice of Qingdao and its nearby Jiaozhou Bay, recognizing its military and trade value,

[14] "Special Issue: Verticality in the History of Science," ed. Wilko Graf von Hardenberg and Martin Mahony, *Centaurus* 62(2020). Andy Hanlun Li, "Volumising territorial sovereignty: Atmospheric sciences, climate, and the vertical dimension in 20th century China," *Political Geography* 111 (2024), https://doi.org/10.1016/j.polgeo.2024.103106.

[15] In the case of dynamic climatology in Austria/Austro-Hungarian, Deborah R. Coen demonstrates how scientists engaged in diverse interpretations and reflections on the concept of "scale." See Coen, *Climate in Motion: Science, Empire, and the Problem of Scale* (University of Chicago Press, 2018). On discussions on "scale" and atmospheric science in Asia, see Fiona Williamson and Vladimir Janković, "A Question of Scale: Making Meteorological Knowledge and Nation in Imperial Asia," *History of Meteorology*, 9 (2020): 1-9, https://meteohistory.org/ojs/index.php/journal/issue/view/1.

[16] One example is the impact of Hong Kong Observatory on the formation of Hong Kong's "inter-port mercantile community," see Marlon Zhu, "Typhoons, Meteorological Intelligence, and the Inter-Port Mercantile Community in nineteenth-century China," (Ph.D. Dissertation, Binghamton University, 2012).

[17] Klaus Mühlhahn, *Herrschaft und Widerstand in der "Musterkolonie" Kiautschou, Interaktionen zwischen China und Deutschland, 1897–1914* [Domination and Resistance in the "Model Colony" Qingdao, Interactions between China and Germany] (R. Oldenbourg Verlag, 2000), 38-67.

and attempting to seize control of it. Ultimately, in 1897, the German navy occupied Qingdao, forcibly pressuring the Qing Dynasty into leasing it to Germany for 99 years.[18]

As the Minister of Imperial Colonial Office (Reichskolonialamt), Bernhard Dernhurg (1865–1937) believed that Germany's overseas colonial ambitions were inseparable from science and technology, which he referred to as "the most important auxiliary science" (die Wichtigste Hilfswissenschaft).[19] In its effort to transform Qingdao into the German Empire's "model colony" (Musterkolonie) in East Asia, German scientists undertook a series of environmental surveys and built scientific infrastructure there. In 1897, during his investigation of Jiaozhou Bay, German hydrologist Georg Franzius (1842–1914) stressed the need to learn from the 1896 disaster, in which the German ship ILTIS was wrecked near Chefoo during a typhoon. He recommended the construction of port infrastructure to defend the coastline against typhoons and other meteorological disasters.[20] Subsequently, Captain Moritz Deimling (1868–1905) led a survey team to conduct scientific observations of Qingdao to inform future planning. This advance team formed the foundation of Qingdao Observatory, a meteorological and astronomical station located on the Qingdao coast, which officially began weather and climate observations in June 1898 and provided storm warnings to ships docked in the port. A meteorological substation was later established in Licun.[21] Undoubtedly, the establishment of the Observatory served Germany's colonial interests,[22] but it also reflected another ambition—the human determination to transform nature—and, as Richthofen noted, the goal of fostering substantial scientific communication.[23]

Unlike the role of German science in South Asia as part of "a shared European project,"[24] Qingdao Observatory exemplifies a broader scope of global scientific collaboration, involving both Western and non-Western actors. When planning the Observatory, Richthofen had already considered the geography of meteorological services in China. While British Hong Kong Observatory (HKO) investigated typhoons and French Zikawei Observatory in Shanghai (Zikawei) conducted meteorological and geomagnetic studies, they still lacked generalized, systematic, and reliable meteorological work. He argued that a sophisticated meteorological observatory in Northern China would fill the gap.[25] The preparation for the Observatory also received support from other European countries. Scientists from Zikawei arrived in Qingdao to assist the Germans in building the

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[18] There has been considerable research on the colonial history of Qingdao in German occupation period. For a representative study, see Mühlhahn, *Herrschaft und Widerstand in der "Musterkolonie" Kiautschou*. For recent English-language works on the economic development of Qingdao and Shandong during this period, see Fion Wai Ling So, *Germany's Colony in China: Colonialism, Protection and Economic Development in Qingdao and Shandong, 1898–1914* (Routledge, 2019).

[19] Bernhard Dernburg, *Zielpunkte des deutschen Kolonialwesens: Zwei Vorträge* [Objectives of German Colonialism: Two Lectures] (1907), 11, Koloniale Sammlungen [Colonial Collections], Universitätsbibliothek Frankfurt am Main [Frankfurt University Library] (KS/UBF).

[20] Georg Franzius, *Kiautschou: Deutschlands Erwerbung in Ostasien* [Qingdao: Germany's Acquisition in East Asia] (Schall & Grund, 1898), 100, Heidelberger Historische Bestände [Heidelberg historical literature].

[21] Moritz Deimling, *Die Vermessung des deutschen Kiautschou-Gebiets: Darstellung der Methoden und Ergebnisse mit 11 Kartenanlagen* [The Surveying of the German Qingdao Territory] (Verlag von G. Reimer, 1901), 5-6, 24-25, KS/UBF.

[22] As Lewis Pyenson pointed out, exact sciences interacted closely with German imperialist strategies. See Pyenson, *Cultural Imperialism and Exact Sciences: German Expansion Overseas, 1900–1930* (Lang, 1985), 247-295. However, Pyenson's view that Qingdao Observatory declined after Germany's departure is clearly one-sided. See Pyenson, *Cultural Imperialism and Exact Sciences*, 270.

[23] Ferdinand von Richthofen, *Shantung und seine Eingangspforte Kiautschou*, 271.

[24] Moritz von Brescius, *German Science in the Age of Empire: Enterprise, Opportunity and the Schlagintweit Brothers* (Cambridge University Press, 2019), 5.

[25] Ferdinand von Richthofen, *Shantung und seine Eingangspforte Kiautschou*, 270-271.

Observatory.[26] Alongside this, Deimling adopted the British methods of latitude and longitude measurement, successfully positioning Qingdao for the first time on the global map.[27] Upon the Observatory's establishment, both HKO and Zikawei became its collaborators, regularly sharing observational data and exchanging technical personnel.[28] The Observatory's continually-improved weather forecasting and harbor infrastructure further stimulated the development of Qingdao's commerce and tourism industries.[29]

Meanwhile, German scientists actively collaborated with scientific institutions from non-European powers, including Japan and the Qing Dynasty. Facing inland China, the Observatory established 10 subsidiary stations, exchanging information with stations in nine inland cities such as Jinan, Taiyuan, and Kaifeng. Toward the Pacific, it maintained communication with meteorological stations in Tokyo, the Ryukyu Islands, Korea, Taiwan, and Manila.[30] As Bruno Meyermann (1876–1963), a German astronomist and the Observatory's first director, described, the Observatory possessed all the meteorological data for East Asia.[31] In addition to its meteorological functions, the Observatory specialized in geomagnetic studies and time measurement, placing great emphasis on technical training. In geomagnetism, it collaborated with observatories worldwide to study the propagation of geomagnetic disturbances.[32] In time service, Qingdao joined the International Time Bureau in Paris, regularly transmitting time signals to the international community.[33] Regarding the training of technical personnel, German scientists attempted to collaborate with the German-Chinese University in Qingdao to offer courses in meteorology and astronomy. Meyermann expressed the hope that, even if Germany's lease ended, the Observatory could become China's national meteorological observatory.[34] Later, while helping the ROC in establishing the Central Observatory in Beijing, the German governor of Qingdao articulated a similar vision: as a teaching institution, the Observatory could remain connected to Chinese universities.[35] As Richthofen envisioned, they hoped that Qingdao would become a scientific center, spreading modern technology across China.[36]

Although Germany's assistance to China's meteorological enterprise reflected the discourse of the civilizing mission and served as a justification for its colonial endeavors, the efforts to connect China and other Asian meteorological stations also positioned Qingdao Observatory as a knot integrating them into Germany's colonial meteorological network. German court poet Ernst von Wildenbruch (1845–1909) once praised this distant observatory on foreign shores as an aide to seafarers, and as a means for the German people to "greet the

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[26] Letters from Chevalier to Oskar Truppel (October 9, 1901), "Kiautschou.-Observatorium" (KO), RM3/6997, Bundesarchiv-Militärarchiv in Freiburg [German Federal Archives - the Department. Military Archives] (BArch/MA).

[27] Moritz Deimling, "Die Vermessung in Kiautschou [The Surveying in Qingdao]," *Marine-Rundschau* 10 (1899): 446-447, KS/UBF.

[28] Letters from Zikawei Observatory to Qingdao Observatory (September, 17, 1902), KO, RM3/6997, BArch/MA.

[29] The 1911 Second Quarter Work Report of Qingdao Observatory, KO, RM3/6998, BArch/MA.

[30] "Vermessung," in *Denkschrift betreffend die Entwicklung des Kiautschou-Gebiets vom Oktober 1898 bis Oktober 1899* [Memorandum concerning the Development of the Kiautschou Territory from October 1898 to October 1899] (Reichsdruckerei, 1900), KS/UBF.

[31] Bruno Meyermann, "Das Kiautschaugebiet [The Qingdao Territory]", in Paul Heidke, "Das Meteorologische Beobachtungsnetz in den Deutschen Kolonien [The Meteorological Observation Network in German Colonies]," *Meteorologische Zeitschrift* (1921): 101-106, HathiTrust.

[32] The 1911 Second Quarter Work Report of Qingdao Observatory, KO, RM3/6998, BArch/MA.

[33] The 1913 First Quarter Work Report of Qingdao Observatory, KO, RM3/6998, BArch/MA.

[34] Meyermann, "Das Kiautschaugebiet," 101-106.

[35] Qingdao Governor's Office to the Naval Department (January 20, 1913), KO, RM3/6998, BArch/MA.

[36] Ferdinand von Richthofen, *Shantung und seine Eingangspforte Kiautschou*, 270-271.

world" (der Gruß er, den der Welt deutsches Volk entrichtet).[37] This German vision of benefiting and greeting the world emphasized the civilizing mission of Germans and Europeans in advancing China's meteorological enterprise. Richthofen's statements about Germany's occupation and development of Qingdao further reflected this prevalent Western mindset: the belief that China lacked both the will and capacity to reverse its decline without the intervention of a wise and external force—the Europeans.[38] It was precisely this mindset and colonial demand that prompted German scientists to send data collected from China and other regions in Asia back to Germany and its colonial scientific network. Meteorological reports, environmental surveys, and academic publications from Qingdao were regularly sent to the German Maritime Observatory in Hamburg.[39] Through his academic network and career, Bruno Meyermann further disseminated the Observatory's comet observation data to scientists and institutions in Germany, German Samoa, Britain, and beyond.[40]

In 1912, Qingdao Observatory acquired a new office building and China's first geomagnetic observation chamber, becoming Germany's Royal Observatory. The next year, at the East Asia Meteorological Conference held in Japan, observatories in Tokyo, Qingdao, Zikawei, and Hong Kong standardized storm warning signals, marking the beginning of standardized meteorological work in East Asia.[41] In just over a decade, this once remote maritime frontier of the Chinese dynasties and overseas fragment of the German Empire had become the meteorological center of Germany and East Asia. Like Paris of Europe, it became the time center of Asia.[42] These two roles then continued to be enacted under the administrations of the two subsequent East Asian regimes.

Towards Navigating the "Chinese-Japanese Sea," 1914–1924

As a continuation of the struggle for military and trade interests in Qingdao, Japan and its ally Britain launched a siege against the Germans in Qingdao in 1914.[43] Following Germany's defeat, Japan became the second custodian of Qingdao Observatory. Although this was a military victory and a regime change where an Asian power replaced a Western one, contemporary Japanese scientists in recent chronicles have reminded us that, in terms of meteorological development, this was "the Succession of Qingdao Observatory" (青島測候所の継承). [44] During this period, the Observatory was incorporated into Imperial Japan's meteorological networks, enriching its multifaceted central role. Building on the German work, meteorology, seismology, and geomagnetism in Qingdao developed rapidly, and the border natural environment, including the maritime areas between China and Japan, was brought into its scope of study, continuing Richthofen's vision.

Japanese scientists recognized the importance of Qingdao Observatory early on. In 1900, Japan had already begun collecting meteorological reports from various locations

[37] The silhouette of this poetic plaque was published in *Der Auslandsdeutsche* [The Overseas German] No.1(1912), KO, RM3/6998, BArch/MA.

[38] Ferdinand von Richthofen, *Shantung und seine Eingangspforte Kiautschou*, 256.

[39] The 1912 Second Quarter Work Report of Qingdao Observatory, KO, RM3/6998, BArch/MA.

[40] Pyenson, *Cultural Imperialism and Exact Sciences*, 267.

[41] Meyermann, "Das Kiautschaugebiet," 101-106.

[42] The 1913 First Quarter Work Report of Qingdao Observatory, KO, RM3/6998, BArch/MA.

[43] On the process of the war of Siege of Qingdao, see Charles B. Burdick, *The Japanese Siege of Tsingtau: World War I in Asia* (Shoe String Press, 1976).

[44] Haruhiko Yamamoto, *Chūō Kishōdai: Teikoku Nihon no kishō kansoku nettowāku no tenkai to shūen* [The Japan Meteorological Agency: Development and Demise of the Meteorological Observation Network in Imperial Japan] (Agriculture and Forestry Statistics Publishing Inc., 2023).

across China, including Jiaozhou Bay, and dispatched technical personnel to China to pursue collaboration.[45] When the Japanese army planned to use artillery shells to destroy the infrastructure of Qingdao, the Central Meteorological Observatory in Tokyo (CMO) sent a letter to the frontline troops, noting that the meteorological, astronomical, and geomagnetic-seismological equipment installed by Germany at the Observatory was of the highest quality. Therefore, the CMO expressed its desire to send specialized technical personnel to accompany the army to Qingdao to prevent any damage to these instruments.[46] As a result, the Japanese military took possession of the German office building and subsidiary observations with virtually no damage to the infrastructure. They also inherited facilities and precision instruments, including the transit instrument room, seismometer room, magnetism room, time ballroom, and louvered screens.[47]

Given Qingdao's geographical location as a new colony and its integration into existing colonial networks, Japan expanded and innovated the scientific work of Qingdao Observatory. While continuing its cooperation with Zikawei and HKO, and maintaining the exchange of meteorological reports, the Observatory's observational scope was extended to connect with mainland Japan, the Japanese-occupied Korea, the Kwantung Leased Territory, and southern China, including another Japanese-occupied colony, Taiwan. Regarding time measurement, Japanese scientists also made improvements, replacing the time ball used during the German occupation with the firing of a cannon at noon each day in the port. These changes substituted sound for a visual signal, enhancing the range of time signal transmission,[48] while also asserting Japan's sovereignty over the Observatory on a broader scale. Furthermore, Japan strengthened the Observatory with new instruments and expanded its operational scope to include oceanic meteorology and the marine chemical industries. These initiatives encompassed a wide range of activities, such as meteorological surveys of the waters near Qingdao, fisheries exploitation, laboratory analysis of seawater composition, and the extraction and production of marine industrial products.[49]

Additionally, Qingdao Observatory's advanced seismic observation capabilities, which had been leading since the German period, met Japan's growing domestic demand for earthquake prediction.[50] In letters to the Japanese Government and the Japanese Navy, the renowned Japanese geophysicist Tanakadate Aikitsu 田中舘愛橘 (1856–1952) pointed out that continuing Germany's previous seismic and geomagnetic works in Asia (referred to as "東洋地方" in his letters) held special significance. Not only would it maintain the Observatory and East Asia's prominent position in the international scientific community, but it would also help Japan secure its representation in international geomagnetic organizations

[45] "Ryojun Ikaiei Kōshūwan oyobi Tenshin gai go-kō no kishō hōkoku densō narabi ni Pekin Dōbun-kangai jūgo kasho no kishō geppō sōfu kata Monbu Daijin yori irai ikken [Request from the Minister of Education Regarding the Transmission of Meteorological Reports from Lushun, Weihaiwei, Jiaozhou Bay, and the Five Outer Ports of Tianjin, as well as the Submission of Monthly Meteorological Reports from Tongwen Guan in Beijing and Fifteen Other Locations]" (8 January 1900), Diplomatic Archives of the Ministry of Foreign Affairs, Japan (MFA), B12082144200.

[46] Chintao Tenmondai no Ken [Documents concerning Qingdao Observatory] (November 1914), National Institute for Defense Studies, Ministry of Defense, Japan (NIDS), C03024368800.

[47] Rinji Chintao Yōkōbu Sokkōjo Senji Nisshi [Temporary Qingdao Naval Station Office Meteorological Observatory Wartime Diary] (December 1914), NIDS, C10080057600.

[48] Jiang Bingran, "Preface," in *Qingdaoshi Guanxiangtai Shizhou Jiniance* [Qingdao Observatory Tenth Anniversary Commemorative Book] (Qingdao Observatory, 1934), 12.

[49] Qingdao Shizhengfu [Qingdao Municipal Government, QMG], "*Qingdao Guanxiangtai Yange jiqi Zhongyaoxing* [The Evolution and Importance of Qingdao Observatory]" (October 18, 1946), Qingdao Municipal Archives (QMA), B0024-001-00240-0088.

[50] Kamada Eiyuki, "Chintao Sokkōjo ni Kansuru Ken [Documents concerning Qingdao Observatory] (July 28, 1922)", NIDS, C03025349700.

and showcase Japanese scholarly achievements to the world. Tanakadate also attached two letters from the Royal Netherlands Meteorological Institute and the British Kew Observatory, both urging Japan not to interrupt the scientific observations at the Observatory.[51] This reminds his earlier appeals in the 1910s, where he viewed the "scientific spirit" as a universal ideal shared by both East and West and a symbol of modernity, thereby he argued that the Japanese could cultivate this spirit like Western people, and strived for scientific innovation rather than merely replicating Western technology.[52] Tanakadate's remarks about scientific spirit and establishing Japan's scientific credentials at the observatories left behind by Germany in its former Chinese colonies reflect the complex implications of Pan-Asianism: it was both an effort towards scientific integration in East Asia and a cloak for Japan's pursuit of leadership and expansionism in the region.

Consequently, although Qingdao did not hold a prominent position among Japan's colonies, during this period, Qingdao Observatory quickly emerged as a center of Japan's meteorological and geomagnetic observation network across East Asia. Moreover, it officially began conducting marine research, focusing on the ocean that Richthofen referred to as the "Chinese-Japanese Sea." This period also saw the utilization of submarine cables between China and Japan to establish a meteorological information network, transforming the Observatory into the "Central Meteorological Observatory." Unlike the earlier exchange of data among observatories, this network involved transnational telecommunications and scientific cooperation across different nations. Notably, this scientific network was woven not in a context of peaceful coexistence between China and Japan, but during a period of intense political confrontation over the sovereignty of the Observatory.

Between Imperial Japan and the Republic of China, 1924–1931

The period of Sino-Japanese confrontation in Qingdao Observatory lasted from 1924 until around 1931. Within the Observatory itself, Chinese and Japanese scientists, despite intense diplomatic negotiations and different ideologies, reached compromises and collaborated in the formulation of the Sino-Japanese meteorological telegraph network. Utilizing submarine cables around this coastal city,[53] this telegraph network transmitted meteorological information between Japan and its colonies and China, with Qingdao as its hub, linking Japan to China's vast interior regions (Fig.2). This network overlaid previous colonial networks for meteorology, geomagnetism, and astronomy that had already connected Germany, Japan, and other countries. As a result, it continued to reinforce the Observatory's complex role as both a peripheral and central node within multiple interconnected scientific networks.

[51] Tanakadate Aikitsu, "Chintao ni oite Chijiki Kansoku Keizoku ni Kansuru Ken [Documents concerning the Continuation of Geomagnetic Observations in Qingdao] (July 14, 1915)", NIDS, C03024548500.

[52] Hiromi Mizuno, *Science for the Empire: Scientific Nationalism in Modern Japan*, 77-78.

[53] The laying and use of maritime cables between China and Japan represent a case of transnational technology transfer and infrastructure modernization, which warrants a more complex and in-depth discussion—likely beyond the primary focus of this paper. For current research on communication technology and Sino-foreign relations in modern China, see Xue Yiqun, *Telegraphing the World: The Construction and Adoption of International Communication Networks in Modern China, 1870–1937* (Social Sciences Academic Press, China, 2022).

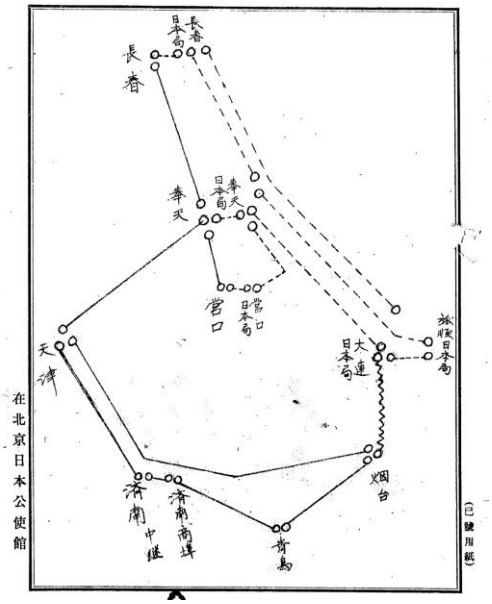

Fig. 2. 支那－関東州－満洲を結ぶ有線（一）、無線（---）、海底ケーブル（~~）のネットワーク [The network of telegraph (—), wireless (---), and submarine cable (~~) connections linking China, the Kwantung Leased Territory, and Manchuria]. From a file dated 1923, reproduced in *Chūō Kishōdai*, 159, courtesy of Diplomatic Archives of the Ministry of Foreign Affairs of Japan (MFA), B04122582500.

According to records left by Chinese meteorologist Zhu Kezhen 竺可楨 (1890–1974), the cause of the standoff was Japan's reluctance to relinquish its scientific interests in Qingdao Observatory after World War I, when China resumed sovereignty over Shandong. Like Tanakadate Aikitsu's rhetoric, Japanese scientists from Korea and Taiwan wrote to the MFA emphasizing that the meteorological operations of the Observatory were of great importance and that the development of meteorology in the ROC was still in its infancy. Therefore, they argued, Japan should continue to lead the scientific work in the Observatory.[54] Zhu also held the view that the ROC government was unwilling to bear the financial costs of the Observatory on its own and did not prioritize meteorological science and technology.[55] His opinions were later validated during the ROC's administration. Government funding was repeatedly delayed, and there were even multiple demands to reduce the salaries of Chinese staff.[56] This situation underscored the disadvantaged position of Chinese scientists within the Observatory's power dynamics, as well as the inadequate support provided by the ROC government.

In 1924, after Jiang Bingran 蔣丙然 (1883–1966), the first Chinese director of Qingdao Observatory, led a team of Chinese technicians into the Observatory, Chinese and Japanese scientists were forced to work together within the Observatory. According to their diplomatic agreement following the Washington Naval Conference (1922), once the Chinese technicians were sufficiently trained, Japanese scientists would design a meteorological telegraph communication plan with them, and then fully return to the Observatory.[57] This treaty

[54] "Sokōsho Santō Ken'an Kaiketsu Kōshō Ikken [Qingdao Observatory, The Documents of Shandong Issue]" (May 29, 1922–April 6, 1923), MFA, B07090860500.

[55] Zhu Kezhen, "Qingdao Jieshou zhi Qingxing [The Situation of the Qingdao Handover]," in *The Complete Works of Coching Chu*, ed. Fan Hongye, Vol.1 (Shanghai Science and Technology Education Press, 2004), 422-423.

[56] Documents submitted by Qingdao Observatory (June 1, 1928), QMA, B0029-001-03102-0051-0056.

[57] Documents concerning the Sino-Japanese Agreement about Qingdao Observatory (October 23, 1924), QMA, B0035-001-00128-0018.

indicated that the key factors determining the ownership of the Observatory were two political and technical issues: who, by which standards to decide whether Chinese technicians were sufficiently trained, and the establishment of a Sino-Japanese meteorological network. Both of these issues were closely tied to the scientists working within the Observatory.

In stark contrast to the diplomatic and political tensions, scientists from both countries maintained relative respect, empathy, and friendly interactions. To demonstrate that their technical expertise was not inferior to that of the Japanese, and to assert their desire for scientific independence, the Chinese scientists worked diligently and frequently competed with their Japanese counterparts in the accuracy of observational data and other scientific activities. Looking back upon this period years later, Jiang Bingran specifically noted that Japanese scientists often sympathized with their hard work and acknowledged the quality of their achievements.[58] The Japanese director Irumada Tsuyoshi 入間田毅[59], who remained at the Observatory, even submitted documents to both the Chinese and Japanese governments, stating that the technical capabilities of Chinese scientists were sufficiently mature and recommending that Japan fully return the Observatory to China. Although the Japanese government retroactively claimed that Irumada's recognition of Chinese scientists was merely unrealistic praise made in a casual setting,[60] this personal document directly influenced a shift in Japan's diplomatic strategy, and provided Chinese scientists with evidence to request the return of the Observatory by the previous treaty, ultimately sparking a new round of negotiations between the two governments.

After Irumada Tsuyoshi's incident, the CMO submitted a new proposal to the MFA, suggesting that Japan abandon Qingdao Observatory and instead establish a new observatory within the Japanese consulate in Qingdao. Its fourth director, Okada Takematsu 岡田武松 (1874–1956), argued that meteorological observation was an international academic endeavor and should not be viewed as an infringement of national sovereignty. He pointed out that there were American meteorological stations in Beijing and Xiamen, and French stations in Shanghai and Suzhou, making it reasonable for Japan to establish an independent meteorological station in China.[61] The examples he cited implied that Japan should claim the same scientific privileges in China as America and France. However, Okada's proposal, somewhat diverging from the views of the Japanese scientists previously mentioned, aimed to separate scientific institutions representing territorial sovereignty from scientific activities embodying an internationalist spirit. That may also reflect Irumada's perspective, although the lack of his personal writings makes it difficult to ascertain whether his actions were driven by empathy among scientists, or by an understanding reached with Okada in the imperial capital. After all, despite submitting a public document that contradicted the Japanese government's official stance, Irumada faced no obvious punishment and continued to serve as director in Qingdao until 1928, after which he returned to Tokyo to resume his

[58] Jiang Bingran, "Sishiwu Nian lai Wo Canjia zhi Zhongguo Guanxiang Shiye [My Experiences in Participating in China's Meteorological Observatory Work Over the Past Forty-Five Years]," in *Special Issue in Celebration of Mr. Jiang's 75th Birthday* (Taipei, 1957), 67.

[59] Information on Tatuyoshi is rather limited, so I have not yet found records left by him, making his true motivation for submitting the documents unclear. However, he presented his opinions to the authorities in the form of official administrative documents, clearly not as informal remarks made under intoxication. Moreover, his correspondence with Jiang Bingran concerning instruments and data demonstrates that he was able to act freely within the Observatory, unimpeded by Chinese restrictions. See Letter from Jiang Bingran to Irumada Tsuyoshi (October 20, 1926), QMA, B0035-001-00127-0010; Letter from Jiang Bingran to Irima Tatuyoshi (July 30, 1928), QMA, B0035-001-00127-0015.

[60] "Kakkoku Kishō Kankei Zakken / Chintao Sokkōjo Kankei" (1924), MFA, B04011381500.

[61] "Kakkoku Kishō Kankei Zakken / Chintao Sokkōjo Kankei" (1929), MFA, B04011382200.

career as a meteorological technician.[62] Although the CMO attempted to advance negotiations, the outbreak of the Northern Expedition (1926–1928) interrupted negotiations, and it was not until 1930 that the Japanese government formally proposed establishing the meteorological telegraph network and returned the Observatory to China.[63]

As early as 1925, shortly after Irumada Tsuyoshi submitted his documents, scientists from China and Japan had already reached a consensus that, given China's already well-trained technical staff, Japan should transfer the full operations of Qingdao Observatory back to China. This agreement marked the beginning of discussions on the Sino-Japanese meteorological telegraph communication plan.[64] From 1925 to 1931, a network for exchanging meteorological information across the maritime regions between China and Japan was gradually established, inherited, and materialized in Richthofen's vision. Specifically, through the Qingdao-Sasebo submarine cables, Qingdao Observatory established connections with the CMO in Tokyo, the Kobe Marine Observatory (KMO), and other meteorological stations in Korea and Taiwan. Besides, via the Yantai-Dalian submarine cables, the Observatory and Japanese observatories shared the meteorological data with Jinan, Yantai, Mukden (present-day Shenyang), and other locations in Northern and Northeastern China.[65] While Japanese was used for Sino-Japanese meteorological exchanges, other routes allowed China to choose an internationally recognized language for communication.[66] After the Sino-Japanese meteorological telegraph communication system was finalized, Japanese technicians withdrew from the Observatory, continuing only limited observational activities within the grounds of the Japanese consulate in Qingdao.[67] Meteorological data and signals of Qingdao were also officially disseminated by Chinese scientists.[68] During this period, both meteorological reports submitted to the Qingdao municipal government and local newspapers categorized observations as "local" (本埠), "domestic" (國內), and Japanese.[69]

In summary, during the Sino-Japanese joint administration, Qingdao Observatory became entangled in a series of sovereignty struggles, highlighting the interaction between science and politics. The creation of the Sino-Japanese meteorological information network did not sever Qingdao's ties to colonial networks following Japan's departure; rather, it expanded its reach into broader regions of mainland China. This information network, which overlapped spatially with the German-managed meteorological station network, represented a continuation of earlier transnational scientific collaboration. It also exemplified the Observatory's instrumental role in enhancing maritime safety and navigation through the shared efforts of meteorological observation and prediction, once again echoing Richthofen's foresight. Almost simultaneously, Chinese scientists began to inherit and utilize the scientific legacy and transnational collaboration foundations left by Germany and Japan in Qingdao.

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[62] "Moto Kisōdai Gishi Irumada Tsuyoshi Jo'i no Ken [Document on the change of position of Irumada Tsuyoshi, former meteorological Observatory technician]" (1928), National Archives of Japan (NAJ), A11113857300.

[63] "Kakkoku Kishō Kankei Zakken / Chintao Sokkōjo Kankei" (1930), MFA, B04011382500.

[64] Document Based on the Japanese Staff's Report on the Qingdao Observatory Staff's Opinions and Standards for Negotiations with Japan (1925), QMA, B0035-001-00128-0109.

[65] Letters from Qingdao Observatory to QMG (October 30, 1924), QMA, B0035-001-00130-0051.

[66] Documents concerning the Proposals put forward by Japanese Technicians at Qingdao Observatory (August 10, 1929), Zhong Ri Jiaoshe Shouhui Qingdao Guanxiangtai [Negotiations between China and Japan over Qingdao Observatory] (ZRJSQG), Academia Historica, 020-010106-0002.

[67] Kakkoku Kishō Kankei Zakken / Chintao Sokkōjo Kankei (1931), MFA, B04011382800.

[68] Documents concerning the Redesign and Re-hoisting of Weather Forecast Flags by Qingdao Observatory (April, 1931), QMA, B0034-001-00177-0042.

[69] Meteorological Reports of Qingdao Observatory (1925), QMA, A0017-002-00067-0035.

Amid similar diplomatic struggles, they chose to make their mark under a different discourse—one centered on nationalism and local science.

Local Scientific Practices and Transnational Cooperation in Qingdao, 1924–1937

For China, Qingdao Observatory in 1924 represented a profound contradiction. It was the observatory most likely to have its sovereignty reclaimed by the ROC, and possessing it would enable Chinese meteorology to stand alongside Britain (HKO) and France (Zikawei).[70] On the other hand, the Japanese staff's presence complicated the full recovery of sovereignty, and entering the Observatory itself meant facing direct scientific competition with Japan. Although Chinese scientists endeavored to make the Observatory a symbol of national science,[71] this colonial-nationalist contact zone sustained existing technologies, infrastructures, developmental strategies, and established scientific networks, allowing knowledge and data from Qingdao to continue circulating within global scientific networks. New meteorological networks and organizational structures oriented toward China gradually emerged, establishing Qingdao as a center for Chinese meteorology and marine research. These overlapping transnational scientific networks deepened the understanding of Qingdao's natural environment, reflecting the interwoven nature of colonial and nationalist modernities and contributing to the shaping of a new coastal city and community.

The seemingly exclusionary anti-colonialist and nationalist tendencies behind the sovereignty negotiation of Qingdao Observatory paradoxically spurred Chinese scientists to actively engage in transnational scientific cooperation and fueled the ongoing development and globalization of the Observatory's colonial scientific legacy. As Jiang Bingran once noted, "rectification of names" (正名) may appear to be a minor detail, but it matters to "national polity or dignity" (國體).[72] Consequently, Chinese scientists emphasized that the naming rights of the Observatory, as well as recognition of scientific achievements and international representation, should belong to China rather than Japan. They aimed to prove that Chinese technicians were sufficiently trained and to secure an equal position for China within the international academic community.[73] Therefore, despite differing political positions and ideologies, they shared with figures like Richthofen and Japanese scientists a similar strategic vision for developing scientific institutions. Geographically, the focus extended from local Qingdao to China's inland regions and maritime territories, while simultaneously seeking transnational cooperation. In terms of science and technology, the development strategy was built upon the legacy of equipment and research from the German and Japanese periods in meteorology, astronomy, and marine research.

As the longest-standing and most fundamental scientific work at Qingdao Observatory, meteorological observation and reporting underwent further development after 1924. The scope of observation expanded to over 80 locations, including Japan, major cities across China, Shanghai, Hong Kong, the Philippines, and Vietnam. Meteorological reports were

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[70] Zhu Kezhen, "Nitiqing Jiaoyubu huo Zhonghuajiaoyugaijinshe Guanli Qingdao Guanxiangtai bing Jiayikuochong An [Proposal to request the Ministry of Education or the Society for the Improvement of Chinese Education to manage and expand Qingdao Observatory]," in *The Complete Works of Coching Chu*, 418.

[71] The most prominent article was the Science Society of China's (中國科學社) manifesto, condemning Japan's colonial actions and framing the recovery of Qingdao Observatory as a sovereignty issue. Leading newspapers such as *Shenbao*, *Ta Kung Pao*, and *Shibao* reported on it, and public discourse became known as the "Call for Scientific Independence" (科學獨立之呼聲).

[72] Documents concerning the Proposals put forward by Japanese Technicians at Qingdao Observatory (April 19, 1928), ZRJSQG, AH, 020-010106-0002.

[73] Documents concerning the Demand for Japan to Fully Return Qingdao Observatory (February 19, 1925), QMA, B0035-001-00128-0051. Zhu Kezhen, "Eliminate Academic Inequality," in *The Complete Works of Coching Chu*, 571.

exchanged twice daily via submarine cables and radiotelegraphy, allowing the collected information to be used for the creation of weather maps and regular broadcasts.[74] Meanwhile, the Qingdao municipal government posted weather maps at transportation junctions and commercial centers of the city to facilitate the daily lives of residents.[75] Ships passing through Qingdao, whether Chinese or foreign, were able to receive these meteorological reports and weather maps.[76] It also collaborated with other meteorological stations in Shandong, aiming to establish a network of meteorological stations across the province and eventually nationwide, expanding the scope of meteorological observations and improving the accuracy of the data.[77] Considering that weather maps are not only the result of knowledge production but also reflect the state's power and its ability to provide public services,[78] the increasingly rich meteorological data observed and produced by Chinese scientists significantly strengthened Chinese meteorology's voice in the international arena.

Besides, Qingdao Observatory represented China at the International Longitude Determination (ILD) in 1926 and 1933. Owing to Japan's deliberate protection of the Observatory during the war, as well as the relatively peaceful collaboration between Chinese and Japanese scientists, the Observatory's infrastructure and instruments were largely preserved until the late 1920s. During Chinese scientists' first participation in the ILD, they utilized these German instruments to correct previous longitude measurements of Qingdao made by German and Japanese scientists.[79] Cooperation with European scientists also continued. Jiang Bingran not only borrowed observational instruments from the French,[80] but also traveled with other astronomical technicians to Zikawei to learn longitude measurement and astronomical observation techniques.[81] During its second participation in the ILD, the Observatory acquired new instruments from Germany and France and reviewed existing observation records. It also advocated for the inclusion of important towns across the country that had not yet been measured to jointly determine the precise location of Qingdao and the entire country on the global map.[82] This effort helped establish or improve meteorological stations in many regions of China, laying the infrastructural foundation for the ROC, and later, the PRC. In addition, concerning time measurement, Chinese scientists recognized that adherence to precise timekeeping was essential for modernization. After discovering errors in the methods used during the German and Japanese periods, such as the use of the time ball and the noon cannon, they continuously improved the time service by adopting the more accurate method of signaling with an electric whistle.[83] The time service at the Observatory

[74] Zheng Weihua, "Qingdaoshi Guanxiangtai Wuxiandianshi Jingguogailue ji Nibanshiye [Overview of the History and Proposed Operations of the Radio Room at Qingdao Observatory]," in *Qingdaoshi Guanxiangtai Shizhou Jiniance*, 139.

[75] Documents concerning the Daily Submission of Weather Forecasts and Weather Maps for Posting to the Public (May, 1925), QMA, B0032-001-00369-0007.

[76] Letters about Distribution of Weather Maps (June 11, 1924), QMA, B0038-001-00353-0049.

[77] Documents concerning Qingdao Observatory's Proposal to Establish Provincial Meteorological Stations (February 28, 1927), QMA, B0035-001-00131-0072.

[78] Aitor Anduaga, *Politics, Statistics and Weather Forecasting, 1840–1910: Taming the Weather* (Routledge, 2019), 3.

[79] Reports on the ILD (March 7, 1927), QMA, B0029-001-02791-0024.

[80] Jiang Bingran, "Lujiabang Cilitai Canguanji [A Visit to Lujiabang Magnetic Observatory]," *The Astronomical and Meteorological Magazine*, 11(1920): 7-20.

[81] *Jiaoao Shangbu Guanxiangtai Canjia Wanguo Jingdu Celiang Chengji Baogaoshu* [Report on the Qingdao Observatory's Participation in the International Longitude Determination] (Qingdao Observatory, 1927), vii.

[82] "Gongzuo Jiyao [Work Memorandum]," in *Qingdao Guanxiangtai Wushizhounian Jiniantekan* [Qingdao Observatory fifty Anniversary Commemorative Book] (Qingdao Observatory, 1948), 67.

[83] Jiang Bingran, "Preface," 12.

became more accurate and extended to a broader geographical range, facilitating Qingdao's integration into transnational networks of industry and economy.

The marine studies initiated during the Japanese administration were further advanced, and Qingdao became the site of China's first aquarium. The establishment of this aquarium was directly influenced by Japanese and European science. As Song Chunfang 宋春舫 (1892–1938), a marine scientist who had worked at the Observatory and the founder of Qingdao Aquarium (Fig.3), explained, the KMO in Japan, along with meteorological observatory in Hamburg, Paris, and Liverpool, all housed marine science research institutions. Monaco also had a dedicated oceanographic museum. Therefore, Song argued that Qingdao should follow foreign countries and lead Chinese science by developing its marine sciences.[84] This pioneering work led to significant academic achievements, including the regular publication of the *Marine Semiannual* 海洋半年刊 and studies on the tides, sea fogs, and water temperatures of the ocean area in Qingdao, which were translated into English and presented at the Pacific Science Congress.

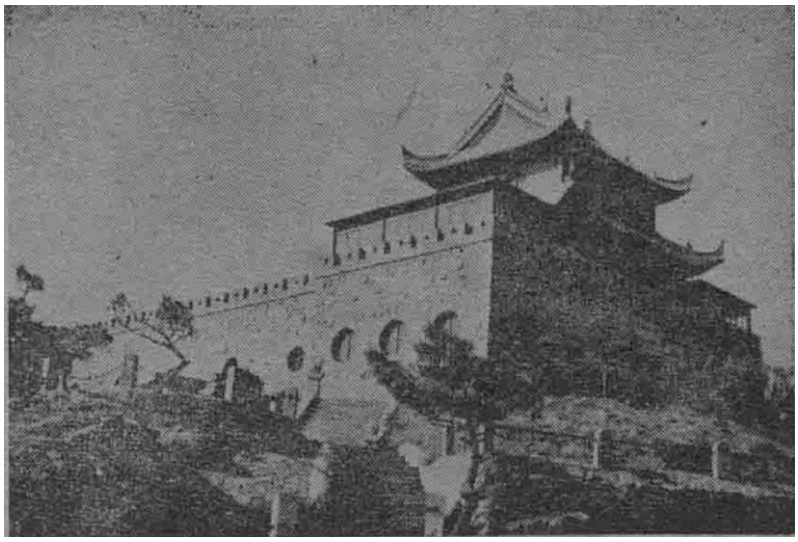

Fig. 3. 青島水族館 [The Qingdao Aquarium]. Courtesy of *Qingdao Guanxiangtai Wushizhounian Jinian Tekan* (Qingdao Observatory, 1948), 19.

In a manner akin to the maps and museums discussed by Benedict Anderson,[85] the meteorological and aquarium components of Qingdao Observatory also served as an important scientific center in constructing "imagined communities" and shaping identity. Within the knowledge world of the Observatory, weather maps and forecasts inform readers of meteorological conditions both within and beyond the region. These maps delineated geographic and national boundaries on flat surfaces, allowing people to see the three-dimensional atmospheric environment. Time service work, on the other hand, established time benchmarks, helping people perceive time in their daily lives. The aquarium at the Observatory housed thousands of marine biological specimens and a large number of live organisms, and it regularly held public exhibitions. In just one year, from 1932 to 1933, it received over 74,000 visitors.[86] Another point to consider is that the Observatory established a new organizational network to facilitate the circulation and dissemination of scientific

[84] Documents concerning the Augmentation of Marine Research, QMA, B0029-001-03903-0067.

[85] Benedict Anderson, *Imagined Community: A Brilliant Exegesis on Nationalism* (Verso Books, 2006), 170-190.

[86] Li Fangcong, "Haiyangke zhi Lueli yu qi Gaikuang [A Brief History and Overview of Marine Science]," in *Qingdao Guanxiangtai Shizhounian Jiniance*, 136.

knowledge. In 1924, the Chinese Meteorological Society was founded in Qingdao, incorporating nearly all meteorological stations and related organizations operated by Chinese scientists at the time.[87] Members of the Society frequently held public lectures in Qingdao to share accessible knowledge on topics like "The Distribution of Air Pressure in China" (中國氣壓之分佈), consistently drawing enthusiastic responses.[88] This Society also set standards for scientific activities, including data collection, instrument calibration, and telegraph requirements, and represented China in the East Asia Meteorological Conference and international meteorological activities, making a milestone in the independent institutionalization and internationalization of Chinese meteorology.

Consequently, within Qingdao Observatory, scientific technologies, infrastructure, and development strategies extended from colonial periods into the Nationalist regime. Although from the moment they entered the Observatory in 1924, Chinese scientists repeatedly emphasized that the Observatory's scientific activities represented anti-colonial national science and independent science. In fact, the scientific systems and knowledge production during Chinese administration were consistent with those followed by German and Japanese scientists in Qingdao. During all three regimes, despite periods of intense political upheaval, its science and technology were employed for the same purpose: to understand, transform, and utilize Qingdao's local natural environment for social and political interests, while contributing local scientific practices from Qingdao to the world and fostering transnational collaboration.

Conclusion

After the outbreak of the Second Sino-Japanese War, Japan once again occupied Qingdao Observatory. While sending Japanese technicians to Qingdao,[89] the Japanese government also allowed two Chinese technicians, who had not managed to flee, to continue working at the Observatory. In 1945, when Qingdao returned to the control of the ROC, they continued their observations.[90] Meanwhile, their three Japanese colleagues—two meteorological observers, Masaki Shiichi 正木史一 and Kibo Ryoichi 吉波良一, along with a radiotelegraph technician, Fukuda Mantoku 福田滿德—were retained by the Nationalist government.[91] During the postwar reconstruction period, the subsidiary station in Licun was also restored to support the development of agricultural meteorology,[92] which would soon become a crucial direction in the advancement of meteorology in the early PRC.[93] The Observatory also received over 60 observation instruments on loan from the United States,[94] and maintained the exchange of meteorological reports and communications with other

[87] Chinese Meteorological Society, "Faqi Zhongguo Qixiang Xuehui Zhiqushu [Statement of Purpose for the Founding of the Chinese Meteorological Society]," *Bulletin of the Chinese Meteorological Society* 1 (1925).

[88] "Zhongguo Qixiang Xuehui Dierri zai Lixian Zhongxue Kaijiangyanhui zhi Jishi [Report on the Chinese Meteorological Society's Lecture at Lixian Middle School]," *Jiaodong News* (September 3, 1925), QMA, D00426-00006-0010.

[89] Haruhiko Yamamoto, *Chūō Kishōdai*, 161.

[90] Report on the Handing of Former Personnel Served in Puppet Organizations at Qingdao Observatory (September 10,1946), QMA, B0035-001-00029-0023.

[91] Japanese Staff Information Form at Qingdao Observatory (1946), QMA, A0021-001-00388-0332.

[92] Documents concerning the Agricultural and Forestry Affairs Office and Qingdao Observatory to Jointly Establish the Licun Meteorological Station (March 15, 1948), QMA, B0032-001-01096-0007.

[93] On the development of agricultural meteorology in the PRC, see Cheng Chunshu, ed., *Forty Years of Agricultural Meteorology in China* (China Meteorological Press, 1994).

[94] "Guanxiangtai Zhuang Xinyiqi; Liushizhong you Meiguo Yun Qing [The Observatory Installed New Instruments; Over Sixty Types Shipped from the United States to Qingdao]," *Minyan News* (August 8, 1946), QMA, D00085-00016-0035.

countries.[95] In 1949, when the CCP took control of the Observatory, they continued to employ the director and technicians from the ROC period. By this time, the Observatory had become the largest meteorological station in China still in operation. Although the CCP government restructured the Observatory's administrative units and functions, transferring astronomical, geomagnetic, and seismic work to the Chinese Academy of Sciences, the core meteorological work continued in the office building constructed by the Germans in 1912.[96]

The priorities of Qingdao Observatory undoubtedly shifted under different regimes, reflecting the colonial exploitative and anti-colonial nation context underpinning both Richthofen's predictions and the collaborative work of Chinese and Japanese scientists. However, across various contexts, the Observatory's tasks and local practices remained consistent. It consistently served as a center of meteorology, advancing scientific and technical capabilities, striving for more precise measurements, and fostering transnational cooperation across Asia and globally. No longer the remote maritime frontier of a fading dynasty, the Observatory transformed into a hub of scientific development within interconnected local, regional, and global scientific networks. These multilayered networks were not constructed solely by any single nation-state within a fixed geographic boundary. Instead, they were collectively constituted through transboundary collaborations involving various state actors. Often misaligned with imperial, colonial, or national borders, these networks adapted to and co-evolved with shifting political powers, ensuring their continuity. Simultaneously, the flourishing of meteorology, astronomy, seismology, geomagnetism, and marine science, rendered the atmosphere, land, tides, and marine life legible and possibly controllable. These factors, intertwined with human activities, forged new environmental and urban orders, creating new conceptions of time and space.

More broadly, exploring and articulating the continuity among different regimes in the 20th century from a scientific perspective is a common issue for many nation-states in Asia and beyond. As the Indian historian Gyan Prakash observes, the complexity of modern Indian science may also be a continuation of colonial polysemy.[97] The story of Qingdao Observatory reminds us that on this issue, the boundaries between periphery and center are blurred, and technicians, local science, and technological practices traversed national borders, transcending the spatial and temporal boundaries of geopolitics. This dynamic rendered Qingdao a unique microcosm of modern science, different colonial and national powers, and multiple modernities interacting with East Asia. Therefore, considering transnational and multiple scientific networks rather than strictly colonial or national science offers a way to navigate the landscape of war, ideological divisions, and ruptures in sovereignty, while seeking long-standing connections, shared commonalities, and overlooked continuities between past and present.

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[95] Call Signs and Timetables for Meteorological Telegraph Stations in Various East Asian Locations (1947), QMA, B0035-001-00037-0019.

[96] Wang Fuzhi, Guan Xin, and Zhong Zhiwei, "Bainian Qingdao Qixiang Shihua [Centennial Qingdao Meteorological Stories]," *Meteorological Knowledge* 4 (2014): 8-10, www.qxzs.org.cn.

[97] Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton University Press, 1999), 7-14.