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The Development and Application of Marine Meteorology in China: A Case Study of Dinghai Meteorological Station, 1930s-1940s

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Introduction

To understand the history of meteorology during the era of the Republic of China (1912-1949), the significance of meteorological stations cannot be ignored, as they formed the indispensable infrastructure for meteorological progress. The Dinghai Meteorological Station (定海测候所, hereafter DMS) was established in 1936 in the eastern coast of Zhejiang Province. Compared to previous studies,[1] this article argues that the DMS case demonstrates how meteorology could be applied locally in a developing country and the challenges it faced. The inputs of Western scientific knowledge since the 16th century had catalysed myriad transformations across China, and the ocean concept was accordingly evolving. For instance, figures such as the politician Liang Qichao (梁启超, 1873-1929) and the industrialist Zhang Jian (张謇, 1853-1926) valued the role of the ocean, advocating for the advancement of the marine economy, protection of maritime rights, and the establishment of a Chinese navy.[2] The emphasis on this aspect was closely related to the military failure of China in the late Qing Dynasty, and the attention of intellectuals to the issue of sea power had also led to multiple

[1] Kevin P. MacKeown, *Early China Coast Meteorology: The Role of Hong Kong* (Hong Kong University Press, 2010). Fiona Williamson, "Just Doing Their Job: The Hidden Meteorologists of Colonial Hong Kong c.1883–1914," *The British Journal for the History of Science* 54, no. 3 (2021): 341-359.

[2] Peng Song 彭松, "梁启超与近代中国海洋意识的发展[Liang Qichao and the Development of Maritime Consciousness in Modern China]," *Research on Chinese Literature* (2019): 146-55. See also Lin Bin 林彬, "张謇海洋观的演变与内涵研究[Research on the Evolution and Connotation of Zhang Jian's Ocean Concept]," *Maritime Education Research* 39, no. 03 (2021): 37-45.

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related articles being published in Chinese journals in the early 20th century.[3] However, compared to military and commercial aspects, advancing these areas of oceanic activity required more in-depth scientific research and perspectives. Thus, this article chooses marine meteorology, 'a subfield of meteorology, dealing with the weather and climate as well as the associated oceanographic conditions in marine, island, and coastal environments.'[4] During the Republic of China period, the development of marine science included research on marine meteorology. Through harnessing insights garnered from meteorological observations to acquire marine knowledge, meteorological stations could bolster the advancement of fisheries and shipping industries. Therefore, the study of DMS explains the localization process of marine meteorology introduced from Western countries.

Regarding meteorological history in China, extensive studies are underway concerning Chinese meteorological stations, with attention focused mainly towards those established by foreign nations, exemplified by the Zikawei Observatory (徐家汇观象台) in Shanghai and the Hong Kong Royal Observatory. For instance, in his examination of the Hong Kong Royal Observatory, Kevin MacKeown elucidated how meteorology, as a scientific discipline, evolved within the British colony to provide weather forecasts for local inhabitants and governing bodies.[5] Lewis Pyenson has investigated the Zikawei Observatory illustrating how French scientific achievements enhanced French cultural influence in East Asia.[6] Wu Yan employed the concept of 'laboratory of the world' to comprehend the role of Zikawei Observatory, elucidating that it gathers local meteorological data to contribute to the advancement of modern scientific knowledge systems in Europe.[7] Nonetheless, scant detailed inquiries exist regarding the establishment of local meteorological stations under direct Chinese influence during the Republic of China. To some extent, this article argues that these local meteorological stations could also be viewed as laboratories for promoting domestic scientific development. Clark Alejandrino's study recounted the establishment of an observatory in Canton in the 1930s, exploring its role in bolstering China's sovereignty by providing local meteorological data and diminishing the influence of foreign meteorological observatories.[8] Fu Gang paid attention to the Qingdao Observatory, meteorologists Jiang Bingran (蒋炳然) and Wang Binhua (王彬华), explaining how they developed marine meteorology during the twentieth century.[9] However, the story of Qingdao Observatory could not fully cover the history of marine meteorology

[3] Yuan Bo 袁博, "困境中前行:近代中国国民海洋观念的觉醒与深化 [Advancing amidst Difficulties: The Awakening and Deepening of Modern Chinese Citizens' Maritime Awareness]," *Journal of Qiqihar University (Phi & Soc Sci)* 01 (2022): 126-130.

[4] L. Xie, B. Liu, "Marine Meteorology," in *Encyclopedia of Atmospheric Sciences, Second Edition,* ed. Gerald R. North, John Pyle and Fuqing Zhang (Academic Press, 2015), 287-292.

[5] MacKeown, *Early China Coast Meteorology*, 27-54.

[6] Lewis Pyenson, *Civilizing Mission: Exact Sciences and French Overseas Expansion, 1830-1940* (Johns Hopkins University Press, 1993), 157-206.

[7] Wu Yan 吴燕, *科学、利益与欧洲扩张——近代欧洲科学地域扩张背景下的徐家汇观象台（1873-1950）, [Science, Interest and Expansion of Europe: Zikawei Observatory (1873-1950) in the Context of the Territorial Expansion of European Modern Science]* (Beijing: China Social Sciences Press, 2013).

[8] Clark L. Alejandrino, "Weathering History: Storms, State, and Society in South China since the Fifth Century CE" (PhD diss., Georgetown University, 2019), 166-74.

[9] Fu Gang 傅刚, "推动中国海洋气象学发展的两位大师——第Ⅰ部分：蒋丙然的故事 [Two Masters Who Promoted the Development of Marine Meteorology in China - Part I: The Story of Jiang Bingran]," *Advances in Meteorological Science and Technology* 14, no.2 (2024): 56-59. See also Fu Gang, "推动中国海洋气象学发展的两位大师——第 II 部分：王彬华的故事 [Two Masters Who Promoted the Development of Marine Meteorology in China - Part II: The Story of Wang Binhua]," *Advances in Meteorological Science and Technology* 14, no. 3 (2024): 40-45.

during the Republic of China, thus this article focuses on the DMS with emphasizing its application in the fishing industry.

The first half of the 20th century saw accelerated advancements in meteorological research across Asia, a phenomenon driven primarily by growing social demands for weather services. This development manifested in region-specific initiatives: in South Asia, the Indian Meteorological Department applied statistical meteorological cartography for monsoon prediction in the early twentieth century, while the Manila Observatory in the Philippines maintained its typhoon warning service since late nineteenth century and actively sought collaboration with Hong Kong through telegraphic networks.[10] Accordingly, this study employs archival materials and newspapers to conduct a micro-historical examination of the Dinghai Meteorological Station, aiming to reconstruct comprehensively the process of its establishment and its operational functions. The creation of this station transcended the domain of pure meteorological advancement, highlighting the role that meteorology assumed in the development of multifaceted industrial sectors. Broadly, this article delineated the constituencies engaged in knowledge construction and the pragmatic application of acquired knowledge, whilst probing the instrumental role of scientific infrastructures in knowledge dissemination.

Dealing with Typhoons

During the early development of modern meteorology in China, investigations into marine meteorology were aimed at mitigating cyclonic systems, particularly typhoons, emanating from the Northwest Pacific. According to the information provided by World Meteorological Organization, a tropical cyclone, such as typhoon, 'is a rapidly rotating storm that begins over tropical oceans, viewed as the second-most dangerous natural hazards, after earthquakes.'[11] Owing to the profound repercussions of typhoons on coastal municipalities and maritime vessels along the southeastern coast, resilience against extreme weather phenomena emerged as a paramount impetus driving meteorological advancements in China at the turn of the twentieth century. In 1869, Chinese Maritime Customs initiated a plan to establish a meteorological network along coastal and riverine regions. This endeavour aimed to ensure the safety of maritime navigation by furnishing meteorological information and typhoon warnings to passing vessels.[12] Meteorological observation was regarded as one of the five fundamental maritime services of the Chinese Maritime Customs. However, in 1879, Shanghai was struck by a typhoon, resulting in substantial economic losses to the shipping industry before the completion of the meteorological network.[13] Subsequently, under the leadership of Robert Hart, Maritime Customs collaborated with the Zikawei Observatory to deliver marine meteorological services. The Zikawei Observatory was expanded into a two-story building, with the establishment of a navigation service department. Moreover, lighthouses and weather stations set up by Maritime Customs facilitated the collection of meteorological data, contributing to typhoon research at the Zikawei Observatory.[14] Although these observational sites were mainly located in coastal areas, the meteorological indices they collected were not

[10] James Beattie, "Climate Change, Forest Conservation and Science: A Case Study of New Zealand, 1860s-1920," *History of Meteorology* 5 (2009): 35-52. See also Marlon Zhu, "Media, Typhoons, and Contests over Meteorological Sovereignty in Nineteenth-Century East Asia," *History of Meteorology* 9 (2020): 1-13.

[11] "Tropical Cyclone", World Meteorological Organization, accessed January 3, 2025, https://wmo.int/topics/tropical-cyclone.

[12] Robert Bickers, "Throwing Light on Natural Laws: Meteorology on the China Coast, 1869–1912," in *Treaty Ports in Modern China: Law, Land and Power*, ed. Robert Bickers and Isabella Jackson (Routledge, 2016), 180-94.

[13] Wu Zengxiang 吴增祥, *中国近代气象台站 [Meteorological Stations in Modern China]* (Qixiang Press, 2007), 24.

[14] Wang Hao 王皓, "徐家汇观象台与近代中国气象学[The Observatory of Zikawei and Meteorology in Modern China]," *Academic Monthly* 49, no. 9 (2017): 171-84.

much different from inland meteorological stations, encompassing air pressure, air temperature, rainfall, wind direction, and weather conditions. The only ocean-related observation at the time pertained to oceanic wave types, which was further constrained by the absence of wave measurement equipment and relied on observers' subjective discernment.[15]

The Zikawei Observatory continue to make further strides in dealing with typhoons. On 1 September 1884, the Gutzlaff Signal Tower was officially established, providing timekeeping and meteorological signals to ships in the vicinity of Shanghai. Following the establishment of the Republic of China, in 1914 the Public Administration of the French Concession in Shanghai established a radio station to broaden its service spectrum by disseminating radio notifications of weather conditions.[16] In light of this, Chinese meteorologists also contributed to this field, aiming to demonstrate China's domestic meteorological research capabilities. In 1925, Jiang Bingran, the director of Qingdao Observatory, published his article titled 'A Record of Typhoons in the Shandong Peninsula (山东半岛飓风记)', which was regarded as the first article on typhoon research found in Chinese academic journal.[17] Nonetheless, research on extreme weather and marine meteorology should also be paid great attention to the target audience of its services, which varies across different coastal regions in China.

Attention to Marine Meteorology

With the establishment of the National Government by the Guomindang party in 1927, the Institute of Meteorology at the Academia Sinica (中央研究院气象研究所, hereafter IMAS) was established as China's official meteorological institution. This institutionalisation underscored the nation's heightened demand for meteorological information, including marine meteorology. In 1928, the Qingdao Observatory inaugurated the Department of Marine Science, marking China's pioneering venture into specialised marine research. Song Chunfang (宋春舫, 1892-1938), the head of the Department of Marine Science and a playwright, developed an interest in oceanography during his visit to France and subsequently began researching it.[18] Under his supervision, the department investigated on oceanic current exploration, seawater analysis, and marine product surveys, thus laying the foundation for marine research in China.[19] Nevertheless, owing to a sovereignty dispute between China and Japan regarding the ownership of Qingdao Observatory, coupled with Qingdao's geographical positioning, opportunities for further advancement in marine research along the south-eastern coast were not immediately taken.[20]

The Chinese Naval Ministry also played an important role in developments. In 1929, the IMAS corresponded with the Department of Seaway Guard in the Naval Ministry (海军部海道巡防处, hereafter DSGNM). For the expediency of military operations, the Naval

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[15] Wu Zengxiang, *Meteorological Stations in Modern China*, 34-36.

[16] Shu Jiaxin 束家鑫 and Jiang Delong 蒋德隆, eds., *上海气象志[Shanghai Meteorological Chronicles]* (Shanghai Academy of Social Sciences Press, 1997).

[17] Fu Gang, "Two Masters Who Promoted the Development of Marine Meteorology in China - Part I: The Story of Jiang Bingran," 58-59.

[18] Ren Haojie 任豪杰, "近代青岛观象台研究(1922—1937) [Research on Qingdao Observatory in Modern Times (1922—1937)]," (Master diss., Qingdao University, 2024), 59-92.

[19] '为测验海洋增设海洋科造具预算书请鉴核的呈[Application for Review about Budget for Adding Tools for Investigating the Ocean by the Department of Marine Science]', 25 December 1928: Qingdao Municipal Archives, Qingdao, B0029-001-03903-0067.

[20] Xiao Liu, "Understanding sovereignty through meteorology: China, Japan, and the dispute over the Qingdao Observatory, 1918–1931," *Annals of Science* 81, no. 3 (2024), 420-439.

Ministry established several meteorological stations under the auspices of the DSGNM. Consequently, the IMAS asked the DSGNM to transmit their observation records to facilitate the plotting of meteorological maps and provision of weather forecasts. Furthermore, historical records maintained by the DSGNM would be transcribed by the IMAS for research purposes. In response to the Naval Ministry's directive, the DSGNM surveyed its subordinate stations, reporting "its management of the Pratas Observatory, in addition to warning stations in Xiamen, Kanmen, and Shengshan. The meteorological records from these stations would be transmitted to the IMAS via telegram."[21] Additionally, meteorological information pertaining to the Far East region received by the DSGNM would be relayed to the Pratas Observatory, which would then disseminate this information to nearby ships to ensure navigational safety.[22] However, the lack of specialised expertise in marine meteorology was an issue faced by both the Qingdao Observatory and the DSGNM in this period.

The talent issue was partly resolved in the early 1930s with the emergence of Lü Jiong (吕炯), a distinguished meteorologist who played a pivotal role in marine meteorology during the Republic of China. After graduating from the Department of Geosciences of National Southeast University (国立东南大学), in the late 1920s Lü became one of the few meteorological personnel in China with a college background. It appears that Lü garnered recognition from his former teacher, meteorologist Zhu Kezhen (竺可桢) who held the position of director of the IMAS, leading to his appointment as a general researcher at the IMAS from 1928.[23] Nonetheless, mere attainment of a university education did not suffice for conducting high-level meteorological research. Therefore, Lü Jiong was dispatched to Germany for further academic pursuits. It seems that in the early twentieth century, dispatching meteorological personnel to Germany for learning advanced knowledge was valued by East Asian countries. Since 1911, the Japanese meteorologist Wasaburo Ooishi also worked for two years at the Lindenberg Aerological Observatory in Germany.[24] Lü's overseas study was fully funded by the IMAS, showing that the institute attached great importance to training meteorological researchers.[25] Further, the areas of study pursued by Lü Jiong mirrored the wider aspirations for Chinese meteorological progress. From 1930 to 1934, Lü successively studied subjects including climatology, oceanography, geology and agricultural meteorology at Berlin University and Hamburg University. These were all areas which were weak links in Chinese meteorological expertise. Unlike his predecessors, who had autonomy in selecting their majors, Lü Jiong was directed to pursue studies abroad with a clear mandate to advance Chinese meteorology.[26]

The importance of marine meteorological information could also be recognised in the competition for certain rights between different countries, such as in the field of telecommunications. When the Zikawei Observatory developed typhoon research and provided warning alerts to the surrounding area, French officials constructed a radio station in the

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[21] Letter from Academia Sinica to the Department of Seaway Guard 海道巡防处, 2 March 1929: Archives of Institute of Modern History, Academia Sinica (hereafter 'AIMHAS'), Taipei, 393/07/01/03/015.

[22] Letter from Academia Sinica to the Department of Seaway Guard 海道巡防处, 2 March 1929: AIMHAS, 393/07/01/03/015.

[23] Zhu Kezhen 竺可桢, *钦天山气象台落成纪念刊 [Qintianshan Meteorological Observatory Memorial]* (Institute of Meteorology, Academia Sinica, 1929), 6.

[24] John M. Lewis, "Ooishi's Observation: Viewed in the Context of Jet Stream Discovery," *Bulletin of the American Meteorological Society* 83, no. 3 (2003): 357-369.

[25] Letter from Zhou Bin 周斌 to the IMAS about Lü Jiong's Assignment to Germany for Studying, 9 January 1934: The Second Historical Archives of China, (hereafter 'SHAC'), Nanjing, 393/128.

[26] Letter from Zhou Bin to the IMAS about Lü Jiong's Assignment to Germany for Studying, 9 January 1934: SHAC, 393/128.

Shanghai concession to access meteorological data from the Zikawei Observatory and transmit it via telegram. In 1933, the Shanghai Coast Radio Station (hereafter SCRS) remarked that,

> …with the cessation of commercial telegram transmissions by the French radio station, the SCRS could assume a more prominent role than before. Efforts should be directed towards enhancing the broadcasting of weather information. Only thus can the French radio station's reputation be challenged, leading ships from various nations to gradually shift their focus away from the station, ultimately enabling the SCRS to supplant it.[27]

In response, the IMAS instructed its subordinate meteorological stations to provide timely daily observation records to the SCRS, whilst treating with caution the possibility of sharing this meteorological data with the Zikawei Observatory. In addition, the IMAS asserted its advantage in furnishing more precise and comprehensive meteorological information to the SCRS.[28] Given the persistent demand for meteorological data, establishing a marine-oriented meteorological station emerged as a priority in China's meteorological agenda, thus prompting the planning of the Dinghai Meteorological Station.

The Plan for Constructing the Dinghai Meteorological Station

In May 1934, the Zhejiang Provincial Government in eastern China convened a conference aimed at revitalising the rural economy, during which it was decided to establish a weather station in Dinghai County. To receive professional assistance, the Zhejiang Provincial Government contacted the IMAS and such planning was passed to Zhu Kehzen.[29] In 1935, the IMAS proposed a plan to establish the Dinghai Meteorological Station to the Department of Construction of Zhejiang Province (浙江省建设厅，hereafter DCZP). According to the letter, the IMAS stressed that: "typhoons routinely sweep the coast of Zhejiang Province, causing significant losses to coastal fisheries. Hence, to safeguard fisheries development, it is imperative to establish meteorological stations to provide meteorological warnings."[30]

Drawing on this letter, it is apparent that the plan was for the DMS to serve the fishing industry. While the eastern region of China boasts a lengthy coastline, the foremost factor in selecting a site for a marine meteorological station may not solely hinge on scientific considerations but also on such economic factors. During the Republic of China era, the economic development of Zhejiang Province was relatively robust compared to other regions in the country.[31] Renowned for its commercial tradition, Zhejiang Province boasted a thriving fishing industry, which constituted a vital economic sector. The Zhoushan Fishing Ground (舟山渔场), located in Dinghai County, was the largest fishing ground in China. By 1931, nearly 70% of the people in Dinghai were employed in fishing and salt production.[32] Due to a vast coastline as well as an extensive river and lake system in China, fishing had long been an

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[27] Letters from International Telecommunication Bureau 国际电信局 to the Academia Sinica, 22 September 1933: AIMHAS, 393/07/01/03/014.

[28] Letters from IMAS to the Academia Sinica, 26 September 1933: AIMHAS, 393/07/01/03/014.

[29] Hu Ruiqi 胡瑞琪, "你们可知舟山普陀青龙山上"风雨表"的故事?[Do you know the story of the barometer on Qinglong Mountain in Putuo, Zhoushan]," Zheli Zhoushan, accessed January 6, 2025, https://mp.weixin.qq.com/s?biz=MzI5NjAzNTc1MA==&mid=2650716539&idx=2&sn=c8124f42880041084d42da341e1a52ff&chksm=f4406db2c337e4a41e59441068e5e27ced89ad705e473a69014a54c65b6a909bb2d06ec7440b&scene=27.

[30] Letters from the Zhongyang Yanjiuyuan 中央研究院 [Academia Sinica] to the Zhejiangsheng Zhengfu 浙江省政府 [Zhejiang Provincial Government], 11 February 1935: AIMHAS, 393/07/03/04/009.

[31] Jiang Hong 江宏, "近代浙商与浙江经济的近代化(1890-1930) [Zhejiang Merchants in Modern China and the Modernization of Zhejiang Economy (1890-1930)]," (PhD diss., Shanghai University of Finance and Economics, 2022), 211-15.

[32] Lin Yanyi 林彦亦, Gong Minli 宫敏丽 and Lu Lijuan 芦立娟, "浅谈近代舟山海洋渔业的发展情况 [Discussion on the Development of Modern Zhoushan Marine Fishery]," *Nongcun Jingji Yukeji 农村经济与科技* 28, no. 13 (2017): 78-80.

important economic activity and played a significant part in generating national taxes. Consequently, during the Republican era, the state accorded considerable importance to the development of fisheries to bolster tax revenues.

Overseas-trained Chinese fisheries experts believed that reasonable and scientific management could improve the efficiency of resource development. These assumptions were based on the idea that applied science and technological expertise could maximise the utility of the environment.[33] However, such endeavours might entail significant environmental repercussions. Interventions in the environment to reap benefits necessitated grappling with environmental threats, including natural disasters, wherein meteorology assumed a pivotal role. It is noteworthy that the impact of natural disasters on fisheries extended beyond the disruption of fishery production and endangerment of fishermen's lives to encompass the sustainable development of fisheries. Following natural disasters in the 1920s that ravaged Taizhou and Wenzhou in Zhejiang Province, affected communities transitioned from net fishing to cage fishing—a lucrative yet unsustainable technology—to supplement their income.[34] As a result, applying meteorological insights to mitigate the impacts of disasters became a focal point for Zhejiang officials. Since 1880, pre-existing marine meteorological observations had been underway in Zhejiang Province, with Chinese Maritime Customs erecting four island lighthouses for weather monitoring, located at Mount Daji, Mount Huaniao, Mount Xiaomian, and Mount Beiyu. These observational outposts conducted rudimentary marine meteorological observations, including atmospheric pressure, temperature, wind direction and strength among other weather conditions. In addition to weather reporting, they also hoisted coastal typhoon warning signals and strong wind forecast signals.[35] However, the meteorological service quality rendered by these lighthouses was inadequate, and the Zhoushan Islands were often hit by typhoons in summer and autumn, causing huge losses to fishermen; a professional marine meteorological station was required.

The establishment of the DMS was a collaborative effort involving the Zhejiang Province Water Conservancy Bureau (浙江省水利局，hereafter ZPWCB), the IMAS, the Dinghai County Government, and the fishing industry itself. It is noteworthy that both the local government and the populace assumed substantial financial burdens, a practice less common in scientific infrastructure development in Western nations. For instance, it was the US Weather Bureau, as the central meteorological agency, that spearheaded the establishment of a meteorological network to disseminate early tornado warnings,[36] whereas the case of the DMS proved that construction required joint efforts. Following this joint establishment model, the IMAS assumed responsibility for instrument provision, while the ZPWCB furnished the requisite land. In order to maintain the normal operation of the station, the IMAS also agreed to contribute one-third of the regular fee of 300 yuan per month.[37]

Despite this, funding emerged as a prevalent challenge in the construction of meteorological stations during the Republican era, which was mirrored at the DMS as well. According to the plan of DCZP, the total funds needed for preparing a meteorological station

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[33] Micah S. Muscolino, *Fishing Wars and Environmental Change in Late Imperial and Modern China* (Harvard University Press, 2009), 8.

[34] Muscolino, *Fishing Wars and Environmental Change in Late Imperial and Modern China*, 148-49.

[35] Zhejiang Provincial Meteorological Bureau 浙江省气象局, "浙江近代的气象工作 [Meteorological affairs in Zhejiang Province in modern times]," in *中国近代气象史资料 [Resources for Meteorological History in China]*, ed. Editorial Committee of Modern Meteorological Resource in China 中国近代气象史资料编委会 (Qixiang Press, 1995), 117-18.

[36] Nancy Mathis, *Storm Warning: The Story of a Killer Tornado* (Touchstone, 2007), 40-59.

[37] Letters from Zhejiangsheng Jiansheting 浙江省建设厅 [DCZP] to the Academia Sinica, 11 March 1935: AIMHAS, 393/07/03/04/009.

amounted to approximately 20,000 yuan. Despite the IMAS's commitment to equipment provision, an additional 10,000 yuan was still needed.[38] Subsequently, for the DMS plan to work, the Zhejiang Provincial Government asked coastal county governments, alongside the fishing industry, to shoulder the financial burden. The ZPWCB even published investment and bidding advertisements for the construction of DMS housing in newspapers. It shows that:

> Experienced individuals involved in construction projects may remit a fee of two yuan to the Department of Factory Affairs within the Hangzhou Water Conservancy Bureau to obtain necessary charts and forms outlining bidding regulations. Following on-site assessments, a deposit of 400 yuan is requisite to the ZPWCB, enabling participation in the bidding process at the DCZP. The outcome will be publicly disclosed at the ZPWCB on 30 April at 2pm.[39]

This endeavour seemingly failed to attract interest from potential bidders, prompting the ZPWCB to extend the bidding deadline. Ultimately, a Shanghai company named Wangsenji (汪森记) undertook the construction project at a cost of 8,900 yuan, significantly below the company's initial offer of 15,000 yuan.

Given that nearby county governments and the fishing community would be the direct beneficiaries of the DMS, it was deemed reasonable for them to bear some of the expenses. The fishermen in Zhejiang Province had a tradition of providing financial backing for official infrastructure projects. Seeking to bolster their influence, fishermen often established fishing lodge organisations to advocate for their interests in local politics and economics. These organisations facilitated dialogue between fishermen and officials regarding marine resource allocation, while also serving as channels for officials to access financial revenue from fishing enterprises. Consequently, funding government construction projects bolstered the legitimacy of fishing lodge organizations.[40] However, the feasibility of implementing this policy warranted scrutiny, as these organizations might be reluctant to shoulder the substantial expenses associated with modern scientific infrastructure, potentially hindering funding efforts.

In the case of the DMS, it is plausible that the fishing industry could face pressure from local authorities, given that their fishing status necessitated official recognition. Furthermore, county governments might find themselves compelled to comply with the central government's administrative directives, thereby obliging them to provide financial backing. Through negotiation, the local representative of the fishing enterprises, Liu Jiting (刘寄亭), acquired three steel-reinforced concrete bungalows and a hut near the proposed DMS site, serving as residences for the station builders. The local fishermen also contributed a budget of 1,000 yuan, comprised of two yuan levied from each large fishing boat, with the owner and tenant each paying half.[41] In addition, the county government allocated 4,000 yuan from local construction funds to cover the expenses of radio sets and signals.[42] However, several challenges impeded progress. Initially, the ZPWCB was tasked with covering 200 yuan of the 300-yuan monthly fee, but budget constraints rendered the ZPWCB unable to fulfil its obligation. Zhu Kezhen even asked Huang Shaohong (黄绍竑), the president of Zhejiang Province, to provide

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[38] Letters from Zhejiangsheng Jiansheting 浙江省建设厅 [DCZP] to the Academia Sinica, 11 March 1935: AIMHAS, 393/07/03/04/009.

[39] "浙江省水利局建筑定海测候所房屋工程继续招商投标广告[Advertisement on the Extending of Bidding for the Housing Project of Dinghai Meteorological Station by the ZPWCB]", *Xinwen Bao 新闻报*, 17 April 1936, 3.

[40] Muscolino, *Fishing Wars and Environmental Change in Late Imperial and Modern China*, 61-62.

[41] Hu Ruiqi, "Do you know the story of the barometer on Qinglong Mountain in Putuo, Zhoushan".

[42] Letters from Zhejiangsheng Jiansheting 浙江省建设厅 [DCZP] to the Academia Sinica, 12 April 1935: AIMHAS, 393/07/03/04/009.

assistance in funding, but it seems that the request was either rejected or just ignored by Shaohong.[43] Moreover, funds raised from the fishing industry fell short. Consequently, the IMAS had to utilise interim funds to supplement the nine-month expenses from July 1935 to March 1936, ensuring the timely completion of construction.[44]

As has been discussed, Lü Jiong's role in promoting the DMS bears further analysis. As one of the few Chinese experts in marine meteorology at that time, Lü was dispatched to Dinghai to conduct on-site investigations during the site selection process. Based on his judgement, Heye Bay in Shenjiamen (Fig. 1) was chosen for its advantageous location atop high ground overlooking the sea, facilitating weather observation and communication with local fishing vessels.[45] The piece of land for the station was purchased at Liu Jiting's expense. More importantly, with Zhu Kezhen appointed as the president of Zhejiang University in March 1936, Lü Jiong took the position as the acting director of IMAS. Accordingly, Lü also participated in the appointment of personnel for the DMS, hence technical personnel from the disbanded Shanghai Meteorological Observatory were deployed, with Wang Guoai appointed as the director.[46]

Fig. 1. Zhejiang Province and the DMS

Source: Adapted from "Map of Zhejiang Province", accessed January 20, 2025, http://bzdt.ch.mnr.gov.cn/browse.html?picId=%224o28b0625501ad13015501ad2bfc0229%22.

[43] "Letters from Zhu Kezhen to Huang Shaohong, 25 January 1936," in *蔡元培论科学与技术[Cai Yuanpei's Discussion of Science and Technology]*, ed. Gao Pingshu (Hebei Science & Technology Press, 1985), 287.

[44] "定海设立测候所[Meteorological Station Set up in Dinghai]," *Shanghaishi Shuichan Jingji Yuekan 上海市水产经济月刊* 5, no. 3(1936): 8.

[45] Letters from the Academia Sinica to Zhejiangsheng Jiansheting 浙江省建设厅 [DCZP], 24 April 1935: AIMHAS, 393/07/03/04/009.

[46] Zhejiang Provincial Meteorological Bureau, "Zhejiang Jindai de Qixiang Gongzuo," 118.

Upon the station's establishment, the IMAS conducted project quality assessments. In October of 1936, the IMAS dispatched Jin Yongshen (金詠深), along with Xu Jiaxuan (徐家谖) from the DCZP and technician Wu Pinfu (吴品福) of the Dinghai County Government to Shenjiamen to inspect the project. Following the investigation, it was determined that the project was not yet fully operational, necessitating the addition of three additional buildings behind the station to serve as service rooms, a kitchen, and a machinery room.[47] Hence, after two months of construction work, the DMS was officially established and put into operation on New Year's Day of 1937. Equipped with a shortwave radio station, the DMS could communicate with other radio stations such as Dinghai, Daishan, Qushan, Putuo, and Jintang to provide weather reports. Subsequently, meteorological services were provided to local fishermen during the day via flags and at night via light bulbs. Additionally, plans were made to establish a marine biology research institute adjacent to the station, to be undertaken by the Institute of Zoology and Botany of the Academia Sinica, however it failed to be established due to the Second World War.[48]

In contrast to other meteorological stations, it appears that the DMS's construction plan exhibited a more deliberate approach, with a focus on fostering the development of fisheries in Zhejiang Province. This inclination also reflects the evolving maturity of scientific institutions in the Republic of China regarding designated scientific planning. Later, for administrative efficiency, the responsibility for the DMS was transferred to the IMAS. Neither the IMAS nor the Zhejiang Provincial Government had previously established a dedicated meteorological alarm system for this region, rendering the DMS, to some extent, a proving ground for typhoon warning methodologies. [49] Moreover, to ensure the acquisition of precise marine meteorological data, observation standards were also regulated under the auspices of the IMAS. In 1937, Lü Jiong personally engaged with the Aviation Administration Department of the Ministry of Transportation to address this matter. At the time, ships did not accord significant importance to seawater thermometers or value the instruments provided by the IMAS. Hence, the observational instruments aboard ships operated by the China Merchants Steam Navigation Company (轮船招商局, hereafter CMSNC) were rudimentary and antiquated, necessitating the integration of new equipment such as marine-use mercury barometers. Additionally, the recorded values from these instruments were markedly inaccurate, with many remaining uncalibrated. Consequently, communications between the ships and the IMAS met with difficulties, thus each vessel was required to send meteorological information twice a day to the CMSNC, which then relayed it to the IMAS. The IMAS would also compile and distribute the "Marine Meteorological Observation Manual (海上气象观测说明书)" to each vessel. Given the generally low educational attainment among crew members, senior personnel such as chief officers, second officers, and third officers required training by the IMAS to ensure accurate recording of meteorological observations.[50] These ships, to some extent, assisted the DMS in collecting meteorological data in the waters adjacent to China, thereby expanding its research scope. Through these efforts, it appears that the Republic of China was poised to invest in advancing marine meteorology.

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[47] "定海测候所与海产研究所[Dinghai Meteorological Station and Institute of Marine Products]," *Kexue 科学* 20, no. 12(1936): 1072.

[48] "定海测候所工程告竣[The Construction of Dinghai Meteorological Station Has Been Completed]," *Shuichan Yuekan 水产月刊*3, no. 11 (1936): 83. See also "Dinghai Meteorological Station and Institute of Marine Products", 1072.

[49] Letters from the Academia Sinica to Zhejiangsheng Jiansheting 浙江省建设厅 [DCZP], 6 February 1935: AIMHAS, 393/07/03/04/009.

[50] Letter from the IMAS to the Aviation Administration Department of the Ministry of Transportation 交通部航政司, 24 April 1937: AIMHAS, 393/07/01/03/028.

Rethinking the Development of Marine Meteorology

Despite the comprehensive design of the DMS, its operations were interrupted because of the Second World War. In August of 1937, as the Japanese army attacked Shanghai, Zhejiang Province was threatened, and Wang Guoai (汪国瑷) resigned in the same month on the grounds of discord with staff, although he might have been greatly affected personally by the war. Afterwards, the DMS did not maintain basic observations for a long time until occupied by Japan in June 1939.[51] Moreover, due to the delay caused by Wu Yonggeng (吴永庚), the succeeding director of the DMS, the instruments could not be relocated to secured zones prior to the Japanese military occupation, leading to Zhu Kezhen's extreme dissatisfaction towards this issue.[52] It seems that the National Government lost control over most coastal areas during the wartime, but the Chinese meteorological community had recognised the significance of marine meteorology and pondered its developmental trajectory. In July of 1942, the IMAS submitted several contingency plans to the Central Planning Board, the department responsible for national construction during wartime. Among these, Lü Jiong proposed a plan titled "the Establishment of Marine Observatory Basing on Oceans and National Defence."[53]

In this eleven-page plan, Lü underscored the importance of marine meteorology and outlined detailed strategies for its future development in China. It is evident that Lü acquired his marine meteorological knowledge primarily during his studies in Germany, and this experience influenced his subsequent actions. He endeavoured to develop marine meteorology in China based on the German model, as reflected in the institutional setup and the use of instruments. Primarily, Lü investigated the significance of meteorological stations from a wartime perspective. He contended that contemporary warfare transcended terrestrial boundaries, with maritime warfare relying heavily on naval and aerial operations, wherein meteorology played a crucial role in guiding air force flights and the navigation of warships. For instance, he highlighted that the Hamburg Ocean Observatory was under the jurisdiction of the German Navy.[54]

In addition to wartime applications, Lü expounded on the relevance of marine meteorology to the fishing industry. Despite China's coastal-dependent fishing industry, regulatory constraints and resistance to reform, coupled with fishermen's limited knowledge, hindered its competitiveness with global peers. Japan, Europe, and the US had not only enhanced their fishing equipment and adopted more precise fishing techniques but were also studying other fishery-related factors. Investigations encompassed seabed depth, seawater temperature at various depths, salinity analysis, tidal variations, water flow direction and velocity, seawater transparency, and plankton distribution. Lü provided an example illustrating how seawater temperature influenced fish distribution, noting the prevalence of flying fish in the sea region between 40 degrees north and south in latitude due to the average summer temperature exceeding 20 degrees Celsius.[55]

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[51] Wen Kegang 温克刚, ed., *中国气象史 [History of Meteorology in China]* (Qixiang Press, 2003), 361.

[52] "Zhu Kezhen's diary for 18 July 1939," in *竺可桢全集 [the Collected Works of Zhu Kezhen], Vol. 7*, Zhu Kezhen (Shanghai Scientific and Technological Education Publishing House, 2005), 125.

[53] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board 中央设计局, July 1942: AIMHAS, 393/07/01/03/014, pp. 1.

[54] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board, pp. 1.

[55] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board, pp. 2.

Emphasising the significance of marine meteorology in practical applications, Lü Jiong elucidated the interplay between meteorology and oceanography from an academic standpoint. With the atmosphere enveloping the sea surface, any alterations in atmospheric elements such as temperature, humidity, and weather could influence the sea surface, thereby inducing changes in temperature and salinity. Conversely, fluctuations in ocean temperature and salinity could reciprocally impact the atmosphere. Moreover, myriad meteorological issues often necessitated insights from oceanography to bolster research efforts. Given the substantial heat capacity of seawater, fluctuations in its temperature were poised to significantly influence terrestrial climates. Lü cited the research of B. Helland Hansen, F. Nansen, and A. Defant, who endeavoured to forecast crop yields in Western Europe based on atmospheric dynamics in the northern Atlantic Ocean. Having previously interned at esteemed institutions such as the Berlin Institute of Oceanography, the Ocean Museum, and the Hamburg Ocean Observatory each for one year, Lü was well-versed in marine sciences. Consequently, he provided an overview of the organization, equipment, and operational scope of marine observatories.[56]

Lü Jiong advocated his vision for establishing marine observatories across China, proposing the establishment of five observatories spanning from south to north: Huludao, Qingdao, Shanghai, Fuzhou, and Guangzhou. he suggested that Shanghai be used as the central observatory, given its role in furnishing meteorological reports for naval and aerial deployments during wartime, further solidified its suitability.[57] Regarding personnel, Lü advocated for distinct groups within each observatory, including navigation, marine meteorology, astronomy, tides, oceanography, and marine aviation meteorology. Moreover, while the focus was predominantly on marine physics, Lü also proposed establishing marine biology and fisheries groups, helmed by respective experts, acknowledging the importance of incorporating biological expertise. Nevertheless, given the scarcity of meteorological personnel and fund in Republican China, Lü had to adjust the plan and recommended prioritizing the construction of infrastructure, followed by gradual expansion in tandem with economic and talent growth. In terms of the groups Lü listed, he underscored the establishment of marine meteorology and oceanography groups as top priorities.[58] Furthermore, Lü meticulously categorized instruments into eight classifications, detailing their names, prices, and manufacturers. While primarily designated for oceanographic and tidal groups, the cumulative cost of these instruments amounted to 70,000 German Marks. Lü advocated prioritizing offshore survey needs and estimated that allocating 20,000 to 30,000 yuan for marine instruments, alongside 10,000 yuan for meteorological instruments, could lay the foundation for a marine meteorological station. Accounting for furniture and ancillary expenses, he recommended an initial investment of approximately 100,000 yuan, with a monthly maintenance outlay of 5,000 yuan and staffing comprising 20 members.[59] It appears that Lü meticulously planned for marine meteorology in China, yet there were doubts about the feasibility of implementing these plans, particularly in the post-war period.

[56] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board, pp. 3-4.

[57] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board, pp. 5.

[58] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board, pp. 6-8.

[59] Plan about 'Establishment of Marine Observatory Basing on Oceans and National Defense' sent by the IMAS to the Central Planning Board, pp. 8-10.

The post-war period of the Dinghai Meteorological Station

With Japan's defeat in the Second World War, the National Government reclaimed a large number of meteorological stations that were controlled by Japan during the war, including the Qingdao Observatory and the DMS. Under the leadership of director Wang Binhua, the Qingdao Observatory continued to conduct research on marine meteorology, including the study of sea fog, which was an important academic contribution later on. The status of the Dinghai Meteorological Observatory has also received further attention.[60] In the summer of 1946, the Zhoushan Islands endured another devastating typhoon, inflicting severe losses on the fishing industry. Responding to this, the marine fishery department of the Jiangsu and Zhejiang regions under the Ministry of Agriculture and Forestry resolved to establish a storm warning station in the area. Technician Feng Zikang (冯子康) was dispatched to assess conditions for a suitable location in the vicinity of the DMS.[61] In June 1947, the DMS resumed operations, relocating to the Dinghai Fisheries School (定海水产学校). During the same month, when a typhoon struck the coastal regions of Zhejiang and Fujian Provinces, the Fishery Bureau of Zhejiang Province directed its subordinate stations to alert fishing groups and hoist typhoon signals for early warning.[62] It appeared that the DMS promptly fulfilled its role. By the end of 1948, it was relocated to the Fire God Temple of Dinghai under the directorship of Xu Jianming (许鑑明), operating under the auspices of the Central Meteorological Bureau (中央气象局, hereafter CMB).[63] Moreover, Lü Jiong had been the leader of the CMB since 1944, and with his support, the CMB upgraded the DMS to a formal marine meteorological observatory, entailing a change in nomenclature and expanded functions. In addition to its prior duties of meteorological monitoring, the upgraded DMS served as an information dissemination hub, broadcasting weather updates to ten major seaports, including Shanghai, Xiamen, and Taipei.[64]

However, solely relying on the DMS as the primary marine meteorological observatory for typhoon early warning might not suffice to meet coastal area demands. Similar issues also happened in developed countries. Alexander Hall pointed out that the devastating 1953 North Sea flood that ravaged Britain's eastern coastline exposed critical flaws in early warning systems. This catastrophic event proved pivotal in shaping modern disaster governance, with the subsequent official inquiry into its causes and impacts laying the foundational framework for contemporary UK flood management strategies and emergency response protocols.[65] While the Meteorological Office in Britain played a key role in the implementation of the warning system, its Chinese counterpart, the CMB, assumed a comparable responsibility. Recognizing the imperative of widespread meteorological information dissemination, the CMB made

[60] J. M. Lewis, D. Koracin and K. T. Redmond, "Sea fog research in the United Kingdom and United States (A Historical Essay Including Outlook)," *Bulletin of the American Meteorological Society* 85, no. 3 (2004): 395-408.

[61] "定海嵊泗列岛设暴风警报站[Setting up Storm Warning Stations on Shengsi Islands in Dinghai]," *Minguo Ribao 民国日报*, 12 August 1946, 5.

[62] Zhejiang Provincial Meteorological Bureau, "Meteorological affairs in Zhejiang Province in modern times", 120. See also Telegram sent by the Zhejiangsheng Yuye Ju 浙江省渔业局 [Zhejiang Provincial Fishery Bureau], 28 June 1947: AIMHAS, 20/24/006/10.

[63] The Central Meteorological Bureau was founded in 1941 by the National Government, which replaced the IMAS in managing the national meteorological cause. Zhejiang Provincial Meteorological Bureau, "Meteorological affairs in Zhejiang Province in modern times," 118.

[64] Letters from Zhongyang Qixiangju 中央气象局[Central Meteorological Bureau (CMB)] to Nonglinbu 农林部 [Ministry of Agriculture and Forestry (hereafter 'MAF')], 3 June 1947: AIMHAS, 20/24/006/18.

[65] Alexander Hall, "Plugging the Gaps: The North Sea Flood of 1953 and the Creation of a National Coastal Warning System," *Journal of Public Management & Social Policy* 22, no. 2 (2015).

further strides in areas under the DMS's jurisdiction. In 1946, the Marine Fisheries Supervision Office of Jiangsu and Zhejiang Regions, a subordinate body of the Ministry of Agriculture and Forestry, proposed to set up a storm warning radio station to assist the DMS's operations.[66] The efficacy of weather forecasts hinged largely on the timeliness of information dissemination. With the radio station's support, fishermen could receive early weather warnings, affording them more time to prepare for weather-related disasters. Moreover, to enhance disaster response efficiency, the Ministry of Agriculture and Forestry stipulated in 1947 that, "all fisheries-related entities, including coastal governments, fishing associations, and fishery companies, should procure radio receivers and transmitters within a specified timeframe to access daily weather reports and storm warnings."[67]

In addition, through collaboration with the National Resources Commission, which produced a large quantity of affordable radios, ordinary fishermen could purchase or rent radios to access weather broadcasts, enhancing their ability to cope with extreme weather.[68] While the extent of implementation by other entities remains uncertain, the China Fisheries Corporation, a Ministry of Agriculture and Forestry subsidiary, indeed outfitted each ship with a radio station.[69]

Another advantage of weather stations for fisheries was proximate timing. During the Republican era, ordinary fishermen often struggled to access timely meteorological information, resulting in forecast failures. Therefore, a time signal was issued daily at the Hangzhou Meteorological Station, then transmitted to each county by the radio station.[70] In terms of the alarm time, the DMS and telecommunication bureau established explicit regulations. According to the international radio regulations, coastal meteorological stations and ship radio stations were required to pause operations and listen for distress signals at 15-18 and 45-48 minutes past each hour. Additionally, a storm alarm would be broadcast every day at 12:50 and 18:50.[71] Such frequent broadcasting aimed to ensure the prompt receipt of early warnings. In addition to broadcasting, the monthly weather report would be sent to the Fishery Bureau of Zhejiang Province, enabling analysis of oceanic conditions.[72] It indicated that the progress in timeliness and early warning systems reflected the improvement in the fishing industry.

More importantly, the establishment of the DMS not only provided meteorological services to fisheries, but also indirectly affected the significance of national sovereignty in fisheries. According to Zhang Jian, strengthening the country's external borders required the expansion and consolidation of fishing rights. Exerting control over marine fisheries was vital for safeguarding national sovereignty and fostering national prosperity.[73] What was worse, in

[66] Letters from the Jiangzhequ Haiyang Yuye Dudaochu 江浙区海洋渔业督导处 [Marine Fishery Supervision Office of Jiangsu and Zhejiang Regions] to Nonglinbu 农林部 [MAF], 16 December 1946: AIMHAS, 20/24/006/15.

[67] Letters from Zhonghua Shuichan Gongsi 中华水产公司 [China Fisheries Corporation] to Nonglinbu 农林部 [MAF], 18 November 1947: AIMHAS, 20/24/006/12.

[68] Letters from Zhonghua Shuichan Gongsi 中华水产公司 [China Fisheries Corporation] to Nonglinbu 农林部 [MAF], 18 November 1947: AIMHAS, 20/24/006/12.

[69]中华水产公司电台证书[Radio Station Form of the China Fisheries Corporation], October 1947: AIMHAS, 20/24/006/12.

[70] Letters from the CMB to the Nonglinbu 农林部 [MAF], 3 June 1947: AIMHAS, 20/24/006/18.

[71]定海测候所暴风警报广播时间表 [Broadcast schedule of storm warning for the DMS], 1 September 1947: AIMHAS, 20/24/006/20.

[72] Telegram sent by the Zhejiangsheng Yuye Ju 浙江省渔业局 [Zhejiang Provincial Fishery Bureau], 28 June 1947: AIMHAS, 20/24/006/10.

[73] Muscolino, *Fishing Wars and Environmental Change in Late Imperial and Modern China*, 76.

the 1930s Japanese vessels, in violation of international law, encroached upon China's territorial waters, imperilling China's fishing interests and the livelihoods of Zhejiang fishermen.[74] Thus, if the meteorological station could aid the normal operation of Zhejiang's fishing industry, it would aid in controlling fisheries in Chinese waters, thereby bolstering the safety of China's fishery resources and safeguarding territorial sea sovereignty.

Functioning as a marine meteorological observatory, the DMS diligently recorded marine meteorological data that was previously overlooked. Through the monitoring of this data, the DMS gathered various metrics, including visibility, sea water temperature, and specific gravity.[75] Concerning meteorological record-keeping, it indicated an ongoing enhancement in the DMS's professional calibre, especially the localization of Western meteorological standards. Due to the diverse Chinese characters used to describe the strength of wind, wind forces were recorded in Chinese characters rather than numbers by associating different Chinese terms with the Beaufort scale. For instance, the *wei feng* (微风, breeze) referred to level 3, while the *he feng* (和风, soft wind) referred to level 4.[76] Compared to earlier records, these detailed entries facilitated the acquisition of more precise information. Nevertheless, challenges persisted in terminology, because thus they probably caused confusion for people who were not familiar with meteorological knowledge.

Drawing upon data from the DMS and the Qingdao Observatory, China gradually established several meteorological stations along China's coastline, marking the nascent emergence of a marine meteorological network in the late 1940s. Moreover, the observed data provided basis for carrying out certain research on natural disasters in Zhejiang. For example, research findings indicated that a discrepancy of over 20% between annual precipitation and the long-term average could precipitate floods or droughts. Geographically, western Zhejiang and the Qiantang River basins were identified as the most susceptible regions based on meteorological data.[77] The above conclusion shows that the collection of meteorological information really provided help for the response to natural disasters.

However, the ramifications of political and social upheaval during the Republic of China era on science cannot be disregarded. At the end of 1947, the wind indicator ball at the DMS, crucial for issuing typhoon signals, was stolen. This incident resulted in the failure to hoist the typhoon signal on the evening of 20 February 1948 when a typhoon struck Zhoushan. Fortunately, the DMS had pre-emptively broadcast an alert through the Ningbo Radio Station the evening prior to the storm. Afterwards, the DMS urged the Fishery Bureau of Zhejiang Province to recreate the typhoon signal to avert such occurrences in the future.[78]

Conclusion

This article has centred focus on the establishment and utilisation of the Dinghai Meteorological Station, to some extent delineating the trajectory of marine meteorology development during the Republic of China era. From the Chinese Maritime Customs and Zikawei Observatory in the early twentieth century, to the Qingdao Observatory and

[74] Muscolino, *Fishing Wars and Environmental Change in Late Imperial and Modern China*, 114.

[75] 定海气象及海洋状况记录表 [Record of meteorological and marine conditions of the DMS], January to March 1948: AIMHAS, 20/24/006/20.

[76] 定海气象及海洋状况记录表 [Record of meteorological and marine conditions of the DMS], January to March 1948: AIMHAS, 20/24/006/20.

[77] Zhejiangsheng Shuiliju Cehousuo 浙江省水利局测候所, "浙江省气候观测 [Meteorological Observation in Zhejiang Province]," *Qixiang Huibao 气象汇报* 1, no. 1 (1946): 35.

[78] "定海测候所风球被窃 [Wind Indicator Ball Pilfered in the Dinghai Meteorological Station]," *Qixiang Huibao 气象汇报* 2, no. 3 (1948): 12.

subsequently to the DMS, this article explored the process of localisation in establishing better marine meteorological knowledge. It argued that meteorological stations were not merely facilities for acquiring and researching meteorological data, but their construction and operation were also shaped by this knowledge. Moreover, the construction of meteorological stations during the Republican era was not simply a political plan, but was influenced by factors such as the economy and society at that time. The demand from the fisheries sector emerged as a pivotal driver for marine meteorology advancement in the construction of DMS. Therefore, this article illustrates that in the construction plan of the DMS, different levels of government and local economic organisations were involved, which was different from the previous construction model of meteorological stations in the Republic of China.

This article had expounded on how wartime heightened attention towards the development of marine meteorology, culminating in a more mature plan. This was exemplified, to some extent, in the post-war phase of the DMS. The establishment of a maritime meteorological network gradually took shape based on the DMS, yielding tangible outcomes in typhoon warnings and marine research. Nonetheless, it is imperative to acknowledge the political and social instability of the Republic of China, along with economic challenges, which impeded meteorological progress. The case of the DMS was considered a ‘laboratory’ for China’s development of marine meteorology, which proves that non-Western countries could also explore the development path of local science through the construction of scientific facilities.

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