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# Transnational Co-production of Knowledge: The Standardisation of Typhoon Warning Codes in the Far East, 1900–1939

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**Abstract** The *why* and the *how* of knowledge production are examined in the case of the transnational cooperation between the directors of observatories in the Far East who drew up unified typhoon-warning codes in the period 1900–1939. The *why* is prompted by the socioeconomic interests of the local chambers of commerce and international telegraphic companies, although this urge has the favourable wind of Far Eastern meteorologists' ideology of voluntarist internationalism. The *how* entails the persistent pursuit of consensus (on ends rather than means) in international meetings where non-binding resolutions on codes and procedures are adopted. The outcome is the co-production of standardised knowledge, that is, the development of a series of processes and practices that co-produce both knowledge and ideas about the social order in a force field characterised by negotiations and power struggles.

**Keywords** Knowledge co-production · Standardisation · Transnational circulation · Internationalism · Typhoon · Asia

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## Introduction

The approach of standardisation has opened the space for a wide range of fresh and stimulating questions for historians. It is, in fact, interesting to see what happens when we set the standardisation of scientific knowledge as the unity of historical analysis.[1] Standardisation of norms and practices is inseparable from internationalisation and cooperation. Scientific organisations such as the International Union of Geodesy and Geophysics (IUGG) and the World Meteorological Organisation (WMO) have attracted the historians' interest with new questions that force us to wonder about the reasons for the comparability and homogeneity of scientific observations and to consider standardised knowledges as mirrors of social and economic order. As an instrument to scrutinise the search for consensus amid competition, the lens of standardisation enable historians to understand power struggles around who comes to standardise and why, and how ideas about knowledge and social order come to be co-produced by multiple factors. All questions lead us to why and how.

The standardisation approach poses great historiographical challenges when the Far East is the object of inquiry.[2] From 1900 to 1939, the Far East was a web of networks with colonial and non-colonial powers and manifold interests at stake. Undersea telegraph companies, maritime commercial networks and imperial geopolitics shaped the production and circulation of knowledge. Hong Kong was a colony whose metropolis (Britain) embodied the world's "cable empire".[3] Japan was characterised by imperialist expansion in Asia, its telecommunications network becoming an imperial nerve system that evolved from dependence to autonomy (Yang 2010; Miyagawa 2008, 2015). China's treaty ports were concessions governed by Western powers, characterised by extraterritoriality, and, with Shanghai as the main hub, by being trade enclaves (Zhu 2012). The Philippines was a former Spanish colony before the American government took over the archipelago, where telegraphic service was left, unlike in Japan, to the private sector (Cushman 2013; Anduaga 2017, 2019). Over this imperial geography, set in typhoon-prone regions, several merchant communities and a transnational Catholic order—the Jesuits—operated across imperial boundaries in Shanghai and Manila.

The "why" and the "how" of knowledge standardisation is captured in the notion of co-production. Co-production is one of the key concepts in the history of standardisation. However, why this is a story of co-production, and not of mere collaboration and/or competition? In STS and social studies of science, co-production pays attention to the social dimensions of cognitive understandings, while at the same time emphasizing the 'epistemic and material correlates of social formations'

[1] For some examples of scientific standardisation, Bartky (1989), Geyer (2001), Alder (2013).

[2] As a geocultural identity, the term "Far East" inheres in the issue of coloniality. Although it denotes an Eurocentric mentality and is even geographically inaccurate, I use it in this paper as most of meteorologists involved in typhoon science at that time referred to the region as the Far East.

[3] The sources cited in this paragraph only include studies on meteorology and telecommunications in the Far East. MacKeown (2010), Williamson (2017), Williamson and Wilkinson (2017), Pui-yin (2003).

(Jasanoff 2004: 3).[4] This notion captures the multidimensionality and interrelation of the process of knowledge standardisation that my research work reveals, pointing to those processes and practices that co-produce both scientific knowledge and ideas about the social order. But this paper adds another dimension: the industrial and mercantile interests in the transnationally produced knowledge. By understanding the knowledge embodied in the storm-warning code standardisation as "co-produced" in this double sense, we gain insight into how certain changing ideas about both the social order and economic profitability influenced the making and use of scientific knowledge, and, in reverse, how this knowledge production was incorporated into practices of companies and corporations, as well as of governance.

To understand the co-production of standardised knowledge in the Far East, one must sharply distinguish *local* from *non-local* storm-warning codes, i.e., between codes that warn of the winds caused by typhoons at seaports and those warning the position and motion of typhoons on the high seas. Within the geopolitical chessboard of the Far East, players' interests from colonial and non-colonial powers were clearly differentiated. Meteorologists and political governors from colonial powers (like Britain in Hong Kong) were concerned with strengthening social safety and maintaining sovereignty by implementing uniform local codes. In contrast, chambers of commerce from main seaports (such as those from Shanghai and Hong Kong) sought maritime security by standardising non-local codes. In addition to the local/non-local distinction, one must distinguish between codes for telegraphic transmission and codes for storm warnings. Telegraph companies aimed to secure maximum profitability in telegraph transmissions between weather services. Chambers of commerce aimed to ensure security in international maritime trade. This quest for security, profitability and sovereignty (i.e., strategic socioeconomic and political reasons) is the core part of the answer to the *why* of the co-production of standardised knowledge.

The present article is based on these conceptual frameworks to answer what James Secord has called 'an issue of real analytical significance—in fact, the central question of our field'. The question is as simple as it is essential: 'How and why does knowledge circulate?' (Secord 2004: 655).[5] These questions are even more pertinent when the content analysed here—typhoon-warning codes— is knowledge in transit between observatories, colonial and non-colonial governments, chambers of commerce, and telegraph companies. The *how* is concerned with meteorologists' practices of communication, the material procedures (storm-signal codes and telegraph codes) that define what I call the transnational co-production of standardised knowledge. The *why* places the observatory at the heart of the analysis. It delves into the reasons that impelled the actors involved to unify storm-warning systems. In this article, it embeds the forge of consensus led by the core group of Shanghai (made up of the Jesuit-run Zikawei Observatory and the Chinese Maritime Customs Service)

[4] On the conceptualization of co-production in social studies of science, see: Latour (1993), Jasanoff (2004), and Witjes (2017).

[5] The 'how' and the 'why' of knowledge circulation are explored in a postwar case study of an American-British encounter by Krige (2012).

and the rivalry of the Hong Kong Observatory that gained momentum first in the 1910s and then in the 1930s. Appeals for unified international codes were expressed principally in socioeconomic terms, in which techno-scientific considerations had an instrumental but subsidiary role. The fact that a typhoon's threat gathered consensus from the many stakeholders was reason enough for the pursuit of transnational cooperation, but not for the creation of international space. Paraphrasing Elisabeth Crawford, Terry Shinn and Sverker Sörlin (1993: 36), typhoon warning would not have become an object of standardisation had it not been for socioeconomic conditions favouring transnational cooperation.[6]

This article is framed by this idea: the analytical approach of "why" and "how" of knowledge co-production. Worthy of closer attention, this idea is a central question for the history of scientific standardisation. The "why" demands a multifaceted research that encompasses circles of scientific, social and political actors and their motivations. Mutual benefit or the conviction that each had something to benefit from the other mobilized the parties involved. It was a sine qua non for the standardisation of storm-warning codes. The "how" will be addressed by describing the search for consensus—on ends rather than means— in international meetings, which had the driving force of the ideology of voluntarist internationalism championed by Far Eastern meteorologists.[7] The collaborative impulse born from consensus was interwoven with a competitive impulse nourished by the rivalry between colonial and non-colonial powers. It is important to bear in mind that the encounters between meteorologists and social actors that will be described below produced standardised knowledge through mutual benefit in a force field characterised by negotiations and power struggles within an ideological context of scientific internationalism.

## The Context of the Co-production of Standardised Knowledge

In the early 1900s meteorologists participating in the International Meteorological Organisation (IMO) commissions became seduced by the possibilities of establishing uniform storm-warning signals on both a global and regional scale. At the 1905 conference in Innsbruck, the director of Zikawei Observatory in Shanghai, Father Louis Froc, proposed an 'international system of weather signals' that would be similar to that operating in Shanghai since 1883 (Froc 1908: 99–101). His idea was in line with Léon Teisserenc de Bort's proposal for a telegraph-based global weather data system (named the *Réseau Mondial*) (Edwards 2006: 232–233) and

[6] Crawford et al. (1993: 36): 'The simple transfer of authority from a national to a transnational bureaucracy is simply not sufficient to create international space'. For them, 'international space' implies that research programs, career-paths, knowledge-producing institutions, and, above all, funding are by no means national.

[7] This essentially voluntary, private mode of operation, found in international organisations, flourished before World War II. For a distinction between voluntarist, professional and government internationalism, see: Geyer and Paulmann 2001: 22. For the transition from voluntarist internationalism to quasiobligatory globalism, see: Edwards (2006).

other global initiatives undertaken in the fields of seismology and oceanography.[8] Like many other turn-of-the-century organisations, Froc's proposal incarnated the ideal of voluntarist and ideological internationalism.

Froc was not a novice in building large-scale warning networks. In 1904, he devised a new code of signals, using shapes and symbols rather than the flags used until then, to transmit the storm warnings issued by Zikawei. Hung from the semaphores of the lighthouses operated by the Chinese Maritime Customs Service (CMCS), Froc's symbols informed navigators of the longitude, latitude and force of storms. With the consent of the CMCS, the code was implemented at all the coastal ports, including Hong Kong.[9] However, his 1905 proposal went a step further as he sought to transplant Shanghai's system in Europe. To this end, the Atlantic, he suggested, could be divided into five or six sections and each section into districts; each district would receive a number, and by displaying the number at the warning stations, all sailors would be informed of the existence of a storm. Other signals would indicate the direction of motion, bad weather and so on (Froc 1908: 101). Seduced by Froc's expertise, the IMO soon took his plan as an opportunity and formed a special commission to deal with a plan that would be the predecessor of the Commission for Maritime Weather Signals first created in London in 1909 (*Report of Proceedings*..., 1909).

Froc's plan was a significant challenge even on a regional scale. Typhoon science represented a geopolitical chessboard with manifold interests at stake. The Hong Kong Observatory (founded in 1882) was a civil agency of a colonial administration, whose metropolis (Britain) epitomised the "cable empire" in the world (MacKeown 2010; Pui-yin 2003; Williamson 2017). This is in stark contrast with the cases of the Philippines and Shanghai, where a religious order—not a civilian agency—led the research and forecasting of typhoons. However, the differences between the observatories in Manila (1865) and Zikawei (1872), run by Spanish and French Jesuits, respectively, were substantial. Firstly, although the two were an arm of Western empires in Asia, the former operated in a colony first under the Spanish Crown and then under American sovereignty, and the latter in a semi-colony under Chinese sovereignty. Secondly, although sovereign, China depended on foreign telecommunications technology (Zhu 2012).

Japan, through the Central Meteorological Observatory in Tokyo (1887), provides an interesting counterpoint to this history. From the 1890s to the 1920s, the Japanese empire established a meteorological system characterised by expansion (not containment), and with a markedly predictive vocation. The meteorological expansion has been often closely intertwined with the construction of modern telecommunications infrastructures. Nowhere was this clearer than in Japan's weather service after its victories in the Sino-Japanese War (1894–1895) and the Russo-Japanese War (1904–1905). The expansion process was bidirectional: With the annexation of

[8] Driven by the needs of standardisation of methods and nomenclature, geophysical sciences and the field sciences generally were out front in organising internationally. See: Stoneley (1970), and Adams (1989).

[9] *Hong Kong Government Gazette*, 22 Dec. 1905; Froc (1909). See also: MacKeown (2010: 187–189).

Taiwan, Japan expanded its weather station network to the south; and with the occupation of Incheon and North Korea, it expanded its nodes and lines to the north, toward Manchuria and Karafuto (Miyagawa 2008, 2015). As an enterprise for producing and controlling imperial natural space, the expansion of Japan's meteorological service was a constituent part of empire-building.

There was one major obstacle to cooperative ventures. Between 1883 and 1907, the founder and first director of the Hong Kong Observatory, William Doberck, virtually rejected any attempt at cooperation with the Jesuit observatories in Zikawei and Manila. His rejection consequently paralysed collaborative activities that involved standardisation of methods and codes, data exchanges and weather forecasts. For example, in 1897, Froc's predecessor at Zikawei, Father Stanislas Chevalier, proposed a gale code of weather telegrams for the Far East (Zhu 2012: 291–292). While it was welcomed in Manila, the Shanghai code was rejected by Doberck on the pretext that the codes regarding winter storms in the north were irrelevant in Hong Kong. But other less tangible reasons lurk behind this pretext of operability. He always held the firm view that the Hong Kong Observatory must preserve its own opinions and the monopoly of issuing weather warnings in the colony.[10] Implementing an extensive British weather observation system based on a single central office (Hong Kong) was the end of colonial power.[11] The idea behind this vision on exclusive sovereignty for the colony was shared by the Hong Kong governor, who approved an alternative solution: a code devised by the Eastern Extension Telegraph Company for forwarding storm warnings issued by the Hong Kong Observatory. With it, coloniality and sovereignty were fused in the language of storm warning systems.[12]

The establishment of IMO's Commission for Maritime Weather Signals in 1909 gave meteorologists in the Far East the opportunity to join an international community of experts who keep regular communication with one another in subsequent meetings. The debates among meteorologists from Zikawei, Hong Kong and Hanoi in between their meetings, opened the "black box" that meant to date the uniformity of codes and signals, and progressively extended their mutual agreements to the other countries, namely, Japan and the Philippines. The venture was so challenging, with advances, setbacks, and tugs-of-war, that detailed minutes were recorded to serve as official evidence from the parties involved. I will examine these

[10] Doberck regarded Hong Kong as the central office and the Jesuit weather services as private, which led him to often disapprove their methods. 'In every country, I said, there must be one central office, to which the observations are telegraphed, and from which the storm-warnings are issued'. Doberck to the Colonial Secretary, 21 April 1897. Public Record Office of Hong Kong, 842, 1/2, No. 67.

[11] This idea was also held by Washington weather authorities, like Cleveland Abbe and Willis Moore. One of Doberck's supporters, Abbe (1899: 160–161) deemed the Jesuit weather service in Manila as a 'voluntary storm-warning service' rather than a national and official service. See also: Zhu (2012: 279–280).

[12] Doberck's aspirations for power were often accompanied by professional jealousy. He could hardly conceal his frustration at the lack of acknowledgement for his being the meteorologist par excellence of the China coast, whereas the observatories in Manila and, especially, Zikawei were lauded for their efficiency, much to his chagrin. Doberck's lack of diplomacy and his thorny relations with the Jesuits have been examined by MacKeown (2010: 95, 173–205; 2004: 5–39).

documents in several steps, which will encompass two long rounds of discussions and exchanges on standardising practices and languages in the 1910s and 1930s. These documents will constitute a fruitful source for analysing the *why* and the *how* of the transnational production of knowledge by meteorologists of the Far East.[13]

## The *Why* of Transnational Co-production of Knowledge

Meteorologists in the Far East showed extraordinary skill in the standardisation and uniformity of codes. This skill was notably reflected in two fields: the codes for weather telegrams and the codes for storm warnings. However, in this unifying intent, while the former was requested by cable and telegraph companies for profitability reasons, the latter was mainly promoted by local chambers of commerce for maritime security reasons. At the same time, the codes for storm warnings could be local and non-local. While the former was boosted and often jealously protected by naval and colonial authorities, the latter was demanded by local chambers of commerce. All this leads us to a highly interesting issue: while standardisation of weather telegrams was co-produced by changing ideas about economic profitability, standardisation of typhoon warnings was co-produced by changing ideas about the social order. Economic and political factors rather than purely scientific reasons not only boosted the efforts of transnational cooperation but also shaped its character.

Transnational cooperation during this period involved two concerns: communication and cognition. Each furthered the standardisation of scientific practices and knowledge in different ways. *Communication* in typhoon science became standardised as codes were drawn up. It stipulated the conditions under which meteorologists could transmit data and weather telegrams from land stations and ships to the central office, and vice versa. These codes were intended for the application of internationally accepted technical standards to ensure telegraphic transmission and operation. *Cognitively*, this implied making storm- warning procedures more uniform, by standardising signals, symbols, and units of notation, languages, and the like. The idea was to bring storm-warning procedures in the countries involved as closely as possible in line with international practice, while addressing local needs at the same time.

a) Codes for Weather Telegrams

The case of the Zikawei's gale code mentioned above clearly shows the potentials and limitations encountered in the early efforts to uniform systems of telegraph

[13] In addition of other materials listed below, the bulk of these exchanges are found in files from the Public Record Office of Hong Kong (hereafter HKRS), including the following repositories: 'Correspondence and Papers relating to the Establishment and Operation of the Royal Hong Kong Observatory', 1882–1912, HKRS 356; 'International Commission for Maritime Meteorology & Storm Warnings', 1912–1936, HKRS 842, 1–19; 'Meteorological Messages and Storm Warnings, 1916–1933', HKRS 842, 1–14; 'Meteorological Messages and Storm Warnings', 'Typhoon Signals', 1927, HKRS 842, 1–22; and 'Maritime Meteorology', 1929-1932, HKRS 842, 1–64.

communication. In 1897, the joint venture of the Great Northern Telegraph Company (GNTC) and the Eastern Extension Company requested Chevalier to devise an abridged gale code of weather telegrams for the Far East. Although Doberck rejected the Shanghai code (for coloniality, sovereignty and monopoly reasons, as was shown), Robert Hart from the CMCS agreed to adopt it in the Chinese customs stations.[14] Shortly thereafter, the observatories in Manila, Tokyo and Taihoku, in Formosa, did the same.[15] Meanwhile, Doberck sought an alternative with the manager of the Eastern Extension in Hong Kong and eventually presented a specific code for the colony.[16]

To understand this commercial involvement well, one must take into account the socioeconomic context of the telegraph companies in China's inter-port mercantile community. In the early 1880s, the Danish GNTC and some harbour masters began to provide weather warnings, partly because of the pressing demand from the local mercantile elite. The deployment of the GNTC along the China Sea greatly facilitated the enterprise, as the stations of Nagasaki, Shanghai, Amoy and Hong Kong formed the hubs of the submarine cables laid by the Danish company.[17] The GNTC sought to 'improve its poor *public relation*' with the elites of these ports, and accordingly decided to transmit news about the weather free of charge.[18] Thanks to its liberal policy of sponsorship, the GNTC was able to sustain an international network of weather-warning exchange for many years without the assistance of the major observatories.[19] Soon other companies such as the Eastern Extension and the Chinese Telegraphic Administration imitated its policy and freely transmitted weather telegrams in East Asia in the 1880s. The free-of-charge policy, however, ceased to be profitable in the late 1890s, leading telegraph companies to request the East Asian meteorologists to reduce the number and length of telegrams by implementing a uniform code.

This standardisation under the pressure of the demands of the telegraph industry is well illustrated in the case of typhoon warnings in the Philippines. Until World War I, the leadership of typhoon science remained, for all intents and purposes, committed to the policies of telegraph companies. Telegraphy added an economic dimension to the typhoon-warning service. At first, many weather offices were resistant, or at least reluctant, to change for fear of compromising efficiency. Nowhere was this more evident than in the Philippine Weather Bureau, whose

[14] 'Storm warnings: Sicawei code to be adopted and used, September 30, 1897', Robert Hart, Circular No.802 of 1897—quoted by Zhu (2012: 293).

[15] *Telegraphic Convention for Transmission of Typhoon and Gale Warnings according to the Zi-Ka-Wei Code* (T'ou-Sè-Wè Orphan Asylum, 1907).

[16] 'Code used by the Eastern Extension Telegraph Company for forwarding storm warnings issued by the Hongkong Observatory', W. Doberck to the Colonial Secretary, 19 Dec. 1897, HKRS 842, 1/2, No. 67.

[17] On the development of telegraphic communications in China from 1860 to 1890, see: Baark (1997); and Ahvenainen (1981: 69–187).

[18] Zhu (2012: 36–37): GNTC's free-of-charge policy 'was unique and unparalleled in other areas suffering from tropical storms around the world'.

[19] In 1883, the GNTC and the Eastern Australia and China Telegraph Company agreed to send weather messages between Hong Kong, Amoy, Foochow, Manila, Nagasaki, Shanghai and Wladiwostock.

typhoon warnings had been always couched in ordinary language (Saderra Masó 1915: 149–150). However, as the introduction of daily weather maps permitted more detailed forecasts, maintaining the same number of words without prejudice to telegraph companies became correspondingly harder. The need for reducing the number of words in telegraphs prompted the general manager of the Eastern Extension to ask the Manila Observatory, in 1907, on adopting a typhoon warning code like Shanghai and Hong Kong.[20] Father José Coronas, the author of the new code, uneasily recognised that these codes did not meet the requirements of Manila because its position was 'different from that of either Hong Kong or Shanghai'. Yet, in compiling the new one, he chose the Hong Kong code for being 'capable of including a greater number of cases' (Coronas 1908: 4). In Manila, new demands on changing economic situations impelled the adoption of Hong Kong codes.

In brief, the prospect of economic saving was a prime incentive for telegraphic standardisation. Meteorologists in the Far East benefited from the free-of-charge policy of major telegraph companies, which reduced the costs of weather telegram transmission.[21] The case with the standardisation of storm-warning codes described below is somewhat different. Here, economic considerations often mingled with political factors, corresponding to the imperialist stances that regarded the weather service as a monopoly of the national central observatory. In such cases, a broad spectrum of motives was interwoven: standardisation could be the prerequisite, as imposed by telegraph companies, for the continued enjoyment of communication infrastructures that transcended the technical capabilities of the nation-state; it could be the effect of the pressure exerted by chambers of commerce for the sake of trade maritime security; but it could also be the outcome of imperial/colonial governments' requirement to ensure local safety and maintenance of public order. Much of this might be termed standardisation for strategic reasons, of which the next section offers good illustrations.

b) Codes for Storm Warnings

From the start, the theme of unity of method and action through cooperation in typhoon prediction was never alien to the commercial world. The cooperation between observatories and inter-port mercantile community began after the Shanghai General Chamber of Commerce established the China Coast Meteorological Service in 1881. The Chamber entrusted the Zikawei Observatory with the task of warning mariners of the weather conditions, specifically during the typhoon

[20] These codes were, respectively, Froc (1905) and Figg (1898).

[21] Observatories saved enormous sums because of the free-of-charge policy. According to the regulations of the cable companies, a service consisted in one having to pay for each word being transmitted. Zwack (1907: xxv) found that the Manila Observatory alone received over 66,000 words per year, all of which passed over the lines of the Eastern Extension, and mostly also over those of the GNTC. Moreover, as it maintained regular communication with Tokyo, Shanghai, Taihoku, Hong Kong, and Phulien, contributing 9,400 words to each, the observatory would have to pay for the 47,000 words.

season.[22] This community was composed of individuals who viewed typhoons as a permanent threat to their activities and businesses, but who, in general, did not pursue research themselves. The leading groups were telegraphic companies, shipping industries and Chinese and English insurance companies. Less numerous were ships' masters and trade houses.[23] Following the mission entrusted, Father Marc Dechevrens devised a semaphore code, which consisted of ten symbols and was used for the daily forecasts he transmitted to ships. His was a flag system of signals—apposite for vessels yet unsuitable to local requirements—which, set on the semaphore poles, was adopted, after some modifications, by all the CMCS's maritime stations (Gauthier 1924: 283–285).[24]

Unlike the "usual" systems applied everywhere, in which gales were reported to seafarers at the exact coastal point where they sailed, the Shanghai warning system, known as the China Coast Code, was a *non-local code*. Local weather conditions were less important than the willingness to prevent the manifold hazards of distant typhoons on the high seas, where the only certainty was loneliness. It was intended to meet the needs of ocean vessels and coasters commanded by certified officers on their trips rather than those of Chinese fishing and trading junks. With officers, however, went a general and detailed forecast issued by Zikawei announcing the position of the cyclone together with the direction followed across the Far East (Haye 1908: 526–528). The "political" implications of this non-local storm-warning code were not lost upon shipmasters and the inter-port mercantile elite, who eventually became party and decision-makers in the promotion of code uniformity. By the late 1890s, members of the elite, through the local chambers of commerce, had begun to pressure the Hong Kong Observatory and the maritime stations dependent on the CMCS into adopting the China Coast Code, which enjoyed great prestige among the mercantile elite. Nevertheless, few were aware that the Zikawei system could only be made internationally systematised in terms of general principles. Different localities required, in principle, different codes.

In contrast to Shanghai, the observatories in Hong Kong and Japan combined *non-local* and *local* systems. Shipmasters and mariners' requirements were as important as the obligation of preventing potential damage caused by cyclones in harbours, where the only safety was advance information. A safety protocol implied, however, an entrenched service of information and warnings of high winds before a cyclone struck—a system of visual and sound signals within an operational matrix determined from the home port. Warning local systems differed from one locality to

[22] I am inspired here by Marlon Zhu's term 'inter-port community', which refers to a common audience shared between Shanghai, Hong Kong, and other minor ports. Its boundary was larger than the sum of the CMCS stations and the two Observatories in Shanghai and Hong Kong. Zhu (2012: 22–23).

[23] Marc Dechevrens to Jules Tailhan, the Procurator of the Kiang-nan Mission, 29 Sept. 1881, Archivum Romanum Societatis Iesu, Rome, SIN 1005, VIII, 12.

[24] The flag system was used on the Shanghai semaphore poles from 1882 until 1904, when they were placed by shapes and symbols. It distinguished gales from typhoons and continental depressions; these were indicated by a two-digit number (based on Marryat's code) for location and further two-digits for probable movement. See: Wen (2004: 429–430) and MacKeown (2010: 187–188).

another.[25] But not only that: they also responded to imperial policies. Local codes that warned of typhoons, gales and depressions went hand in hand with the political ideals of empire in Japan and Britain: security of national infrastructure (ports, telegraph poles and lines, public buildings, etc.), maintenance of public order and prevention of human and material damage. The rule of British law was naturally in harmony with the proper compliance of standard international codes, and, in this regard, the Hong Kong Observatory periodically urged Zikawei and the CMCS stations to adopt those codes.[26]

The political tensions over storm-warning systems came to the fore especially concerning the non-local code in Hong Kong. In 1902, the Hong Kong Chamber of Commerce complained to the colonial government that Doberck usually refused to accept storm warnings from Zikawei and that his prejudices and professional jealousy were affecting the quality standards of the weather service. The Chamber expected Doberck to do his duty. The fulfilment of this duty entailed both the reciprocal exchange of storm warnings with other observatories and the adoption of an effective and complete code of flag signals at the port.[27] Zikawei's system remained as *virtutum speculum*. As a letter from the Chamber to the colonial secretary said, 'it may be useful...to mention that Shanghai possesses a code of signals worked on information supplied by Sicawei Observatory...which is admittedly the best in the Far East' (MacKeown 2010: 184). With this inference came deference and deferral. After hearing the argument of Frederic George Figg, the observatory's acting director, against Zikawei's flag system (according to him, little visible in calm weather, and too complicated for local junks),[28] the colonial government concluded that changing the Hong Kong system was not prudent.[29] However, a subsequent letter of complaint endorsed by thirty-eight shipmasters, together with a report of the Chamber's committee of enquiry, seem to have influenced events, because in 1904 the Government decided to adopt the China Coast Code developed at Zikawei.[30] Changing ideas about maritime security contributed to this decision. The decision spelt a precedent for the primacy of shipmasters' maritime security over scientific rivalry.

[25] From 1884 to 1906, for example, Hong Kong Observatory beat on a black drum and fired a gun to warn of imminent gale-force winds (Wai 2004: 63–71). In Japan, until 1891, when it modified its warning system, the Central Meteorological Observatory in Tokyo used three types of flags (triangular for wind direction, rectangular for the state of the sky, and a pennant for temperature change) (Nakamura 1899: 24–25).

[26] See, e.g., Froc's objections against the adoption of international storm-warning codes, in: Froc to Capt. Eldridge, Coast Inspector, 3 Dec. 1919, 'Hydrographers, Naval Officials, Shipping, Merchants, Meteorological, etc.', Second Historical Archives of China (hereafter SHAC) 679 (1) 761; Froc to Capt. Hillman, Coast Inspector, 26 Feb. 1926, Ibid., SHAC (1) 765.

[27] Doberck established the first non-local storm-warning system in 1884 by using visual signals in the form of a red drum, cone and ball. Wai (2004: 68–70) and Lui, Lee and Shun (2018: 3–4).

[28] While the Hong Kong signal system distinguished only four quarters, the China Coast Code recognised eight compass directions. MacKeown (2010: 186–189), and Table A in Lui, Lee and Shun (2018: 59).

[29] See: F.H. May, the colonial secretary, to the Chamber of Commerce, *Hong Kong Telegraph*, 2 Sept. and 7 Oct. 1902.

[30] *Hong Kong Telegraph*, 30 Jan. 1903.

The China Coast Code, advocated by the Chamber of Commerce, made the Hong Kong Observatory realise that uniformity was compulsory to compete in the Far East's scientific arena. Enforcement policy, however, gradually changed with the "consensus atmosphere" created in the IMO in the mid-1900s and the 1910s. The consensus was then welcomed in the Far East, if only because it would enable East Asian observatories to proceed in any event by using common standards. This is profoundly related to the IMO's internationalist context in those years. The extension of the China Coast Code was approved in Zikawei in the year of the first conference of weather services of the Far East, which was held in Tokyo in 1913, after which many of their directors accepted, partially or wholly, the new code and discussed its desirability for the region. After all, an important portion of the international meteorological meetings at that time was devoted to setting standards for various commissions and nation-states. Inasmuch as reaching agreement required intense negotiations on substantive aspects, code uniformity was a history of consensus and dissension. In time, directors in East Asian weather services would come to view matters in this way.

## The *How* of Transnational Co-production of Knowledge

The successor of the China Coast Code, the so-called China Seas Storm Signal Code, was the dominant code system in the interwar years. It was adopted, after tortuous negotiations, at Zikawei in 1913 and then in Hanoi and CMCS stations. Although reluctant at first, the Hong Kong Observatory adopted it in 1920. The weather services in Japan and the Philippines partially did in the 1930s. This section will show how standardised knowledge was co-constructed in a multipolar field of negotiations, power struggles, and colonial/non-colonial powers under an ideological backdrop of scientific internationalism—based on ideals such as uniformity, simplicity and universality.

The operative terms in this new stage of standardised meteorology were simplicity, universalism and cooperation. Although their application could take various forms, the words had scientifically internationalist, even ideological, connotations. At a time when national rivalry and competition were *in crescendo*, internationalist imagery drew increasingly upon metaphors of fraternity, especially those associated with the universalism and utilitarianism of science. Partly to counter the national power struggles in the organisation of maritime meteorology, apologists for internationalism offered an alternative: a more harmonious plan of a coordinated system of storm-signal codes, whose consensual implementation would give participating countries the chance to compromise local and non-local codes. Examples of this plan can be found in the first meetings of the commission for Maritime Weather Signals held in London (1909) and Berlin (1910), where changes in the warning codes used in Europe and the Far East (Japan) were discussed.[31] These first meetings served as the basis for more ambitious plans. Thus, in the London meeting in 1912, the British Meteorological Office was requested to issue the report *Summary of Maritime Weather Signals in use in the various countries of the globe* each year, and that the summary be divided into two sections, one for local and the other for non-local signals (*Report of Proceedings* … 1912).

All these measures might have been to untangle the various chaotic systems for transmitting weather-related signals, but they also brought the notion of scientific internationalism to the Far East. Perhaps the most influential and eloquent advocate of this internationalism in the Far East was Louis Froc, director of Zikawei for thirty-six years, from 1896 to 1932 (†) (Gauthier 1932). For Froc, the need for globalised standards in maritime weather signals, a topic widely discussed in meetings at the IMO commission, precisely paralleled the challenge of securing a viable and unified cyclone-warning code in the Far East. Hence, he had no qualms about the claims in the London meeting (1912) that 'nowhere, except in the Far East, is there practical means to indicate by universally adopted symbols the position and course of cyclones'.[32] Well-founded fears by chambers of commerce as regards the journeys of sea-going vessels, together with fears of the resurgence of rivalry with Hong Kong, fuelled Froc's interest in championing the doctrine of *simplicity and uniformity* (his preferred mottos) and, if at all possible, remaining in Zikawei hands.[33]

Whether personal or institutional, the bonds of transnational cooperation were tightened by the tragedy of the 1906 typhoon in Hong Kong, when national rivalry and phobias were set aside for the sake of the citizens' welfare. The storm not only left a trail of death and destruction, it also ushered what an editorial in the *Hong Kong Daily Press* called 'an exhaustive enquiry', or a formal enquiry 'touching the whole conduct' of the Hong Kong Observatory and its relations with other stations in Manila and Shanghai (Wai 2004: 23).[34] The committee of the enquiry concluded, in a report issued one month after the misfortune, that before the impact there was no indication of the typhoon approaching the bay. Manila and Zikawei were not public enemies, went the committee's argument; henceforth, it was necessary to take a different path, not one of competition and mistrust, but rather one that promoted transnational cooperation, a relationship that was the opposite of what had been done until then. Exchange of weather information and typhoon warnings was essential. Moreover, weather science was a field for standardised knowledge.

[31] One of the four resolutions in Berlin was the 'adoption of an international system of five storm signals by day and five by night, with red and white lanterns'. See: Cannegieter (1963: 39); and *Report of proceedings…* (1909).

[32] 'Appendix VII. Non-Local Storm Signals. Proposal of the Rev. L. Froc, Zi-ka-wei'. In: *Report of Proceedings* (London, 1912), 16 –17, on p. 17.

[33] Championing the cause of simplicity and uniformity, Froc participated in the London meeting of 1909, where he proposed to establish semaphores at least in tropical countries, to signal to the steamers the position and motion of the centres of cyclones. The proposal was accepted in the London meeting of 1912.

[34] For a detailed account of Hong Kong newspapers news on the typhoon of 18 September 1906 and their attacks against Doberck's forecasting methods, see: Zhu (2012: 288–300).

The report implicitly conveyed the need for observatories in the Far East to face the challenge of adopting unified warning codes and improving warning signals. The message caught on in Hong Kong, and with it came steps for cooperation and code standardisation.[35]

For a perspective on this new stage of cooperation, it is useful to examine the first Conference of the Directors of the Weather Services of the Far East held in Tokyo in 1913. In a letter before the event, its organiser Kiyoo Nakamura lamented to Thomas F. Claxton, director of the Hong Kong Observatory, that the weather telegrams which the East Asian services were exchanging with one another lacked uniformity, 'both as regards the form and the code employed'. Such inconsistencies, he added, 'have caused many errors, delayed transmission, and thus greatly reduced the value of telegrams'. Not only that; 'the want of uniformity also in storm-signals is a source of much confusion to sea-faring men'.[36] The conference was intended to discuss such problems. Bruno Meyermann from the Tingtau Observatory proposed the unification of storm-signals in the Far East.[37] On the contrary, Fr. José Algué, director of the Manila Observatory, declined Nakamura's invitation for finding the event unnecessary.[38] Although the aims were ambitious in a way that they aspired to unify both telegraphic codes and storm signals, the conference had no policy-making power. Devoid of government representatives, its role was merely advisory.

By 1914, the deliberations and practices of informal and formal exchange of views that had taken place before and during the Tokyo Conference gave way to a new phase of transnational cooperation in Zikawei, Hong Kong, Hanoi and the CMCS, in which the language of *simplicity* and *economy* became the dominant tongue.[39] Cooperation, however, meant different things to the participants involved: Transnational cooperation between empires and coastal colonies was an option; but there was also cooperation within the Chinese empire, with Zikawei and the CMCS at the helm. Those who promoted unified weather codes tested both alternatives and carefully moved in each. In 1912, Froc spoke to Claxton of the need for simpler and more complete storm signals for shipmasters, and suggested a system that provided sixteen-point compass directions instead of the earlier eight-point.[40] Less personal in the forms, but no less warmly received, was the memorandum prepared by Captain W.F. Tyler, coast inspector at the Maritime Customs in Shanghai; with Froc's help, Tyler proposed a new non-local storm-signal code for the region in 1914.[41] He submitted the scheme to several weather services in the Far East for their consideration.

[35] After Doberck's retirement in September 1907, F.G. Figg took over and, at the request of the Hong Kong government, visited Manila Observatory in 1909. Wai (2004: 23–25).

[36] Nakamura to Claxton, 4 Nov. 1912. HKRS, 356-1-3. See also Claxton to Nakamura, Ibid.

[37] 'Dr. B. Meyermann's proposals'. *Report of Proceedings of the Conference of the Directors of the Weather Services of the Far East*. [Tokyo]: [Central Meteorological Observatory of Japan], [1913], p. 44.

[38] K. Nakamura, 'Introductory', Ibid., p. 5.

[39] Notable examples of cooperation can be found in Nakamura to Claxton, Tokyo, 28 March 1912; Froc to Claxton, Zikawei, 3 Mai 1912; Selga to Claxton, Manila, 15 Aug. 1912; HKRS, 356-1-3.

[40] Froc to Claxton, Zikawei, 3 Mai 1912, HKRS, 356-1-3.

[41] Tyler to Froc, Shanghai, 25 March 1914, HKRS, 356-1-2(2). It includes: 'Append: Memorandum concerning proposed storm signal code on the coordinate system'.

Claxton regarded it as a 'considerable improvement on the China Coast Code', which could be used in Hong Kong, provided that the 'modifications suggested below' were addressed.[42] Tyler's scheme represented a step forward. The China Coast Code provided only the cyclone position and its direction of motion, whereas the new code also gave its speed and intensity. It also involved the use of ten symbols instead of the usual six. Positions were indicated by the latitude and longitude of the centre of a circle of a specified radius within which the eye of the typhoon lay. For Froc, the new code had the 'advantage of simplicity and economy'. The code, according to him, 'is most likely to be adopted outside the Far East and become a truly universal method'.[43] For Froc, therefore, typhoon science provided a paragon of unity for the Far East, and a tantalising paradigm for epistemic universalism.

However, prewar exciting optimism was deadened by tedious technical debates among meteorologists in Hong Kong and those in Zikawei and Hanoi. The question of what information the code should give and the method of signalling it became battle horse. The code proposed by Tyler and Froc contained four 'radius signals', roughly indicating the degree of accuracy with which the centre of the cyclone was located, while Claxton countered that using 'velocity signals' as 'radius signals' was not often accurate enough to convey a position. Henry Gauthier from Zikawei radically opposed the use of a velocity signal, and left the decision to Georges Le Cadet from Hanoi. Yet, Le Cadet had promised to adopt all of Zikawei's suggestions on the matter.[44] Additionally, claims of primogeniture and merit addled the debates. Tyler's letters gave the impression that he and Froc came up with the idea of signalling the position of typhoons by latitude and longitude. Yet, Claxton claimed that 'it was one of the first things that occurred to me upon arrival in Hong Kong' in 1911.[45] By 1917, the consensual code envisioned in the Tokyo conference had been overshadowed by a gloomy landscape of discrepancies, conflicting egos and one-sidedness that the incipient culture of transnational science was unable to illuminate.

Indeed, this gloomy atmosphere invaded everything. Hong Kong prepared its own code, and while acknowledging the resolutions from the Tokyo conference as true ideals of uniformity and universalism, it preferred a different path. In 1917, Hong Kong introduced a new non-local code superseding the China Coast Code and the Hong Kong Telegraphic Code (in use from the early 1910s), as well as a new local warning system that allowed, by wireless telegraphy, some room for manoeuvre before the local gales arrived.[46] By doing so, Hong Kong regained and ensured

[42] 'Memorandum by the Director of the Royal Observatory, Hong Kong, on a new non-local storm signal code proposed by the Coast Inspector of the Chinese Maritime Customs', 24 June 1916. HKRS, 356-1-2(2).

[43] Froc to Tyler, Zikawei, 25 March 1914, HKRS, 356-1-2(2).

[44] 'Report on the negotiations for the adoption of a uniform non-local storm warning code for Shanghai, Hong Kong and Hanoi', Claxton. 21 Dec. 1916. HKRS, 356-1-2(2).

[45] 'Remarks by the Director of the Royal Observatory of Hong Kong, on Captain Tyler's letters of July 7 and July 10, 1917", 7 and 10 July 1917. HKRS, 356-1-2(2).

[46] 'Memorandum on a Proposed New Non-Local Storm Warning Code for Hong Kong', by Claxton, 17 April 1917. HKRS, 356-1-2(2); and 'Additional Memorandum', 18 May 1917. Ibid. See also Lui, Lee and Shun, 'Evolution', pp. 5–6; Wai, 'Tropical Cyclone', pp. 25–28.

colonial power on both local and non-local codes. Manila declined to change its storm-signal code and Japan adopted a new one without reference to the other observatories. Thus, Japan followed Hong Kong's conduct. For their part, the observatories of Zikawei and Hanoi and the CMCS stations strengthened bonds of transnational co-production without compromising their commitment to the Far East. Zikawei continued using the China Seas Storm Signal Code and other East Asian Coastal ports joined in 1918. 'The only hope I can see for uniformity', Claxton averred in 1917, 'is for one service to adopt a national code, and meet those who are seriously striving at uniformity to adopt it'.[47]

Against this bleak picture, the image of uniformity championed by advocates of international science seemed more and more unviable and hardly achievable. However, Hong Kong's stance unexpectedly changed sometime in 1920 for socioeconomic rather than scientific reasons. As the nature of maritime meteorology changed with the postwar rise of wireless telegraphy and transoceanic trade, the metaphors of fraternity used to promote transnational cooperation came again onto the scene. In a context of calls for meteorological modernization, the Hong Kong Chamber of Commerce urged the colonial government to boost funding to the Observatory, so that its director could 'issue more frequent weather reports, particularly in the typhoon seasons, on the lines of those issued by Manila and Zi Ka Wei'.[48] The adoption of the China Seas Storm Signal Code reflected the close ties between power and knowledge. Once again, like in 1906, changing ideas about collaboration versus competition impelled code standardisation. In hindsight, Tyler's 1916 words sound prophetic when he warned Claxton that if Hong Kong rejected Zikawei's proposals, Hanoi and Zikawei would adopt the code, and Hong Kong would be 'forced by public opinion to adopt it later on'.[49] The significance of a national system of storm-signal codes diminished next to the increasing demands for uniformity from the prosperous and vibrant Far East with interwoven interests.

Over the 1920s, the evocation of transnational cooperation grew more urgent. Meteorologists and advocates of scientific internationalism equally deemed standardised knowledge as desired and desirable. However, desires were almost always confused with reality. Speaking to the audience of the Pacific Science Congress, held in Java in 1929, Claxton recalled that only a few countries had unified codes, and that not much was done about the situation. Uniformity was desirable in codes used for telegraphic transmissions and storm warnings, as well as in the Greenwich Mean Time at which observations were made.[50] According to him, 'uniformity is desirable, but impossible to achieve, as some Bureaus are able to give more detailed storm warnings than others and so require a more detailed scheme of storm signals' (Claxton 1930: 926). For uniformity to be reached, the stimulus of another

[47] Claxton, 'Remarks', Ibid.

[48] The request was made in 1921 by the future chairman of the Chamber of Commerce and member of the Legislative Council of Hong Kong: 'The Chamber of Commerce, and the shipping and general community have a strong feeling that [the Observatory] needs expansion'. Quoted by Wai (2006: 36).

[49] 'Report on the negotiations', Ibid.

[50] For instance, it was the case that some ships kept three different meteorological logs for three different weather bureaus.

East Asian congress was required. Thus, a new phase entered for transnational co-production of storm warning codes when the conference of directors of Far Eastern weather services convened in Hong Kong in 1930.[51] At this stage, their interests united with chambers of commerce's interests, reassuming the mottos of simplicity and economy of bygone days.

To understand better this transition, it is useful to look at a previous event, the Conference of British Empire Meteorologists of 1929 in London. In this event, Claxton presented the laudable, if rather optimistic, proposal of devising a uniform code of storm warning signals for the whole world. Yet, as agreement could not be reached for the British Empire, he instead suggested organising a conference of meteorologists from the Far East, in the hope that uniformity could be attained in that region, where conditions were, to a certain extent, uniform. Its aim would be, therefore, the adoption in the Far East of uniform codes for storm warnings and the transmission of daily weather reports by cable.[52] Shortly afterwards, the International Conference of Directors of Weather Services held in Copenhagen approved his idea (Cannegieter 1963: 68–69). The British imperial science pushed for a new momentum of cooperation, where the Hong Kong Observatory played an especially active part.

In 1930, the Hong Kong conference of directors brought together representatives from the Philippines, Indochina and China (including Zikawei, Nanking, Pratas and Tsingtao), and received full backing from Malaysia and the CMCS. The attendant directors and invited shipmasters embodied an affable, highly productive 'transnational enterprise', promoting a good number of discussions and recommendations. Claxon, following the resolutions adopted in Copenhagen, facilitated the discussions. The 'non-local code' and 'local code' became the target of debates. By the end of the conference, the representatives had agreed that the China Seas Storm Signal Code and the Hong Kong Code, as revised by Claxton and amended at the conference, be adopted as the non-local and local codes, respectively, in the Far East.[53]

If the Tokyo conference proved premonitory and that in Hong Kong recommendatory, subsequent meetings were bilateral. Informal communications increased among Far Eastern weather services, especially between Hong Kong and Manila, and particularly in the field of storm-warning procedures, as the Philippines stood as guard against typhoons approaching Hong Kong. Manila and Hong Kong sought opportunities of improving their local signal systems for mutual benefit, following the resolutions adopted in the 1930 conference. As Algué's successor, Fr. Miguel Selga, noted in this conference, the agreement was both necessary and complicated: the Hong Kong Local Code could well meet the needs of Hong Kong and Shanghai—two seaports of great importance but with small area of hinterland under their jurisdiction—but was 'insufficient' for the marine and agricultural needs of the

[51] *Conference of Directors of Far Eastern Weather Services. Report of Proceedings with Appendices and List of Delegates* (Hong Kong: The Royal Observatory, 1930).

[52] Conference of Directors of Far Eastern Weather Services (1930: 1–7).

[53] 'Resolutions Adopted at the Hong Kong Meteorological Conference, 1930', in *Conference of Directors* (1930: 58–60).

Philippines.[54] Several meetings between the Observatory and the Weather Bureau were held in this regard. Among the most significant was the conference on storm-warning procedures held in Manila in 1934. This initiative engendered revisions of the local storm code in 1935, whereby a uniform code containing four international symbols was adopted in the two places (Starbuck 1951: 31).[55]

In retrospect, these resolutions were significant not so much for what was said as for what was legally binding. Political commitments of these recommendations were glossed over; this was a meeting of scientists, not of government representatives, let alone an intergovernmental summit of national weather services. Hand in hand with this acknowledgement of voluntarist internationalism went the certainty that the attendant directors were at liberty to accept or refuse resolutions. Consistent with a time characterised by the rhetorical calls for international science, there was no political demand, no mention of legal enforcement of standards or, for that matter, of warning codes. Nowhere this freedom of action was clearer than in the local signal code revised in 1931 following the resolutions from the 1930 Conference. Thus, the code was extended to ten signals, even if signal number four was used in the Philippines, but not in Hong Kong (Lui et al. 2018: 6).[56] As it turned out, all these resolutions were non-binding and non-mandatory. All were subject to the whims and preferences of a central power. It was the government, with the advice of the chambers of commerce, that decided whether it was willing to adopt a new code or continue to use one that, though safe, did not meet international standards. This was to be the most important contradiction, and the permanent paradox, confronting typhoon science and meteorology generally in the interwar years.

After World War II, the new meteorological organisation born as a specialised agency of the United Nations pursued interests that were not often in line with those of the IMO. In conformity with the UN rules of membership, the newly founded World Meteorological Convention could only be represented by ‘sovereign states’, which excluded not only divided states such as Germany—the goal of the discriminatory criterion—but also colonial territories and stateless nations.[57] Inevitably, the spirit of the UN brought with it what Clark Miller has described as a new world view: the ‘new vocabulary of “States” instead of “countries” superimposed a *geo-political* imagination of the world over the *geographical* imagination that had previously organized meteorological activities’ (Miller 2001, quoted by Edwards 2006: 236). Thereafter, it would be these more geopolitical, less geographical frameworks that were to force their way into postwar international meteorological cooperation,

[54] ‘Minutes of Proceedings’, in *Conference of Directors* (1930: 16).

[55] *Hong Kong Storm Signals. The Local and Non-Local Codes With Notes on Their History and Significance, and Map of the Far East* (Hong Kong: Hong Kong Prison, Stanley, 1938).

[56] *Annual Report of the Director of the Royal Observatory, Hong Kong, for the year 1930* (Hong Kong: Noronha & Co., 1931).

[57] The Conference on Storm Warning Procedures held in Manila in 1949, with the aim of bringing into line with international standards the practices of the various weather services, narrowly escaped this criterion. The conference was convened under the IMO. The World Meteorological Convention entered into force in 1950, and the World Meteorological Organisation (WMO) superseded the IMO in 1951. See: Cannegieter (1963: 95–116); Daniel (1973: 25–30).

relegating efforts of voluntarist internationalism to a subsidiary role and treating the questions of codes and standardised practices from a quasiobligatory globalism (Edwards 2006: 235–239).

## Conclusion

In the historiography of knowledge production, two questions have received little attention: Why were scientists from various disciplinary communities and nation-states devoted to the standardisation of instruments, observations and codes? And how was this process conducted? Both questions are closely tied to the rise of scientific internationalism in both the age of nationalism and contexts of coloniality. This paper has addressed both questions.

The *why* required an approach of network that engaged interconnected nodes of observatories, mercantile communities, and their motivations. The *how* was discussed by describing the processes of transnational cooperation in the standardisation of storm warnings as a result of negotiations, power struggles, and colonial/non-colonial powers under the ideological backdrop of scientific internationalism which increasingly gained importance throughout the interwar years.

Consensus—or the disposition to share a general agreement or idea by all—brought the directors of the Far Eastern observatories together in storm warning codes. They unanimously agreed on the need for uniform signal codes in all corners of the Far East. This consensus atmosphere was reached only in the late 1900s and the 1910s, under the IMO's umbrella, after a phase of enforcement policy and, especially in the 1930s, when the reluctance and fears of the previous World War began to dwindle. However, the cooperative impetus encouraged by consensus intertwined with a competitive impetus spurred by institutional and personal rivalries. Directors soon realised that the ideal solution was to propose a code to the weather services for their consideration, and, once met, draw up non-binding resolutions in conferences, always bearing in mind that codes could be arbitrarily changed for local reasons. The Far Eastern directors chose this path at the Tokyo Conference of 1913. They fully agreed on the end (uniform codes), but not on the means, let alone the ways to implement them. The directors aspired to a standardised code at the 1930 conference. Yet the non-binding nature of the resolutions they were adopting stymied their aspirations. This principle of consensus (on end rather than means) is core to answering the *how* of the co-production of standardised knowledge.

Directors from the Far East were unanimous on the need to draw up uniform codes and rules. Behind this unanimity were ideals of scientific internationalism, which shifted from prewar simplicity and uniformity to wartime simplicity and economy and then postwar uniformity, fraternity and cooperation. Where they differed was in the means to reach this end and how they were to be implemented. Behind these discrepancies were the divergent interests between colonial and non colonial powers. Hong Kong's meteorologists and political governors aimed at erecting a British meteorological observation system centred on the colony and based on sovereignty and control. This authority comprised the monopoly of issuing storm warnings and drawing up especially local (more than non-local) codes on the basis that Hong Kong was an exclusive and distinctive territory. Japan shared similar aspirations—albeit as an imperial (rather than colonial) power. In Manila, the Jesuits, who ran the colonial weather bureau, were zealous to uphold their own local codes, especially for the sake of the archipelago's marine and agricultural interests. Although sharing concerns, colonial powers' interests differed from those of non-colonial ones. Unlike those from Manila, the Jesuits from Zikawei ran the meteorological service of an inter-port mercantile community (not a colonial power), in which the Shanghai Chamber of Commerce sought maritime security and trade profitability by promoting the standardisation of non-local storm-warning codes. Their zeal was directed at non local, rather than local, warning systems.

The distinction between the *why* and the *how* is an analytical tool that cannot hide the ideological backdrop of scientific internationalism behind knowledge co-production. As experts in typhoons (a phenomenon of transnational scope), they promoted cross-national relations, whether through individuals, national weather services and colonial agencies, in pursuit of certain ideals, such as uniformity, simplicity and universality. These modes of engagement were also an ideological expression of their professional, yet voluntarist, internationalism. Whether in Tokyo or Hong Kong, they organised international meetings to address needs and demands that transcended nation-states, regardless of the non-binding nature of the resolutions approved. Unlike the WMO's institutionalised internationalism, which sought involvement from governments, the Far Eastern experts established connections with one another regardless of interstate relations (Geyer and Paulmann 2001: 1–25). Eventually, they contributed to denationalise—rather than internationalise—science by trans-nationalising international relations.

The adoption, first, of the China Coast Code and, then the China Seas Storm Signal Code served that purpose. The Hong Kong Observatory had at first rejected both systems for scientific and nationalistic reasons, later accepted them by the Chamber of Commerce's requirement, and eventually ended up recommending their uniform application across the Far East. Sharing the same threat of typhoons was not a sufficient condition for all the nation-states in the region to promote international science. Indeed, such standardisation of knowledge would not have been possible had there been no economic and political factors fuelling, if not impelling, international scientific collaboration.

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