Asian Extremes: Experience, Exchange and Meteorological Knowledge in Hong Kong and Singapore c.1840-1939

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Introduction

On 29 July 1939, the aircraft carrier HMS Eagle was off the northern entrance of the Formosa Strait, approximately 25°N, 121°E. The ship's meteorological officer was formulating the current synoptic weather situation, which included a typhoon to the south or south-east of Formosa with a second typhoon much further east in about 144°E. It might be expected that in 1939, the existence and position of a typhoon could be corroborated easily by contemporary 'experts' situated nearby. However 'The utmost confusion prevailed' noted the officer 'among the experts at Zikawei, Manila & Hong Kong today …I think there is no doubt that a typhoon reached Formosa … this was also confirmed by Zikawei's signals, but Manila gave it a position much further East while Hong Kong stoutly maintained that there were no typhoons on the map at all'.[1] The level of bewilderment over such a significant event may seem surprising to our modern eyes but this would not be considered unusual to anyone who had studied the correspondence of the above mentioned observatories for the early twentieth century. Confusion, mediocre communication channels and, on occasion, outright antipathy, limited what might otherwise have been a profitable and progressive relationship between meteorological services. This is explained by the history of the development of meteorology in the Asia-Pacific region.

[1] UK National Meteorological Archive (hereafter NMA), E17, Meteorological Logbook of the HMS Eagle, 29 July 1939.

Pertinent to understanding this story has been the reframing of the science within the historiography to reveal its regional and global heritage, with emphasis placed on how the circulation of knowledge across time and space led to scientific evolution and discovery.[2] This should be allied in this instance with the concept of an 'imperial meteorology'.[3] The imperial framework creates a permeable space for the transfer of knowledge at the same time as providing the resources and contexts for its development.[4] In the imperial colonies (not just of Britain but the German, French, Dutch and Japanese empires especially), concern over desiccation – localised climate change induced by man's impact on the environment – was a significant contributing factor toward increasing investment in meteorological research.[5] Colonial officers engaged in fields as seemingly diverse as forestry, medicine, and engineering believed in the importance of improving and increasing observations of rainfall and temperature to better understand the phenomena. This investment was made possible by technological innovation. Key here were the widespread installation of underwater telegraph cable from the 1850s,[6] improvements in the accuracy and precision of observational instruments, and standardisation in observational practice and reporting.[7] Crucial here were the

[2] See for example: Brett M. Bennett & Joseph M. Hodge, eds, *Science and Empire: Knowledge and Networks of Science across the British Empire, 1800-1970* (London: Palgrave MacMillan, 2011); D. N. Livingstone and C. W. J. Withers, 'Thinking Geographically about Nineteenth-Century Science' in D. N. Livingstone and C. W. J. Withers, *Geographies of Nineteenth-Century Science* (Chicago: Chicago University Press, 2011), 1-20; Lissa Roberts, 'Situating Science in Global History: Local Exchanges and Networks of Circulation', *Itinerario* 33 (2009): 19-30; Simon Naylor, 'Introduction: historical geographies of science – places, contexts, cartographies', *British Journal for the History of Science* 38:1 (2005): 1-12; D. N Livingstone, *Putting Science in its Place: Geographies of Scientific Knowledge* (Chicago: Chicago University Press, 2003).

[3] M. Mahony, 'For an Empire of 'all types of climate': meteorology as an imperial science', *Journal of Historical Geography* 51 (2016): 29-39; M. Zaiki and T. Tsukahara, 'Meteorology on the Southern Frontier of Japan's Empire: Ogasawara Kazuo at Taihoku Imperial University', East Asian Science, Technology and Society: and International Journal 1:2 (2007): 183-203

[4] J. McAleer, "Stargazers at the World's End: Telescopes, Observatories, and 'Views' of Empire in the Nineteenth Century British Empire", *British Journal for the History of Science* 46:3 (2011): 389-413; David Aubin, Charlotte Bigg and H. Otto Sibum, eds, *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture* (Durham, NC: Duke University Press, 2010); G. A. Good, 'A Shift of View: Meteorology in John Herschel's Terrestrial Physics' in J. R. Fleming, V. Jankovic & D. R. Coen, eds, *Intimate Universality: Local and Global Themes in the History of Weather and Climate* (Mass.,: Science History Publications, 2006), pp. 35-67; S. M. Razaullah Ansari, 'Early Modern Observatories in India, 1792-1900' in Chattopadhyaya, ed., *History of Science,* pp. 349-380: Brian Warner, *Royal Observatory, Cape Town, 1820–1831: The Founding of a Colonial Observatory* (Dordrecht: Kluwer Academic Publishers, 1995).

[5] For more on desiccation see: Gregory Barton, 'Empire Forestry and the Origins of Environmentalism', Journal of Historical Geography 27, no. 4 (2001): 529-552 or Richard Grove, *Green Imperialism: Colonial Expansion, tropical island Edens and the origins of environmentalism, 1600-1860* (Cambridge: Cambridge University Press, 1995).

[6] Katherine Anderson, *Predicting the Weather: Victorians and the Science of Meteorology* (Chicago: The University of Chicago Press, 2005), p. 1.

[7] See M. F. Maury, *Explanations and Sailing Directions to Accompany the Wind and Current Charts, 7th Ed.* (Philadelphia: E. C. & J. Biddle, 1855), Chap. XX 'Maritime Conference Held at Brussels for Devising a Uniform System of Meteorological Observations at Sea; 1853'; V. Janković, *Reading the Skies: A Cultural History of English Weather, 1650-1820* (Manchester: Manchester University Press, 2000), p. 157.

adoption of Francis Beaufort's wind force scale, Luke Howard's classification system for clouds, and Henry Piddington's standardised vocabulary for storms across the British Empire.[8]

Whilst attention has been drawn to the story of meteorology in the China Seas region,[9] and British meteorology and British imperial meteorology in this period,[10] meteorology in Britain's overseas colonies in Hong Kong and Singapore has been less considered. Notable exceptions include Kevin MacKeown, Ho Pui-Yin and Wai Man-Kui's work on the Hong Kong Observatory and typhoon forecasting respectively.[11] All three scholars drew attention to the role of typhoons in advancing meteorological research, especially the critical necessity of improving the storm warning system and, later, to produce more accurate weather forecasts. For the cities of Hong Kong and Singapore a typhoon (Hong Kong) or a flood (Singapore), could result in disaster, destroying the lives of local inhabitants and/or the livelihoods of maritime traders, shipping companies and fishing industry upon which the ports depended economically. The main task of the early weather watchers then was to study and improve their knowledge of extreme weather systems and to provide advance storm warnings. This was achieved through a combination of techniques, including collating barometric observations across as wide an area as possible (terrestrial and marine) and by communicating news of approaching storms from regional registering stations, observatories and nearby ships. Key to the success of the latter was the effectiveness of communications. The laying of electric telegraph across the mid-to-late nineteenth century played a major role here, making possible the rapid transmission of news across the meteorological hubs of the Philippines, Japan, China,

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[8] H. Piddington, *The Sailor's Horn-Book for the Law of Storms* (1848); W. Reid, *An Attempt to Develop the Law of Storms by Means of Facts* (1838).

[9] Robert Bickers, "'Throwing Light on Natural Laws": Meteorology on the China Coast, 1869-1912' in Robert Bickers and Isabella Jackson, eds, *Treaty Ports in Modern China: Law, Land and Power* (Routledge, 2016), pp. 179-200; Gregory T Cushman, 'The Imperial Politics of Hurricane Prediction: From Calcutta to Manila and Galveston, 1839-1900' in Erika Marie Bsumek, David Kinkela, and Mark Atwood Lawrence, *Nation-States and the Global Environment: New Approaches to International Environmental History* (Oxford Scholarhsip Online, 2013); James F. Warren, 'Weather, History and Empire: The Typhoon Factor and the Manila Galleon Trade, 1565-1815' in Geoff Wade and Li Tana, eds, *Anthony Reid and the Study of the Southeast Asian Past* (Singapore: ISEAS, 2012), pp. 183-220; James F. Warren, 'Scientific Superman: Father Jose Algue, Jesuit meteorology, and the Philippines under American Rule, 1897-1924' in A. W. McCoy and F. A. Scarano, eds, *Colonial Crucible: Empire in the Making of the Modern American State* (Wisconsin: The University of Wisconsin Press, 2009), pp. 508-519; A. Udías, *Searching the Heavens and the Earth: The History of Jesuit Observatories* (Dordrecht/Boston/London: Kluwer Academic Publishers, 2003); Lewis Pyenson, *Civilizing Mission: Exact Sciences and Overseas French Expansion, 1830-1940* (Baltimore and London: John Hopkins University Press, 1993).

[10] See, for example, Mahony, "For an Empire of 'all types of climate'; P. Moore, *The Weather Experiment: The Pioneers who Sought to See the Future* (London: Vintage, 2015); McAleer, "Stargazers at the World's End; Aubin, Bigg and Sibum, eds, *The Heavens on Earth;* J. Golinski, *British Weather and the Climate of Enlightenment* (Chicago: Chicago University Press, 2007): Anderson, *Predicting the Weather;* R. Hamblyn, *The Invention of Clouds: How an Amateur Meteorologist Forged the Language of the Skies* (London: Picador, 2001); Janković, *Reading the Skies*.

[11] See P. Kevin MacKeown, *Early China Coast Meteorology: The Role of Hong Kong* (Hong Kong: Hong Kong University Press, 2011); Wai Man-Kui, 'The Early Tropical Cyclone Warning Systems in Hong Kong, 1841-1899', Hong Kong Meteorological Society Bulletin»14:1:2 (2004): 49-81; Pui-yin Ho, *Weathering the Storm: Hong Kong Observatory and Social Development* (Hong Kong University Press, 2003).

Hong Kong, and Malaya. After 1915, radio telegraphy was used to communicate between shipping and the mainland in Hong Kong.

Nevertheless, as Jan Golinski reminds us, the history of meteorology was not a linear or clear-cut progression; caution should be applied in conceptualising it within a developmental teleological framework.[12] Certainly, the proliferation of conflicting scientific theories would dog would-be meteorologists throughout the nineteenth century. The many different explanations for cyclonic storms for example – especially pertinent to the China Seas – caused decades of debate.[13] The collation of a global observational record – one of the main means of studying the weather before 1900 – was problematized by a lack of consistency. This was due to a scarcity of registering stations, especially outside of urban areas; short operating periods of only a few years in some cases before they were abandoned, and problems of communicating the observations themselves. The revolutionary telegraph, for example, was plagued with problems, malfunctioning or being abandoned due to political unrest, limited or poor maintenance, cost, and with some irony, even bad weather. As MacKeown also rightly points out, the contentious personalities of the observatory directors – especially the long-standing William Doberck in Hong Kong – also limited the possibilities of progressive research between countries.

This paper seeks therefore to accomplish four interconnected aims. First, to consider the development of meteorological services in British Hong Kong, and to a lesser extent Singapore, to highlight a lesser known aspect of the story of nineteenth and early twentieth century colonial meteorological science. Second, to draw attention to the region's extreme weather as a unique factor which differentiated imperial science in the colonies from meteorology in Britain. The weather provided a catalyst for investment in regional research ultimately critical to understanding global drivers in the evolution of meteorological science. Third, to consider the history of making observations in the region. This history joined the maritime community with the terrestrial meteorological organisations. As scholars have noted, ships could rightly be considered 'itinerant observatories' generating knowledge through the intimate experience of ship's officers with oceanic weather.[14] Finally, it will explore something of the knowledge network that linked the colonial port city of Hong Kong, and to a lesser extent Singapore, via the shipping and communications channels that criss-crossed the China Seas and connected East and Southeast Asia.

[12] J. Golinski, *British Weather and the Climate of Enlightenment* (London and Chicago: Chicago University Press, 2007), p. 8.

[13] G. Kutzbach, *The Thermal Theory of Cyclones: A History of Meteorological Thought in the Nineteenth Century* (American Meteorological Society, 1979).

[14] John Herschel coined the phrase and it has been used to good affect by historians including: Simon Naylor, 'Weather Instruments all at Sea: Meteorology and the Royal Navy in the Nineteenth Century' in F. MacDonald and C. W. J. Withers, eds, *Geography, Technology and Instruments of Exploration* (Oxon: Routledge, 2016), pp. 77-96.

Making observations: imperial storm science across land and sea

In the sixteenth and seventeenth centuries, knowledge of winds, currents, and weather along the trade routes that crossed the China Seas stretching from Singapore north to Macau and Hong Kong and then east along the China coast to Taiwan, Korea, Japan, and south-east to Manila, was considered sensitive commercial intelligence to be kept secret, if possible, from potential rivals. That situation could not last. By the nineteenth century, it had become a matter of the greatest urgency to collaborate across borders – both geographic and political – to collect meteorological observations, especially to facilitate early storm warnings. As James Warren has shown for Manila, the monsoon and typhoon seasons had the ability to change the course of history for the regional shipping industry.[15] With a typhoon season in the China Seas that affected mainland Hong Kong between May and November, and a north-east monsoon affecting Singapore from November to January, both port entrepôt were affected by extreme weather. The typhoons had the force to severely disrupt regional trade for both commercial ports, as well as wreaking havoc on Hong Kong through a combination of wind, tidal surge and flood. In Singapore, there were no typhoon but the monsoon brought heavy rains and storms which had the potential to inundate the low-lying marshy town. An improved understanding of the weather was thus critical to all aspects of life across land and sea in this region and there should be little distinction made between maritime and terrestrial scientific developments.

At sea, the process of studying the weather began from time immemorial but commercially, written sailing instructions were some of the first accounts to detail marine weather that were made available publicly. In Britain, the seventeenth century records of the English East India Company (EEIC) were invaluable resources. The information in these sailing instructions came from accounts and experiences of sailing masters, often accompanied by a generalized explanation of the winds, currents and storms that might be encountered on a voyage. Sailing directions were a practical tool to assist the mariner however, and seldom incorporated the latest scientific thinking. The reason for this is easily explained. The simple descriptive model of the wind system, and in particular the monsoon, as illustrated in the sailing directions, accurately reflected what the mariner actually experienced. Scientific refinement was thus of academic interest but deemed to have little practical application. Hurricanes, typhoons and cyclonic storms were however a different matter, and the study of countless observations and experiences of what came to be called revolving storms, promoted strategies of avoidance, mitigation and even exploitation.

Negotiating monsoon winds in both the Indian Ocean and China seas was also a matter of the practical application of information disseminated through the handing on of personal experience, and more formally through printed sailing directions. Where a scientific explanation of the monsoon was attempted, it usually involved the accepted understanding of the time. This was the seasonal heating and cooling of the Asian continent that caused the monsoon winds to blow from one direction and then later in the year to reverse that direction. It

[15] Warren, 'Weather, History and Empire'.

was the same phenomenon as the local diurnal change from land breeze to sea breezes, familiar to all mariners, but on a continental scale.[16] The modern explanation of the passage of the monsoon trough, or Inter-Tropical Convergence Zone (ITCZ) would have made little impact on the practical application of observed experience.

This practical application is illustrated well by the advice given in the 1843 edition of Horsburgh's *India Directory*. It is worth quoting at length.

> Ships bound to China, which depart from Singapore or Banca Straits in February, March and part of April, may expect a tedious beating passage: in March, April or May, they may proceed by the Inner Passage, along the coast of Cochin-China, which is generally the most expeditious route in these months; but when June approaches the South-west monsoon is set regularly in, the track by the Macclesfield Bank seems preferable, the winds being more steady in the open sea than near the coast. Even so early as April …. A ship may sometimes get a westerly breeze blowing out of the Gulf of Siam, to carry her to the Macclesfield Bank, and afterwards easterly winds, to run to the Grand Ladrone; but if she proceed by the Inner Passage, easterly winds may retard her progress around the south-east coast of Hainan, and thence to the entrance of the Canton River.[17]

This is the closest thing to a weather report, or rather weather advice that a ship's master could expect at that time. As such it was based on (as the title page from Horsburgh clearly states) 'original journals of the Honourable Company's ships, and from the observations and remarks resulting from the experience of twenty-one years in the navigation of those seas.'[18] Sailing directions such as Horsburgh and those that both preceded and came after, were some of the earliest (Western) disseminations of weather and climatic knowledge in the monsoon seas, based entirely on local observation and the careful accumulation and analysis of data collected over many years. It was an extraordinary achievement made purely for commercial, rather than scientific, purposes.

Typhoons were the other major weather phenomena encountered by ships on the passage across the China Seas. Typhoons were a danger that could result in the total loss of ship, crew and cargo. As with the regime of monsoon winds, sailing directions carefully documented the most dangerous season and the areas most prone to these devastating events. However, this was still not sufficient, as Horsburgh lamented:

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[16] James Horsburgh, *The India Directory or Directions for Sailing to and from the East Indies, China, Australia and the Interjacent Ports of Africa and South America.* (1852), vol. 1, iii-iv.

[17] James Horsburgh, *The India Directory or Directions for Sailing to and from the East Indies, China, Australia and the Interjacent Ports of Africa and South America.* (London, 1843), vol. 2, p. 292.

[18] Ibid.

> To be able to prognosticate the coming of these tempests would be very useful to navigators, but this cannot be done with certainty, for they frequently commence without giving much indication of their approach. …. Marine barometers, if well constructed seem to afford the best means of anticipating these tempests; for on the south coast of China, there is a greater fall of the mercury than might be expected within the tropics.[19]

It was in this respect that science needed to be applied to the vast amounts of locally gathered observations to be found in ships' logs and journals. This was not easily achieved despite the obvious need and clear benefits. As late as 1875, Labrosse's sailing directions for the China Seas cast doubt on some of the earlier work that had been done in trying to understand the behaviour of typhoons.

> …[The] track of typhoons …. obeys neither the general law governing cyclones of the northern hemisphere, nor any fixed rule …. After a perusal of Piddington's researches, it must be admitted that the track of typhoons lies between NNW and SSW; but it is best not to rely too confidently on this …

Labrosse continues, stating how some typhoons have behaved differently, then; '…. It is clear that no fixed rule can be given to avoid typhoons; … we shall confine ourselves to giving general advice.' After giving this advice, largely drawn from Horsburgh, he concludes that typhoons are to be feared and that almost all measures taken to avoid them are of little use.[20] Labrosse was clearly aware of Piddington's work but maybe not the work of others such as William Birt.

Previous decades had produced volumes of work describing hurricanes, cyclones and typhoons. There were many scientists and others interested in researching this topic, chief among them William Redfield, William Reid, Heinrich William Dove, Charles Meldrum, Bernhardus Varenius, Henry Piddington, Benito Viñes and later in the nineteenth century John Eliot, to name just a few. Piddington, (referred to by Labosse above) a former mariner turned scientist and based in Calcutta, having been inspired by Reid's *Law of Storms*, wrote twenty-three storm memoirs, as well as many other articles on storms, most of them published in the *Journal of the Asiatic Society of Bengal*. In the *Fourth Memoir on the Law of Storms*, Piddington was requested by the secretary of the Marine Board to investigate the loss of the *Golconda*, bound from Singapore to Macao in 1840, and caught by a typhoon in the China Sea. Piddington drew upon the logs and journals of other vessels traversing the China Sea at that time and his analysis concluded that there were in fact two storms and that those vessels that

[19] Ibid., p. 289. This and other sets of sailing directions by others such as Findlay and Rosser contain a profusion of accounts of typhoons and hurricanes, littered with barometric pressure observations, gleaned from vessels whose logbooks are likely no longer extant.

[20] F. Labrosse (trans J. W. Miller), *The Navigation of the Pacific Ocean and China Seas* (1875), pp. 27, 29.

survived had heeded the advice given in the *Law of Storms*. His analysis also confirmed that the storms behaved in accordance with current theory and that the typhoon was a rotary storm.[21]

The type of research performed by Piddington was essential, but difficult to carry out and to communicate to those most in need of the results. At a meeting of the Asiatic Society in 1840, Piddington submitted a memorandum outlining the difficulties he encountered in obtaining extracts from logbooks to carry out his researches. Commanders were unwilling to hand over extracts, and Piddington asked the Society to apply to the Government to issue an order making it compulsory to hand over information on storms. As commanders were answerable only to the ship owners for their logs, it was considered unlikely that the Government would consider such a measure, but the Society's secretary stated that he would at least write to the Government asking them to make an appeal to ships' officers.[22]

Piddington's contemporary in Mauritius, Charles Meldrum, had better fortune in gathering data, as he did not rely on goodwill and the submission of logbooks, but sent his assistants to transcribe parts of the logbooks of ships in port. Meldrum was working to a plan, outlined and partly implemented by Alexander Thom, which would have ultimately resulted in a network of meteorological observations from stations collecting data from shipping. The collection points included Mauritius, Bombay, Calcutta, Ceylon, Swan River and Melbourne, the intention being to produce published data and results across the Indian Ocean. The extension of this plan to the China Sea would have been a next logical step, but the overall plan lacked both support, co-operation and funding to publish the results, apart from an initial volume covering a single month in 1853.[23] The precious and irreplaceable raw data gathered by Thom and Meldrum, along with its results still sits (unused) in an archive in Mauritius in need of urgent conservation.

From this it can be seen that early work on storms and typhoons and the benefit of the resulting analysis was difficult both to gather and, more critically, difficult to communicate. In 1848, after reconstructing yet another severe storm, Piddington issued a strong statement in conclusion.

> If warnings like these are not listened to, it is difficult to say what will be required. Nothing short of a whole fleet would seem sufficient to rouse the attention of those who it behoves to insist upon the laws of our science being as duly attended to as the lead and the chart, and upon every Commander intrusted (sic) with public property noting in his log his reasons for standing on or heaving to on the approach of bad weather; and this will, in case of his return to port in

[21] Henry Piddington, 'A Fourth Memoir of the Law of Storms in India, being remarks and documents relative to the loss of the Ship *Golconda,* in the Tyfoons of 22nd to 24th September 1840, in the China Sea', *Journal of the Asiatic Society of Bengal*, vol. 10 (1841): 895-906.

[22] *Journal of the Asiatic Society of Bengal*, vol. IX (1840), 'Proceedings of the Society', 552-4.

[23] Charles Meldrum, *Contributions to the Meteorology and Hydrography of the Indian Ocean (part 1) a Meteorological Journal of the Indian Ocean for the month of March 1853*, (1854), i-v.

> a disabled state, at once show if he understood his position or not. If he did not, he is unfit for the command of a vessel till he does.[24]

The slow and piecemeal accretion of observational data, with little in the way of a formal system of analysis or communication, except by individual publication, did enable some progress in understanding typhoons and cyclones. In 1858, M. F. Maury remarked on the recurvature of typhoons and their unusual tracks, but admitted that the reason for this behaviour was a puzzle to both meteorologists and navigators.[25] By the 1860s W. H Rosser, in his sailing directions included very detailed 'meteorological signs preceding a hurricane, which included portents observed by sight, sound and feeling. This was drawn largely from Birt's *Handbook of the Law of Storms*, published in 1853 and re-issued in 1879.[26] Rosser himself published his own law of storms, joining a pantheon of similarly titled volumes. Most of these volumes were derivative, borrowing heavily from previous publications, yet slowly producing a comprehensive list of advice for mariners to observe, or ignore if they chose. Rosser's publication was unique however, and its chief interest, for the historian at least, is not the advice given to mariners but the extraordinarily detailed historiography of the development of the science surrounding cyclones and cyclone theory from the time of Columbus up until the time Rosser was writing.[27]

At this point the somewhat troubled progress of the early communication of knowledge and understanding of hurricanes and typhoons had reached a logical conclusion in the advice issued through sailing directions and the innumerable variations of the *Law of Storms*. Effective typhoon forecasting, as opposed to simply recognizing the portents, required a network of observers and a means (such as telegraph) to issue warnings. Nevertheless, the behaviour of typhoons was now well documented if imperfectly understood. This was in part due to governmental intervention in requesting that information contained in logs be handed over to port or meteorological authorities on land, as had been hoped back in the 1840s. In Hong Kong for instance, Colonial Secretary Frederick Stewart intervened to make sure that the observatory received observations taken on board ships that docked at port from the 1880s.[28] These observations were collated by the observatory's first female member of staff Anna Doberck (sister to director William) from 1892; from which she personally constructed pilot charts.

Thus in Hong Kong, as in most parts of the world, the story of meteorological science began in earnest with the making and collation of instrumental weather observations, a trajectory that closely mirrored and connected with maritime developments. In line with early

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[24] Henry Piddington, 'Fifteenth Memoir of the Law of Storms', *Journal of the Asiatic Society of Bengal*, vol XVII (1848): 27-56.

[25] M. F. Maury, *Explanations and Sailing Directions to Accompany the Wind and Current Charts*, (1858), vol. 1, p. 262.

[26] W. H. Rosser & J. F. Imray, *The Seaman's Guide to the Navigation of the Indian Ocean and China Sea* (1867), pp. 148-9.

[27] W. H. Rosser, *The Law of Storms Considered Practically* (1876).

[28] Public Records Office Hong Kong (hereafter PRO), Hong Kong Record Series (hereafter HKRS) 356 1-1-2, f. 94. Frederick Stewart to William Doberck, 5 November 1888.

nineteenth century thinking to advance understanding of the weather, the recording of observations was considered the essential step in building a body of data from which to extrapolate patterns and to understand the working of storms.[29] From the 1840s the British Association for the Advancement of Science (BAAS) and the Royal Society had worked toward a grand plan of establishing a global network of imperial observatories from which could be gathered systematic, daily terrestrial observations, to augment information from the naval and East India Company ships log books. In line with this, the number of registering stations was gradually expected to increase.

Ideal versus reality? The situation in Hong Kong and Singapore

The reality was a far less structured and less co-ordinated affair. The British colonies at Singapore and Hong Kong are excellent examples of the degrees of success and variances from country-to-country. Between the 1820s and 1860s registering stations were limited and experiments in producing consistent meteorological series ad hoc. A temperature and rainfall series survives for Singapore for 1820-23 made by then Governor William Farquhar at Fort Canning, who also made observations in Malacca (1809) and in Georgetown, Penang (1815-16, 1820-21, 1823).[30] Between 1839 and 1841 Joseph S. Travelli – a missionary – made observations at Ryan's Hill at the American Board of Foreign Missions where Travelli was then based.[31] Then from 1835 to 1836 rainfall and temperature observations were published in *The Singapore Free Press and Mercantile Advertiser* but thereafter only sporadic records survive until the late 1860s. There was, for example, an observatory operating in Singapore between 1841-5. Established as part of Edward Sabine and the BAAS 'Magnetic Crusade',[32] the Singapore Observatory was closed due to a lack of funds and political will.[33] Although meteorological observations were only made as a by-product of the magnetic investigation, the observatory did produce a consistent four year temperature series for Singapore and, for a few months in Sarawak, Borneo during 1842.[34] Likewise, a series of meteorological and tidal observations were started in 1844 at Penang Island but ceased in 1846 by order of the

[29] Anderson, *Predicting the Weather*, pp. 6, 132-140; Mahony, 'For an Empire': 30-1; Golinski, *British Weather,* p. 210; F. Williamson, 'Weathering the British Empire: meteorological research in the early nineteenth-century Straits Settlements', *British Journal for the History of Science* 48:3 (2015): 475-492, 6-7; Good, 'A Shift of View', p. 35.

[30] Thermometrical and Barometrical Tables communicated by Lieut. Col. William Farquhar, *Transactions of the Royal Asiatic Society of Great Britain and Ireland,* Vol. 1, Appendix 1: 585-599.

[31] Joseph S. Travelli, "Abstract of a Meteorological Register kept at Singapore", *The American Journal of Science and Arts XLIV* (1843): 150-8.

[32] J. Cawood, 'The Magnetic Crusade: Science and Politics in Early Victorian Britain', ISIS, 70:4 (1979): 493-518.

[33] Williamson, 'Weathering the British Empire': 486, 488.

[34] The observations made by Lieutenant Charles Elliot are available online at the British Geological Survey: http://www.geomag.bgs.ac.uk/data_service/data/yearbooks/sin.html

government.[35] As the century progressed and the call for extending observations became more mainstream, the Straits Settlements rather fell by the wayside. A small observing facility was located at Mount Faber from the 1880s[36] until 1934 when it moved to the new Kallang airfield, but it was 1928 before it was equipped with the latest wireless receiving equipment and a traveling micrometer for time determination.[37]

Weather observation throughout most of the nineteenth century in Singapore was not the job of a formal meteorological service but a combination of the colonial medical branch, public works departments, or private plantation or estate owners.[38] In the 1860s for example, observations were made at Killeney Estate on River Valley Road, by Jonas Vaughan, ex-seaman, who published the rainfall, temperature and wind readings in the Government Gazette.[39] Other stations were gradually added over the 1870s and 1880s, including Perseverance Estate at Geylang owned by the Alsagoff family.[40] Registering stations were often located at hospitals too in order to study the relationship of rain and temperature with health. In Singapore, this included the Convict Hospital at Bras Basah and the Pauper Hospital, likely part of the large Tan Tock Seng hospital facility. There were also stations at the P&O Depot at New Harbour; Water-works Reservoir, Thompson Rd (made by James McRitchie Municipal Engineer); and of course the Botanic Gardens (made by Superintendent Nathanial Cantley).

In the early twentieth century, formal responsibility for meteorology was passed from the medical department to the Museums Department in Singapore under the direction of Mr Herbert Robinson. Robinson, Director of Museums between 1908 and 1926, had an active interest in the science. He appointed a Mr Kelliher as a Meteorological Officer in the direct pay of the Museums Department and it was under the ward-ship of these two men that meteorological study experienced something of a revival in Malaya. Robinson was critical of the quality of observations taken by the medical branch previously, suggesting that staff were ill-trained, instruments were not standardised, and readings were temporally erratic.[41] Whether or not his criticisms can be credited with any veracity, it was he, along with George Maxwell – then Chief Secretary for the Federated Malay States (FMS) – who argued the urgent need for

[35] British Library (hereafter BL), India Office Records (hereafter IOR), F/4/2170/104987: Extract of a dispatch from the Government of India to the Honourable Court of Directors, 23 May 1846.

[36] The observatory is marked on a map of 1882: NAS, C.O. 129/205. Media - Image Number: D2014040098, Survey of Mount Faber Range and country surrounding Singapore, 1882.

[37] The National Archives UK (hereafter TNA), CO273/552/12: Apparatus for installation at Mount Faber Observatory, 1928.

[38] TNA: CO273/541, G. Maxwell and H. C. Robinson, 'A Meteorological Service for Malaya', p. 1 and The Singapore Free Press and Mercantile Advertiser, 24 January 1927, p. 7.

[39] Observations available in the Straits Settlements Government Gazette for 1864-6, available at National University of Singapore Law Library (Singapore-Malaysia Collection).

[40] Observations available in the Straits Settlements Government Gazette TNA, CO273 (5), 1875.

[41] TNA: CO273/541/4: G. Maxwell and H. C. Robinson, 'A Meteorological Service for Malaya', p. 1.

consistency and improvement in the meteorological services in the 1920s. This was made all-the-more pressing by the expansion of aviation services across Singapore and the peninsula.[42]

Responsibility for meteorology was passed over again on 1 January 1927, this time to the Survey Department (part of the Public Works Department).[43] This was an interim measure, as plans were afoot to create a dedicated Meteorological Branch. In 1927 it was vaunted to establish

> groups of the second order stations down each coast and along the centre of the Peninsula … In addition it is hoped to establish a large number of stations at which temperature and rainfall data will be collected with the co-operation of the planting community.[44]

The service began formal operations in Kuala Lumpur in 1929. Under the new branch, seventeen new fully-equipped stations were built across the peninsula, in addition to those already established.[45] The headquarters moved to Singapore in 1931.

In Hong Kong, the situation was a little different. Before 1860, meteorological research was – like Malaya – small-scale. Observations were made at government departments, hospitals, police stations and at the Harbour Master's Office.[46] There were also sporadic weather records made by visiting scientists including Frank Julius Ferdinand Meyer in the early 1830s and – like Singapore – some interested individuals made meteorological diaries. Diaries were kept by meteorology enthusiast and Dutch consul Mr Blettermann and an English merchant Thomas Beale, for instance.[47] The early collection of observations along the China coast by the Chinese Maritime Customs Service (CMCS) were far more significant. These were published in the *Canton Register*, an English-language newspaper founded by two Scotsmen in 1827.[48] Robert Hart's revival of the CMCS in the 1860s was a significant staging point in the modernisation of meteorology and the establishment of a regional observational network. Hart was the mainland service's Inspector-General from 1863 and it was he who requested that each customs station in China and Hong Kong be outfitted with meteorological instruments;

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[42] NAS, M712/14-15, f. 79. Extract from the Malaya Tribune, 14 June 1926: Air Liners: Big Scheme for Malaya; M712/14-15 ff.84-5. Report submitted by Samuel G. Ebling, Vice Consul in charge 14 Sept 1927. Proposed service by Air Survey Company Ltd.

[43] TNA, CO273/541/4 Proposal to establish a Meteorological Department for Malaya: Memorandum on a Pamphlet entitled 'A Meteorological Department for Malaya' by Sir George Maxwell and Herbert C. Robinson, written by Victor A. Lowinger, Surveyor General (Federated Malay States and Straits Settlements), 24 October 1927, pp.1, 3.

[44] R. L. Jarman, *Annual Reports of the Straits Settlements, 1855-1941, Vol. 9., 1927-31* (Slough: Archive Editions: 1998) Report for 1927, p. 304.

[45] TNA, CO273/541/4 Memorandum on the general scheme for the systematic study of the climate of Malaya, 14 October 1927, pp. 1-5.

[46] Ho, Weathering the Storm, p. xii.

[47] Ibid.

[48] A. Le Pichon, ed., *China Trade and Empire: Jardine, Matheson & Co. and the Origins of British Rule in Hong Kong 1827-1843* (Oxford: Oxford University Press, 2006), p. 67.

that observations made at lighthouses be made use of, and that meteorological registering stations be established along the coast and linked by telegraph.[49] Although his scheme was met with a certain amount of ambivalence, especially when it came to Hong Kong soil, Hart did a great deal to standardise and reform meteorological services along the China coastline. Observations of temperature, rainfall, wind, cloud, ozone, and pressure made at Hong Kong were published in the *China Mail* from at least the 1860s.[50]

In the 1880s the trajectories of meteorology in Hong Kong and Singapore began to diverge. In 1883, the British government paid for an observatory to be opened in Hong Kong. Its staff were expected to take charge of meteorological research and, from 1884, the institution provided the main source of observational data for terrestrial Hong Kong. It was envisaged that the observatory would provide an important link in a regional observational network, filling a gap essential for improving early storm warnings for Hong Kong, Macau and Manila.[51] The early emphasis of the Hong Kong Observatory was on protecting the interests of the shipping industry. The provision of a time service for ships, the making of weather observations and issuance of typhoon warnings were considered vital. Despite some suggestion that wider meteorological research lagged initially,[52] the letters, reports and correspondence of the successive directors – including the first director William Doberck – show that impetus to catch up came from Colonial Secretary Frederick Stewart who continually pushed Doberck to spend more effort on making observations and issuing daily reports and storm warnings for the public.[53] Doberck – trained as an astronomer in Europe – may arguably have lacked experience in the field.[54] After arriving in the Far East from his previous position in Ireland, Doberck was thus asked to spend two months visiting Swatow (Shantou), Amoy (Xiamen), Shanghai and other cities on the Chinese coast, as well as travelling on the Imperial Customs Revenue Cruiser to lighthouses including those on Macau and Penghu Island in the Taiwan Strait.[55] Whilst in Shanghai and Amoy he inspected, adjusted and verified extant meteorological equipment, and took his own observations during the expedition.[56]

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[49] Fir more on Hart and the Service see: Bickers, "'Throwing Light on Natural Laws".

[50] See for example, *The China Mail,* 11 January 1868, available online from Hong Kong Public Libraries: https://mmis.hkpl.gov.hk/

[51] Anthony Dyson, *From Time Ball to Atomic Clock* (Hong Kong: Hong Kong Government Printer, 1983), p. 19.

[52] Correspondence between the Acting Colonial Secretary Frederick Stewart and Doberck in 1886 critiqueS the latter's 1885 report for its lack of effort in producing daily weather reports or storm warnings for the public, and neglect of any analysis of the China Coast observations: HKRS 356 1-1-2, ff. 4r-5v Colonial Secretary's Office to the Government Astronomer, 2-4 March 1886.

[53] HKRS356 1-1-2, ff. 4r-5v Colonial Secretary's Office to the Government Astronomer, 2-4 March 1886; f. 60 Invitation from Frederick Stewart to William Doberck to sit on a specially convening storm signalling board, 13 March 1886.

[54] MacKeown, *China Coast Meteorology*, p. 62-3.

[55] HKRS356 1-1-1, 79. Despatch 1351 from the Colonial Secretary's Office, Hong Kong, 23 August, 1883; HKRS356 1-1-1, Inspectorate General of Customs Circular No. 235, 7 September 1883.

[56] Hong Kong Government Reports Online (hereafter HKGRO); Administrative Reports (hereafter AR), 1883: Observatory Reports. Report from the Government Astronomer, together with Instructions for making Meteorological Observations, 17 November 1883, p. 1.

His trip was vital in establishing links with the Imperial Maritime Customs Service – the CMCS – which was to prove the richest and most important source of regional observations, and the main network for communicating them, for many years to come. During his first few months in Hong Kong, Doberck (usually at the insistence of the Colonial Secretary) was to highlight the absolute necessity of expanding the range and diversity of meteorological observations and registering stations, a mission that was to consume a large part of his time at Hong Kong Observatory. The extension, he argued, could be done only with the cooperation of Hart and the CMCS and it was largely a result of the Hart's efforts along with Father Marc Dechevrens, Director of the Zikawei Observatory at Shanghai, that the wide-ranging network of coastal and riverine registering stations were established and their observations standardised. Doberck requested that registers from the old and new stations mainland China and Macau (including Kiungchow [Hoihow], Pakhoi [Beihei], Canton [Guangzhou] Swatow [Shantou], and Ningpo [Ningbo] amongst others), be sent to the Observatory monthly and that the network of Chinese stations making observations be extended to thirty-five (the latter request was ignored).[57] After receiving the observations – via the customs services at Amoy and Shanghai – Doberck intended that his observatory staff would make corrections and revisions as necessary and construct daily weather maps from the data contained therein.[58] Although Doberck's prime function was that of astronomer, his early work on the law of storms in the China Seas published in 1886 – without governmental financial support or impetus – shows a commitment to meteorological research, especially that which directly affected Hong Kong.[59] It is also likely that he was trying to make a name for himself as his pamphlet drew directly from the earlier studies and styles of Reid, Piddington, Rosser and Birt. It did his reputation little good however, especially as the maritime community threw doubt on Doberck's findings, suggesting the text had little applicability in the real experiential world of seafaring.

On joining Hong Kong Observatory Doberck had become part of a major communications and knowledge network that incorporated some of the most significant sites of learning and important scholars of meteorology in Asia. Because of the regular progression of typhoon tracks across the China Seas, excellent communications between China and Hong Kong were essential but so too was a good relationship and rigorous communication with Manila, Taiwan, Korea and Japan. In 1883, an arrangement was made with the Great Northern and the Eastern Extension Telegraph Companies to send – at no cost – observations between Hong Kong, Manila, Xiamen, Fuzhou, Shanghai, Vladivostock and Nagasaki.[60] By 1895, the Eastern Extension Telegraphic Company (EETC) exchanged daily observations with

[57] MacKeown notes that Doberck's proposal for 35 stations was not taken up, possibly because of a lack of enthusiasm on the part of Hart and Dechevrens to take direction from the Colonial Office: MacKeown, *China Coast Meteorology,* pp. 77-8.

[58] HKGRO, AR, 1883: Observatory Reports. Report from the Government Astronomer, together with Instructions for making Meteorological Observations, 17 November 1883, p. 2.

[59] HKRS 356 1-1-2, f. 18. Government Order from the Colonial Secretary to the Director of the Observatory in regard to the publishing of a pamphlet, 11 September 1886. Here Stewart tells Doberck that there will be no financial or resource support for the publishing of his book though Doberck can publish by 'any private arrangement he likes'.

[60] HKGRO, AR, 1883: Observatory Reports. Report from the Government Astronomer, together with Instructions for making Meteorological Observations, 17 November 1883, p. 3.

Singapore, Haiphong, Xiamen, Shanghai, Bolinas, Nagasaki, Vladivostock, and Macau.[61] Observations were also received at Hong Kong and Manila from stations in Taiwan via Taihoku (which included readings made at stations at Taihoku, Taichu, Tainan, Koshun [Hengchun] and the Penghu Islands).[62] In 1898 the board of Directors of the EETC had authorised observations to be taken by their own officers stationed at Capiz and Tuburan in the Visayas (Philippines) and promised that these would be communicated to Hong Kong.[63] By the early 1900s thirty-one stations were included in the China Coast Meteorological Register (CCMR) observational network.[64] By 1904, telegrams were received at Hong Kong twice daily from Cap St Jacques (Vũng Tàu, Vietnam), Cap Padaran (Mui Dinh, Vietnam), and Labuan in the Straits Settlements (Sabah, Malaysia).[65]

The extension of the observational network directly resulted from the need to address the extremes of weather by improving storm forecasting. The weather was the catalyst that led to many investments in the science. Certainly, the establishment of the Hong Kong Observatory and the Malayan Meteorological Department can be cited as good examples of this. In Hong Kong, there had been calls from at least 1861 for an institution to provide a time service and storm warnings for shipping without success. The major typhoon that devastated Hong Kong in 1874 alerted the public to the benefits of a local observatory and heightened pressure on the government to enact their earlier plans. Drawn-out discussions were moved forward and the Observatory opened in 1883.[66] In similar vein, it could be argued that the restructuring of the Malayan meteorological service from 1927-1929 could have been inspired by some of the most serious floods to have been known in that region. Although discussions had been underway from as early as 1919 that the colony needed an improved service, 1925 and 1926 saw major flooding in Singapore and in rural Malaya respectively. The floods crippled large swathes of agricultural land and caused massive destruction of infrastructure.[67] A significant component of the planned new service was to increase the number of manned meteorological registering stations across the peninsula to improve the collection of rainfall data, especially in rural areas. This was intended as 'a preliminary to scientific investigation and a systematic study of the climate ... [and a] … foundation on which can be built a Meteorological Department capable of dealing with the needs of aviation, upper air research work, the distribution and exchange of information and weather predictions'.[68]

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[61] HKRS8421/2 General Correspondence 1895-7, 28/4-5, Communication from L. Webster RE Meteorological Telegrams 17 October 1895.

[62] HKRS8421/2, 7, Letter to Doberck from H. Kondo, Taihoku Meteorological Station, 6 November 1896.

[63] HKRS842/3 1898-1903. Letter to the Colonial Secretary at Hong Kong from Manager-in-China, EETC, 17 March 1898.

[64] An example of Acting Observatory Director Frederick Figg's copy of the CCMR can be found at: HKRS842/4 General Correspondence 1903-1913, CCMR, 10 September 1903.

[65] HKRS842/4 General Correspondence 1903-13, Letter from Director of Meteorological Services Indo-China to HKO, 2 May 1902 & Letter from Eastern Extension Telegraph Company 20 August 1904.

[66] MacKeown, *China Coast Meteorology*, pp. 27-8.

[67] For more on the 1926 floods, see F. Williamson, 'The Great Flood of 1926: Environmental Change and Disaster Governance in British Malaya', *Journal Ecosystem Health and Sustainability*, Environmental Impact of Disasters - special issue, 2:11 (2016).

[68] Jarman, *Annual Reports:* Report for 1927, p. 304.

Controversy and confusion: the 1906 typhoon and its consequences

All such systems however – whether national or international – relied heavily on the effectiveness of the communications network. This was far from perfect. As the example of the HMS Eagle in 1939 showed, observers could not always agree on the trajectory or even the existence of a typhoon. This could have disastrous consequences. Waking up on 18 September 1906, Hong Kong inhabitants were entirely unprepared for what that day would bring. A typhoon, short but almost unprecedented in strength, was to wreak utter havoc in the colony. At 8am the first warning was given out in the form of the hoisting of a black signal drum (the final in a stage of red to black storm warnings), and the typhoon gun was fired at 8.40 signalling the immediate arrival of the storm. It was too late for the ships, fishing boats and sampans which were already out at sea and could not return to shore in time. It has been suggested that fifty per cent of Hong Kong's Chinese junks and sampans were destroyed that day and a number of larger merchant and naval vessels were grounded or sunk.[69] These included the German steamer *Petrarch*, the British sloop-of-war *Phoenix*, the French destroyers *Fronde* and *Francisque,* and the Canadian *Monteagle*.[70] On land, serious flooding, wind-driven high waves, and a massive storm surge of 6.10m at Tai Po – one of the highest ever recorded for that area – caused massive destruction.[71] Contemporary estimates suggested that between 4000 to 10,000 people died that day.[72]

The Observatory received a large apportionment of blame for the tremendous loss of life and damage to property during this typhoon and a public inquiry was initiated. The investigation, led by a Royal Navy Officer, a master mariner and the manager of the Eastern Extension Telegraph Company, was confidently expected to 'exonerate the Director and Staff of the Observatory'.[73] Certainly, Governor Matthew Nathan argued that he saw no possible way the organisation could have released an earlier warning. An inquiry was necessary to assuage the public outcry – taken up by the contemporary press – that staff should have and significantly, could have, given a much earlier warning of the impending storm. This view was publicised by French consul to Hong Kong Monsieur Liébert, who contended that French ships in the area had been warned by Zikawei Observatory staff long before Hong Kong Observatory had raised the Black Drum.[74] Hong Kong Observatory contested this, arguing that the last news they had received from Zikawei had been the previous evening and that 'this typhoon gave no

[69] Li Woon Yee, *The Typhoon of 18 September 1906*, Royal Observatory, Hong Kong, Occasional Paper no. 36 (1976), p. 3.
[70] *The Calamitous Typhoon at Hong Kong, 18 September, 1906* (Hong Kong: Hong Kong Daily Press, 1906) p. 5. http://ebook.lib.hku.hk/HKG/B36228084.pdf. Accessed 05.01.2017.
[71] Li, *Typhoon of 18 September 1906*, p. 3.
[72] *Calamitous Typhoon*, p. 1.
[73] HKGRO, *Report of a Committee,* p. 42 and HKGRO (1842-1941), Hong Kong Hansard, Reports of the Meetings of the Legislative Council, Session 1906: Report of the Meeting 20 September 1906, pp. 51-4.
[74] HKGRO, *Report of Committee appointed to enquire whether earlier warning of the typhoon of September 18th, 1906, could have been given to shipping*; Supplement to the Hong Kong Gazette, 22 March 1907.

indication of its existence until close to the Colony'.[75] The incident is also revealing of the strained relationship between the French Jesuits at Zikawei and staff – Doberck especially – at Hong Kong.[76]

After the 1906 typhoon, Doberck made it a personal mission to contact comparable observatories around the world to step up the collection of meteorological observations to better understand the weather patterns of the China Seas. Much of this work was actually undertaken by Doberck's capable meteorological assistants, Anna Doberck and Frederick Figg, the latter succeeding Doberck as Director in 1907. The efforts taken to improve the quality, quantity and, critically, the frequency of observations can be seen to have paid dividends by 1912. A letter to then Hong Kong director Thomas Claxton from Frere Louis Froc, director of Zikawei Observatory, in 1912 noted how 'owing to increased certainty in the telegraphic transmissions of meteorological data, it is now possible to ascertain the direction in which the typhoon is travelling or from which a gale may be expected to a closer degree than hitherto'.[77] Claxton continued the work, attempting to persuade all those observatories in his immediate network – namely Tokyo, Zikawei, Manila and Indo-China – of the importance of simultaneous observations. Claxton argued that this was the only way to guarantee effective daily weather maps for the region.[78]

To facilitate research, successive directors of the Far East stations had also sought to improve the *historical* record of observations for the region for some time. In a government notice issued from the Hong Kong Observatory on 16 February 1893 for instance, Doberck invited 'Owners, Agents and Masters of Vessels … to forward old logbooks on loan to this Observatory' for the purpose of tabulating 'all observations made on board ships between Singapore and 180º E, Gr. Longtitude and between 0º and 45º latitude…with the view of the issue of pilot charts for the China Seas and the North Pacific'.[79] Writing to various meteorological organisations globally, including those in Washington, Paris, and St Petersburg,[80] as well as shipping companies like the P&O, he asked if they could furnish him with observations made during voyages on the China Seas.[81] Doberck also communicated with Gilbert T. Walker, Director-General of Indian Observatories who, in 1905, had sent copies of 'all charts issued by the various meteorological offices of India' to Hong Kong along with

[75] *Calamitous Typhoon*, p. 1.

[76] For more on this controversy see, F. Williamson, Uncertain Skies: 'Forecasting' Typhoons in Hong Kong c. 1874-1906, *Quaderni Storici* (Forthcoming, 2018).

[77] HKRS356 1-1-3, Zikawei to HKO concerning addition to the typhoon warning signal, 1912.

[78] HKRS356 1-1-3, especially 86, 92, 97 HKO 41/12, Claxton to Harbour Master Macau, 12 March 1912; HKO 19/12 Claxton to Director Central Observatory Indo-China, 17 February 1912; HO 18/12 Claxton to Superintendent Eastern Extension Telegraph Company, 21 February 1912.

[79] HKRS8421/1 General Correspondence 1891-4, 107a, Government Notification No. 63, 16 February 1893.

[80] This communication worked two-ways: in 1906 the US Department of Agriculture Weather Bureau also requested daily weather information from HKO: HKRS842/4 General Correspondence 1903-1913 f. 20. Letter from USDOA Weather Bureau to HKO 8 August 1906.

[81] HKRS8421/1 General Correspondence 1891-4, 107a/c, Letter from Washington to Doberck 17 March 1893; Letter from Shipmaster's Society Fenchurch Street London Letter from P&O Managing Directors to Doberck, 9 June 1893;

signal codes and storm telegraphic code for reference.[82] An important avenue for furthering collaboration on such matters was attendance at the meteorological conferences for the Far East, the first of which was held in 1913 in Tokyo. Over succeeding years, a variety of conferences brought the various directors – including those of Malaya and Hong Kong – into direct contact, including during the Conference of Empire Meteorologists held in 1919, 1929, and 1935;[83] the meetings of the International Meteorological Committee and the Conferences of the Regional Meteorological Commission for the Far East (first held in Hong Kong in 1937).[84]

It should not be assumed however that these networks were effective or, that communications were trouble-free. The outcome of the meteorological Conference held in Tokyo in 1913 for instance was a lack of agreement and discord on the main item under the discussion: the standardisation of storm signals, especially the types of code used and the manner of signalling them, a problem that was to dominate correspondence between Hong Kong, Manila, Tokyo and Shanghai for many years to come.[85] The breakdown of telegraphic communication was also to dog the meteorological services throughout the nineteenth and early twentieth centuries. Cable lines may have existed but they broke down with regularity during bad weather. In 1887 Doberck had noted the problem – even within Hong Kong – of telegraphic communication. During typhoons, when swift communication was utterly essential, the telegraph between the Observatory and the Central Police Station would not work.[86] This was not just a localised problem. Trans-marine cables regularly broke down and were considered unreliable. In 1903, for example, a complaint was made to the Consul General at Shanghai regarding the meteorological observations 'which are supposed to be received twice daily from the Imp. Mar. Customs [sic] authorities at Hankow, Hainan. These observations rarely arrive in time to be made use of by the Hong Kong Observatory & repeated representations on the subject have had no result'.[87] On other occasions the outbreak of war brought disruption or the total breakdown of services. In 1898 for instance, the outbreak of the hostilities between Spain and America meant the loss of the Manila cable between Luzon and Hong Kong: an essential node in the regional storm warning network.[88] At the same time, the cable between Samsui and Amoy had been destroyed during troubles in mainland China necessitating observations from that region be communicated via Japan.[89] This was also the case during the Chinese Revolution

[82] HKRS842/4 General Correspondence 1903-1913, fol. 13. Letter from G. T. Gilbert to HKO, 30 October 1905.
[83] For more on the conferences see Mahony, 'For an Empire'.
[84] TNA, CO323/1525/1. International Meteorological Committee: Far East Regional Committee, Preliminary Report of the Proceedings 13-21 January 1937.
[85] HKRS356 1/2/2, unmarked folio. Letter from the Colonial Secretary Hong Kong to the British Consul, Hanoi, nd. 1917; HKRS356 1/2/2, unmarked folio. Letter from the Coast Inspector, Maritime Customs at Shanghai to Mr Le Cadet, Director Hanoi Observatory 8 February 1917.
[86] HKRS356 1/1/2, f. 32r. Report of the Director of the Observatory for 1886, 31 December 1886.
[87] HKRS356 1/2/1, unmarked folio. Letter from the Colonial Secretary's Office at Hong Kong to H.B.M. Consul General Shanghai, 23 July 1903.
[88] HKRS842 3 1898-1903, unmarked folio. Letter to EETC from the Colonial Secretary 14 June 1898 & 18 June 1898.
[89] HKRS842/3, f. 20. Communication between the Hong Kong Chamber of Commerce and Director of the Observatory, 17 June 1898.

of 1911 and, although the service was resumed during 1913, Claxton reported that 'the morning observations are never received in time to be utilised for the Weather Map'.[90] Other communication problems were caused by finances (many observations were transmitted freely on the good will of the telephone company)[91] and by personality. In 1899, for example, there was a 'suspension of telegraphic typhoon warnings given at Manila, for any place outside of the Philippines' due to ongoing hostility between Doberck and José Algue, Director of the Manila Observatory, peaking after Doberck's statement that 'the Observatory in Manila is in the hands of men who possess very little scientific education' and his continued assertion that the Manila Central Observatory continually communicated sensational and inaccurate typhoon warnings to the Hong Kong press.[92]

Conclusions

Building on recent work highlighting British meteorology as a lens into the networks of knowledge that stretched across an increasingly connected world and Kapil Raj's call to 'relocate' modern science, this article has sought to offer a corrective to a meteorological historiography which privileges institutional and epistemological histories from the metropoles of European and North American power.[93] The history of meteorological services in Hong Kong and Singapore shows how a combination of global and local factors influenced and directed the development of meteorological research. Studies of the weather in late nineteenth century and early twentieth century Hong Kong and Singapore were based on collating historic and contemporary observations over a wide geographic area, in order to perceive climatic patterns and to establish the laws governing events such as typhoons. Over the period in question the number of registering stations and observatories in Hong Kong and in Singapore was increased, through a variety of private and public investment. By the early twentieth-century, the system of sporadic observations made by interested individuals or under different government or military departments had been overtaken by the more formal provision of a government sponsored meteorological service. This approach to research reflected global meteorological studies over the same period.

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[90] Report of the Director of the Royal Observatory, Hong Kong, for the year 1913, E.5. http://sunzi.lib.hku.hk/hkgro/view/a1913/193.pdf. Accessed 04.01.2017.

[91] HKRS842/3, unmarked folio. Correspondence between the EETC and Hong Kong Observatory, 14 March 1906.

[92] HKRS842/3, General Correspondence 1898-1902, 28, Letter to the Director of the Hong Kong Telegraph from José Algue, Director of Manila Central Observatory, 7 March 1899. Doberck's relationship with, and antagonism towards, the Manila Observatory is covered extensively in MacKeown, *China Coast Meteorology,* esp. Ch. 4.

[93] John McAleer, 'Stargazers at the World's End: Telescopes, Observatories, and "Views" of Empire in the Nineteenth Century British Empire', *British Journal for the History of Science* 46:3 (2011): 389-413; David Aubin, Charlotte Bigg and H. Otto Sibum, eds, *The Heavens on Earth: Observatories and Astronomy in Nineteenth-Century Science and Culture* (Durham, NC: Duke University Press, 2010); Kapil Raj, *Relocating Modern Science: Circulation and the Construction of Knowledge in South Asia and Europe, 1650-1900* (Basingstoke: Palgrave Mamillan, 2007); Katherine Anderson, *Predicting the Weather: Victorians and the Science of Meteorology* (Chicago: The University of Chicago Press, 2005).

In both ports however, it is possible to see the influence of factors closer to home. The weather, especially the typhoon and monsoon seasons respectively, played a role in directing the trajectories of the meteorological services in both colonies. In Hong Kong, the typhoons that annually wreaked havoc on the island demanded attention, stimulating discussion and research in storm theory, and investment in storm warning systems. In Singapore, the lack of such extremes meant that the formal meteorological service developed later, although the need to improve rainfall observations was a significant stimulus toward increasing registering stations across the country. The mariners who traversed the China Seas were also major players in understanding the tropical weather during the nineteenth century. It was they who witnessed first-hand storms and typhoons and made breakthroughs based on experience, often in contrast to prevailing theory. Thus, the combination of marine and terrestrial weather observers across the China Seas was critical to regional meteorological science.

Personalities and people also played a major role in the different histories of meteorology in the two ports. In Singapore, despite the lack of an observatory to direct research work, support and interest from the influential George Maxwell and Herbert Robinson helped to eventually reframe the meteorological services there. In Hong Kong, the series of colonial governors, especially Frederick Stewart in the early years, were key to pushing the successive observatory directors to focus more on meteorological work. Likewise, the difficult relationships sustained between William Doberck and the Jesuit scholars at Manila and at Shanghai was a significant, even dangerous, problem. The personality of key players affected the communication of meteorological observations between Manila, Shanghai and Hong Kong which, as we saw in 1899 and in 1906, could have serious consequences. This article has not focussed on the controversies generated by Doberck in his relationship with these two observatories as that topic has been covered in depth elsewhere, especially by Kevin MacKeown. Suffice to say that Doberck's difficult relationship with the Jesuit scholars at both observatories added to the problems already inherent in the communicational infrastructure. The telegraph was a vital but erratic tool, subject to breakdown and interruption. When working, however, it formed the basis on a remarkable network of meteorological scholars and organisations crossing Asia from Japan to Hong Kong, from Russia to Singapore. This physical network formed the basis of the scholarly network that corresponded on research and innovation including the regional storm signal system, and which gathered at the imperial meteorological conferences of the early twentieth century. Much more work needs to be undertaken on piecing together the personal dynamics and scientific discoveries of this incredible network, in addition to that already undertaken for Manila and Shanghai.

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