

For an empire of 'all types of climate': meteorology as an imperial science

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This article explores the relationship between meteorology, British imperialism and evolving forms of scientific internationalism in the twentieth century. Focussing on a series of imperial meteorology conferences begun in 1919, it is shown how the British Empire was positioned in the interwar period as a corrective to skewed forms of scientific internationalism which were emerging in meteorology, with standards and data formats biased towards Northern climates. Possessed of an empire of 'all types of climate', British meteorologists identified themselves as a counterbalance to a perceived eurocentrism in international meteorology. The Empire was thus a convenient shortcut to a truly 'global' science, while meteorology itself emerged as a potentially powerful new resource as aviation and agricultural developmentalism took hold. The paper contributes to debates about the spatialities of scientific practice, offering the imperial as an interstitial space where a new globalism might be reconciled with the Empire's diversity of climates and meteorological techniques. It argues that empire was an important way in which meteorology became global – both in its subject matter and in its practices.

Keywords: history of meteorology; internationalism; geography of science; climate; empire; conferences

Those concerned with science's geographies have insisted that the powerful globalism of disciplines like meteorology lies not simply in their truth-production but in their ability to master space.¹ The making of knowledge which can transcend the local circumstances of its production demands the spatial extension and mobility of tools, techniques and ideas. Creating authoritative knowledge of space requires the replication of place – the laboratory or the observatory – in and through networks tethered to coordinating 'centres of calculation'.² The emergence in the second half of the twentieth century of the climate as an intrinsically global system attests to the successful construction of a global calculative apparatus, facilitated by what Paul Edwards calls 'infrastructural globalism'.³ This globalism

has a particular historical depth, rooted in the internationalist ambitions of early twentieth-century European meteorologists, but brought to maturity in part through the power of Cold War-era American scientific diplomacy.⁴ With the post-World War II rise of the governmental World Meteorological Organization (WMO), cooperative internationalism could bear fruit in the form of newly global visions of the atmosphere. Current historical work on meteorology has narrated this triumph of the global, which culminated in the rise of global predictive modelling.⁵

This paper explores the period before the triumph of Edwards' infrastructural globalism. The first half of the twentieth century was a period of faltering internationalism in meteorology, as the voluntarism of the International Meteorological Organization (IMO, the WMO's non-governmental predecessor) struggled to unite the world's meteorologists around a shared calculative apparatus in the face of diverse standards, data formats, practices and interests. Katharine Anderson has argued that 'the meaning of global science needs to be investigated through... shifting contemporary characterizations of meteorology as global, national, or local science'.⁶ This essay responds to this challenge, but seeks to add another spatiality to Anderson's triptych: meteorology as imperial science. In meteorology, intersections of atmosphere and empire are suggestive of spatialities which trouble Anderson's hierarchy of global, national and local.⁷ As Helen Tilley has argued, imperial scientific institutions 'occupied an interstitial space that was neither national nor international', while Joseph Hodge has described imperial science as a site where the pursuit of universalist aims (such as 'development') occurred through new ways of dealing with local specificities.⁸ In the case of British Empire meteorology, it is argued here, this interstitial space was defined in both scientific and governmental discourses as one of great climatic diversity, of a kind which

posed challenges to an emerging globalism in meteorological practices while also presenting opportunities for new kinds of economic exploitation. By examining the work done by this idea of diversity in the interstitial space of Empire, we can further understand, in meteorology, 'the ways in which ideas and techniques moved across nations, empires, and international bureaucracies'.⁹

This paper investigates the role of empire in meteorology's shuttling between the local and the global, the national and the international. Imperial meteorology emerges here as a science steeped in evolving national interests and imperial priorities, but also positioned as a corrective to a biased internationalism and a waypoint on the road to a truly global science. Taking the British Empire as an example, the focus is a series of meetings convened between 1919 and 1989 known as the Conference of Empire (later Commonwealth) Meteorologists (CEM or CCM). In their negotiation of emerging international standards and practices in the face of imperial climatic diversity, the conferences present a means to examine how a global calculative apparatus was being constructed *through* Empire. However, this was far from a post-national, post-ideological notion of scientific internationalism.¹⁰ Rather, this is also a story of the construction of a calculative apparatus *for* Empire, as meteorologists responded to pleas for greater contributions to economic and military projects. The paper focuses especially on the meetings which took place in 1919, 1929 and 1935. By focussing on discussions of aviation meteorology, the suitability of international data codes for colonial climates and the possibilities of agricultural meteorology, it is shown how imperial meteorology was positioned as a calculative apparatus adapted to shifting global and local conditions.

As well as being an age of imperial revival and flux, the interwar period saw rapid change in meteorology as the technologies of the aeroplane and wireless telegraphy, along with new theories of air masses and fronts, transformed the possibilities and expectations of weather prediction.¹¹ The argument is that narratives of twentieth-century meteorological internationalism which fail to account for imperial structures and their infrastructural residues miss an important set of building blocks in the socio-technical construction of a modern scientific discipline with a distinctly international (albeit greatly uneven) geography and a conspicuously global field of vision. In more recent years this global vision has produced concerns about anthropogenic climate change, and Commonwealth Meteorologists conferences have accordingly shifted their focus from geographic diversity to temporal change. But the chief claim of the paper is that, through efforts to reconcile an emerging globalism with the climatic diversity of Empire, early twentieth-century British imperial meteorology was a key, yet heretofore neglected, element of how meteorology became global – both in its subject matter and in its practices.

EARLY STIRRINGS OF AN IMPERIAL METEOROLOGY

Jan Golinski concludes his study of eighteenth-century British weather knowledges by ruminating on the geographies of Enlightenment-era meteorology. The seventeenth and eighteenth centuries saw repeated attempts to perfect a Baconian system of observation and theoretical induction, with characters like Joseph Hooker, Robert Boyle and Henry Cavendish repeatedly insisting on the need for greater coordination in meteorological observation around the British Isles and, increasingly, beyond.¹² Other European elites also sought to encourage greater imperial coordination of British scientific practice. Echoing Alexander von Humboldt's pleas of 1836 for the Royal Society to make better use of the

geographic expanse of British colonial possessions for scientific purposes, European meteorologists at early twentieth-century international meetings continuously referred to the importance of the publication of meteorological data from 'distant regions'.¹³ For G.K. Lempfert, Assistant Director of the Meteorological Office, '[t]hese resolutions were in large measure... directed at us of the British Empire'.¹⁴

Lempfert's imperial self-admonition reveals anxieties about the failure of British meteorology to appropriately coordinate its imperial activities. Although meteorology had become, along with its geophysical siblings, 'a means for the scientific mastery of geographical space', it was far from a globally unified or coordinated discipline.¹⁵ However, at the dawn of the twentieth century the practical empiricism (and even parochialism) of official British meteorology – as described by Anderson – was giving way to a new interest in worldwide 'centres of action', wherein large pressure or temperature gradients might hold the key – through carefully sited observatories – to understanding weather patterns across large expanses of the globe.¹⁶ In India, John Eliot had come to realise, through his work on the Indian monsoon, that making sense of a space like the Indian Ocean as a whole, where weather on one side was seemingly linked to weather on the other, would have to be a metropolitan project.¹⁷ Likewise, the Meteorological Office's new chief, Napier Shaw, was being drawn to 'suggestive' correlations between UK rainfall and the southern trade winds, as captured by an anemograph lent to the colony of Saint Helena.¹⁸ Against this backdrop, in 1905 a committee of the British Association for the Advancement of Science (BAAS) made recommendations to the British government that the London Meteorological Office should take responsibility for the coordinated compilation, publication and analysis of meteorological data for the entirety of the British Empire. The renowned meteorologist

Alexander Buchan and geographer and British Rainfall Organization director Hugh Robert Mill joined Napier Shaw and the committee members of the Mathematical and Physical Science section of the BAAS in lobbying for imperial coordination, responding in no small part to pleas for greater imperial cooperation made by Eliot at the previous meeting. The 1905 memorandum, published in the proceedings of the BAAS's 1905 meeting in South Africa and subsequently conveyed to the Colonial Office, argued that the 'organisation of a Central Meteorological Department for the British Empire would be of the highest benefit to the progress of Meteorological Science and its application to the economic problems of the various Colonies and Dependencies'.¹⁹

1905 also saw a discernible increase in the amount of commissions the Meteorological Office was performing for the crown colonies, most notably in the supply of instruments.²⁰ But even as the circulation of instruments around the Empire intensified, the committee's memorandum pointed out that there was still 'no provision for the systematic treatment of the meteorology of the British Dominions' and colonies. India, Australia, New Zealand, Mauritius and a few of the states of modern day South Africa had institutions charged with the conduct and compilation of meteorological observations. Important records were started in places such as Singapore and Toronto with the onset of the Magnetic Crusade of the 1840s, but datasets were often discontinuous.²¹ A rudimentary network of twenty-nine overseas and colonial observatories was maintained by the Royal Engineers from 1852, and then by the Army Medical Department from 1862 to 1886.²² Data from this network and from nascent meteorological organisations in sub-Saharan Africa was compiled and published by the German-English geographer and cartographer E.G. Ravenstein through the BAAS in the 1890s, while meteorologists in Australia and India had been sharing rainfall data

amid nascent understandings of global atmospheric connectivity.²³ But, for the Empire as a whole, the lack of a comprehensive system of data exchange meant that the imperial atmosphere, as an interconnected space, was largely unknown.

In recommending the establishment of a 'distinct department' of the Meteorological Office, 'with separate provision', to be headed by a new assistant director, the committee outlined three new roles: to advise colonial and dominion governments on instruments and methods of observation; to compile and periodically publish data on the 'climatic conditions of the various parts of the Empire'; and to provide a scientific staff to analyse the patterns of imperial weather, to formulate meteorological laws, and 'ultimately... anticipate the occurrences of abnormal seasons'.²⁴

The Meteorological Committee, an oversight body chaired by Shaw and constituted largely by government officials and academics with a stake in the work of the Meteorological Office, conveyed their support of the BAAS memorandum to the Colonial Office and the Treasury.²⁵ However, the Committee protested that, without the provision of extra funding, the Office could not take on the responsibility of coordinating an imperial programme of meteorological observation and theoretical induction. A new section with a new assistant director would require a not insignificant addition of around £2,000 to the Office's annual parliamentary vote of £15,300. But the Treasury made it clear that no extra funds would be forthcoming, and suggested that 'the requirements of the case could be substantially met by the improvement of the meteorological information contained in the various Colonial Reports'. Rather than the UK government footing the bill for imperial coordination, 'the several Colonies and Dependencies should be requested to supply such information on a common (and extended) form in their periodical reports', with the director of the

Meteorological Office acting as an advisor, through the Colonial Office, on the form which these circulating statistics should take.²⁶

The actual practice of colonial meteorology was far outside the control of the Meteorological Office, reflecting the assumption that colonies should be largely self-sufficient in their governmental conduct. Circular instructional memoranda only yielded modest convergences and improvements in colonial meteorological technique, as reflected in the jumble of differently-formatted tables, mis-named variables and statements of errata which constituted the Meteorological Office's reprints of colonial returns, which began in 1910.²⁷ The persistently patchy quality of the returns forced the Meteorological Office, in 1923, to begin publishing notes alongside the numbers detailing the conditions and inconsistencies of the data collection, weighing their credibility. This 'meta-data', as it would be known today, was generated by a questionnaire sent from London to those responsible for enumerating the weather in the colonies.²⁸

Following the failure of the proposal for an Imperial Meteorological Office, metropolitan minds turned from coordinating and gathering the Empire's weather data to gathering together its weather men. The thrust again came from John Eliot, and plans were hatched to hold a meeting alongside the gathering of the Royal Society of Canada in May 1908.

However, Eliot's death in March of that year and an insufficient number of Empire representatives in attendance precluded the convening of an official meeting. Nonetheless, when the caravan of the BAAS rolled into Winnipeg in 1909, a few imperial delegates gathered in a hotel to discuss plans for the colonial weather summaries, and resolved that '[i]t is desirable to arrange for the exchange on an organised basis of meteorological data between the different portions of the British Empire'.²⁹ Following consultations with other

colonial meteorologists, the plan saw the Meteorological Office taking on the responsibility for reprinting colonial returns and distributing them to the wider scientific community. The 1909 gathering of imperial meteorologists also saw discussions of standardized units for pressure and temperature which formed, for Meteorological Office synoptician and World War I military meteorologist Ernest Gold in later reflections, 'the basis of the *Réseau Mondial*' – the IMO's attempt to construct a representative 'worldwide network' of climatological stations which would produce a global picture of the atmosphere.³⁰ The *Réseau Mondial* had been proposed by Léon Teisserenc de Bort in 1905, building on earlier arguments for the establishment of new weather stations in the great meteorological 'centres of action'.³¹ An IMO commission was appointed for its execution in 1907, but the scheme faltered in the face of 'prohibitive expense' and de Bort's subsequent death.³² Reflecting the new prominence given to international issues within the Meteorological Office, Napier Shaw took on the responsibility for the network, but the barriers to receiving data on time and in the correct formats proved great and publication was often delayed by over a decade. Nonetheless, the *Réseau Mondial* broke new ground in international cooperation and its datasets still form an important part of centennial scale climate reconstructions.³³

The 1909 meeting highlights the ambiguities of meteorological internationalism, as plans were hatched in the same room for both imperial coordination and a more classically 'internationalist' form of cooperation in the *Réseau Mondial*. In both cases metropolitan ambition would soon rub up against the vagaries of local meteorological practices and the governmental structures in which they were embedded. Although the boundaries between, and relative value of, theoretical (or 'pure') meteorology and applied, governmental

meteorology were still uncertain and contested, the systematic study of the weather was emerging as a key marker of modern statecraft.³⁴ In 1877 Major George Chesney, promoter of more direct British involvement in the government of India, remarked that the 'study of the rainfall is one of the first duties of a civilized government'.³⁵ Later, Sir George Simpson, head of the Meteorological Office from 1920 to 1938, ruminated on how the early years of the twentieth century saw meteorology go from being 'a somewhat despised science' to 'an important Government department and an indispensable part of public service'.³⁶ Meanwhile, the role and status of the British Empire was up for debate and, as many scholars have shown, science and technical expertise offered either legitimation or new potential to imperial projects, with the notion of 'development' becoming an organising principle of imperial paternalism.³⁷ Imperial science, themed around a nascent 'unity of concept and action through cooperation', offered a model imperial polity.³⁸ For members of the metropolitan elite like Shaw and Simpson, a globalised meteorology could contribute both to the development of unifying geophysical laws as well as to the successful government and cooperative development of a widespread empire. In the rest of this paper, I follow the evolution of British imperial meteorology up to the mid twentieth century. The periodic Conferences of Empire Meteorologists provide both a convenient lens onto British meteorological practice and a means of making sense of the metropole-colony tensions which marked the slow emergence of meteorological globalism.

1919: A NEW ASSOCIATION

Although the first officially constituted 'Conference of Empire Meteorologists' was held in 1929, the series arguably started in 1919 with the holding of the Conference of Meteorologists of British Dominions. Despite the Meteorological Office taking on in 1910

something of the imperial clearing-house role envisaged by the 1905 BAAS committee, there was little systematic coordination of empirical and theoretical meteorological work around the Empire before and, especially, during World War I. For Napier Shaw, however, the war gave renewed urgency to the question of imperial coordination. He wrote to the under-secretary of state in the Colonial Office to outline his thinking:

the scope of meteorological work has been very much widened by the experience of national and imperial requirements during the war, and the extension of aerial navigation will form a new means of communication, even between the most widely separated parts of the Empire, which is more dependent than other means of communication upon effective knowledge of meteorological conditions.

For Shaw, although the Great War had riven the world asunder, it had also made the world smaller, as the possibilities of aerial transport gave a new complexion to imperial relationships. Suddenly it was the atmosphere, and not just the oceans, which was the connective space of the British Empire. This new atmospheric imperialism meant that meteorology could and should be central to post-war efforts to reorder fractured societies and international relationships. Writing to the minister for reconstruction, Shaw argued:

As a part of reconstruction the collection of a body of statistics upon which to base information about climate and weather in the British Isles and the other parts of the British Empire ought now to be systematized.

Existing connections between British and colonial services needed strengthening, and Shaw was now convinced that a formal conference was the way to proceed, as opposed to either a dedicated arm of the Meteorological Office or the kind of *ad hoc* gathering in the Canadian hotel of 1909.³⁹ Initially scheduled to coincide with and feed into the Paris peace

negotiations in early 1919, which would feature discussions on international aerial navigation, the conference was eventually held in September of that year in the rooms of the Royal Society.

The conference was attended by representatives from Australia, Canada, Ceylon, Egypt, India, New Zealand and South Africa.⁴⁰ Alongside them sat representatives of various branches of the Meteorological Office, the Air Ministry, the Admiralty's Meteorological Service and, at his own request, Conservative peer and aviation enthusiast the 2nd Lord Montagu of Beaulieu.⁴¹ Drawing on wartime experiences of military coordination, those assembled discussed arrangements for the exchange of data by wireless telegraphy on land and at sea in the service both of data accumulation and of emerging forms of aerial transport.⁴² Techniques for upper air observation and the selection of new stations for the *Réseau Mondial* initiative also filled the agenda, as the meteorologists used their imperial reach to seek a new calculative apparatus capable of offering a global picture of the atmosphere. Yet from the limited documentary evidence that remains, the conference appears to have mainly been an exercise in information-sharing and acquaintance-making; most of these people had never met before.⁴³ Notes were exchanged on the actual form of the different meteorological services being represented – a surprising indication of the lack of knowledge these services had of each other, and sometimes of themselves. The head of the South African service, for example, revealed that he didn't even know how many weather stations he had feeding information in to his office.

Matters of technical standardisation were prominent – such as the agreed timing of meteorological balloon ascents – but formal agreements and decisions were deferred to the forthcoming meeting of the IMO in Paris. So, with formal mechanisms of coordination off

the table or deferred, discussion centred instead on techniques of cooperation, with goals ranging from the statistical analysis of the Empire's seasonal weather data to the meteorological colonisation of territories recently ceded by Germany. The most enthusiastic supporter of imperial cooperation was the Reverend Colonel D.C. Bates of New Zealand. This was the first time that New Zealand had been represented at any international meteorology conference, and Bates admitted to finding it all 'very tedious'.⁴⁴ But his interest was piqued by the possibility of aligning his own scientific interests with those of others, declaring early on that 'the Dominion has endeavoured to follow Great Britain and fulfil its obligations to its own people, to the Empire and to the scientific world'.⁴⁵

It was Bates who initially proposed the resolution that the conference be put on a permanent footing. In New Zealand, Bates saw a lack of resources and limited scope for international cooperation as hindering meteorological progress. Imperial cooperation, however tedious to organise, was the answer:

Organisation on an Imperial basis can alone create standards for the scattered dominions and keep the several meteorological services efficient in a time of change such as the present crisis of financial stress and political strife.⁴⁶

Bates saw himself as an agent of 'British science', expressing concern for example that in Samoa, recently placed under New Zealand's trusteeship and home to a 'fine Meteorological Observatory' of German origin, the failure to coordinate resources to support meteorology could lead to a loss of 'prestige' for 'British science... in the Pacific'.⁴⁷ Bates and others at the conference clearly saw the opportunity to strengthen the worldwide activities of this 'British science', and to amplify the diverse voices which constituted it in international settings like the IMO. A resolution was passed expressing 'regret that the

Meteorologists of the Dominions have not had any opportunity of considering the meteorological details embodied in the [1919] Convention relating to International Aerial Navigation'.⁴⁸

Marshalling the voice of the community of imperial meteorologists in response to other forms of internationalism, such as conventions governing the provision of weather information for pilots, would become a key tenet of the Conference of Empire Meteorologists as it would evolve over its following iterations. But the 1919 conference was also a site where the geographic diversity of nascent meteorological services could be exploited to imperial gain. This is clearest in the calls of H.D. Grant, superintendent of the Admiralty Meteorological Service, for the centralization of theoretical study of the tropical storms of the Atlantic, Pacific and Indian Oceans – all of which threatened British shipping and commerce. The practice of tracing storm tracks on the reverse of monthly weather reports, and computing only average storm paths, was insufficient when it was the extreme, rather than the mean, which was the key object of anticipation.⁴⁹ Grant therefore proposed 'that this aspect of Meteorology should be made a special study of the British Empire State Meteorological Office in London', and the conference resolved that 'an Organisation be established to deal with the question on imperial lines'.⁵⁰

Although the US Weather Bureau had established a hurricane warning service across the West Indies in 1898, the slower work of analysing how hurricanes work was considered something that the British office, although always far from the eye of the storm, had a stake in pursuing.⁵¹ The desire to make sense of the weather's extremes, rather than just the circulating averages of meteorological summaries, reflected also a wish to come to terms with the climatic diversity of the British Empire through strategies of imperial coordination

and cooperation. But the centralisation of hurricane studies in London was not a metropolitan initiative imposed on the imperial meteorologists. It was rather a seemingly consensual move, perhaps gaining legitimacy through the face-to-face interactions facilitated by this new technology of British science policy, the imperial conference.⁵² As will be explored below, through this and other decisions the Empire was collectively figured as both a shortcut to a truly global understanding of atmospheric circulation, and a way of relating emergent global practices to the regional and local variations of climate with which British administrators were becoming increasingly familiar.⁵³

1929: BETWEEN AIRSPACE AND MICRO-CLIMATES

At the much larger Conference of Empire Meteorologists in 1929, the rhetoric of imperial coordination, cooperation and service would reach a new level. The 1929 conference occurred in the aftermath both of the consequential Imperial Conferences of the 1920s, and after a number of other imperial scientific conferences, the most significant perhaps being the Imperial Agricultural Research Conference of 1927 which led to the establishment of eight new agricultural research bureaux (Table 1). Such events commonly featured quixotic rhetorics of imperial unity, although earlier organicist metaphors of the scientific and commercial coordination of a single, imperial body were increasingly giving way to an enthusiasm for cooperation, whose 'mechanism was not to be the formal command, but the informal conference'.⁵⁴ In the field of forestry, imperial conferences were held regularly in the interwar period with the ambition of bringing the Empire's diverse epistemic and technical practices of forestry into greater union, with the state forestry of India providing a seemingly durable and transportable model.⁵⁵

Table 1 Interwar imperial science conferences

Dominions/Empire Meteorologists Conferences	1919, 1929, 1935
Empire Forestry Conferences	1920, 1923, 1928, 1935
Imperial Entomological Conferences	1920, 1925, 1930, 1935
Imperial Botanical Conference	1924
Imperial Mycological Conferences	1924, 1929, 1934
Imperial Agricultural Research Conference	1927
Empire Survey Officers Conferences	1928, 1931, 1935
Commonwealth Scientific Conference	1936

Based on Tilley, Africa as a Living Laboratory, p131

The first forestry conference of 1920 occurred amid the din of 'ardent British imperialists' articulating the 'ambitious hope that a self-sufficient, supremely competitive Empire would emerge as a special corrective to rapidly evolving international insecurities'.⁵⁶ After a decade of relative prosperity and advances in the sciences of the air, a similarly heady mix of technological optimism and bombastic political rhetoric pervaded the 1929 meteorological proceedings.⁵⁷ As aviation technologies had advanced, hopes that the red blocs of imperial maps could be tied together by an efficient, British system of air transport were beginning to materialise.⁵⁸ Likewise, airships offered the prospect of a slow, dignified mode of imperial transport. The success of both of these technologies would be dependent on the careful marshalling and coordination of meteorological knowledge.

While the forestry conferences largely aimed at furthering the spread of the Indian model of forest management (initially enshrined in the Indian Forest Charter of 1855), the meteorology conferences gave greater weight to metropolitan practices and priorities. For the Air Ministry, the chief aim of the conference was to 'bring before the Empire meteorologists the problems of Empire meteorology and to show how they were being

dealt with in Great Britain'.⁵⁹ This time, invitations were sent out through official diplomatic channels, although the Meteorological Office had first consulted the directors of the dominion services as to whether or not the heads of the colonial services should be invited at all. The dominions unanimously agreed to colonial inclusion, but the fact that the Meteorological Office considered that an Empire conference could be sufficiently imperial with only dominion representation reflects the fact that aviation, with its emerging geography of inter-dominion mobility, was top of the list of subjects to be discussed. Trans-continental flying required not only the circulation of knowledge of average atmospheric conditions in different parts of the globe, but also the production of short-term forecasts for pilots before take-off and the intricate coordination of information provision from meteorological services to pilots *en route*. Here, the subject matter of an imperial meteorology was not just the global atmosphere as a dynamic physical system, but as a complicated and hazardous space to traverse.

As with most of the conference topics, discussions began with a detailed outline of British practices, reinforced by visits to the Cardington airship works and Croydon aerodrome, where delegates could inspect the 'elaborate meteorological organisation' already established by the British office.⁶⁰ Imperial Airways even treated the meteorologists to a short flight in an air liner, which for many may have been their first experience of being airborne. With the shape of British practices firmly established in colonial minds, the dominion or colonial service representatives could then respond with their own experiences or with pleas for flexibility in the introduction of uniform methods. Sub-committees were set-up to consider the specific requirements for aerial navigation on the Cape-to-Cairo and London-to-Karachi routes. Notes were compared in a plenary session about the uneven

geography of upper air observations and the difficulty of obtaining hydrogen for pilot balloons in remote colonial locations. Disagreement reigned on the correct way to monitor and record thunderstorms, whose violence and intermittency posed challenges both to airship navigation and to disciplined meteorological observation. How to even define a colonial thunderstorm? Relying on lightning could cause confusion with the sparks of new electric trains, but sometimes there would be no audible thunder. Precipitation was an unreliable signifier as dry South African storms were among the most dangerous. D.C. Bates thought that the audible occurrence of thunder would be 'satisfactory for natives to observe', but in Malaya thunder could be heard almost every day, rendering the British suggestion of recording the frequency of thunder heard somewhat problematic. Across Malaya and neighbouring regions, 'the frequency of actual thunderstorms' observed by eye was recorded by lighthouses and steamships, but this conflicted with the emerging British practice of recording for airships the audibility of thunder – a tactic which offered information for a wider area. In the end, the meeting agreed that 'the specification of frequency of thunder heard should be adopted, but that observations should be supplemented by the frequency of thunderstorms and possibly by observations of lightning'. This discussion set the tone for the rest of the conference – metropolitan calls for imperial standardisation, followed by colonial pleas for flexibility, with compromise eventually reached and framed with ungainly caveats catering to diverse local needs and practices.⁶¹

Between the 1919 and 1929 conferences changes had been afoot in broader forms of meteorological internationalism. Excluded from IMO discussions in 1919, German and Austrian meteorologists had been welcomed back into the fold by the mid 1920s, and new consensuses had been emerging on observing techniques and on the standardisation of the

codes used in wireless transmissions of data between observatories, ships and aeroplanes.⁶²

A global system of marine meteorology was emerging whereby 'selected ships' under different national flags would be responsible for collecting and communicating standardised meteorological data. The 1929 Empire conference saw responsibilities for the data from dominion-registered ships begin to be shifted from London and onto the dominion meteorological services, in a Balfourian redistribution of data sovereignty. At the subsequent IMO meeting, each nation was formally made responsible for collecting data from their allotted number of observing ships.⁶³ But while we may consider bodies like the IMO as operating on a broader spatial plane than the Empire Meteorologists – coordinating global infrastructures and bringing imperial practices into line with those of other powers – the dominance of European and North American voices in the ostensibly global fora of the IMO meant that the British Empire emerged in this period as a competing object and subject of meteorological internationalism. It was internationalist not in the sense of being apolitical or inherently peaceful, as the prominence of military concerns (relating for example to smoke screens, gunnery and military aviation) at the Empire conferences attests. Rather, for those metropolitan meteorologists well-versed in the frustrations of the IMO, the Empire offered a ready-made confederation of like-minded nations and thus an alternative route to a meteorology global in both its subject matter and practices.

This was particularly true of Napier Shaw in 1929. Now retired, and his new unofficial status perhaps enabling a more expansive rhetoric, Shaw claimed that he knew of 'no organisation more suited' to the task of meteorological globalism 'than the British Empire which within its boundaries comprise[s] all types of climate'.⁶⁴ While this could simply be the metropole making a virtue of necessity, for Shaw this climatic diversity seemingly offered a corrective

to the skewed globalism of other international fora like the IMO. This corrective was pursued in discussions of the applicability of, for example, internationally agreed data transmission codes to tropical climates. While metropolitan voices prioritised uniformity, colonial delegates from beyond the temperate latitudes asked where, in the international codes put forward by the IMO, was a place to communicate Egyptian dust storms, the haze of the Indian plains, the squalls of the East African coast, or – in a common refrain – the simple diurnal variations of many tropical climates which were unlike anything in the high latitudes. Despite British representatives again emphasising the need for global homogeneity, delegates from tropical countries largely concurred with India's C.W.B. Normand in affirming that he 'did not think it possible to devise one code that would be suitable for the whole world... [T]he provision for two alternative codes... offered opportunities for elasticity'.⁶⁵ The Empire conference agreed alternative code formations whereby the final sections of the precisely formatted wireless message were adjustable to the specifics of local climates. This flexibility was then formally adopted in the IMO's guidelines at the subsequent international conference in Copenhagen.

In the exchange of synoptic weather messages, and in messages between ships and shore stations, a new level of global homogeneity was achieved precisely through the technical accommodation of the apparent heterogeneity of global weather conditions. Following the seemingly fractious exchanges in London between metropolitan and colonial meteorologists, British Empire representatives positioned themselves as the spokespeople of this heterogeneity.⁶⁶ In contrast to earlier pleas from the likes of von Humboldt for the British to make better use of colonial data, now their Empire of 'all types of climate', with its mobile meteorologists, reams of data and diverse, situated scientific practices was being

constructed as what Michel Callon might call an 'obligatory passage point' – a means of shuttling between the local and the global, the national and the international; an interstitial space for reconciling the vagaries of local practice with the vaulting ideals of scientific internationalism.⁶⁷

We can see, therefore, how the Empire was being positioned as part of the process by which meteorology could become global in its subject matter by becoming appropriately global in its practices. But this will to standardise amid the climatic, governmental and practical diversity of Empire was also geared towards more straightforwardly material gains. At the 1929 conference the Empire Marketing Board (EMB) sponsored three days' worth of discussion of agricultural meteorology. Formed in 1926 by Colonial Secretary Leo Amery, the EMB was a response to the view that, in the face of a still divided Europe, '[i]t looks as though the ideal economic unit of the future would be a unit combining both temperate and tropical countries. The British Empire presents special opportunities for the creation of such a unit'.⁶⁸ With an eye on the USA and a perception of direct links between American climatic diversity and economic vitality, a climatic sensibility at the heart of the EMB mission led to an enthusiasm for the opportunities offered by agricultural meteorology. This was a sub-discipline which was, and perhaps still is, ambiguously defined as either the application of existing meteorological knowledge to agricultural practices, or the pursuit of new knowledges of plant-atmosphere interactions. The EMB, as part advertising agency, part substitute for 'imperial preference' trading tariffs, and part research funder, was keen to support this field, however ill-defined. The EMB had already funded the retired Napier Shaw to the tune of twenty-five guineas to conduct preliminary investigations into the correlation between weather and sultana crops, but he found little, and argued that extremes of

temperature – again rendered invisible by circulating meteorological averages – were the likely causes of yield variation.⁶⁹ So when word got around that the Empire's meteorologists were returning to London, the EMB, with support from the Ministry of Agriculture and Fisheries (MAF), sensed an opportunity to refine the calculative apparatus through which the Empire's climates could be rendered economically productive.⁷⁰

British agricultural workers involved in the Crop Weather Scheme, a joint research initiative of MAF and the Meteorological Office, were invited to attend the agricultural discussions, and a larger hall at the Civil Service Commission in Burlington Gardens was secured for the occasion. The discussions between the assembled meteorologists and agriculturalists, with Napier Shaw in the chair, were somewhat strained, at least initially. The two parties struggled to agree on the spatial boundaries of each other's expertise and responsibility. Did epistemic responsibility shift from the plant scientist to the meteorologist at the boundary of the leaf, the top layer of the soil, or somewhere in the wider agricultural landscape? Echoing more recent debates about the interface between climate models and studies of climate change impacts, agriculturalists complained that extant meteorological data was ill-suited to their calculative needs. Meteorology, it seemed, offered spatial abstraction from a few, approximately representative points in space. But the agriculturalists were more interested in the specificities of the points themselves; alas, 'there is no crop growing inside the rain gauge'.⁷¹ The meteorologists – led by the new head of the Meteorological Office, George Simpson – retorted that they simply didn't know what variables the agriculturalists were interested in, and it was the latter's job to define which variables were relevant.

Despite renewed interest in matters of weather and climate among foresters during this period, imperial forestry never made it onto the Empire meteorologists' agenda, even with

topics like the suitability of imported crops to new colonial soils and climates echoing contemporary conversations within in the arboricultural community.⁷² It was perhaps the new institutional presence enjoyed by agricultural meteorology in Great Britain, particularly within MAF and the EMB, which enabled the meteorological community to be drawn into direct, if contentious, discussions with these particular potential users of their knowledge. Napier Shaw privately expressed surprise that, far from the conference as a whole sticking to 'its meteorological mutton' and questions of aerial navigation, the 'Ministry of Agriculture managed to get the other applications of meteorology into the limelight'.⁷³ Perhaps as a result of Shaw's 'remarkable firmness' in the chair, some agreements were eventually reached between the agriculturalists and meteorologists.⁷⁴ Resolutions were passed on the need for improved joint working, for climatic pedagogy in the Empire's schools, and to average weather data by the week rather than the month. The suggested establishment of an imperial clearing house for agricultural weather data was greeted particularly enthusiastically. Shaw himself reprised his contribution to the 1905 calls for an imperial weather centre by supporting the establishment of such a clearing house:

If the range of climate and weather in the United States of America requires a Weather Bureau to prevent its citizens' efforts from being wasted, for want of knowledge of the weather and its meaning in beneficence and maleficence, what sort of Weather Bureau does the British Empire require in order to make the most of the soil that it possesses?⁷⁵

Shaw's reference to the US Weather Bureau echoes the EMB's envious eye on the US and its apparent economic mastery of its climatically diverse territory. The clearing house idea was subsequently investigated by a sub-committee of MAF's Agricultural Meteorological

Committee, which found that the youthfulness of the science perhaps made such a bureau as yet unnecessary. Data from the temperate dominions was already circulating to the benefit of British workers. In the tropical Empire, efforts should be concentrated on improving meteorological networks before seeking to apply data to agriculture.⁷⁶ Formal decision was nonetheless deferred to the Imperial Agricultural Research Conference planned in Australia for 1932 which, owing to the ensuing worldwide economic crash, never happened.⁷⁷

Despite the agricultural section of the 1929 conference not having the institutional legacies some had hoped for, the gathering nonetheless tells us something about the paths being taken by imperial meteorology in this period. The meeting contributed to the ongoing formalization of imperial cooperation in agricultural research described by Joseph Hodge, and illustrates how meteorologists were responding – or were being encouraged to respond – to evolving practices and ideologies of imperial development.⁷⁸ In the context of international data standards, the Empire's climatic diversity had exposed the eurocentrism of emerging international agreements.⁷⁹ In the agricultural context, this diversity was considered an economic resource, ripe for science-led development. But embracing this climatic diversity demanded the social work of negotiating difference, whether between disciplines, or within meteorological practice. So while George Simpson protested that the agricultural micro-climate was 'really not the business of the meteorologist', and Napier Shaw derided the concept as fatuously self-contradictory, colonial meteorologists like British East Africa's Albert Walter embraced it whole-heartedly, reporting back to the next empire conference in 1935 on promising collaborative work with the agricultural scientists of the Amani Research Institute while stressing, again, that many of the standards and variables

favoured by metropolitan meteorologists had little value in the tropics.⁸⁰ For Walter, it had to be extremes rather than means, diurnal variations rather than daily averages. George Simpson again wondered aloud whether 'the study of micro-climatology was within the province of meteorologists', but in colonial settings disciplinary boundaries were clearly less sites of definition and exclusion, and more liminal spaces where novel solutions to emerging problems of colonial administration might be found.⁸¹ However, with the EMB having been wound-up in 1933, and the idea of a centralised clearing house put on ice, metropolitan scepticism about the proper place of agricultural meteorology saw it largely excluded from the 1935 programme.

1935: NEW REGIONALISMS

Eschewing the sedentary 'micro-climates' of crops, the 1935 conference focused much more on questions of aeronautical and military mobility. With the rise of both night-flying and so-called 'blind-flying' (military planes hiding out in clouds), methods of airborne sight and foresight were increasingly delegated to the meteorologist, and new demands for predictions of atmospheric visibility over wide areas placed a particular strain on efforts to coordinate meteorological services along new air corridors. The continuing rise of aviation saw new regional forms of meteorological coordination and competition emerging during this period. In the South American context, Gregory Cushman has described neo-colonial competition between German and American aviators and meteorologists during the interwar period, which saw early German dominance of commercial aviation primed by the application of German scientific expertise, particularly the influential maritime meteorology of the *Deutsche Seewarte*. But this dominance soon gave way to a new American hegemony, with Pan-American Airways attaining market supremacy by the mid 1930s and

relying to a large extent on their own private meteorological networks.⁸² Yet this neo-colonial space of competing foreign business interests and emerging forms of post-colonial dependency can be contrasted with colonial Africa, where the continuing presence of formal empires shaped different geographies of meteorological organisation. Here again we can see how British colonial interests influenced emerging forms of internationalism.

Africa had been a recurrent object of discussion at the 1929 talks, as the 'wildest parts' of the continent, as they were described in 1919, were being opened up to aerial navigation and meteorological investigation. The 1929 conference featured an important resolution to establish a meteorological service for West Africa, to be modelled on the new British East African Meteorological Service (BEAMS). The prominence and promises of African meteorology would continue into the 1935 Conference, when a sub-committee on meteorology in Africa was convened with the rapid development of aviation a key topic of concern. The committee was chaired by Albert Walter, former government meteorologist for Mauritius and now head of BEAMS. Building on the findings of this committee and the apparent need for continental cooperation beyond imperial boundaries, Walter proposed to a subsequent meeting of the International Meteorological Organisation that regional commissions be set up to deal with the specific meteorological requirements of different world regions. At the Empire conference Walter, according to his own memoirs,

took a very active part in the discussions. This was of course to be expected as the opening up of extensive areas in the tropics of Central Africa, which the East African service was controlling, brought a new dimension into the International [Meteorological] Organisation, which had hitherto been dominated by conditions obtaining in the high latitude European continent.⁸³

Walter's proposal for trans-imperial, trans-national regional commissions was adopted by the IMO, and Regional Commission No. 1 (Africa) met for the first time in Lusaka in August 1936, under Walter's chairmanship.⁸⁴ The resolutions and recommendations of this conference were roundly accepted by the IMO in 1937, which resolved that:

[the IMO] wishes to assure the Regional Commissions that it will give such consideration to any of their recommendations as will lead to modifications in International Resolutions, Codes and practice, to meet their needs, and so realise that world-wide uniformity which is so desirable.

Walter described this meeting and the setting-up of regional commissions – which persist within the WMO – as the greatest achievement of his career. His evaluation of the episode is worth quoting at length:

This resolution was a great achievement for me as it gave official recognition to a principle for which I had been contending for several years, that the colonial services and, especially those in the tropics, had to deal with conditions both administrative and scientific which had no parallel in the more advanced organisations of Europe and the meteorological conditions of higher latitudes.

Up to the present there had been a tendency on the part of our English colleagues in the Air Ministry to treat with contempt the colonial Directors who had not been recruited from the ranks of the Air Ministry officials, if they dared to suggest that problems of tropical meteorology were not amenable to treatment by methods laid down by the pundits who pontificated from Kingsway. I was particularly pleased that we had not only received the 'imprimatur' from the International authorities, but

had wrung an approving recognition from our principal critic in the English service, Colonel Gold himself.⁸⁵

We can see in this episode the role that the Conferences of Empire Meteorologists played in the evolving internationalism of meteorology. Walter's experience of running what was already essentially a regional service in East Africa was significant. Although the proposed unification of the East African colonies had recently been rejected, the East African Governors' Conference stood as a forum for sharing and coordinating colonial governance. The Meteorological Service was one of its first initiatives, although not without resistance from some of the East African governments who failed to see the requirement for a dedicated service. Persuasion largely came from London. A statement from George Simpson to the East African Governors was seemingly instrumental in persuading them of the value of a dedicated meteorological service. Simpson stressed the centrality of meteorology to aviation, and emphasised the route to uniformity:

meteorology cannot be done piecemeal, and the same methods and times of observations must be used throughout a continent. In Europe, in spite of strong national feeling, this end has been achieved by very close international co-operation. It is therefore obvious that it would be best if possible to start with a unified service in East Africa.⁸⁶

Starting in 1929 with a modest annual budget of £6,400 (the London Office spent £141,533 that year), the BEAMS drew on financial contributions from all of Britain's East African territories along with Egypt and Sudan, who saw value in improved rainfall information from the Nile headwaters.⁸⁷ Yet even by 1934, after five years of BEAMS, the governors were reluctant to invest more funds. J.E.W. Flood, assistant secretary in the Colonial Office,

commented on a plea from Walter for help from the Colonial Development Fund that 'the upkeep and expansion of a meteorological service is essentially part of the day to day activities of Govt [sic]. I want to batter that into them'.⁸⁸

Walter's experience of negotiating these competing demands and engaging in the socio-technical work of constructing a regional infrastructure fed into his drive towards the regional commissions. Africa was described in 1935 by N.P. Sellick, Southern Rhodesia's meteorologist, as a 'meteorological "Babel" with a chorus of mutes'.⁸⁹ While some in the Meteorological Office – like the synoptically-minded Colonel Gold – may have been sceptical about the scientific languages being spoken in this Babel, Walter and his allies in the Colonial Office saw in the territorial expanse of the British Empire a means for letting the African sky begin to speak with one voice. It was only from the basis of strong, autonomous colonial services, able to resist the kind of 'foreign' intrusions of private weather services as seen in South America, that Walter believed meteorology's coordinated conquest of space could continue.⁹⁰ In Africa, Walter's Regional Commission, a direct product of the 1935 Empire conference, was the coordinating instrument.

We have seen, then, how the Conferences of Empire Meteorologists – and the Empire more broadly – were spaces for negotiating between the demands of global standardisation and local accommodation to the Empire's climatic diversity. It is perhaps unsurprising that the scale of the region should emerge from these conferences as a form of international mediation between the emerging global order of organised meteorology and the local realities of running a shoe-string colonial weather service. If we consider, as Tilley suggests, the imperial as an interstitial space between the national and the international, in the

organisation of a global meteorology Empire produced the region as an enduring interstitial space between the local and the global.

WHITHER IMPERIAL METEOROLOGY? TOWARDS DECOLONISATION AND COMMONWEALTH

For the first time, and as would happen in future, the CEM of 1946 was held after, rather than before, the conference of the IMO. This tells us something about how the practices and politics of meteorological internationalism shifted radically in the immediate post-war period. The 1946 IMO meeting laid the groundwork for the establishment of the WMO in 1950, which put the international organization on a more secure, intergovernmental footing. That said, the delegates of the 1946 Empire conference still managed to articulate a clear role for Empire.

The intensity of aerial combat in World War II meant that the atmosphere had reached a new level of military significance, and many discussions at the 1946 conference pertained to how new knowledge of the upper air, obtained through intensive observational campaigns in the main theatres of war, could be disseminated and replicated throughout the Empire.⁹¹

The reinstatement of widespread communications gave renewed emphasis to the standardising urge of previous conferences, but attention focused on the expansion and intensification of observation networks, particularly in the high latitudes. A role was envisaged for the Commonwealth in not just bringing together knowledge from diverse places, but in reaching out to new locations such as Antarctica to create new sites of meteorological knowledge production.

At the same time, plans were agreed to intensify the circulation of meteorologists themselves around the Empire, in an echo of the mobility of personnel brought on by the war. An exchange programme was agreed at the conference with priority given to

meteorologists sharing responsibility for particular air routes. The aircraft plying these routes were to become meteorological instruments themselves, with resolutions to attach thermometers to commercial aircraft and even to allow forecasters to travel with the pilots, to familiarise themselves directly with the atmosphere they were trying to predict.

The meetings after 1946, generally held every four years, took on a much more relaxed atmosphere of information-sharing and acquaintance-making, not unlike the very first meeting in 1919. Paralleling the decline of the coordinating role of metropolitan expertise in fields such as agriculture following the apogee of post-war developmentalism in the late 1940s and early 1950s, ideals of Commonwealth cooperation faded in the shadows of an ascendant WMO.⁹² Informality was formally adopted in 1963, and the meetings became less and less significant for the Meteorological Office after then, at least according to the attention afforded them in the organization's annual reports. The requirement to produce formal resolutions and decisions was gone. Rather than being strategically timed to happen before major international meetings, so as to coordinate the 'imperial position', the Conferences of Commonwealth Meteorologists, as they became known, were promoted as sites for friendly conversation and even relaxation, deliberately juxtaposed to the bureaucratic tedium of the WMO meetings.

Yet it is still important to attend to the role of these gatherings and networks in the co-production of new knowledges and political identities.⁹³ The CCM still officially exists to this day, albeit in a seemingly quite fragmentary and unstable way. But during the 1980s the meetings became a forum for discussing emerging concerns about anthropogenic climate change, with the particular geography of the Commonwealth directing attention towards the possible fate of small island states under rising seas. Elongating the trend in imperial

science observed by Hodge in the early to mid twentieth century, attention switched from the potential exploitation of the atmosphere as a resource to its potential degradation.⁹⁴

The Commonwealth was arguably important in fostering the new collective consciousness and identity of small island states as a community united in opposition to the rising seas. An assessment of the future course and impacts of climate change by a Commonwealth study group in 1989, which predated the first Intergovernmental Panel on Climate Change report, prioritised the impacts of climate change on small and vulnerable states, and pointed to the CCM as a key resource in efforts to make sense of and combat these threats.⁹⁵ Since then, Commonwealth figures have repeatedly referred to climate change as an issue through which the Commonwealth can make itself relevant and useful, albeit with debatable levels of impact.⁹⁶

CONCLUSIONS

This article has argued that British imperial meteorology is an important part of the story of how meteorology became global, both in its subject matter and its practices. In terms of subject matter, imperial meteorology took a particular interest in large-scale spatial correlations, promoting exploration of the upper air and establishing the kind of datasets which could enable new appreciations of the atmosphere as a global, interconnected system.⁹⁷ As a set of practices, imperial meteorology aided the globalisation of the science through new drives for coordination and standardisation which were motivated by a combination of epistemic, technical, political and commercial demands. But the Conferences of Empire Meteorologists also show how imperial meteorology, despite the best efforts of metropolitan weather men, was not something which could diffuse easily from London. The Empire's climatic diversity posed challenges to eurocentric international

codes and practices; the Empire, we might say, was a proving ground for an emerging global meteorology. Colonial meteorologists were often bellicose in their defence against a perceived rigidity in metropolitan assumptions about how new scientific practices could be applied in far-flung colonial outposts. As a result, Empire representatives began to lobby for greater flexibility in meteorology's emerging infrastructural globalism. The conferences were sites of contestation as well cooperation; in the process of coming to terms with the diverse practices of the Empire's meteorologists, and for attempting new forms of unification and standardisation which ultimately fed into emerging international organisation.

New Zealand, India, British East Africa – these delegations all had something to gain from imperial cooperation, whether that be through the amplification the Empire offered in international fora (such as for Bates in 1919), or through the opportunities afforded by imperial conferences to confront international rules with colonial realities (as in 1929). The likes of Australia and Canada were more cautious in their imperial enthusiasm – they already had relatively strong voices internationally, or were developing other patterns of cooperation, in the latter's case particularly with the US.⁹⁸ But we can nonetheless usefully think the imperial as an interstitial space between the national and the international, where universalist aims and local specificities might be reconciled – resulting, in the case of the 1935 meeting, in the formation of the IMO's Regional Commissions.⁹⁹ As a space of climatic diversity, the Empire offered its meteorologists a means of testing and contesting the applicability of new standards, while offering its governments new reasons to summon meteorological expertise. Sporadic bursts of imperial enthusiasm for agricultural meteorology were shaped by a sense of climatic diversity as an economic resource, even if

the spatial scales of the requisite investigations proved too 'micro' for some meteorologists, and for the purposes of direct imperial cooperation. Nonetheless, agricultural meteorology became a major preoccupation in some colonies, even as it slid down the (metropolitan) agenda of imperial conferences.

The Conferences of Empire (and then Commonwealth) Meteorologists provide more than just a convenient lens onto the practices and politics of twentieth-century meteorology. Rather, as Roy Macleod suggests, such conferences should themselves be considered technologies of a particular kind of international cooperation, indicative of a broader shift in imperial science policy from ambitions of imperial coordination and control to a hoped-for commonwealth of friendly cooperation. At these imperial conferences, this impulse saw the British Empire presented both as a shortcut to the global, and an access point to diverse, regional climates. The historiography of global atmospheric science is enhanced by a new focus on this interstitial nature of imperial space.

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⁶⁰ *Nature*, 14 Sept 1929, 427.

⁶¹ *CEM* 1929, 16.

⁶² In 1922 French and Belgian meteorologists were still uneasy about the Central Powers attending international meetings – see Shaw to Lempfert, 14 Dec 1922, Sir Napier Shaw papers, Box 2, NMLA. Nonetheless, Austria's Felix Exner attended the 1923 international Conference of Directors in Utrecht, and Germany's Hugo Hergesell attended the IMO Commission for the Exploration of the Upper Air in 1925. International data transmission was increasingly being conducted through standardised, coded wireless messages to ensure brevity and to overcome language difficulties, with one- or two-letter symbols standing in for terms like 'visibility' or 'wind force'.

⁶³ Katharine Anderson, Marine meteorology. The numerical dominance of British flag-carriers in the international scheme, which allotted 'selected ship' status according to each nation's percentage of global tonnage, meant that many dominions and colonies found themselves short of local marine observations. In 1935 British ships were thus encouraged to communicate directly with local dominions or colonies when in their waters, rather than with London.

⁶⁴ *CEM* 1929, 46.

⁶⁵ *CEM* 1929, 71.

⁶⁶ It is of course challenging to correctly interpret the nature of verbal interactions when mediated through official conference reports, which in this case may offer a biased, metropolitan perspective. However, it is this metropolitan status which perhaps encouraged a written emphasis on verbal disagreements between metropole and colony. Personal memoirs can then add colour to our understanding of the social relationships involved – see below.

⁶⁷ M. Callon, Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay, in: J. Law (Ed), *Power, Action and Belief: A New Sociology of Knowledge?* Routledge, 1986, 196–233.

⁶⁸ Stephen Tallents, quoted in Powell, 'Dominion over palm and pine', 853.

⁶⁹ CO 758/32/1, TNA.

⁷⁰ CO 758/32/2, TNA.

- ⁷¹ R.A. Fisher, quoted in *Conference of Empire Meteorologists 1929, Agricultural Section, Part II: Papers and Discussions*, London, 1929, 291.
- ⁷² See, for example, B.M. Bennett, Naturalising Australian trees in South Africa: climate, exotics and experimentation, *Journal of Southern African Studies* 37 (2011) 265–80; G.A. Barton and B.M. Bennett, Edward Harold Fulcher Swain's vision of forest modernity, *Intellectual History Review* 21 (2011) 135–50.
- ⁷³ Shaw to Kidson, 24 Mar 1930, Sir Napier Shaw papers, Box 1, NMLA.
- ⁷⁴ Kidson to Shaw, 30 Jan 1930, Sir Napier Shaw papers, Box 1, NMLA.
- ⁷⁵ CEM 1929, *Agricultural Section*, 4.
- ⁷⁶ Clearing Station for Agricultural Meteorology, MAF 33/682, TNA.
- ⁷⁷ CO 758/72/1, TNA.
- ⁷⁸ Hodge, *Triumph of the Expert*.
- ⁷⁹ There are interesting parallels here with Barton's work on imperial organic agriculture as a trustworthy and beneficent 'antidote' to capitalist agro-industrialism. G. Barton, Albert Howard and the decolonization of science: from the Raj to organic farming, in: B.M. Bennett, J.M. Hodge (Eds), *Science and Empire: Knowledge and Networks of Science Across the British Empire, 1800-1970*, Basingstoke, 2011, 163-186.
- ⁸⁰ George Simpson, CEM 1929, *Agricultural Section*, 292
- ⁸¹ George Simpson, CEM 1935, 60. On 'boundary work' in science, see T.F. Gieryn, *Cultural Boundaries of Science*, Chicago, 1999.
- ⁸² Cushman, *Struggle over airways*.
- ⁸³ A. Walter, *Echoes of a Vanishing Empire, being the Memoirs of a Meteorologist and Civil Servant in the Colonial Empire* (1968), MSS Brit. Emp. R.9 and r.10, Commonwealth and African Collections, Bodleian Library, University of Oxford, 343.
- ⁸⁴ *Regional Commission No. 1 (Africa): Minutes of the First Meeting Held at Lusaka, the Capital of Northern Rhodesia, August 17th to 26th, 1936*. IMO Secretariat.
- ⁸⁵ Walter, *Echoes of a Vanishing Empire*, 357-8.
- ⁸⁶ G.C. Simpson, Memorandum on the proposal to form an East African Meteorological Service, 1928, CO 822/8/9, TNA. See also J.M. Kenworthy, Albert Walter, O.B.E (1877-1972): Meteorologist in the Colonial Service, Part II., *Occasional Papers on Meteorological History*, Royal Meteorological Society, 2014.

- ⁸⁷ CO 822/8/9, TNA. For the British office's finances, see *Report of the Meteorological Committee*, 1930, BJ 8/35, TNA.
- ⁸⁸ Comment in Climatic survey of East Africa, CO 822/63/9, 2, TNA.
- ⁸⁹ N.P. Sellick, Meteorology in Africa, Appendix XXI in *CEM* 1935, 145.
- ⁹⁰ Walter, *Echoes of a Vanishing Empire*, 324.
- ⁹¹ On modernity and the militarisation of the atmosphere see P. Sloterdijk, *Terror from the Air*, London, 2009.
- ⁹² Hodge, *Triumph of the Expert*, chapter 7.
- ⁹³ S. Jasanoff (Ed), *States of Knowledge: The Co-Production of Science and Social Order*, London, 2004.
- ⁹⁴ Hodge, *Triumph of the Expert*.
- ⁹⁵ M.W. Holdgate, J. Bruce, N. Desai, O. Mascarenhas, H. Shihab, R.F. Camacho, F.U. Mahtab, W.J. Maunder, S. Tewungwa, *Climate Change: Meeting the Challenge*, Commonwealth Secretariat, 1989.
- ⁹⁶ See S. Mole, Cultivating a climate of change, available at <http://www.global-briefing.org/2012/04/cultivating-a-climate-of-change/>. Accessed 4 June 2015.
- ⁹⁷ For example, many of the temperature records in regions such as East Africa which now form part of datasets of global mean temperature (and its recent anthropogenic changes) can be traced to this period of meteorological formalisation. See T.J. Osborn and P. D. Jones, The CRUTEM4 land-surface air temperature data set: construction, previous versions and dissemination via Google Earth', *Earth System Science Data* 6 (2014) 61–68. See also Appendix I in Allan and Ansell, A new globally complete monthly historical gridded mean sea level pressure dataset.
- ⁹⁸ Cushman, Struggle over airways.
- ⁹⁹ On Empire and universalism, see Hodge, *Triumph of the Expert*.