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The 'genie of the storm': cyclonic reasoning and the spaces of weather observation in the southern Indian Ocean, 1851-1925

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Abstract

This article engages with debates about the status and geographies of colonial science by arguing for the significance of meteorological knowledge-making in late-nineteenth and early-twentieth century Mauritius. The article focuses on how tropical storms were imagined, theorised and anticipated by an isolated – but by no means peripheral – cast of meteorologists who positioned Mauritius as an important centre of calculation in an expanding infrastructure of maritime meteorology. Charles Meldrum in particular earned renown in the mid-nineteenth century for theoretical insights into cyclone behaviour and for achieving an unprecedented spatial reach in synoptic meteorology. But as the influx of weather data dried up towards the end of the century, attention turned to new practices of 'single-station forecasting', by which cyclones might be foreseen and predicted, not through extended observational networks, but by careful study of the behaviour of one set of instruments in one place. These practices created new moral economies of risk and responsibility, as well as 'a poetry', as one meteorologist described it, in the instrumental, sensory and imaginative engagement with a violent atmospheric environment. Colonial Indian Ocean 'cyclonology' offers an opportunity to reflect on how the physical, economic and cultural geographies of an island colony combined to produce spaces of weather observation defined by both connection and disconnection, the latter to be overcome not only by infrastructure, but by the imagination.

Keywords meteorology; Mauritius; observation; islands; Indian Ocean

Introduction

Islands occupy a special place within the history of science. Scientists, colonial administrators, and their historians have often interpreted islands as 'natural laboratories' – uniquely closed spaces, set apart from the wider world, fenced off by their natural oceanic boundaries, and thus amenable to unique forms of knowledge production, social experimentation, and environmental control. But in the case of a science like meteorology, whose object of study reaches emphatically beyond the bounds of such island laboratories, Simon Naylor has recently suggested that islands can perform a variety of spatial functions. In his study of William Reid's work on hurricanes during his time as governor of Bermuda, Naylor argues that the island functioned as a form of laboratory, but also variously as archive and field. As archive, the island was a place where data could be amassed, stored, and disseminated; as field, where epistemic authority was drawn from long periods of careful local observation; and as laboratory, it was a site where apparently universal laws could be tested in a fashion which was independent of locale.[1] This tripartite spatiality of island meteorology can greatly enrich the historiography of island science. The tension between the fact that meteorology is a science which unavoidably takes place within its object of study – the atmosphere – and the uneven patterning of meteorology's social and cultural authority, has informed a burgeoning literature on the historical geographies of atmospheric science, concerned with the spaces of knowledge production and circulation, the enduring importance of place in meteorological practice, and the scalar interactions of local, national, imperial and global knowledge-making.[2] The historical geography of meteorology can therefore make important contributions to understanding the historical role of islands in scientific practice and discourse, and of the relationships between science, empire and colonialism.

The atmospheric environments of colonised islands were frequently a matter of intense scientific interest and speculation. As Richard Grove has shown, concerns about local climatic change – common features of Enlightenment environmental thought – found their earliest expressions in places such as Saint Helena and Mauritius. These seemingly Edenic places, the last bastions of divine natural harmony, were uniquely vulnerable, it was thought, to human interventions like tree-felling and plantation agriculture which could fundamentally alter the natural balance which assured adequate rainfall and climatic moderation. This conception of island climates as being relatively closed systems invited experiments in conservation policy and practice, and islands became increasingly regulated and controlled environments as colonial states sought – with varying levels of commitment – to manage new (and newly conceived) assemblages of people, plants, animals, and atmosphere.[3]

Yet the fate of island colonies was, of course, shaped to no less a degree by much wider atmospheric dynamics. The trade winds which carried ships to and fro, the rain bands which brought liquid sustenance from across the ocean, the cyclonic storms which whipped the tropical seas into frenzies of wind and rain – all these phenomena helped make and break the fortunes of island experiments, and historical actors were in many respects no less conscious of the vast spatial scales on which they operated than we are today.[4] Yet the need to reach beyond the island itself in order to understand how colonists sought to make sense of and manage their more immediate environments has been largely unmet in island historiography. The aim of this special issue – to reconceptualise the Indo-Pacific world as a space of islanded interconnections[5] – helps us get towards the required dissolution of the boundaries which have arisen between island history and the spaces which surround and, in a sense, define the island – the oceans, with their possibilities for inter- and disconnection, their geophysical turbulence, their dynamic, often puzzling interactions with the atmosphere above, and their cultural loading with ideas of inhospitability and an unruly spaciousness. To think island science beyond the island in this way is to position islands within what Siobhan Carroll labels the 'atopia' of ocean and atmosphere; spaces of cultural-economic circulation and domination which nonetheless evaded territorial control, and which were possessed of a 'natural alterity'. They were instances of Spivak's 'planetary' spaces, which can freely 'undo, arrest, deviate, or destroy the human systems of global circulation with which they become associated'.[6]

The history of meteorology provides fertile ground to think through the weaving of island life, in both the biophysical and social senses, into broader oceanic and atmospheric environments. In this paper I focus on the development of meteorology in Mauritius between the mid-nineteenth and early-twentieth centuries, examining the emergence of a uniquely vibrant and very public culture of atmospheric knowledge-making, and the articulation of such knowledge-making within broader projects of island economy. The paper falls into two main parts. The first examines the emergence of a dedicated Meteorological Society on Mauritius in the 1850s, and traces its efforts to use ship logbooks to build a new picture of the behaviour of Indian Ocean cyclones in particular, and of tropical storms in general. Here, following Naylor, Mauritius functioned as archive; a storehouse of meteorological data, and an important centre of calculation.[7] Through the combined and uneven labours of ship captains and meteorological clerks, 'serviceable truths' were produced which were recognised in metropolitan scientific circles, while also serving local decision-making.[8] While much meteorological historiography tells of the progressive defeating of space by network technologies, the second part of this paper examines what happened when the observational 'network' established in the mid-nineteenth century collapsed as shipping patterns changed. No longer the meteorological archive of the southern Indian Ocean, Mauritius was re-made by meteorologists such as Thomas Claxton and Albert Walter as a field where new understandings of cyclone behaviour offered the promise of reconciling island economics with the vagaries of the tropical atmosphere, and as a laboratory where newly universal laws could be applied in local predictive practices which combined written rules, theoretical knowledge, and the imaginative projection of cyclone behaviour in a space which eluded direct meteorological observation. Meteorology in this period developed through new observational practices and new social relationships, the meteorologist becoming a newly accountable actor, and the observatory a newly regulated space, within colonial society.

In constructing an historical geography of island meteorology, the paper aims to contribute to ongoing debates about the nature of colonial science, and about the assumed relationship between 'centres' and 'peripheries' in the production of scientific knowledge. The functioning of Mauritius as a meteorological archive means rich records are available to the historian, encompassing reams of weather data along with scientific publications, government reports, correspondence, and newspaper coverage of the island's meteorological life. These sources are supplemented here by the personal recollections of one meteorologist, Albert Walter, whose idiosyncratic writings offer a unique insight into the daily routines and personal struggles which are so often absent from the archives of all but the most celebrated in the science. By reconstructing first the emergence of a meteorological culture on Mauritius, and then by following the traces of controversy, whether theoretical or political, the aim is to understand the status and geographies of colonial science by exploring how Mauritius was positioned as a centre of meteorological knowledge-making, a node in expanding imperial and global networks, but one nonetheless shaped by concerns and circumstances which were thoroughly local – both to the island itself, and to the world of the Indian Ocean.

A place for meteorology

> *The position of the island is peculiarly adapted to the purposes of observation…situated in the midst of the Indian Ocean, and placed at a distance from the influence of great continents; it seems as if Nature had formed it as a spot where man may, if he chooses, investigate her elementary laws by observing the phenomena which they govern.*[9]

Historians have recently sought to go beyond centre-periphery models of scientific practice and 'diffusion', which position colonial sciences as subservient, derivative and inferior to metropolitan sciences.[10] Alongside broader moves in imperial historiography, the primacy of the metropole has been re-thought, and networks of colonial science have come to be read as polycentric, often transient, with relations not of dependency but of reciprocity and exchange.[11] Richard Grove, for example, has emphasised the contributions of colonial scientists and savants to emerging understandings of atmospheric patterns and interconnections from the late eighteenth century onwards, while Gregory Cushman has emphasised the complex trans-national and trans-imperial exchanges which shaped the development of tropical meteorology, both in the tropics, and in the meteorological citadels of temperate capitals.[12] Mauritius has provided its own grist to the revisionist mill, with William K. Storey's history of sugar cane botany providing further evidence of the existence of distinctive colonial cultures of scientific knowledge-making, organised around local needs, attuned to local structures of authority and sociologies of trust, and productive of their own truths, many furnished with the ability to travel beyond the local contexts of their making.[13] Re-tooling the language of centricity, Lissa Roberts has recently described French Mauritius as a location which a number of actors sought to position as a 'centre of accumulation'. Writing against McClellan III and Regourd's arguments about the functioning of colonial science in the context of a centralising French state,[14] Roberts argues that processes of centralisation are best studied as multiple, contested and, essentially, polycentric. Efforts to make Mauritius a centre of accumulation of wealth, information and power played out through multiple connections, through alliances made and battles fought at a range of spatial scales. Centralisation efforts made French Mauritius not only an object of intensified knowledge-making itself, with island surveys of land and resources proliferating, but also an entrepôt for knowledges concerned with, and relevant to, wider processes and spaces – hydrography, navigation, botany, acclimatisation, agricultural improvement. While this culture of centralisation might have been closely associated with the structures and styles of French administration, the bi-lingual meteorological culture of the mid-nineteenth century reflects a deepening of this urge to position Mauritius as a centre for the accumulation of information and the dispersal of new knowledge.

Mauritius, dubbed the 'star and key of the Indian Ocean' in the mid eighteenth century, was described in 1807 by the French colonial official Félix Renouard de Sainte-Croix as 'a central geographical point between every other place in the world'.[15] This notion of geographical centrality continued under the British, who took control of the island in 1810 in a bid to secure their hegemony over the trading routes to India. Strategically important, Mauritius became a garrison colony, where the intention was never to promote widespread British settlement but simply to guarantee defence of a crucial maritime trading route.[16] For the next few decades, a British ruling and military class would co-exist – often in great tension – with a landowning French agricultural elite, and from 1835 with freed African slaves and indentured Indian labourers. British trading rules meant the island's own economic survival depended on the production of export commodities, and the island's reliance on sugar cane, thought the most resilient crop to tropical cyclones, expanded rapidly. From 4,148 tons in 1816, production reached 150,480 tons by 1862.[17]

Lying within the tropics, Mauritius is cooled for most of the year by the south-east trades and enjoys reasonably reliable rainfall. Occasionally however the rains fail, while during the warm, humid summer months the island is periodically visited by violent cyclones. As such, study and speculation about the weather has long formed part of the island's scientific, economic and cultural life. The formal making of meteorological records on Mauritius can be dated to 1774, when Jean-Nicolas Céré, the gardener and agronomist who would become Director of the Botanical Garden in 1775, began making daily weather observations.[18] Mariners plying the waters around the island and traversing the Indian Ocean had also by this time begun piecing together the patterns of oceanic and atmospheric circulation which both drove and arrested trade between the Mascarenes and Asia.[19] The first public observatory on the island was set up in 1832 by Colonial Lloyd, the surveyor-general, on the harbour-side in Port Louis, where daily weather observations were made alongside seemingly more functional work on magnetism and time keeping. But despite the new regularity this afforded to Mauritian meteorology, the observatory rarely published its findings, thus limiting its impact in scientific, maritime and agricultural communities, and by the 1840s the observatory's equipment was considered sorely outdated. This was a situation which greatly irked the young Charles Meldrum who, in 1848, travelled to the island to take up the position of Professor of Mathematics at the Royal College. Meldrum had graduated with an MA from the Marischal College in Aberdeen in 1844, and went on to work on the educational staff of the Bombay Presidency before moving to Mauritius.[20] Meldrum quickly became interested in the meteorology of the island, and in 1851 he secured the backing of fellow men of science, government officials, planters, mariners and military officers for the formation of a Meteorological Society, under the official patronage of the Governor. The first

President was Colonial Secretary and future Governor of the Bahamas Charles J. Bayley. Lieutenant-Colonel Robe, deputy quartermaster general and former lieutenant-governor of South Australia, served as Vice-President along with the naturalist François Liénard, while Meldrum and Henri Bousquet, the acting Government Observer, jointly took on the role of Secretary.

The Meteorological Society of Mauritius, the first of its kind in the British colonial world, took as its first aim the procurement of high quality instruments with which observations could be made at Mauritius and its dependencies, such Rodriques and the Seychelles. While the Admiralty in London had expressed their sympathy to the Society's aims, a hoped-for grant was not forthcoming, and the Society would have to rely on its own funds. Although he been appointed Vice-Secretary, the founding of the society had understandably irked Bousquet, a Creole meteorologist 'of unbounded enthusiasm',[21] who perhaps interpreted it as 'a reflection on his own inadequacy' and initially resisted the request for hourly observations to be made at the Port Louis observatory. The struggle for meteorological authority became a struggle over space. The Society was permitted to rent rooms at the observatory from the government for its meetings and a nascent library, but the rent was set so high – amounting to about half the government's own contribution to the Society's coffers – that they were forced to vacate them in 1853.[22]

Even if Mauritius was a 'peculiarly' and naturally-adapted spot for meteorology, the new Society had no natural right to the observatory. Support was again sought in London. In 1854 Edward Sabine expressed his enthusiasm for the new organisation, having regretted that 'there is an Observatory at Port Louis, the property of Government, and that there is an Observer paid by funds allotted from the Colonial revenue for the express purpose of making observations; but that the Observatory is occupied as a residence, and the Observer receives the salary but makes no observations'[23] The following year, after representations from the Colonial Office in London, where the value of the observatory sciences was slowly being acknowledged, the Society was allowed back in. The Secretary of State commanded that the observatory buildings be made available to the Society rent-free, while the Admiralty, recently convinced of the value of a systematic approach to maritime meteorology,[24] also agreed to an annual subsidy of £50 to help with publishing costs.[25] With that, the instruments which had been ordered from London and Bombay two years earlier could finally be installed and put to use. Barometers were sent to Rodrigues and the Seychelles, and monthly reports received in return. Not long after the time that Port Louis couldn't seem to claim half an observatory, the town could briefly boast two, with the Royal Engineers establishing a node in their rapidly expanding network of imperial magnetic observatories some 300 yards from the harbour-side observatory. Weather observations were made here every six hours until 1858, when it was pulled down to make way for a new railway line.

The Society aimed from the outset at developing a wide membership structure, not just to bring in funds, but to ensure that its meteorological truths could be 'serviceable' to all interested parties on the basis of their collaborative production. This was particularly significant on an island where, as Meldrum opined,

> Her Civil and Military Officers, her Planters and Merchants, together with a general population descended from two nations pre-eminently distinguished for their love and promotion of every branch of science and industry will not, it is hoped, be altogether indifferent to work in which their own personal interests and the interests of science and humanity are alike concerned.[26]

This was a moment when the institutionalisation of meteorology as a distinct branch of physical science was starting to take hold in Europe, albeit amidst widespread disagreement as to its rigour, precision, and practical utility.[27] Many of meteorology's potential patrons showed little faith in the use value of the science, with its low levels of predictive skill and lack of general physical theory, so sympathisers took every rhetorical opportunity to convince doubters that this was a science worth backing. Many of the early speeches and exchanges at the Meteorological

Society meetings featured vaulting statements about the centrality of weather to everyday life, particularly in an island colony threatened regularly by drought, storms, and climatically-linked diseases, along with calls for the weather-minded polity to put some faith in a nascent science of the atmosphere. By 1853 the itinerant army surgeon Alexander Thom, who in 1845 had published *An Inquiry into the Nature and Course of Storms in the Indian Ocean South of the Equator,*[28] had been elected the next President of the Society, although his term was to be cut short by illness and a return to England, where he died the following year. Much like William Reid's earlier work in the West Indies, Thom's *Inquiry* used a number of ships' logs to reconstruct the behaviour of recent storms, most notably one which struck Rodrigues in 1843. His work offered one of the clearest early statements of the theory that gyratory storms form through the meeting of opposing currents of air, but his target audience also included sailors in need of advice on how to anticipate the bearing of storms, and on how to position themselves to avoid their worst ravages.

'Cyclonology', as it was beginning to be called, was to be the chief area of interest for the Society, and the ambition to expand an observational network on land and sea was geared towards building the foundational laws upon which could be based new ways of understanding, sensing, and perhaps predicting the storms which were so much a part of the consciousness of an island society organised around agriculture and maritime trade. The Society aimed to develop the approach pursued by Thom in the 1840s – compiling, tabulating and analysing observations made aboard ships calling at Mauritius and, in the process, it was hoped, helping to rationalise and standardise the making of these observations. The aim, ultimately, was to publish compiled, simultaneous observations not only for Mauritius itself, but for the entire Southern Indian Ocean. In fact, earlier ambitions on the island had been to construct a global picture, but the weight of the required work meant that the Indian Ocean was a more practical aim.[29] It was a task similar in scope to Maury's efforts to chart the winds of the North Atlantic, but with the crucial difference that 'while he [Maury] gives the general direction of the prevailing winds in separate squares of five degrees each, for particular seasons, our attempt is to shew how the atmospheric currents curve and deflect, over all the Indian Ocean, *at the same time* and from day to day, during the course of the year'.[30]

Around this time effort was being made in London and elsewhere to formalise the practice of meteorology at sea. While some within the Admiralty had been keen on promoting maritime meteorology since the early decades of the nineteenth century, it took the intervention of the Royal Society before barometers were formally issued to Royal Navy ships in 1843, with the updated *Admiralty Instructions* of 1844 requiring captains make four observations daily.[31] Turning merchant ships into reliable observatories was, of course, a rather more difficult task, although officers on East India Company ships were often keen weather documenters.[32] The efforts to turn both merchant and naval ships into 'itinerant observatories'[33] nonetheless reflects the wider juxtaposition between the idealised regularity of geophysical observation and the real-life instability of its social, political and material superstructures, which has been well documented in the burgeoning history of the observatory sciences.[34] This instability was a common feature of early colonial meteorology, where the sporadic observations of explorers and missionaries had yet to be supplemented by centralised networks under governmental control.[35] Mid-nineteenth century weather data may have 'followed the paths of British ships and traced a geography of storms that conformed to the contours of Britain's imperial interests',[36] but the metropolitan organs of state could not necessarily be relied upon for moral or financial support to budding colonial meteorologists. It is against this background of a science still struggling for authority and recognition in London and other imperial centres which makes the Mauritian case so unique: here was a meteorological society with ambitions – if not yet the means – to develop a centralised structure, with public service at its centre, which pre-dated the founding, in 1854, of the Meteorological Department of the Board of Trade in London by three years. Indeed, it was in the same year of latter's founding that the three posts of Government Observer, Officer-in-

Charge of the Royal Engineers' observatory, and Secretary of the Meteorological Society were given to one man, Lieutenant Fyers of the Royal Engineers. But it was Charles Meldrum who nonetheless remained the driving force behind the Society's most ambitious projects; the William Reid of the southern hemisphere. Although Fyers succeeded in winning the Society free access to the Observatory following supportive interventions from London, it wasn't until Meldrum's re-election as Secretary in 1859 that the Society's new instruments, procured both from London and from the Bombay Geographical Society, were installed and put to work.

Constructing cyclones

The Meteorological Society's main advances were not to arise from the theoretically rarefied (but in practice rather troubled) spaces of the island's successive observatories. They were to arise instead from the even more unruly space of the ocean, criss-crossed by merchant vessels with their army of potential observers, some of whom embraced the role eagerly, albeit with varying levels of formality or regularity. From the outset the Society had employed a clerk whose job it was to go aboard every ship entering Port Louis harbour, brandishing a letter from the Secretary requesting permission to make a copy of the log book and its weather observations. Meldrum would amass and study these copies, along with copies of log books deposited at the London Meteorological Department and subsequently despatched to Mauritius, tabulating into single tables the relatively synchronous observations of dozens of ships at different points in the southern Indian Ocean. This became very much Meldrum's project, with Bousquet unconvinced of the merit of studying the often unreliable observations of mariners.[37] While Bousquet favoured the local knowledge of fishermen and long-time residents as cyclonological sources, Meldrum pressed ahead with the project of enrolling and assembling the region's mariners into a dispersed, moving network of reliable meteorological observers. While following Thom's model, the work also accorded with the vision of Parisian meteorologist Urbain Le Verrier, who suggested that while the French concentrated on expanding their field of meteorological vision in the Atlantic, the British take care of the observations in the Indian and Pacific oceans, making use of the points and nodes of their imperial networks to create new centres of meteorological calculation.[38] But while the Indo-Pacific might have been conceived as a 'British' meteorological region, the majority of the ships calling at Port Louis were voyagers of the Indian Ocean, particularly the England-India routes, and the Society's more global ambitions were limited to their local ocean basin on account of the practical difficulties of reconstructing synoptic conditions from any farther afield.

The copying and the tabulating was taxing work in itself; extracting meaning from it all was made all the more difficult by the lack of standard instruments and techniques used on-board ships, the frequent contradictions between captains' and masters' logbooks, and the unwillingness of some mariners to open up their logbooks to any outside scrutiny at all. The latter were easily dismissed by the Society though – any Captain whose character led him to so jealously guard his logbook would likely not fit the model of a well-disciplined and faithful weather observer anyway. The Society nonetheless sought to make known the difficulties they were working with. In a concerted bid to attract more public and mariner support, the Society took to publishing much of the ship data in its rawest form, in order to illustrate to their interlocutors and potential allies just how difficult the work of standardisation and tabulation could be. The aim was to 'shew how difficult a task it is to trace out the general law of storms from data in which inconsistencies and inaccurate observations are mixed up with a few great truths'.[39] Although far from Latour's circulating immutable mobiles, with their flattening of the messiness and contingencies of scientific production into polished graphical forms, these messy tables served similar purposes: on the one hand claiming authority by illustrating the expanding spatial reach of the Society across the ocean, and on the other, illustrating the hard work and self-sacrifice of Society members, particularly Meldrum, in working-through the often chaotic raw data with which they were presented. It was an exercise in enrolling allies – allies that would offer this expanding network renewed support in return for promised serviceable truths, and allies who would more conscientiously uphold their side of the bargain through more careful observational efforts.

By 1859 Thom's vision of charts showing weather conditions 'at the same time' had been fulfilled, with the raw tables of data being translated into synoptic charts which, for the first time, gave a snapshot view of weather conditions across an area as wide as an ocean basin. This was new for meteorology, with previous charts or maps of a similar scale presenting only idealised models of the trade winds or general circulation, or covering smaller areas. Figure 1 shows the fruits of Meldrum's labours – the spiralling winds of two cyclones "raging furiously", moving westward across the Indian Ocean towards Madagascar, each arrow a wind direction sensed simultaneously on-board a numbered ship. Two cyclones are detected to the south of the Cape as well, while the Bay of Bengal and the South China Sea appear placid by comparison. This ability to compile and visualise synoptic data on such a scale aroused great interest in London and other meteorological metropoles, but the lack of printing facilities on Mauritius meant that in the immediate term, only pen-and-ink copies of the charts could be produced, and their circulation was initially limited.[40] Yet the lessons of the charts could nonetheless be communicated locally to mariners through the Society's meetings and its periodic publications. When Meldrum first presented his synoptic charts to the Society he was not yet speaking of the holy grail of prediction, but rather of anticipation and planning based on well-ascertained data. Meldrum argued that his object was 'not to advocate any theory or hypothesis, but to arrive at truth through just a careful examination of facts'.[41]

<Figure 1. Two cyclones at noon of the 13th of February. From *Synoptic weather charts of the Indian Ocean for the month of February, 1861*, Meteorological Society of Mauritius. Information provided by the National Meteorological Library and Archive – Met Office, UK>

Meldrum devoted much of this empirical energy to examination of the question of whether winds blow in circles around a low pressure system, or in incurving spirals. In the 1840s Henry Piddington, a former merchant captain and, from 1844, curator of the Museum of Economic Geology in Calcutta, published a range of treatises on the law of storms, building upon the ideas of Atlantic observers William C. Redfield, based in New York, and William Reid. Redfield, who had influentially noted the circularity of hurricane winds in the 1830s, had nonetheless supposed that the winds must be more spiralling than circular, in common with other aerial or aqueous vortices. Practical restraints had nonetheless kept him from publicising these particular thoughts, not least because a circular storm diagram proved easier to print than a spiral one: 'the storm figure on my Chart of the storm of 1830, was directed to be engraved in spiral or involute lines, but this point was yielded for the convenience of the engraver'.[42] In Calcutta, Piddington was moved to take up the study of tropical storms when he encountered Reid's *An Attempt to Develop the Law of Storms by Means of Facts* (1838), and set about the 'tedius and sometimes repulsive' work of acquiring ships' logs from 'the unwilling, the dilatory or the diffident' sea captains plying the Indian Ocean and the Bay of Bengal.[43] Piddington produced an influential series of articles and a number of editions of his *Sailor's Horn Book for the Law of Storms*, which, like Thom's 1845 work, made the theories of Redfield, Reid and others legible to those tasked with making consequential navigational decisions on their basis.

These books were exercises in the making and communicating of serviceable truths. Piddington is perhaps best known for introducing the term 'cyclone' for revolving tropical storms, although this term was intended to tidy up the loose semantics of hurricanes, typhoons and gales, rather than to precisely denote a spiralling rather than circular motion. Piddington nonetheless was among the first to give new credence to the spiral hypothesis, and translations of his work by Bousquet saw his ideas disseminated to a wide audience in Mauritius. Piddington placed particular emphasis on the log of the *Charles Heddle* which in 1845 was caught in a cyclone near

Mauritius, and 'scudded round and round for five successive days!'[44] The log book showed the ship to have gradually spiralled towards the centre of the storm, in a 'natural experiment' which appeared to bear out the spiral hypothesis, along with other emerging evidence, such as the peppering of ships near the centres of storms with land birds, insects and butterflies, which were surely 'carried inwards by the incurving tendency of the winds…If the wind blew in true circles they would be scattered all over the body of the cyclone'.[45] Yet Piddington's advice to sailors on how to judge the patterns of the winds, and how to best navigate them, remained based on the assumption of circular winds, and his 'horn cards' – wind diagrams printed onto transparent sheets (made from animal horn) to be read on top of maritime charts – followed an earlier circular design by Reid.[46]

Meldrum's expanding field of synoptic oceanic vision meant he could make stronger claims than those of the natural experiments of atmospheric flotsam and spiralling ships. He drew on observations of wind and pressure from dozens of different vessels taken at approximately the same time in different locations, vessels which were, like the mythical blind men and the elephant, each experiencing a different local part of a wider whole. By piecing together these distributed testimonies, Meldrum began to confidently assert that the winds blowing in a cyclonic system do so according to a spiral pattern, and frequently in an elliptical rather than a circular shape. At the September 1860 meeting of the Society Meldrum offered his detailed analysis of two storms from the preceding cyclone season. He argued that 'Both storms were, apparently, a conflict between the trade and monsoon; but in neither of them did the wind blow in a circle, unless close to the centre. It was, however, evidently moving around a central point, or had a strong tendency to do so.' He went on:

> There are no means of determining the exact forms of the cyclones on each day; but it is evident that the wind did not blow in true circles. From observations made on all sides of the Phoenix storm, on the 25th, it would appear that the meteor had a helical form; for,

> while the SE trade swept round on its Western side, and the NW monsoon on its Eastern side, in two distinct curves, there was an Easterly stream of air (between the N E.ly and S. E.ly winds) extending over several degrees, and directed towards the vortex. On that day, then, and also on subsequent days, the bearing of the centre, at some distance, could not have been determined by the rules laid down on the subject. From the winds and weather at Port Louis on the 25th, for example, the centre, according to the Law of Storms, should have been due North of the island, whereas it was WNW of it; and the bearing of the centre from St Denis, where the wind was SE., should have been NE, whereas it was about NNW.[47]

Meldrum's new empirical support for the emerging spiral hypothesis would, in the course of time, give sailors new laws by which to work out the position and possible track of a storm, and to avoid its worst ravages. The community of Mauritius cyclonologists were not as sanguine as Piddington as to the significance of circular versus spiral theories for the instructions to be given to sailors. An episode in February 1860 seemed to bear out their concerns: 41 vessels left the roadsteads of Réunion in anticipation of a storm, armed with sailing directions based on the idea of circular winds. Of the 41, 3 were lost without trace, 3 were wrecked on the coast of Madagascar, and 25 suffered serious damage and financial loss. Instructions based upon a spiral and elliptical hypothesis, it was assumed, would have saved lives and property.[48] Meldrum began to achieve international renown for his work. He was elected a Fellow of the British Meteorological Society in 1868, and during the 1870s his renown spread further, as scientists and mariners in different corners of the world recognised the significance of his work, which was described in one Wellington newspaper as "One of the most important contributions recently made to science", yet "so deeply practical".[49] He was elected a Fellow of the Royal Society in 1876, with nominations from such scientific luminaries as Edward Sabine, James Glaisher and Francis Galton. In the same year he was awarded an LL.D. from the University of Aberdeen.

'Meldrum's rules' for cyclone navigation became touchstones for sailors plying the southern Indian Ocean, their utility championed by the likes of Ralph Abercromby,[50] and thereby dislodging the inertia of the circular hypothesis which seemed to owe as much to contemporary printing practices as to the dynamics of theoretical change. In 1885 he submitted to the British Association for the Advancement of Sciences a series of yearly charts of all known cyclones in the Southern Indian Ocean from 1848 to 1885; an atlas which would become both a standard navigational reference, and a landmark in the development of synoptic meteorology.[51]

A new Law of Storms[52] did not only offer new means for sailors to navigate their way safely through the cyclone season. The accumulation at Mauritius of reams of data was also furnishing serviceable truths which could guide the sensing of a distant storm from an island observatory:

> If during [the summer] months the Mercury gradually descends for two or three days with a S.Ely wind, however fine the weather may be here, it may be inferred with the utmost certainty that a storm or gale has set in on the equatorial border of the trade-winds; and experience shows that the storm may then be at a distance of several hundreds of miles. If the barometer continues to fall with the wind still at S.Erd, and the weather getting worse, it may be inferred with equal certainty that the storm is advancing towards the Island.[53]

'From a careful analysis of the observations taken at sea', Meldrum argued, 'viewed in connection with observations taken at Port Louis, our knowledge of the Meteorology of the Indian Ocean is such that we can now tell with certainty not only when bad weather prevails at a distance, but almost with equal certainty, where it prevails'.[54]

Alongside work on rainfall periodicity and links between climate, vegetation and health, Meldrum continued to refine his cyclonology, and began using his new-found laws to issue storm warnings to the press when a cyclone appeared to be in the vicinity. Following his appointment as Government Observer in 1861 he oversaw the long-desired move to a new Observatory, the Royal Alfred Observatory (RAO), of which he became the Director in 1874. From this new elevated, isolated location at Pamplemousses, away from the physical shelter and troubled history of the harbour-side site, the meteorologist could see further, trusting the records of wind direction to be representative of a broader atmospheric field, while enjoying the order and serenity of a model observatory. It was at this site that the focus of Mauritian meteorology began to shift. The opening of the Suez Canal in 1869 and the coeval rise of steam-powered shipping meant Mauritius was frequently bypassed by ships travelling between Europe and Asia. Although it had early been surmised that steam ships, with their ability to maintain a steady course amidst strong winds, would offer new opportunities to observe 'cross sections' of a storm (as opposed to the scudding and spiralling of ships under sail), this wasn't of much use if the information wasn't then deposited at Port Louis. The network of transient observers that Meldrum had encouraged began to slowly disperse, and the island's status as an archive and entrepôt of meteorological knowledge started to wane. By 1901, the year of Meldrum's death following an earlier return to Scotland, the efforts to produce daily synoptic charts had ceased, save for the occasional chart during the cyclone season to display storm tracks. The ship data, once collected with a view to 'obtaining a correct representation of the atmospheric conditions over the Indian Ocean', were 'now well nigh useless'.[55] With this we can say that Mauritian meteorology became more islanded[56] – concerned less with the geophysics of an ocean basin, and more with the management of risk upon the island itself; a shift which was forced by changing geographies of oceanic trade, but one which was also enabled by the serviceable truths which had been built during Mauritius's time as a centre of meteorological calculation.

The arts of forecasting

Meldrum had furnished himself, and his colleagues and successors, with new practices for constructing and anticipating weather 'at a distance'. Although the expansion of Mauritius's meteorological empire had proceeded through the establishment of telegraphic links to surrounding islands, this system provided little help in forecasting cyclones. In the British Isles, telegrams from the west coast meant that information about the weather could out-run the weather itself, and warnings could be issued about approaching storms.[57] In Mauritius, the techniques of sensing cyclones at a distance expanded the field of vision beyond that of the comparatively more limited telegraph system, which didn't connect the island to anywhere that could detect an approaching cyclone earlier than the RAO itself. The superior instruments at the RAO could detect a hurricane not much later than the observers at Rodrigues, who came into telegraph contact with the opening of the Durban-Perth segment of Britain's 'All-Red' line in 1901.[58] However, by closely observing the behaviour of the barometer, anemometer and of the clouds, and by comparing this behaviour with the laws being laid down by Meldrum and others, it seemed possible to determine the location and direction of a cyclone hundreds of miles away, and thus to determine the probability of it striking Mauritius. Prediction, rather than law-building, thus became the chief means by which meteorology claimed a part in the public life of the colony.

The predictive skill of such techniques was severely tested by the devastating cyclone which struck the colony on the 29th of April, 1892, leaving over 1100 dead, 2000 wounded, one-third of Port Louis levelled, and the colony's agro-industrial infrastructure in disarray (see figure 2).[59] In the preceding days a low barometer and veering wind had prompted the acting Governor Hubert Jerningham to enquire of the danger. With the barometer rising slightly on the 28th, no great risk was identified, although the harbour master was warned of a heavy sea. By the morning of the 29th conditions became more ominous. The barometer was falling again, and the government's chief administrative officer was warned by telegram that 'the depression was recurving and approaching the island'.[60] The telegram never reached its destination, and soon communication across the whole island was disrupted as the storm, seemingly unanticipated by all but a nervous few at the observatory, on the harbour side and in the governor's mansion, started to bear down upon the island and wreak its havoc. But in spite of the carnage, the unusual timing and behaviour of the storm – appearing as it did several weeks after the usual end of the season and taking an unusual south-easterly track – brought the meteorologists a pardon from the Governor. The disturbance, Jerningham later wrote, being 'probably exceptional', meant 'it was excusable on the part of the meteorologists of the island to telegram on the evening of the 28th…[that] there was nothing to be apprehended'.[61]

<Figure 2. 'Port Louis after the hurricane of 1892'. Reproduced with permission from CO 1069/746, The National Archives, Kew.>

The 1892 storm, which lived long in the cultural memory of the colony, could have dealt a fatal blow to the authority of the island's meteorologists.[62] As it was though, a shared understanding of the 'law of storms' across the communities of knowledge makers and users, and crucially of the epistemological limits of such laws, meant that the imperfection of the meteorologist's craft was accepted and accounted for in the apportioning of blame. The laws, as serviceable truths, were taken as workable guides to anticipate and prepare for storms, their incertitude acknowledged and treated as an epistemological inevitability rather than a failing of the meteorologists themselves.

A few years later a young meteorologist named Albert Walter arrived in Mauritius following a short stint tabulating meteorological and astronomical observations at Greenwich Observatory.[63] The twenty-year-old newcomer was assigned quarters at the Observatory, in a small outbuilding in which the previous two European assistants had died of malaria, the disease having become endemic to the area during the construction of the Observatory in the 1860s. The most urgent of his new tasks was familiarising himself with the latest understandings of Indian Ocean meteorology, and particularly with Meldrum's work on the patterns and behaviour of cyclones. He spent weeks engrossed in Meldrum's charts, learning the laws which would enable him to practice the 'art', as he called it, of single station forecasting.[64] Good forecasts depended not only on good instruments, but on the particular expertise of the local forecaster. Forecasting cyclones was a combination of learned, relatively formal laws, and an ability to rapidly compute the relationship between those laws and the ever-changing responses of the meteorological instruments; together enabling the imaginative projection of a storm's location and track. The detection of a distant cyclone therefore meant battening down the hatches at the observatory, and the beginning of a long, lonely vigil by the side of the barometer.

On one evening in February 1902 Walter and Thomas Claxton, the Director, left the observatory and headed home. Owing to the site's malarial tendencies, all the observatory staff had been excused to live up-country. But that night the barometer was falling, and reports had arrived from Rodrigues of a cyclone approaching there, albeit heading south, and thus likely to miss Mauritius by a wide margin. Like in April 1892, an early telegram was issued predicting no danger for the island. However, by 10pm the barometer was falling rapidly at Mauritius and Claxton was banging on Walter's front door, as it was clear the storm had changed track and was heading for the island. With no transport available, there began a six-hour epic of the two meteorologists trudging through the night, through heavy rain and gale-force winds, drenched to the skin and dodging falling trees, traversing the ten miles to Port Louis so they could take a train up to the Observatory. When they finally arrived in the capital early the next morning no train driver would leave town for fear of being blown off a bridge, and by 9am all telegraphic communication was down.

Subsequent reports from ships suggested that the Rodigues cyclone had indeed continued south, but in doing so had masked a second approaching cyclone. The official report of the RAO argued that forecasting this second, disguised cyclone would have been impossible but Walter, not lacking in confidence in his new found forecasting abilities, disagreed, and argued that a proper study of the instruments of the observatory could have disentangled the two signals.[65]

This incident saw the Governor enact a law that either the Director or his assistant must be in attendance at the Observatory at all times during the cyclone season. For Walter, now Assistant Director, these new rules of responsible meteorological conduct meant that most of the next few Christmases were spent in watchful isolation at Pamplemousses. During the very next cyclone season however, Claxton was thrown out of his cariole while traveling – in some dereliction of his duty, Walter would suggest – from the Observatory to Port Louis. He was perhaps only saved from the worst effects of a serious head wound by the fact that the accident occurred outside the house of a prominent doctor on the island, who took charge of his treatment. Laid up for several months in the capital, Claxton was forced to pass on responsibility to Walter for a cyclone season which saw four storms pass close to the island. Walter later recalled:

> The Governor suspended his instructions in regard to residence, informing me that he had complete confidence in my discretion to reside at the Observatory whenever it was necessary. This decision, of course, threw a very heavy responsibility on my shoulders but it resulted in establishing me as a reliable single station forecaster in the eyes of the government and the general public.[66]

Throughout the second half of the nineteenth century meteorologists had been divided on the origins and functioning of cyclonic storms, with consequences for how the possibility of prediction was conceived. Thermal or convective theories, which saw the release of latent heat through the condensation of water vapour as the chief source of kinetic energy in cyclones, slowly came to marginalise earlier, dynamic or mechanical theories which saw the existence of conflicting currents in the wind field as the chief source of motion. James Pollard Espy's early convective theory of the 1830s required the thermodynamic advances of the 1850s and 1860s before it could be enumerated, and later studies of surface temperatures and cloud and precipitation patterns appeared to support the notion of convection being the key source of kinetic energy. Convective theory, rooted as it was in the key theoretical concerns of mid-nineteenth century physics, would go on to secure reasonably widespread acceptance in meteorological communities in North America and Europe, following Espy's sparring on the matter with Redfield[67]. However, disagreements remained, and were heightened as observations began to be made of the upper atmosphere, with temperature discrepancies above cyclonic systems and competing views of the independence of cyclones from the general circulation posing challenges to a unified convective theory.[68] Mechanical theories thus continued to propagate. Hippolyte Marié-Davy, head of the Paris Observatory's troubled storm warning service in the 1860s and later Director of the Montsouris Observatory[69], posited cyclonic storms, whether of tropical or extra-tropical varieties, as large rotating aerial disks whose centrifugal forces caused the outflow of air, the diminution of pressure in the centre, and thus the inflow of air at lower and higher altitudes. Similar ideas were put forward by the Swiss-born Marc Dechevrens, director of the Jesuit observatory at Zikawei in modern-day Shanghai from 1877-87, and later the founder of an observatory at the Maison Saint Louis on the island of Jersey. Dechevrens found support for his 'whirl-generator' hypothesis through empirical studies at the Puy de Dôme and the Pic du Midi, posing direct challenges to convective theories.[70] The respected astronomer Hervé Faye, a tracer of comets and theorist of solar radiation, also published profusely on cyclone theory, positing a model whereby cyclones formed in the upper strata of the atmosphere, with kinetic energy 'propagated downward by descending motion accompanied by gyration around a vertical axis'.[71]

The conflict between largely Francophone mechanical theories and the convective theories which found greater favour among Anglophone meteorologists was played out, appropriately, in the public and bilingual meteorological culture of Mauritius. In February 1902 the French language daily newspaper *Le Cernéen* published a piece which put Faye's theories, recently compiled in his *Nouvelle étude sur les tempêtes, cyclones, trombes ou tornados*,[72] alongside the ideas of William Ferrel, who at that moment was perhaps the paradigmatic convective theorist. Albert

Walter, writing in the *Proceedings* of the Meteorological Society, found the symmetrical treatment of these bodies of work deeply unwarranted.[73] Walter and Claxton were both committed to convective theories, and Walter railed, with uncharacteristic directness and large doses of sarcasm, against Faye's apparently circular reasoning about the role of upper air currents in directing storms, and thus of the possibility of identifying the currents by tracking the storms themselves. Walter drew attention too to Faye's contradiction of the spiral hypothesis with his insistence that cyclonic winds are 'regulierement circulaire'. While Meldrum's apparent confirmation of the spiral hypothesis had become a serviceable truth for mariners and forecasters alike, meteorological theorists were still divided, with Napier Shaw – Director of the Meteorological Office in London from 1905 to 1920 – recollecting in 1926 that 'even within our own official experience we have received protests against Meldrum's representation of incurved spiral paths as being erroneous'.[74] But Walter saved most of his ire for a passage in the *Nouvelle étude* which compared terrestrial atmospheric cyclones to the cyclonic behaviour of sunspots, particularly in how they apparently functioned as descending gyratory currents. In some ways this was Faye claiming the terrestrial atmosphere for the theoretical and analogical reasoning of astronomers; students of the heavenly bodies, with their superior grasp of physical theory, could lower their eyes to earth, ready to interpret the more mundane phenomena of fluid motion which animated the atmosphere. But Walter, while admitting great empirical deficiencies in collective understandings of the tropical atmosphere, could nonetheless point to a growing armoury of local observational data which appeared to support a modified version of dominant convective theories. Cloud observations at the RAO contradicted Faye's arguments about gyratory action originating in the cirrus stratum, while the amassed studies of cyclone tracks seemed to contradict emerging ideas about the continual circulation of new masses of air through cyclonic storms, indicating their imbrication with the general circulation.[75] Walter instead sided more with Ferrel, arguing that southern hemisphere tropical cyclones were quite independent of any anticyclonic action and of the general circulation writ large – 'our cyclones are quite distinct in themselves and quite independent of any anticyclonic action'.[76] This theoretical stance – cyclonic storms with 'definite boundaries'[77] – furnished the Mauritius meteorologists with discrete entities which could be tracked, understood and perhaps predicted without the observational apparatus which would have furnished a picture of the wider synoptic situation. Viewed from Mauritius at the turn of the century, a tropical cyclone was a distinct object, an island in itself, roaming around an otherwise blank and, crucially, now largely un-observed oceanic space according to empirically-derived rules whose regularity permitted a novel form of prediction.

The resulting predictive efforts were, however, not without their deficiencies, and were built around relationships of trust and authority which came under frequent strain. The seemingly troubled relationship between Claxton and Walter ('Claxton was not too fond of me', Walter recalled[78]) continued to fracture during subsequent cyclone seasons. Walter had been taking on extra work compiling and analysing sugar cane statistics, while Claxton 'did all he could to make life difficult by insisting on the first and last train each day for attendance at the Observatory'.[79] On the 10th of January 1910 Claxton and Walter had disagreed over the significance of a falling barometer and Claxton, less concerned about the prognosis than his assistant, headed home, leaving Walter to observe an incoming storm without the Directorial authority to issue a warning and keep ships in the harbour. A worried telephone call from the Harbour Master informing Walter that the *Loodiana* was setting sail despite worsening conditions led to frantic attempts to reach Claxton at home. But with no official word forthcoming from the Director, the Harbour Master was powerless to prevent the departure. The *Loodiana* was lost in the storm, along with 176 passengers and crew.[80] Not long after the official inquest, the Directorship of the Hong Kong Observatory fell open. The Colonial Office wanted Walter to apply, but the Colonial Secretary on Mauritius seemingly stopped the proposal reaching Walter, and put Claxton forward instead. Claxton left Mauritius in May 1911, with Walter taking over as Director of the Royal Alfred.[81]

By this point Walter had established himself as a prominent figure in island society. In 1910 he published *The Sugar Industry of Mauritius: A Study in Correlation*, the product of a number of years' work examining meteorological and agricultural records, the latter gleaned from the island's largely French planter establishment. Walter had married into a prominent French landowning family, easing his making of new links among the island's Francophone elite. His book made a number of claims about how cane yields were affected by climatic conditions, but his most ambitious arguments concerned the effects of cyclones. He suggested that observations of cyclone intensity at opposite ends of the island allowed him to infer, through techniques of statistical interpolation, the intensity of the cyclone at all points in between. 'Isoptherms', lines of equal devastation, could be drawn across the map of the island, allowing the presumed effects of a transiting storm to be down-scaled to the level of an individual plantation. Walter proposed his statistical machinations as the basis for a cyclone insurance scheme, whereby the true value of lost crops could be inferred not from the unreliable and often tardy testimony of insurance field inspectors, but from the statistical manipulation of meteorological data.

Walter was working on his statistics during a period of acute capital shortage on Mauritius. The plantation economy had frequently struggled through periods of low sugar prices and insufficient credit. Between 1892 and 1909, steadily falling prices along with a damaging series of droughts, cyclones, and disease outbreaks hurt the prospects for outside capital investment,[82] and Walter's scheme aimed to smooth the inter-annual cycle of capital circulation, which saw capital lying dormant between December and April, while profits were frequently consumed by the repair of storm-damaged buildings and equipment.[83] Walter's proposals received the support of the planter and financial communities, but it wasn't until after World War II that a cyclone insurance scheme based on his calculations was instituted.[84] By that time Walter had long since moved on to Nairobi, where he led the establishment of the British East African Meteorological Service. Working across huge swathes of territory, he regretted the loss of his island laboratory where total vision and freedom from 'the effect of extraneous outside influences' had allowed him to trace, across a wide range of phenomena, 'the relation of cause and effect' in seemingly precise terms.[85] Despite ongoing efforts to develop new infrastructures for field-based agricultural meteorology, it wasn't until his involvement in the post-war development of Britain's 'groundnut scheme' in Tanganyika, with the possibility of intensive monitoring of climate and crops, that Walter could at last regain something of the laboratory vision he felt himself to have attained in Mauritius.

The cyclonic sublime

Making knowledge about cyclones in colonial Mauritius was always about finding imaginative ways of filling in the gaps in-between sparse, often unreliable instrumental observations, whether that be the retrospective construction of cyclone tracks and behaviour from loosely coordinated ship observations, or Walter's inferences about the damage wrought by cyclones in between the points where the cyclone, and its effects, could be directly observed. The practice of single station forecasting pushed the challenges of 'remote sensing' even further, and in a curious passage in his memoirs Walter related the emotional, imaginative work which lay behind this palimpsest of observation, projection and correction. In the preface to a passage entitled 'The Cyclone…A meteorological fantasy…or an objective reality?' he appealed to future keepers of his memoirs to either retain this section within the memoirs of his 'official life', or to relegate it to the more informal autobiography he planned to write for his family. Their decision was to be based on whether Walter's animist reading of the character of cyclones was in future deemed to be nearer fantasy or reality. When compiling his notes in the 1960s, Walter appeared to be leaning towards the latter, noting the new trend for naming individual storms as affirmation that others shared his appreciation for the individual character and essence of discrete storms.[86]

In the passage, made-up of diary entries and text written during his time in Mauritius, Walter's otherwise business-like tone erupts into a riot of metaphor and allusion as he describes the process of communing with this 'deadly creature of Nature'. From the moment a disturbance is first registered by the barometer, he writes that 'I felt that there was a special genie of the storm with which my own consciousness seemed to be in contact'. The first feeling was of 'uneasy anticipation accompanied by the perception of peculiar moaning in the gentle gusts of the wind which to me was always the prelude to a storm'. It was this perception which sent Walter to his post at the Observatory to begin his lonely vigil with barometer and anemometer. From there he would observe the development of high cirrus clouds 'streaming out from the centre of the storm' like 'a host of fairy chariots mounted by the gremlins of the storm'. The roar of the sea would start to sound an 'ominous accompaniment… to the great atmospheric orchestra', and as he 'followed each slight change in the wind and pressure, summing up almost unconsciously, the probabilities of their significance, there always seemed to be a directing consciousness of control saying: 'not this way but that''.

These themes of consciousness and control recur throughout the passage. He describes the storm as a 'living organism' being created and 'built up by some active intelligence of which I myself became consciously a part'. As the storm neared, he 'never felt terrified' but, he argues, 'I…felt that I was part of it and in control'. Once the centre of the storm had passed over the island and the observatory, he writes 'there grew a sense of achievement, of finality and satisfaction, as the muted sounds of the storm played their andante movement'. As the eye moved off and the drama increased again there was nothing more to be done by way of forecasting, and so Walter could revel in the extreme aesthetics of thunder and lightning, wind and rain.[87]

While the passage might be dismissed as irrelevant to the real business of cyclone prediction, the terminology Walter uses – 'glamour', 'romance', 'poetry', the force of 'imagination' – speak in important ways to our understanding both of scientific observation, and to the moral economy of forecasting. Lorraine Daston has written of how practices of observation are shaped by pedagogy, experience and habit into the 'all-at-once-ness' of scientific perception, what field naturalists refer to as 'jizz' – the 'sure, swift, silent' movement from flashes of perception to reliable knowledge, 'without pause for mental analysis'.[88] We might wonder whether Walter's cyclonic metaphors – fairy chariots ridden by gremlins, a cascading orchestra of multiple sections – were not just means of retrospectively colouring his story, but played a more active role in producing pattern and order in the sensory experience of a storm. We can understand this method of sensing cyclones as a process of gestalt perception, a sensory perception of synthesis, through the recognition of form, pattern, and the coalescence of key attributes of a storm which is either heading out to sea, or coming this way.

Turn of the century cyclone forecasting in Mauritius was quite clearly reliant on tacit and 'personal knowledge' in Polanyi's sense,[89] as illustrated by the economy of responsibility which had grown around it. In some sense then this was little different to the broader nineteenth century politics of weather forecasting and storm warning, where public debates about the authority of meteorology were widespread, at least in western Europe and North America, along with the sometimes tragic politics of forecasters' personal reliability and responsibility.[90] But what's unique in Mauritius is the combination of a well-developed culture of public meteorological debate and an almost complete lack of the infrastructure for seeing further, such that storm forecasters in Great Britain, the US and the West Indies by that time had, for example. Cables from surrounding islands weren't much help, as by the time a storm had been sensed there it would be too late to start the process of observation, prediction and warning on Mauritius. The consequent reliance on what we might call an individual's cyclonic jizz, and the social pressure brought to bear on the forecaster, is reflected in Walter's rendering of the sudden freedom of responsibility when the eye of the storm arrives. With the storm squarely overhead, no more forecasting is required, and despite the destruction undoubtedly being caused to the neighbourhood, the gestalt perception of the storm can switch from anxious anticipation to aesthetic pleasure in something which, in Walter's rendering, is very much akin to the sublime.[91]

Conclusion

The history of Mauritian meteorology narrated here enriches the historiography of meteorology's global 'march'[92] by offering further evidence of the capacity of places which could be considered colonial 'peripheries' to produce novel theoretical knowledge with global applications.[93] Insights such as that concerning the spiralling winds of cyclonic storms are a further refutation of diffusionist geographies of science: far from a dependence on the metropole, the successes of Mauritian meteorology were built upon colonial networks of alliance and patronage which encompassed local merchants, planters, and passing seamen, strained relations with the colonial government, and occasional and modest support – moral and financial, plus a few tables of data – from London. In the mid-nineteenth century the regular passage of trading ships meant that the Meteorological Society could become a powerful centre of calculation, the island a rich meteorological archive, with Meldrum in particular earning renown throughout the Empire and wider world for his new delineation of the Law of Storms. However, the changing geographies of maritime mobility re-oriented the practice of meteorology on Mauritius, which became much more focused on the observatory as a space carefully regulated in terms of epistemic practices and responsible conduct, and on a science which could help make the colonial economy more productive and resilient in the face of a fickle climate. The island came to function as both a laboratory where new laws could be tested and put to work, and a field where the local effects of meteorological phenomena could be closely observed. The serviceable truths which resulted from the earlier observational work brought the island's meteorologists into new relationships of service and accountability, in a moral economy made manifest in the government's regulation of meteorological conduct, as well as in the narrative structure of Albert Walter's cyclonic sublime.

This was an instrumental, sensory and imaginative engagement with a frequently violent atmospheric environment, through fields of vision which waxed and waned with the comings and goings of imperial trade, and which were constituted by a combination of instrumental observation, learned laws, and imaginative projections.

The literature on the history of island science and island environments would be enhanced by examining not just the construction of the island as an object of knowledge and control, but also by examining the place of islands in scientific and political projects which took much wider, more unruly spaces as their object and setting. The history of Indian Ocean meteorology can contribute to a broader historiographical turn which sees the region as a space of significant interconnections which crossed colonial boundaries and waxed and waned as economic, political and technological systems shifted.[94] We can see these dynamics in the circulation and adaptation of ideas between places like Calcutta and Mauritius; in the itinerant 'colonial lives' of figures like Meldrum, Walter and Claxton between Bombay, Port Louis, Nairobi and Hong Kong;[95] and in the technologies and media which shuttled weather observations and warnings from island to island, from ship to shore and back again. These technologies expanded meteorological fields of vision, but also lead to disconnection as when, for example, steamships began to bypass Mauritius and attention turned to single-station forecasting, a technique which would later come to prominence on ships in World War II, when radio black-outs created sparse informational environments like those encountered by cyclone forecasters in Mauritius around the dawn of the twentieth century.[96] Within these regional and trans-regional geographies, we can understand islands like Mauritius variously as archives, fields, and laboratories, where data could be amassed from afar, generated through watchful, local observation, and apparently universal laws tested against the specifics of locality.[97] Situating these functions within atopia such as the Indian Ocean, where projects of domination rub up against the arresting forces of a 'natural alterity',[98] offers the scope for better understanding the polycentric geographies of colonial science, as well as the place of scientific knowledge, and collaboratively negotiated serviceable truths, in the reproduction of colonial societies.

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[1] Simon Naylor, 'Log books and the law of storms: maritime meteorology and the British Admiralty in the nineteenth century', *Isis* (2015) 106, pp.771–797. See also Deborah R. Coen, 'The storm lab: meteorology in the Austrian Alps', *Science in Context* (2009) 22, pp.463–486.

[2] Vladimir Jankovic, *Reading the Skies: A Cultural History of English Weather, 1650-1820*, Chicago: University of Chicago Press, 2000; Simon Naylor, 'Nationalizing provincial weather: meteorology in nineteenth-century Cornwall', *The British Journal for the History of Science* (2006) 39, pp.407–33; Lucy Veale, Georgina Endfield and Simon Naylor, 'Knowing weather in place: the Helm Wind of Cross Fell', *Journal of Historical Geography* (2014) 45, pp.25–37; Martin Mahony, 'For an empire of 'all types of climate': meteorology as an imperial science', *Journal of Historical Geography* (2016) 51, pp.29-39; James Bergman, 'Knowing their place: the Blue Hill Observatory and the value of local knowledge in an era of synoptic weather forecasting, 1884–1894', *Science in Context* (2016) 29, pp.305–346. On meteorological science and the imperial state, see Katharine Anderson, *Predicting the Weather: Victorians and the Science of Meteorology*, Chicago: University of Chicago Press, 2005, chapter 6.

[3] Richard H. Grove, *Green Imperialism: Colonial Expansion, Tropical Island Edens and the Origins of Environmentalism, 1600-1860,* Cambridge: Cambridge University Press, 1995; see also Etienne Stockland, 'Policing the oeconomy of nature: The oiseau martin as an instrument of oeconomic management in the eighteenth-century French maritime world', *History and Technology* (2014) 30, pp.207–231.

[4] See for example Stuart B. Schwartz, *Sea of Storms: A History of Hurricanes in the Greater Caribbean from Columbus to Katrina,* Princeton, NJ: Princeton University Press, 2015.

[5] To borrow the term from Sujit Sivasundaram, *Islanded: Britain, Sri Lanka, and the Bounds of an Indian Ocean Colony,* Chicago: University of Chicago Press, 2013.

[6] Siobhan Carroll, *An Empire of Air and Water: Uncolonizable Space in the British Imagination, 1750-1850,* Philadelphia, PA: University of Pennsylvania Press, 2015, p.7; Gayatri Chakravorty Spivak, *Death of a Discipline,* New York: Columbia University Press, 2003. On the complex history of oceanic territoriality, see Philip E. Steinberg, *The Social Construction of the Ocean,* Cambridge: Cambridge University Press, 2001.

[7] Bruno Latour, *Science in Action*, Cambridge: Harvard University Press, 1987, p.232.

[8] I take the notion of 'serviceable truths' from contemporary studies of regulatory science, meaning 'a state of knowledge that satisfies tests of scientific acceptability and supports reasoned decision making, but also assures those exposed to risk that their interests have not been sacrificed on the altar of an impossible scientific certainty'. See Sheila Jasanoff, *The Fifth Branch: Science Advisers as Policymakers,* Cambridge: Harvard University Press, 1990, p.250. On the broader sociology of truth-making, see Steven Shapin, *A Social History of Truth*. Chicago: University of Chicago Press, 1994.

[9] Alexander Thom, 'Preface', *Proceedings of the Meteorological Society of Mauritius* (1853), pp.iv-xii, quotation p.iv

[10] George Basalla, 'The spread of western science', *Science* (1967) 156(3775), pp.611–22; Lewis Pyenson, *Cultural Imperialism and Exact Sciences: German Expansion Overseas, 1900-1930,* New York: P. Lang, 1985; Lewis Pyenson, *Civilizing Mission: Exact Sciences and French Overseas Expansion, 1830-1940,* Baltimore, MD: Johns Hopkins University Press, 1993.

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[12] Richard H. Grove, 'The East India Company, the Raj and the El Nino: The critical role played by colonial scientists in establishing the mechanisms of global climate teleconnections, 1770-1930', in Richard H. Grove, Vinita Damodaran, and Satpal Sangwan (eds.) *Nature & The Orient*, Oxford: Oxford University Press, 1998, pp.301–23; Gregory Cushman, 'The imperial politics of hurricane prediction: from Calcutta and Havana to Manila and

Galveston, 1839-1900', In Mark Lawrence, Erika Bsumek, and David Kinkela (eds.) *Nation-States and the Global Environment*, Oxford: Oxford University Press, 2013 pp. 137–162.

[13] William K. Storey, *Science and Power in Colonial Mauritius,* Rochester: University of Rochester Press, 1997. Storey built here on the work of Madeleine Ly-Tio-Fane, for example her *The Triumph of Jean Nicolas Céré: And His Isle Bourbon Collaborators*, Paris: Mouton, 1970.

[14] James E. McClellan III and Francois Regourd, *The Colonial Machine: French Science and Overseas Expansion in the Old Regime,* Turnhout: Brepols, 2012.

[15] Quoted in John McAleer, *Britain's Maritime Empire: Southern Africa, the South Atlantic and the Indian Ocean, 1763–1820*, Cambridge: Cambridge University Press, 2017, p.7.

[16] Ashley Jackson, *War and empire in Mauritius and the Indian Ocean*, Basingstoke: Palgrave, 2001, p.17.

[17] Storey, op. cit. (13), p.27.

[18] Island of Mauritius Meteorological Service, *Meteorology in Mauritius, 1774-1974,* Vacoas, 1974.

[19] Lissa Roberts, '"Le Centre de Toutes Choses": constructing and managing centralization on the Isle de France', *History of Science* (2014) 52, pp.319–42.

[20] Edley Michaud, 'Meteorologist's profile - Charles Meldrum', *Weather* (2000) 55, pp.15–17. Little remains of Meldrum's own correspondence, except for fragments in the National Archives, Kew, and the collections of the Royal Society. The National Archives of Mauritius hold some correspondence, but relating to later periods. The account presented here of Meldrum's work therefore largely draws on published sources. One of his successors, Albert Walter, left a wealth of personal papers and correspondence to Oxford University, and use is made of these in the second half of the paper.

[21] Charles Bruce, *The Broad Stone of Empire: Problems of Crown Colony Administration, With Records of Personal Experience. Vol. II,* London: Macmillan, 1910, p.265. Bruce was Rector of the Royal College in Port Louis from 1868-78, and returned as Governor in 1897, a post he held for six years. 'Creole' in this period referred to a Mauritian-born person of French descent, rather than of African descent as now.

[22] Island of Mauritius Meteorological Service, op. cit. (18), p.2

[23] Edward Sabine to Captain W.A.B. Hamilton, 26 July 1854. The National Archives (subsequently TNA), Kew, BJ 3/54.

[24] Naylor, op. cit. (1).

[25] Bruce, op. cit. (21) p.265.

[26] Charles Meldrum, 'Report On the best means of carrying out the objects of the Meteorological Society of Mauritius: read before a Meeting of the Society on the 11th September 1851' in *Transactions of the Meteorological Society of Mauritius* (1851) 1, p.10. The Society started with 12 members, growing to 47 in 1859 and 92 in 1866.

[27] These contestations are best illustrated by Anderson, op. cit. (2).

[28] Alexander Thom, *An Inquiry into the Nature and Course of Storms in the Indian Ocean South of the Equator*, London: Smith, Elder & Co., 1845.

[29] Lieutenant Fyers to Robert Fitzroy, 21 April 1856, TNA, BJ 7/1013.

[30] Thom, Presidential address, *Proceedings of the Meteorological Society of Mauritius* (1853) pp.1-18, quotation p.11, emphasis in original

[31] Simon Naylor, 'Weather instruments all at sea: meteorology and the Royal Navy in the nineteenth century', in Fraser MacDonald and Charles W.J. Withers (eds.) *Geography, Technology and Instruments of Exploration*, Farnham: Routledge, 2015, pp.77–96.

[32] Naylor, op. cit. (1), p.776.

[33] John Herschel, quoted in Naylor, op. cit. (1) p.774.

[34] See for example, David Aubin, Charlotte Bigg and H. Otton Sibum (eds.) *The Heavens on Earth: Observatories and Astronomy in Nineteenth Century Science and Culture*, London: Duke University Press, 2010; Anderson, op. cit. (2); Naylor, op. cit. (1); Lorraine Daston, 'Unruly weather: natural law confronts natural variability', in Lorraine Daston and Michael Stolleis (eds.) *Natural Law and Law of Nature in Early Modern Europe: Jurispudence, Theology, Moral and Natural Philosophy*, Aldershot: Ashgate, 2008, pp.233–48.

[35] Mahony, op. cit. (2).

[36] Naylor, op. cit. (1) p.782.

[37] Bruce, op. cit. (21), p.265. Bousquet continued to make observations and to carefully observe passing cyclones. In 1866 he attempted to publish his tables and charts in Paris, but was rebuffed on account of the expense. Discouraged, he proceeded to destroy the two-volume manuscript. See 'Bousquet, Eugène Henri', *Dictionnaire de Biographie Mauriciennce.* Port Louis: Société de l'histoire de l'île Maurice (1941). Thank to Jacques Pougnet for drawing my attention to his episode.

[38] Mann, R. J. (1875). Address delivered by the President at the annual general meeting, January 21st, 1874. *Quarterly Journal of the Royal Meteorological Society*, *2*(10), 59–74. On Anglo-French meteorological rivalries in the Atlantic region, see Locher, F. (2008). *Le savant et la tempête: étudier l'atmosphère et prévoir le temps au XIXe siècle*. Rennes: Presses Universitaires de Rennes.

[39] Thom, op. cit. (9), p.xiii.

[40] Napier Shaw's 1926 volume on the history of meteorology describes Meldrum's charts as the first 'daily charts of the oceans', appearing over a decade before Capt. N. Hoffmeyer's daily charts of the Atlantic emanated from the Danish Meteorological Institute. Napier Shaw, *Manual of Meteorology, Volume I: Meteorology in History,* Cambridge: Cambridge University Press, 1926, p.287.

[41] Report of the 1859 Annual Meeting, contained in *Proceedings of the Meteorological Society of Mauritius 1859-60* (1861)*,* vol. 5*,* p.23.

[42] Redfield, quoted in Henry Piddington, *The Sailor's Horn Book for the Law of Storms*, 3rd edn, London: Williams and Norgate, 1860, p.108.

[43] Quoted in A. K. Sen Sarma, 'Henry Piddington (1797-1858): A Bicentennial Tribute', *Weather* (1997) 52, pp.187–93. Quote p.188.

[44] Piddington, op. cit. (42), p.108.

[45] Piddington, op. cit. (42), pp.113-4.

[46] See Naylor, op. cit. (1), p.786.

[47] Charles Meldrum, 'On the weather and hurricanes in the Indian Ocean from the 18th to the 29th of February, 1860', *Proceedings of the Meteorological Society of Mauritius* (1861) vol. 5, p.157

[48] Bruce, op cit. (21), p.268.

[49] 'A new discovery in the "Law of Storms"', *Wellington Independent*, 17 March 1874, reprinted from *The New York Herald*. The publishing history of this piece indicates something of the global circulation which Meldrum's work started to enjoy in the 1870s.

[50] See for example Ralph Abercromby, 'On Meldrum's Rules for Handling Ships in the Southern Indian Ocean', *Proceedings of the Royal Society of London* (1888) 44, pp.314–17.

[51] *Cyclonic tracks in the South Indian Ocean from Information Compiled by Dr. Meldrum*. London: Meteorological Office, 1891.

[52] Charles Meldrum, *The Law of Storms*, Port Louis, 1876. Available at the National Meteorological Archive, Exeter (subsequently NMA), Y23.D2.

[53] Charles Meldrum, 'On the oscillations of the barometer at Mauritius in connection with the Cape Gales', *Proceedings of the Meteorological Society of Mauritius* vol. 6, pp.9-16. Quote p.9

[54] Charles Meldrum, 'Annual Report', *Proceedings of the Meteorological Society of Mauritius* (1862) vol. 5, p.79.

[55] Thomas F. Claxton, quoted in *Proceedings and Transactions of the Meteorological Society of Mauritius (New Series)* (1901) vol. 2, p.11

[56] Borrowing the term from Sivasundaram, op. cit. (5).

[57] Anderson, op. cit. (2) p.114.

[58] Daniel R. Headrick, *The Tentacles of Progress: Technology Transfer in the Age of Imperialism, 1850-1940,* Oxford: Oxford University Press, 1988, p.108.

[59] Hubert E.H. Jerningham, 'Cyclone of April 29 1892 in Mauritius', in *The Hurricane: Mauritius, April 29, 1892*. Port Louis: Central Printing Establishment, pp.1-9.

[60] Quoted in B.M. Padya, *Weather and Climate of Mauritius* (Moka: Mahatma Gandhi Institute, 1989), p141

[61] Jerningham, op. cit. (59), p.3.

[62] Compare, for example, the more antagonistic politics surrounding the prediction of the Galveston hurricane of 1900, as reported in Cushman op. cit. (12), pp.155-157. Also Jamie Pietruska, 'Hurricanes, crops, and capital: the meteorological infrastructure of American Empire in the West Indies', *The Journal of the Gilded Age and Progressive Era* (2016) 15, pp.418–445, especially pp.431-432.

[63] For biographical details, see Joan M. Kenworthy, *Albert Walter, O.B.E (1877-1972) Meteorologist in the Colonial Service Part I : His Early Life and Work in Mauritius*, Reading: Royal Meteorological Society, Occasional Papers on Meteorological History, 2013, Joan M. Kenworthy, *Albert Walter, O.B.E (1877-1972): Meteorologist in the Colonial Service, Part II*, Reading: Royal Meteorological Society, Occasional Papers on Meteorological History, 2014.

[64] Walter left behind a considerable person archive and memoirs, which are held in the Commonwealth and African manuscript collection at the Bodleian Library, University of Oxford. This passage draws largely on his memoirs, *Echoes of a Vanishing Empire, being the Memoirs of a Meteorological and Civil Servant in the Colonial Empire, 1897-1947*. MSS. Brit. Emp. r. 9-10.

[65] Thomas F. Claxton, *Annual Report of the Royal Alfred Observatory for the year 1902*. NMA, Y17.K2; Walter, op. cit. (64), pp.33-34 .

[66] Walter, op. cit. (64), p.39.

[67] James Rodger Fleming, *Meteorology in America, 1800-1870,* Baltimore, MD: Johns Hopkins University Press, 2000.

[68] Gisela Kutzbach, *The Thermal Theory of Cyclones: A History of Meteorological Thought in the Nineteenth Century,* Washington, DC: American Meteorological Society, 1979.

[69] John L. Davis, 'Weather Forecasting and the Development of Meterorological Theory at the Paris Observatory, 1853--1878', *Annals of Science* (1984) 41, pp.359-382.

[70] Marc Dechevrens, 'On Vertical Currents in Cyclones', *American Meteorological Journal* (1886) 3, pp.170–186;H.W. Harrington, 'Comments on Dechevrens' 'On Vertical Currents...", *American Meteorological Journal*, 3 (1886), 184–86. Kutzbach, op. cit. (68), p.137.

[71] Kutzbach, op. cit. (68), p.84.

[72] Hervé Faye, *Nouvelle Étude Sur Les Tempêtes, Cyclones, Trombes Ou Tornados,* Paris: Gauthier-Villars et Fils, 1897.

[73] Albert Walter, 'On the Origin and Propagation of Cyclonic Storms', *Proceedings and Transactions of the Meteorological Society of Mauritius (New Series)* (1902) 3, pp.1–19.

[74] Shaw, op. cit. (40), p.298

[75] Frank Bigelow, *Report on the International Cloud Observations, May 1 1896 - July 1 1897,* Washington, DC: U.S. Weather Bureau, 1898.

[76] Walter, op. cit. (73), p.18.

[77] Walter, op. cit. (73), p16.

[78] Walter, op. cit. (64), p.32.

[79] Walter, op. cit. (64), p.47.

[80] "*Loodiana"*, Board of Trade Official Inquiry, 1910. Southampton Central Library, Maritime Collection. Available at http://www.plimsoll.org/resources/SCCLibraries/WreckReports2002/19975a.asp. Last accessed 13 June 2017.

[81] Walter, op. cit. (64). Unfortunately Claxton appears to have left behind little by way of his own recollections of these events.

[82] Storey, op. cit. (13).

[83] Albert Walter, *The Sugar Industry of Mauritius: A Study in Correlation; Including a Scheme of Insurance of the Cane Crop against Damage Caused by Cyclones,* London: A.L. Humphreys, 1910.

[84] J.B.G.S. Staub, *Crop Insurance in Mauritius, 1946-1971,* Port Louis: Cyclone and Drought Insurance Board, 1971.

[85] Walter, op. cit. (64), p.133.

[86] Walter, op. cit. (64), pp.38a-38b. The unusual numbering of the pages reflects their uncertain position in his memoirs.

[87] Walter, op. cit. (64), pp.38a-38b.

[88] Lorraine Daston, 'On scientific observation', *Isis* (2008) 99, pp.97–110, quote p.101. See also R. Ellis, 'Jizz and the joy of pattern recognition: virtuosity, discipline and the agency of insight in UK naturalists' arts of seeing', *Social Studies of Science* (2011) 41, pp.769–90.

[89] Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy,* London: Routledge, 1973.

[90] On the suicide in 1865 of Robert Fitzroy, see Naylor, op. cit. (2), p.417; Anderson, op. cit. (2), p.120-121; see also Peter Nichols, *Evolution's Captain: The Dark Fate of Robert Fitzroy, the Man Who Sailed Charles Darwin around the World*, London: Profile, 2003.

[91] There is surprisingly little literature on atmospheric aesthetics and the sublime, save for work on the visual cultures of cloud observation. See e.g. Anderson, op. cit. (2) pp.219-227; John E. Thornes, 'Cultural climatology and the representation of sky, atmosphere, weather and climate in selected art works of Constable, Monet and Eliasson', *Geoforum* (2008) 39, pp.570–80.

[92] Napier Shaw, 'The march of meteorology: random recollections', *Quarterly Journal of the Royal Meteorological Society* (1934) 60, pp.101–20.

[93] In this respect the paper seeks to extend the insights provided in Gregory Cushman's recent work, op. cit. (12). For more on the importance of looking to 'peripheries' in the history of meteorology, see Anderson, op. cit. (2) chapter 6; Cushman, Humboldtian Science, Creole Meteorology, and the Discovery of Human-Caused Climate Change in South America. *Osiris* (2011) 26, pp. 16–44; and Martin Mahony & Angelo Matteo Caglioti, 'Relocating meteorology', *History of Meteorology* (2017) 8, pp.1-14.

[94] Sugata Bose. (2009). *A Hundred Horizons: The Indian Ocean in the Age of Global Empire*. Cambridge, MA: Harvard University Press; Metcalf, T. R. (2007). *Imperial connections: India in the Indian Ocean arena, 1860-1920*. Berkeley, CA: University of California Press.

[95] Lambert, D., & Lester, A. (2006). *Colonial lives across the British Empire: imperial careering in the long nineteenth century*. Cambridge: Cambridge University Press.

[96] For example, 'Single observer forecasting', AIR 2/2083, The National Archives.

[97] Naylor, op. cit. (1).

[98] Carroll, op. cit. (6), p.7.