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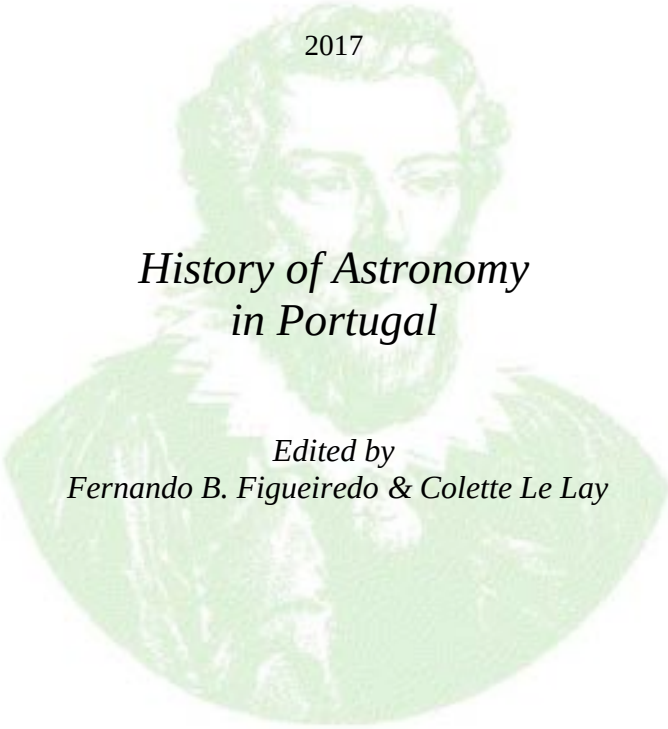

History of Astronomy in Portugal

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Meteorology, Timekeeping and "Scientific Occupation": Colonial Observatories in the Third Portuguese Empire[1]

Pedro M. P. Raposo*

Abstract

This paper presents a tentative overview of colonial observatories in the Third Portuguese Empire (1825-1957). The main issue under focus is the problem of action from a distance, that is, the attempts to steer an imperial network of observation from Lisbon, the tensions and obstacles that emerged in this undertaking, and the strategies implemented as a response. The paper develops around five key episodes: the attempt to create an imperial network of meteorological outstations controlled by the Infante D. Luis Meteorological Observatory (Lisbon), in 1857, the establishment of the Luanda Observatory (later João Capelo Observatory) in 1879, the inauguration of the Campos Rodrigues Observatory in Lourenço Marques (nowadays Maputo) in 1908, the attempt to upgrade the João Capelo Observatory in the 1920s, and the constitution of the National Meteorological Service of Portugal in 1946. These episodes are placed in their political context and approached with regard to the aspirations of imperial resurgence that underlay the Third Portuguese Empire.

Keywords: astronomy, meteorology, observatories, Third Portuguese Empire, colonial science.

Résumé

Ce chapitre présente un aperçu des observatoires coloniaux du Troisième Empire portugais (1822-1975). Il met essentiellement l'accent sur le problème de l'action à distance, c'est-à-dire des tentatives pour diriger un réseau impérial d'observation depuis Lisbonne, des tensions et obstacles qui apparurent, et des stratégies déployées pour y répondre. Le chapitre est organisé autour de cinq moments-clefs : la tentative de création d'un réseau impérial de stations météorologiques contrôlées par l'observatoire météorologique Infante D. Luis (Lisbonne) en 1857, la fondation de l'observatoire de Luanda (par la suite observatoire João

[1] Research presented in this paper was carried out under the post-doctoral grant SFRH/BPD/73373/2010 awarded by the FCT – Portuguese Foundation for Science and Technology. An earlier version was presented at the Centre François Viète, University of Nantes, on 26 November 2013.

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Capelo) en 1879, l'inauguration de l'observatoire Campos Rodrigues à Lourenço Marques (aujourd'hui Maputo) en 1908, l'essai de rénovation de l'observatoire João Capelo dans les années 1920, et la constitution du Service National Météorologique du Portugal en 1946. Ces événements sont placés dans leur contexte politique et envisagés au filtre des aspirations à une renaissance impériale qui servirent de socle au Troisième Empire portugais.

Mots-clés : astronomie, météorologie, observatoires, Troisième Empire portugais, science coloniale.

OBSERVATORIES played an important part in the development of European colonial expansion (Aubin *et al.*, 2010, p. 2). Besides assisting navigation, metropolitan observatories supported colonial surveys, promoted the mapping of previously uncharted skies, and set the guidelines for the study of colonial climates. Colonial observatories were often founded as a consequence of these undertakings. In other cases, they emerged together with aspirations and agendas that equated local autonomy with scientific progress. All of these settlements were involved in complex networks that shaped the geographies of empire, as they nurtured the circulation of practitioners, instruments, ideas and techniques over vast geographical areas.

The establishment and development of a network of colonial observatories were an endeavour recurrently embraced by stalwarts of the Third Portuguese Empire[2], which lasted from the 1820s (after the independence of Brazil) to 1975. This paper stems from preliminary research on this subject; it is intended to provide a tentative overview of Portuguese colonial observatories and their relations with the metropolis.

The provisional picture conveyed in the pages that follow develops around five key episodes: the attempt to create an imperial network of meteorological observatories and outstations controlled by the Infante D. Luis Meteorological Observatory (Lisbon) in 1857, the establishment of the Luanda Observatory (later João Capelo Observatory) in Angola in 1879, the inauguration of the Campos Rodrigues Observatory in Lourenço Marques (nowadays Maputo) in Mozambique in 1908, the attempt to upgrade the

[2] This expression is drawn from (Clarence-Smith, 1985). For a recent approach to the Portuguese empire in this period see (Jerónimo, 2012). For a more comprehensive picture of the empire in its several stages see (Disney, 2009; Bettencourt, 1988).

João Capelo Observatory in the 1920s, and the constitution of the National Meteorological Service of Portugal (based in Lisbon) in 1946. Approaching these undertakings requires us to go through distinct periods of Portuguese history: the liberal monarchy (1820-1910), especially the period known as Regeneração (1851-1890), the First Republic (1910-1926), and the Estado Novo (1933-1974).[3] Imperial and colonial agendas changed in the course of these political regimes but, one way or another, they were always grounded in the mythical idea of reviving the glories of the First Empire – that is, the maritime and commercial empire founded in the sixteenth century – and thus compensate for the loss of Brazil, the great colonial domain of the Second Empire. Africa, and especially Angola and Mozambique, constituted the focal point of these ambitions. The observatories and observing networks of these former Portuguese colonies will receive especial attention.

Colonial observatories constitute the subject of a growing body of literature. They have been approached, for instance, as focal points for the introduction and development of instrumental sciences in the colonial context, as undertakings entangled in conflicting views on how to assemble a proper observatory, and as nodes of the logistic circuits of empire (Zuidervaart, 2004; Schaffer, 2012; Mcaleer, 2013). These issues can also be identified in what follows, but this paper is mainly concerned with a more general problem: the problem of action from a distance,[4] that is, the attempts to steer an imperial network of observation from Lisbon, the tensions and obstacles that emerged in this undertaking, and the strategies implemented in order to overcome its predicaments.

Dreams of a "New Brazil"

Between 1853 and 1854, Guilherme Dias Pegado (1804-1885), a physics lecturer at the Polytechnic School of Lisbon,[5] steered the installation of a meteorological observatory in the premises of that school. Pegado was aware of the growing concerns with the standardisation of meteorological practices, an issue that was thoroughly discussed (albeit with limited success) at the international meteorological conference convened by Mat-

[3] The Estado Novo ("New State") was preceded by a military dictatorship that lasted from 1926 to 1933.

[4] The classic study by Bruno Latour (1987, ch. 6), *Science in Action*, and especially the concept of "centre of calculation", are particularly useful here.

[5] Escola Politécnica de Lisboa.

thew Fontaine Maury (1806-1873) and held in Brussels in 1853 (Anderson, 2010, p. 245).

After decades of turmoil and instability (Bonifácio, 2009) – due to the Napoleonic invasions, a civil war between liberals and absolutists, and the frequent upheavals that followed – Portugal was seeking to pacify its political life and to find a place amidst the modern nations of Europe. A decisive *coup d'état* in May 1851 inaugurated a period known as Regeneração. It lasted roughly until 1890 and was marked by a significant investment in transport and communication infrastructures (railways, roads, a telegraphic network) (Telo, 2004). The organisation of a national meteorological service and its involvement with the international scientific milieu was very much attuned to this agenda of modernisation.

In 1856, the observatory founded by Pegado was named Infante D. Luis Observatory[6] (henceforth IDLO) after its patron Prince Luis (later King Luis I). The IDLO was meant to function as a centre of calculation for meteorology in the mainland. It was also assigned the supervision of meteorological observations carried out aboard Portuguese vessels (Simões *et al.,* 2013, p. 106-111). There was still a lot to do at the metropolis; a meteorological network would have to be built from scratch. But the overseas empire was not forgotten. In April 1857, the Minister of the Navy, Viscount Sá da Bandeira (1795-1886) ordered the installation of meteorological stations in Cape Verde, Angola, Portuguese India, and Macau (a station had already been installed in Lourenço Marques). Sá da Bandeira had been campaigning for a "New Brazil" in Africa since the 1830s. As a keen purveyor of Portugal's imperial rebirth, he did not hesitate to endorse this grand meteorological plan. Guilherme Pegado was required to supervise the assemblage of colonial stations from the metropolis. A decree dated 17 August 1857, also signed by Sá da Bandeira, determined that colonial governors should carry out a periodical inspection of instruments and observations, and present, at least, one report per year. Official documents from 1858 and 1859 mention the dispatch of instruments, as well as observing protocols and forms to Cape Verde, Bissau, Angola, Mozambique, and Goa (Ferreira, 1962, p. 6).

In general, the implementation of this plan progressed slowly. By that time, Portuguese colonies were generally regarded as the last stop for exiles and freebooters. Solid administrative frameworks (let alone educational systems and scientific institutions) were generally lacking. Thus, it is not surprising that there was no dedicated personnel for the meteorological stations. The first observations were usually performed by Naval officers

[6] Observatório Meteorológico do Infante D. Luiz.

and medical doctors deployed to colonial service (Ferreira, 1952, p. 14). Naval officers began to observe in Luanda in 1857. Religious missions, settled in the Angolan hinterland, also maintained some observing series. The first meteorological records concerning Cape Verde refer to observations made by medical doctors, from 1864 onwards. In Mozambique, regular work seems to have started much later, in 1876, by the hand of Naval officers. In Portuguese Guinea, systematic observations began in the early twentieth century only (Ferreira, 1952, p. 11).

The meteorological activity might have developed more steadily in Goa, where an observatory was installed in 1860 at the Mathematical and Military School of the Portuguese Engineering Corps in India.[7] In Macau, observations were made from 1862 onwards, first at the Military Hospital of the Peninsula, and later at the captaincy of Macau's port.[8] However, in the face of the "Scramble for Africa", Portuguese authorities increasingly directed their attention towards the African colonies, and especially to Angola and Mozambique. In 1875, the Lisbon Geographical Society[9] (henceforth LGS) was launched to promote the exploration of the African hinterland, which hitherto remained largely unknown (Medeiros, 2004). Portugal claimed to be the historical sovereign of those territories, but after the colonial conference held in Berlin in 1884-5, effective occupation became the sole criterion of sovereignty accepted by the other colonial powers.

It was in this context that an observatory was, for the first time, established in Portuguese Africa with a permanent character, within the institutional framework of colonial administration. The Luanda Meteorological Observatory was founded in April 1879, under the aegis of the Department of Public Works of Angola. Its regulations, issued in July 1879 (Government of Angola, 1879), prescribed a staff of two elements (the director and an assistant observer), who were expected to work in the observatory and to develop a network of meteorological stations. Each station was to be equipped with a barometer, thermometers, an udometer (rain gauge), an evaporimeter, a weather vane, an ozonometer, a print showing the different types of clouds, and some accessory devices. A detailed set of instructions for each kind of observation was also included in the regulations. All of these dispositions were sanctioned by the metropolitan authority of the IDLO, which, by that time, was directed by João Carlos de Brito Capelo (1831-1901). Educated as a Naval officer, Capelo becomes an ob-

[7] In 1871 the School was replaced with the Professional Institute of Goa, to which the observatory remained appended.

[8] *Boletim Oficial do Estado da Índia*, 2 October 1860.

[9] Sociedade de Geografia de Lisboa.

server at the IDLO in 1855. In 1875, he was appointed Director. Capelo's works on ocean streams, terrestrial magnetism, and solar activity garnered him recognition in Portugal and abroad (Bonifácio *et al.*, 2007). In 1916, the Luanda Observatory was rechristened João Capelo Observatory[10] (henceforth JCO) in his honour.

The original location of the Luanda Observatory was probably the captaincy of the city's port. In 1881, it was transferred to the former cathedral of Angola (the Church of Nossa Senhora da Conceição), whose tower was, by then, the tallest construction in Luanda (fig. 1). The Observatory was also equipped with instruments for magnetic observations (Sociedade de Geografia de Lisboa, 1882, p. 296-299), and with a time-ball, which suggests that there was an astronomical installation for timekeeping purposes as well. Unfortunately, the timekeeping activity of the JCO is poorly documented.

Figure 1 - The Luanda Observatory (*Source:* O Occidente, *n°166, 1883*)

As to meteorology, tables summarising observations for 10-day periods were regularly published in the official bulletin of the colony, at least from January 1879, that is, prior to the official foundation of the observatory. This suggests that the regulations of July 1879 were issued as an at-

[10] Observatório João Capelo.

tempt to consolidate on-going meteorological work, to justify the change of premises, and to foster the development of a meteorological network. It was not an easy task in a colony where the infrastructure and administrative framework were generally incipient. Observations were submitted to the IDLO, but over the next decades, the coverage of the territory would remain insufficient to provide for comprehensive climatological studies.

The Africanist agenda gained momentum in Portugal throughout the 1880s, but was seriously challenged in 1890. The Portuguese had been nourishing dreams of a great colony extending from the coasts of Angola to the shores in Mozambique, on the opposite side of the continent. However, England also intended to reinforce its African domain with a long railway connecting the Cape with Cairo, and did not want the Portuguese on the way. On 11 January 1890, Lisbon was compelled to order a retreat of Portuguese military forces deployed in disputed territories between Angola and Mozambique. The Portuguese authorities could do little more than to comply and seek a satisfactory deal in the ensuing negotiations (Teixeira, 1990). The episode, known in Portugal as the "British Ultimatum", triggered perceptions of imperial fiasco and national abashment, putting the Portuguese liberal monarchy in jeopardy. But it also gave a new thrust to imperial aspirations in the country. Over the next two decades the Republican ideology would get stronger and stronger, until taking over in the revolution of October 5th, 1910. And so did the idea of imperial re-enactment, which was keenly incorporated in the Republican propaganda and increasingly perceived as a formula for national rebirth.[11]

"An Outburst of Instruction": The Campos Rodrigues Observatory in Lourenço Marques

The Portuguese techno-scientific elite was generally keen to embrace this ideal and to shape it into a programme of rational colonialism. Ernesto de Vasconcelos (1852-1930)[12] featured among those who took on this task. A naval officer and hydrographical engineer by training, Vasconcelos paved a sound career in the politics and the administration of the empire. A founding member of the Lisbon Geographical Society, he became its Perpetual Secretary in 1911. This appointment allowed him to consolidate a *persona* he had been crafting for years: that of a mastermind commanding the techno-scientific resurgence of the Portuguese empire.

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[11] For a comprehensive picture of the First Portuguese Republic and its ideological foundations, see (Rosas & Rollo, 2010).

[12] For a biographical synopsis see (Canas, 2009, p. 69-79).

Meteorology and climatology – the study of climate in a certain region over extended periods of time for the purpose of infra-structural planning, agricultural programs, public health management and similar ventures – occupied an important place in Vasconcelos's musings. In 1901, he convened the first national colonial congress, in which he presented his outlook for Portuguese colonialism in Africa (Vasconcellos, 1901). A programme of colonial meteorology was necessary, he claimed, to correct a historical mistake. The first settlers had been seduced by luxuriant vegetation and natural harbours sheltered from the wind. Vasconcelos seemingly upheld to the out-dated theory of miasmas, according to which "bad air" (air contaminated by rotting organic matter) was the cause of epidemics (Halliday, 2001). He was particularly concerned with "mephitic" emanations and malaria bouts in the hotter lowlands, especially in the proximity of rivers and lakes. New colonial ventures, he claimed, should preferentially aim at higher-altitude plateaus where circulation of air was stronger. Systematic observations were needed to assess the climatic suitability of prospective sites. For this purpose, Vasconcelos proposed a network of meteorological stations covering both the seaside and the high-altitude areas in the hinterland. Religious missions would work the high-altitude stations, leaving observations in the coast to port captains and health delegates. This network was to be centred upon three interconnected observatories: the Luanda Observatory, a new observatory to be established in Lourenço Marques, and also a new observatory in Lisbon, which was to act as the imperial overlord of the whole network.

By the early twentieth century, Vasconcelos was widely respected in Portugal as a purveyor of scientific colonialism, but he was not the only one to nurture observatory projects. Without his knowledge, a new observatory started to take shape in Lourenço Marques in 1905. The idea had been launched by Vasconcelo's fellow Naval officer and hydrographical engineer, Hugo de Lacerda (1860-1944), by then the captain of Lourenço Marques' port and the head of a public works programme aimed to upgrade its facilities.

Lourenço Marques' port was crucial for Mozambique's economy. Together with a railway connecting the Mozambican capital with Johannesburg, it constituted a major gateway for people and goods in South-eastern Africa. After the South-African War of 1899-1902, the ports of the Cape and Durban emerged as serious competitors. The programme commanded by Lacerda was meant to secure the competitiveness of the Portuguese

port.[13] Lacerda also saw it as an opportunity to present Portugal as a sophisticated colonial overlord, for which the establishment of an observatory in the port seemed very appropriate.

The Luanda Observatory had been officially in activity for a quarter of a century now, but it was not in Angola that Lacerda sought inspiration for his endeavour. Similarly to Vasconcelos, he had practised at the IDLO and at the Astronomical Observatory of Lisbon[14] (henceforth AOL) as part of his training as a hydrographical engineer. Lacerda maintained close ties with the AOL thereafter.

The AOL was founded in 1857 to collaborate with the Pulkovo Observatory (near St. Petersburg, Russia) in the development of stellar astronomy, namely in the measurement of stellar parallax. However, due to delays in its construction and to a shortage of qualified personnel, it was eventually refashioned as an observatory devoted to timekeeping, and accessorily to the measurement of stellar positions.[15] From the 1880s onwards the AOL firmed its status as a national timekeeper, transmitting the official time to a time-ball in the port of Lisbon.[16] The exactness of the Lisbon time signals became a badge of the AOL's commitment to precision. The astronomer César Augusto de Campos Rodrigues (1836-1919), also a Naval officer and hydrographical engineer by training, gave an important contribution to this state of affairs, with his technical contraptions and studies on observing methods. In 1904, he was awarded the Valz Prize of the Academy of Sciences of Paris. The prize consolidated his image as a local scientific hero, and firmed the AOL's status as an internationally respected centre of positional astronomy. This imbued Lacerda with the confidence necessary to engage in a transfer of timekeeping technology from the AOL to the remote harbour area of Lourenço Marques.

The AOL was in its heyday, contrasting with the IDLO. Over the previous decades, the IDLO had functioned as a one-man-observatory. It fell into decline after the demise of its virtuoso meteorologist João Capelo in 1902. The focal point of Portuguese meteorology gradually diverted towards the Azores, where the Army officer and science enthusiast Francisco Afonso Chaves (1857-1926) had recently established the Meteorological

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[13] (Castelo Branco, 1906). On the relations between Mozambique and South Africa in this period see (Katzenellebogen, 1982, p. 79-99).

[14] Observatório Astronómico de Lisboa.

[15] On the foundation and history of the AOL until 1910 see (Raposo, 2010).

[16] This time-ball was installed in 1885, in replacement of an older (and very inaccurate) time-ball that had been at work since the 1850s. The later probably served as a model for the time-ball of the Luanda Observatory, which can be seen in fig. 1.

Service of the Azores[17] (henceforth MSA), based at the Ponta Delgada Meteorological Observatory (Tavares, 2009). Chaves took advantage of the importance of Atlantic data for weather forecasts in order to firm the Azores as a major node in the international meteorological networks, and to fashion himself as a spokesman for Portuguese meteorology, in which he succeeded.

Lacerda made sure to consult the IDLO, but also brought Chaves in as an adviser. And the MSA provided more than a source of meteorological expertise. In 1901, the Ponta Delgada Observatory had inaugurated its own time service. In the face of the intense naval traffic that crossed the Azores, Chaves decided to complement the meteorological service with a chronometric checkpoint for navigation. Frederico Oom (1864-1930), astronomer at the AOL and Campos Rodrigues's sidekick, was required to supervise its installation. After discussing the costs and benefits of a proper astronomical observatory with Chaves, Oom recommended a parsimonious solution: a reliable clock at the Ponta Delgada Observatory, to be rated on a regular basis by an automatic time signal transmitted from Lisbon via the submarine cable. Oom himself supervised the installation of this system. This experience served as a test for further transfers of the AOL's timekeeping expertise and techniques.

Both Oom and Chaves travelled to the Mozambican capital, where they respectively coordinated the installation of the meteorological and astronomical departments of the new observatory. Before visiting Lourenço Marques, Oom also went to Hamburg, to study the observatory and the timekeeping system at work in the port of that city.

In 1908 the new observatory was inaugurated in Lourenço Marques and officially named Campos Rodrigues Observatory.[18] It was located near to the port, in an area of public estate, beside a major access to the city (Polana road). Lacerda conceived the observatory as a local monument of science: he wanted the surrounding parks to be freely accessed by passers-by, so that they could experience "a natural incitement to a burst of instruction".[19]

The meteorological building, which included the director's lodgings, sported the chalet style common in Lourenço Marques at the time (fig. 2). The astronomical facilities were, in comparison, much humbler. A small transit instrument was mounted on a pier inside a shed with meridian shut-

[17] Serviço Meteorológico dos Açores.

[18] "Observatório Campos Rodrigues".

[19] "(…) natural incentivo ao derramamento da instrução" (Observatório Campos Rodrigues, 1909, p. 7).

ters (fig. 3). Observations of stars were carried out with this instrument three times a week (weather permitting) by the American method, that is, by recording the observations with an electric chronograph. The observations were used to rate a sidereal time clock, and then, through the appropriate conversion, a solar mean-time clock. The two clocks were kept in a room appended to the meridian shed, which was also used as a computing office.

After some initial setbacks, time signals started to be sent regularly, via the telegraphic network, to a clock installed in the boarding area of the port. The signals were also relayed to a system of luminous semaphores that displayed the time in the freight area. This arrangement replicated the system of public time signals that Oom had saw at the Hamburg port. It was eventually adopted in Lisbon as well.[20]

Figures 2 and 3 - The meteorological and astronomical buildings of the Campos Rodrigues Observatory, 1908 (Source: Historical Archive of the Astronomical Observatory of Lisbon /MUHNAC)

Lacerda's astronomical ambitions actually went beyond timekeeping. He wanted the observatory to participate in the investigation of latitude variations, to measure and refine right ascensions of the southern stars, and to observe occasional phenomena such as eclipses and occultations (Observatório Campos Rodrigues, 1909, p. 4). A direct intervention in colonial surveying operations was not considered, because there was already a Surveying Department in Mozambique when the CRO was founded. But the CRO did participate in major geodesic campaigns such as the Portuguese Survey of South-Eastern Africa (1907-1914) and the resolution of a

[20] A very schematic and succinct journal written by Oom during this mission is kept at the Historical Archive of the AOL, in the file C648, together with correspondence exchanged with Richard Schorr (1867-1951), the director of the Hamburg Observatory at the time.

boundary dispute with England concerning an area known as Barotseland (nowadays in Zambia), as a coadjutant, not as an overlord (Santos, 1986 ; Observatório Campos Rodrigues, 1915, p. 4 ; Gago Coutinho, 1911).

The CRO also contributed with data for the study of latitude variations promoted by the International Geodesic Association (which Portugal had joined in 1867). However, the astronomical section remained essentially focused on timekeeping. Its apparatus did not allow for much more. Not all Portuguese dignitaries shared Lacerda's enthusiasm for the observatory. Mozambique's Governor Freire de Andrade (1859-1929), a military engineer and stalwart of colonial development,[21] questioned the CRO's relevance for the local economy. As a consequence, the colonial authorities provided limited funding. Lacerda and Oom were forced to order a Bamberg transit instrument, much less reliable than the Repsold instruments used for decades at the AOL. They also had to buy cheaper clocks, a predicament that Campos Rodrigues and Frederico Oom sought to circumvent by examining, testing, and whenever possible, improving the equipment before shipping it to the CRO.

However, the behaviour of instruments in the remote lands of South-eastern Africa was often deviant from their performance in the metropolis. This is well illustrated by the first mean solar time clock of the CRO, ordered from the Munich-based firm Riefler. Campos Rodrigues and Oom knew in advance that it would never perform at the same level as the AOL's clocks,[22] but tried to improve it as much as possible nevertheless. After thorough tests at the AOL they deemed it able to provide a satisfactory level of precision. But once installed at the CRO, its march proved so irregular that there was no option other than acquiring another clock.[23] In these circumstances, replacing or fixing an instrument usually required sending it back to the metropolis, from where it would be redirected to an expert firm abroad, or from where an order for a replacement would be placed and processed. The whole circuit of supply, test and delivery, which involved Lisbon, instrument workshops located elsewhere in Europe, and the Portuguese colonies, had to be re-enacted. The picture was worsened by the absence of advanced instrument and clockmakers in the Portuguese mainland itself.

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[21] Freire de Andrade held the post of Governor of Mozambique between 1906 and 1910. The observatory was already under construction when he took over.

[22] In Lisbon, Krille and Max-Richter clocks were used to keep, respectively, sidereal time and mean solar time.

[23] The acquisition of the CRO's instruments is documented in the abovementioned file C648 of the Historical Archive of the AOL.

Staffing the CRO constituted an additional problem. The observatory was under the aegis of the port's captaincy, thus its personnel usually came from the ranks of the War Navy. But it was not easy to find officers as enthusiastic, talented or committed to science as Campos Rodrigues or Hugo de Lacerda. Most officers who sought appointments at the CRO did so to escape from other colonial appointments, and usually did not stay long. Military discipline, which played a pivotal role, for instance, in the early development of the Indian meteorological network (Anderson, 2010, p. 276-282), was of little use for the CRO. Directors and sub-directors were required to practice at the metropolitan observatories (AOL and IDLO) before starting to serve at the CRO. But this period of practice did not suffice to prepare them to deal with the technical quandaries that often emerged in the observatory's daily life. Moreover, the personnel often felt ill and maladapted to the tropical climate of the colony – or at least they claimed so, in order to justify their will to leave. Contrary to British India, where natives were used as cheap labour; Portuguese colonial authorities generally excluded the natives from such functions, which narrowed down the pool of prospective observers.

It was only from 1916 onwards that the CRO's staff found some stability, with the appointment of Manuel Peres Júnior (1888-1968) to the post of director. Peres had practised for two years at the AOL, after obtaining a degree in mathematics from the Faculty of Sciences of Lisbon.[24] Better prepared and more dedicated than his predecessors, Peres consolidated a tradition of accurate timekeeping in the colony, whilst promoting the development of the Mozambican meteorological network.

The meteorological equipment of the CRO comprised five basic sets of instruments, for the following measurements: air pressure; measurements in the shade (temperature, evaporation and humidity); precipitation and soil temperature; direction and intensity of winds; actinometry (study of solar irradiation). The apparatus also included some self-recording instruments, namely a thermograph, two barographs, a psychrometer (for humidity), an udograph (for precipitation), and a Jordan heliograph (an instrument that recorded sunlight on an especial type of paper) (Observatório Campos Rodrigues, 1909). A forecast system based on isobars was eventually implemented.[25] The data used in the production of the forecasts was collected through a network of meteorological stations that started to expand after

[24] The Faculty of Sciences of Lisbon was established in 1911 in the sequence of the Republican Revolution of 1910, replacing the Polytechnic School of Lisbon (Simões *et al.*, 2013, p. 106-111).

[25] On isobars and meteorological mapping see (Anderson, 2010, ch. 5).

the Great War. It counted on stations at port captaincies, administrative services, private companies, and also on amateur contributors. Peres placed a considerable effort in disciplining station observers, distributing standardised instructions and forms, offering apprenticeships at the CRO, and carrying out inspections in situ whenever possible. However, it was only with the professionalization of observers and the introduction of financial prizes in the early 1920s that the observing routines in the network reached a satisfactory level of stability and reliability.[26]

Peres also managed to secure a place for the CRO in the international networks of meteorology. In the second meeting of the International Union of Geodesy and Geophysics, held in Madrid in 1924, the acclaimed British meteorologist William Napier Shaw (1854-1945) included the Portuguese observatory in a group of eight observatories (among 50) which were to be favoured as observing nodes in the study of solar irradiation (Shaw, 1925, p. 85-128).

The news certainly pleased Lacerda, who, by this time, was in Macau commanding a new harbour venture. Garnering recognition from abroad was the utmost achievement he had desired for the Mozambican observatory. In fact, Lacerda had conceived the CRO as a catalyser of scientific liaisons between Mozambique and South Africa. As interim director of the CRO, a post he held between 1908 and 1909, he obtained the agreement of the Johannesburg Observatory to standardise meteorological telegrams in the whole region (Observatório Campos Rodrigues, 1909, p. 9); he also promoted joint longitude measurements and barometric investigations.[27] With the aim of strengthening these ties, Lacerda suggested that the South African Association for the Advancement of Science (SAAAS) hold one of its annual meetings in the Mozambican capital. The SAAAS had been founded in 1903, reflecting the importance of science and technology to the ideology of South African autonomy (Dubow, 2006).

Lacerda's idea was well accepted by the Association. Between the 1st and the 13th of July 1913, Lourenço Marques hosted the eleventh meeting of the SAAAS. The meeting evinced a blatant imbalance between the scientific milieus of the two colonial domains. While South-Africa sported various observatories, museums, and other cultural institutions where the sciences were enthusiastically cultivated, Mozambique had little more to

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[26] See the reports of the CRO (*Relatório do Observatório Campos Rodrigues em Lourenço Marques*) for the years 1914-1925.

[27] *Circular No.15, 1914, January 19, of the Union Observatory*; Augusto Teixeira, "Diferença de longitude entre Johanesburgo e Lourenço Marques", Historical Archive of the AOL, C648 (Observatório Campos Rodrigues, 1910).

display than the CRO. This imbalance was evident in the proportion of papers presented by South-African and Portuguese (or Mozambique-based) attendants, which was clearly favourable to South-Africa.[28]

The meeting served its purpose nonetheless. The South-African scientific community keenly accepted Mozambique as a scientific partner. Over the first decades of its existence, the CRO remained a favoured focal point for scientific exchange. Both sides valued the liaison, as it represented a form of regional affirmation against the backdrop of the British Empire. Joint scientific pursuits also helped to cultivate an atmosphere of inter-colonial friendliness, much needed since relations between Mozambique and South-Africa were often plagued by tensions concerning the Lourenço Marques port and the supply of workforce to the South-African mines.

In spite of its substantial achievements, the CRO was not always well regarded in Lisbon. In 1921, Vasconcelos wrote that the CRO represented a considerable expenditure but was still performing below the expectations (Vasconcelos, 1921, p. 455), a remark that echoed Freire de Andrade's criticism. Vasconcelos probably never reconciled with the idea of having been superseded by Lacerda in the foundation of an observatory in Mozambique. Moreover, his plan for a new imperial observatory never took off. His only achievement in this regard was to establish a service of colonial meteorology under the aegis of the Ministry for the Colonies, which, starting in 1915, published an annual report summarising meteorological data collected from all over the empire, under the title *Anais Meteorológicos das Colónias* (Meteorological Annals of the Colonies).

Another critic of the CRO was Manuel de Brito Camacho (1862-1934), a prominent Republican who governed Mozambique between 1921 and 1923. In 1926 Brito Camacho wrote that "almost nothing really scientific and clearly useful has been done with respect to meteorology in the colony, albeit there is in Lourenço Marques an observatory entrusted with these investigations."[29] It was true that by then the CRO was still dealing with a shortage of station observers, and striving to extend its coverage of the hinterland. Still, Brito Camacho's remarks were unfair. Given the circumstances, the CRO had reached a noteworthy level of performance, especially when compared to the older observatory of Angola.

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[28] The programme and the proceedings of the conference are presented in (SAAAS, 1913).

[29] "Quasi nada ha feito, até agora, de verdadeiramente scientifico e manifestamente util, com respeito à meteorologia da provincia, não obstante haver em Lourenço Marques um Observatorio destinado a esses estudos" (Camacho, 1926, p. 134).

"Scientific Occupation" and Imperial Circuits: the João Capelo Observatory in Luanda

In 1912, José Ribeiro Norton de Matos (1887-1955) was appointed governor of Angola. Norton de Matos is best remembered in Portugal for daring to present himself as a democratic presidential candidate against Oliveira Salazar's dictatorship, the Estado Novo, in 1948.[30] This initiative granted him an enduring aura of freedom's paladin; his colonial legacy is more controversial. The efforts he placed at modernising Angola are undisputed. But his action as colonial governor is also marred by a seeming penchant for authoritarianism, coupled with an ambivalent attitude towards native populations. Norton de Matos showed concern for their working conditions and stood for their inclusion in the colonial administrative apparatus. However, he did so always from a strongly Eurocentric perspective, grounded on equal amounts of racism and paternalism. The education and assimilation of natives should, in his view, be carefully limited so that they did were not seduced by independentism. Whenever they were and showed it, Norton de Matos responded with stark repression.[31]

Norton de Matos's faith in the imperial destiny of Portugal was apparently fierce, and so was his trust in science as a tool to fulfil such a destiny. A military surveyor by training, he firmly believed, like Vasconcelos, Lacerda and other contemporaries, that the erstwhile glories of the Portuguese maritime empire could be revived through a steady programme of rational colonialism focused on Africa, which he often referred to as "scientific occupation". To promote science in the African colonies was, in Norton de Matos's own words, to "re-establish, in everything that concerns us [the Portuguese], the historical truth"[32] that is, the continuation of a civilising mission deeply inscribed in Portugal's fate as an imperial nation.

Norton de Matos first governed Angola between 1912 and 1915. He returned in 1921 as High-Commissioner of the Portuguese Republic (a post

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[30] Norton de Matos did not run in the end, arguing that the elections would be manipulated by the regime, as they were in fact. On Oliveira Salazar and his dictatorial regime see the last section of this paper, "Amorim Ferreira (1895-1974), the Estado Novo, and the National Meteorological Service".

[31] For an overview of Norton de Matos's political action in Angola see (Wheeler, 2009, p. 171-175).

[32] "Restabelecer em tudo que nos diz respeito a inteira verdade histórica: - que nos baste sempre a memória do que fizemos e o conhecimento do que somos capazes de fazer" (Matos, 1944, p. 15).

equivalent to governor), in which he stayed until 1924.[33] During his first tenure, Norton de Matos sought to reverse the generally backward state of the colony by reorganising its administrative framework: the departments for public works and agriculture, the customs, the mail and telegraph offices, among other services (Government of Angola, 1921, p. 55). His techno-scientific concerns dwelt primarily in the colonial health system and the surveying department (Government of Angola, 1921, p. 54), but meteorology was not forgotten. In a circular dated from April 1913, Norton de Matos demanded the higher civil servants of Angola to maintain a decent and "European" appearance in the premises they oversaw, to be aware of all legislation related to their assignments, and to obtain all instruments necessary to characterise the geography of their circumscriptions, which included their climatology.[34]

Norton de Matos's first tenure coincided, in fact, with a period of growth for the Angolan meteorological network. Between 1911 and 1915, roughly 30 new stations were installed. But the network as a whole remained incipient. Ever dissatisfied with the slow progress of meteorology in Portuguese Africa, Ernesto de Vasconcelos noted in 1915 that observations were often discontinued in Angola. The available series were not credible, he claimed, due to the lack of standardised instructions, to the frequent changes of personnel, and to the fact that many observers did not recognise the importance of their assignments. Vasconcelos also blamed the Portuguese National Press in Angola for adjourning the publication of meteorological reports (Vasconcelos, 1915, p. 5).

As far as astronomy was concerned, the time service of the JCO was seemingly in a deplorable state. In 1911, the AOL was informed that a Bamberg transit instrument used to carry out time observations had reached an advanced state of disrepair, and that the time-ball system was "the most primitive one": an assistant pulled a rope to release the ball upon hearing a ring clumsily activated by a clock. This arrangement rendered an average error of three seconds in the time signal,[35] which for the AOL astronomers was outrageous. The AOL published a quarterly report with the errors of the Lisbon time-ball to cents of a second. Frederico Oom liked to flaunt that the error of the Lisbon time signal rarely went above a few

[33] For a detailed analysis of Norton de Matos's first tenure in Angola, see (Dáskalos, 2008).

[34] "Circular do Governador Geral de Angola, de 17 de Abril de 1913", in (Matos, 1953, p. 155-156).

[35] Unidentified sender to Campos Rodrigues, 21 January 1911, Historical Archive of the AOL, file DD601.

tenths of a second – a widespread benchmark of chronometric acumen in the late nineteenth century and the early twentieth century (Canales, 2011), which the AOL had militantly embraced.

A serious attempt to improve the general situation of the JCO took place in Norton de Matos's second tenure as head of Angola's administration. Adamant to extend the "scientific occupation" of the colony, he promptly launched the Geological Mission of Angola (Teixeira, 1979, p. 21), and endorsed a lavishly-funded congress of colonial medicine that took place in Luanda in July 1923. Counting on an international and intercolonial audience (with attendants from the British, French and Belgian domains in Africa), the congress was intended to show that Portuguese authorities were concerned with native populations and generally committed to developing their colony on rational grounds (Matos, 1944, p. 292; Government of Angola, 1922).

Colonial medicine was the focal point for techno-scientific liaisons, which left the JCO in a secondary position. But Norton de Matos also had ideas for the observatory. In a speech delivered on 15 March 1922 (Matos, 1926, p. 164), he declared that the JCO and its meteorological services required an urgent upgrade. A new supply of instruments was eventually demanded from the metropolis, in order to re-enact dismantled stations and develop the network. The High Commissioner also wanted the astronomical section to be revamped, for which he summoned Frederico Oom to Angola. The astronomer visited the JCO in August 1922. In his report on the visit,[36] Oom stated it was pointless to compete with well-established observatories such as those of Durban and the Cape; the Portuguese authorities should focus instead on a reliable time service instead, using the CRO as a model. A second of precision was, according to Oom, the minimum goal to be attained, if Luanda wanted to sport a trustworthy time signal. Portugal's prestige was at stake, he further remarked, as Luanda's time service was the only one available in the region. Ideally, an effort should be made to work on tenths of seconds. Consequently, Oom added, the JCO should be transferred to purpose-built premises. And time observations with a theodolite, a makeshift solution that had been adopted in place of the deranged Bamberg transit, were to be discarded altogether.

In the sequence of Oom's visit, several astronomical instruments were sent from the JCO to Lisbon for repair. Most of them were deemed

[36] Frederico Oom, "Novo Observatório em Luanda", 30 September 1922, Historical Archive of the AOL, file DD601.

useless, or, at best, to contain some reusable components.[37] A set of new instruments was ordered in 1923. It included a new Bamberg transit, a Max-Richter clock, and a Nardin chronometer. Once again, the instrumental circuits of the empire proved difficult to deal with. The chronometer was successfully tested in Lisbon, but in Luanda its march revealed irregularities. A clockmaker based in the Angolan capital was unable to repair it, thus the chronometer had to be sent back to Lisbon. A local clockmaker managed to fix it, but some accessories had to be ordered from the Nardin firm in Switzerland. The chronometer returned to Luanda in 1928 only. There was also trouble with the new Bamberg transit. Oom had asked Bernhard Wanach (1867-1928) of the Potsdam Geodetic Institute to test the instrument there, which caused a delay in its dispatch to Lisbon. And when the instrument was finally unpacked in Luanda in 1925, the personnel of the JCO were desolate to find that some components were missing. In the case of the clock, the situation was even more dramatic, as both the clockmaker and Wanach died before it was dispatched to Angola.[38]

Further research is needed to clarify what happened in the ensuing years, but it is certain that the assemblage of the new observatory was yet to be completed when Norton de Matos ended his second appointment in 1924. The construction of new premises was postponed due to financial difficulties[39] and workforce issues. European workers were scarce and generally regarded as cunning opportunists, whilst natives were deemed lazy and untrustworthy.[40] It was not easy to recruit personnel for the observatory either, a situation that changed only when wages were raised.[41]

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[37] These instruments included the already mentioned Bamberg transit, a 108-mm Bardou telescope, 3 chronometers (by Dent, Debbie, and Casella), a Fortin barometer, part of a Casella anemograph, and a barometer. See "Relação dos instrumentos astronómicos e meteorológicos, pertencentes ao Observatório "João Capelo" de Luanda, que foram recebidos em 16 de Julho de 1913 no Observatório Astronómico de Lisboa (Tapada), vindos da Agência Geral de Angola para se decider [sic] sobre o seu possível aproveitamento", 1 September 1923, Historical Archive of the AOL, file DD601.

[38] The problems surrounding the acquisition of these instruments are partially documented in the file cited in the previous note.

[39] Vasco Lopes Alves to Frederico Oom, 23 April 1925, Historical Archive of the AOL, file DD601.

[40] J. A. Bacelar[?] to Frederico Oom, 16 September 1913, Historical Archive of the AOL, file DD601.

[41] J. A. Bacelar[?] to Frederico Oom, 18 January 1923, Historical Archive of the AOL, file DD601.

Significant improvements seem to have taken effect only by the late 1930s. In 1937 a new publication was launched: the Meteorological and Climatological Elements of Angola (*Elementos Meteorológicos e Climatológicos de Angola*). Angola's meteorological network grew substantially in the ensuing years. By the early fifties, the JCO controlled more than 180 stations (Serviço Meteorológico de Angola, 1954, p. 7-8; Ferreira, 1952, p. 15) and presented its results in three different publications: annual proceedings, tables of high altitude observations with balloons, and reports of ground observations.[42] A time service with radiotelegraphic transmission of time signals was also at work.

By the same time, on the other side of the continent, the CRO counted on auxiliary observatories at Beira (the second major city in Mozambique), Lumbo (a coastal town close to the Island of Mozambique), and Tete (in the central area of the colony). It controlled a network that summed up to 105 stations for ground observations, with three additional stations for balloon surveys (Ferreira, 1952, p. 16). Magnetic observations were also carried out at the JCO (the CRO had abandoned this kind of work early in its history due to the development of electric traction in its vicinities).

By the mid-twentieth century the two major Portuguese observatories in Africa had consolidated their performance as colonial centres of calculation. But this did not mean, necessarily, more autonomy from the metropolis. On the contrary, they were now under the strict control of a new imperial overlord.

Amorim Ferreira (1895-1974), the Estado Novo, and the National Meteorological Service

In 1933, the Constitution of the Estado Novo was formally approved, firming the ground for a dictatorial regime that would last until 1974.[43] Fiercely commanded by António de Oliveira Salazar (1889-1970), the regime used the political instability of the First Republic (between 1910 and 1926 there were 39 cabinets and numerous episodes of political violence) as a major argument to impose a strict order, grounded on political surveillance and repression. Empire was embraced as a badge of grandeur and might, and reviving its erstwhile glories became one of the Estado Novo's foundational myths (Rosas, 2012, p. 34).

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[42] Respectively: *Anuário Meteorológico do Observatório João Capelo; Observações meteorológicas de altitude em Angola; Observações Meteorológicas de superfície em Angola.*

[43] For a comprehensive picture of the Estado Novo, see (Mattoso & Rosas, 1998).

Although akin to the regimes of Hitler and Mussolini, the Estado Novo collaborated with both sides in World War II. The defeat of the Axis was expected to favour the democratisation of Portugal and the independence of its overseas colonies. That was not the case. Salazar's government was occasionally defied in the ensuing years (for instance, by Norton de Matos), but the dictator and his entourage were adamant to keep up the status quo. The Estado Novo would now seek to project an external image of sophistication and benevolence while maintaining the nation and the empire under its strict rule, resorting to brutal repression in national and colonial affairs whenever it was found necessary.

The reorganisation of meteorology in the mainland and the empire was attuned to this agenda, as it could be used to sport scientific acumen while allowing for greater centralisation and control. The multiplication of meteorological services in Portugal over the first half of the twentieth century provided a convenient argument for centralisation. By the end of World War II there were seven state meteorological departments in Portugal, each operating more or less independently of the others: the IDLO, the SMA, and the meteorological services attached to the War Navy, the Ministry of the Colonies, the Department for Agriculture, the Secretariat for Commercial Flights, and the Ministry of War. In the colonies, meteorology was officially under the aegis of the War Navy, except in Guinea, where it was supervised by the local aeronautic authority. By then, the JCO and the CRO were very much regarded as independent by the IDLO, which was still the overlord of Portuguese meteorology, but just nominally.

The IDLO had been directed, since 1937, by Herculano de Amorim Ferreira (1895-1974) (Peixoto, 1980), a professor of physics at the Faculty of Sciences of Lisbon. During the interwar period, meteorology had become an academic discipline on its own right, increasingly relying on physics, and with its own community of practitioners (Harper, 2012; Neber, 1995). Amorim Ferreira sought to implement these trends in Portugal, while steering a new effort to centralise meteorological activity in the metropolis and the empire.

Once appointed director of the IDLO, Ferreira immediately sought to activate a legal disposition issued in 1923, which established a National Climatological Service under the guidance of the IDLO. This provided him with a leverage point to extend his influence and authority over all other meteorological services in Portugal. The fact that Ferreira was very well placed in Salazar's regime was obviously of great advantage. He was a

member of parliament[44] for many years, and the Sub-Secretary of State for Education between 1944 and 1946. It was around this time that Salazar's government entrusted Ferreira with the reorganisation of Portuguese meteorology, an issue that, according to a biographer, the physicist discussed thoroughly with the dictator himself (Peixoto, 1980, p. 67).

The result was the National Meteorological Service[45] (SMN), founded in August 1946. Amorim Ferreira was promptly appointed Director, a post he maintained until retiring in 1965. Henceforth all meteorological work in the Portuguese mainland, the islands of Madeira and the Azores, and the overseas colonies was to be closely supervised by the SMN. In 1950 all colonies were officially endowed with a meteorological service constituting a sub-department of the SMN (Ferreira, 1952, p. 14). In the metropolis, all meteorological and geophysical observatories (IDLO, eventually renamed as D. Luis Institute of Geophysics; the Institute of Geophysics of the University of Porto, former Queen Amélia Observatory, and the Geophysical Institute of Coimbra) were equally placed under its aegis (Ferreira, 1952, p. 10). The constitution of this new meteorological overlord was accompanied by an effort to redefine the professional training and status of meteorologists and other practitioners of the Earth sciences. For that purpose, degrees in geoscience were established at the universities of Lisbon, Coimbra and Porto. Students enrolled in these new programmes were expected to take posts at the colonial observatories upon obtaining their diplomas (Ferreira, 1962, p. 29).

Angola and Mozambique remained the centres of the network, but the activity of other observatories in the Portuguese empire seems to have gained momentum as well. By the early 1950s, a central observatory in the Island of Sal, Cape Verde, controlled an ancillary observatory installed in Mindelo (S. Vicente Island), 30 stations for ground observations, and an outpost for aerial observations at Praia (Island of Santiago). The Cape Verde Observatory also supervised an ancillary observatory established in Bissau (Portuguese Guinea), which served as the main node for a twelve-station network. In the far-eastern edges of the empire, the Goa Observatory commanded 15 stations (Ferreira, 1952, p. 15-16). The Macau Observatory got an additional impulse in the 1950s from the Italian meteorologist

[44] It must be remarked that the parliament of the Estado Novo (Assembleia Nacional) was essentially an echo chamber of the dictatorial government, constitutionally prevented from questioning its decisions, and inaccessible to those who showed the least sign of opposition to the regime. There was an advisory board, the Câmara Consultiva, which acted more or less as a High Chamber. Amorim Ferreira was also a member for a number of years.

[45] Serviço Meteorológico Nacional.

Ernesto Gherzi, S. J. (1886-1973). Gherzi was a keen investigator of storms in the seas of China, and the former director of the Zikawei Observatory in Shangai. He stayed in Macau between 1950 and 1954, before moving to Canada.[46] The Portuguese government hired him during that period to steer the reorganisation of Macau Observatory, where, besides implementing the dispositions established by the SNM, Ghenzi also conducted investigations on cosmic rays. By the early 1960s, the Macau Observatory controlled a five-station network, deemed adequate to its small territory (Ferreira, 1960, p. 10). In East Timor, meteorology had been brought into a halt during World War II, as a consequence of the Japanese occupation of the island. All equipment and records maintained by the Portuguese authorities were lost at that time (Ferreira, 1960, p. 29). By the mid-1960s, Timor's meteorological network had been fully re-established and significantly extended. It comprised 26 stations and was controlled by an observatory located in the capital, Dili (Ferreira, 1960, p. 29-30). All of these colonial services included at least one station for aerial observations and maintained forecasting services.

In the metropolis, the SNM kept on amassing and publishing the data submitted by the colonies, as the IDLO and the Ministry of the Colonies had done prior to its foundation. Hitherto the function of the metropolitan "centres of calculation" had been essential to accumulate data from all over the empire. Apart from the elaboration of summary tables, few "calculations" had actually been performed. The development of the colonial networks and their tighter control from the metropolis put the SNM in a good stead to change this picture. In 1965, Amorim Ferreira presented a comprehensive study of dynamical climatology concerning Southern Africa (Ferreira, 1965), with data collected through the Mozambican and Angolan networks. Originally requested by the Portuguese Air Force, this work was crafted by Amorim Ferreira to serve a wide range of purposes: aerial navigation, agriculture, tourism, public health and urban planning, among others. The old dream of a steadfast imperial centre of meteorology in Lisbon, planning and fostering colonial development on the grounds of comprehensive climatological studies, was seemingly coming true. But as imperial meteorology started to get sounder, the empire began to crumble down. Salazar and his successor Marcelo Caetano (1906-1980)[47] fiercely resisted the post-war wave of decolonisation, to no avail. In 1961, Portugal lost its

[46] On Ernesto Gherzi see (Udías, 2003, p. 123-124; Bell, 1974).

[47] Marcelo Caetano succeeded Salazar in 1968 as President of the Governmental Council, which in practice meant that he became Portugal's new dictator. He was overthrown by the coup d'état of April 25th, 1974 (see below).

territories in India (Goa, Damão e Dio) after their occupation by Indian troops. In the same year, the Estado Novo launched a war against pro-independence groups in Guinea-Bissau, Angola and Mozambique. The war went on until the "Carnation Revolution" of April 25th, 1974, which finally put an end to the Estado Novo. This was also the end of the overseas empire. It was officially dissolved in 1975.[48] The former colonial observatories and their networks were eventually transformed into the national meteorological services of the new independent nations that emerged from the Portuguese Empire.

Concluding Remarks

Portuguese imperial climatology was entangled in a conundrum: it could have been helpful to architect consistent plans of colonisation, but without solid infrastructures and the human resources necessary to accommodate and maintain an efficient network of meteorological stations, and an observatory properly equipped and staffed to coordinate it in each colony, it could not take off.

Moreover, imperial grand plans and colonial undertakings were not always in tune, and this seems to have been one of the major issues. The case of the CRO is very illustrative: whilst Ernesto de Vasconcelos envisaged a great meteorological network to foster colonisation in the hinterlands of Angola and Mozambique, Hugo de Lacerda was more concerned with the immediate survival of Lourenço Marques as a harbour city, and with Portugal's status and prestige in the regional context. Freire de Andrade's reservations towards the CRO also indicate that commitment to colonial development, as seen from the colony itself, was not a guarantee of endorsement to observatory ventures.

Nevertheless, meteorology was relatively easy to accommodate with the idea of scientific colonialism, as exemplified by Norton de Matos's policies for Angola. With its potential benefits for the planning of new settlements, for the study of public health issues, for agriculture, and for the safety of navigation, meteorology had a strong resonance with colonial progress. It was different with astronomy. Accurate timekeeping was helpful for navigation and to project an image of scientific acumen. But apart from

[48] Due to its special statute, Macau returned to Chinese administration in 1999 only. In East Timor the situation was more nebulous. Portugal remained as the official administrator of the territory, but in 1975 it was invaded by Indonesian forces. It was only in 2002 that the independent Democratic Republic of East-Timor was recognised on the grounds of international law.

that function, astronomy had little to offer in terms of immediate colonial development, especially taking into account that surveying services usually preceded the foundation of observatories in the Portuguese colonies, thus astronomical departments were generally redundant in terms of territorial mapping and control.

Any attempts to engage in pursuits more ambitious than timekeeping would collide with the dubious quality of the available instruments, the enduring difficulties surrounding their installation and use, and the complex imperial circuits of instrument supply and repair - not to mention the scarcity of skilful personnel, let alone virtuosi practitioners such as Campos Rodrigues. It is also important to note that the AOL had itself been reshaped from an observatory suited to foster stellar astronomy into a rather modest establishment committed to positional astronomy, and mainly timekeeping. The AOL never engaged in astrophysical research; its few notable works always dwelt in positional astronomy, and its badge of public utility was timekeeping. The metropolitan observatory achieved recognition by concentrating its limited resources on this niche. A similar approach can be recognised in Frederico Oom's advice to the renewal of the JCO, which was certainly also informed by the setbacks experienced at the CRO.

It must be noted that the CRO and the JCO were not the only African colonial observatories where meteorology took over astronomy and other observatory sciences. The observatories of Mauritius and Madagascar, for instance, followed a similar path.[49] But in the neighbour South-Africa astronomy got a solid footing, especially at the observatories of the Cape and Johannesburg.[50] In fact, the latter began to function mainly as a meteorological observatory and ended up as a respectable centre of astronomy. Various factors contributed to this state of affairs: the solid traditions of astronomy and instrument making in the centre of the empire, Britain; the relatively early foundation (1820) and steady development of the Royal Observatory of the Cape; a network of learned institutions fomenting a south-Africanist ideology grounded in science; and the prestige garnered by astronomers such as David Gill (1843-1914) at the Cape and Robert Innes (1861-1933) in Johannesburg. The contrast with the Portuguese colonies is paramount.

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[49] On the observatory of Mauritius (Royal Alfred Observatory) see (Kirk-Greene, 2001, p. 170-171; Macmillan, 1914, p. 192; Anonymous, 1873, p. 243). Meterological reports for this settlement are available online at: http://docs.lib.noaa.gov/rescue/data_rescue_mauritius.html. On the Observatory of Madagascar see (Udías, 2003, p. 147-148; 169-170).

[50] On the history of these observatories see (Mcaleer, 2013; Evans, 1988, p. 107-109; Warner, 1979).

In any case, the main goal behind the promotion of an imperial network of observatories in the Third Portuguese Empire was the climatological characterisation of the Portuguese colonies. Amorim Ferreira upheld it as the main goal of National Meteorological Service, whose centralistic agenda was itself an image of the stern authoritarianism enforced by the Estado Novo. Although the Mozambique and Angola observatories (especially the CRO) managed to achieve a certain degree of autonomy before being engulfed by the NMS, a tighter control from the metropolis, together with advanced training for future staff members, seems to have been effective in spurring meteorological activity in the other colonies.

However, more research is needed to fully appreciate the history of all of these establishments prior to the NMS, and to calibrate the real impact of Amorim Ferreira's reforms. One idea likely to remain in the face of new historical evidence is that the Portuguese imperial network of observatories and its predicaments, the way the network was revamped by the Estado Novo, and its dissolution after the revolution of April 5th 1974, constitute a mirror image of the Third Portuguese Empire itself, as it can be inferred from the preliminary material presented in this paper.

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