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Sources of Maritime Weather Monitoring in the Ottoman Navy at the Age of Modern Observatories, 1868-1914

Modern Rasathaneler Çağında Osmanlı Donanmasında Deniz Hava Gözlemlerinin Kaynakları, 1868-1914

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ABSTRACT

During the 19th and 20th centuries, especially in Europe and North America, meteorology evolved into modern science with a primary focus on enhancing navigational safety and agricultural productivity. This scientific advancement found its way into the publications of the Ottoman Navy, which aimed to educate sailors. These publications disseminated contemporary theoretical and practical information on weather monitoring, which complemented traditional observational methods of natural phenomena that seafarers had already used since ancient times. Simultaneously, ancient astrometeorological sources persisted into the 20th century. Although there are no tangible traces of their use by sailors, these traditions included meteorological predictions at sea, serving either symbolic or popular purposes. From the publications of the Ottoman Navy to astrometeorological sources, this paper aims to present a bibliographical survey of maritime weather monitoring with a particular emphasis on the intersection of modern scientific advancements and traditional knowledge in the field of maritime meteorology.

Keywords: Meteorology, maritime weather monitoring, Ottoman Navy, modern science, astrometeorology.

ÖZ

19. ve 20. yüzyıllarda, özellikle Avrupa, ve Kuzey Amerika'da, meteoroloji modern bir bilime dönüşmüştür. Bu dönüşümün başlıca etkenleri seyir güvenliğinin ve tarımsal verimliliğin arttırılması olmuştur. Meteoroloji alanındaki bilimsel ilerlemeler Osmanlı Donanması denizcilerini eğitmeyi amaçlayan yayınlarda da yer bulmuştur. Böylelikle, hava durumunun izlenmesine ilişkin çağdaş teorik ve pratik bilgiler, denizcilerin eski çağlardan beri kullandıkları doğa olaylarına ilişkin geleneksel gözlem yöntemlerini tamamlayıcı olmuşlardır. Aynı zamanda, eski astrometeoroloji kaynakları 20. yüzyıla kadar devam etmiştir. Her ne kadar denizciler tarafından kullanıldıklarına dair somut izler bulunmasa da bu kaynaklar deniz hava tahminleri içermenin yanı sıra sembolik ya da popüler amaçlara hizmet

etmişlerdir. Bu makale, Osmanlı Donanması yayınlarından astrometeorolojik kaynaklara kadar, deniz meteorolojisi alanında modern bilimsel gelişmeler ile geleneksel bilginin kesişimine özel bir vurgu yaparak, deniz hava durumunun izlenmesine ilişkin bibliyografik bir inceleme sunmayı amaçlamaktadır.
Anahtar sözcükler: Meteoroloji, deniz hava gözlemleme, Osmanlı Bahriyesi, modern bilim, astrometeoroloji

Introduction

In the 19th century, the emergence of meteorology as a distinct discipline was a significant milestone in advancing scientific modernity. This period saw the convergence of astronomers, mathematicians, and physicists, who contributed to the growth of meteorology through their prolific publications.[1] European powers, especially those with overseas colonial interests, were instrumental in establishing observatories not only within their own borders but also in their colonial territories. The British focused their meteorological efforts on the Indian and Pacific Oceans, whereas the French initially concentrated on Europe before expanding their observations to the Atlantic.[2] Government-funded scientific expeditions characterized this era by investigating the climates and atmospheric phenomena of diverse global regions.

In 1829, German geographer Alexander von Humboldt received authorization from Russian Tsar Nicolas I to establish a meteorological station network across northern Asia. By 1833, Humboldt was actively involved in the Magnetischer Verein, a joint venture spearheaded by German physicists Carl Friedrich Gauss and William Weber, which connected about 20 observatories worldwide to study the Earth's magnetic fields.[3] Additionally, in 1835, the French launched an expedition aboard the vessel *La Recherche* to the northern reaches of Lapland. During the same decade, Belgian astronomer and founder of the Brussels Observatory, Adolphe Quetelet, conducted barometric observations coordinated by John Herschel, a renowned astronomer and meteorologist. Quetelet also played a significant role in geomagnetic studies alongside German and British scientists. Upon his appointment as the director of the Brussels Observatory in 1842, Quetelet compiled observational data from 41 European observers on the spring equinox of 1840, which he later published in the *Bulletin et les Mémoires de l'Académie Royale des Sciences de Bruxelles*.[4]

As imperial powers amassed scientific knowledge of the Earth and its atmosphere, they sought to leverage this information to consolidate and extend their control, aligning with their expansionist objectives.[5] Steamships, which facilitate rapid and regular exchanges of messages, passengers, and goods between distant ports, emerged as pivotal instruments of this global expansion. However, the frequent occurrence of adverse weather conditions,

1 J.-B. Fellens, *Manuel de Météorologie ou Explication théorique et démonstrative des phénomènes connus sous le nom de météores* (Paris: Roret, 1828) ; Pères de la Compagnie de Jésus, *La météorologie et le météorographe à l'exposition universelle, Extrait des études religieuses, historiques et littéraires* (Paris: Gauthier-Villars, 1867).

2 Martin Mahony, "The 'genie of the storm': cyclonic reasoning and the spaces of weather observation in the southern Indian Ocean, 1851-1925," *The British Journal for the History of Science* 51 (2018): 615.

3 Aitor Anduaga, *Politics, Statistics and Weather Forecasting, 1840-1910. Taming the Weather* (London and New York: Routledge, 2020), 63.

4 Fabien Locher, *Le savant et la tempête. Etudier l'atmosphère et prévoir le temps au XIXe siècle* (Rennes: Presses universitaires de Rennes, 2008), 19-36.

5 Simon Naylor, "Log Books and the Law of Storms," *Isis* 106 (2015): 772.

including storms, at sea underscores the importance of maritime meteorology. In this regard, from the early 19th century, the British Admiralty mandated its officers to maintain detailed weather records, signifying the growing recognition of meteorology's strategic value. By 1843, captains of British naval ships were officially required to possess barometers and conduct four daily weather observations.[6] Likewise, lieutenants were tasked with recording meteorological data in their logbooks.[7] Despite these measures, the complexity of weather phenomena across different global regions has highlighted the limitations of isolated efforts. Consequently, the safety of long-distance navigation underscores the need for international cooperation in meteorological research. One of the earliest proponents of international collaboration in maritime meteorology was American Marine Officer Matthew Fontaine Maury (1806-1873). Recognizing the critical need for global cooperation, Maury initiated a conference in 1851, which was subsequently held in Brussels in 1853. The conference aimed at the standardization of maritime meteorological measurements, marking a significant step toward international coordination in this field.[8]

The Crimean War (1853-1856) served as another pivotal opportunity for global cooperation in maritime meteorology. A devastating hurricane struck the Allied forces' ships off the Sebastopol Coast on November 14, 1854, resulting in the destruction of nearly all vessels caught in the storm and significant loss of life. In the aftermath, Urbain Le Verrier, director of the Paris Observatory, sought to understand the events of that November. He dispatched a bulletin to observatories across Europe, requesting meteorological observations from November 12 to 16. Receiving approximately 250 responses from observatories in England, Belgium, Holland, Prussia, Austria, Sweden, and others, Le Verrier concluded that the catastrophe could have been lessened had a warning been telegraphed from Vienna to Sebastopol in advance.[9] To prevent future tragedies, the Paris Observatory established an international telegraphic network for meteorological communication by the end of the war.

The international telegraphic network for meteorological communication expanded rapidly, growing from eight members in 1858 to fifteen by the end of 1859 and reaching nineteen by the end of 1860. Based on the quantitative and accurate data received, the Paris Observatory began publishing a daily bulletin that summarizes the weather in France and Europe. This period saw the development of synoptic forecasting and the introduction of daily weather charts that highlighted atmospheric depressions. These techniques remained standard

6 Mahony, "Indian Ocean, 1851-1925," 615.

7 Naylor, "Law of Storms," 776.

8 Guy Houvenaghel, "International Maritime Conference 1853," in *The Palgrave Dictionary of Transnational History*, ed. Akira Iriye and Pierre Yves Saunier (London: Palgrave Macmillan, 2009), 563-564.

9 Alfred Fierro, *Histoire de la météorologie* (Paris: Éditions Denoël, 1991), 110-111; Observatoire impériale de Paris, *Historique des entreprises météorologiques, 1864-1867* (Paris: Gauthier-Villars, 1868), 1-11; P. Levot, *Récits de naufrages, incendies, tempêtes et autres événements de mer* (Paris: Challamel Ainé, Libraire-éditeur, 1882), 160-225.

until the advent of digital simulations in the 20th century.[10] The significance of nautical meteorology was further highlighted in the 1876 International Congress of Geography in 1876. Additionally, the latter half of the 19th century witnessed the organization of specialized meteorological congresses in various cities, including Vienna (1873 and 1876), Paris (1878, 1885, and 1896), Rome (1879), Berne (1880), Copenhagen (1882), Zurich (1888), Munich (1891), Chicago (1893), Uppsala (1894) and Innsbruck (1905).[11] These congresses served as crucial platforms for scientific discourse and significantly contributed to the standardization of data collection and sharing methodologies.

Although the Ottoman Empire participated in just the initial meteorological congress held in Vienna in 1873,[12] its strategic geographical location at the juncture of continents and seas made it a strategic partner in the international meteorological telegraph cooperation that began in 1854. The Empire's first recorded observatory in Istanbul was established during the reign of Murad III by Takiyüddin in 1577. Within this institution, Takiyüddin made various astronomical observations, including observations of the moon, sun, and stars.[13] However, in 1580, the Imperial Observatory in Istanbul was ordered to be demolished by Sultan Murad III, following the advice of Shaykh al-Islam Ahmed Şemseddin Effendi, who was convinced that such observations could lead to disasters.[14]

Until the latter half of the 19th century, the Ottoman Empire had no meteorological observatories. During this period, European missionaries and scientists made individual observations. In the 17th century, Italian military officer and naturalist Luigi Ferdinando Marsigli conducted comprehensive studies on the Bosporus, examining wind patterns,

10 Fabien Locher, "Atmosphere of globalisation. Depressions, the astronomer and the telegraph (1850-1914)," (tr. Neil O'Brien, Seema Sarangi) *Revue d'histoire moderne & contemporaine* 56 (2009): 77-103.

11 K. A. Manssen, *Rapport du Comité permanent du premier congrès météorologique de Vienne. Réunion de Londres* (Paris: Imprimerie à vapeur, l'Industrie, 1876) ; *Congrès international de météorologie tenu à Paris du 24 au 28 août 1878, Comptes rendus*, *No. 20 de la Série* (Paris: Imprimerie nationale, 1878); *Rapport sur les travaux du deuxième congrès international des météorologistes réunis à Rome du 14 au 22 avril 1879, Procès-verbaux et appendices* (Rome: Imprimerie Héritiers Botta, 1879); Bureau central météorologique de France, *Rapport du Comité météorologique international, Réunion de Berne, 1880* (Paris: Gauthier-Villars, 1882); Bureau central météorologique de France, *Rapport du Comité météorologique international, Réunion de Copenhague, 1882* (Paris: Gauthier-Villars, 1884); *Rapport du Comité météorologique international, Réunion de Zurich, 1888* (Paris: Gauthier-Villars, 1889); Bureau central météorologique de France, *Rapport de la Conférence météorologique, internationale, Réunion de Munich, 1891* (Paris: Gauthier-Villars, 1893); U.S. Department of Agriculture, *Weather Bureau, Report of the International Meteorological Congress held at Chicago, ILL., August 21-24, 1893*, *under the auspices of the Congress Auxiliary of the World's Columbian Exposition. Part II* (edited by Oliver L. Fassig, Secretary: Washington, D.C., Weather Bureau, 1895).

12 Aristide Coumbary, *Dersaadet Rasadhane-i Amiresinin Cevv-i Havaya Dair 20 Senelik Tarassudat-ı Neticesi* (Istanbul: Matbaa-i Osmaniye, 1304 Hijri Calendar (subsequently H.), 1886/1887 Gregorian Calendar, subsequently G.).

13 Süheyl Ünver, *İstanbul Rasathanesi* (Ankara: TTK, 2014), 39-73; Khaled El-Rouayheb, "The Myth of 'The Triumph of Fanaticism' in the Seventeenth-Century Ottoman Empire," *Die Welt des Islams* 48 (2008): 202.

14 Kübra Fettahoğlu, *Rasathane-i Amire (1868-1922)* (Ankara: TTK, 2019), 7.

currants, water levels, and marine life in the area.[15] By the 1830s, Europeans had expanded their meteorological observations in Istanbul and the imperial provinces, employing modern instruments.[16] However, these efforts, characterized by temporary and small-scale stations, have failed to achieve the systematic collection and dissemination of meteorological data across extensive geographical areas.

Nearly three centuries after the first known observatory effort, the Ottoman Empire established an observatory in Istanbul in 1868, which was dedicated to meteorological observations within the ambit of the international telegraphic network centered on the Paris Observatory. The Imperial Observatory in Istanbul was inaugurated in the residence of its first director, Aristide Coumbary, located on Pera Hill. In 1868, Marié-Davy, commissioned by the French Ministry of Education to evaluate meteorological establishments in the Ottoman Empire, personally delivered some delicate instruments to the Imperial Observatory. Subsequently, the Ottoman government established additional meteorological stations in various provinces.[17]

Despite these efforts, the Imperial Observatory in Istanbul and its provincial stations have encountered challenges in effective operation both within the international network and across the Empire. By 1915, the administration of the Imperial Observatory reported that the provincial stations did not function as full-fledged observatories but were rather telegraph stations equipped with meteorological instruments dispatched by the State in 1875. These stations suffered from organizational issues and material damage, rendering them ineffective. At that time, the only facility that could be considered a true observatory within the Ottoman Empire was located in Istanbul.[18]

It is essential to underline that since its inception in 1868, the Istanbul Observatory and its affiliated provincial stations had not been engaged in weather forecasting. Their primary focus was on conducting daily atmospheric observations,[19] including the measurement of air

15 Luigi Ferdinando Marsigli, *Osservazioni intorno al Bosforo Tracio overo Canale di Constantinopoli, rappresentate in lettera alla sacra real maesta di Cristina, Regina di Svezia, da Lvigi Ferdinando Marsilii* (Rome, Nicolò Angelo Tinassi, 1681).

16 "Observations faites à Constantinople, au collège des Lazaristes, pendant l'année 1835," in *Comptes rendus hebdomadaires des séances de l'Académie des sciences (1838) VI (*Bachelier, Gauthier-Villars: Paris, 1838), 822; Eugène Grellois, "Observations faites à Constantinople, de décembre 1854 à mars 1856, par M. Le docteur Grellois," in *Voyage dans la Turquie d'Europe: description physique et géologique de la Thrace. T2*, Auguste Visquenel (A. Bertrand: Paris, 1868), 57-71; Pierre de Tchiatcheff, *Asie Mineure: Description physique, statistique et archéologique de cette contrée, Partie 2* (Paris: Gide et J. Baudry, puis L. Guérin, 1856).

17 Marié-Davy, «Rapport Adressé A Son Exc. Le Ministre de l'Instruction Publique par Marié-Davy», in *Annuaire de la Société météorologique de France*, Tome seizième, Séance du 8 décembre 1868, Présidence M. Charles Sainte-Claire Deville (Paris: Gauthier-Villars, F. Savy 1868), 174-189.

18 Maarif-i Umumiye Nezareti, *Rasadhane-i Amire'nin 1912, 1913, 1914 Senelerine Aid Hülasa-yı Rasadatı* (Istanbul: Matbaa-i Amire, 1330 *Rumi* calendar (subsequently R.), 1914/1915 G.), 3-4.

19 Salim Aydüz, "Kandilli Rasathanesi," *Türkiye Diyanet Vakfı İslam Ansiklopedisi XXIV*, (Istanbul: TDV

temperature and pressure and the transmission of these data to the Paris Observatory. Although these systematic observations enriched long-term climatological records, as reflected in the observatory's publications, they were not intended for immediate maritime weather prediction applications. This approach underscores the observatory's dedication to compiling extensive climate data rather than its direct use in real-time maritime forecasting.

Similarly, the publication of meteorological observation data in Ottoman newspapers followed a pattern focused on observation over prediction. Between 1868 and 1891, the Francophone newspaper *La Turquie* published several meteorological data entries. In the realm of publications in Ottoman Turkish, the official local newspaper *Takvim-i Vekayi* disseminated local meteorological observations and barometric measurements throughout the provinces from 1862 to 1892. With the turn of the 20th century, *Takvim-i Vekayi*, along with *İkdam* (1897-1923), continued to report temperature readings throughout the Ottoman Empire. Other newspapers, such as *Sabah*, *Tanin*, *Servet-i Fünun*, *Tercüman-ı Hakikat*, *Maarif*, *Malumat*, and *Takvimli Gazete*, also published meteorological observations, although for shorter durations.[20] However, these publications primarily featured observational data, with little emphasis on weather forecasting.

Despite the limitations in weather forecasting capabilities within the Ottoman observatories, an international telegraphic network initiated by the Paris Observatory during the Crimean War was strategically established to function as a storm warning system. This network, in conjunction with routine data exchanges with Paris, primarily aims to issue timely alerts about approaching storms to maritime vessels. Aristide Coumbary, the inaugural director of the Istanbul Observatory, underscored in his 1886-87 publication the critical role of this international network in providing storm alerts for the Ottoman Empire, particularly for storms emanating from Western Europe.[21] Thus, the network served as a vital early warning system, enabling the rapid dissemination of hurricane observations to regions in the projected path of the storm, thereby facilitating prompt advisories on imminent weather threats. The advent of such an international telegraphic network marked a significant advancement in early warning systems, enhancing global storm preparedness and mitigation through collaborative efforts. This pioneering effort not only showcased the benefits of international cooperation in meteorological pursuits but also set the foundation for the evolution of modern storm alert systems.[22]

However, the Imperial Observatory in Istanbul faced challenges in initiating synoptic weather forecasting for the Eastern Mediterranean before World War I, which was hindered by

Yayınları, 2001), 301-303.

20 Fettahoğlu, *Rasathane*, 16 and 85-94; Remzi Çavuş, "Osmanlıca Basında Sunulan Hava Durumu," *Vakanüvis* 4 (2019): 560-581.

21 Coumbary, *Dersaadet*, 5.

22 Observatoire impérial de Paris, *Historique des entreprises météorologiques, 1851-1867* (Paris: Gauthier-Villars, 1868), 1-11.

inadequate station coverage and limited support from Ottoman authorities. Additionally, even if weather forecasts had been available, the dissemination of such information to mariners on the high seas via wireless transmission was not yet feasible because this technology was only accessible in the World War I era. While wireless communication technology was employed to some extent in the United States for communication with steamers and in the United Kingdom for vessels up to 500 km from the Irish coast,[23] it remained unutilized by Ottoman observatories. The development of wireless telegraphy in the 1890s by pioneers such as Guglielmo Marconi, William Crookes, and Oliver Lodge represented a breakthrough,[24] yet at the turn of the century, it remained a nascent technology worldwide. In 1902, Leduc Effendi, the vice technical advisor of the Imperial Ministry of Posts and Telegraphs (*Posta ve Telgraf Nezareti*), authored a report in French on wireless telegraph technology, with a Turkish version prepared by Mustapha Fuad Bey, the vice director of the same administration.[25] Despite these reports, the effective implementation of wireless technology was not until after the First World War.[26]

The prevailing conditions, notably during the period between the establishment of the Istanbul Observatory (1868) and the beginning of the Great War (1914), prompted the essential question of how sailors in the Ottoman Navy navigated the challenges of sea-based weather monitoring and prediction. Within this framework, this article seeks to unravel two critical questions: Firstly, what were the primary sources of meteorological instruction for sailors in the Ottoman Navy? Second, what did these sources reveal about the integration of modern meteorology in the Ottoman Empire?

In pursuit of answers to these questions, the first section of this paper explores the geographical and meteorological insights documented by Ottoman Navy officers from the premodern era to the 19th century. This approach contextualizes the foundational knowledge upon which subsequent advancements are built. In the second section, the focus shifts to modern maritime meteorology within the Ottoman Navy School, highlighting the adoption of measurements and instruments aboard ships. This section also examines how these modern practices coexisted with traditional sea observation methods during the 19th and early 20th centuries. Despite the modernization of meteorological practices, section three explores

23 "Şuun-u Mütenevvia. Telsiz Telgraf ve Hadisat-ı Cevviye Hakkında Malumat," *Servet-i Fünun*, 24 Nisan 1324 R., May 7, 1908 G., no. 889, vol. 35, 79.

24 Sungook Hong, "Marconi and the Maxwellians: The Origins of Wireless Telegraphy Revisited" *Technology and Culture* 35 (1994): 717-749, 719.

25 Letter of the Ministry of Posts and Telegraphs to the Grand Vizierate (*Sadaret*), 23 Nisan 1318 R. [May 6, 1902 G.], Y.MTV., Turkish Presidency State Archives of the Republic of Turkey (subsequently BOA), Y. MTV. 229/66; *Rapport sur la télégraphie sans fil, en langue française et langue turque*, Leduc Effendi, BOA, Y. MTV, 229/66/3/2; *Telsiz Telgraf Hakkında Türkçe ve Fransızca Rapordur*, Mustafa Fuad Efendi, BOA, Y.MTV., 229/66/3/90.

26 Locher, "Atmosphere of globalisation", XVI.

the persistence of ancient astrometeorological traditions within Ottoman culture while also highlighting the absence of concrete evidence for their practical application by Ottoman sailors.

Before commencement, it is essential to delineate the limitations and underscore the significance of this study. This study originates from the foundation of the Imperial Observatory in Istanbul in 1868, a landmark in the modernization of meteorology in the Ottoman Empire. It extends to the brink of 1914, a period that culminated with the First World War - a time of substantial scientific progress in climatology and meteorology that was[27] paralleled by significant technological advancements, especially in aviation.[28] These developments necessitate a detailed examination to define the temporal boundaries of our analysis. Moreover, the complex and diverse nature of the Ottoman maritime community requires a precise definition of 'Ottoman sailor'. This term, critical to this study, is specifically used to refer to individuals affiliated with the Ottoman Navy. By focusing on sources from the Ottoman Navy, we intentionally exclude those involved in commercial maritime activities or engaged in private short-distance navigation. This approach allowed for a concentrated study of the Ottoman Navy, offering a clearer and more interdisciplinary investigation of the subject.

The contribution of this article to Ottoman science historiography is noteworthy and deserving of attention. Despite its vital role in ensuring the safety and efficiency of navigation, weather monitoring at sea has been overlooked in the historiography of the Ottoman Empire during the 19th and 20th centuries. Existing work in Ottoman maritime history has predominantly focused on ship types, construction, and maintenance, neglecting atmospheric phenomena.[29] In addition, meteorology was notably absent in the historiography of the extensive reforms undertaken by the Ottoman Navy during the mentioned periods. Studies on the Istanbul observatory have mainly focused on its institutional history, or occasionally on actors, rather than on its practical utility for navigation or agriculture.[30] Therefore, this article aims to fill a notable gap in the understanding of the sources, methods, and role of weather monitoring in the Ottoman Navy during the scientific modernization era, contributing to the emerging historiography of Ottoman Turkish meteorology.

27 Kübra Fettahoğlu, "1917'de Kurulan Tedkikat-ı İklimiyye Encümeni'nin Çalışmalarını Düzenleyen Talimatnâmeler," *Osmanlı Bilimi Araştırmaları* 22, 2 (2021): 277-340.

28 Osman Yalçın, "Havacılık, Hava Gücünün Doğuşu ve Birinci Dünya Savaşı'nın Etkisi," *Ankara Üniversitesi Türk İnkılâp Tarihi Enstitüsü Atatürk Yolu Dergisi* 59, (Güz 2016).

29 Funda Songur, *Osmanlı Bahriyesinde Lojistik. İmkanlar, Kabiliyetler ve Üslerin Durumu 1867-1914* (Istanbul: Timaş Yayınları, 2022); Evren Mercan, *Modern Harp Gemileri 1850'den Günümüze* (Istanbul: Kronik Yayınları, 2022); Levent Düzcü, *Yelkenliden Buharlıya Geçişte Osmanlı Denizciliği (1827-1853)* (Istanbul: Doğu Kütüphanesi Yayınları, 2017).

30 Fettahoğlu, *Rasathane*; Mustafa Aktar, *Rasathane İle Bilimde Yüz Elli Yıl* (Istanbul: Yapıkredi Yayınları, 2022); Sevtap Kadıoğlu, *Osmanlı'dan Cumhuriyet'e Meteorolojinin Kurumsallaşması ve Ahmet Tevfik Göymen* (Istanbul: Anka Matbaa, 2012).

Maritime Mastery and Meteorological Advances from the 16th to the 19th century

Contrary to the conventional perception of the Ottomans as primarily focused on land-based expansion, maritime endeavors played a significant role in their empire-building efforts. By the latter half of the sixteenth century, the Ottoman Empire had established itself as a dominant maritime force in the Mediterranean, exerting control over the eastern Mediterranean, actively engaging in the western Mediterranean, and maintaining a notable influence along the North African coast, reaching as far as Morocco.[31] Within this context, the acquisition and development of geographical knowledge were pivotal to Ottoman expansion across different seas. Initially, Ottoman geographical understanding was largely shaped by Arabic and Persian works. However, starting in the 16th century, a notable shift occurred as the Ottomans began to produce original geographical texts. Prominent works from this era include Piri Reis's *Kitab-ı Bahriye*, Seydi Ali Reis's *Kitabu'l Muhit fi ilmi'l-Eflak ve'l-Ebhûr*, *Mir'atü'l Memalik*, Emir Mehmed Suudi's *Tarih-i Hind-i Garbi*, and Aşık Mehmed's *Menazır'ül-Avalim*.[32] These contributions marked a significant milestone in the development of the Ottoman geographical literature, reflecting the Empire's growing maritime ambitions and its engagement with the broader world.

These seminal sources offered practical meteorological insights specifically designed for sailors, aiming to augment Ottoman seafarers' navigational skills in the face of complex maritime challenges. In the *Kitab-ı Bahriye* (Book of Navigation), Piri Reis, a captain, admiral, and geographer, presents observations of atmospheric conditions across various seas, including the Mediterranean Sea, Persian Gulf, Indian Ocean, and Atlantic Ocean. Authored in 1526, his work not only included navigational maps but also examined the navigational instruments and techniques used by the Portuguese, such as astrolabes, hourglasses, and methods for calculating parallels.[33] Piri Reis particularly emphasized the navigational hazards of the Indian Ocean, addressing the prevalent storms and heavy rainfall. His comprehensive treatment of these subjects in the *Book of Navigation* offers invaluable historical insights into the navigational tools that Ottoman sailors relied upon.

Furthermore, the *Kitabu'l Muhit* (Book of Ocean), authored by Seydi Ali Reis, an Ottoman sailor and geographer who served in the Indian fleet in 1554, provides essential

31 Kate Fleet, "Ottoman expansion in the Mediterranean," in *The Cambridge History of Turkey*, Vol 2, ed. S.N. Faroqhi, K. Fleet. (Cambridge: Cambridge University Press, 2012), 141-172.

32 Mahmut Ak, *Menâzırü'l-Avâlim*, Vols. 1-3, (Ankara: TTK, 2007); Didem Sevtap Kaya, "Osmanlı Dönemi ve Cumhuriyetin İlk Yıllarında Coğrafya Ders Kitapları Literatürü," *Türkiye Araştırmaları Literatür Dergisi* 33 (2020): 287; Ahmet Üstüner, "Klasik Çağ Sonrası Osmanlı Coğrafya Çalışmaları," *Türkiye Araştırmaları Literatür Dergisi* 33 (2020): 41-144.

33 Ekmeleddin İhsanoğlu (ed.), *Osmanlı Coğrafya Literatürü Tarihi, History of Geographical Litterature During the Ottoman Period, Vol. I* (Istanbul: IRCICA, 2000), 22; Y. Nemlioğlu Koca, "Reading Geography: A Systematic Evaluation on Kitab-ı Bahriye (Book of Navigation) Copies," *International Journal of Geography and Geography Education (IGGE)* 42 (2020): 509-510.

meteorological guidance for navigating the turbulent conditions of the Indian Ocean, with a focus on strong winds and storms.[34] Seydi Ali Reis not only covers meteorological considerations but also documents the use of navigational instruments like compasses, astrolabes, and maps. His subsequent work, *Mir'at-ül Memalik* (Mirror of Countries), expanded on the application of these instruments, including the astrolabe and equatorial circle, on land during his travels from India to Istanbul.[35] Thus, the works of Seydi Ali Reis present a coherent picture of sixteenth-century Ottoman maritime expertise, particularly highlighting advanced navigational practices through the specific mention of instruments. These contributions underscore the sophisticated understanding and application of Ottoman sailors' meteorological and astronomical knowledge, reflecting a rich tradition of navigational science within the Empire.

The Ottoman Navy's utilization of these seminal texts is not fully documented; however, their importance in maritime history is indisputable. These works served not only as crucial repositories of information on climatic conditions across various seas and oceans but also as foundational pillars for the burgeoning field of Ottoman geographical science. By laying the groundwork for a comprehensive understanding of geography, they played a pivotal role in advancing the theoretical knowledge of geography and navigation. This intellectual framework was vital for supporting the Ottoman expansion and fostering engagement with diverse regions over the ensuing centuries.

Given the absence of modern meteorological instruments like thermometers and barometers during their era, Piri Reis and Seydi Ali Reis relied primarily on direct observation and astrometeorological techniques for their atmospheric assessments. In his *Book of Sea*, Piri Reis applied astrometeorological principles to predict maritime weather conditions. He interpreted meteorological phenomena through the lens of the moon's proximity to various astrological signs, which he categorized into four elements: wind, water, earth, and fire. According to him, during the dominance of wind signs such as Gemini (22 May - 21 June), Libra (23 September - 23 October), and Aquarius (21 January - 18 February), sailors could anticipate strong winds and potentially stormy weather. Conversely, water signs, including Cancer (22 June - 22 July), Scorpio (24 October - 22 November), and Pisces (19 February - 20 March), were associated with windy and rainy conditions.[36] This approach by Piri Reis highlighted an early attempt to systematize meteorological knowledge using the astrological framework available at the time, reflecting the innovative observation methods employed by Ottoman sailors to navigate the challenges of the sea.

34 Pınar Emiralioğlu, *Geographical Knowledge and Imperial Culture in the Early Modern Ottoman Empire, Transculturalisms, 1400-1700* (New York: Routledge, 2016), 122-124.

35 Gaye Danışan, "A Sixteenth-Century Ottoman Compendium of Astronomical Instruments. Seydi Ali's Mirat-ı Kâinat," in *Scientific Instruments between the East and the West. Scientific Instruments and Collections Series, Vol. 7,* ed. N. Brown et al. (Leiden, Boston: Brill, 2019), 1-15.

36 Gaye Danışan, "16. Yüzyılda Osmanlılarda Deniz Astronomisi ve Astronomi Aletleri / 16th-Century Ottoman Nautical Astronomy and Astronomical Instruments," (Doctoral thesis, Istanbul: Istanbul University, 2016), 235.

The issue of weather remained a significant concern for the Ottoman state from the 16th to the 18th centuries. Within this framework, the 16th century also witnessed the emergence of the *Mühimme Defterleri*.[37] (Imperial Registers as crucial archival sources, offering detailed insights into the climate and weather phenomena within the Ottoman territories). These records, from a military standpoint, indicate that Ottoman campaigns were strategically scheduled to start post-significant spring rains, continuing through the summer. The registers meticulously document the occurrences of natural disasters, including those induced by rain, winds, earthquakes, storms, and thunderstorms, highlighting the environmental challenges faced during military operations.[38] By the 17th century, authors such as Hasan Beyzade Ahmed Pasha in *Hasan Beyzade Tarihi,* Tugi in *Musibetname*, and Mehmed Hemdemi Çelebi in *Solak-Zade Tarihi* provided nuanced descriptions and observations of weather-related events. Notable among these accounts were the severe winter of 1621 and the extraordinary phenomenon of sea freezing over Istanbul.[39]

The 17th century marked a significant epoch in the history of meteorological science, particularly in Europe, with the advent of key measurement instruments. Innovations such as Galileo's temperature experiments, the medical thermometer invented by Antonio Santorio in 1612, Francis Bacon's weather glass in 1620, and the barometer created by Evangelista Torricelli were instrumental in transitioning meteorology toward data-driven science.[40] The establishment of the *Academia del Cimento* in Florence in 1657 further propelled this advancement, fostering the development of additional meteorological tools like the hygrometer, pluviometer, and anemometers.[41] These contributions were pivotal in laying the groundwork for meteorology to evolve into modern science by the 19th century, despite the gradual pace of development as evidenced by the delayed efficient development of mercury thermometers until the 18th century.[42]

While meteorological instruments underwent significant advancements in 17th and 18th-century Europe, a notable gap existed in their documentation within the Ottoman Navy's context until the 19th century. The 18th-century observations by Venetian Jesuit philosopher Giambattista Toderini at the Ottoman Naval Engineering School (*Mühendishane-i Bahri-i*

37 The names given to the books in which the minutes of the Imperial Council (*Dîvân-ı Hümâyun*) were collected.

38 Elif Avcı, "Mühimme Defterleri Işığında XVI. Yüzyılın ikinci yarısında Osmanlı Devleti'nde Doğal Afetler," (Master Thesis, Ankara: Gazi University, 2020), 69-79.

39 Arslan Doğan, "İstanbul'da Meydana Gelen Doğal Afetler ve Sosyal Hayata Etkisi (XVI. ve XVIII. Yüzyıl)," (Master Thesis, Konya: T.C. Selçuk Üniversitesi, 2017), 42-45.

40 Kevin Anthony Teague and Nicole Gallicchio, "The Birth of Modern Meteorology (1800-1950," in *The Evolution of Meteorology. A look into the Past, Present, and Future of Weather Forecasting*, ed. Kevin Anthony et al. (Hoboken, NJ: Wiley Blackwell, 2017), 19-29; H. Howard Frisinger, *The History of Meteorology to 1800* (Boston: American Meteorological Society Historical Monograph Series, 1983), 100.

41 Fierro, Météorologie, 59-64.

42 İrfan Elmacı, "Simyadan Kimyaya Osmanlı İmparatorluğunda Teknoloji," *Osmanlı Bilimi Araştırmaları* XIX 2 (2018), 274.

Hümayun) do not, for instance, mention specific meteorological tools. Toderini's accounts focus instead on a wide range of other instruments, including geographic maps in Turkish and French, ship drawings, navigation tools, maritime atlases, European maps, a celestial globe annotated in Turkish, a Parisian metal armillary sphere, Arab astrolabes, sundials in both Turkish and French, an English octant by Jean Hadley, various compasses, and Galileo's compass.[43] This discrepancy highlights a crucial aspect of the historical development of meteorological practices, suggesting that the Ottoman Navy delayed integrating these scientific advancements compared to their European counterparts. The detailed inventory provided by Toderini underscored the diverse technological resources available to the Ottoman Navy, even in the absence of explicit references to meteorological instruments, indicating a complex landscape of knowledge and tool utilization.

Before the 19th century, while direct references to meteorological instruments in the Ottoman context are absent, the incorporation of meteorological concepts into Ottoman Turkish through translations from European sources is evident. A notable instance is the translation of Jacques Robb's *La méthode pour apprendre facilement la géographie* (1685) into Ottoman Turkish in 1733 by Petros Baronian. This work, titled *Risâle-i Coğrafya. Fennümâ-yı Câm-ı Cem'ez-Fenn-i Coğrafya*, is preserved in the Topkapı Palace Library (Hazine 444) and[44] includes diverse meteorological insights, such as descriptions of wind types and climates, alongside specific measurements, indicating an early engagement with European meteorological thought.[45] The 18th century also witnessed a modernization wave within Ottoman engineering that led to the publication of new scientific texts, notably from the Imperial Land Engineering School (*Mühendishane-i Berri-i Hümayun*), established in 1797. Between 1797 and 1824, this institution printed approximately 66 books covering a wide range of topics, including water, customs tariffs, pilgrimage, medicine, atlas geography, astronomy, and geometry.[46] This period marked the beginning of a concerted effort to integrate contemporary scientific knowledge into Ottoman educational and military frameworks.

The 19th century saw significant advancements in meteorology in Europe and North America, characterized by a shift toward a more quantitative understanding of atmospheric physics. This era's scientific breakthroughs had a global impact, profoundly influencing various domains, including the maritime operations of the Ottoman Navy. An examination of

43 Yerasimos, "Les ingénieurs", 49-50.

44 Feza Günergün, "La Traduction de l'abrégé de la Sphère de Jacques Robbe, Géographe du Roi de France par Petros Baronian, Drogman a Istanbul: Cem-Nümâ Fi Fenn El-Coğrafya", *La Révolution Française* 12 (2017), 1-19; Ahmet Üstüner, "Avrupa Coğrafyacılığının Osmanlı Dünyasına İntikali: Tercüme Eserler [The Transfer of European Geography Studies to the Ottoman World: Translated Works]," in ed. Recep Şentürk, et al., *İslam'da Medeniyet Bilimleri Tarihi* (Istanbul: İbn Haldun Ünv. Yay., 2021), 70-107.

45 M. Robbe, *Methode pour apprendre facilement la Géographie* (Paris: Chez Antoine Dezallier, 1685), 35-52.

46 Kemal Beydilli, *Türk Bilim ve Matbaacılık Tarihinde Mühendishane Matbaası ve Kütüphanesi (1776-1826)* (Istanbul: Eren, 1995), 259-261.

the literature produced for the Ottoman Navy during this period reveals a marked recognition of meteorology as an emerging modern science. This recognition underscores a parallel development within the Ottoman Empire, mirroring the global trajectory toward integrating meteorological science into naval practices.

Emergence of Modern Meteorological Knowledge in the Ottoman Navy (19th-20th century)

The 19th century witnessed a significant production of geographical texts by the Chief Navy School (*Bahriye Mektebi*) Printing House, embedding practical meteorological knowledge crucial for maritime navigation. *Fenn-i Coğrafya* (Geographical Science), published in 1857, offered theoretical insights into wind types and directions, along with comprehensive details on seas, oceans, islands, and straits across the globe.[47] Another significant publication, *Heyet-i Arz* (Structure of the Earth), circa 1896/1897, expanded on these themes and provided valuable information on global wind directions, straits, islands, and peninsulas.[48]

The era also saw an uptick in geography-related translations, notably following the 1870 issuance of the Authorship and Translation Regulation (*Telif ve Tercüme Nizamnamesi*) by the Ottoman government. This regulation underscored the inclusion of climatic, topographical, agricultural, commercial, and demographic information in geography texts, aligning with the administrative and educational reforms of the Tanzimat period (1839-1876).[49] The Imperial Translation Office (*Tercüme Odası*), established in 1821, was instrumental in facilitating these translations, with figures such as Ahmed Nermi Efendi, a translator for Sultan Abdülhamid II, translating around 200 travel books. Contributions from Güzeloğlu Aram and Chief Astrologer Osman Sa'ib Efendi further enriched the Ottoman Empire's geographical and meteorological literature, satisfying the evolving curricular needs of modern educational institutions.[50]

Complementing these scholarly efforts, Ottoman travelers' accounts of navigating the world's seas provided first-hand geographical and meteorological observations. A notable account is that of Mühendis Faik Bey, who described his Atlantic voyage aimed at reaching the Persian Gulf via the Cape of Hope with two corvettes. His journey from Brazil to Bombay and eventually to the Persian Gulf was marked by encounters with challenging weather conditions, offering insights into winds and storms encountered in distant waters.[51] Together, these printed sources, translations, and travelers' narratives significantly contributed to the

47 *Fenn-i Coğrafya* (Istanbul: *Mekteb-i Bahriye* Printing House, 1273 H., 1856 - 1857 G.), 5-6 and 408.
48 Ali Nazima, *Heyet-i Arz* (Dersaadet: Kasbar Matbaası, 1314 H., 1896-1897 G.).
49 Kaya, "Osmanlı Dönemi", 288-292.
50 Üstüner, "Klasik Çağ", 41-104.
51 Mühendis Faik Bey, *Seyahatname-i Bahr-ı Muhit*, (Istanbul : Mekteb-i Bahriye-i Şahane Matbaası, 1868), 63.

accumulation and dissemination of meteorological knowledge within the Ottoman Empire, reflecting a growing recognition of meteorology's importance in both academic and practical maritime contexts.

Throughout the 19th and early 20th centuries, navigation guides published by the Chief Navy School Printing House were indispensable for sailors, providing comprehensive geographical, oceanographic, and meteorological knowledge. These guides were theoretically vital, offering detailed information and navigational instructions for various seas and oceans, including aspects such as winds, potential hazards, depths, rocks, coastlines, and islands. Ottoman Navy captains were mandated to keep these guides aboard their vessels with the expectation that they would update or annotate them in response to unforeseen dangers or discoveries encountered during their voyages.[52] A quintessential example of such resources is the *Rehber-i Derya* (Maritime Guide) by Vice Admiral Süleyman Faik, which intricately details the winds and currents around Mediterranean islands, such as Crete, Rhodes, and Chios.[53] Similarly, the navigation guide for the Red Sea provides in-depth descriptions of its channels, major ports, principal cities, and the prevailing winds in Port Said.[54]

Notably, these guides often lacked sufficient maps or illustrations, presumably because maps were utilized separately. This practice was evidenced by a regulation from the Chief Navy School, which stipulated that ships affiliated with the school were to carry specific maps of the Mediterranean and the Black Sea as of 1851.[55] By the 1880s, the printing capabilities of the Ministry of the Navy's printing house had significantly improved, enabling the publication of sea maps and portolans crucial for navigation. Furthermore, following the adoption of upper plate printing techniques in 1891, the printing house successfully incorporated photographs into its publications. Today, maps produced by the Navy School Printing House are preserved at the Istanbul Navy Museum.[56]

The logbooks, alongside personal accounts and maritime guides, served as crucial documentary sources for the Ottoman Navy, chronicling the daily operations and experiences of its crew members. These records are expected to include meteorological observations, given their significance in maritime navigation. However, an investigation of the 1857/1858 logbook of the steamer *Girit* revealed a notable omission of atmospheric phenomena. Instead,

52 *Mülazım-ı Evvellerin Kılavuzluk Kursu* (Istanbul, Temmuz 1326 R., 1910 G.), 10-16.

53 Süleyman Faik, *Rehber-i Derya, Kısm-ı Evvel, Sevahil ve Cezair-i Bahr-ı Sefid'in Tarifatını Havidir* (Istanbul: Mihran Matbaası, 1299 H., 1881/1882 G.), 6.

54 Mütercim Cemal and Tevfik, *Rehber-i Bahr-i Ahmer* (Istanbul: Istepan Matbaası, 1307 H. 1889/1890 G.), 7-8, 146 and 415-418.

55 Nurcan Bal, "XIX. Yüzyılda Osmanlı Bahriyesi'nde Gemi İnşa Teknolojisinde Değişim: Buharli Gemiler Dönemi," (Master's Thesis, Mimar Sinan Güzel Sanatlar Üniversitesi, 2010), 222-223.

56 Mehmet Korkmaz, *Bahriyede Bir Ömür, Sultan II. Abdülhamid'in Bahriye Nâzırı, Hasan Hüsnü Paşa* (Istanbul: Selenge Yayınları, 2022), 111-113; Cevat, Ülkekul, *Türk Seyir, Hidrografi ve Oşinografi Çalışmalarının 1909 Öncesi* (Istanbul: Navy Museum of Istanbul, 2009), 52-55.

this logbook meticulously records details pertaining to activities, missions undertaken, visits by pashas, and the distribution of crew salaries, offering a glimpse into the naval life rather than the environmental conditions encountered.[57]

Further scrutiny, particularly a recent study focusing on Ottoman logbooks during the reign of Sultan Abdülhamid II (1876-1909), underscores this pattern. The Naval Legislation (*Bahriye Kanunnamesi*) of 1880/1881 explicitly required Navy sailors to document daily weather observations in both the morning and afternoon, including observations of wind forces. Despite this directive, an analysis of 56 logbooks from the Hamidian period revealed that detailed meteorological data remained scarce, indicating a discrepancy between legislative requirements and practical implementation in logbook entries.[58] However, note that the aforementioned examples represent only a fraction of the available records. Consequently, they do not provide a basis for broad generalizations about the practice of documenting meteorological information in the Ottoman Navy logbooks. A substantial number of logbooks have yet to be examined in detail, suggesting a vast field of study for future research endeavors. Nonetheless, in a pivotal article on the utilization of barometers aboard ships in 1893, Navy officer Ahmed Şükrü emphasized the critical importance of documenting barometric readings either in general logbooks or in dedicated meteorological journals (*Kuyudat-ı Alaim-i Semaviyye Jurnali*). This article also reveals the existence of a meteorological division within the Navy (*Alaim-i Semaviyye İdaresi*), which is responsible for providing sailors with barometer data.[59] This development underscores the institutional acknowledgment of meteorological science in naval operations.

The introduction of meteorological instruments into Ottoman naval practices, as well as in primary and secondary sources, notably surged in the 19th century, particularly after the founding of the Imperial Observatory in Istanbul in 1868. A document from 1869 references the acquisition of anemometers, chronometers, and other astronomical instruments and books by the observatory, highlighting the observatory's immediate efforts to equip the institution following its establishment.[60] By 1886-1887, Aristide Coumbary, the director of the Imperial Observatory, provided a comprehensive inventory of instruments, including anemometers, pluviometers, hygrometers, barometers, and thermometers, sourced from esteemed European manufacturers like Richard and Fortin. This detailed account illustrates the observatory's commitment to adopting advanced meteorological tools.[61]

57 *Girit Vapuru Seyir Defteri*, Özel No: 45, 1275 H. (1858-1859), Türk Deniz Arşivi.

58 Mehmet Korkmaz, Evren Mercan, "Harp Gemisi Seyir Jurnali Defterleri Üzerinden Sultan II. Abdülhamid Donanmasının Tahlili," *Vakanüvis-International Journal of Historical Researches* 8 (2023): 1982-2986.

59 Mülazım Ahmed Şükrü, "Mübahis-i Alaim-i Cevviyye. Barometrelerin Usul-i İdare ve İstimalleri," *Mecmua-i Fünun-u Bahriyye* 4, 12, (1893), 497-498.

60 Hakan Anameriç and Fatih Rukancı, "Rasadhane-i Amire'ye 1869 Yılında Alınan Bazı Araç ve Kitaplar Hakkında Belgeler," *Ankara Üniversitesi Dil ve Tarih-Coğrafya Fakültesi Dergisi* 49 (2009): 223-244.

61 Coumbary, *Dersaadet*, 2-3.

Along with the imperial observatory, regulations from the Chief Navy School further indicated that Ottoman naval vessels designated for educational purposes were mandated to be equipped with marine clocks, barometers, and thermometers, in addition to carrying maps of the Mediterranean and Black Sea.[62] A 20th-century naval education textbook reaffirmed the necessity of thermometers and barometers on ships, aligning them with contemporary scientific standards.[63] Moreover, a breadth of scientific literature from the 19th and 20th centuries introduced sailors to meteorological instruments, providing foundational knowledge on the use of barometers and thermometers.[64] Despite these advancements, reliance on such instruments alone was deemed insufficient for comprehensive weather monitoring at sea, indicating a nuanced understanding of meteorological needs in maritime navigation.

In 1896, Ottoman army officer Haydar Daniş emphasized the symbiotic relationship between thermometers and traditional observational methods for weather prediction. Daniş explained that forecasting storms or tornadoes should not rely solely on measuring changes in temperature and wind forces but should also incorporate observations of natural phenomena, such as sunrise, sunset, and rainfall patterns.[65] This perspective underscores a holistic meteorological approach that combines empirical data with time-honored observational techniques.

Asuman provides another important text that elucidates the complementarity between instrumental measurements and natural observations for storm prediction at sea. Authored by Chief Astrologer Ismetzade Mehmed, the book delineates various storm types and offers guidance for sailors in anticipating storms through environmental cues. Mehmed posited that a clear sky with faintly shining stars may foretell thunderbolts, while an abundance of falling star signals impending windy and rainy weather. Furthermore, the appearance of Saint-Elmo's fire can be identified as an indicator of future storms. In addition to these observations, Mehmed provided insights into the use of meteorological instruments, particularly barometers, highlighting their value as complementary tools for accurate weather forecasting.[66]

Diverse sources in the Ottoman context further illustrate the synthesis of instrumental measurements and natural observations in meteorological practices. For instance, in a navigation guide published in 1871, Navy Captain Kasımpaşalı Mehmed discussed how

62 Bal, "XIX. yüzyılda", 222-223.

63 *Mülazım-ı Evvellerin Kılavuzluk Kursu*, 42-43.

64 *Mecmuatü'l Bahriyun* (Istanbul: Bahriye Matbaası, 1319 R., 1903-1904 G.), 73-80; *Gemicilere Mahsus Barometre Risalesi*, *Bahriye Erkan-ı Harb Dairesinin Harita-yı Bahriye Ahzı Şubesi Tarafından Tercüme Edilmiştir* (Istanbul: Matbaa-yı Bahriyede, 1330 R., 1914-1915 G.).

65 Haydar Daniş, *Hava-yı Nesimi*, *Hadika-yı Marifet* (Istanbul: Alem Matbaası, 1312 H., 1894/1895 G.).

66 İsmetzade Mehmed Arif, *Asüman* (Istanbul: Matbaa-i Hüseyin Enver, 1310 H., 1892/1893 G.), 52-54 and 70.

sudden fluctuations in barometer readings could presage adverse weather conditions.[67] Alongside providing guidance on the use of thermometers, he elucidated traditional methods of solar observation for weather prediction, noting that a red sunrise often portends inclement weather, including wind and rain. The 19th and 20th centuries saw a broader scientific dialog on the celestial influences on weather. Mustafa Hilmi, an astronomy professor at the Chief Navy School, examined the moon's impact on terrestrial and meteorological conditions. In his work, Hilmi articulated the moon's influence on oceanic tides and highlighted the long-recognized correlation between lunar phases and weather patterns, knowledge that sailors and farmers had leveraged for centuries.[68] Contributing to this discourse, the article "The Spots of the Sun" (*Güneşin Lekeleri*), featured in the Ottoman periodical *Servet-i Fünun* in 1905, considers European scientific interpretations of meteorological phenomena - such as heatwaves, storms, and hail - through the lens of solar activity.[69]

In addition to observations from the sky, other sources insist on the use of the human body and animals in storm predictions at sea. In his book entitled *Rules of Storms*, the director of the Imperial Observatory in Istanbul, Aristide Coumbary, explained in 1875 how sailors could use their bodies to determine the center of a cyclone. Once the storm was detected, to determine on which side it was, a sailor 'could turn his face to the wind and walk on the ship while opening his arms'. Coumbary's method applies to sizable oceanic cyclones and relies on a straightforward geometric principle. In the context of a counterclockwise-rotating vortex, an individual inside and facing the incoming wind will have the vortex center to his right. Given that all cyclones in the Northern Hemisphere rotate counterclockwise, their right arm points toward the center. Conversely, in the Southern Hemisphere, where cyclones rotate clockwise, the opposite holds true. Therefore, beyond mathematical measurements, the feeling of the wind on the human body could be a useful method for determining the direction of the wind.[70] Coumbary's "Rules of Storms", extends well beyond the geometric argument concerning the position of a vortex center. In terms of modern meteorological concepts such as traveling vortex and equatorial symmetry, this booklet encapsulates many essential ideas that will shape meteorological science over the next 50 years. In the realm of meteorology, it is one of the most state-of-the-art Ottoman publications of the entire 19th century. Furthermore, its direct relevance to sailors adds another layer of significance.

Integrating human sensory experience and animal behavior in weather forecasting is a notable aspect of traditional maritime and terrestrial meteorological practices. Navy officer

67 Kasımpaşalı Mehmed Kapudan, *Rehber-i Bahriyyun* (1286 H., 1869-1870 G. or 1286 R., 1870-1871), 6-16.
68 Mustafa Hilmi, *Kamere Matuf İstidlalat-ı Havaiye* (Istanbul: Matbaa-yı Ebüzziya, 1306 H., 1889/1890 G.), 3-8.
69 "Güneşin Lekeleri," *Servet-i Fünun*, 27 Temmuz 1321 R., August 9, 1905 G., no. 746, 15th year, vol. 29., 278-279.
70 Aristide Coumbary, *Fırtınaların Kavanini* (Istanbul: Imprimerie et Litographie Voutyras, 1875), 7-9.

and captain Mustafa Paşazade Ahmed, in his navigational guide for sailors, highlighted how physiological changes in humans can serve as indicators of impending weather changes. Specifically, he posited that dry and wrinkled hands signal the approaching arrival of cold weather, illustrating a direct connection between human physical responses and climatic conditions. Moreover, Ahmed's observations extend to avian behavior as a predictive tool for weather forecasting. According to his guide, the directional flight of birds -from land to sea- heralds favorable weather, whereas a reversal in their flight path suggests the onset of a storm. [71] This reliance on bird behavior highlights an empirical approach to anticipating weather changes based on the natural world.

In addition to the maritime context, terrestrial observations of animal behavior also played a crucial role in weather prediction. Local knowledge among villagers in the early 20th century held that specific swallow flight patterns -such as gliding close to the ground or skimming river surfaces with their wings- were precursors to deteriorating weather conditions or imminent storms. [72] An article titled 'Barometric Animals' published in *Servet-i Fünun* in 1897 further supported scientific interest in the relationship between animal behavior and weather phenomena. This section delves into studies on the sensitivity of certain animals, particularly cold-blooded species like frogs, to changes in air pressure, indicating a broader scientific inquiry into biometeorological indicators.[73]

Observation of animal behavior, particularly in relation to weather forecasting, maintained its validity well into the mid-20th century. Throughout the 1930s and 1940s, scientists continued to explore the efficacy of using fish in European lakes and birds as reliable indicators of weather predictions. [74] In 1948, Turkish Navy officer C. Eyiceoğlu identified specific behaviors- such as swallows flying at high altitudes and seabirds moving toward or away from the coast - as significant markers of atmospheric changes at sea.[75] This acknowledgment of avian patterns alongside other natural phenomena highlights the continuous reliance on traditional meteorological observation techniques.

Despite technological innovations, such as the first infrared satellites launched into space by the United States in the 1960s for meteorological measurements, sailors continued to analyze the sky, cloud formations, and bird behaviors. This persistence underscores a deep-rooted belief in the complementary nature of traditional observational methods alongside

71 Mustafa Paşazade Ahmed Kapudan, *Muavin-i Bahriyyun Yahud Hikmet-i Bahriye* (Istanbul: Basiret Matbaası, 1292 H., 1875/1876 G.), 67-90.

72 "Ahval-i Havaiyeye Dair," *Servet-i Fünun*, 27 Eylül sene 1322 R., October 10, 1906 G., no. 807, 16th year vol. 32, 6-8.

73 "Barometrik Olan Hayvanlar", *Servet-i Fünun*, 28 Teşrinsani 1307 R., December 9, 1891 G., no. 39, 152.

74 Gary Lockhart, *The Weather Companion* (New York, Chichester, Brisbane, Toronto, Singapore: Wiley Science Editions, 1988), 138-145.

75 Kur. Onyzb. C. Eyiceoğlu, "Meteoroloji ve Denizcilik," *Deniz Mecmuası* 382 (1948), 39-46.

modern technological tools. Animals, particularly birds, have long been recognized as precursors for detecting weather variations, acting as the "ancestors of satellites" because of their innate ability to sense impending changes in weather conditions before humans.[76]

The co-existence and complementarity between contemporary meteorology and ancient observational practices underscore a significant trend in meteorological historiography. These findings validate the notion that the evolution of modern science, particularly as it unfolded in the Western world, did not merely augment existing knowledge systems. Instead, this approach often led to hybridization, integrating with traditional methodologies to form a more comprehensive approach to understanding weather phenomena.[77] Further exploration of Ottoman maritime meteorology's historical context reveals an expansive narrative that extends beyond the official geographical manuals and navigation guides issued by the Ottoman Navy. Popular astrological sources, including calendars and prophetic volumes (*melhame*) predicting future events, reveal a fascinating continuity: the enduring presence of ancient astrological practices within Ottoman popular culture well into the 19th and 20th centuries.

Celestial Divination and Meteorological Insights: Tracing Astrometerological Traditions in the Ottoman Navy

Astrometeorology, the practice of predicting weather through astrological calculations, was a prevalent approach in medieval times,[78] emerging as an "established branch of knowledge" within the broader fields of astronomy and technology by the 14th century.[79] The 15th-century astronomer Johannes Müller, also known as Regiomontanus, exemplified this tradition by forecasting weather based on planetary conjunctions, establishing a direct correlation between celestial events and terrestrial phenomena, such as weather conditions, harvests, and the availability of natural resources.[80] Despite its prominence, this astrometeorological approach has faced criticism for its inaccuracy, notably from the Augustinian canon Kilian Leib (1471-1553), who argued that it led to erroneous predictions.[81] Nonetheless, astrometeorology persisted as a significant aspect of European meteorology throughout the 16th century. [82]

76 Joe Klipffel, *Prévoir le temps par les dictons marins et savoir lire les signes du ciel* (Paris: Arthaud, 1971), 146-151.

77 Martin Mahony, Angelo Matteo Caglioti, "Relocating meteorology," *History of Meteorology* 8 (2017): 1-14.

78 Stuart Jenks, "Astrometeorology in the Middle Ages," *Isis* 74 (1983): 185-210.

79 Anne Lawrence-Mathers, "Astrometeorology and Mechanisation," in *Medieval Meteorology: Forecasting the Weather from Aristotle to the Almanac,* ed. Anne Lawrence-Mathers (Cambridge: Cambridge University Press, 2019), 152-172.

80 Wolfgang Behringer, *A Cultural History of Climate*, (Cambridge: Polity Press, 2010), 101.

81 Wolfgang Behringer, *A Cultural History of Climate*, (Cambridge: Polity Press, 2010), 101.

82 Danielle le Prado-Madaule, "L'astrométéorologie: influence et évolution en France 1520-1640," *Histoire, Économie et Société* 15 (1996), 179-201.

By the 18th century, however, as astrology became more popular than academic studies, it faced increasing scrutiny and was gradually excluded from university curricula across Europe.[83] In the 19th century, astrometeorology found refuge within the almanac tradition, contributing to meteorology's popularization in the United Kingdom through publications like the *Illustrated London Almanack*, *Murphy's Weather Almanac*, and *Zadkiel's Almanac*. Despite their popularity during the Victorian Era,[84] the scientific community largely dismissed these sources.

In France, astrometeorological sources also enjoyed popularity in the 1830s and 1840s. However, as meteorology began to solidify as a science grounded in empirical data and mathematical principles during the 19th century, the delineation between science-based forecasting and astrological prophecy became increasingly clear.[85] French physicist and astronomer François Arago critically addressed the reliance on astrological prophecies for weather prediction in his publication, *Annuaire du Bureau des longitudes*. In an 1846 article, he cautioned readers against astrometeorologic almanacs that echoed the forecasting methods of historical figures like Nostradamus or Mathieu Laensberg, marking a shift toward a more scientifically rigorous understanding of meteorology.[86]

Within Ottoman traditions, the *melhames* and calendars of the chief astrologer (*takvim-i müneccimbaşı*) stand out as some of the earliest astrological sources that included meteorological predictions. Yazıcı Salahuddin, in his *Melhame-i Şemsiyye* completed in 1408, offers predictions regarding 25 natural phenomena through astrological interpretations of rainbows, thunder, and storms.[87] This work exemplifies the integration of astrological practices to understand and predict weather-related events.

A distinguished member of the Ottoman ulama during the 15th century, Sheikh Vefa, also contributed to this body of knowledge by making meteorological predictions within his *melhame* for April according to the Rumi calendar. Notably, in the sixth section of his work, he posited that the sighting of a rainbow from the East during this month signified the abundance of rain and violent sea waves. In the following section, he associated thunderstorms with the onset of wars, underscoring the perceived interconnectedness between atmospheric conditions and terrestrial events.[88]

83 Simone Dolet, "L'astrologie saine de Giuseppe Toaldo et les séismes, clés de la prédiction des changements climatiques?, " *Dix-huitième siècle* 54 (2022): 51.

84 Katharine Anderson, *Victorians and the Science of Meteorology. Predicting the Weather* (Chicago and London: The University of Chicago Press, 2005), 64.

85 Katharine Anderson, "Looking at the sky: the visual context of Victorian meteorology," *British Journal for the History of Science* 36 (2003): 305.

86 Locher, *Le Savant*, 29-30.

87 Ekmeleddin İhsanoğlu (ed.), *Osmanlı Astroloji Literatürü Tarihi ve Osmanlı Astronomi Tarihi Zeyli, History of Ottoman Astrology Literature and Supplement to the History of Ottoman Astronomy Literature*, *Vol I* (Istanbul: IRCICA, 2011), 3.

88 Faysal Okan Atasoy, "Melhame-i Şeyh Vefa Giriş-Metin-Sözlük / Melhame-i Şeyh Vefa Introduction-Text-

Furthermore, a 17th-century *melhame* incorporating meteorological forecasts for the month of Azer according to the Celali calendar (corresponding to March in the Rumi calendar) is accessible in the Gallica database of the *Bibliothèque Nationale de France*. Although the author of this melhame remains unnamed, the text references various sources to make his predictions. It forecasts significant rainfall for March, drawing connections between rainbows, the reddening of the sky, thunder, and falling stars as the harsh winter conditions.[89]

The amalgamation of celestial divination with meteorological insight not only highlights the depth of the Ottoman astrological traditions but also reveals a profound connection between celestial and terrestrial domains, as scholars from the 15th to the 17th centuries. This combination of ancient astrological sources and a sophisticated interpretation of natural phenomena underscores a richly nuanced understanding of the universe. These examples vividly illustrate the Ottoman Empire's intellectual milieu, characterized by a seamless integration of celestial observations and meteorological predictions. This intricate mosaic of insights, in which celestial movements and terrestrial weather patterns are seen as interconnected, reflects a worldview in which the macrocosm and microcosm are in constant dialog. The scholarly works from this era, ranging from *melhame* to the calendars of chief astrologers, serve not merely as historical curiosities but as a testament to an enduring quest to comprehend and harness the forces of nature through the lens of celestial influence.

The 19th century in the Ottoman Empire witnessed the persistence of astrological traditions within the fabric of popular culture. Esseyid Mehmed Sabit's *melhame* from 1878 stands as a testament to this enduring practice, providing a variety of predictions for the coming year. Sabit's work is notable not only for its meteorological forecasts, including expectations of rain and thunderstorms but also for its contemplation of more dire predictions, such as maritime disasters and bloodshed.[90] Crucially, Sabit's methodology extends beyond mere prophecy. His reference to the cold conditions of the preceding month of Muharrem as a harbinger of another severe winter illustrates a nuanced approach to forecasting. This reliance on empirical observation - acknowledging past weather patterns as predictors of future climatic conditions - reveals a methodological sophistication that blurs the lines between traditional astrological practices and emerging empirical methods that would define modern meteorology. This blending of astrological prophecy with empirical observation underscores the complex intellectual landscape of Ottoman astrometeorology during this period. Astrological traditions, which are rooted in celestial divination, are not isolated from the observable realities of the natural world. Instead, they often incorporated these realities

Vocabulary," (Master's thesis, Istanbul: Marmara Üniversitesi, 2001), 46.

89 *Traité des présages à tirer des phénomènes astronomiques et des particularités qui se produisent dans chacun des mois de l'année solaire*, 1651-1700, Supplément turc 243. BnF-Gallica, 1v-7r.

90 Esseyid Mehmed Sabit, *Melhame, 1294 Teşrin-i evvel Ahkamı* (Istanbul: Vezir Hanı, Mustafa Efendi Basmahanesi, 1878 G.,), 9-18.

into their frameworks, indicating a proto-scientific reasoning that recognized the value of historical weather patterns in predicting future events.

Furthermore, along with astronomical calendars, the calendars of the chief astrologer (*takvim-i müneccimbaşı*) made their way into the 19th and 20th centuries. While astronomical calendars of the 19th century such as *Rebi-i Marifet* published by Ebu Ziya in 1885-1886 contained meteorological instructions for sailors,[91] an astrological calendar from 1869, for instance, made end-of-month predictions based on stellar observations, including weather forecasts like winds, snow, and storms.[92] Other calendars such as *Takvim-i Sal* or *Ahkam-ı Sal* enjoyed widespread popularity.[93] The tradition of producing astrological calendars by the chief astrologer served as a cornerstone of Ottoman astrological and astronomical practice. These calendars were not merely chronological markers; they offered a wealth of information on celestial events, such as eclipses, and provided practical and seasonal guidance.[94]

In earlier centuries, the strategic importance of these astrological calendars had been profound, influencing the Ottoman military's operational planning and execution.[95] This reliance on celestial phenomena for critical decisions underscored the deeply integrated nature of astrological knowledge within the administrative and military strategies of the Empire. However, by the 19th and 20th centuries, the context within which these calendars were produced and utilized had shifted dramatically. The advent of modern navigation techniques and the increasing precision of scientific meteorology have begun to overshadow traditional astrological methods. Consequently, the practical utility of astrological calendars for navigation and strategic planning has diminished. Instead, these calendars acquired a more symbolic significance, representing a link to cultural and intellectual traditions despite rapidly advancing scientific knowledge and technological capabilities. Despite this shift, the continued production and use of astrological calendars into the 19th and 20th centuries have highlighted a resilient strand of Ottoman cultural identity. They serve as a testament to the enduring appeal of astrological practices, even as their direct application in matters such as navigation has become more symbolic than substantive.

While astrometeorological traditions have transcended centuries and maintained their presence through Ottoman *melhames* and calendars, their presence within the Ottoman Navy, an institution at the forefront of modernization, remains scarce. A remarkable

91 Dursun Ayan, "Astronomik Düzenlilikten Sosyo-Matematik Uylaşıma Takvim," *Osmanlı Bilimi Araştırmaları* 9 (2008): 216.

92 *Takvim-i Müneccimbaşı* (Istanbul, 1286 H.,1869/1870 G.), 1, 12 and 13.

93 Süleyman Faik, *Takvim-i Sâl. 1 Şaban 1307 - 29 Receb 1308,* March 23, 1890-March 10, 1891 G.; Müneccimbaşı Hüseyin Hilmi, *Takvim-i Sâl, 20 Rebiulevvel 1329 - 30 Rebiulevvel 1330*, March 21, 1911-March 19, 1912.

94 Salim Aydüz, "Osmanlı Astronomi Müesseseleri," *Türkiye Araştırmaları Literatür Dergisi*, 4 (2004): 411-454.

95 Ahmet Tunç Şen, "Reading the Stars at the Ottoman Court: Bāyezīd II (r. 886/1481-918/1512) and his Celestial Interests," *Arabica* 64 (2017): 582-583.

exception is the 1913/1914 *Illustrated Navy Astrologer (Musavver Donanma Müneccimi)*, which was published by the Ottoman Navy Association *(Osmanlı Donanma Cemiyeti)*. This almanac, offering detailed meteorological instructions for sailors, including wind predictions and navigational advice, marks a singular instance of an astrological reference in modern naval publications. The almanac's predictions for specific wind conditions and suitable days for navigation during March in the Mediterranean and Black Sea underscore the potential continuity of astrometeorological practices.[96] However, the absence of a methodological explanation for these forecasts introduces uncertainty about their foundation, whether in traditional astrological calculations or empirical observations and statistical analyses from prior years. This ambiguity raises questions about the enduring influence of astrometeorological traditions within the 20th-century context. Given the Navy's early and enthusiastic adoption of European educational models and scientific methods, the likelihood of astrological predictions permeating its educational system seems minimal. The Navy's modernization trajectory, engaging with European-trained instructors and staff, demonstrates a departure from astrological methods in favor of empirical, scientifically grounded practices.

Conclusion

By tracing Ottoman naval documentation and ancient astrometeorological sources, this study revealed diverse maritime meteorological surveillance methods, emphasizing the parallel development of modern scientific advancements and traditional knowledge in maritime meteorology. Throughout the 19th and 20th centuries, meteorological progress in Europe and North America has shifted significantly toward modern science, prioritizing navigational safety and agricultural productivity. This shift affected Ottoman Navy publications aimed at educating sailors on contemporary meteorological surveillance.

Building on these sources, this article explored the evolution of maritime weather monitoring within the Ottoman Navy, emphasizing the interplay between ancient traditions and modern meteorology. Findings indicated that meteorology, which was initially integrated with astronomy and geography during the premodern period, continued this trend into the 19th and 20th centuries. Publications from Ottoman Navy officers during this period demonstrated the emergence of meteorology as a distinct discipline within the Ottoman Empire. Within this framework, scientific analysis methods, such as observing and measuring atmospheric phenomena, were integrated into traditional sailor practices dating back to ancient times.

Additionally, although ancient astrometeorological sources persisted in Ottoman popular culture until the 20th century, tangible evidence of their use by sailors is lacking. As demonstrated in this article, modern meteorological sources indicate that Ottoman

96 Donanma-ı Osmani Cemiyeti, *Musavver Büyük Donanma Müneccimi,* (Istanbul: Matbaa-i Ahmed İhsan ve Şürekası, 1330 R., 1914-1915 G.), 79-96.

Navy officers adhered to scientific principles and consciously avoided pseudoscience. Consequently, astrometeorological sources related to maritime weather monitoring in the 19th and 20th centuries stand as a testament to symbolic or popular traditions rather than scientific purposes.

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