

# Jesuit Contribution to Science 1814–2000

## A Historiographical Essay

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### Abstract

After their restoration in 1814, the Jesuits renewed their scientific tradition and have continued it up to the present day. Although this period has not received as much attention as the one stretching from the foundation of the order in 1540 to its suppression in 1773, the establishment of observatories throughout the world, beginning in 1824 and tapering off since about 1970, has aroused a certain degree of interest among historians. Articles on the subject are divided into those of general scope and those dealing with specific observatories. The fields of astronomy, meteorology, and geophysics are of particular interest, and special attention is given to the study of tropical hurricanes, seismology, and geomagnetism. These articles are a good source of information about Jesuits' work in the observatories. But other Jesuit scientific contributions have received little attention. One such neglected subject is the research conducted at Jesuit colleges and universities in fields like mathematics, physics, and biology. Contributions to biology and environmental studies, especially in India, are a more recent concern that the literature has yet to address. Another area awaiting fuller development is the biography of Jesuit scientists, although some attention has been given to Angelo Secchi (1818–78) and Stephen Perry (1833–89). (Pierre Teilhard de Chardin [1881–1955], who has a very abundant bibliography devoted to him, is a special case.) The spirituality of Jesuit scientists and their position in the dialogue between science and religion are ripe for further exploration as well.

### Introduction

The Jesuit contribution to science has received considerable attention from historians, especially since around 1980. Most of these works concern the period from 1540 to 1773, that is, from the founding of the Society of Jesus by Ignatius of Loyola (c.1491–1556) to its suppression by Pope Clement XIV. Sheila J. Rabin has presented a very complete historiographical essay about Jesuit science during this period.<sup>1</sup> In contrast, the Jesuit contribution to science since the restoration of the order in 1814 has received very little attention. Carl-Henry Geschwind goes so far as to say, "By the nineteenth century the early Jesuit scientific tradition had faded away, so that contemporary Jesuits, like other Catholic priests, were no longer commonly associated with serious scientific accomplishments."<sup>2</sup> He makes an exception only for the seismological work conducted in the United States in early twentieth century.

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1 Sheila J. Rabin, "Early Modern Science. A Historiographical Essay," *Journal of Jesuit Studies* 1, no 1 (2014): 88–104.

2 Carl-Henry Geschwind, "Embracing Science and Research: Early Twentieth-Century Jesuits and Seismology in the United States," *Isis* 89 (1998): 27–49.

While it may be true that Jesuit scientific work in the modern era has not had the same appeal for historians as that conducted in the seventeenth and eighteenth centuries, it does not deserve Geschwind's overall disqualification. Since 1814, the Jesuits have counted among their ranks two fellows of the Royal Society of London, one member of the American National Academy of Science, thirty-one members of the Royal Astronomical Society, and many others belonging to local academies of science.<sup>3</sup> They have also founded seventy-five observatories throughout the world and presently manage 133 universities, where a number of Jesuits are professors of science. This is hardly the work of any "other Catholic priest," as Geschwind observed. During the modern period, Jesuits have especially excelled in astronomy, geophysics, meteorology, geomagnetism, and the natural sciences through work done at their observatories, colleges, and universities.

Although it is possible to find some literature on the subject, the Jesuits' more recent work has not stirred up the interest of historians the way that of the previous period has. An important new element that has been particularly neglected is the apologetic intention informing many of the Jesuits' modern scientific endeavors. The order has presented their work as a practical refutation of the widespread opinion, present since the middle of the nineteenth century, that there is a fundamental incompatibility between science and Christian faith. The issue is fascinating, but literature about Jesuit science in this period does not give it the attention it deserves. The Jesuits' exploration of the relationship between science and religion is another important topic that has been practically ignored.

The only work that provides comprehensive coverage of Jesuit scientific endeavors in the past two hundred years is my own recent book, *Jesuit Contribution to Science: A History*, in which five of eleven chapters are dedicated to the modern era.<sup>4</sup> In these chapters, I discuss the founding of new observatories after 1814, covering Jesuit work in astronomy, meteorology (especially in relation to tropical hurricanes), seismology, and geomagnetism. A chapter is dedicated to Angelo Secchi (1818–78), Stephen Perry (1833–90), James B. Macelwane (1883–1956), and Pierre Teilhard de Chardin (1881–1955), who are considered to be the main figures of the period. The section about Jesuit professors of science in universities and secondary schools pays special attention to their work in botany and zoology, particularly in India. In the epilogue, I explore the relationship between Jesuit science and Ignatian spirituality, a problem that has hitherto received little attention.

References to Jesuit scientific contributions in the modern era can be found in a few other works as well. George Bishop dedicates four chapters of his short history of Jesuits in science and mathematics to modern Jesuit scientists, including specific chapters on Secchi, Perry, and Teilhard de Chardin.<sup>5</sup> A more recent work by François Euvé also devotes a few pages to Jesuit scientists of this period.<sup>6</sup> Jaime Fernández and Eduardo di Vita provide a list of Jesuit scientists, including 118 from the modern era (108 born in the nineteenth century and ten in the twentieth), but the information given for each is limited to succinct biographical data and a short list of publications.<sup>7</sup> A final chapter on Jesuit scientists of the

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3 Agustín Udías, "Serving God and Science," *Astronomy and Geophysics* 42 (2001): 23–24.

4 Agustín Udías, *Jesuit Contribution to Science: A History* (Dordrecht: Springer, 2015). A Spanish version with more coverage for Spanish Jesuits: *Los jesuitas y la ciencia: Una tradición en la iglesia* (Santander: Sal Terrae, 2014).

5 George D. Bishop, *Jesuit Pioneers of Modern Science and Mathematics* (Anand, Gujarat: Gujarat Sahitya Prakash, 2005).

6 François Euvé, *Mathématique, astronomie, biologie et soin des âmes: Les jésuites et les sciences* (Brussels: Lessius, 2012).

twentieth century offers a brief overview mentioning the work of thirty-three of them, but most of these were already included in the previous list.

There are also some general articles about Jesuit scientists that include information concerning the period since 1814. The earliest, a 1937 article by Manuel M. Sánchez Navarro-Neumann dedicated to Jesuit astronomers, gives the names of thirty-one Jesuits who worked at observatories during this timeframe.<sup>8</sup> Johan Stein, director of the Vatican Observatory, provides a longer treatment of an equal number of Jesuit scientists (although not the same ones).<sup>9</sup> Antonio Due Rojo includes a short presentation covering 1814–1940,<sup>10</sup> and Daniel O’Connell dedicates two pages to the same.<sup>11</sup> The renowned Jesuit seismologist James B. Macelwane also published a short article on American Jesuit scientists, all of whom, naturally, belong to the modern period.<sup>12</sup> Francisco Malta Romeiras has recently published a detailed work about modern Portuguese Jesuit scientists and, with Henrique Leitão, a series of articles on the same subject.<sup>13</sup> These articles, plus the books mentioned above, comprise nearly everything that one can find on the topic of Jesuit contributions to science since 1814. The contrast between this relative paucity and the abundance of literature on pre-suppression Jesuit science is stark.

## Jesuit Observatories

The most remarkable chapter in the history of modern Jesuit science is the establishment of their network of observatories. The first was that of the Roman College (in Rome), which came under Jesuit direction in 1824. (It had been established in 1787, when the college was managed by secular clergy following the suppression of the Jesuits in 1773.) A total of seventy-five observatories were founded between 1824 and 1957: twenty-six in Europe, twenty-two in North America, eighteen in Central and South America, and nine in Asia and Australia. The first observatories were usually focused on astronomy but made meteorological and geophysical observations as well. Those founded later were most often dedicated to meteorology, seismology, and geomagnetism. Some were important research institutions; others were small meteorological and seismological stations. Those established in the mission lands of Africa and Asia were in many instances the first scientific institutions to appear in those countries and thus helped launch their scientific development.

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- 7 Jaime Fernández Rodríguez, and Eduardo de Vita, *Presença dos jesuitas no mundo científico* (São Paulo: Edições Loyola, 2004).
- 8 Manuel M. Sánchez Navarro-Neumann, "Jesuitas astrónomos," *Brotéria* 24 (1937): 423–36.
- 9 Johan Stein, "La Compagnia di Gesù e le scienze fisiche e matematiche," *Vita e pensiero* 19 (1941): 3–23.
- 10 Antonio Due Rojo, "La Compañía de Jesús y la ciencia," in *Dios y la ciencia*, ed. Antonio Due Rojo (Granada: Facultad de Teología S.L., 1941), 199–217.
- 11 Daniel O’Connell, "Jesuit Men of Science," *Studies* 45 (1956): 307–18.
- 12 James B. Macelwane, "American Jesuits in Science," *Thought* 16 (1941): 122–33.
- 13 Francisco Malta Romeiras, "A ciência da Companhia de Jesus nos séculos XIX e XX em Portugal," *Brotéria* 179 (2014): 429–54 and *Ciência, prestígio e devoção: Os jesuitas e a ciência em Portugal* (Cascais: Lucerna, 2015); Francisco Malta Romeiras and Henrique Leitão, "Jesuitas e ciência em Portugal I: António Oliveira Pinto S.J. e as primeiras experiências com radioactividade em Portugal; II: Carlos Zimmermann S.J. e o ensino da microscopia vegetal; III: As expedições científicas a observação dos eclipses solares de 1900 e de 1905; IV: A revista *Brotéria—Ciências naturais* e a sua recepção nacional e internacional; and V: Os colegios de Campolide e de São Fieles a implantação da república," *Brotéria* 174 (2012): 9–20; 124–213; 213–27; 323–33; 425–40.

The phenomenon of Jesuit observatories, which is important by virtue of their number and worldwide distribution alone, has not received the historical attention it deserves. The earliest work about these institutions is that of Pierre de Vrégille, whose 1906 article gives a very complete description of the twenty-five observatories operating at that time.<sup>14</sup> Short accounts of the eighteen observatories existing in 1914 are found in general works from that year about the Society of Jesus since its restoration.<sup>15</sup> William Stauder and I describe the geophysical observatories in a 1991 article, and a later piece of my own provides a brief account of all Jesuit observatories.<sup>16</sup>

A more complete history can be found in my book *Searching the Heavens and the Earth: The History of Jesuit Observatories*.<sup>17</sup> In part one, I trace the history of modern Jesuit observatories from the establishment of the first one in 1824 to the closing or transfer of the majority of them between 1950 and 1970. Along the way, I offer detailed descriptions of the founding, development, and demise of each of the seventy-five institutions in question. Part two provides a list of these observatories and includes detailed information about each of them (key dates, directors and collaborators, buildings, and instrumentation) as well as a bibliography. Part three offers short biographies of fifty-eight directors of the main observatories plus lists of selected publications and an additional bibliography.

Some literature exists for individual observatories, but it is not always easy to find. The most important institutions are treated in publications that give pertinent descriptions of their buildings, instruments, history, research, and published works. Among those so favored are the observatory of the Roman College (Rome, Italy, 1824–79),<sup>18</sup> the observatory of Stonyhurst College (Lancashire, England, 1838–1974),<sup>19</sup> Haynald Observatory (Kalocsa, Hungary, 1878–1950),<sup>20</sup> Cartuja Observatory (Granada, Spain, 1902–75),<sup>21</sup> Ebro Observatory (Roquetas, Spain, 1904–),<sup>22</sup> and Georgetown University Observatory (Washington, D.C., USA, 1844–1972).<sup>23</sup> In these facilities, Jesuits carried out pioneering research in astrophysics, solar physics, geomagnetism, and seismology.

A case that has received special attention is that of the Vatican Observatory. The observatory was founded by Pope Leo XIII in 1890 as a pontifical institution and was entrusted to the Jesuits in 1906. Sabino Maffeo's two books on the subject give a very complete description of the observatory and trace the history of both the institution and its works up to the present time.<sup>24</sup> The facility has remained in Jesuit hands since the

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14 Pierre de Vrégille, "Les observatoires de la Compagnie de Jésus au début du XXe siècle," *Revue des questions scientifiques*, 59 (1906): 10–72, 493–579.

15 Pierre Albers, *Liber saecularis Societatis Iesu ab anno 1814 ad annum 1914* (Rome: Curia Generalis Societatis Iesu, 1914).

16 Agustín Udías and William Stauder, "Jesuit Geophysical Observatories," *EOS Transactions of American Geophysical Union*, 72 (1991): 185–89; Agustín Udías, "Observatories of the Society of Jesus, 1814–1998," *Archivum historicum Societatis Iesu*, 64 (2000): 151–78.

17 Agustín Udías, *Searching the Heavens and the Earth: The History of Jesuit Observatories* (Dordrecht: Kluwer, 2003).

18 Aldo Altamore and Sabino Maffeo, eds., *Angelo Secchi: L'avventura scientifica del Collegio Romano* (Foligno: Quater, 2012).

19 T. E. Muir, "Excursus: The Stonyhurst Observatory 1838–1992," in *Stonyhurst College, 1593–1993* (London: James and James, 1993).

20 I. Mojzes, ed., *A Kalocsai Haynald Observatórium története* (Budapest: Országos Műzaki I. K. K., 1986).

21 Javier Piñar Samos, *Observatorio de Cartuja, 1902–2002* (Granada: Caja de Granada, 2003).

22 Manuel García Doncel and Antoni Roca Rosell, *Observatorio del Ebro: Un siglo de historia (1904–2004)* (Roquetas: Observatorio del Ebro, 2007).

23 Francis J. Heyden, *The Beginning and End of a Jesuit Observatory (1841–1972)* (Manila: Publications of Manila Observatory, 1975).

directorship of Johann Hagen (1847–1930), the first Jesuit to hold that position, and is currently home to some fifteen active Jesuit astronomers.<sup>25</sup>

The observatories established in mission countries deserve special attention.<sup>26</sup> Important scientific work in astronomy, meteorology, and seismology has been conducted in such far-flung places as Manila Observatory (Philippines, 1865–),<sup>27</sup> Zikawei Observatory (Shanghai, China, 1872–1949),<sup>28</sup> and Ksara (Lebanon, 1907–79) in Asia;<sup>29</sup> Ambohidempona Observatory (Tananarive, Madagascar, 1889–1967) in Africa;<sup>30</sup> Belen Observatory (Havana, Cuba, 1857–1961) in the Caribbean Region;<sup>31</sup> and the Observatorio de San Calixto (La Paz, Bolivia, 1892–),<sup>32</sup> the Observatorio de Física Cósmica (San Miguel, Argentina, 1935–77),<sup>33</sup> and the Instituto Geofísico (Bogotá, Colombia, 1941–) in South America.<sup>34</sup> The work of the observatories run by French Jesuits has been criticized by Lewis Pyenson as that of "functionary missionaries" rather than "real scientists," but this characterization is unfair.<sup>35</sup> Aitor Anduaga has shown that the research conducted by the Spanish Jesuits in Manila was as scientifically rigorous as any, and his observation is equally applicable to the work of Jesuits at other mission observatories.<sup>36</sup> Furthermore, in assessing the quality of such work, it is necessary to take into account the difficulty of conducting scientific research in these countries at the turn of the nineteenth century. An additional complicating factor was the Jesuits' relationship with the colonial administrations, which often required the Society's assistance with such practical matters as cartography, time services, weather forecasts, and earthquake risk studies. Regardless, there can be no doubt that Jesuit observatories in mission lands contributed to those countries' early scientific development.

Most of the Jesuit mission observatories closed between the years 1950 and 1970, for a variety of reasons. Those in Kalocsa, Havana, and Shanghai were confiscated or shut down by the communist governments. Others continue to operate even today, but as state institutions.

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- 24 Sabino Maffeo, *In the Service of Nine Popes: 100 Years of the Vatican Observatory* (Vatican City: Vatican Observatory, 1991); *La Specola Vaticana: Nove papi, una missione* (Vatican City: Pubblicazioni della Specola Vaticana, 2001).
- 25 H. Dopp, "Johann Georg Hagen, S.J., 1847–1930," *Revue des questions scientifiques* 99 (1931): 5–37; Johan Stein "P. Giovanni Hagen S.J.," *Atti della Pontificia Accademia delle Scienze dei Nuovi Lincei* 84 (1931): 66–84; Arndt Latußeck, "Via nubila am Grund des Himmels: Johann Georg Hagen und die kosmischen Wolken" (PhD Thesis, Hamburg University, 2009); Maffeo, *Specola*, 69–98.
- 26 Pierre Lejay, "Trois observatoires de Mission," *Études* 182 (1925): 594–602; Ricardo Cirera, "Principales observatorios de la Compañía de Jesús en las misiones," *Ibérica* 24 (1925): 24, 41–44, 72–77.
- 27 John S. Schumacher, "One Hundred Years of Jesuit Scientists: The Manila Observatory," *Philippine Studies* 13 (1965): 258–86.
- 28 Joseph Dehergne, "Zi-ka-wei l'Observatoire des cyclones," *Météorologie* 4 (1976): 179–88.
- 29 J. Dufay, "L'Observatoire de Ksara et le Service Météorologique en Syrie," *Revue scientifique (Revue rose)*, 70 (1932): 65–68.
- 30 Charles Poisson, *Un cinquantenaire, l'Observatoire d'Abohidempona à Tananarive, Madagascar, 1889–1939* (Paris: Edition Dillen, 1939).
- 31 Manuel Gutiérrez Lanza, "El observatorio del Colegio de Belén," *Revista Belén* 16 (1929): 855–59.
- 32 R. R. Coenraads, "The San Calixto Observatory in La Paz, Bolivia: Eighty Years of Operation; Director Dr. Lawrence A. Drake," *Journal and Proceedings of the Society of New South Wales* 126 (1993): 191–98.
- 33 Ignacio Puig, "El observatorio de San Miguel, República Argentina," *Publicaciones del Observatorio de San Miguel* 2 (1935): 1–40.
- 34 A. Alfaro, "Instituto Geofísico Universidad Javeriana: Sesenta años 1941–2001," *Hoy en la Javeriana* 38, no. 1156 (2001): 12–13.
- 35 Lewis Pyenson, "Pure Research, Jesuit Institutions and Metropolitan Ambitions: The Evolution of French Policies Overseas, 1880–1940," *Chine et Europe: Évolution et particularités des rapports est–ouest du XVIe au XXe siècle; Actes du IVE Colloque International de Sinologie de Chantilly* (Paris: 1991), 249–71.
- 36 Aitor Anduaga, "Spanish Jesuits in the Philippines: Geophysical Research and Synergies between Science, Education and Trade, 1865–1898," *Annals of Science* (2013), doi: 10.1080/0033790.2013.841289.

## Tropical Hurricanes

Most of the Jesuit observatories mentioned above also performed meteorological observations, and so meteorology soon became a field of active Jesuit research.<sup>37</sup> The Jesuits' most important contribution in this area was unquestionably their work on tropical hurricanes, which was carried out in the Caribbean, the Far East, and the Indian Ocean. Benito Viñes (1837–93), the director of Belén Observatory, was the first to study tropical storms.<sup>38</sup> Beginning in 1870, he analyzed every hurricane in the Caribbean to determine its organization, circulation and translation. Using a primarily empirical approach, he formulated several laws about the circulation and path of tropical storms in the region.<sup>39</sup> Viñes put his knowledge to practical use by forecasting the arrivals of hurricanes in Cuba, beginning with the hurricane of September 13, 1875. His public announcement of the storm's arrival in Havana two days before it hit was the first successful prediction of a hurricane using modern scientific methods.<sup>40</sup> After Viñes's death, his work was continued by his successors at Belén Observatory until the Castro government closed it in 1961.

Beginning in 1879, Federico Faura (1840–97) and José Algué (1856–1930) applied Viñes's ideas about tropical hurricanes to typhoons in the Philippines.<sup>41</sup> Charles Deppermann (1889–1957) later became the first person to use the principles of frontology and air mass analysis, as developed by the Norwegian meteorologist Jacob Bjerknes (1897–1975), to study the genesis and path of such storms.<sup>42</sup>

A third group of Jesuits studying tropical hurricanes were those at the Zikawei Observatory in China. Charles Dechevrens (1845–1923) led the way with practical studies aimed at forecasting typhoons along the Chinese coast.<sup>43</sup> His studies were continued by Louis Froc (1859–1932) and Ernesto Gherzi (1886–1976) until the observatory was confiscated by the communist government in 1949.<sup>44</sup>

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37 Agustín Udías, "Jesuits' Contribution to Meteorology," *Bulletin of the American Meteorological Society* 77 (1996): 2307–15; "Meteorology in the Observatories of the Society of Jesus," *Archivum historicum Societatis Jesu* 65 (1996): 157–70, and *Jesuit Contribution*, 157–71.

38 Luis E. Ramos Guadalupe, *Father Benito Viñes: The 19th Century Life and Contributions of a Cuban Hurricane Observer and Scientist*, translated by Oswaldo García (Boston: American Meteorological Society, 2014).

39 Benito Viñes, *Apuntes relativos a los huracanes de las Antillas en septiembre y octubre de 1875* (Havana: El Iris, 1877) and *Investigaciones relativas a la circulación y traslación ciclónica en los huracanes de las Antillas* (Havana: Avisador Comercial, 1895).

40 Walter M. Drum, *The Pioneer Forecasters of Hurricanes* (Washington, D.C.: Stormont and Jackson, 1905); R. M. DeAngelis, "The Hurricane Priest," *ESSA World* (October 1968): 16–17.

41 Federico Faura, *Señales precursoras de temporal en el archipiélago filipino* (Manila: Observatorio de Manila, 1882); Eduardo Fontseret, "Rdo. P. Federico Faura," *Memorias de la Real Academia de Ciencias y Artes de Barcelona* 22, no. 5 (1930): 78–84; José Algué, *Baguíos o ciclones filipinos: Estudio teórico* (Manila: Juan de León, 1897) and *The Cyclones of the Far East* (Manila: Government Printing Office, 1904); Luis Rodés, "El R. P. José Algué," *Razón y fe* 91 (1930): 553–55.

42 Charles E. Deppermann, *Outline of Philippine Frontology* (Manila: Bureau of Printing, 1937) and *Some Characteristics of Philippine Typhoons* (Manila: Bureau of Printing, 1939); James J. Hennessey, "Charles E. Deppermann, S.J.: Philippine Scientist," *Philippine Studies* 5 (1957): 31–35.

43 Henri Gauthier, "Un maître en physique du globe (M. Dechevrens)," *Études* 178 (1924): 272–91.

44 Louis Froc, *Atlas of the Tracks of 620 Typhoons (1893–1919)* (Shanghai: Zikawei Observatory, 1920); Henri Gauthier, "Au service de tous et de chacun: Le Père Louis Froc (1859–1932)," *Études* 213 (1932): 373–86; G. L. Belt, "Father Gherzi S. J., 1886–1973: An Appreciation," *Journal of the Hong Kong Branch of the Royal Asiatic Society* 14 (1974): 85–91.

## Seismology: The Science of Earthquakes

At the end of the nineteenth century and into the twentieth, Jesuits devoted a good deal of attention to seismology, and their work in this field has received significant scholarly consideration.<sup>45</sup> Seismology as a science began with the installation of the first seismological stations sometime around 1880. The Jesuits joined the enterprise soon after, constructing their first seismological station in Frascati (near Rome) in 1888. By 1957, they had installed a total of thirty-eight throughout the world, which is why John Ebel has called seismology the "Jesuit science."<sup>46</sup> The Jesuit seismological stations in South America, Asia, and Africa, which for some time were the only stations operating in those countries, are of particular interest. Also of note is the network of sixteen seismological stations that was installed at American Jesuit colleges in 1911, dubbed the "Jesuit Seismological Service." It was the first continent-wide seismological network with uniform instrumentation. The network, which was reorganized as the "Jesuit Seismological Association" (JSA) in 1925, was tasked with determining the origin, time, and location of earthquakes occurring anywhere in the world, a service it provided until about 1960.<sup>47</sup> Several Jesuit seismologists focused their research on the problem of microseisms, the continuous waves sometimes observed in seismograms.<sup>48</sup> In 1951, Ernesto Gherzi, the last director of Zikawei Observatory and a member of the Pontifical Academy of Science, organized an international study week at the Vatican that was devoted to the subject.<sup>49</sup>

Among the many Jesuit seismologists about whom we can find information, the most important is undoubtedly James B. Macelwane (1883–1956), who in 1925 reorganized and subsequently directed the JSA.<sup>50</sup> He established the first academic department of geophysics in North America, at Saint Louis University, and also published the first textbook of seismology (*Introduction to Theoretical Seismology*, New York: J. Wiley, 1936). His main research work was the study of the structure of the earth's interior through the observation of seismic waves. He was elected a member of the National Academy of Science, the only Jesuit to merit that honor, and the American Geophysical Union awards an annual medal bearing his name. In the 1930s, Macelwane was instrumental in the introduction of scientific research to American Jesuit universities. Even Geschwind recognizes Macelwane's

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45 Manuel M. Sánchez Navarro–Neumann, "Os jesuitas e a sismologia," *Brotéria* 24 (1937): 145–51; Daniel Linehan, "Jesuits in Seismology," *Earthquake Information Bulletin* 16 (1984): 156–65; Agustín Udías and William Stauder, "The Jesuit Contribution to Seismology," *Seismological Research Letters* 67 (1996): 10–19; Agustín Udías, "Jesuits' Studies of Earthquakes and Seismological Stations," in *Geology and Religion: A History of Harmony and Hostility*, ed. Martina Kölbl–Ebert (London: The Geological Society S.P. 310, 2009), 135–43.

46 John Ebel, "The Jesuit Science," *Company* (Summer 2009): 28–31.

47 James B. Macelwane, "The Jesuit Seismographic Stations in the United States and Canada: a Retrospect," *Bulletin of the Seismological Society of America* 16 (1926): 187–93; Nicholas H. Heck, "The Jesuit Contribution to Seismology in the U.S.A.," *Thought* 19 (1944): 221–28; James B. Macelwane, ed., *Jesuit Seismological Association, 1925–1950: Twenty-fifth Anniversary Commemorative Volume* (St. Louis: Saint Louis University, 1950).

48 For example: Charles Deppermann, "Father Algué and Microseisms," *Bulletin Seismological Society of America* 41 (1951): 301–2; Ernesto Gherzi, "Étude sur le microséisms," *Observatoire de Zikawei: Notes séismologiques* 5 (1924): 1–16; Jesús Emilio Ramírez, "An Experimental Investigation on the Nature and Origin of Microseisms at St. Louis Missouri," *Bulletin of the Seismological Society of America* 30 (1940): 34–84; 139–78.

49 *Semaine d'étude sur le problème des microséisms* (Vatican City: Pontifical Academy of Sciences, 1952).

50 Perry Byerly and William Stauder, "James B. Macelwane, S.J., September 28, 1883–February 15, 1956," *Memoirs of the National Academy of Science* 31 (1958): 254–81; Victor Blum, "Sketch of the Life of James Bernard Macelwane, S.J.," *Earthquakes Notes* 27 (1956): 9–11; Henry Birkenhauer, "Father Macelwane and the Jesuit Seismological Association," *Earthquakes Notes* 27 (1956): 12–13; Carl-Henry Geschwind, "Embracing Science and Research"; Udías, *Jesuit Contribution*, 203–7.

role in this, and points to the resistance he faced from other Jesuit professors, who put greater emphasis on teaching.<sup>51</sup>

Information about several other important Jesuit seismologists is also available. One such figure is Daniel Linehan (1904–87), director of the Weston Seismological Observatory from 1950 to 1974 and famous scientific explorer. Linehan mounted expeditions to Africa, Asia, and South America, many of them as part of UNESCO missions, and participated in one trek to the Arctic as well as three to the Antarctic.<sup>52</sup> Another important figure is Manuel Sánchez Navarro–Neumann (1867–1941), director of the Cartuja Observatory between 1915 and 1931, who published the first modern catalogue of earthquakes in Spain and the first modern Spanish-language book on seismology (*Terremotos, sismógrafos y edificios* [Madrid: G. López del Horno, 1916]).<sup>53</sup> In South America, a land of large and frequent earthquakes, Jesuits installed seven seismological stations; notable Jesuits who worked there include Jesús Emilio Ramírez (1904–81), director of the *Instituto Geofísico* in Bogotá, Colombia, and Ramón Cabré (1922–97),<sup>54</sup> director of the seismological station of La Paz.<sup>55</sup> Both conducted pioneering studies of seismicity and seismic risk in South America. And following the Jesuits' installation of the first seismographs in the Philippines (at the Manila Observatory) in 1868, Miguel Saderra–Masó (1865–1939) published important studies on Philippine earthquakes.<sup>56</sup>

## Other Scientific Fields

The scientific contributions of Jesuits teaching in universities and secondary schools have received even less attention than the work done in Jesuit observatories. Although the schools often emphasized teaching over scientific inquiry, the two cannot be completely separated. To be a good teacher at a university requires some engagement with research. Little has been written about the scientific work of Jesuit university professors, but the science textbooks they wrote can give us some indication of their interests.<sup>57</sup>

Jesuits have made some interesting contributions to modern biology, particularly in the areas of botany and zoology. Christian Kummer gives a good summary of the work done by German Jesuits, especially Erich Wasmann (1859–1931) and Adolf Haas (1914–82).<sup>58</sup> Jesús Bastero has written a book about Longinos Navás (1858–1938), a professor in the Jesuit school of Zaragoza (Spain) and a recognized entomologist who specialized in neuroptera,<sup>59</sup>

51 Carl-Henry Geschwind, "Embracing Science and Research."

52 John F. Devane and James P. McCaffrey, "Reverend Daniel Linehan (1904–1987)," *Bulletin of the Seismological Society of America* 78 (1988): 1618–20; Charlotte B. Harvey, "The Voyage of the Monte Carlo," *Boston College Magazine* (Fall 2000): 1–4; Udías, *Jesuit Contribution*, 182–83.

53 Antonio Due Rojo, *Labor científica del R. P. Manuel Sánchez Navarro–Neumann, S. J.* (Granada: Observatorio de Cartuja, 1940); Udías, *Jesuit Contribution*, 178.

54 Jesús Emilio Ramírez, *Historia del Instituto Geofísico al conmemorar sus 35 años (Universidad Javeriana) I: Antecedentes y fundación, II: Los años de la guerra, 1944–1945, and III: Consolidación del Instituto Geofísico* (Bogotá: Guadalupe, 1977).

55 Richard W. Ott, "Rev. Ramón Cabré Roigé, S. J., May 2, 1922–February 24, 1997," *Seismological Research Letters* 68 (1997): 901.

56 Miguel Saderra–Masó, *La sismología en Filipinas* (Manila: Ramirez y Cia, 1895) and *Catalogue of Violent and Destructive Earthquakes in Philippines* (Manila: Bureau of Printing, 1910).

57 For example: Theodor Wulf, *Lehrbuch der Physik* (Freiburg: Herder, 1926); Eduardo Vitoria, *Manual de química moderna* (Barcelona: Casals, 1910) (15 editions, last in 1955); B. Rajam, *Atomic Physics* (Delhi: S. Chad, 1966).

58 Christian Kummer, "Forschung und Weltanschauung: Die Rolle der deutschen Jesuiten in der Biologie," *Sammelblatt des historischen Verein Ingolstadt* 109 (2002): 105–20.

and Francisco Malta Romeiras has studied the work of Portuguese Jesuits such as Joaquim da Silva Tavares (1866–1931), Cândido Azevedo Mendes (1874–1943) and Luis Jorge Archer (1926–2011) in detail. He has also investigated the role played by the Jesuit journal *Brotéria* in the furthering of biological research.<sup>60</sup>

At the beginning of the twentieth century, Jesuits in India began a series of brilliant and still ongoing studies in botany and on its relation to agriculture, ecology, and the environment. They include the work of Ethelbert Blatter (1877–1934), who assembled a collection of nearly three million plants known as the *Blatter herbarium*; Hermenegildo Santapau (1903–70), who studied the flora of Purandhar; and Koyapillil M. Matthew (1930–2004), who investigated the *shola* forests of south India. To my knowledge, very little has been written about this work except for what was published by the Jesuit scientists themselves.<sup>61</sup>

An important source of information about Jesuit scientific activity in the United States in contemporary times is the *Bulletin of the American Association of Jesuit Scientists*, published from 1922 to 1966. The association was formed by Jesuits in the northeastern states but later expanded into all fifty. By 1954, it boasted 254 members, mostly professors of science at Jesuit universities and high schools, and met once a year. The *Bulletin* published interesting articles about the work of Jesuit scientists, the history of Jesuit science, and reflections about the relationship between the Jesuits' scientific work and their spirituality.

Another source of information are the publications of the international coordinator of Jesuits in the positive sciences, a post created in 1968 by Superior General Pedro Arrupe. The first series, entitled *Bulletin de liaison des jésuites scientifiques*, consisted of six issues published between 1970 and 1975; the second, *Jesuits in Science*, appeared fifteen times between 1982 and 1999. The bulletins offered a wealth of interesting information about the ongoing endeavors of Jesuit scientists but, unfortunately, have been discontinued.

## Angelo Secchi and Stephen Perry

Two Jesuit scientists of the modern era have received special attention: Angelo Secchi and Stephen Perry, both of whom were elected members of the Royal Society of London. They are the only Jesuits to have received that honor in the past two centuries.

Angelo Secchi was the director of the observatory of the Roman College from 1849 to 1872, where he did significant research in astronomy, meteorology, and geomagnetism.<sup>62</sup> He is best remembered for his pioneering work in astrophysics, in particular the first classification of the spectra of stars.<sup>63</sup> Along with Pietro Tacchini, he founded the Italian Society of Spectroscopists. He also carried out many years of solar observations, which

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59 Juan Jesús Bastero Monserrat, *Longinos Navás: Científico jesuita* (Zaragoza: Universidad de Zaragoza, 1989).

60 Francisco Malta Romeiras, "The Emerging of Molecular Genetics in Portugal: The Enterprise of Luís Archer," *Archivum historicum Societatis Iesu* 82 (2013): 501–12, "A ciência da Companhia de Jesus nos séculos XIX e XX em Portugal," *Brotéria* 179 (2014): 429–54, and "The Journal *Brotéria* (1902–2002): Jesuit Science in the 20th Century," *Journal of History of Science and Technology* 6 (2012): 100–9.

61 Leo D'Souza, "Jesuit Contribution to Environmental Protection," <http://www.sjweb.info/sjs/networks/ecology/Indian%20jesuits%20Contribution%20to%20Environmental%20Protection.pdf> (last access April 21, 2016).

served as the basis for his popular book *Le Soleil* (Paris: Gauthiers-Villars, 1870). Another of Secchi's books, *L'unità delle forze fisiche* (Rome: Tipografia Forense, 1864), is an interesting effort to show that all physical phenomena can be explained by the general laws of mechanics, in keeping with the mechanist program of nineteenth-century physics.

Stephen Perry was the director of the observatory of Stonyhurst College from 1860 to 1864 and from 1868 to 1889, where he conducted groundbreaking research in astronomy, geomagnetism, and solar physics.<sup>64</sup> Thanks to his widely recognized scientific work, he was asked to lead six scientific expeditions financed by the British government and the Royal Society with the participation of the Royal Navy. Four were to observe solar eclipses, from Cádiz (1870), Carriacou Island, Antilles (1886), Kineshma, Russia (1887), and Salut Isle, Guyana (1889), and two were to observe transits of Venus through the solar disk, from the Kerguelen Islands, Indian Ocean (1874) and Madagascar (1882).<sup>65</sup> During Perry's time, Stonyhurst Observatory became a center for the training of Jesuits who later became directors of other observatories.

## Pierre Teilhard de Chardin

Pierre Teilhard de Chardin is a special case among Jesuit scientists.<sup>66</sup> The importance and worldwide influence of his philosophical and theological thought often leads people to forget that he was, first and foremost, a Jesuit scientist who had a long career in geology and paleontology.<sup>67</sup> Over the course of his career, Teilhard developed an original system of thought located on the frontiers among science, philosophy, theology, and mysticism. As both a Jesuit priest and a passionate scientist, his great concern was to integrate Christian thought with the new evolutionary worldview presented by science. He was also a Christian

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- 62 Victor van Tricht, "Le Père Secchi," *Revue des questions scientifiques* 4 (1878): 353–402; François Moigno, *Le Révérend Père Secchi: Sa vie* (Paris: Gauthiers-Villars, 1879); Carlo Briccarelli, "Della vita e delle opere del P. Angelo Secchi della Compagnia di Gesù," *Memorie della Pontificia Accademia dei Nuovi Lincei* 4 (1888): 6–105; Aloysius L. Cortie, "Angelo Secchi, S.J.," in *Twelve Catholic Men of Science*. ed. B. Windle (London: Catholic Truth Society, 1923), 149–64; Mario Vigano, "Cento anni di astrofisica: Nel centenario della morte del Padre Angelo Secchi," *La Civiltà cattolica* 129 (1978): 538–49; Aldo Altamore and Sabino Maffeo, eds., *Angelo Secchi: L'avventura scientifica del Collegio Romano*, vol.5: *Bibliografia su Angelo Secchi* (Foligno: Quater, 2012), 286–89; Ileana Chinnici, "Il profilo scientifico e umano di Angelo Secchi," in *Angelo Secchi: L'avventura scientifica del Collegio Romano*, ed. Aldo Altamore and Sabino Maffeo (Foligno: Quater, 2012), 43–64; Udiás, *Jesuit Contribution*, 193–98.
- 63 Angelo Secchi, *Sugli spettri delle stelle fisse* (Rome, 1968); Aldo Altamore, "La nascita della nuova astronomia," in *Angelo Secchi: L'avventura scientifica del Collegio Romano*, ed. Aldo Altamore and Sabino Maffeo (Foligno: Quater, 2012), 109–43.
- 64 Aloysius L. Cortie, *Father Perry: The Jesuit Astronomer*, 2<sup>nd</sup> ed. (London: Catholic Truth Society, 1890); J. Thirion, "Le R. P. Perry," *Revue des questions scientifiques* 27 (1890): 201–8; George D. Bishop, "Stephen Joseph Perry (1833–1889): Priest, Scientist, Educator" (MA Thesis, University of Manchester, 1977) and "Stephen Perry (1833–1889): Forgotten Jesuit Scientist and Educator," *Journal British Astronomical Association* 89 (1979): 473–84; Udiás, *Jesuit Contribution*, 199–203.
- 65 Stephen J. Perry, *Notes on a Voyage to Kerguelen Islands to Observe the Transit of Venus, December 8, 1874* (London: Henry S. King, 1876); Joseph Ashbrook, "Father Perry's Expedition to Kerguelen Islands," *Sky and Telescope* (June 1966): 340–41; Peter D. Hingle, "The Priest and the Stuffed Penguin: Father Stephen Perry S.J. and the Transit of Venus; Expeditions to Kerguelen Island, 1874 and Madagascar, 1882," *Journal of the British Astronomical Association* 115 (2005): 150–58, 168–70; Walter Sidgreaves, "The Last Scientific Voyage of H.M.S. Fawn," *The Month* 47 (1883): 457–82.
- 66 A few examples of books about Teilhard's life and thought are: Claude Cuénot, *Pierre Teilhard de Chardin: Les grandes étapes de son évolution* (Paris: Librairie Plon, 1958); Paul Grenet, *Teilhard de Chardin: The Man and His Theories* (New York: Paul S. Eriksson, 1965); Robert Speaight, *Teilhard de Chardin: A Biography* (London: Collins, 1967); Mary Lukas and Ellen Lukas, *Teilhard: A Biography* (London: Collins, 1977); Ursula King, *Spirit of Fire: The Life and Vision of Teilhard de Chardin* (New York: Orbis Books, 1998); Patrice Boudignon, *Pierre Teilhard de Chardin: Sa vie, son oeuvre, sa réflexion* (Paris: Édition du Cerf, 2008).
- 67 Teilhard's scientific works have been published by Nicole and Karl Schmitz–Moormann, eds., *Pierre Teilhard de Chardin l'oeuvre scientifique*, 10 vols. (Olten: Walter-Verlag, 1971).

mystic who claimed to discover the cosmic Christ in the fibers of matter and as the ultimate end of the evolution of the universe. At the core of Teilhard's thought and mysticism was the question of how to understand the place of man and the role of Christ in an evolutionary world.<sup>68</sup>

During Teilhard's lifetime, the publication of his writings was barred by ecclesiastic authorities, but private copies circulated freely among his friends and followers. When his works finally saw the light of day, following his death in 1955, they had an enormous impact and were rapidly translated into many languages. Extensive bibliographies of books and articles about Teilhard's life and thought published through 1980 can be found in the works of László Polgár, Joan E. Jarque, and Joseph McCarthy.<sup>69</sup> After 1980, interest in Teilhard seems to have declined, but recently there has been something of a revival. Amy Limpitlaw gives a list of 521 Teilhard-related publications from 2000 to 2008, showing the continuing fascination of the man's ideas.<sup>70</sup>

## Dialog between Science, Religion, and Spirituality

A final and crucially important element of the Jesuits' scientific work in the modern period was their resistance to nineteenth-century current of rationalist thought that so aggressively asserted the incompatibility of science and religion. Jesuit researchers framed their work as a practical refutation of such ideas, showing that one could be both a deeply religious person and a dedicated scientist.

Some went even further by directly joining the discourse on the relationship between science and religion. One of the first to do so was Robert A. Brungs (1931–2006), a professor of physics at Saint Louis University who founded the Institute for Theological Encounter with Science and Technology (ITEST) in 1968.<sup>71</sup> Its purpose was to study advances in science and technology and consider their meaning for the Christian faith, a mission it continues today. The Vatican Observatory, led by its director George Coyne and by William Stoeger (Jesuit astronomer), entered the fray in 1987 by sponsoring a study week on the theme "Our Knowledge of God and Nature: Physics, Philosophy and Theology."<sup>72</sup> It also held a series of conferences between 1991 and 1999, in collaboration with the Center for Theology and the

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68 Teilhard's religious and mystical thought can be found in Henri de Lubac, *La pensée religieuse du Père Teilhard de Chardin* (Paris: Aubier, 1962); Christopher F. Mooney, *Teilhard de Chardin and the Mystery of Christ* (Garden City, N.J.: Doubleday-Image, 1968); and the more recent Thomas M. King, *Teilhard de Chardin* (Wilmington: Michel Glazier, 1988); Édith de la Héronnière, *Teilhard de Chardin: Une mystique de la traversée* (Paris: Albin Michel, 2003); André Danzin and Jacques Masurel, *Teilhard de Chardin: Visionnaire du monde nouveau* (Paris: Rocher, 2005); Gustave Martelet, *Teilhard de Chardin: Prophète d'un Christ toujours plus grand* (Paris: Lessius, 2005); and Agustín Udías, "Christogenesis: The Development of Teilhard's Cosmic Christology," *Teilhard Studies* 59 (2009): 1–22.

69 László Polgár, *Internationale Teilhard bibliographie, 1955–1965* (Munich: Karl Abner, 1965); Joan E. Jarque, *Bibliographie générale des oeuvres et articles sur Pierre Teilhard de Chardin* (Fribourg: Editions Universitaires, 1970); László Polgár, *Bibliographie sur l'histoire de la Compagnie de Jésus*, vol. 3: *Les personnes* (Rome: Institutum Historicum Societatis Iesu, 1990), 359–63; Joseph M. McCarthy, *Pierre Teilhard de Chardin: A Comprehensive Bibliography* (New York: Garland, 1981).

70 Amy Limpitlaw, "The Continuing Influence of French Theologian Pierre Teilhard de Chardin in the Twenty-First Century," *American Theological Library Association: Summary of Proceedings* 62 (2008): 141–73.

71 Robert Brungs, "The Science-Faith Controversy: Is the Old Conflict Being Revived? *Atheism and Dialogue*, 19 (1984): 37–49; "The Institute for Theological Encounter with Science and Technology, *Annuario Societatis Jesu* (1978): 108–12; Robert Brungs and Eva-Maria Amrhein, *The Vineyard: Scientists in the Church* (St. Louis: ITEST Faith/Science Press, 1992), 146.

72 Robert John Russell, William R. Stoeger, and George V. Coyne, eds., *Physics, Philosophy and Theology: A Common Quest for Understanding* (Vatican City: Vatican Observatory, 1988).

Natural Sciences (Berkeley, California), the proceedings of which were published in five volumes.<sup>73</sup> These types of endeavors have yet to be fully explored.

A related topic that also deserves a more in-depth treatment is the connection between Jesuits' spirituality and their commitment to science. So far, there are only a few articles about this relationship, most of them written by Jesuit scientists themselves. In general, they try to link Jesuit scientific work to Ignatian spirituality as developed in the *Spiritual Exercises*, focusing in particular on the Ignatian idea of "finding God in all things."<sup>74</sup> It is another area ripe for further investigation.

## Conclusion

The scientific work conducted by Jesuits during the nineteenth and twentieth centuries has received little attention from historians of science, especially compared to what has been written about Jesuit science in earlier centuries. This deserves to change. The establishment of a worldwide network of Jesuit observatories, for example, is an important phenomenon that needs additional study and interpretation, particularly when it comes to the founding of observatories in the mission lands of Africa, Asia, and South America and the relationship of those institutions to the scientific development of their host countries. The work of Jesuits in the fields of botany and zoology and its connection with their missionary enterprises is also in need of further exploration. The same can be said of the role played by Jesuit professors of science in the worldwide network of Jesuit universities and secondary schools.

Most Jesuit scientists of this time period, as well as their work and publications, are practically unknown. This is unfortunate, as an investigation of their lives and labors could shed much light on the relationship between science and religion. Specifically, Jesuit scientific work in the late nineteenth and early twentieth centuries can be read as an apologetic response to the growing perception that science and Christian faith were incompatible. The Jesuits thus played a significant role in the development of the modern dialog between science and religion, a role that should be studied further. It would also be worthwhile to investigate the connection between Jesuits' scientific work and Ignatian spirituality, particularly in the case of such emblematic figures as Teilhard de Chardin.

The history of Jesuit science in the modern era is a rich field that that has barely begun to be explored. Its further development should be a top priority for scholars in engaged in Jesuit studies and historians of science alike.

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73 The titles of the five volumes are: *Quantum Cosmology and the Laws of Nature* (Vatican City: Vatican Observatory, 1993), *Chaos and Complexity* (Vatican City: Vatican Observatory, 1995), *Molecular and evolutionary Biology* (Vatican City: Vatican Observatory, 1998), *Neuroscience and the Person* (Vatican City: Vatican Observatory, 1999), and *Quantum Mechanics* (Vatican City: Vatican Observatory, 2001), all with the subtitle *Scientific Perspective on Divine Action*.

74 Timothy E. Toohig, "Physics Research, a Search for God," *Studies in the Spirituality of Jesuits* 21, no. 2 (1999): 1–26; Paul Gabor, "Jesuit Identity and Science: An Inside Look," in *Proceedings of the Bohemia Jesuitica Conference (Prague, 25–27 April 2006)*, ed. Petra Čemus (Prague: Carolinum, 2010), 647–60; Agustín Udías, "Jesuit Scientific Tradition and Ignatian Spirituality," *Lo sguardo: Rivista di filosofia* 10 (2012): 207–19; George Coyne and Agustín Udías, "Spiritual Foundations for Jesuit Commitment to Science," *Conversations on Jesuit Higher Education* 47 (2015): 2–7.

*For more bibliographical information, consult [Boston College Jesuit Bibliography: The New Sommervogel Online \(NSO\)](#).*