History of the International Earth Rotation and Reference Systems Service

The Foundation Phase and Establishment of the International Latitude Service at the end of the 19th Century

In 1861, the military geodesist Johann Jacob Baeyer (1794–1885) took the first steps towards establishing a comprehensive, approved method of arc measurement in Central Europe by submitting the memorandum "*On the Size and Figure of the Earth: a Memorandum on the Establishment of a Central European Arc Measurement*" to the Prussian Ministry of War. The method outlined in his memorandum sought to determine the size and shape of the Earth through latitudinal and longitudinal measurements, a technique that was already in use for measuring stations in a number of countries at that time.[1] The motivation for this new method stemmed from recurring contradictions and misinterpretations of measurements caused by using other older methods.

Baeyer began focusing exploration and observation of planet Earth from a Eurocentric perspective, ensuring coherence and establishing a methodological working approach that led to unification one year later. A surprisingly high number of expert delegates from 15 different countries had travelled to the first Conference of the Central European Arc Measurement 1864 in Berlin. This conference ensured this unification and thus put Baeyer's plans into concrete terms, focusing especially on content-related and organizational tasks. These delegates worked to build principles of early international cooperation in astronomical geodesy that eventually became the backbone of of international research, design, and monitoring in this field. A Permanent Commission was formed, consisting of the scientific heads of *Central European Arc Measurement*. This effort was led by a Prussian state-sponsored *Central Bureau* in Berlin, with Johann Jacob Baeyer serving as appointed president.[2]

Because of the wide processing spectrum and the increasing number of cooperation partners from different countries, the *Central European Arc Measurement* was renamed *European Arc Measurement in 1867,* and then *International Arc Measurement* in 1886. The Royal Prussian Geodetic institute was then founded in 1869, with the support of Baeyer and the astronomer Wilhelm Foerster (1832-1921). With the foundation of this institute in Berlin, the Prussian capital then became the world's most important contact point for astronomical geodesy.

The institute initially had its main office in the private villa of Theodor Albrecht (1843–1915), who was then an assistant at the *Central Bureau*, as well as additional offices in three other flats

in Berlin. Support from the physician and scientist Rudolf Virchow (1821–1902) in the Prussian House of Representatives led to Prussian state funding approval for an institute building in Telegrafenberg, Potsdam. The site for the new intitute had already been the home of the Astrophysical Observatory since 1880, and the Meteorological and Geomagnetic Observatory since 1889. Upon its completion in 1892, the new Royal Prussian Geodetic Institute building housed both the organisational tasks of the *Central Bureau* as well as the pending measuring and monitoring tasks of the new "institute" all under one roof.[3] In the following years, the the institute was expanded, and additional buildings were built – these buildings are still used today by the German Research Centre for Geosciences (Deutsches GeoForschungsZentrum).[4]

After the death of Baeyer, the geodesist and mathematician Friedrich Robert Helmert (1843–1917) was appointed head of both the institute and the *Central Bureau* in 1886, and one year later he was appointed professor of mathematical geodesy at the University of Berlin.[5] In the following years, Helmert became the figurehead of the institute and was a central point of contact in Prussian Berlin.

While today questions on the size, shape, movement, deformation, or gravity field changes of our earth are determined primarily by satellite, scientists previously used manual measuring and monitoring methods. The International Latitude Service started its work in 1899 using these manual methods, and installed a network of measuring stations worldwide. The preparations for the foundation of a Latitude Service, and its Central Bureau, had already begun years earlier, when the need to create an institution that performs a transparent observation of Earth's motion with uniform measurement methods was first identified at the 11th General Conference of the International Arc Measurement in Berlin.[6]

Fig. 1: Carl Theodor Albrecht (30 Aug. 1843 – 31 Aug. 1915). Courtesy of Christoph Albrecht

The geodesists Friedrich Robert Helmert, Wilhelm Foerster and Carl Theodor Albrecht are considered the founding fathers of the International Latitude Service. Theodor Albrecht played a fundamental role. Not only was he tasked with the management of the International Latitude Service, but he also personified combined theoretical knowledge and practical skills for the observation and measurement work in astronomical geodesy. Theodor Albrecht is considered one of the most successful geodetic astronomers to have lived, because of his practical skills, wide variety of interests, and education.[7] His father, the Dresden town councilor, soap boiler and amateur botanist Friedrich Wilhelm Albrecht, and his mother, Christiane, awakened his sparked his lifelong interest in hiking, mountaineering and observation of nature in Saxon Switzerland, near his hometown of Dresden. In his school days, he showed an early aptitude for a variety of topics from the natural sciences. He was especially interested in mathematics, the weather, star gazing, and botany, as well as associated practical activities.[8]

Albrecht studied under the geodesist August Nagel (1821–1903) and the mathematician Oskar Schlömilch (1823–1901) at the Dresden Polytechnic. He completed his degree in mathematics and natural sciences education, with a minor in botany. Due to his excellent academic achievements, Albrecht received several commendations and prizes, including the silver medal of Dresden Polytechnic at the completion of his studies.[9] He later attended lectures on mathematics, physics and astronomy at the University of Berlin as well as visiting Leipzig observatory to study astronomy.[10] On the recommendation of the director of the Leipzig observatory, Karl Christian Bruhns (1830–1881), one of the initiators[11] of the *Central Bureau* of the Central European Arc Measurement in Berlin, Albrecht began to work as an assistant in the said office in 1866, where he mainly made geodetic calculations and measurements.[12] He took part in the telegraphic longitude determination (using electric telegraphs) of Göttingen–Leiden–Dangast in Göttingen in 1869, and conducted the reduction of observations of the longitude determination of Berlin–Lund in the following years. He earned his doctorate degree from University of Leipzig with the thesis *On the determination of longitude differences using electric telegraphs* in the same year.[13]

Theodor was one of the first staff members hired after the foundation of the Royal Prussian Geodetic Institute in 1870, three years later he became the head of the Astronomical Department, and in 1873 he was appointed professor.[14] In that same year, his first book, *Formeln und Hilfstafeln für geographische Ortsbestimmung nebst kurzer Anleitung zur Ausführung derselben,* was published.[15] This soon became knowns as *Albrechts-Tabellen* (Albrecht's tables) by geodesists, something that made Albrecht famous worldwide and far

beyond the boundaries of his discipline. The *Albrechts-Tabellen* were the basis for the daily work of each geodesist for nearly 100 years since their first appearance in 1873.

Albrecht began a systematic analysis of well-known geodetic-astronomical measurement and calculation methods, developing tools and methods for determining deflection, and refining them theoretically and practically to achieve highest performance. In order to verify his theoretical assumptions in altimetry, Albrecht even undertook air journeys originating in Leipzig and Dresden in 1872 with the French balloonist Théodore Sivel (1834–1875).[16]

In preparation for the General Conference of the International Arc Measurement in 1895, Albrecht started to develop a concept that included his intended network of measuring stations[17] around the world, and would require the creation of an observation program to investigate and record the movements of the Earth. In 1895, Albrecht and his colleagues Wilhelm Foerster and Friedrich Helmert successfully argued for the foundation of an International Latitude Service during the aforementioned conference.[18]

These efforts reflected both good international and close domestic cooperation between Albrecht and his peers, such as Stuttgart professor Ernst von Hammer (1858–1925). Their work was based mainly on that of the professor of International Arc Measurement in Württemberg, which in turn had been coordinated by Theodor Albrecht in Berlin and further expanded in the context of the International Latitude Service in 1899.[19] An expression of the good relationship between Albrecht and von Hammer was the fact that the latter spoke up for awarding Theodor Albrecht the title of "*Doktor-Ingenieur Ehrenhalber*" (honorary doctor) by the Technical University of Stuttgart in 1913,[20] following his admittance to *Leopoldina,* the oldest academy of science in the world, in 1882.

The scientific management of the International Latitude Service, known today as the International Earth Rotation and Reference Systems Service, was transferred to Theodor Albrecht in 1899. Albrecht started his chairchip with an unprecedented worldwide scientific coordination effort that was funded by twenty-two participating countries, ushering in the beginning of global scientific Earth measurement.

Albrecht was one of the first scientific global players. He travelled to 18 measuring stations worldwide at the age of 71 for the trigonometric network, and took his last measurements in Horta on the Azores shortly before the beginning of World War I. Friedrich Helmert died in 1917, and throughout his life was as prominent as Albrecht and defended Germany's interests in the international scientific community.

Albrecht made his workplace, the Royal Prussian Geodetic Institute in Berlin, the epicentre of geodesy for half a century.[21] Unfortunately, the Institute's status was not only lost through the death of Theodor Albrecht, who died shortly after his 72nd birthday in August 1915, but also due to World War I. The loss of those scientists, as well as the rapidly changing political situation, greatly contributed to the restructuring of the scientific community of geodetic astronomers that followed thereafter.

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[1] Dick, Wolfgang R., 1994, Die Vorgeschichte von Johann Jacob Baeyers „Entwurf zu einer Mitteleuropäischen Gradmessung", in: Buschmann, Ernst (ed.), 1994, Aus Leben und Werk von Johann Jacob Baeyer, Frankfurt am Main, pp. 105–144; Buschmann, Ernst, 1987, 125 Jahre Baeyer-Denkschrift, in: Vermessungstechnik, 35, 1, pp. 13–14; Johann Jacob Baeyer, 1861, Über die Größe und Figur der Erde, Berlin; id., 1862, Das Messen auf der Sphäroidischen Erdoberfläche, Berlin.

[2] Buschmann, Ernst, 2000, Geodätisch-astronomische Aspekte, in: Wolfgang R. Dick, Klaus Fritze (eds.), 300 Jahre Astronomie in Berlin und Potsdam, Frankfurt am Main, pp. 143ff.

[3] Schmehl, Heinz, 1940, 70 Jahre Geodätisches Institut, in: Zeitschrift für das Vermessungswesen, 69. Jg., H. 1, p. 4.

[4] ibid., p. 4.

[5] Wissenschaftliche Sammlung der Humboldt-Universität zu Berlin, Kabinett des Wissens, Personen-ID: 16022, Biografie: Friedrich Robert Helmert.

[6] Höpfner, Joachim, 1999, On the Contribution of the Geodetic Institute Potsdam to the International Latitude Service, GeoForschungsZentrum Potsdam: STR99/08, p. 8.

[7] cf. Helmert, Friedrich, 1915, Todesanzeige [conc. Th. Albrecht], In: Astronomische Nachrichten 201, Nr. 4814, p. 270.

[8] estate of Georg Helm, Georg Helm: Nachruf Theodor Albrecht, 1915, courtesy of Lore Ehrhart.

[9] see Jahresbericht der Kgl. Polytechnischen Schule 1864/65 (university archives of TU Dresden, special thanks to Frau Dipl.-Archivarin (FH) Jutta Wiese for her support).

[10] cf. Helmert, Friedrich, 1915.

[11] cf. Buschmann, Ernst, Kautzleben, Heinz, 1987, Erdmessung – 125 Jahre erstes internationales geodätisches Programm, in: Vermessungstechnik 35, 4, p. 111.

[12] Höpfner, Joachim, 1999, On the Contribution of the Geodetic Institute Potsdam, S. 22; Galle, Andreas, 1915, Theodor Albrecht. Vierteljahrsschrift der Astronomischen Gesellschaft 50, 3–4, p. 170.

[13] Albrecht, Theodor, 1869, Über die Bestimmung von Längen-Differenzen mit Hilfe des elektrischen Telegraphen. Berlin.

[14] cf. Buschmann, Ernst, 2000, Geodätisch-astronomische Aspekte, p. 144ff.; Höpfner, Joachim, 2000, The International Latitude Service – A Historical Review, From The Beginning To Its Foundation In 1899 And The Period Until 1922. In: Surveys in geophysics 21, Issue 5, p. 530ff.

[15] cf. Albrecht, Theodor, 1873, Formeln und Hilfstafeln für die geographische Ortsbestimmung nebst kurzer Anleitung zur Ausführung derselben. Leipzig.

[16] estate of Georg Helm, Georg Helm: Nachruf Theodor Albrecht. 1915. Courtesy of Lore Ehrhart.

[17] cf. Albrecht, Theodor, 1896, Wahl der Stationen für den internationalen Polhöhendienst. Berlin.

[18] cf. Galle, Andreas, 1915, Theodor Albrecht. Vierteljahrsschrift der Astronomischen Gesellschaft 50, 3–4, p. 170.

[19] Hammer, Ernst, 1909, Zweites Astronomisches Nivellement durch Württemberg: im Meridian 8˚33' östlich von Greenwich; Bestimmung der Polhöhe und der meridionalen Lotabweichungskomponente auf den acht Stationen: Schwenningen, Horgen, Oberndorf, Schopfloch, Durrweiler, Ettmannsweiler, Wildbad, Schwann. In: Württembergische Veröffentlichung für die internationale Erdmessung. Stuttgart.

[20] Register der Ehrenpromovenden der Universität Stuttgart, university archives of Stuttgart.

[21] cf. Helmert, Friedrich, 1915, p. 270.