Meteorol. Z. (Contrib. Atm. Sci.), Vol. **31**, No. 5, 415–427 (published online August 2, 2022)

150 Years: The Leipzig Meteorological Conference, 1872, a Milestone in International Meteorological Cooperation

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(Manuscript received February 8, 2022; in revised form May 17, 2022; accepted May 17, 2022)

Abstract

One hundred and fifty years ago, a meteorological conference was held in Leipzig as part of the anniversary meeting of the Society of German Natural Scientists and Physicians (Gesellschaft Deutscher Naturforscher und Ärzte), founded in Leipzig in 1822. This meeting, intended as a preparatory meeting for the 1st International Meteorological Congress held in Vienna a year later, ultimately laid the foundation for today's World Meteorological Organization. The organizers of the Leipzig Conference (was held on 14–16 August 1872) were the German Carl Christians Bruhns (1830–1881), the Austrian Carl Jelinek (1822–1876) and the Swiss Heinrich von Wild (1833–1902). The discussions at the conference were conducted on the basis of a catalogue of 26 questions on the most pressing issues of the use of measuring instruments, observation periods, and data exchange (catalog in English translation in the appendix) that were sent together with the invitation. The main concern here was to enable consistency between individual states. Based on the Report on the Negotiations of the Meteorological Assembly at Leipzig (Vienna, 1872), which also contains opinions expressed by meteorologists who were not present at the conference, the results of this trend-setting Leipzig assembly are presented here, that was a milestone in international meteorological cooperation.

Keywords: History, Leipzig Meteorological Conference 1872, 1st International Meteorological Congress Vienna 1873, International Meteorological Organization

1 Introduction

A meteorological conference was held in Leipzig on the 14–16 August 1872, as part of the 50th anniversary celebrations of the Society of German Natural Scientists and Physicians (*Gesellschaft Deutscher Naturforscher und Ärzte*). It was organized by the German Carl Christians Bruhns (1830–1881), the Austrian Carl Jelinek (1822–1876) and the Swiss Heinrich (Ivanovic) von Wild (1833–1902) who was in Russian service at the time. A total of 52 scholars from 9 countries accepted the invitation, and others wrote letters commenting on the issues raised at the conference. On the 40th anniversary of the founding of the World Meteorological Organization (WMO) in 1990, the importance of this conference was acknowledged: *"The achievements of the Leipzig Conference were twofold. It brought together most of the world's foremost meteorologists who were able, in large measure, to reach agreement on standardized methods of observation and analysis, including the use of a single set of symbols. It also prepared the way for holding, in Vienna in the following year, the First International Meteorological Congress"* (Ashford et al., 1990).

In 1972, the 100th anniversary of the Leipzig Conference was celebrated in the German Democratic Republic (GDR) in the form of a meteorological conference with international participation, mainly from Eastern Europe. As at the conference 100 years ago, the focus here was on questions of future development (Böhme, 1973). The anniversary was widely publicized, e. g. by issuing representative postage stamps (Fig. 1, the issue honouring the Leipzig Conference contains two other stamps). The great importance attached to the anniversary of the Leipzig Meteorological Conference must

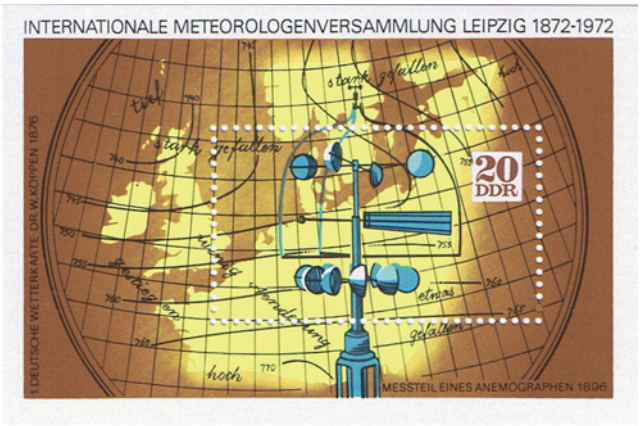

Figure 1: The block of the GDR postage stamp commemorating the 100th anniversary of the Meteorological Conference (issued 23 March 1972; Michel No. 1745/Block 34). The stamp shows an anemograph from 1896 and the first German weather map by Wladimir Köppen (1846–1940) from 1876.

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DOI 10.1127/metz/2022/1134

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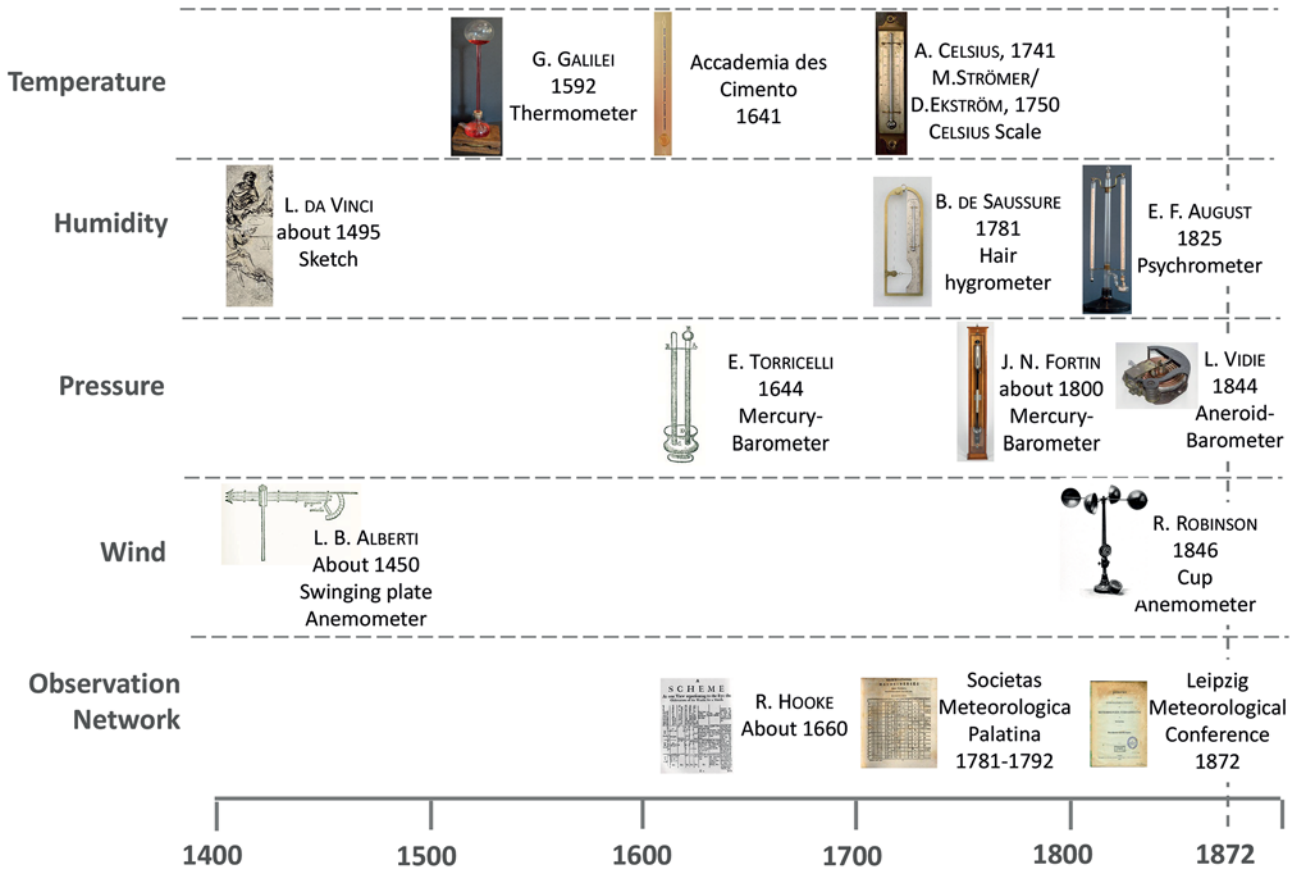


Figure 2: Chronology of the development of meteorological measuring instruments (it is indicated when these instruments could be considered functional in today's sense) and measuring programs. The miniaturized illustrations are taken from Körber (1987) and Foken (2021).

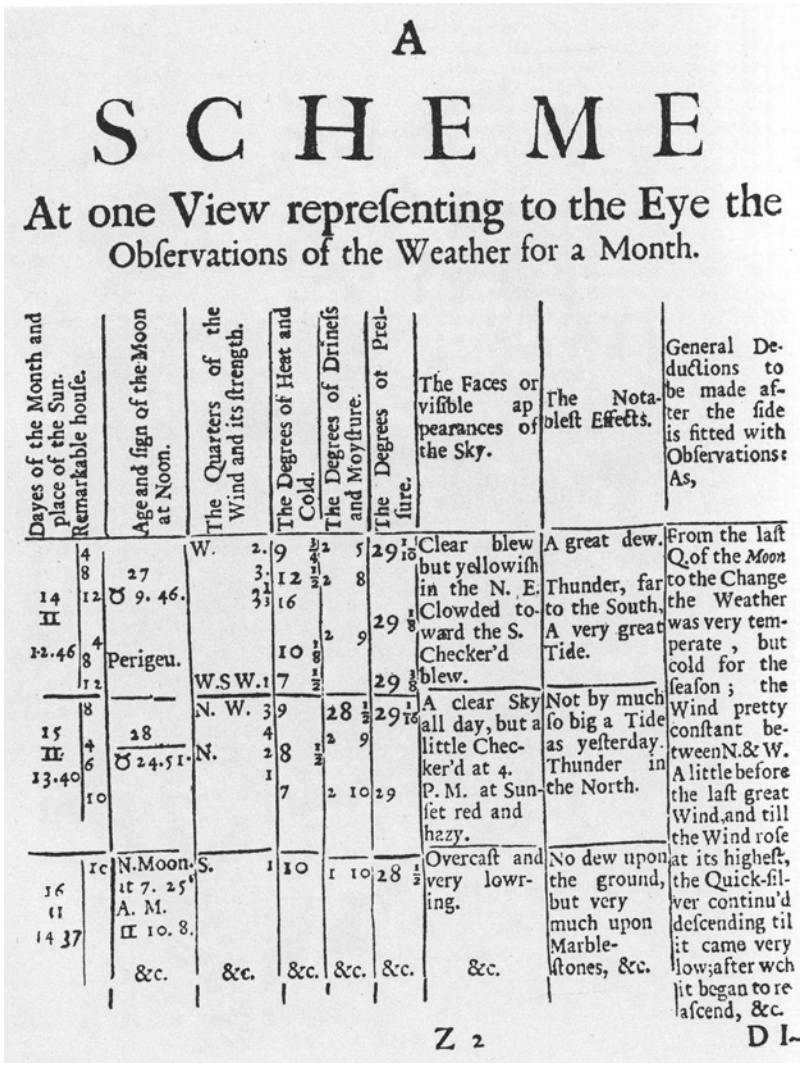
also be seen in a political context. In 1972, a treaty concerning the basis of relations (*Grundlagenvertrag*) between the Federal Republic of Germany (FRG) and the GDR was signed. This treaty provided the basis for the admission of both German states to the United Nations (UN) in 1973, and thereby the accession of the GDR to the WMO in 1973 (the FRG had been a member since 1954).

It is therefore appropriate to commemorate the Leipzig Meteorological Conference in the year of its 150th anniversary (Börngen et al., 2022). This article is intended as a contribution to this, from the beginning of cooperation in the meteorological field to the 1st International Meteorological Congress in Vienna in 1873, with the work of the organizers being specifically acknowledged. It is fortunate that this tribute can take place within the framework of the D-A-CH 2022 Meteorological Conference in Leipzig on 21–25 March, organized by the Meteorological Societies of Germany, Austria, and Switzerland.

2 The long road to the Leipzig Meteorological Conference

The origins of meteorology can be found in the monograph of the same name by Aristotle (384 BCE–322 BCE, 2017), first published in 350 BCE, with the first hygrometers likely developed in the Western Han dynasty of ancient China between 200 BCE and 10 CE (Wang and Zhang, 1988) or at the Tower of the Winds in Athens (37 BCE). We associate the development of modern wind measurement with Leon Battista Alberti (1404–1472), that of humidity measurement with Leonardo da Vinci (1452–1519), that of temperature measurement with Galileo Galilei (1564–1641) and that of pressure measurement with Evangelista Torricelli (1608–1647).

It took a long time, however, until measuring instruments were available that could reliably and independently measure the state of the atmosphere (Fig. 2, Foken, 2021; Körber, 1987; Middleton, 1969). This was first achieved for temperature in 1641, when the previously open glass thermometer was sealed off from the direct influence of the outside air (pressure and wind). After this development, supported by the Grand Duke of Tuscany, Ferdinando II de Medici (1610–1670) and the Accademia des Cimento, thermometers were built all over Europe. The scale commonly used today, according to Anders Celsius (1701–1744), was created in 1741. Märten Strömer (1707–1770) and Daniel Ekström (1711–1755) inverted the Celsius scale in 1750 so that 0 °C corresponded to the freezing point of water.



A

SCHEME

At one View repreſenting to the Eye the Obſervations of the Weather for a Month.

Dayes of the Month and place of the Sun. Remarkable houſe.	Age and ſign of the Moon at Noon.	The Quarters of the Wind and its ſtrength.	The Degrees of Heat and Cold.	The Degrees of Drineſs and Moyſture.	The Degrees of Preſſure.	The Faces or viſible appearances of the Sky.	The Notableſt Effects.	General Deductions to be made after the ſide is fitted with Obſervations: As,
14 ♓ 12.46	☌ 9. 46. Perigeu.	W. W.S.W.	9 12 16 10 7	2 2 2	29 29 29	Clear blew but yellowiſh in the N. E. Clowded toward the S. Checker'd blew.	A great dew. Thunder, far to the South. A very great Tide.	From the laſt ☾ of the *Moon* to the Change the Weather was very temperate, but cold for the ſeaſon; the Wind pretty conſtant betweenN.& W. A little before the laſt great Wind,and till the Wind roſe at its higheſt, the Quick-ſilver continu'd deſcending til it came very low;after wch it began to reaſcend, &c.
15 ♓ 13.40	28 ☌ 24.51.	N. W. N.	9 8 7	28 2 9 2 10	29 29	A clear Sky all day, but a little Checker'd at 4. P. M. at Sunſet red and hazy.	Not by much ſo big a Tide as yeſterday. Thunder in the North.	
16 ♈ 14 37	N.Moon. ♌ 7. 25' A. M. ♎ 10. 8.	S.	10	1 10	28	Overcaſt and very lowring.	No dew upon the ground, but very much upon Marble-ſtones, &c.	
	&c.	&c.	&c.	&c.	&c.	&c.		

Z 2 D I-

Figure 3: Observation scheme of the Royal Society of London according to the design of Robert Hooke, 1667. (reproduction from T. Sprat: The history of the Royal Society of London for the improving of natural knowledge, London 1667, Körber, 1987, p. 134).

In the case of moisture measurement, the development of a functioning hair hygrometer can be dated to 1781 (Benedict de Saussure, 1740–1799) and that of a psychrometer to 1880 (Richard Assmann, 1845–1918), although somewhat earlier developments were also promising. The development of barometers proved to be a lengthy process in order to safely correct for the influence of temperature and to create a reliable vacuum. This was achieved around 1800 by Jean Nicholas Fortin (1750–1831). A much simpler measuring principle was the aneroid barometer by Lucien Vidie (1805–1866), patented in 1844. For centuries, little attention had been paid to wind speed, probably because its cause was insufficiently known. It is therefore not surprising that after the initial work was performed in the 18th century, the first cup anemometer dates to as late as 1846 (Thomas Romney Robinson, 1792–1882). Nevertheless, a selection of suitable measuring instruments was indeed available at the end of the 18th century, so that Alexander von Humboldt (1769–1859), for example, was already able to make reliable measurements on his voyage to South America (1799–1804).

The Accademia del Cimento in Florence was the first institution to set up a measuring network of 7 stations in 1654. Around 1660, the English polymath Robert Hooke (1635–1703), who also became known as the designer of various meteorological measuring instruments, proposed the first guideline for conducting weather observations. In addition to the date and time of the observation, he recommended recording the temperature, humidity, wind, pressure, coverage (amount) and genera (types) of clouds as well as special observations (Fig. 3).

In 1723, the English physicist James Jurin (1684–1750) published an invitation for meteorological observations. The Royal Society in London and the Academies of Science in Berlin and St. Petersburg responded to this invitation. In 1771, Johann Heinrich Lambert (1728–1777), at the Berlin Academy of Sciences, proposed the creation of a worldwide meteorological network (Foken, 2021; Körber, 1987). One of the first meteorological networks was organized by Karl Theodor, Elector of Palatinate and later Bavaria too (1724–1799), who initially founded a scientific academy at Mannheim in 1763 before establishing the

first meteorological society, the Societas Meteorologica Palatina, in 1780 (Lüdecke, 2010; Societas Meteorologica Palatina, 1793). Johann Jakob Hemmer (1733–1790) developed this network, with 36 stations in Europe, 2 in North America and 1 in Greenland. The network had a significant influence on, for example, the standardization of the times of the day at which climatological observations are performed, i.e. 07:00 local time (LT), 14:00 LT and 21:00 LT. Data from the network was published for the period 1781–1792, with only 8 stations being observed over the entire period. After the death of Hemmer in 1790 and changes in the political situation due to the French Revolution, the observations were stopped again (Körber, 1987). An exception is the temperature measurements that have been carried out at the Hohenpeißenberg in Germany (at 989 m ASL) from 1781 until today, and represent the longest time series of temperature measurements at a mountain site worldwide (Winkler, 2006; 2015). Since the second half of the 18th century, continuous time series of meteorological observations have been available, such those from Basel (1761), Prague (1775) and Vienna (1775) (Linke and Baur, 1962). Subsequently, smaller networks of meteorological stations were established around the world, in Germany, e.g. the network initiated by Johann Wolfgang von Goethe (1749–1832) in the Grand Duchy of Saxe-Weimar-Eisenach in 1821–1832 (Bernhardt, 2004). That particular network included the weather station at Jena, which started operating in 1813 and is still in operation today. In association with the Leipzig Meteorological Conference, the network in Saxony is of interest. This was established by the astronomer Carl Christian Bruhns (1830–1881), comprised more than 20 stations and was in operation from 1863, (observations until 1875, see Bruhns, 1866–1880). It closed a gap between the Prussian measuring network operated by Heinrich Wilhelm Dove (1803–1879) and that of the Central Institution for Meteorology and Earth Magnetism in Vienna (since 1904 Central Institution for Meteorology and Geodynamics, Hammerl and Staudinger, 2021).

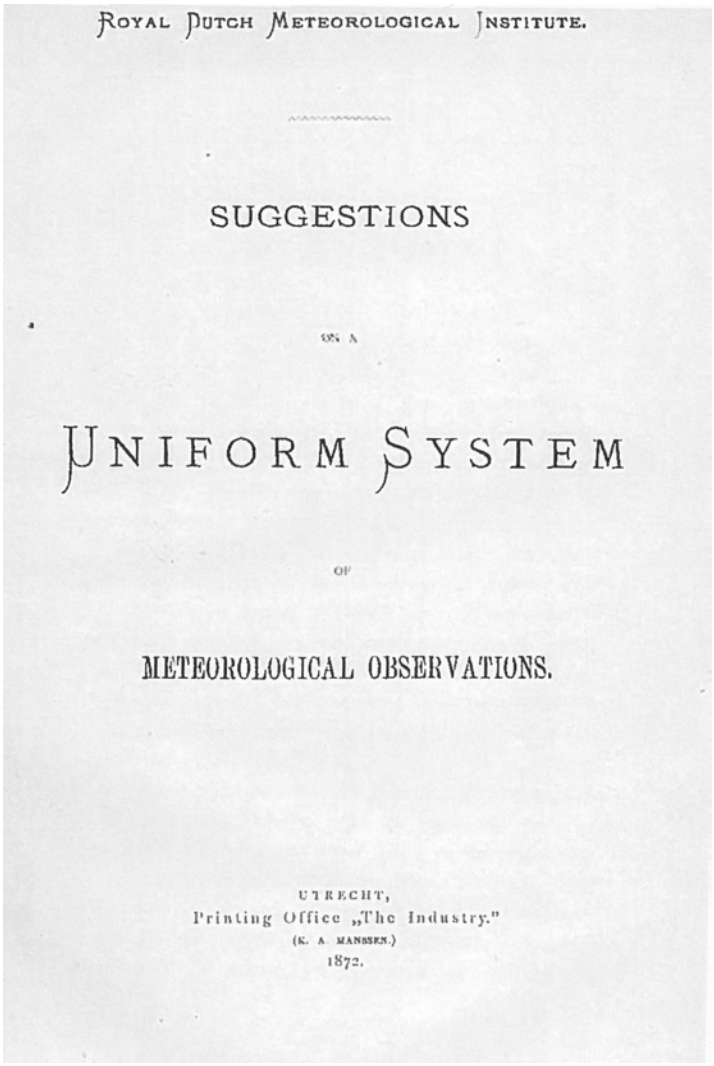
In 1826, Heinrich Wilhelm Brandes (1777–1834) constructed the first weather maps based on pressure observations made across Europe at 18:00 on 24 December 1821 and at 03:00, 10:00 and 20:00 local time the next day (Börngen, 2017). The general problem was the merging of measurement data from different regions, which was only possible with a long time delay. The invention of the electric telegraph in 1837 by Samuel Finley Breese Morse (1791–1872) was a milestone in this regard. At the end of the 1840s, the electric telegraph became widespread in Europe and was used to transmit weather reports and the first weather forecasts (Moore, 2016). The usefulness of weather reports and wind maps was particularly recognized in seafaring. The storm-related sinking of the French battleship *Henry IV* and of other vessels on 14 November 1854, during the Crimean War, decisively promoted the drawing of current weather maps based on weather data transmitted by telegram (Körber, 1997). The US naval officer Matthew Fontaine Maury (1806–1873) was one of the first to compile weather observations from sailing ships. He also took the initiative to convene the Conference on Maritime Meteorology in Brussels in 1853, under the leadership of Lambert Adolphe Jacques Quetelet (1796–1874), Director of the Brussels Observatory, and representatives from nine countries (Belgium, Denmark, France, Great Britain, the Netherlands, Norway, Portugal, Sweden and the USA), at which he made the following proposal:

"... the navies of all maritime nations should co-operate and make these meteorological observations in such a manner and with such means and implements, that the system might be uniform and the observations made on board the public ship be readily referred to and compared with the observations made on board all other public ships, in whatever part of the world. And, moreover, as it is desirable to enlist the voluntary co-operation of the commercial marine, as well as that of the military of all nations in this system of research, it becomes not only proper, but politic, that the forms of the abstract log to be used, with the description of the instruments to be employed, the things to be observed, with the manipulation of the instruments and the methods and modes of operation should be the joint work of the principal parties concerned" (Ashford et al., 1990).

3 The preparation of the Leipzig Meteorological Conference

The meteorological conference in Brussels led to, among other things, the establishment of the first state meteorological service in England in 1854 with Vice-Admiral Robert FitzRoy (1805–1865) as its first director, and, in the same year, the Royal Dutch Meteorological Institute with Prof. Christoph Heinrich Dietrich Buys Ballot (1817–1890) as its first director. Meteorological services were also established in other countries. At the suggestion of von Humboldt, the Royal Prussian Meteorological Institute was founded in Berlin in 1847, with Dr. Wilhelm Mahlmann (1812–1848) as its first director (Körber, 1997). He was followed in 1849 by Prof. Dove. In Austria, Prof. Karl Kreil (1798–1862) was appointed director of the Central Institution for Meteorology and Earth Magnetism in Vienna in 1851. The first meteorological societies were also founded at this time, such as the Austrian Meteorological Society in 1865.

In the following years, there were various attempts to unify meteorological observations. In 1860, Dove proposed a conference of meteorologists to parallel the meeting of Swiss natural scientists (*Schweizer Naturforscherversammlung*) in 1863. This proposal was supported by Buys Ballot with some additions by Kreil (Buys Ballot, 1872). He was also in contact with Prof. Henrik Mohn (1835–1916) from Christiania (Oslo), Prof. Niels Henrik Cordelus Hoffmeyer


ROYAL DUTCH METEOROLOGICAL INSTITUTE.

SUGGESTIONS

ON A

UNIFORM SYSTEM

OF

METEOROLOGICAL OBSERVATIONS.

UTRECHT,
Printing Office „The Industry."
(K. A. MANSSEN.)
1872.

Figure 4: Title page of BUYS BALLOT's Suggestions on a Uniform System of Meteorological Observations (Utrecht, 1872)

(1836–1884) from Copenhagen and GEORG NEUMAYER (1826–1909), the hydrographer of the Royal Navy in Berlin (DEKKER, 2017). Further proposals were made by Prof. QUETELET of Belgium (1867) und Prof. JELINEK of Austria (1867). After a trip to visit European meteorological stations in 1868, Dr. ÉMILIEN JEAN RENOU (1815–1902) and Dr. EDME HIPPOLYTE MARIÉ-DAVY (1820–1893) of France noted (ANONYMOUS, 1893) that their proposal for a permanent and annually convening Congress of the Physics of the Earth was met with general approval (ASHFORD et al., 1990; BÖHME, 1973).

In January 1872, BUYS BALLOT (Fig. 5d) had hopes that there would be a General Congress of Meteorologists, possibly in Vienna, the same year. For this purpose, he wrote an extensive document (Fig. 4) with explanations of the most important upcoming problems (BUYS BALLOT, 1872). However, all the proposals could only be dealt with at the Leipzig Conference. VON WILD (Fig. 5b) visited BRUHNS (Fig. 5a) in the spring of 1872. Together with JELINEK (Fig. 5c), they agreed to invite meteorologists to a conference in Leipzig on 14 August 1872, where the meeting place is unknown. Together with the invitation (Fig. 6, May 1872), a catalogue of 26 questions to be discussed was sent out (BRUHNS et al., 1872, see Appendix 1). The basis for this questionnaire was undoubtedly the BUYS BALLOT document, which contains extensive explanations for all 26 questions. The Leipzig Conference was certainly a personal achievement for BRUHNS, who, although not a meteorologist, strongly supported meteorology and the collection of data (BÖRNGEN, 2006). See Appendix 2 for a brief biography of each of the organizers of the conference.

4 The 1872 Leipzig Meteorological Conference

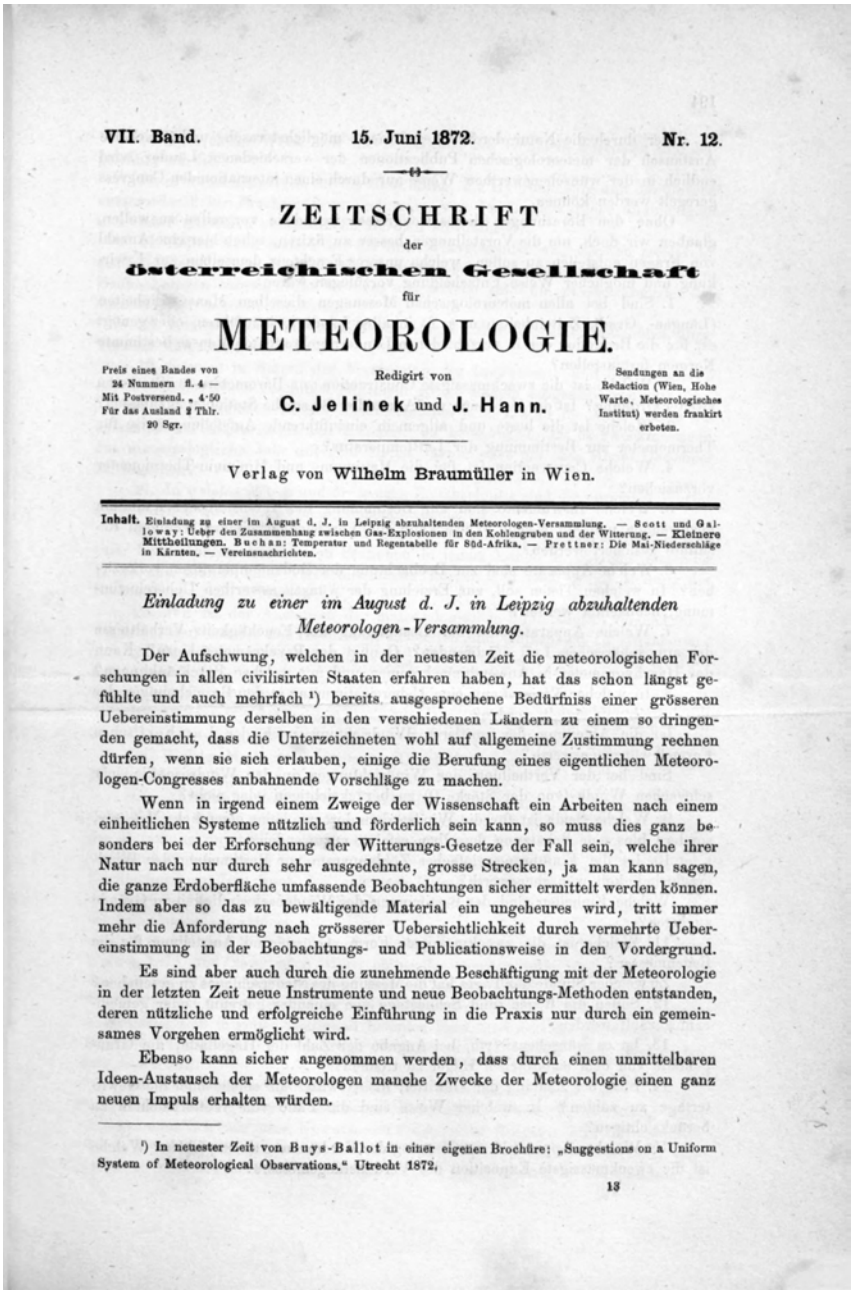
The invitation to the meeting was accepted by 52 participants from 9 countries (Germany, England/Scotland, Estonia, Finland, Italy, The Netherlands, Austria, Russia and the USA). The recent Franco-German War was the reason for the absence of their French colleagues. Among the participants still known today were,

a) b) c) d)

Figure 5: Leading scientists at the Leipzig Meteorological Conference, 1872, a) Carl Christian Bruhns, b) Carl Jelinek, c) Heinrich von Wild, d) Christoph Heinrich Dietrich Buys Ballot; Image sources: a) Astronomische Gesellschaft (1883), b) Archive Central Institution for Meteorology and Geodynamic, Vienna, c) Cannegieter (1963, p. 21), d) Archive Rijksmuseum Boerhaave in Leiden (1923)

besides the 3 inviting scientists, the director of the Royal Dutch Meteorological Institute C.H.D. Buys Ballot, the director of the Royal English Meteorological Service R.H. Scott (1833–1916), the hydrographer G. Neumayer, and Julius Ferdinand von Hann (1839–1921), an employee at the Central Institution for Meteorology and Earth Magnetism in Vienna. The basis for the deliberations was a catalogue of 26 questions sent out in advance. These were discussed in several meetings that took place from 12:00 to 16:00 local time on 14–16 August 1872. Since some well-known meteorologists, among others, H.W. Dove from Berlin, Hugo Hildebrand Hildebrandsson (1838–1925) from Upsala, H. Mohn (1835–1916) from Christiania (Oslo), Captain N.H.C. Hoffmeyer (1836–1884) and Johann Rudolf Wolf (1816–1893) from Zurich could not participate, their opinions about the topics to be discussed were available in the form of 24 letters. Detailed minutes of the discussions and these 24 letters were published (Fig. 7, anonymous, 1872). They also appeared as a supplement to the *Zeitschrift der österreichischen Gesellschaft für Meteorologie* (volume VII, No. 24). Furthermore, added to the minutes were the results of the negotiations of the French natural scientists in Bordeaux in September 1872, which were also based on the questionnaire.

The meeting was opened by Bruhns. At his proposal, Buys Ballot, Scott and von Wild were elected to chair the sessions of the 3-day conference. Instead of an agenda, the questions were discussed one after the other. Questions 1–17 addressed metrological problems, questions 18–21 concerned calculation



VII. Band. 15. Juni 1872. Nr. 12.

ZEITSCHRIFT
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Inhalt. Einladung zu einer im August d. J. in Leipzig abzuhaltenden Meteorologen-Versammlung. — Scott und Galloway: Ueber den Zusammenhang zwischen Gas-Explosionen in den Kohlengruben und der Witterung. — Kleinere Mittheilungen. Buchan: Temperatur und Regentabelle für Süd-Afrika. — Prettner: Die Mai-Niederschläge in Kärnten. — Vereinsnachrichten.

Einladung zu einer im August d. J. in Leipzig abzuhaltenden Meteorologen-Versammlung.

Der Aufschwung, welchen in der neuesten Zeit die meteorologischen Forschungen in allen civilisirten Staaten erfahren haben, hat das schon längst gefühlte und auch mehrfach [1]) bereits ausgesprochene Bedürfniss einer grösseren Uebereinstimmung derselben in den verschiedenen Ländern zu einem so dringenden gemacht, dass die Unterzeichneten wohl auf allgemeine Zustimmung rechnen dürfen, wenn sie sich erlauben, einige die Berufung eines eigentlichen Meteorologen-Congresses anbahnende Vorschläge zu machen.

Wenn in irgend einem Zweige der Wissenschaft ein Arbeiten nach einem einheitlichen Systeme nützlich und förderlich sein kann, so muss dies ganz besonders bei der Erforschung der Witterungs-Gesetze der Fall sein, welche ihrer Natur nach nur durch sehr ausgedehnte, grosse Strecken, ja man kann sagen, die ganze Erdoberfläche umfassende Beobachtungen sicher ermittelt werden können. Indem aber so das zu bewältigende Material ein ungeheures wird, tritt immer mehr die Anforderung nach grösserer Uebersichtlichkeit durch vermehrte Uebereinstimmung in der Beobachtungs- und Publicationsweise in den Vordergrund.

Es sind aber auch durch die zunehmende Beschäftigung mit der Meteorologie in der letzten Zeit neue Instrumente und neue Beobachtungs-Methoden entstanden, deren nützliche und erfolgreiche Einführung in die Praxis nur durch ein gemeinsames Vorgehen ermöglicht wird.

Ebenso kann sicher angenommen werden, dass durch einen unmittelbaren Ideen-Austausch der Meteorologen manche Zwecke der Meteorologie einen ganz neuen Impuls erhalten würden.

[1]) In neuester Zeit von Buys-Ballot in einer eigenen Brochüre: „Suggestions on a Uniform System of Meteorological Observations." Utrecht 1872.

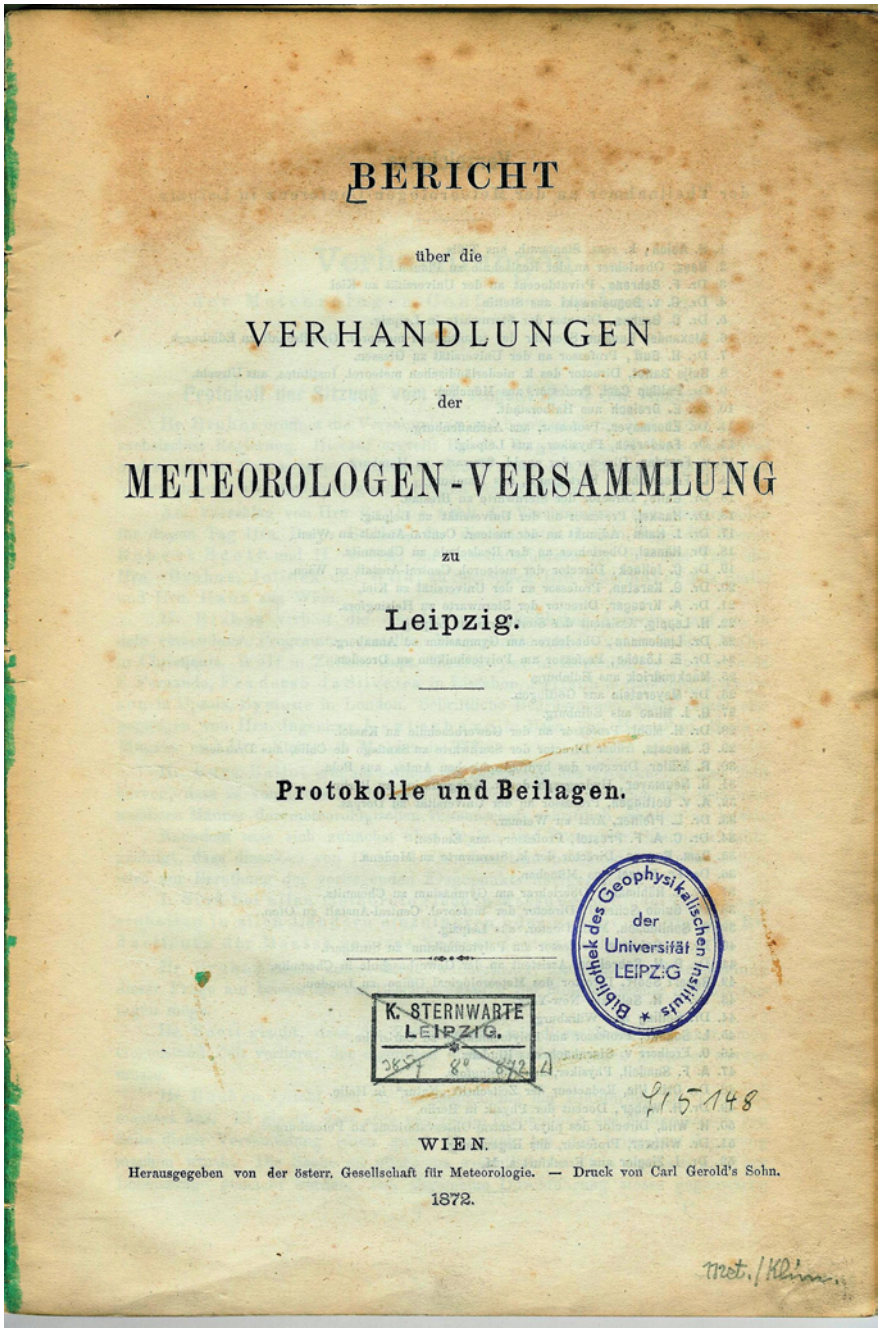
13

Figure 6: Front page of the Zeitschrift der österreichischen Gesellschaft für Meteorologie with the invitation to the Leipzig Meteorological Conference (Bruhns et al., 1872)

methods and questions 22–26 dealt with the details of data publication and exchange. The discussion was very lengthy, so that by the afternoon of the second day, it had only reached question 6. At the suggestion of von Wild, questions 18 onwards were discussed first. The second day ended with the discussion on question 20. At the suggestion of Bruhns, it was determined that questions 7–17 and 21–26 should be clarified in small groups, to be able to cover them all on the third day.

Since the meeting did not have a quorum, decisions had to be postponed to an international meeting still to be convened. Reports were requested on individual points documenting the current situation, e.g. that by von Hann on a decision about future pressure measurement with mercury barometers or aneroid barometers. On the morning of the last day, the sub-commission for maritime meteorology met, with the significant participation of Buys Ballot, Scott and Neumayer. The focus was on recommendations about uniform observation methods (instruments and times) at sea and on land and the adoption of the metric system of measurement. The exchange of data, including that of the Navy, was also recommended.

Question 1, about the general use of metric system of measures, at least for mean values, could only be considered as a recommendation and would have to be defined by governmental authorities. International data exchange is now SI-compliant (SI, 2019).


BERICHT

über die

VERHANDLUNGEN

der

METEOROLOGEN-VERSAMMLUNG

zu

Leipzig.

Protokolle und Beilagen.

WIEN.

Herausgegeben von der österr. Gesellschaft für Meteorologie. — Druck von Carl Gerold's Sohn.
1872.

Figure 7: Title page of the protocol of the 1872 Leipzig Meteorological Conference.

Questions 2–17 concerned the measurement of various meteorological elements (see Appendix 1). In Table 1, these questions have been ordered according to whether they are about measuring devices, locations or data calculations. The questions were a reflection of the development of meteorological measurement techniques at the end of the 19th century, as described in Section 2. On the one hand, the development of measuring instruments had progressed to the point where reliable measurements could be made. On the other hand, there were still so many types of devices that it was not easy to decide which to recommend. Typical questions were about whether to use a mercury or aneroid barometer, a hair hygrometer or a psychrometer. The cup anemometer was recommended, but the estimation by various scales according to Beaufort and the wind vane according to von Wild (common in St. Petersburg) were also discussed.

Some questions seem as if they could be from this century or at least the end of the last. While there is no longer a question of measuring the temperature at a window (for the convenience of the observer), the nature of the temperature screen or its ventilation is still relevant (Foken and Bange, 2021a). The same applies to the placement of precipitation gauges (Cauteruccio et al., 2021). The WMO has found an apparent compromise

Table 1: Assignment of individual questions 2–17 to specific meteorological elements and problems (questions with a grey background are still relevant today).

Meteorological element	Type of device	Installation	Calculation/Observation
Air pressure	Question 2		
Air temperature		Question 3	
Maximum and minimum temperature	Question 4		
Radiation	Question 5		
Soil temperature	Question 6	Question 6	
Humidity	Question 7		
Wind direction			Question 8
Wind speed	Question 10		Question 9 (scale)
Precipitation		Question 11	
Day with rain/snow			Question 12
Day with hail/soft hail			Question 13
Day with thunderstorms			Question 14
Evaporation	Question 15		
Cloudiness			Question 16
Electricity	Question 17		

here, by defining quality classes for the measurement depending on the set-up (WMO, 2018). Even the question of the correct calculation of the mean wind direction is asked time and again today (Foken and Bange, 2021b). A standardized evaporation measurement still does not exist, and measurements of atmospheric electricity have largely been abandoned. Many historical details of these developments can be found in the *Springer Handbook of Atmospheric Measurements* (Foken, 2021), so a detailed description is not necessary here.

The counting of days with special events (e.g., temperature $< 0\,°C$) was discussed extensively, such as the question of whether days with rain and snowfall should be recorded separately or together. A unanimous recommendation was made for a scale of 0–10 for sky coverage and the use of symbols for different hydrometeors. Due to the recent decrease in stations with visual observations, the question of determining cloud cover has again become topical (Foken and Rülke, 2021).

Question 18 dealt with the unification of the observation times, because the 3 observation times of the Societas Meteorologica Palatina were not generally accepted. This problem was referred to a future congress, as it applied chiefly to the subsequent questions. There was general consensus that however one selects the times a same daily average must result. Due to automation of weather observations, this question is no longer relevant today.

Question 19 dealt with conducting inspections of observation stations, the performance of comparative measurements, the use of comparative equipment and permissible deviations. This remains a topic for discussion to this day and has been resolved by setting standards in certain levels (i.e. primary and secondary) (WMO, 2018).

The determination of mean values (question 20) brought, after initial discrepancies as to the annual mean (calendar year or meteorological year starting from December), an agreement on daily mean, monthly mean and the mean of the calendar year. Only the division of the year into pentads, 72 according to Buys Ballot or 73 according to Dove (common today), remained unresolved, but hardly plays a role today.

Closely related to question 20 was question 21 about the determination of normal periods. The starting date was set at 1 January 1871, with a minimum length of 5 years. Today, the beginning is still valid, in principle, but the length is set at 30 years.

The next questions concerned the exchange of measurement data. Question 22 was about the number of stations to be communicated and the meteorological parameters, measured values and means to be recorded. A limiting factor was also the money available. The model of the tables from St. Petersburg was used, but a decision was postponed. For the dissemination, an exchange of publications was considered (question 23), even though not all countries had central institutes that could take over this function (question 24).

Question 25 was associated with the desire to send weather telegrams. This could not be resolved because of the different political conditions and was forwarded to the Commission for Maritime Meteorology for political clarification.

Finally, it was unanimously decided (question 26) to hold a meteorological congress in Vienna in 1873, together with the World's Fair, with the organizers of the Leipzig Conference being elected to the permanent bureau to prepare the meeting. In the spring of 1873, the Austrian government issued a diplomatic invitation to the 1st Meteorological Congress in Vienna, scheduled for 2–16 September and to be chaired by Buys Ballot, who in March 1873 supplemented his *Suggestions on a Uniform System of Meteorological Observations* (Buys Ballot, 1873). In view of his earnestness, also in preparation of the Leipzig meeting, his biography is given in Appendix 2.

Figure 8: The Austrian stamp (Michel No. 1423) shows the building of the Austrian Academy of Sciences, the probable venue for the conference, at Universitätsplatz, now Dr.-Ignaz-Seipel-Platz, in Vienna, from a painting by Bernardo Bellotto, called 'Canaletto' (1721–1780).

5 First meteorological Congress in Vienna and conclusion

The invitation of the Austrian government to the meteorological congress in Vienna was accepted by 32 delegates from 19 countries (Austria, Bavaria, Belgium, China, Denmark, German Empire, Great Britain and Ireland, Greek, Hungary, Italy, the Netherlands, Norway, Portugal, Russia, Spain, Sweden, Switzerland, Turkey, and the USA). The opening took place on 2 September 1873, with a greeting by the Minister of Education, C. von Stremayr, followed by a lecture by C. Jelinek on the tasks of the conference. It is generally referred to as the 1st International Meteorological Congress and founding conference of the International Meteorological Organization (IMO) (Ashford et al., 1990; Cannegieter, 1963; Keil, 1962; Schlegel, 1987), and sometimes also as the second conference after the Conference of Maritime Meteorology in Brussels in 1853 (WMO, 2000).

Jelinek expressed his regret about the absence of the French delegates, without naming them specifically. The following statement is significant: *"Furthermore, it is to be regretted that due to the nature of the composition of the congress, which only admits government delegates, it was not possible for many excellent meteorologists who were present at the Leipzig Conference to participate in the work of the Meteorological Congress"* (anonymous, 1873).

Austria commemorated the 100th anniversary of the founding of the IMO in 1973 with a postage stamp (Fig. 8). About 55 other countries, such as the FRG (Michel No. 760) and Switzerland (official WMO stamp, Michel No. 10/13), also issued special stamps to mark the occasion.

The basis for the deliberations was again a catalogue of 29 questions, which were largely identical to those in the Leipzig catalogue (anonymous, 1873). The 'Permanent Committee' set up in Leipzig was confirmed under the leadership of Buys Ballot. It held meetings almost every year until the Second International Meteorological Congress took place in Rome in 1879. Because comprehensive literature on the work of the IMO is available, no further statements will be made here (Ashford et al., 1990).

The difference between the conferences in Leipzig and Vienna becomes obvious when comparing the minutes of both conferences (anonymous, 1872; anonymous, 1873). The Vienna document contains, to a large extent, templates on the issues to be discussed and the corresponding votes on them. The representatives of the states were guided not only by scientific points of view, but also by national needs and political strategies (the documents are comparable to those of international organizations that still exist today). This is a circumstance which was already regretted by the scientist Jelinek in his introduction. The Leipzig document, especially the comprehensive presentations on questions 1–6 discussed on the first day, contains a critical analysis of previous scientific findings and a discussion on an appropriate evaluation. This kind of approach can still be found today in the deliberations of the International Panel on Climate Change (IPCC) or at expert meetings of national and international scientific societies. This approach, practised in Leipzig, i.e. independent of administrative and political constraints, is essential to then transfer scientific best practices into practice by means of international organizations.

However, the Leipzig Conference was also a clear commitment to equal measuring times and a standardization of the units of measurement on the basis of the metric system, even if no decisions could be made. Concerns were expressed by anglophone countries regarding the use of Celsius degrees, because Fahrenheit degrees guaranteed a better resolution of temperature measurement. Recommendations were also made regarding the preferred use of certain measurement methods. Also noteworthy is the foresight expressed by Buys Ballot that the provision of near real-time weather observations was essential for weather forecasting; this became increasingly important in the second half of the 19th century. The collaboration of Bruhns, Jelinek and von Wild in Central Europe also underscored the importance of land-based meteorological observations, which were already well established among the maritime states by the mid-19th century.

Finally, as already noted, it must be emphasized that after a 20-year standstill in international cooperation, the Leipzig Conference paved the way for international cooperation on equal terms in the field of meteorology, thus opening the way for modern weather forecasting.

Acknowledgments

We thank Prof. Dr. David Schultz and an anonymous reviewer for helpful comments to improve the article. Funded by the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – 491183248. Funded by the Open Access Publishing Fund of the University of Bayreuth and funding from the German Meteorological Society.

Appendix 1: Catalogue of the 26 questions from the invitation to the Leipzig conference (Bruhns et al., 1872)

1. Is it necessary to introduce the same units of measurement (units of distances, degrees, time, etc.) in all countries, or is it sufficient to establish certain standards for the reduction of the measurements used in different countries?*
2. What is the most appropriate construction of barometers for second order stations. Should the use of aneroids be allowed for such stations?
3. What is the best method of setting up thermometers for the determination of air temperature, to be introduced generally?
4. Which construction is preferable for the maxima and minima thermometers?
5. What instruments should be used to determine the intensity of radiation, and how can the comparability of the results obtained be ensured?
6. Which apparatuses are preferable for the observation of ground temperatures? At what depths should observations be made to obtain desirable agreement?
7. What apparatus should be used to determine the humidity of the atmospheric air? Is the psychrometer sufficient for this purpose? Can the hair hygrometer be used and with what limitations?
8. In what way can agreement be reached in the designations of wind direction? Is the derivation of mean wind direction by Lambert's formula desirable?
9. What scale should be used for wind force where no actual measurement but merely an estimate of it is made?
10. Is it desirable to introduce simple counters for the determination of wind speed? What units should be used to determine wind speed?
11. What is the most convenient form, size and installation for rain gauges? At what hour of the day should rainfall be measured?
12. Should the rain and snow days be counted separately or together?
13. Is it desirable to separate the soft hail from the hail itself when counting the number of hailstorms?
14. When counting thunderstorms, are the thunderstorms as such or the thunderstorm days to be counted? In what way are the cases of weather lightning to be taken into account.
15. What apparatus is recommended for measuring evaporation? What is the most appropriate exposure of the evaporimeter?
16. In what manner should the cloudiness of the sky be estimated and designated? Is it desirable to introduce certain symbols for cloudiness, hydrometeors, and other extraordinary phenomena, independent of the national language, and thus universally understood?
17. Should meteorological elements other than those enumerated in the foregoing, e.g., electricity, etc., be included in the scope of normal observations, and what are the most useful instruments for their observation?
18. Is it possible to establish consistent observation dates for the normal observations?
19. Can general rules be established for the verification of instruments and the inspection of meteorological stations?
20. According to which rules, time periods, etc., should the mean values of the various meteorological elements be calculated? Is it more appropriate to start the meteorological year with the month of January or with the month of December?
21. In what way and for what periods of time the normal values of the different meteorological elements are to be derived?
22. Is it desirable and possible to publish the meteorological observations of a limited number of stations in each country in a consistent manner and within a relatively short time after the observation is made?
23. What is the quickest, safest and easiest way to organize the exchange of meteorological publications from different institutions and countries?
24. Is it desirable to establish in each country one or more central offices for the management, collection, and publication of meteorological observations?
25. Does the exchange of meteorological telegrams seem so useful as to give it an even wider distribution and firmer organization?
26. What measures should be taken to implement the decisions and realization of the Meteorological Congress?

*Note: The discussion on question 1, in contrast to the question, concerned the introduction of the metric system following the demand of Buys Ballot (1872)

Appendix 2: Biographies of the organizers of the conferences in Leipzig 1872 and Vienna 1873

Carl Christian Bruhns (Fig. 5a) was born in Plön on 22 November 1830 and was privately engaged in mathematics and astronomy but took up an apprenticeship as a locksmith. After his mathematical abilities were noticed, he first worked at the observatory in Berlin. He received his doctorate in 1856 and habilitated at the University of Berlin in 1859. In 1860, he was appointed director of the Leipzig Observatory and Professor of astronomy at the University of Leipzig. There, he worked to establish a network of meteorological measurements in Saxony and set up a weather forecasting office but was himself not actively involved in meteorological research. His research focused on astronomic and geodetic work. He was elected to be a member of the Leopoldina Academy in 1867 and became a member of the Saxon Society (from 1919, the Academy) of Sciences in 1869. Bruhns died in Leipzig on 25 July 1881 (Hänsel, 2006).

Carl Jelinek (Fig. 5b) was born in Brno on 23 October 1822, and studied law, physics and astronomy in Vienna. He received his doctorate in 1843. He was an assistant at the Vienna Observatory until 1847 and then at the Prague Observatory until 1852, when he was appointed Professor of Mathematics in Prague. In 1863, he was appointed director of the Central Institution for Meteorology and Earth Magnetism in Vienna and Professor of Physics at the University of Vienna. There, he advocated the use of modern meteorological observation instruments. He was appointed a member of the Academy of Sciences in Vienna in 1866 and an honorary member of the Royal Meteorological Society in 1874. Jelinek died in Vienna on 19 October 1876 (Steinhauser, 1974).

Heinrich von Wild (Fig. 5c) was born on 17 December 1833 in Uster, Canton Zurich. He studied physics in Zurich and Königsberg, received his doctorate and habilitation at the University of Zurich in 1857, and became Professor and director of the astronomical observatory in Bern in the same year (until 1868). In 1868, he was elected member of the Academy of Sciences and became director of the Main Physical Observatory in St. Petersburg until 1895. In 1879, he became President of the International Meteorological Committee. In 1880, he became president of the 1st International Polar Commission and organized the 1st International Polar Year (1882–1883). In both Switzerland and Russia, he expanded the meteorological station network extensively. In 1895, von Wild returned to Zurich, where he died on 5 September 1902 (Awetissow, 2003).

Christoph Heinrich Dietrich Buys Ballot (Fig. 5d) was born in Kloetinge (The Netherlands) on 10 October 1817. He studied the natural sciences, including chemistry, physics, geology and astronomy, in Utrecht, earning his doctorate in 1844. In 1847, he was appointed Professor of Experimental Physics at the University of Utrecht. In the same year, he founded the meteorological observatory at the Sonnenborgh bastion, which, in 1854, became the Royal Dutch Meteorological Institute, of which he was the first director. In 1855, he became a member of the Royal Netherlands Academy of Arts and Sciences. In 1857, almost simultaneously with William Ferrel (1817–1891), he discovered the baric wind law. Buys Ballot chaired the First Meteorological Congress in Vienna in 1873 and was Chairman of the Permanent Committee until the 2nd Congress in Rome in 1879. He died in Utrecht on 3 February 1890 (Dekker, 2017).

References

anonymous, 1872: Bericht über die Verhandlungen der Meteorologenversammlung zu Leipzig. – Wien, 31, XXXIX pp., https://opacplus.bsb-muenchen.de/Vta2/bsb11046233/bsb:10313778?page=3. The 1873 English translation by the MetOffice (UK) is available at https://library.metoffice.gov.uk/Portal/Default/en-GB/RecordView/Index/445402.

anonymous, 1873: Bericht über die Verhandlungen des internationalen Meteorologen-Congresses zu Wien. – Druck der k. k. Hof- und Staatsdruckerei, Wien, 117 pp. The 1873 English translation by the MetOffice (UK) is available at https://library.metoffice.gov.uk/Portal/Default/en-GB/RecordView/Index/445402.

anonymous, 1893: Marié-Davy. – Nature **48**, 351–351. DOI: 10.1038/048351a0.

Aristotle, 2017: Meteorology. – Clarendon Press, Oxford, 86 pp.

Ashford, O.M., S. Gupta, P.J. Meade, H. Taba, G. Weiss (Eds): 1990: Forty years of Progress and Achievement. – WMO-No. **721**, World Meteorological Organization, Geneva, 215 pp.

Awetissow, G.P., 2003: Imena na karte Rossijskoi Arktiki (Names on the map of the Russian Arctic). – Nauka, Sankt Petersburg.

Bernhardt, K.-H., 2004: Johann Wolfgang von Goethes Beziehungen zu Luke Howard und sein Wirken auf dem Gebiet der Meteorologie. – Proceedings of the International Commission on History of Meteorology **1**, 28–40.

Böhme, W., 1973: 100 Jahre Meteorologenkonferenz Leipzig 1972. – Abh. Meteorol. Dienstes DDR **110**, 7–16.

Börngen, M., 2006: Carl Christian Bruhns' Förderung der Meteorologie. – In: Hänsel, C. (Ed.): Carl Christian Bruhns, ein bedeutender Naturwissenschaftler in der zweiten Hälfte des 19. Jahrhunderts. – Verlag der Sächsischen Akademie der Wissenschaften, Leipzig, 61–91.

Börngen, M., 2017: Heinrich Wilhelm Brandes (1777–1834). – Edition am Gutenbergplatz, Leipzig, 43 pp.

Börngen, M., T. Foken, D.M. Schultz, 2022: The 150th Anniversary of the Leipzig Meteorological Conference: Standardizing Observations and Analysis Methods. – Monthly Weather Rev. 150:1897–1899 DOI:10.1175/MWR-D-22-0162.1.

Bruhns, C., 1866–1880: Resultate aus den meteorologischen Beobachtungen angestellt an mehreren Orten im Königreich Sachsen, **1–12**. – Ernst Julius Günther und B.G. Teubner, Dresden und Leipzig.

Bruhns, C., H. Wild, C. Jelinek, 1872: Einladung zu einer im August d. J. in Leipzig abzuhaltende Meteorologen-Versammlung. – Zeitschrift der österreichischen Gesellschaft für Meteorologie VII (12), 193–196.

Buys Ballot, C.H.D., 1872: Suggestions on a uniform system of meteorological observations. – Royal Dutch Meteorological Institute, Utrecht, 63 pp.

Buys Ballot, C.H.D., 1873: A Sequel to the Suggestions on a Uniform System of Meteorological Observations. – Royal Dutch Meteorological Institute, Utrecht, 56 pp.

Cannegieter, H.G., 1963: The history of the International Meteorological Organization 1872–1951. – Ann. Meteorol. **1**, 280.

Cauteruccio, A., M. Colli, M. Stagnaro, L.G. Lanza, E. Vuerich, 2021. In situ precipitation measurements. – In: Foken, T. (Ed.): Handbook of Atmospheric Measurements. – Springer Nature, Switzerland, 359–400. DOI: 10.1007/978-3-030-52171-4_12.

Dekker, K., 2017: Buys Ballot, veel meer dan zijn wet. – Meteorologica **26**, 4–7.

Foken, T. (Ed.), 2021: Springer Handbook of Atmospheric Measurements. – Springer Cham, LVIII, 1748 pp. DOI:10.1007/978-3-030-51171-4.

Foken, T., J. Bange, 2021a: Temperature sensors. – In: Foken, T. (Ed.): Springer Handbook of Atmospheric Measurements. – Springer Cham, 183–208. DOI:10.1007/978-3-030-52171-4_7.

Foken, T., J. Bange, 2021b: Wind sensors. – In: Foken, T. (Ed.): Springer Handbook of Atmospheric Measurements. Springer Cham, 243–272. DOI:10.1007/978-3-030-52171-4_9.

Foken, T., R. Rülke, 2021: Visual observations. – In: Foken, T. (Ed.): Springer Handbook of Atmospheric Measurements. Springer Cham, 645–657. DOI:10.1007/978-3-030-52171-4_22.

Hammerl, C., M. Staudinger, 2021: 170 Jahre ZAMG 1851 – 2021. – Leykam Verlag, Graz.

Hänsel, C. (Ed.), 2006: Carl Christian Bruhns, ein bedeutender Naturwissenschaftler in der zweiten Hälfte des 19. Jahrhunderts. – Abhandlungen der Sächsischen Akademie der Wissenschaften zu Leipzig – Mathematisch-naturwissenschaftliche Klasse, Band 64, Heft 2. Verlag der Sächsischen Akademie der Wissenschaften, Leipzig, 99 pp.

Keil, K., 1962: Die internationalen Verbindungen auf dem Gebiet der Meteorologie. – In: Linke and F. Baur (Eds): Meteorologisches Taschenbuch, Neue Ausgabe, Bd. I, 2. Aufl. – Akad. Verlagsges. Geest & Portig, Leipzig, 621–635.

Körber, H.-G., 1987: Vom Wetteraberglauben zur Wetterforschung. – Edition Leipzig, Leipzig, 231 pp.

Körber, H.-G., 1997: Die Geschichte des Preußischen Meteorologischen Instituts in Berlin. – Gesch. Meteorol. Deutschl. **3**, 1–71.

Linke, F., F. Baur (Eds), 1962: Meteorologisches Taschenbuch, Neue Ausgabe, 2nd edition, **I**. – Akademische Verlagsgesellschaft Geest & Portig K.-G., Leipzig, 806 pp.

Lüdecke, C., 2010: Von der Kanoldsammlung (1717–1726) bis zu den Ephemeriden der Societas Meteorologica Palatina (1781–1792) – Meteorologische Quellen zur Umweltgeschichte des 18. Jahrhunderts. – In: Popplow, M. (Ed.): Landschaften agrarisch-ökonomischen Wissens. Strategien innovativer Ressourcennutzung in Zeitschriften und Sozietäten des 18. Jahrhunderts, Cottbuser Studien zur Geschichte von Technik, Arbeit und Umwelt, Bd. 30. – Waxmann Verlag, Münster, München, 97–119.

Middleton, W.E.K., 1969: Invention of the Meteorological Instruments. – The Johns Hopkins Press, Baltimore, 362 pp.

Moore, P., 2016: The Weather Experiment: The Pioneers who Sought to see the Future. – Vintage, New York, 432 pp.

Schlegel, M., 1987: Wolrd Meteorological Organization (WMO). – In: Fischer, G. (Ed.): Landolt-Börnstein-Group V Geophysics 4A. – Springer, Berlin, Heidelberg, 460–466. DOI:10.1007/10339647_68.

SI, 2019: Le Système international d'unités (The international system of units), 9th edition. – Bureau International des Poids et Mesures, Sèvres, 216 pp.

Societas Meteorologica Palatina (Ed.), 1793: Ephemerides Societatis Meteorologicae Palatinae. observationes anni 1789 – Societas Meteorologica Palatina, Mannheim, 185 pp.

Steinhauser, F., 1974: Jelinek, Carl, Meteorologe. – In: Stolberg-Wernigerode, O.Z. (Ed): Neue deutsche Biographie. – Duncker & Humblot, Berlin, 389–390.

Wang, P.K., D. Zhang, 1988: An Introduction to Some Historical Governmental Weather Records of China. – Bull. Amer. Meteor. Soc. **69**, 753–758. DOI:10.1175/1520-0477(1988)069<0753:AITSHG>2.0.CO;2.

Winkler, P., 2006. Hohenpeißenberg 1781–2006 – das älteste Bergobservatorium der Welt. – Gesch. Meteorol. Deutschl. **7**, 174 pp.

Winkler, P., 2015: Frühgeschichte des Bergobservatoriums Hohenpeißenberg – neue Erkenntnisse und Präzisierungen. – Gesch. Meteorol. Deutschl. **10**, 115 pp.

WMO, 2000: WMO, 50 years of service. – WMO-No. **912**. World Meteorological Organization, Geneva, 32 pp.

WMO, 2018: Guide to Instruments and Methods of Observation. – WMO-No. **8**, Volume I – Measurement of Meteorological Variables. – World Meteorological Organization, Geneva, 548 pp.