

The Climate of Tübingen A.D. 1596–1605, on the basis of Martin Crusius' *Diarium*

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SUMMARY

Martinus Crusius (1526-1607), one of the 16th century's German humanists, kept personal notes in diary form for the period 1596-1605. This academic professor has provided us in his *Diarium* (Diary) with a systematic collection of daily records of various personal, historic and literary notes. But he was also interested in recording the day-to-day weather, extreme weather events and other environmental phenomena, such as phenological events, vine-harvest dates etc. Over 3,000 descriptive daily records of weather and other environmental phenomena have been derived from the *Diarium*. Assessment of the data is attempted considering various historic and philological parameters relevant to the author, his time, his work and the Diary he kept. Data on snow and snow-cover are discussed in this paper. Crusius' terminology on snow is approached, and the numbers of days with snowfall and snow-cover for the period 1597-1605 in Tübingen (Germany) are compared with averages of the 20th century relevant meteorological data.

Πολλάκις τινὸς φοβεροῦ δοκοῦντος εἶναι πράγματος, γελοία ἢ ἔκβασις.
(Martini Crusii *Diarium*, v.3, p.15,10)

1. INTRODUCTION

Personal writings have been classified by palaeoclimatologists as among the most valuable types of evidence for reconstructing past climates. Letters, journals and diaries began to survive in significant numbers in Europe from the end of the middle ages through the 18th century. A great many of them had an outward-looking orientation and often gave attention to natural phenomena and climate (Ingram, Underhill and Farmer 1981: 186-187; Lamb 1977: 29-31).

Since the last century, weather diaries from the pre-instrumental era have attracted the interest of the scientific community. The authors of such texts used to note down observations about weather and climate at different levels of detail and in a more or less daily sequence. This type of evidence has been evaluated by many researchers as precious for climatic reconstructions and has been

incorporated into many weather compilations and syntheses (Bell and Ogilvie 1978; Ingram, et al. 1981: 192-193).

In Southern Germany many weather diaries kept since the late 15th century have remained untapped. These works were in most cases personal writings compiled by clergymen, astronomers, lawyers etc. Gustav Hellmann's authoritative works have helped many modern scholars to investigate the climate history of central Europe and to reconstruct weather patterns over extended European areas with a considerable degree of accuracy, based on such sources (Glaser 1992 for further bibliography; Hellmann 1883; Hellmann 1921; Hellmann 1924; Hellmann 1926; Schwarz-Zanetti and Schwarz-Zanetti 1992).

Tübingen (in Württemberg, southern Germany; lat.: 48°31', long.: 4°1', 328 m a.s.l.) is one of the central European cities to have very early non-instrumental daily meteorological observations since the beginning of the 16th century A.D. Our knowledge of the climate history of these early years is based mainly on a weather diary containing 5,500 observations, kept by Johannes Stoeffler, the astrologer at the University of Tübingen, during the period 1507-1530; and it is supplemented by the observations of Joachim Camerarius (1500-†1574), Professor of Greek and Latin at the same University (Hellmann 1883: 72; Schwarz-Zanetti and Schwarz-Zanetti, 1992: 39ff.). Also, the first daily instrumental meteorological measurements in Europe were kept in Tübingen by Rudolf Jakob Camerarius (1665-†1721), Professor of Botany at the University of Tübingen, between 1691 and 1694 (Hellmann 1883: 72, 828, 881; Lenke 1961).

A lesser-known source for Tübingen's climate history in the 16th century is the Diary of Martinus Crusius (1526-†1607). Crusius, who was Professor of Greek and Latin at the University of Tübingen, used to keep personal notes in diary form, and recorded – among various details of historical and philological interest – the day-to-day weather conditions and natural phenomena during the years 1596-1605. Hellmann, in his extensive investigations on German meteorological sources, seems to have completely ignored Crusius (Hellmann 1883; Hellmann 1921; Hellmann 1924; Hellmann 1926). It was not until 1927 that the first volume of Crusius' *Diarium* appeared in print (Göz and Conrad 1927), and the meteorological information hidden in the *Diarium* still remains largely unnoticed by modern researchers of climate history. Only in 1960 did Curt Weikinn publish the second Part of his Catalog on Texts for European Weather History and take advantage of some isolated records from Crusius' *Diarium*, particularly for the year 1598. Weikinn's references to the first published volume of Crusius' *Diarium* considered solely some information on river floods in Italy (Weikinn 1960: 420-423, 429). Crusius' daily weather observations – a rich collection of direct and proxy documentary evidence for Tübingen's weather and climate at the turning of the 16th century – remains so far unexploited.

The aim of this paper is to introduce the reader to the weather and environmental material hidden in Crusius' *Diarium* and elaborate some palaeoclimatic data for interpretive analysis through the presentation of a sample of Crusius' meteorological records. For a better understanding of the palaeoclimatic mate-

rial, various historical and philological problems related to the author, his work and his Diary are highlighted and discussed. Palaeoclimatic data are statistically processed and quantified, to provide a tabulation of the daily observations and to establish the frequency of snowfall and the duration of snow-cover in Tübingen for the period 1597-1605. Then, a comparison of the obtained frequencies of the yearly totals and means with existing modern Tübingen data is attempted. The entire weather and environmental content of Martinus Crusius' *Diarium* will appear in a forthcoming publication (Telelis in prep.).

2. THE DIARIUM

2.1. *The author and his time*

Martin Kraus (Figure 1) was the name of Martinus Crusius before he changed it, according to the humanistic fashion of his time. Born at Grebern (in the bishopric of Franconia, Southern Germany) in 19 September 1526 (Julian calendar), Crusius took his first lessons from his father, who was a priest in Ulm. At Strasbourg Crusius continued his academic studies in Greek and Latin and took his degree in philosophy. In 1554 he became director of the School of Latin in Memmingen. Crusius came to Tübingen in 1559, where he was nominated Professor of Greek and Latin, and later Professor of Rhetoric and Poetry. In this position he remained until his death (†25 February 1607; Julian calendar). From



FIGURE 1. Two different portraits of Martinus Crusius. From:

a. «*Prosopographiae Heroum atque Illustrium Virorum Totius Germaniae, pars tertia, eaque Primaria Authore Heinrico Pantaleone Physico Basiliensi Basiliae, in Officina Haeredum Nicolai Brylingereri, Anno 1566*».

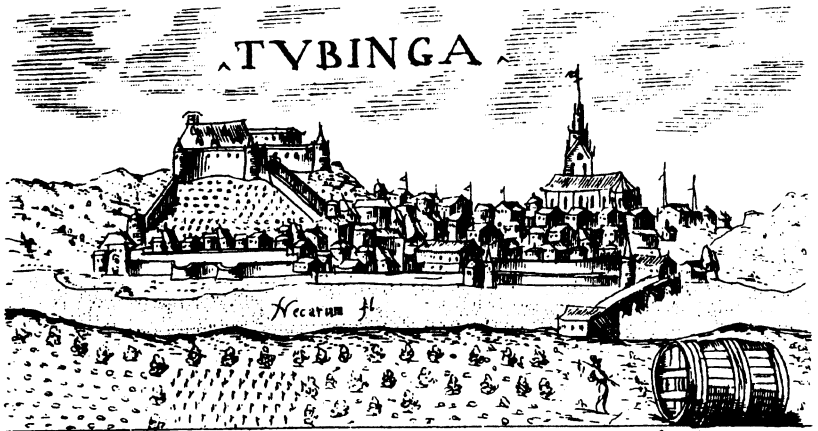
b. «*Turcograeciae Libri Octo a Martino Crusio, in Academia Tybingensi Graeco & Latino Professore utraque lingua edita, Anno 1584*».

1571, he was the owner of a house near the University on the bank of the river Neckar, where he lived in comfort with his third wife and their three children. He was married first in 1558, then for a second time after the death of his first wife and their three children, and finally for a third time after the death of his second wife, daughter and mother during the pestilence of 1566 (Forderer 1959: 54; Karouzou 1973: 116-117).

Crusius' systematic attention to matters of environmental and meteorological importance is not easily explicable. He was no peasant, vine grower or miller, for whom the weather would be a vital factor. As a citizen of a pre-industrial city, however, Crusius was obliged to take account of weather and its effects upon rural production. The survival of preindustrial societies was almost directly affected by meteorological balance. Under the diary entry of 07[17]/06/1602 Crusius notes down: 'Ἀὐχμὸς. *Torrentes (.ut, Stainach.) exsiccantur. Gramina campi Neccarici exuruntur. Das futer wirdt theur waerden. Princeps noster, quia vites gelu April. 21. 22. 23. perditae, imminuit vinum Studiosis suis in Stipendio illustri.*' (Drought. The torrents have dried up [also in Steinach]. The plants of the Neckar fields have withered. Fodder will rise in price. As the vines perished from frost on April 21, 22 and 23, our Rector has cut down the wine for the students at table). Thus his interest in vine harvest dates, vine quality, grain production, food prices etc. was quite justified.

But how can we explain Crusius' persistence in keeping systematic notes of daily weather observations? His profession was the teaching of Ancient Greek and Latin. Was observing weather only a part of an interest in the more practical side of his life (dressing, food production, prices)? Is there any possibility that Crusius' weather sensitivity can be related to more theoretical (i.e. scientific) aspects of his academic activity? A possible answer to those questions can be reached if we take into consideration the spirit and the mentality of his time.

Crusius was an industrious and popular academic, whose interests were not restricted to the fields of ancient Greek, Latin and Hebraic literature. He was also – as one may deduce from information hidden in the *Diarium* – a book collector (a library rich in rare works was left by Crusius after his death), a qualified theologian (from his studies in Strasbourg), a historian with contacts all over Greece, a poet, translator, teacher and preacher. In a word, he was a typical humanist. His academic position in the University of Tübingen gave him the opportunity to make intellectual contact (and sometimes engage in controversy) with professors from other scientific disciplines, thus expanding his horizon of interests. 'Partly perhaps of the emphasis upon eloquence, humanism and the classics, the 16th century, in general, was not an age of scientific specialization, but was marked by a somewhat amateurish literary interest. Schoolmasters philosophized, men of letters tried to practice medicine, physicians professed astrology and astrologers medicine', asserts Lynn Thorndike (Thorndike 1941: V, 8). And such an inference is corroborated by inquiry into the academic life and the Who's Who of 16th century Tübingen.



Tubinga in ducatu Württembergensi ad Neccarum flumen urbs admodum elegans; frumēto, et uino copiosa, quae bona a deo largita tam incolis quam suis conterminis populis comunicat, utraque in lapideo ponte neccari ripam coniungit; ornamēto fci litterarū, ac uniuersitatis compicua;

FIGURE 2. View of Tübingen from undated copperplate engraving (probably since 1572). Collection in Tübingen. (Source: Decker-Hauff and Setzler 1977: 82).

Decades before Crusius' promotion as professor, the University of Tübingen had been the centre of an eminent tradition in astronomy and astrology. One of Crusius' predecessors was Joachim Camerarius (1500-†1574), Professor of Greek and Latin for the period 1541-1574. He is known to have been interested in astrology since 1535, when he published a book on '*...Phaenomena, quae est siderum et stellarum historiola. Prognostica, ubi 330 indicia tempestatum indicatur*' (Hellmann 1883: 72). A significant source of Camerarius' interest in astrology was Melanchthon, who had also studied astrology and astronomy in the University of Tübingen under Johannes Stoeffler, one of the most respected astrologers of that time and the author of an early non-instrumental weather diary (Baron 1978: 203; Schwarz-Zanetti and Schwarz-Zanetti 1992: 39ff.).

Among the masters of natural science, with whom Crusius exchanged many letters, was Johannes Kepler (1571-†1630). Crusius mentions in his *Diarium* that on June 13th 1596 (Julian calendar) he received a letter from Kepler that contained political prognosis derived from astrological observations (Göz 1921: 369; Göz and Conrad 1927: 110). Crusius had established a friendship with Kepler, who already was Professor of Mathematics in Graz-Styria, while he was studying mathematics and astronomy at the University of Tübingen under Professor Michael Maestlin. Crusius and Maestlin used to have frequent academic and personal contacts. From the *Diarium* we learn that the two men used to exchange opinions on various astronomical and astrological issues. On

February 26th 1596 (Julian calendar) Crusius writes that the appearance of a peculiar half-moon with two stars – observed and recorded by Maestlin – should be perceived as a portent of war against the Turks (Göz and Conrad 1927: 286).

Nicodemus Frischlin (1547-†1590), was another person of some consequence in the history of education and letters, as well as of astronomy and astrology. He was a pupil of Crusius and he became involved in a grammatical controversy with his ex-teacher. He also published in 1586 a study on the congruence of the astronomical art with celestial doctrine and with natural philosophy (*'De astronomicae artis cum doctrina coelesti et naturali philosophia congruentia...'*) and he rejected weather prediction from stars and planets. (Thorndike 1941: VI, 192).

The aforementioned direct or indirect intellectual links between Crusius and some scientific personages of his time may help us to obtain a rough idea not only of the amateurish 'interdisciplinary' interests of 16th century scholars, but may also allow us to attempt an interpretation of Crusius' interest in weather phenomena. Crusius seems to have been stimulated in his recording of daily weather conditions by the possibility of astrological prediction. His astronomical and astro-meteorological awareness is obvious in the *Diarium*. Crusius was eager to report the phases of the moon, every sun and moon eclipse, and, sometimes, he used to employ in his daily entries astrological and alchemic symbols the meaning of which is not fully identifiable. The meteorological meaning of some zodiac, astrological and alchemic symbols (Fish: ♉, Aquarius: ♒, ♊, ♋, ♌, ♍, ♎, ♏, ♐, ♑, ♒, ♓, Saturn: ♄, in combination with numbers – showing perhaps the position of the Moon) remains uninterpreted by the editors of Crusius' Diary. They are probably some private abbreviations employed by Crusius to help him in noting down distinct weather conditions (Göz and Conrad 1931: vii & 262, note). The alchemic symbol of 'Caesio' ☿ is interpreted by the editors of Crusius' Diary as an indication for very clear atmosphere and a pale blue color of the sky (Göz and Conrad 1931: 180, note). These are facts that corroborate Crusius' tendency to correlate daily meteorological phenomena with celestial processes.

2.2. Content of *Diarium*

Crusius was a typical representative of the humanistic spirit of his time, and until the end of his life he was busy with writing and teaching. A glance at the list of his writings persuades us of the wide spectrum of his interests. The *Diarium* is one of the most essential works of Crusius, and it has a strongly personal character. In fact, we are confronting Crusius' notebook; the material stored in it was in many cases quarried for his other writings.

Crusius' *Diarium* covers nine manuscript volumes (Mh 466: vols. 1-9), situated at the University Library of Tübingen. The edition of the *Diarium* covers the last four and a half manuscript volumes (Mh 466: vol. 5, p.559 – vol.9 and Mh 198), under the initial title given by the author: *'Diarium, id est, Historica 2 1/2 annorum à me Martino Crusio Tybingae quotidie annotata pro me'* and, from

vol.6 onwards, under the title: 'Ephemerides anni 1596 ex parte, 1597, 1598 ex parte'. Göz and Conrad decided on this arrangement because the last part of the full text appears in true diary form, namely as day-to-day records (Göz and Conrad 1927; Göz and Conrad 1931; Stahlecker and Staiger 1958; Staiger 1961). The first three and a half manuscript volumes (Mh 466: vols. 1-5, p.558), are collections of information, passages, excerpts and epistles from 1573 to 1595, which appear, from the third manuscript volume onwards, as records under

499.

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Episc. Corping contra Genu. auctor. 7.
7 72 Lomi ita ping Gura. 110. 2. 3.

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lego. Vincti. 7 hinc confirmati. ^{ca. 15. 15. 15.}
1. Confirmati. parvuldas. ^{ca. 15. 15. 15.} post D. Hupf.
Colum. 7 hinc et Ioan. 15. a. 15. 15. 15. ^{ca. 15. 15. 15.}
et. Suijji ego Gura. ^{ca. 15. 15. 15.}
Iam hinc scilicet vasa ^{ca. 15. 15. 15.} hinc. ^{ca. 15. 15. 15.}
Collegia. M. C. Bure. s. Maij. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
in B. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}

Maij. 4. Die 4. festo. iustit.
D. Carol. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
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medic. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
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21. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
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Hathwin. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
D. Hupf. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
D. Muggling. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
D. Ringla. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
Collig. ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.} ^{ca. 15. 15. 15.}
May

FIGURE 3. Sample of a page from Crusius' Diarium manuscript (Mh 466: vol. 8, p.499 = p.265, 10-32 of the third published volume. Source: Stahlecker and Staiger 1958: 1).

isolated month entries. Crusius has incorporated much from this material in his earlier works: *Turcograecia* (1584), *Germanograecia* (1585) and *Annales Suevici* (1595) (Göz and Conrad 1927: xiii; Stahlecker 1942: 25-26).

The *Diarium* contains various details of Crusius' private and academic life, as well as evidence of other historical and philological matters of his time. This work has been evaluated by modern researchers as a precious source for 16th century European cultural history, as well as one of the most detailed diaries of its time. It not only provides valuable historical, philological and ethnographic information, but also reflects the life-style of a 16th century scholar, whose sensitive mind was ready to note down whatever might strike his attention: thoughts and material for his books, dreams, memories and events from private and social life, spectacular events of public life, every-day weather and natural phenomena (Mystakides 1898; Göz 1921; Göz 1933; Stahlecker 1942; Forterer 1959; Karouzou 1973; Bernath and Schröder 1974: 337-339).

3. FORM, STRUCTURE AND RELIABILITY OF THE METEOROLOGICAL EVIDENCE

From the first pages of the *Diarium* it is obvious to the reader that the text is uniform in structure. Because of the diary character of the writing, Crusius used to keep his notes in a specific way and he maintained that style up to the last page of the work. The daily entries are structured according to the following scheme:

1. In the *heading* of every daily entry the author used to record calendar information. The month is cited in Latin, the date with Arabic numbers, and the day of the week is cited by the use of the astrological symbols of the seven planets. In cases of religious feasts an abbreviated indication of the feast follows. The heading of every daily entry is completed with a brief description of the weather conditions of the day, almost always in Latin. Symbols and expressions referring to astrological details (position of the moon and other planets, eclipses etc.) and, sometimes, to rural activities (e.g. vintage) also occur. In isolated cases unexpected ironic or personal comments can be found in this section. Meteorological terminology used in heading entries appears mainly in Latin. Some isolated phrases appear in Greek or German-Schwäbisch.
2. In the *main body* of his daily entries the author used to quote whatever might excite his imagination, his scientific awareness and his human sensitivity, or whatever would be useful to the practical needs of his life or the needs of his literary activity. First he described his previous night's dreams, always in Greek. Then followed notes on his personal, family and academic activities, his health, thoughts and desires, as well as summaries of his correspondence or his preachings (mainly in Latin, but also in Greek, and with isolated phrases in German-Schwäbisch, Italian or French).

Observations on weather appear, as mentioned above, under the heading of each daily entry. In this part of the daily entries Crusius describes with isolated adjectives/adverbs or short phrases the weather of every day and the previous night. The words or phrases, and their abbreviated forms, are separated by commas or colons. Each stem seems to correspond to one of the four crude fractions of the day: *mané*, *meridie*, *vesperi*, *noctu* (morning, midday, evening, night). That division of the day and night into four time-periods is not always used. Many weather entries contain up to three isolated descriptive words or phrases in the heading. In most of these cases, the stems function as 'blanket terms', and they are obviously employed by the author as typical meteorological descriptions outlining the dominant meteorological condition of the day.

The main body of Crusius' daily entries is of no less meteorological and environmental importance than the heading. Crusius makes notes in the main body of his entries in cases of exceptional or impressive weather phenomena (e.g. great storms, thunders and thunderbolts, harsh cold etc.), as well as when he wants to describe the harmful consequences of exceptional weather phenomena. Nor are phenological observations and harvest/vintage dates neglected.

The total number of weather observations in Crusius' *Diarium* for the period 1596-1605 is quite high, but there are some gaps. In 1596 records from January to September are sporadic, and there is no information at all from Sept. 20th to Nov. 25th 1604, or after Sept. 1st 1605 (Julian calendar). But it is obvious that for the period 1597-1603 we possess a weather diary that contains daily weather evidence of astonishing density (Table I).

Year	Days with records	Completeness of records per year	Missing daily records
1596	116	31.78%	249
1597	360	98.63%	5
1598	362	99.17%	3
1599	362	99.17%	3
1600	363	99.18%	2
1601	365	100%	0
1602	362	99.17%	5
1603	364	99.72%	1
1604	287	78.41%	78
1605	190	52.05%	175
Total → 3131			Total missing → 521

TABLE I. Total number of Crusius' *Diarium* weather records per year for the period 1596-1605. For the assessment of the yearly totals the dates have been reckoned on the basis of the new (Gregorian) calendar.

But can the *Diarium* be considered as reliable source for palaeoclimatic research? Because of the personal character of the work, the reliability of the information must be considered as wholly beyond question. The author's relation of the described events – either of his private or social life – is direct and frank.

Crusius was an eyewitness of what he reports. From the *Diarium* we obtain information concerning his daily life-style and the way he set about keeping his Diary. His house was at Lustnauer Tor, an area at the bank of the Neckar river, in the western quarter of Tübingen. Every day he used to wake up very early in the morning and work until noon in a special room of his house – a laboratory that he called his *Museum*. From internal information we learn that Crusius used to note down his daily records in the *Diarium* sitting in his *Museum* office. Sometimes, writing in a very cold room, early on a winter morning, was not a comfortable pastime: in 12[22]/01/1600 he protests, '*Atramentum in Museo congelascit, me hoc noctu scribente*' (Tonight the ink froze in the Laboratory, while I was writing). Crusius used to give two lectures daily in the University. He also had other academic activities which took him out of the house to the city centre. During these day-time hours we suppose that he was taking account of the weather and its variations. And during his promenades at Österberg – a hill in Tübingen, where Crusius used to visit his large private garden – he had the opportunity to observe the blooming of the trees and the environmental changes that took place during the succession of the seasons (Stahlecker 1942: 26).

In cases in which Crusius did not have direct experience of the meteorological conditions, he does not hesitate to mention the source of his information. In 20[30]/04/1604 he reports: '*Tonuit etiam, ut nepos ait*' (it thundered, my nephew says). His honesty in quoting the sources of his information is obvious also in the main body of his daily records. Under the special title '*Nova*' (News) Crusius reports on any remarkable information which has reached him from far away. This would be news in brief sent by post from a relative in Ulm or from an information office in Augsburg (Stahlecker 1942: 30). In addition, Crusius used to take advantage of oral accounts, rumours etc. In most of these cases he quotes – or lets the reader suspect – the origin of his information.

Though there is no case of intentionally misleading information in the *Diarium*, a few remarks must be made concerning the degree of accuracy of the observations. Crusius' age (over 70) could be considered a factor that might restrict the reliability of his records. For example, he complained vigorously at severe cold or heat. But these exaggerated protestations should not be perceived as distorting. His discomfort was highlighted by the use of a large variety of terms and expressions, and his irony is also in some cases an indication of how important weather was for him and how sensitive he was to the fluctuations of temperature and humidity. For example, on 15[25]/12/1601, Crusius' record, '*frigido, ventoso. Quàm bene!*' (cold, windy. How pretty!) is no more than an ironic comment on a new – and unpleasant for him – change of weather conditions. The degree of the fluctuation could perhaps be disputed, but the fact of the change should be perceived as unquestionable.

Finally, Crusius in his writings used to follow the Julian calendar. As a Calvinist in his religious beliefs, he remained faithful to the old calendar, which was also in use at that time in Württemberg, Germany. However, in some cases he also quotes dates according to the Gregorian (new) calendar (Göz and Conrad 1931: vii & 262, note).

4. ANALYSIS OF SNOW CONDITIONS CITED IN CRUSIUS' *DIARIUM*

1597 A.D.

Nov.17. «*humidae nivis. Tieffer waeg*»: humid snow. Snowed up deeply.

Dec.27. «*humido. nivali*»: humid. snowy.

28. «*nivali*»: snowy.

29. «*nivali et sicco*»: snowy and dry.

31. «*nivali humidoque*»: snowy and humid.

1598 A.D.

Jan.08. «*sereno, sic satis frigido, alba nive*»: fair, quite cold, white snow.

09. «*simili*»: likewise [fair, quite cold, white snow].

10. «*simili*»: likewise [fair, quite cold, white snow].

11. «*sereno et nivali*»: fair and snowy.

14. «*frigidissimo*»: very cold.

§: «*Concioni M. Wielandi, paries liberos cum dolore, interfui, magiore frigore: et niuibus congelatis.*»: I was present at the meeting of M. Wieland, you will give birth with pain, in harsh cold and frozen snow. [Crusius plays on words].

19. «*nivoso*»: snowy.

20. «*simili*»: likewise [snowy].

§: «*...Frigora magna apud nos, et nives altae.*»: «...Great cold by us, and old snows.»
[Phrase in a summary of a letter to M. I. Memb. and M. W. Haunoldo].

24. «*simili. Liquitur nix*»: likewise [more tepid]. Snow melts.

Feb.03. «*simili, interdum ningente*»: likewise [cold], occasionally snowing up.

04. «*manè ningente, postea sereno, frigido*»: morning snowing up, then fair, cold.

05. «*Ninxit, quieuit, vesperi pluit*»: it snowed, quiet, in the evening it rained.

07. «*sereno, nec frigido nimis*»: fair, not too much cold.

23. «*sereno, post nives*»: fair, then snow.

§: «*Auff der Alb, haben sie schon 46 schnee, disen winter gehabt.*»: On the Alps, there is already 46 [Zoll] snow during this winter. [1 Zoll ≈ 2 cm].

24. «*nivali*»: snowy.

TABLE II. Sample evidence on snowfall and snowcover from Crusius' *Diarium* (snow period 1597/98).

Note. The dates have been reckoned and are presented in this table according to the new (gregorian) calendar. This means that there have been added 10 days to Crusius' dates. In *italics* and between « » are presented the original daily meteorological observations made by Crusius. Occasionally, after § follow passages deriving from the main body of the daily records of the *Diarium*, also in *italics* and between « ». Comments between [] are made by the author of this paper.

Snowfall is an evident natural occurrence that could not but stimulate the attention of a concerned observer such as Crusius. In the *Diarium* there is obviously no reference to data of quantitative form in terms of numeric values. Therefore, the obtained data permits analysis by the frequency of its mentions. This provides the basic analytic statistic; the number of days with snowfall and snow-cover per month is counted and interpreted with regard to the averages in modern times.

We shall start with a concrete example of evidence, so that the form, the structure and the terminology of the daily meteorological entries, as well as the nature of the relevant palaeoclimatic evidence hidden in Crusius' text is highlighted. In Table II, all references from the *Diarium* concerning snowfall and snow-cover for the snow period 1597/98 are presented.

4.1. Discussion of Crusius' snow terminology

Meteorological phenomena are described in the *Diarium* by the use of a wide spectrum of meteorological terms and expressions. Here our view is focused on terms and expressions employed by Crusius when observing snow.

A classification of terms and expressions concerning snow, according to the parameters of the form of snow and its timing, is as follows:

1. Terms relating to snowfall

i. Before snowfall

-nivoso= snowy

-nives minante= threatening to snow

ii. During snowfall

-ningente= snowing

-parva nix= tiny snow

-nova nive= new snow

-alba nive= white snow

-maiuscula Nive cadente= drifting snow

-magna nix= heavy snowfall

-magna copia nivis= very heavy snowfall

iii. After snowfall

-quieuit= it stopped <snowing>

-ninxit= snowed

-niveo= snow-covered

-nivali= snowy

2. Terms for snow-cover

i. Snowing up

-nive decidua= snow has fallen

-durantibus nivibus= enduring snow

-nives iacent= snow is lying

-nive (alta) iacente= old snow lying

-nives iacebat= snow was lying

- nivibus iacentibus= snow lying
- nivibus ubique iacentibus= snow was over everywhere
- ubique nix= snow everywhere
- iacente densa nive= thick snow lying
- magna copia Nivis iacente= great abundance of snow lying
- humidae nivis *tieffer waeg*= deep, moist snow
- nivibus congelatis= frozen snow

ii. Melting of snow

- liquitur nix= snow melting
- liquescente nix= snow starting to melt
- altis nivibus liquescentibus= old snow beginning to melt
- nivibus diffluentibus= snow flowing away

The extent of Crusius' awareness of snowfall and snow-cover is evident from the rich variety of terms and expressions he uses. This wide spectrum of various and, sometimes, overlapping terms indicates the intention of the observer/author to introduce a crude intensity scale of the phenomena into his daily meteorological descriptions. But the calibration of Crusius' own intensity scale is not easy to ascertain. Crusius' meteorological terminology is of a qualitative character. Any attempt to evaluate the quantitative character of the isolated terms concerning snow (or any other meteorological element) must be pure speculation. Crusius' philological background provides him with a rich linguistic apparatus, and with a wide choice for the definition of any meteorological situation. For instance, the differentiation in the use of the terms *nivoso* (= snowy) and *nivali* (= snowy) is not very clear in the text. *Nivoso* means literally 'snowy', in a general sense, 'it is snowing', 'there is such a weather that it seems to be going to snow', 'it often snowed'; *nivali* means 'of snow' associated with 'cover' or similar terms. *Nivoso* appears only in 5 daily entries; *Nivali* in 32. In 27/11[07/12]/1603 Crusius quotes: '*frigido et nivoso. Magna nix*' (cold and snowy. Heavy snowfall). The meaning of *nivoso* seems to be in this entry 'it seems to be going to snow', while in a later phase of the day the snowfall is recorded with the phrase *Magna nix*. But how can we be sure that this phrase is not a pleonasm – a habit that is sometimes apparent in other entries of the *Diarium*?

From a purely meteorological point of view, Crusius' high educational level may restrict effective climatological interpretation of the meteorological information that the *Diarium* contains. If Crusius had not been an experienced literary man and an eloquent author – as his vast work reveals – the *Diarium* would perhaps have been a source of more explicit and precise daily meteorological information.

4.2. Snowfall frequency and duration of snow-cover 1597-1605

As stated above, the monthly and annual number of days with snowfall can easily be counted and compared to the averages of modern times. However, it is not so easy to count the days with snow-cover as recorded in the *Diarium*. According

to modern climatology, a day with snow-cover can be defined as a day during which more than the half of the surrounding area of a meteorological station is covered with snow at 07.30 (Pfister 1977: 451). It is obvious that we cannot expect consistency in such degree from Crusius' records. In many cases Crusius notes down snowfall, but he does not comment either on the duration of the snow-cover or on its melting. In these cases we infer that it snowed and melted again during the same day.

Crusius makes reference to snowfall and snow-cover in the *Diarium* in 136 cases (days). In this section, these records are submitted to statistical analysis and compared to the averages of modern periods (1881-1930 and 1950-1961, after Daubert 1967: 83-84 tab.21-25).

According to modern observations (Daubert 1967: 83), snowfall normally occurs in Tübingen from December to March. In some years snow may also be observed during October and May. A survey of the dates of first and last snowfalls in Crusius' *Diarium* for the period 1597-1605 on an annual basis shows that, in some cases, the dates deviate from modern averages. For the

Winter period	First snowfall	Last snowfall	Snow-free period
1596-1605			
1596/97	06. Jan.	14. Apr.	268 days
1597/98	17. Nov.	24. Feb.	266
1598/99	30. Sep.	29. Mar.	185
1599/1600	28. Nov.	27. Apr.	214
1600/01	14. Nov.	05. Apr.	224
1601/02	19. Oct.	28. Dec. 1601	295
1602/03	27. Nov.	23. Feb.	277
1603/04	07. Dec.	10. Apr.	240
1604/05	18. Dec.	11. Apr.	252
Average	21. Nov.	20. Apr.	246
= Probably earlier date because of missing information for the period Aug.-Nov. 1604.			
1881-1930			
Earliest term	04. Oct. 1881	15. Feb. 1910	
Latest term	09. Dec. 1906	18. May. 1882	
Average	14. Nov.	11. Apr.	215
1950-1961			
Earliest term	14. Oct. 1952	11. Feb. 1959	
Latest term	20. Dec. 1953	07. May. 1957	
Average	20. Nov.	06. Apr.	229

TABLE III. First and last snowfall in Tübingen 1596-1605; 1881-1930; 1950-1961 (new calendar).

winter of 1596/97 a quite late first snowfall was observed (6 Jan.), while for 1598/99 a very early first snowfall is recorded (30 Sept.). More striking is the date of the last snowfall of the winter of 1601/02, which occurred in 28 Dec. 1601, almost 3 months earlier than the average date for the decade (Table III).

On average, Tübingen gets snow for almost 23 days per year. January is the month with the highest frequency of snowfalls (5-7 days). Crusius' snowfall data present an altogether different picture from these modern averages (Table IV). The average of 11.4 days per year with snowfall for the period 1597-1605 appears considerably lower than the modern one.

period	J	F	M	A	M	J	J	A	S	O	N	D	sum
(a) 1597-1605	2.0	2.6	2.0	1.4					0.1	0.4	1.0	1.9	11.4
(b) 1891-1930	5.9	5.2	4.6	1.4	0.1					0.2	1.7	4.4	23.5
(c) 1950-1961	6.9	6.4	1.9	1.9	0.3					0.2	1.2	2.8	21.6
difference													
(a-b)	-3.9	-2.6	-2.6	0	-0.1				+0.1	+0.2	-0.7	-2.5	-12.1
difference													
(a-c)	-4.9	-3.8	+0.1	-0.5	-0.3				+0.1	+0.2	-0.2	-0.9	-10.2

TABLE IV. Average of days with snowfall (≥ 0.1 mm) 1597-1605; 1891-1930; 1950-1961.

Though the annual totals of days with snowfall indicate that the average for the years 1597-1601 is very close to that of modern times (16-20 days/year), the period 1602-1605 shows extremely low values (1-5 days/year). If we check the days with snowfall for each snow period (Figure 4), we observe a significant variation between the periods 1596/7-1600/01 and 1601/02-1604/05. In the former, the number fluctuates from 10 to 20 days with snowfall; in the latter, from 4 to 7 days. The winter 1599/1600 seems to have been rich in snowfalls (20 days). By contrast, the winter of 1602/03 had very little snowfall (only 4 days).

Crusius' comments, in some cases, are helpful for the scrutiny of the snow conditions in isolated snow periods. For instance, the weather during the winter 1597/8 was very snowy. In 6[16]/1/1598 Crusius noted down: '*Audimus his diebus, in tantis Alpium vicinarum niuibus, inveniri homines mortuos. Non interfui antemerid. concioni D.D.Gerl. propter frigus, senio meo parkens. ...Magno frigore.*' (We heard these days that in the entire region of the Alps, many people were killed by the snow. I did not attend the meeting at Gerlach's because of the cold. As an old man, I was shivering. ...Great cold), and a few days later, in 13[23]/2/1598: '*Auff der Alb, haben sie schon 46 schnee, disen winter gehabt.*' (On the Alps, there has already been 46 [Zoll] snow this winter. [1 Zoll \approx 2 cm]). Snow was also abundant during the winter 1600/01. Crusius mentions in 5[15]/2/1601: '*frigido, semper iacentibus nivibus: quia saepe hac hyeme*

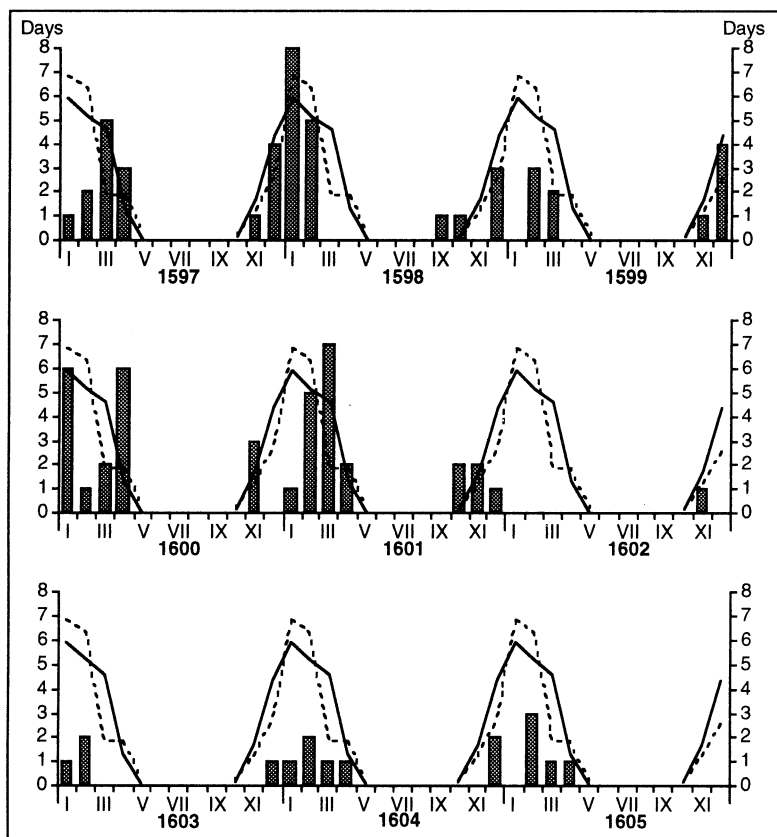


FIGURE 4. Variation of the number of days with snowfall in Tübingen 1597-1605 (obtained from Crusius' *Diarium*), in comparison with the modern averages (≥ 0.1 mm): 1891-1930 (—); 1950-1961 (- - -).

ningit.' (Cold, continually lying snow; because it is snowing incessantly this winter).

As shown in Table IV, the annual average of days with snowfall for the period 1597-1605 in Tübingen is considerably lower than the modern one. But, if we compare these numerical values with the average number of snowfalls recorded in Tübingen by Johannes Stoeffler for the period 1517-1524 (Schwarz-Zanetti and Schwarz-Zanetti 1992: 40, tab. 3a), then we obtain values quite close to those derived from Crusius. If we compare the monthly averages, we observe a notable variation among Crusius', Stoeffler's and modern snowfall-values for the month of January (Table V). Snowfall in Tübingen during January for the period 1597-1605 is 2 days less than for the period 1517-1524, and about 3.9 to 4.9 days less than for modern times.

year	J	F	M	A	M	J	J	A	S	O	N	D	sum
Days with snowfall per month A.D. 1597-1605 by Martin Crusius (Jul. cal.)													
1597		6	1	3							1	7	18
1598	8	3							1	1		3	16
1599	1	3	1								1	6	12
1600	5	1	5	2							3		16
1601	5	4	6							2	2	1	20
1602											1		1
1603	1	2										1	4
1604	1	2	2									2	7
1605		3	1	1									5
Days with snowfall per month A.D. 1517-1524 by Johannes Stöffler (Jul. cal.)													
1524	4		2								3		9
1523	3	3									4	9	19
1522	4	2								1	3	3	13
1521	3		3	1									7
1520	2	3	3		1				1			3	13
1519	8	5	2							2	3	5	25
1518	5	5	7								3	3	23
1517	5	1	1	1							6	4	18
Averages													
(a) 1597-1605	2.3	2.7	1.8	0.7					0.1	0.4	1	2.5	11.5
(b) 1517-1524	4.3	2.4	2.3	0.3	0.1				0.1	0.4	2.8	3.4	15.9
difference													
(a-b)	-2	+0.3	-0.5	+0.4	-0.1				0	0	-1.8	-0.9	-4.4

TABLE V. Days with snowfall in Tübingen (Julian calendar):

A.D. 1597-1605 observed by Martinus Crusius and A.D. 1517-1524 observed by Johannes Stoeffler.

Source: A.D. 1517-1524: Schwarz-Zanetti and Schwarz-Zanetti 1992: 40, Table 3a.

As mentioned above, the procedure of reckoning the days with snow-cover recorded in the *Diarium* is not always trustworthy; especially when Crusius does not give any information on the duration of the snow-cover or the melting of the snow. Therefore, with some degree of speculation, a few differences may be discerned with regard to the duration of snow-cover between modern and Crusius' reconstructed time-series data (Figures 5 and 6).

The modern annual average snow-cover in Tübingen is 32.6 and 37.1 days for depth of snow ≤ 1 cm and ≥ 1 cm respectively (Daubert 1967: 83). The annual average for the period 1597-1604, as reconstructed from Crusius' information, is 38.8 days. It is worth mention that the duration of snow-cover was between 50 and 63 days for the snow periods 1599/1600, 1600/01 and 1601/2. These winters had about 25 days more snow-cover than the modern average. The duration of

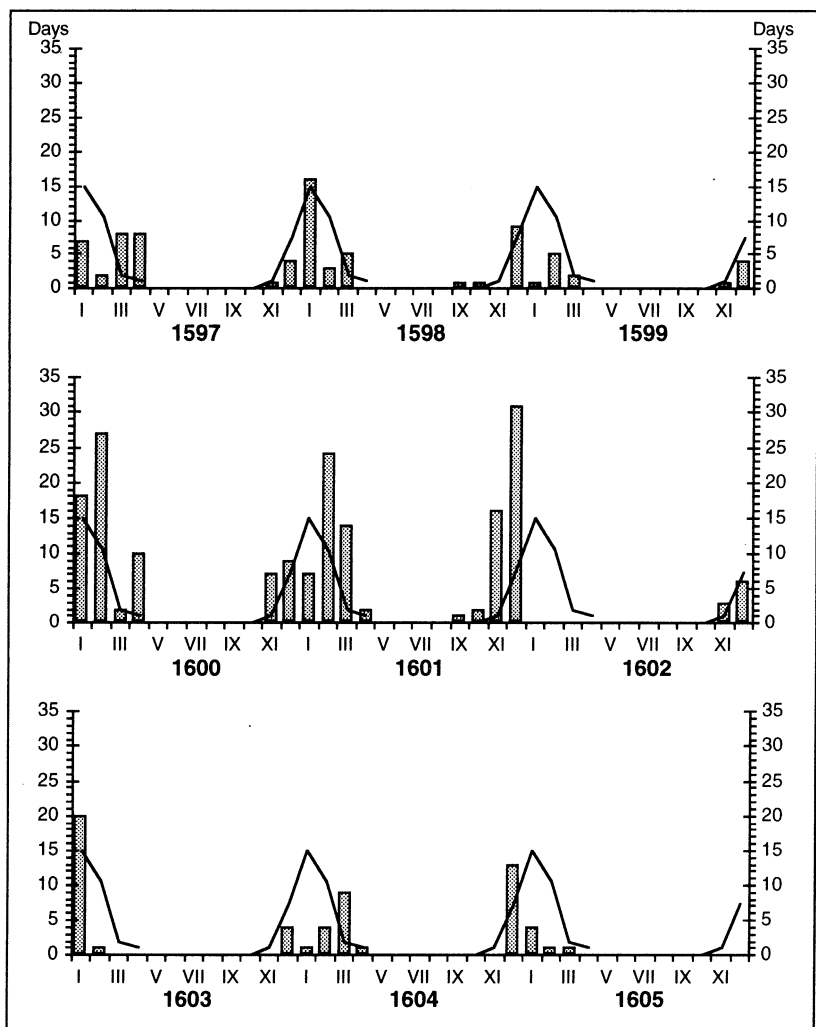


FIGURE 5. Variation of the number of days with snowcover in Tübingen 1597-1605 (obtained from Crusius' *Diarium*), in comparison with the modern average (≤ 1 cm): 1950-1961 (—).

snow-cover in the remaining winters (1596/97, 1597/98, 1598/99 and 1602/3, 1603/4, 1604/5) was less than the modern average.

Finally, Table VII shows the first and last appearance of snow-cover in Tübingen for the years 1597-1605, compared with modern data.

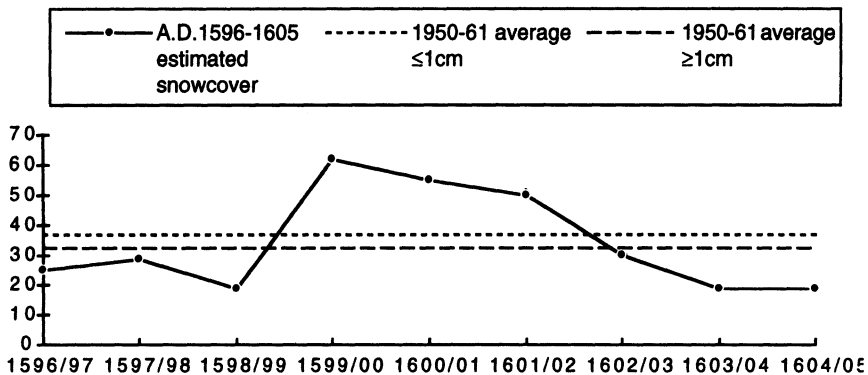


FIGURE 6. Annual total of estimated days with snowcover in Tübingen 1596-1605; 1950-1961 (average of days with snowcover ≥ 1 cm and ≤ 1 cm).

Period / Value	First snowcover	Last snowcover
1597-1605		
Earliest term	31. Oct. 1601	22. Nov. 1601
Latest term	06. Jan. 1597*	24. Apr. 1600
Average	03. Dec.	06. Feb.
1950-1961		
Earliest term	27. Oct. 1950	03. Feb. 1959
Latest term	09. Jan. 1960	29. Apr. 1959
Average	02. Dec.	21. Mar.
* = Not safe date because of missing information for the period Jan.-Oct. 1596.		

TABLE VI. First and last snowcover in Tübingen 1597-1605; 1950-1961.

4.3. Conclusions

In his *Diarium* Martinus Crusius provides a wealth of documentary climatic evidence. His day-to-day descriptions of weather elements produce a data set of great importance for the reconstruction of Tübingen's climate for almost a decade (1597-1605). Further investigation and analysis of the daily weather records gives rise to interpretive problems concerning the exact content and the quantitative character of the meteorological terms employed by Crusius. These problems have been approached in this paper on the basis of classifying meteorological information under the headings of snowfall and snow-cover.

Using the snowfall and snow-cover data gathered from *Diarium*, the annual average number of days with snowfall during the period 1597-1605 in Tübingen

appears to be considerably lower than the modern one. Study of the monthly incidence of snowfall provides a picture of winters with scanty snowfalls. A similar picture is also obtained for Tübingen during the earlier period of 1517-1524, using data derived from Johannes Stoeffler's weather diary. In a very few cases the monthly average is considerably higher than the modern averages (January 1598, April 1600, November 1600, March 1601). On the other hand, there are several winters with no, or very few, days of snowfall during January and February. The winters 1601/02-1604/5 seem to have been exceptionally poor in snow. Moreover, no significant frequency of snowfall is reported for October, November, March and April (which would have pointed to below average temperatures in those months). Only for the year 1600 does snowfall data indicate a possibly reduced temperature régime.

Snow-cover – as an eye-catching meteorological feature – also has its position in Crusius' weather records. The persistence of snow-cover is related to the sequence and duration of weather patterns favouring accumulation and ablation. A very small number of days with snow-cover is usually related to warm winters (Pfister 1992). This régime seems to have been dominant during the years 1597-1605 in Tübingen, with the exception of the winter 1600/01. For this winter there are a lot of historical records from various sources attesting to abundant snow in western and central Europe (Hennig 1904: 100 & 198 tab.V; Easton 1928: 55). Elaboration of all available information has shown that this winter was 'severe and very cold' in Europe (Camuffo and Enzi 1992: 151 tab. 7.1).

Further research in the weather records of the *Diarium* will provide meteorological information for other elements (temperature, rain etc.) and will help to construct a more precise picture of the meteorological régime in Tübingen at the end of the 16th and the beginning of the 17th century (Telelis in prep.).

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