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# From Data to Climatological Indices - The Case of the Grotzfeld Data Set

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## The Grotzfeld Collection – From Sources to Climatological Indices

Starting in the 1980s, the data set presented here was initially collected by Prof. Dr. Heinz Grotzfeld and his working group at the Institute of Arabic and Islamic Studies of the University of Münster in the framework of the paleoclimate program of the German Federal Government. This program was sponsored by the former Federal Ministry for Research and Technology (BMFT) with the aim of exploring written sources of the Near and Middle East for climate reconstructions, adopting and developing appropriate procedures of quantification.

In the framework of this project, several thousand data with relevance regarding climatology and environmental history were acquired. Its sources are mainly chronicles and annals, a genre that was established in the orient since the 8th century, mainly by scholars and historians. Although their main focus was the documentation of the lives of important persons, they also included information about extraordinary phenomena, including climatic, social and political incidents.

Due to political changes the concentration of source material shifted over time: Between the 9th and the 13th centuries, the majority of sources came from Iraq, afterwards from Syria- Palestine and Egypt. Generally the majority of information originates in major cities and therewith densely settled areas such as Baghdad, Damascus and Cairo, which at the same time served as scientific centers (Vogt et al. 2011)..

## Source-critical evaluation and primal coding of data

Firstly, the acquired sources were source-critically evaluated to ensure their reliability and to be able to extract useable insights. In doing so, existing source-critical approaches were used (c.f. Glaser, 2013). Following hermeneutic principles, these issues of critical source analysis were mainly developed on the basis of European documentary sources. Nevertheless, they proved to be helpful guidelines for an initial evaluation of the Arabic sources. In accordance with the sociocultural circumstances, the data sets were then modified. Firstly, the historic place names were synchronized with their modern analogies and the date specifications given in the hijra calendar system based on lunar months were converted into the Gregorian calendar . Another significant difference lies in the fact that Arabic sources focus more on hygric aspects like precipitation, aridity and drought, while European documents tend to concentrate on thermal matters. This implies a further differentiation of the respective terminologies. Like in other areas of the Mediterranean climate zone, the seasonal focus lies in the hydrological winter, this being the relevant time for agricultural utilization.

Initially, the newly acquired data sets were coded using the HISKLID scheme established by the parallel project on paleoclimate by Glaser&Hagedorn. This first codification included the determination of place, time and content (Glaser&Militzer 1993, Glaser 1996). First evaluations of this database allowed for regionally differentiated and indicated time series (Grotzfeld 1991).

## Grotzfeld data set reloaded – transfer of data to tambora.org

After Prof. Grotzfeld´s retirement this valuable data set, unique for this region and time, remained in his previous institute in Münster, mainly still documented in form of handwritten file cards. As in many similar cases, over time these data would have become inaccessible and unavailable for subsequent studies. The work

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of decades, financed by public money, would have been lost.

Thanks to personal contacts and knowledge of this situation, however, it was possible to transfer the Grotzfeld data set to tambora.org as part of a DFG-project carried out in the years 2010 to 2013 (GL 358/8-1), thus ensuring the long-term data storage and protection (Riemann et al. 2016). Thereby, the data set was not only digitized, but also thoroughly reviewed and revised. This particularly included a more detailed codification. Additionally, a regional climate model was developed to allow an assessment of the spatial representation of the indices obtained from these codifications (Riemann 2012).

### Generation of digitized data and new codification of the data set

In a first step, the file cards were digitized; the German, English or Arabian handwritten entries were transferred into a word processing program and consistently translated. To allow a correct temporal codification of the data, the date specifications were converted into the Gregorian calendar.

وقد ذكرنا ماجرى على النخل في السنةالماضية من البرد والريح، فلما جاءت
هذه السنة عدم الرطب إلاّ مايجلب من بعد، فبيع كل ثلاثة أرطال بدينار جلالي،
واشتد البرد فجمدت حافات دجلة، ووقفت العروب بعكبرا عن الدوران لجمود
ماحولها، وهلك ببغداد من النخل عشرات ألوف.

*In the year 419 H ∼ 1028 AD; (25.05.419 = 21.6.1028)*
*Because of the already mentioned coldness and wind of the last year there had been no dates apart from those, which had been imported. Therefore the prices had been very high.*
*The coldness had been this strong, that both sides of the Tigris river had been over frozen and the watermills stopped.*
*Thousands of palm trees had been damaged.*

*Figure 1:* Text sample with transcription. Source: Ibn al-Jawzi, Vol. 9, p. 218 (cf. Ibn al-Athir, al-Kamil, Vol.9, p. 370).

The HISKLID based coding scheme that was used for the first codification by Grotzfeld´s working group has been strongly modified and extended during the course of the project. In periodic meetings the citations of the Grotzfeld collection were source-critically evaluated following Gadamer´s hermeneutic approach. The pre-coded data were iteratively controlled and adapted to the strongly extended scheme of tambora.org to ensure an optimized and consistent generation of semantic profiles. Missing codifications were identified and added; automated processes like calendar adaptations were evaluated. For many of the climate relevant events mentioned in the citations certain knowledge of place and climate was indispensable. One example of such location-dependent classifications is the low tide at the Nile, which does not describe an extremely low flow rate (following the Central European definition), but the Nile´s normal state.

### Derivation of indices

Based on these newly coded data with their consistent semantic profiles new indices were derived. Not only were the data temporally and locally attributed, but also their content was coded and indexed. The new codification also included a revision of the previous scaling of climatic values as its use of even class numbers created an artificial asymmetry, which did not correspond to the climatic realities. The new odd-numbered scaling scheme used by tambora.org is based on the coding scheme of HisKliD 2.0 and provides seven indices: extremely hot receives the value '+3', very warm '+2', warm or above average '+1' and normal '0'. Cold temperatures are depicted on the negative scale. The value 0 corresponds to the long-term mean value, the step widths of the negative and positive index classes to the standard deviation of 0.75 (Glaser 1996, Glaser 2013).

These indices are weighted as their frequency distribution has to coincide with the one actually recorded.

Average values occur most frequently. The higher the absolute value of an index, the lower the probability that it is being classified (Riemann 2012). These findings were confirmed by the results of the parallel project based on the almost daily and therewith highly resolved diary entries of Ibn Tawq. Although he rarely noted down average temperatures – mostly only when it was cold before and the cold weather let up –, but as days without temperature recordings have to be classified as normal, these clearly outnumber those with entries on heat or cold.

For the indexation of precipitation, indirect information had to be transformed into codeable rain equivalents. Such descriptions include "water was flowing out of the gutter" (almost exclusively accompanied by the indication "it was raining a lot") or "the roof was dripping", which were coded with "plenty of rain" and "very much rain". The respective indices of these codifications were only inserted when there was an explicit description of the duration of the rainfall event. For the codification of precipitation in form of snow, another scheme was introduced in which 1,000 mm of fresh snow equate to a water equivalent of 100 mm (Grotzfeld 1990)

For the high resolution time span of Ibn Tawq´s diaries 1480 - 1501 AD in the region around Damascus, a detailed analysis of the hygric and thermal circumstances was derived, which in turn served for the calibration of the indexing technique explained above. These were correlated with recent comparative data providing differentiated insight into the weather development in this phase of the Little Ice Age.

As a matter of course, a specific degree of uncertainty remains, even if the high resolution data offer very good calibration possibilities. As every chronologist described precipitation events differently, Grotzfeld initially only incorporated the values of expressions that were used by both Ibn Tawq and Ibn Ḥijjī. In the following, precipitation amounts were also assigned to the expressions only occurring in Ibn Tawq´s diary. Admittedly, these results remain estimated values, as the perception of precipitation intensities is always subjective. Even if Ibn Ṭawq and Ibn Ḥijjī used the same expression, they might describe different precipitation values. A precise quantification is, however, only of minor importance in climatic reconstructions. For the analysis of long-term climatic developments, general trends and fluctuation are more important than absolute values (Riemann 2012).

Another possibility to evaluate the quality of the sources used is a cross-validation of the astronomical or earthquakes events with astronomical calculators like CalSky.com and earthquake catalogues. Such a comparison of Ibn Tawq´s astronomical entries shows a very high correlation with the calculated astronomic events, highlighting the extraordinary quality of his observations.

Temperature data were examined as deviations from the corresponding mean value. The sums of al thermal indices per season were listed and compared to show seasonal and interannual temperature fluctuations. Additionally, weather elements like the degree of cloud coverage and the frequency of dust were reconstructed and phenological data as well as natural phenomena were evaluated. Last but not least, weather profiles of the individual years were generated.

## Indexed source texts for the Far and Middle East

In the following, the result of this long and laborious process is presented. The original, translated text citations are supplemented by their temporal and spatial information and by short content-related analyses. The two data sets of the tambora.org data series Vol. 1 and 2 complement each other spatially and with regards to content (Schönbein et al. 2016).

Interested parties may retrieve and freely use the complete data set in digital form via the online portal tambora.org. Both forms – the analogous and the digital one – are meant to encourage the submission of additional data sets that can be published via the allocation of citeable dois within the CRE-infrastructure.

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