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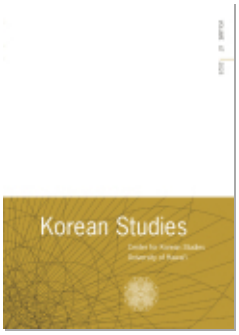


Korean Studies, Volume 47, 2023, pp. 8-33 (Article)

Published by University of Hawai'i Press
*DOI:* *https://doi.org/10.1353/ks.2023.a908616*

# Korean Chronicles Under a Macroscope: Towards a Digital Infrastructure in Premodern Korean Studies

*Hyeok Hweon Kang and Michelle Suh*

Starting in the 1990s, digital humanists have endeavored to create the "macroscope," a holistic research environment that allows for a flexible, multiscalar reading of large text corpora. Many macroscopes have since emerged, from fields as diverse as Danish folklore studies, English literary studies, and Chinese biographical studies. But in creating Silloker, we are the first to offer a "historian's macroscope" for premodern Korean chronicles. Silloker is a digital platform that opens creative avenues into studying Korea's Chosŏn dynasty (1392–1910). Its title takes after *Chosŏn wangjo sillok* ("Veritable Records of the Chosŏn Dynasty" 朝鮮王朝實錄), court annals that cover five centuries and topics as varied as diplomacy, economy, religion, quotidian life, and natural phenomena. For this archive and others—for example, *Diaries of the Royal Secretariat* 承政院日記 (*Sŭngjŏngwŏn ilgi*), *Records of the Border Defense Council* 備邊司謄錄 (*Pibyŏnsa tŭngnok*)—our platform features new search capacities and tools for exploratory data analysis. First, it allows users to make unified queries across multiple archives and download the search results. Second, it offers a tool for aggregating and graphing the frequency of search hits throughout the five-centuries long dynasty, generating real-time results in table and graph. This essay introduces Silloker, its functionalities, and data architecture. It then provides an example case study of the Little Ice Age in Korea to demonstrate the platform's utility for historical research.

Keywords: macroscope, digital humanities, sillok, Chosŏn Korea, search engine, Little Ice Age, data visualization

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Premodern Korean studies has been a field ripe for the "digital turn." Korea's Chosŏn dynasty (1392–1910) in particular boasts one of the largest corpora of digitized texts for the premodern world. For instance, the *Veritable Records of the Chosŏn Dynasty* (*Chosŏn wangjo sillok* 朝鮮王朝實錄; hereafter *Sillok*) are daily court annals that cover five centuries and topics as varied as diplomacy, economy, religion, quotidian life, and natural phenomena. This amounts to 49,646,667 characters and 1894 books, fully digitized. But it is just a sliver of the whole: *Diaries of the Royal Secretariat* (*Sŭngjŏngwŏn ilgi* 承政院日記) is four times larger, *Record of Daily Reflections* (*Ilsŏngnok* 日省錄) comes close to the *Sillok*, and then there is the *Compendium of Korean Collected Works* (*Han'guk munjip ch'onggan* 韓國文集叢刊) featuring approximately 15,018 books by 1,259 authors.[1] These digital archives present unique opportunities for studying Chosŏn with computational methods, and contributing Korean data to the burgeoning field of digital humanities (hereafter DH). The opportunities have remained largely unexplored, however.

This has in part to do with what Javier Cha terms the "digital/humanities divide."[2] Cha shows compellingly that despite the explosive growth of digitized historical data in South Korea, its potential for DH has mired in a rift between the "digital" and the "humanities." Starting in the 1980s, Korean officials and industry leaders sought a post-industrial transformation and invested heavily in information and communications technology (ICT). But South Korean ICT only took off in the 1990s, particularly after the 1997 Asian financial crisis. Advances were made in semiconductors, consumer electronics, and telecommunications, which catapulted Samsung, LG, SK Hynix, and Korea Telecom into the global market. And in the informatization of its cultural heritage, too, South Korea became "a digital power" (*tijit'ŏl kangguk* 디지털강국).[3] With a fund of $108 million USD, the Ministry of Communication and Technology launched the Informatization Labor Project (*Chŏngbohwa kŭllo saŏp* 정보화근로사업) in 1998, supporting the digitization of historical works in public research institutes. This also gave occasion to a unified platform named National DBs (*Kukka tibi* 국가 DB), where 62 databases on Korean history and culture—including those identified above—were made available and searchable.[4] The corpus of digitized texts has since grown further and today, government initiatives continue to invest an annual budget of $66.4 million (14 times larger than that of the NEH Office of Digital Humanities in the United States).[5]

The abundance of digitized information notwithstanding, Korean humanities has yet to go fully digital—a foundational shift that transcends

beyond simply enjoying historical data in digital, searchable form, to employing computational methods to better query, contextualize, and analyze said data. Cha aptly summarized the issue at hand: "the availability of digitized materials, no matter how large in scale and how high in quality, does not spontaneously lead to explorations in new modalities enabled by digitization and digital technologies."[6] How then might one go about encouraging such explorations? And what might these explorations look like in terms of concrete research outcomes?

Other authors in this special issue provide important answers and case studies, and more will emerge from the continual training and professionalization of digital humanists in Korean studies. But a "digital turn" would also entail the widespread use—beyond self-identified digital humanists—of computational methods and tools. On this, and with regards to premodern Korea in particular, there is then an identifiable problem to be solved: a disconnect between the National DBs, built under government directives, and the shifting interests of "grassroots historians" whose research—traditional or computational—may require alternative search engines as well as new media for exploratory data analyses. Addressing this problem has significant outcomes: it not only presents a novel resource for premodernists and lowers their barriers of entry into the field of DH. It also addresses a longstanding, crucial concern in that field—that is, how to build a sustainable infrastructure for digital humanistic inquiry, one which offers a dynamic study environment for data mining, analysis, and visualization.

In DH-speak, this is essentially the problem of building a "macroscope"—a holistic research environment that allows for a flexible, multiscalar reading of large text corpora.[7] As defined by the term's originator Katy Börner, macroscopes are capacious instruments that "provide a 'vision of the whole,' helping us 'synthesize' the related elements and detect patterns, trends, and outliers while granting access to myriad details."[8] At their best, then, these tools do not fix their gaze on the "great unread."[9] They become adjustable so as to combine both close and distant reading practices,[10] and "intelligent" in the sense of connecting main texts to other contextual sources as well as generating real-time visualizations with, for instance, geographical referencing and network analyses. Since the 1990s, digital humanists of many walks—from Danish folklorists to English literary scholars and classical Chinese philologists—have attempted to a create such a macroscope for their respective fields. And their efforts led to now-mature platforms such as Voyant Tools, Palladio, EarlyPrint, Intelligent Search Engine for Belief Legends

(ISEBEL), Network Navigator, Chinese Text Project, The China Biographical Database, and so on.

The challenges of crafting a macroscope, however, are still with us and their utility depends on the nature of the texts—and contexts—they (re)present. For instance, the limitation with some macroscopes is that they are unevenly "general-purpose" or too specific. Having broad usage, of course, is good, but most of the currently available tools and platforms are not always generally useful: despite being language-agnostic, their utility value is determined by the level of text preprocessing needed (and whether its experience is readily shared and available).[11] Surely, this will improve as more macroscopes—and basic resources to build them bigger and better—emerge from, for instance, East Asian data. But the biggest challenge of going macroscopic is to "crosswalk," that is, move beyond a single corpus or project to include multiple corpora, resources, and features. Understandably, the works of many pioneers have thus tended to be "singletons": to date, while social historians have examined marriage practices based on a single genealogy record,[12] diplomatic historians tried network analysis on a set of international criminal data,[13] and intellectual historians ran topic modeling on a local newspaper or chronicle archive,[14] their works have remained fundamentally "atomistic" approaches to the problem of the macroscope.[15]

Given these limitations, critics have now begun to prioritize "fine-tuning," rather than amplifying, the macroscope.[16] For instance, as Cha demonstrates with a new workflow based on Neo4j data management system, Korean DH scholars can "create personal libraries tailored to their projects rather than engage in macro-level 'distant readings' of a centralized repository."[17] Doing so overcomes the problems inherent in macroscopes, "which are not permanent and authoritative stores of information, but rather imperfect collections with complicated backstories" to begin with.[18] It also aims at creating a small yet capacious database, rather than aspiring for "universality," which is not only impractical but prohibitive for individual researchers.[19]

This is a compelling way forward, but we argue that it's too early to declare bigger macroscopes passé: they can be just as useful, complementary to its "fine-tuned" peers, and particularly efficient in a field like premodern Korean Studies—rich with open access repositories (e.g., *Sillok*) yet deprived of a suitable infrastructure to service them.

As a test case, we thus offer Silloker, our first attempt at creating a holistic "historian's macroscope" for premodern Korean chronicles.[20] Silloker is a research environment that joins major Chosŏn archives in a

single search engine and allows the users to (1) query across multiple archives and download search results, and (2) graph the frequency of search hits across time. These features reflect our aim to create a macroscope which not only unifies and curates the existing "chronicle" archives, but also integrates the tools for exploratory data analysis as well as data visualization and navigation. Though in its early stages, Silloker has some unique functionalities: for Koreanists, it unifies for the first time their multiple centralized repositories at the data level[21]; for East Asianists, it represents the first "relative frequency graph" function for literary Sinitic texts that searches across multiple repositories[22]; and for the broader field of DH, it offers a distinct case of a macroscope built from open source centralized repositories (freely downloadable through the South Korean government) and featuring exploratory data analyses on well-transcribed and systematically curated texts (as opposed to say, OCR-based public domain books in Google Books Ngram Viewer).

## Premodern Korean DH: Its Current State and Future

Let us first situate Silloker properly in the history of Korean DH. There was in premodern Korean studies "DH" avant la lettre. As early as 1966, two historians Edward Wagner (1924–2001) and Song June-ho (MR: Song Chunho, 1922–2003) worked on a database of civil examination (*munkwa*) passers with punch cards at the Harvard-Yenching Institute. Their Wagner-Song Munkwa Project marked the first computational approach to Korean humanities, and it compiled as many as 14,600 successful passers according to their personal and familial information.[23] Even before 2001, however, when this data became published in CD-ROM (deemed at the time a high-capacity storage medium), another pioneer Kim Hyeon (MR: Kim Hyŏn) led the digitization of *Sillok*. Starting in the 1990s, at the Korea Institute of Science and Technology, Kim transferred more than 50 million characters of chronicle data into a CD-ROM, making this crucial resource searchable for the first time.[24]

But Kim's greatest contribution was in creating a "portable" data architecture—based on XML schema—that has defined the way Korean historical data is curated to this day. In creating his online edition of *Sillok*, Kim "played a key role in reworking the archive's data ontology for the internet"—namely, building a database with hundreds of XML documents, each containing individual chronicle entries with mark-ups. This basic architecture became the model for other databases that arose since the

1990s, including first the *Compendium of Korean Collected Works* and by extension, the "national DB super-collection," which today boasts of 78 individual DBs under the categories of "history," "culture," and "education."[25]

From the 1960s to the present, and from punch cards to CD-ROM and XML, Korean historical data has undergone a revolution in digital accessibility. Yet, writing in 2022, the current state of historical DBs leaves much to be desired: their data architecture and online search services are no longer "remarkably up-to-date in database and content-management technologies."[26] Bogged down by size and locked in a bureaucracy, they have the following limitations that restrict the users' experience and engagement with the provided data.

Take, for instance, a historian who wishes to undertake quantitative research on the relationship between statecraft and agricultural practices in the Chosŏn. A natural place to begin would be to search key terms such as "recommending agriculture" (*kwŏnnong* 勸農) and "agricultural treatises" (*nongsŏ* 農書) in the online DBs for government records—for example, *Sillok*, of course, but also *Sŭngjŏngwŏn ilgi* and *Records of the Border Defense Council* 備邊司謄錄 (*Pibyŏnsa tŭngnok*). Currently, these DBs offered by the National Institute of Korean History (hereafter Institute) provide a reliable and convenient access to relevant records.[27]

Problems arise, however, if the researcher wants to "mine" and visualize the data. How did the court's involvement in agricultural practices change over time? Did it increasingly produce and circulate more agricultural treatises? To answer these questions, one needs first to aggregate the frequency of search terms above and inspect for any rise and fall of the data. But because the current user interface presents the entries in multiple layers, it is difficult to get an aggregate sense—or "distantly read"—the underlying data. That is, one would need to click into each entry and back, which quickly becomes inefficient—and error-prone—when there are hundreds and thousands of output. To be sure, the current DB does offer a "download" feature, but it is not functional: what the user receives is the metadata only (i.e., a topic sentence that describes the content of the entry).

"Data mining" in premodern Korean studies has thus been manually driven, as in accessing each entry, copying and pasting onto a document.[28] It has also been prohibitive to those without the resources to hire (often graduate student) labor. To find out if the above questions are even worth asking from a quantitative angle, an individual researcher would need months, if not years. To manipulate and visualize said data would be still further away.

Of course, search engines can't be the panacea to historical research. Open access to these important archives alone is a boon that is rarely enjoyed in other fields. Moreover, a historian must still closely read, historicize, and understand the sources at hand, without which an aggregate count is meaningless. Yet, many of the problems identified above can be—and have been—resolved with the new search platform, Silloker.

## Silloker and its Features

Silloker alters the way we interact with chronicle data by opening new avenues for data mining and manipulation as well as real-time visualization. Two features contribute to this end: "Search and Download" and "Aggregation."

The first feature allows users to search across multiple archives and store the results in various forms (e.g., CSV, TSV, Excel, Word). Currently, three major archives are serviced on the platform—*Sillok*, *Sŭngjŏngwŏn ilgi*, and *Pibyŏnsa tŭngnok*; but the *Ilsŏngnok* will be added later to complete the set commonly used for Chosŏn historical research. But already, users can perform effective queries across available archives. They can employ multiple keywords in conjunction, and with parameters of their choosing such as year range and record type. The search result is also provided in a simple, streamlined user interface that minimizes clicks (Fig. 1): all the relevant metadata (book, date, title, etc.) are presented with full text, which precludes the need to route in and out of entries, and back and forth between tabs.

If deemed worthy of storing and further manipulating the data, the researcher can download the entire query result in say a TSV (tab separated value) format (Fig. 1). At the least, this eliminates the need for brute data mining by manually copying and pasting thousands of entries—or for automated web scraping which can overload and crash the servers. For more ambitious users, the feature also provides new flexibilities to undertake further computational work such as network analysis and topic modeling. Still more possibilities will open up in the future as we plan to allow querying by categories (or topics) of entries as well as markup tags like names, books, and locations.

The second feature aggregates and graphs the frequency of search hits across time (five centuries, from 1392 to 1910) and multiple archives (identified above). This "Aggregation" tool visualizes any given search term on-demand. In a single page, users can generate real-time results in both

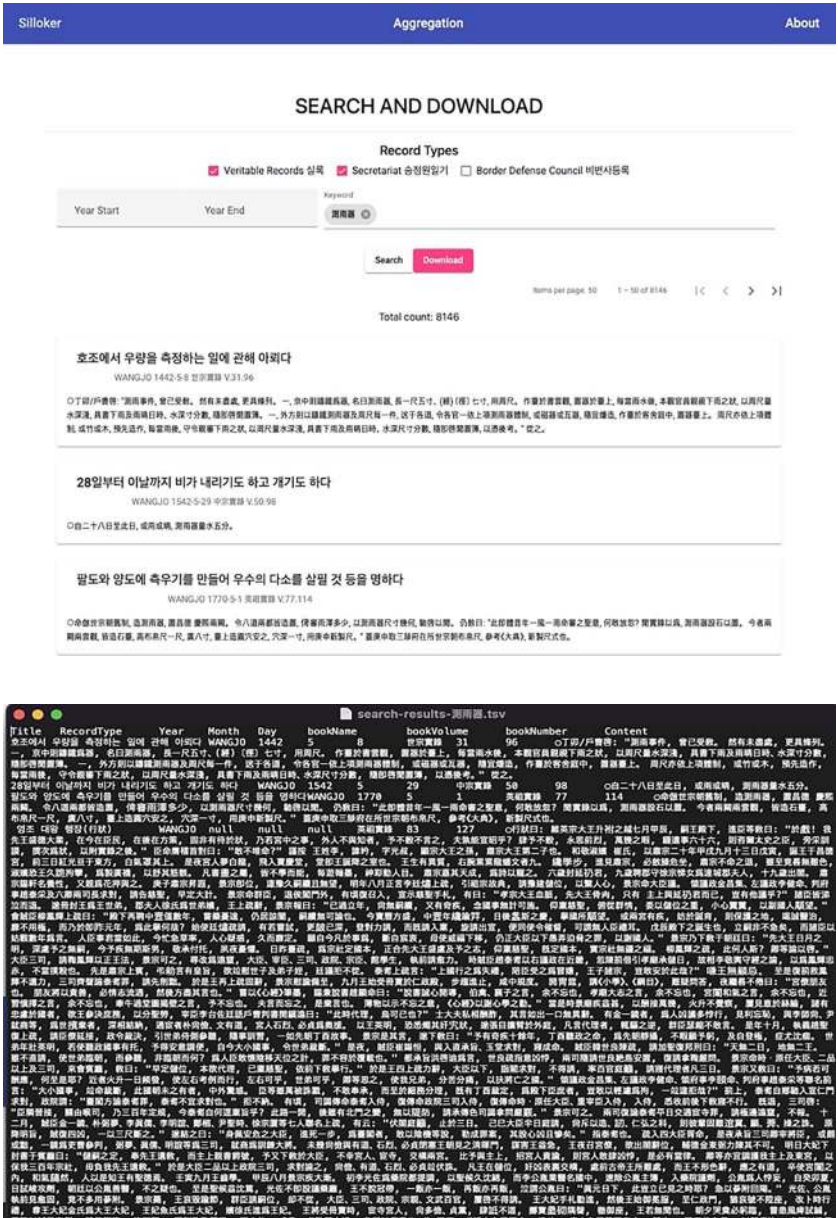


*Fig. 1.* The search (a) and download (b) results for "rain gauge" (*ch'ŭgugi* 測雨器) in Silloker.

table and graph. Also, with every search ensues three graphs that help contextualize the data shown: (1) frequency graph, (2) total records graph, and (3) relative frequency graph. The frequency graph displays the total number of entries containing the given keyword(s) by year. The total records graph—which is static across search terms—gives the rate of documentation, that is, how many entries in total were kept each year per record type. Taking the ratio of the values from the first graph to the second, the relative frequency graph shows the relationship between the number of keyword hits and the total number of records written per given year.

Let's put this concretely with an example search term, "rain gauge" (*ch'ŭgugi* 測雨器). The first graph for this term shows its incidence throughout the dynasty, which from two archives (*Sillok* and *Ilgi*) alone is a total of 8146 results. One can immediately see that most results are clustered in the late eighteenth and nineteenth centuries (Fig. 2). This raises an important research question, Why, if this device was first conceived in the fifteenth century, do we see its unprecedented discussion starting in the late eighteenth century? But for this question to be worthy of pursuing seriously, some predictable concerns about the nature of the provided data need to be alleviated. Are there simply more records available to us over time? Is the sudden proliferation of hits we see in the last two centuries a function of this increase in documentation—rather than indicative of a historically interesting phenomenon?

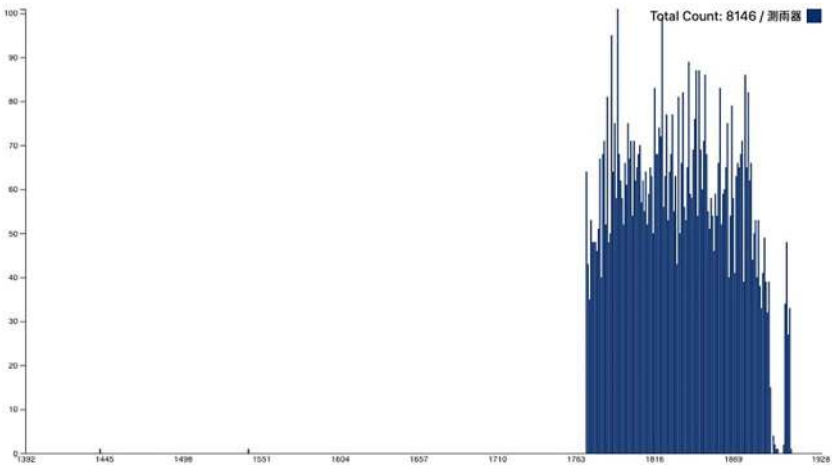


*Fig. 2.* Frequency graph for the term "rain gauge" (*ch'ŭgugi* 測雨器) in *Sillok* and *Ilgi*. From Silloker.

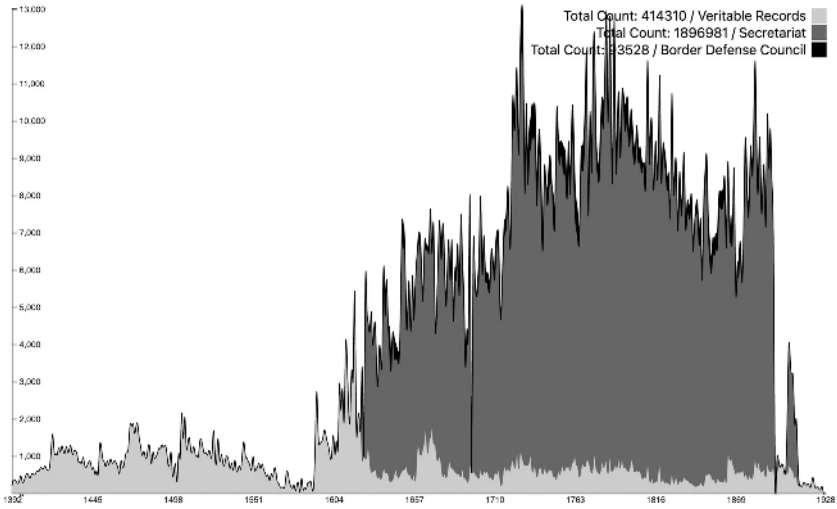


*Fig. 3.* Total records graph. From Silloker.

The total records and relative frequency graphs do not answer the first question, which can only be addressed through the traditional tools of historiography. But they anticipate the methodological concerns. The total records graph (Fig. 3), for instance, indicates that there was indeed an explosive growth in court documentation after the eighteenth century. This is in part due to the relative loss of records during the East Asian War of 1592–1598 (e.g., *Ilgi* only begins in 1623 for this reason). But the contour of this graph matches closely that of the frequency graph, indicating that where there is a rise or fall, it was likely due to corresponding changes in the total amount of documentation. Not all is lost, however, because the relative frequency graph helps pinpoint what might still be significant moments. As shown in Figure 4, the contour of this graph is markedly different because it calculates the ratio of search term to total records. Regardless of documentation practices, then, there were marked discussions of rain gauges around 1850s and 1900s (which were periods not previously highlighted in other graphs). Why?

This supports the findings of Jongtae Lim (Im Chongt'ae), historian of science who has already shown that Chosŏn monarchs in the eighteenth century championed the rain gauge as an instrument for local governance.[29] But by using Silloker, one can ask questions for further research, such as the last one. And still more directions can be generated by

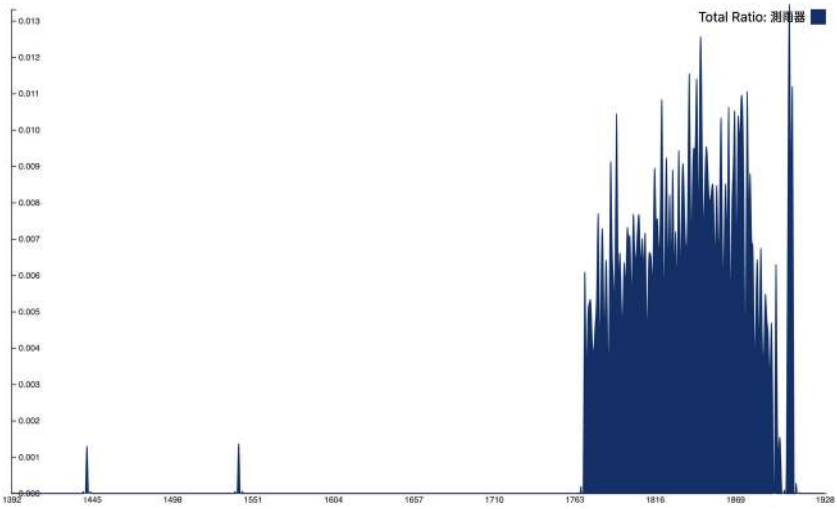


*Fig. 4.* Frequency of the term "rain gauge" (*ch'ŭgugi* 測雨器) in *Sillok* and *Ilgi*, expressed as a percentage of the total number of records written. From Silloker.

users, as the underlying data for these frequency search results, too, can be downloaded to perform custom and advanced aggregation analytics as needed.

## How Silloker is/was Built

The combination of Silloker's data acquisition and visualization features is not found in other Korean historical DBs. To document the feat as well as facilitate future improvements, then, this section presents an overview of our data architecture as it stands and how it came to be. In doing so, we argue that our system has unique advantages of "unifying" the multiple archives rather than superficially joining them at an interface level.

Silloker began as an "add-on" feature of sorts to the national DBs: rather than hosting an independent database, it channeled data from existing DBs (through the APIs provided by the Institute) and offered a preliminary version of the Aggregation tool. This soon proved unsustainable, however: there was no way for us to add, edit, or manipulate the underlying data, making our services dependent on existing DBs and bound by their limitations. The multiple archives also have their individual servers, which are only joined by the Institute at the interface level (see for example http://db.history.go.kr).

We then acquired the original data and built our own database instead. Acquiring the data was relatively easy, thanks to a statue by the South Korean government called the "Act on Promotion of the Provision and Use of Public Data" (*Konggong teit'ŏbŏp* 공공데이터법).[30] Through this, we could petition and obtain all of the currently transcribed text files, tagged with relevant biographical and spatial metadata. The problem, however, was that the data arrived in forms that were difficult work with—for example, XML, Excel files or worse yet, HTML. Moreover, some sections were fraught with errors like missing tags, not to mention that the different archives had inconsistent formatting.

Cleaning and parsing the data then was a painstaking process. Some manual work went in to fix errors. Multiple versions of parser programs were built in Python and Java to comb through and extract the data from the texts as well as from within the XML tags. But because of discrepancies between the datasets (and their own unique types of tags), we could not create a generic program for all the archives, having to tailor to each.

Yet, by breaking up the existing formats and reassembling them radically, a more streamlined data architecture emerged with new capacities. Unlike the Institute's model, which simply links the individual DBs at the interface level (re-routing results back to their respective servers), ours

**Table 1. Detailed Schema View of the *Record Entity* Table in the Silloker Database**

| Column | Type | Modifier |
|---|---|---|
| id | bigint | not null default nextval ('record_entity_id_seq'::regclass) |
| title | character varying (512) | |
| record_type | character varying (64) | Not null |
| year | integer | |
| month | integer | |
| day | integer | |
| book_name | character varying (128) | |
| book_volume | character varying (64) | |
| book_number | integer | |
| content | text | |
| original_source_reference | character varying (128) | |
| additional_information | character varying (1024) | |
| is_user_edited | boolean | default false |
| **Indexes:** | | |
| "record_entity_pkey" PRIMARY KEY, btree (id) | | |
| "record_title_index" btree (title) | | |
| "record_type_index" btree (record_type) | | |
| "source_reference_index" btree (original_source_reference) | | |

**Table 2. A List of Tag Categories and the Number of Unique Tag Values for Each Category**

| Tag Category | Number of Unique Tags |
|---|---|
| reign | 157 |
| book title | 14,840 |
| position | 5899 |
| name | 472,337 |
| location | 70,835 |
| topic | 219 |

truly unifies the underlying data through integrated searches. "Unified" here means that the data schema is now sufficiently abstracted and consistent to query across all of the archives it hosts (e.g., tags that cut across *Sillok*, *Sŭngjŏngwŏn ilgi*, and the *Pibyŏnsa tŭngnok).*

For more advanced readers, the technical dimensions of our database are further outlined here. Silloker currently contains the following two tables: Record Entity, Record Tag. The entity table (Table 1) contains all the entries along with their metadata like date, title, and book identifier. The tag table (Table 2) shows various identifiers and their respective categories like places, people, location, etc. There are six tag categories and a list of record

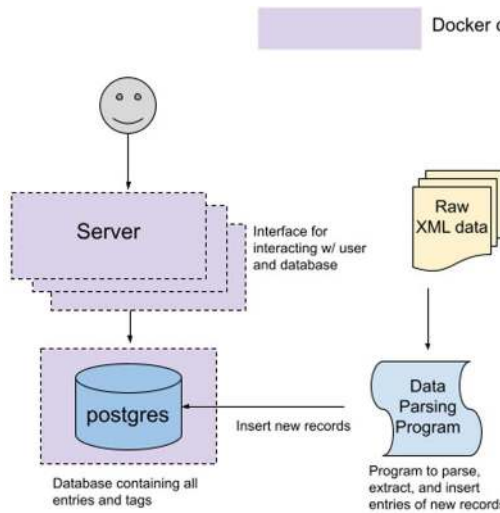


*Fig. 5.* High Level Technology Stack and User Workflow. Postgres (RDBMS) is used as the database to securely store and retrieve the data. Our server is built in AngularJS and Java Spring Framework, which provide an interface for users to interact with the rest of the system. The servers and database are stored in Docker Image for easy startup and portability.

entries they link back to. A total of over 10 million tags have been extracted and made compatible from the acquired datasets.

Finally, Silloker has an integrated workflow as shown in Figure 5. Users interact with the server through a web browser, which communicates with the database to retrieve data that they request. Any time a new record type is added to the system, a separate program will take the raw data to parse, extract, and insert it into the existing database.

These are the details that power our search engine and its unique combination of data querying and aggregation capacities. Beyond the example of rain gauge, however, how actually useful is Silloker for research?

## Use Case 1: Querying the Little Ice Age

Our example case study concerns a topic in Korean and global history that has seen quantitative approaches from early on: the Little Ice Age (hereafter LIC). According to climate historians, the early modern world was forged in ecological crisis. From roughly 1550 to 1850, there was a temperature drop on Earth that proved catastrophic across the world. Owing to decreasing volcanic and solar activity, crops failed, people starved, states warred, and epidemics spread.[31]

From its inception, the subject has attracted quantitative scholarship from fields as varied as climatology, economics, and history. Hubert H. Lamb was a pioneer who used historical records and data on glacier movement to propose that much of Europe underwent a period of cooling from about 1550 to 1850.[32] His argument then found support in English climatologist Gordon Manley's work, which showed similar temperature anomalies through the Central England Temperature (CET) record, an impressive dataset that stands as the world's longest time series of monthly mean temperatures.[33] Later, Historian Emmanuel Le Roy Ladurie corroborated the LIC in French history using variances in wine harvest cycles during the period, 1480–1880.[34]

The LIC research has recently expanded in geographical scope. Scholars can now assert with greater certainty that the period of cooling was indeed global and catastrophic throughout. Besides research on Argentina, Mexico and others,[35] compelling new studies have emerged on East Asia, thanks in part to its documentary heritage and the availability of instrumental as well as non-instrumental records on climate events.[36] For our purposes, the LIC research has also gained some traction in Chosŏn studies, which likewise started with quantitative approaches.

The Korean LIC scholarship began with Historian Yi Tae-jin and his 1995 article on the distribution of natural and human calamities during the Chosŏn period. In the *Sillok*, he (and his research team, yet unidentified in publications) found a total of 25,201 entries on various kinds of calamities from 1392 to 1863. There were three broad categories of events collected: "celestial abnormalities" (meteors, colored vapors, comets, new stars, abnormal sun/moon, halo, daytime appearance of Venus, etc.); "terrestrial and atmospheric abnormalities" (thunder, lightning, hail, frost, unseasonal snow, heavy rain/snow, rain/wind/dust storms, etc.); and "human catastrophes" (epidemics and water, cold and pest damages, etc.).[37]

Using this wide-ranging dataset, Yi argued that Chosŏn in the LIC was a disaster peninsula. Between the years 1500 and 1750, the LIC caused calamities such as droughts, floods, plagues, and famines. Nature, he argued, also played a nontrivial factor in determining the course of dynastic history: one finds between clusters of unfavorable weather conditions what historians have called "reigns of great peace" (*t'aep'yŏng sŏngdae* 太平聖代), between Kings Sejong and Sŏngjong (1418–1495) and Kings Yŏngjo and Chŏngjo (1721–1800).[38]

After Yi's pioneering work, historian Seong-Rae Park (Pak Sŏngnae) criticized his findings for taking the *Sillok*'s weather records at face value, that is, without considering their politicized nature, and potential unreliability. But the LIC scholarship has since moved on and diversified. Some like Kim Yŏn'ok, Yi Hochŏl, and Pak Kŭnp'il developed further attempts at quantification, suggesting a "cooling index" or socio-economic measures (e.g., levels of rice possession, state revenue and land tax exemption).[39] Others like Kim Tŏkchin and Kim Mun'gi who are steeped in social and environmental history probed particular topics in relation to the LIC such as famines and fish migration.[40] In a full circle, Yi too has since grown his dataset by including results from the *Ilgi*, which he has generously shared with us in 2015.

Using Silloker, we make just two reflections on the utility of computational methods to studying the Korean LIC. The linchpin of Yi's data consists of three data categories that pertain directly to global cooling—frost, hail, and unseasonal snow. His visualization of these (Fig. 6) shows indeed the contours of the LIC as argued in his works. But what happens if we bring Silloker to bear on the data, which were manually compiled over several years?

Our first reflection is that with the right set of key terms, Silloker can effectively test the results of existing quantitative research or replace it with a few clicks. To be sure, finding key terms that are inclusive yet precise

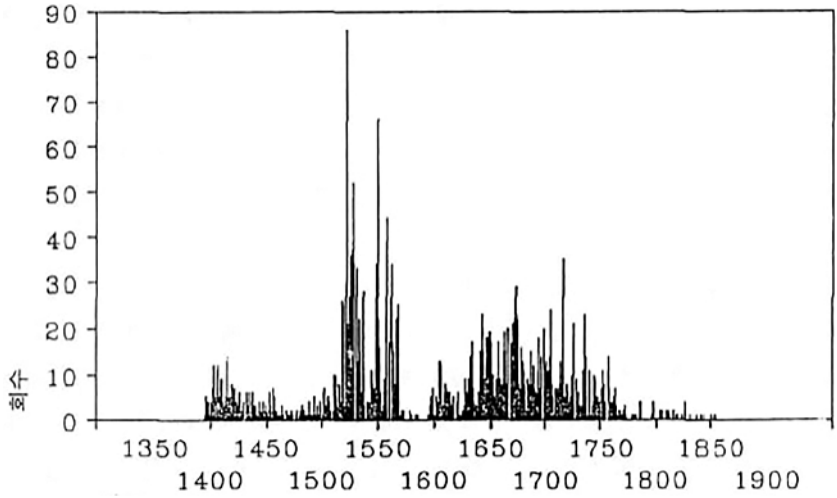


*Fig. 6.* Chronological distribution of records about frost, hail, and unseasonal snow in the *Sillok* by Yi T'aejin. 1996 article, global history, p. 215.

enough to render good data is difficult. By good data, we mean records that indicate, for example, an actual (at least intended as such) observation of the weather, rather than say, the mention of frigid weather as a literary metaphor or cautionary tale for bad kingship. In brute data mining, this is an issue mitigated by the historian sifting through the relevant entries and making contextual judgements to weed out irrelevance. We found, however, that with respect to records on cold weather, such aberrations were minimal (due to the stability of some terms and the formulaic nature of entries), especially if we used a set of terms drawn from close reading. Several such terms were identified to be reliable for two of the three factors: frost and hail (Table 3).[41]

**Table 3. Frequency Data on the Incidence of Frost and Hail in *Sillok* and *Ilgi*, Manually Compiled by Yi's Research Team (Left Column) and Computationally on Silloker (Right Column)**

| | Yi | Silloker |
|---|---|---|
| Frost | 1038 | 303<br>(Search terms used: 木氷, 隕霜, 繁霜) |
| Hail | 2156 | 2825<br>(Search term used: 雨雹) |
| Frost and hail combined | N/A | 182<br>(Search term used: 霜雹) |
| Total | 3194 | 3310 |

Using these search terms, we were able to confirm that the data from Silloker corresponded closely with Yi's in both quantity and shape: querying these terms in our platform yielded 3310 hits (comparable to Yi's 3194 records) and aggregating them produced a graph that confirms the basic contours of the Korean LIC as identified by Yi (Fig. 7). There are some discrepancies to be sure.[42] But the close correspondence also gives confidence in our tool as data aggregation and analytics is more about trend observation rather than a science of exact count. Moreover, it bears noting, of course, that for Silloker to function as it did here, an intimate understanding of the nature of *Sillok* entries and close reading of records on cold weather events were crucial. Yet, the platform did reduce the act of translating such contextual understanding into quantitative research into a matter of seconds.

Second, our aggregation tool, especially its relative frequency graph function, can better pinpoint moments of significance in the Korean LIC. One of several minor peaks in the frequency graph, the years from 1669 to 1671 emerge in the relative frequency graph as an all-time high for five centuries (Fig. 8). The graph shows, in other words, that during this period, there were more records about frost and hail per total number of records written than any other year in Chosŏn history. Were these indeed an anomalous set of years?

Yes, coinciding with this spike is the worst famine in Korean history known to date. The Kyŏngsin famine struck an unprecedented number of

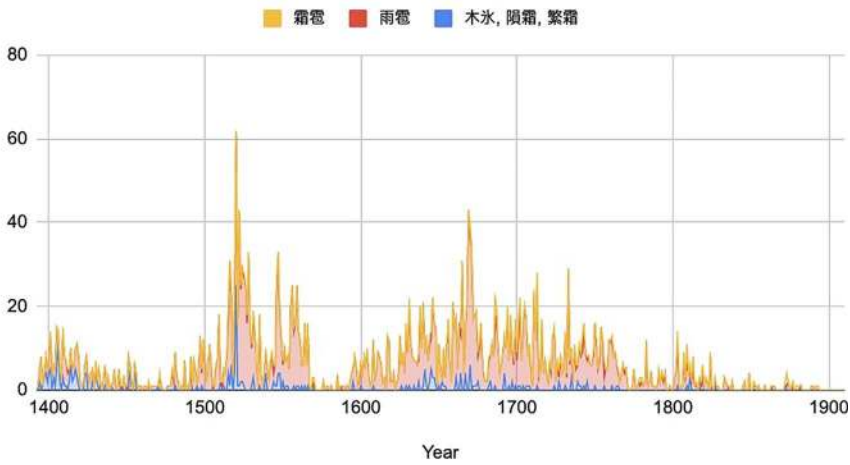


*Fig. 7.* Aggregation of the terms indicating "frost" and "hail" in *Sillok* and *Ilgi*. The frequency data was downloaded from Silloker and then graphed in Google Sheets for customization.

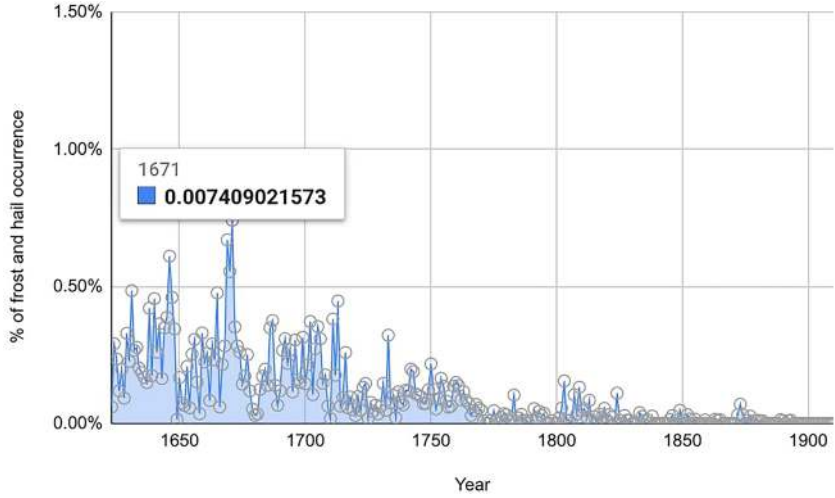


*Fig. 8.* Frequency of terms indicating "frost" and "hail" in *Sillok* and *Ilgi*, expressed as a percentage of the total number of records written. The data was downloaded from Silloker and then graphed in Google Sheets for customization.

360 villages at the time, which includes every village in all eight provinces of Chosŏn. Though the fatality rates varied, scholars estimate about 100,000 deaths in 1671, and higher figures for 1670. In places like Kyŏngsang province where good data survive, we know that at least 25% of the population (as many as 242,500) was starving in May 1670. As the crisis likely led to weaker immune systems, epidemics also grew quickly throughout the peninsula, infecting 52,000 during the two years and killing about half of them. Just within Seoul, unnamed epidemics infected more than one-fifth of the population. Famine and fatalities were most severe in the southern provinces. In Chŏlla province, the breadbasket of the Korean peninsula, as many as 54% of the total population allegedly died.[43]

Had this topic not already seen Kim Tŏkchin's meticulous scholarship, our graph would have highlighted the lacuna. But with the benefit of his scholarship, we can conclude, first, that our relative frequency graph supports his view that the Kyŏngsin famine was likely caused by harsh weather: often, discussions about the LIC is too macro-historical, but here the data compellingly point to a specific moment of its manifestation. Silloker also produces a new observation about the significance of this moment: there was at the time of the famine an unprecedented discussion about frost and hail at court throughout the entire five-centuries history of Chosŏn.

## Conclusion: Towards an "Intelligent" Search Engine

Silloker offers a new macroscope for chronicle data in premodern Korean studies: the "Search and Download" function performs unified queries across multiple archives and replaces the toil of manual data compilation; the "Aggregation" function graphs the frequency of hits with real-time visualization and some contextualization of data. These features draw on a unique data architecture which effectively integrates the different datasets in a single storage (or "persistence") system and presents them in an effective user workflow. And tentatively, the utility of this macroscope has been demonstrated with a case study: as shown by its querying of the Korean Little Ice Age, Silloker served not only to test existing scholarship, but to generate new research questions and isolate moments of significance that may otherwise go unnoticed.

There is much room for improvement, however. First, we have recently attempted to enhance our search engine through topic modeling, that is, to automate the weeding of "noise" in search terms by allowing users to filter their results. But our trials with MALLET (MAchine Learning for LanguagE Toolkit) have so far been unsuccessful, which accords with the results of others who have likewise found single-character topic modeling or even 2–4 gram analyses problematic. Various positive results have also been reported, however, and we look forward to learning from other projects that implement topic modeling successfully at the level of macroscopes.[44]

Other horizons for Silloker include developing geographic heat maps, integrated biographical data, and keyword frequency charts that consider the day or month (as opposed to year or reign title) of occurrence. Our progress, however, also depends heavily on the development of basic resources for Korean DH, such as historical geospatial data sources and sets (c.f. China Historical GIS project).[45] And more importantly, potential collaborations and integrations with other "fine-tuned" macroscopes—for example, biographical databases and social mobility indices—will enrich the contextualization of search data. Through these and other ways yet anticipated, the efforts to build a sustainable digital infrastructure have distinct prospects in premodern Korean studies, and we await other use cases by researchers to illuminate new paths towards a more intelligent Silloker.

## Notes

1. For a useful summary of the current state of digitization, see Javier Cha, "Digital Korean Studies: Recent Advances and New Frontiers," *Digital Library Perspectives* 34, no. 3 (2018): 227–44. The online databases for *Sillok* and *Sŭngjŏngwŏn ilgi* are currently hosted by the National Institute of Korean History (*Kuksa p'yonch'an wiwonhoe* 국사편찬위원회). See, respectively, http://sillok.history.go.kr and http://sjw.history.go.kr. They are also available in the Korean Classics DB (https://db.itkc.or.kr), where one can also search the *Record of Daily Reflections* and the *Compendium of Korean Collected Works*.

2. Javier Cha, "Digital / Humanities: New Media and Old Ways in South Korea," *Asiascape: Digital Asia* 2, no. 1–2 (2015): 136.

3. Cha, "Digital / Humanities," 134–8.

4. Ibid., 131. Also see Cha, "Digital Korean Studies," 230.

5. Cha, "Digital / Humanities," 138.

6. Cha, "Digital Korean Studies," 228.

7. Katy Börner, "Plug-and-Play Macroscopes," *Communications of the ACM* 54, no. 3 (2011): 60. Also see Adam Crymble, *Technology and the Historian: Transformations in the Digital Age* (Chicago: University of Illinois Press, 2021), 18; Shawn Graham, Ian Milligan, and Scott Weingart, *Exploring Big Historical Data: The Historian's Macroscope* (London: Imperial College Press, 2015); Timothy R. Tangherlini, "The Folklore Macroscope: Challenges for a Computational Folkloristics," *Western Folklore* 72, no. 1 (2013): 7–27; Javier Cha, "Fine-Tuning the Historian's Macroscope: Data Reuse and Medieval Korean Biographical Records in Neo4J," unpublished paper.

8. Börner, "Plug-and-Play," 60.

9. Graham, Milligan, and Weingart, *Exploring Big Historical Data*, 70–1.

10. On "distance" and distant reading, see Franco Moretti, "Conjectures on World Literature," *New Left Review* 1 (2000): 57.

11. For instance, to run MALLET (MAchine Learning for LanguagE Toolkit) on literary Sinitic texts, one could attempt single-character topic modeling but with little success. Despite that the package is language-agnostic, the asymmetrical development of natural language processing across languages can still create uneven access and utility. An example is discussed at the very end of this essay.

12. Lee Sangkuk and Lee Wonjae, "Strategizing Marriage: A Genealogical Analysis of Korean Marriage Networks," *Journal of Interdisciplinary History* 48, no. 1 (2017): 1–19. Also see Lee Sangkuk and Park Jong Hee, "Quality over Quantity: A Lineage-Survival Strategy of Elite Families in Premodern Korea," *Social Science History* 43, no. 1 (2019): 31–61.

13. Hyeok Hweon Kang, "Digital Humanist as Historical Detective? Investigating International Crime on the Korea Strait, 1662–1666," unpublished paper. Also see Jennifer Xu and Hsinchun Chen, "Criminal Network Analysis and Visualization," *Communications of the ACM* 47, no. 6 (2005): 100–7.

14. Hŏ Su, "*Kaebyŏk* nonjo ŭi sahoejuŭihwa e kwanhan saeroun chŏpkŭn? T'op'ik yŏn'gyŏlmang punsŏk ŭl chungsim ŭro" [A New Approach to the Spread of Socialist Influence in *Kaebyŏk*? An Analysis of Topic Networks], *Inmun nonch'ong* 78, no. 1 (2021): 221–62; Ian Matthew Miller, "Rebellion, Crime and Violence in Qing China, 1722–1911: A Topic Modeling Approach," *Poetics* 41 (2013): 626–49; Robert K. Nelson, "Introduction," *Mining the Dispatch*, August 1, 2022, https://dsl.richmond.edu/dispatch/about.

15. Tangherlini, "The Folklore Macroscope," 8. These are also individual projects—not platforms that make their knowledge accessible and reproducible.

16. Cha, "Fine-tuning."

17. Ibid., 2.

18. Ibid., 28.

19. Ibid.

20. I use the term "chronicles" here to refer to historical documents with a time stamp, or in Korean, *pyŏnyŏn saryo* (편년사료).

21. Currently, the National DBs are only superficially linked at the interface level: search on the National Institute of Korean History (*Kuksa p'yonch'an wiwonhoe* 국사편찬위원회)'s website, for example, reroutes users back to individual DBs and their respective servers, rather than performing integrated searches.

22. By relative frequency, we mean the relationship between the number of keyword hits and the total number of records written per given year. This function in Silloker is similar to that offered by Google Books Ngram Viewer (not to be confused with the simpler, "Ngram" function, which we refer to as "frequency graph"). Currently, relative frequencies are not provided in most East Asia-related DH platforms, including CrossAsia, and LoGaRT (Local Gazetteer Research Tools), and CText Text Tool plugins, which has only the "N-gram" function. One of the anonymous reviewers of this article has pointed out, however, that Academia Sinica was the first to demonstrate this functionality at large scale since the 1990s. We have thus qualified our statement by adding that Silloker offers it across multiple centralized repositories which overlap chronologically.

23. Youngsoo Kim, "'Humanities Content' and Its Discontent: Reshaping Digital Humanities in South Korea," in *Digital Humanities and Scholarly Research Trends in the Asia-Pacific*, ed. Shun-han Rebekah Wong, Haipeng Li, and Min Chou (Hershey, PA: IGI Global, 2019), 119–21. Also see Cha, "Digital Korean Studies," 229; Cha, "Digital / Humanities," 128, 137–8; and Sun Joo Kim, "The Wagner-Song Munkwa Project and Its Legacy in the Research of Korean History," 2019, https://projects.iq.harvard.edu/files/gpks/files/sun_joo_kim_the_wagner-song_munkwa_project_and_its_legacy_in_the_research_of_korean_history.pdf.

24. Cha, "Digital Korean Studies," 231–3.

25. Ibid.

26. Cha, "Digital Korean Studies," 231.

27. See note 1.

28. Historian Yi T'aejin's Little Ice Age research is one example, to be discussed at the end of this essay.

29. Jongtae Lim (Im Chongt'ae), "Measuring the Rainfall in an East Asian State Bureaucracy: The Use of Rain-Measuring Utensils in Late Eighteenth-Century Korea," in *Science and Confucian Statecraft in East Asia*, ed. Jongtae Lim and Francesca Bray (Leiden; Boston: Brill, 2019), 190–214.

30. This statute allows any Korean citizen to obtain public data produced by government institutions as long as said data do not relate to privacy or national security issues. For details, see https://www.data.go.kr/ugs/selectPortalPolicyView.do.

31. Geoffrey Parker, *Global Crisis: War, Climate, and Catastrophe in the 17th-century* (New Haven: Yale University Press, 2013). Also see Brian Fagan, *The Little Ice Age: How Climate Made History, 1300–1850* (New York: Basic Books, 2000); and Jean M. Grove, *Little Ice Ages: Ancient and Modern* (London: Routledge, 2004).

32. H.H. Lamb, *Climate, History and the Modern World* (Muethen, 1982), 201–26. Also see H.H. Lamb, *Weather, Climate and Human Affairs* (Routledge, 1988), 122–63.

33. The Central England Temperature record is the longest standardized instrumental measurement of monthly temperature, from the year 1659 to the present. Manley Gordon, "The Mean Temperature of Central England, 1698–1952," *Quarterly Journal of the Royal Meteorological Society* 79 (1953): 242–61. Also see Manley Gordon, "Central England Temperatures: Monthly Means 1659 to 1973," *Quarterly Journal of the Royal Meteorological Society* 100 (1964): 389–405.

34. Emmanuel Le Roy Ladurie, *Times of Feast, Times of Famine: A History of Climate Since the Year 1000* (New York: The Noonday Press, Straus and Giroux, 1988), 227–43.

35. M.A. Cioccale, "Climatic Fluctuations in the Central Region of Argentina in the Last 1000 Years," *Quaternary International* 62 (1999): 35–47. Also see Y. Nakajima, *Kikin nihonshi* (Famines in Japanese History) (Tokyo: Yuzankaku Suppan, 1987); and J.D. Post, "Climatic Variability and the European Mortality Wave of the Early 1740s," *Journal of Interdisciplinary History* 15 (1984): 1–30; and S.L. Swan, "Mexico in the Little Ice Age," *Journal of Interdisciplinary History* 11 (1981): 633–48.

36. For instance, S.W. Wang argues that China's northern and eastern regions underwent climatic aberrations during a cooling period of 1450–1890. His argument resonated with historians of China who have attributed climate change to crop failures, rebellions and increased warfare during the seventeenth century, and ultimately to the momentous dynastic exchange between the Ming dynasty (1368–1644) and Qing (1644–1912). S.W. Wang, "Climate of the Little Ice Age in China," *Proceedings of the International Symposium on the Little Ice Age* (1992), 116–21. Japanese scholars have also noted similar climate change during roughly the same period, focusing on its impact on agricultural yield and famine in late Tokugawa Japan (1600–1868). Ikuo Maejima and Yoshio Tagami, "Climate of Little Ice Age in Japan," *Geographical Reports* of Tokyo Metropolitan University 18 (1983): 91–115.

37. Yi T'aejin, "Sobingg'i (1500–1750) chŏnbyŏn chae-i yŏn'gu wa 'Chosŏn wanjo sillok' – global history ŭi han chang" [Celestial Changes during the Little Ice Age (1500–1750) and the Annals of Chosŏn Dynasty: A Piece of Global History], *Yŏksa Hakbo* 149 (1996): 203–36; and Yi T'ae-jin, "Sobingg'I (1500–1750) ŭi chŏnchae hyŏnsang-chŏk wŏn'in: 'Chosŏn wanjo sillok' ŭi kwanryŏn kirok punsŏk" [The Causes of Celestial Phenomenon during the Little Ice Age (1500–1750): An Analysis of Related Records in the Annals of Chosŏn Dynasty], *Kuksakwan ronchong* 72 (1996): 80–126. Also see Na Jongil, "17-segi wigiron kwa han'guksa" (The 17th Century General Crisis Thesis and Korean History), *Yŏksa Hakbo* 94–95 (1987): 421–73.

38. Yi, "Sobingg'i (1500–1750) chŏnbyŏn," 215.

39. Kim Yŏnok, "The Little Ice Age in Korea," *Proceeding of the International Symposium on the Little Ice Age* (Tokyo, 1992), 170–75; and Yi Hochŏl and Pak Kŭnp'il, "19 segi cho Chosŏn ŭi kihu pyŏndong kwa nongŏp wigi" [Climatic Change and Agricultural Crisis in Chosŏn Korea, 1799–1825], *Chosŏn sidae sahakbo* 2 (1997): 123–92.

40. Kim Tŏkchin, *Tae kigŭn, Chosŏn ŭl twidŏpta: uri ka mollattŏn 17-segi ŭi tto tarŭn yŏksa* [The Great Famine Overturning the Chosŏn Dynasty: A Different History of the 17th century that We Did Not Know] (Seoul: P'urŭn Yŏksa, 2008); and Kim Mun'gi, "Sobinggi wa ch'ŏngŏ: Ch'ŏn, hae, in ŭi kwanjŏm esŏ" (Little Ice Age and the Pacific Herring: From the Perspective of Heaven, the Ocean, and Humanity], *Yŏksa wa kyŏnggye* 89 (2013): 69–108.

41. The search terms for frost and hail are relatively stable and reliable for aggregation, unlike "unseasonal snow" which can find expression in a number of ways (e.g., 霜雹失序, 嚴霜早隕, 雪非時) that all result in low hits.

42. For instance, our terms for frost yielded only about a third of Yi's. The discrepancy is due to at least two reasons. Silloker may be at fault because the aggregation search includes insignificant entries as explained. Yi's research may likewise have errors in the process of manually compiling tens of thousands of data points. Further refining of search terms as well as Regex searches will yield more accurate results.

43. Kim Tŏkchin, *Tae kigŭn, Chosŏn ŭl twidŏpta*.

44. Miller, "Rebellion, Crime and Violence"; Cha, "Digital Korean Studies," 236, 240.

45. China Historical GIS: https://gis.harvard.edu/china-historical-gis.

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