

# Sun, Climate and Political Disintegration

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## 1. Introduction

The studies of the influence of climate and cosmophysical factors on the historical process already have themselves a long history. In XI century the great Arab historian Ibn Khaldun explained the low development of the European Kingdoms, compared to that of the Arab Caliphate with the cold climate in Europe. Nowadays the climatic factor for the development of civilisations is widely considered. Among many others, the works of Huntington [8] and Wheeler [16] can be mentioned in this context as being of special importance.

A.L.Tchijevsky was the first who found a strong correlation between the solar activity and the historical process (in terms of frequency of occurrence of mass movements of different kind) [13]. During several decades after publishing of Tchijevsky's book his theories were ignored by the mainstream in historical sciences. However, in the end of XX century a new interdisciplinary branch – that of Mathematical History – started to develop in strong controversy to the philosophical arguments of Karl Popper [10] who claimed that finding any morphological laws in History are impossible in principle.

The new branch attempts to integrate the most successful theoretical achievements in explaining the historical processes on the base of mathematics and natural sciences. Among them are the theories of Ibn Khaldun (asabiya) [5], passionarity (L.N. Gumilev) [7], A.L.Tchijevsky (solar activity) [13], P.Turchin (demographic cycles) [15], Yu. Chtchapova (applications of Fibonacci series in the periodisation of the ancient history) [2] and others.

One of the most important processes which takes place in the world history is that of political (in medieval times – mainly feudal) disintegration and integration.

In this paper are proposed special indices measuring the degree of political disintegration in different scales. Some examples of such indices are calculated and are analysed in relation to climatic changes and global solar minima and maxima during the last two millennia.

## 2. Indices of political disintegration

In order to measure the degree of political disintegration, we need to construct corresponding index (or indices). Let each independent unit for which we

have any information available, be assigned a number  $i$ .  $i = 1, 2, \dots, n$ , where  $n$  is the number of all independent units. Let each available source of information about these independent units be assigned a number  $j$ ,  $j=1, \dots, m$ . Then the indicator of existence of the  $i$ -th unit for the calendar year  $t$ , according to the source of information  $j$ , is defined as follows:

$$I_{ij}(t) = \begin{cases} 1, & \text{if the unit existed during the whole year } t \\ 1/2, & \text{if the unit existed during part of year } t \\ 0, & \text{if the unit did not exist during year } t \end{cases}$$

Then as an index of political disintegration we can consider the number of existing for the corresponding year de facto independent states, chosen according to some clearly defined criteria (by geographic region, by civilisation, by sources of information, etc.), i.e.:

$$I_A(t) = \sum_{\{i,j\} \in A} I_{ij}(t)$$

From statistical point of view more relevant indicator would be the ratio

$$R_A(t) = I_A(t) / S_A(t),$$

where  $S_A(t)$  is the total area of the states, belonging to the set, for time moment  $t$ . Such an indicator, however, is often difficult to be calculated. As we shall see below, it is also often not so necessary, because in many cases of practical interest we can restrict to sets with constant or at least approximately constant area.

There is, however, one important disadvantage in the use of the above introduced notation – it does not take into account the different calendar systems which were in use in the past. The main difficulties are caused by those calendars in which the length of the year is different from that of the Julianic year. For example, dates according to the lunar calendar from Hijra with year about 354 days long, are often the only available ones for the Islamic kingdoms. Two approaches are possible here. One is to consider separate indexes for different calendar systems. The other is to apply standard rules for converting dates from one calendar to another. In this paper the second approach is preferred and the conversion rules applied are the same as in [1].

### 3. Data

The data was collected from the handbooks of Morby [9], Tapsell [12] and Bosworth [1]. First two cover the whole world, and the last – only Islamic monarchies. Being all dynastic handbooks, they do not contain data about republics (with some exceptions like Venice). The republics are, however, less than 5% of all states that existed in the time interval from V century AD to the end of XVIII century, which is the time frame of our interest.

The missing data problem must be treated carefully, as the depth of our knowledge about history of Mediterranean significantly differs, for example, from that of Americas. To say more, even in context of the available information, the above mentioned authors are not always objective. The Morby's handbook is clearly eurocentric, more than half of its entries belonging to Europe. Tapsell's book this claims to compensate this misbalance – with partial success, as we shall see below.

Another question is whether all of the states in our database are completely and equally independent. The obvious answer is – they are not, neither de jure, neither de facto, and range from empires covering large parts of Eurasia to small semi-independent entities, satellites of some of the big powers. The objective estimation of the degree of independence was not considered as an option for this paper, as it would do it too complicated.

The processing of more detailed works on the world political history, such as that of Truhart [14] is planned for the near future. They must be used with care because they give not the most essential information for the corresponding region but the complete picture of what is known at the time they were composed, being complete at some points and very fragmentary in others. This can make the indices derived from them even more biased than the indices derived from the books of Morby, Tapsell and Bosworth, although the latter are also not perfect and need additional improvement.

In order to restrict the influence of missing data on our results, the indices were calculated not only for the whole world, but also separately for four regions with well known history and clearly defined borders. Region A covers the territory of the Roman Empire at the time of her greatest extent, with added the neighbouring Scotland, Ireland and Armenia. Region B corresponds to the remaining part of Europe, where the first known states were built in VIII-X centuries – Scandinavia, Germany, Poland, Russia, etc. Region C covers Eastern Asia – China, Tibet, Mongolia, Japan, Korea and Indo-China. Region D corresponds to the Indian subcontinent.

The Islamic civilisation is counted separately. Obviously, it did not occupy constant area. Nevertheless, it's indices are also of interest, as the process of integration/disintegration most take place within the same civilisation and studying the civilisation dynamics in this context must not be neglected.

## 4. Results

### 4.1. World

As it can be seen from Fig. 1 both world indices, based on data from Tapsell and Morby respectively, are highly correlated (the coefficient of correlation is 0.952). Despite the high correlation, there are some differences in the behaviour of the two indices. The index based on Morby's data starts to grow around 800 AD, achieves a clear peak in the middle of XIV century (plague pandemic!) and slowly decreases after. The more detailed and homogenous index, based on Tapsell's data, also starts to grow in 800 AD, reaches a plateau in 1200-1400, decrease until the beginning of XVIII century and then marks another, smaller peak.

In order to remove the random fluctuations from both curves, a number of methods as SSA and functional data analysis can be applied. Here, however, these advanced methods are not necessary, as the behaviour of the indices is rather simple. Instead they are piecewise approximated by lines, the time endpoints chosen as important solar activity and/or climate time points (see Table 1) where the slope of both curves suddenly changes. For each piece data are fitted using linear regression model

$$I(t) = \alpha + \beta t + \varepsilon_t,$$

containing linear part and normally distributed error terms. The latter are clearly not independent (as they must be in the classic regression model). Here, however, we can still look at this fit in the context of the functional data analysis fitting data with low-order splines, being actually linear functions, with knots at the chosen endpoints [11].

The estimated coefficients (slopes) are given in Table 1 together with their estimated standard errors (SE).

The piecewise linear fit is almost perfect, showing statistically significant decrease of the slope during Oort solar minimum (1040-1080). The number of independent political units decreases during Dalton minimum, which can be easily explained by the two simultaneous processes – napoleon wars in Europe and british colonisation of India.

But the main result is the overall growth of both indexes during the Medieval Warm Period and the simultaneous decrease during the following so called Little Ice Age [6] This allows us to propose a hypothesis that the political disintegration processes are stimulated by the climate warming and, respectively, that the decrease of the mean annual temperatures stimulates the opposite processes of

political centralisation. The same holds in XX century, when the process of political disintegration in different forms (decolonisation in Africa, Asia and Oceania, independence of the former USSR and Yugoslavia republics, etc.).

No	Time interval	$\hat{\beta} \pm SE$ (Morby)	$\hat{\beta} \pm SE$ (Tapsell)
1	600-800 AD	-0.007±0.002	0.023±0.003
2	800-1040	0.251±0.002	0.336±0.004
3	1040-1080	0.021±0.010	0.017±0.027
4	1080-1250	0.139±0.005	0.149±0.006
5	1250-1350	0.172±0.016	-0.016±0.011
6	1350-1715	-0.079±0.003	-0.122±0.002
7	1715-1850	-0.013±0.007	Non-linear

Table 1. Estimated coefficients of linear regression of the index  $I(t)$ , calculated on the base of complete data from [Morby] and [Tapsell] on time  $t$  for different time intervals. 1. Before the Medieval Warm Period. 2-5. Medieval Warm Period: 2. Before Oort Solar Minimum. 3. Oort Minimum. 4. After Oort Minimum to the end of the Medieval solar maximum. 5. After the end of the Medieval solar maximum (Main part of this interval is covered by Wolf minimum 1280-1350) . 6-7. Little Ice Age: 6. Before the end of Maunder minimum. 7. After the end of Maunder minimum.

## 4.2. Regions

As different regions are characterised by different climatic patterns, we constructed our indices, following the methods, described in section 2, for several regions chosen with respect to both climate and data availability.

From Fig 2-5 one can see that the process of disintegration starts in all four regions simultaneously about 800 AD, synchronously with the beginning of the Medieval Warm Period. For region B (Northern Europe) this is also the beginning of the state-building process. In region A the number of independent units increases until 1000-1050 and then is stable for 300-350 years, starting to decrease with the beginning of the Little Ice Age.

In region B the process of political disintegration continued during the whole Medieval Warm Period, the peak being marked by the Great Famine in 1316 (Tapsell) and the plague pandemic in 1349 (Morby). The second peak in ~1700 is observed only for data based on Morby and is specific for Germany, because Morby's description of German dynasties is extremely detailed.

Region C shows several peaks – in 550, 950 and 1200, which are related in first place with political processes in China. It seems that here disintegration continued during the Little Ice Age also but the small amount of data does not allow further conclusions.

In Region D the processes are similar to those in region C, but the peaks are placed in 1580 and 1780. As they are related mainly with non-Islamic states (described in detail by Tapsell), these peaks can be considered as specific for the Hindu-Buddhist civilisation, as those observed for region C can be specific for Chinese civilisation. Maybe in both cases they are related with some demographic cycles. This problem requires further study.

### **4.3. Islamic civilisation**

The number of Islamic states also starts to grow intensively in the beginning of the IX century. It achieves its first peak in the beginning of the XI century and then oscillates, remaining relatively stable, with one gap in the XVII and the beginning of XVIII century, covered mainly by Maunder solar minimum, raising further questions.

## **5. Maunder minimum**

It seems that the coincidence between the unusually long and stable reign of Louis XIV of France (1638-1715) and the Maunder minimum of solar activity (1640-1715), which was indicated by some authors [3] as curious, must be considered as a part of global tendency in the world historical process. During Maunder minimum political stabilisation of Russia took place after the Time of Troubles, the reforms of Peter I the Great were realised. The reign of Kangxi (1661-1722), longest in Chinese history, is considered as a symbol of prosperity, the “golden age” of imperial China. The process of intensive feudal decomposition of India started after the end of the reign of the last Great Mughal – Aurangzeb (1657-1707).

In the same context must also be mentioned the simultaneous epochs of prosperity of arts in China and in Europe during the Maunder minimum, found by Ertel [4]. This synchronicity and others similar to it require further study.

## **6. Theoretical explanations of possible relationship**

If we try to extrapolate the morphological law of Tchijevsky [13], which is proven to be valid for 11-year solar cycles, to the global solar minima, we can

expect these epochs to be times of low activity of the mass movements, increased political stability and prosperity of sciences and arts.

According to L.N.Gumilev [7] the passionary impulses of ethnogenesis take place in the epochs of low solar activity. The early phase of the ethnogenesis is often characterised by political centralisation of large regions.

According to the theory of demographic cycles in the agrarian states [15], as a consequence of the fall of the mean annual temperature could occur a shortening of the resources which makes economically disadvantageous the existence of multiple centres of power and thus prevents further political decomposition.

## 7. Conclusions

There is a correlation between the climatic changes and the processes of political disintegration in both global and continental/ subcontinental scales.

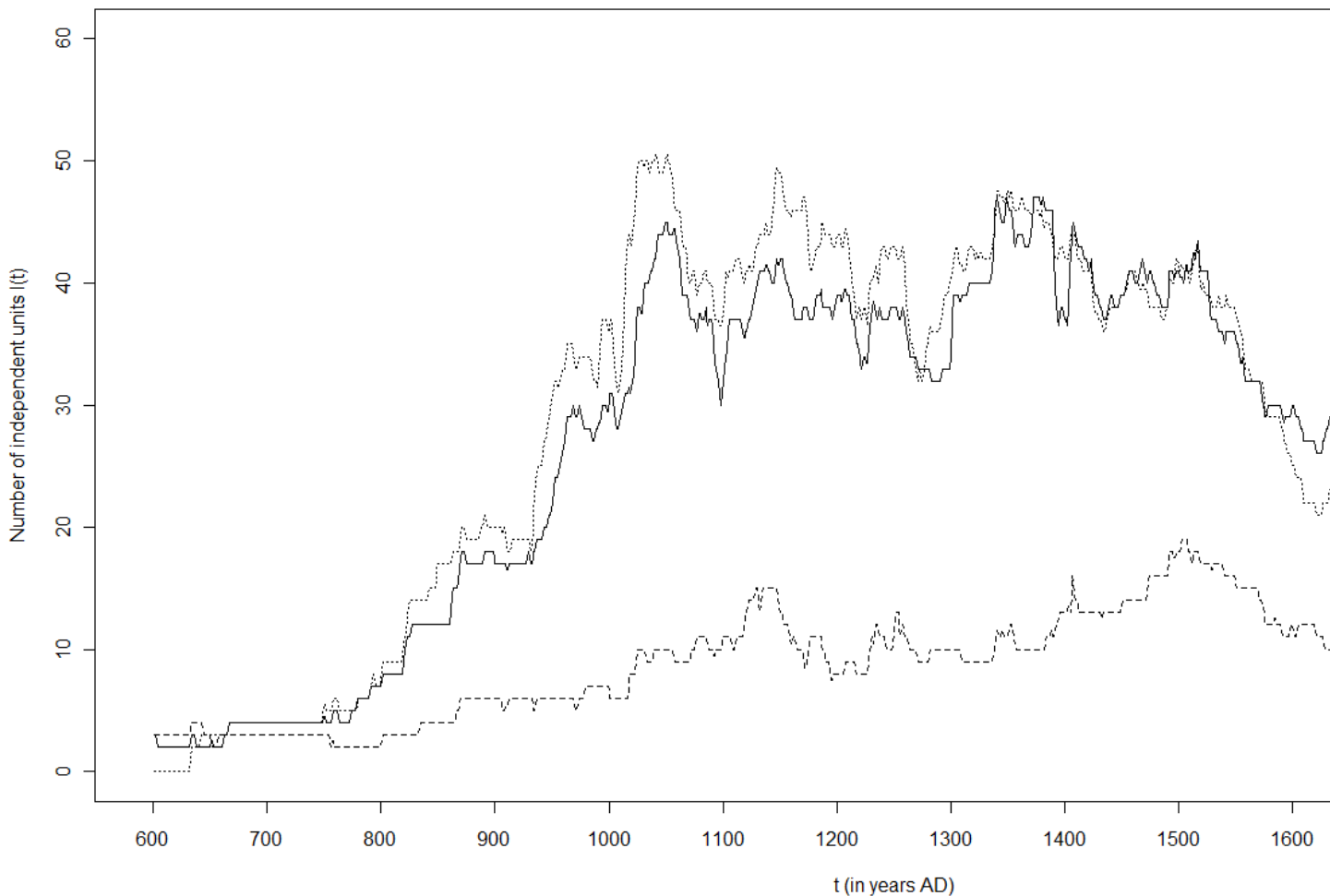
The existence of a correlation between the solar activity and the disintegration processes can be possibly explained by solar impact on the climate. This correlation requires further study for its confirmation.

The influence of cosmophysical factors on the historical process is embedded naturally in the models considered by the contemporary Mathematical History

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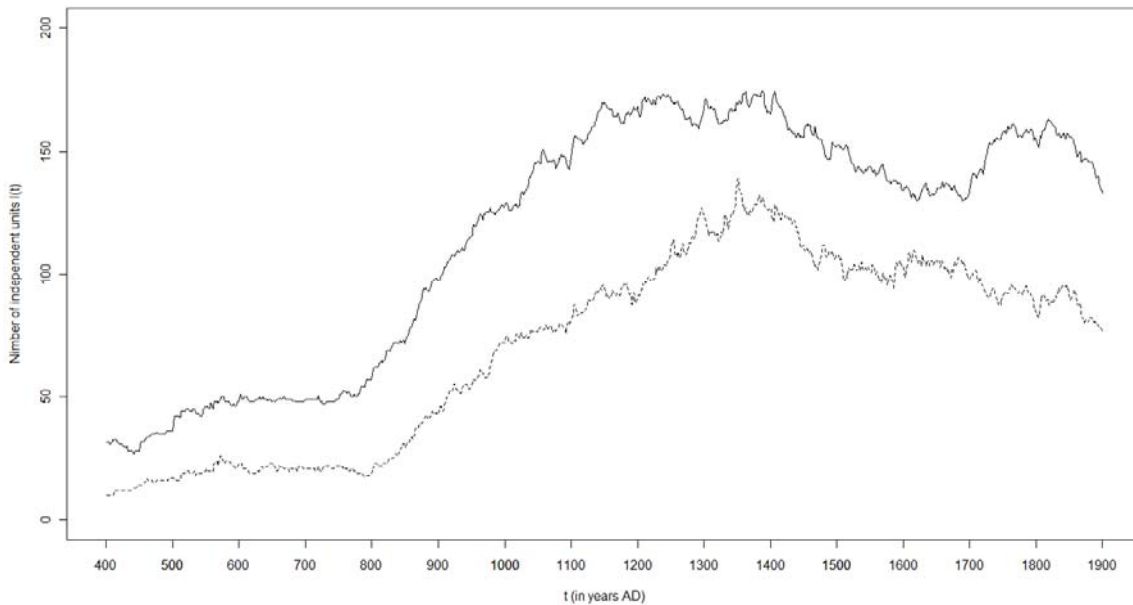
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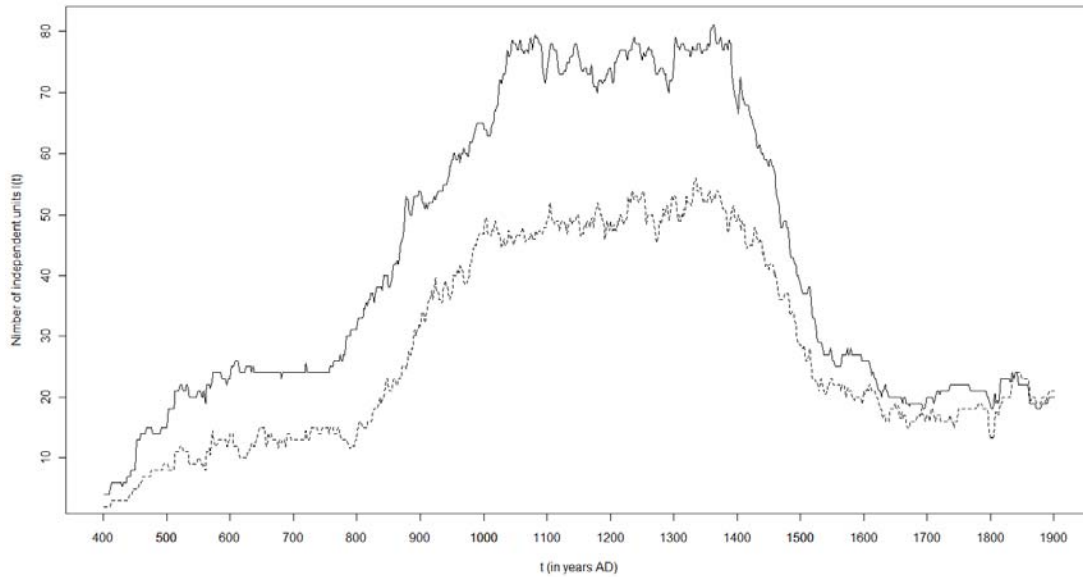


**Fig 6.** Plot of the indices of political disintegration  $I(t)$  for the whole for the Islamic civilisation, based on data from Tapsell (solid line), Morby (dashed line) and Bosworth (dotted line), vs. time. Tapsell and Morby data include several pre-Islamic dynasties.

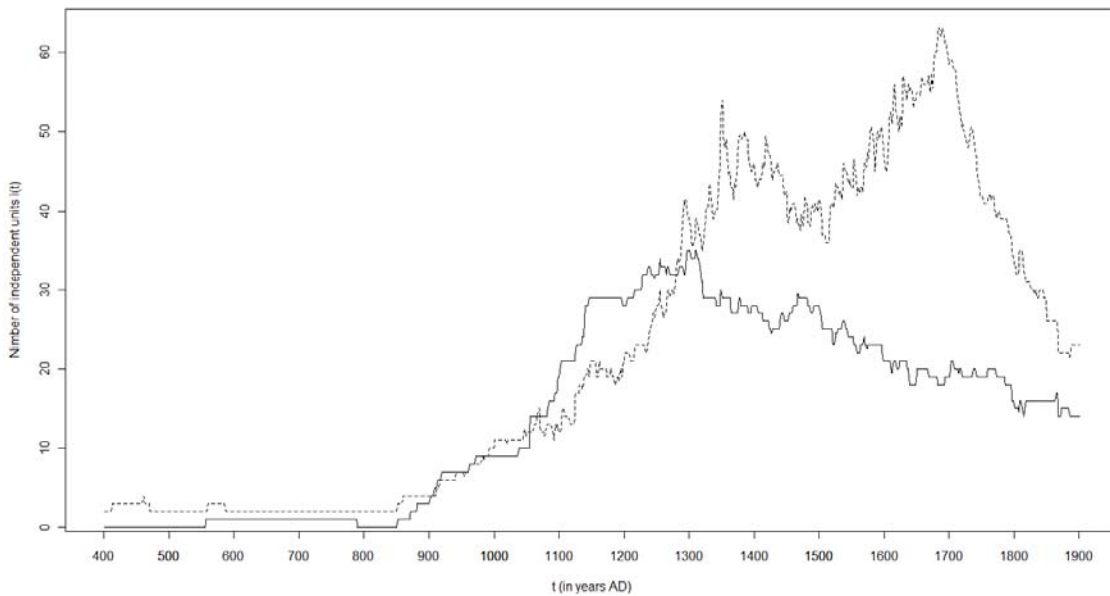




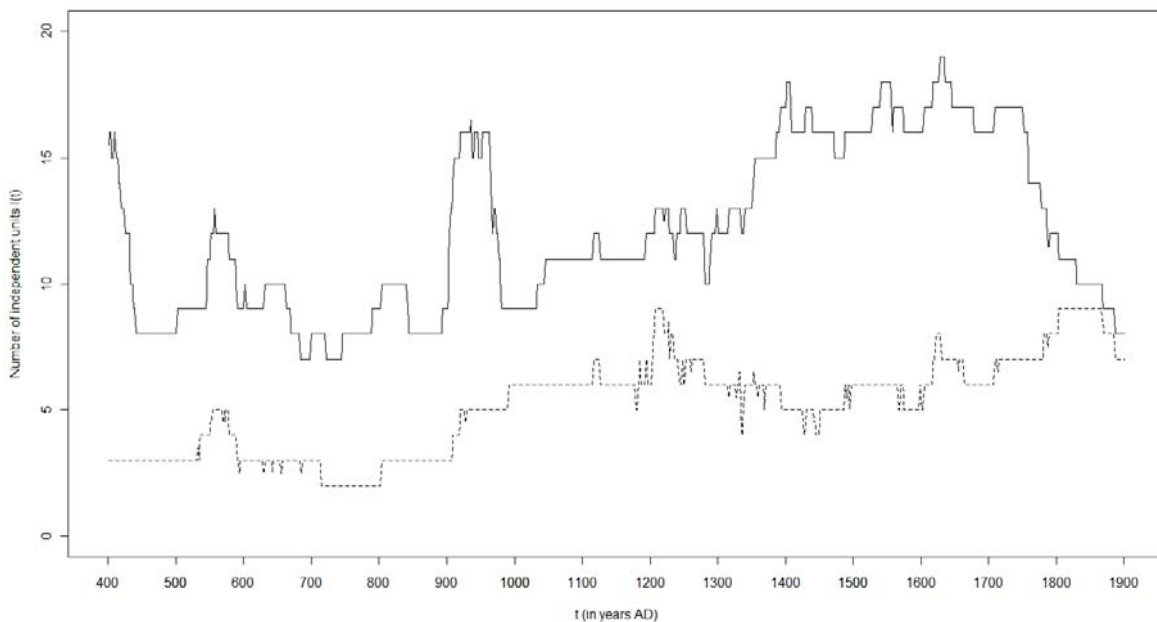
**Fig 1.** Plot of the indices of political disintegration  $I(t)$  for the whole world, based on data from Tapsell (solid line) and Morby (dashed line), vs. time.



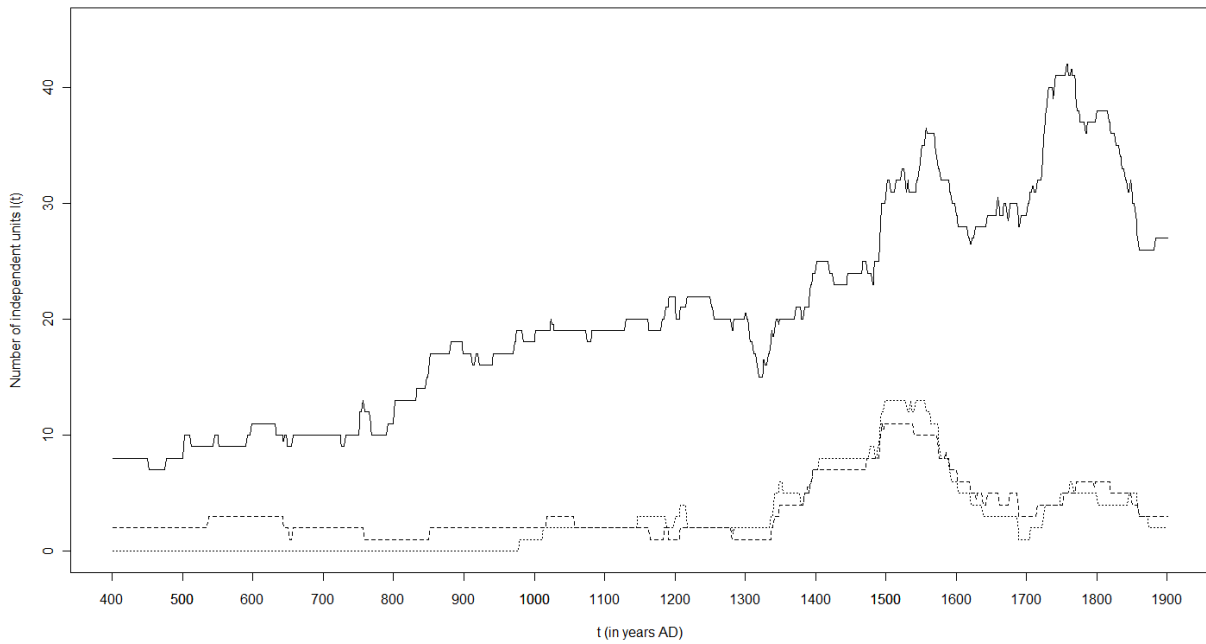
**Fig 2.** Plot of the indices of political disintegration  $I(t)$  for the whole for region A (territory of the Roman Empire at the time of her greatest extent), based on data from Tapsell (solid line) and Morby (dashed line), vs. time.



**Fig 3.** Plot of the indices of political disintegration  $I(t)$  for the whole for region B (Northern Europe), based on data from Tapsell (solid line) and Morby (dashed line), vs. time.



**Fig 4.** Plot of the indices of political disintegration  $I(t)$  for the whole for region C (Eastern Asia), based on data from Tapsell (solid line) and Morby (dashed line), vs. time.



**Fig 5.** Plot of the indices of political disintegration  $I(t)$  for the whole for region D (Indian subcontinent), based on data from Tapsell (solid line), Morby (dashed line) and Bosworth (dotted line, Islamic states only), vs. time.