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Analysis of seasonality in selected climatology element time series in the Czech Republic

1. Introduction

An initial example: the inhabitants' quality of life is heavily influenced by agricultural products' accessability and production stability (not only) within their native country. Agricultural production depends vitally on weather and climatological conditions. In the contemporary world, with its globalizating trends and interconnected transfer routes, there are large possibilities how to avoid negative impacts of food shortage caused by both terrible droughts and devastating floods. We are able to forecast – with high probability – what the weather in the near future will be like. Our capability to construct sophisticated climate evolution models of different scales is also obvious. These factors prevent troughs of quality of life caused by short-time fluctuations in weather conditions, allowing us to react to predicted long-time changes in climate conditions. Extreme weather and climate change consequencies (e.g. rising sea levels) are serious enough to substantially affect quality of life. The above mentioned example of climate and socio-economic relations is not definitely the only one…

This paper concentrates on the past developments. It aims to give a well-founded view on the seasonality development in selected climatology element time series in the Czech Republic. These particular elements are: monthly average temperatures, average monthly maximum and minimum temperatures, monthly precipitation sums and monthly sunshine duration sums. The main objective of the paper is the construction of time series composed of moving-seasonal factors calculated from the input time series.

This concept was first presented in [5] where a unique time series of monthly average temperatures from Prague-Klementinum measuring station (P1PKLM01) was analysed. The uniqueness of this time series consists in its length – it is uninterrupted back to 1775.[1] A lot of scientific researches have been devoted to analyses of this time series. As was shown e.g. in [6], [7] – approximately since the second half of the 19th century temperatures measured there started to rise. Manifestations of a heat island in the Klementinum temperature time series were also described convincingly [1].

2. Data Assessment

This section describes the origin of data used for the analysis, gives a more detailed definition of relevant climatology elements and includes a complete characteristics of elementary (input) time series, as well as the necessary geography of selected measuring stations.

2.1. CLIDATA database

The CLIDATA system is primarily intended for archiving of climatological data, data quality control and administration of measuring stations. The data from approximately 1600 observatories and measuring stations, which are currently in operation, are stored in the database. Nearly 200 meteorological elements and other characteristics are being recorded at these stations of different types. SQL is used to gain the requested selection of data from the database. More information on how the database works, how the data are acquired and can be used, is available in [2], [3] and [4], for instance.

2.2. Selected Climatology Elements

The main factor in answering the basic question – which climatology elements are suitable for this project's purposes – was the presence of month seasonality (S = 12) in monthly time series. The selection of five climatological (meteorological) elements serves this purpose. The monthly data were calculated as averages of daily values (in three cases) and as sum totals (in two cases) respectively. A more detailed description of the data used follows:

— monthly average temperature[2] (the element marked as T) – the value for each calendar month is calculated as a simple arithmetical average of daily average temperatures within this calendar month. Daily average temperature is hereafter calculated as

$$\frac{(T07 + T14 + 2.T21)}{4}, \qquad (2.1)$$

[1] It seems to be the longest complete monthly time series in the Czech Republic.
[2] = monthly average of daily average temperatures.

where *T07*, *T14* and *T21* are temperatures measured during each day in (the so called) climatological terms. They are approx.[3] 7 a.m., 2 and 9 p.m. within the Central European Time (CET) zone.

— monthly average of maximum temperatures (TMA) – simple arithmetical average of daily maximum temperatures. Daily maximum temperature is the highest temperature measured between 9 p.m. CET on the previous day and 9 p.m. CET on the day when daily maximum temperature is measured.
— monthly average of minimum temperatures (TMI) – simple arithmetical average of daily minimum temperatures. Daily minimum temperature is the lowest temperature measured between 9 p.m. CET on the previous day and 9 p.m. CET on the day when daily minimum temperature is measured.
— monthly precipitation amount (SRA) – total of daily precipitation sums. Daily precipitation sum is the amount of water fallen both in liquid and solid form on the horizontal area in the given territory, expressed by the height of water column in millimetres[4].
— monthly sunshine duration (SSV) – total of daily sunshine durations. The daily sunshine duration is represented by the time interval, during which the direct beam solar radiation reaches the Earth's surface.

2.3. Elementary[5] Time Series

As it is desirable to have complete elementary time series (no missing values), the length of time series for currently measuring stations without any missing values has become the most important factor for the selection of measuring stations for each of the climatology elements. Ten measuring stations with ten longest time series available were chosen for the analysis.

For more detailed information about selected measuring stations, see appendix 1. The structure of tables is as follows:

— GH_ID – identification symbol of the measuring station
— FULL_NAME – the whole name of the station
— LATITUDE, LONGITUDE – geographic coordinates in the form of degrees, minutes, seconds[6]
— ELEVATION – altitude of the station in metres above sea level
— BEGINNING – first year of complete monthly time series

[3] Because of Local Mean Solar Time (LMST).
[4] Providing there is no percolation, exhalation and drainage.
[5] The word "elementary" is used to distinguish between time series described in section 2.2 and those that represent the main aim of this work (to be constructed).
[6] ddmmss.

3. Technical Support

The software application was designed for the purpose of this project. In the first step it allows .csv datafile with a proper structure to be loaded onto the application. In the second step the user is asked to specify

a. length of the moving interval (moving part) in years (*LMI*)
b. size of the movement in years (*SM*)
c. whether the calculation will be made either for additive or multiplicative seasonality

For example, the selection of *LMI* = 5 and *SM* = 3 will split time series beginning in the year 1775 into a sequence of the following time series: 1775–1779, 1778–1782, 1781–1785… In the third (last) step, seasonal factors or seasonal indices (according to the type of seasonality) within each of the time series are calculated, and final .xls datafile is saved.

An example of how the final data file may look like is shown in table 3.1. The structure of table is as follows:

— GH_ID – identification symbol of the measuring station
— EG_EL_ABBREVIATION – mark of a climatology element
— PERIOD – time period for which a corresponding seasonal factor was calculated
— MONTH – calendar month
— VALMON01 – seasonal factor for the given measuring station, climatology element, time period and calendar month

Table 3.1. Example of final .xls datafile

GH_ID	EG_EL_ABBREVIATION	PERIOD	MONTH	VALMON01
P1PKLM01	T	1775–1779	1	−13,62
P1PKLM01	T	1775–1779	2	−6,87
P1PKLM01	T	1775–1779	3	−4,14
P1PKLM01	T	1775–1779	4	−0,35
P1PKLM01	T	1775–1779	5	4,72
P1PKLM01	T	1775–1779	6	7,45
P1PKLM01	T	1775–1779	7	9,62
P1PKLM01	T	1775–1779	8	10,78
P1PKLM01	T	1775–1779	9	5,13
P1PKLM01	T	1775–1779	10	−0,34
P1PKLM01	T	1775–1779	11	−4,72
P1PKLM01	T	1775–1779	12	−7,65

Table 3.1. Example of final .xls datafile (cont.)

GH_ID	EG_EL_ABBREVIATION	PERIOD	MONTH	VALMON01
P1PKLM01	T	1778–1782	1	−11,48
P1PKLM01	T	1778–1782	2	−9,80
P1PKLM01	T	1778–1782	3	−4,23

4. Statistical Background

Even though this initial stage of the project focuses on the construction of time series that are to be devoted to detailed statistical analysis in the subsequent phase in the future, it is still necessary to mention the statistical background already used in this paper.

4.1. Classical Decomposition of Time Series

Perhaps the simplest (and also the most frequent) conception of modelling time series is a univariate model

$$y_t = f(t, \varepsilon_t),\ t = 1, 2, \ldots, n, \tag{4.1}$$

where y_t is the value of an indicator that is to be modelled in time t and ε_t is the value of a random component (error component) in time t. There are more possible ways how to approach this model; one of them is by means of a classical (formal) model.

The classical (formal) model deals only with the description of forms of movement (and not with relevant reasons of dynamics in time series). This model is based on the decomposition of time series into four (in the most cases) components (forms) of time movement. These are:

— trend component T_t – a trend represents the main tendency in a long-time development of values of an analysed indicator in time,
— seasonal component S_t – a seasonal component is a regular deviation from the trend component. This regular deviation may appear in time series with the periodicity lower or equal to one year,
— cycle component C_t – by a cycle component we mean fluctuations in the trend (as a consequence of a long-time development) with the wave length higher than one year,
— random component ε_t – a random component is such a quantity that cannot be described by any function of time. It is the component that remains after T_t, S_t and C_t have been removed.

There are two types of the decomposition:

a. additive: $$y_t = T_t + S_t + C_t + \varepsilon_t \text{ and} \tag{4.2}$$

b. multiplicative: $$y_t = T_t S_t C_t \varepsilon_t \,. \tag{4.3}$$

4.2. Moving Averages

The principle of moving averages consists in the substitution of sequence of empirical observations by a series of averages calculated from these observations. During the sequential calculation of averages we proceed (move) by one observation ahead, leaving out the oldest (the first) observation from the particular group. A very important point is to specify the number of observations to be averaged. This number is called the length of the moving part.

When the moving part length is an even number, the averages calculated in this way are called centered moving averages. As we are dealing with month seasonality in this project, we are particularly interested in moving averages with the length of the moving part equal to number twelve. These averages are calculated as follows:

$$\overline{y}_t = \frac{1}{24}(y_{t-6} + 2y_{t-5} + \ldots + 2y_{t-1} + 2y_t + 2y_{t+1} + \ldots + 2y_{t+5} + y_{t+6})\,. \tag{4.4}$$

4.3. Additive and Multiplicative Seasonality

There are plenty of methods how to enumerate seasonality (seasonal component) in a statistical theory. Two of them (the basic ones) are mentioned here.

4.3.1 Additive Seasonality

In this case, we consider type (4.2) decomposition of time series. It is possible to write the model (4.2) in the following form:

$$y_{ij} = T_{ij} + S_{ij} + \varepsilon_{ij}, \; i = 1, 2, \ldots, m, j = 1, 2, \ldots, r, \tag{4.5}$$

where i indicates an ordinal number of years, j represents the sequence of particular periods[7] within the year and r is the number of partial periods within the year[8]. Further we assume that the seasonal component

$$S_{ij} = \beta_j \text{ for the season } j \text{ in all years } i = 1, 2, \ldots, m, \tag{4.6}$$

where β_j for $j = 1, 2, \ldots, r$ are unknown seasonal parametres, whereas

$$\sum_{j=1}^{r} S_{ij} = \sum_{j=1}^{r} \beta_j = 0 \text{ for all years } i = 1, 2, \ldots, m. \tag{4.7}$$

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[7] seasons.

[8] e.g. $r = 4$ for time series with quarterly periodicity and $r = 12$ for time series with monthly periodicity.

Thanks to the estimation of the trend component, we know the quantities T_{ij} (most often it will be an application of moving averages), so we can easily create a series of empirical seasonal factors (differences)

$$y_{ij} - T_{ij} = S_{ij} + \varepsilon_{ij}\,,\ i = 1, 2, \ldots, m, j = 1, 2, \ldots, r, \tag{4.8}$$

or according to (4.6)

$$y_{ij} - T_{ij} = s_j + \varepsilon_{ij}\,. \tag{4.9}$$

Average seasonal factors are given by equation

$$\bar{s}_j = \frac{1}{m}\sum_{i=1}^{m}(y_{ij} - T_{ij})\,, j = 1, 2, \ldots, r. \tag{4.10}$$

These average seasonal factors do not meet the requirement (4.7) – we will adjust them by proper standardization:

$$\hat{s}_j = \bar{s}_j - \frac{\sum_{k=1}^{r}\bar{s}_k}{r}\,. \tag{4.11}$$

For the sake of simplicity, we will call the values calculated in (4.11) "seasonal factors". These seasonal factors can be interpreted in the same units as the values in the analysed time series.

4.3.2 Multiplicative Seasonality

In this case we consider type (4.3) decomposition of time series. It is possible to write the model (4.3) in this form:

$$y_{ij} = T_{ij}S_{ij}\varepsilon_{ij}\,,\ i = 1, 2, \ldots, m, j = 1, 2, \ldots, r, \tag{4.12}$$

where i indicates an ordinal number of years, j represents the sequence of particular periods within the year and r is the number of partial periods within the year. Here we can write

$$S_{ij}\varepsilon_{ij} = \frac{y_{ij}}{T_{ij}}\,,\ i = 1, 2, \ldots, m, j = 1, 2, \ldots, r, \tag{4.13}$$

whereas we want

$$\sum_{j=1}^{r} S_{ij} = r \ \text{ for all years } i = 1, 2, \ldots, m. \tag{4.14}$$

As we know the quantities T_{ij}, we can easily calculate seasonal indices; average seasonal indices will be given by the equation

$$\bar{s}_j = \frac{1}{m}\sum_{i=1}^{m}\frac{y_{ij}}{T_{ij}},\, j = 1, 2, \ldots, r. \tag{4.15}$$

These average seasonal indices do not fulfill the presumption (4.14) – we will adjust them by proper standardization:

$$\hat{s}_j = \frac{r}{\sum_{k=1}^{r}\bar{s}_k}\bar{s}_j\,. \tag{4.16}$$

In this paper we will call the values calculated in (4.16) as "seasonal indices". These seasonal indices are usually interpreted in terms of percentage.

5. Moving-seasonal Time Series

A moving-seasonal time series for each calendar month is constructed from the final datafile by selection of rows (table 3.1) corresponding to the given month. In this section, the main results are presented and some comments on the structure of appendices are made.

5.1. Selected calendar months, element T, station P1PKLM01

Five calendar months were chosen – January and December as representatives of substandard (cold) months, July and August as above-average (warm) months and April as an average month[9]. For this section purposes, all moving-seasonal time series were calculated under *LMI* = 30 and *SM* = 1. Such a high *LMI* is possible because of very long input time series (average monthly temperatures at P1PKLM01). The results in appendix 2 allow comparison of the development of moving-seasonal time series based on the presumption of additive or multiplicative seasonality. The visual analysis of calculated time series is – without using any other sophisticated statistical methods – also possible.

Firstly, an upward trend is visible in moving-seasonal time series of January and December; it means that the rate at which these months were under average within years is decreasing. In moving-seasonal time series for July and August a downward trend is evident; this shows that the rate at which these months were above average within years is decreasing (again). In other words, graphs presented in appendix 2 show that the "strength" of seasonality fell during the last two centuries. April was a slightly[10] below-average month, as can be seen from the April graph.

[9] The month with average temperatures near the average within each year.

[10] Values very close to zero in the additive-seasonality graph and to number one in the multiplicative-seasonality graph respectively.

Secondly, the development of moving-seasonal time series calculated with the presumption of additive or multiplicative seasonality is quite similar. This result will be discussed in the next section as well.

In all the following sections, moving-seasonal time series will be constructed for January exclusively. January was chosen due to an interesting development of "its" moving-seasonal average monthly temperature time series[11]; there is an upward trend with sharp peaks.

5.2. Selected combination of LMI and SM, element T, station P1PKLM01

The average monthly temperatures measured at P1PKLM01 served as the input time series for this section as well. Several combinations of *LMI* and *SM* were chosen to find out how their choice affects the results (moving-seasonal time series). Each combination of *LMI* and *SM* was again calculated under both additive and multiplicative seasonality. Graphs of constructed moving-seasonal time series are available in appendix 3.

Referring to visual analysis, it is possible to make the following conclusions:
- *LMI* works as a smoothing factor; the higher LMI, the smoother moving-seasonal time series
- *SM* determines the number of values which constitute the moving-seasonal time series
- combination choice of *LMI* and *SM* depends on the objective for which the moving-seasonal time series is constructed; e.g. if we want to follow the main trends, we tend to choose higher *LMI*; when we want to make only the main peaks visible, we select higher *SM*.

The result of comparison of moving-seasonal time series developments based on the presumption of additive or multiplicative seasonality is the same as that in 5.1 section. The developments of corresponding pairs of moving-seasonal time series are almost identical; it is obvious especially for *LMI* = 30 and *SM* = 30.

In all the following sections, only moving-seasonal time series based on additive seasonality and for *LMI* = 10 and *SM* = 1[12] will be constructed.

5.3. Selected stations, element T

In each of appendices 4–8 all graphs have the same scale on both axis. This makes visual analysis much easier. That is why we can see clearly from the graphs in appendix 4 that all the main oscillations are quite similar for all ten selected stations, as far as the element T is concerned. Another advantage is that

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[11] It would surely be interesting to see moving-seasonal time series for elements SRA and SSV for different months as well, but due to the range of this paper, only moving-seasonal time series for January are presented here.

[12] An "average" combination allows to identify most of the possible attributes of constructed moving-seasonal time series.

different trends (until the 50s of the 20th century) are evident. For some of the presented series (e.g. O3PRER01, O2OLOM01), the current trend is constant, however, for most of them the trend is upward. The third result is that divergent levels of values for different measuring stations can be seen. Moving-seasonal time series for some stations (e.g. P2SEMC01, O1OPAV01) lie much lower than for other stations. This means that average temperatures in January were relatively more below-average at these measuring stations each year than they were below-average at most of the chosen measuring stations.

5.4 Selected stations, elements TMA and TMI

Eight out of ten measuring stations, which were used for the construction of moving-seasonal time series for the element T, were chosen for elements TMA and TMI as well. This shows how exceptional the chosen measuring stations are. The main visual analysis results of moving-seasonal time series graphs for the element TMA are de facto the same as those described in section 5.3 – three regular oscillations at the end of the constructed time series, significant peaks and perceptible trends. As the longest time series for the element TMA is much shorter than the longest time series for the element T, the scale of time axis in appendix 5 graphs allows us to analyse these facts visually in more details than it was possible from graphs in appendix 4.

The main difference between moving-seasonal time series for elements TMI (see the graphs in appendix 6) and TMA is as follows: in the case of the element TMI, all values for each measuring station are approximately 2 °C lower than they are in the case of the element TMA[13]. It is obvious that present trends and significant oscillations remained identical in moving-seasonal time series for the element TMI to those for the element TMA. For the most measuring stations, amplitudes of oscillation waves for the element TMI seem much higher than for the element TMA. However, it is advisable – due to the different scale of *y*-axis – to be cautious in making conclusions (based only on a visual analysis). An application of advanced statistical methods would bring more accurate findings.

5.5. Selected stations, element SRA

In appendix 7 there are graphs of moving-seasonal time series for ten selected measuring stations for the element SRA. It is interesting that there are no distinctive upward or downward trends in these graphs. All graphs more or less oscillate around a constant. This implies that the rate of below-average precipitation in January within each year does not change in time. The above mentioned constant differs considerably between the selected stations. It is also remarkable that the graph for the station O1OPAV01, for instance, has no wave in the

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[13] This can be seen on the *y*-axis of all graphs in appendices 5 and 6.

1980s. Graphs amplitudes vary markedly as well; the highest amplitude for the station P3HAVL01 is approximately 30 millimetres, for the station P1PKAR01 it is around 10 millimetres only.

5.6. Selected stations, element SSV

Input monthly time series of the element SSV were shorter than the other elements' series. The longest time series from the measuring station P1PKAR01 begins in the year 1935. This implies that our conclusions based on graphs presented in appendix 8 do not have such an informative value as those based on longer input time series. Values of moving-seasonal time series differ significantly from one station to another. It is obvious that the elevation of a measuring station affects the constructed time series considerably. For higher altitudes, the sunshine duration in January is relatively less below-average within each year (=moving-seasonal time series consist of higher values) than the sunshine duration at lower altitude measuring stations. There are no obvious upward or downward trends in most series presented in appendix 8.

6. Conclusion

This paper deals with an initial stage of the project of moving-seasonal time series construction in the Czech Republic conditions. Input data used for this purpose are described in detail. Software employed for the project and programme functionalities are presented. Necessary statistical background (basic statistical methods used in the software) is also mentioned.

The graphs in appendices represent a large amount of calculations. Main results are these. The choice of additive or multiplicative seasonality does not determine the shape of moving-seasonal time series. For average monthly temperatures, moving-seasonal time series in under-average months follow upward trend. For months that are above average, the trend is downward. Particular selection of *LMI* and *SM* depends on the objective with which moving-seasonal time series are constructed. Moving-seasonal time series for elements T, TMA and TMI show similar features – recurring oscillations and trends. In the case of elements SRA and SSV, moving-seasonal time series show more differences between measuring stations and no strong upward or downward trend.

There are large possibilities of further statistical analysis of moving-seasonal time series. Harmonic analysis, spectral analysis, trend analysis or principle component analysis are just a few examples of statistical methods that can be used for deeper research of constructed series. Wide possibilities of a follow-up research consist also in constructing moving-seasonal time series for other months than January, choosing other combinations of *LMI* and *SM* and, of course, application of the method to completely different input time series. Interesting results may be also obtained from the research of moving-seasonal time series based on socio-economic, environmental and other indicators.

Literature

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Additional sources

www.chmi.cz
www.clidata.cz

Summary

Quality of life and the environment are ambivalently interconnected phenomena. The former declines if the latter deteriorates, and vice versa, the healthy environment is a factor that increases quality of life. The environmental process referred to as "global climate changes" is a widely debated issue. This paper focuses on an aspect of this subject implicit in the development of some climatology element time series. It particularly presents time series of the selected elements measured in the Czech Republic territory. Some statistical methods have been applied as a main tool of the research into these time series.

Appendix 1

Table 2.3.1. Geography of selected measuring stations – element T

GH_ID	FULL_NAME	LATITUDE	LONGITUDE	ELEVATION	THE BEGINNING
P1PKLM01	Praha, Klementinum	500527	142509	191	1775
C2TABO01	Tábor, Náchod	492607	143942	461	1875
O3PRER01	Přerov	492526	172423	202.7	1875
O1OPAV01	Opava, Otice	495511	175234	270	1876
C2CBUD01	České Budějovice	485742	142805	388	1883
P2SEMC01	Semčice	502202	150016	234	1920
P1PKAR01	Praha, Karlov	500403	142507	232	1921
U1MIL001	Milešovka	503317	135553	833	1939
P3HAVL01	Havlíčkův Brod	493642	153448	455	1941
O2OLOM01	Olomouc, Holice	493433	171704	210	1946

Table 2.3.2. Geography of selected measuring stations – elements TMA and TMI

GH_ID	FULL_NAME	LATITUDE	LONGITUDE	ELEVATION	THE BEGINNING
C2CBUD01	České Budějovice	485742	0142805	388	1884
C2TABO01	Tábor, Náchod	492607	0143942	461	1893
O1OPAV01	Opava, Otice	495511	0175234	270	1908
P2SEMC01	Semčice	502202	0150016	234	1920
P1PKAR01	Praha, Karlov	500403	0142507	232	1921
U1MIL001	Milešovka	503317	0135553	833	1939
P3HAVL01	Havlíčkův Brod	493642	0153448	455	1941
O2OLOM01	Olomouc, Holice	493433	0171704	210	1947
U2LIBC01	Liberec	504612	0150127	397.7	1949
C2NADV01	Nadějkov, Větrov	493102	0142758	615	1951

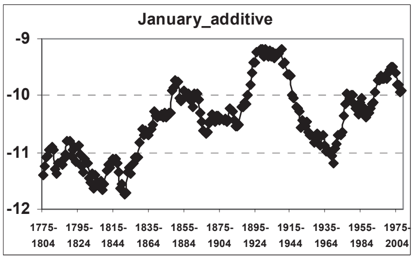
Table 2.3.3. Geography of selected measuring stations – element SRA

GH_ID	FULL_NAME	LATITUDE	LONGITUDE	ELEVATION	THE BEGINNING
O3PRER01	Přerov	492526	172423	202.7	1875
C2CBUD01	České Budějovice	485742	142805	388	1876
O2OLKL01	Olomouc, Klášterní Hradisko	493632	171551	215	1876
C2TABO01	Tábor, Náchod	492607	143942	461	1901
O1OPAV01	Opava, Otice	495511	175234	270	1906
C2KARD01	Kardašova Řečice	491052	145147	452	1932
P2SEMC01	Semčice	502202	150016	234	1934
P1PKAR01	Praha, Karlov	500403	142507	232	1938
U1MIL001	Milešovka	503317	135553	833	1939
P3HAVL01	Havlíčkův Brod	493642	153448	455	1941

Table 2.3.4. Geography of selected measuring stations – element SSV

GH_ID	FULL_NAME	LATITUDE	LONGITUDE	ELEVATION	THE BEGINNING
P1PKAR01	Praha, Karlov	500403	0142507	232	1935
P2SEMC01	Semčice	502202	0150016	234	1938
U1DOKS01	Doksany	502730	0141013	158	1952
P1PRUZ01	Praha, Ruzyně	500603	0141528	364	1954
C1CHUR01	Churáňov	490406	0133654	1117.8	1955
O1LYSA01	Lysá hora	493246	0182652	1321.8	1956
P3PRIB01	Přibyslav, Hřiště	493458	0154545	530	1956
H3HRAD01	Hradec Králové, Nový Hradec Králové	501034	0155019	278	1958
O1MOSN01	Mošnov	494154	0180718	250.4	1960
B1HOLE01	Holešov	491907	0173424	223.6	1961

Appendix 2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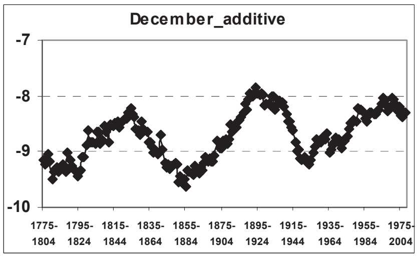
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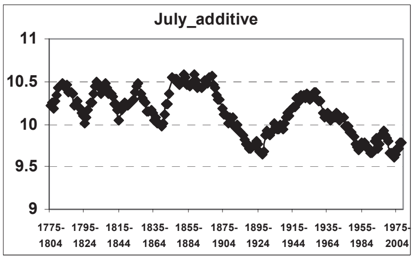
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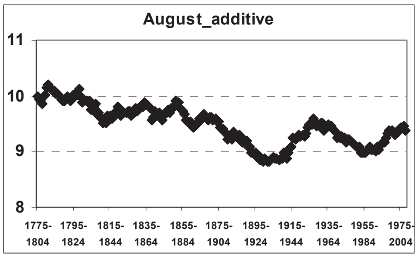
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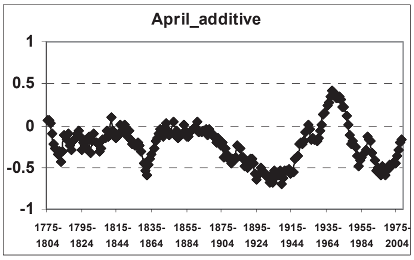
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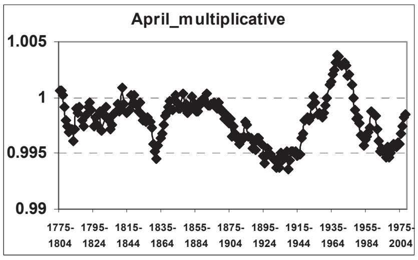
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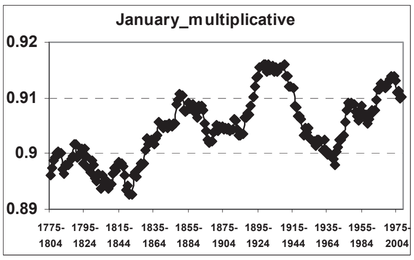
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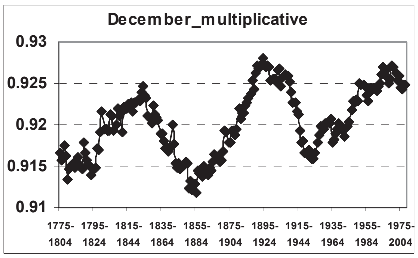
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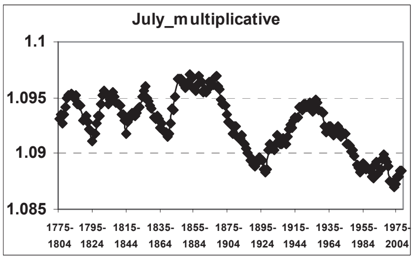
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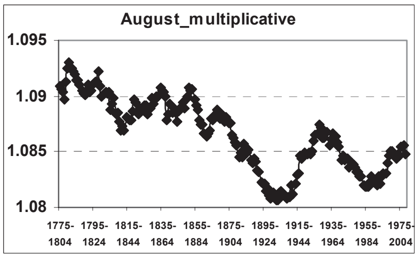
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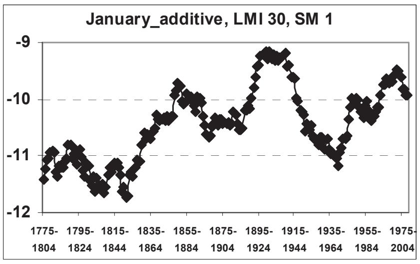
Appendix 3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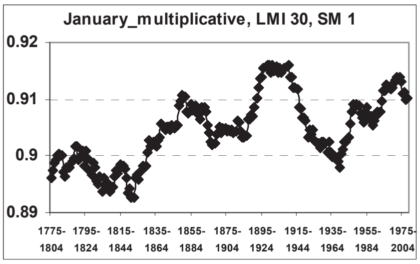
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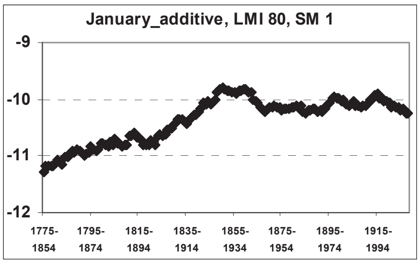
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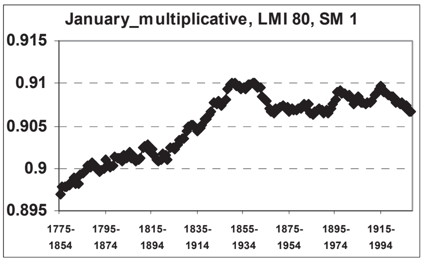
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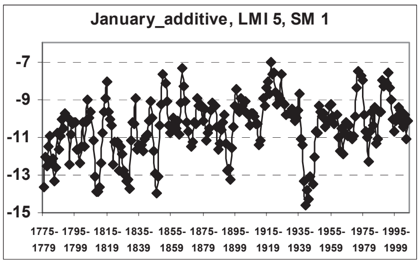
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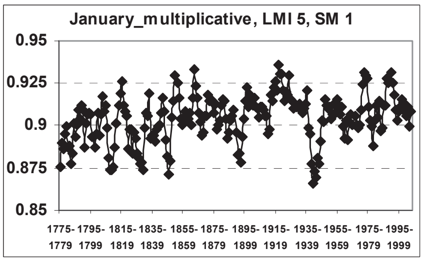
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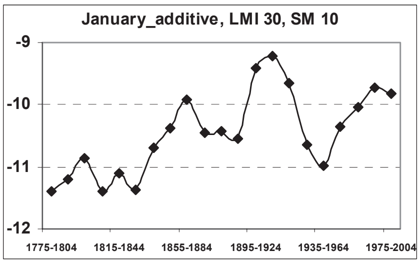
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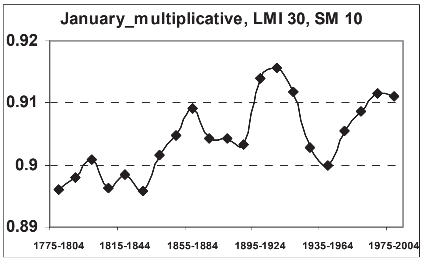
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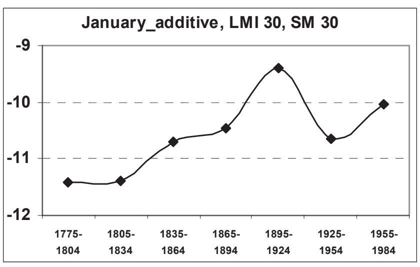
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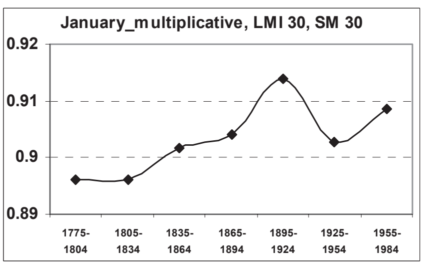
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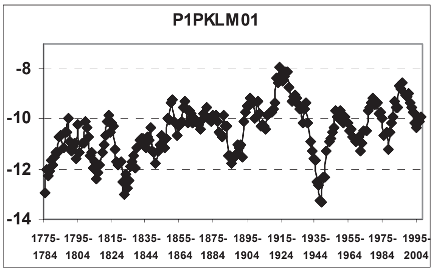
Appendix 4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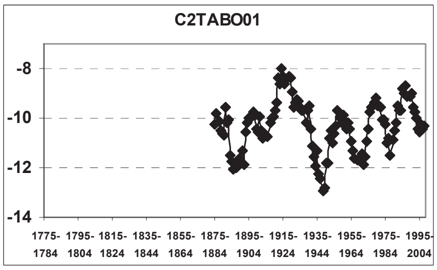
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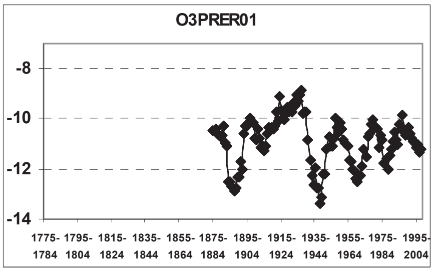
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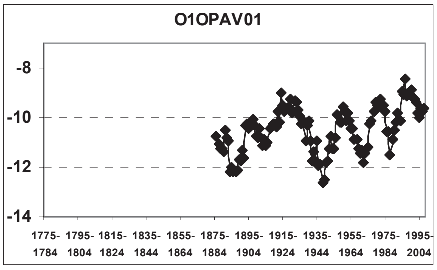
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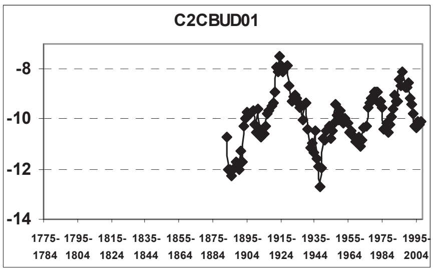
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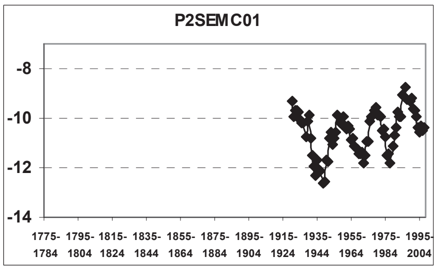
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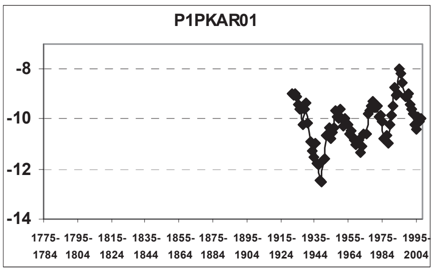
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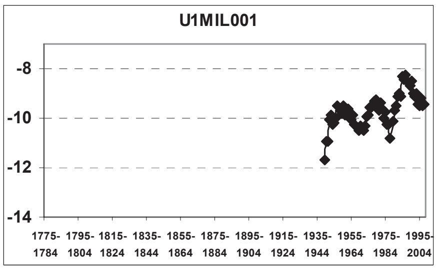
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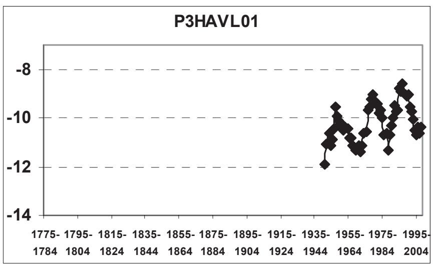
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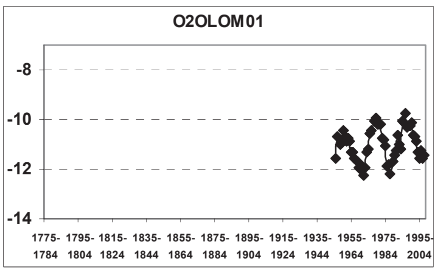
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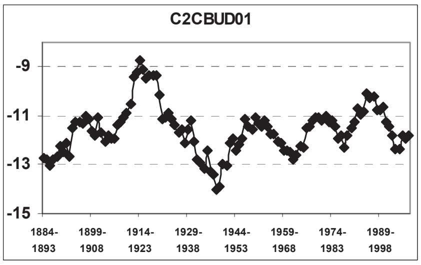
Appendix 5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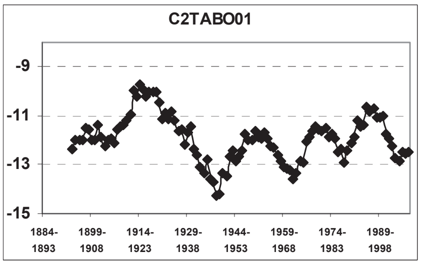
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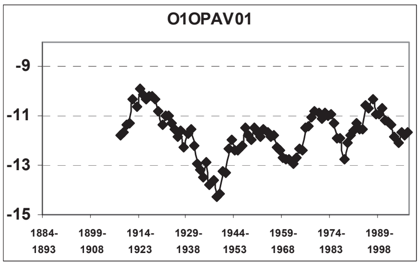
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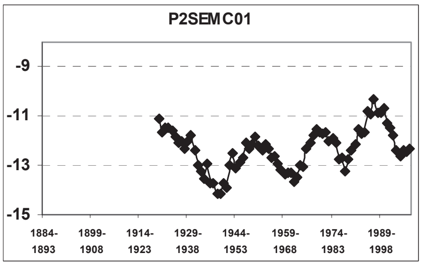
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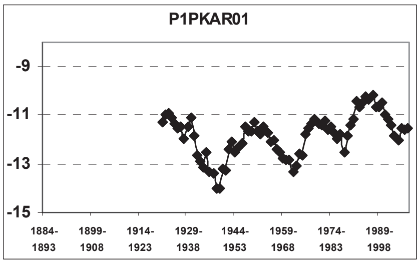
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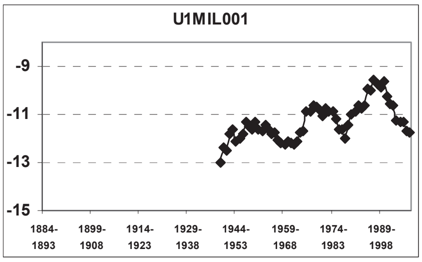
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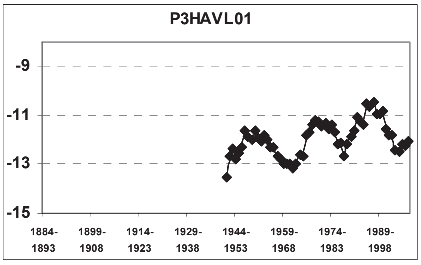
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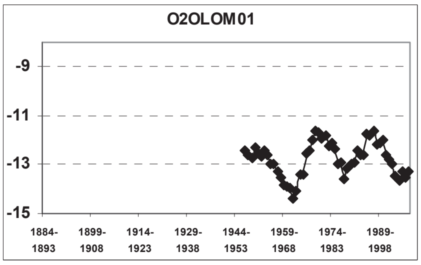
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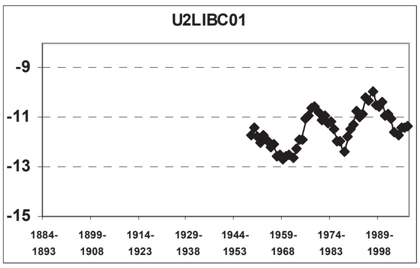
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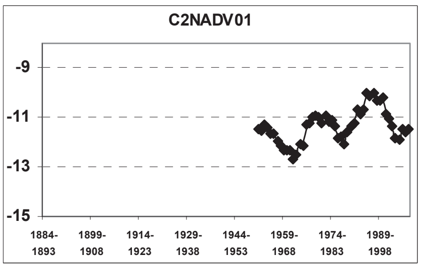
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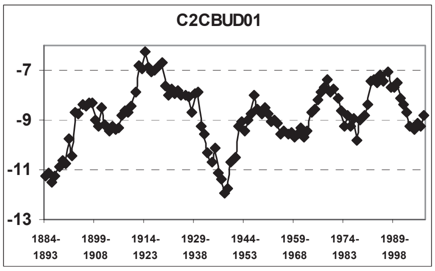
Appendix 6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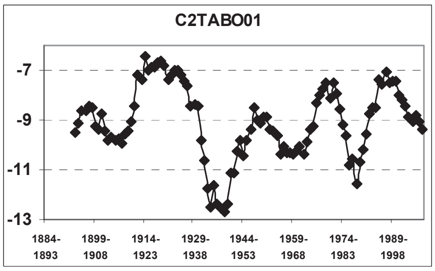
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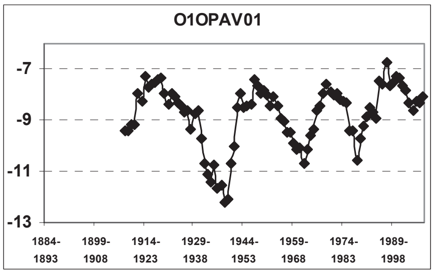
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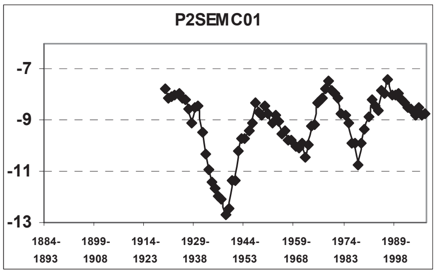
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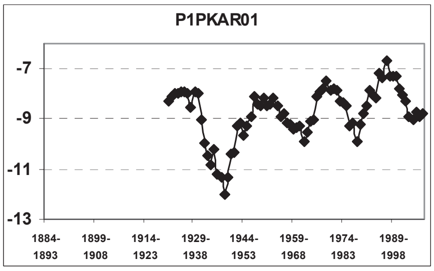
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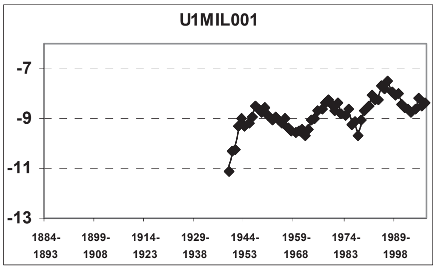
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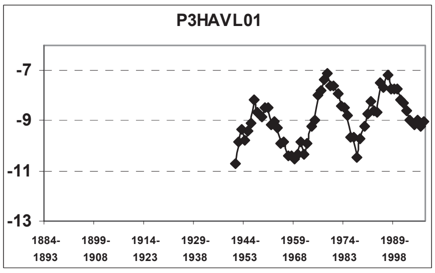
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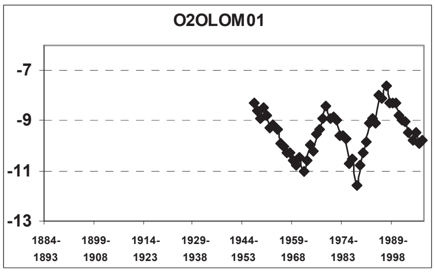
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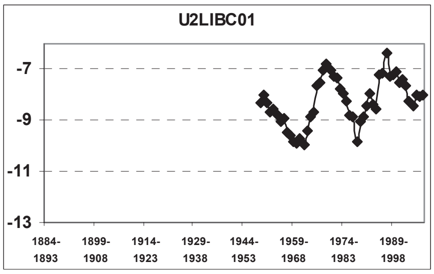
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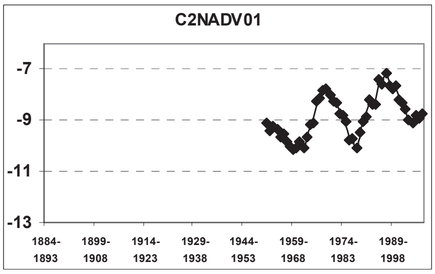
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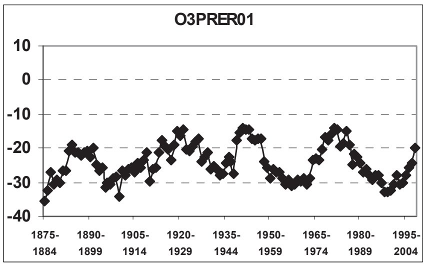
Appendix 7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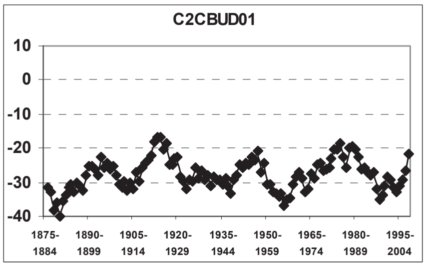
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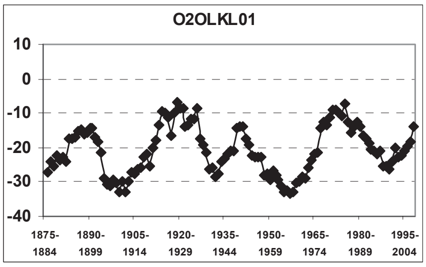
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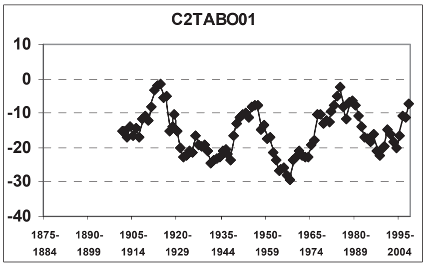
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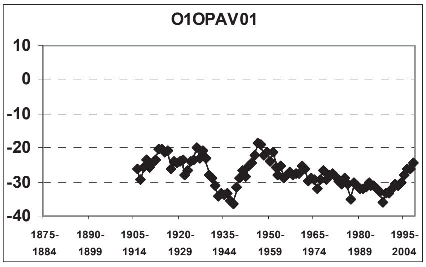
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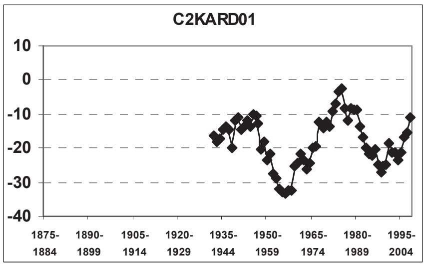
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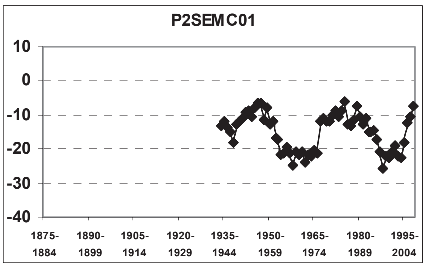
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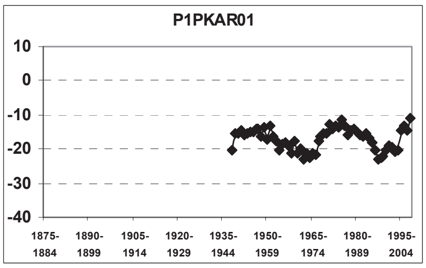
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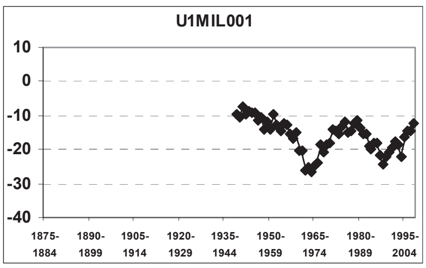
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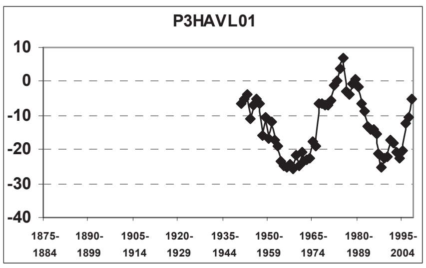
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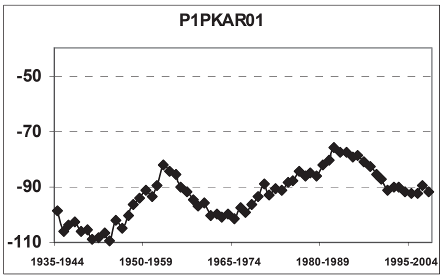
Appendix 8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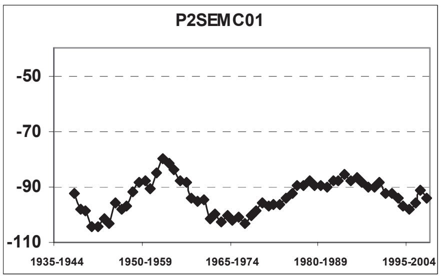
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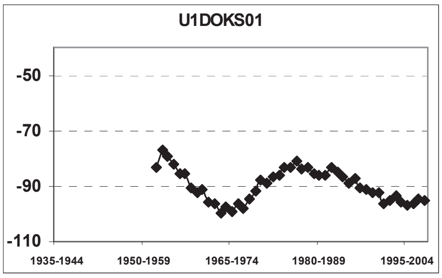
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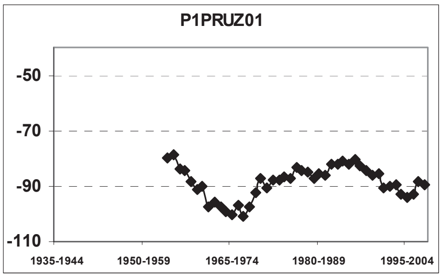
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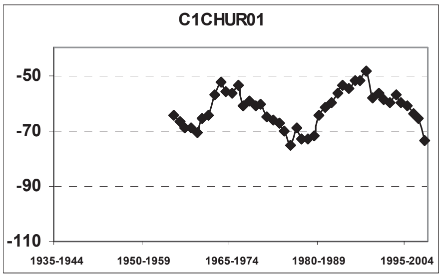
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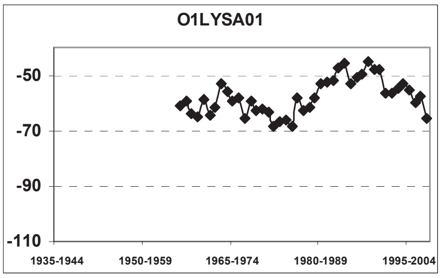
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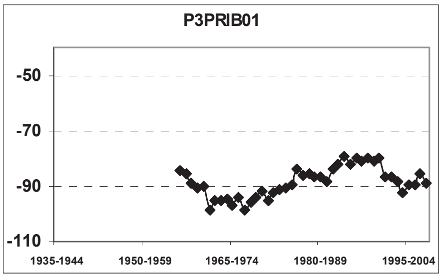
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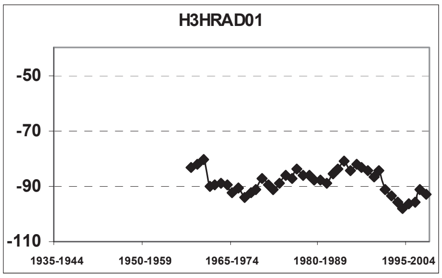
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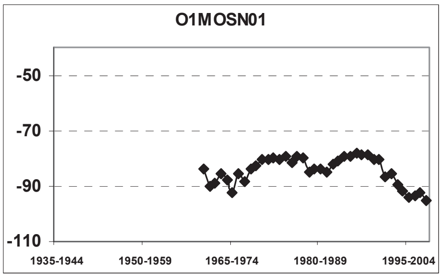
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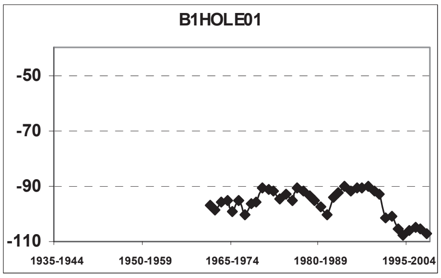
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