

ChronoLog 2.0: User Manual



ChronoLog is a software tool for computer-assisted chronological research in archaeology, available at no cost at chrono.ulb.be. Running ChronoLog requires a working Java installation (<https://www.java.com/ES/download/>).

This user manual succinctly presents the usage of ChronoLog from a practical perspective. For a more detailed presentation of the ChronoLog principles, concepts, and data model, see:

Levy, E. and Geeraerts, G., Pluquet, F., Piasetzky, E. and Fantalkin, A.,
[*Chronological Networks in Archaeology: a Formalised Scheme*](#). Journal of
Archaeological Science 127, 2021.

Part I: The ChronoLog data model

1. Chronological networks

ChronoLog enables users to model chronological data in the shape of a network. We define a *chronological network* as an object consisting of three types of data: periods, sequences and synchronisms, which are described below.

1.1. Periods

A *period* is defined as continuous interval of time, without gaps. It is characterized by a *start date*, an *end date*, and a *duration*. While these three quantities are clearly correlated (since the duration is the difference between the start date and the end date), each of them can be set independently in ChronoLog, as complete knowledge on all three parameters is not always available.

Bounds

ChronoLog allows to encode lower bounds (i.e., minimal values) and upper bounds (i.e., maximal values) on the start date, the end date and the duration of a period. None of these bounds are mandatory. Hence the duration, start date and end date can either be *unknown* (no bound at all), *lower bounded* (e.g., “at least 10 years”, or “after 1200 CE”), *upper bounded* (e.g., “at most 20 years”, or “before 1300 CE”), in a *range* (e.g., “between 10 and 20 years”, or “between 1200 and 1300 CE”), or *known* (e.g., “15 years”, or “1250 CE”).

Since version 2.0, ChronoLog has two possible views on these data: the “full view” and the “concise view”:

Full view. The full view (Figure 1) was the standard view used in ChronoLog up until version 1.2, and is now deprecated. It shows all the lower and upper bounds for the duration, start date and end date of each period, even unknown bounds (represented by a question mark). In this view a *known* date or duration is represented by setting an equal value for the lower and the upper bound. Figure 1a gives an example of a period in full view, with a start date after (or equal to) 1200 CE, an end date before (or equal to) 1300 CE, and a duration of 50 years. The values located on the right side of the arrows are the bounds computed by the software and will be explained below (Section 2a). Encoding or modifying a bound is done by clicking directly on the bound, which displays an input dialog (Figure 1b).

Concise view. The new default view (since ChronoLog 2.0), called the “concise view” (Figure 2), represents these bounds in concise form. Instead of displaying all the 6 bounds (earliest start, latest start, earliest end, latest end, minimum duration, maximum duration) explicitly, a summarized version of the information is given, hiding unknown bounds, and showing exact values only once (rather than with 2 bounds). The concise view shows the input bounds in straight fonts and the computed bounds in italics.

Moving between the full view and the concise view is done via the “View” menu. This menu also allows to show the inputs only, in concise view.

(a) Full view: input bounds on the left, results on the right.

(b) The bounds input dialog.

Figure 1. (a) A ChronoLog period with a start date not earlier than 1200, an end date not later than 1300 and a duration of 50 years (full view). (b) The input dialog displayed when clicking on a bound. Note that the bounds located on the left side of the arrows represent the encoded data, those on the right side of the data are computed by the software.

Period A
(50 y.)
[1200, 1250] - [1250, 1300]

(a) Concise view (inputs [straight] and results [italics]). The duration is shown in the center, the start date at the left, the end date at the right.

Period A
(50 y.)
[after 1200] - [before 1300]

(b) Concise view (inputs only)

Inputs for Period A

? Start End Duration

Unknown

Known: [input field]

After: 1200

Before: [input field]

Range: from [input field] to [input field]

OK Cancel

(c) Editing a period in concise view.

Figure 2. (a) A ChronoLog period with a start date not earlier than 1200, an end date not later than 1300 and a duration of 50 years (concise view). (b) The concise view, showing inputs only. (c) The input dialog.

1.2. Sequences

A *sequence* is defined as a set of periods that are contiguous in time. The end date of a given period is identical to the start date of the next period in the sequence. Every period belongs to exactly one sequence. Figure 3 provides an example of a sequence in ChronoLog. The sequence contains two periods, one of known duration (50 years), the other with bounded duration (between 20 and 40 years). The sequence is further known to have started after 1200 CE, and to have ended before 1300 CE.

Sequence S	
Period A	
Start:	[1200 , ?] → [1200 , 1250]
End:	[? , ?] → [1230 , 1280]
Duration:	[30 , 30] → [30 , 30]
Period B	
Start:	[? , ?] → [1230 , 1280]
End:	[? , 1300] → [1250 , 1300]
Duration:	[20 , 50] → [20 , 50]

Figure 3. A sequence comprising two periods (in full view). The first period starts not earlier than 1200 CE and lasts 30 years. The second period ends not later than 1300 and lasts between 20 and 50 years.

1.3. Synchronisms

We define a *synchronism* as any chronological relation involving two different periods. The simplest type of synchronism is the *contemporaneity* synchronism, defined as two periods A and B having at least one unit of time in common. In more formal terms, this synchronism is defined as period A not ending before the start of period B, and period B not ending before the start of period A. ChronoLog allows users to encode a wide set of possible types of synchronisms between periods. The window for choosing a synchronism is shown in Figure 4. Clicking on a specific type of synchronism displays its definition on the right side of the window.

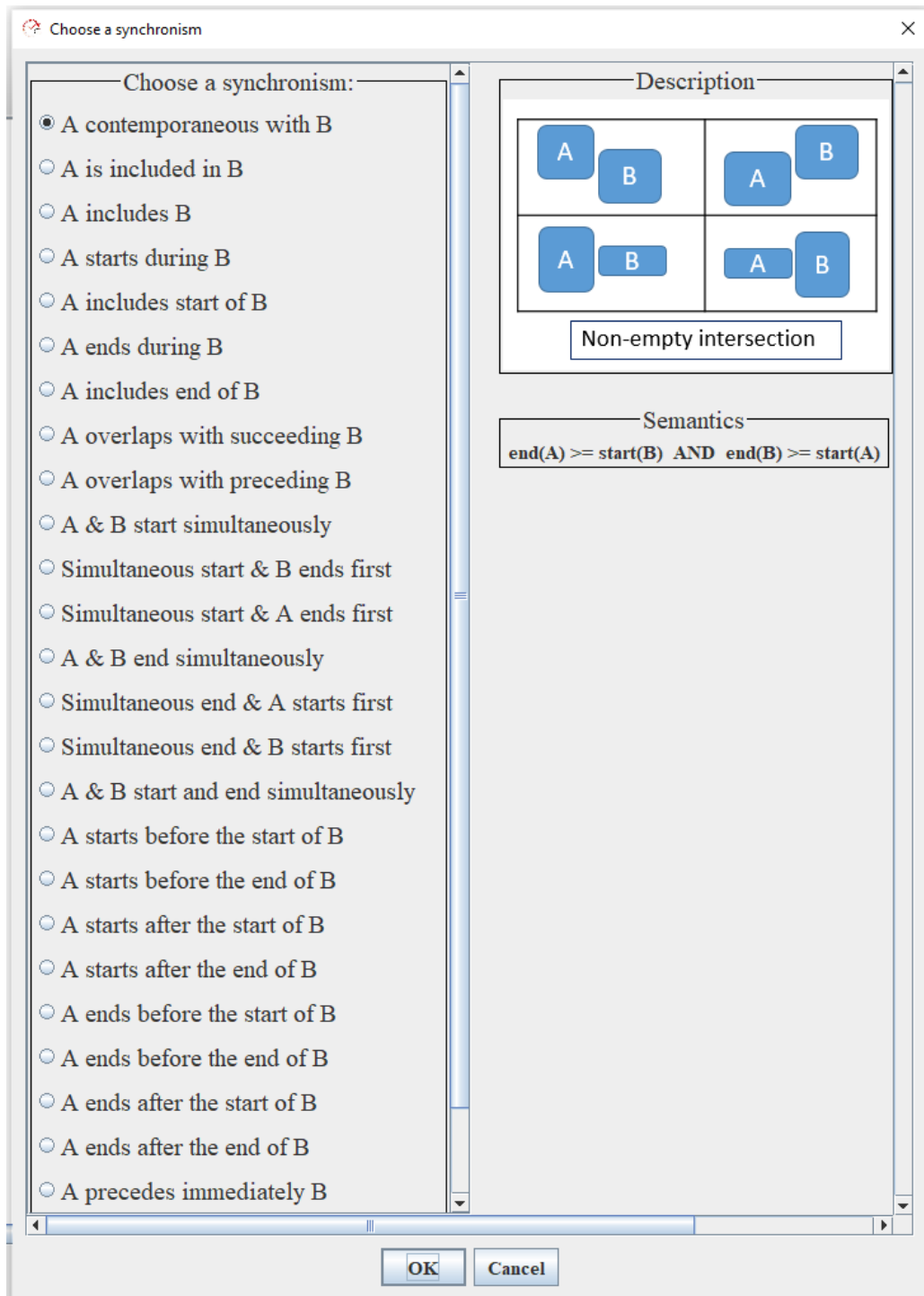


Figure 4. The ChronoLog synchronism chooser dialog, showing all types of synchronisms supported by the software.

2. Operations on chronological networks

2.1. Consistency check

Given a chronological network comprising a set of sequences, periods and bounds, ChronoLog checks automatically whether the encoded data are consistent with each other. For example, a period taking place before 1200 CE cannot be contemporaneous with a period taking place after 1300 CE. The consistency check is automatically launched every time a change is made to the network, i.e. every

time one adds, modifies or deletes a period, a sequence or a synchronism. In case the model is found to be inconsistent, a pop-up dialog informs the user that the model is inconsistent, and proposes an explanation as to why it is inconsistent (see Figure 5).

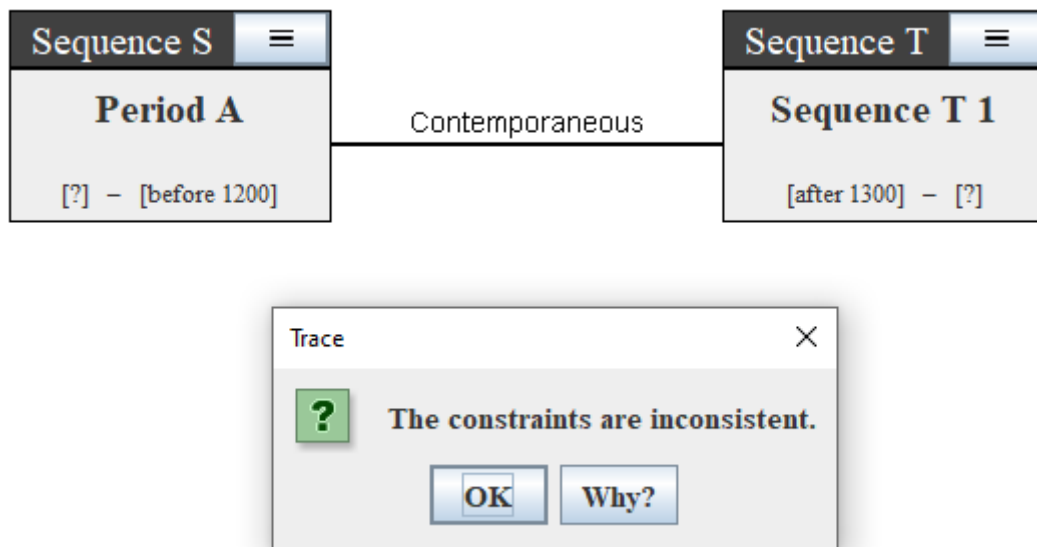
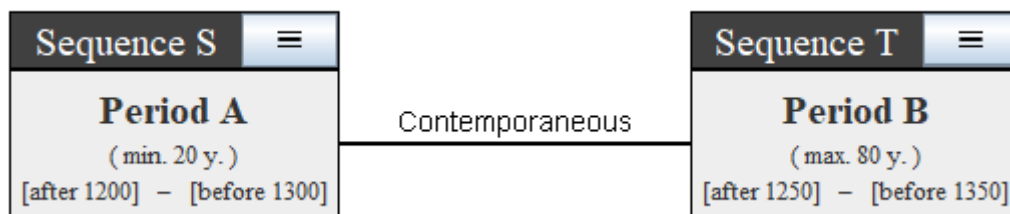


Figure 5. An example of a non-consistent model (showing inputs only): period A ends not later than 1200, period B starts not earlier than 1300, and both periods are linked by a contemporaneity synchronism.

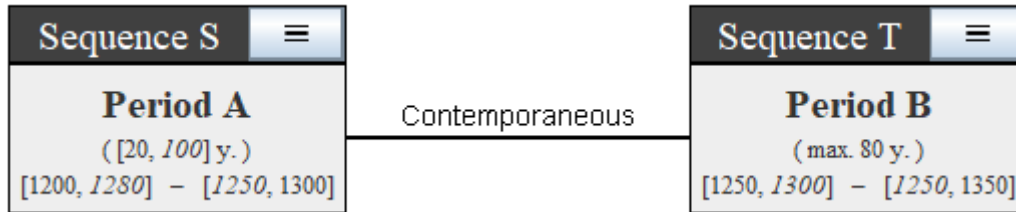
2.2. Tightening

The tightening operation consists in using the encoded bounds and synchronisms in order to compute the tightest possible ranges on each start date, end date and duration. These new bounds will be called *posterior* (or *computed*) bounds. ChronoLog guarantees these bounds to optimal in the following sense: no further tightening of the posterior ranges can be obtained using the encoded prior data¹. In other words, any more precision on the dates and durations can only be obtained by adding more data into the system. The computed bounds are shown inside each period, after the arrows. Figure 6 provides an example of tightening.



(a) Inputs only

¹ For a mathematical justification of this statement, see: Gilles Geeraerts, Eythan Levy, and Frédéric Pluquet. [Models and Algorithms for Chronology](#), in: Proceedings of The 24th International Symposium on Temporal Representation and Reasoning (TIME), 2017. Leibniz International Proceedings in Informatics, Vol. 13, p. 13:1-13:18.



(b) Result of the tightening procedure

Figure 6. Example of tightening. The values located on the right side of the arrows depict the posterior bounds. All of the start date, end date and duration assumptions have been improved, except the duration of Period B.


Part II: User manual

3. File operations


3.1. Creating a new model

A new model is created using *File* → *New* or by clicking the  icon.

3.2. Opening and closing a model

A previously saved model file can be opened using *File* → *Open* or by clicking the  icon. A model can be closed using *File* → *Close*.

3.3. Saving a model

A model can be saved into a file (with “.clog” extension) by using *File* → *Save* or by clicking the  icon. Alternatively, one can use the “Save as” feature, available through *File* → *Save as*.

3.4. Importing and exporting to CSV

In order to export to a CSV file the computed results (computed ranges) for each date and duration of a model, use *File* → *Export results to CSV*.

Exporting the input data of a model (sequences and synchronisms) is done in two steps: one needs to export separately the sequences and the synchronisms. Two CSV files are thus created. To export the sequences of a model to a CSV file, use *File* → *Export sequences to CSV*. To export the synchronisms of a model to a CSV file, use *File* → *Export synchronisms to CSV*.

Once exported, the user can edit these files with any CSV editor if he wishes. To reimport them into ChronoLog, use *File* → *Import sequences to CSV* (for sequences) and *File* → *Import synchronisms to CSV* (for synchronisms). The sequences file must be imported before the synchronisms file.

For all CSV import and export options, the separator is the semi-colon.

3.5. Resetting a model



The current model can be reset to a blank one using *File* → *Reset*.

3.6. Exporting the model as an image

The current model can be exported as an image (*png*, *jpg*, *gif* or *bmp*) using *File* → *Export as image*.

3.7. Exporting the model to OxCal

The current model can be exported as an OxCal (see <https://c14.arch.ox.ac.uk/oxcal.html>) Bayesian

radiocarbon model using *File* → *Export to OxCal* or using the  icon. ChronoLog then launches the “OxCal export” dialog (Figure 7) into which users can encode their radiocarbon determinations for each ChronoLog period. In addition, the dialog allows the user to choose whether to use the input bounds or the ChronoLog computed bounds in the OxCal script. ChronoLog then creates a script in the OxCal language with Bayesian priors equivalent to the ChronoLog sequences, bounds and synchronisms. Every ChronoLog period is translated to a ChronoLog phase into which the radiocarbon determinations are inserted. Alternatively, one can also export one sequence to OxCal, instead of the whole, model, by clicking on the “Menu” button  of the sequence toolbar, then choosing “Export sequence to OxCal”. For full details on the conversion rules from ChronoLog to OxCal, see:

Levy, E., Piasezky, E., Fantalkin, A. and Finkelstein, I. 2022: [From Chronological Networks to Bayesian Models: ChronoLog as a Front-end to OxCal](#). Radiocarbon 64: 101-134.

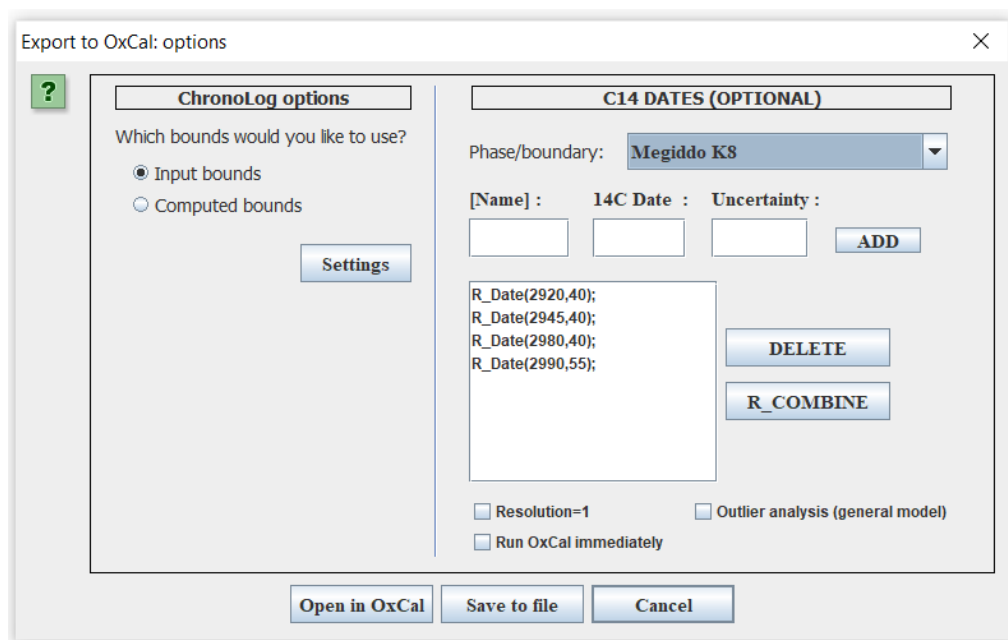




Figure 7. The “OxCal export” dialog.

4. Inserting sequences into a model


4.1. Creating a new sequence

A new sequence can be created using *Insert* → *New sequence* or by clicking the  button. This will launch a dialog asking for the name of the sequence. The new sequence will contain only one period. For adding new periods to the sequence, see below.

4.2. Inserting a component from the ChronoLog library

A component can be added to the current model using *Insert* → *Insert from library* or by clicking the  button. The component can consist of a single sequence, or a group of sequences, with possible synchronisms between them. The component is **added** to the current model, without erasing its current contents.

4.3. Inserting a component from a ChronoLog file (*clog* format)

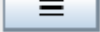
A component can be added to the current model using a previously saved “.clog” file (see above for instructions on file saving). This can be done using *Insert* → *Insert from file* or by clicking the  button. The component contained in the file is **added** to the current model, without erasing the model’s current contents.

4.4. Inserting a component from a CVS file

CVS files for sequences and synchronisms exported through *File* → *Export sequences to CSV* (for sequences) and *File* → *Export synchronisms to CSV* (see above) can be inserted in an existing model using *Insert* → *Insert sequences from CSV* (for sequences) and *Insert* → *Insert synchronisms from CSV*. The difference between these operations and the former operations *File* → *Import sequences from CSV* and *File* → *Import synchronisms from CSV* is that the latter create a new model while the insertion operations add data to the current model.

5. Editing sequences

5.1. Deleting a sequence

A sequence can be removed from the model by clicking the  button located near the sequence name, then clicking on “Delete sequence” (see Figure 8).

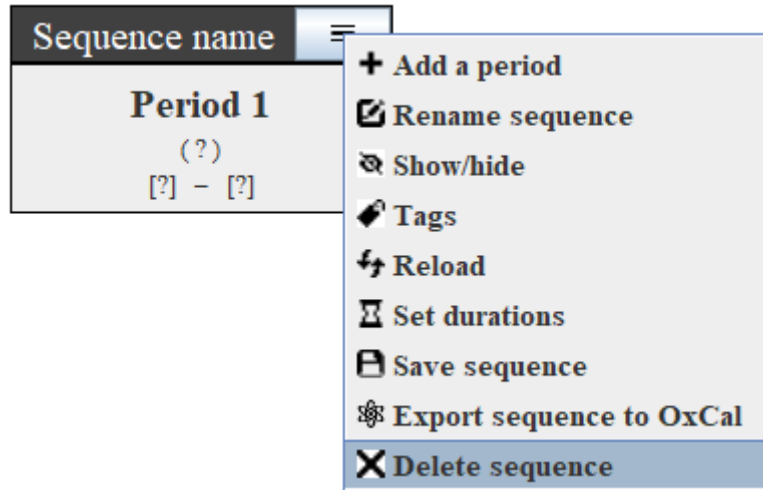



Figure 8. Deleting a sequence

5.2. Adding a period to a sequence

A period can be added at the end of a sequence by clicking the  button located near the sequence name, then clicking on “Add a period” (see Figure 9).

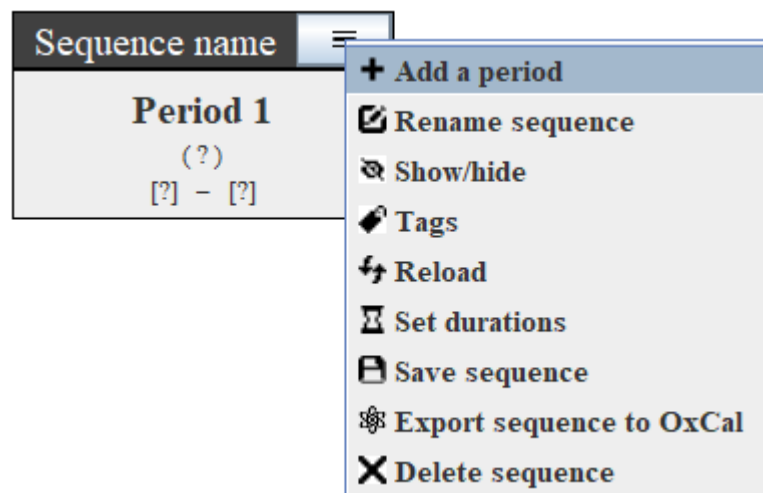




Figure 9. Adding a period to a sequence


5.3. Renaming a sequence

A sequence can be renamed by clicking the  button located near the sequence name, then clicking on “Rename sequence”.


5.4. Hiding a sequence

A sequence can be hidden by clicking the  button located near the sequence name, then clicking on “Show/hide”. A hidden sequence appears as shaded and has no effect anymore on the model. Neither its periods nor its synchronism are taken into consideration when checking the model’s consistency and when computing the tightened ranges of dates and durations. Unhiding a sequence is done by clicking on the same button.


5.5. Saving a sequence to a file

A sequence can be saved to a “.clog” file in order to be inserted into future models. This is done by clicking on the  button located near the sequence name, then choosing “Save sequence”. A saved sequence is saved “as is”, without other sequences and synchronisms.


5.6. Changing all period durations

The durations of all periods of a sequence can be changed at once. This is done by clicking on the  button located near the sequence name, then choosing “Set durations”.

5.7. Reloading a sequence

The default values of a sequence can be reloaded after they have been changed. This is done by clicking on the  button located near the sequence name, then choosing “Reload”. This only affects the bounds of the dates and durations of the sequence’s periods. It has no effect on synchronisms. The default values are defined as “unknown” for newly-created sequences, and as the initially loaded ones if the sequences was loaded from a library or from a file.

5.8. Tagging a sequence

Each sequence can be assigned a series of tags. In order to add or remove tags from a sequence, click on the “Menu” button  of the sequence toolbar, then choose “Tags” (see Figure 10).

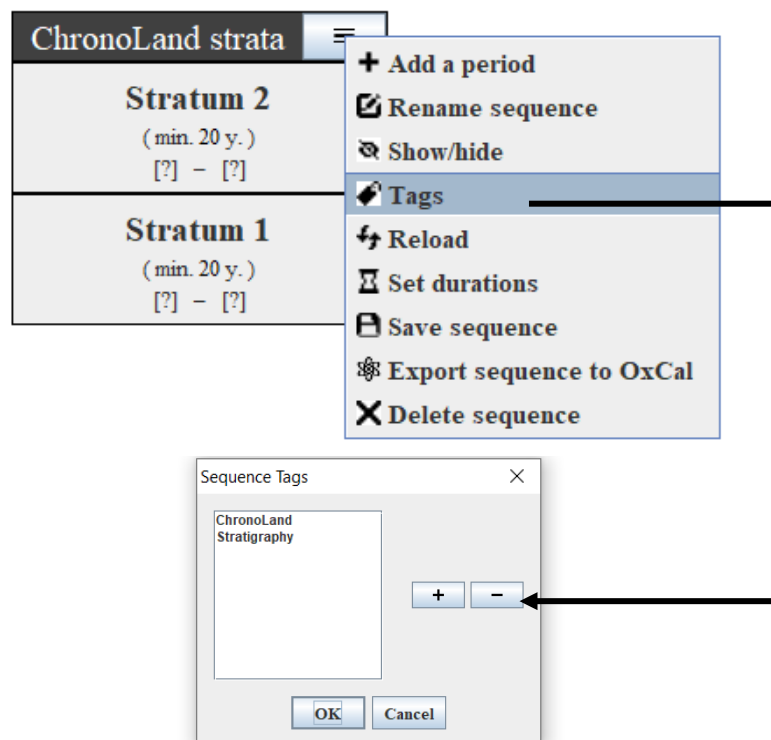


Figure 10. Pop-up dialog showing the two tags (namely “ChronoLand” and “Stratigraphy”) of the sequence “ChronoLand strata”.

5.9. Hiding/showing sequences according to tags

The bottom part of the ChronoLog window contains the tags panel. This panel allows the user to check/uncheck the desired tags. After clicking on “Select”, all tags that are unchecked are hidden from

the model, using the same sequence hiding mechanism as described above. The effect of this procedure is that each sequence which has at least one unchecked tag becomes hidden (even if it does have another that which is not hidden). Figure 11 provides an example of hiding a specific tag.

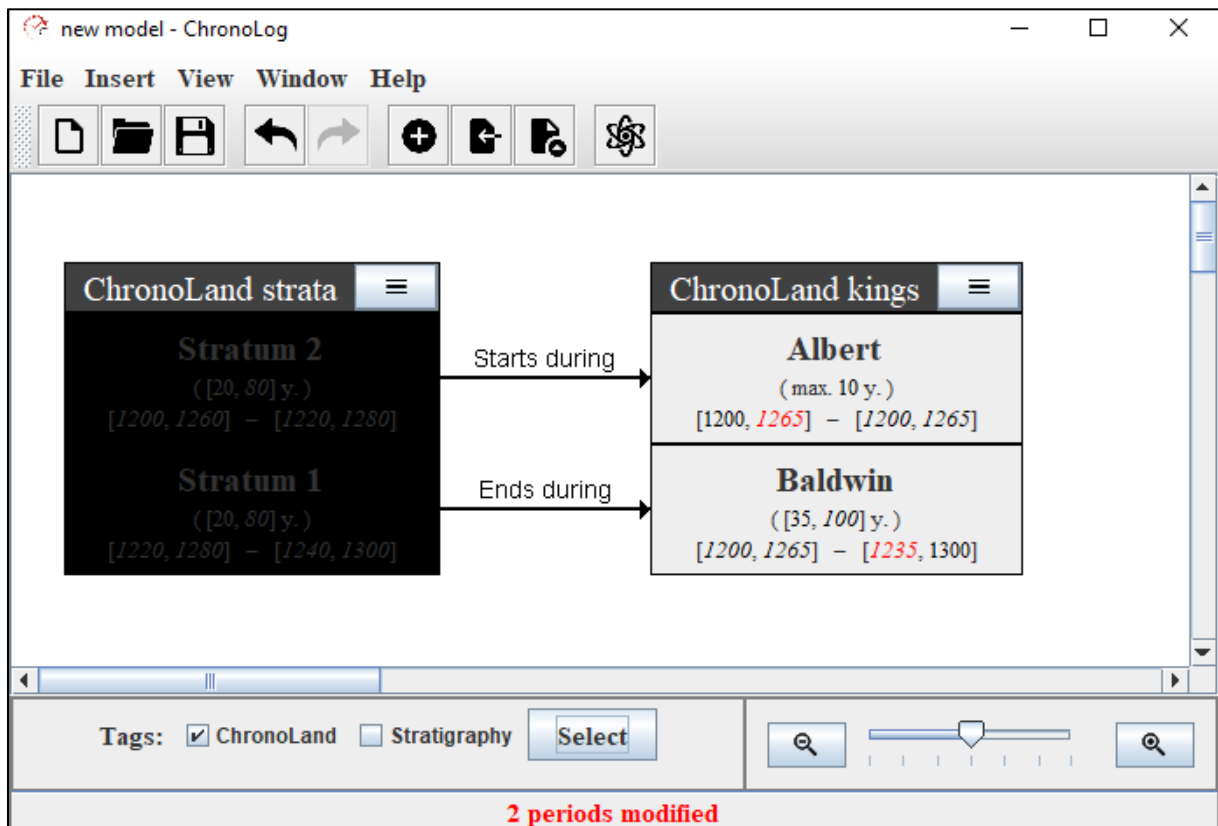


Figure 11. Hiding the “Stratigraphy” tag. This has the effect of automatically hiding the “ChronoLand strata” sequence, since this sequence has the “Stratigraphy” tag (in full view).

5.10. Moving a sequence

Sequences can be moved by drag and drop, by clicking on the sequence name.

6. Editing periods

6.1. Renaming a period

A period can be renamed by clicking on it, then choosing “Rename” in the context menu (see Figure 12). Note that two periods may not have the same name.

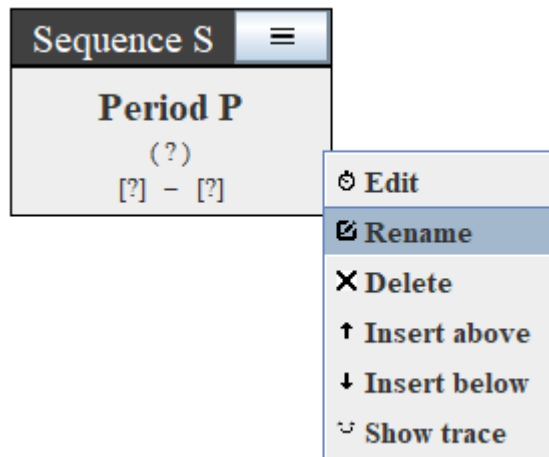


Figure 12. Changing the name of a period.

6.2. Deleting a period

A period can be deleted by clicking on it, then clicking on “Delete” in the context menu. Deleting a period removes it from its sequences, and removes all its synchronisms from the model. The sequence, and all the other periods contained in it, are not removed however.

6.3. Inserting a new period above a given period

A new period can be inserted above a given period. The new period is thus earlier in time than the given period. This is done by clicking on the period, then choosing “Insert above” in the context menu.

6.4. Inserting a new period below a given period

A new period can be inserted below a given period. The new period is thus later in time than the given period. This is done by clicking on the period, then choosing “Insert below” in the context menu.

6.5. Editing a prior bound

A newly created period has unknown prior bounds for its start date, end date and duration. In order to set such a prior bound, one clicks on a period, then on “Edit” in the context menu. This will launch a window enabling the user to input an unknown value for the bound, a known value, a lower bound, an upper bound, or a range. Figure 13 shows an example of setting an earliest start date for a period. Setting other types of bounds (latest start date, earliest end date, latest end date, minimum duration and maximum duration) is done in the same way. Dates BCE are set using a negation sign, as in -1234. Editing a period immediately launches a consistency check of the model, and recomputes the tightened (posterior) ranges.

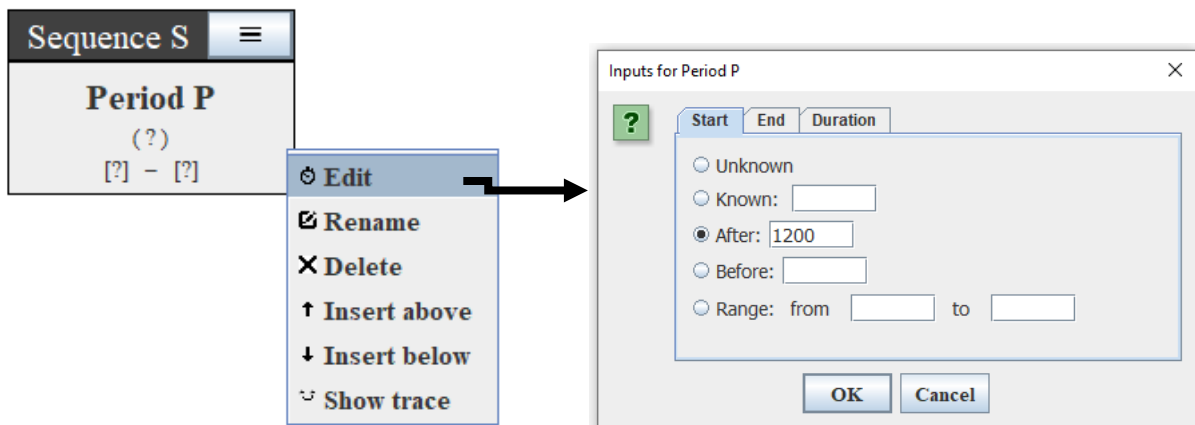


Figure 13. Setting an earliest start date of 1200 CE for a period.

6.6. Consulting traces

In order to obtain a trace (i.e. a justification) for a computed bound, click on the period, then on “Show trace” in the context menu. A popup menu then asks the user for which bound he wants a trace. This trace is then displayed in a separate pop-up dialog (see Figure 14). Bounds and synchronisms participating in the trace are highlighted in pink (except for duration traces).

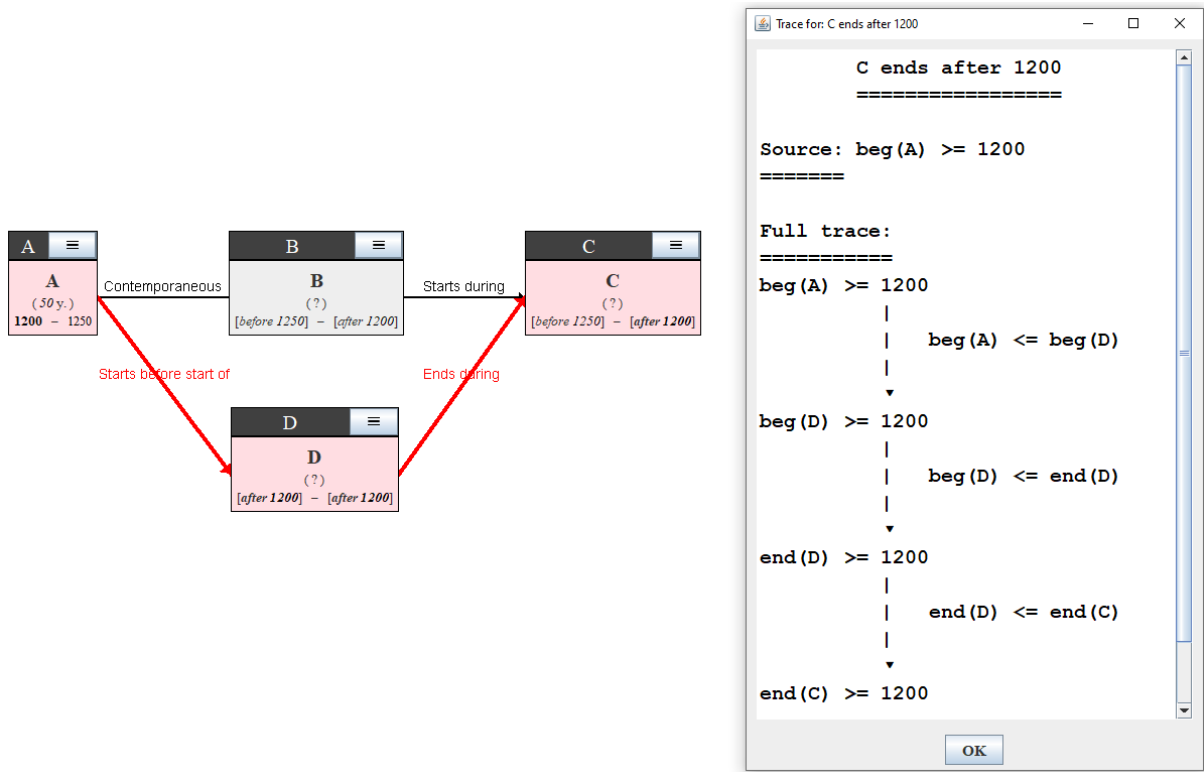


Figure 14. Example of a trace showing why period C ends after 1200. The trace is graphically displayed in red, and the involved bounds are shown in bold. A popup window also displays a mathematical view of the trace.

7. Working with synchronisms

7.1. Adding a synchronism

A synchronism can be added by connecting two periods directly with the mouse, or by using the synchronisms panel accessible through *Window* → *Synchronisms*. In both cases, a dialog appears asking the user to choose the desired type of synchronism. Each synchronism type is provided with a formal definition and an explanatory figure (see Figure 15). Another way to connect two periods, especially useful for periods that are far from each other, is to click on a period, drag a line and release it in an empty spot. A dialog then appears asking the user to choose the destination period (see Figure 16).

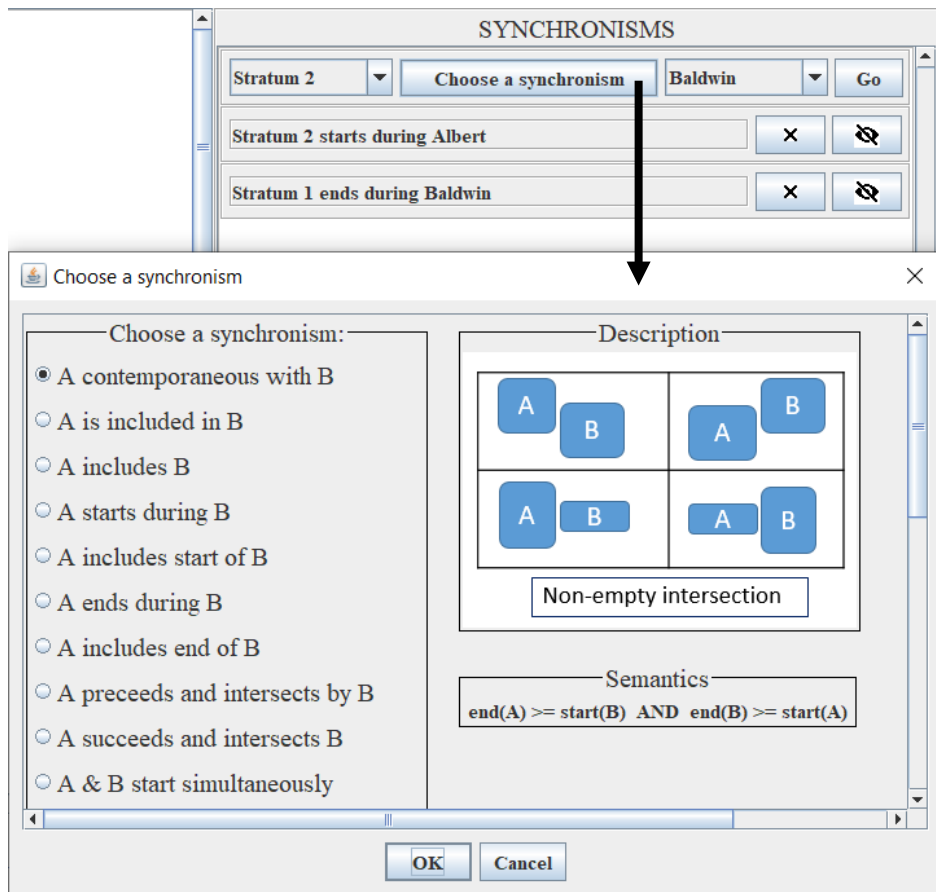


Figure 15. The synchronisms creation dialog.

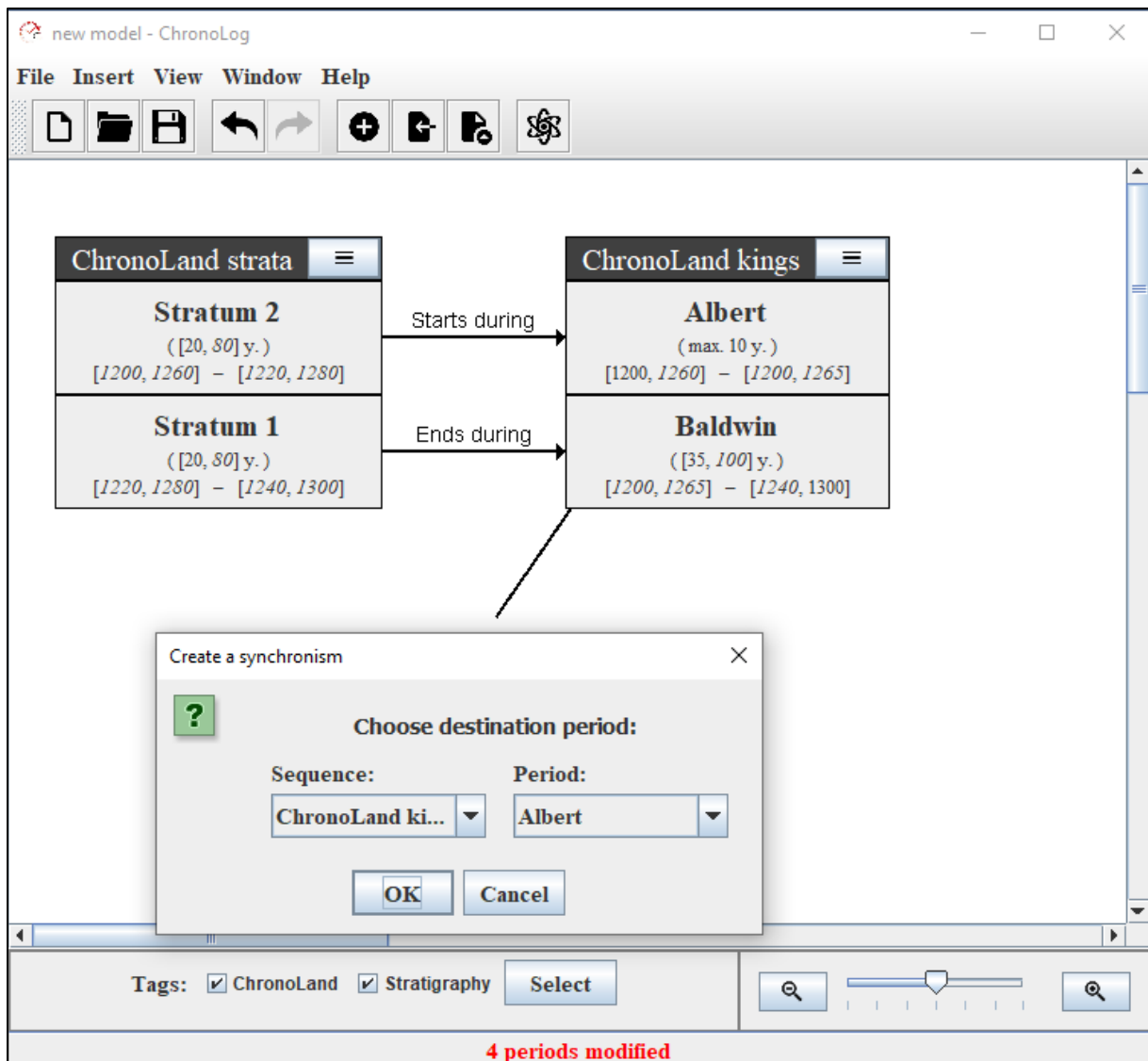


Figure 16. Creating a synchronism by releasing the mouse in empty space.

7.2. Consulting a synchronism

Each synchronism appears both as an arrow connecting two periods. Clicking on a synchronism's arrow displays a small pop-up dialog showing the full name of the synchronism, and allowing to hide it, modify it or delete it (see Figure 17).

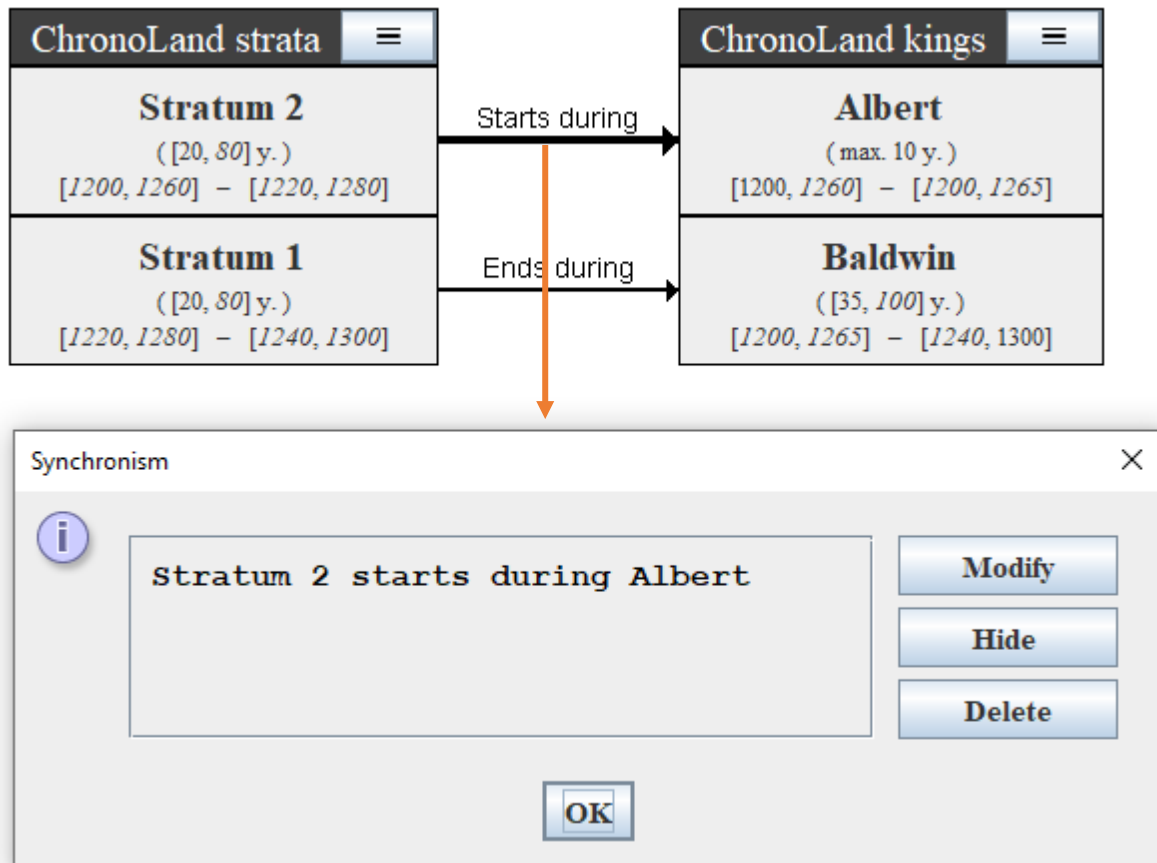



Figure 17. Pop-up dialog obtained by clicking on a synchronism.


7.3. Deleting a synchronism

A synchronism can be deleted by clicking on the synchronism's arrow, then clicking on the "Delete" button of the ensuing pop-up dialog (see Figure 17). Alternatively, one can also delete the synchronism

by clicking on the  button of the synchronisms panel.

7.4. Hiding a synchronism

A synchronism can be hidden by clicking on the synchronism's arrow, then clicking on the "Hide" button of the ensuing pop-up dialog (see Figure 17). Alternatively, one can also delete the synchronism

by clicking on the  button of the synchronisms panel. A hidden synchronism is no longer part of the current model, and thus is not taken into account when checking the consistency of the model nor in computing the tightened bounds. In order to unhide a synchronism, repeat the same operation.

7.5. Modifying a synchronism

The type of a synchronism can be modified by clicking on the synchronism's arrow, then clicking on the "Modify" button of the ensuing pop-up dialog (see Figure 17).

7.6. Moving a synchronism

A synchronism's arrow can be moved by clicking and dragging it with the mouse (see Figure 18).

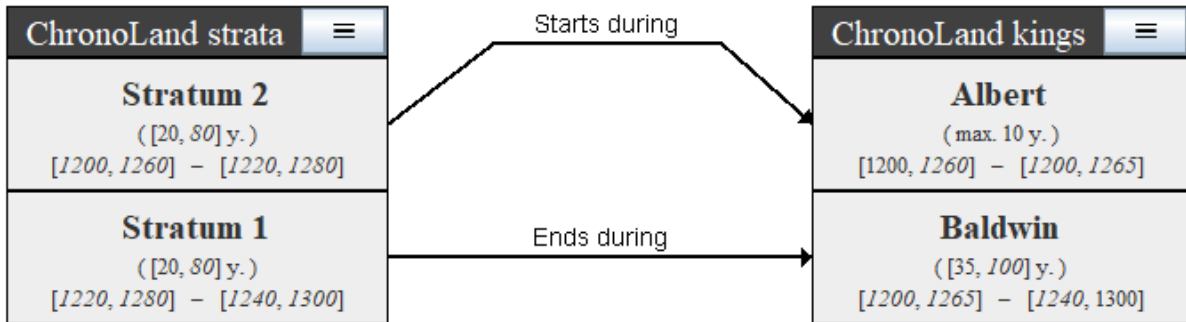


Figure 18. Moving the synchronism between “Stratum 2” and “Albert”.

8. Visual tools

The model can be zoomed in through *View* → *Zoom in* and *View* → *Zoom out*, or through the sliding bar located at the bottom right of the ChronoLog window.

Part III: Example: the Kingdom of ChronoLand

1. Introduction

This section presents an artificial example called “ChronoLand”, which represents a simple use case with two kings and two archaeological strata, with two synchronisms between kings and strata. The purpose of the example is to show that even in such a small data set, computing the optimal chronological bounds (as well as performing other types of queries, see below) is not an easy task without the aid of a computational tool such as ChronoLog.

2. Data

In the Kingdom of ChronoLand, Kings Albert and Baldwin reigned in succession. We do not know their precise reign dates, but both reigns are known to have occurred between 1200 and 1300 CE. We also know from ancient annals that Albert’s reign did not exceed 10 years, and we know from epigraphic sources that Baldwin reigned at least 35 years. Recent excavations at ChronoCity, the capital city of ChronoLand, have unearthed two archaeological strata: Stratum 1 and Stratum 2. The earlier stratum, Stratum 1, was built on bedrock, and contained an in-situ stela of King Albert, claiming he built ChronoCity. The latest stratum, Stratum 2, was destroyed by fire in a heavy conflagration. According to ancient annals, the city was destroyed during the reign the reign of King Baldwin and was never reoccupied. Finally, we assume that each of our strata has a duration of at least 20 years.

3. Modelling

In order to simplify things, we first show (Figure 19) the modelling of the ChronoLand example with only its input data (recall that a view showing only inputs is available through *View* → *View mode* → *Concise view (inputs only)*). Figure 20 then shows the complete ChronoLand model, with the computed (optimal) bounds in italics. These bounds are the result of the tightening operations. Some of them are straightforward: the 1265 upper bound on the start of Baldwin stems from the 1300 latest end of Baldwin and the 35 years minimum duration of his reign. Others are more tricky, like the 1240 lower bound on the end of Baldwin’s reign. This bound stems from a longer chain of implications, starting from the 1200 lower bound on the start of Albert, going through the 20 years minimum

duration of Stratum 2 (via the “starts during” synchronism), the 20 years minimum duration of Stratum 1, then looping back to Baldwin through the “ends during” synchronism

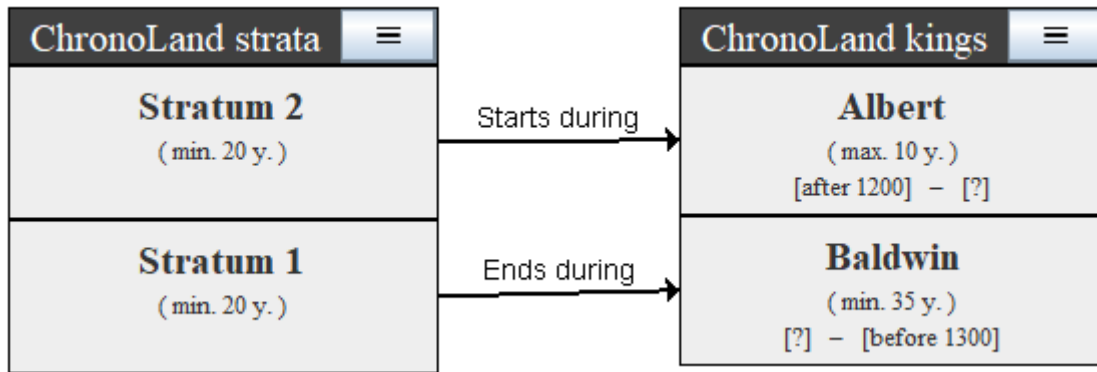


Figure 19. Modelling the ChronoLand data with ChronoLog (showing inputs only).

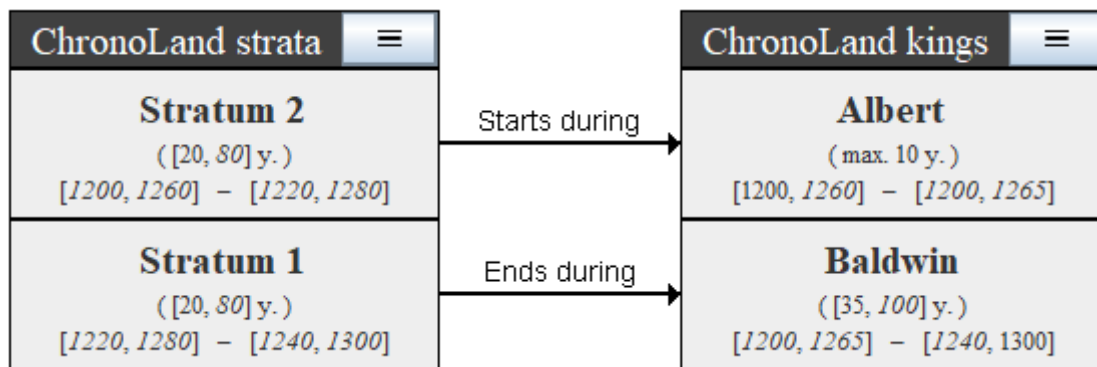


Figure 20. Modelling the ChronoLand data with ChronoLog (showing all data)

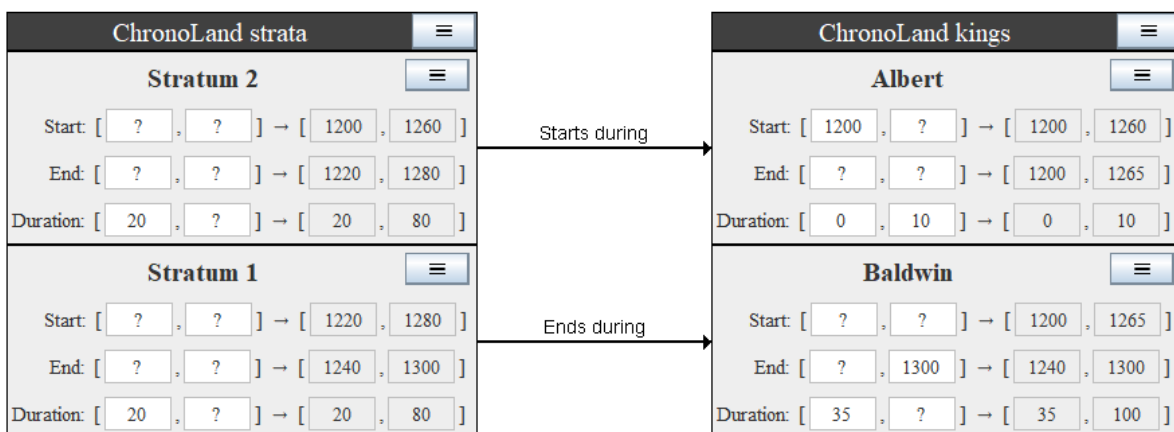


Figure 21. Modelling the ChronoLand data with ChronoLog (“Full view”)

The bounds located on the right side of the arrows are the result of the tightening operations. Some of them are straightforward: the 1265 upper bound on the start of Baldwin stems from the 1300 latest end of Baldwin and the 35 years minimum duration of his reign. Others are more tricky, like the 1240 lower bound on the end of Baldwin’s reign. This bound stems from a longer chain of implications, starting from the 1200 lower bound on the start of Albert, going through the 20 years minimum

duration of Stratum 2 (via the “starts during” synchronism) , the 20 years minimum duration of Stratum 1, then looping back to Baldwin through the “ends during” synchronism.

For the sake of completeness, we also provide the (now deprecated) “full view” (recall that the full view was the standard view until ChronoLog 1.2, and can still be accessed through *View* → *View mode* → *Full view*) in Figure 21. In this view, the bounds located on the left side of the arrows are the input bounds, and the bounds located on the right side of the arrows are the result of the tightening operations.

Figure 22 presents the full trace for this computed bound, as obtained by clicking on the “1240” button in ChronoLog.

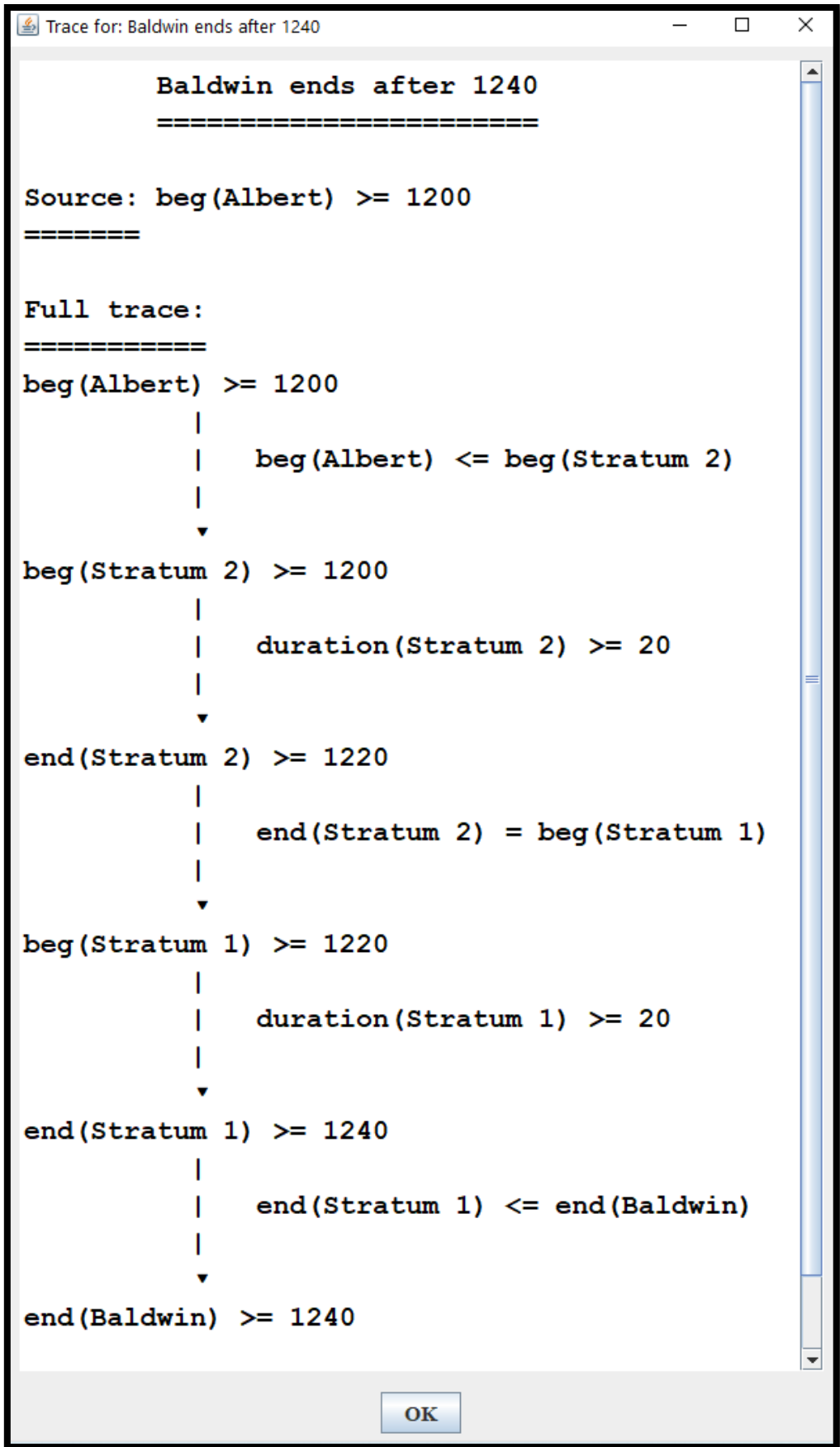


Figure 22. A justification of the computed 1240 lower bound for the end of Baldwin's reign, as obtained by Chronolog (by clicking on the "1240" button).

4. Querying the model

a. Detecting inconsistency in a model

One usage of ChronoLog is to test the global impact of a local change to the chronological network. For example, what if Baldwin reigned at most 25 years, instead of at least 35 years? In this case, ChronoLog will report that the model is not consistent, as shown in Figure 23. Here again, ChronoLog reports automatically the cause of the inconsistency, as shown in Figure 24. Here, the cause stems from the fact that the new 25 years upper bound yields a 35 years maximum duration for the whole dynasty, which is not enough to encompass the 40 years minimum duration (20 + 20 years) of the two strata.

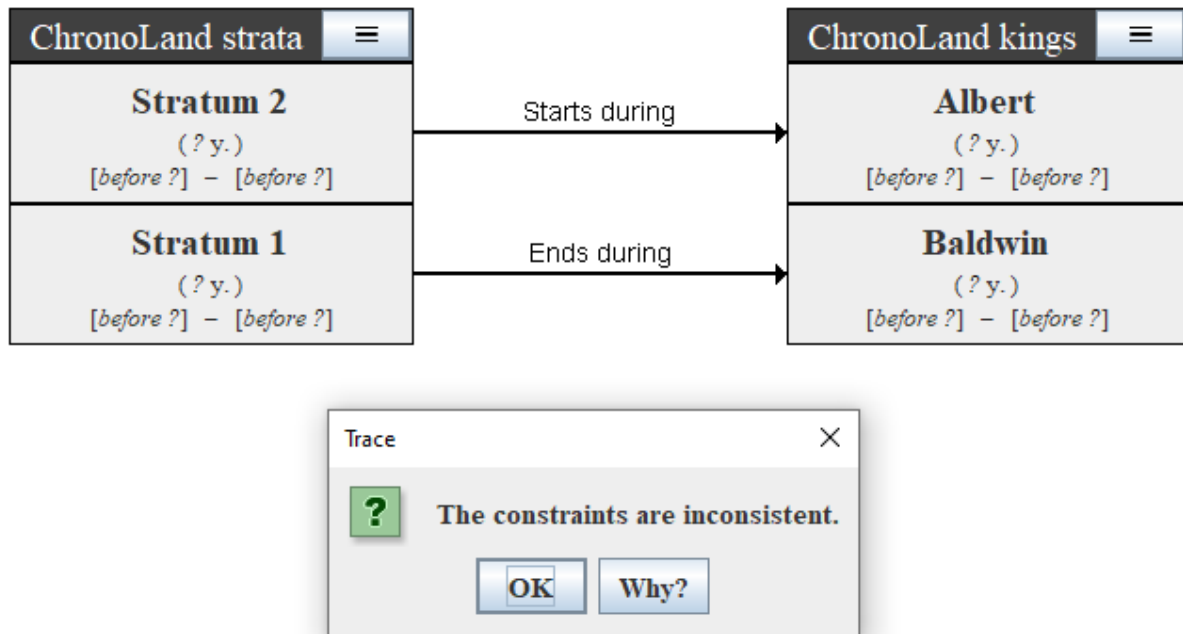


Figure 23. Changing the duration bounds of Baldwin to maximum 25 years yields an inconsistency result.

```

Inconsistency trace
The prior constraint: duration(Stratum 2) >= 20
contradicts the computed constraint: duration(Stratum 2) <= 15

Trace for: duration(Stratum 2) <= 15
=====
beg(Stratum 2)
  |
  |   beg(Albert) <= beg(Stratum 2)
  |
  v
beg(Albert)
  |
  |   duration(Albert) <= 10
  |
  v
end(Albert)
  |
  |   beg(Baldwin) = end(Albert)
  |
  v
beg(Baldwin)
  |
  |   duration(Baldwin) <= 25
  |
  v
end(Baldwin)
  |
  |   end(Stratum 1) <= end(Baldwin)
  |
  v
  
```

Figure 24. ChronoLog trace for the inconsistency result when limiting Baldwin’s duration to 25 years (partial view).

b. Checking the global impact of local changes to the network

What if we wish to set a realistic upper bound on the reign length of Baldwin. We know he reigned at least 35 years, but clearly no king can reign forever. How would a bound of, say, 70 years on his reign affect the overall chronology? Such questions are not easy to answer without a computational tool. ChronoLog’s answer to this question is shown in FIGFGG: the two strata get an upper bound of 60 years instead of 80 years. This stems from the fact that the maximum duration of the dynasty is now 80 years and that each stratum lasts at least 20 years. Hence the other stratum can last at most 80-20 years.

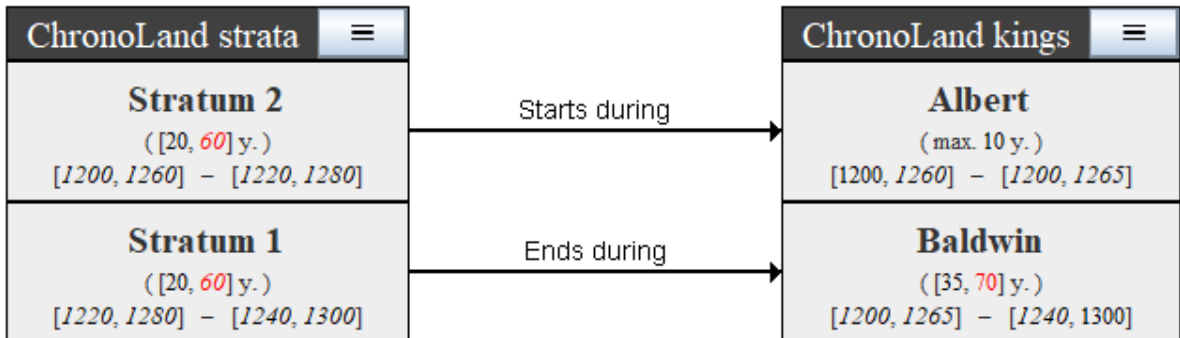


Figure 25. Result of setting an additional 70 years upper bound on Baldwin’s reign.

c. Testing hypotheses

ChronoLog also allows to test hypotheses. We know for example that stratum 2 was built by Albert. But who built stratum 1? The computed date ranges do not provide an answer, since stratum 1 starts in the range [1220-1280], which could a priori correspond both to Albert's reign (located within the range [1200-1265]) and Baldwin's reign (located within the range [1200-1300]). Let us therefore test whether it is possible that Albert built stratum 1. We therefore add the synchronism "Stratum 1 starts during Albert" to the model. This new synchronism yields an inconsistency, detected by ChronoLog: stratum 1 cannot have been built by Albert, because this would require the whole of stratum 2 to be included within Albert's reign, which is too short (at most 10 years) to encompass the whole of stratum 2's duration (at least 20 years). We can thus conclude that stratum 1 was built during Baldwin's reign. This is illustrated in Figure 26.

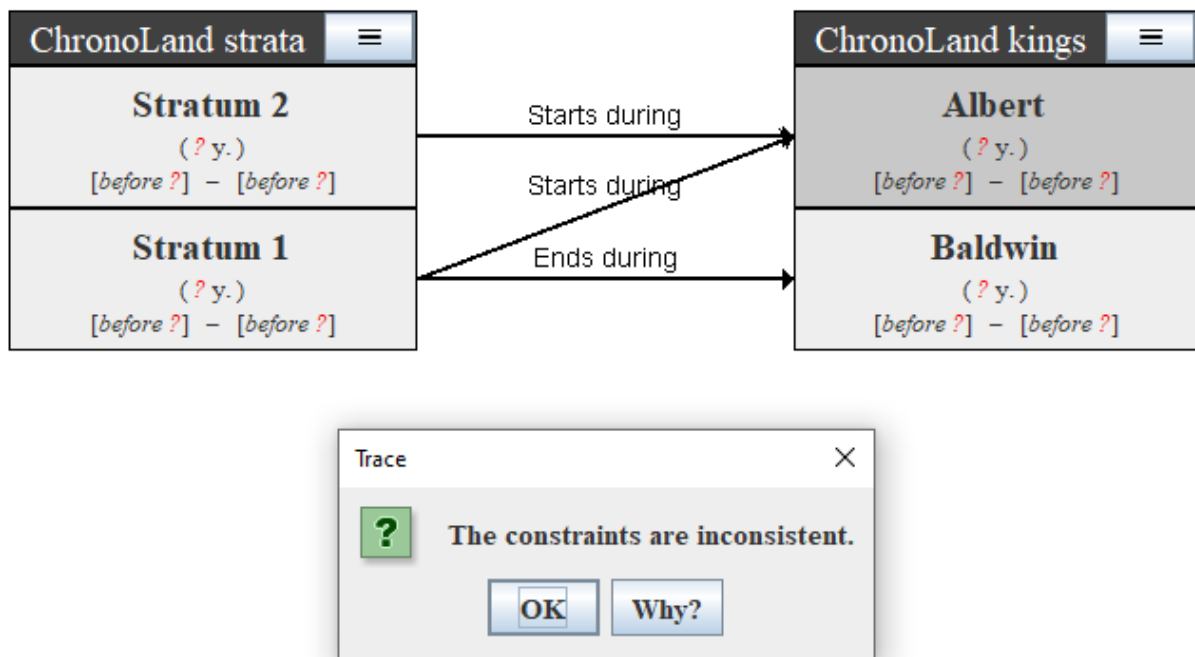


Figure 26. Result of adding the synchronism "Stratum 1 starts during Albert" to the model. ChronoLog detects an inconsistency, implying that stratum 1 was built during Baldwin's reign.

Part IV: References

Publications

1. Geeraerts, G. and Levy, E. and Pluquet, F. 2017. [Models and Algorithms for Chronology](#). In: Proceedings of TIME 2017, 24th International Symposium on Temporal Representation and Reasoning, Sven Schewe and Thomas Schneider and Jef Wijsen, editors. Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik.
2. Levy, E. and Geeraerts, G., Pluquet, F., Piasetzky, E. and Fantalkin, A. 2021. [Chronological Networks in Archaeology: a Formalised Scheme](#). Journal of Archaeological Science 127: 1-27.
3. Levy, E., Piasetzky, E. and Fantalkin, A. 2021. [Archaeological cross-dating: a formalized scheme](#). Archaeological and Anthropological Sciences 13: 1-30.

4. Levy, E., Piasezky, E., Fantalkin, A. and Finkelstein, I. 2022: [From Chronological Networks to Bayesian Models: ChronoLog as a Front-end to OxCal](#). Radiocarbon 64: 101-134.
5. Levy, E., Finkelstein, I., Martin, M.A.S. and Piasezky, E. 2022: [The Date of Appearance of Philistine Pottery at Megiddo: A Computational Approach](#). Bulletin of the American Schools of Oriental Research 387: 1-30.

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ChronoLog is a tool for computer-assisted chronological research in archaeology. The tool is freely available online at chrono.ulb.be. Running ChronoLog requires a working Java installation (<https://www.java.com/ES/download/>).

If you use ChronoLog, or publish chronological results obtained with the help of ChronoLog, please include a link to the utility's web page (chrono.ulb.be), and a reference to the following article:

Levy, E. and Geeraerts, G., Pluquet, F., Piasezky, E. and Fantalkin, A. 2021. *Chronological Networks in Archaeology: a Formalised Scheme*. Journal of Archaeological Science 127: 1-27.