



ChronoModel

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Modeling in archaeology - what for ?

- ★ Dating one or several archaeological events using both a set of contemporaneous artefacts and an archaeological context
- ★ Constructing chronologies
- ★ Estimating the duration of an archaeological phase

Example : Bouquets of Sennefer's tomb, "Mayor of the city" (Thebes) during the 18^{ième} dynasty

Dating one of the three phases of Sennefer's burial using radiocarbon dates made on the Bouquets found at the entrance of the tomb and historical information.

Ref : Quiles *et al.* Bayesian modelling of an absolute chronology for Egypt's 18th Dynasty by astrophysical and radiocarbon methods. Journal of Archaeological Science, 2013, 40, 423–432

ChronoModel - The Event model

Modeling steps

What is an event ?

★ In ChronoModel, an event refers to the date of an archaeological event determined by a collection of contemporaneous archaeological objects which are dated using different methods such as radiocarbon, thermoluminescence, archaeomagnetism, *etc.*

→ You will need to define what an event represents in your own project, that is in a particular period of time, a particular geographic area ...

Example : Bouquets of Sennefer's tomb

Archaeological event : Sennefer's burial

Dated event : The death of flowers that constituted the bouquets
In this first modeling, each bouquet was associated with an event, that is the death of flowers of each bouquet was estimated separately.

Including prior information

- ★ Information coming from historic (or geologic, environmental, ...) knowledges or from the archaeological site.

- ★ **Study period :**

Hypothesis : the event's date belongs to the study period.

Without any further information, the event's date is assumed to be uniformly distributed on the study period.

- ★ **Constraint :**

Temporal order

For instance stratification or anteriority - posterity relationship

- ★ **Boundary :**

Events may be bounded before (or after) a historical date.

Example (cont.)

Prior information available for the bouquets of Sennefer's tomb

★ Study period :

18th Egyptian dynasty

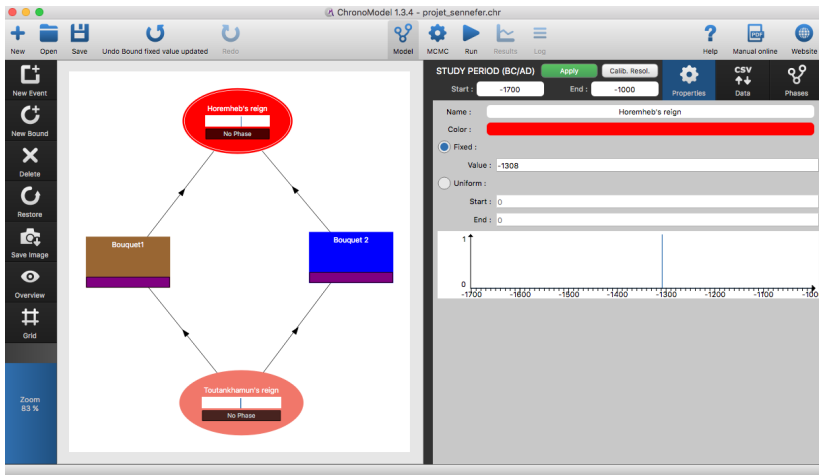
- Let's take -1700 à -1000

★ Prior information about the historical context :

"The archaeological material found inside the tomb shows three burial phases. They occurred between the beginning of the reign of Tutankhamun and the beginning of the reign of Horemheb"

- Addition of two **bounds** corresponding to the beginning of each reign (-1356, -1312)
- Addition of **temporal order constraints** between events and bounds

ChronoModel implementation



Including measurements

★ **Datations (or measurements)**

Archaeological objects found on the site. Samples collected.

Datation of these samples by one or several methods (radiocarbon, thermoluminescence, archeomagnetism ...)

Conversion into calendar dates using a calibration process.

★ **Example of the bouquets of Sennefer's tomb**

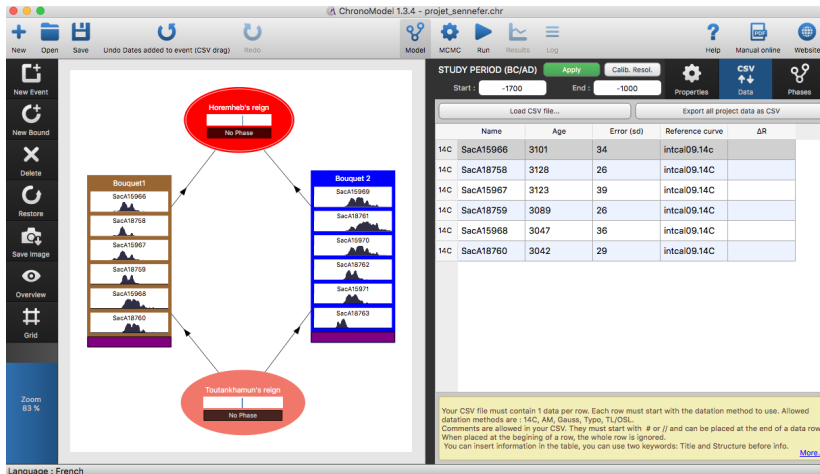
Measurements :

2 bouquets found at the entrance of the tomb

6 datations by radiocarbon per bouquet

Use of the calibration reference curve intcal09.14c

Modeling with ChronoModel - Including observations



Bayesian modeling

PRIOR information

Historical context and / or
context from the site

OBSERVATIONS

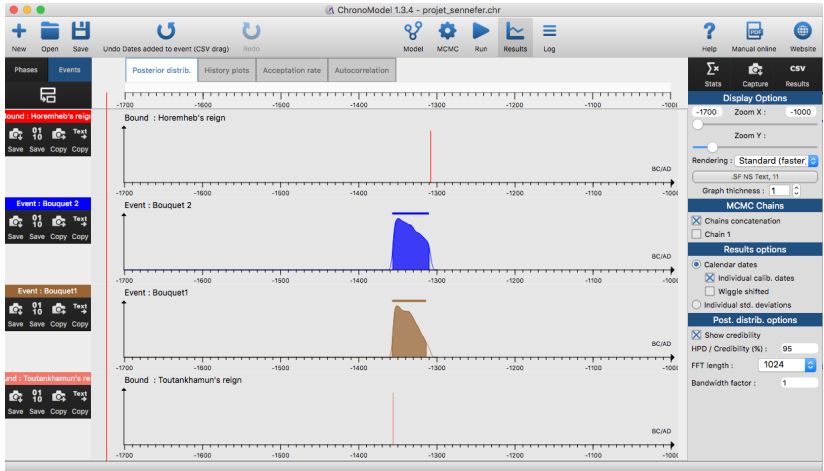
Measurements (datations)
C14, TL/OSL, AM, ...

=

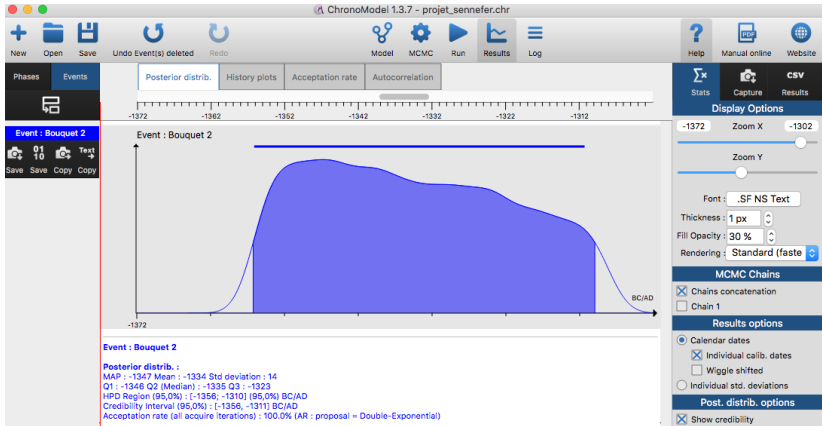
POSTERIOR information

Summary : posterior distribution, mean (**MEAN**), maximum *a posteriori* (**MAP**), the smallest credibility interval (**CI**), highest probability density region (**HPD**)

Posterior densities

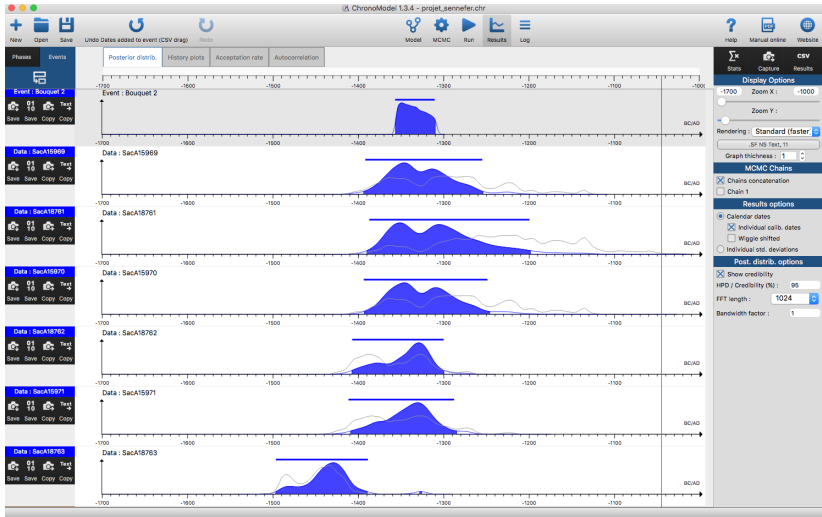


Posterior summaries



The line above the curve represents the smallest credible interval.
The HPD region is presented by the colored area under the curve.

Posterior densities - Bouquet 1



Archaeological phases

Modeling of a phase

What is a phase ?

★ In ChronoModel, a phase gathers several events on the basis of one or several geographical criteria, one or several environmental criteria, ...

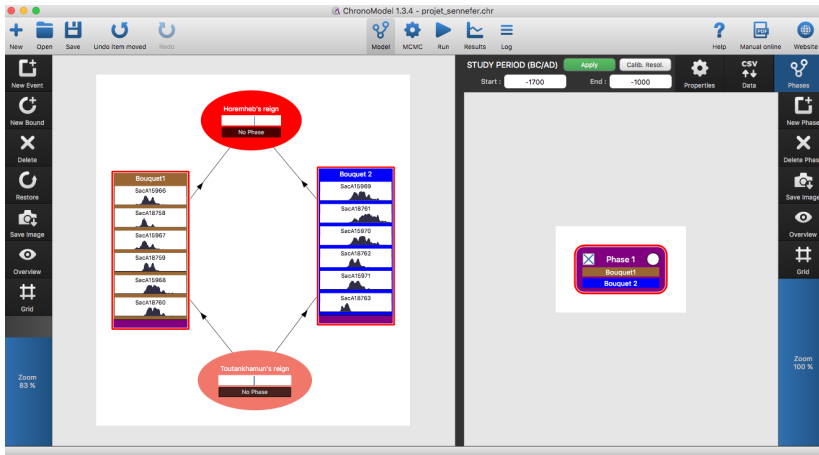
No hypothesis is made according to the position/distribution of events in a phase.

★ **Example : The bouquets of Sennefer's tomb**

Phase : Sennefer's burial.

- All bouquets are gathered in a phase.

ChronoModel implementation



Including prior information

- ★ Information about the **duration** of a phase :
a phase may last at most x year
- ★ **Temporal order** between two phases :
all the events of the first phase happened before those of the second phase.
- ★ **Hiatus** between two phases :
the time elapsed between two phases was at least of x year.

Posterior information

A phase is characterised by its beginning, its end and its duration.

★ **The beginning :**

$$\alpha = \text{minimum}(\theta_{j,j=1\dots r})$$

★ **The end :**

$$\beta = \text{maximum}(\theta_{j,j=1\dots r})$$

★ **The duration :**

$$\tau = \beta - \alpha$$

Summary : posterior distribution, mean (**MEAN**), maximum *a posteriori* (**MAP**), the smallest credibility interval (**CI**), highest probability density region (**HPD**)

Posterior densities related to a phase

