

## Modélisation de la niche à partir d'un modèle mécaniste de la reproduction



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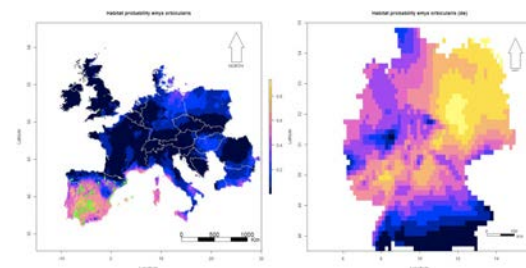
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## Niche model for distribution of species

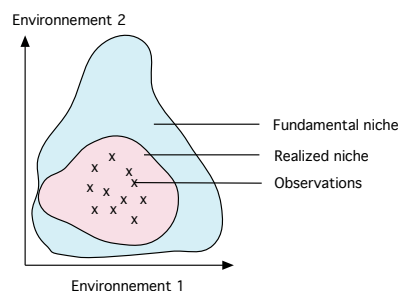
- The method commonly used to establish constraints on the distribution of a species is to establish a correlative model explaining the presence of the species based on environmental variables:



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## However...

- A very strong assumption of this kind of model is that the observations used to calibrate the model reflect the fundamental niche (abiotic conditions).



Whereas observations are a minored biased representation of the realized niche.

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## Alternative : mechanistic model

- The fundamental niche can be defined from a mechanistic model and future projections will be more realistic.
- However, a true mechanistic model is often extremely difficult to conceive as soon as one is interested in a species inserted in a community within an ecosystem.
- The alternative is to model a fundamental biological processes necessary for the survival of the species.
  - Reproduction is an essential activity for the persistence of a species

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## European freshwater turtles

*Emys orbicularis* is a freshwater turtle widespread across all European continent... and a little bit more because recently populations have been found in Kazakhstan.

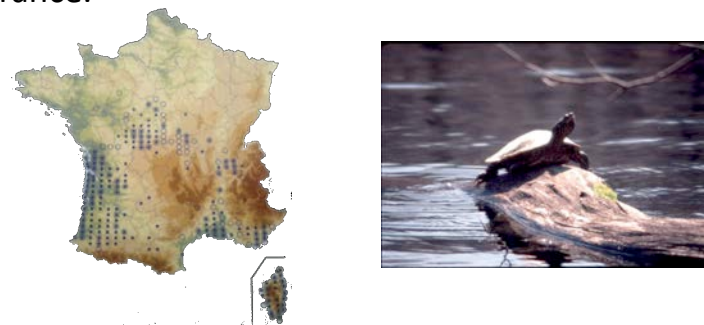


Lenk, P., Fritz, U., Joger, U. & Wink, M. (1999) Mitochondrial phylogeography of the European pond turtle, *Emys orbicularis* (Linnaeus 1758). *Molecular Ecology*, **8**, 1911-1922.

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## *Emys orbicularis* in France

This species is located at the half-South of France.



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## Climates of France

- Continental France shows various climates and could be used as a test to check climate constraint:

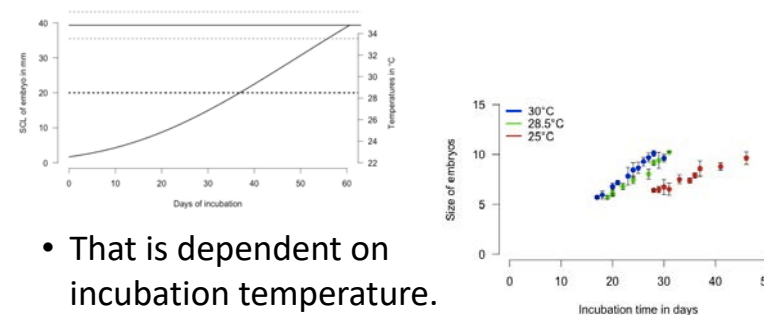
oceanic, continental,  
Alpine and Mediterranean



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## Growth model of a reptile embryo

- The growth of the embryo is modeled according to a Gompertz growth curve

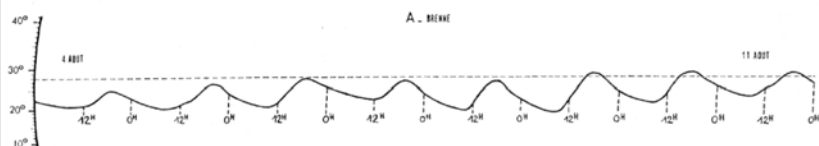


- That is dependent on incubation temperature.

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## Growth model of a reptile embryo

- The growth of the embryo is modeled according to a Gompertz curve whose instantaneous rate can vary according to incubation temperature:



Pieau, C., 1974. Sur la différenciation sexuelle chez des embryons d'*Emys orbicularis* L. (Chélonien) issus d'oeufs incubés dans le sol au cours de l'été 1973. Bulletin de la Société Zoologique de France 99, 363-376.

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## Thermal reaction norm of embryo growth from natural nests

- Field • Record temperatures during incubation for natural nests (# 20 nests)
- Field • Record incubation length for these nests
- Laboratory • Search what are the parameters of the Gompertz and the Schoofield models that produced the observed size of hatchlings

Girondot, M., Kaska, Y., 2014. A model to predict the thermal reaction norm for the embryo growth rate from field data. Journal of Thermal Biology 45, 96-102.

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## Embryo growth thermal reaction norm for *Emys orbicularis*

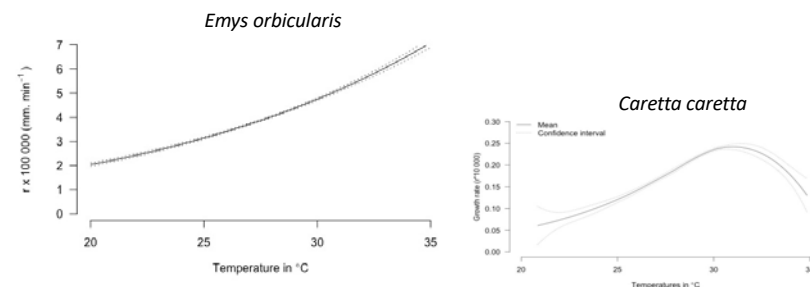
- European Freshwater pond turtle
  - 2 monitored nests with 20 sexed embryos
  - 10 incubations at varying temperatures with 222 sexed embryos
  - 22 incubations at constant temperatures with 1293 sexed embryos
  - 280 incubations at 3 constant temperatures in which the development was interrupted to measure and sexe the embryo



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## Modeled thermal reaction norm

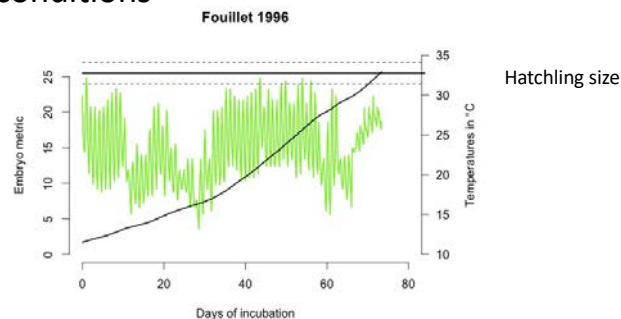
- The thermal reaction norm for growth of the embryo has been fitted from all these data.



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## Application to field-incubated nests

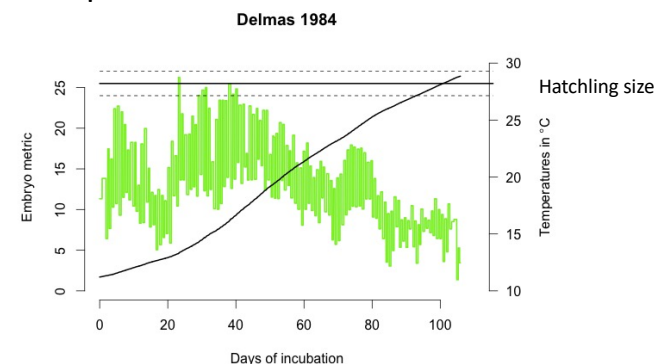
- Example with nests incubated in natural conditions



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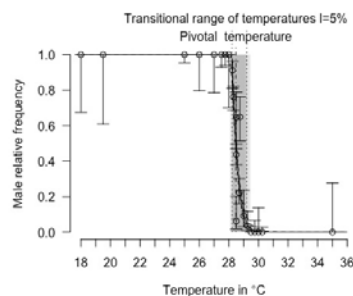
## Application to field-incubated nests

Example with nests incubated in natural conditions



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## Détermination du sexe sensible à la température



Pieau C, 1971. Sur la proportion sexuelle chez les embryons de deux Chéloniens (*Testudo graeca* L. et *Emys orbicularis* L.) issus d'oeufs incubés artificiellement. C. R. Acad. Sci. Paris 272(D): 3071-3074.  
Pieau C, 1972. Effets de la température sur le développement des glandes génitales chez les embryons de deux Chéloniens, *Emys orbicularis* L. et *Testudo graeca* L. C. R. Acad. Sci. Paris 274(D): 719-722.

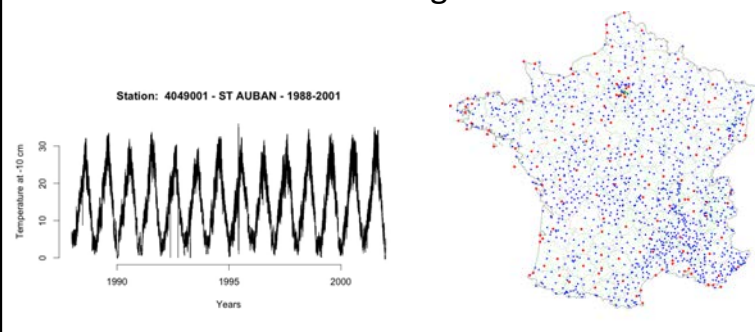


Attention, ce pattern peut être considéré comme un artéfact de laboratoire obtenu à température constante ! Ne pas l'utiliser directement pour estimer le sex ratio d'un nid en conditions naturelles.

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## Application of the model at the scale of France

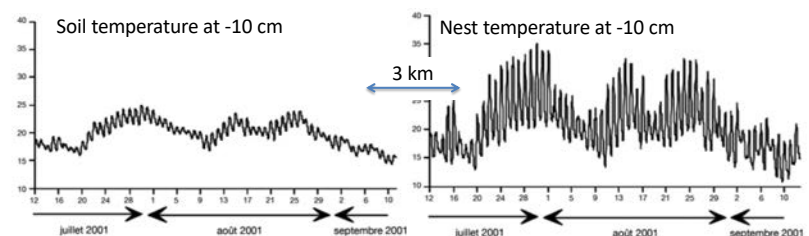
- The temperatures at -10 cm is recorded in France in 91 meteorological stations each 6 h.



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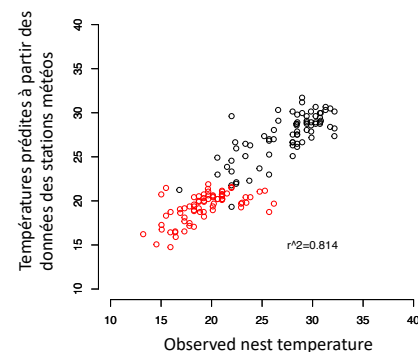
## Application of the model at the scale of France

- The temperatures at -10 cm is recorded in France in 91 meteorological stations.
- The *Emys orbicularis* nest is located at # -10 cm but a conversion must be done because choice of nesting site by females is not the same than meteo station:



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## Conversion of air or soil temperatures to nest temperature

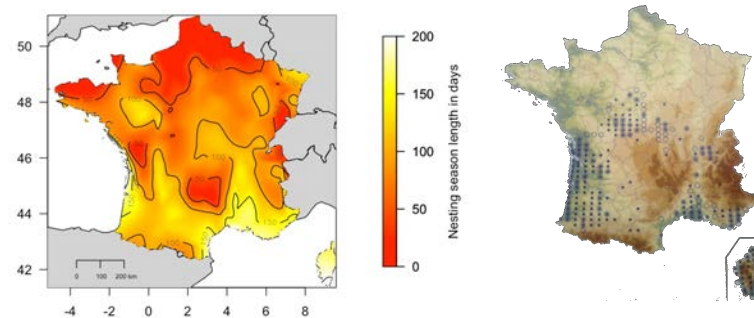


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## Length of the nesting season

i.e. How many days it is possible for a turtle to nest during the season for the incubation lasts before 100 days

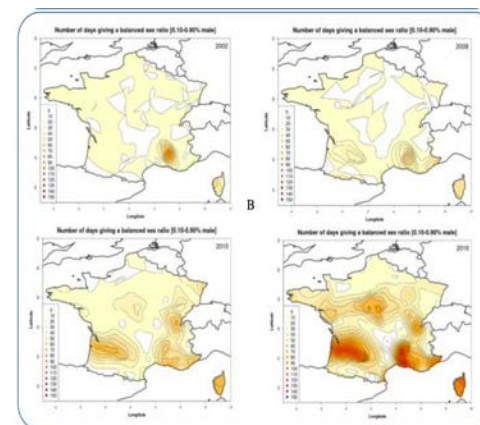
Average potential nesting season length between 1984 to 2001



Logistic regression weighted for spatial autocorrelation  $p < 0.0001$

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## Sex ratio entre 0,1 et 0,9



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Projet collaboratif: Paramétrer le modèle permettant d'expliquer la repartition d'*Emys orbicularis* en prenant en compte la diversité des situations sur le terrain

- La norme de réaction de la croissance n'est connue que pour les populations de Brenne
  - La norme de réaction de la croissance est un caractère génétique et est soumis à sélection donc est potentiellement différent selon les populations.
- Hétérogénéité des températures mesurées sur le terrain sur les sites de ponte en prenant en compte les pontes dans des endroits rares
- Introduire la détermination du sexe dans le modèle... mais là encore, le patron de la sensibilité à la température n'est connu que chez les populations de Brenne

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## Thermal reaction norm of embryo growth from natural nests

- |            |  |
|------------|--|
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