# Local minima and capture-recapture models

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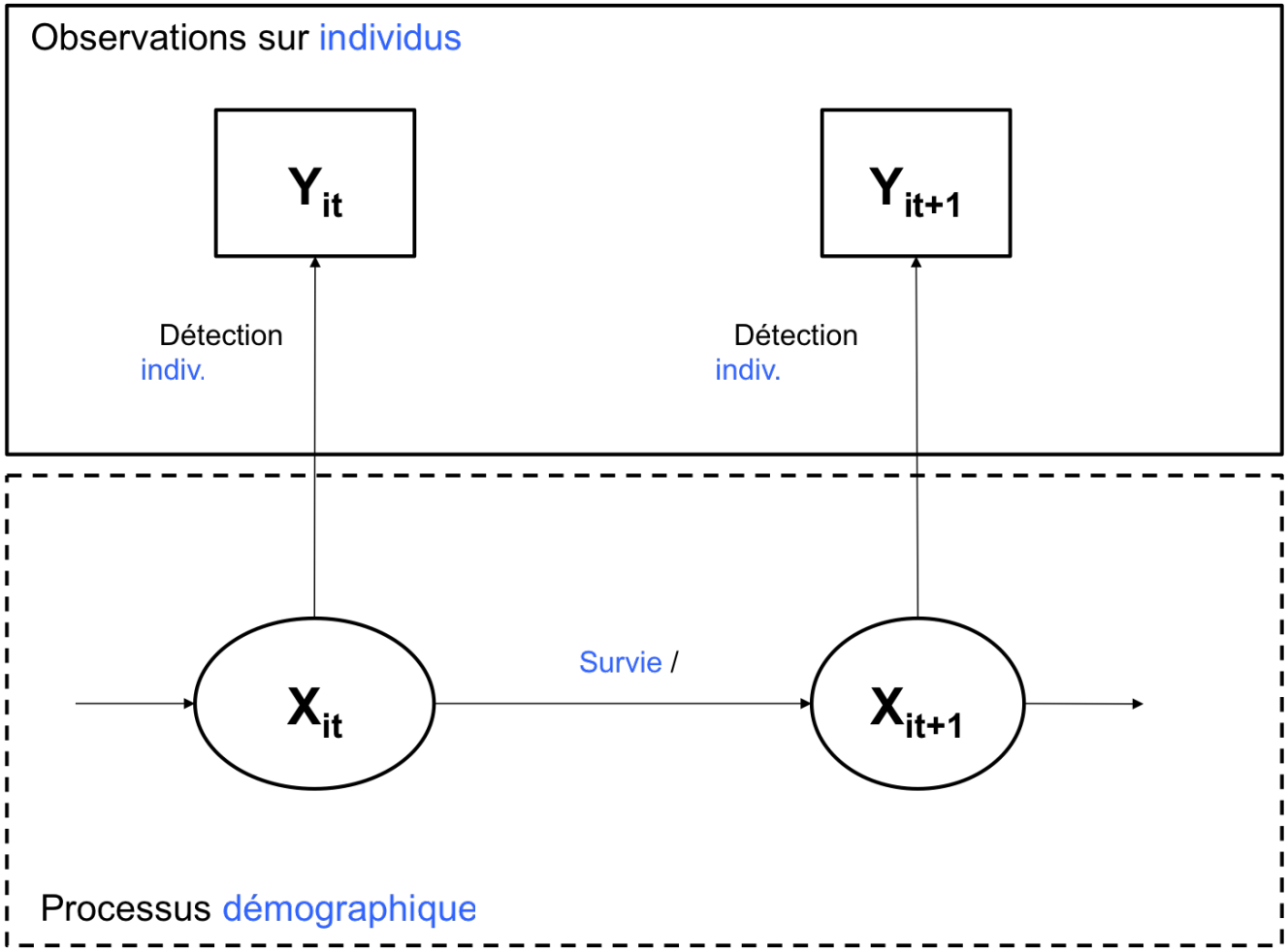
# Multistate capture-recapture models

- Individual data on marked animals/plants
- Repeated sampling in time
- Survival, movement between states
- States = sites, breeding, disease, behavior
- Individual detectability < 1, heterogeneous

- Lebreton, J.-D., Nichols, J.D., Barker, R.J., Pradel, R. & Spendelow, J.A. (2009) Modeling Individual Animal Histories with Multistate Capture-Recapture Models. Advances In Ecological Research, 41, 87–173.

# CR models are hierarchical





- Gimenez, O., Lebreton, J.-D., Gaillard, J.-M., Choquet, R. & Pradel, R. (2012) Estimating demographic parameters using hidden process dynamic models. TPB, 82, 307–316.
- Gimenez, O., Rossi, V., Choquet, R., Dehais, C., Doris, B., Varella, H., Vila, J.-P. & Pradel, R. (2007) State-space modelling of data on marked individuals. Ecol Mod, 206, 431–438.

# Simulated data

- 2 states, 7 occasions
- Survival = 1, detection = 0.6
- Transition 1 -> 2 = 0.6
- Transition 2 -> 1 = 0.85

```
2021202 4;          1110101 4;
2020201 4;          1010101 4;
2020202 4;          1010102 4;
2201021 4;          2102011 4;
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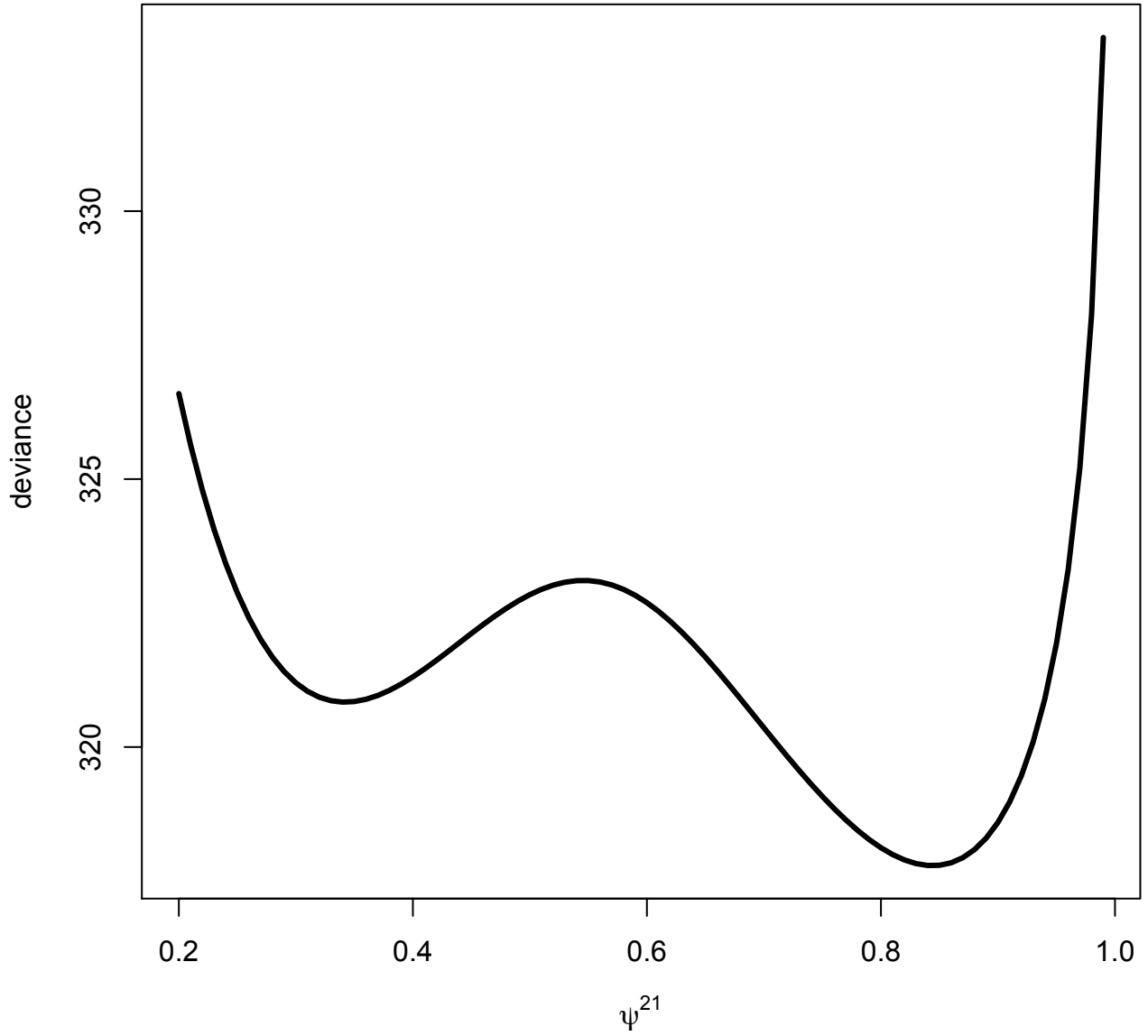
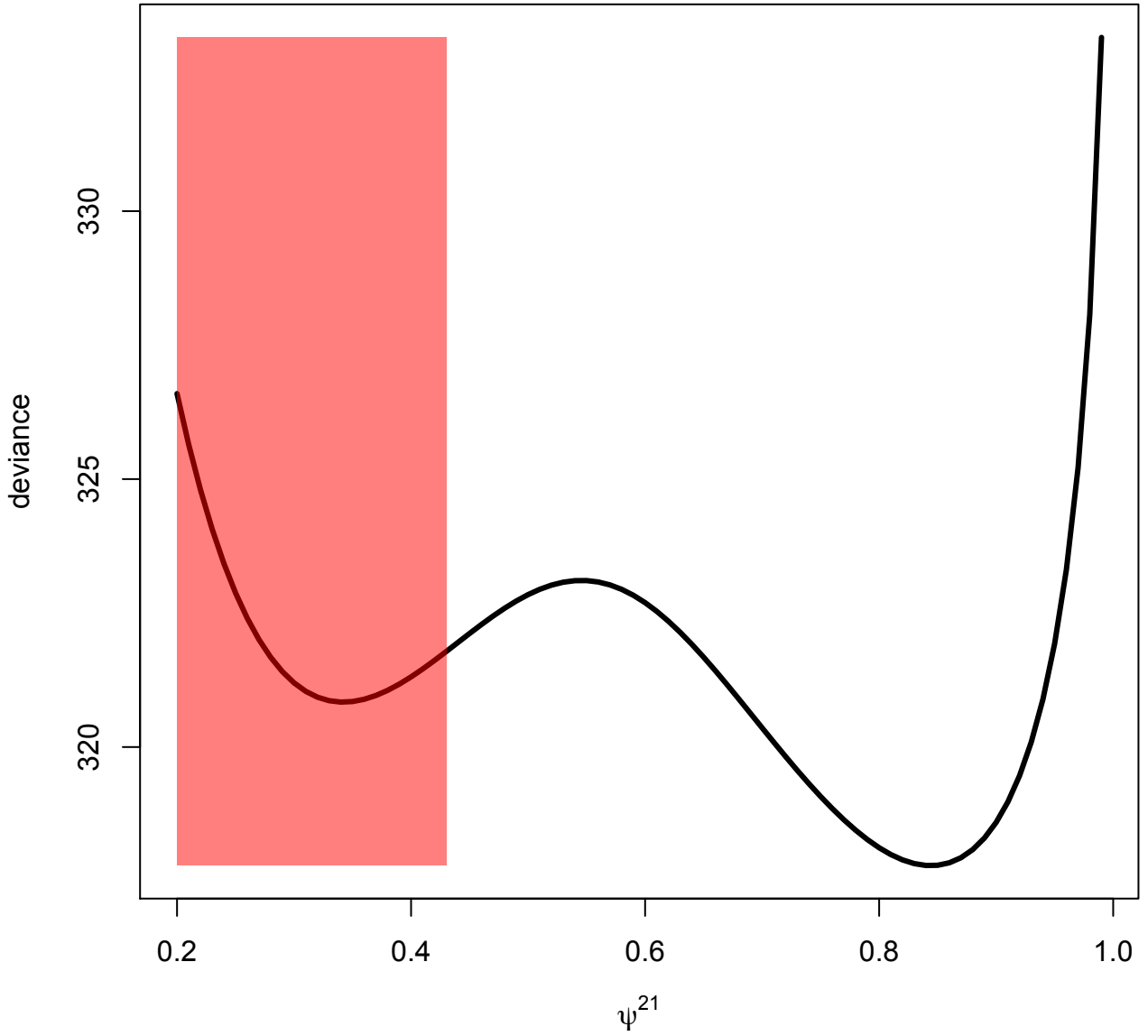
- Courtesy of J. Dupuis; cf. Gimenez, O., Choquet, R., Lamor, L., Scofield, P., Fletcher, D., Lebreton, J.-D. & Pradel, R. (2005) Efficient profile-likelihood confidence intervals for capture-recapture models. Journal of Agricultural, Biological, and Environmental Statistics, 10, 184–196.

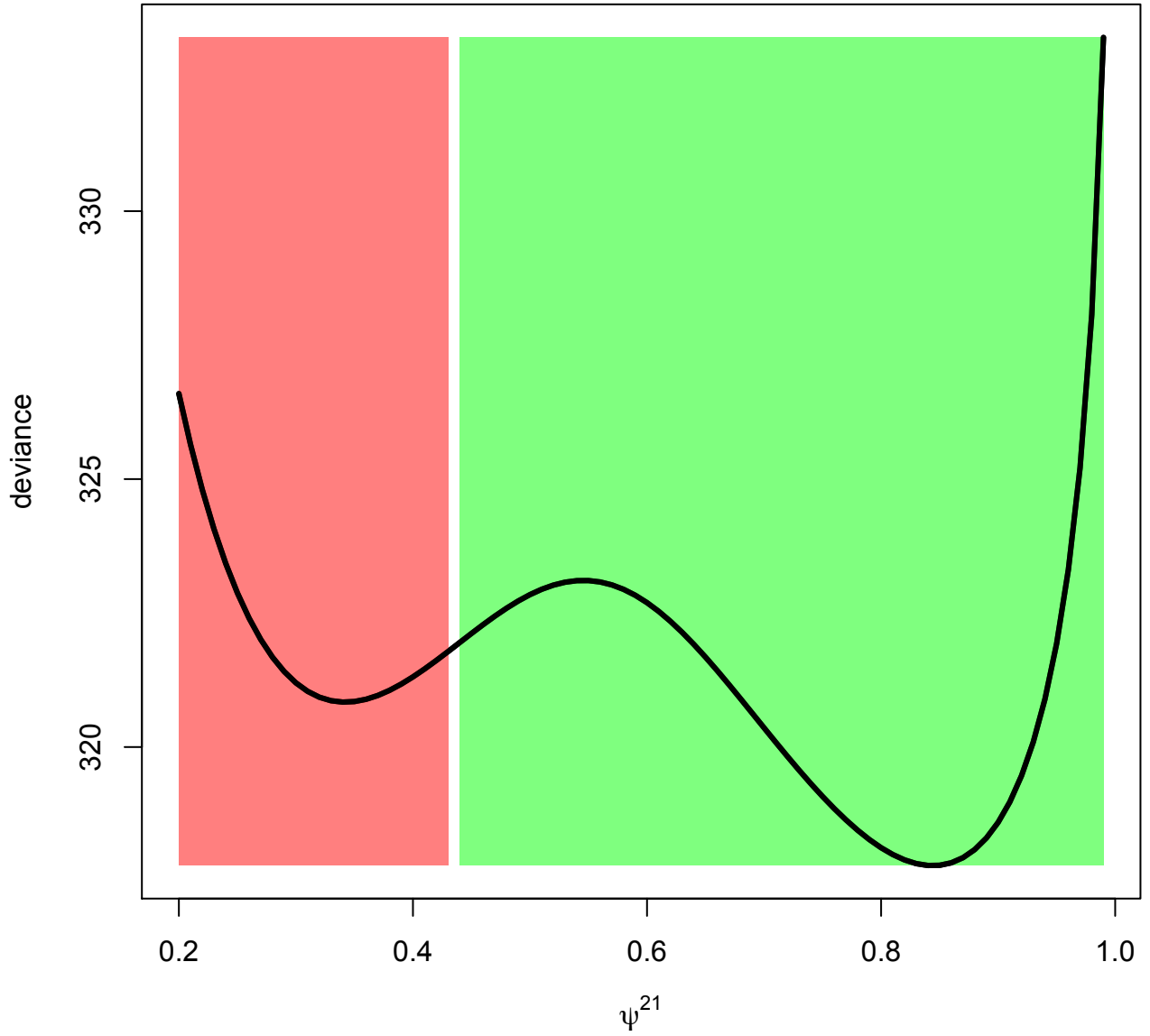
# Deviance as a function of transition 2->1



# Initial values lead to *local* minimum



# Initial values lead to *global* minimum



# Influence of link function?

$\Psi^{12} = 0.6; \Psi^{21} = 0.85$

# Influence of link function?

- Sin link function: $\Psi^{12} = 0.25$; $\Psi^{21} = 0.34$ !

- E. Cooch, G. White 2012, Gentle introduction to MARK, ch 9

$\Psi^{12} = 0.6$; $\Psi^{21} = 0.85$

# Influence of link function?

- Sin link function: $\Psi^{12} = 0.25$; $\Psi^{21} = 0.34$ !
- Logit link function: $\Psi^{12} = 0.60$; $\Psi^{21} = 0.84$

- E. Cooch, G. White 2012, Gentle introduction to MARK, ch 9

$\Psi^{12} = 0.6$; $\Psi^{21} = 0.85$

# BFGS vs. simulated annealing

- Sin link function BFGS: $\Psi^{12} = 0.25$; $\Psi^{21} = 0.34$

- E. Cooch, G. White 2012, Gentle introduction to MARK, ch 9

$\Psi^{12} = 0.6$; $\Psi^{21} = 0.85$

# BFGS vs. simulated annealing

- Sin link function BFGS: $\Psi^{12} = 0.25$; $\Psi^{21} = 0.34$
- Sin link function SA: $\Psi^{12} = 0.60$; $\Psi^{21} = 0.84$

- E. Cooch, G. White 2012, Gentle introduction to MARK, ch 9

$\Psi^{12} = 0.6$; $\Psi^{21} = 0.85$

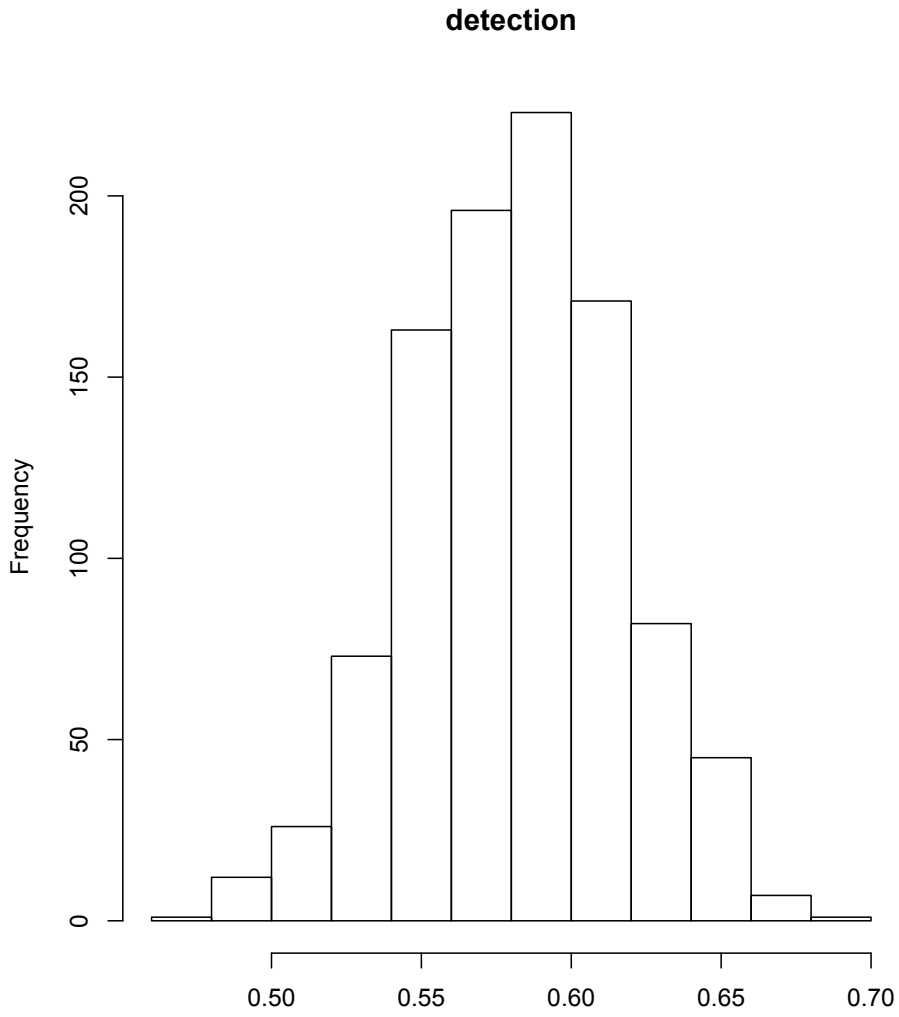
# BFGS vs. simulated annealing

- Sin link function BFGS: $\Psi^{12} = 0.25$; $\Psi^{21} = 0.34$
- Sin link function SA: $\Psi^{12} = 0.60$; $\Psi^{21} = 0.84$
- But: SA is much (much) slower than BFGS

- E. Cooch, G. White 2012, Gentle introduction to MARK, ch 9

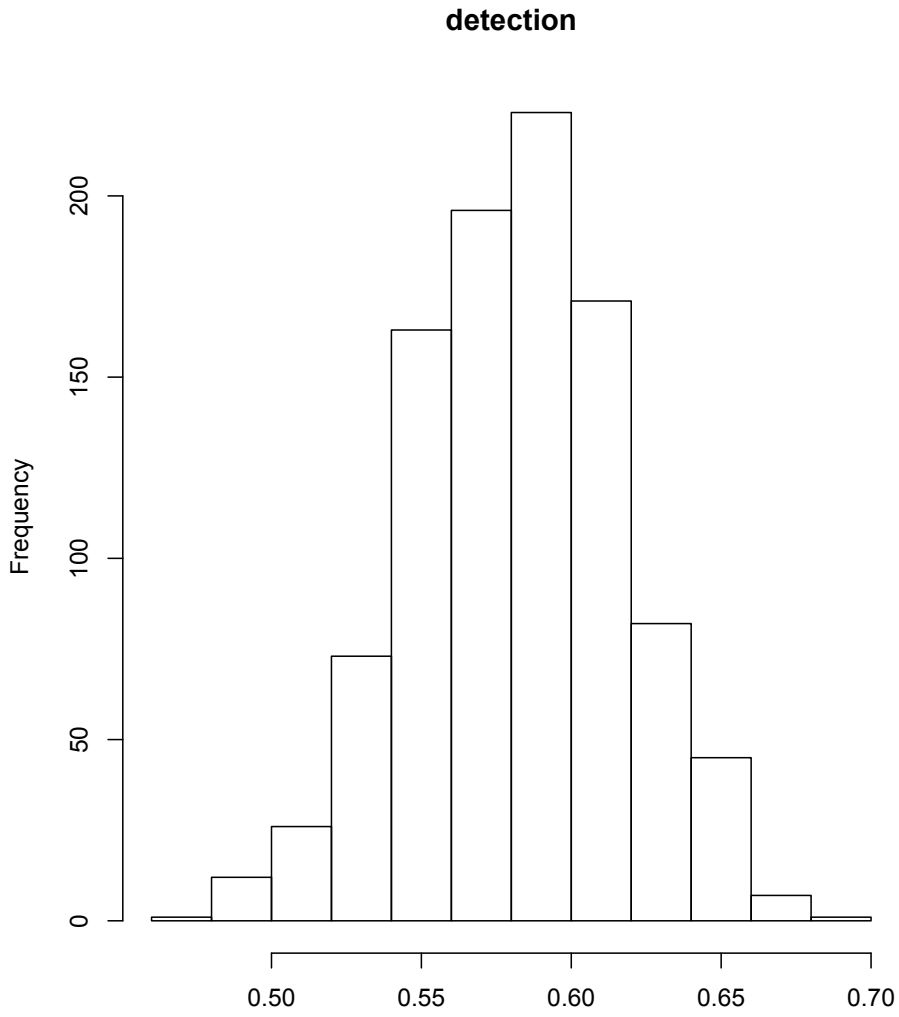
$\Psi^{12} = 0.6$; $\Psi^{21} = 0.85$

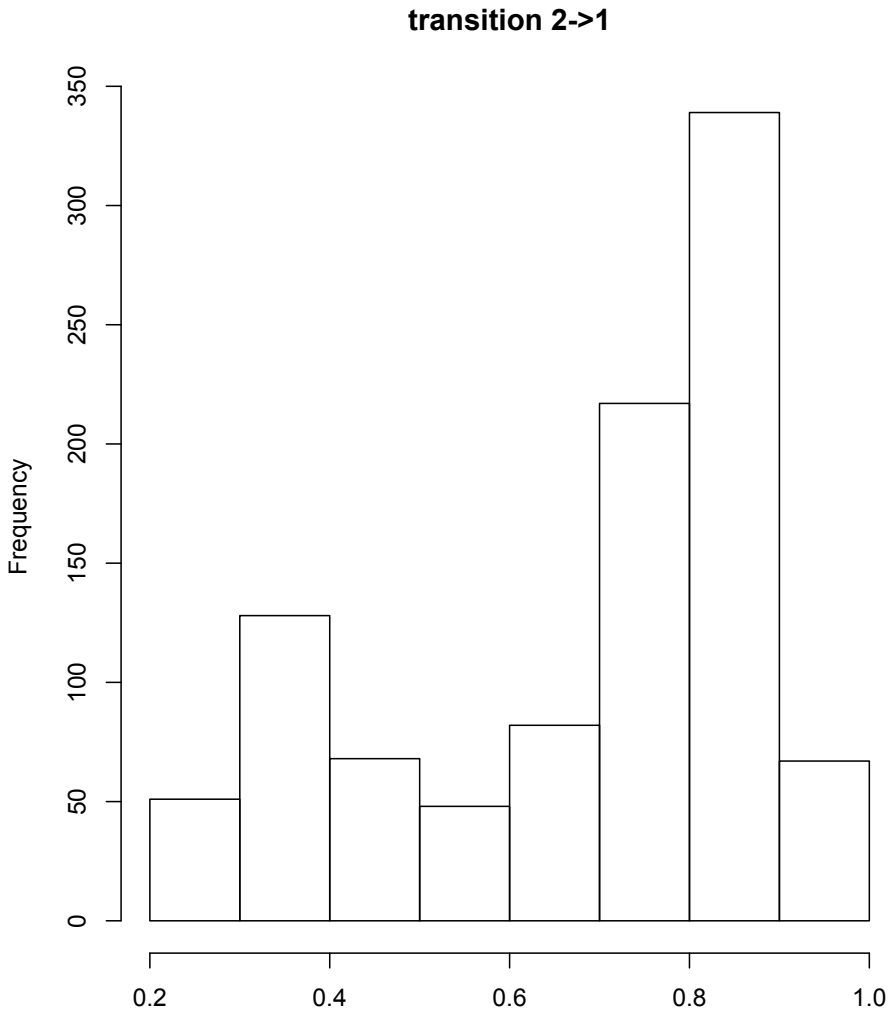
# MCMC




detection = 0.6; $\Psi^{21} = 0.85$

# MCMC




detection = 0.6; $\Psi^{21} = 0.85$

# Implementation

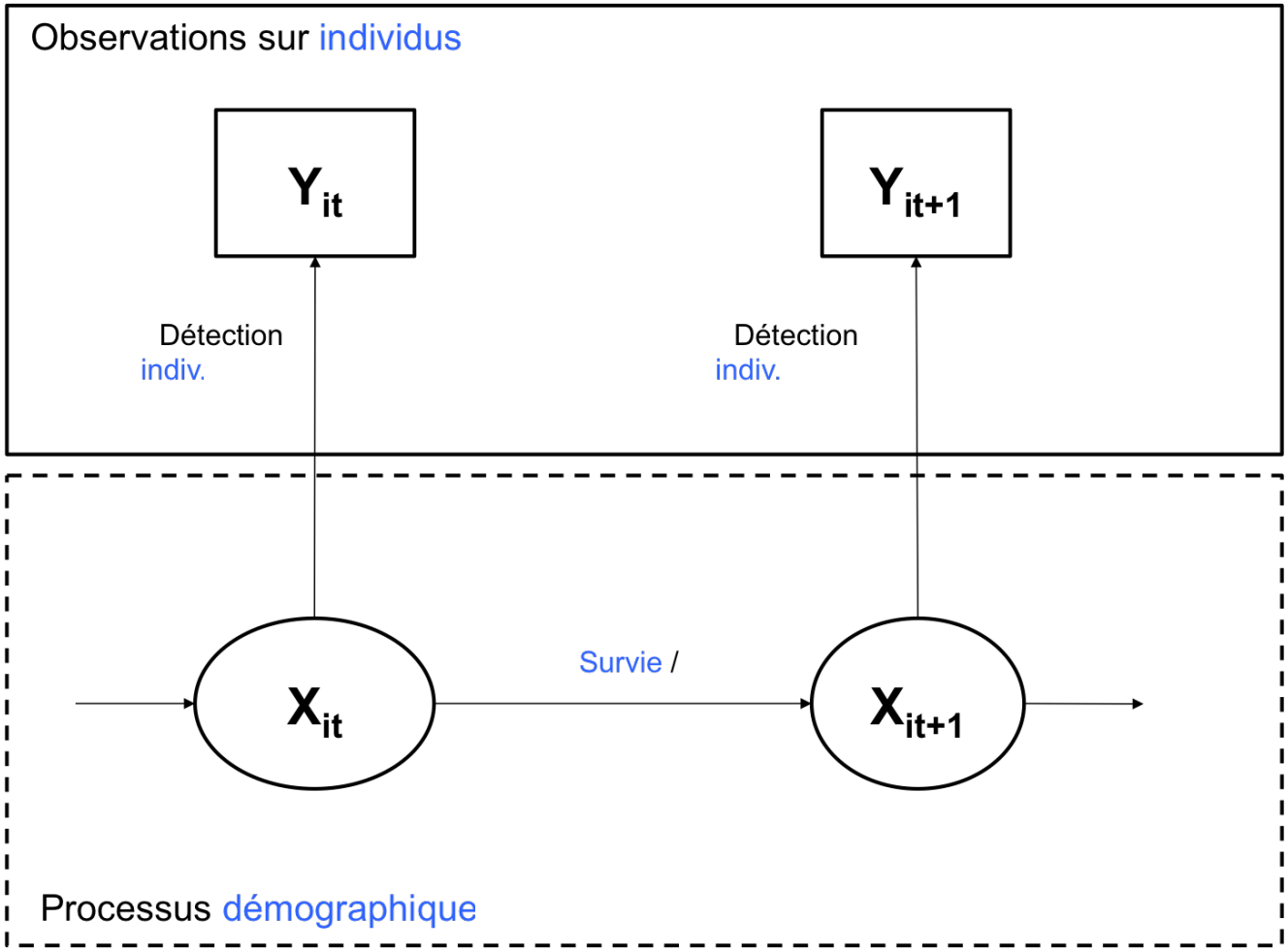
- Mark called from R using package Rmark
- Jags called from R using package R2jags
- Code and slides available on GitHub:

  https://github.com/oliviergimenez/multistate_local_minima

# Ongoing work

- Local minima in dynamic occupancy models?

# CR models are hierarchical





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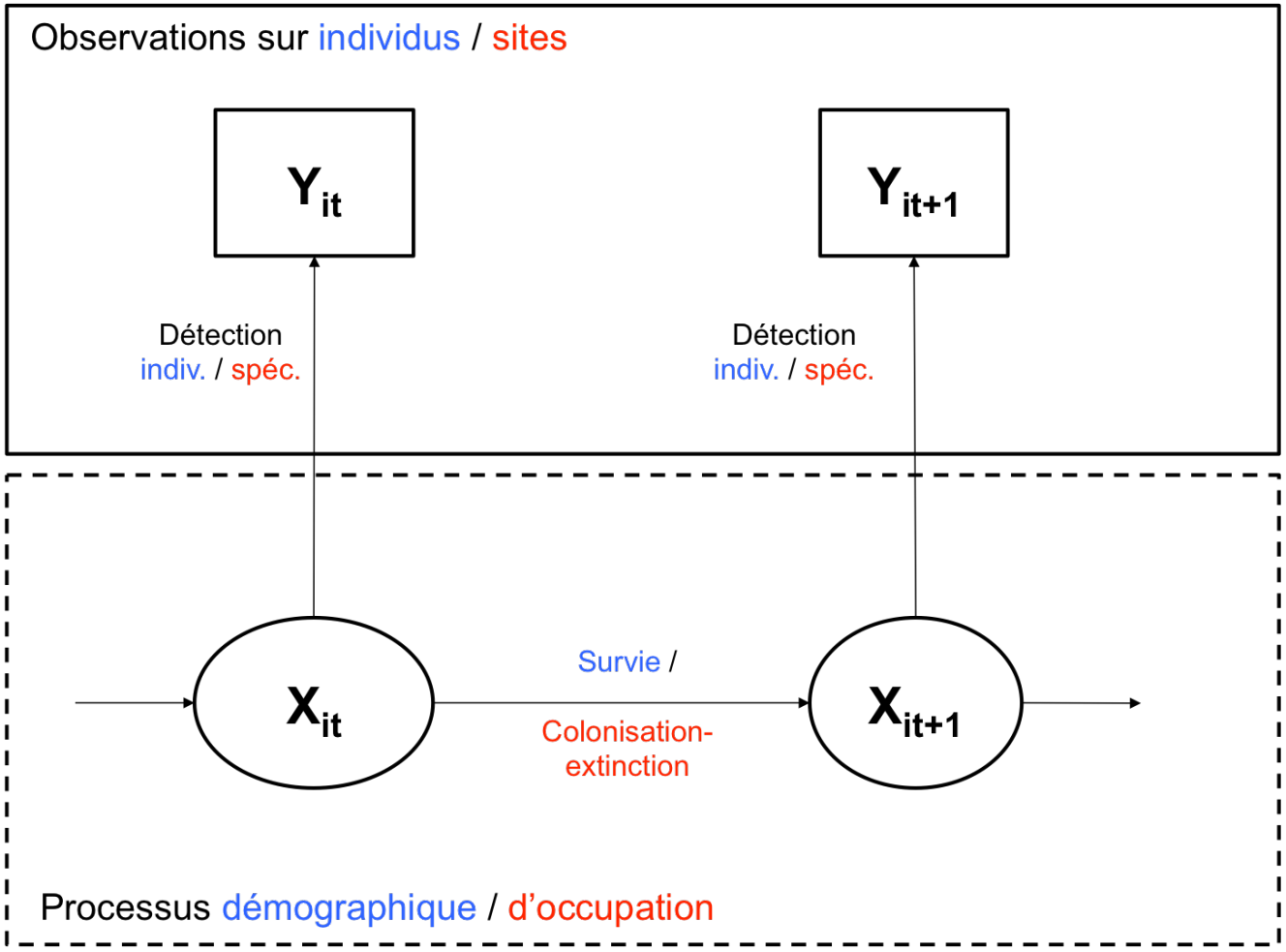
# Occupancy models are hierarchical




- Gimenez, O., Blanc, L., Besnard, A., Pradel, R., Doherty, P.F., Marboutin, E. & Choquet, R. (2014) Fitting occupancy models with E-SURGE: Hidden Markov modelling of presence-absence data. Methods in Ecology and Evolution, 5, 592–597.

# Explore other avenues…

BIOMETRICS 57, 240-244

## Minimising model fitting objectives that contain spurious local minima by bootstrap restarting

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*Journal of Statistical Software*
*May 2011, Volume 42, Issue 11.* *http://www.jstatsoft.org/*

## Genetic Optimization Using Derivatives: The rgenoud Package for R

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Jasjeet S. Sekhon
UC Berkeley

## An escape-from-local minima technique in unconstrained optimization using a grid-like approach and interval equations

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*Key words:* Global Optimization, grid-like technique, interval equations, escape from local minima.

## Regrouping Particle Swarm Optimization: A New Global Optimization Algorithm with Improved Performance Consistency Across Benchmarks

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3rd International Conference on Experiments/Process/System Modeling/Sim

## MULTISTART OPTIMIZATION WITH A TRAINABLE DECISION MAKER FOR AVOIDING HIGH-VALUED LOCAL MINIMA

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