OCaml Users in PariS: Epidemiological inference in OCaml

Benjamin Nguyen-Van-Yen

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- And I decided to do it in OCaml...

Some of the things I did during my PhD

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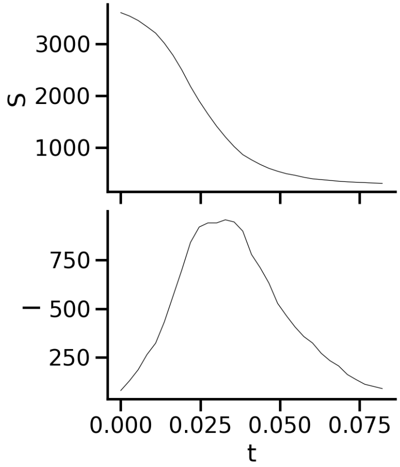
Simulations of SIR-like ODE models

$$\begin{tikzcd} S \arrow[d, bend right, "\beta \frac{S}{N} I"'] \\ I \arrow[d, bend right, "\gamma I"'] \\ R \end{tikzcd}$$



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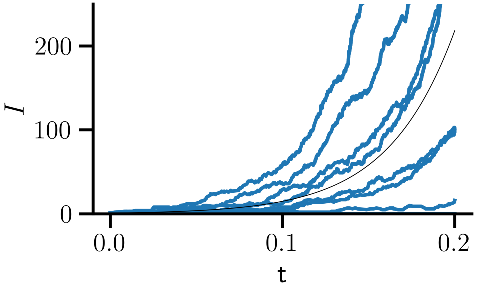

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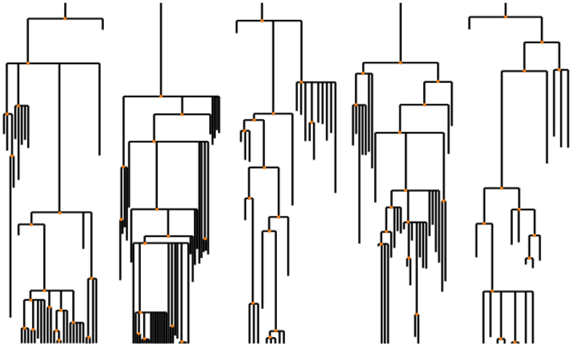

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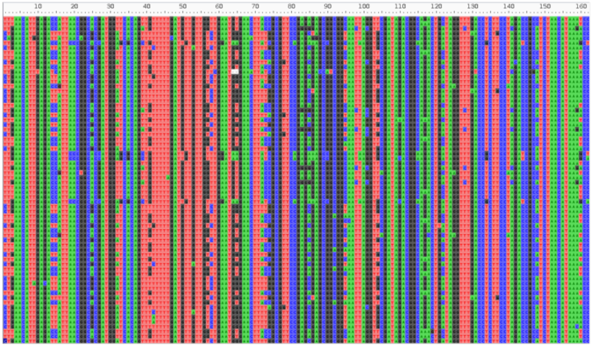

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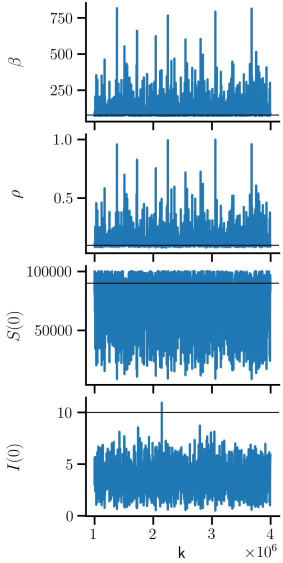

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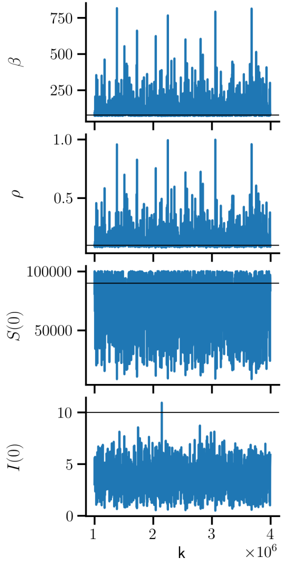

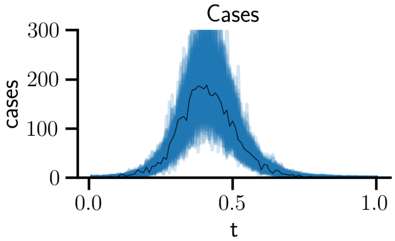

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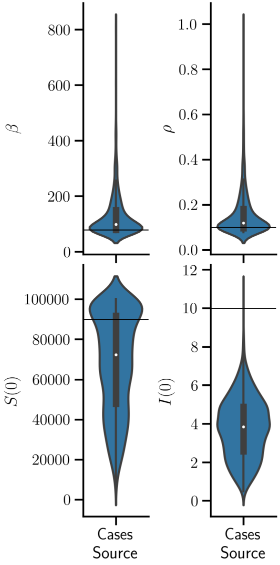

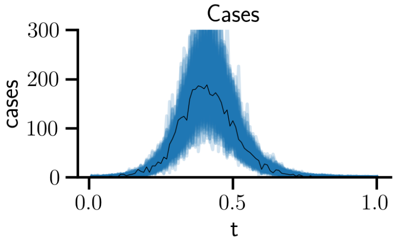

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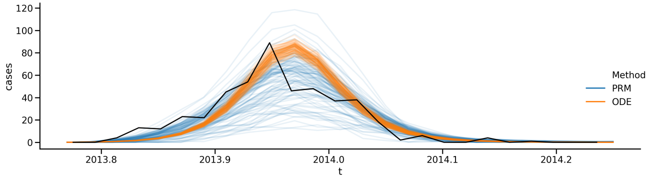

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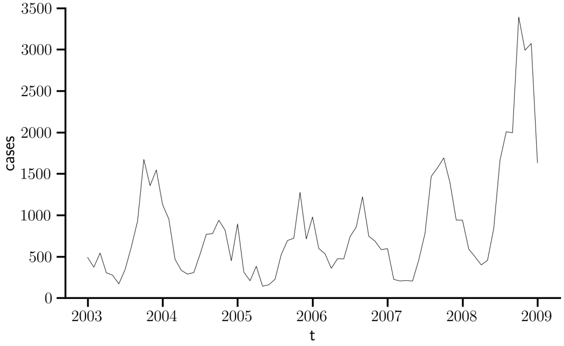

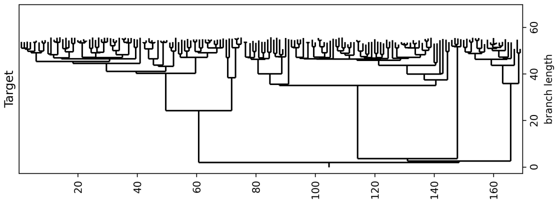

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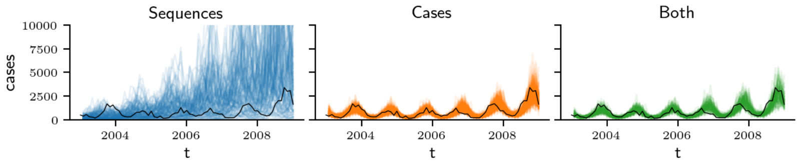

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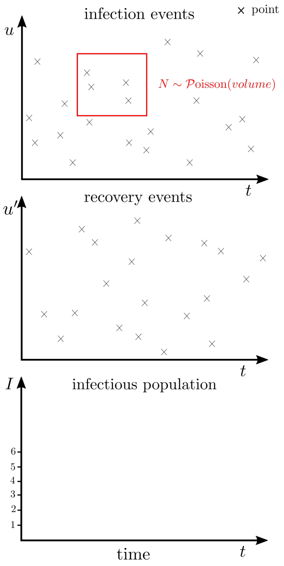
https://gitlab.com/bnguyenvanyen/ocamlecoevo

A few examples

Poisson Random measures



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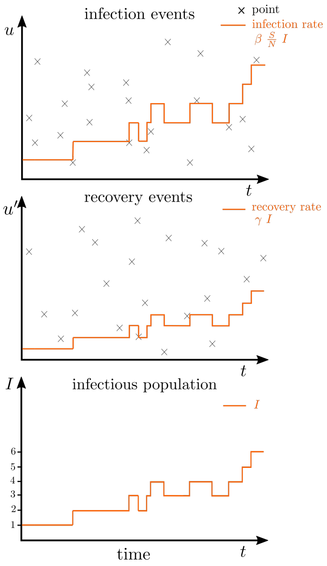

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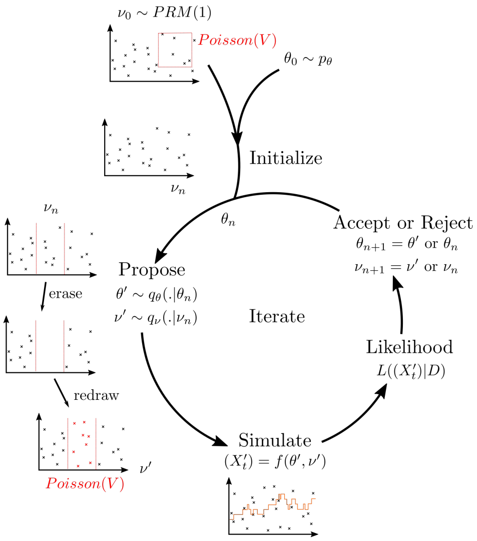

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Ecology-evolution dynamics: populations of individuals with traits

```
type id = [ `Id ]
type nonid = [ `Nonid ]

type 'a isid =
  | Isid of ('a, id) eq
  | Isnotid of ('a, nonid) eq

module type TRAIT = sig
  type 'a t

  type 'a group

  val isid : 'a group -> 'a isid

  val group_of : 'a t -> 'a group

  val of_group : nonid group -> nonid t
end
```

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val count : 'a group -> t -> int
val choose : rng -> 'a group -> t -> 'a indiv
```

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SIR-like models

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type 'a payload

type _ t =
  | S : nonid t
  | E : idor payload -> idor t
  | I : idor payload -> idor t
  | R : nonid t
  | C : nonid t
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```
module Make (Get : GET) = struct
  type t = Get.t

  let leave_exposed par _ z =
    let e = Get.exp z in
    F.Pos.Op.((Param.sigma par) * e)

  let recovery par _ z =
    let i = Get.inf z in
    F.Pos.Op.((Param.nu par) * i)

  let immunity_loss par _ z =
    let r = Get.rem z in
    F.Pos.Op.((Param.gamma par) * r)

  ...
end
```

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Inference across simulation methods

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type continuous_pop = ...
type discrete_pop = ...

type ode_sim = ...
type sde_sim = ...
type exact_sim = ...
type approx_sim = ...
type fast_sim = ...
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```
type _ pop =
  | Continuous : continuous_pop pop
  | Discrete : discrete_pop pop

type _ prm_sim_mode =
  | Exact : exact_sim prm_sim_mode
  | Approx : approx_sim prm_sim_mode
  | Fast : fast_sim prm_sim_mode

type _ sim_mode =
  | Ode : ode_sim sim_mode
  | Sde : sde_sim sim_mode
  | Prm : 'a prm_sim_mode -> 'a sim_mode

type ('pop, 'sim) settings =
  | Ode : (continuous_pop, unit) settings
  | Sde : (continuous_pop, Sim.Dbt.t) settings
  | Prm : 'a prm_sim_mode -> (discrete_pop, 'a)
```

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Notes de conclusion

Thank you !