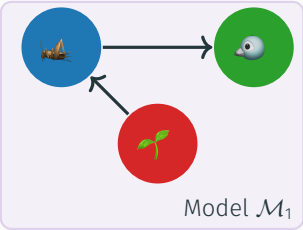
PiecewiseInference.jl: a machine learning framework for inverse ecosystem modelling

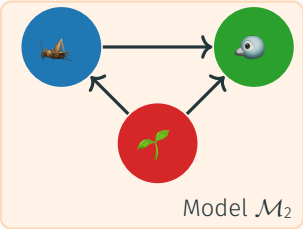
Victor Boussange[1,2], Pau Vilimelis Aceituno[2], and Loïc Pellissier[1,2]

April 26, 2023

[1]WSL Birmensdorf, [2]ETH Zürich

Motivation





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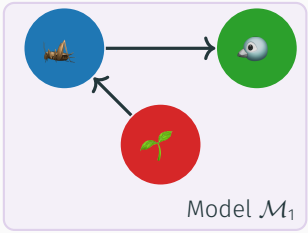
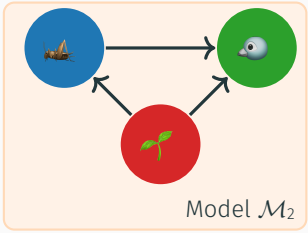
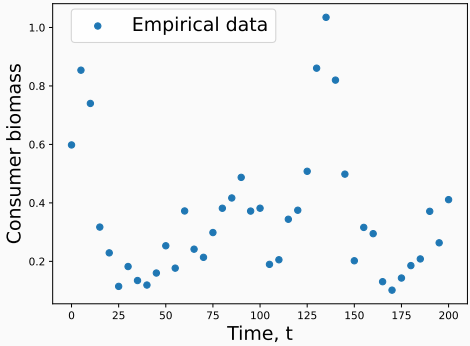

Model $\mathcal{M}_1$


Model $\mathcal{M}_2$


Empirical data
Consumer biomass
Time, t
1.0
0.8
0.6
0.4
0.2
0
25
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125
150
175
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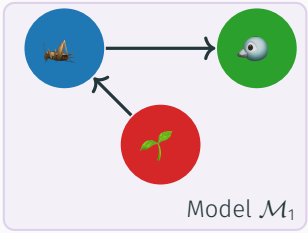
Motivation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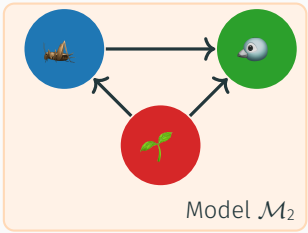
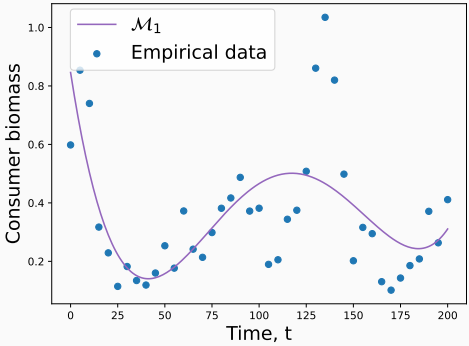

Model $\mathcal{M}_2$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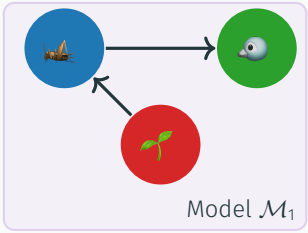
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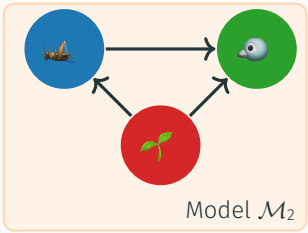
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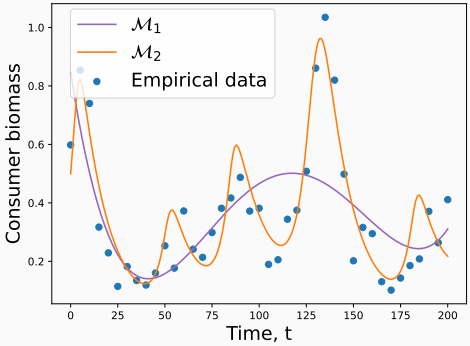
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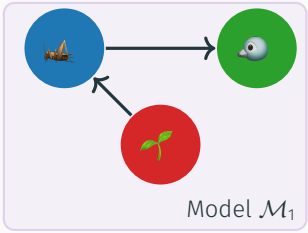
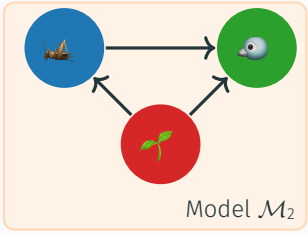
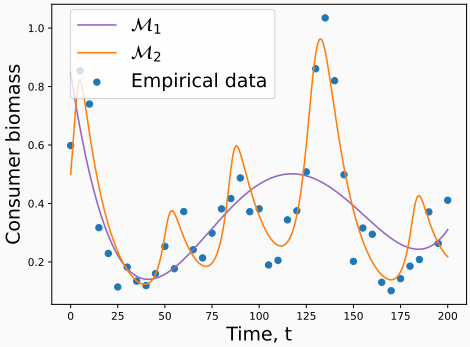
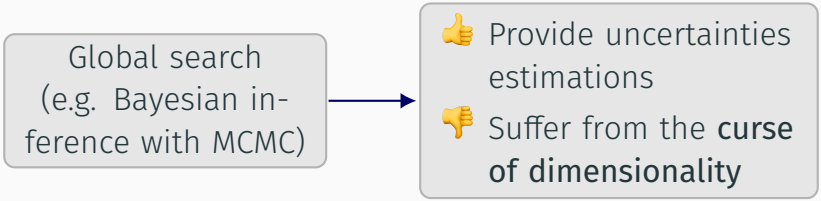






$P(\mathcal{M}_2|\text{Data}) > P(\mathcal{M}_1|\text{Data})$

Inverse modelling methods



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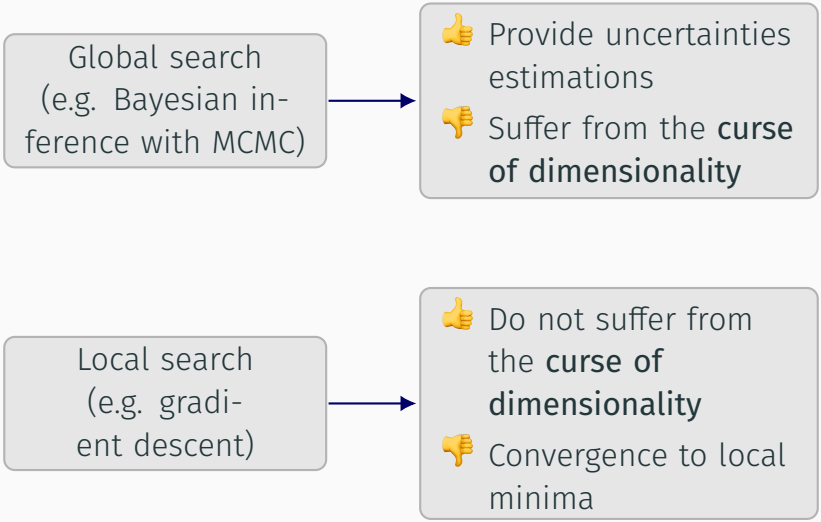
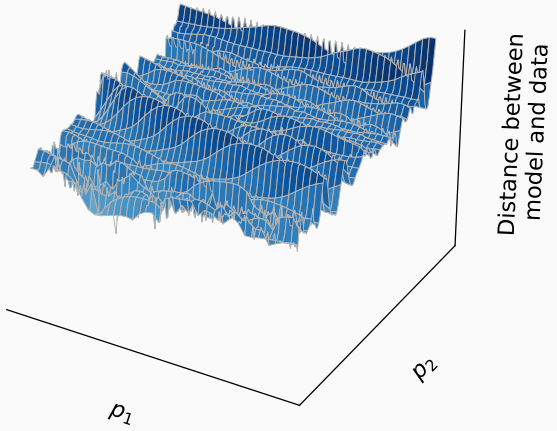


Model non-linearities lead to highly complex likelihood landscapes



A framework for inverse ecosystem modelling

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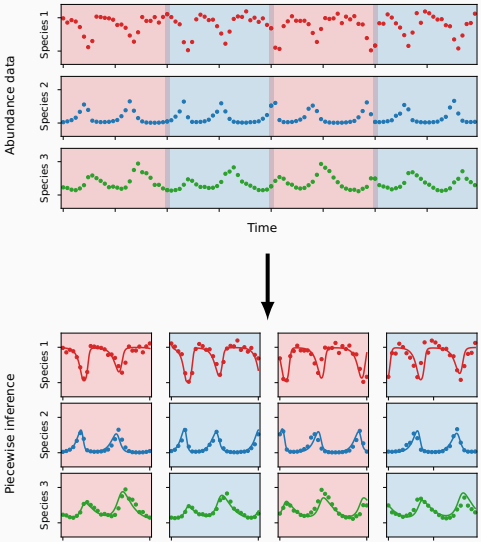

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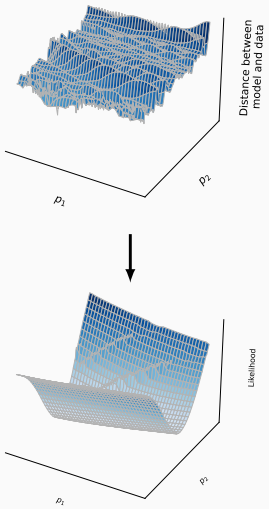
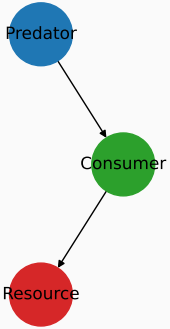


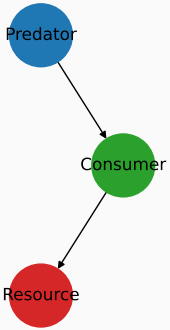
Optimal segment size

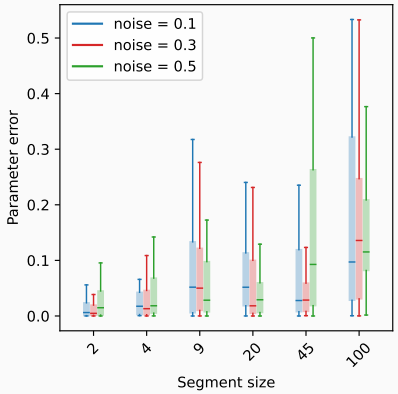


Chaotic food web system

Hastings et al. 1991.

Optimal segment size





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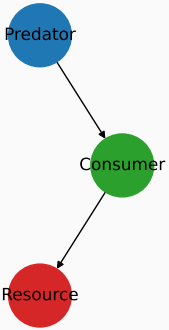

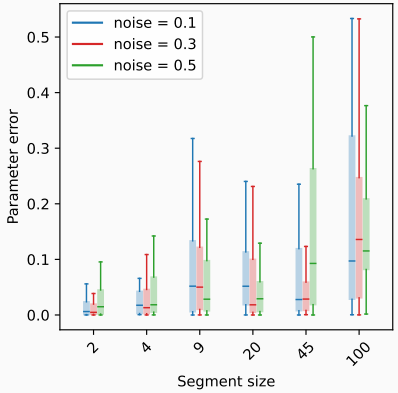

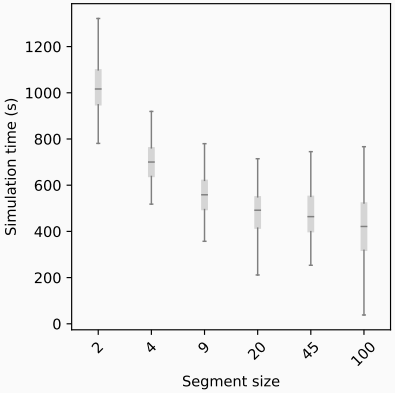

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Scaling with model complexity

$\mathcal{M}_3$ 

3 state variables, 9 parameters

$\mathcal{M}_5$ 

5 state variables, 18 parameters

$\mathcal{M}_7$ 

7 state variables, 24 parameters

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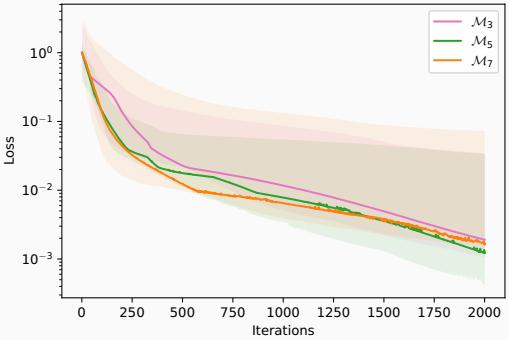

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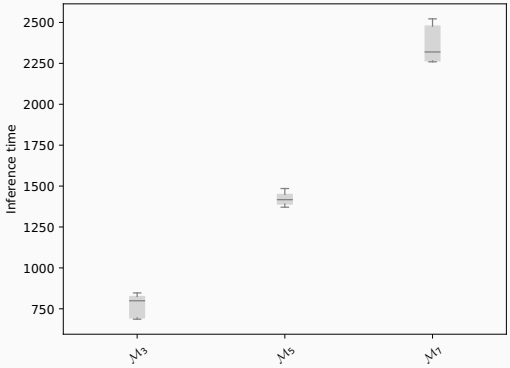

Hypothesis testing and processes discovery

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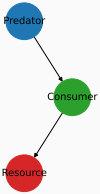

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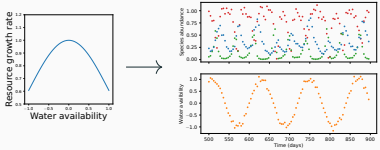

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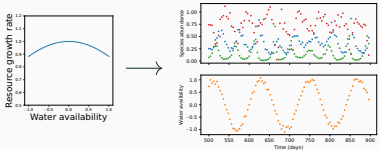

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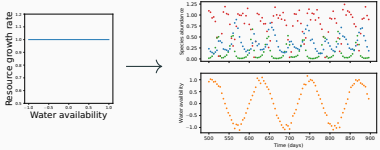
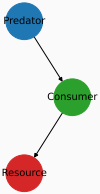


Hypothesis testing and processes discovery



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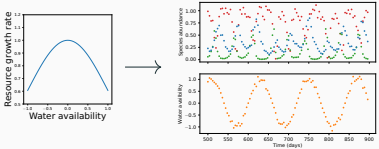

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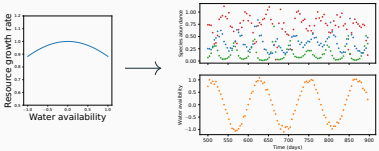

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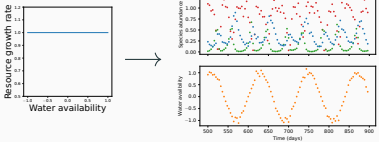
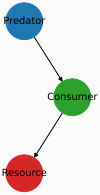


$r_R = cst.$

Model $\mathcal{M}$

Hypothesis testing and processes discovery



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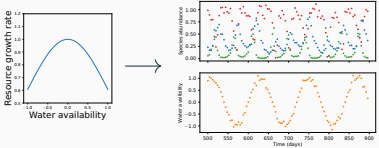

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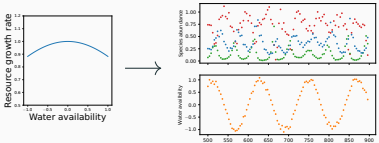

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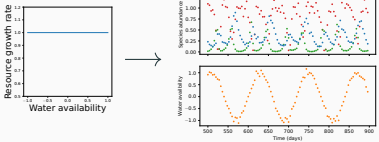

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Model $\mathcal{M}$

$r_R = f(\text{water avail.})$

Model $\mathcal{M}^*$

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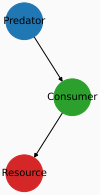

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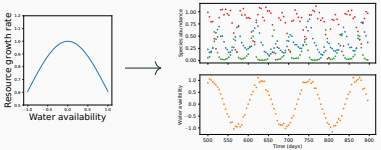

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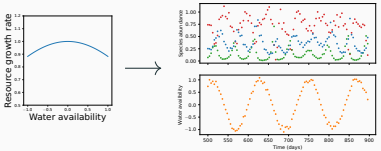

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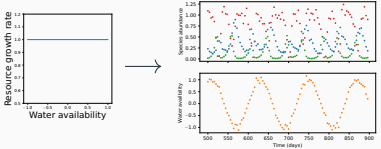

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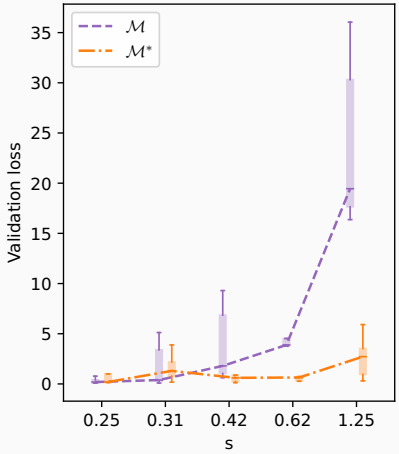

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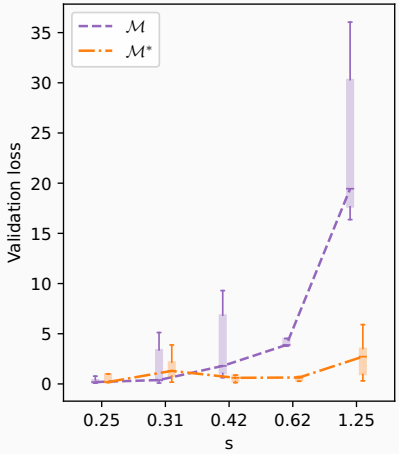
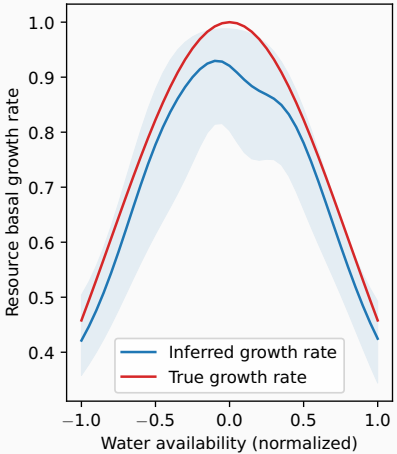
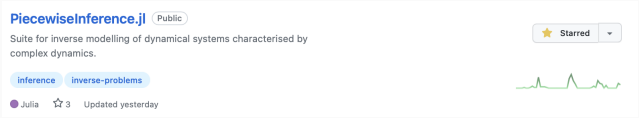




The ecosystem we are developing, and the next projects



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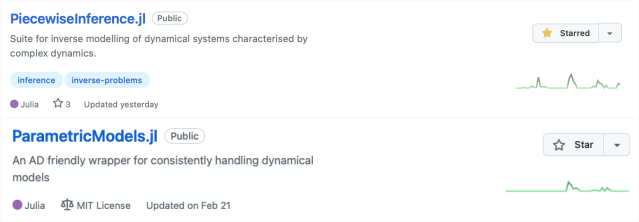

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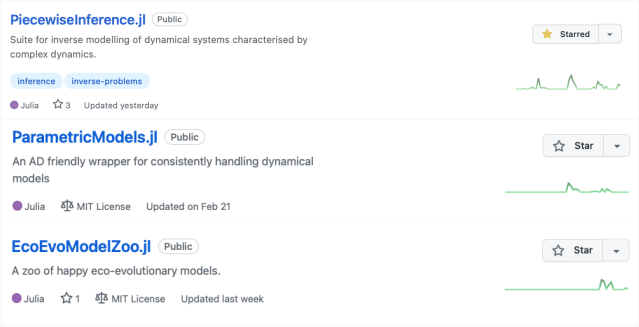

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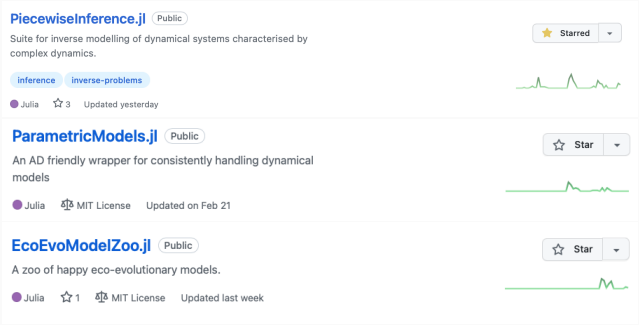

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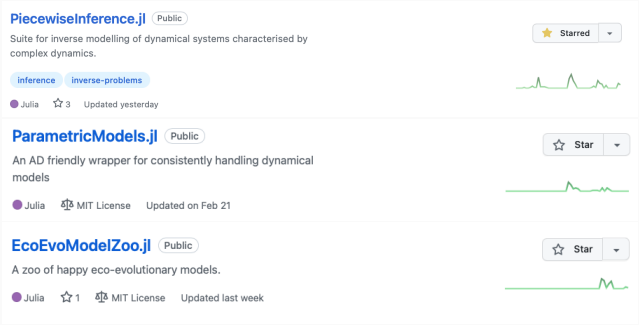

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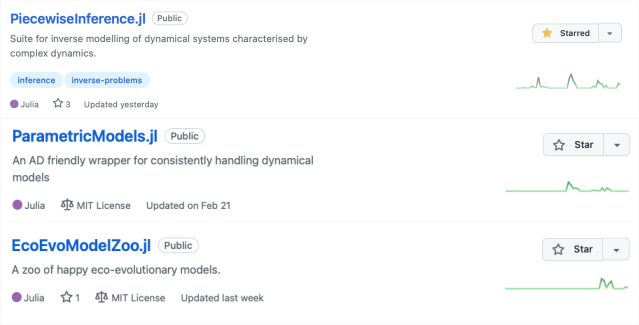

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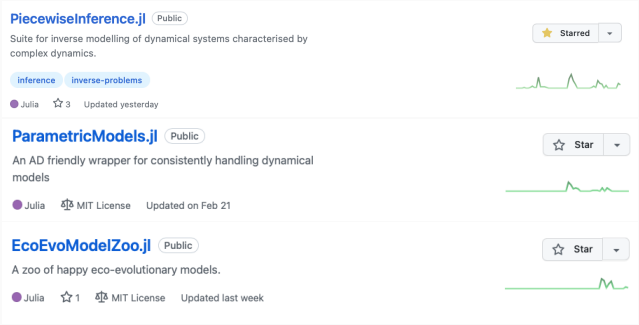
- Food webs dynamic in the Bay of Biscay with **Trawl Survey Data**

The ecosystem we are developing, and the next projects



A few tutorials available @vboussange.github.io

Ongoing projects

- Food webs dynamic in the Bay of Biscay with **Trawl Survey Data** 🚢
- Artic plant community build-up with **sedaDNA** 🧬

Summary and perspectives

- PiecewiseInference.jl: an efficient inference framework combining **a segmentation method** together with **automatic differentiation** and **Deep Learning optimizers**

Summary and perspectives

- PiecewiseInference.jl: an efficient inference framework combining **a segmentation method** together with **automatic differentiation** and **Deep Learning optimizers**
- Our framework can help better understand and predict the dynamics of biodiversity by allowing
  - the **testing ecological theory against data**
  - **learning the parametrization** of ecological processes

Boussange, V., Vilimelis-Aceituno, P., Pellissier, L., *Mini-batching ecological data to improve ecosystem models with machine learning*. [bioRxiv] (2022)

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for `PiecewiseInference.jl` tutorials.

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Thanks for your attention!