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Exploration de modèles multi-agents

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Etienne Delay, Sébastien Rey-Coyrehourcq. Exploration de modèles multi-agents. École thématique. Oléron, France. 2017. cel-02285696

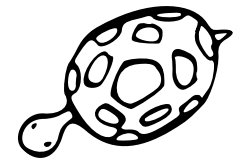
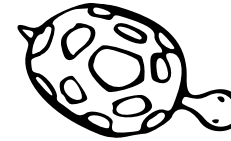
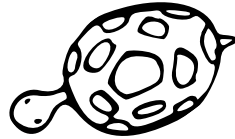
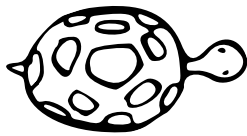
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Submitted on 12 Sep 2019

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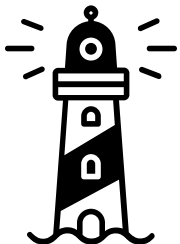
Exploration de modèles multi-agents

Etienne Delay

<http://geolab.univ-bpclermont.fr/spip.php?article184>

Sébastien Rey Coyrehourcq

<http://orcid.org/0000-0001-7296-9695>



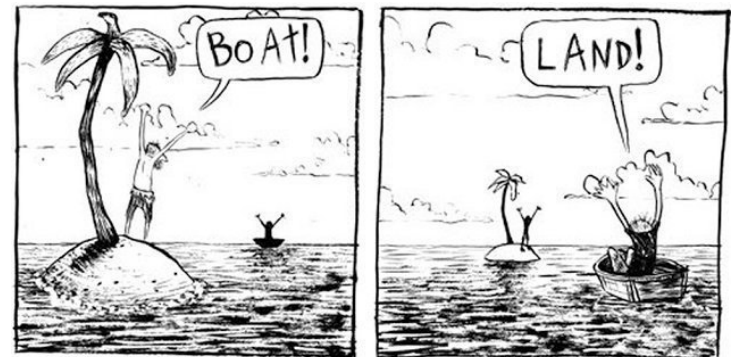
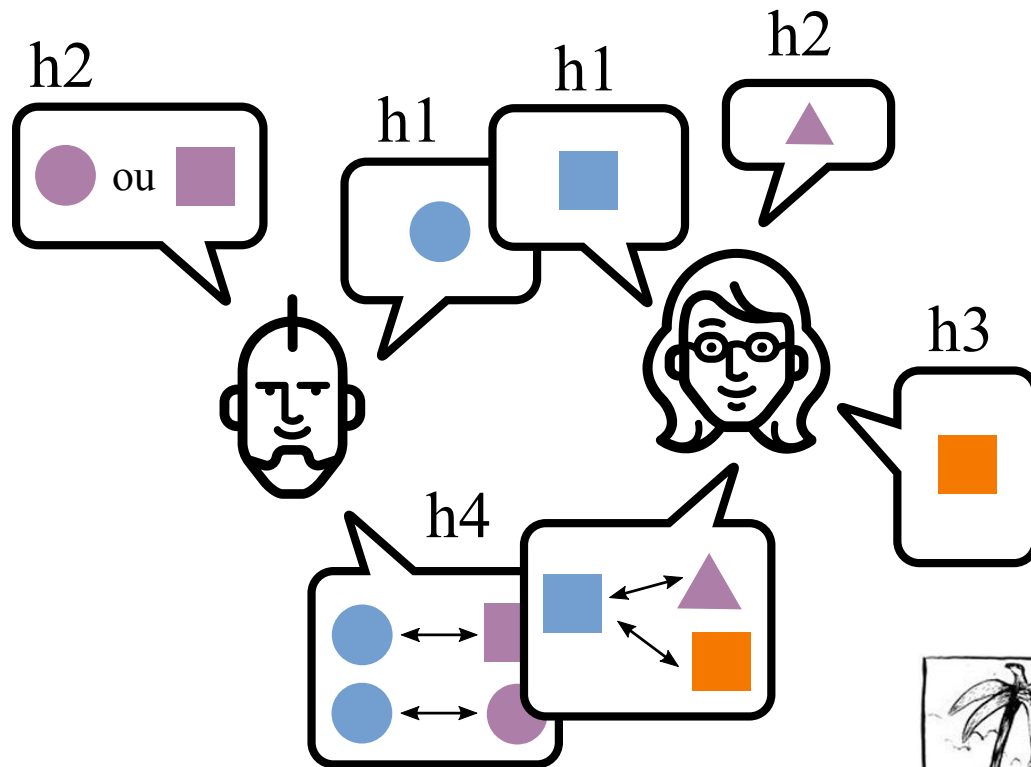
MAPS 10 - Oléron
06/2017

Résultats et script disponible sur [github](#) 

<https://slides.com/sebastienreycoyrehourcq/>

Explorer pour discuter

Des conceptions complémentaires de la réalité



Explorer pour faire des choix

connaître et agir sur la dépendance au chemin

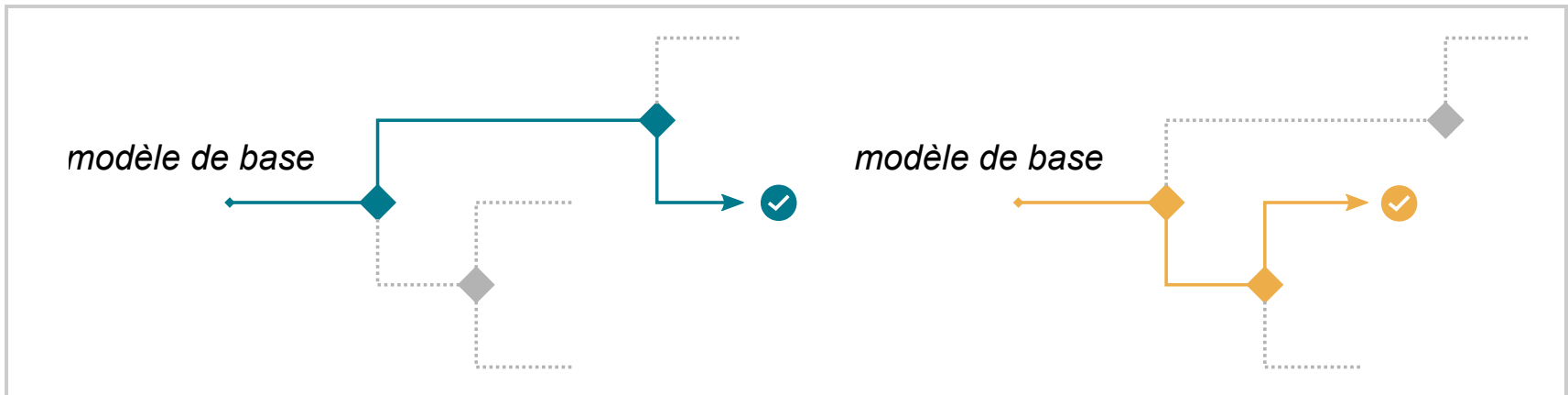


(1, 2)

[Grimm2016, Cottineau2016]



Les **choix** génèrent des **chemins** expliquant le même **pattern**



Deconstruire & reconstruire pour mieux comprendre ...

① **Look back** and challenge choices (◆)

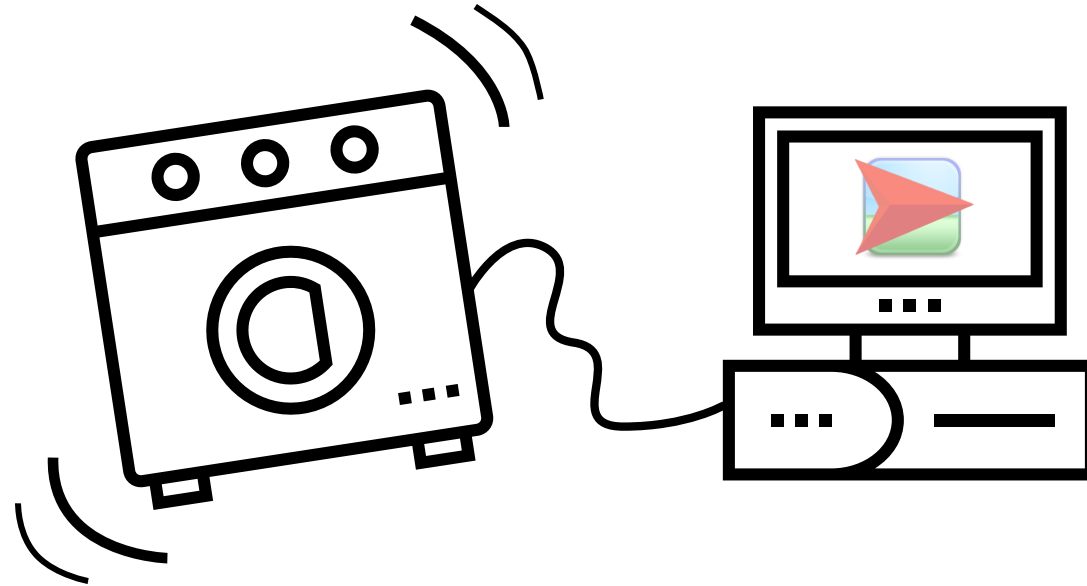
② Know **where** and **when**
parameters and **mechanisms** break

③ **Share** your results
and **challenge** others

Cumulative knowledge

Explorer pour comprendre

le "laboratoire virtuel", un agitateur d'idées
mais pas que ...



comportements attendus / simulés ?
défaillances ?
robustesse(s) ?



Bénéfices de l'exploration

L'exploration des modèles revient donc à **organiser** :

- a) la saine **confrontation** des points de vue
- b) la mesure des **écarts** entre **comportements internes attendus et simulés**
- c) la chasse aux **bugs** et **cas limites**

Autrement dit, un processus **systematique** qui stimule **l'effet de surprise**.



Analyse de sensibilité ?



"Sensitivity analysis (SA) is used to **explore the influence of varying inputs on the outputs of a simulation model** (Ginot et al. 2006).

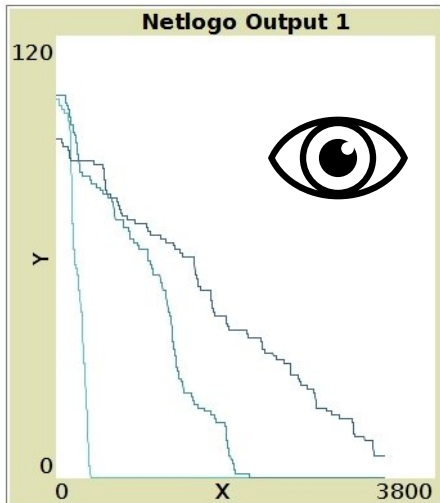
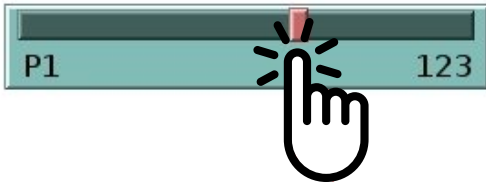
"By exploring the sensitivity of model output to changes in parameters, we learn about **the relative importance of the various mechanisms** represented in the model and how robust the model output is to parameter uncertainty."

[Thiele2014]

- sensibilité **locale**
- sensibilité **globale**

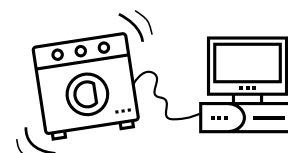
Comment ?

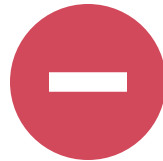
stratégie / DOE
"One-Variable-At-A-Time"



évaluation à l'oeil
"Face Validity"

Sensibilité locale - OAT

- peu fiable 
- couteux en temps
- limité
- difficilement reproductible

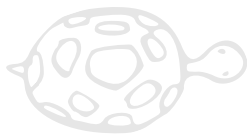


- ludique
- interactif
- exploratoire
- incrémental
- essai erreur

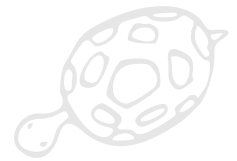


"**Tinkering**" de Papert & Retsnick



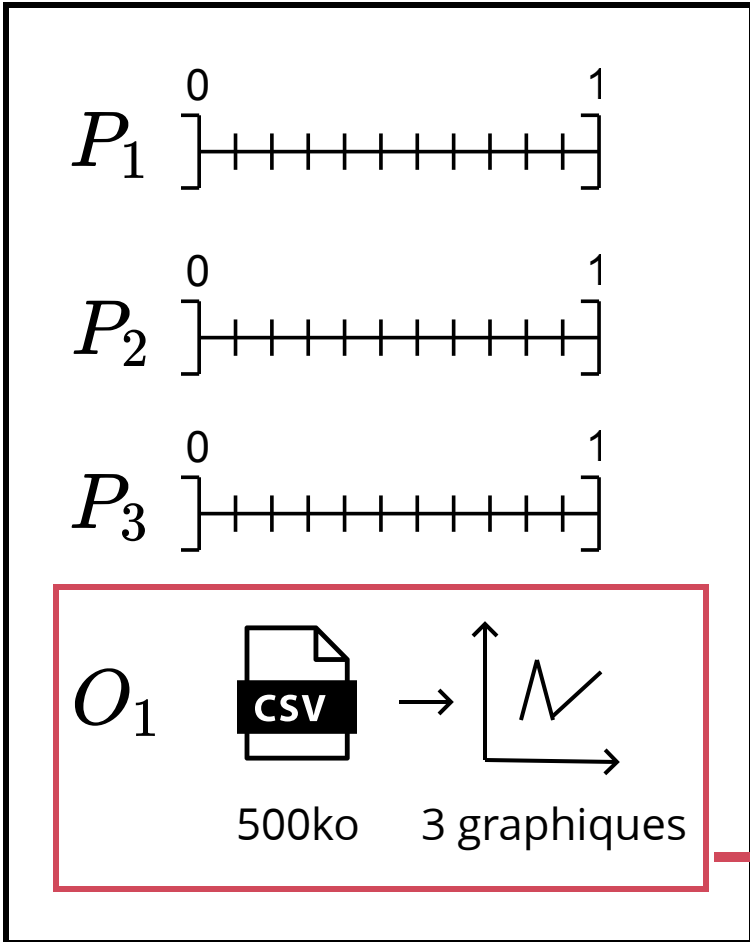


Comment ?



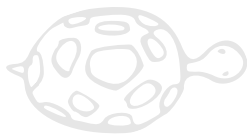
Une première étape pour systématiser OAT ?

=> Sensibilité Globale

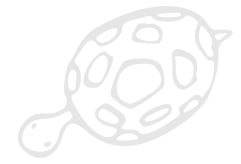


un modèle simple,
un **plan d'expérience complet** :

P1 x P2 x P3



Comment ?



1 er problème - Explosion combinatoire

$$discreteStep^{\left(\sum_{i=1}^n P_i\right)} * replication * duree$$

$$\{replication \in \mathbb{R} \mid 30\}$$

$$\{duree \in \mathbb{R} \mid 1minute\}$$

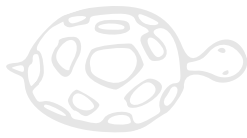
$$discreteStep = 11 \quad P = 3$$

$$11^3 * 30 * 1min = 39930min = 27jours$$

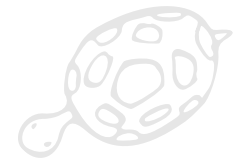
$$11^3 * 30 * 500ko = 19965000Ko = 19Go$$

$$11^3 * 30 * 3graphiques = \underline{119790graphiques}$$

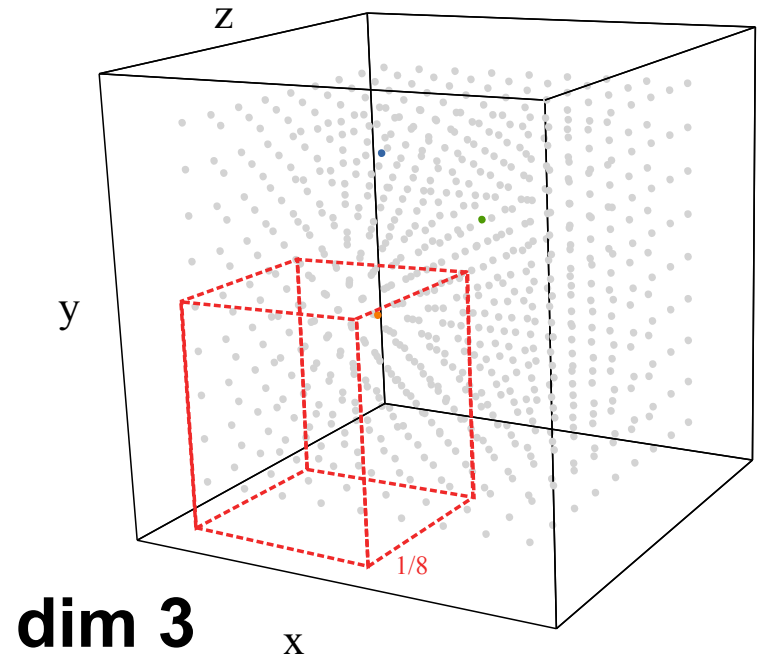
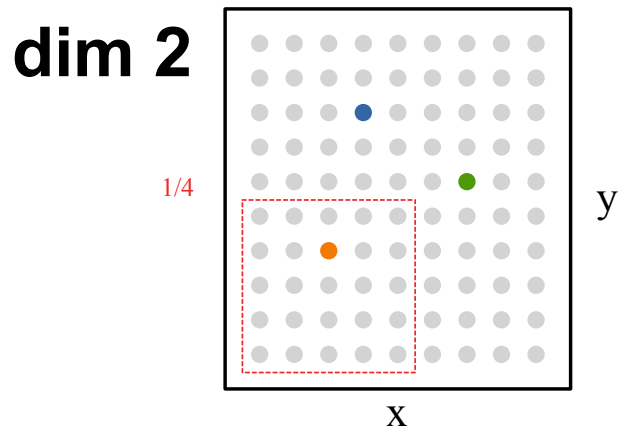
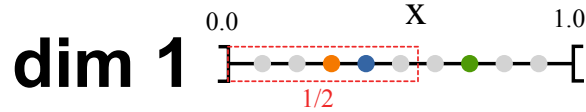
Durée & Volumétrie impossible à gérer



Comment ?



2 ème problème - "Curse Dimensionality"

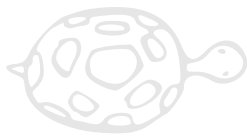


dimensions

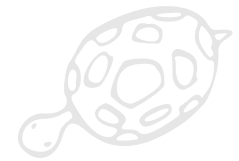
=



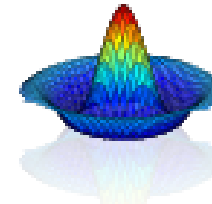
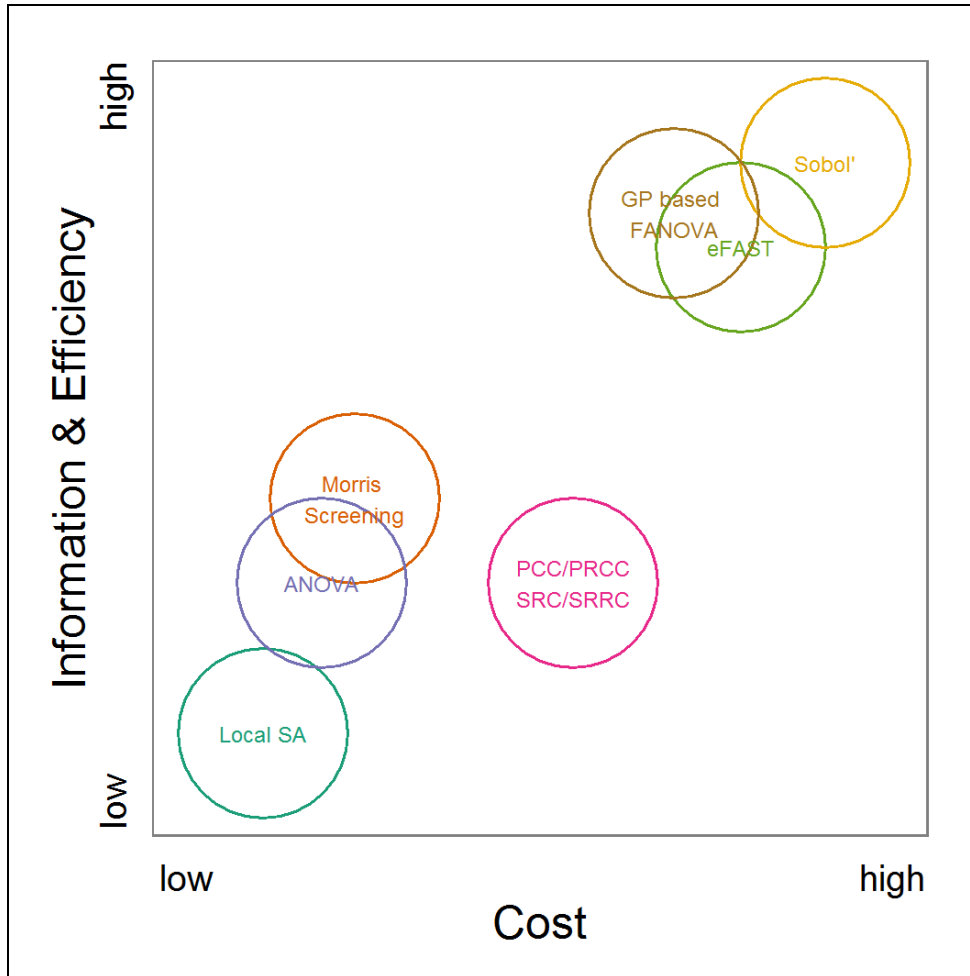
couverture à nb points égal



Comment ?

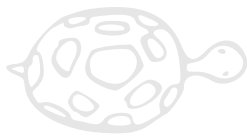


Une première solution, des méthodes plus sioux.

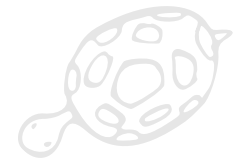


MEXICO
WEXICO

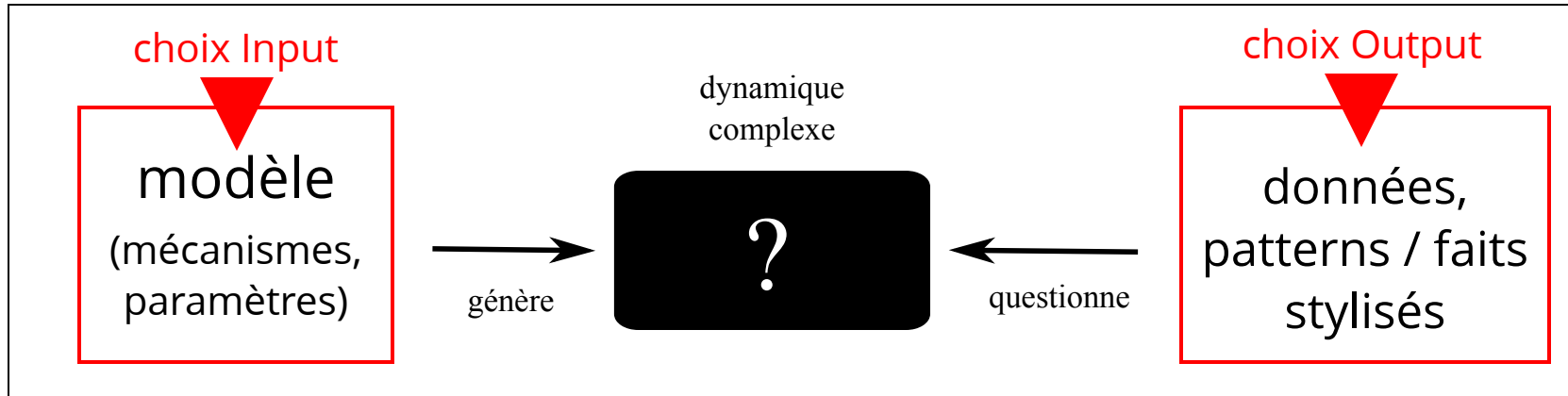
<http://reseau-mexico.fr/>



Comment ?



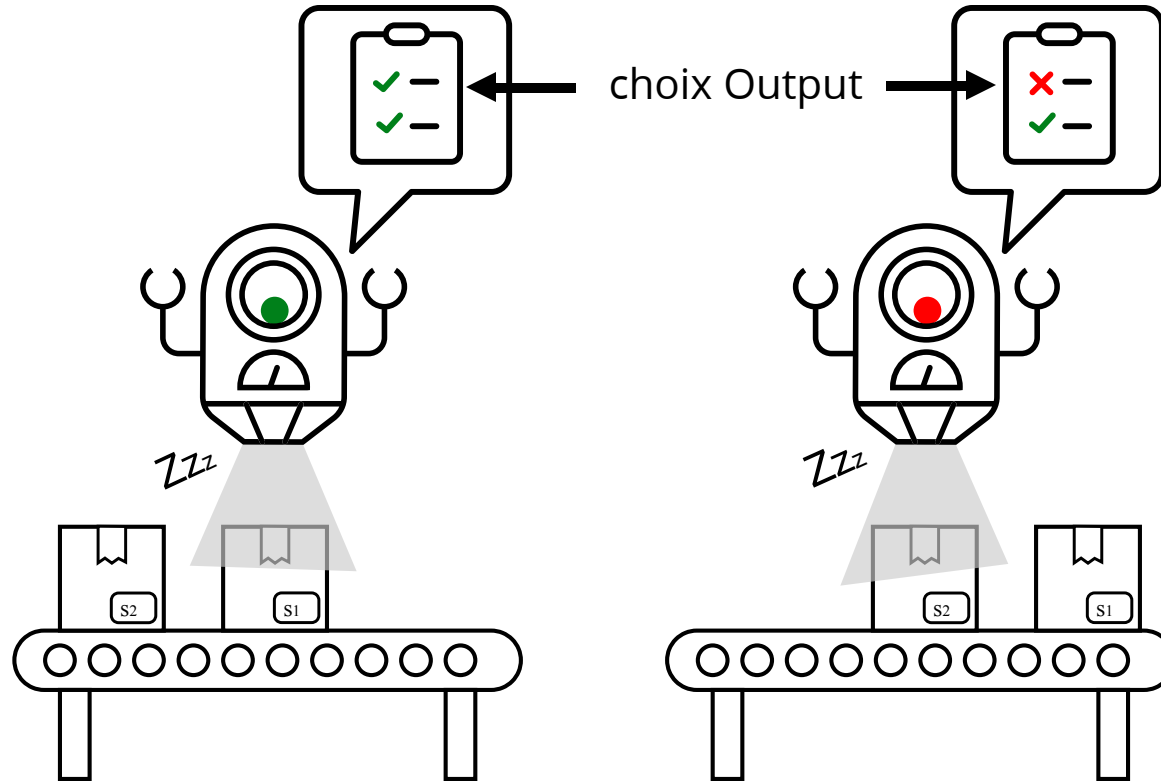
Une deuxième solution, changer d'approche !



Organiser une **mise en tension** entre les **choix Input - Output**

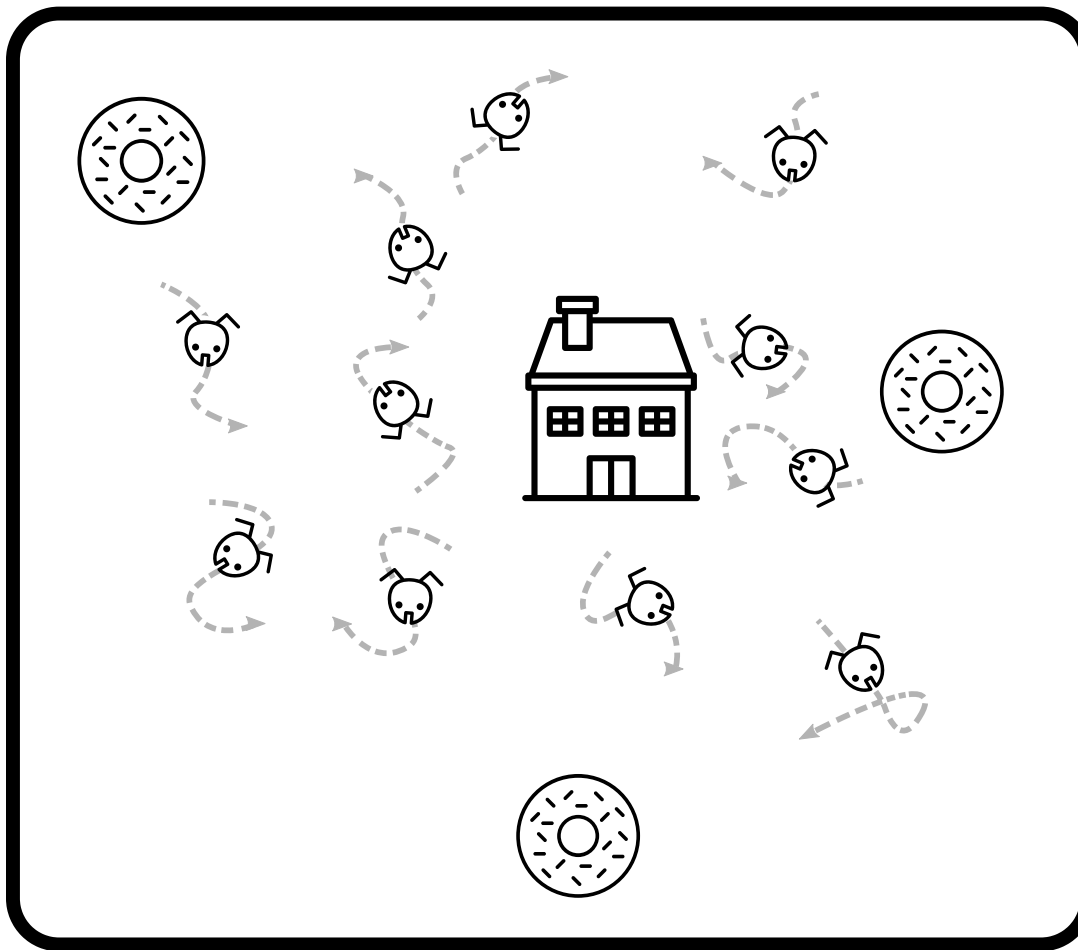
Comment ?

Quelle mise en tension ?



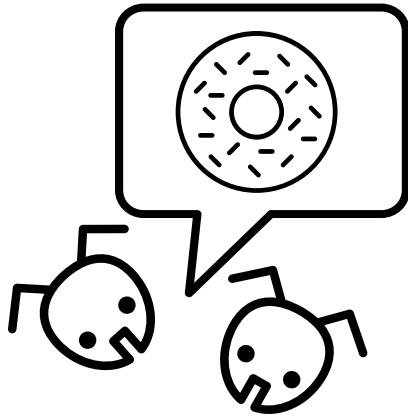
Des **critères quantifiés** pour "guider"
une exploration automatisé

Example "Ants"

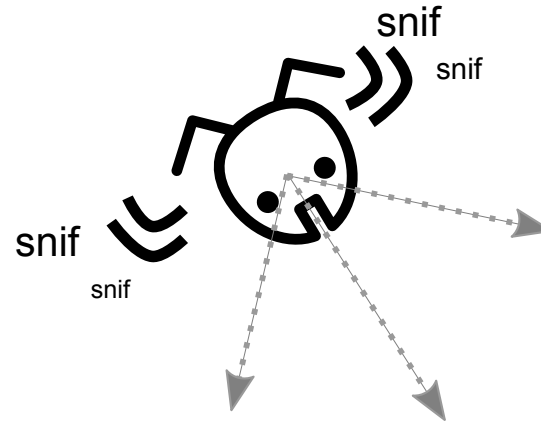


"random walk"

Example "Ants"



Utilisation de traces
ou "**phéromones**"



Alignement avec les
traces **les plus fortes**

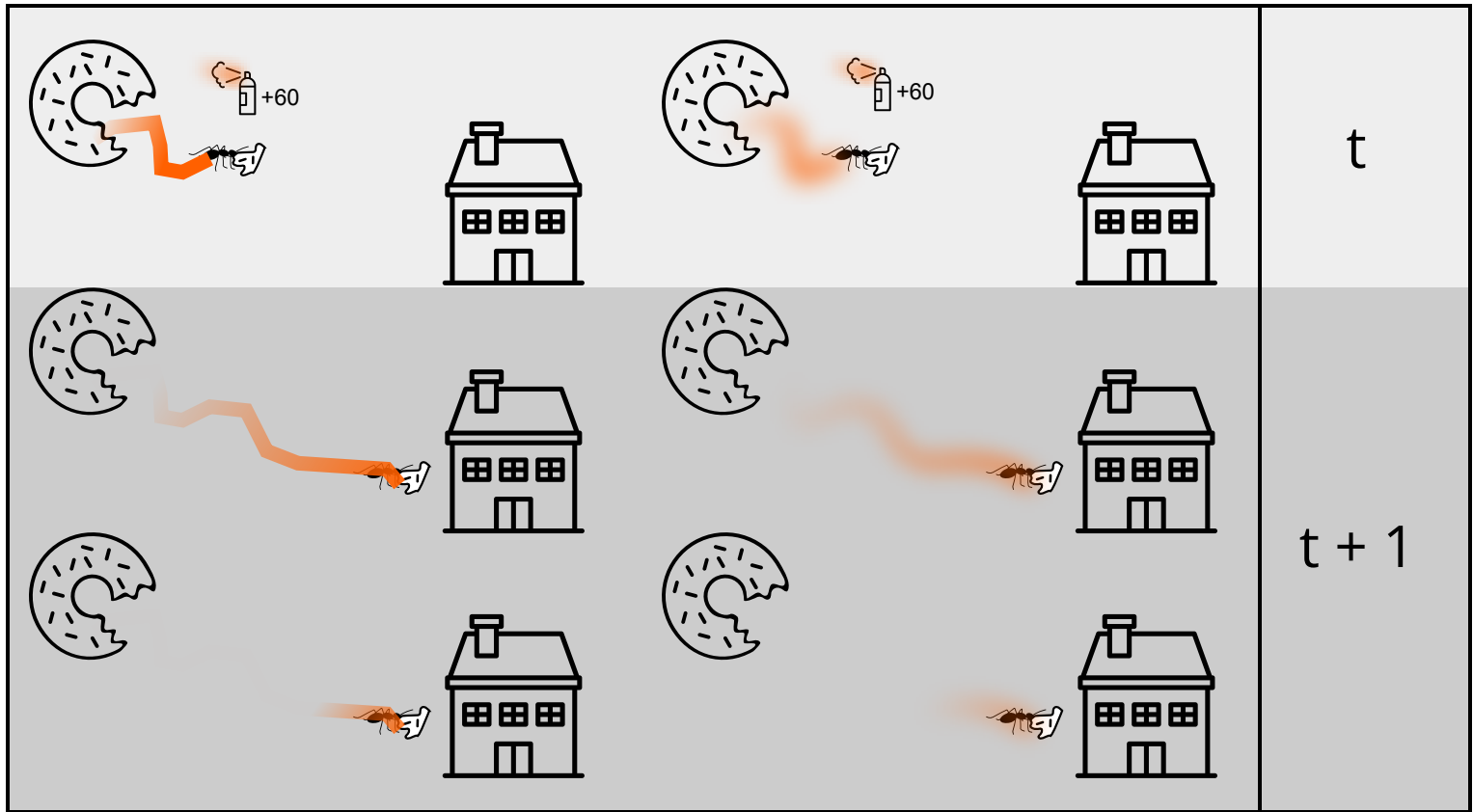
Example "Ants"

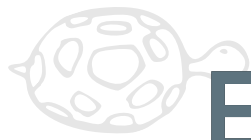


diffusion

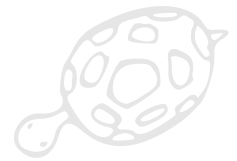


evaporation

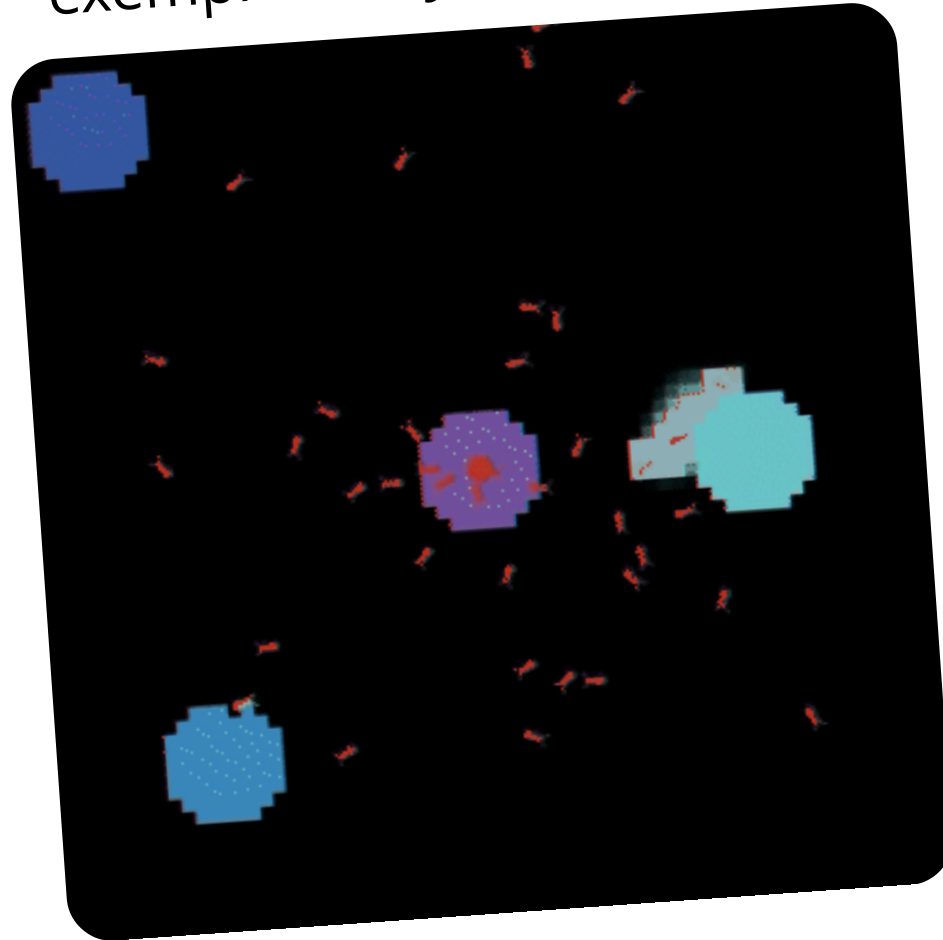




Example "Ants"

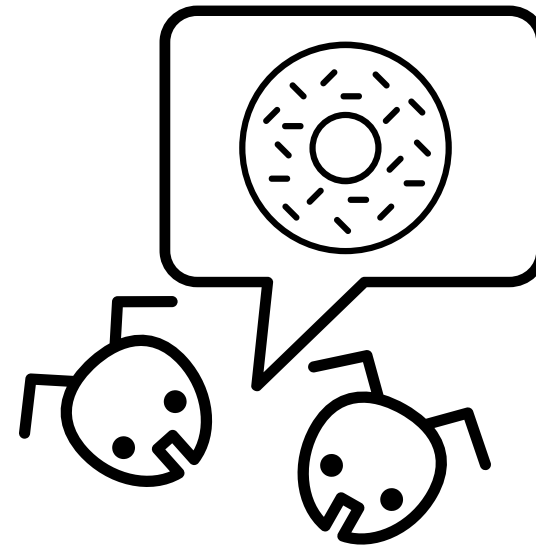
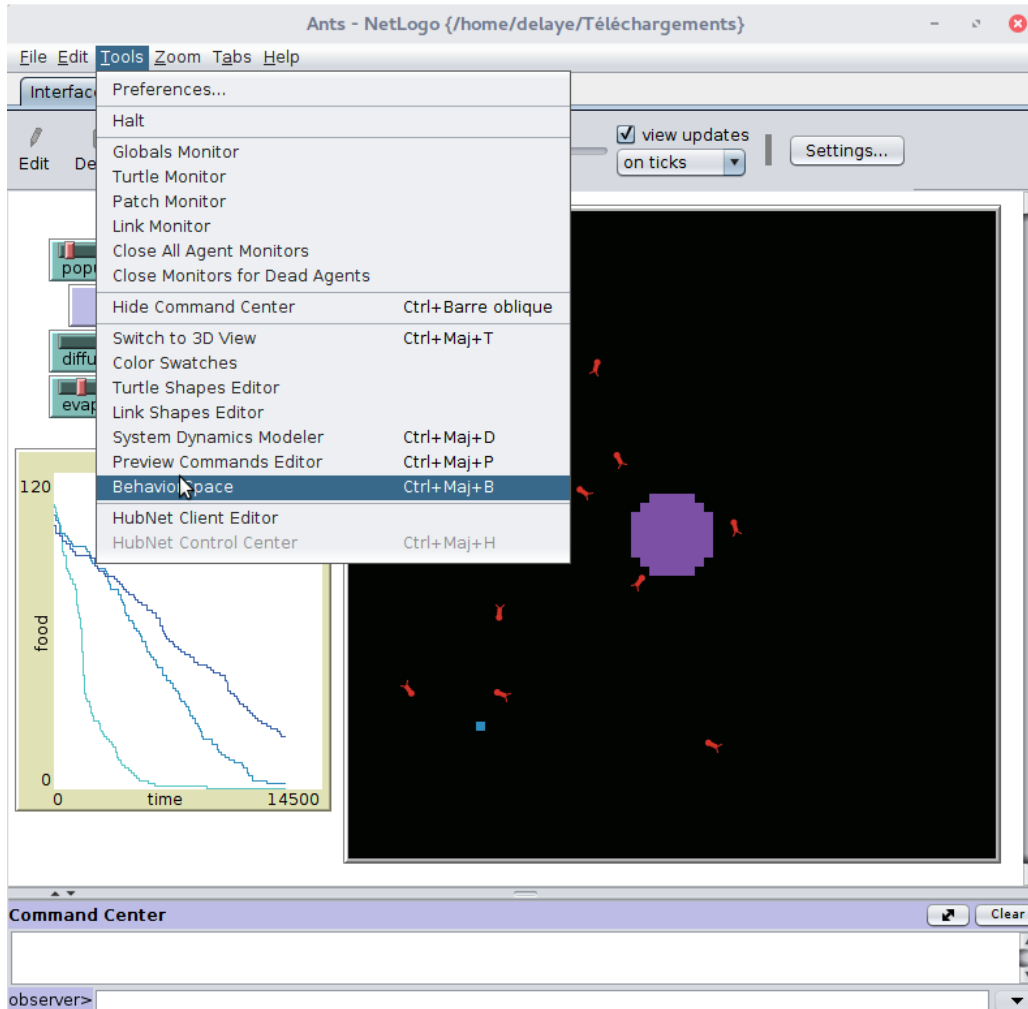


exemple de dynamique



Example "Ants"

Le BehaviorSpace



Utilisation de traces
ou "phéromones"

Example "Ants"

Le BehaviorSpace : config 4810 simulations

Experiment

Experiment name

Vary variables as follows (note brackets and quotation marks):

```
["evaporation-rate" [10 10 90]]  
["population" [100 20 200]]  
["diffusion-rate" [10 10 90]]
```

Either list values to use, for example:
["my-slider" 1 2 7 8]
or specify start, increment, and end, for example:
["my-slider" [0 1 10]] (note additional brackets)
to go from 0, 1 at a time, to 10.
You may also vary max-pxcor, min-pxcor, max-pycor, min-pycor, random-seed.

Repetitions

run each combination this many times

Run combinations in sequential order
For example, having ["var" 1 2 3] with 2 repetitions, the experiments' "var" values will be:
sequential order: 1, 1, 2, 2, 3, 3
alternating order: 1, 2, 3, 1, 2, 3

Measure runs using these reporters:

```
sum [food] of patches
```

one reporter per line; you may not split a reporter across multiple lines

Measure runs at every step
if unchecked, runs are measured only when they are over

Setup commands:

Go commands:

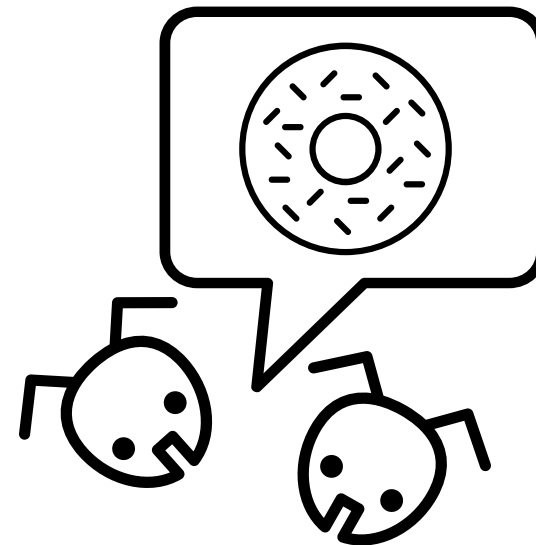
Stop condition:

Final commands:

the run stops if this reporter becomes true run at the end of each run

Time limit

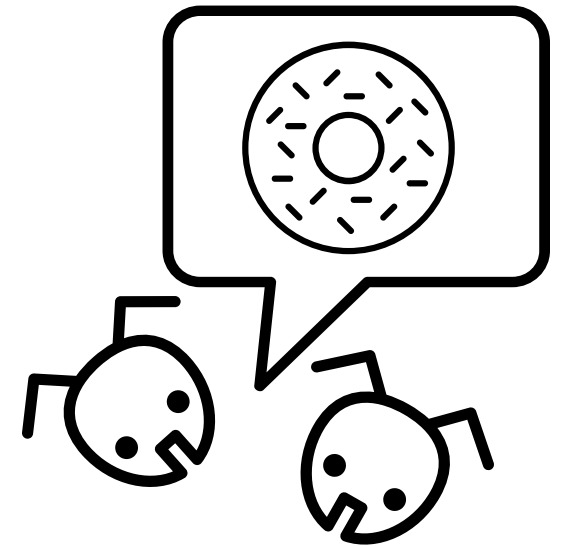
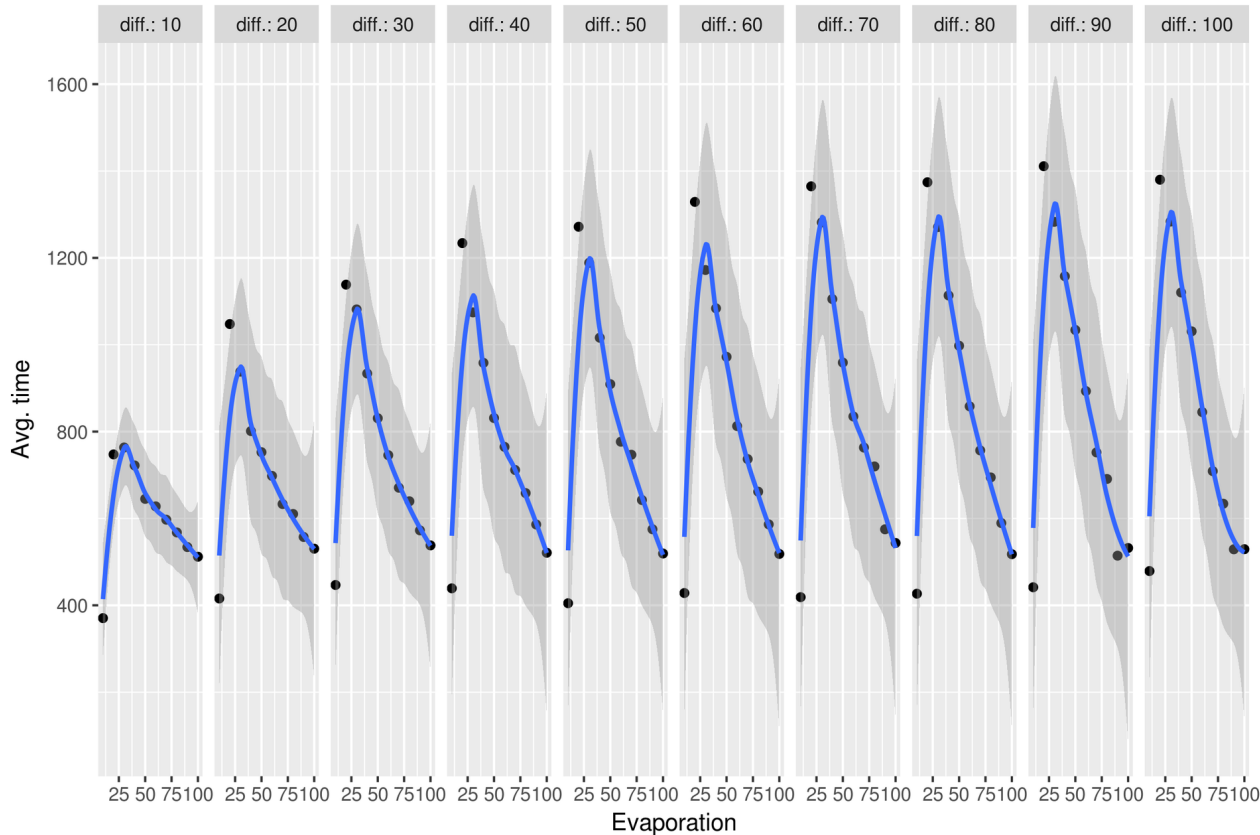
stop after this many steps (0 = no limit)



Utilisation de traces
ou "phéromones"

Example "Ants"

Ant : results for pop. 150



Utilisation de traces
ou "phéromones"

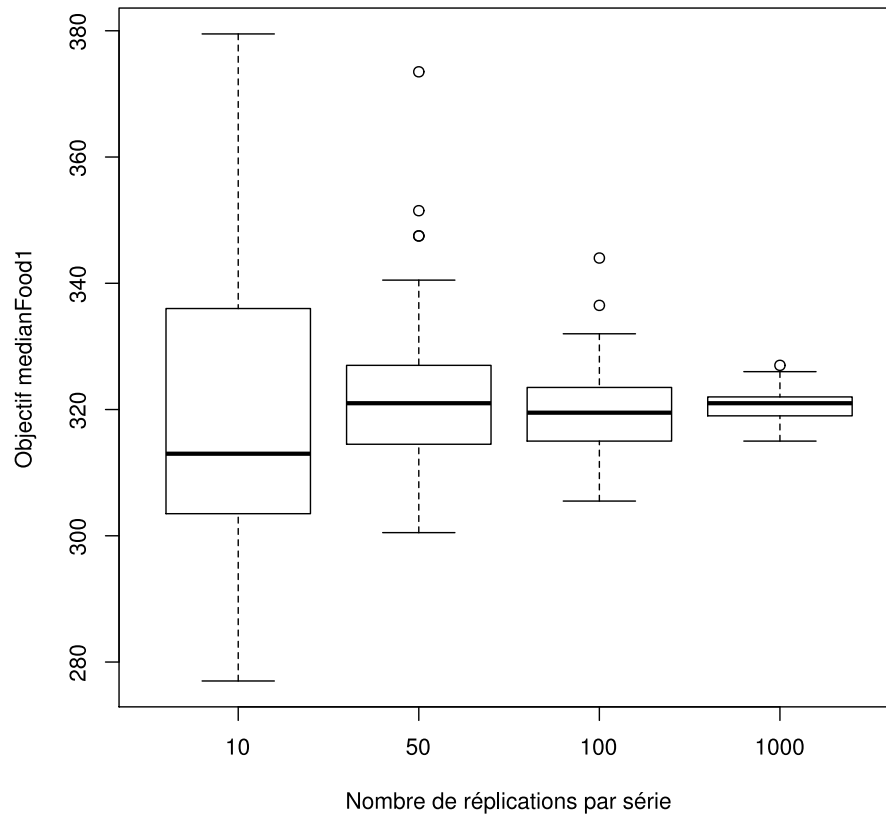


Résultats et script disponible sur [github](#)

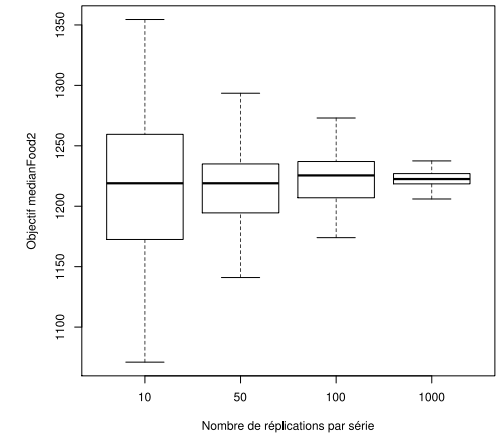
Exemple "Ants"

Mesurer le rôle de **l'aléatoire** dans les simulations ?

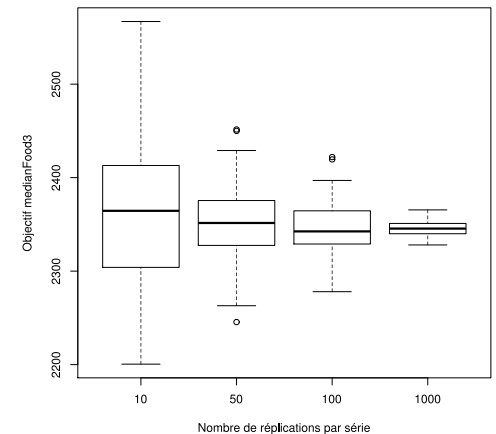
Médiane sur l'objectif food1 sur 100 séries de répliations



Médiane sur l'objectif food2 sur 100 séries de répliations



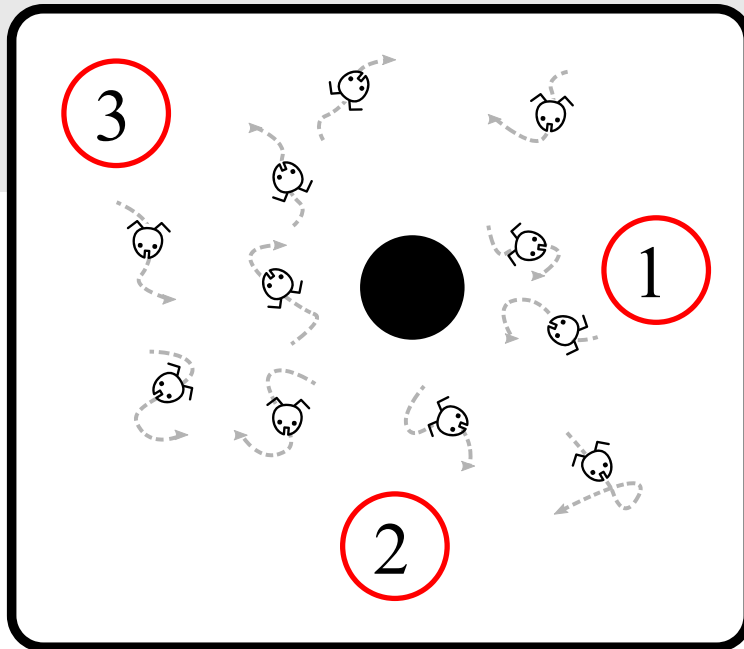
Médiane sur l'objectif food2 sur 100 séries de répliations



100 * médiane de 10,50,100,1000 répliations

Example "Ants"

Que veut on tester/savoir ?



Quelle valeurs de (*diffusion, evaporation*) **minimise** le temps de consommation des trois **tas de nourriture** ?

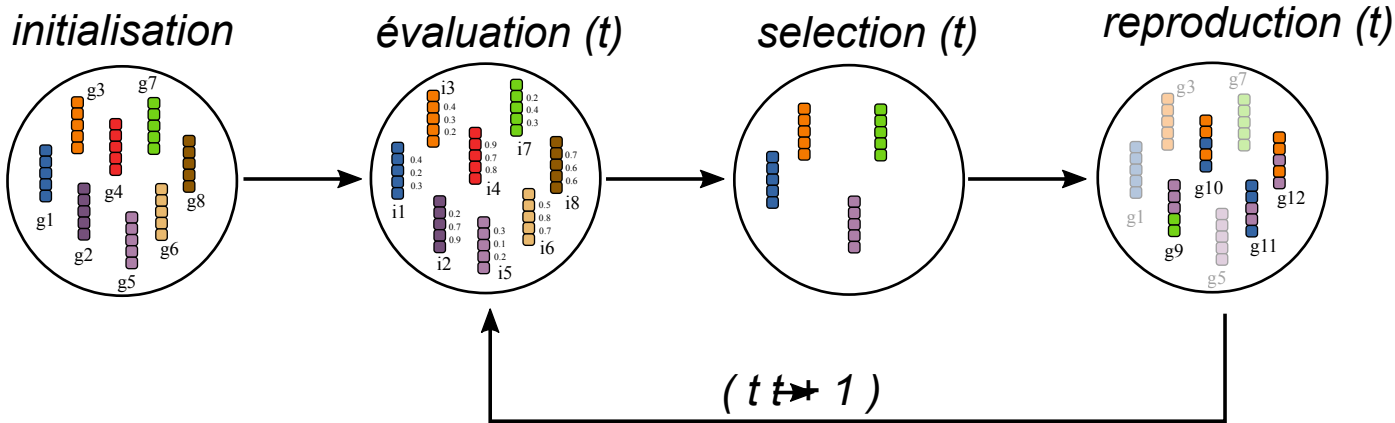
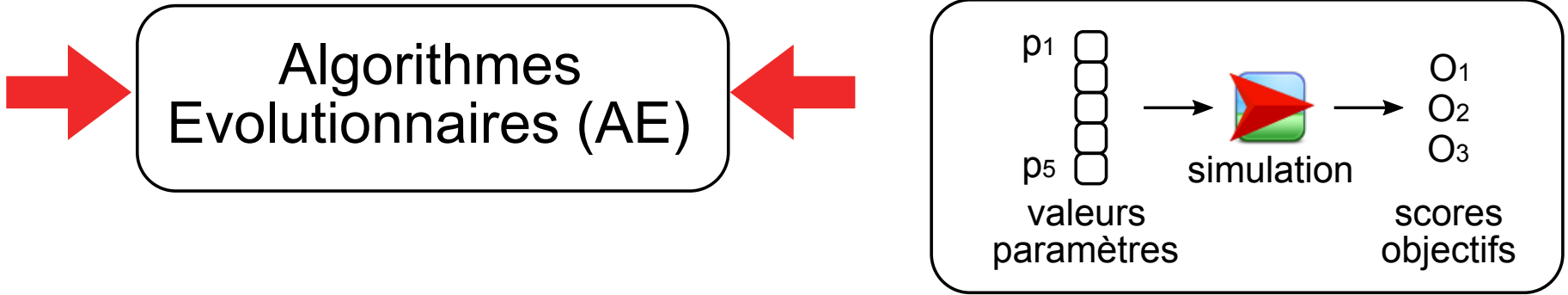
trois objectifs

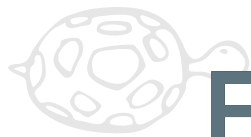
$$Obj_1 = \textit{ticks} \text{ quand } \textcircled{1} \leq 0$$

$$Obj_2 = \textit{ticks} \text{ quand } \textcircled{2} \leq 0$$

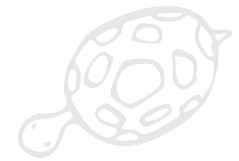
$$Obj_3 = \textit{ticks} \text{ quand } \textcircled{3} \leq 0$$

Comment ?





Example "Ants"



Le Behavior Search

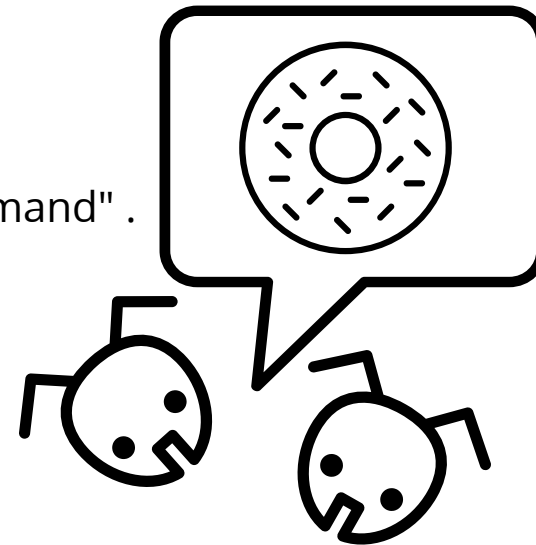
Disponible avec Netlogo depuis la version 6.0.1

Windows: Run

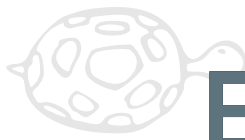
"app\behaviorsearch\behaviorsearch_headless.bat".

Mac: Run "behaviorsearch/behaviorsearch_gui.command" .

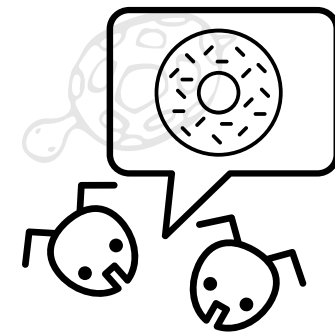
Linux: Run "./Behaviorsearch" .



Utilisation de traces
ou "phéromones"



Example "Ants"



Le Behavior Search

Untitled - BehaviorSearch 1.02

File Help

/home/delaye/github/MAPS-10/supports-cours/explorations-modeles/Ants_es.nlogo

Parameter Specification

```
["diffusion-rate" [0 1 99]]
["evaporation-rate" [0 1 99]]
["population" 150]
```

Setup: setup
Step: go
Measure: ticks
Measure If: true
Stop If: sugar_in_word <= 0
Step Limit: 4000 model steps

Search Method Configuration

StandardGA

Parameter	Value
mutation-rate	0.03
population-size	50
crossover-rate	0.7
population-model	generational
tournament-size	3

Use fitness caching

Search Encoding Representation

GrayBinaryChromosome

Objective / Fitness Function

Goal: Maximize Fitness

Collected measure: AT_FINAL_STEP

10 replicates

Combine replicates: MEAN

Take derivative? Use ABS value?

w.r.t. ---- $\Delta =$ 0.0

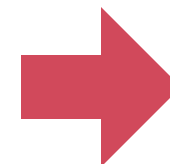
Evaluation limit: 300 model runs

BestChecking replicates: 0

Search Progress

From all searches:
Best found so far:
diffusion-rate=91,0000
evaporation-rate=21,0000
population=150,000
Fitness= 2883,40

Finished search 10 of 10: (1:59:10 elapsed - -:7:-27 remaining)



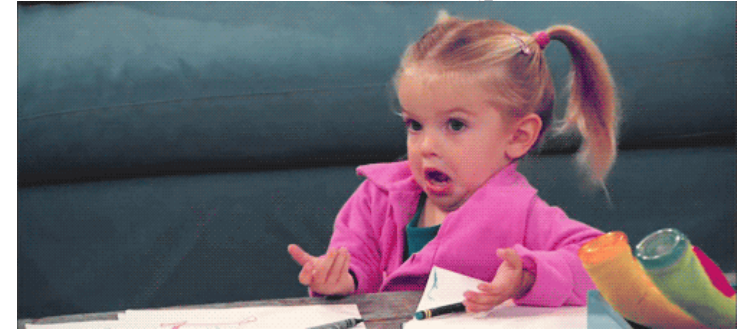
Très lent ...

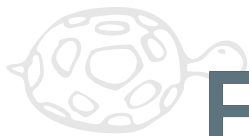
Example "Ants"



Aller plus loin : R et NetLogo avec RNetlogo

```
1 ## Un exemple d'utilisation simple de RNetlogo
2 ## Formation MAPS10
3
4 library("RNetLogo")
5
6 #localiser l'installation de netlogo
7 nl.path <- "~/app/NetLogo_6.0.1/app"
8 NLStart(nl.path, gui = FALSE) #lance netlogo avec (TRUE) ou non (FALSE) une gui
9
10 ##Definition du chemin du modèle
11 model.path <- "/home/delaye/github/MAPS-10/supports-cours/explorations-modeles/Ants_es.nlogo"
12 ## chargement du modele dans netlogo
13 NLLoadModel(model.path)
14
15 ##Parametres
16 my.pop <- 120
17 my.diff <- 30
18 my.evap <- 20
19
20
21 ## change parameter
22 NLCommand("set population ", my.pop)
23 NLCommand("set diffusion-rate ", my.diff)
24 NLCommand("set evaporation-rate ", my.evap)
25
26 NLCommand("setup")
27 agent.df<- data.frame() ## data.frame pour stocker les pos des agents
28 j <- 0
29 for(i in 1:2000){ ##On fera 2000 itération ?
30   NLCommand("go")
31   if(j >= 10){ ## à chaque multiple de 10 on sauvegarde la position des agents
32     pos.agents <- NLGetAgentSet(c("who", "xcor", "ycor", "color",
33                                   "ticks", "turtles"))
34     agent.df <- rbind(agent.df , pos.agents)
35     j = 1
36   }
37   j <- j + 1
38 }
39 }
40
41 save(agent.df, file = "/home/delaye/github/MAPS-10/simulation.RData")
42
43 NLQuit()
44
```





Example "Ants"



Aller plus loin : R et NetLogo avec RNetlogo

©Copyright JASSS



Jan C. Thiele, Winfried Kurth and Volker Grimm (2014)

Facilitating Parameter Estimation and Sensitivity Analysis of Agent-Based Models: A Cookbook Using NetLogo and R

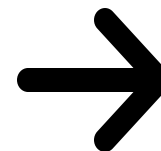
<http://jasss.soc.surrey.ac.uk/17/3/11.html>

Example "Ants"

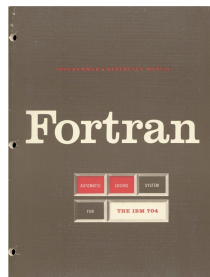
Aller encore plus loin ...



"High Performance Computing"



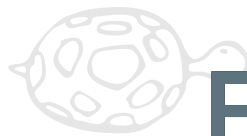
1954 - 2017



1993

Wait? Really?





Example "Ants"



<http://openmole.org>

Aller plus loin encore avec **OpenMOLE**

Créer des "chaînes de traitements"
parallélisables, reproductibles, simples (ou complexes) sans
aucune connaissance des technologies **HPC**

Plusieurs types de plan d'expériences : Plan complet, LSH, Analyse de sensibilités, Algorithmes Evolutionnaires, etc.

```
val i = Val[Double]
val res = Val[Double]
```

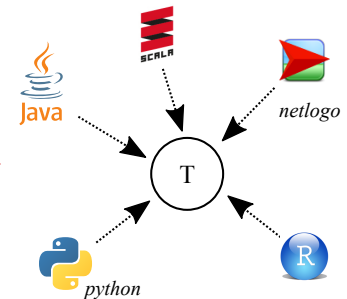
```
val exploration =
  ExplorationTask(i in (0.0 to 100.0 by 1.0))
```

```
val model =
  ScalaTask("val res = i * 2") set (
    inputs += i,
    outputs += (i, res)
  )
```

```
val env = LocalEnvironment(4)

exploration -< (model on env hook ToStringHook())
```

Plusieurs tâches différentes !

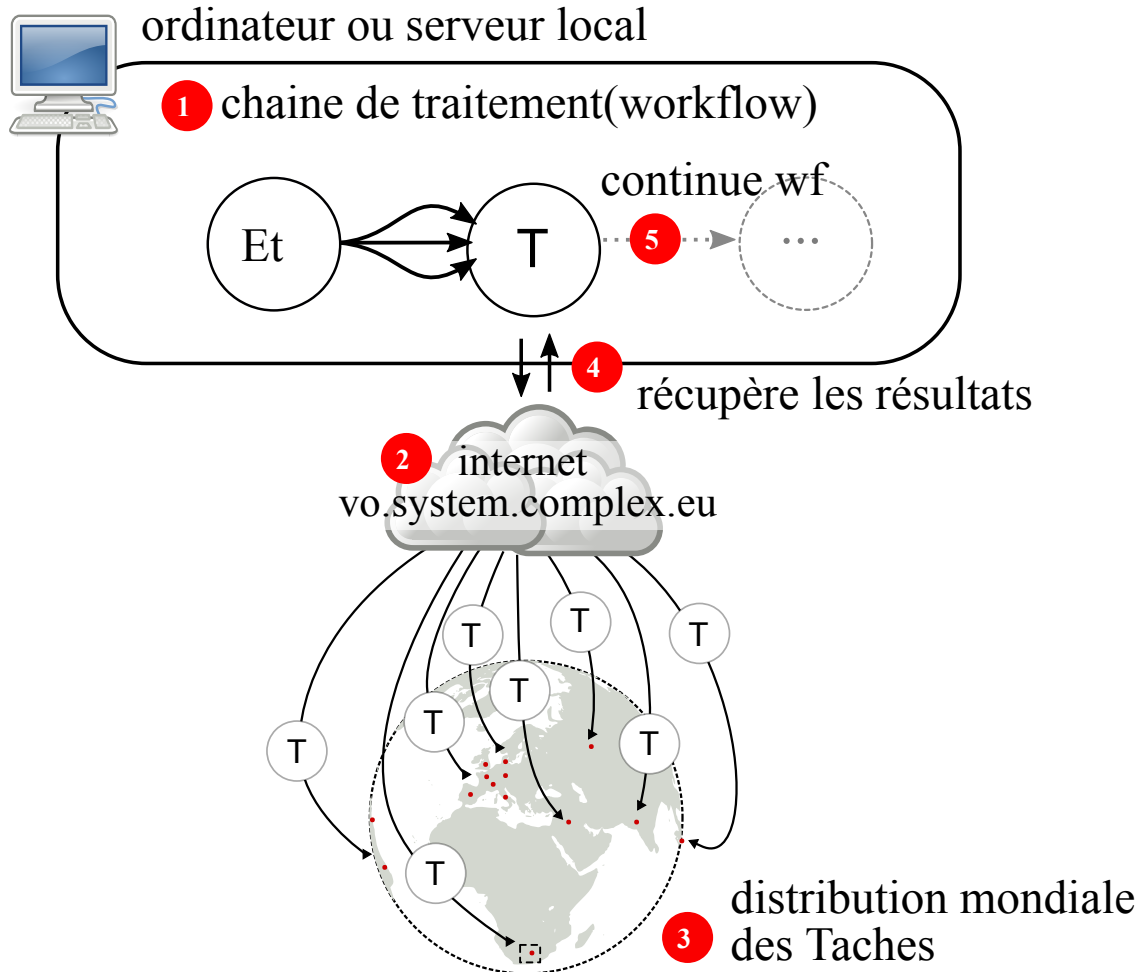


Support de multiples technologies HPC : Cluster, grille de calcul, etc.

Langage de scripts (DSL) **simple et flexible** pour composer les workflow

Example "Ants"

Aller plus loin encore avec OpenMOLE



Example "Ants"



<http://openmole.org>

D'un plan d'expérience simple ...

```
// Define the input variables
val gPopulation = Val[Double]
val gDiffusionRate = Val[Double]
val gEvaporationRate = Val[Double]
val seed = Val[Int]
val i = Val[Double]

// Define the output variables
val food1 = Val[Double]
val food2 = Val[Double]
val food3 = Val[Double]

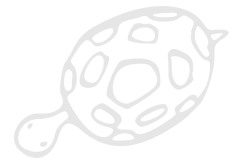
val exploration =
  ExplorationTask(
    (gDiffusionRate in (1.0 to 100.0 by 10.0)) x
    (gEvaporationRate in (1.0 to 100.0 by 10.0)) x
    (seed in (UniformDistribution[Int]() take 5)))

// Define the NetlogoTask
val cmds = Seq("random-seed ${seed}", "run-to-grid")
val ants =
  NetLogo5Task(workDirectory / "ants.nlogo", cmds) set (
    // Map the OpenMOLE variables to NetLogo variables
    netLogoInputs += (gPopulation, "gpopulation"),
    netLogoInputs += (gDiffusionRate, "gdiffusion-rate"),
    netLogoInputs += (gEvaporationRate, "gevaporation-rate"),
    netLogoOutputs += ("final-ticks-food1", food1),
    netLogoOutputs += ("final-ticks-food2", food2),
    netLogoOutputs += ("final-ticks-food3", food3),
    gPopulation:= 100.0,
    // The seed is used to control the initialisation of the random number generator of NetLogo
    inputs += seed,
    outputs += (seed, gDiffusionRate, gEvaporationRate)
  )

val saveHook = AppendToCSVFileHook(workDirectory / "ant_exploration.csv")

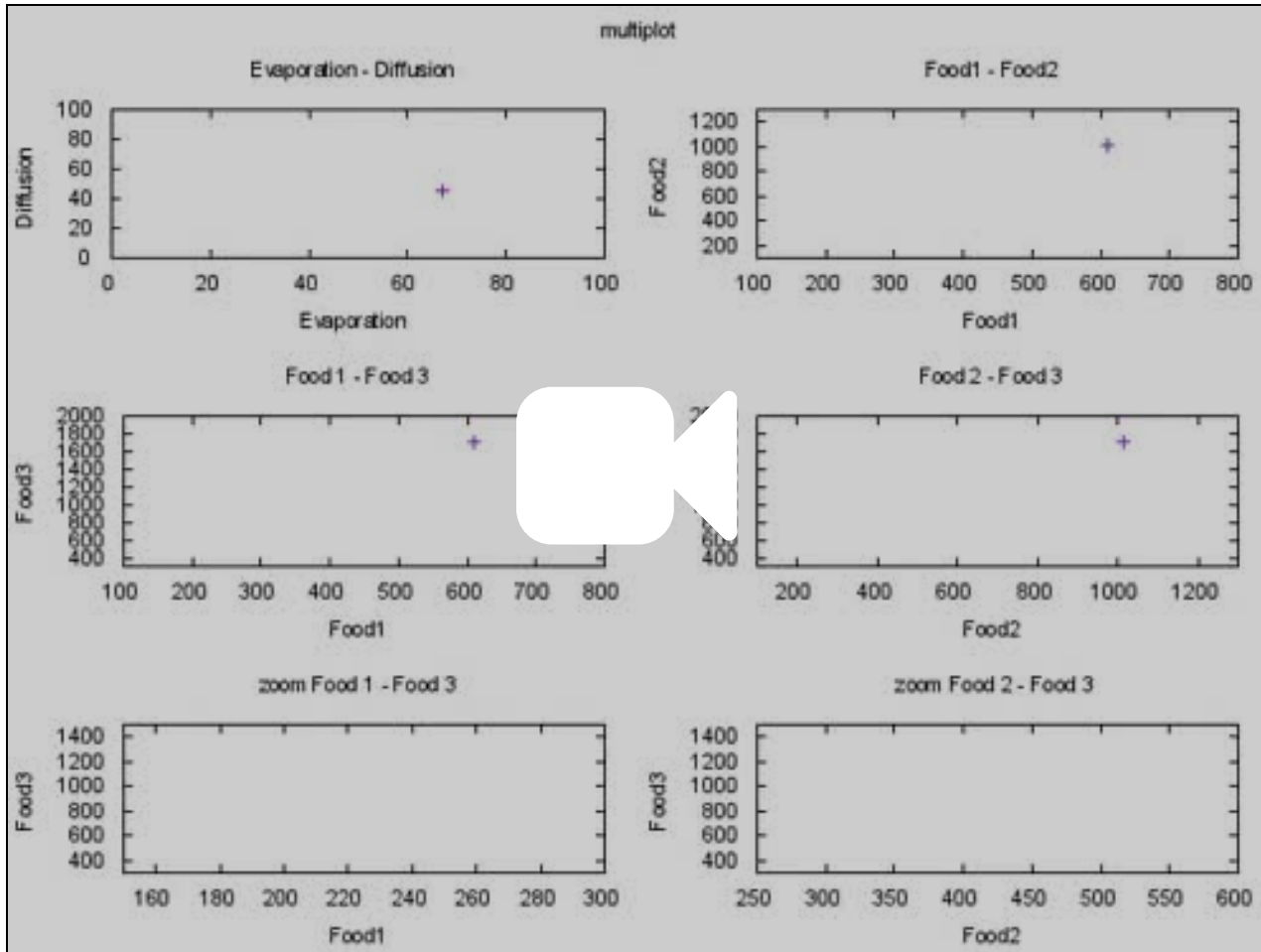
val env = LocalEnvironment(4)

exploration -< (ants on env) hook saveHook
```



Example "Ants"

à une optimisation multi-critères ...



Pour aller plus loin

références et entrées vers + de biblio

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++ David O'Sullivan !! ++

++ Volker GRIMM !! ++



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