Introduction

Jean-Noël Aubertot

Outline

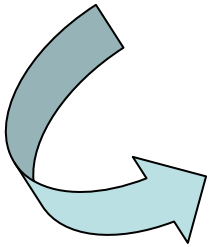
1) What is a model?

2) Why develop mathematical models?

3) How to develop and use mathematical models?

4) Conclusion

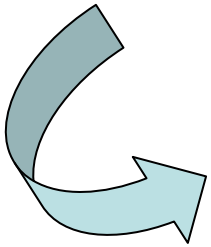
1) What is a model?



A model is a simplified representation of a system.


U.S.NAVY

1) What is a model?



A model is a point of view on a given system.

1) What is a model?

Models can be pictorial, sculptural, musical, conceptual, **mathematical**, …

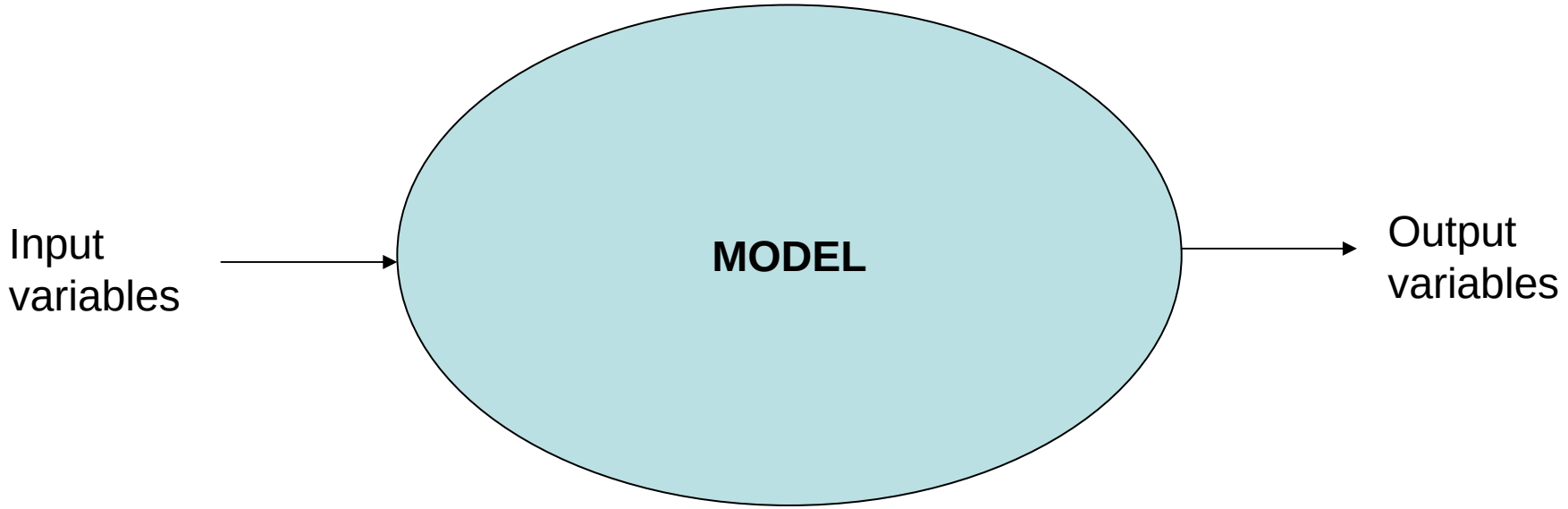
1) What is a (mathematical) model?

- a mathematical model is a simplified representation of a system

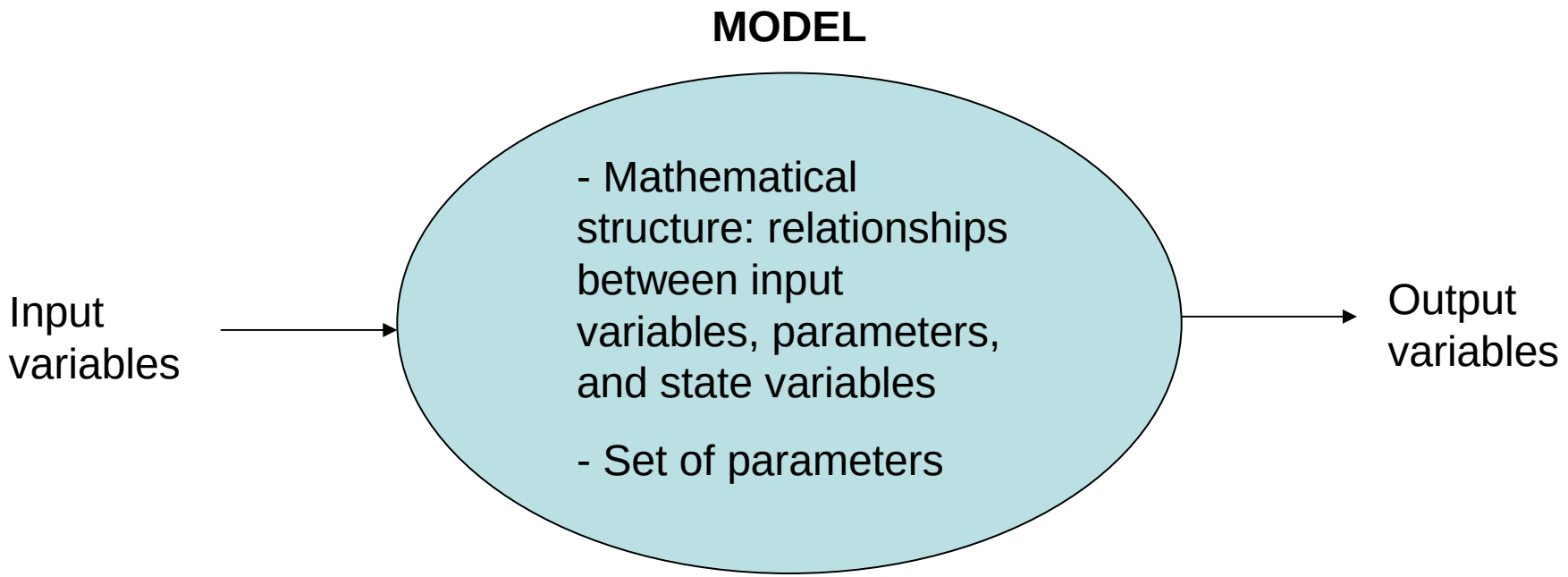
- a mathematical model represents a system structure and behavior by a set of equations

- a mathematical model should be able to predict a system behavior given an initial state and system inputs over time

1) What is a (mathematical) model?



1) What is a (mathematical) model?



Parameters are terms in the model that are fixed during a model run (a simulation) but can be changed in different runs as a method for conducting sensitivity analysis or to achieve calibration goals.

1) What is a (mathematical) model?

Mathematical models can be categorised according to several criteria:

- static/dynamic
- for dynamic models: continuous/discrete time
- spatially explicit/non spatially explicit
- for spatially explicit models: raster/vector
- mechanistic/empirical

Mechanistic versus empirical

A mechanistic model is a model that has a structure that explicitely represents an understanding of physical, chemical, and/or biological processes. Mechanistic models quantitatively describe the relationship between some phenomenon and underlying first principles of cause. Hence, in theory, they are useful for inferring solutions outside of the domain that the initial data was collected and used parameterise the mecanisms.

An empirical model is a model that has a structure determined by the observed relationship among experimental data. These models can be used to develop relationships that are useful for forecasting and describing trends in behaviour but they are not necessarily mechanistically relevant.

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- stochastic/deterministic

Stochastic versus deterministic

A stochastic model is a model that includes variability in model parameters.

A deterministic model is a model that provides a single solution for the state variables. Changes in model outputs are solely due to changes in input variables.

2) Why develop models?

- to provide predictions

Poznan Prévision Yahoo! Météo - Mozilla Firefox

Fichier Édition Affichage Historique Marque-pages Outils ?

http://fr.weather.yahoo.com/PLXX/PLXX0040/index_c.html

Débuter avec Firefox INTRANET AGIR

YAHOO! FRANCE Météo

Accueil - Yahoo! - Aide

The Weather Channel meteo123.com

Yahoo! Météo - Poznan

°C ou °F

Météo > Pologne > Poznan

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- Santé
- Football
- Voyages

Aujourd'hui

9°	Nuages épars	Max. 8°	Min. 2°

10:00 CET dim.

<-10 -10 -5 0 5 10 15 20 25 30 35+

Humidité:	82%
Vent:	O/27 km/h
Visibilité:	9.99 km
Point de rosée:	6°
Pression:	Inconnu
Lever du soleil :	7:16
Coucher du soleil	15:58

lun.	mar.	mer.	jeu.
Nuages épars	Averses l'après-midi	Averses	Averses
Max. 5	Max. 3	Max. 3	Max. 5
Min. -1	Min. 0	Min. 1	Min. 2

meteo123.com

- Prévisions - 10 jours
- Climatologie

Catégories Yahoo!

- Climatologie
- Météorologie
- Prévisions météo
- Sismologie
- Volcanologie

Cartes et Images

Prévisions Satellite Maximales Minimales Précip

Publicité

MILPV

Communicating system

Potato Late blight

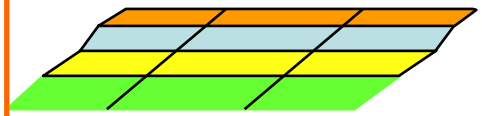
Liberté • Égalité • Fraternité
RÉPUBLIQUE FRANÇAISE

MINISTÈRE
DE L'AGRICULTURE
DE L'ALIMENTATION
DE LA PÊCHE
ET DES AFFAIRES RURALES

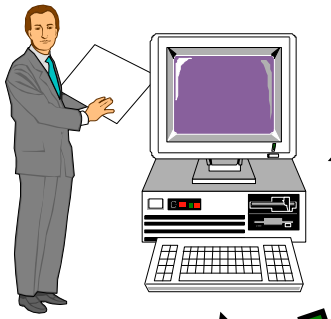
Server

Models
Data bases
Expert system

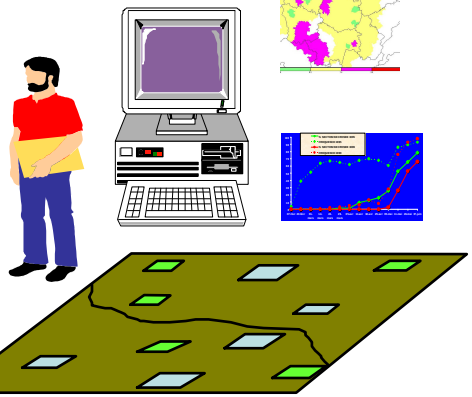
Experimental network



Automatic weather stations

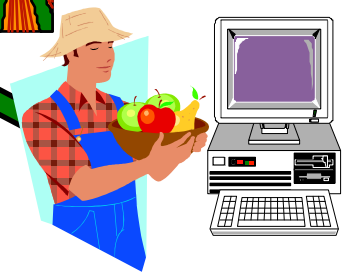


Regional observations by engeneers of the French Ministry of Agriculture



Monitoring network

Farmer monitoring



Jacques Rouzet

SPV

2) Why develop models?

- to provide predictions

- to describe and understand the structure of a system

- to gather existing knowledge

- to replace time-consuming or dangerous experiments

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- to provide predictions

- to describe and understand the structure of a system

- to gather existing knowledge

- to replace time-consuming or dangerous experiments

- to use as pedagogical tools

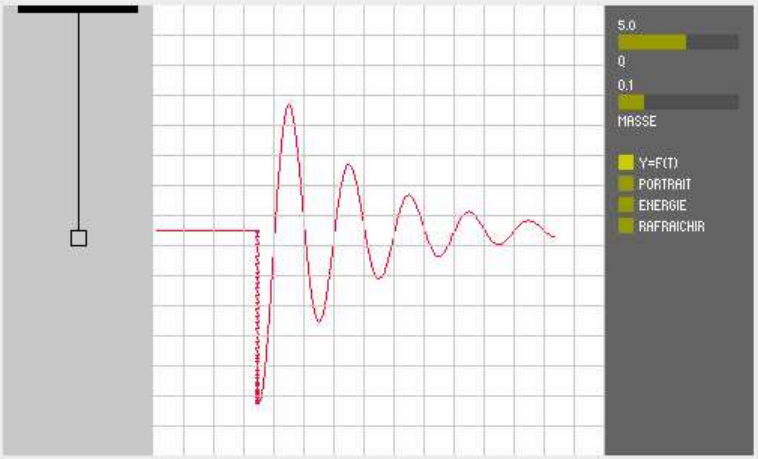
L'OSCILLATEUR HARMONIQUE EN RÉGIME LIBRE

Le système masse-ressort amorti

On simule le déplacement $y(t)$ d'une masse accrochée à un ressort élastique. Les frottements avec l'air sont modélisés par une force opposée à la vitesse $f = -\alpha v$ où α désigne le coefficient de frottement.

Les paramètres sont la masse m (kg), la constante de raideur k (N/m) et le facteur de qualité $Q = \sqrt{(km)}/\alpha$ (sans dimension) inversement proportionel au coefficient de frottement.

L'Applet JAVA



Tirez sur la masse en cliquant dessus avec la souris puis lâchez : vous observez les oscillations d'un oscillateur harmonique amorti.

Source code: oscillateur1 Built with Processing.

Commandes :

14 Nove - Une clé pour transformer toutes voitures à votre image
14 Nove - Les bébés Homo erectus naissaient avec un gros cerveau
14 Nove - Exoplanètes: les voir pour le croire
13 Nove - Quand les soldats communiqueront par la pensée
13 Nove - Du plancton marin retrouvé dans de l'ambre
13 Nove - Fin de la mission Phoenix
13 Nove - Une gigantesque aurore boréale autour du pôle de Saturne
12 Nove - Le hack de la protection BD+ des disques Blu-Ray dévoilé
12 Nove - Un anticorps contre l'obésité ?
12 Nove - L'oiseau qui maitrisait les microfluides
12 Nove - Vérifier sans faille les démonstrations mathématiques par ordinateur
11 Nove - Nouveau dossier: Retour sur le mondial 2008 de l'automobile
11 Nove - Les montagnes stabilisent le carbone dans la croûte terrestre
11 Nove - Les Prairies canadiennes vues de l'espace
10 Nove - ESA Lunar Robotics Challenge


acer
acer

3) How to develop and use mathematical models?

critical stages

1) define the purpose of the model

2) define the considered system

3) identify the users of the model

4) write down the conceptual framework

5) choose a mathematical formalism

6) choose a programming environnement (Excel VBA, Fortran, C/C++, S+, R, Mathematica, Mapple, MathLab, Scilab, …)

7) gather the available knowledge (or set up experiments)

8) write down equations

3) How to develop and use mathematical models?

subsequent stages (some are optional)

9) estimate parameters using a data set

10) evaluate the predictive quality of the model

11) evaluate the usefulness of the model

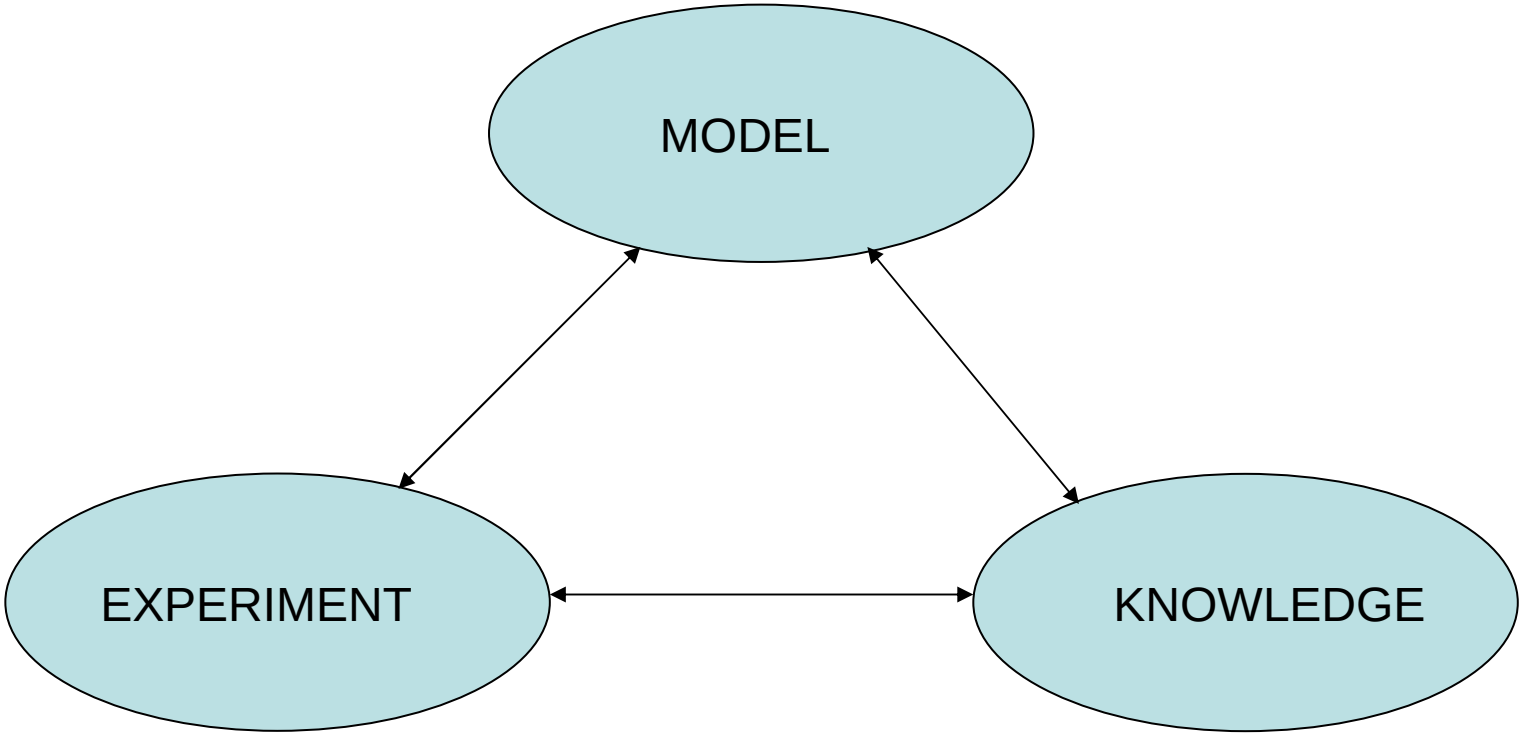
12) perform a sensitivity analysis

13) perform an uncertainty analysis

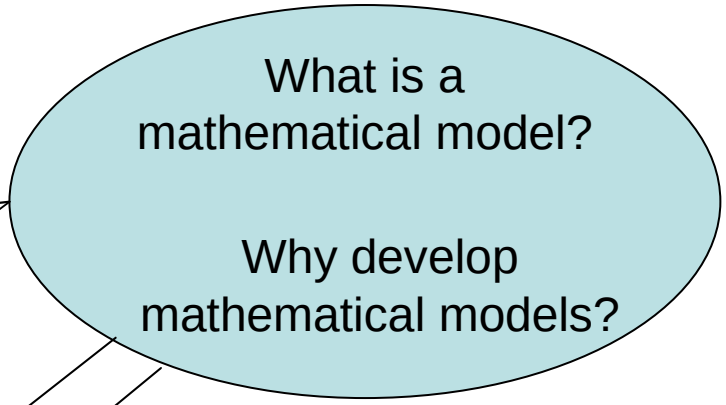
14) use the model

15) go back to number 7 (sometimes, go back to 1!)

CONCLUSION



		DAY 1 (18 November)		
From	**To**	**Topic**	**Time minutes**	**Code**
9:00	9:30	Welcome, who is who	30	MJ+all
9:30	10:15	Introduction	45	JNA1
10:15	10:30	Coffee (15 min.)	15	
10:30	12:00	Basic concepts	90	DM1
12:00	12:45	Lunch (45 min.)	45	
12:45	14:45	Example 1. Predator-prey system	120	DW1
14:45	15:00	Coffee (15 min.)	15	
15:00	16:00	Uses of dynamic system models	60	JNA2
16:00	16:30	Modeling and experimentation	30	JNA3
		DAY 2 (19 November)		
From	**To**	**Topic**	**Time (hours)**	**Lecturer**
9:00	9:30	Dimensional analysis	30	JNA4
9:30	10:45	Example 2: The wheatpest model - part 1	75	JNA5-1
10:45	11:00	Coffee break	15	
11:00	12:15	Example 2: The wheatpest model - part 2	75	JNA5-2
12:15	13:00	Lunch break (45 min.)	45	
13:00	13:25	The stages of a modeling project	25	DW2
13:25	13:45	Computer considerations	20	DW3
13:45	14:00	Coffee break (15 min.)	15	
14:00	16:00	Methods: evaluation for prediction	120	DW4
17:00	19:00	**Workshop dinner**	Old Market "Sphinx restaurant	
20:00	22:00	**Concert** "People & Plant Earth"	Blue Note club	
		DAY 3 (20 November)		
From	**To**	**Topic**	**Time (hours)**	**Lecturer**
9:00	11:00	Methods: evaluation for decision making	120	DM2
11:00	11:15	Coffee break (15 min)	15	
11:15	13:15	Methods: parameter estimation	120	DM3
13:15	14:00	Lunch break (45 min.)	45	
14:00	15:30	Methods: uncertainty and sensitivity analyses	90	DM4
15:30	15:45	Coffee break (15 min.)	15	
15:45	16:15	Methods: use of real-time data	30	DM5
16:15	16:30	Summary and certificates	15	JNA+DM+DW



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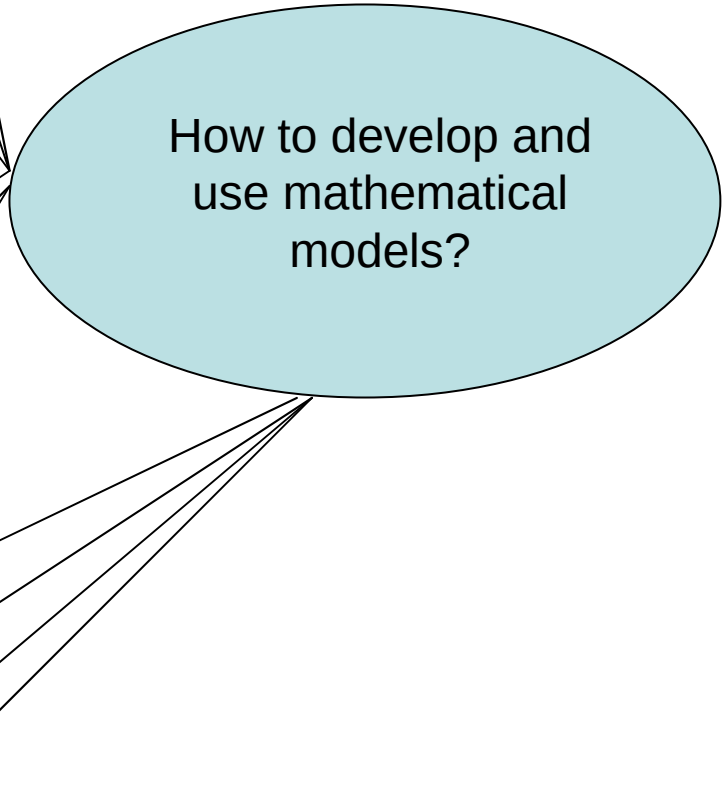

CONCLUSION

« All models are false, some are useful. »

George E. P. Box, cited *ca.* 12345 times by Daniel in his e-mail signature.