Mathematical Models in Education for Sustainable Development

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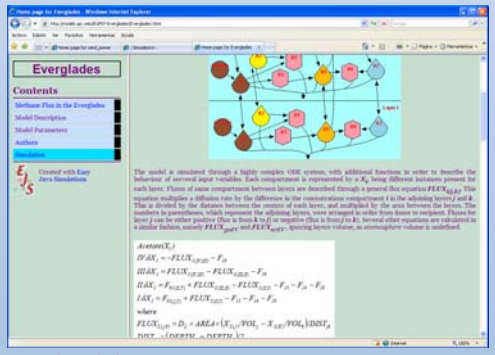
ABSTRACT- To introduce the concept of Sustainability in the university technological studies the transversality is one of the best options because its high efficiency: teaching staff with a low level of sustainability awareness can teach their own subjects using tools, examples and practices that can have a high dose of awareness. In this work, we present a collection of mathematical models that can help teaching staff in Modelling and Simulation of Dynamic Systems subjects to introduce Sustainability through those examples. The models are collected in MODEL.UPC.EDU web where also some pedagogical methodology examples are shown to help the lecturers and laboratory instructors in such subjects.

MODEL.UPC.EDU



USERS OF THE WEB

- Professionals that need to validate an specfic model
- Teaching staff for educational purposes (theory and laboratory practices) in different disciplines

LIST OF MODELS

The web contains an everyday-growing list of models about sustainable problems related to different disciplines: Biology, Technology, Economy, Ecology, Human Development…

Aquatic systems
- PZNP
- Two Box Ocean
- Tritium & Helium
- PZNPO with methane estimation

Water management
- Sediment
- Oxygen sag
- Respirometry
- Wastewater treatment by submarine emissary

Human and social development
- Model of Tourism (Cassagrandi and Rinaldi)

Renewable energies
- Wind power
- Sultana Grape Solar Dryer

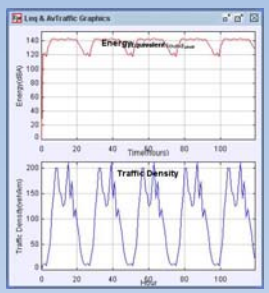
Sustainable city
- Indoor Air Quality
- Traffic Noise Simulation - Leq Prediction

Greenhouse gases
- Methane flux in the Everglades
- Methane and water pressure drainage

Populations
- Chaos to Order in aquatic ecosystems
- Competition between Species
- Mutualism between Species

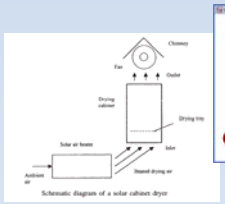
Traffic Noise Simulation

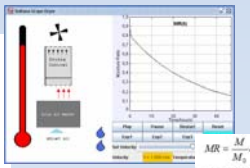
In this model the equivalent energy for sonic level is studied. The conditions where the model is applied in traffic roads and the annoyance is calculated depending on the kind of vehicles and their amount and the distance to the road. An estimation of the average traffic density is also provided.



Sultana Grape Solar Dryer

It is possible to simulate the temperature that sultana grape are subjected and to know the required time to dry them if the environmental temperature and the speed of the air through a cabinet are known. The air is heated by effect of the sun reducing the moisture of the grapes. This example uses empirical data from an experiment carried out in Antalya (36º53'N, 30º42'E), Turkey.





$$MR = \frac{M}{M_0} = a\exp(-k_1 t) + b\exp(-k_1 t)$$

$$T = -15.8V^2 + 25.1V + 30.3$$

where:

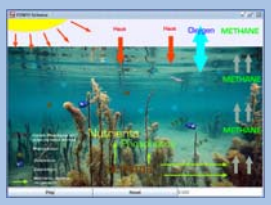
$$a = 0.336 - 0.004T$$

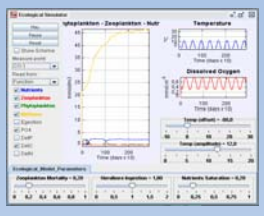
$$k0 = 7.703 - 8.717\ln(V)$$

$$b = 0.806V^{-0.09}$$

$$k1 = -0.141 + 0.048\ln(V)$$

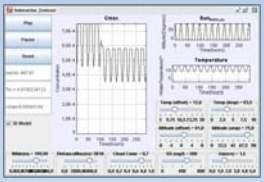
Ecological simulator PZNPO

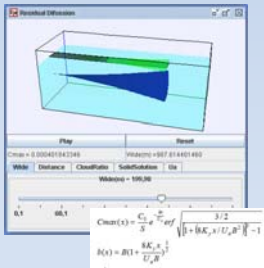




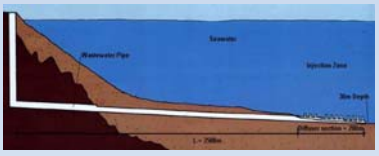
This model is based on UPC Castelldefels' pond. Different real data (chemical, physical, geological...) are stored in a database and the model simulates the cycle of nutrients by the trophic levels in the pond as well as it estimates the methane emissions in the atmosphere. It is possible to forecast the evolution of phytoplankton, zooplankton, nutrients, phosphate, carbon and methane.

Wastewater treatment by submarine emissary





This model simulates waterwaste treatment when it is dumped to the sea; the pollutants create a plume with different disolution rates, an specific speed and a level of pollution that can be estimated depending on some real conditions like the solar radiation, the level of clouds in the sky and the shape of the emissary. This model is based in a real emissary in the Mediterranean sea at Barcelona shore.



$$C_{max}(x) = \frac{C_0}{S} e^{\frac{x}{Ky}} erf\sqrt{\left[1 + \left(\frac{kK_y x}{U_a B^{2/3}}\right)^{3/2}\right]^{-1}}$$

$$b(x) = B\left(1 + \frac{kK_y x}{U_a B^{\frac{4}{3}}}\right)^{\frac{2}{3}}$$

where

$$Ky = 0.00487 B^{\frac{4}{3}}$$

$$erf(x) = \frac{2}{\sqrt{\Pi}} \int e^{-t^2} dt$$

$$k = \frac{\ln 10}{T_{90}}$$

$$T_{90} = \left[\frac{S_z}{60}(1 - 0.65C_s 2\left(1 - \frac{S_z}{800}\right) + 0.02 \cdot 10^{(20 - 20)}\right]$$

DO NOT FORGET TO VISIT
MODEL.UPC.EDU
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