Calibration of a lumped nitrogen model in a Mediterranean forested catchment named Fuirosos, Catalonia

By:

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Introduction

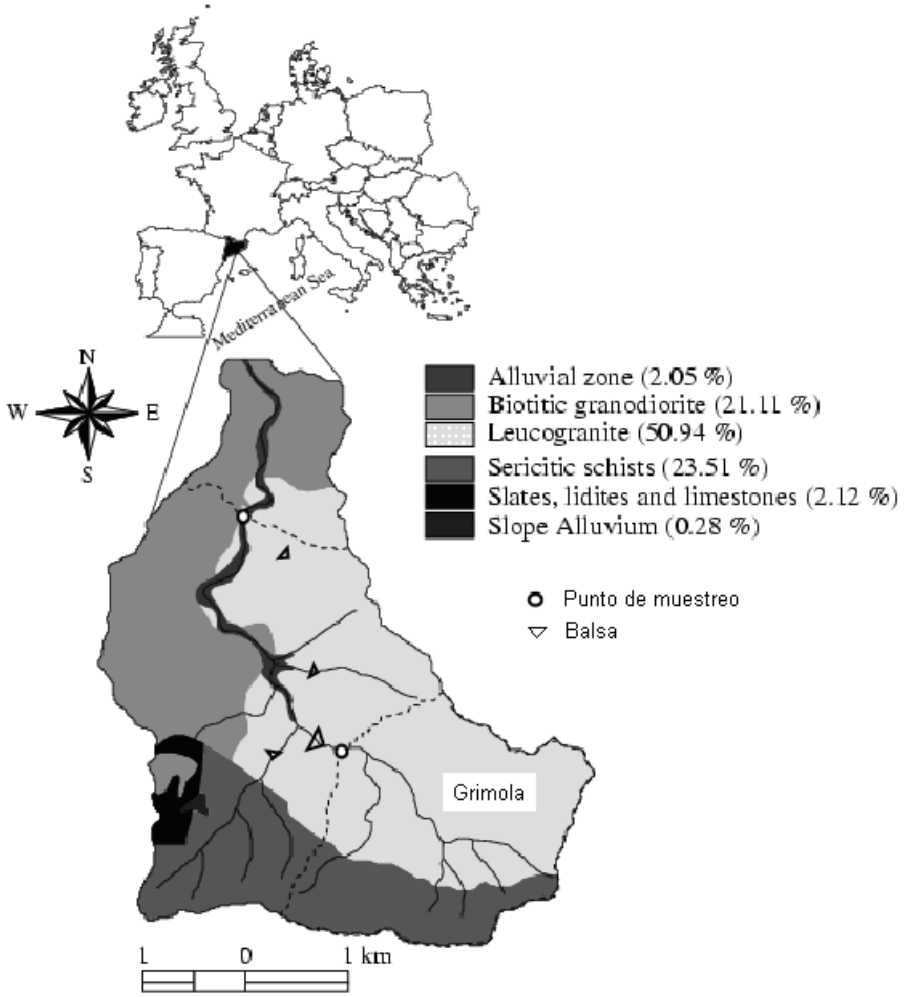
- Mediterranean ecosystems
  - Mediterranean catchments are characterized by a ***complex hydrological behaviour*** that presents high inter and intra-annual variability (Gallart et al., 2002)
  - ***Altering dry*** and ***humid conditions*** that have great influence on the catchment hydrological response (Medici et al., 2008) and soil microbial activity (Birch 1964, Austin et al., 2004, Reynolds et al., 2004)
  - Rainfall inputs to a dry soil represent ***pulses*** that trigger a cascade of biogeochemical and biological transformations (Schiwinning et al., 2004)

Objective

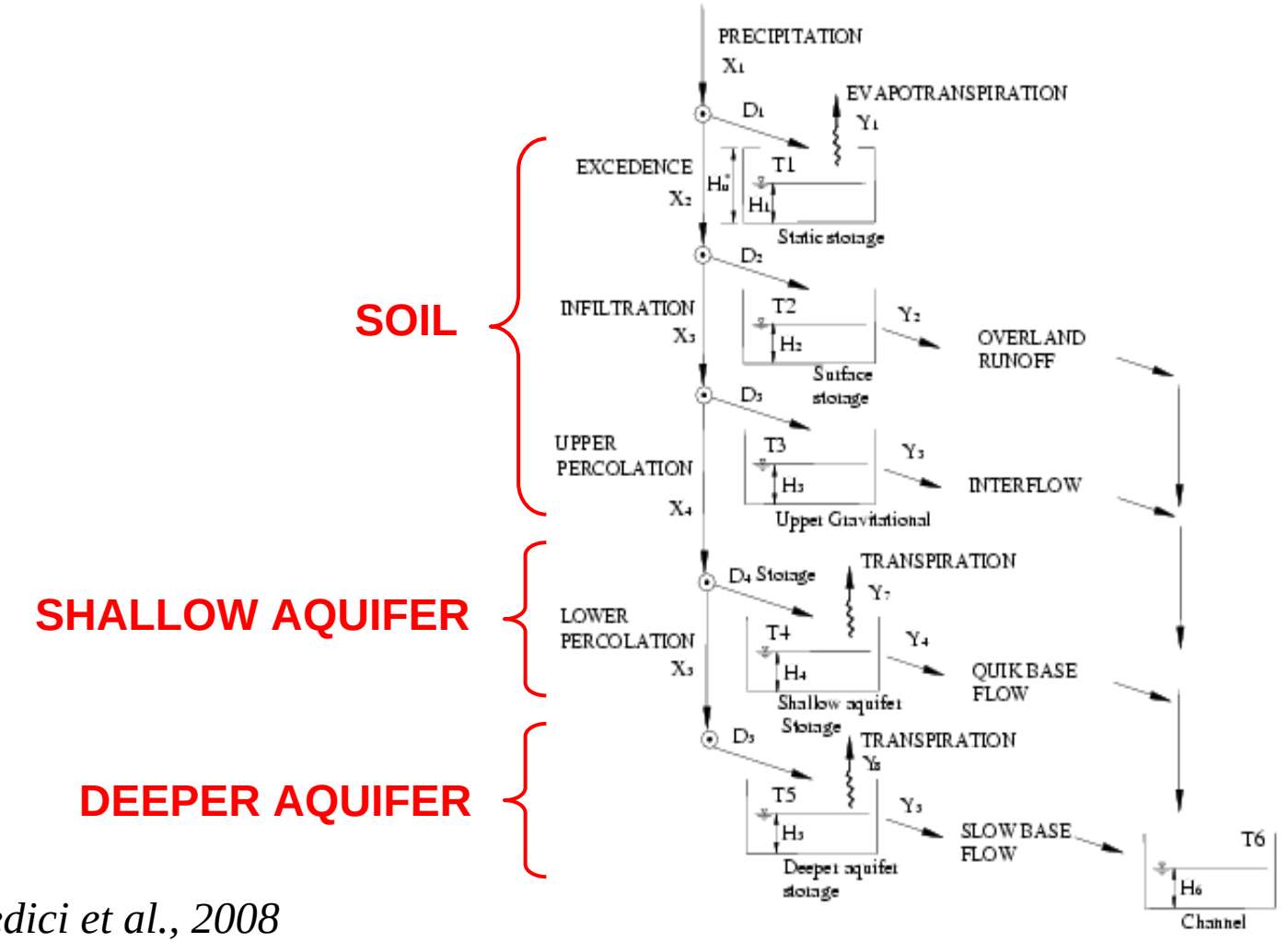
- The aim of this work was to develop a conceptual model of nitrogen dynamics capable of application in Mediterranean catchments.
  - Following the philosophy of the process-based INCA-N model (Wade et al., 2004) for which problems were observed when applied to Mediterranean systems (Bernal et al., 2004)
  - A recently developed hydrological model **LU4** (*LUmped 4 hydrological responses* model, Medici et al., 2008) was extended through the inclusion of processes representing the inorganic nitrogen cycle, obtaining the ***LU4-N*** model

Study site: Fuirosos catchment

- Catchment area: 13 km^2
- Forest covers 90% of tot. area
- Lithology:
  - Granodiorite
  - Leucogranite
  - Schists
  - Well-developed riparian zone at the valley bottom
- Mediterranean climate:
  - Mean annual Ppt: 750 mm
  - Mean annual PET: 975 mm
- Intermittent stream



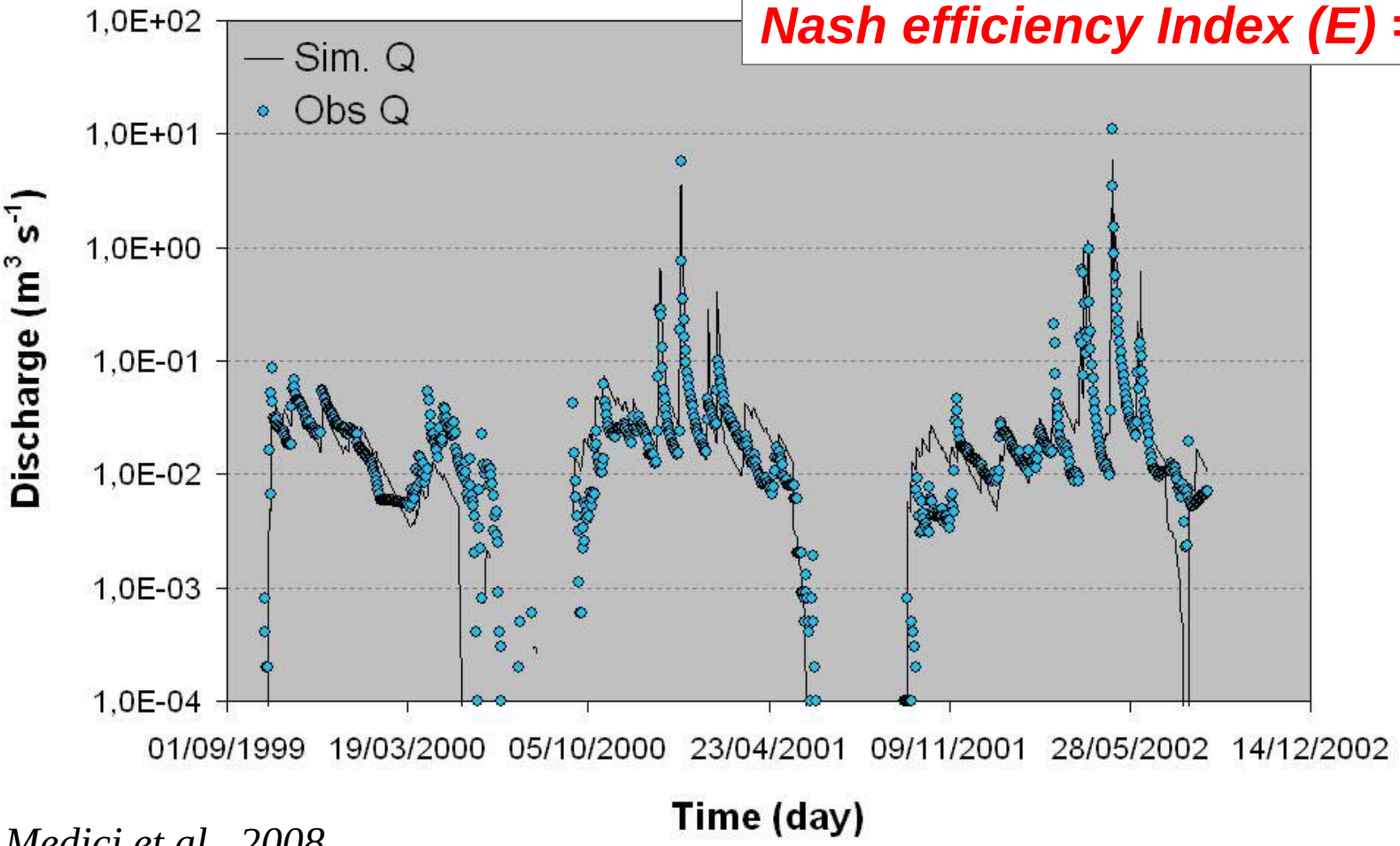
LU4: Hydrological calibration



Medici et al., 2008

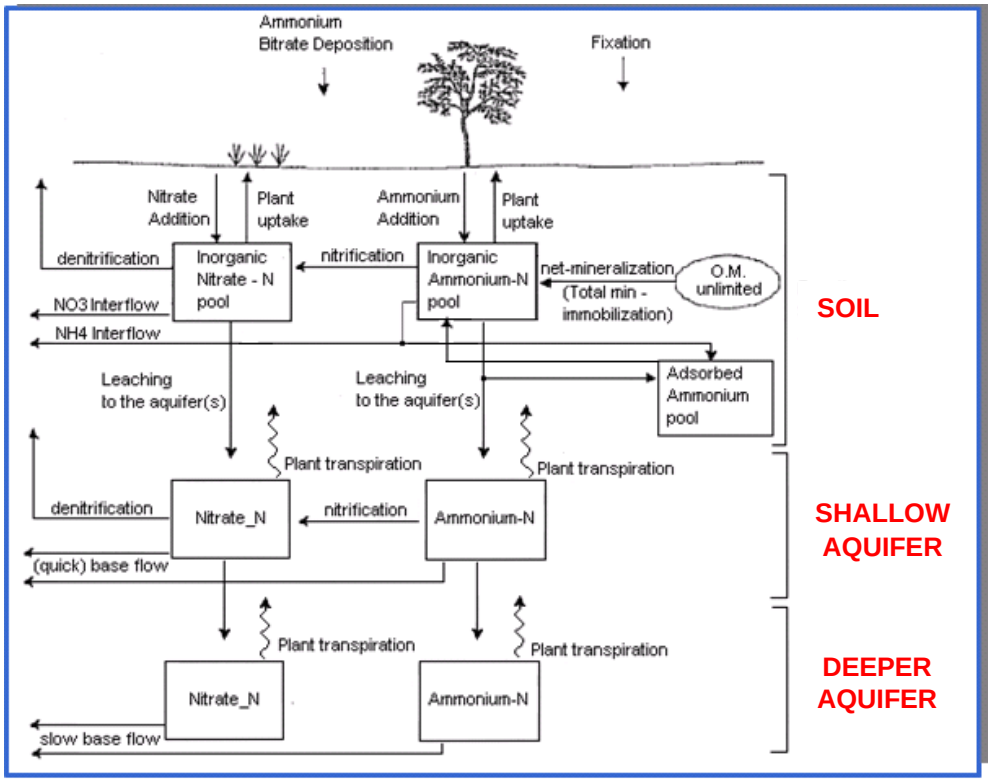
LU4: Hydrological calibration

Nash efficiency Index (E) = 0.7



Medici et al., 2008

LU4-N model : INCA-based Nitrogen Cycle

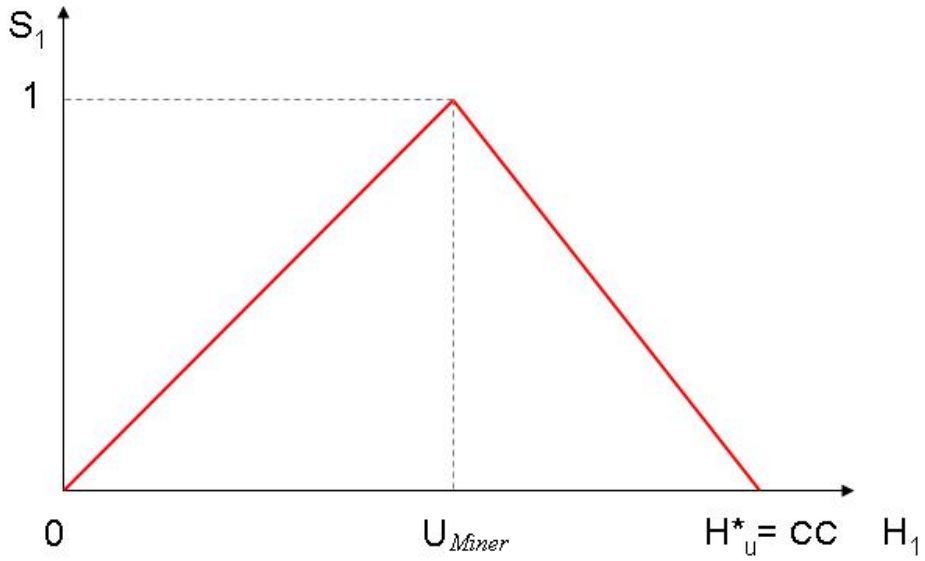


- The model provides a simplified conceptualization of nitrogen cycle in ***soil*** and ***shallow aquifer***.
- The model includes a ***soil moisture threshold*** for all the considered soil biological processes, expressed as a percentage of the maximum amount of water retained by upper soil capillary forces (H_u^*).

LU4-N model: Soil moisture thresholds

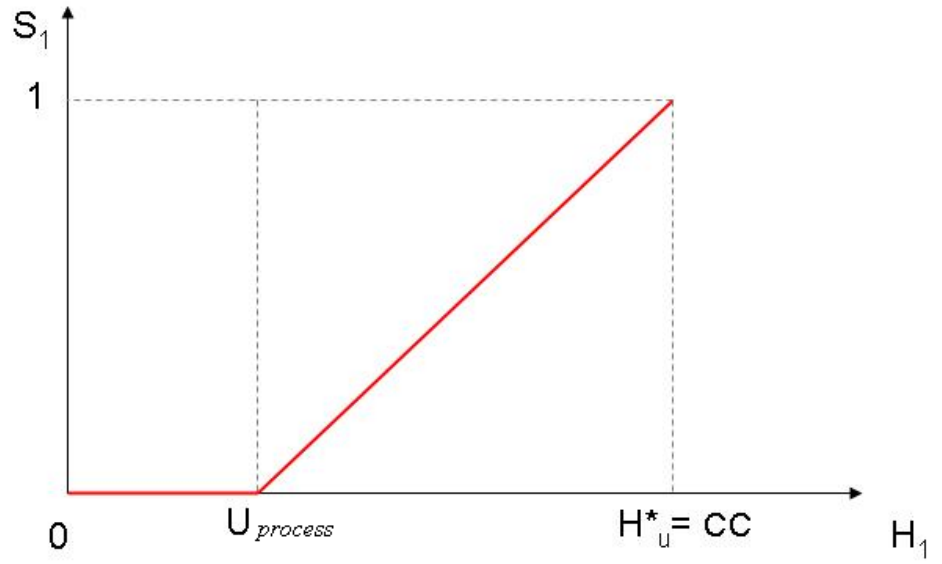
- Mineralization:
  - S_1 is the soil moisture factor
  - H_1 is the actual static storage water content (mm/day)
  - H_u^* is maximum amount of water retained by upper soil capillary forces (mm)
  - U_{Miner} is the soil moisture threshold for mineralization (%), expressed as a percentage of Hu* (mm)

$$\left(M_{NH_4}\right)_{Mineral.} = K_{Miner} \cdot S_{1\_Miner} \cdot TF$$



LU4-N model: Soil moisture thresholds

- Other soil processes:
  - Nitrification
  - Denitrification
  - Immobilization
  - Plant uptake

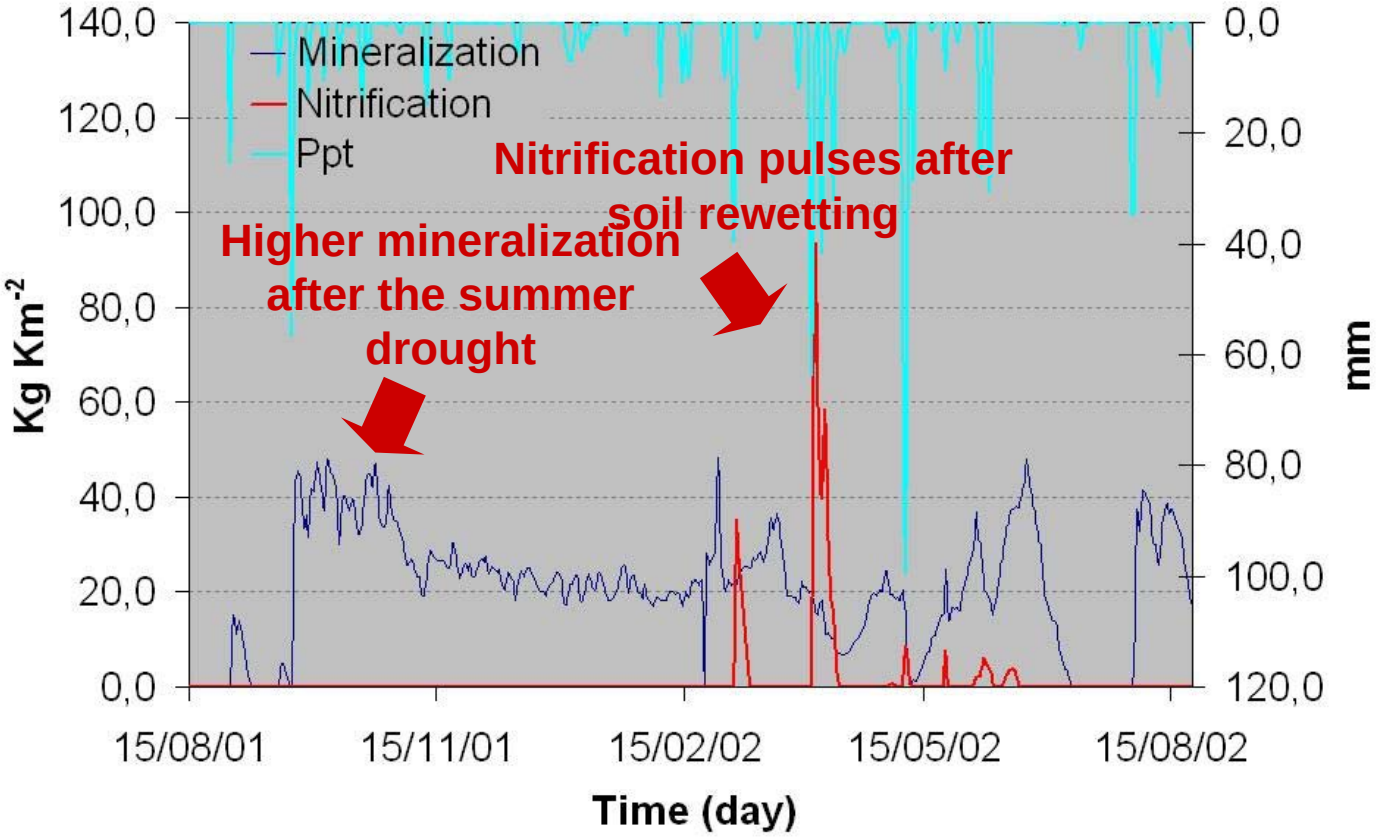


LU4-N Model Parameters

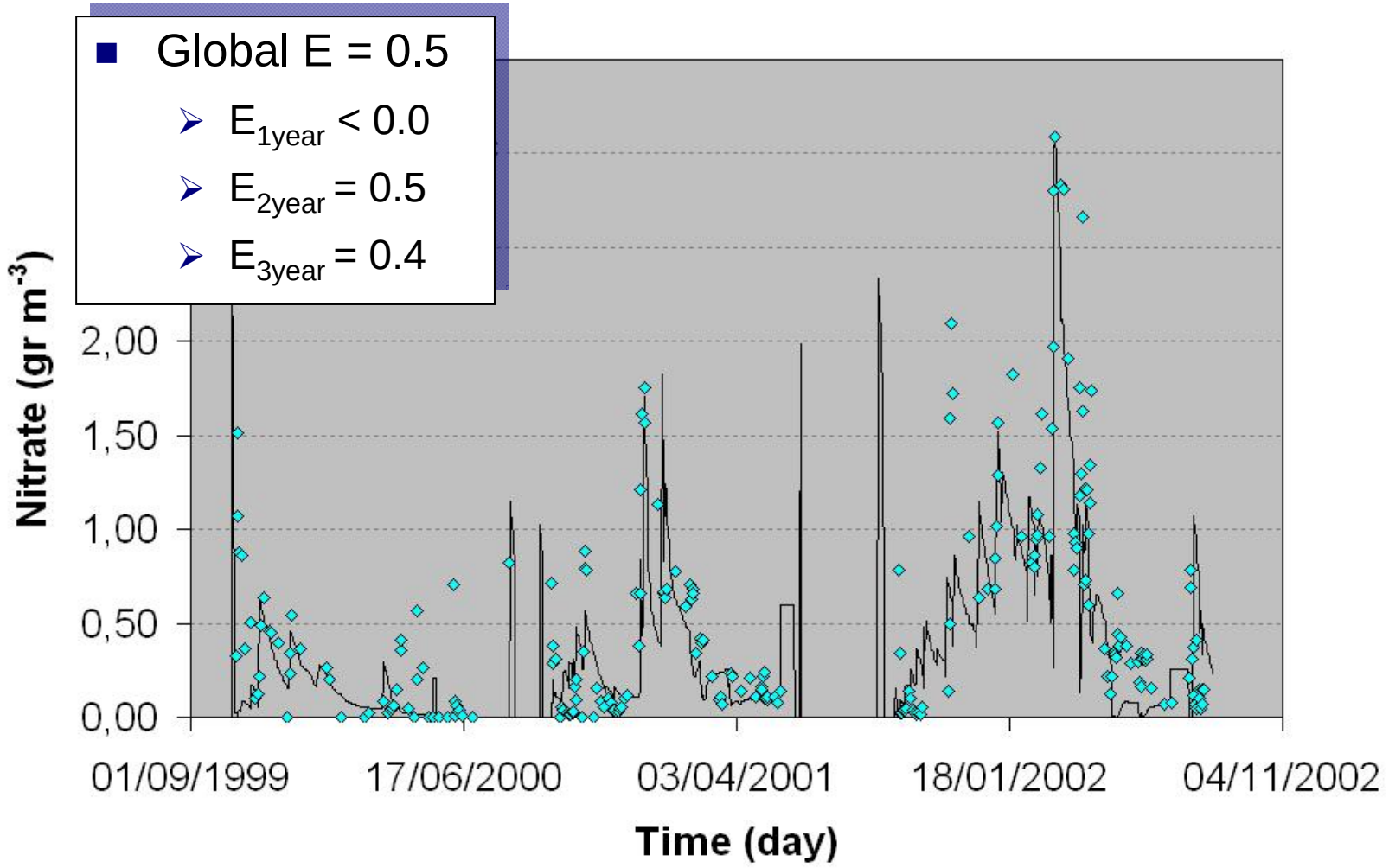
Moisture thresholds		LU4-N
U_{Min}	*Mineralization soil moisture threshold*	43%
U_{denitr}	*Denitrification soil moisture threshold*	80%
U_{nitr}	*Nitrification soil moisture threshold*	51%
$U_{NO_3uptake}$	*NO_3 Uptake soil moisture threshold*	0%
$U_{NH_4uptake}$	*NH_4 Uptake soil moisture threshold*	0%
$U_{Immob.}$	*Immobilization soil moisture threshold*	38%

Soil moisture effect

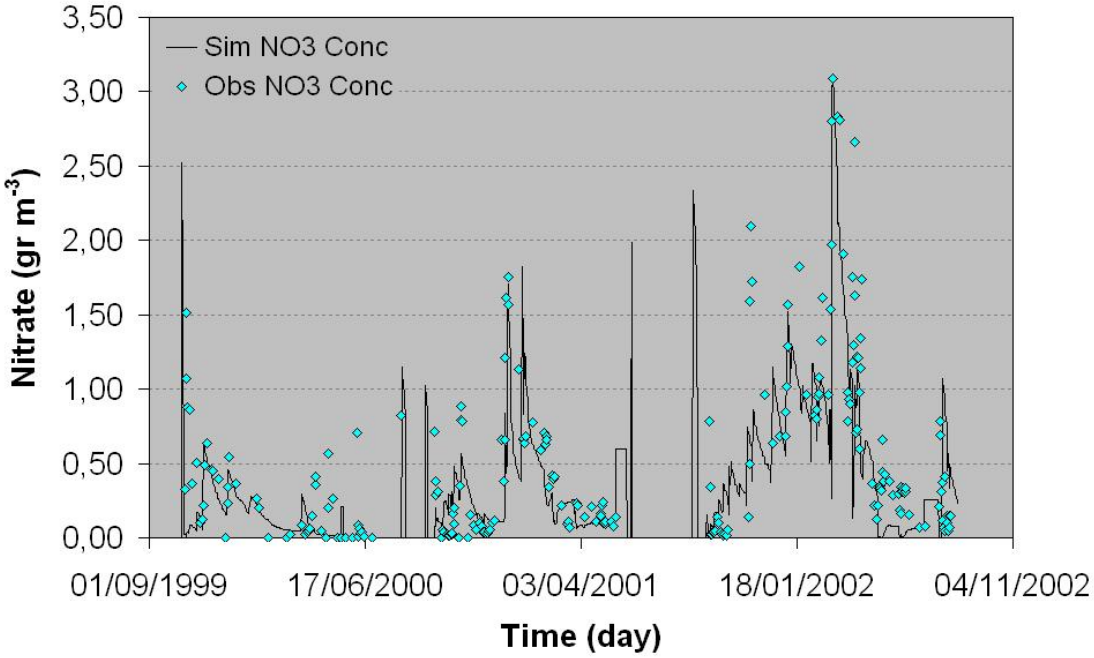
- 2001/2002



LU4-N: Nitrate calibration



LU4-N: Nitrate calibration



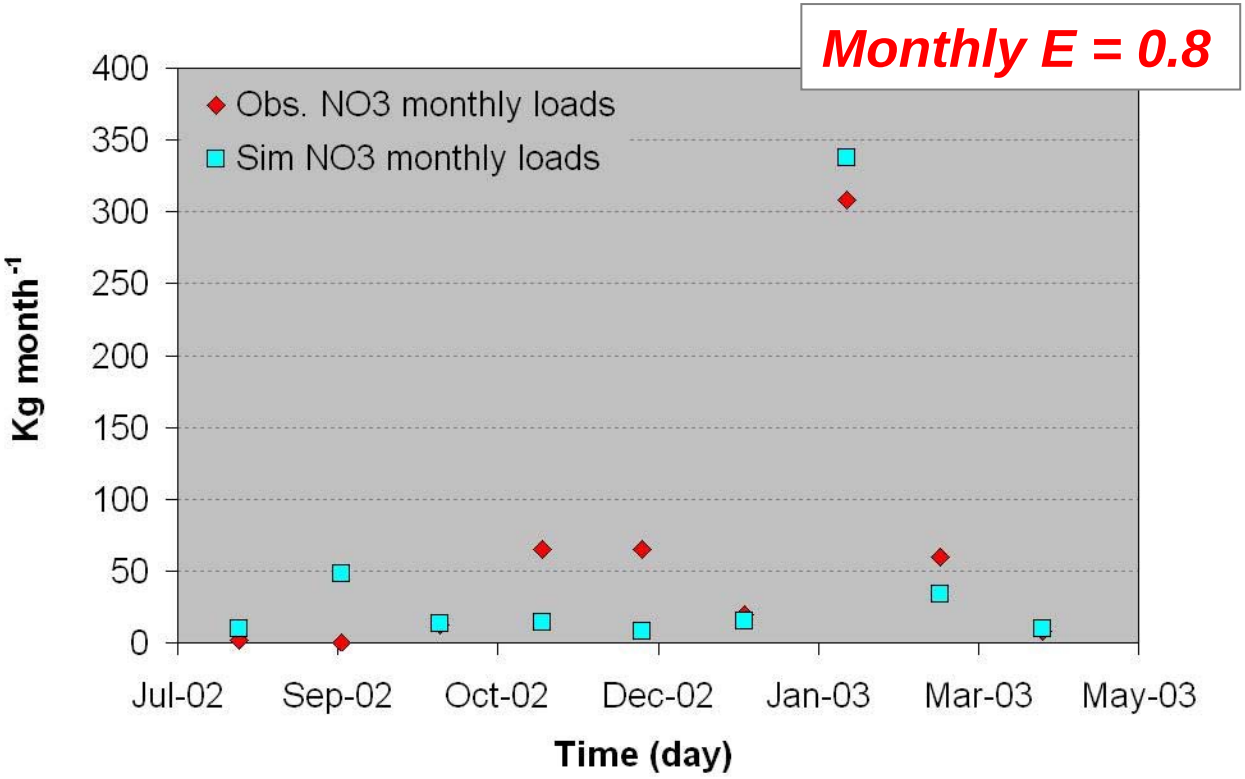
M:N=10:1

Nitrogen annual processes rate:

N Processes	Measured values [Kg ha⁻¹ day⁻¹]*	Sim. values [Kg ha⁻¹ day⁻¹]
Net mineralization	32.4 – 80.1	62.9
Net nitrification	4.4 – 7.5	6.26
Immobilization	0.08	4.83
Nitrate uptake by vegetation	10.3 - 58	13.07
Ammonium uptake by vegetation	53 – 80.5	58.94

* After Bernal et al., (2004)

LU4-N: Nitrate validation



- For the temporal validation the model could only reproduce the monthly nitrate loads

Conclusions

- From the result obtained, the soil nitrogen cycle at Fuirosos, seems to be largely influenced by the rain episodes that induce catchment re-wetting.
  - According to the LU4-N model conceptualization microbial processes occur in pulses, stimulated by soil moisture increasing after rain
- The inclusion of thresholds also allowed reproducing the observed ratio between mineralization and nitrification characteristic of Mediterranean regions, which has been shown to be around 10:1 (Serrasoles et al., 1999).

Conclusions

- The ability of the LU4-N model to reproduce the observed NO_3 stream concentration for the three year calibration period suggest that the key factors and processes controlling the hydrological and N behaviour are included within the model conceptual scheme and that their mathematical representation seems reasonable.

Conclusions

- The temporal validation process call for caution when considering the result obtained
- The model sensitivity analysis (not showed in this presentation) pointed out the mineralization as a key process
- Intermittent streams and their associated riparian zone have been highlighted as ‘hot spots’ for biogeochemical processes in arid and semiarid regions (McIntyre et al., 2009)

Further research step:

- Mineralization better representation, taking into a account a semidistributed spatial description (i.e. introducing a riparian zone) may lead to more satisfactory results especially for the validation year

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