Carbon-nitrogen-water interactions: is model parsimony fruitful?

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INTRODUCTION

Carbon and nitrogen cycles are highly intertwined and both should be related to the water balance. Usually, these models are complex and they have high parameter requirements. For this reason, parsimonious models, can be valuable tools to predict carbon and nitrogen concentrations in soils.

This work aims to compare the capability of three models in reproducing the interaction between the carbon and nitrogen cycles and the water cycle. The models are BIOME-BGCMuSo [2], LEACHM [4] and our proposed model: a simple carbon-nitrogen model based on [3], coupled to the hydrological model Tetis [1].

STUDY AREA

- **Semi-arid experimental plot**
  - La Hunde, East of Spain
- Area: **1800 m²**
- Annual average **precipitation: 464 mm**
- Annual average **ET_0: 749 mm**
- **Holm oak** *(Quercus ilex)*

FIELD DATA

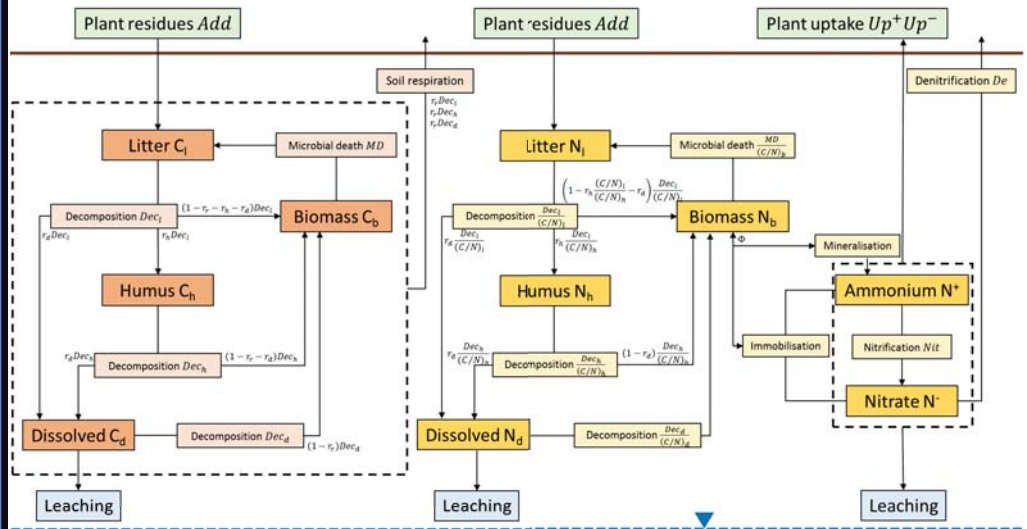
Hydrological measurements (daily)

- Soil water content: soil moisture sensors
  - 9 sensors (15cm) + 3 sensors (30cm)
- Plant transpiration: sap flow sensors
  - 4 trees (diametric distribution)

Chemical measurements (every 2 months)

- Punctual soil samples
  - Dissolved organic carbon
  - Microbial biomass carbon
  - Ammonium
  - Nitrate
- Accumulated data
  - Mineralization
  - Nitrification

CARBON-NITROGEN MODEL



Decomposition

$Dec_i = [\varphi f(s) f(t) k_i C_b] C_i$

φ: accounts for a reduction of the decomposition rate

Microbial death

$MD = k_d C_b$

Net mineralisation

Mass balance in C_b

Nitrification

$Nit = [f(s) f(t) k_n C_b] N^+$

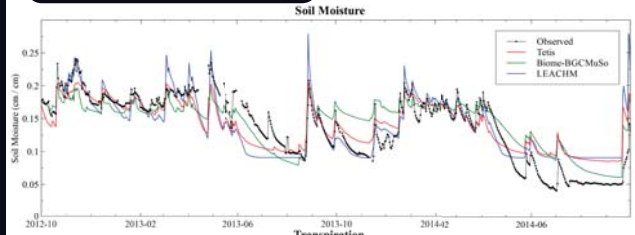
Denitrification

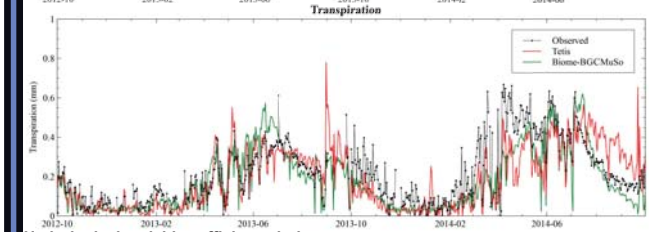
$De = [f(s) f(t) k_{de}] N^-$

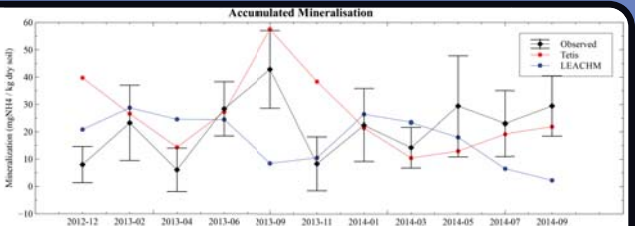
Plant uptake

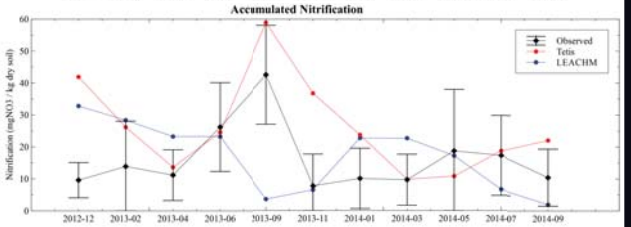
- Passive: transpiration
- Active: plant demand

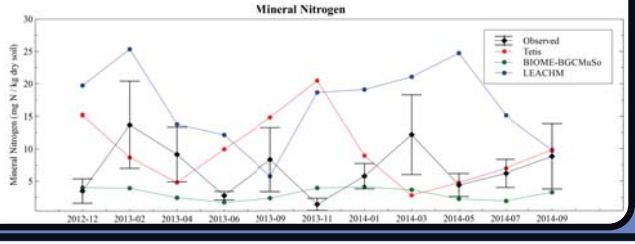
RESULTS











Hydrological variables efficiency index:

- Tetis model → SM: 0.74 Tr: 0.46
- Biome-BGCMuSo → SM :0.68 Tr: 0.57
- LEACHM → SM: 0.65 Tr: poor performance

Wet year followed by a very dry year → difficult modelling of transpiration in models with static vegetation

Chemical performance:

- Tetis model → Overestimation of all the variables in autumn.
- Biome-BGCMuSo → Underestimation of mineral nitrogen.
- LEACHM → Good performance of mineralisation and satisfactory of nitrification. Overestimation of mineral nitrogen probably due to the bad transpiration performance.

CONCLUSIONS

Although the proposed model obtains worse results than Biome-BGCMuSo in the case of transpiration, it obtains a satisfactory result. However, in the case of soil moisture it obtains the best performance. LEACHM obtains good results in the case of soil moisture but it seems impossible to reproduce the transpiration dynamics.

In the case of the chemical variables, LEACHM and the proposed model, obtain satisfactory results, however, Biome-BGCMuSo shows mineral nitrogen concentrations lower than the observed ones.

Hence, **the proposed model** can be a **valuable tool** to reproduce the carbon and nitrogen dynamics. It obtains a **satisfactory performance** in both, reproducing the **hydrological cycle** and the **carbon and nitrogen cycles**.

ACKNOWLEDGEMENTS

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