TWP2. TOWARD AN INTEGRATED MODELLING OF THE MEDITERRANEAN SYSTEMS

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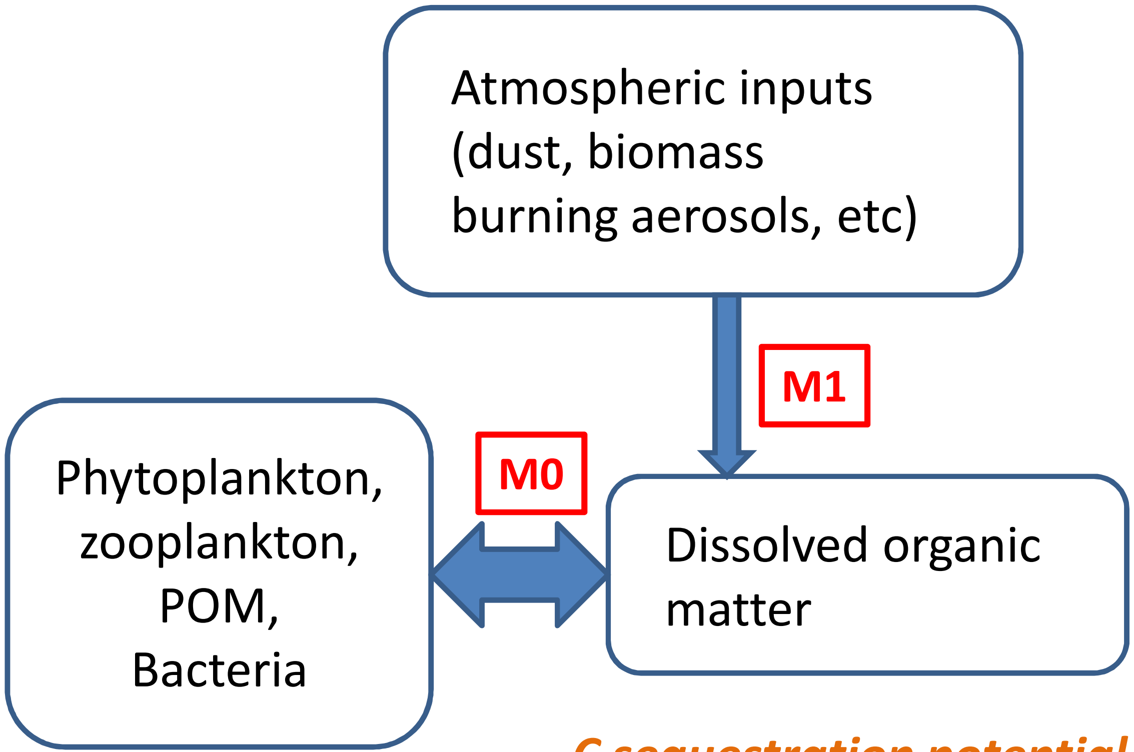
Question from the SAB last year: **Why?**

External forcing, globalization

Climate Change

We see the Mediterranean region as a socio-ecological system with interactions between the terrestrial ecosystems, the marine ecosystems, and the society.

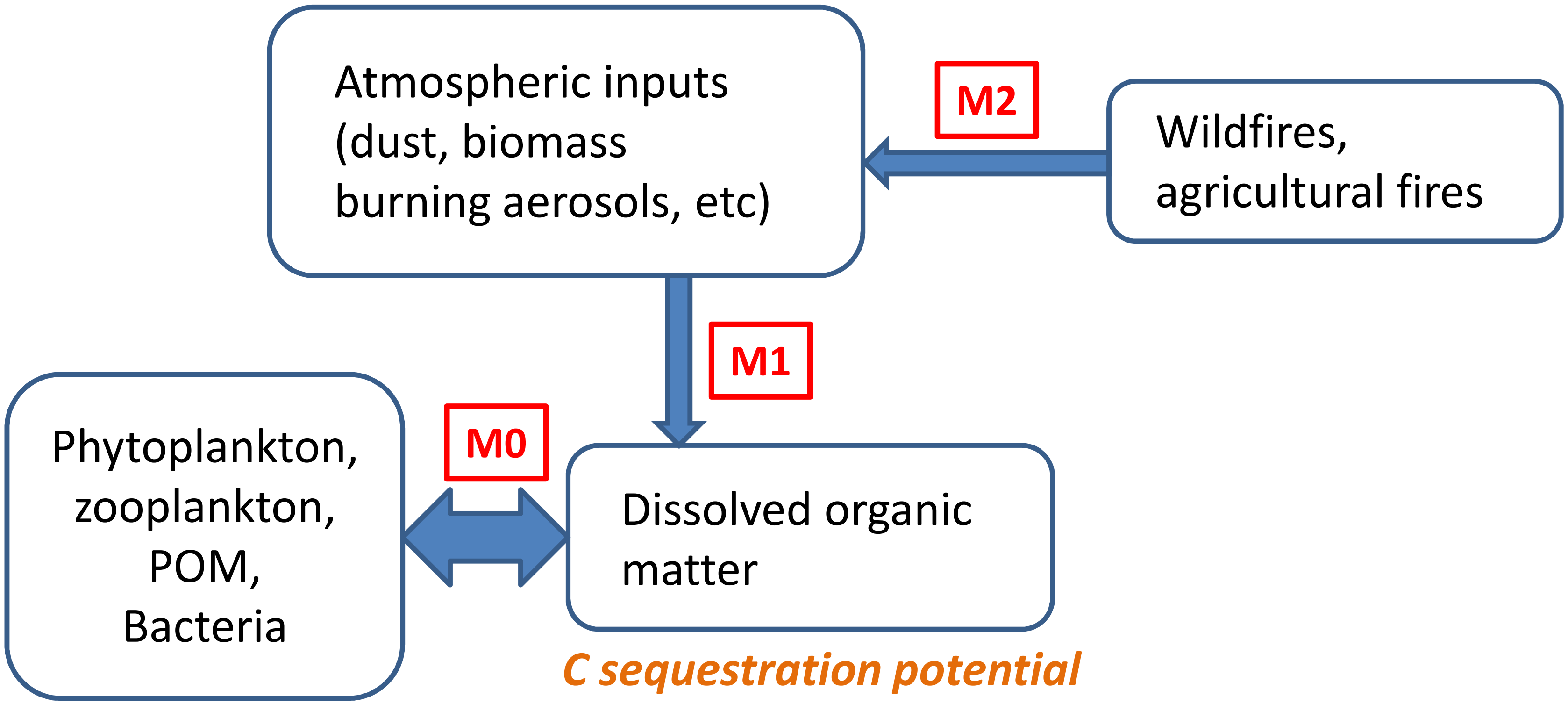
Role of atmospheric input on the stoichiometry and degradability of dissolved organic matter in the Mediterranean Sea (Kahina Djaoudi, MIO)



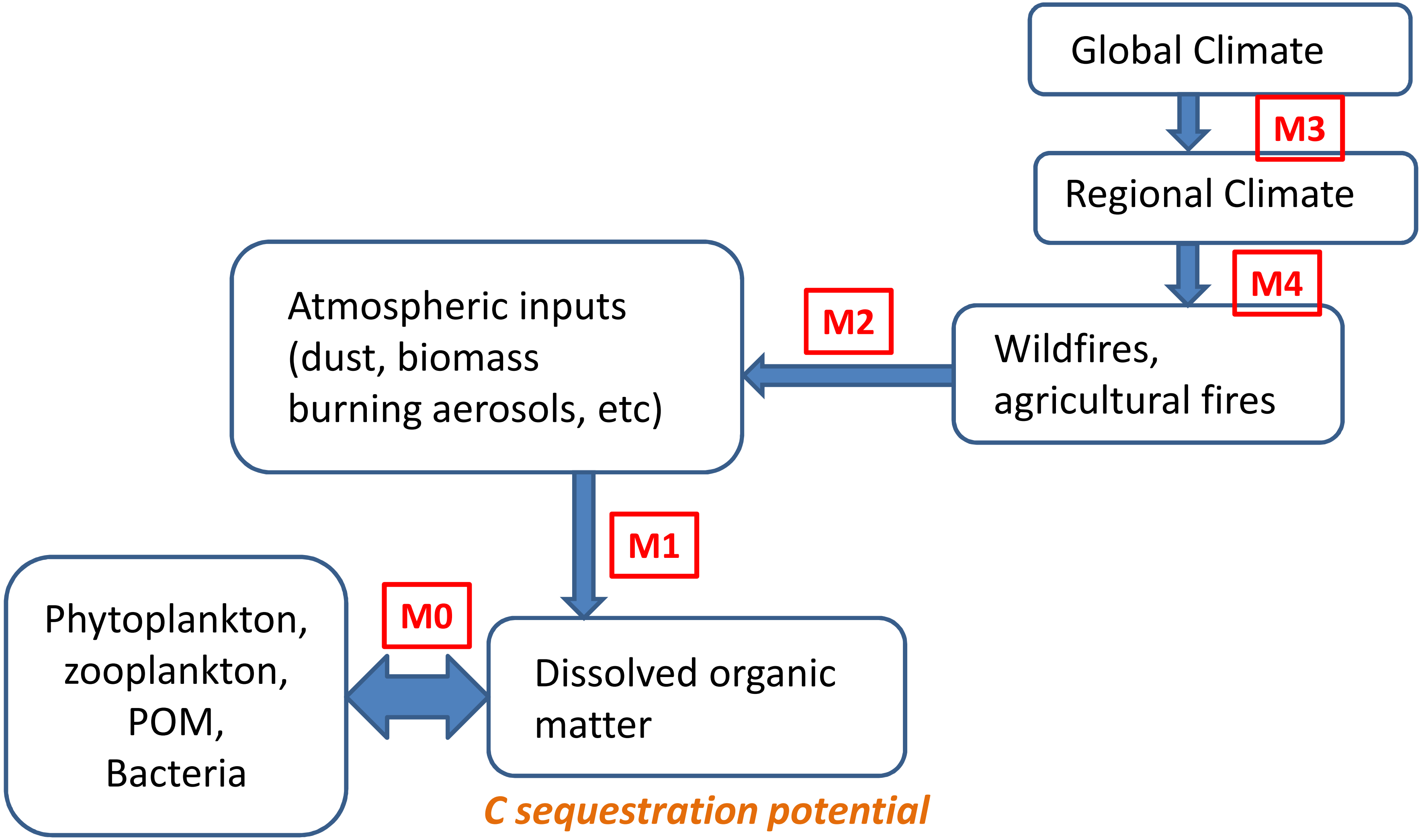
C sequestration potential

How will this evolve in the future ?

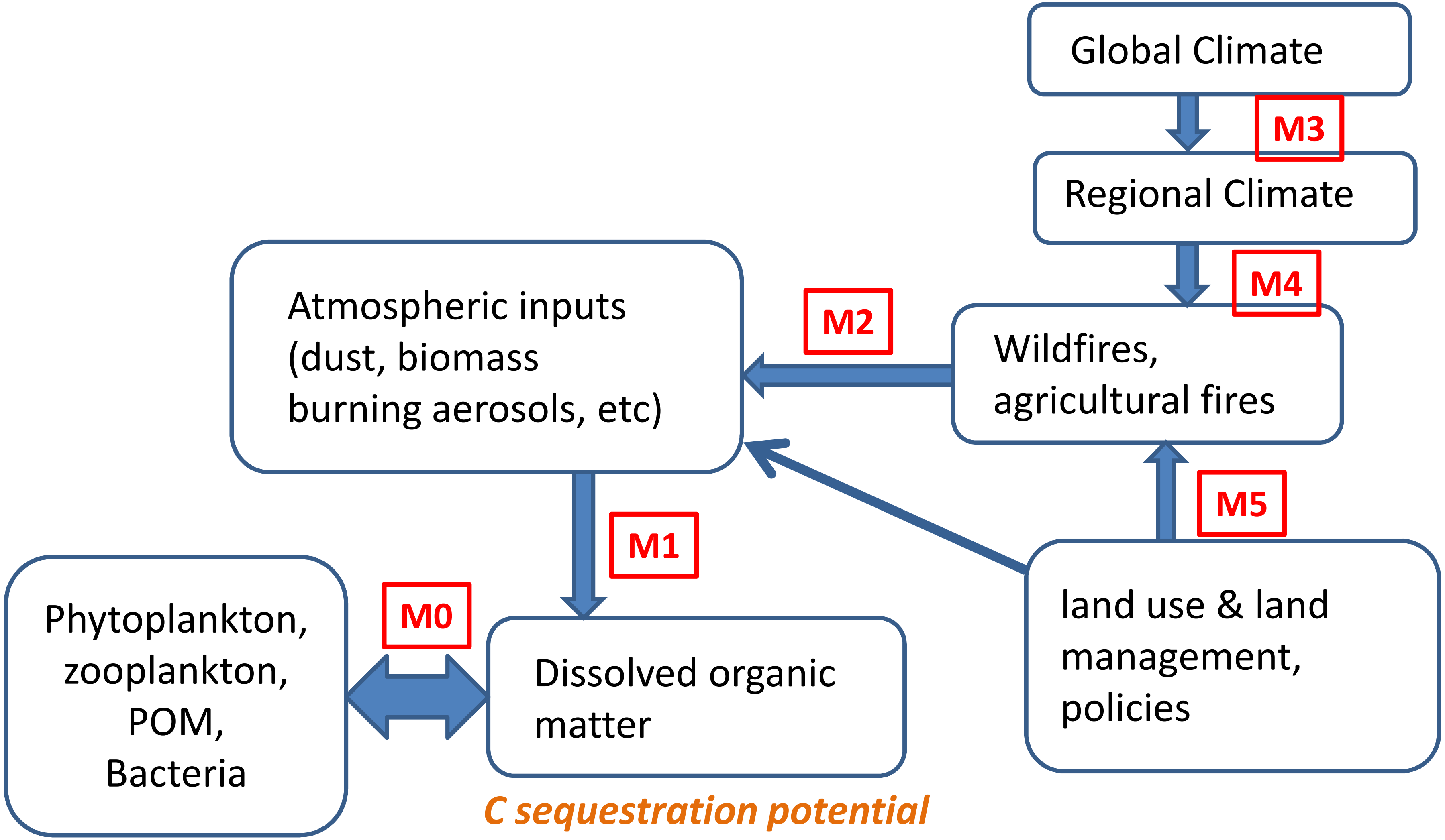
TWP2 Integrated Modelling



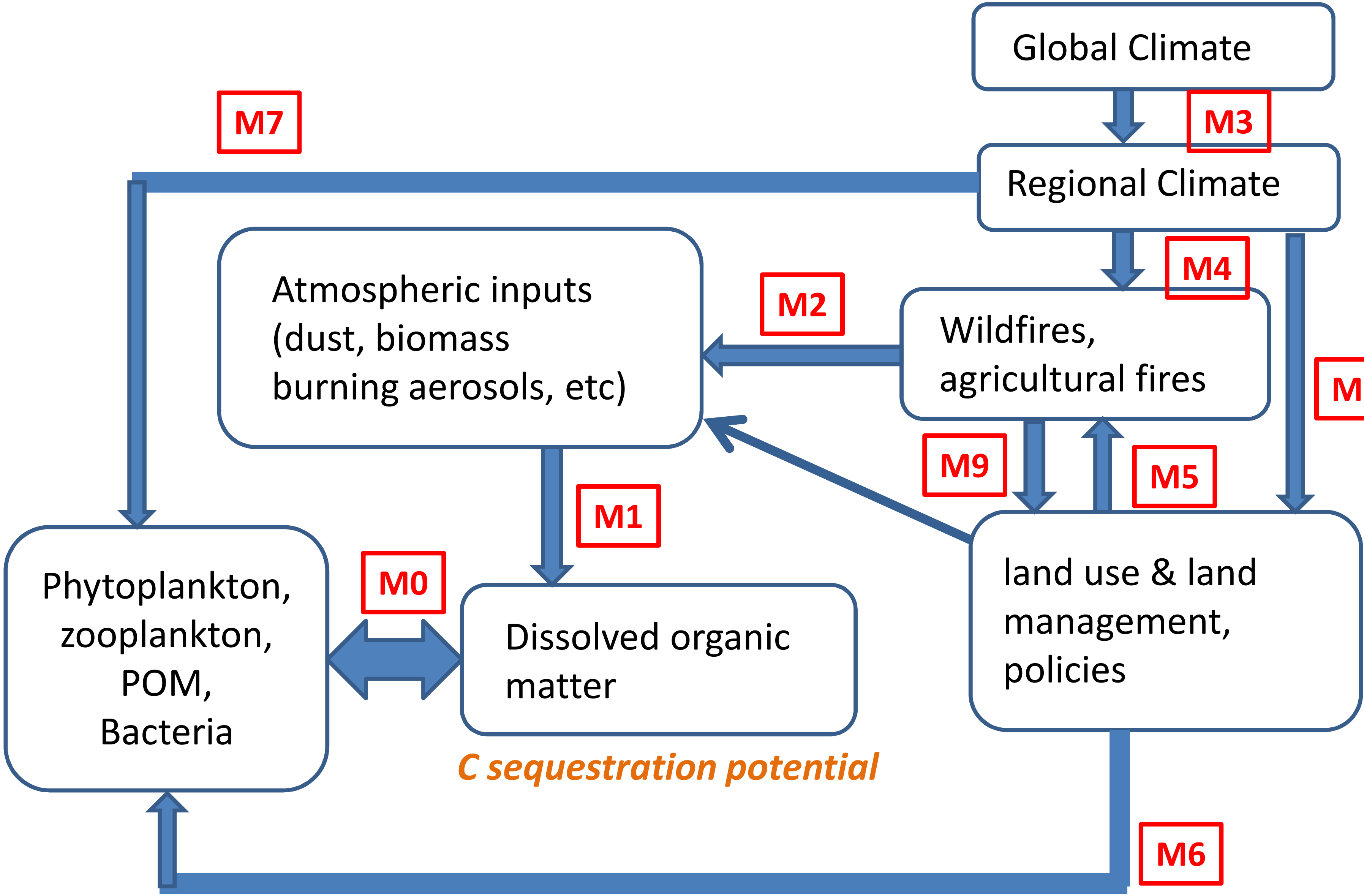
TWP2 Integrated Modelling



TWP2 Integrated Modelling



TWP2 Integrated Modelling



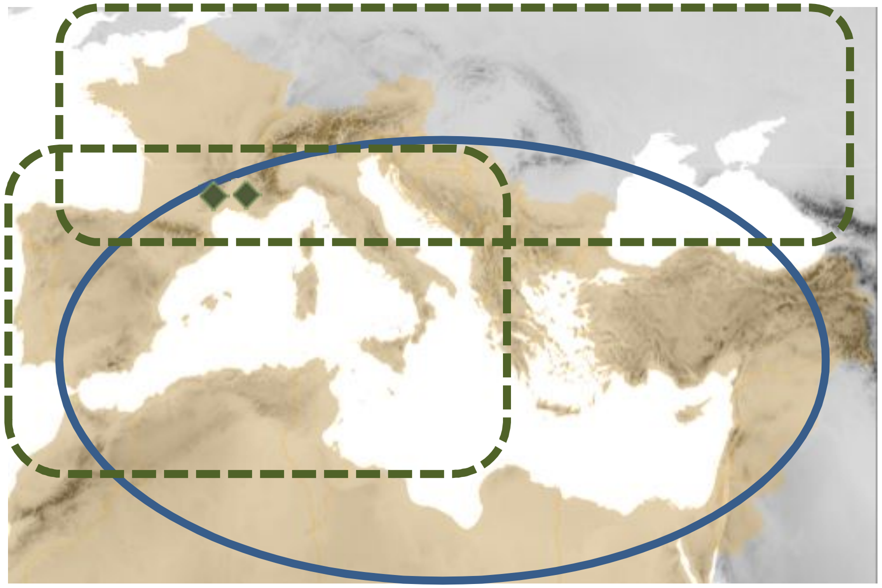
- Climate change and human activities are likely to strongly affect the Mediterranean socio-ecological systems on a short time scale (< 20 years)
- We need scenarios to support policies of mitigation and adaptation
- We need **up-to-date models in each discipline**, **their integration in a generic Mediterranan vision**, and **their coupling**
- Simulations for the past, the present, and the future:
  - past: backward simulations of the past socio-ecological systems (also a proof of the method)
  - present: sensitivity studies (to different modes of model coupling, to various human forcings, etc)
  - future: climate and socio-economic scenarios

What have been done until now?

1) Finished projects (post-docs): forests, agro-ecosystems, marine biology

They all focused on model development:

- **MAIDEN** for simulating climate impacts on Mediterranean forest productivity (photosynthesis & carbon allocation)
- **LPJmL** for simulating the functioning of important Mediterranean agrosystems (agricultural trees)
- **ECO3M-Med** for modelling the impact of the quantity and quality of nutrient inputs on the structural and functional dynamics of planktonic diversity



Assessing the vulnerability to global change of western Mediterranean forests using tree rings using a mechanistic approach

Guillermo Gea-Izquierdo (CEREGE, IMBE, ECCOREV)

MAIDEN / MAIDENiso

- Using various data (eddy covariance CO_2 flux, dendrochronology, forest inventory) from 2 sites in Mediterranean forests, MAIDEN was developed to represent the effect of climate on photosynthesis and carbon allocation in Mediterranean evergreen forests.
- It is designed for data assimilation, and can be used for simulating climate change impact on forest productivity and vulnerability in the Western Mediterranean

Gea-Izquierdo et al. (2015) Biogeosciences, 12, 2745-2786
+ 4 related publications

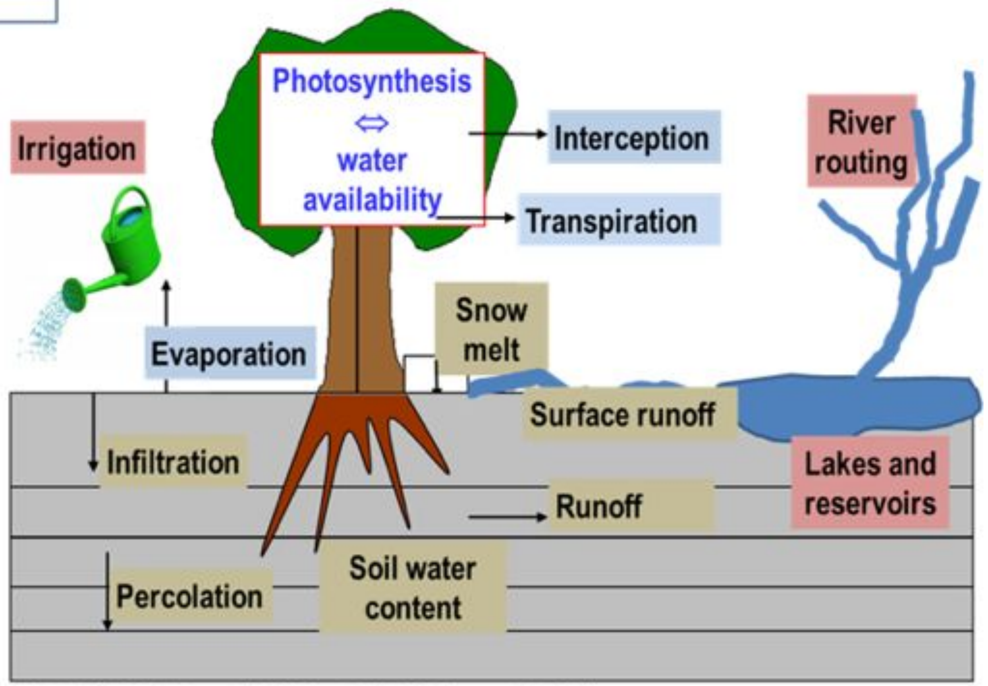
Solar energy for irrigation: mitigation and adaptation option for the Mediterranean?

Marianela Fader (IMBE)

Modelling requirement:
- irrigation water consumption under climate change
- solar energy potential for pumping energy

→ modelling the water cycles of **all** irrigated agrosystems

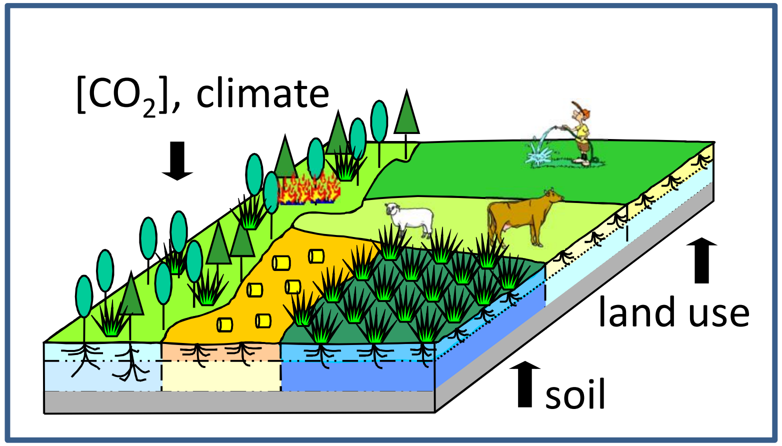
Use of the agro-ecosystem model LPJmL
(a coupled crop model and hydrological model)

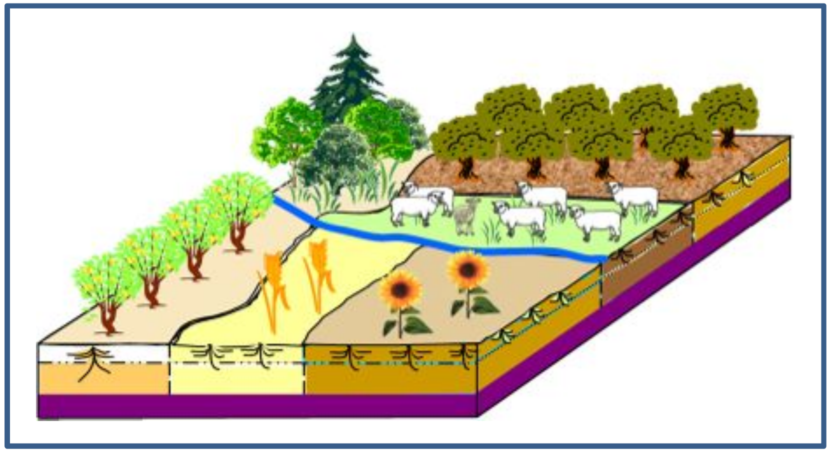


(Sitch et al., 2003; Gerten et al., 2004; Rost et al., 2008; Biemans et al., 2009)

Future irrigated agriculture in the Mediterranean?

M. Fader (OT-Med post-doc)





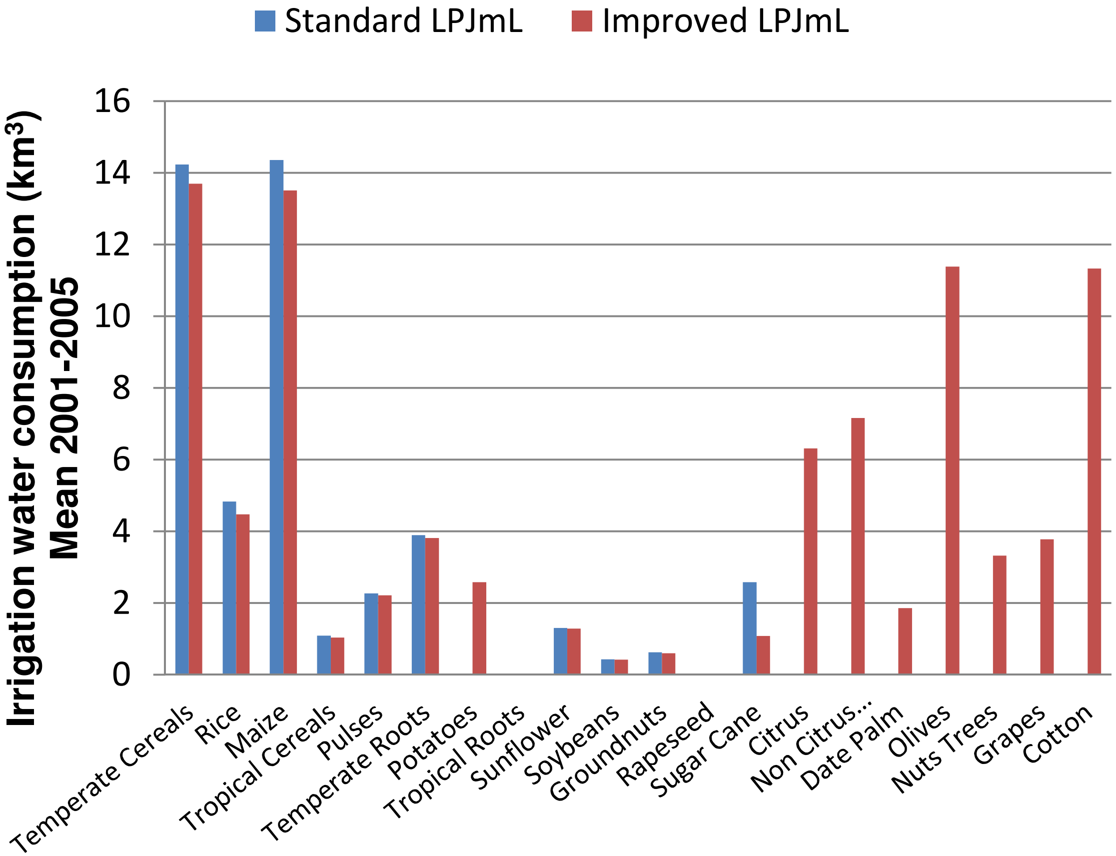
Standard agro-ecosystem model LPJmL: 12 crop functional types covering « only » 51% of the irrigated agricultural areas in the Mediterranean.

LPJmL for the Mediterranean, addition of agricultural trees (perennial crops): 22 crop functional types covering 88% of the irrigated agricultural areas.

Future irrigated agriculture in the Mediterranean?

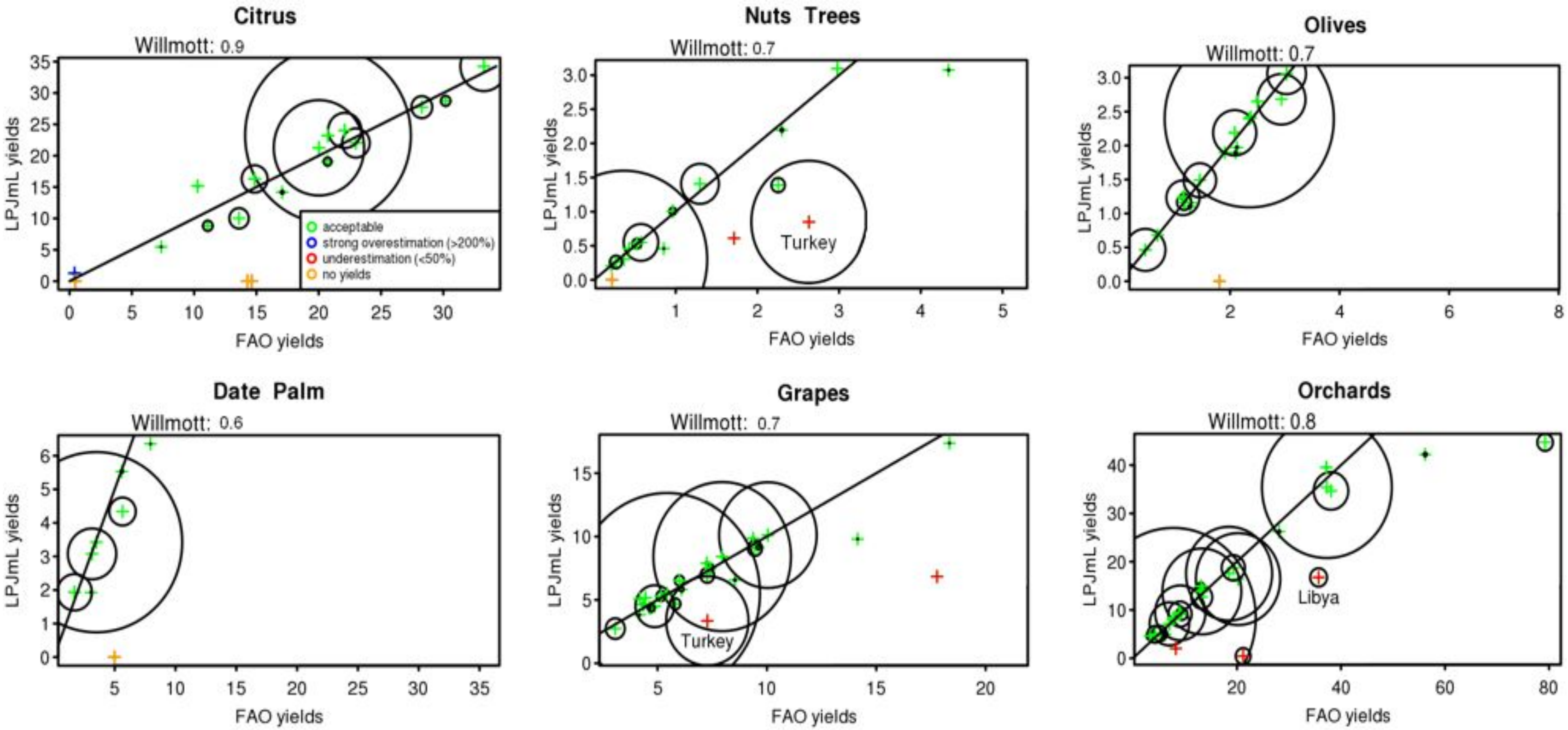
M. Fader (OT-Med post-doc)

- ➢ accounting for most of the crop types with high water requirement



Future irrigated agriculture in the Mediterranean?

M. Fader (OT-Med post-doc)

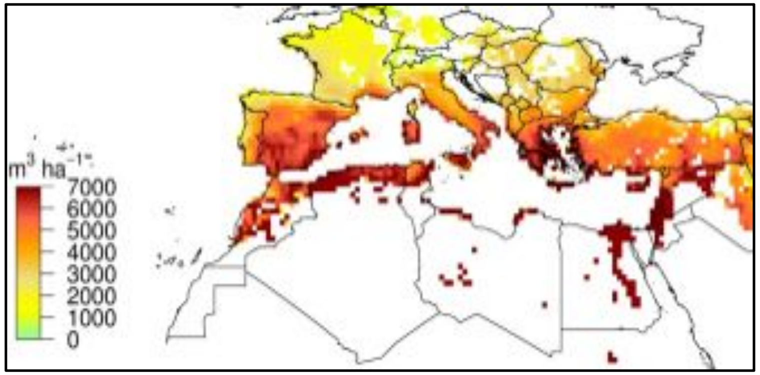


Evaluation of the LPJmL-simulated yields against FAO data at the national scale

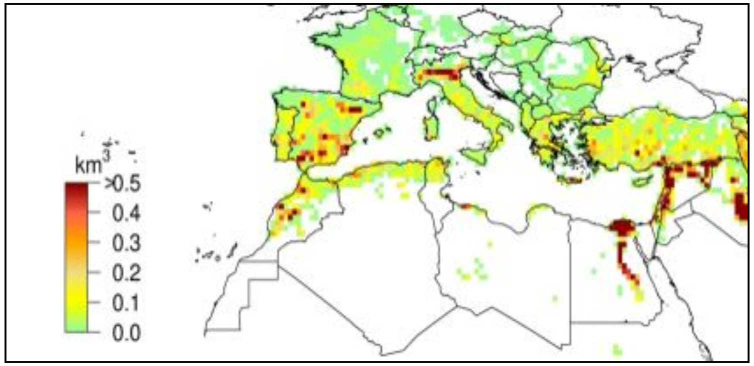
TWP2 Integrated Modelling

Future irrigated agriculture in the Mediterranean?

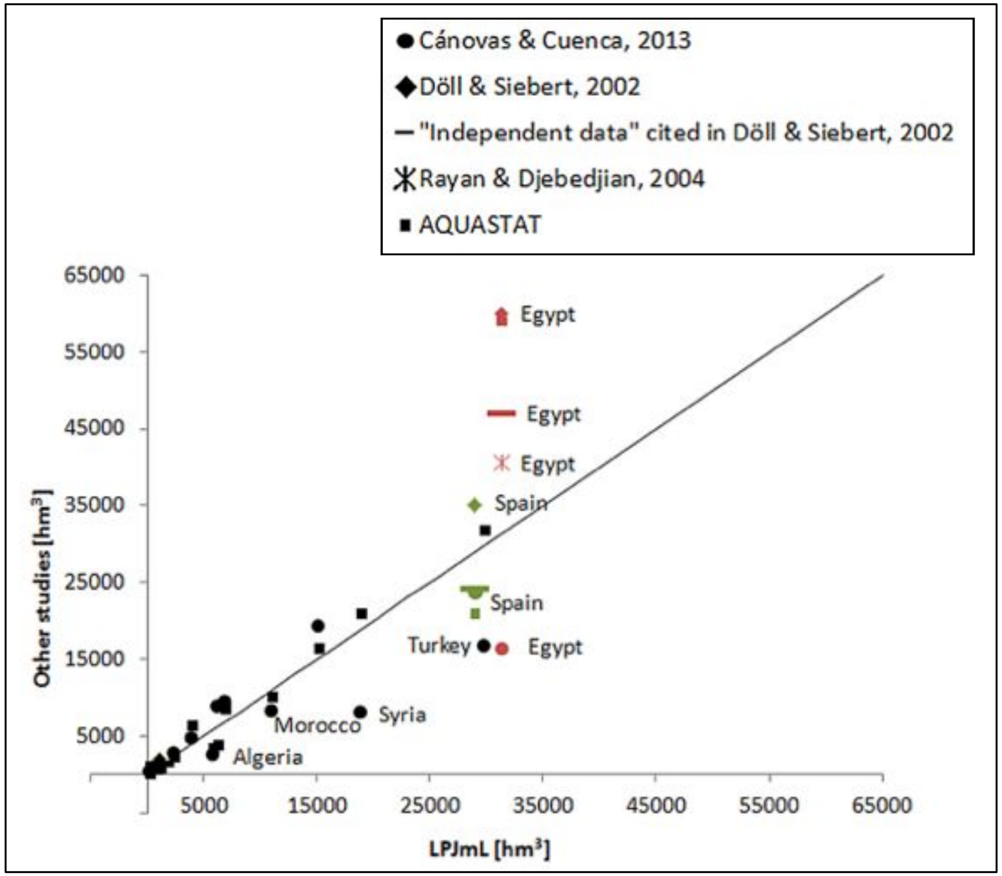
M. Fader (OT-Med post-doc)



LPJmL-simulated net irrigation water requirements (m^3/ha)



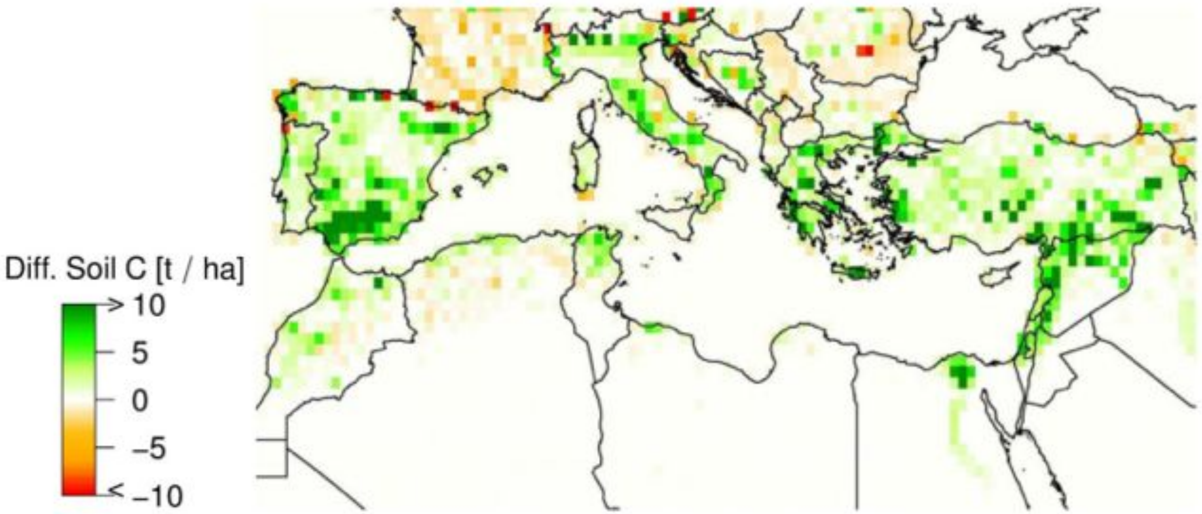
LPJmL-simulated gross irrigation water demand (km^3/cell), at 30 arc minutes resolution



Comparison of LPJmL-simulated gross irrigation water requirements (hm^3) with other estimates

Future irrigated agriculture in the Mediterranean? *M. Fader (OT-Med post-doc)*

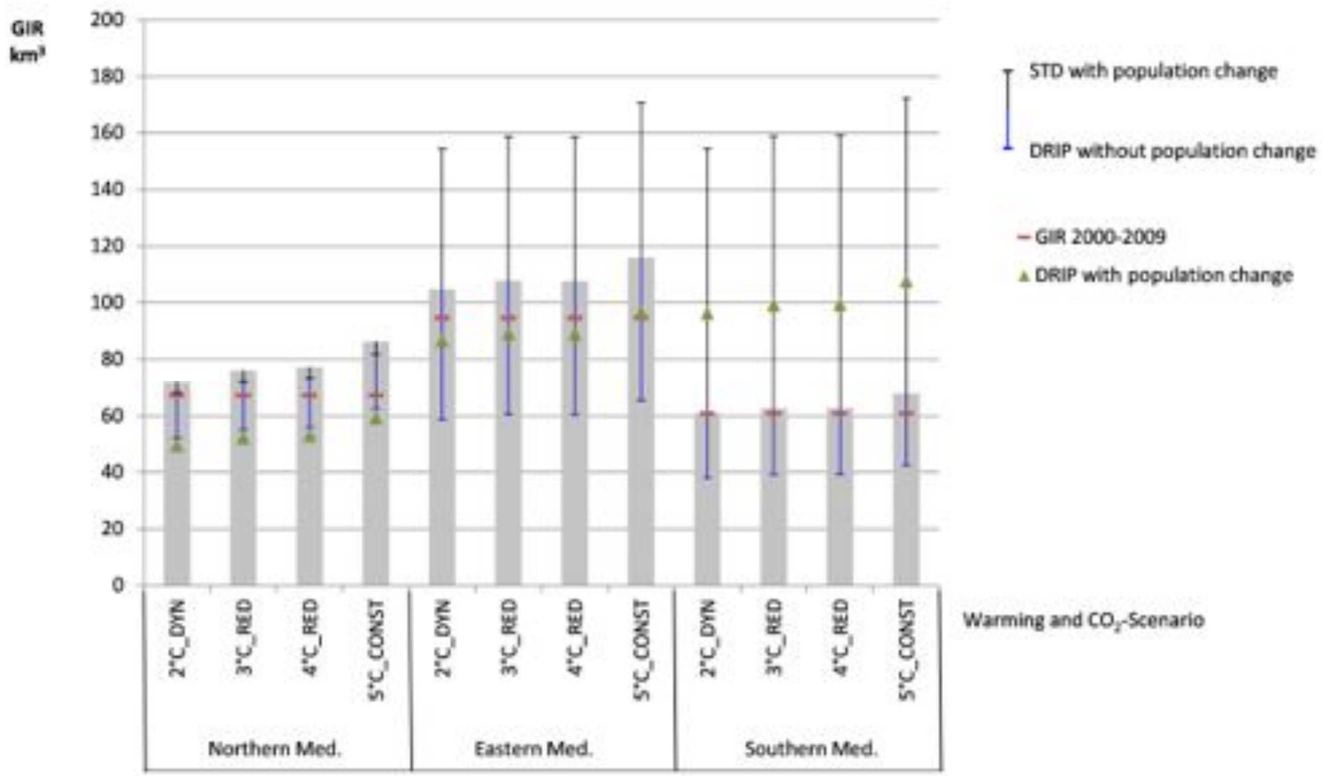
=> impact on other ecosystem properties



Change in LPJmL-simulated soil organic carbon (average 2000–2009) after the implementation of agricultural trees.

Future irrigated agriculture in the Mediterranean? *M. Fader (OT-Med post-doc)*

Simulation under climate change & irrigation scenarios:



More efficient irrigation may need to compensate increases in irrigation water requirements

Median (19 GCMs) of gross irrigation water requirements for 5 warming levels, 3 irrigation scenarios (STD, IMP, DRIP) and 3 CO_2-scenarios (column represents RED and whiskers, DYN and CONST).

Future irrigated agriculture in the Mediterranean?

M. Fader (OT-Med post-doc)

- Fader et al. (2015) Geoscientific Model Development, 8, 3545–3561
- Fader et al. (2015) Hydrology and Earth System Sciences Discussions, 12, 8459–8504.

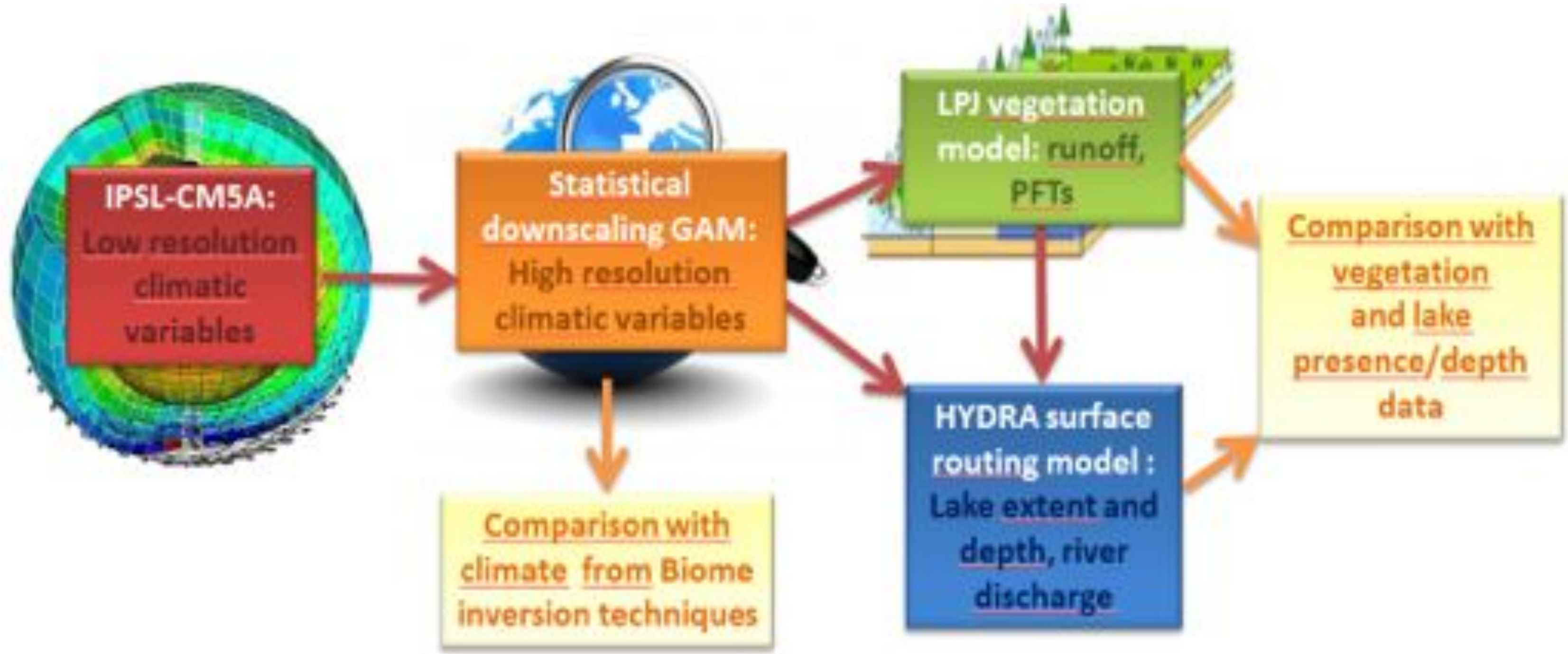
+ 2 related publications

Solar energy for irrigation ? => paper in preparation

Morocco

Project Chad-UNITE (CEREGE, LSCE, IMBE) *Camille Contoux (OT-Med post-doc)*

Understanding the Long-term variability of Lake Chad environments:
a paleoclimate modelling approach for a better assessment of future changes

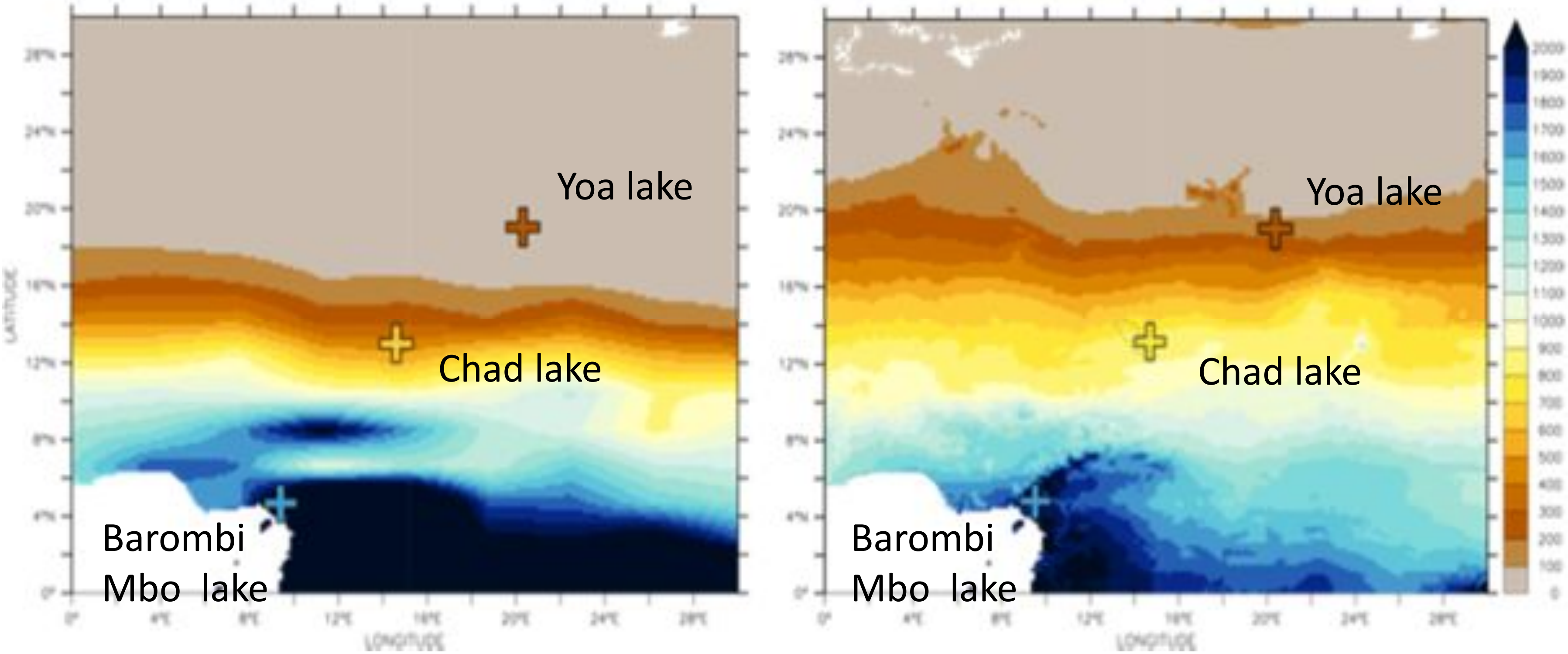


Sketch of the methodology employed

TWP2 Integrated Modelling

Project Chad-UNITE (CEREGE, LSCE, IMBE) *Camille Contoux (OT-Med post-doc)*

Statistical downscaling of precipitation for the mid-Holocene



bilinear interpolation *statistical downscaling*

Data-model comparison of annual mean precipitation (mm/yr) Data: annual mean precipitation estimates from pollen reconstruction. Model: IPSL-CM5A climate model

- WP2

Carbon cycle and biodiversity in Mediterranean oak forest: impact of climate change (CYCABIOCLIM)

PhD Susana Patricia da Silva Pereira (IMBE)

- WP1

Modern and past recharge of the Saharan Aquifer Systems by coupling geochemical tracers ($_{14}C$, $_{36}Cl$,…) and hydrological modeling

PhD Chloé Poulin (CEREGE)

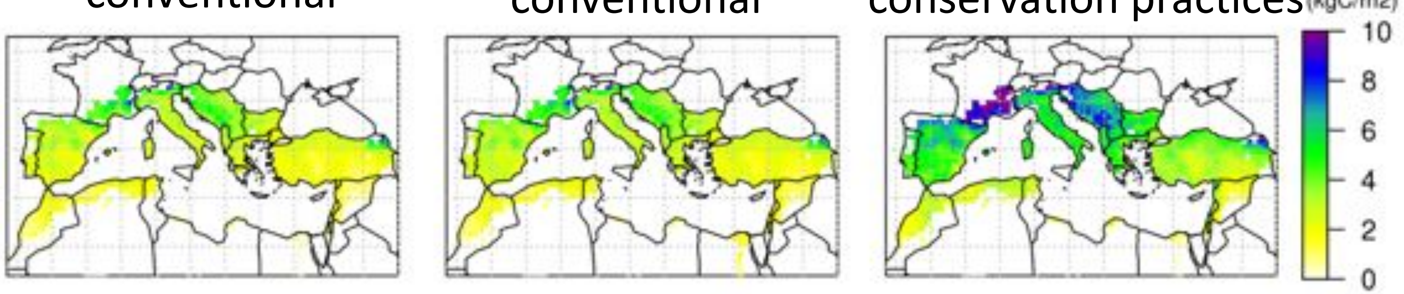
Modelling of Mediterranean agrosystems functioning. Analysis of scenarios for the future of the Mediterranean agriculture in a context of global change

Ph D Simon Decock (IMBE)

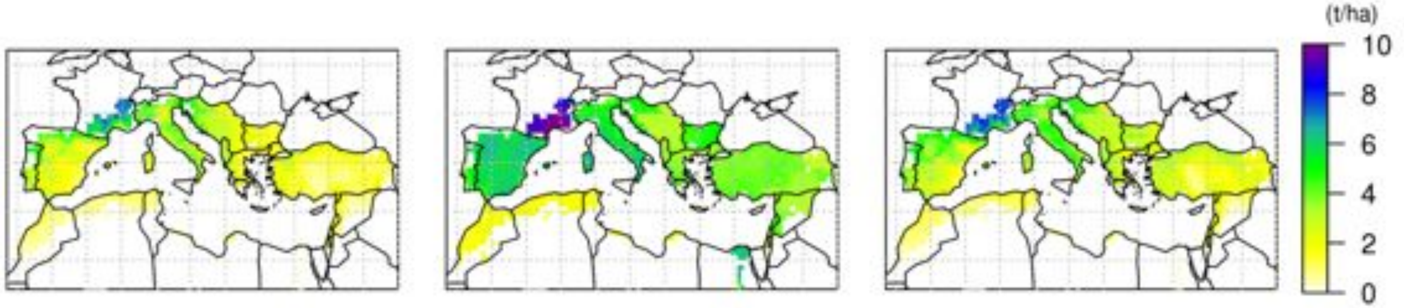
Land use: temperate cereals

rainfed conventional | irrigated conventional | rainfed with soil conservation practices

SoilC *(kgC/m²)*

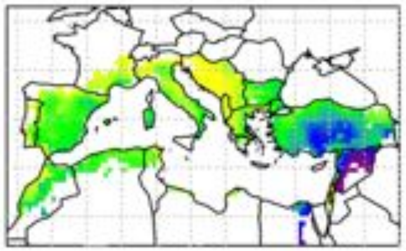


Yield *(tDM/ha)*

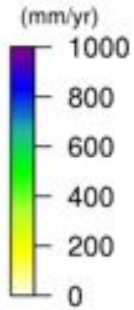


Irrigation water consumption *(mm/yr)*

none



none



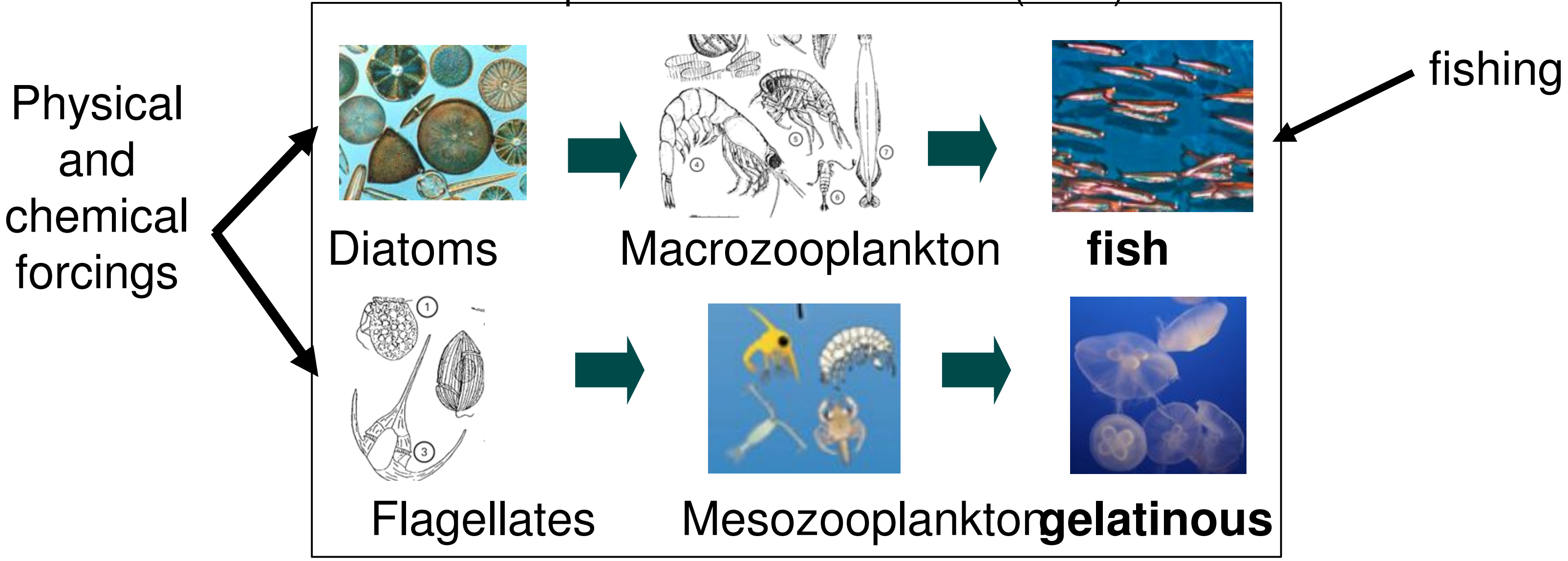
(outputs LPJmL in progress)

Modeling of the impact of continental nutrient inputs on the dynamics of planktonic diversity

E. Alekseenko (OT-MED post-doc), M. Baklouti, F. Carlotti, P. Garreau

* First step in TWP2 towards the integration of the **marine** (NEMO-MED12/Eco3M-MED) and the **continental** (LPJmL) ecosystem models through river outputs

Adapted from Parsons & Lalli (2002)



Modeling of the impact of continental nutrient inputs on the dynamics of planktonic diversity

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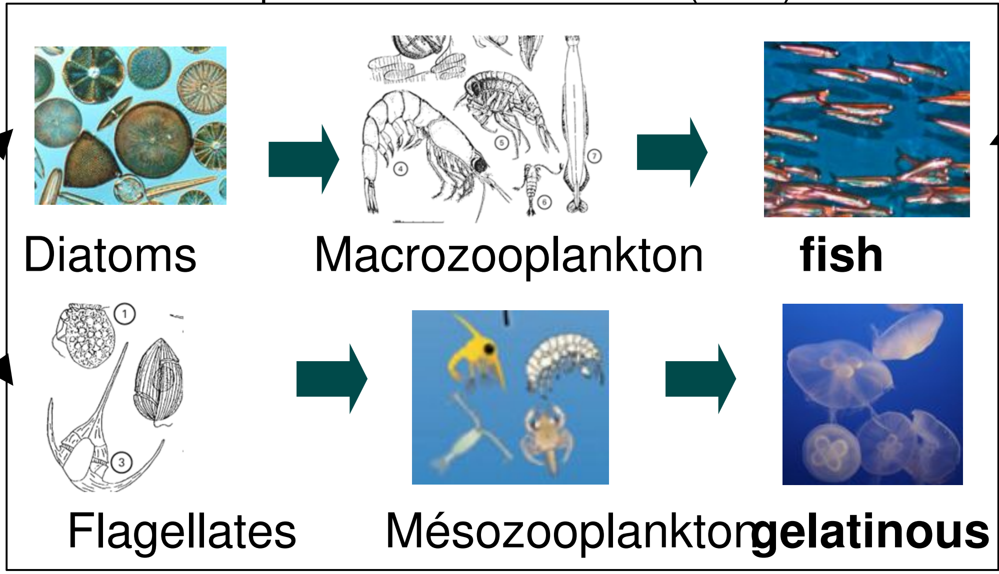
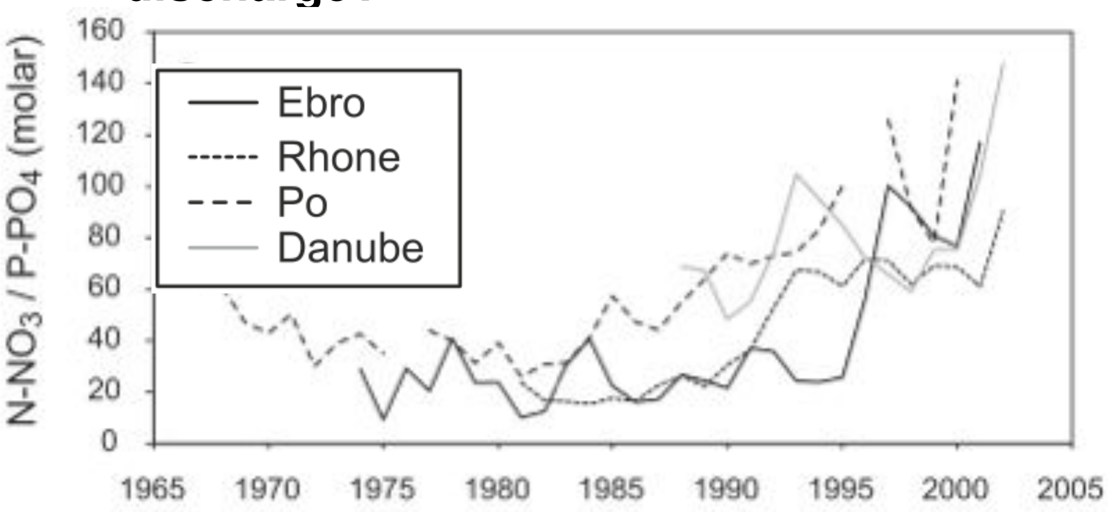
Physical and chemical forcings

Adapted from Parsons & Lalli (2002)



fishing

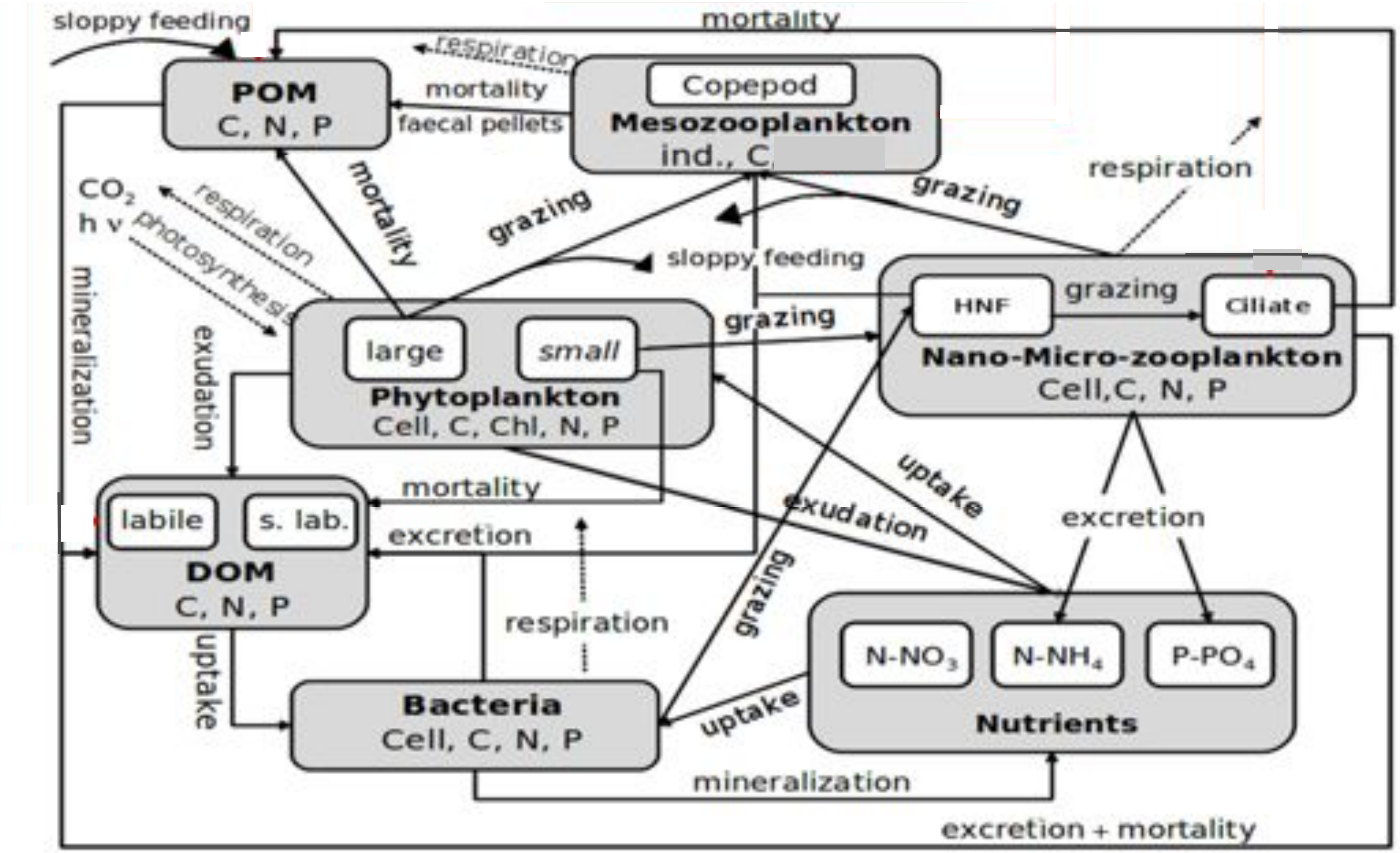
High (and increasing) NO_3:PO_4 ratios in river discharge?



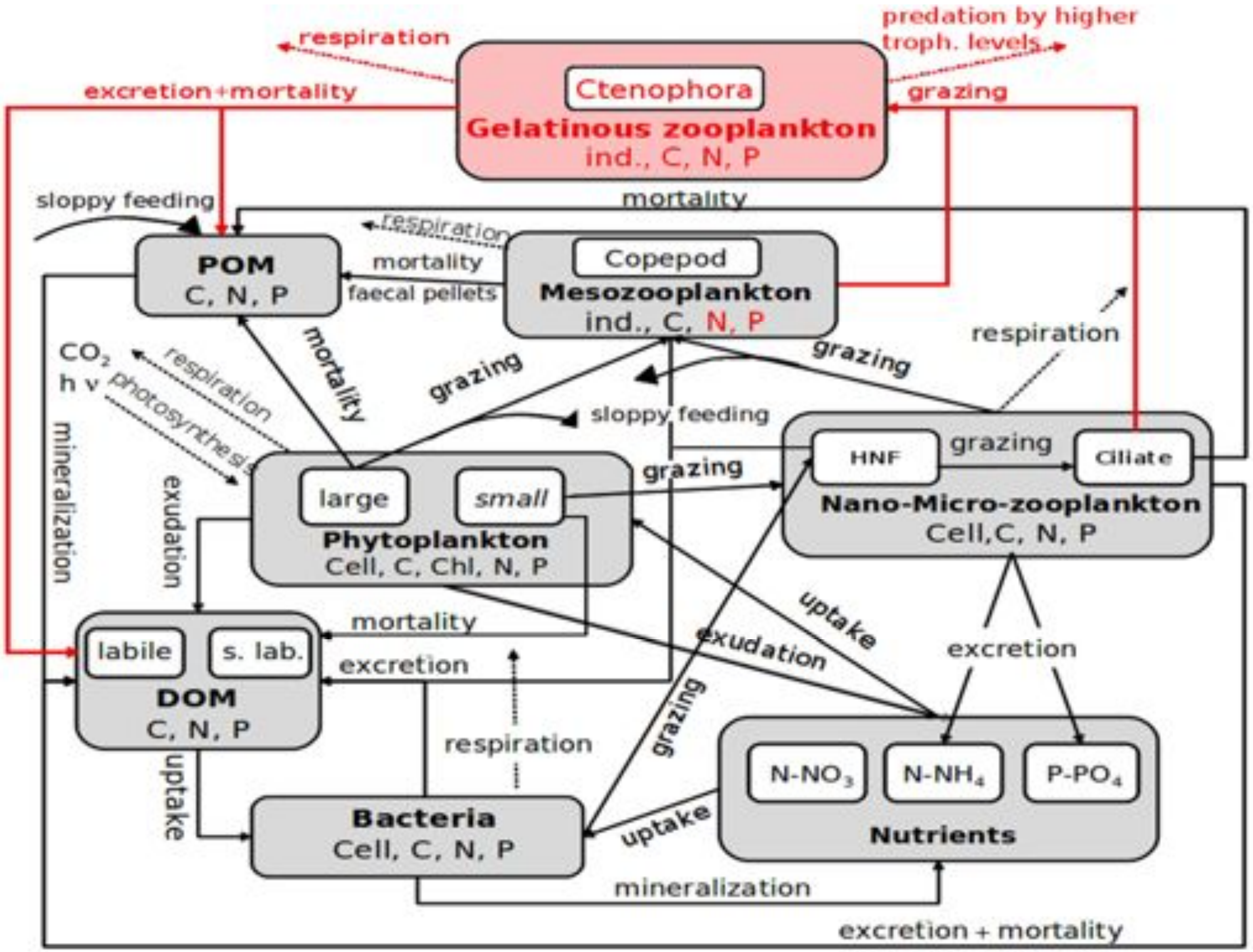
- More generally, how does the NO_3:PO_4 ratio impact the structure of the marine food web ?

Starting point

The mechanistic biogeochemical model Eco3M-MED



New features of the biogeochemical model

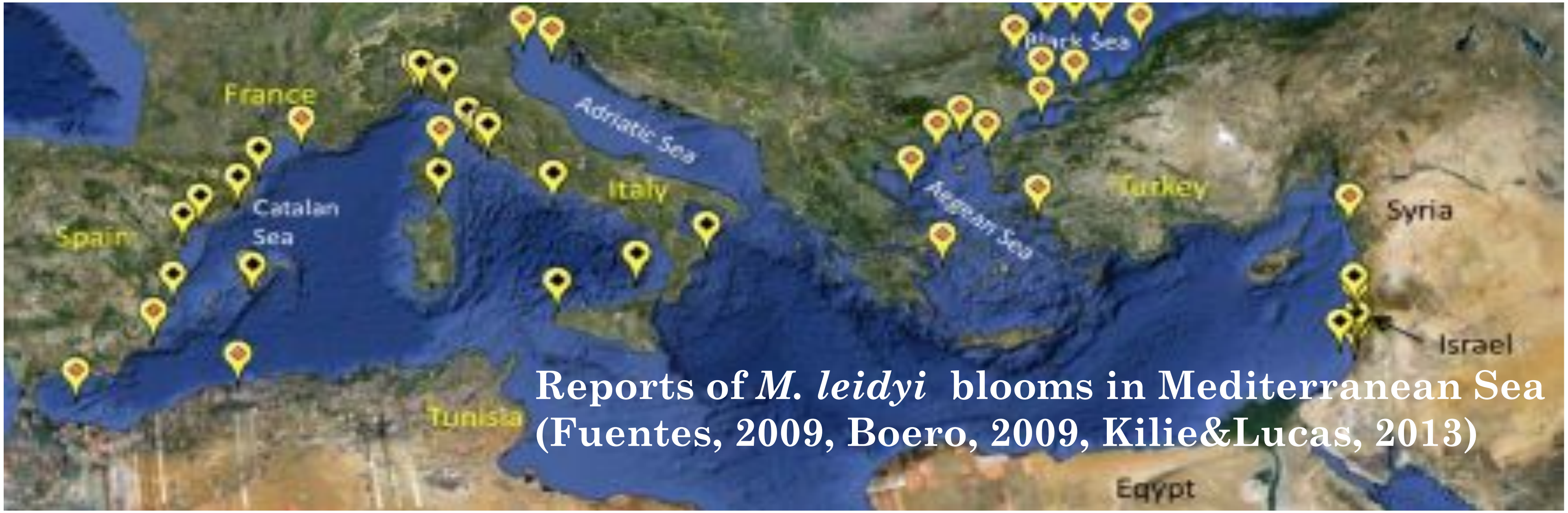


Ctenophore *Mnemiopsis leidyi*

- First implemented in the generic gelatinous compartment of the model: the ctenophore *Mnemiopsis leidyi*

- An alien species which, from the Black Sea has continuously spread to other seas of the Mediterranean basin

- M. leidyi competes with zooplanktivorous fish (anchovy,...) and pelagic larvae.



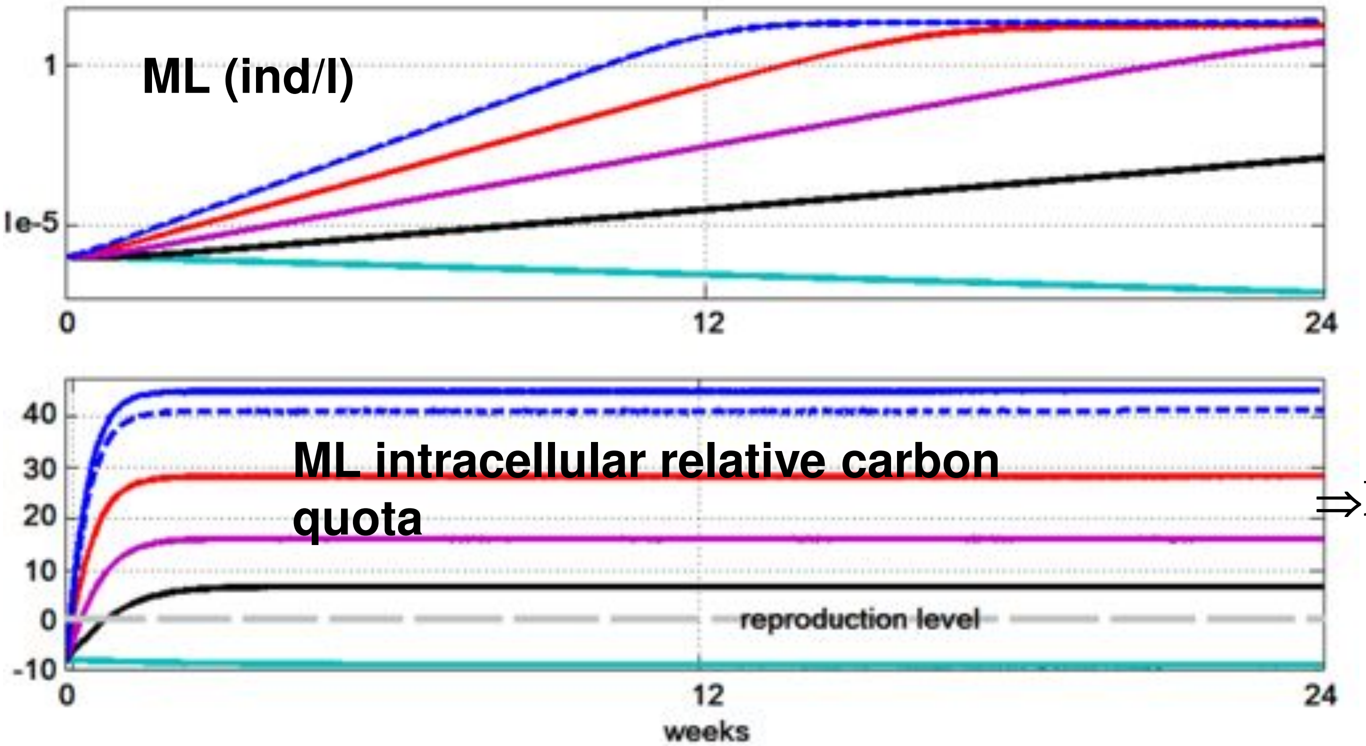
Reports of *M. leidyi* blooms in Mediterranean Sea (Fuentes, 2009, Boero, 2009, Kilie&Lucas, 2013)

0D preliminary tests

Assessment of the model outputs relative to *M. leidyi* (*Alekseenko et al., in prep.*):

- Growth and reproduction rates according to food quality and quantity
- Starvation tests (from 1 to 12 weeks)
- Impact of temperature
- Impact of NO_3/PO_4 ratio
- Effect of implicit overfishing

Example : ML evolution in presence of constant food (copepod)



Copepod conc. (ind/m³):
250 000 - 100 000
25 000
10 000
5000
2500

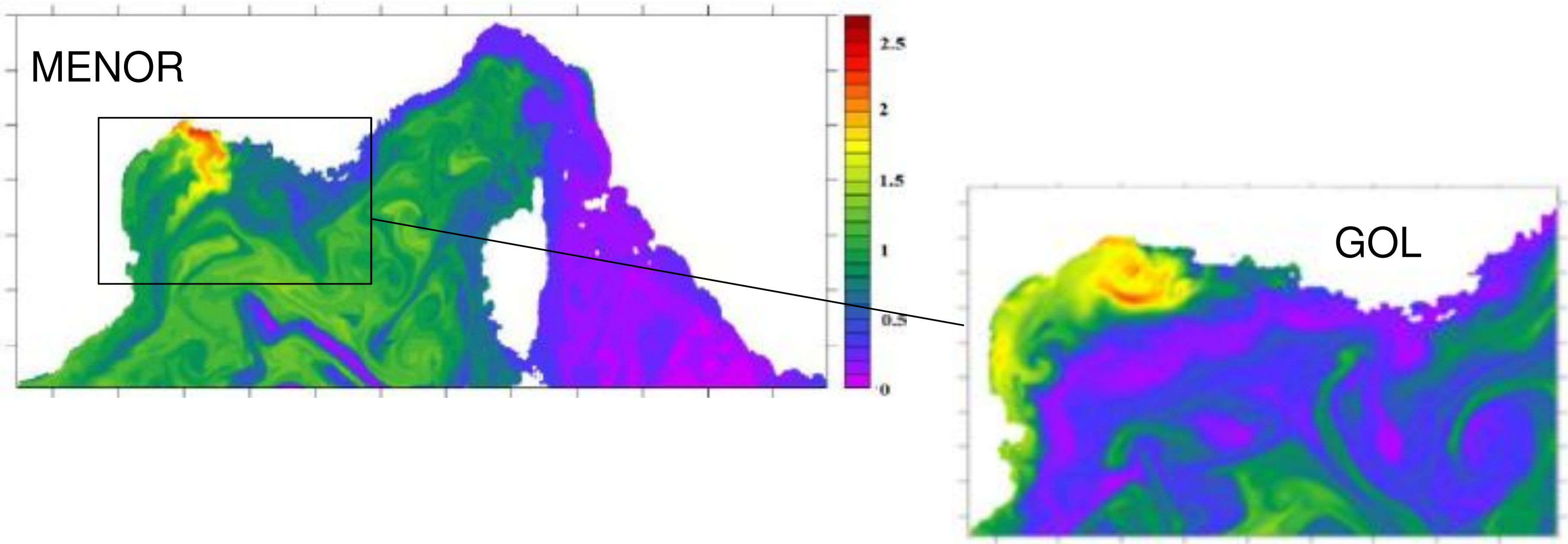
⇒ML has strong survival ability at any food concentration higher than <u>2500 ind/m³</u>

Modeling of the impact of continental nutrient inputs on the dynamics of planktonic diversity

E. Alekseenko (OT-MED post-doc), M. Baklouti, F. Carlotti, P. Garreau

- MARS3D hydrodynamical model: **1.2 km resolution; 30 vertical levels**

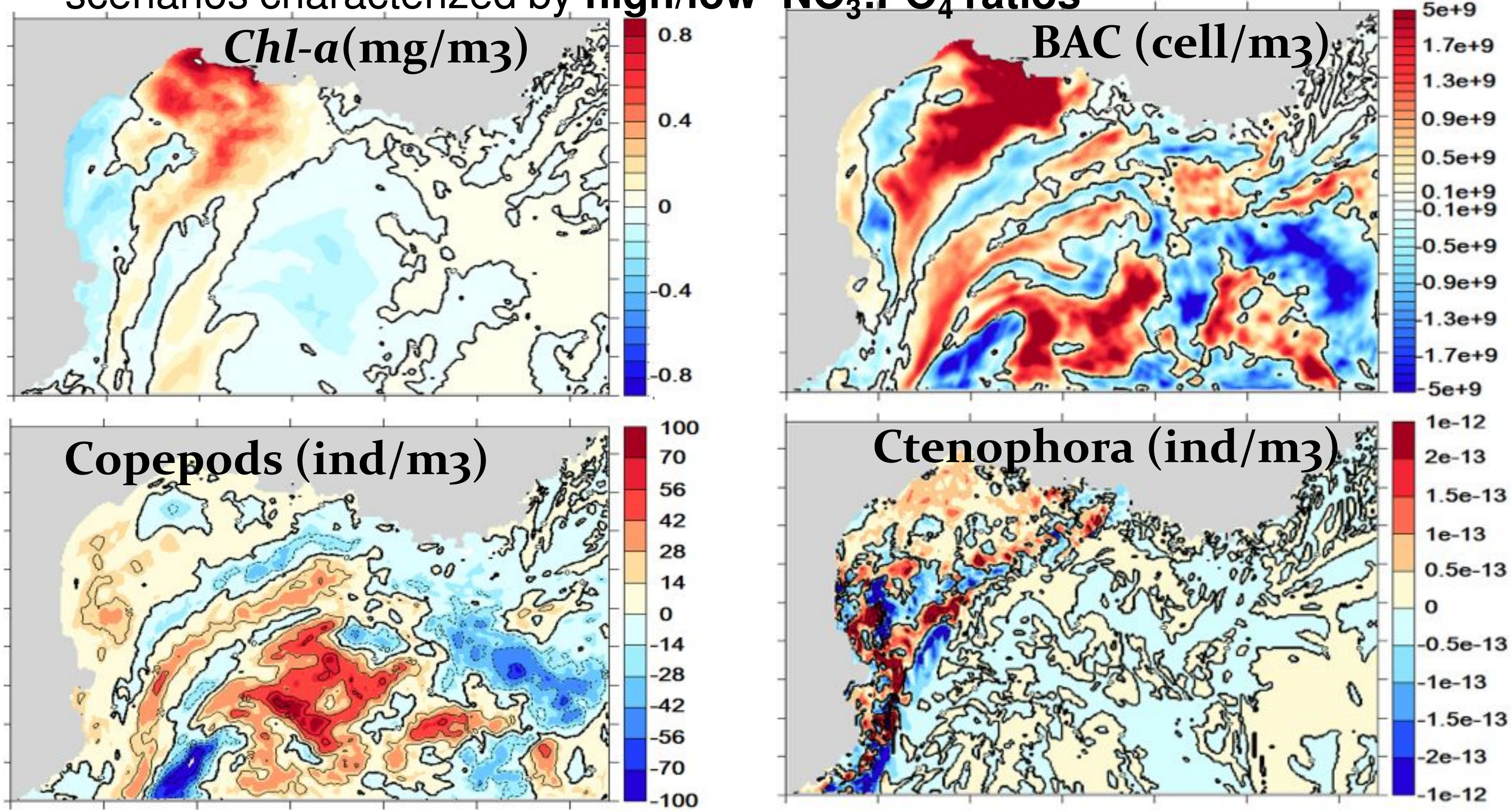
- Coupled with the Eco3M platform



Due to high computational costs, the GOL configuration has been used for scenarios but it has benefitted from boundary conditions provided by the MENOR configuration

Scenarios on NO_3:PO_4 ratio

Difference during the bloom period (Feb.-Apr.) between two academic scenarios characterized by **high/low NO_3:PO_4 ratios**



- A change in NO3 :PO4 of Rhone River significantly impacts the food web
- The difference in Chl-a is of the same order of value as mean Chl-a level in the GoL

Conclusion and Perspectives

- Academic scenarios on the NO_3:PO_4 ratio in the Rhône River showed a significant impact on the structure of the trophic web even after only 2 years of simulation

=> What would be the impact in the longer term ?

=> How does this ratio impact carbon sequestration ?

=> What would be the answer at the scale of the whole Med. Sea ?

=> What will be the actual evolution of the NO_3:PO_4 ratio in Mediterranean Rivers according to climate change / agricultural changes / … ?

=> LaSeR-Med project