Towards an integrated view of climate, air pollution, land use and their impacts on social-ecological systems at regional scales

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I. Objective

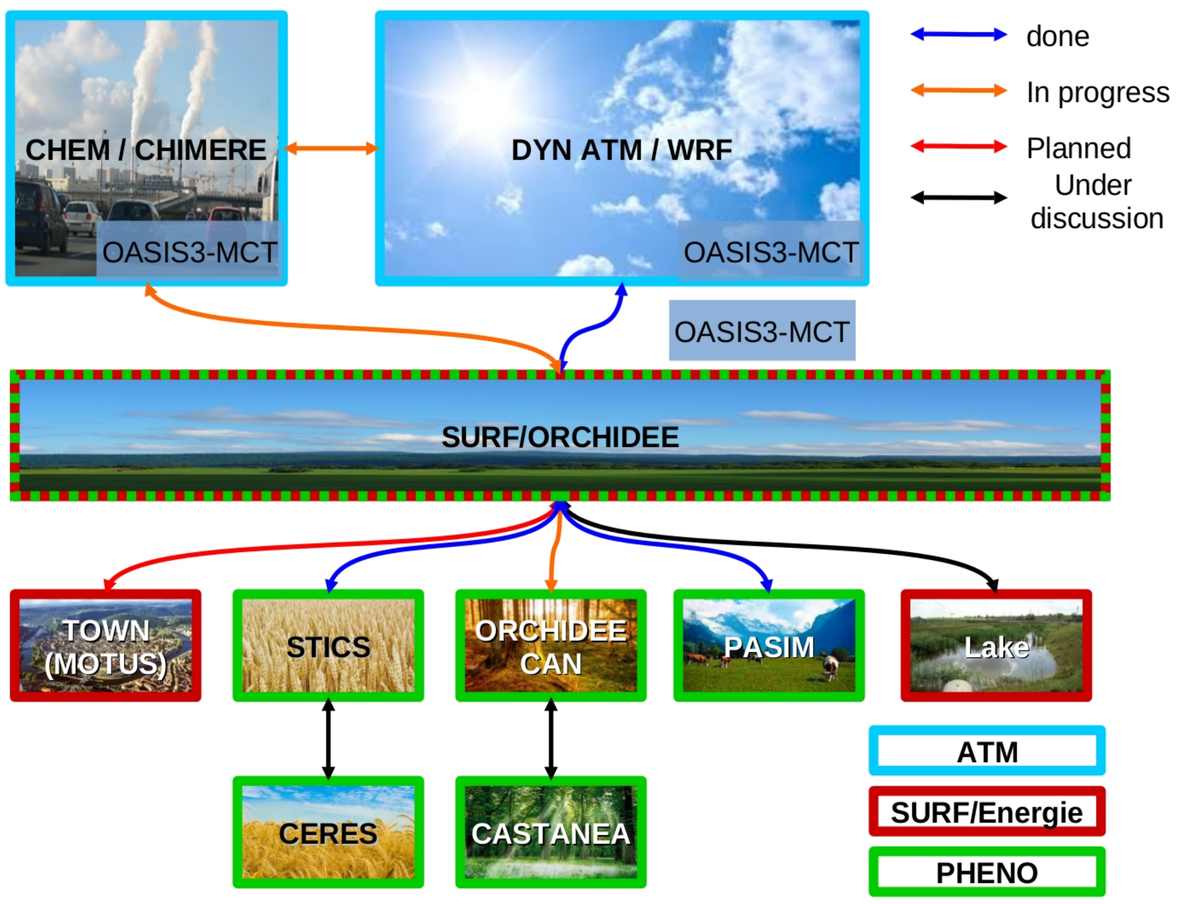
One aim of the BASC 5th Flagship "Model integration and multi-scale modelling in SES: from concepts to evolvable coupling tools " is to study socio-ecological (SES) systems, at the regional/territorial spatial scale, and through the coupling of various models reproducing the links between different components of the Earth system. These components are i) the atmosphere, ii) the functioning of ecosystems and biodiversity, iii) the economy, public policy, as well as the management of land.

The main interactions between regional/local climate, ecosystem functioning and societal choices remain misrepresented in models, while these spatial scales are pivotal to solve societal and scientific problems linked to the uses of land. As a consequence, land management is complex by nature and requires interdisciplinary research to analyze and design landscape development. Thus, the coupling offline or online between different models could provide efficient insights in the context of a multidisciplinary approach.

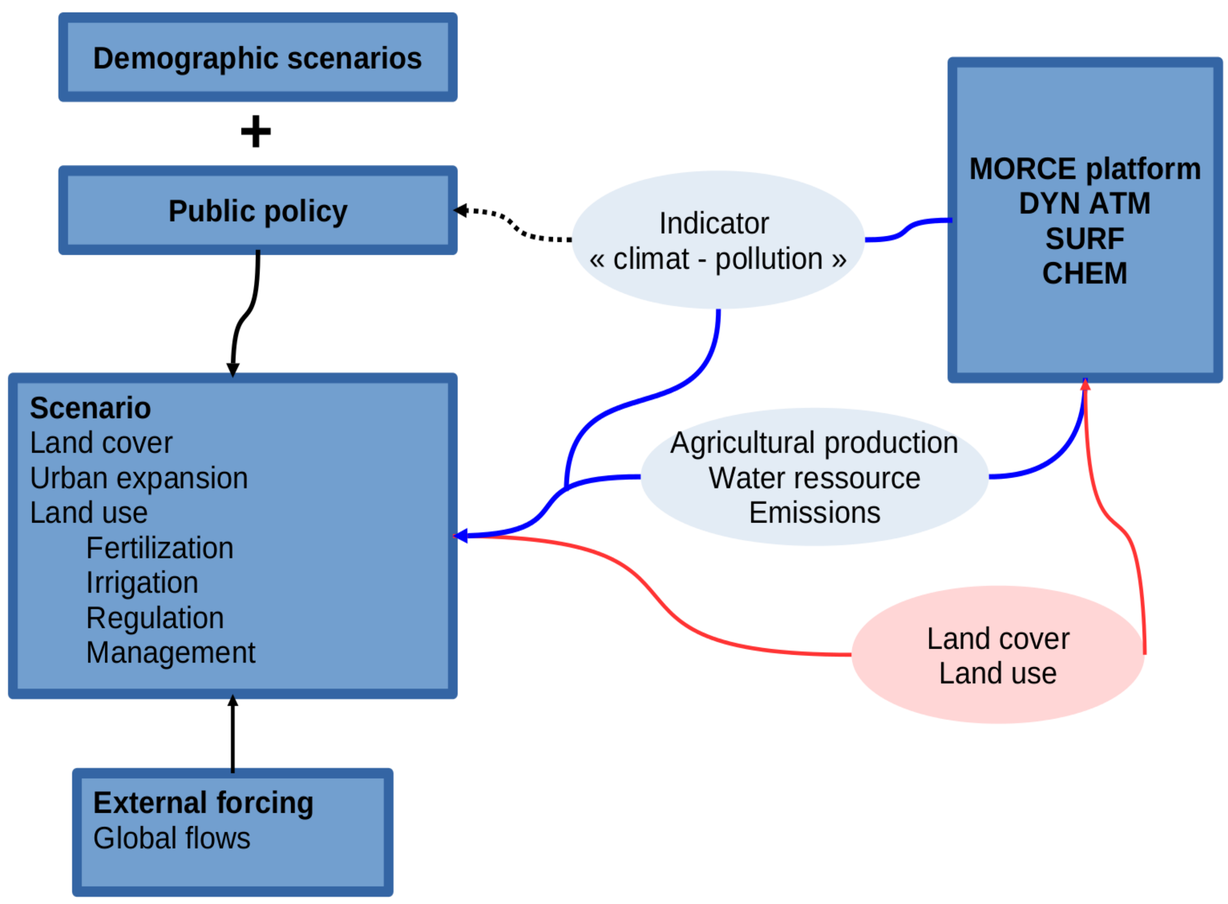
II. Tools

Integrated Assessment Models (IAMs) are informatic tools that bring together and summarize information from diverse fields of study, which perfectly fulfill the aim of BASC 5th Flagship about multi-scale and inter-disciplinary modeling For this purpose, an inventory of model used or developed within BASC was made in 2014 and is available at http://www6.inra.fr/basc/Recherche/Modeles
Models of interest in creating an IAM would be so far:

- ORCHIDEE is the IPSL **land surface mode**l and describes the fast processes of the terrestrial biosphere and also simulates the phenology and carbon dynamics.
- WRF is a **regional climate model** developed at NCAR. WRF is a non-hydrostatic model which allows an accurate representation of kilometric scale processes.
- CHIMERE is a multi-scale model for **air quality** forecasting and simulation (IPSL-INERIS).
- PASIM is a process-based **grassland ecosystem** model (INRA).
- STICS / CERES are **generic crop models** developed at INRA.
- CASTANEA is a process-based **forest ecosystem model** (ESE).
- Town model - MOTUS project (Modelling of Temperature in Urban and peri-urban Systems), see Patrick Stella's poster.



The MORCE (Model of the Regional Coupled Earth system) platform developed at IPSL.

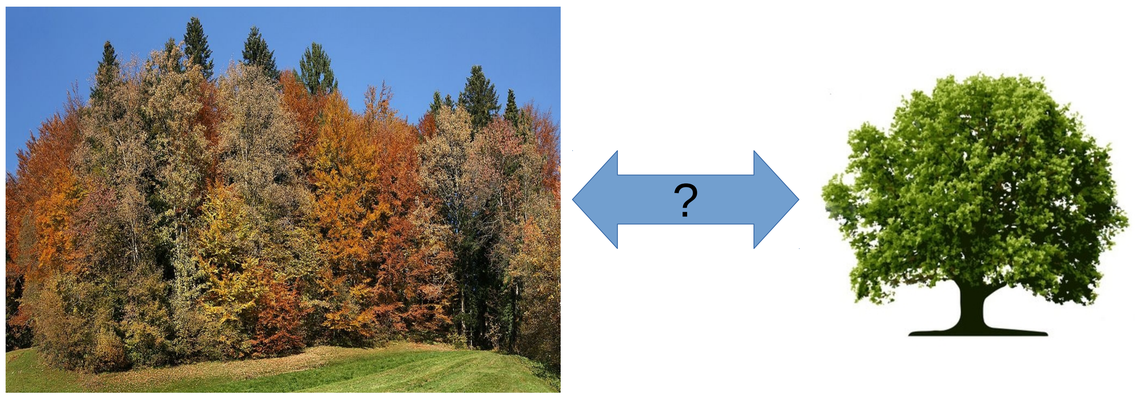


Interactions between the MORCE platform and the socio-economic models.

III. How shall we represent the diversity of landscapes in our land-surface models at regional scale?

Climate models have been designed to represent biogeochemical and biophysical processes of the major ecosystems on a global scale (e.g., ORCHIDEE). The coarse resolution simplifies a multitude of ecosystems into a few generic plant functionnal types (PFTs). For example, nearly all tree species in France are grouped into three PFTs in the ORCHIDEE model. However agronomists and ecologists have developed growth models calibrated for one crop or tree species that are probably better suited for representing these plants than PFTs. On a regional or local scale, there is less need for a generalist PFT approach and the potential use of species or ecosystem specific models is more relevant. Improving current PFTs parameterization by implementing applied plant growth models could provide a more realistic vegetation feedback, a better assessment of climate impact on terrestrial biome and greatly facilitate dialog with stakeholders.

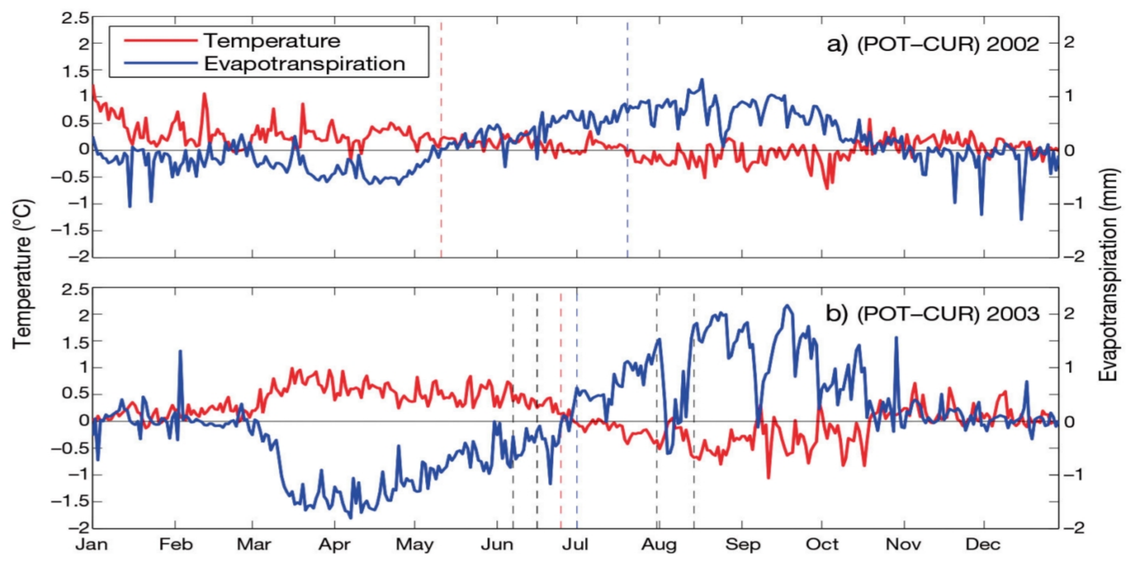
We have at our disposal a set of models to test and quantify the impact of a greater consideration of landscape diversity on a regional climate model. The couping between the forest (CASTANEA) ecosystem model -instead of using ORCHIDEE- and the regional climate model (WRF) is currently under progress. Thus, we will compare the performance of a species approach against a PFT approach on climate modeling.



Plant functionnal type or a mix of species : What are the consequences for climate and ecosystems ?

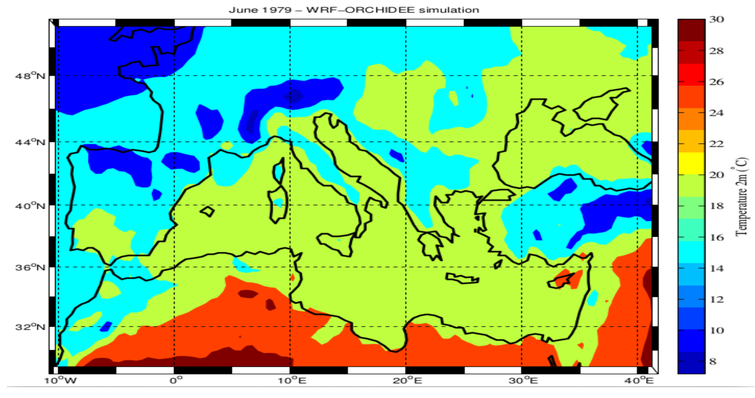
IV. Evidences that Land-Uses and phenology matters in regional climate.

Using the WRF regional climate model coupled with the ORCHIDEE land surface model, two land cover scenarios (afforestation and agricultural) were qualitatively compared in their heatwave mitigation ability over France for the years 2002 and 2003.



Difference between the POT (forest) and CUR (agricultural) simulations for the evapotranspiration (blue) and surface temperature (red) at 15:00 h UTC for (a) 2002 and (b) 2003. Dashed lines — black: limit of June and August heatwaves; blue (red): sign switch in temperature (evapotranspiration) difference.

The same coupled model WRF-ORCHIDEE is used to assess interannual variability improvement in earth system model by taking into account interactions between climate and a long term phenology dynamic (i.e. the vegetation physiological characteristics in relation with climate variability). These simulation used for this study are performed in the framework of the CORDEX international program.



Surface air temperature (at 2 m above ground) averaged over June 1979 and performed by the WRF-ORCHIDEE coupling, part of the MORCE platform.

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