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Introduction

- ❖ Modelling the fate of pesticides in the environment helps prevent and manage soil and water contamination
- ❖ In particular, groundwater protection is a key issue for human health and resources sustainability
- ❖ In Europe, assessment of predicted pesticides (and metabolites) concentrations in groundwater (PEC_{gw}) at 1 m depth is mandatory for their registration (European Regulation EC 1107/2009)
- ❖ Then each European country approves plant protection products (PPP) for specific agricultural uses
- ❖ At the European level, PEC_{gw} are estimated for pesticide use in crop monoculture. At the French level, refined assessment considering crop rotations can be performed
 - ➔ To achieve the sustainable use of pesticides, the European Commission promotes the introduction of new cropping systems based on integrated pest management (IPM) approaches (Directive EC 2009/128)
 - ➔ IPM is based on more complex cropping practices (cover crops, mulch...) than monoculture and rotation

Objectives

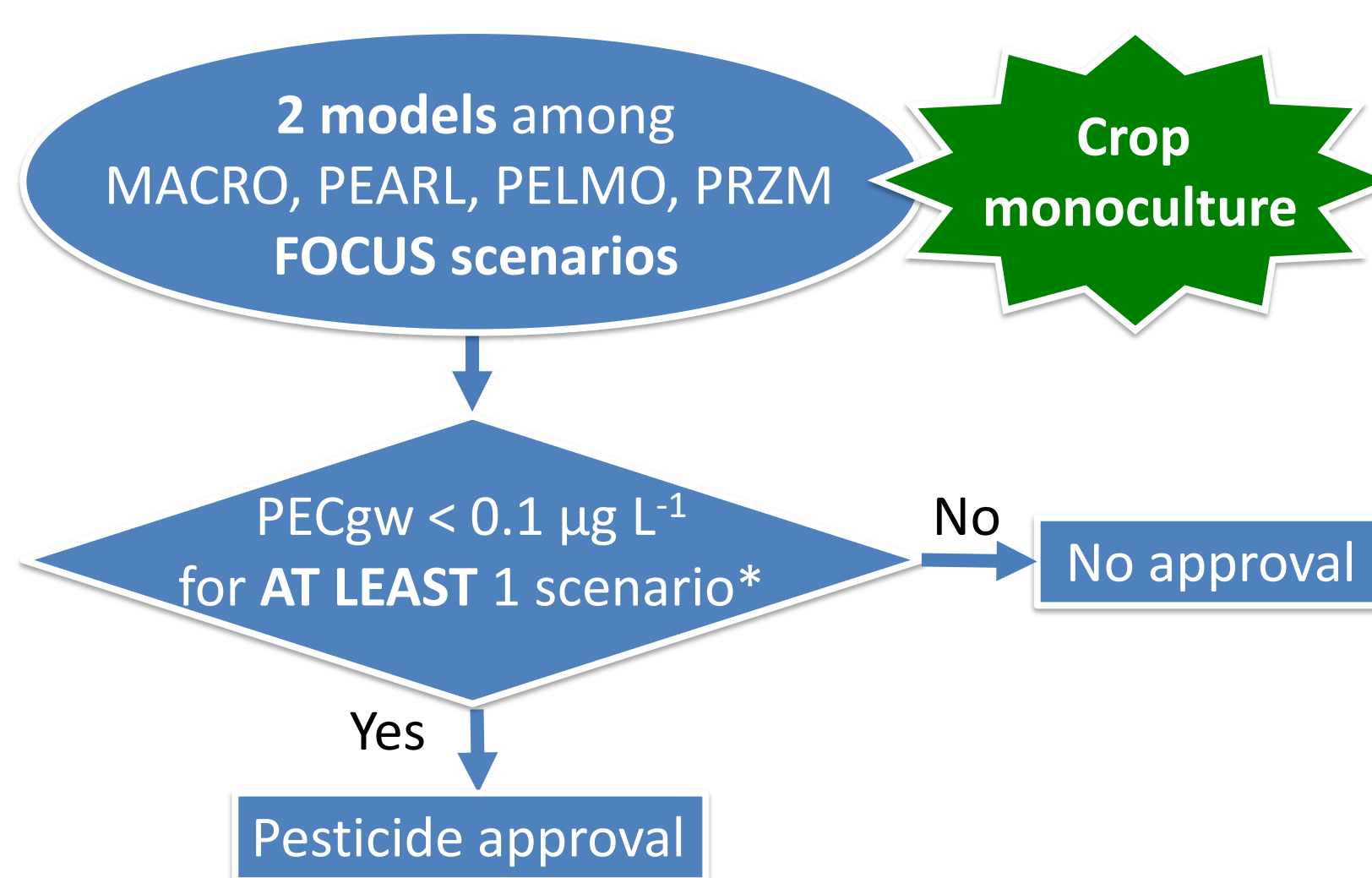
- ❖ To review the models and methods used at the European and French levels to assess the PEC_{gw}
- ❖ To identify the strong and weak points of models and methods regarding cropping practices
- ❖ To present the recent developments that will help consider complex cropping practices in PEC_{gw} assessment



Cropping practices in the assessment of pesticides PEC_{gw}: regulatory requirements and recent developments

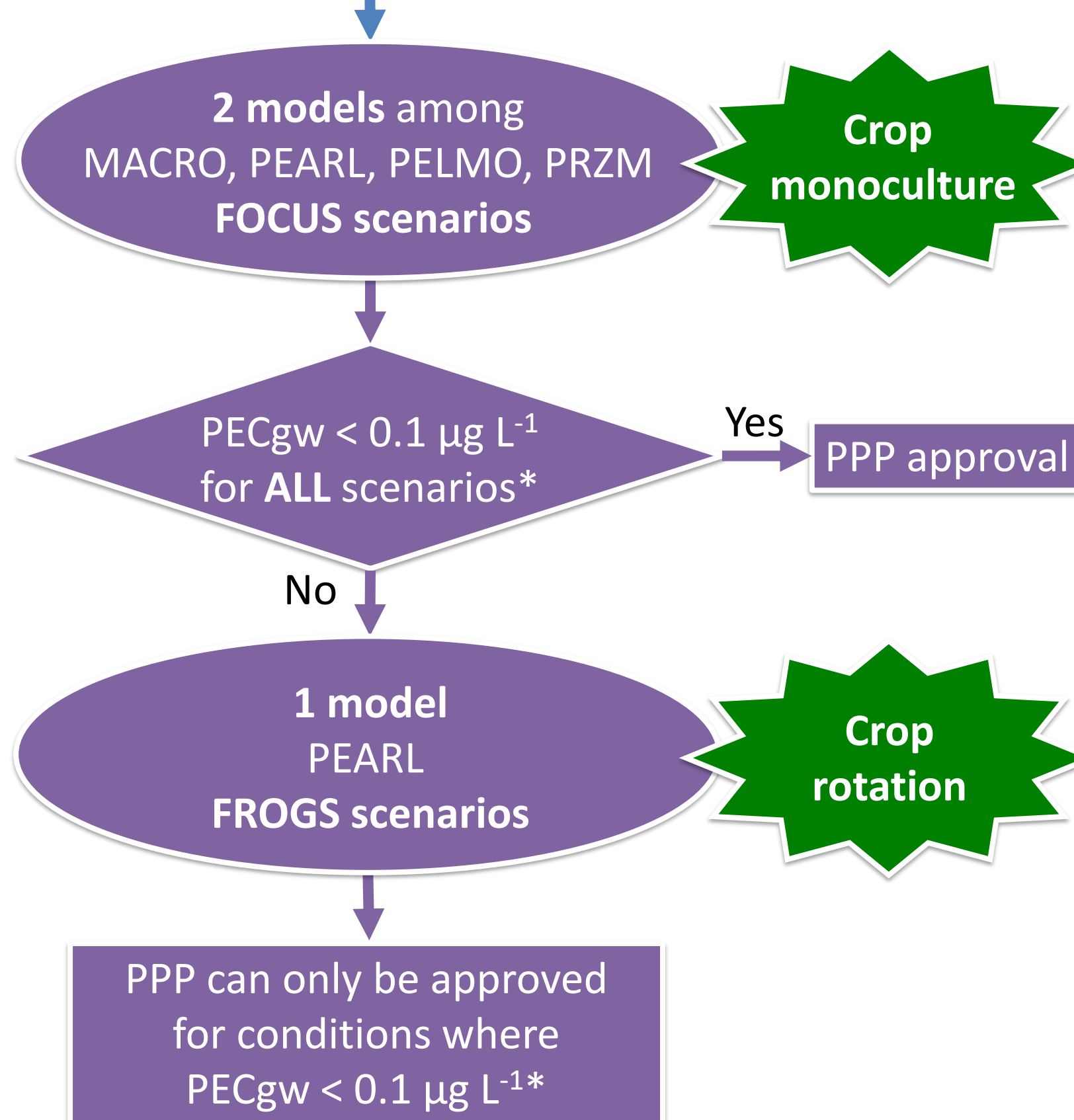
Regulatory risk assessment of PEC_{gw} at the European and French levels

European level: Assessment of PEC_{gw} for pesticide (active substance) approval



* For pesticide and metabolites of toxicological relevance

French level: Assessment of PEC_{gw} of each pesticide contained in plant protection product (PPP) for PPP approval



* For pesticide and metabolites of toxicological relevance

- MACRO (Water and solute transport in macroporous soils, Larsbo and Jarvis, 2003)
- PEARL (Pesticide Emission Assessment at the Regional and Local scales, Leistra et al., 2001)
- PELMO (Pesticide Leaching Model, Klein, 1995)
- PRZM (Pesticide Root Zone Model, Carsel et al., 1998)

Table 1. Description of FOCUS European and FROGS French scenarios for PEC_{gw} assessment: pedoclimatic and cropping practices scenarios

Scenarios	Pedoclimatic scenarios	Cropping practices scenarios
FOCUS	<ul style="list-style-type: none"> • 9 representative European scenarios (Fig. 1): 9 climates and corresponding soil types ➢ Mean annual temperature: 4 to 18°C ➢ Precipitations: 493 to 1150 mm ➢ Soils: loam, loamy fine sand, sandy loam, silt loam, silty clay loam 	<ul style="list-style-type: none"> • Crop monoculture ➢ Field crops: beans, cabbage, carrots, cotton, linseed, maize, oilseed rape, onions, peas, potatoes, spring cereals, soybean, sugar beet, sunflower, tobacco, tomatoes, winter cereals ➢ Perennial: apples, bush berries, citrus, grass, strawberries, vines
FROGS	<ul style="list-style-type: none"> • 390 representative French scenarios: 31 climates (Fig. 2), 19 soil types (not all soil types in the 31 climatic zones) ➢ Mean annual temperature: 10 to 15°C ➢ Precipitations: 684 to 1018 mm ➢ Soils: arenosol, cambisol, fluvisol, gleysol, luvisol, podzolusol, rendzine, solonchak 	<ul style="list-style-type: none"> • Crop rotation ➢ oilseed rape - winter wheat - sunflower ➢ barley - winter wheat - sunflower ➢ winter wheat - maize - barley ➢ oilseed rape - winter wheat - maize ➢ potato - winter wheat - barley ...

FOCUS: Forum for the Coordination of pesticide fate models and their Use (<http://esdac.jrc.ec.europa.eu/projects/focus-dg-sante>)
FROGS: French Refinement of Groundwater Scenarios (<https://frogs-outil.com/>)

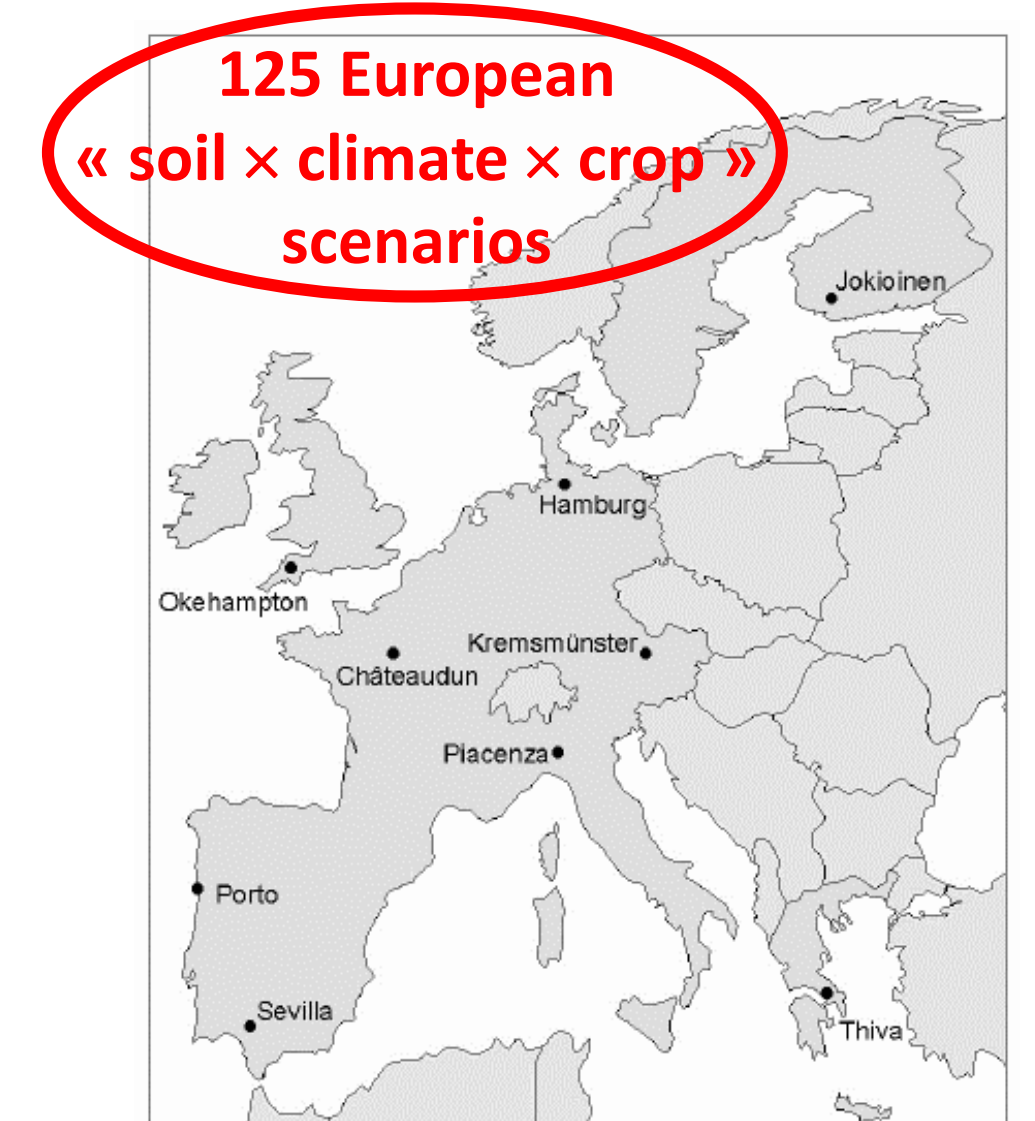


Fig. 1. Location of the 9 FOCUS European scenarios for PEC_{gw} assessment (FOCUS, 2000)

European level

- The assessment of PEC_{gw} for pesticide use in crop monoculture can be considered as a worst case
- FOCUS scenarios do not allow to consider diversified crop rotations
- The representation of cropping practices in the models is incomplete: the description of the crop is only based on maximum leaf area index, root depth and height

French level

- FROGS scenarios allow to propose risk mitigation measures based on specific cropping practices (i.e. crop rotation)
- However, they do not take into account cropping practices such as cover crops, mulch...

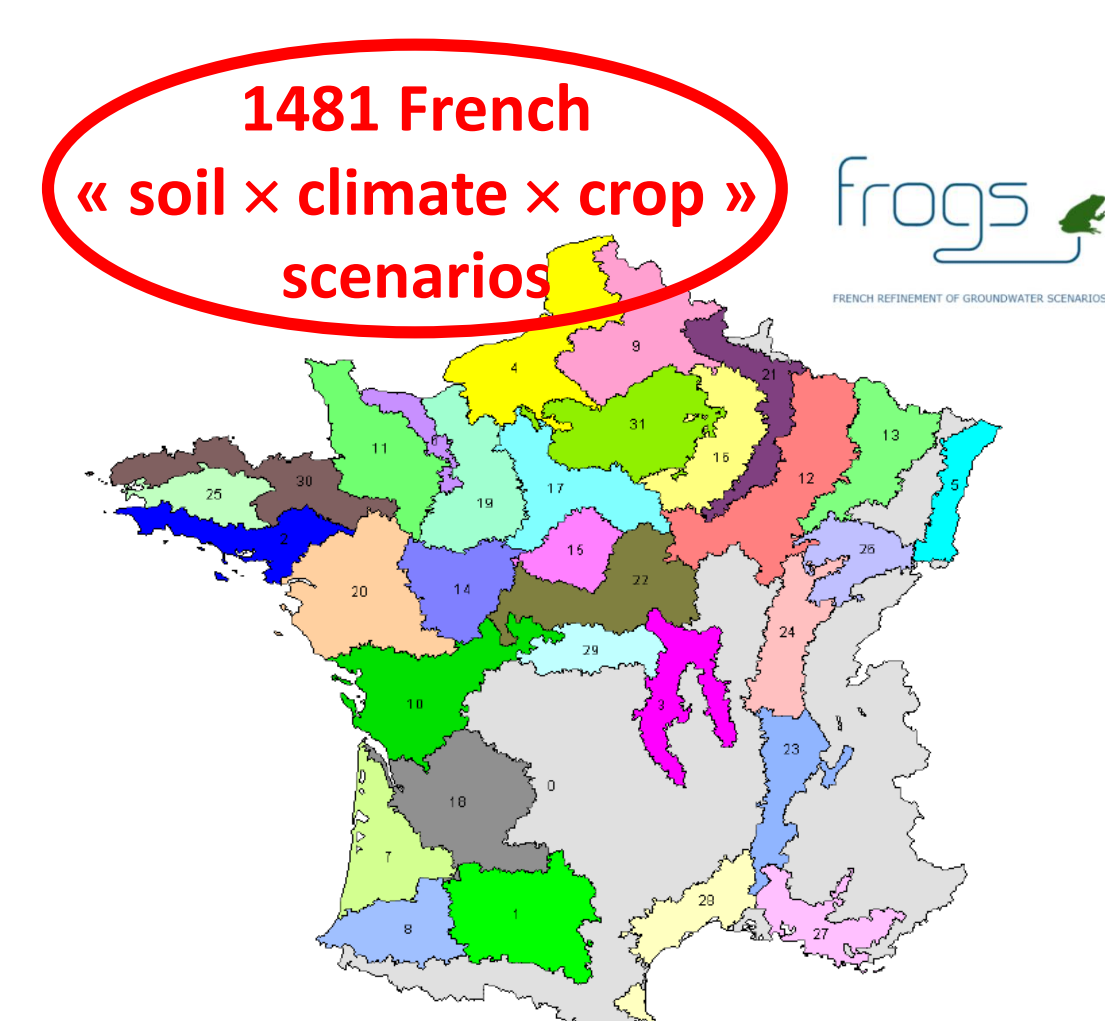
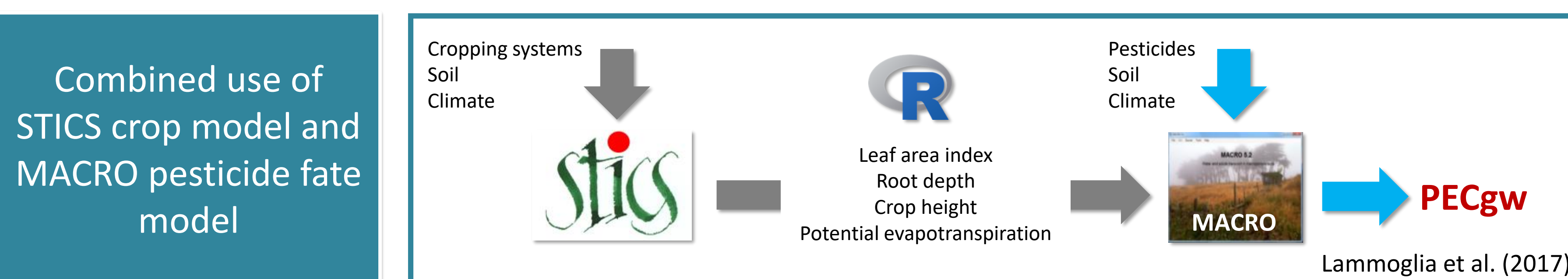


Fig. 2. Location of the 31 FROGS French agronomic scenarios for PEC_{gw} assessment (homogeneous geographic entities which show common agricultural and physical conditions for the growing of arable crops) (FROGS, 2013)

Recent developments to assess the PEC_{gw} of pesticides used in complex cropping systems

- ❖ Need of new modelling tools to assess the PEC_{gw} of pesticides used in complex cropping systems:



- Crop models are able to simulate refined crop development and various cropping practices (cover crops, mulch, fertilization...)
- STICS crop model (Brisson et al., 2003) has been widely tested and its performance was shown to be good
- MACRO is known to be efficient to simulate the fate of pesticides
- ➔ STICS-MACRO is a new promising tool to assess the PEC_{gw} of pesticides used in various cropping systems (Lammoglia et al., 2017)

Conclusion and perspectives

- ❖ Diversified cropping practices are increasingly adopted for a sustainable use of pesticides
- ❖ Current assessment of PEC_{gw} for pesticide approval is done for crop monoculture at the European level, and can take into account crop rotations at the French level
- ❖ In the future, the diversity of cropping practices might be considered in modelling for pesticide regulatory risk assessment

