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CyberPlantS: a European initiative towards collaborative plant modeling

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Highlights: The current European research landscape of 3D plant modeling shows fragmentation and critically lacks coordination. The CyberPlantS initiative aims at creating the first European network on advanced plant simulation systems and associated e-infrastructure. The network will aim at innovation in computational plant modeling with a focus on plant architecture and plant-environment interactions. It is focused on the development of a new paradigm, namely cyberplants. Cyberplants refers to cybernetic systems, as biological and environmental components of vegetation exchange signals to achieve specific goals. Cyberplants also refers to cyberspace, which designates a collaborative approach based on a network community relying on a cyberinfrastructure.

Keywords: collaborative approach, modeling cyber-infrastructure

Vegetation management faces challenges arising from a shift in perception of the roles of agriculture and forestry. It is expected to ensure food security, preserve the environment (diminish pollution, preserve biodiversity), provide materials for bio-economy, improve quality of life, and substitute fossil resources. To face these challenges in an increasingly complex and rapidly changing context (climate, land use, world economy, etc), new vegetation management strategies have to be developed. In parallel to field trials, modeling and simulation tools are necessary to address such a complexity. Models have already been used for vegetation management and have proven their potential benefit. However, the development of vegetation management in the changing context of a sustainable future, where plant canopies will become spatially more heterogeneous (providing low inputs to vegetation, preserving biodiversity, developing new cropping/forestry systems like intercropping, etc) and where current statistical correlations linking the plant functioning and environment may become erroneous, will impose new constrains on vegetation models. Future models should thus be able to explicitly deal with feedback loops between individual plants and their local environment (where environment consists of the physical surrounding above and below ground, but also the biotic environment including neighboring plants).

In the 1990's, pioneering scientists recognized the importance of developing models of plant growth, which explicitly represented plant architecture in three dimensions. They started to design Functional-Structural Plant Models and associated software platforms. Emphasis on combining plant function with plant structure, irrespective of the target of the application (agriculture, horticulture, forestry), has been a cohesive force. Different modeling approaches and systems have been developed, but inter-operability among them is just beginning to emerge. The current European research on 3D plant modeling shows fragmentation and lacks coordination. Developing a European strategy in the domain of 3D plant simulations is becoming an urgent necessity. The CyberPlantS initiative aims at creating a European network on advanced plant simulation systems and associated cyber-infrastructure. This initiative gathers scientists in ecophysiology, agronomy, and forestry as well as in physics, mathematics, and computer science, for the development of a new paradigm, namely *cyberplants*. This term is intended to highlight three key aspects of the new concept: i) the term "cyberplants " refers to the cybernetics approach, which aims at studying complex, dynamical, goal-oriented systems. A cyberplant therefore consists of modular, fully interoperable and interchangeable computational components. ii) "cyberplants " refers to cyber-space, as it is intended to create a collaborative framework based on a network community and relying on an e-infrastructure. (iii) It finally refers to the future generation of students and scientists who are subjected to live in an increasing digital world.