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LINKING L-SYSTEMS AND MASS BALANCES TO MECHANISTICALLY MODEL PLANT GROWTH IN REDUCED GRAVITY ENVIRONMENTS

Abstract

Future long-duration human space missions and the establishment of permanent off-Earth bases will require life-support systems capable of ensuring atmosphere revitalization, water recycling and waste treatment for crew survival. The Micro-Ecological Life Support System Alternative (MELiSSA) is a closed-loop inspired from a lake ecosystem, which can ensure these functions. This project of the European Space Agency (ESA) is a life-support system based on biological processes functioning with microorganisms and higher plants and providing a cycling of mass, including O2 production, CO2 removal, water recycling, waste treatment, and food production.

The growth and development of higher plants are strongly influenced by environmental conditions (e.g. gravity, pressure, temperature, relative humidity, partial pressure of O2 or CO2) so bio-regenerative life support systems require a high level of control and management. In order to understand and predict the effects of microgravity or of a reduced gravity environment (like on Mars or on the Moon) on plant growth at its morphological, physicochemical and biochemical levels, a mechanistic physical model of plant growth is being developed. Such a model applied to life-support systems requires incorporating plants behavior for a wide range of environmental conditions, unlike most models developed for agronomy, which are usually developed to work in specific Earth conditions.

The first mechanistic plant growth model developed in the framework of the MELiSSA project attempts to address limitations of current existing models developed for agronomy. Based on this work, a preliminary model is defined with the addition of gravity, thus taking into account mechanisms such as gravitropism and root absorption, with a simple morphology model.

Plant morphology is typically addressed using L-systems, which are a grammar enabling accurate representations of plant morphology, but which are usually not linked to physical and chemical processes occurring in plants. In this presentation, the addition of L-systems into the afore-described model is discussed. This enables to link mass balances and plant morphology in a mechanistic way.