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# A Path to Improved Understanding of Complex Soil Systems

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**Abstracts**

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## On the Need to Establish an International Soil Modeling Consortium

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Soil is one of the most critical life-supporting compartments of the biosphere. Soil provides numerous ecosystem services, such as a habitat for biodiversity, water, and nutrients, as well as producing food, feed, fiber, and energy. To feed the rapidly growing world population in 2050, agricultural food production must be doubled using the same land resources footprint. At the same time, soil resources are threatened due to improper management and climate change.

Soil is not only essential for establishing a sustainable bio-economy, but also plays a key role in a broad range of societal challenges including (1) climate change mitigation and adaptation, (2) land-use change, (3) water resource protection, (4) biotechnology for human health, (5) biodiversity and ecological sustainability, and (6) combating desertification. Soils regulate and support water, mass and energy fluxes between the land surface, the vegetation, the atmosphere, and the deep subsurface and control storage and release of organic matter affecting climate regulation and biogeochemical cycles. Despite the many important functions of soil, however, many fundamental knowledge gaps remain regarding the role of soil biota and biodiversity on ecosystem services, the structure and dynamics of soil communities, the interplay between hydrologic and biotic processes, the quantification of soil biogeochemical processes and soil structural processes, the resilience and recovery of soils from stress, as well as the prediction of soil development and the evolution of soils in the landscape— to name a few.

Soil models have long played an important role in quantifying and predicting soil processes and related ecosystem services. However, a new generation of soil models based on a whole systems approach—comprising all physical, mechanical, chemical, and biological processes—is now required to address these critical knowledge gaps and thus contribute to the preservation of ecosystem services, improve our understanding of climate-change–feedback processes, bridge basic soil science research and management, and facilitate the communication between science and society . To meet these challenges, an international community effort is required, similar to initiatives in systems biology, hydrology, and climate and crop research.

We therefore propose to establish an international soil modeling consortium with the aims of 1) bringing together leading experts in modeling soil processes within all major soil disciplines, (2) addressing major scientific gaps in describing key processes and their long-term impacts with respect to the different functions and ecosystem services provided by soil, (3) intercomparing soil-model performance based on standardized and harmonized data sets, (4) identifying interactions with other relevant platforms related to common data formats, protocols, and ontologies, (5) developing new approaches to inverse modelling, calibration, and validation of soil models, (6) integrating soil modeling expertise and state of the art knowledge on soil processes in climate, land surface, ecological, crop, and contaminant models, and (7) linking process models with new observations, measurements, and data evaluation technologies for mapping and characterizing soil properties across scales. Our consortium will bring together modelers and experimental soil scientists at the forefront of new technologies and approaches to characterize soils. By addressing these aims, the consortium will contribute to improving the role of soil modeling as a knowledge dissemination instrument in addressing key global issues and stimulating the development of translational research activities. This presentation will provide a compelling case for this much-needed effort, with a focus on tangible benefits to the scientific and food-security communities.