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In the early 21st century, climate change has emerged as one of the great societal challenges. Taking effective actions to address this concern is complicated by many technological hurdles and socio-economic challenges. Agriculture is a critical player in this arena, because it disproportionately influences climate change as a fraction of its contribution to the global economy. Agriculture also disproportionately suffers from climate change through the effects of weather extremes that can result in crop and animal losses. But the agricultural sector also offers some of the most promising solutions to climate change through improved production practices and efficiencies that can reduce greenhouse gas emissions, as well as through opportunities around carbon sequestration in soils.

This book addresses an important aspect of the scientific needs around this issue: the quantification of agricultural greenhouse gas emissions through the use of numerical simulation models. Why are computer models critical to this effort? First, it is practically impossible to measure greenhouse gas emissions from agricultural practices on a continuing basis, which would be required if we want to document climate benefits from changes in agriculture. Second, we need to project outcomes from different management scenarios into the future to predict potential long-term benefits. Accurate simulation models have the potential to allow us to meet these needs at low cost. This book discusses the recent advances that have been made in this area, as well as scientific issues around the effective use of such models. This helps advance our ability to address the climate change challenges of the present and the future.

The Soil Science Society of America, American Society of Agronomy, and Crop Science Society of America believe that agriculture and science are important elements of the solution to the climate challenge, and this book is an important contribution to that effort.

Harold van Es, 2016 President, Soil Science Society of America
Paul Fixen, 2016 President, American Society of Agronomy
Michael A. Grusak, 2016 President, Crop Science Society of America
In the past ~130 years (1883–2012), the global surface temperature has increased by an average of about 0.85°C (IPCC, 2014). In the last 50 years, the increase has been much faster. Some precipitation patterns have also changed. The year 2004 has been the warmest year on record since the 1880. These changes are already having effects on physical (e.g., glaciers cover) and biological systems in the Northern Hemisphere (IPCC, 2007, 2014). Lobell et al. (2011) have shown that in some major cropping regions of the world, global yields of corn and wheat have declined by 3.8 and 5.5%, respectively, from 1980 to 2008 due to climate change. There is evidence to suggest that the climatic changes are very likely due to increase in greenhouse gas (GHG) emissions due to human activity (IPCC, 2007, 2014). These emissions have been increasing since the start of the Industrial Revolution in 1750, with a 70% increase between 1970 and 2004 (IPCC, 2007). The CO₂ emissions account for 77% of the total GHG emissions, the rest being mainly CH₄ and N₂O gases. Agriculture directly accounts for approximately 13% of the total anthropogenic emissions, and deforestation, mainly for agriculture, contributes another ~15 to 20% of human-caused emissions. In the 21st century, further average temperature increases are estimated to range from 1.8 to 4.0°C, depending on the different GHG emission scenarios. Precipitation is likely to increase at high latitudes and decrease in most subtropical land regions of the world, which are important agricultural regions, by as much as 20%, along with changes in snow, glacier water supply, and extreme events. Cereal crop productivity may increase slightly at mid to high latitudes with temperature increases between 1 to 3°C and decrease above 3°C. At low latitudes, the cereal crop production will likely decrease in the whole range of temperature increases, 1 to 5°C. In order to minimize the harmful effects on agricultural production, we need to reduce the GHG emissions that are causing the climatic changes.

The purpose of this Volume 6 of the ASA, CSSA, and SSSA Advances in Agricultural Systems Modeling series is to document recent advances in understanding, synthesis, and modeling of GHG emissions and changes in carbon storage in agricultural and forest systems, and how changes in soil and crop management affect these processes. The scope spans from simple empirical models based on how key driving variables impact emissions and carbon stock changes to mechanistic models that represent the processes that control emissions and their interactions. Validation of the ability of different models to quantify and
synthesize the experimental data from different systems, and how management practices effect emissions and carbon storage are emphasized. The validated models and decision support tools developed from these will estimate GHG emission and C changes in agricultural systems and guide strategies for mitigation and adaptations to climatic changes.

Additional motivation for this volume is to bring together scientists from different disciplines, worldwide, to encourage further transdisciplinary research in the area of GHG emissions and C changes, and its synthesis to: (i) fill knowledge gaps in our scientific understanding of processes and management effects in the current models, (ii) improve existing concepts and approaches in the models, (iii) advance their applicability to larger spatial areas, and (iv) develop system-based strategies and tools for mitigation of the GHG effects.

Based on a review of the subject matter by the organizers, some of the specific areas of knowledge gaps needing better understanding and quantification for system models are listed below. Contributions for this volume listed under the next section have been selected around these areas.

- Effects of soil, environmental, crop and management factors on GHG emissions and C changes
- Effects of climate variables and global change on GHG emissions, crop yields, livestock production
- Quantification of model uncertainty
- Comparisons of model outputs with other models and different types of measurements.

Stephen J. Del Grosso, Lajpat R. Ahuja, and William J. Parton, Editors

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