

The Agricultural Modeling Intercomparison and Improvement Project (AgMIP) for evaluating agricultural impacts of and adaptations to climate change

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Keywords: models, impact assessment, climate change, ensembles, uncertainty

1. Introduction

The Agricultural Model Intercomparison and Improvement Project (AgMIP, www.agmip.org) is an international collaboration of scientists and stakeholders, with the aim of assessing climate impacts on food security and planning for a more resilient future for food production [1]. Participation in ongoing AgMIP activities, or the proposal of new activities, is open to all scientists.

AgMIP has a two-track approach toward its objectives (Fig. 1): the first is concerned with the methodology of climate impact assessment. Studies here concern interconnecting, evaluating and improving the agricultural and economic models required for impact assessment. The second track involves applications of the models, in order to evaluate climate change impact on future food production, trade and food security.

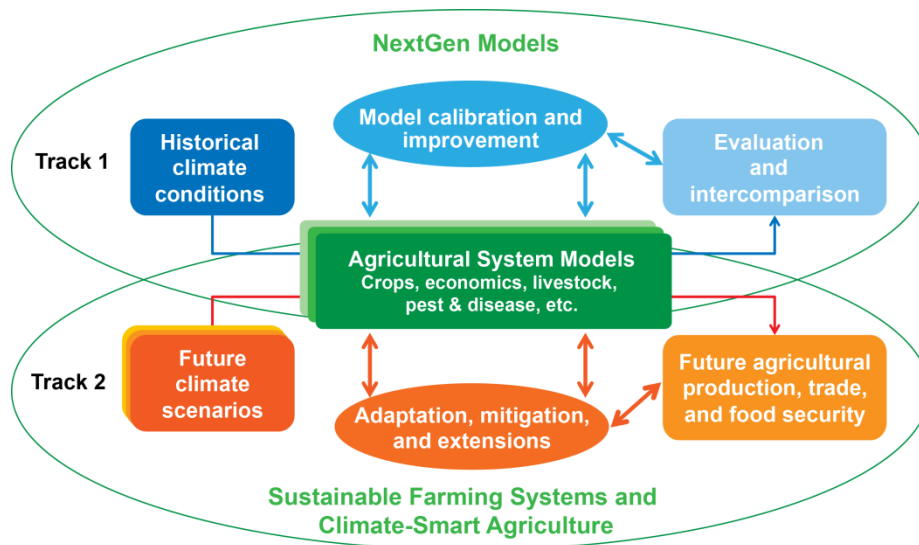


Fig. 1. The two track approach of AgMIP

Two innovative, defining characteristics of AgMIP are the emphasis on multi model intercomparison and the collaboration of multiple modeling disciplines. While multi-model intercomparisons have been a crucial aspect of climate research since 1989, they are much more recent in the field of crop modeling, and AgMIP has been the leading proponent of systematic large-scale crop model intercomparisons. By bringing together diverse modeling communities, including researchers involved in climate, crop, economic, pest and disease and livestock modeling, AgMIP has made it possible to produce impact assessments that are cutting edge in all of the disciplines involved.

2. AgMIP Activities

Fig. 2 shows the range of projects that are currently underway in AgMIP. We comment specifically on three petals of that diagram.



Fig. 2. Current AgMIP activities

2.1 Crop Model Intercomparison and Improvement

The crop model intercomparison and improvement projects are organized by crop species. Multiple crop modeling groups participate in each case. In a first step, multiple sites with observed data are identified. Then each model is used to simulate for those sites, using the same input information. The range of model results is an indication of model variability, and the discrepancy between models and observations is an indication of model reliability. Subsequent steps are concerned with comparing models for future climate, and model improvement.

Fig. 3 shows the results from the initial wheat pilot intercomparison study, with twenty seven modeling groups [2]. Simulated results were compared with observed results from four contrasting locations. In the first simulation protocol (low information), the modeling teams were provided with phenology data from each location in order to adjust the models to the wheat variety at that location. In the second protocol (high information), full data on crop performance from each location was provided, to allow more complete model calibration.

Two aspects of these results are of particular interest. First, there is substantial variability between models. This represents uncertainty in both model structure and in parameterization. Secondly, the average over models seems to be quite a good predictor. This was also found in the pilot projects for maize ([3] and rice [4].

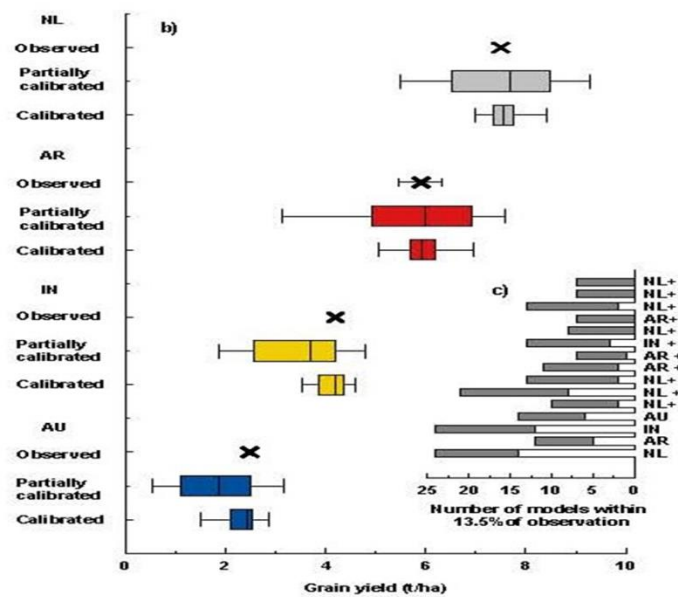


Fig. 3. Simulations with a multi-model ensemble of wheat models compared with observed data from four sites.

2.2 Regional Integrated Assessments

The UK Agency for International Development has financed a major AgMIP project centered on regional integrated assessment in Sub-Saharan Africa and South Asia (with teams in the Indo-Gangetic Basin, Pakistan, Southern India and Sri Lanka) [5]. In each case the teams include local climate scientists, agronomists and economists, who work with other AgMIP scientists. The first phase ran from 2011-2014. Each team chose one or two representative production systems, and addressed three questions related to the impact of climate change on yield and on livelihoods. First, how would yield and livelihoods change under climate change (mid-century versus baseline). Secondly, what would the change be if one takes into account trends in farming systems affecting prices, costs, availability of inputs, subsidies etc. Finally, how would future production be changed if adaptation measures were taken, such as changing sowing date or using better-adapted varieties. In each case at least two crop models were used, to obtain a preliminary measure of model uncertainty.

A major focus of the project has been on developing relationships with multiple national and regional stakeholders, including national agricultural ministries, non-governmental organizations, regional adaptation planners, extension agents and smallholder farming groups.

2.3 Cross-cutting Themes – Uncertainty

Running across all of the AgMIP work is the notion of uncertainty. Results are obtained by simulating with models, but of course simulated results will not in general be identical to true results. The difference between the two, considered in a probabilistic sense, is the uncertainty of the simulated results.

The uncertainty theme has two major objectives. The first is to aid the various projects for those aspects specifically related to uncertainty. The second is to identify and address new questions related to uncertainty in impact analysis. Emphasis has been on uncertainty in crop models, but it should be kept in mind that impact assessment involves an uncertainty cascade, from climate to crop to economic models.

One study in this theme considered the uncertainty when using the mean or median of a multi-model crop ensemble as a predictor. It was found that if one looks at multiple outputs, both the mean and median are better predictors than even the best individual model, and that the median is slightly better than the mean [6].

Impact assessments involve averages over years (average future production versus baseline) and also perhaps spatial averages. It is important then to understand how averaging affects model uncertainty, as compared to uncertainty for results for a single year and location. It was shown that averaging necessarily reduces prediction error, to an extent that can be estimated if one has an appropriate sample [7].

Model calibration (estimation of model parameters) is a major difficulty in crop modeling. To date most calibration work for crop models has focused on goodness-of-fit, but in statistical parameter estimation there is also emphasis on the uncertainty associated with the estimated parameters. The importance of evaluating the uncertainty in crop models was illustrated with a case study on rice in Sri Lanka [8].

3. Ways Forward

The next phase of AgMIP will focus on three areas. The first is coordinated global and regional multi-model assessments. Regional studies take into account local farming systems and socioeconomic conditions, and thus can provide detailed input information for simulations. Global gridded crop studies, which provide results in every spatial cell, can then be used for gap-filling and aggregation across regions. The regional and global production results will interact with regional and global economic models, which determine costs and prices.

The second area of emphasis is modeling for sustainable farming systems. Full understanding and credibility of global simulations for impact assessment require consideration not only of individual crops, but also cropping systems and pasture systems, and interactions between crops and soils and between crops and pests and diseases. AgMIP has enlarged to cover these topics.

The third area of emphasis is next generation knowledge products based on improved models and data. This will involve better testing and inter-comparison of existing models, not only crop models but also livestock and regional economic models. In parallel, there is a need for development and testing of individual modules that go into these models, and of strategies for integrating them into an overall model. Finally, there is a need for new IT tools for data archiving and retrieval, for multi-model comparisons and for visualization of model results useful to knowledge product developers and end-users.

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