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The Purdue Agro-climatic (PAC) dataset for the U.S. Corn Belt: Development and initial results

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ABSTRACT

This study is a result of a project titled "Useful to Usable (U2U): Transforming Climate Variability and Change Information for Cereal Crop Producers". This paper responds to the project goal to improve farm resiliency and profitability in the U.S. Corn Belt region by transforming existing meteorological dataset into usable knowledge and tools for the agricultural community.

A high-resolution agro-climatic dataset that covers the U.S. Corn Belt was built for the U2U project based on a Land Data Assimilation System (LDAS) framework. This data referred to as the Purdue Agro-climatic (PAC) dataset is a gridded, continuous dataset suitable for agroclimatic and crop model studies over the U.S. Corn Belt. The dataset was created at 4 km, subdaily spatiotemporal resolution and covers the period of 1981–2014. The dataset includes a range of variables such as daily maximum/minimum temperature, solar radiation, rainfall, evapotranspiration (ET), multilevel soil moisture and soil temperatures. The data were compared to field measurements from Ameriflux and the Soil Climate Analysis Network (SCAN), and with coarser but widely used atmospheric regional reanalysis data products. Validations indicate an overall good agreement between this dataset and field measurements. The agreement is particularly high for radiation and temperature parameters and lesser for rainfall and soil moisture data. Despite the differences with observations, the data show improvements over the coarser resolution products and other available models and thus highlights the value of the dataset for agroclimatic and crop model studies.

This high-resolution dataset is available to the wider community, and can fill gaps in observed data records and increase accessibility for the agricultural sector, and for conducting variety of if-then assessments.

1. Introduction

Agriculture is highly dependent on weather and climate. The U2U (www. Agclimate4u.org) project aims to "transform climate variability and change information for cereal crop producers" for improving the resiliency and profitability of farms

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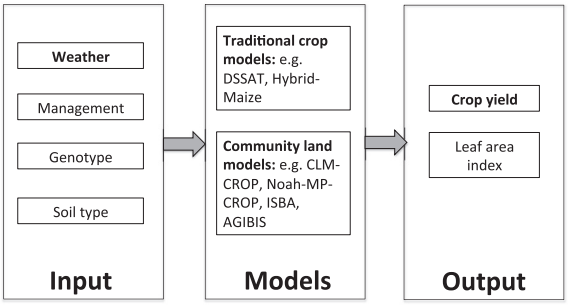

Fig. 1. Operational flow of large-scale crop modeling.

in the U.S. Corn Belt. This project seeks to deliver improved decision support tools, datasets and trainings. The U2U team is a diverse scientific group including climatologists, crop modelers, agronomists, economists, and social scientists (Prokopy et al., 2015). One of the objectives of climatologists and crop modelers group is to provide useful and usable dataset for users including crop modelers and producers (Niyogi and Andresen, 2011).

A majority of the agroclimatic assessments until now is based on point/field scale studies. Studies of food security under a changing climate and extreme weather, highlight an increasing demand for large spatial scale crop yield simulations (Hansen and Jones, 2000; Niyogi and Andresen, 2011; Rosenzweig et al., 2013; Takle et al., 2014; McDermid et al., 2015). As a result, a growing number of studies have been conducted on largescale crop simulations using traditional crop models (e.g., Rosenzweig et al., 2014; Elliott et al., 2014; Liu et al., 2015).

Fig. 1 summarizes the building blocks and the operational flow of such regional largescale simulations. Generally, the input data comprises of four groups: (i) weather (e.g. air temperature, solar radiation and precipitation), (ii) management practices (planting date, plant population and irrigation), (iii) plant genotype and (iv) regional soil texture and characteristics. These data are provided/needed at grid-by-grid basis across the study domain to the different crop simulation models. The models being run are either statistical models (e.g. Lobell et al., 2008) or traditional crop models, such as DSSAT (Jones et al., 2003), Hybrid-Maize (Yang et al., 2004), or part of land modeling system such as CLM-Crop (Drewniak et al., 2013), Noah-MP-Crop (Liu et al., 2016), ISBA (Garrigues et al., 2015), Agro-IBIS (Kucharik, 2003), ISAM (Song et al., 2013). The typical output of interest from these models are the crop yield, leaf area index, and evapotranspiration. The availability and usability of current input datasets however, are inadequate to fill the increasing demand for high spatiotemporal resolution regional crop simulations (Rosenzweig et al., 2013).

In this paper, we focus on one particular aspect of the data needs, those related to the weather input dataset. The regional agro-meteorological applications are often constrained by the spatially discontinuous meteorological data from regular weather stations. Further, the application of crop models is often limited by lack of hydro-meteorological input data, such as solar radiation, soil moisture and evaporation/transpiration. These variables are not routinely available from weather stations except for specific experimental field programs. The representation of spatial heterogeneity of weather and climate information is important for regional crop modeling (Doering, 2002; Niyogi et al., 2015). As a result, most models are run with default values or approximations based on empirical rules, and highlight the need for a high-resolution spatial, agro-climate dataset.

The climate community widely relies on reanalysis datasets that blend observations with detailed models in creating the gridded products (e.g. Kalnay et al., 1996; Mesinger et al., 2004). These reanalysis products are available as a scientific resource to the atmospheric community for a wide range of applications, and have also been a source of meteorological input for crop models studies. These datasets while suitable for large scale dynamical studies are generally too voluminous to store locally and too coarse for regional scale crop studies. Further, these data are not easy to use or work with for lay users (see for e.g. Table 1). Additionally, it is also difficult to extract the necessary data that is needed as an input for regional studies. Hence, an outstanding issue has been: how do we make these datasets useable for the broader agroclimate community, and crop modelers, more specifically?

Table 1
Examples of current reanalysis datasets (Including PAC dataset in this study).

Dataset	Time period	Highest Temporal resolution	Spatial Coverage	Typical Spatial resolution (Approximately)	Reference
NARR	1979–2015	3 h	North America	32 km	Mesinger et al. (2004)
MERRA-2	1980–present	3 h	Global	50 km	Rienecker et al. (2011)
NLDAS-2	1979–present	Hourly	North America	12 km	Mitchell et al. (2004)
AgMERRA	1980–2010	Daily	Global	27 km	Ruane et al. (2015)
Daymet	1980–2015	Daily	North America	1 km	Thornton et al. (2016)
PAC	1980–2014	Sub-daily	U.S. Corn Belt	4 km	This study

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