C02: Agrometeorological and Satellite derived Decision Support Tools for Agriculture in a Changing Climate

Conveners: Andrew Nadler, Manasah Mkhabela and Yinsuo Zhang

Co-chairs: Andrew Nadler[1], Manasah Mkhabela[2] and Yinsuo Zhang[3]

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Session Description

Advanced satellite imagery and weather monitoring technologies have enabled the timely monitoring of crop and environmental conditions in near-real-time and to adopt decision support tools that assist with *crop management and environmental sustainability*. These tools are becoming more sophisticated as the industry continues to invest in the application of these tools, from precision agriculture at the farm level to yield forecasting at regional and global levels. This session will review the trends in technologies and tools that utilise agrometeorological and satellite (remote sensing) derived inputs for on-farm precision farming and decision making across all scales. The session will also cover/ demonstrate the use of these technologies and tools across all scales for crop growth monitoring/modelling, disease/pest prediction and monitoring and yield forecasting under extreme variable weather and a changing climate.

Primary Affiliation: CSAFM

NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE MAY BE SUBJECT TO CHANGE.

ORAL SESSION C02a

Chairs: Andrew Nadler, Manasah Mkhabela & Yinsuo Zhang **Room: GEOG 100**

Wednesday, May 31st

TIME	AUTHORS	TITLE
11:00	Tao Li, Tri Deri Setiyono, Tianyi Zhang, Samaredu Mohanty, Manuel Marcaida III, Emmali Manalo	Enabling ORYZA to use remote sensing data for real-time crop growth monitoring and accurate yield prediction
11:15	Antoun El Khoury*, Catherine Champagne, Bahram Daneshfar, Yinsuo Zhang, and Ousmane Seidou	Identifying, evaluating and mitigating the impact of drought and excess moisture on agriculture in Canada under current and future climate using DSSAT model
11:30	Yinsuo Zhang, Bahram Daneshfar, Aston Chipanshi, Catherine Champagne, Andrew Davidson and Jacob Mardian	Forecasting Canola Yield at Township Scale in the Canadian Prairies Using Earth Observation-Based Data
11:45	Manasah S. Mkhabela , Paul R. Bullock and Harry D. Sapirstein	Characterising the most critical climatic parameters that impact wheat quality on the Canadian Prairies using Partial Least Square (PLS) analysis
12:00	Pierre-Yves Gasser, Scott Smith, Michael Bock, Peter Schut and Denise Neilsen	Investigating the Impact of Future Climate Scenarios on Small Grain Production in Peace River AB using the Land Suitability Rating System
12:15	Yinsuo Zhang, Bahram Daneshfar, Aston Chipanshi, Lauren Koiter, Catherine Champagne, Andrew Davidson, Tommy Gui, Benjamin Deschamps, Frederic Bedard and Gordon Reichert	Development of the Crop Extent Maps for Major Canadian Crops and their Application in Earth Observation-Based Crop Yield Forecasting

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SUBMITTED ABSTRACTS

C02-01: Enabling ORYZA to use remote sensing data for real-time crop growth monitoring and accurate yield prediction

Tao Li[1], Tri Deri Setiyono[1], Tianyi Zhang[2], Samaredu Mohanty[1], Manuel Marcaida III[1], Emmali Manalo[1]

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Abstract
ORYZA is a widely used process crop model for simulating rice growth dynamic and predicting yield under various production environments. Model parameterization is a key constraint for applying ORYZA at the scale beyond field level. Additional functions were integrated to use periodic remote sensing data to improve the model's capability in rice growth monitoring and yield forecasting at the regional scale. The remotely sensed data assimilated into ORYZA include: (1) cultivated rice area, (2) planting and flowering dates, (3) leaf area index (LAI), and (3) status of soil water. At regional scale, soil data were obtained from global and national soil database. Daily weather data for pre-forecast dates were obtained from national meteorological stations, NASA real-time weather database, and NCEP database while those for onward dates were derived from an analog forecast based on historical weather data and seasonal weather outlook. The in-season growth and yield forecast of ORYZA were resumed from the planting to the maturity of the crop as long as remote sensing data were available at any time during the growing season. The remotely sensed data were used to adjust model input parameters and the daily growth rates of biomass accumulation and assimilate allocation among plant organs. Simulation accuracy for the final grain yield can be improved significantly after 5 to 7 replications. The validation studies showed that yield prediction accuracy was 81 to 93% at regional scale, while at field level it reached 94%. The system of ORYZA with enabled remote sensing data assimilation does not need intensive model parameterization and can achieve real-time crop monitoring goal and has the potential for effectively monitoring rice growth and forecasting yield from plot to regional scales. Such real-time crop growth information is beneficial for in-season crop management advisory to reduce the impacts of unfavorable climatic extremes.

Presentation type: Oral Presentation

C02-02: Identifying, evaluating and mitigating the impact of drought and excess moisture on agriculture in Canada under current and future climate using DSSAT model

Antoun El Khoury[1,2]* , Catherine Champagne[1] , Bahram Daneshfar[1] , Yinsuo Zhang[1] , and Ousmane Seidou[2]

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Abstract
Drought and floods are natural hazards that occur under unusual weather conditions and can have significant impacts on natural systems and human activities, including agriculture. Drought and floods are expected to become more frequent and intense in arid and semiarid regions of western North America. Studies revealed that future climate change will likely affect crop production in the northern and mid-latitude countries with positive or negative impacts, and negative impacts are more likely expected to occur in the low latitude countries. Early crop yield forecasting models can play an effective role in reducing the impacts of climate variability on agriculture at the field scale. The objective of this research is to use DSSAT (Decision Support System for Agrotechnology Transfer) to simulate canola growth (measured indirectly by Leaf Area Index and Plant Area Index) and yield (as biomass and seed) in 192 townships located in the Canadian Prairies. These townships were selected because they are among the largest canola producers in the Canadian Prairies and have contrasting moisture and drought conditions. DSSAT is a crop simulation model that is coupled with soil, weather, and crop management databases, and allows for the simulation of over 42 crops (as of version 4.6). The Cropping System Model (CSM)-CROPGRO-Canola model will be used in this work to simulate the growth, development, and yield of canola in the study area. Various statistical analyses will be applied to evaluate the performance of DSSAT in simulating canola yield on different types of soil and compare its outputs to observations. Linking the low/high soil moisture to its relative crop productivity through DSSAT will lead to a better diagnosis of the crop productivity variation causes. It will also help to identify possible impacts of climate change on canola productivity in Canada and can assist policymakers to implement adequate mitigation approaches.

Presentation type: Oral Presentation

C02-03: Forecasting Canola Yield at Township Scale in the Canadian Prairies Using Earth Observation-Based Data

Yinsuo Zhang[1], Bahram Daneshfar[1], Aston Chipanshi[1],
Catherine Champagne[1], Andrew Davidson[1] and Jacob Mardian[1, 2]

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Abstract
During the last decade, crop yield forecasting models have been developed using increasingly available Earth Observation (EO)-based data. The Canadian Crop Yield Forecaster (CCYF) is one such modelling tool designed to provide regional and national crop yield outlooks during and shortly after the growing season. The CCYF integrates climate, soil and satellite derived indices of vegetation health and environmental stresses using a statistical yield forecasting model. Currently, the smallest modelling unit for CCYF is the Census Agricultural Region (CAR) which represents the smallest official reporting unit of crop statistics by Statistics Canada. Census Agricultural Regions vary in size and normally cover a large geographical area. Within a single CAR polygon, crop yields and their responses to environmental factors can vary considerably. It is thus desirable to have yield models at scales smaller than CAR, in order to capture the sub-CAR yield variation. In this study, the CCYF was calibrated to forecast canola yield at township scale in the Canadian Prairies. The township (~10x10 km) canola yields were derived by interpolating and aggregating the field level (~800x800 m) crop insurance data across the townships. The predictor variables were selected from the 250m resolution MODIS derived NDVI, the 10km gridded climate variables (temperature and precipitation) and their derivatives, and other derived or integrated EO datasets (e.g. satellite derived soil moisture, modelled water stress indices and EO-based evaporative indices). The preliminary results showed that the forecasting skill of canola yield at the township scale is comparable or better than the skill at CAR scale, although the model building data at township scale had a much shorter record than that at the CAR scale. This promising result will be tested further with other crops and extended to other agricultural landscapes of Canada.

Presentation type: Oral Presentation

C02-04: Characterising the most critical climatic parameters that impact wheat quality on the Canadian Prairies using Partial Least Square (PLS) analysis

Manasah S. Mkhabela[1] , Paul R. Bullock[1] and Harry D. Sapirstein[2]

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Abstract

The Canadian Prairies experience a wide range of growing season weather conditions, which consequently have a major impact on wheat quality. The main objective of this study was to characterise agro-climatic parameters that impact spring wheat quality using partial least squares (PLS) analysis. Agronomic and weather data collected from several wheat trials in Manitoba and Saskatchewan from 2003 to 2006 were utilised in the study. Fifty-three (53) agro-climatic parameters (predictor variables) were derived from the agronomic and weather data and used in the PLS analysis. Wheat quality characteristics including Grain Protein Content (GPC), Farinograph Absorption (FarAB), Dough Development Time (DDT) and Loaf Volume (LVol) for two varieties (AC-Barrie and Superb) were used as the response variables. Wheat quality data for AC Barrie were used to develop the PLS models, which were in-turn used to predict quality characteristics for Superb. Results showed that 3 separate 3-variable PLS models explained 83% of variability in GPC, 80% of variability in DDT and 69% of variability in LVol, respectively. Meanwhile, a 4-variable PLS model explained 82% of the variability in FarAB. When the developed PLS models were used to predict quality characteristics for the variety Superb, the overall average of the predicted values were not significantly different ($p>0.05$) from the overall average of the observed values for all quality characteristics except for FarAB. Predicted values correlated well with observed values with R^2 values ranging from 0.69 for LVol to 0.96 for GPC, indicating that the PLS models accounted for 69 to 96% of the variability in the various wheat quality characteristics. The mean bias error (MBE) for GPC was zero indicating perfect model simulation. MBE values for all the other quality characteristics were negative suggesting underestimation of these quality characteristics. These results may imply that only GPC is directly affected by growing-season weather conditions.

Presentation type: Oral Presentation

C02-05: Investigating the Impact of Future Climate Scenarios on Small Grain Production in Peace River AB using the Land Suitability Rating System

Pierre-Yves Gasser[1], Scott Smith[2], Michael Bock[3], Peter Schut[1] and Denise Neilsen[2]

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Abstract
The Land Suitability Rating System (LSRS) is a spatial modeling tool that generates a class rating for individual parcels of land for specific agricultural field crops based on a soil-climate-landscape potential. LSRS draws information from the Canadian Soil Information Service (CANSIS) soil name and layer tables, a crop parameter table and monthly normal temperature and precipitation values to generate a land rating where class 1 is fully suitable and class 7 is unsuitable for the concerned crop. The system has traditionally been used to evaluate land suitability under current climate conditions. However, with climate change scenario data now readily available across the country we used LSRS to predict future changes in land suitability for spring seeded small grains in the Peace River district of Alberta. To evaluate the sensitivity of LSRS to varying climate inputs, we used two historical baseline (1951-1980, 1981-2010) and three future time periods (2011-2040, 2041-2070, 2071-2100). Future projections giving a range of normal to hot and wet to dry scenarios were derived from six General Circulation Models (GCMs) covering two Representative Concentration Pathways (RCP 4.5 and RCP8.5) High resolution (1000 m grid) monthly temperature and precipitation values were linked to the individual polygons of a detailed (1:20,000 scale) soil map. Soils were ranked by texture and taxonomic groupings in their susceptibility to changing climate conditions. Total hectares of ranked soils were tallied and mapped. LSRS effectively integrated multiple soil, climate and landscape factors to illustrate that land suitability will be affected by both temperature and precipitation changes with a general trend (five of six models) toward increasing requirement for irrigation in order to maintain optimum cereal production in the coming century.

Presentation type: Oral presentation

C02-06: Development of the Crop Extent Maps for Major Canadian Crops and their Application in Earth Observation-Based Crop Yield Forecasting

Yinsuo Zhang[1], Bahram Daneshfar[1], Aston Chipanshi[1], Lauren Koiter[1, 2], Catherine Champagne[1], Andrew Davidson[1], Tommy Gui[1, 2], Benjamin Deschamps[1], Frederic Bedard[3] and Gordon Reichert[3]

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Abstract
Crop extent maps are essential map layers in Earth Observation (EO) based crop yield forecasting. These maps are used to improve the skill of crop yield forecasting by limiting the analysis area to where the target crop has been dominantly grown. The availability of high resolution EO derived crop maps allows for improved delineation at regional and national scales of crop area and extent and thus has facilitated more precise masking of model inputs. In this study, a set of crop extent maps for five major Canadian crops (wheat, barley, canola, corn and soybeans) were created based on annual crop inventory maps and statistical surveys of crop area at the Census Agricultural Region (CAR) level. These crop extent maps were used to extract crop yield predictor variables in the Canadian Crop Yield Forecaster (CCYF), a regional crop yield forecasting tool. Two simulation experiments were conducted by using two types of crop extent maps: (1) a generalized cropland extent map (one map for all crops) and (2) a crop specific extent map (one map for each crop). The forecasted yield outputs from the two types of crop extent maps were evaluated by comparing the Bravais and Pearson coefficient of determination and root mean squared errors computed using a Leave-One-Out-Cross-Validation procedure (LOOCV). The analysis was conducted at three spatial scales: CAR, province and national. Improvements in the yield forecast skill were observed when a crop specific extent map was used for all crops in specific regions and at certain spatial scales. Among the five studied crops, only the soybean yield model showed consistent improvement at all scales and for most of the soybean growing regions. For spring wheat, canola, barley and grain corn, improvements were found mostly in regions where the crop is sparsely distributed or clustered.

Presentation type: Oral presentation