Development of agricultural drought indices, evaluation of PAMII moisture and ET estimates and crop yield forecasting on the Canadian Prairies using MODIS-NDVI data

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Objectives

- **Identify drought indices that correlated closely with Canadian Prairie spring wheat yield and several quality parameters**
  - Agricultural and Forest Meteorology, 2010, 150(3): 399-410

- **Validate and if necessary modify the soil water component of PAMII for spring wheat using detailed soil water and meteorological data obtained from five different sites in MB and SK**
  - Canadian Journal of Soil Science, will be published in August 2010 Issue

- **Compare spring wheat ET estimates from PAMII1+2 to those obtained using the FAO56 Penman-Monteith and a simplified water balance method**
  - Agricultural Water Management, In Review

- **Evaluate the possibility of using new Moderate Resolution Imaging Spectroradiometer (MODIS)-NDVI data to forecast crop yield on Canadian Prairie and identify the best period for making reliable yield forecasts**
  - Agricultural and Forest Meteorology, In Review
METHODS
Crop Yield and Area Data

- 1976-2006 crop yield data for 40 CAR from Statistics Canada
- Crops: Wheat, Canola, Barley and Field Peas
- Peas from 1987
- 4 crops represent 75% of total area harvested over 1997-2006 period

Census Agriculture Regions (CAR) of the Prairie Provinces
Census Agricultural Regions (CAR) and Annual Crop Areas of Western Canada

Sub-humid CAR
Semi-arid CAR
Sub-arid CAR
Annual Crop Area
MODIS-NDVI Data

- Dekadal MODIS-NDVI data for Prairie window from Canada Centre for Remote Sensing
- NDVI data covered 2000-2006 May-August
- Crop Cover Mask for annual crops from Statistics Canada
- Extracted mean NDVI for cropped area in each CAR
- \[ \text{NDVI} = \frac{(\text{NIR} - \text{RED})}{(\text{NIR} + \text{RED})} \]
Statistical Analysis

- Correlation and Regression analysis:
  - Dekadal NDVI versus Crop Yield (each crop each CAR and Agro-Zone)
  - Also $\sum$NDVI data (2, 3 or 4 dekads) with highest $r$ values
  - Model performance tested using root mean square error (RMSE) and mean bias error (MBE)
Results
Evolution of correlation coefficient
Relationship between NDVI and Wheat Yield

\[ R^2 = 0.47 \]

\[ R^2 = 0.63 \]

\[ R^2 = 0.80 \]
Relationship between NDVI and Canola Yield

![Graph showing the relationship between NDVI and canola yield with different R² values for SUB HUMID (R² = 0.49), SEMI ARID (R² = 0.82), and ARID (R² = 0.32).](graph.png)
Relationship between NDVI and Barley Yield

![Graph showing the relationship between NDVI and Barley Yield. The graph includes data for different climate zones: SUB HUMID, SEMI ARID, and ARID. The R² values for each region are 0.48, 0.56, and 0.90 respectively.](image-url)
Relationship between NDVI and Peas Yield

Peas Yield

NDVI

Yield (kg ha\(^{-1}\))

0
500
1000
1500
2000
2500
3000
3500
4000

SUB HUMID
SEMI ARID
ARID

\(R^2=0.53\)

\(R^2=0.89\)

\(R^2=0.71\)
Summary

- **Best Prediction @ flowering-grain filling stage:**
  - **Sub Humid Zone:** 3rd Dekad June - 3rd Dekad July
  - **Semi Arid and Arid Zones:** 1st Dekad July - 1st Dekad August

- **$R^2$ values:**
  - Generally highest in Semi Arid and lowest in Sub-humid for all crops
  - **Wheat:** 0.47-0.80 (RMSE 6-34%)
  - **Canola:** 0.32-0.82 (RMSE 10-58%)
  - **Barley:** 0.48-0.90 (RMSE 8-25%)
  - **Field Peas:** 0.53-0.89 (RMSE 10-38%)

- **Yield forecasts ~2 months before harvest**

- **57/84 (~70%) of predicted yields within ± 10% of actual yield**

- **Further work:** Combine NDVI with ET and SPI
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