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Assessment of potential agricultural management strategies to adapt to climate variability and climate change in Canada

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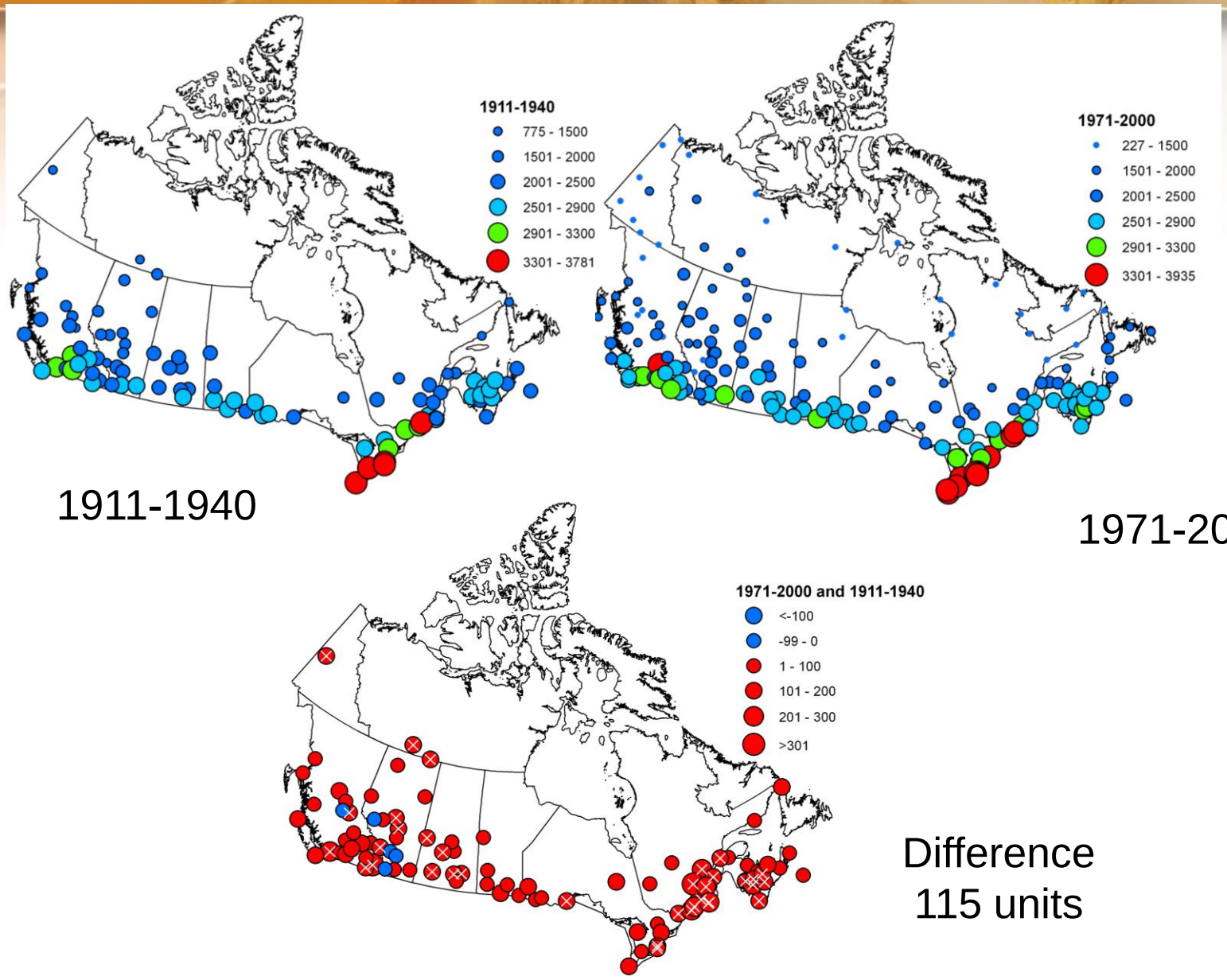
Canada

Overview

1. Historical trends in climate
2. Development and parameterization of DNDC_Canada model
3. Methods for simulating the effects of agricultural management on yield and GHG emissions under a variable climate
4. Projections of crop production in Canada
5. Projections of GHG emissions

Long-term trends (CHU)

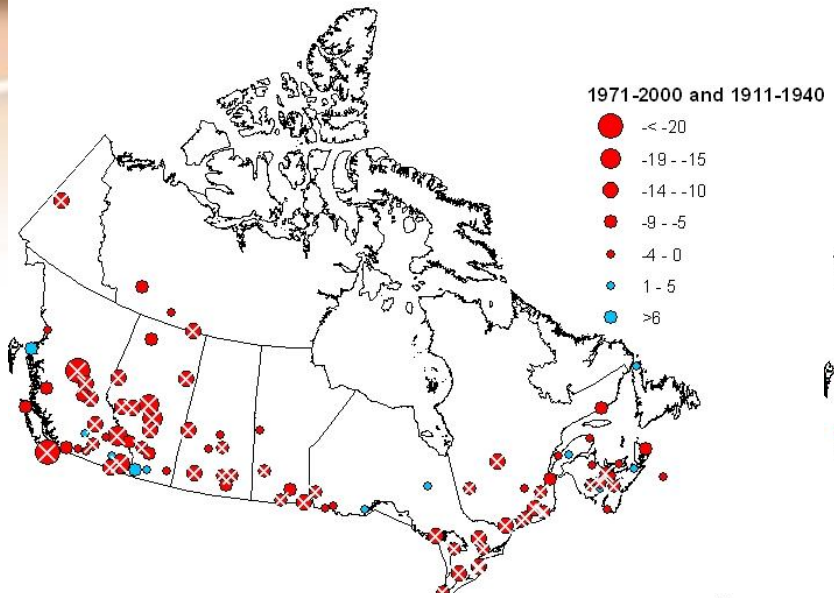


1911-1940

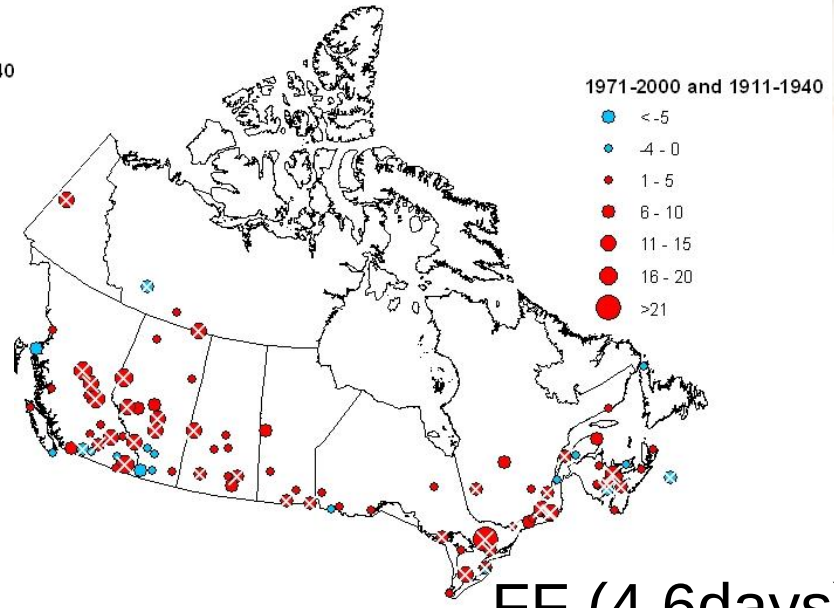
1971-2000

Difference
115 units

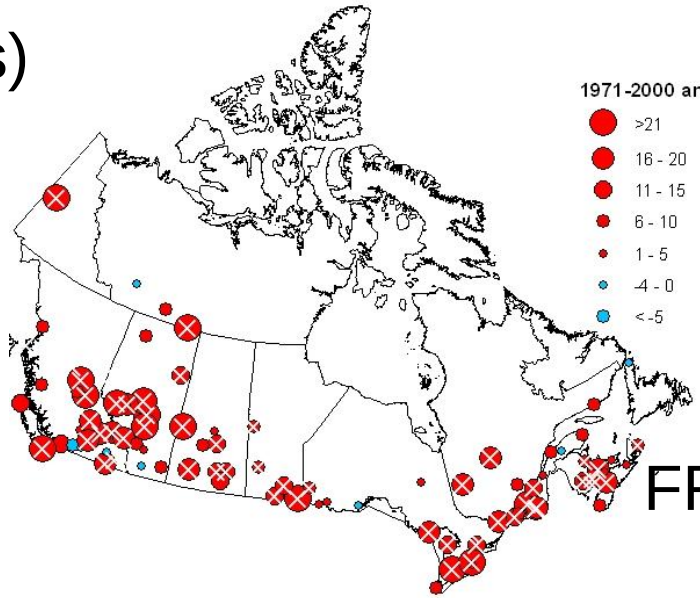
Long-term trends (SF, FF, FFD)



SF (-6.9days)
In average

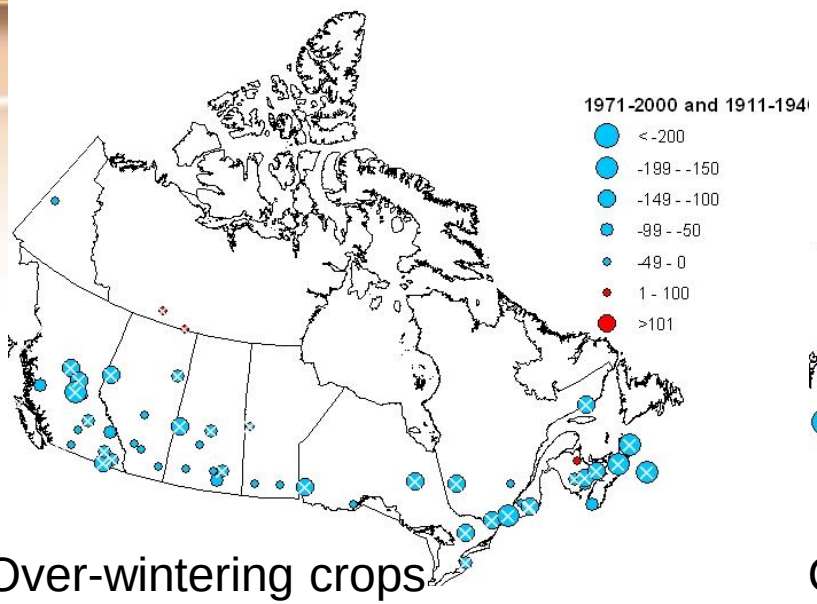


FF (4.6days)

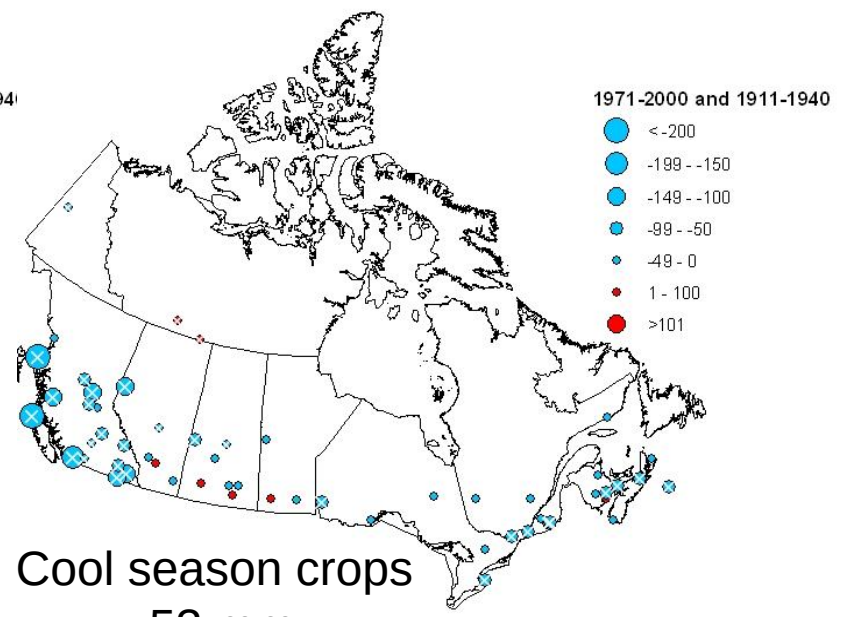


FFD (11.4days)

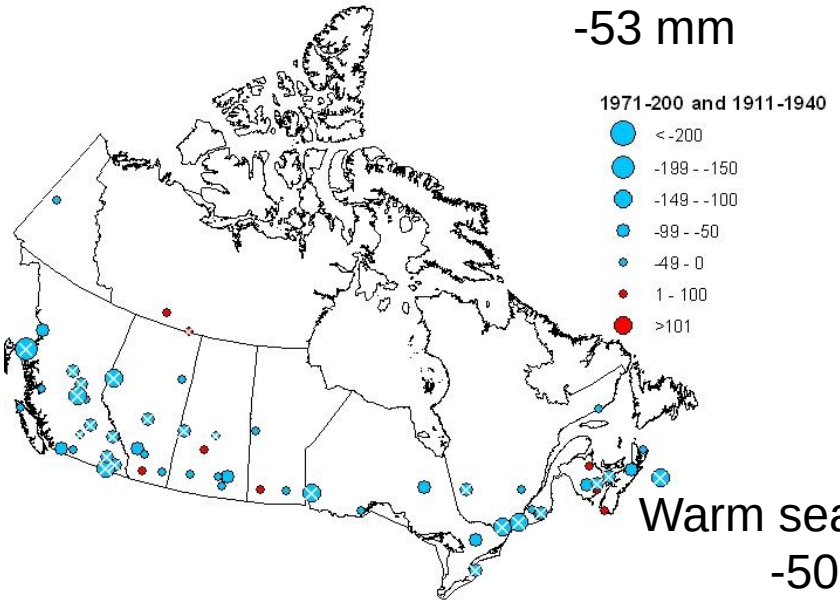
Long-term trends (WD)



Over-wintering crops
-92 mm

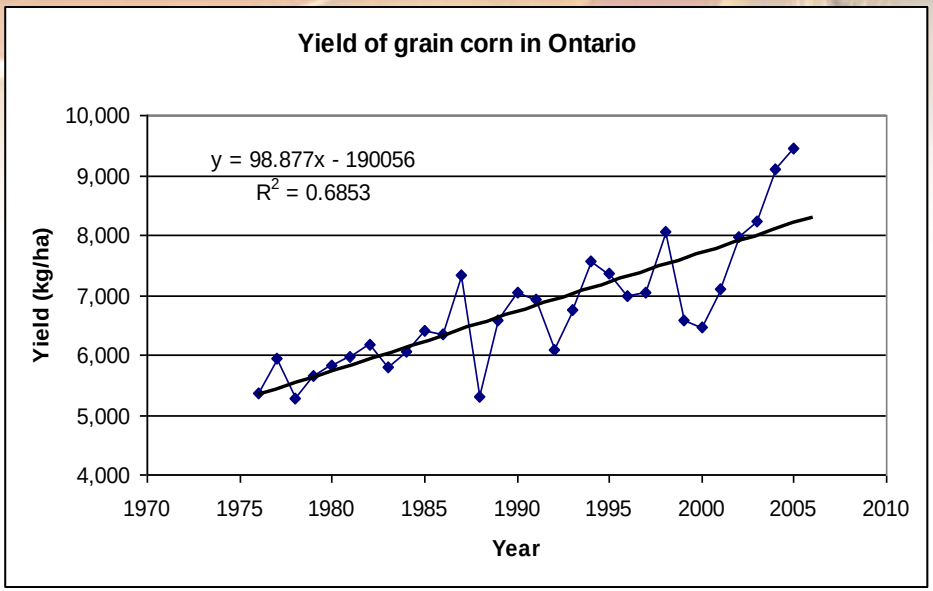


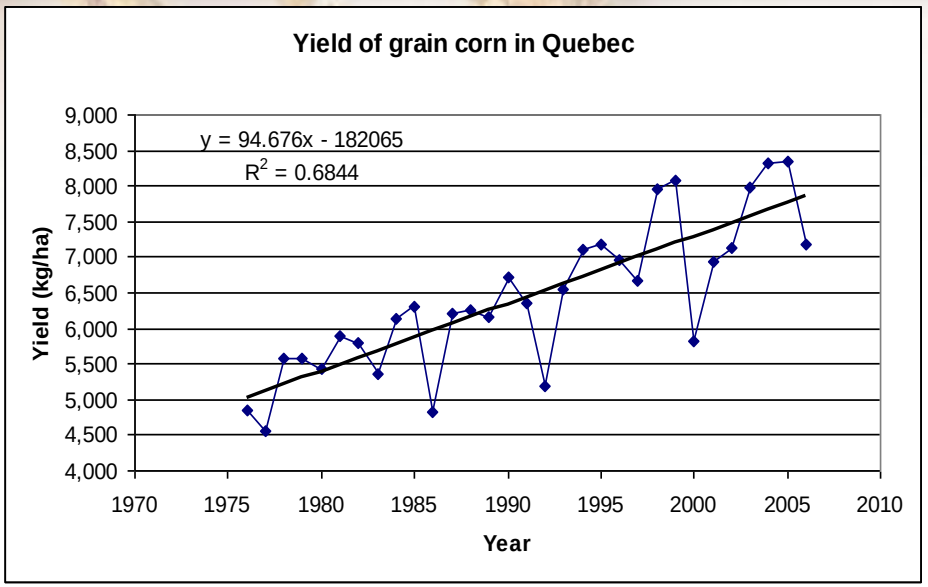
Cool season crops
-53 mm



Warm season crops
-50 mm

Historical trends in corn yield for Eastern Canada

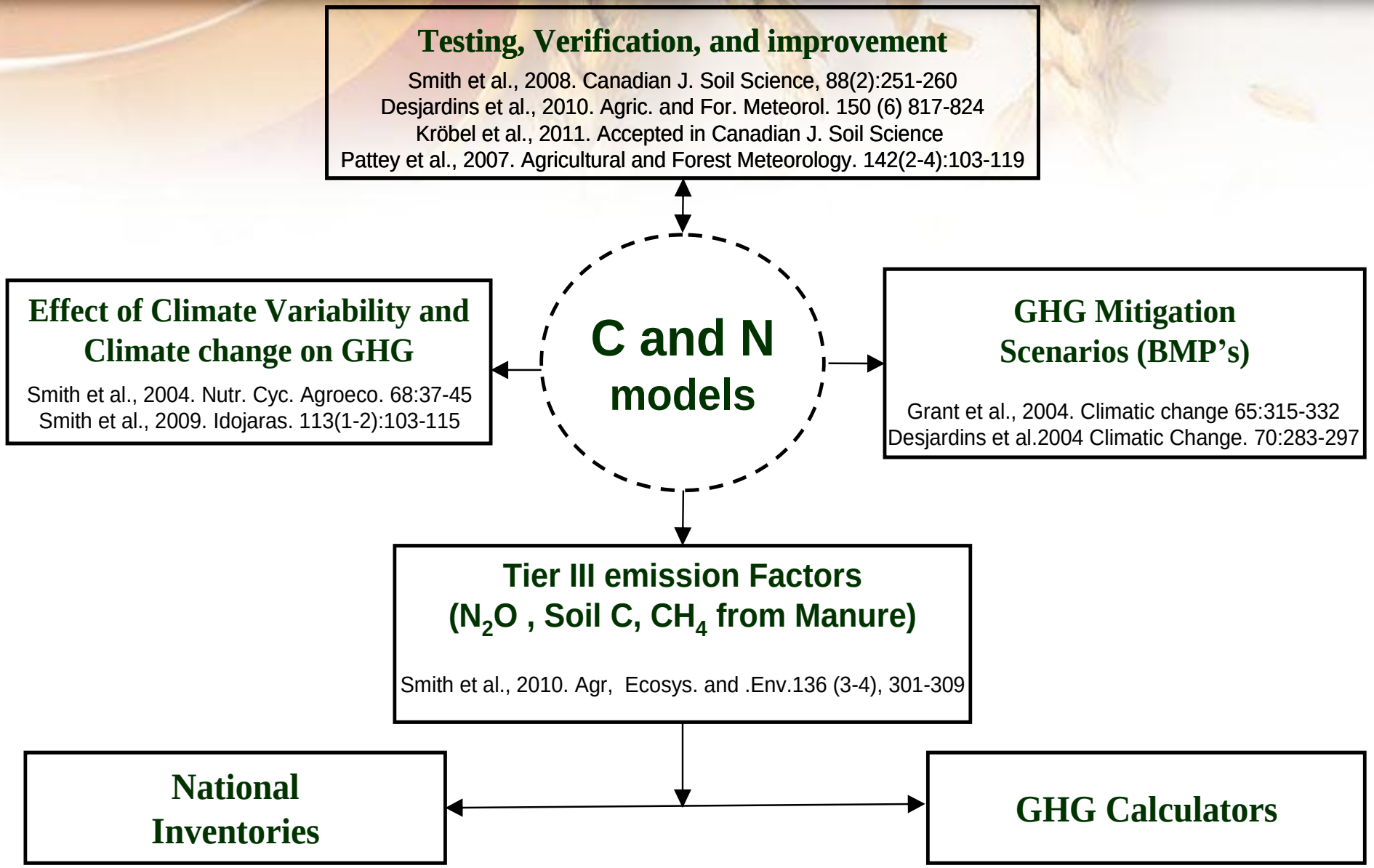




Trends of increased yield are primarily attributed to

- Improved management (tillage, erosion control, pest control, drainage, and irrigation)
- Development of new crop varieties that need less crop heat units
- Climate change as growing season is getting longer with more available Crop Heat Units

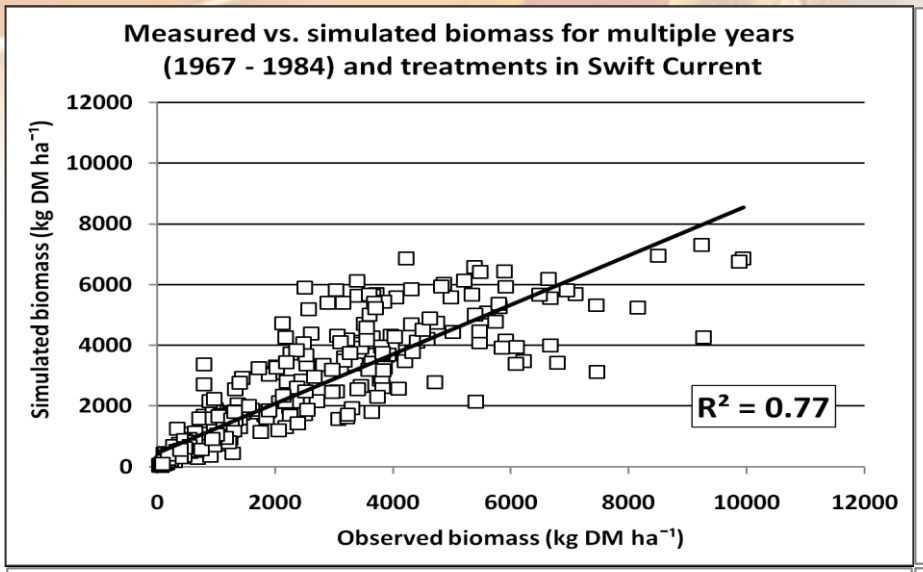
Development of improved process-based models to better estimate crop biomass production and GHG emission intensities from agroecosystems

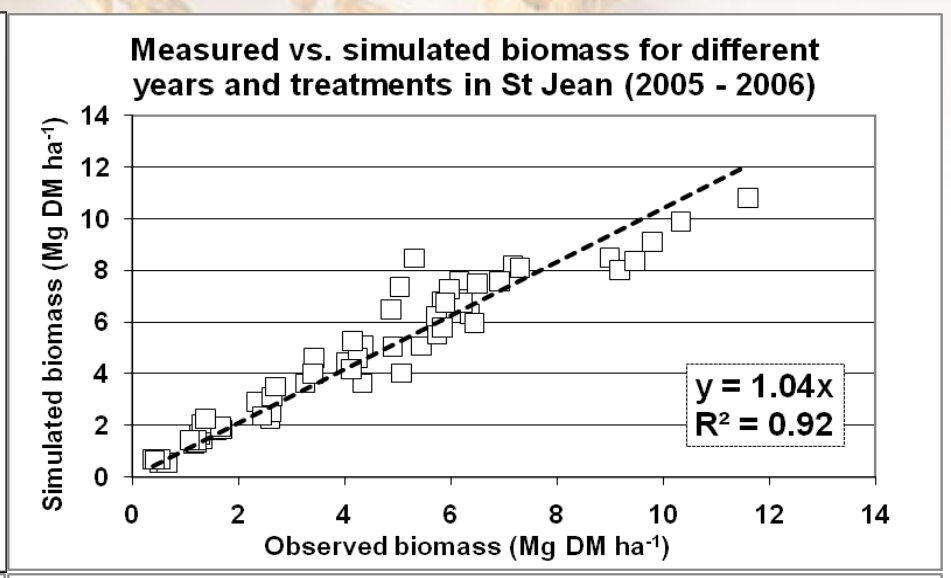


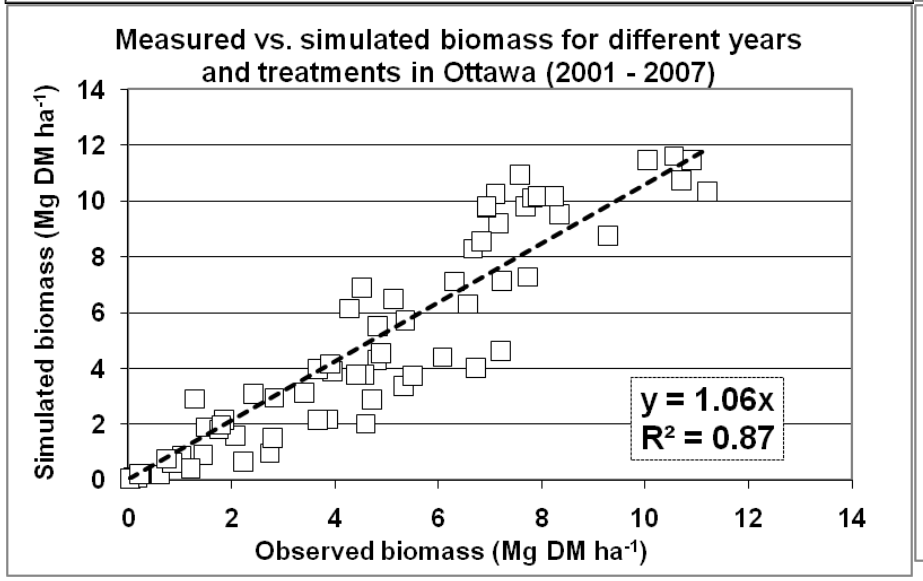
Developments of the DNDC_Canada model

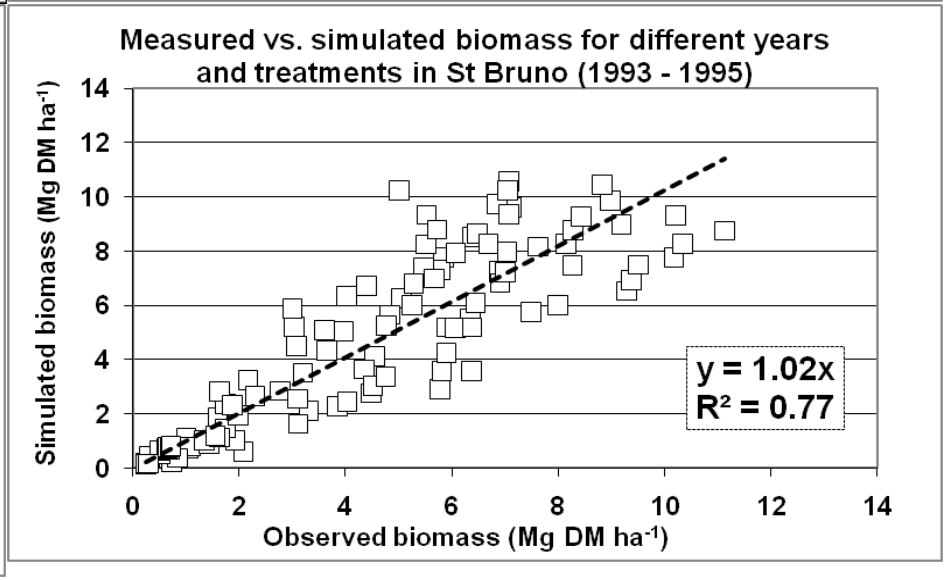
- Developed new Canada specific crop growth submodel
  - modified empirical growth curve
  - dynamic biomass fractioning
  - new routine for root growth and development
  - dynamic plant C:N ratios
- Added an equation to limit evaporation based on residue cover
- Developed a routine to bury crop residue
- Included a function to improve effect of temperature stress on plant growth
- Included cold damage for over wintering crops
- Enabled non-linear increases in atmospheric CO_2 concentrations
- Added an auto-fertilization routine

DNDC biomass simulations

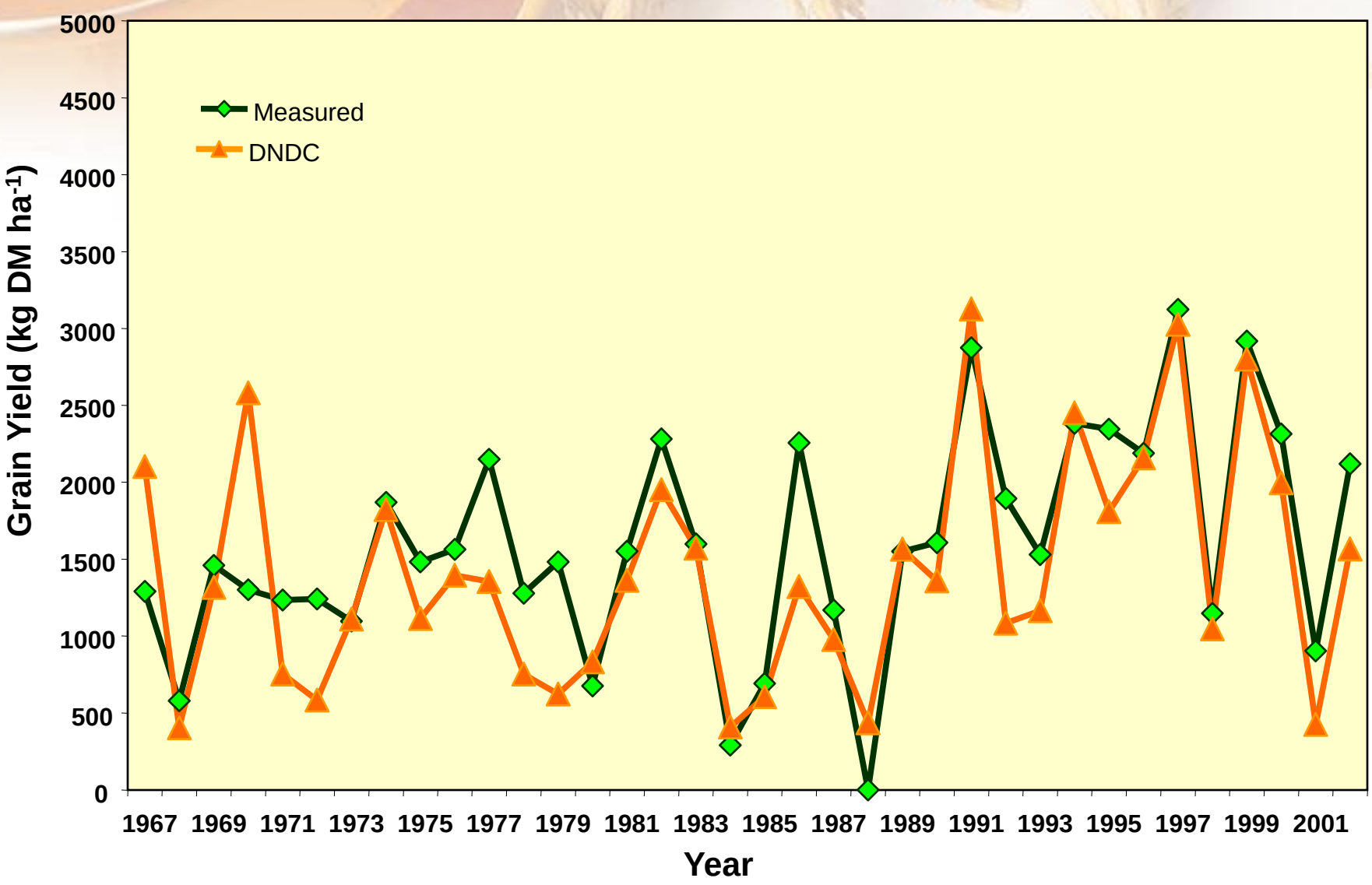






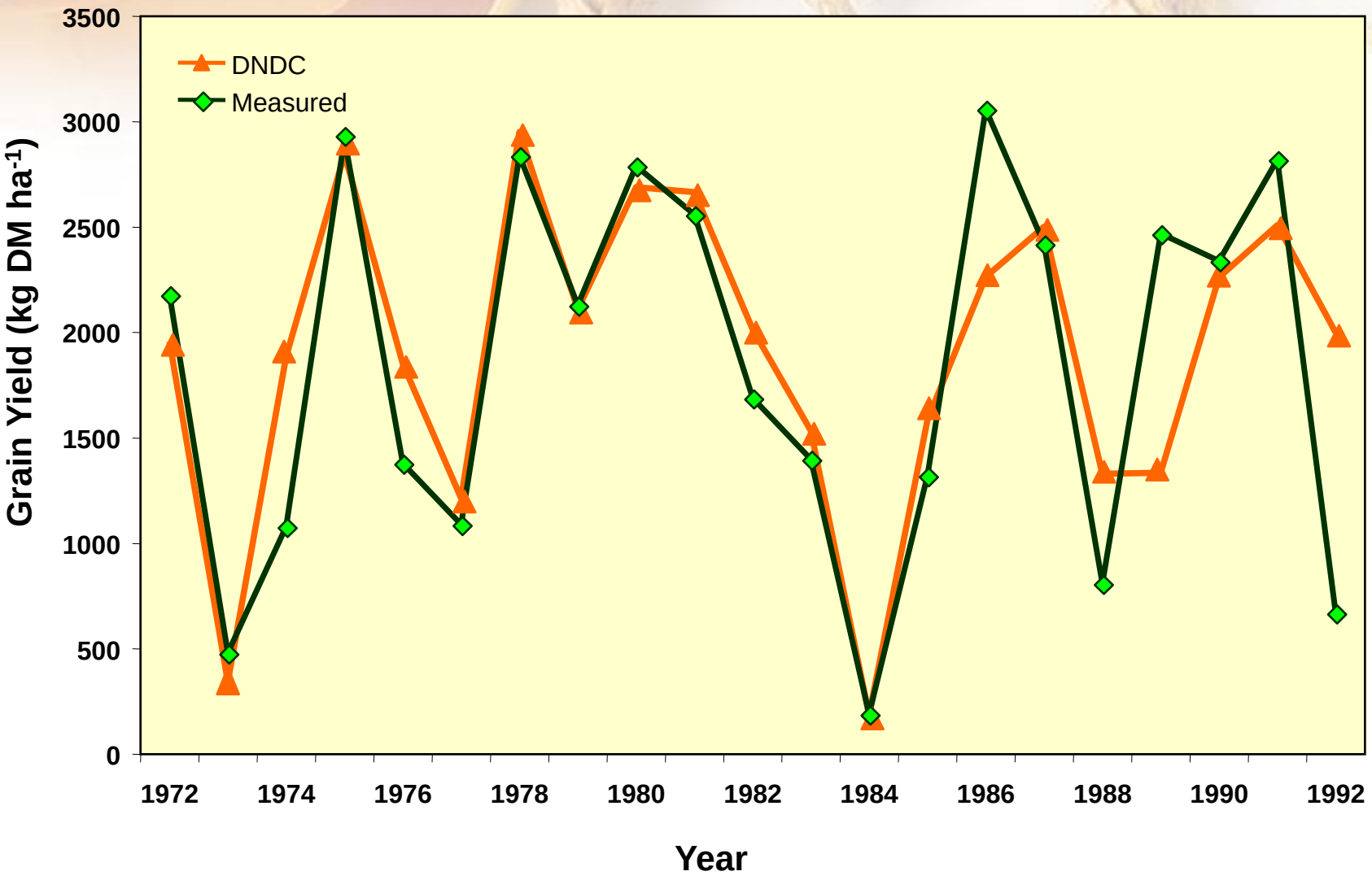


Estimated Grain Yields for fertilized wheat: Swift Current, SK (semi-arid)



Estimated grain yields for fertilized wheat

Lethbridge, Alberta (Dark Brown Chernozem)



Modeling approach to simulate the effects of future climate projections on agricultural systems

Objective

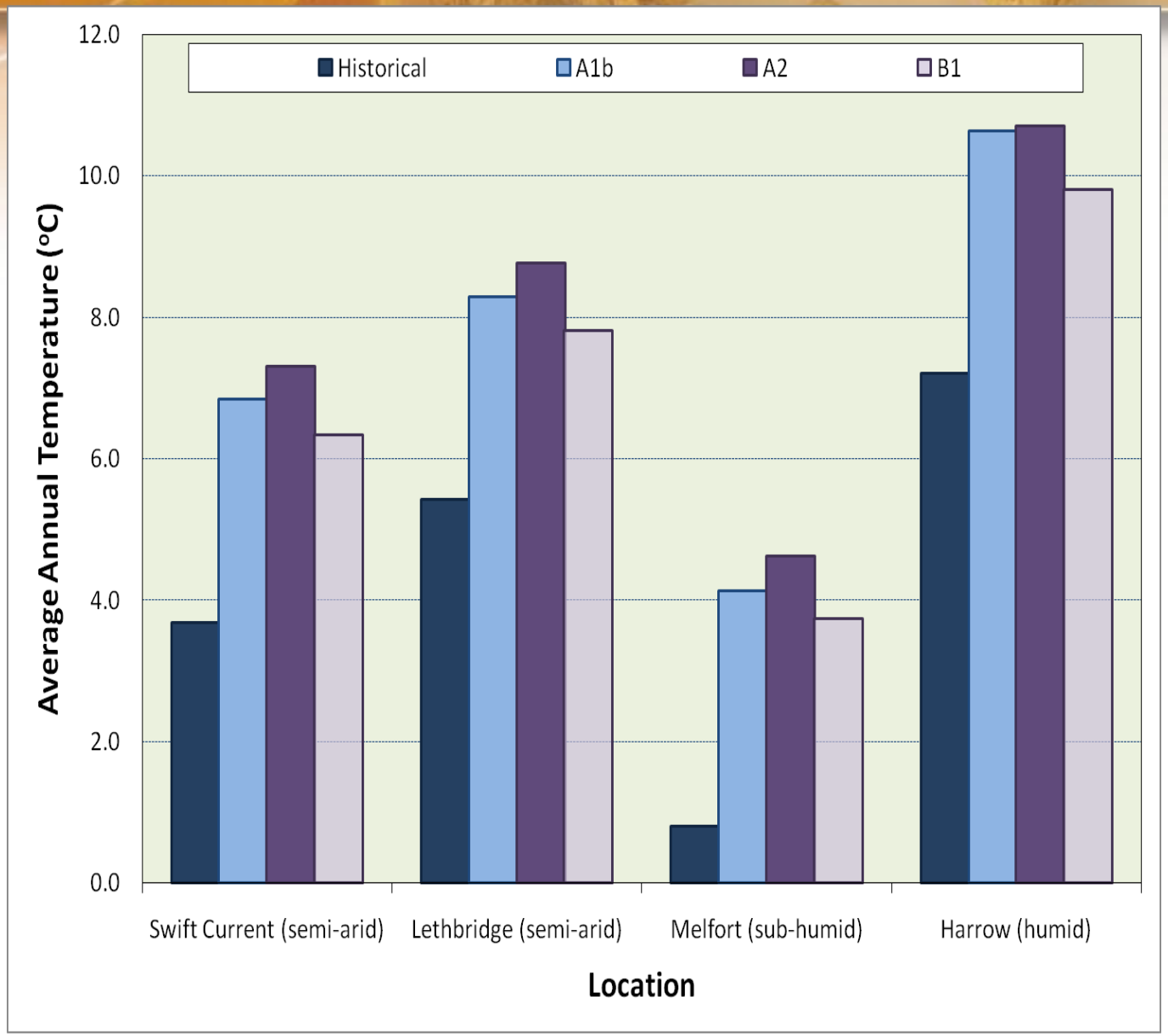
- Simulate the effect that agricultural practices may have on crop yields, SOC and N_2O emissions under climate change
- Focus on projections at Research Stations where DNDC has been validated for predicting crop biomass

AAFC-WG, a stochastic weather generator, was used to develop 100 years of historical and future weather data

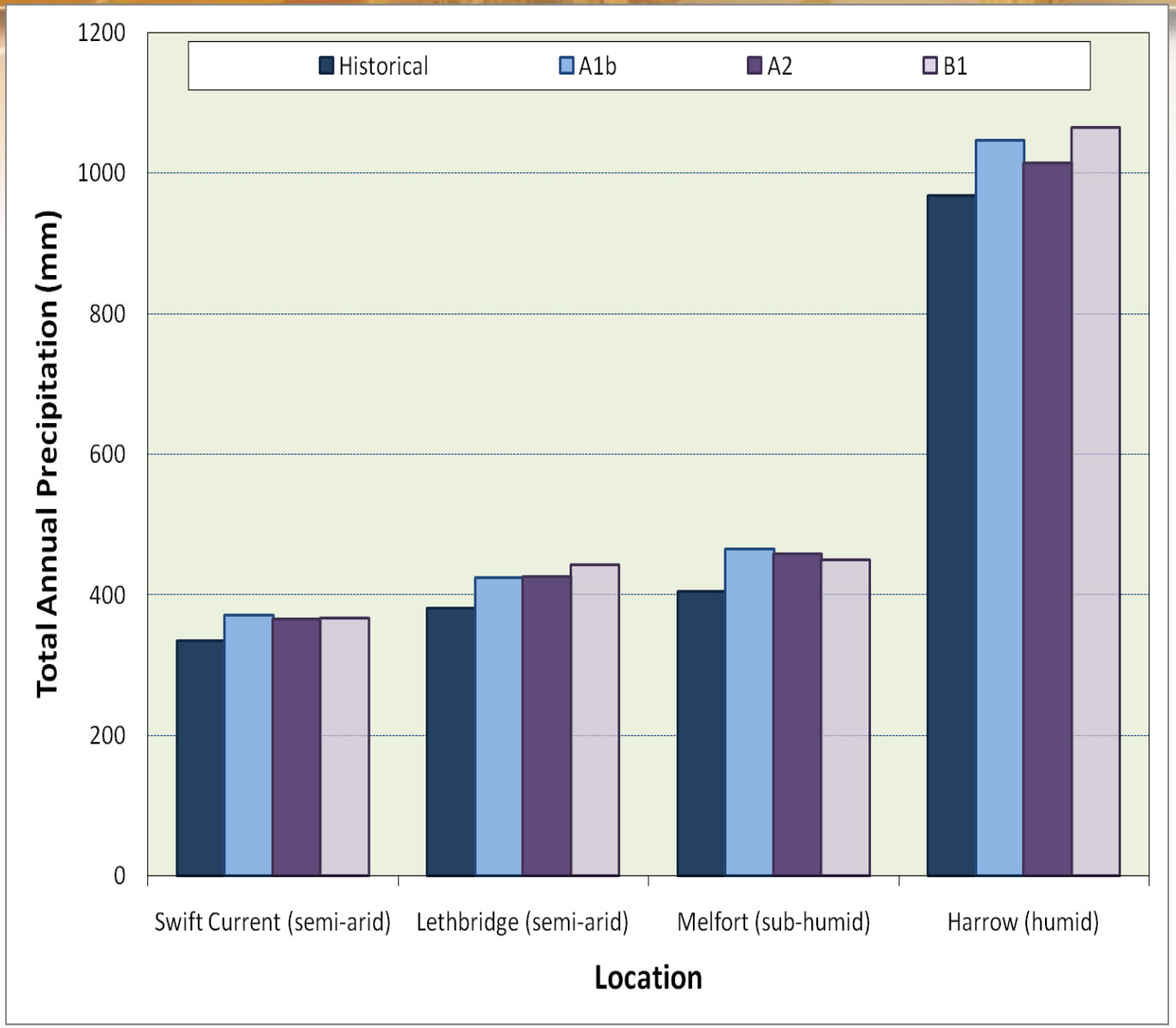
- The data was derived from simulations conducted by the coupled global climate model (CGCM3)
- Historical (1961-1990)
- SRES Climate scenarios A1b, A2, B1 (2040-2069)

The DNDC model was employed using site specific agricultural activity data to simulate trends in yield and GHG emissions under historical climate and climate change scenarios

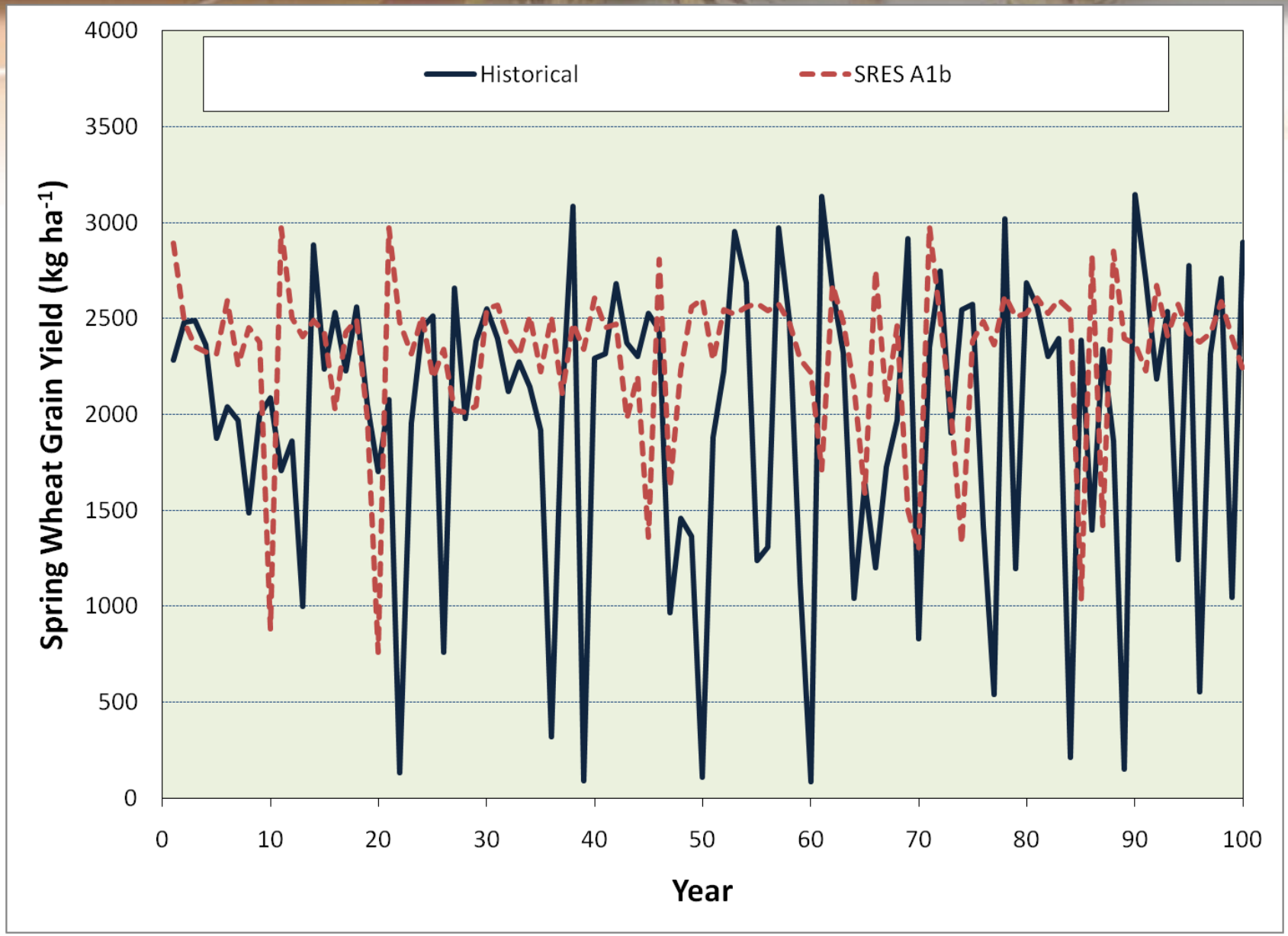
Predicted average temperature at research sites



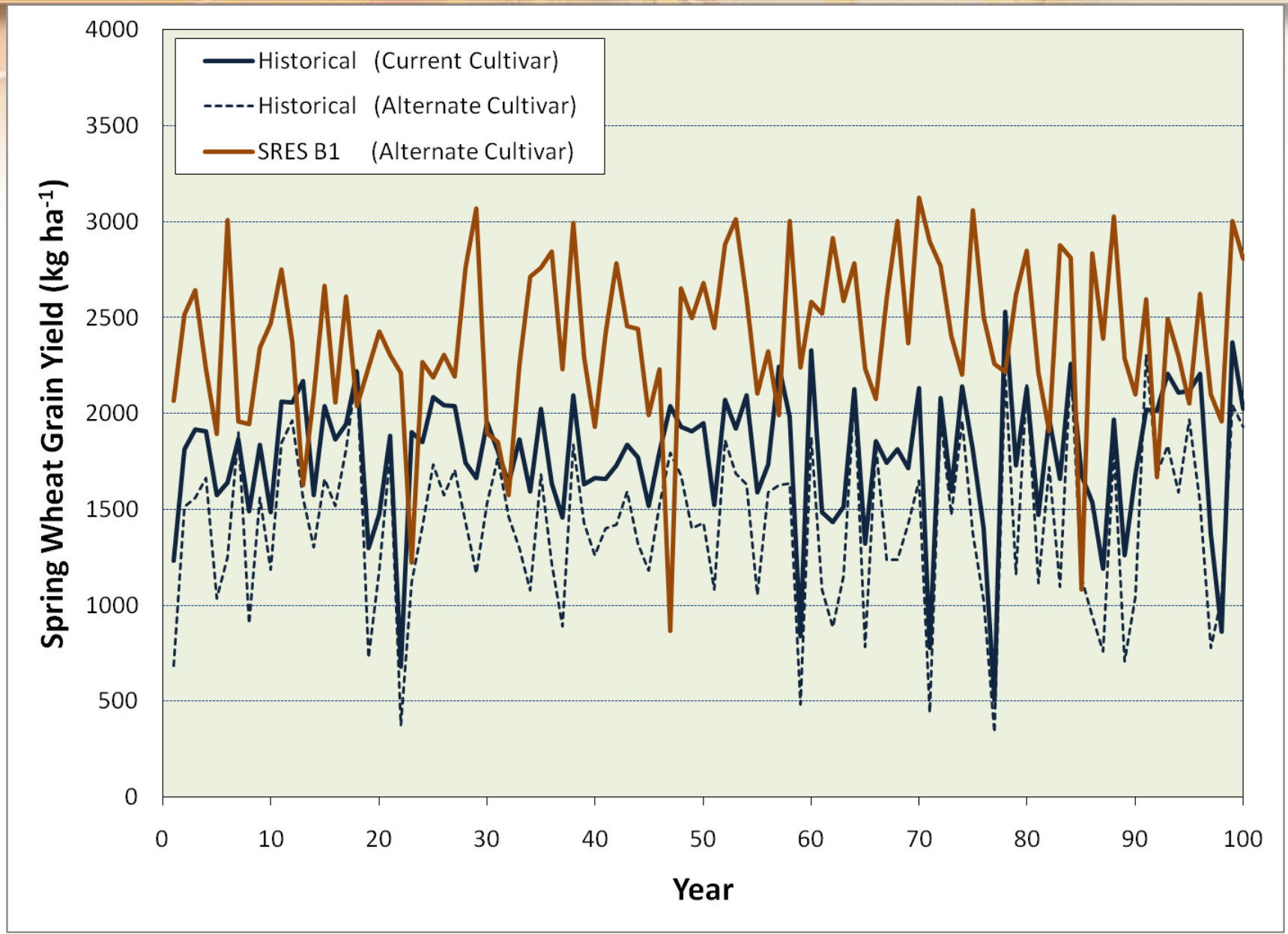
Predicted average precipitation at research sites



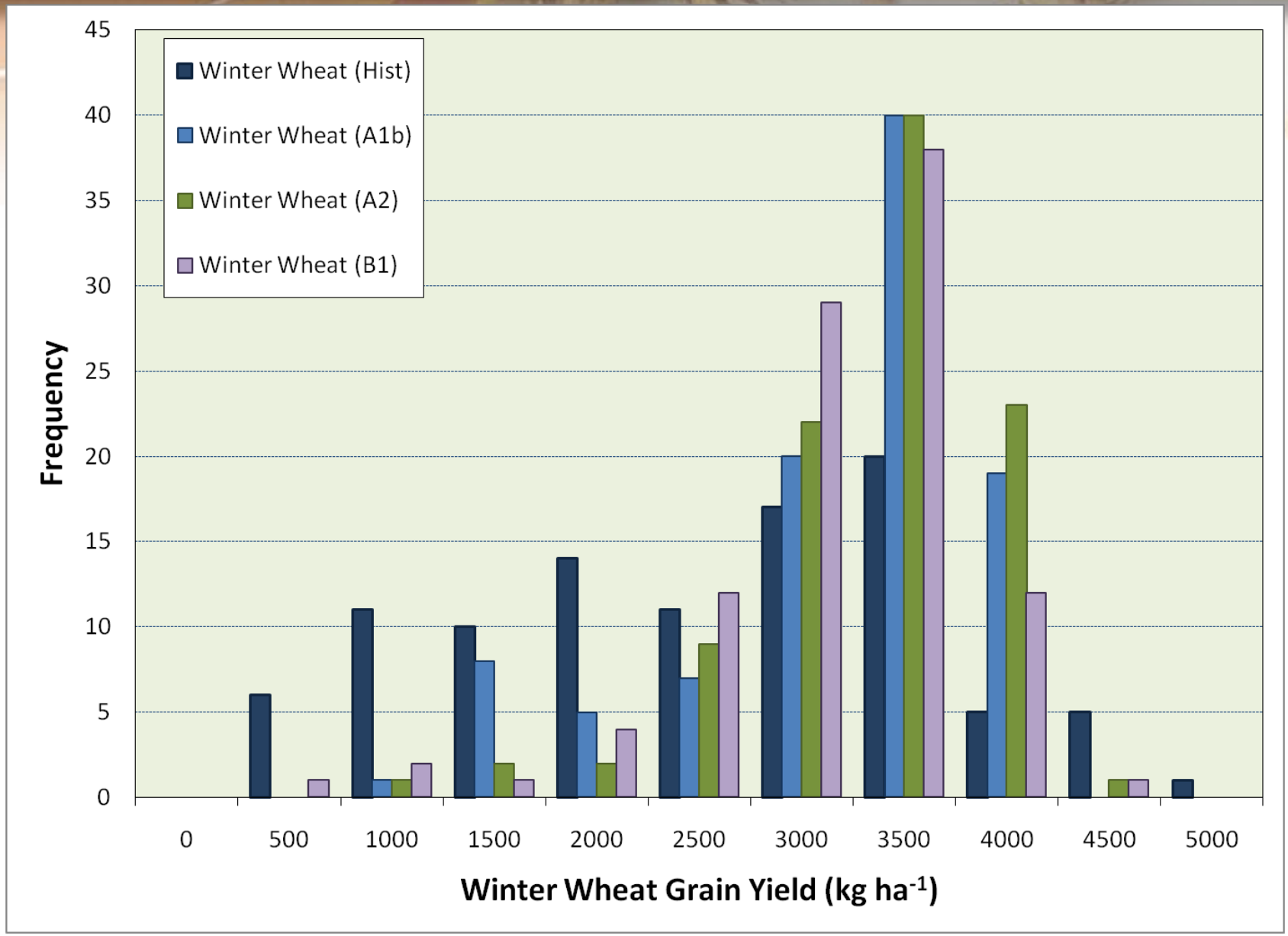
Predicted effect of spring wheat yield under A1b climate scenario for a semi-arid soil



Predicted effect of agricultural management on wheat yield under SRES climate scenarios at Lethbridge Research Station

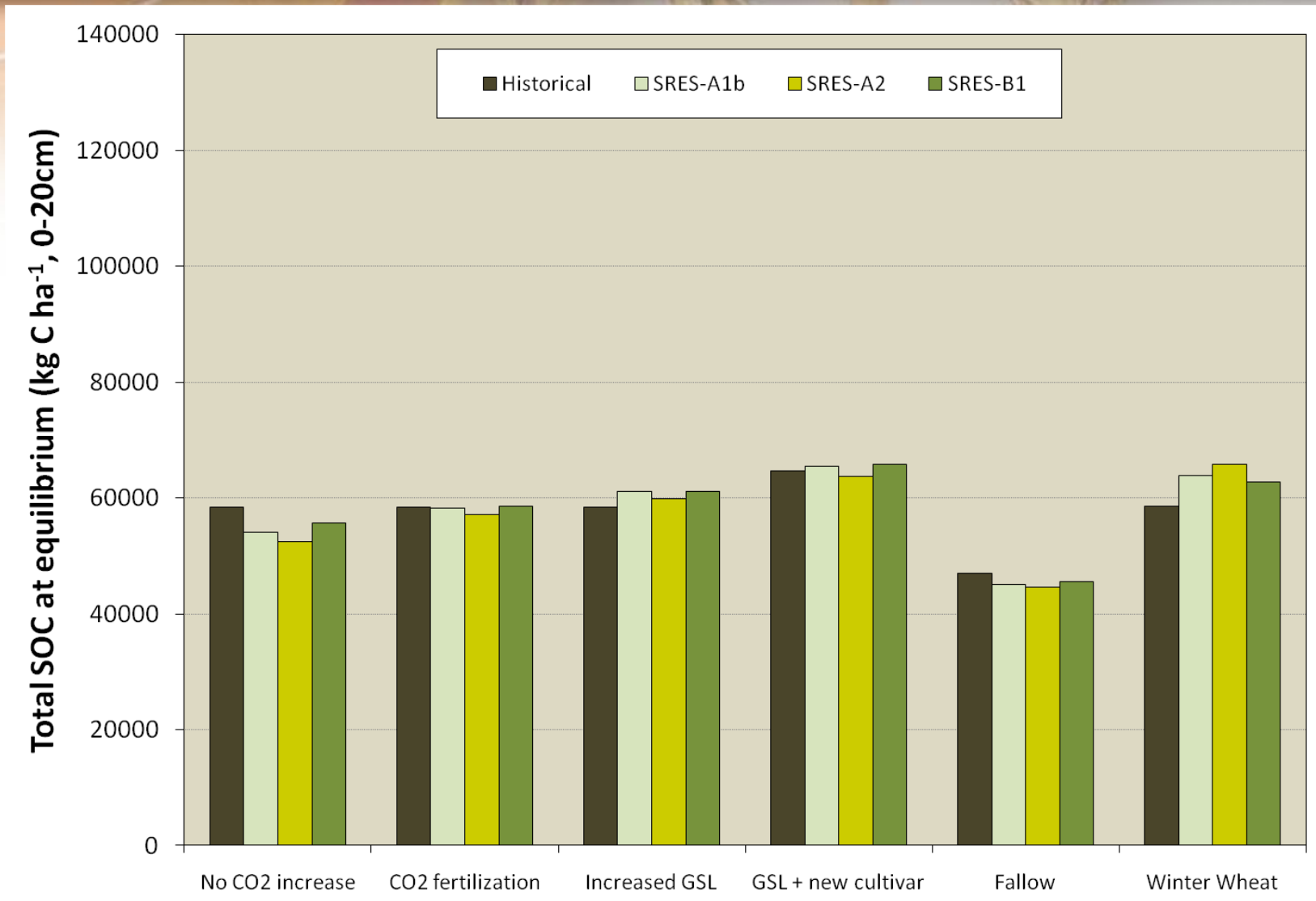


Frequency Distribution of Winter Wheat Yield under SRES climate scenarios



Predicted effect of agricultural management on corn yield under SRES climate scenarios at Harrow Research Station

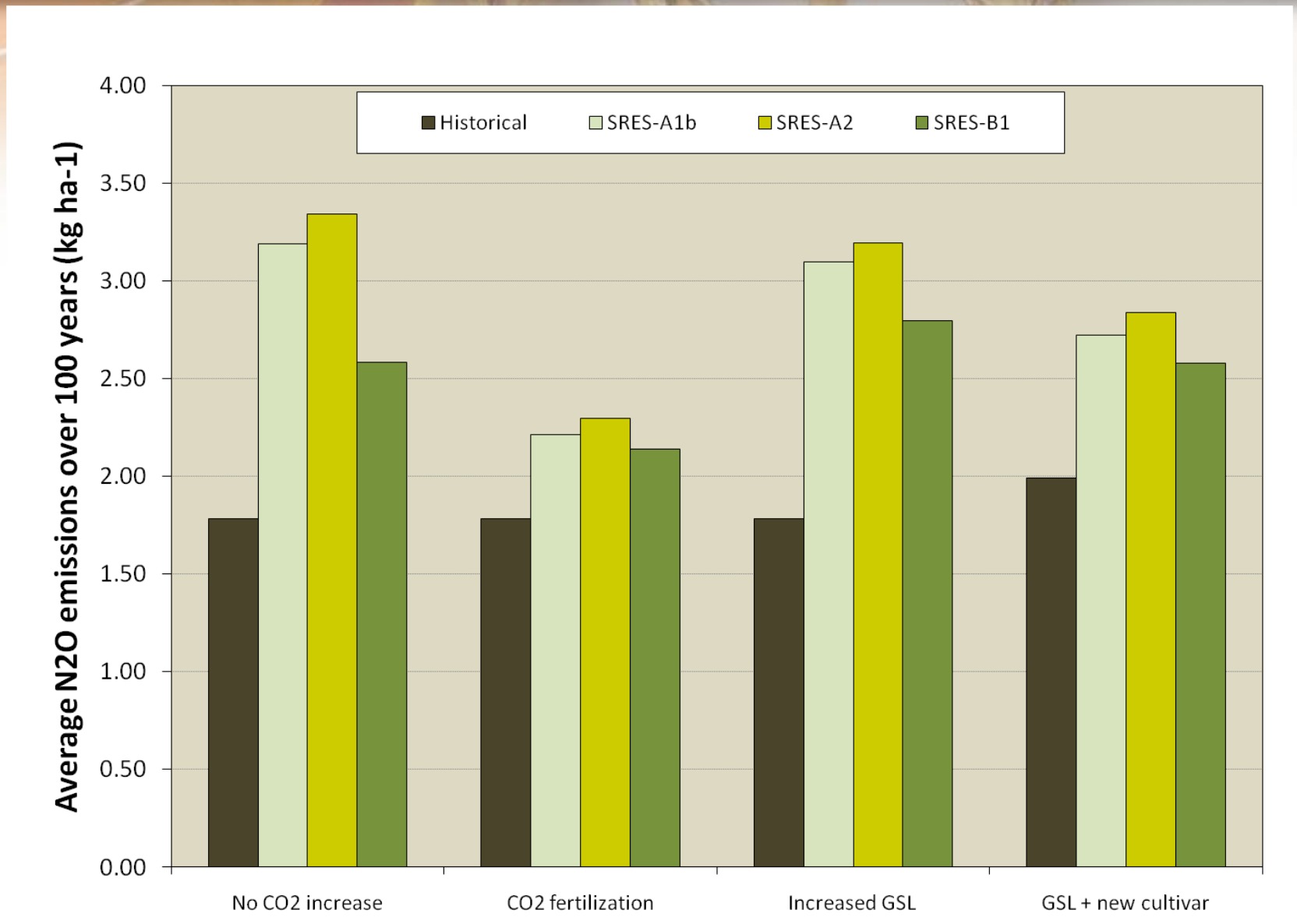
Predicted effect of agricultural management on SOC under SRES climate scenarios at Lethbridge Research Station



Predicted effect of agricultural management on SOC under SRES climate scenarios at Harrow Research Station

Predicted effect of agricultural management on N_2O emissions under SRES climate scenarios at Lethbridge Research Station

Predicted effect of agricultural management on N_2O emissions under SRES climate scenarios at Harrow Research Station



Summary

- Historical trends in temperature and precipitation across Canada are beneficial for agricultural production in most areas
- Climate models project a warmer future with more precipitation but sometimes a net water deficit
- The DNDC_Canada model is able to reasonably predict interannual variations in historical crop yields
- Crop biomass production is predicted to increase under climate scenarios
- Winter wheat should be a more viable crop to grow in the future
- Net GHG emissions are predicted to decline in western semi-arid and sub-humid soils but may increase in Eastern humid soils


THANK YOU!
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Modeling approach: Simulations at each site

Historical climate 1961-1990

- Wheat or corn
- Wheat-wheat-fallow
- Winter wheat

Climate scenarios (A1b, A2 and B1) 2040-2069

- Wheat or corn
  - With no CO_2 fertilization
  - With CO_2 fertilization
  - Increased length of growing season
  - Alternative cultivar (requires more crop heat units)
- Wheat-wheat-fallow
- Winter wheat