Estimating the effect of climate change on crop biomass production and GHG emissions at experimental sites in Canada

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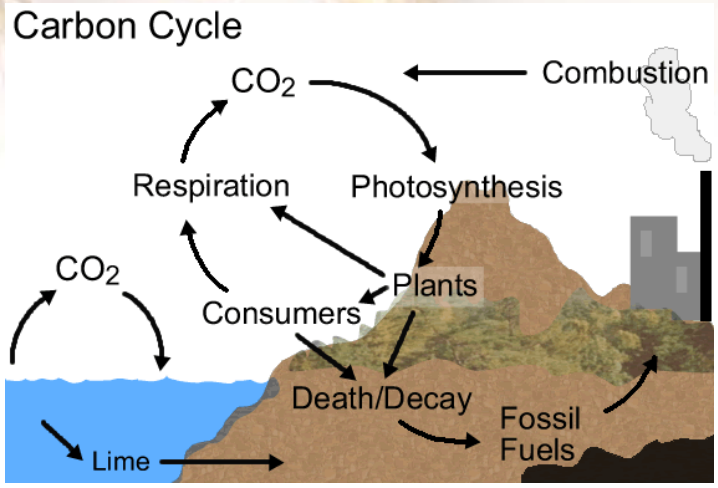
Overview

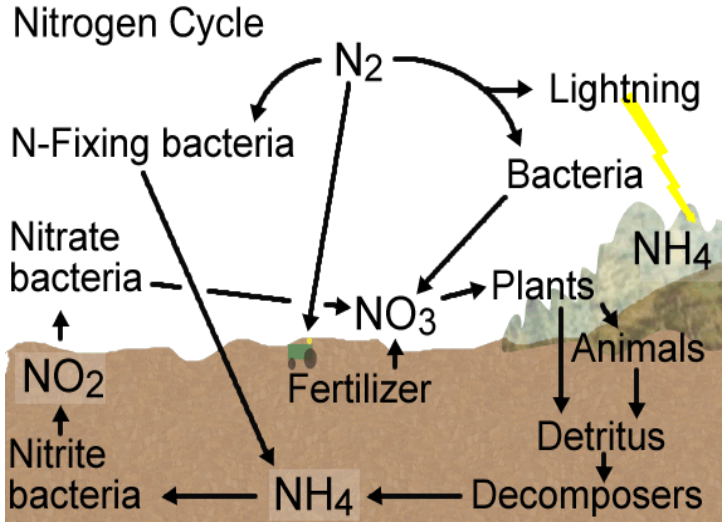
- Recent DNDC improvements
- Comparison of DNDC estimates to measurements of crop yields and N_2O emissions
- The effect of climate change on yield and GHG emissions at experimental sites

The DNDC model

DNDC

- Tested and parameterized for many agroecosystems around the world
- Several teams in different countries are working on improving the model – new DNDC network
- Source code is available and is relatively simple to understand
- Data inputs are manageable
- Widely used (IPCC, linked with economic model in Europe)





Estimating the effect of climate change on crop biomass production and GHG emissions at experimental sites

Objectives:

- Use data from experimental sites to test and improve the ability of the DNDC model to estimate crop biomass production and N_2O emissions in Canada
- Use IPCC climate scenarios to predict changes in crop yields and GHG emissions at these experimental sites from 2000 to 2100

Recent DNDC improvements

Biomass production and soil hydrology

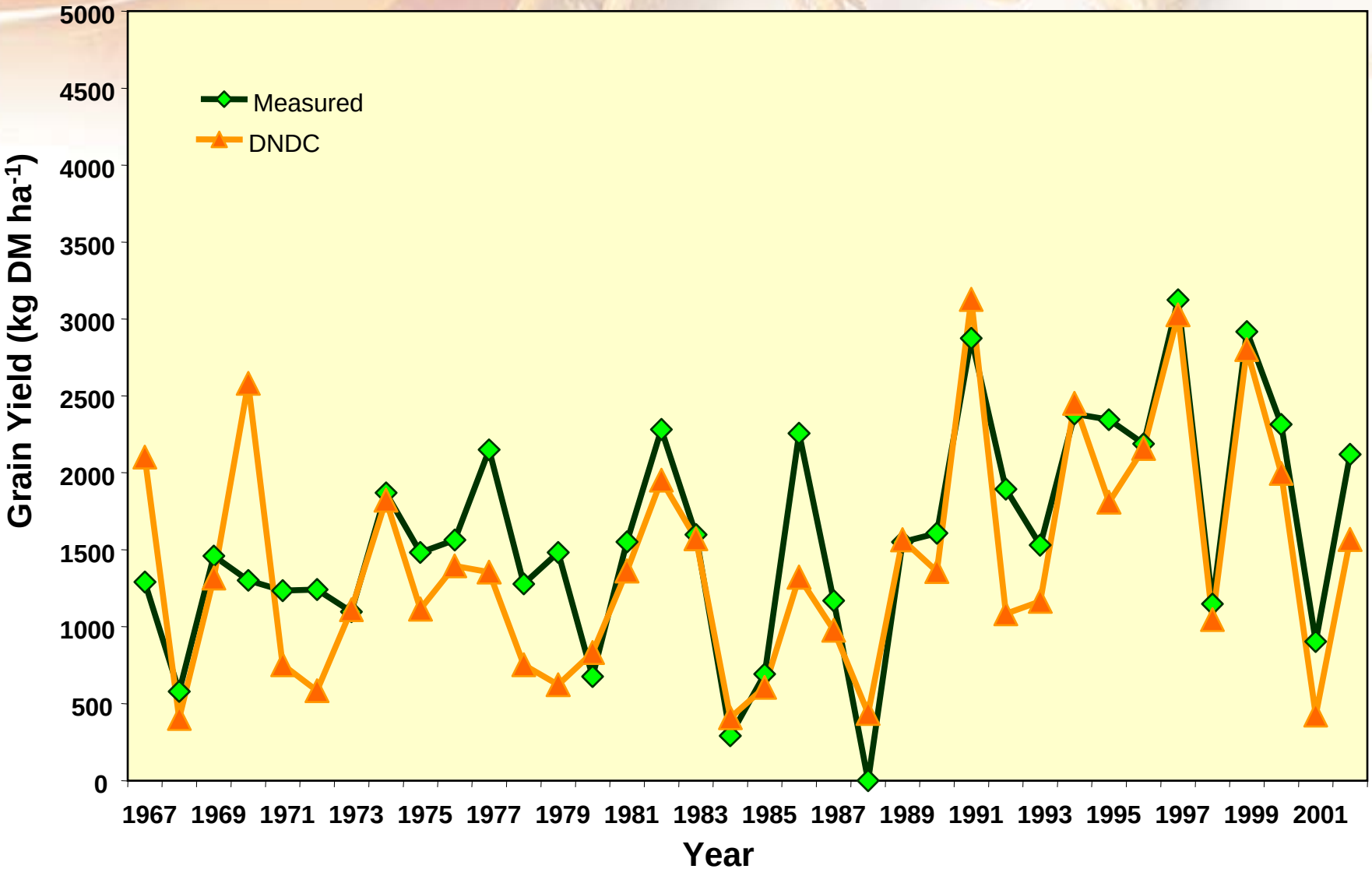
- Incorporated water deficit stress on plant growth during early vegetative stage
- Used detailed biomass destructive data to improve vegetative growth curves
- Included a process to better allocate above/belowground biomass during water stress
- Added wind speed in the evapotranspiration subroutine
- Added solar radiation in plant growth routine
- Added an equation to limit evaporation based on residue cover
- Allowed direct input of some soil hydraulic properties and added a function to let water contents go below wilting point

Climate change

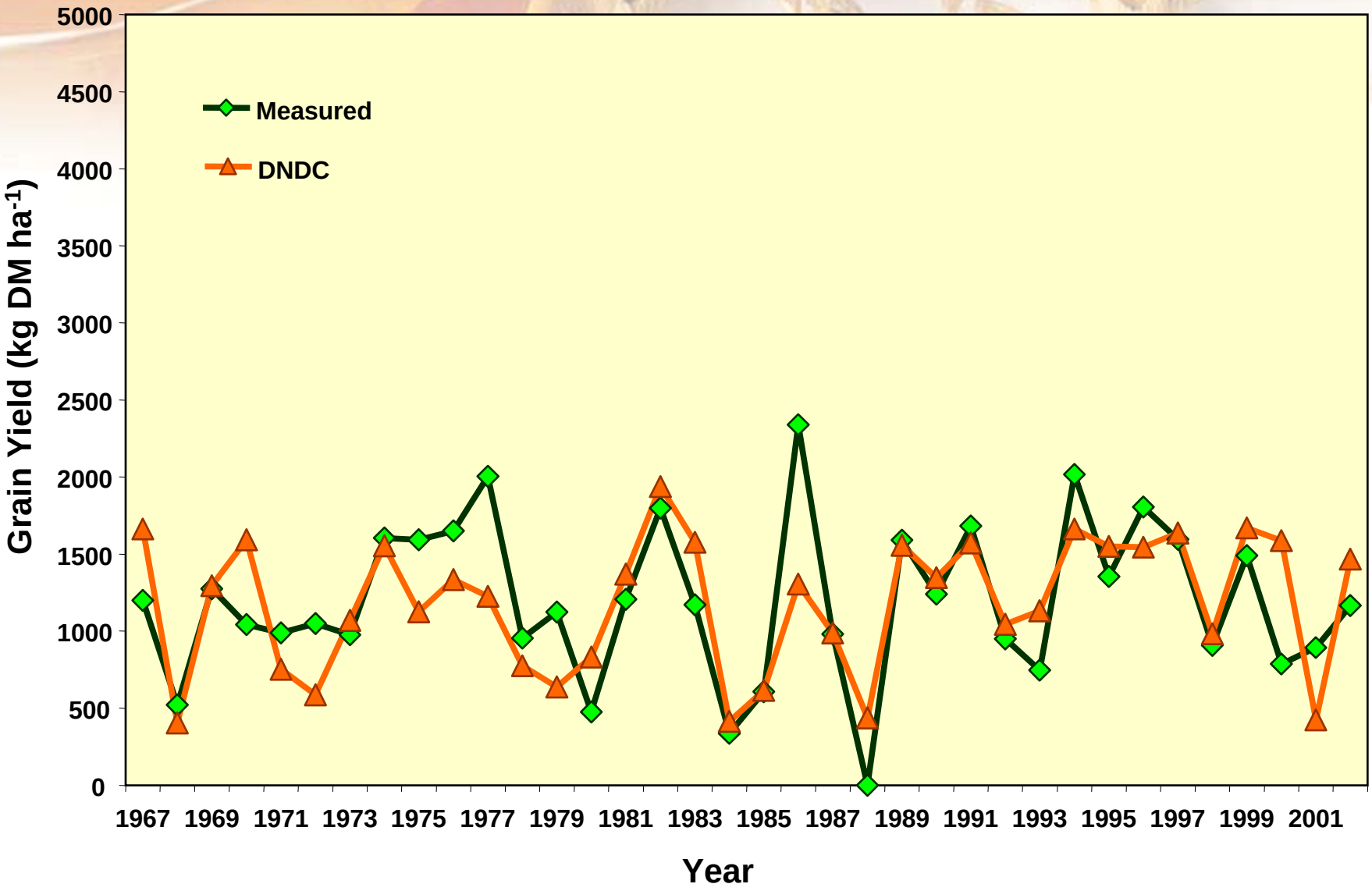
- Introduced feature that allows non-linear increases in atmospheric CO_2 concentrations
- Included a function to improve effect of temperature stress on plant growth
- Added an auto-fertilization routine (N requirement of crop - N in soil)

Comparison of DNDC estimates to measurements of crop yields and N_2O emissions

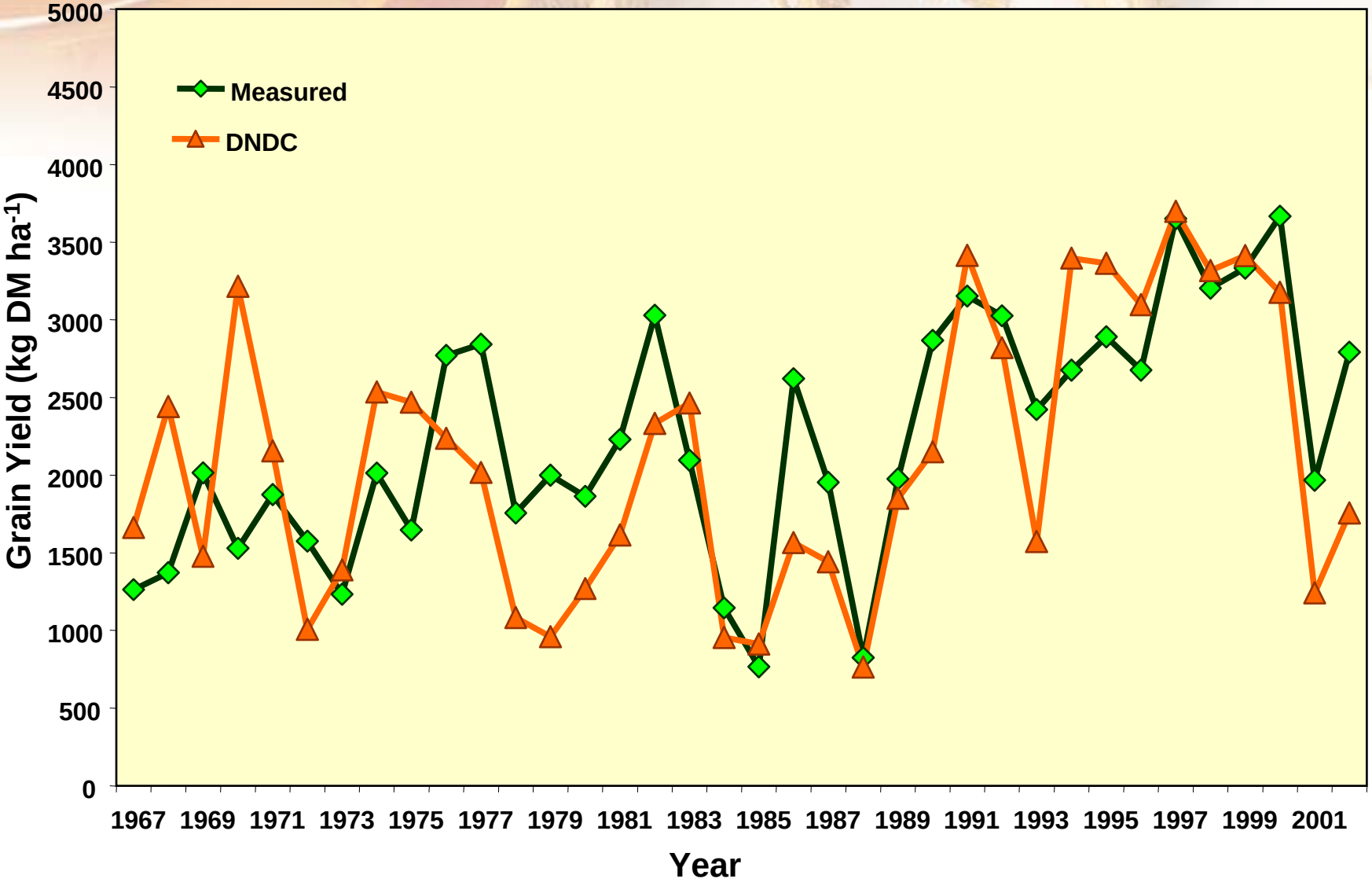
Estimated Grain Yields for fertilized wheat: Swift Current, SK (semi-arid)



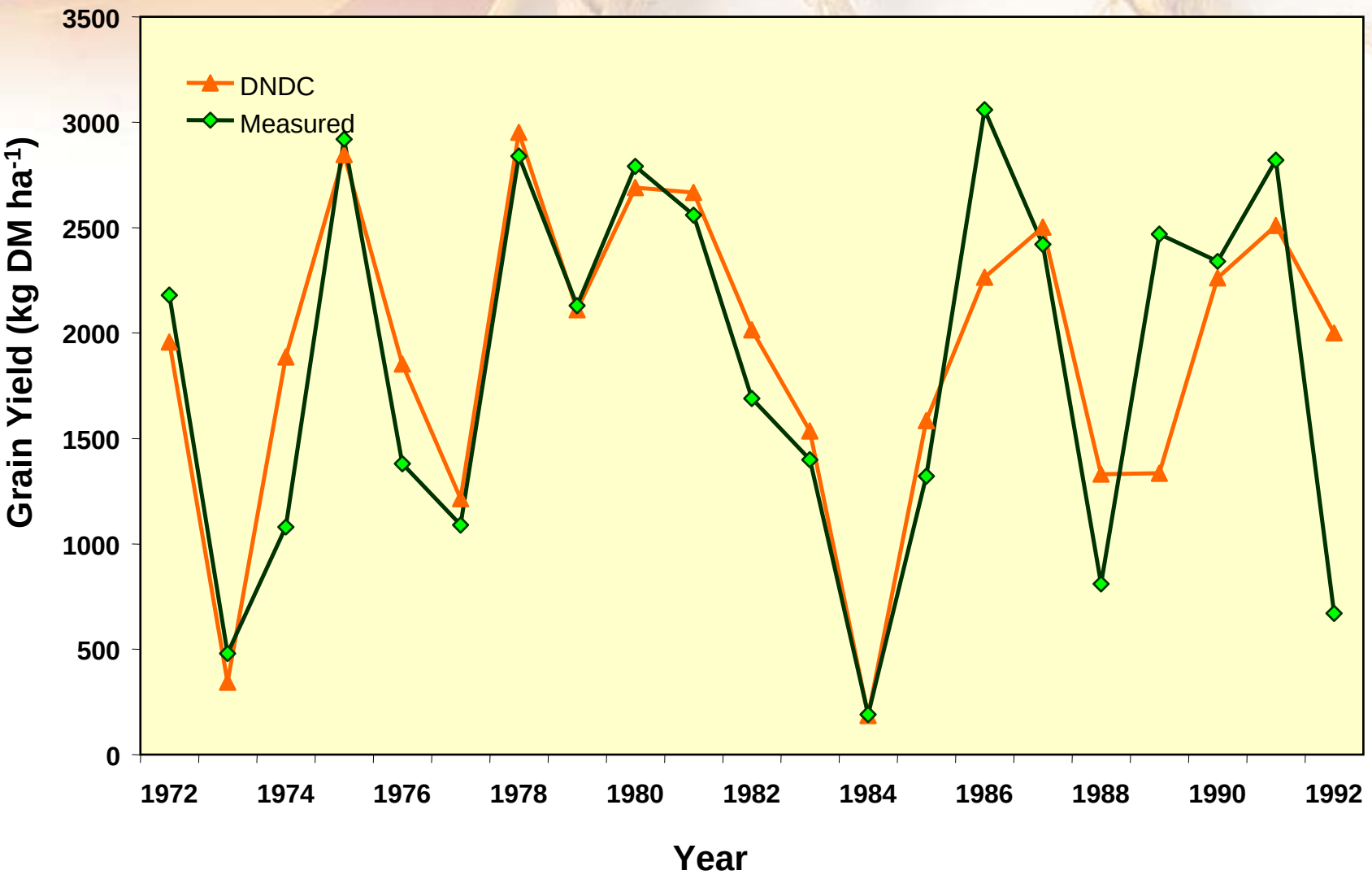
Estimated Grain Yields for unfertilized wheat: Swift Current, SK (semi-arid)



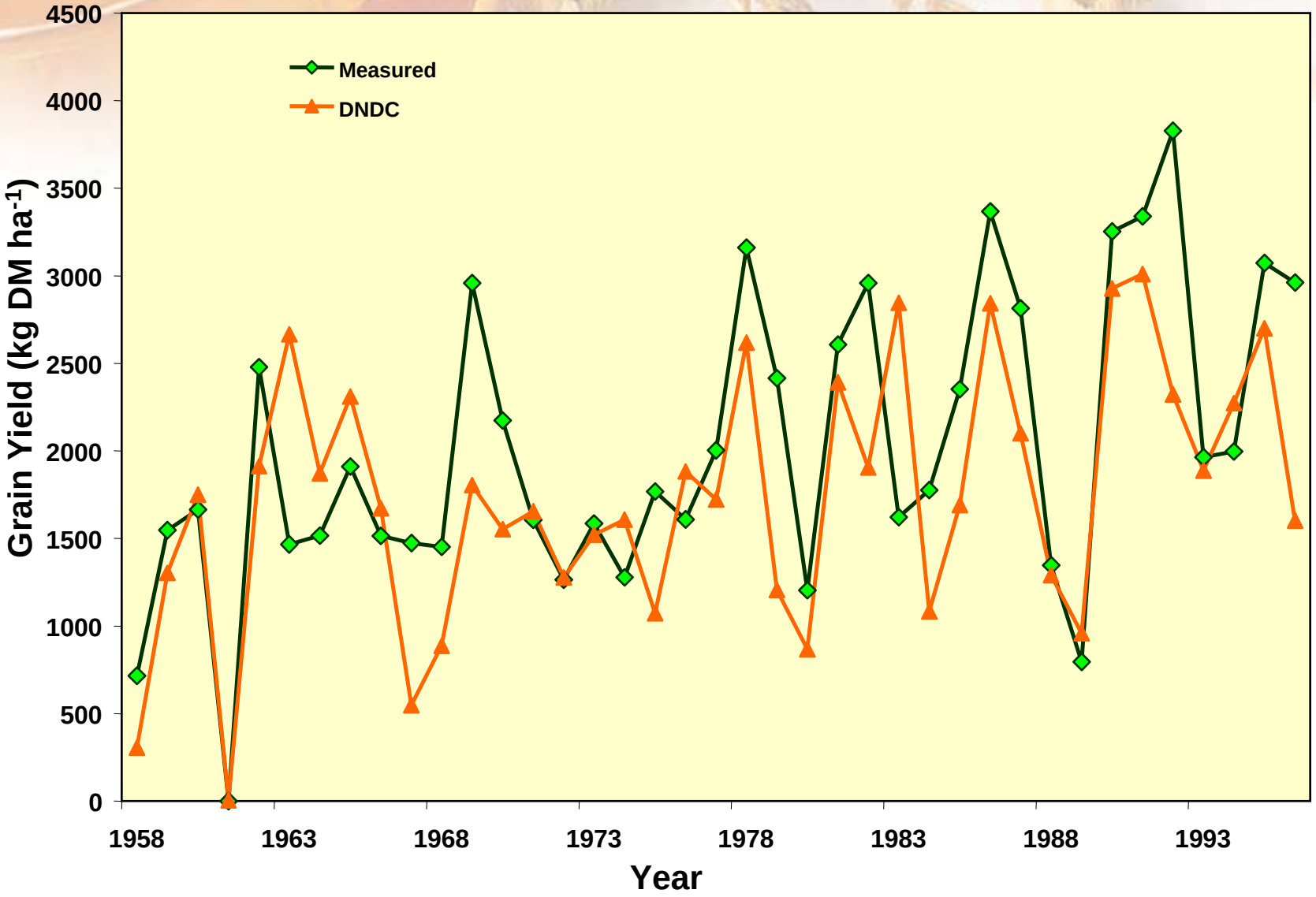
Estimated Grain Yields for fertilized wheat-fallow: Swift Current, SK (semi-arid)



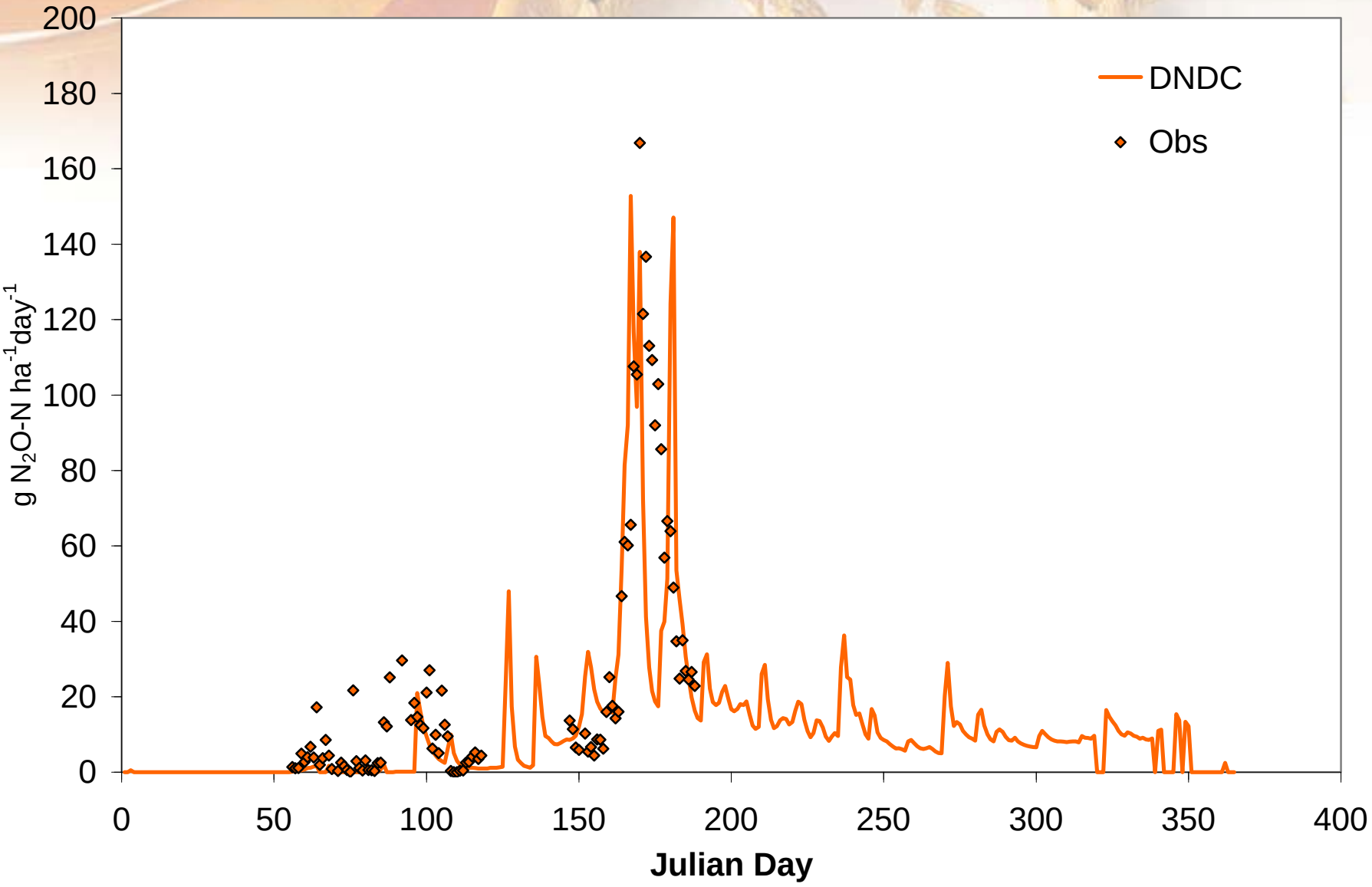
Estimated grain yields for fertilized wheat Lethbridge, Alberta (Dark Brown Chernozem)



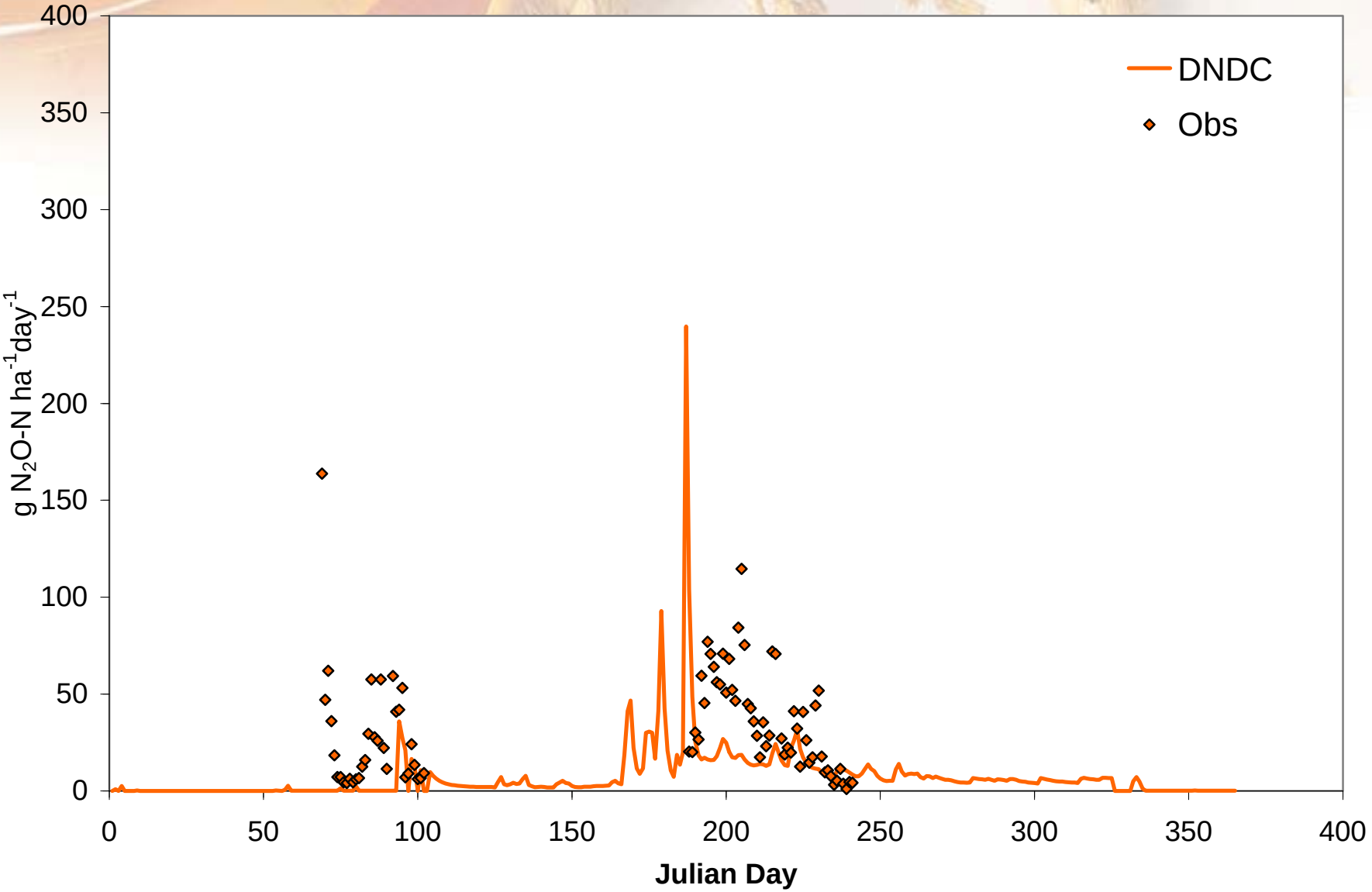
Estimated Grain Yields for ContW (N+P)
Indian head, Saskatchewan (sub-humid)



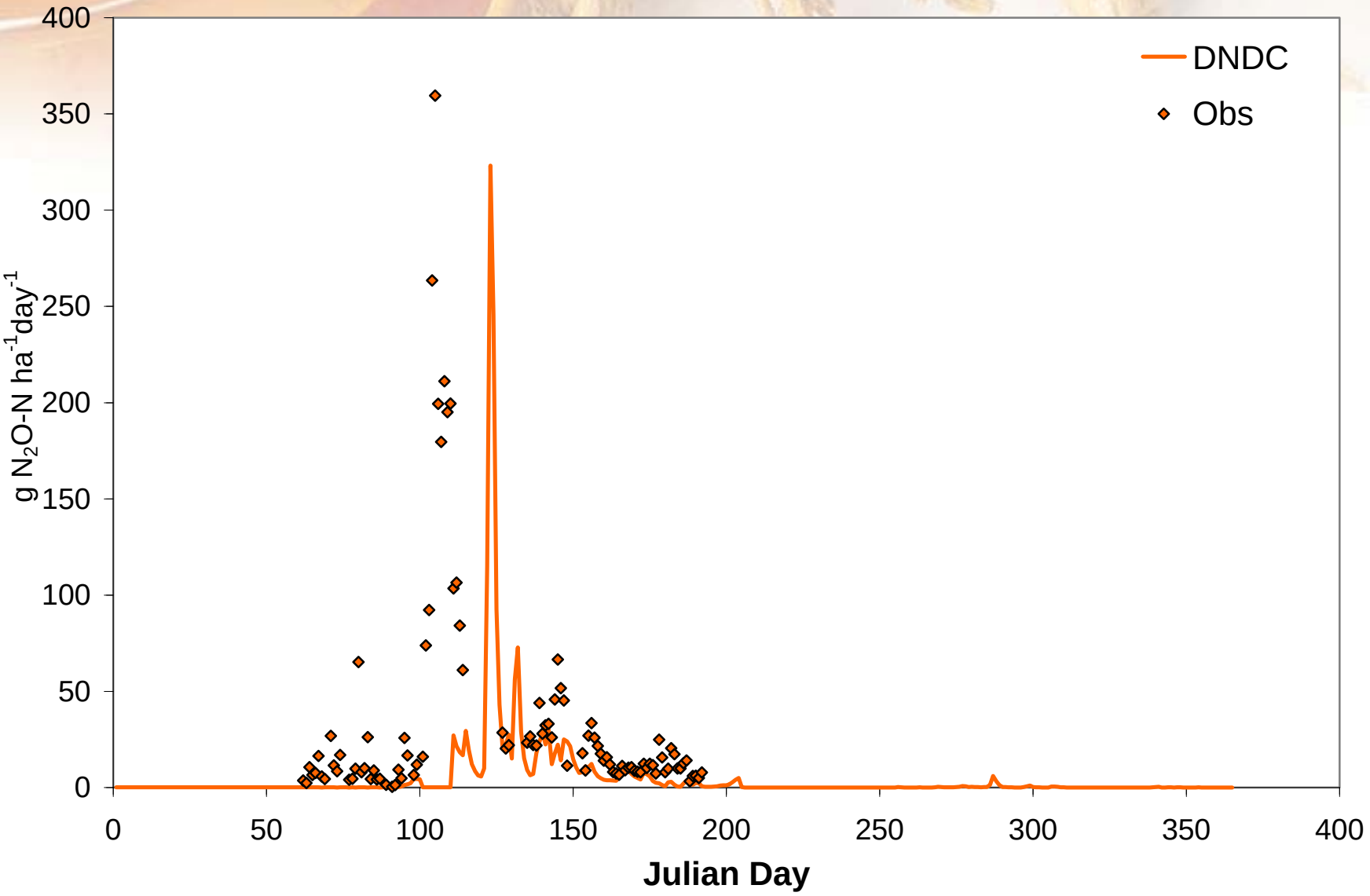
Estimates of N_2O emissions, Ottawa Ontario, Humid site, corn 1998



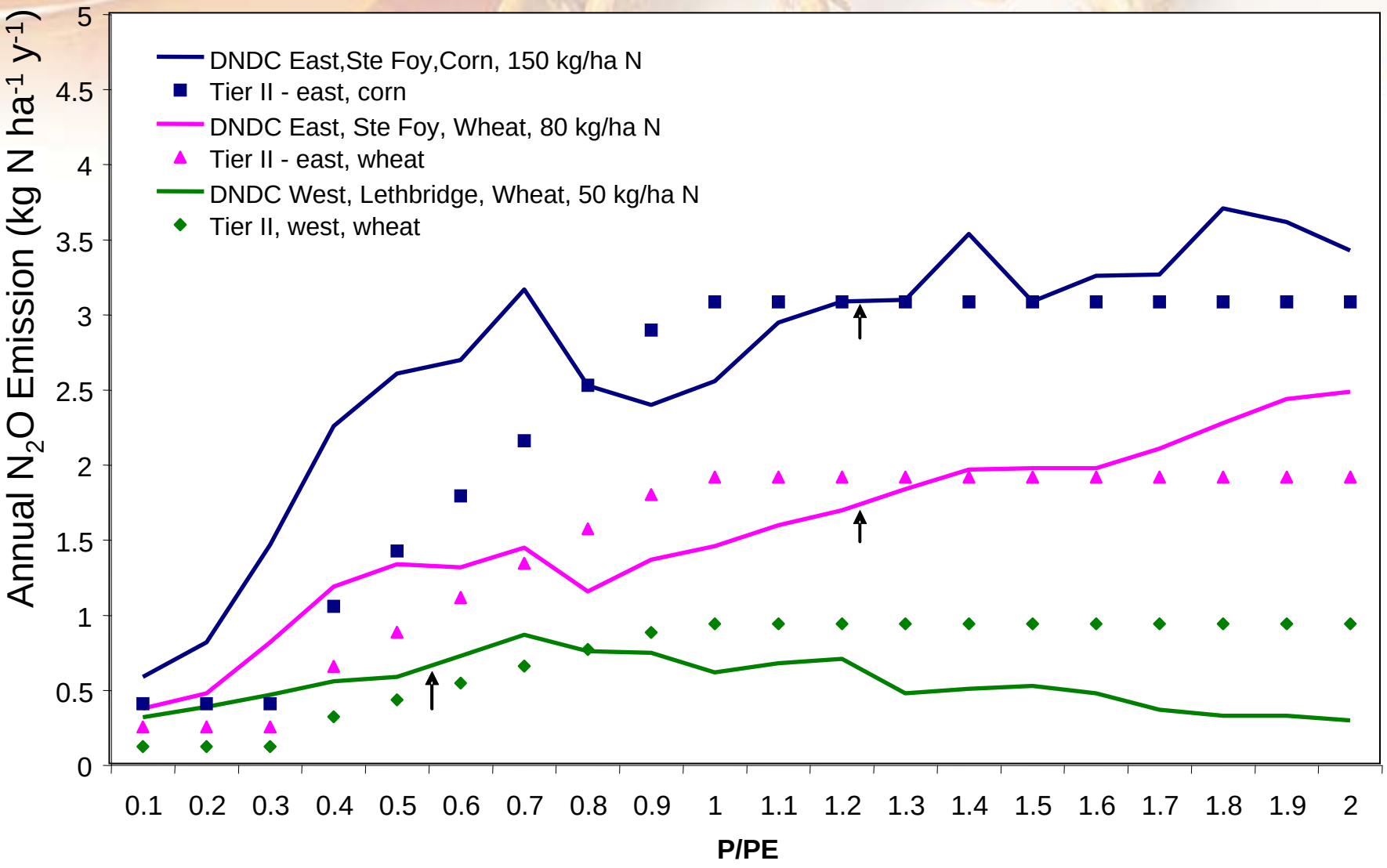
Estimates of N_2O emissions, Ottawa Ontario, Humid site, corn 2000



Estimates of N_2O emissions, Ottawa Ontario, Humid site, wheat 2001



Comparison of DNDC and Tier II IPCC methodology



The effect of climate change on yield and GHG emissions at experimental sites

SRES Climate Scenarios

IPCC SRES A2

- continuously increasing population.
- slower and more fragmented technological changes than other scenarios.
- higher CO_2 concentrations and temperatures than B2

IPCC SRES B2

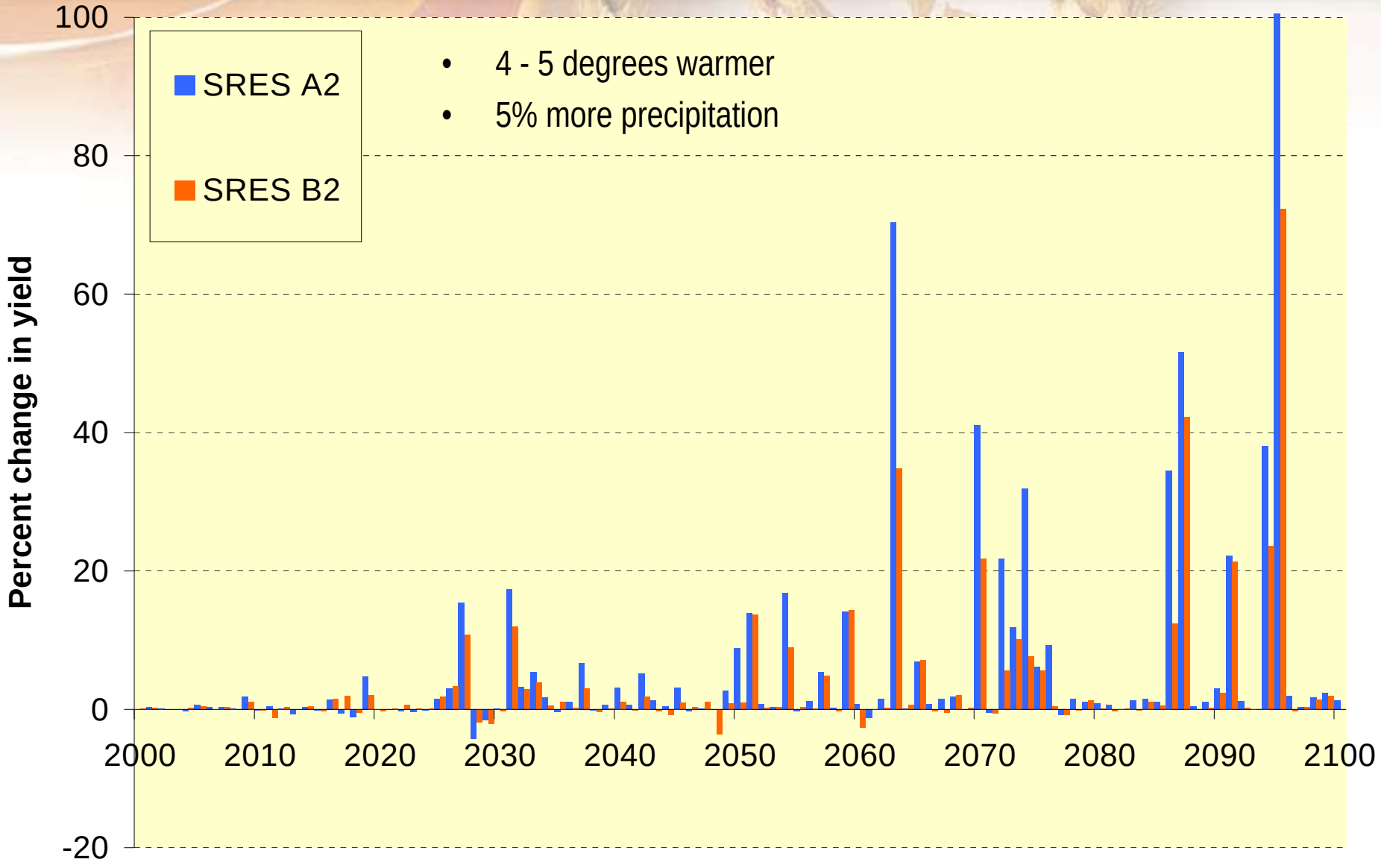
- more ecologically friendly
- continuous population increase but less than A2 scenario
- lower CO_2 concentrations and temperatures than A2

Generation of weather data from climate scenarios

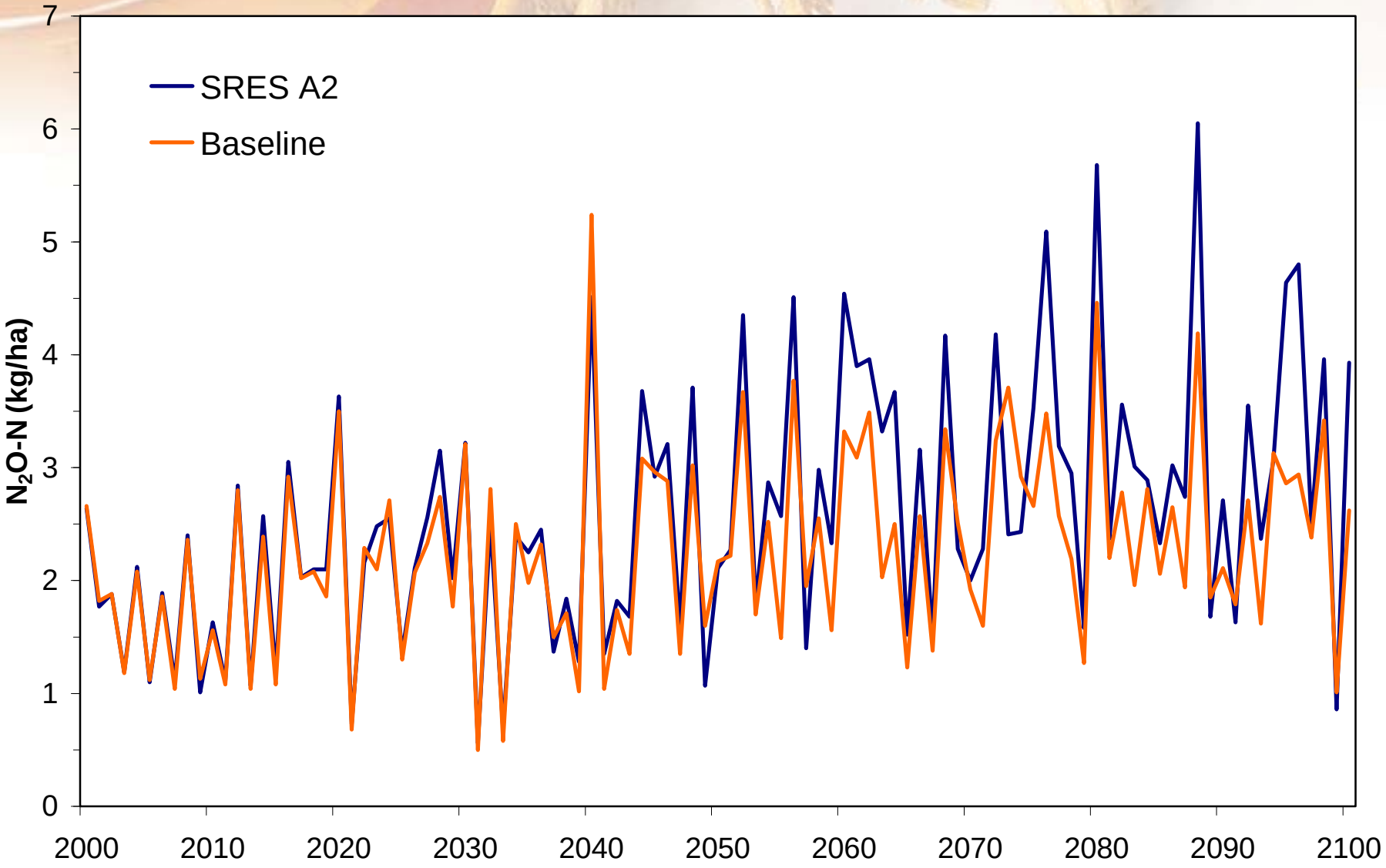
Methodology for applying climate scenarios

- Site specific daily weather data from 1970-1999 was randomized over a 100 year period (2000-2100)
- Seasonal changes in temperature and precipitation were applied based on averaged regional estimates from AOGCM simulations for IPCC SRES A2 and B2 scenarios (IPCC report on Climate Change: Impacts, Adaptation and Vulnerability (*Carter et. al*., 2007)
- Simulations with and without CO_2 fertilization

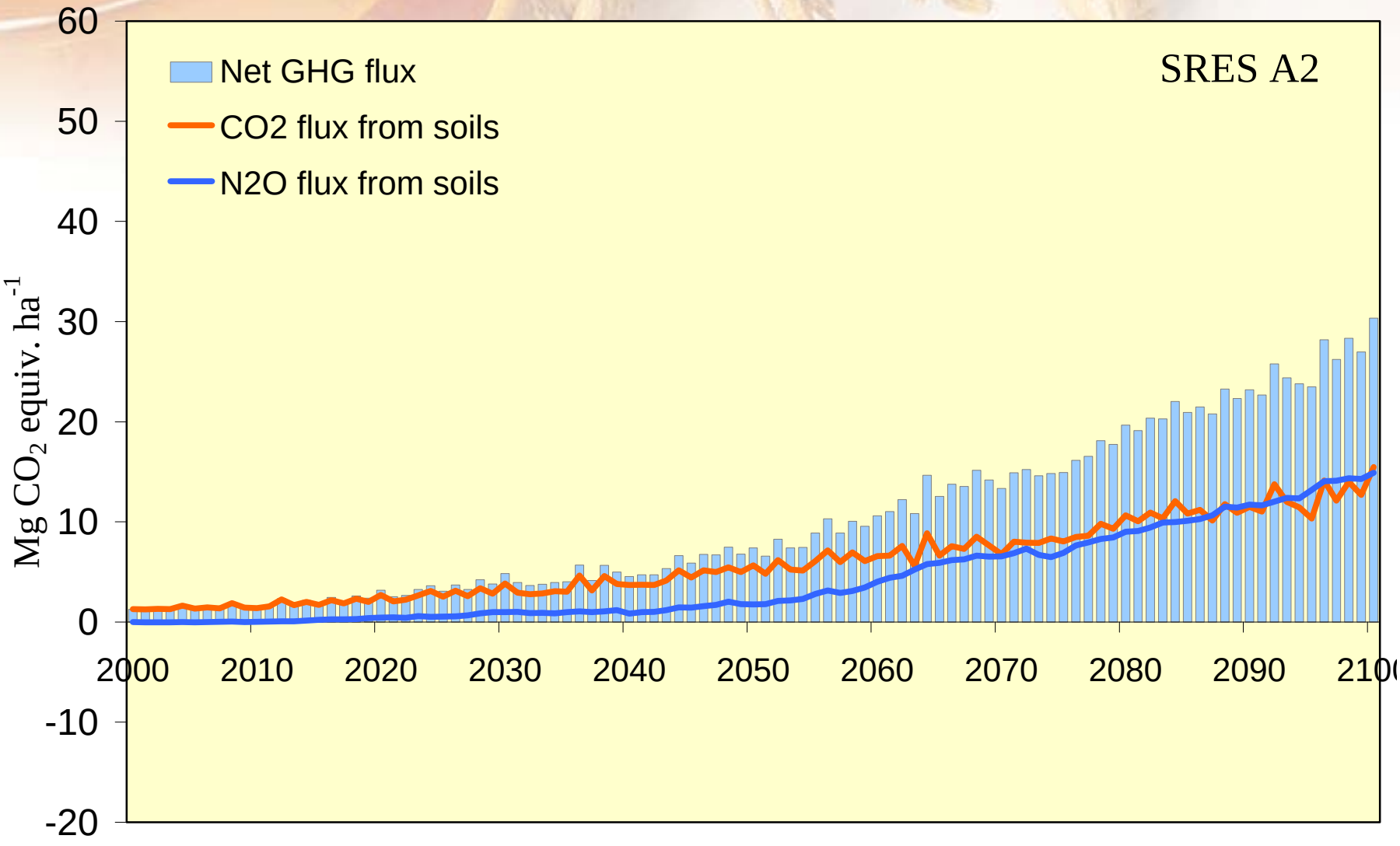
Effect of climate change on crop yield, corn-wheat-corn-soybean rotation, Ottawa, Ontario (2000-2100)



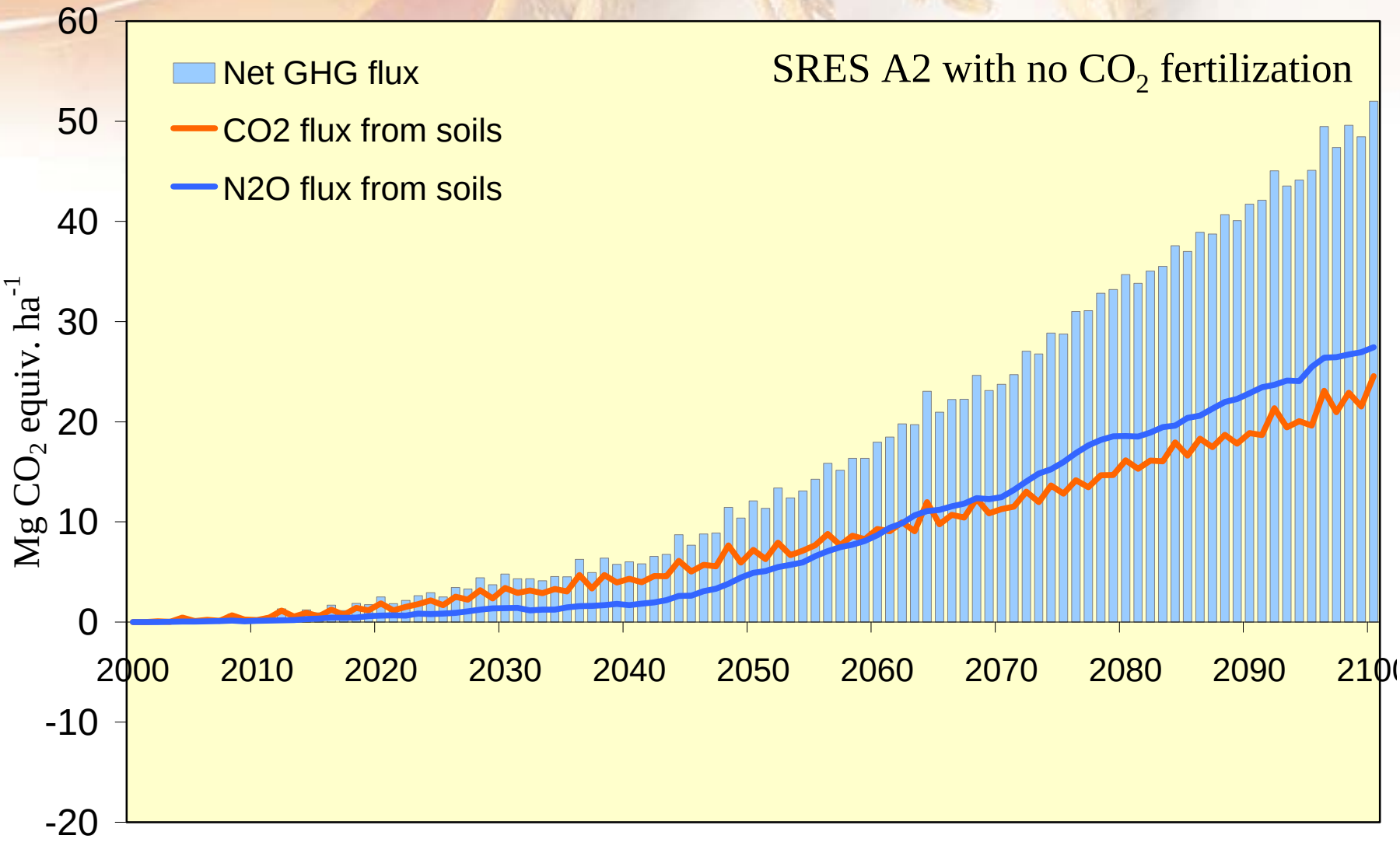
Effect of SRES A2 climate scenario on N_2O emissions
Ottawa, humid site



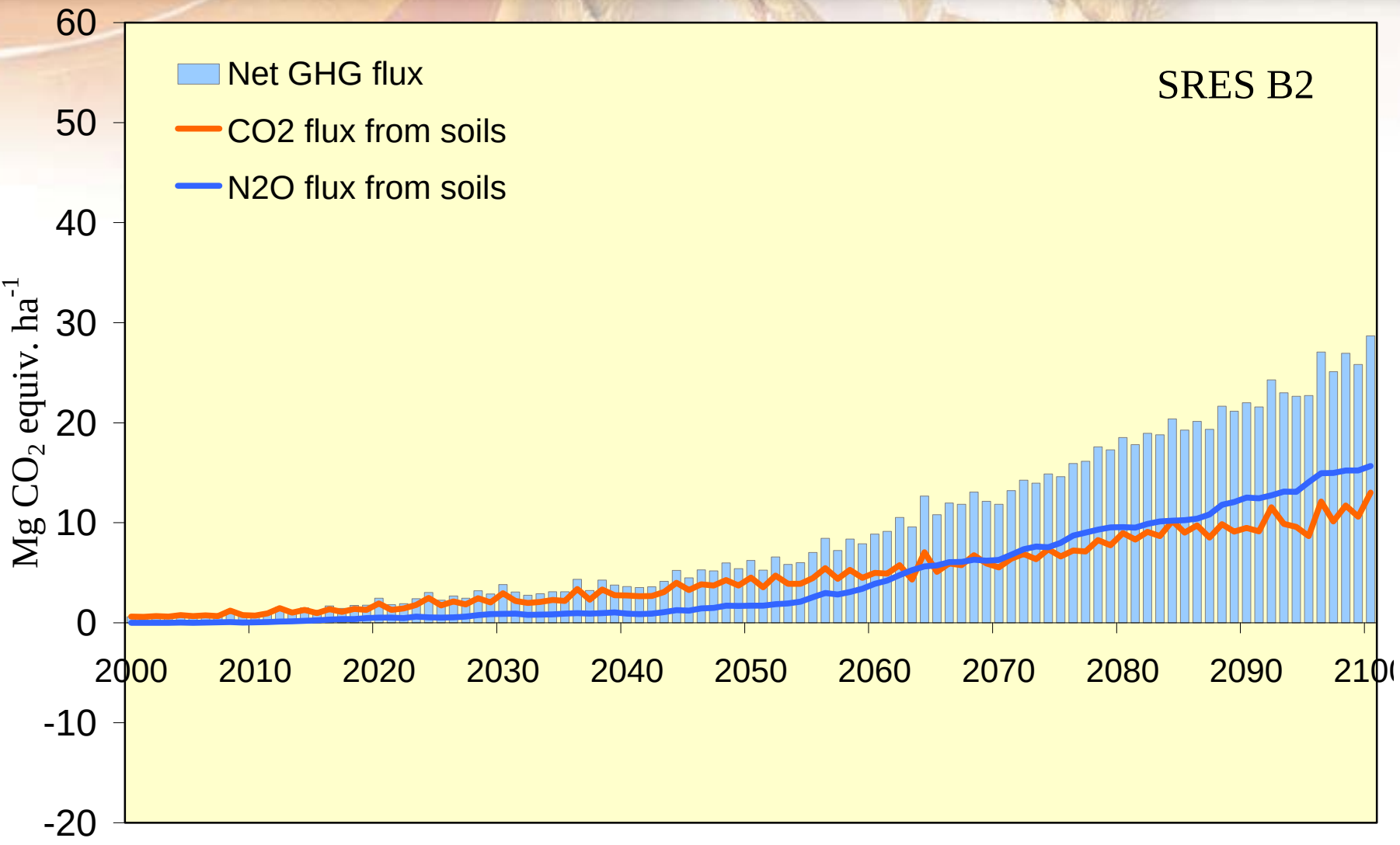
Effect of SRES A2 climate scenario on net GHG emissions
Ottawa, humid site



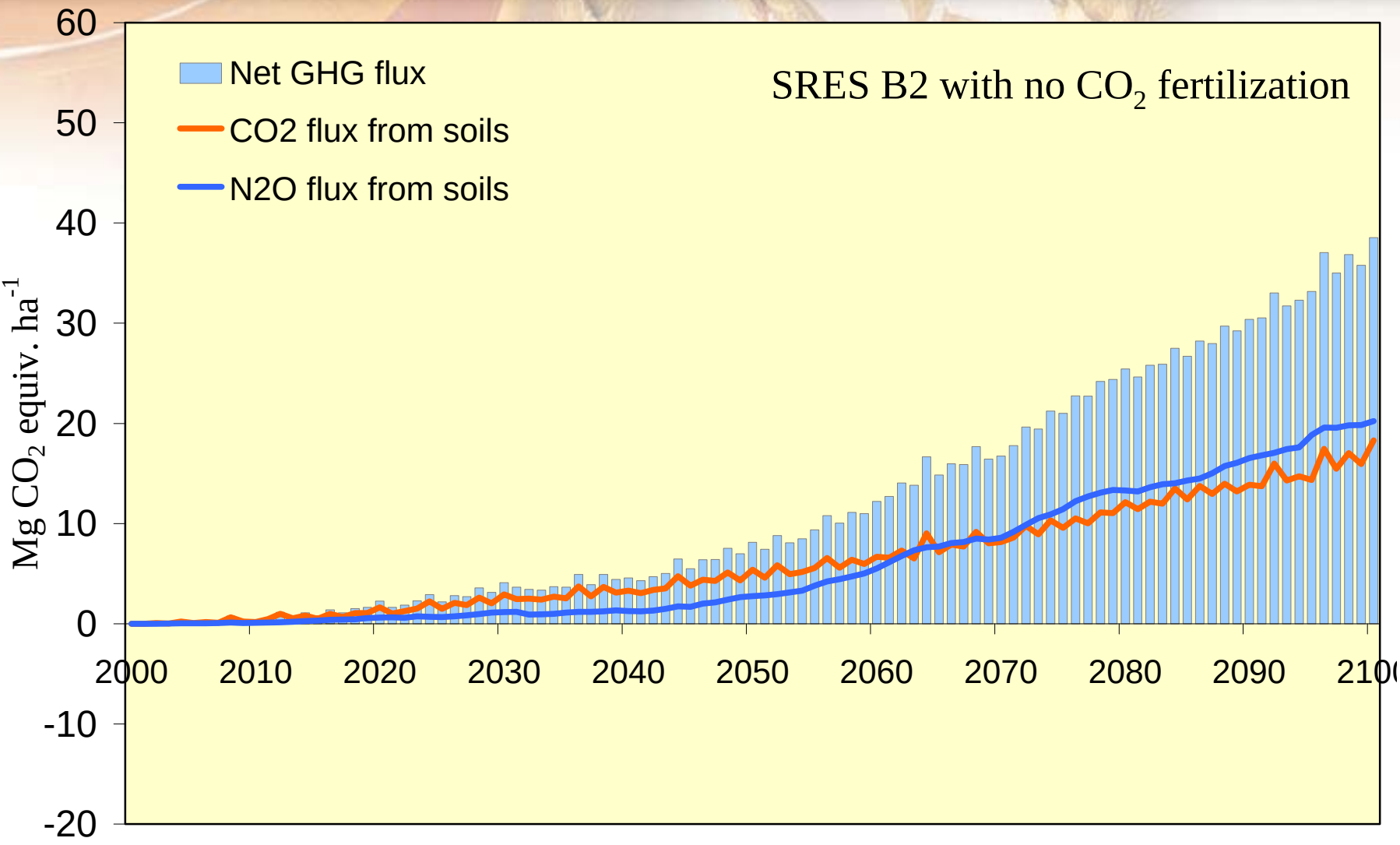
Effect of SRES A2 climate scenario with no CO_2 fertilization on net GHG emissions, Ottawa, humid site



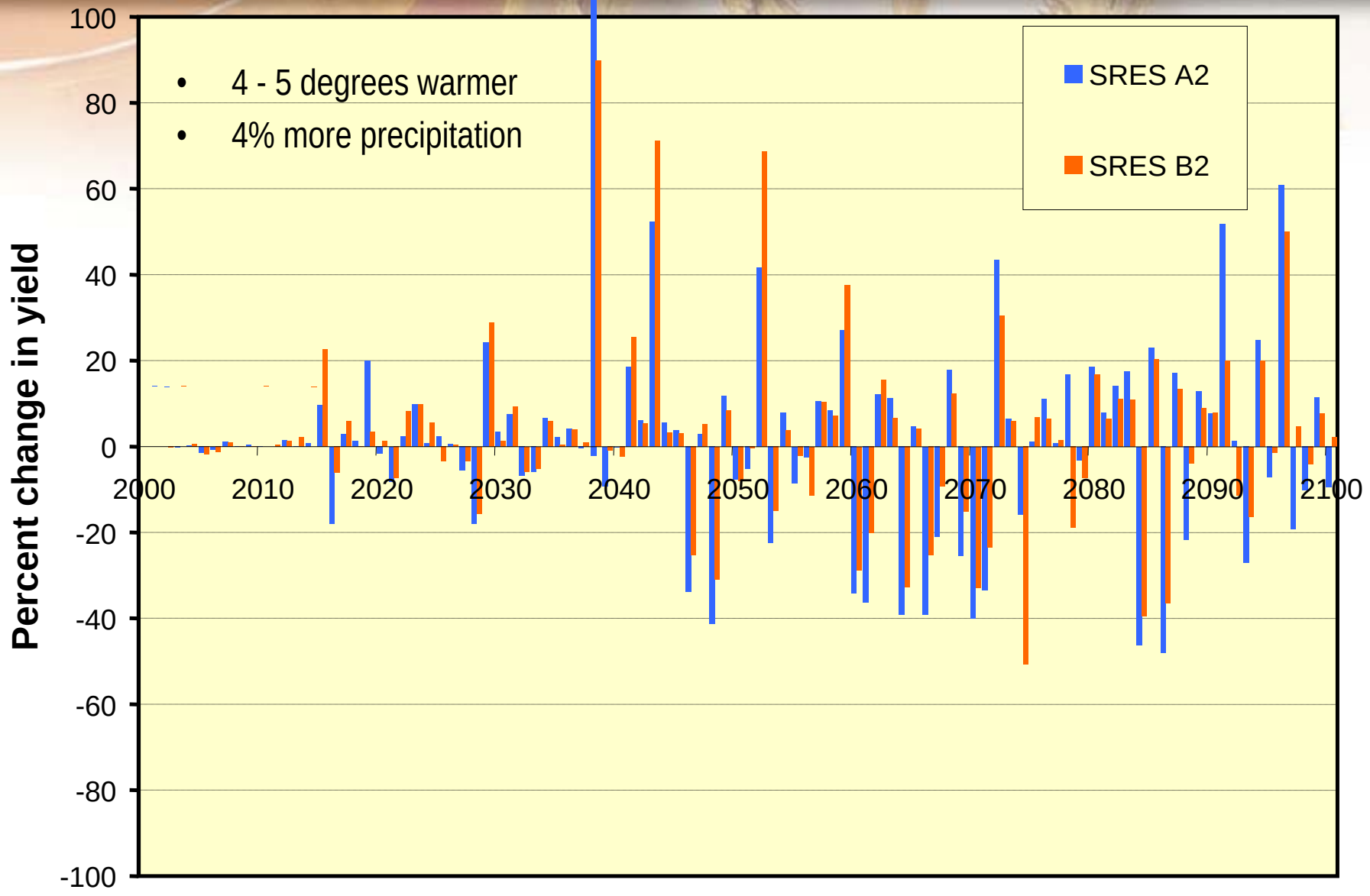
Effect of SRES B2 climate scenario on net GHG emissions
Ottawa, humid site



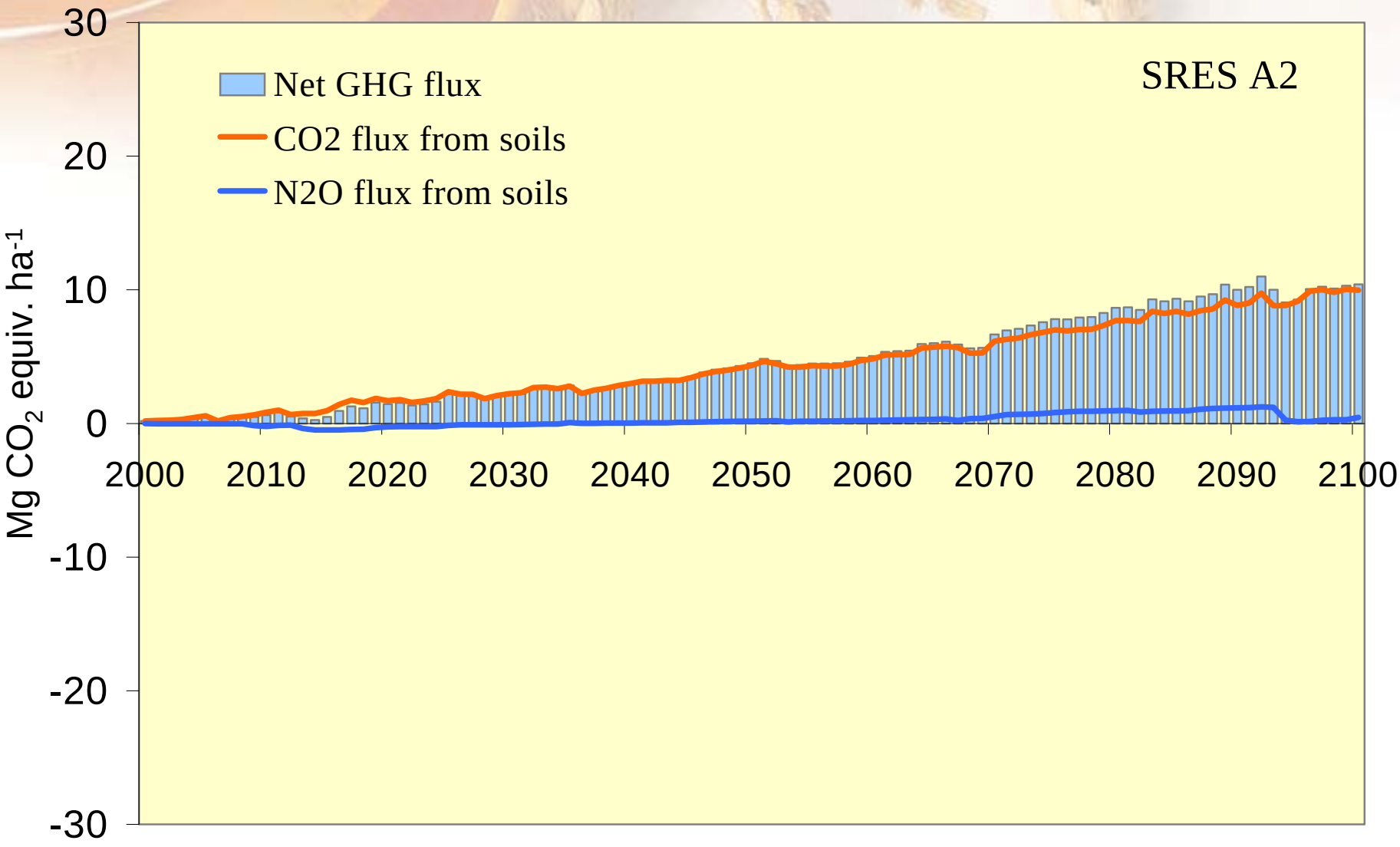
Effect of SRES B2 climate scenario with no CO_2 fertilization on net GHG emissions, Ottawa, humid site



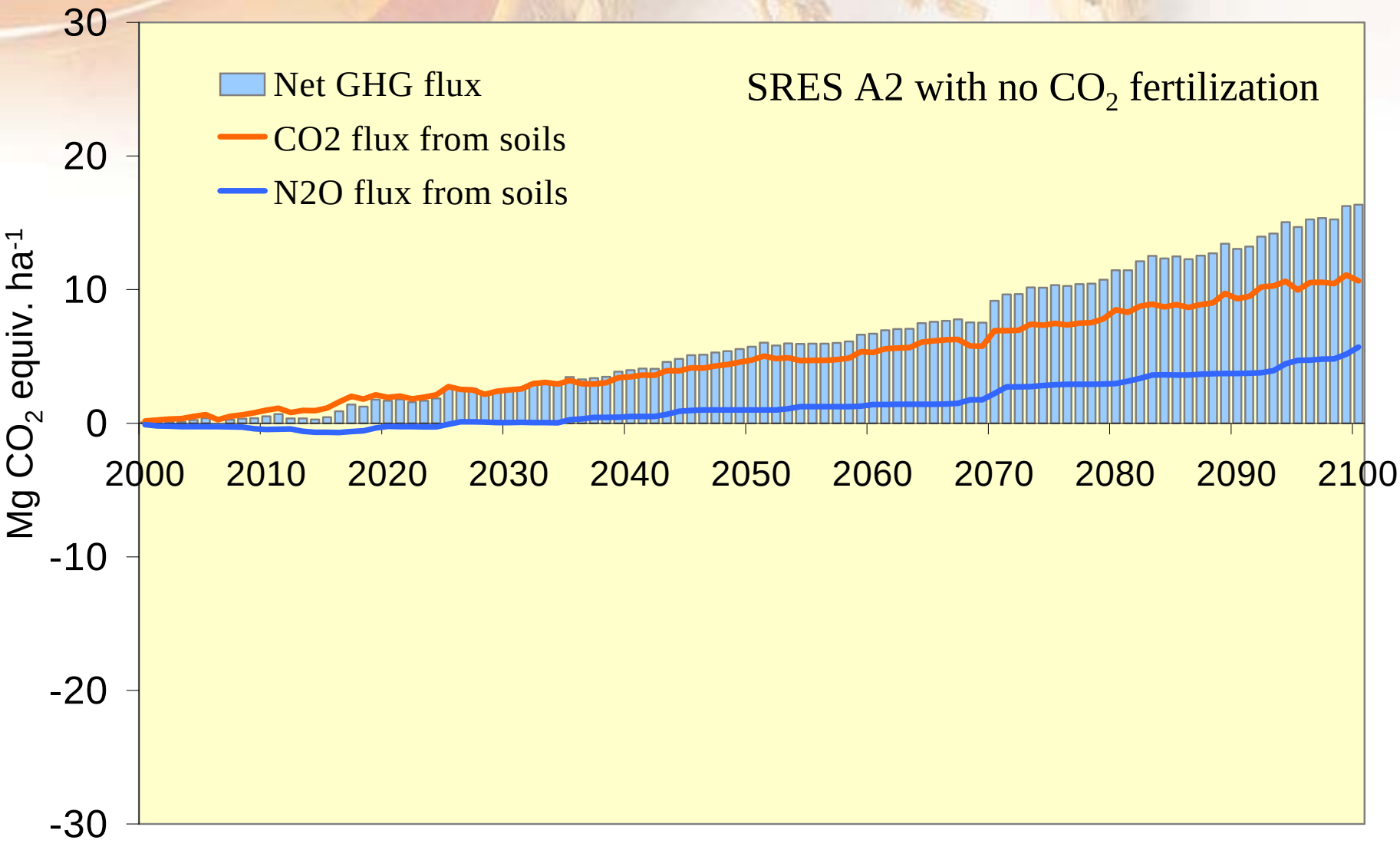
Effect of climate change on wheat yield
Lethbridge Alberta (2000-2100)



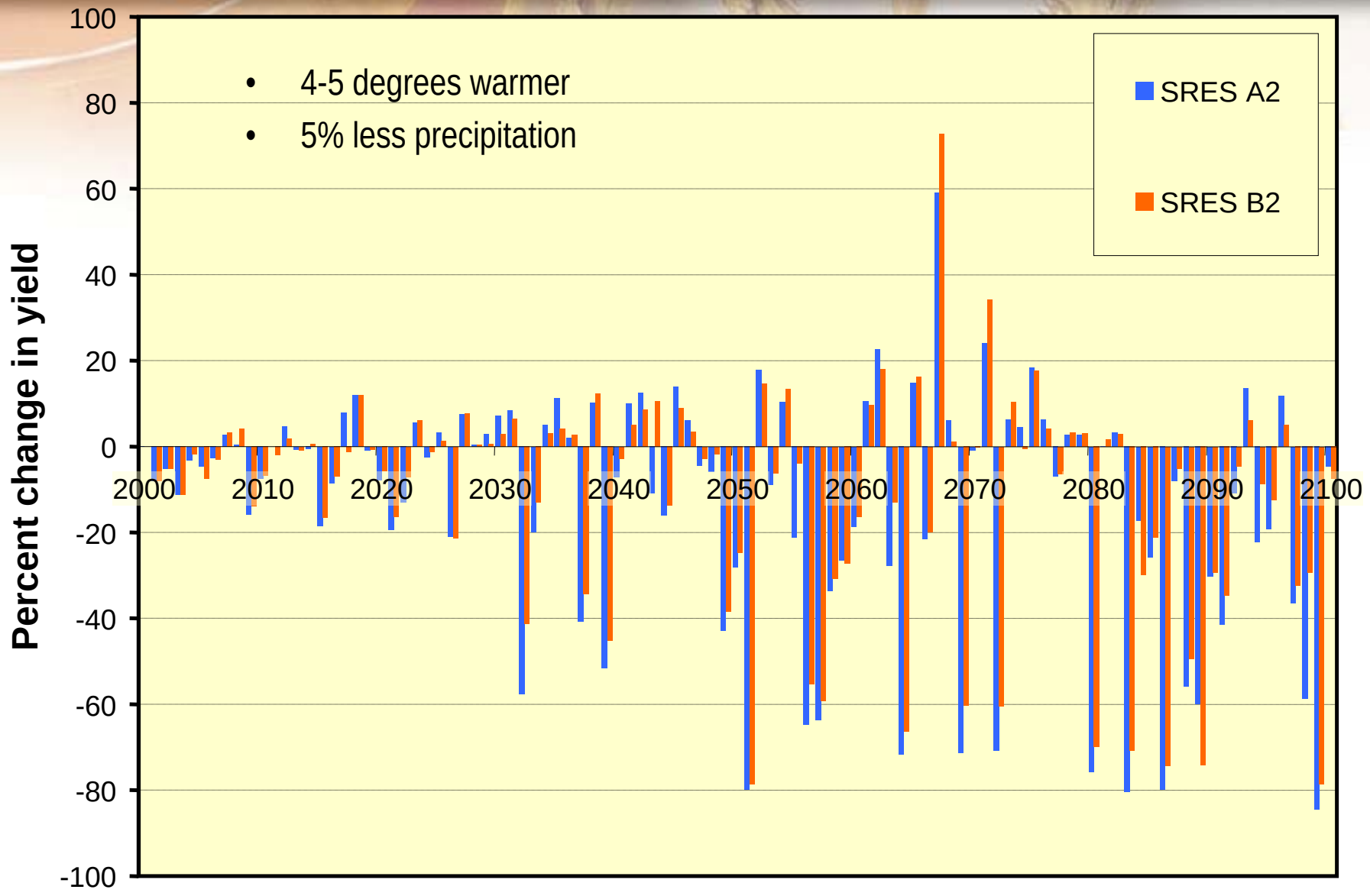
Effect of climate change on GHG emisisons
Lethbridge Alberta, A2 climate scenario



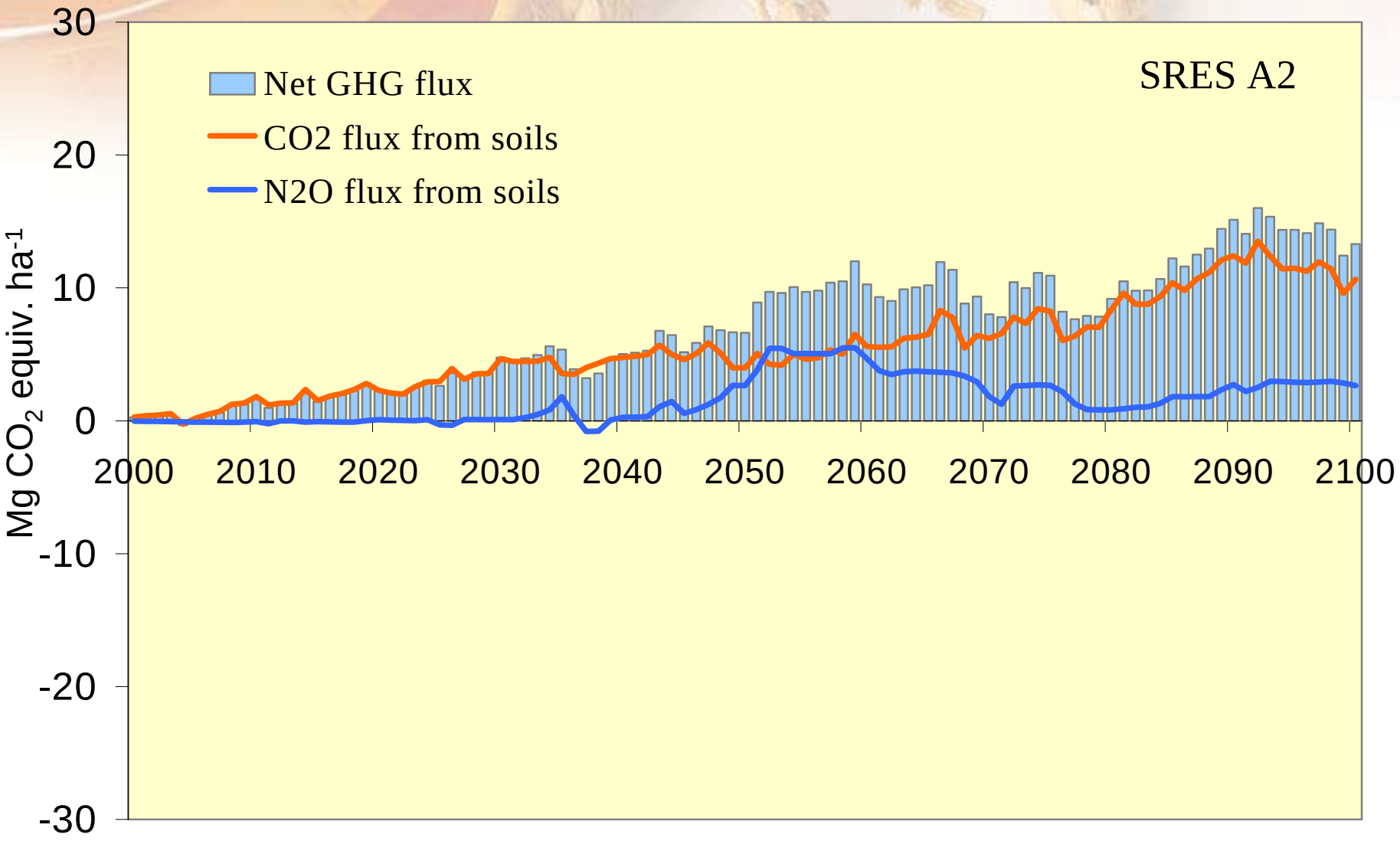
Effect of climate change on GHG emisisons
Lethbridge Alberta, A2 climate scenario with no CO_2 fertilization



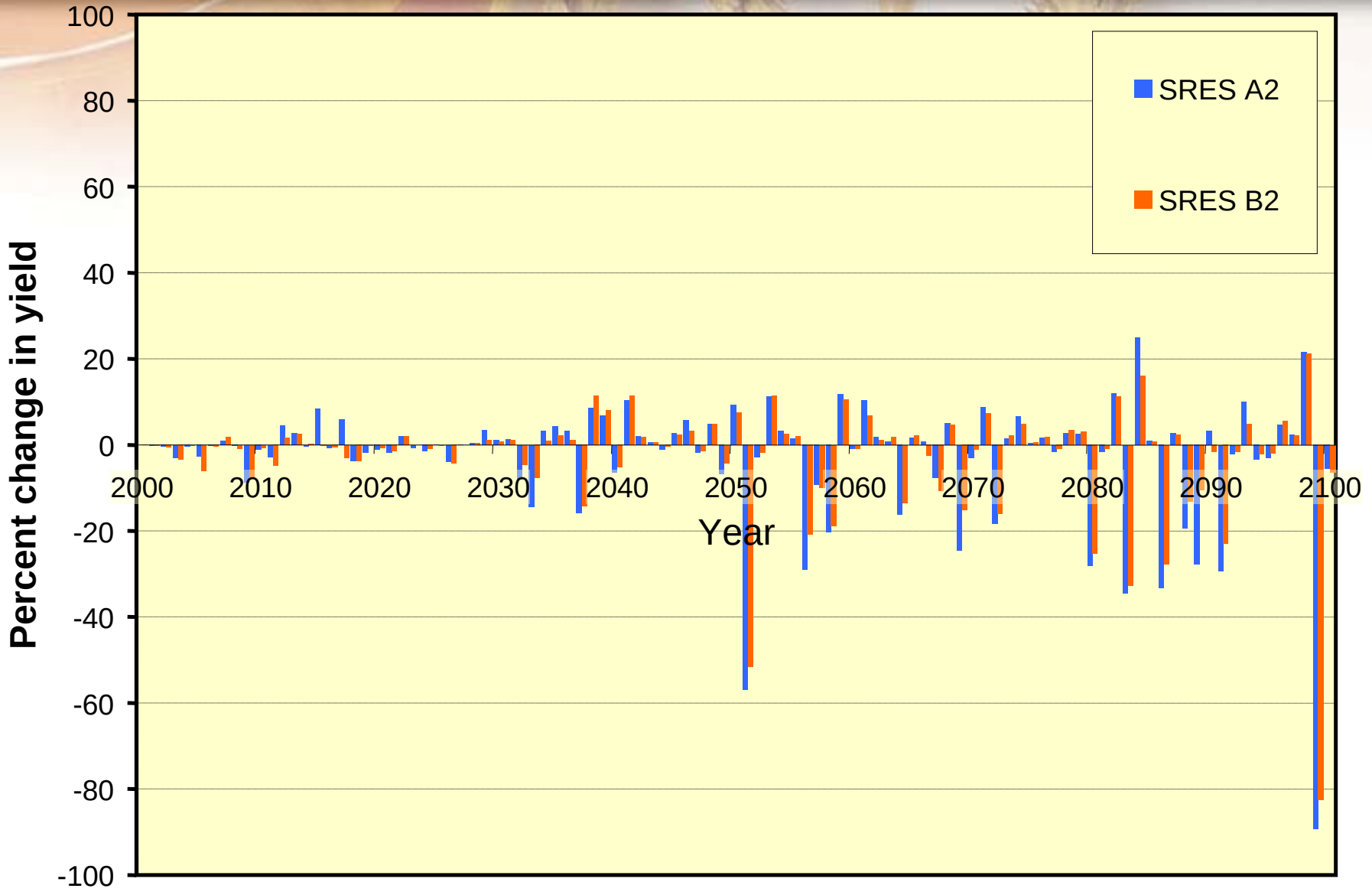
Effect of climate change on wheat yield
Indian Head, Saskatchewan (2000-2100)



Effect of climate change on GHG emisisons
Indianhead Alberta, A2 climate scenario



Effect of climate change on wheat yield, wheat-fallow rotation at Indian Head, SK (2000-2100)



Conclusions

- The ability of the DNDC model to estimate crop biomass production and nitrous oxide emissions in Canada has been improved
- The DNDC model predicts that a changing climate could result in soil carbon loss across Canada and an increase in N_2O emissions in humid soils.
- We are developing a framework for estimating the effect that climate has on GHG emissions and emission factors. Our goal is to simulate biomass production and GHG emissions for a wide range of mitigation and adaptation measures under a changing climate