POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

Leibniz Gemeinschaft

Climate change impacts on crop yields and food self-sufficiency in sub-Saharan Africa

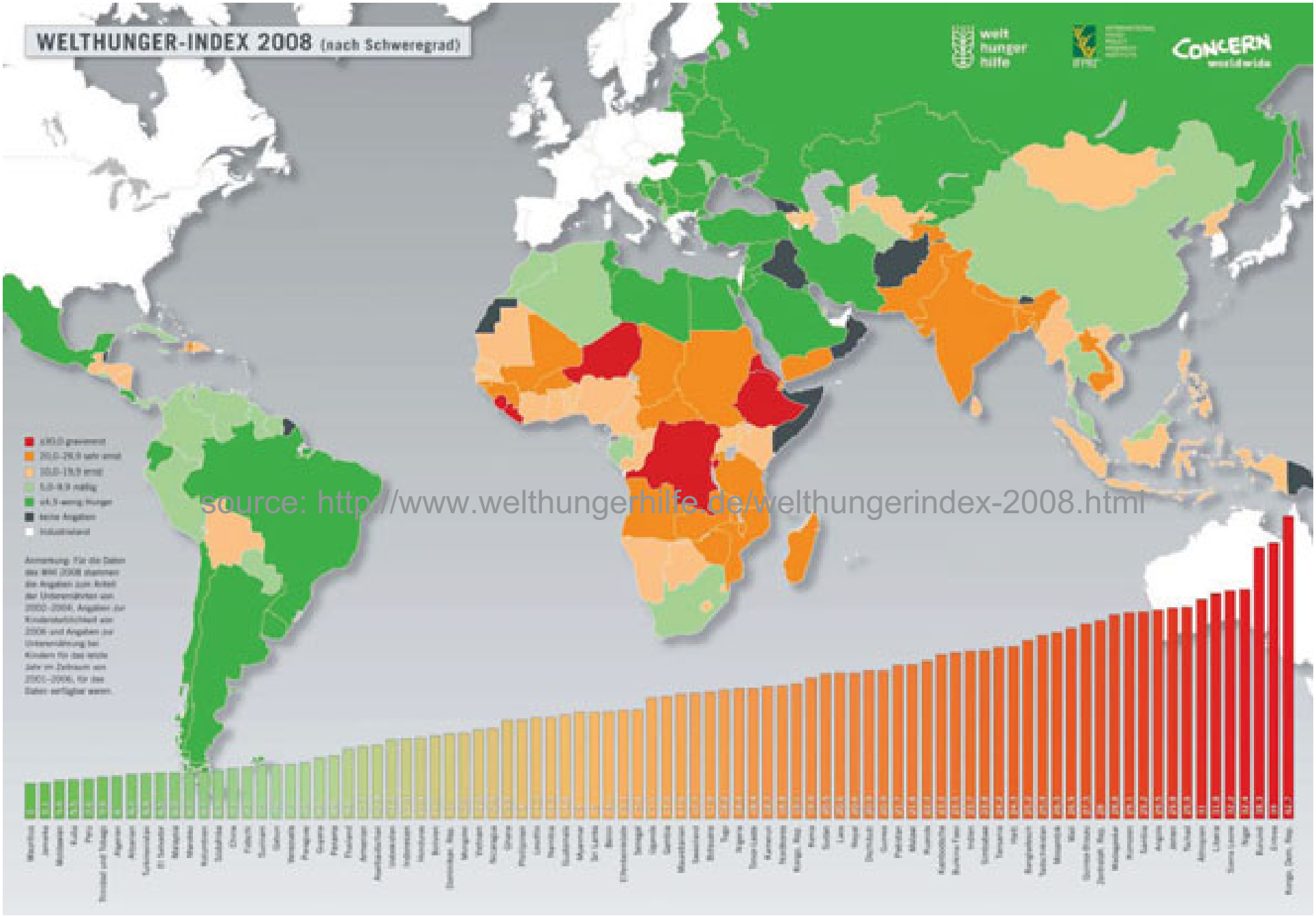
A LPJmL study

Oral presentation

Global Change in Africa: Projections, Mitigation, and Adaption

Katharina Waha & Christoph Müller

PIK


WELTHUNGER-INDEX 2008 (nach Schweregrad)
welt hunger hilfe
CONCERN worldwide
source: http://www.welthungerhilfe.de/welthungerindex-2008.html
≥ 30 extremely alarming
<30-20 alarming
<20-10 serious
<10-5 moderate
<5 low hunger
No data

Main questions

- To what extent will climate change impact crop yields, thus food production?
  - What could be the benefit of elevated CO_2 concentrations?
- How will food self-sufficiency change?

$$\text{food self-sufficiency} = \frac{\text{food production}}{\text{food demand}}$$

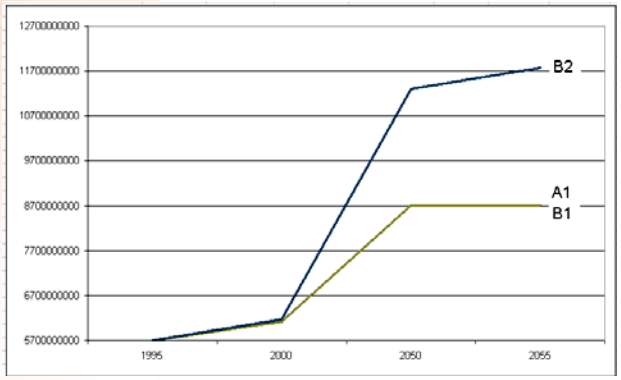
Modeling climate change impacts

The LPJmL model

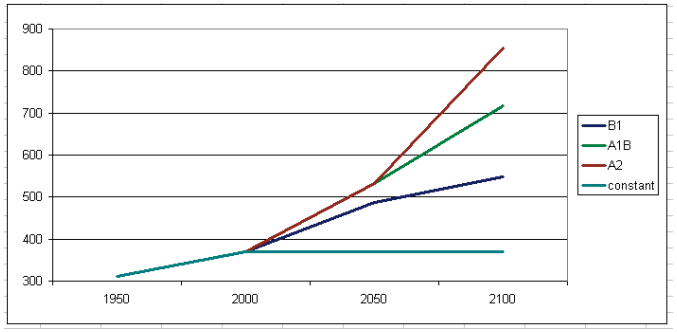
- dynamic global vegetation model
- simulates key ecosystem processes of natural and agricultural vegetation in a process-based way
- high spatial resolution (0.5°x0.5° grid cells) and daily timesteps
- ability to dynamically simulate ecosystem and plant responses to climate variations
- results are successfully compared with observations for:
  - phenology and yields (Bondeau et al. 2007)
  - evapotranspiration (Sitch et al. 2003)
  - river runoff (Gerten et al. 2004)
  - soil moisture (Wagner et al. 2003)

Modeling climate change impacts
Input Data

World population development
2000 - 2050

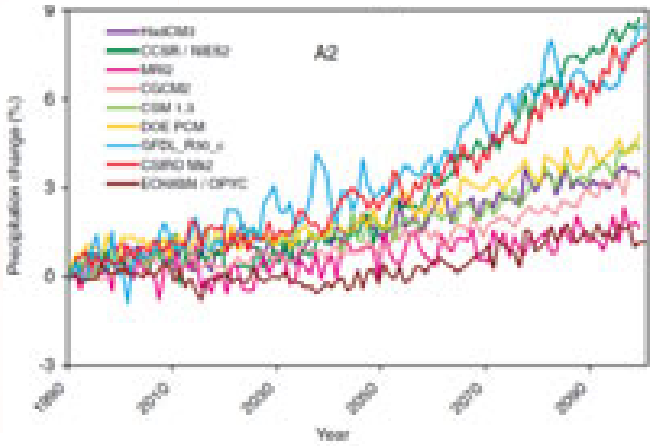


Change of carbon dioxide
concentration 2000 - 2050

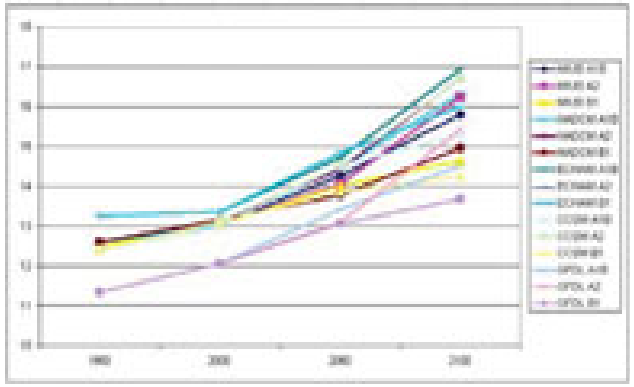


30 model runs

Rainfall change 2000 - 2050

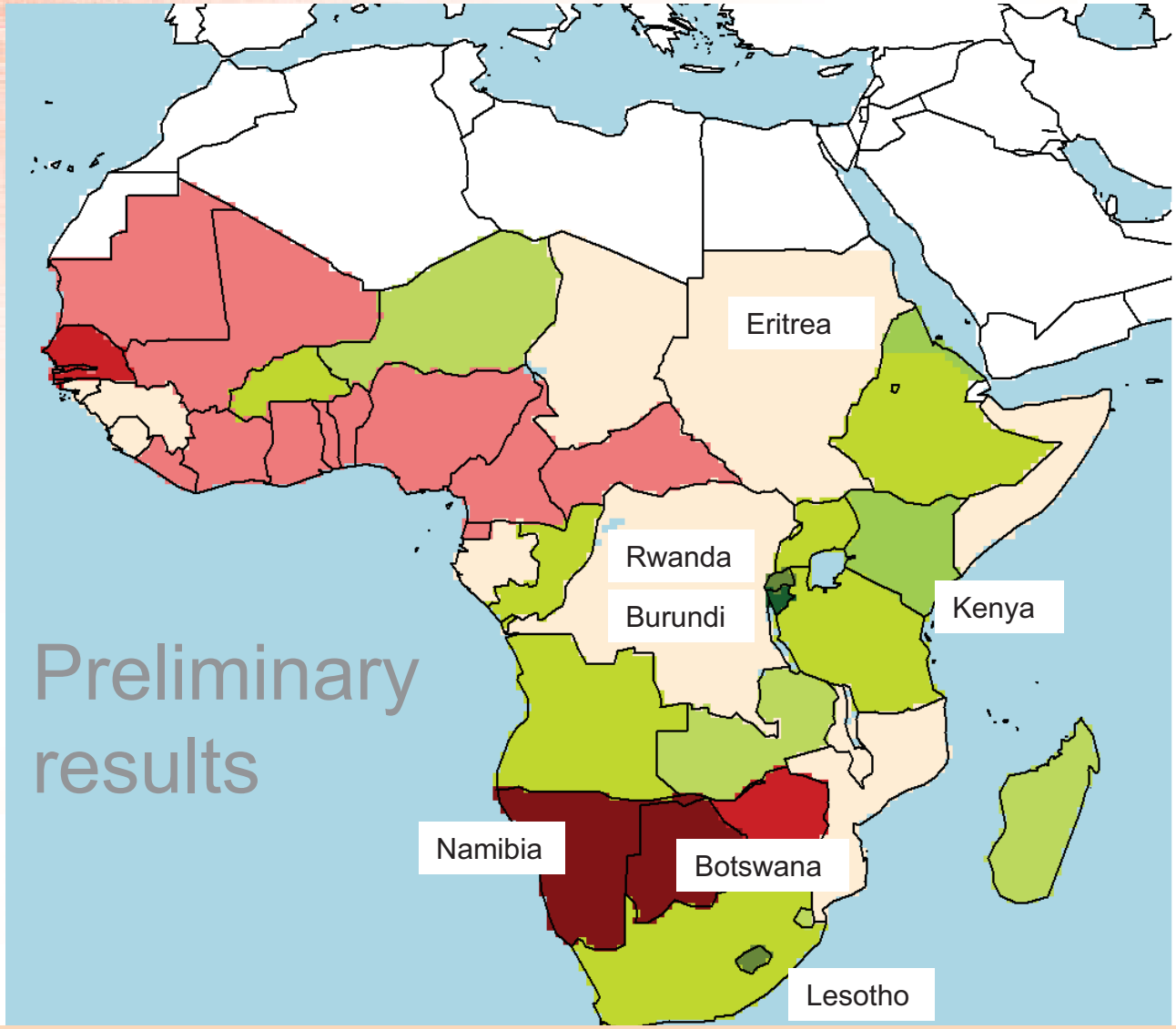


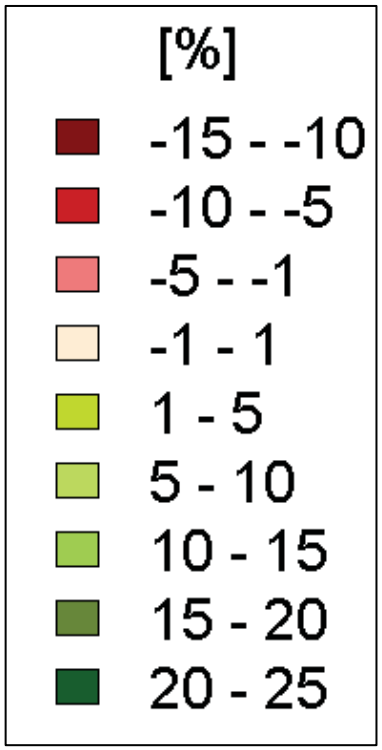
Temperatur change 2000 - 2050



Range of yield
changes

Yield change in sub-Saharan Africa 2000 to 2050





Mean of 5 **G**lobal**C**irculation**M**odels,
3 emission scenarios,
2 carbon dioxide concentrations scenarios

Katharina Waha & Christoph Müller

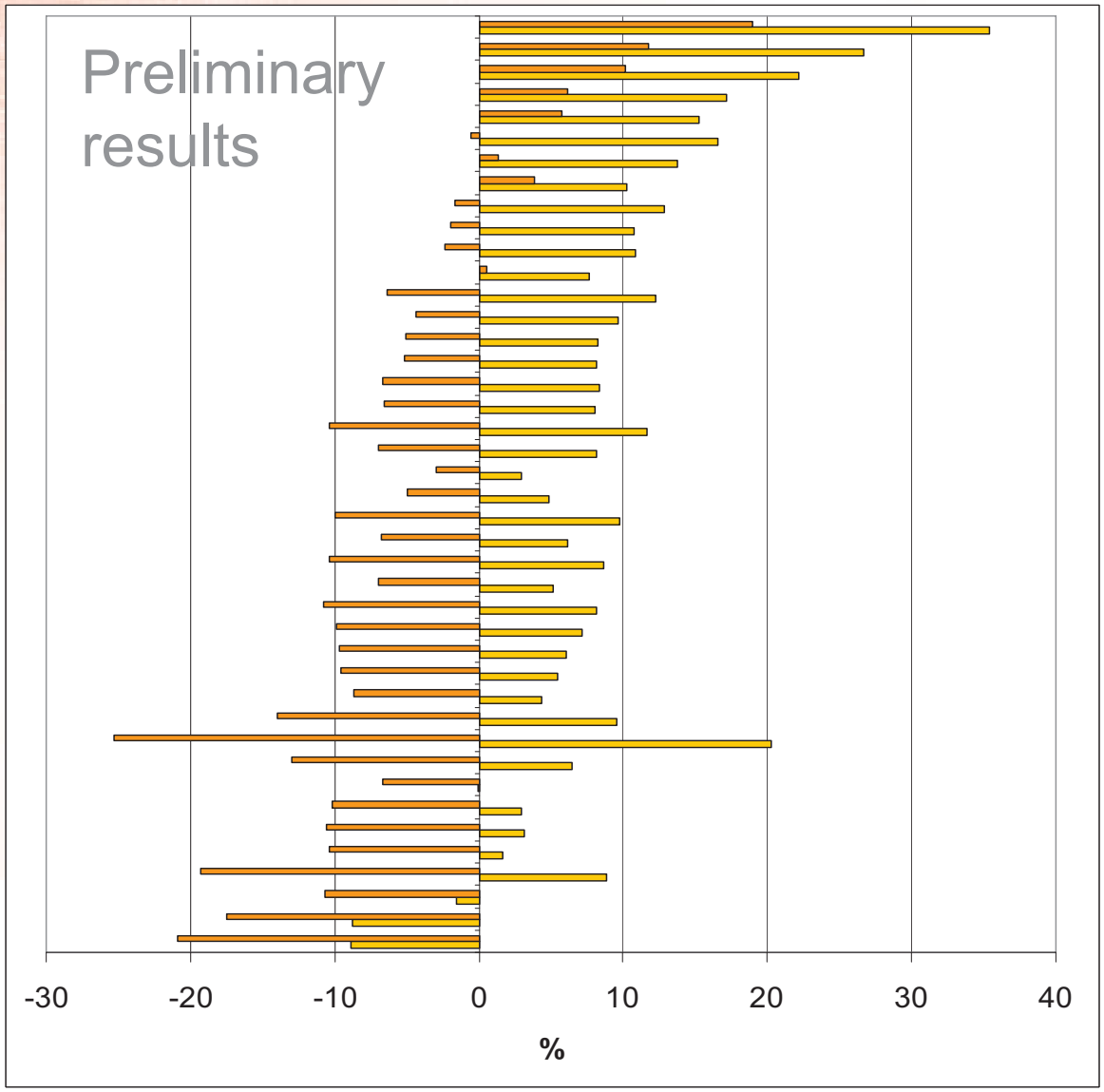
The CO_2 fertilization effect

- crop yield is expected to increase about 30% in C3 plants and 10% in C4 plants due to doubling CO_2 concentration
- main plant responses to elevated CO2:
  - stomata closure and decrease in stomata conductance
  - increase in the rate of photosynthesis
  - increase in water use efficiency

  Streck, N.A. (2005): Climate change and agroecosystems: the effect of elevated atmospheric CO_2 and temperature on crop growth, development, and yield
- the magnitude and even the direction of climate change effects on crop yields depend on CO_2 concentrations

  Tubiello et al. (2002): Effects of climate change on US crop production: simulation results using two different GCM scenarios. Part I: Wheat, potato, maize, and citrus

The CO_2 fertilization effect



Burundi, Lesotho, Rwanda, Kenya, Eritrea

> 10% increase

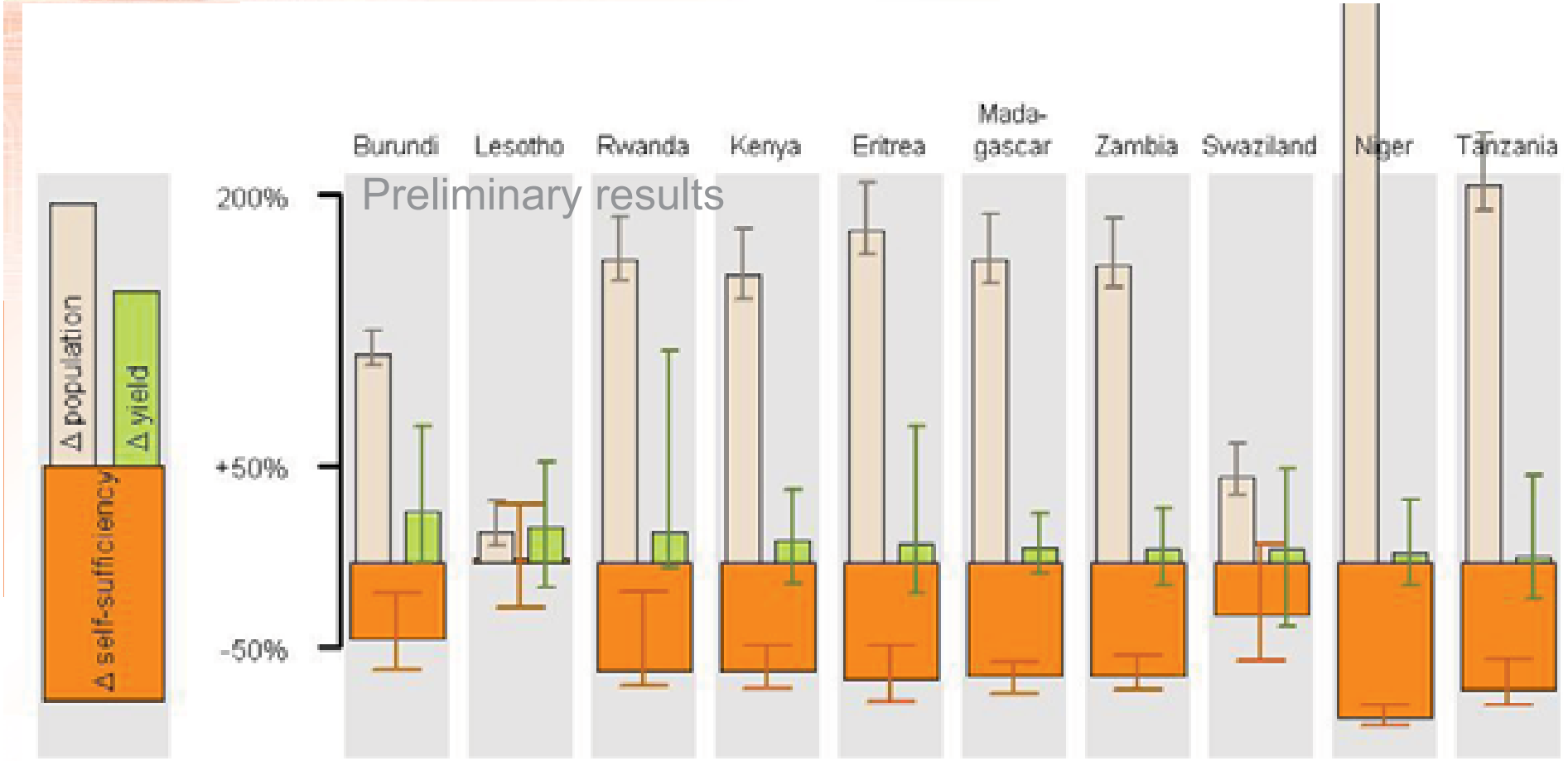
mean yield change no CO2 effect

mean yield change CO2 effect

Namibia, Botswana

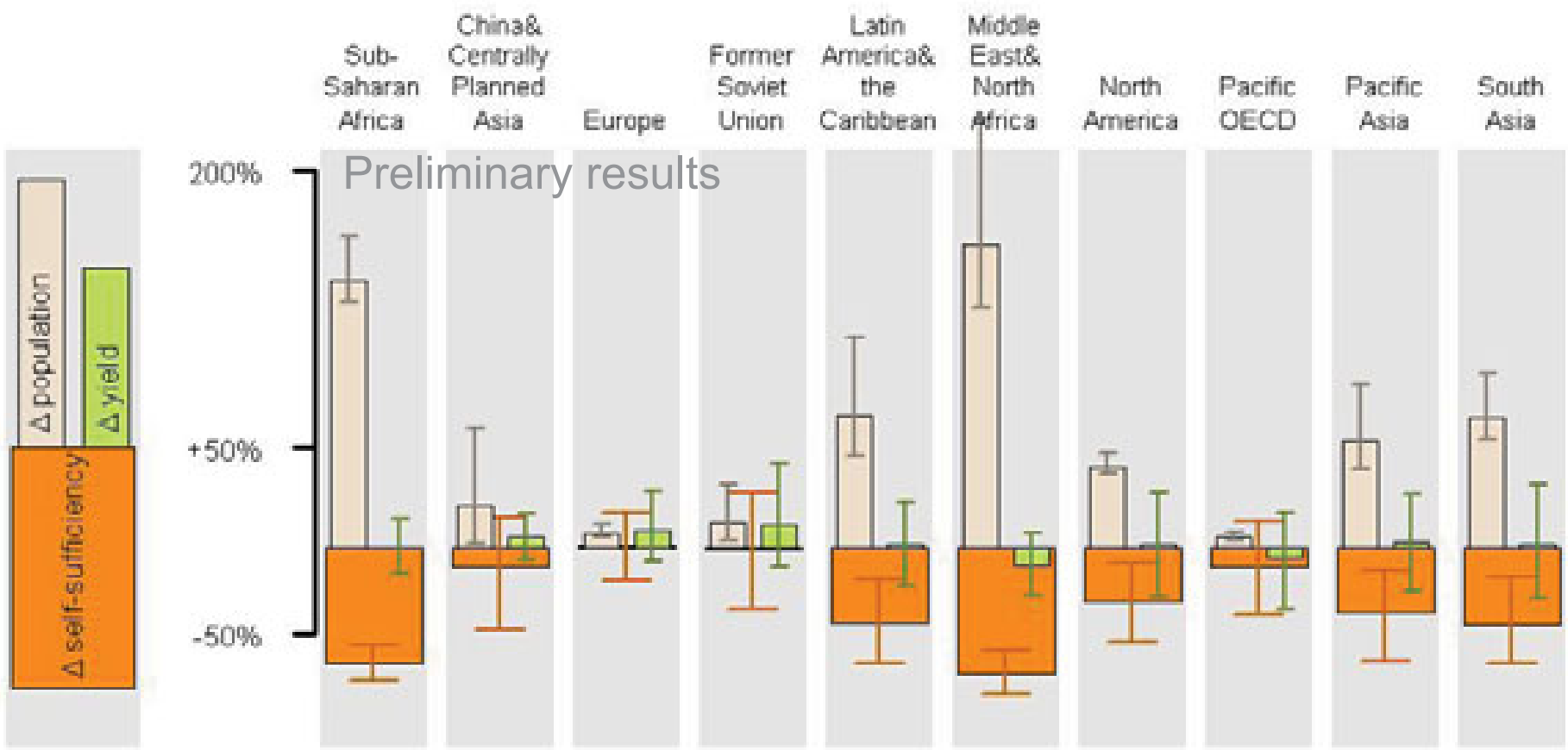
> 10% decrease

Yield and self-sufficiency change in sub-Saharan Africa 2000 to 2050



Mean, Max and Min of 5 **G**lobal**C**irculation**M**odels, 3 emission scenarios, 2 carbon dioxide concentration scenarios, 2 population scenarios

Global yield and self-sufficiency change 2000 to 2050



Mean, Max and Min of 5 **G**lobal**C**irculation**M**odels, 3 emission scenarios, 2 carbon dioxide concentration scenarios, 2 population scenarios

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Thank you!

Potsdam Institute for Climate Impact Research

The Price of Land.

Future Global Land-use Patterns for Food, Forest and Fuels

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Literature

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