

# How will climate change affect future potato production and water use in South Africa?

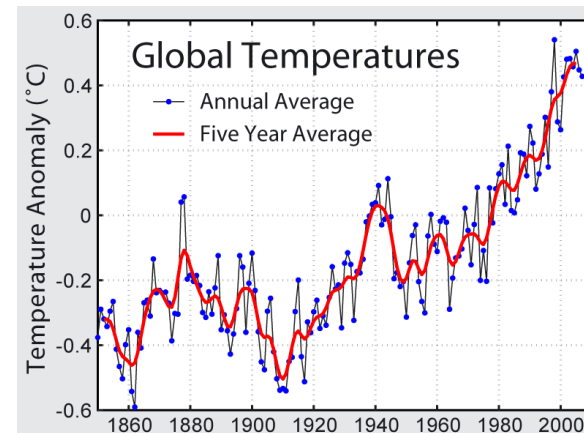
Martin Steyn<sup>1</sup>, Anton Haverkort<sup>1,2</sup>,  
Linus Franke<sup>2</sup> and Francois Engelbrecht<sup>3</sup>

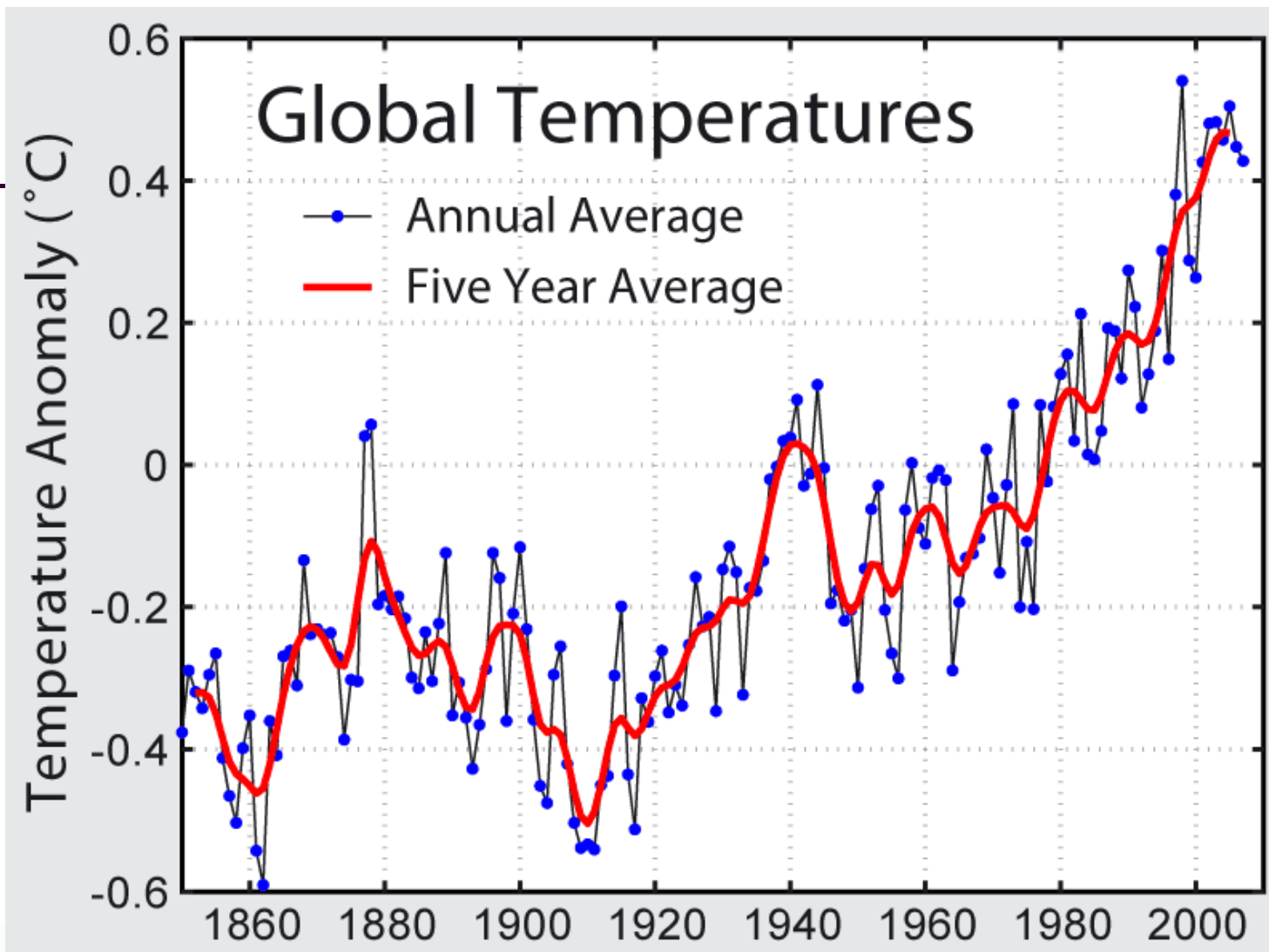
<sup>1</sup> University of Pretoria; <sup>2</sup> Wageningen University and Research Centre; <sup>3</sup> CSIR



# Introduction

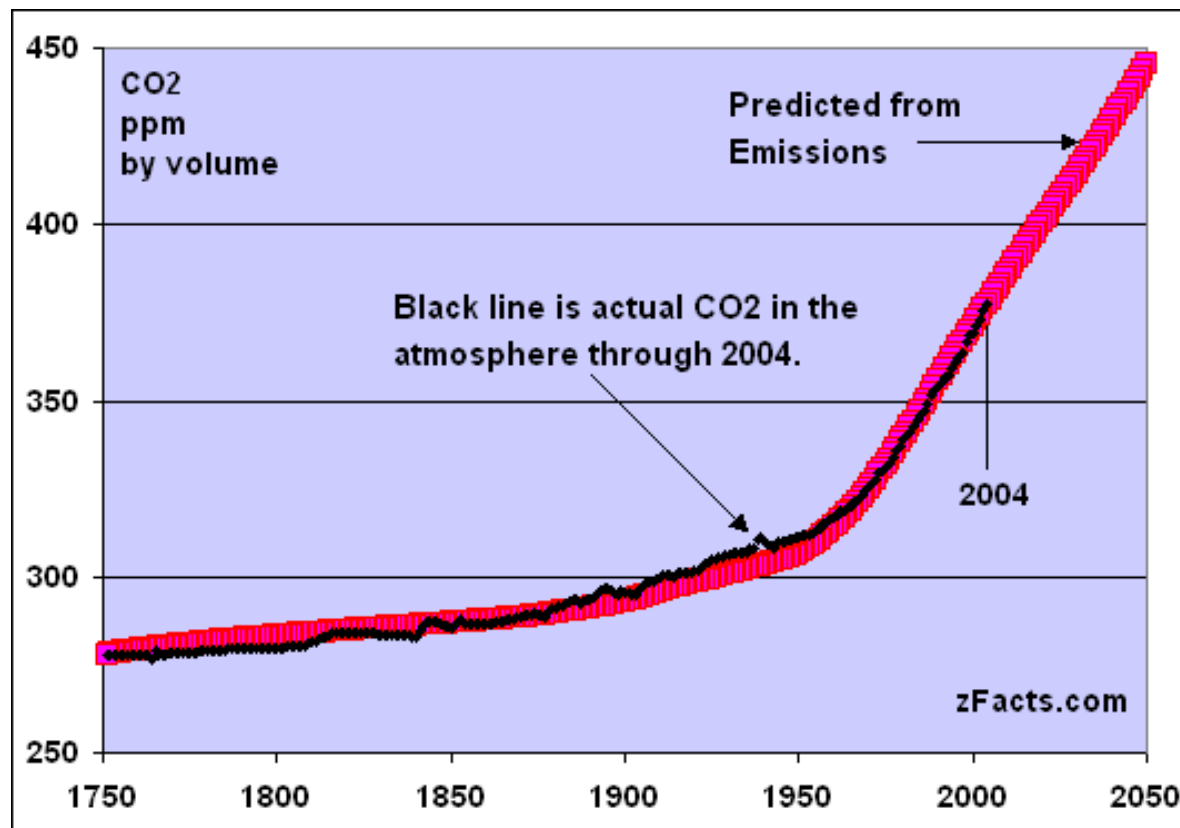
- 🔥 What is Climate Change?
- 🔥 Is it real?
- 🔥 If so, how will it affect crop production in future?

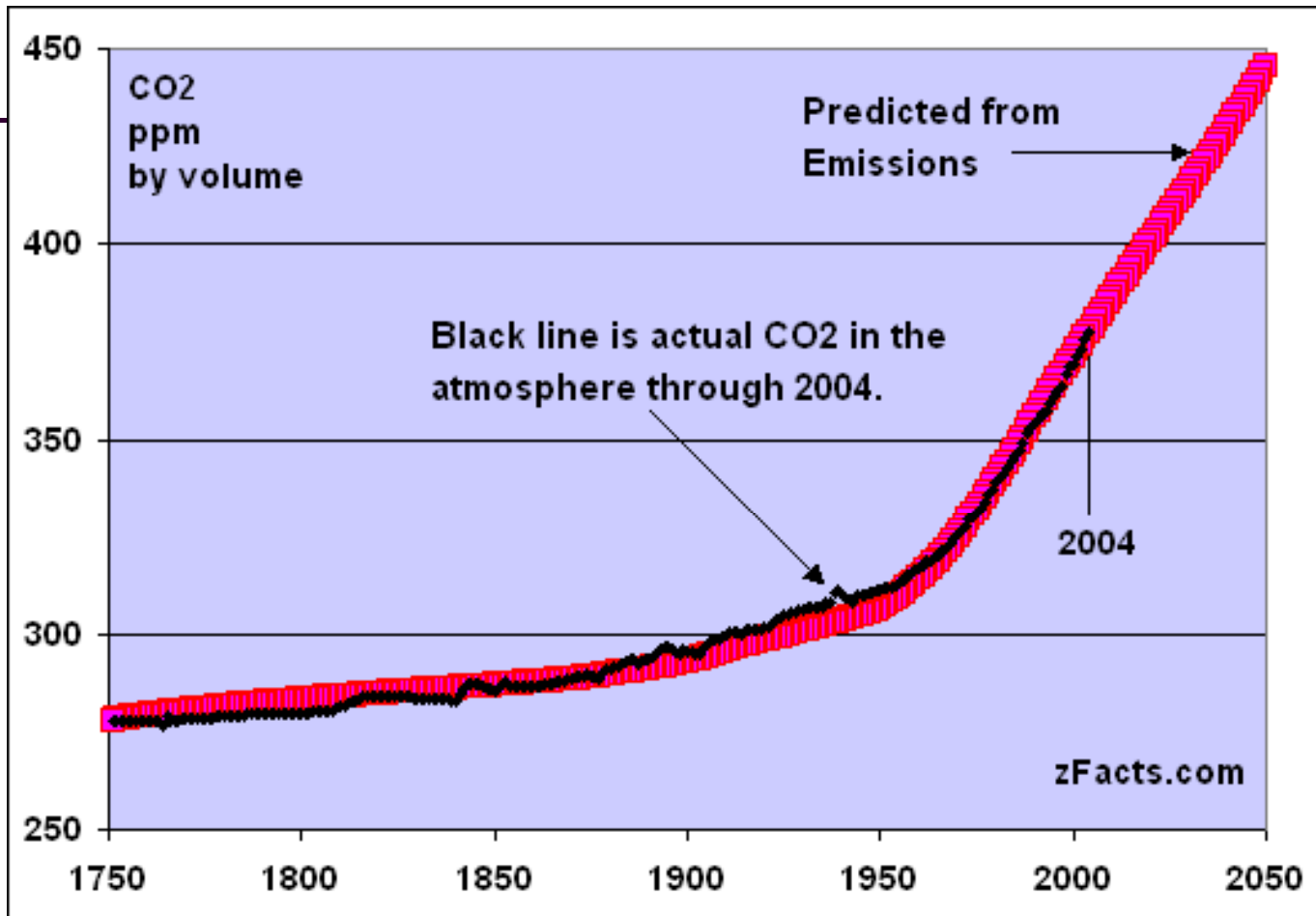




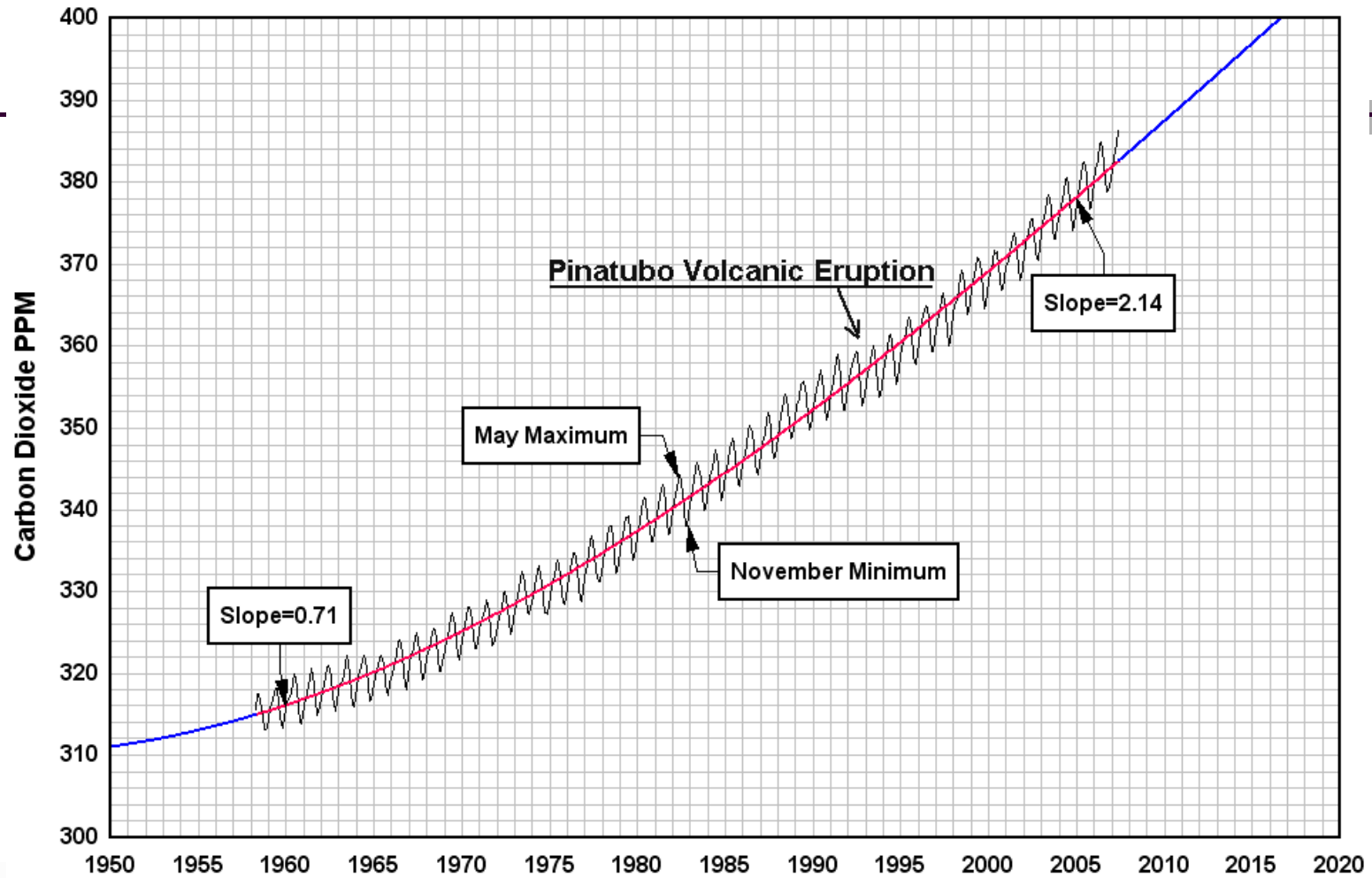
# Introduction

- ♦ Steep rise in “greenhouse gas” (CO<sub>2</sub>) emissions, especially since 1950's



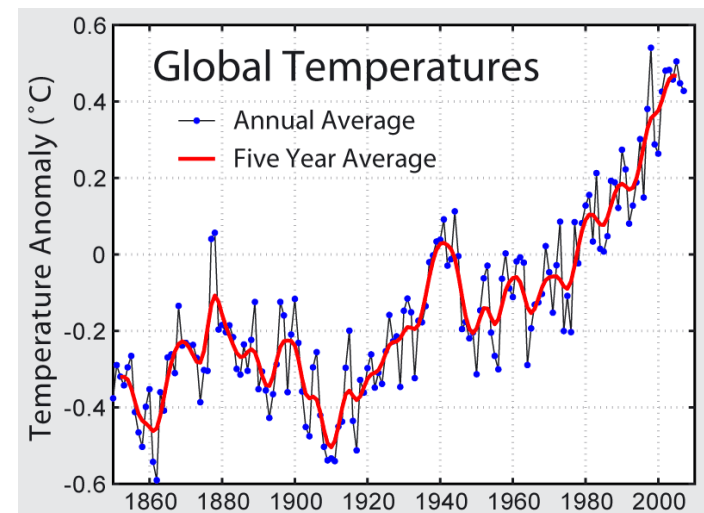
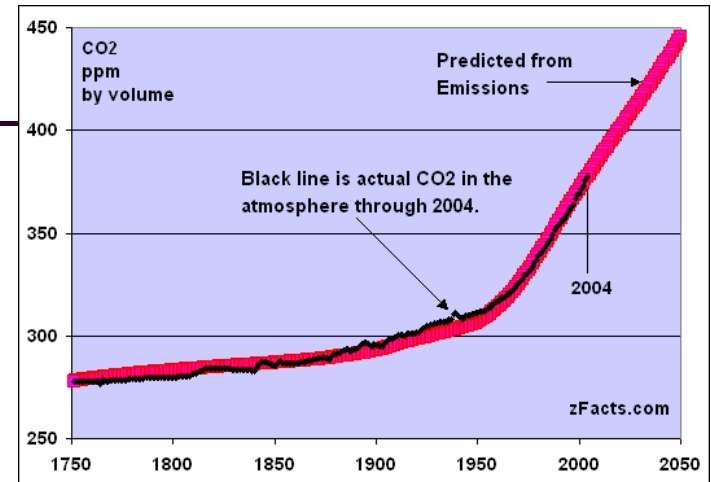


## Atmospheric Carbon Dioxide During the Past 50 Years



# Introduction

- Simultaneous rise in  $\text{CO}_2$  and global temperatures not a coincidence!
- Greenhouse gases act like a blanket
- reflects heat back to earth



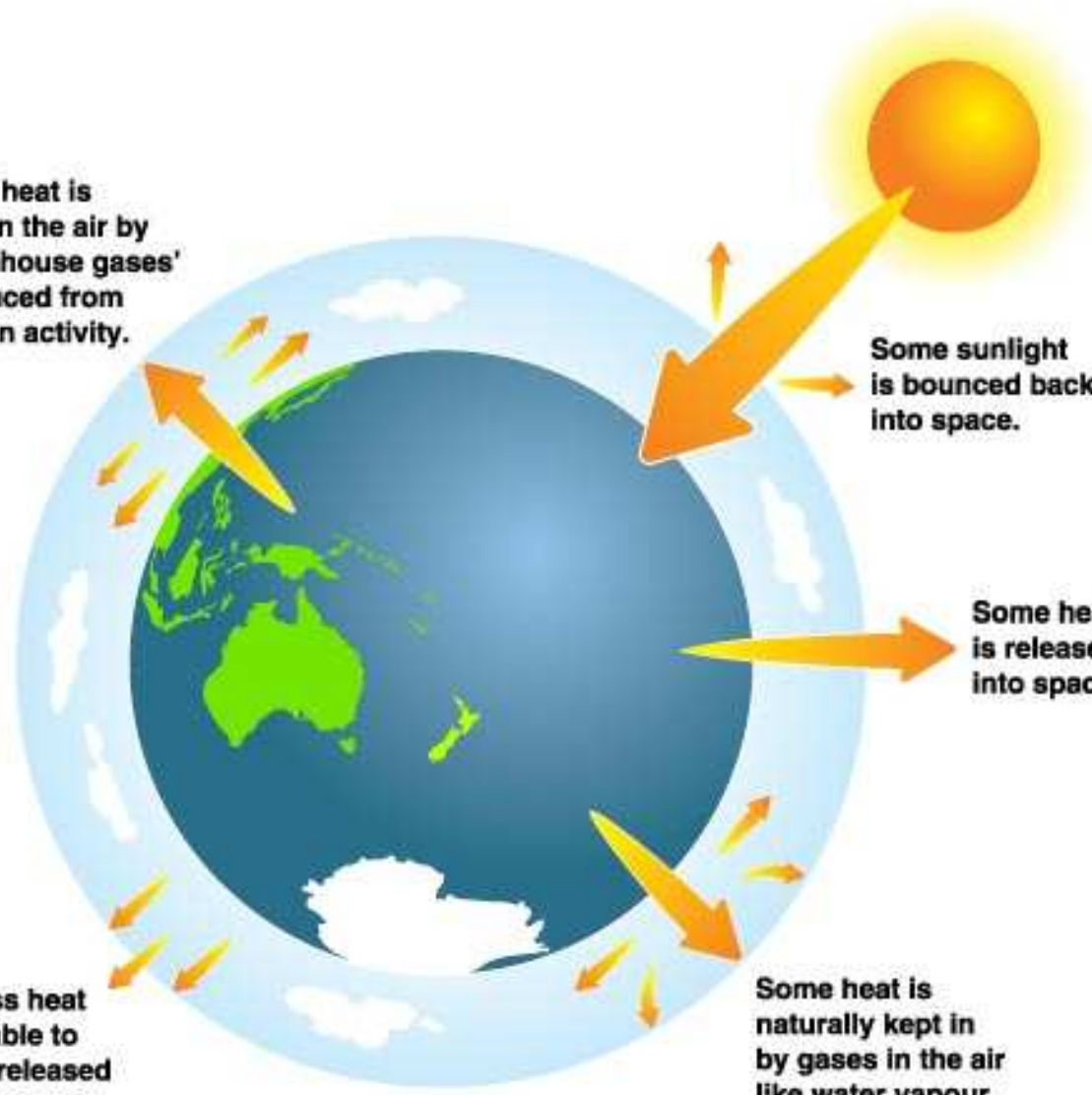
Extra heat is kept in the air by 'greenhouse gases' produced from human activity.

Some sunlight is bounced back into space.

Some heat is released into space.

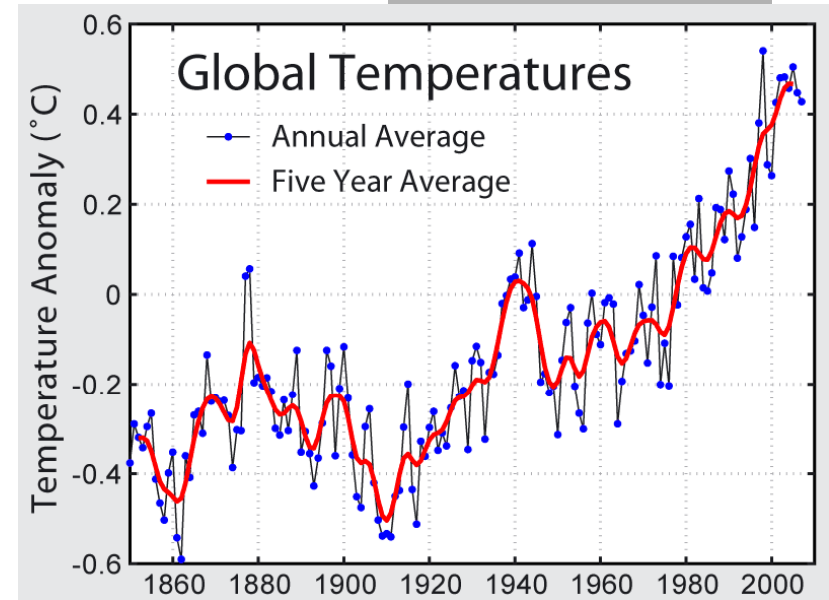
Less heat is able to be released into space.

Some heat is naturally kept in by gases in the air like water vapour.

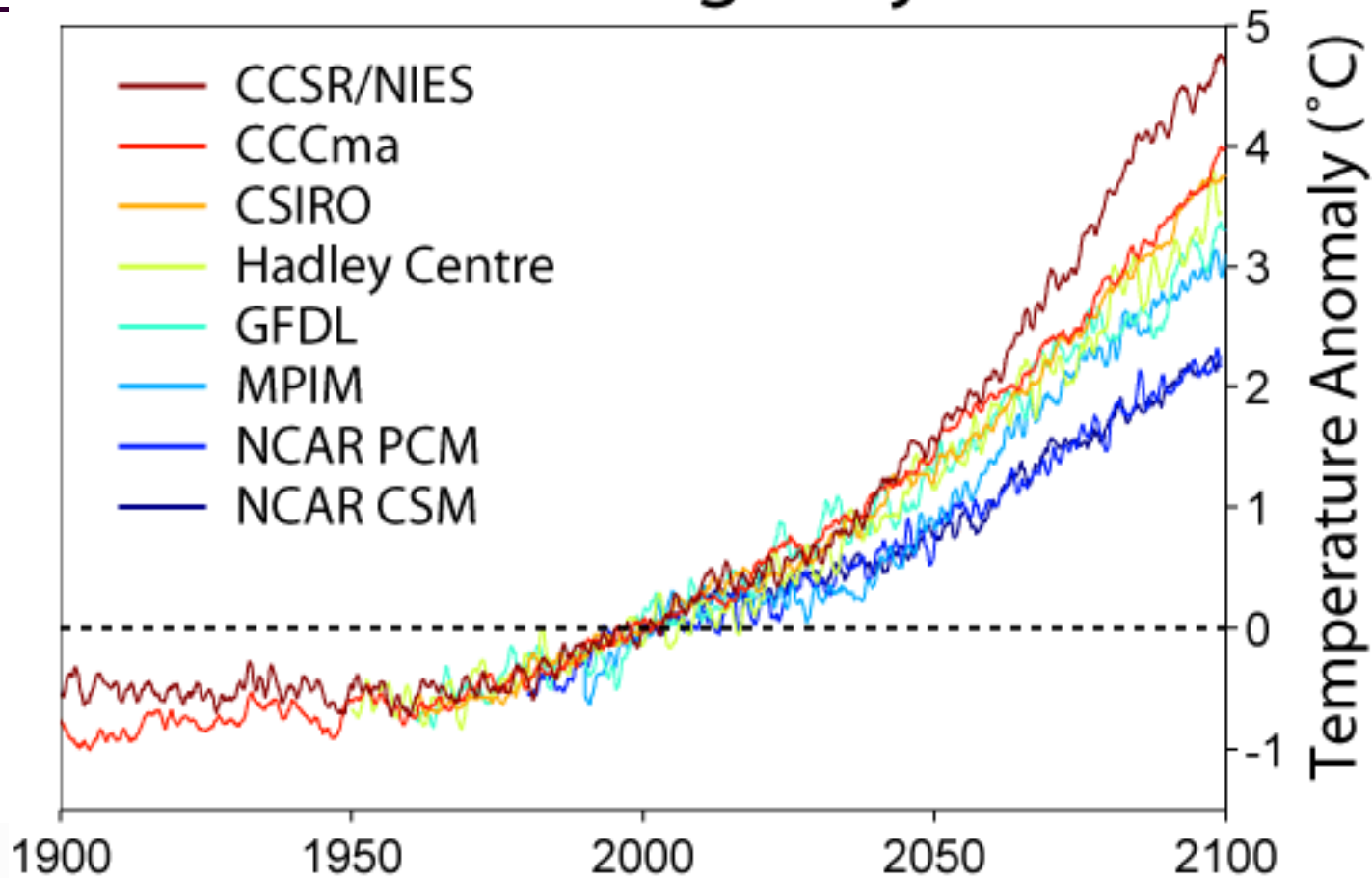


# Introduction

- Result: gradual rise in temperatures
- Greenhouse effect - Global warming
- Most warming has occurred over past 50 years
- Expected that temperatures will continue to rise further



# Global Warming Projections



# Introduction

- 🔥 Looking at yesterday's temperatures
- 🔥 Global warming seems to be real!
- 🔥 Just look how the size of ladies underwear has changed over the past centuries!



# Introduction

- Rainfall amounts and distribution will also change
- Increase in extreme weather events e.g. floods, droughts, heat waves, tornadoes
- Most severe changes expected in semi-arid areas, e.g. Southern Africa



# Introduction

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- Potato is a temperate crop
- Prefers mild temperatures and ample water
- Higher day temperatures - some areas become less suitable for potato production
- Lower tuber yields and quality



# Introduction

- Potato farming most important economic activity in some areas
- Direct and serious risk to future crop production and food security
- Therefore study conducted to investigate:
  - potential impacts of climate change over next 30 - 40 years on potato production in SA
  - mitigation strategies

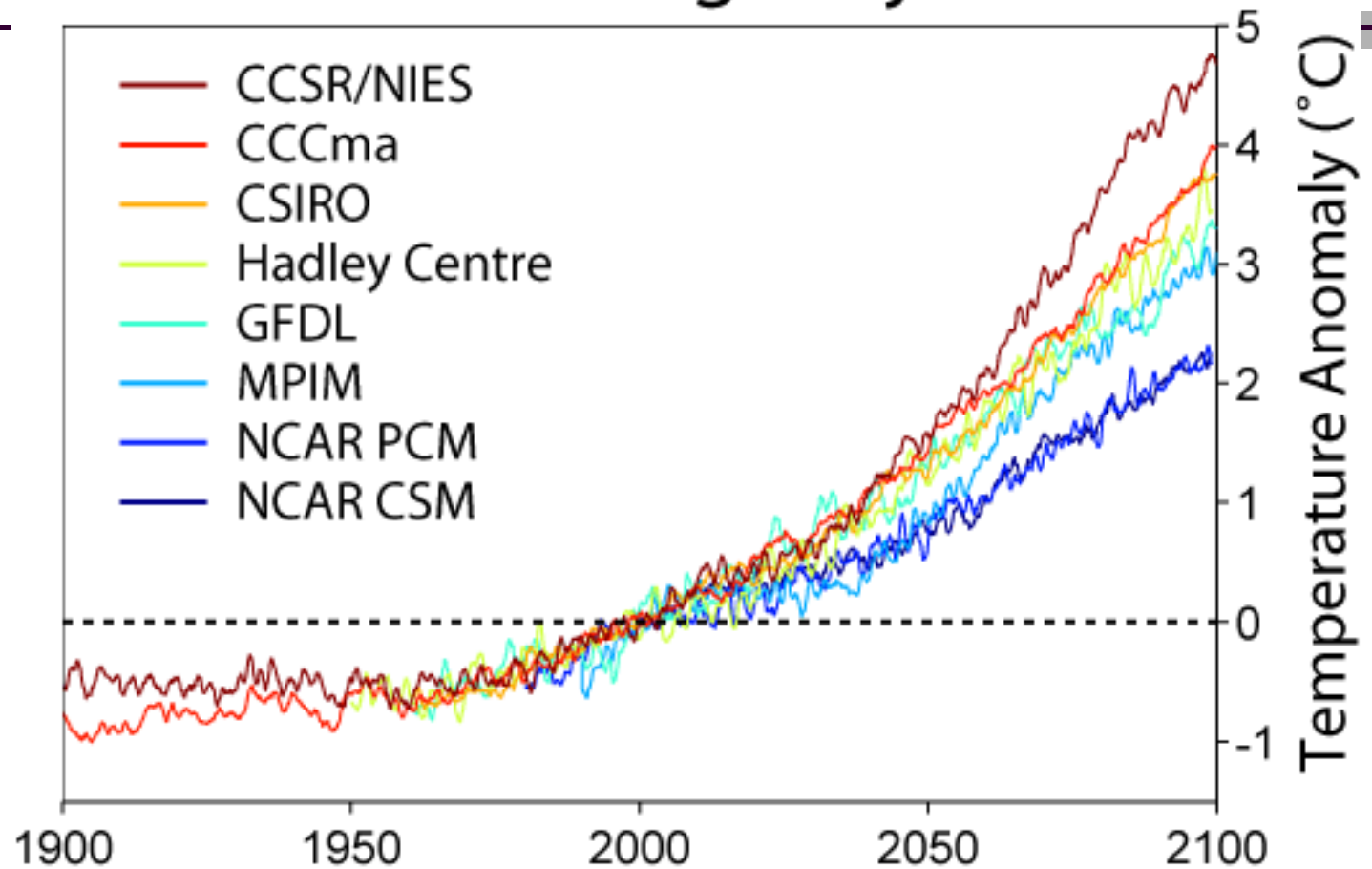


# Materials & methods

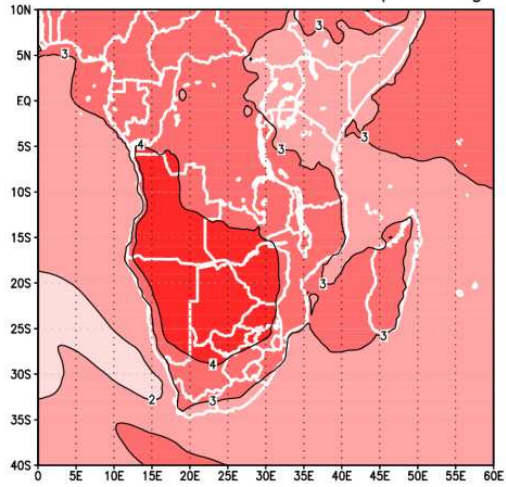
- ♦ Used 6 IPCC climate change models to simulate historical and future climate data (6 scenarios) for Southern Africa
  - ♦ temperature, rainfall, solar radiation and ETo
  - ♦ period 1961 - 2050
- ♦ Obtained daily long-term (12-18 years) historical weather data for potato regions
- ♦ Used as baseline to calibrate climate model



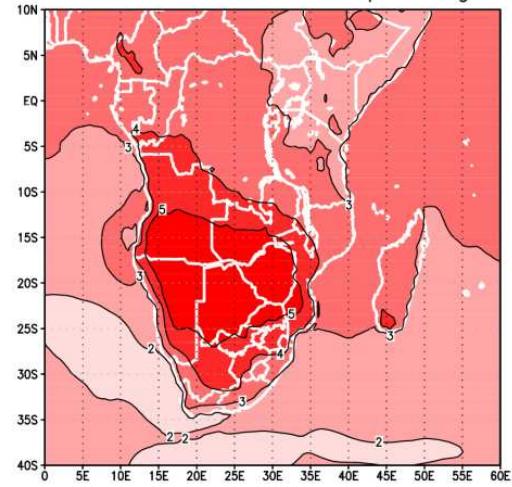
# Global Warming Projections



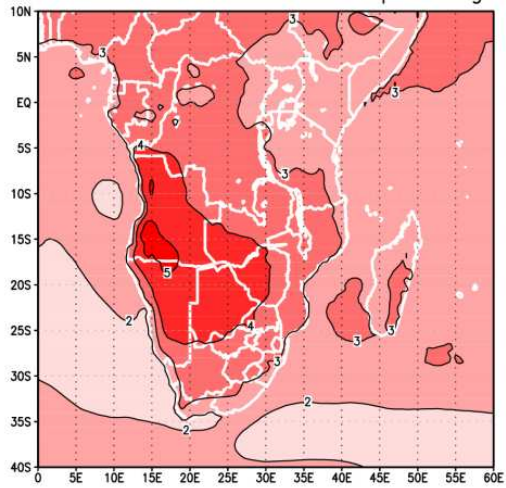
CCAM-GFDL2cm.0 Max temp change



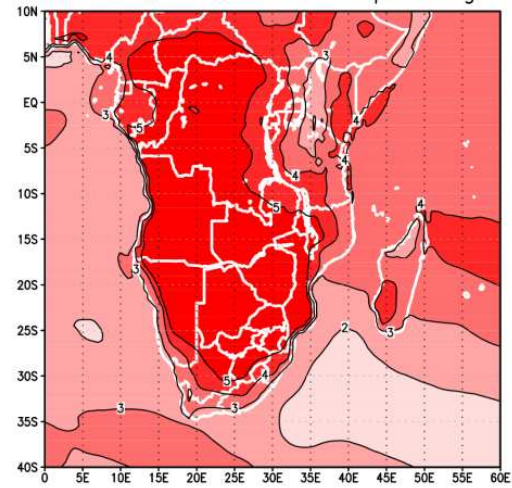
CCAM-ECHAM5 Max temp change



CCAM-GFDLcm2.1 Max temp change

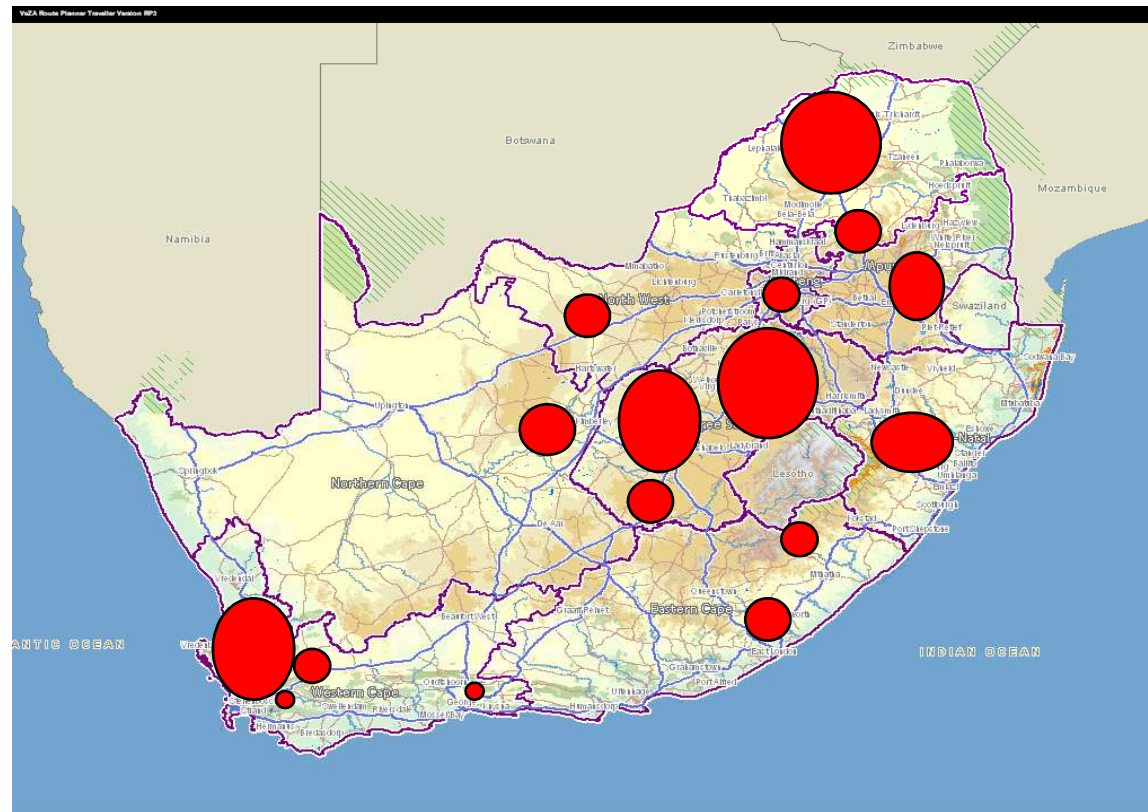


CCAM-MIROCmr Max temp change



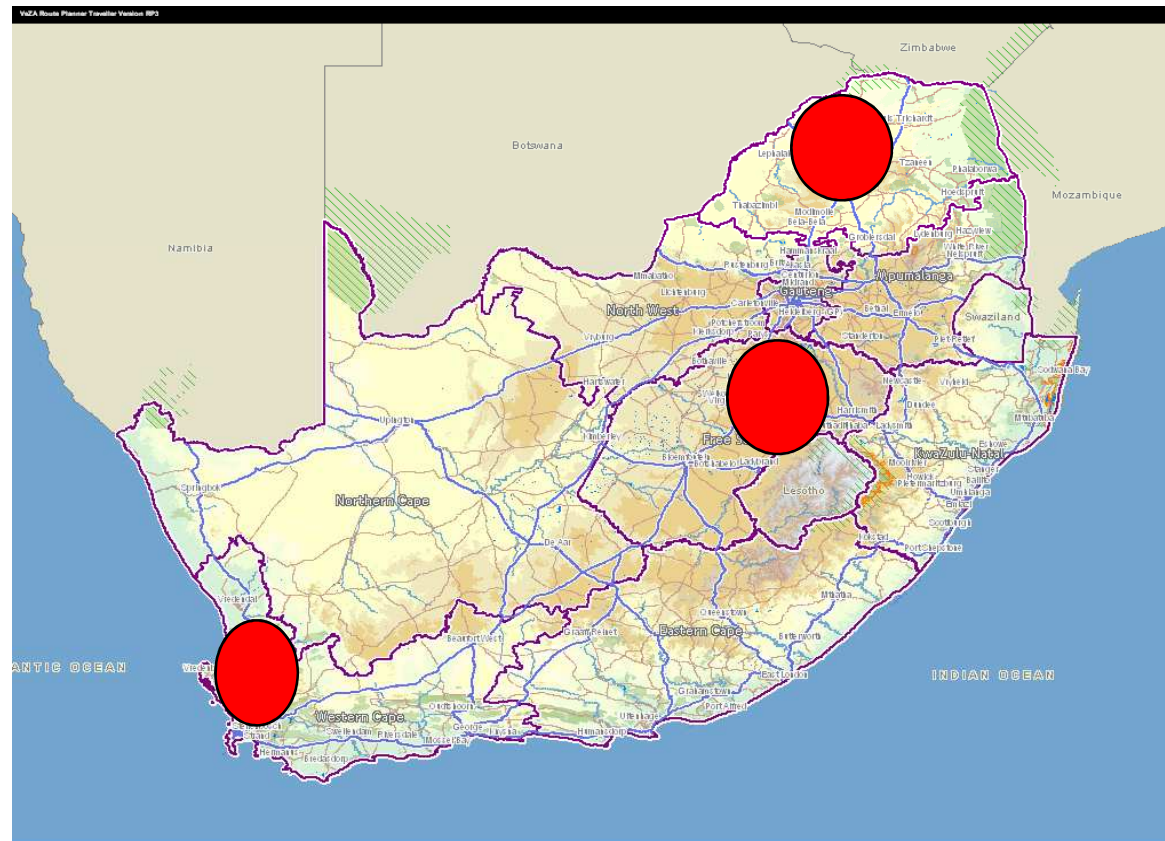
# Materials & methods

## 🔥 16 potato regions in South Africa



# Materials & methods

- 🔥 Focus on larger potato regions in South Africa



# Materials & methods

## 4 distinct potato cropping systems

- Summer crop without rainfall - Sandveld
- Summer crop with rainfall - Eastern Free State
- Winter crop with rainfall - Sandveld
- Winter crop without rainfall - Limpopo



# Materials & methods

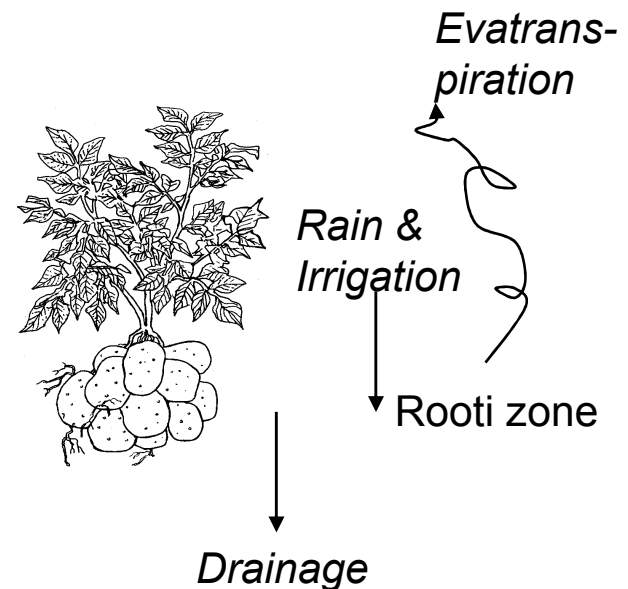
- Downscaled CC model forecasts to higher spatial resolution
- LINTUL crop growth model used to simulate potential potato yields
  - Past 1961-1970
  - Current 2000-2010
  - Future 2040-2050



# Materials & methods

## LINTUL crop model

- Driven by temperature, solar radiation, precipitation and ETo
- Assumes full irrigation
- Simulates TDM, tuber yield
- RUE - adjusted for  $[CO_2]$
- Water use of potato crops



# Results

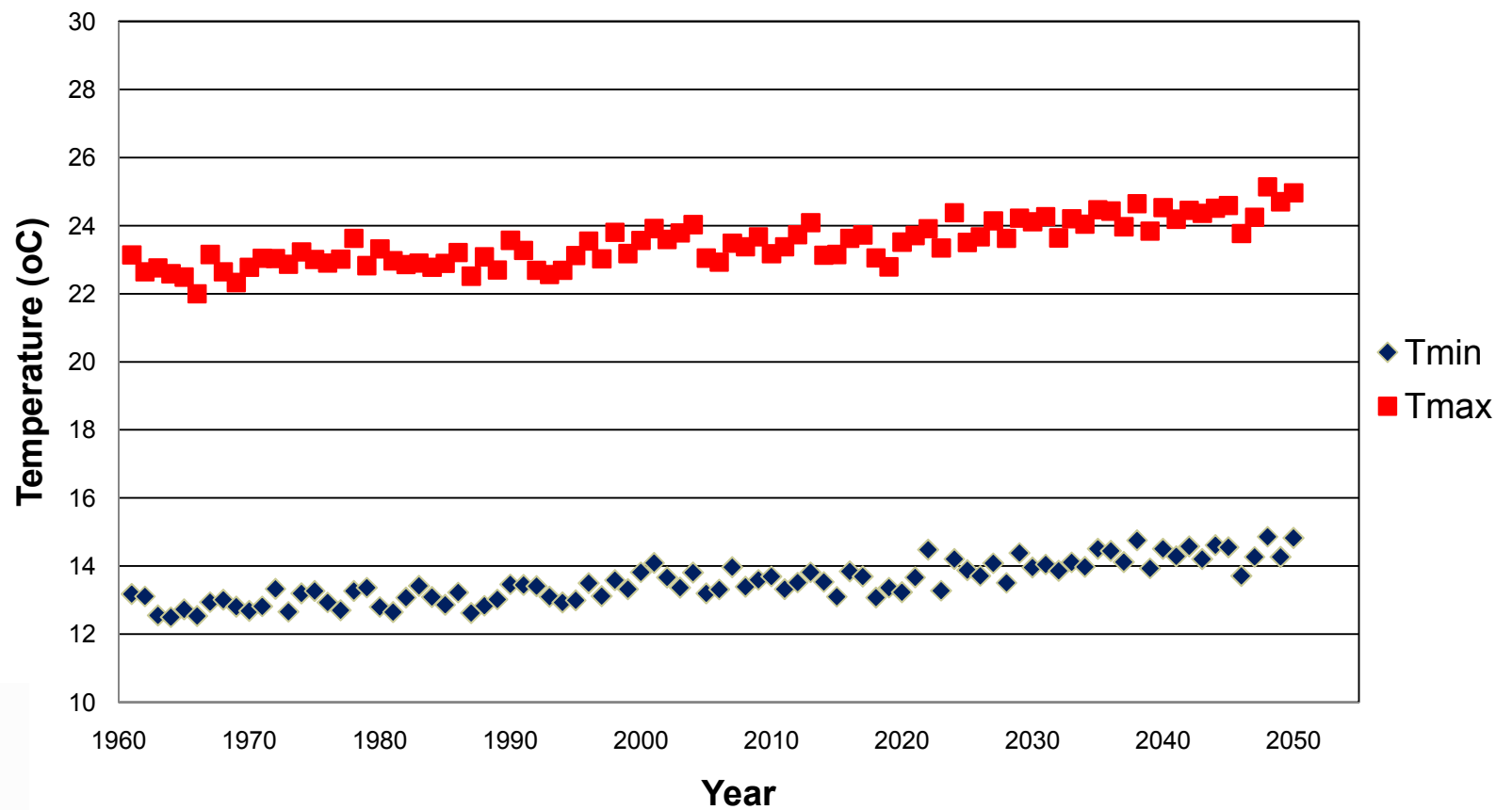
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- **Climate change forecasts for SA**
- **Only temperature and rainfall showed clear trends**



# Results

## Yearly average temperature



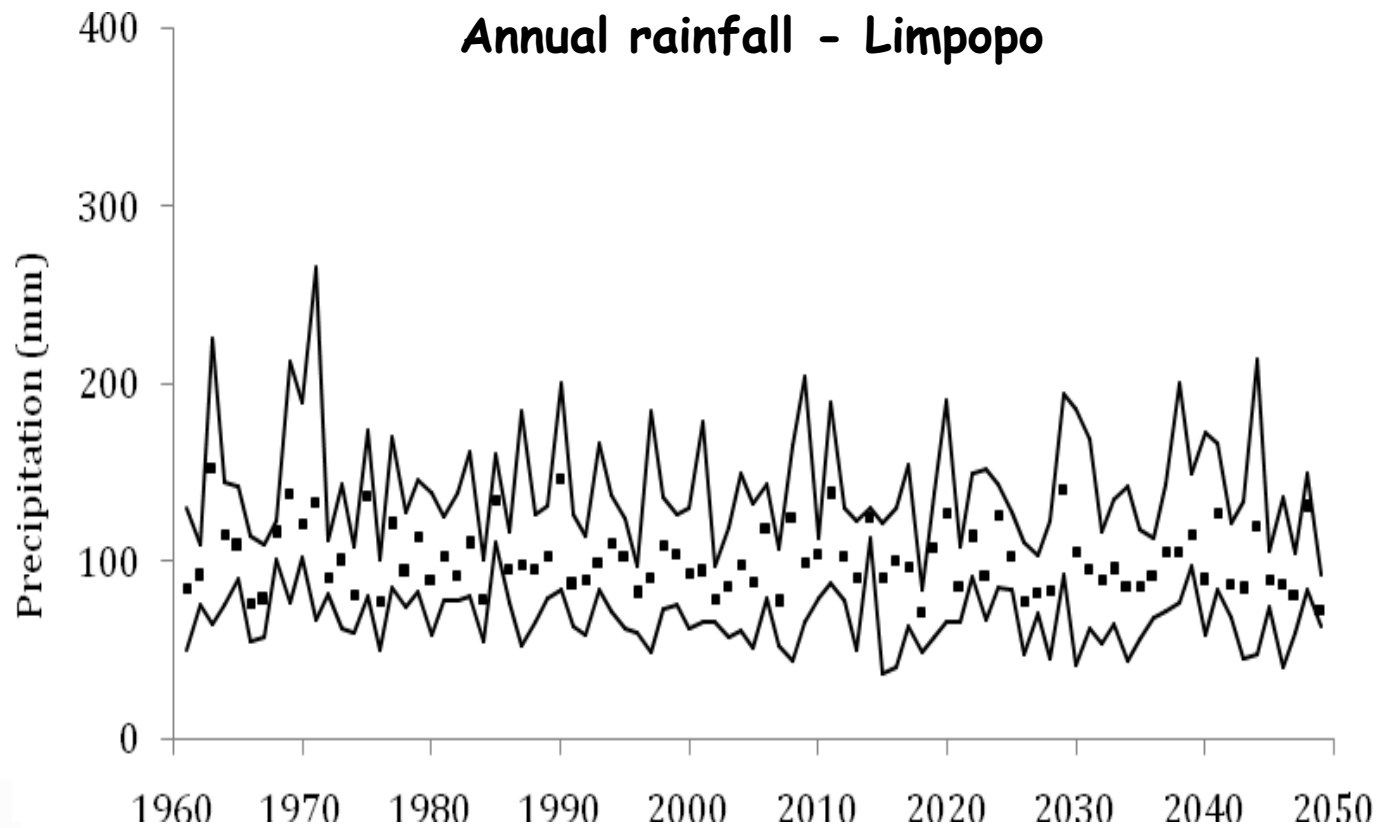
# Results

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- **Temperatures: increase of 2°C in average temperature over 90 year period**
- **Rainfall: no change or slight decline in annual**



# Results



# Results

- $\text{CO}_2$  concentration of atmosphere: A2 scenario of IPCC forecasts a  $\text{CO}_2$  rise from 315 ppm in 1960 to 550 ppm in 2050
- Research has shown higher  $\text{CO}_2$  levels will result in yield increases for  $\text{C}_3$  crops
- Higher RUE in models



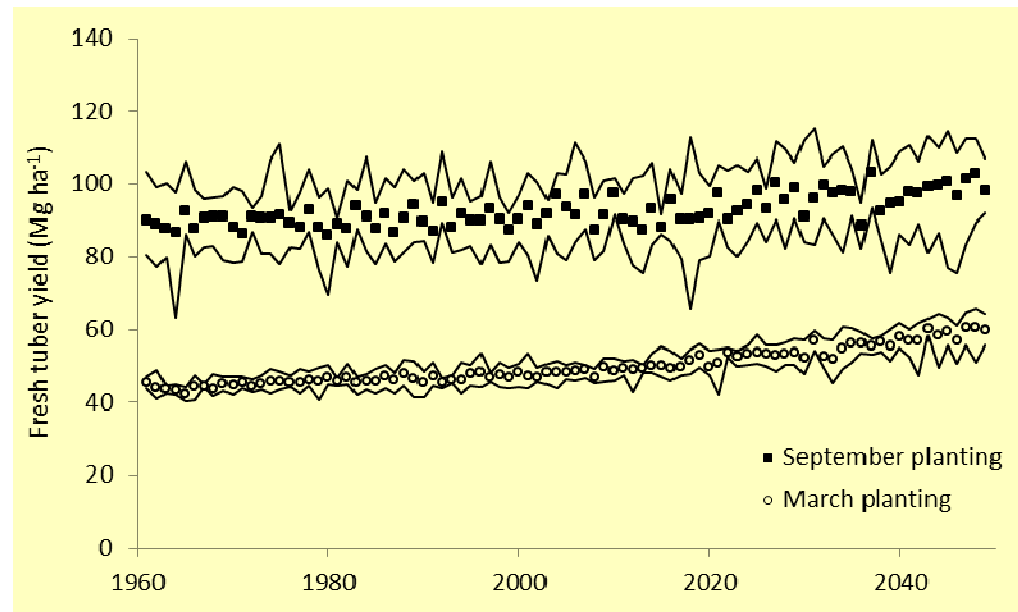
# Results

- Root and tuber crops will benefit most of all crops (Jaggard *et al.*, 2010)
- Strong sink from early in growing season
- Potato: net yield increase of 28.5%
- Higher yields expected if all other factors stay same



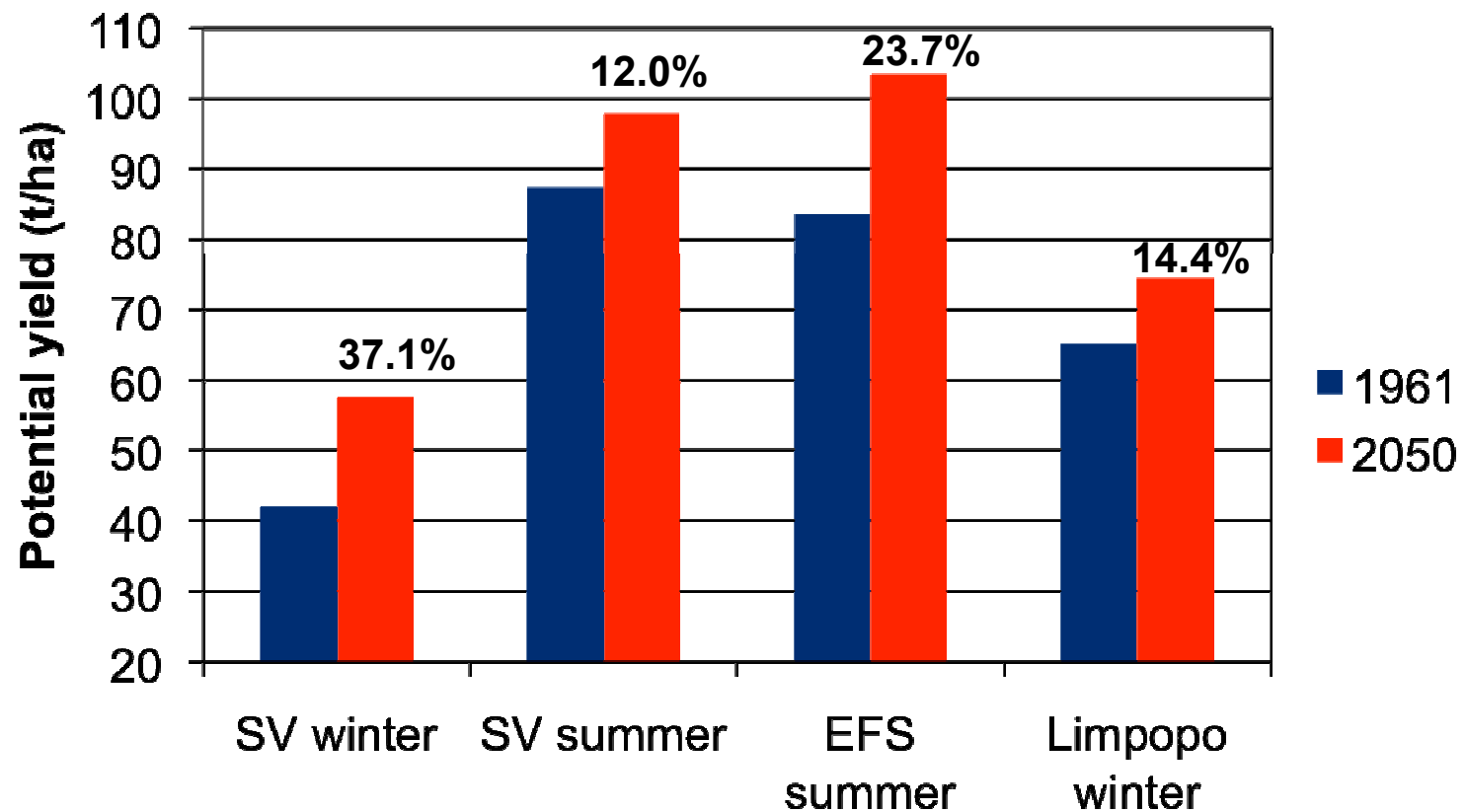
# Results

- LINTUL model forecasts higher yields for all 4 systems
- More heat stress in summer seasons
- Moderate positive effects of higher  $CO_2$  levels



# Results

## 🔥 Potential tuber yields

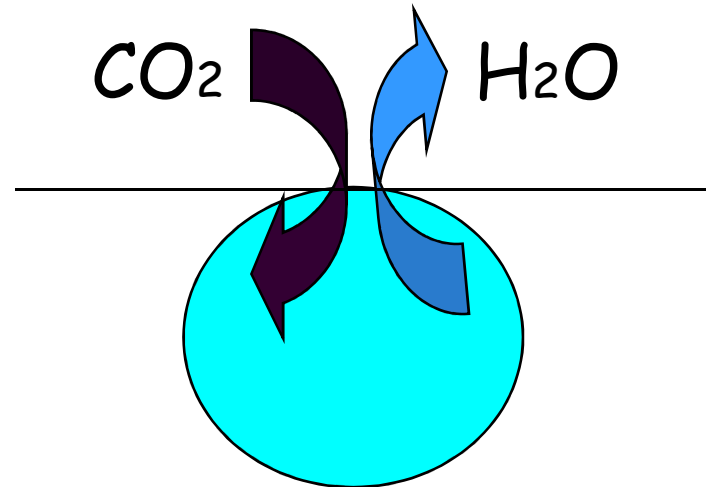


# Results

- WUE of potato will generally increase by 11% (Jaggard *et al.*, 2010) due to
- Higher yields
- Lower water use
- $WUE = Yield / ET$  (kg/ha/mm)



# Results

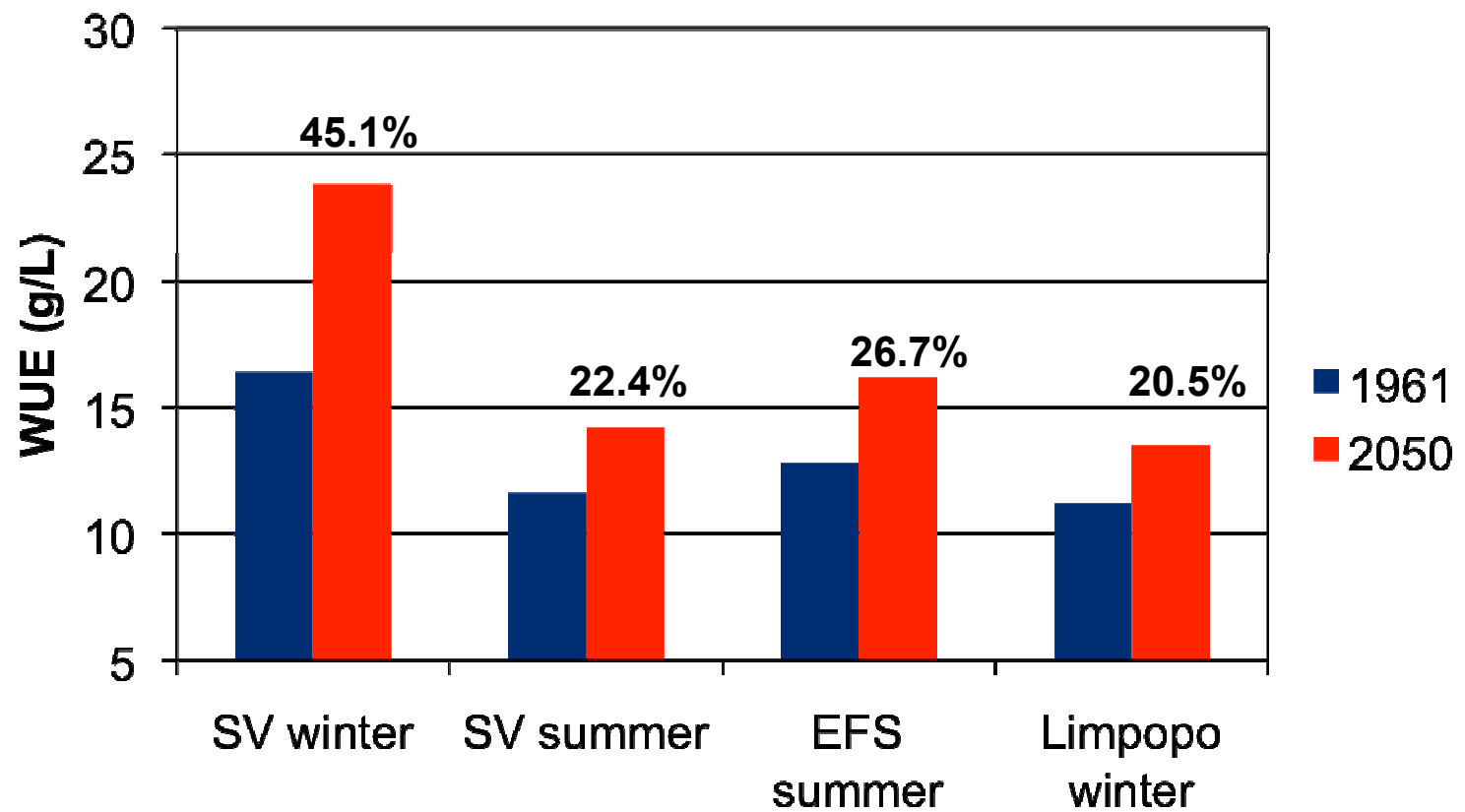


- Higher atmospheric [ $CO_2$ ]
- Lower stomatal conductance,
- Drop in transpiration rate



# Results

## 💧 WUE increase



# Summary of results

- Potato yields will generally increase - most for cooler seasons / locations
- In warmer climates - more heat stress, which will moderate positive effects of higher  $CO_2$
- WUE will increase - potatoes need less water
- Assumptions
  - potatoes irrigated
  - enough water available for irrigation



# Further studies

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- Expand study to more regions
- Develop possible mitigation strategies, e.g. shift planting dates to avoid
  - heat stress
  - frost periods
- Effect of CC on expected spread of important potato pests and diseases



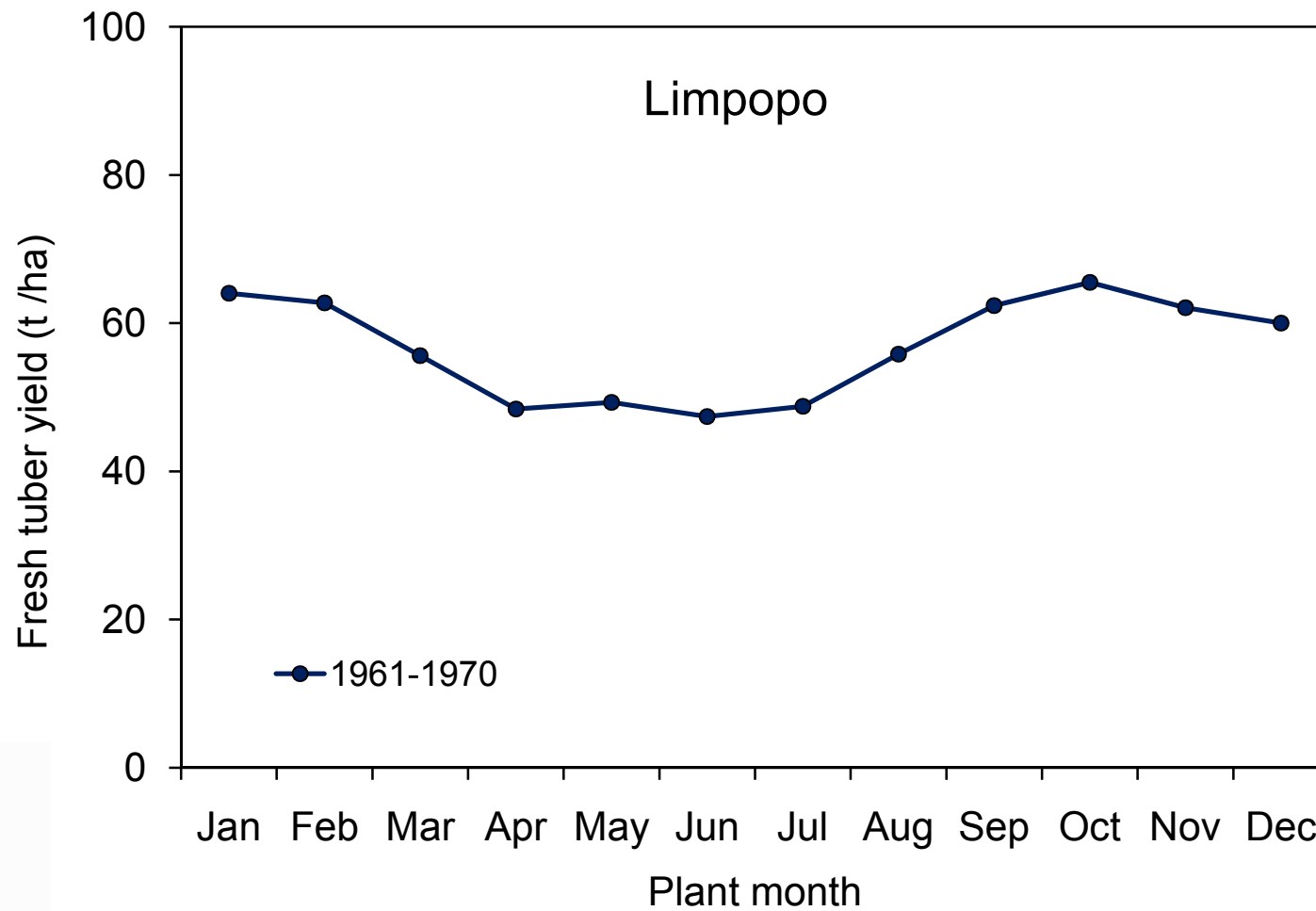
# Further studies

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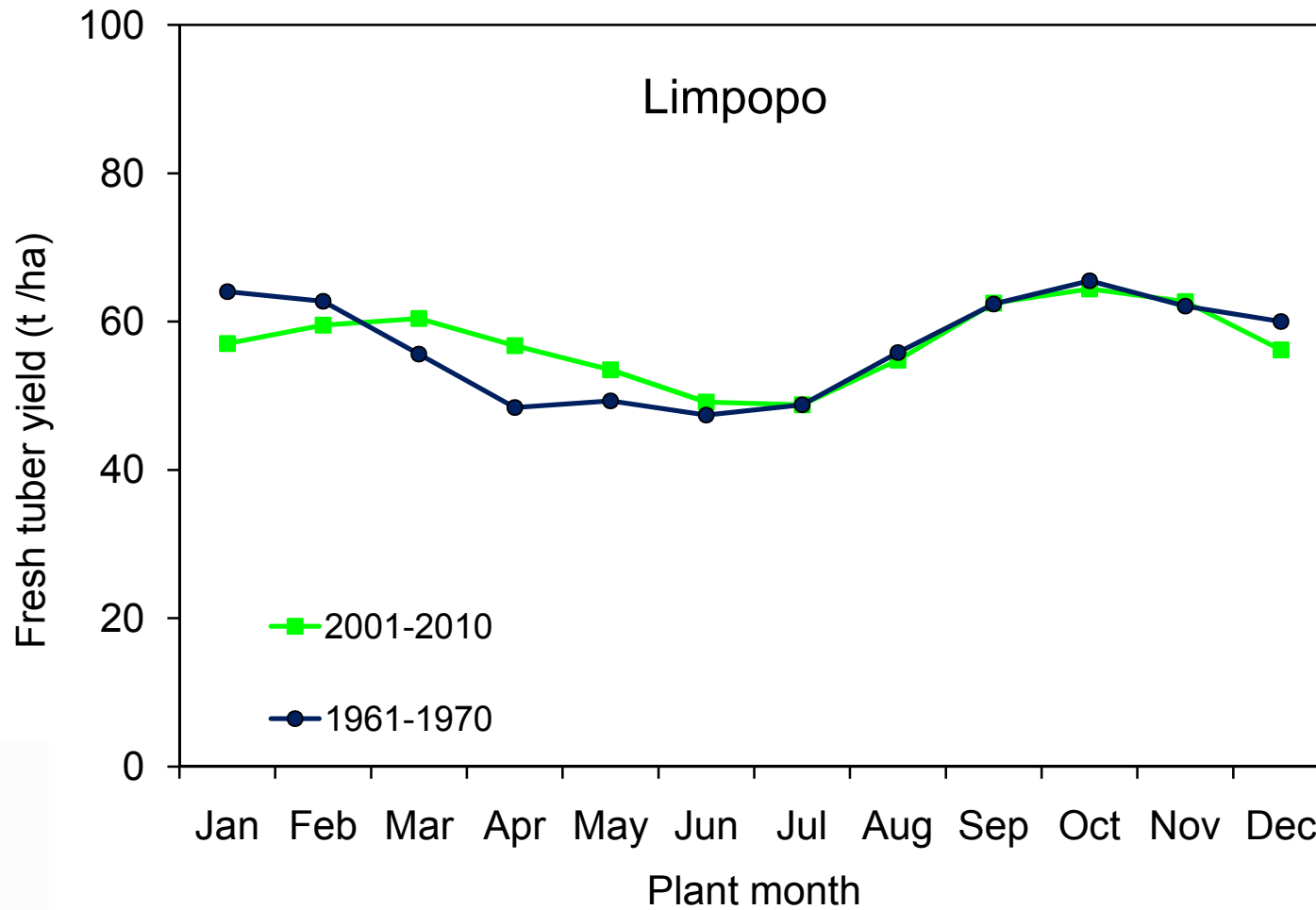
- Mitigation strategies - shift in planting dates
- Example of Limpopo
  - Currently main planting period: Jun-Aug
  - Early planting: end Feb-Mar
- How will that change in future?



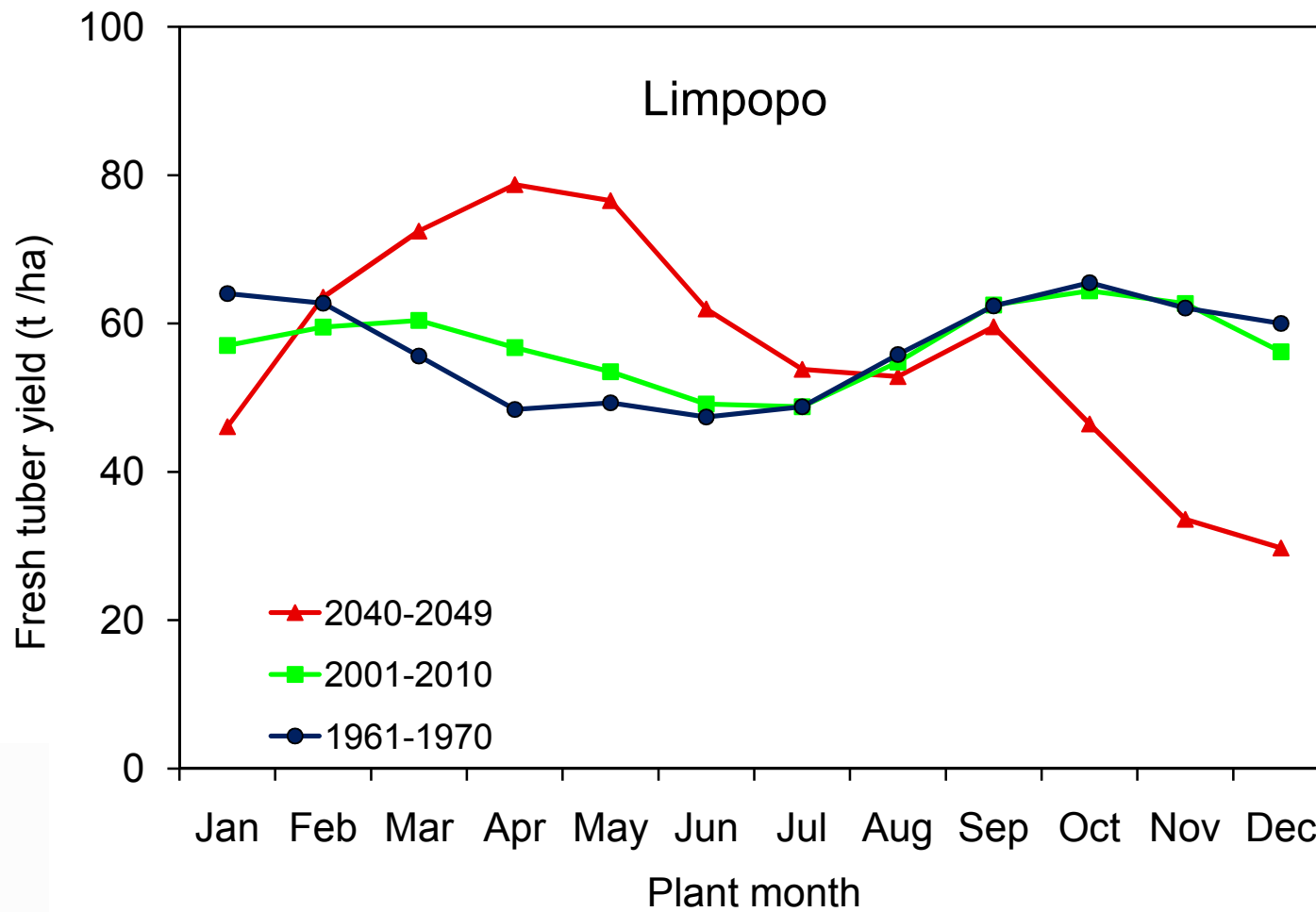
# Further studies



# Further studies



# Further studies



# Further studies

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- Limpopo - shift in main planting period
  - from Jun-Aug to Mar-May
  - winter frost will disappear
  - avoid heat stress of Jun-Aug planting



# Conclusions

- ♦ Climate change prospects for potato generally positive for these 4 systems
  - ♦ Higher yields
  - ♦ Less irrigation water required, > WUE
- ♦ Negative effects of high summer temperatures compensated for by positive effect of increased  $CO_2$  on LUE and WUE
- ♦ Growers in some regions can mitigate negative effects of higher summer temperatures by
  - ♦ shifting planting dates



# Acknowledgements

- 🔴 Potatoes SA
- 🔴 THRIP
- 🔴 University of Pretoria
- 🔴 WUR
- 🔴 CSIR

