Modelling CO_2 response of wheat

Garry O'Leary, James Nuttall, Brendan Christy, Kirsten Barlow, Penny Riffkin, Glenn Fitzgerald and Robert Redden and National and International collaborators, [Neil Huth, Davide Cammarano, Claudio Stöckle, Bruno Basso, Iurii Shcherbak, Qunying Luo, Immaculada Farre-Codina, Jairo Palta and Senthold Asseng]

Why model CO_2 response?

- Single sites are not very representative of the diverse growing conditions encountered by farmers

- Models provide an objective way to analyse responses in other locations
  - Including the interactions of temperature

- The Australian AGFACE site is unique
  - Non-irrigated
  - Medium-High evaporation/rain ratio
  - (3:1) and VPD (0.5 kPa)

Many models

- Around 30 wheat models world-wide
  - Various constructions but most include eCO_2
  - The international move to an ensemble of models (AgMIP)
- Large variance among models in response to high temperature
- Need more targeted field experiments to unravel the interactions
- Need models with a wide range of genotypes specifically adapted to respective mega-environments.

AgMIP
The Agricultural Model Intercomparison and Improvement Project

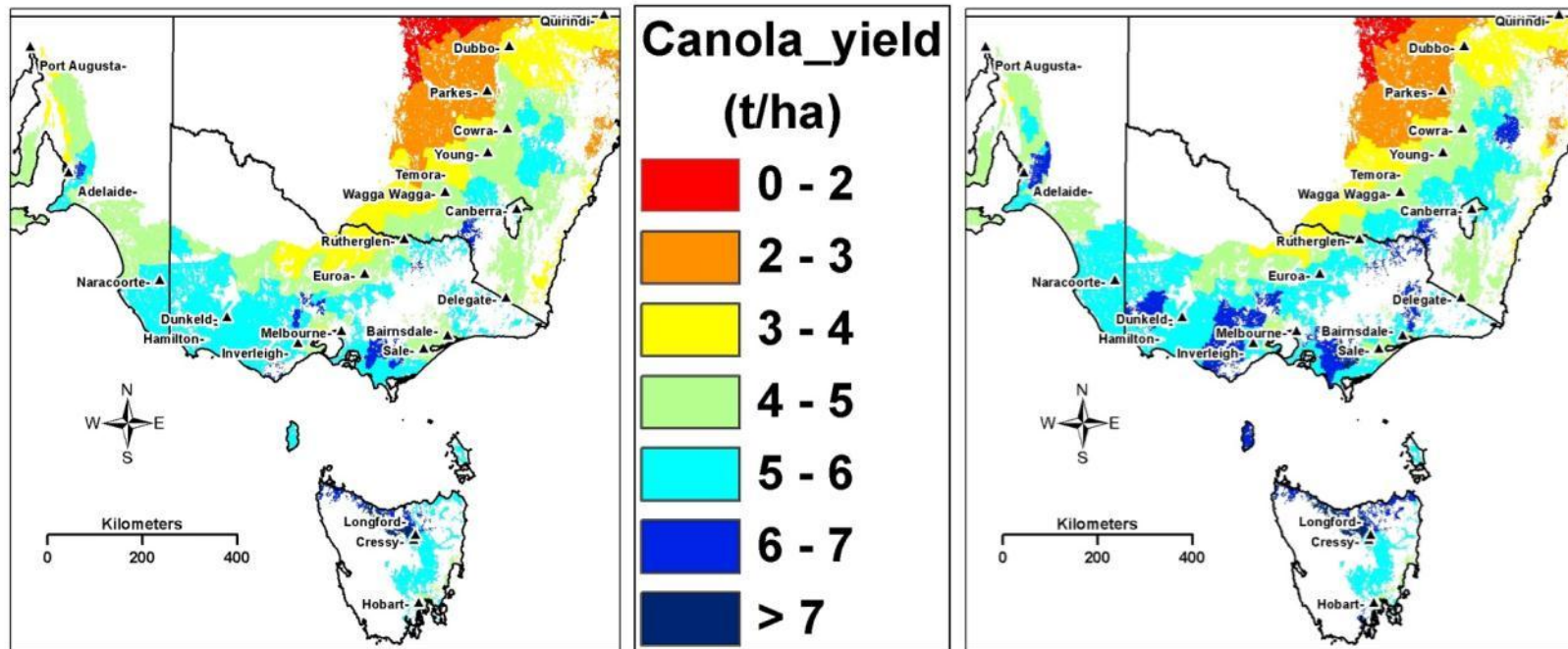# Crop adaptation across the landscape

Effects over time
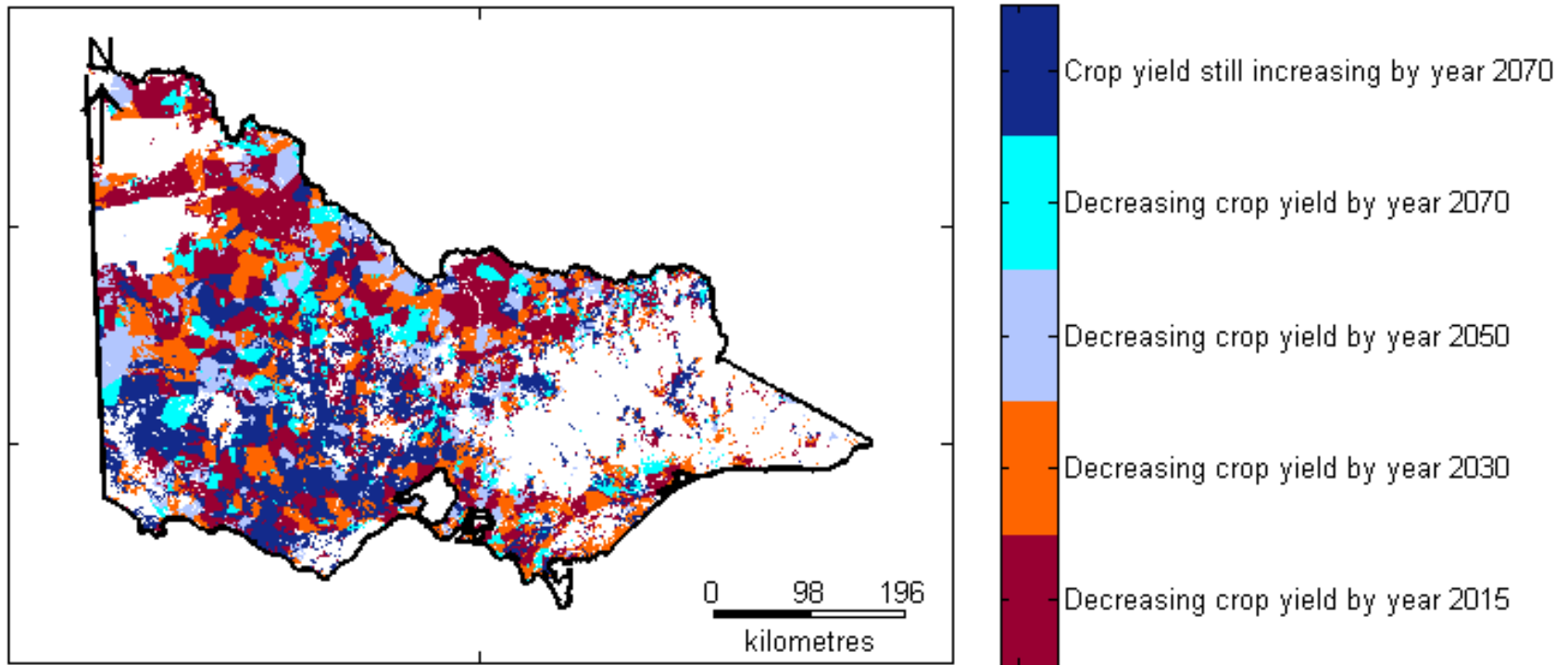
- CSIRO A1Fi CCAM Mark 3 present-day long-season cv. - includes eCO2, temperature and soil type
- Landscape "clumpiness" due to soil type by rainfall interactions
- Southern region (HRZ - dark blue) yields still increasing in 2070

O'Leary et al., 2011

Crop adaptation across the landscape

Trait analyses of cultivars

Hyola 50   CBI 8802

Canola_yield (t/ha)
- 0 - 2
- 2 - 3
- 3 - 4
- 4 - 5
- 5 - 6
- 6 - 7
- > 7

Average Canola Yield (1961-2010)

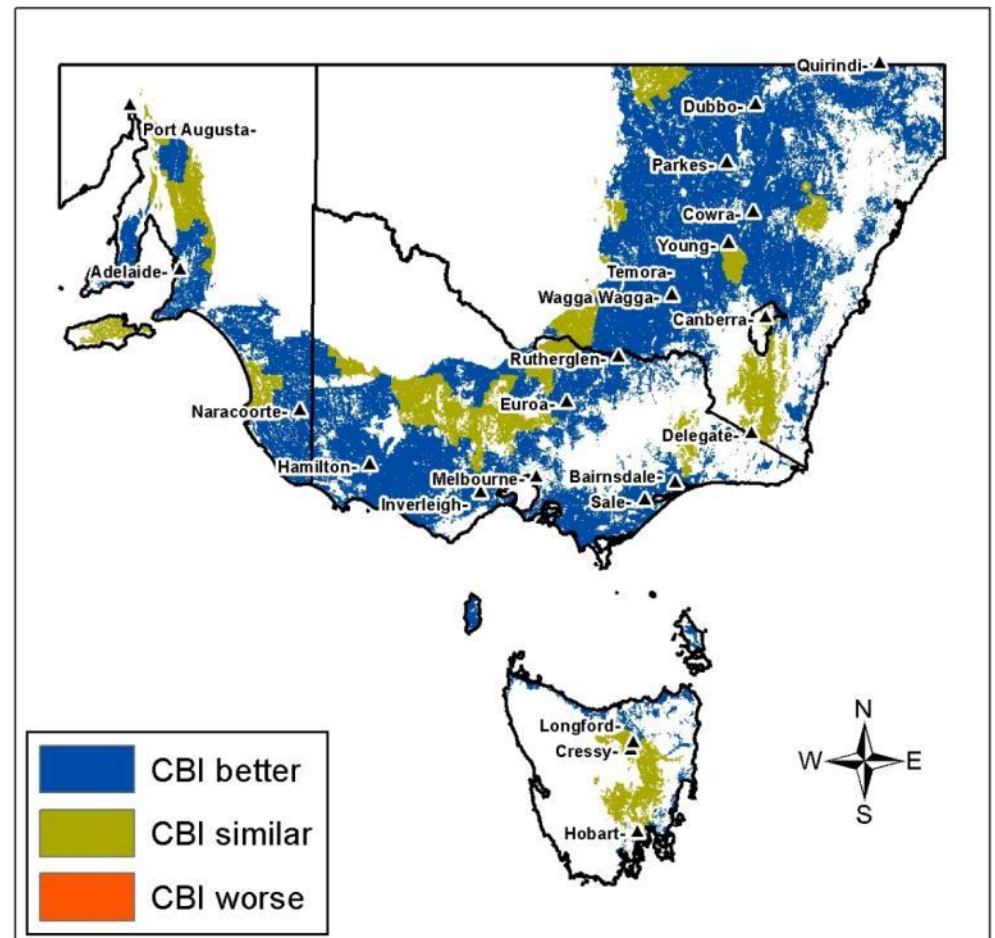Christy et al., 2014

The difference between cv CBI 8802 and Hyola

CBI 8802 grown instead of Hyola in this area

➡ additional 39,392 tonnes of canola produced

@ $468/t (5 year average) ➡ $18.4 million

Across the whole study area

- 26.6 million ha >400 mm/year

CBI 8802 was better than Hyola in 14 million ha.

CBI better
CBI similar
CBI worse

Christy et al., 2014

Model improvements

- Extreme temperature on grain yield and quality
  - Tested across different environments (AgMIP), including crop wild relatives and experimental varieties
  - Need new models for grain quality

- Temperature*CO_2 interactions
  - Early growth in TE models (cold/hot)
  - Genetic variation in main responses and interactions

- Validation data sets for ensembles

- Interest in modelling canopy dynamics
  - Structural-Functional models
  - Soil and canopy temperature
  - Genetic diversity, plant habit, flag L, RUE & TE combinations

Questions?

- How do we extrapolate across the landscape?
  - Pixel by pixel (how large 200 m or 200 km?)
  - Representative groups?
- What complexity is needed in the crop models to develop future cultivars?
  - Leaf area index, Specific leaf nitrogen
  - Less than daily time steps?
  - Photosynthesis and respiration
  - Genetic diversity – specific adaptation to mega-environments
  - Response to extreme abiotic stresses

AGFACE partners and supporters