Simulation of adaptive site-specific irrigation control performance with spatially variable rainfall

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Overview

- Background – irrigation management and control
- 'VARIwise' software for simulation of irrigation control

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- ‘VARIwise’ software for simulation of irrigation control
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- Simulation of adaptive control strategies
- Conclusion

Background – 1. irrigation management

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2. Can use plant, soil and/or weather data
3. Automatic implementation enables real-time control

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2. Can use plant, soil and/or weather data
3. Automatic implementation enables real-time control

But:

4. Affected by spatial and temporal variability

Background – 2. ‘adaptive’ control

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- Accounts for ***spatial variability*** in the field

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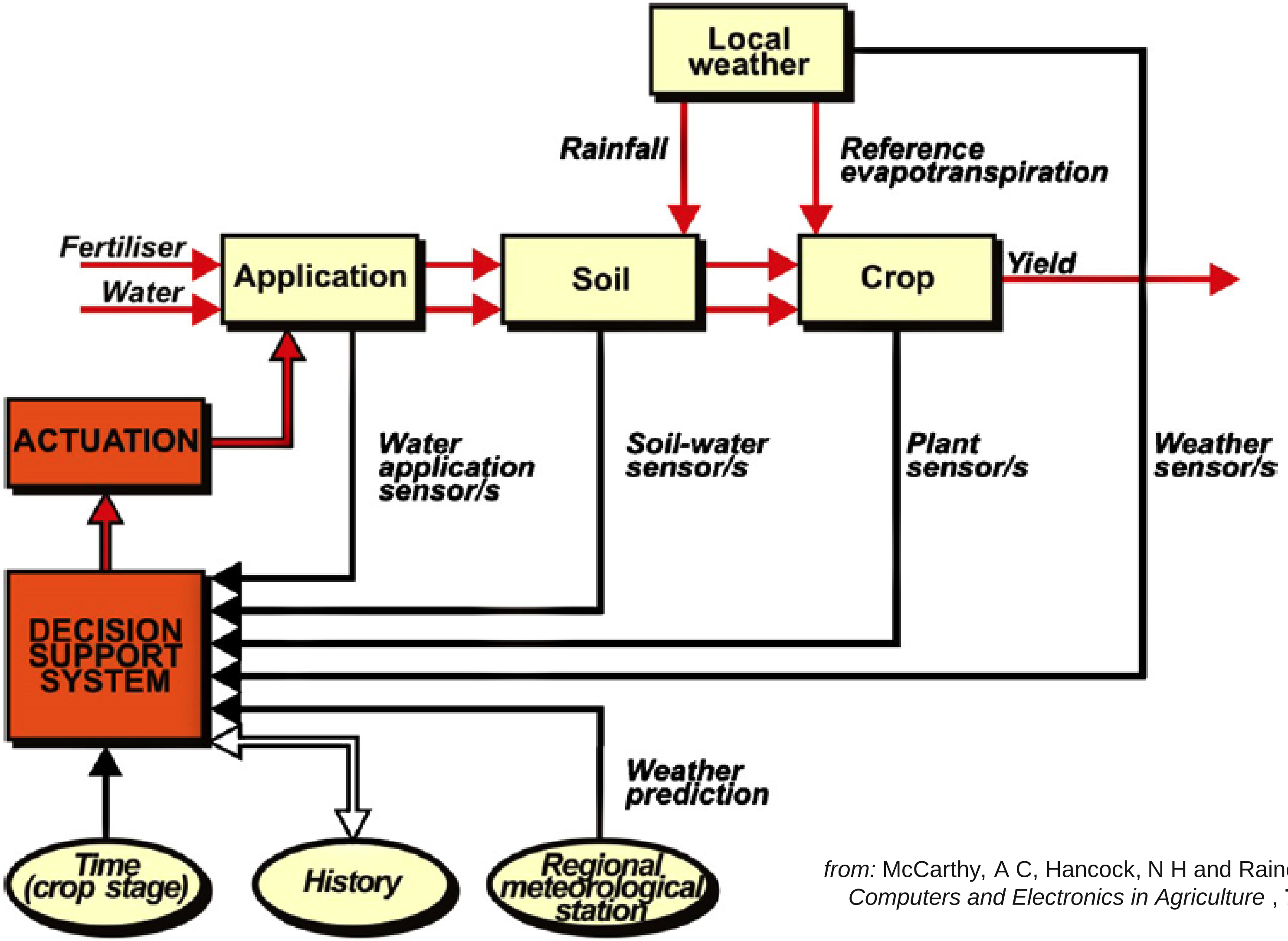
Background – 2. 'adaptive' control

- Accounts for ***temporal variability*** in the field
- Accounts for ***spatial variability*** in the field
- Adjusts applicator hardware to improve irrigation timing/volume
- Can improve crop water use efficiency while maintaining or improving crop yield

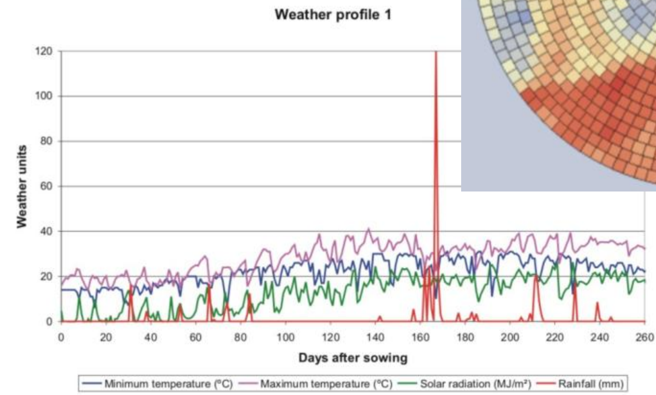
Control simulation framework 'VARIwise'

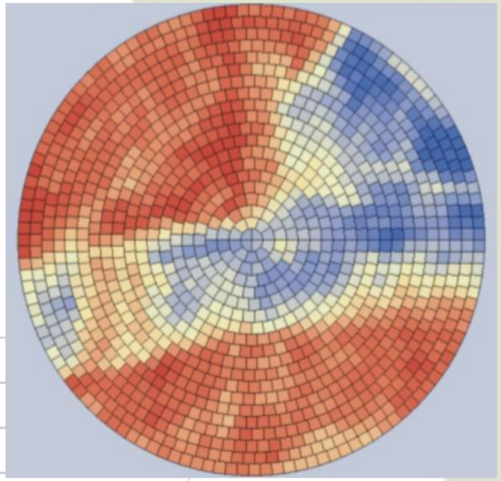


from: McCarthy, A C, Hancock, N H and Raine, S R (2010) *Computers and Electronics in Agriculture* , **70**(1) 117-128

Control simulation framework ‘VARIwise’

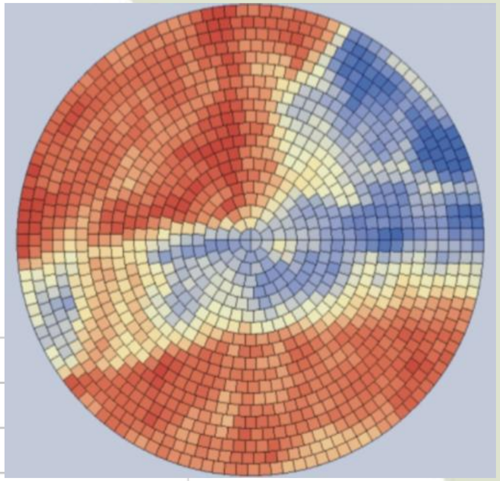
- Input of field scale variations down to one square metre
- Input of data at any temporal scale

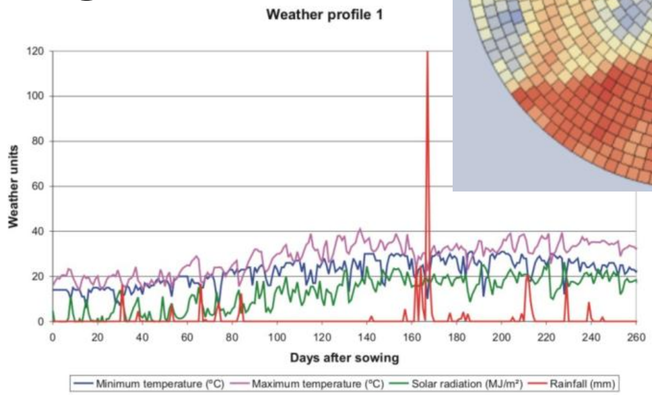




Control simulation framework 'VARIwise'

- Input of field scale variations down to one square metre
- Input of data at any temporal scale
- Cotton model OZCOT is integrated for irrigation control simulation
- Integrates control strategies for CPIMs (and LMIMs)





Adaptive control strategies:
1. *Iterative Learning Control (ILC)*

- Uses the error between the ***measured*** and ***desired*** soil moisture deficit after the previous irrigation,
- . . . to ***adjust*** the irrigation volume of the next irrigation event.

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- Uses the error between the ***measured*** and ***desired*** soil moisture deficit after the previous irrigation,
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- 'Learns' from history of prior error signals to make better adjustments.

Adaptive control strategies:
2. '*Model Predictive Control*' (MPC)

- A *calibrated* cotton model simulates and *predicts* the next required irrigation, i.e. volumes and timings
  - according to evolving crop/soil/weather input
  - separately for all cells/zones
- *Calibration* is adjusted according to *measured* (or emulated) crop response

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- We might *choose* to implement the MPC irrigation scheme that maximises the final cotton yield (as predicted by the evolving model)

Evaluating variability in VARIwise

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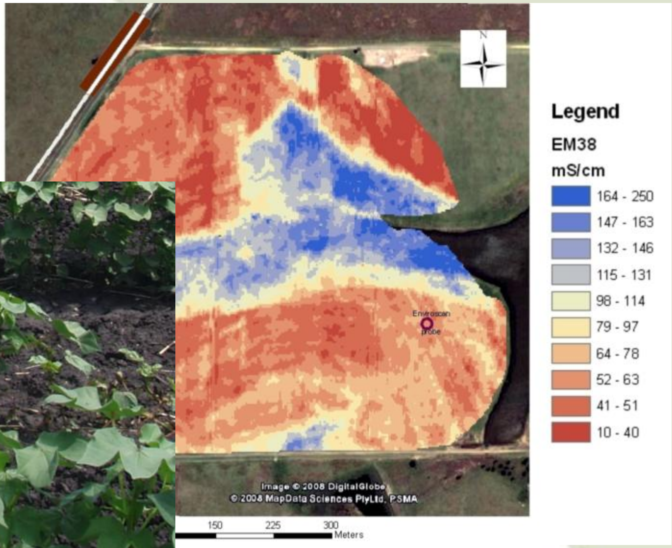
- VARIwise can be used evaluate effect of variability of:

  - weather
  - soil
  - plant



on yield/WUE and control performance

Spatial variability of rainfall

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- Spatial variability of natural rainfall in Queensland summer cropping areas can be substantial
- Typically weather data is only measured for a single point nearby
- Spatial variability of rainfall is often unquantified
- The effect on irrigation optimisation is unknown

Spatial variability of rainfall – Case study methodology

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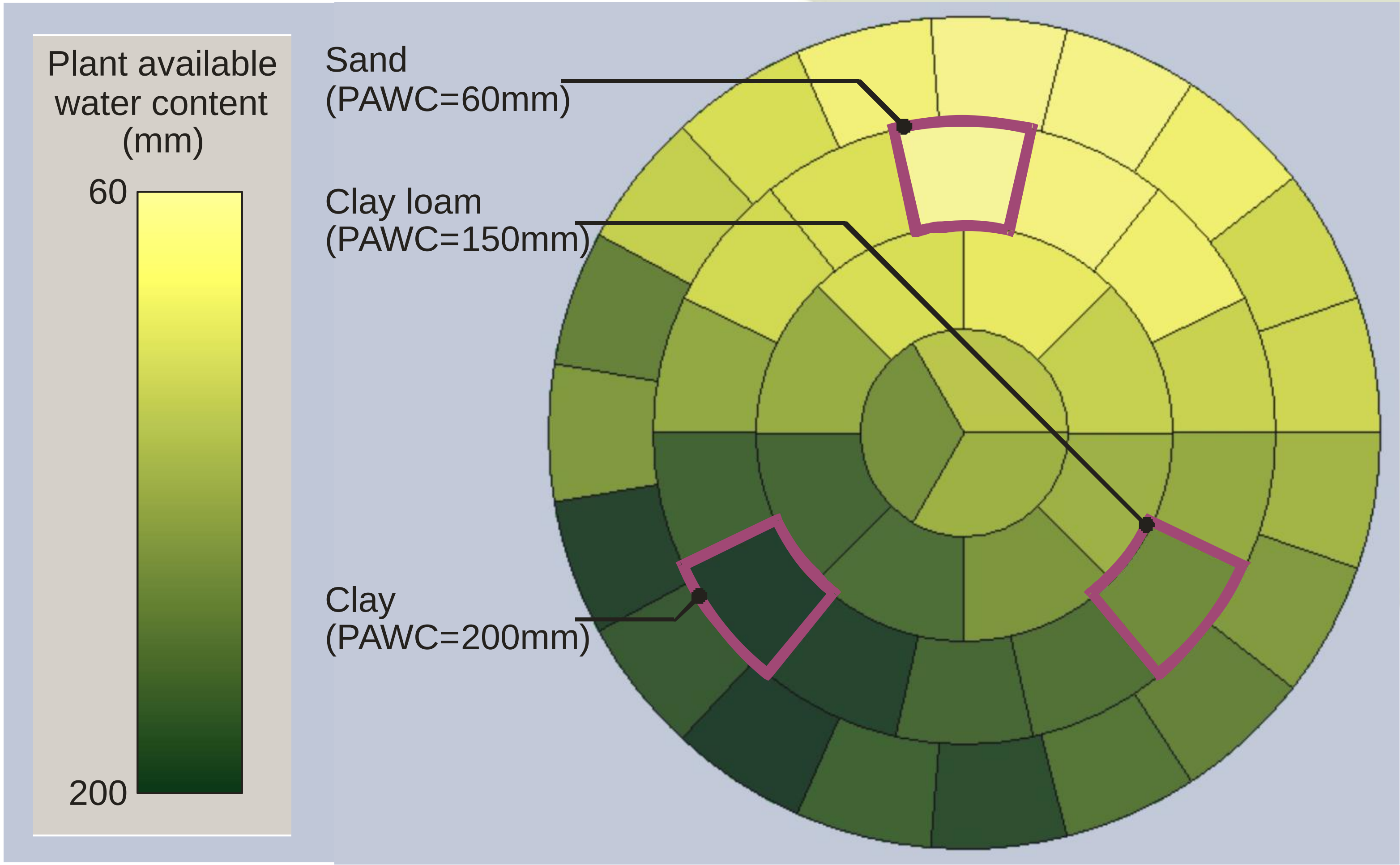
- Rainfall was *spatially varied* by applying a Gaussian distribution of variability to the rainfall measurement in each cell
- Average rainfall values were obtained from SILO weather data
- Two amounts of imposed variability, 20% and 50%, were evaluated
- Ten replicates of each rainfall pattern were simulated

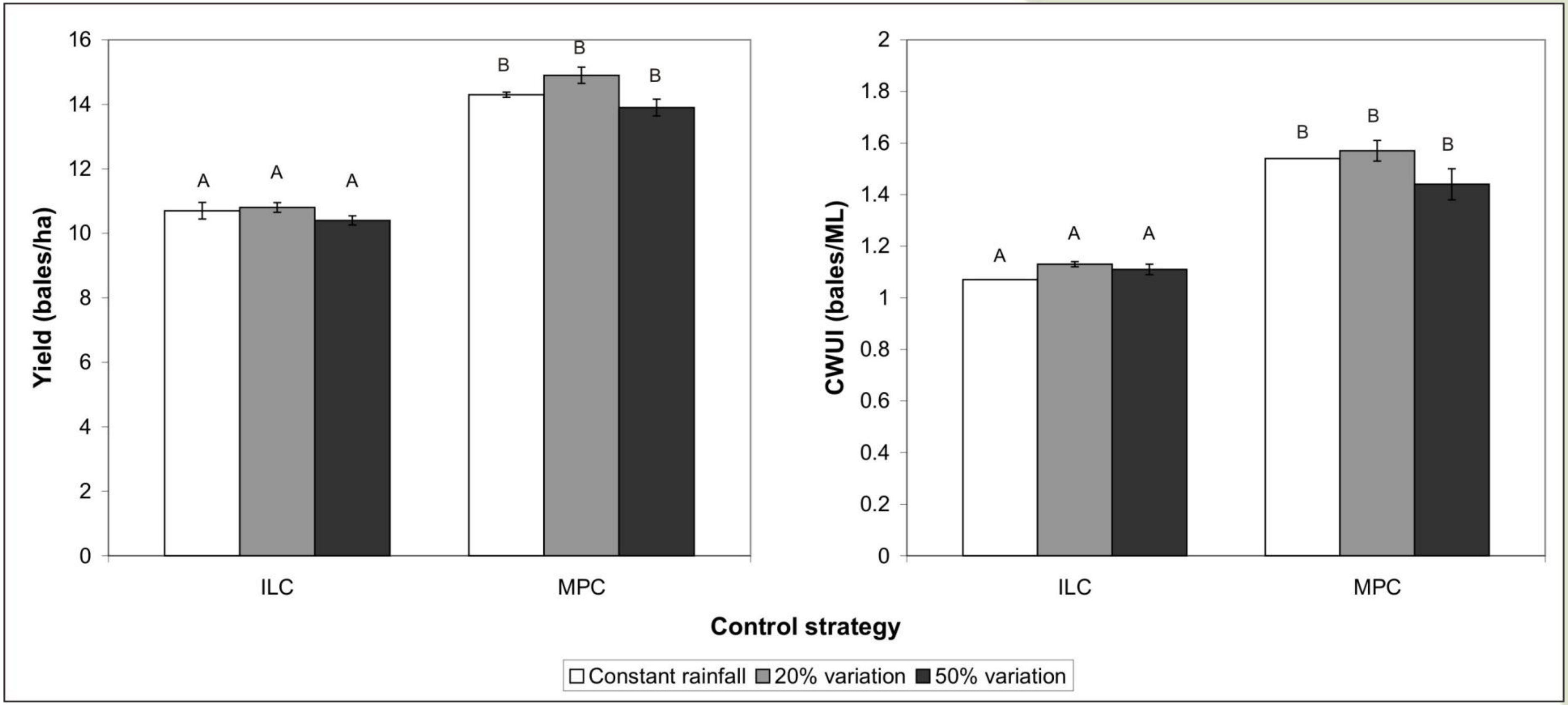
Spatial variability of rainfall – Case study inputs

- Cotton was sown on a 400 m diameter centre pivot-irrigated field on 4 October
- The field was automatically divided into 44 cells
- Irrigations occurred until 14 March of the following year
- Initial stored soil moisture = 50 mm

Case study inputs – soil variability



Spatial variability of rainfall – Case study results



Conclusions

1. **Advanced process control can be successfully applied to irrigation**

2. **Advanced process control is robust to rainfall variability**

   i.e. accommodates major rainfall variability with minimal loss of yield

Acknowledgements

- Australian Research Council
- Cotton Research and Development Corporation

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