Applying multiple crop models for assessing climate change impact: The devil is in the detail

***Peter Thorburn**, CSIRO, Australia; **Ken Boote,** Uni of Florida; **Jim Jones,** Uni of Florida;*
***Jesse B. Naab**, Savanna Agric. Res. Inst., Ghana; **John Hargreaves**, CSIRO Australia;*
***Matthew Jones**, SASRI, South Africa; **Jonathan Hickman**, GISS NASA, New York;*
***KPC Rao**, ICRISAT, Kenya; **Olivier Crespo**, Uni Cape Town, South Africa;*
***Simbarashe Chinorumba**, Zimbabwe Sugar Assoc Exp Station;*
***John Antle,** Oregon State Uni; **Alex Ruane**, Columbia Uni & GISS NASA, New York;*
***Cynthia Rosenzweig,** Columbia Uni & GISS NASA, New York*




AgMIP The Agricultural Model Intercomparison and Improvement Project

AgMIP Objectives *(paraphrased)*

- Consistent *approach to climate change impact & adaptation analyses*
- *Better representing uncertainty*
  - Ensemble approach
  - *Quantification*
- *Improving modelling of climate change effects in crops*
- *Building foundations in regions to model climate change adaptation and mitigation*

➢ **How do we set up multiple models efficiently?**

AgMIP The Agricultural Model Intercomparison and Improvement Project

Rosenzweig et al., 2012 (Ag For Met)

Case study 1: Simulating maize production on farms in Machokas, Kenya, for use in impact assessment

- Farm surveys[1] undertaken on 47 farms
  - Information on crops grown and management
  - Information on soils available
  - Solid base for applying another model
- Wide range of management and production
  - N from 0 to 200 kg ha^{-1}
  - Yield from ~0 to >6 t ha^{-1}

Run	Obs	Sim-BL	Sim-CC	Ratio	BL-2	CC-2
1	1601	946	301	0.32	539	172
8	964	748	747	1.00	426	426
9	270	748	747	1.00	426	426
34	56	995	1541	1.55	567	878
35	2621	4899	2981	0.61	2792	1699
36	845	817	544	0.67		
37	760	2670	1811	0.68		
38	3862	6783	5027	0.74		
39	5379	3553	2295	0.65		
40	2207	6668	4088	0.61		
41	6207	2770	2621	0.95		
42	3241	5924	3493	0.59		
43	710	1030	707	0.69		
44	553	579	838	1.45		
45	98	579	838	1.45		
46	1000	1476	1474	1.00		
47	832	1476	1474	1.00	841	840

[1]Classens et al., 2012 (Ag Syst).

Models applied

DSSAT CERES-Maize

- Previously simulated Machokas maize production
- Crop parameters developed from the Katumani exp.
- Crop model derived from CERES
- Tipping bucket layered water balance
- Multi-pool soil C&N model
  - Adopted from CENTURY

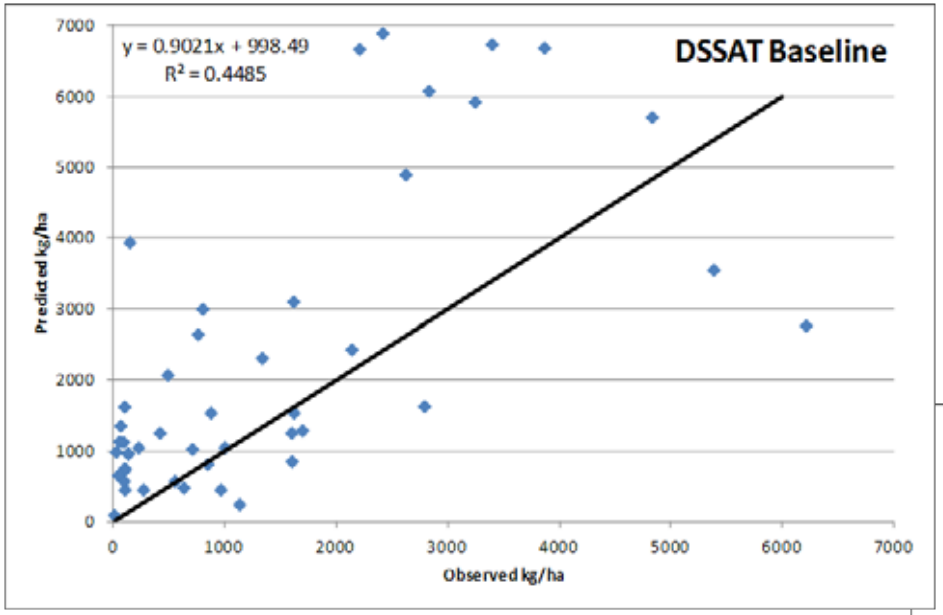
APSIM-Maize

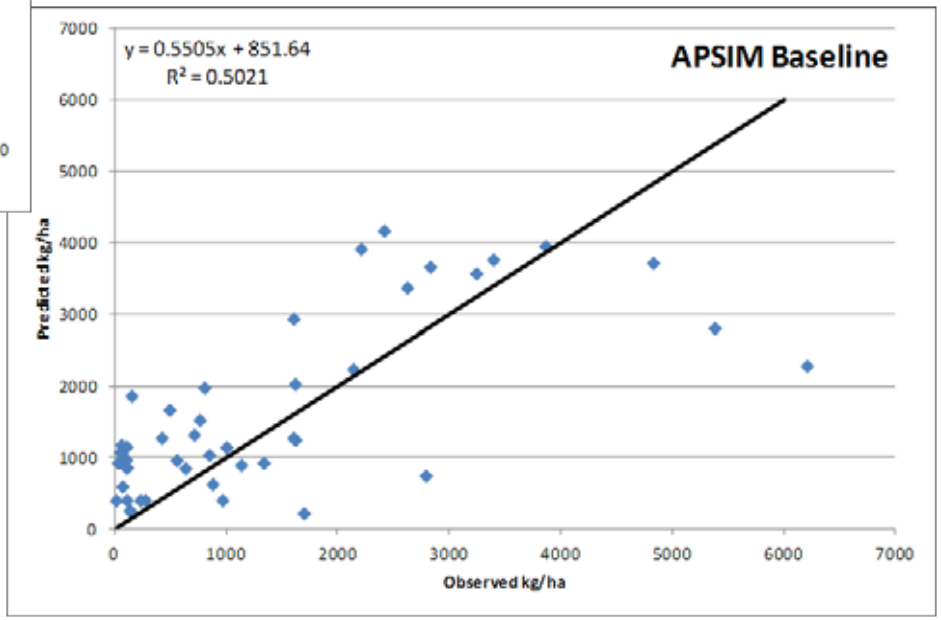
- Previously applied to maize production in eastern Kenya
- Crop parameters developed from the Katumani exp.
- Crop model derived from CERES
- Tipping bucket layered water balance
- Multi-pool soil C&N model
  - Very adapted from CERES

Significant similarity between the models.
Efficiency in sharing parameters, etc?

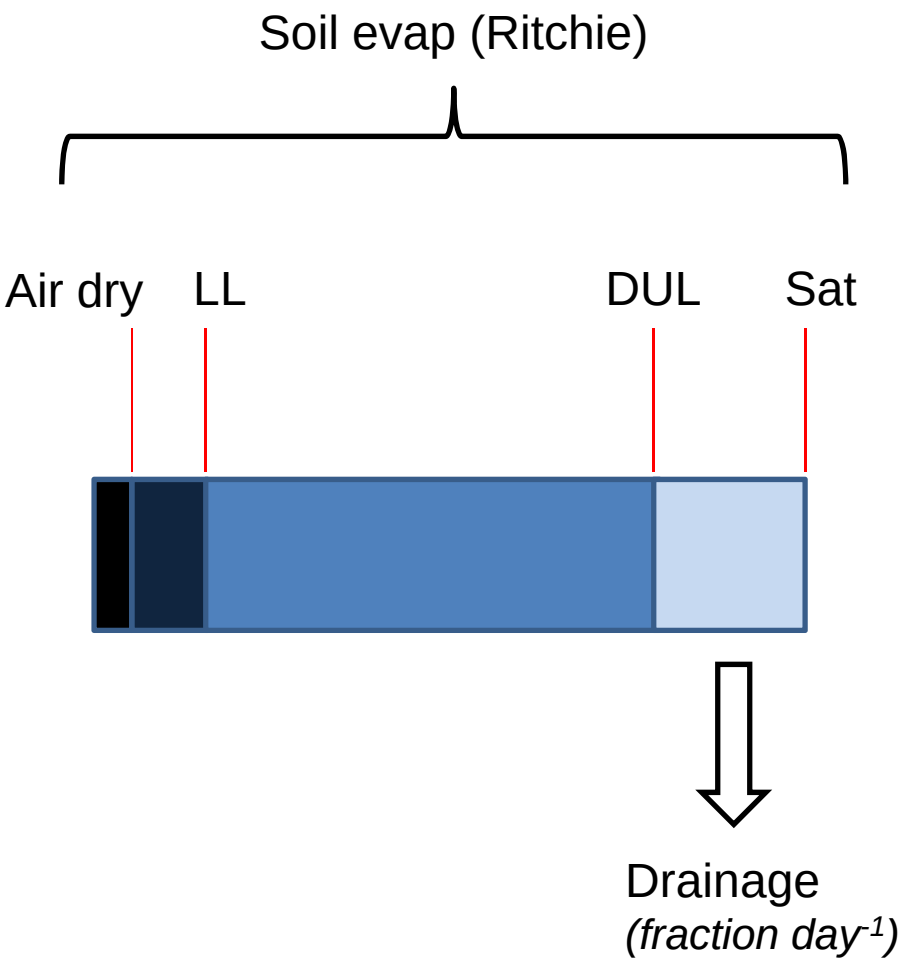
How did the models perform?

Similarly well, but differently…





Soil water models – interchanging parameter values?



- Soil water parameters defined similarly
- Established methods of measurement or estimation (e.g. pedotransfer functions)
- *[Theoretical framework exists to derive Richards Eqn parameters for other models]*

➢ **Solid info base for sharing parameters in multi-model application**

Maize models – interchanging parameter values?

Some differences in definitions and default assumptions

DSSAT approach

- Development at high temp
  - Dev at TT > opt = Dev at opt
- Min. soil available water for maize germination
  - 0.02 (cm^3 cm^{-3})
- TT from end of juvenile stage to floral initiation
  - Min time = 4 day
- Leaf appearance
  - No. GDD between successive leaf tip appearances
  - Cultivar parameter

APSIM approach

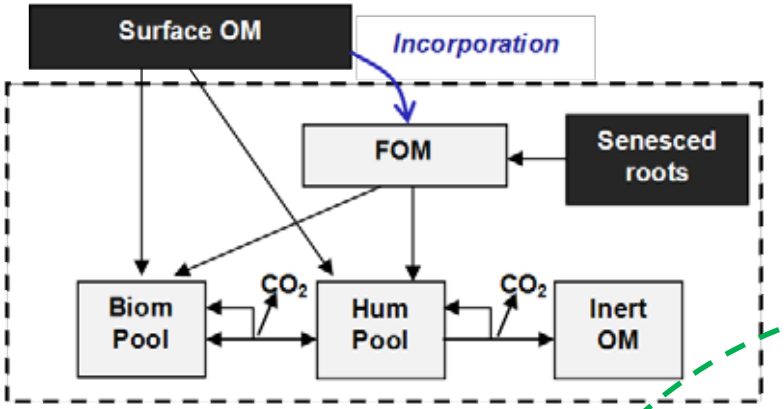
- Development at high temp
  - Dev at TT > opt slows to 0
- Min. available soil water for maize germination
  - 0.0 (mm mm^{-1})
- TT from end of juvenile stage to floral initiation
  - Default value = 0
- Leaf appearance
  - No. GDD to initiate each leaf priomordium (until floral initiation occurrence)
  - Species parameter

"Similar" models evolved to be quite different

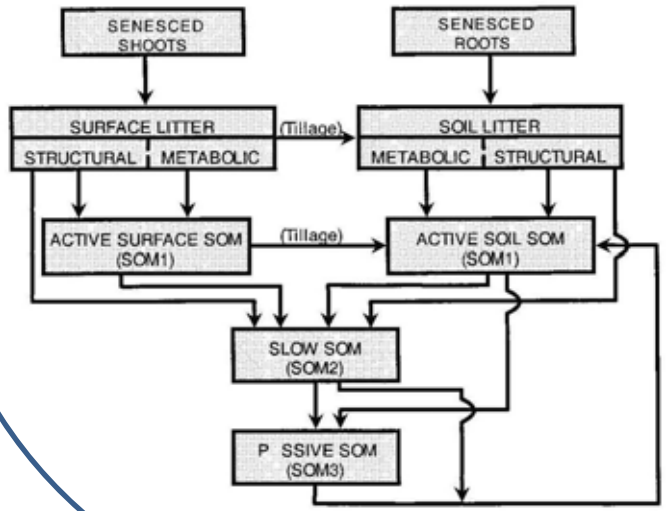
Hickman 2012, pers. comm.

Soil C&N models – interchanging parameter values?

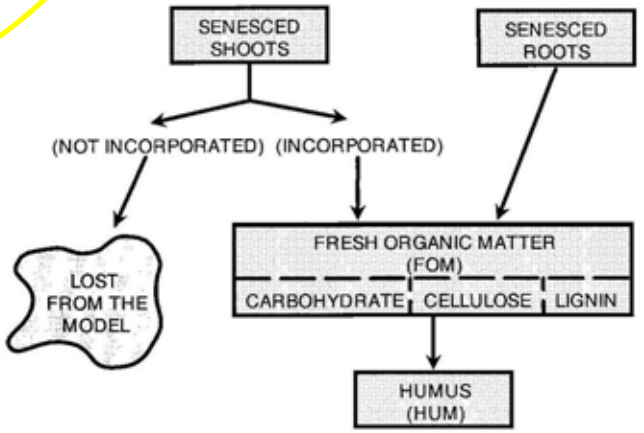
APSIM SoilN[1]



DSSAT Century[2]



DSSAT 'Godwin'[2]



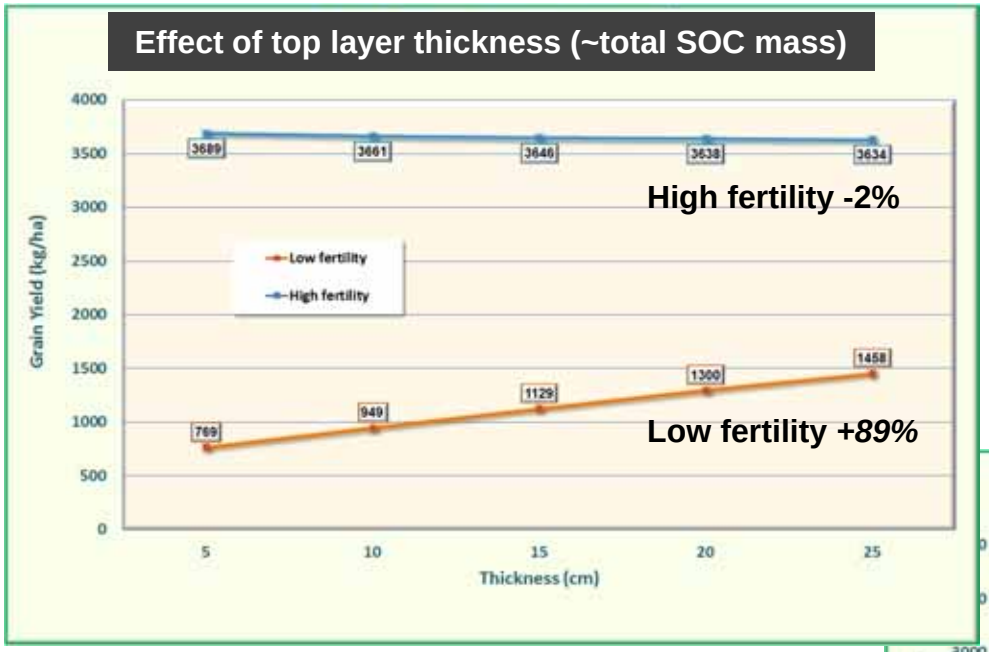
Differences in:

- Pool structure, kinetics, bio-chem.
- Can't equate pools

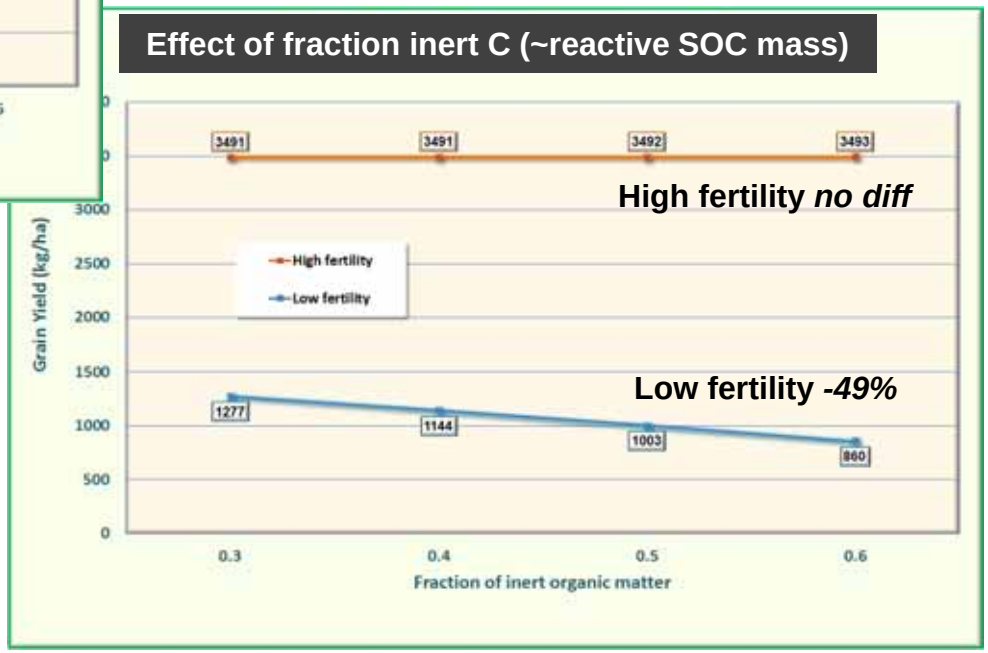
[1]Thorburn et al., 2005 (FCR)

[2]Gijsman et al., 2002 (Agron J)

Expression of different soil C parameterisation: Example for APSIM[1]



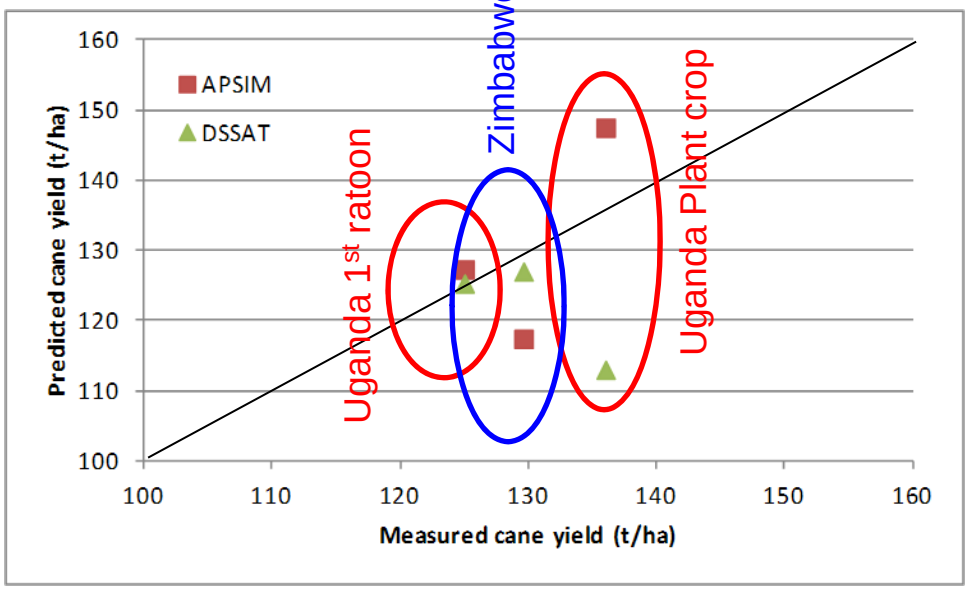
- Effects expressed in low fertility soil
- Mineralised N more important
- How do we get information to support parameterisation?



[1]Rao et al., 2012 (AgMIP Global Workshop, Rome, Oct 2012)

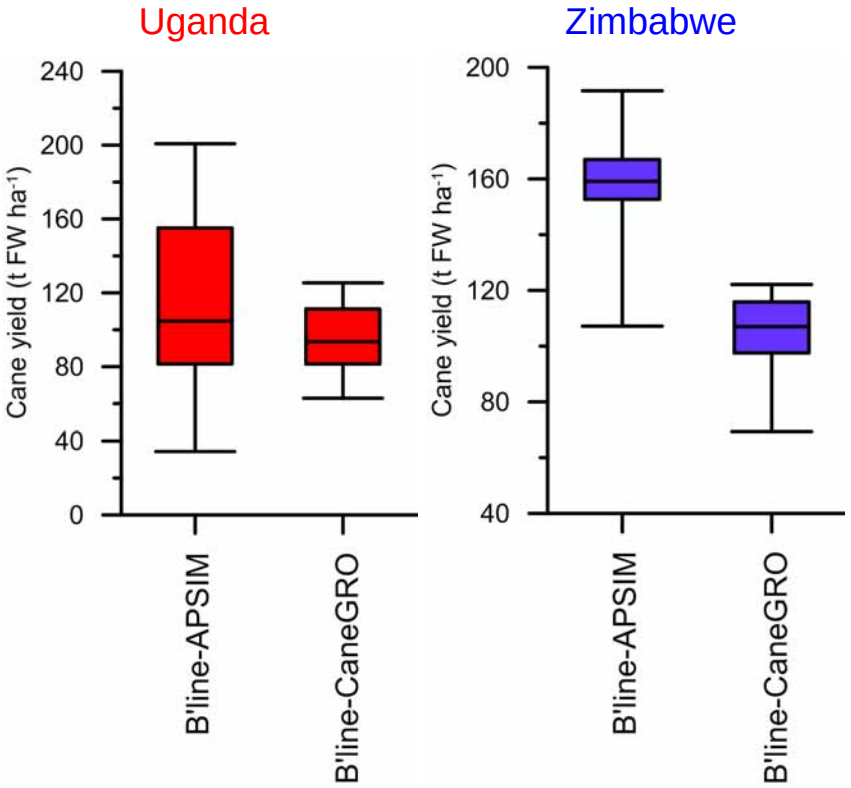
Case study 2: Extrapolating from initial calibration to 30 year simulations for sugarcane

Calibration

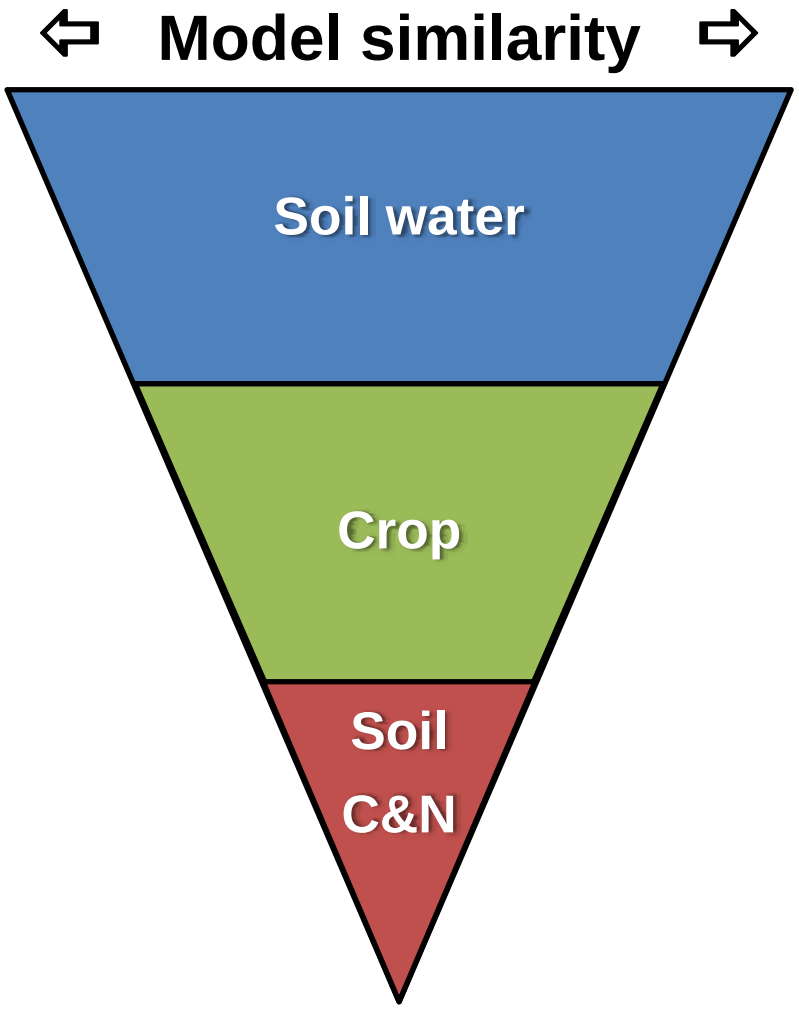


- Difference come about from
  - Climate-crop-soil interactions outside calibration cond'tns
  - Management control in the models (e.g. Irrigat'n)
- Having good calibration doesn't mean the models will 'agree' in long-term simulations
- Need for multi-year crop data

30 year simulations



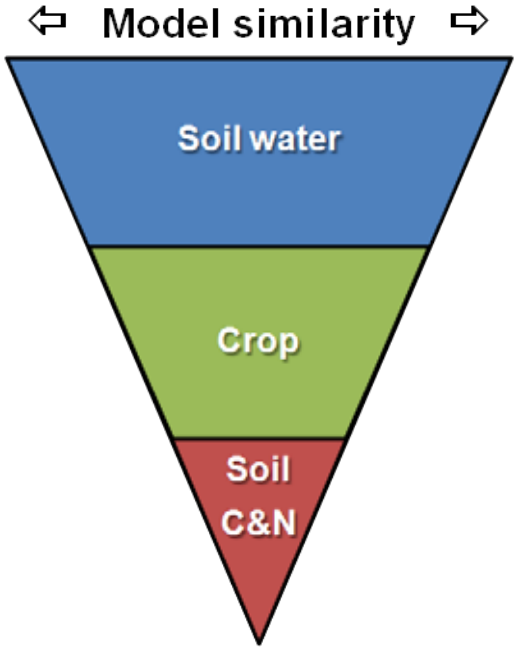
Conclusions



- Learned about transferability of information for/on model parameters
  - Soil Water > Crop > Soil C&N
- Emphasises the need for good experimental information on which to base models
- Likely data availability in applications:
  - Developing soil water parameter values ☑
  - Testing soil water predictions ☒
  - Developing crop parameter values ☒
  - Testing crop predictions ☑
  - Developing soil C&N parameter values ☒
  - Testing soil C&N predictions ☒
- Can't get overconfident from a single year's data

AgMIP The Agricultural Model Intercomparison and Improvement Project

Thank you



Dr Peter Thorburn
CSIRO, Australia
Peter.thorburn@csiro.au

AgMIP The Agricultural Model Intercomparison and Improvement Project