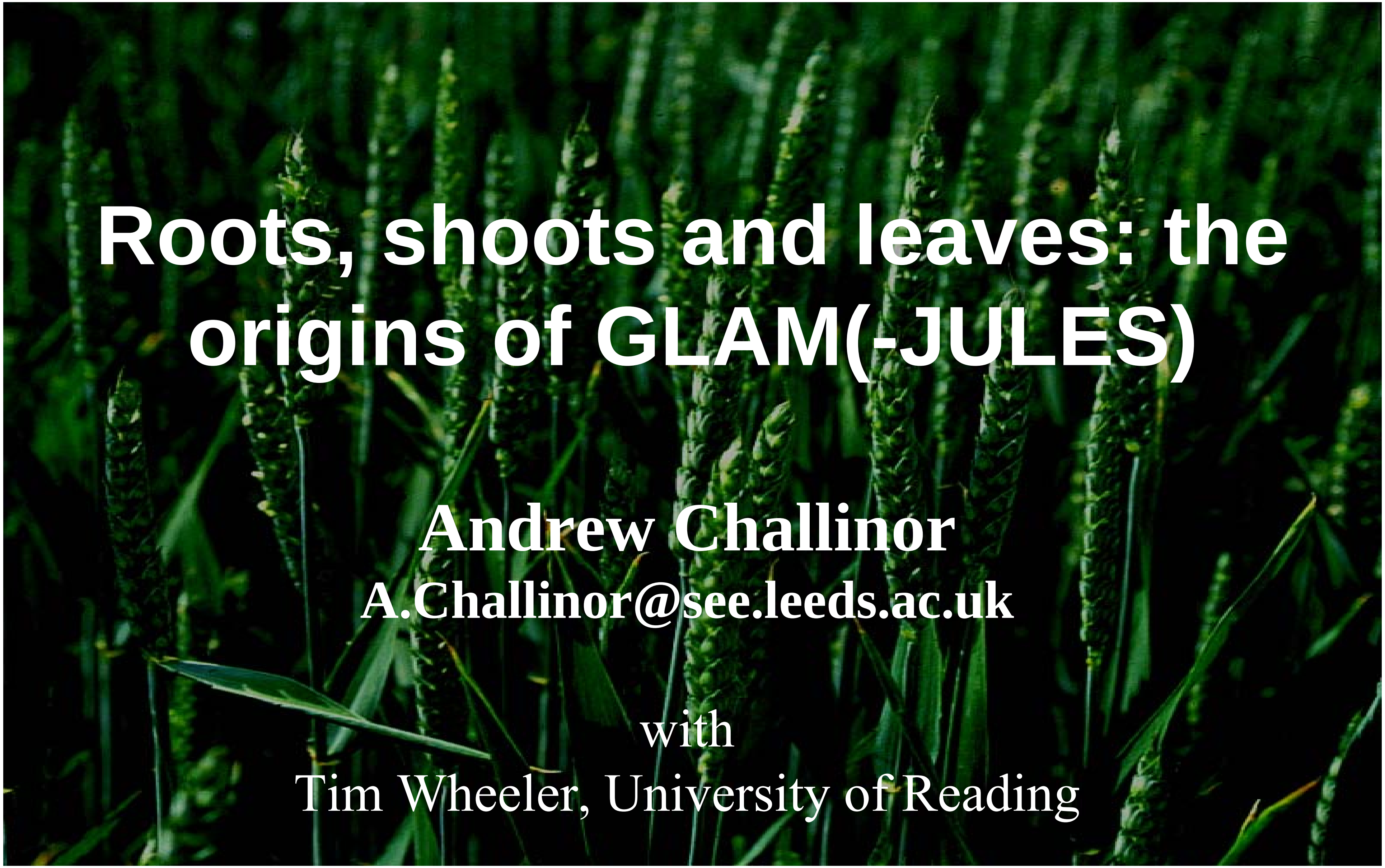
Institute for Atmospheric Science

UNIVERSITY OF LEEDS



Roots, shoots and leaves: the origins of GLAM(-JULES)

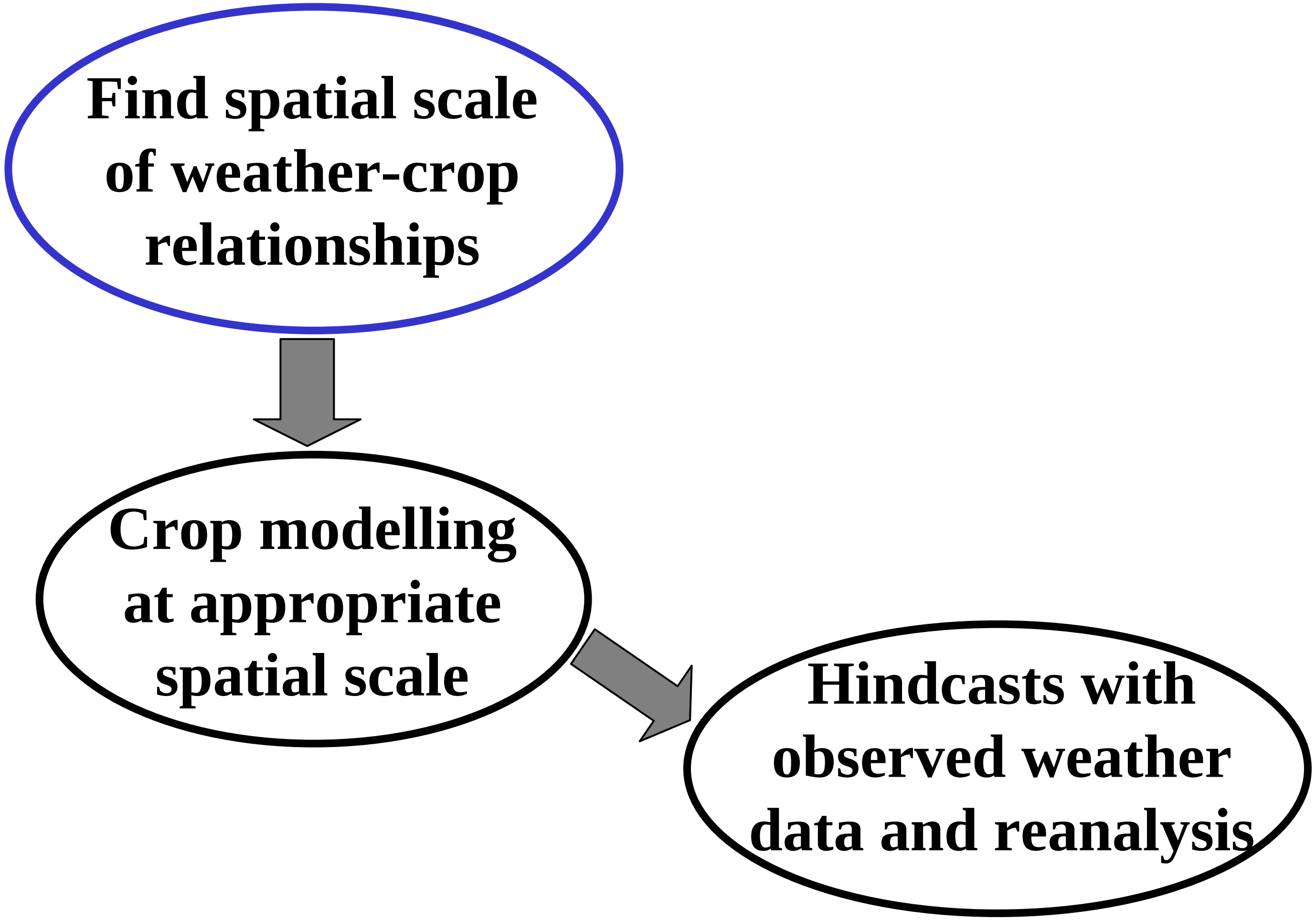
Andrew Challinor

A.Challinor@see.leeds.ac.uk

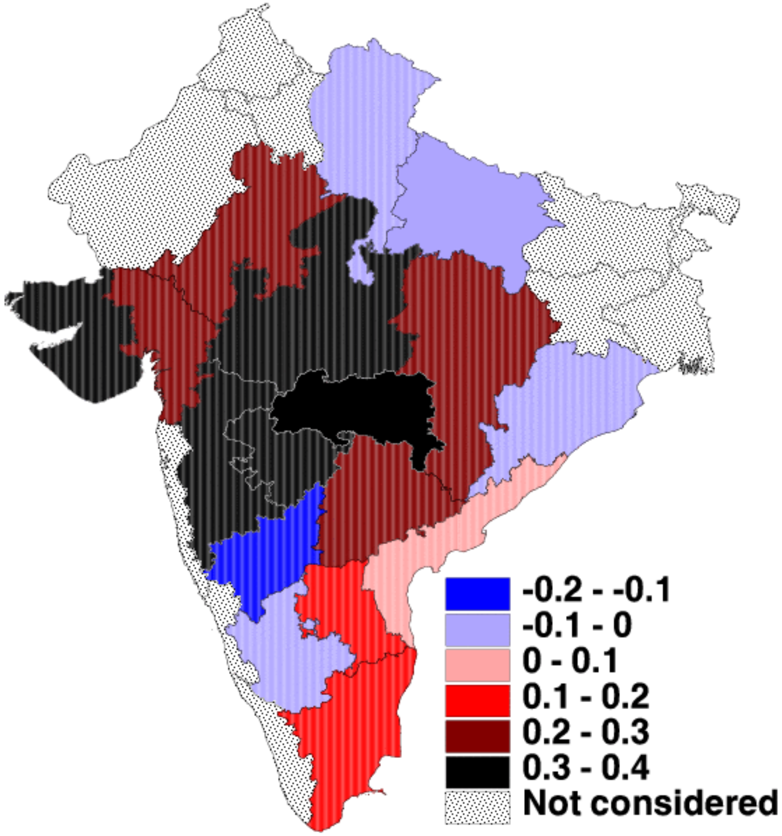
with

Tim Wheeler, University of Reading

Combined crop-climate forecasting

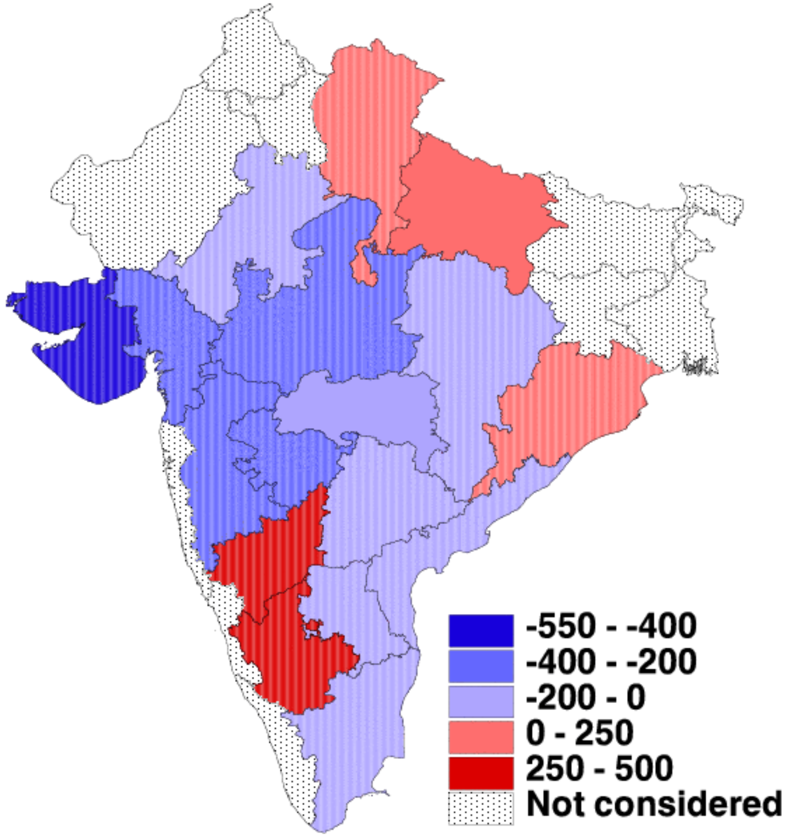


The spatial scale of yield-weather relationships: EOF analysis



First EOF of sub-divisional yield

(23.4% of variance)

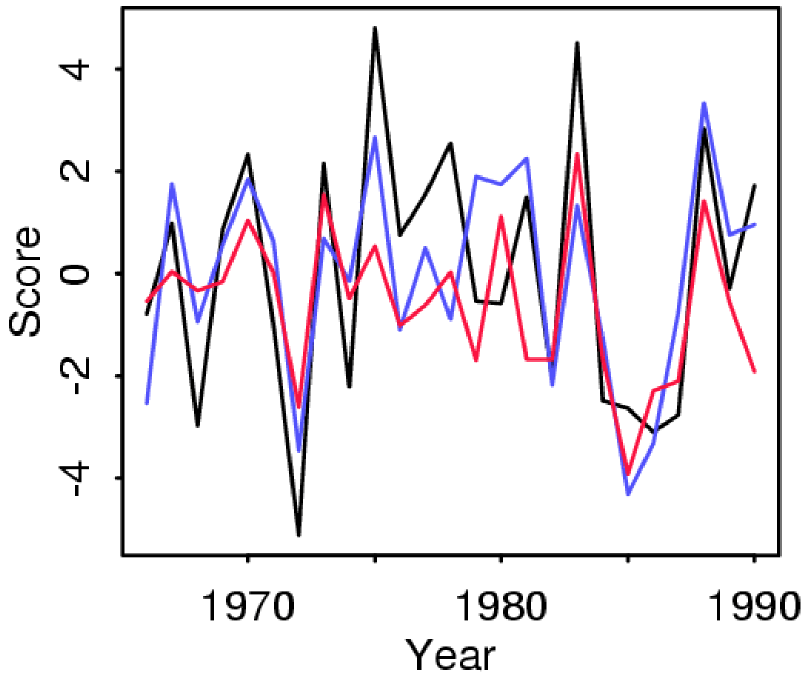


Yield anomaly for 1985

Challinor et. al. (2004)

Principle component time series

- **Coherent associated large-scale patterns of seasonal rainfall and groundnut yield in India**



First principal component of

rainfall

yield

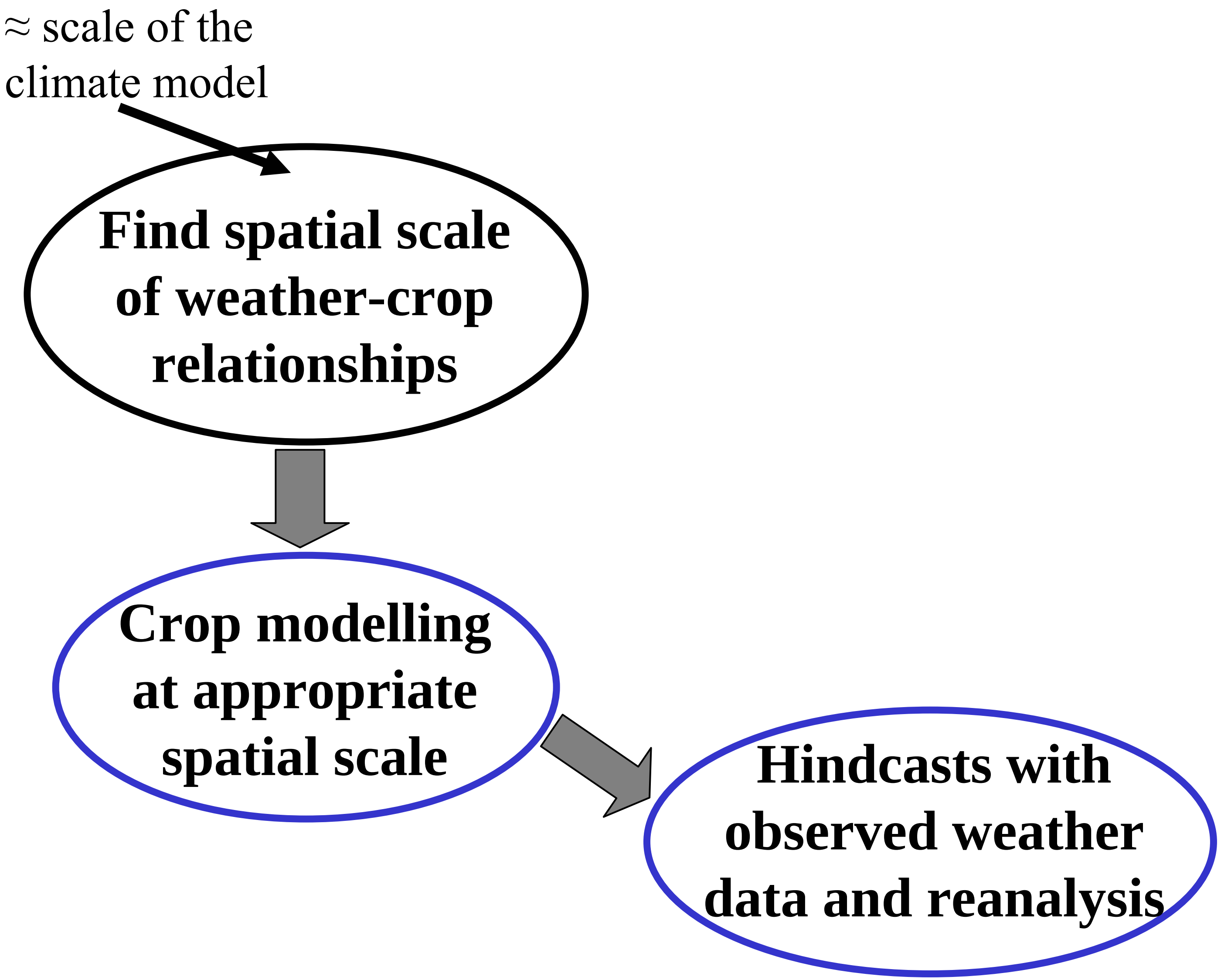
and PC3 of

850hPa circulation

r^2(ppn,yield)=0.53

r^2(circ,yield)=0.45

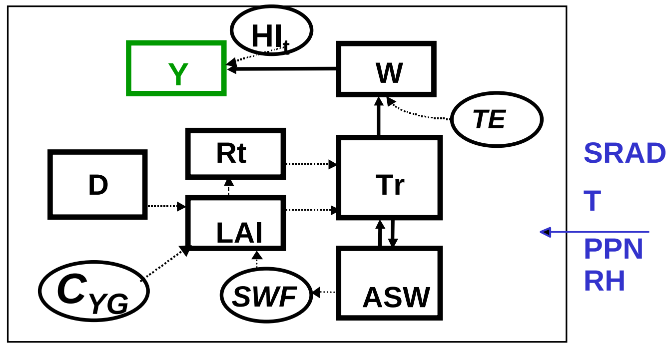
Combined crop-climate forecasting



Crop modelling methods circa 2000

- Empirical and semi-empirical methods
  - + Low input data requirement
  - + Can be valid over large areas
  - – May not be valid as climate, crop or management change
- Process-based
  - + Simulates nonlinearities and interactions
  - – Extensive calibration is often needed
  - – skill is highest at plot-level

General Large Area Model for Annual Crops (GLAM)



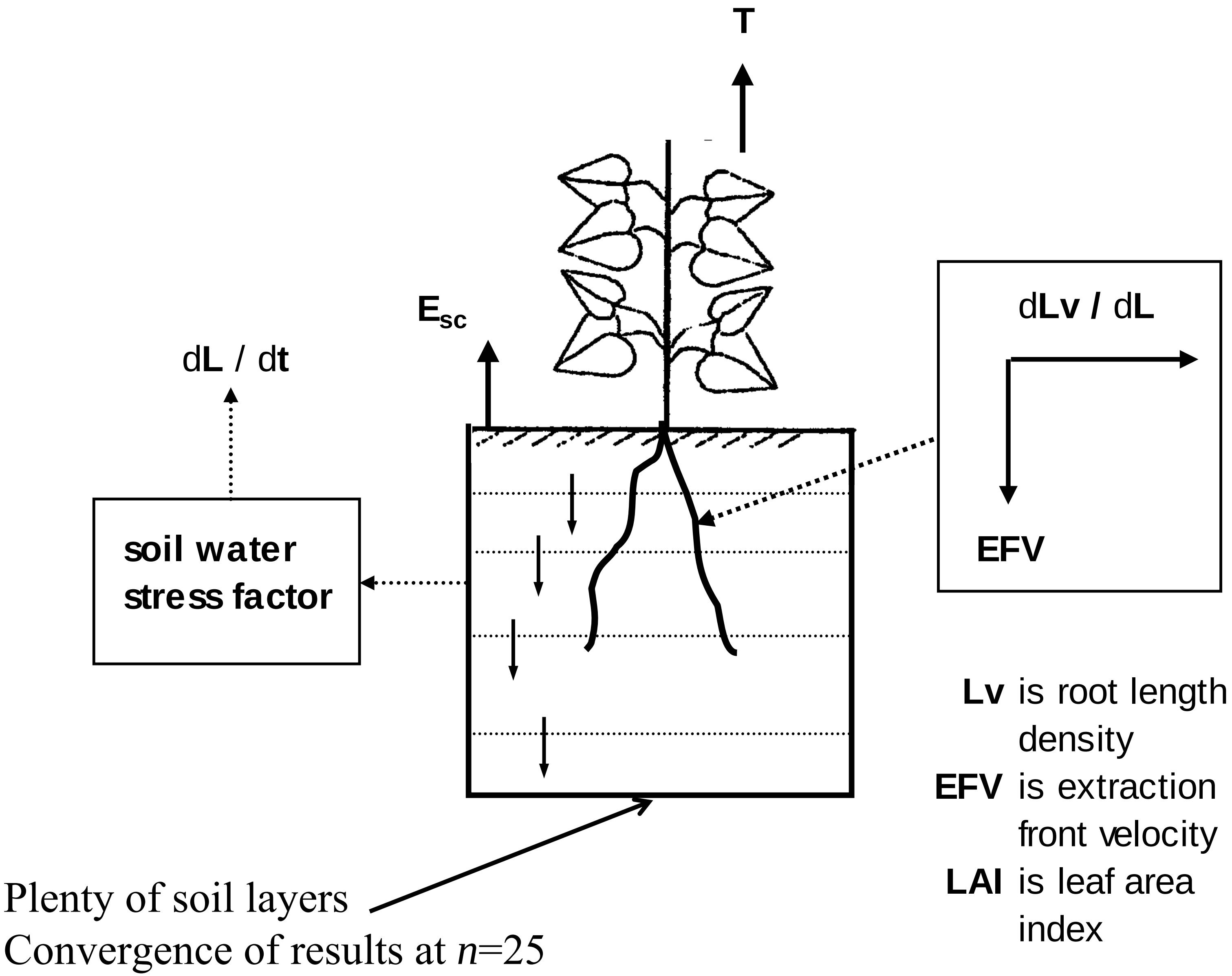
Challinor et. al. (2004)

- Combines:
  - the benefits of more empirical approaches (low input data requirements, validity over large spatial scales)

  with

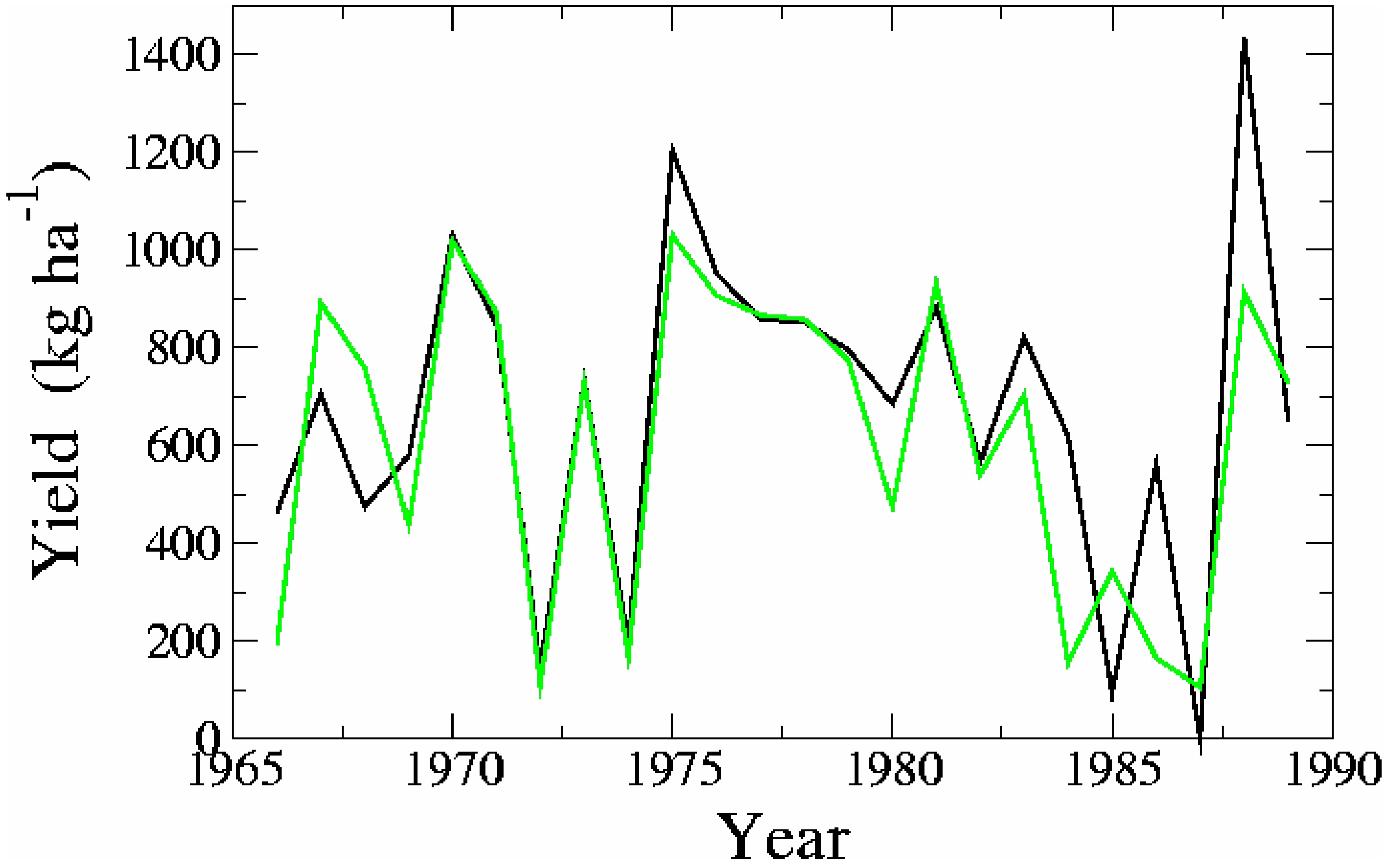
  - the benefits of the process-based approach (e.g. the potential to capture intra-seasonal variability, and so cope with changing climates)

- Yield Gap Parameter to account for the impact of differing nutrient levels, pests, diseases, non-optimal management etc.


T
E$_{sc}$
dL / dt
dLv / dL
EFV
soil water stress factor
Lv is root length density
EFV is extraction front velocity
LAI is leaf area index
Plenty of soil layers
Convergence of results at *n*=25

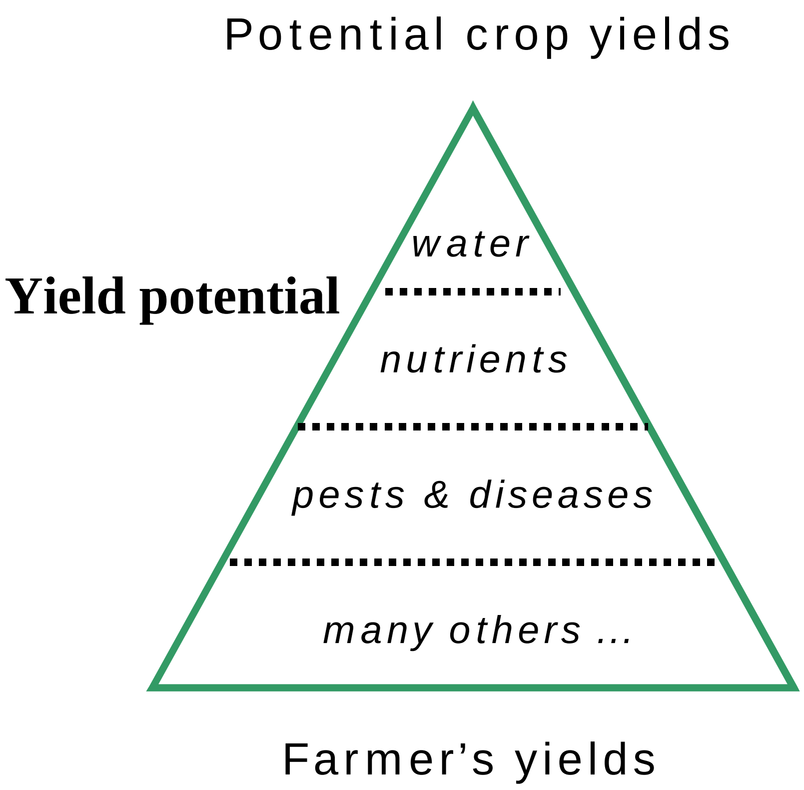
General Large-Area Model for annual crops

Results: groundnut yield in Gujarat



Challinor, A. J., T. R. Wheeler, J. M. Slingo, P. Q. Craufurd and D. I. F. Grimes (2004). Design and optimisation of a large-area process-based model for annual crops. Agricultural and Forest Meteorology, 124, (1-2) 99-120.

The yield gap parameter



GLAM uses a time-independent site-specific yield gap parameter

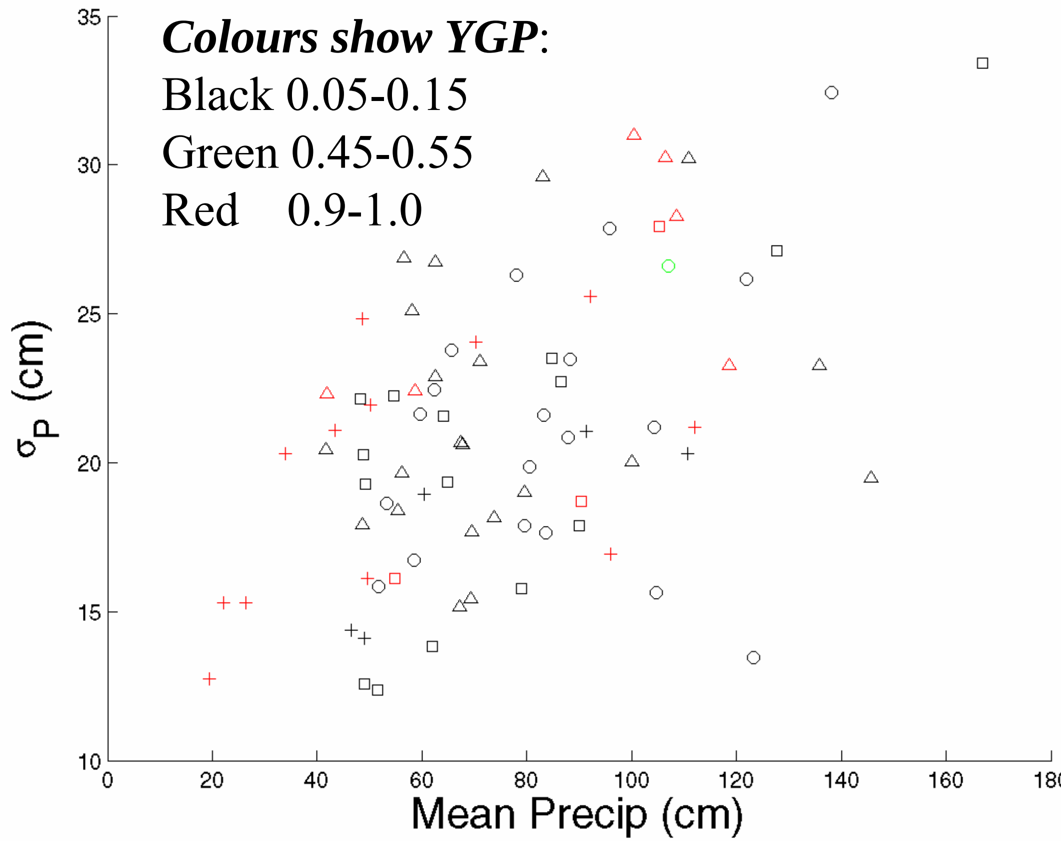
GLAM can be used to simulate yield potential, but:
- Less useful
- Validation data harder to find

To what extent are mean yields determined by YGP?

• YGP values differ when calibrated on different input data; Hence it contains an element of bias-correction.

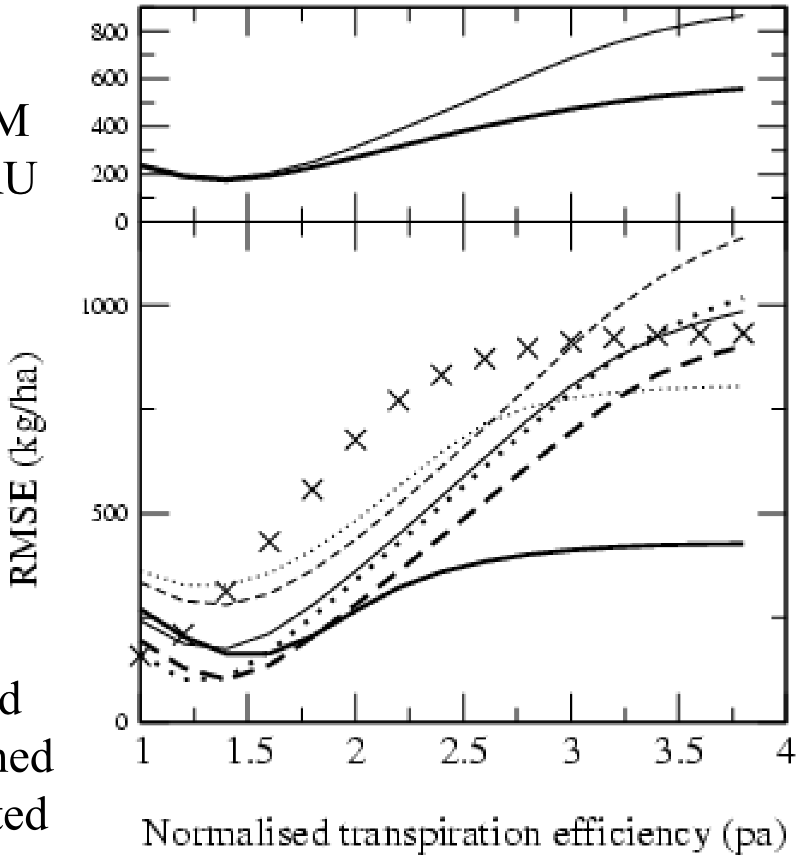
• However, does this mean that the mean yields are tuned to correct values by varying YGP?

Symbols show accuracy in simulation of mean yield:
Circles: within 5%
Squares: within 10%
Triangles: within 25%
+ : within 50%
X : within 100%



Optimisation of global parameters for groundnut across India

Thin – IITM
Thick - CRU



UP – solid
GJ – dashed
AP – dotted

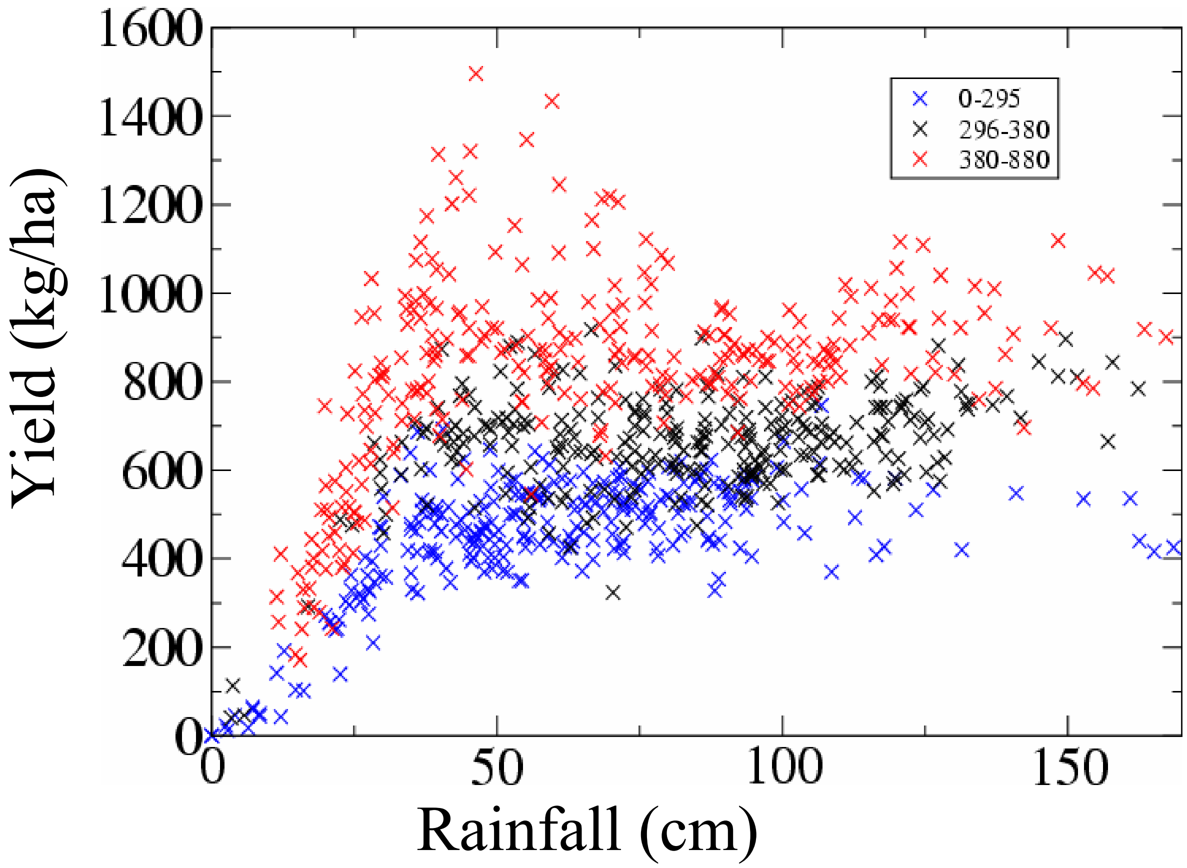
X – IITM-calibrated UP CRU run

Optimal values are within literature range (~ 1.3 - 4 Pa)

Optimal values are stable over space and input dataset provided C_{YG} is calibrated

C_{YG} can correct for (some) data input bias

Model response to rainfall and radiation



Irrigated GLAM RUE = 0.71, 0.99, 1.00 g/MJ

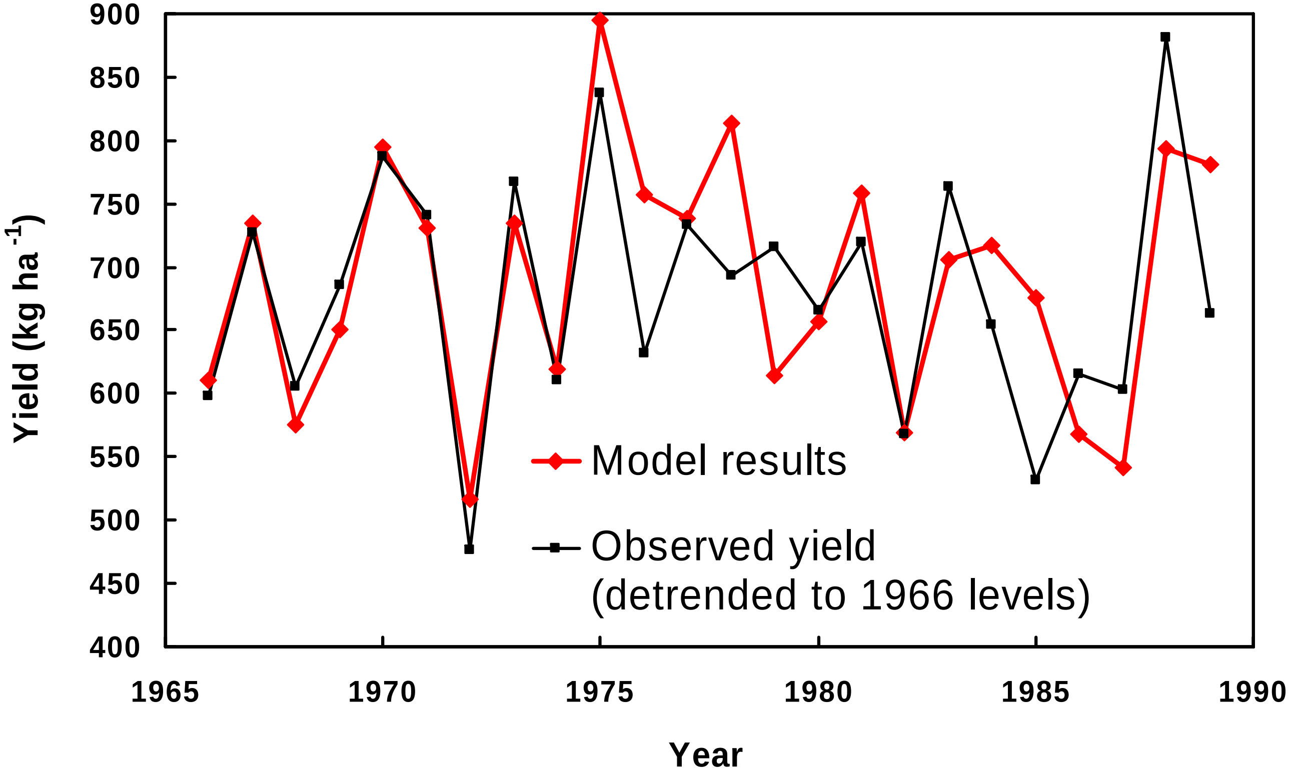
Rainfed GLAM RUE = 0.83, 0.63, 0.40 g/MJ

Observed values e.g. 0.74 (Azim-Ali, 1998), 1.00 (Hammer et. al. 1995) g/MJ

UP, AP, GJ

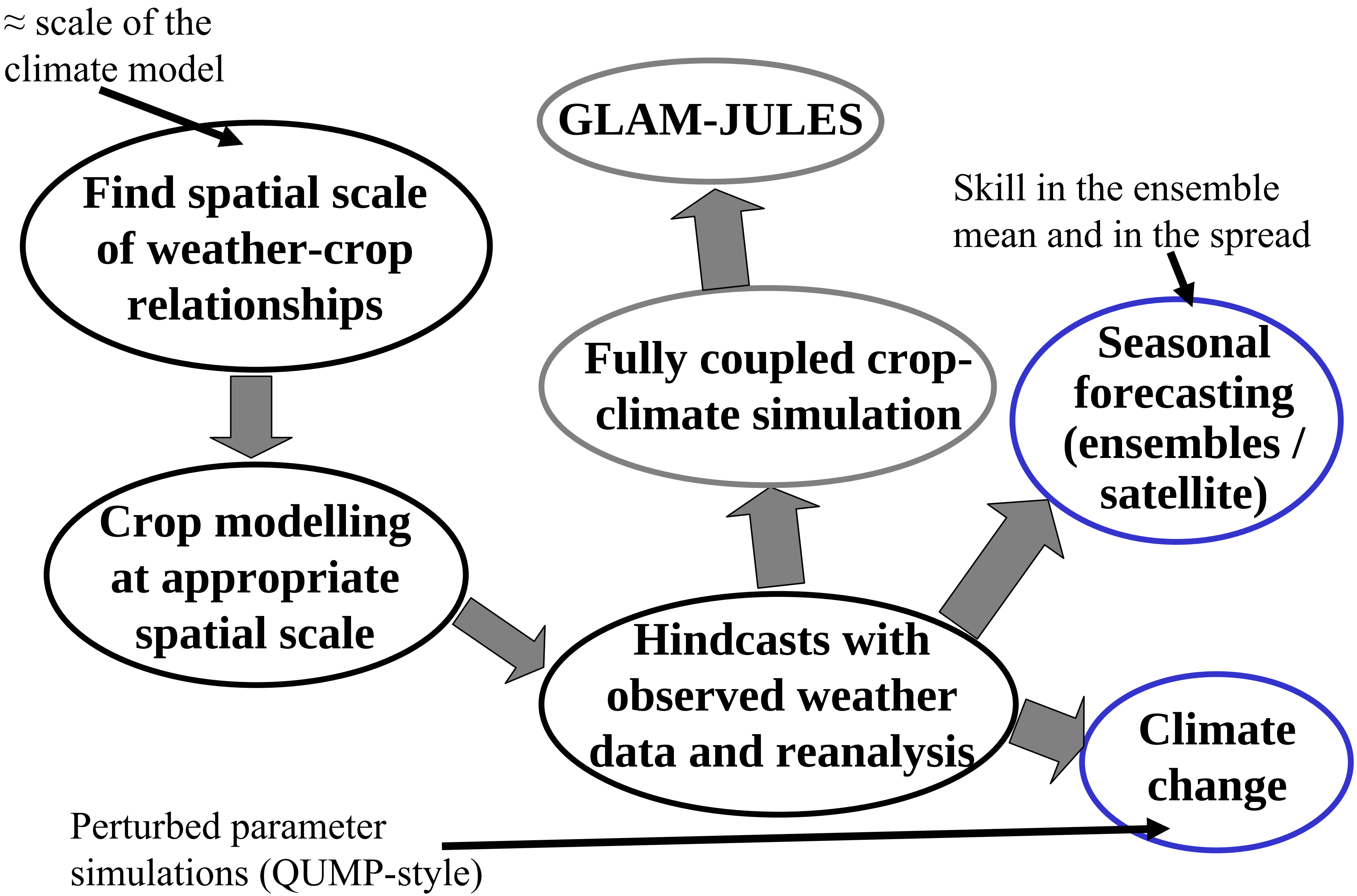
General Large-Area Model for annual crops

Results: all-India groundnut yield



Challinor, A. J., T. R. Wheeler, J. M. Slingo, P. Q. Craufurd and D. I. F. Grimes (2004). Design and optimisation of a large-area process-based model for annual crops. Agricultural and Forest Meteorology, 124, (1-2) 99-120.

Combined crop-climate forecasting

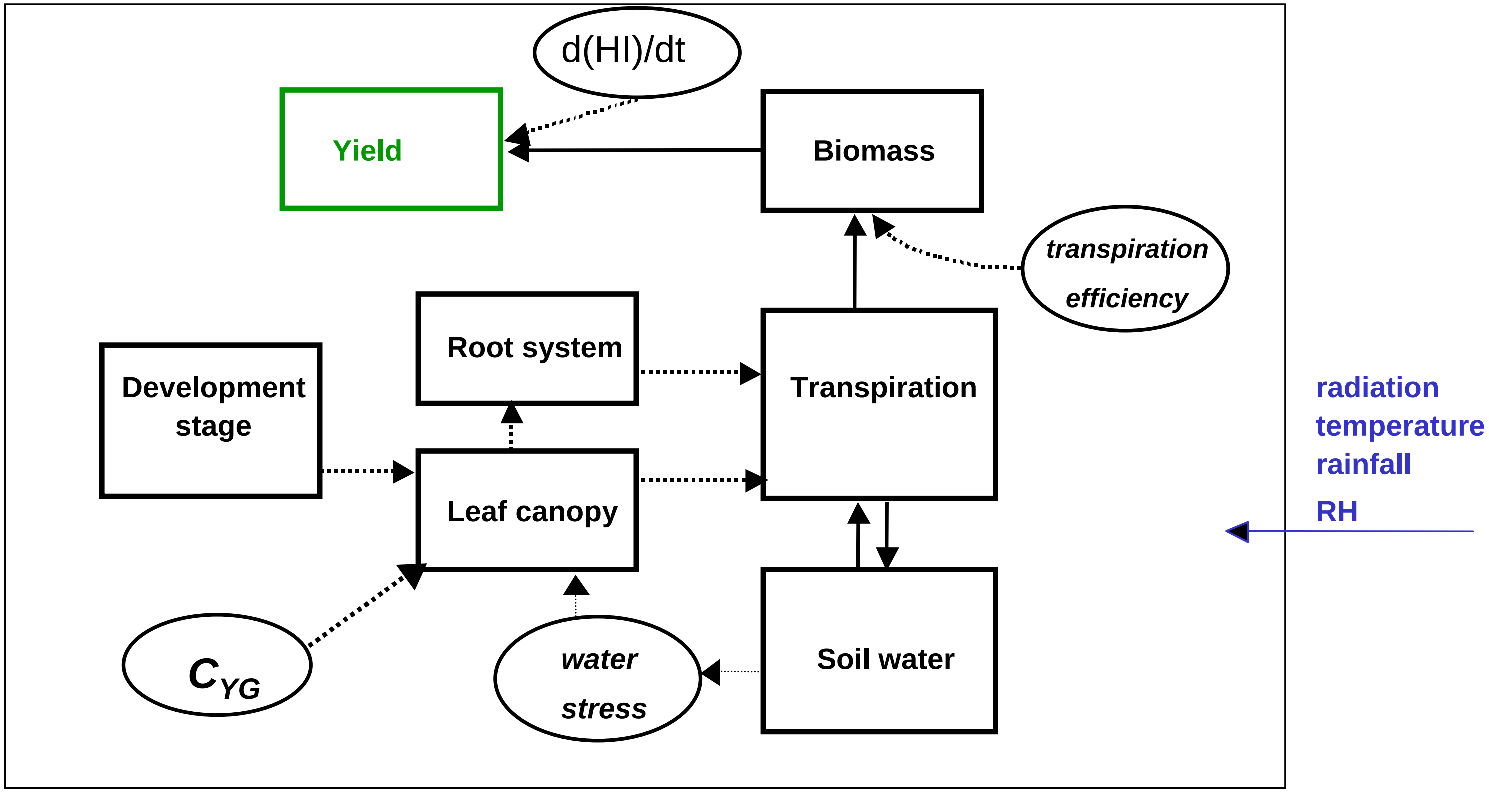


Conclusions

Land surface and boundary-layer modelling based on a sound understanding of underlying physics and biology (and chemistry) enables

- Prediction using robust process-based models
- ‘Large area’ modelling, which is especially useful as computer power and resolution increase
- Quantification of uncertainty due to both parameter values and model formulation
- Study of interactions between processes

General Large Area Model for Annual Crops (GLAM)



radiation
temperature
rainfall
RH