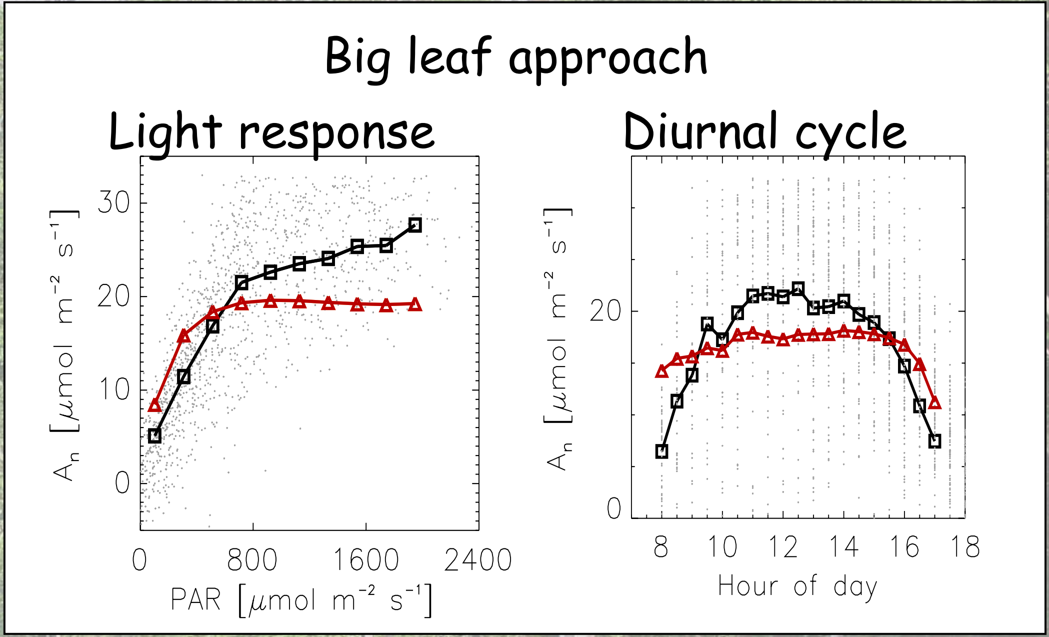
Improving representation of radiation interception and canopy photosynthesis within JULES

Lina Mercado, Chris Huntingford, John Gash, Peter Cox, Richard Ellis, Doug Clark, Paul Alton and other CLASSIC partners

JULES launch
Reading, 02.10.06

Why are we looking at radiation interception and carbon uptake within JULES ?



Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model

Peter M. Cox*, Richard A. Betts*, Chris D. Jones*, Steven A. Spall* & Ian J. Totterdell†

** Hadley Centre, The Met Office, Bracknell, Berkshire RG12 2SY, UK*
† Southampton Oceanography Centre, European Way, Southampton SO14 3ZH, UK

Radiation interception: old *vs* new approach

Beer's law

$I = Io * e^{-k * LAI}$

No scattering: i.e. sum of reflected and transmitted light

Two stream approximation (Suits, 1972; Sellers, 1995) :

Vertical profiles:

upward and downward diffusive radiative fluxes

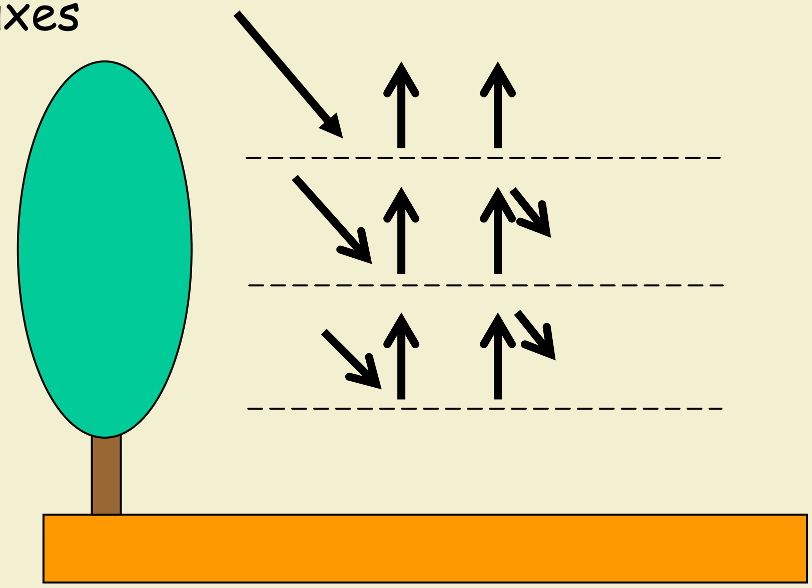
Takes into account:

Leaf and soil scattering

LAI and Leaf angle distribution

Angle of incident radiation

Diffuse and direct radiation



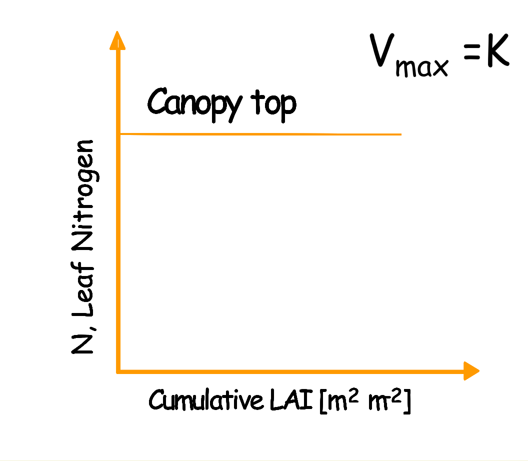
Canopy photosynthesis: old vs new approach

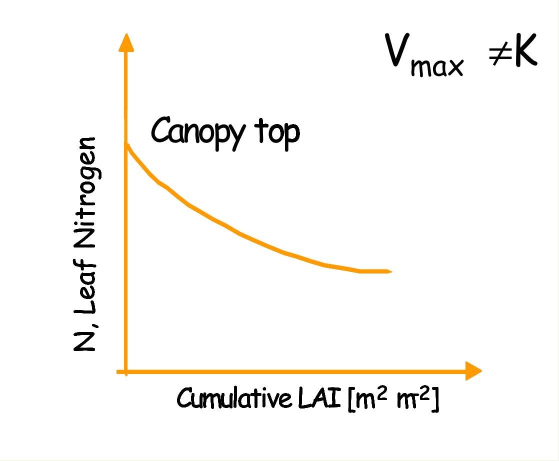
Big leaf - 1 single layer
Photosynthesis - Proportional to average absorbed irradiance
Σ leaf capacities

Multilayer Σ photosynthesis at each layer

- VERTICAL variations in light (homogeneous)
  variations in parameters , N = f(V_{max})
  canopy microclimate (T, VPD)

Standard JULES





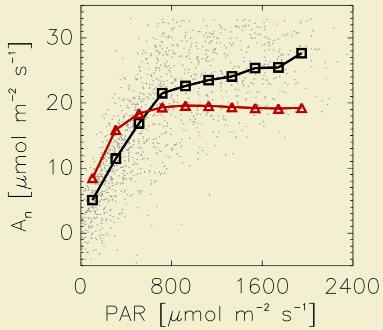
Model evaluation: rainforest site

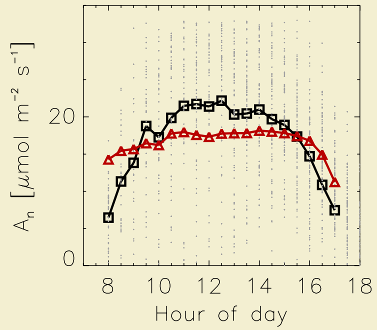
A_n= net carbon uptake = Total photosynthesis (GPP) – leaf respiration

Light response   diurnal cycle

Big leaf model

y= 0.85x r^2= 0.89



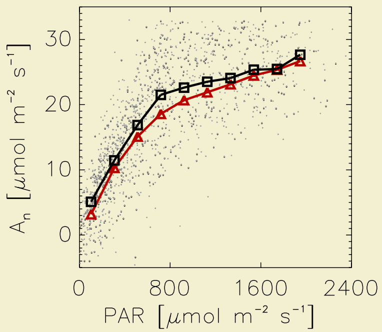


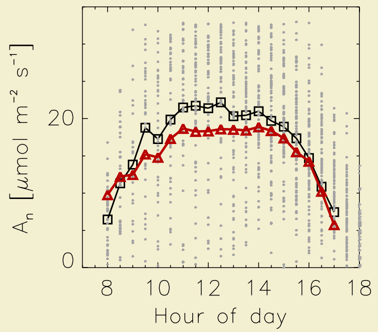
Multilayer

V_{max} =K
y= 0.83x r^2= 0.92

$V_{max} \neq k$

y= 0.86x r^2= 0.93





Further Analysis: rainforest site

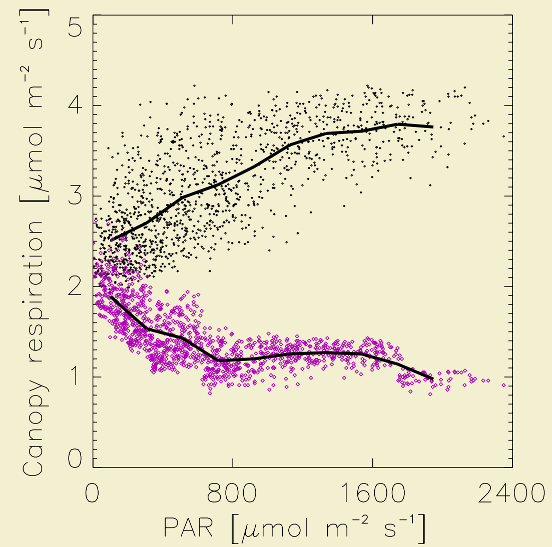
Possible reasons for remaining discrepancy

- A_n data (NEE + ecosystem respiration) is too high: ecosystem respiration (soil CO_2 efflux)

- Model A_n is too low:

  model parameters: **increase V_{max}**

  model process : **decrease leaf respiration due to light inhibition** (Brooks & Farquhar 1985)

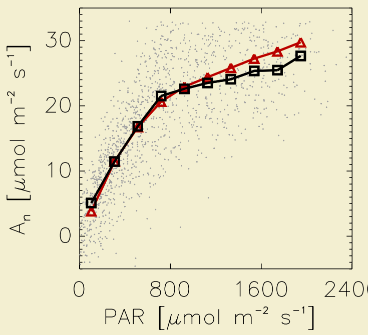


V_{max}= 18% higher (42-50 µmol m^{-2} s^{-1})
y= 0.96x r^2= 0.92

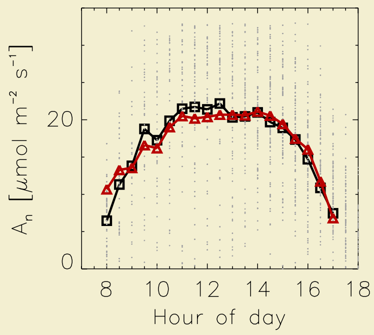
Inhibition of leaf respiration by light

y= 0.96x r^2= 0.93

Light response



diurnal cycle

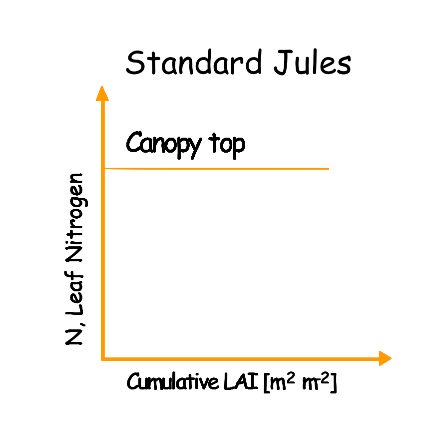


Initial results from global implementation

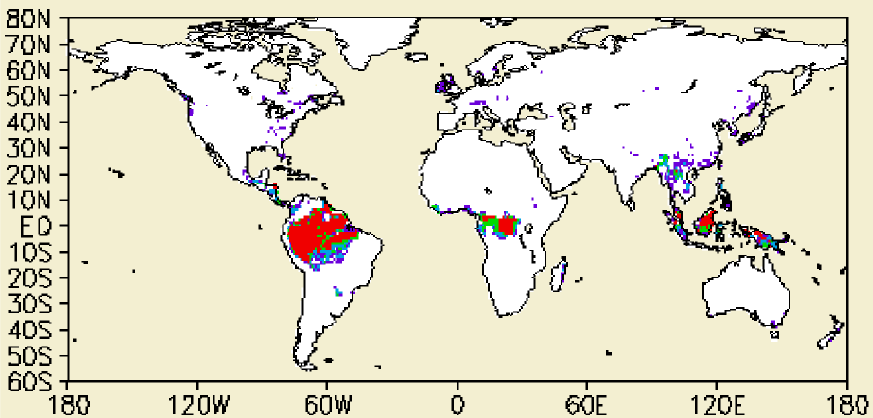
Comparison of **GPP** and **NPP** = GPP - Plant Respiration

big leaf (BL) & multilayer (ML) approach (V_{max}=k)

Mean June from 1986-1995

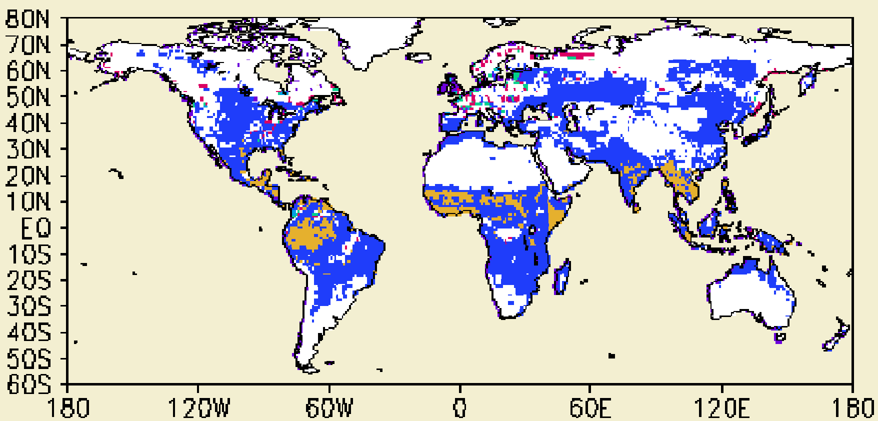


GPP (ML)- GPP (BL)

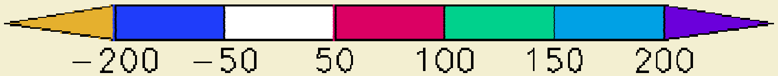


[Kg C ha^{-1} $month^{-1}$]

NPP (ML)- NPP (BL)



[Kg C ha^{-1} $month^{-1}$]



Acknowledgements to Doug Clark and Richard Ellis for gridded JULES and global runs

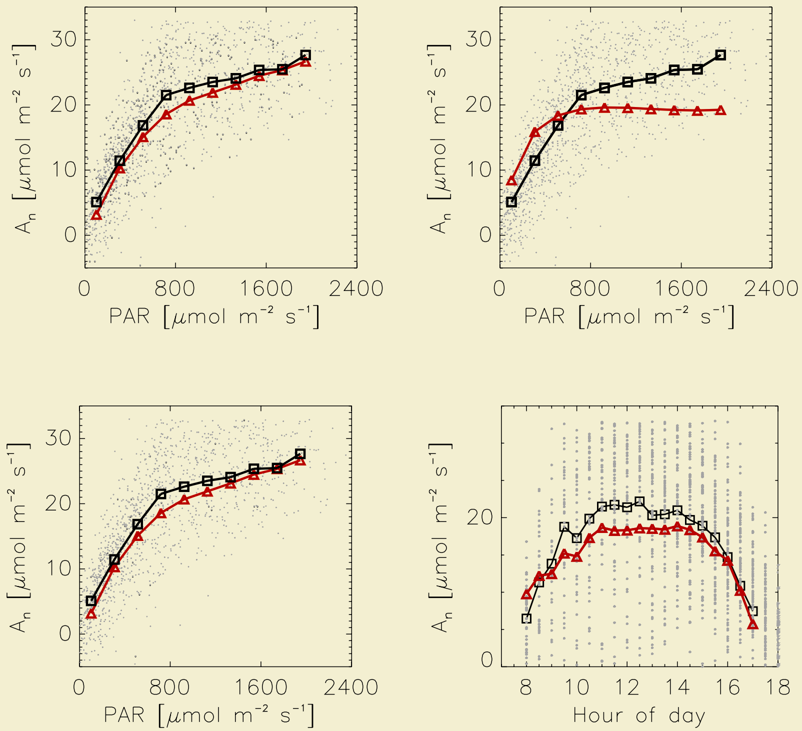
Conclusion

- Jules with multilayer gives improved results to big leaf

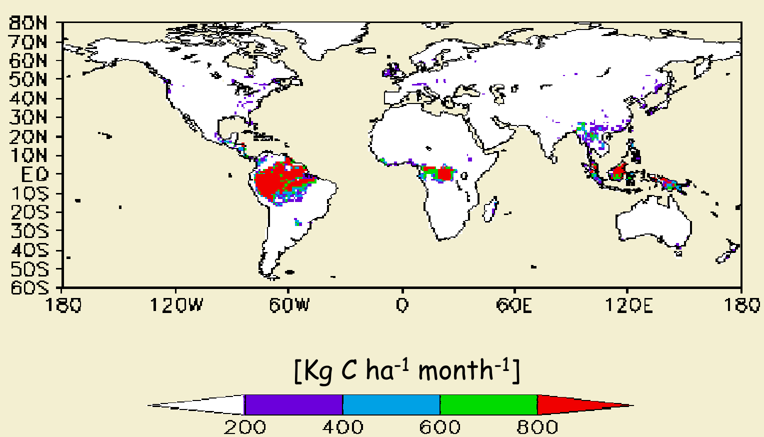
- Jules is able to represent the observations

- Initial global simulations indicate main differences in GPP using multilayer approach in the tropics

Multilayer | Big leaf



GPP (ML)- GPP (BL)



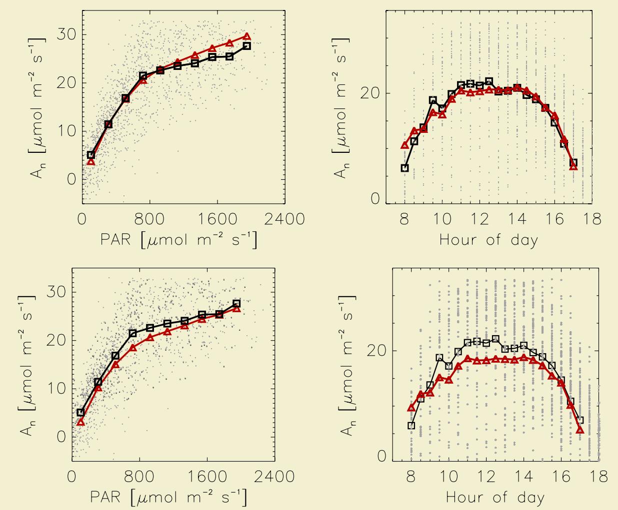
Further work

Further improvements are obtained for the tropical site

- Increasing V_{max} or

- Including inhibition of leaf respiration by light

Light response diurnal cycle



Initial global simulations indicate

a reduction of tropical NPP with multilayer

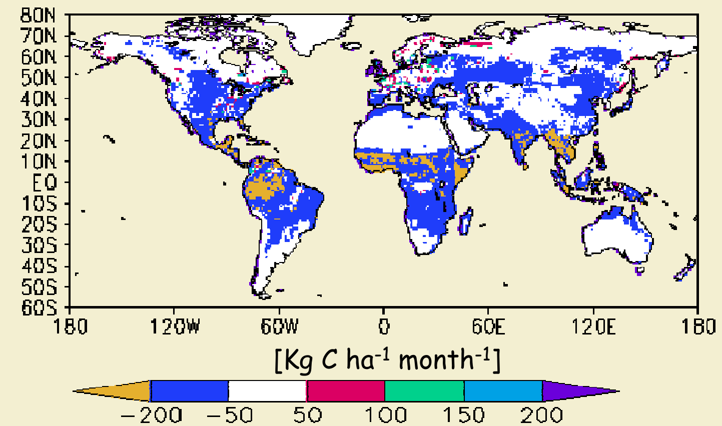
approach

Current work

Implementation of varying N with canopy depth

Implementation of inhibition of leaf respiration by light

NPP (ML)- NPP (BL)

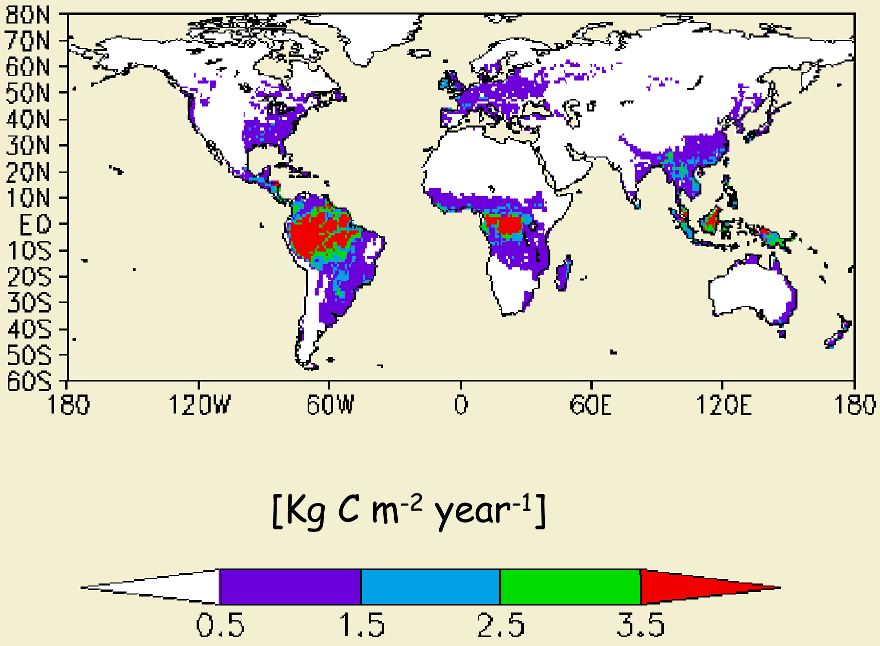


Outlook

- Validation of global model (GPP)

- Tool to simulate effects of diffuse irradiance on GPP

Mean annual GPP (1985-995) multilayer



Mean annual NPP (1985-995) multilayer