JULES_crop update

a coupled land surface – generalised dynamic crop model

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WHY?

- 12% of ice-free land surface covered with crops in year 2000 (Ramankutty et al. 2008)
- The timings and patterns of crop growth are rather different to those of natural vegetation
- Recent work has shown crops to influence regional climate through land surface feedbacks (e.g. Cooley et al. 2005, Osborne et al. 2007)

AIMS

To design a model that:

- allows JULES to more accurately simulate land surface processes and fluxes over croplands

- simulates ‘farm-level’ crop productivity

- uses as much of the JULES code base as possible (changing as little of JULES as possible)

REPRESENTING CROP VARIATION

- Which crops?

- How to represent development and growth of these crops?

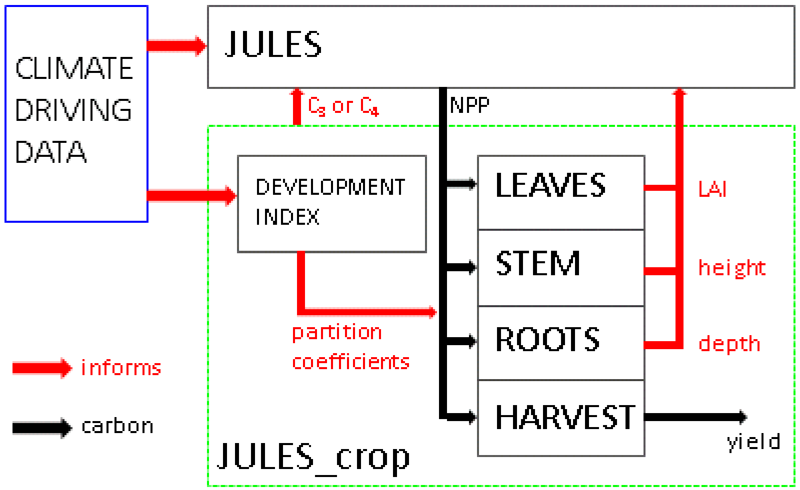
We have defined 12 crop functional types → CFTs
(JULES has 5 PFTs)

These are very similar to the CFTs in **LPJ-mL**
(Bondeau et al. 2007)

These represent crop process variation… (but do they represent variation in ‘crop influence’ on the land surface?)

DEFINING A GENERALISED DYNAMIC CROP

- Crop sown
- Seedling emerges
- Assimilates carbon, grows…
- …
- Flowers
- Assimilates carbon, fills 'grain'…
- …
- Matures
- Crop harvested



→ CROP DEVELOPMENT

CROP DEVELOPMENT (DVI)

Development is a function of temperature (and photoperiod)

DVI:	→ 0 sowing to emergence	(emergent)
DVI: 0	→ 1 emergence to flowering	(vegetative)
DVI: 1	→ 2 flowering to maturity	(reproductive)

(Photo-) Thermal time requirement for each stage to complete

This scheme generalises (e.g. wheat, potato, cassava, sugarcane)

USING JULES TO ASSIMILATE CARBON (i.e. GROW)

NPP = GPP – RESPIRATION

JULES appears to underestimate NPP for developing crops

$$\mathrm{NPP} = 0.012\{A_c + R_{dc}\beta\} - 0.012R_{dc}\left\{\beta + \frac{\mu_{rl}n_l\sigma_l L + \mu_{rs}n_l 0.01hL}{n_l\sigma_l L}\right\}$$
$$- r_g\left\{0.012\{A_c + R_{dc}\beta\} - 0.012R_{dc}\left\{\beta + \frac{\mu_{rl}n_l\sigma_l L + \mu_{rs}n_l 0.01hL}{n_l\sigma_l L}\right\}\right\}$$

$$\mathrm{NPP} = 0.012\left(1 - r_g\right)\left(A_c - R_{dc}\left\{\frac{\mu_{rl}n_l\sigma_l L + \mu_{rs}n_l 0.01hL}{n_l\sigma_l L}\right\}\right)$$

$$\mathbf{NPP} = \mathbf{0.012}\left(\mathbf{1} - \boldsymbol{r_g}\right)\left(\boldsymbol{A_c} - \boldsymbol{R_{dc}}\left\{\frac{\boldsymbol{C_R} + \boldsymbol{C_S}}{\boldsymbol{C_L}}\right\}\right)$$

r_g = growth respiration coefficient
A_c = net canopy photosynthesis
R_{dc} = (non-moisture stressed) canopy dark respiration

GROWING CROPS

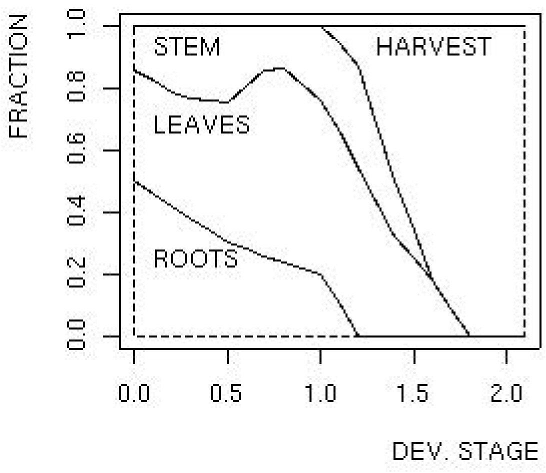
Assimilated carbon is partitioned to:

- Roots
- Stems
- Leaves
- Storage organs

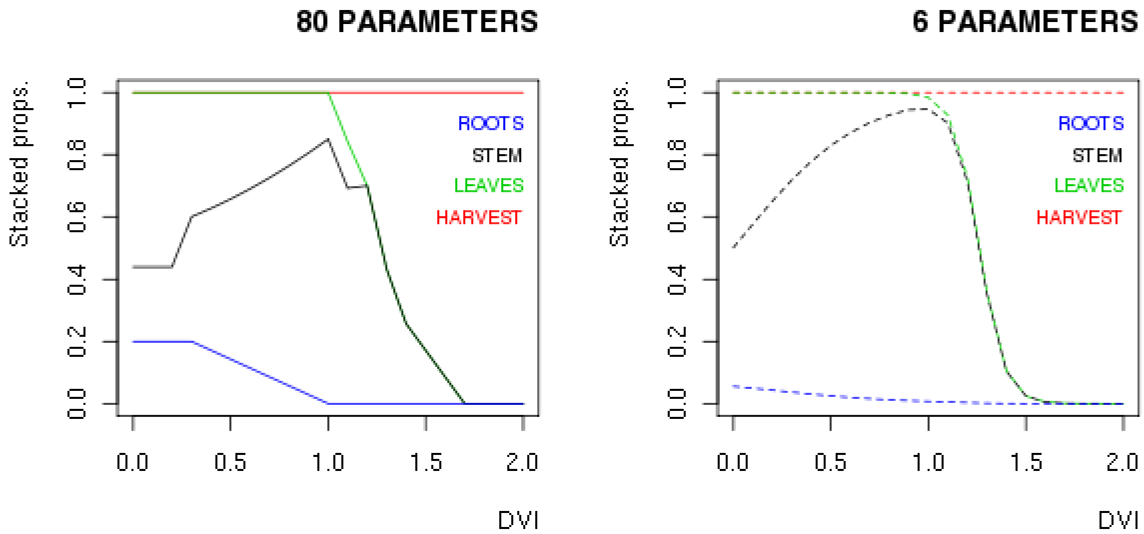
PARTITION COEFFICIENTS ~ DEVELOPMENTAL STAGE (DVI)

GROWING CROPS

Partition coefficients ~ developmental stage (DVI)



example:
CFT 7 soya (Penning de Vries et al. 1989)
48 parameters



Example: CFT 5 rapeseed (van Diepen et al. 1989)

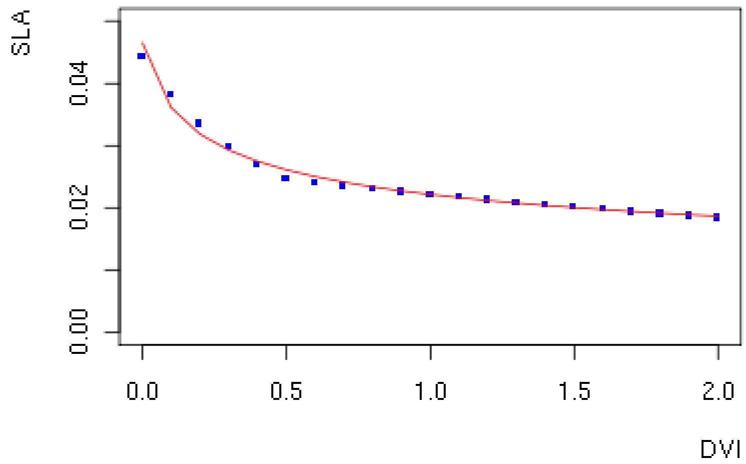
- originally 44 parameters, sampled to 80 parameters
- fitted with 6 parameters using a **multinomial logit regression** on DVI

- $C_{LEAF} \rightarrow LAI$

- $LAI = SLA * C_{LEAF}$ (or, more specifically, leaf biomass!)

… except, SLA varies with developmental stage

For example, SLA for maize (CFT 11):



$SLA_{MAIZE} = \mathit{0.022}DVI^{\mathit{-0.259}}$

CROP HARVESTED

- DVI = 2 → yield removed, C_L C_S and C_R set to zero
- ‘Sow’ again when conditions suitable
  (‘sow rule’ + emergence TT requirement ensures crops grow at right time… important for any transient model runs)

SO, JULES_crop STATUS:

- Working code
- Runs for 12 CFTs using GSWP2 driving data
- Very generalisable: different crops, different harvesting methods etc. (different vegetation types?)
- Currently working on calibrating parameter sets
  → Metropolis-Hastings ?


THANK YOU
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