Recent developments in JULES-crop

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Met Office   JULES-crop

- ► JULES-crop is a generic parameterisation of crops, which has been in JULES since version 4.0.

- ► Each crop is treated as a separate surface tile.

- ► Rate of crop development is determined by temperature and parametrised by the crop development index (DVI).
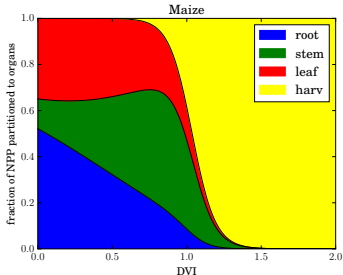
sown	emerges	flowers	harvested
-1	0	1	2

DVI

Met Office Crop carbon pools

► NPP is distributed to leaf, root, stem, harvest and reserve carbon pools according to DVI.

► Carbon is moved between carbon pools to simulate the remobilisation of stem reserves and leaf senescence.

► LAI is calculated from leaf carbon, canopy height is calculated from stem carbon

Recent improvements to JULES-crop

New parameters

- ▶ improved parametrisation of senescence (`mu_io`, `nu_io`, `sen_dvi_io`)

- ▶ `initial_carbon_io`: carbon in crops at emergence

- ▶ `t_mort_io`: temperature of second soil layer which triggers harvest (if crop has already flowered)

- ▶ `yield_frac_io`: fraction of the harvest carbon pool which is added to the crop yield diagnostic

New diagnostics

- ▶ `harvest_trigger`: Condition which triggered crop harvest

- ▶ `harvest_counter`: Can be used to keep track of the number of crop harvests within a time period

There are three FLUXNET sites at Mead, Nebraska: irrigated maize, irrigated maize/soybean rotation, non-irrigated maize/soybean rotation.

Sukyer et al 2004, Verma et al 2005 (photo credit: fluxnet.ornl.gov).

- Old parametrisation: a fraction 0.05 of leaf carbon is moved to the harvest pool per day after $\mathrm{DVI} = 1.5$.

- New parametrisation: a fraction

$$\min \left[\mu \left(\mathrm{DVI} - \mathrm{DVI}_{sen} \right)^{\nu}, 1 \right] \tag{1}$$

of leaf carbon is moved to the harvest pool per day after $\mathrm{DVI} = \mathrm{DVI}_{sen}$.
This reduces to the previous parametrisation when $\mathrm{DVI}_{sen}=1.5$, $\mu=0.05$, $\nu=0.0$.

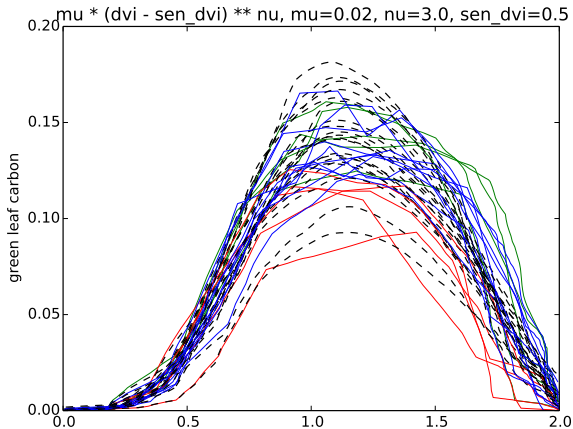# Senescence: old parametrisation

mu * (dvi - sen_dvi) ** nu, mu=0.05, nu=0.0, sen_dvi=1.5
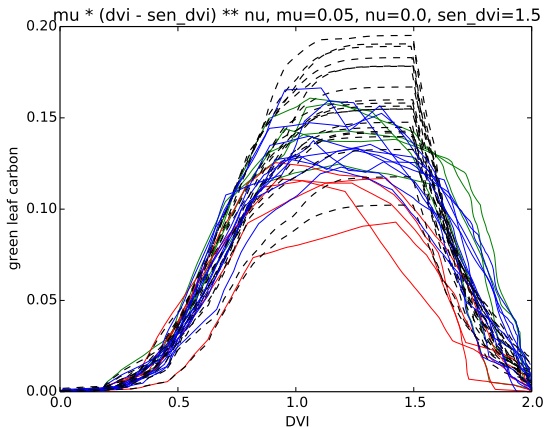
Coloured lines: Mead FLUXNET observations for maize.

Black lines: simulated.

Senescence: tuned new parametrisation

mu * (dvi - sen_dvi) ** nu, mu=0.02, nu=3.0, sen_dvi=0.5

Coloured lines: Mead FLUXNET observations for maize.
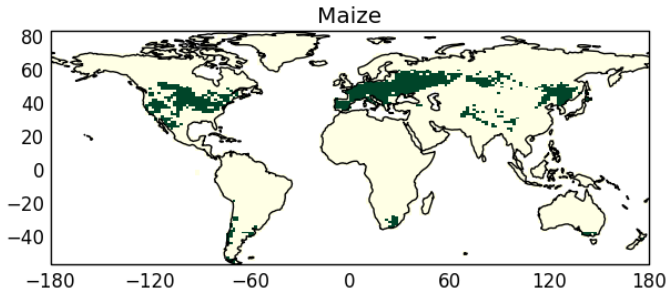
Black lines: simulated.

Mead FLUXNET observations for maize
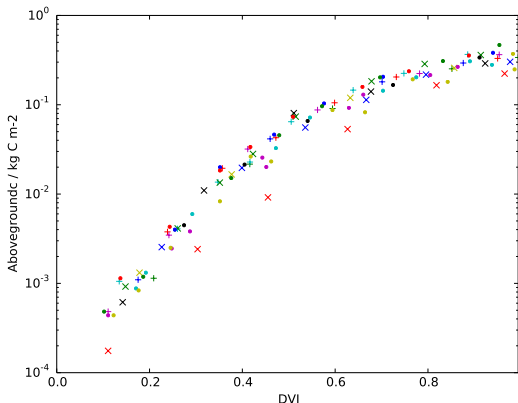
Initial carbon was previously hard-wired to 0.01 kg C m^{-2} which for maize is equivalent to aboveground carbon of approximately 0.005 kg C m^{-2}.

Soil temperature which triggers harvest

Maize

Green: grid boxes where crop was harvested because temperature in second soil layer went below t_mort=8°C in at least one year in the global runs in Osborne et al 2015.

This plot was created using the new diagnostic `harvest_trigger`.

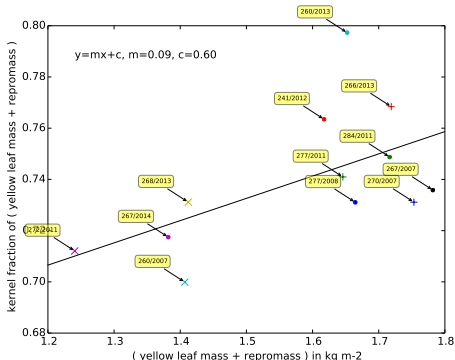In JULES-crop, the harvest carbon pool includes

- ▶ the economically valuable part of the plant (maize: kernel)

- ▶ other reproductive parts of the plant (maize: cob, husk, ear shank, silk)

- ▶ yellow leaves

The yield fraction converts the mass of the carbon in the harvest pool on the day of harvest into carbon mass of yield.
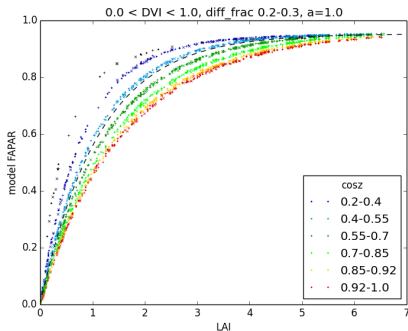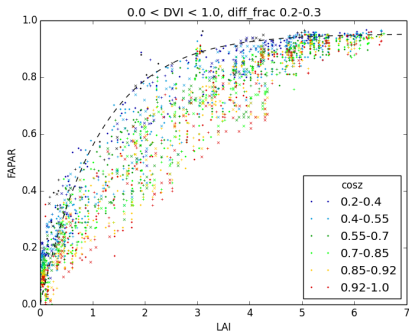
Yield fraction of harvest pool

The Mead FLUXNET observations (maize) are labelled with the day of year and year that the observation was taken (last measurement day before harvest in each year).

Canopy structure factor

Mead FLUXNET observations for maize before flowering. Colours show the cosine of the zenith angle.

Left: FAPAR observations with diffuse radiation fraction between 0.2 and 0.3.
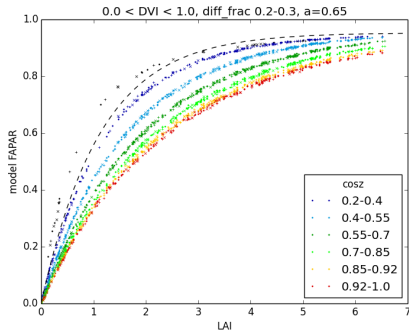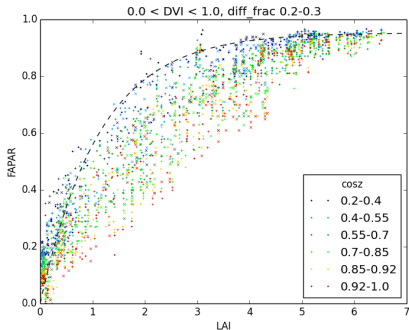Right: model FAPAR using observed diffuse radiation fraction (0.2-0.3) and assuming uniform canopy (a=1) using sellers.py (Quaife 2016).

Canopy structure factor

Mead FLUXNET observations for maize before flowering. Colours show the cosine of the zenith angle.
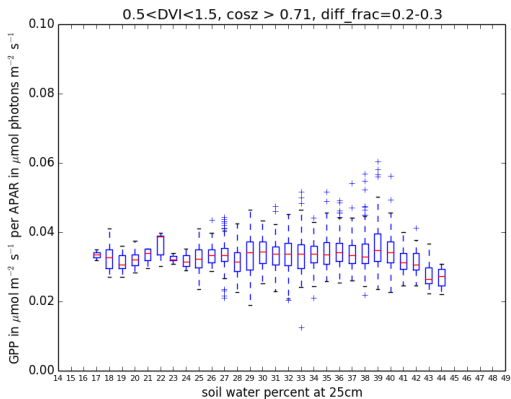

Left: FAPAR observations with diffuse radiation fraction between 0.2 and 0.3. Right: model FAPAR using observed diffuse radiation fraction (0.2-0.3) and assuming a non-uniform canopy with a=0.65 using `sellers.py` (Quaife 2016).
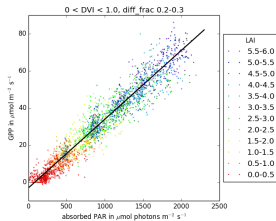
Soil moisture stress
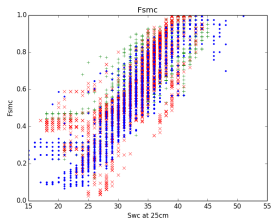

0.5<DVI<1.5, cosz > 0.71, diff_frac=0.2-0.3

0 < DVI < 1.0, diff_frac 0.2-0.3

Soil moisture stress factor (fsmc) based on soil moisture obs and an exponential root distribution with e-fold depth 0.5m.

Fsmc

Mead FLUXNET obs for maize. Site is silty clay loam ($\theta_w = 0.25$, $\theta_c = 0.39$).

Soil moisture stress

Two new options for soil moisture stress have been added to JULES vn4.6:

- ▶ Soil moisture stress factor can be calculated based on the average soil properties in the root zone (as opposed to being weighted by root mass density)
- ▶ Soil moisture threshold at which plant starts to experience stress can be pft-dependent

But there is still lots more to do in this area → new Process Evaluation Group on improving the parametrisation of soil moisture stress on vegetation. Email Anna Harper or me for more information.
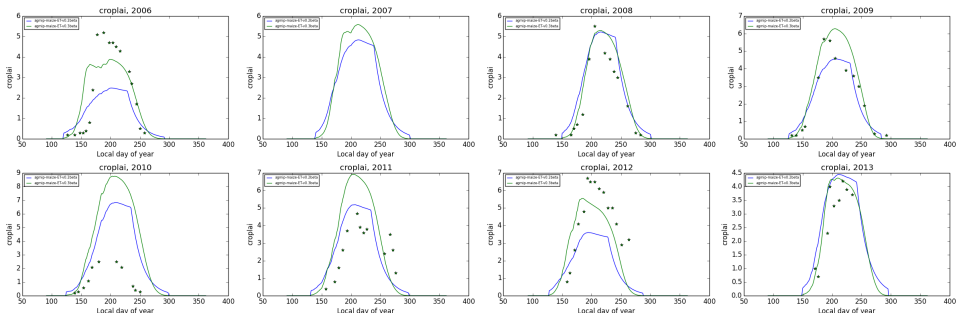
AgMIP

JULES is currently participating in two parts of the Agricultural Model Intercomparison and Improvement Project:

▶ The AgMIP Maize Evapotranspiration Study

▶ The AgMIP Global Gridded Crop Model Intercomparison Phase 2

LAI against day of year for obs (points), agmip-maize-ET-v0.2beta (blue) and agmip-maize-ET-v0.3beta (green).

JULES-crop users meeting

- 1st-2nd August, Met Office

- Share experiences of using JULES-crop

- Everyone welcome!

- Email pete.falloon@metoffice.gov.uk for more information.