Alignment of Daisy with FOCUS recommendations

The original purpose of Daisy was to estimate nitrogen leaching as a function of soil, weather, and management. An important aspect of this is mineralization and immobilization of nitrogen in the soil, both of which are linked to soil carbon turnover. When support for pesticides was added to Daisy, the default assumption was that pesticides could be treated like other forms of carbon turnover with regards to the effect of heat and moisture. In this section the traditional Daisy approach will be compared to FOCUS recommendations, mostly from (FOCUS 2002)(referred to as GG2002 in the following), and we choose which one to follow when setting the new Daisy pesticide parameter 'decompose_soil_factor' to 'FOCUS',

Pesticide fate on canopy

When a pesticide is applied on the field, the canopy will intercept some of it, and some will bypass the canopy and hit the soil directly. In Daisy, the fraction of the pesticide that hit the canopy is equal to the canopy cover, which is calculated with Beer's law:

$$1 - e^{-k\,\mathrm{LAI}}$$

Here LAI is the leaf area index, which is calculated dynamically as part of the crop model, and k is a crop specific extinction coefficient with a default value of 0.5. In FOCUS, a table is used to determine canopy interception (GG2002, Table 2.4.2-1) as a function of crop type and development. We will continue to use the dynamic cover calculated by Daisy.

The pesticide may be washed off the canopy by rain, or degraded by various processes that are combined in a single parameter, the decomposition rate. The default decomposition rate for pesticides on canopy in Daisy is 0.0083 per hour, with no source given. This corresponds to a half-life of approximately 3.5 days (first order decomposition). The default decomposition rate for pesticides on canopy recommended by FOCUS is 10 days. Since no source was given for the Daisy value, we chose to use the value recommended by FOCUS.

Canopy washoff

The function for canopy washoff in FOCUS (GG2002, section 7.4.11) is purely a function of the amount of water dripping off the plant ("net precipitation" in FOCUS terminology):

$$\mathrm{M} = \mathrm{M}_0\, e^{-f_{\mathrm{FOCUS}}\,\mathrm{R}}$$

Here M0 is the original pesticide content on the canopy, M is the content after R amount of drip off, and f_{FOCUS} is a *foliar extraction coefficient* with the default value of 0.05 mm^{-1}. The function used by Daisy is similar:

$$\text{M} = \text{M}_0\, e^{-f_{\text{Daisy}} \frac{R}{I}}$$

The only difference is the introduction of I, the amount of intercepted water on the canopy. The canopy washoff coefficient (f_{Daisy}) is a number between zero and one, with zero meaning all of the pesticide is sorbed to the leaves, and one meaning all of the pesticide is fully dissolved in the intercepted water. The default value for f_{Daisy} has been 1, corresponding to a pesticide that does not sorb to the leaves. The interception capacity in Daisy is a simple function of LAI, by default $I = I_c$ LAI, with a default value for I_c of 0.5 mm. This means that the relationship between the washoff functions in Daisy and FOCUS can be described as:

$$f_{\text{Daisy}} = f_{\text{FOCUS}}\, I_c\, \text{LAI}$$

The FOCUS parameterization is from H. Willis et al. (1982), which is an experiment with artificial rain on a mature cotton crop. Unfortunately, neither the interception capacity nor the LAI is given for the cotton crop, however by assuming a LAI of 3 for a mature cotton crop and the default Daisy interception capacity per LAI, we get a value of $f_{\text{Daisy}} = 0.075$. This value has been used in our simulations. With this value, we get identical washoff as FOCUS when LAI is 3, but much faster washoff for a lower LAI as seen on Figure 1.

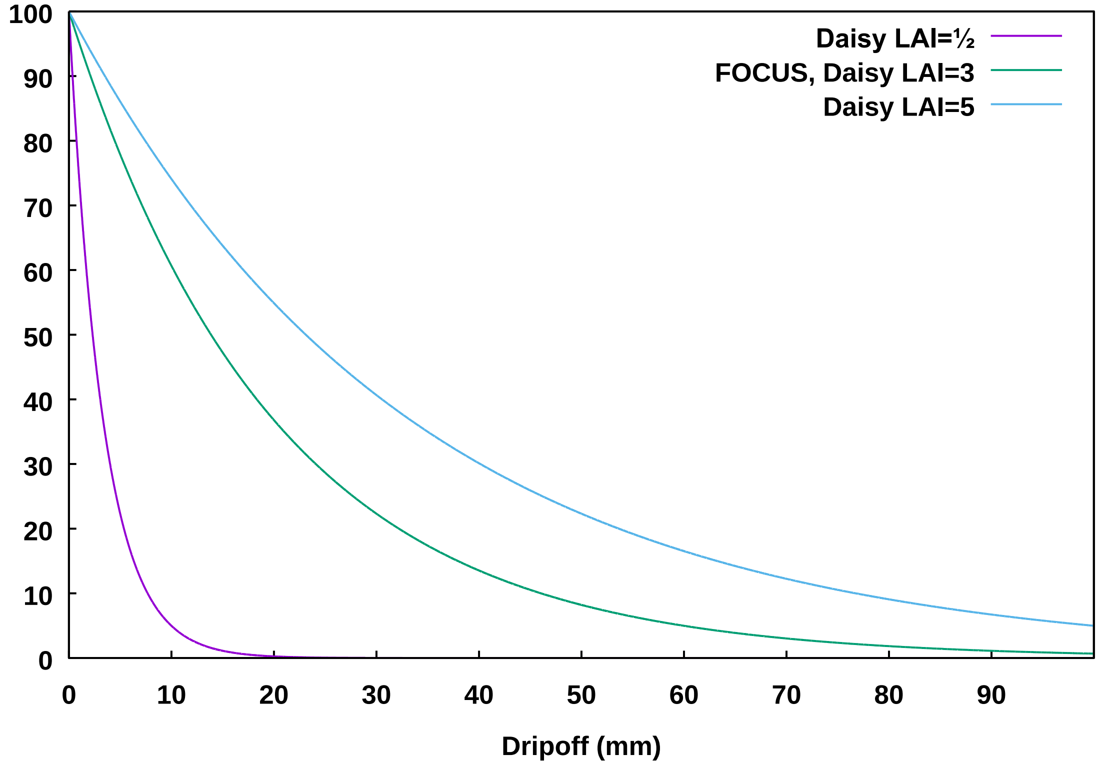

Figure 1: Relative amount of compound left on canopy as a function of drip off for different values of LAI. The result of using FOCUS default value for the washoff parameter is shown, and the Daisy washoff parameter that has been set to match FOCUS for LAI = 3.

We choose to use $f_{\mathrm{Daisy}} = 0.075$ in the present project.

Depth factor

For simulation of nitrogen leaching, Daisy has a complex system of carbon pools with varying turnover rates and C/N ratios. The system is dominated by a plowing layer, where most carbon is added. In FOCUS, a much simpler system is used, where the turnover rate for pesticides is adjusted as a function of depth (GG2002, section 7.4.6). Here again, the assumption is that the fast turnover happens in a plowing layer and decrease with depth. Below 1 meter, there is no degradation. In Daisy, general turnover will happen in the biologically active part of the soil, meaning where there are roots and earthworms, even below 1 meter. However, lacking a better model for pesticides, we follow the FOCUS depth function (Table 1).

Table 1: Relative degradation rate as a function of depth.

Depth [cm]	Degradation rate [%]
0-30	100
30-60	50
60-100	30
>100	0

Heat factor

By default, Daisy will use the same heat effect on pesticide decay in the soil as it uses for general carbon turnover. It is shown on Figure 2 together with the heat effect used in the FOCUS models (GG2002, section 7.4.11). Both Daisy and FOCUS use a simple exponential function for the main part of the curve, but with some deviations:

- Daisy is normalized to 10 °C ("field conditions") while FOCUS is normalized to 20 °C ("lab conditions").
- Both curves are linear at the cold end, starting with no degradation at 0 °C. The linear part in FOCUS ends at 5 °C, while the linear part in Daisy ends at 20 °C.
- Daisy reaches a maximum at 37 °C, and decrease down to 60 °C at which point microbes responsible for the degradation are assumed to be dead.

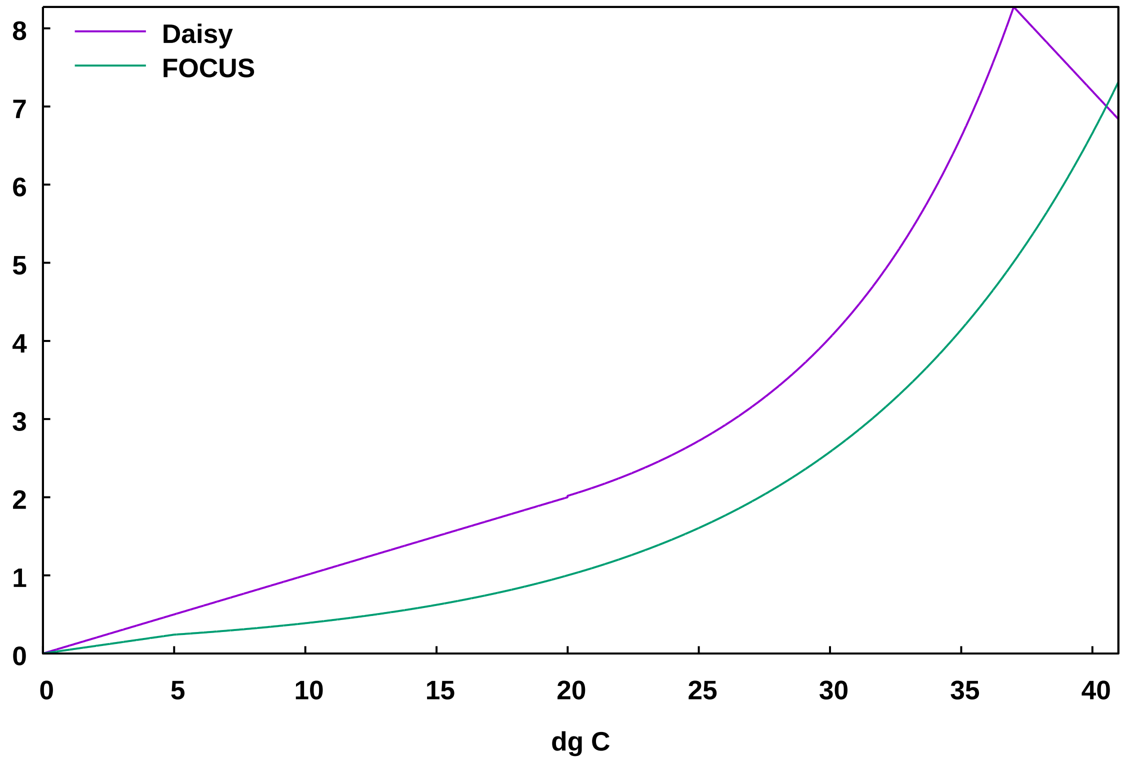

Figure 2: Effect of temperature on pesticide decay in soils used in Daisy and FOCUS.

Water factor

The water effect on carbon turnover in Daisy is described solely as a function of the pressure potential. At pF 0 it is 60 % linearly increasing to 100 % at pF 1.5. Between pF 1.5 and pF 2.5 it is 100 % and linearly decreasing to 0 % at pF 6.5. The curve is shown on Figure 3. IN FOCUS, a mixture of pressure and water content is used (GG2002, section 7.4.5). Decay is assumed to be 100 % above field capacity, defined as pF 2, and 0 % when the water content is less than half of the water content at wilting point, defined as pF 4.2. Between the two points, a water factor is defined as a power function of the relative water content. The FOCUS function is shown for two different soils on the same figure.

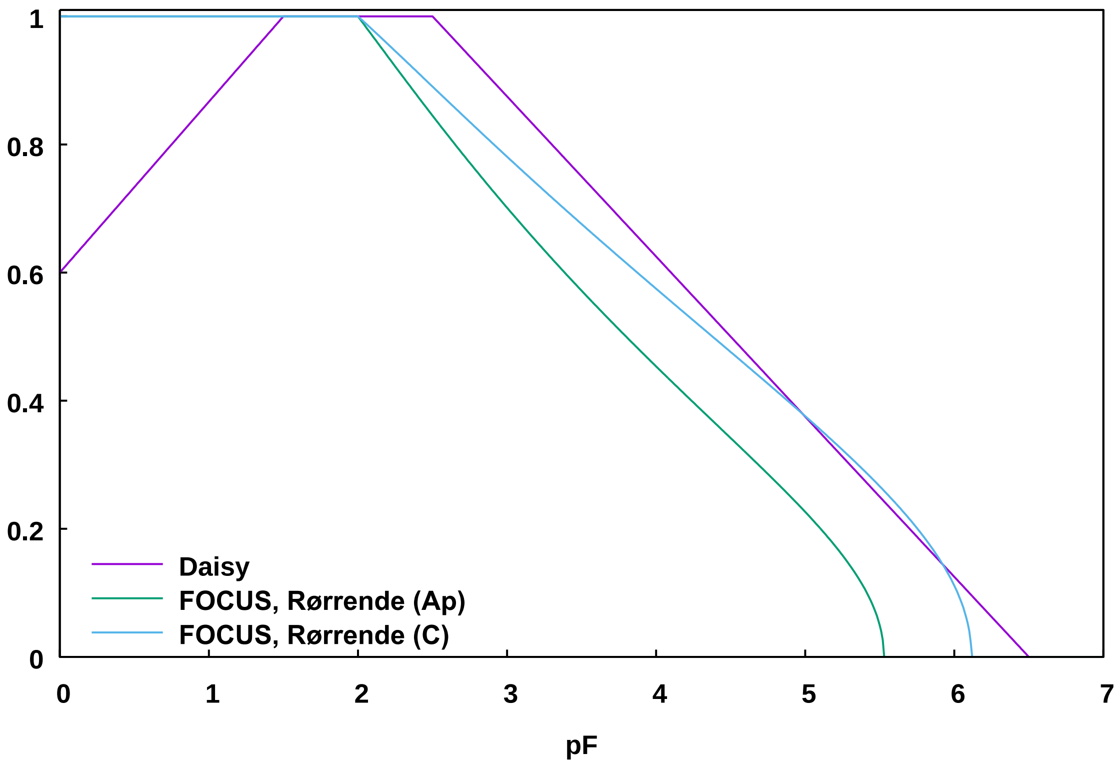

Figure 3: Relative decay as a function of pressure head in Daisy, and for two specific soils in FOCUS.

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