Appendix 3.3- Alignment of Daisy with FOCUS recommendations

1 Background

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 Appendix the traditional Daisy approach will be compared to FOCUS recommendations, mostly from (FOCUS 2002) (referred to as GG2002 in the following). A special option called "FOCUS" has been added under "chemical" in Daisy allowing users to parameterize Daisy as close to the FOCUS-recommendations as possible. Differences and options are described here.

2 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:

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

Where LAI is the leaf area index, which is calculated dynamically as part of the crop model based on the development in biomass in leaves over time (see Chapter 10), 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.

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 is 10 days in the FOCUS sub-model, following FOCUS recommendations.

3 Canopy wash-off

The function for canopy wash-off 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):

$$M = M_0 \cdot e^{-f_{FOCUS} \cdot R}$$

Here M_0 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:

$$M = M_0 \cdot e^{-f_{Daisy} \cdot \frac{R}{I}}$$

The only difference is the introduction of *I*, the amount of intercepted water on the canopy. The canopy wash-off coefficient (f_{Daisy}) is a number between zero and one, with zero meaning that all the pesticide is sorbed to the leaves, and one meaning that all 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 wash-off functions in Daisy and FOCUS can be described as:

$$f_{Daisy} = f_{FOCUS} \cdot I_C \cdot LAI$$

The FOCUS parameterization stems from Willis et al. (1982) and is based on 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 fDaisy = 0.075. With this value, we get identical wash-off as FOCUS when LAI is 3, but much faster wash-off for a lower LAI as seen on Figure 1..

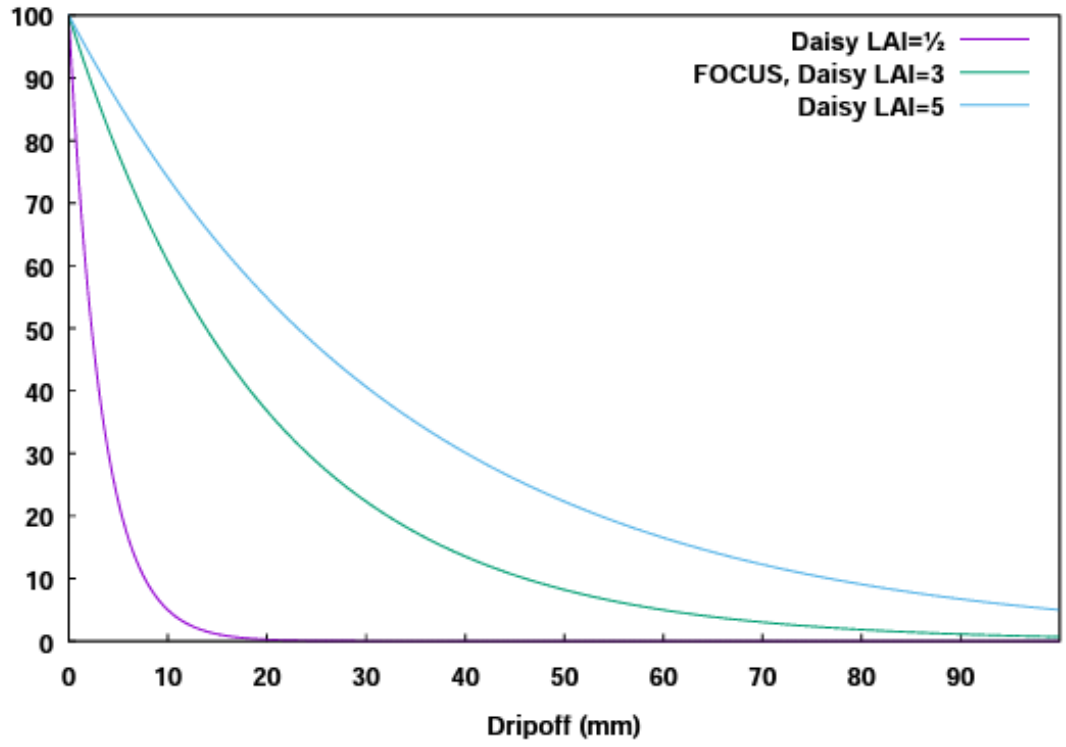

Figure 1: Relative amount of compound left on canopy as a function of drip off for different values of LAI. The result of using FOCUS default value for the wash-off parameter is shown, and the Daisy wash-off parameter that has been set to match FOCUS for LAI = 3.

To obtain the best correspondence with FOCUS recommendations, we suggest using f_{Daisy} = 0.075 (canopy washoff coefficient 0.075 [<fraction>]).

4 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 plough layer, where most carbon is added. FOCUS, uses a much simpler system, 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 the plough layer and decreases 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, to comply with the FOCUS recommendations, the FOCUS depth function (Table 1) has been added to the FOCUS-parameterisation in Daisy as (z -30 -60 -100) and (z factor 1 0.5 0.3).

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

5 Heat factor

By default, Daisy will use the same heat effect on pesticide decay in the soil as it uses for general carbon turnover. Figure 2 shows the Daisy heat effect 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.

The Daisy temperature function reaches a maximum at 37 °C and decreases down to 60 °C at which point microbes responsible for the degradation are assumed to be dead.

In the FOCUS-option in Daisy, a heat function has been implemented similar to what is used in the MACRO 5.0-model (part of the FOCUS models),

$$f_{Heat} = \begin{cases} 0 & \text{if } T \le 0 \\ 0.2T \cdot e^{\left(\alpha(5-T_{ref})\right)} & \text{if } 0 < T < 5 \\ e^{\left(\alpha(5-T_{ref})\right)} & \text{if } 5 \le T \end{cases}$$

where T is temperature [°C], T_{ref} is 20 [°C] and α is 0.0948 [K^{-1}]).

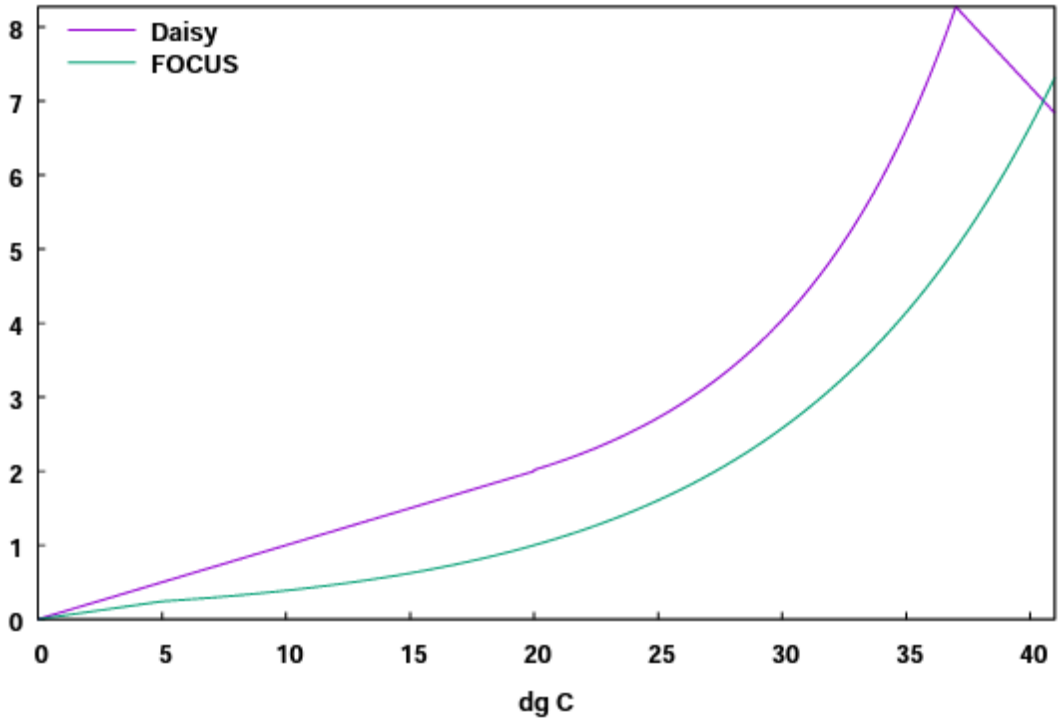

Figure 2: Effect of temperature on pesticide decay in soils used in Daisy and FOCUS.

6 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 to describe the effect of water content (GG2002, section 7.4.5). Decay is assumed to be 100 % above field capacity (θ_{fc}), defined as pF 2, and 0 % when the water content is less than half of the water content at wilting point ($0.5 \cdot \theta_{wp}$), 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 soil horizons in Figure 3. The equation implemented in Daisy for the FOCUS option is similar to the one included in MACRO 5.2 and described below:

$$f_\theta = \begin{cases} 0 & \text{if } \theta \le 0.5 \cdot \theta_{wp} \\ \left(\dfrac{\theta - 0.5 \cdot \theta_{wp}}{\theta_{fc} - 0.5 \cdot \theta_{wp}} \right)^B & \text{if } 0.5 \cdot \theta_{wp} < T < \theta_{fc} \\ 1 & \text{if } \theta_{fc} \le \theta \end{cases}$$

The default value of B = 0.49.

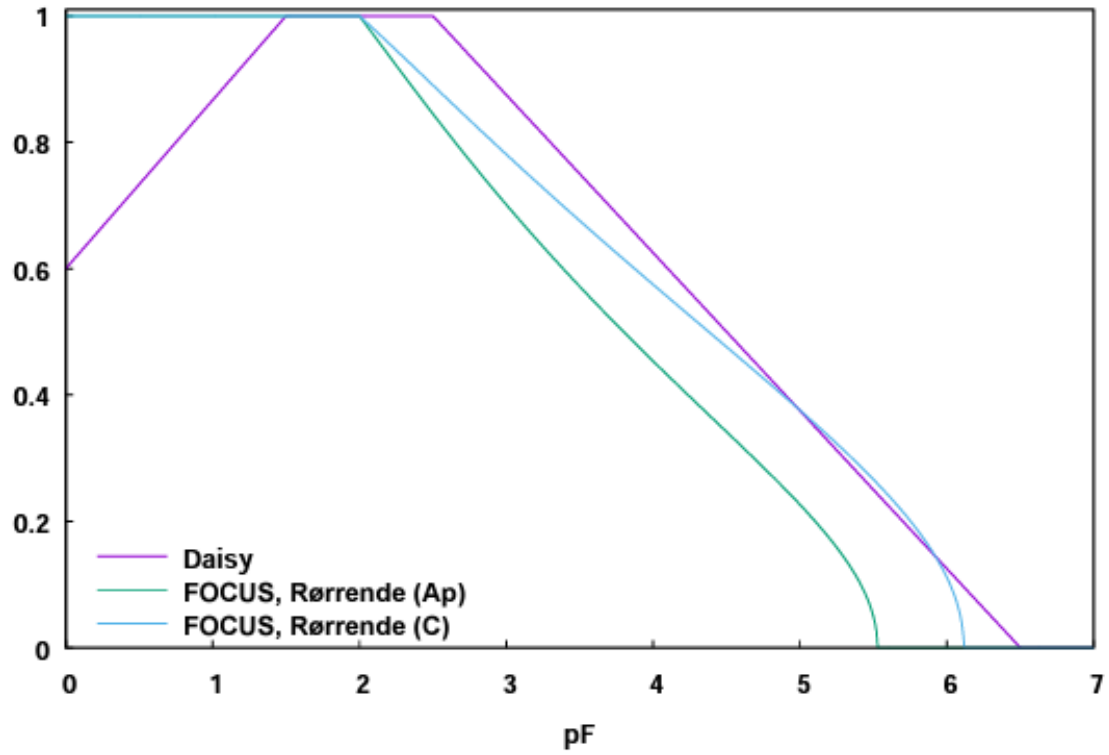

Figure 3: Relative decay as a function of pressure head in Daisy, and for two specific soils in FOCUS.

7 Parameter overview

Table 2. Related Parameter names in Daisy. The FOCUS submodel is situated under "chemical".

Name and explanation		Model (in Daisy)	Parameter name (Daisy reference manual)	Default	Default unit
c_{irrOH}	Concentration of solute in overhead irrigation water	irrigation	*specified with name and value*	user specified	[g cm^{-2} mm^{-1}]
	Canopy dissipation halftime	FOCUS	*canopy dissipation halftime*	240	[h]
f_{Daisy}	Canopy wash-off coefficient	FOCUS	*canopy washoff coefficient*	0.075	[ ]
z	Depths specified for the depth factor	FOCUS	*z*	(z -30 -60 -100)	[cm]
z_factor	Relative degradation of pesticide as function of the specified depths, z	FOCUS	*z_factor*	(z factor 1 0.5 0.3)	[ ]
T_{ref}	Reference temperature for the temperature function	FOCUS	*T_ref*	20	[dg C]
α	Exponent in the temperature function	FOCUS	*alpha*	0.0948	[K^{-1}]
B	Exponent on the water factor	FOCUS	*B*	0.49	[ ]

Original text from	Project report	
Updated by	date	For Daisy version
Styczen, M & Holbak, M.	2023-05-16	6.32

8 References

FOCUS. “Generic guidance for FOCUS surface water Scenarios”. EEC, December 2002. http://eusoils.jrc.ec.europa.eu/public_path/projects_data/focus/sw/docs/Generic%20FOCUS_SWS_1.2.pdf.

Willis, G., L. L. McDowell, L. D. Meyer, og L. M. Southwick. “Toxaphene Washoff from Cotton Plants by Simulated Rainfall”. *Transactions of the ASAE* 25, nr. 3 (1982): 642. https://doi.org/10.13031/2013.33588.