FACTORS AFFECTING SPRING PESTICIDE SPRAY OPERATIONS IN CENTRAL SWEDEN

Towards refining the FOCUSsw D1 scenario pesticide application timing

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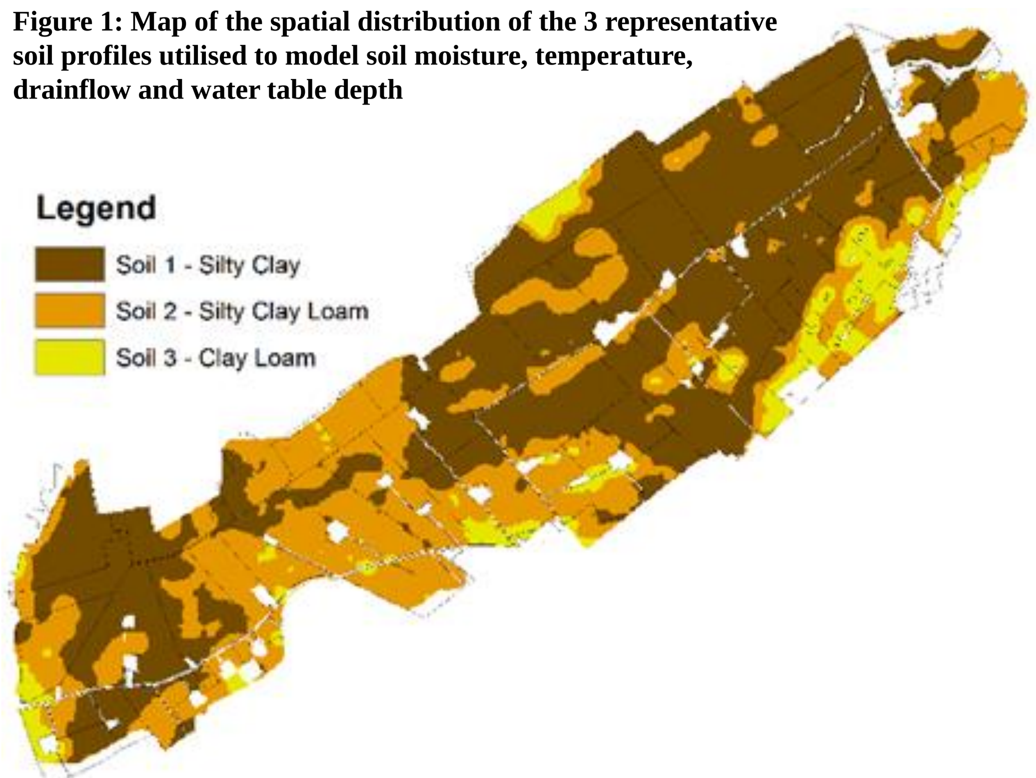
Determining appropriate pesticide application windows and dates of application is an important component of pesticide exposure modelling and can have a marked impact on the outcome of surface water (SW) risk assessments, especially where these are on the fringe of the drainflow period. The current FOCUSsw pesticide application timer (PAT) considers patterns of rainfall to define a realistic worst-case application date. In certain cases, an application window recommended by AppDate v3.0, also lacks realism as it provides a single application date range that cannot take into account seasonality effects. In the real-world farmers have to consider a range of other climatic and soil condition factors when deciding the practicality to spray pesticides, for example, can they traffic their land with a sprayer.

Methodology

The Swedish Agricultural University (SLU) have collected detailed field level information of cropping and field operations within their O18 research catchment for >2 decades. The soils and weather within this catchment are closely aligned with that of the D1 scenario offering a good opportunity to explore factors affecting farmer decision making regarding spring spray operations.

Figure 1: Map of the spatial distribution of the 3 representative soil profiles utilised to model soil moisture, temperature, drainflow and water table depth



Field operations: Data collected by the SLU for each field in each year regarding the spraying of pesticides were extracted for the spring period, March through May.

Soil moisture, soil temperature, drainflow and water table depth: Daily soil moisture status (expressed as percentage of field capacity - pF2), soil temperature (°C), drainflow flux (mm/day) and water table depth (m) were modelled with the dual porosity MACRO v5.2 model using 3 representative drained soil profiles[1, 2], crop parameters associated with the Swedish national scenarios for the dominant crops and daily weather data.

Weather: Daily weather data were sourced from the catchment, a nearby SMHI weather station and in some cases the MARS 25 km meteorological dataset for the grid square within which the catchment is located.

Analysis: For each soil trafficking date for each field, the corresponding data were extracted from the weather file and MACRO simulation modelling results for the corresponding field, representative soil profile and crop type in that harvest year. This combined dataset of pesticide application dates, weather and soil condition metrics was used in subsequent analyses focused on defining clear limits to spraying with a view to developing new rules that could be added to the FOCUSsw Pesticide Application Timer (PAT) to define more realistic application days taking into account characteristics such as soil moisture deficit and average air temperature in a manner similar to Tomasek [3].

Results

The assessment indicates that farmers in the O18 catchment (Figure 2):

- Do not spray if -
  - There is snow on the ground
  - Average air temperature is freezing (< -2 °C)
- Seldom spray if –
  - Average air temperature is cold (< 6 °C)
  - Air is calm (< 0.6 m/s) or windy (> 4.5 m/s)
  - Day is not dry or has light rain (< 3 mm)
  - Soil moisture deficit (mm) is low (< 5 mm in top 10 cm)
  - Drainflow is active (> 0.3 mm)

Soil moisture (% of pF2) and average air temperature (°C) were best suited for defining spray days. The modelled trafficability days using these two factors for the D1 soil under winter cereal production demonstrates (Figure 4):

- The onset of trafficability varies by year
- This is in agreement with the observed rainfall and application data as well as discussions with farmers and agronomists

Both are likely factors that a farmer might reasonably consider before trafficking their land to apply pesticides[4].

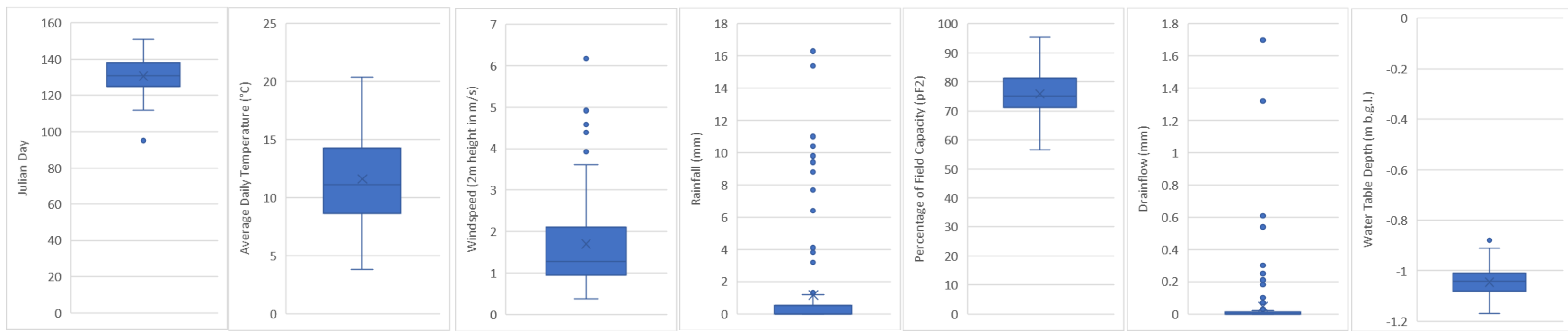


Figure 2: Box and whisker plots of the characteristics of the first application day in spring for all soils under winter cereal production

Addition of these soil trafficability factors into the FOCUSsw PAT (Figure 3) results in small, but potentially meaningful changes in the application date; in most cases delaying the application (up to 35 days) but in some advancing it (up to 12 days).

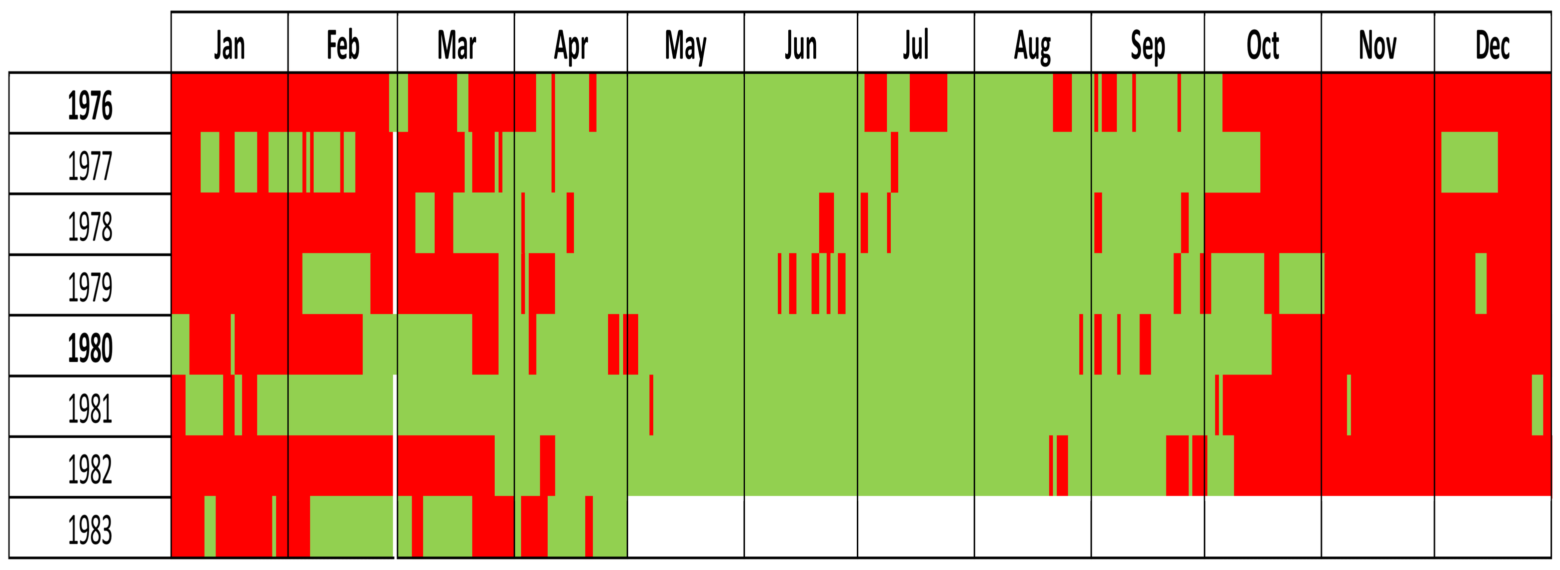


Figure 3: Trafficability day heatmap (green = trafficable) for D1 soils under winter cereal production in the FOCUSsw scenario

Figure 4: Comparison of observed monthly rainfall averages, modelled trafficable days and observed Julian day of first spring application to any soil under any crop in the O18 catchment

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2000	34.5	47.4	26.9	76.0	60.3	54.1	71.5	32.9	26.0	109.6	61.5	84.6
2001	40.9	31.8	29.9	52.1	63.5	36.0	83.0	58.7	61.5	71.1	16.2	26.7
2002	55.2	56.8	26.3	21.2	97.5	101.9	59.4	46.9	8.4	48.6	76.6	12.0
2003	20.9	4.0	13.2	68.5	50.2	79.9	129.3	30.2	7.2	46.3	61.6	57.8
2004	22.2	36.6	13.9	17.3	35.0	90.5	125.7	60.9	55.2	61.8	57.5	22.2
2005	36.6	17.5	16.2	22.9	67.6	84.7	105.7	45.0	13.9	56.4	39.5	26.8
2006	17.6	25.5	30.1	54.2	54.0	34.0	39.6	89.8	32.7	104.1	36.1	79.9
2007	72.8	18.7	43.2	26.2	68.2	92.3	152.0	46.0	85.6	4.6	31.7	37.6
2008	58.9	48.8	42.4	25.8	22.2	38.7	77.2	127.5	57.1	81.1	64.1	29.3
2009	10.6	19.1	35.5	3.8	36.4	46.4	132.9	54.9	17.9	61.6	72.2	26.3
2010	15.7	32.0	25.1	13.0	37.4	63.6	141.6	81.4	36.2	58.8	41.8	11.2
2011	15.4	11.8	27.6	18.8	58.2	170.6	71.2	149.2	84.8	52.6	34.4	37.8
2012	33.8	10.0	5.6	59.6	62.2	159.4	72.8	60.4	118.8	96.4	48.2	39.0
2013	14.6	11.4	1.2	29.0	43.6	59.6	35.8	62.0	6.6	90.0	33.2	48.2
2014	48.4	34.0	29.0	32.4	57.4	69.0	33.4	183.0	17.6	49.4	50.4	65.2
2015	47.6	10.4	30.6	24.6	78.4	37.0	95.0	64.0	81.4	4.0	74.6	55.4
2016	28.0	31.4	32.1	43.5	24.2	48.0	43.5	64.1	23.9	28.6	30.0	30.3
2017	6.2	19.6	30.2	24.8	23.6	47.4	34.0	107.2	56.8	82.4	63.0	31.3
2018	55.1	16.5	18.5	35.6	10.4	34.9	26.3	66.2	54.0	26.4	10.9	36.5
Minimum	6.2	4.0	1.2	3.8	10.4	34.0	26.3	30.2	6.6	4.0	10.9	11.2
Average	33.4	25.4	25.1	34.2	50.0	70.9	80.5	75.3	44.5	59.7	47.6	39.9
50th Percentile	33.8	19.6	27.6	26.2	54.0	59.6	72.8	62.0	36.2	58.8	48.2	36.5
Maximum	72.8	56.8	43.2	76.0	97.5	170.6	152.0	183.0	118.8	109.6	76.6	84.6

Figure 4a: Observed monthly mean precipitation (mm) in the O18 catchment

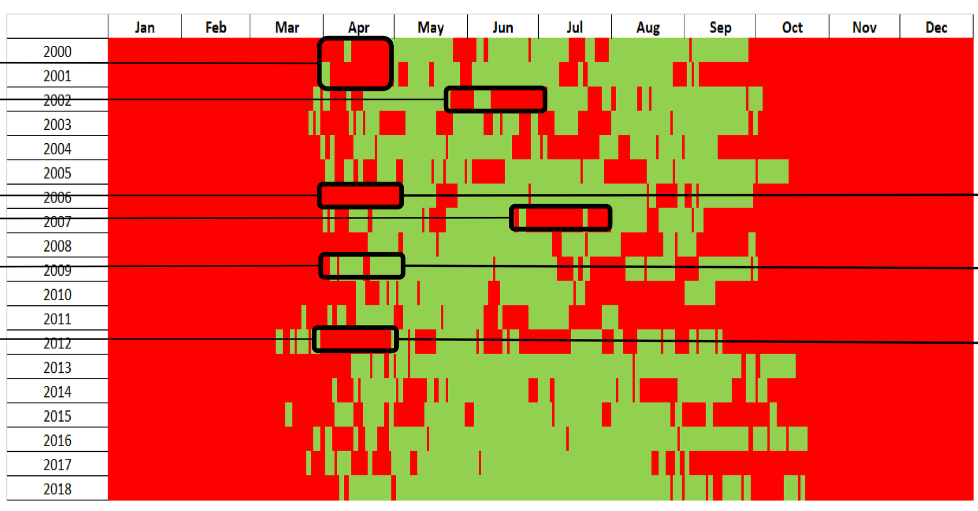
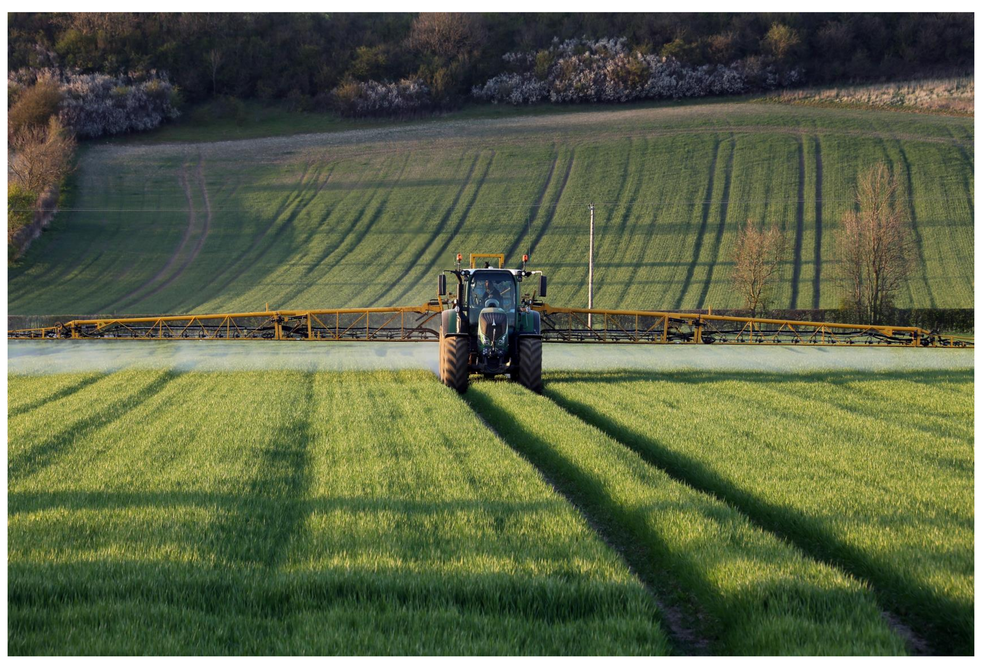


Figure 4b: Trafficable day (in green) heatmap for D1 soil under winter cereal production in the O18 catchment

Year	Number of applications	Percentage of all applications (%)	Julian Day Statistic				
			Min	10th Percentile	Average	90th Percentile	Max
2002	19	2.5%	127	129.4	136.2	141.0	143
2003	52	6.8%	121	131.0	140.3	148.0	151
2004	54	7.1%	124	129.3	138.0	149.7	152
2005	41	5.4%	121	125.0	137.6	150.0	150
2006	31	4.1%	124	125.0	132.9	151.0	151
2007	52	6.8%	115	117.1	131.5	145.9	151
2008	42	5.5%	116	125.1	130.9	146.6	151
2009	58	7.6%	91	106.7	133.6	149.0	150
2010	47	6.2%	125	130.6	138.9	144.0	148
2011	44	5.8%	110	129.0	137.7	146.0	151
2012	57	7.5%	119	139.6	143.1	148.4	149
2013	48	6.3%	129	138.0	143.4	151.0	151
2014	67	8.8%	110	114.0	123.4	141.0	143
2015	48	6.3%	111	112.0	127.8	144.0	151
2016	50	6.6%	66	126.0	133.0	149.0	150
2017	50	6.6%	95	122.0	127.0	143.1	147

Figure 4c: Annual summary statistics for Julian day of first application for all soils and all crops in the O18 catchment



Conclusions

These results suggest that the addition of the soil trafficability and spray factors not only introduces more realism into the PAT but that this detail may have the potential to alter modelling results and the risk assessment outcome. The results from this study clearly indicate that substantial but related annual variation in weather, soil conditions and field operations occur. The results highlight the increased necessity to consider realism in annual application and crop timing representation in the context of multi-year FOCUSsw "repair" simulations where each year contributes to the final (as yet undefined) regulatory exposure endpoint.

Acknowledgements:

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References:

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4 Earl, R., 1997. Prediction of trafficability and workability from soil moisture deficit. Soil & Tillage Research, 40: 155-168.