

Investigating the fate and transport behavior of pesticides in air via bioindicator plants and bulk deposition samplers in southeastern Germany

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INTRODUCTION

Understanding the off-field movement of plant protection products (PPPs) via air is important for environmental exposure assessment and for minimizing potential contamination of non-target crops.

Scientific literature and national monitoring studies on PPP active substances in air have increased in Europe over the last decade^{1,2}. Recent monitoring studies in precipitation and vegetation have also drawn attention to atmospheric transport of PPPs³.

However, standardized measurements¹ and contextual information needed to interpret, compare, and elucidate findings are often lacking. Furthermore, the distinction between long-range transport and local off-target movement is often unclear in publications.

How can different passive monitoring systems, particularly bulk deposition samplers and bioindicator plants, help identify factors influencing the off-field transport and atmospheric deposition of PPPs across sites with different land use patterns?

METHODS

What Bulk deposition

wet + dry
collector
bottle
maintained
at 6-10°C



When

Collection periods of 27-29 days from mid-March until mid-December in 2018-2020 and year-round in 2021 and 2022

Where

Bavaria:
• agricultural site Neusling (NEU)
• background site Weibersbrunn (WBB), ~3km forest radius, 280km away from NEU

How

HPLC-MS, 135 PPP active substances + metabolites
LOQ of 2 ng/L for most analytes

Bioindicator plants

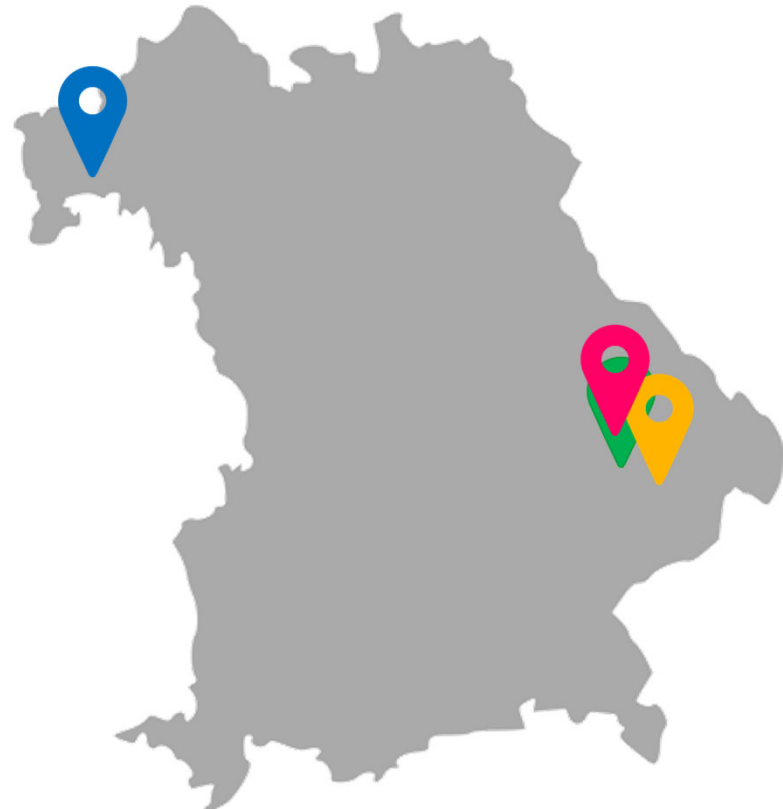
Welsh ryegrass



Mangold chard

Contextualization:

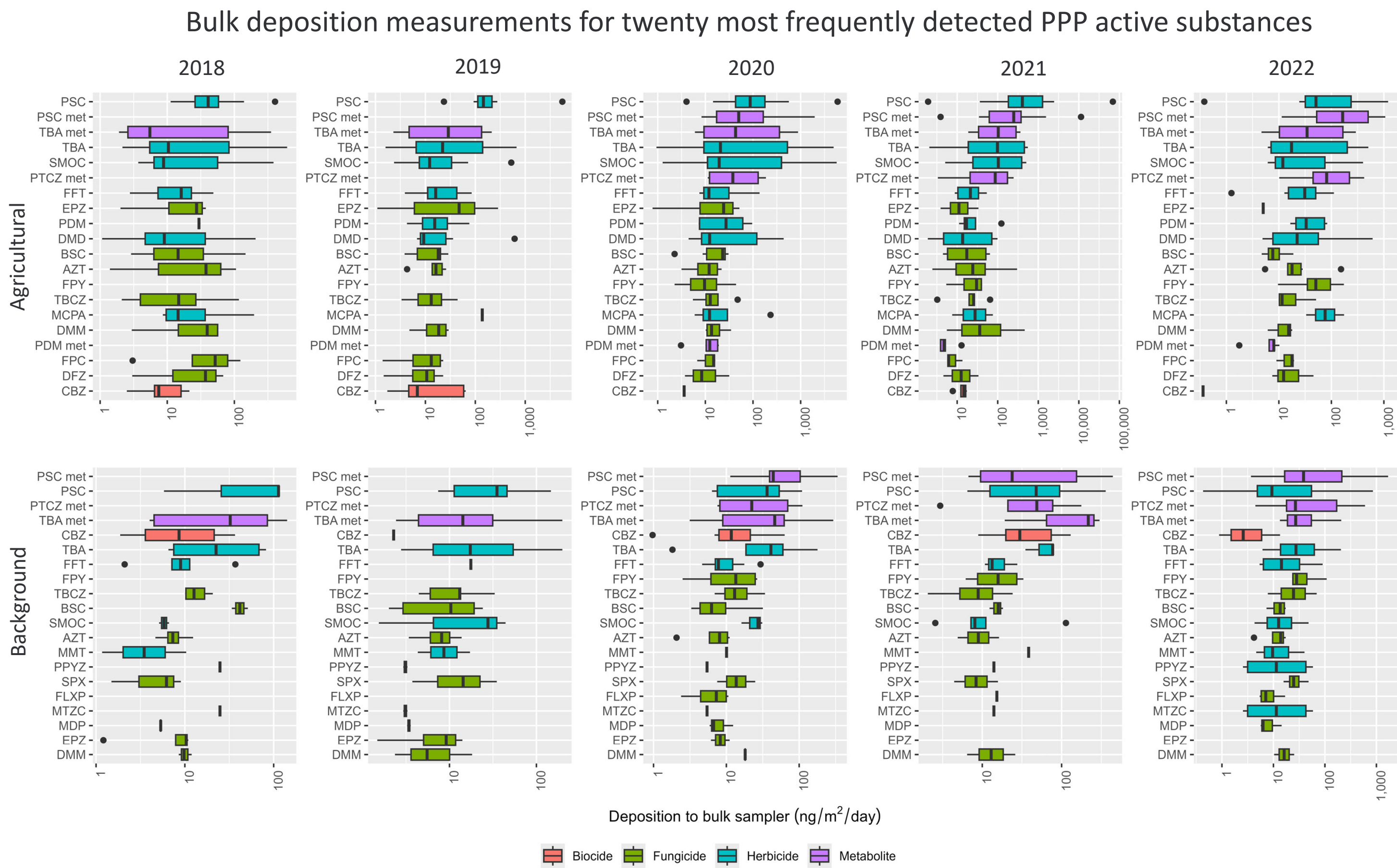
- PPP active substance properties and registered application patterns (EFSA, BVL)
- Land use data (InVEKos database)
- Temperature, precipitation, relative humidity, and wind speed



RESULTS AND DISCUSSION

Bulk Deposition

- Highest mean deposition rates at NEU were for substances sold at >200 tons/year, with a vapor pressure and equilibrium partitioning between air and moist soil conducive to volatilization
- Prosulfocarb maximum bulk deposition at NEU in 2021: spray drift from potato field 5 m away, 0.5% of maximum application rate
- Similar substance suite observed at both sites (% >LOQ correlated), yet deposition rates at WBB significantly < NEU, except for prosulfocarb in autumn: similar % cereals at 3-15km radius
- Seasonal peaks coincided with application windows

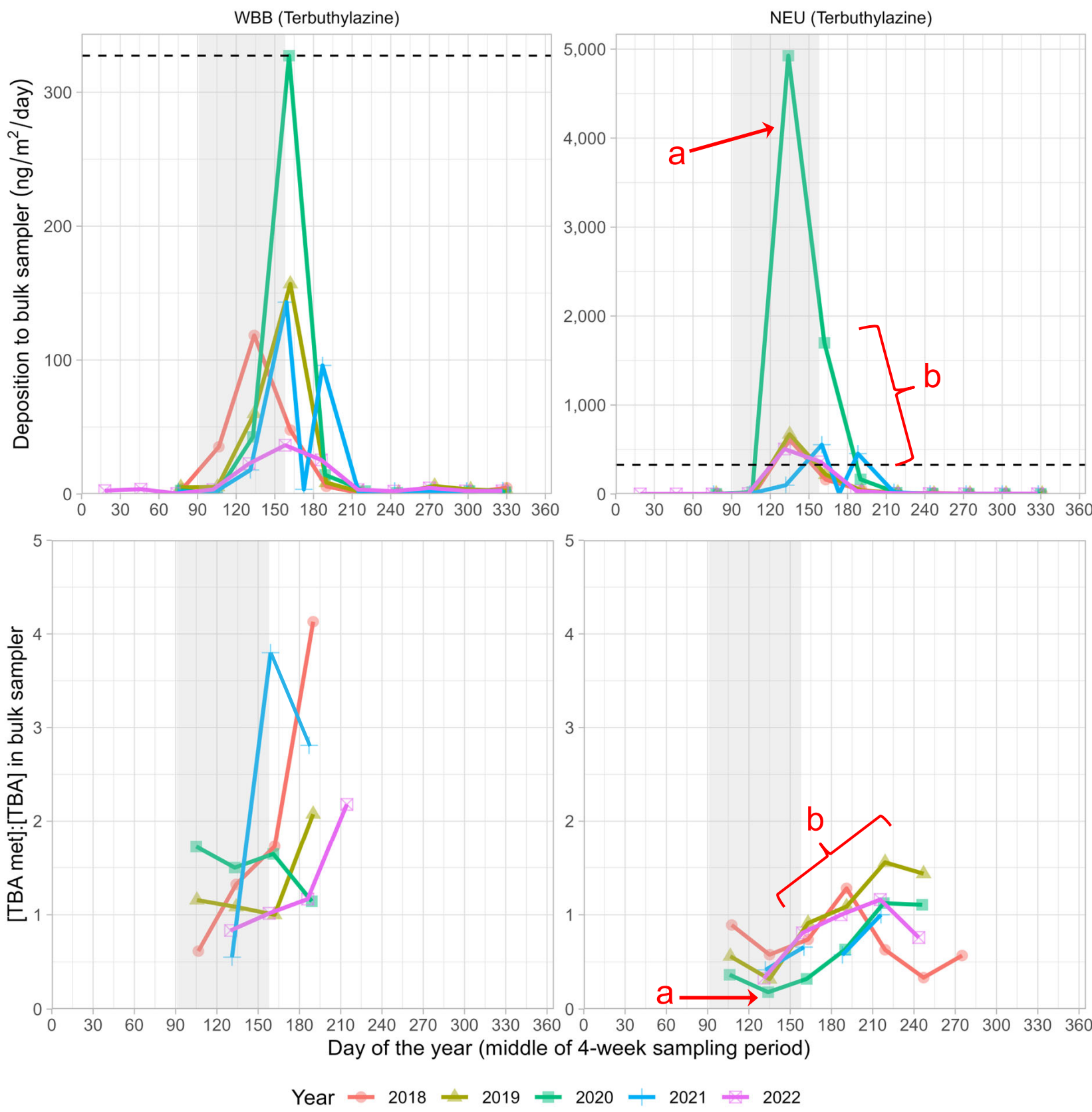


Biomonitoring Data

Substance	Detections ≥ 0.01 mg/kg		Detections ≥ 0.001 and < 0.01 mg/kg	
	Ryegrass	Chard	Ryegrass	Chard
Dimethomorph	1	0	6	4
Ethofumesate	1	0	13	0
Pendimethalin (PDM)	6	0	22	20
Phenmedipham	4	0	0	1
Propamocarb	17	8	22	23
Prosulfocarb (PSC)	14	6	14	14
S-metolachlor (SMOC)	2	0	9	5
Tebuconazole (TBCZ)	2	0	10	3
Terbutylazine (TBA)	21	27	24	26
Azoxystrobin (AZT)	2	0	-	-
Aclonifen	4	0	-	-
Benthiavalicarb	1	0	-	-
Cyproconazole	1	1	-	-
Fluazinam	5	0	-	-
Fluopyram (FPY)	5	0	-	-
Mandipropamid	1	0	-	-
MCPA	2	0	-	-
Metalaxyl-M	3	0	-	-
Metribuzin	6	10	-	-
Metobromuron	1	0	-	-
Prothioconazole	2	0	-	-

Generally, ryegrass is more sensitive, substance-specific exceptions?

Metabolite: Parent Ratios



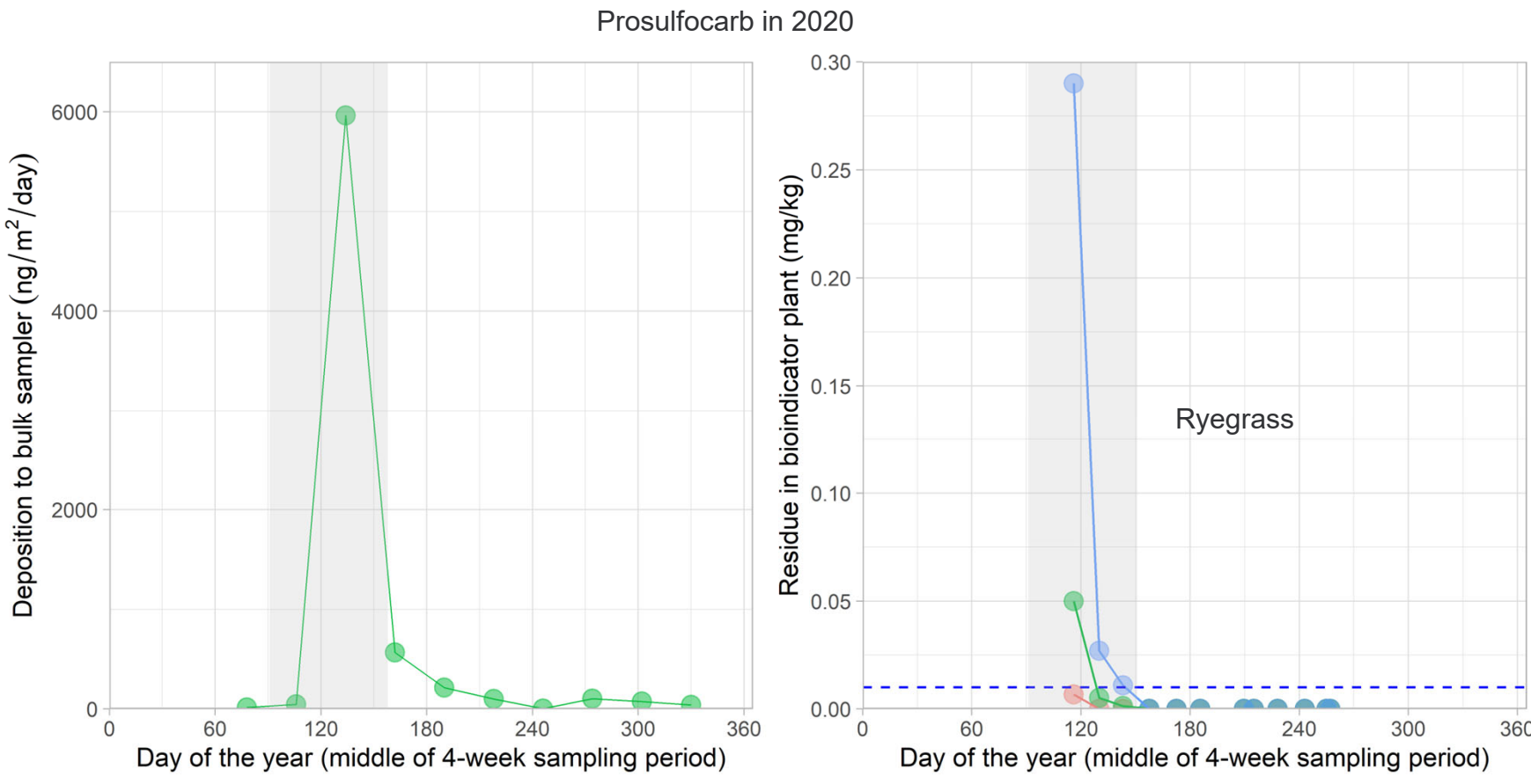
NEU

- Peak within application window (grey), "fresh" residues potentially from spray drift or wind-borne particles
- Aged residues → in-soil metabolism followed by volatilization

WBB

- Delayed peak at lower magnitude
- Higher metabolite:parent ratio → aged, volatilized residues

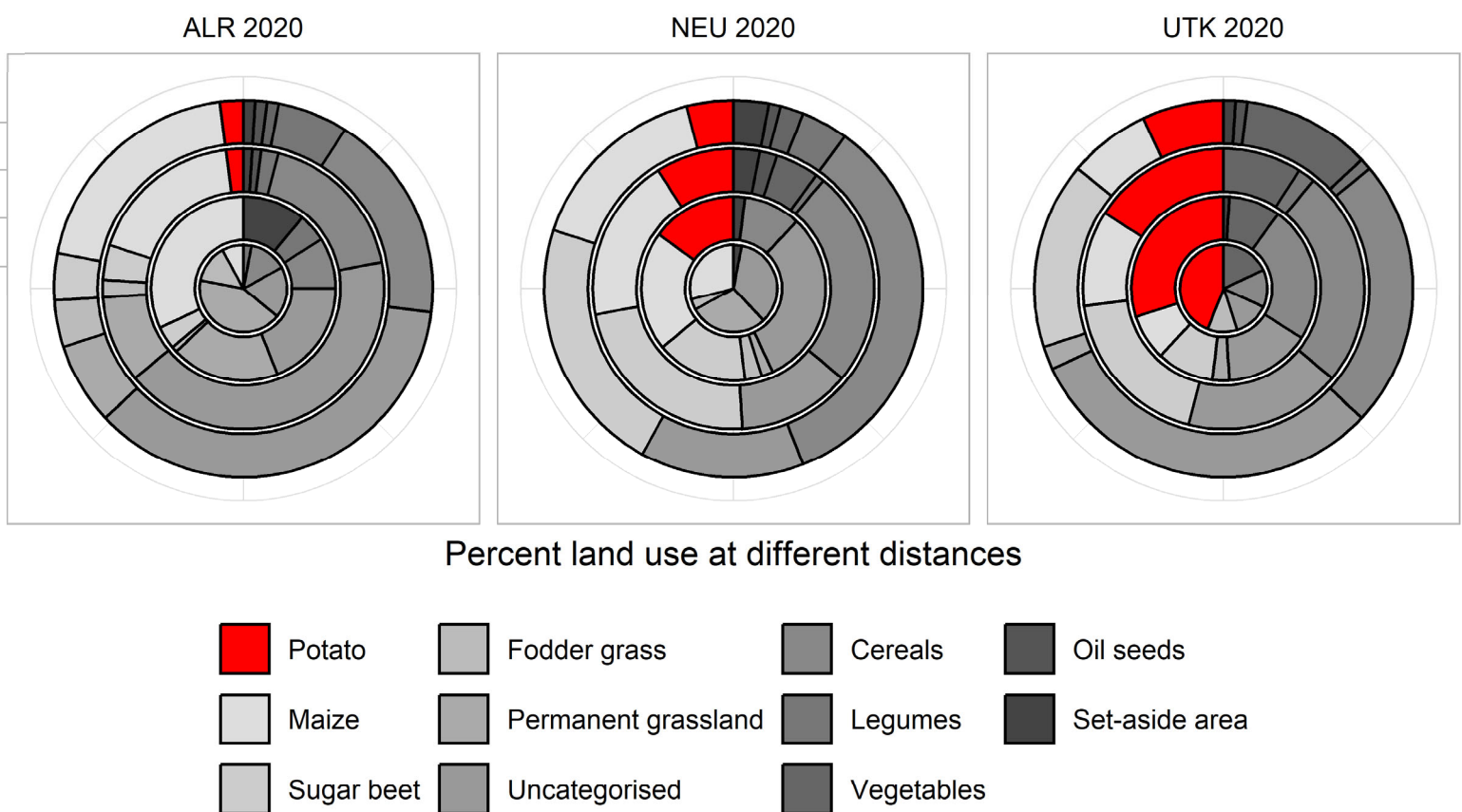
Context-setting



- 2020 and 2021 prosulfocarb peak bulk deposition and maximum residues in ryegrass occurred within the expected potato application window
- Biomonitoring results correspond to the relative sizes of the potato area around measuring sites
- Similar observations for: ethofumesate and phenmedipham and sugar beet cultivation, terbutylazine and maize cultivation

No consistent statistically significant correlations between:

- bulk-deposition and weather data
- bulk-deposition and biomonitoring datasets at NEU → different measurement set-ups (sampling periods, temperature)



CONCLUSIONS

- 5 years of PPP active substance measurements in bulk precipitation at an agricultural and background site and 3 years of biomonitoring at three agricultural sites in Bavaria provided complementary data to improve the understanding of atmospheric off-field transport of PPPs.
- Seasonal peaks in bioindicator plant residues and in bulk deposition, together with low metabolite:parent ratios, corresponded with expected applications to target-crop areas within 1.5km. Although these findings are not risk indicators, continued advice on mitigation measures and label-compliant good agricultural practice remains important.
- When investigating pesticide transport via air, measurement matrices and methodologies should be carefully selected to address specific research questions. Conclusions based only on one system should not be directly transferred to another, even between different bioindicator plant species.
- Harmonized measurement protocols (i.e., sampling interval) are needed to enable or improve comparisons across media and studies.
- Detailed site characterization, especially surrounding land use, and PPP application data are essential for interpreting PPP residue and deposition data.

REFERENCES:
1. Brüggermann, M., Mayer, S., Brown, D., Terry, A., Rüdiger, J., & Hoffmann, T. (2024). Environ. Sci. Eur., 36, 39. DOI: 10.1186/s12302-024-00870-4
2. Vinck, A.-K., Felkers, E., Urtizberea, M., Hewitt, N. J., Bürling, K., & Morriss, A. (2024). Regul. Toxicol. Pharmacol. 149, 105627. DOI: 10.1016/j.yrtph.2024.105627
3. Additional references are available in the open access scientific article associated with this poster. Follow the QR code for more information.

