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Long-range atmospheric transport of currently-used pesticides over Europe

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Introduction

Pesticides are widely used in agriculture and their global use has significantly increased from 2.4 to 4.2 million tons from 1990 to 2019(1). As a result, pesticides have been found in various environmental matrices, raising concerns about their negative impacts on the environment. However, information on their presence in air is limited, as monitoring is available only for a few rural sites and a limited number of compounds. Therefore, there is a need to assess the presence of pesticides at a larger scale, including in Europe, which contributes to about 12% of all pesticides used worldwide. Moreover, once emitted into the air, pesticides are subject to several processes affecting their atmospheric residence time and their potential to be transported over long distances via air to remote areas, such as the Arctic or mountainous sites, where these substances were never used. While it was long thought that current-use pesticides were not prone to long-range atmospheric transport due to their short atmospheric half-lives (i.e., less than two days), recent studies have shown that more than 20 pesticides have reached the Arctic via air(2, 3). Therefore, it is necessary to re-evaluate our understanding on the potential for long-range atmospheric transport of current-use pesticides.

Objectives of the study

- **Identify the pesticides prone to long–range atmospheric transport**
- **Characterize occurrence of pesticides at the European level**

Methodology

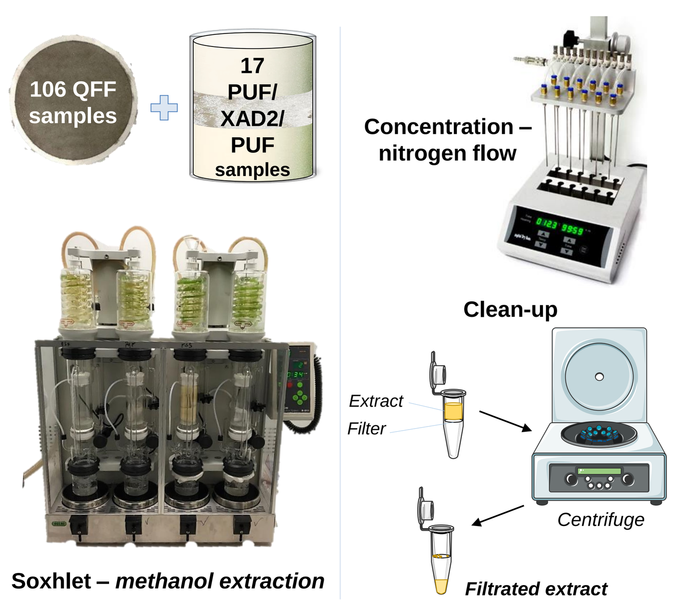
29 SITES - 17 EUROPEAN COUNTRIES

Classified into 4 categories based on land-use analysis

AIR SAMPLING

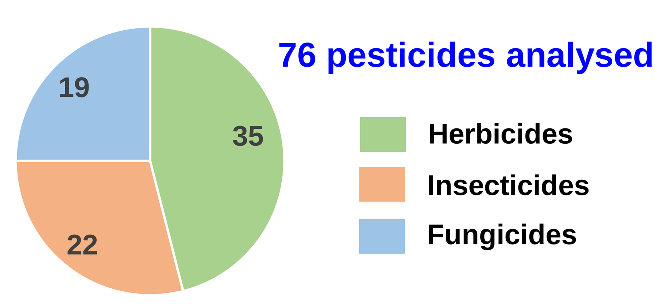
Collected:
- Particulate phase with quartz fiber filter (QFF, n= 29 sites)
- Gaseous phase using a PUF/XAD2/PUF combination (n= 6 sites)

SAMPLE PREPARATION



PESTICIDES ANALYSIS

Chromatographic methods coupled to a tandem mass spectrometer



Results - Pesticides prone to long-range atmospheric transport (LRAT)

1) Selection criteria for LRAT

SITE	Category	Criteria
ADA	Polar	Distance from application sources
PAL		
ZPO		
HAC	Mountain	Sampled free tropospheric air *
SBO		
UFS		

* In the *free troposphere*, transport is faster and atmospheric lifetimes are extended

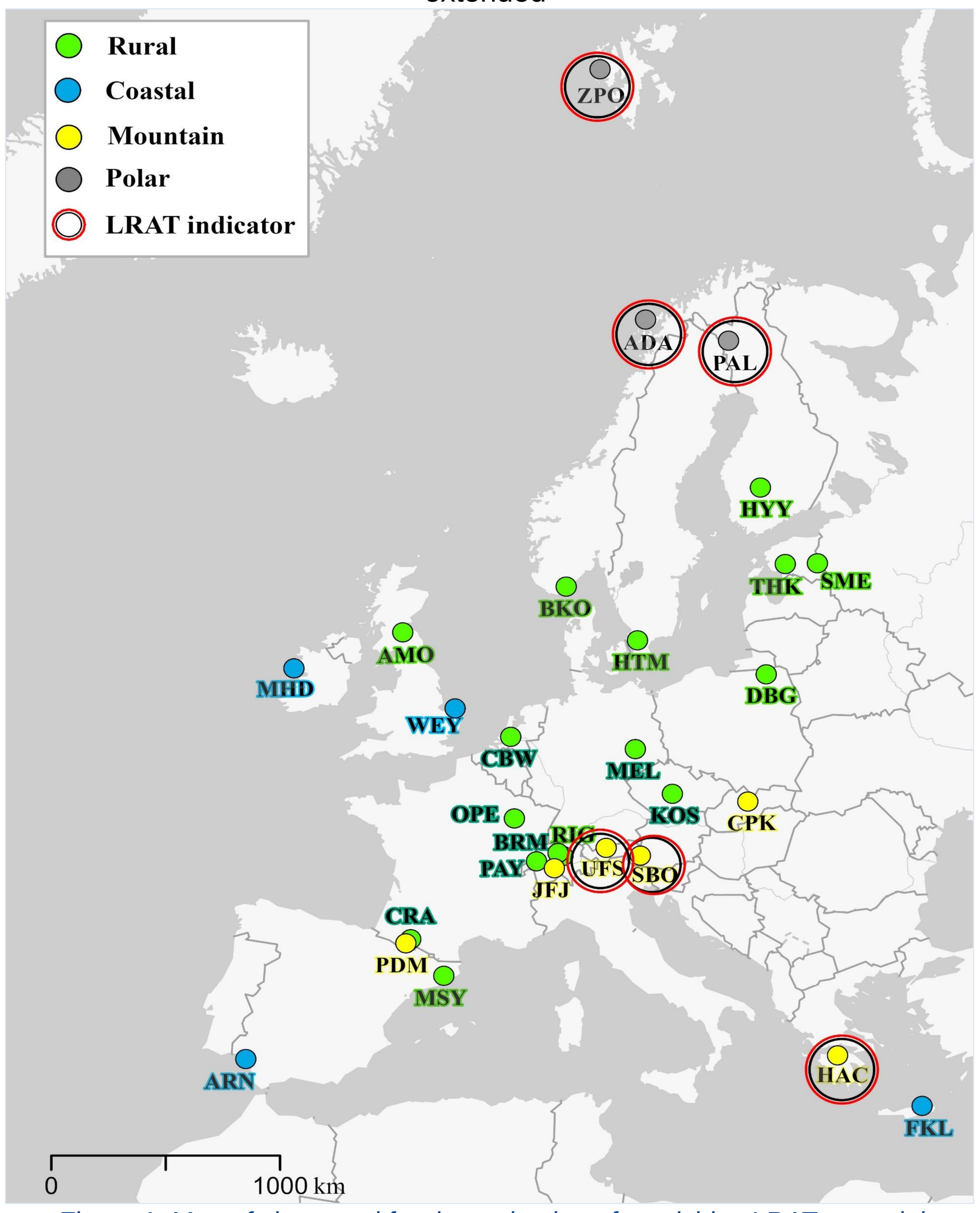


Figure 1: Map of sites used for determination of pesticides LRAT potential

2) Identification of pesticides prone to LRAT

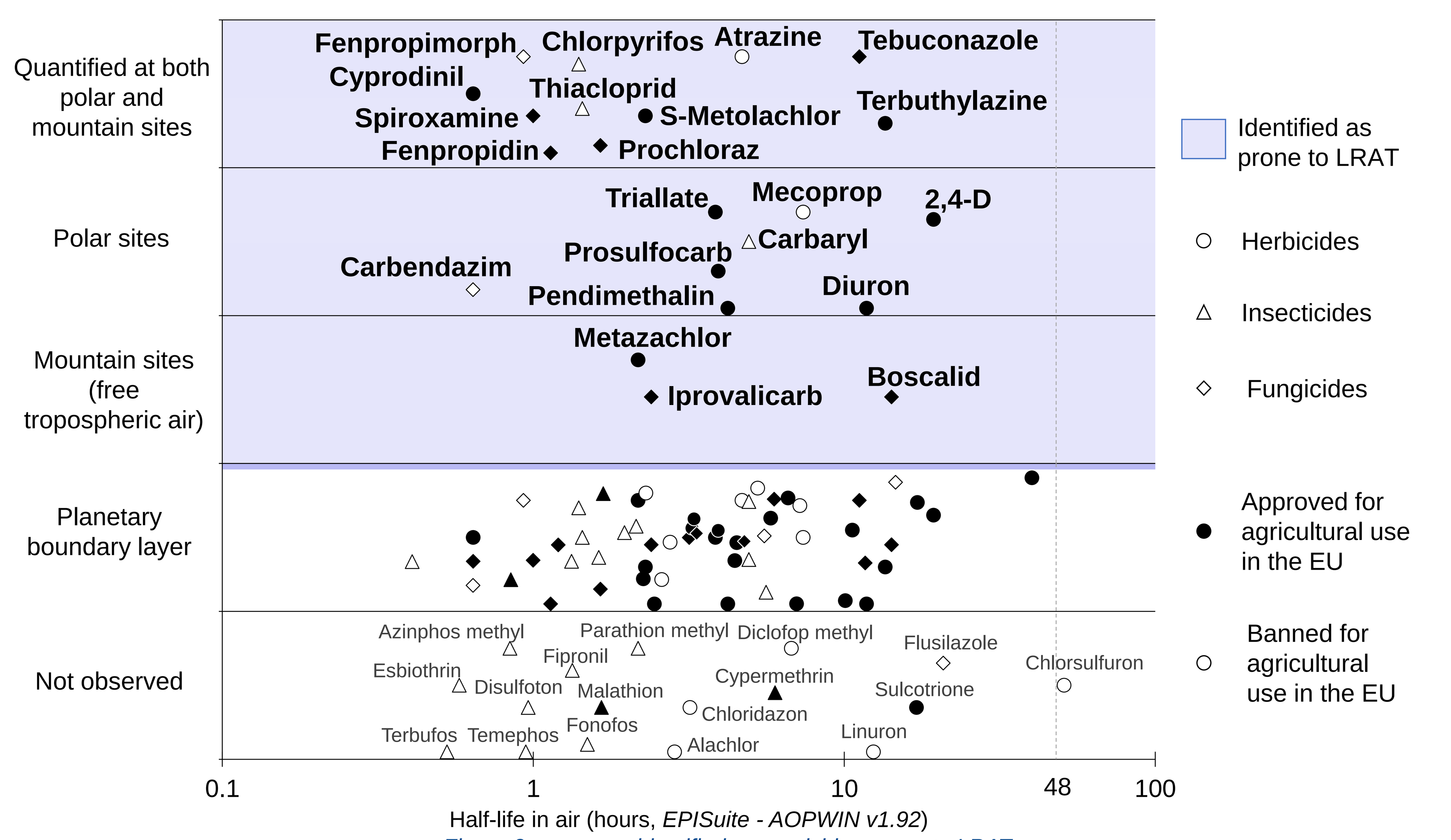


Figure 2: summary identified as pesticides prone to LRAT

3) Air masses origins – selected examples

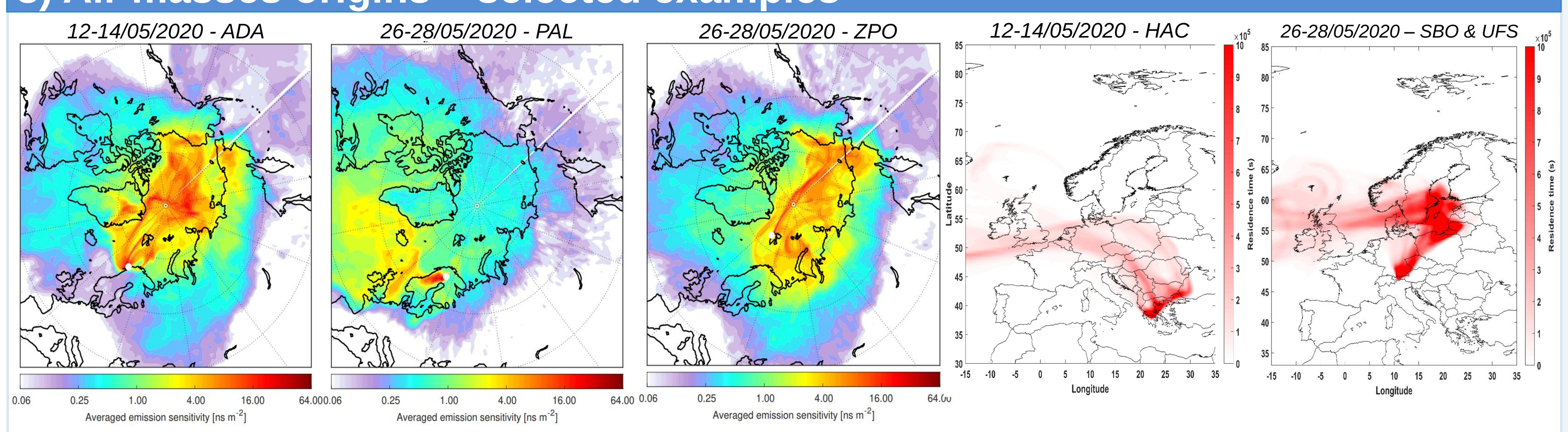


Figure 3: Polar and Mountain sites 10 days backward trajectories (FLEXPART v8.20)

*Not pictured are air masses with northern Atlantic and inner Arctic influenced for polar sites

Results - European pesticides distribution

1) Overall results

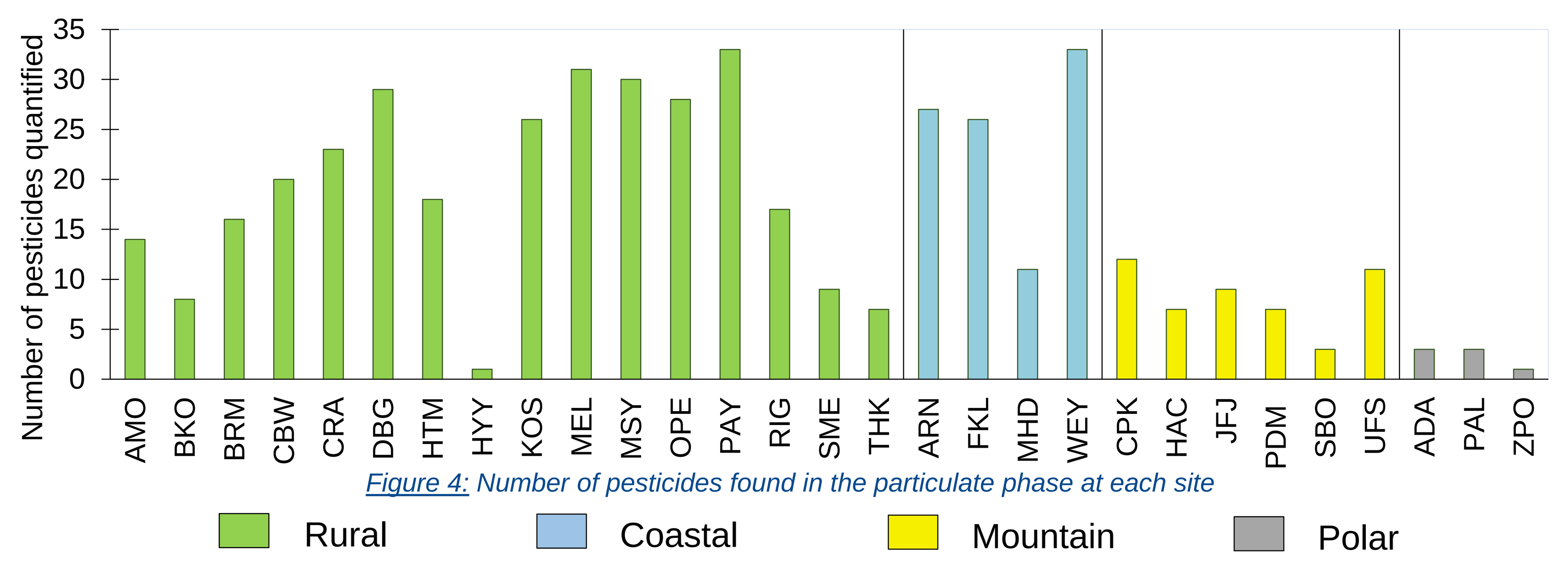


Figure 4: Number of pesticides found in the particulate phase at each site

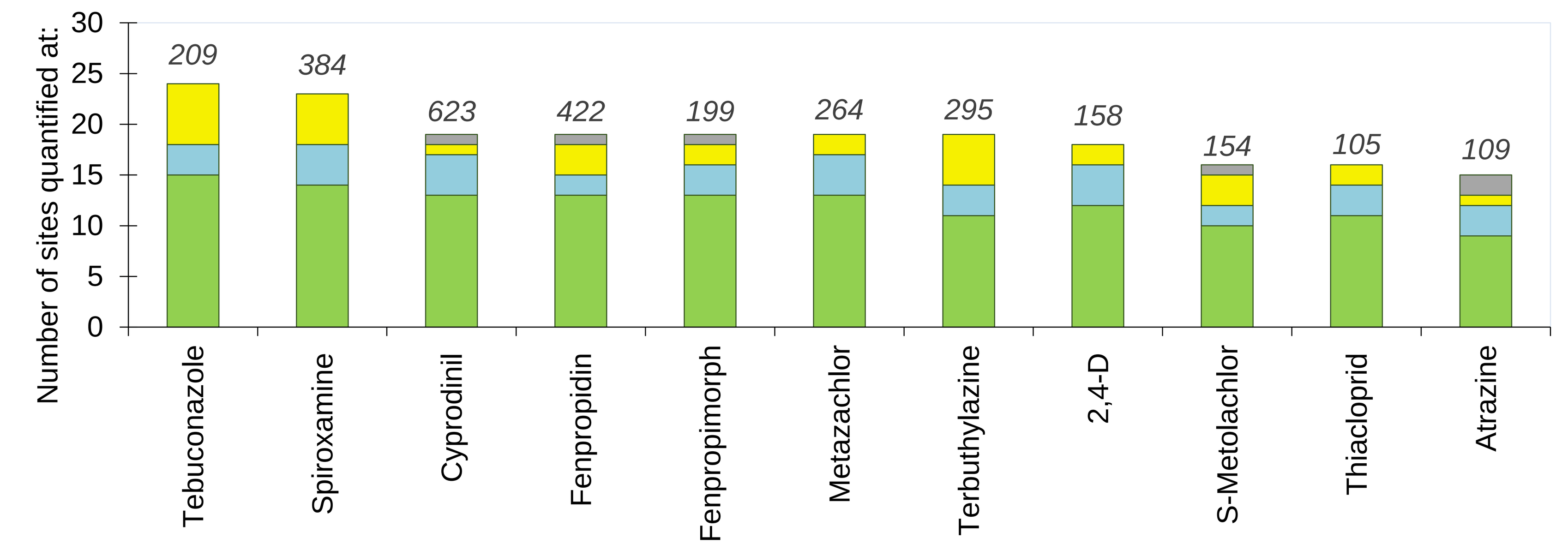


Figure 5: Most frequently quantified pesticides (Quantification freq. >50%) and their associated relative standard deviation (RSD, in %) values

2) Influencing factors

Factors	*p-value*	Coefficient
Site category	*0.0003*	-5.503
Agricultural area (%)	*0.0242*	0.242
Latitude	*0.0002*	-0.55

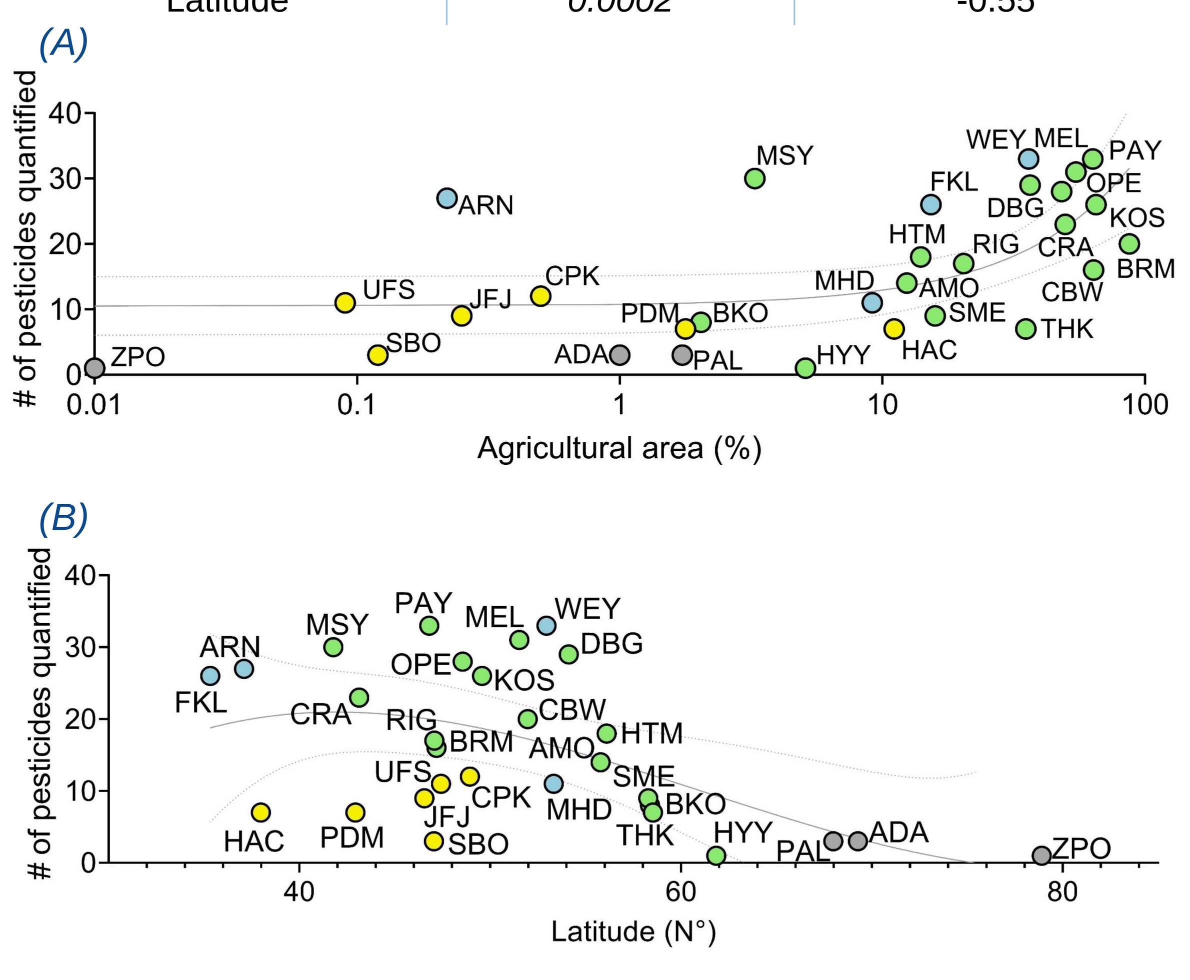


Figure 6: Percentage of agricultural area (A) and latitude (B) influence on pesticide distribution

Scientific impact

In a diverse European atmosphere containing a wide range of pesticide mixtures, 22 currently-used pesticides were identified as having the potential for long-range atmospheric transport (LRAT). Despite over 70% of these pesticides being approved for use in Europe, their identification as LRAT-prone suggests a flaw in current risk assessment procedures. The current LRAT assessment method relies solely on *in silico* calculations of persistence in air, which overly simplifies lifetime in air, neglecting relevant atmospheric processes and environmental conditions. The presence of these LRAT-prone pesticides in remote ecosystems highlights the urgent need for revision of the current risk assessment methodology.

References

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