METHODOLOGY FOR QUANTIFYING THE IMPACT OF SMART FARMING APPLICATION ON LOCAL-SCALE AIR QUALITY OF FARMS IN GREECE

Evangelia Fragkou, George Tsegas, Athanasios Karagkounis, Fotios Barmpas, and Nicolas Moussiopoulos

Sustainability Engineering Laboratory, Aristotle University of Thessaloniki, Thessaloniki, Greece

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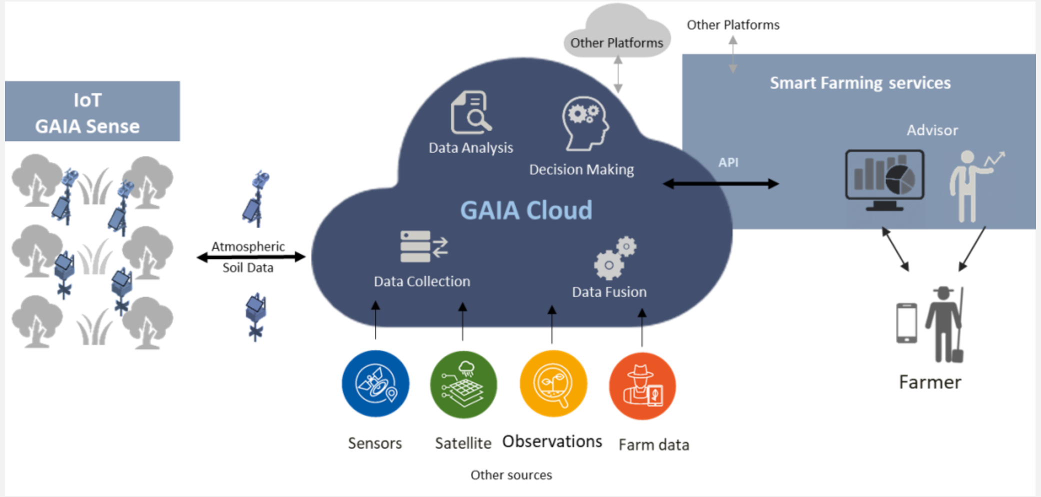
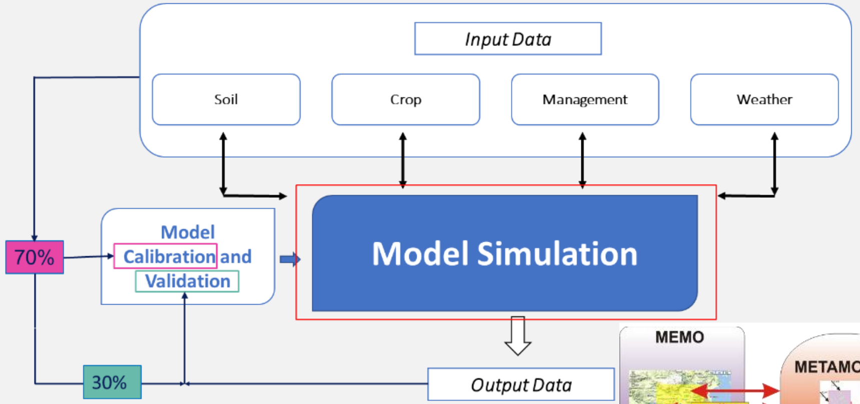
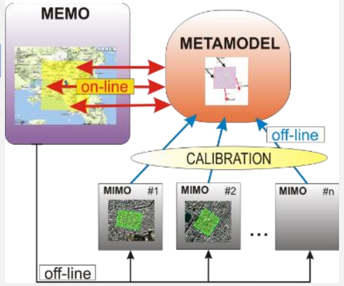
LIFE GAIA Sense: Air Quality Impact Assessment

“Smart Farming” solution for reducing the consumption of natural resources, as a way to protect the environment and support Circular Economy agriculture models.

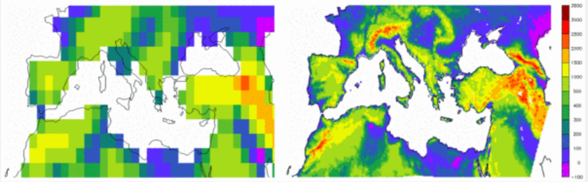


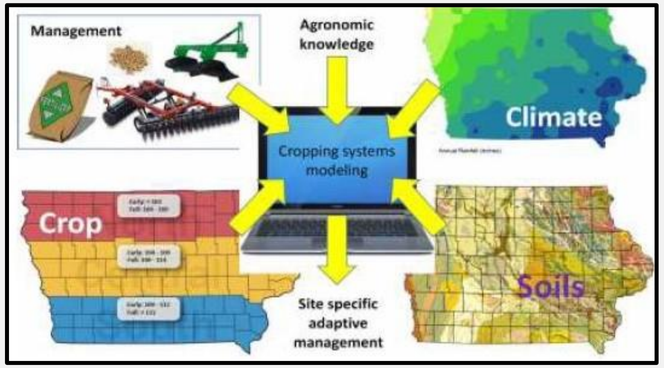
Multi-scale Modelling Methodology for Assessing Air Quality Impacts



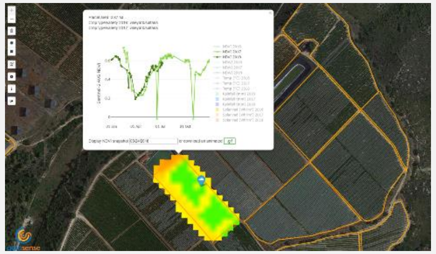


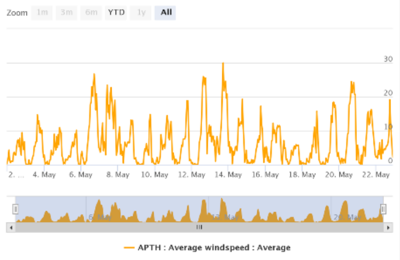
Dynamical Downscaling of Climate Data





GAIA Sense Remote Data





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Environmental modelling for impact assessment

Objective:

Risk assessment of air, soil and water pollution due to agrochemicals and fertilizers applied in irrigated agriculture

Means:

- ❑Numerical modelling processes:
  - ➢ Atmospheric emissions
  - ➢ Chemistry and deposition
  - ➢ Nitrogen soil processes, ammonium exchange uptake and mass transport
- ❑Quality assurance of numerical modelling:
  - ➢ Calibration
  - ➢ Validation and verification
  - ➢ LCA for the estimation of pollutants fate using international standards and eco-indicators

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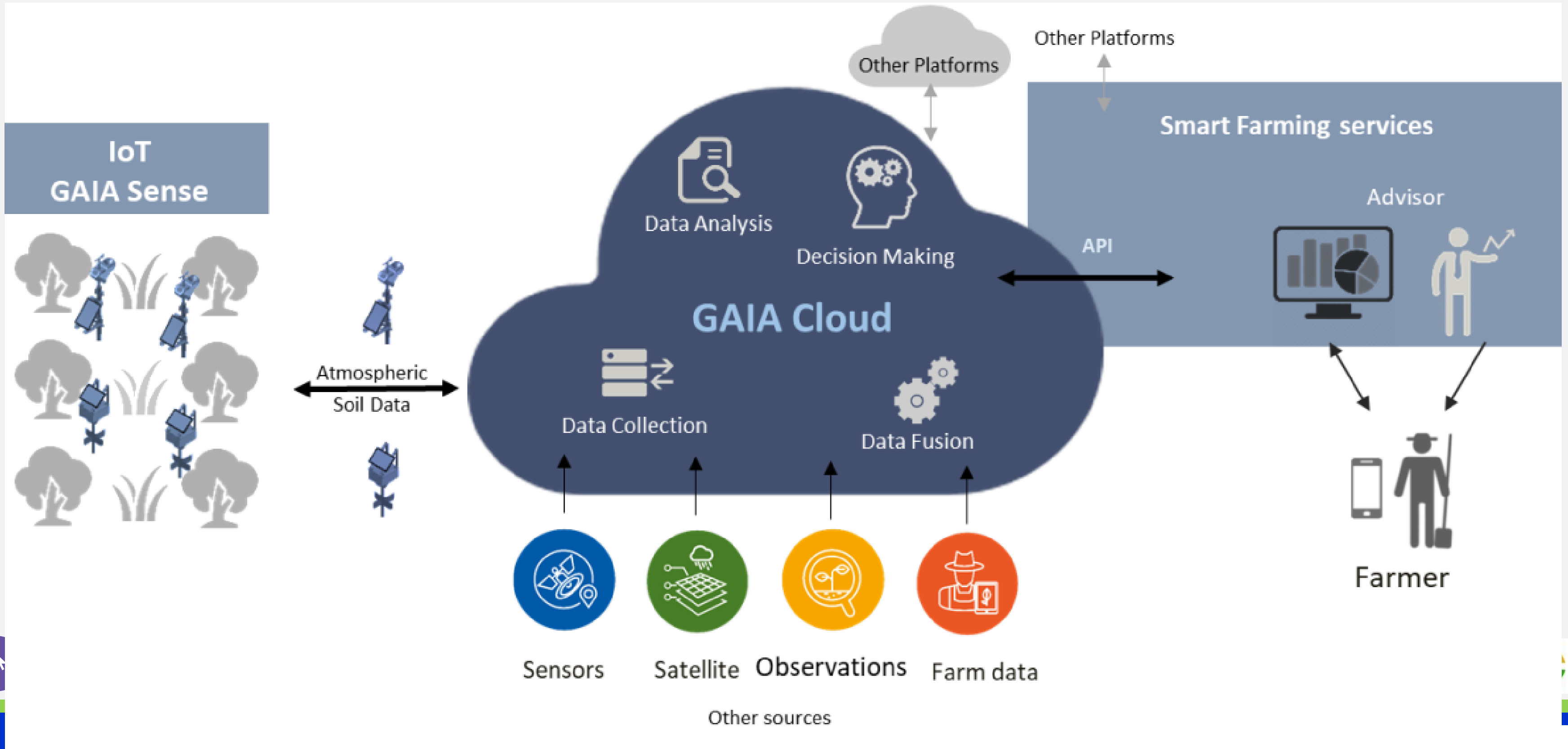
Monitoring Input data

A wide range of technology solutions are used to provide high resolution data for monitoring and modelling purposes in the SF application parcels. In this way, high spatial and temporal resolution data are available to scientists for analysis and to farmers for everyday information purposes.



Remote sensing:
Earth observation data from Copernicus/ESA

Field:
atmospheric and soil data from Gaiatrons

Eye:
field observations, lab analyses

Farm:
schedule/timing of field activity data

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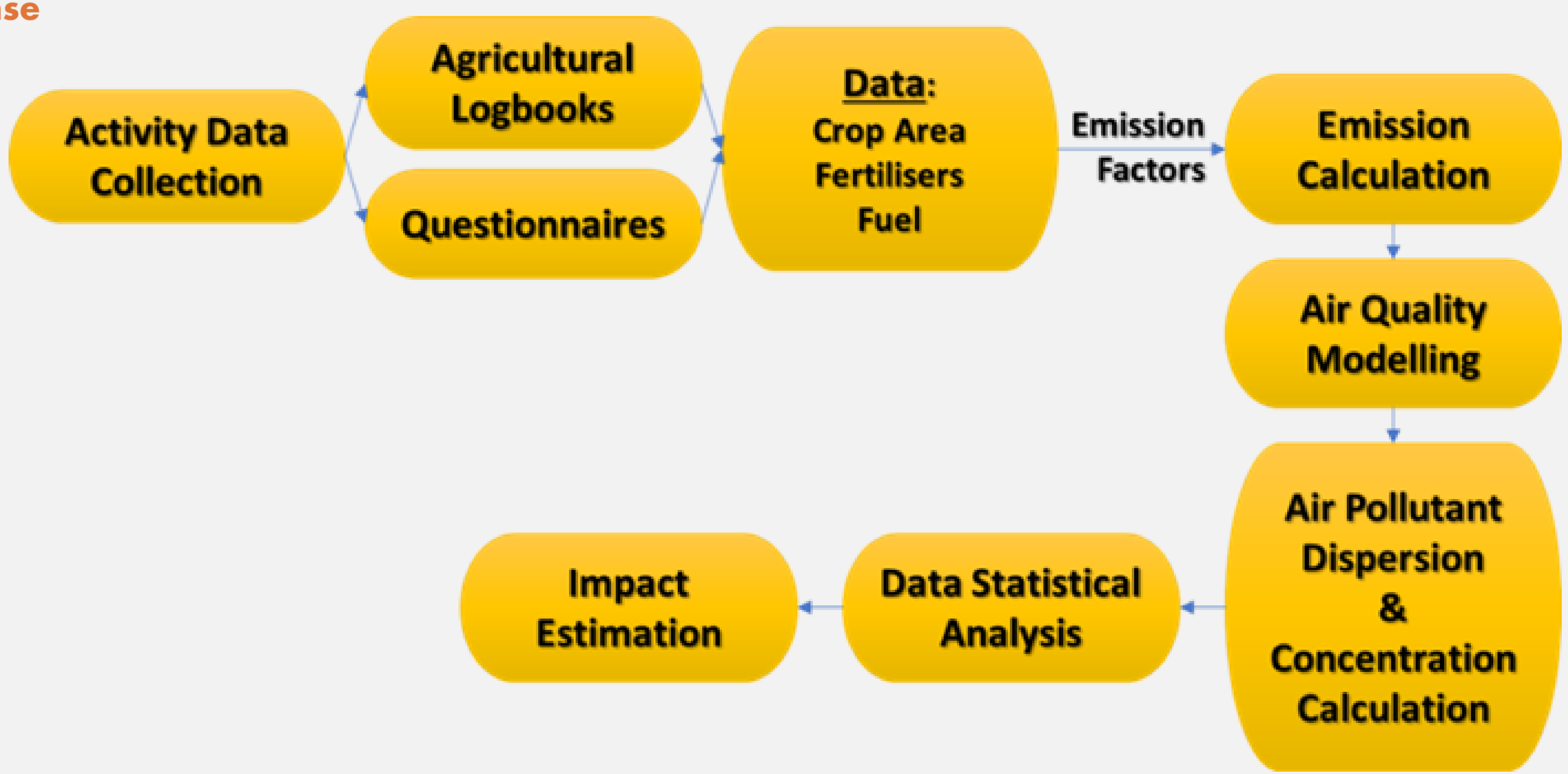
Atmospheric impact assessment methodology



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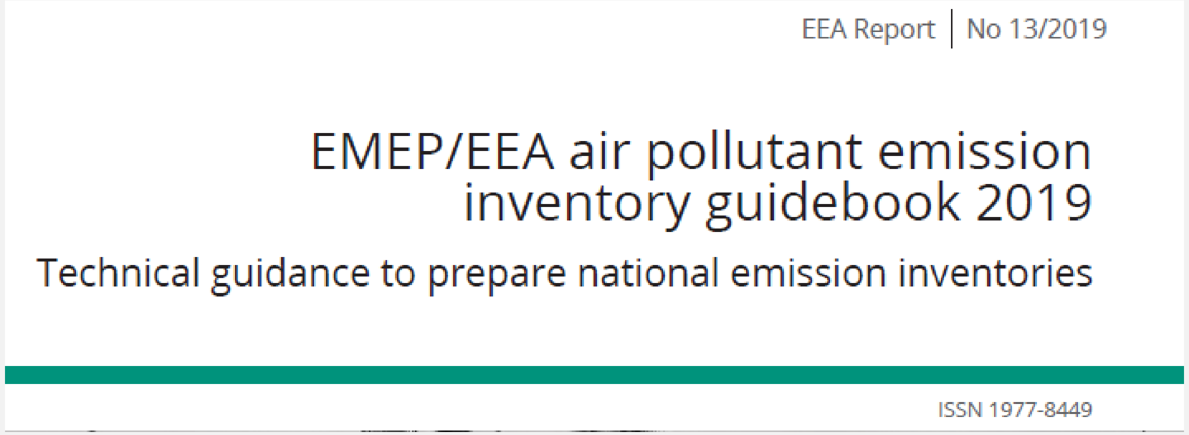
Input data: Emissions of agricultural atmospheric pollutants (1)

- Emission factors from the EMEP/EEA air pollutant emission inventory guidebook 2019: 1A.4 non-road mobile machinery, 1A.4 cii Agriculture Off Road Vehicles & other Machinery and 3D (Crop production and agricultural soils) NFR categories are used.


EEA Report | No 13/2019

EMEP/EEA air pollutant emission inventory guidebook 2019

Technical guidance to prepare national emission inventories

ISSN 1977-8449

- Detailed activity data of the specific SF application areas related to agricultural activities are from targeted questionnaires for farmers participating in SF applications, in order to produce realistic emissions data.

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Input data: Emissions of agricultural atmospheric pollutants (II)

- A set of environmental indicators targeted the impact on the atmospheric environment and were included to provide quantitative activity data for calculating atmospheric pollutant emissions.
  1. Use of chemical and organic fertilisers – type (name) and quantity (annual quantity in kg or l per ha) of fertiliser for the specific crop type and the application frequency (e.g. per year or season)
  2. Energy use – annual consumption of transport fuel in litres, annual energy use in KWh (including energy for irrigation e.g. pumping, drilling), and annual consumption of machine lubricants in litres
- Tier 1 methodology was applied to calculate emissions of PM10, PM2.5, NO, NMVOC, using the default emission factors (EFs) for NFR Source category 3.D (Crop production and agricultural soils) from Table 3.1 of the EMEP EMEP/EEA emission inventory guidebook 2019. On-site data for quantities of fertiliser (kg of fertiliser N) applied and size of the cultivated area (ha) were derived from farmers' questionnaires and logbooks. The percentage of N of each fertiliser was estimated from the fertiliser commercial name and composition.

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Input data: Emissions of agricultural atmospheric pollutants (III)

- Tier 1 methodology was used for emissions calculation of GHGs (CH_4, CO_2, N_2O) and atmospheric pollutants (NH_3, NMVOC, NO_x, PM_{10} and $PM_{2.5}$), employing the default EFs for NFR Source category 1.A.4.c.ii-Agriculture from Table 3-1 (Tier 1 emission factors for off-road machinery) of the EMEP EMEP/EEA emission inventory guidebook 2019. On-site activity data on fuel consumption were derived from farmers' questionnaires.
- Tier 1 methodology was used for calculating N_2O emissions from fertiliser application in agricultural soils, according to the default value of 1% of kg^{-1} fertiliser N applied of IPCC.
- Tier 2 methodology was applied for the calculation of NH_3 emissions resulting from soil fertilisation, using EMEP/EEA 2019 EFs and taking into account the climate zone of the pilot farm, the soil pH and the amount of N applied to the soil as calculated from the information in the farmers' questionnaires and logbooks.

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Tier I EFs for the calculation of local-scale emissions

Pollutants	NFR category: Fertiliser application (NFR 3D)	Non-road machinery (NFR 1.A.4 cii)	Standing crops (NFR 3D) ($kg \cdot ha^{-1}$)	Agricultural operations (NFR 3D) ($kg \cdot ha^{-1}$)
PM_{10}	-	1913 $g \cdot tonnes^{-1}$ fuel	-	1.56
$PM_{2.5}$	-	1913 $g \cdot tonnes^{-1}$ fuel	-	0.06
NO_x	-	34457 $g \cdot tonnes^{-1}$ fuel	-	-
NO	0.04 kg NO_2 kg^{-1} fertiliser N applied	-	-	-
NMVOC	-	3542 $g \cdot tonnes^{-1}$ fuel	0.86	-
NH_3	Table 3.2	8 $g \cdot tonnes^{-1}$ fuel	-	-
N_2O	0.01 kg N_2O–N $(kg\ N)^{-1}$	136 $g \cdot tonnes^{-1}$ fuel	-	-
CO_2	-	3160 $kg \cdot tonnes^{-1}$ fuel	-	-
CH_4	-	87 $g \cdot tonnes^{-1}$ fuel	-	-

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Tier 2 NH_3 EFs based on fertilizer application data

EFs for N_{H3} emissions from fertilisers (in g NH_3 (kg N applied)$^{-1}$)

Type of crop	Field location	Climate zone	Soil pH	Fertiliser	Type of fertiliser	EF
Pistachio	Vovu, Aegina (Attiki)	Temperate(2)	High(3)	34.5-0-0 13-13-13	AN NPK mixture	33 94
Walnut	Elassona (Larissa)	Temperate	High	33.5-0-0	AN	33
Walnut	**Elassona (Larissa)**	**Temperate**	**High**	**12-0-2.5[a]** **35-0-0[b]** **5-10-20[c]**	**NK mixture** **AN** **NPK mixture**	**33** **33** **94**
Grape	Megalos Valtos, Kiato (Korinthia)	Temperate	High	12-11-18[d]	NPK mixture	94
Olive	**Stylida (Fthiotida)**	**Temperate**	**High**	**19-6-15[e]** **20-5-10[f]**	**NPK mixture** **NPK mixture**	**94** **94**
Tomato	Kesari, Kiato (Korinthia)	Temperate	High	15-15-15 18-44-0 3-33-0[g] 20-20-20[h]	NPK mixture NP mixture NP mixture NPK mixture	94 94 94 94
Cotton	Melissochori (Larissa)	Temperate	High	33.5-0-0	AN	33
Peach	**Skydra (Pella)**	**Temperate**	**High**	**12-12-17**	**NPK mixture**	**94**

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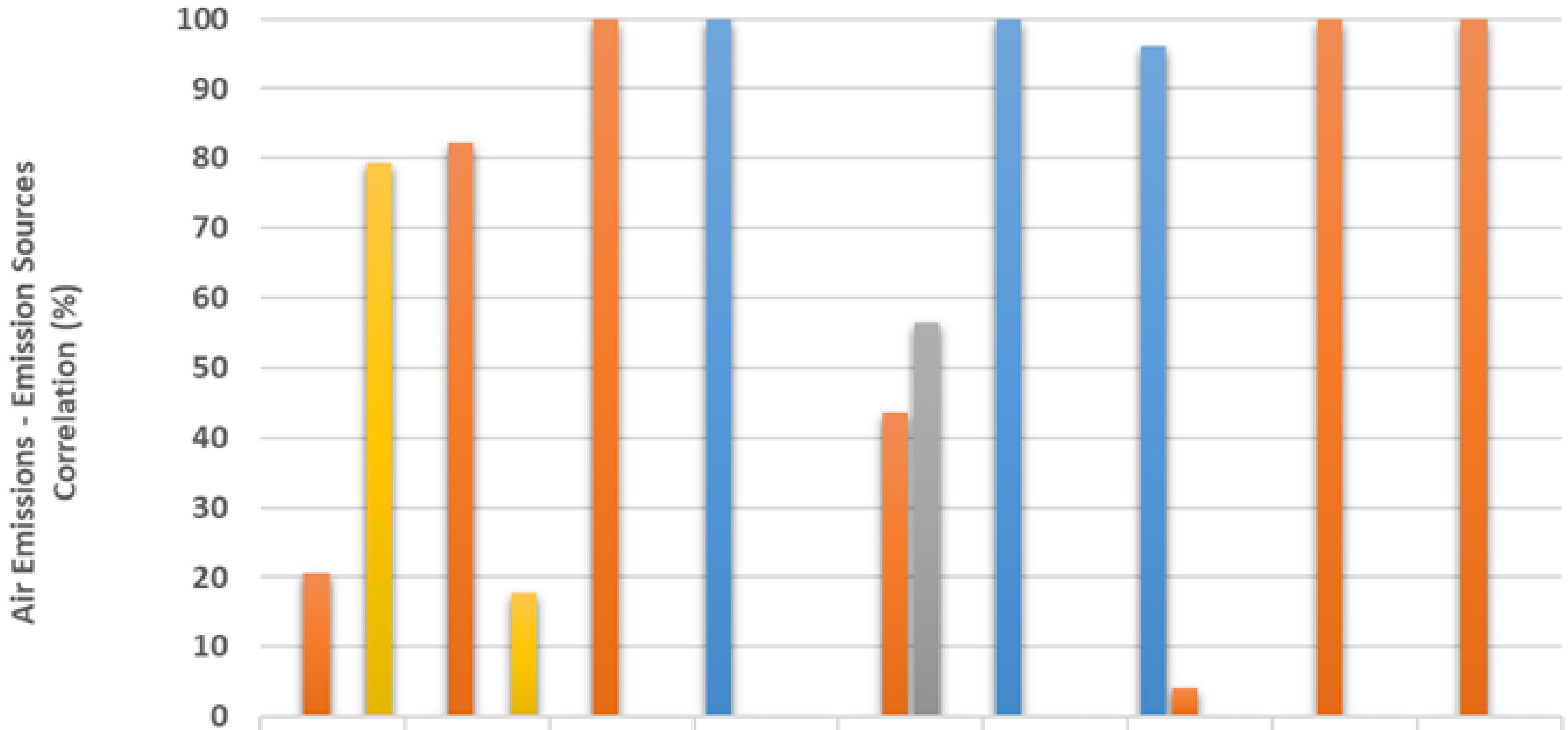
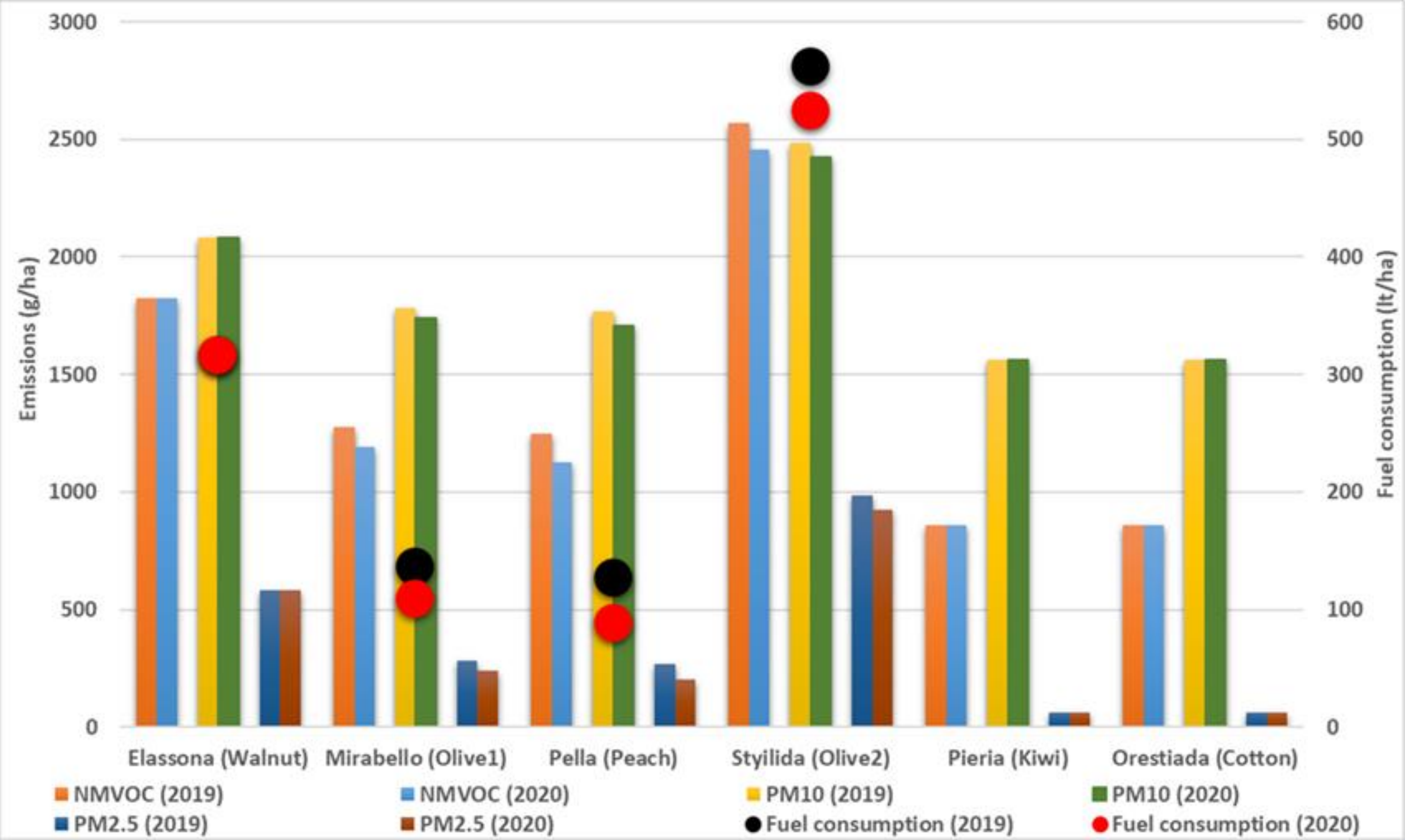
Agricultural emissions: source contribution

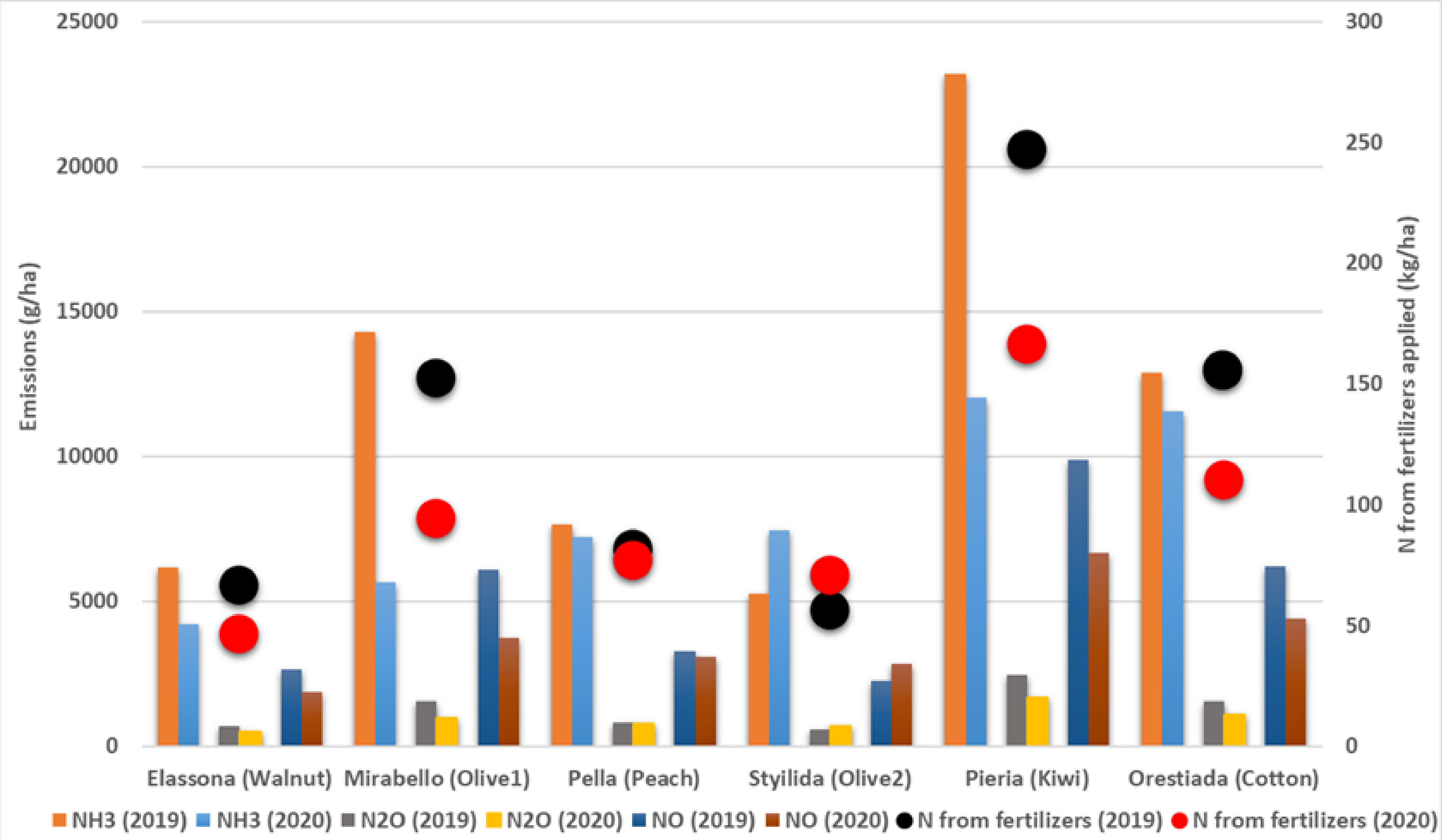


	PM10	PM2.5	NOx	NO	NMVOC	NH3	N2O	CO2	CH4
N in Fertilisers	0	0	0	100	0	99.97	95.97	0	0
Fuel Consumption	20.65	82.27	100	0	43.49	0.03	4.03	100	100
Standing Crops	0	0	0	0	56.51	0	0	0	0
Other Agricultural Activities	79.35	17.73	0	0	0	0	0	0	0

Agricultural emissions per crop (I)



Agricultural emissions per crop (II)



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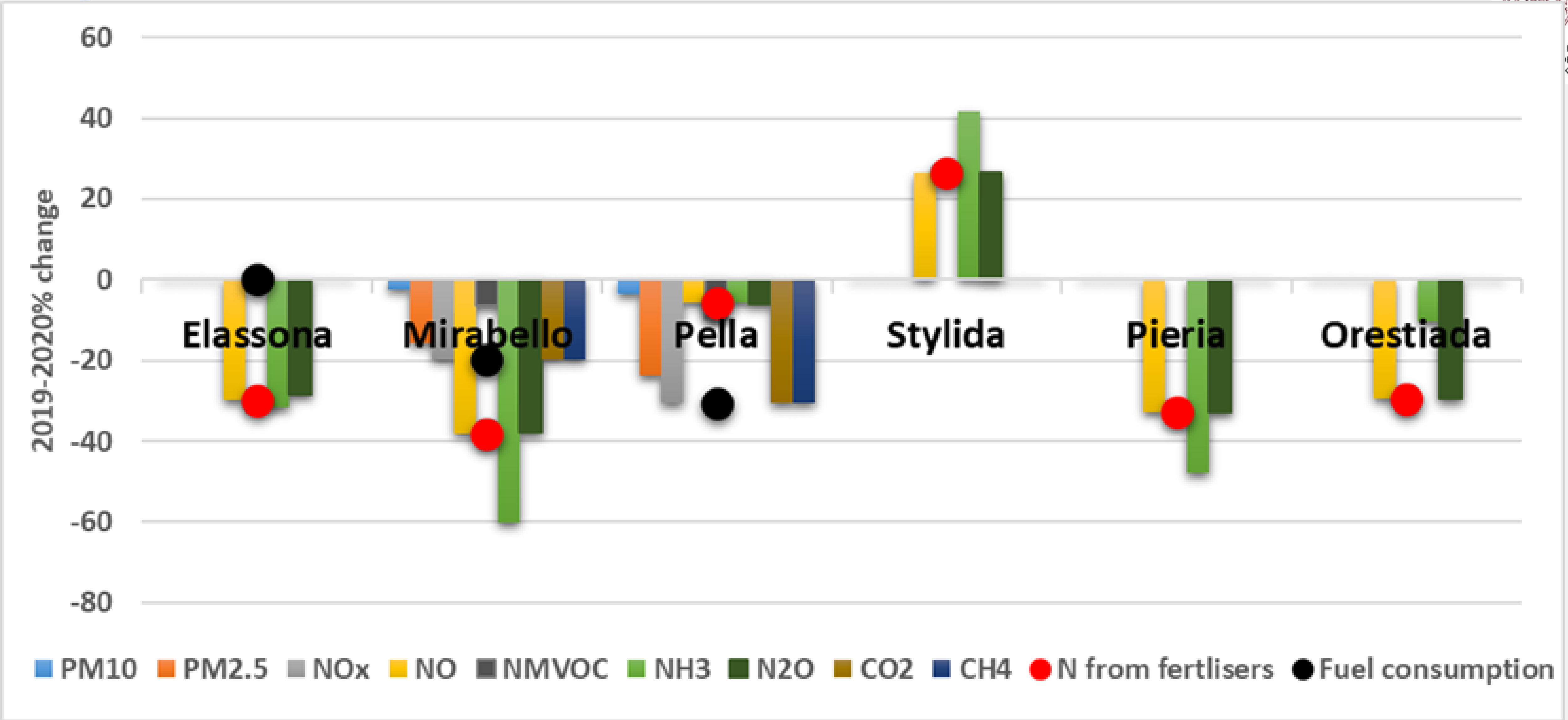
Agricultural emissions percentage % change



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Dispersion calculations

- Lagrangian trajectory model (AUSTAL2000) with linear diagnostic flow model (TAldia) including the influence of topography
- Mostly linear response to emissions is expected, excluding the distance-from-source dependence of PM due to deposition effects resulting from the size partitioning
- **Objective 1**: obtain a quantitative assessment of the change in additional loads in short distances inside and around each application area
- **Objective 2**: investigate potential non-linearities in NH_3 response due to the non-uniform temporal distribution of fertilizer application

Gyldenkærne S., Carsten Ambelas Skjøth, Ole Hertel, Thomas Ellermann (2005) A dynamical ammonia emission parameterization for use in air pollution models. *Journal of Geophysical Research* **110(7)**: D07108.10.1029/2004JD005459

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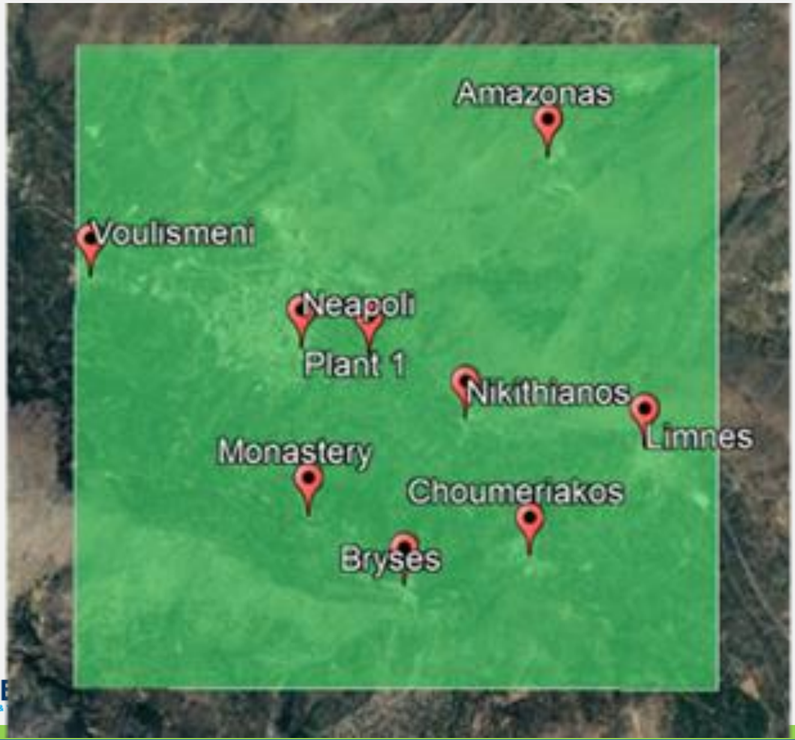
AUSTAL2000 computational domains

Three sets of receptor points were defined to assess the pollution effect due to emissions withing each field.

Elassona

Mirabello



Pella

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Reductions of annual average concentrations and deposition rates in Mirabello pilot area

Location	Field_SW		Bryses		Limnes	
Pollutant	Average Annual Reduction	Annual Percentage Reduction (%)	Average Annual Reduction	Annual Percentage Reduction (%)	Average Annual Reduction	Annual Percentage Reduction (%)
	Concentrations (μg/m³)	Concentrations	Concentrations (μg/m³)	Concentrations	Concentrations (μg/m³)	Concentrations
NO_2	$4.03 \cdot 10^{-5}$	41.66	$5.1 \cdot 10^{-5}$	41.64	$5.58 \cdot 10^{-7}$	41.66
NO_x	$4.31 \cdot 10^{-3}$	40	$1.3 \cdot 10^{-4}$	40	$2.39 \cdot 10^{-6}$	40
VOC	$4.43 \cdot 10^{-4}$	17.61	$1.34 \cdot 10^{-5}$	17.6	$2.45 \cdot 10^{-7}$	17.56
PM_{10}	$2.35 \cdot 10^{-4}$	8.25	$5.18 \cdot 10^{-6}$	15.86	$1.08 \cdot 10^{-7}$	12.79
NH_3	$8.15 \cdot 10^{-3}$	41.69	$6.62 \cdot 10^{-5}$	41.68	$1.99 \cdot 10^{-6}$	41.67
	Deposition g/(m²d)	Deposition	Deposition g/(m²d)	Deposition	Deposition g/(m²d)	Deposition
PM_{10}	$1.9 \cdot 10^{-8}$	1.26	$4.01 \cdot 10^{-10}$	4.39	$9 \cdot 10^{-12}$	2.19
	Deposition g/(m²d)	Deposition	Deposition g/(m²d)	Deposition	Deposition g/(m²d)	Deposition
NH_3	$5.4 \cdot 10^{-6}$	41.67	$2.97 \cdot 10^{-8}$	41.67	$1.43 \cdot 10^{-9}$	41.68

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Conclusions

- The modelling methodology employed in the frame of GAIA Sense relies on high-resolution meteorological input data from sensors, high-resolution topography data and realistic activity data for atmospheric emissions calculation at farm level.
- Emissions calculation follows a combined Tier1 – Tier2 approach. The results of emissions calculation indicate the correlation of the studied pollutants to major contributing emissions sources in agriculture.
- The input data are fed into a Lagrangian dispersion model, in order to assess the impact of SF on air pollution at a farm scale.
- In almost all cases, lower fuel consumption and fertilizer use in the SF application has resulted in reduced emissions.
- No major non-linear response in calculated NH_3 additional loads was observed.

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Thank you very much for your attention!

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