MODELLING METHODOLOGY FOR ASSESSING ATMOSPHERIC IMPACTS FROM SMART FARMING APPLICATION

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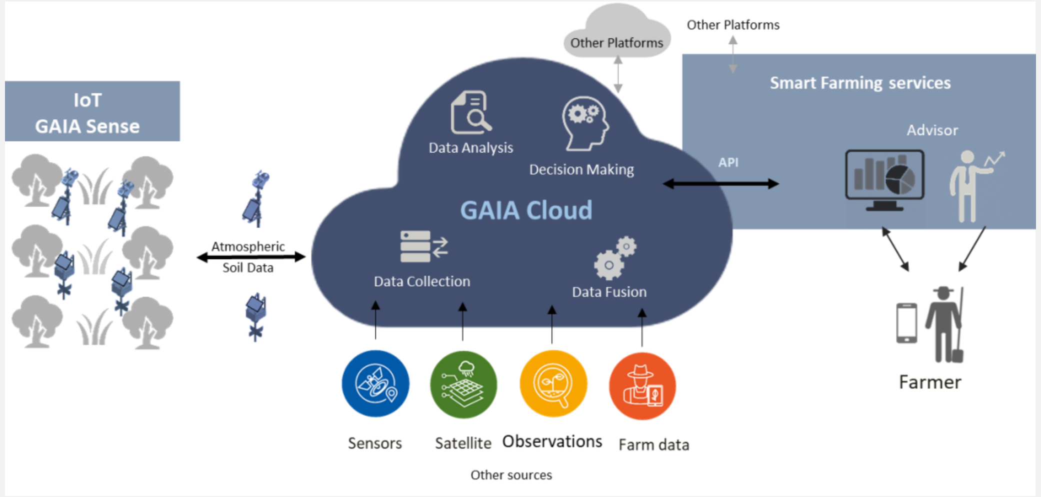
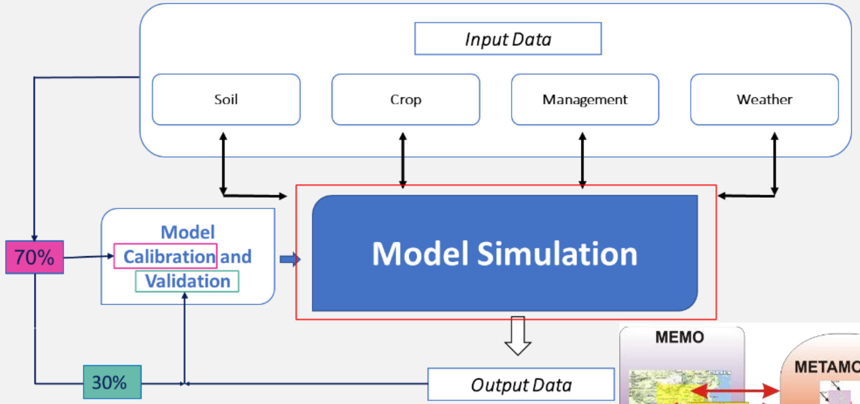
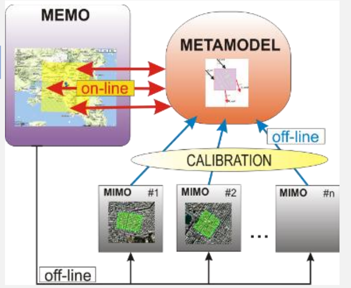
LIFE GAIA Sense: Air Quality Impact Assessment

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

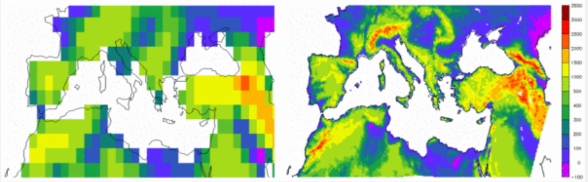


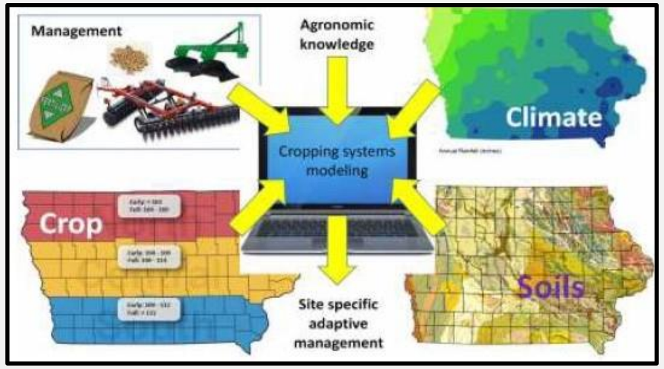
Multi-scale Modelling Methodology for Assessing Air Quality Impacts



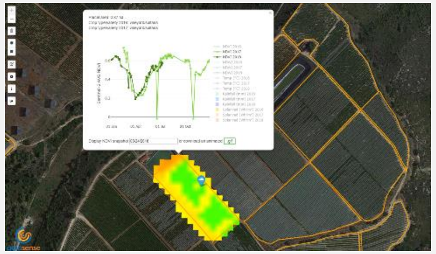


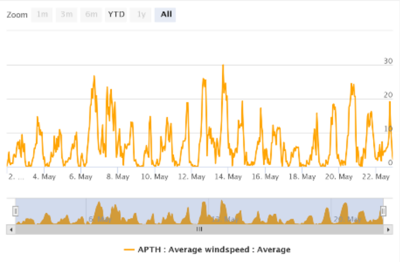
Dynamical Downscaling of Climate Data





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 (data obtained from sub action B7.1)
- ❑Account for extreme weather events impacts frequency increase
- ❑LCA for the estimation of pollutants fate using international standards and eco- indicators

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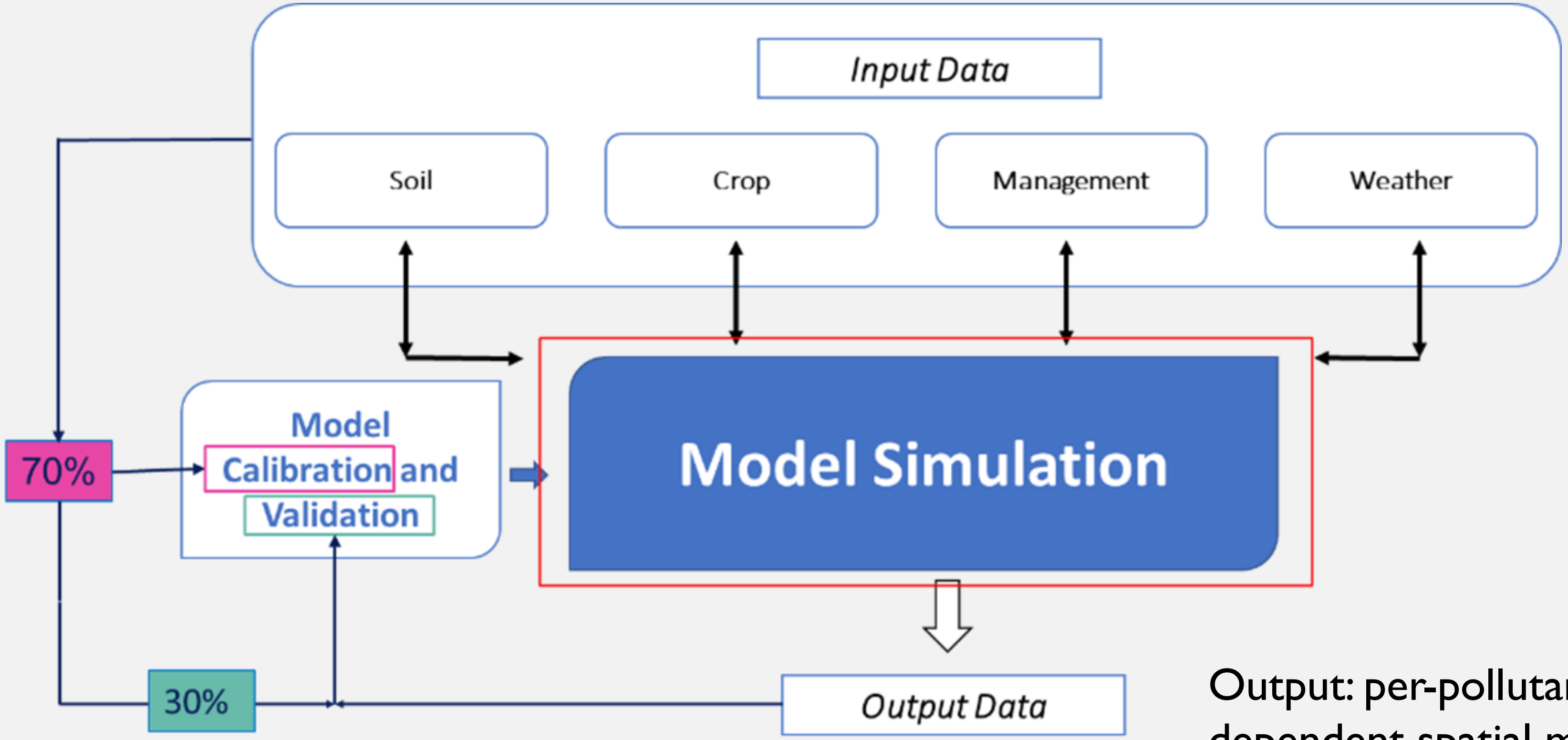
Modelling Overview



- Physical modelling based on morphology and pollutant emissions
- Climatic parameters explicitly taken into account
- Data collected in near-real time:
  - 70% used for calibration
  - 30% reserved for validation

Output: per-pollutant time-dependent spatial mapping of pollution

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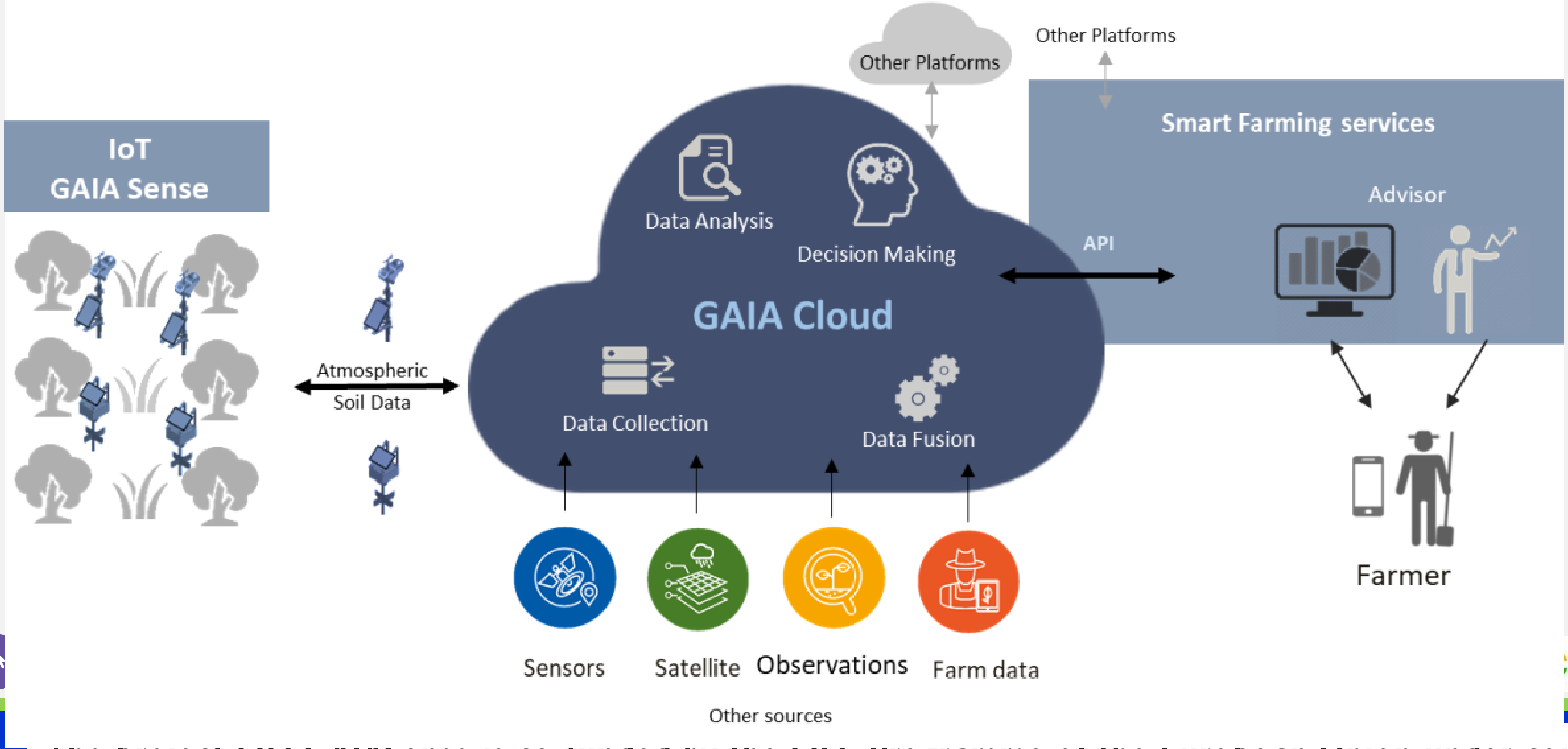
Monitoring Input data

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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MEMICO: two way meso – micro coupling in three steps

- **1st step:**

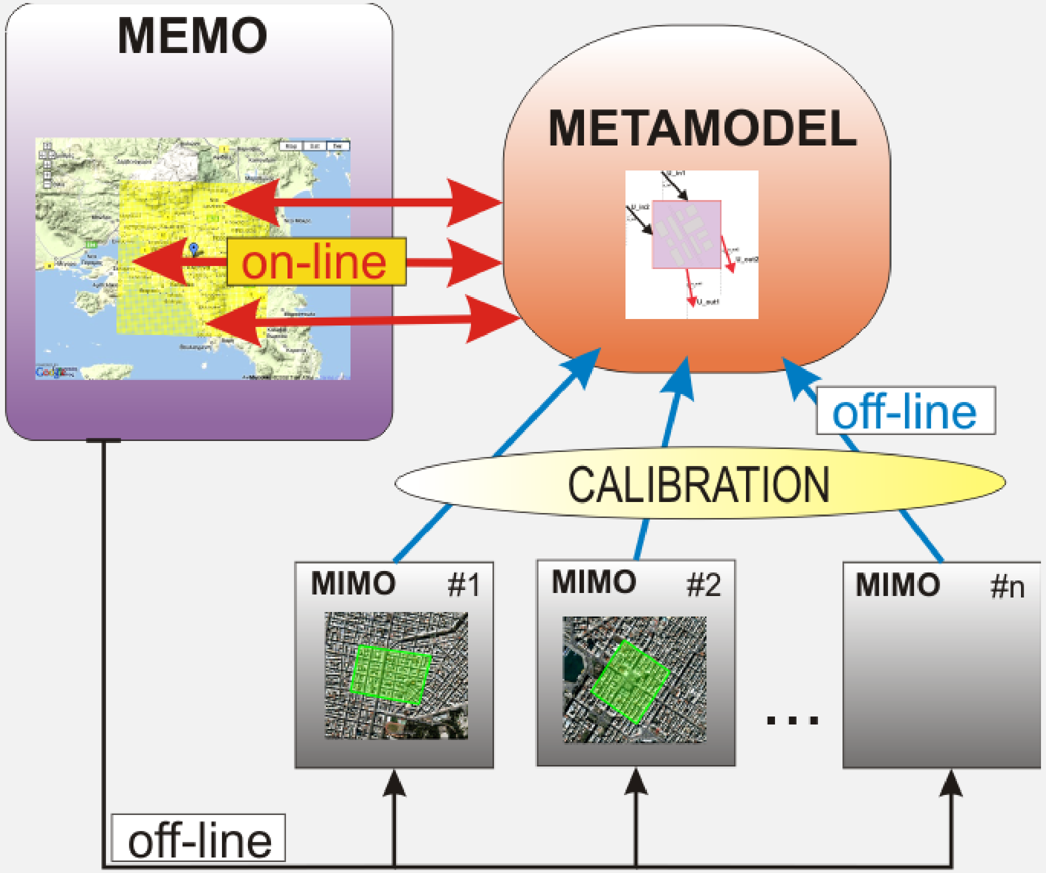
  Boundary Conditions calculated from an initial MEMO run are used for multiple MIMO cases (off-line process)

- **2nd step:**

  The response of each microscale domain is used as calibration input for an interpolating metamodel

- **3rd step:**

  The calibrated metamodel is fast enough to be used in on-line coupling with MEMO



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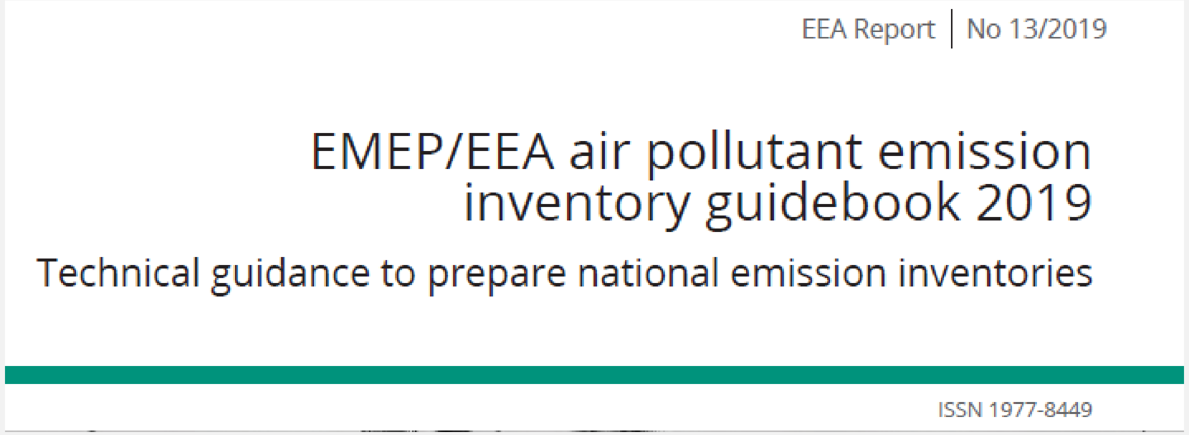
Input data: Emissions of agricultural atmospheric pollutants (1)

- 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 NH3 emissions resulting from soil fertilisation, 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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NH_3 EFs based on fertilizer application data

Table 1. EFs for N_{H3} emissions from fertilisers applied (in g NH_3 (kg N applied)$^{-1}$) (Tier 2 approach)

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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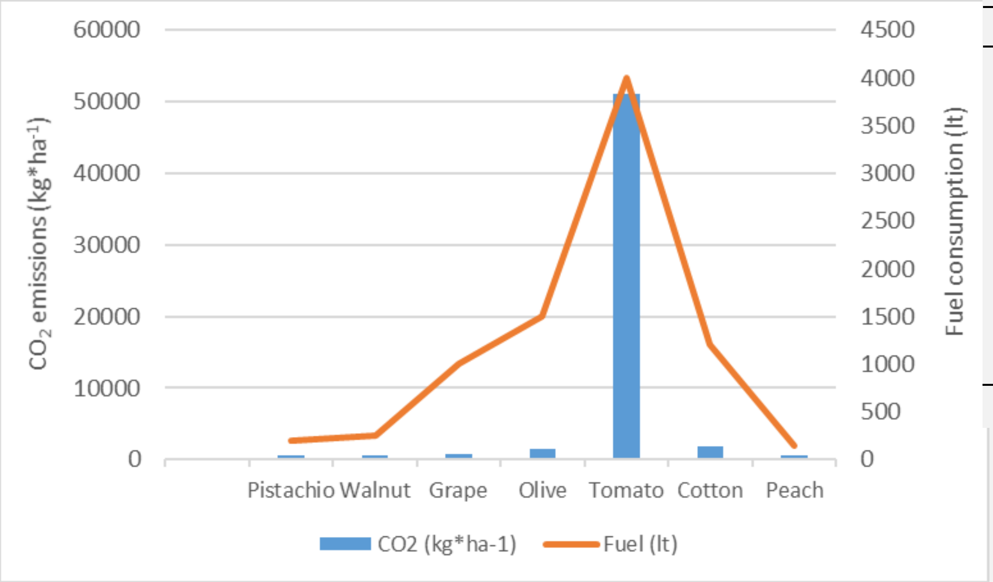
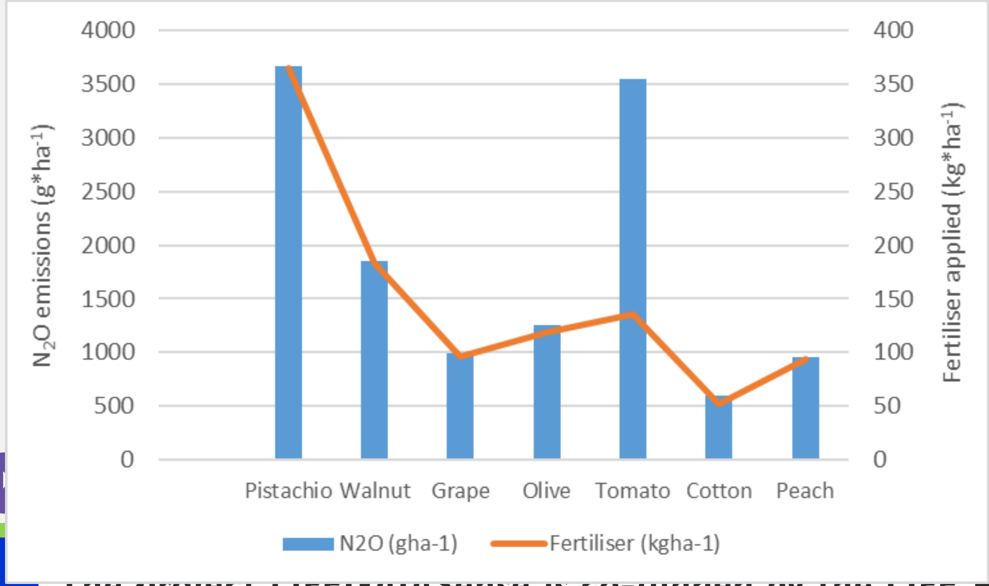
Agricultural emissions calculation

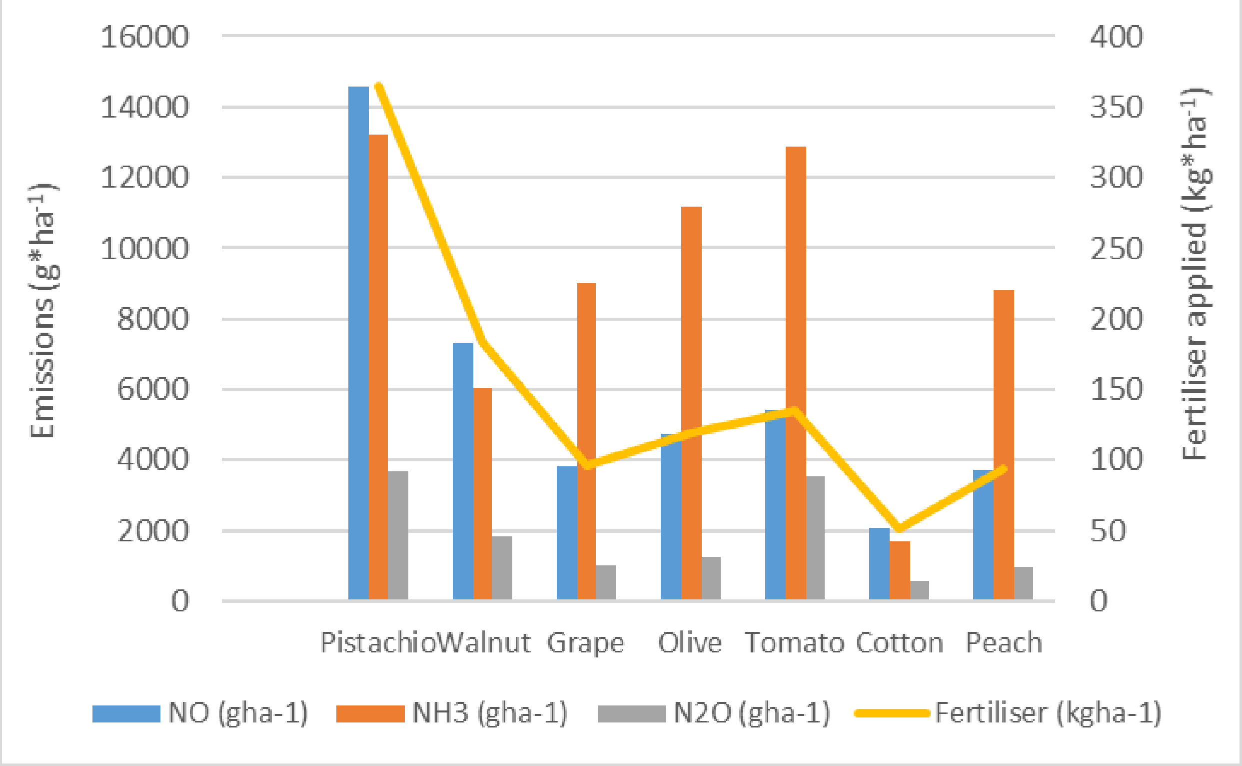
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Total emissions from agricultural activities														
2	Pistachio (B	Fertiliser ap	Fertiliser (k	**Total Fertilis**	Non-road machinery (g	Fuel (ton	**Total non-roa**	Stand	Harvest	Area (ha	**Total Stand**	**Total Act**	**Total Categories**	Total EFs EMEP PM	**Total EMEP P**
3															
4	PM10				1913	0,17	325,21			1,7			325,21	1560	
5	PM2.5				1913	0,17	325,21			1,7			325,21	60	
6	NOx				34457	0,17	5857,69						5857,69		
7	NO	40	214,37	8574,8									8574,8		
8	NMVOC				3542	0,17	602,14	860		1,7	1462		2064,14		
9	NH3	50	214,37	10718,5	8	0,17	1,36						10719,86		
10	N2O				136	0,17	23,12						23,12		
11	CO2				3160000	0,17	537200						537200		
12															
13															
14															
15	Walnuts (Γκ	Fertiliser ap	Fertiliser (kg)		non-road machinery (g	Fuel (tonne)		Standing crops		Area (ha)				Total EFs (g/ha)	
16															
17	PM10				1913	0,42	803,46			1,7			803,46	1560	
18	PM2.5				1913	0,42	803,46			1,7			803,46	60	
19	NOx				34457	0,42	14471,94						14471,94		
20	NO	40	11,9	476									476		
21	NMVOC				3542	0,42	1487,64	860		1,7	1462		2949,64		
22	NH3	50	11,9	595	8	0,42	3,36						598,36		
23	N2O				136	0,42	57,12						57,12		
24	CO2				3160000	0,42	1327200						1327200		

Agricultural emissions from baseline data



Pollutants	Type of crop						
	Pistachio	Walnut	Grape	Olive	Tomato	Cotton	Peach
PM_{10}	1891.85	1878.83	2024.59	2481.07	32532.38	2707.8	1870.86
$PM_{2.5}$	391.85	378.83	524.59	981.07	31032.38	1207.8	370.86
NO_x	5977.23	5742.83	8368.13	16590.41	557875.24	20674.2	5599.26
NO	14580	7308.67	3840	4746.67	5400	2064	3744
NMVOC	1474.43	1450.33	1720.2	2565.41	58206.67	2985.2	1435.58
NH_3	13219.39	6030.92	9025.94	11158.52	12864.17	1707.6	8799.7
N_2O	3668.59	1849.83	993.03	1252.15	3551.9	597.6	958.1
CO_2	548163.27	644897.96	2740816.33	1521481.48	10963265.31	3288979.59	513500
CH_4	15.09	14.5	21.13	41.89	1408.57	52.2	14.14





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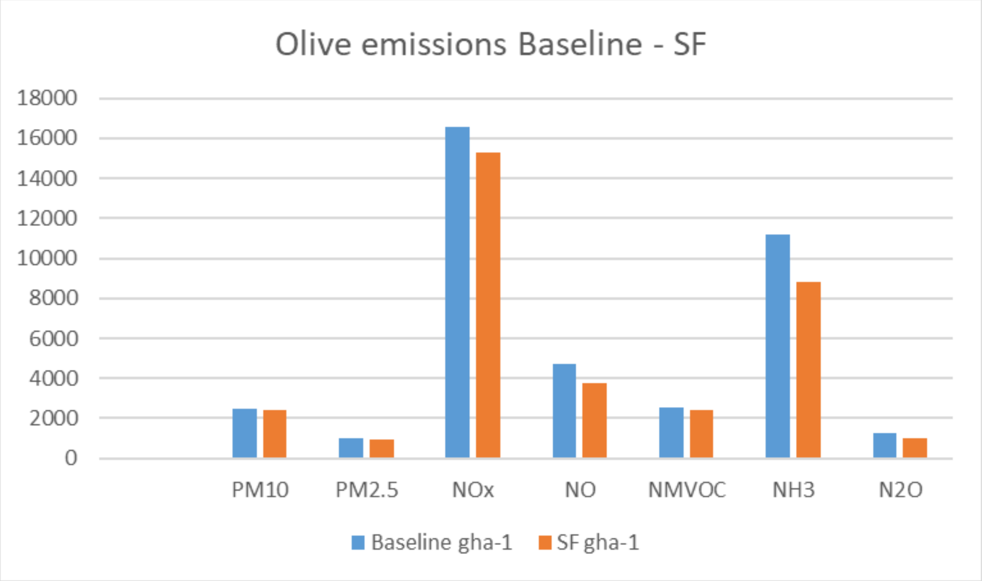
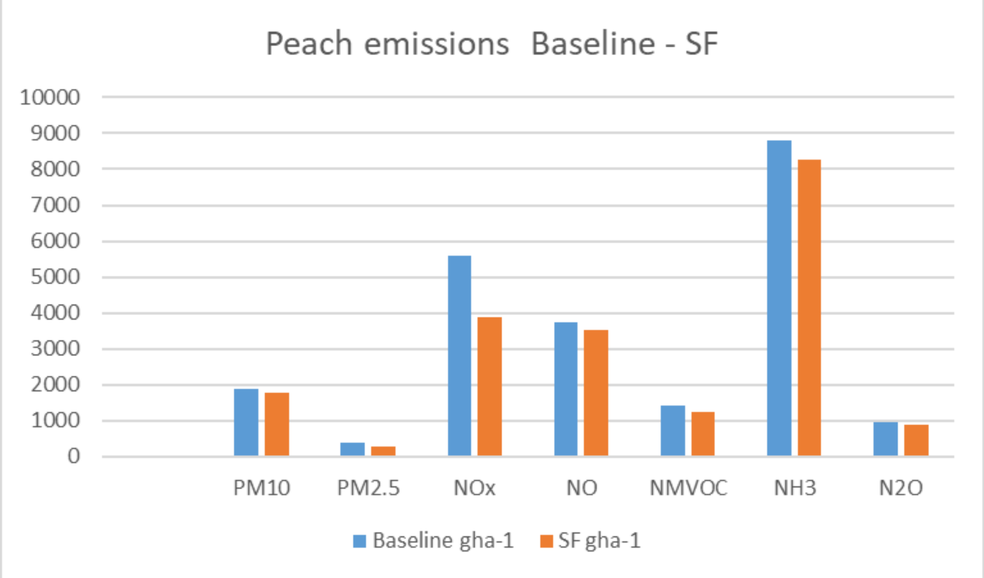
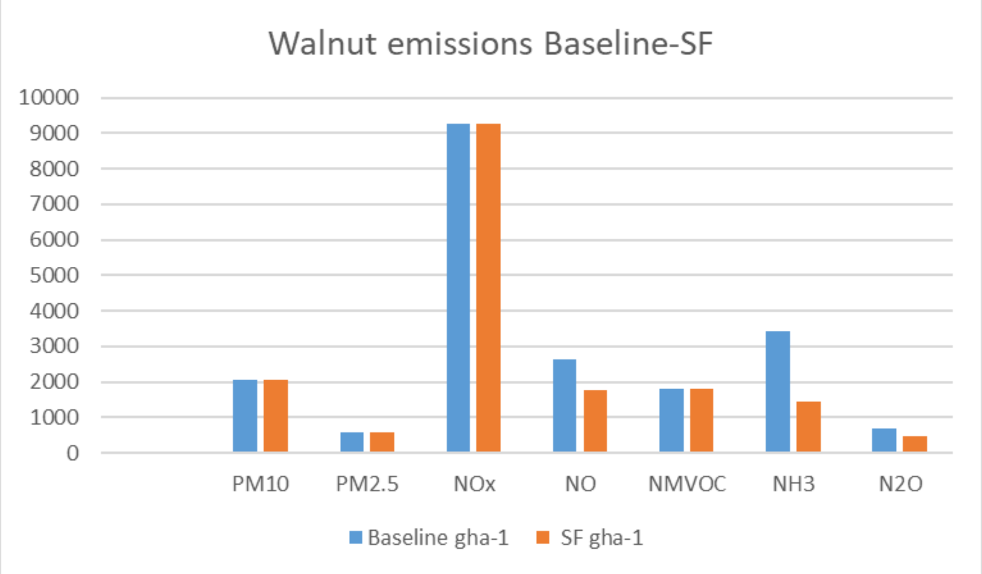
Emissions comparison from baseline and SF data



Pollutants	Type of crop					
	Walnut		Olive		Peach	
	Baseline	SF	Baseline	SF	Baseline	SF
PM_{10}	2074.19	2074.19	2481.07	2410.22	1870.86	1775.21
$PM_{2.5}$	574.19	574.19	981.07	910.22	370.86	275.21
NO_x	9260.32	9260.32	16590.41	15314.22	5599.26	3876.41
NO	2622.5	1765	4746.67	3758.52	3744	3510
NMVOC	1811.91	1811.91	2565.41	2434.22	1435.58	1258.48
NH_3	3445.03	1458.84	11158.52	8836.07	8799.7	8249.4
N_2O	692.18	477.8	1252.15	1000.07	958.1	892.8
CO_2	849250	849250	1521481.48	1404444.44	513500	355500
CH_4	23.38	23.38	41.89	38.67	14.14	9.79





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Conclusions

- The atmospheric modelling is one of several components contributing to the comprehensive evaluation of the environmental impact of SF GAIA Sense application.
- In the proposed modelling methodology relies on high-resolution meteorological input data from sensors, high-resolution topography data and realistic activity data for atmospheric emissions calculation at farm level.
- The input data are fed into a two-way coupled mesoscale-microscale atmospheric modelling system, in order to calculate the impact of SF on air pollution at a farm scale.
- 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.
- Lower fuel consumption and fertilizer application in the SF application has resulted in reduced emissions of related pollutants.

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Thank you very much for your attention!

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