DIRETTA STREAMING 15 / 16 DICEMBRE 2021

AGRESTIC

Life

Il progetto LIFE AGRESTIC ha ricevuto finanziamenti dal Programma LIFE dell'Unione Europea

MID TERM CONFERENCE

LIFE AGRESTIC

Reduction of Agricultural GReenhouse gases EmiSsions Through Innovative Cropping systems

Il consorzio

Coordinatore:

HORT@ — From research to field

Partner:

Università Cattolica del Sacro Cuore

Institute of Life Sciences — Sant'Anna School of Advanced Studies – Pisa

ART-ER Attractiveness Research Territory

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1.
Modelling the GHGs emissions from agricultural soils.

Marco Acutis *University of Milano*

- What GHGs are involved ?
- Drivers of soil emissions.
- Models for GHGs simulation
- Performances and applicability of the GHG models
- Conclusions

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What GHGs are involved ?*

Agricultural soil emits:

CO_2 from root respiration and root, anaerobic and aerobic microbial respiration. in average roots emits 50% of CO_2 (range: 10-90%)

CH_4 in soils is produced by methanogenesis under anaerobic conditions and is consumed by methanotrophic microorganisms that use O_2 and CH_4 for their metabolism under aerobic conditions. CO_2 equivalent: 28-30.

N_2O releases are driven by nitrification (oxidation of NH_4^+ to NO_3^- via NO_2^-) and denitrification (reduction of NO_3^- to N_2O and N_2). CO_2 equivalent: 250-300.

NO_x, but they are not GHG

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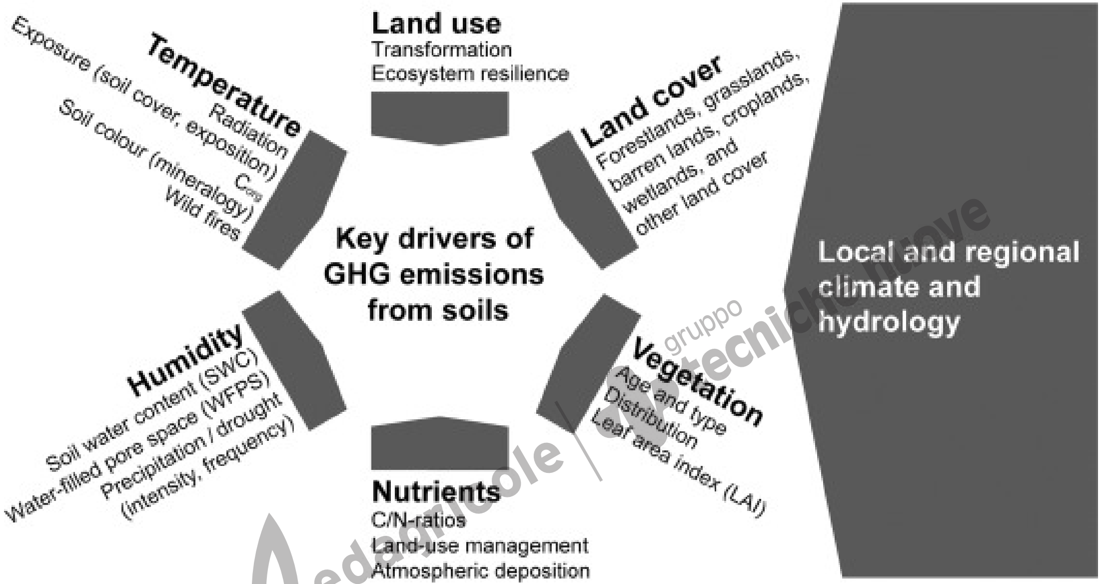
Drivers of soil emissions



*Oertel, C., Matschullat, J., Zurba, K., Zimmermann, F., Erasmi, S., 2016. Greenhouse gas emissions from soils—A review. Geochemistry 76, 327–352. https://doi.org/10.1016/j.chemer.2016.04.002

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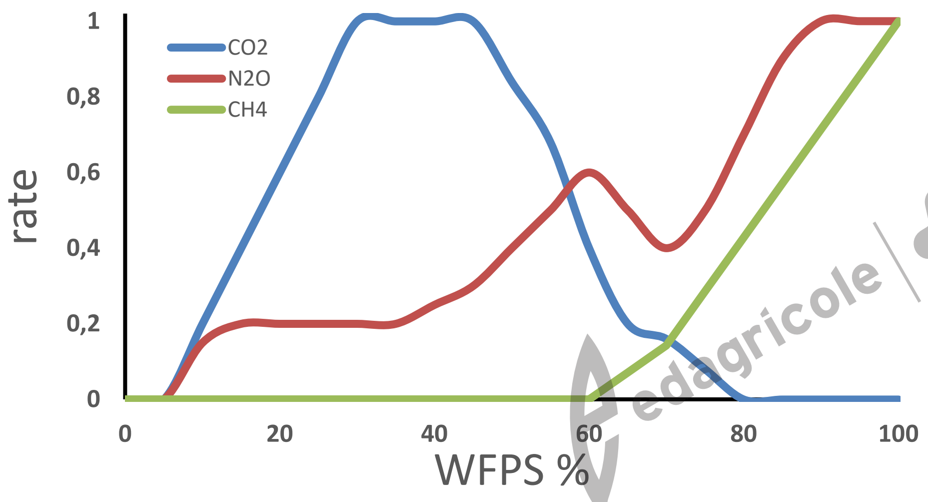
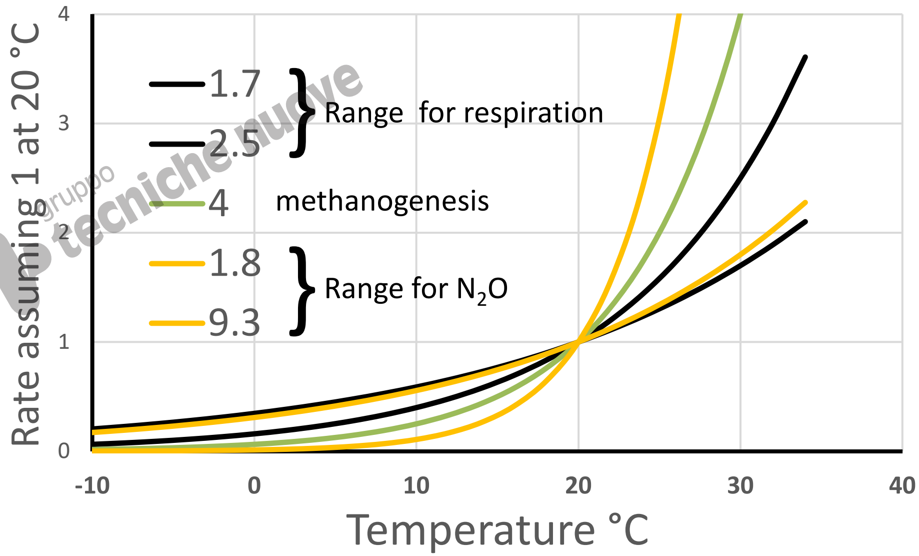
Drivers of soil emissions (2)

Main drivers are the Soil Water content (expressed in term of Water Filled Pore Space) and temperature





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Drivers of soil emissions (3)

Other drivers are absolutely important:

Fertilization (organic and mineral)

Amount of soil organic matter and its change at short and long time

C/N ratio

Tillage (conservation agriculture)

Residues (mulch)

Soil pH

Liming

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Models for GHGs simulation

The IPCC approach (based on EF, it is not really a model)

TABLE 11.1 (UPDATED)
DEFAULT EMISSION FACTORS TO ESTIMATE DIRECT N_2O EMISSIONS FROM MANAGED SOILS

Emission factor	Aggregated		Disaggregated		
	Default value	Uncertainty range	Disaggregation[4]	Default value	Uncertainty range
EF_1 for N additions from synthetic fertilisers, organic amendments and crop residues, and N mineralised from mineral soil as a result of loss of soil carbon[1] [kg N_2O–N (kg N)$^{-1}$]	0.010	0.001 – 0.018	Synthetic fertiliser inputs[5] in wet climates	0.016	0.013 – 0.019
			Other N inputs[6] in wet climates	0.006	0.001 – 0.011
			All N inputs in dry climates	0.005	0.000 – 0.011

A large set of coefficients are reported in table to estimate yield, N contents in plant residues, etc..

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Models for GHGs simulation

Process based model approach

- process-based models predict daily to weekly fluxes, important for designing and management interventions to mitigate emissions.
- however, they are complex and heavily rely on site and version-specific parameterizations that are sometimes ad hoc tunings.
- algorithms of popular biogeochemical models (DayCent, DNDC, EPIC) are usually derived from laboratory-based responses to individual environmental factors.

Models for GHGs simulation

What models are available able to simulate at the same time CO2, N2O and CH4 in agricultural systems ?

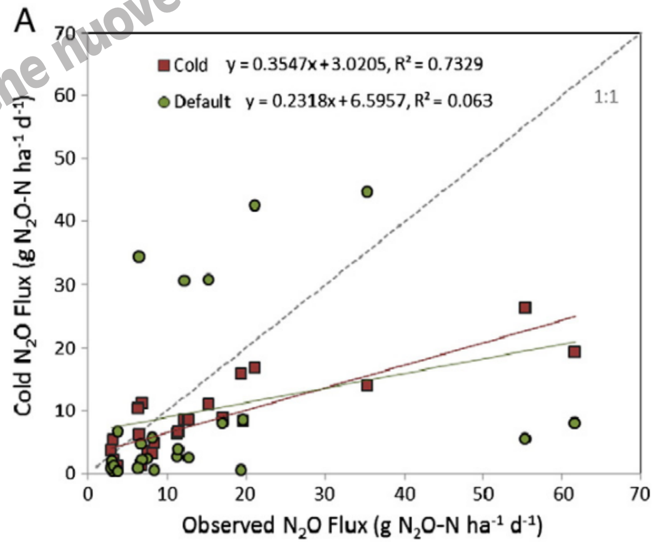
- DayCent: “weak” in water dynamic simulation
- DNDC: "weak” in water dynamic simulation, crop simulation, tillage.
- EPIC: "weak” in water dynamic simulation.
- Animo: "weak" in usability (3 model have to run toghether), tillage, excellent in hydrology
- DSSAT: modular model that can include models for GHG
- A lot of other models can simulate 2 out of 3 GHG e.g.: Stics, Salus, Apsim, Armosa, water and nitrogen management model (WNMM) from China, RZWQM2 and at least 30 others

Performances and applicability of the GHG models

All the actual GHG models need strong calibration on high quality data.

- CO_2 is the GHG easier to measure, and models offer good reliability (but CO_2 emissions from the soil are only a part of the carbon balance).

- When calibrated, all the models offer reasonably good simulations, at least useful to compare cropping systems and for regional scale, also in future climate
- Simulation performance are variable even after calibration, in different experiments
- Correct prediction of WFPS is the key point



- Default =uncalibrated
- Cold = after 47 parameters calibration

Models for GHGs simulation. Statistical model – machine learning

- When a large dataset of measured data is available, few predictors can give good estimate of N_2O emissions when a ML algorithm is used.
- It is possible also to couple a process based model to obtain some variables used after in the machine learning process.

Input	Full ML model	Coupled model	Possible to estimate
Water filled pore space	*	*	model
Ammonium N content		model	model
Nitrate N content		model	model
Clay	*	*	*
Soil organic carbon	*	*	model
Days after fertilization	*	not needed	not needed
N application rate	*	*	*
Mean daily temperature	*	*	*
cumulative rain in the last 2 days	*	*	*

*= measured data

D.Saha, B. Basso, G. P. Robertson (2021) Machine learning improves predictions of agricultural nitrous oxide (N_2O) emissions from intensively managed cropping systems. Environ. Res. Lett. 16

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CONCLUSIONS

We have the need to estimate the emission from agricultural soil.

- When we project new cropping systems, the risk is to store more carbon in soil but to emit more N_2O.
- Models are the best resources that we have to planning cropping systems.
- The quality level of the simulation of the available models just sufficient when there is the support of excellent experimental data.
- Emission factor based prediction are totally inadequate (good only for large scale inventories).
- Machine learning is really promising, but there are few applications.
- There is the need of more research, based on shared approach with stakeholders

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