

How to better integrate soils and water for modelling nutrients and diffuse pollution

*Dr. Panos Panagos
EU Soil Observatory*

European Commission
Joint Research Centre (JRC)
Directorate D Sustainable Resources

Outline

- **EU Soil Observatory**
- **Soil Erosion by water and sediments distribution in European Union**
- **Mercury hotspots and diffuse contamination in the EU**
- **Phosphorus losses from EU agricultural soils**
- **Global P losses due to erosion**

EU Soil Observatory

Vision

Should become the principal provider of reference data and knowledge at EU-level for all matters relating to soil.



Research & Innovation



Stronger European Soil Data Centre (ESDAC)



EU-wide Soil Monitoring



Monitoring soil related policies



European Soil Forum



Geoderma Regional
Volume 29, June 2022, e00510



Soil priorities in the European Union

Panos Panagos ^{a,*,}, Luca Montanarella ^{a,}, Mirco Barbero ^{b,}, Annette Schreegans ^{c,}, Laura Aguglia ^{c,}, Arwyn Jones ^{*}

Show more

+ Add to Mendeley Share Cite

<https://doi.org/10.1016/j.geodrs.2022.e00510>

Get rights and content

Under a Creative Commons license

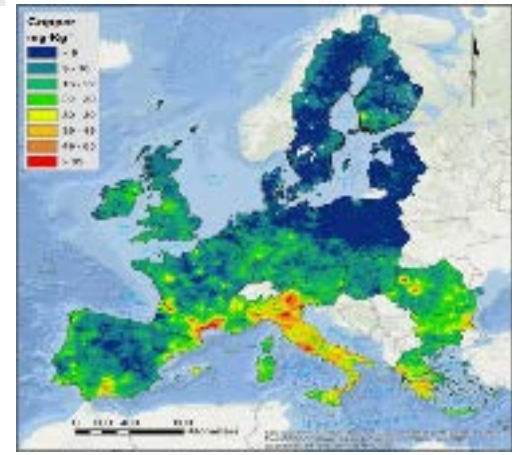
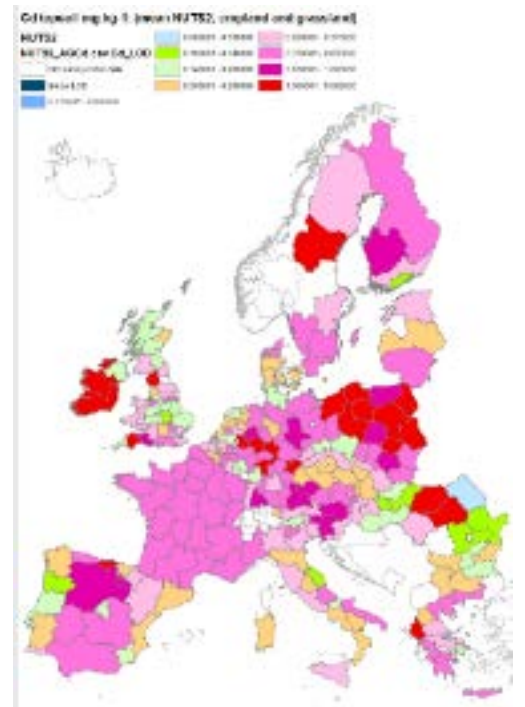
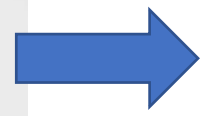
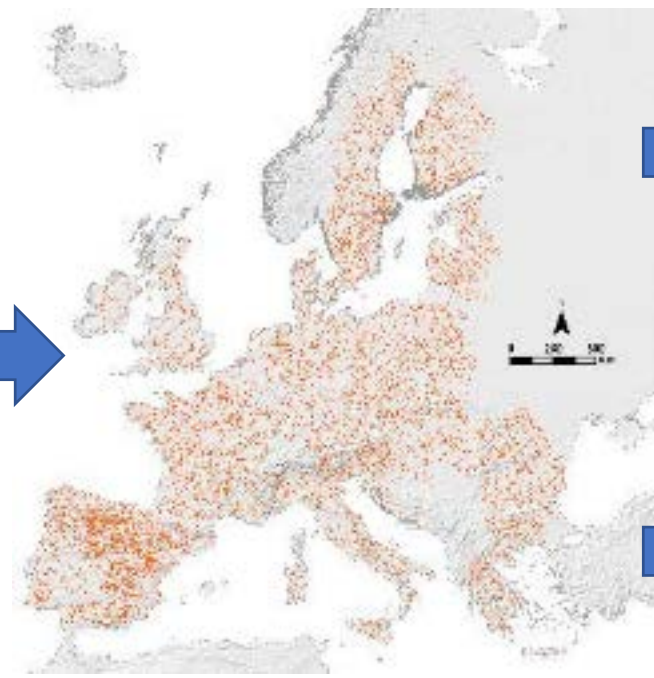
Open access



LUCAS SOIL survey

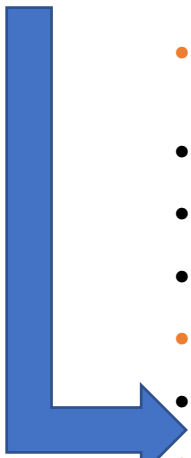
The JRC manages the LUCAS SOIL survey: sample design, measurement protocols through integrated analysis and monitoring, training of surveyors

EU-wide soil monitoring

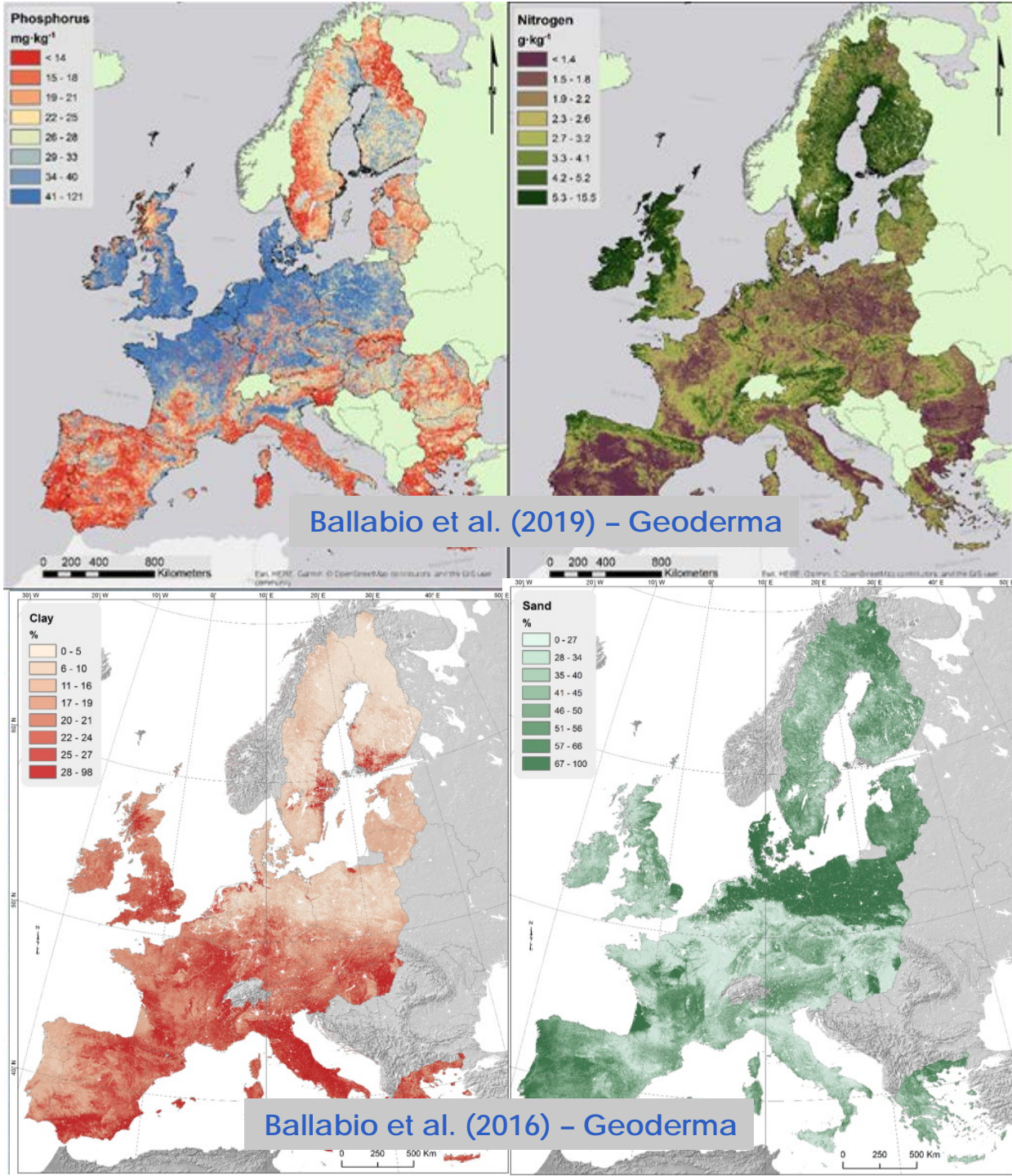


- Surveys (and the resulting data) span multiple years 2009, 2015, 2018, 2022
- 42,000 observations
- Soil archive at the JRC premises in Ispra (IT)
- Close cooperation with MSs

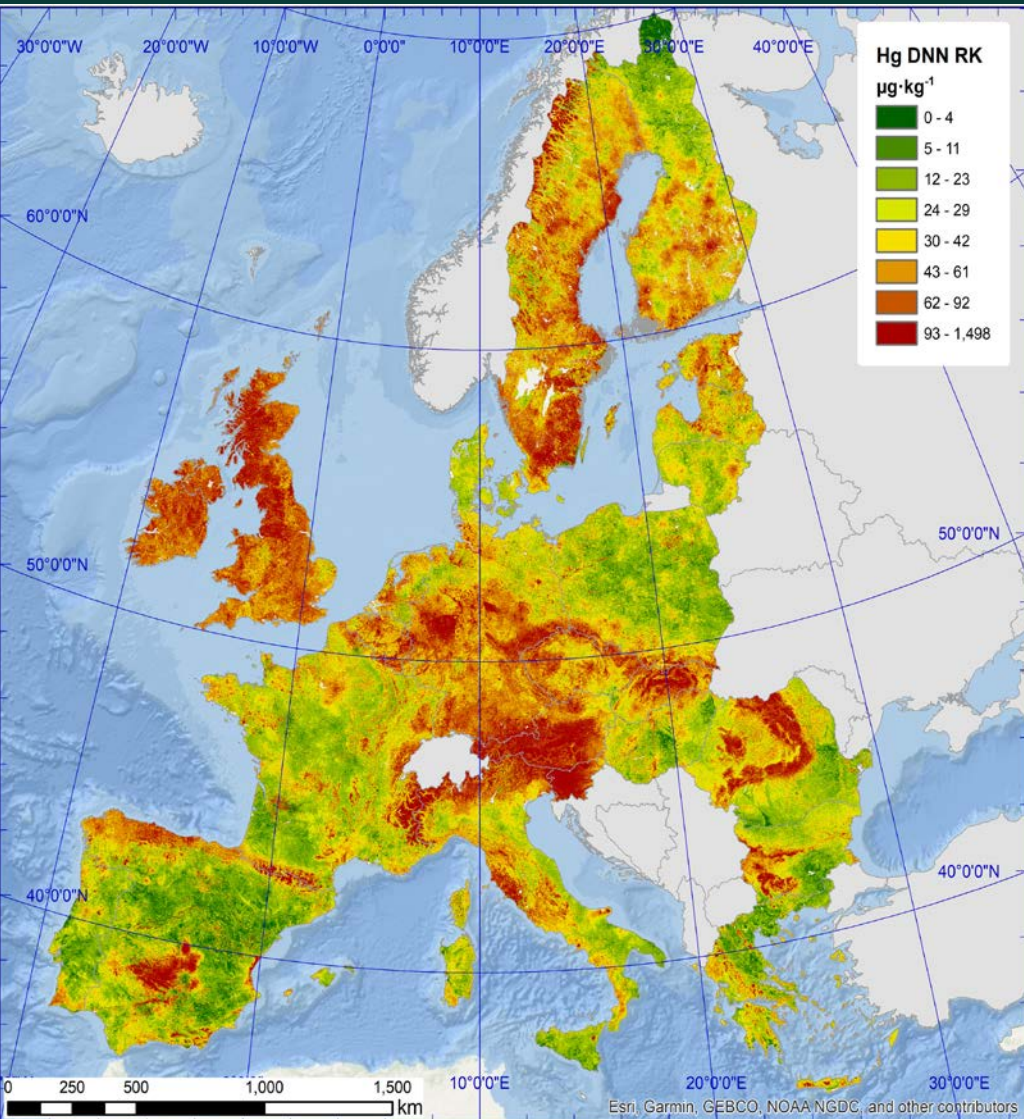
From monitoring chemical, physical and biological soil properties to modelling the spatial distribution of soil properties in the EU



- Coarse fragments
- **particle-size distribution (clay, silt, sand)**
- pH
- Organic carbon
- Carbonate content
- **Total nitrogen content**
- **Extractable potassium content**
- **Phosphorous content**
- Cation exchange capacity
- Electrical conductivity
- Heavy Metals
- Multispectral properties
- Pesticides (90 substances)
- Neonicotinoid insecticides
- Fungicides (e.g. copper in soils)
- Herbicides
- Antibiotics
- Soil Biodiversity



Mercury (Hg) distribution in EU soils



Toxic elements such as arsenic (As), lead (Pb) and mercury (Hg) poses a significant risk to **human health** The case of **Minamata mercury contaminated fish** (1950's).

Low levels in EU – only 0.8% higher than 0.5 mg Kg^{-1} (**Threshold**)

Mercury **natural** distribution in soils is linked to **soil organic carbon, temperature, NDVI and land cover.**

The main **anthropogenic source** is the **mining activities** (Mt Amiata, Asturias, Idrija-Slovenia) and Coal power plants, Chlor-Alkali industry

Hg pool in EU topsoils: 44.8 Million tons Science of the Total Environment 769 (2021) 144755



A spatial assessment of mercury content in the European Union topsoil

Cristiano Ballabio ^{a,*}, Martin Jiskra ^b, Stefan Osterwalder ^c, Pasquale Borrelli ^d, Luca Montanarella ^a, Panos Panagos ^a

^a European Commission, Joint Research Centre (JRC), Ispra, Italy

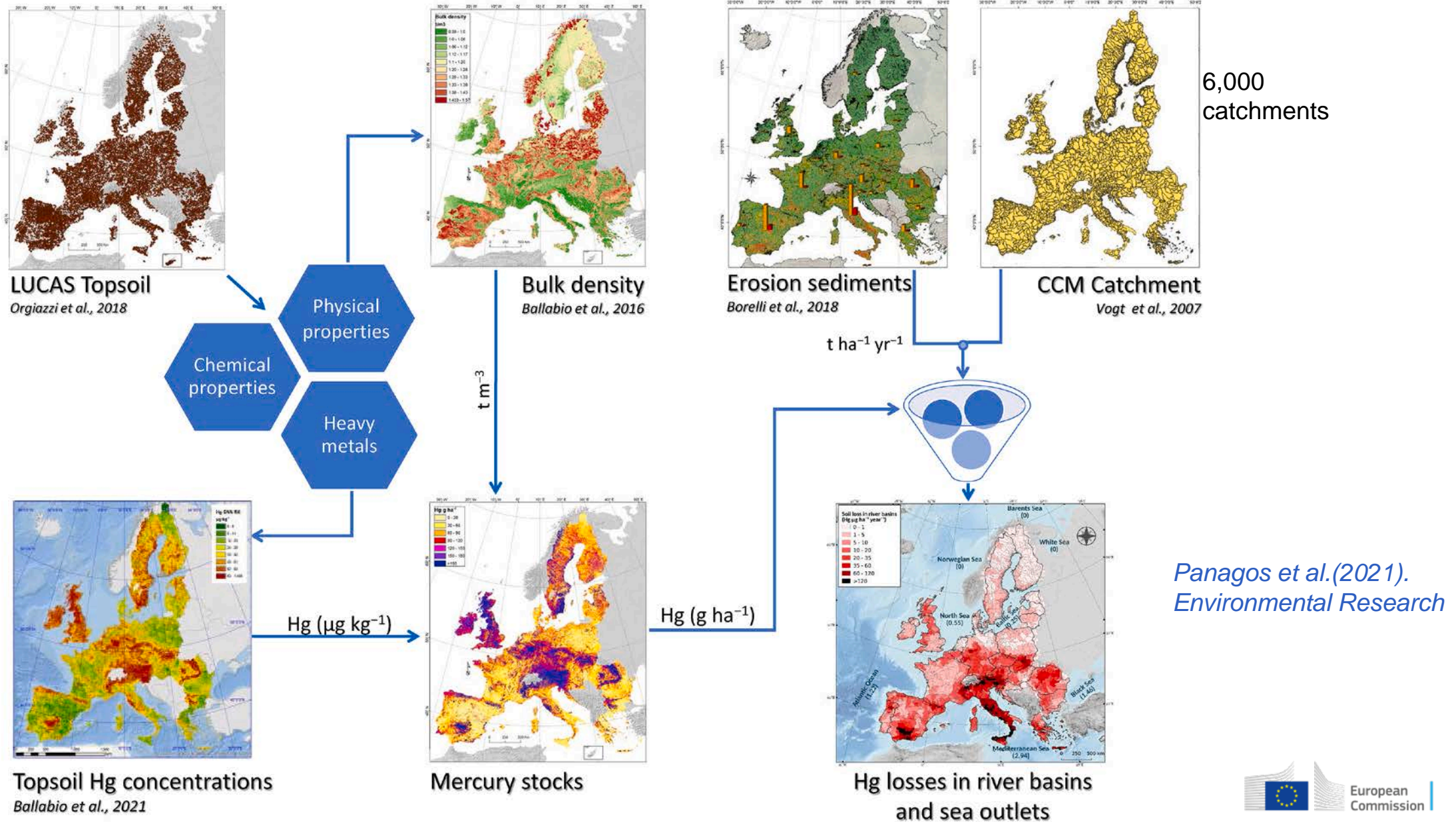
^b Environmental Geosciences, University of Basel, Basel, Switzerland

^c Université Grenoble Alpes, CNRS, IRD, Grenoble INP, IGE, Grenoble, France

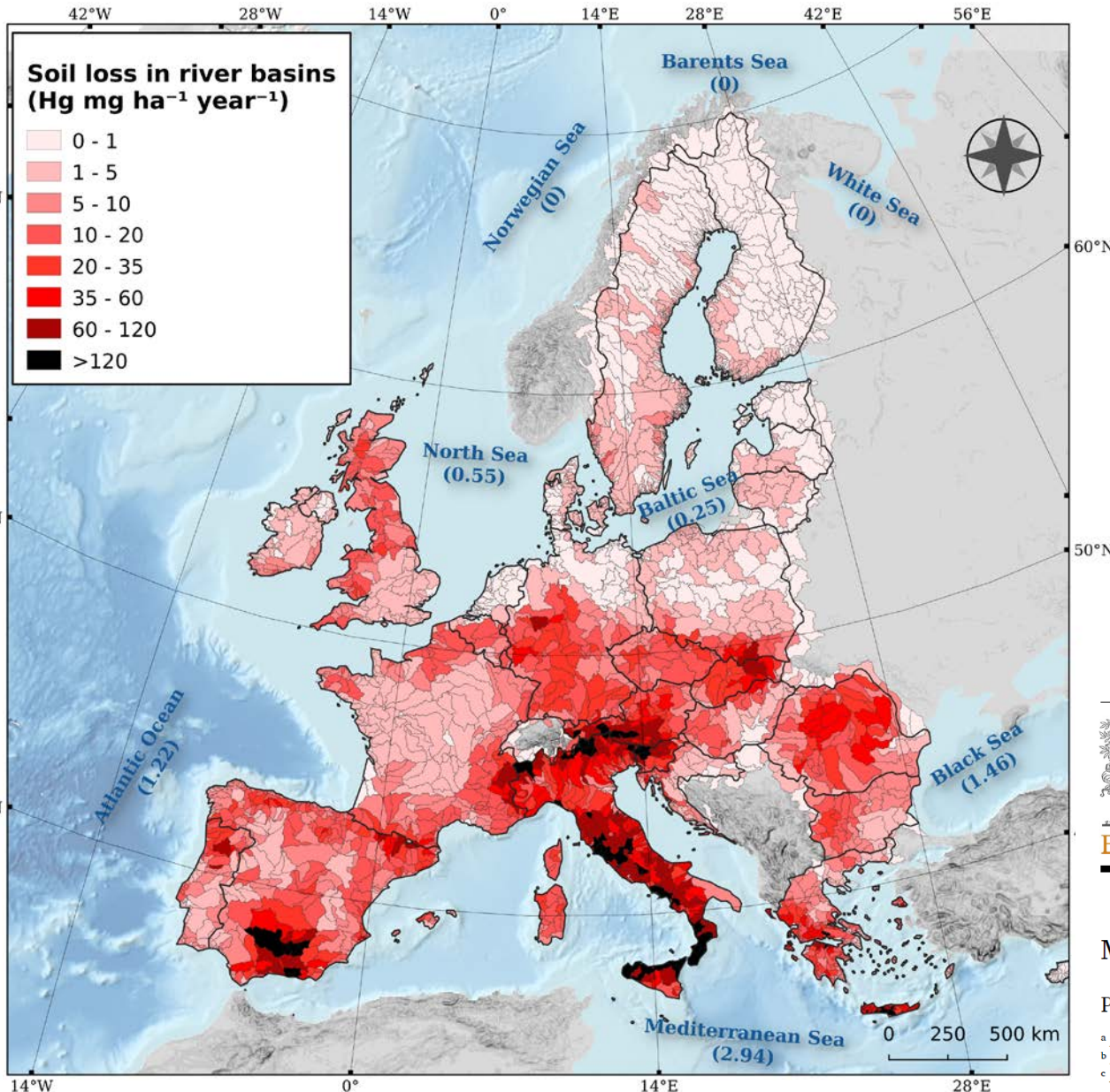
^d Università degli Studi di Pavia, Dipartimento di Scienze della Terra e dell'Ambiente, Pavia, Italy



Integration of Mercury (Hg) with sediment losses



Mercury losses with sediment fluxes



Displaced Hg: 43 tonnes Hg yr⁻¹. (102 mg Hg ha⁻¹ yr⁻¹)

Fluxes to river basin and sea outlets:

- 6 tonnes Hg yr⁻¹
- 14 mg Hg ha⁻¹ yr⁻¹
- **14% of the displaced Hg is routed to river basins** (the rest 86% deposited in the closest field)
- **Mediterranean basin** has the highest pressure due to combined high sediment fluxes and many Hg hotspots.

Environmental Research 201 (2021) 111556

Contents lists available at [ScienceDirect](#)

Environmental Research

journal homepage: www.elsevier.com/locate/envres



ELSEVIER



Mercury in European topsoils: Anthropogenic sources, stocks and fluxes

Panos Panagos^{a,*}, Martin Jiskra^b, Pasquale Borrelli^c, Leonidas Liakos^a, Cristiano Ballabio^a

^a European Commission, Joint Research Centre (JRC), Ispra, Italy

^b Environmental Geosciences, University of Basel, Switzerland

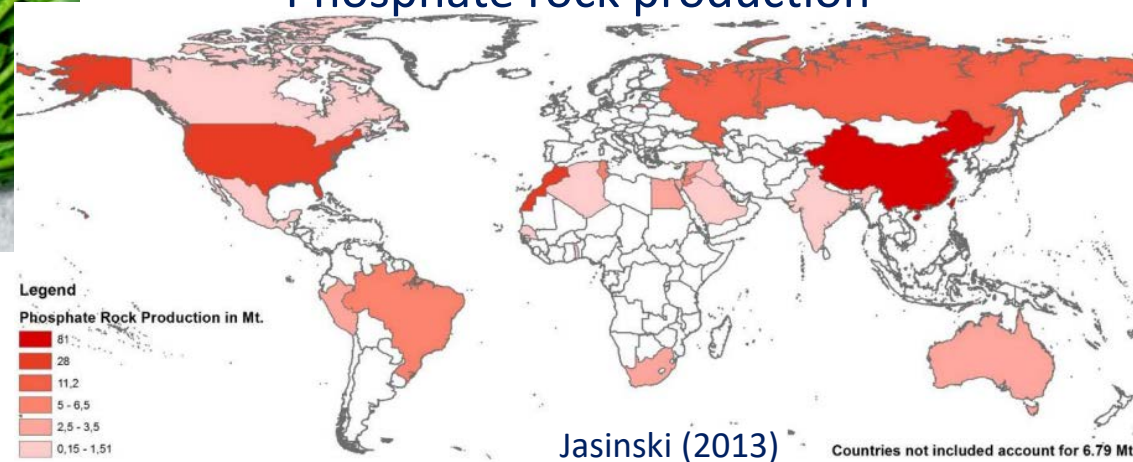
^c Department of Earth and Environmental Sciences, University of Pavia, 27100, Pavia, Italy

Importance of Phosphorus



Important for agriculture
Crucial for plant nutrition and food security

Phosphate rock production



Eutrophication in fresh waters



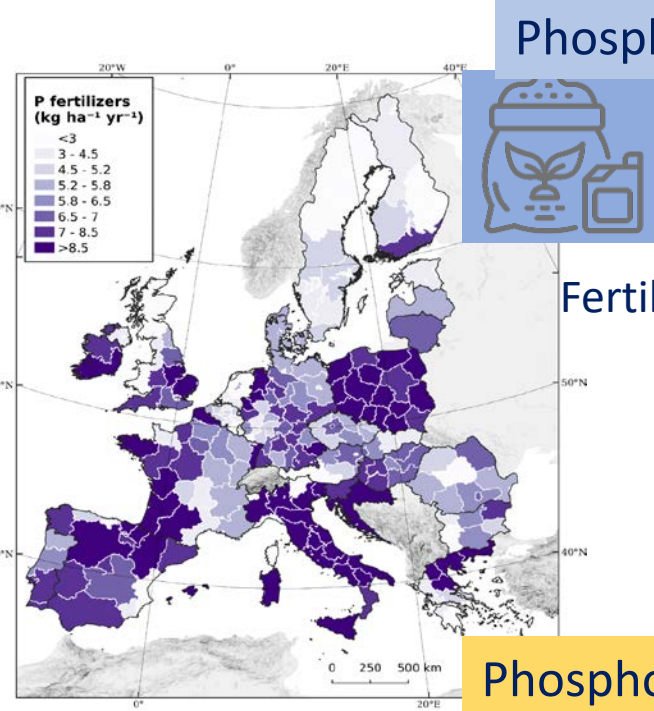
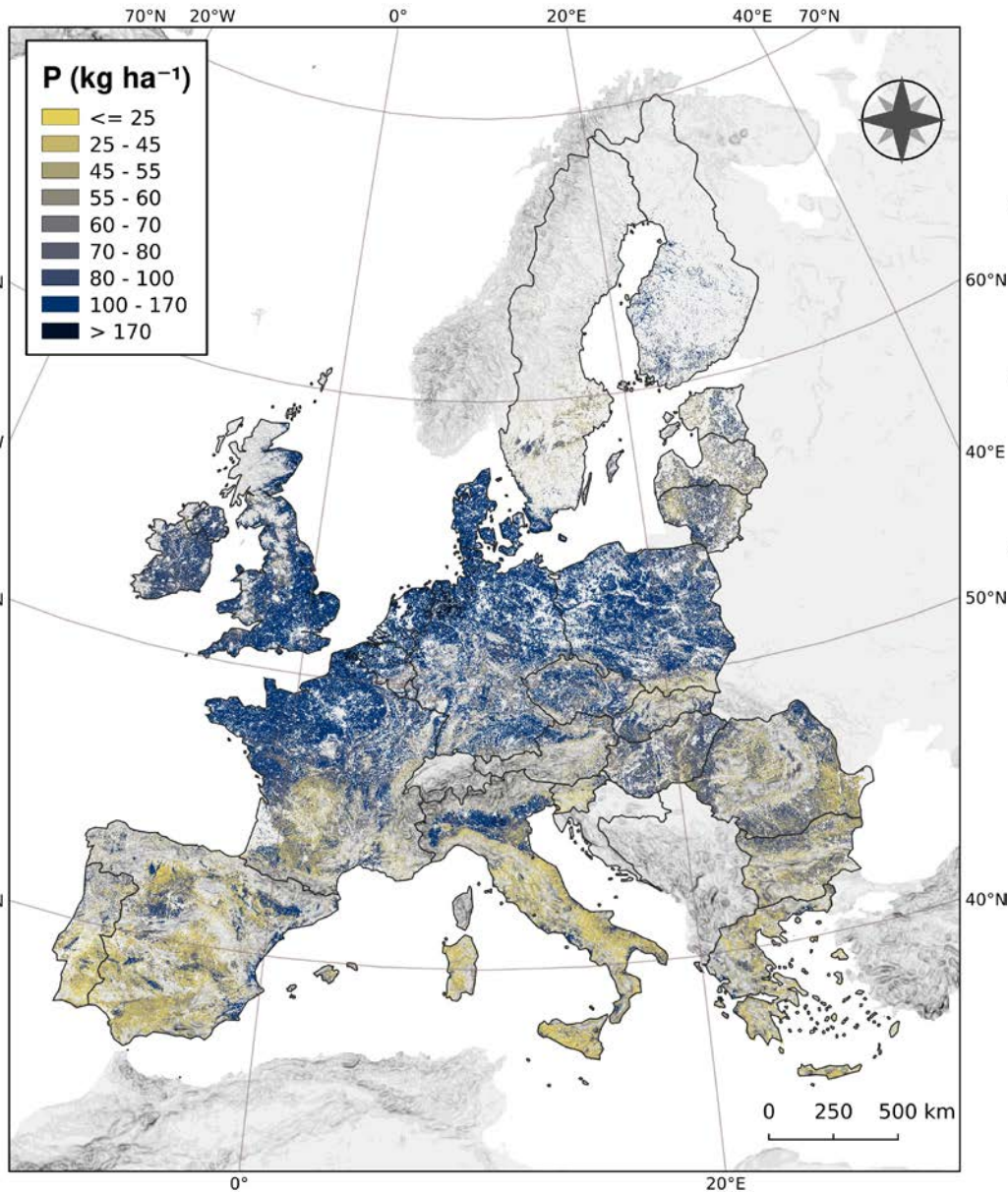
Agriculture: Common Agricultural Policy (CAP)

Environment: Zero Pollution Action Plan, Integrated Nutrient Management

Trade: Costs of fertilizers

Plus: Farm to Fork

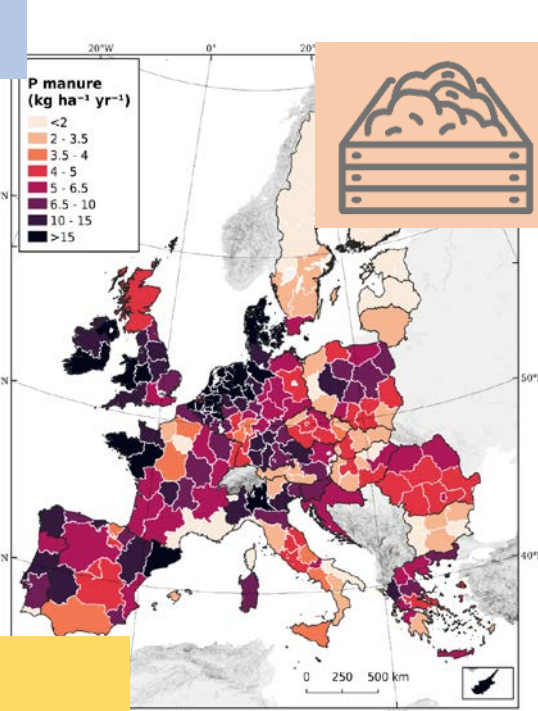
Phosphorus stocks in EU agricultural soils



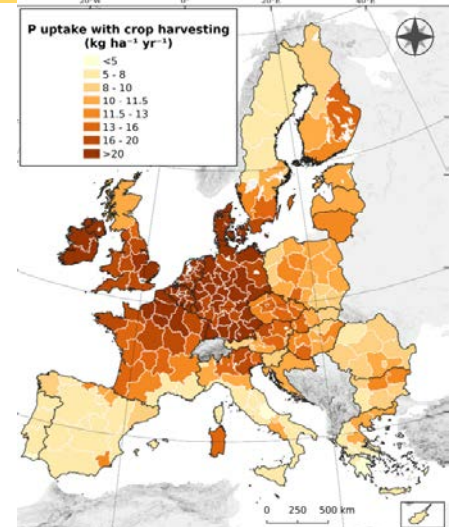
Phosphorus inputs

Fertilizers

Manure



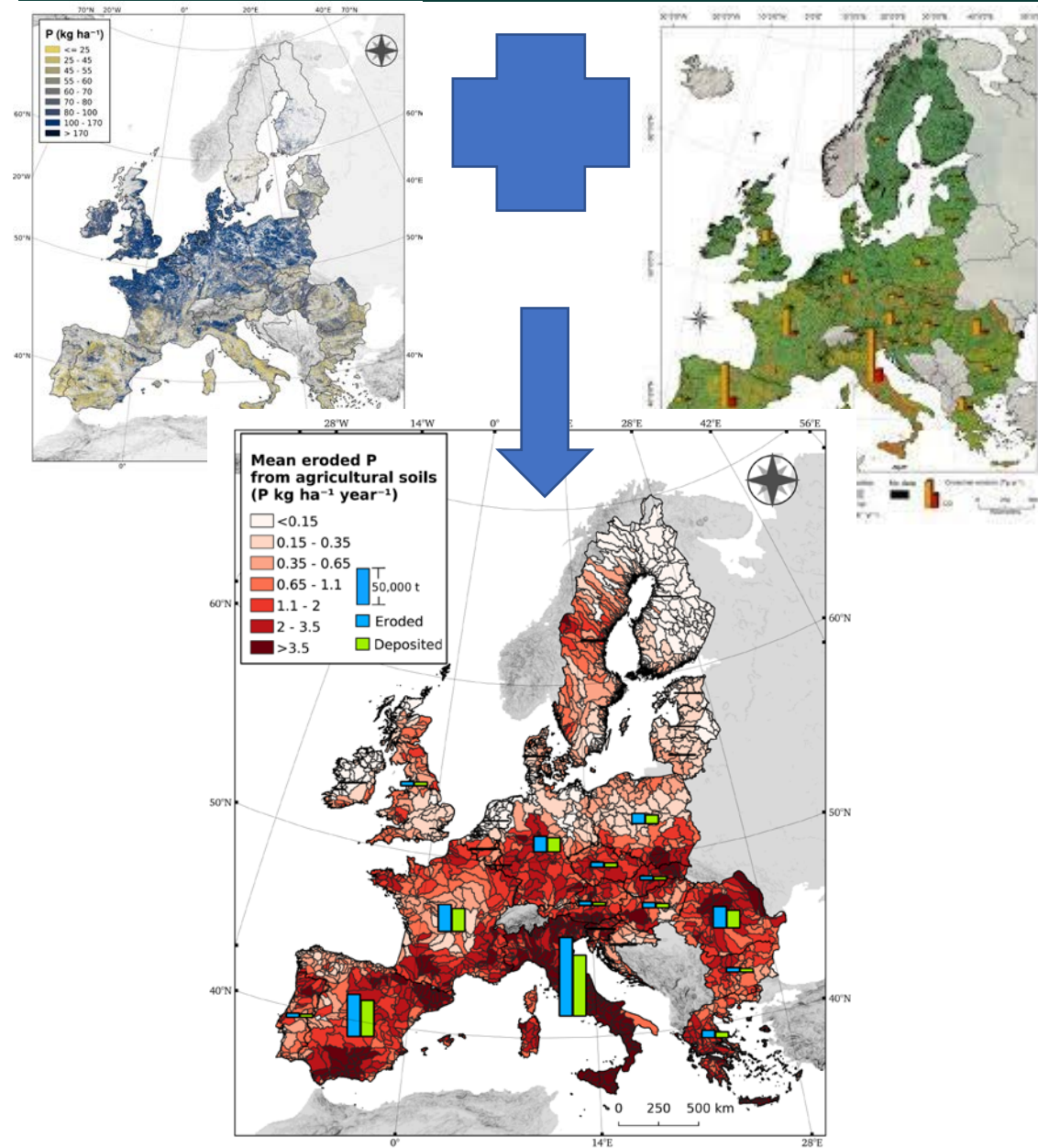
Phosphorus outputs



Mean annual crop productivity (t ha⁻¹)

Plant residue production

Phosphorus and soil erosion



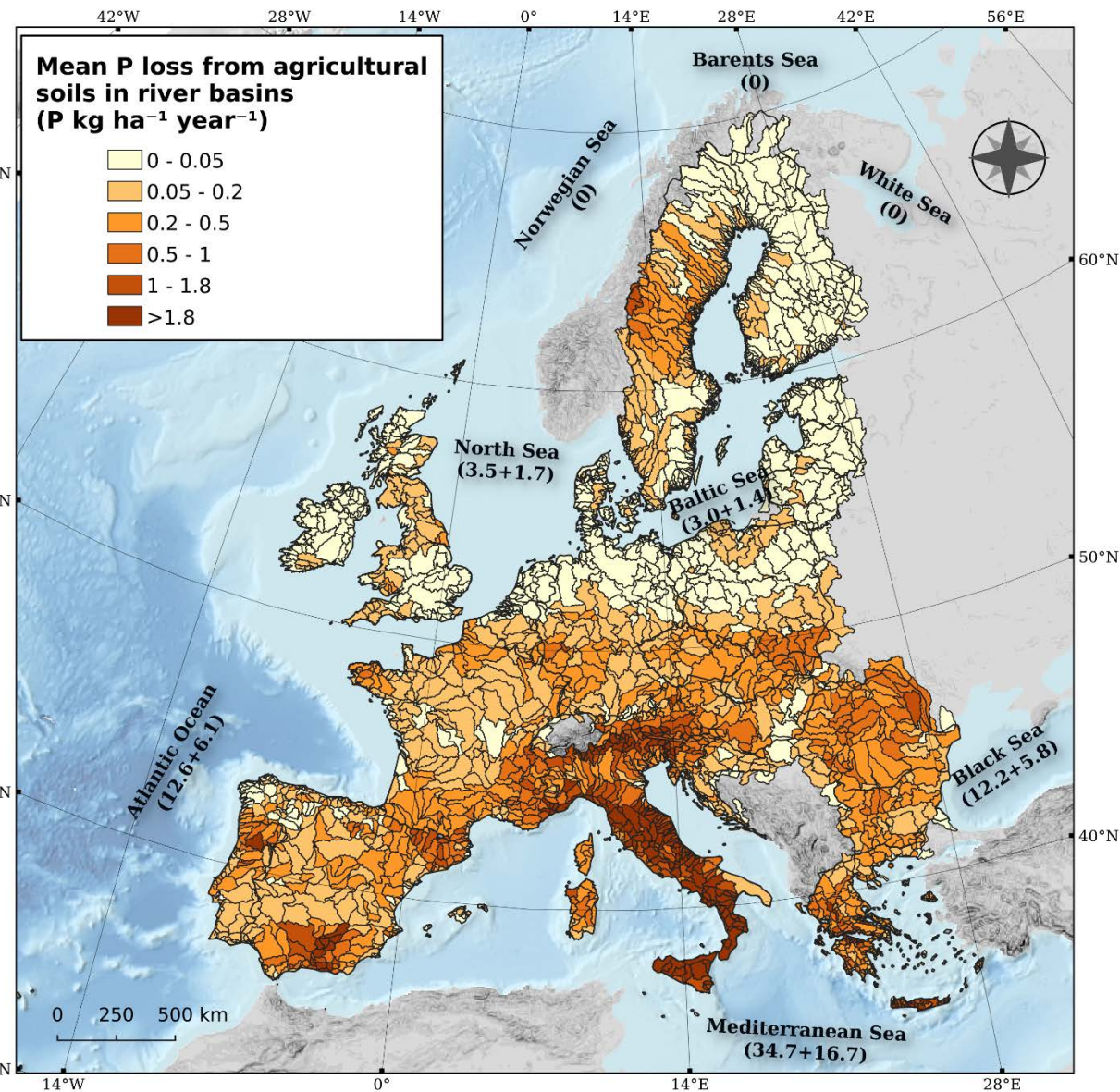
Coupling P total stocks in EU agricultural soils (Source: LUCAS) with (+) Soil loss by water erosion (WATEM/SeDEM model)

Estimate the phosphorus loss due to water erosion to:

- 370,000 tonnes of P displaced ($2 \text{ kg ha}^{-1} \text{ yr}^{-1}$)
- 82% deposited in the field / 18% lost in the river basins and sea outlets.

Grouped by 6,000 major catchment in EU (source: CCM River and Catchment Database)

P losses to river basins and sea outlets



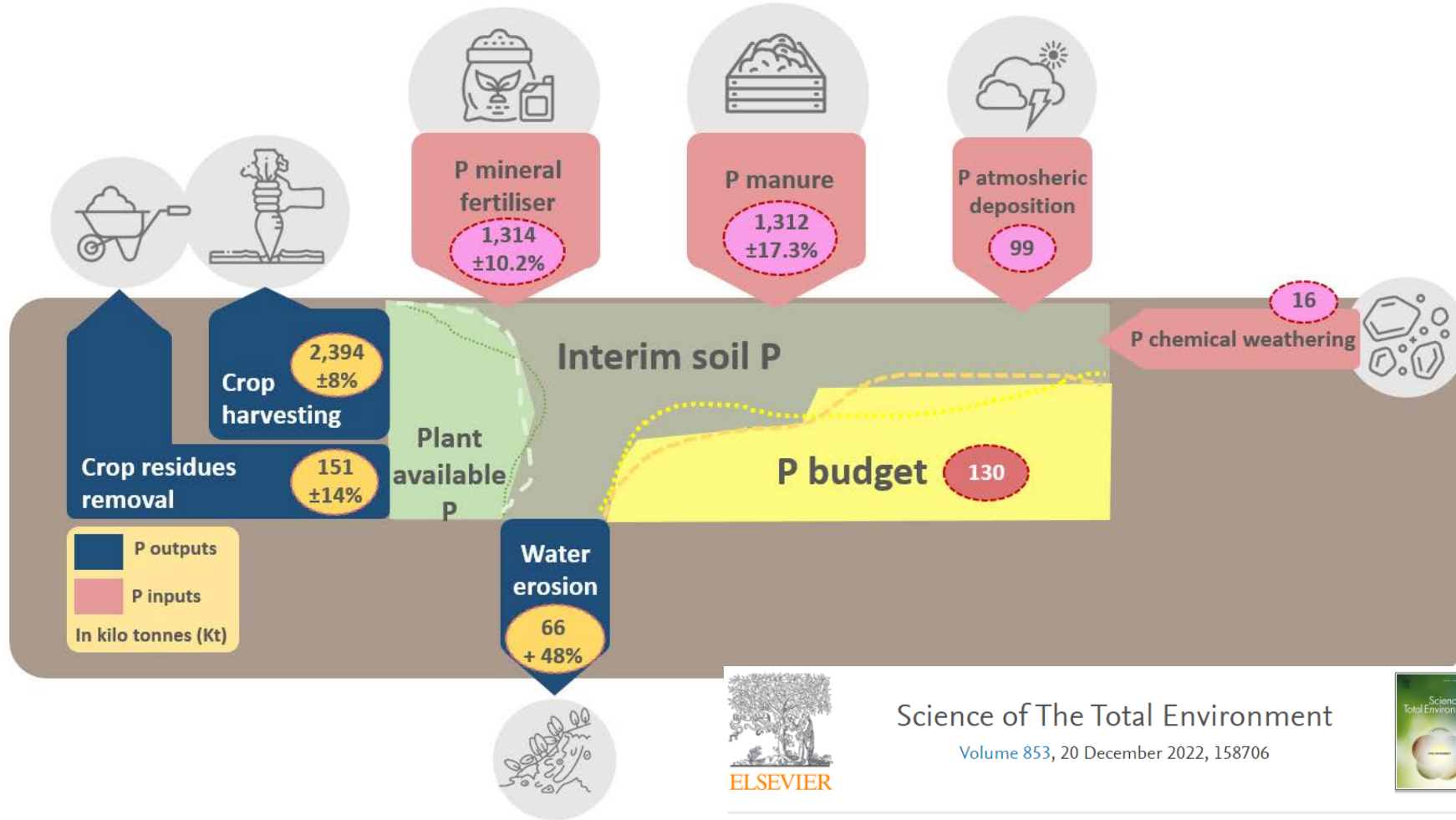
Phosphorus routed in rivers and sea outlets is a small portion (15-20%) compared to the total P displaced

Total P fluxes to river-basins and sea outlets: **100,000 tonnes ($0.4\text{-}0.5 \text{ kg P ha}^{-1} \text{ yr}^{-1}$)** taking into account the enrichment factor)

Italy has 4 times higher P losses compared to the mean EU

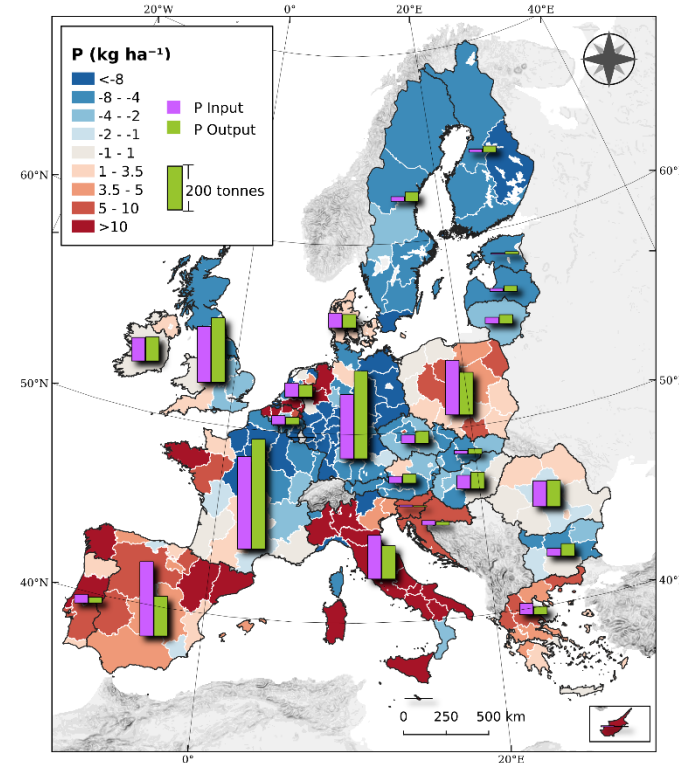
Mediterranean Sea: almost half of P losses

Phosphorus budget in EU agricultural soils



In the EU, we estimated an average surplus of $0.8 \text{ kg P ha}^{-1} \text{ yr}^{-1}$ with **high variability between countries & some regional variations**

Ample possibility to improve P management at regional scale by **reducing inputs in regions with high surplus** rebalancing fertilization



Science of The Total Environment
Volume 853, 20 December 2022, 158706

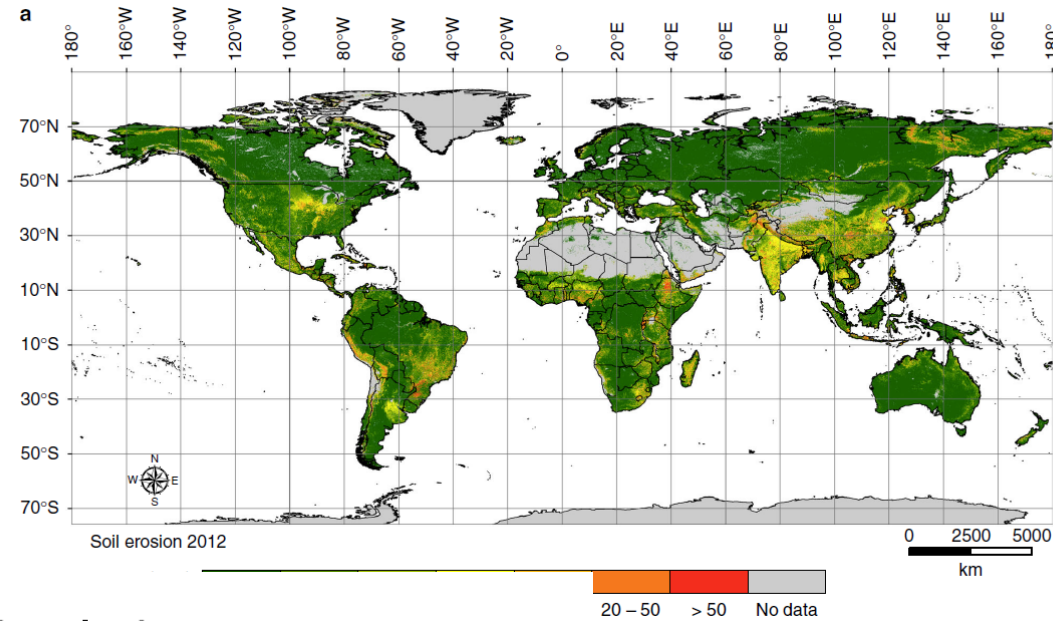


Improving the phosphorus budget of European agricultural soils

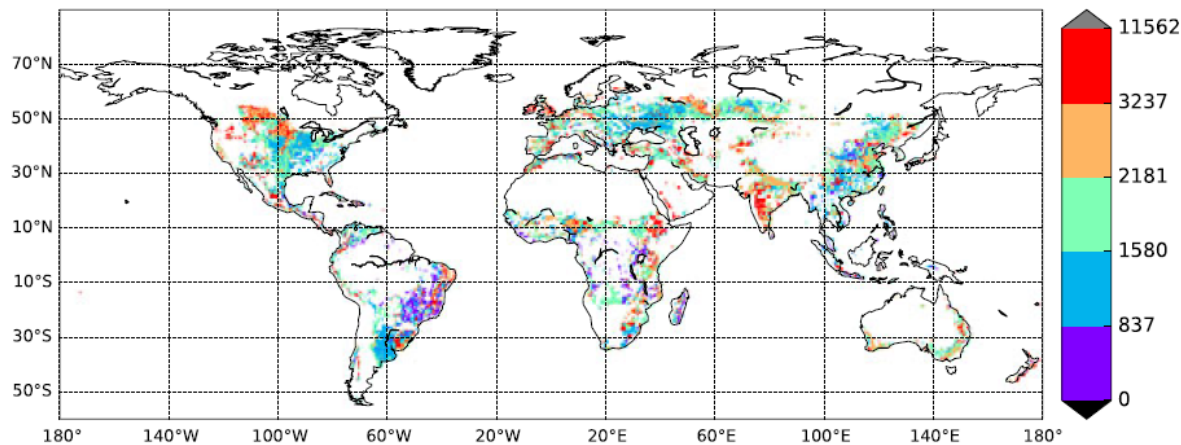
Panos Panagos ^a, Julia Köningner ^a, Cristiano Ballabio ^a, Leonidas Liakos ^a, Anna Muntwyler ^a, Pasquale Borrelli ^b, Emanuele Lugato ^a

Global approach: assessing P loss due to soil erosion

Spatially discrete soil erosion rates from Borelli et al., 2017



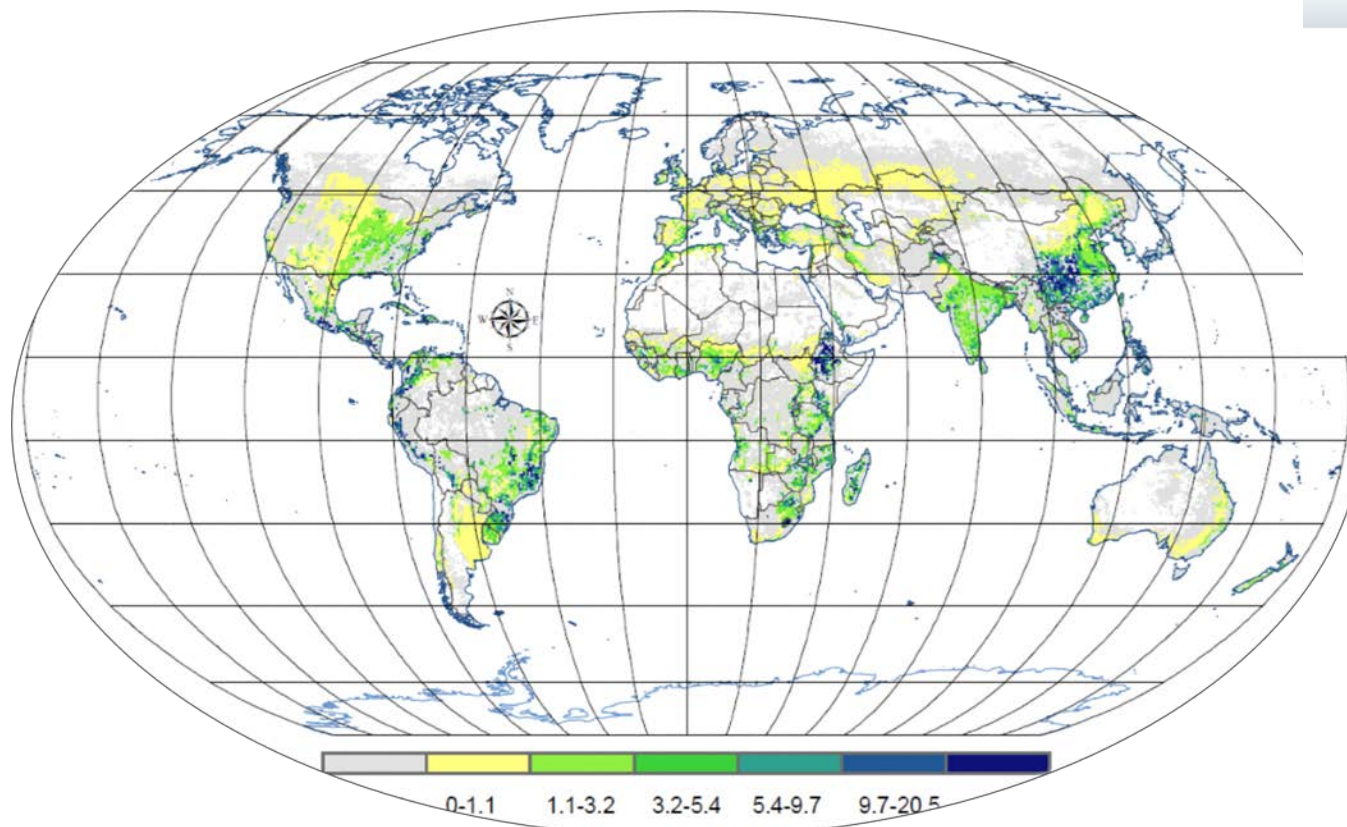
P_{TOT} : mean of the simulations



Spatially discrete soil P contents from Ringeval et al., 2017

(kgP ha⁻¹)

Obvious but overlooked: soil erosion neglect in the global phosphorus cycle



Global P losses due to soil erosion ($\text{kg P ha}^{-1} \text{ yr}^{-1}$)

ARTICLE

<https://doi.org/10.1038/s41467-020-18326-7>

OPEN



Global phosphorus shortage will be aggravated by soil erosion

Christine Alewell¹, Bruno Ringeval², Cristiano Ballabio³, David A. Robinson⁴, Panos Panagos³ & Pasquale Borrelli^{1,5}

- Very high losses: Eastern China, Indonesia, regions of south-eastern Africa, Central America and South America
- High losses: most of India, regions of Southern Africa and South America

Concluding remarks

- **Phosphorus losses of high importance** for agriculture, environment and farmers income.
- JRC/EUSO studies focus not only in **spatial distribution** but also explaining the **main reasons** behind the high concentrations; important to identify not only surplus but also deficit.
- Importance of modelling **Sediments distribution**
- **Modelling integration**: Soil pollution (Heavy metal, microplastic, pesticides, etc) → Sediment transport → water pollution (eutrophication)
- **Policy challenges (in the area of EU Green Deal)**: The Zero Pollution Action Plan, Farm to Fork, Soil Mission, Soil Monitoring Law

panos.panagos@ec.europa.eu

<http://esdac.jrc.ec.europa.eu>

@PanosPanagos33

Thank you for your attention!



EU SOIL
OBSERVATORY