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StatEO

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Sen4Stat: leveraging EO data and in-situ surveys for agricultural statistics

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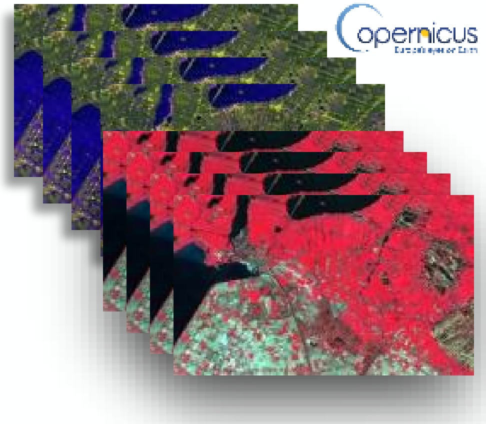
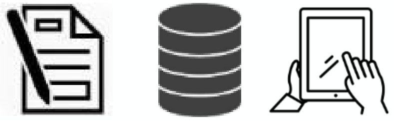
1: UCLouvain, Belgium; 2: FAO

Sen4Stat: coupling EO data and statistical surveys for improved agricultural statistics

Sentinel-1 and -2

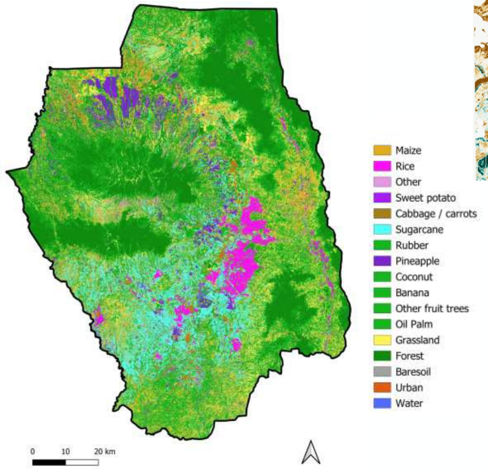


Agri. surveys

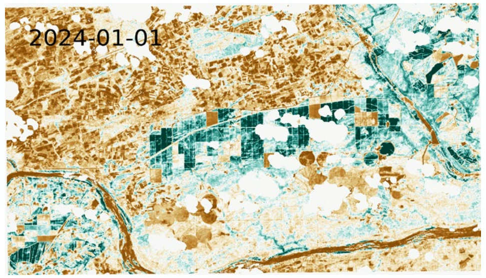


EO products

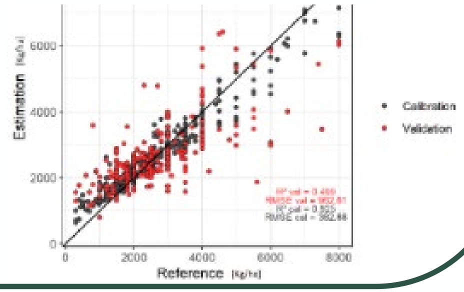
PHILIPPINES – BUKIDNON province
Crop type map



ZIMBABWE
Crop growing metrics evolution



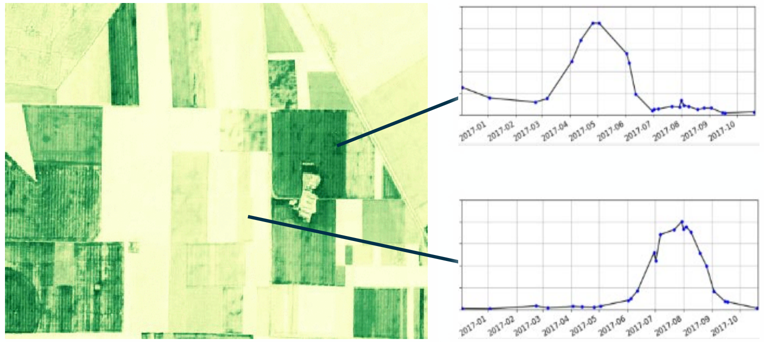
SPAIN – CASTILLA Y LEON
Soft wheat yield estimation



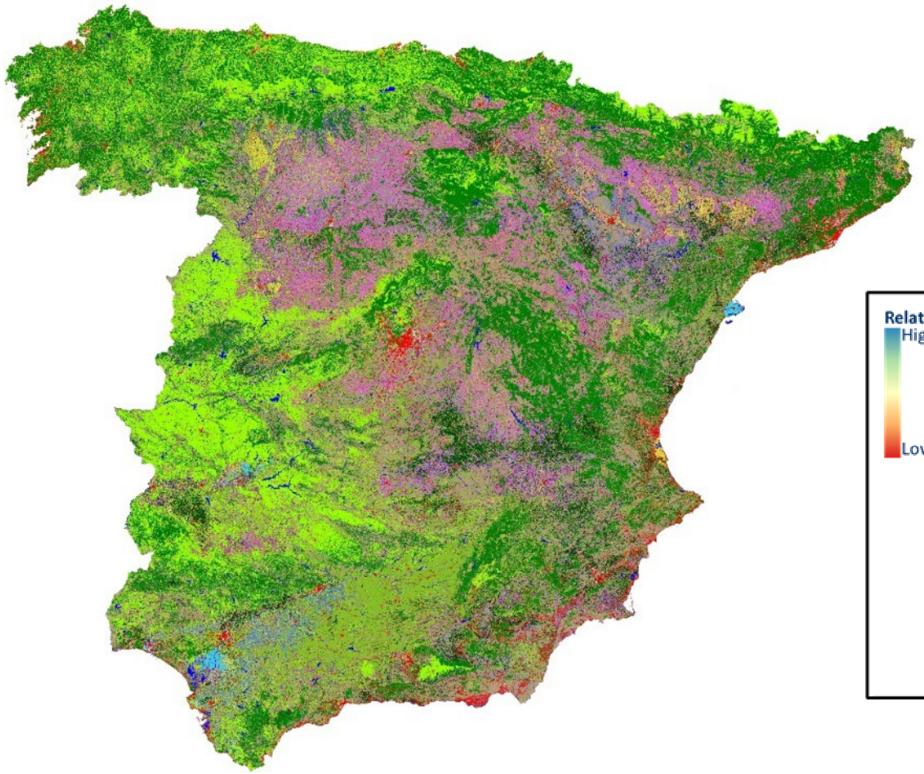
Key EO Impacts

- COST EFFICIENCY
- STAT. GRANULARITY
- STAT. TIMELINESS
- SAMPLING DESIGN
- SURVEY & DATA QA
- DOWNSTREAM APPLICATIONS

Sen4Stat: an ESA open-source SAR and optical toolbox for operational crop type mapping and monitoring at national scale

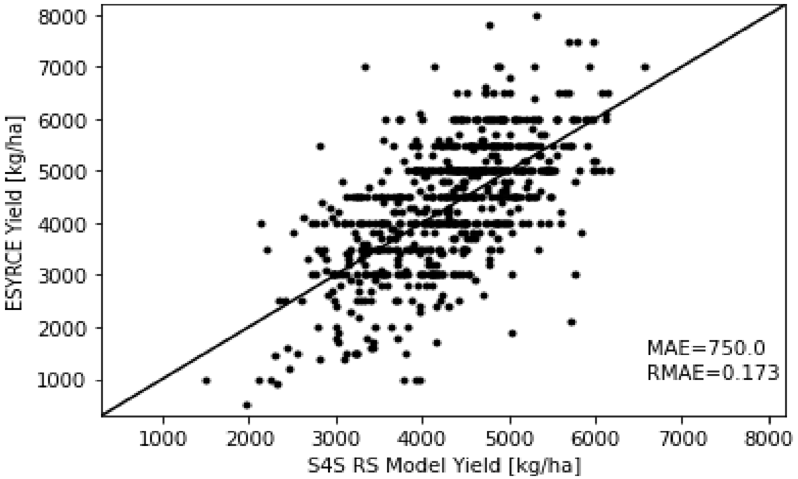


1. **Optical 10m cloud free temporal synthesis and SAR temporal synthesis**
2. **Time series of spectral indices** (NDVI, coherence,…) and **biophysical variables** (LAI, fCover, fAPAR)
3. **10m crop type maps** along the season based on in situ dataset and stratification
4. **A large set of crop growth conditions metrics**
5. **Crop yield estimation** at various aggregation levels (national, regional, …)



EO Yield Model

Barley Two Row

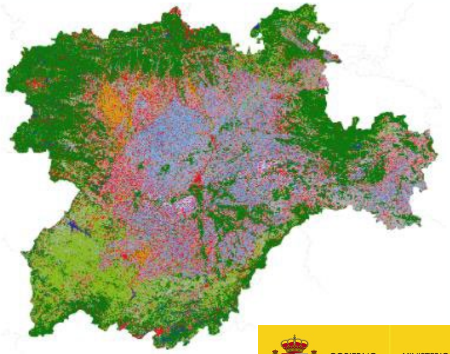


Sen4Stat: Integrating EO significantly decreases the error for acreage estimates of main crops

Integrated list and area ESYRCE 2020

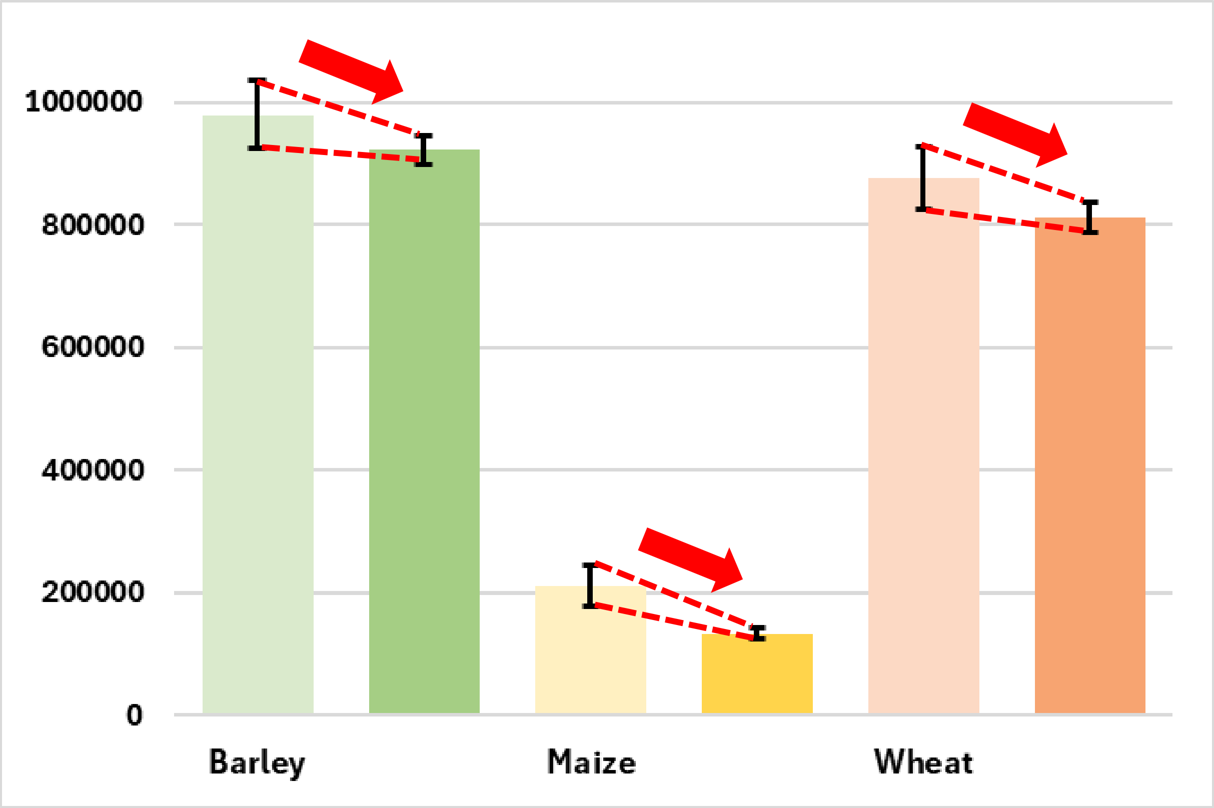
Inference

Crop type map (OA >85%)



Reg. Est.

Acreage estimates for 3 main crops in Castilla y Leon (2020)

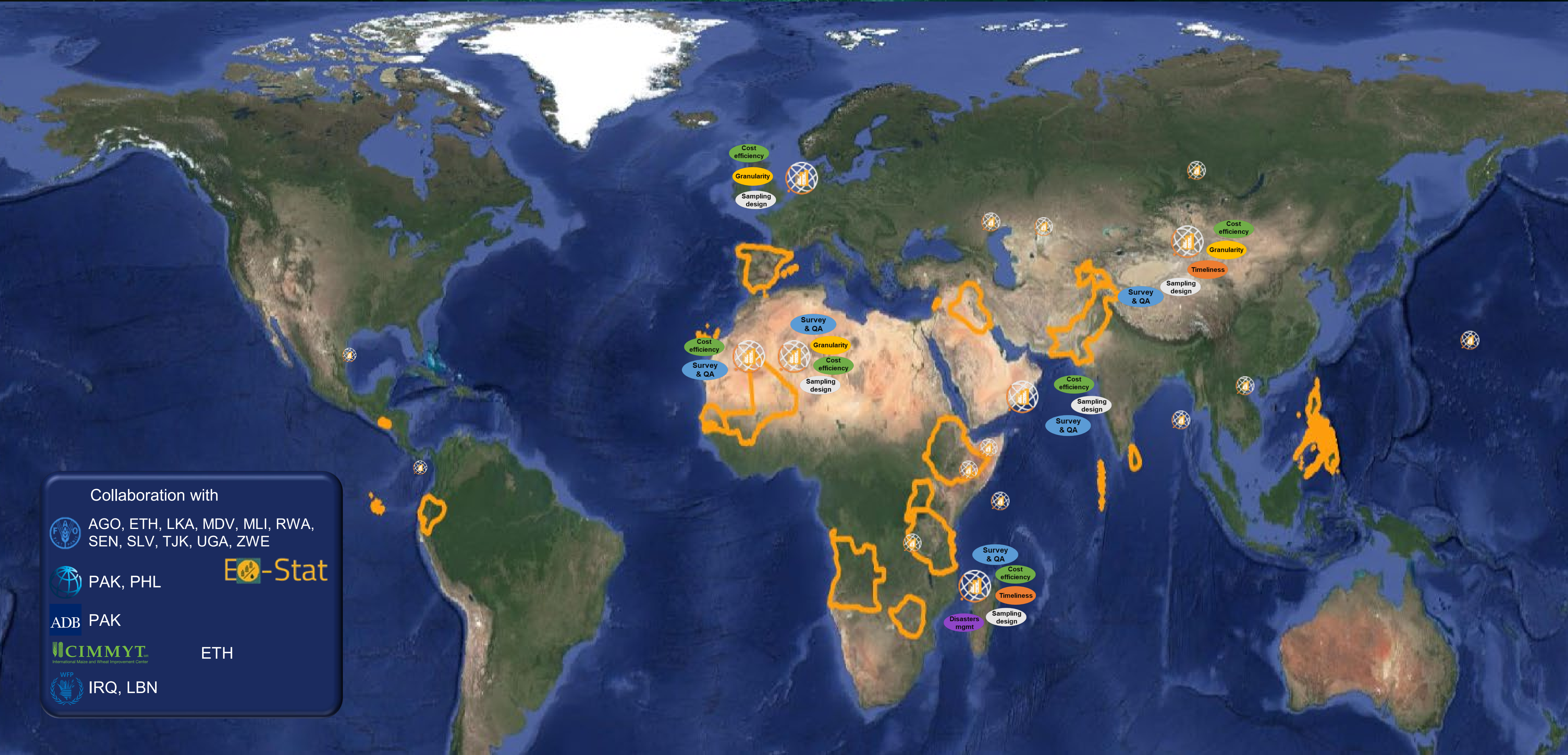


5,73	16,64	4,36

EO+ESYRCE Relative Efficiency >>> 1

Integrating **EO** data allows **increasing the estimation precision** at **marginal cost**

Sen4Stat implementation in 6 countries and Sen4Stat feasibility in many more



Capitalizing and complementing existing NSOs surveys to leverage EO assets

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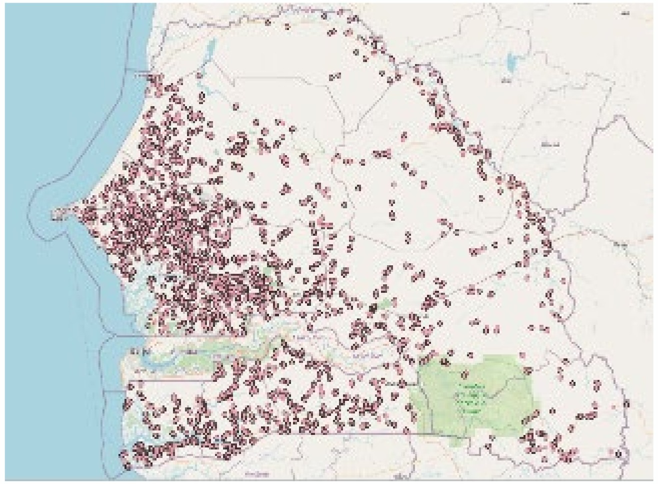
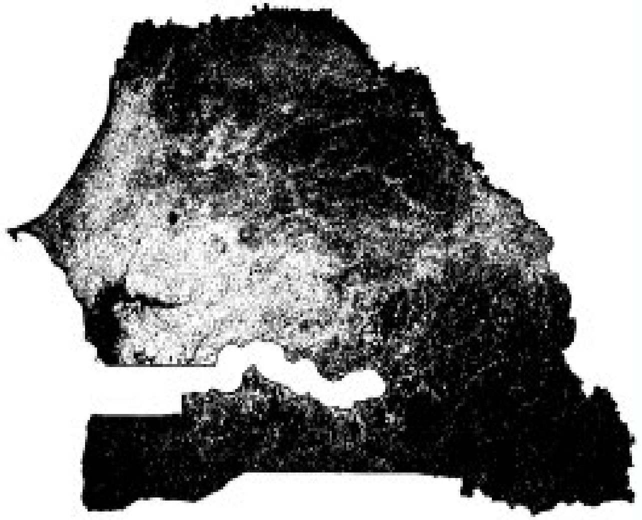
List sampling frame:

Senegal Sen4Stat use case: a small protocol adaptation for enabling operational use of EO data

- ✓ Overall accuracy : 98%
- ✓ Cropland F-Score : 76%
- ✓ Non cropland F-Score : 99%



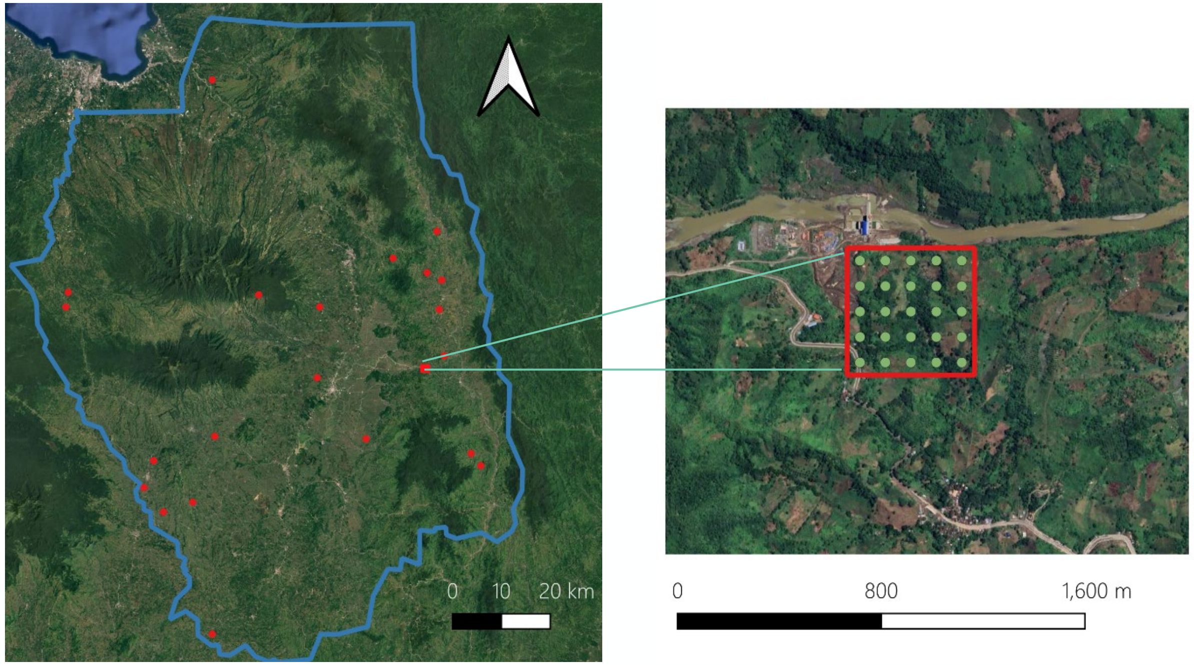


DAPSA FAO Sen4Stat

EOStat project

Area Sampling Frame:

Two-stage stratified design developed by Sen4Stat→ cost-efficient area estimates with uncertainties

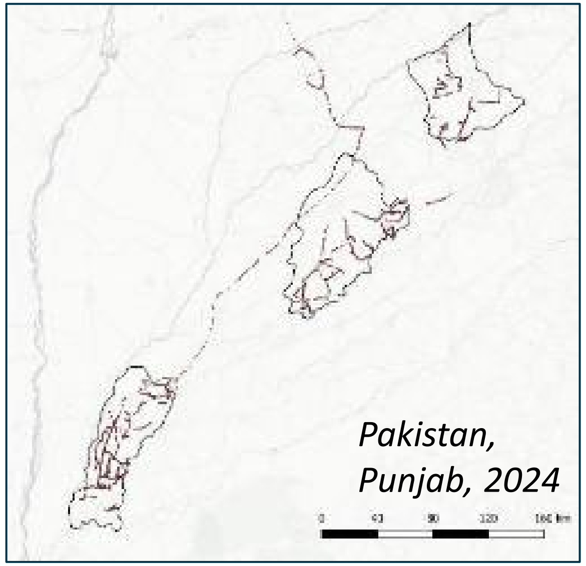


Additional in-situ data for the EO products

1. **Non cropland data for easy classes**
   Easy non cropland area collected once for all years through visual interpretation of VHR imagery or on existing VHR imagery platforms (Bing map, Google map, etc.)

2. **Opportunistic data collection for all other classes**
   By windshield observation along traveling roads or implemented independently to collect enough samples for each crop type (including minor crops, fallows, etc.)

3. **Additional covariates to better interpret EO signal**



Within parcel heterogeneity

Mixed cropping (groundnut >>> maize)

Large in situ georeferenced crop datasets are collected... but most georeferencing are not EO and statistics compatible

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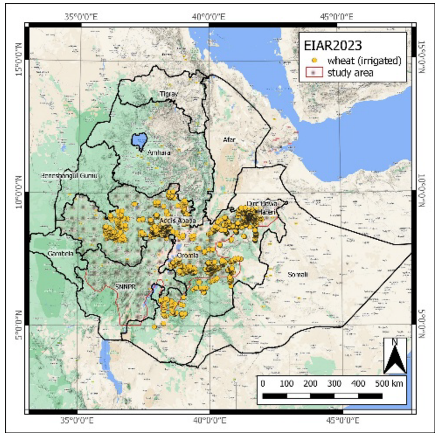
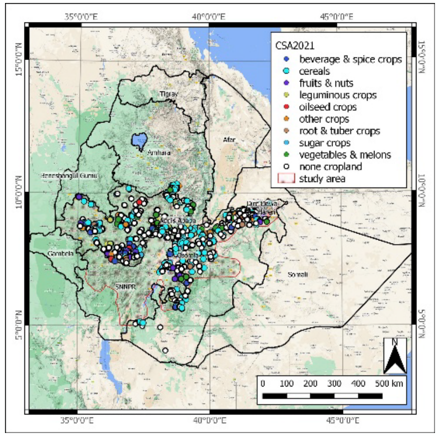
Example 2: Great Ethiopian datasets could not be used for Sen4Rust mapping





EIAR 2023: 16,278 samples in field clusters of irrigated wheat with GPS coordinates from cluster centroids

CSA 2021: 25,598 samples but GPS locations clustered and multiple crops for single sample

EIAR Ethiopian Institute of Agricultural Research

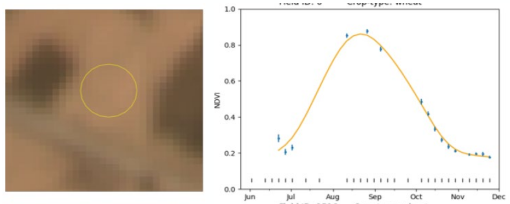
CIMMYT International Maize and Wheat Improvement Center

UNIVERSITY OF CAMBRIDGE

ETHIOPIAN STATISTICAL SERVICE

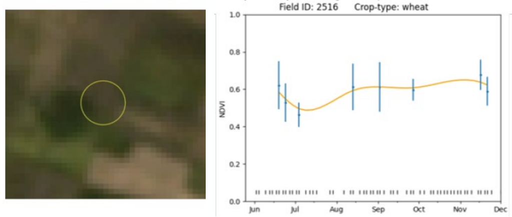
UCLouvain

Intensive quality control combining in situ data sources



Expected NDVI mean and std profile for wheat field from Sentinel-2

=> visual confirmation on Planet cloud-free image



Unexpected NDVI mean and std profile for wheat field from Sentinel-2

=> visual confirmation on Planet cloud-free image

Leading to **2,793 harmonized, quality-controlled georeferenced in situ samples** over Ethiopia

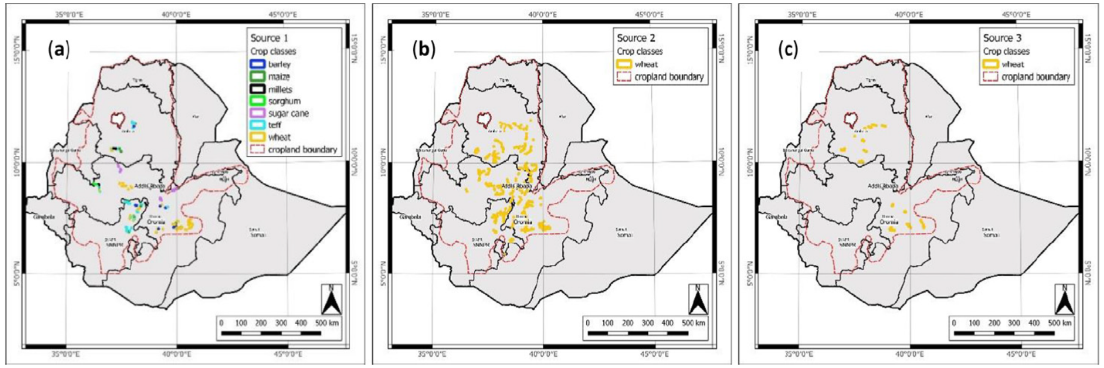


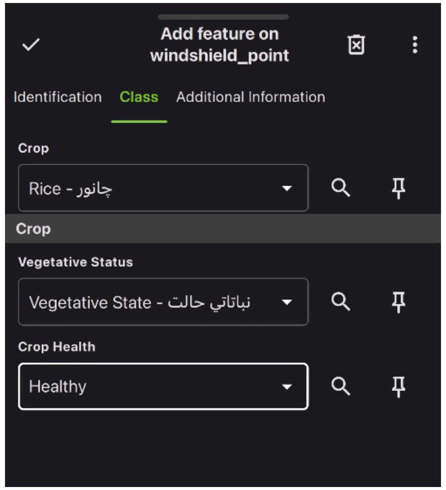
Fig. 2. Location of the source datasets and the distribution of the fields, showing crop classes (**a**) *Source 1* – Ground Data Collection Campaign (GDCC); (**b**) *Source 2* – Wheat Rust Toolbox (WRTB); and (**c**) *Source 3* – Farm Household Survey Database (FHSD).

(Blasch et al. 2024 – *EthCT2020)*

The three roles of in-situ data and the cost-efficiency challenge

1. For calibration to train (AI) models for EO derived crop type and yield estimation
2. For independent validation to assess the quality of EO-derived products
3. For unbiased area and yield estimation at different aggregation levels

Challenge for nation wide campaign: Minimizing costs while meeting all statistical requirements for calibration, validation and unbiased area/yield estimation.



Sen4Stat Hands-on tomorrow at 2:30 p.m. (Science Hub)

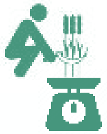
Measuring crop production on the ground: georeferencing also needed

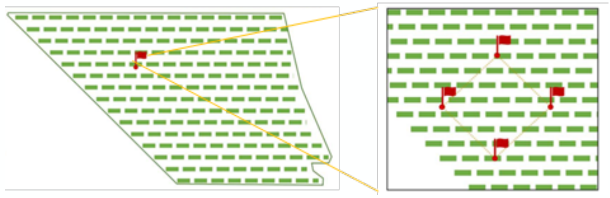
1. Yield value (measurement or estimate) with precise georeferencing coordinates

- At field level: area and location of the field (at harvest time or from farmer)
- At farm level: areas and location of the fields associated to the yield value
- At subplot level: subplot area and location in the field with precise georeferenced data

2. Possible data sources

- Crop Cutting
- Plant Counting / Weighting
- Transport Production Counting (bags/containers)
- Expert Observation
- Farmer Declaration



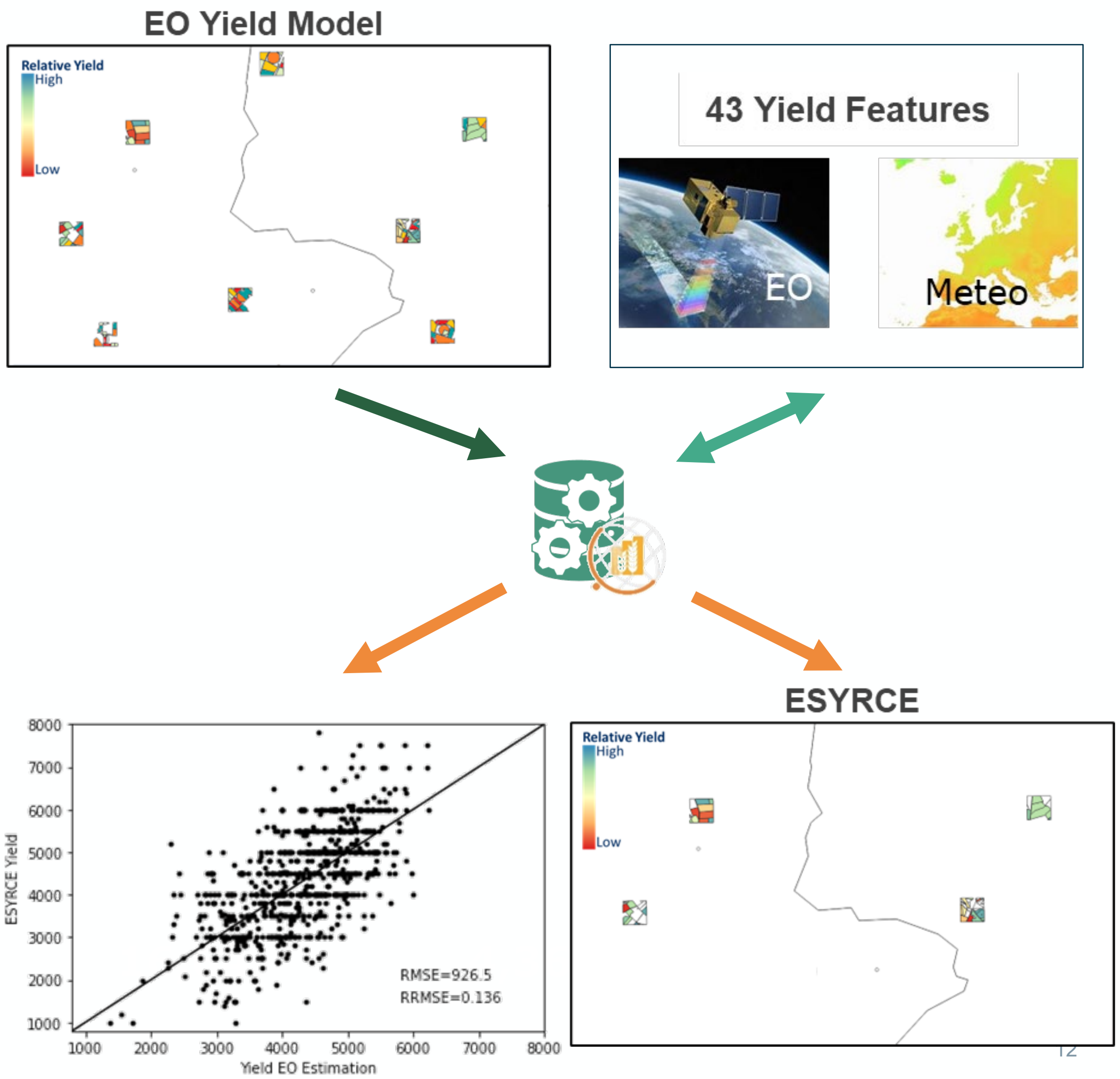


Sen4Stat: EO added-value for yield estimation

Barley yield estimation in Castilla y Leon, 2020

	ESYRCE			EO Yield Model		
	N	Mean	Sd	N	Mean	Sd
Àvila	107	4241.5	**83.0**	150	4232.4	**34.9**
Burgos	315	4826.8	**64.9**	446	4764.3	**38.2**
Leòn	37	3822.0	**103.8**	52	3817.5	**57.0**
Palencia	211	4602.1	**32.3**	302	4557.5	**17.0**
Salamanca	87	4155.8	**63.1**	122	4155.8	**57.9**
Segovia	206	4168.0	**52.5**	294	4134.1	**35.4**
Soria	192	3640.1	**35.2**	275	3542.6	**26.8**
Valladolid	320	4574.6	**37.8**	459	4531.1	**26.5**
Zamora	142	4586.8	**65.0**	204	4569.1	**54.7**
Castilla Y Leòn	1617	4426.5	**16.5**	2304	4391.9	**14.0**

EO for increasing the precision of yield estimation



Large in situ georeferenced crop datasets are collected…
…but most georeferencing are not EO compatible

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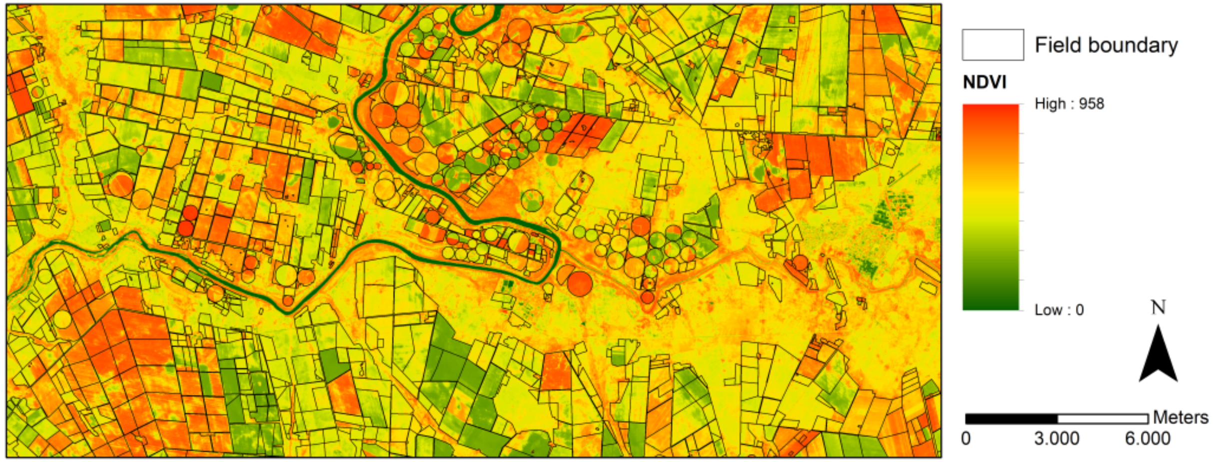
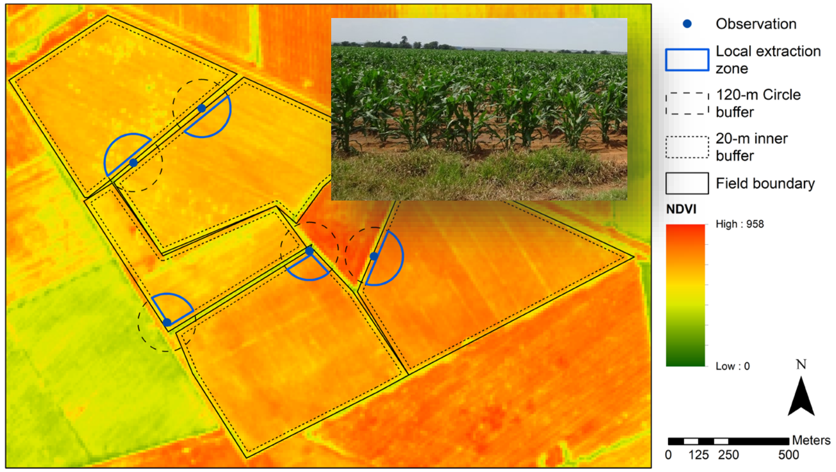
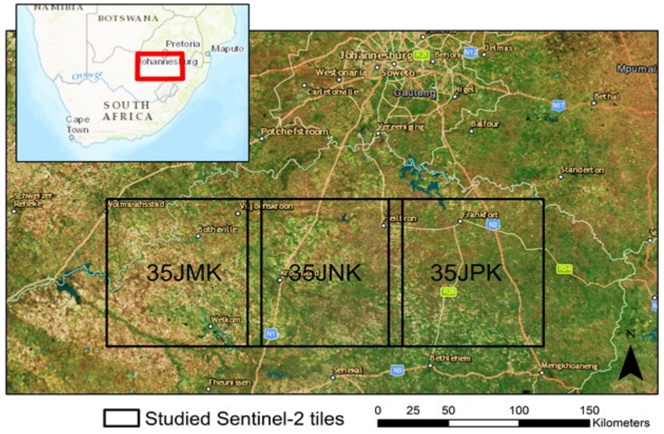
Example 1: Great in situ dataset from insurance company for corn in Free State, South-Africa

Parcel delineation available



Georeferenced in situ observation on the road… but for which roadside ?



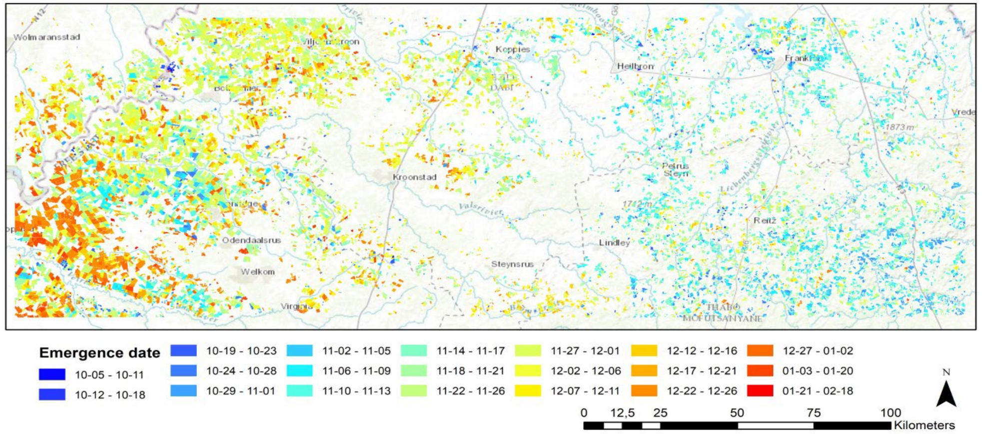


Complementary in situ dataset

ECoLaSS Project

ARC • LNR

Emergence date map for 2016 maize



Pre-requisite to couple satellite images and in-situ data

GPS coordinates at the parcel-level, not at the household-level