Assessing potential of the Sentinel-2 satellite imagery for monitoring of agricultural fields in Poland

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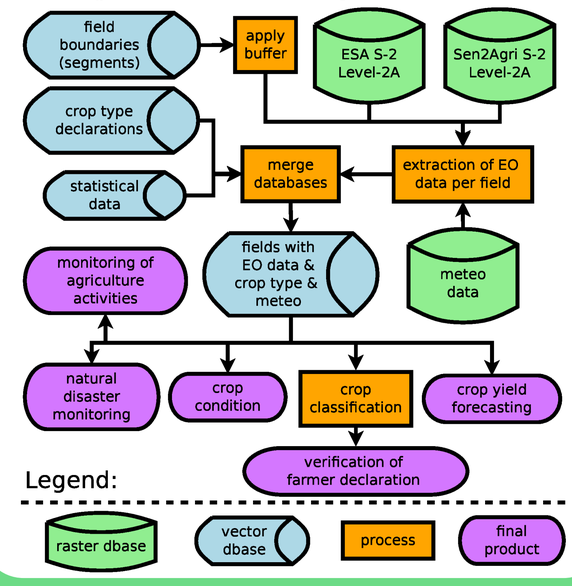
Introduction

The Sentinel-2 (S-2) satellite constellation with the MSI instrument onboard featuring wide swath (290 km), high temporal (5 days) and spatial (10 m) resolutions, provides unprecedented potential for country-scale monitoring of agricultural fields. Consequently, by means of remote sensing techniques, it is possible to recognise crop types and analyse vegetation condition with high accuracy, even in countries (such as Poland) with frequent cloud cover and small agricultural fields. Such information is of great value for the commercial usage (e.g. precision farming, insurance companies) and for the governmental institutions (e.g. Ministry of Agricultural, paying agencies, statistical offices). In this respect, the ESA EOStat project will provide operational system for agriculture monitoring in Poland based on the Sentinel-1, -2, -3 data, that will support: (1) generation of statistical data on agricultural production and (2) verification of farmers' obligations under the Common Agricultural Policy.

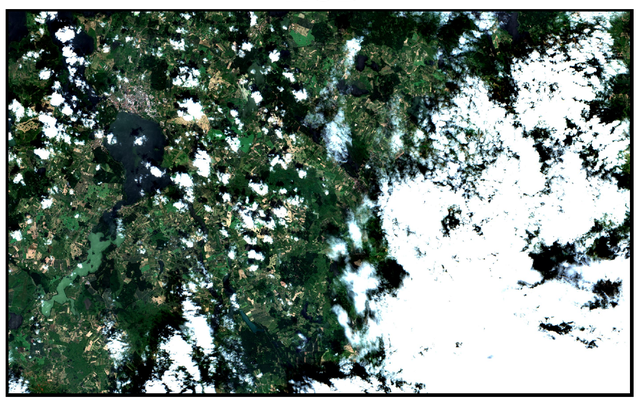
Objectives of the study

The main aim of this study is to assess the potential of two Sentinel-2 Level-2A products (ortorectified, geocoded and atmospherically corrected reflectances) for agricultural monitoring. The first dataset is the official ESA product acquired directly from the https://scihub.copernicus.eu. The second S-2 Level-2A product was generated from the official S-2 Level-1C ESA product by mean of the MACCS processor embeded in the Sen2Agri v1.8.3 system.

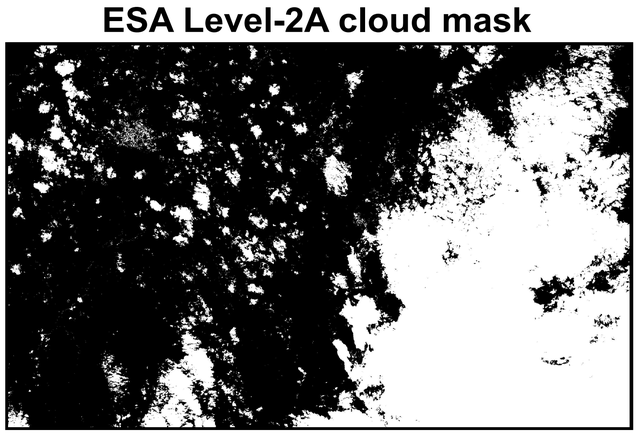
System to be implemented



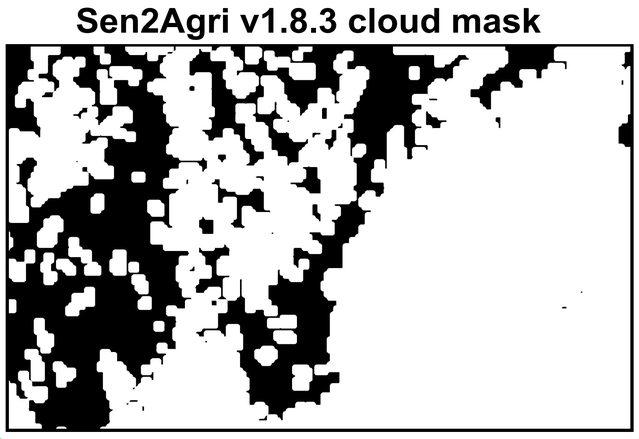
RGB



ESA Level-2A cloud mask



Sen2Agri v1.8.3 cloud mask



Input data

Within the study the following input datasets were used:
- ESA Sentinel-2 Level-2A product
- ESA Sentinel-2 Level-1C product used further by the MACCS processor to generate Level-2A product within the Sen2Agri system
- agricultural field boundaries with crop type information provided by the Polish Agency for Restructuring and Modernisation of Agriculture (ARMA) extracted from annual farmers' declarations
- in-situ crop type data provided by the Statistics Poland agency

Sen2Agri system

The Sen2Agri system is an open source operational system generating agricultural products from Sentinel-2 and Landsat-8 satellite imageries i.e.:
- monthly cloud-free composites of surface reflectance at 10 – 20 m resolution
- monthly cropland masks, delivered from the agricultural mid-season onwards
- cultivated crop type maps at 10 m resolution, delivered twice in the seasons
- periodic vegetation condition maps e.g. NDVI and LAI

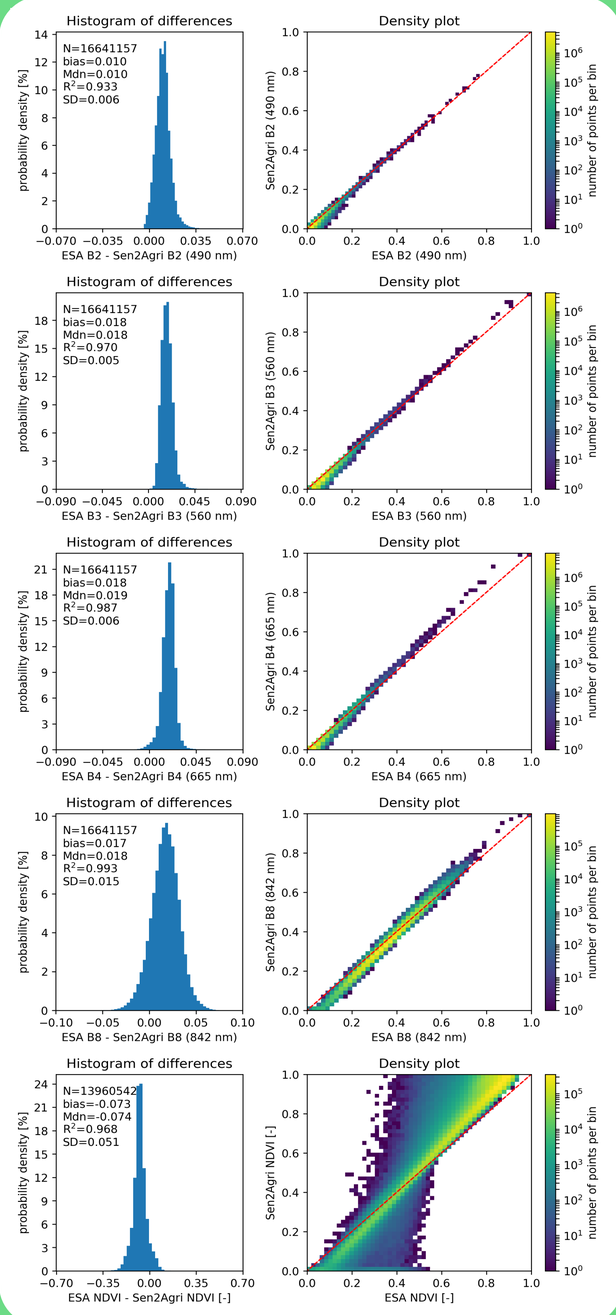
Sen2Agri is funded by ESA, for information visit: http://www.esa-sen2agri.org/

Methods

First phase of the study was rasterization of vector data with agricultural field boundaries (red lines). In order to extract homogeneous pixels 15 m buffer was applied (green lines). Further, a pixel distribution between 50 and 90 percentile NDVI value was selected and averaged for a single agricultural field. In this way influence of residual could cover and shadows was reduced. Acquired NDVI time series for few crop types and fields are depicted in the bottom left panel.

Second phase of the study involved generation of histograms of differences and scatter plots between Sentinel-2 Level-2A products provided by ESA and Sen2Agri. In this analysis extracted pixels originated from the union of cloud masks (left panel), so only clear-sky pixels from both datasets were used.

Ultimately, the Sen2Agri classification accuracy was assessed using 30 crop types (bottom right panel) validated against in situ data and farmers' declarations.

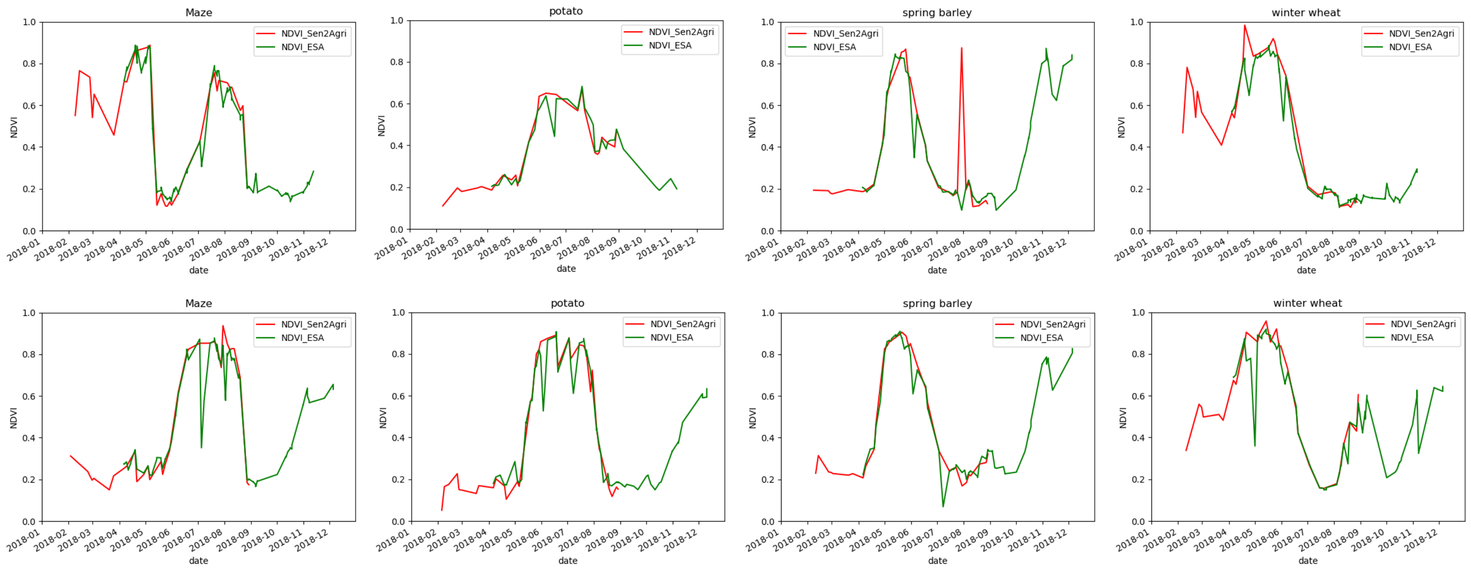


Rasterizing field boundaries

Conclusions

1) Differences between Sentinel-2 Level-2A products provided by the ESA and Sen2Agri system are mainly related to cloud masking and not to atmospheric correction. In this respect, the ESA cloud mask has to be further improved.
2) Sentinel-2 satellite constellation allows for agricultural monitoring at a field scale and for extraction of spectral signatures from homogeneous pixels.
3) Sen2Agri provide accurate classification for a complex crop type combination.
4) Within the EOStat project funded by ESA the advanced EO processing system will be developed to support agriculture monitoring in Poland.

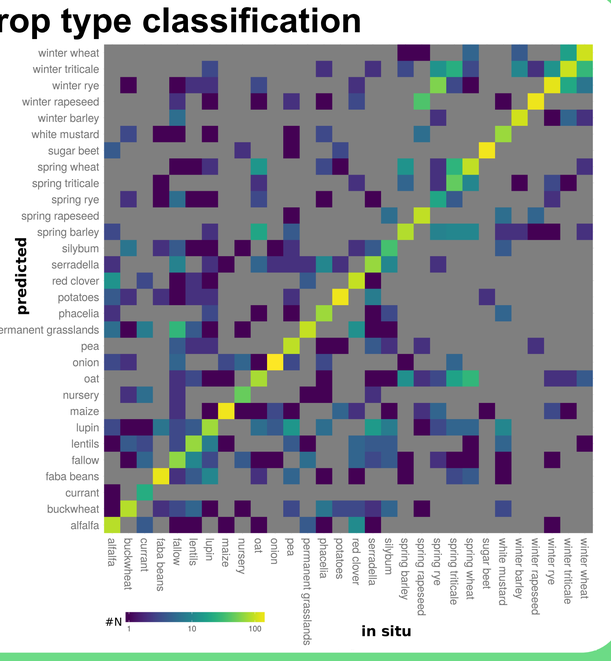
NDVI derived from Sentinel-2 Level-2A products generated by ESA and Sen2agri



Crop type classification

crop type:	Precision	Recall	F1
alfalfa	0.77	0.67	0.72
buckwheat	0.68	0.77	0.72
currant	0.96	0.42	0.59
faba beans	0.79	0.89	0.84
fallow land	0.57	0.43	0.49
lentils	0.61	0.62	0.61
lupin	0.43	0.6	0.5
maize	0.82	0.95	0.88
nursery	0.77	0.76	0.76
oat	0.49	0.57	0.53
onion	0.83	0.93	0.88
pea	0.82	0.66	0.73
permanent grasslands	0.61	0.84	0.71
phacelia	0.82	0.64	0.72
potatoes	0.84	0.9	0.87
red clover	0.79	0.67	0.72
serradella	0.58	0.58	0.58
silybum	0.54	0.43	0.48
spring barley	0.56	0.69	0.62
spring rapeseed	0.84	0.64	0.73
spring rye	0.46	0.16	0.24
spring triticale	0.62	0.31	0.42
spring wheat	0.59	0.58	0.58
sugar beet	0.93	0.98	0.95
white mustard	0.81	0.65	0.72
winter barley	0.87	0.86	0.86
winter rapeseed	0.73	0.93	0.82
winter rye	0.55	0.82	0.66
winter triticale	0.5	0.68	0.57
winter wheat	0.79	0.69	0.74

Accuracy: 0.69
Kappa: 0.68



Acknowledgments

The Authors would like to gratefully acknowledge: European Space Agency (ESA) for distribution of the Sentinel-2 imagery and for funding of the EOStat project; Sen2Agri system developers; Orfeo ToolBox developers; MACCS developers; Polish Agency for Restructuring and Modernisation of Agriculture (ARMA) for distribution of the agricultural field boundaries and farmers declarations; Statistics Poland (GUS) for distribution of the in-situ crop type data, Space Research Centre (CBK) of the Polish Academy of Sciences and Kappazeta company for scientific consultations.