



Project Title:

Crop mapping and yield forecasting for Ukraine

ESA Contract Number 000111

**Project Coordinator
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**National Technical University of
Ukraine "Igor Sikorsky Kyiv
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The objectives of the project

Main objective

to use the CREODIAS IaaS service provided by the CREODIAS environment to classify crops and predict yields based on satellite and meteorological data available in the EO data repository

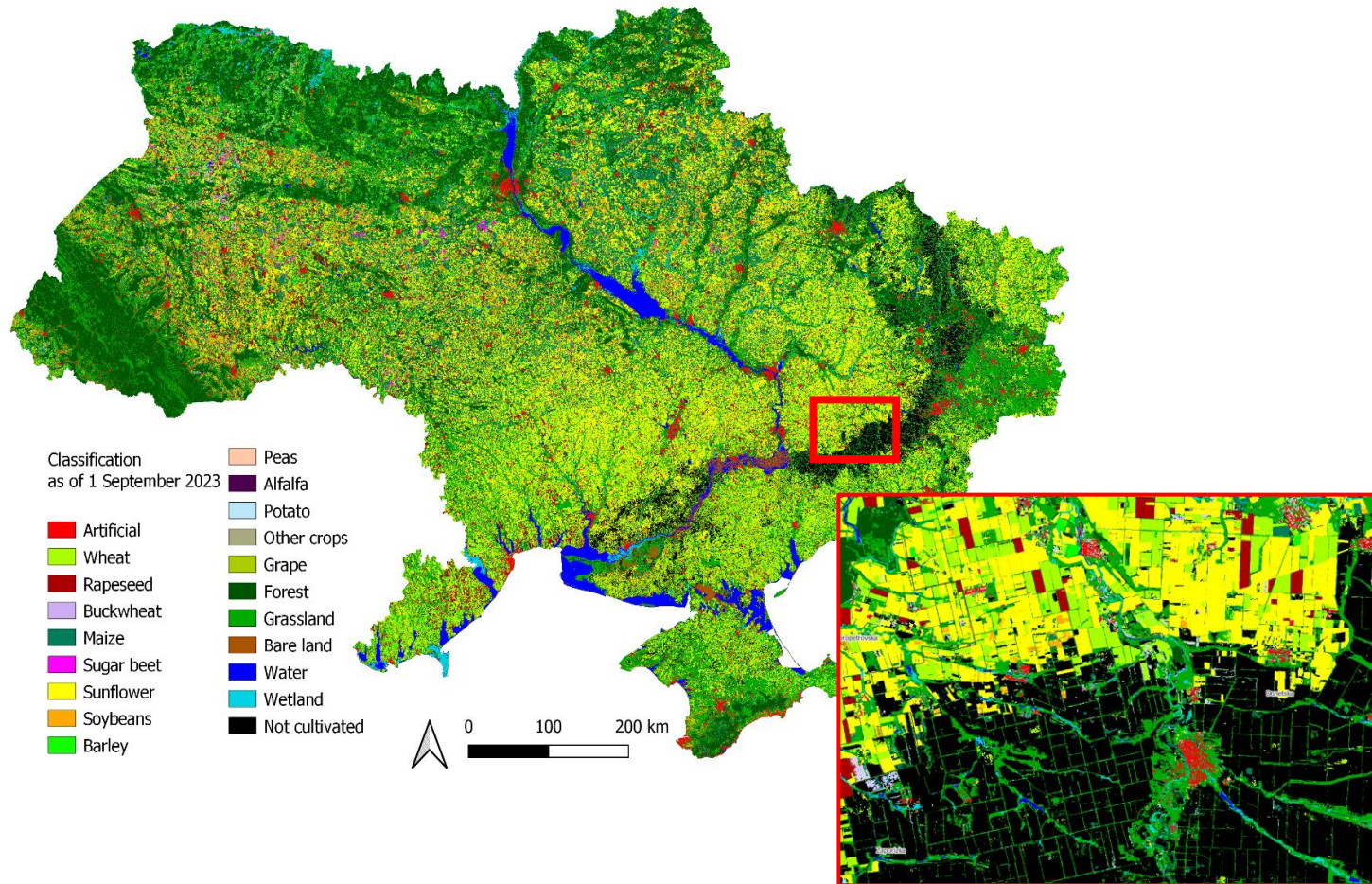
Secondary objective

to provide the generated results to the ESA WorldCereal project and to the EO4UA initiative



Classification in CREODIAS Cloud Platform

Ukraine 2023

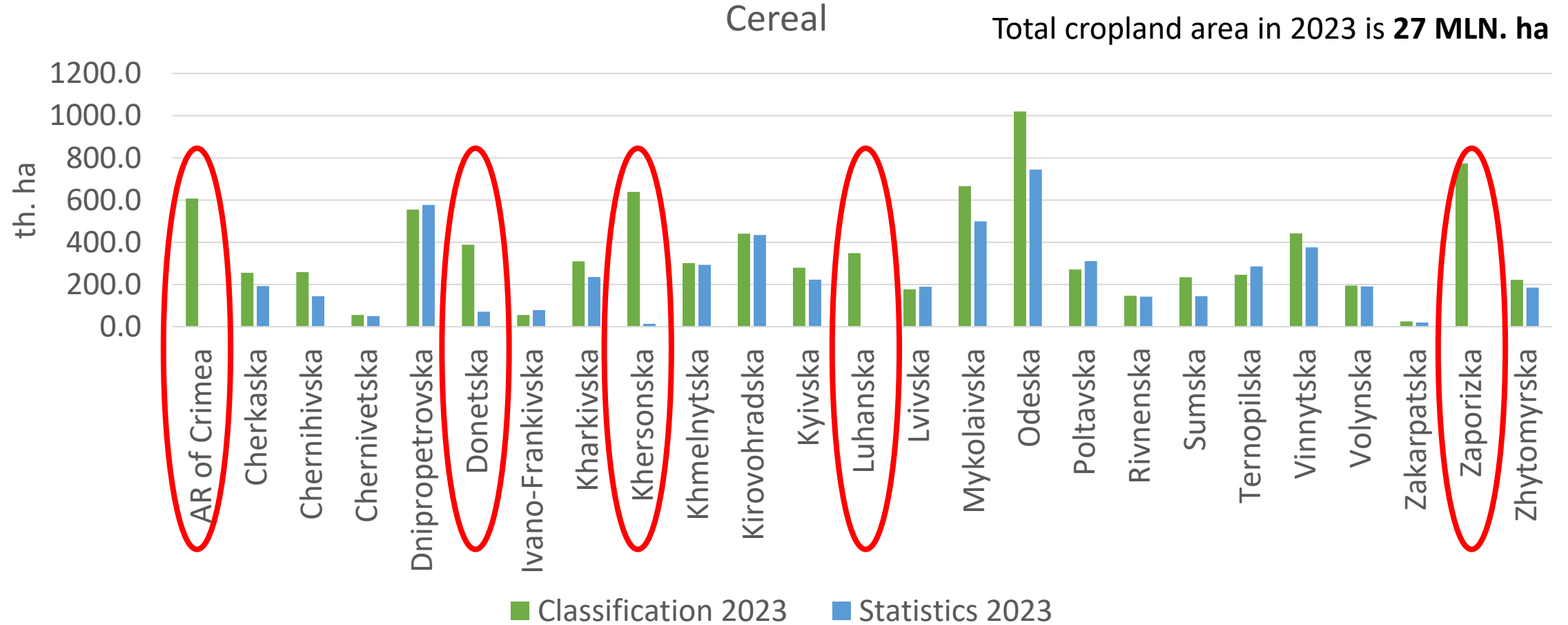


Class	PA	UA	F1
Artificial	88,7	81,9	85,2
Wheat	98,7	90,6	94,5
Rapeseed	96,1	98,6	97,3
Buckwheat	54,8	92	68,7
Maize	93,6	91,3	92,4
Sugar beet	95,7	93,2	94,5
Sunflower	98,6	97,6	98,1
Soybean	88,8	88,5	88,7
Other crops	75,1	67,5	71,1
Forest	100	97,8	98,9
Grassland	90,9	85,9	88,3
Bareland	72,6	85	78,3
Water	100	99,4	99,7
Wetland	94	92,7	93,4
Barley	62,7	90,1	73,9
Peas	80,9	100	89,5
Alfalfa	29,3	87,5	43,8
Grape	87,6	51,2	64,7
Not cultivated	88,2	96,6	92,2
Potato	72,8	18,9	30,1
Overall Accuracy	OA = 93,1%		



Cereal areas comparing to statistics (2023)

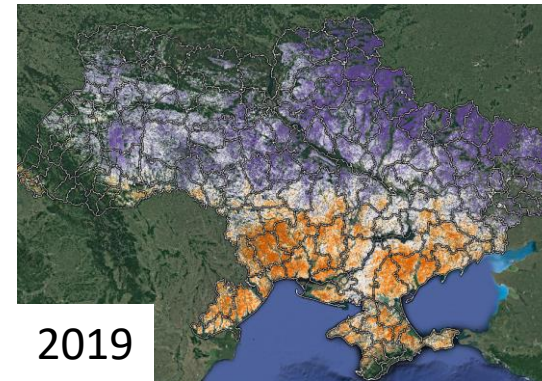
in conditions of the absence or partial absence of statistics



partial or total absence of statistical information

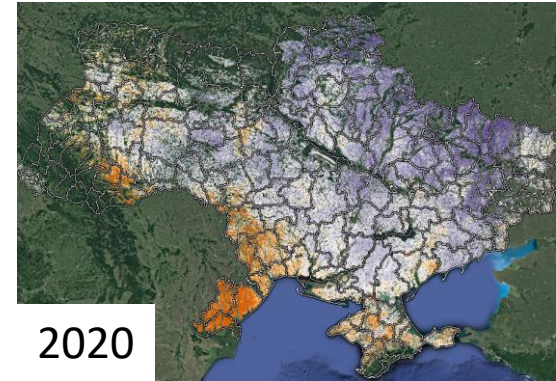


Land surface temperature in CREODIAS (Sentinel-3) as input meteorological information for forecasting winter crop areas and yields



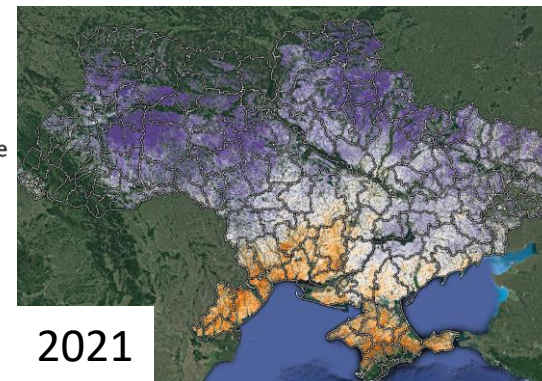
2019

1 Oct. 2018 – 1 Apr. 2019



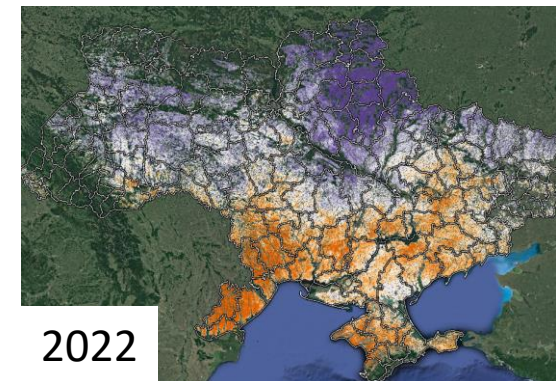
2020

1 Oct. 2019 – 1 Apr. 2020



2021

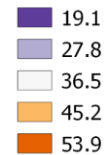
1 Oct. 2020 – 1 Apr. 2021



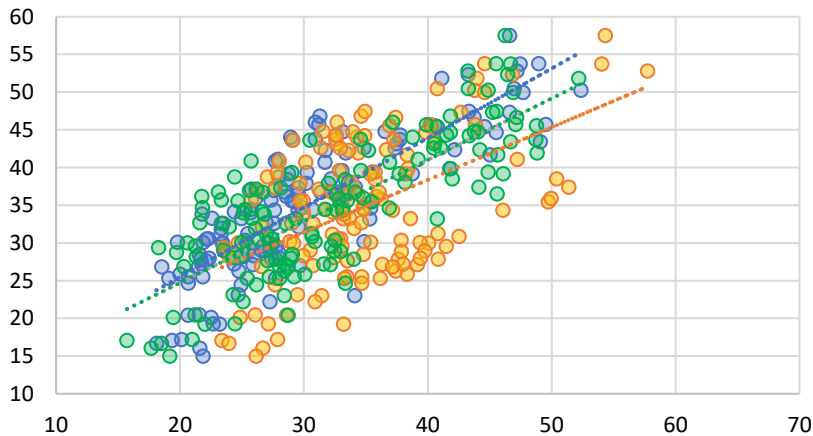
2022

1 Oct. 2021 – 1 Apr. 2022

Cumulative temperature (C)



Different years comparison (regions level)



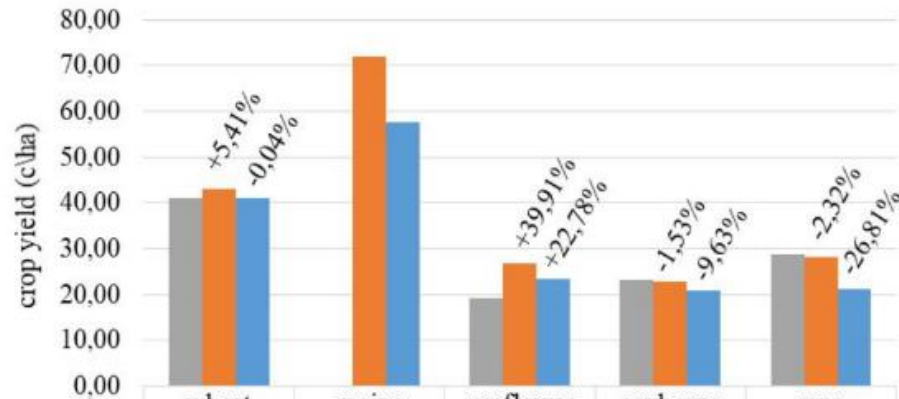
Correlation	
2022 - 2021	0,82
2022 - 2020	0,52
2022 - 2019	0,80

- 2021 and 2022 $R^2 = 0.68$
- 2020 and 2022 $R^2 = 0.27$
- 2019 and 2022 $R^2 = 0.64$



Crop yield forecast for major crops in Ukraine, 2022

Comparison of official and predicted crop yield (c\ha)



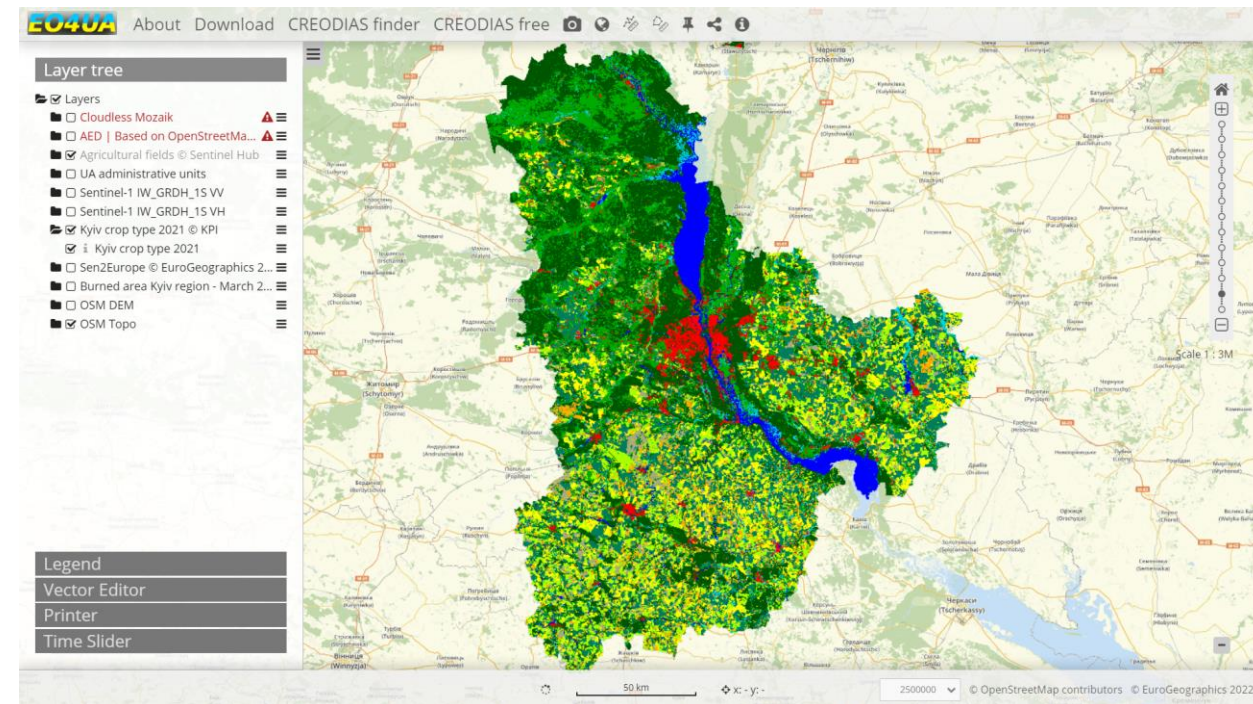
	wheat	maize	sunflower	soybeans	rape
■ Ukraine (of. data)	41,00	19,20	23,30	28,90	28,90
■ Ukraine (Sentinel-2)	43,22	71,93	26,86	22,94	28,23
■ Ukraine (Modis)	40,98	57,66	23,57	21,06	21,15

Crop \ Region	Wheat		Sunflower		Soybeans		Rapeseed		Maize	
	MOD	S2	MOD	S2	MOD	S2	MOD	S2	MOD	S2
Vinnyska	4,81	4,72	2,95	3,26	2,08	2,75	2,08	3,08	6,99	9,00
Volynska	4,55	4,46	2,69	2,90	2,69	2,64	2,69	3,23	8,42	8,98
Dnipropetrovska	3,27	NaN	1,98	NaN	1,52	NaN	1,53	NaN	2,96	NaN
Donetska	3,10	NaN	1,77	NaN	NaN	NaN	NaN	NaN	2,98	NaN
Zhytomyrska	4,31	4,30	2,46	2,46	2,29	2,64	2,31	2,84	6,83	6,80
Zakarpatska	3,34	3,24	2,03	2,15	2,25	2,31	2,28	NaN	5,10	5,27
Zaporizka	2,84	NaN	1,42	NaN	3,18	NaN	3,17	NaN	3,42	NaN
Ivano-Frankivska	5,02	4,68	2,79	2,77	2,41	2,76	2,42	NaN	6,51	6,78
Kyivska	3,90	4,06	2,49	2,78	1,64	2,16	1,62	2,69	5,62	7,77
Kirovohradska	3,53	4,43	2,03	2,50	1,18	1,20	1,22	2,40	3,99	4,95
Luhanska	3,25	NaN	1,74	NaN	NaN	NaN	NaN	NaN	3,15	NaN
Lvivska	4,97	4,78	2,73	2,73	2,66	2,70	2,69	2,95	7,31	7,33
Mykolaiivska	3,01	3,11	1,61	1,86	1,05	1,35	1,06	2,08	3,23	3,82
Odeska	2,28	2,96	1,54	1,72	1,54	2,02	1,56	2,37	3,38	4,59
Poltavska	4,24	NaN	2,44	NaN	1,59	NaN	1,57	NaN	5,45	NaN
Rivnenska	4,69	4,72	2,69	2,77	2,56	2,58	2,55	NaN	7,35	8,39
Sumska	5,26	NaN	2,84	NaN	NaN	NaN	NaN	NaN	7,85	NaN
Ternopil'ska	5,53	5,36	2,82	3,23	2,71	2,92	2,74	3,31	8,17	9,48
Kharkiv'ska	3,75	NaN	2,67	NaN	1,24	NaN	1,33	NaN	4,04	NaN
Kherson'ska	3,33	3,85	1,49	NaN	3,29	NaN	3,29	NaN	6,82	7,95
Khmelnytska	5,74	5,10	3,41	3,45	2,77	2,66	2,76	3,11	8,95	9,29
Cherkaska	4,16	4,58	2,56	2,82	1,59	1,67	1,53	2,86	5,65	6,84
Chernivetska	5,04	4,09	2,72	2,70	1,90	2,10	1,93	NaN	6,17	5,63
Chernihiv'ska	4,44	5,04	2,70	2,89	2,17	2,24	2,17	2,97	8,04	9,39
Ukraine (mean)	4,10	4,32	2,36	2,69	1,93	2,29	1,94	2,82	5,77	7,19



EO4UA

- consortium for sharing data and products on CREODIAS for support of Ukraine
 - Initiator - CloudFerro
 - Partners – public and private institutions
- EO4UA Objectives
 - To monitor Ukrainian environment, especially food production and forestry
 - To help Ukrainian scientists to continue their research work
 - To gather EO experts willing to help Ukrainians
 - To provide a large processing environment combined with an EO data repository
 - To facilitate consecutive studies by providing outcomes of the previous ones
 - To inform general public about the environmental condition in Ukraine

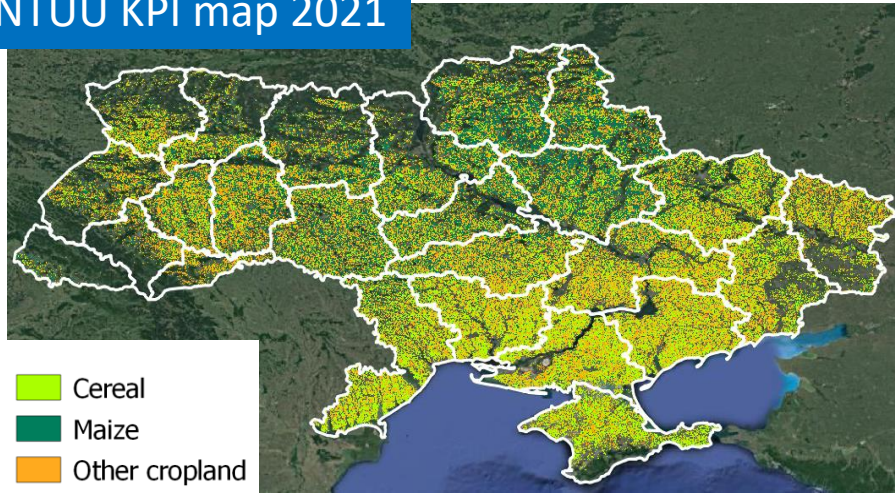


Obtained results are available on EO4UA geoportal

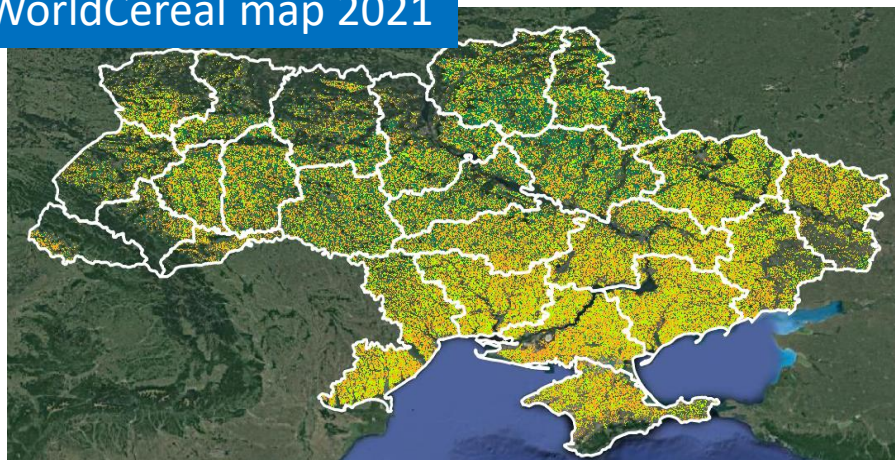


Comparison obtained maps with WorldCereal product

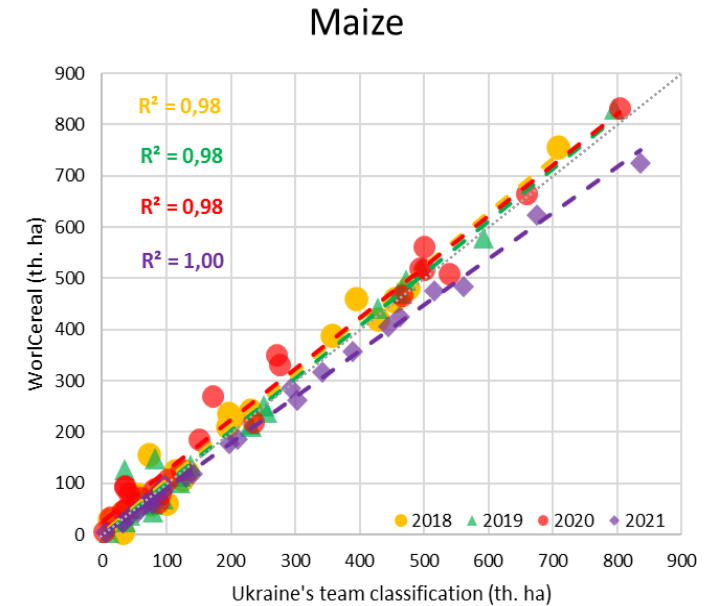
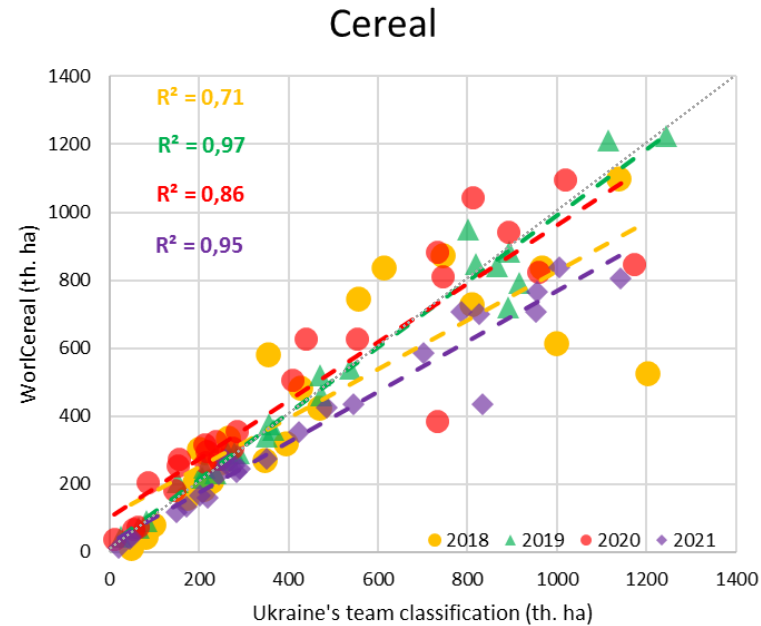
NTUU KPI map 2021



WorldCereal map 2021



Area comparison at oblast level





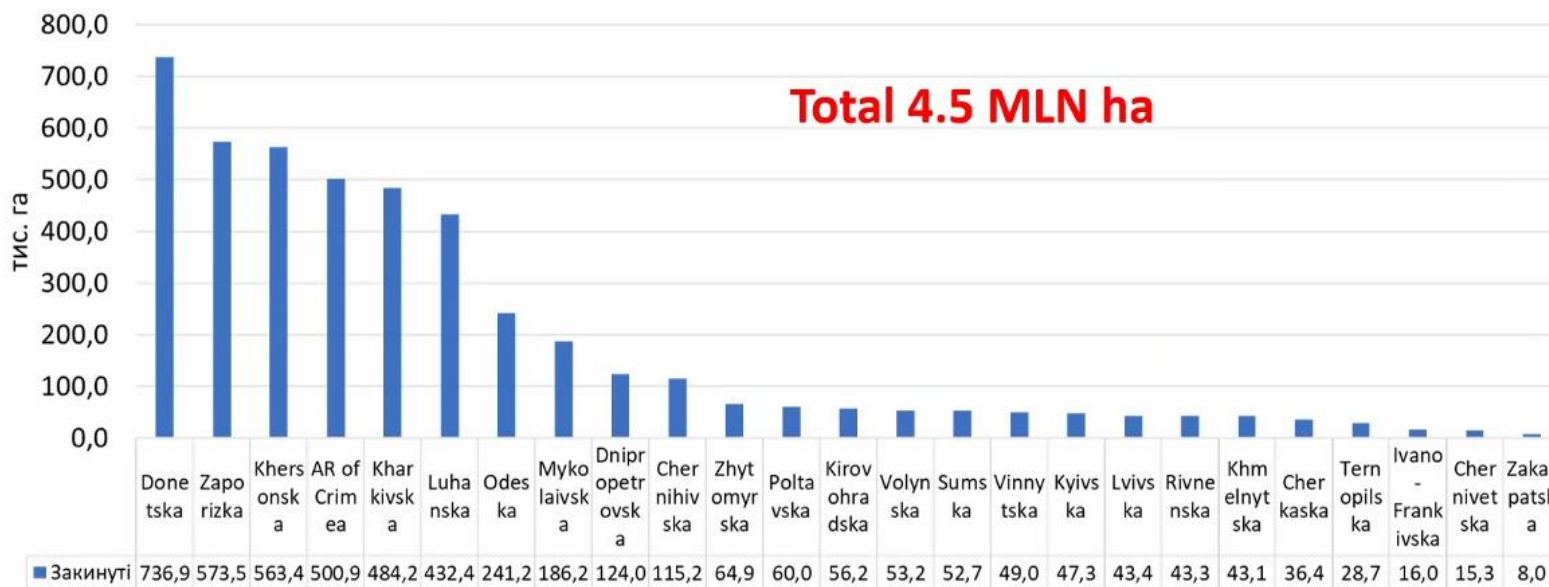
Main results

- The use of CREODIAS IaaS service made it possible to use developed machine learning algorithms to classify big satellite data (time series for all Ukraine) in conditions of unstable electricity supply in the country
- Thanks to the CREODIAS cloud storage, the amount of pre-processing of satellite data for their use in the classification task has been significantly reduced
- The obtained results are valuable for state authorities, in particular for the Ministry of Agrarian Policy, the State Statistics Service and the Ministry of Digital Transformation, as well as for international partners for cross-validation and comparison of the obtained products in different ways (in particular ESA WorldCereal project)
- The ability to estimate cultivated areas and yields in inaccessible territories (especially occupied ones) and in conditions of lack of statistical information



Presented results at EURO-GEO 2023

Uncultivated agricultural fields in 2023 comparing to 2021



Talking:



References

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- Nataliia Kussul, Sophia Drozd and Hanna Yailymova. **Forecast of Yield of Major Crops in Ukraine in War Conditions 2022 based on MODIS and Sentinel-2 Satellite Data**. Proceedings of International Conference on Applied Innovation in IT. 2023. pp. 89-95. DOI:10.25673/101923.
- Kussul N., Shelestov A., Yailymov B., Yailymova H. **Analysis of Cultivated Areas in Ukraine During the War**. In: 12th International Conference on Dependable Systems, Services and Technologies (DESSERT'2022), December 9-11, 2022, Greece, Athens. DOI: 10.1109/DESSERT58054.2022.10018813.
- Leonid Shumilo, Sofia Drozd, Nataliia Kussul, Andrii Shelestov, Sergiy Sylantyev **Mathematical Models and Informational Technologies of Crop Yield Forecasting in Cloud Environment**. In: Ilchenko, M., Uryvsky, L., Globa, L. (eds) Progress in Advanced Information and Communication Technology and Systems. MCiT 2021. Lecture Notes in Networks and Systems, vol 548. Springer, Cham. pp. 143–164. DOI: 10.1007/978-3-031-16368-5_7.