Using earth observation data to augment agricultural statistics in Poland

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Agricultural statistics supported by satellite data

- **Crop area recognition – pilots since 2015**
- **Vegetation monitoring – for last 20 years**
- **Yield estimation – pilots since 2015**
- Monitoring of extremal conditions for plants i.e. ground frost, freezing, drought, floods – ad hoc projects

Pilot survey to isolate particular groups of crops and land cover classes

Methodology (1)

Central Statistical Office, RSO Olsztyn, RSO Lublin

Space Research Centre - Polish Academy of Science

- Two regions: Warmia-Mazury (2015, 2016), Lubelskie (2016)
- Selection of fields wider and longer that 60 m X 60 m
- Ca 2000 points in each region in each repetition
- Layer from admin data: Land Use Fields - ARMA (The Agency for Restructuring and Modernization of Agriculture)
- ArcGIS

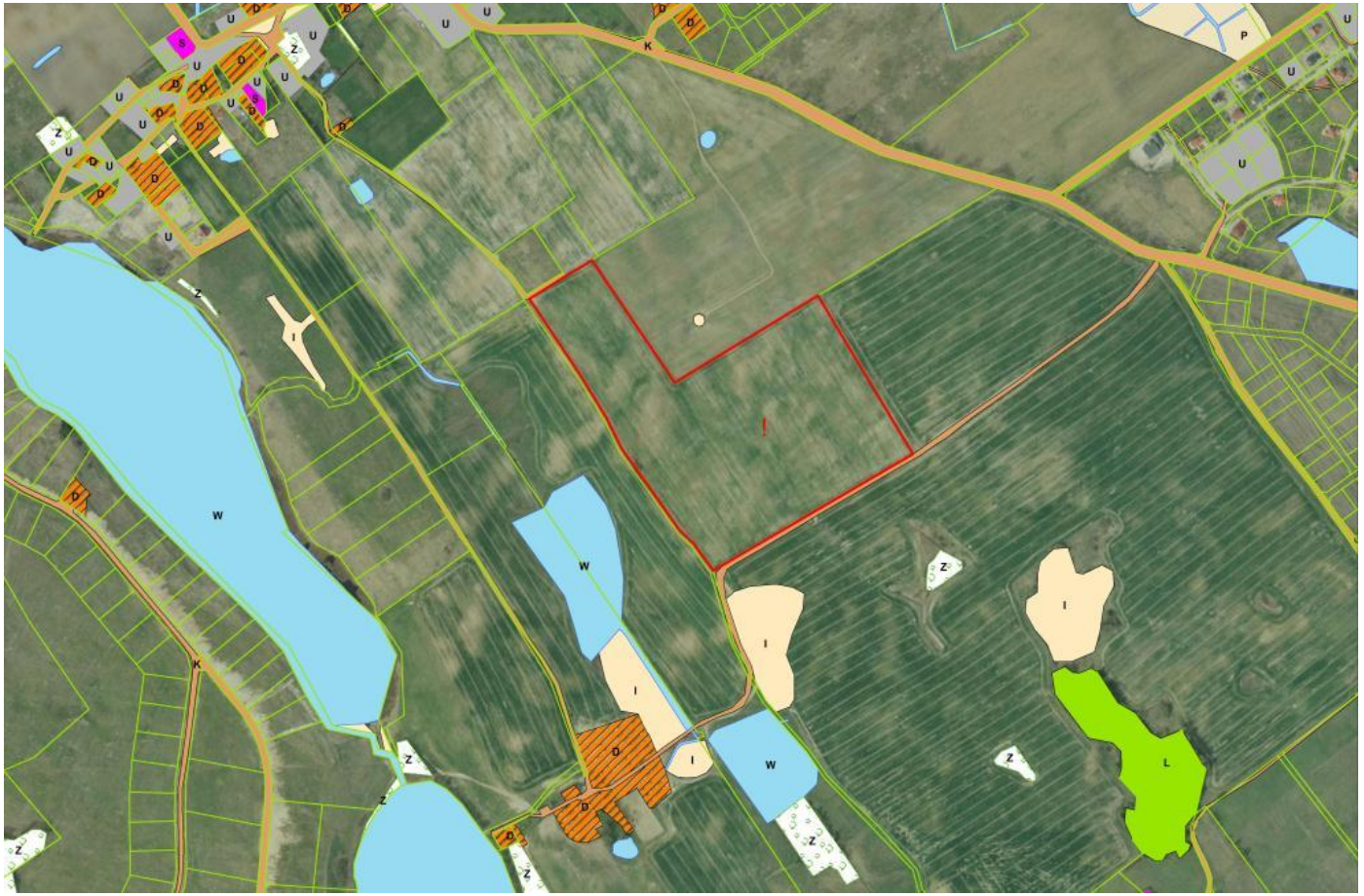
Methodology (2)

- In situ survey - June / July 2015r. and June / July 2016
- 4 (8) interviewers
- allocation of network zones for each interviewer
- getting directions to the selected plots
- photos (series of geo-tagged images)
- Questionnaire content: latitude and longitude, type of crop, phase of plant condition, landform, type of soil, humidity, photos etc

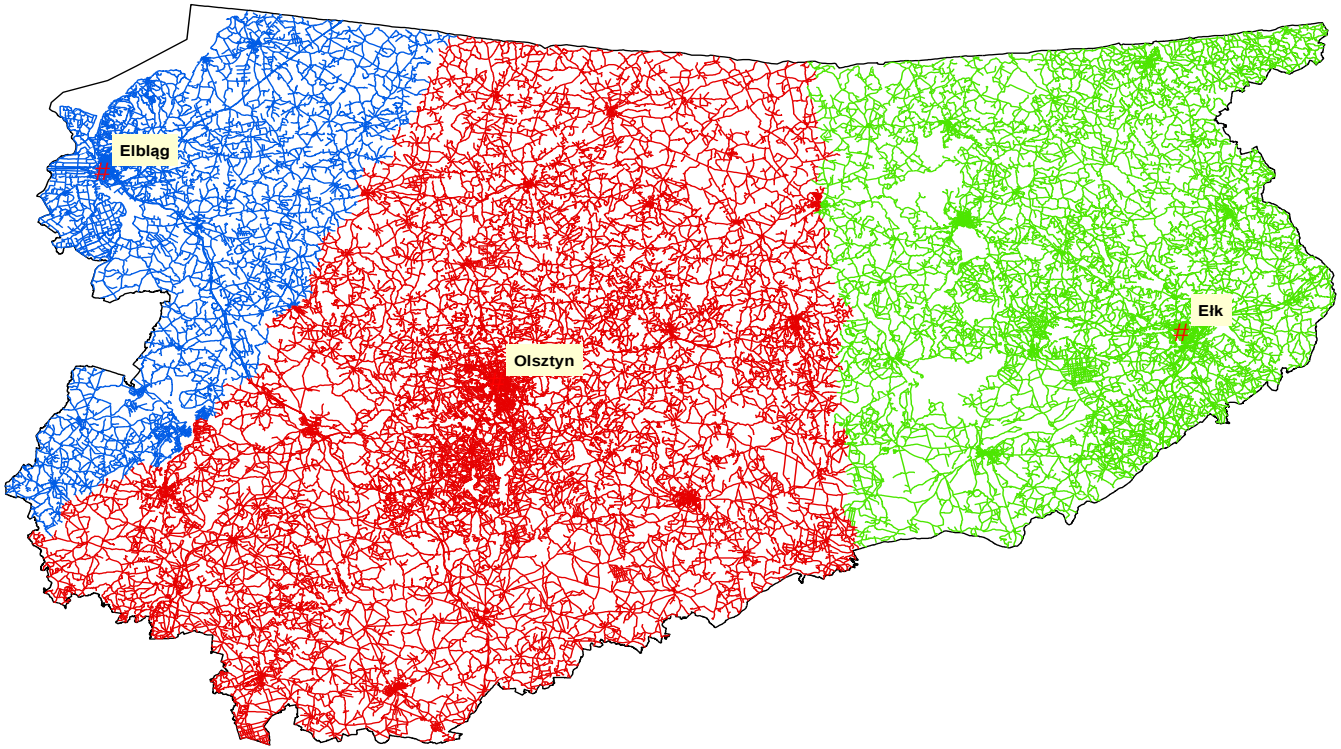
Methodology (3)

- Sentinel-1 data
- Huge amount of data - **1.5 TB per scene**
- Sentinel 2 (Landsat 8) - supportive
- LPIS (ARMA) segmentation
- MT_SAR software (specifically developed for this purpose)
- Time series for classes of spectral reflections for each crops
- Calculations (time series of matrices coherence, entropy, Wishard classifier, sigma factors, etc.)
- Multi-temporal data were classified using different classification approaches.

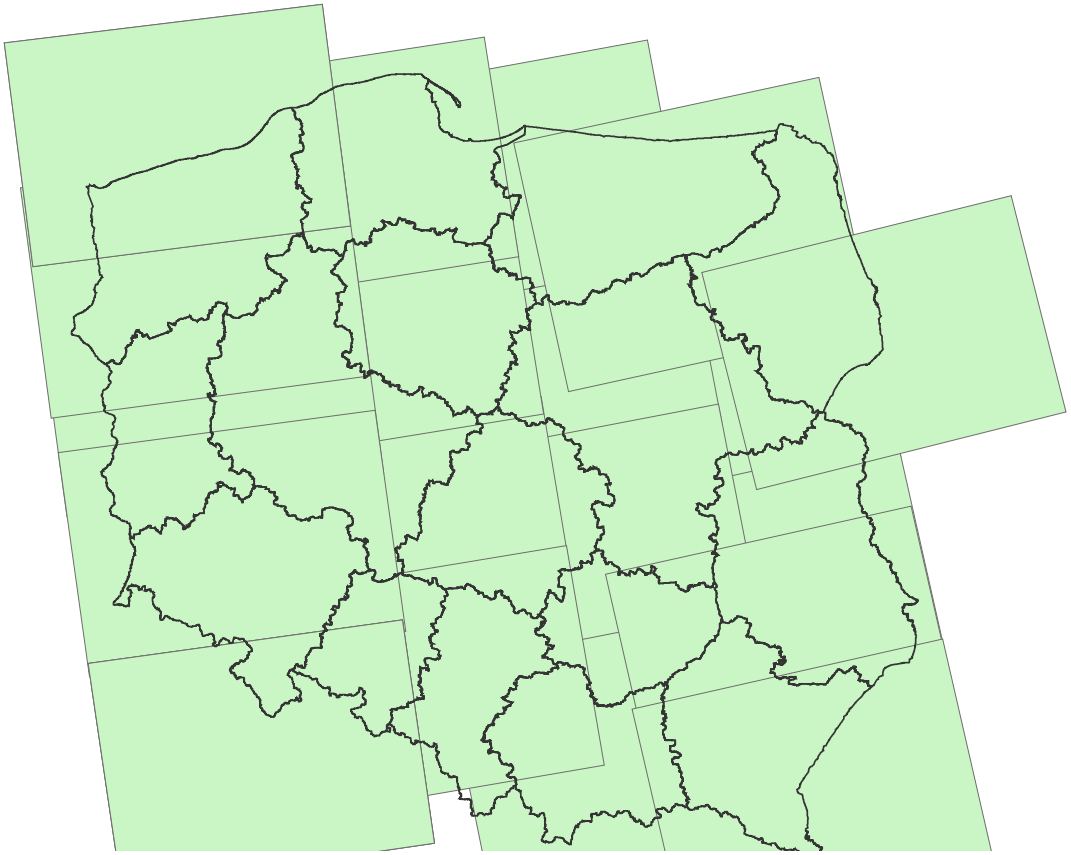
The example of the point used for the test.



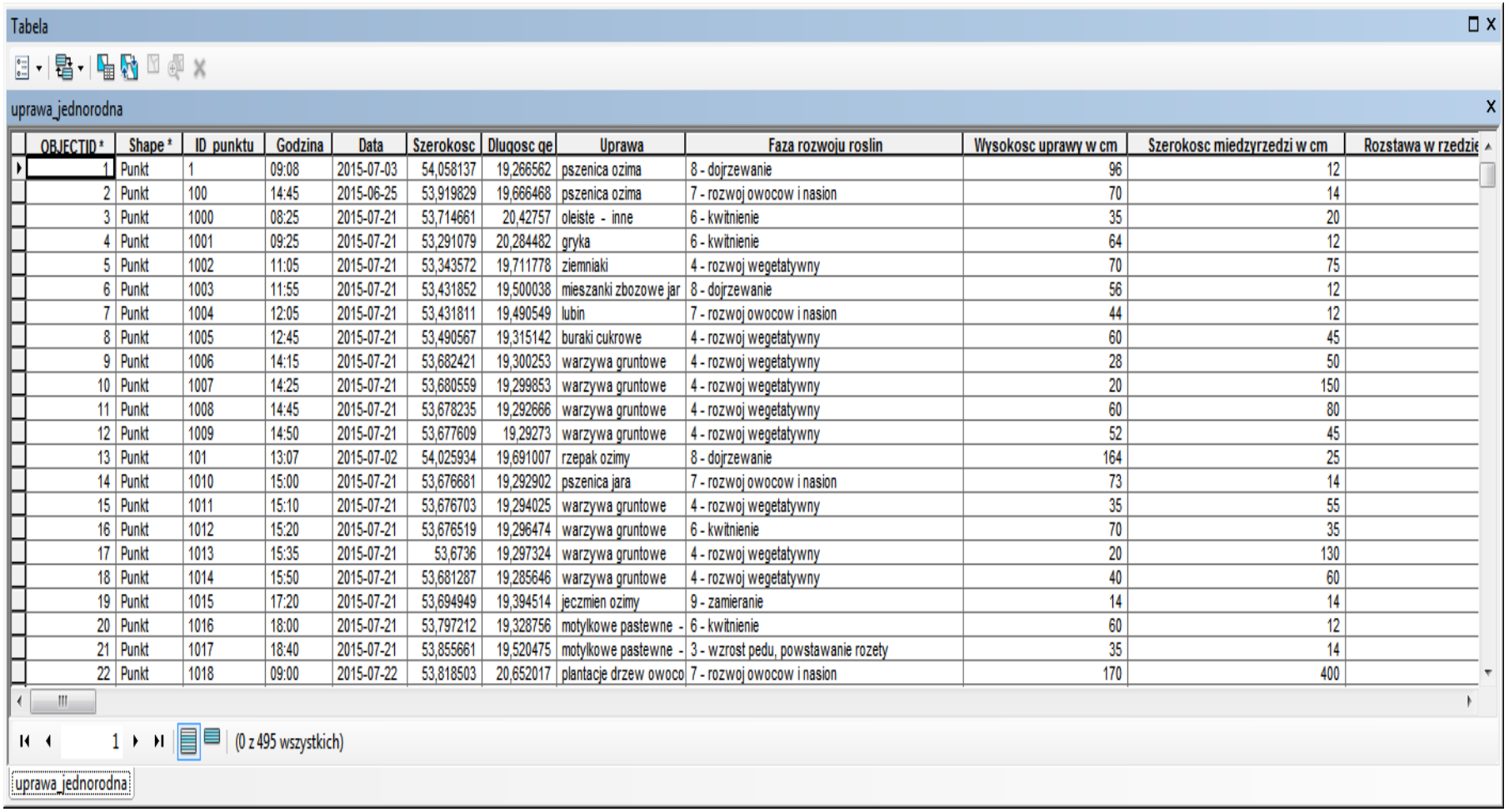
Allocation of network zones for interviewers with respect to the road system in the Warmia-Mazury.



Sentinel 1 – ascending scenes



Verification, standardization, geographical reference = geodatabase.



Tabela

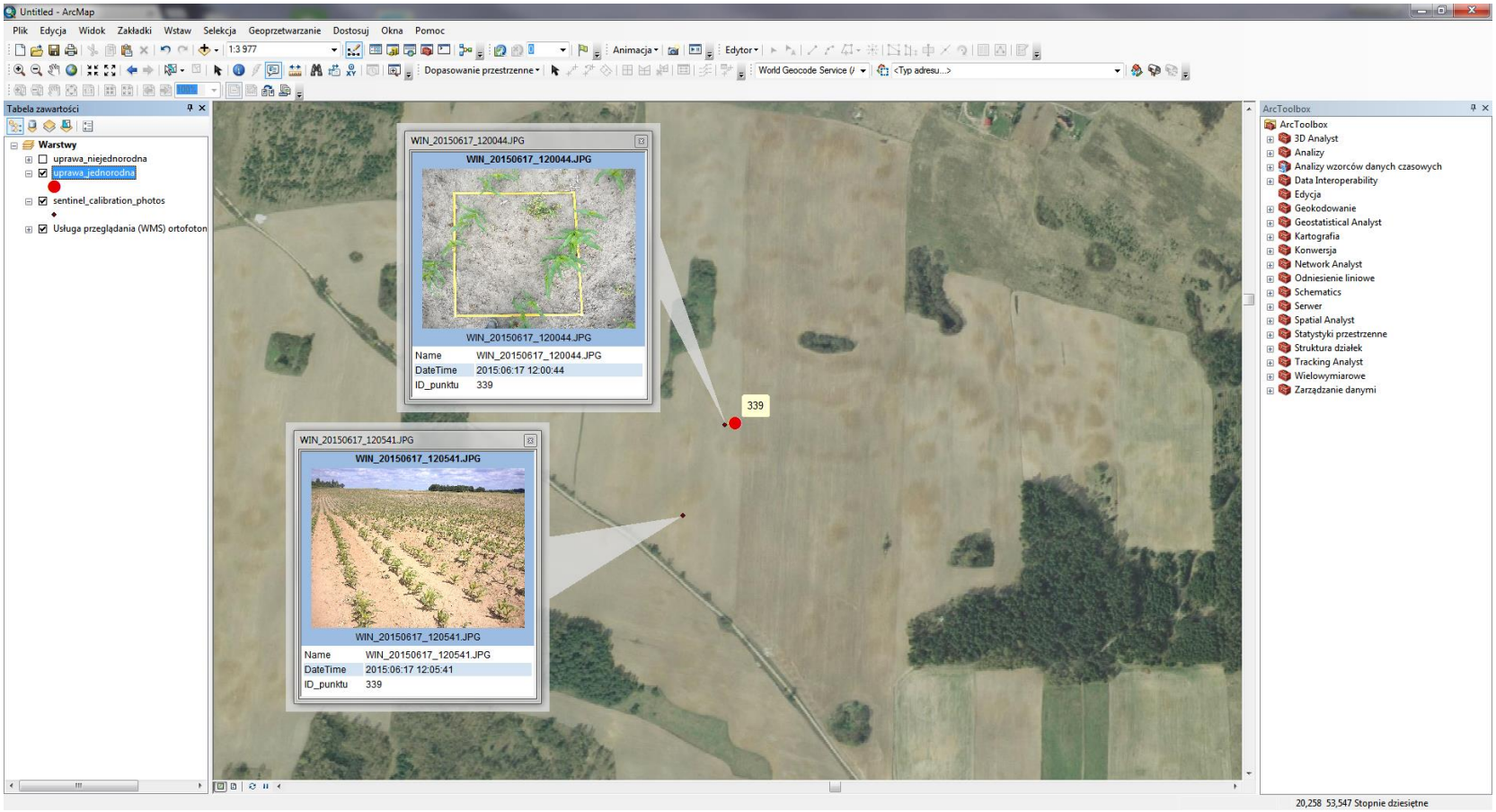
uprawa_jednorodna

OBJECTID *	Shape *	ID_punktu	Godzina	Data	Szerokosc	Dlugosc ge	Uprawa	Faza rozwoju roslin	Wysokosc uprawy w cm	Szerokosc miedzyrzedzi w cm	Rozstawa w rzedzie
1	Punkt	1	09:08	2015-07-03	54,058137	19,266562	pszenica ozima	8 - dojrzewanie	96	12	
2	Punkt	100	14:45	2015-06-25	53,919829	19,666468	pszenica ozima	7 - rozwoj owocow i nasion	70	14	
3	Punkt	1000	08:25	2015-07-21	53,714661	20,42757	oleiste - inne	6 - kwitnienie	35	20	
4	Punkt	1001	09:25	2015-07-21	53,291079	20,284482	gryka	6 - kwitnienie	64	12	
5	Punkt	1002	11:05	2015-07-21	53,343572	19,711778	ziemniaki	4 - rozwoj wegetatywny	70	75	
6	Punkt	1003	11:55	2015-07-21	53,431852	19,500038	mieszanki zbozowe jar	8 - dojrzewanie	56	12	
7	Punkt	1004	12:05	2015-07-21	53,431811	19,490549	lubin	7 - rozwoj owocow i nasion	44	12	
8	Punkt	1005	12:45	2015-07-21	53,490567	19,315142	buraki cukrowe	4 - rozwoj wegetatywny	60	45	
9	Punkt	1006	14:15	2015-07-21	53,682421	19,300253	warzywa gruntowe	4 - rozwoj wegetatywny	28	50	
10	Punkt	1007	14:25	2015-07-21	53,680559	19,299853	warzywa gruntowe	4 - rozwoj wegetatywny	20	150	
11	Punkt	1008	14:45	2015-07-21	53,678235	19,292666	warzywa gruntowe	4 - rozwoj wegetatywny	60	80	
12	Punkt	1009	14:50	2015-07-21	53,677609	19,29273	warzywa gruntowe	4 - rozwoj wegetatywny	52	45	
13	Punkt	101	13:07	2015-07-02	54,025934	19,691007	rzepak ozimy	8 - dojrzewanie	164	25	
14	Punkt	1010	15:00	2015-07-21	53,676681	19,292902	pszenica jara	7 - rozwoj owocow i nasion	73	14	
15	Punkt	1011	15:10	2015-07-21	53,676703	19,294025	warzywa gruntowe	4 - rozwoj wegetatywny	35	55	
16	Punkt	1012	15:20	2015-07-21	53,676519	19,296474	warzywa gruntowe	6 - kwitnienie	70	35	
17	Punkt	1013	15:35	2015-07-21	53,6736	19,297324	warzywa gruntowe	4 - rozwoj wegetatywny	20	130	
18	Punkt	1014	15:50	2015-07-21	53,681287	19,285646	warzywa gruntowe	4 - rozwoj wegetatywny	40	60	
19	Punkt	1015	17:20	2015-07-21	53,694949	19,394514	jeczmien ozimy	9 - zamieranie	14	14	
20	Punkt	1016	18:00	2015-07-21	53,797212	19,328756	motylkowe pastewne -	6 - kwitnienie	60	12	
21	Punkt	1017	18:40	2015-07-21	53,855661	19,520475	motylkowe pastewne -	3 - wzrost pedu, powstawanie rozety	35	14	
22	Punkt	1018	09:00	2015-07-22	53,818503	20,652017	plantacje drzew owoco	7 - rozwoj owocow i nasion	170	400	

1 (0 z 495 wszystkich)

uprawa_jednorodna

Visualization of the geodatabase with images.



Classification of radar data from Sentinel 1 in 2015 in relations to the training sample (in situ).

Method of classification	The data classified	Overall accuracy [%]
Support Vector Machine (SVM)	Sigma	81,0
Support Vector Machine (SVM)	Sigma, Entropy, Alfa	77,5
Decision Trees (DT)	Sigma	73,4
Decision Trees (DT)	Sigma, Entropy, Alfa	73,5
Decision Trees (DT)	Time series	72,8
K-Nearest Neighbours (KNN)	Wishard's classifier	81,7

Comparison of the results with the estimated surface crops by CSO for 2015

Surface classes in hectares in the province. Warmia and Mazury													ARMA			
CBK PAN													SUM LPiS	Additional estimation_ RczBR	Total	Area size (CSO))
Type of crop	KNN1	%	DT1	%	DT2	%	SVM1	%	SVM2	%	DT3	%				
Maize	56456	141.3	54654	136.8	42296	105.8	31455	78.7	32236	80.7	40428	101.2	28838	11120	39959	46744
Sugar beats	2622	102.6	7151	279.9	7151	279.9	12422	486.2	11993	469.4	18603	728.1	2555	0	2555	2150
Winter wheat	146520	153.9	160853	168.9	126962	133.3	138757	145.7	144270	151.5	118758	124.7	81004	14228	95232	137261
Buckwheat	7381	309.1	7683	321.8	5902	247.2	16329	683.9	15139	634.0	2050	85.9	2215	173	2388	5300
Spring barley	27757	185.3	37181	248.2	25197	168.2	33163	221.4	31131	207.8	64207	428.7	11198	3781	14978	27852

Challenges

- Combining Sentinel 1 & Sentinel 2 & Admin Data
- Enhancing the pilot in 2016 to two regions (Lubelskie & Warmia and Mazury) – currently results are being analyzed
- High quality of in situ data required (minimally 30 plots per a crop plant)
- Access to admin data from the applications for direct payments (ARMA), which are spatially referenced to the vector layer parcels
- Logistical challenges - large areas of regions 24 173 km^2 & 25 122 km^2
- Dealing with the huge amount of data
- Setting the pilot for the whole country in 2017

Monitoring of plant growth
Yield and harvest forecasts using satellite data

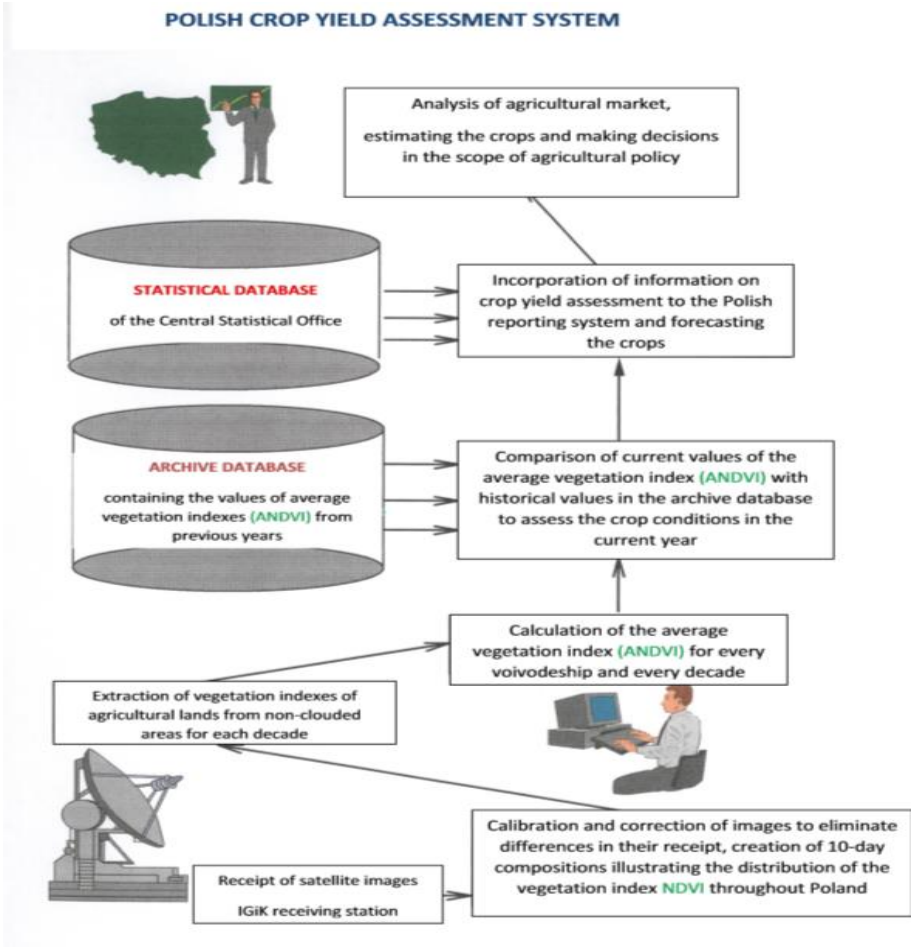
Methodology

- Department of Agriculture in the Central Statistical Office
- Institute of Geodesy and Cartography in Warsaw

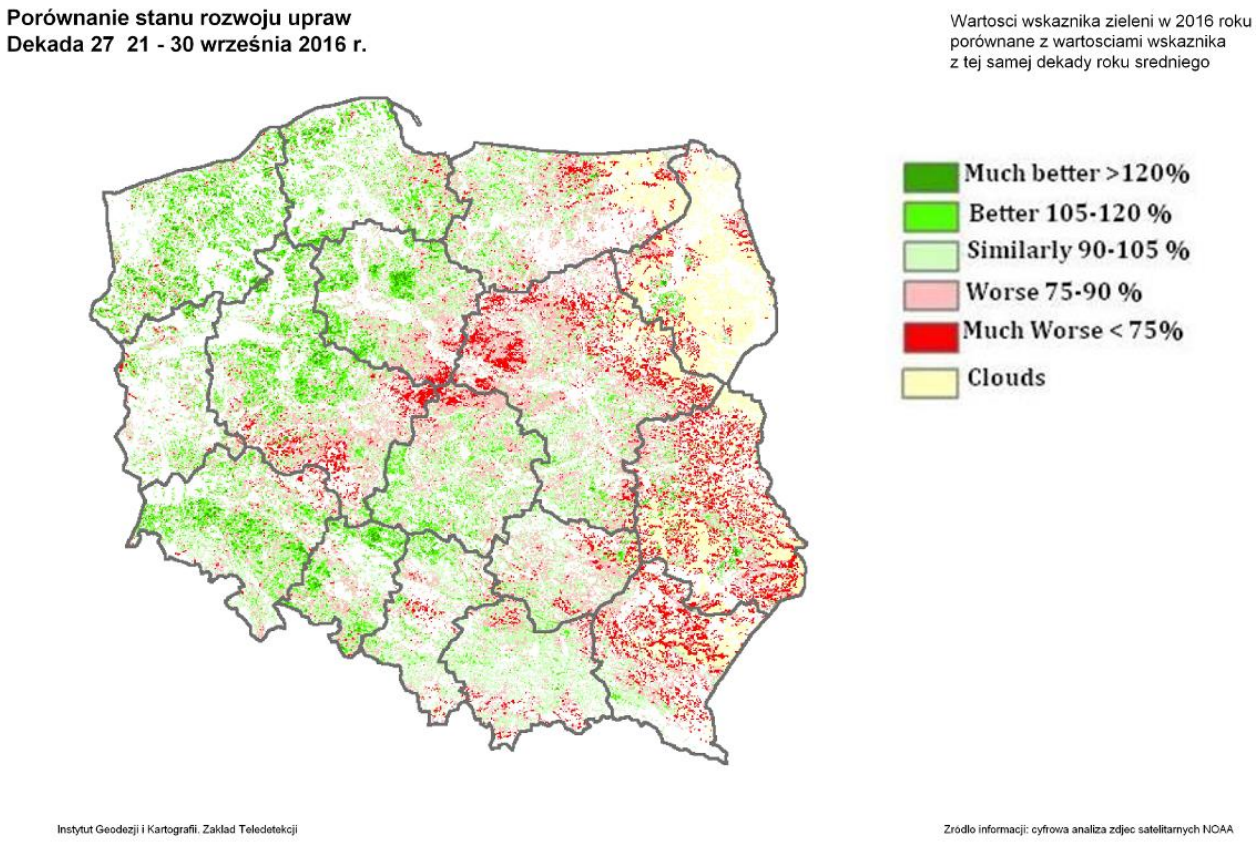
- Data time series of yield and harvest estimates
- Comparative model for yield/harvests estimating

- Data time series of NDVI for whole area of the country

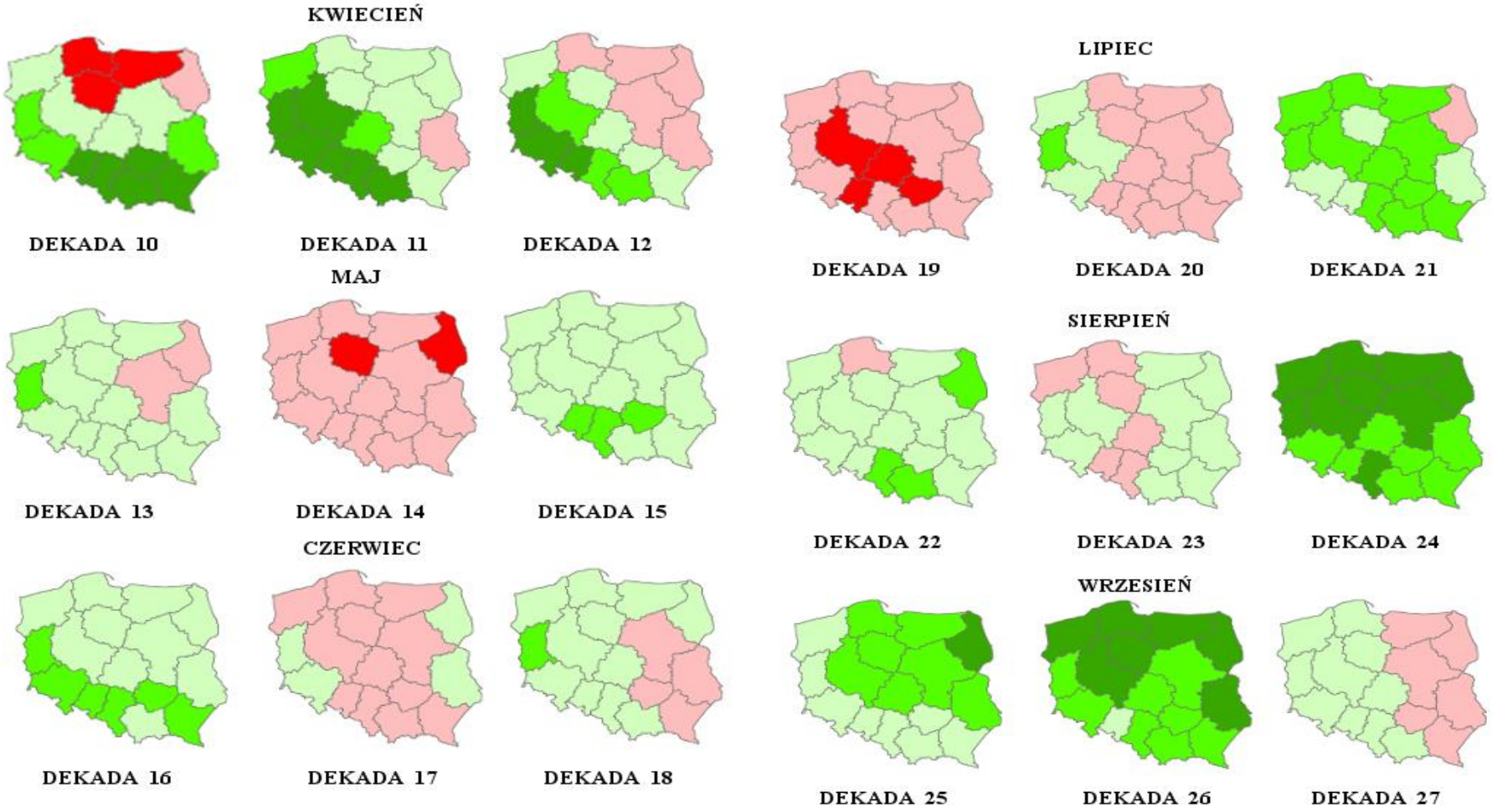
The diagram of the yield assessment system



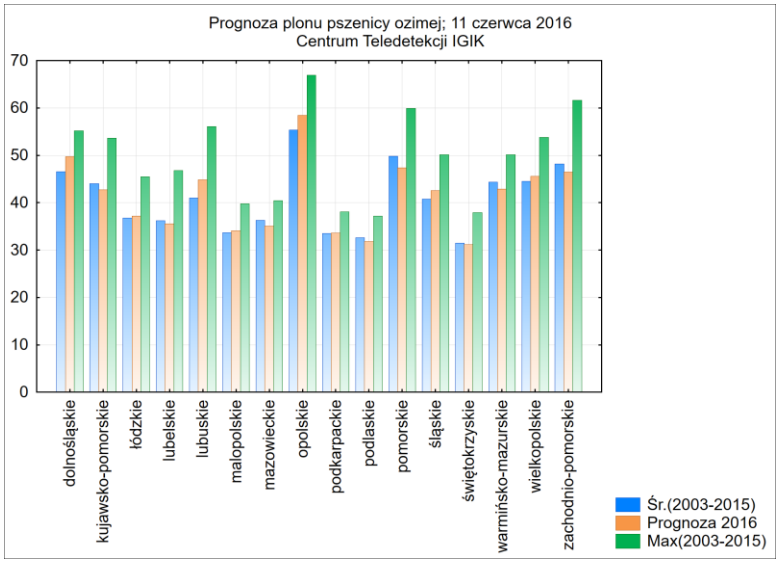
Comparison of NDVI in September 2016 to the average year

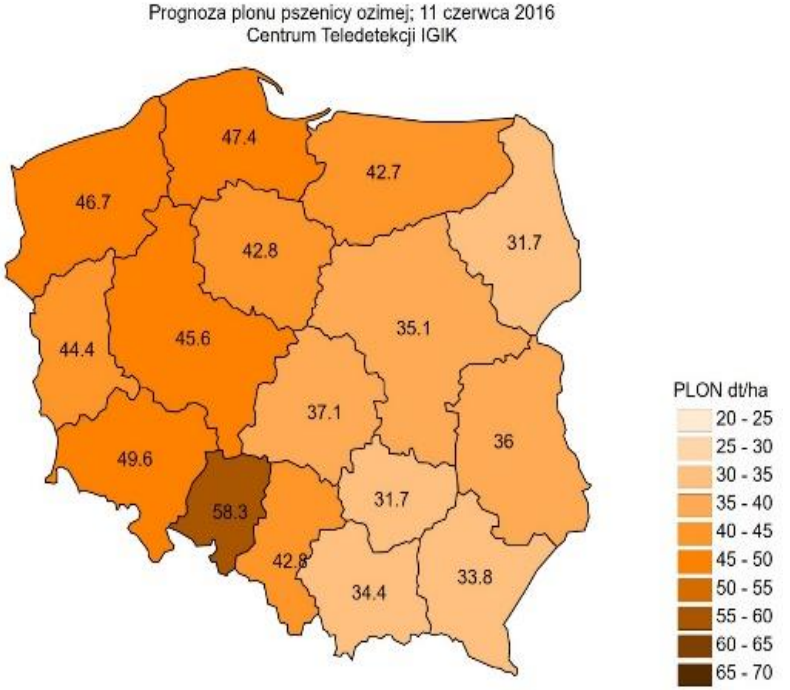


NDVI index in April – September 2016 for regions (NTS2) in comparison to the average year



Estimates of wheat yields for regions (NTS2)





Comparison of the yield estimates coming from satellites and current statistics

Voivodship (NTS 2)	Estimated yields (dt/ha)		Yield difference	
	Satellite	Statistical	dt/ha	%
DOLNOŚLĄSKIE	48,7	53,0	4,3	108,8
WARMIŃSKO-MAZURSKIE	43,3	50,9	7,6	117,6
WIELKOPOLSKIE	44,1	48,9	4,8	110,9
ZACHODNIOPOMORSKIE	46,1	59,2	13,1	128,4

Conclusions

- Weaker vegetation in eastern, central and north western Poland – the effect of the drought in 2015 and the first half of 2016.
- The selection of agricultural areas helps to separate them from the other land cover classes using e.g. LPIS
- Ancillary to existing yield and harvest estimates
- Earlier start of vegetation (climate changes) becomes important at result interpretation
- Yields and in consequence harvests are underestimated by the models based on satellite data due to use of long time series with low yield estimates as background
- Yield increase because of highly specialized agricultural holdings and farm modernization – substantial changes in efficiency (yielding)

Future plans for use of satellite data

- Developing the system of the crop area assessment and replacement of existing surveys and estimates
- Switching to the satellite technics and harvest modelling and replacing the existing system
- Delivering information on lower levels of aggregation (parcel ?)
- Earlier information providing (July or earlier ?)
- More applications in land cover and land use statistics
- Enhanced use in forestry and grassland statistics

EUROSTAT programs where satellite data are objectives

- ESS ADMIN VIP – use of administrative data in statistics including issues related to multisource statistics
- ESSNET ADMIN – quality of multisource statistics
- ESSNET BIG DATA – matching administrative data i.e. LPIS with big data i.e. satellite imagery in agriculture statistics