



# Оценивание площадей посевов сельськохозяйственных

## культур в Украине

### по спутниковым и наземным данным

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Скакун С.В.

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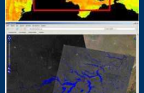
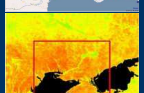
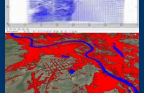
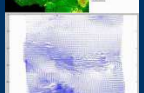
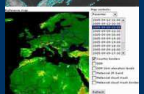
ИНСТИТУТ КОСМИЧЕСКИХ  
ИССЛЕДОВАНИЙ НАНУ-НКАУ

Київ,  
2010

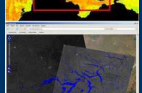
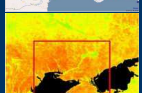
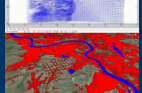
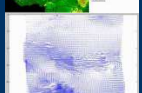
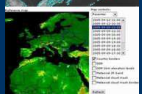
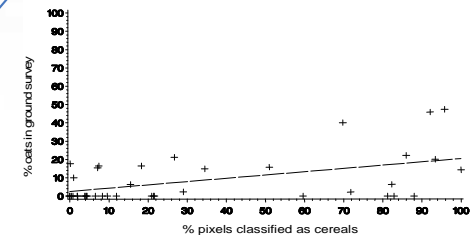
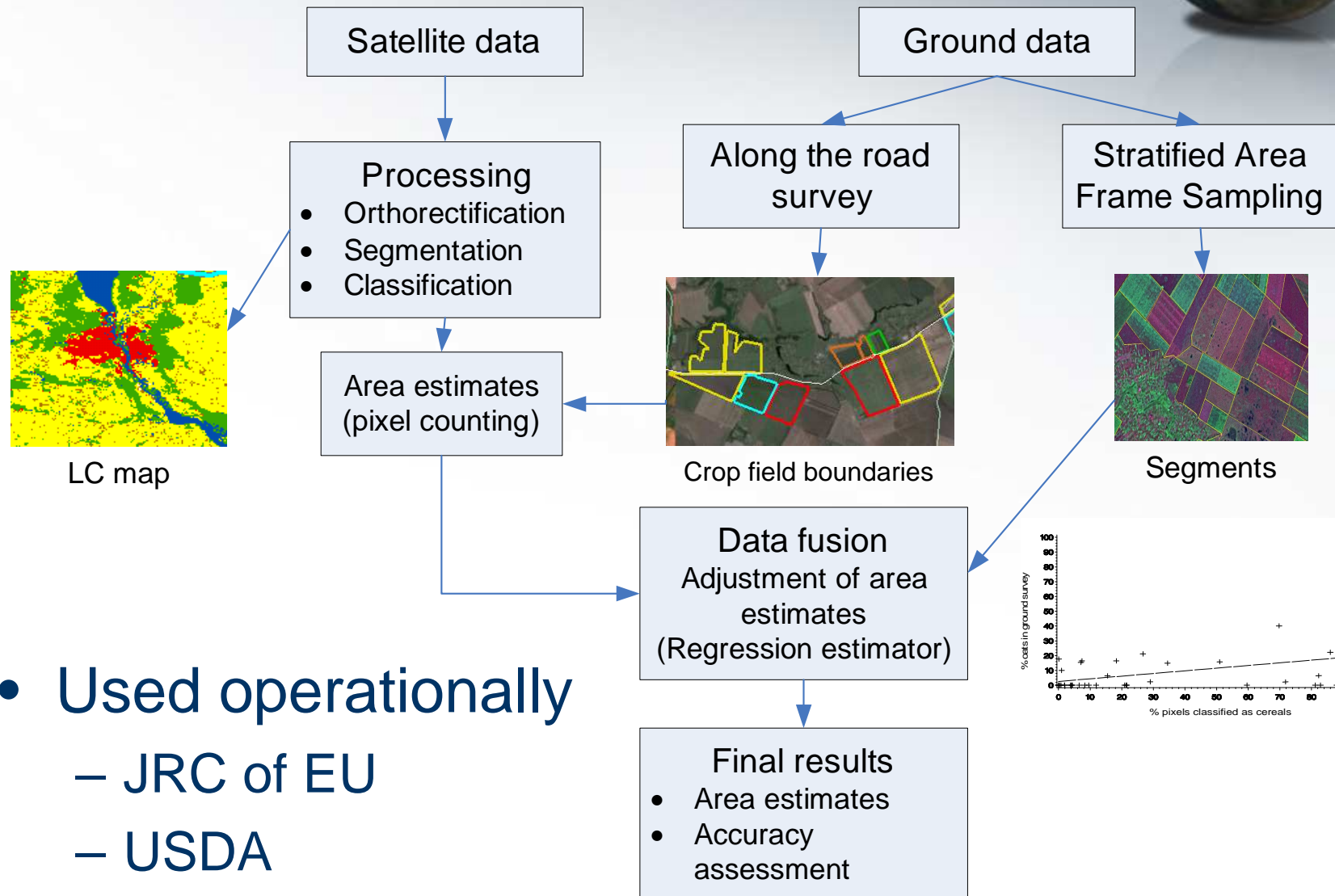
# Crop acreage estimation



- Contract of the Joint Research Centre of the European Commission
  - “Crop area estimation with satellite images in Ukraine”, 2010
- Contractor:
  - Space Research Institute NASU-NSAU
  - With the participation of experts from:
    - Ukrainian Hydrometeorological Center
    - National University of Life and Environmental Science of Ukraine
- Objective
  - to provide crop area estimation with satellite images in Ukraine



# Workflow of area estimation



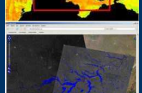
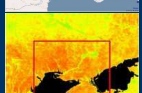
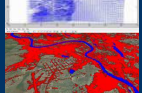
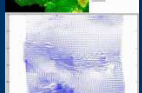
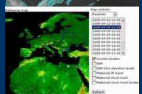
# Proposed area



- 3 administrative regions (oblasts)
  - Kyivska (28 000 km<sup>2</sup>)
  - Kmelnitska (20 000 km<sup>2</sup>)
  - Zhytomyrska (29 900 km<sup>2</sup>)



	Crop land area, ha	Cereal, ha
Kyivska	1 019 100	538 000
Kmelnitska	778 200	394 200
Zhytomyrska	655 900	209 400
<b>Total</b>	<b>2 453 200</b>	<b>1 141 600</b>



# Crop types in the areas

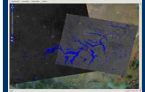
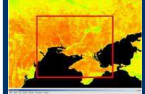
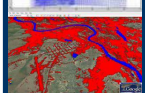
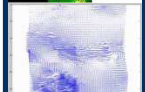


- Crops with 3% of the crop land in the selected regions
  - winter wheat, spring barley, maize, soya, sunflower, potatoes, sugar beet and oilseed rape.

Crop area distribution in Kyivska, Khmel'nitska and Zhytomyrska oblasts (in x1000 ha)

Crop type	Kyivska	%	Kmel'nitska	%	Zhytomyrska	%	Total	%
winter wheat	267,9	31,82	178,9	29,83	113,8	34,93	560,6	33,96
spring barley	152,7	18,14	153,1	25,53	61,6	18,91	367,4	22,25
maize	117,4	13,94	62,2	10,37	34	10,44	213,6	12,94
sugar beet	51,7	6,14	35,6	5,94	21,6	6,63	87,3	5,29
sunflower	27	3,21	5,1	0,85	2	0,61	32,1	1,94
soya	53,7	6,38	10,3	1,72	6,7	2,06	64	3,88
oilseed rape	48,2	5,73	72,7	12,12	18,2	5,59	120,9	7,32
potato	100,1	11,89	71,8	11,97	58,6	17,99	171,9	10,41
vegetables	23,2	2,76	10	1,67	9,3	2,85	33,2	2,01
<b>Total</b>	<b>841,9</b>	<b>100</b>	<b>599,7</b>	<b>100</b>	<b>325,8</b>	<b>100</b>	<b>1651</b>	<b>100</b>

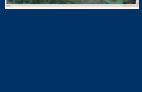
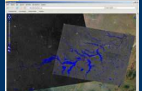
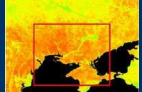
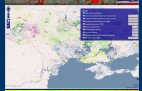
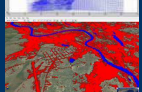
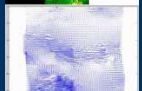
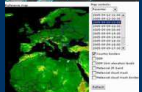
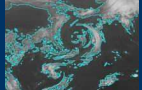
[Source: Ukrainian State Department of Statistics, *Agricultural Crops in 2007, Statistical Bulletin*]



# Type of data



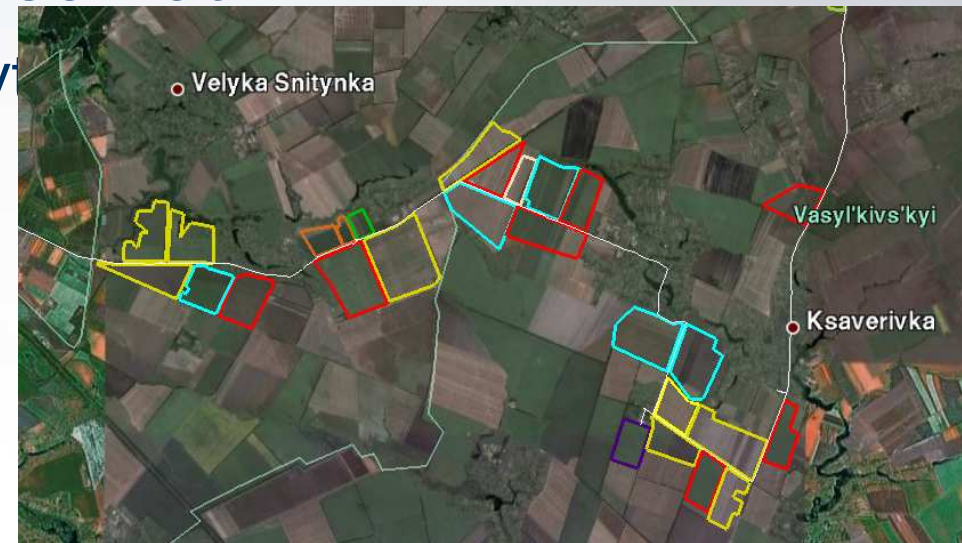
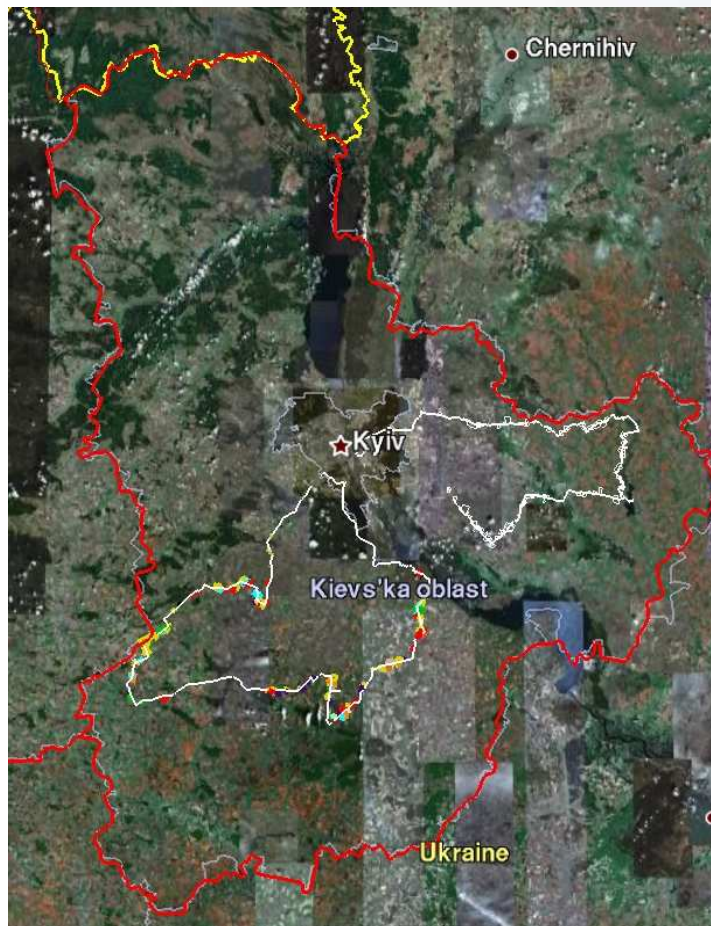
- Ground data
  - Ground surveys
    - surveys along the roads
      - geolocation data from GPS, crop type and ground photos
      - ~ 2x1000 fields
    - surveys to support area frame sampling
  - Data will be collected in the middle of June 2010 when all crops are present
- Satellite data
  - Ranging from mid to high resolution
    - MODIS, AWiFS, LISS-III, RapidEye
    - Landsat5 TM



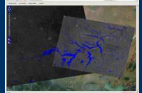
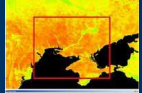
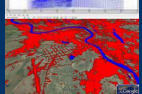
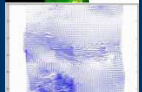
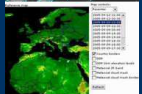
# Along the road surveys



- 2000 km has covered
- 2000 fields were observed



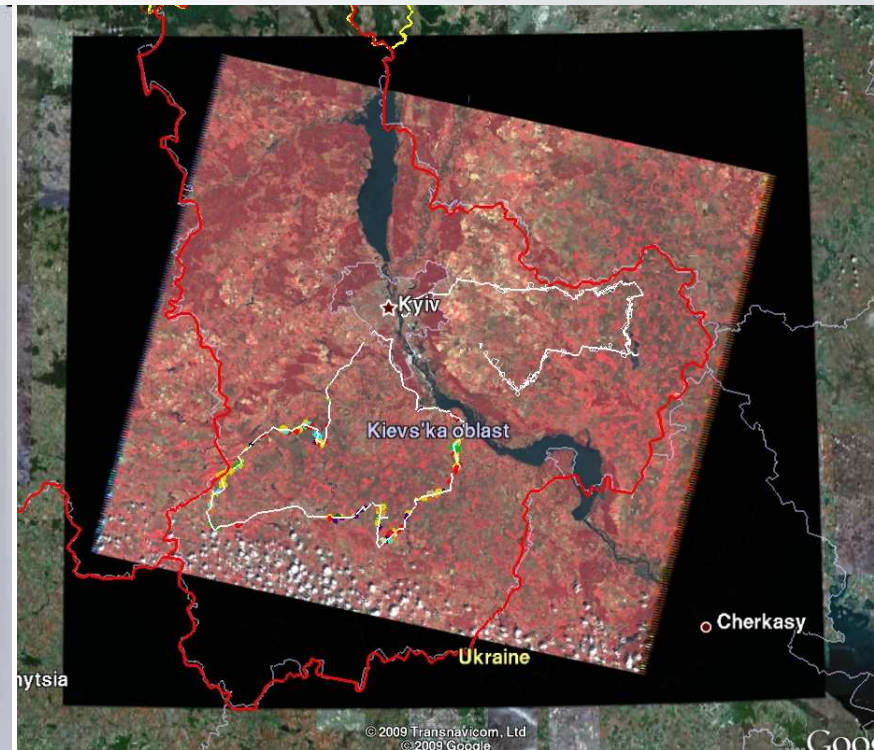
- 2 test surveys in 2009
- 300 fields labelled



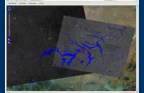
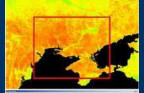
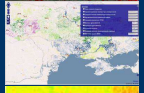
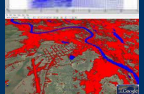
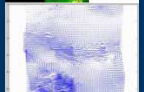
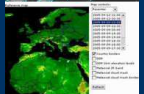
# Along the road surveys (2)



- Current satellite data to help with ground visits
- Modern smartphones/phones with GPS



Landsat-5/TM, 2009-04-21

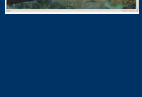
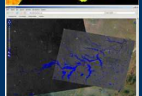
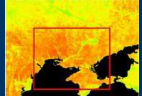
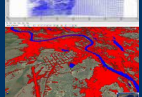
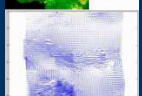
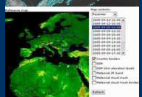
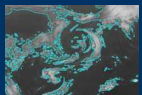
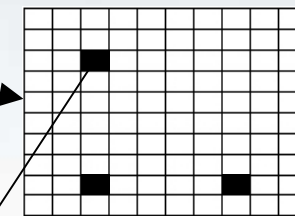
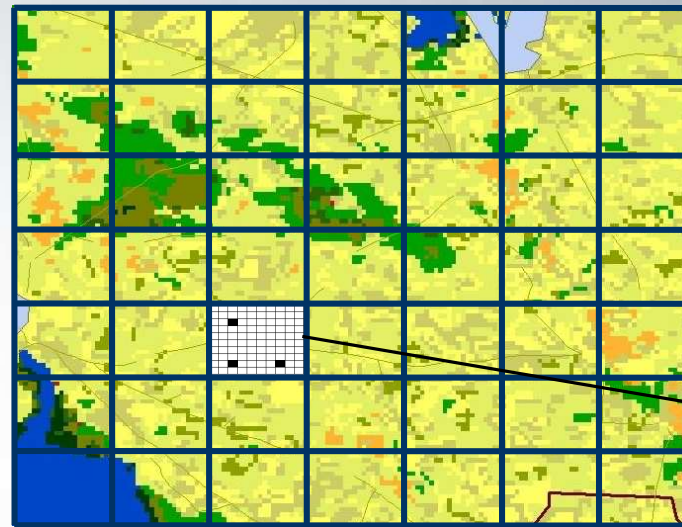




# Stratified Area Frame Sampling



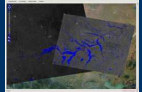
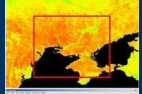
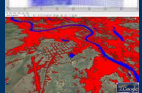
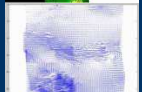
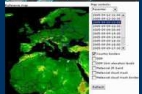
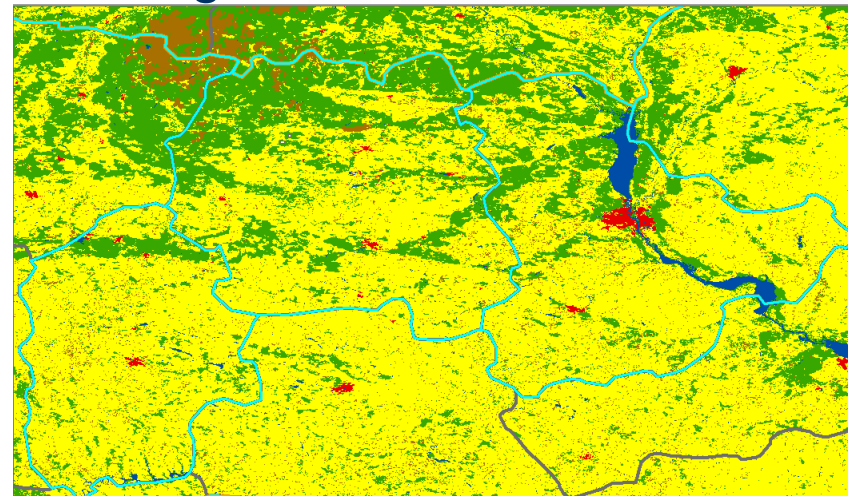
- Sampling approach
  - regular grid of sampling units of 40x40 km
  - 4x4 km segments
  - each segment will contain 15-20 fields in average
  - ~90 segments (30 segments per obl.)



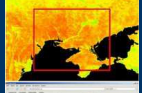
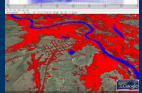
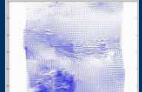
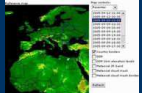
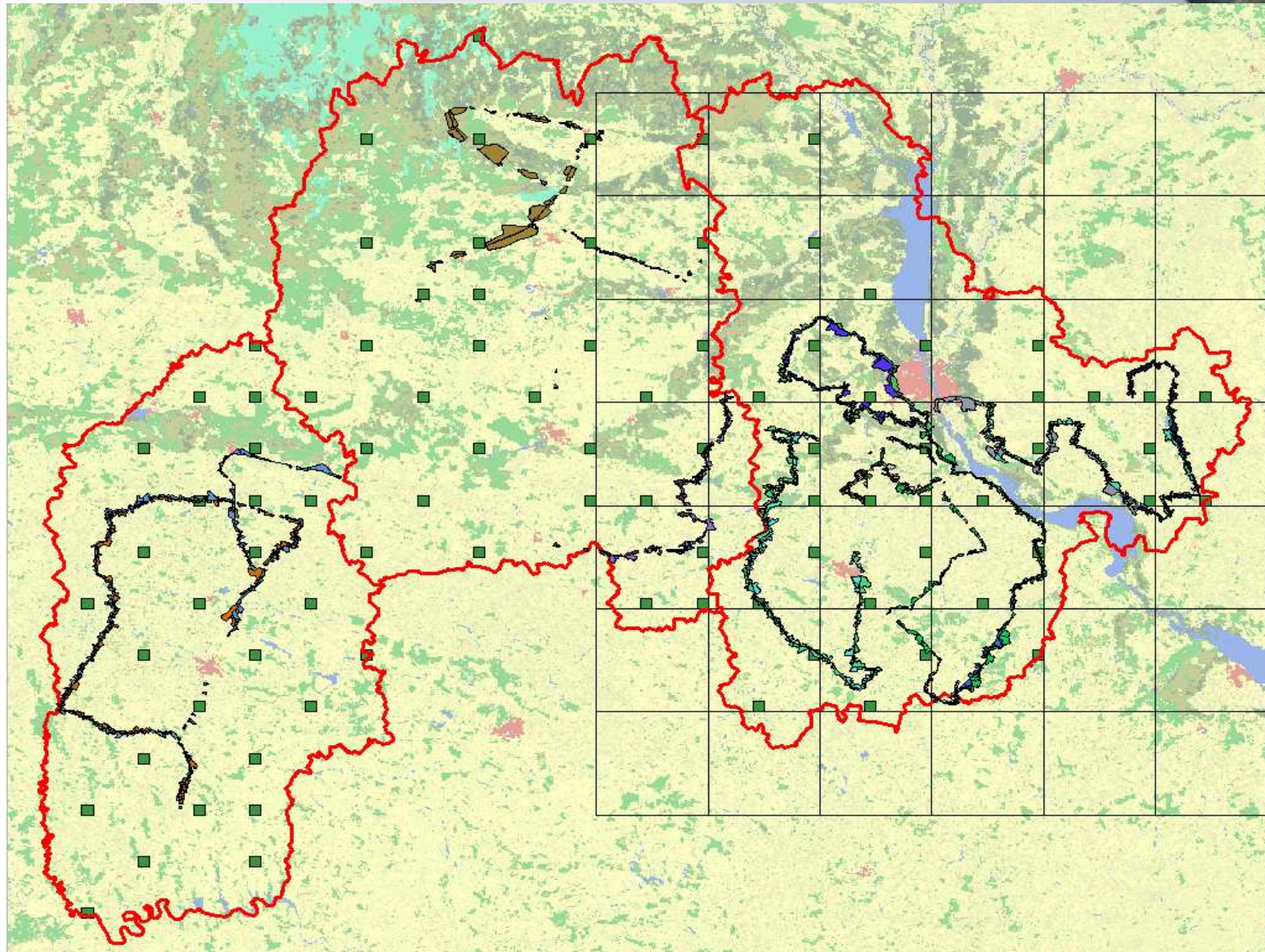
# Stratification



- Land cover maps
  - ESA GLOBCOVER (300m)
- Strata
  - Three strata will be used:
    - 1<sup>st</sup>: segments w/out agriculture lands
    - 2<sup>nd</sup>: segments with <50% agriculture lands
    - 3<sup>rd</sup>: segments with >50% agriculture lands
- Nomenclature
  - LUCAS: **Land Use/Cover Area frame Statistical Survey**



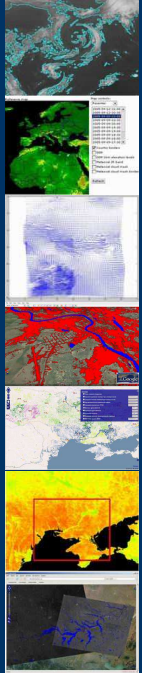
# Ground survey data



# Nomenclature



code	class
A11	Artificial with little vegetation, including dumpsites, mining sites, etc
A12	Urban vegetation (parks, leisure or sport areas, etc)
A13	Greenhouses
B11	Winter wheat (1)
B12	Spring wheat
B13	Winter barley
B14	Spring barley (2)
B16	Maize
B19	Other cereals
B21	Potatoes
B22	Sugar beet
B31	Sunflower
B32	Rapeseed
B33	Soy beans
B34	Vegetables
B38	Family gardens (3)
B39	Other annual crops
B40	Fodder in arable land and temporary grass
B50	Fallow (non cultivated for one year, but in the crop rotation). It can be ploughed or with natural vegetation.
B60	Permanent crops (mainly fruit trees) and nurseries
C10	Forest and woodland
E01	Permanent grassland with sparse tree/shrub cover
E02	Permanent grassland without tree/shrub cover (4)
F00	Bare land (natural vegetation covers <20% of the soil)
G01	Water
G02	Wetland
G03	Glaciers, permanent snow



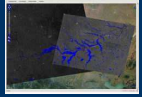
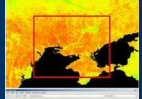
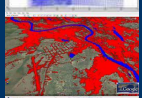
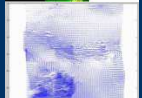
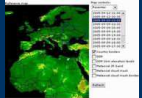
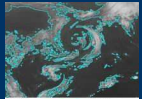
# Survey Forms



A	Surveyor ID: _____	B	Segment ID: _____	C	District (in case of boundary, mention both)
	Date: ____/____/____ DD  MM  YY	E	Start time: ____:____:____ HH  MM  SS	F	End time: ____:____:____ HH  MM  SS

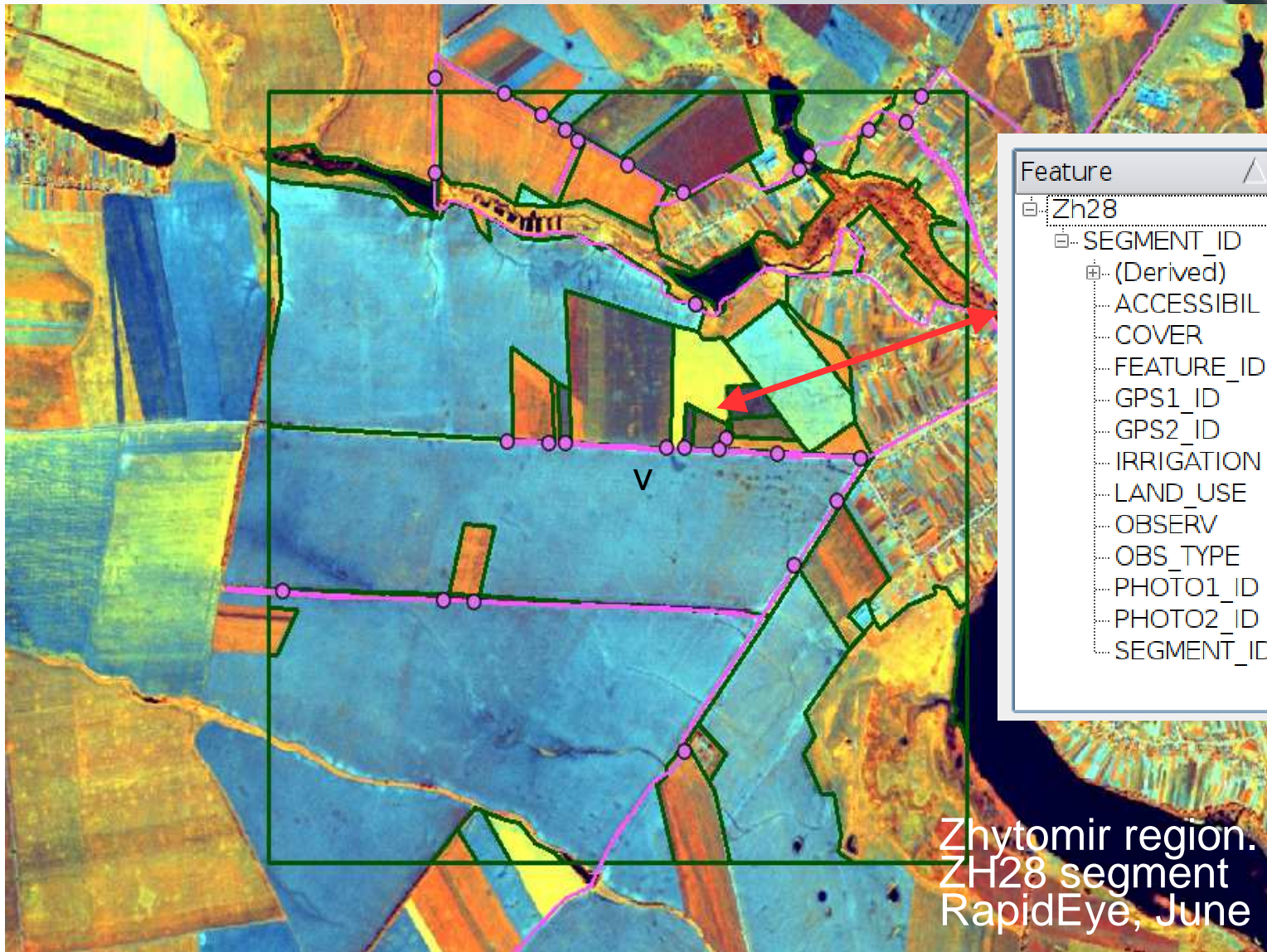
Filed number	Main use	Secondary use	% of cover for secondary use	Type of observation (1)	Irrigation? (yes=1)	Photo id (number)	GPS id (3).	Accessibility from road (2)	observations

- **Minimum size for polygon reporting: 100x100 m**
- **Type of observation** (correspond to the conditions of observation in the current year).
  - 1.Complete perimeter
  - 2.Field reached , 0-20m to point
  - 3.Field visible, >20 m to point or through a fence or other obstacle
  - 4.Photo-interpretation, not visible on the ground
- **Accessibility** (long term criterion)
  - 1.Adjacent to a drivable tarmac road
  - 2.Adjacent to a drivable dirt road
  - 3.Easily reachable with a mountain bike
  - 4.Accessible only walking



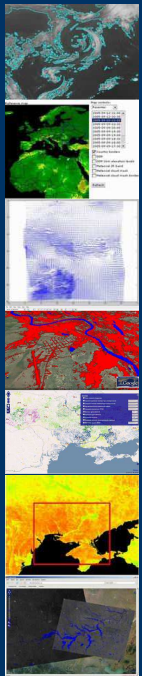


# Segment surveying example (2)



Feature	Value
Zh28	Layer
SEGMENT_ID	ZH28
(Derived)	
ACCESSIBIL	2
COVER	100
FEATURE_ID	19
GPS1_ID	017
GPS2_ID	NULL
IRRIGATION	0
LAND_USE	B22
OBSERV	NULL
OBS_TYPE	2
PHOTO1_ID	IMG_2993
PHOTO2_ID	NULL
SEGMENT_ID	ZH28

Zhytomir region.  
ZH28 segment  
RapidEye, June

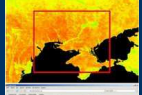
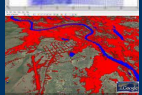
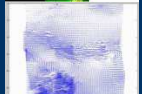
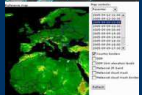


Kyiv,  
2010

# Area Estimates. Sample only



use	all			K			KH			ZH		
	mean	std	m/s	mean	std	m/s	mean	std	m/s	mean	std	m/s
A11	0.007	0.002	37.0	0.012	0.006	51.2	0.001	0.000	50.5	0.006	0.002	30.2
A12	0.000	0.000	88.3	0.000	0.000	97.6	0.000	0.000	-	0.000	0.000	97.6
A13	0.000	0.000	99.2	0.001	0.001	97.6	0.000	0.000	-	0.000	0.000	-
B11	0.076	0.011	15.0	0.114	0.020	18.0	0.096	0.020	21.1	0.038	0.011	30.1
B14	0.039	0.008	20.4	0.033	0.011	31.9	0.061	0.015	24.2	0.031	0.016	51.8
B16	0.059	0.010	17.6	0.109	0.020	18.3	0.043	0.013	31.2	0.026	0.016	59.6
B19	0.044	0.007	16.8	0.035	0.011	30.4	0.059	0.017	29.0	0.041	0.009	22.7
B21	0.000	0.000	58.3	0.000	0.000	57.2	0.000	0.000	89.4	0.000	0.000	-
B22	0.005	0.002	30.6	0.008	0.003	38.4	0.007	0.003	47.8	0.001	0.001	97.6
B31	0.014	0.004	29.9	0.025	0.008	31.9	0.016	0.010	61.3	0.003	0.002	67.5
B32	0.012	0.004	31.3	0.005	0.004	86.7	0.025	0.008	30.2	0.007	0.007	97.6
B33	0.036	0.008	20.9	0.055	0.012	21.9	0.028	0.010	36.5	0.026	0.015	60.4
B34	0.000	0.000	99.2	0.000	0.000	97.6	0.000	0.000	-	0.000	0.000	-
B38	0.124	0.014	11.4	0.131	0.028	21.6	0.141	0.023	16.2	0.105	0.018	17.6
B39	0.017	0.008	45.8	0.007	0.004	54.9	0.052	0.027	51.4	0.001	0.000	53.5
B40	0.012	0.003	24.4	0.009	0.003	32.4	0.007	0.003	49.3	0.020	0.007	36.6
B50	0.019	0.005	27.9	0.005	0.002	42.7	0.053	0.016	30.2	0.006	0.004	58.4
B60	0.006	0.003	53.6	0.003	0.002	67.5	0.013	0.009	70.8	0.002	0.001	49.1
B70	0.009	0.004	46.0	0.007	0.003	39.9	0.018	0.014	78.0	0.007	0.006	82.6
C10	0.252	0.026	10.4	0.223	0.042	18.8	0.165	0.041	24.6	0.321	0.032	10.1
E01	0.120	0.016	13.3	0.070	0.018	25.6	0.108	0.023	21.4	0.183	0.035	19.1
E02	0.090	0.015	16.7	0.093	0.033	35.0	0.071	0.020	28.1	0.107	0.021	19.3
F00	0.004	0.003	88.4	0.001	0.001	70.6	0.000	0.000	-	0.010	0.009	97.6
G01	0.022	0.010	46.5	0.030	0.016	55.1	0.005	0.003	54.6	0.023	0.019	82.7
G02	0.026	0.012	44.8	0.025	0.012	46.9	0.011	0.006	53.1	0.036	0.026	72.8





# Satellite images



- **Sensors**

- **AWIFS**

- 5 images
    - Coverage: 370x370 km
    - Resolution: 60 m

- **LISS-3**

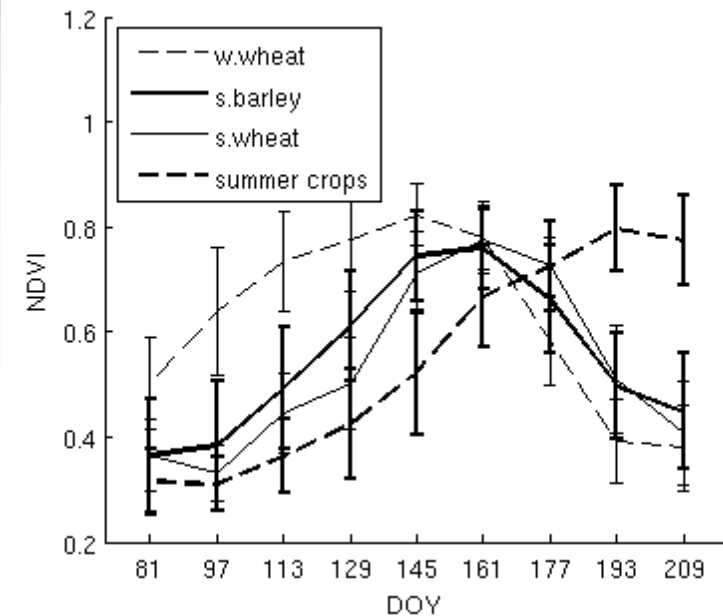
- 3 images
    - Coverage: 140x140 km
    - Resolution: 20 m

- **RapidEye**

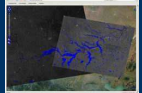
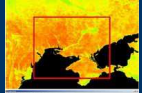
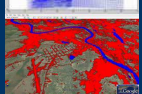
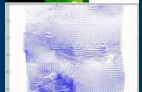
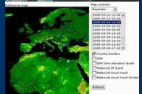
- 3 images
    - Coverage: 70x70 km
    - Resolution: 5 m

- **Timing**

- (1) 15-30 April 2010
    - for winter crops identification.
  - (2) 20 May - 20 June 2010
    - flowering of winter rape, discriminate between winter and spring crops.
  - (3) 10 August - 10 September 2010
    - discriminate between spring and summer crops



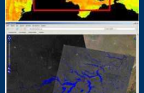
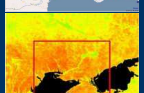
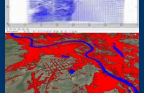
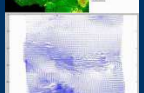
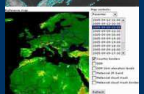
Crop timings in Kyiv obl., 2009



# Image Processing



- Pre-processing
  - geocoding and orthorectification
  - ground survey: collection of GCPs of clearly identified objects (buildings, crossroads, etc)
- Segmentation
  - watershed segm. for LISS-III and RE data
- Image classification
  - Neural Network (Multilayered Perceptron)
  - Support Vector Machine (SVM)
  - Decision tree classifiers (like C4.5) can also be used



# Area estimation



- Pixel counting
  - Hard and soft classification
- Regression estimator

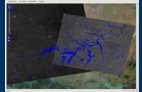
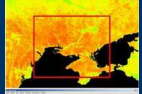
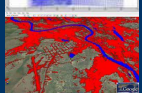
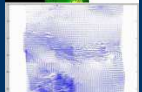
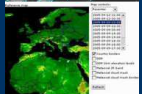
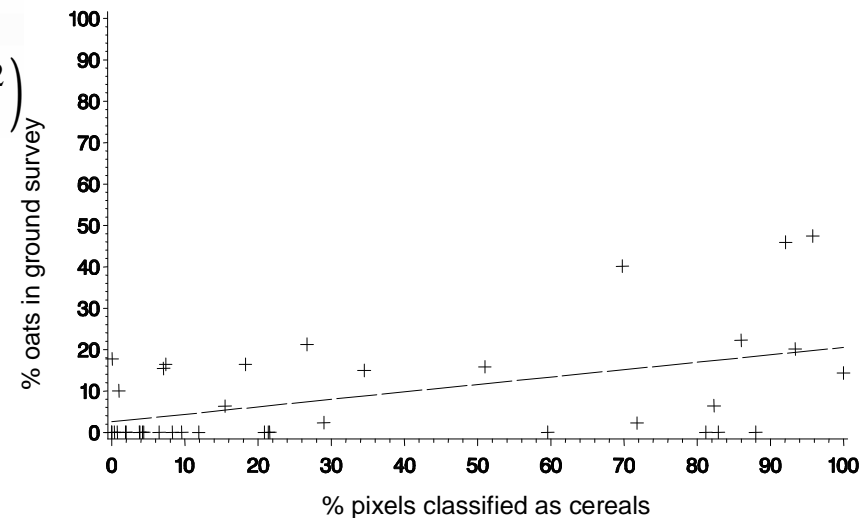
$$\hat{y}_{dif} = \bar{y} + b(\mu_x - \bar{x}) \qquad \hat{y}_{reg} = \bar{y} + b(\mu_x - \bar{x})$$

$$\hat{V}(\hat{y}_{dif}) = \frac{N-n}{N \times n} (s_y^2 - 2b_0 s_{x,y} + b_0^2 s_x^2)$$

$$V(\hat{y}_{reg}) = \frac{N-n}{N \times n} \left( 1 + \frac{1}{n-3} + \frac{2G_x^2}{n^2} \right) \sigma_y^2 (1 - \rho^2)$$

$$G_x = \frac{k_{3x}}{\sigma_x^3}$$

$$\hat{V}(\hat{y}_{reg}) \approx \frac{1}{n} s_y^2 (1 - r_{xy}^2)$$



# Classification. MODIS data



- Data from JRC
  - ETRS-LAEA
  - 250 m
  - 10 days int.
- Training set
  - along roads
  - 24k pixels
- Test set
  - AFS
  - 6600 pixels
- Classifier: nonlinear SVM
- Accuracy: CV: 75%, train: 88%, test: 47%

Test Confusion Matrix

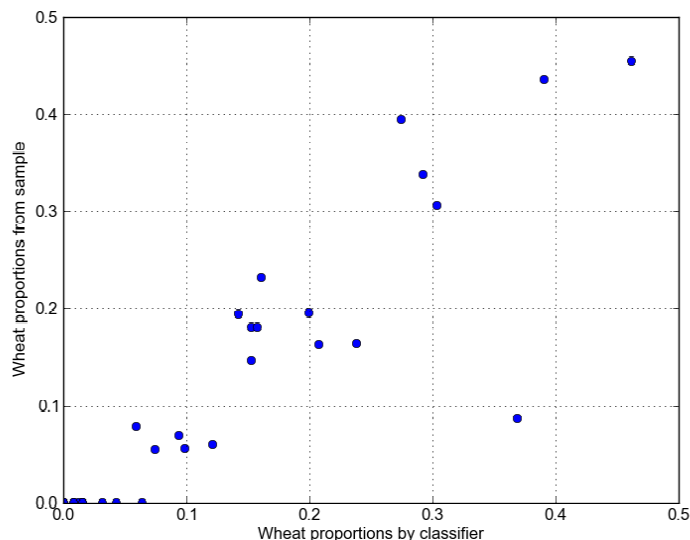
1	495 7.4%	48 0.7%	42 0.6%	43 0.6%	62 0.9%	13 0.2%	5 0.1%	21 0.3%	73 1.1%	61.7% 38.3%
2	103 1.5%	22 0.3%	21 0.3%	26 0.4%	28 0.4%	2 0.0%	0 0.0%	5 0.1%	42 0.6%	8.8% 91.2%
3	41 0.6%	6 0.1%	470 7.1%	110 1.7%	55 0.8%	6 0.1%	0 0.0%	10 0.2%	94 1.4%	59.3% 40.7%
4	31 0.5%	5 0.1%	136 2.0%	142 2.1%	39 0.6%	5 0.1%	0 0.0%	3 0.0%	45 0.7%	35.0% 65.0%
5	25 0.4%	2 0.0%	8 0.1%	9 0.1%	657 9.9%	57 0.9%	0 0.0%	16 0.2%	37 0.6%	81.0% 19.0%
6	6 0.1%	1 0.0%	7 0.1%	4 0.1%	179 2.7%	968 14.9%	0 0.0%	36 0.5%	18 0.3%	79.7% 20.3%
7	28 0.4%	14 0.2%	19 0.3%	7 0.1%	350 5.3%	39 0.6%	3 0.0%	80 1.2%	23 0.3%	0.5% 99.5%
8	19 0.3%	8 0.1%	8 0.1%	11 0.2%	257 3.9%	73 1.1%	1 0.0%	202 3.0%	20 0.3%	33.7% 66.3%
9	122 1.8%	25 0.4%	149 2.2%	84 1.3%	377 5.7%	28 0.4%	3 0.0%	55 0.8%	346 5.2%	29.1% 70.9%
	56.9% 43.1%	16.8% 83.2%	54.7% 45.3%	32.6% 67.4%	32.8% 67.2%	81.6% 18.4%	25.0% 75.0%	47.2% 52.8%	49.6% 50.4%	50.0% 50.0%
	1	2	3	4	5	6	7	8	9	



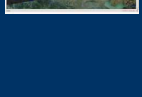
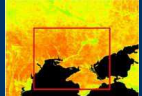
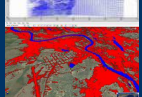
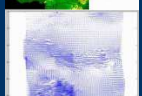
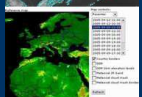
# Relative Efficiency. Kyivska obl.



Wheat proportions scatterplot



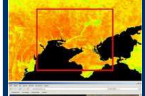
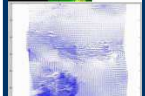
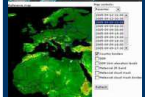
$$\hat{V}(\hat{y}_{reg}) \approx \frac{1}{n} s_y^2 (1 - r_{xy}^2)$$



class#	code	description	ro	1/(1-ro^2)	relative eff.	Error, %. Survey only	Error, %. + sat. data	Area estimation, %
1	B11	wheat	0,88	4,54	2,13	18,0	8,45	11,4
2	B14	spring barley	0,04	1,00	1,00	31,9	31,87	3,4
3	B16	maize	0,79	2,67	1,63	18,3	11,21	10,6
4	B33	soy beans	0,72	2,05	1,43	21,9	15,30	5,5
5	B38	family gardens	0,71	2,01	1,42	21,6	15,24	13,1
6	C10	forest & woodland	0,97	18,71	4,33	18,8	4,35	22,3
7	E01	grassland w. shrub	0,14	1,02	1,01	25,6	25,34	7,0
8	E02	grassland wo. Shrub	0,62	1,62	1,27	35,0	27,51	9,3



Thank you!



Kyiv,  
2010