Mapping croplands using Landsat data over Europe, Russia, Middle East, and Central Asia

Aparna Phalke and Mutlu Ozdogan

Center for Sustainability and the Global Environment (SAGE)
Nelson Institute for Environmental Studies
University of Wisconsin - Madison

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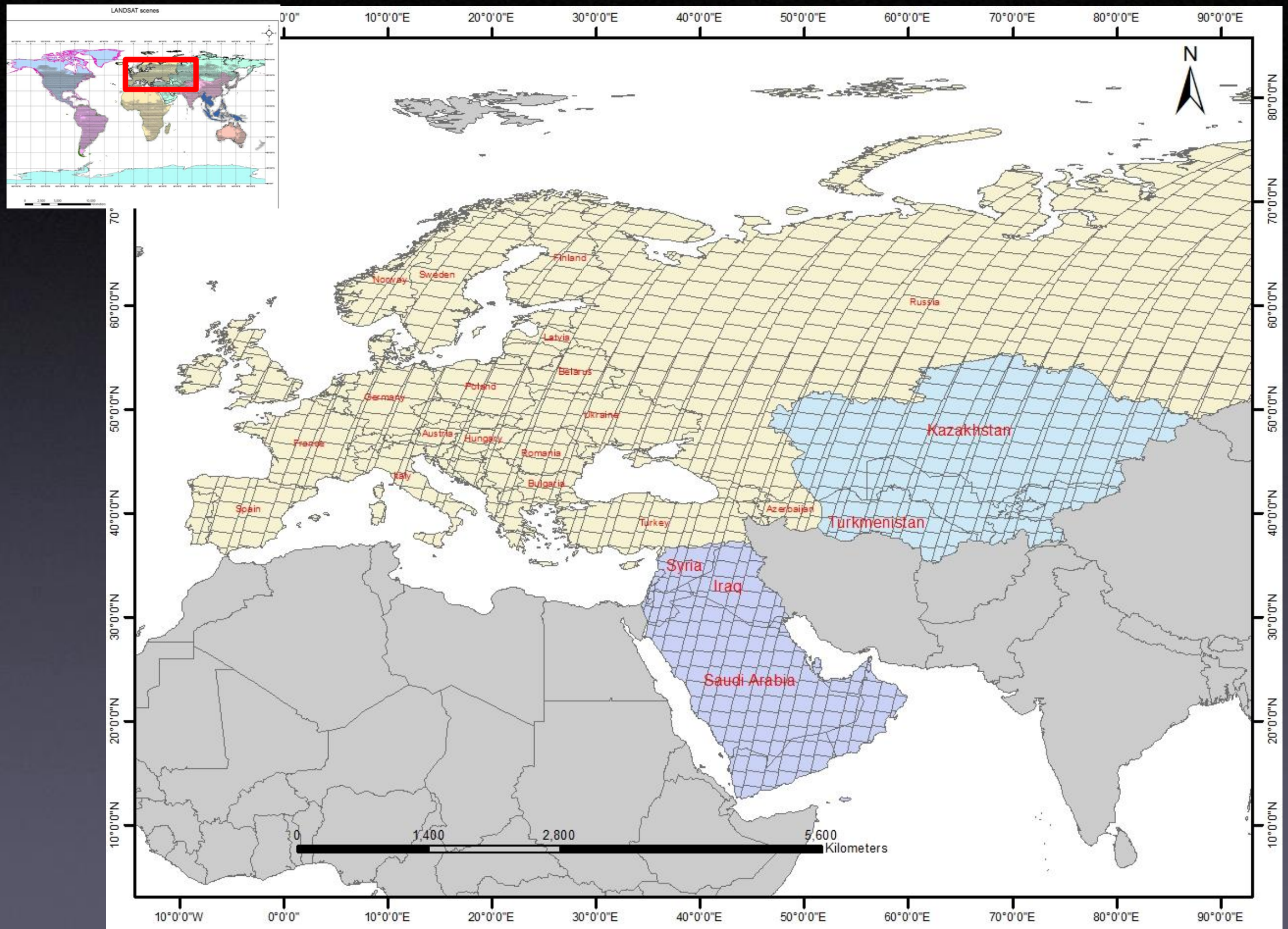
Highlights

- Cropland extent mapping in Europe, West Asia, Middle East, and Central Asia
- Preliminary accuracy assessment
- Assessment of wall to wall map (Area comparisons)
- Post-processing with HSeg algorithm
- Follow-on products

Study Area


LANDSAT scenes
N
Finland
Norway
Sweden
Russia
Latvia
Belarus
Poland
Germany
Ukraine
Austria
Hungary
France
Romania
Italy
Bulgaria
Spain
Turkey
Azerbaijan
Kazakhstan
Turkmenistan
Syria
Iraq
Saudi Arabia
0
1,400
2,800
5,600
Kilometers
10°0'0"W
0°0'0"
10°0'0"E
20°0'0"E
30°0'0"E
40°0'0"E
50°0'0"E
60°0'0"E
70°0'0"E
80°0'0"E
90°0'0"E
10°0'0"N
20°0'0"N
30°0'0"N
40°0'0"N
50°0'0"N
60°0'0"N
70°0'0"N
80°0'0"N

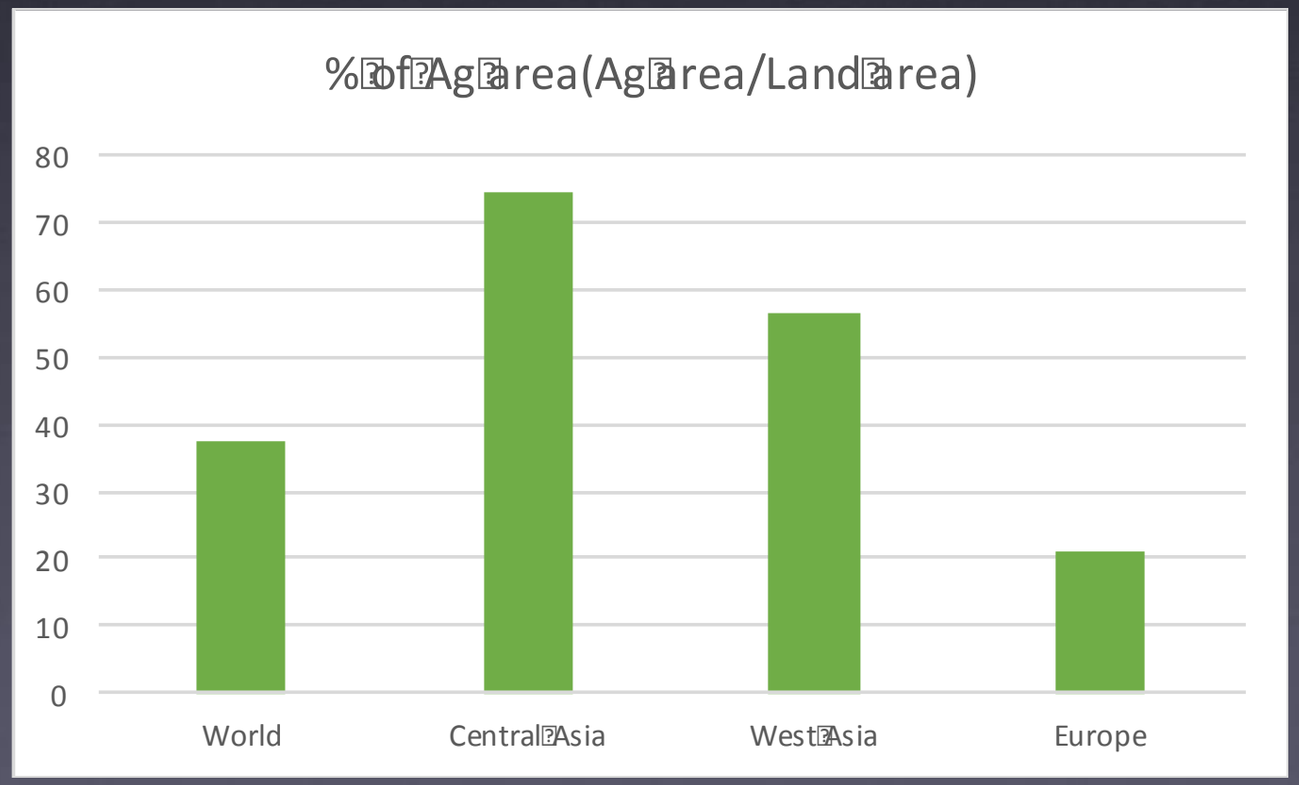
State of agriculture

Available resources, land use history, and demographic trends drive agriculture presence in Europe, West Asia, and Central Asia

	Europe	**West Asia**	**Central Asia**
Country	Portugal, Spain, France, Germany, Belgium, Netherlands, Switzerland, Italy, Denmark, Poland, Andorra, Czech Republic, Slovakia, Slovenia, Austria, Hungary, Croatia, Serbia, Romania, Bulgaria, Macedonia, Albania, Greece, Moldova, Lithuania, Latvia, Estonia, Ukraine, Russia, Sweden, Norway, Finland, Macedonia, U.K., Ireland, San Mario, Malta, Luxemburg, Montenegro, Liechtenstein etc. (**46 countries**)	Armenia, Azerbaijan, Bahrain, Cyprus, Georgia, Iraq, Israel, Jordan Kuwait, Lebanon, Occupied Palestinian Territory, Oman, Qatar, Saudi Arabia, Syria, Turkey, U.A.E., Yemen **(18 Countries)**	Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, Tajikistan **(5 countries)**

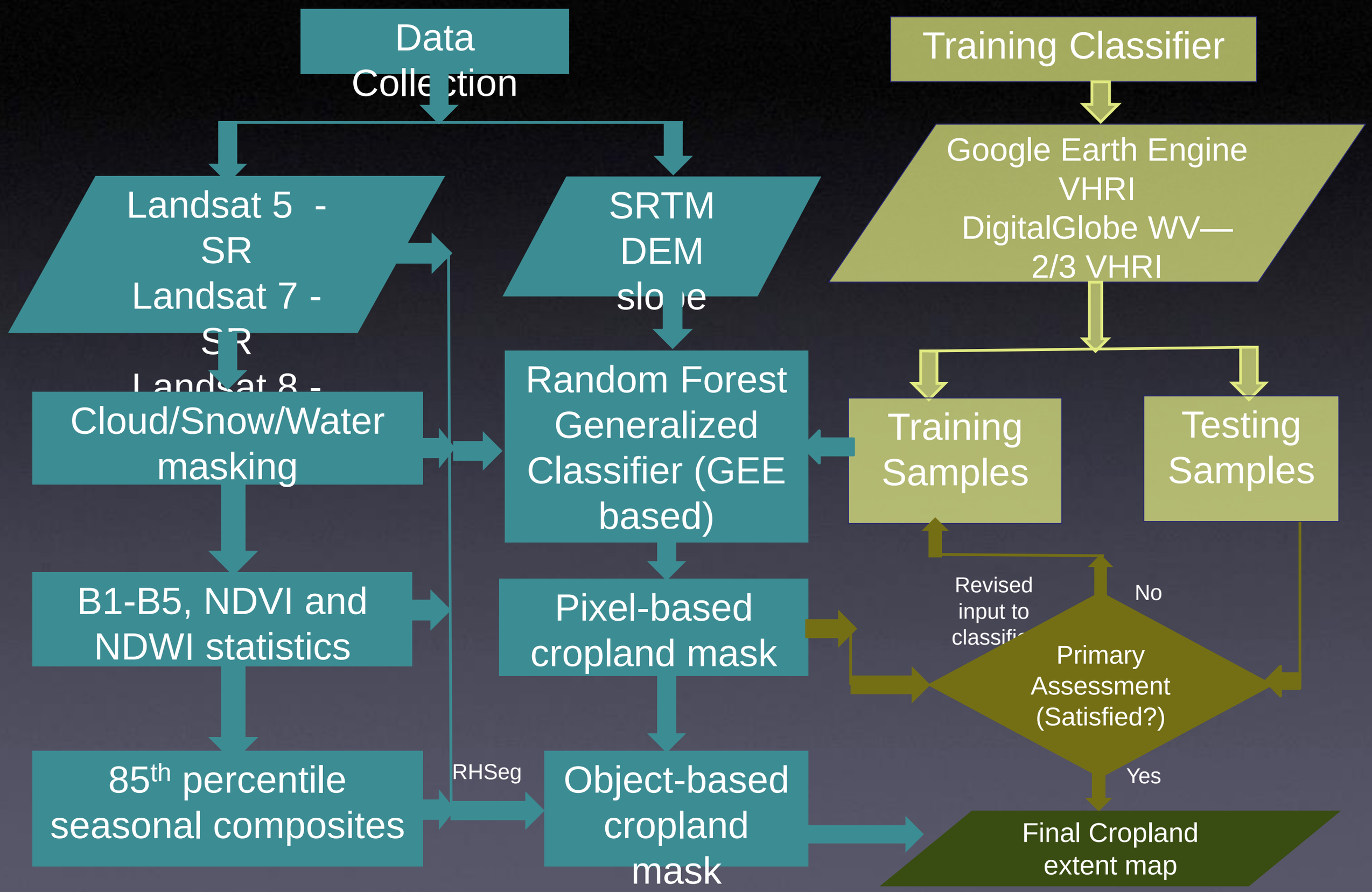
Agricultural area

	World	Central Asia	West Asia	Europe
Country area(1000 ha)	13466561.23	400172.7 (2.97%)	482969.1(3.59%)	2305772.8 (17.12%)
Land area(1000 ha)	13009010.23	392561.6(3.01%)	480507.4(3.69%)	2213351(17.01%)
Agricultural area(1000 ha)	4900105.17	292902.1(5.98%)	272695.59(5.57%)	468280.88(9.56%)

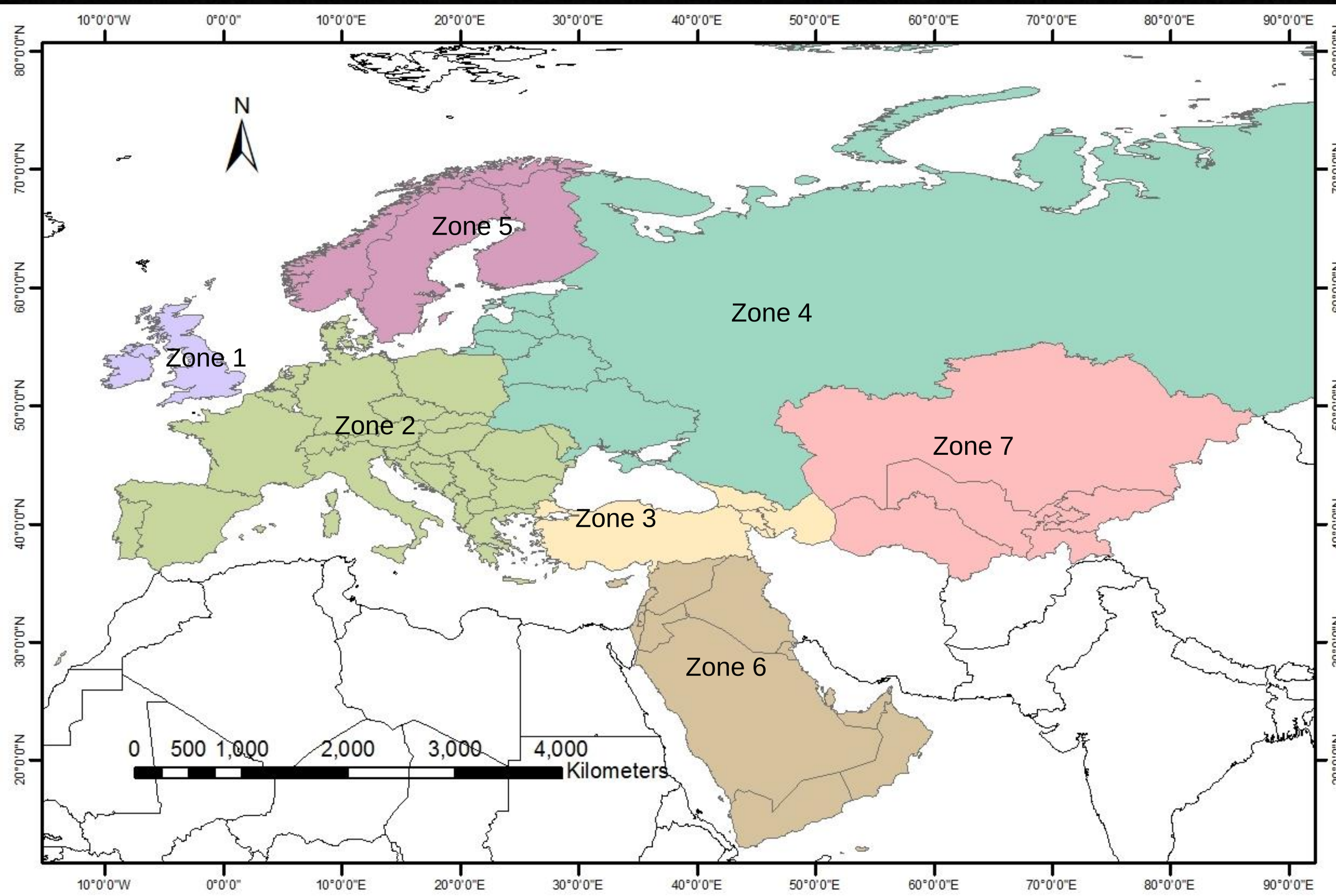


FAO (2014)

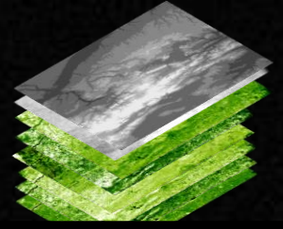
Methodology



Step 1: Study area Stratification



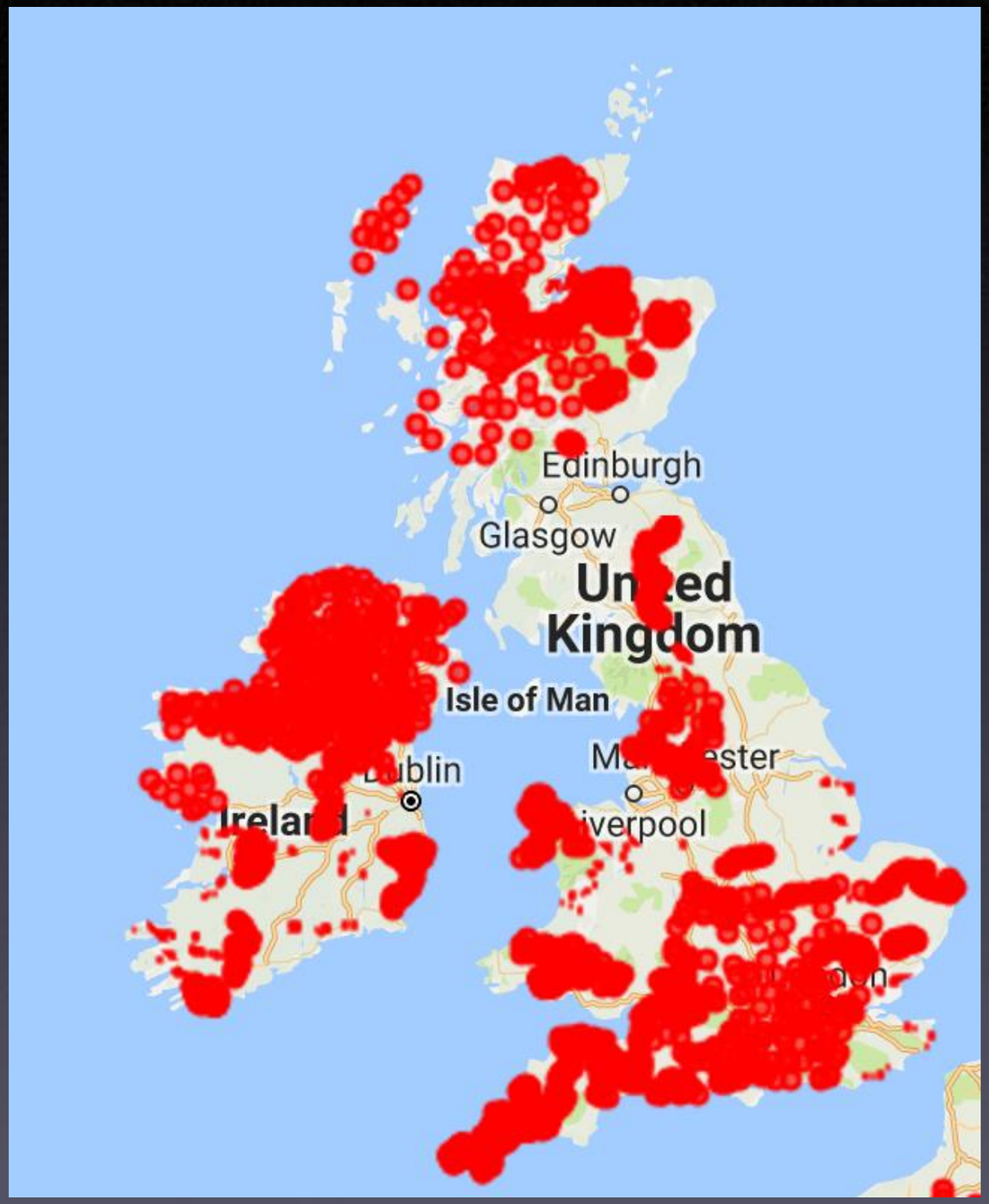
Data Input for classifier for different regions



Zones	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7
Countries in the zones	UK, Ireland	Portugal, Spain, France, Germany, Belgium, Netherlands, Switzerland, Italy, Denmark, Poland, Andorra, Czech Republic, Slovakia, Slovenia, Austria, Hungary, Croatia, Serbia, Romania, Bulgaria, Macedonia, Albania, Greece, Moldova	Turkey, Georgia, Armenia, Azerbaijan	Lithuania, Latvia, Estonia, Ukraine, Russia	Sweden, Norway, Finland	Syria, Cyprus, Lebanon, Israel, West bank, Jordan, Iraq, Saudi Arabia, Oman, U.A.E., Kuwait, Qatar, Bahrain, Yemen	Kazakhstan, Uzbekistan, Turkmenistan, Kyrgyzstan, Tajikistan
Seasons	Three seasons (S1: 61-150, S2: 151-240, S3: 241-330)	Six seasons (S1: 1-60, S2: 61-120, S3: 121-180, S4: 181-240, S5: 241-300, S6: 301-305)	Four Seasons (S1: 1-90, S2: 91- 180, S3: 181-270, 271-365)	Six Seasons (S1: 1-60, S2: 61-120, S3: 121-180, S4: 181-240, S5: 241-300, S6: 301-305)	Three Seasons (S1: 61-150, S2: 151-240, 241-330)	Four Seasons (S1: 1-90, S2: 91- 180, S3: 181-270, S4: 271-365)	Three seasons (S1: 1-120, S2: 121-240, S3: 241- 365)
Input Bands (2013-2015)	**Total 24 bands**: 1. Per year per season NDVI and NDWI (18 bands) 2. Standard Deviation of NDVI (1 band) 3.NDVI and NDWI max and min 85th percentile of overall composite (4	**Total 56 bands:** 1.Six seasons per year NDVI and NDWI bands i.e. NDVI (18 Bands), NDWI (18 bands) 2. Slope (1 band) 3. Standard Deviation of NDVI, Range of NDVI and Minimum of NDVI of overall composite (3 bands) 4. Landsat SR B1,B2,B3,B4,B5 and B7 maximum and minimum 75th percentile of overall composite (12 bands) 5. NDVI and NDWI max and min	**Total 49 bands**: 1. Four seasons per year NDVI, NBR, VARI (36 bands) 2. Landsat SR B1,B2,B3,B4, B5 and B7 maximum and minimum 85th percentile of overall	**Total 56 bands:** Same as zone 2	**Total 23 bands**: 1. Per year per season NDVI and NDWI (18 bands) 2. Standard Deviation of NDVI (1 band) 3.NDVI and NDWI max and min 85th percentile of overall composite (4	**Total 36 bands:** Same as zone 3	**Total 32 bands**: Four seasons per year NDVI, NBR, VARI (27 bands) 2. Standard Deviation of NDVI (1 band) 3.NDVI and NDWI max and min 85th percentile of overall composite (4

Zone 1 train/test samples

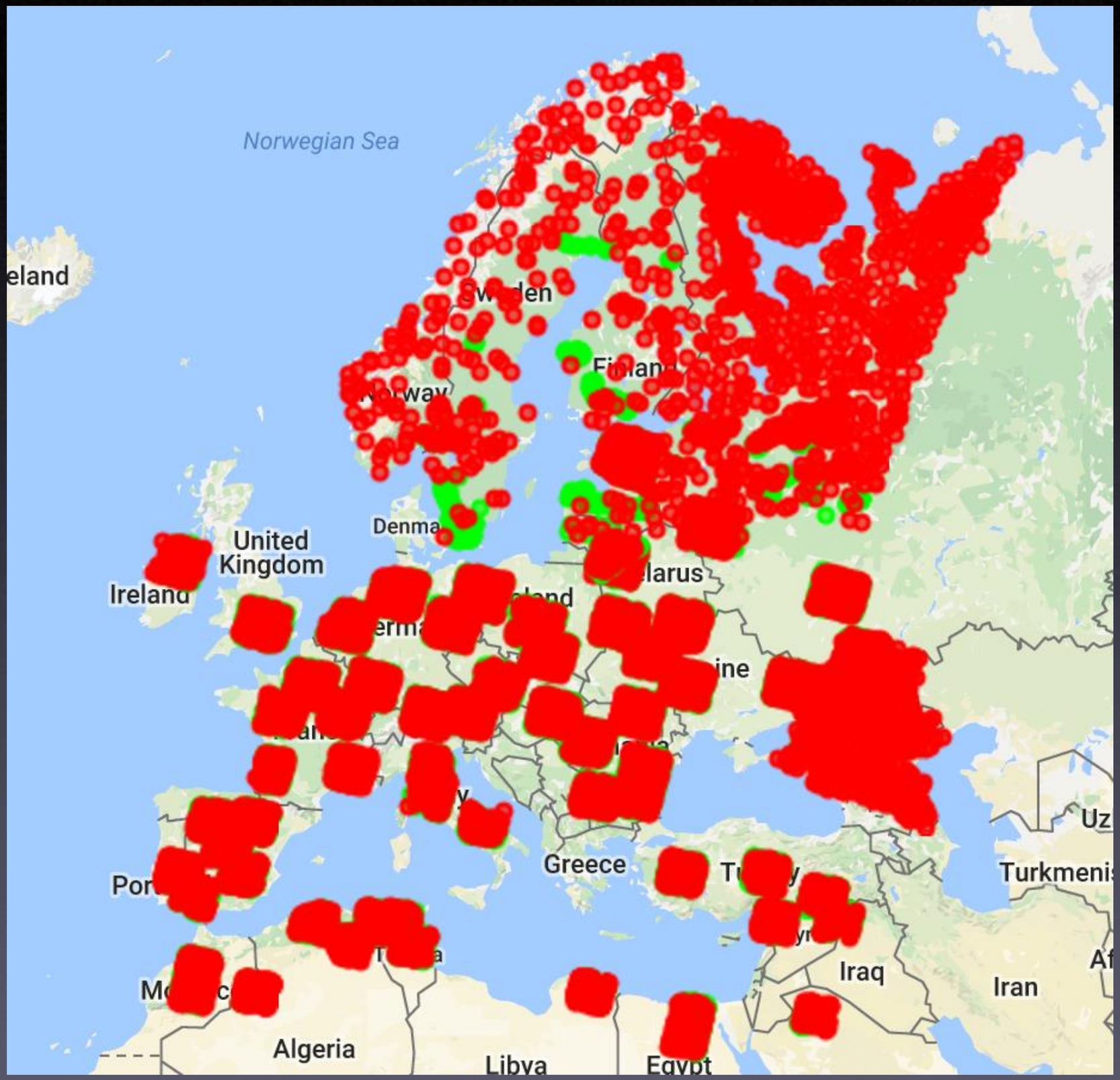
Crop
Samples(2667)



Non-Crop
Samples(2249)

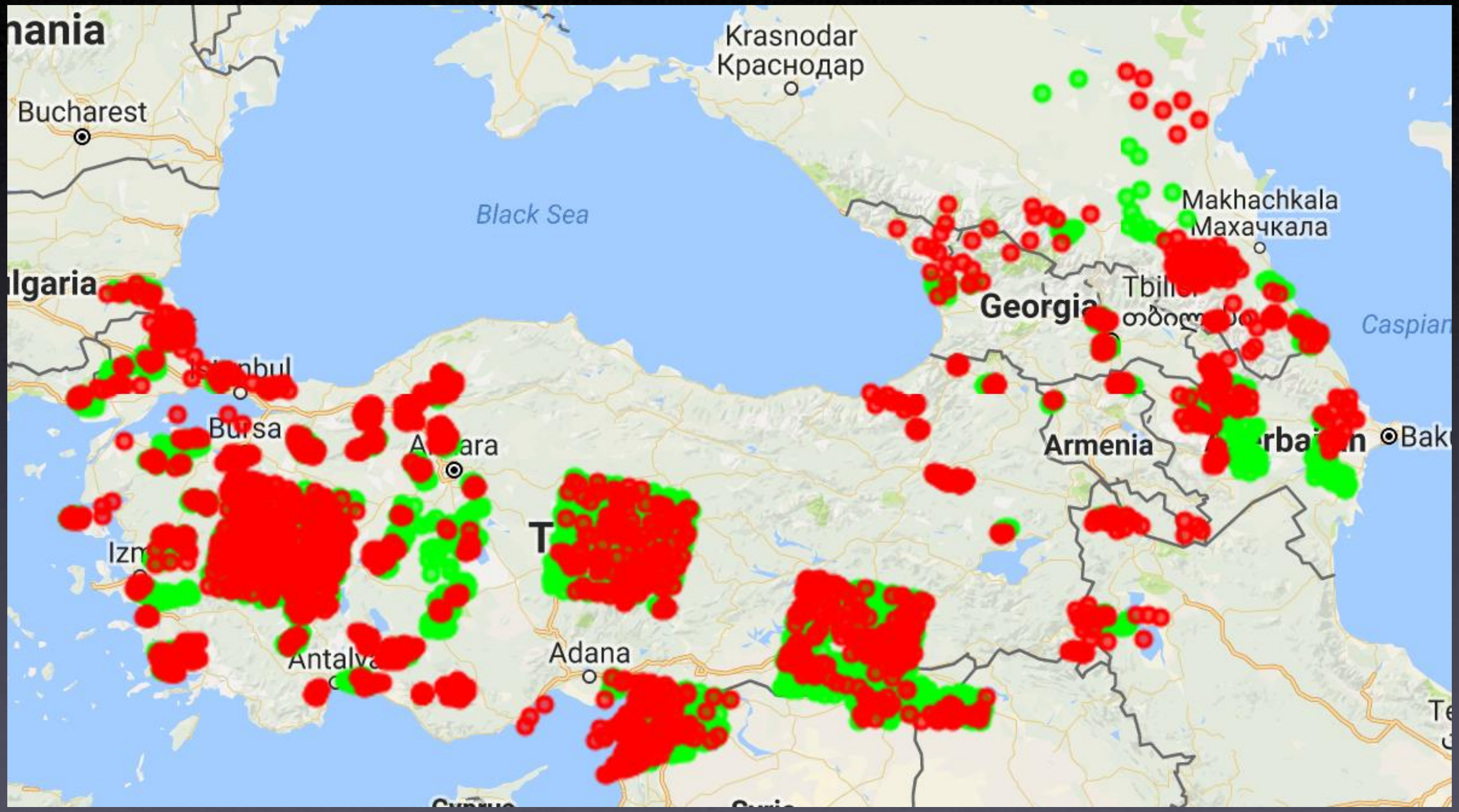
Zone 2, 4 and 5 train/test samples

Non-crop
Crop



Zone3 train/test samples

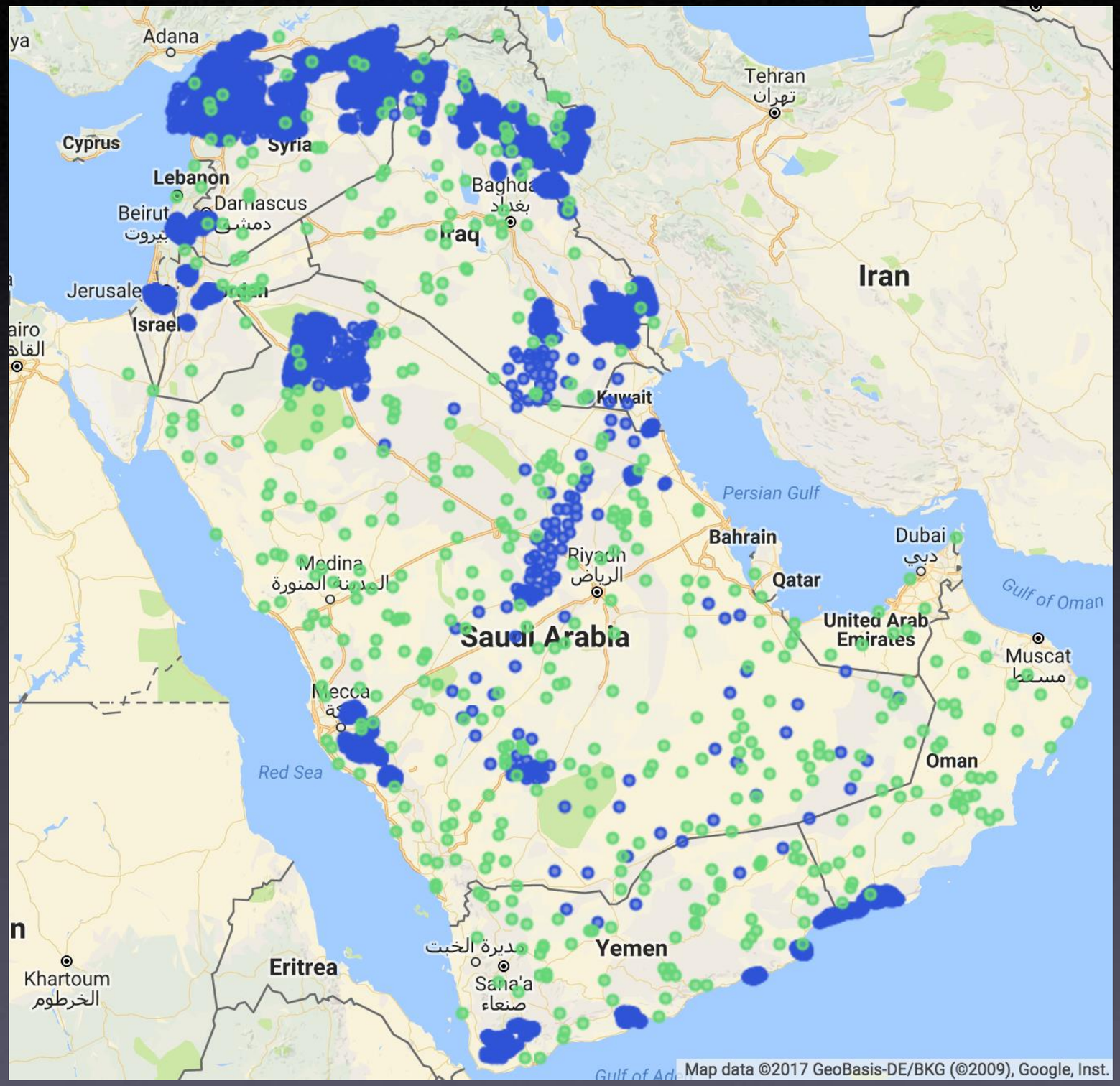
Non-crop
Crop



Crop
Samples(2762)

Non-Crop
Samples(2516)

Zone 6 train/test samples

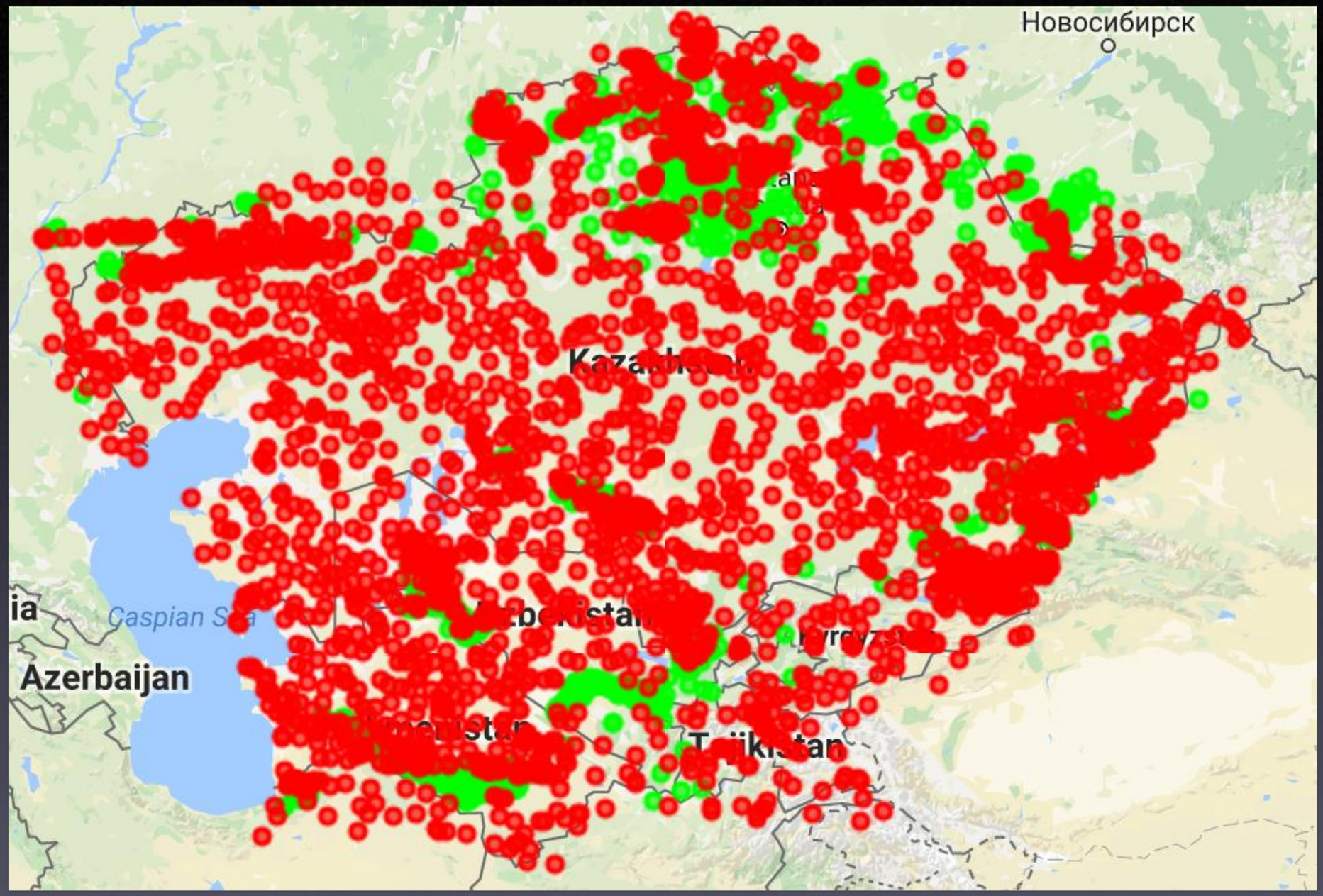


Crop samples:2535

Non-Crop samples:3412

Zone 7 train/test samples

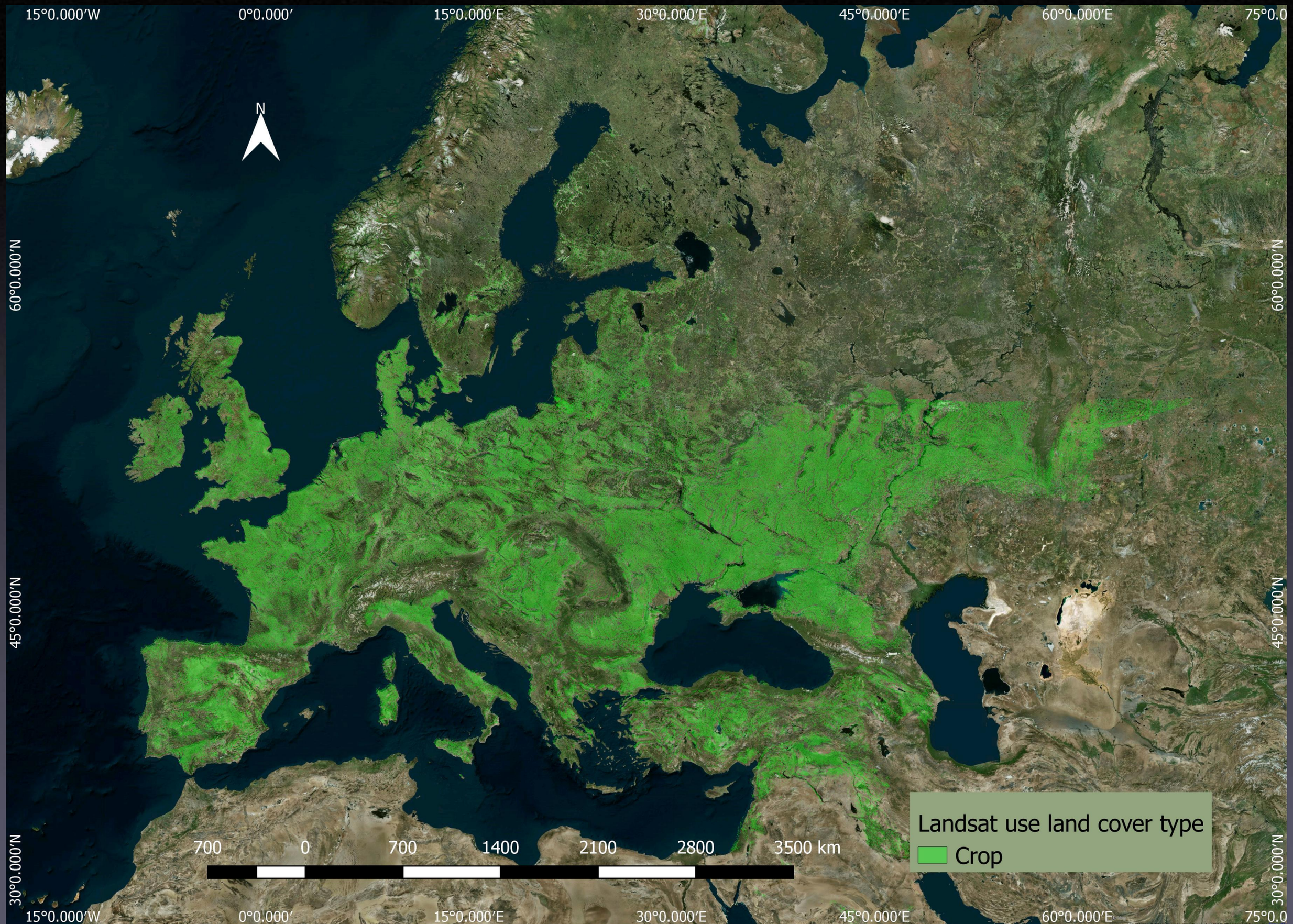
Non-crop
Crop



Crop
Samples(3094)

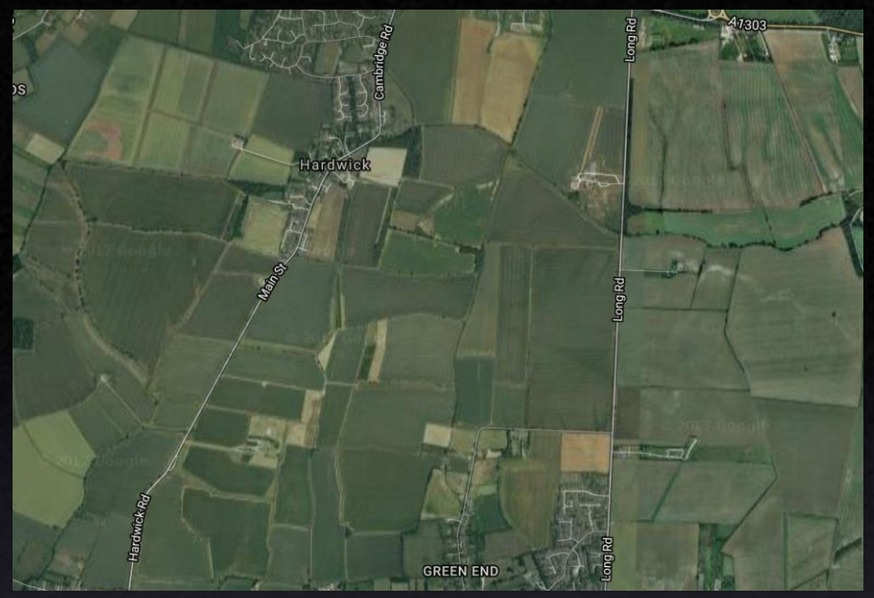
Non-Crop
Samples(4306)

Results: Zone1, Zone2, Zone3 and Zone4 (Europe and Russia)

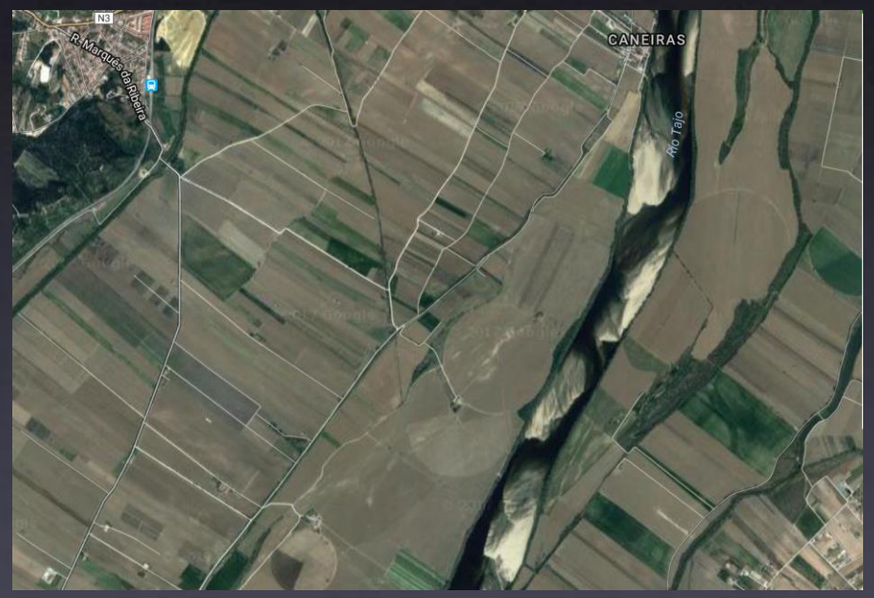


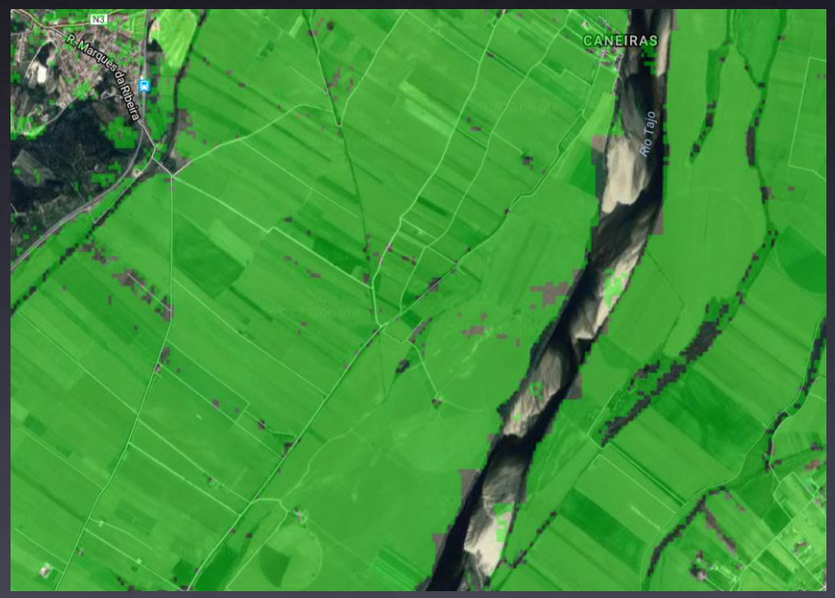
Results: Zone1, Zone2, Zone3 and Zone4 (Europe and Russia)

UK

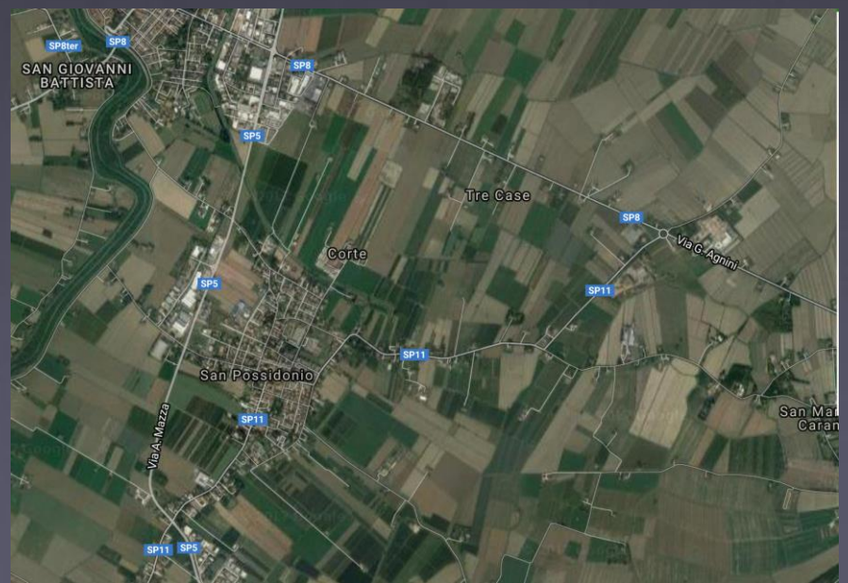


Portugal



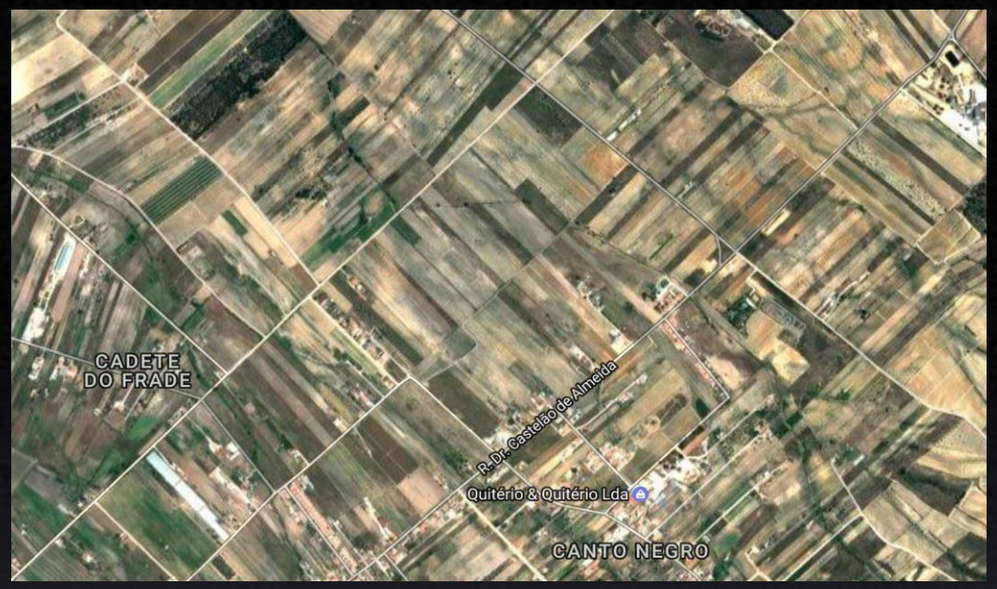


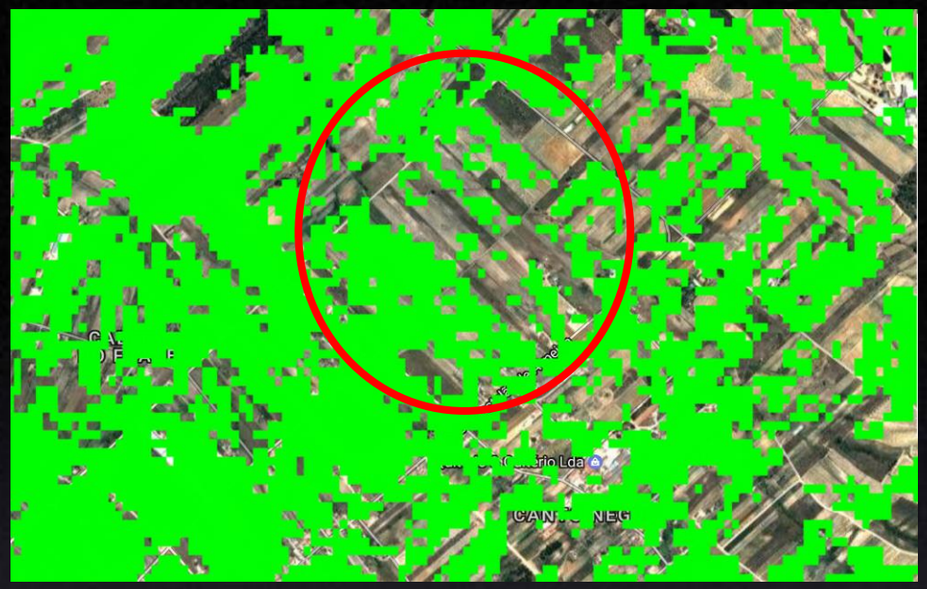
Italy



Results: Zone1, Zone2, Zone3 and Zone4 (Europe and Russia)

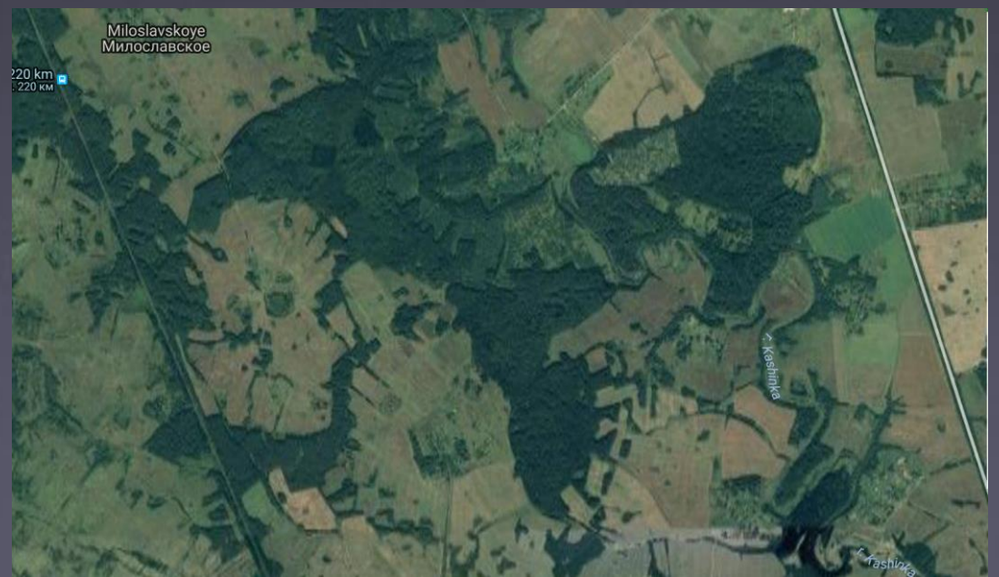
Portugal





UK

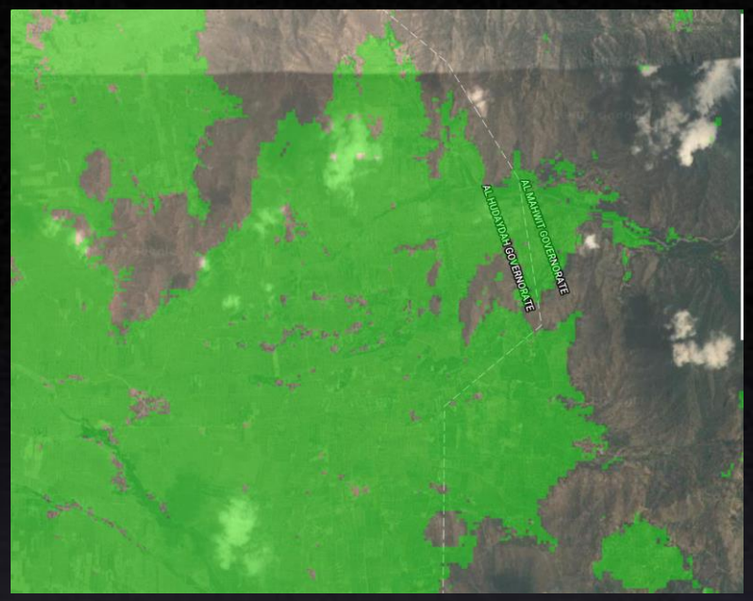
Russia



Results: Zone 7 (Middle East)

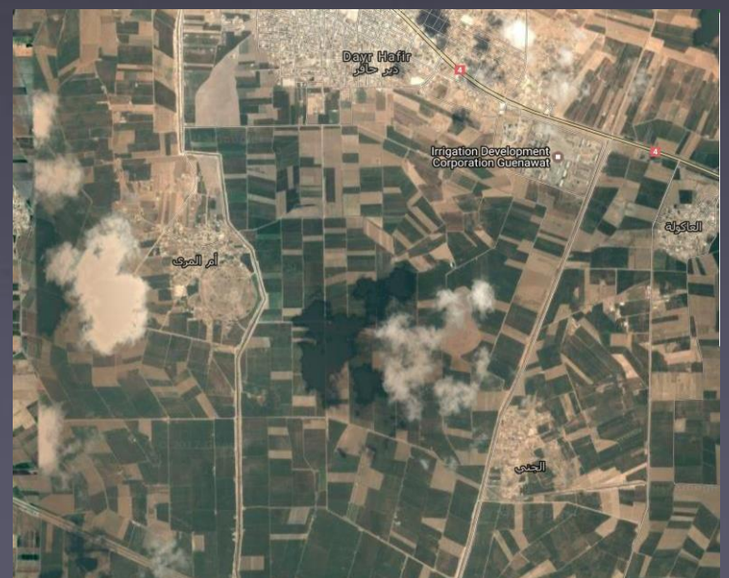
Results: Zone 7

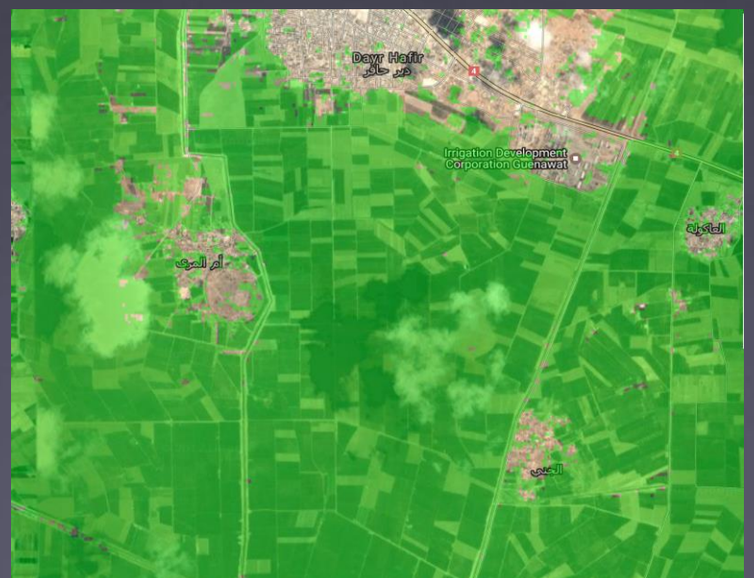
Yemen



Saudi Arabia

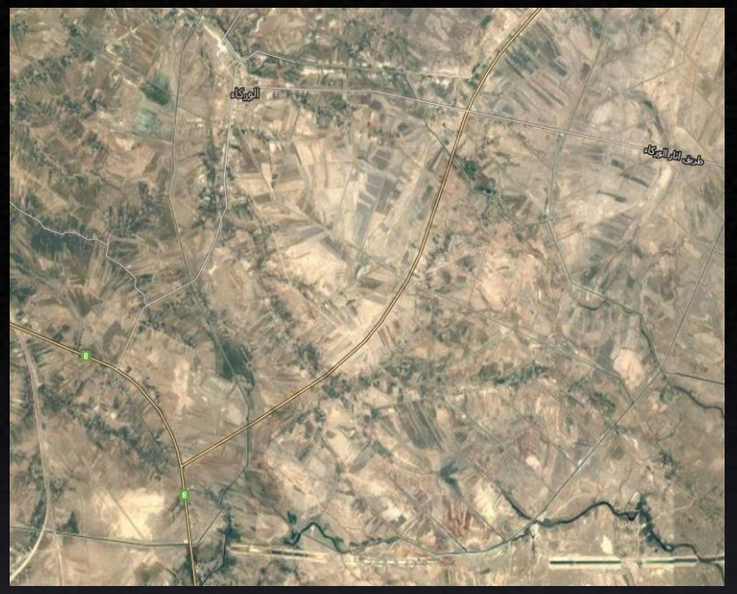
Iraq

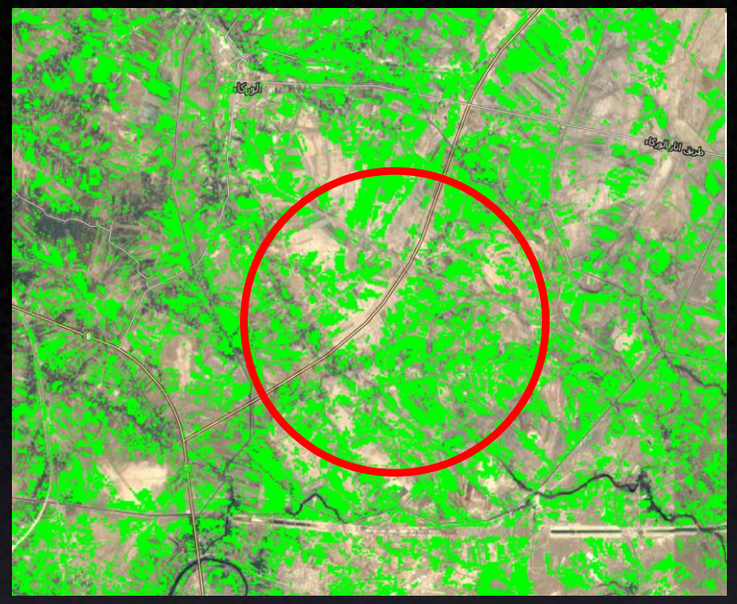




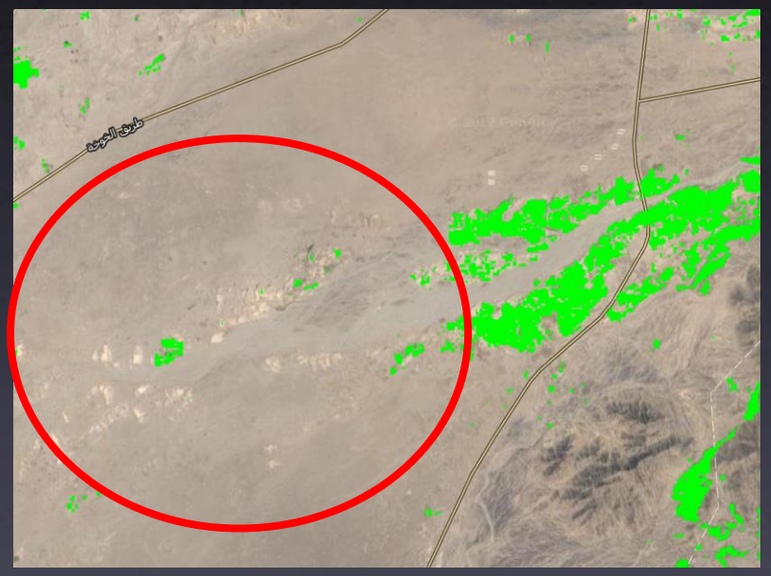
Results: Zone 7

Iraq

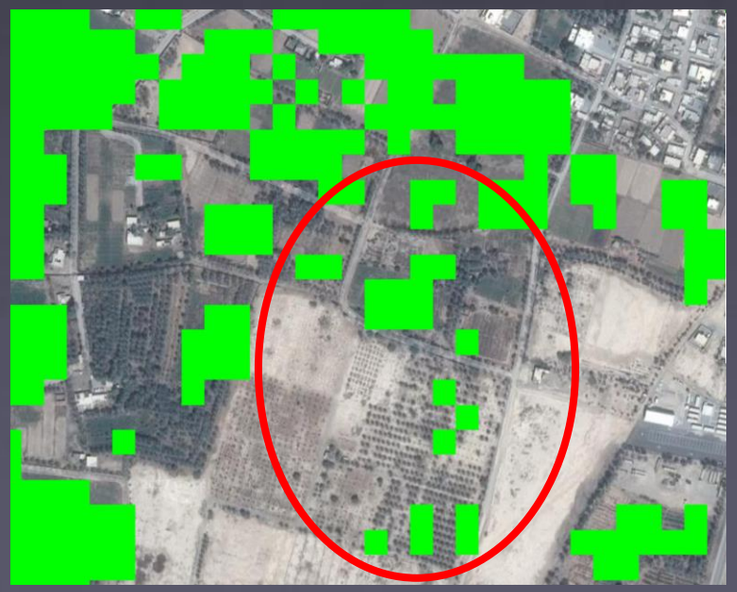




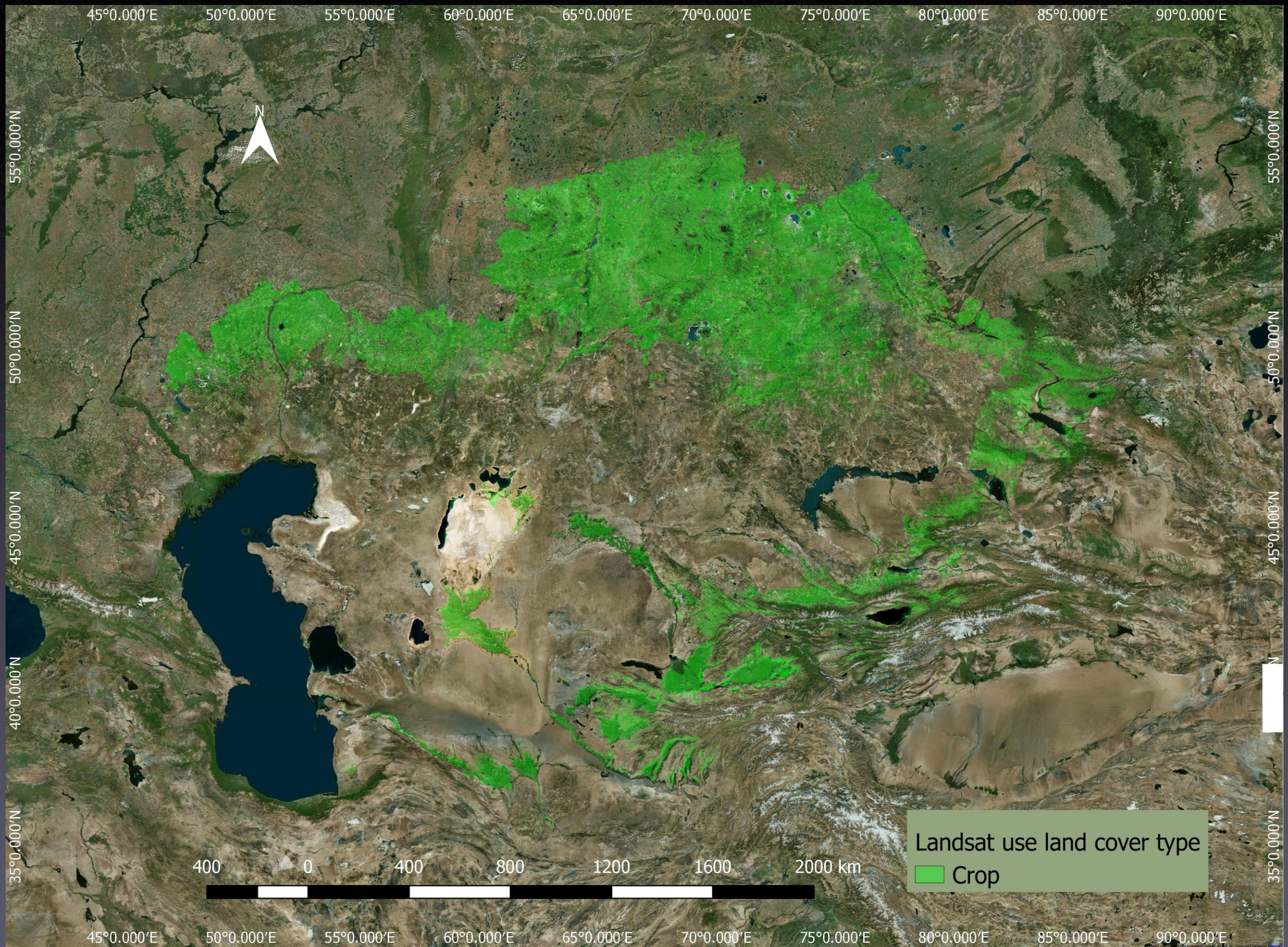
Yemen



Oman

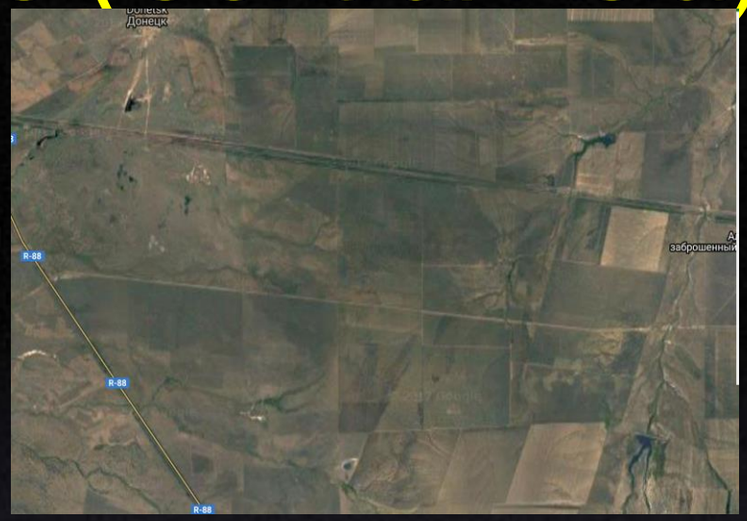


Results: Zone 8 (Central Asia)

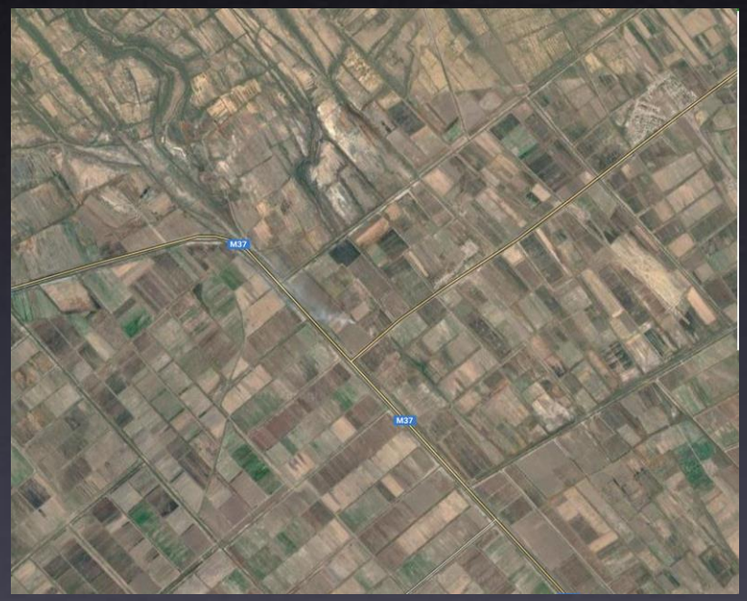


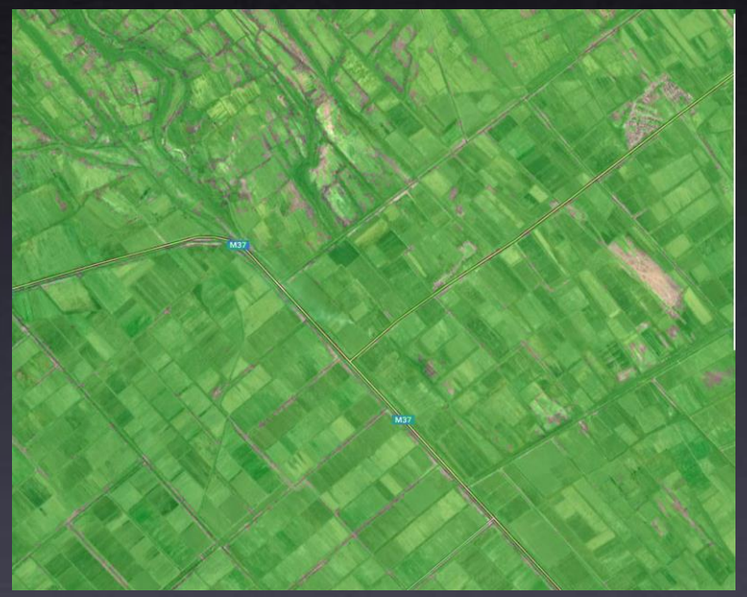
Results: Zone 8 (Central Asia)

Kazakhstan



Turkmenistan



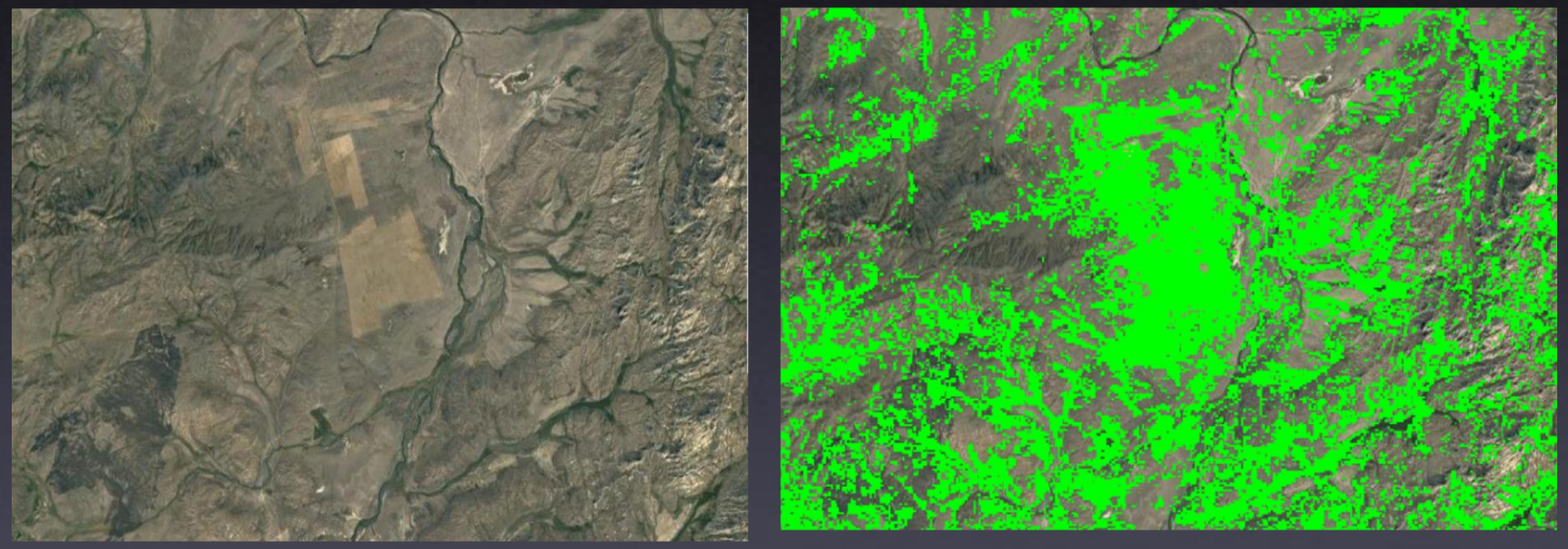


Uzbekistan

Results: Zone 7 (Central Asia)

Kazakhstan

Kazakhstan



Kazakhstan

Europe and Russia (Zone 2, 3, 4 and 5)

	Crop	Non-crop		User's Accuracy
Crop	411	61	472	87.07%
Non-crop	65	596	661	90.166%
	476	657	1133	
Producer's Accuracy	86.34%	90.71%	**88.879%**	

UK an Ireland (Zone 1)

	Crop	Non-crop		User's Accuracy
Crop	28	5	33	84.85%
Non-crop	18	31	49	63.26%
	46	36	82	
Producer's Accuracy	60.86%	86.11%	**71.95%**	

Middle-east (Zone 6)

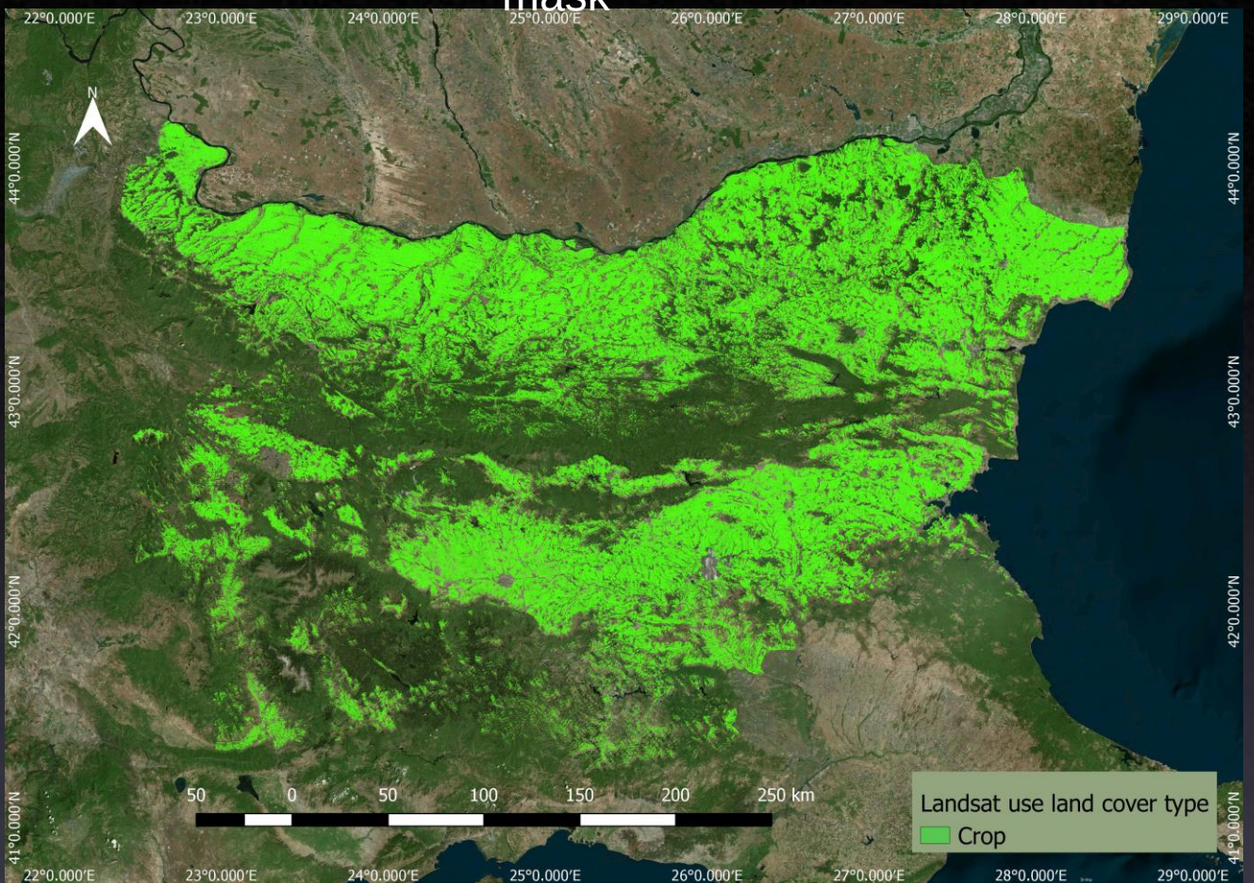
	Crop	Non-crop		User's Accuracy
Crop	290	15	305	95.08%
Non-crop	35	226	261	86.59%
	325	241	566	
Producer's Accuracy	89.23%	93.78%	**91.17%**	

Central Asia (Zone 7)

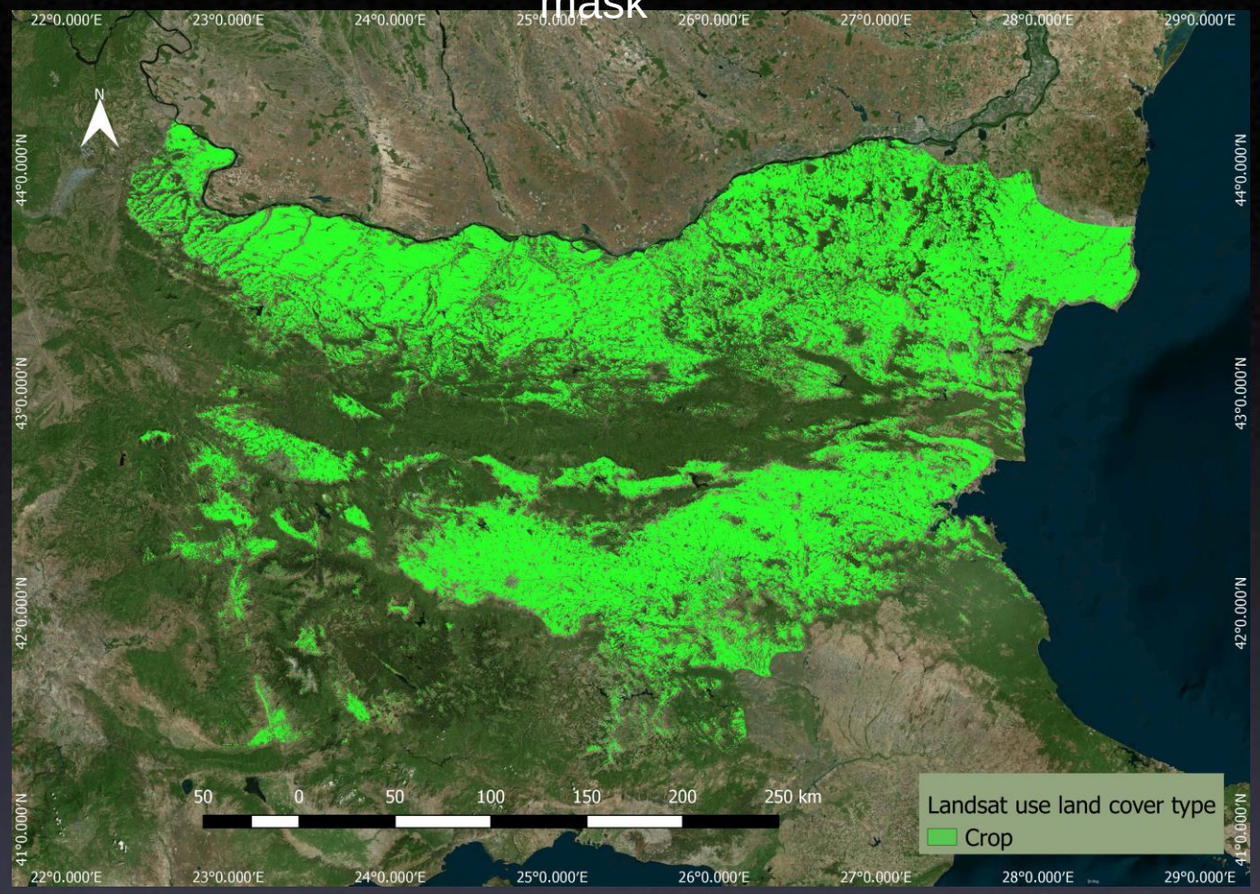
	Crop	Non-crop		User's Accuracy
Crop	150	8	158	94.94%
Non-crop	39	597	636	93.87%
	189	605	794	
Producer's Accuracy	79.37%	98.67%	**94.08%**	

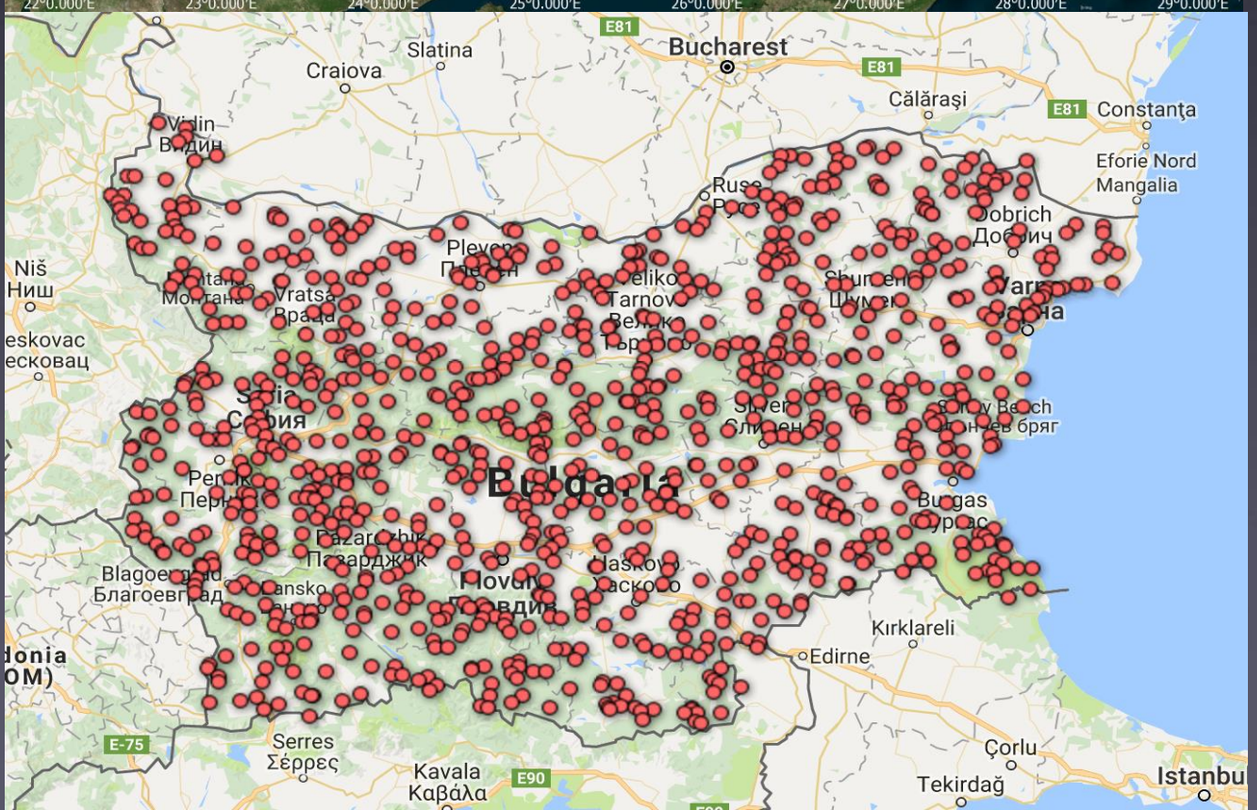
Comparison of CORINE and GFSAD30 Bulgaria Map

CORINE Bulgaria Crop-mask



GFSAD30 Bulgaria Crop-mask





	Crop	Non-crop		User's Accuracy
Crop	281	66	347	80.98%
Non-crop	55	598	653	91.58%
	336	664	1000	
Producers Accuracy	83.64%	90.06%	**87.9%**	

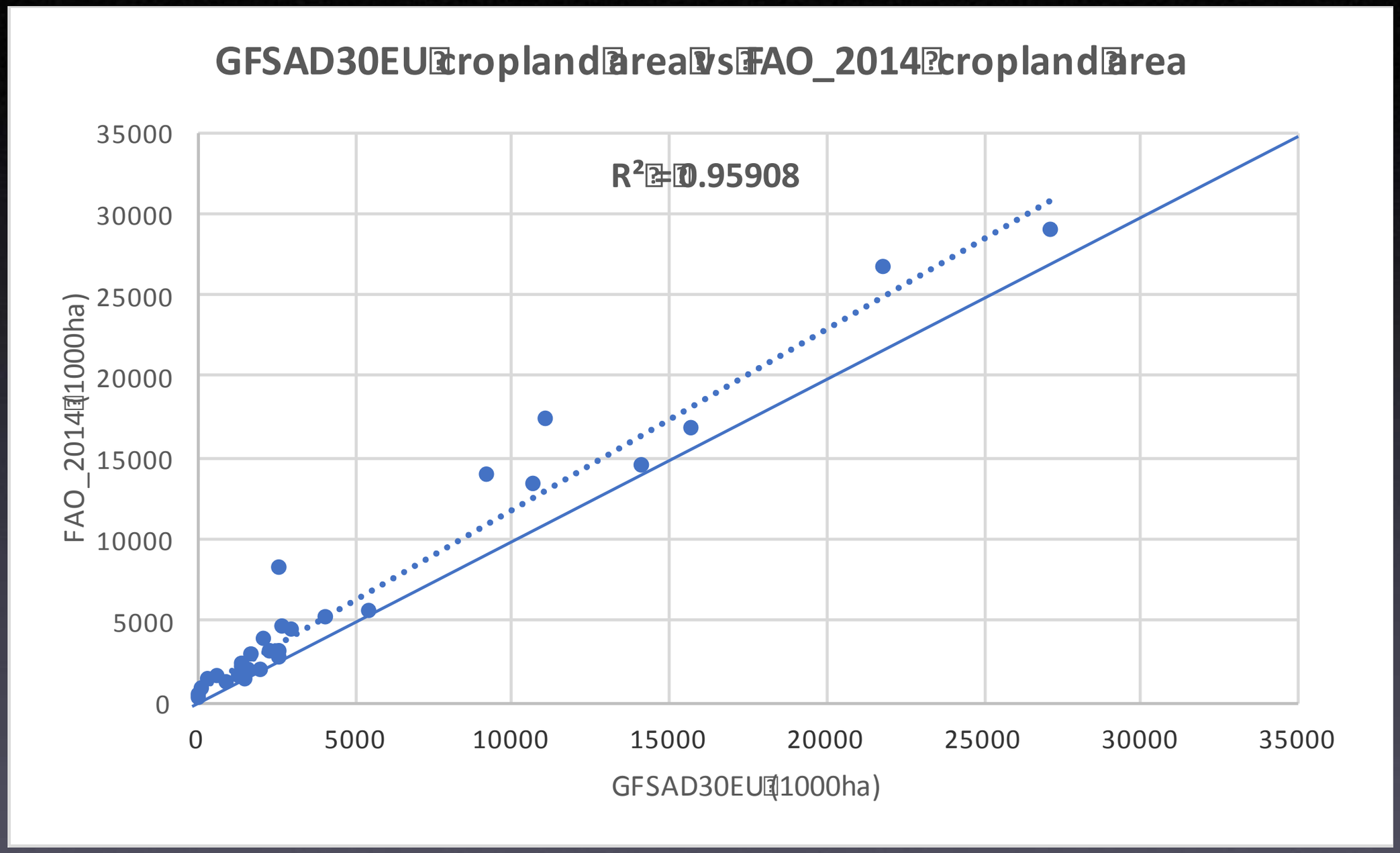
Area Comparisons (Europe)

Country	GFSAD30EU (ha)	MIRCA (ha)	FAO ha	GFSAD30/MIRCA Ratio	GFSAD30/FAO Ratio
Belgium	1550682.22	3230784.25	1331300	0.48	1.16
Netherlands	2066897.761	1040835.13	1839100	1.99	1.12
Hungary	5539201.911	4883556	5346000	1.13	1.04
Croatia	1349176.415	1594850	1508800	0.85	0.89
Denmark	2667883.93	2603932.25	2629000	1.02	1.01
Estonia	958539.2766	842763.38	974300	1.14	0.98
Poland	14184016.61	14485510	14424000	0.98	0.98
Germany	15782485.31	12328316	16725000	1.28	0.94
France	27186173.7	19627780	28766500	1.39	0.95
Spain	21923614.36	18748612	26578000	1.17	0.82
Latvia	1726562.254	1907594.38	1872000	0.91	0.92
Sweden	2688435.794	2600998.25	3032700	1.03	0.89
Czech Republic	3108064.908	3154321	4216000	0.99	0.74
Italy	10740526.22	9559511	13162000	1.12	0.82
Luxembourg	110660.4064	61664.63	130990	1.79	0.84
Bulgaria	4156371.866	3675655.75	4977000	1.13	0.84
Lithuania	2371408.016	3002289	2952400	0.79	0.80
Slovakia	1525803.38	1544638	1924600	0.99	0.79
Romania	9320335.211	10163640	13830000	0.92	0.67
Finland	1489225.477	2256338.5	2267100	0.66	0.66
Switzerland	678350.0676	465169.94	1522700	1.46	0.45
United Kingdom	11136212.57	6566839	17232000	1.70	0.65
Ireland	2744303.561	1150308.5	4466000	2.39	0.61
Austria	1748514.463	1470857.88	2714200	1.19	0.64
Portugal	2196002.853	2704045.75	3701600	0.81	0.59
Greece	2671408.063	3814012	8175000	0.70	0.33
Slovenia	238278.1292	200577.97	614990	1.19	0.39
Montenegro	96815.78937	381027.81	230320	0.25	0.42
Macedonia	455038.3235	646759.88	1263000	0.70	0.36

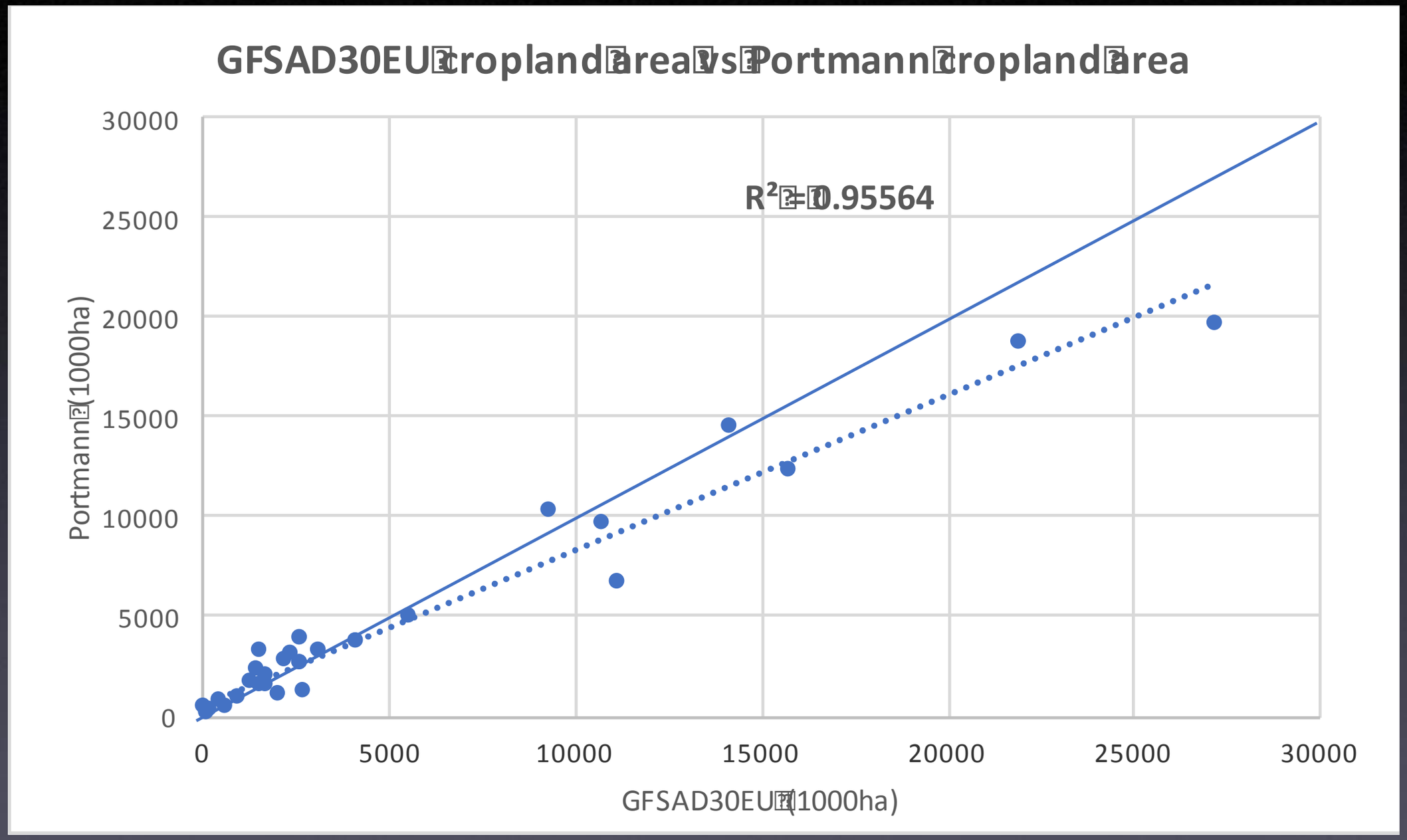
Continue..

Country	GFSAD30	MIRCA	FAO(ha)	GFSAD30/MIRCA	GFSAD30/FAO
	ha	ha	ha	Ratio	Ratio
Norway	1689739.629	691298.19	986700	2.44	1.71
Moldova	2473776.111	2171410	2458000	1.14	1.01
Serbia	3051929.992	3434898.75	3506400	0.89	0.87
Ukraine	35153118.88	34483060	41272000	1.02	0.85
Azerbaijan	3536422.475	2518816	4769700	1.40	0.74
Belarus	6270203.105	6266646	8632000	1.00	0.73
Turkey	25829387.3	23230840	38561000	1.11	0.67
Armenia	1119947.254	661525.88	1681090	1.69	0.67
Liechtenstein	2907.264295	4031.08	5320	0.72	0.55
Georgia	1340802.877	1195714.63	2557400	1.12	0.52
Albania	379598.8429	801083.06	1174290	0.47	0.32
Andorra	2834.58458	1123.36	20900	2.52	0.14
Middle-east					
Bahrain	1416.032202	8223.87	8600	0.17	0.16
Kuwait	15295.46396	16712.93	152100	0.92	0.10
Yemen	1507491.411	1655153.88	23546000	0.91	0.06
Oman	80079.17928	126395.37	1468800	0.63	0.05
Syria	4992895.206	4741505.5	13921000	1.05	0.36
Jordan	246339.3847	406141.81	1064000	0.61	0.23
Lebanon	150224.6919	338571.06	658000	0.44	0.23
Qatar	12274.24889	12520	65600	0.98	0.19
United Arab Emirates	68142.7792	394786.16	382300	0.17	0.18
Central Asia					
Kyrgyzstan	2086087.235	2094459.63	10557100	1.00	0.20
Turkmenistan	3977431.632	2605478.25	33838000	1.53	0.12
Kazakhstan	7.55E+07	23102226	216992000	3.27	0.35
Uzbekistan	7996874.121	6051359	26770000	1.32	0.30
Tajikistan	1225413.3	1363954.5	4745000	0.90	0.26

Area Comparisons (GFSAD30 vs. FAO)



Area Comparisons (GFSAD30 vs. Portmann et al)



Where are we heading?

- Post processing of pixel based maps
- Permanent crops (orchards plantations)
- Combining Landsat and Sentinel-2 for crop type mapping

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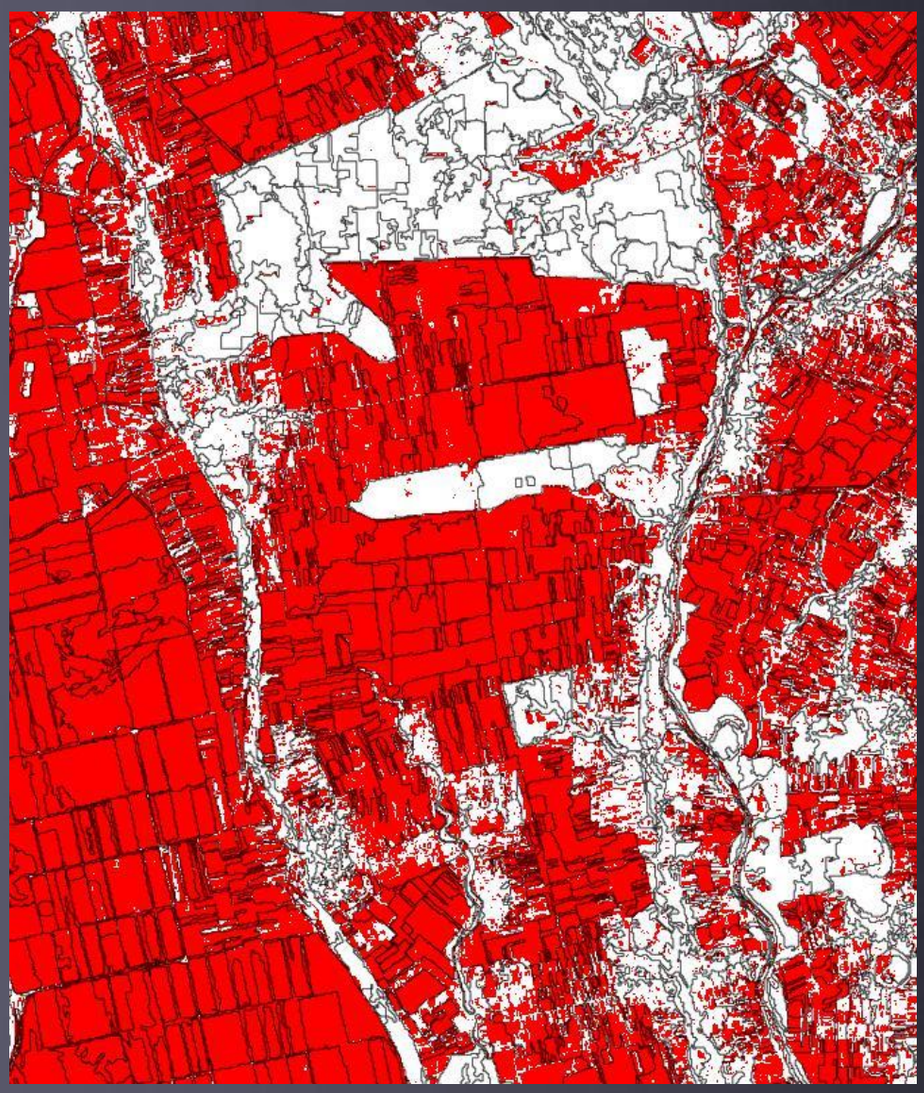
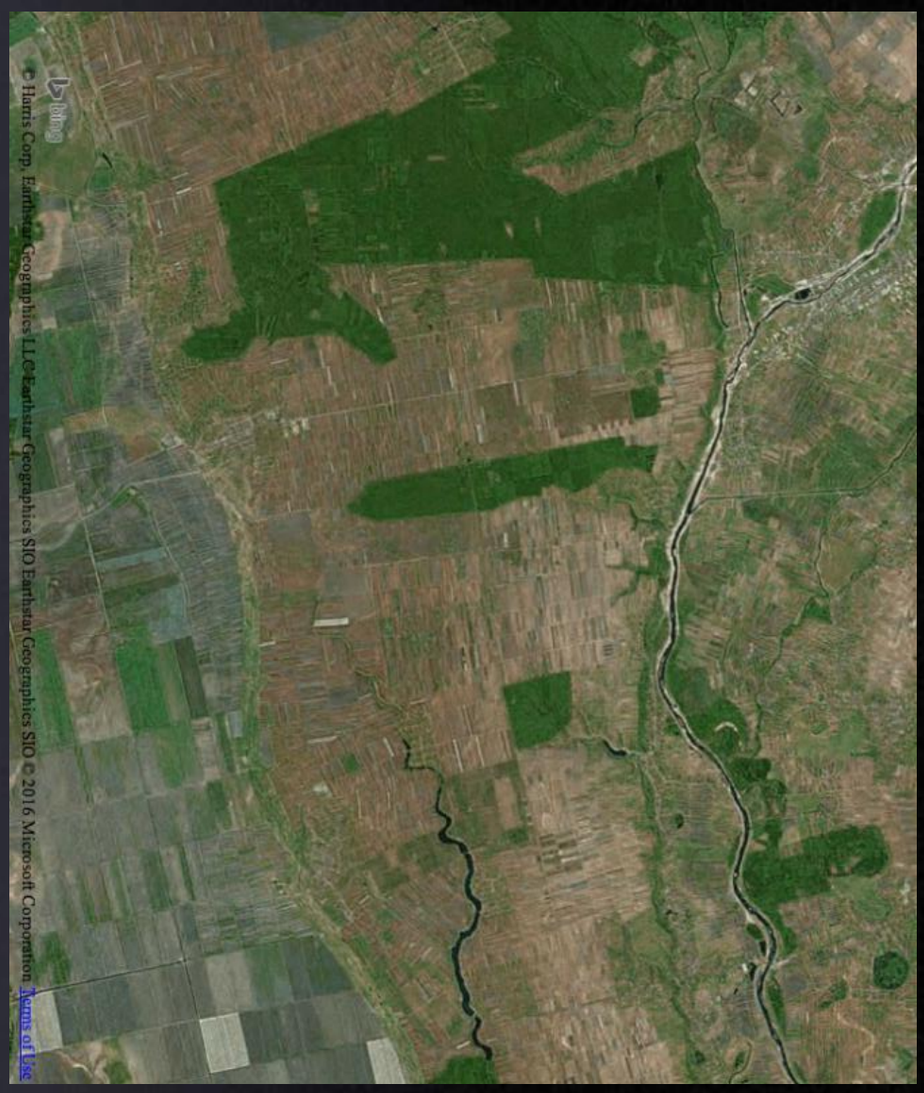
Post-processing with RHSeg

- We use Landsat images from two different seasons (one from the spring and another from the summer) as input to an image segmentation algorithm (RHSeg)
- Use 6 pixel (~0.5 ha) minimum mapping unit
- Convert per-pixel maps to per region or object maps using the plurality (majority) rule (recently started using thresholds as low as 20 percent)
- Produces cleaner, more accurate, and more meaningful maps

Per pixel map



High res image



Per region map

High res im segm

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- Post processing of pixel based maps
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Permanent crops

Where are we heading?

- Post processing of pixel based maps
- Permanent crops (orchards plantations)
- Combining Landsat and Sentinel-2 for crop type and cropping intensity mapping

Hierarchical approach

Crop/No-crop — Image classification

↓

Cropping intensity — Peak counting

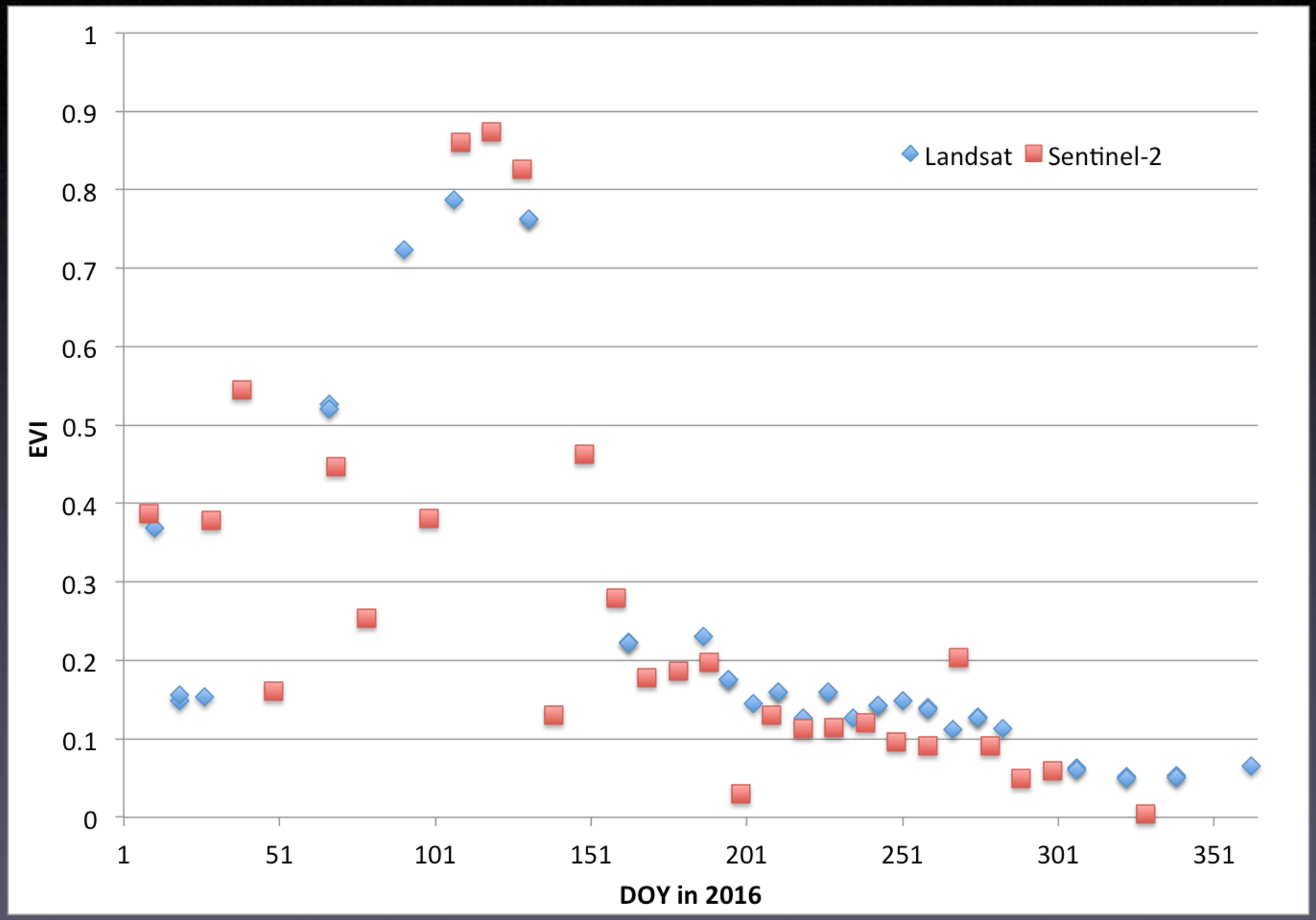
↓

Dominant crop type — Timing of the peak(s)

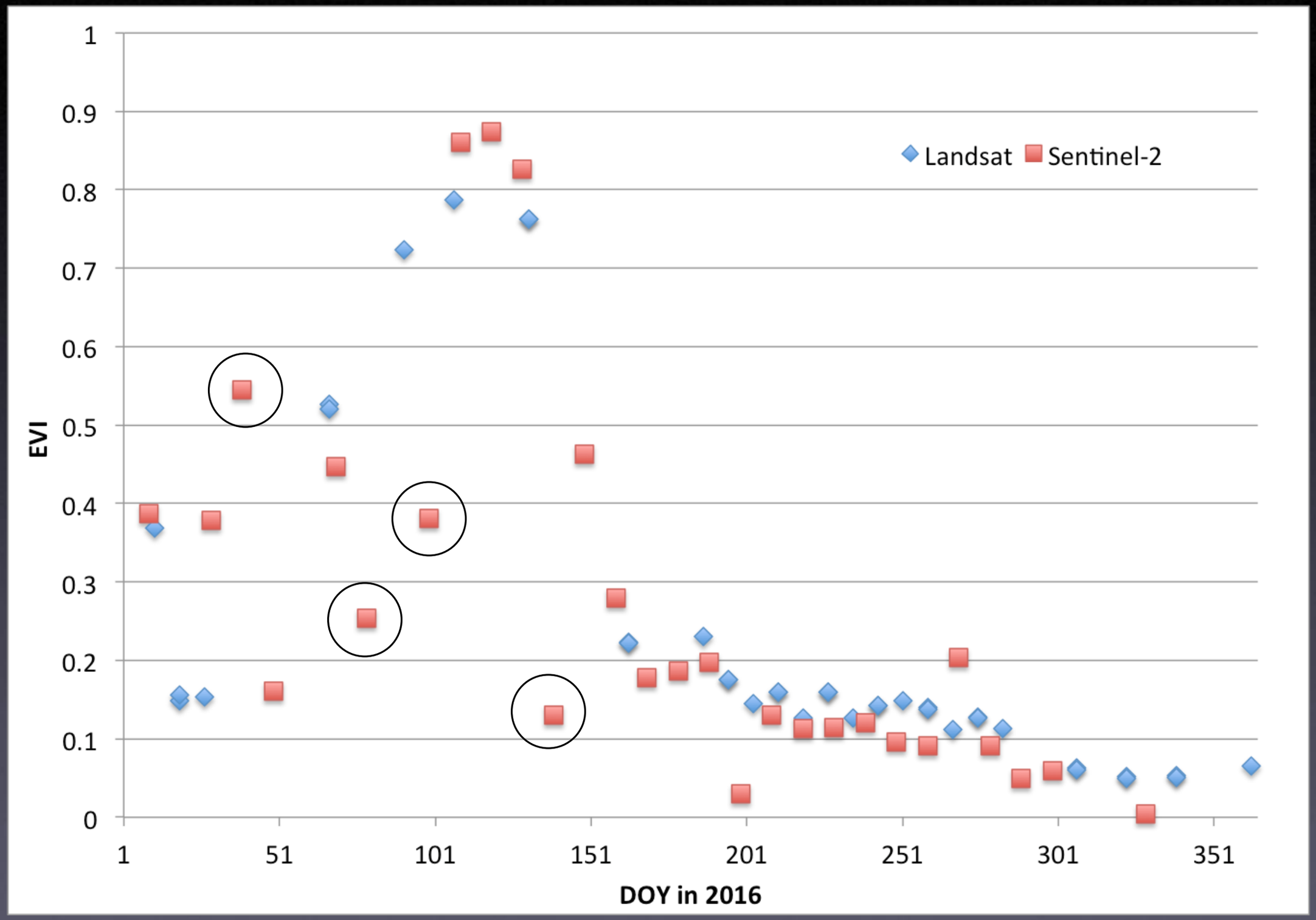
↓

Irrigated vs non-irrigated — Accumulated VI

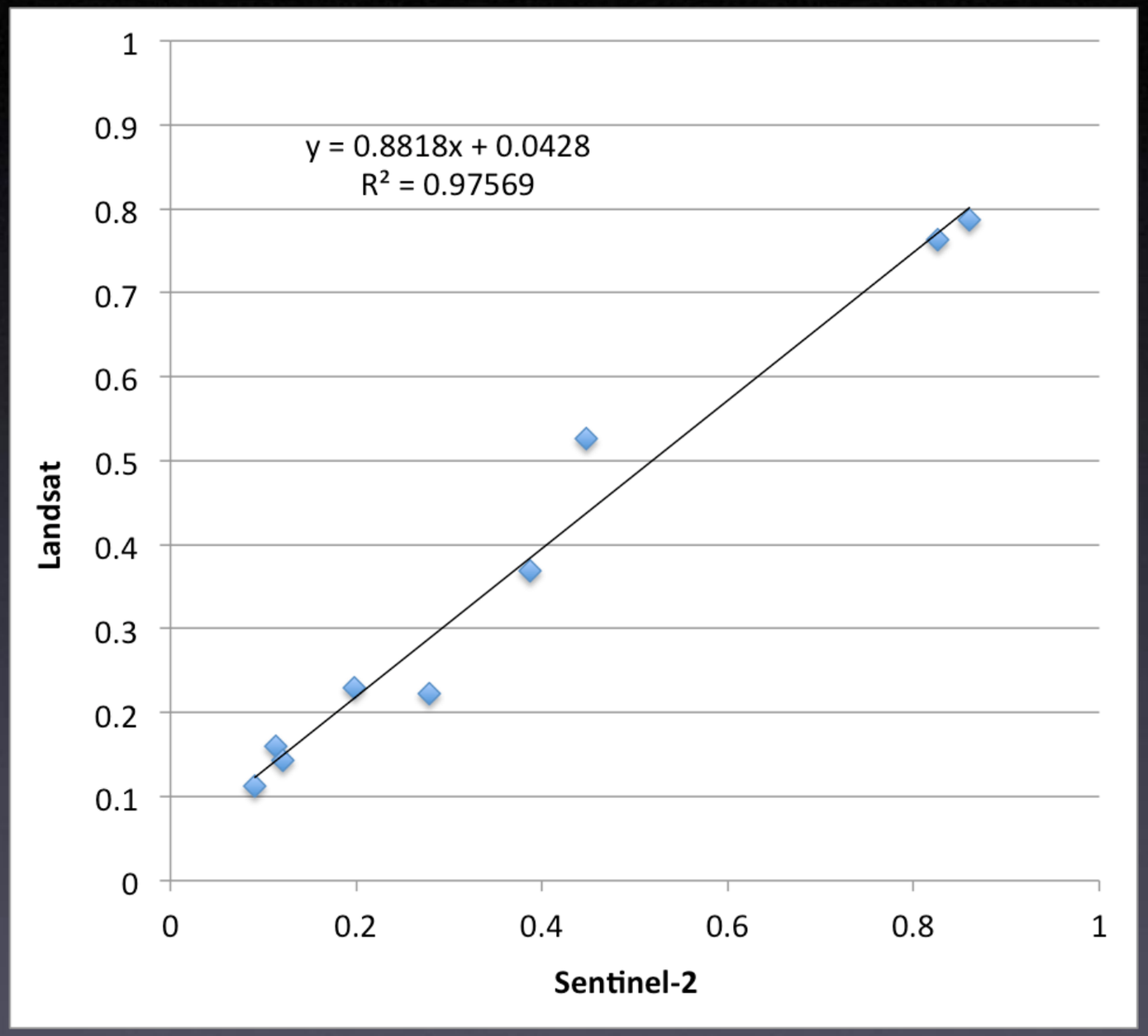
Winter wheat in Turkey



Winter wheat in Turkey

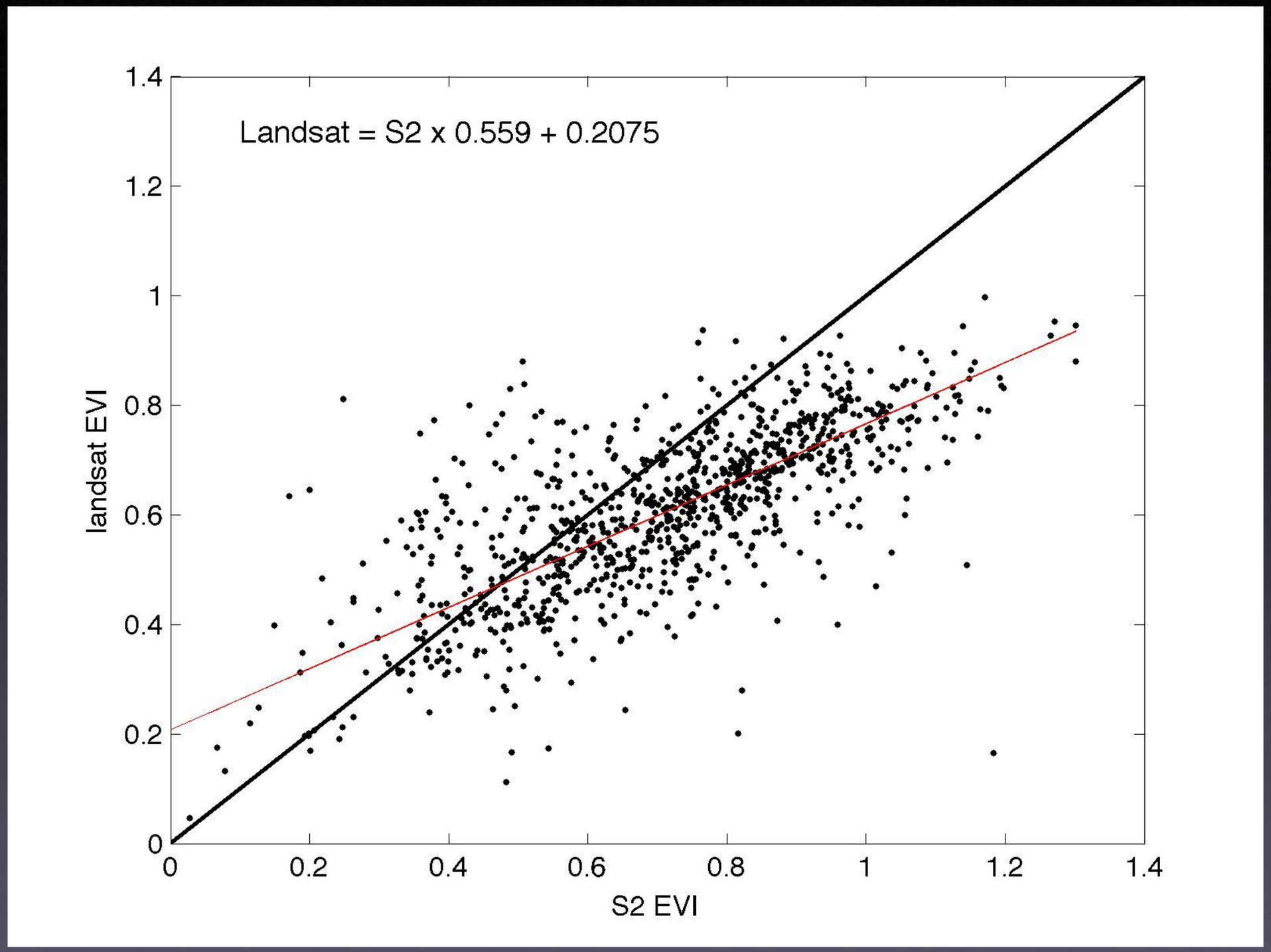


“Harmonizing” Landsat and Sentinel-2



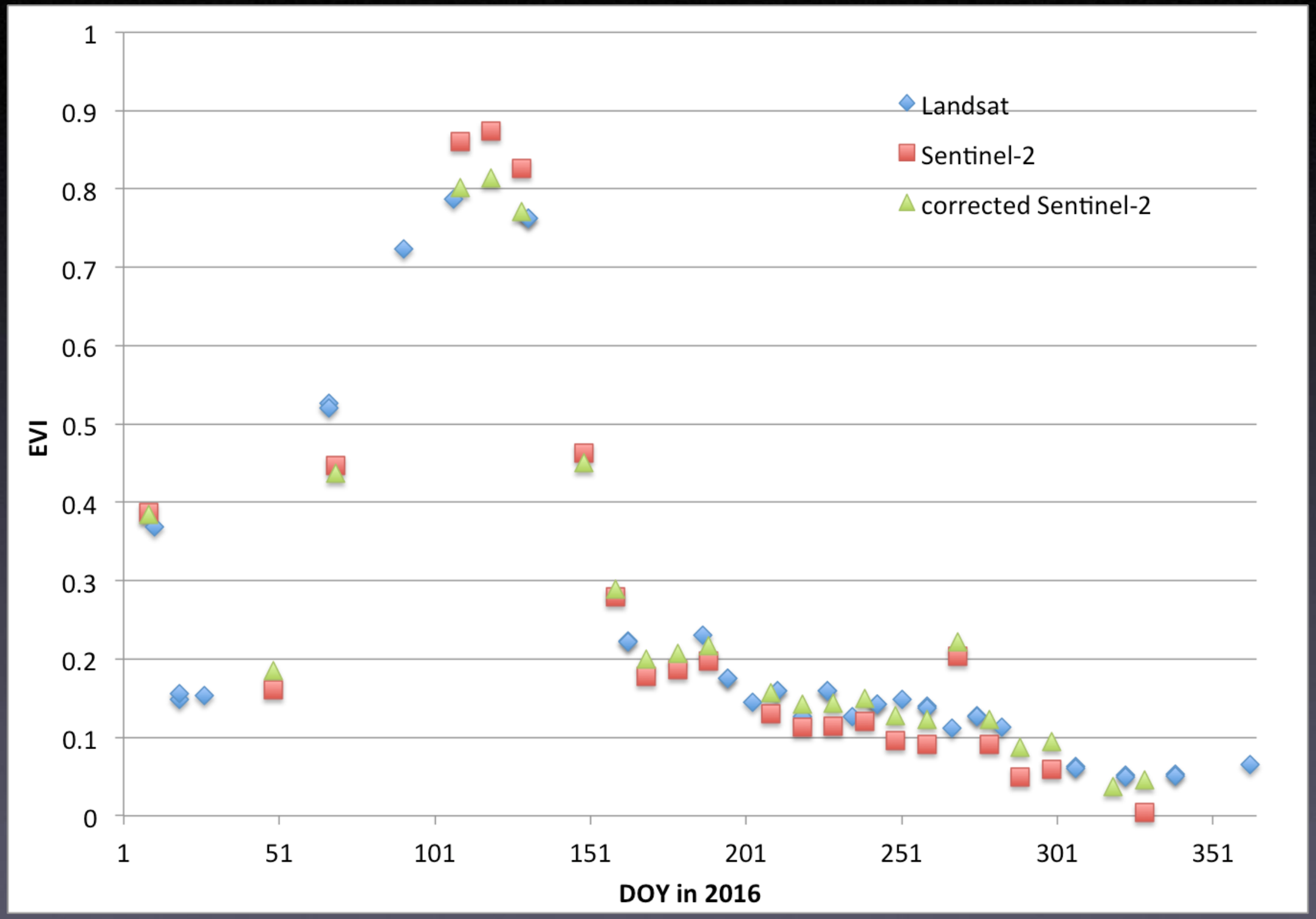
Empirical correction in EVI space

“Harmonizing” Landsat and Sentinel-2



Empirical correction in EVI space

Winter wheat in Turkey



Conclusions

- We mapped ~400 Mha of agricultural land in Europe, Russia, Middle East, and Central Asia
- This agriculture occurs across diverse climates and cultivation practices
- Issues related to:
  - *Missing cultivated areas*
  - *Missing permanent crops*
  - *Missing long year fallows*
- Segment-based results always better but may need strict thresholds
- Getting ready for the next phase of the project (crop type mapping, irrigation identification etc.)

Thank you

Questions?