

The added value of multi-temporal Sentinel-2 data in agriculture and forestry

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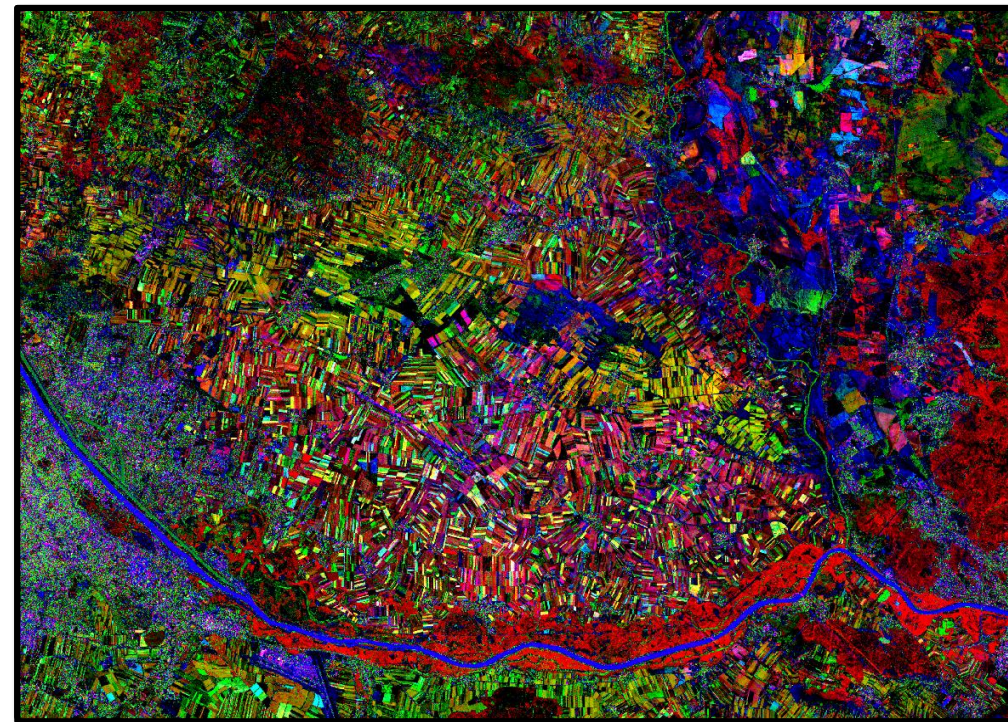
Workshop ASAP-Projekt Acube
Organisation: Franz Schmid, Wolfgang Fahrner (BMNT), Tim Ng (EODC)
Datum: 16 Oktober 2018 ab 13:00
Ort: BMNT, Raum 626 am Stubenring 12



sentinel-2

■ Sentinel-2

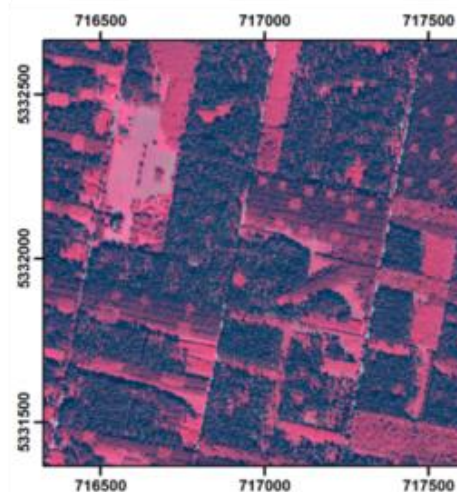
- 10 spectral bands (+3)
- 10-20 m spatial resolution
- wide swath width (290 km)
- high revisit time (~5 days)



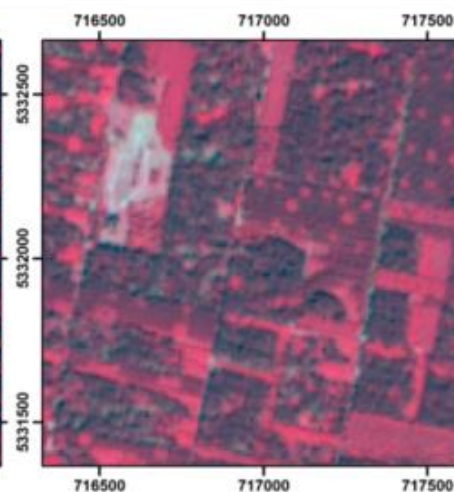
PCs: 1-2-3: 30/08/2015

PCs: 5-6-7: 30/08/2015

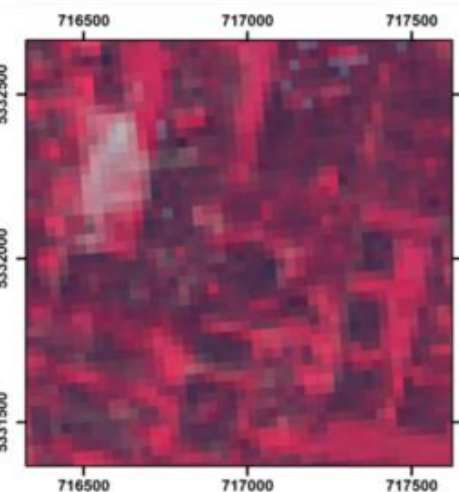
WorldView-2



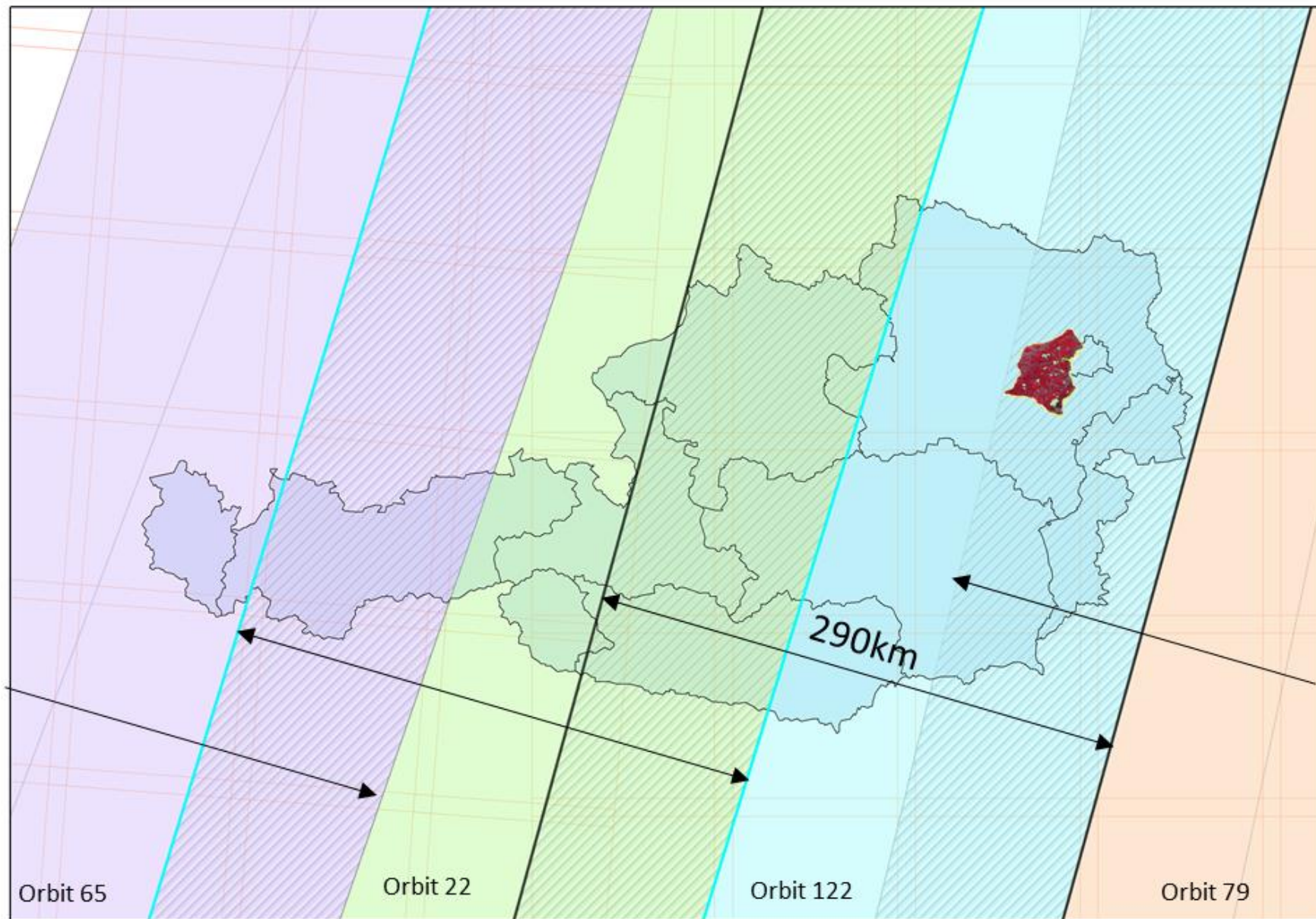
Sentinel-2



Landsat-8



A data cube is needed to facilitate the exploitation of multi-temporal and multi-satellite datasets



Multi-temporal Sentinel-2 data, how it helps in monitoring:

Crop types & rotations



Forest types and changes



Potential productivity of crops



Example study: crop type classification

Altitude / Topography: Flat topography with an altitude of ~ 160-180m above sea level

Climate type: Continental

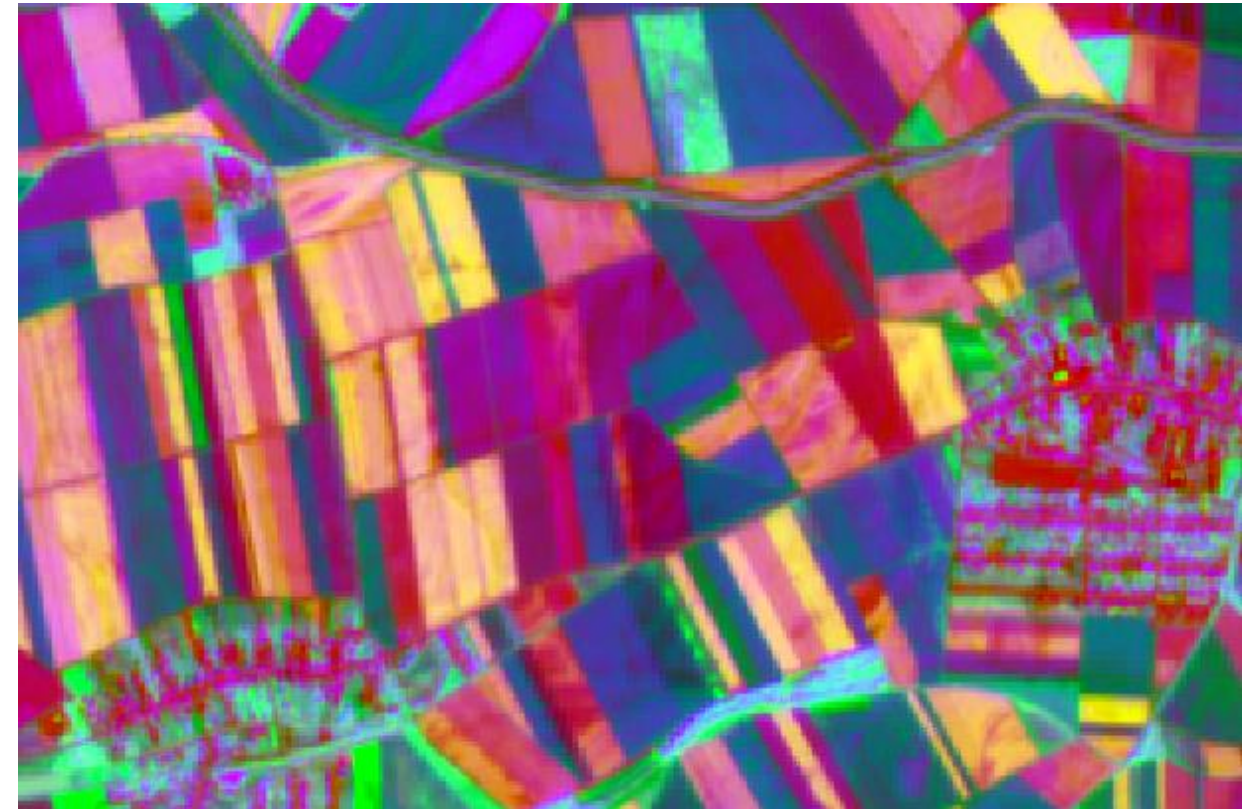
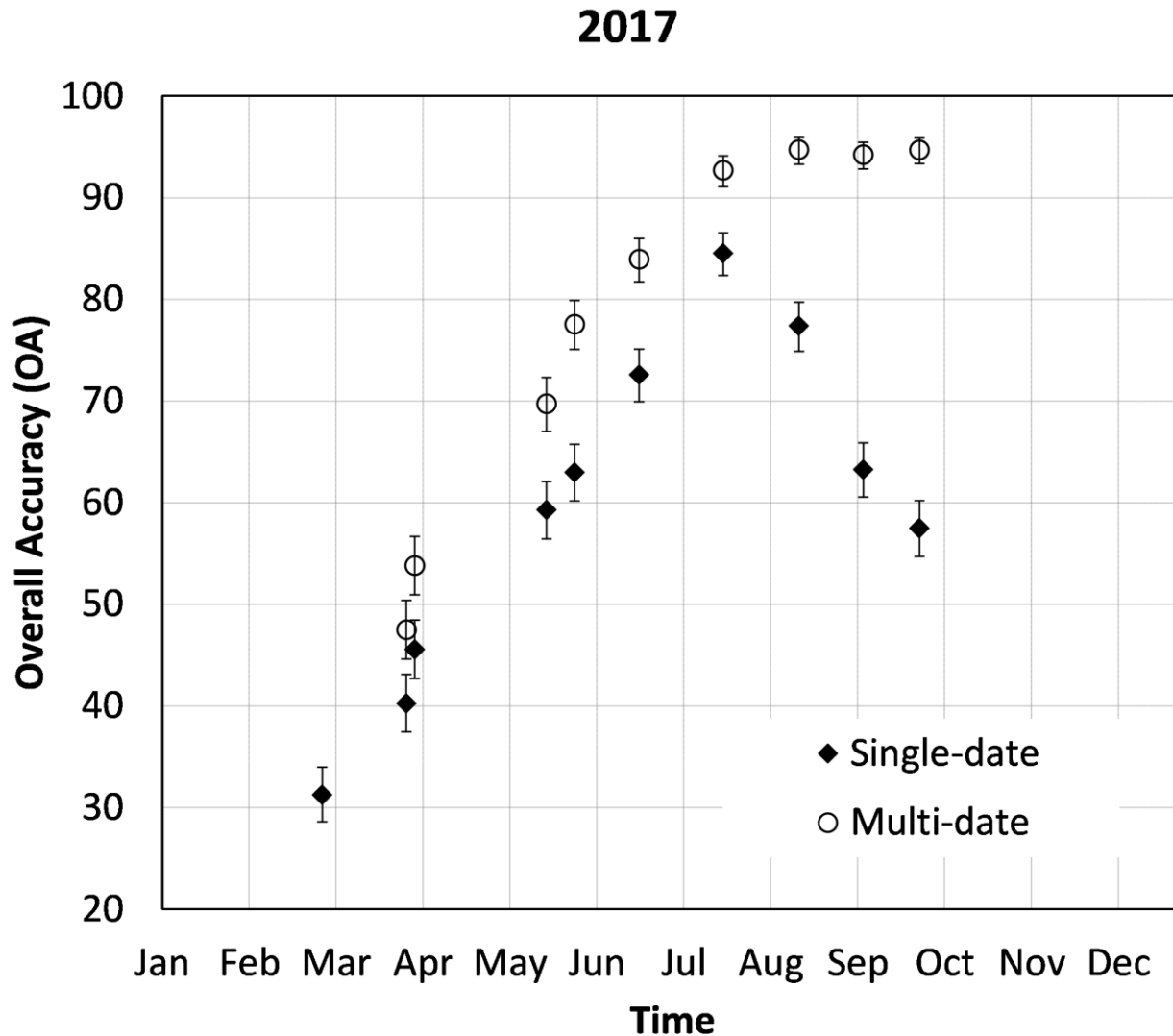
Average annual rainfall: ~550 mm

Average annual ET: ~640 mm



Main crops include durum wheat, grain maize, soybean, sunflower and various vegetables

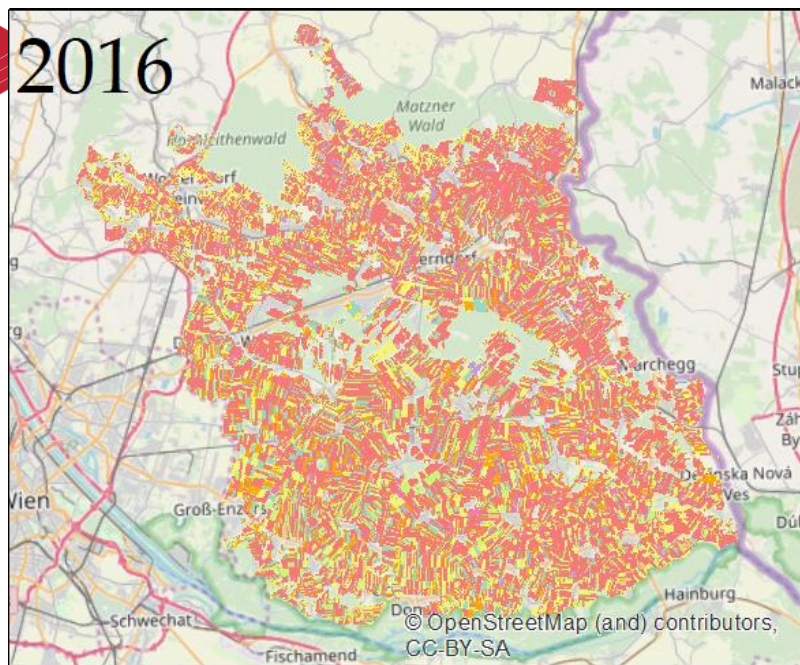
How much does multi-temporal Sentinel-2 data improve crop type classification?



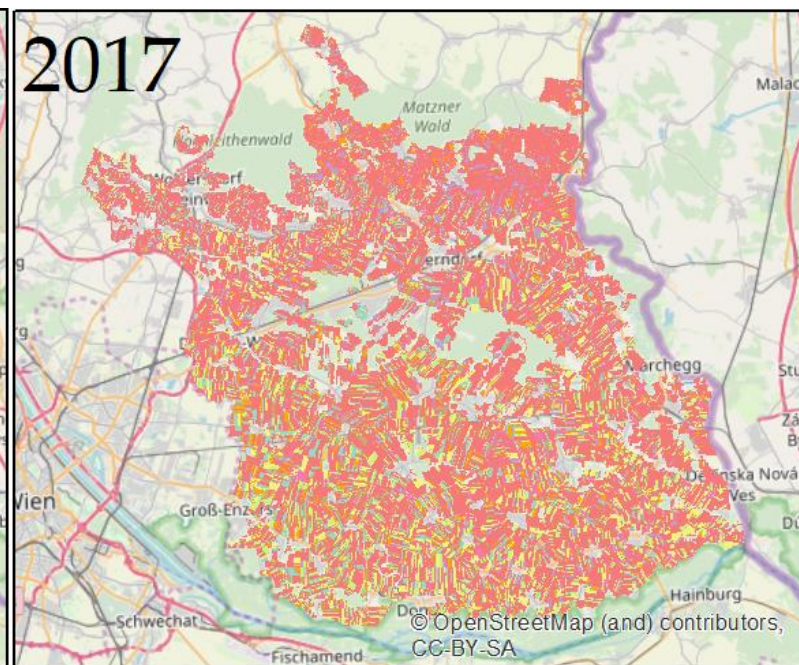
PCs of the spectral-temporal data stack



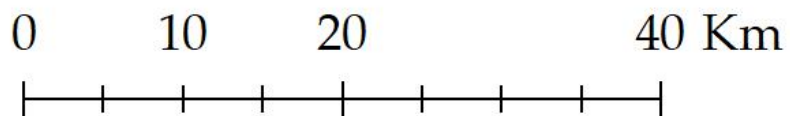
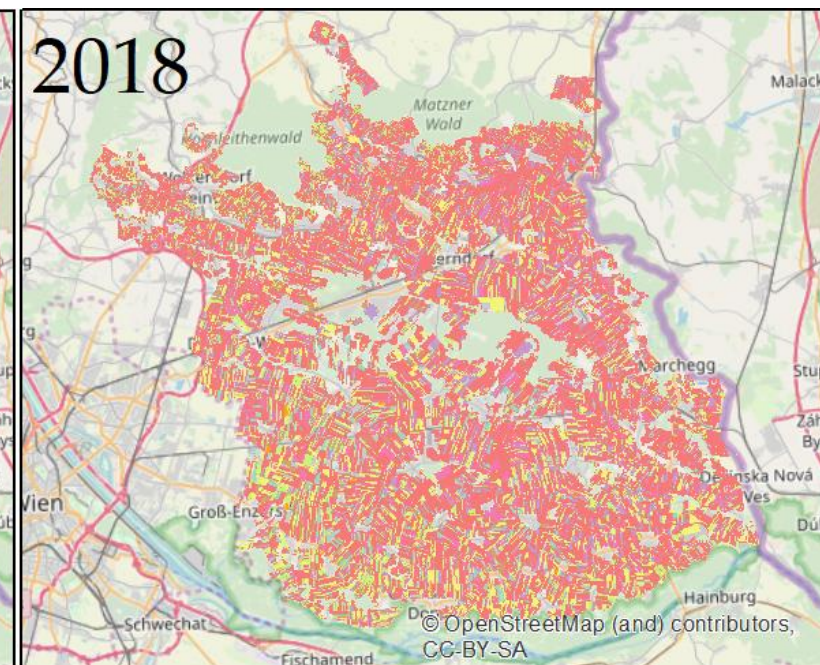
2016



2017



2018



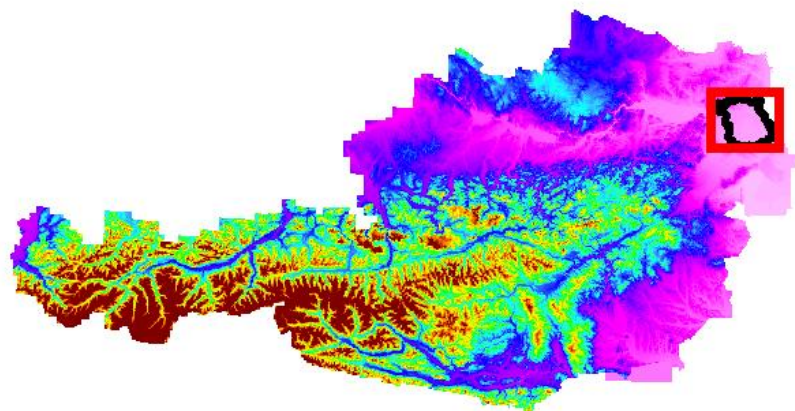
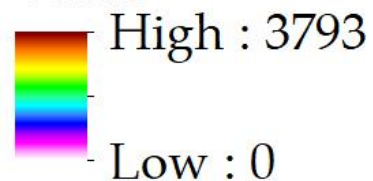
- | | | | |
|---------------|--------|-----------|-----------------|
| Maize | Onion | Soybean | Other vegetable |
| Sugarbeet | Potato | Pumpkin | Alfalfa |
| Winter cereal | Carrot | Sunflower | Asparagus |
| | | | Pea |

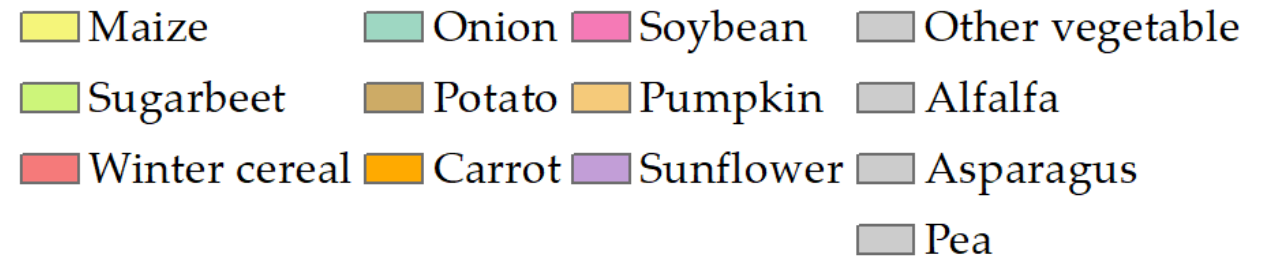
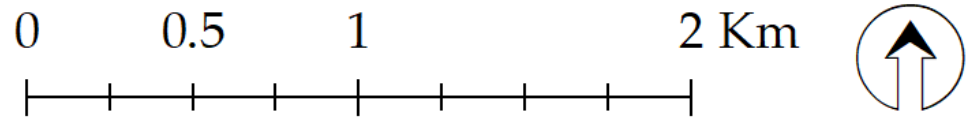
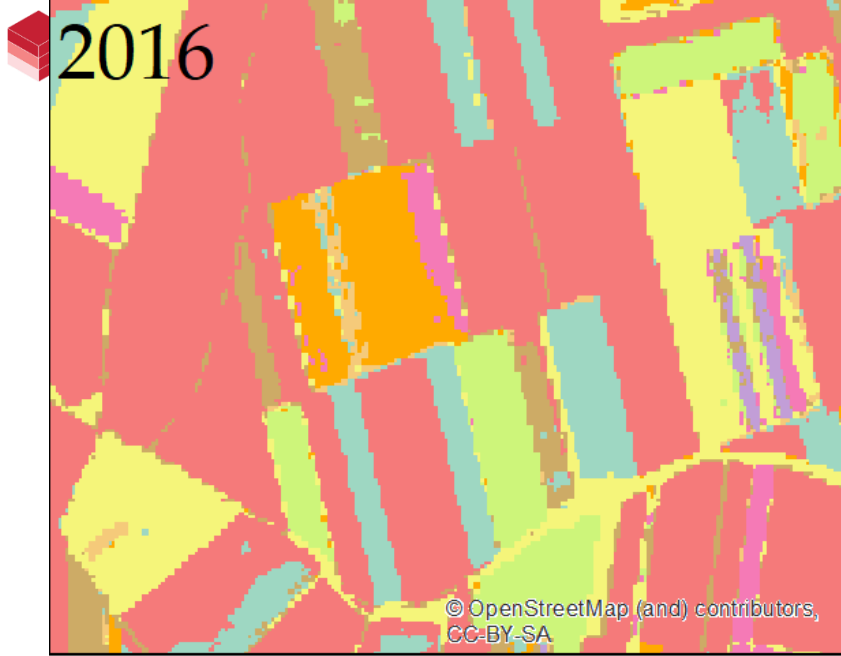
in gray:
only present in 2018

Marchfeld region

DEM

Value

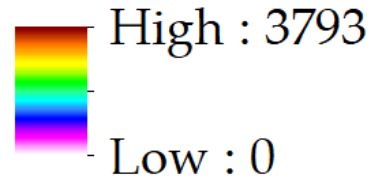




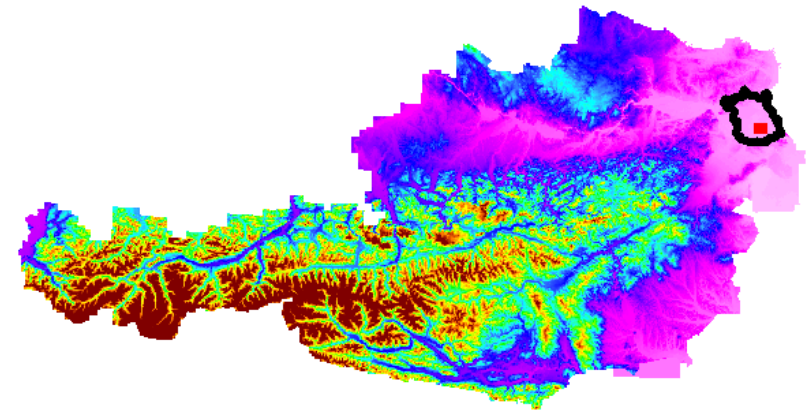
Marchfeld region

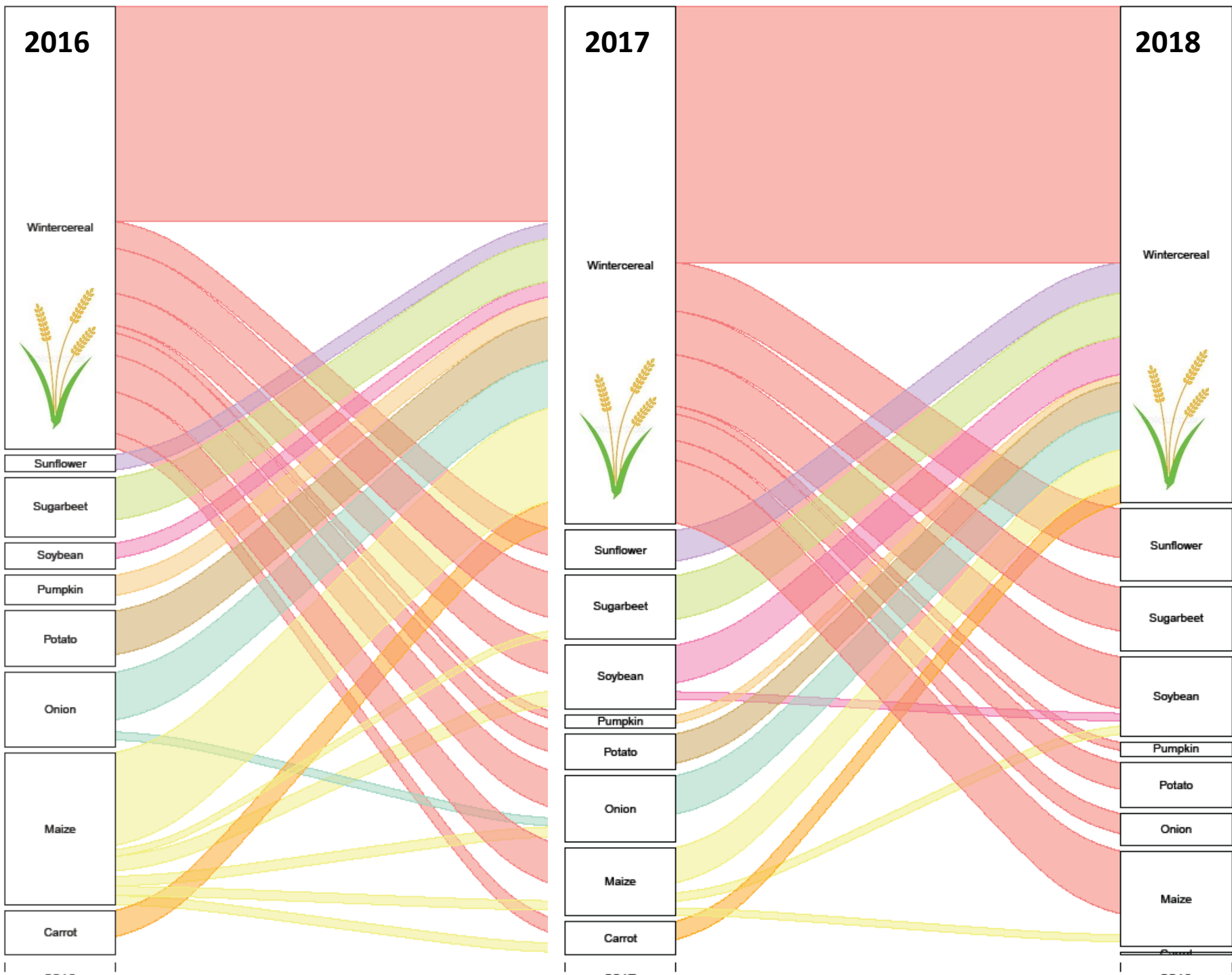
DEM

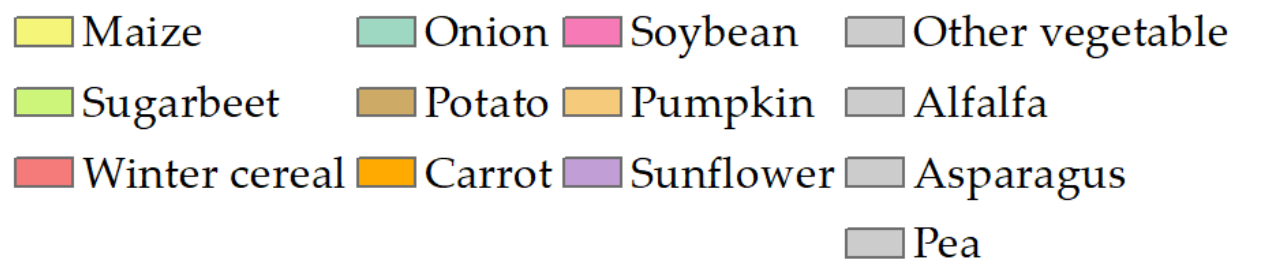
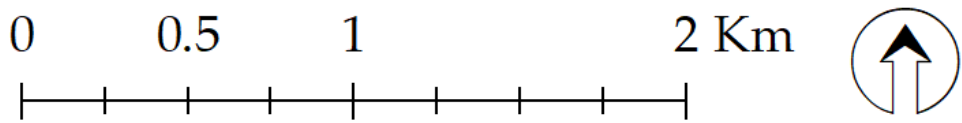
Value



in gray:
only present in 2018

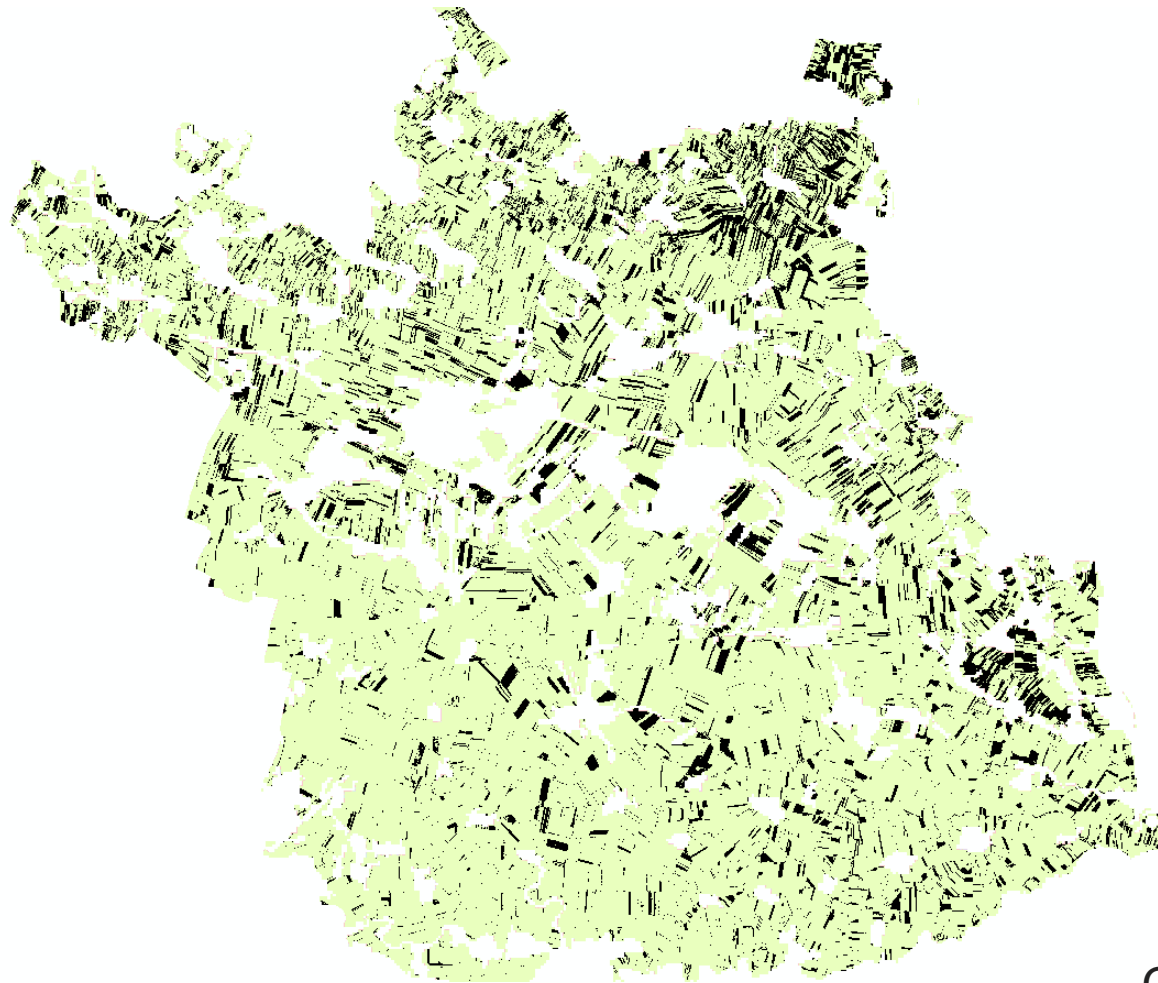






Single crop production systems (over the period 2016-2018) are marked in **black in 2018**

Crop rotations: Single- vs multi-crop rotation



14 % of total crop land was under a single crop production system in the years 2016-2018 (in black)

Comparison 2016 vs 2017: <https://arcg.is/XOmDq>
Comparison 2017 vs 2018: <https://arcg.is/0bSeyX>

Error matrix (RF OOB) 2016 & 2017

2016		Carrot	Maize	Onion	Potato	Pumpkin	Soybean	Sugar beet	Sunflower	Winter cereal	User's accuracy
Carrot	95	1	0	1	0	0	0	0	0	0	0.979
Maize	3	160	0	2	1	3	0	1	0	0	0.941
Onion	2	6	110	1	1	0	0	3	2	0	0.880
Potato	2	0	0	98	0	0	2	3	0	0	0.933
Pumpkin	0	1	0	0	61	0	0	1	0	0	0.968
Soybean	0	0	0	1	0	78	0	0	0	0	0.987
Sugar beet	0	3	0	4	0	3	169	0	0	0	0.944
Sunflower	0	0	0	0	0	0	0	55	0	0	1.000
Winter cereal	0	0	4	1	0	0	0	0	352	0	0.986
Producer's accuracy	0.931	0.936	0.965	0.907	0.968	0.929	0.988	0.873	0.994	0.958	

2017		Carrot	Maize	Onion	Potato	Pumpkin	Soybean	Sugar beet	Sunflower	Winter cereal	User's accuracy
Carrot	63	1	0	0	0	2	0	0	0	0	0.955
Maize	1	210	1	0	0	18	0	0	0	0	0.913
Onion	0	5	116	1	0	3	0	0	0	0	0.928
Potato	2	1	0	97	1	0	2	1	0	0	0.933
Pumpkin	1	0	0	0	49	0	0	1	0	0	0.961
Soybean	4	2	0	0	0	94	5	1	0	0	0.887
Sugar beet	0	3	0	1	0	2	178	0	0	0	0.967
Sunflower	1	0	0	0	1	1	1	42	0	0	0.913
Winter cereal	1	0	0	0	0	0	0	0	276	0	0.996
Producer's accuracy	0.863	0.946	0.991	0.980	0.961	0.783	0.957	0.933	1.000	0.946	



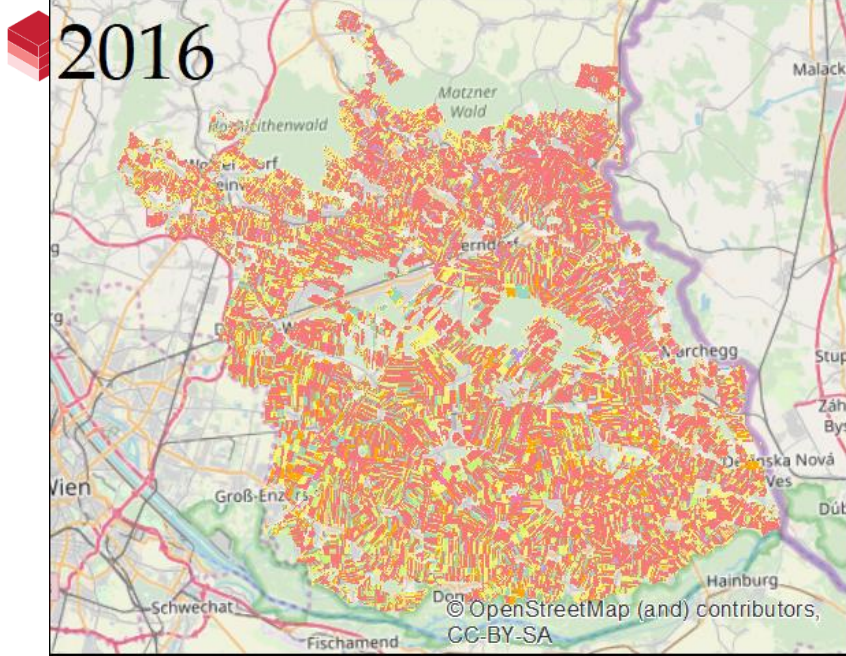
International Journal of Applied Earth Observation and
Geoinformation

Volume 72, October 2018, Pages 122-130



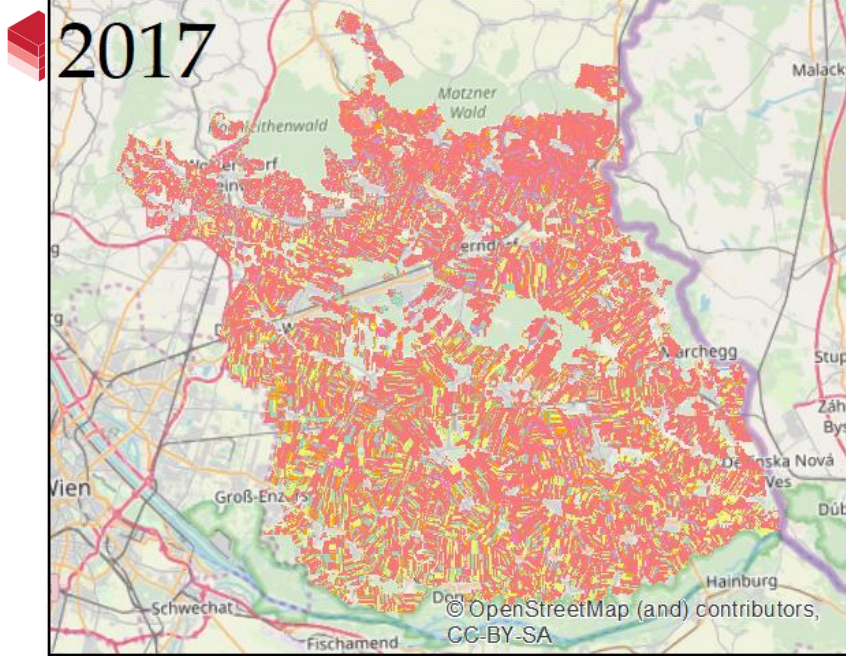
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type classification?

<https://doi.org/10.1016/j.jag.2018.06.007>



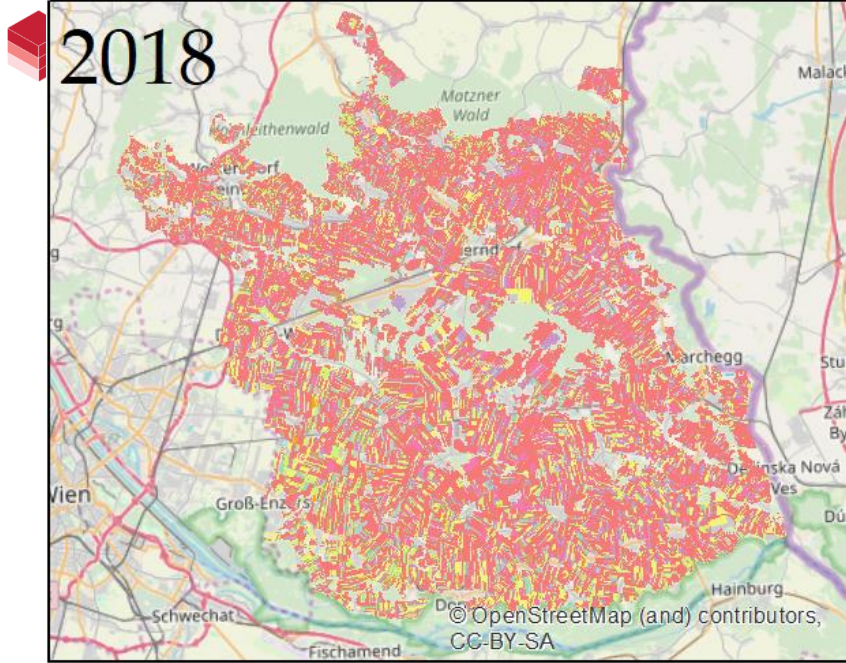
Error matrix independent validation n = 5219

2016	Maize	Vegetable	Potato	Pumpkin	Soybean	Sugar beet	Sunflower	Winter cereal	User's accuracy
Maize	559	12	0	2	0	6	0	1	0.964
Onion & Carrot	82	384	16	3	1	0	0	20	0.759
Potato	2	15	218	2	0	15	5	1	0.845
Pumpkin	1	8	9	126	0	0	6	1	0.834
Soybean	5	9	3	1	230	3	0	1	0.913
Sugar beet	10	2	8	1	0	599	0	2	0.963
Sunflower	0	2	6	0	0	0	126	2	0.926
Winter cereal	10	10	1	1	1	1	0	2690	0.991
Producer's accuracy	0.836	0.869	0.835	0.926	0.991	0.960	0.920	0.990	0.945



Error matrix independent validation n = 5085

2017	Maize	Vegetable	Potato	Pumpkin	Soybean	Sugar beet	Sunflower	Winter cereal	User's accuracy
Maize	545	21	3	0	49	0	16	8	0.849
Onion & Carrot	45	372	6	7	26	9	13	38	0.721
Potato	2	7	256	2	9	10	8	7	0.850
Pumpkin	0	12	0	70	4	0	4	0	0.778
Soybean	36	10	1	1	205	0	0	2	0.804
Sugar beet	3	15	2	4	6	543	10	10	0.916
Sunflower	1	9	14	0	2	10	138	12	0.742
Winter cereal	1	7	0	0	1	1	0	2492	0.996
Producer's accuracy	0.861	0.821	0.908	0.833	0.679	0.948	0.730	0.970	0.909



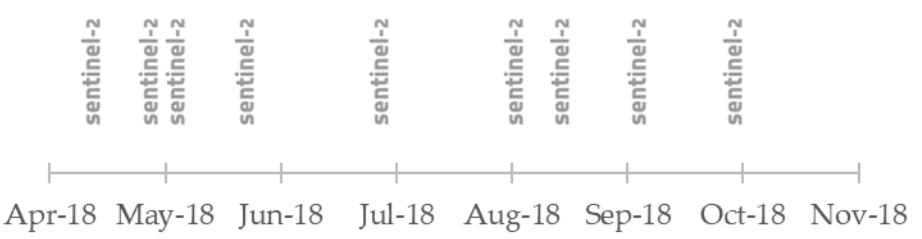
Error matrix (based on RF OOB) n = 1149

Classification algorithm: Random Forest

Features: S2A&B L2A data in visible, Red-Edge, NIR and SWIR

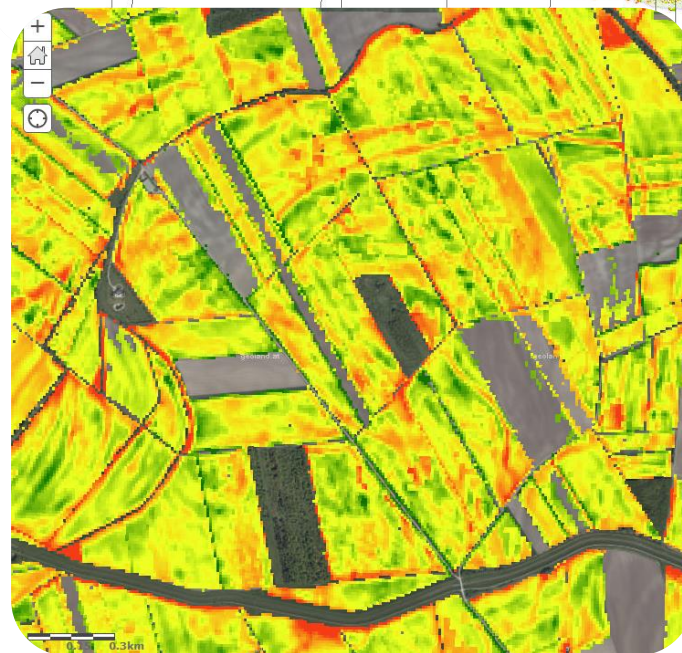
Error matrix: out of bag error (OOB)

Temporal distribution of S2 acquisitions:

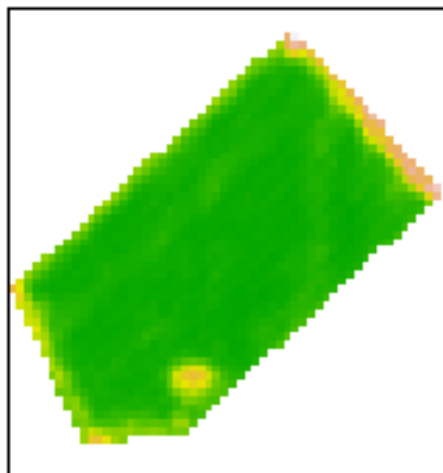


2018	Alfalfa	Asparagus	Carrot	Mais	Onion	Pea	Potato	Pumpkin	Sugarbeet	Sunflower	Soybean	Vegetable	Winter cereal	User's accuracy
Alfalfa	15	0	0	0	0	0	0	0	0	0	0	0	0	1
Asparagus	0	2	0	1	0	0	0	0	0	0	0	0	0	0.667
Carrot	0	0	5	0	1	0	0	0	0	0	3	0	0	0.556
Mais	0	0	0	166	0	3	0	0	1	0	4	0	3	0.938
Onion	0	0	0	0	80	0	0	0	0	0	1	0	0	0.988
Pea	0	0	0	0	1	38	0	0	3	3	0	0	0	0.844
Potato	0	0	0	0	0	0	76	0	0	3	6	0	5	0.844
Pumpkin	0	0	0	0	1	0	0	35	0	0	3	0	0	0.897
Sugarbeet	0	0	0	0	1	0	1	0	94	0	0	0	0	0.979
Sunflower	0	0	0	2	0	0	0	0	0	142	3	0	0	0.966
Soybean	0	0	0	3	0	0	1	0	0	8	208	0	2	0.937
Vegetable	0	0	0	1	1	1	0	0	1	0	1	16	0	0.762
Winter cereal	0	0	0	1	0	0	0	0	0	0	0	0	203	0.995
Producer's accuracy	1	1	1	0.95	0.94	0.9	0.97	1	0.95	0.91	0.9083	1	0.95	0.940

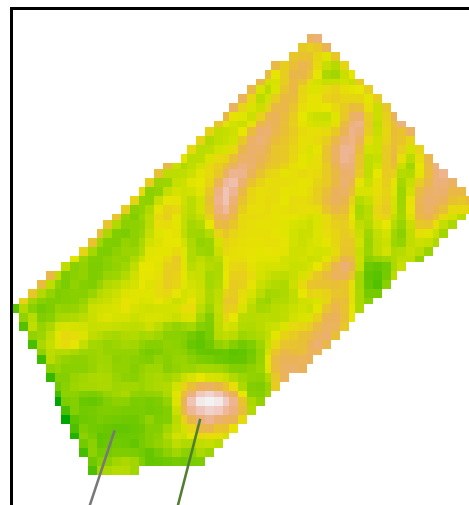
Example study: crop yield potential



Calculation:
Integrates **crop development over multiple years** and local **climate**



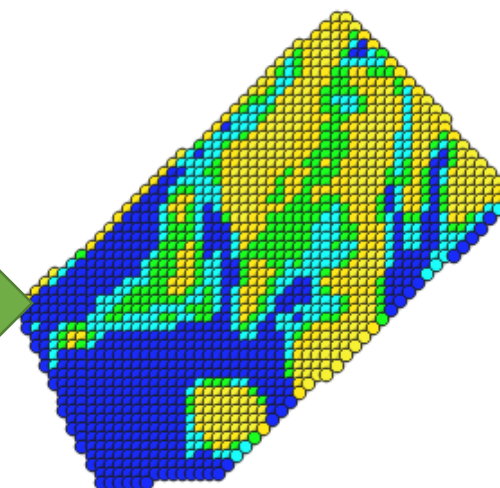
Yield potential map



High

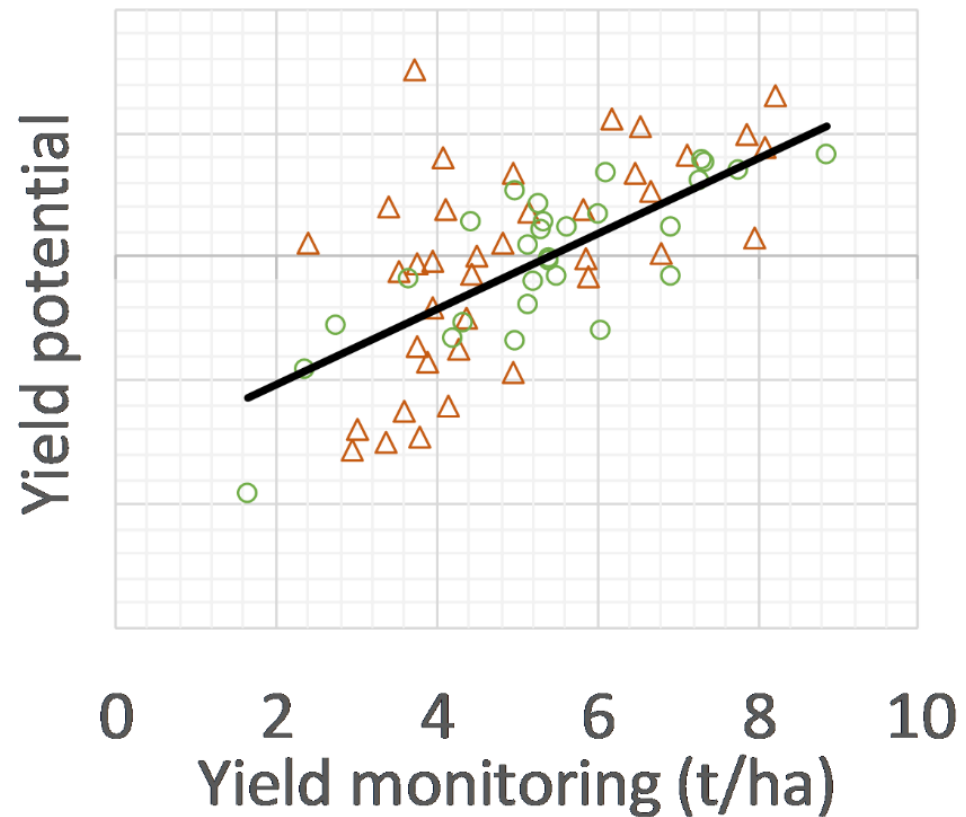
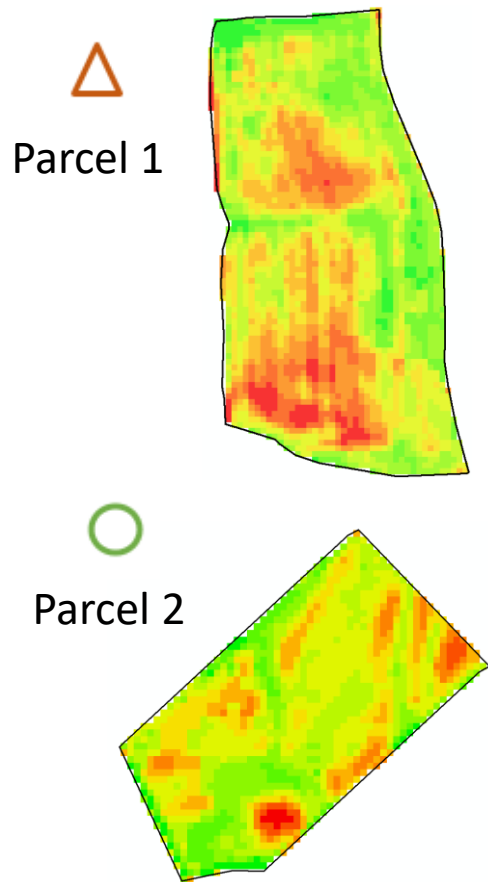
Low

N application zones



Nährstoffempfehlung	
43 HERRENFELD	
Winterraps	7,7753 ha
N Obergrenze CC/OPUL	140,00 kg/ha
N Empfehlung SGD7:	143,00 kg/ha
P205 Empfehlung SGD7 (B):	83,75 kg/ha
K205 Empfehlung SGD7 (B):	200,00 kg/ha
N bereits gedüngt:	0,00 kg/ha
P205 bereits gedüngt:	0,00 kg/ha
K20 bereits gedüngt:	0,00 kg/ha
N noch zu düngen	140,00 kg/ha
N Empfehlung gelbe Zone (0,87 ha)	89,00 kg/ha
N Empfehlung grüne Zone (3,96 ha)	124,00 kg/ha
N Empfehlung hellblaue Zone (1,75 ha)	159,00 kg/ha
N Empfehlung dunkelblaue Zone (1,20 ha)	194,00 kg/ha
Kontrolle Ø N Empfehlung :	138,74 kg/ha

Yield potential vs Actual Yield (yield monitor)



Example study: Wienerwald Biosphere Reserve

- Established: 2005
- Located between the Northern Alps and the Pannonic Basin next to Vienna (Austria)
- 105.645 ha, lower Austria + Vienna
- > 60% of the area are forest - largest contiguous deciduous beech forest in Central Europe
- Important biodiversity hot spot throughout Europe
- Wooded hills alternates with meadows, pastures, vineyards and dry grasslands
- Aim: Ecological, sustainable economic and social development of the region



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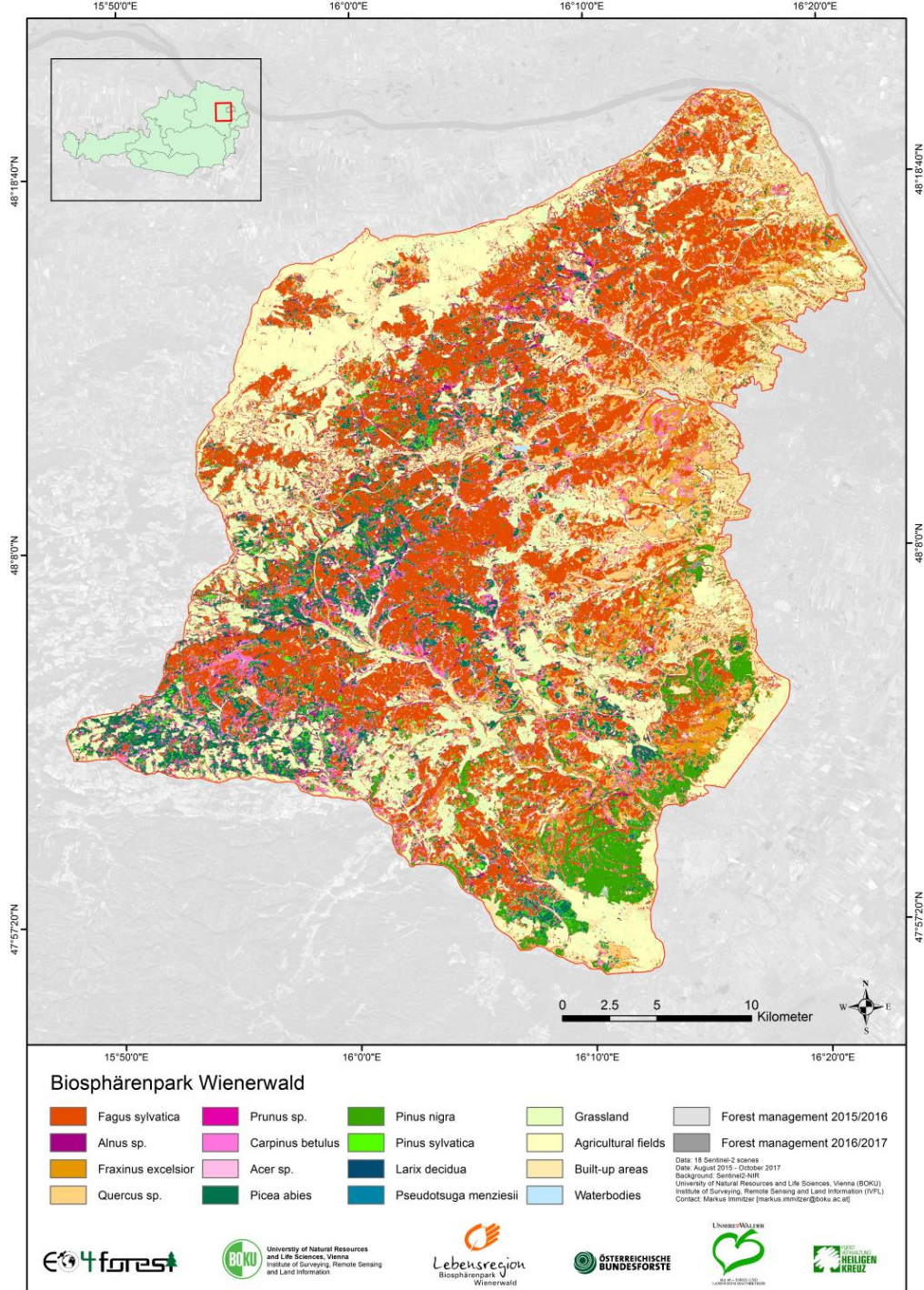
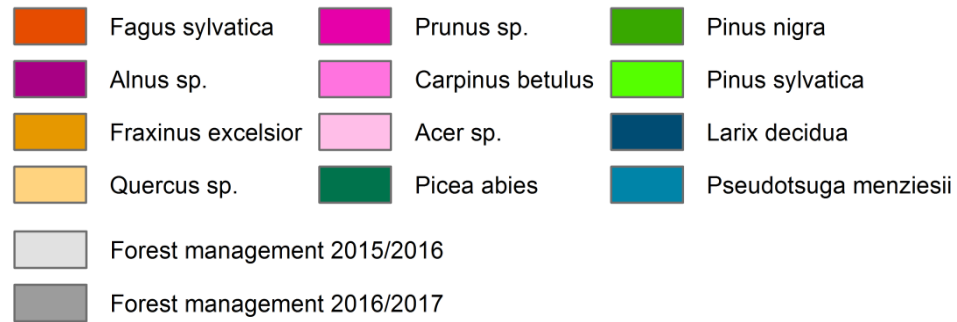
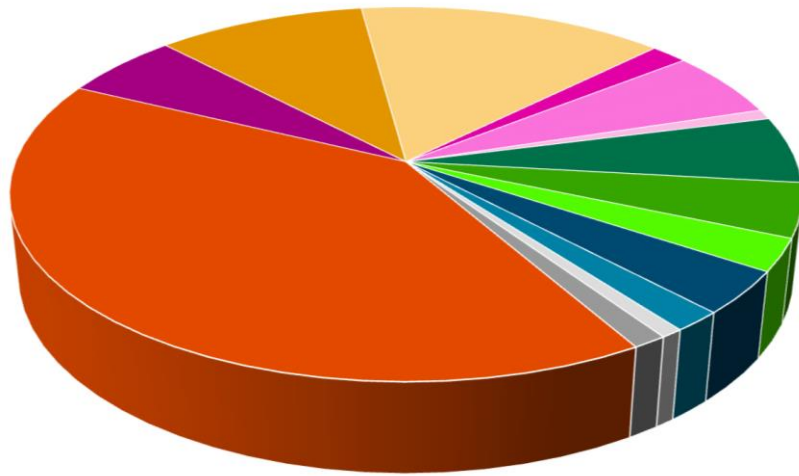


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10/17/2018

Results tree species

- Land cover classification combined with best tree groups models
- Forest changes masked out



Results - tree species

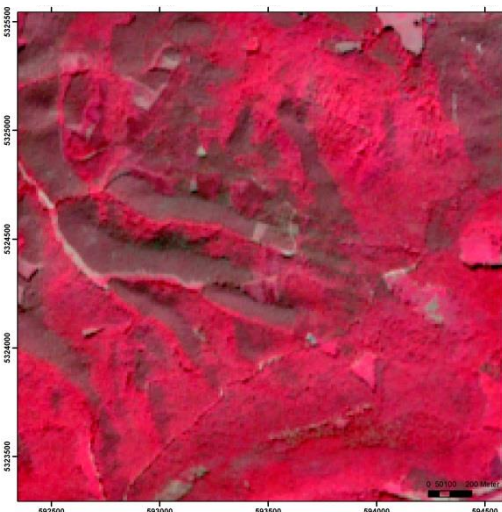
- Best tree group models aggregated



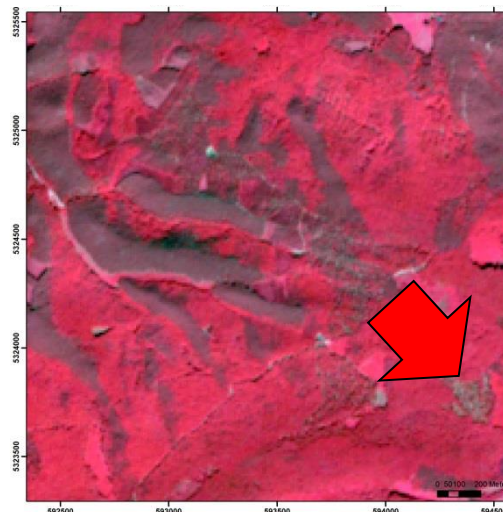
Classification	Reference												
	FS	AG	FE	QU	PR	CP	AC	PA	PN	PS	LD	PM	UA
<i>Fagus sylvatica</i>	211	4	7	7	4	12	8						83.4%
<i>Alnus glutinosa</i>	0	44	0	1	0	0	0						97.8%
<i>Fraxinus excelsior</i>	0	0	44	3	0	0	7						81.5%
<i>Quercus sp.</i>	0	1	5	117	1	4	2						90.0%
<i>Prunus sp.</i>	0	0	0	0	18	0	0						100.0%
<i>Carpinus betulus</i>	4	2	3	1	1	48	0						81.4%
<i>Acer sp.</i>	0	1	1	1	1	1	16						76.2%
<i>Picea Abies</i>								132	0	3	1	1	96.4%
<i>Pinus nigra</i>								1	101	1	1	2	95.3%
<i>Pinus sylvestris</i>								1	4	75	0	0	93.8%
<i>Larix decidua</i>								1	1	0	46	1	93.9%
<i>Pseudotsuga menziesii</i>								0	1	0	1	52	96.3%
∑ reference data	215	52	60	130	25	65	33	135	107	79	49	56	1006
PA	98.1%	84.6%	73.3%	90.0%	72.0%	73.8%	48.5%	97.8%	94.4%	94.9%	93.9%	92.9%	
	OA 89.9%						Kappa 0.885						

Change detection – Forest management activities

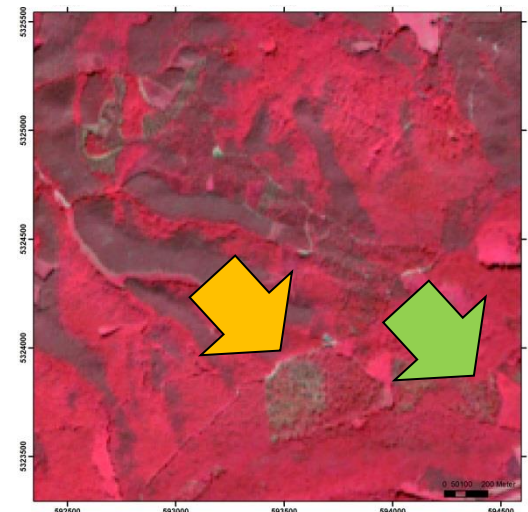
August 2015



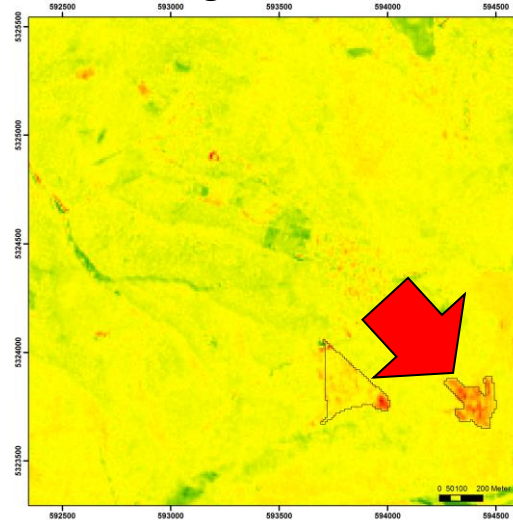
August 2016



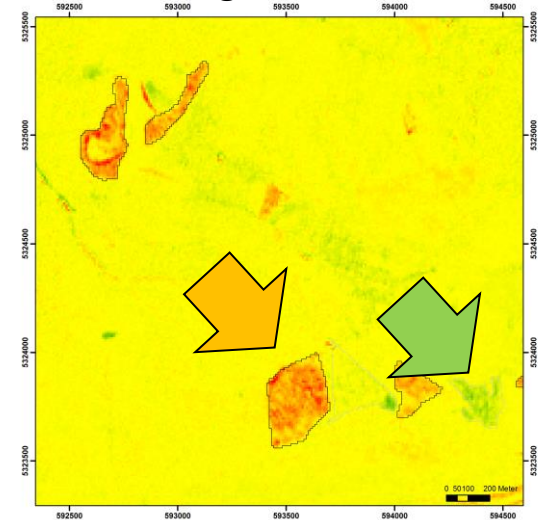
August 2017



Change 2015-2016



Change 2016-2017



Difference
Actual year –
previous year

Thank you for your attention

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