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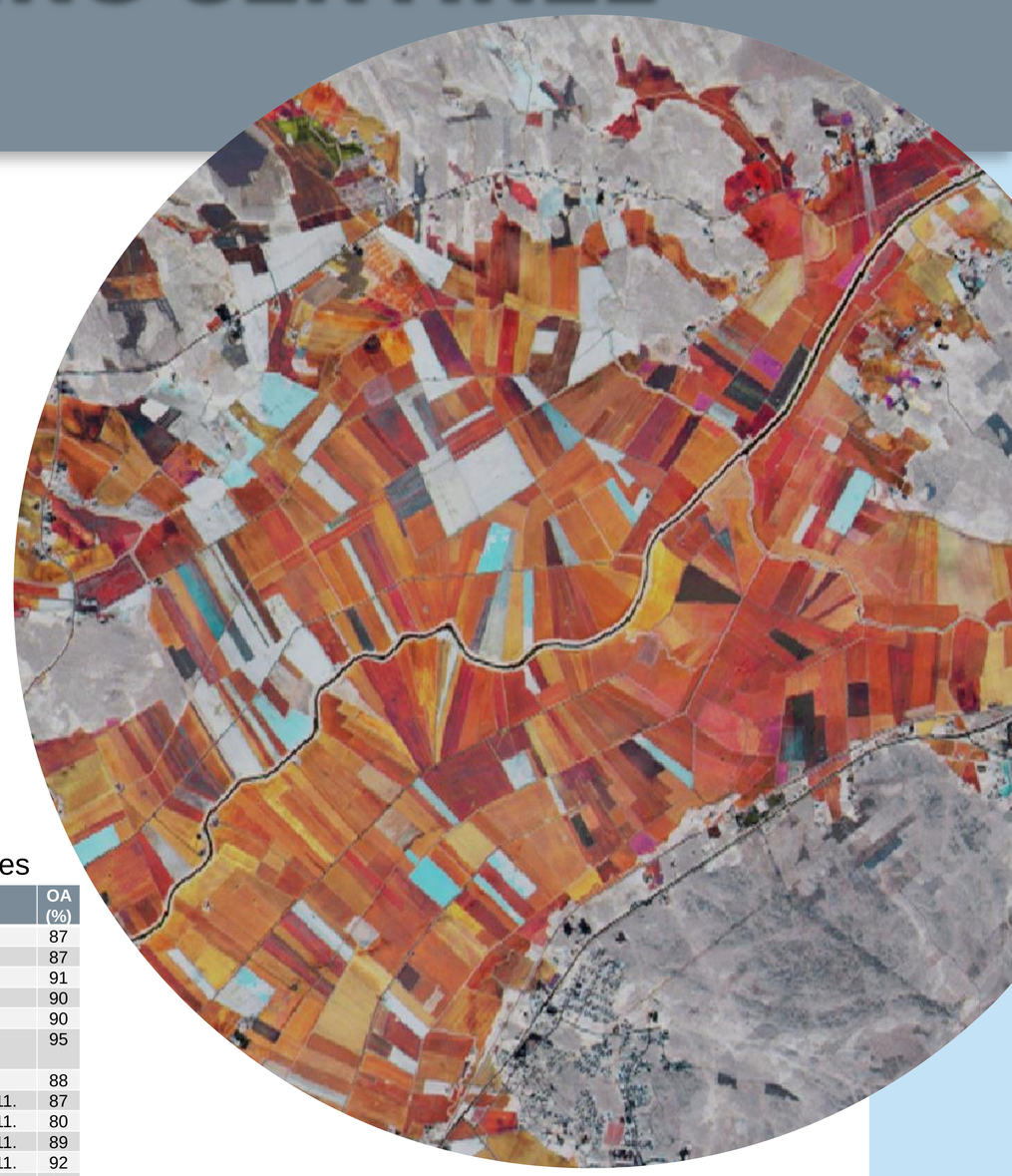
DEVELOPMENT OF FINNISH AGRICULTURAL MONITORING SYSTEM UTILIZING SENTINEL IMAGES

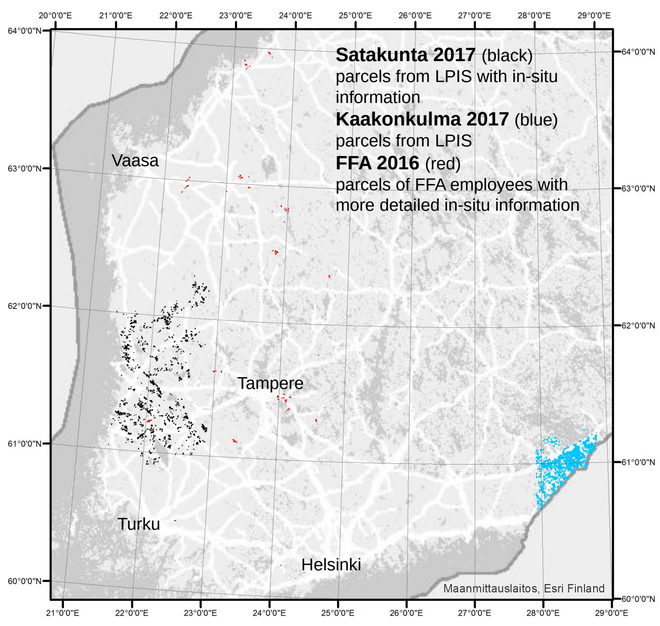


Seinäjoki town, R: NDVI max 1.6.-30.6.2018, G: NDVI max 15.5.-15.6.2018, B: NDVI max 1.5.-31.5.2018
Original data from ESA Copernicus Sentinel Program, processing by SYKE and Finnish Meteorological Institute

In Finland, the management of agricultural subsidies of the Common Agricultural Policy (CAP) of European Union is the responsibility of Finnish Food Authority (FFA). FFA is responsible for both making the payments to the final beneficiaries and controlling that no undue payments are made. The controls in Finland are currently carried out as various cross checks between farmers' applications and FFA register data, but also as on-the-spot-checks in the field.

This current system for controls is in need of development. The new system should not only be more cost efficient but also faster, in order to enable FFA to make payments on time. This study will aid these objectives by providing information based on remote sensing for the control process. The more specific aims are the classification of tillage practices, the classification of crop types and the search of anomalous parcels.

TEST AREAS



SATELLITE IMAGES AND GIS DATA

Sentinel-1
- 2016 and 2017, selected images
- Processed using SNAP at SYKE, 10 m pixel

Sentinel-2
- 2016 and 2017, all images
- Indices NDVI, NDTI, NDMI, NDBI, NDSI
- Processed with CalFin Calvalus-cluster of Finnish National Satellite Data Centre, 10 m pixel

GIS-data
- Finnish Land Parcel Identification System LPIS
- 10 m DEM of National Land Survey

CLASSES

Ploughing classification

Class	Satakunta 2017 (MMU 0.5 ha)	FFA 2016
Grass	856*	174**
Ploughed	128*	69**
Lightly tillaged	74**	22**
Autumn cereals	52*	
Stubble field		39**

*based on recoding of LPIS data **in-situ information

Crop type classification

Satakunta S2	Satakunta S1	Kaakonkulma
Autumn wheat 21 parcels	Grass 1118	Autumn cereals 320
Spring wheat 252	Peas 21	Spring cereals 7502
Autumn rye 35	Oil crops 58	Root crops 13
Barley 553	Spring cereals 1799	Grass 7081
Oats 593	Root crops 75	Garden 89
Broad bean 19	Broad bean 24	
Potato 61	Fallow 30	
Sugar beet 45	Potato 79	
Oil plants 45	Autumn cereals 61	
Cumin 31		
1 year grass 23		
Multi-year grass 595		
Natural treatment field 179		
Fallow 39		

Image processing partly done at Finnish Satellite Data Centre.
Study has been funded by Finnish Geospatial Platform project (Ministry of Agriculture and Forestry) and Framework Partnership Agreement on Copernicus User Uptake (FPCUP) of European Union.

PLOUGHING CLASSIFICATION

Satakunta 2017 test area, kNN-classifier, 4 classes

Features	Time	OA (%)
VV, NDVI, NDTI*	April 2017	87
VV, VH, NDVI, NDTI, NDMI, NDSI*	April 2017	87
VV[1], VH[1], NDVI[12], NDTI[12], NDMI[12], NDSI[12]*	April[1], May[2] 2017	91
Sentinel-2 10 m & 20 m bands	21. & 24.5.2017	90
VV[1], VH[1], Sentinel-2 10 m & 20 m bands[2]	April[1], 21. & 24.5.2017[2]	90
VV[1], VH[1], NDVI[123], NDTI[123], NDMI[123], NDSI[123]*	April[1], May[2] 2017, Autumn 2016[3]	95
NDVI, NDTI, NDMI, NDSI*	Autumn (15.9.-30.11.) 2016	88
VV mean, max, min	2016: 4.10., 16.10., 28.10., 8.11., 20.11.	87
VH mean, max, min	2016: 4.10., 16.10., 28.10., 8.11., 20.11.	80
VV & VH mean, max, min	2016: 4.10., 16.10., 28.10., 8.11., 20.11.	89
daily VV & VH, ascending orbit	2016: 4.10., 16.10., 28.10., 8.11., 20.11.	92
daily VV & VH, descending orbit	2016: 4.10., 16.10., 28.10., 8.11., 20.11.	91
daily VV & VH, mean of orbits	2016: 4.10., 16.10., 28.10., 8.11., 20.11.	92
VV[1] mean, max, min, NDVI[2], NDTI[2], NDMI[2]	2016: 4.10., 16.10., 28.10., 8.11., 20.11.[1] Autumn (15.9.-30.11.) 2016[2]	92
daily VV[1] mean of orbits, NDVI[2], NDTI[2], NDMI[2]	2016: 4.10., 16.10., 28.10., 8.11., 20.11.[1] Autumn (15.9.-30.11.) 2016[2]	92

*Image indices mosaicked according to maximum NDVI of time period.
VV & VH monthly means unlessstated otherwise

FFA 2016 test area, kNN classifier, 4 classes

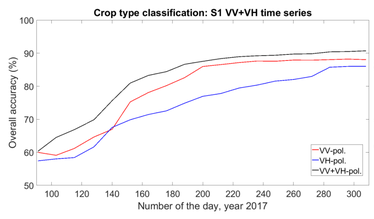
Features	Time	OA (%)
VV, VH	20. & 22.11.2016	78

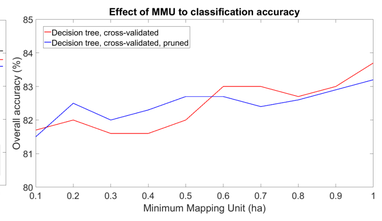
Especially Stubble and Grass are mixed, also Lightly tillaged and Ploughed
NDVI should be also used in classification, NDTI and NDMI would also help

CROP TYPE CLASSIFICATION

Satakunta 2017 test area, Sentinel-2 image index time series
- kNN classifer, 14 classes, OA about 70%
- Grasses mixed with each other, and oats
- Spring cereals mixed with each other
- Later image index mosaics (autumn, OA 60%) more important than early spring (April OA 46%)
- NDVI and NDTI most important indices

Satakunta 2017 test area, Sentinel-1 time series
- kNN classifier, 9 classes, OA about 90% at its best
- Classification of time series by starting from the image of the first date and adding new images as time goes by (figure below on left)





Minimum mapping unit of parcels has quite small effect to classification accuracy (figure above on right)
- Kaakonkulma 2017 test area, decision tree classifier with different parameters
- DT much faster than kNN, OA a bit worse

Monthly NDVI vs. 5 day mean NDVI time series
- Kaakonkulma 2017 test area, 5 classes, kNN-classifier
- 5 day mean NDVI time series: OA about 89%
- Monthly NDVI time series: OA about 85%

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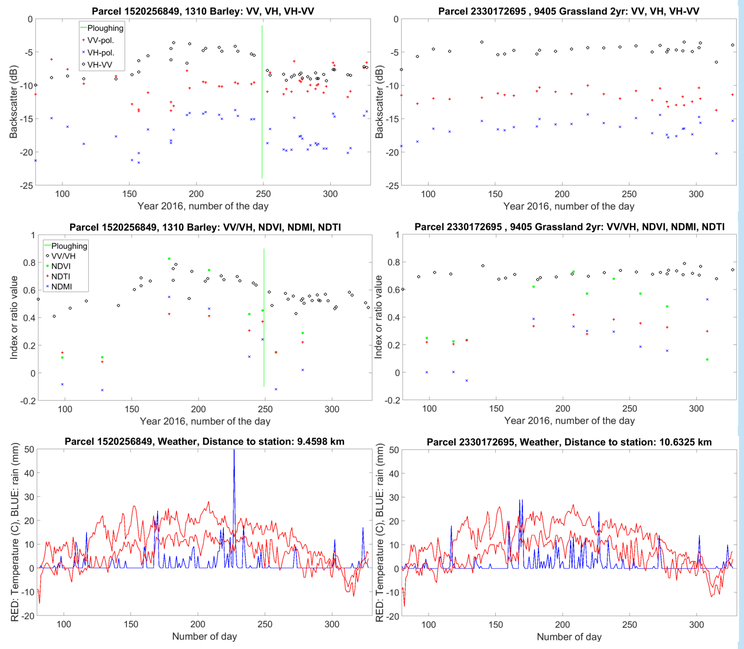
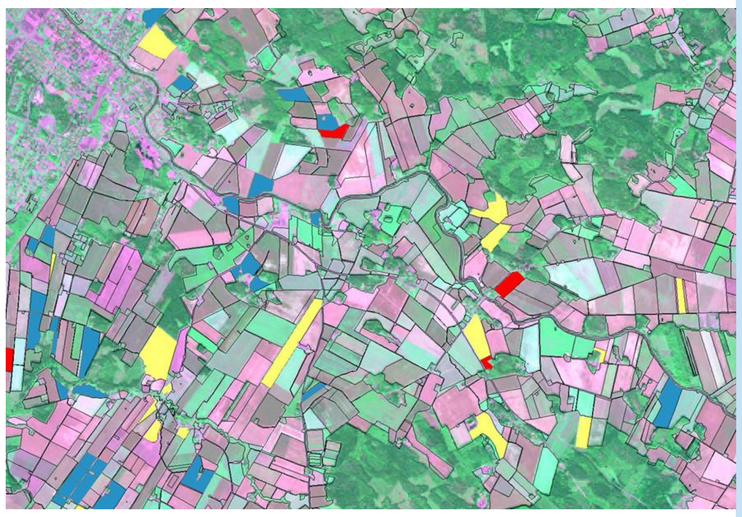
EXAMPLES OF TIME SERIES OF PARCELS



ANOMALOUS PARCELS

Compare the average value of parcel to average value of all parcels of that crop reported by farmer



Red: parcels where NDVI is considerable (2*std) smaller than the mean of that crop
Yellow: NDVI slightly smaller
Blue: NDVI slightly larger

NLS NATIONAL LAND SURVEY OF FINLAND
PTA Paikkatietoalusta www.paikkatietoalusta.fi
Ministry of Agriculture and Forestry of Finland