Improved Grassland Prototypes

The prototype for grassland aims at improving the existing HRL2015 Grassland mask. The investigations focused thereby on various grassland product and production aspects: the use of EO input data, the data analysis approaches, the automation of processes and the development of new products which are of great interest for users. The main requirements addressed during testing and prototype are summarized below:

- **Input Data:** Full use of complete Sentinel-2A+B and Sentinel-1 time series; provide a seamless, wall-to-wall product where data gaps due to cloud cover have been maximally reduced;
- **Production:** Improved level of automation of processes to accelerate processing time;
- **Product definition:** Improved thematic classification accuracy (user´s, producer´s, overall accuracy); improve 20m spatial resolution to 10m and MMU of 1 ha
- **New products:** Investigate a future change detection and a further grassland discrimination between e.g. intensively managed (frequently cut grassland) and extensively managed (more natural, extensively used or grazed grassland);
- **Methodology:** Design a fully integrated SAR/optical time series analysis approach to benefit from the multi-sensor characteristics.

Based on these requirements, **one prototype** on **improved permanent grassland identification** has been developed as part of WP 43 and tested on a selection of sites that were presented in Table 1.

Table 1: Demonstration sites for the grassland prototypes

Prototype Grassland – Demonstration Sites					
Site	***NORTH***	***CENTRAL***	***WEST***	***SOUTH-WEST***	***SOUTH-EAST***
Countries	*Sweden*	*Germany, Austria, Switzerland*	*Belgium, France*	*France, Spain*	*Greece, Bulgaria, Macedonia, Serbia*
Biogeographic Region	*Boreal*	*Continental, Alpine*	*Atlantic, Continental*	*Atlantic, Alpine, Mediterranean, Continental*	*Mediterranean, Continental, Alpine*
Phase 1			X		
Phase 2		X	X		X

IMPROVED PERMANENT GRASSLAND IDENTIFICATION

As **input data** sets, full Sentinel-1 and Sentinel-2 data archives have been chosen. From SAR archives, the polarisations VV/VH were best-suited for that task and therefore selected from the database.
Additionally, specific **in-situ data** necessary for training and validation purposes have been applied, namely visually controlled LUCAS point data, LPIS Data (where available) and VHR Data from the Data Warehouse.

The **methodological approach** designed uses a multi-sensor data integration where a fusion on pixel level is applied by stacking different S-1/S-2 features into one dataset. This stack is afterwards utilized as input for the classification approach. Various optical and SAR features have been tested from which the following proved to be the most promising:

- optical annual indices applied: CI_green, CI_red_edge; EVI, MCARI_705_740, MTCI, NBR, NDMI, NDRE1, NDRE2, NDVI, OSAVI_705_740, REP, SAVI, TCB, TCG, TCW, TCARI
- optical annual features applied: median, mean, maximum, minimum and standard derivation

- Seasonal optical median composites derived from the optical reflectance bands: the bands GREEN, NNIR and SWIR are more promising to differentiate between grassland and non-grassland than the other S-2 bands.
- Annual statistical SAR features selected: MIN, MAX, MEAN, STD, CoV, DIFF

Moreover, specific **time windows** have been investigated. The research showed, that the spring season (March-April), late summer (July – August) and autumn (September-October) seasons are found to be important to contribute to the grassland/cropland discrimination.

Based on these input features and time windows, a selection of **test cases** was defined and classified using the **Supervised Random Forest Classifier**:

- SAR + seasonal features,
- SAR + VI (Vegetation Index) + seasonal features,
- SAR + OPT + seasonal features,
- SAR + OPT + VI + seasonal features

The **most promising results** over all test cases could be achieved combining annual statistical multi-temporal filtered SAR features in combination with annual and seasonal optical features from March-April, July-August and September-October and annual vegetation indices. The overall thematic accuracy reached was 90.86% (Producer´s accuracy grassland 77.25%, User´s accuracy grassland 78.60%, Producer´s accuracy non-grassland 94.45%, User´s accuracy non-grassland 94.02%).

Further investigations to be targeted in phase 2 will focus on the following requirements:

- determine the optimal combination of features and indices derived from the optical as well as SAR dense time series at the biogeographical region level
- improve thematic accuracy
- Focus on further curve fitting and outlier-detection (e.g. selected features like e.g. greenness vs. brightness) for approach to optimally utilize the information content of temporal trajectories
- Signature anomaly detection related to agriculture and grassland
- distinguish between intensively/extensively managed grassland
- Comparative analysis to distinguish different types of grasslands and different grassland management intensities
- Improvement of MMU from 1 ha to 0.5 ha
- Test approaches to derive grassland change between two status layers or as an incremental update.

Prototype Specifications

Table 2: Grassland prototype specifications.

Grassland 10m	**Acronym** GRA	**Product category** Improved Primary Status Layer
Reference year 2017		
Geometric resolution Pixel resolution 10m x 10m, fully conform with the EEA reference grid		
Coordinate Reference System European ETRS89 LAEA projection		
Geometric accuracy (positioning scale) Less than half a pixel. According to ortho-rectified satellite image base delivered by ESA.		

Thematic accuracy

Minimum 85% overall accuracy

Data type

8bit unsigned raster with LZW compression

Minimum Mapping Unit (MMU)

Pixel-based (1ha)

Necessary attributes

Raster value, count, class name, area (in km2), area percentage (taking outside area not into account)

Raster coding (thematic pixel values)

0: all non-grass areas

1: Grassy and non-woody vegetation

254: unclassifiable (no satellite image available, or clouds, or shadows)

255: outside area

Metadata

XML metadata files according to INSPIRE metadata standards

Delivery format

GeoTIFF

Colour table

ArcGIS *.clr format

Class Code	Class Name	Red	Green	Blue	
0	all non-grass areas	240	240	240	
1	Grassy and non-woody vegetation	70	158	74	
254	unclassifiable (no satellite image available, or clouds, or shadows)	153	153	153	
255	outside area	0	0	0	