Possible Use of Synthetic Aperture Radar Images in IACS

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New Sentinel satellite images available for IACS

COPERNICUS is financed by the EC:

- Developed for vegetation monitoring, one of the main target is the agriculture and environment policy

SENTINEL 1 – Synthetic Aperture Radar (SAR) continuous all-weather, day- and-night imagery at C-band, dual polarization - can transmit a signal in one polarization mode (H or V) and receive in both horizontal (H) and vertical (V) polarization

  20 m spatial resolution, Revisit time: 6 days

SENTINEL-2 – Optical MultiSpectral Instrument (MSI) 13 spectral bands: four bands at 10 metres, six bands at 20 metres and three bands at 60 meters spatial resolution. ESA delivers orthorectified products 100 km tiles in UTM/WGS84 projection.

  Revisit time: 10 days (5 days will be if S2B will be operative – in a few month

Figure 1: SENTINEL-2 10 m spatial resolution bands: B2 (490 nm), B3 (560 nm), B4 (665 nm) and B8 (842 nm)
Advantages
strengths, new possibilities

• Country wide free availability – we are able to monitor with the same method the entire area
• Synergic use of optical and radar data is possible
• Radar is weather independent – under cloud detection, excellent for water detection
• Radar images contain far more additional information to the optical: selection of specific targeted descriptors to find specific crop features agro techniques (done or not done)
• Entire biomass content is detected, under-leaf effects are detectable
• Weekly revisit allows continuous monitoring of the vegetation growth and agricultural technological actions
• Transparent and repeatable processes
• If the image is taken, the processing is time-independent

Doubths and Limitations at PA level

• Special knowledge/experience is needed to develop the PA-specific applications „too scientific” – requires outside sources
• No capability to store such amount of raster data at a PA, to be able to retrieve all the data supporting decisions
• Spatial resolution (GSD = 10-20 m) is not suitable for area measurement – prior delineation/measurement of the parcel is needed
• Not applicable on fragmented landscape with small (<1ha) parcels
• Crops cannot be separated on species level – diversification problems can be filtered
• EC approval and change of existing procedures to implement new approaches in OTSC - pilot studies including validation are preconditions
Results of the remote sensing for agriculture

Hungarian research team - Government Office Capital City Budapest, Department of Geodesy, Remote Sensing and Land Offices

- The state institute responsible for geodesy, cartography and remote sensing had been continuously working together with the PA for LPIS and CwRS development and maintenance since 2004
- Polarimetric radar application team is acting since 2006.

Main results:
- Participation in ESA and COPERNICUS projects
- Participation in SOAR-EU project of the Canadian Space Agency
- Synergic use of multi temporal optical and radar images
- Arable crop type and crop phenophasis identification
- Detecting crop damages and deceases (corn root warm)
- Detecting force majeure and it’s damage (waterlog, drought, ice storm)
- Land cover classification - grassland and natural vegetation types
Fusion of the Sentinel-1 and Sentinel-2 Data for Mapping High Resolution Land Cover Layers

Results:
Fusion of radar and optical images gives the good solution to eliminate cloud problems.

To increase the accuracy geometrical problems and appropriate filtering must be solved.

10 best polarimetric descriptors are selected and they are as important as the $\sigma_0$ intensity.

Classmap derived from radar(34)+optical(1) time series:
Used bands from radar image:
- Standard deviation of Shannon entropy
- Mean of anisotropy, mean of alpha,
- Mean of 2nd eigenvalue,
- Mean of $\sigma_0$ of VH band

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SENTINEL-1 Radar color composite of 5 time series std of SE, mean of l2, mean of alpha

SENTINEL-2 color composite 14/08/2015 (NIR, SWIR1, Red-edge1)
Analysis of the main arable crops' phenology by polarimetric descriptors derived from H/A/α decomposition of Sentinel-1 time series data

Study area by the river Tisza

Results:

- In examination of 2 years crop developments have a **recurrent, recognizable phenology profiles** in different radar signatures.
- Radar polarimetric decomposition parameters - gives added information to describe crops' condition: structure, biomass status, water content.
- Sigma noughts (abs. value of intensity) itself is not enough for the agricultural analysis.
- Radar features have high potential to retrieve valuable information about the crop status, the **real potential is in the fusion of radar and optical data**.

### Crops examined

- **Maize**: 20 parcels = 544 ha
- **W. wheat**: 20 parcels = 535 ha
- **Sunflower**: 20 parcels = 461 ha
- **Rapeseed**: 21 parcels = 522 ha

### Study area by the river Tisza

- **Winter wheat**
- **Rapeseed**

**Phenology profiles**

- **2015** (details of phenological stages for each crop)
- **2016** (details of phenological stages for each crop)

**Published at**: PolinSAR 2017, January 23-27 - Frascati, Italy
• The winter crops and summer crops are separated well.

• There is a short mixing period when summer crops are growing and winter crops are harvested.

• The rapeseed has a characteristic separation in different short period.

• Maize and sunflower have a similar features in H-α space.
Operational projects in Hungary where radar is used

Monitoring the spread of ragweed = Ambrosia artemisiifolia – allergic weed – the example shows the presence of flowering ragweed in a sunflower parcel.
Since 2010

Monitoring of western corn rootworm damage in maize fields by using integrated radar (ALOS PALSAR) and optical (IRS LISS, AWiFS) satellite data.
L-band polarimetric radar data introduce a competitive indicator to detect structural (disorder) damages.
Operational use of radar in the Agricultural Risk Management System - force majeure: **drought on arable crops**

Comparing the radar polarimetric descriptors how the difference between the „usual” and „drought-effected” parcels can be detected.
Operational use of radar in the Agricultural Risk Management System - force majeure: ice storm damage

Ice storm damage – example shows a winter wheat parcel
- Yellow: not damaged reference parcel
- Blue: damaged parcel

Hungarian State Treasury
Challenges for the paying agencies of using Sentinel images in IACS controls

• Detecting the
  – existence and duration of catch crops
  – timing of the hay cut on PP
  – ploughing on a set-aside parcel
  – if the winter soil cover is kept
  – weed, encroachment of scrubs
  – non compliance with minimum activity
• Verifying force majeure cases

• Focusing on agricultural parcel level inspection
• Fast and objective
• Reducing field visits
  The method fits to the current regulative environment, technical recommendations if the parcel boundary is already validated on a VHR or on-the-spot

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• Standardised monitoring of the entire population of declared parcels to filter problems and to target OTSC
• Reducing accepted area based on HR or HHR images

• Pilot projects are needed for proving the methodology, validation and real implementation in the IACS workflow.
• Best approaches must be proven by the EC before operational use.
• MS are willing to cooperate but also expressed the need of EC/ESA/JRC support.
• The developments requires extra funding if EC recommends to use the new technologies.
• Common data availability is essential.
Possibilities of using the crop clustermap in IACS:

- helping to localise the parcels already at declaration stage (input support for better result!)
- filtering crop and diversification non-compliances and supporting CwRS decision
- opens the possibility for „overall monitoring method” and filtering problems for larger parcels

Ortho images, cluster map and declaration are all from year 2015
Challenges of using the new image sources and processing technologies in LPIS maintenance – simplification!

Does the current direction of increasing the spatial accuracy for LPIS and parcel measurement leads to better finding the risk of the found or not?

Are we on the right way to spend resources on delineating by CAPI hardly delineable natural non-eligible features at 100-500 m² size on a single VHR image? - rather than working on monitoring the eligibility and MA during the entire vegetation period, to filter larger areas with essential risk?

Are we able to decide the eligible area of a PP temporary effected by water or being marshy on a single true colour ortho image? – or monitoring of biomass suitable for animal feed during the entire vegetation period would lead to better categorisation, and also capable to detect self maintaining pasture?

Synergic use of optical and radar images are capable to more detailed grassland categorisation = update of PP layer ???

Calculation and update of PP pro-rata can be supported by multi temporal image analysis ???

Automatic detection of LCC changes and changes of artificial surfaces can direct the RP update ???
Haycut detection

Average temporal development of polarimetric descriptor „SE”(a) and NDVI (b) for different categories based on reference data (Lake Tisza site)

The real potential of this method is the possibility to follow the cut weakly!
General conclusions

• The real challenge of using the Sentinels’ data in IACS is the timing: weakly free availability – the possibility of continuously monitoring the agricultural activity opens new approaches at most steps of the IACS workflow: LPIS, declaration, controls, retroactive analysis …

• Radar images brings new additional information about the structure and about the entire vegetation content (not only it’s surface) of the crops, that is why synergic use with the optical multi spectral images leads to retrieving additional information.

• There are several very promising technical result as a solid knowledge base of using Sentinels, but operational implementation in the IACS workflow is still limited. Pilot projects could force the validation of best approaches.

• MS requires the active involvement of the EC to support the use of Sentinels’ data in IACS: improving data availability, sources for pilots, validation of methods, evaluation of the technical guidance.…
Thank you for the attention!

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