Winter crops coverage's classification in the Southeast of the Buenos Aires province, Argentina.

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Abstract

Accurate crop production data is fundamental for reducing uncertainly and volatility in the domestic and international agricultural markets. Earth observation data helps to quantify in a timely, precise and objective way different areas of food production at a regional and global scale. Developing countries like Argentina heavily rely in agriculture from an economic standpoint, where 60 percent of their exports are of agro-industrial origins. The Buenos Aires Grain Exchange (BAGE) is a non-profit organization that aims to provide free an open data related to crop production. The Agricultural Estimates Department of the BAGE estimates crop area, yield and production independently since 2000. By providing weekly objective information, the Grain Exchange helps different actors of the agricultural chain, such as producers, traders, seed companies, market analyst, policy makers, into their day to day decision making. Since 2015/16 season, the Grain Exchange has worked on the adoption of EO tools into their crop estimations together with the University of Maryland, and as a partner of NASA Harvest, by developing a new earth observations-based method to identify winter crop planted area at a regional scale, that is tailored to the budget constrains (such as hardware, software and knowledge) that developing countries such as Argentina have. The methodology is based on free GIS-Software, basic knowledge of satellite imagery analysis and free LandSat 8 images. Results of this methodology applied during 2016/17 winter-crop season were presented at AGU 2017, under the poster name "Winter Crop Mapping for Improving Crop Production Estimates in Argentina". During the 2017/18 the methodology was improved by adding free high-spatial resolution images (Sentinel-2) with the aim of improving estimation under cloud presence. Preliminary results indicated that overall the classification accuracy of the cropland and non-cropland classes are sufficient to improve downstream production estimates, with the potential of replicating this methodology in other developing countries that heavy relies on agriculture and have resources constrains to use EO data.

Background

Land usage studies are essential to understand food production all over the world. Argentina is an important player for its arable-land extension and crop production and exports. In order to quantify its food production and exports that largely supply international markets, it is essential to make accurate crop planted area estimates. Since 2015/16 season, the Grain Exchange has worked on the development of a new earth observations-based method to identify the winter crop planted area that uses freely available medium-resolution satellite data such as Landsat-8. Together with the availability of freeware GIS-software, the new approach offers the possibility of estimating accurate winter-crops planted area at a low cost, avoiding expensive investments in software and hardware for data processing and time-consuming analyst work.

During the 2017/18 season, the presented methodology was complemented with Sentinel-2 images, with the aim of increasing the probabilities of accessing cloud-free images thus increasing the analyzed area. This new approach was used to study the Southeast of Buenos Aires province, one of the main Argentina's winter crop regions.

Objectives

Figure 1. (Left) Argentina Cropping Zones.

- Developing a reliable low-cost methodology for estimating winter crop planted area at regional scale that can easily be used in other developing countries.
- Improve the winter-crop area of study by adding Sentinel-2 clouds-free images in those regions where LandSat-8 scenes registers high percentage of clouds-cover during key phenological stages of winter crops.
- Reduce the investment on hardware and software.
    - The methodology is run in a freeware software (QGis) and the temporal data requirement is reduced to only two images per scene all along the winter crop season.
- Minimizes the need of in situ ground truth data, making this methodology accessible to low income countries.

Data

- Landsat-8 or Sentinel-2 images were selected to represent the early planting and peak vegetative stages of the winter crops based on known crop phenologies, for the area under study.
    - Landsat-8 images without clouds as close as possible to the selected dates were analyzed. If there is no availability of LandSat-8 free-clouds images, it can be replaced by Sentinel-2 images without clouds.
    - A total of 14 images were selected between both Sentinel-2 and LandSat-8 satellites (Table 1).

Satellite	Reference	T1 Date	T2 Date
LandSat 8	224_86	6/11/2017	
	224_87	6/11/2017	
	225_86	5/1/2017	11/25/2017
	225_87	5/1/2017	
	226_86	6/9/2017	11/16/2017
	226_87		11/16/2017
Sentinel 2	L1C_T20HPC	05/27/2017	
	L1C_T21HVU		11/22/2017
	L1C_T21HVT		11/22/2017
	L1C_T21HUU		11/22/2017
	L1C_T21HUT		11/22/2017
	L1C_T20HQC		11/30/2017

Table 1. (Right) Primary scenes used for winter crop classification. T1 date refers to early planting scene, T2 date refers to peak vegetative scene.

- NDVI [1] images were made from each Landsat-8 and Sentinel-2 scene.
- Ground data samples were taken during crop-tours in the reproductive stages of winter crops (wheat and barley).
- Different vegetative covers in more than 50 randomly distributed sampling points were identified.

Methods Overview

- Two key phenological stages of wheat and barley were identified. Both crops share similar phenology development in a timeline and account for approx. 90% of winter crop area in Argentina. Specifically in the area under analysis, the average percentage of production of both crops is 42 to 47 % of the total planted area:
- The first date, T1, was selected during the seeding period, when NDVI values of wheat and barley are close to 0 due to the lack of vegetative coverage on its plots (fallow period following the previous harvest).
- The second date, T2, was selected at the heading stage for both crops, when NDVI values reach their peak during the winter crop season. Due to the large latitude difference along the entirety of Argentina's crop area, the date selection was based on a phenological crop calendar created previously by the Buenos Aires Grain Exchange at regional scale.
- Analysis of NDVI-images from Landsat-8 or Sentinel-2 scenes of both selected dates (seeding windows and heading stage) was conducted. For ease of analysis, NDVI values were rescaled from the range [-1, 1] to [0, 2].
- The differences between the second and the first date (i.e. T2 – T1) were calculated to obtain to types of values:
- Negatives values: due to vegetation that was detected in the first date and then disappeared in the second one (e.g. weeds in a plot during the winter-crop season, plots later burned to prepare for the summer crop production season).
- Positive values (typically between 0 and 0.5): due to vegetation actively growing during the winter until the spring time, when the peak of NDVI is reached by winter crops (e.g. wheat and barley plots).

Validation

- Validation was based on photointerpretation of a stratified random sample (~3000 samples) of independent ground truth data.
- Validation samples were identified from bi-temporal satellite image pairs reflecting i) the condition before or shortly after planting, and ii) the condition near the vegetative peak of the winter crop.
- Ideally, validation scenes would be of higher resolution (~10x) than the map to be validated, however, this requirement mandates aerial or very high spatial resolution satellite data, the cost of which is prohibitively expensive.
    - We use an alternative method applied in literature [2,3] whereby multiple photointerpreters each evaluate all points in the sample to reduce the effects of interpreter bias in mixed pixels.
    - Additionally, higher resolution (10m) Sentinel-2 imagery was used whenever possible.
- Crop-tours were also conducted during the reproductive stages of wheat and barley in Buenos Aires Province, and in particular in the area under study. Ground truth measurements were taken during each crop tour to identify vegetative cover in more than 50 randomly sampled points.

Results

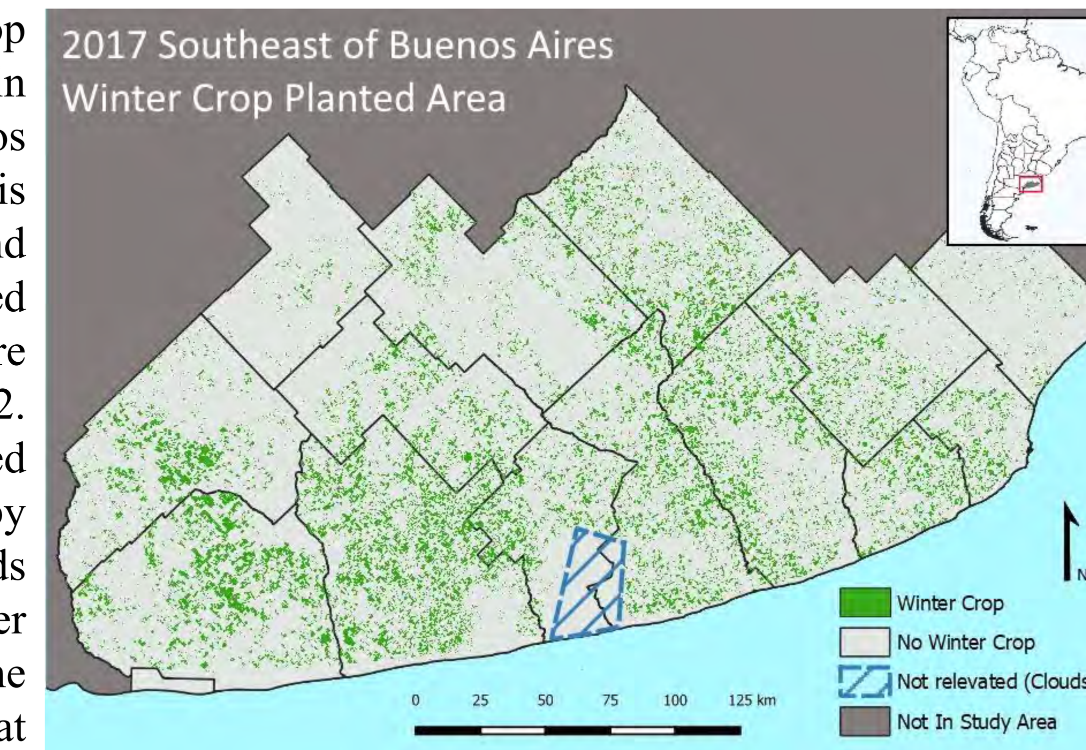

Figure 2 2017 Winter Crop Planted Area at Southeast of Buenos Aires Province

The 2017 winter crop planted area in Southeast of Buenos Aires province map is shown in Figure 2 and the satellite-based validation results are shown in Table 2. Visually, the planted area indicated by Figure 2 corresponds well with known winter cropped areas. The total cropped area at regional level is in agreement with published statistics within five percent for the Southeast of Buenos Aires region.

Same methodology was ran with only LandSat-8 images during the 2016/17 season and its overall accuracy was 87,7 % that season. During the 2017/18 season Landsat-8 images registered high percentage of cloud coverage during key date of this methodology and the winter crop mask of main part of the region was possible thanks to the incorporation of Sentinel-2 images (there was a sector with clouds in both satellite products that couldn't be solved). Validations results show slightly better numbers in stratified zones with larger agriculture area (High Agricultural Strata).

LOW AGRICULTURE STRATA

Total	Labeled as crop	Validated as crop	Accuracy	C.I.	Labeled as non crop	Validated as non-crop	Non-crop accuracy	C.I.
300	24	13	54.17	6.90	276	262	94.93	2.63

HIGH AGRICULTURE STRATA

Total	Labeled as crop	Validated as crop	Accuracy	C.I.	Labeled as non crop	Validated as non-crop	Non-crop accuracy	C.I.
1000	185	119	64.32	6.90	815	669	82.09	2.63

Table 2 2017 Winter Crop Validation Results

Conclusions

- Results show that the approach is viable for winter crop mapping in Argentina. These methods should be considered a first step with further refinement necessary to reduce possible commission/omission errors for the crop class.
- It is expected that the increasing availability of Sentinel-2 data for the 2018 season and beyond will improve future results through increased spatial resolution as well as increasing the probability of obtaining cloud-free pixels closer to the ideal T1 and T2 dates.
- While these methods have the potential to be implemented on a yearly basis, they should be considered preliminary and complementary to the existing method and not as a replacement for it.
- This information is an important input to G-20 initiatives such as the Agricultural Market Information System (AMIS) and GEOGLAM which monitor price volatility and crop conditions globally.

References

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