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## In - season progressive crop type mapping in war affected Ukraine

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The invasion of Ukraine by Russian forces was expected to have global impact on food trade and security, since Ukraine is a breadbasket cereals and oil seeds producer. The NASA Harvest « Rapid Agricultural Assessment for Policy Support » (RAAPS) team was triggered early in the conflict to provide answers to the following questions :

- (i) How much winter cereals, winter oil seeds and summer crops were planted in Ukraine during the 2021-2022 cropping season?
- (ii) What proportion of those crops fell under the Russian occupied area?
- (iii) How much cropland was left unplanted in 2022 due to the war?

As insights had to be produced within season, the NASA Harvest RAAPS team produced the first ever, Ukraine scale in-season crop type map based on Planet Labs 3 meter spatial -, 4 bands spectral -, and daily temporal - resolution data. Since no labeled datasets were available early enough in-season for applying supervised machine learning techniques, cropland was progressively mapped into four classes (winter cereals, rapeseed, summer crops and barren/non cultivated plots), using semi-supervised clustering techniques and heuristical thresholdings. Expert domain knowledge allowed to cope with missing ground truth training data. First, active cropland was separated into winter crops and potential summer crops. K-means clustering of April and May Planet images, followed by visual cluster assignment, allowed to efficiently separate green crops (winter crops) from barren soils (potential summer crops). Then, another K-means clustering allowed to split winter crops into winter cereals and rapeseed as of end of May, based on the intense yellow flowering signal of the latter. Finally a set of NDVI based heuristics was applied on potential summer crops in order to assess if green-up happened or not. Crops which did not green up as of the 11th of July 2022 were considered barren/non-planted.

Road side ground surveyed crop type information collected in free Ukraine has been provided by Kussul & al. (2022) in August 2022. Validation against this data provided an overall accuracy of 94 % and a mean F1-score of 91 % for winter cereals, rapeseed and summer crops. No unplanted

fields were collected as part of the ground campaign. Several assessments of proportional area per crop type and occupation status were performed throughout the growing season, as occupation boundaries kept moving. As of the 11th of July 2022, 23.03 % of Ukraine's cropland was occupied. 55.29 % of all detected barren fields were located within occupied territories, mainly scattered around the front line. 33.9 % of all winter crops were under occupied territory when harvest ready (mid July).

This crop type map was used for computing harvested area, estimating yield and for production computation. Following NASA EarthObservatory articles were published, providing information to the public and private sector: (i) <https://earthobservatory.nasa.gov/images/150025/measuring-wars-effect-on-a-global-breadbasket> (ii) <https://earthobservatory.nasa.gov/images/150590/larger-wheat-harvest-in-ukraine-than-expected>