Crop yield assessment and mapping by a combined use of Landsat-8, Sentinel-2 and Sentinel-1 images

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Content

- Update on winter wheat yield mapping in Ukraine
  - Adding 2019 validation
  - Adding Gaussian processes
  - Combining optical + SAR data

- Maize and soybean yield assessment at field scale in Iowa (2018-2019)
  - Using Planet data
  - Using HLS data
Crop yield assessment and mapping by a combined use of Landsat-8, Sentinel-2 and Sentinel-1 images

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  - C. Champagne (Agriculture and Agri-Food Canada)
  - JECAM
- Objective:
  - to develop a new algorithm and products for agriculture monitoring, namely crop yield assessment and mapping, by combining moderate spatial resolution images acquired by Landsat-8, Sentinel-2 and Sentinel-1/SAR remote sensing satellites
- Crops:
  - wheat
  - corn
  - soybean
Crop yield assessment methodology

- Methodology (for winter wheat)

Winter crop mapping

- Cropland mask
- Calculate maximum NDVI from March 1 to April 6
- Run Gaussian mixture model (GMM) over cropland mask
- Winter crop map

Landsat-8
Sentinel-2A
Sentinel-2B

Phenological fitting

- Meteorological data
- Reference data

Yield model

- Winter wheat yield map

Winter crop yield mapping
Crop yield assessment at **regional scale**

Multi-source image time series

Cross-validation

- 2016-2019
- Regional scale
- Two models:
  - Linear with L2 regularization, and
  - Gaussian Process (GP)
    - Kernel ~ Const * RBF + WhiteNoise

- Defined a specification for wheat yields:
  - spec = 0.06 + 0.06 * yield [t/ha]
    - E.g. 4.0 ± 0.3 [t/ha]
Example of yield map for 2018

Winter wheat yields, t/ha
- 2
- 2.5
- 3
- 3.5
- 4
- 4.5
- 5
- 5.5
- 6
- No data
Combining optical + SAR

- Optical and SAR indices show similar temporal behavior on the growing season.
  - Optical: Difference Vegetation Index (DVI) from HLS
  - SAR: Gamma-nought VH/VV ($\gamma T_0$) from Sentinel-1
Combining optical + SAR

- Temporal profiles of DVI from HLS and SAR-derived

Year 2017
Ground data: crop yields at field scale

Field scale yields for corn and soybean (Hamilton County, IA, USA). Provided by Iowa State University.
Results: PlanetScope

- The coefficient of determination ($R^2$) between yields and Planet-derived surface reflectance’s varied among fields from 0.1 to 0.75 (average among 15 fields was 0.34±0.17)

- Temporal variations of $R^2$ for single-date linear relationships between yields and Planet-derived surface reflectance for two different fields of soybean: one field featuring a high coefficient of determination (0.76) and another field poor correspondence (0.28)
Correlating in-field yields with HLS data

- Maximum per-field Rsq between yields and linear models based on various features
Correlating in-field yields with HLS data

- Examples of fields with the highest and lowest correlations between SR and yields
Correlating in-field yields with HLS data

Fields - Corn

- Mean Yield (bu/ac)
- Maximum R² - SR
- Equation: \( y = -65.851x + 229.693 \)
- R²: 0.402

Fields - Soybean

- Mean Yield (bu/ac)
- Maximum R² - SR
- Equation: \( y = -37.964x + 73.705 \)
- R²: 0.646
Conclusions

- Regional (for Ukraine) winter wheat yield prototype product is available
  - Plans to extend to major wheat producing regions in Ukraine and Kansas

- Potential for improvements in yield assessment by combining optical + SAR data

- Corn/soybean, Iowa
  - 4 PlanetScope’s spectral bands at 3 m explained from 10% to 75% of in-field corn/soybean yield variability
  - Similar results for HLS at 30 m resolution
  - Rsq generally decreases as yields increases
Thank You!