Crop Yield Monitoring at Field Scale with Satellite Data

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Introduction

- Evaluation was carried out within NASA's "**Private Sector Small Constellation Satellite Data Product Pilot**" program
  - https://earthdata.nasa.gov/esds/small-satellite-data-buy-program/csdap-pilot-evaluation

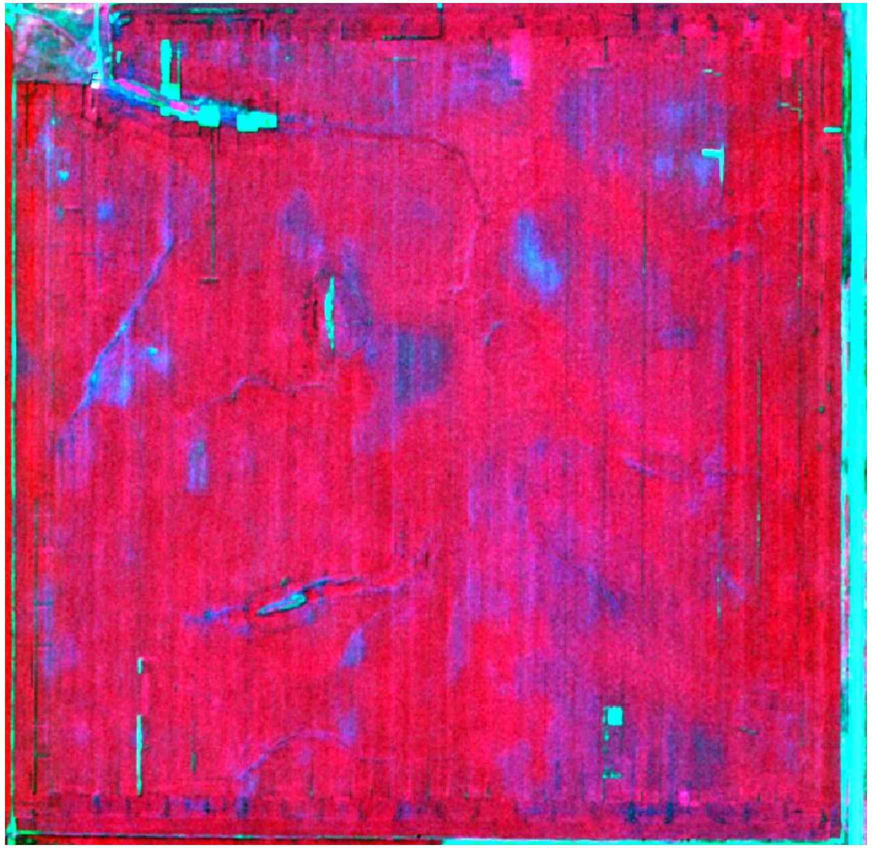
- Evaluation of **very-high spatial resolution** (VHR) satellites (<5 m)

- Objective:
  - Evaluation of VHR satellite data (Planet, Worldview-3) for **agricultural monitoring tasks**

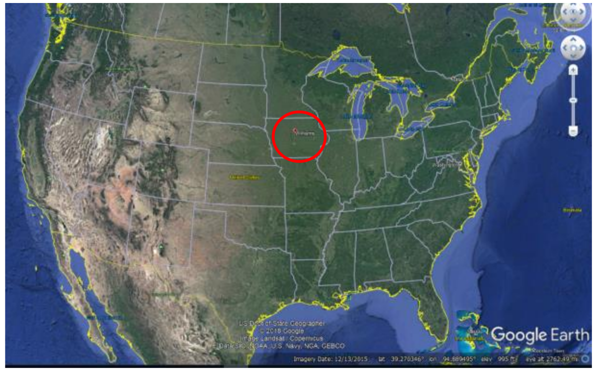
Objectives of the VHR study for Ag

- To evaluate VHR data (1-3 m) on capturing a **field-level yield variability**

- Importance:
  - Insurance industry
  - Fine scale crop production mapping
  - Crop yield gap analysis
  - Guiding sample collection
    - e.g. yield cuts



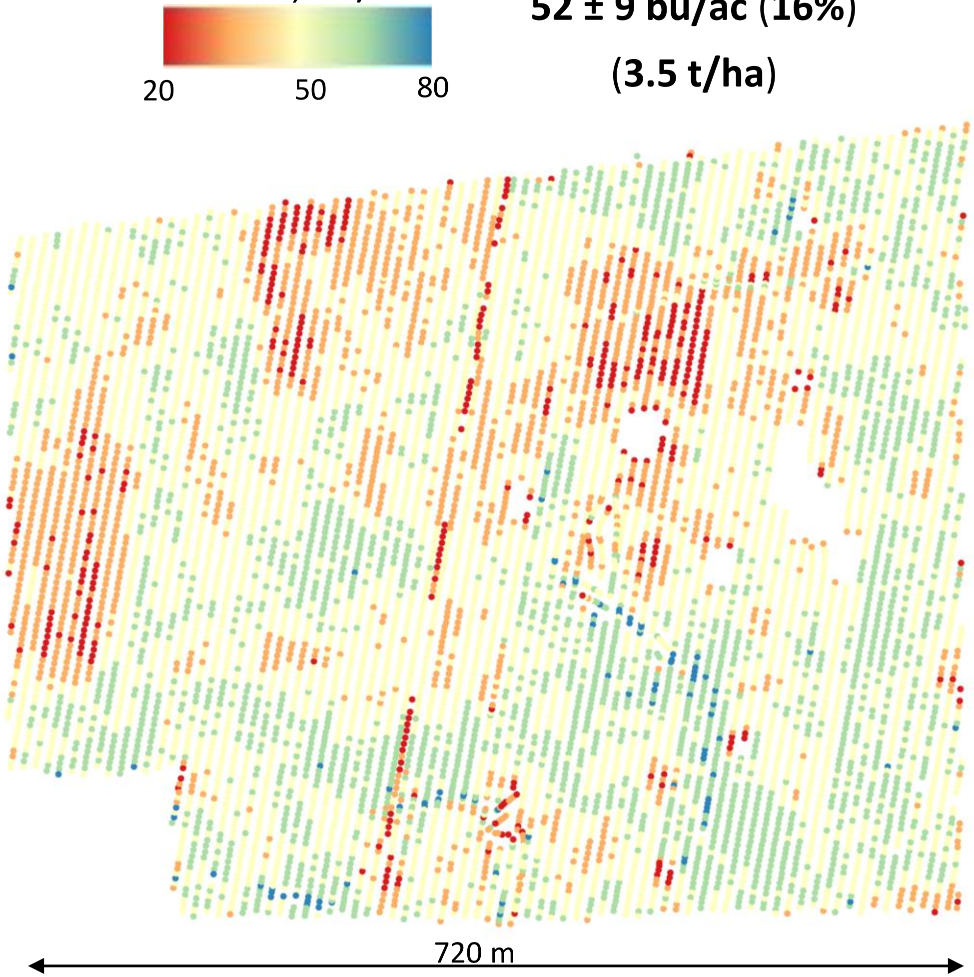
Ground data: crop yields at field scale



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

Soybean

Yield, bu/ac



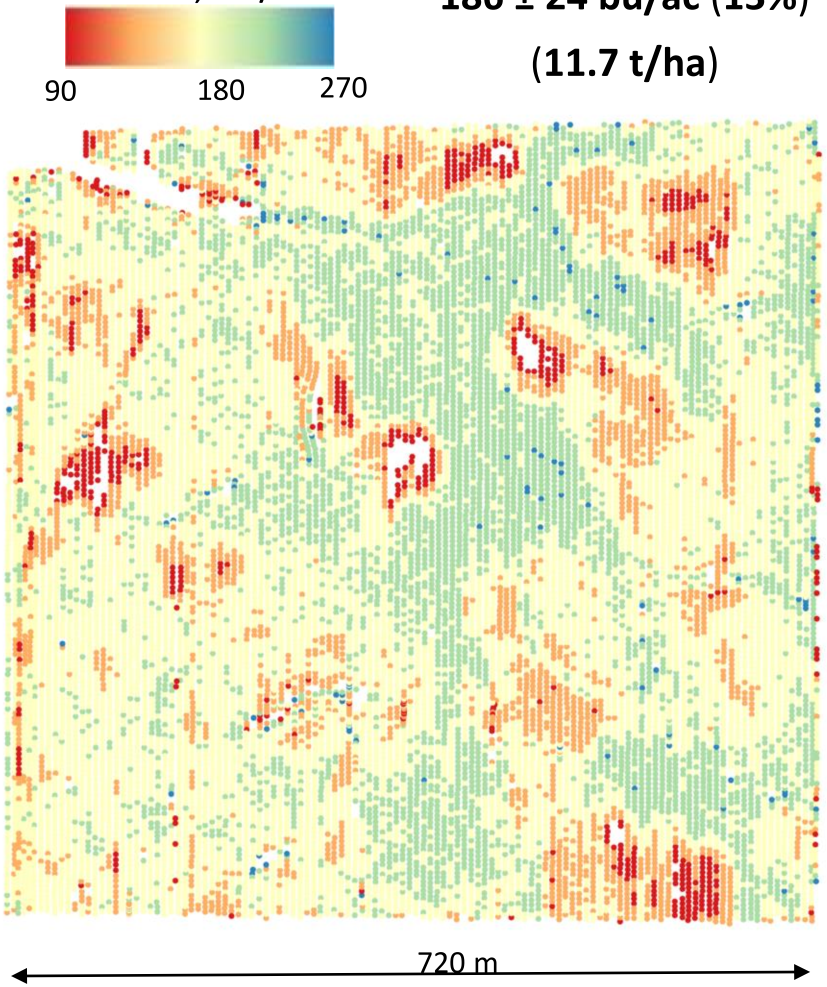
Field scale yield:

52 ± 9 bu/ac (16%)

(3.5 t/ha)

Corn

Yield, bu/ac



Field scale yield:

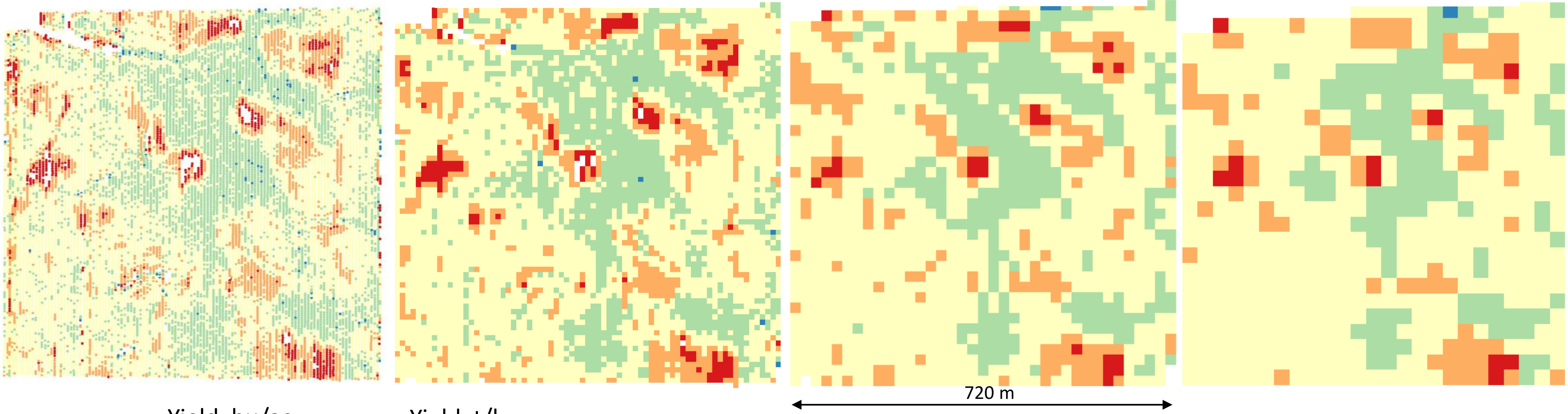
186 ± 24 bu/ac (13%)

(11.7 t/ha)

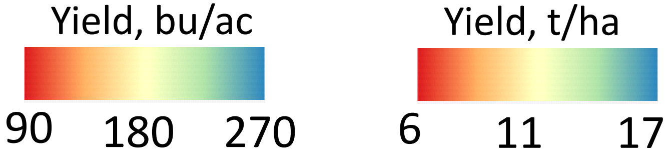
Effect of spatial resolution on capturing yield variability

- Simulating yields at various spatial resolutions
  - ***Relative efficiency = VarianceYield(@Xm) / VarianceYield(@3m)***
    where X is 10, 20, 30

Spatial resolution **3 m**	Spatial resolution **10 m**	Spatial resolution **20 m**	Spatial resolution **30 m**
Relative efficiency = **1**	Relative efficiency = **0.86**	Relative efficiency = **0.72**	Relative efficiency = **0.59**

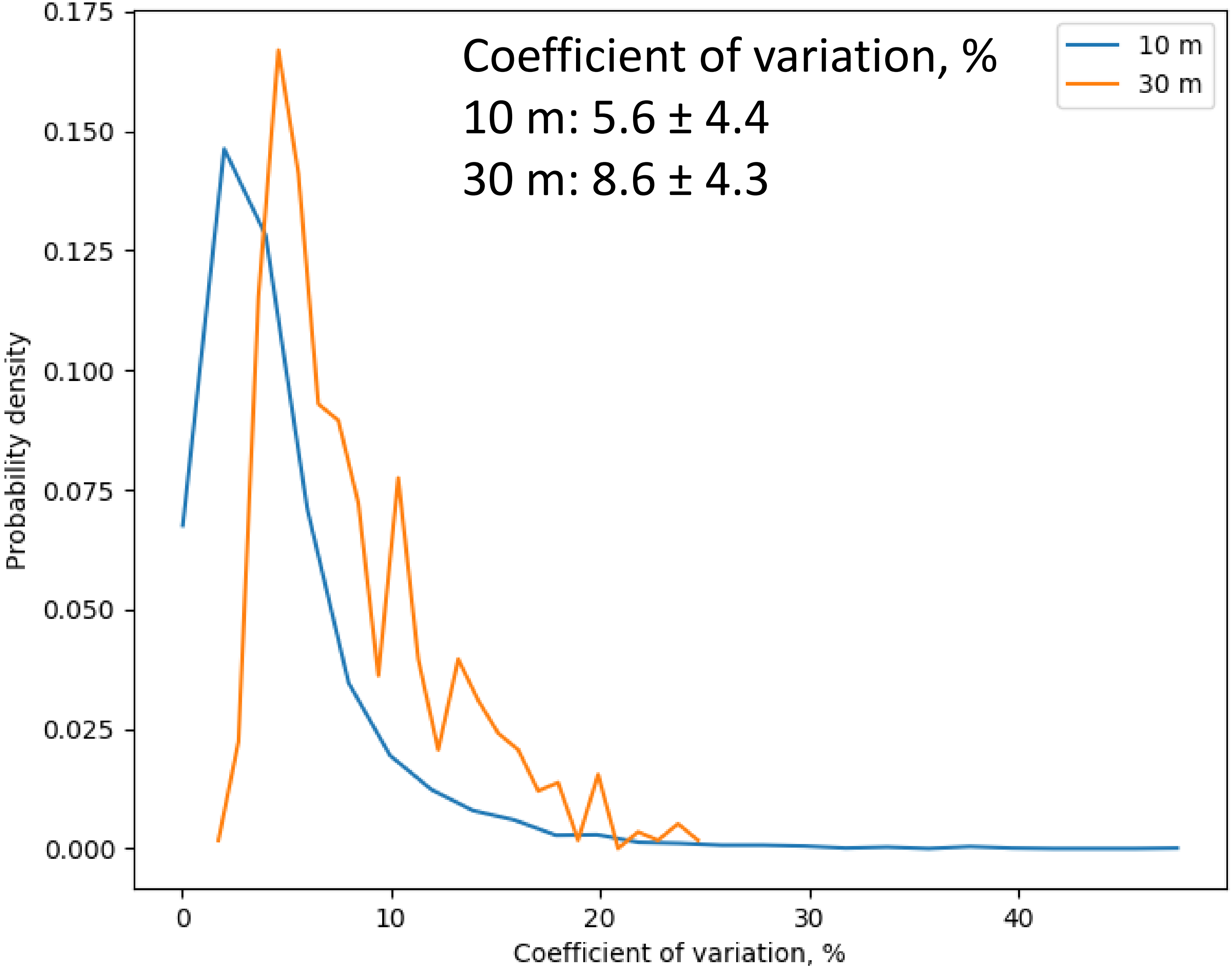


Corn



Effect of spatial resolution on capturing yield variability

- Yield variation inside the pixel



Remote sensing data

- Maxar: WorldView-3 (WV-3)
  - 2 images
  - 8 spectral bands

- Planet: PlanetScope
  - 270 unique scenes, ~84,000 km^2
  - Near-daily coverage
  - 4 spectral bands

- Harmonized Landsat Sentinel-2 (HLS)

- Atmospheric correction
  - **LaSRC**: Land Surface Reflectance Code – adaptation from Landsat 8 and Sentinel-2 (Vermo
et al. 2016)

WV-3, 21 July 2018, 1.2 m, Red-Green-Blue

Planet/PlanetScope, 30 August 2018, 3 m, Red-Green-Blue

Results: WV-3

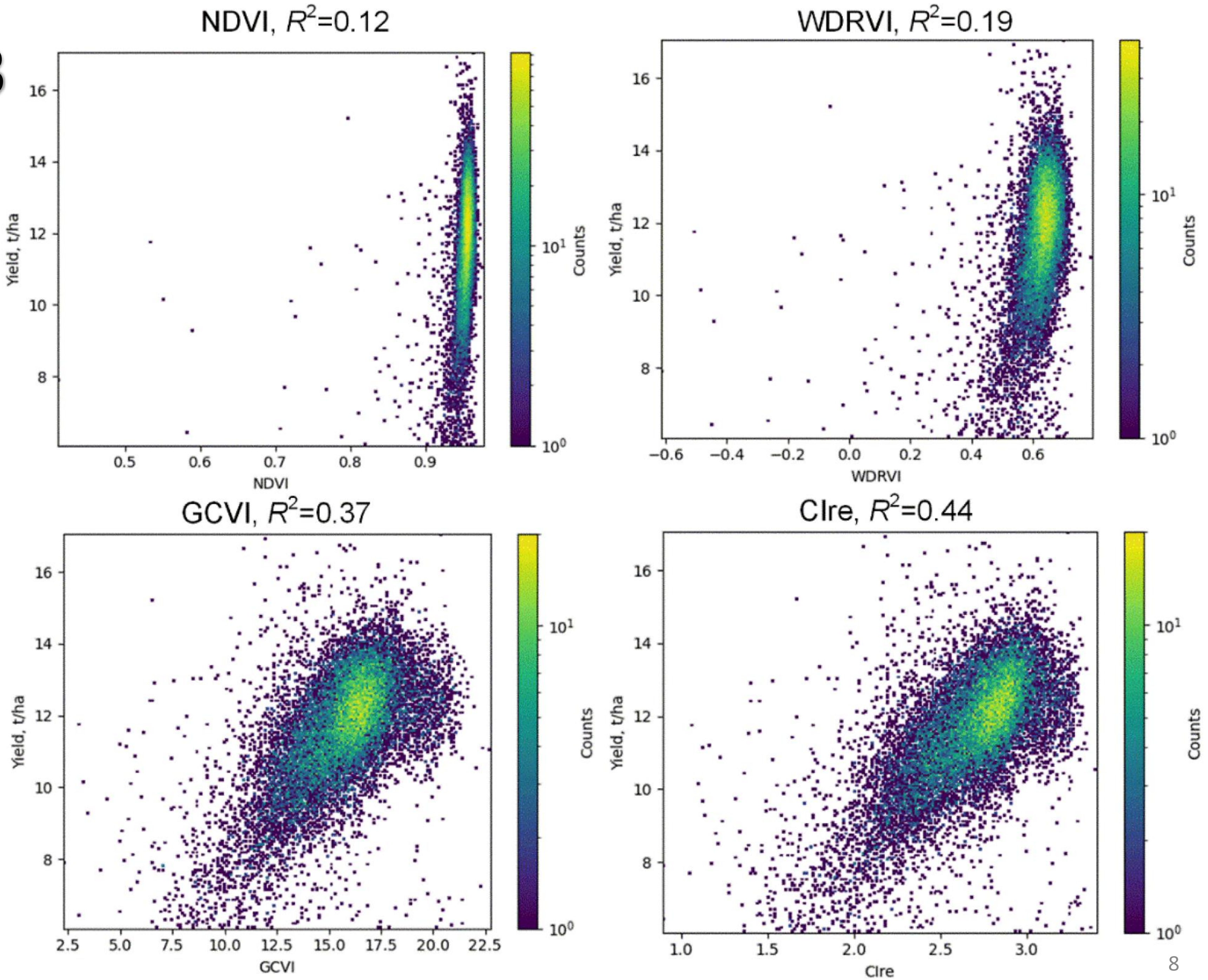
WV-3
Corn
21 July 2018, DOY=202

NDVI: $\dfrac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}}$

WDRVI: $\dfrac{0.1\rho_{NIR} - \rho_{RED}}{0.1\rho_{NIR} + \rho_{RED}}$

GCVI: $\dfrac{\rho_{NIR}}{\rho_{GREEN}} - 1$

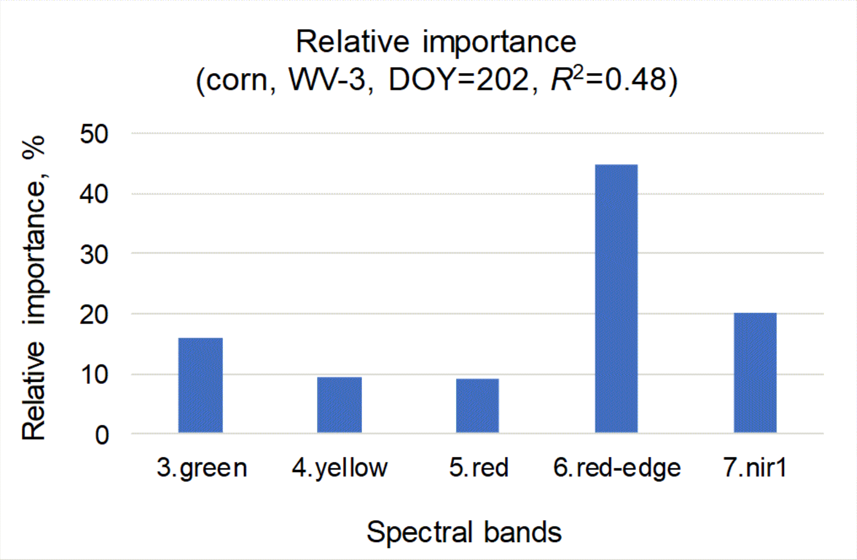
CIre: $\dfrac{\rho_{NIR}}{\rho_{RED-EDGE}} - 1$

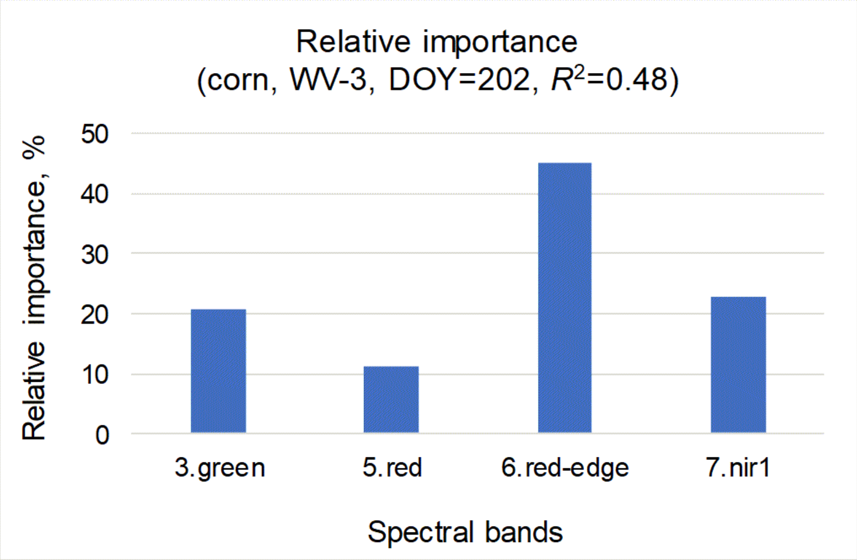


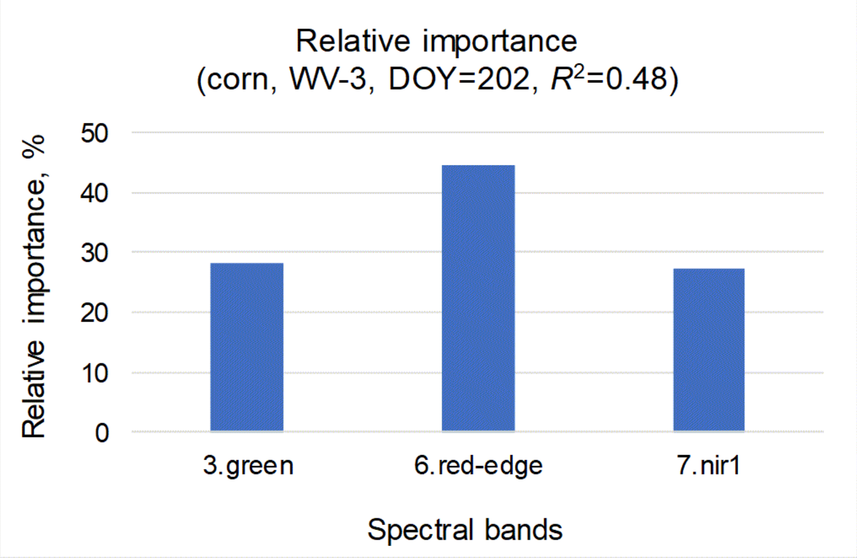
Results: WV-3

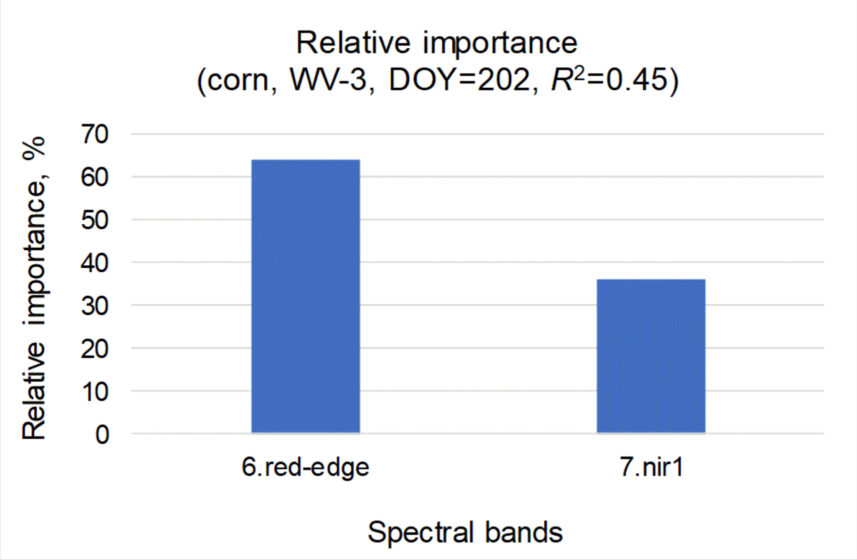
WV-3
Corn
21 July 2018, DOY=202

The red-edge (0.726 µm), green (0.552 µm), and NIR (0.831 µm) bands were the most important in explaining yield variance at field scale







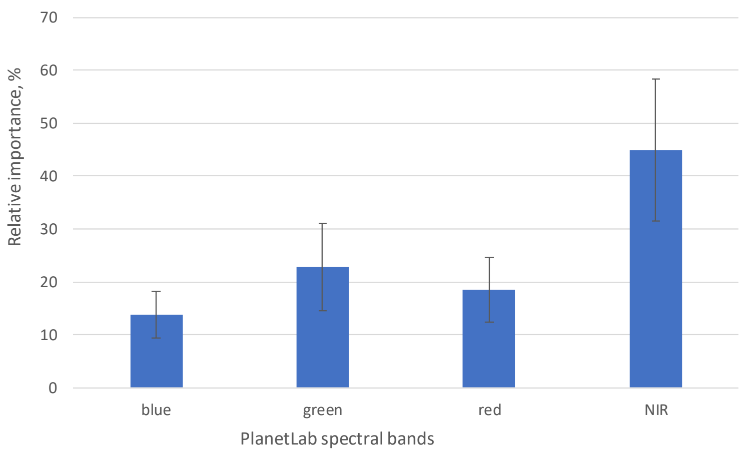


Results: PlanetScope

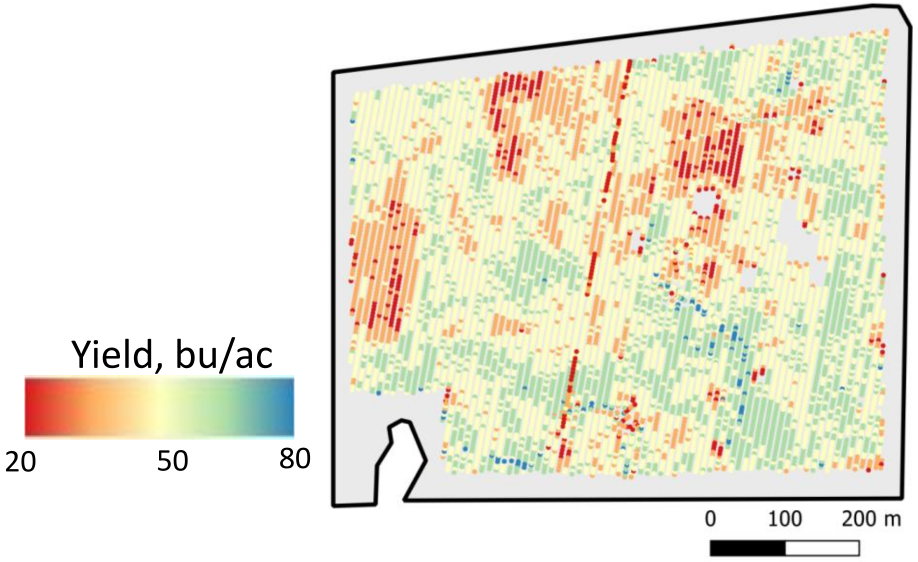
Planet, soybean, R^2 over time

Maximum R^2=0.59 for DOY=242 (30 August)

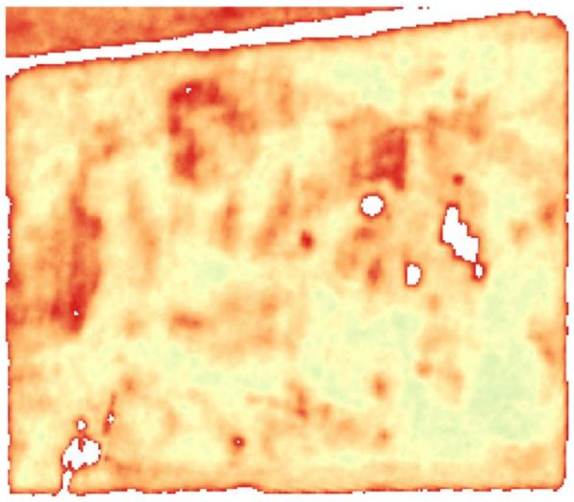
Relative importance



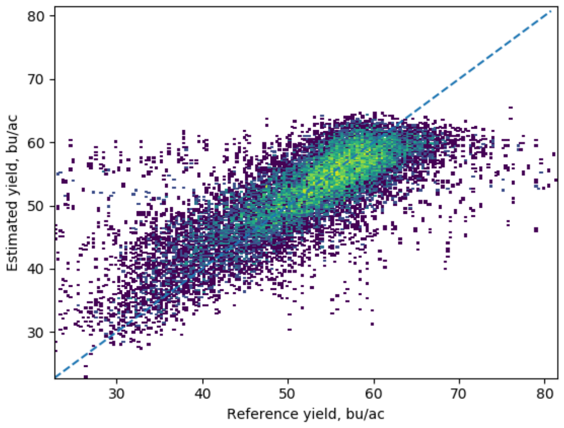
Yield (from machinery)



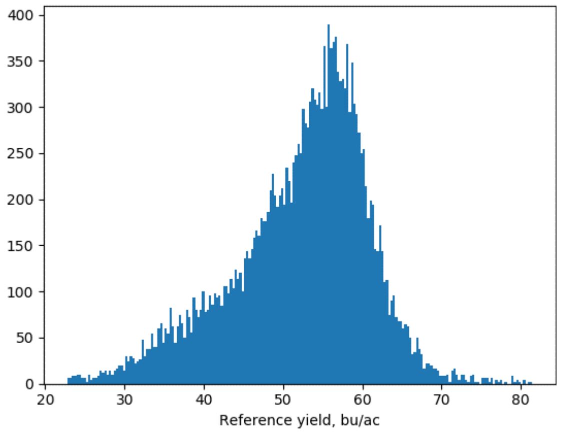
Yield (from satellite, 3m)



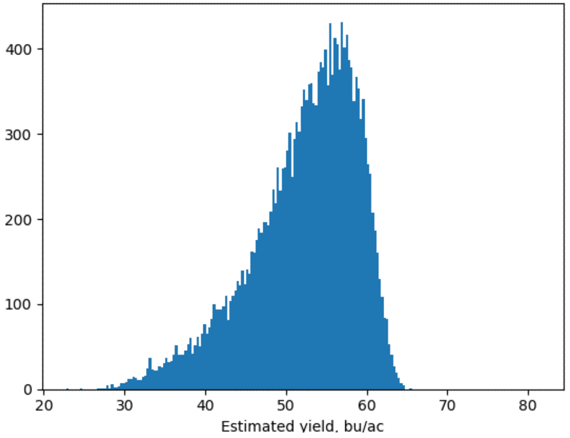
1-1 plot ref. vs est.



Distribution ref. yields



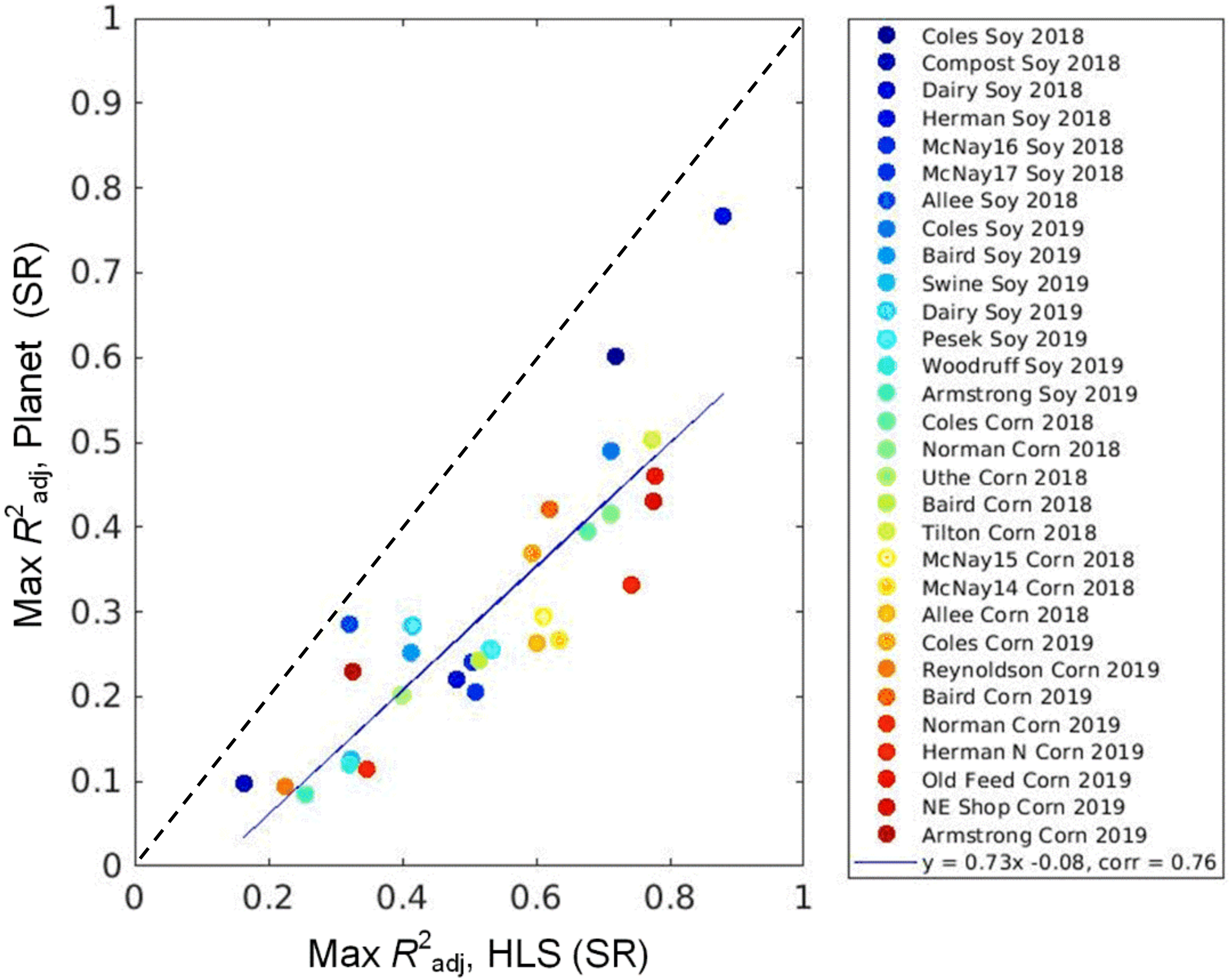
Distribution est. yields



Relative efficiency = **0.59**

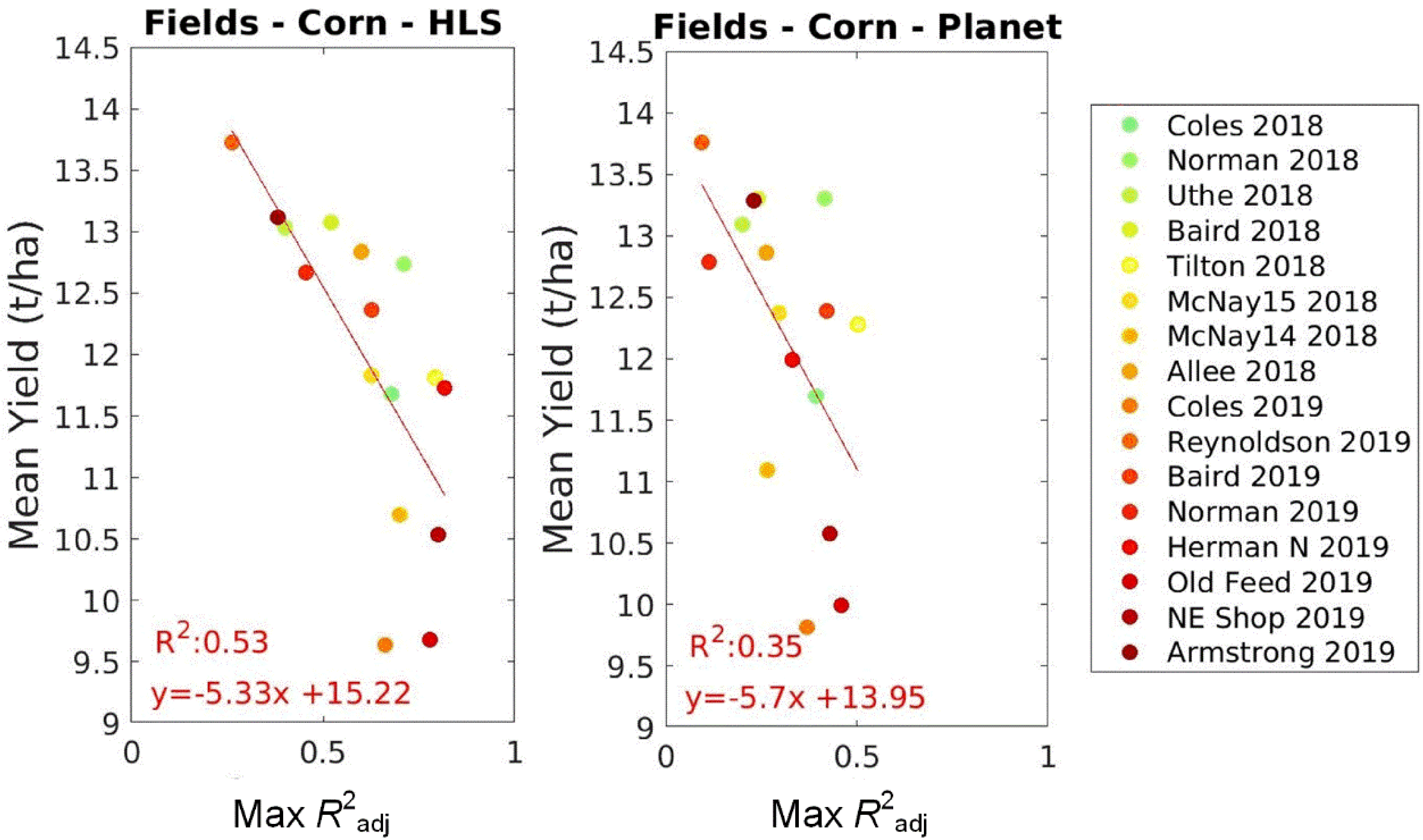
Results: PlanetScope vs HLS

- Planet (3 m)
  - R^2: 0.09 to 0.77 (0.30 ± 0.16)
- HLS (30 m)
  - R^2: 0.21 to 0.88 (0.56 ± 0.19)



Results: PlanetScope vs HLS

- Dependence of the coefficient of determination R^2 for the best HLS- and Planet-based models on field yield for corn



Conclusions

- Capturing in-field yield variability depends on the spatial resolution of remote sensing data:
  - e.g., 10-m data explain 86% and 30-m ~60% compared to 3-m

- Most important spectral bands explaining corn/soybean yield variability
  - green/yellow, red edge and NIR

- The high temporal frequency of Planet allows identification of the optimal date for yield assessment
  - 4 PlanetScope's spectral bands at 3 m explained from 10% to 75% of in-field corn/soybean yield variability

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Assessing within-Field Corn and Soybean Yield Variability from WorldView-3, Planet, Sentinel-2, and Landsat 8 Satellite Imagery

by Sergii Skakun [1,2,3,*], Natacha I. Kalecinski [1], Meredith G. L. Brown [1,4], David M. Johnson [5], Eric F. Vermote [3], Jean-Claude Roger [1,3] and Belen Franch [1,6]

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Crop yield estimation at different growing stages using a synergy of SAR and optical remote sensing data

Natacha I. Kalecinski [a b], Sergii Skakun [a b], Nathan Torbick [c], Xiaodong Huang [c], Belen Franch [d], Jean-Claude Roger [a b], Eric Vermote [b]

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