

New Methods in Earth Observation

Overview and Our Methods in Context

Class 2

Introduction

- Today:
 - Review of McCabe et al. paper
 - Overview of key limitations/innovations in EO
 - Comparison of different sensor networks
 - Housekeeping: computing, R setup

Software check-in

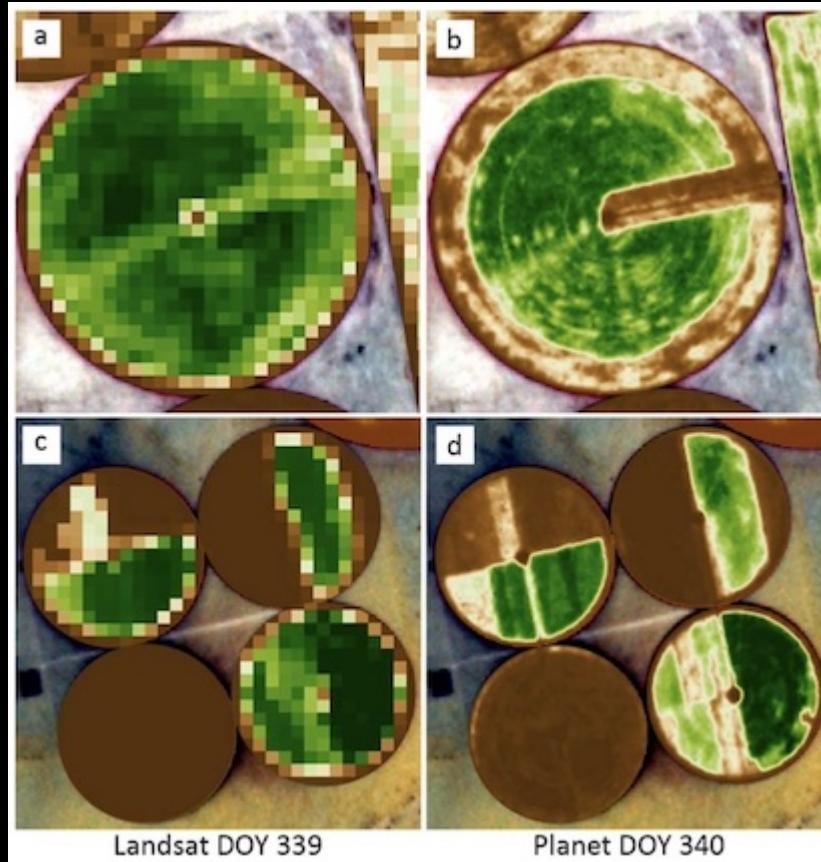
- Have you been able to clone the class repo?

Background

- Limits to Earth Observation

PHYSICS	ENGINEERING	INSTITUTIONAL	SOCIAL
Orbital	Maintenance	Policy choices	Expertise barriers
Energy/photons <i>resolution vs extent</i> <i>resolution vs interval</i>	<i>engineering quality</i>	<i>Access restrictions</i> <i>Technical restrictions</i> <i>EO investments</i>	<i>Which method?</i> <i>lack of training</i> <i>tyranny of choice</i> <i>Understanding limits</i>
Time/history	Data transmission/storage	Capacity	Incentive barriers
Perspective/proximity	Hardware compatibility		<i>Reward structures</i> <i>reproducibility</i> <i>Focus/AOIs</i>
Terrain/cover <i>spectral contrast</i> <i>BRDF</i> <i>Blindspots</i>	Software/data/model compatibility		Cultural <i>Market interests</i> <i>Tech differences</i>
Atmosphere <i>cloud cover</i>	Cal/val data N/Q		Cognitive <i>Human perception??</i>
	Cost <i>spectral resolution</i> <i>interval</i> <i>rocket trips</i>		

McCabe et al (2017)



McCabe et al (2017)

- What are key limitations to EO mentioned in this paper?
 - physical
 - economic
 - institutional
 - knowledge

McCabe et al (2017)

- How does the use of Planet CubeSats overcome these limitations?
- What limitations remain, and what new limitations are introduced?

Background

Collapsed limits down to:

- Physical
- Methodological
- Societal

Physical Limits 1

- Space-time tradeoff
- Initiated by conflict between resolution and extent
- Youtube video by Middlebury RS
 - SNR = signal-to-noise ratio
 - IFOV = instantaneous field of view

Physical Limits 2

- Temporal: length of record

Physical limits 3

- Surface characteristics: terrain and vegetation
- Atmosphere
- Perspective

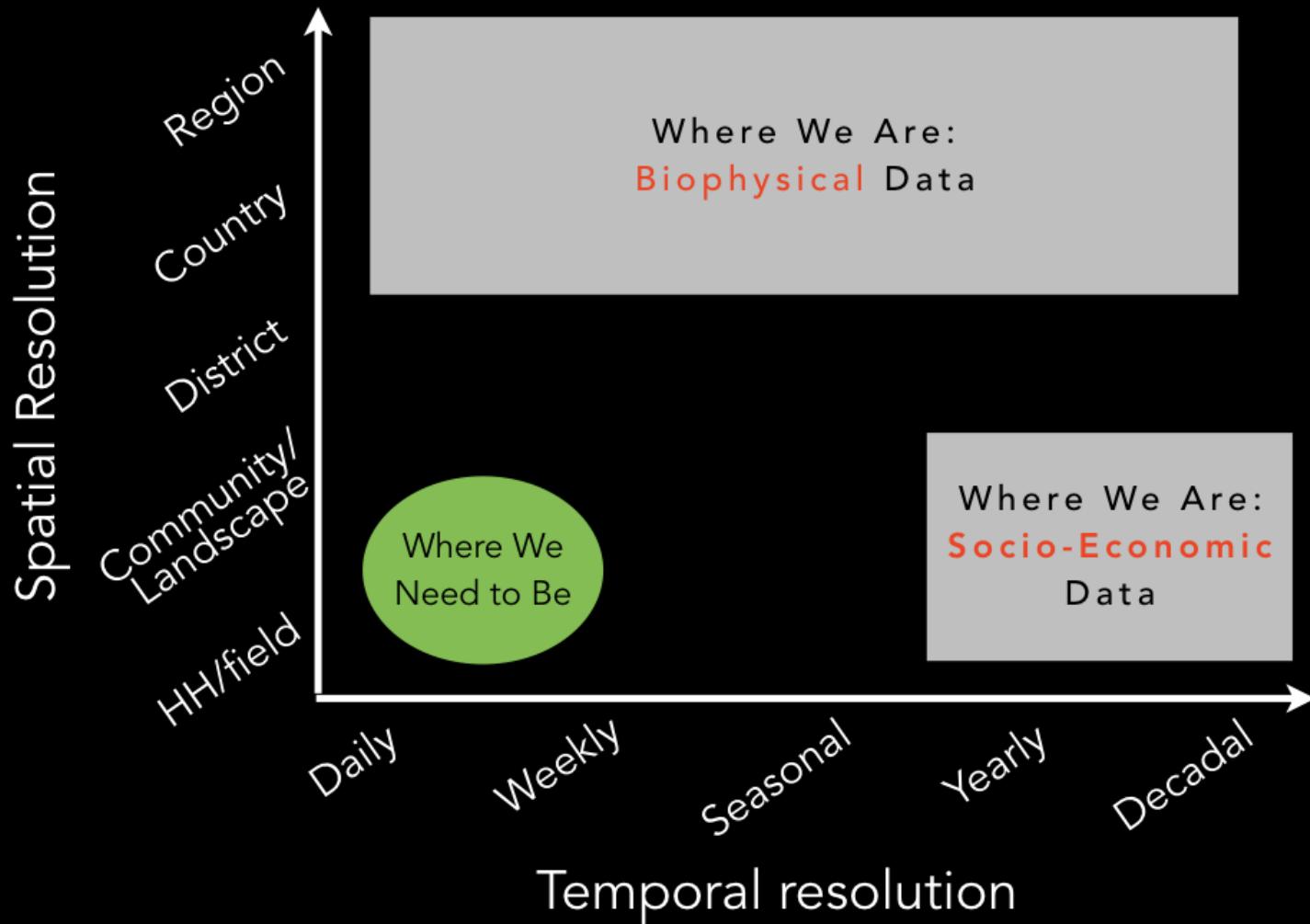
Methodological Limits

- Inadequate models:
 - Need these to solve the inverse problem
 - Models outpaced by EO data
- Not enough cal/val data
- Competing standards

Societal Limits

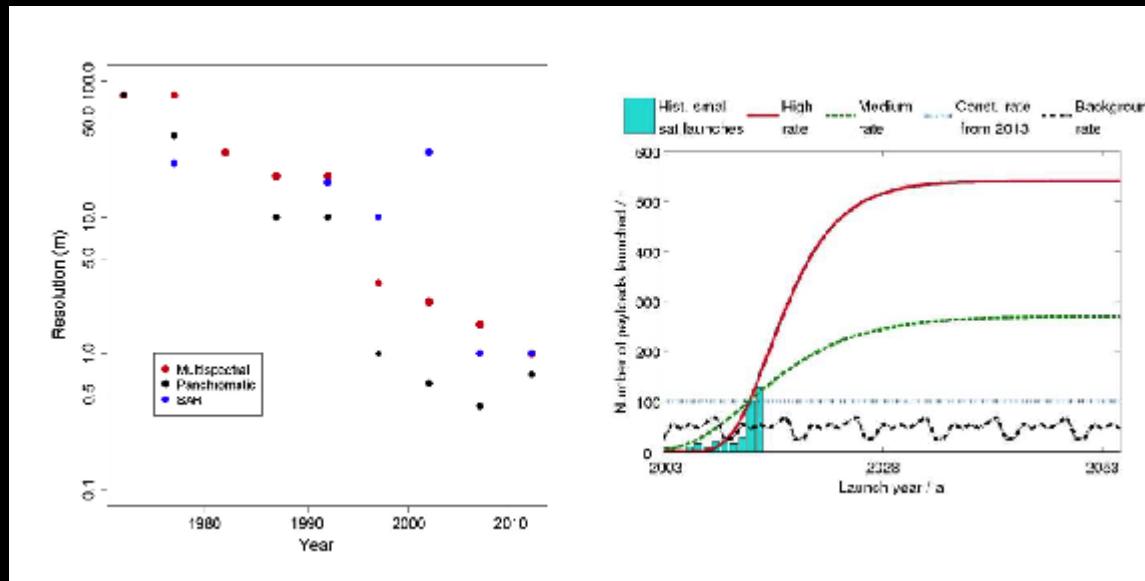
- Expertise barrier
- Institutional limitations
 - Data access and collection policies
 - Coordination
- Accessibility to methods
- Collection biases

The Combined Effect of Limits



Innovation Pushing Back Limits 1

- More Eyes in the Sky



Left: max. resolution versus year of launch (Belward & Skøien, 2015), Right: number of launches (Radtke et al, 2017)

Limits Addressed

- Physical:
 - Space-time tradeoff mitigated:
 - Resolution versus extent
 - Atmospheric interference
 - Terrain effects (more radar)
 - Perspective (more radar and lidar)
- Societal:
 - Accessibility (cheaper)

How Our Methods Fit In

- PlanetScope, SmallSats

Innovation Pushing Back Limits 2

- Upping the N

ENGAGING CITIZENS IN ENVIRONMENTAL MONITORING

GEO Wiki

- » Home
- » News
- » Publications
- » Downloads
- » Sources

Games

- » Picture Pile
- » Picture Paint
- » FAQ

Get involved now!

Participate in these ongoing projects and join the citizen science movement to help us address global land cover issues

FotoQuest Go
Join FotoQuest Go and explore the outdoors! Help us monitor changes in land use and land cover.

Picture Pile
Sort pictures and win great prizes! You can help us tackle global issues like deforestation.

LACO-Wiki
Discover the new web portal to validate your map products from local to global scales.

FotoQuestGo

New! Global Built-Up Surfaces
We're launching a new campaign to validate 2 maps of built-up surfaces. Help us identify these areas! Stay tuned!

Geo-Wiki pictures
Capture different landscapes using your smartphone and share with others through Geo-Wiki.

Picture Paint
Paint pictures and win great prizes! You can help us tackle global issues like deforestation.

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Limits Addressed

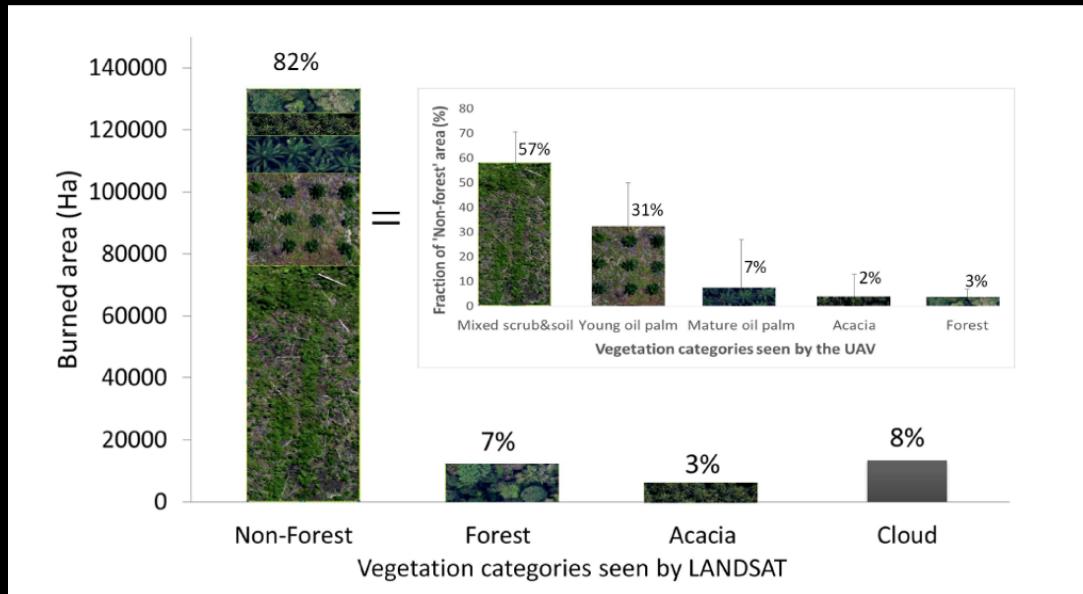
- Physical:
 - Perspective
- Methodological:
 - Inadequate calibration/validation data
 - Better models
- Societal:
 - Accesibility

How Our Methods Fit In

- Crowdsourcing platform
- Arable ground sensors

Innovation Pushing Back Limits 3

- Peering into the gaps (due to time, cloud cover)



Limits Addressed

- Physical
 - Space-time tradeoff
 - Perspective
- Methodological
 - Inadequate cal/val
- Societal
 - Cost/accessibility

How Our Methods Fit In

- UAS
- Arable ground sensors

Innovations Pushing Back Limits 4

- Advances in sensors/communications

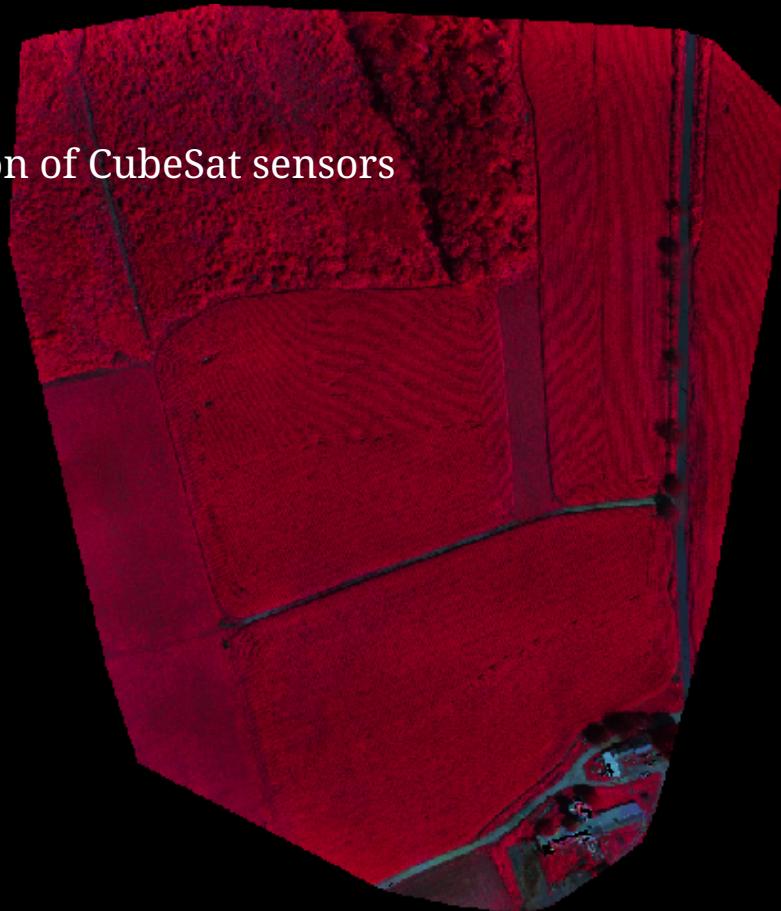


Limits Addressed

- Physical:
 - Space-time tradeoff
 - Perspective
- Methodological
 - Better models
 - Inadequate cal/val
- Societal
 - Cost/accessibility

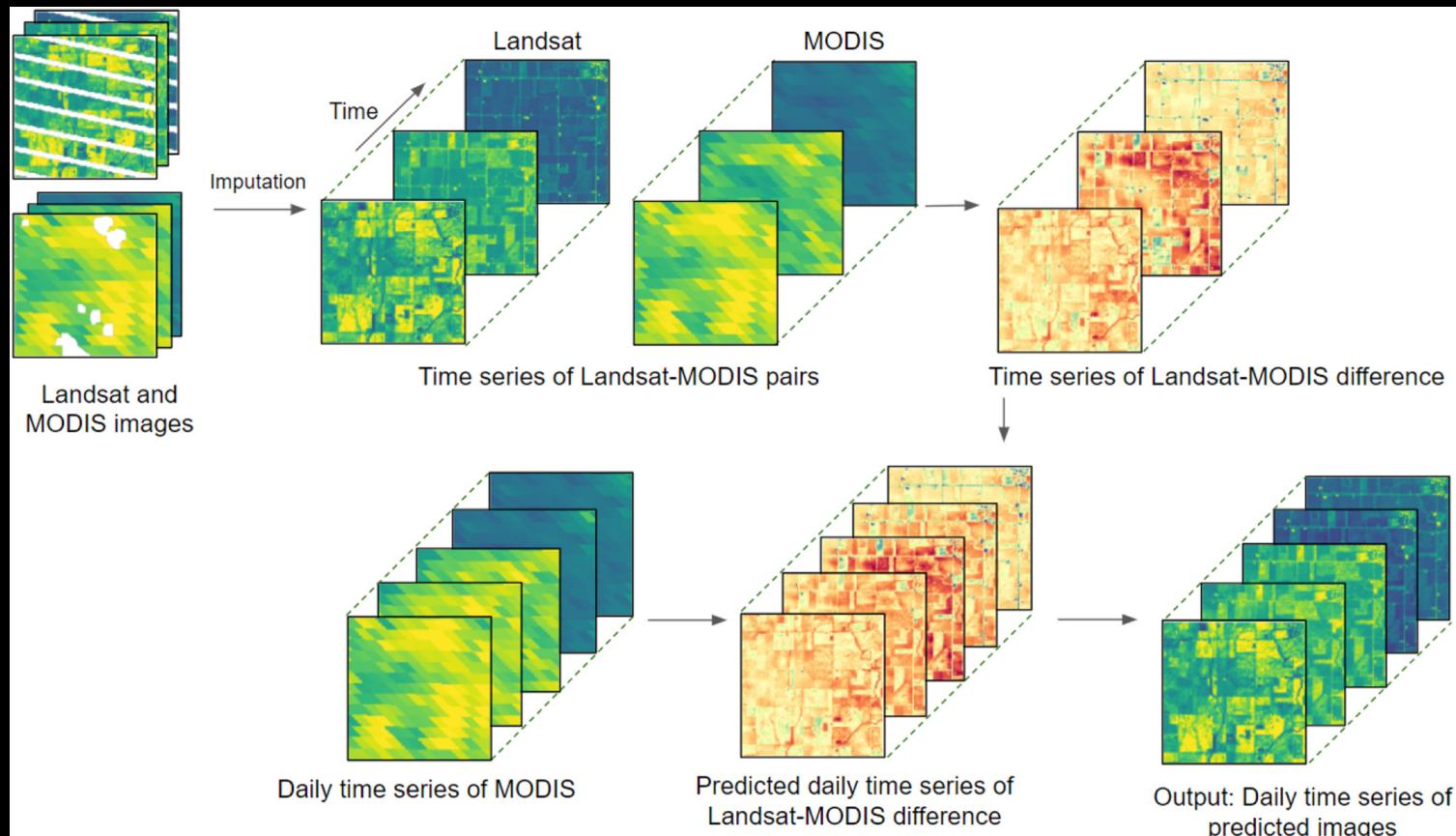
How Our Methods Fit In

- Sequoia
- Miniaturization of CubeSat sensors

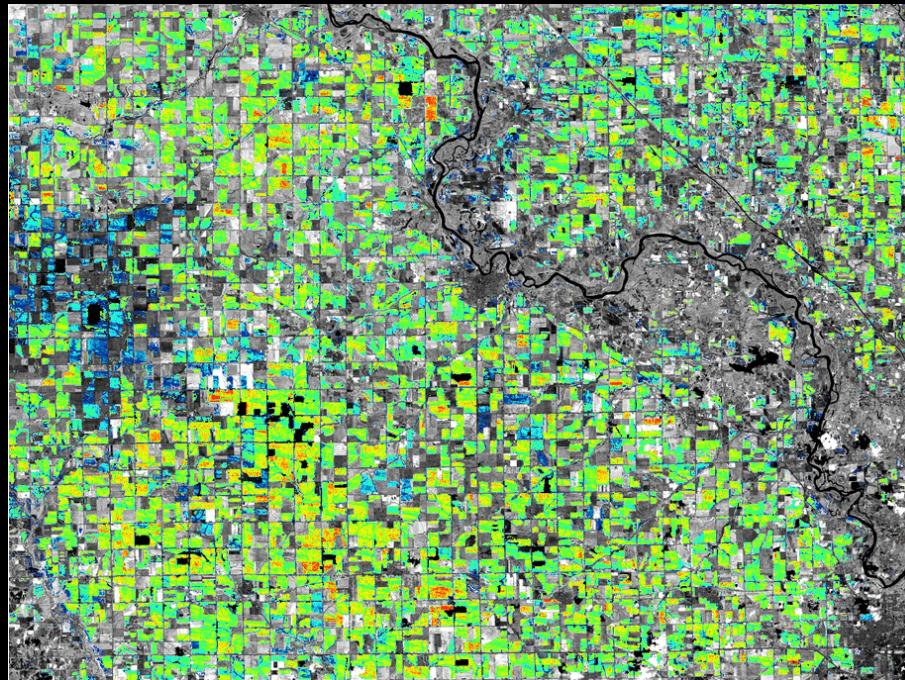


Innovations Pushing Back Limits 5

- Data and model-data fusion



- Scalable Yield Mapping (Lobell et al, 2015)



Limits Addressed

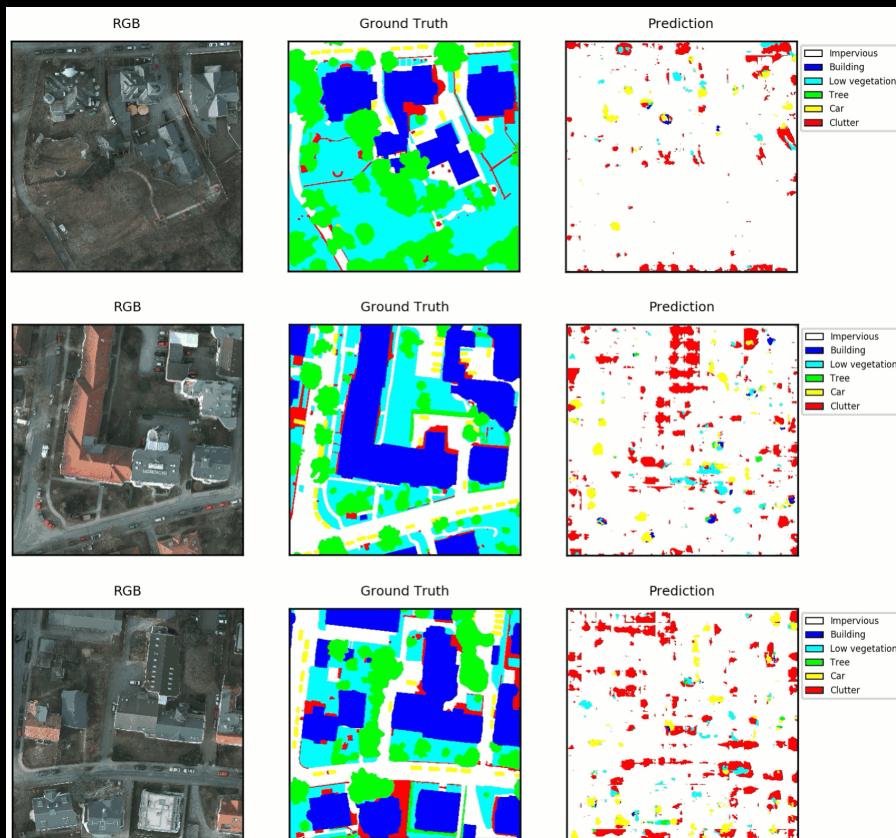
- Physical:
 - Space-time tradeoff
 - Duration
- Methodological
 - Better models

How Our Methods Fit In

- Arable Marks + Ebee + Planet + DSSAT crop model & R package

Innovations Pushing Back Limits 6

- Computer vision, machine, and deep learning

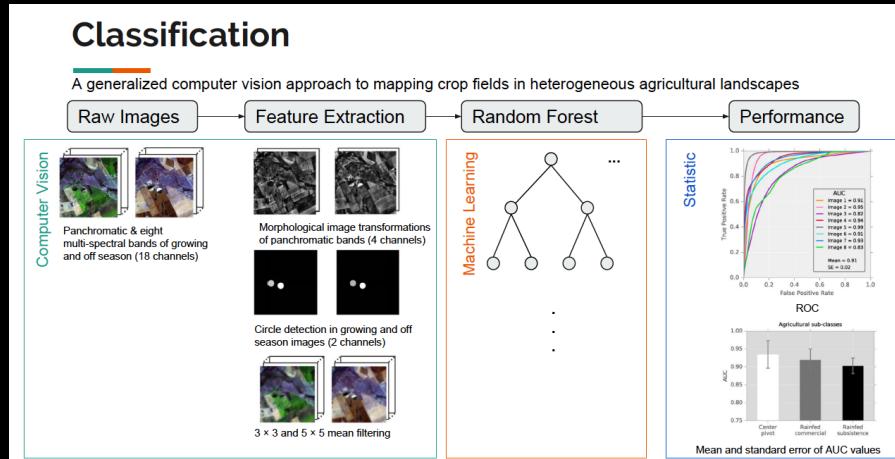


Limits Addressed

- Methodological:
 - Inadequate models

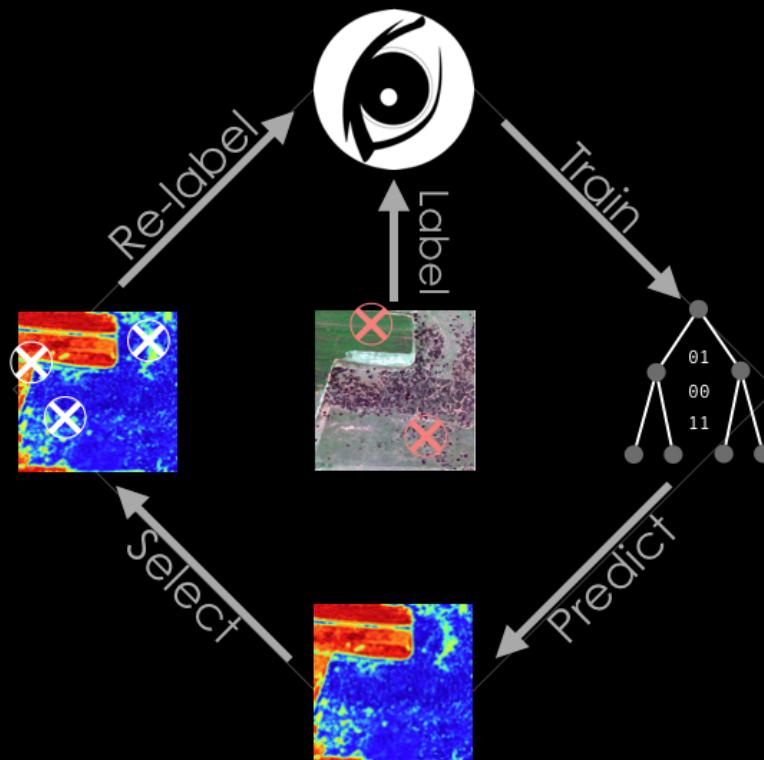
How Our Methods Fit In

- Debats et al (2016) (adapted by Song and Young, 2018)



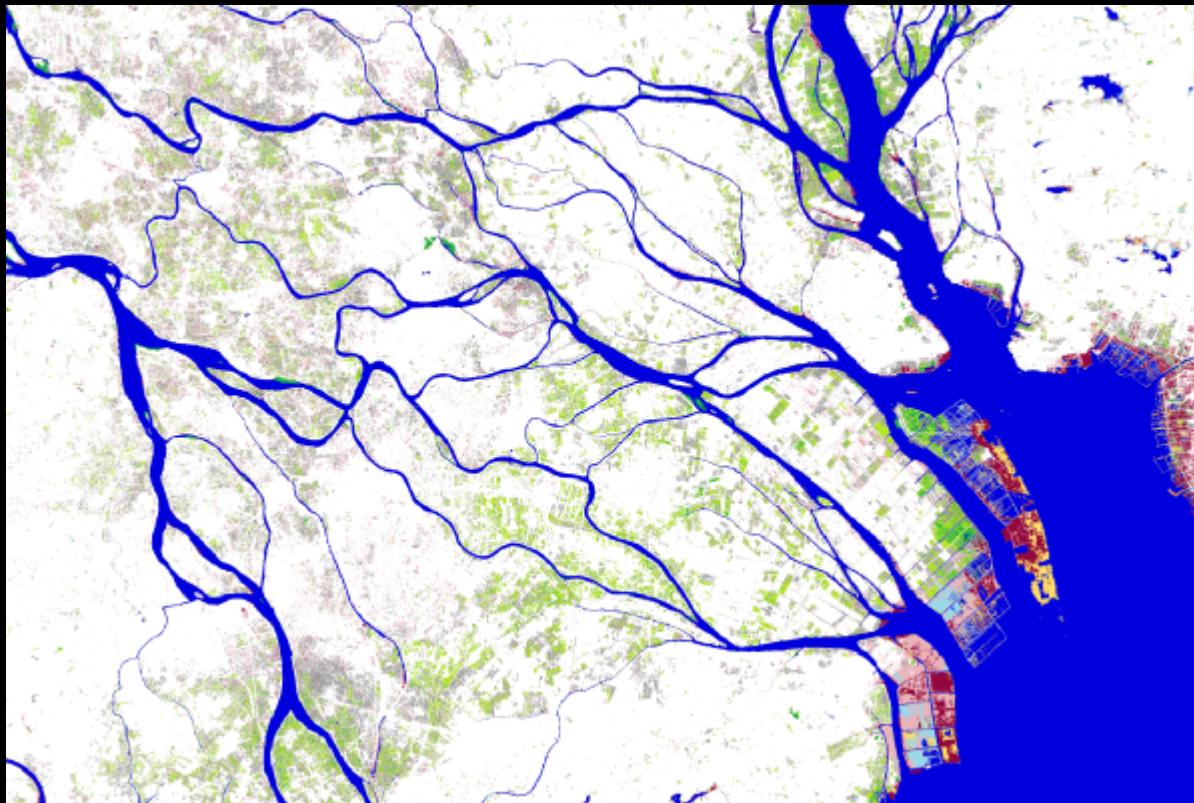
How Our Methods Fit In

- Active learning (Debats et al, 2017; Elmes et al, 2020)
- RadiantEarth machine learning data sets



Innovations Pushing Back Limits 7

- Cloud-based data and analytical platforms



Limits Addressed

- Methodological:
 - Inadequate models
- Societal:
 - Accessibility

How Our Methods Fit In

- Compare Sentinel-1 and Sentinel-2 imagery on Google Earth Engine
- Process Planet
- Host and view UAS imagery

Whittier Farms image comparison

- Open "whittier_comparison.R" in materials --> code --> R
- This likely won't work yet, but you can follow along

Multispectral sensor comparison

- In groups, open the "Multispectral sensor comparison sheet"
- Your group is assigned a sensor. Try to fill out the sheet!
- Your answer may be "it depends", this is OK! Try to explain what your answer depends on

Multispectral sensor comparison

- How well would your group's sensor be used for the following applications?
 - Precision irrigation for vineyards
 - Mapping forest fire burn areas
 - Mapping smallholder agriculture productivity (small, irregular shaped fields) at a (state/district) scale
 - Mapping national crop productivity over multiple years

For next class

- Read Manfreda et al. (2018)
- Watch full video on remote sensing resolutions
- Install RStudio packages (details on Slack)
- Download/install eMotion and Pix4D software (details on Slack)