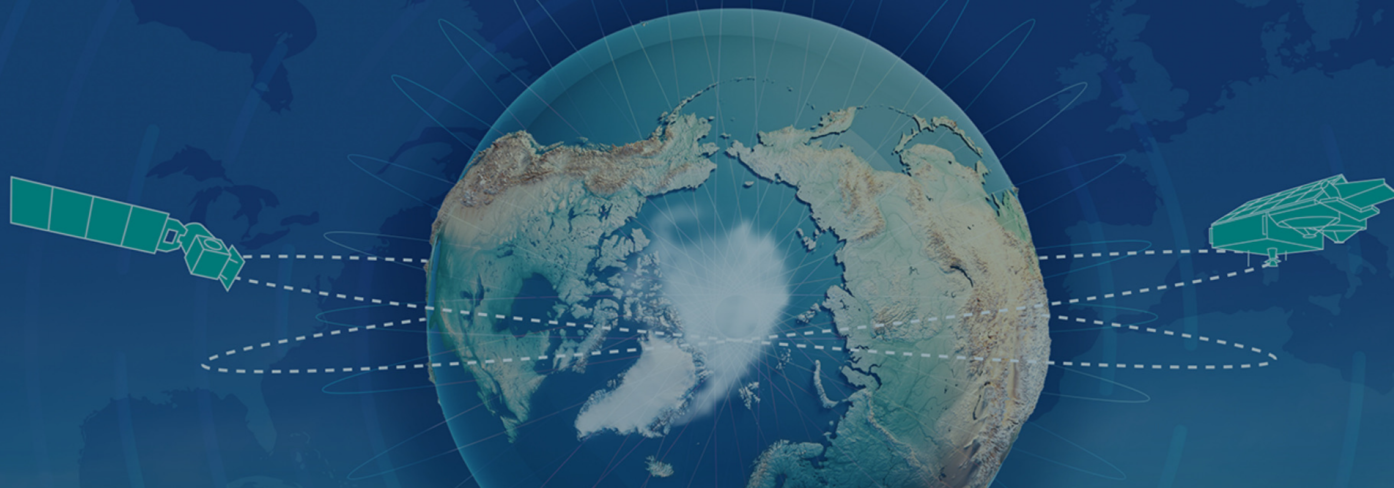

Agricultural Crop Height Retrieval From ICESat-2

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Acknowledgments:

- ***supported by ICESat-2 team and Dr. Thorsten Markus of NASA HQ.***

Outline

- CALIOP/CALIPSO, ATLAS/ICESat-2, ATLID/EarthCARE
- The revised Density-Dimension Algorithm (DDA)
  (identify crop and land surface photons to get crop height)
- Crop results
  (Spring Crops, Fall Crops)
- Summary and Future work

CALIPSO => ICESat-2 => EarthCARE =>

Lidar	CALIPSO 2006 ~ 2023	ICESat-2 2018 ~	EarthCARE 2024 ~	CALIGOLA under consider ~2032
Wavelength (nm)	532, 1064	532	355	355, 532, 1064
Channels	Polarization	Elastic	HSRL, Polarization	Polarization, Raman (407.5, 650). Fluorescence(450,685)
Vert. Res.	30 m	Photon counting	~103 m	~ 1.25m
Spatial Res.	1/3 km	0.7 m	285 m	75~150 m
Off angles	0.3°, 3°, 30°	up to 5°	3°	12°

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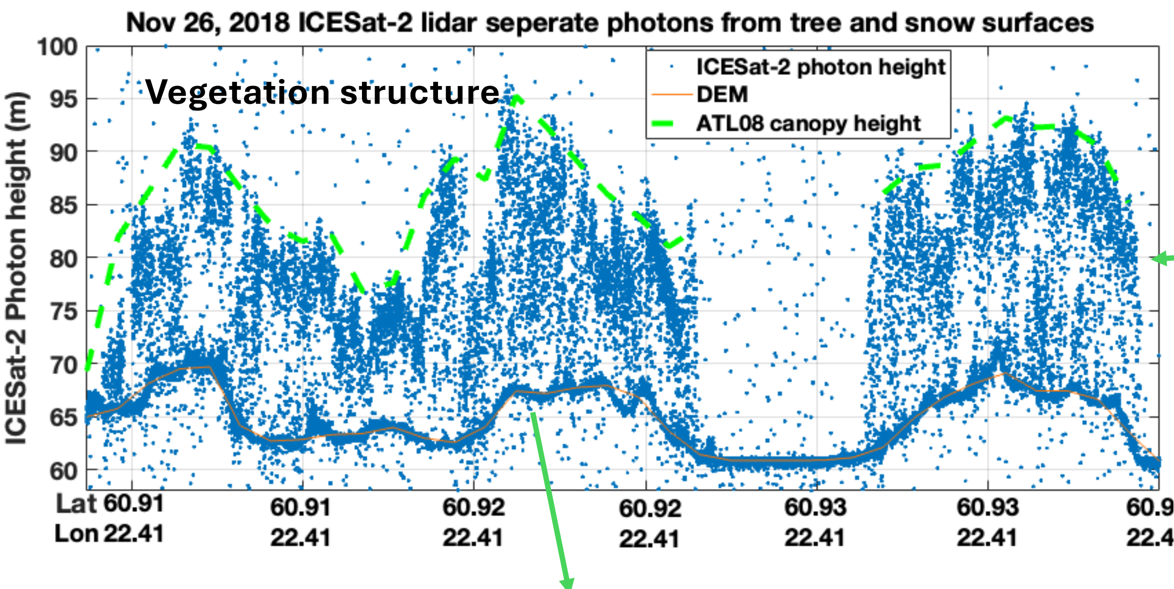
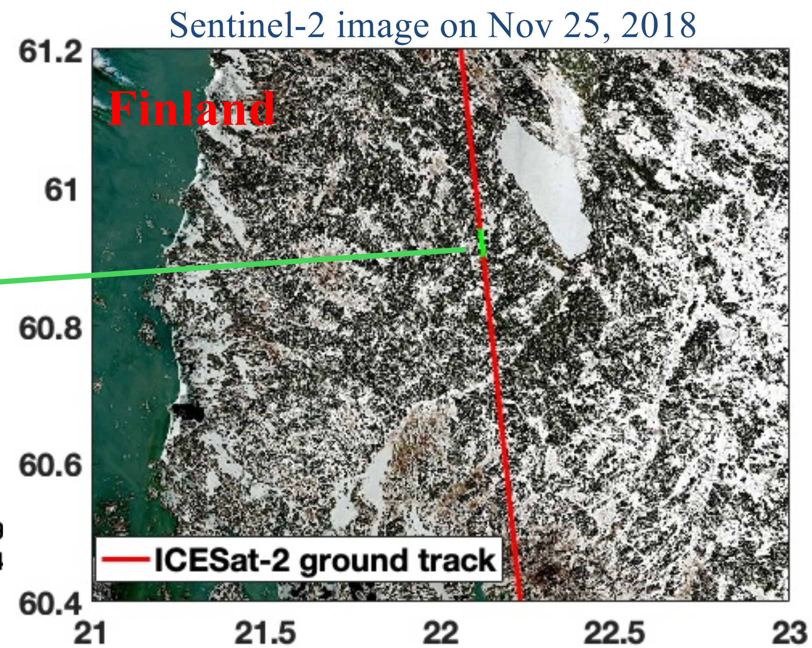
ICESat-2 separate photons from canopy and snow surfaces





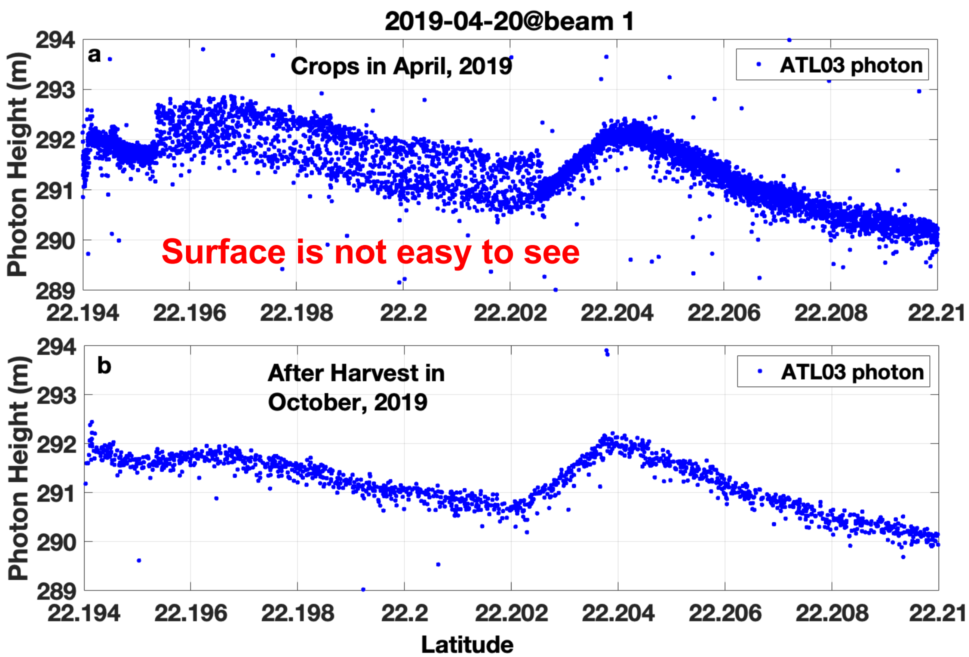
Current work:
Snow depth retrieval below Trees

Hu et.al, 2022, Lu et.al., 2022

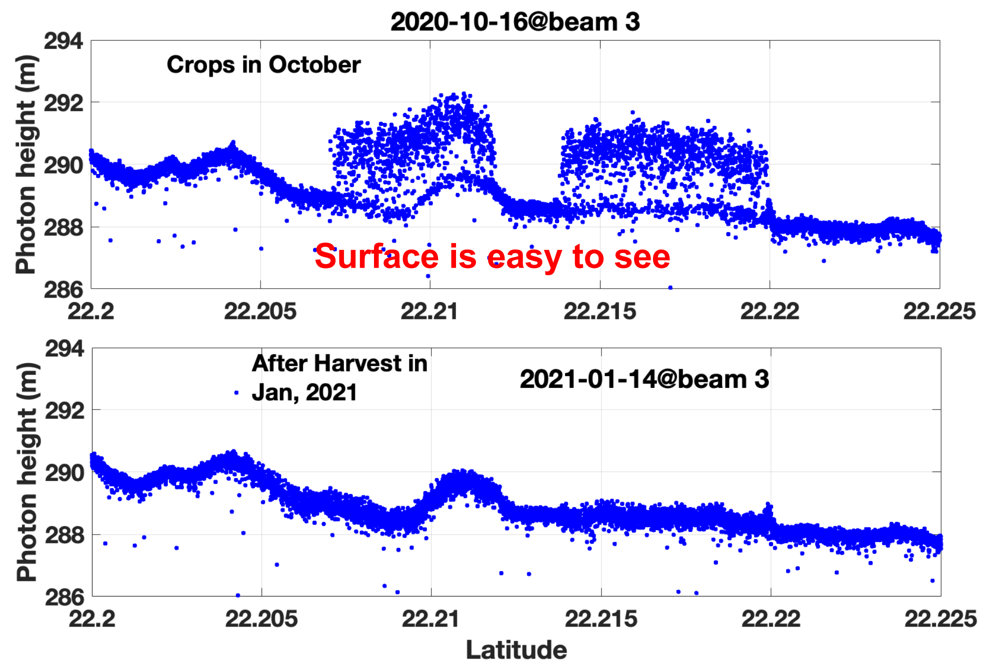
Can ICESat-2 provide crop height?

- Accurate crop height measurements can help estimate yield potential and overall agricultural productivity
- Monitoring crop height is crucial for optimizing agricultural practices and ensuring food security.

Spring Crop

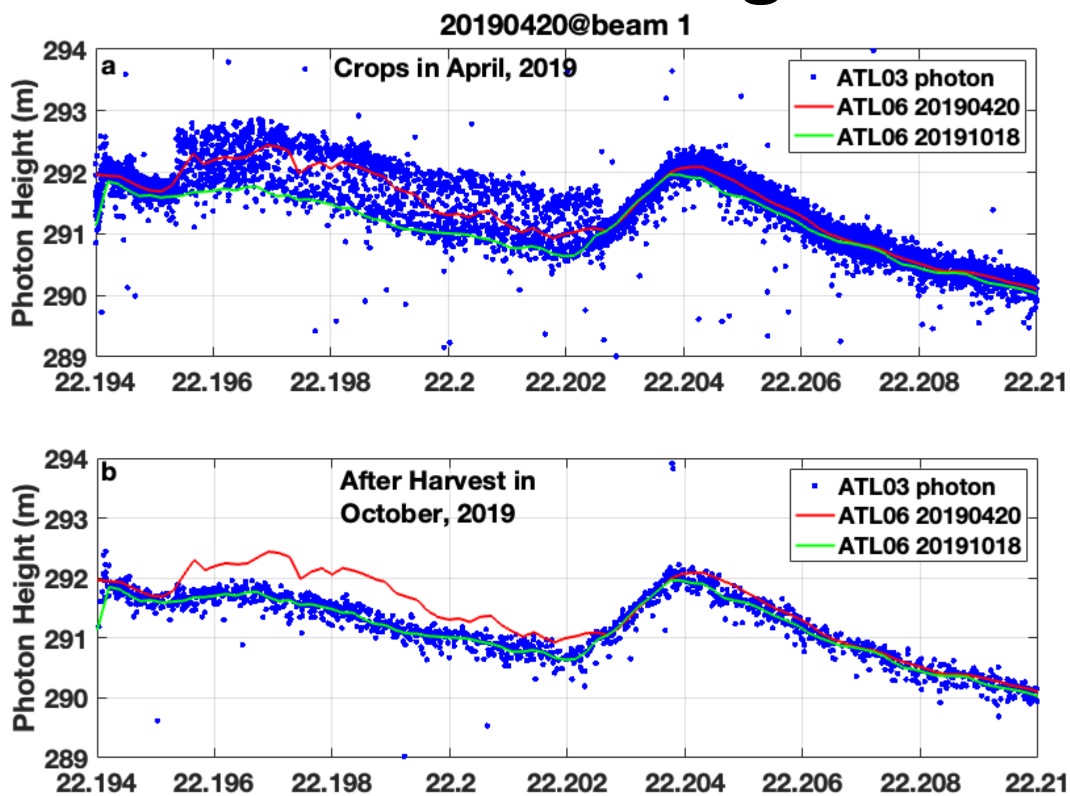


Fall Crop

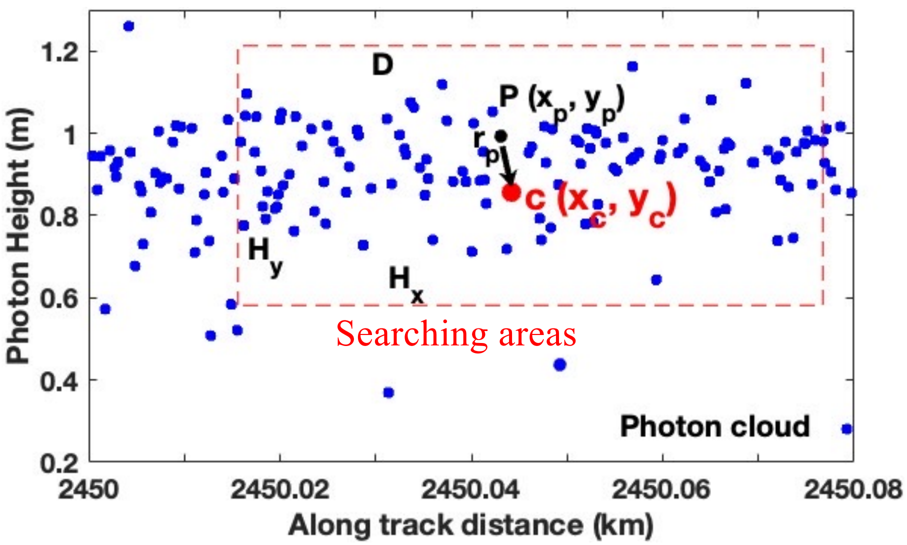


Crops introduce bias in surface height in ATL06

Surface bias due to crop: ~0.5m



The revised Density-Dimension Algorithm (DDA)



Distance between photons (p, c):

$$r_p = \sqrt{\left[\left(x_p - x_c\right)/\alpha\right]^2 + \left(y_p - y_c\right)^2}$$

Weight function: $w(p) = e^{-\left(\frac{r_p}{\sqrt{2}\sigma}\right)^2}$ (0,1)

Density of photon c: $f(c) = \sum_{p \in D} w(p)$

α is an anisotropy parameter used to change the relative weights of the contributions made to r_p in the along-track and vertical directions.

σ is the standard deviation, controlling contributions of r_p to $w(p)$ and f(c).

H_x, Hy, are defined searching areas in two directions.

- U. C. Herzfeld et.al., 2014, 2017, 2023
- Lu et.al., 2024 under review

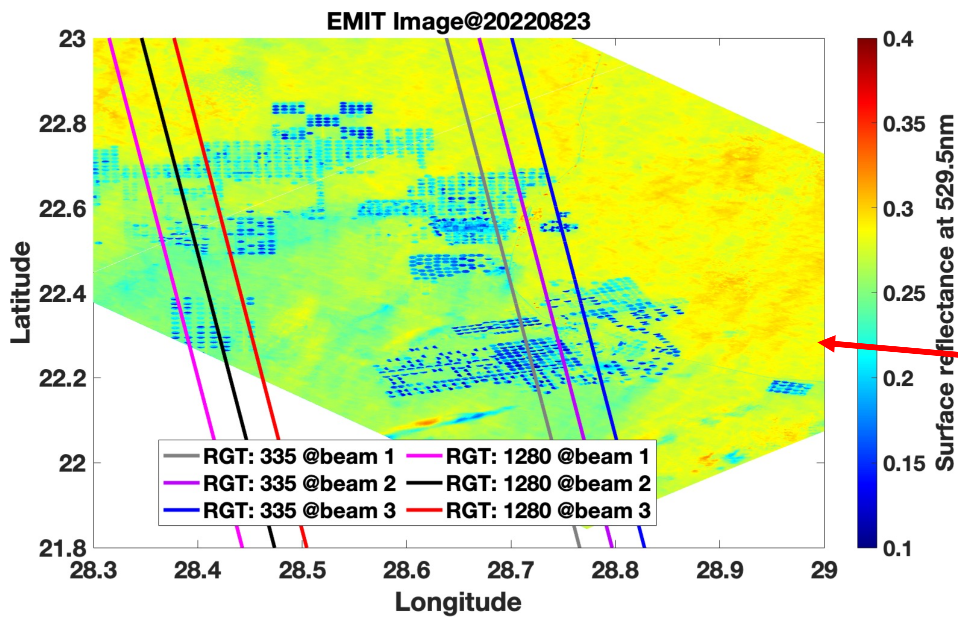
Typical values used in DDA-bathymetry and DDA-crop

Parameters	DDA-bathymetry		DDA-crop
	Local peak method	Threshold method	
α	300	10	150 - 300
Hx (m)	2000	2000	50 - 100
Hy (m)	1	0.3	0.3
σ (m)	3	1	1

Sensitivity studies of parameter values for bathymetry and crop

Parameter	Lower	Higher
α	0.5	300
Hx (m)	20	2000
Hy (m)	0.3	3
σ (m)	0.5	5
q-quantile	0.02	0.40

Lu et. al., 2024, under review



EMIT measures the radiance in spectral bands from 381 nm to 2493 nm,

- In total 285 bands with ~7.4nm resolution;
- 60m spatial resolution ;
- A view swath of 75km;
- Between 52° North and South.

EMIT primary purpose:
To determine the sources of dust in the atmosphere

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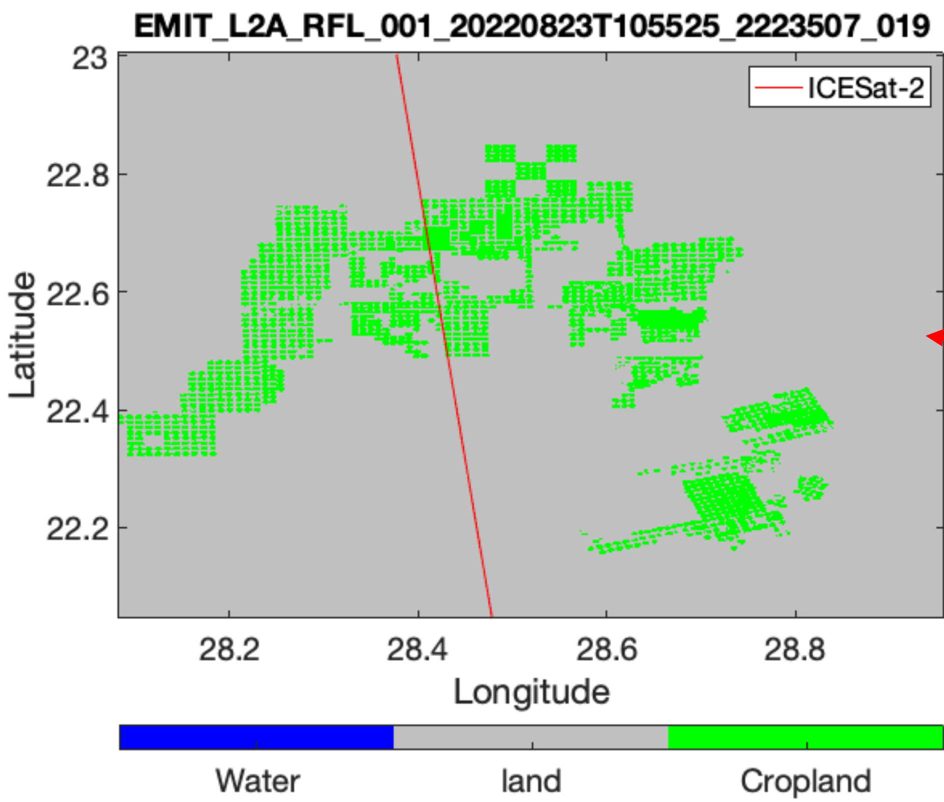

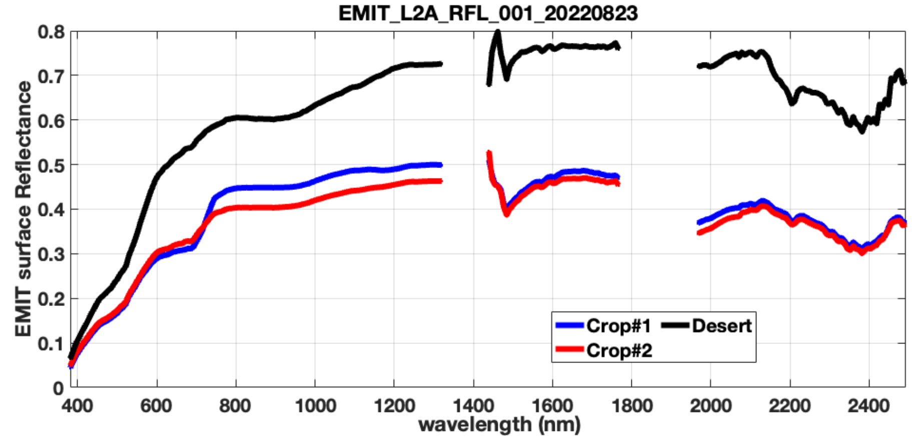

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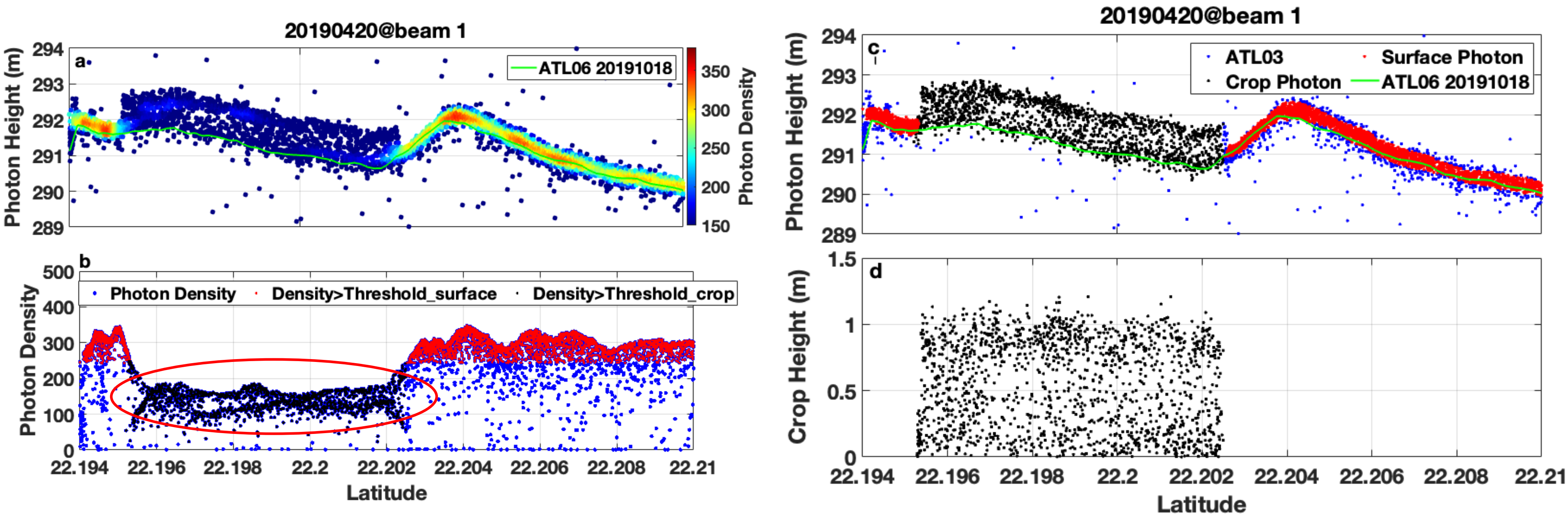
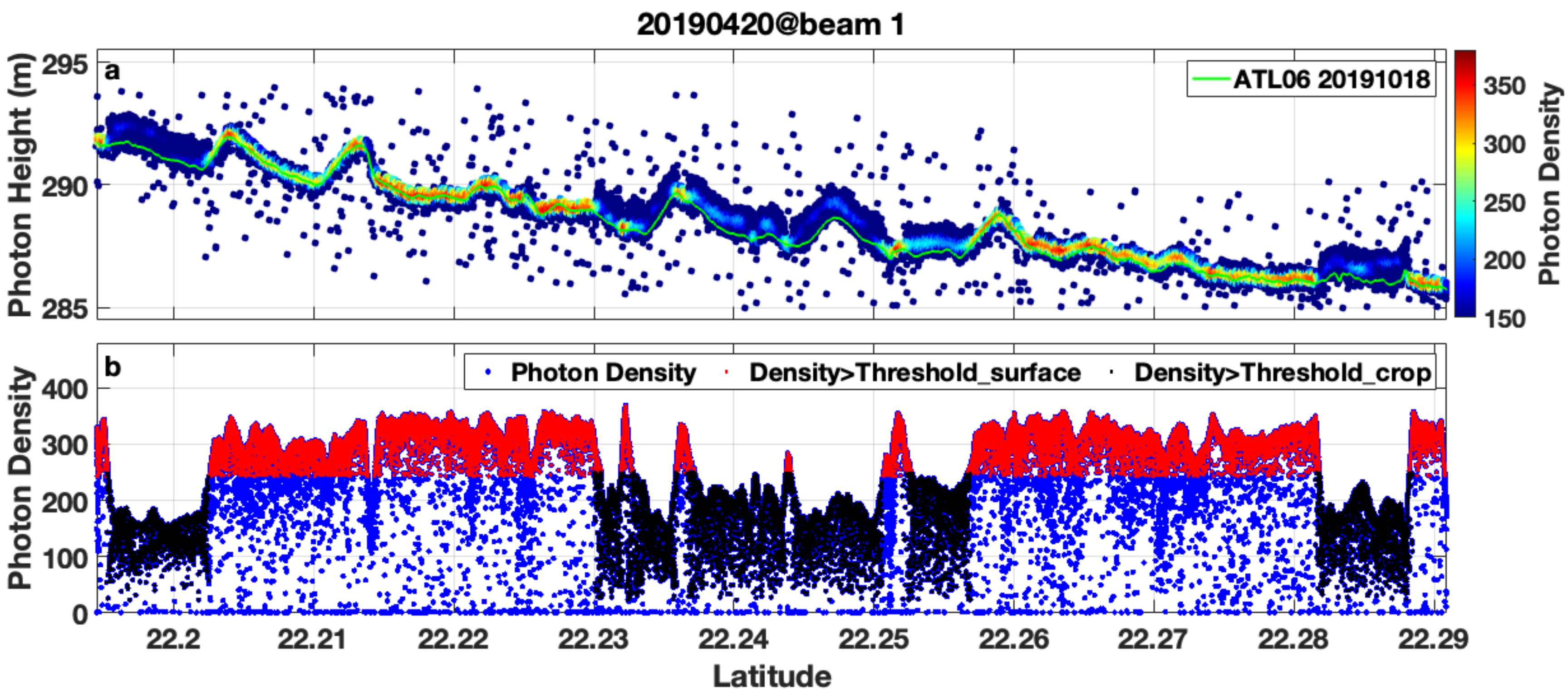
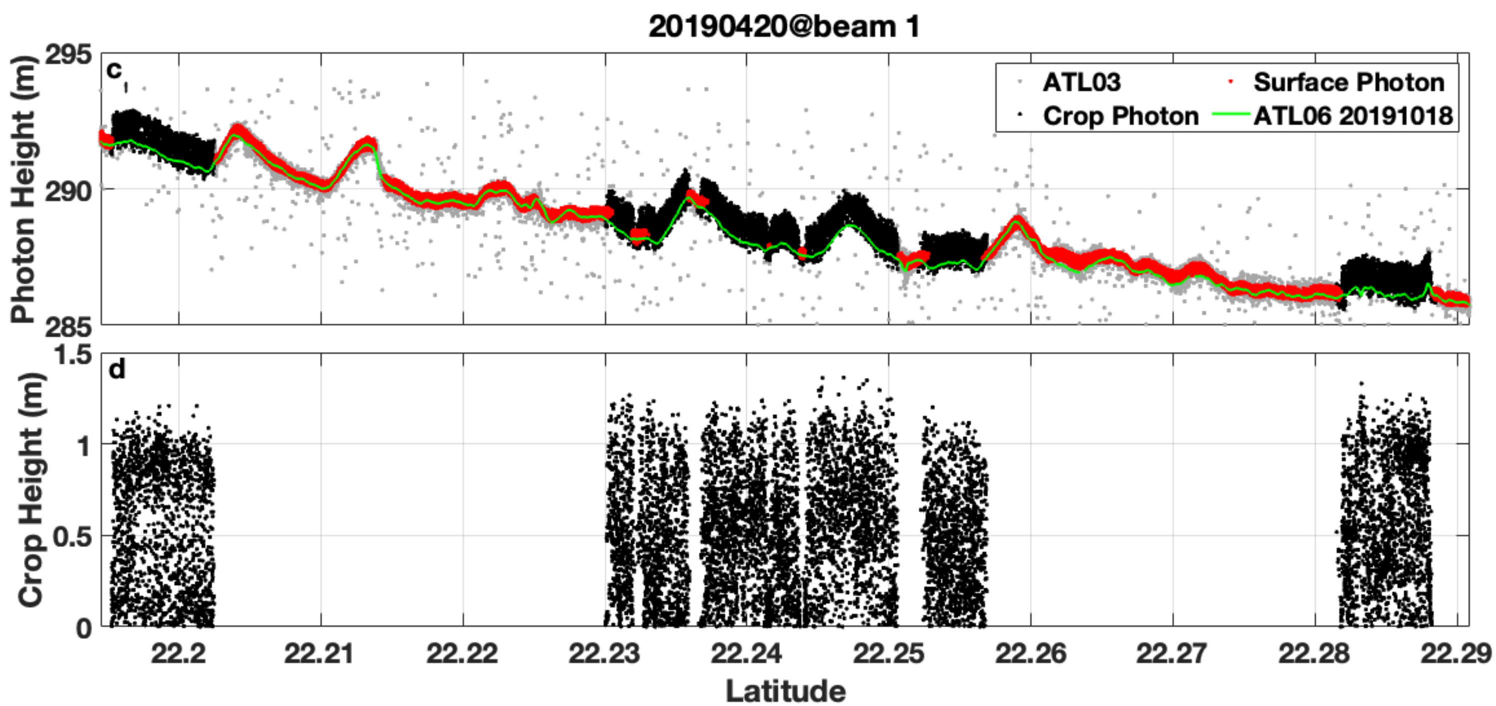
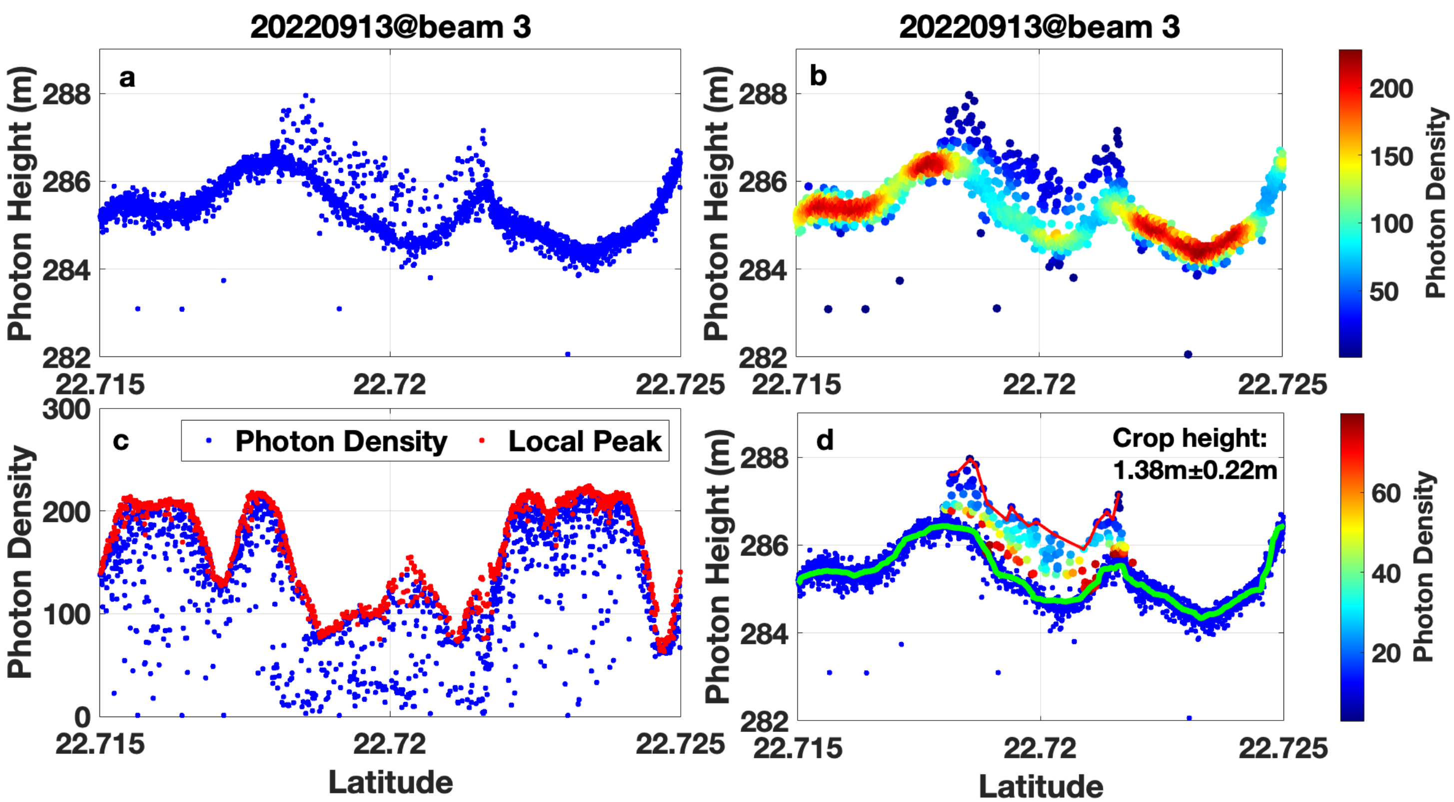



20190420@beam 1
a
ATL06 20191018
Photon Height (m)
295
290
285
Photon Density
350
300
250
200
150
b
Photon Density
Density>Threshold_surface
Density>Threshold_crop
400
300
200
100
0
22.2
22.21
22.22
22.23
22.24
22.25
22.26
22.27
22.28
22.29
Latitude

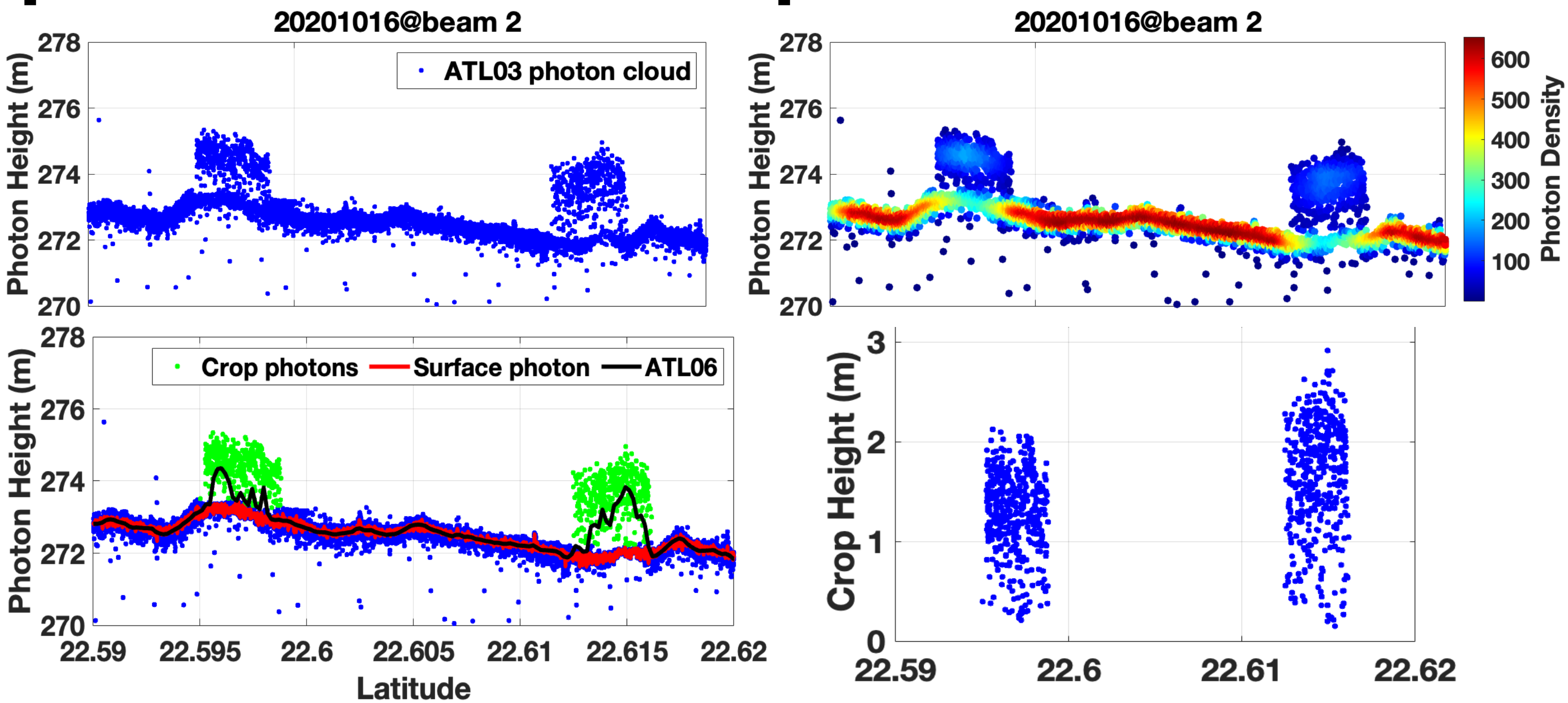
Crop results – in Spring



Crop results – Fall crop



Crop results – Fall crop



Surface bias up to 1.92m

Lu et. al., 2024, under review

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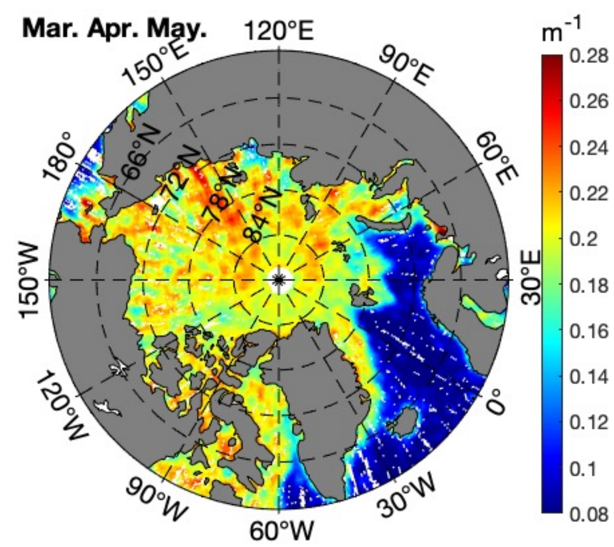
Summary and Future work

1. Unique measurements of ICESat-2 lidar for

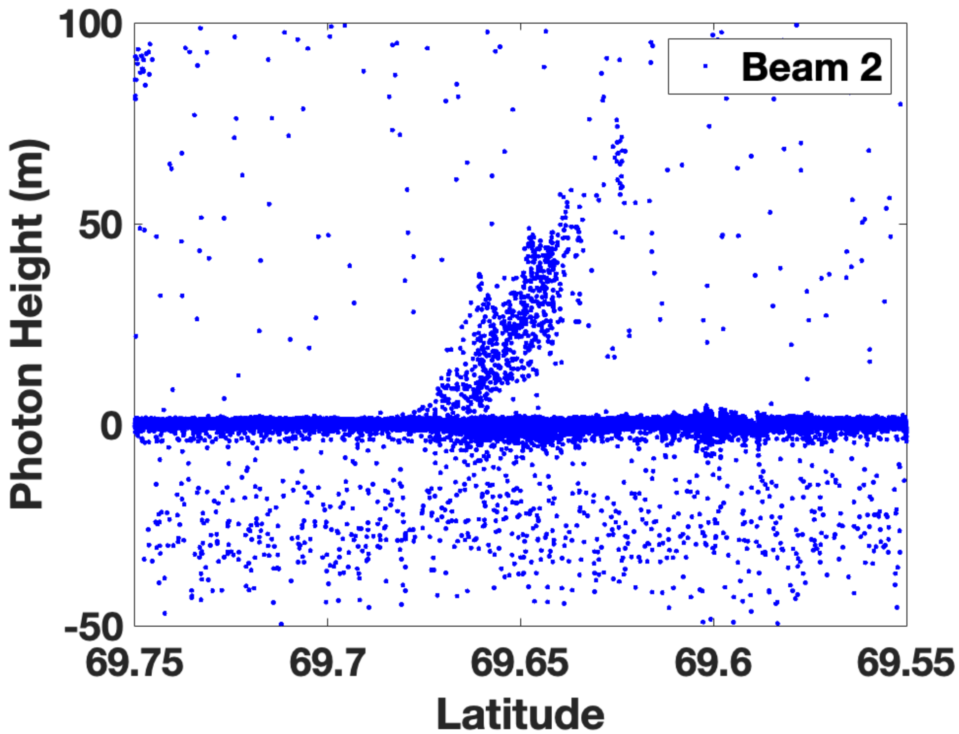
- **Direct measure of Crop height**
- **Direct measure of water properties in upper ocean layers**

2. Future work

- **Combine Images (Landsat, EMIT, Sentinel) with ICESat-2 => Global crop study, e.g., crop height, crop density, crop biomass.**



ICESat-2 detect geothermal eruption?



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