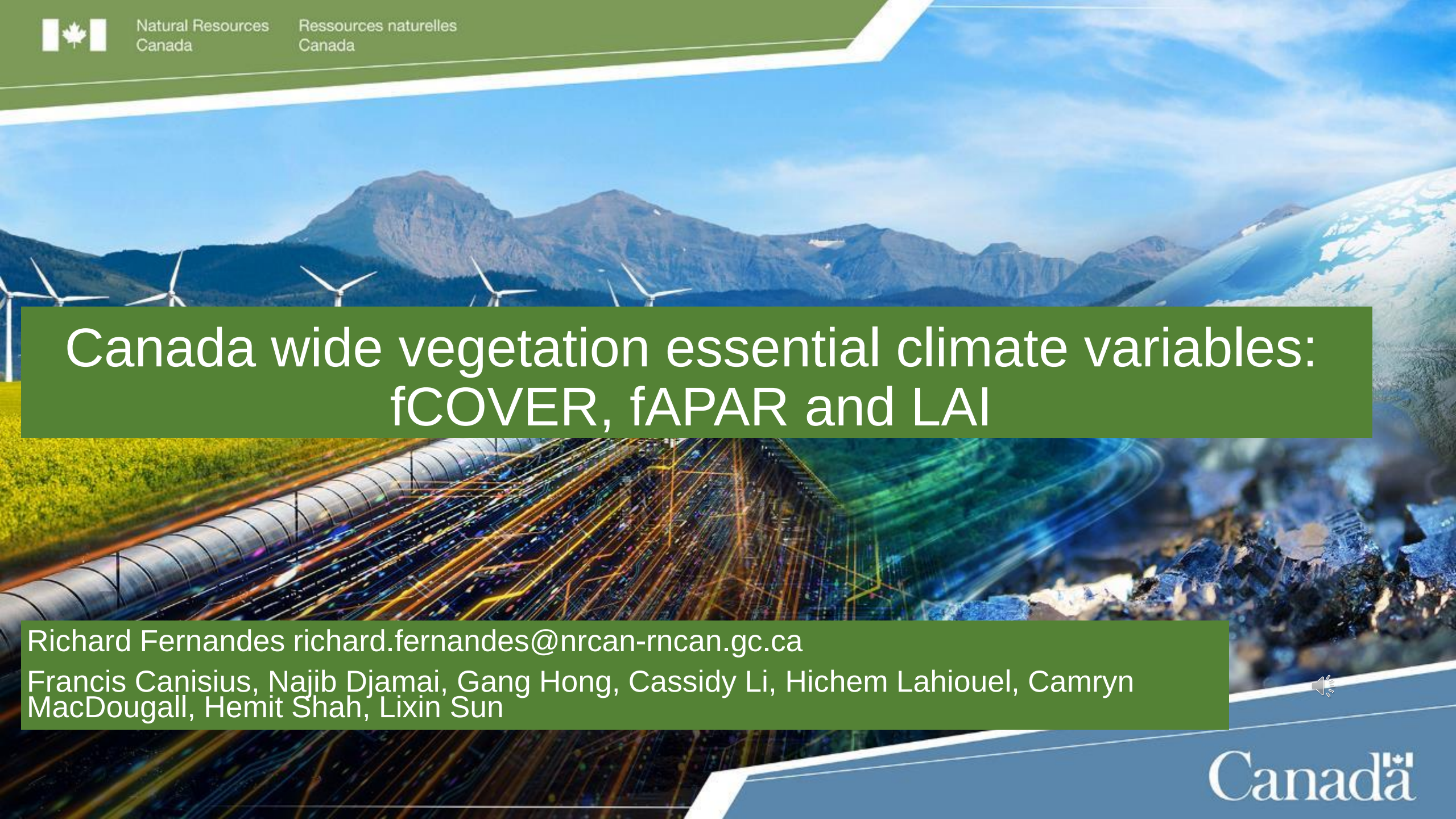
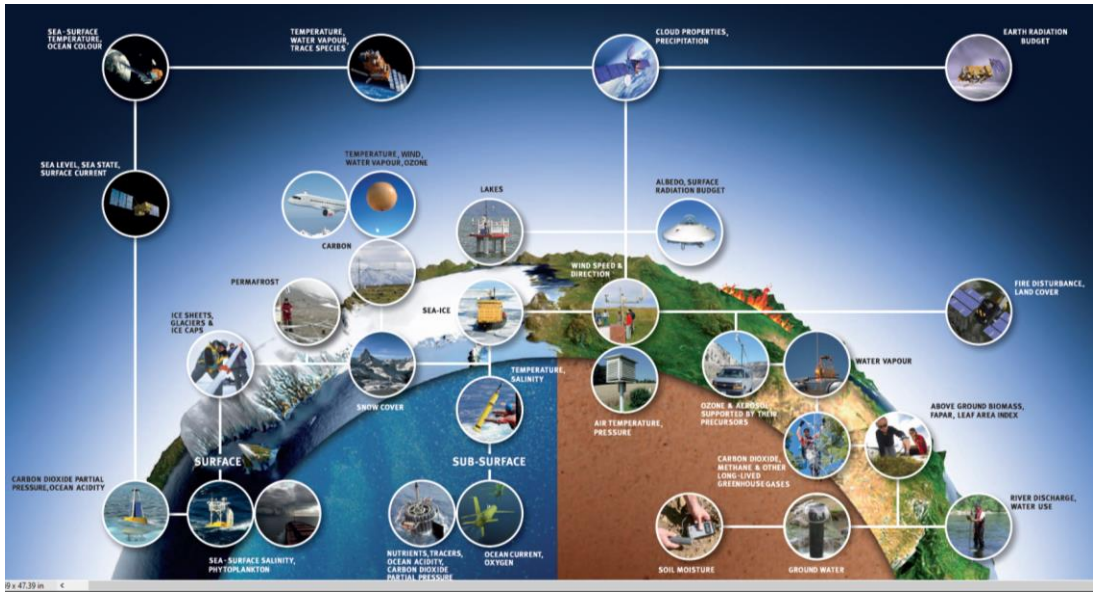

Natural Resources Canada
Ressources naturelles Canada
Canada wide vegetation essential climate variables: fCOVER, fAPAR and LAI
Richard Fernandes richard.fernandes@nrcan-rncan.gc.ca
Francis Canisius, Najib Djamai, Gang Hong, Cassidy Li, Hichem Lahiouel, Camryn MacDougall, Hemit Shah, Lixin Sun
Canada

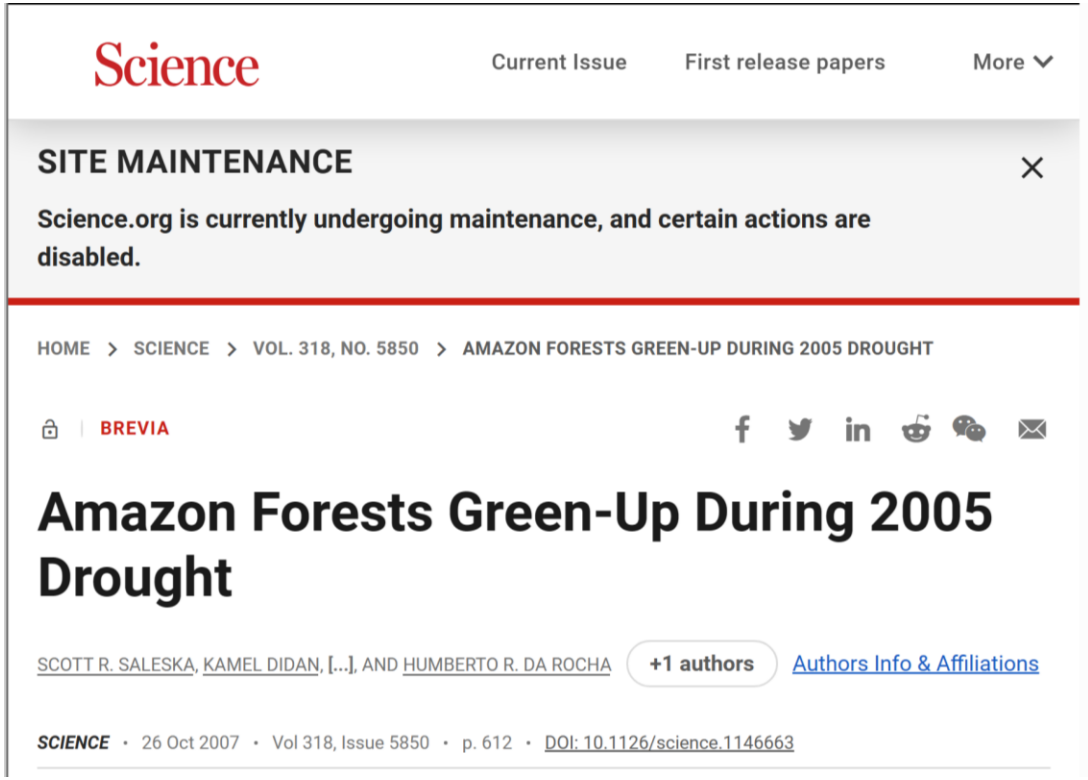
Vegetation Essential Climate Variables



https://gcos.wmo.int/en/essential-climate-variables

- Canopy Cover (fCOVER)
  - Foliage presence
  - Habitat
  - Land cover change
- fAPAR
  - Foliage productivity/health
  - Status and trends
  - Crop modelling
- Leaf Area Index
  - Foliage density/biomass
  - Status and trends
  - Ecosystem/weather models

Why not just use a vegetation index?

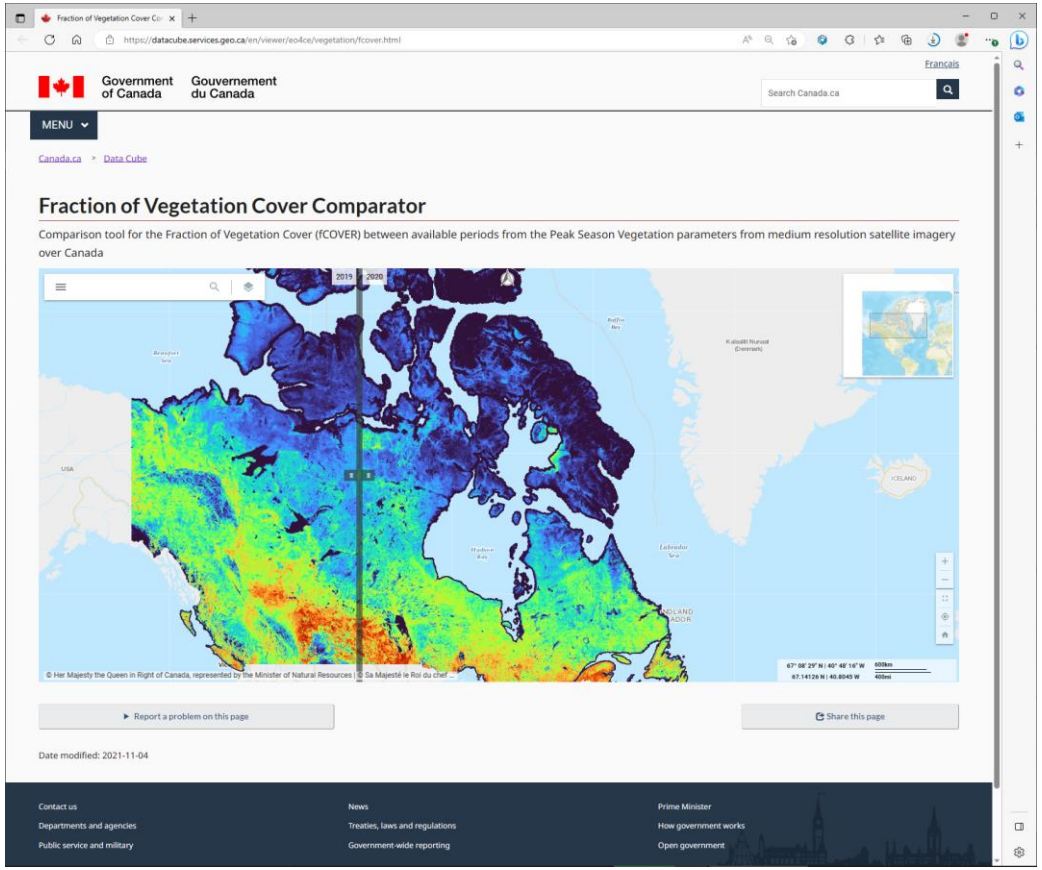


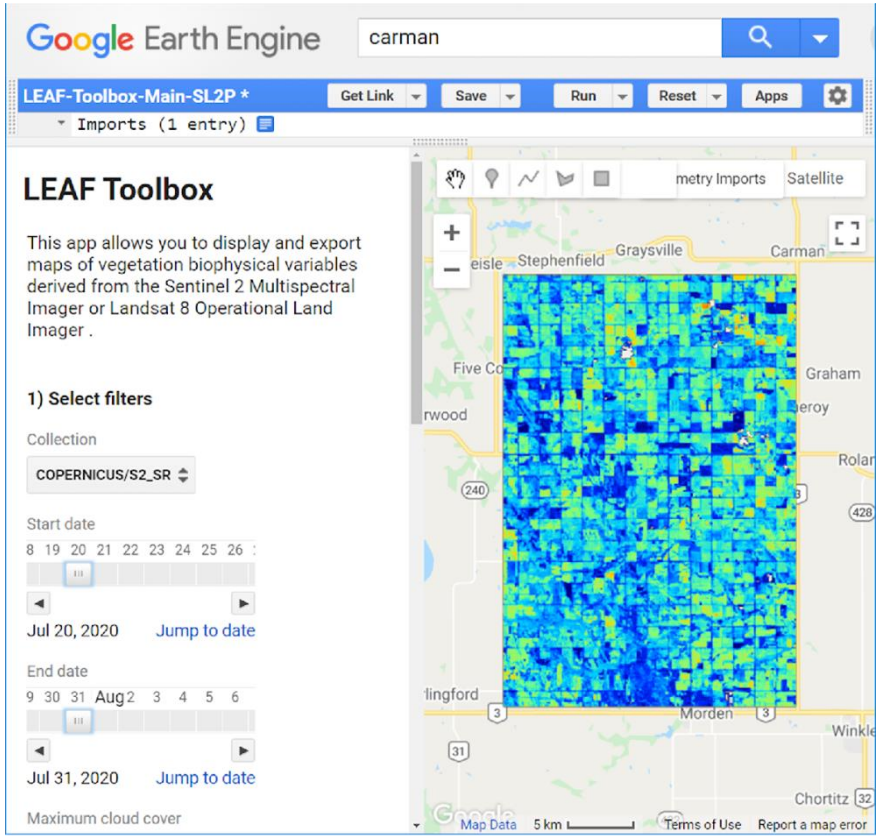
GCOS User Requirements

Variable	Definition	Horizontal Resolution m			Temporal Resolution days			Uncertainty (%,abs), 2σ			Stability %/10y		
		G	B	T	G	B	T	G	B	T	G	B	T
fCOVER	the fraction of ground covered by green vegetation	10	30	333	7	30	99	-	-	10%, 0.05			
fAPAR	part of PAR that is effectively absorbed by plants	10	-	250	1	-	10	5%, 0.025	-	10%, 0.05	1.5		3
LAI	Half total green foliage area per horizontal ground area	10	100	250	1	-	10	10%, 0.5	15%, 0.5	20%, 0.5	3		6

https://library.wmo.int/index.php?lvl=notice_display&id=22135

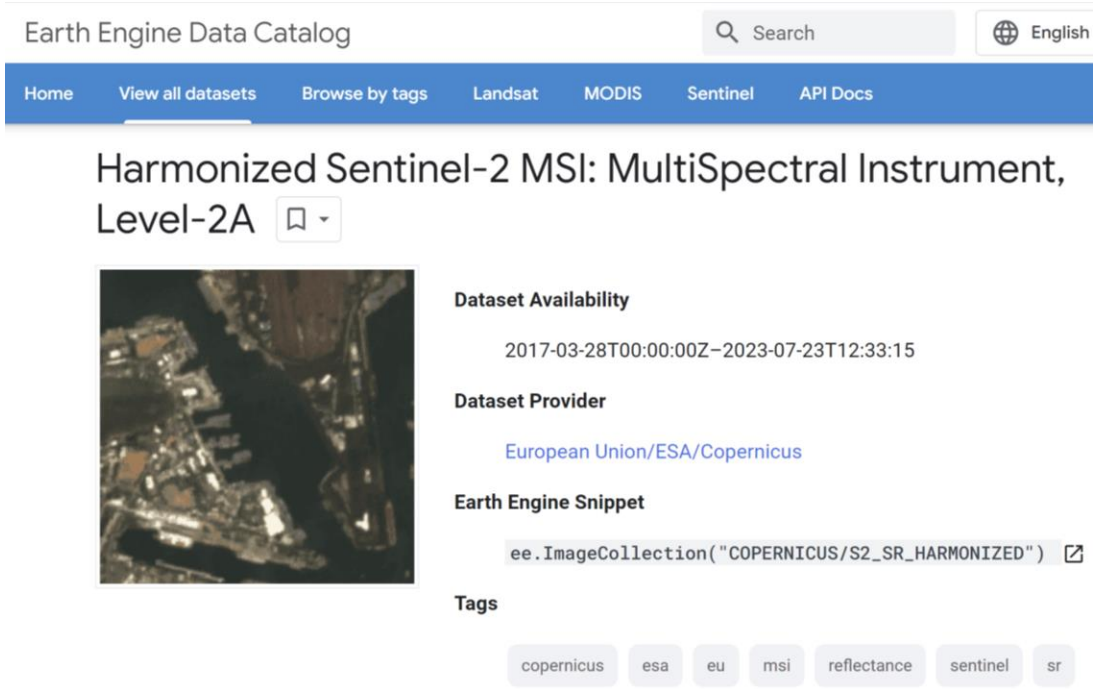
Government of Canada Products



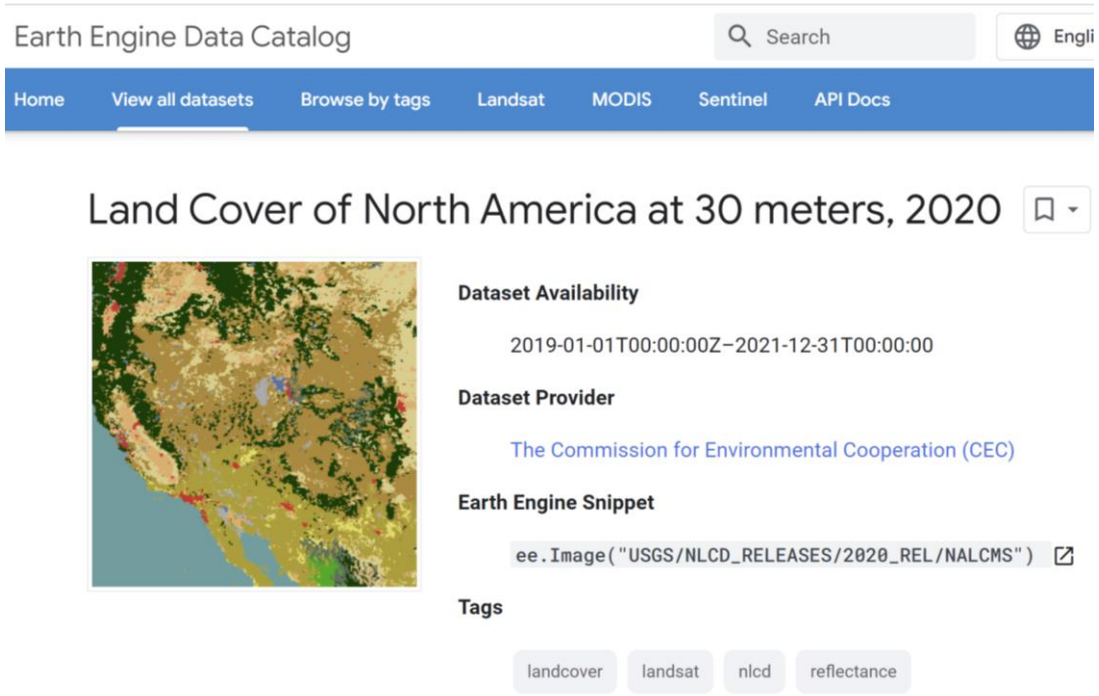


http://github.com/rfernand387/LEAF-Toolbox

Input Satellite Data Records



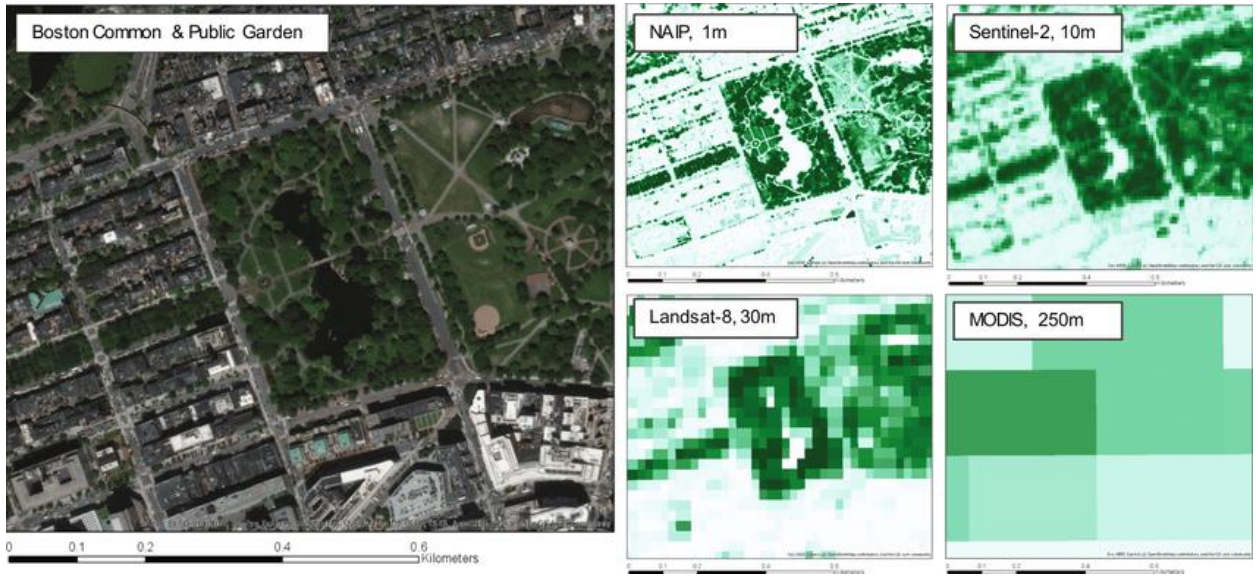
Prior to 2019 to be available in 2024



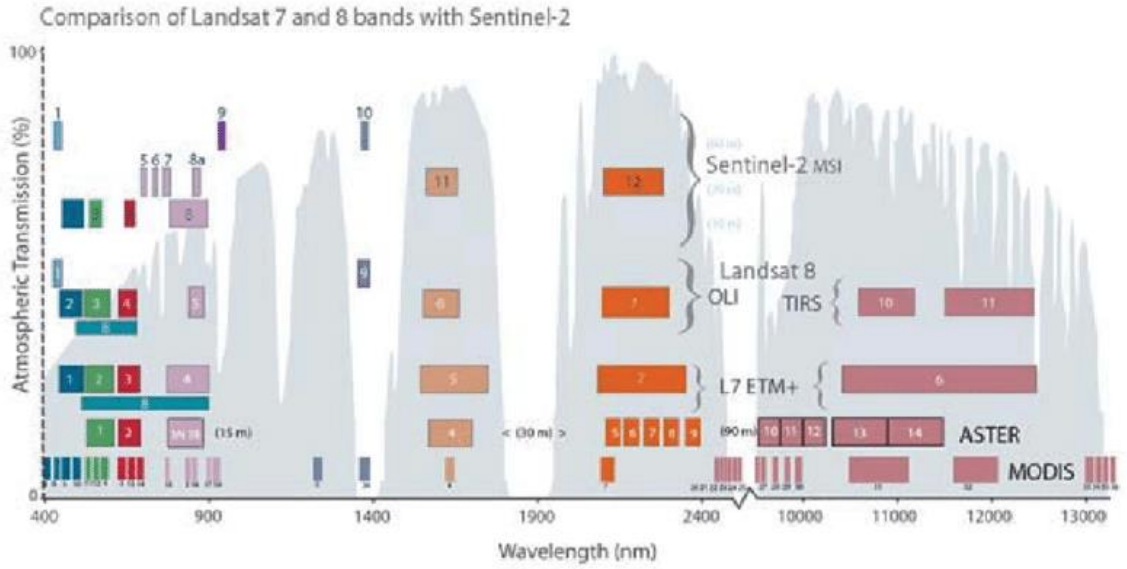
Annual products to be employed in 2024.

Why not use MODIS or Landsat?

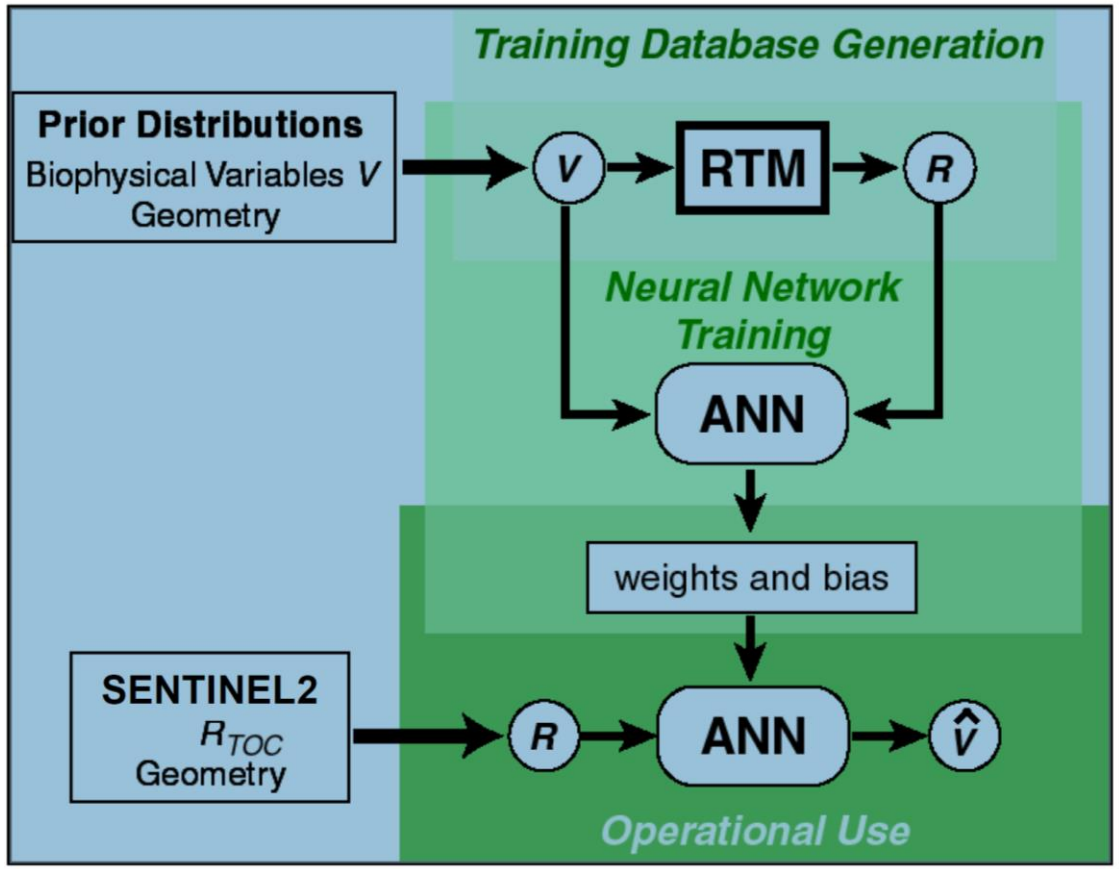
Spatial resolution

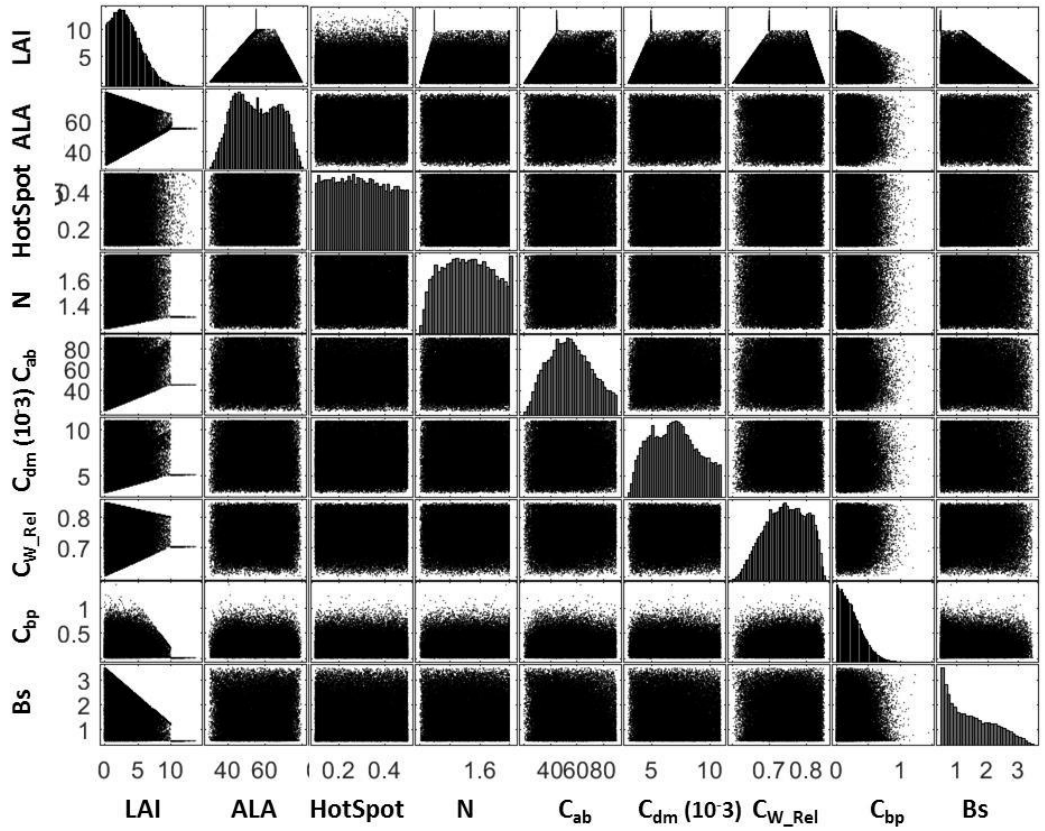


Spectral resolution



Algorithm – SL2P-CCRS

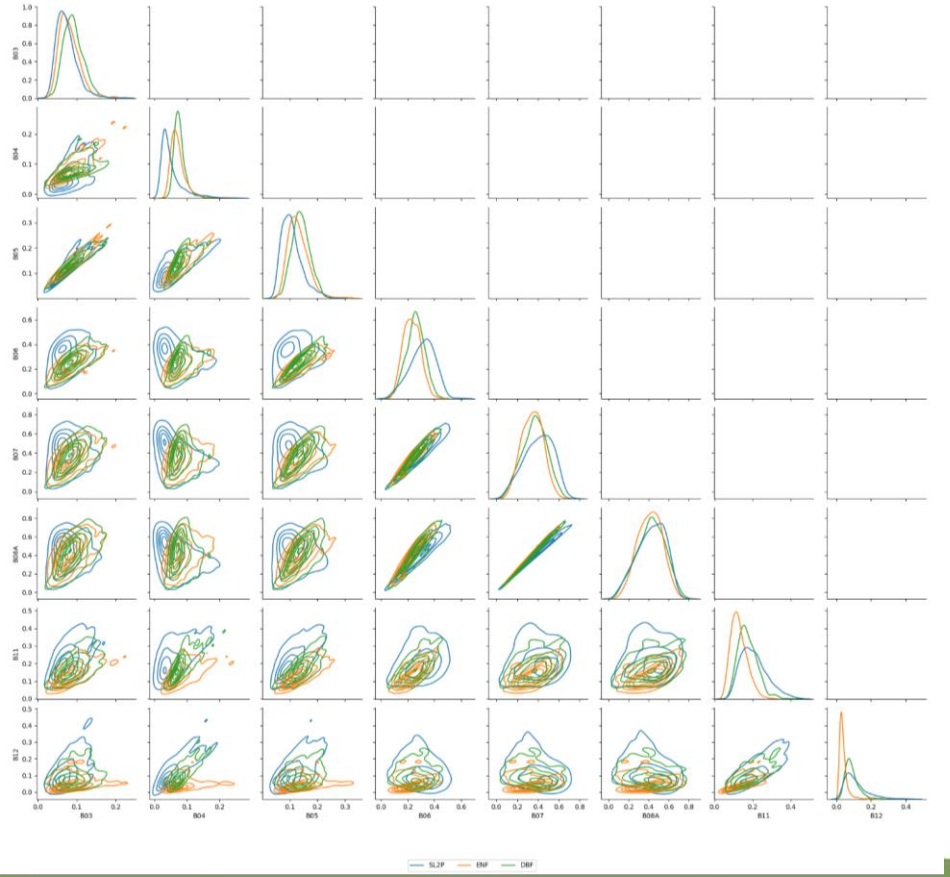




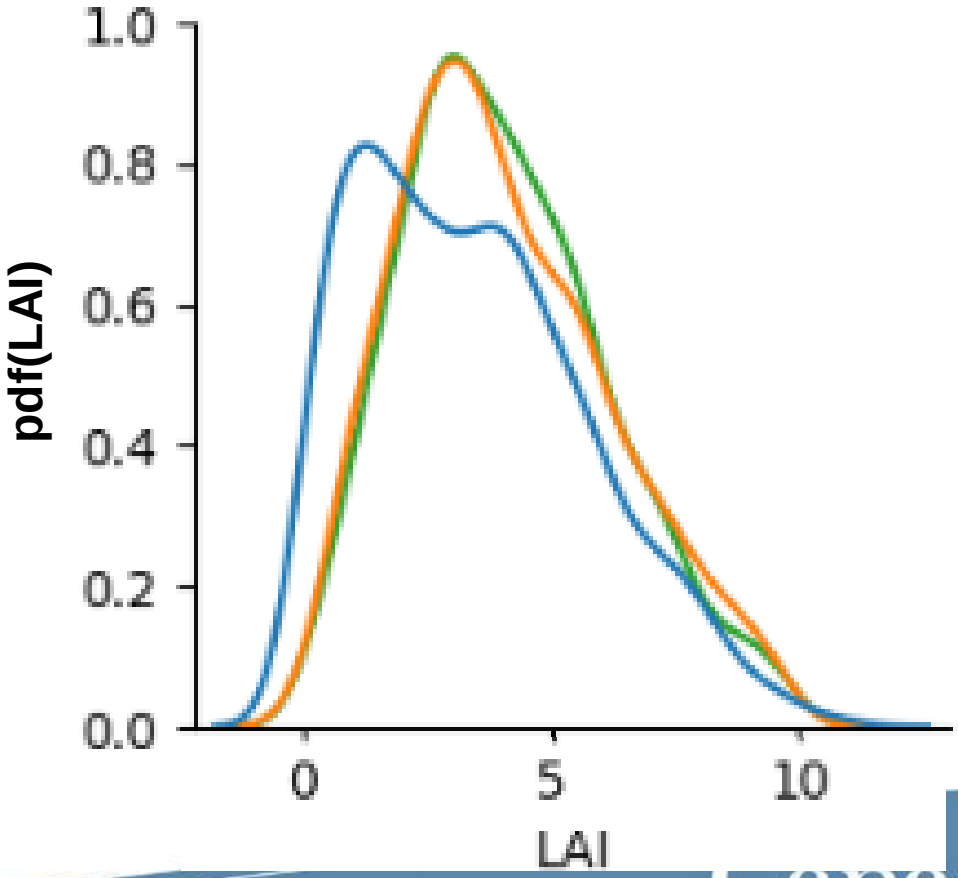
https://github.com/rfernand387/SL2P-CCRS/blob/main/Documents/SL2P-CCRS-ATBD.docx

Algorithm – Quality Indices

- Out of Domain

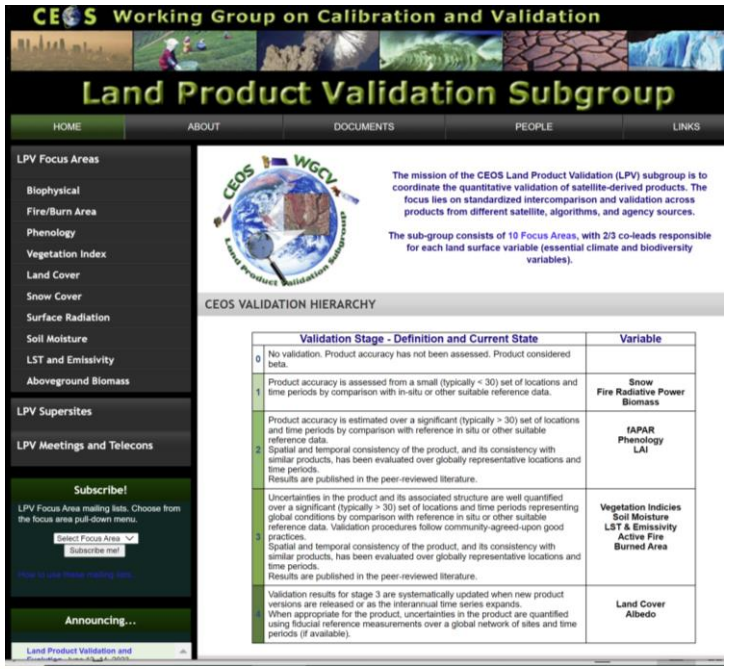


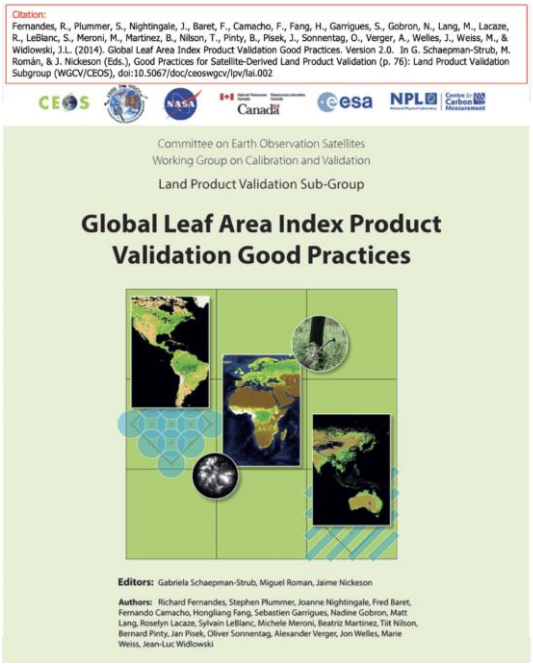
- Out of Range

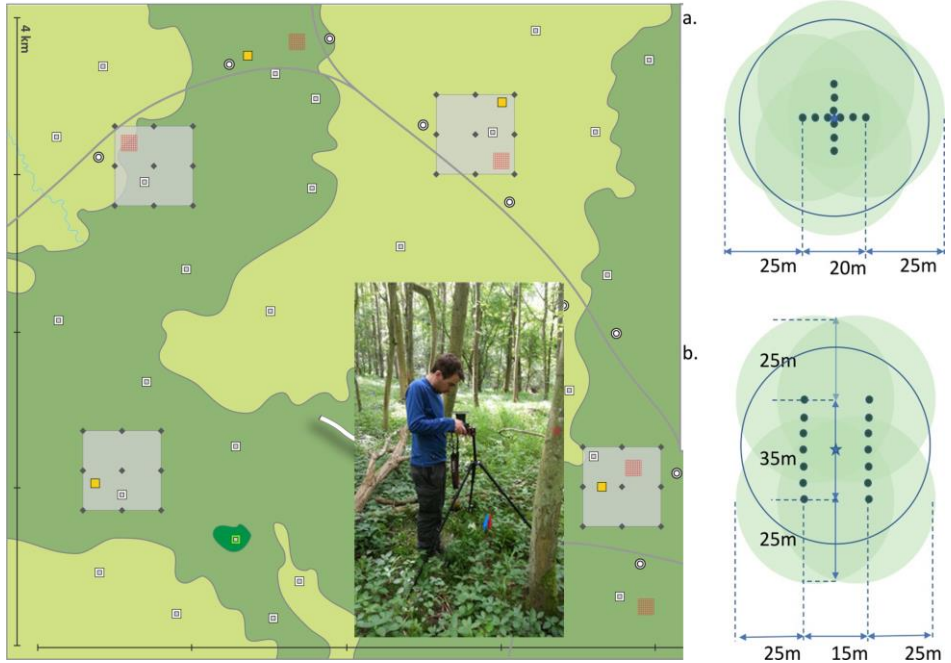


Validation Methodology

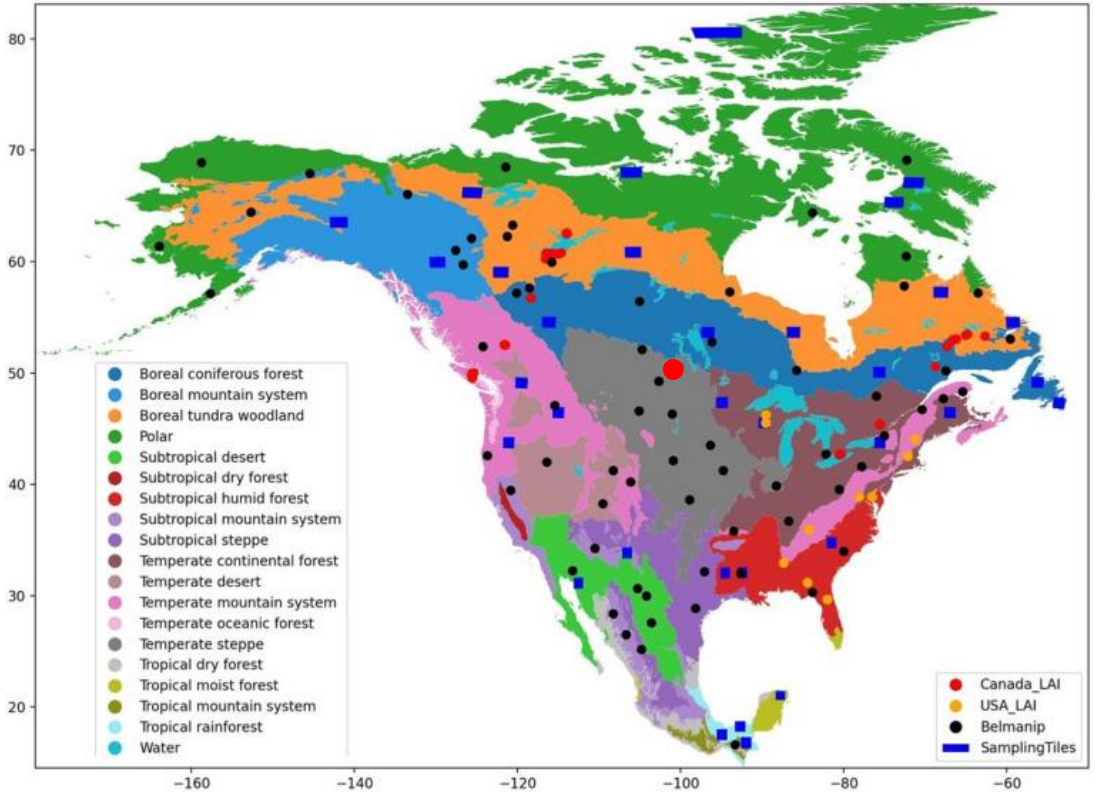
Uncertainty (U) : RMSE
Accuracy (A): average difference
Precision (P): RMSE after subtracting A
Uncertainty Agreement Ratio (UAR): fraction retrievals meeting user requirement



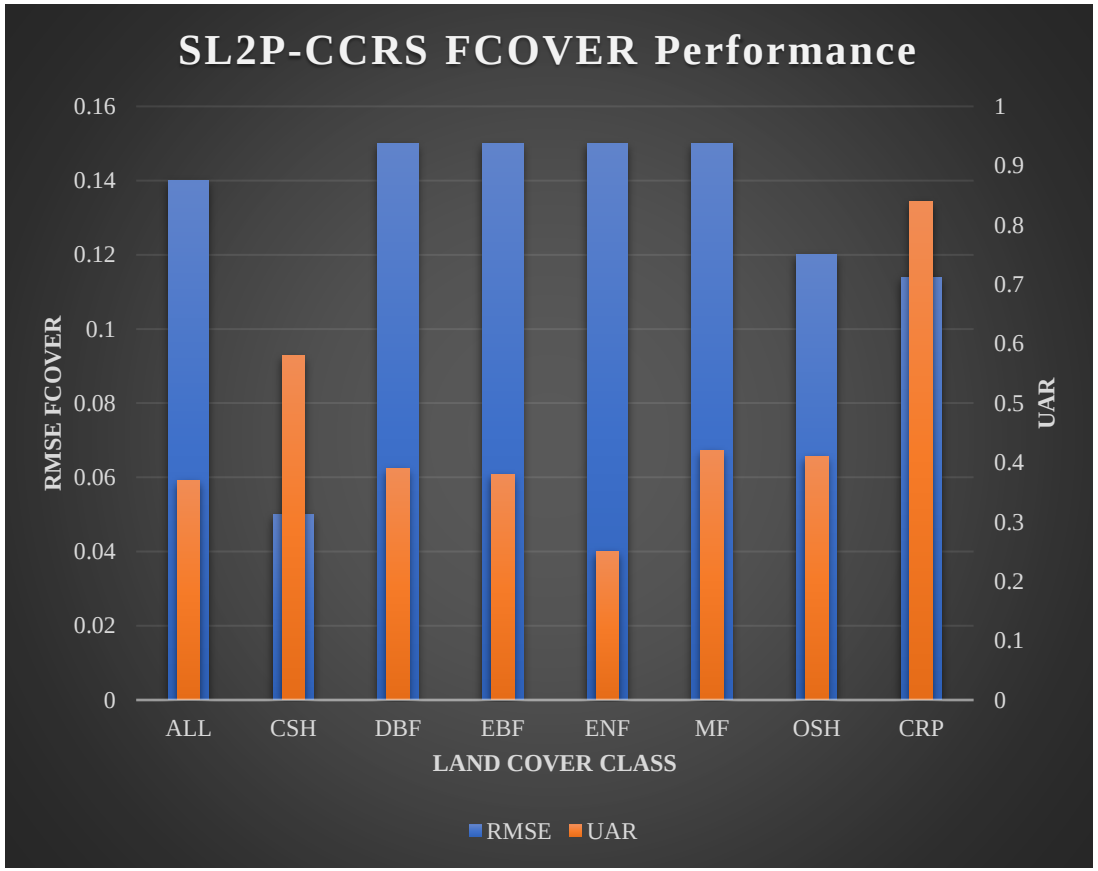


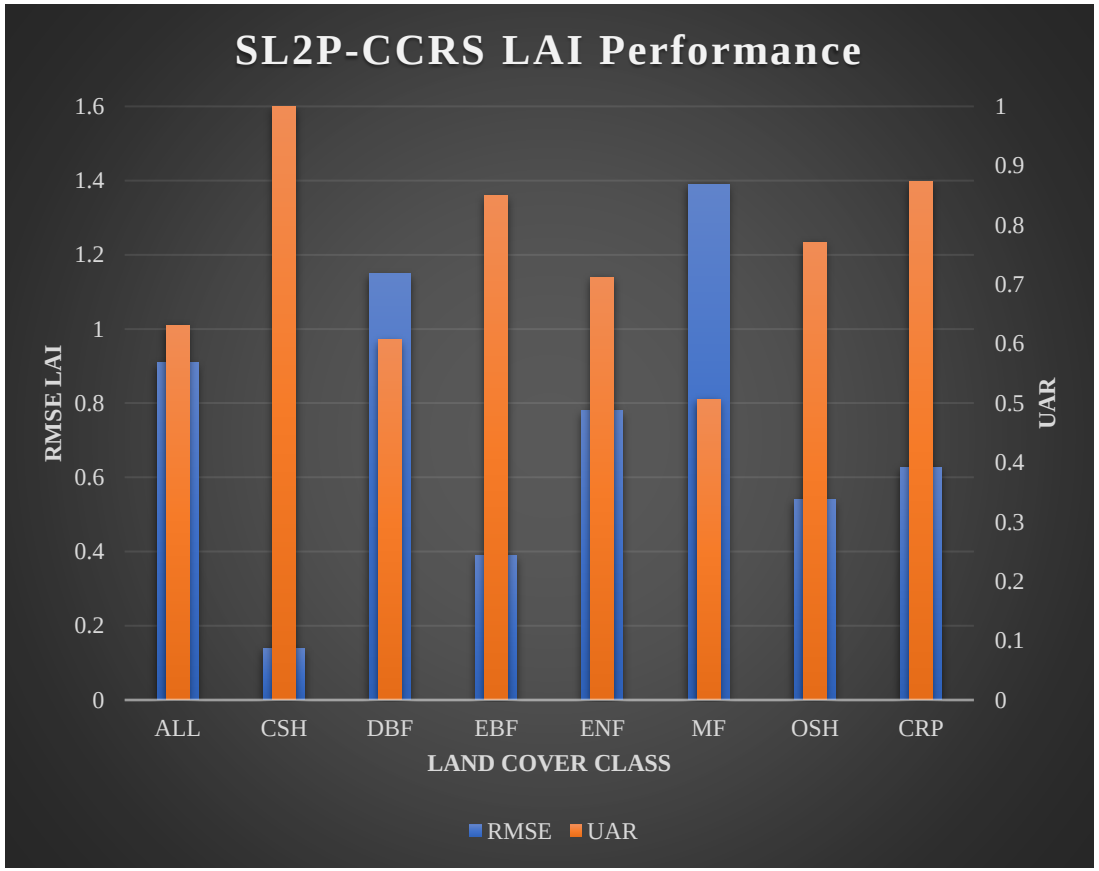


Validation Sites (232 sites, 1385 samples)

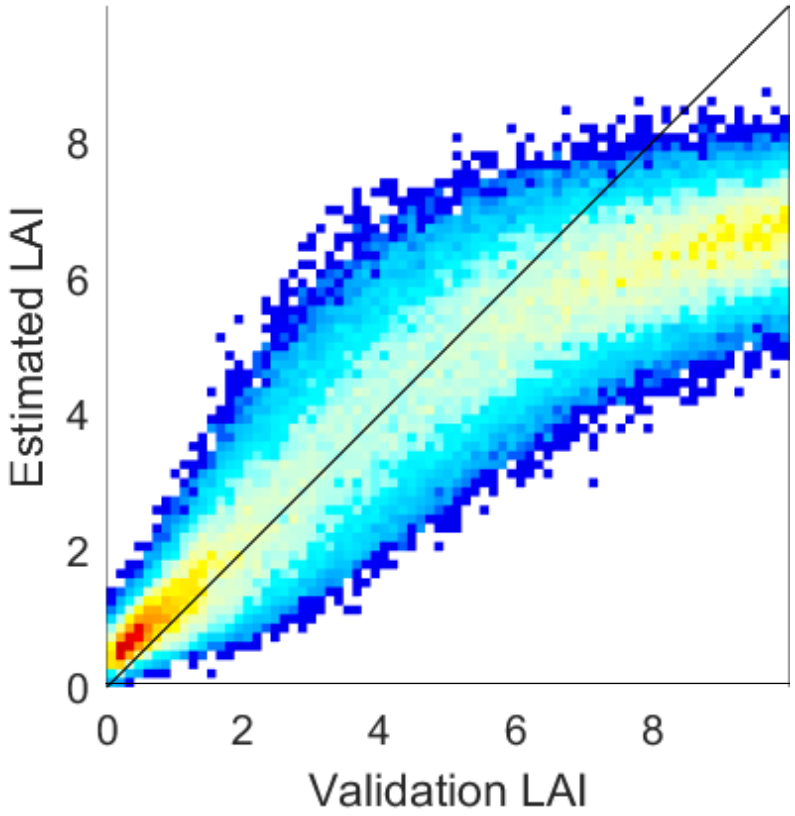


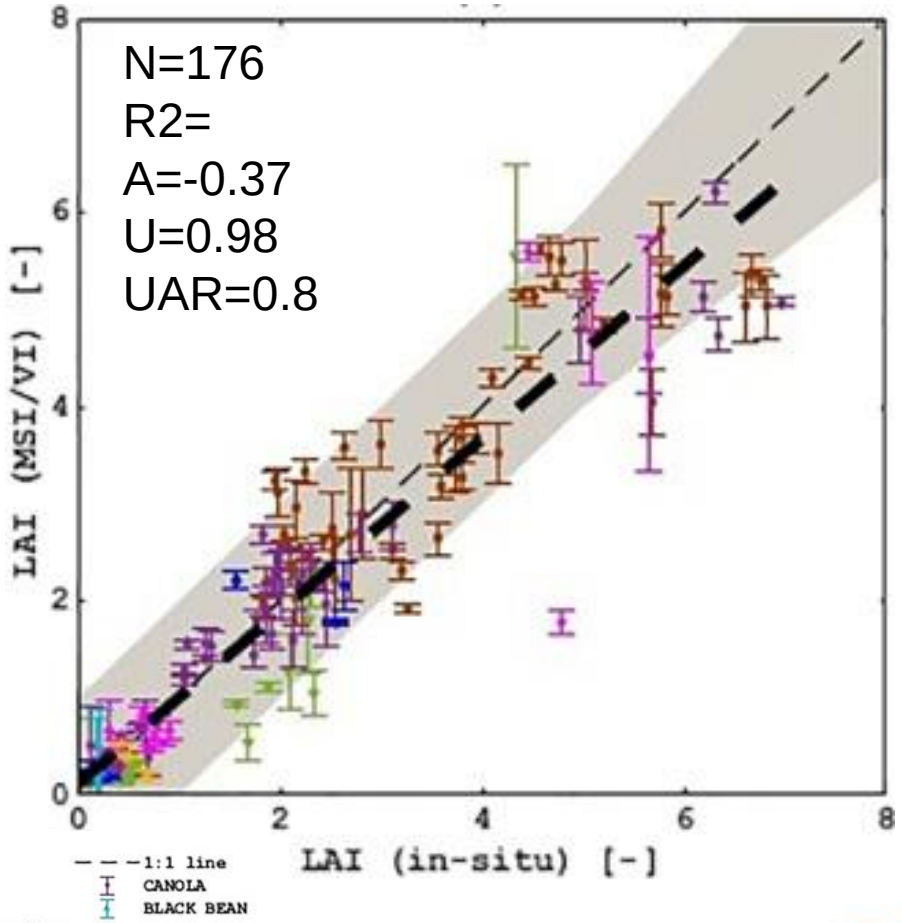
SL2P-CCRS Validation Summary (n=1385)



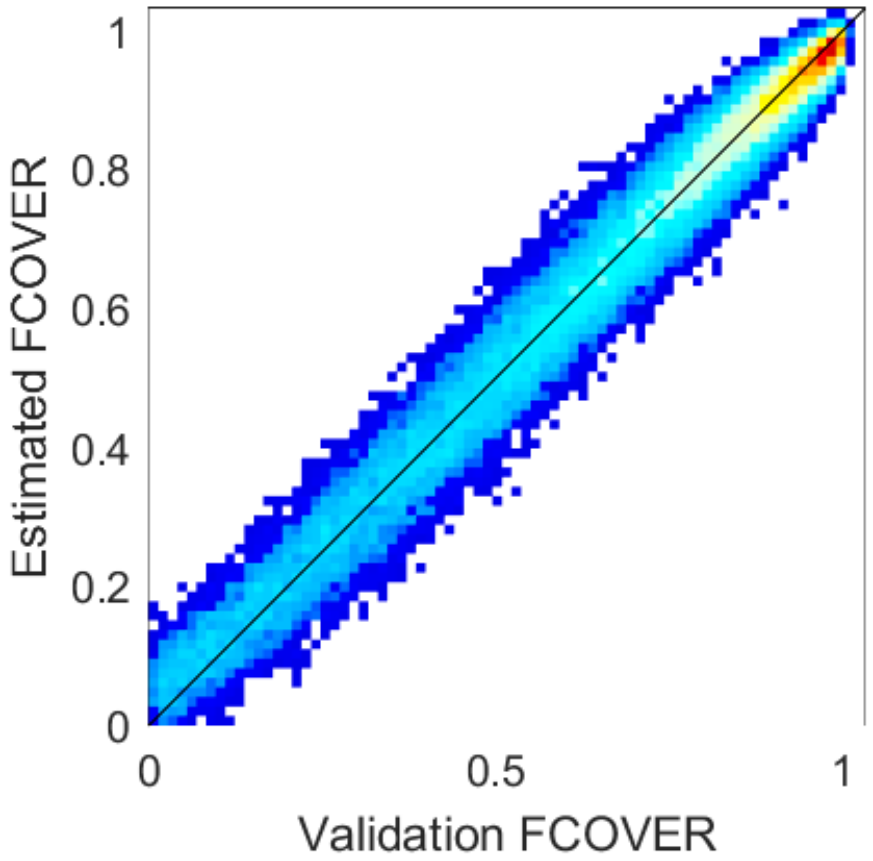


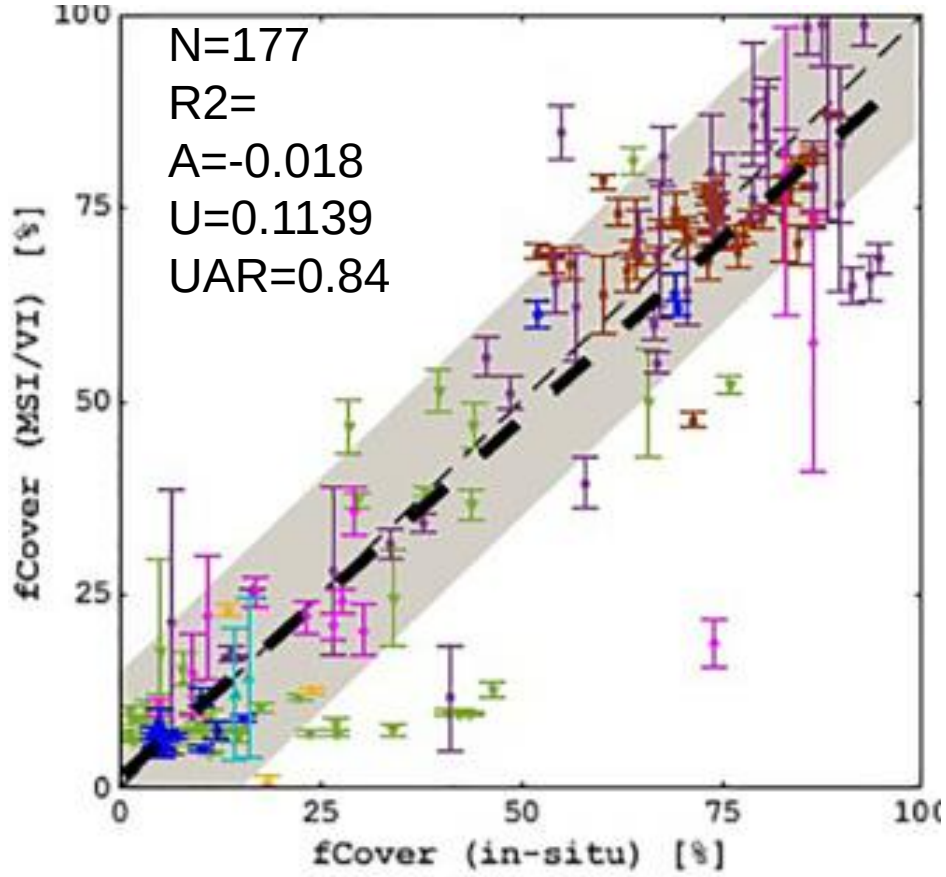
Non-woody vegetation: LAI





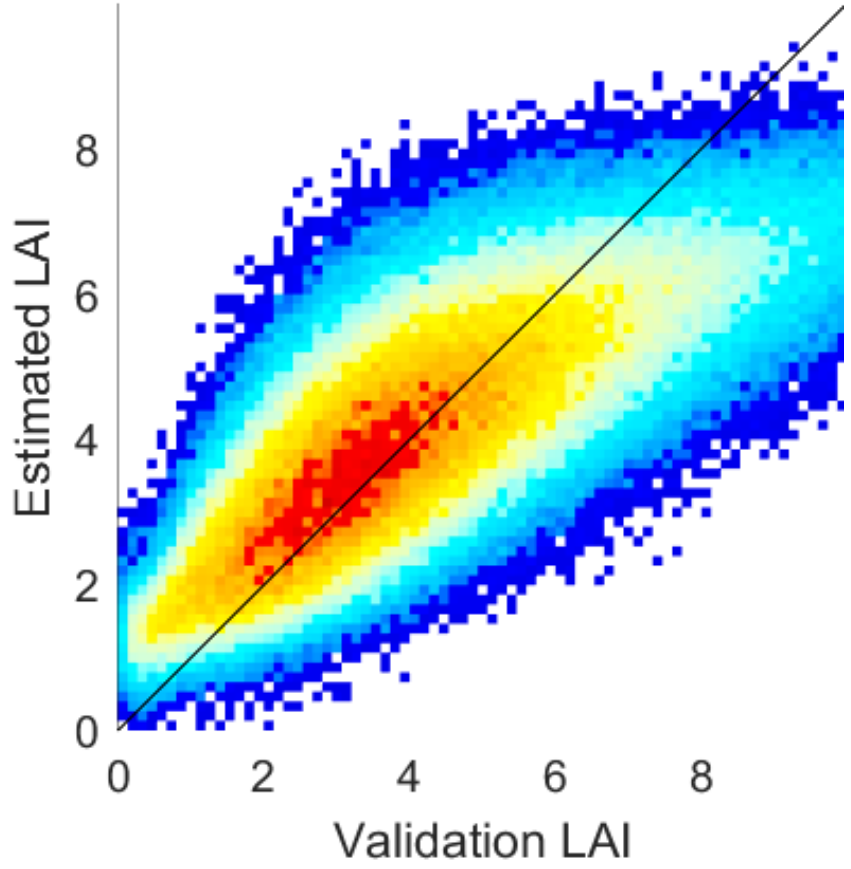
Non-woody vegetation: fCOVER

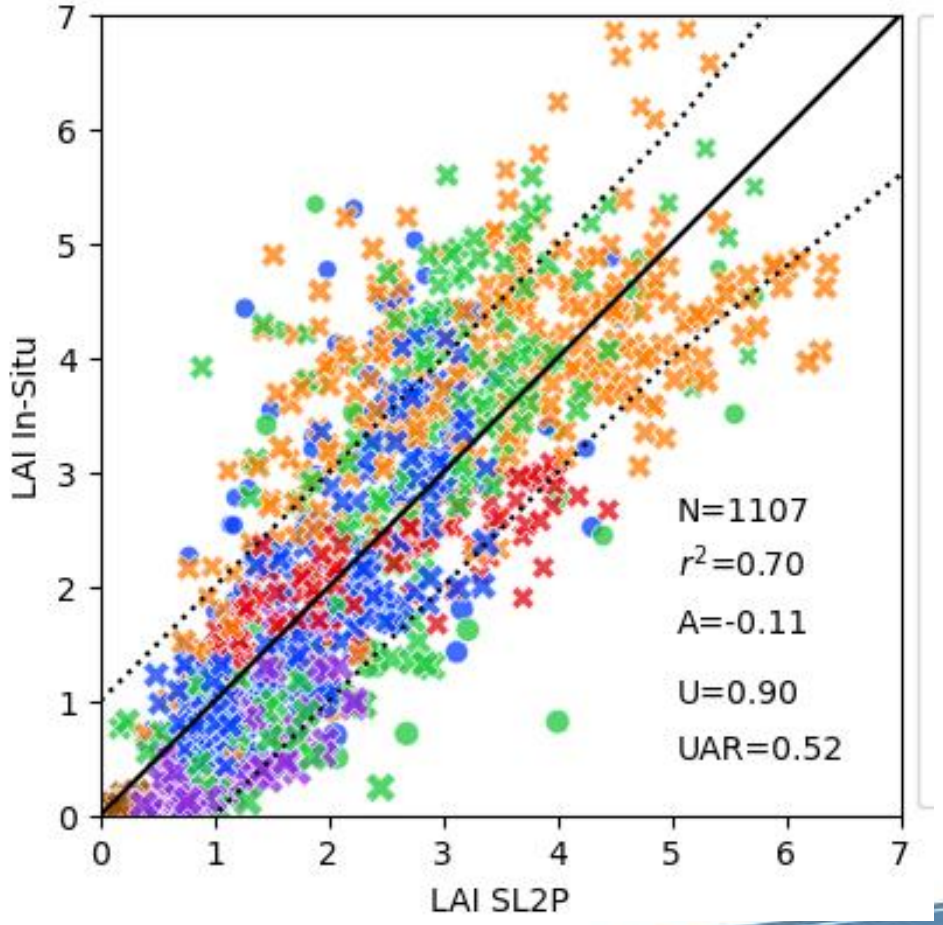




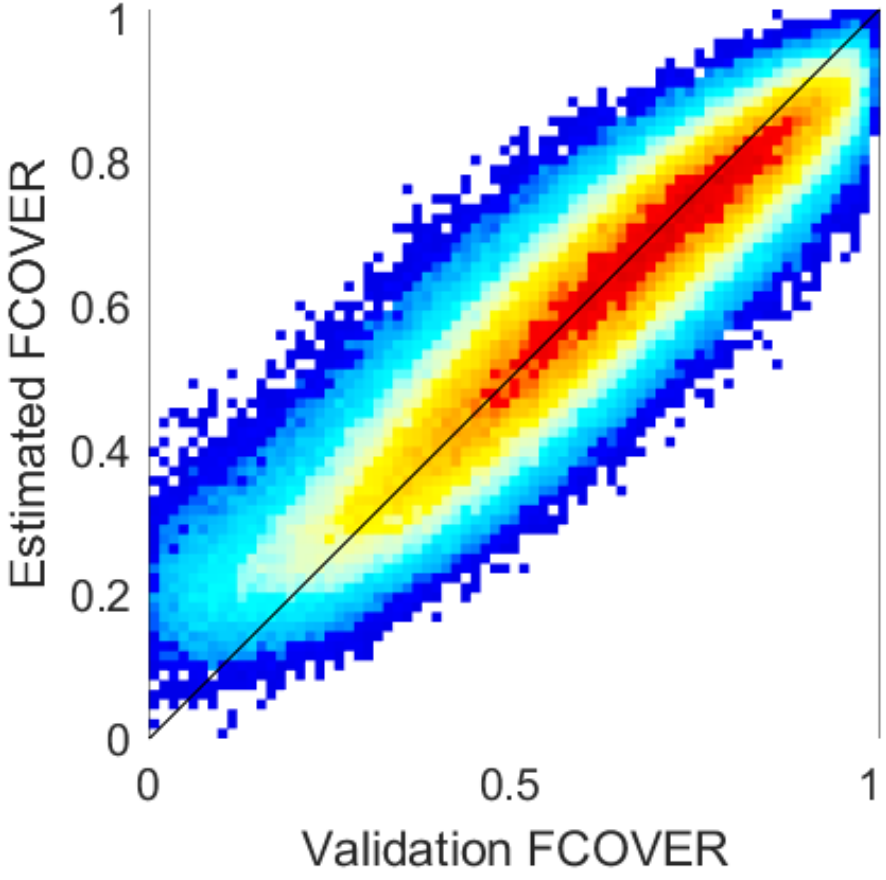
SEN4SCI uncertainty requirement
SOYBEAN
OAT
ALFALFA
WHEAT
CORN
Overall linear regression function
1:1 line
CANOLA
BLACK BEAN

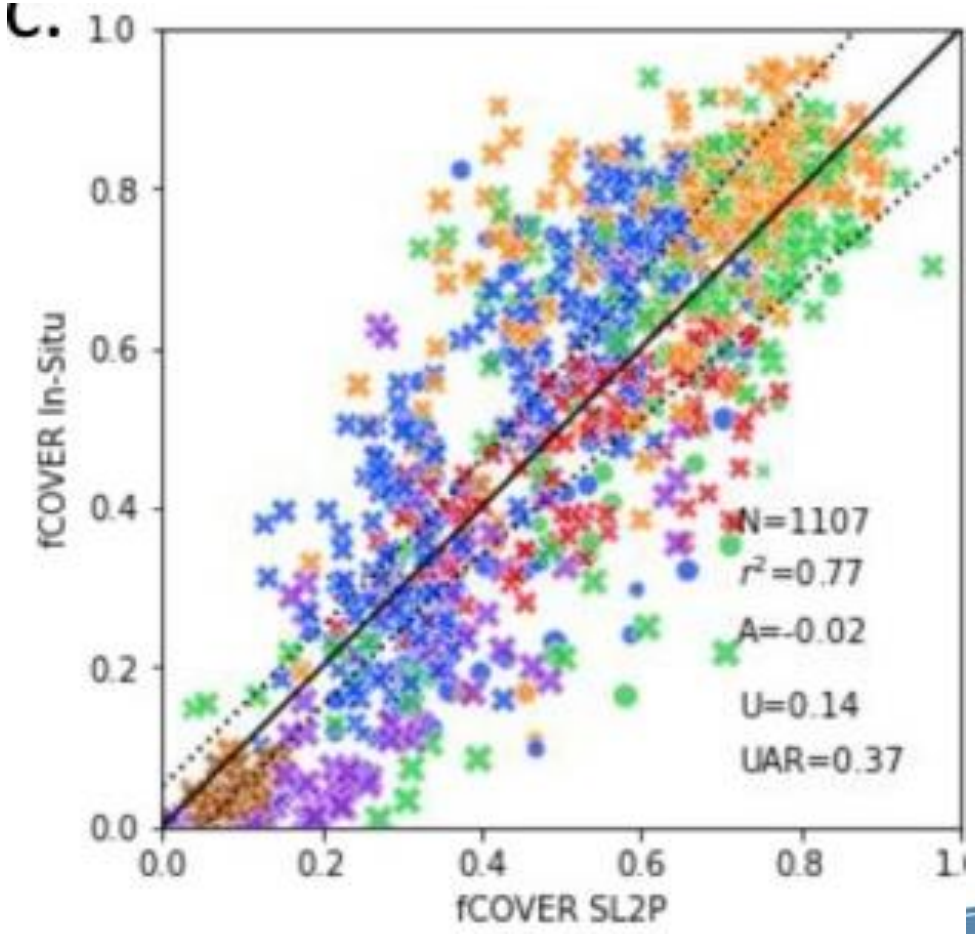
Woody vegetation: LAI





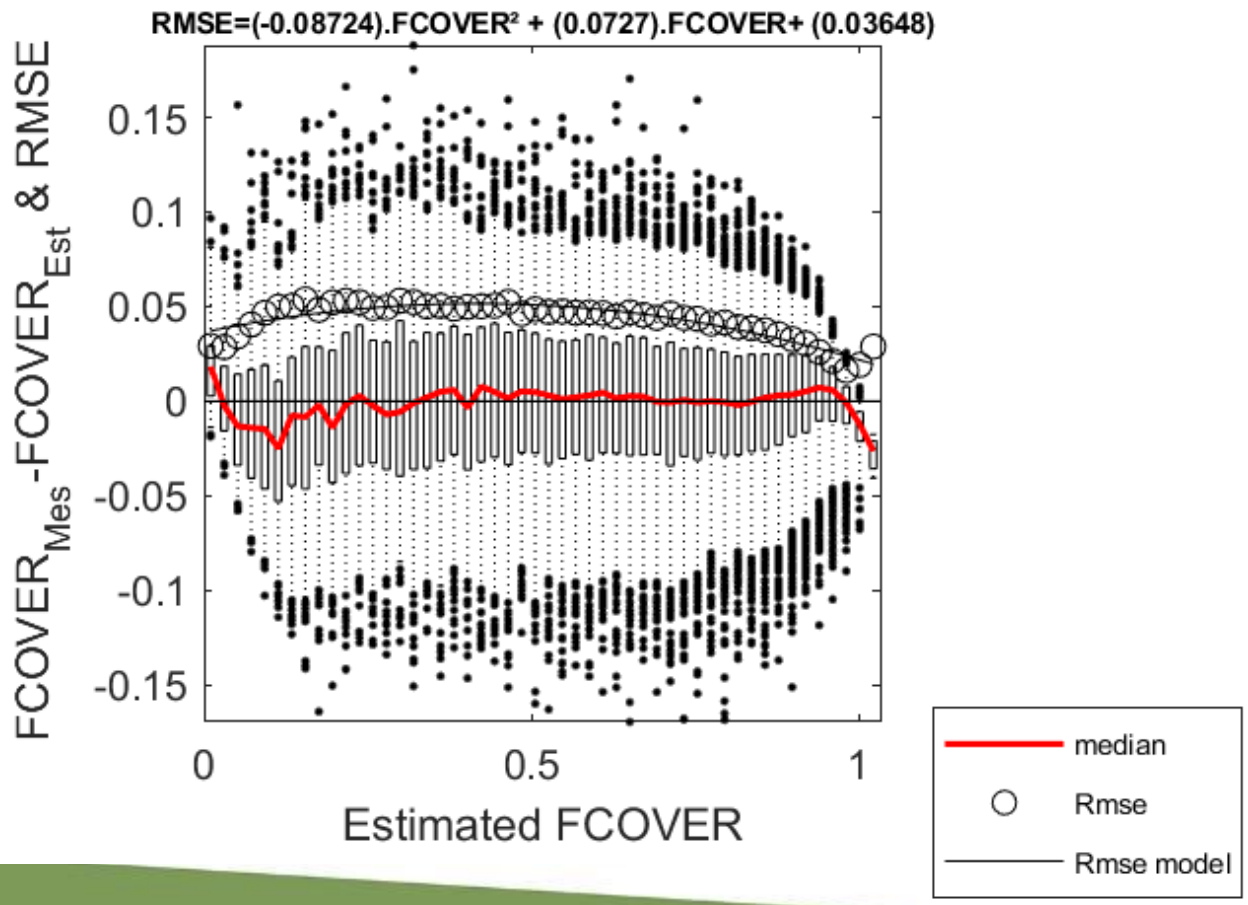
Woody vegetation: fCOVER



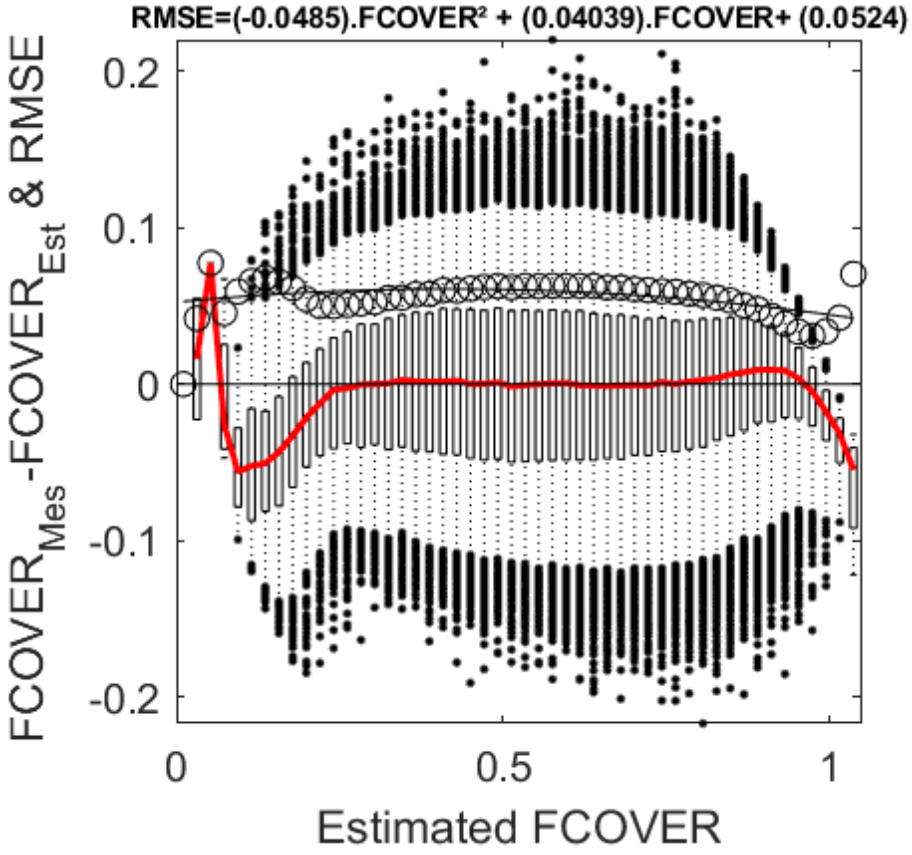


Uncertainty Models – FCOVER

Non-Woody

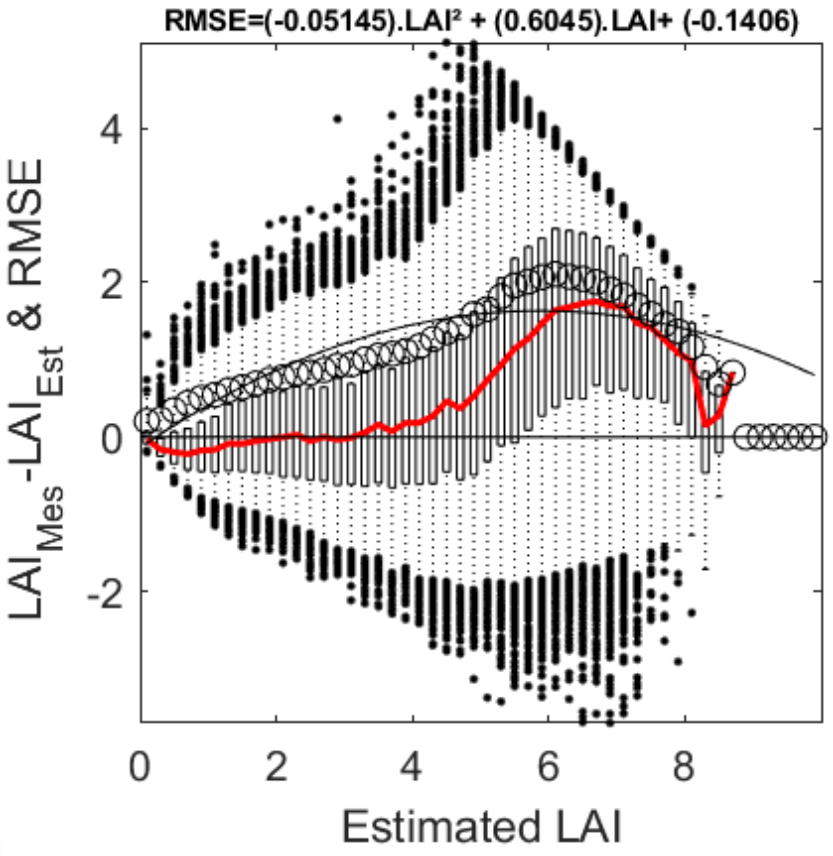


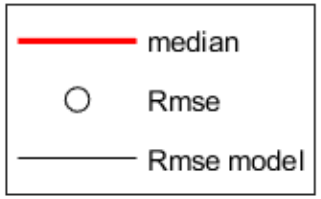
Woody



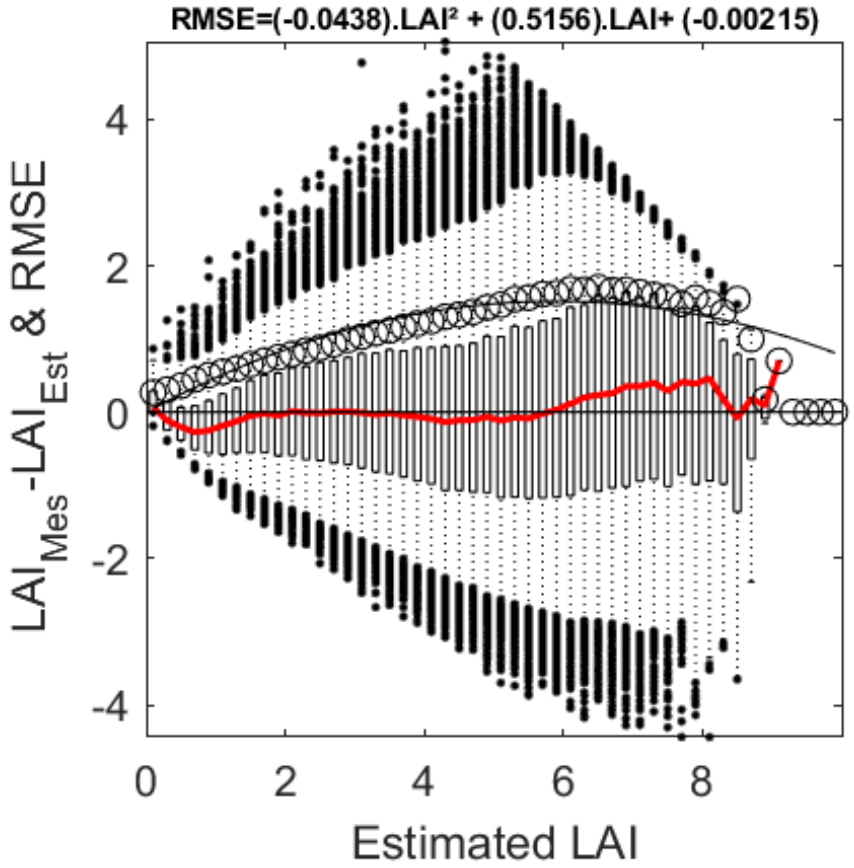
Uncertainty Models – LAI

Non-Woody





Woody



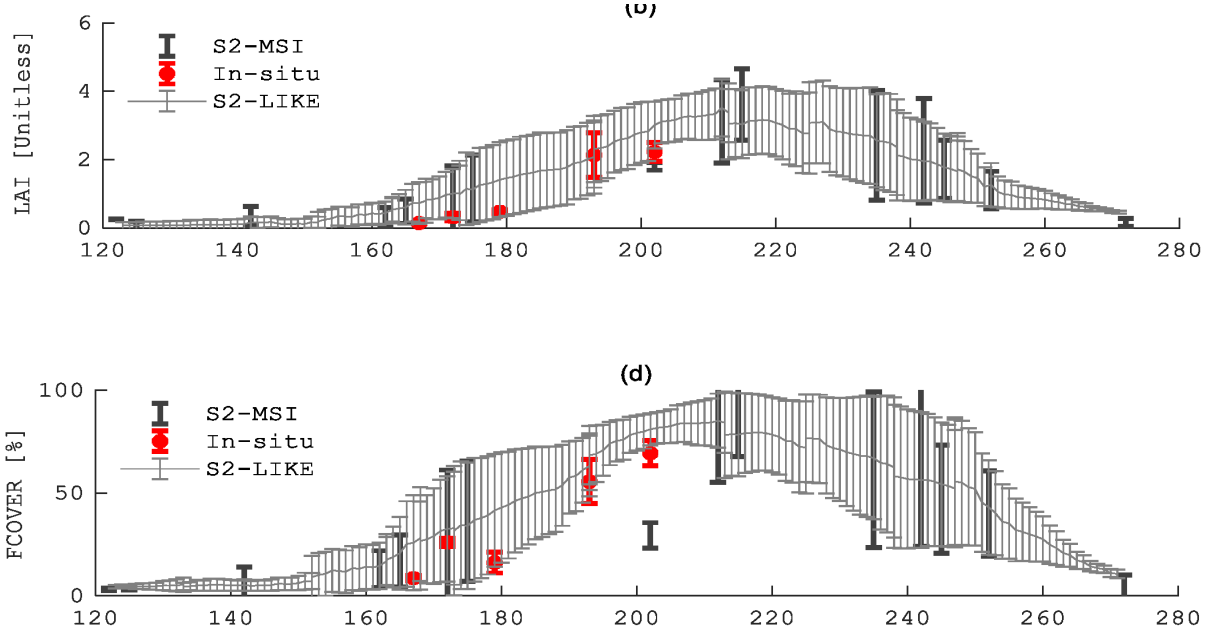
User Caveats

- Snow free, vegetated
- Within domain and range
- 20m pixel U:
  - Lower: cross-validation RMSE
  - Upper: in-situ validation RMSE
- Aggregated pixels
  - RMSE models to be confirmed

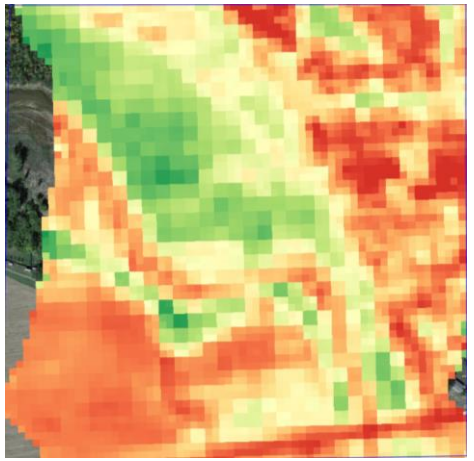
- Issues
  - Partial snow
  - Flooding
  - Terrain shadow
  - Terrain slope
  - Haze and clouds
  - Mixed cover classes
  - Land cover error

Potential Enhancements

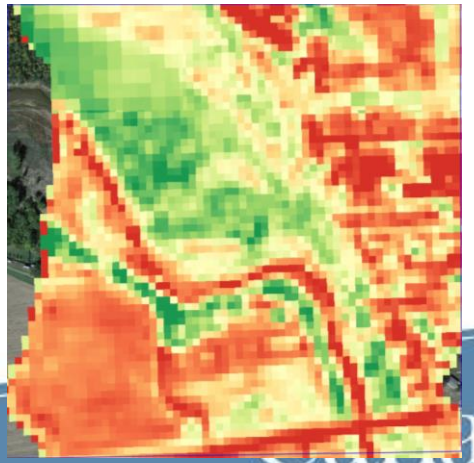
- Daily Estimation (S2+MODIS)



- Downscaling to 10m (S2)

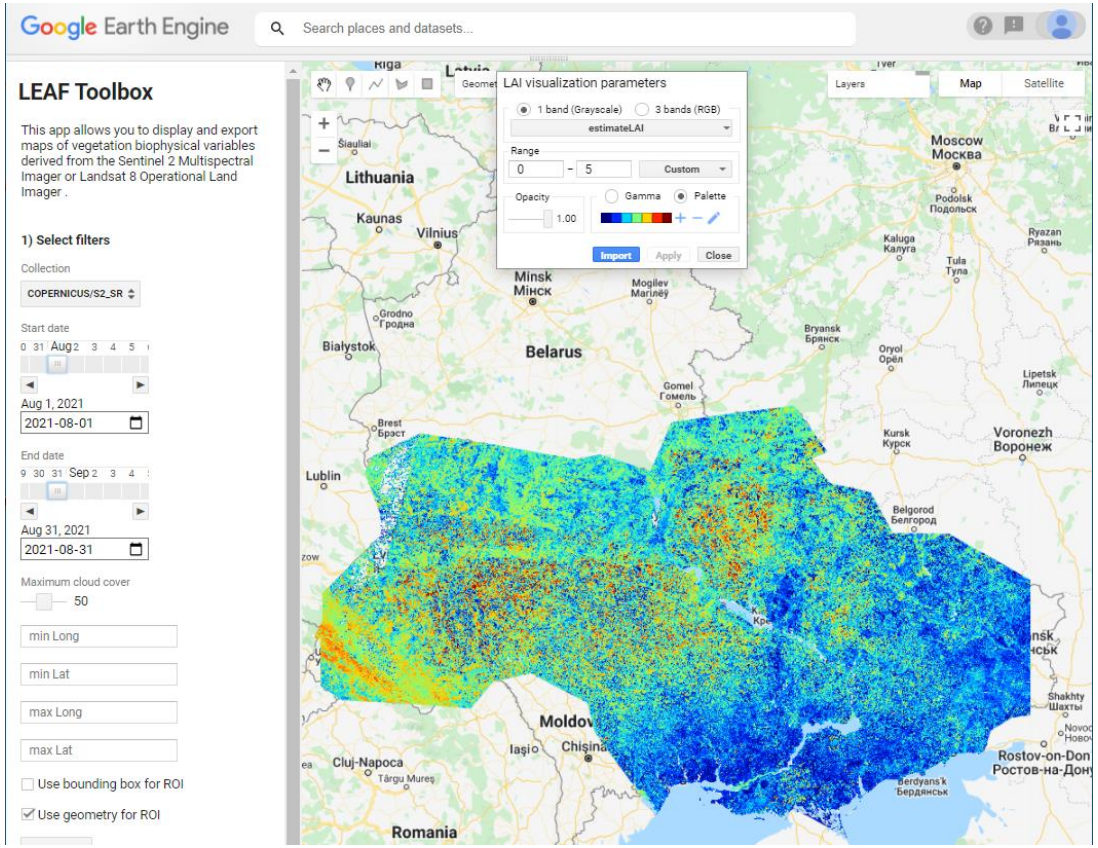


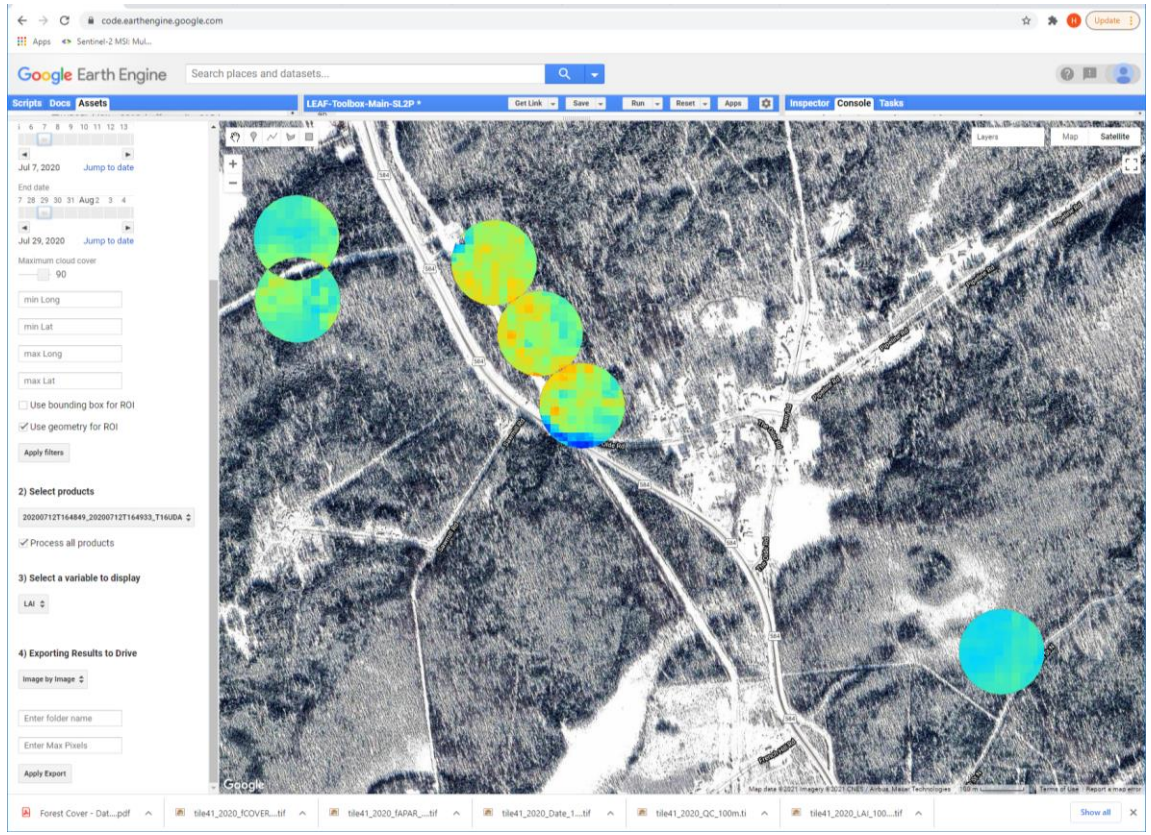
LAI
20m



LAI
10m

LEAF-Toolbox





References

- Code
  - fqqlsun/LEAF_production (github.com)
  - rfernand387/LEAF-Toolbox (github.com)
  - rfernand387/SL2P-CCRS: CCRS Version of the SL2P Processor for mapping vegetation using satellite imagery. (github.com)
- ATBDs
  - https://github.com/rfernand387/SL2P-CCRS/blob/main/Documents/SL2P-CCRS-ATBD.docx
  - http://step.esa.int/docs/extra/ATBD_S2ToolBox_V2.0.pdf
- Product User Guides
  - https://sites.google.com/view/leaf-toolbox-canada-laiv1/home
  - https://sites.google.com/view/leaf-toolbox-canada-fapar1/home
  - https://sites.google.com/view/leaf-toolbox-canada-fcover1/home
- Data
  - https://datacube.services.geo.ca/en/viewer/eo4ce/vegetation/monthly-vegetation.html
  - https://open.canada.ca/data/en/dataset/37745ea7-d0cf-4ef6-b6b8-1cb3a7fce0b8