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Improving the Simplified Level 2 Prototype Processor for Retrieving Canopy Biophysical Variables from Sentinel 2 Multispectral Instrument Data

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Essential Variables

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Essential Climate Variables

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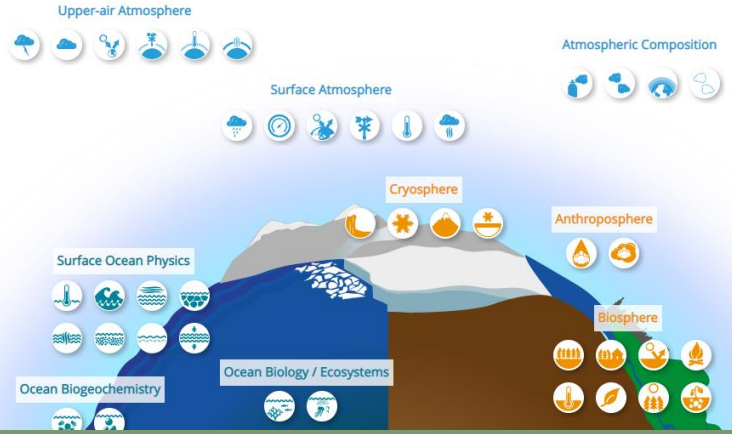
What are Essential Climate Variables (ECVs)?



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What are EBVs?

EBVs are the abbreviation for Essential Biodiversity Variables.
These Essential Biodiversity Variables, defined as the derived measurements required to study, report, and manage biodiversity change, focusing on status and trend in elements of biodiversity should play the role of brokers between monitoring initiatives and decision makers. They provide the first level of abstraction between low-level primary observations and high-level indicators of biodiversity.

Criteria for Essential Biodiversity Variables

An ideal EBV should be

- able to capture critical scales and dimensions of biodiversity
- biological
- a state variable (in general)
- sensitive to change
- ecosystem agnostic (to the degree possible)
- technically feasible, economically viable and sustainable in time

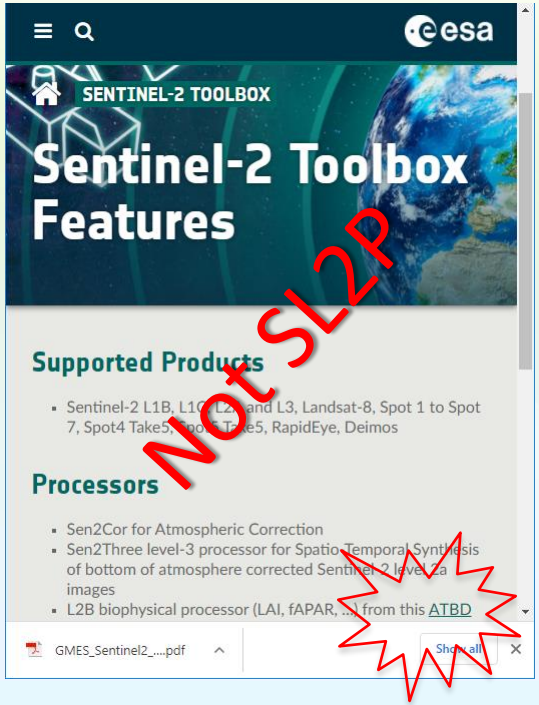
Sentinel 2 Mission Product Requirements

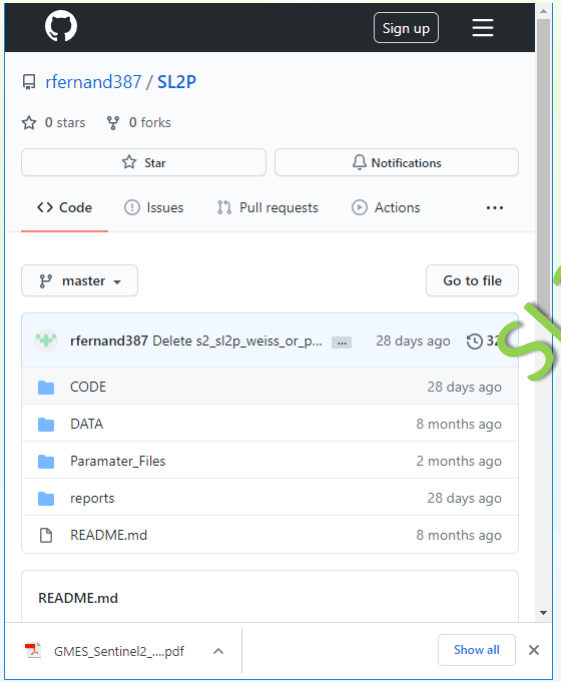
The catalogue of the Level 2b and Level 3 products should include those in Tables 3.15.1 (main) and 3.15.2 (secondary/optional).

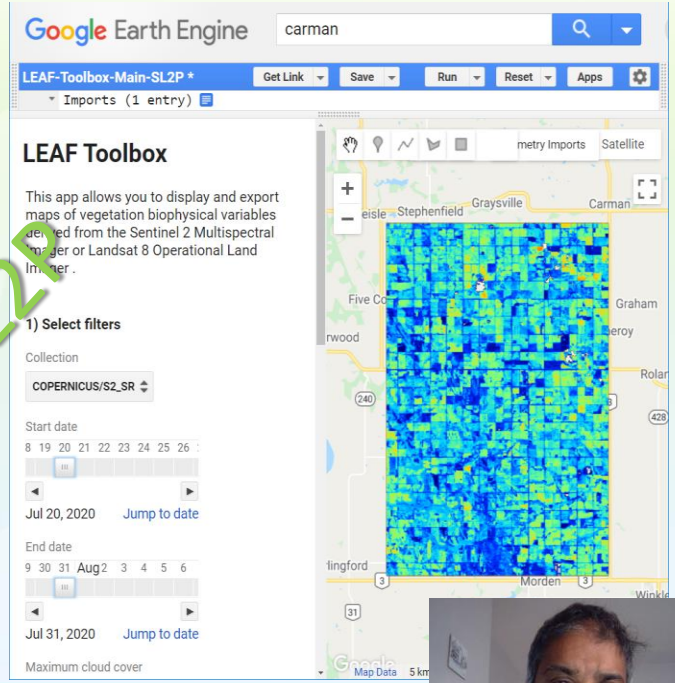
Abbreviation	Name	Description	Goal Accuracy	Threshold Accuracy
LC	Land Cover Map	Land cover with a set of generic classes compatible with those already used for generic services such as GLC 2000 and CORINE.	TBD	TBD
CDM	Change Detection Map	Product indicating major land use conversion processes	TBD	TBD
LAI	Leaf Area Index	Map with the green leaf area per unit soil area.	**15%**	**25%,0.75**
FVC	Fraction of Vegetation Cover	% of the land surface covered by vegetation.	**10%,0.05**	**20%,0.10**
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation	Fraction of the radiation in the photosynthetic domain (400-700nm) that is absorbed by leafs. Values range between 0 and 1. Product to provide continuity of MGVI [RD-12]. For Sentinel-2 this index would provide MGVI at high resolution.	**10%,0.05**	**20%,0.10**
Cab	Leaf Chlorophyll Content	The amount of chlorophyll per square centimetre. This product would provide continuity of MTCI [RD-14]. For Sentinel-2 this index would provide MTCI at high resolution. This index is directly related to the chlorophyll content of vegetation.	TBD	TBD
C_w	Leaf Water Content	The amount of water in weight (grams) or volume (cubic centimetres) per unit leaf weight (grams) or volume (cubic centimetres). This parameter can be remotely sensed and is important in estimating the potential of transpiration and the vegetation energy balances.	TBD	TBD
SC	Snow Cover	Fraction of the surface covered by snow.	TBD	TBD

Simplified Level 2 Prototype Processor (SL2P)

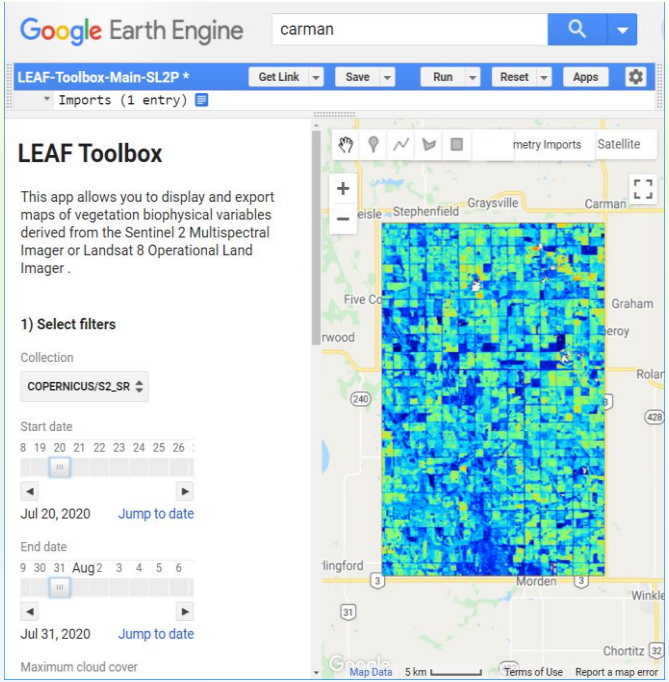
S2Toolbox ≠ MATLAB = Google Earth Engine







LEAF-Toolbox (Landscape Evolution and Forecasting)



Cell Phone/Google Earth Engine/Python

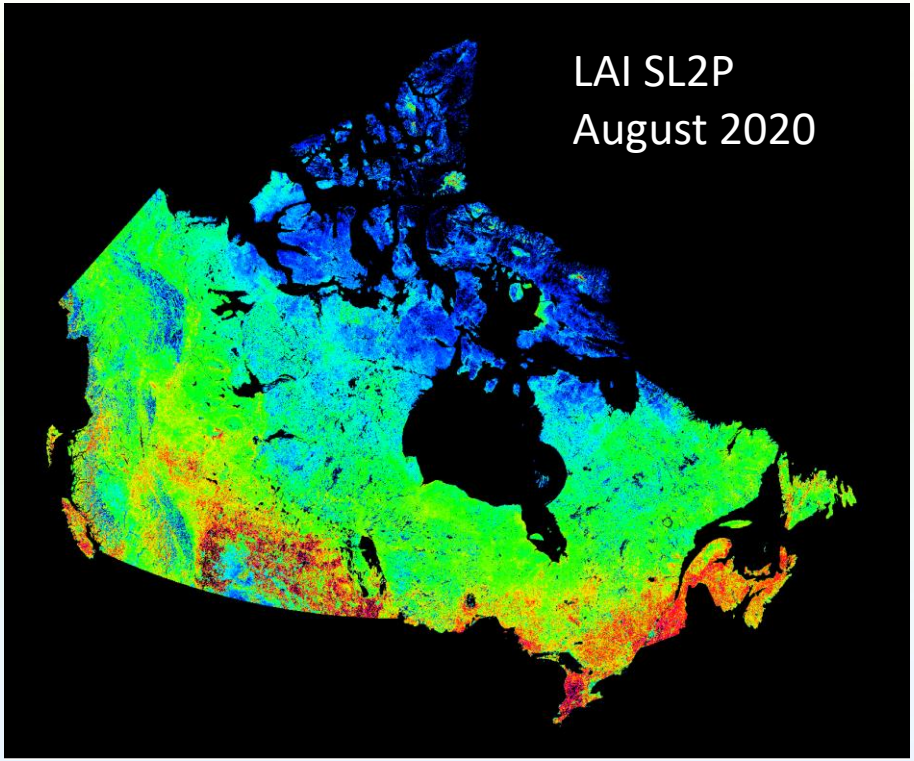
Multi Layer Neural Network
User specified via CSV files per Land Cover

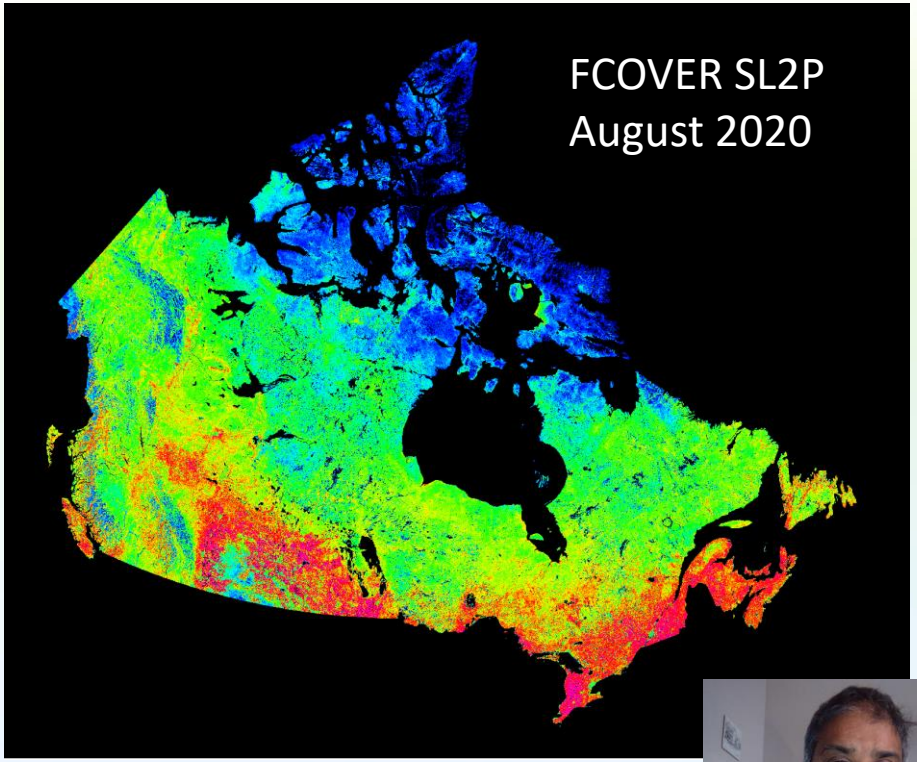
Process 1000 granules<2minutes
Arbitrary spatial subsetting
Per granule or mosaic output
Export to Google Drive

Parsing utility for SL2P Matlab output

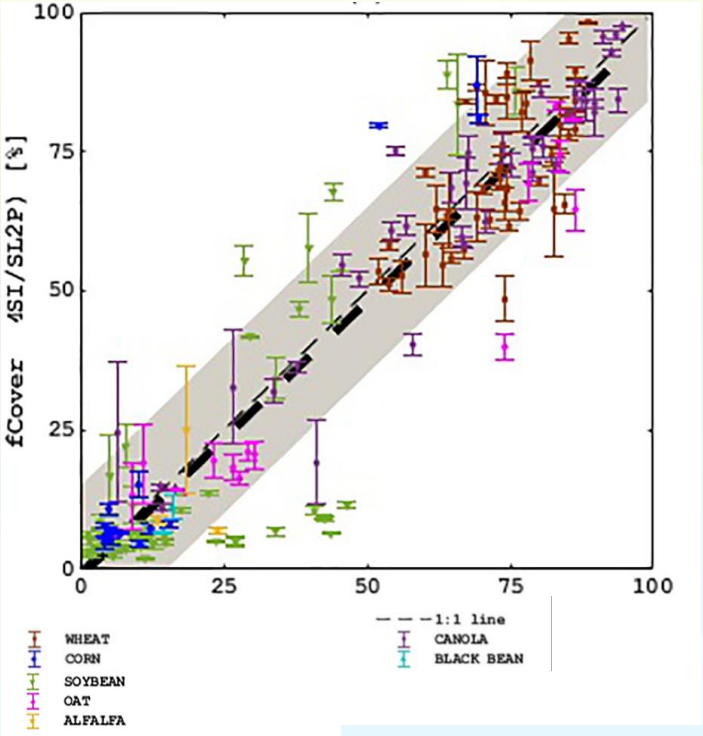
https://rfernand387.users.earthengine.app/view/leaf-toolbox-sl2p
https://code.earthengine.google.com/bb6f7efc2cd7dc30189505d7e303c565

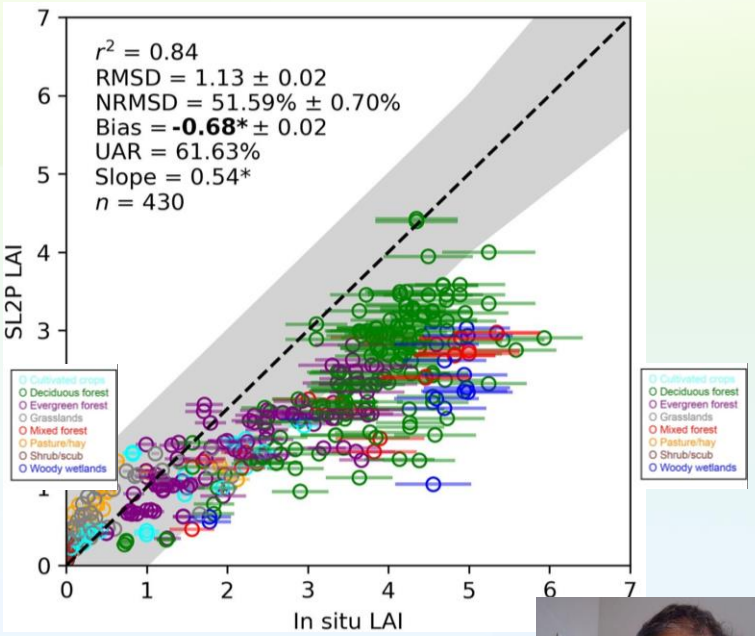
100m Monthly Mosaics of Canada



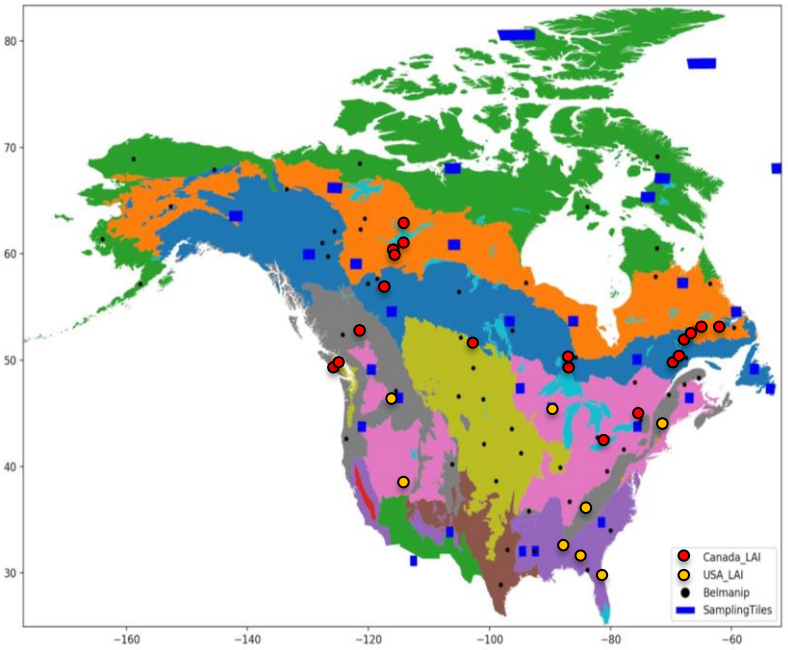


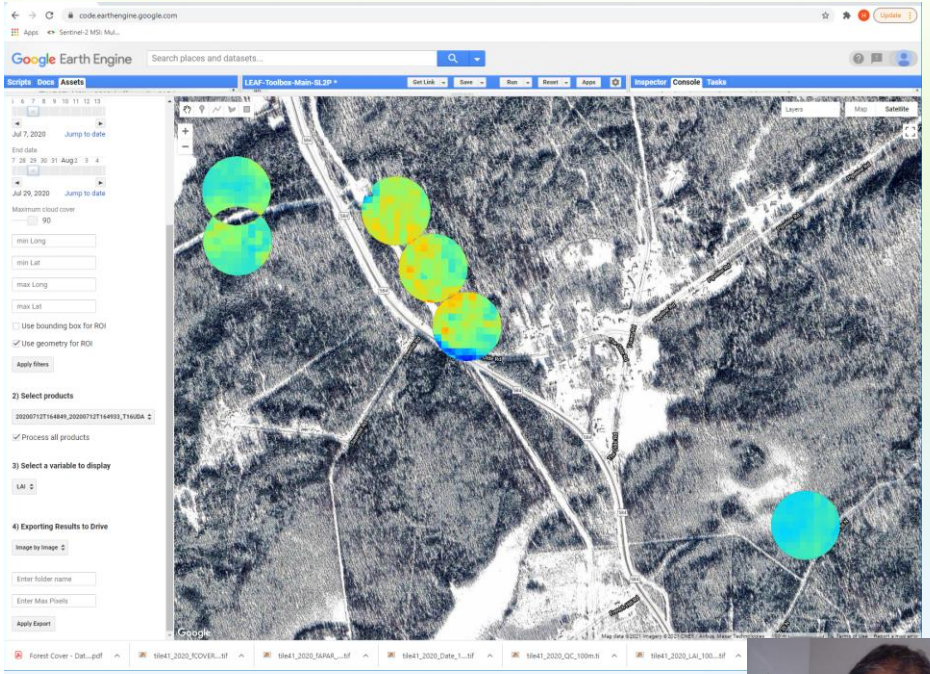
Sample Validation Results





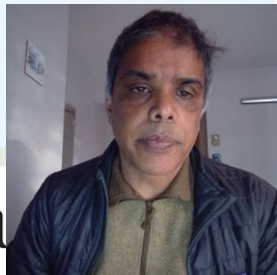
Automated open source validation using GEE





Research Questions

- Can we reduce SL2P LAI, fAPAR and FCOVER uncertainty over forests?
- Hypotheses:
  - H(0): SL2P, global database + PROSAIL
  - H(a): Land cover database + PROSAIL
  - H(b): Land cover/species database + FLIGHT
- Test over NEON and CCRS sites

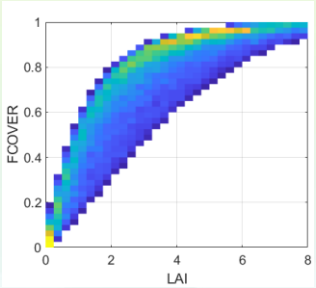


Treatments

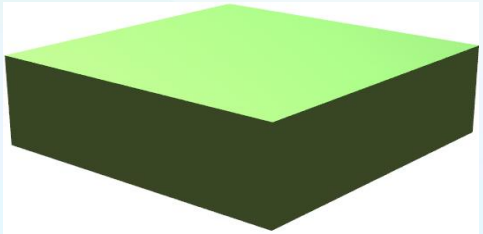
H(0): SL2P

Global in-situ PROSAIL parameters. Modal LAI ~2. No clumping.

Deciduous Broadleaf Forest Calibration



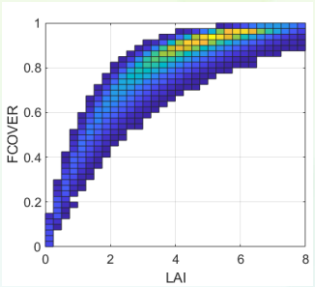
Homogenous turbid RT model.



H(a): CCRS-SAIL

Land cover based PROSAIL parameters. Modal LAI ~4. Clumping from clumping index.

Deciduous Broadleaf Forest Calibration

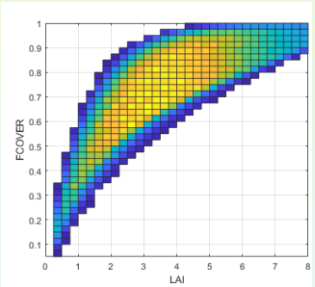


Heterogenous turbid RT model.

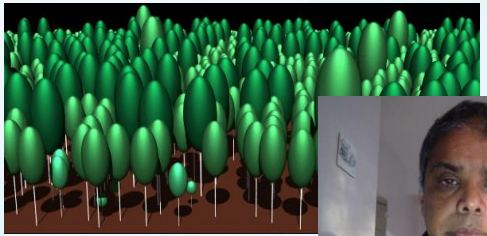
H(b): CCRS-FLIGHT

Species cover based PROSAIL parameters. Modal LAI ~4. Clumping from canopy architecture.

Deciduous Broadleaf Forest Calibration

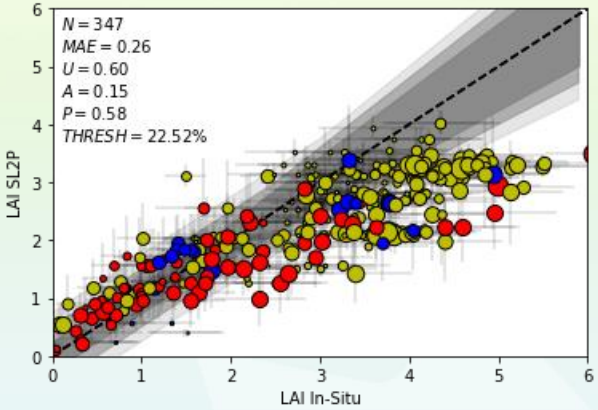


Hetrogenous discrete RT model.

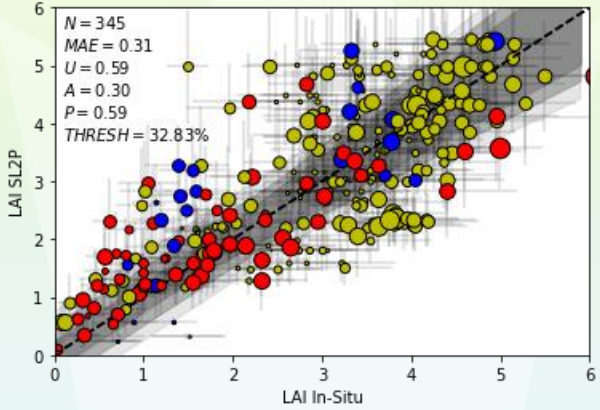


Results-LAI

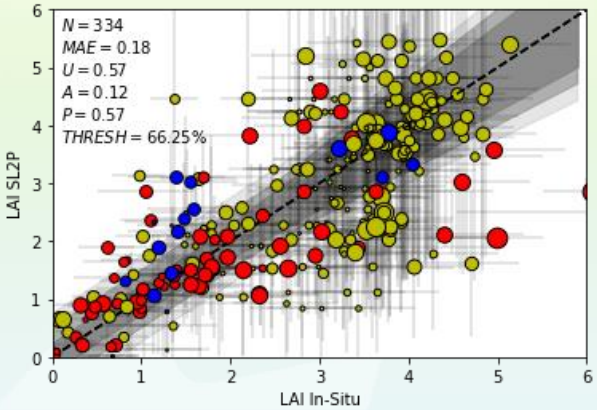
H(0): SL2P



H(a): CCRS-SAIL

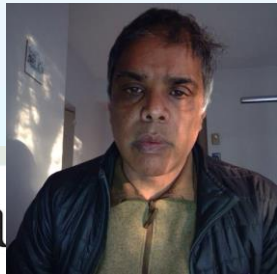


H(b)CCRS-FLIGHT



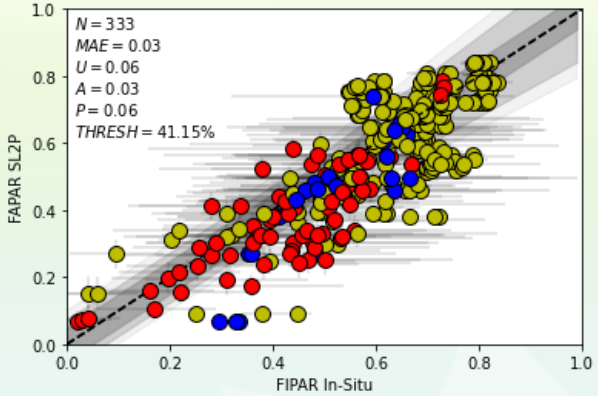
- **Needleaf Forest**
- **Broadleaf Forest**
- **Mixed Forest**

Symbol size proportional to clumping

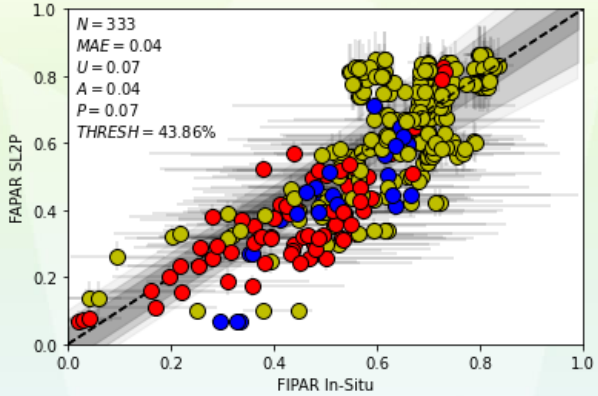


Results-fAPAR

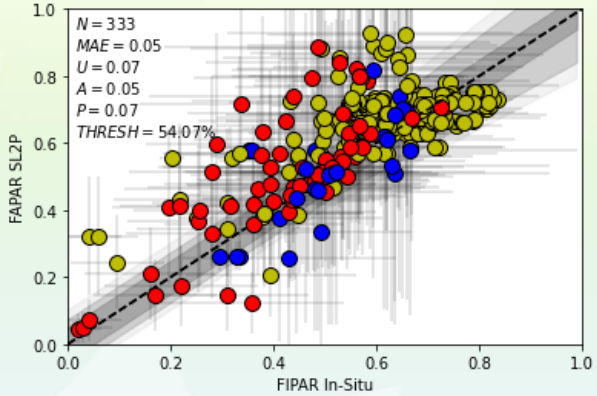
H(0): SL2P



H(a): CCRS-SAIL



H(b)CCRS-FLIGHT

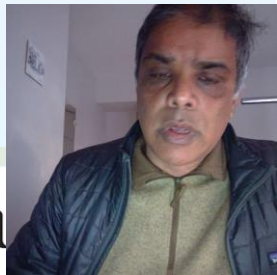


- **Needleaf Forest**
- **Broadleaf Forest**
- **Mixed Forest**

Symbol size constant (not proportional to clumping)

Discussion

- In-situ, algorithm standard errors sufficient to test hypotheses for large (>300) sample sizes
- Google Earth Engine facilitates large area validation (using LEAF-Toolbox)
- LAI:
  - SL2P biased LAI>2 due to lack of clumping
  - SL2P+clumping decreased bias but increased precision error vs SL2P
  - FLIGHT+species lower bias even greater precision error than SL2P
- fAPAR
  - SL2P and SL2P+clumping similar



Recommendations

- LAI<2 and fAPAR: H(0) SL2P recommended
- LAI>2 H(a) SL2P+clumping recommended due to low H(b) precision
- How can we increase H(b) precision LAI>2
  - Other inversion algorithms
  - Ancillary datasets, high res imagery to constrain clumping
  - Temporal smoothing to reduce uncertainty due to input error
  - Calibration using in-situ reference measurements
- SL2P+clumping should be implemented and compared to MODIS an