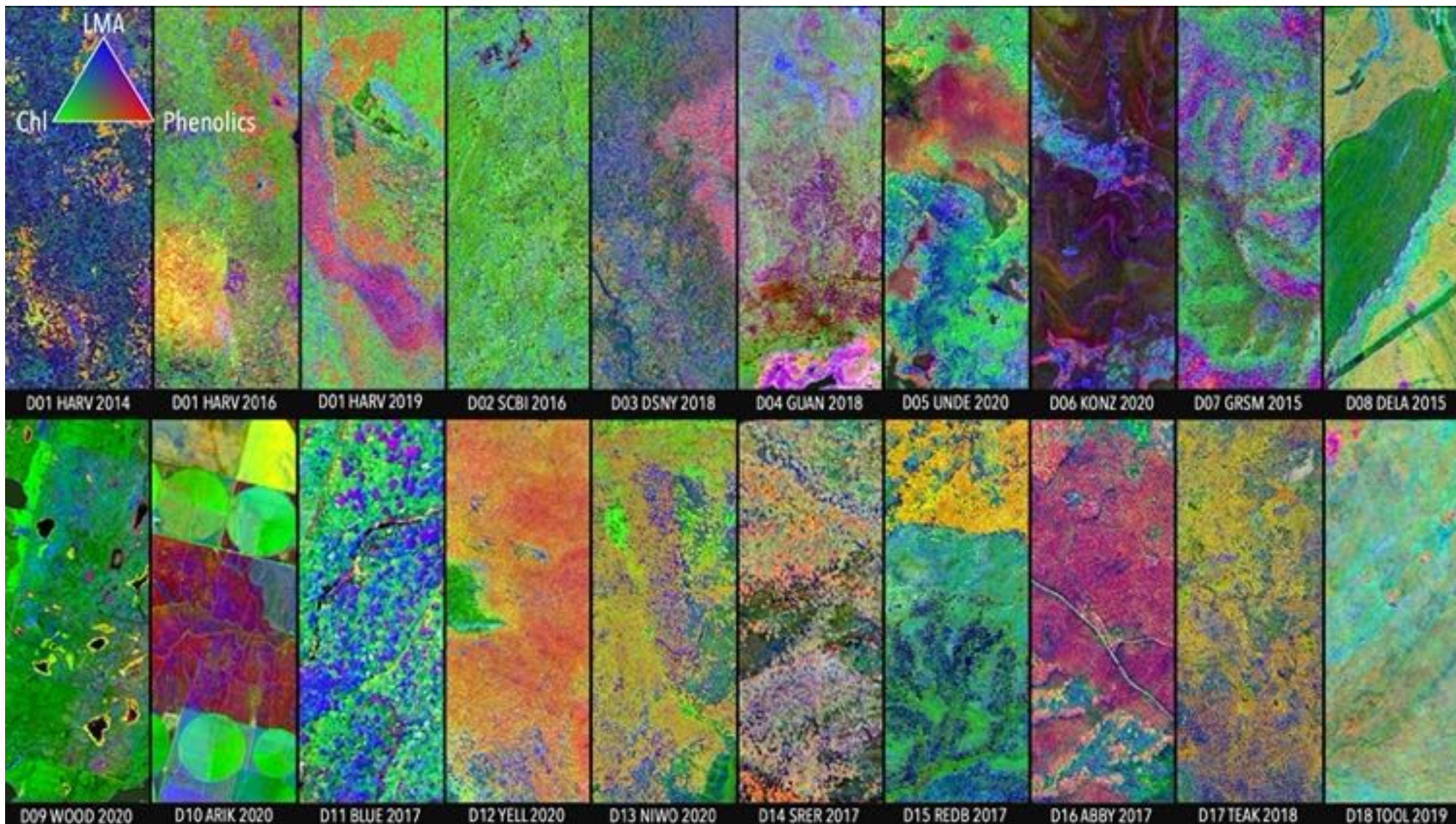




Synergies among proposed vegetation products for upcoming spaceborne imaging spectroscopy missions



Phil Townsend




Image by Kyle Kovach





CHIME and SBG Target Products

CHIME

DOMAIN	THEMATIC AREA	VARIABLES CHPPP	CHIME Candidate Algorithms
AGRICULTURE / FOOD SECURITY	Assessment of biophysical and biochemical variables related to the crops and of agronomic interest 	Leaf/Canopy Pigment Content	Semi-empirical modelling based on narrow-band vegetation indices; Hybrid methods based on ANN/LUT or other machine learning algorithms applied to vegetation canopy radiative transfer models outputs (e.g. PROSAIL).
		Leaf/Canopy Nitrogen Content	
		LAI	Narrow-band vegetation indices; Hybrid methods based on ANN/LUT or other machine learning algorithms e.g. GPR methods applied to vegetation canopy reflectance models (e.g. PROSAIL).
		Canopy Water Content	
		Leaf/Canopy Pigment Content	
Leaf Mass/Area			

SBG

Cover Classifications	Cloud, Water, Land Cover, Plant Functional Types, etc.
PRODUCT Algorithms	
Terrestrial Ecosystems	
Vegetation Traits	Nitrogen, LMA, Chlorophyll, Canopy water
Evapotranspiration	ET*, Evaporative stress index
Proportional Cover	GV, NPV, Substrate, Snow/Ice, Burned Area

SBG Algorithm Working Group

Initial Conclusions:

- Algorithms for plant traits, plant species / vegetation types and biodiversity are immature for application at global scale
- Rich heritage at local to regional scales that can be leveraged

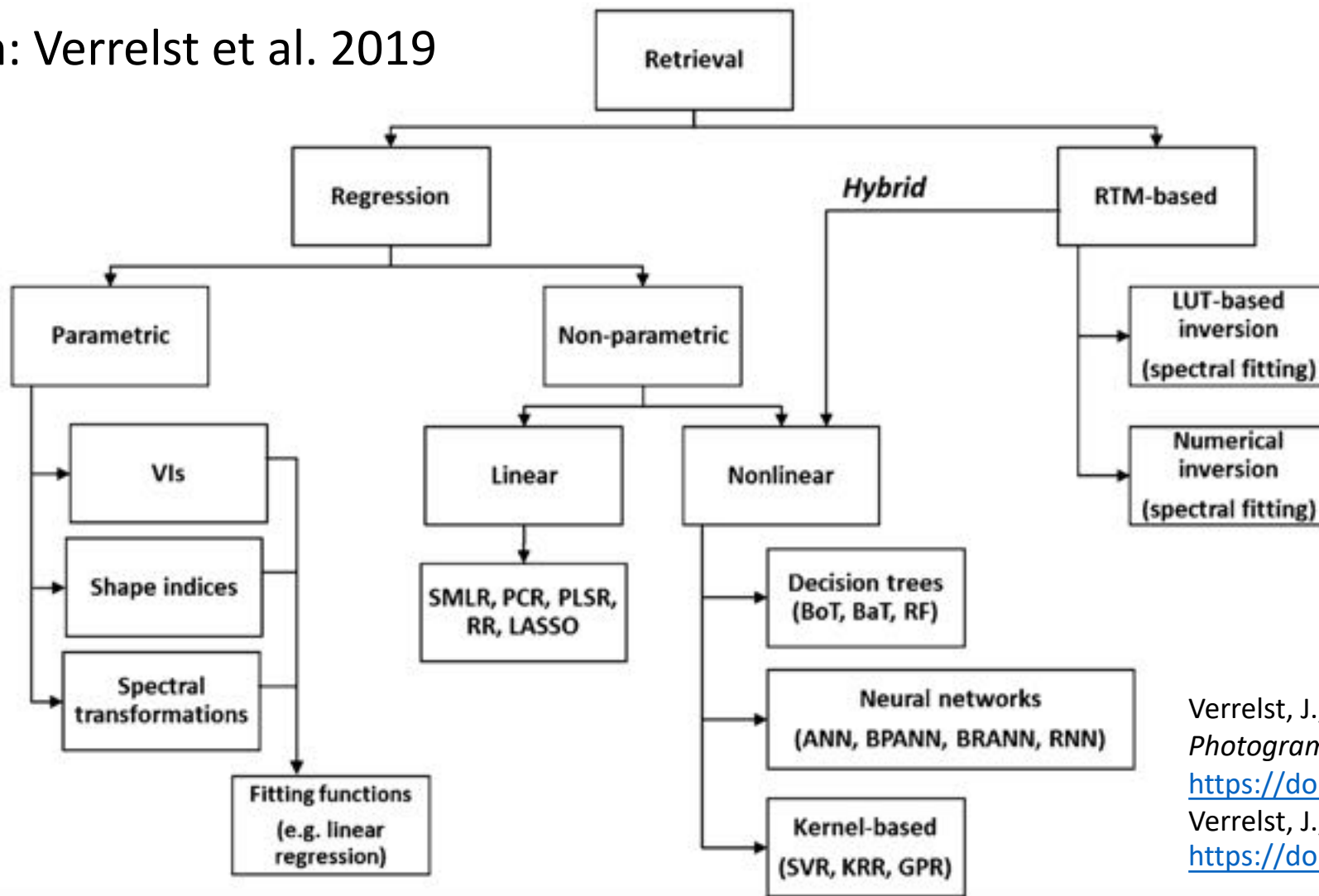
- Vegetation → *Focus Agriculture*
 - Leaf Canopy Nitrogen Content
 - Leaf Canopy Pigment Content
 - Leaf Area Index
 - Canopy Water Content
 - Leaf Mass per Area (LMA, SLA)
- Vegetation → *Focus Natural Vegetation*
 - Foliar Nitrogen
 - Chlorophyll
 - Canopy Water Content
 - Leaf Mass per Area (LMA, SLA)
 - Fractional Cover (GV, NPV)
 - Substrate, Soils, Water, Snow, Ice
 - Biodiversity Metrics





Taxonomy of Algorithms

From: Verrelst et al. 2019



Trait Algorithms

Initial thoughts:

- Physical models (hybrid) likely tractable for simple canopies (crops)
- Data-driven approaches current necessity in natural ecosystems

Verrelst, J., et al., 2015. *ISPRS Journal of Photogrammetry and Remote Sensing* 108, 273–290. <https://doi.org/10.1016/j.isprsjprs.2015.05.005>

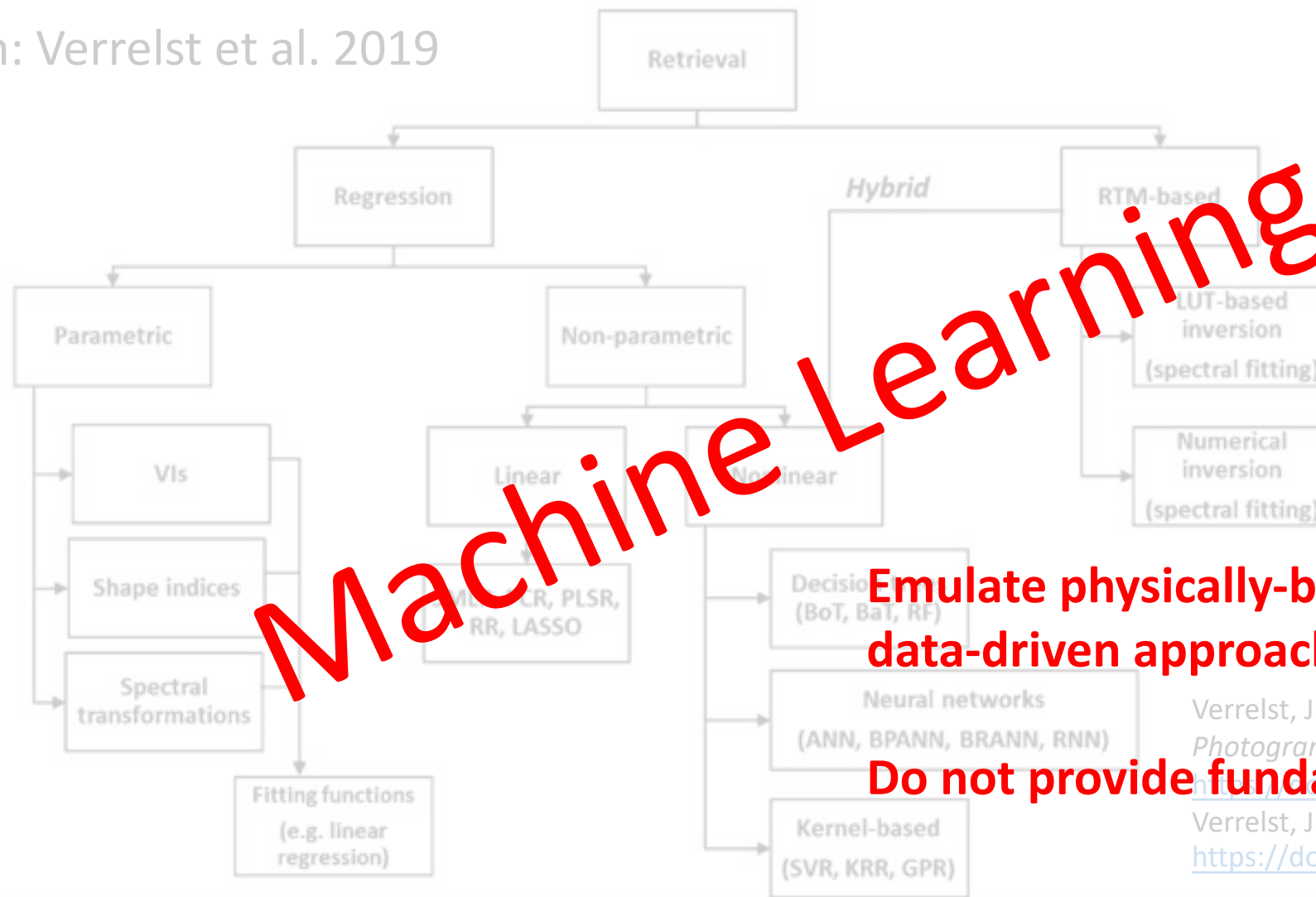
Verrelst, J., et al., 2019. *Surv Geophys* 40, 589–629. <https://doi.org/10.1007/s10712-018-9478-y>





Taxonomy of Algorithms

From: Verrelst et al. 2019



Trait Algorithms
Initial thoughts:

- Physical models (hybrid) likely tractable for simple canopies (crops)
- Data-driven approaches current necessity in natural ecosystems

Emulate physically-based, hybrid and/or data-driven approaches

Do not provide fundamental understanding

Verrelst, J., et al., 2015. *ISPRS Journal of Photogrammetry and Remote Sensing* 108, 273–290.

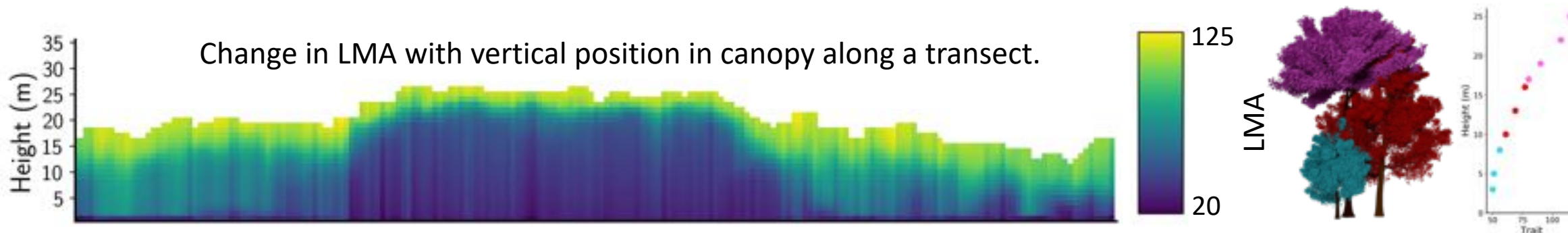
Verrelst, J., et al., 2019. *Surv Geophys* 40, 589–629. <https://doi.org/10.1007/s10712-018-9478-y>





CHIME and SBG Vegetation Product Definitions

Vegetation Traits: **Leaf Mass per Area (LMA):** units g m^{-2}
~Specific Leaf Area (SLA): units $\text{cm}^2 \text{g}^{-1}$ or $\text{m}^2 \text{kg}^{-1}$



Key points:

- LMA is a leaf-level measurement.
- LMA maps \rightarrow top of canopy (TOC) trait value.
- LMA changes with light environment in a crown.
- Good prospects for harmonization of TOC LMA.





CHIME and SBG Vegetation Product Definitions

Vegetation Traits: Leaf / Canopy Chemistry Content
i.e., Nitrogen/Chlorophyll/Water Content

Units Matter: Conventionally by plant physiologists:
Concentration is a mass-based measurement
(e.g. %N or N_{mass}) mg g^{-1}
Content is an area-based measurement
(e.g. N_{area}) g m^{-2}
 $N_{\text{mass}} \times \text{SLA} = N_{\text{area}}$ but only top-of-canopy (leaf)

Mass vs. area based measurements both have important applications.





CHIME and SBG Vegetation Product Definitions

Vegetation Traits: Leaf vs Canopy Chemistry

Leaf vs Canopy: Canopy measurements require leaf area index (LAI) $\text{m}^2 \text{m}^{-2}$ to scale properly
LAI is tractable in simple canopies (low LAI)
Canopy level estimates will require modeling
Leaf level estimates may be more tractable, but will be restricted to top-of-canopy

Leaf and canopy level measurements both have value.

Photosynthesis occurs at the leaf level.

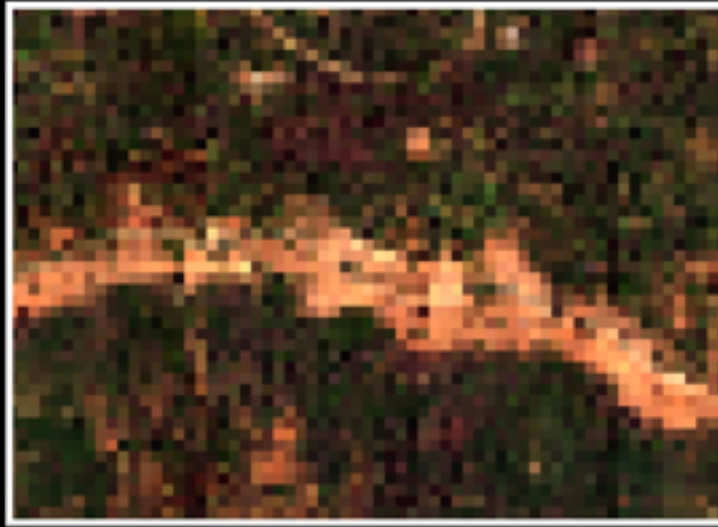


Key conclusions: 1) Need for common calibration / validation / training data sets, regardless of algorithms used; 2) Need multi-scale data-- in-situ samples, UAV, aerial images, global/repeat

Leaf Mass per Area (LMA)



NEON 1m



NEON 1m aggregated to 14m



AVIRIS-Classic 14m

