

Commercial Satellite Data (CSD) Analysis for Characterizing Canopy Chlorophyll and Photosynthetic Productivity for Agricultural and Forest Monitoring

PI Petya Campbell; Co-Is: Jana Albrechtova, Jon Atherton, K. Fred Huemmrich, Junchang Ju,
Petr Lukes, Chris Neigh, and Albert Porcar Castel

Objectives

- 1) Using existing CSD data and field measurements of photosynthetic pigments and GPP, produce algorithms and extrapolate at VHR the field data from the sampled plots to the homogenous canopy within the site and image, separately for crops and forests. The outputs include algorithms and VHR resolution Cab and GPP datasets.
- 2) Using the VHR Cab and GPP datasets with the HLS data produce robust algorithms, to demonstrate that the CSD provides reliably a bridge, to extrapolate the full range and spatio-temporal dynamics in Cab and GPP, to a larger/regional extent. The outputs include VHR and mid-resolution Cab and GPP algorithms and seasonal datasets, for crops and forests.
- 3) At VHR and 30 m resolution produce seasonal time series of Cab, GPP and 'function/stress estimates', as the difference between optimal vs. observed vegetation traits for the study regions.

Table 2. Study sites, location, vegetation type, available field collections and commercial satellite data (CSD) assets

Study site e and location lat/lon)	Vegetation Type	Site, Canopy and Climate Description (size, canopy age, height, mean annual temperature)	Field Data+	Network	CSD Assets number images
OPE3 , Greenbelt, MD, USA (39.030686, -76.84546)	Maize and Soybean, high-low nitrogen (N), rainfed and irrigated treatments	22 ha; 0.0-2.5 m height; 22 T°C; 50 m asl; warm temperate climate - large CCab/GPP gradient	2012-2020, 2023; sampled 3-7 times/season, D-FL0X: 2017-2019, 2023	LTAR ¹ , eddy covariance (EC) data 2012-current	WV 65 ⁺ , Planet++ 680, DESIS 11, PRISMA 14
Mead, NE, USA (41.1649, -96.4701)	Maize-soybean rotation, optimal N; NE-3 is rainfed and NE-1,-2 irrigated	3 sites ~400 m diameter; 0-2.2 m height; 10 T°C - continental climate; providing large CCab gradient	Cab, LAI, CCab 2018, sampled 3-5 times/season	Fluxnet ² , EC data 2017-current	WV 11, Planet 653, DESIS 14, RPISMA 9
MD, USA (38.888253, -76.561471)	Mixed hardwood forest, dominated by tulip poplar (<i>L. tulipifera L.</i>)	~ 2.5 km ² , 110-120 years, ~ 40 m height, LAI ~ 2-6 ± 0.5, 20 T°C, 100 m asl	2017-2019, 3 times/season, D-FL0X: 2020-2021, 2023	ForestGEO ⁴ NEON ³ , EC data 2018-current	WV 12, Planet 502, DESIS 26, PRISMA 6
Lanžhot , Czech Republic (CZ)	Deciduous hard-wood floodplain forest, very diverse	17 plots in 90+ m areas, 100+ years, 150 m asl, variable height, 9.5 T°C, 533 mm precipitation	2019-2020, 436 samples, sampled 2-5 times/season	Fluxnet, ICOS ⁵ , eLTER ⁶ EC data 2018-current	Planet 609, DESIS 6, PRISMA 7
Štítná (STI) , CZ (49.035702, 17.969308)	Monospecific mountainous beech forest (<i>Fagus sylvatica L.</i>)	10 plots in 90+ m areas, 116 years, 540 m asl, 28 m height, 8.3 T°C, 770 mm precipitation	2020-2021, 208 samples, sampled 2-5 times/season	Fluxnet, ICOS ⁵ , eLTER EC data 2018-current	Planet 290, DESIS 7, PRISMA, 5
Bily Kriz (BK) , CZ (49.502115, 18.539068)	Monospecific Norway Spruce forest, two age cohorts (<i>Picea abies L.</i>)	10 plots in 90+ m areas, 44-70+ years, 850-908 m asl, height and LAI vary, 6.7 T°C, 1239 mm precip.	2020-2021, 282 samples, sampled 2-5 times/season	Fluxnet, ICOS ⁵ , eLTER ⁶ EC data 2018-current	WV 7, Planet 281, DESIS 9
Hyytiälä (HYY) , Finland (61.84741, 24.29477)	Boreal forest dominated by Scots pine (<i>Pinus sylvestris L.</i>)	10.5 ha, 4 plots 50 m diam., 181 m asl, 3.5 T°C, 711 mm precipitation, variable height and LAI	2010, 2014, 2015, 2017 sampled 1-3 times/year	Fluxnet, ICOS, eLTER, EC data 2014-current	WV 8, Planet 275, PRISMA 8

+ Field data include: seasonal profiles in LAI, bio-chemical parameters (Cab, Car, SLA, water content EWT); canopy height (m); annual crop yield; diurnal & seasonal continuous canopy reflectance for OPE3 & SERC (D-FL0X); eddy covariance tower data; leaf reflectance & transmittance; quantification of inner leaf structure for Czech sites; airborne hyperspectral and thermal images for Czech sites.

¹Long Term Agricultural Research (LTAR), ²Fluxnet, ³National Ecological Observatory Network, ⁴ForestGEO, ⁵Integrated Carbon Observation System, ⁶European Long-Term Ecosystem Research (eLTER), ++PlanetScope RapidEye & SuperDoves

CSD Filtering and stratification to CROPS and FORESTS

DESIS
30m Reflectance

WV-2,-3 & PlanetScope
5m Reflectance

Field Data
Cab, Ccar, LAI, H m
GPP, PARI, T°C
reflectance

HLS (L-8, S-2)
Filtering and stratification to
CROPS and **FORESTS**

CROPS | FORESTS
separately

SCOPE RTMo

Modeled bio-
physical traits

**SCOPE
simulations**

Modeled
30m CCab, GPP

CROPS | FORESTS
separately

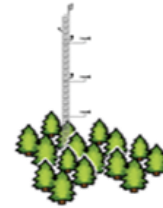
Reflectance Bands
VIs sensitive to
CCab and GPP

ARTMO/MLRA

Algorithms CCab, GPP

**5m CCab and GPP
Time series**

**30m CCab and GPP
Time series**



training
validation

Predicted vs. observed
GPP & CCab

training
validation

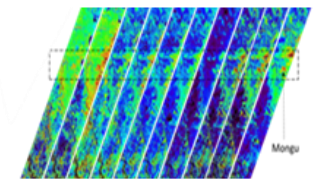
CROPS | FORESTS
separately

Reflectance Bands
VIs sensitive to
CCab and GPP

ARTMO/MLRA

**30m CCab, GPP
Time series**

Evaluated against flux
tower GPP and field CCab



estimates with regional
and larger extent

Additional image stratification
to improve GPP & CCab estimates

Evaluation
of GPP & CCab