















Satellite-based Evapotranspiration Modeling and Hyperspectral Imaging for Regional Indicators of Droughts in Ethiopia: The SEMHy-ARID project

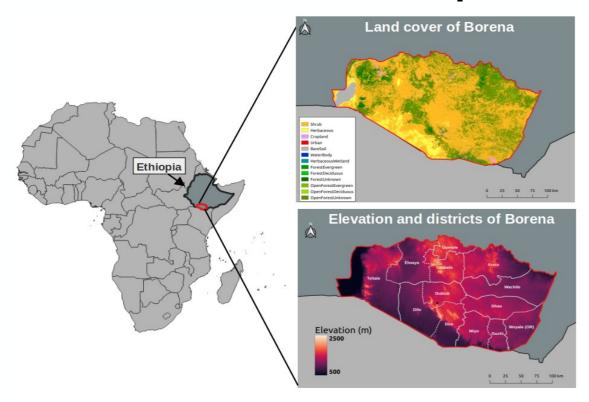
María Dolores Raya-Sereno, Vicente Burchard-Levine, Tinebeb Yohannes, Elias Cherenet, Héctor Nieto, Fatma Trabelsi, Abebe Mohammed Ali

Living Planet Symposium 23-27 June 2025

1. Objectives



Borena, Southern Ethiopia



Mean Annual Precipitation ~ 350 mm/year

Two main rainy seasons: March to May and Oct to Nov

- Rangelands: high dependence on pastoral activities
- Recent drought events (2019-2022) have devastated the region

Main objective

Improve EO-based drought indicators using satellite imagery suited for semi-arid rangeland conditions





2

1. Objectives



Previous project

EO-DBE project (2022-2023)



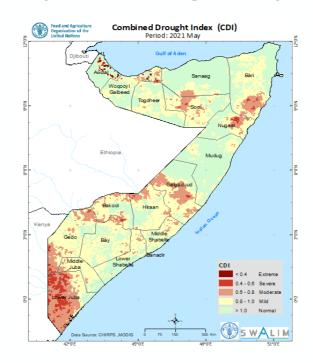
Cloud-based composite drought index (CDI) which integrated both meteorological and multispectral datasets to better account for vegetation's response to droughts



COPERNICUS satellites

Composite Drought Index (CDI)

- The **CDI** integrates **many variables** into one combined index
- Simple to implement and easy to communicate policymakers and general public



CDI = f(Precip, Ta, NDVI)



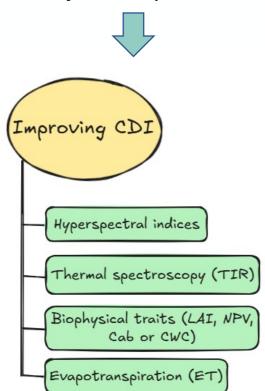
Used by **FAO-SWALIM** (in Somalia)

1. Objectives



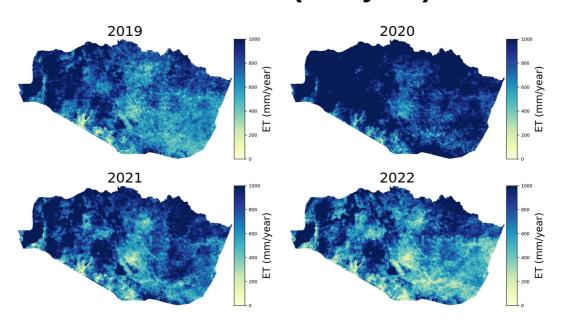
Actual project

SEMHy-ARID (2024-2026)



Studies¹ have shown that **evapotranspiration (ET)** has faster response to water deficit compared to NDVI or spectral indices (especially for **semi-arid regions**)

Annual ET (mm/year)



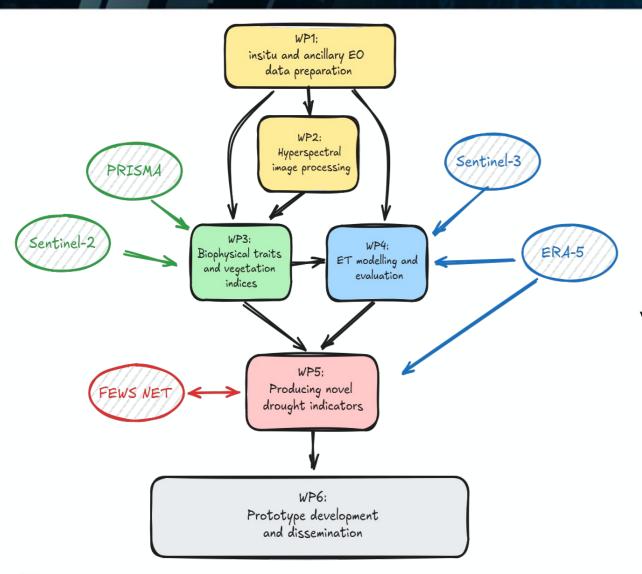
3SEB Sentinel-3 results (300m)

¹Joiner, J., Yoshida, Y., Anderson, M., Holmes, T., Hain, C., Reichle, R., Koster, R., Middleton, E., & Zeng, F.-W. (2018). Global relationships among traditional reflectance vegetation indices (NDVI and NDII), evapotranspiration (ET), and soil moisture variability on weekly timescales. Remote Sensing of Environment, 219, 339–352. https://doi.org/10.1016/j.rse.2018.10.020

→ THE EUROPEAN SPACE AGENCY

2. Methodology





Research team members



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Héctor Nieto (Tech4Agro, CSIC)



Tinebeb Yohannes (World Resources Institute)







Fatma Trabelsi (University of Jendouba)

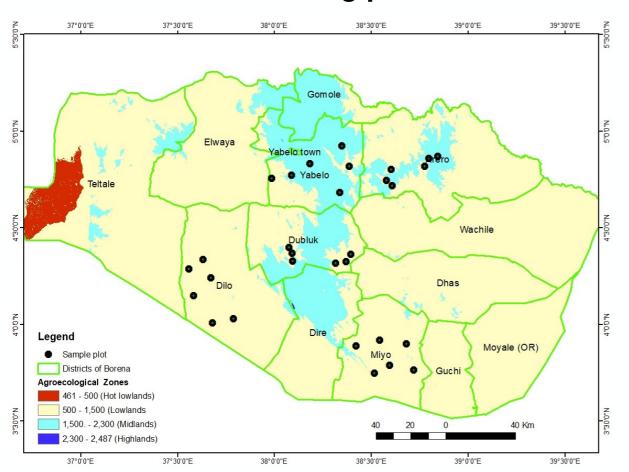
3. Update of progress

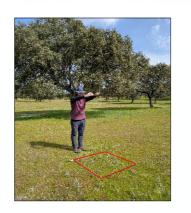


WP and ta	asks									١	∕lont	hs						
		Leader	Participants	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
WP1	In situ and ancillary EO data collection						wo	RK										
T1.1	Ancillary EO data preparation (LULC, DEM)	EC	TY, FT, AMA, MDRS				II	N— RESS	:									
T1.2	Validation dataset collection and processing	AMA	EC, FT, TY, VBL															
WP2	Hyperspectral image processing																	
T2.1	Acquisition and pre-processing of PRISMA imagery	MDRS	AMA, EC				(\checkmark))										
WP3	Estimating biophysical traits & vegetation indices																	
T3.1	Retrieval Biophysical traits (LAI, NPV, Fg, CWC) and vegetation indices with with S2/3 and PRISMA	MDRS	AMA, HNS, EC, VBL															
WP4	ET modelling & evaluation											W	ORK IN—					
T4.1	Retrieval of daily ET with TSEB/3SEB	VBL	HNS, EC, FT, TY									PRO	GRESS	;				
T4.2	Validation of daily ET against flux towers	VBL	HNS, EC, FT, TY)				
WP5	Producing novel drought indicators																	
T5.1	Computing monthly and seasonal drought indicators	TY	AMA, MDRS, VBL, HNS															
T5.2	Spatio-temporal analysis of drought occurence	FT	EC, TY, MDRS, VBL															
WP6	Prototype development & dissemination																	
T6.1	Midterm progress report	AMA	MDRS, VBL, TY, EC, FT, HNC								1							
T6.2	ESA Living Planet symposium participation	TBC	TBC							(\mathscr{I}				\rightarrow	$\overline{}$		
T6.3	Final report	MDRS	AMA, VBL, TY, EC, FT, EC															
T6.4 T6.5	Open source code and repository Peer reviewed article submission	VBL AMA	AMA, MDRS, HNS, TY, FT, EC MDRS, VBL, TY, EC, FT, HNS															



WP1. Protocol for taking pictures







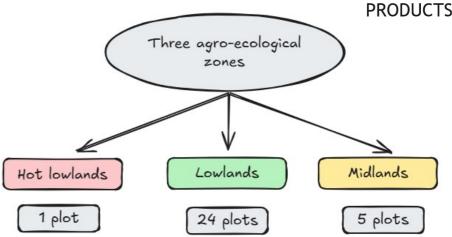
TO SUPPORT
VALIDATION OF
REMOTE SENSING

BRIEF DESCRIPTION
Protocol for in situ pictures acquisitions
in grasslands using and smartphone and
the Epicollect app

aría del Pilar Martín Isabel aría Dolores Raya Sereno Icente Burchard Levine



epicollect5



June 2025 → dry season October 2025 → rainy season



WP1. Protocol for taking pictures

June 2025 → dry season 🕢



AAAS Plant Phenomics Volume 2022, Article ID 9803570, 17 pages https://doi.org/10.34133/2022/9803570



Taking photos in the field



epicollect5



Cut the photos to 1 x 1 m dimensions





Research Article

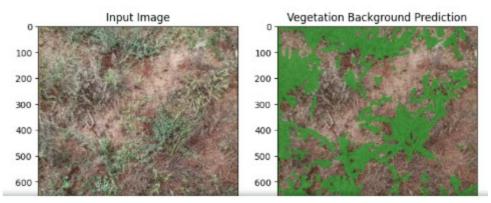
SegVeg: Segmenting RGB Images into Green and Senescent Vegetation by Combining Deep and Shallow Methods

Mario Serouart (1), 1,2 Simon Madec, 1,3 Etienne David, 1,2,4 Kaaviya Velumani, 4 Raul Lopez Lozano (1), 2 Marie Weiss (1), 2 and Frédéric Baret (1)



https://github.com/mserouar/SegVeg

RAW Proporciones para Z1_P1_S1.png: Green vegetation (RAW) : 30.45% Senescent vegetation (RAW) : 62.61% Soil (RAW) : 6.94% ### XGBoost Model ###





WP2. Hyperspectral imaging processing



Download images (level 2D)

Geometric correction and quality check

Radiometric correction and quality check

45 PRISMA images from 2020 to 2024 (cloud < 10%)

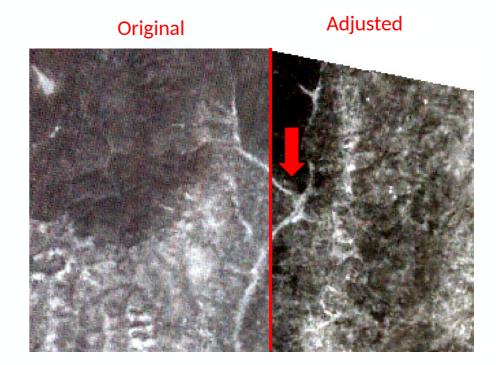


Automated and Robust Open-Source Image Co-Registration Software

https://github.com/GFZ/arosics

Removal of atmospheric and noise bands (comparison with ASD)









WP3. Estimating biophysical traits

Table 4. PROSAIL radiative transfer model input parameters used to build the look-up table (LUT) and the corresponding values for wetland, taiga, and tundra biomes.

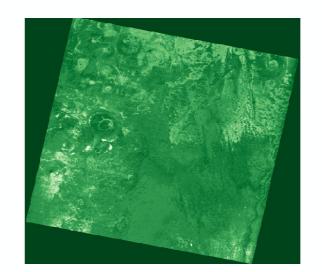
Parameter	Symbol	Unit	Range or fi	Range or fixed Values				
1 manifester	- ,	Citi	Min	Max				
Leaf dry mass per area	C _m	g/cm ²	0.003	0.025	[54]			
Equivalent water thickness	Cw	g/cm ²	0.005	0.035	[54]			
Leaf structural parameter	N		1.2	2.2	[54]			
Chlorophyll content	C_{ab}	μg/cm ²	5	70	[56]			
Carotenoid content	Car	μg/cm ²	8		[57]			
Anthocyanin content	Ant	μg/cm ²	0		[57]			
brown pigment content	C_{brown}		0		[57]			
Leaf area index	LAI	m^2/m^2	0.2	8	[56]			
Leaf inclination distribution function type	$Type_{Lidf}$		2	[57]				
Leaf inclination distribution function a	LID_{Fa}	degree	20	70	[56]			
Leaf inclination distribution function b	LID_{Fb}		()	[57]			
Hot spot factor	$H_{\rm spo}t$		0.5/	[58]				
Soil reflectance factor	Psoil		0.3	0.6	[57]			
Sun zenith angle	t_{s}	degree	25	35	Sentinel-2 metadata			
Observation zenith angle	t_0	degree	0	15	Sentinel-2 metadata			
Azimuth angle	psi	degree	50	210	Sentinel-2 metadata			



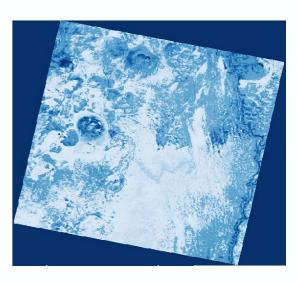


https://github.com/hectornieto/pypro4sail

CAB – 20200618 Min 36 – Max 60 μg/cm²



CWC - 20200618 Min 0 - Max 0,01 g/cm²



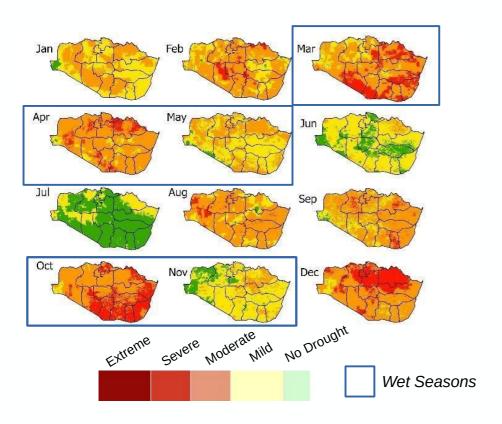
Ali, A. M., Darvishzadeh, R., Skidmore, A., Heurich, M., Paganini, M., Heiden, U., & Mücher, S. (2020). Evaluating Prediction Models for Mapping Canopy Chlorophyll Content Across Biomes. *Remote Sensing*, *12*(11), 1788. https://doi.org/10.3390/rs12111788

5. Next steps



WP5. Producing novel drought indicators

CDI results for 2021



WP6. Prototype development & dissemination

- Improve open-source CDI for the Borena region based on:
 - Hyperspectral indices
 - Biophysical traits
 - Evapotranspiration
- Jupyter notebook to document, disseminate and run CDI







Thank you for your attention







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