Intra- and Inter-annual vegetation dynamics in Eastern Africa (EA) revealed by Solar-Induced chlorophyll Fluorescence (SIF)

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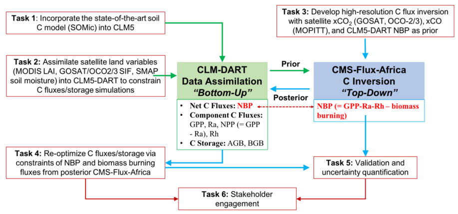
Background, Motivation, Objective

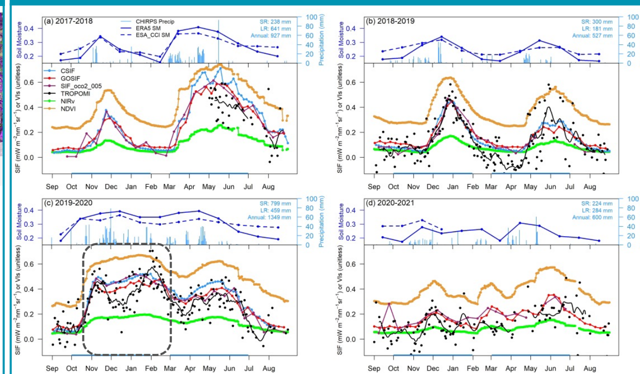
Motivation: Following the 2015 Paris Agreement, countries worldwide are actively taking measures to mitigate climate change by reducing greenhouse gases (GHGs) emissions, which fundamentally altered the traditional practices for carbon monitoring, reporting, and verification (MRV). This is particularly true in East Africa (EA), where large-scale land restoration programs have been actively pursued for sustainable development. These efforts can significantly reshape the dynamics and evolution of terrestrial carbon sources/sinks, yet considerable uncertainties exist regarding their magnitude and trajectories. Thus, there is a critical need for an accurate carbon monitoring system in EA that can be used to monitor carbon sinks/sources, verify climate impact, inform ongoing and future land and carbon management programs

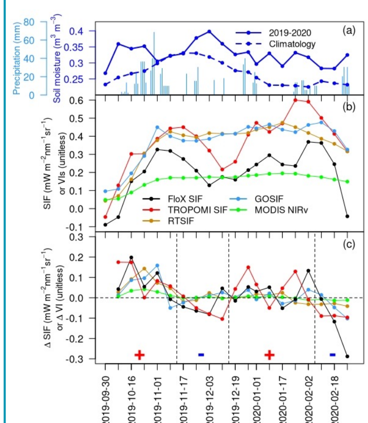
Ethiopian's Land Restoration Program

Objective: *Develop the first CMS prototype in EA that integrates "bottom-up" land model simulations constrained by multiple satellite observations and "top-down" carbon inversion to quantify carbon budgets at 0.5° x 0.625° (2009-2024 or beyond)*

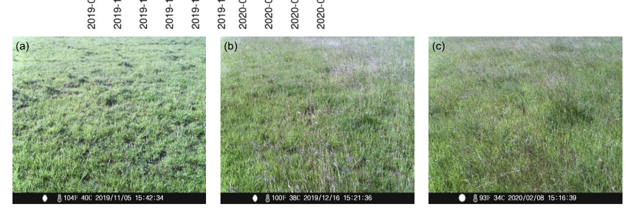


Intra-annual SIF Dynamics from 2017 to 2021 at Kapiti

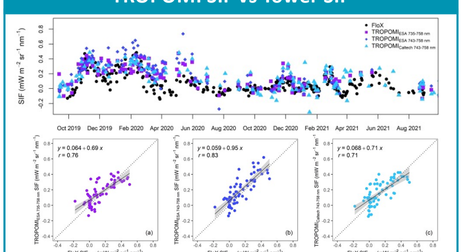




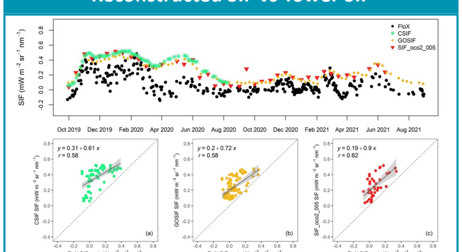
- TROPOMI SIF presented a strong and persistent reduction (~41%), consistent with tower SIF (46%), while the three OCO-2 based reconstructed SIF products only showed a slight and transient reduction (12%).
- The temporal changes of satellite SIF (ΔSIF) exhibits greater variation than that of VI (ΔVI); while the former is more consistent with in-situ measurements.



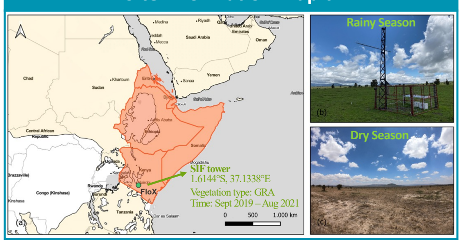
TROPOMI SIF vs Tower SIF



Reconstructed SIF vs Tower SIF

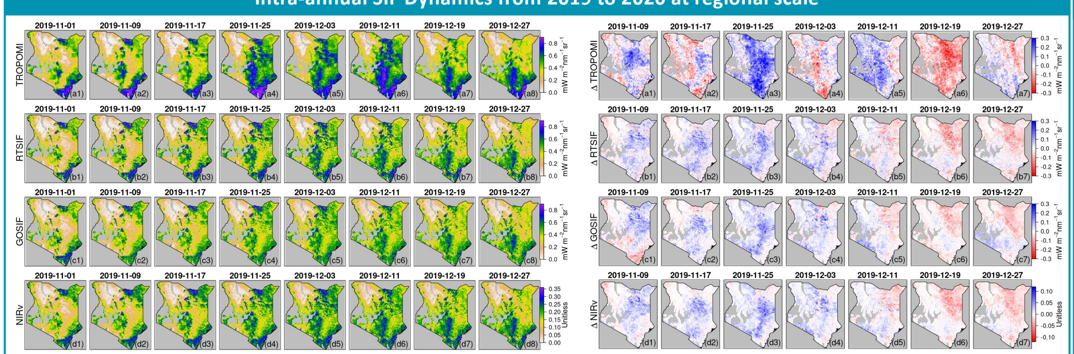


Site Information: Kapiti



Data	Spatial resolution	Temporal resolution	Temporal coverage	Reference
TROPOMI	7 km along track and 3.5–15 km across track	Daily	May 2018 - present	Köhler et al., 2018; Guanter et al., 2021
RTSIF	0.05°	8 day	2000 - 2020	Chen et al., 2022
CSIF	0.05°	4 day	2000 - 2020	Zhang et al., 2018
GOSIF	0.05°	8 day	2000 - 2022	Li & Xiao, 2019
SIF_oco2_005	0.05°	16 day	2014 - 2021	Yu et al., 2019
MODIS NBAR	500 m	Daily	2000 - 2023	Schaaf & Wang, 2021
CHIRPS precipitation	0.05°	Daily	1981 - 2023	Funk et al., 2015
ESA-CCI soil moisture	0.25°	Daily	1978 - 2022	Preimesberger et al., 2021
MODIS LST	0.05°	Monthly	2000 - 2023	Wan et al., 2021
DEM	90 m	2000	2000	NASA JPL, 2013
MODIS LC	0.05°	Annual	2000-2023	Friedl and Sulla-Menashe, 2022

Intra-annual SIF Dynamics from 2019 to 2020 at regional scale



Key Points

We report the first tower-based SIF measurements in the Horn of Africa (HoA) collected at a grassland site

We perform the first validation of satellite SIF products in the HoA drylands
- TROPOMI: r = 0.71 - 0.83
- Three OCO-2 based reconstructed products: r = 0.58 – 0.62

All satellite SIF products can generally capture the intra- and inter-annual variations, but only TROPOMI can better capture the fast-changing intra-annual dynamics.