



Assessment of terrestrial carbon stocks from regional to agricultural landscapes using SMAP-L4 Carbon Net Ecosystem Exchange dataset: review and application (Maradi, Republic of Niger)

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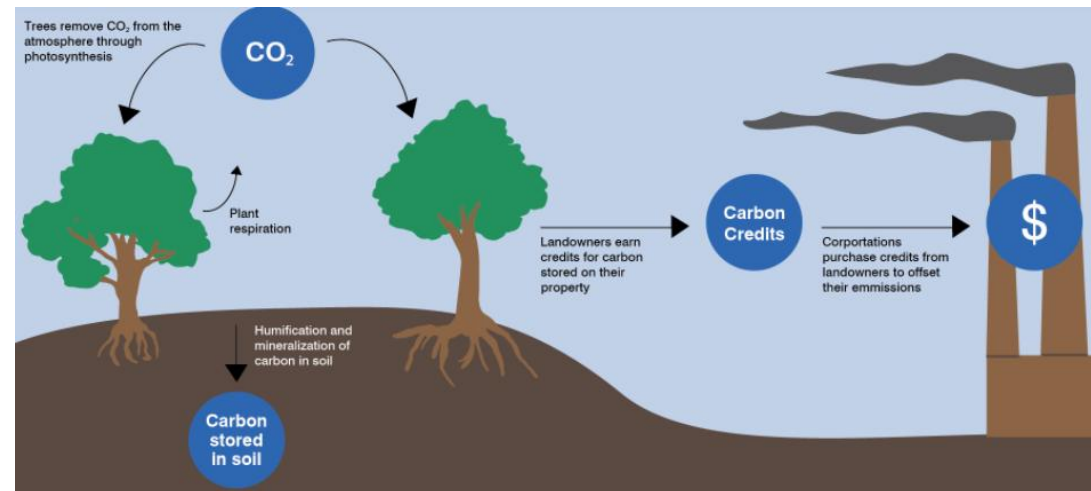


**SUSTAINABLE
DEVELOPMENT
GOALS**
17 GOALS TO TRANSFORM OUR WORLD



SDGs & Climate change mitigation : toward a regionalized Man-Environment monitoring centre

- ODDs to reach...
- Climate change mitigation...
- Functionment of the terrestrial C cycle in agroecosystems



Satellite observation dataset within a larger systemic/holistic observatory

Hot semi-arid biomes and their soils as sinks of global C:

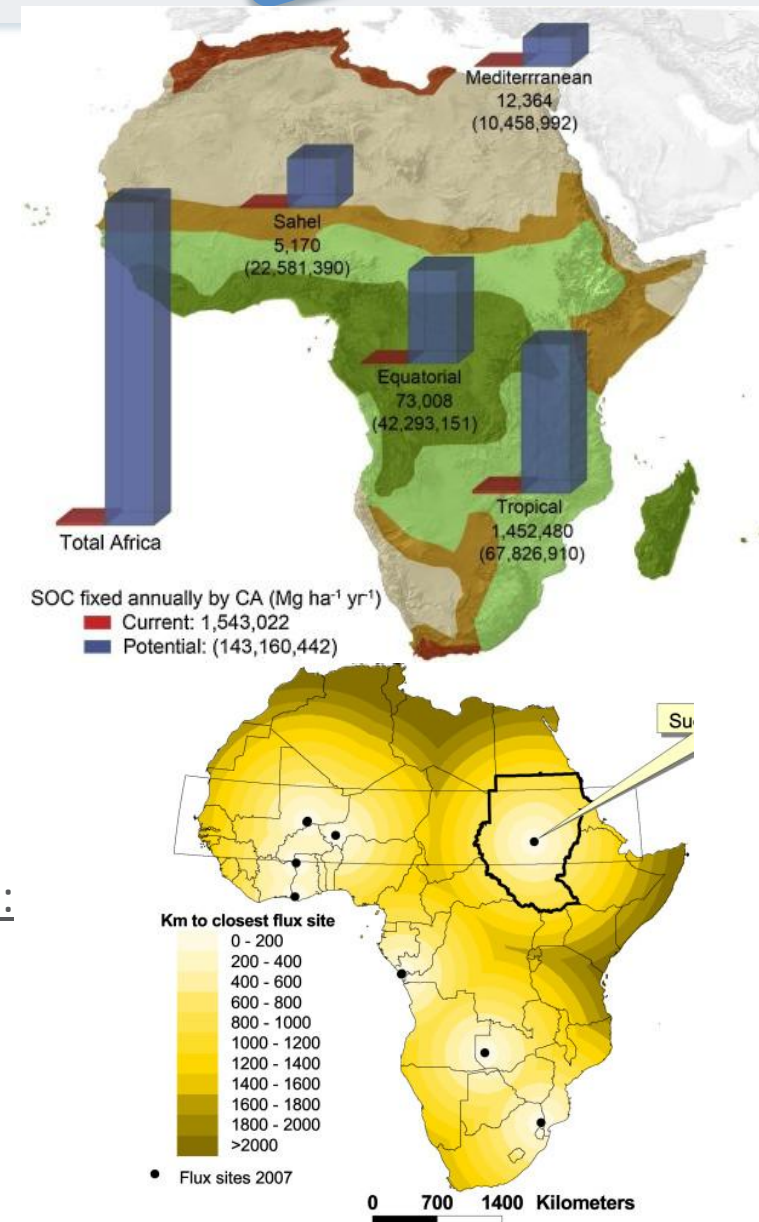
- ~ 50% of emerged land (IPCC, 2021)
- Very high levels of Net Ecosystem Exchanges (Tagesson et al., 2015)

Influence of sahelian agroecosystems on the continental carbon cycle:

- Strong dependencies to pluvial systems mixing agriculture with pastoralism
- High population rates = high needs
- Policies: re-forestation, setting up of Natural Regeneration Techniques and inscription within Rural Code (i.e. Republic of Niger)

Terrestrial carbon related metrics, indicators, products and analysis:

- Strong needs to be observed, surveyed, assessed, routined, mapped from a holistic way

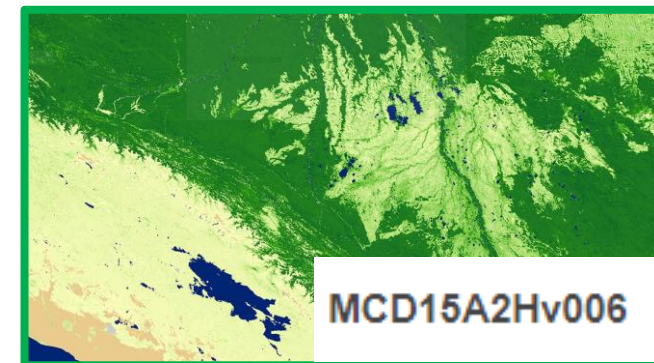
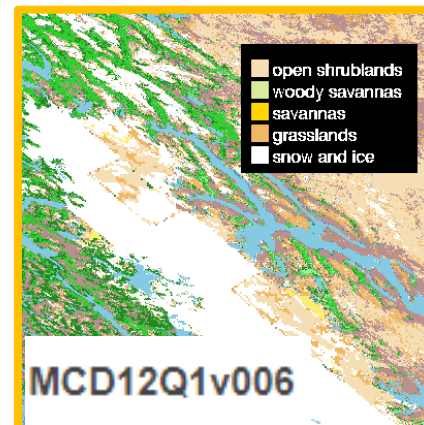
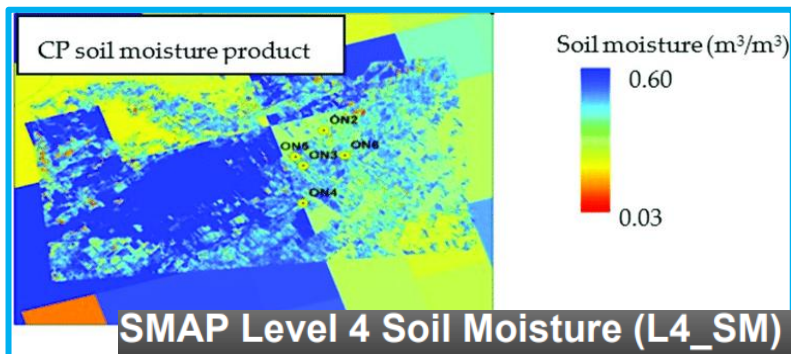


1. What are SMAP Carbon products? What could(nt) they say?
2. Pre-processing of SMAP Carbon products for applied uses?
3. Carbon exchanges increasing/decreasing in central Sahel?
4. Interannual variability? Differences between landscapes?

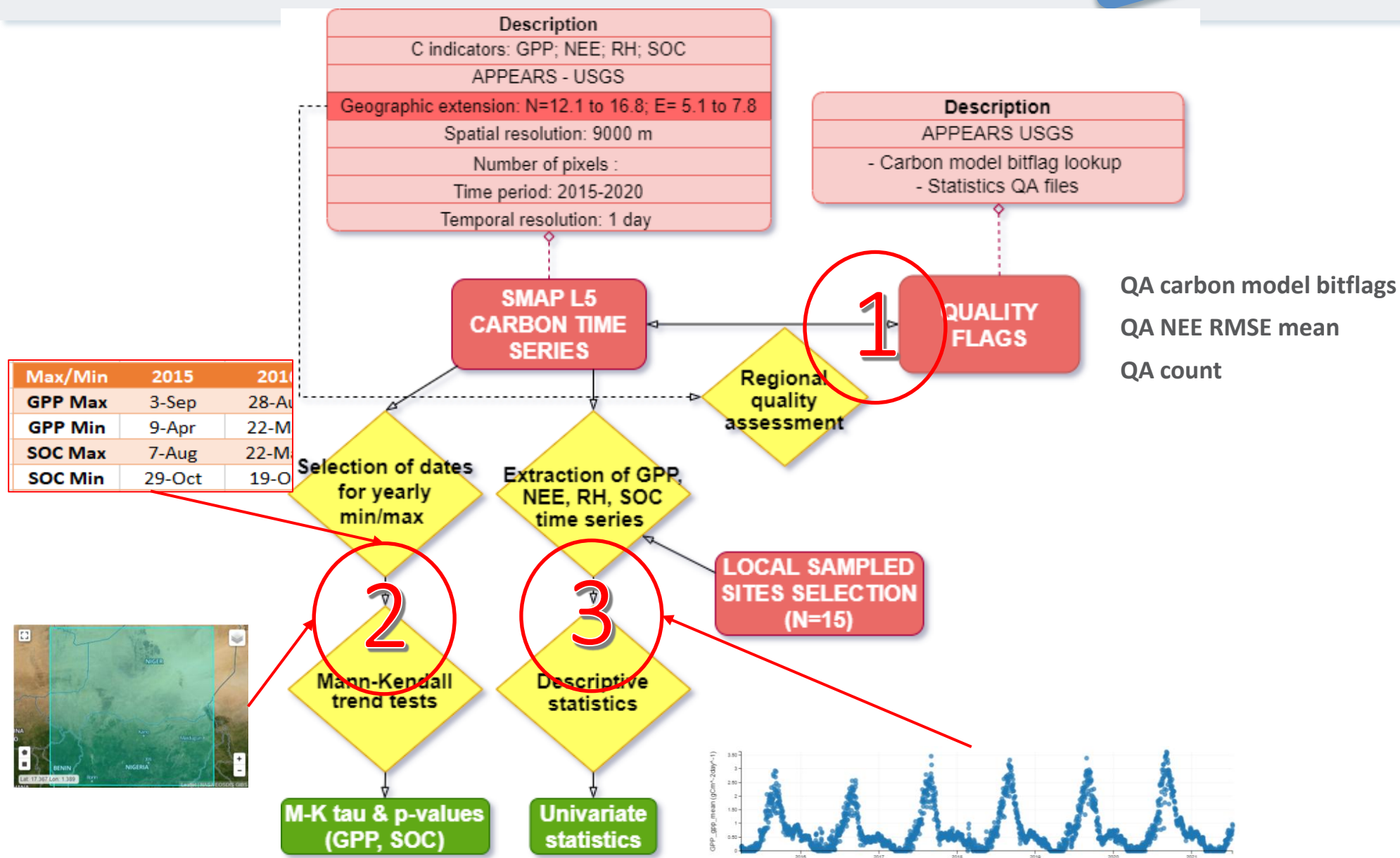
2. Material (1)

SMAP L4 Global Daily Carbon Net Ecosystem Exchange

- Global Primary Productivity (GPP), Net Ecosystem Exchange (NEE), Heterotrophic Respiration (HR), Soil Organic Carbon (SOC)
- Time series : 2015-2020, daily measurement; Spatial resolution : 9 km
- Model output: fusion of
 - GMAO/GEOS5 meteorological data (daily, spatial res. 27 km)
 - **SMAP L4 Surface & Root Zone Soil Moisture (3 hours, 9 km)**
 - **Plant Functional Types MOD12Q1 (yearly, 500 m)**
 - **fPAR & LAI MOD15A2 (8 days, 500 m)**



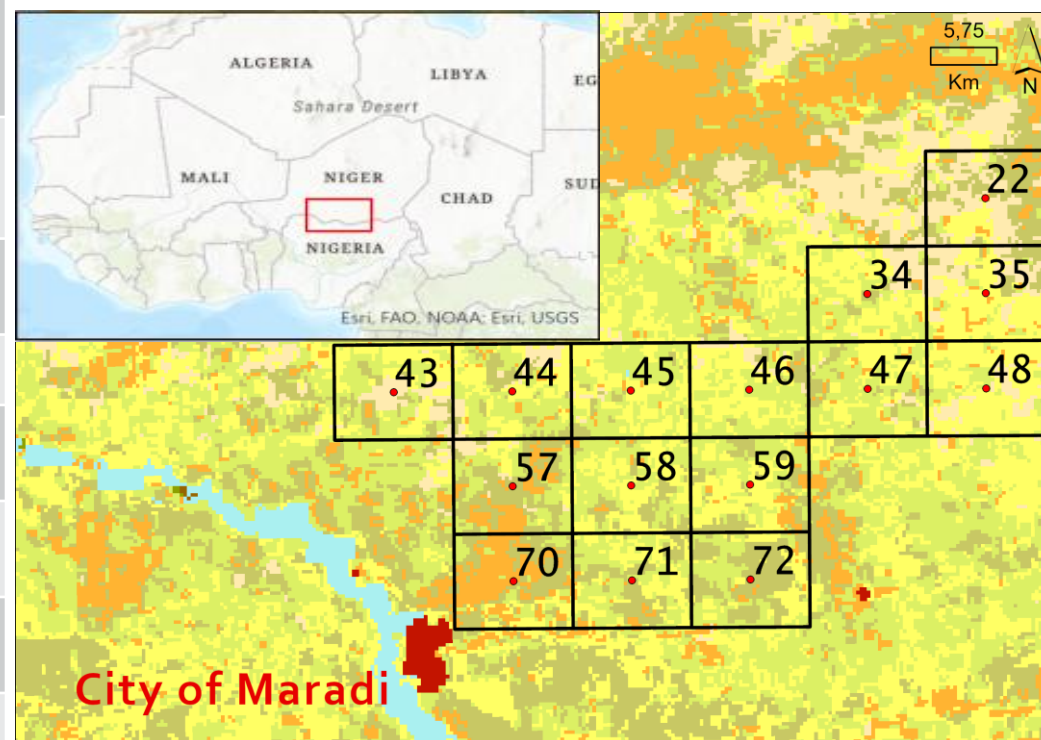
2. Material & Methods (2)



2. Material and methods (3)

Study area and site selection

Pixel ID	Min LC	Maj LC
43 – 44 – 58 – 71	Grassland	Mosaic cropland with natural vegetation
34 – 35 – 46 – 59	Grassland	Rainfed crops
57 – 72	Sparse herbaceous cover	Mosaic natural vegetation with crops
70	Rainfed crops	Grassland
71	Grassland	Mosaic cropland with natural vegetation
22	Mosaic cropland with natural vegetation	Mosaic natural vegetation with crops
47	Sparse herbaceous cover	Mosaic cropland with natural vegetation
45	Irrigated/flooded cropland	Mosaic cropland with natural vegetation
48	Mosaic natural vegetation with crop	Rainfed crops



3. Consistency of SMAP observations

a. Interannual variations of the subregion

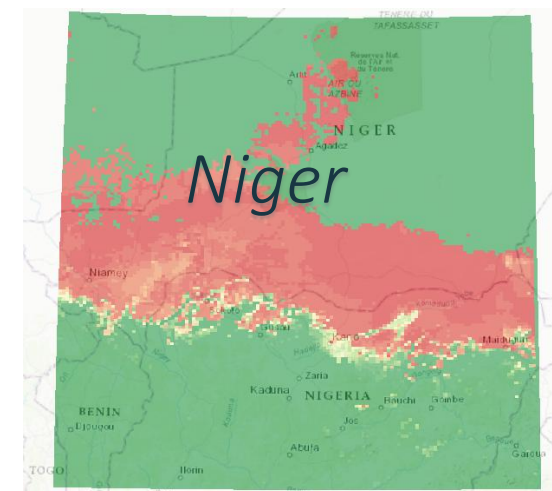
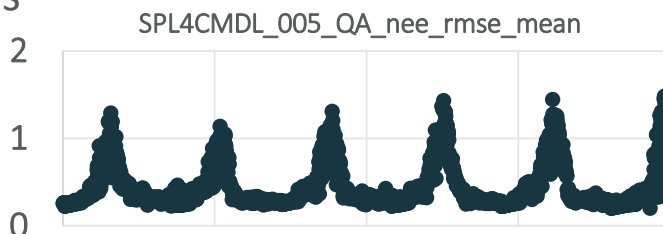
Max/Min	2015	2016	2017	2018	2019	2020	2021
GPP Max	23-Sep	31-Jul	24-Aug	15-Aug	12-Sep	8-Sep	7-Sep
GPP Min	23-Apr	1-Mar	3-Apr	1-Apr	17-Mar	28-Feb	29-Mar
SOC Max	28-May	7-May	25-May	25-Apr	1-May	23-Apr	4-May
SOC Min	18-Oct	9-Oct	9-Oct	18-Oct	1-Nov	21-Oct	7-Oct

b. SMAP Quality Assessment files

RMSE <1gCm-2-d-1

NEE, GPP, RH, SOC within valid range

NEE RSME mean ranges from 0.2 to 1.5

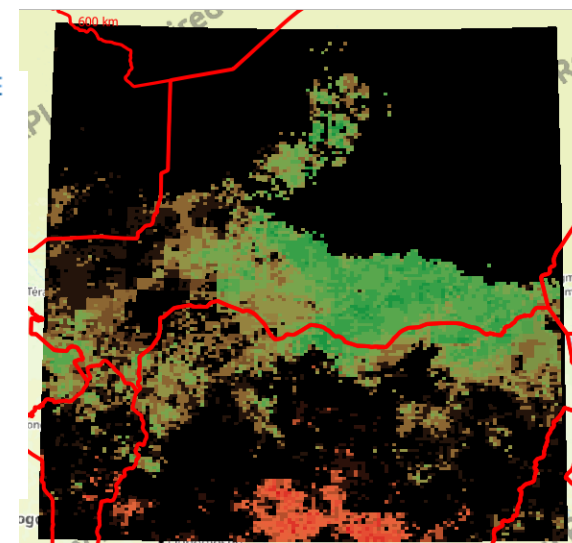
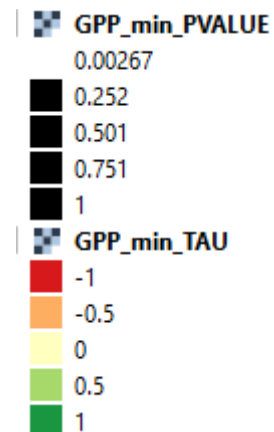
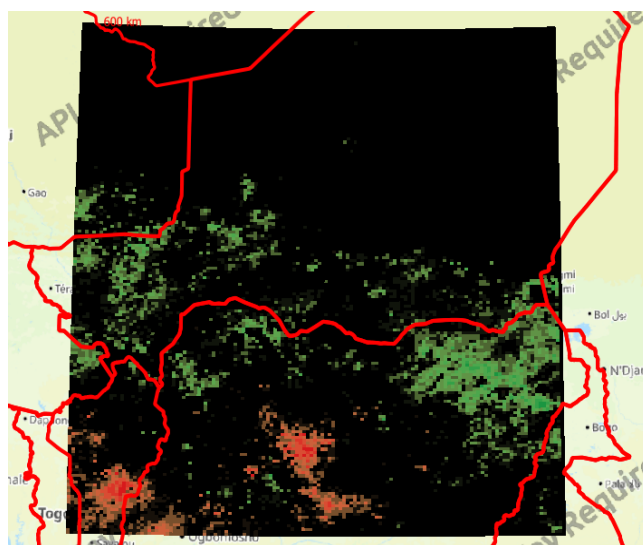
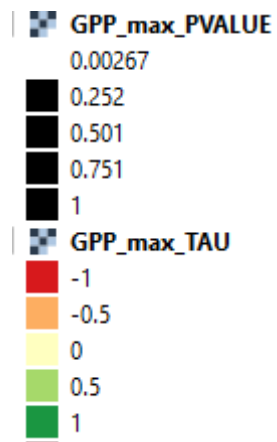
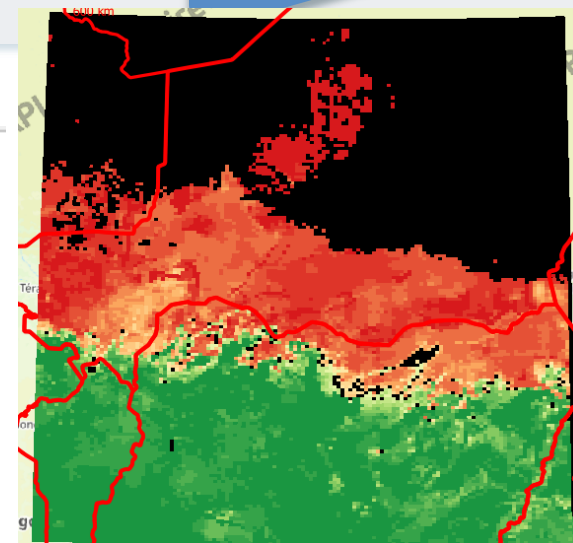
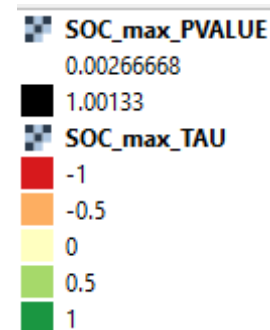


c. SMAP C products validation

	SMAP	Benchmark	Reference(s)	Comment
GPP	[0; 4.5] gCm-2d-1	[0; 8]	(1) John, Chen et al., 2013	(1) Shrubland, steppes of Mongolia
NEE	[-1.36; 1.79] gCm-2d-1	[0.09; 13.1]	Propastin & Kappas, 2009	(1) Steppe grassland, Kazakhstan
RH	[0.16; 2.23]			
SOC	[1378; 1495] gC m-2 d-1	[1323; 3758] gCm-2 ; [1156; 2534] gCm-2	(1) Alam & Sarr, 2010; (2) Woome et al., 2004	(1) Topsoil SOC density, Sudanese Sahel (2) Topsoil C density, from degraded grassland to shrubby grassland

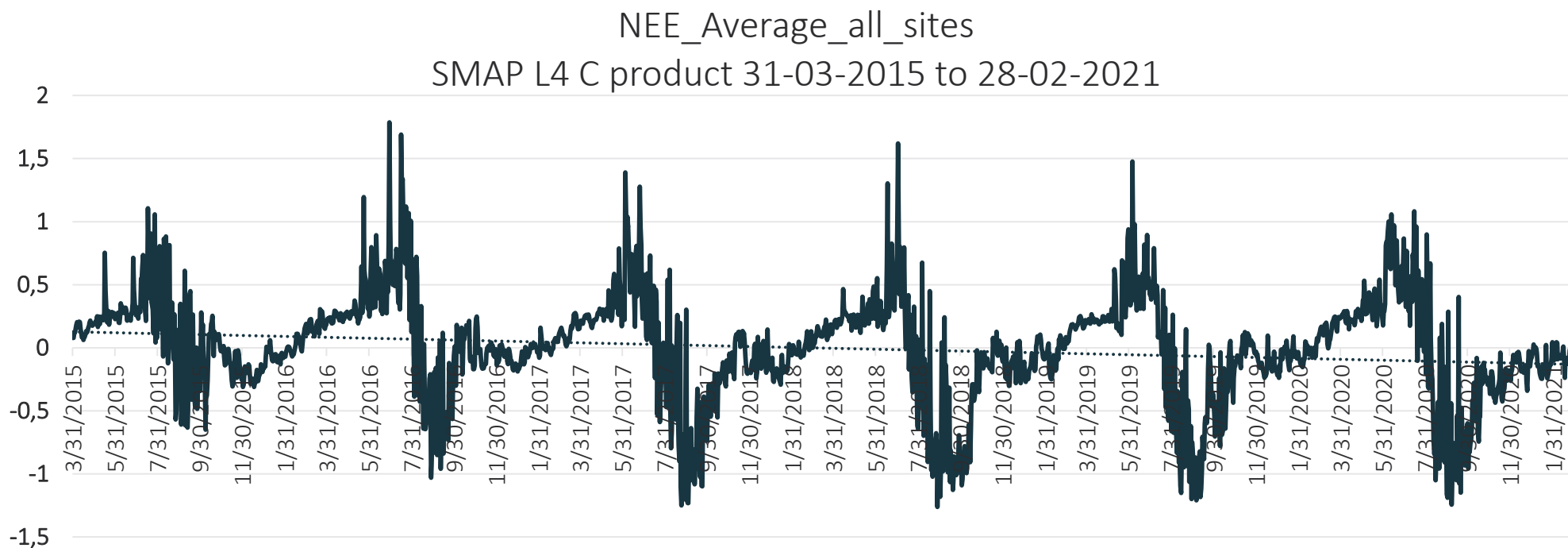
4. Mann-Kendall regional trend test

	Global Primary Productivity		Soil Organic Carbon	
	Annual min	Annual max	Annual min	Annual max
Pixels p<0.05	1842 (8%)	294 (1,3%)	85 (0,37%)	994 (4,3 %)
Total pixels	22 848 (100%)			



5. Pluriannual variability of ecosystem C fluxes

	GPP	NEE	RH	SOC
Unit	gC m ⁻² d ⁻¹			gC m ⁻²
Averaged min	0	-1.365	0.158	1378
Averaged max	4.694	1.791	2.229	1495
Overall mean	1.192	-0.003	0.679	1435
Overall median	0.878	0.016	0.485	1435
Averaged SD	1.09	0.419	0.461	28.9



Regional & local consistency of SMAP C products

- Match with literature findings on related ecosystems
 - Strong periodicity of NEE-RMSE : RMSE comprised within 0,5; 1,5 at the end of the wet season
- => Reinforcing dataset trustability by comparing with local eddy fluxes towers

Assignments of regional and local trends: too soon for now, but...

- 7 years (e.g. peaks and lows)
 - Other components to explain such geographical heterogeneity ?
- ⇒ Longer time series to confirm results (i.e. MODIS GPP)

Conclusions

1. What are SMAP Carbon products? What could(nt) they say?
⇒ **Daily assimilation dataset, giving main C fluxes at a 9 km level (2015-today)**
2. Pre-processing of SMAP Carbon products for applied uses?
⇒ **Geo selection: local or regional (e.g. point/area)**
⇒ **Spatial and temporal QA assessment (NEE-RMSE)**
3. Carbon exchanges increasing/decreasing in central Sahel?
⇒ **NEE is decreasing for the studied area...**
4. Interannual variability? Differences between landscapes?
⇒ **... but a lot of spatial heterogeneity (locally)**



Thank you!

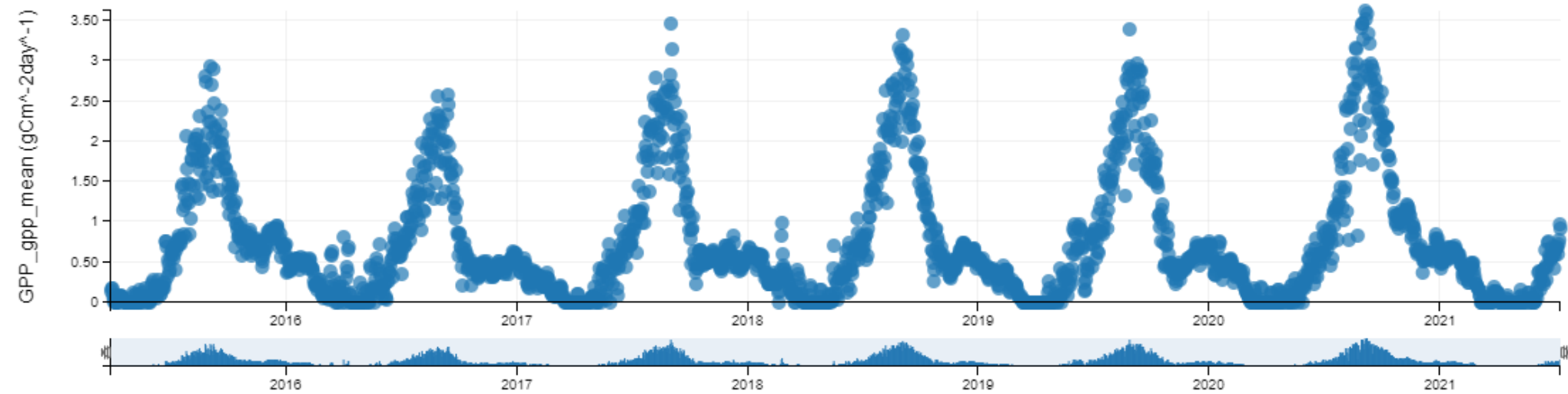
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References

- TAGESSON, Torbern, FENSHOLT, Rasmus, CROPLEY, Ford, *et al.* Dynamics in carbon exchange fluxes for a grazed semi-arid savanna ecosystem in West Africa. *Agriculture, Ecosystems & Environment*, 2015, vol. 205, p. 15-24.
<https://doi.org/10.1016/j.agee.2015.02.017>
- ARDÖ, Jonas, MÖLDER, Meelis, EL-TAHIR, Bashir Awad, *et al.* Seasonal variation of carbon fluxes in a sparse savanna in semi arid Sudan. *Carbon balance and management*, 2008, vol. 3, no 1, p. 1-18.
- GONZALEZ-SANCHEZ, Emilio J., VEROZ-GONZALEZ, Oscar, CONWAY, Gordon, *et al.* Meta-analysis on carbon sequestration through Conservation Agriculture in Africa. *Soil and Tillage Research*, 2019, vol. 190, p. 22-30.
- JOHN, Ranjeet, CHEN, Jiquan, NOORMETS, Asko, *et al.* Modelling gross primary production in semi-arid Inner Mongolia using MODIS imagery and eddy covariance data. *International journal of remote sensing*, 2013, vol. 34, no 8, p. 2829-2857. <https://doi.org/10.1080/01431161.2012.746483>
- PROPASTIN, Pavel et KAPPAS, Martin. Modeling net ecosystem exchange for grassland in Central Kazakhstan by combining remote sensing and field data. *Remote Sensing*, 2009, vol. 1, no 3, p. 159-183.
<https://doi.org/10.3390/rs1030159>
- KIM, Youngwook, KIMBAL, John S., PARAZOO, Nicholas, *et al.* Monitoring ECO-Hydrological Spring Onset Over Alaska and Northern Canada with Complementary Satellite Remote Sensing Data. In : *2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS*. IEEE, 2021. p. 6363-6366.
<https://doi.org/10.5067/9IKKQ4BL3PK8> [accessed on 2021-11-09]
- JONES, Lucas A., KIMBALL, John S., REICHLE, Rolf H., *et al.* The SMAP level 4 carbon product for monitoring ecosystem land-atmosphere CO₂ exchange. *IEEE Transactions on Geoscience and Remote Sensing*, 2017, vol. 55, no 11, p. 6517-6532.
- ARTHUR ENDSLEY, K., KIMBALL, John S., REICHLE, Rolf H., *et al.* Satellite Monitoring of Global Surface Soil Organic Carbon Dynamics Using the SMAP Level 4 Carbon Product. *Journal of Geophysical Research: Biogeosciences*, 2020, vol. 125, no 12, p. e2020JG006100.

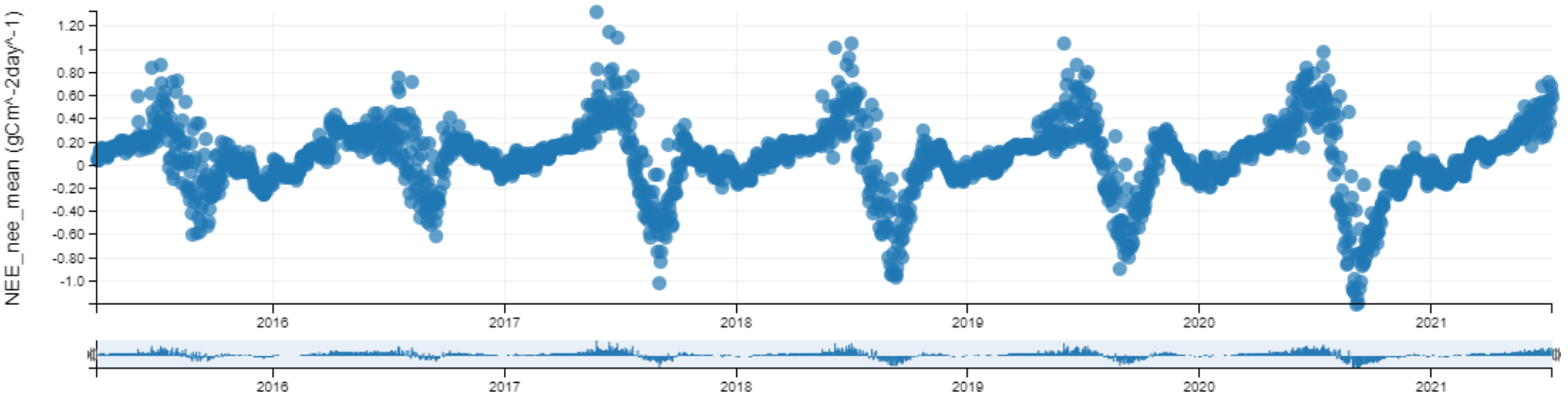
Annexe

GPP – Wankama site



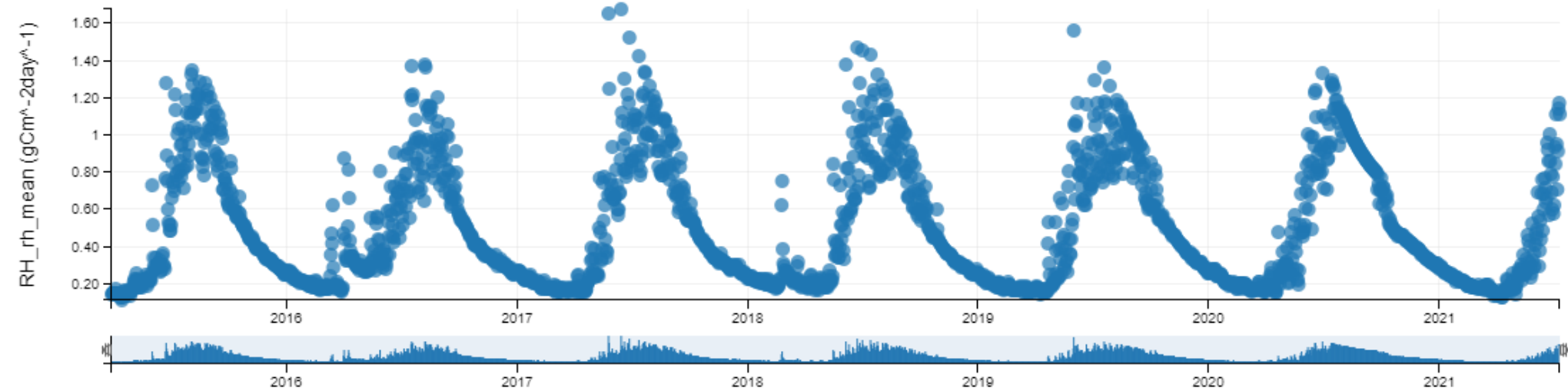
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NEE – Wankama site



Annexe

RH – Wankama site



Annexe

SOC – Wankama site

