Relationship between vegetation dynamics and methane emissions from wetlands in East Africa

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Methane is emitted from a variety of natural (~55%) and anthropogenic (~45%) sources. Wetlands are the single largest natural source of methane. About a third of all CH_4 in the air originates from wetlands.

Satellite data reveal increased methane emissions in East Africa compared to the a priori emissions from WetCHARTs and GFED.

The increase of CH_4 emissions could be caused by the variation of wetland in East Africa.

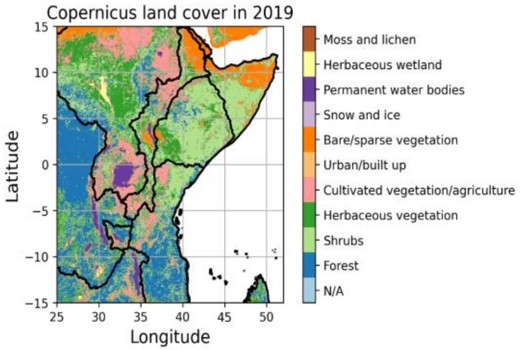

Fig. 1 Land cover in East Africa from Copernicus Global Land Service data in 2019

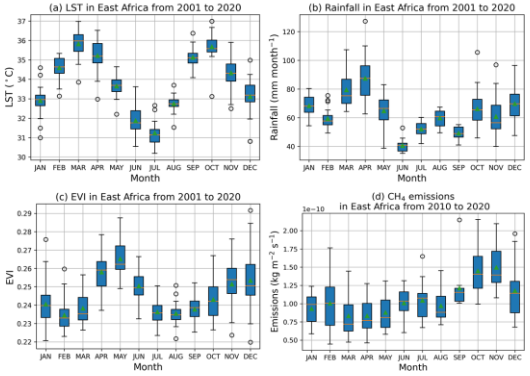

Fig. 2 Seasonality of (a) LST, (b) RF, (c) EVI, and (d) methane emissions in East Africa.

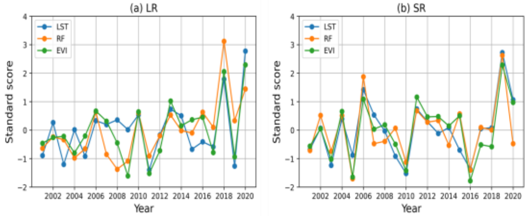

Fig. 3 Annual variation of normalized LST, RF, and EVI in the (a) LR and (b) SR seasons. Note that the normalized LST is flipped to show the correlation.

Data and Methods

Vegetation dynamics: MODIS Enhanced Vegetation Index (EVI) at monthly and 1 km resolutions.

Rainfall (RF): Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) at monthly and 0.05 degree resolutions.

Temperature: MODIS Land Surface Temperature (LST) product at monthly and 0.05 degree resolutions.

CH_4 emissions (2010-2020) estimated from the GOSAT data.

Time period: 2001 to 2020

Region: East Africa (LAT: -15° to 15°, LON: 25° to 52°)

We focus on the temporal anomaly of EVI, rainfall, and LST, which is defined compared to the mean state from 2001 to 2020. For CH_4 emissions, the mean state is defined as 2010-2020.

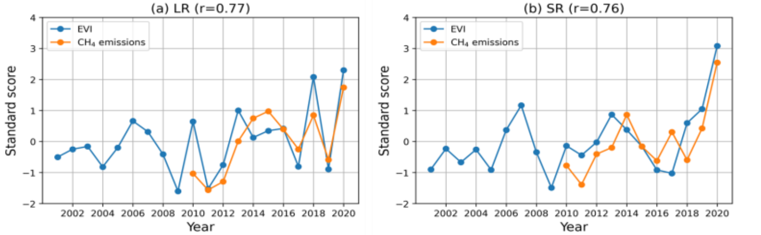

Fig. 4 Annual variation of normalized EVI and methane emissions in the (a) LR and (b) SR seasons in East Africa

Results: There are two typical seasons: the long rains (LR) corresponding to the months of March to May and the short rains (SR) corresponding to the months of October to December (Figure 2b). These two seasons are related to the seasonality of vegetation growth (Figure 2c). Emissions of CH_4 show no obvious seasonality, except for relatively high emissions at the end of a year (Figure 2d).

Vegetation growth in East Africa is strongly correlated with rainfall and LST over the last two decades with significant correlations (Figure 3).

In LR, the correlation of EVI and CH_4 emissions is significant with a correlation coefficient of 0.77 (Figure 4a). In SR, the correlation between cumulative EVI (averaged over a whole year) and CH_4 emissions in SR is 0.76 (Figure 4b).

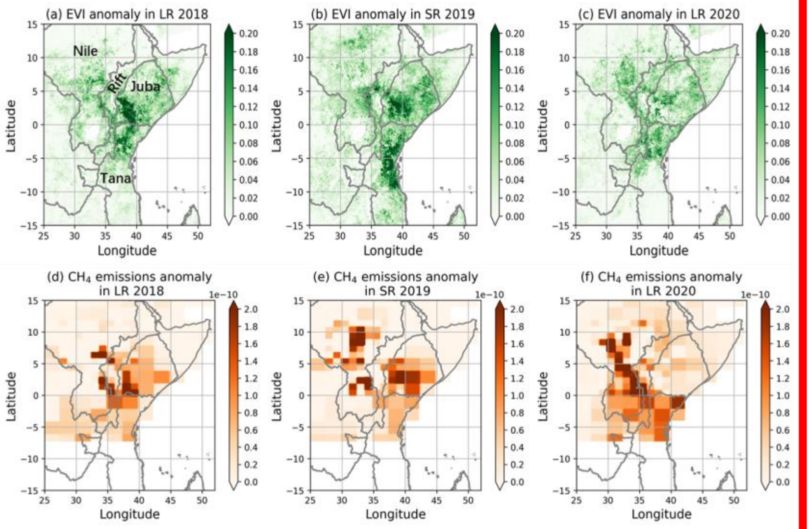

Fig. 5 Spatial patterns of anomalous (a-c) EVI and (d-f) methane emissions (units are kg m^{-2} s^{-1}) in the LR 2018 (left column), the SR 2019 (middle column), and the LR 2020 (right column).

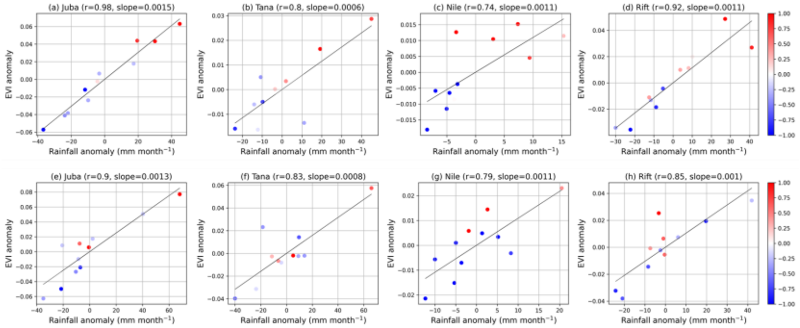

Fig. 6 The relationship between anomalous RF, EVI, and methane emissions (indicated by the color scale, units are kg s^{-1}) in each water basin from 2010 to 2020 (each dot represents a year) in the LR (top panels) and SR (bottom panels). The values in brackets are the correlation coefficient (pass the 99% confidence test) and the slope between rainfall and EVI anomalies.

Figure 5 shows that increased EVI in the rainy seasons (LR 2018, SR 2019, and LR 2020) is spatially correlated with increased CH_4 emissions, which are concentrated in four water basins (Juba, Tana, Rift, and Nile) corresponding to herbaceous vegetation, shrubs, and cultivated vegetation/agriculture (Fig. 1).

There are significant correlations between anomalous rainfall and EVI in each water basin (Fig. 6), suggesting that vegetation growth in East Africa is linearly influenced by rainfall.

These regression models offer a possible approach for continuous estimating and predicting CH_4 emissions from East African wetlands.

Take home message

Wetlands are an important source of methane emissions in East Africa over the last decade.

The spatial correlation between CH_4 emissions and EVI is better than that of rainfall although rainfall is a driving factor.

A simple linear regression model can be used to estimate total CH_4 emissions based on EVI and rainfall observations in East African water basins.