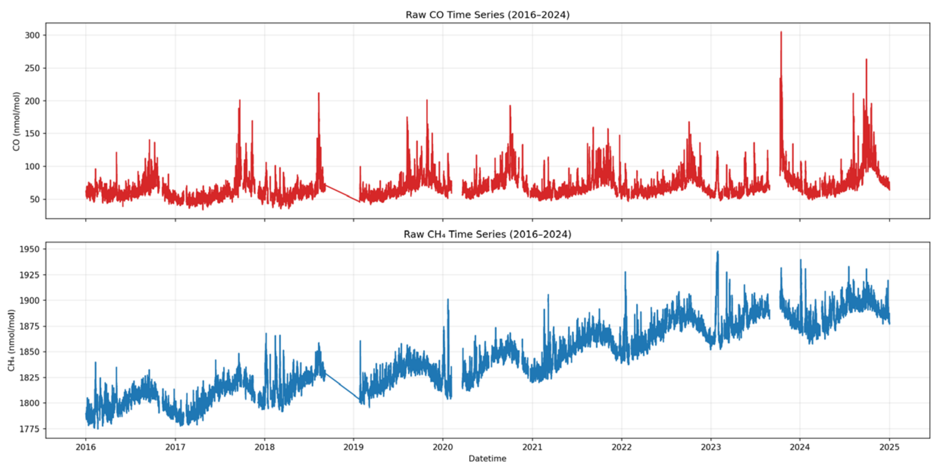
Exploration of methane sources in southern Africa

M. De Mazière[1], N. Selleslags[2], J. Brioude[3], S. Callewaert[1], F. Desmet[1], B. Dils[1], N. Kumps[1], B. Langerock[1], J.-M. Metzger[3], M.K. Sha[1]

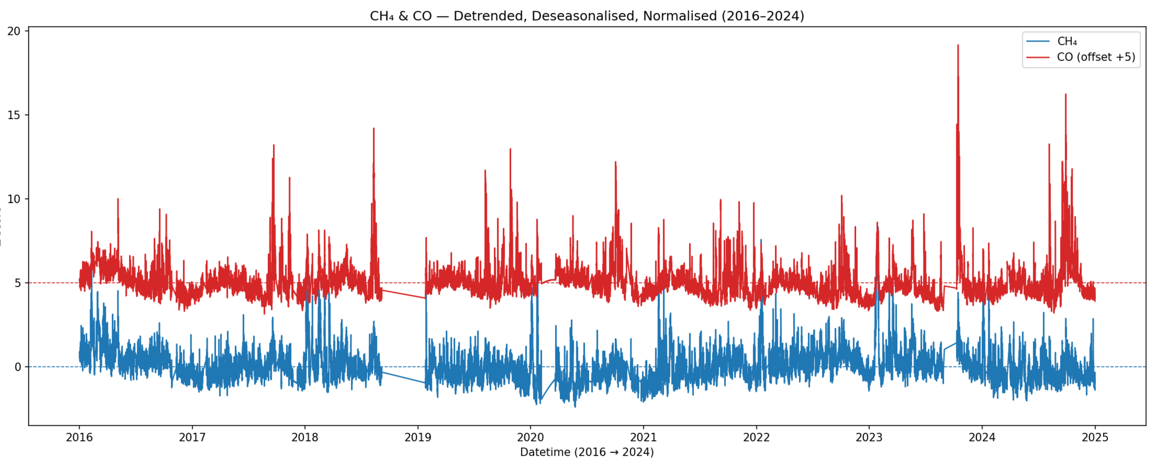
[1]Royal Belgian Institute for Space Aeronomy (IASB-BIRA), [2]University of Liège (ULiège), [3]Université de la Réunion-LACy (UR-LACy)

High enhancements of CH_4 concentrations are observed at the ICOS atmosphere station of La Réunion - Maido (RUN), especially every calender year during austral summer. The objective of this study is to investigate the origin of these enhancements using multi-year ICOS near-surface concentration measurements. After de-trending, de-seasonalisation and normalisation of the CH_4 and CO time series from 2016 to end 2024, we analysed the peak events and associated CH_4-CO correlations to identify potential source signatures. Back trajectories (HYSPLIT) and FLEXPART footprints were used to characterise the air mass origins during these CH_4 peak events. Our preliminary analysis suggests that regional agricultural emissions—potentially linked to rice cultivation—may contribute to these recurrent local summer methane enhancements.
We have restricted the study to **2016–2024** to avoid a known anomaly in 2015 and to have complete years. A large data gap between 1 Sept 2023 – 11 Oct 2023 was removed.

Raw CH_4 and CO time series at RUN

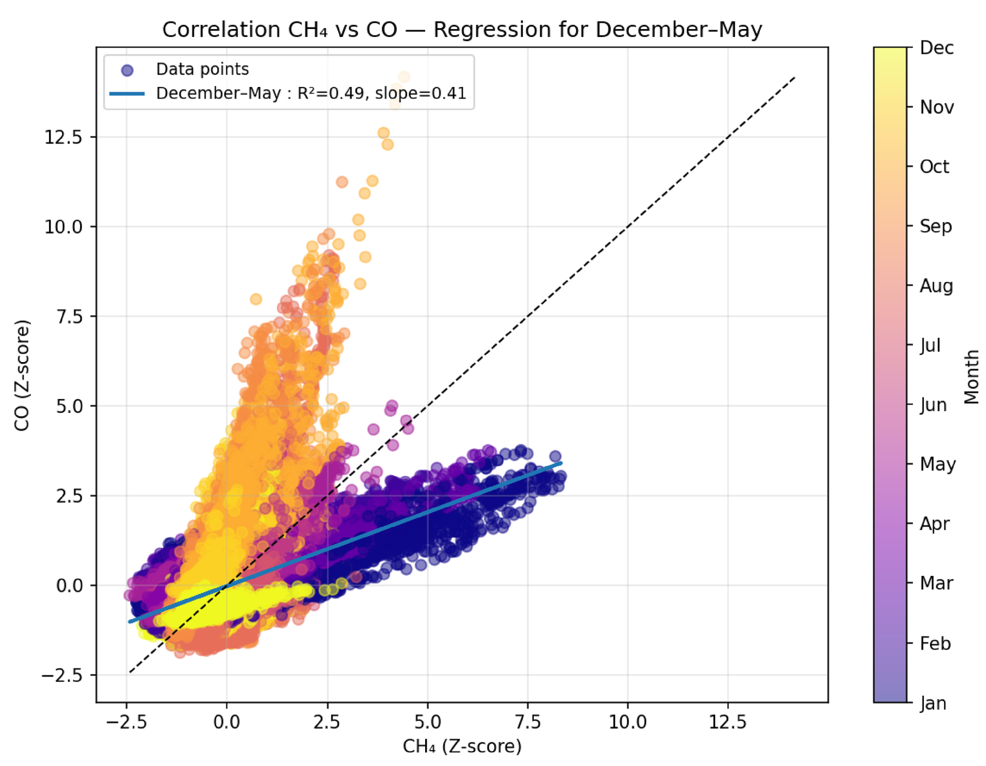


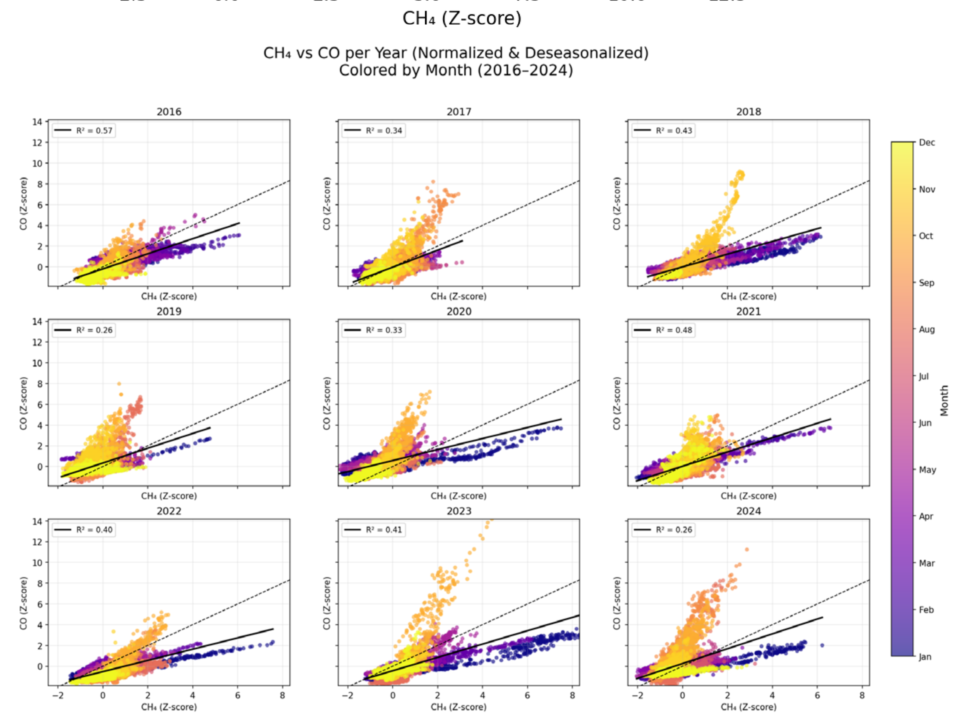
Processed CH4 and CO series (detrended, deseasonalised, normalised + offsets)



As our focus is on the high CH_4 peak events, and possible correlations with high CO events, we apply three preprocessing steps:

1. Linear detrending: CH_4: +0.65 %/year; CO: +3.5 %/year
2. seasonality removal: A simple 1-year sinusoidal model
3. Normalisation (Z-score): $z = \frac{x-\mu}{\sigma}$ z = z-score, with x : observed value, μ: average value, σ: standard deviation





CO to CH_4 CO correlations

Upper plot combines all nine years of data (2016-2024) and shows CO versus CH_4 coloured by month ; regression for December–May data

Lower plot: 3×3 grid of yearly CO versus CH_4 scatter plots (2016–2024)

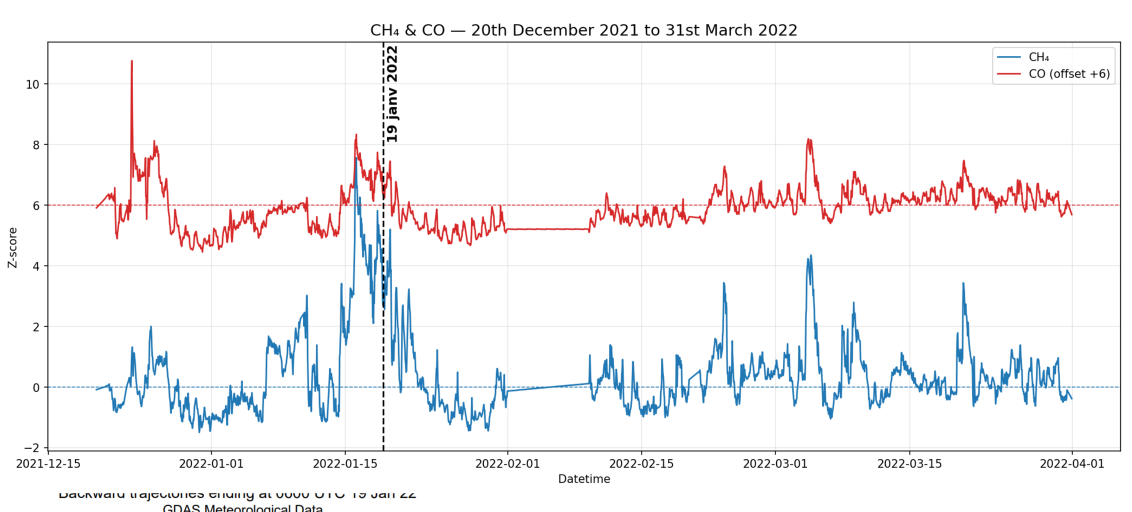
CH_4 and CO show a clear, robust correlation.
We have not found anu correlation with CO_2 – which is the reason why we do not show any CO_2 data

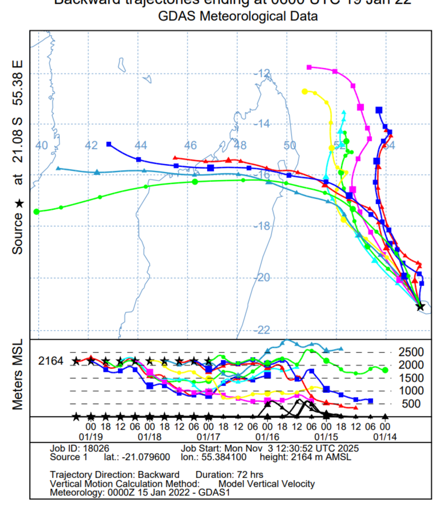
Two regimes appear in the correlation between CH_4 and CO:

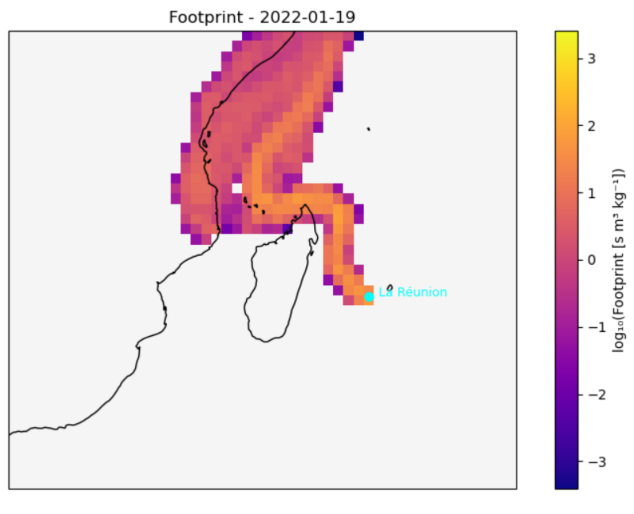
- December–May
  Strong linear CH_4: CO correlation → Indicates co-transport of slightly polluted, continental-influenced air.
- September–November (biomass-burning season)
  Points strongly deviate from the regression line→ Characteristic of emission plumes from Southern Hemisphere African biomass burning.

- A clear CH_4 : CO correlation between January and March, suggesting a consistent mechanism that affects both gases.

19 January 2022 as a representative example.

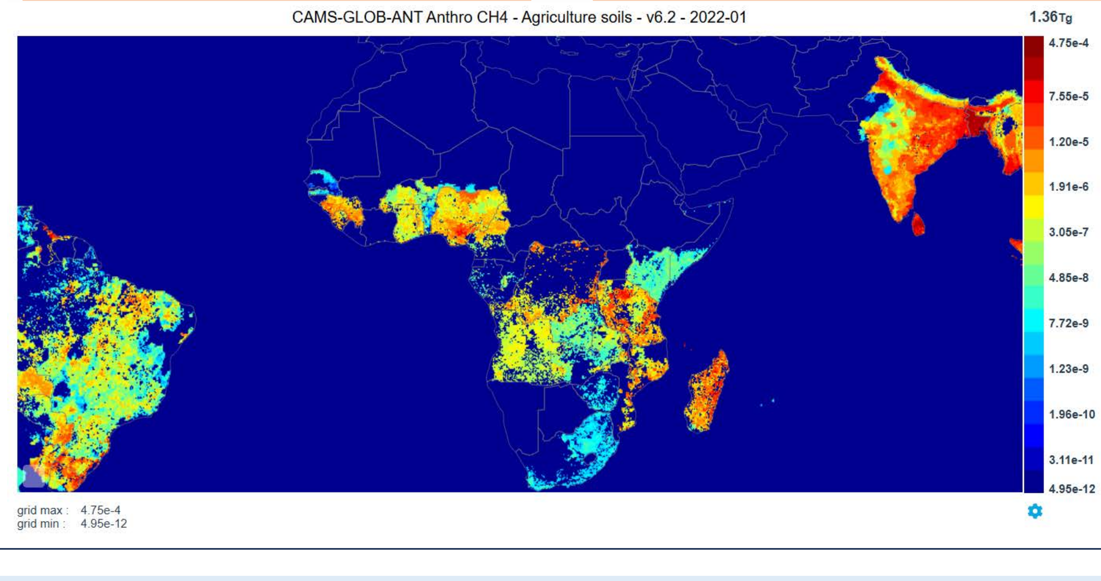




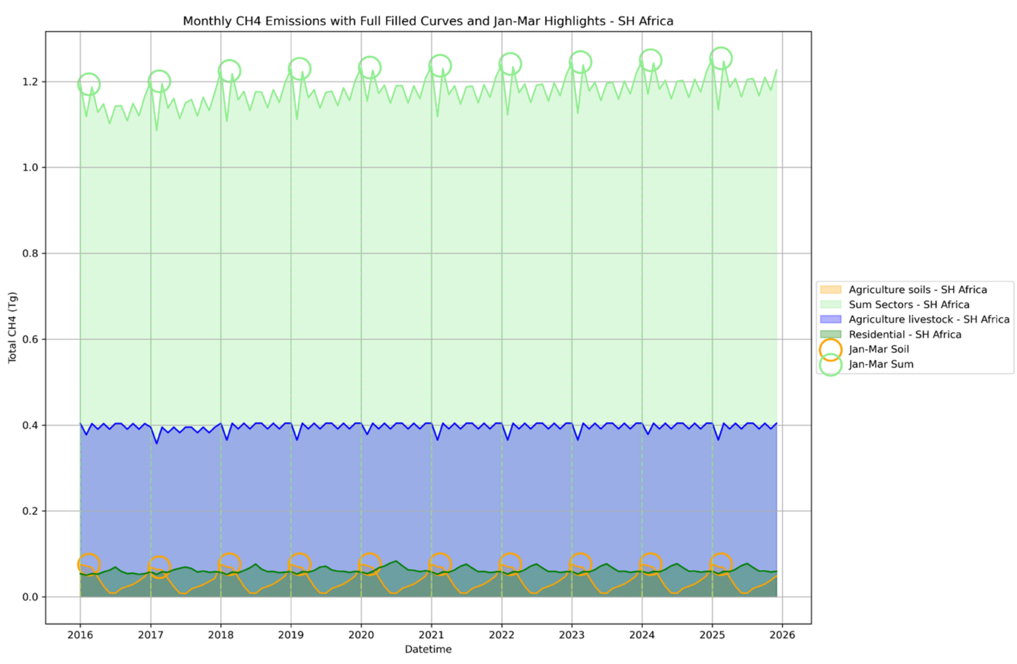


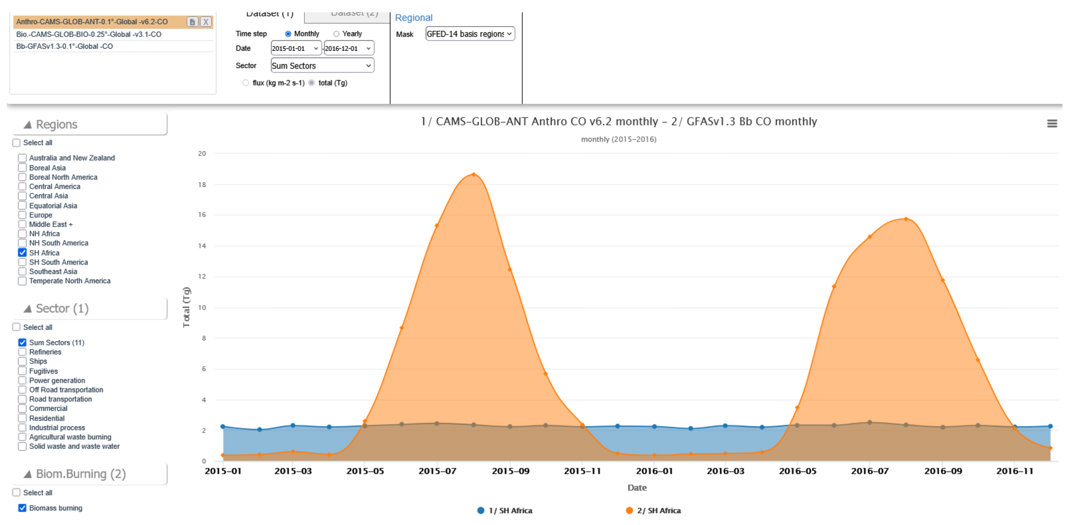
HYSPLIT trajectories

FLEXPART footprints



Source of CH_4 enhancements





- Long-range transport rather than local sources
  All CH_4 and CO peak events occur uniformly throughout the day, with no day–night difference. This indicates that the enhancements are not caused by advected local pollution, but are instead consistent with long-range transported air masses reaching La Réunion.
- ECCAD emissions over Southern Hemisphere Africa show that methane is dominated by anthropogenic sources. Agricultural livestock contributes most but has no clear seasonality whereas agricultural soils display a small but consistent summer increase (Dec–Mar), which aligns with the timing of the methane enhancements observed at La Réunion.

  This could point to rice-pad emissions in Madagascar and Mozambique (January–March)
  Cf. Jiang, J., et al., (2024). 20m Africa Rice Distribution Map of 2023/ Dataset available at https://doi.org/10.5281/zenodo.13729353

- Why correlated with CO ? Still open question…

Acknowledgements: National ESFRI-FED project ICOS-BE; ECCAD database (https://eccad.aeris-data.fr/context/)