ESA Climate Space – RECCAP2

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Article published in Nature, January 2026

Xu, Y., Ciais, P., Santoro, M. et al. Small persistent humid forest clearings drive tropical forest biomass losses. Nature 649, 375–380 (2026). https://doi.org/10.1038/s41586-025-09870-7

Tropical forests hold nearly half of Earth's above-ground forest carbon, yet they are increasingly threatened by human-driven disturbances and climate-intensified fires and storms. The RECCAP-2 study published in Nature provides the most spatially detailed picture to date of how tropical forest carbon has changed over the past 30 years — and reveals that the smallest deforestation clearings, often less than two hectares, are responsible for more than half of total carbon losses. Using a high-resolution bookkeeping approach that integrates sub-hectare Earth observation data with innovative, spatially explicit biomass recovery curves, the research team mapped carbon losses and recovery trajectories across all tropical forests from 1990 to 2020.

Key Findings

- Tropical humid forests lost 15.6 ± 3.7 Pg of carbon over the past three decades, while tropical dry forests remained roughly carbon-neutral.
- Small clearings (<2 ha) represent only 5% of disturbed forest area but account for 56% of net carbon losses, primarily due to persistent land-use conversion to croplands, pastures, roads, or settlements.
- Fire-driven carbon losses in many dry tropical forest regions are partly balanced by long-term post-fire recovery, unlike the persistent impacts of small-scale deforestation and non-fire degradation.
- Disturbances have progressively shifted into denser, more carbon-rich humid forests, amplifying the climate impact of each hectare lost.
- By contrast, repeated fires in dry forests have gradually reduced per-event losses due to declining fuel loads.
- Undisturbed tropical forests remain a net carbon sink, partially compensating for losses in disturbed areas — but the overall tropical AGC balance from 1990–2020 is close to neutral.

The study represents the first spatially explicit 30-meter resolution reconstruction of carbon losses and gains across all tropical forests. Unlike previous global models that rely on simplified assumptions or continental averages, this new approach captures how disturbance type, size, and local climate conditions shape forest recovery, thanks to new high resolution biomass maps from the European Space Agency. The findings highlight urgent priorities for climate mitigation:

- Reducing small-scale agricultural expansion and degradation, especially across Africa, where such disturbances account for over 97% of net carbon losses.
- Protecting young, recovering forests, whose carbon sequestration potential is sharply reduced by repeated disturbances.
- Strengthening monitoring of forest edges and encroachment fronts where carbon-dense forests are increasingly exposed.

The team emphasizes that the method can support national carbon inventories, REDD+ implementation, and targeted conservation planning. By revealing where carbon losses occur—and where forests are successfully regrowing—the study provides a powerful tool for safeguarding one of Earth's most important climate buffers.

ESA has published a news story in the CCI web site. The paper had a high impact in the media

Article published in Science, February 2026

Ciais et al. ,Why methane surged in the atmosphere during the early 2020s. Science 391 eadx8262(2026). DOI:10.1126/science.adx8262

Methane—the second most important human-driven greenhouse gas after carbon dioxide—rose at an unprecedented rate in the early 2020s. The international study published in Science and supported by RECCAP2 showed that this surge was driven primarily by a temporary weakening of the atmosphere's ability to remove methane, combined with climate-driven increases in natural emissions in Africa, Asia and the Arctic.

Analyzing satellite observations, ground-based measurements, atmospheric chemistry data, and using advanced computer models, the researchers found that a sharp decline in hydroxyl (OH) radicals during 2020–2021 explains around 80% of the year-to-year variation in methane growth. The OH radicals act as the atmosphere's main "detergent," breaking down methane. When OH levels dropped, methane accumulated faster. At the same time, climate variability strongly amplified methane emissions from natural sources. An extended La Niña period from 2020 to 2023 brought wetter-than-average conditions across much of the tropics, expanding flooded areas and increasing methane emissions from wetlands and inland waters. The largest increases occurred in tropical Africa and Southeast Asia, while Arctic wetlands and lakes also showed significant growth. In contrast, South American wetlands declined sharply in 2023 during an extreme El Niño-related drought. Crucially, the study finds that fossil fuel emissions and wildfires played only a minor role in the recent methane surge. Isotopic evidence from atmospheric methane further confirms that microbial sources—wetlands, inland waters, and agriculture—dominated the observed changes. The findings showed important weaknesses in current methane emission models, many of which underestimated wetland emissions during this period. The authors stress the need for improved monitoring of flooded ecosystems, better representation of soil and water dynamics, and closer integration of atmospheric chemistry with climate variability.

Key Findings

- The early-2020s methane surge was mainly caused by a weakened atmospheric sink, not runaway emissions.
  A temporary drop in hydroxyl (OH) radicals—the atmosphere's primary methane "cleanser"—during 2020–2021 explains about 80–85% of the year-to-year variability in methane growth.
- Reductions in nitrogen oxides (NO_x) and carbon monoxide (CO) during pandemic lockdowns reduced OH levels, allowing methane to accumulate faster in the atmosphere.
- Exceptionally wet conditions during a prolonged La Niña (2020–2023) boosted methane emissions from wetlands and inland waters, especially in tropical Africa and Southeast Asia, with additional increases in Arctic regions.
- Changes in fossil fuel and biomass-burning methane emissions were comparatively small and cannot explain the observed global methane spike.
- Current bottom-up emission models miss critical dynamics.Many widely used models underestimate wetland and inland-water emissions during the surge, highlighting urgent gaps in monitoring flooded ecosystems and microbial methane processes.

ESA has published a news item and a nice animation on the CCI web site. The paper had a high impact in the media

Vanity Fair 2026

The immodest coordinator of the project has been best scientist in the word in environmental and climate science for what it is worth

Article published in Nature Comm., Nov. 2025

Wang, H., Ciais, P., Yang, H. …, JP Wigneron, Land use-induced soil carbon loss in the dry tropics nearly offsets gains in northern lands. Nat Commun 16, 10008 (2025). https://doi.org/10.1038/s41467-025-64929-3

At the global scale, changes in soil carbon are difficult to measure and global models are poorly constrained. In this study, published in Nature Communications, we propose a framework for mapping annual changes in soil carbon and litter (SOCL), based on the difference between net land CO_2 flux derived from atmospheric inversions and satellite-based maps of biomass changes. Our results show that

-SOCL accumulated at a global rate of approximately 0.34 (±0.30, ±1 sigma) billion tonnes of carbon per year (PgC yr^{-1}) between 2011 and 2020.

-The largest SOCL sink was found in boreal regions (0.93 ± 0.45 PgC per year in total), particularly in undisturbed peatlands and managed forests.

-The greatest losses occur in the dry tropics (−0.50 ± 0.47 PgC per year) and are associated with agricultural expansion resulting from changes in land use, cropland management, and grazing.

-Conversely, forests in the wet tropics act as a net soil carbon sink (0.32 ± 0.35 PgC per year).

The results highlight significant mitigation opportunities in the dry tropics for restoring agricultural soil carbon.