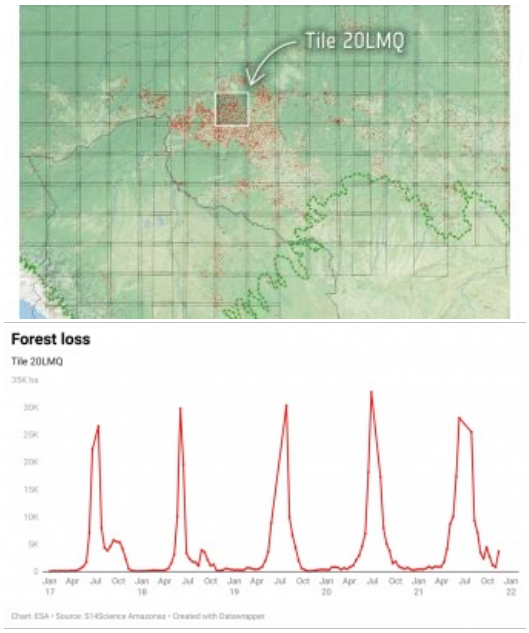
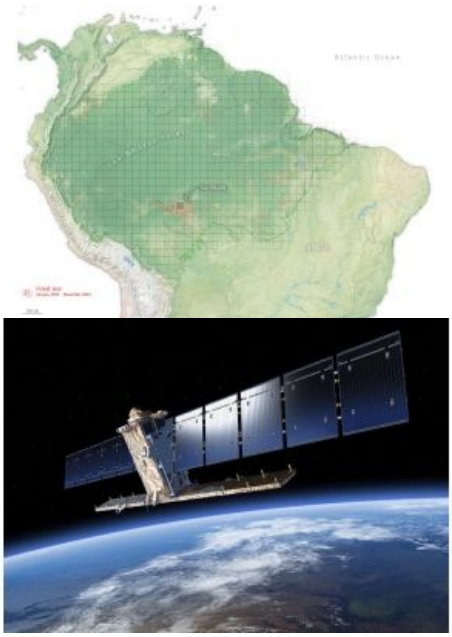
Exploring Amazon forest loss through Sentinel-1â€™s radar data cube





The 'Sentinel-1 for Science: Amazonas' project, led by ESA, supports the monitoring and mitigation of climate change-related impact on forests by processing radar images to detect forest loss. The project employs a transparent approach to estimate loss via space-time data cube design, extracting statistical information at each radar time-series point. This powerful tool tracks changes and enables conservation efforts. Accurate and timely data supports decision-making in addressing climate change and preserving ecosystems.

Forests hold a vast amount of Earth's terrestrial carbon and play an important role in offsetting anthropogenic emissions of fossil fuels. Since 2015, the world's tropical forests can be observed regularly at an unprecedented 6- to 12-day interval thanks to the Copernicus Sentinel-1 mission.

Developing reliable indicators for tracking forest loss

Millions of gigabytes of synthetic aperture radar (SAR) data are acquired both day and night, regardless of cloud cover, haze, smoke or aerosols. This allows deforestation and forest degradation to be monitored at least biweekly. The challenge, however, lies in finding adequate methods to extract meaningful indicators of forest loss from the vast amounts of incoming radar data, such that anomalies in the time-series can be regularly and consistently detected across tropical forests. Such forest-monitoring methods should be transparent and easily understandable to the wider public, enabling confidence in their use across various public and private sectors.

Map of the Amazon rainforest showing the observed forest loss visible in red. (Image courtesy: ESA, data: Sentinel-1 for Science: Amazonas)

Space-time data cubes

The 'Sentinel-1 for Science: Amazonas' project utilizes Sentinel-1 satellite radar imagery in a transparent and straightforward approach to estimate forest loss through a space-time data cube design, extracting relevant statistical information. This innovative methodology enables effective management and conservation efforts, providing valuable data for monitoring changes in forest cover over time. The project's cutting-edge technology supports urgent action against climate change and preserving precious ecosystems.

With this approach, the project demonstrates the use of Sentinel-1 data to create a dynamic deforestation analysis over the Amazon basin. From 2017 to 2021, the team were able to detect forest loss of over 5.2 million hectares, which equates to an area roughly the size of Costa Rica.

Neha Hunka, remote sensing expert at Gisat, commented: "What we are seeing from space is over a million hectares of tropical moist forests disappearing each year in the Amazon basin, with the worst year being 2021 in Brazil. We can track these losses and report on them transparently and consistently every 12 days henceforth."

Billions of pixels from the Sentinel-1 satellites from early 2015 to December 2021, each representing a 20x20m section of forest, are

harmonized under the StatCubes design, and a simple thresholding approach to detect forest loss is demonstrated in the first version of the results.

This graph here displays the forest loss data for a specific area of the Amazon rainforest known as 'Tile 20LMQ'. The seasonality of forest loss in the chosen area is likely due to the increased land clearing during the dry season, resulting in a peak in deforestation as seen in the graph. (Image courtesy: ESA, data: Sentinel-1 for Science: Amazonas)

Vast amount of data handling and processing

The largest challenge in the project was the vast amount of data handling and processing. The team used several user-friendly software tools to access the data efficiently – processing over 450TB of data to create the forest loss maps. Anca Anghelea, open science platform engineer at ESA, added: “By providing open access data and code through ESA’s Open Science Data Catalogue and openEO Platform, we aim to enable researchers around the world to collaborate and contribute to the advancement of knowledge about our global forests and the carbon cycle. Thus, in the last phase of the project, a key focus will be on Open Science, reproducibility, long-term maintenance and evolution of the results achieved in the ‘Sentinel-1 for Science: Amazonas’ project.”

Following on from the project, the next goal is to achieve a product of carbon loss from land cover changes, working together with ESA’s Climate Change Initiative team. This goal will contribute to ESA’s Carbon Science Cluster.

The current results of the project are now available by clicking here. ‘Sentinel-1 for Science: Amazonas’ is implemented by a consortium of four partners: Gisat, Agresta, Norwegian University of Life Sciences and the Finnish Geospatial Research Institute. The team uniquely combines complementary and strong backgrounds in forestry and carbon assessments, multi-temporal SAR analysis and data fusion, and big-data processing capabilities.

The Sentinel-1 constellation, comprised of two satellites, provides a wealth of valuable data and imagery. (Image courtesy: ESA)