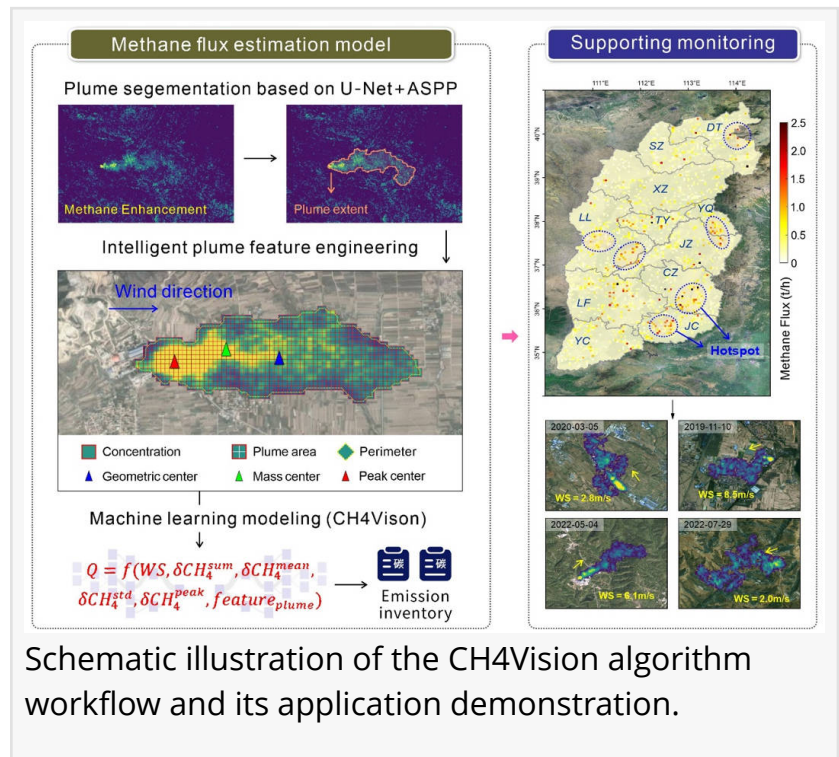


Machine learning tracks methane emissions from orbit

GA, UNITED STATES, April 8, 2026 /EINPresswire.com/ -- Methane is one of the most powerful greenhouse gases, yet quantifying its emissions remains difficult at large scales. A new framework, [CH4Vision](#), addresses this problem by estimating methane flux directly from hyperspectral satellite imagery. By combining plume morphology, concentration patterns, and machine learning, the method improves both the accuracy and robustness of satellite-based methane monitoring. The approach offers a practical path toward large-area emissions surveillance and could strengthen efforts in climate mitigation and environmental governance.



Schematic illustration of the CH4Vision algorithm workflow and its application demonstration.

Methane is the second most important anthropogenic greenhouse gas after carbon dioxide, with a global warming potential roughly 28–34 times greater over a 100-year timescale. Major sources include fossil-fuel production, agriculture, livestock, and landfill waste. In recent years, hyperspectral satellite remote sensing has become an important means of detecting methane emissions because it can identify methane absorption features and reveal plume structures from orbit. However, converting these observations into reliable emission estimates remains a major challenge. Widely used approaches such as the integrated mass enhancement (IME) method depend on simplified assumptions about the relationship between plume mass and wind speed. In practice, these assumptions often fail to capture the complex interaction between atmospheric transport and plume shape, leading to substantial uncertainty in methane flux estimates.

To address this limitation, researchers from East China Normal University and collaborating institutions recently reported (DOI: [10.34133/remotesensing.1013](https://doi.org/10.34133/remotesensing.1013)) a new methane-monitoring framework called CH4Vision in the *Journal of Remote Sensing* (published February 27, 2026).

Using hyperspectral observations from the GaoFen-5 satellite, CH4Vision estimates methane emission flux by analyzing both plume morphology and concentration distributions. Rather than relying on a simple linear relationship, the framework uses machine learning to infer emission rates from a richer set of plume characteristics, with the goal of improving the reliability of satellite-based methane quantification.

The core idea of CH4Vision is that methane plumes contain spatial information that reflects source strength. Instead of focusing mainly on plume area and wind speed, as in conventional IME-based methods, the framework extracts a broad set of descriptors that characterize plume geometry and concentration structure. These include plume area, perimeter, aspect ratio, gradient-related features, and concentration statistics. CH4Vision then integrates these variables into a random-forest regression model, allowing it to capture nonlinear relationships between plume structure and emission intensity.

To build the framework, the researchers first generated a large training dataset using atmospheric large-eddy simulations. These simulations produced thousands of methane plume scenarios under different emission rates, wind conditions, and turbulence regimes. The simulated plumes were then embedded into hyperspectral scenes acquired by the Advanced Hyperspectral Imager on GaoFen-5. Methane enhancement concentrations were retrieved using an improved algorithm known as SSRMF, which reduces background noise and false detections by reconstructing pixel-level reference spectra and preserving spatial continuity across plume structures. From the resulting plume maps, the team extracted morphological and concentration-based features and used them to train a random-forest regression model containing 500 decision trees to estimate methane flux directly from plume characteristics and wind information.

The model performed well in evaluation tests. Compared with the IME method, CH4Vision increased the coefficient of determination (R^2) by 3–9% and reduced estimation errors by 14–36.5%. It also showed greater resilience to uncertainty in wind speed and methane retrieval, which is particularly important for operational monitoring under real observational conditions. These results suggest that incorporating plume morphology into the estimation process can substantially improve methane flux quantification from satellite imagery.

The framework was further tested in both controlled and real-world settings. In controlled methane release experiments conducted in Arizona, CH4Vision predicted emission rates within about ± 100 kg per hour of the true values. When applied to satellite observations over Shanxi Province in China, the method detected hundreds of emission sources and indicated that traditional IME-based approaches substantially underestimated emissions from strong sources. These findings support the practical value of CH4Vision for identifying and quantifying methane emissions in complex real environments.

Overall, CH4Vision provides a powerful new tool for monitoring methane emissions from space. By improving the accuracy and robustness of satellite-based flux estimates, the framework could

help researchers better constrain global methane budgets and identify major emission hotspots. It may also support environmental regulation, climate policy, and energy-sector oversight. Because the method emphasizes plume morphology rather than gas-specific assumptions, it may be adaptable in the future to other atmospheric pollutants detectable by hyperspectral satellites.

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