PRESS RELEASE

Tracking greenhouse gases with a laser

In the face of advancing climate change, we drastically need to monitor and understand the various sources and sinks of greenhouse gases worldwide in real time. One focus to accomplish this is to regulate and monitor man-made methane emissions. Laser systems, as developed by researchers at Fraunhofer ILT, offer ways to do exactly this: At the heart of LIDAR instruments, they can precisely determine greenhouse gases in the atmosphere with high spatial and temporal resolution, even from great distances, and do so worldwide.

The summer of 2024 was by far the hottest since we began keeping records. This global warming is caused by the gas emissions in the atmosphere, mainly those of methane and carbon dioxide. As a greenhouse gas, methane is more than 25 times more active than carbon dioxide.

Although it is largely known how methane enters the atmosphere, it is usually unclear where and when this happens and to what extent. It is therefore important to precisely record and monitor the concentration of greenhouse gases in the atmosphere. Until now, methane from space has only been measured passively, i.e. via the sunlight absorbed by this gas in the atmosphere. The concentration can then be calculated from the absorption. However, this method only works during the day and its accuracy is limited.

Alternatively, a LIDAR (LIght Detection And Ranging) system can determine the methane concentration directly. The LIDAR system uses lasers with two wavelengths at around 1645 nm to make the measurement independent of external factors, e.g. the strongly fluctuating reflectivity of the earth's surface. For this purpose, it measures the light absorption of the atmosphere at wavelengths of maximum and minimum methane absorption. The methane concentration in the air column in the measurement path is calculated by comparing the measured values.

LIDAR measurement with the helicopter

LIDAR technology is a well-established method to investigate and determine local methane concentrations emitted from pipelines: Natural gas consists of around 85 percent methane; accordingly, every leak during exploration or transportation is a source of methane. Such leaks are not only harmful to the climate, but also pose an acute risk of explosion, which is why operators check pipelines, compressor stations

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and other facilities for methane leaks. The company Adlares from Teltow near Berlin has implemented the CHARM (CH4 Airborne Remote Monitoring) process for this purpose, which can measure methane concentrations from a helicopter as it flies over the pipelines.

The helicopter flies at speeds of up to 180 km/h at an altitude of 100 to 150 meters and, thanks to its high measuring rate of 1000 measuring points per second, can register leakage rates from 150 l/h at wind speeds of up to 24 km/h. The beam source for the LIDAR system was developed by a team at the Fraunhofer Institute for Laser Technology ILT in Aachen. The second CHARM generation system contains two diode-pumped Nd:YAG lasers with a particularly narrow line width. Adlares supplied an optical parametric oscillator that converts the wavelength of the laser from around 1 µm to the mid-infrared at 3.3 µm.

In the meantime, the helicopter has not only flown several 10,000 kilometers of pipelines with the LIDAR system, but has also examined emissions from landfills, wastewater treatment plants, coal mines and farms. The system is so sensitive that it can even measure the emissions of a single cow.

Mapping the Earth's atmosphere with the satellite

Individual facilities can be checked quickly by helicopter, but this approach is too expensive and slow to search for methane sources globally. When permafrost thaws, for example, it can emit methane in low concentrations over huge areas.

This is why the German and French space agencies planned the MERLIN mission (Methane Remote Sensing LIDAR Mission) several years ago. A satellite will measure and map the methane concentration in the earth's atmosphere from an altitude of around 500 kilometers. On board the satellite will be a LIDAR instrument with a laser beam source from Fraunhofer ILT in Aachen.

The technologies for the LIDAR instrument of the MERLIN mission were designed and developed by a consortium of German industrial companies and research institutes. Scientific responsibility lies with the LIDAR department of the DLR Institute of Atmospheric Physics (IPA) in Oberpfaffenhofen, Germany.

Fraunhofer ILT has been developing technologies for such space-qualified laser systems for partners such as the German Aerospace Center DLR, Airbus Defence and Space, TESAT Spacecom and European Space Agency ESA for years. The Aachen-based institute has now developed a complete manufacturing technology for this purpose. The components manufactured in this way can withstand the stresses and strains of launch and operation in space.

The laser in the core of the LIDAR system must be able to withstand shocks of up to 300 g and vibrations of up to 25 g, as well as alternating thermal loads from -30 °C to +50 °C. The developers also have to avoid organic materials such as adhesives as far as possible so as not to contaminate the high-purity mirror surfaces. And, of course, the laser must function maintenance-free and without degradation for the duration of the mission of more than three years.

LIDAR: Technology of the Future

ESA considers LIDAR systems to be an important future technology with great potential for the further development of global weather models: Firstly, they can significantly improve weather forecasting with a particular focus on disaster management. As weather extremes caused by climate change increase, so does the need for early warning and rapid action.

Secondly, as renewable energies expand, the need for accurate forecasts for local wind conditions and hours of sunshine increases. The higher the proportion of volatile power sources, the more important it becomes to carefully manage and control the grid infrastructure. In this way, LIDAR systems and research at Fraunhofer ILT are supporting Europe on its way to achieving net-zero emissions, a balanced balance of greenhouse gas emissions by 2050.

Image 1:
The helicopter with the LIDAR system has already flown several 10,000 km and checked pipes for leaks.
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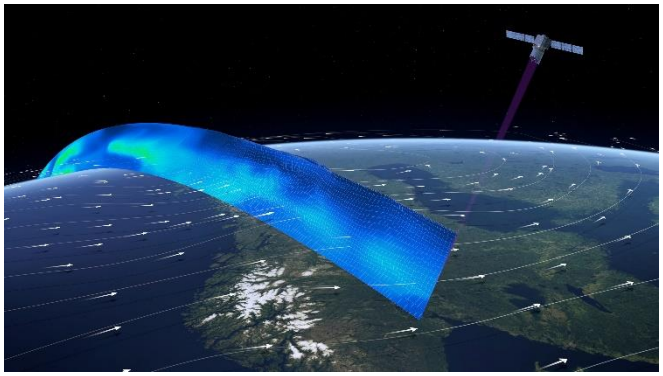

Image 2:
The successor to the ADM Aeolus satellite will use a powerful UV-LIDAR to measure wind profiles over the Earth in detail.
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Image 3:
The experts at Fraunhofer ILT have spent years perfecting the assembly of laser systems for use in the aerospace industry.
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