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Advancements in Remote Sensing Technologies for Monitoring Greenhouse Gas Emissions and Sources/Sinks

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Abstract

Greenhouse gases (GHGs) play a significant role in global warming, climate change, and its impact on the environment. Therefore, it is crucial to identify and monitor the sources and sinks of these gases to develop effective mitigation strategies. Remote sensing techniques have proved to be useful in detecting and mapping GHG sources and sinks globally. This review provides an overview of the various remote sensing techniques used to detect GHGs, their applications, and the challenges involved in the detection and mapping of GHGs. The review highlights the applications of remote sensing techniques for agriculture, forestry, and other land use sectors. Finally, the review concludes with the current state of remote sensing of GHGs and future prospects.

Keywords: *Greenhouse gases, remote sensing, sources, sinks, agriculture, forestry, land use, climate change.*

INTRODUCTION

Greenhouse gases (GHGs) play a vital role in the Earth's energy balance and climate system. These gases include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and fluorinated gases such as hydro fluorocarbons (HFCs), per fluorocarbons (PFCs), and sulfur hexafluoride (SF6). GHGs trap the sun's heat energy and warm the Earth's surface, leading to global warming and climate change. Human activities such as the burning of fossil fuels, deforestation,

agriculture, and industrial processes are the primary sources of GHG emissions.

To develop effective mitigation strategies, it is crucial to identify and monitor the sources and sinks of GHGs accurately. Remote sensing techniques have proved to be useful in detecting and mapping GHG sources and sinks globally. Remote sensing refers to the collection of data about an object or phenomenon without physically contacting it. It includes various techniques such as satellite imagery, aerial photography, and ground-based sensors.

This review provides an overview of the various remote sensing techniques used to detect GHGs, their applications, and the challenges involved in the detection and mapping of GHGs. The review highlights the applications of remote sensing techniques for agriculture, forestry, and other land use sectors. Finally, the review concludes with the current state of remote sensing of GHGs and future prospects.

Remote Sensing Techniques for GHGs Remote sensing techniques have been used to detect and map GHGs in the atmosphere, land, and ocean. The most commonly used techniques include satellite-based remote sensing, ground-based remote sensing, and airborne remote sensing.

Satellite-based remote sensing is the most widely used technique for GHG detection and mapping. Satellites such as the Orbiting Carbon Observatory-2 (OCO-2) and Greenhouse Gases Observing Satellite (GOSAT) use spectrometers to measure the absorption of sunlight by GHGs in the atmosphere. This absorption pattern can be used to estimate the concentration of GHGs in the atmosphere.

Ground-based remote sensing techniques involve the use of sensors placed on the ground to measure GHG concentrations in the atmosphere. These sensors include Fourier Transform Infrared Spectroscopy (FTIR), cavity ring-down spectroscopy (CRDS), and tunable diode laser absorption spectroscopy (TDLAS). Ground-based sensors provide high-precision measurements of GHGs, but they are limited in spatial coverage.

Airborne remote sensing involves the use of aircraft equipped with sensors to measure GHGs in the atmosphere. Airborne remote sensing provides higher spatial resolution than satellite-based remote sensing but is limited in temporal coverage.

Applications of Remote Sensing for GHGs
Remote sensing techniques have various applications in the detection and mapping of GHG sources and sinks. The following are some of the applications of remote sensing for GHGs:

Agriculture

Agriculture is a significant source of GHG emissions, mainly through the use of fertilizers and livestock management. Remote sensing techniques have been used to detect and map GHG emissions from agriculture. For example, satellite-based remote sensing has been used to map methane emissions from rice paddies and manure management systems. Ground-based sensors have also been used to measure GHG emissions from livestock and soil.

Forestry

Deforestation and forest degradation are significant sources of GHG emissions. Remote sensing techniques have been used to detect and map forest cover changes and quantify carbon stocks in forests. Satellite-based remote sensing has been used to monitor deforestation rates and estimate carbon emissions from forest loss. Ground-based sensors have been used to measure carbon stocks in forests and monitor forest management activities.

Other land use sectors: Remote sensing techniques have been used to detect and map GHG emissions from other land use sectors such as wetlands, urban areas, and transportation. For example, satellite-based remote sensing has been used to detect and map methane emissions from wetlands and landfills. Ground-based sensors have been used to measure GHG emissions from urban areas and transportation.

LITTERATURE REVIEW

Various studies have been conducted on remote sensing of GHGs and their sources and sinks. In a study conducted by Saito et al. (2020), the authors used satellite-based remote sensing to estimate methane emissions from rice paddies in Japan. The study found that methane emissions from rice paddies could be estimated accurately using satellite-based remote sensing.

In another study, Buchwitz et al. (2015) used satellite-based remote sensing to detect and map carbon dioxide emissions from fossil fuel combustion. The study found that satellite-based remote sensing could provide accurate estimates of carbon dioxide emissions from fossil fuel combustion at the regional scale.

A study conducted by Hu et al. (2019) used satellite-based remote sensing to

detect and map carbon dioxide emissions from power plants in China. The study found that satellite-based remote sensing could provide accurate estimates of carbon dioxide emissions from power plants.

In a study conducted by Alden et al. (2016), ground-based sensors were used to measure methane emissions from livestock in California. The study found that ground-based sensors could provide accurate measurements of methane emissions from livestock.

CONCLUSION

Remote sensing techniques have proved to be useful in detecting and mapping GHG sources and sinks globally. Satellite-based remote sensing is the most widely used technique for GHG detection and mapping, followed by ground-based and airborne remote sensing. Remote sensing techniques have various applications in the detection and mapping of GHG sources and sinks in agriculture, forestry, and other land use sectors.

However, the detection and mapping of GHGs using remote sensing techniques still face several challenges. These challenges include the need for improved sensor accuracy and resolution, cloud cover, and atmospheric interference. Furthermore, the cost of remote sensing equipment and data processing can limit the widespread use of remote sensing techniques.

Despite these challenges, the use of remote sensing techniques for GHG detection and mapping is expected to increase in the future, given the urgency of the climate change crisis. Future research should focus on improving sensor accuracy and resolution, developing new algorithms for GHG detection and mapping, and reducing the cost of remote sensing equipment and data processing.

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