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CO_2 capture and storage monitoring based on remote sensing techniques: A review

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ABSTRACT

Carbon Dioxide (CO2) has been causing harmful effects to the environment and even to the whole earth. Nowadays, it is the leading cause of global warming and the greenhouse effect that poses a serious threat to the welfare of the planet earth and its inhabitant plants, animals, and humans alike. After years of theoretical demonstration and field tests, carbon capture and storage (CCS) has been proven to be an effective approach to reduce atmospheric CO_2 and has made an important contribution to reducing global greenhouse gas emissions. The monitoring of storage site leakage is an important link to ensure the effective implementation of the project such as injection of CO_2 into deep Earth to drive the oil and gas to shallow depth of Earth for increasing the oil/gas productions and meanwhile to protect the surrounding environment and personnel from the harmful effects of CO_2 leakage. As a new leakage monitoring method, remote sensing has been successfully applied in many storage sites with its advantages of extensive scope of observations, non-contact and long-term cost-effective monitoring. In this study, various remote sensing monitoring technologies are summarized and discussed in terms of their advantages and disadvantages in applications, their development trend in the future, and promising remote sensing monitoring system for the safety of different CO_2 injection stages.

1. Introduction

Carbon dioxide (CO_2), a primary greenhouse gas, is an important factor in global warming by trapping heat in the atmosphere. Extreme weather and melting glaciers caused by global warming greatly impact the survival of species worldwide, and can even be devastating (Anderson et al., 2016). However, the CO_2 content in the atmosphere is still increasing. The National Oceanic and Atmospheric Administration's Mauna Loa observatory detected that the concentration of CO_2 in the atmosphere has exceeded 415 ppm, which is the highest level ever recorded (Global Monitoring Laboratory, 2020). The 2019 Emissions Gap Report of the United Nations Environment Programme (UNEP) warned that even if all of the unconditional commitments under the Paris Agreement were met, the global temperature could have still been raised by 3.2 °C, and only an annual decrease of CO_2 emissions about 7.6% would keep global warming below 1.5 °C (UNEP, 2019). Based on the IPCC report released in 2018, if temperature increased about 1.5 °C in the future, species extinctions would occur, approximately 6% of insects, 8% of plants and 4% of vertebrates among the 105,000 species studied would be vanished (IPCC, 2018). At the same time, climate change would tend to affect poorer subsistence communities through decreases in crop production and quality but increase of crop pests and diseases, and disrupt ultimately to culture (Koelbl et al., 2015).

The CO_2 in the atmosphere mainly originates from the burning of fossil fuels, the respiration of plants and animals, and the decomposition of animal and plant carcasses by microorganisms (Alonso et al., 2017; de Coninck et al., 2009). Among these sources, CO_2 emissions from industrial production urgently need to be reduced, because they have been doubled in emission in the past 30 years and were most likely not to be controlled (J. Chen et al., 2019). In 1989, the Massachusetts Institute of Technology (MIT) proposed the Carbon Capture and Storage Technologies (CC&ST) project that provided an entirely new approach to carbon emissions and storage (Herzog H, 1993). CCS sites now are effective to increase energy production, including CCS-EOR (Enhanced Oil Recovery) which

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