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Tracking carbon dioxide emissions from space could help support climate agreements

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NASA's Orbiting Carbon Observatory (OCO-2) satellite can make precise measurements of global atmospheric carbon dioxide (CO2) from space. Credit: NASA/JPL-Caltech

The central objective of the Paris Agreement is to limit Earth's warming to well below 2 C above pre-industrial levels, but preferably 1.5 C.

This challenging task will require policies and tools to enable every sector of society to drastically reduce greenhouse gas (GHG) emissions to eventually reach net-zero.

Enacting the most effective and efficient strategies to reduce emissions starts with knowing in detail where, when and how much of these greenhouse gases we are emitting, followed by implementing emission reduction policies and tracking our progress.

Is it possible to track carbon dioxide (CO_2) emissions and emission reductions from space? New research from my group shows that it is.

Why CO_2 matters

CO_2 is the primary greenhouse gas driving climate change. Burning fossil fuels for electricity generation, heating buildings, industry and transportation has elevated the CO_2 in our atmosphere well beyond natural levels.

Currently, CO_2 emission reporting is mainly done by accounting for the mass of fossil fuels purchased and used, then calculating the expected emissions—not actual atmospheric CO_2 measurements. The finer details about exactly when and where the emissions occurred are often not available, but more transparent monitoring of CO_2 emissions could help track the effectiveness of policies to reduce emissions.

Today GPS satellites help us to get around, meteorological satellites track weather systems and communication satellites relay TV, internet and telephone signals. It is time we use satellites to help tackle the biggest challenge that humanity has ever faced—climate change.

Satellites for measuring CO_2

A global network of ground-based CO_2 measurements began in 1957 and now consists of over one hundred stations around the world. Accurate and precise measurements from these stations have revealed a lot about changes in global atmospheric CO_2 and Earth's overall carbon cycle, but we can't place these stations everywhere on Earth.

Satellites can observe the entire planet. Those that measure CO_2 in the lower atmosphere near Earth's surface (where CO_2 emissions and CO_2 uptake by plants happens) first began making measurements in 2002. Since then, they have been getting better and better at doing it, but there have been setbacks along the way.

About a decade of effort by NASA went into developing the Orbiting Carbon Observatory (OCO) satellite to make precise measurements of atmospheric CO_2 across the Earth.

In 2009, OCO was lost due to a launch problem. After sustained advocacy for a rebuild of this important climate mission, NASA secured new funding to launch the OCO-2 satellite in 2014 and OCO-3 to the International Space Station in 2019.

The OCO missions were designed to improve our understanding of vegetation's CO_2 absorption, also known as the land carbon sink. But what about fossil fuel CO_2 emissions?

A new way to verify CO_2 emissions

In 2017, I led a research team that published the first study showing that we can quantify CO_2 emissions at the scale of an individual power plant using OCO-2 observations.

Since OCO-2 was not designed for this purpose, its coverage and infrequent visits were inadequate for operational global CO_2 emission monitoring, but we can still quantify emissions in select cases when the satellite passes close enough and gets a good cloud-free view.

OCO-3 is very similar to OCO-2, but has an additional pointing mirror that enables it to better map CO_2 around targets of interest like the Bełchatów Power Station in Poland, Europe's largest fossil fuel burning power plant and CO_2 source.

With ten clear views of CO_2 emission plumes from Bełchatów imaged by OCO-2 and OCO-3 from 2017-2022 analyzed in our new study, we were able to determine emissions on those days.

European power plants report hourly power generation but only annual CO_2 emissions. Power generation fluctuates with electricity demand and generating unit shutdowns (for maintenance or decommissioning) and CO_2 emissions are expected to exhibit proportional fluctuations.

We confirmed this using OCO-2 and OCO-3 in our recent paper, which showed that satellite observations can track changes in facility-level CO_2 emissions. This means that satellites can be used to verify (or refute) reported CO_2 emission reductions that result from climate change mitigation—like mandated efficiency improvements, carbon capture and storage technology, etc.

Emissions monitoring for the Paris Agreement

Our approach can be applied to more power plants or modified for CO_2 emissions from cities or countries with OCO-2 and OCO-3. We can also try integrating the satellite observations with CO_2 monitoring from the ground or aircraft.

While we are already working on this, advances will only be incremental until the launch of the European Commission-funded Copernicus Anthropogenic CO_2 Monitoring Mission or "CO2M". CO2M is comprised of two satellites, aiming to launch in late 2025.

These satellites will provide about 50 times as much coverage as OCO-2 and OCO-3 combined and will form the space component of Europe's system for CO_2 emissions Monitoring, Verification and Support (MVS).

CO2M will be a major advance, but just like successful global climate action, requires contributions from many countries. The long-term robust operational global monitoring of GHG emissions will need a constellation of satellites contributed by multiple countries as part of an integrated global observing system.

Hopefully, with new, more detailed and transparent tracking of human-caused greenhouse gas emissions to assess and guide us toward the most effective policies, society can achieve the emission reductions needed to reach net-zero in time.

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