Session 3: Questions & Answers

Please type your questions in the Question Box. We will try our best to answer all your questions. If we don't, feel free to email Abhishek Chatterjee (abhishek.chatterjee@jpl.nasa.gov), Vivienne Payne (vivienne.h.payne@jpl.nasa.gov), Junjie Liu (junjie.liu@jpl.nasa.gov), Karen Yuen (karen.yuen@jpl.nasa.gov), David Moroni (david.f.moroni@jpl.nasa.gov), or Erika Podest (erika.podest@jpl.nasa.gov).

Question 1: Are there any global standards for new buildings in terms of CO_2 impacts with respect to urban growth?
Answer 1: Please see the 2022 Global Status Report for Buildings and Construction from the UN Environment Programme: (https://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction). The report provides a review of policies, technologies, and where the building sector aligns with the Paris Agreement goals. In general, buildings are included in climate pledges under the Paris Agreement – known as Nationally Determined Contributions (NDCs) – and mandatory building energy codes. As per the report, the number of NDCs that mention buildings have grown from 88 in 2015 to 158 in 2021. However, progress on buildings and construction policies and action remains slow. Over the same period, the number of countries with building energy codes rose from 62 to 79. However, only 26% of countries have mandatory building energy codes for the entire sector.

Question 2: Which observation mode is ideal for studying urban emissions?
Answer 2: The Snapshot Area Mapping (SAM) mode is best suited for studying urban emissions. Please see various science publications using the SAM data at https://ocov3.jpl.nasa.gov/science/publications/.

Question 3: Does CO_2 concentration depend on the population density of the geographical area?
Answer 3: There is a strong interplay between population and area on CO_2 emissions, which also changes whether the city falls within an Annex-I or non-Annex I country. Please see this study for an in-depth analysis of the relationship between urbanization and CO_2 emissions: https://www.nature.com/articles/s41467-019-11184-y.

Question 4: Does any country have a legal responsibility to reduce emissions for their public transport sectors?
Answer 4: Yes. In Europe, in 2019, as part of the European Green Deal, the Council of the EU and the European Parliament adopted the very first legislation targeting the CO_2 emissions of new heavy-duty vehicles in the EU: Regulation (EU) 2019/1242. Initially, only emission standards were set for large heavy-duty vehicles (>16 tons), which account for around 65-70% of total CO_2 emissions from heavy-duty vehicles. From 2025, new registrations of heavy-duty vehicles in the EU will have to show an average reduction of 15% in CO_2 emissions compared with a reference period (01/07/2019-30/06/2020). Then, from 2030, this reduction will have to reach 30%. The regulation also provides for mandatory monitoring and reporting of CO_2 emissions and fuel consumption of new heavy-duty vehicles, to ensure compliance with CO_2 reduction targets. In a 2022 review, these standards have been extended to other types of heavy vehicles, such as small trucks (<16 tons), buses and coaches. In a regulation drafted on February 14, 2023, the European Commission suggests new, more ambitious EU targets with CO_2 emission reductions of:

15% from January 1, 2025,
45% from January 1, 2030,
65% from January 1, 2035,
90% from January 1, 2040.

Please see:
https://climate.ec.europa.eu/system/files/2023-02/policy_transport_hdv_20230214_proposal_en_0.pdf and associated regulation documents.

Question 5: Why is it called a Bottom-Up Approach?
Answer 5: It is called “Bottom-Up” because it is developed from the ground up. These approaches use direct flux monitoring and/or sectoral activity data gathered from various socioeconomic sources to develop spatiotemporally explicit, mechanistic CO_2 emissions.

Question 6: Is there a plan to be able to access OCO data from Google Earth Engine?
Answer 6: As was previously mentioned in the Q&A for Parts 1 and 2, GEE is not within the scope for this training.

Question 7: At what altitudes are these changes observed?
Answer 7: The ISS flies at a height of ~400-420 km above the Earth. Therefore, OCO-3 is observing the XCO_2 from that height. This is different from OCO-2, which flies at a height of ~705 km above the Earth.

Question 8: Do you have a similar example for agricultural land? Or, say, a new football field being constructed for FIFA?
Answer 8: OCO-3 SAM observations are made over an area of ~80 km by 80 km. Individual soundings are approximately ~4.5 km2. Hence, it is of much larger size than a plot of agricultural land or a football field.

Question 9: How has the dynamic nature of the atmosphere, particularly in terms of clouds and aerosols, been accounted for in the accuracy of CO_2 measurements? How does the accuracy and coverage of different satellite data, such as OCO-2, OCO-3, and GOSAT compare?
Answer 9: Please see the details covered in Part 1 of this training on how the retrievals are performed taking into account the impact of clouds and aerosols. These measurements are subsequently validated against a network of ground reference measurements. Also, see this paper for comparison between OCO-2 and OCO-3: https://amt.copernicus.org/articles/16/3173/2023/amt-16-3173-2023.html. It provides references for previous studies that have compared OCO-2 and GOSAT data also.

Question 10: What is the viewing angle of the device (sensor) during shooting?
Answer 10: I am not sure what is meant by shooting here. Please clarify. The sensors for SAM are shot in nadir (straight down).

Question 11: How quickly does a satellite or group of satellites see a particular object of interest?
Answer 11: This depends upon the trajectory of the satellite orbits. The International Space Station on which OCO-3 is located goes around the Earth 16 times a day. There are instances where we can see the same location multiple times during a day, or sometimes there is a gap of a few days before we see the same location. Of course, remember that because of clouds and aerosols, even if we pass over the same location, we may have data gaps if there are thick clouds or aerosols present.

Question 12: Is it possible to visualize the transport and fate at regional scales?
Answer 12: OCO-3 SAMs are over an area of ~80 km by 80 km. These data are used to infer emission estimates at local and regional scales.

Question 13: For the top-down approach, would you say the accuracy of this modeling approach will improve due to improvement in communication technologies?
Answer 13: Even with a high resolution atmospheric transport model, we still need to account for factors such as wind speed. Improved estimates will lead to improved accuracy. We will look into this further with more clarification.

Question 14: How can I generate the animation of the observations in urban areas on slide number 20?
Answer 14: You can write scripts in Matlab or Python to do those animations.

Question 15: Is there a legal definition of the background values for different locations?
Answer 15: No, there is no legal definition. As mentioned during the webinar, current approaches are best on scientific best practices.

Question 16: GHG emissions consist of 6 types of gasses, how does SAM help in identifying them separately?
Answer 16: The OCO-3 SAM only provides information about CO_2. It does not provide information about any of the other gasses. Hence, as shown in the webinar, we need to bring in information from other sensors like the European TROPOMI mission (NO_2, CO, CH_4) or NASA's EMIT mission (CH_4).

Question 17: Why is CO_2 considered the most important greenhouse gas to report, despite the presence of other gasses like NO_2 and SO_2?
Answer 17: Please see this page on what gasses are considered greenhouse gasses - https://www.epa.gov/ghgemissions/overview-greenhouse-gases. CO_2 is the longest-lived greenhouse gas in the atmosphere. NO_2 and SO_2 are not considered greenhouse gasses, they are pollutants and do not absorb direct infrared radiation like CO_2 and other greenhouse gasses. They are often considered indirect greenhouse gasses because of chemical reactions in the atmosphere and their impact on other species that can then impact the direct greenhouse gasses like CO_2 and CH_4.

Question 18: How easy would it be to globally reduce or eliminate fluorinated gasses as inputs to the dynamic situation?
Answer 18: Refer to the link in Question 17.

Question 19: Is there a reason that developing cities have a higher incline of emission ratio per GDP?
Answer 19: The primary reason being that as developing regions are growing economically, they tend to use less sustainable sources of energy due to cost benefits.

Question 20: Will the EMIT data be publicly available for commercial use for a commercial company? If yes, how do I access the data for use?
Answer 20: Yes, the EMIT data is publicly available. Please see various EMIT data products that are available at:
https://lpdaac.usgs.gov/product_search/?query=EMIT&view=cards&sort=title.

Question 21: Are CMIP5 emissions of carbon monoxide significant to investigate?
Answer 21: Unfortunately, I am not an expert on carbon monoxide (CO).

Question 22: How much CO_2 and CH_4 data is available over Nigeria?
Answer 22: OCO-3 SAMs of CO_2 data are available over the city of Lagos. However, there is regular nadir and glint data of CO_2 from both OCO-2 and OCO-3 over Nigeria. You can get CH_4 data from the European TROPOMI mission.

Question 23: Is there a way to convert OCO-3 and OCO-2 data from nc4 to csv or Tiff using Python scripts?
Answer 23: Yes, that is possible and we have developed a notebook to do that. We will make it available in the folder once we get clearance. Please check back at a later date.

Question 24: How do we set the min-max of the color bar? Is it picking the range from the dataset or do we define it explicitly?
Answer 24: In the notebook, in cell 14, you can define and adjust the min/max for the values range of XCO_2.

Question 25: In the presentation, the point was raised about validation of bottom-up estimates using OCO-3 SAM observations. How can we do that with differences in spatial resolution and other issues?
Answer 25: Bottom-up estimates are typically available at a very high spatial resolution. Those estimates need to be aggregated up to the same resolution as the top-down estimates obtained using OCO-3 SAM observations. The estimates from the different approaches need to be at the same resolution for a robust comparison. In addition, one can look at other diagnostics, such as time trends or spatial gradients to compare estimates from different approaches.

Question 26: Is it possible to export data to raster (geotiff) format? Is there data that can be accessed all over the world?
Answer 26: Please see answer to question 23.

Question 27: Why are there straight lines/patches with the same color in the city data in the hands-on exercise? How do you remove those?
Answer 27: Lines can appear in our mapping because we are using all the obtained data and they reflect the data gathered in the collection path from ISS. For a specific urban area and the cleaner presentation, please go to https://ocov3.jpl.nasa.gov/sams/ where you can look up the SAMs that have been created by the science team. This particular notebook is useful to get an idea about where we have data for a particular time and region.

Question 28: How do you obtain the background CO_2 in an urban area?
Answer 28: The answer to this question is provided in Slide 23 -
https://appliedsciences.nasa.gov/sites/default/files/2024-07/OCO_Part3_Final.pdf
The slide also provides information about various peer-reviewed publications that can be further reviewed to understand the different techniques that can be used to define the background CO_2.

Question 29: Where can you obtain the geographic boundary for an urban city such as Los Angeles?
Answer 29: For Los Angeles, you can obtain the county raster map here -
https://geohub.lacity.org/datasets/lahub::county-boundary/about

Within the United States, most city's GIS and Planning agencies have these datasets and raster layers available. TIGER data from the United States Census Bureau also provides this information.

Question 30: Are there any sensors or algorithms to evaluate N_2O emissions?
Answer 30: There are algorithms that evaluate N_2O. Most of this information is in situ data. There is a proposed mission to the European Space Agency that may/may not be operational: https://www.sciencedirect.com/science/article/pii/S0034425721004089.

Question 31: What global monitoring systems are available to track fluorinated gasses? Are there any satellite missions you know of which could measure these, whether they were originally designed to or not?
Answer 31: Fluorinated gases are primarily measured using ground-based networks that are operated by our colleagues at the National Oceanic and Atmospheric Administration Global Monitoring Laboratory - please see https://gml.noaa.gov/dv/iadv/. There are also other consortiums like the Advanced Global Atmospheric Gases Experiment (AGAGE) that comprises various international laboratories and organizations that operate ground-based networks to measure a variety of greenhouse gases and air pollutants, including fluorinated gases. Please see https://www-air.larc.nasa.gov/missions/agage/ for more details.