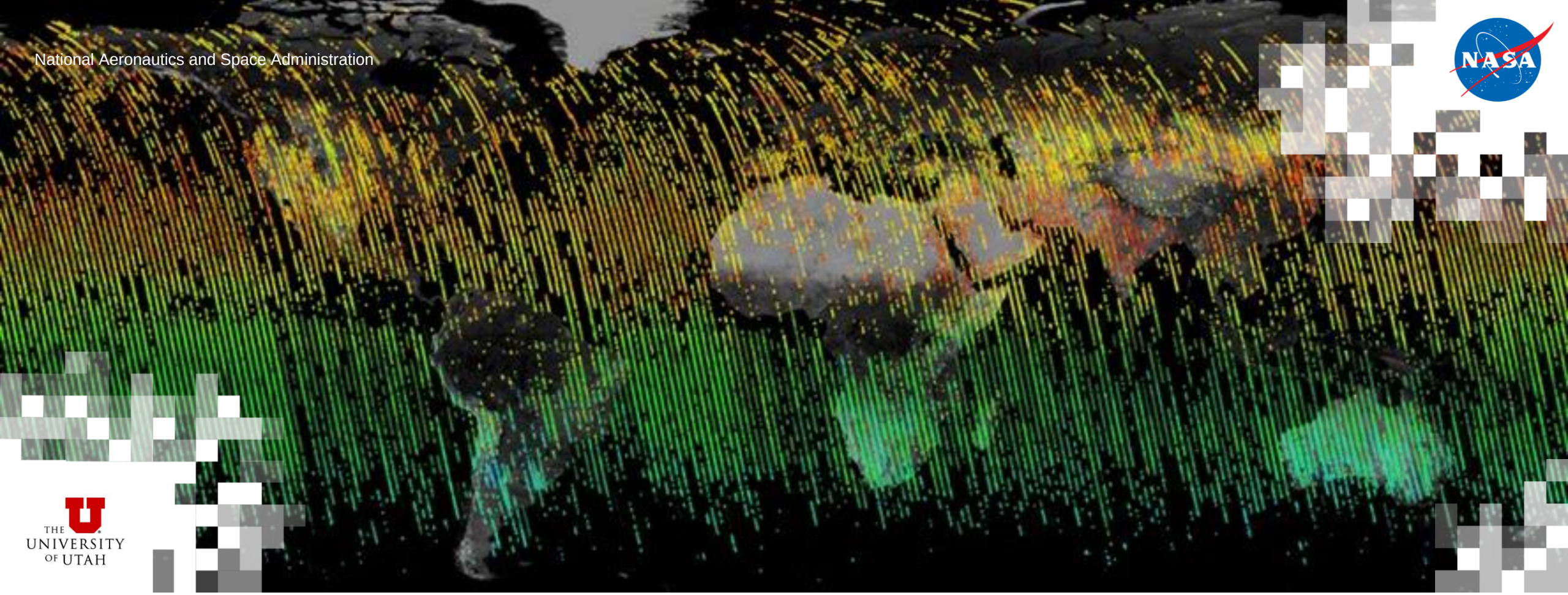


How to Access and Visualize OCO-2 and OCO-3 Data

Karen Yuen, Sagar Limbu, and Charles Thompson

May 26, 2022

Webinar Agenda

Part 1: An Introduction to XCO_2 with OCO-2 and OCO-3

- EDT (UTC-4:00)
- Tuesday, May 24, 2022
- Trainers: Vivienne Payne (JPL)
- Background of the XCO2 measurement and how it is measured
- Description of the OCO-2/OCO-3 sensors
- Characteristics, limitations and validation of the measurement
- Q&A

Part 2: A Demonstration on how to Access and Visualize OCO-2/OCO-3 Data

- EDT (UTC-4:00)
- Thursday, May 26, 2022
- Trainers: Karen Yuen (JPL)
- Use of Jupyter Notebook to access, search, filter and display XCO_2 data
- Q&A

Part 3: XCO_2 in Support of Global and Regional Climate-Related Studies

- EDT (UTC-4:00)
- Tuesday, May 31, 2022
- Trainers: Abhishek Chatterjee (JPL)
- Global and regional carbon flux estimation, and carbon cycle response to climate variability and changes in anthropogenic emissions
- Q&A

Part 4: XCO_2 in Support of Local and Regional Climate-Related Studies

- EDT (UTC-4:00)
- Thursday, June 2, 2022
- Trainers: John Lin (University of Utah)
- Climate impacts from localized emissions, air quality, and urban density
- Q&A

Learning Objectives

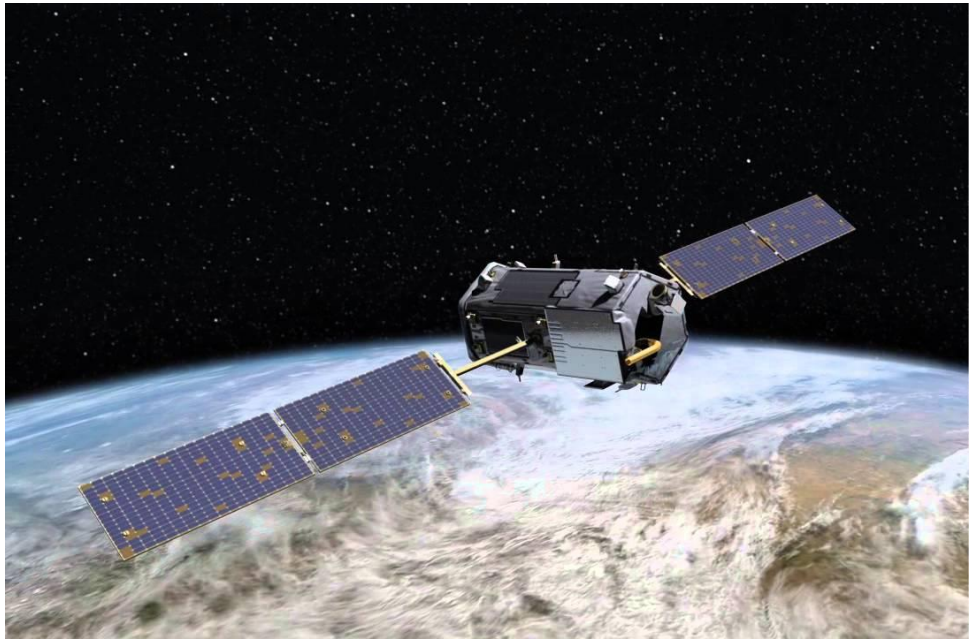
By the end of this demonstration attendees will be able to:

- Understand the characteristics and limitations of XCO2 measurements from space
- Understand the type of climate studies that these measurements can support
- Be able to open and visualize XCO_2 data from OCO-2 and OCO-3

Overview

1. A summary of the characteristics of OCO-2 and OCO-3
2. OCO-2 Measurement Approach
3. OCO-3 Measurement Approach
4. Recap of XCO2 Measurement
5. Spatial and Temporal Resolution for OCO-2 and OCO-3
6. Timeline of Available XCO2 data
7. Where to Download Data
8. Product and Naming
9. Documentation for data products (ATBD and User Guide and Link)
10. Demonstration Portion with Jupyter Notebook

OCO-2 and OCO-3

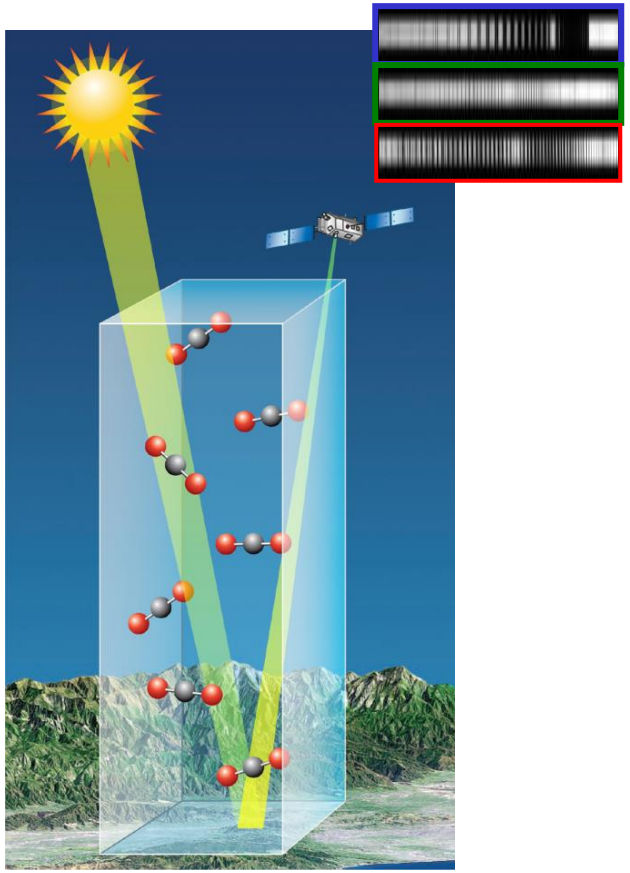


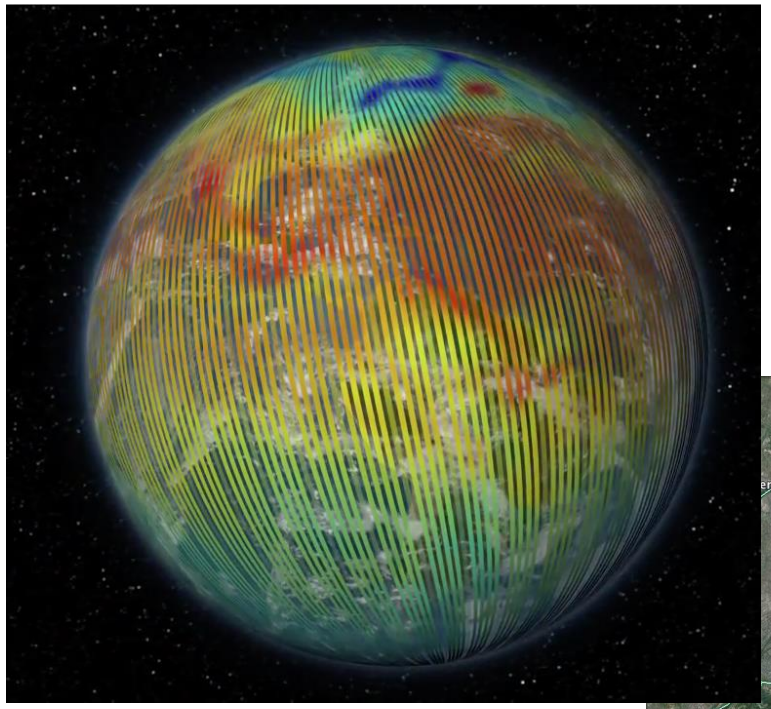
OCO-2 (2014 - Present)

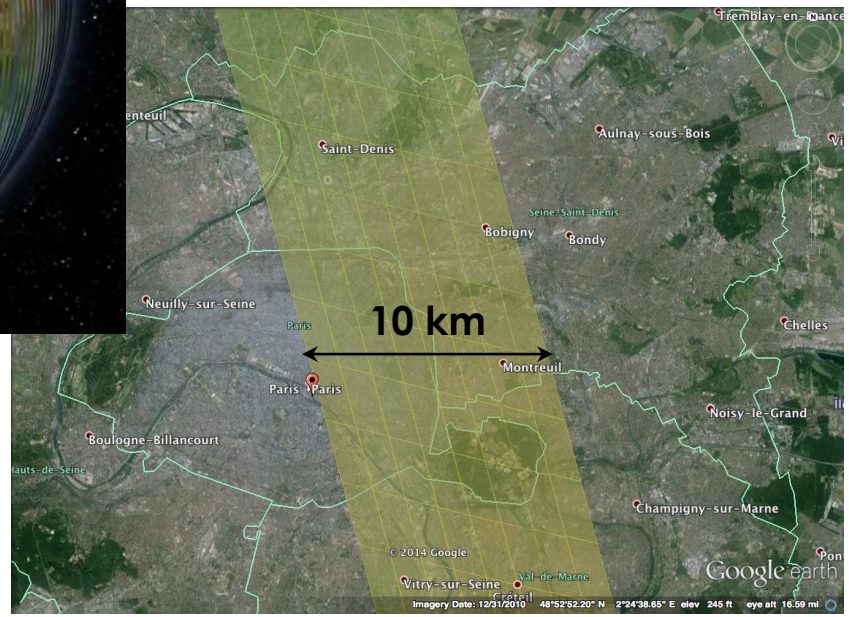
OCO-3 on ISS (2019 - Present)

OCO-2 Measurement Approach

Collect spectra of CO_2 & O_2 absorption in reflected sunlight over the globe





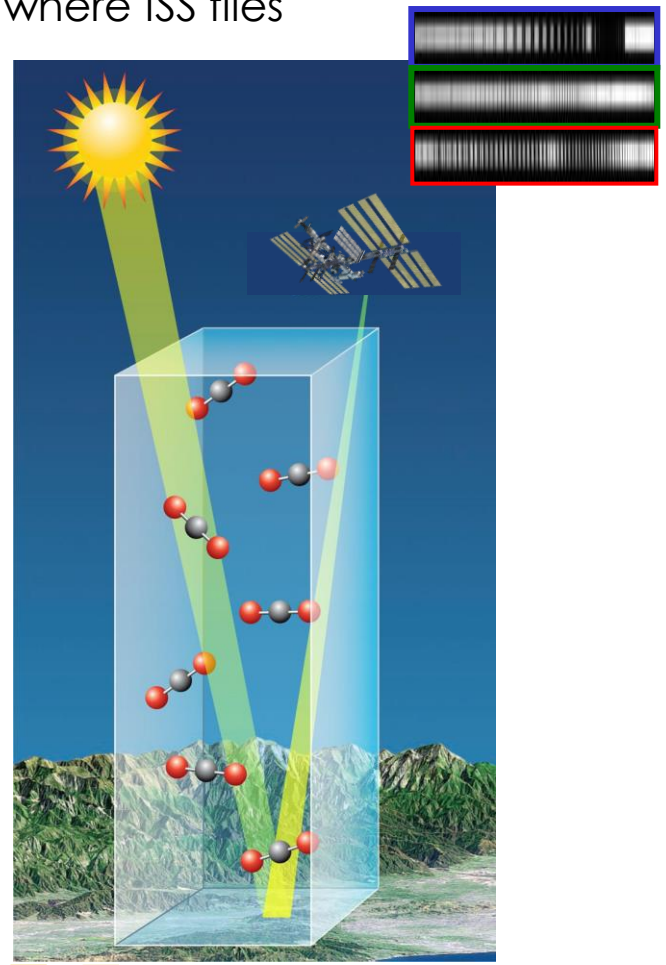


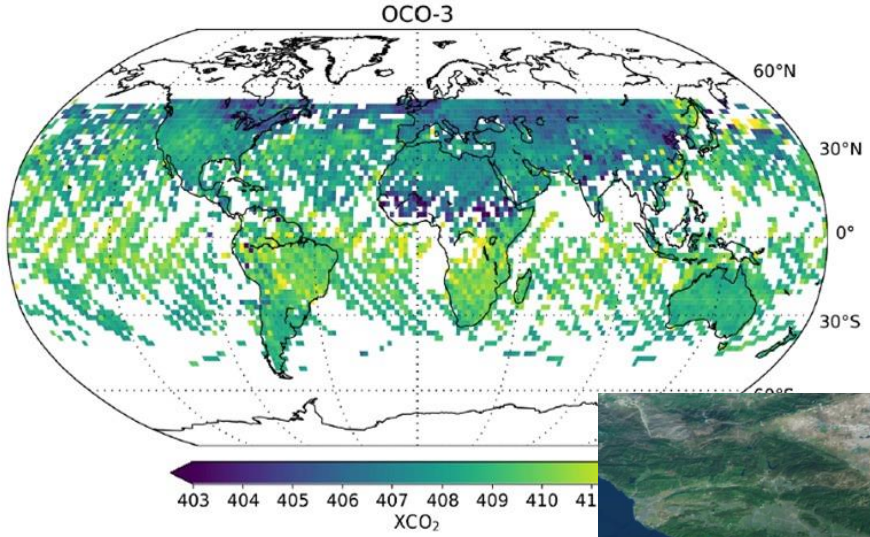
OCO-2 Measurements:

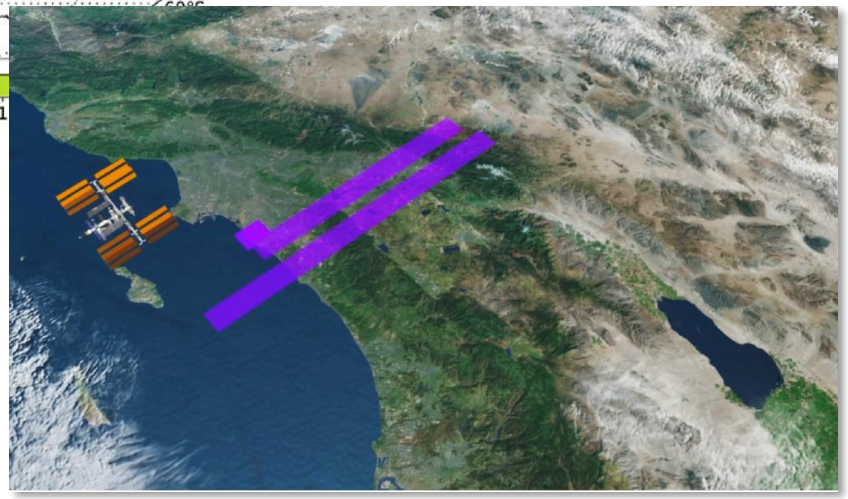
- Global
- Precise
- Small Footprints

OCO-3 Measurement Approach

Collect spectra of CO_2 & O_2 absorption in reflected sunlight over where ISS flies



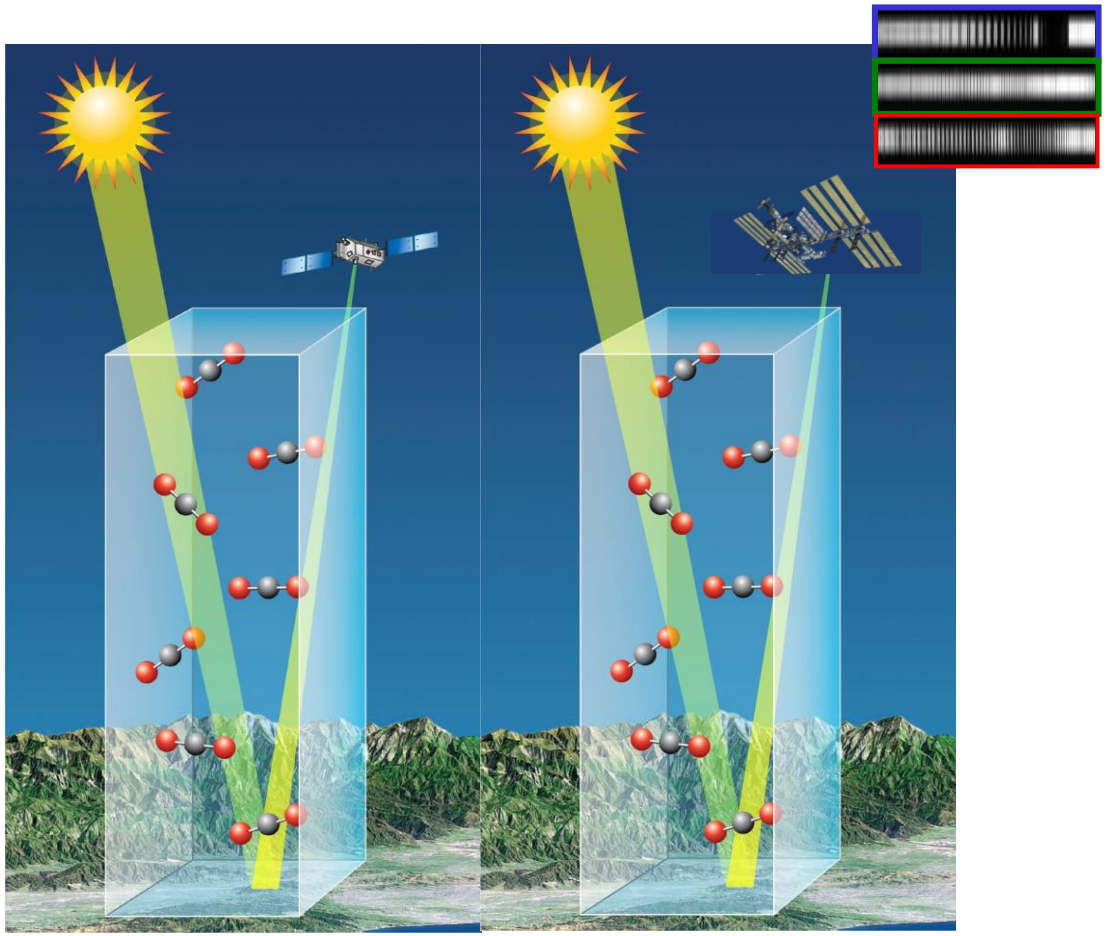




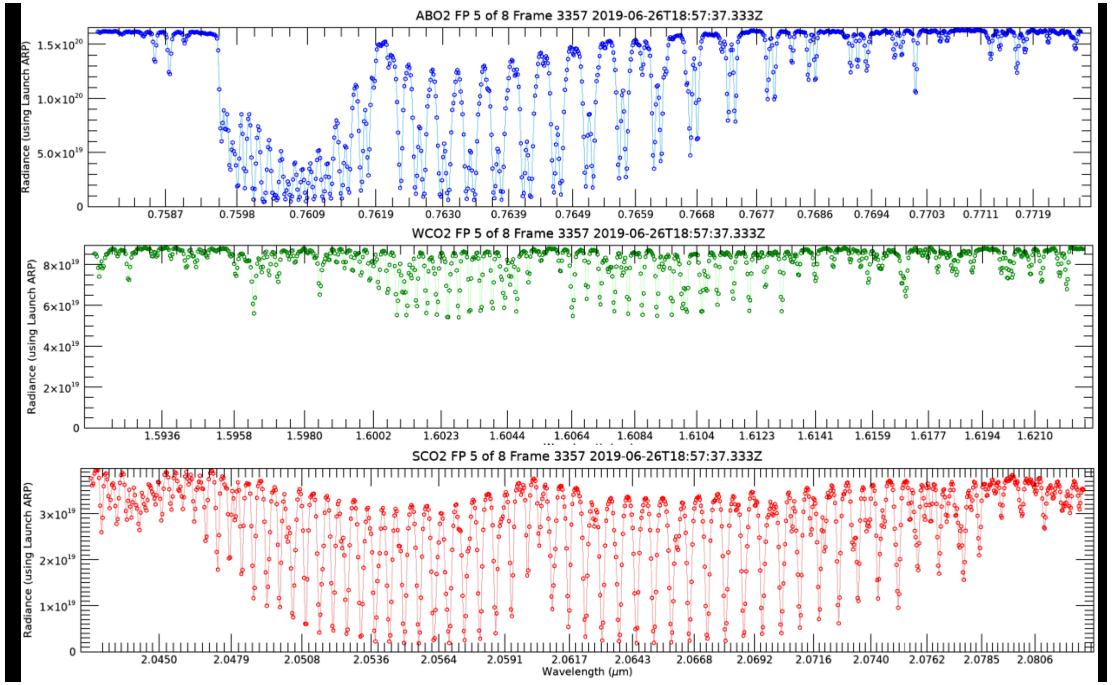
OCO-3 Measurements:

- 52 Degrees North/South Latitude
- More Precise and Denser Footprint than OCO-2
- Mapping Capability of 80 x 80 km

Recap of the XCO_2 Measurement



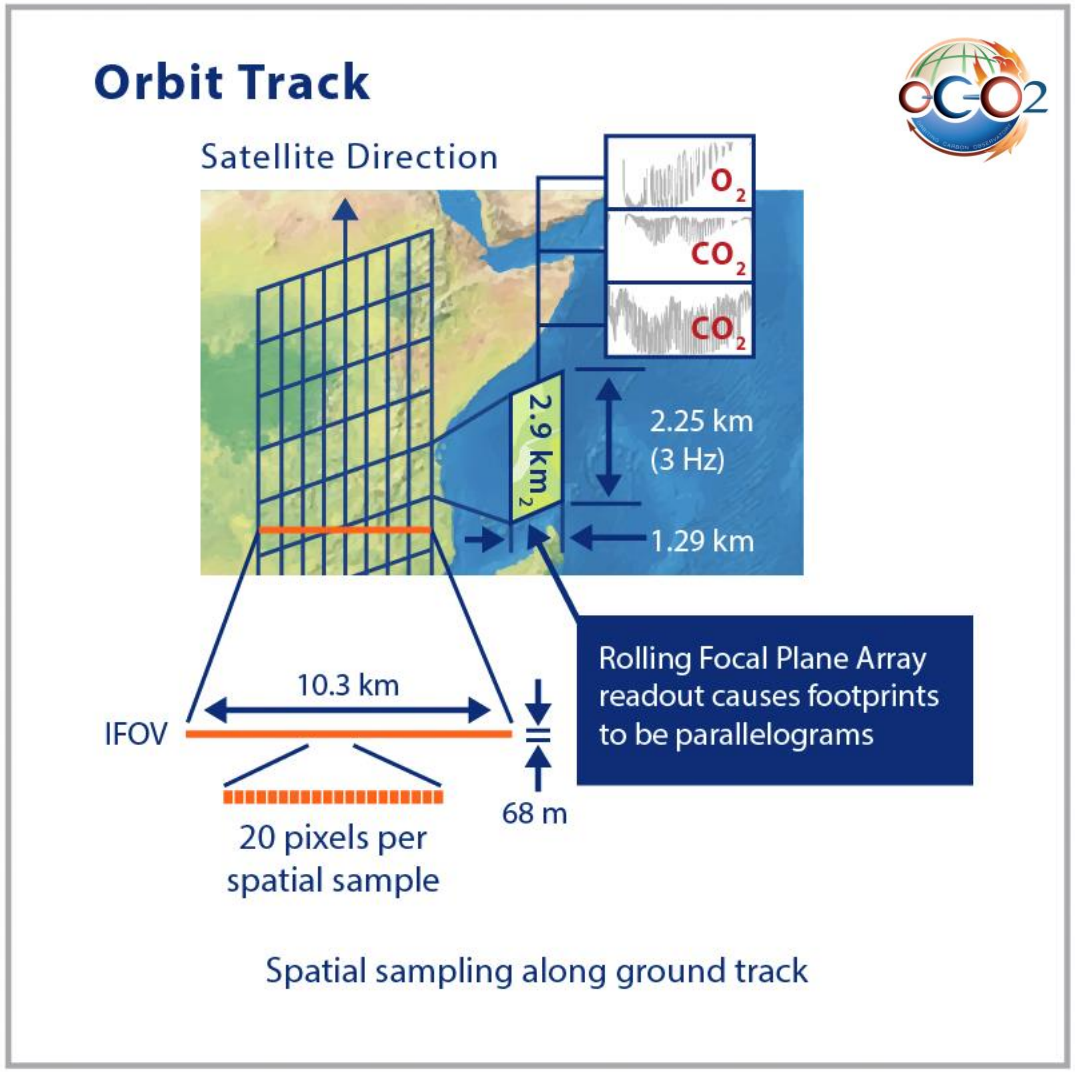
XCO_2 is the column average volume mixing ratio. This is a measure of the amount of carbon dioxide in the atmosphere within the column.

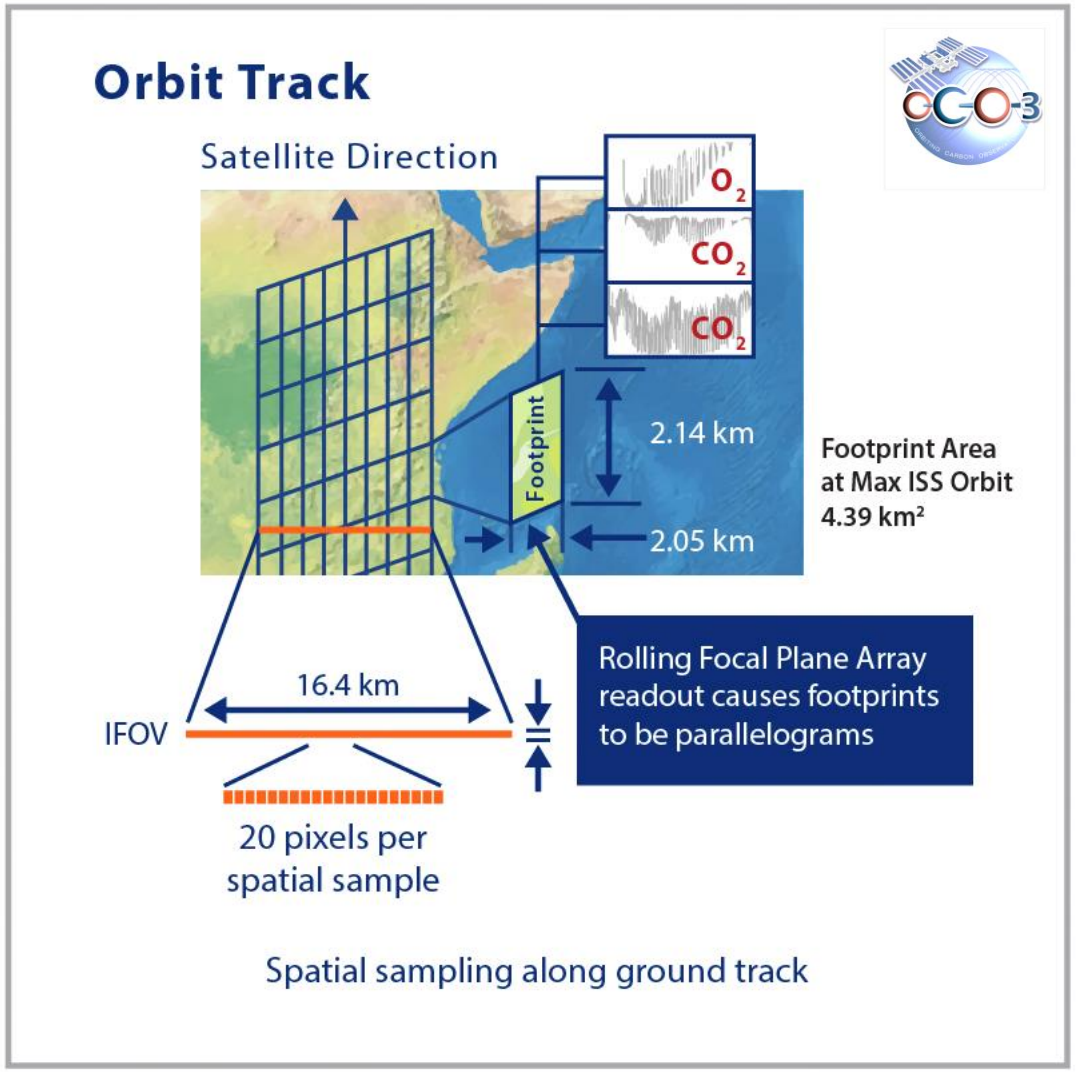


Gas molecules in the Earth's atmosphere absorb the sunlight at specific wavelengths, creating "fingerprints" that can be detected by a spectrometer.

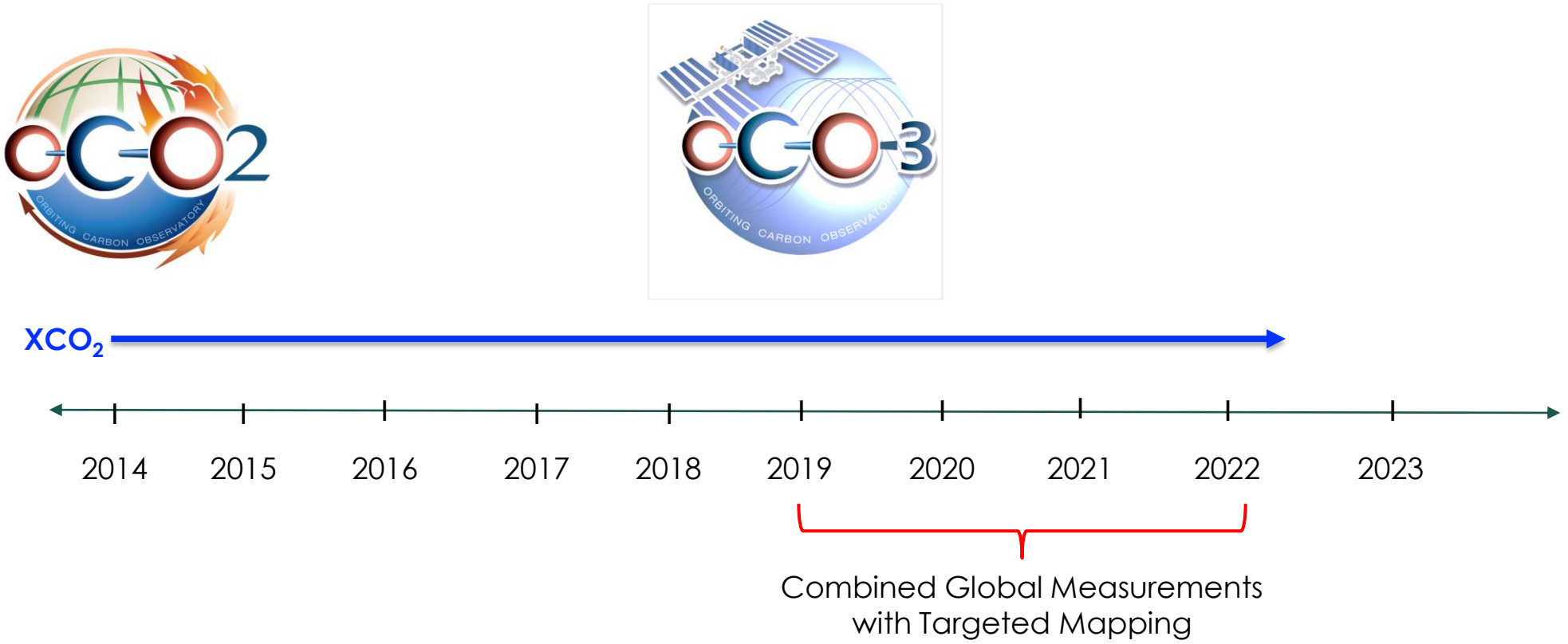
A spectrometer creates spectra, or photos of these "fingerprints". Then the absorption levels shown in these spectra, like a captured image, tells us how many molecules were in the region where the instrument measured.

Spatial Resolution for OCO-2 and OCO-3





Timeline of Available XCO2 Data

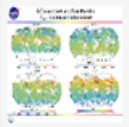


Where to Download Data

https://daac.gsfc.nasa.gov/datasets?keywords=OCO-2&page=1
https://co2.jpl.nasa.gov/

Image	Dataset	Source	Version	Time Res.	Spatial Res.	Process Level	Begin Date	End Date
 Hover	OCO-2 Level 2 bias-corrected XCO2 and other select fields from the full-physics retrieval aggregated as daily files, Retrospective processing V10r (OCO2_L2_Lite_FP 10r) Subset / Get Data	OCO-2 OCO-2	10r	16 days	2.25 km x 1.29 km	2	2014-09-06	2022-03-01
 Hover	OCO-2 Level 2 bias-corrected XCO2 and other select fields from the full-physics retrieval aggregated as daily files, Retrospective processing V9r (OCO2_L2_Lite_FP 9r) Subset / Get Data	Earth Observation Satellites OCO-2	9r	16 days	2.25 km x 1.29 km	2	2014-09-06	2020-01-22
 Hover	OCO-2 Level 2 bias-corrected solar-induced fluorescence and other select fields from the IMAP-DOAS algorithm aggregated as daily files, Retrospective processing V10r (OCO2_L2_Lite_SIF 10r) Subset / Get Data	OCO-2 OCO-2	10r	16 days	2.25 km x 1.29 km	2	2014-09-06	2022-02-28
 Hover	ACOS GOSAT/TANSO-FTS Level 2 bias-corrected XCO2 and other select fields from the full-physics retrieval aggregated as daily files V9r (ACOS_L2_Lite_FP 9r) Subset / Get Data	GOSAT TANSO-FTS	9r		10.5 km x 10.5 km	2	2009-04-20	2020-01-01
 Hover	OCO-2 Level 2 geolocated XCO2 retrievals results, physical model, Retrospective Processing V10r (OCO2_L2_Standard 10r) Get Data	OCO-2 OCO-2	10r	16 days	2.25 km x 1.29 km	2	2014-09-06	2022-03-01
 Hover	OCO-2 Level 2 geolocated XCO2 retrieval results and algorithm diagnostic information, Retrospective Processing V10r (OCO2_L2_Diagnostic 10r) Get Data	OCO-2 OCO-2	10r	16 days	2.25 km x 1.29 km	2	2014-09-06	2022-02-28
 Hover	OCO-2 Level 2 spatially ordered geolocated retrievals screened using the IMAP-DOAS Preprocessor (IDP), Retrospective Processing V10r (OCO2_L2_IMAPDOAS 10r) Get Data	OCO-2 OCO-2	10r	16 days	2.25 km x 1.29 km	2	2014-09-06	2022-03-01

Product & Naming from OCO-2

Image	Dataset	Source	Version	Time Res.	Spatial Res.	Process Level	Begin Date	End Date
 Hover	OCO-2 Level 2 bias-corrected XCO2 and other select fields from the full-physics retrieval aggregated as daily files, Retrospective processing V10r (OCO2_L2_Lite_FP 10r) Subset / Get Data	OCO-2 OCO-2	10r	16 days	2.25 km x 1.29 km	2	2014-09-06	2022-03-01

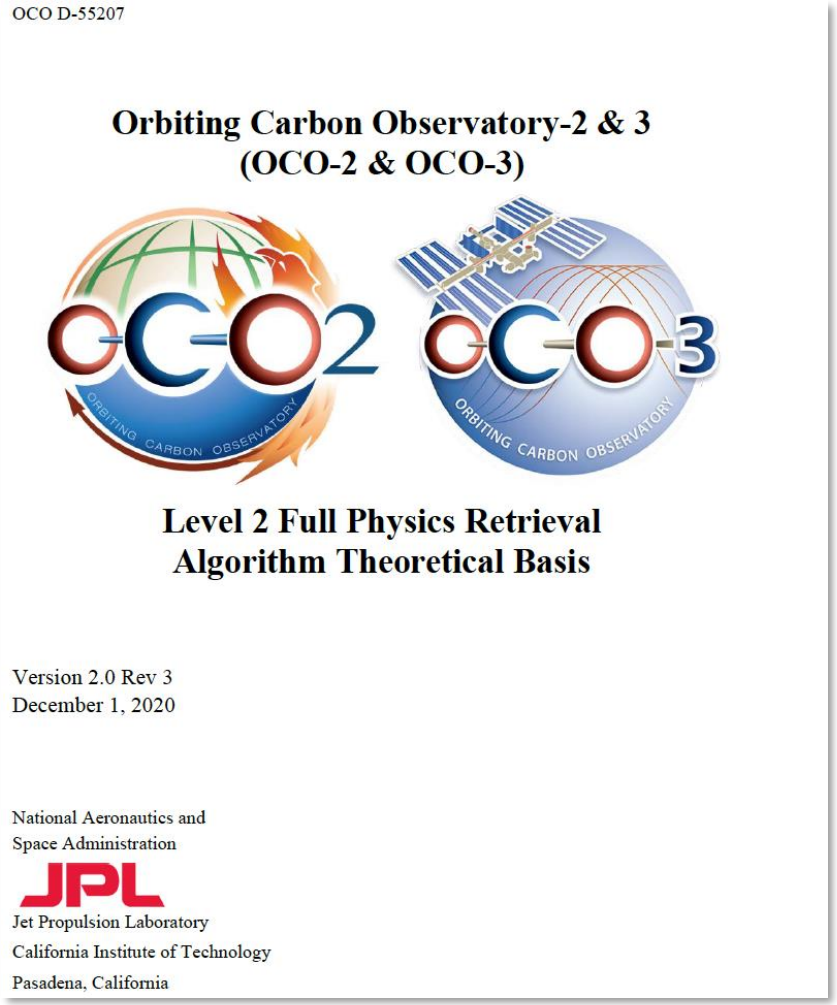
OCO-2 LiteXCO2 File Naming Convention:

oco2_LtCO2_[AcquisitionDate]_{ShortBuildID]_[ProductionDateTime][Source].nc4

oco2_LtCO2_191018_B10_v0.nc4

ATBD and User Guide

https://docserver.gesdisc.eosdis.nasa.gov/public/project/OCO/OCO_L2_ATBD.pdf



OCO D-55207

Orbiting Carbon Observatory-2 & 3
(OCO-2 & OCO-3)

Level 2 Full Physics Retrieval Algorithm Theoretical Basis

Version 2.0 Rev 3
December 1, 2020

National Aeronautics and
Space Administration

JPL
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

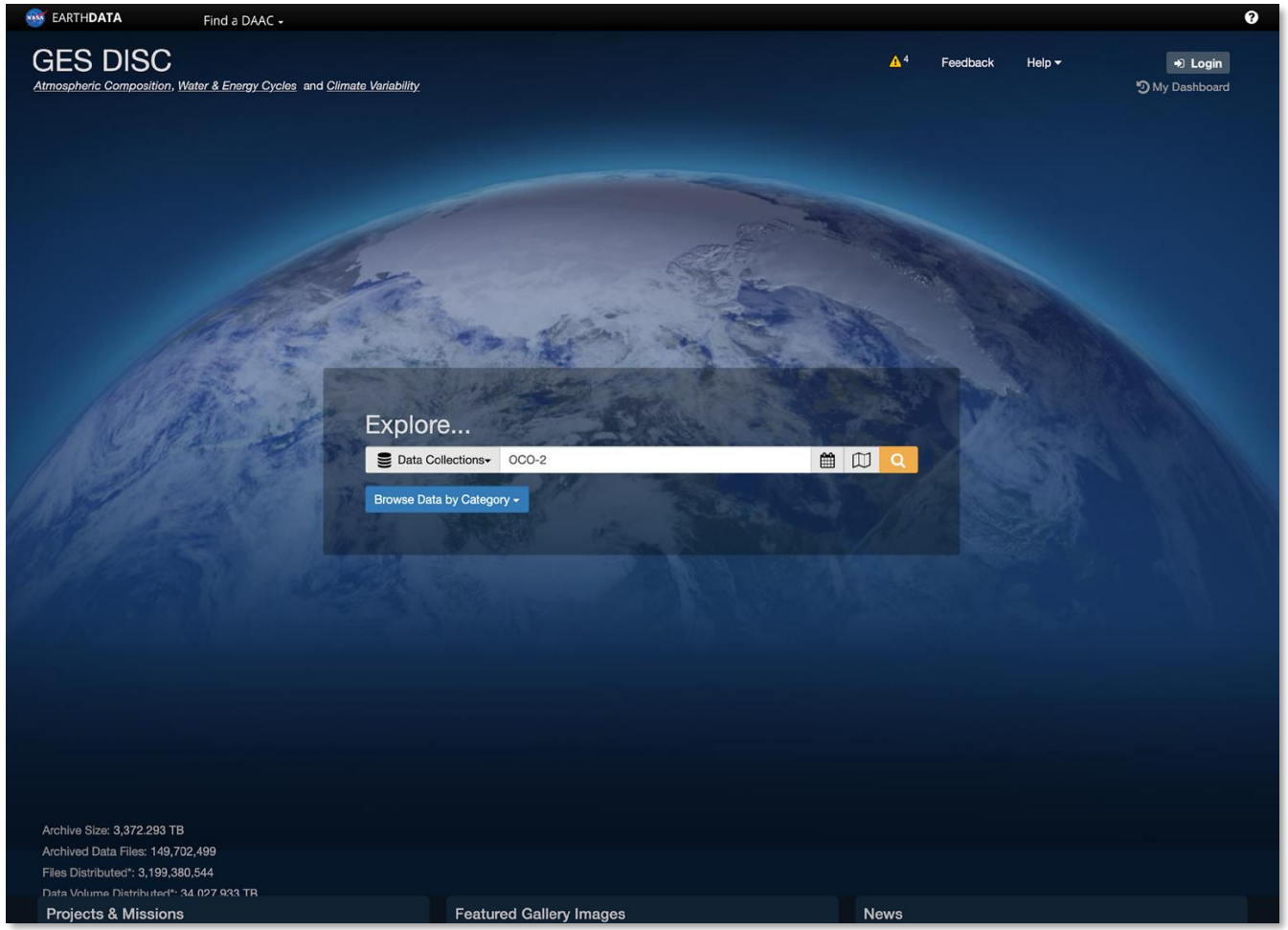
Getting Started

OCO-2 and OCO-3 data are stored at the GES DISC!

Be sure to register for a profile. It's free!

You can browse and look without a login, but you will need one to download data files.

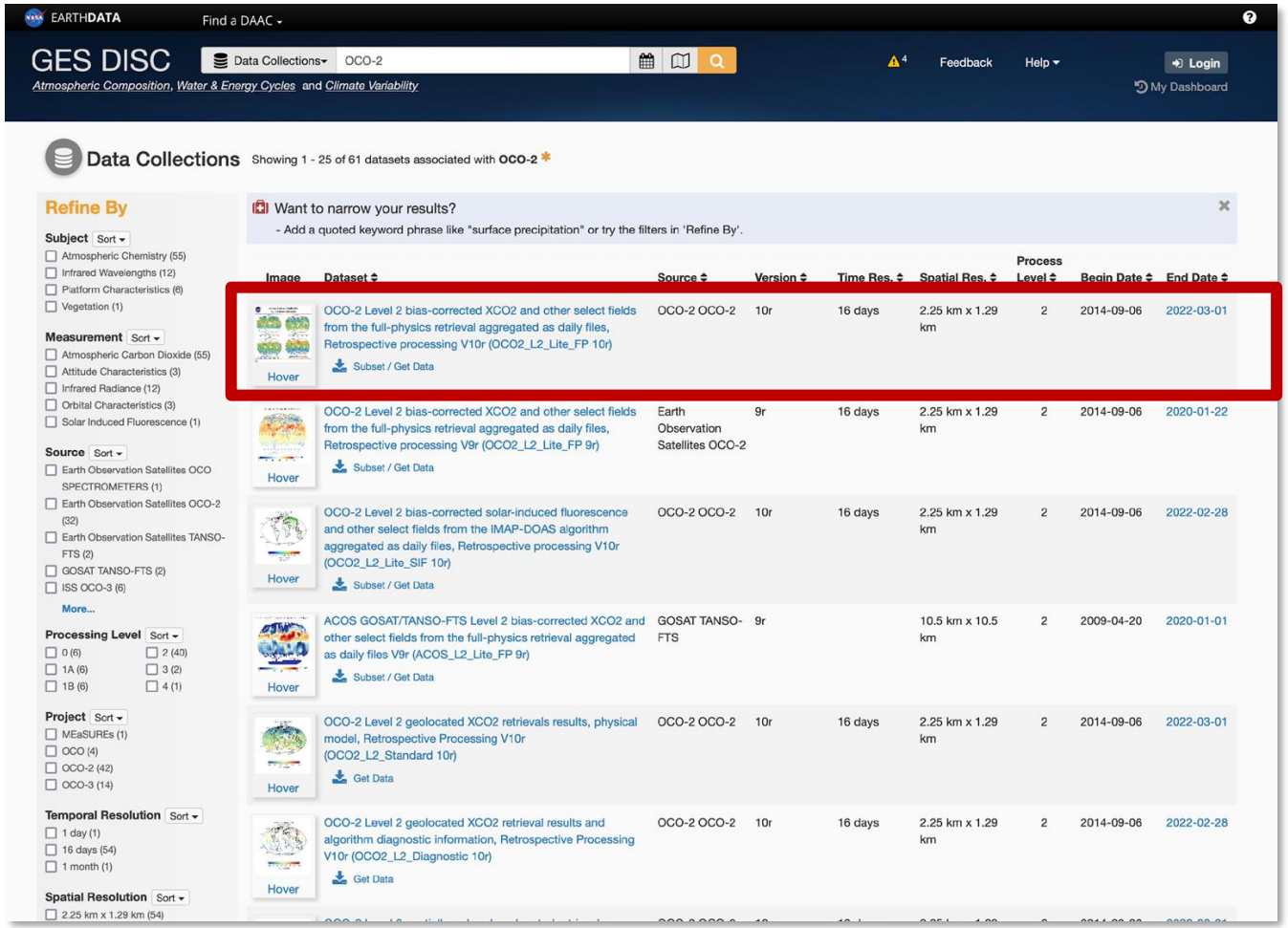
You can always find the data or data collections by entering "OCO-2" or "OCO-3" in the search bar.



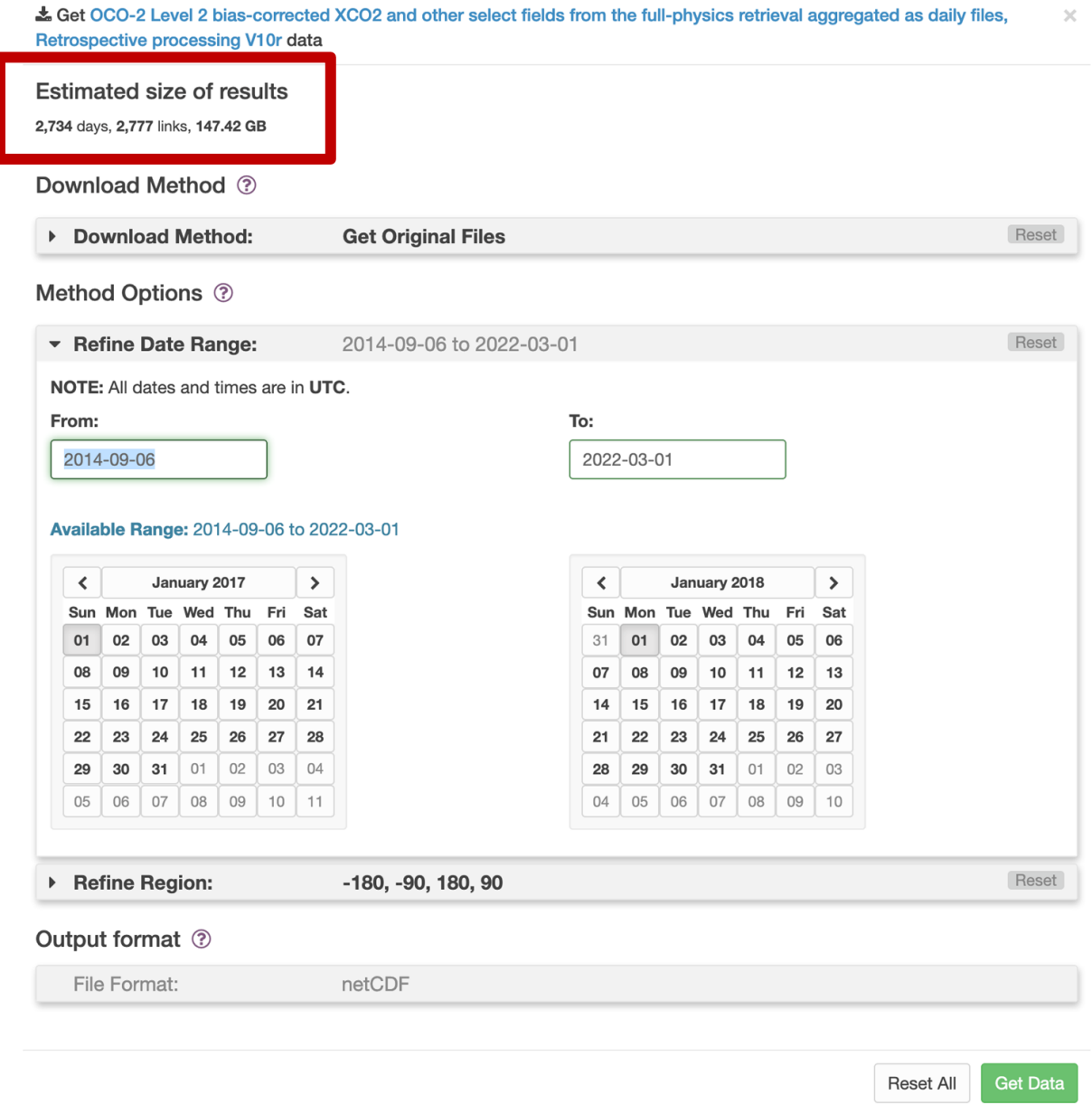
Getting Started

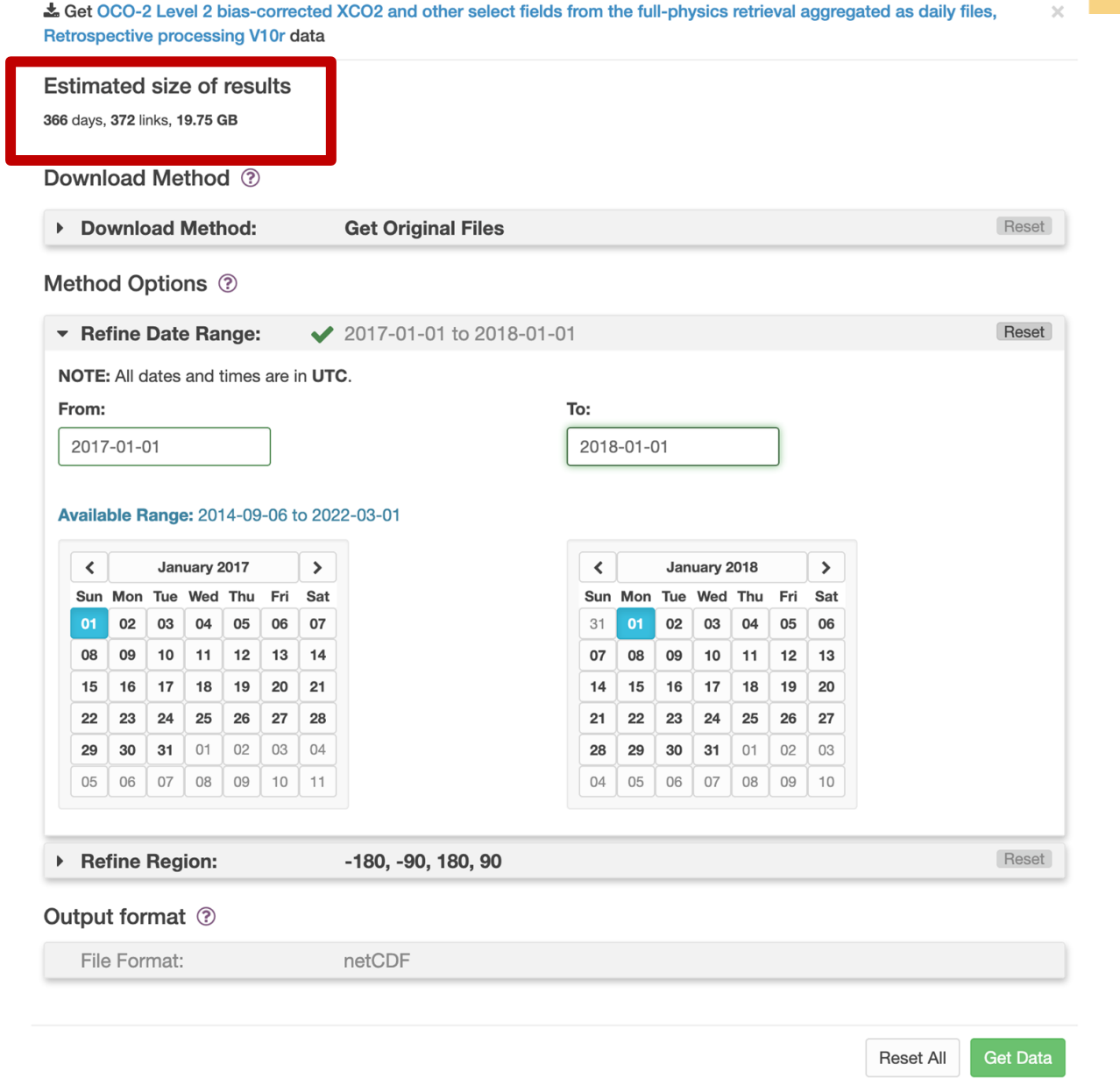
You will get a list of products.

We are only focusing on the XCO2 Lite product, which happens to be the top one.

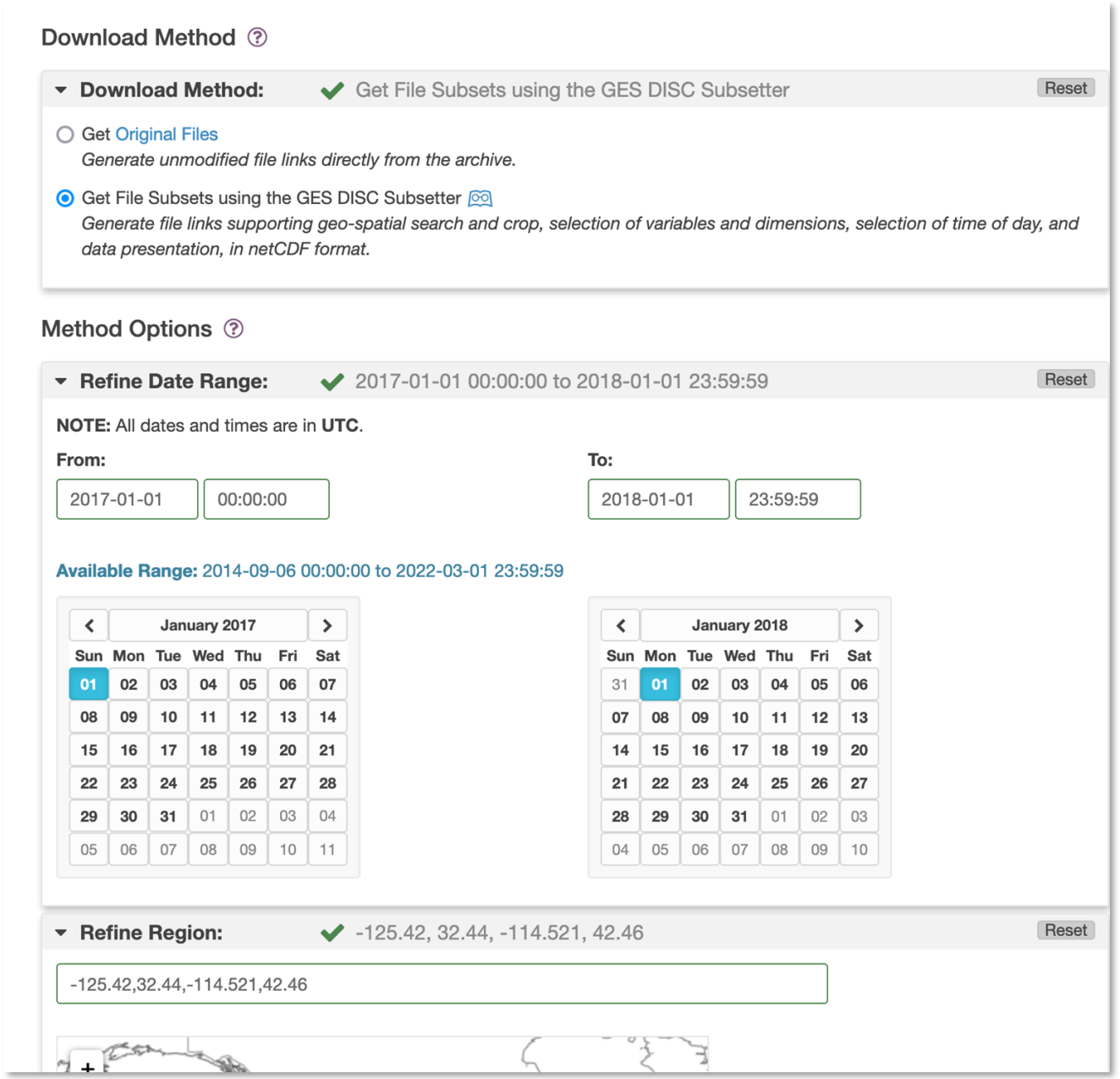


Getting Started

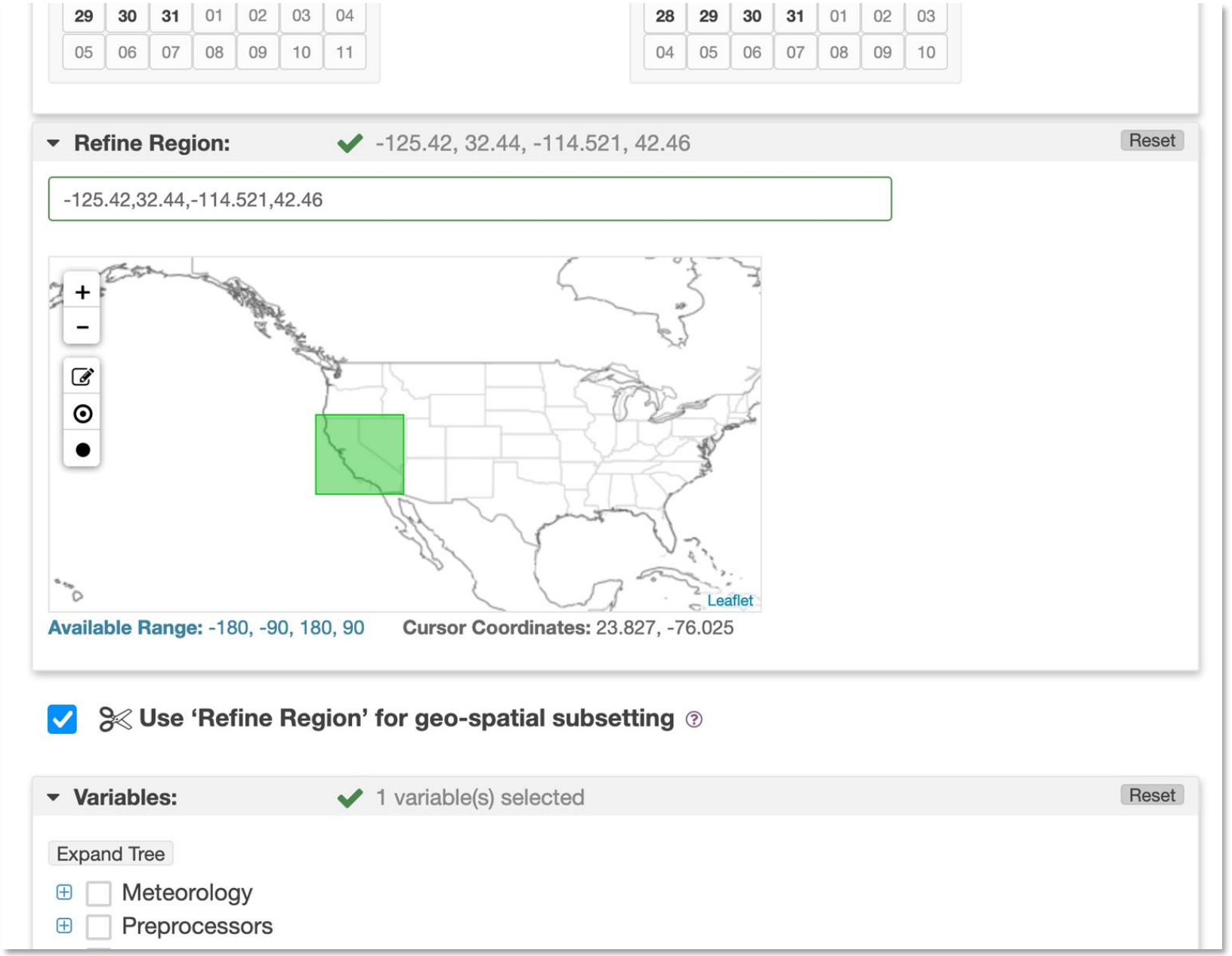




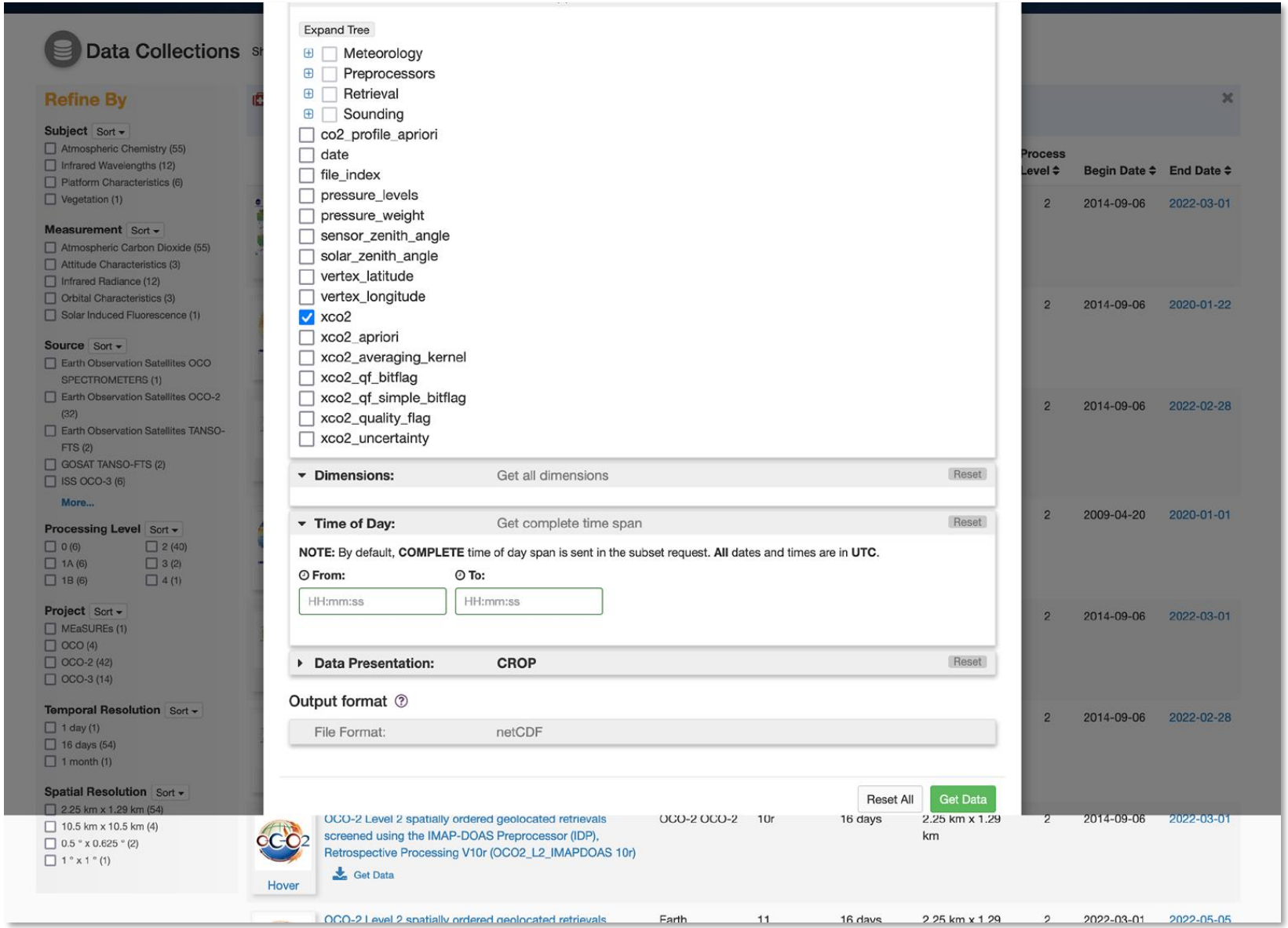
Getting Started



Getting Started



Getting Started



Getting Started

Data File Links for OCO-2 Level 2 bias-corrected XCO2 and other select fields from the full-physics retrieval aggregated as daily files, Retrospective processing V10r

Results (found 309 links in range from 2017-01-01 to 2018-01-02):

Download as txt files

Download links list (This list is valid for **2** days) | Instructions for downloading

User's Guide
OCO_L2_ATBD.pdf
README document
OCO2_L2_Lite_FP.10r:oco2_LtCO2_170101_B10206Ar_200730053044s.nc4
OCO2_L2_Lite_FP.10r:oco2_LtCO2_170102_B10206Ar_200730053400s.nc4
OCO2_L2_Lite_FP.10r:oco2_LtCO2_170103_B10206Ar_200730053434s.nc4
OCO2_L2_Lite_FP.10r:oco2_LtCO2_170104_B10206Ar_200730053446s.nc4
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▸ Selected Parameters

Job ID: 627546322bb51434b1de7cf0

Jupyter Notebook Portion

Before following along, you will need to download some software packages for this portion of the training. This is also what you will need in order to work with the data.

We have found the easiest and most straightforward way to work/display the data is to use Conda.

We will be working in Python 3, and Python and Jupyter notebook are packaged within Conda. Please follow the install directions listed for your operating system (Windows, Mac OS, Linux).
https://docs.conda.io/projects/conda/en/latest/user-guide/install/index.html

The libraries that you will need to use and import in the code below should be included in Conda.
We have made some files available for download. OCO-2 Data files are large so it will take some time to download! This is just a sample. You can always download more files to check things out.

Please remember which directory you download your files, and we recommend creating a folder for the data.

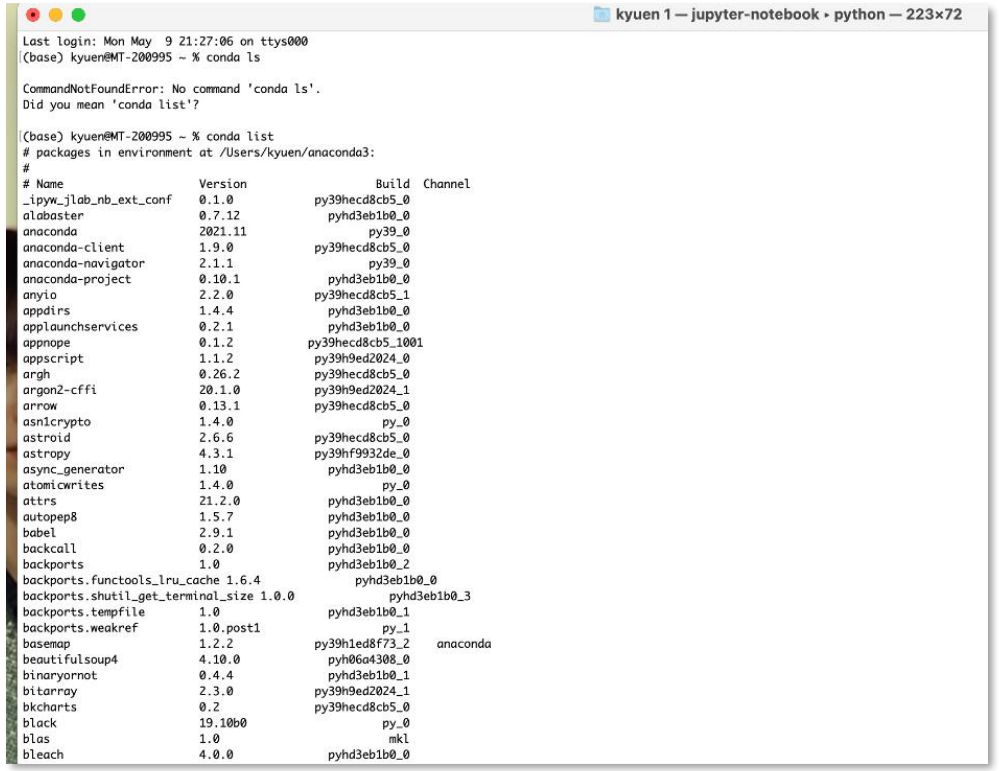
Jupyter Notebook Installation Guide (if you would prefer to just load this without Conda)

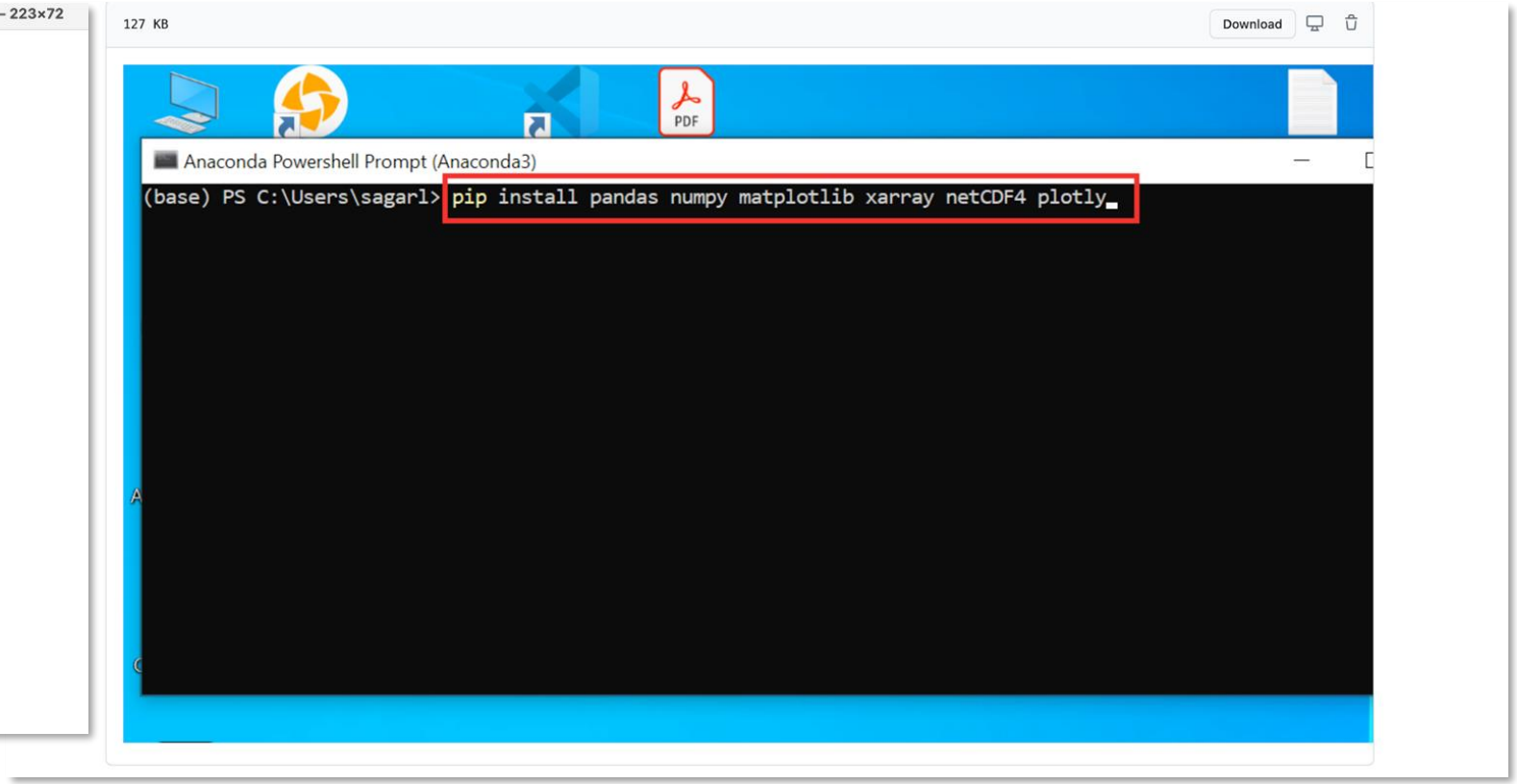
From this list of websites, you can follow instructions to setup Jupyter Notebook:

- https://jupyter.org/install
- https://www.geeksforgeeks.org/how-to-install-jupyter-notebook-in-windows/
- https://test-jupyter.readthedocs.io/en/latest/install.html

Next Step

The libraries you need should be installed with Conda. To verify, open a terminal and type Conda List. Scroll to check that what you need is there. If not, do pip install.



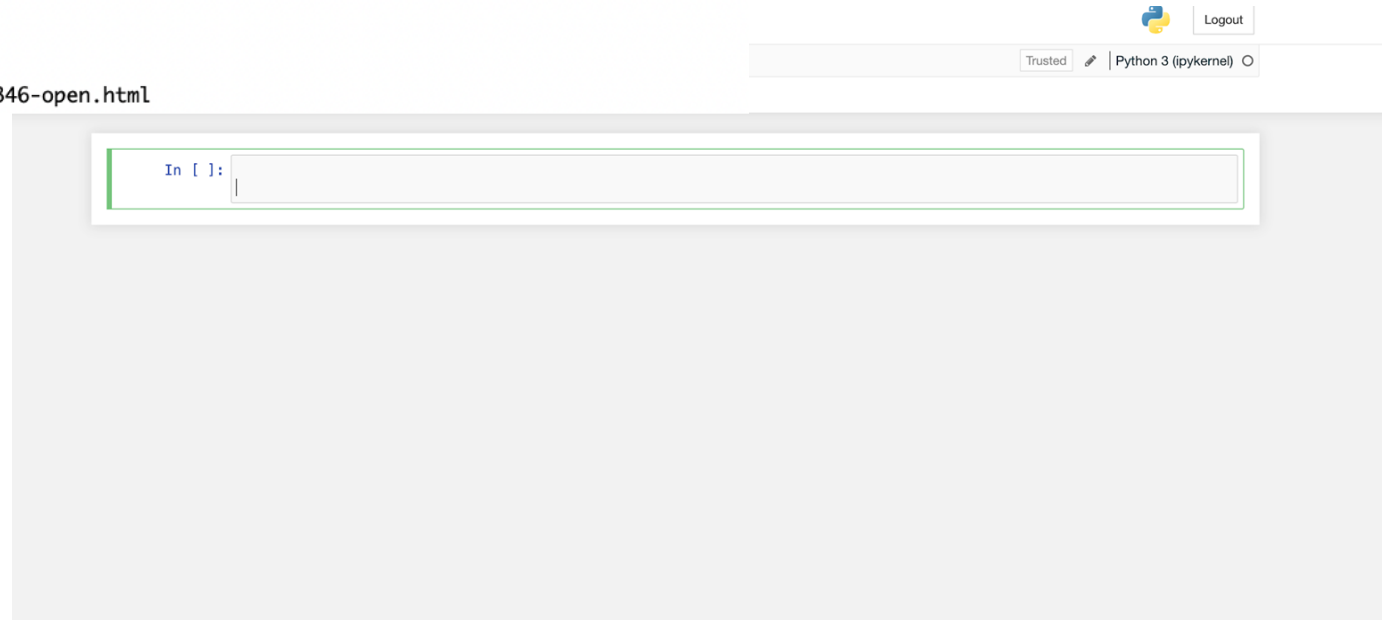


Final Step

To open up Jupyter notebook, you simply type Jupyter notebook in terminal and prompt and it will open up a new notebook in your chosen browser.

```
Last login: Mon May  9 21:29:44 on ttys001
(base) kyuen@MT-200995 ~ % jupyter notebook
[I 2022-05-12 19:39:01.808 LabApp] JupyterLab extension loaded from /Users/kyuen/anaconda3/lib/python3.9/site-packages/jupyterlab
[I 2022-05-12 19:39:01.808 LabApp] JupyterLab application directory is /Users/kyuen/anaconda3/share/jupyter/lab
[I 19:39:01.813 NotebookApp] The port 8888 is already in use, trying another port.
[I 19:39:01.813 NotebookApp] The port 8889 is already in use, trying another port.
[I 19:39:01.814 NotebookApp] Serving notebooks from local directory: /Users/kyuen 1
[I 19:39:01.814 NotebookApp] Jupyter Notebook 6.4.5 is running at:
[I 19:39:01.814 NotebookApp] http://localhost:8890/?token=8d904a1bab00dd06d19f4c44d22cae9bd1cc91121be9e98b
[I 19:39:01.814 NotebookApp]  or http://127.0.0.1:8890/?token=8d904a1bab00dd06d19f4c44d22cae9bd1cc91121be9e98b
[I 19:39:01.814 NotebookApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[C 19:39:01.818 NotebookApp]

    To access the notebook, open this file in a browser:
        file:///Users/kyuen%201/Library/Jupyter/runtime/nbserver-29346-open.html
```



References

Get Data:

https://daac.gsfc.nasa.gov/datasets?keywords=OCO-2&page=1

https://co2.jpl.nasa.gov/

Github/ColLab for Code:

https://github.com/sagarlimbu0/OCO2-OCO3

https://github.com/kyuenjpl/ARSET_XCO2

https://colab.research.google.com/drive/13KC3vPt6DXj8bQAyc7MHfjimNjJDdMfK?authuser=1

Contacts

- Trainers:
  - Karen Yuen: karen.yuen@jpl.nasa.gov

- Training Webpage:
  - https://appliedsciences.nasa.gov/join-mission/training/english/arset-measuring-atmospheric-carbon-dioxide-space-support-climate

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APPLIED REMOTE SENSING TRAINING PROGRAM
TRAIN - EMPOWER - ADVANCE

Thank You!