
cartoframes Documentation

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CARTO

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A Python package for integrating [CARTO](#) maps, analysis, and data services into data science workflows.

Python data analysis workflows often rely on the de facto standards [pandas](#) and [Jupyter notebooks](#). Integrating CARTO into this workflow saves data scientists time and energy by not having to export datasets as files or retain multiple copies of the data. Instead, CARTOframes give the ability to communicate reproducible analysis while providing the ability to gain from CARTO's services like hosted, dynamic or static maps and [Data Observatory](#) augmentation.

CHAPTER 1

Features

- Write pandas DataFrames to CARTO tables
- Read CARTO tables and queries into pandas DataFrames
- Create customizable, interactive CARTO maps in a Jupyter notebook
- Interact with CARTO's Data Observatory
- Use CARTO's spatially-enabled database for analysis
- Try it out without needing a CARTO account by using the [Examples functionality](#)

CHAPTER 2

Common Uses

- Visualize spatial data programmatically as matplotlib images or embedded interactive maps
- Perform cloud-based spatial data processing using CARTO's analysis tools
- Extract, transform, and Load (ETL) data using the Python ecosystem for getting data into and out of CARTO
- Data Services integrations using CARTO's [Data Observatory](#) and other [Data Services APIs](#)

CHAPTER 3

Try it out

The easiest way to try out cartoframes is to use the cartoframes example notebooks running in binder: <https://mybinder.org/v2/gh/CartoDB/cartoframes/master?filepath=examples> If you already have an API key, you can follow along and complete all of the example notebooks.

If you do not have an API key, you can use the [Example Context](#) to read the example data, make maps, and run arbitrary queries from the datasets there. The best place to get started is in the “Example Datasets” notebook found when running binder or downloading from the [examples](#) directory in the cartoframes GitHub repository.

Note: The example context only provides read access, so not all cartoframes features are available. For full access, [Start a free 30 day trial](#) or get free access with a [GitHub Student Developer Pack](#).

CHAPTER 4

More info

- Complete documentation: <http://cartoframes.readthedocs.io/en/latest/>
- Source code: <https://github.com/CartoDB/cartoframes>
- bug tracker / feature requests: <https://github.com/CartoDB/cartoframes/issues>

Note: *cartoframes* users must have a CARTO API key for most *cartoframes* functionality. For example, writing DataFrames to an account, reading from private tables, and visualizing data on maps all require an API key. CARTO provides API keys for education and nonprofit uses, among others. Request access at support@carto.com. API key access is also given through [GitHub's Student Developer Pack](#).

Install Instructions

To install *cartoframes* on your machine, do the following to install the latest version:

```
$ pip install cartoframes
```

cartoframes is continuously tested on Python versions 2.7, 3.5, and 3.6. It is recommended to use *cartoframes* in Jupyter Notebooks (*pip install jupyter*). See the example usage section below or notebooks in the [examples directory](#) for using *cartoframes* in that environment.

5.1 Virtual Environment

5.1.1 Using *virtualenv*

Make sure your *virtualenv* package is installed and up-to-date. See the [official Python packaging page](#) for more information.

To setup *cartoframes* and *Jupyter* in a [virtual environment](#):

```
$ virtualenv venv
$ source venv/bin/activate
(venv) $ pip install cartoframes jupyter
(venv) $ jupyter notebook
```

Then create a new notebook and try the example code snippets below with tables that are in your CARTO account.

5.1.2 Using *pipenv*

Alternatively, [pipenv](#) provides an easy way to manage virtual environments. The steps below are:

1. Create a virtual environment with Python 3.4+ (recommended instead of Python 2.7)
2. Install *cartoframes* and *Jupyter* (optional) into the virtual environment

3. Enter the virtual environment
4. Launch a Jupyter notebook server

```
$ pipenv --three
$ pipenv install cartoframes jupyter
$ pipenv shell
```

Next, run a Python kernel by typing `$ python`, `$ jupyter notebook`, or however you typically run Python.

5.2 Native pip

If you install packages at a system level, you can install *cartoframes* with:

```
$ pip install cartoframes
```

Example usage

6.1 Data workflow

Get table from CARTO, make changes in pandas, sync updates with CARTO:

```
import cartoframes
# `base_url`s are of the form `https://{username}.carto.com/` for most users
cc = cartoframes.CartoContext(base_url='https://eschbacher.carto.com/',
                              api_key=APIKEY)

# read a table from your CARTO account to a DataFrame
df = cc.read('brooklyn_poverty_census_tracts')

# do fancy pandas operations (add/drop columns, change values, etc.)
df['poverty_per_pop'] = df['poverty_count'] / df['total_population']

# updates CARTO table with all changes from this session
cc.write(df, 'brooklyn_poverty_census_tracts', overwrite=True)
```

Write an existing pandas DataFrame to CARTO.

```
import pandas as pd
import cartoframes
df = pd.read_csv('acadia_biodiversity.csv')
cc = cartoframes.CartoContext(base_url=BASEURL,
                              api_key=APIKEY)
cc.write(df, 'acadia_biodiversity')
```

6.2 Map workflow

The following will embed a CARTO map in a Jupyter notebook, allowing for custom styling of the maps driven by TurboCARTO and CARTOColors. See the [CARTOColors wiki](#) for a full list of available color schemes.

```
from cartoframes import Layer, BaseMap, styling
cc = cartoframes.CartoContext(base_url=BASEURL,
                              api_key=APIKEY)
cc.map(layers=[BaseMap('light'),
               Layer('acadia_biodiversity',
                     color={'column': 'simpson_index',
                           'scheme': styling.tealRose(5)}),
               Layer('peregrine_falcon_nest_sites',
                     size='num_eggs',
                     color={'column': 'bird_id',
                           'scheme': styling.vivid(10)})],
       interactive=True)
```

Note: Legends are under active development. See <https://github.com/CartoDB/cartoframes/pull/184> for more information. To try out that code, install *cartoframes* as:

```
pip install git+https://github.com/cartodb/cartoframes.git@add-legends-v1#egg=cartoframes
```

6.3 Data Observatory

Interact with CARTO's [Data Observatory](#):

```
import cartoframes
cc = cartoframes.CartoContext(BASEURL, APIKEY)

# total pop, high school diploma (normalized), median income, poverty status,
# (normalized)
# See Data Observatory catalog for codes: https://cartodb.github.io/bigmetadata/index.
# html
data_obs_measures = [{'numer_id': 'us.census.acs.B01003001'},
                      {'numer_id': 'us.census.acs.B15003017',
                       'normalization': 'predenominated'},
                      {'numer_id': 'us.census.acs.B19013001'},
                      {'numer_id': 'us.census.acs.B17001002',
                       'normalization': 'predenominated'}]
df = cc.data('transactions', data_obs_measures)
```

6.4 CARTO Credential Management

6.4.1 Typical usage

The most common way to input credentials into cartoframes is through the *CartoContext*, as below. Replace *{your_user_name}* with your CARTO username and *{your_api_key}* with your API key, which you can find at https://{your_user_name}.carto.com/your_apps.

```
from cartoframes import CartoContext
cc = CartoContext(
    base_url='https://{your_user_name}.carto.com',
    api_key='{your_api_key}'
)
```

You can also set your credentials using the *Credentials* class:

```
from cartoframes import Credentials, CartoContext
cc = CartoContext(
    creds=Credentials(key='{your_api_key}', username='{your_user_name}'))
)
```

6.4.2 Save/update credentials for later use

```
from cartoframes import Credentials, CartoContext
creds = Credentials(username='eschbacher', key='abcdefg')
creds.save() # save credentials for later use (not dependent on Python session)
```

Once you save your credentials, you can get started in future sessions more quickly:

```
from cartoframes import CartoContext
cc = CartoContext() # automatically loads credentials if previously saved
```

6.5 Experimental features

CARTOframes includes experimental features that we are testing for future releases into cartoframes core. These features exist as separate modules in *contrib*. These features are stand-alone other than sometimes relying on some cartoframes utilities, etc. Contrib features will also change often and without notice, so they should never be used in a production environment.

To import an experimental feature, like vector maps, do the following:

```
from cartoframes.contrib import vector
from cartoframes import CartoContext

cc = CartoContext()
vector.vmap([vector.Layer('<table name>'), ], context=cc)
```

6.5.1 CartoContext class

This class is the workhorse of CARTOframes by providing all functionality related to data access to CARTO, map creation, and Data Observatory functionality.

6.5.2 CartoContext

```
class cartoframes.context.CartoContext (base_url=None, api_key=None, creds=None, session=None, verbose=0)
```

CartoContext class for authentication with CARTO and high-level operations such as reading tables from CARTO into dataframes, writing dataframes to CARTO tables, creating custom maps from dataframes and

CARTO tables, and augmenting data using CARTO's [Data Observatory](#). Future methods will interact with CARTO's services like [routing](#), [geocoding](#), and [isolines](#), PostGIS backend for spatial processing, and much more.

Manages connections with CARTO for data and map operations. Modeled after [SparkContext](#).

There are two ways of authenticating against a CARTO account:

1. Setting the `base_url` and `api_key` directly in `CartoContext`. This method is easier.:

```
cc = CartoContext(  
    base_url='https://eschbacher.carto.com',  
    api_key='abcdefg')
```

2. By passing a `Credentials` instance in `CartoContext`'s `creds` keyword argument. This method is more flexible.:

```
from cartoframes import Credentials  
creds = Credentials(username='eschbacher', key='abcdefg')  
cc = CartoContext(creds=creds)
```

creds

Credentials instance

Type `Credentials`

Parameters

- **base_url** (*str*) – Base URL of CARTO user account. Cloud-based accounts should use the form `https://{username}.carto.com` (e.g., <https://eschbacher.carto.com> for user `eschbacher`) whether on a personal or multi-user account. On-premises installation users should ask their admin.
- **api_key** (*str*) – CARTO API key.
- **creds** (`Credentials`) – A `Credentials` instance can be used in place of a `base_url/api_key` combination.
- **session** (`requests.Session`, *optional*) – requests session. See [requests documentation](#) for more information.
- **verbose** (*bool*, *optional*) – Output underlying process states (`True`), or suppress (`False`, default)

Returns A `CartoContext` object that is authenticated against the user's CARTO account.

Return type `CartoContext`

Example

Create a `CartoContext` object for a cloud-based CARTO account.

```
import cartoframes  
# if on prem, format is '{host}/user/{username}'  
BASEURL = 'https://{}/.carto.com/'.format('your carto username')  
APIKEY = 'your carto api key'  
cc = cartoframes.CartoContext(BASEURL, APIKEY)
```

Tip: If using cartoframes with an [on premises CARTO installation](#), sometimes it is necessary to disable SSL verification depending on your system configuration. You can do this using a [requests Session](#) object as follows:

```
import cartoframes
from requests import Session
session = Session()
session.verify = False

# on prem host (e.g., an IP address)
onprem_host = 'your on prem carto host'

cc = cartoframes.CartoContext(
    base_url='{host}/user/{user}'.format(
        host=onprem_host,
        user='your carto username'),
    api_key='your carto api key',
    session=session
)
```

write(df, table_name, temp_dir=SYSTEM_TMP_PATH, overwrite=False, lnglat=None, encode_geom=False, geom_col=None, **kwargs)
Write a DataFrame to a CARTO table.

Examples

Write a pandas DataFrame to CARTO.

```
cc.write(df, 'brooklyn_poverty', overwrite=True)
```

Scrape an HTML table from Wikipedia and send to CARTO with content guessing to create a geometry from the country column. This uses a CARTO Import API param *content_guessing* parameter.

```
url = 'https://en.wikipedia.org/wiki/List_of_countries_by_life_expectancy'
# retrieve first HTML table from that page
df = pd.read_html(url, header=0)[0]
# send to carto, let it guess polygons based on the 'country'
# column. Also set privacy to 'public'
cc.write(df, 'life_expectancy',
         content_guessing=True,
         privacy='public')
cc.map(layers=Layer('life_expectancy',
                   color='both_sexes_life_expectancy'))
```

Parameters

- **df** (pandas.DataFrame) – DataFrame to write to table_name in user CARTO account
- **table_name** (str) – Table to write df to in CARTO.
- **temp_dir** (str, optional) – Directory for temporary storage of data that is sent to CARTO. Defaults are defined by [appdirs](#).
- **overwrite** (bool, optional) – Behavior for overwriting table_name if it exists on CARTO. Defaults to False.

- **lnglat** (*tuple, optional*) – lng/lat pair that can be used for creating a geometry on CARTO. Defaults to `None`. In some cases, geometry will be created without specifying this. See CARTO’s [Import API](#) for more information.
- **encode_geom** (*bool, optional*) – Whether to write *geom_col* to CARTO as *the_geom*.
- **geom_col** (*str, optional*) – The name of the column where geometry information is stored. Used in conjunction with *encode_geom*.
- ****kwargs** – Keyword arguments to control write operations. Options are:
 - *compression* to set compression for files sent to CARTO. This will cause write speedups depending on the dataset. Options are `None` (no compression, default) or `gzip`.
 - Some arguments from CARTO’s Import API. See the [params listed in the documentation](#) for more information. For example, when using *content_guessing='true'*, a column named ‘countries’ with country names will be used to generate polygons for each country. Another use is setting the privacy of a dataset. To avoid unintended consequences, avoid *file*, *url*, and other similar arguments.

Returns `BatchJobStatus` or `None`: If *lnglat* flag is set and the `DataFrame` has more than 100,000 rows, a `BatchJobStatus` instance is returned. Otherwise, `None`.

Note: `DataFrame` indexes are changed to ordinary columns. CARTO creates an index called *cartodb_id* for every table that runs from 1 to the length of the `DataFrame`.

tables()

List all tables in user’s CARTO account

Returns `list of Table`

read (*table_name, limit=None, index='cartodb_id', decode_geom=False, shared_user=None*)

Read a table from CARTO into a pandas `DataFrames`.

Parameters

- **table_name** (*str*) – Name of table in user’s CARTO account.
- **limit** (*int, optional*) – Read only *limit* lines from *table_name*. Defaults to `None`, which reads the full table.
- **index** (*str, optional*) – Not currently in use.
- **decode_geom** (*bool, optional*) – Decodes CARTO’s geometries into a [Shapely](#) object that can be used, for example, in [GeoPandas](#).
- **shared_user** (*str, optional*) – If a table has been shared with you, specify the user name (schema) who shared it.

Returns `DataFrame` representation of *table_name* from CARTO.

Return type `pandas.DataFrame`

Example

```
import cartoframes
cc = cartoframes.CartoContext(BASEURL, APIKEY)
df = cc.read('acadia_biodiversity')
```

delete (*table_name*)

Delete a table in user's CARTO account.

Parameters **table_name** (*str*) – Name of table to delete

Returns None

query (*query*, *table_name=None*, *decode_geom=False*)

Pull the result from an arbitrary SQL query from a CARTO account into a pandas DataFrame. Can also be used to perform database operations (creating/dropping tables, adding columns, updates, etc.).

Parameters

- **query** (*str*) – Query to run against CARTO user database. This data will then be converted into a pandas DataFrame.
- **table_name** (*str*, *optional*) – If set, this will create a new table in the user's CARTO account that is the result of the query. Defaults to None (no table created).
- **decode_geom** (*bool*, *optional*) – Decodes CARTO's geometries into a [Shapely](#) object that can be used, for example, in [GeoPandas](#).

Returns DataFrame representation of query supplied. Pandas data types are inferred from PostgreSQL data types. In the case of PostgreSQL date types, dates are attempted to be converted, but on failure a data type 'object' is used.

Return type pandas.DataFrame

Examples

Query a table in CARTO and write a new table that is result of query. This query gets the 10 highest values from a table and returns a dataframe, as well as creating a new table called 'top_ten' in the CARTO account.

```
topten_df = cc.query(
    '''
        SELECT * FROM
        my_table
        ORDER BY value_column DESC
        LIMIT 10
    ''',
    table_name='top_ten'
)
```

This query joins points to polygons based on intersection, and aggregates by summing the values of the points in each polygon. The query returns a dataframe, with a geometry column that contains polygons and also creates a new table called 'points_aggregated_to_polygons' in the CARTO account.

```
points_aggregated_to_polygons = cc.query(
    '''
        SELECT polygons.*, sum(points.values)
        FROM polygons JOIN points
        ON ST_Intersects(points.the_geom, polygons.the_geom)
        GROUP BY polygons.the_geom, polygons.cartodb_id
    ''',
    table_name='points_aggregated_to_polygons',
    decode_geom=True
)
```

map (**kwargs)

Produce a CARTO map visualizing data layers.

Examples

Create a map with two data Layers, and one BaseMap layer:

```
import cartoframes
from cartoframes import Layer, BaseMap, styling
cc = cartoframes.CartoContext(BASEURL, APIKEY)
cc.map(layers=[BaseMap(),
               Layer('acadia_biodiversity',
                     color={'column': 'simpson_index',
                           'scheme': styling.tealRose(7)}),
               Layer('peregrine_falcon_nest_sites',
                     size='num_eggs',
                     color={'column': 'bird_id',
                           'scheme': styling.vivid(10)}),
               ],
       interactive=True)
```

Create a snapshot of a map at a specific zoom and center:

```
cc.map(layers=Layer('acadia_biodiversity',
                    color='simpson_index'),
       interactive=False,
       zoom=14,
       lng=-68.3823549,
       lat=44.3036906)
```

Parameters

- **layers** (*list, optional*) – List of zero or more of the following:
 - **Layer**: cartoframes Layer object for visualizing data from a CARTO table. See Layer for all styling options.
 - **BaseMap**: Basemap for contextualizing data layers. See BaseMap for all styling options.
 - **QueryLayer**: Layer from an arbitrary query. See QueryLayer for all styling options.
- **interactive** (*bool, optional*) – Defaults to True to show an interactive slippy map. Setting to False creates a static map.
- **zoom** (*int, optional*) – Zoom level of map. Acceptable values are usually in the range 0 to 19. 0 has the entire earth on a single tile (256px square). Zoom 19 is the size of a city block. Must be used in conjunction with lng and lat. Defaults to a view to have all data layers in view.
- **lat** (*float, optional*) – Latitude value for the center of the map. Must be used in conjunction with zoom and lng. Defaults to a view to have all data layers in view.
- **lng** (*float, optional*) – Longitude value for the center of the map. Must be used in conjunction with zoom and lat. Defaults to a view to have all data layers in view.
- **size** (*tuple, optional*) – List of pixel dimensions for the map. Format is (width, height). Defaults to (800, 400).

- **ax** – matplotlib axis on which to draw the image. Only used when `interactive` is `False`.

Returns Interactive maps are rendered as HTML in an *iframe*, while static maps are returned as matplotlib Axes objects or IPython Image.

Return type IPython.display.HTML or matplotlib Axes

data_boundaries (*boundary=None, region=None, decode_geom=False, timespan=None, include_nonclipped=False*)

Find all boundaries available for the world or a *region*. If *boundary* is specified, get all available boundary polygons for the region specified (if any). This method is especially useful for getting boundaries for a region and, with `CartoContext.data` and `CartoContext.data_discovery`, getting tables of geometries and the corresponding raw measures. For example, if you want to analyze how median income has changed in a region (see examples section for more).

Examples

Find all boundaries available for Australia. The columns *geom_name* gives us the name of the boundary and *geom_id* is what we need for the *boundary* argument.

```
import cartoframes
cc = cartoframes.CartoContext('base url', 'api key')
au_boundaries = cc.data_boundaries(region='Australia')
au_boundaries[['geom_name', 'geom_id']]
```

Get the boundaries for Australian Postal Areas and map them.

```
from cartoframes import Layer
au_postal_areas = cc.data_boundaries(boundary='au.geo.POA')
cc.write(au_postal_areas, 'au_postal_areas')
cc.map(Layer('au_postal_areas'))
```

Get census tracts around Idaho Falls, Idaho, USA, and add median income from the US census. Without limiting the metadata, we get median income measures for each census in the Data Observatory.

```
cc = cartoframes.CartoContext('base url', 'api key')
# will return DataFrame with columns `the_geom` and `geom_ref`
tracts = cc.data_boundaries(
    boundary='us.census.tiger.census_tract',
    region=[-112.096642, 43.429932, -111.974213, 43.553539])
# write geometries to a CARTO table
cc.write(tracts, 'idaho_falls_tracts')
# gather metadata needed to look up median income
median_income_meta = cc.data_discovery(
    'idaho_falls_tracts',
    keywords='median income',
    boundaries='us.census.tiger.census_tract')
# get median income data and original table as new dataframe
idaho_falls_income = cc.data(
    'idaho_falls_tracts',
    median_income_meta,
    how='geom_refs')
# overwrite existing table with newly-enriched dataframe
cc.write(idaho_falls_income,
    'idaho_falls_tracts',
    overwrite=True)
```

Parameters

- **boundary** (*str*, *optional*) – Boundary identifier for the boundaries that are of interest. For example, US census tracts have a boundary ID of `us.census.tiger.census_tract`, and Brazilian Municipios have an ID of `br.geo.municipios`. Find IDs by running `CartoContext.data_boundaries` without any arguments, or by looking in the [Data Observatory catalog](#).
- **region** (*str*, *optional*) – Region where boundary information or, if *boundary* is specified, boundary polygons are of interest. *region* can be one of the following:
 - table name (*str*): Name of a table in user’s CARTO account
 - bounding box (list of float): List of four values (two lng/lat pairs) in the following order: western longitude, southern latitude, eastern longitude, and northern latitude. For example, Switzerland fits in `[5.9559111595, 45.8179931641, 10.4920501709, 47.808380127]`
- **timespan** (*str*, *optional*) – Specific timespan to get geometries from. Defaults to use the most recent. See the Data Observatory catalog for more information.
- **decode_geom** (*bool*, *optional*) – Whether to return the geometries as Shapely objects or keep them encoded as EWKB strings. Defaults to False.
- **include_nonclipped** (*bool*, *optional*) – Optionally include non-shoreline-clipped boundaries. These boundaries are the raw boundaries provided by, for example, US Census Tiger.

Returns If *boundary* is specified, then all available boundaries and accompanying *geom_refs* in *region* (or the world if *region* is `None` or not specified) are returned. If *boundary* is not specified, then a `DataFrame` of all available boundaries in *region* (or the world if *region* is `None`)

Return type `pandas.DataFrame`

data_discovery (*region*, *keywords=None*, *regex=None*, *time=None*, *boundaries=None*, *include_quantiles=False*)

Discover Data Observatory measures. This method returns the full Data Observatory metadata model for each measure or measures that match the conditions from the inputs. The full metadata in each row uniquely defines a measure based on the timespan, geographic resolution, and normalization (if any). Read more about the metadata response in [Data Observatory](#) documentation.

Internally, this method finds all measures in *region* that match the conditions set in *keywords*, *regex*, *time*, and *boundaries* (if any of them are specified). Then, if *boundaries* is not specified, a geographical resolution for that measure will be chosen subject to the type of region specified:

1. If *region* is a table name, then a geographical resolution that is roughly equal to *region size / number of subunits*.
2. If *region* is a country name or bounding box, then a geographical resolution will be chosen roughly equal to *region size / 500*.

Since different measures are in some geographic resolutions and not others, different geographical resolutions for different measures are oftentimes returned.

Tip: To remove the guesswork in how geographical resolutions are selected, specify one or more boundaries in *boundaries*. See the boundaries section for each region in the [Data Observatory catalog](#).

The metadata returned from this method can then be used to create raw tables or for augmenting an existing table from these measures using `CartoContext.data`. For the full Data Observa-

tory catalog, visit <https://cartodb.github.io/bigmetadata/>. When working with the metadata DataFrame returned from this method, be careful to only remove rows not columns as `CartoContext.data` `<cartoframes.context.CartoContext.data>` generally needs the full metadata.

Note: Narrowing down a discovery query using the *keywords*, *regex*, and *time* filters is important for getting a manageable metadata set. Besides there being a large number of measures in the DO, a metadata response has acceptable combinations of measures with demonimators (normalization and density), and the same measure from other years.

For example, setting the region to be United States counties with no filter values set will result in many thousands of measures.

Examples

Get all European Union measures that mention freight.

```
meta = cc.data_discovery('European Union',
                        keywords='freight',
                        time='2010')
print(meta['numer_name'].values)
```

Parameters

- **region** (*str or list of float*) – Information about the region of interest. *region* can be one of three types:
 - region name (*str*): Name of region of interest. Acceptable values are limited to: ‘Australia’, ‘Brazil’, ‘Canada’, ‘European Union’, ‘France’, ‘Mexico’, ‘Spain’, ‘United Kingdom’, ‘United States’.
 - table name (*str*): Name of a table in user’s CARTO account with geometries. The region will be the bounding box of the table.

Note: If a table name is also a valid Data Observatory region name, the Data Observatory name will be chosen over the table.

- bounding box (*list of float*): List of four values (two lng/lat pairs) in the following order: western longitude, southern latitude, eastern longitude, and northern latitude. For example, Switzerland fits in `[5.9559111595, 45.8179931641, 10.4920501709, 47.808380127]`

Note: Geometry levels are generally chosen by subdividing the region into the next smallest administrative unit. To override this behavior, specify the *boundaries* flag. For example, set *boundaries* to `'us.census.tiger.census_tract'` to choose US census tracts.

- **keywords** (*str or list of str, optional*) – Keyword or list of keywords in measure description or name. Response will be matched on all keywords listed (boolean *or*).

- **regex** (*str*, *optional*) – A regular expression to search the measure descriptions and names. Note that this relies on PostgreSQL’s case insensitive operator `~*`. See [PostgreSQL docs](#) for more information.
- **boundaries** (*str or list of str*, *optional*) – Boundary or list of boundaries that specify the measure resolution. See the boundaries section for each region in the [Data Observatory catalog](#).
- **include_quantiles** (*bool*, *optional*) – Include quantiles calculations which are a calculation of how a measure compares to all measures in the full dataset. Defaults to `False`. If `True`, quantiles columns will be returned for each column which has it pre-calculated.

Returns A dataframe of the complete metadata model for specific measures based on the search parameters.

Return type `pandas.DataFrame`

Raises

- **ValueError** – If *region* is a `list` and does not consist of four elements, or if *region* is not an acceptable region
- **CartoException** – If *region* is not a table in user account

data (*table_name*, *metadata*, *persist_as=None*, *how='the_geom'*)

Get an augmented CARTO dataset with [Data Observatory](#) measures. Use `CartoContext.data_discovery` to search for available measures, or see the full [Data Observatory catalog](#). Optionally persist the data as a new table.

Example

Get a `DataFrame` with Data Observatory measures based on the geometries in a CARTO table.

```
cc = cartoframes.CartoContext(BASEURL, APIKEY)
median_income = cc.data_discovery('transaction_events',
                                  regex='.*median income.*',
                                  time='2011 - 2015')
df = cc.data('transaction_events',
             median_income)
```

Pass in cherry-picked measures from the Data Observatory catalog. The rest of the metadata will be filled in, but it’s important to specify the geographic level as this will not show up in the column name.

```
median_income = [{ 'numer_id': 'us.census.acs.B19013001',
                   'geom_id': 'us.census.tiger.block_group',
                   'numer_timespan': '2011 - 2015' }]
df = cc.data('transaction_events', median_income)
```

Parameters

- **table_name** (*str*) – Name of table on CARTO account that Data Observatory measures are to be added to.
- **metadata** (*pandas.DataFrame*) – List of all measures to add to *table_name*. See `CartoContext.data_discovery` outputs for a full list of metadata columns.

- **`persist_as`** (*str*, *optional*) – Output the results of augmenting *table_name* to *persist_as* as a persistent table on CARTO. Defaults to `None`, which will not create a table.
- **`how`** (*str*, *optional*) – **Not fully implemented.** Column name for identifying the geometry from which to fetch the data. Defaults to *the_geom*, which results in measures that are spatially interpolated (e.g., a neighborhood boundary’s population will be calculated from underlying census tracts). Specifying a column that has the geometry identifier (for example, GEOID for US Census boundaries), results in measures directly from the Census for that GEOID but normalized how it is specified in the metadata.

Returns A `DataFrame` representation of *table_name* which has new columns for each measure in *metadata*.

Return type `pandas.DataFrame`

Raises

- **`NameError`** – If the columns in *table_name* are in the *suggested_name* column of *metadata*.
- **`ValueError`** – If metadata object is invalid or empty, or if the number of requested measures exceeds 50.
- **`CartoException`** – If user account consumes all of Data Observatory quota

6.5.3 Map Layer Classes

class `cartoframes.layer.BaseMap` (*source*='voyager', *labels*='back', *only_labels*=False)
Layer object for adding basemaps to a cartoframes map.

Example

Add a custom basemap to a cartoframes map.

```
import cartoframes
from cartoframes import BaseMap, Layer
cc = cartoframes.CartoContext(BASEURL, APIKEY)
cc.map(layers=[BaseMap(source='light', labels='front'),
               Layer('acadia_biodiversity')])
```

Parameters

- **`source`** (*str*, *optional*) – One of `light` or `dark`. Defaults to `voyager`. Basemaps come from <https://carto.com/location-data-services/basemaps/>
- **`labels`** (*str*, *optional*) – One of `back`, `front`, or `None`. Labels on the front will be above the data layers. Labels on back will be underneath the data layers but on top of the basemap. Setting labels to `None` will only show the basemap.
- **`only_labels`** (*bool*, *optional*) – Whether to show labels or not.

class `cartoframes.layer.Layer` (*table_name*, *source*=None, *overwrite*=False, *time*=None, *color*=None, *size*=None, *opacity*=None, *tooltip*=None, *legend*=None)

A cartoframes Data Layer based on a specific table in user’s CARTO database. This layer class is used for visualizing individual datasets with `CartoContext.map`’s *layers* keyword argument.

Example

```
import cartoframes
from cartoframes import QueryLayer, styling
cc = cartoframes.CartoContext(BASEURL, APIKEY)
cc.map(layers=[Layer('fantastic_sql_table',
                    size=7,
                    color={'column': 'mr_fox_sightings',
                          'scheme': styling.prism(10)}))])
```

Parameters

- **table_name** (*str*) – Name of table in CARTO account
- **Styling** – See `QueryLayer`
- **a full list of all arguments arguments for styling this map data** (*for*) –
- **layer.** –
- **source** (*pandas.DataFrame, optional*) – Not currently implemented
- **overwrite** (*bool, optional*) – Not currently implemented

class `cartoframes.layer.QueryLayer` (*query, time=None, color=None, size=None, opacity=None, tooltip=None, legend=None*)

`cartoframes` data layer based on an arbitrary query to the user's CARTO database. This layer class is useful for offloading processing to the cloud to do some of the following:

- Visualizing spatial operations using [PostGIS](#) and [PostgreSQL](#), which is the database underlying CARTO
- Performing arbitrary relational database queries (e.g., complex JOINS in SQL instead of in `pandas`)
- Visualizing a subset of the data (e.g., `SELECT * FROM table LIMIT 1000`)

Used in the `layers` keyword in `CartoContext.map`.

Example

Underlay a `QueryLayer` with a complex query below a layer from a table. The `QueryLayer` is colored by the calculated column `abs_diff`, and points are sized by the column `i_measure`.

```
import cartoframes
from cartoframes import QueryLayer, styling
cc = cartoframes.CartoContext(BASEURL, APIKEY)
cc.map(layers=[QueryLayer(''
                        WITH i_cte As (
                            SELECT
                                ST_Buffer(the_geom::geography, 500)::geometry As_
↪the_geom,
                                cartodb_id,
                                measure,
                                date
                            FROM interesting_data
                            WHERE date > '2017-04-19'
                        )
                        SELECT
                            i.cartodb_id, i.the_geom,
```

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(continued from previous page)

```

        ST_Transform(i.the_geom, 3857) AS the_geom_
↪webmercator,
        abs(i.measure - j.measure) AS abs_diff,
        i.measure AS i_measure
    FROM i_cte AS i
    JOIN awesome_data AS j
        ON i.event_id = j.event_id
    WHERE j.measure IS NOT NULL
        AND j.date < '2017-04-29'
    ''',
    color={'column': 'abs_diff',
          'scheme': styling.sunsetDark(7)},
    size='i_measure'),
    Layer('fantastic_sql_table'))

```

Parameters

- **query** (*str*) – Query to expose data on a map layer. At a minimum, a query needs to have the columns *cartodb_id*, *the_geom*, and *the_geom_webmercator* for the map to display. Read more about queries in [CARTO's docs](#).
- **time** (*dict or str, optional*) – Time-based style to apply to layer.

If *time* is a *str*, it must be the name of a column which has a data type of *datetime* or *float*.

```

from cartoframes import QueryLayer
l = QueryLayer('SELECT * FROM acadia_biodiversity',
               time='bird_sighting_time')

```

If *time* is a *dict*, the following keys are options:

- **column** (*str*, required): Column for animating map, which must be of type *datetime* or *float*.
- **method** (*str*, optional): Type of aggregation method for operating on [Torque Tile-Cubes](#). Must be one of *avg*, *sum*, or another [PostgreSQL aggregate functions](#) with a numeric output. Defaults to *count*.
- **cumulative** (*bool*, optional): Whether to accumulate points over time (*True*) or not (*False*, default)
- **frames** (*int*, optional): Number of frames in the animation. Defaults to 256.
- **duration** (*int*, optional): Number of seconds in the animation. Defaults to 30.
- **trails** (*int*, optional): Number of trails after the incidence of a point. Defaults to 2.

```

from cartoframes import Layer
l = Layer('acadia_biodiversity',
         time={
             'column': 'bird_sighting_time',
             'cumulative': True,
             'frames': 128,
             'duration': 15
         })

```

- **color** (*dict or str, optional*) – Color style to apply to map. For example, this can be used to change the color of all geometries in this layer, or to create a graduated

color or choropleth map.

If *color* is a `str`, there are two options:

- A column name to style by to create, for example, a choropleth map if working with polygons. The default classification is *quantiles* for quantitative data and *category* for qualitative data.
- A hex value or [web color name](#).

```
# color all geometries red (#F00)
from cartoframes import Layer
l = Layer('acadia_biodiversity',
          color='red')

# color on 'num_eggs' (using default color scheme and
# quantification)
l = Layer('acadia_biodiversity',
          color='num_eggs')
```

If *color* is a `dict`, the following keys are options, with values described:

- *column* (*str*): Column used for the basis of styling
- *scheme* (*dict*, optional): Scheme such as *styling.sunset(7)* from the *styling module* of cartoframes that exposes [CARTOColors](#). Defaults to *mint* scheme for quantitative data and *bold* for qualitative data. More control is given by using *styling.scheme*.

If you wish to define a custom scheme outside of [CARTOColors](#), it is recommended to use the *styling.custom* utility function.

```
from cartoframes import QueryLayer, styling
l = QueryLayer('SELECT * FROM acadia_biodiversity',
               color={
                   'column': 'simpson_index',
                   'scheme': styling.mint(7, bin_method='equal')
               })
```

- *size* (*dict or int, optional*) – Size style to apply to point data.

If *size* is an `int`, all points are sized by this value.

```
from cartoframes import QueryLayer
l = QueryLayer('SELECT * FROM acadia_biodiversity',
               size=7)
```

If *size* is a `str`, this value is interpreted as a column, and the points are sized by the value in this column. The classification method defaults to *quantiles*, with a min size of 5, and a max size of 5. Use the `dict` input to override these values.

```
from cartoframes import Layer
l = Layer('acadia_biodiversity',
          size='num_eggs')
```

If *size* is a `dict`, the follow keys are options, with values described as:

- *column* (*str*): Column to base sizing of points on
- *bin_method* (*str*, optional): Quantification method for dividing data range into bins. Must be one of the methods in `BinMethod` (excluding *category*).
- *bins* (*int*, optional): Number of bins to break data into. Defaults to 5.

- `max` (*int*, optional): Maximum point width (in pixels). Setting this overrides *range*. Defaults to 25.
- `min` (*int*, optional): Minimum point width (in pixels). Setting this overrides *range*. Defaults to 5.
- `range` (*tuple* or *list*, optional): a *min/max* pair. Defaults to `[1, 5]` for lines and `[5, 25]` for points.

```
from cartoframes import Layer
l = Layer('acadia_biodiversity',
          size={
              'column': 'num_eggs',
              'max': 10,
              'min': 2
          })
```

- **opacity** (*float*, *optional*) – Opacity of layer from 0 to 1. Defaults to 0.9.
- **tooltip** (*tuple*, *optional*) – **Not yet implemented.**
- **legend** – **Not yet implemented.**

Raises

- **CartoException** – If a column name used in any of the styling options is not in the data source in *query* (or *table* if using `Layer`).
- **ValueError** – If styling using a `dict` and a `column` key is not present, or if the data type for a styling option is not supported. This is also raised if styling by a geometry column (i.e., `the_geom` or `the_geom_webmercator`). Further, this is raised if requesting a time-based map with a data source that has geometries other than points.

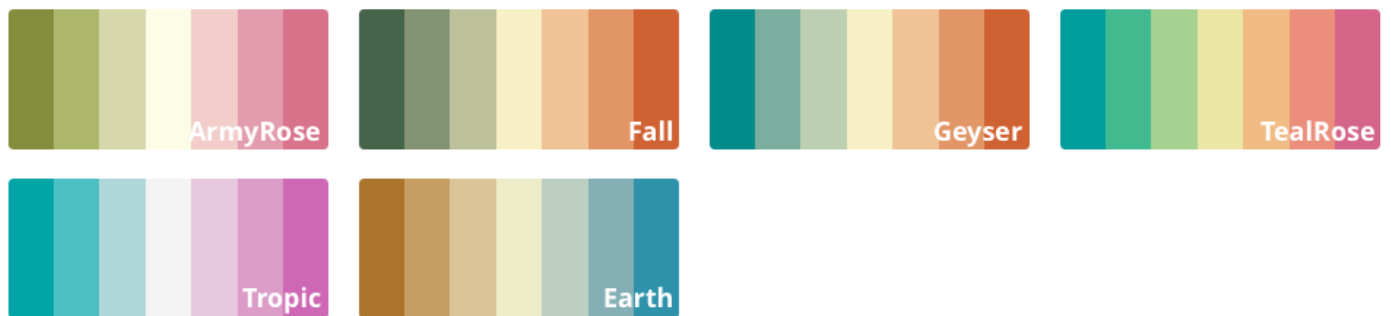
6.5.4 Map Styling Functions

Styling module that exposes CARTOColors schemes. Read more about CARTOColors in its [GitHub repository](#).

Sequential Schemes



Diverging Schemes



Qualitative Schemes



class `cartoframes.styling.BinMethod`

Data classification methods used for the styling of data on maps.

quantiles

Quantiles classification for quantitative data

Type `str`

jenks

Jenks classification for quantitative data

Type `str`

headtails

Head/Tails classification for quantitative data

Type `str`

equal

Equal Interval classification for quantitative data

Type `str`

category

Category classification for qualitative data

Type `str`

mapping

The TurboCarto mappings

Type `dict`

`cartoframes.styling.get_scheme_cartocss(column, scheme_info)`

Get TurboCARTO CartoCSS based on input parameters

`cartoframes.styling.custom(colors, bins=None, bin_method='quantiles')`

Create a custom scheme.

Parameters

- **colors** (*list of str*) – List of hex values for styling data
- **bins** (*int, optional*) – Number of bins to style by. If not given, the number of colors will be used.
- **bin_method** (*str, optional*) – Classification method. One of the values in `BinMethod`. Defaults to *quantiles*, which only works with quantitative data.

`cartoframes.styling.scheme(name, bins, bin_method='quantiles')`

Return a custom scheme based on CARTOColors.

Parameters

- **name** (*str*) – Name of a CARTOColor.
- **bins** (*int or iterable*) – If an *int*, the number of bins for classifying data. CARTOColors have 7 bins max for quantitative data, and 11 max for qualitative data. If *bins* is a *list*, it is the upper range for classifying data. E.g., *bins* can be of the form (10, 20, 30, 40, 50).
- **bin_method** (*str, optional*) – One of methods in `BinMethod`. Defaults to *quantiles*. If *bins* is an iterable, then that is the bin method that will be used and this will be ignored.

Warning: Input types are particularly sensitive in this function, and little feedback is given for errors. `name` and `bin_method` arguments are case-sensitive.

```
cartoframes.styling.burg (bins, bin_method='quantiles')
    CARTOColors Burg quantitative scheme
cartoframes.styling.burgYl (bins, bin_method='quantiles')
    CARTOColors BurgYl quantitative scheme
cartoframes.styling.redOr (bins, bin_method='quantiles')
    CARTOColors RedOr quantitative scheme
cartoframes.styling.orYel (bins, bin_method='quantiles')
    CARTOColors OrYel quantitative scheme
cartoframes.styling.peach (bins, bin_method='quantiles')
    CARTOColors Peach quantitative scheme
cartoframes.styling.pinkYl (bins, bin_method='quantiles')
    CARTOColors PinkYl quantitative scheme
cartoframes.styling.mint (bins, bin_method='quantiles')
    CARTOColors Mint quantitative scheme
cartoframes.styling.bluGrn (bins, bin_method='quantiles')
    CARTOColors BluGrn quantitative scheme
cartoframes.styling.darkMint (bins, bin_method='quantiles')
    CARTOColors DarkMint quantitative scheme
cartoframes.styling.emrld (bins, bin_method='quantiles')
    CARTOColors Emrld quantitative scheme
cartoframes.styling.bluYl (bins, bin_method='quantiles')
    CARTOColors BluYl quantitative scheme
cartoframes.styling.teal (bins, bin_method='quantiles')
    CARTOColors Teal quantitative scheme
cartoframes.styling.tealGrn (bins, bin_method='quantiles')
    CARTOColors TealGrn quantitative scheme
cartoframes.styling.purp (bins, bin_method='quantiles')
    CARTOColors Purp quantitative scheme
cartoframes.styling.purpOr (bins, bin_method='quantiles')
    CARTOColors PurpOr quantitative scheme
cartoframes.styling.sunset (bins, bin_method='quantiles')
    CARTOColors Sunset quantitative scheme
cartoframes.styling.magenta (bins, bin_method='quantiles')
    CARTOColors Magenta quantitative scheme
cartoframes.styling.sunsetDark (bins, bin_method='quantiles')
    CARTOColors SunsetDark quantitative scheme
cartoframes.styling.brwnYl (bins, bin_method='quantiles')
    CARTOColors BrwnYl quantitative scheme
cartoframes.styling.armyRose (bins, bin_method='quantiles')
    CARTOColors ArmyRose divergent quantitative scheme
```

```

cartoframes.styling.fall (bins, bin_method='quantiles')
    CARTOColors Fall divergent quantitative scheme

cartoframes.styling.geyser (bins, bin_method='quantiles')
    CARTOColors Geyser divergent quantitative scheme

cartoframes.styling.temps (bins, bin_method='quantiles')
    CARTOColors Temps divergent quantitative scheme

cartoframes.styling.tealRose (bins, bin_method='quantiles')
    CARTOColors TealRose divergent quantitative scheme

cartoframes.styling.tropic (bins, bin_method='quantiles')
    CARTOColors Tropic divergent quantitative scheme

cartoframes.styling.earth (bins, bin_method='quantiles')
    CARTOColors Earth divergent quantitative scheme

cartoframes.styling.antique (bins, bin_method='category')
    CARTOColors Antique qualitative scheme

cartoframes.styling.bold (bins, bin_method='category')
    CARTOColors Bold qualitative scheme

cartoframes.styling.pastel (bins, bin_method='category')
    CARTOColors Pastel qualitative scheme

cartoframes.styling.prism (bins, bin_method='category')
    CARTOColors Prism qualitative scheme

cartoframes.styling.safe (bins, bin_method='category')
    CARTOColors Safe qualitative scheme

cartoframes.styling.vivid (bins, bin_method='category')
    CARTOColors Vivid qualitative scheme

```

6.5.5 Example Datasets

Download, preview, and query example datasets for use in cartoframes examples. Try examples by [running the notebooks in binder](#), or trying the [Example Datasets notebook](#).

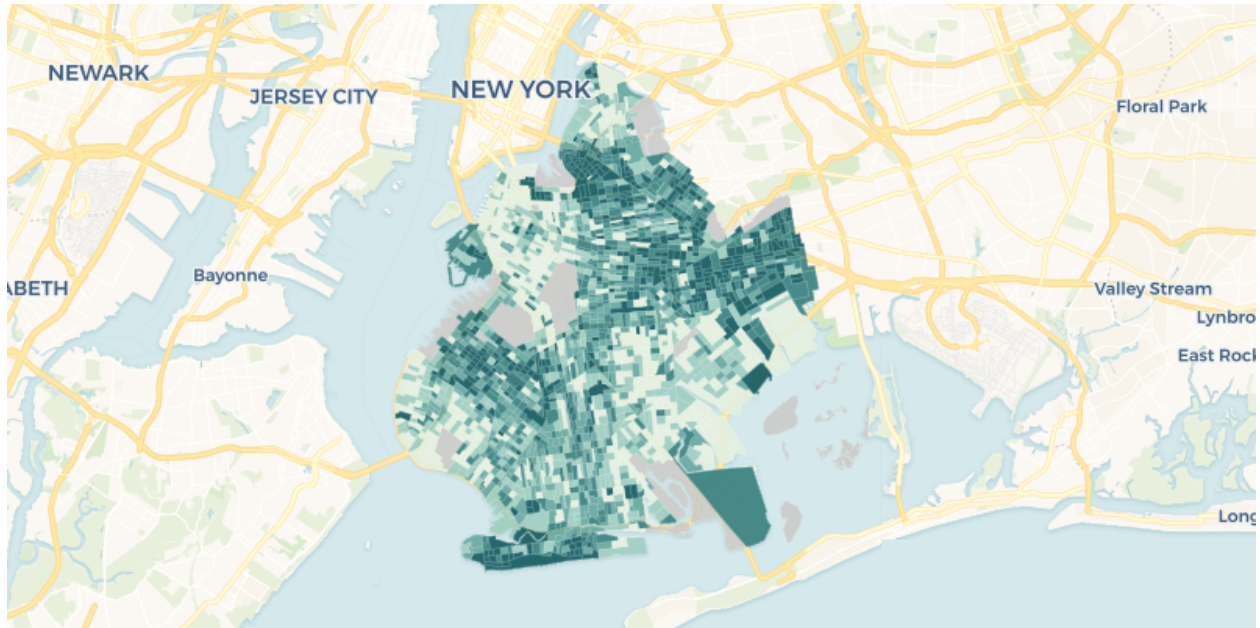
In addition to the functions listed below, this examples module provides a `CartoContext` that is authenticated against all public datasets in the <https://cartoframes.carto.com> account. This means that besides reading the datasets from CARTO, users can also create maps from these datasets.

For example, the following will produce an interactive map of poverty rates in census tracts in Brooklyn, New York (preview of static version below code).

```

from cartoframes.examples import example_context
from cartoframes import Layer
example_context.map(Layer('brooklyn_poverty', color='poverty_per_pop'))

```

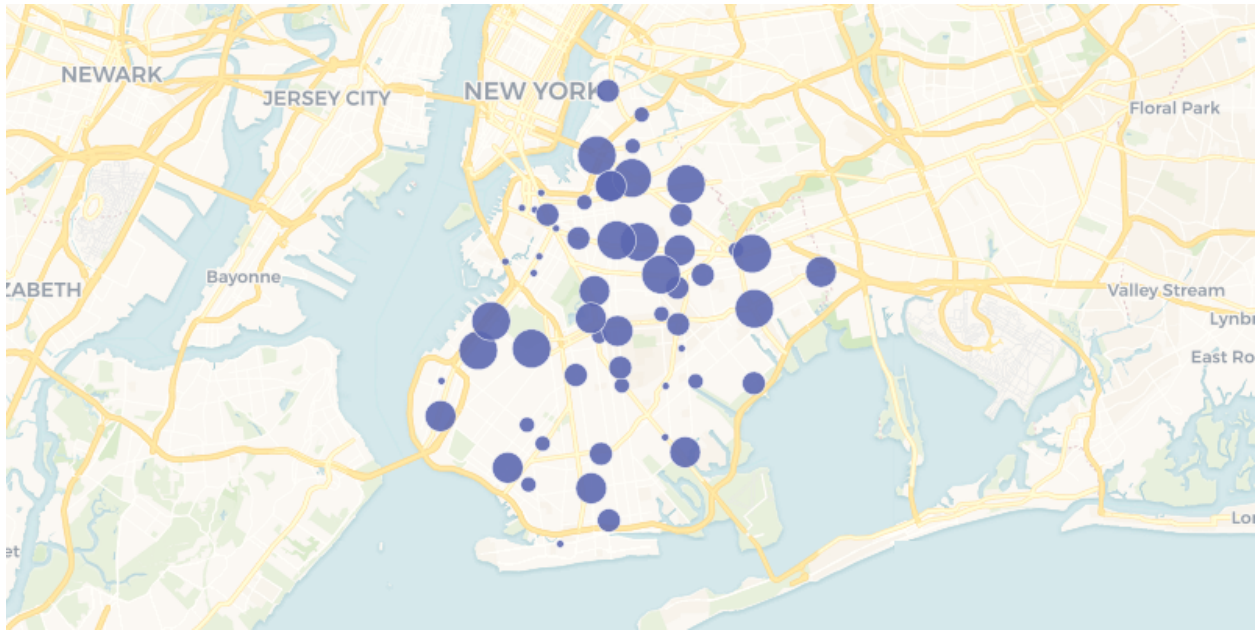


To query datasets, use the `CartoContext.query` method. The following example finds the poverty rate in the census tract a McDonald's fast food joint is located (preview of static map below code).

```
from cartoframes.examples import example_context

# query to get poverty rates where mcdonald's are located in brooklyn
q = '''
    SELECT m.the_geom, m.cartodb_id, m.the_geom_webmercator, c.poverty_per_
    ↪pop
    FROM mcdonalds_nyc as m, brooklyn_poverty as c
    WHERE ST_Intersects(m.the_geom, c.the_geom)
'''
# get data
df = example_context.query(q)

# visualize data
from cartoframes import QueryLayer
example_context.map(QueryLayer(q, size='poverty_per_pop'))
```



To write datasets to your account from the examples account, the following is a good method:

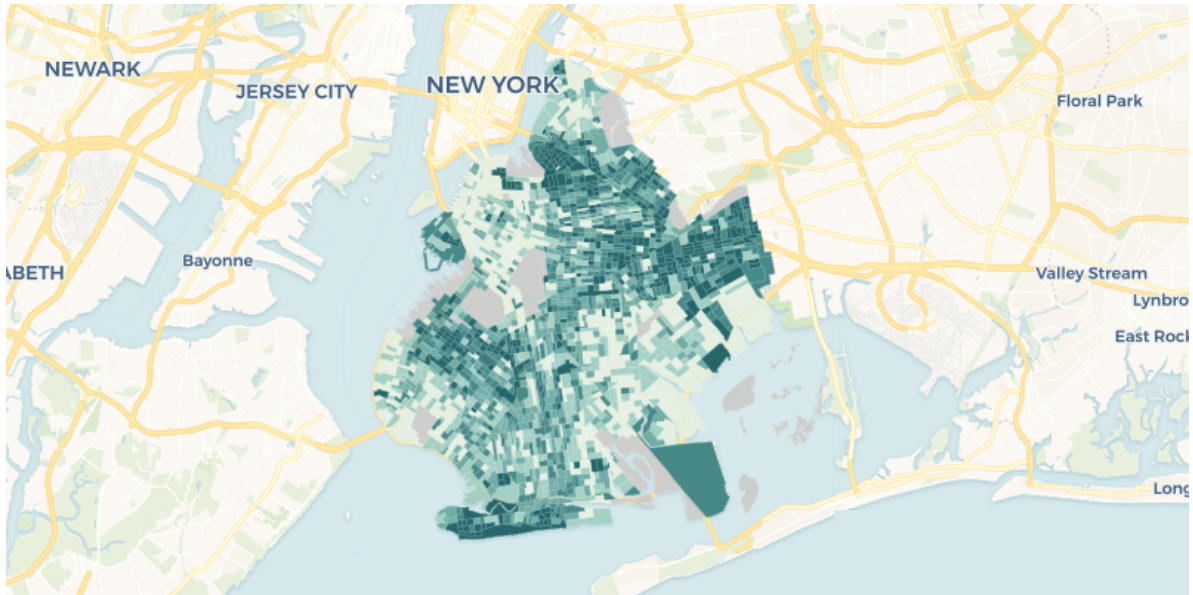
```
from cartoframes import CartoContext
from cartoframes.examples import read_taxi
USERNAME = 'your user name'
APIKEY = 'your API key'
cc = CartoContext(
    base_url='https://{}.carto.com'.format(USERNAME),
    api_key=APIKEY
)
cc.write(
    read_taxi(),
    'taxi_data_examples_acct',
    lnglat=('pickup_latitude', 'pickup_longitude')
)
```

Data access functions

`cartoframes.examples.read_brooklyn_poverty` (*limit=None, **kwargs*)

Read the dataset *brooklyn_poverty* into a pandas DataFrame from the cartoframes example account at https://cartoframes.carto.com/tables/brooklyn_poverty/public This dataset contains poverty rates for census tracts in Brooklyn, New York

The data looks as follows (styled on *poverty_per_pop*):

**Parameters**

- **limit** (*int*, *optional*) – Limit results to *limit*. Defaults to return all rows of the original dataset
- ****kwargs** – Arguments accepted in `CartoContext.read`

Returns Data in the table `brooklyn_poverty` on the cartoframes example account

Return type `pandas.DataFrame`

Example:

```
from cartoframes.examples import read_brooklyn_poverty
df = read_brooklyn_poverty()
```

`cartoframes.examples.read_mcdonalds_nyc(limit=None, **kwargs)`

Read the dataset `mcdonalds_nyc` into a pandas DataFrame from the cartoframes example account at https://cartoframes.carto.com/tables/mcdonalds_nyc/public This dataset contains the locations of McDonald's Fast Food within New York City.

Visually the data looks as follows:



Parameters

- **limit** (*int*, *optional*) – Limit results to *limit*. Defaults to return all rows of the original dataset
- ****kwargs** – Arguments accepted in `CartoContext.read`

Returns Data in the table `mcdonalds_nyc` on the cartoframes example account

Return type `pandas.DataFrame`

Example:

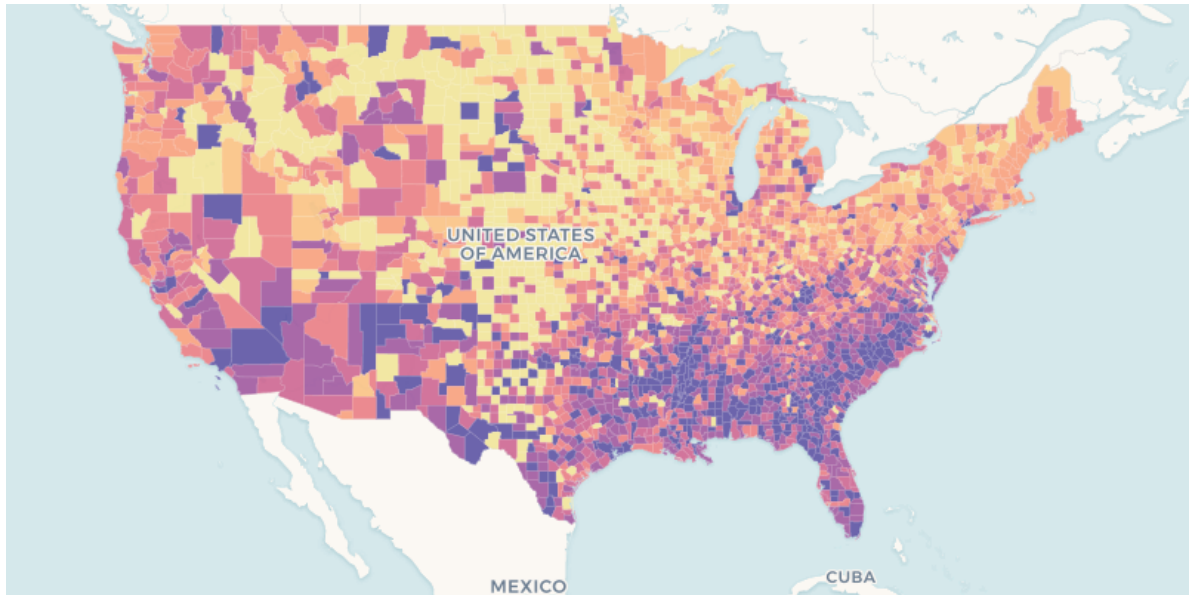
```
from cartoframes.examples import read_mcdonalds_nyc
df = read_mcdonalds_nyc()
```

`cartoframes.examples.read_nat(limit=None, **kwargs)`

Read *nat* dataset: US county homicides 1960-1990

This table is located at: <https://cartoframes.carto.com/tables/nat/public>

Visually, the data looks as follows (styled by the *hr90* column):

**Parameters**

- **limit** (*int*, *optional*) – Limit results to *limit*. Defaults to return all rows of the original dataset
- ****kwargs** – Arguments accepted in `CartoContext.read`

Returns Data in the table *nat* on the cartoframes example account

Return type `pandas.DataFrame`

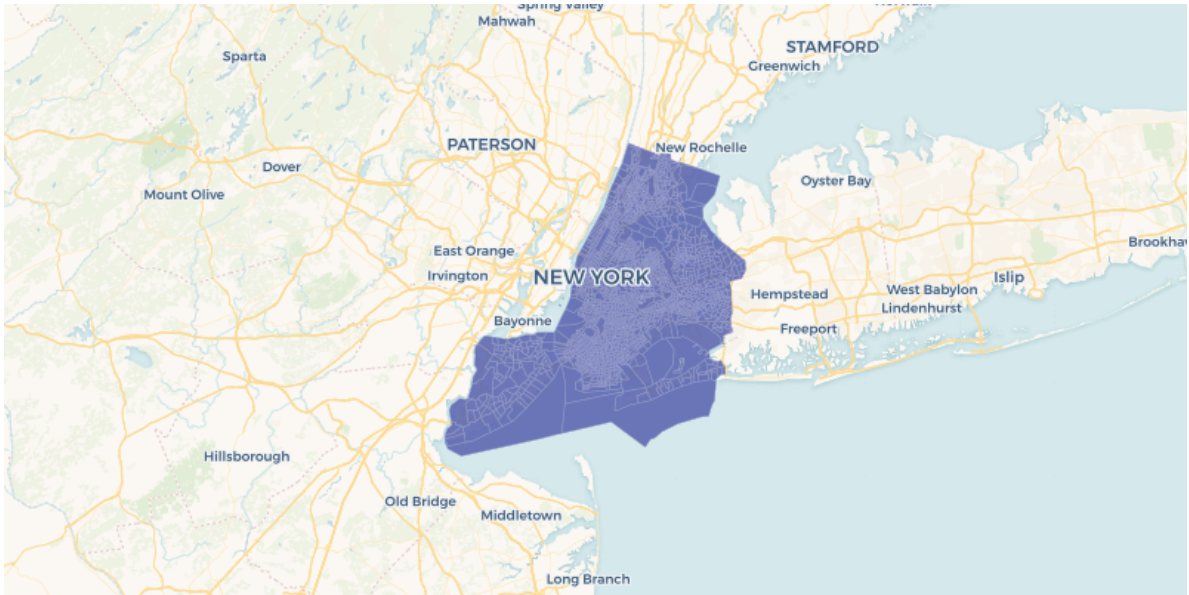
Example:

```
from cartoframes.examples import read_nat
df = read_nat()
```

`cartoframes.examples.read_nyc_census_tracts` (*limit=None*, ***kwargs*)

Read the dataset *nyc_census_tracts* into a pandas DataFrame from the cartoframes example account at https://cartoframes.carto.com/tables/nyc_census_tracts/public This dataset contains the US census boundaries for 2015 Tiger census tracts and the corresponding GEOID in the *geom_refs* column.

Visually the data looks as follows:



Parameters

- **limit** (*int*, *optional*) – Limit results to *limit*. Defaults to return all rows of the original dataset
- ****kwargs** – Arguments accepted in `CartoContext.read`

Returns Data in the table `nyc_census_tracts` on the cartoframes example account

Return type `pandas.DataFrame`

Example:

```
from cartoframes.examples import read_nyc_census_tracts
df = read_nyc_census_tracts()
```

`cartoframes.examples.read_taxi` (*limit=None*, ***kwargs*)

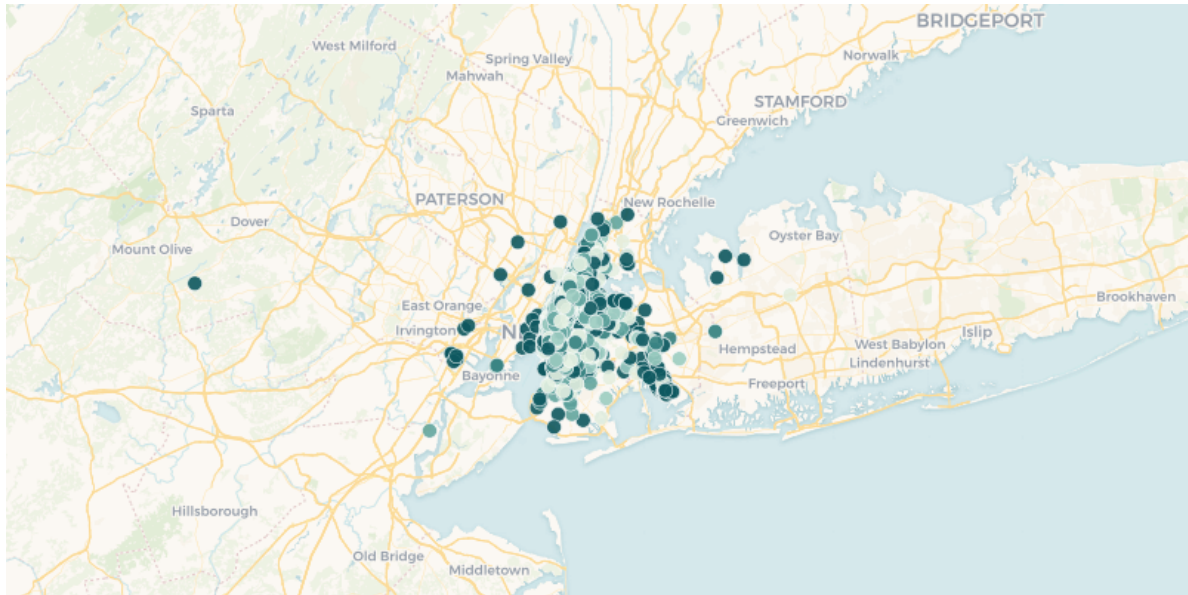
Read the dataset `taxi_50k` into a pandas DataFrame from the cartoframes example account at https://cartoframes.carto.com/tables/taxi_50k/public. This table has a sample of 50,000 taxi trips taken in New York City. The dataset includes fare amount, tolls, payment type, and pick up and drop off locations.

Note: This dataset does not have geometries. The geometries have to be created by using the pickup or drop-off lng/lat pairs. These can be specified in `CartoContext.write`.

To create geometries with `example_context.query`, write a query such as this:

```
example_context.query('''
    SELECT
        CDB_LatLng(pickup_latitude, pickup_longitude) as the_geom,
        cartodb_id,
        fare_amount
    FROM
        taxi_50
''')
```

The data looks as follows (using the pickup location for the geometry and styling by `fare_amount`):



Parameters

- **limit** (*int*, *optional*) – Limit results to *limit*. Defaults to return all rows of the original dataset
- ****kwargs** – Arguments accepted in `CartoContext.read`

Returns Data in the table `taxi_50k` on the cartoframes example account

Return type `pandas.DataFrame`

Example:

```
from cartoframes.examples import read_taxi
df = read_taxi()
```

Example CartoContext

class `cartoframes.examples.Examples`

A `CartoContext` with a CARTO account containing example data. This special `CartoContext` provides read access to all the datasets in the cartoframes CARTO account.

The recommended way to use this class is to import the `example_context` from the `cartoframes.examples` module:

```
from cartoframes.examples import example_context
df = example_context.read_taxi()
```

The following tables are available for use with the `CartoContext.read`, `CartoContext.map`, and `CartoContext.query` methods.

- `brooklyn_poverty` - basic poverty information for Brooklyn, New York
- `mcdonalds_nyc` - McDonald's locations in New York City
- `nat` - historical USA-wide homicide rates at the county level
- `nyc_census_tracts` - Census tract boundaries for New York City
- `taxi_50k` - Taxi trip data, including pickup/drop-off locations. This table does not have an explicit geometry, so one must be created from the `pickup_latitude/pickup_longitude` columns, the

dropoff_latitude/dropoff_longitude columns, or through some other process. When writing this table to your account, make sure to specify the *lnglat* flag in `CartoContext.write`

Besides the standard `CartoContext` methods, this class includes a convenience method for each of the tables listed above. See the full list below.

`read_brooklyn_poverty` (*limit=None, **kwargs*)

Poverty information for Brooklyn, New York, USA. See the function `read_brooklyn_poverty` for more information.

Example:

```
from cartoframes.examples import example_context
df = example_context.read_brooklyn_poverty()
```

`read_mcdonalds_nyc` (*limit=None, **kwargs*)

McDonald's locations for New York City, USA. See the function `read_mcdonalds_nyc` for more information

Example:

```
from cartoframes.examples import example_context
df = example_context.read_mcdonalds_nyc()
```

`read_nat` (*limit=None, **kwargs*)

Historical homicide rates for the United States at the county level. See the function `read_nat` for more information

Example:

```
from cartoframes.examples import example_context
df = example_context.read_nat()
```

`read_nyc_census_tracts` (*limit=None, **kwargs*)

Census tracts for New York City, USA. See the function `read_nyc_census_tracts` for more information

Example:

```
from cartoframes.examples import example_context
df = example_context.read_nyc_census_tracts()
```

`read_taxi` (*limit=None, **kwargs*)

Taxi pickup and drop-off logs for New York City, USA. See the function `read_taxi` for more information

Example:

```
from cartoframes.examples import example_context
df = example_context.read_taxi()
```

6.5.6 contrib

`contrib` is an experimental library of modules in the `contrib` directory. These modules allow us to release new features with the expectation that they will change quickly, but give users quicker access to the bleeding edge. Most features in `contrib` will eventually be merged into the `cartoframes` core.

vector maps

This module allows users to create interactive vector maps using CARTO VL. The API for vector maps is broadly similar to `CartoContext.map`, with the exception that all styling expressions are expected to be straight CARTO VL expressions. See examples in the [CARTO VL styling guide](#)

Here is an example using the example `CartoContext` from the [Examples](#) class.

```
from cartoframes.examples import example_context
from cartoframes.contrib import vector
vector.vmap(
    [vector.Layer(
        'nat',
        color='ramp(globalEqIntervals($hr90, 7), sunset)',
        strokeWidth=0),
    ],
    example_context)
```

class `cartoframes.contrib.vector.BaseMaps`

Supported CARTO vector basemaps. Read more about the styles in the [CARTO Basemaps repository](#).

darkmatter

CARTO's "Dark Matter" style basemap

Type `str`

positron

CARTO's "Positron" style basemap

Type `str`

voyager

CARTO's "Voyager" style basemap

Type `str`

Example

Create an embedded map using CARTO's Positron style with no data layers

```
from cartoframes.contrib import vector
from cartoframes import CartoContext
cc = CartoContext()
vector.vmap([], context=cc, basemap=vector.BaseMaps.positron)
```

class `cartoframes.contrib.vector.Layer` (*table_name*, *color=None*, *size=None*, *time=None*, *strokeColor=None*, *strokeWidth=None*, *interactivity=None*, *legend=None*)

Layer from a table name. See [vector.QueryLayer](#) for docs on the style attributes.

Example

Visualize data from a table. Here we're using the example `CartoContext`. To use this with your account, replace the `example_context` with your `CartoContext` and a table in the account you authenticate against.

```

from cartoframes.examples import example_context
from cartoframes.contrib import vector
vector.vmap(
    [vector.Layer(
        'nat',
        color='ramp(globalEqIntervals($hr90, 7), sunset)',
        strokeWidth=0),
    ],
    example_context)

```

```

class cartoframes.contrib.vector.LocalLayer(dataframe, color=None, size=None,
                                             time=None, strokeColor=None,
                                             strokeWidth=None, interactivity=None,
                                             legend=None)

```

Create a layer from a GeoDataFrame

TODO: add support for filepath to a GeoJSON file, JSON/dict, or string

See [QueryLayer](#) for the full styling documentation.

Example

In this example, we grab data from the cartoframes example account using `read_mcdonalds_nyc` to get McDonald's locations within New York City. Using the `decode_geom=True` argument, we decode the geometries into a form that works with GeoPandas. Finally, we pass the GeoDataFrame into `LocalLayer` to visualize.

```

import geopandas as gpd
from cartoframes.examples import read_mcdonalds_nyc, example_context
from cartoframes.contrib import vector
gdf = gpd.GeoDataFrame(read_mcdonalds_nyc(decode_geom=True))
vector.vmap([vector.LocalLayer(gdf), ], context=example_context)

```

```

class cartoframes.contrib.vector.QueryLayer(query, color=None, size=None, time=None,
                                             strokeColor=None, strokeWidth=None,
                                             interactivity=None, legend=None)

```

CARTO VL layer based on an arbitrary query against user database

Parameters

- **query** (*str*) – Query against user database. This query must have the following columns included to successfully have a map rendered: `the_geom`, `the_geom_webmercator`, and `cartodb_id`. If columns are used in styling, they must be included in this query as well.
- **color** (*str*, *optional*) – CARTO VL color styling for this layer. Valid inputs are simple web color names and hex values. For more advanced styling, see the CARTO VL guide on styling for more information: <https://carto.com/developers/carto-vl/guides/styling-points/>
- **size** (*float or str*, *optional*) – CARTO VL width styling for this layer if points or lines (which are not yet implemented). Valid inputs are positive numbers or text expressions involving variables. To remain consistent with cartoframes' raster-based Layer API, `size` is used here in place of `width`, which is the CARTO VL variable name for controlling the width of a point or line. Default size is 7 pixels wide.
- **time** (*str*, *optional*) – Time expression to animate data. This is an alias for the CARTO VL `filter` style attribute. Default is no animation.

- **strokeColor**(*str*, *optional*) – Defines the stroke color of polygons. Default is white.
- **strokeWidth**(*float or str*, *optional*) – Defines the width of the stroke in pixels. Default is 1.
- **interactivity**(*str*, *list*, *or dict*, *optional*) – This option adds interactivity (click or hover) to a layer. Defaults to `click` if one of the following inputs are specified:
 - `dict`: If a `dict`, this must have the key `cols` with its value a list of columns. Optionally add `event` to choose `hover` or `click`. Specifying a `header` key/value pair adds a header to the popup that will be rendered in HTML.
 - `list`: A list of valid column names in the data used for this layer
 - `str`: A column name in the data used in this layer

Example

```
from cartoframes.examples import example_context
from cartoframes.contrib import vector
# create geometries from lng/lat columns
q = '''
    SELECT *, ST_Transform(the_geom, 3857) as the_geom_webmercator
    FROM (
        SELECT
            CDB_LatLng(pickup_latitude, pickup_longitude) as the_geom,
            fare_amount,
            cartodb_id
        FROM taxi_50k
    ) as _w
'''
vector.vmap(
    [vector.QueryLayer(q), ],
    example_context,
    interactivity={
        'cols': ['fare_amount', ],
        'event': 'hover'
    }
)
```

`cartoframes.contrib.vector.vmap(*args, **kwargs)`
CARTO VL-powered interactive map

Parameters

- **layers** (*list of Layer-types*) – List of layers. One or more of `Layer`, `QueryLayer`, or `LocalLayer`.
- **context** (`CartoContext`) – A `CartoContext` instance
- **basemap** (*str*) –
 - if a *str*, name of a CARTO vector basemap. One of *positron*, *voyager*, or *darkmatter* from the `BaseMaps` class
 - if a *dict*, Mapbox or other style as the value of the *style* key. If a Mapbox style, the access token is the value of the *token* key.

Example

```
from cartoframes.contrib import vector
from cartoframes import CartoContext
cc = CartoContext(
    base_url='https://your_user_name.carto.com',
    api_key='your api key'
)
vector.vmap([vector.Layer('table in your account'), ], cc)
```

CARTO basemap style.

```
from cartoframes.contrib import vector
from cartoframes import CartoContext
cc = CartoContext(
    base_url='https://your_user_name.carto.com',
    api_key='your api key'
)
vector.vmap(
    [vector.Layer('table in your account'), ],
    context=cc,
    basemap=vector.BaseMaps.darkmatter
)
```

Custom basemap style. Here we use the Mapbox streets style, which requires an access token.

```
from cartoframes.contrib import vector
from cartoframes import CartoContext
cc = CartoContext(
    base_url='https://<username>.carto.com',
    api_key='your api key'
)
vector.vmap(
    [vector.Layer('table in your account'), ],
    context=cc,
    basemap={
        'style': 'mapbox://styles/mapbox/streets-v9',
        'token': '<your mapbox token>'
    }
)
```

6.5.7 Credentials Management

Credentials management for cartoframes usage.

class `cartoframes.credentials.Credentials` (*creds=None, key=None, username=None, base_url=None, cred_file=None*)

Credentials class for managing and storing user CARTO credentials. The arguments are listed in order of precedence: `Credentials` instances are first, `key` and `base_url/username` are taken next, and `config_file` (if given) is taken last. If no arguments are passed, then there will be an attempt to retrieve credentials from a previously saved session. One of the above scenarios needs to be met to successfully instantiate a `Credentials` object.

Parameters

- **creds** (`cartoframes.Credentials`, optional) – `Credentials` instance
- **key** (*str*, optional) – API key of user's CARTO account

- **username** (*str*, *optional*) – Username of CARTO account
- **base_url** (*str*, *optional*) – Base URL used for API calls. This is usually of the form `https://eschbacher.carto.com/` for user `eschbacher`. On premises installations (and others) have a different URL pattern.
- **cred_file** (*str*, *optional*) – Pull credentials from a stored file. If this and all other args are not entered, Credentials will attempt to load a user config credentials file that was previously set with `Credentials(...).save()`.

Raises `RuntimeError` – If not enough credential information is passed and no stored credentials file is found, this error will be raised.

Example

```
from cartoframes import Credentials, CartoContext
creds = Credentials(key='abcdefg', username='eschbacher')
cc = CartoContext(creds=creds)
```

base_url (*base_url=None*)

Return or set *base_url*.

Parameters **base_url** (*str*, *optional*) – If set, updates the *base_url*. Otherwise returns current *base_url*.

Note: This does not update the *username* attribute. Separately update the username with `Credentials.username` or update *base_url* and *username* at the same time with `Credentials.set`.

Example

```
>>> from cartoframes import Credentials
# load credentials saved in previous session
>>> creds = Credentials()
# returns current base_url
>>> creds.base_url()
'https://eschbacher.carto.com/'
# updates base_url with new value
>>> creds.base_url('new_base_url')
```

delete (*config_file=None*)

Deletes the credentials file specified in *config_file*. If no file is specified, it deletes the default user credential file.

Parameters **config_file** (*str*) – Path to configuration file. Defaults to delete the user default location if *None*.

Tip: To see if there is a default user credential file stored, do the following:

```
>>> creds = Credentials()
>>> print(creds)
Credentials(username=eschbacher, key=abcdefg,
            base_url=https://eschbacher.carto.com/)
```

key (*key=None*)

Return or set API key.

Parameters **key** (*str, optional*) – If set, updates the API key, otherwise returns current API key.

Example

```
>>> from cartoframes import Credentials
# load credentials saved in previous session
>>> creds = Credentials()
# returns current API key
>>> creds.key()
'abcdefg'
# updates API key with new value
>>> creds.key('new_api_key')
```

save (*config_loc=None*)

Saves current user credentials to user directory.

Parameters **config_loc** (*str, optional*) – Location where credentials are to be stored. If no argument is provided, it will be send to the default location.

Example

```
from cartoframes import Credentials
creds = Credentials(username='eschbacher', key='abcdefg')
creds.save() # save to default location
```

set (*key=None, username=None, base_url=None*)

Update the credentials of a Credentials instance instead with new values.

Parameters

- **key** (*str*) – API key of user account. Defaults to previous value if not specified.
- **username** (*str*) – User name of account. This parameter is optional if *base_url* is not specified, but defaults to the previous value if not set.
- **base_url** (*str*) – Base URL of user account. This parameter is optional if *username* is specified and on CARTO's cloud-based account. Generally of the form `https://your_user_name.carto.com/` for cloud-based accounts. If on-prem or otherwise, contact your admin.

Example

```
from cartoframes import Credentials
# load credentials saved in previous session
creds = Credentials()
# set new API key
creds.set(key='new_api_key')
# save new creds to default user config directory
creds.save()
```

Note: If the *username* is specified but the *base_url* is not, the *base_url* will be updated to `https://<username>.carto.com/`.

username (*username=None*)

Return or set *username*.

Parameters *username* (*str*, *optional*) – If set, updates the *username*. Otherwise returns current *username*.

Note: This does not update the *base_url* attribute. Use *Credentials.set* to have that updated with *username*.

Example

```
>>> from cartoframes import Credentials
# load credentials saved in previous session
>>> creds = Credentials()
# returns current username
>>> creds.username()
'eschbacher'
# updates username with new value
>>> creds.username('new_username')
```

6.5.8 BatchJobStatus

class `cartoframes.batch.BatchJobStatus` (*carto_context, job*)

Status of a write or query operation. Read more at [Batch SQL API docs](#) about responses and how to interpret them.

Example

Poll for a job's status if you've caught the `BatchJobStatus` instance.

```
import time
job = cc.write(df, 'new_table',
               lnglat=('lng_col', 'lat_col'))
while True:
    curr_status = job.status()['status']
    if curr_status in ('done', 'failed', 'canceled', 'unknown', ):
        print(curr_status)
        break
    time.sleep(5)
```

Create a `BatchJobStatus` instance if you have a *job_id* output from a `CartoContext.write` operation.

```
>>> from cartoframes import CartoContext, BatchJobStatus
>>> cc = CartoContext(username='...', api_key='...')
>>> cc.write(df, 'new_table', lnglat=('lng', 'lat'))
'BatchJobStatus(job_id='job-id-string', ...)'
>>> batch_job = BatchJobStatus(cc, 'job-id-string')
```

job_id

Job ID of the Batch SQL API job

Type str**last_status**Status of `job_id` job when last polled**Type** str**created_at**

Time and date when job was created

Type str**Parameters**

- **carto_context** (`CartoContext`) – `CartoContext` instance
- **job** (*dict or str*) – If a dict, job status dict returned after sending a Batch SQL API request. If str, a Batch SQL API job id.

get_status ()

return current status of job

status ()Checks the current status of job `job_id`**Returns** Status and time it was updated**Return type** dict**Warns** `UserWarning` – If the job failed, a warning is raised with information about the failure

6.5.9 Cheat Sheet

For most operations below, you need to create a `CartoContext` object. For example, here's how user *cyclingfan* with API key *abc123* creates one:

```
from cartoframes import CartoContext
cc = CartoContext(
    base_url='https://cyclingfan.carto.com',
    api_key='abc123'
)
```

How to get census tracts or counties for a state

It's a fairly common use case that someone needs the Census tracts for a region. With `cartoframes` you have a lot of flexibility for obtaining this data.

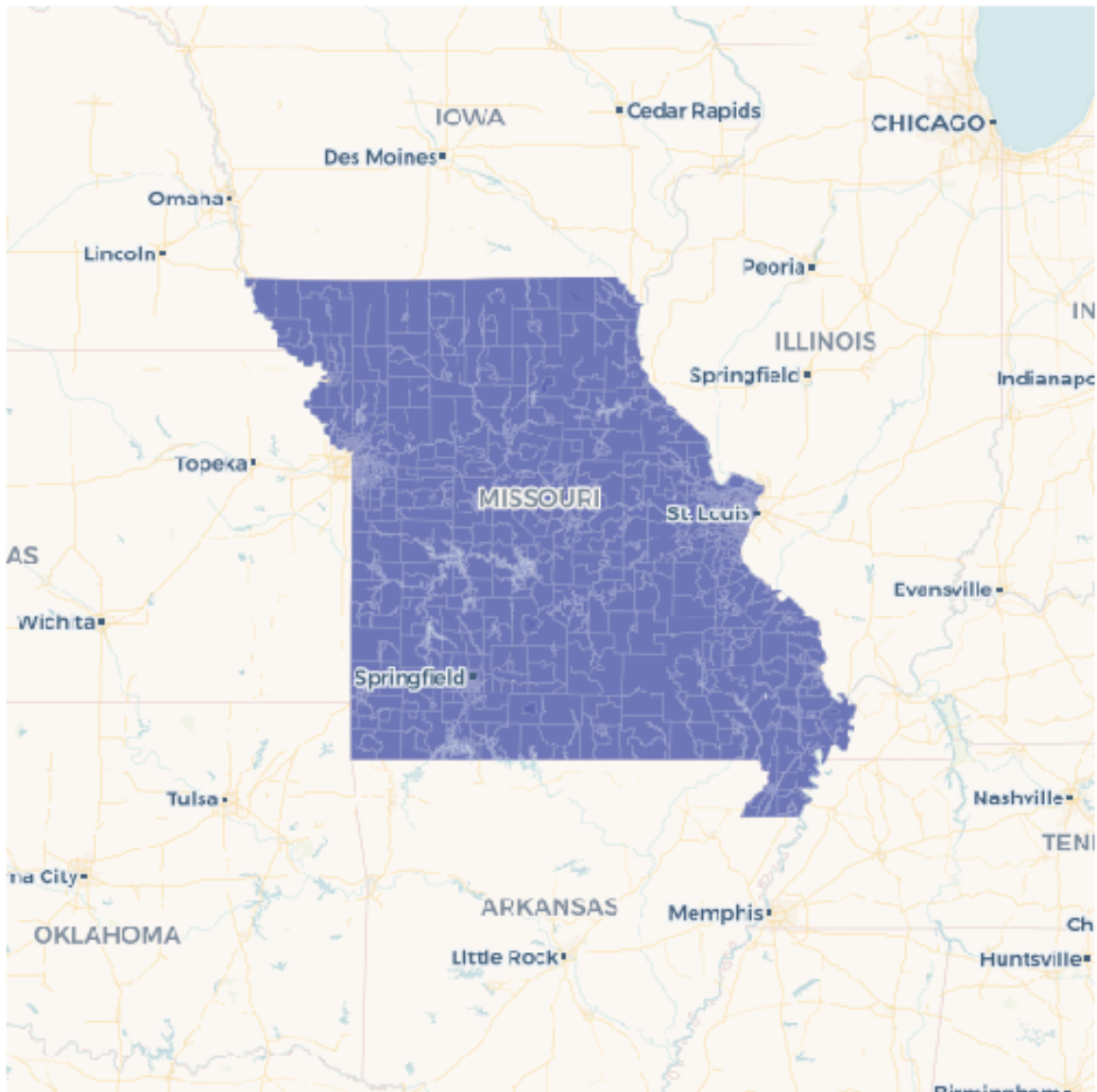
1. Get bounding box of the region you're interested in. Tools like [Klockan's BoundingBox tool](#) with the CSV output are perfect. Alternatively, use a table with the appropriate covering region (e.g., an existing table with polygon(s) of Missouri, its counties, etc.).
2. Get the FIPS code for the state(s) you're interested in. The US Census [provides a table](#) as do many other sites. In this case, I'm choosing 29 for Missouri.

```
# get all census tracts (clipped by water boundaries) in specific bounding box
missouri_ct = cc.data_boundaries(
    region=[-95.774147, 35.995682, -89.098846, 40.613636],
    boundary='us.census.tiger.census_tract_clipped'
)

# filter out all census tracts that begin with Missouri FIPS (29)
# GEOIDs begin with two digit state FIPS, followed by three digit county FIPS
missouri_ct = missouri_ct[missouri_ct.geom_refs.str.startswith('29')]

# write to carto
cc.write(missouri_ct, 'missouri_census_tracts')

# visualize to make sure it makes sense
cc.map(Layer('missouri_census_tracts'))
```



Since `pandas.Series.str.startswith` can take multiple string prefixes, we can filter for more than one state at a time. In this case, get all Missouri and Kansas counties:

```
# get all counties in bounding box around Kansas and Missouri
ks_mo_counties = cc.data_boundaries(
    region=[-102.177729674, 35.995682, -89.098846, 40.613636],
    boundary='us.census.tiger.county'
)

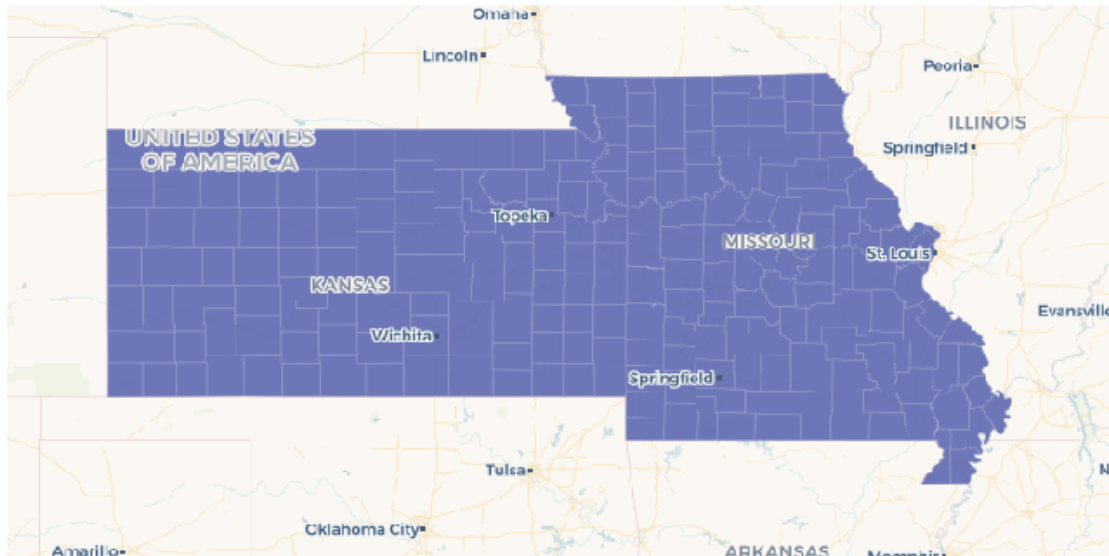
# filter out all counties that begin with Missouri (29) or Kansas (20) FIPS
ks_mo_counties = ks_mo_counties[ks_mo_counties.geom_refs.str.startswith(('29', '20'))]

# write to carto
cc.write(ks_mo_counties, 'ks_mo_counties')
```

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```
# visualize to make sure it makes sense
cc.map(Layer('ks_mo_counties'))
```



Get raw measures from the DO

To get raw census measures from the Data Observatory, the key part is the use of *predenominated* in the metadata and *how='geoid'* (or some other *geom_ref*) when using *CartoContext.data*. If you don't use the *how=* flag, the Data Observatory will perform some calculations with the geometries in the table you are trying to augment.

Here we're using a dataset with a column called *geoid* which has the GEOID of census tracts. Note that it's important to specify the same geometry ID in the measure metadata as the geometries you are wishing to enrich.

1. Find the measures you want, either through *CartoContext.data_discovery* or using the [Data Observatory catalog](#).
2. Create a dataframe with columns for each measure metadata object, or a list of dictionaries (like below) for your curated measures. Be careful to specify the specific geometry level you want the measures for and make sure the geometry reference (e.g., GEOID) you have for your geometries matches this geometry level.

```
# get median income for 2006 - 2010 and 2011 - 2015 five year estimates.
meta = [{
  'numer_id': 'us.census.acs.B19013001',
  'geom_id': 'us.census.tiger.census_tract',
  'normalization': 'predenominated',
  'numer_timespan': '2006 - 2010'
}, {
  'numer_id': 'us.census.acs.B19013001',
  'geom_id': 'us.census.tiger.census_tract',
  'normalization': 'predenominated',
  'numer_timespan': '2011 - 2015'
}]

boston_data = cc.data('boston_census_tracts', meta, how='geoid')
```

Tip: It's best practice to keep your geometry identifiers as strings because leading zeros are removed when strings are converted to numeric types. This usually affects states with FIPS that begin with a zero, or Zip Codes in New England with leading zeros.

Engineer your DO metadata if you already have GEOID or another geom_ref

Use `how='geom_ref_col'` and specify the appropriate boundary in the metadata.

How to get a matplotlib figure with four maps

Creating a small multiple is a handy for data science visualizations for comparing data on multiple maps.

In this example, we use the `example_context`, so no CARTO account is required for the snippet to work.

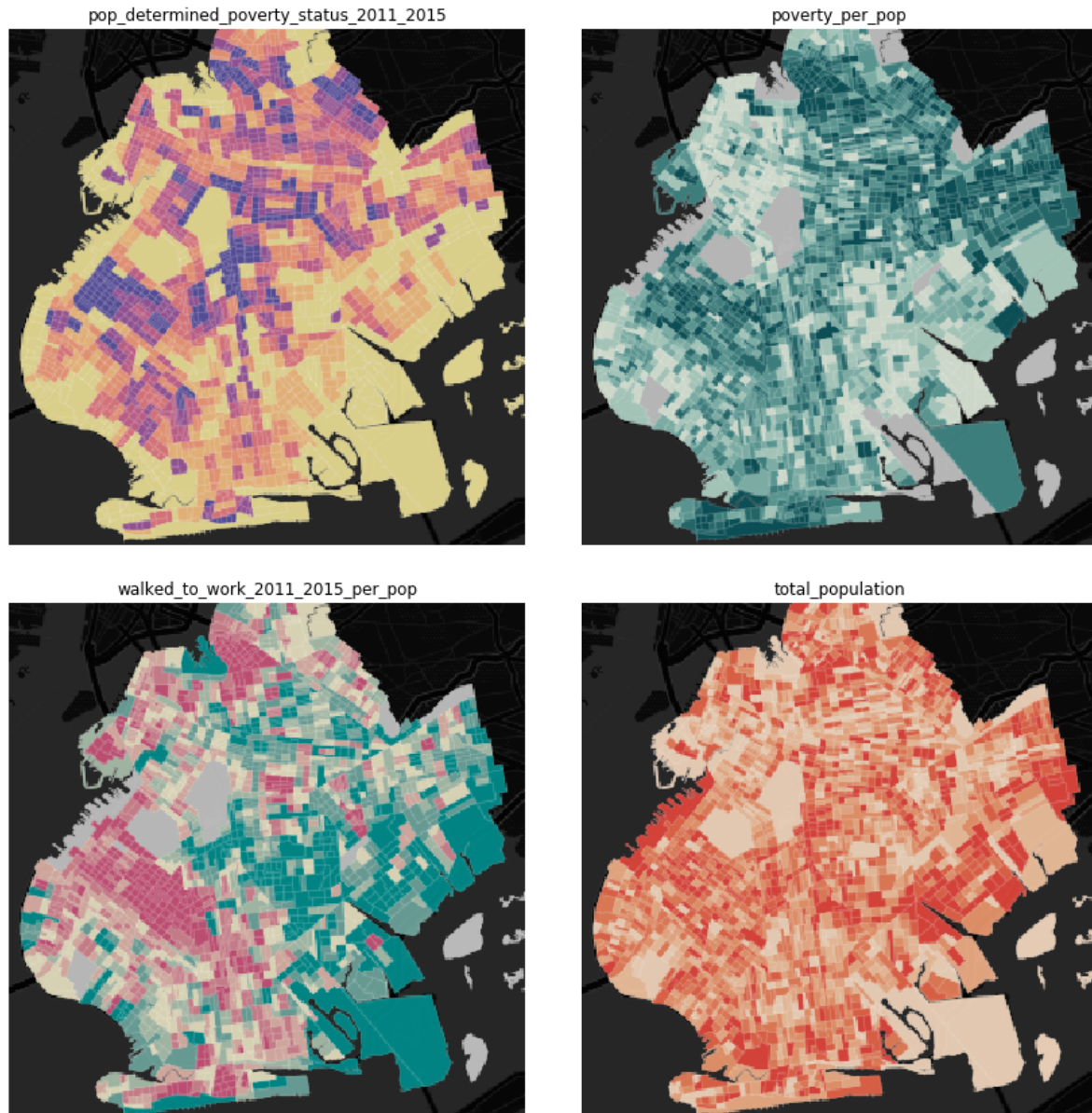
```
from cartoframes import BaseMap, Layer, styling
from cartoframes.examples import example_context
import matplotlib.pyplot as plt

# table in examples account
# preview with:
#     example_context.read_brooklyn_poverty()
table = 'brooklyn_poverty'

# columns and color scheme for visualization
# view available columns with:
#     example_context.read_brooklyn_poverty().columns
cols = [('pop_determined_poverty_status_2011_2015', 'Sunset'),
        ('poverty_per_pop', 'Mint'),
        ('walked_to_work_2011_2015_per_pop', 'TealRose'),
        ('total_population', 'Peach')]

fig, axs = plt.subplots(2, 2, figsize=(8, 8))

for idx, col in enumerate(cols):
    example_context.map(layers=[BaseMap('dark'), Layer(table,
        color={'column': col[0],
              'scheme': styling.scheme(col[1], 7, 'quantiles'})}],
        ax=axs[idx // 2][idx % 2],
        zoom=11, lng=-73.9476, lat=40.6437,
        interactive=False,
        size=(288, 288))
    axs[idx // 2][idx % 2].set_title(col[0])
fig.tight_layout()
plt.show()
```



Get a table as a GeoDataFrame

CARTOframes works with GeoPandas.

1. For any *CartoContext.read* or *CartoContext.query* operation, use the *decode_geom* flag set to *True*, like below.
2. Wrap the result of step 1 in the GeoPandas GeoDataFrame constructor

Your new GeoDataFrame will now have geometries decoded into Shapely objects that can then be used for spatial operations in your Python environment.

```
from cartoframes import CartoContext
import geopandas as gpd
cc = CartoContext()
```

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```
gdf = gpd.GeoDataFrame(cc.read('tablename', decode_geom=True))
```

You can reverse this process and have geometries encoded for storage in CARTO by specifying *encode_geom=True* in the *CartoContext.write* operation.

Skip SSL verification

Some on premises installations of CARTO don't need SSL verification. You can disable this using the requests library's *Session* class and passing that into your *CartoContext*.

```
from requests import Session
session = Session()
session.verify = False

cc = CartoContext(
    base_url='https://cyclingfan.carto.com/',
    api_key='abc123',
    session=session
)
```

Reading large tables or queries

Sometimes tables are too large to read them out in a single *CartoContext.read* or *CartoContext.query* operation. In this case, you can read chunks and recombine, like below:

```
import pandas as pd

# storage for chunks of table
dfs = []

# template query
q = '''
SELECT * FROM my_big_table
WHERE cartodb_id >= {lower} and cartodb_id < {upper}
'''

num_rows = cc.sql_client.send('select count(*) from my_big_table')['rows'][0]['count']

# read in 100,000 chunks
for r in range(0, num_rows, 100000):
    dfs.append(cc.query(q.format(lower=r, upper=r+100000)))

# combine 'em all
all_together = pd.concat(dfs)
del dfs
```

When writing large DataFrames to CARTO, cartoframes takes care of the batching. Users shouldn't hit errors in general until they run out of storage in their database.

Perform long running query if a time out occurs

While not a part of cartoframes yet, [Batch SQL API](#) jobs can be created through the [CARTO Python SDK](#) – the CARTO Python package for developers. Below is a sample workflow for how to perform a long running query that would otherwise produce timeout errors with `CartoContext.query`.

```
from cartoframes import CartoContext, BatchJobStatus
from carto.sql import BatchSQLClient
from time import sleep

cc = CartoContext(
    base_url='https://your-username.carto.com',
    api_key='your-api-key'
)

bsc = BatchSQLClient(cc.auth_client)

job = bsc.create(['''
UPDATE really_big_table
SET the_geom = cdb_geocode_street_point(direccion, ciudad, provincia, 'Spain')
''',
])

bjs = BatchJobStatus(cc, job)
last_status = bjs.status()['status']

while curr_status not in ('failed', 'done', 'canceled', 'unknown'):
    curr_status = bjs.status()['status']
    sleep(5)
    if curr_status != last_status:
        last_status = curr_status
        print(curr_status)

# if curr_status is 'done' the operation was successful
# and we can read the table into a dataframe
geocoded_table = cc.read('really_big_table')
```

Subdivide Data Observatory search region into sub-regions

Some geometries in the Data Observatory are too large, numerous, and/or complex to retrieve in one request. Census tracts (especially if they are shoreline-clipped) is one popular example. To retrieve this data, it helps to first break the search region into subregions, collect the data in each of the subregions, and then combine the data at the end. To avoid duplicate geometries along the sub-region edges, we apply the `DataFrame.drop_duplicates` method for the last step.

```
import itertools

# bbox that encompasses lower 48 states of USA
bbox = [
    -126.8220242454,
    22.991640246,
    -64.35549002,
    51.5559807141
]

# make these numbers larger if the sub-regions are not small enough
```

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(continued from previous page)

```

# make these numbers smaller to get more data in one call
num_divs_lng = 5
num_divs_lat = 3

delta_lng_divs = (bbox[2] - bbox[0]) / num_divs_lng
delta_lat_divs = (bbox[3] - bbox[1]) / num_divs_lat

sub_data = []
for p in itertools.product(range(num_divs_lng), range(num_divs_lat)):
    sub_bbox = (
        bbox[0] + p[0] * delta_lng_divs,
        bbox[1] + p[1] * delta_lat_divs,
        bbox[0] + (p[0] + 1) * delta_lng_divs,
        bbox[1] + (p[1] + 1) * delta_lat_divs
    )
    _df = cc.data_boundaries(
        region=sub_bbox,
        boundary='us.census.tiger.census_tract_clipped'
    )
    sub_data.append(_df)

df_all = pd.concat(sub_data)[['geom_refs', 'the_geom']]
df_all.drop_duplicates(inplace=True)
del sub_data

```

6.5.10 ETL with cartoframes

One common use case for cartoframes is its use in an ETL (Extract, Transform, and Load) process. The most common pattern is to load the data into CARTO:

```

from cartoframes import CartoContext
import pandas as pd

# create cartocontext for your carto account
cc = CartoContext(<your credentials>)

# Extract into a pandas' DataFrame (can be replaced by other operation)
raw_data = pd.read_csv('https://<remote location>.csv')

# Transform
processed_data = <some processing pipeline>

# Load into your carto account
cc.write(processed_data, 'processed_data')

```

Use cases

- Syncing datasets that aren't accessible to the Import API's sync option or that need intermediate processing
- Connecting datasets that reside in datalakes to CARTO
- Subsampling large datasets for preview in CARTO

Examples

- [Hive -> CARTO connector](#)
- [Accessing and parsing a live data feed](#)
- [Live Power Outage reporting for Massachusetts](#)

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Indices and tables

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