TEMPO via the Python Interface to Remote Sensing Information Gateway

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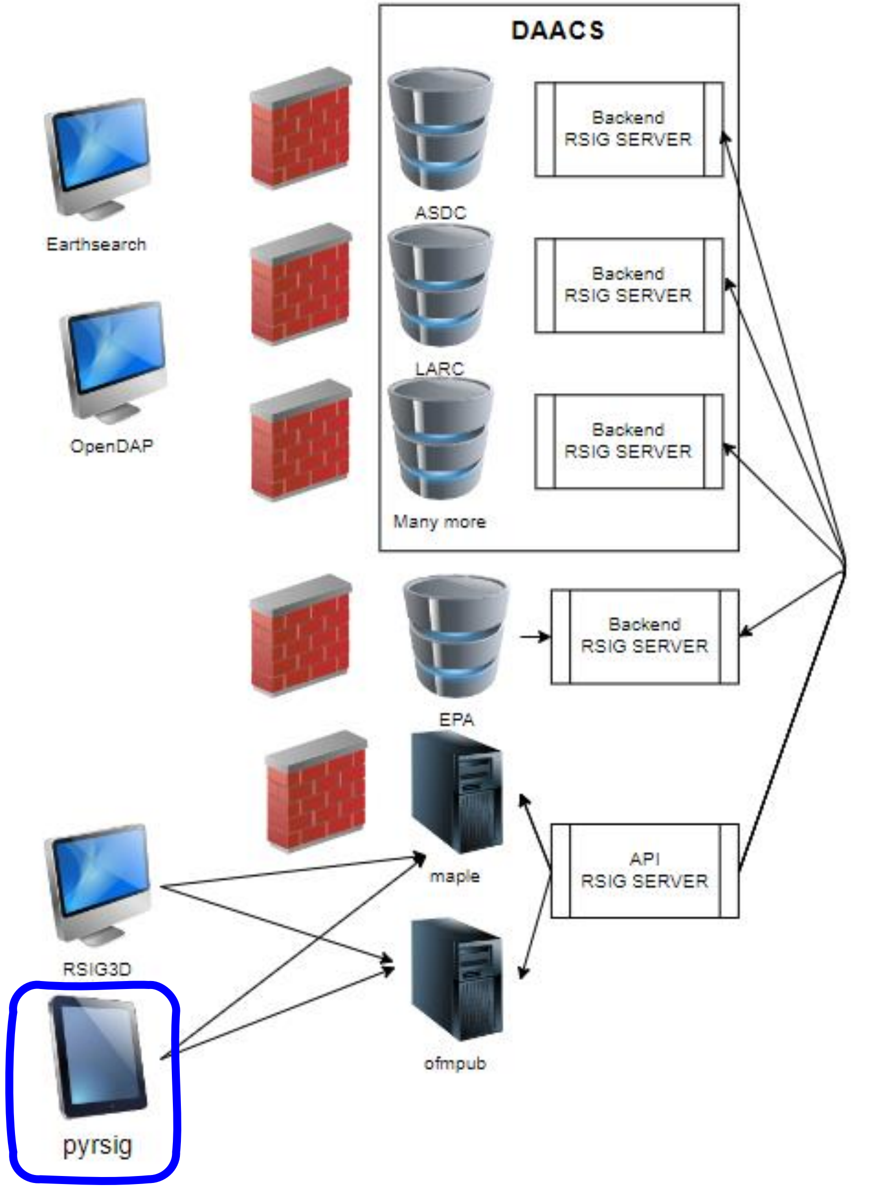
Overview

- Skills will be covered in the presentation
  - Setting up your python environment,
  - Using an example Jupyter notebook,
  - Retrieving TEMPO data using RSIG via pyrsig, and
  - Analyzing TEMPO data with example time series plots and maps
- Potential Applications
  - Assess how TEMPO agrees (or not) with available AQS monitors.
  - Compare TEMPO spatial gradients on stagnant days with emission data.
  - Compare TEMPO spatial gradients on all days with socioeconomic data.

RSIG is EPAs gateway to remote sensing data

- RSIG is a server and client system
- RSIG server is really a web of servers (EPA and NASA)
  - An EPA server provides a single front end application programming interface.
  - EPA and NASA servers provide services to the front end.
  - Provides satellite data, AQS data, EQUATES data, etc.
- RSIG3D is the client graphical user interface
  - Great for point and click analyses.
  - Not the focus today, see Jim Szykman, Luke Valin, Matt Freeman or Todd Plessel for more on that.
- And, pyrsig is a client for advanced analyses that leverages RSIG's easy access.
  - Great for custom analyses.
  - Runs in the cloud (AWS, Google Colab, or atmos)
  - Cloud apps work with workstation, phone, or tablet



barronh.github.io/pyrsig/

https://barronh.github.io/pyrsig/

pyrsig

Search docs

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pyrsig User's Guide

Python interface to RSIG Web API

RSIG server prepares the data!

The key value of *pyrsig* is to present RSIG data in pandas DataFrames and xarray Datasets. This makes it easy to do advanced analyses in a pythonic way. Example analyses are provided, but the sky is the limit.

Getting Started

The best way to get started is to install (see below) and then explore the examples gallery.

Installation

pyrsig is avalable through pypi.org, but is still in rapid development. You can get the latest release from pypi via the command below.

```
pip install pyrsig
```

Get data examples

Examples showing how to get data.

Get DataFrame for PurpleAir PM25

Get DataFrame for TropOMI NO2

Get DataFrame for AQS ozone

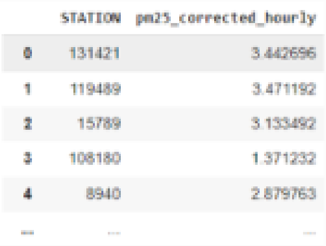
Get IOAPI formatted NetCDF TropOMI NO2

Get List of Possible Coverages

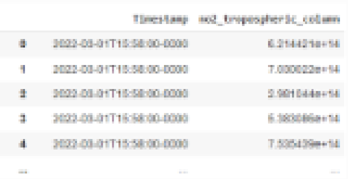
Get COARDS formatted NetCDF TropOMI NO2

Get data examples

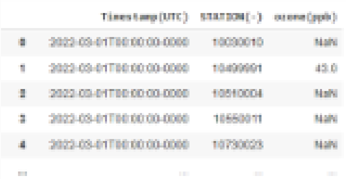
Examples showing how to get data.



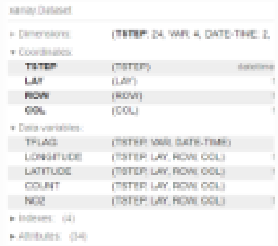
Get DataFrame for PurpleAir PM25



Get DataFrame for TropOMI NO2



Get DataFrame for AQS ozone

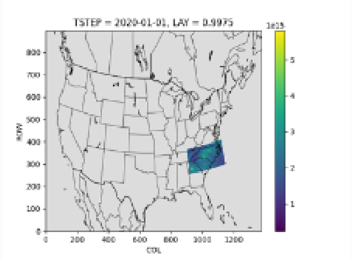


Get IOAPI formatted NetCDF TropOMI NO2

```python
import pyrsig

rsigapi = pyrsig.RsigApi(bdate='2022-03-01')
df = rsigapi.to_dataframe('tropomi.offl.no2.nitrogendioxide_tropospheric_column')
print(df.shape, *df.columns)
# (303444, 4) Timestamp(UTC) LONGITUDE(deg) LATITUDE(deg) nitrogendioxide_tropospheric_column(molecules/
```

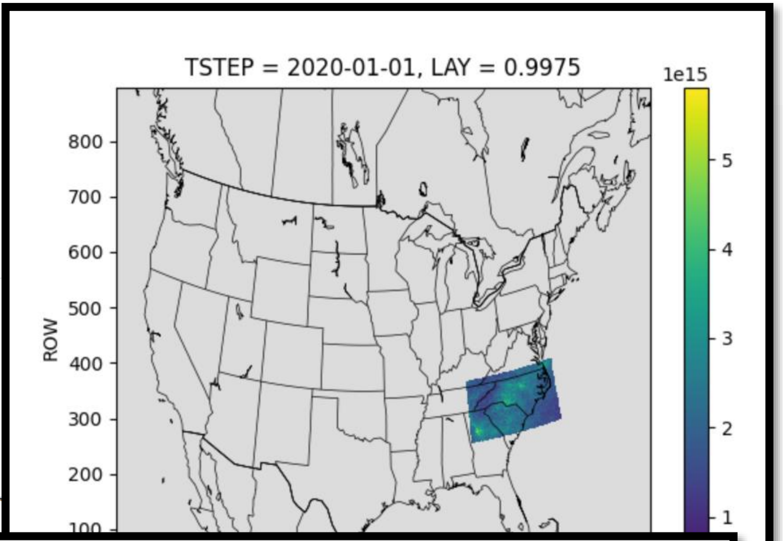
Oversample examples

Examples showing data oversampling of satellite data on



Oversample CONUS at 4k

Previous



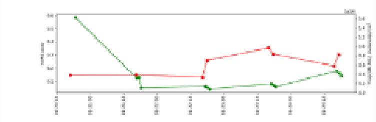

```python
import matplotlib.pyplot as plt
import pyrsig
import pandas as pd
import xarray as xr
import pycno
import os


# Create a working directory
gdnam = '4US1'
bdate = '2021-01-01'
edate = '2021-01-15'
wdir = f'{gdnam}/{bdate[:4]}'

os.makedirs(gdnam, exist_ok=True)

rsigapi = pyrsig.RsigApi(
    bdate=bdate, bbox=(-85, 33, -75, 37),
    encoding={"zlib": True, "complevel": 1, "_FillValue": -9.999e36},
    workdir=wdir, grid_kw='4US1'
)

# Update to download daily averages instead of hourly
rsigapi.grid_kw['REGRID_AGGREGATE'] = 'daily'

# Loop over days
dss = []
for bdate in pd.date_range('2020-01-01', '2020-01-15'):
    print(bdate)
    try:
        ds = rsigapi.to_ioapi(key='tropomi.offl.no2.nitrogendioxide_tropospheric_column', bdate=bdate)
        dss.append(ds)
    except Exception as e:
```

pyrsig

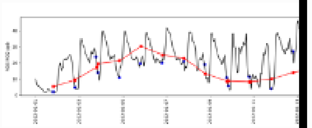
Search docs

Timeseries examp

Examples showing timeseries analyses that i

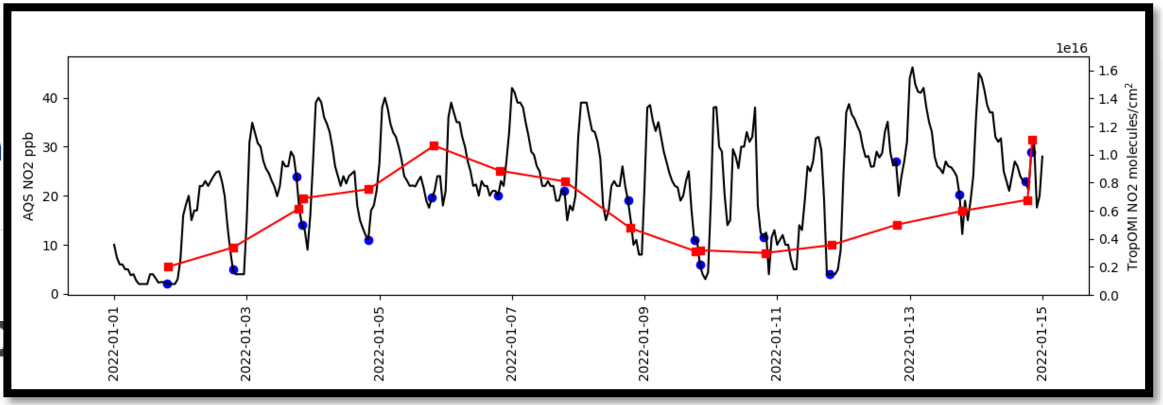


NYC VIIRS AOD vs TropOMI NO2



Phoenix AQS vs TropOMI

Previous




```python
import matplotlib.pyplot as plt
import pyrsig

# Create an RSIG api isntance
# Define a Time and Space Scope: here end of February around Phoenix
rsigapi = pyrsig.RsigApi(
    bdate='2022-01-01', edate='2022-01-15',
    bbox=(-112.3, 33.25, -111.85, 33.65)
)

# Get AQS NO2 with dates parsed and units removed from column names
aqsdf = rsigapi.to_dataframe('aqs.no2', parse_dates=True, unit_keys=False)

# Get TropOMI NO2
tomino2df = rsigapi.to_dataframe(
    'tropomi.offl.no2.nitrogendioxide_tropospheric_column',
    unit_keys=False, parse_dates=True
)


# Create spatial means for TropOMI and AQS
tomids = (
    tomino2df.groupby('time').median()['nitrogendioxide_tropospheric_column']
)
aqsds = aqsdf.groupby(['time']).median()['no2']

# Subset AQS to overpass times
oaqsds = aqsds.loc[aqsds.index.isin(tomids.index.floor('1h'))] # just overpass t

# Create axes with shared x
fig, ax = plt.subplots(figsize=(12, 4),
                       gridspec_kw=dict(bottom=0.25, left=0.05, right=0.95))
ax.tick_params(axis='x', labelrotation = 90)
tax = ax.twinx()
```

How to run any example on Jupyter?

- Configure
  - Open a new notebook
  - Add “%pip install --user netcdf4 pyproj pycno pyrsig”
  - And run it (once on atmos; each time for Colab or Sagemaker)
- Go to https://barronh.github.io/pyrsig/
  - Navigate to example
  - Copy code from example
  - Paste it in your colab notebook
  - Click play button

If this is your first time running Jupyter on atmos:
Instructions are at “Jupyter via OnDemand” in https://gaftp.epa.gov/Air/aqmg/bhenders/tutorials.html

TEMPO Tutorial

- https://gaftp.epa.gov/Air/aqmg/bhenders/tutorials.html
  - Click on “TEMPO pyrsig training notebook (May 2023 meeting)
  - The link takes you to a github gist.
- To run on Google Colab, click the “Open in Colab” badge
  - Click play on each cell
  - The first code cell will tell you to restart. Choose “runtime”, then “restart runtime”.
  - Then run the rest of the cells.
- To run on atmos, download the notebook and upload to atmos
  - Open JupyterHub on Atmos
  - Navigate to /home/bhenders/tutorials/pyrsig/tempo
  - Open SetupEnvironmetn.ipynb and run it
  - Open tempo_pyrsig.ipynb
    - Choose “File” “Save as” and save in your own space to run it

We’ll do this together

Questions?

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