



cmaqsatproc v2: Satellite data processing for CMAQ

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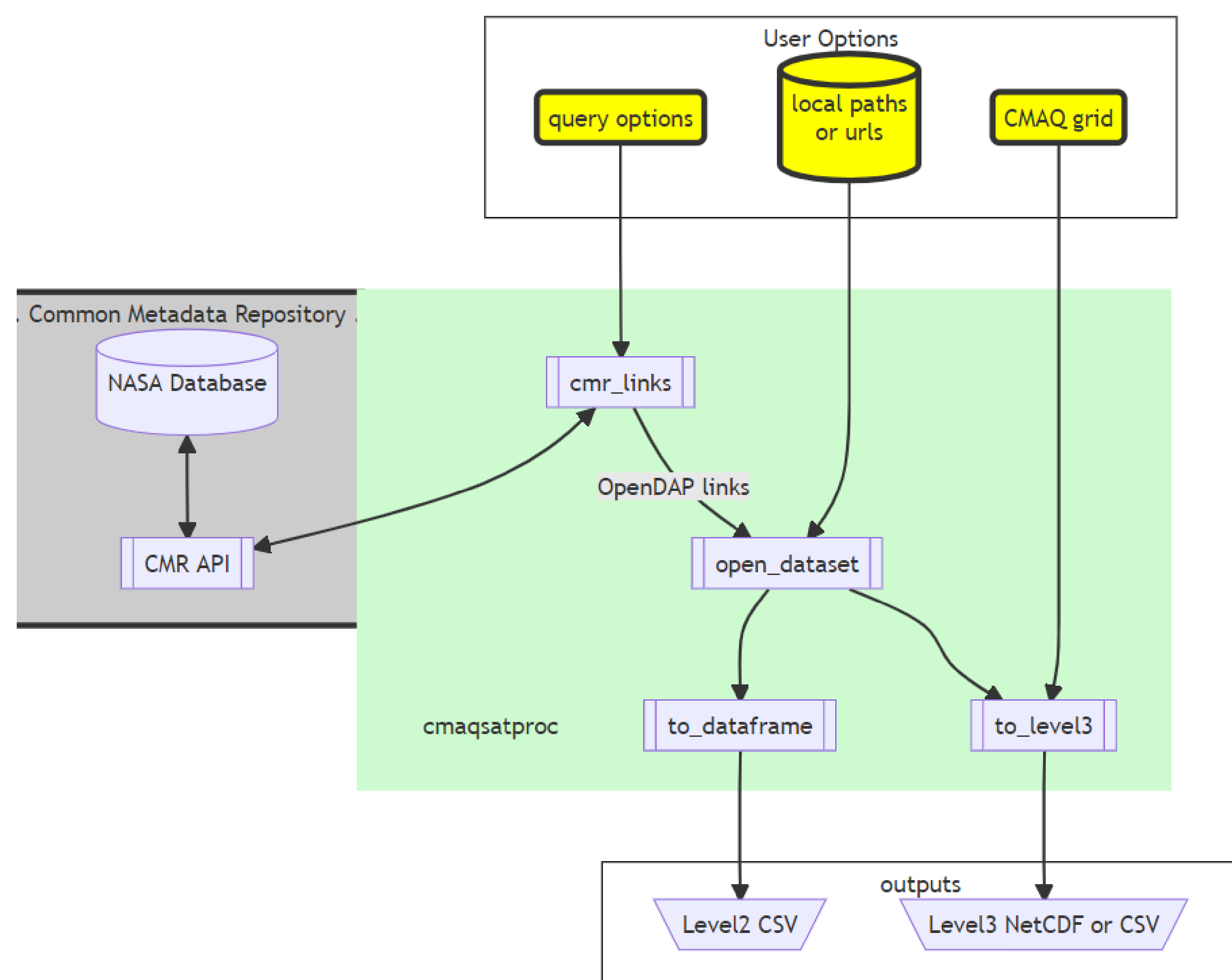
Overview

Introducing a simple way to process satellite data for CMAQ. The overall goal is to make satellite data comparable to CMAQ, which will enhance the community ability to evaluate CMAQ meaningfully against satellites.

Basic Overview

cmaqsatproc includes a single framework for data discovery, transformation to CMAQ grids, and adjustment of the satellite data using the CMAQ vertical profile.

- User supplies date and satellite product.
- Program queries NASA's Common Metadata Repository.
- Outputs Level 3 gridded NetCDF files
- Converts CMAQ to match satellite (and *vice versa*)



Satellite Products Currently Supported (more to come)

| Satellite | Instrument | Product | Reader Name | Download | OpenDAP | S3 |
|-------------------------------|------------|--------------------------|---|------------------|------------------|--------|
| Aura | Aura | NO2 HCHO O3 | OMNO2 OMHCHO OMO3 | ✓ ✓ ✓ | ✓ ✓ ✓ | |
| Terra Aqua | MODIS | AOD | MOD04 L2 MOD04 L3 | ✓ ✓ | | |
| Metop-A Metop-B Metop-C | IASI | NH3 | IASI_NH3 | ✓ ✓ ✓ | | |
| Sentinel-5 | TropOMI | NO2 HCHO CO CH4 | TropOMINO2 TropOMIHCHO TropOMICO TropOMIC3 | ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ | |
| GOES-16 GOES-17 | ABI | AOD | goes aod | ✓ ✓ | | ✓ ✓ |
| SNPP | OMPS | NO2 O3 | OMPS.NPP_NMNO2.L2 OMPS.NPP_NMTO3.L2 | ✓ ✓ | | |
| | VIIRS | AOD | AERDB.L2.VIIRS.SNPP AERDT.L2.VIIRS.SNPP | ✓ ✓ | | |

Example TropOMI NO2 Application with Python

```
import cmaqsatproc as csp
```

```
GDNAM = '12US1'; date='2019-07-24'  
readername = 'TropOMINO2' # or TropOMIHCHO, VIIRS AERDB, ...  
outpath = f'{readername}-{date}-{GDNAM}.nc'
```

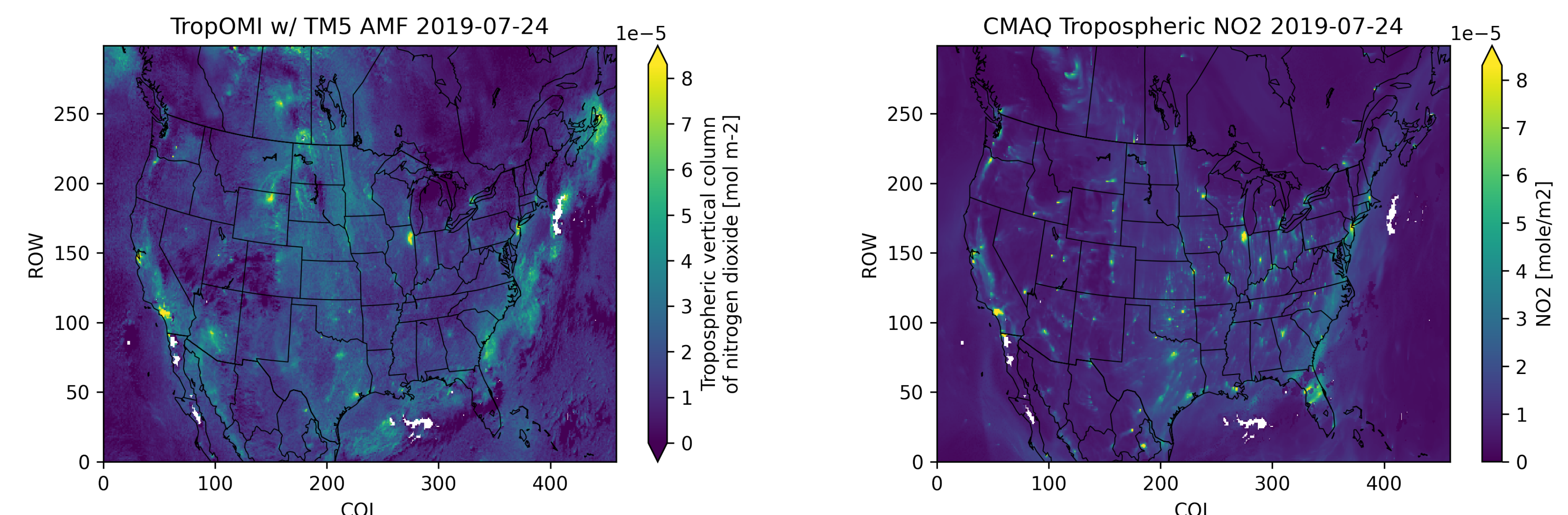
```
cg = csp.open_griddesc(GDNAM)  
satreader = csp.reader_dict[readername]
```

```
l3 = satreader.cmr.to_level3(  
    temporal=f'{date}T00:00:00Z/{date}T23:59:59Z',  
    bbox=cg.csp.bbox(), grid=cg.csp.geodf, verbose=9  
)  
l3.to_netcdf(outpath)
```

No downloaded files required!

TropOMI NO2 with TM5 AMF (left) and CMAQ (right)

- TropOMI measures a slant column density (SCD) and counts molecules proportional to the environment-specific extinction efficiencies.
- CMAQ counts molecules equally and integrates along a vertical path.
- Air Mass Factor ($VCD = SCD / AMF$) corrects TropOMI for geometry and efficiency based on the TM5 model *prior* vertical profile.



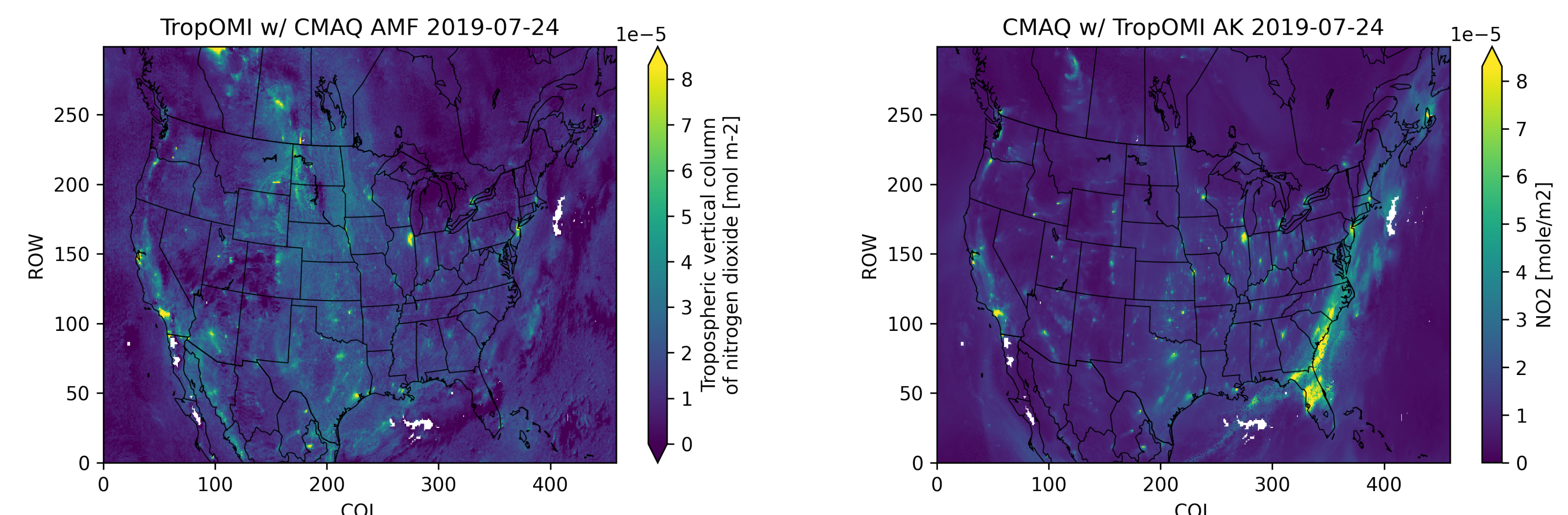
- An CMAQ-based **AMF** would be different...

Process Satellite with CMAQ and CMAQ with Satellite

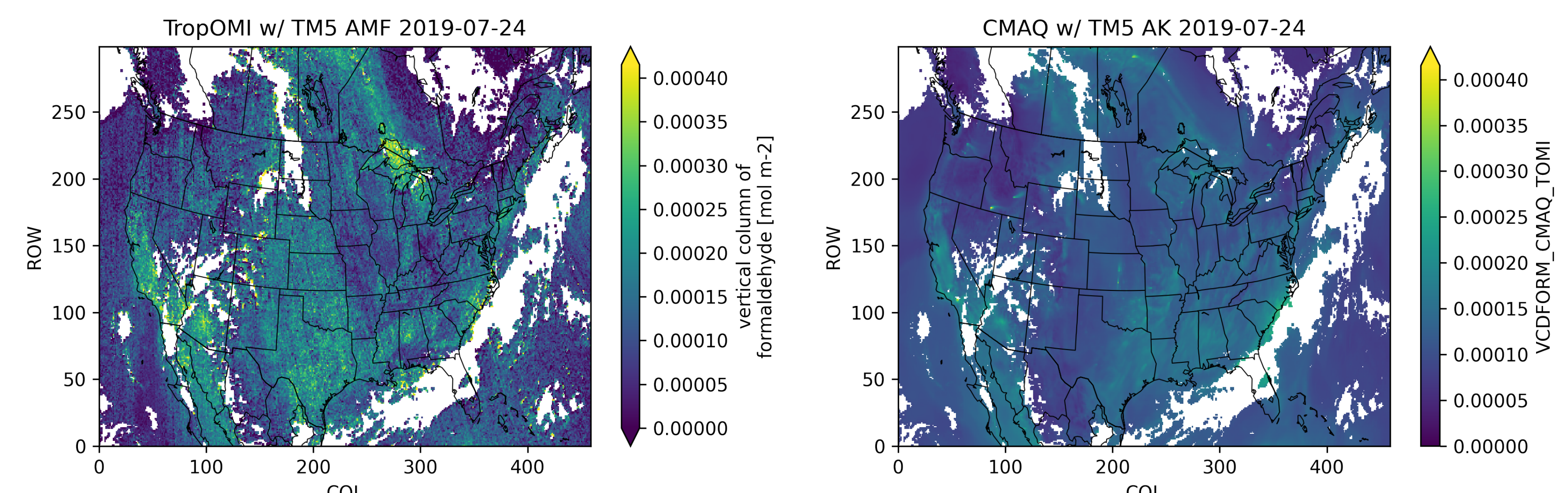
```
qf = csp.open_ioapi(f'CCTM CONC {date}-{GDNAM}.nc')[['NO2']]  
mf = csp.open_ioapi(f'METCRO3D {date}-{GDNAM}.nc')  
qf['DENS'] = mf['DENS']  
qf['ZF'] = mf['ZF']  
qf['PRES'] = mf['PRES']  
# Create satellite according to CMAQ, and CMAQ according to satellite  
overf = satreader.cmaq_process(qf, l3)  
overf.to_netcdf(f'{readername}-{date}-{GDNAM}.CMAQ.nc')
```

TropOMI NO2 with CMAQ AMF (left) and CMAQ with TropOMI AK (right)

- The TropOMI VCD can be recalculated from the CMAQ prior
- Or, CMAQ can be "observed" by the TropOMI averaging kernel (AK).

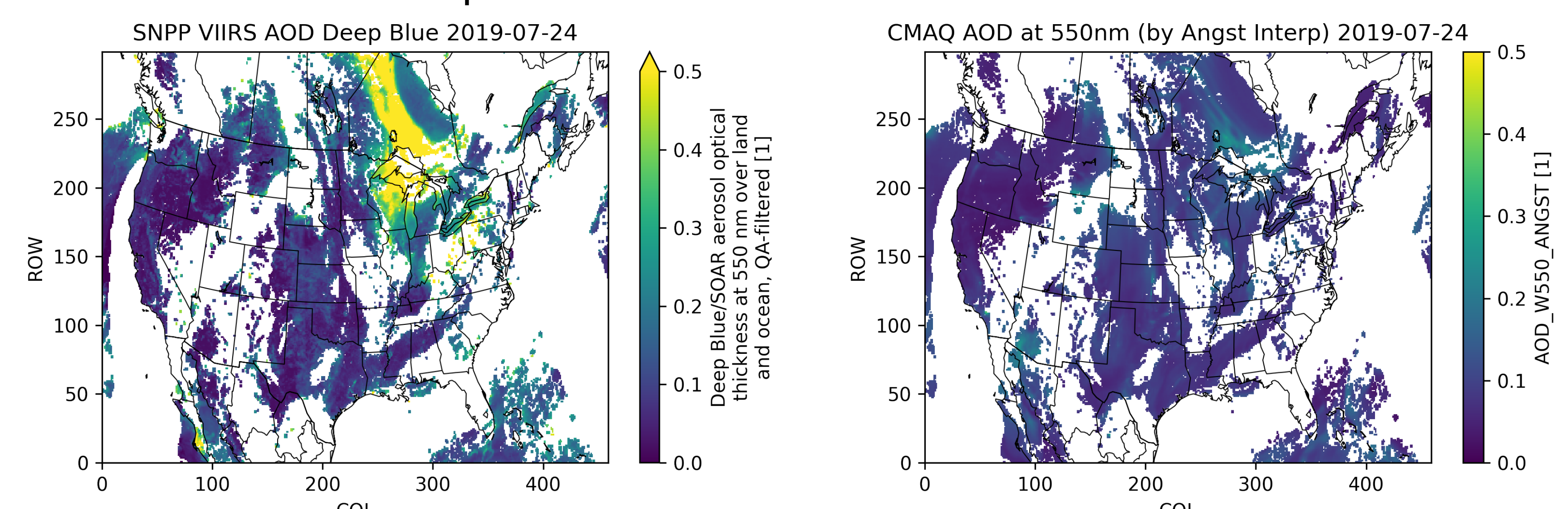


TropOMI HCHO (left) and CMAQ (right) both with TropOMI AK



SNPP VIIRS AOD (left) and CMAQ AOD (right) at overpass

- There was a smoke plume in the north.



Installation and More Information

For more info: <http://github.com/barronh/cmaqsatproc>
To install: run 'pip install <https://github.com/barronh/cmaqsatproc.git>'