

Tropospheric Emissions:  
Monitoring of Pollution



# TEMPO Trace Gas Algorithms

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Smithsonian

Hourly Measurement of Pollution

60 minutes



# TEMPO Data Products



| Level | Product                                      | Algorithm                            |
|-------|--|--------------------------------------|
| L0    | Digital counts                               | Raw to L0                            |
| L1-b  | irradiance                                   | SAO L0-1                             |
|       | radiance                                     | SAO L0-1                             |
| L2    | Cloud <sup>NRT</sup>                         | OMI O2-O2                            |
|       | O <sub>3</sub> profile                       | SAO O3 profile                       |
|       | Total O <sub>3</sub>                         | TOMS V8.5                            |
|       | NO <sub>2</sub> <sup>NRT</sup>               | SAO trace gas, strat/trop separation |
|       | H <sub>2</sub> CO <sup>NRT</sup>             | SAO trace gas                        |
|       | C <sub>2</sub> H <sub>2</sub> O <sub>2</sub> | SAO trace gas                        |
|       | H <sub>2</sub> O                             | SAO trace gas                        |
|       | BrO  | SAO trace gas                        |
|       | Aerosol <sup>NRT</sup>                       | OMAERUV                              |
|       | SO <sub>2</sub> <sup>NRT</sup>               | OMSO2 PCA                            |
|       | <b>TEMPO/GOES-R product</b>                  | GOES-R products on TEMPO pixels      |
| L3    | Gridded L2                                   | SAO L2-3                             |
| L4    | UVB  | OMI/GEMS UVB                         |

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| L3    | Gridded L2                                   | SAO L2-3                             |
| L4    | UVB  | OMI/GEMS UVB                         |



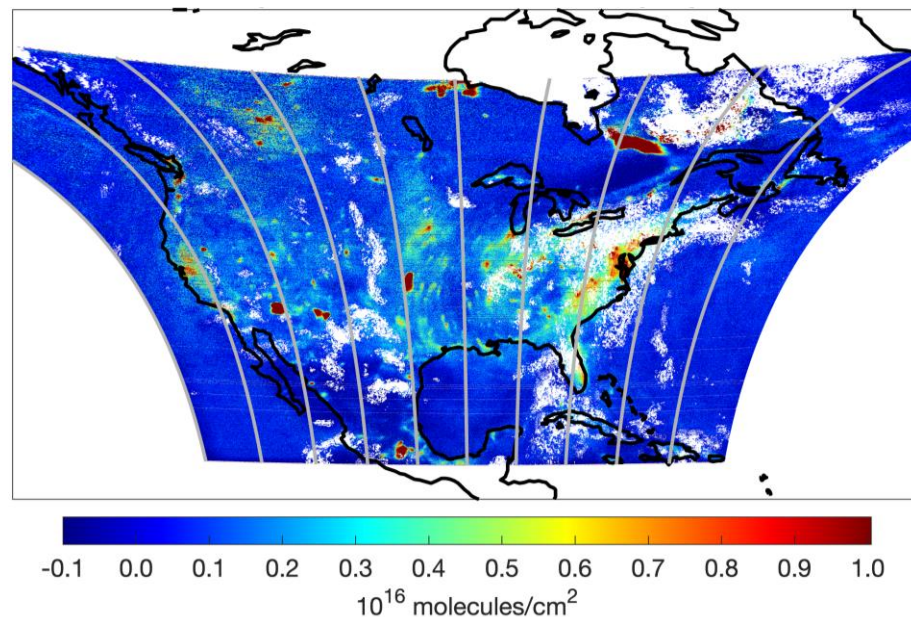
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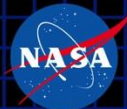
Trace gas algorithm depends on other algorithms:

1. Raw → Level 0
2. INR (Uses GOES-R imagery)
3. Level 0 → 1B (calibrated)
4. Cloud retrieval

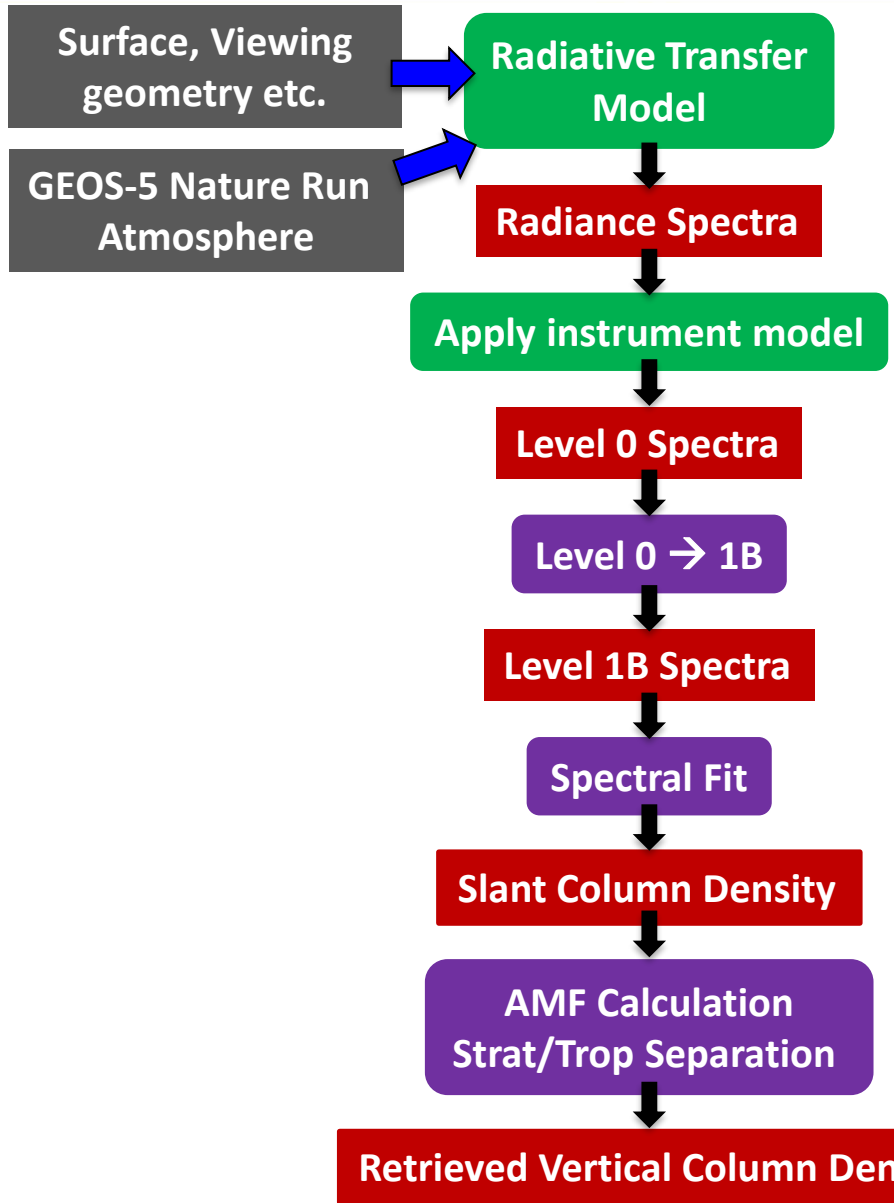
- Algorithm components:
  1. Spectral fitting → *NO<sub>2</sub> slant column density*
  2. Air mass factor
  3. Stratosphere/troposphere separation [Geddes et al., 2018]
- Several inputs:
  - Trace gas profiles (GEOS-CF)
  - Surface reflectance
  - Snow/ice cover, etc..
- Data will be provided by SAO to NASA Atmospheric Science Data Center
  - Available on cloud
- Two products planned:
  1. Near-real time (NRT)
  2. Offline with improved ancillary data

NO<sub>2</sub> Tropospheric Column  
01 July, 17:00 UTC

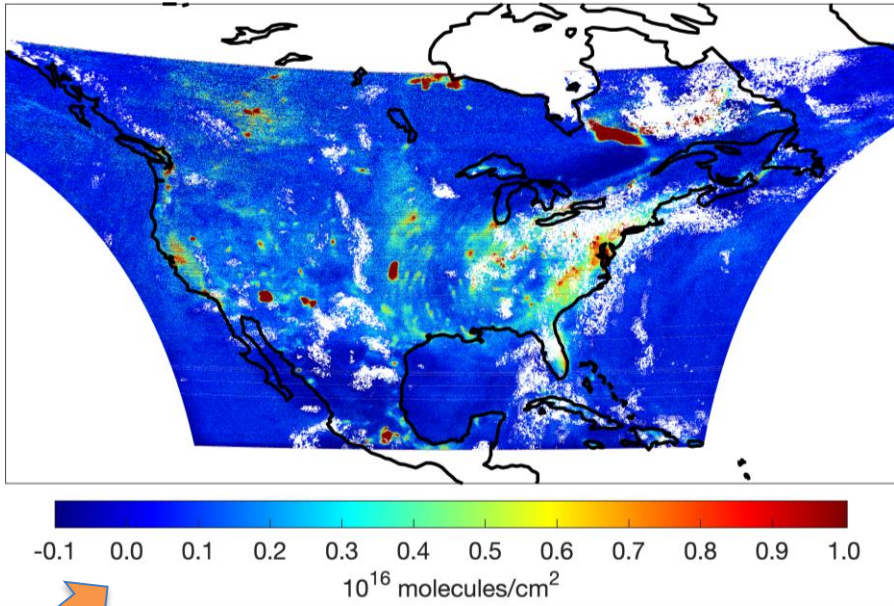




- Heritage: OMI HCHO, BrO, OClO operational products
- Initial development:
  1. Defined TEMPO file formats
  2. Created simple synthetic TEMPO data
  3. Modified OMI cloud code for TEMPO
  4. Modified OMI trace gas code for TEMPO
- First tests:
  - Use very simple synthetic data to check internal consistency
- More advanced testing:
  - Use synthetic TEMPO spectra simulated with atmosphere from GEOS-5 nature run (2013-2014, 12.5 x 12.5 km<sup>2</sup>)
  - Will soon test with GEMS spectra



NO<sub>2</sub> Tropospheric Column  
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Surface, Viewing  
geometry etc.

GEOS-5 Nature Run  
Atmosphere

Radiative Transfer  
Model

Radiance Spectra

Apply instrument model

Level 0 Spectra

Level 0 → 1B

Level 1B Spectra

Spectral Fit

Slant Column Density

AMF Calculation  
Strat/Trop Separation

Retrieved Vertical Column Density

**This step is VERY slow!**

One TEMPO hourly scan = 2.6 million  
spectra

Simulation:

- 290 – 795 nm
- Resolution: 0.01 nm (UV), 0.002 nm (VIS)

*1-hour scan = ~10 days on 640 CPUs*

TEMPO team is using a single day (10 hourly scans) for testing retrievals.



- Applications users do not need to test retrievals
  - They need:
    - TEMPO-format files
    - Realistic Level 2 NO<sub>2</sub> columns
    - Sometimes vertically-resolved scattering weights and other support data
- To speed things up, we skip radiative transfer simulation
  - Generate Level 2 slant columns with look-up tables and a noise model
- NASA MSFC is providing these proxy data to early adopters
  - <https://weather.msfc.nasa.gov/tempo/>