

Tropospheric Emissions:  
Monitoring of Pollution



# TEMPO Ground Systems: Cloud Processing

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Hourly Measurement of Pollution

60 minutes

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- **Starting point: OMI Raman-scattering cloud code (OMCLDRR)**
- **Modification for TEMPO**
  - **Changes common to all science codes**
  - **Cloud-specific changes**
- **Testing**
- **Resource usage**
- **Further work**

➤ **Main products:**

- **Cloud Fraction**
- **Cloud Pressure (optical centroid pressure)**

➤ **Code characteristics:**

- **~10000 lines of Fortran90, ~120 subroutines / functions**
- **Inputs:**
  - **HDF-EOS2/HDF4 radiance and irradiance**
  - **ASCII and fortran binary format calibration files (climatologies, cross-sections, lookup tables, etc.)**
- **Output: HDF-EOS5/HDF5**

➤ **Fast code: ~70s to process one OMI orbit.**

# Modifications for TEMPO: common to all codes



- **File format changes:**
  - TEMPO will use netCDF4/HDF5 throughout
  - Replace HDF-EOS with TEMPO I/O library built on netCDF4 (libtio)
- **Error handling and logging:**
  - ECS SDP Toolkit over-complicated for our needs
  - Replace with dedicated error handling and logging library (libtell)
- **Compilers:**
  - OMCLDRR built using PGI compiler
  - TEMPO software development uses GNU and Intel compilers



- **Remove/disable unused experimental/test code**
- **Remove OMI-specific features**
  - Spatial zoom mode, small pixel data, row anomaly, etc.
- **Reformat fortran binary calibration files to netCDF**
  - Smaller, human readable files with no significant loss of speed
- **Results:**
  - ~1000 lines of code removed,
  - netCDF I/O added but HDF-EOS I/O retained for testing,
  - Speed of code retained.
- **Refactoring for TEMPO mostly complete**

## ➤ Regression testing

- Nightly build compiles and runs GNU and Intel versions of code every weekday, using OMI data
- Output compared with baseline file “blessed” by GSFC developers
- Cross-comparison of HDF-EOS and netCDF inputs/outputs
- Tests specific capabilities: spline and linear interpolation, wavelength shift & squeeze, output of residuals

## ➤ Integration testing

- Reduced-size TEMPO-format granule processed through Cloud, NO<sub>2</sub>, HCHO codes, using pipeline manager prototype

## ➤ Throughput tests

- Tests with full-size TEMPO granule - no problems identified

- Time to process one OMI orbit: ~70s (Intel Xeon 2.8 GHz)
- Memory usage: ~112 MB
- Compare to other science codes:
  - Total O<sub>3</sub>: ~70s
  - Trace gas (HCHO, NO<sub>2</sub>): ~1 hour
  - O<sub>3</sub> profile (not yet updated for TEMPO): several hours
- TEMPO 6-minute granule size equivalent to ~2.5 OMI orbits
  - Tests confirm equivalent scale-up in processing time.
- Conclusion: Cloud code will be a minor resource user, no problems expected even with increased capabilities

- **Incorporate improvements from GSFC developers:**
  - **Uncertainty estimation**
  - **Improved surface reflectance climatology**
- **Issues to be resolved:**
  - **Test data**
  - **Cloud mask product**
- **CDR-level review of Cloud, Trace gas, and Total O<sub>3</sub> codes scheduled for October**
  - **We expect to have a prototype pipeline including all three codes, updated for TEMPO, ready for the review**
- **Take-home message: Cloud code modifications for TEMPO on schedule, no problems expected**